SANITARY SEWER FLOW MONITORING AND INFLOW / INFILTRATION STUDY

West Bay Sanitary District

June 2014

V&A

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Prepared for

West Bay Sanitary District
500 Laurel Street
Menlo Park, CA 94025

Prepared by

V&A

June 2014

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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
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.
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 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 and often dictates the required capacity of downstream facilities to carry these peak instantaneous flows. Overflows are often attributable to high inflow rates.

Term	Definition
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, *RDI*	The estimated RDI rates at a period 24 hours or more after the conclusion of a 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.

Term	Definition
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, rainfall monitoring, and inflow and infiltration (I/I) analysis within the West Bay Sanitary District (District). Flow and rainfall monitoring was performed over a 10-week period from January 17, 2014, to April 13, 2014, at 16 open-channel flow monitoring sites throughout the District. The purpose of this study was to measure sanitary sewer flows at the flow monitoring sites and estimate available sewer capacity and infiltration and inflow (I/I) occurring in the basins upstream from the flow monitoring sites.

Site Flow Monitoring and Capacity Results

Peak measured flows and the corresponding flow levels (depths) are important to understand the capacity limitations of a collection system. The peak flows and flow levels reported are from the peak measurements as taken across the entirety of the flow monitoring period. Peak flows and levels may not correspond to a rainfall event, but instead may be caused due to blockages, grease or roots that cause a backflow condition.

Table 1 summarizes the peak recorded flows, levels, *d/D* ratios, and peaking factors per site during the flow monitoring period. Figure 1 shows a schematic diagram of the peak measured flows with peak flow levels. Capacity analysis data is presented on a site-by-site basis and represents the hydraulic conditions only at the point site locations.

Table 1. Summary of Capacity Analysis

Site	ADWF (mgd)	Peak Measured Flow (mgd)	Peaking Factor*	Diameter (in)	Peak Level (in)	*d/D* Ratio	Level Surcharged above Crown (ft)
Site 1	0.935	2.118	2.27	23.5	12.7	0.54	-
Site 2	1.184	2.378	2.01	30	20.5	0.68	-
Site 3	0.089	0.230	2.57	15	3.4	0.22	-
Site 4	0.436	1.028	2.36	24	8.8	0.37	-
Site 5	1.426	3.574	2.51	24	7.2	0.30	-
Site 6	1.154	2.849	2.47	23.75	10.8	0.45	-
Site 7	0.156	0.825	5.29	15	4.2	0.28	-
Site 8	0.233	0.842	3.61	20.75	5.4	0.26	-
Site 9	0.499	1.332	2.67	21	7.2	0.34	-
Site 10	0.269	0.913	3.39	22.75	4.9	0.22	-
Site 11	1.733	3.795	2.19	54	16.6	0.31	-
Site 12	0.090	0.261	2.91	11.75	3.5	0.29	-
Site 13	0.021	0.194	9.31	10	3.2	0.32	-

Site	ADWF (mgd)	Peak Measured Flow (mgd)	Peaking Factor*	Diameter (in)	Peak Level (in)	*d/D* Ratio	Level Surcharged above Crown (ft)
Site 14	0.103	0.346	3.36	15	3.7	0.24	-
Site 15	0.237	0.825	3.48	18	3.8	0.21	-
Site 16	0.008	0.092	11.02	10	1.7	0.17	-

*Sites with peaking factors higher than the typical design values are highlighted in red.

The following capacity analysis results are noted:

- **Peaking Factor:** Seven sites (Sites 7, 8, 10, 13, 14, 15, and 16) had peaking factors that exceeded typical design threshold limits for peak flow to average dry weather flow ratio. It should be noted that the peaking factors for Sites 13 and 16 are high because of the low ADWF for both sites and unstable flow pattern for Site 16 since it was possibly on an overflow line.
- ***d/D* Ratio:** All of the monitoring sites had *d/D* ratios less than the typical design threshold value.

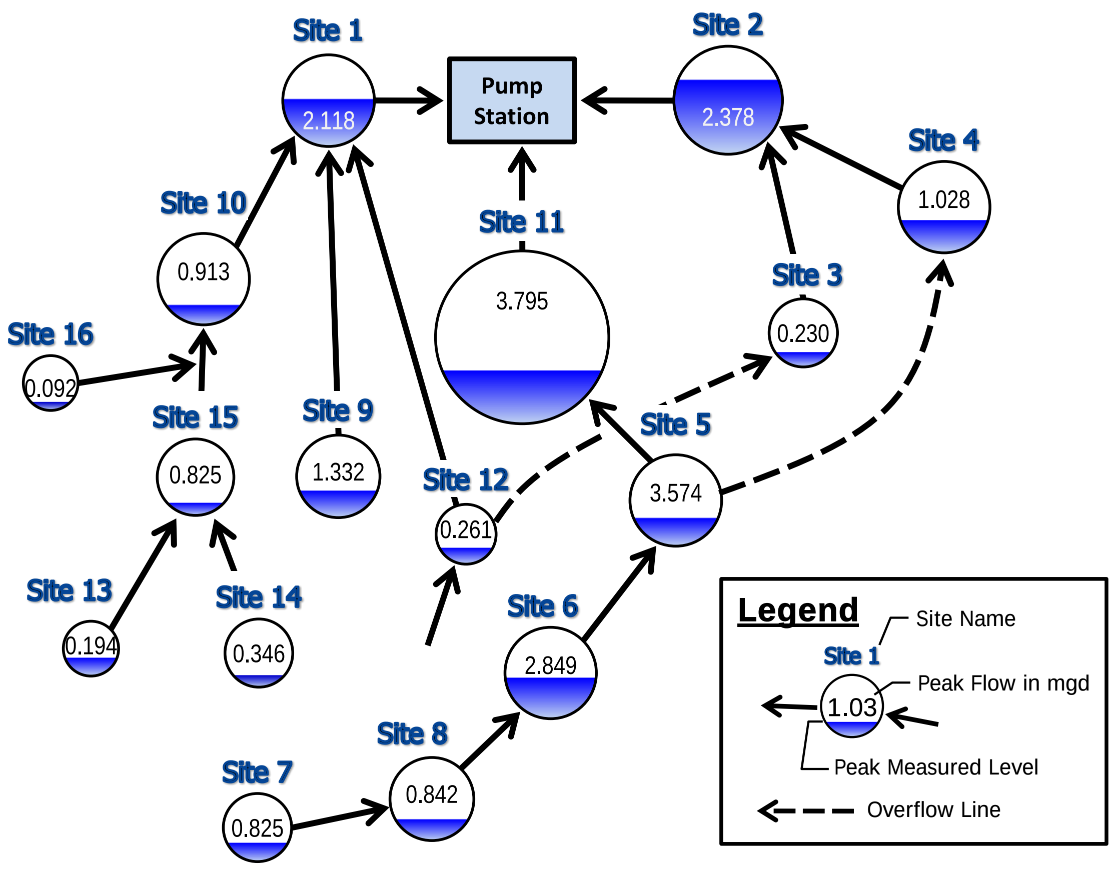


Figure 1. Peak Measured Flow (Flow Schematic)

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 6 represents the least. The final I/I values and I/I analysis data were taken from the February 28 – March 2, 2014 rainfall event. Refer to the *I/I Methods* section for more information on inflow analysis methods.

Table 2. I/I Analysis Summary

Basin	Peak I/I Rate (mgd)	RDI Rate (mgd)	Total I/I (million gallons)	Inflow Ranking	RDI Ranking	Evidence of High GWI?	Combined I/I Ranking
Basin 1	0.324	0.001	2,000	4	11	No	14
Basin 2	0.382	0.036	352,000	10	6	Yes	4
Basin 3	0.108	0.007	54,000	11	8	Yes	9
Basin 4	0.420	0.036	123,000	5	4	No	6
Basin 5	0.548	Negl.	27,000	3	13	No	13
Basin 6	0.719	0.030	273,000	9	10	No	12
Basin 7	0.147	0.030	236,000	13	7	No	8
Basin 8	0.260	0.054	183,000	6	2	No	5
Basin 9	0.315	0.044	225,000	12	5	No	7
Basin 11	0.055	Negl.	91,000	14	14	No	11
Basin 12	0.157	0.004	103,000	1	9	No	2
Basin 13	0.170	0.009	128,000	2	3	Yes	1
Basin 14	0.173	Negl.	82,000	7	12	No	10
Basin 15	0.196	0.048	183,000	8	1	No	3

*Basins that were ranked to be top five basins for I/I analysis are highlighted in red.

Recommendations

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

1. **Determine I/I Reduction Program:** The District 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 occurs in Basins 1, 4, 5, 12, and 13.
   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. The highest normalized rainfall-dependent infiltration was occurring in Basins 4, 8, 9, 13 and 15. The basins with detectable groundwater infiltration were Basins 2, 3, and 13.
2. **I/I Investigation Methods:** Potential I/I investigation methods include the following:
   a. Smoke testing.
   b. Mini-basin flow monitoring.
   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.
3. **I/I Reduction Cost-Effectiveness Analysis:** The District 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

Scope and Purpose

V&A has completed sanitary sewer flow monitoring, rainfall monitoring, and inflow and infiltration (I/I) analysis within the West Bay Sanitary District (District). Flow and rainfall monitoring was performed over a 10-week period from January 17, 2014, to April 13, 2014, at 16 open-channel flow monitoring sites throughout the District.

West Bay Sanitary District provides wastewater services to the City of Menlo Park, Atherton, and Portola Valley and unincorporated areas of Santa Clara and San Mateo counties, including portions of East Palo Alto and Woodside.

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

Flow Monitoring Sites and Rain Gauges

Flow monitoring sites are the locations where the flow monitors were placed. Flow monitoring site data may include the flows of 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. Rain data was obtained from three rain gauges installed by V&A. The flow monitoring and rain gauge locations are listed in Table 3 and shown in Figure 2.

Table 3. List of Flow Monitoring and Rain Gauge Locations

Monitoring Site	Pipe Diameter (in)	Location
Site 1	23.5	Haven Avenue at the Atherton Channel
Site 2	30	Near bike path at Bayfront Park and Marsh Road
Site 3	15	Intersection of Hill Avenue and Hamilton Avenue
Site 4	24	Terminal Avenue, just east of Almanor Avenue
Site 5	24	Hollyburne Avenue, south of Van Buren Road
Site 6	23.75	Willow Road, northeast of Alma Street
Site 7	15	Alpine Road, north of Westridge Drive
Site 8	20.75	Alpine Road, north of Highway 280
Site 9	21	Middlefield Road, southeast of Prior Lane
Site 10	22.75	On shoulder of El Camino Real, south of Atherton 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 11	54	In field south of Independence Drive
Site 12	11.75	Oak Grove Avenue, northeast of Mills Street
Site 13	10	Atherton Avenue, north of Alameda De Las Pulgas
Site 14	15	Atherton Avenue, north of Mulberry Lane
Site 15	18	Atherton Avenue, northeast of Stevenson Lane
Site 16	10	Atherton Avenue, northeast of Austin Avenue
Rain Gauges		
RG 1	Pump Station, Portola Road, Portola Valley	
RG 2	Pump Station, corner of Hamilton Court and Hamilton Avenue	
RG 3	2 Stowe Lane, Menlo Park	

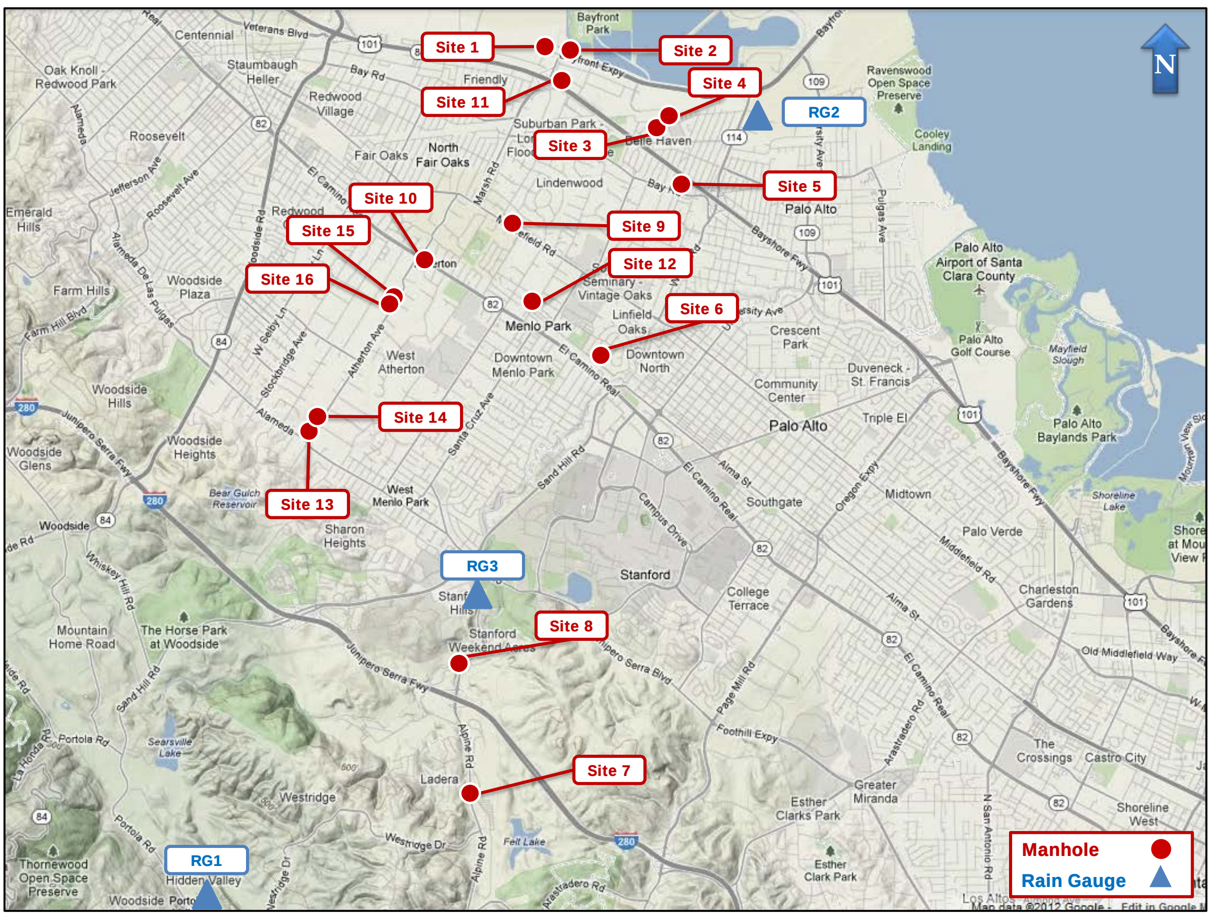
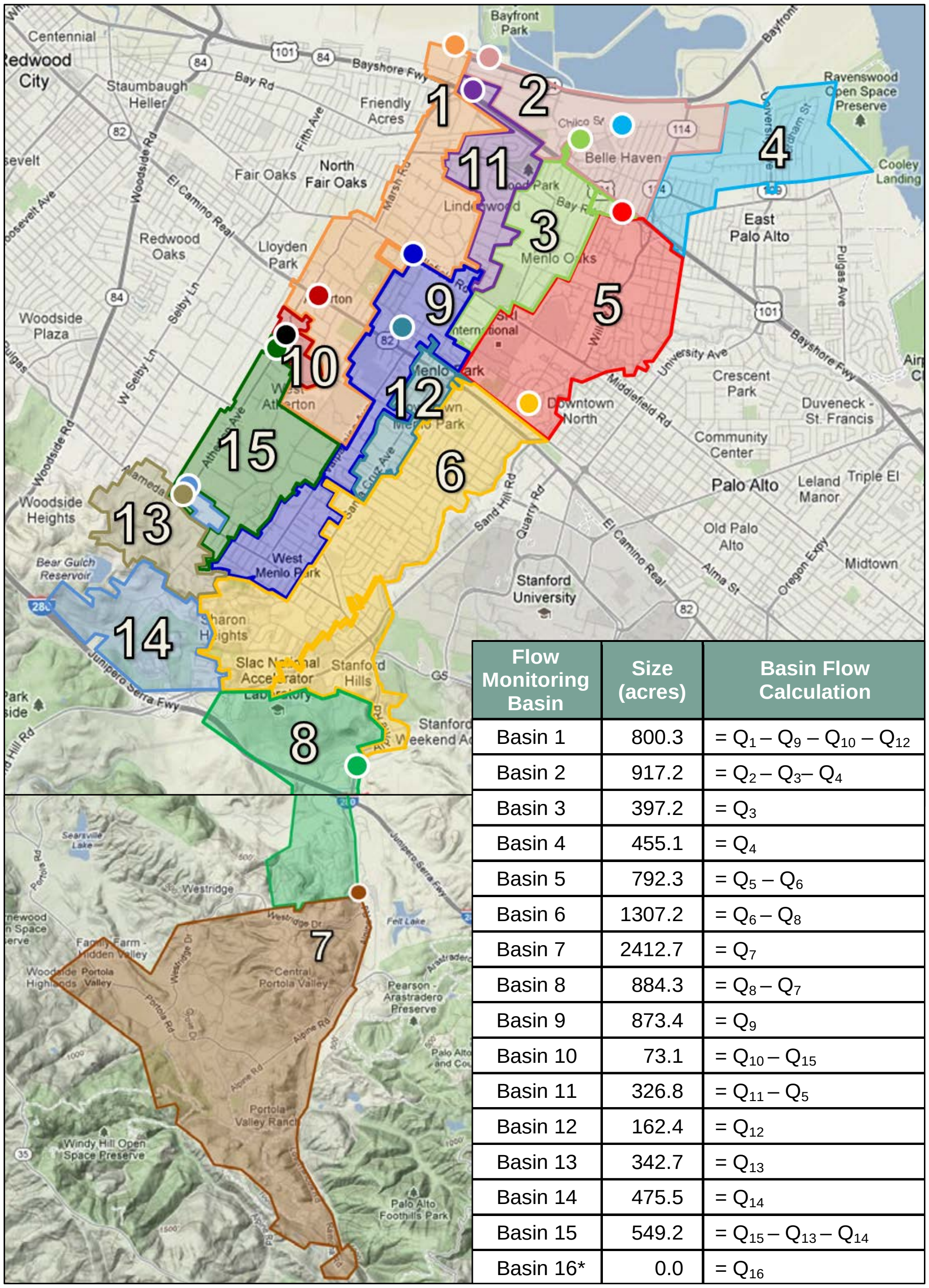


Figure 2. Map of Flow Monitoring Sites and Rain Gauges

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. After a basin of interest is established, the flow generated within the basin is the difference between the flows measured in the inlet and outlet of the basin. If there is no inlet flow, the flow from the basin is exclusively measured by the outlet flow meter. The monitoring basins are shown in Figure 3.



Flow Monitoring Basin	Size (acres)	Basin Flow Calculation
Basin 1	800.3	$= Q_1 - Q_9 - Q_{10} - Q_{12}$
Basin 2	917.2	$= Q_2 - Q_3 - Q_4$
Basin 3	397.2	$= Q_3$
Basin 4	455.1	$= Q_4$
Basin 5	792.3	$= Q_5 - Q_6$
Basin 6	1307.2	$= Q_6 - Q_8$
Basin 7	2412.7	$= Q_7$
Basin 8	884.3	$= Q_8 - Q_7$
Basin 9	873.4	$= Q_9$
Basin 10	73.1	$= Q_{10} - Q_{15}$
Basin 11	326.8	$= Q_{11} - Q_5$
Basin 12	162.4	$= Q_{12}$
Basin 13	342.7	$= Q_{13}$
Basin 14	475.5	$= Q_{14}$
Basin 15	549.2	$= Q_{15} - Q_{13} - Q_{14}$
Basin 16*	0.0	$= Q_{16}$

Figure 3. Flow Monitoring Basin Map

* Acreage for Basin 16 was not provided as Site 16 may be an overflow line.

METHODS AND PROCEDURES

Confined Space Entry

After the flow monitoring sites were determined, a confined space entry was followed in order to install the flow meter into the manhole. 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 23.5%), 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 to monitor the atmosphere using another four-gas monitor 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 one Teledyne Isco 2150 meter in each monitoring site listed in Table 3. Isco 2150 meters use submerged sensors with a pressure transducer to collect depth readings and an ultrasonic Doppler sensor to determine the average fluid velocity. The ultrasonic sensor emits high-frequency sound waves, which are reflected by air bubbles and suspended particles in the flow. The sensor receives the reflected signal and determines the Doppler frequency shift, which indicates the estimated average flow velocity. The sensor is typically mounted at a manhole inlet to take advantage of smoother upstream flow conditions. The sensor may be offset to one side to lessen the chances of fouling and sedimentation where these problems are expected to occur. Manual level and velocity measurements were taken during installation of the flow meters and again when they were removed and compared to simultaneous level and velocity readings from the flow meters to ensure proper calibration and accuracy. Figure 4 shows a typical installation for a flow meter with a submerged sensor.

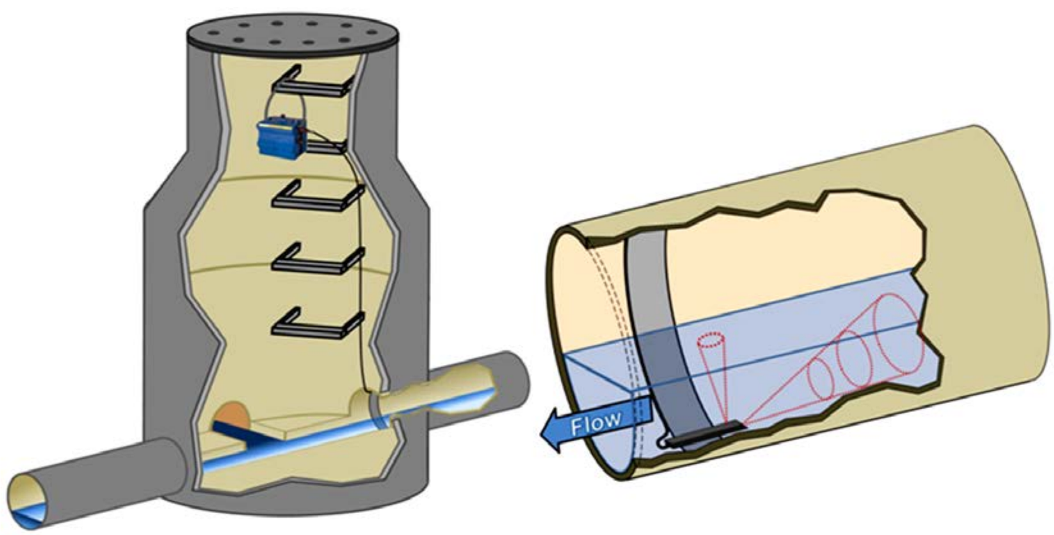


Figure 4. Typical Installation for Flow Meter with Submerged Sensor

Flow Calculation

Data retrieved from the 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.

Average Dry Weather Flow Calculation

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. The overall average dry weather flow (ADWF) is calculated per the following equation:

$$ADWF = \left(ADWF_{Mon-Fri} \times \frac{5}{7}\right) + \left(ADWF_{Sat-Sun} \times \frac{2}{7}\right)$$

Figure 5 illustrates the varying flow patterns within a work week.

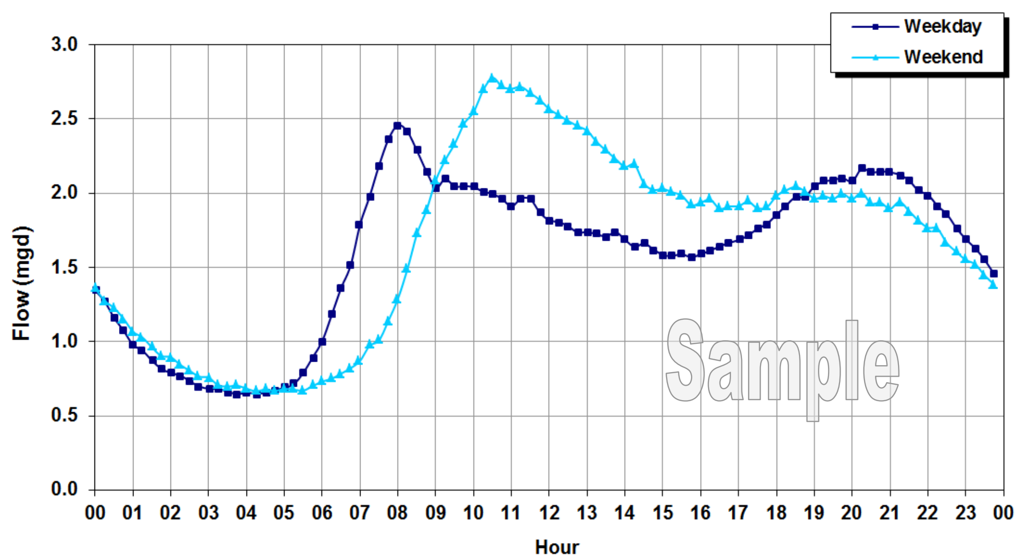


Figure 5. Sample ADWF Diurnal Flow Patterns

Background on Inflow / Infiltration

Inflow and infiltration (I/I) consists of storm water and groundwater that enter the sewer system through pipe defects and improper storm drainage connections and is defined as follows:

Definition and Typical Sources

- **Inflow:** Storm water 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.
- **Infiltration:** 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.

Figure 6 illustrates the possible sources and components of I/I.

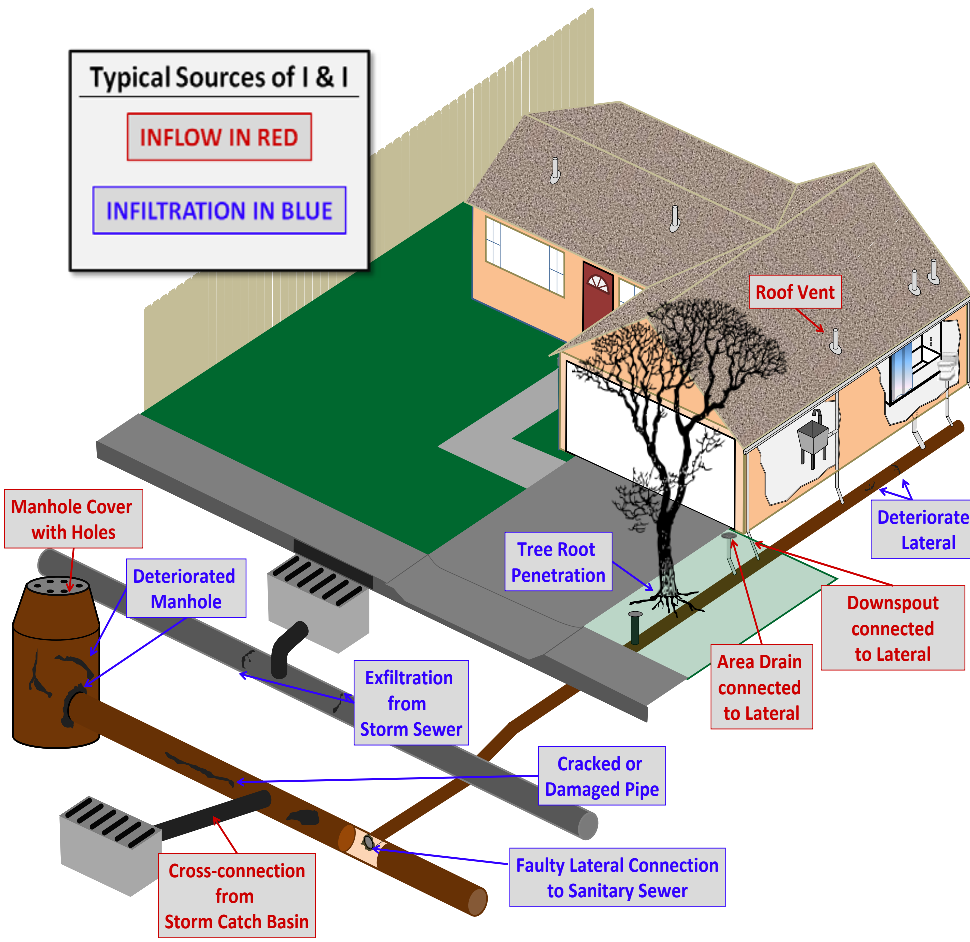


Figure 6. Typical Sources of Infiltration and Inflow

Infiltration Components

Infiltration can be further subdivided into components as follows:

- **Groundwater Infiltration:** 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:** 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** is storm water which enters the collection system indirectly through pipe defects, but normally 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.

Impact and Cost of Source Detection and Removal

- **Inflow:**
  - **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 upsetting the biological treatment (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. These 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.

- **Infiltration:**
  - **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 of I/I

Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event. 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. Realtime flows were plotted against ADWF to analyze the I/I response to rainfall events. Figure 7 illustrates a sample of how this analysis is conducted and some of the measurements that are used to distinguish infiltration and inflow. Similar graphs were generated for the individual flow monitoring sites and can be found in *Appendix A*.

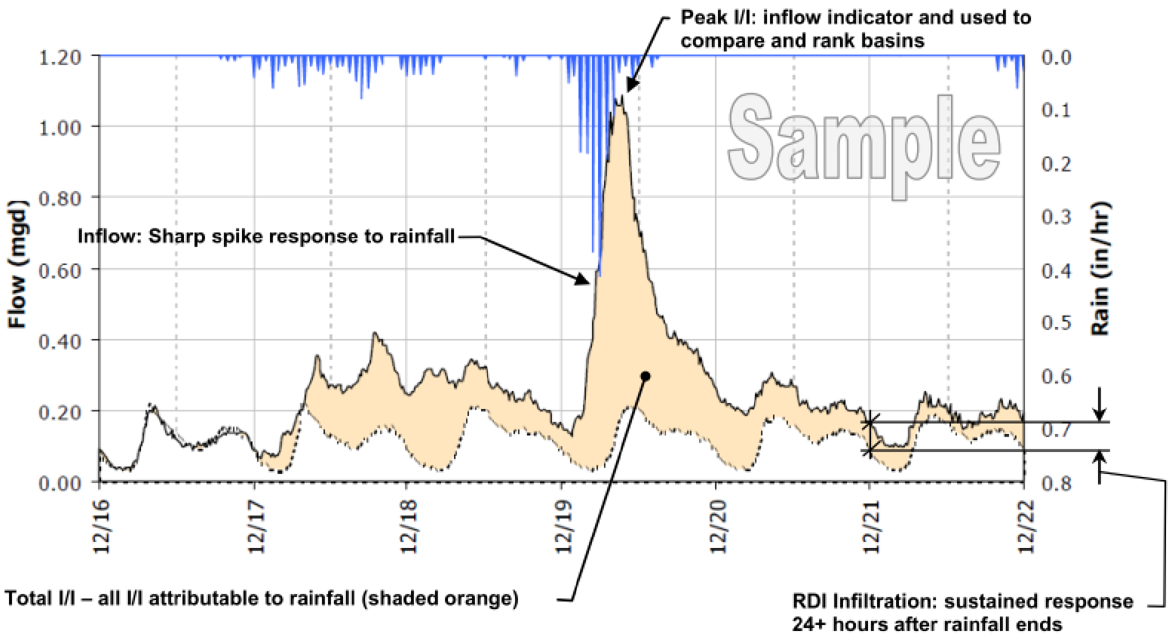


Figure 7. Sample Infiltration and Inflow Isolation Graph

Figure 8 shows sample graphs indicating the typical graphical response patterns for inflow and infiltration in a more detailed version.

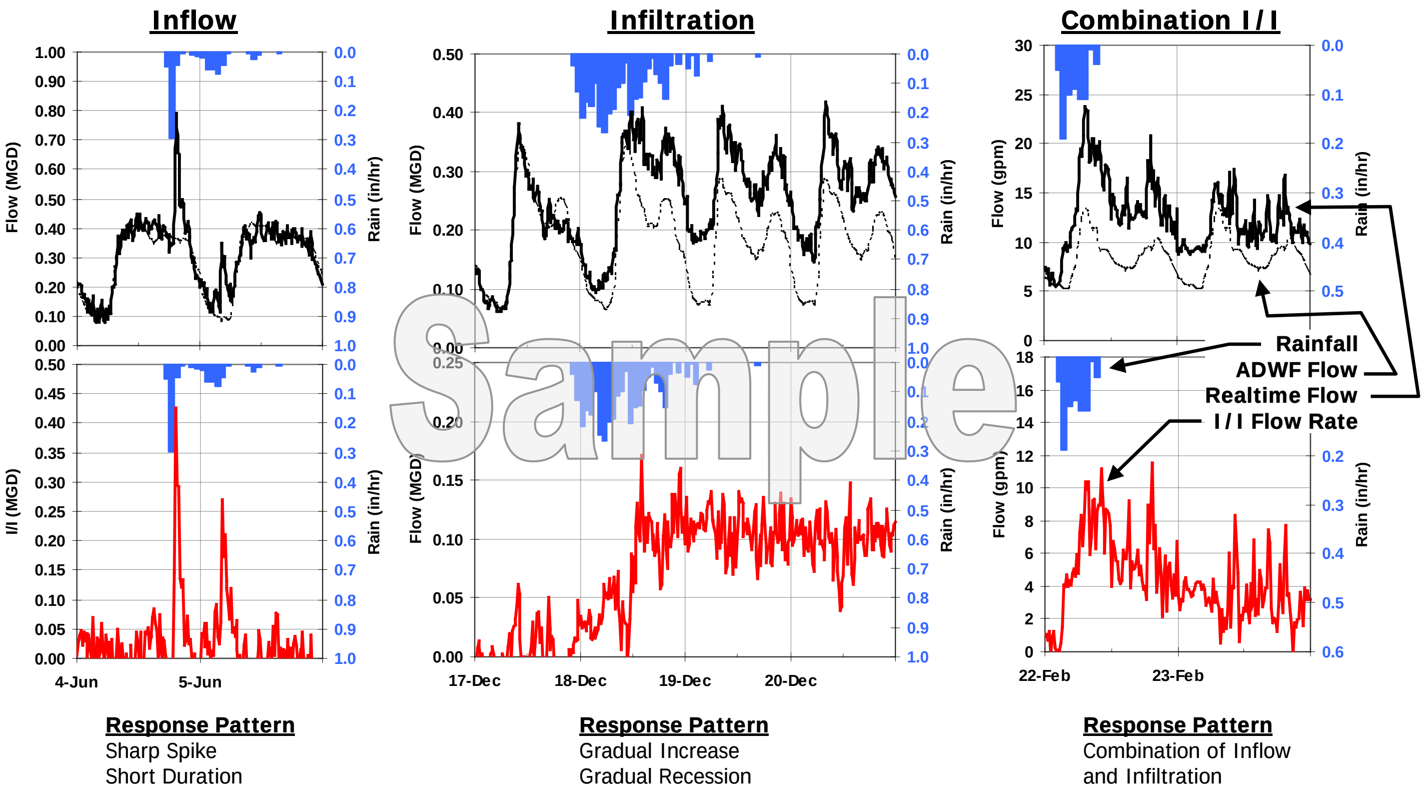


Figure 8. Inflow and Infiltration: Graphical Response Patterns

Analysis Methods

After differentiating I/I flows from ADWF flows, various calculations can be made to: (1) 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. Some analysis methods are shown as follows:

Inflow Indicators

Inflow is characterized by sharp, direct spikes occurring during a rainfall event. Peak I/I rates are used for inflow analysis[3]. After determining the peak I/I flow rate for a given site, and for a given storm event, there are three 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 IDM:*** Peak measured I/I rate divided by length of pipe within the drainage basin, expressed in units of inch-diameter-mile (IDM) (miles of pipeline multiplied by the diameter of the pipeline in inches). Final units are gallons per day (gpd) per IDM.
- ***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.

[3] 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.

- ***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

- **Rainfall-Dependent Infiltration:** 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, different set periods may be examined to determine the basins with the greatest or most sustained rainfall-dependent infiltration rates.
- **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. As with inflow, GWI infiltration rates can be normalized by means of pipe length (IDM), basin area (acres), and dry weather flow rates (ADWF). These methods are discussed in further detail in the *Groundwater Analysis* section later in this report.

Combined I/I Indicators

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:

- ***Combined I/I Flow Rate per IDM:*** Total infiltration (gallons) divided by length of pipe (IDM) and divided by storm event rainfall (inches of rain). Final units are gallons per day (gpd) per IDM per inch-rain.
- ***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 falls that enters the sanitary sewer collection system." Systems with R-values less than 5%[4] 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.

The infiltration and inflow indicators were normalized by basin area and by ADWF in this report. Final rankings were determined by weighting the normalization methods by 50% for ADWF, and 50% for basin area, with ties broken by ADWF. The per-ADWF method is given the tie-break because it is normalized by actual sanitary waste usage. The per-acre method was not given the tie-breaker because the catchment area per each flow monitoring basin is estimated but requires a thorough hydrologic study to determine the true watershed.

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

RESULTS AND ANALYSIS

Rainfall Event Analysis

In order to perform I/I analysis, rainfall data should be collected in order to distinguish the wet weather days from the dry weather days. Rainfall intensity, duration, and frequency are also required to conduct the synthetic I/I analysis. Rain data collected from three sites was analyzed for the duration of the study to capture rainfall across the limits of the District boundary, illustrated earlier in Figure 2.

Rain Gauge Data

There were two main rainfall events that occurred over the course of the flow monitoring period. Figure 9 graphically displays the rainfall activity recorded at RG 1 over the flow monitoring period for illustration purpose.

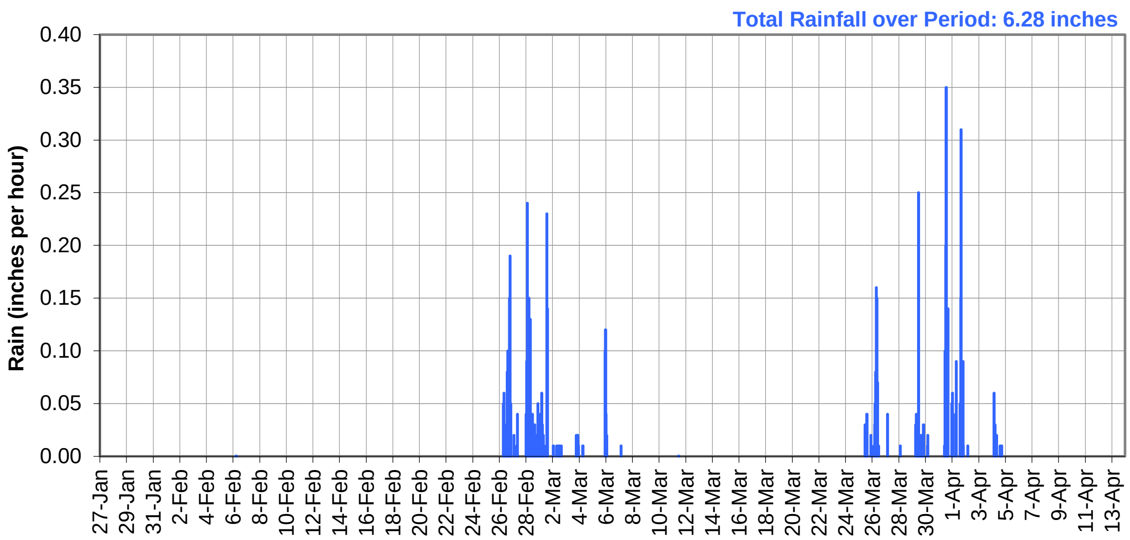


Figure 9. Rainfall Activity at the RG 1

Figure 10 shows the rain accumulation plot of the period rainfall, as well as the historical average rainfall[5] in the District during this project duration. The total historical rainfall is 6.6 inches. The accumulated rainfall recorded by the three rain gauges ranged from 69% to 95%.

[5] Historical data taken from the WRCC (Station 046646 in Palo Alto): http://www.wrcc.dri.edu/summary/climsmnca.html

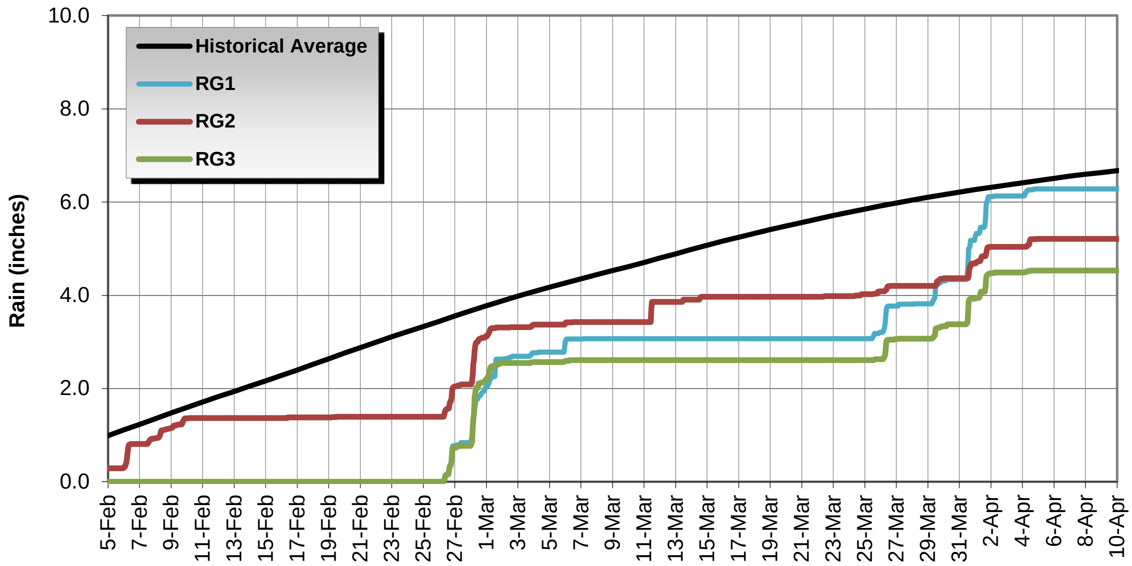


Figure 10. Accumulated Precipitation Monitored from Different Locations

Table 4. Rainfall Events Used for I/I Analysis

Rainfall Event	RG 1 (in)	RG 2 (in)	RG 3 (in)
Event 1: February 28 to March 2, 2014	1.79	1.22	1.78
Event 2: March 31 to April 2, 2014	1.78	0.67	1.09
Total over Monitoring Period	*6.28*	*5.21*	*4.53*

Rainfall 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 in West Bay as approximately 4 inches (Figure 11). This means that in any given year, at this specific location, there is a 10% chance that 4 inches of rain will fall in any 24-hour period.

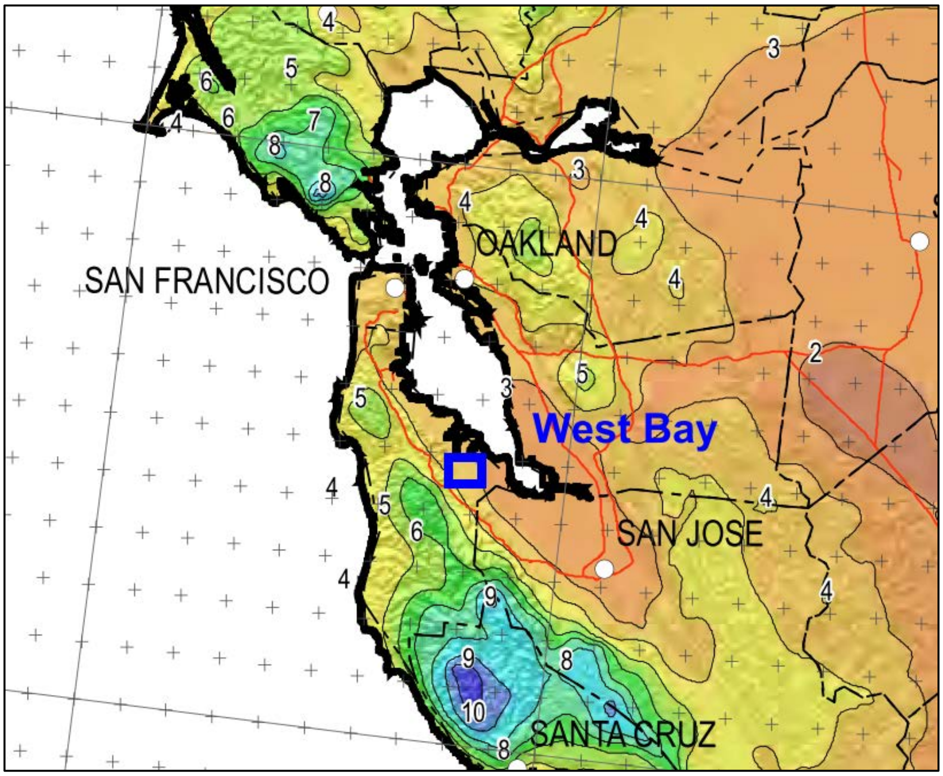


Figure 11. NOAA Isopluvials of 10-Year, 24-Hour Precipitation in inches

From the NOAA frequency maps, for a specific latitude and longitude, the rainfall densities for period durations ranging from 1 hour to 24 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 all the rainfall events on the rain event frequency plot determines the classification of the storm event, shown in Figure 12 through Figure 14 for all the rain gauges.

[6] Sanitary sewers are often designed to withstand I/I contribution to sanitary flows for specific-sized “design” storm events.

[7] NOAA Atlas 14, Volume 6, Version 2 California ftp://hdsc.nws.noaa.gov/pub/hdsc/data/sw/ca10y24h.pdf

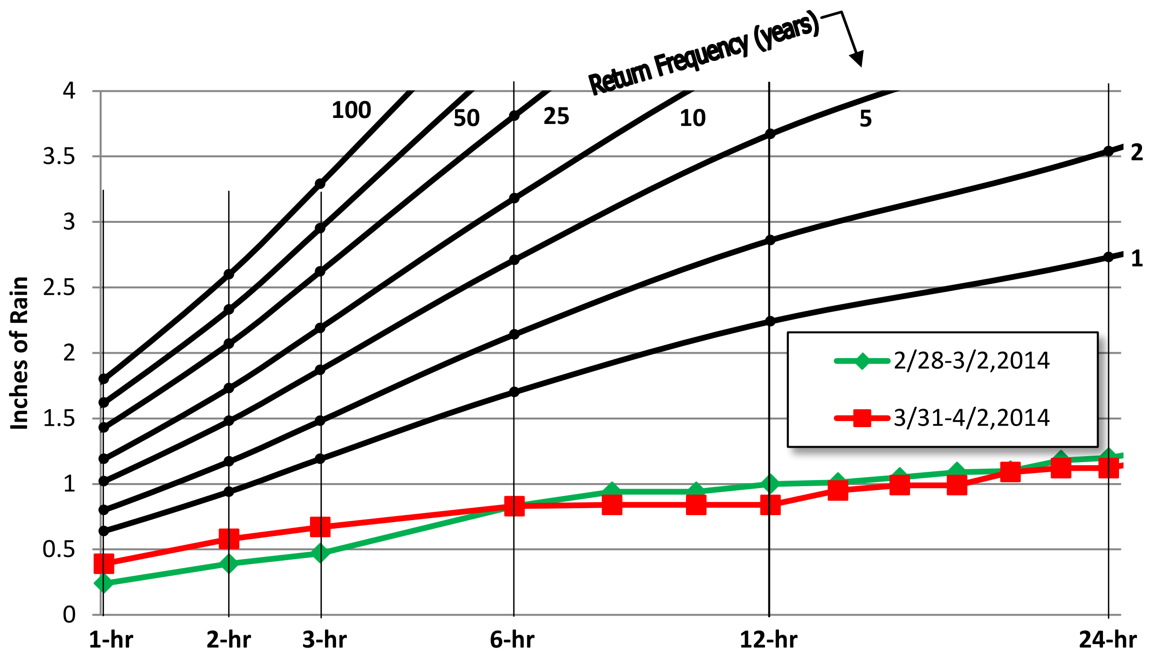


Figure 12. Storm Event Classification at RG 1

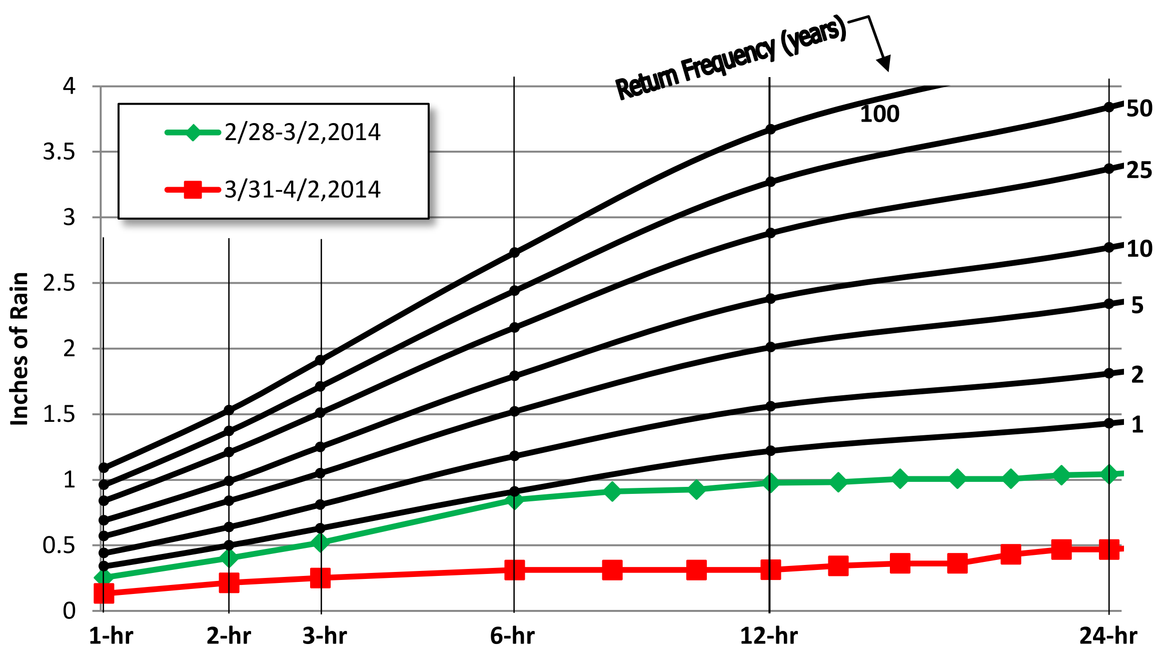


Figure 13. Storm Event Classification at RG 2

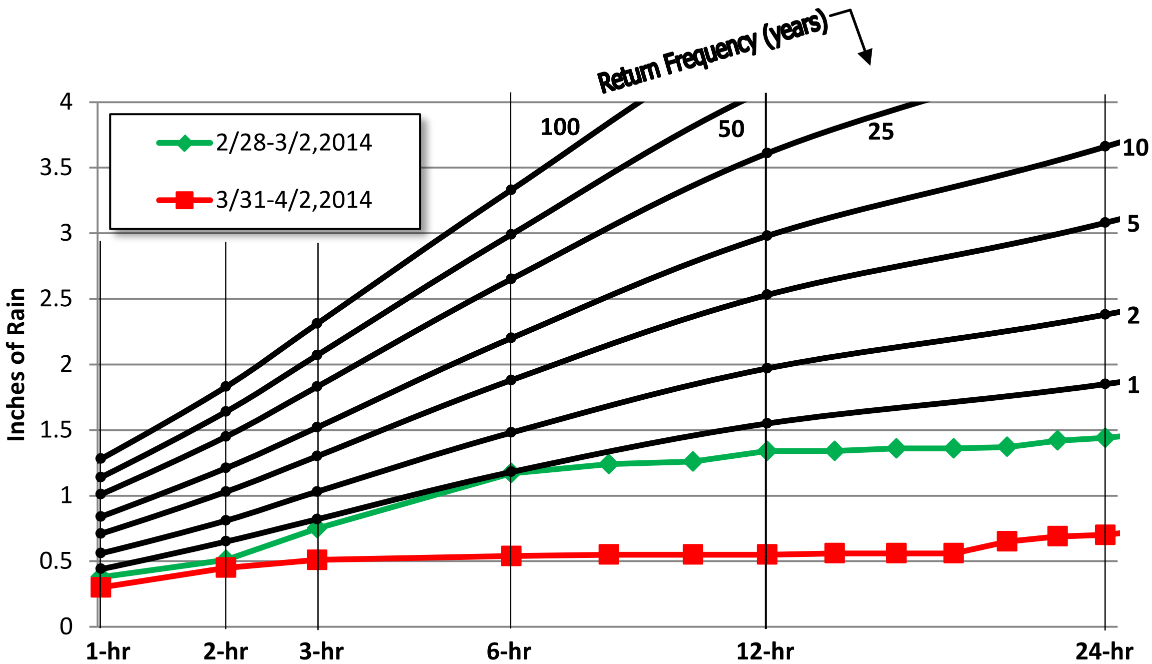


Figure 14. Storm Event Classification at RG 3

Table 5 summarizes the classification of the rainfall events that occurred during the flow monitoring period.

Table 5. Classification of Rainfall Events

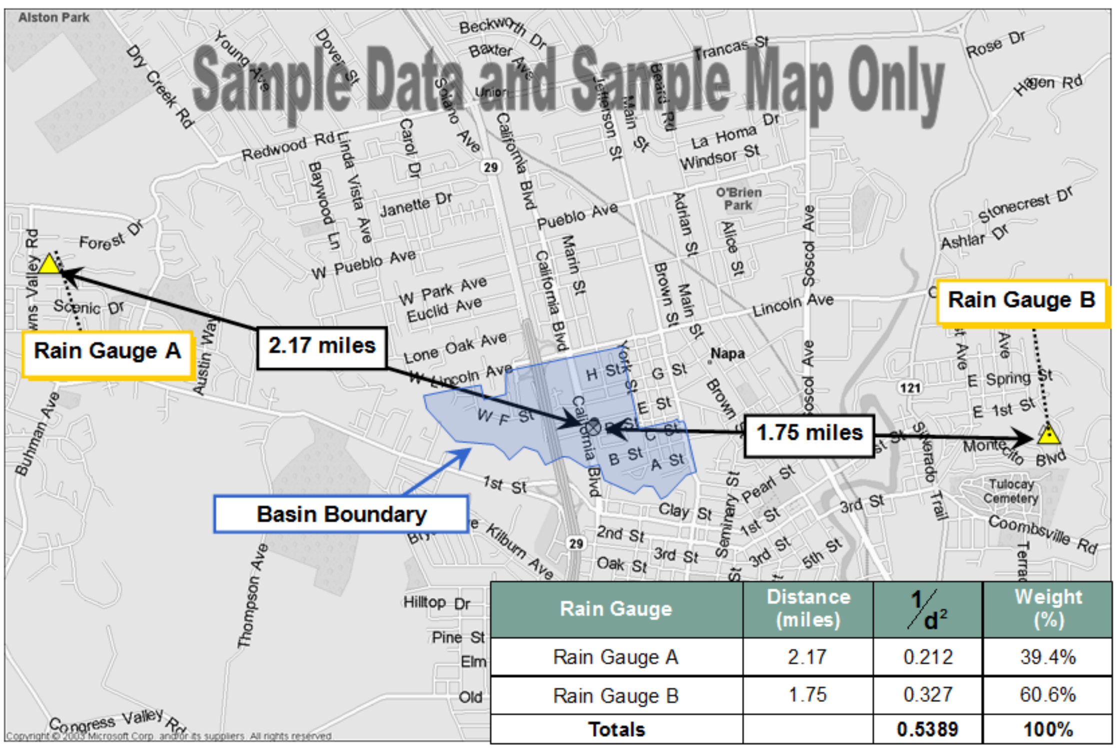
Rainfall Event	RG 1	RG 2	RG 3
Event 1	Less than 1-Year	Nearly 1 year, 6-hour event	Nearly 1 year, 6-hour event
Event 2	Less than 1-Year	Less than 1-Year	Less than 1-Year

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:

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

The value of p is user defined. The most common choice for hydrological studies of watershed areas is $p = 2$. Figure 15 illustrate the IDW method with sample data. The rain gauge distribution as calculated for each flow monitoring site is shown in Table 6.



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 15. Rainfall Inverse Distance Weighting Method

Table 6. Rain Gauge Distribution by Basin

Monitoring Basin	RG 1	RG 2	RG 3
Basin 1	0%	35%	65%
Basin 2	0%	99%	1%
Basin 3	0%	84%	16%
Basin 4	0%	100%	0%
Basin 5	1%	0%	99%
Basin 6	37%	0%	63%
Basin 7	84%	0%	16%
Basin 8	76%	0%	24%
Basin 9	0%	32%	68%
Basin 10	0%	19%	81%
Basin 11	0%	7%	93%
Basin 12	0%	31%	69%
Basin 13	21%	12%	67%
Basin 14	24%	0%	76%
Basin 15	0%	19%	81%

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 7 lists the average dry weather flow (ADWF) recorded during this study for the flow monitoring sites.

Figure 16 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 7. Dry Weather Flow Summary

Monitoring Site	Weekday ADWF (mgd)	Weekend ADWF (mgd)	Overall ADWF (mgd)	Weekend/ Weekday Ratio
Site 1	0.956	0.882	0.935	0.92
Site 2	1.252	1.012	1.184	0.81
Site 3	0.093	0.081	0.089	0.88
Site 4	0.435	0.436	0.436	1.00
Site 5	1.461	1.338	1.426	0.92
Site 6	1.182	1.084	1.154	0.92
Site 7	0.159	0.148	0.156	0.93
Site 8	0.236	0.228	0.233	0.97
Site 9	0.511	0.468	0.499	0.92
Site 10	0.278	0.248	0.269	0.89
Site 11	1.758	1.672	1.733	0.95
Site 12	0.094	0.080	0.090	0.85
Site 13	0.019	0.026	0.021	1.35
Site 14	0.107	0.093	0.103	0.87
Site 15	0.246	0.215	0.237	0.87
Site 16	0.009	0.007	0.008	0.85

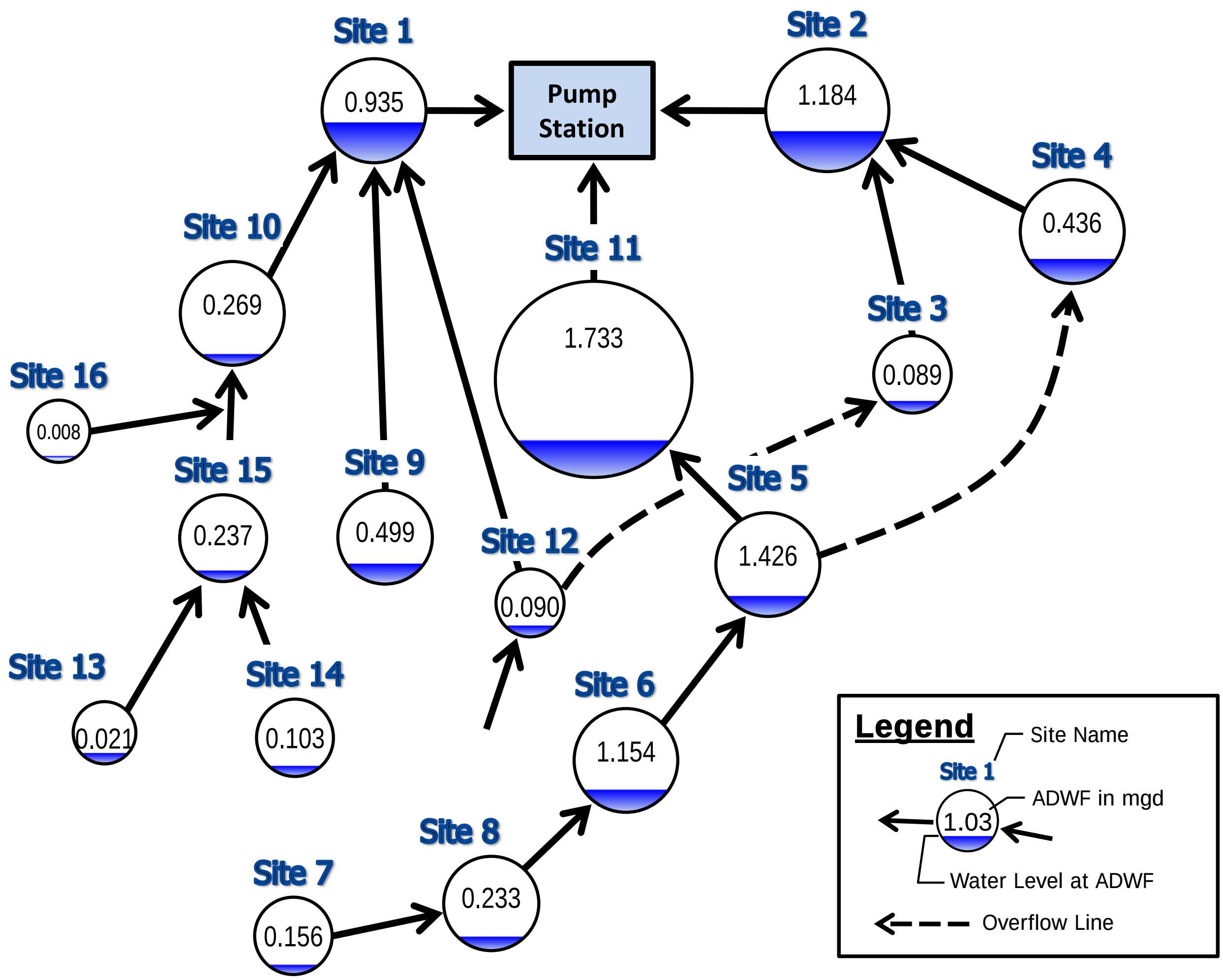


Figure 16. Average Dry Weather Flow (Flow Schematic)

Flow Monitoring: Peak Measured Flows and Pipeline Capacity Analysis

Peak measured flows and the corresponding flow levels (depths) are important to understand the capacity limitations of a collection system. The peak flows and flow levels reported are from the peak measurements as taken across the entirety of the flow monitoring period. Peak flows and levels may not correspond to a rainfall event, but instead may be caused due to blockages, grease or roots that cause a backflow condition.

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 for the flow monitoring study.

Table 8 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 point site locations. Hydraulic conditions in other areas of the collection system will differ.

Table 8. Capacity Analysis Summary

Site	ADWF (mgd)	Peak Measured Flow (mgd)	Peaking Factor	Diameter (in)	Peak Level (in)	*d*/*D* Ratio	Level Surcharged above Crown (ft)
Site 1	0.935	2.118	2.27	23.5	12.7	0.54	-
Site 2	1.184	2.378	2.01	30	20.5	0.68	-
Site 3	0.089	0.230	2.57	15	3.4	0.22	-
Site 4	0.436	1.028	2.36	24	8.8	0.37	-
Site 5	1.426	3.574	2.51	24	7.2	0.30	-
Site 6	1.154	2.849	2.47	23.75	10.8	0.45	-
Site 7	0.156	0.825	5.29	15	4.2	0.28	-
Site 8	0.233	0.842	3.61	20.75	5.4	0.26	-
Site 9	0.499	1.332	2.67	21	7.2	0.34	-
Site 10	0.269	0.913	3.39	22.75	4.9	0.22	-
Site 11	1.733	3.795	2.19	54	16.6	0.31	-
Site 12	0.090	0.261	2.91	11.75	3.5	0.29	-
Site 13	0.021	0.194	9.31	10	3.2	0.32	-
Site 14	0.103	0.346	3.36	15	3.7	0.24	-
Site 15	0.237	0.825	3.48	18	3.8	0.21	-
Site 16	0.008	0.092	11.02	10	1.7	0.17	-

*Sites with peaking factors higher than the typical design values are highlighted in red.

The following capacity analysis results are noted:

- **Peaking Factor:** Seven sites (Sites 7, 8, 10, 13, 14, 15, and 16) had peaking factors that exceeded typical design threshold limits for peak flow to average dry weather flow ratio. It should be noted that the peaking factors for Sites 13 and 16 are high because of the low ADWF for both sites and unstable flow pattern for Site 16 since it was possibly on an overflow line.
- ***d/D* Ratio:** All of the monitoring sites had *d/D* ratios less than the typical design threshold value.

Figure 17 and Figure 18 shows bar graphs of the capacity results. Figure 19 shows a schematic diagram of the peak measured flows with peak flow levels.

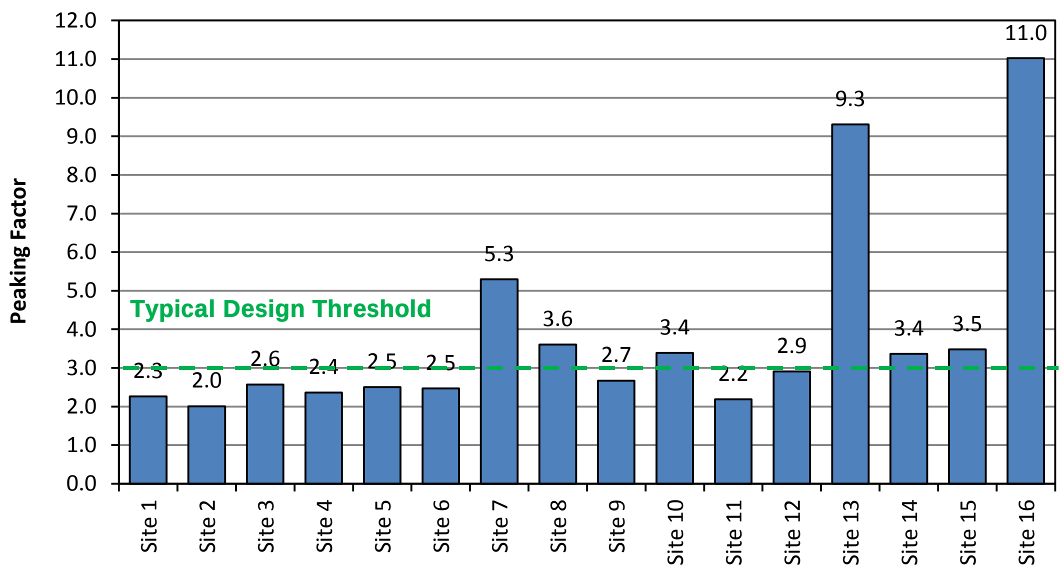


Figure 17. Capacity Summary: Peaking Factors

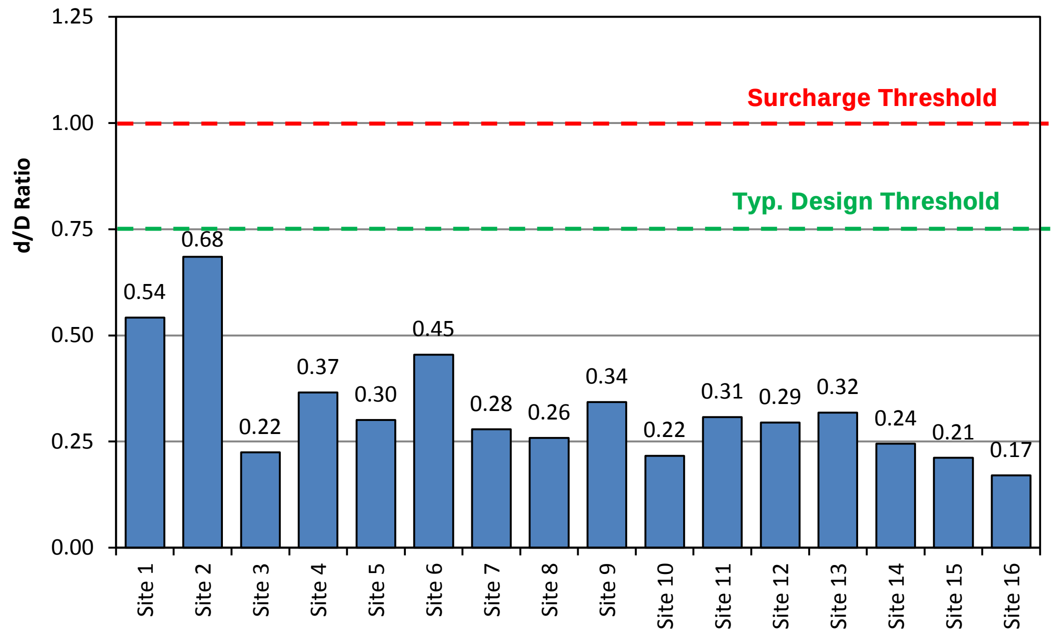


Figure 18. Capacity Summary: *d/D* Ratios

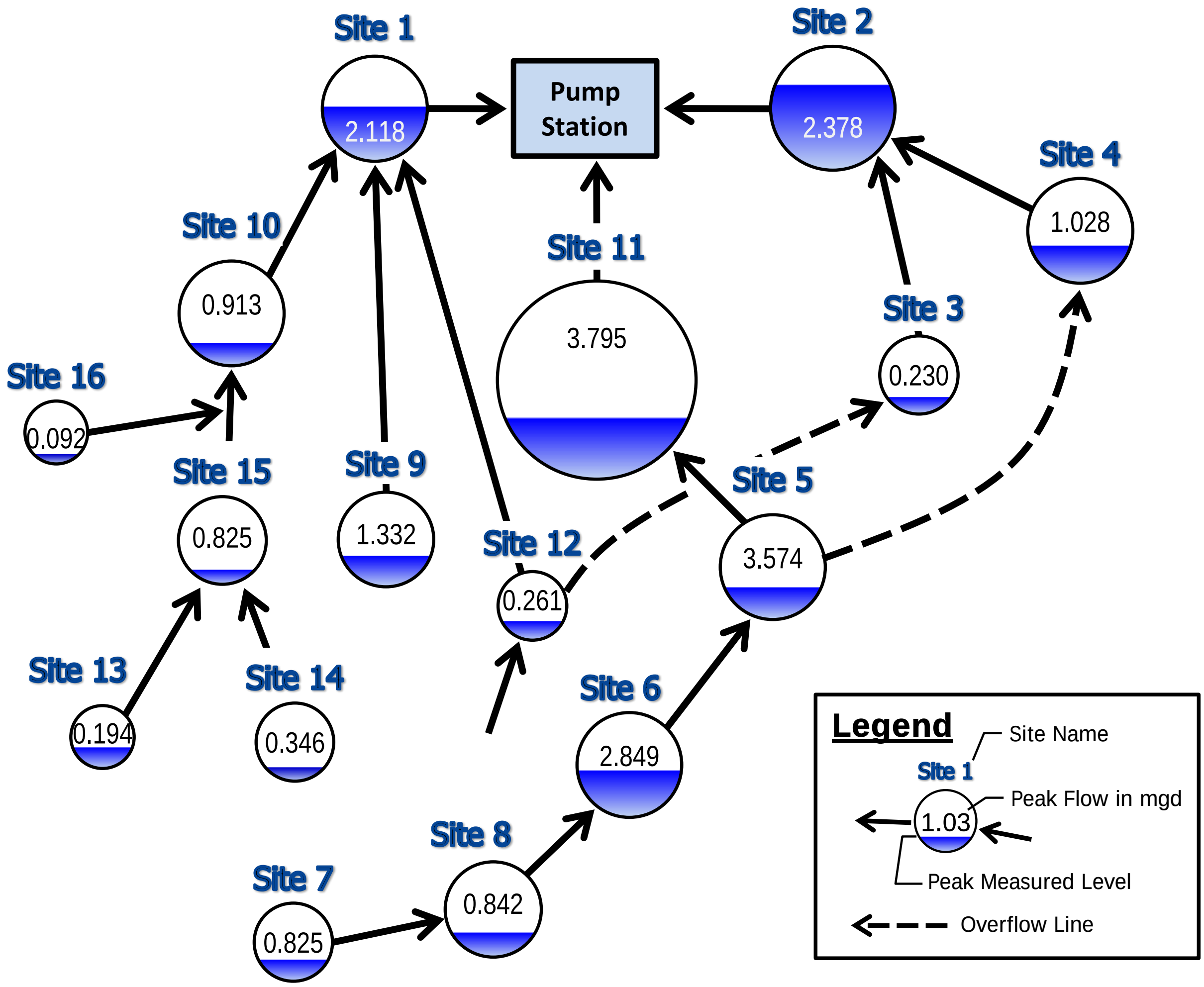


Figure 19. Peak Measured Flow (Flow Schematic)

Inflow and Infiltration: Results

Rainfall Event 1 elicited the greatest I/I response of all monitored storm events. The following analyses for inflow and infiltration are based on Storm Event 1 data. Refer to Appendix A for more detailed information on Rainfall Events 1 and 2. The following information should be noted.

- Basin 10 is the smallest basin in the system and the I/I is an indirect measurement. Errors of subtraction of flow can cause significant uncertainty of normalized I/I compared to the other basins. Therefore, Basin 10 was not included for I/I analysis.
- Site 16 is an overflow line and was not assigned a value for basin area (acreage). Additionally, flows were generally extremely low and there was negligible evidence of I/I contribution during the rainfall events. Site 16/Basin 16 was not analyzed for I/I contribution in this report.

Inflow Results Summary

Table 9 summarizes the peak measured I/I flows and inflow analysis results for Rainfall Event 1. Figure 20 and Figure 21 show bar graph summaries of the inflow analysis, and Figure 22 shows a temperature map summary of the inflow analysis results per basin.

Table 9. Basins Inflow Analysis Summary

Basin	ADWF (mgd)	Peak I/I Rate (mgd)	Peak I/I per Acre (gal/day-acre)	Peak I/I per ADWF	Inflow Ranking
Basin 1	0.077	0.324	405	4.2	4
Basin 2	0.659	0.382	735	0.6	10
Basin 3	0.089	0.108	271	1.2	11
Basin 4	0.436	0.420	924	1.0	5
Basin 5	0.272	0.548	692	2.0	3
Basin 6	0.921	0.719	550	0.8	9
Basin 7	0.156	0.147	61	0.9	13
Basin 8	0.077	0.260	294	3.4	6
Basin 9	0.499	0.315	360	0.6	12
Basin 11	0.307	0.055	167	0.2	14
Basin 12	0.090	0.157	966	1.8	1
Basin 13	0.021	0.170	497	8.2	2
Basin 14	0.103	0.173	364	1.7	7
Basin 15	0.113	0.196	357	1.7	8

Ranking of 1 represents most inflow after normalization.

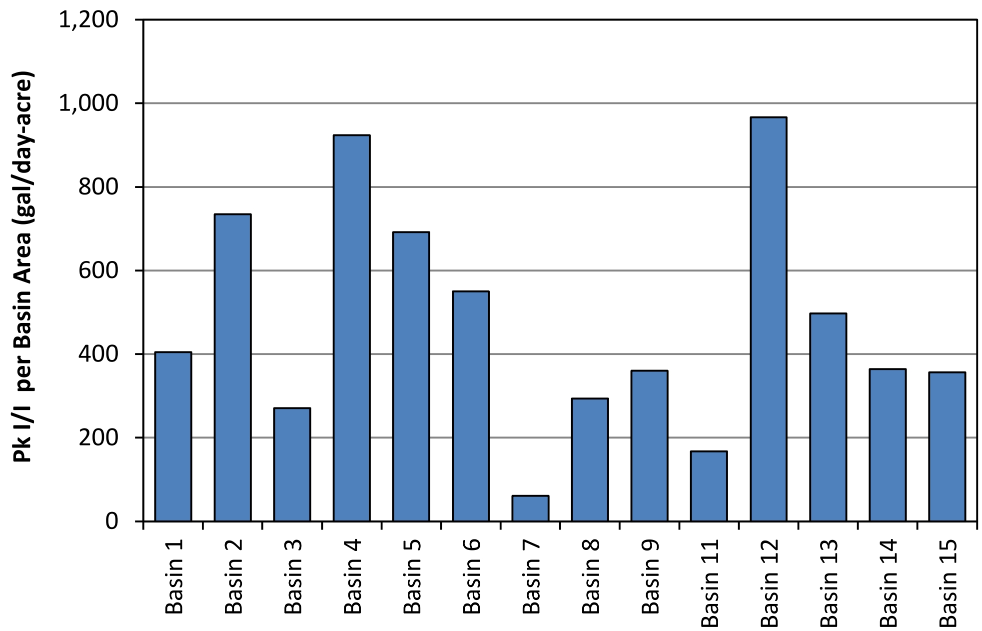


Figure 20. Inflow Analysis Summary – Peak I/I to Basin Area

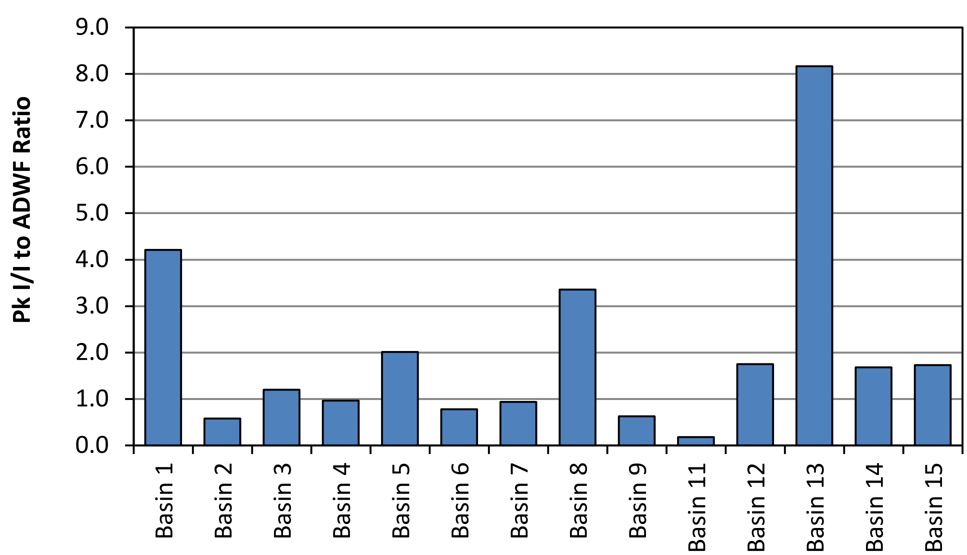


Figure 21. Inflow Analysis Summary – Peak I/I to ADWF

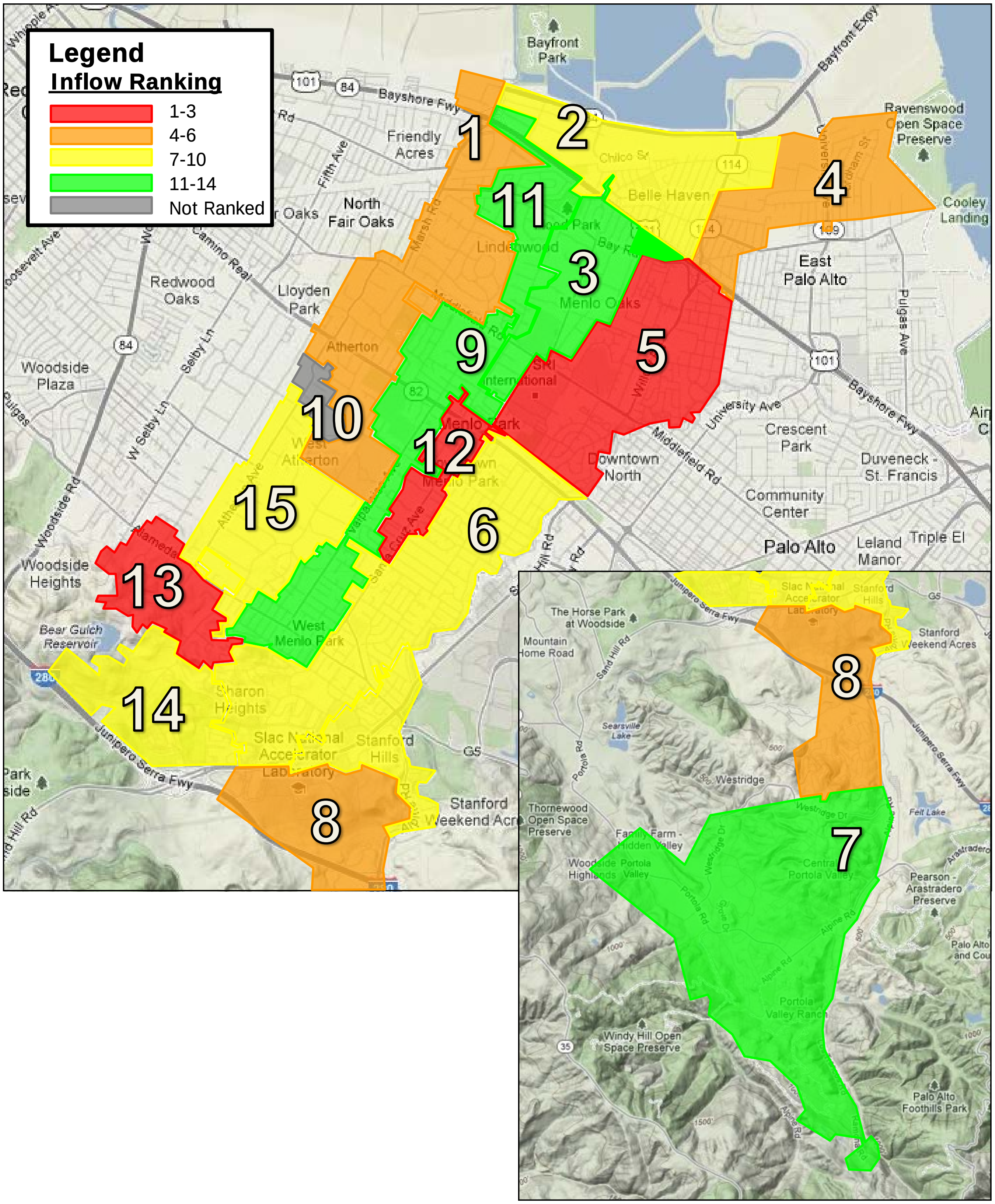


Figure 22. Inflow Temperature Map (by Rank)

Infiltration Results Summary

Table 10 summarizes the calculated RDI flow rates for Rainfall Event 1 after the conclusion of the storm event (refer to the *I/I Analysis Methods* section for more information on RDI analysis methods). There were several sites with negligible RDI flow rates. Figure 23 and Figure 24 show bar graph summaries of the RDI analysis, and a temperature map by overall ranking is shown in Figure 25.

Table 10. Basins RDI Analysis Summary

Basin	ADWF (mgd)	RDI Rate (mgd)	RDI per Acre (gal/day-acre)	RDI per ADWF	RDI Ranking
Basin 1	0.077	0.001	1	1%	11
Basin 2	0.659	0.036	69	5%	6
Basin 3	0.089	0.007	18	8%	8
Basin 4	0.436	0.036	78	8%	4
Basin 5	0.272	Negl.	-	-	13
Basin 6	0.921	0.030	23	3%	10
Basin 7	0.156	0.030	12	19%	7
Basin 8	0.077	0.054	61	69%	2
Basin 9	0.499	0.044	50	9%	5
Basin 11	0.307	Negl.	-	-	14
Basin 12	0.090	0.004	22	4%	9
Basin 13	0.021	0.009	27	45%	3
Basin 14	0.103	Negl.	-	-	12
Basin 15	0.113	0.048	87	42%	1

Ranking of 1 represents most RDI after normalization.

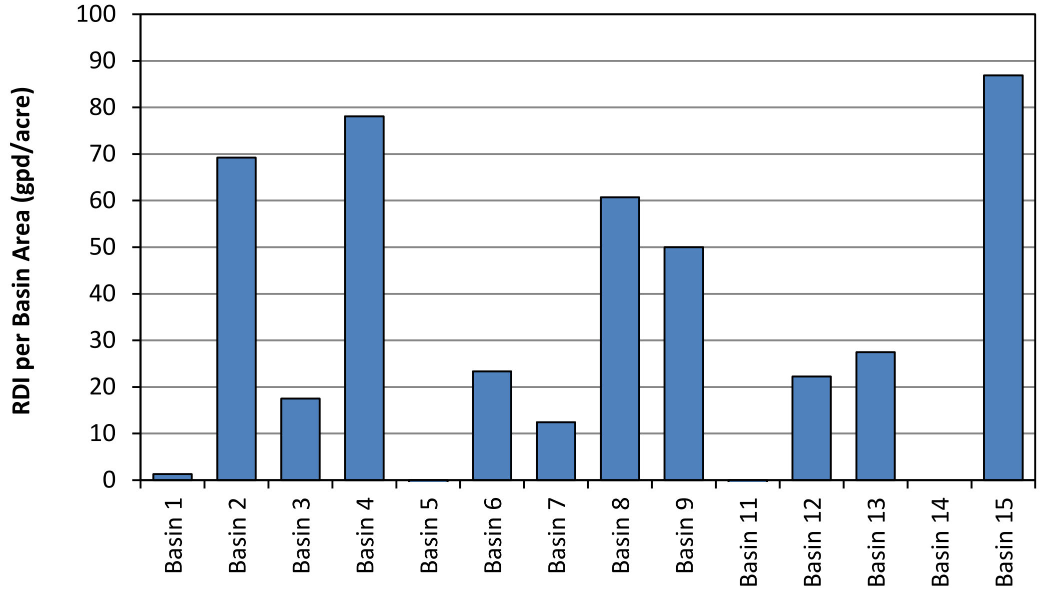


Figure 23. RDI Analysis Summary – RDI Rate to Basin Area

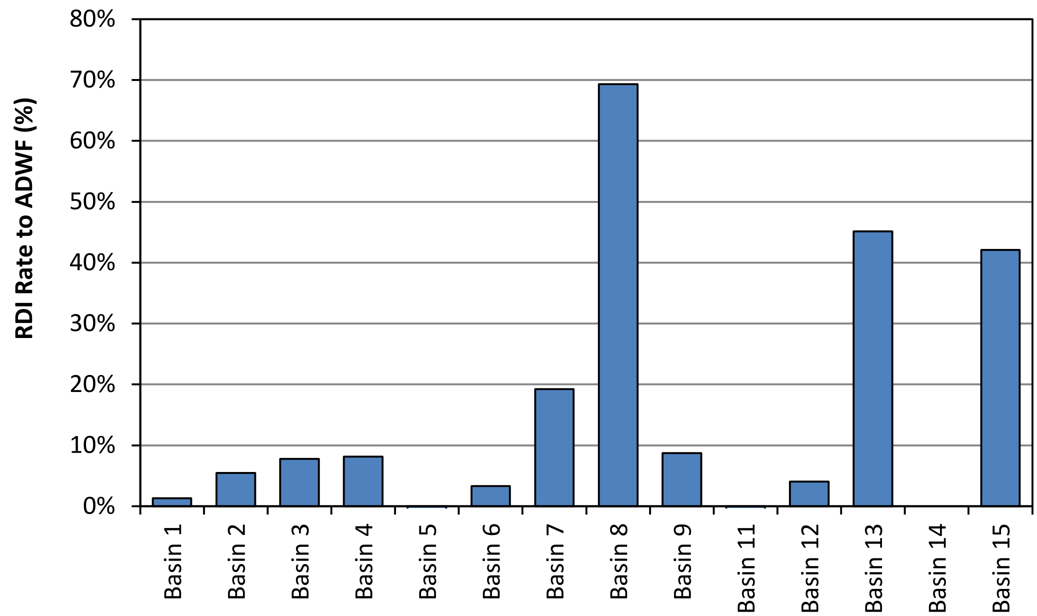


Figure 24. RDI Analysis Summary – RDI Rate to ADWF

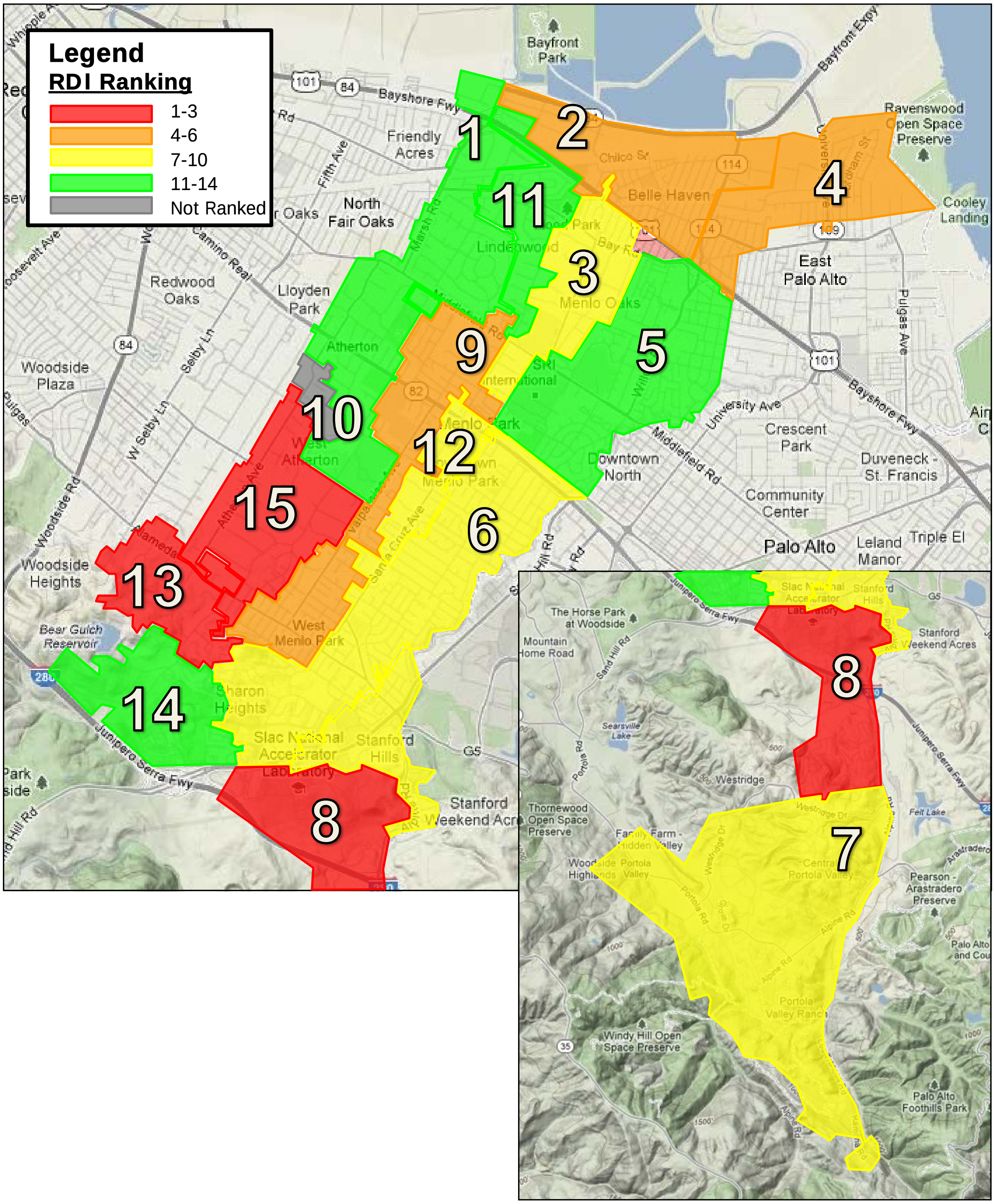


Figure 25. RDI Temperature Map (by Rank)

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[8]. 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.

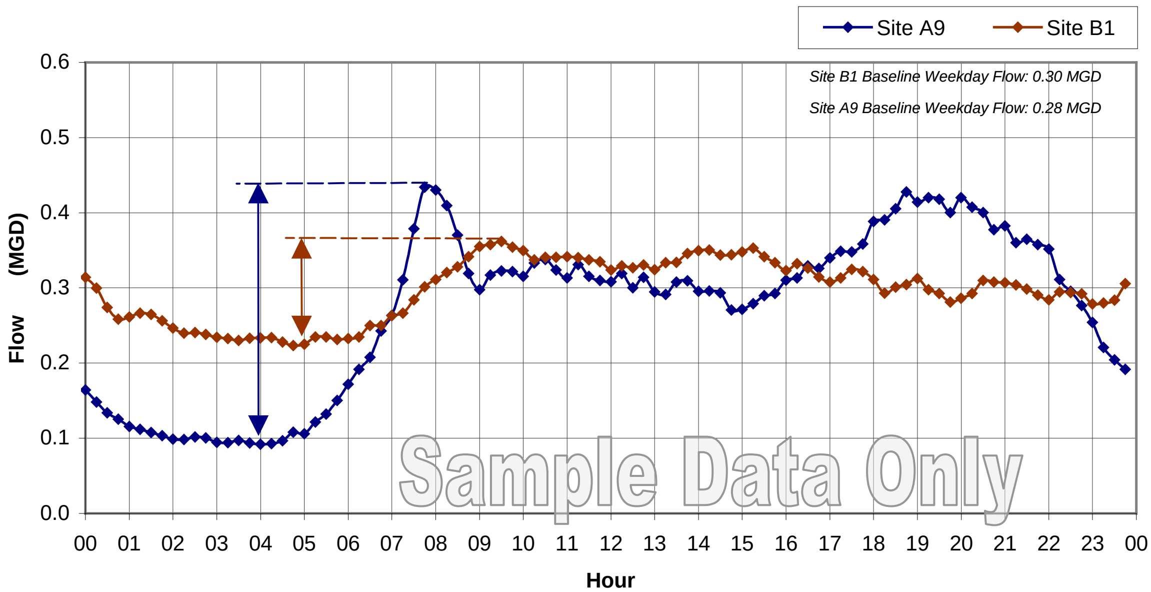


Figure 26. Groundwater Infiltration Sample Figure

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, etc.), has a possibility of higher levels of groundwater infiltration in comparison to the rest of the collection system. Figure 27 plots the low-to-ADWF flow ratios against the ADWF flows for the sites monitored during this study. The dotted line shows "typical" low-to-ADWF ratios per the Water Environment Federation (WEF)[9].

Sites 2, 3, and 13 show evidence of GWI rates higher than the normal values (Figure 27). Basin 3 and 13 were stand-alone basins which were monitored by only one site with the same identification number. Thus the GWI rate for Basins 3 and 13 were above the WEF typical Low-to-Average Ratio, indicating the possibility of excessive groundwater infiltration. Basin 2 was downstream of Basin 3 and 4. Basin 4 has no GWI issue. The flow rate of Site 3 is negligible compared to that of Site 2. Thus, the high GWI rate measured from Site 2 is considered to occur within Basin 2.

[8] Theoretically imagining an extreme 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.

[9] WEF Manual of Practice No. 9, "Design and Construction of Sanitary and Storm Sewers."

Figure 28 shows a color-coded map of the basin with rates of groundwater infiltration above typical groundwater infiltration standards (as set forth by WEF).

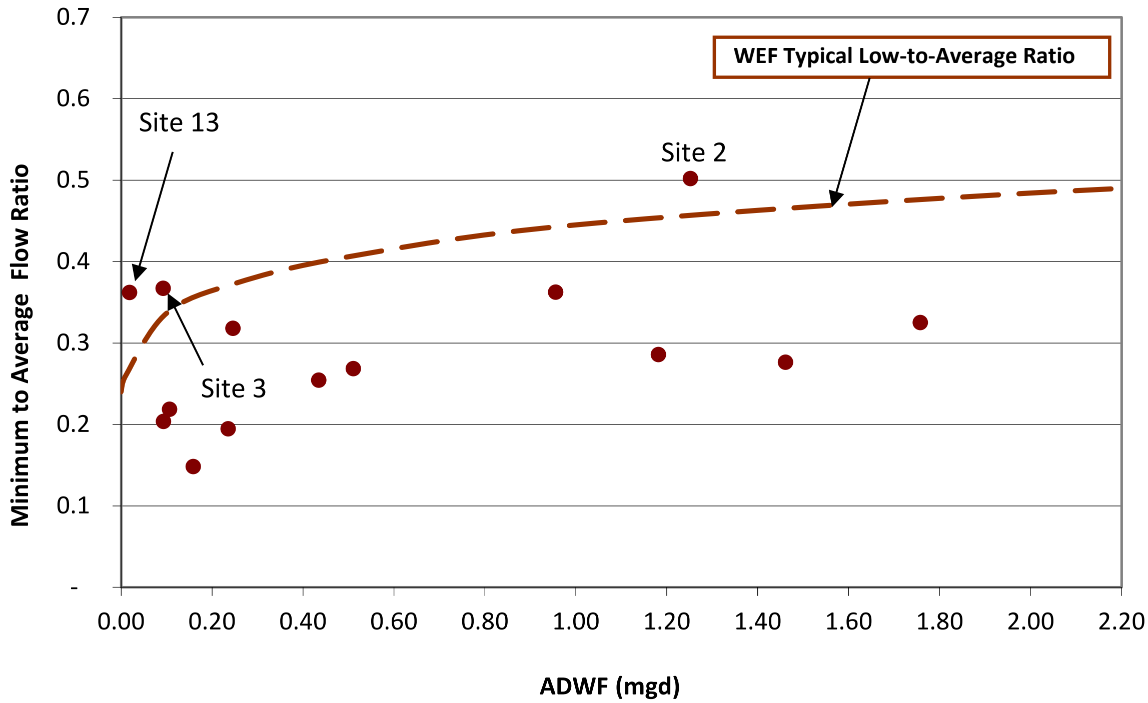


Figure 27. Minimum Flow Ratios vs. ADWF[10]

[10] 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.

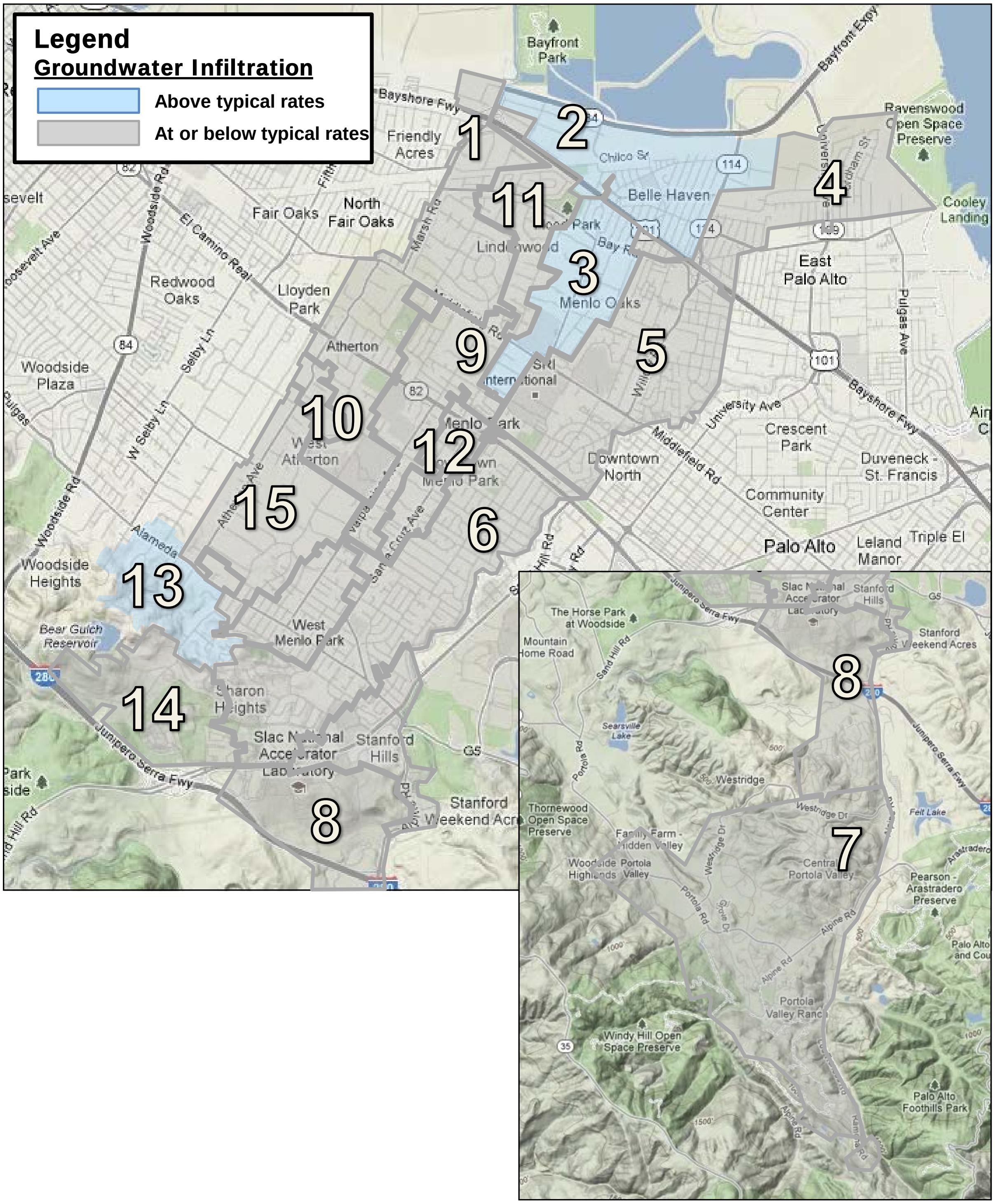


Figure 28. Basins with Groundwater Infiltration

Combined I/I Results Summary

Combined I/I analysis considers the totalized volume of both inflow and rainfall-dependent infiltration over the course of a storm event.

Table 11 summarizes the combined I/I flow results for Rainfall Event 1 (refer to the *I/I Analysis Methods* section for more information on inflow analysis methods). Combined I/I flows were normalized by the acreage and ADWF methods, with ties broken by the ADWF ranking. Figure 29 and Figure 30 show bar graph summaries of the combined I/I analysis, and a temperature map by overall ranking is shown in
Figure 31.

Table 11. Basins Combined I/I Analysis Summary

Basin	ADWF (mgd)	Total I/I (gallons)	R-Value (%)	Total I/I Per ADWF Per Inch of Rain (day/in)	Combined I/I Ranking
Basin 1	0.077	2,000	0.01%	0.02	14
Basin 2	0.659	352,000	2.01%	0.43	4
Basin 3	0.089	54,000	0.38%	0.46	9
Basin 4	0.436	123,000	0.80%	0.23	6
Basin 5	0.272	27,000	0.07%	0.06	13
Basin 6	0.921	273,000	0.43%	0.16	12
Basin 7	0.156	236,000	0.20%	0.82	8
Basin 8	0.077	183,000	0.42%	1.29	5
Basin 9	0.499	225,000	0.59%	0.28	7
Basin 11	0.307	91,000	0.59%	0.17	11
Basin 12	0.090	103,000	1.45%	0.71	2
Basin 13	0.021	128,000	0.80%	3.55	1
Basin 14	0.103	82,000	0.35%	0.44	10
Basin 15	0.113	183,000	0.73%	0.96	3

Ranking of 1 represents most combined I/I after normalization.

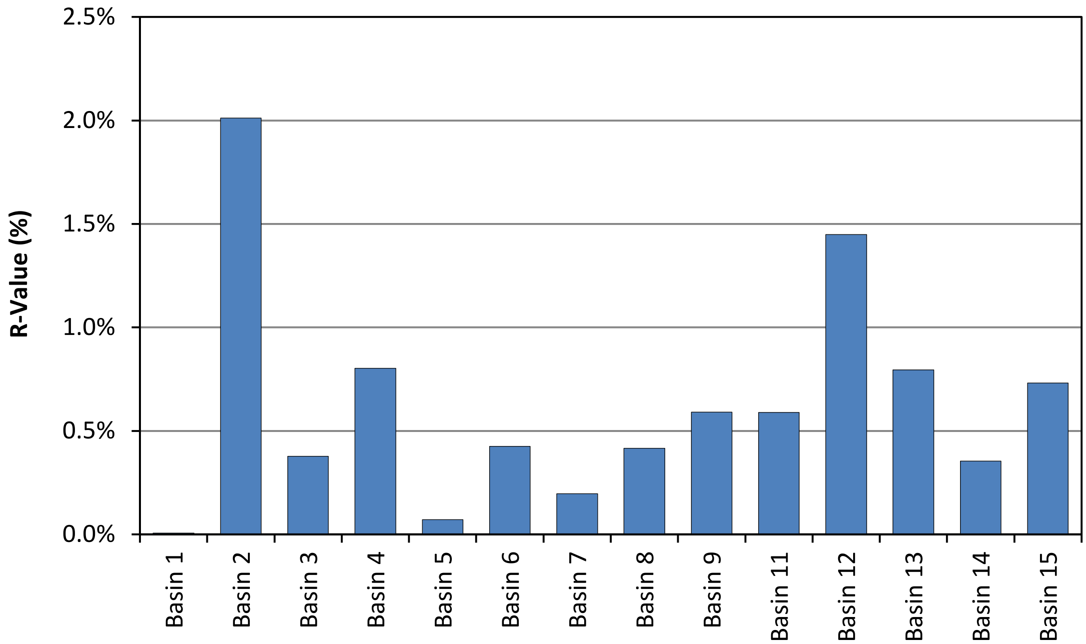


Figure 29. Combined I/I Analysis Summary – Total I/I to Total Precipitation (R-Value)

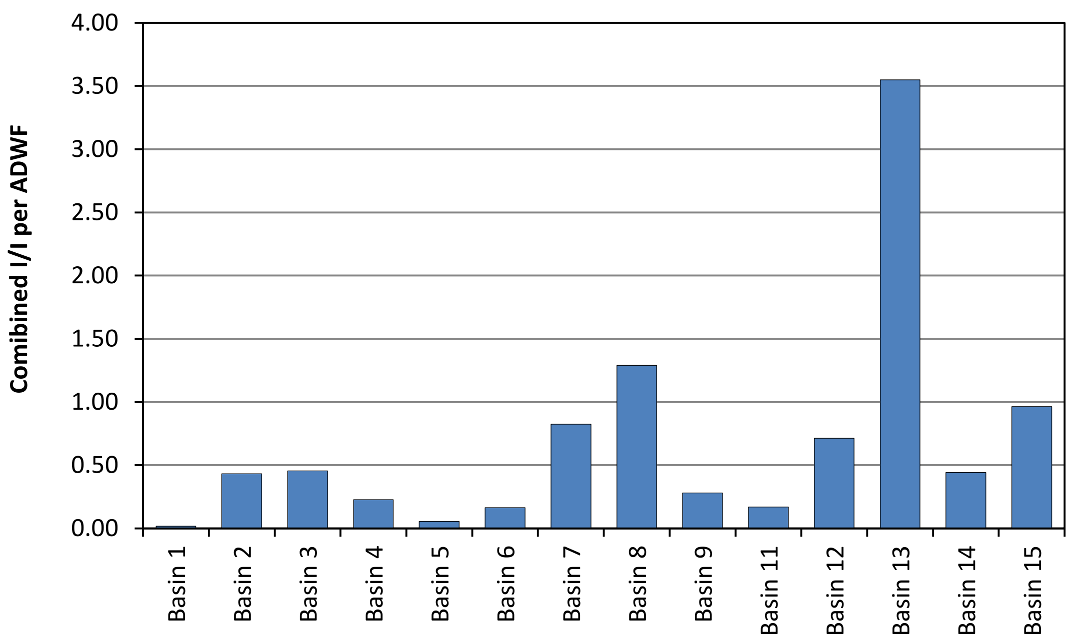


Figure 30. Combined I/I Analysis Summary – Total I/I to ADWF

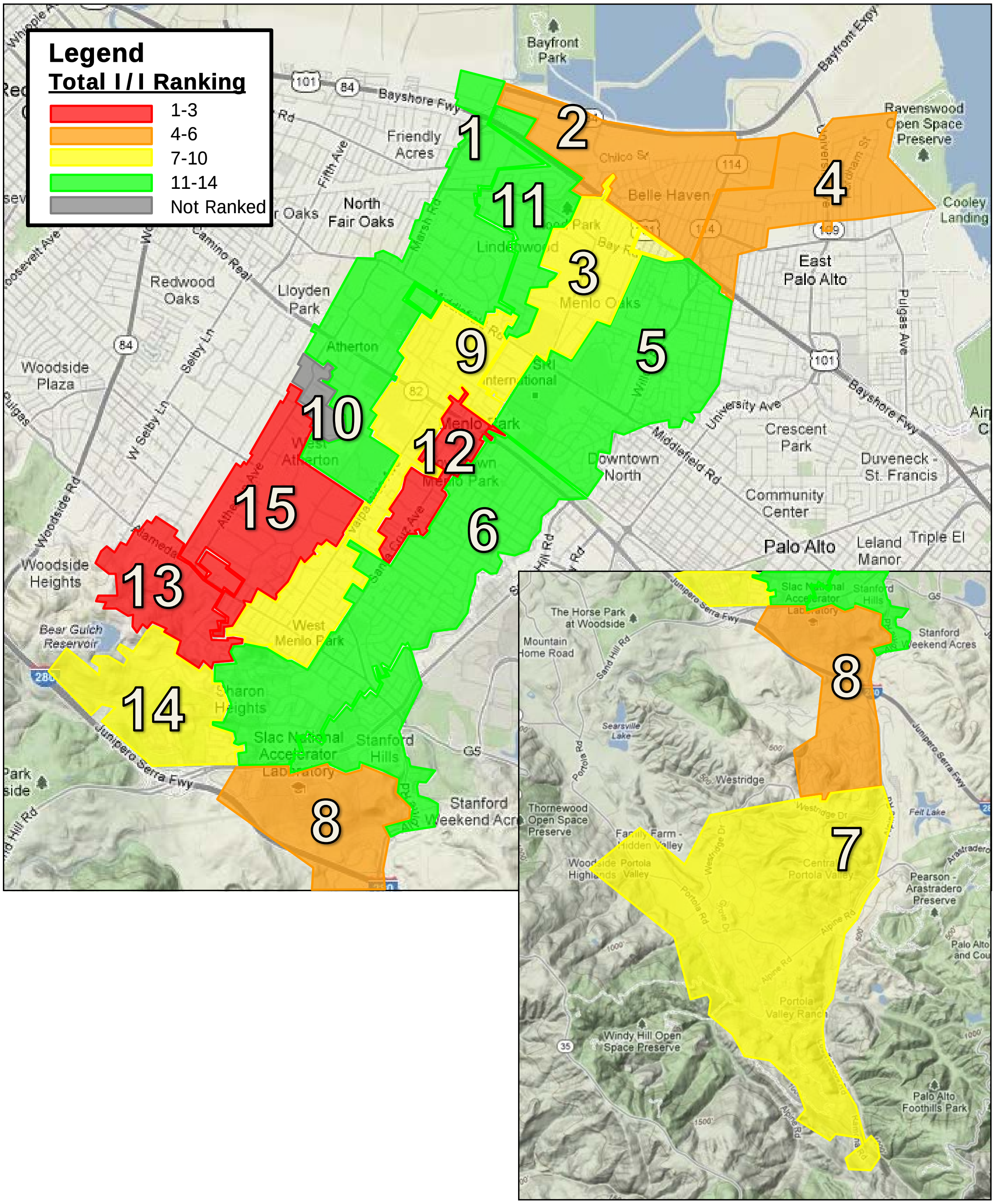


Figure 31. Combined I/I Temperature Map (by Rank)

RECOMMENDATIONS

The I/I issues have been summarized for each basin and listed in V&A advises that future I/I reduction plans consider the following recommendations:

1. **Determine I/I Reduction Program:** The District 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 occurs in Basins 1, 4, 5, 12, and 13.
   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. The highest normalized rainfall-dependent infiltration was occurring in Basins 4, 8, 9, 13 and 15. The basins with detectable groundwater infiltration were Basins 2, 3, and 13.
2. **I/I Investigation Methods:** Potential I/I investigation methods include the following:
   a. Smoke testing.
   b. Mini-basin flow monitoring.
   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.
3. **I/I Reduction Cost-Effectiveness Analysis:** The District 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

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 1

Location: Haven Avenue at the Atherton Channel

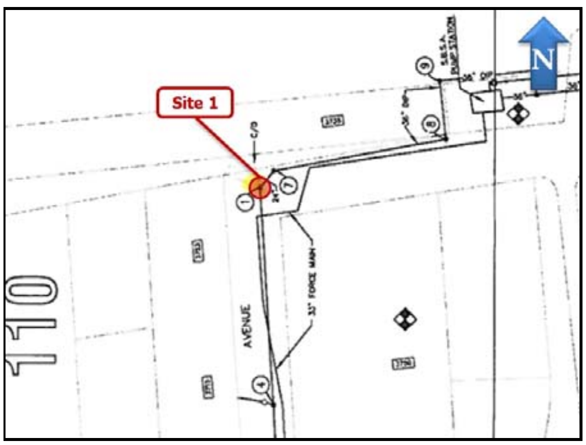
Data Summary Report

SITE 1

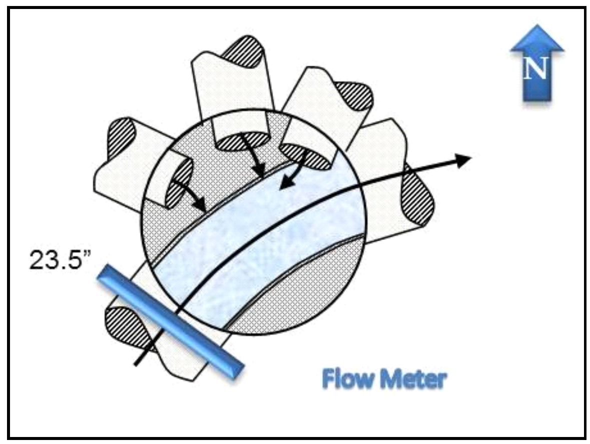
Site Information

Location:	Haven Avenue at the Atherton Channel
Coordinates:	122.1810° W, 37.4869° N
Rim Elevation:	10 feet
Pipe Diameter:	23.5 inches
Baseline Flow:	0.935 mgd
Peak Measured Flow:	2.118 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

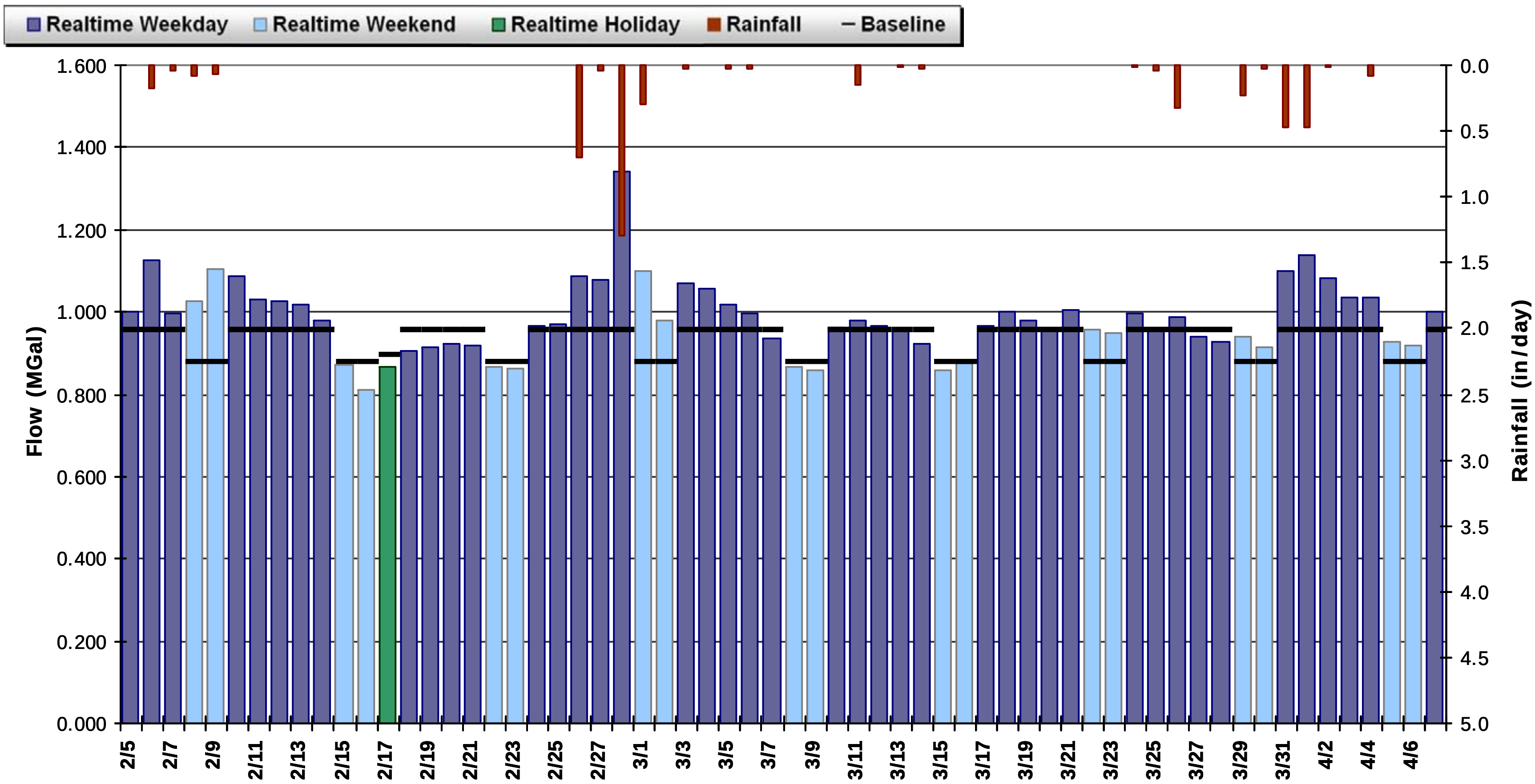

Plan View

SITE 1

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.982 MGal **Peak Daily Flow: 1.341 MGal** **Min Daily Flow: 0.810 MGal**

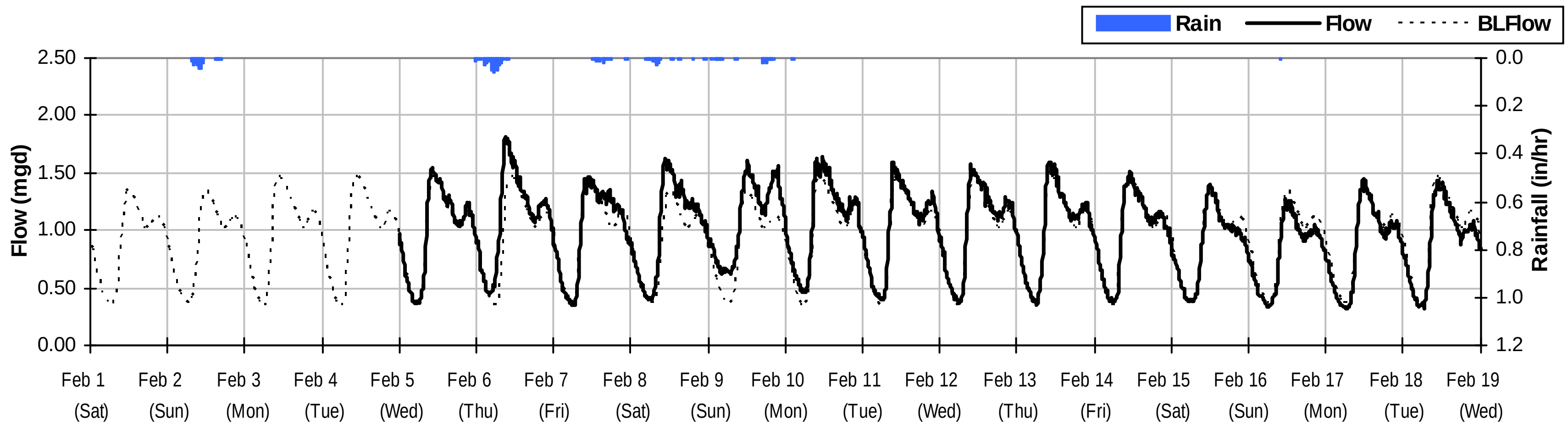
Total Period Rainfall: 4.67 inches

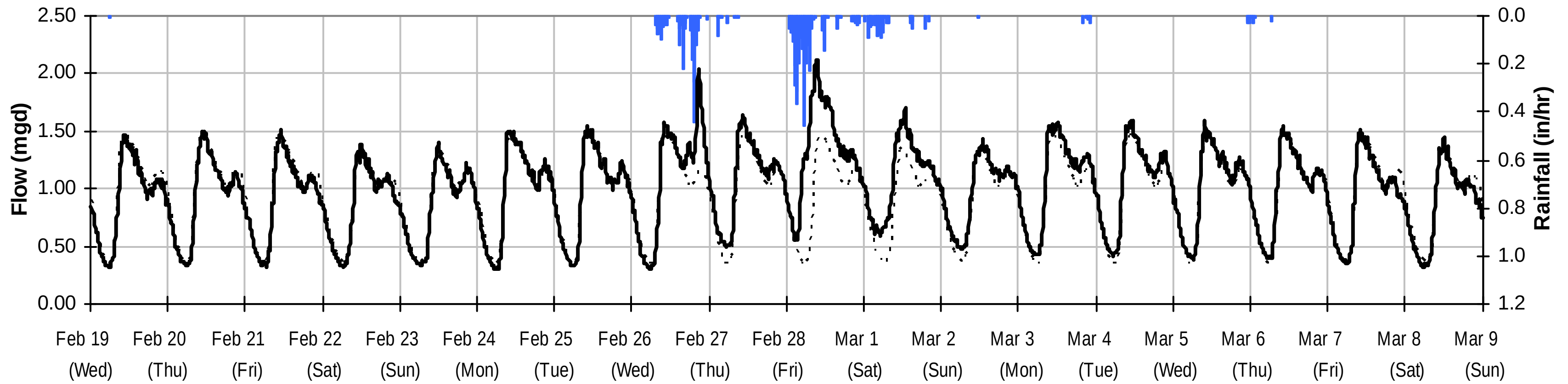


SITE 1

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.77 inches **Avg Flow: 0.982 mgd** **Peak Flow: 2.118 mgd** **Min Flow: 0.301 mgd**

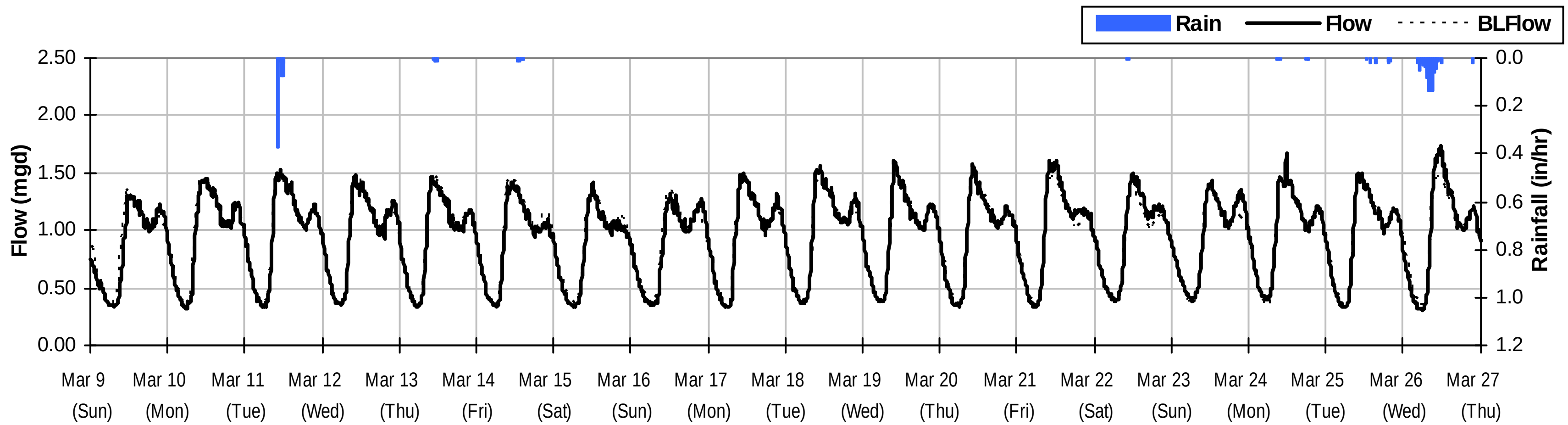


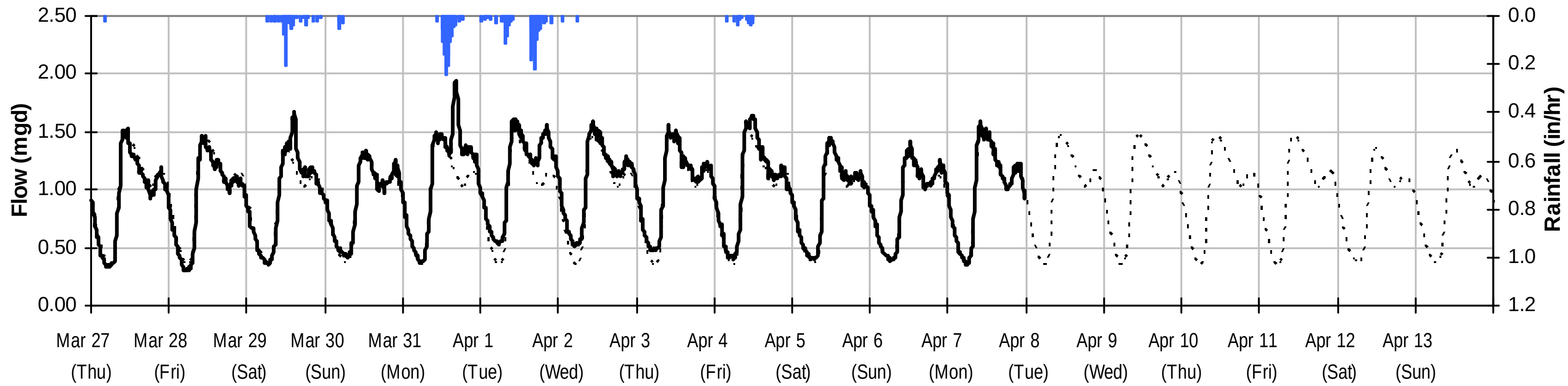


SITE 1

Period Flow Summary: March 9 to April 14, 2014

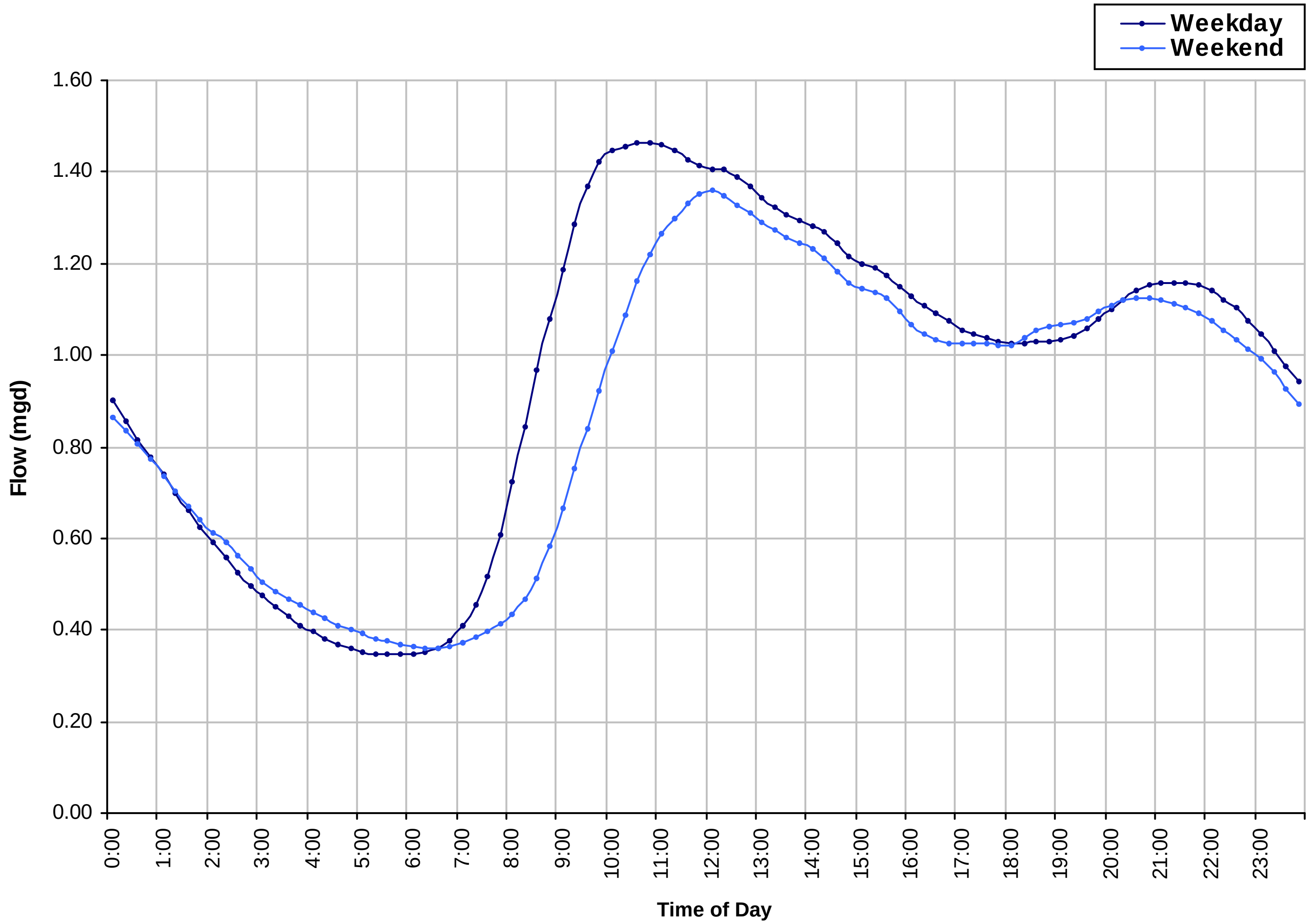
Total Monthly Rainfall: 4.77 inches **Avg Flow: 0.982 mgd** **Peak Flow: 2.118 mgd** **Min Flow: 0.301 mgd**



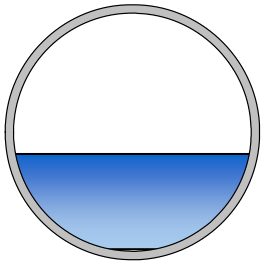


SITE 1

Baseline Flow Hydrographs

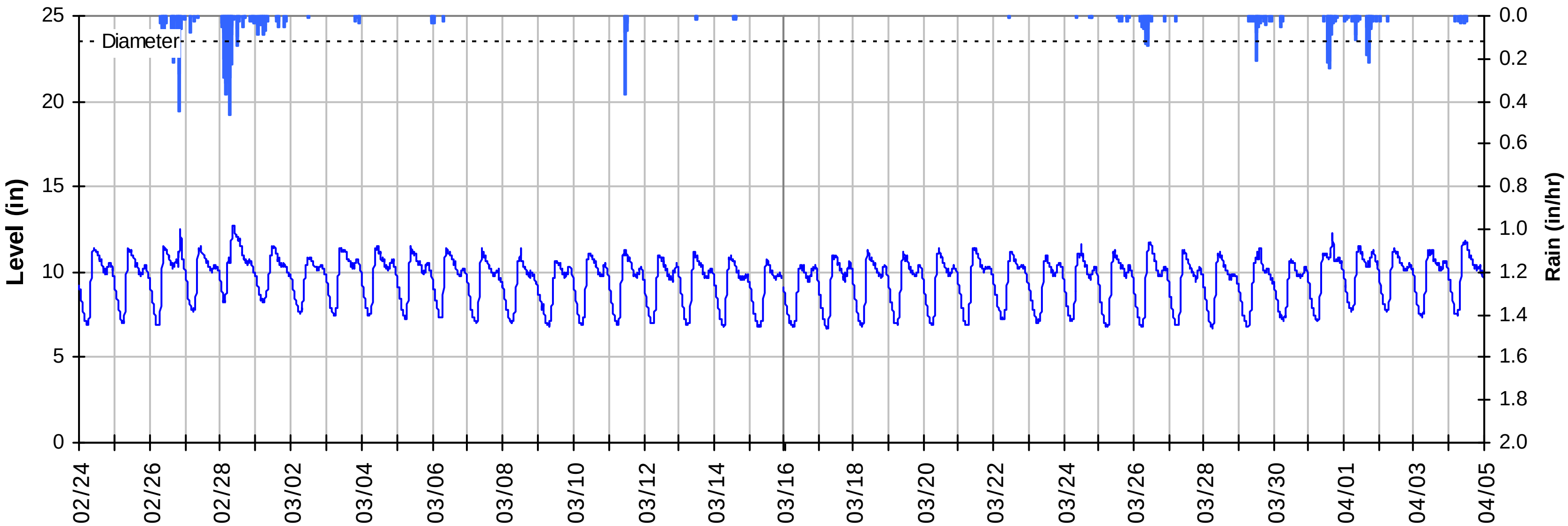


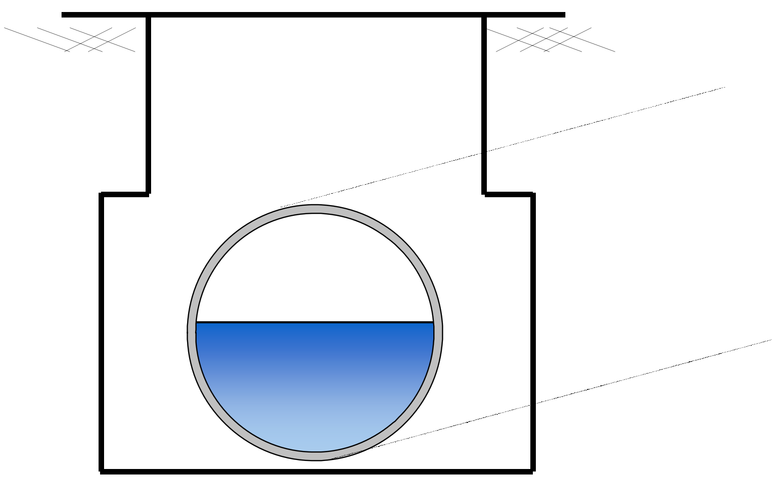
Baseline Flow:
0.935 *mgd*



SITE 1
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

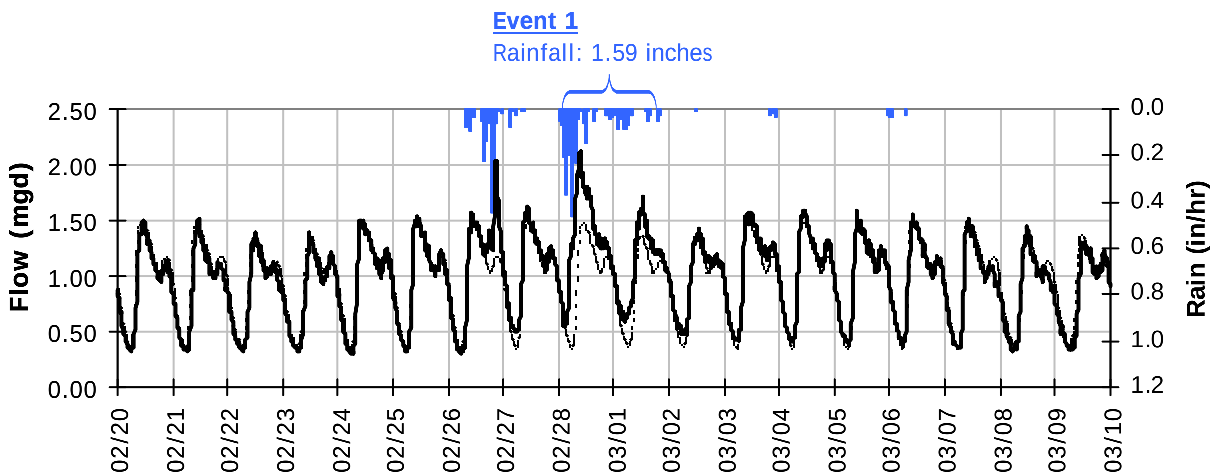




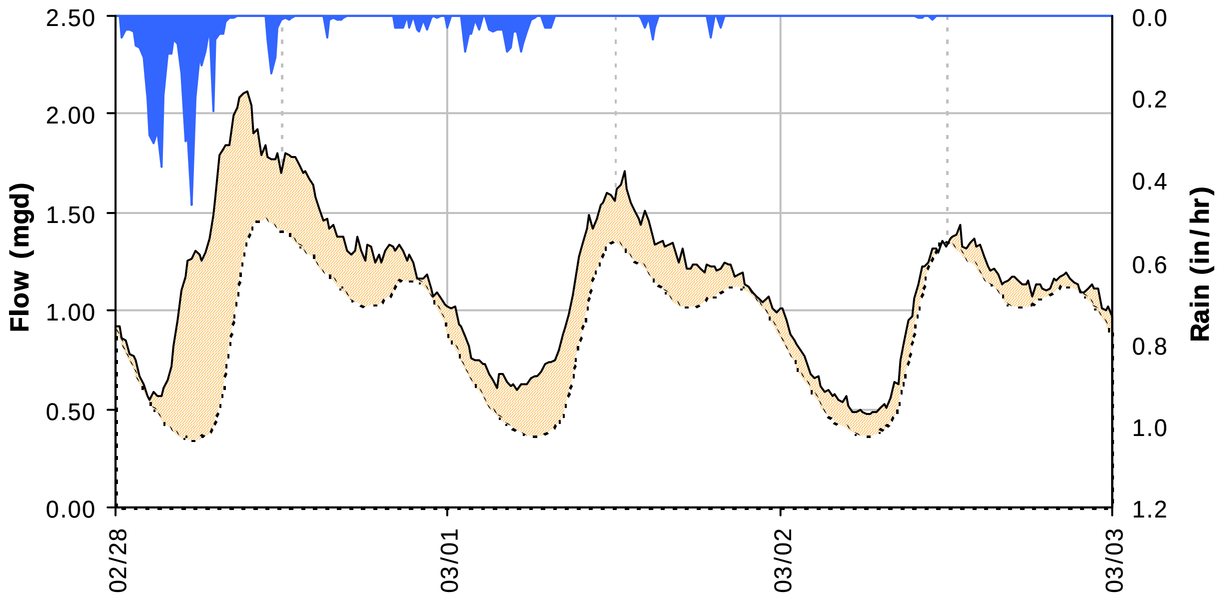
Pipe Diameter:	23.5 *inches*
Peak Measured Level:	12.7 *inches*
Peak d/D Ratio:	0.54

SITE 1
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

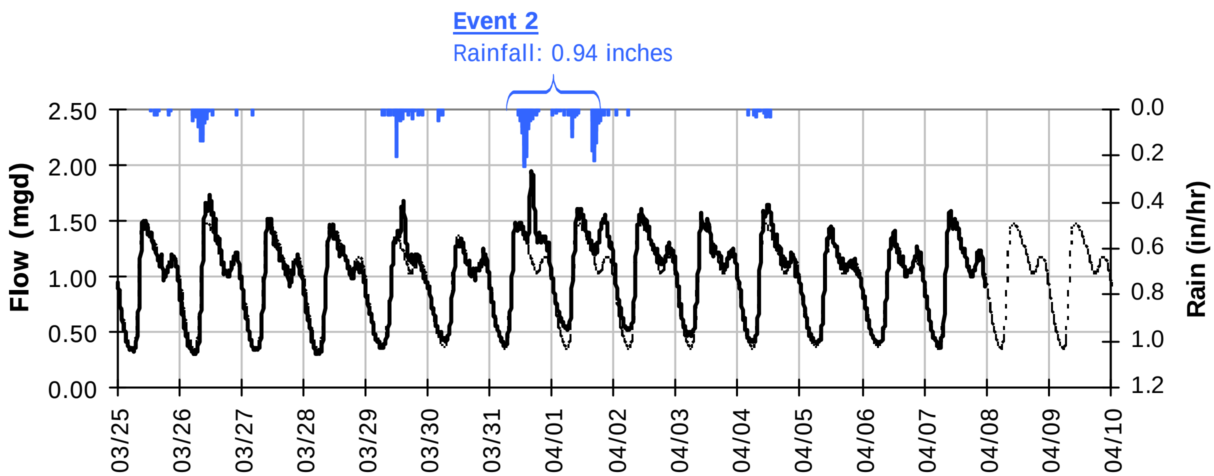


Storm Event I/I Analysis (Rain = 1.59 inches)

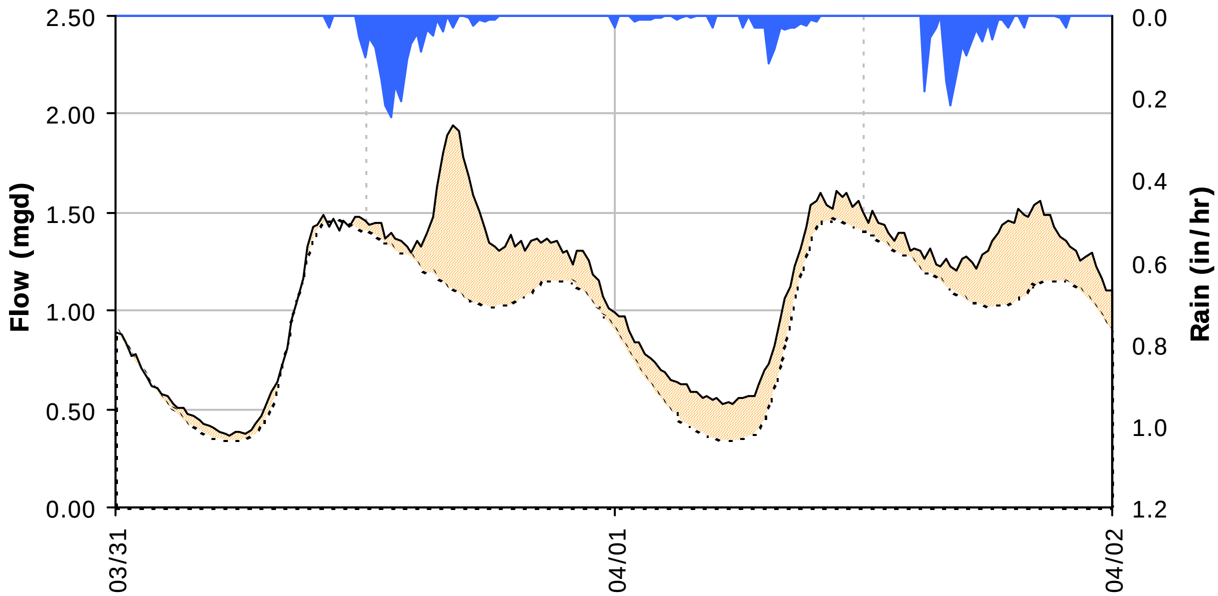
Capacity		Inflow / Infiltration	
Peak Flow:	2.12 *mgd*	**Peak I/I Rate:**	1.15 *mgd*
PF:	2.27	**Total I/I:**	701,000 *gallons*

SITE 1
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



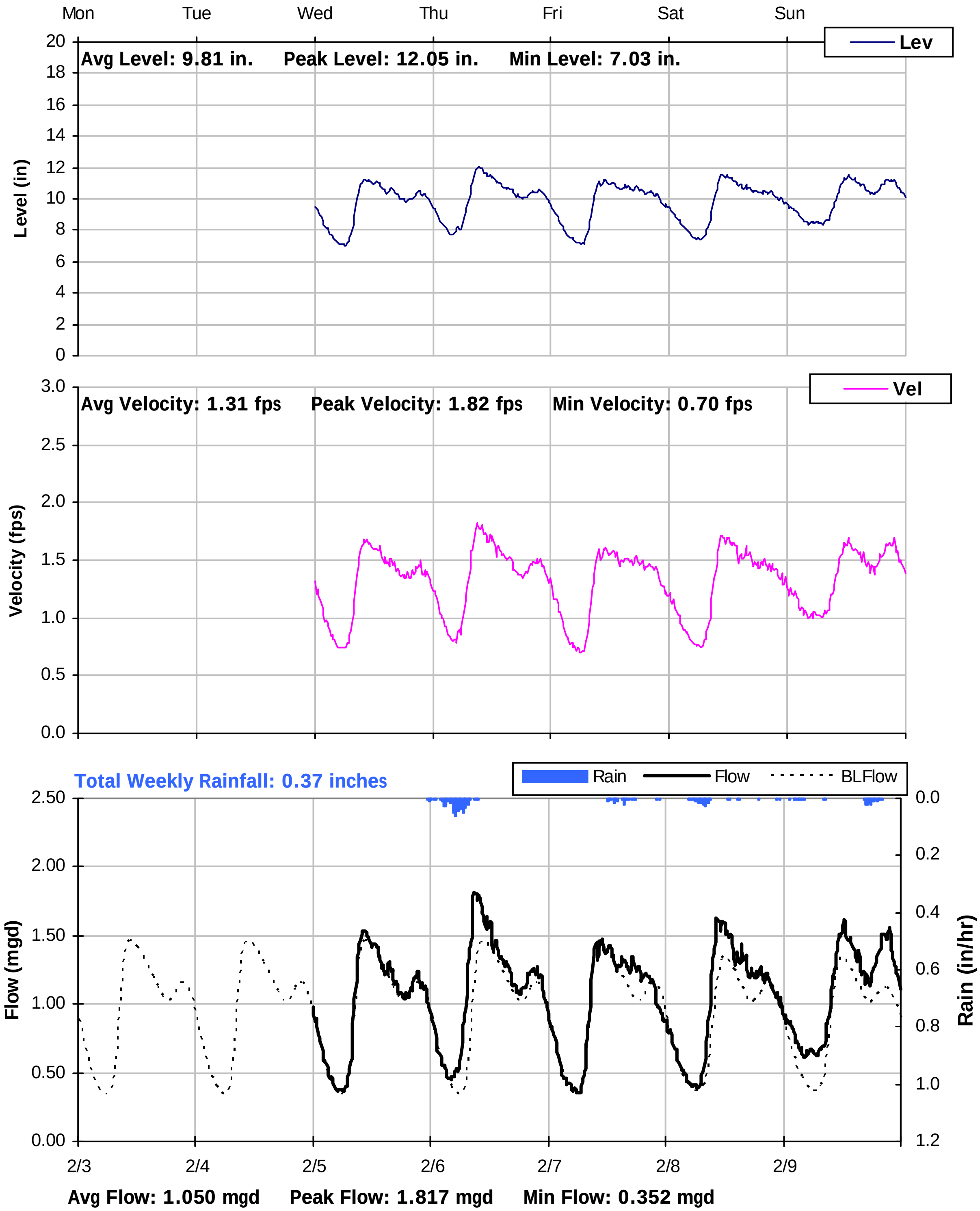
Event 2 Detail Graph



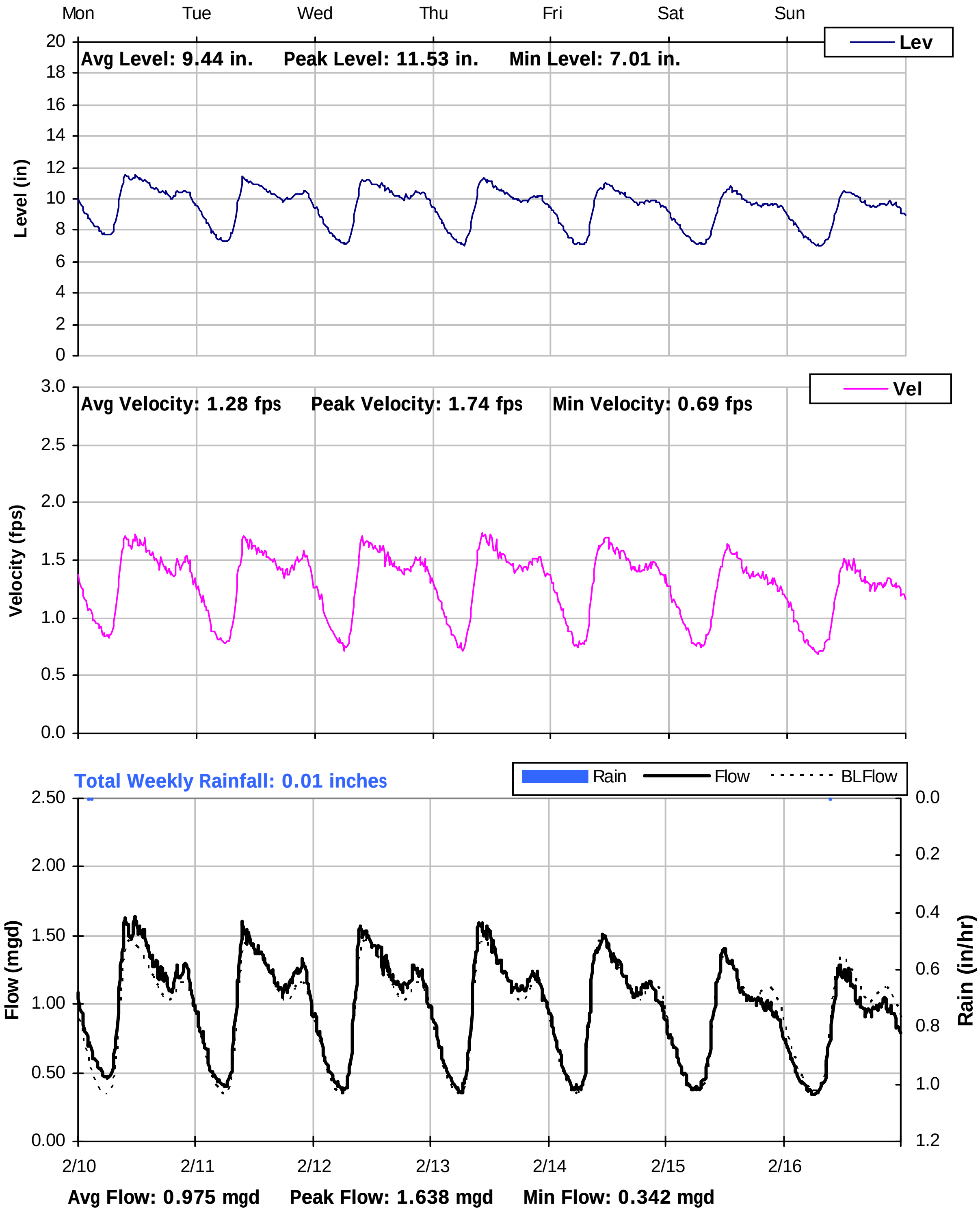
Storm Event I/I Analysis (Rain = 0.94 inches)

Capacity		Inflow / Infiltration	
Peak Flow:	1.94 *mgd*	**Peak I/I Rate:**	0.83 *mgd*
PF:	2.08	**Total I/I:**	502,000 *gallons*

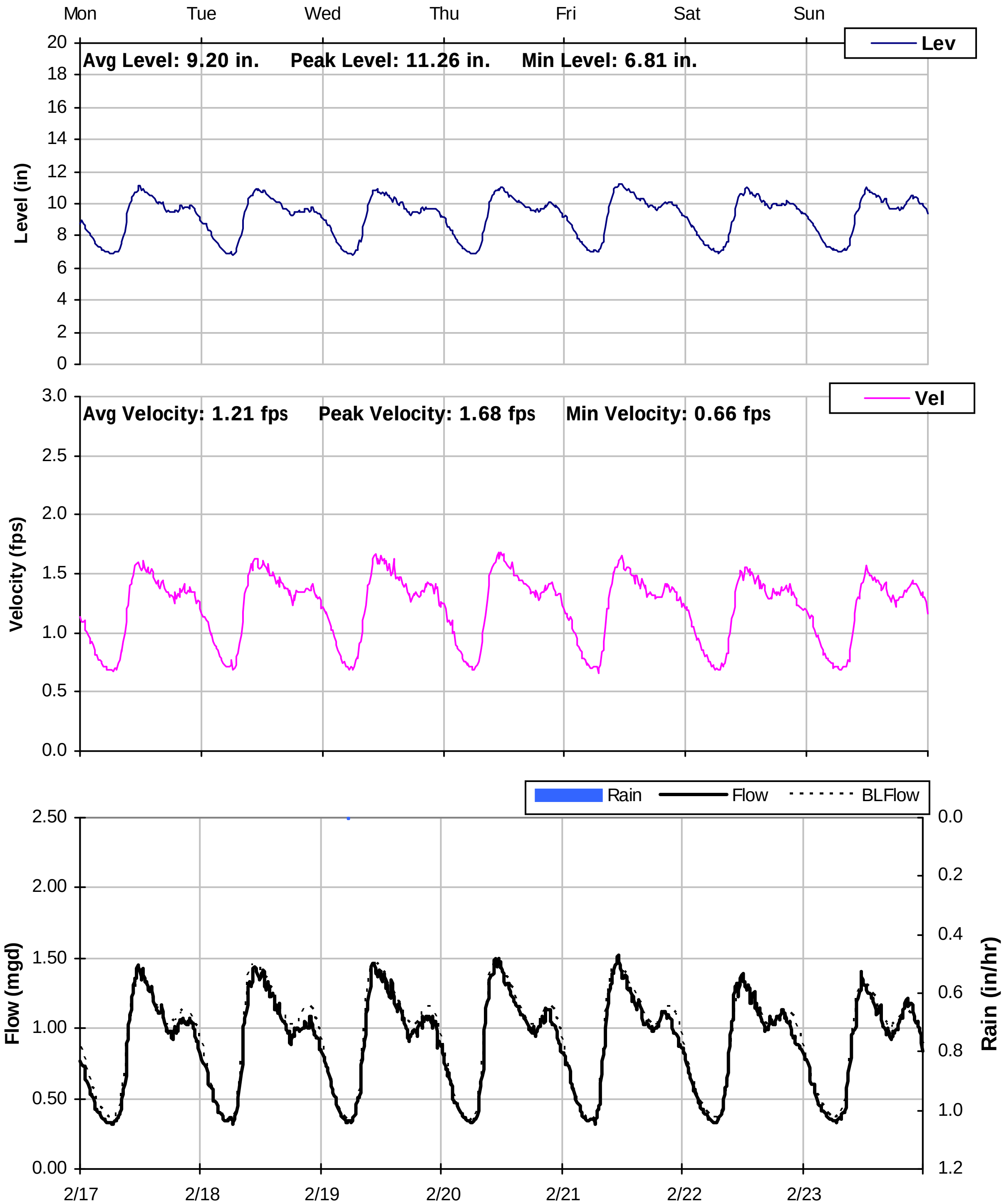
SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

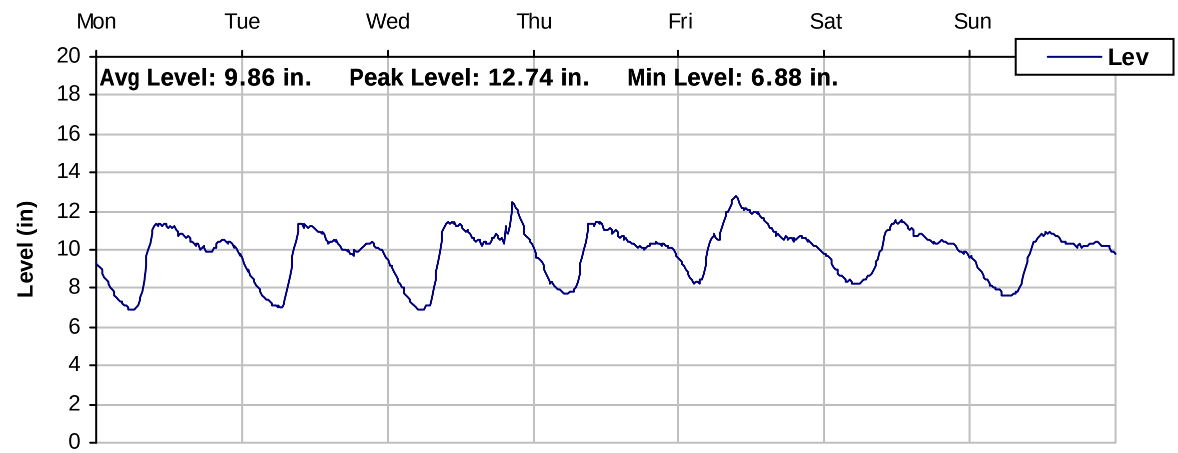


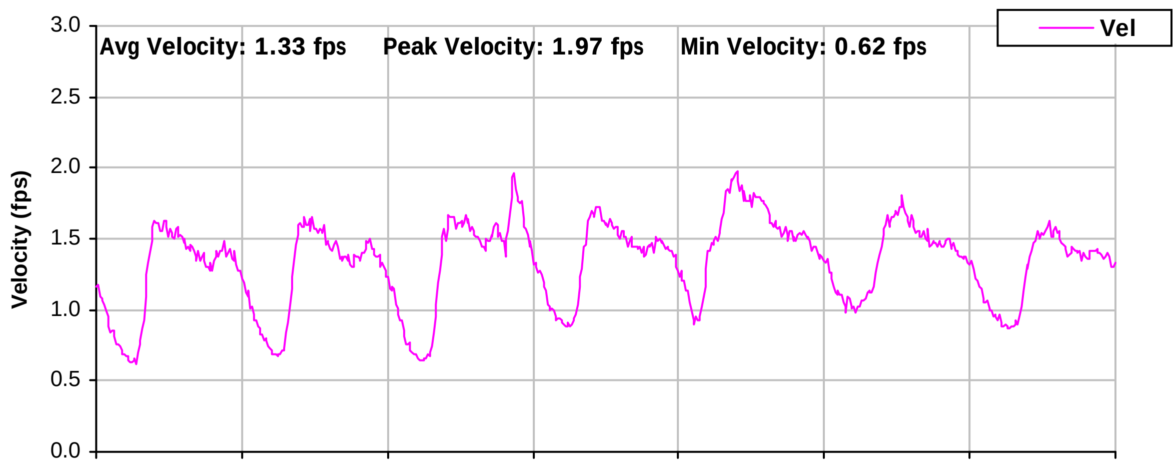
SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

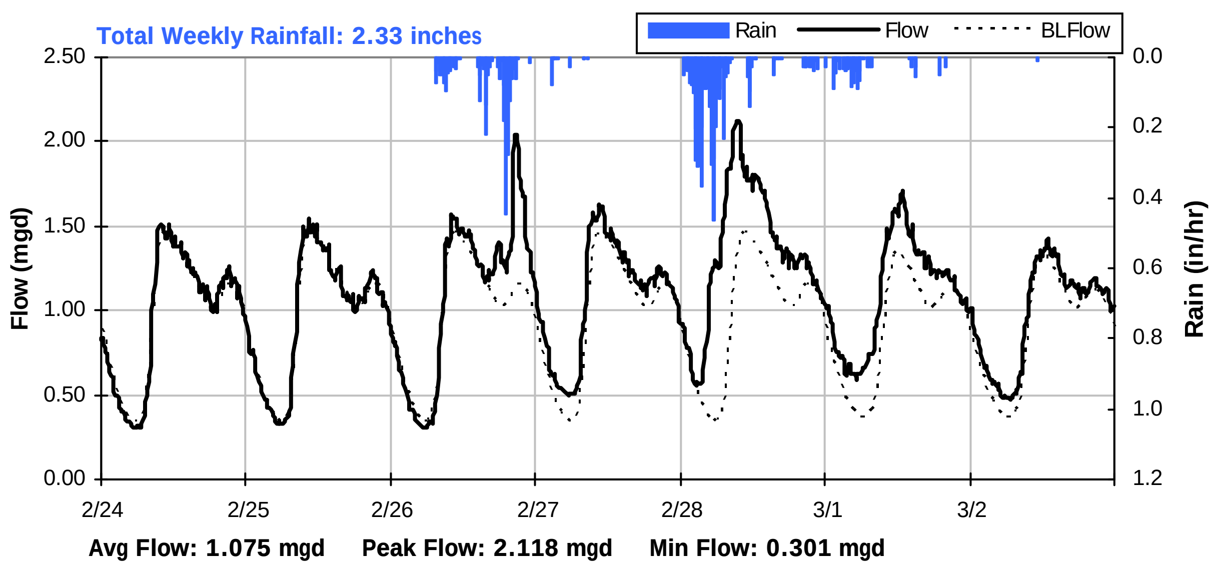


Avg Flow: 0.894 mgd Peak Flow: 1.519 mgd Min Flow: 0.320 mgd

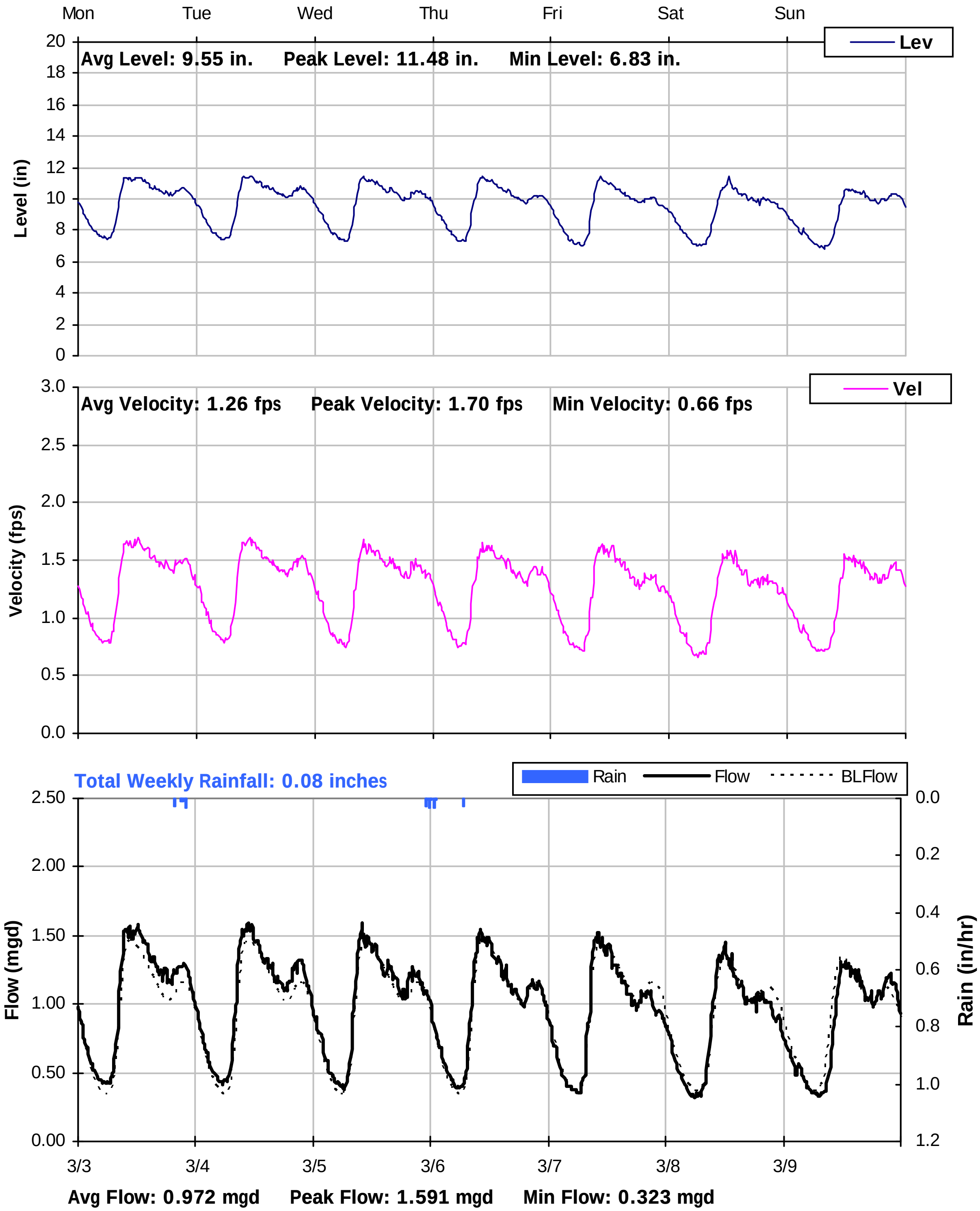
SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014







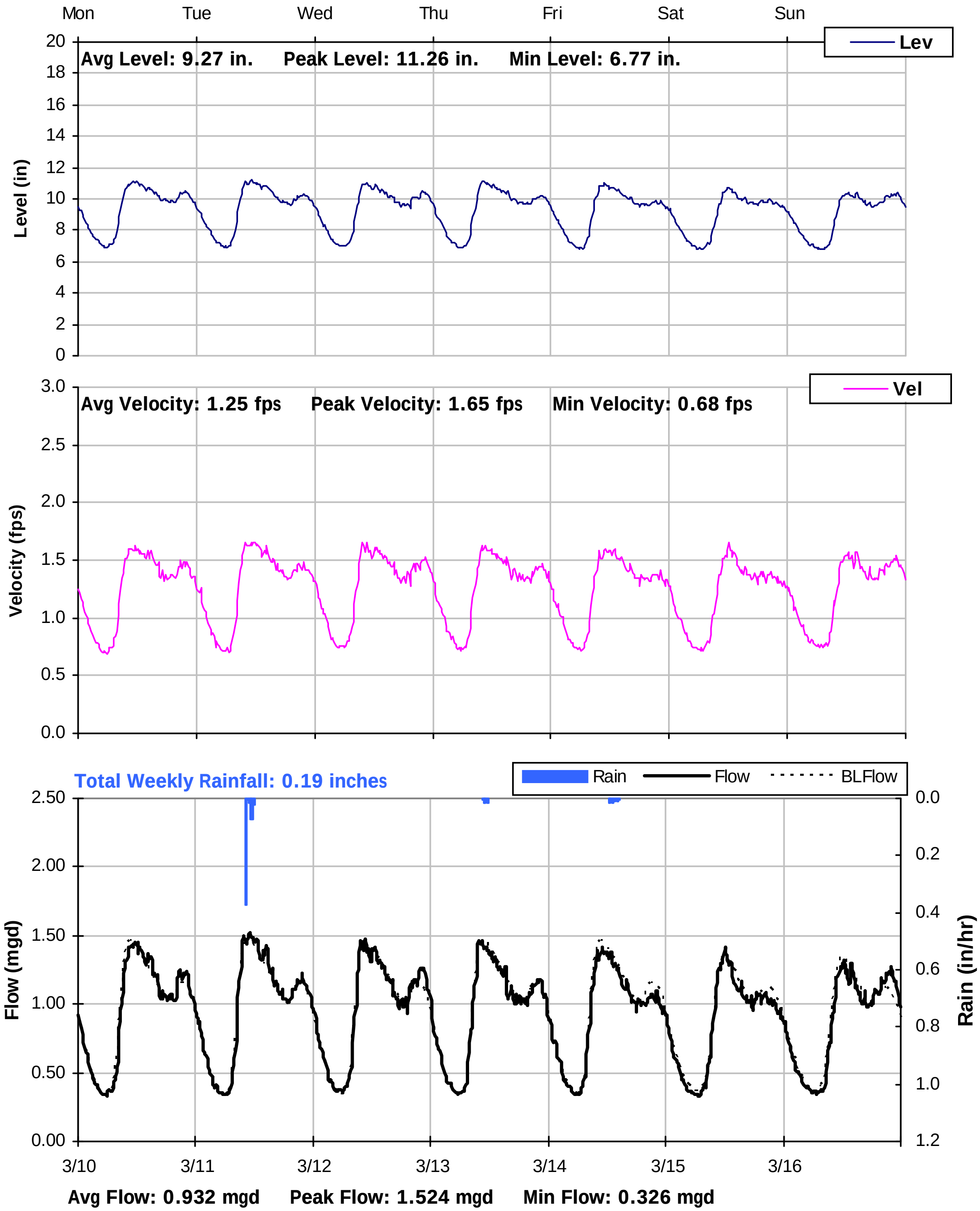
SITE 1
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



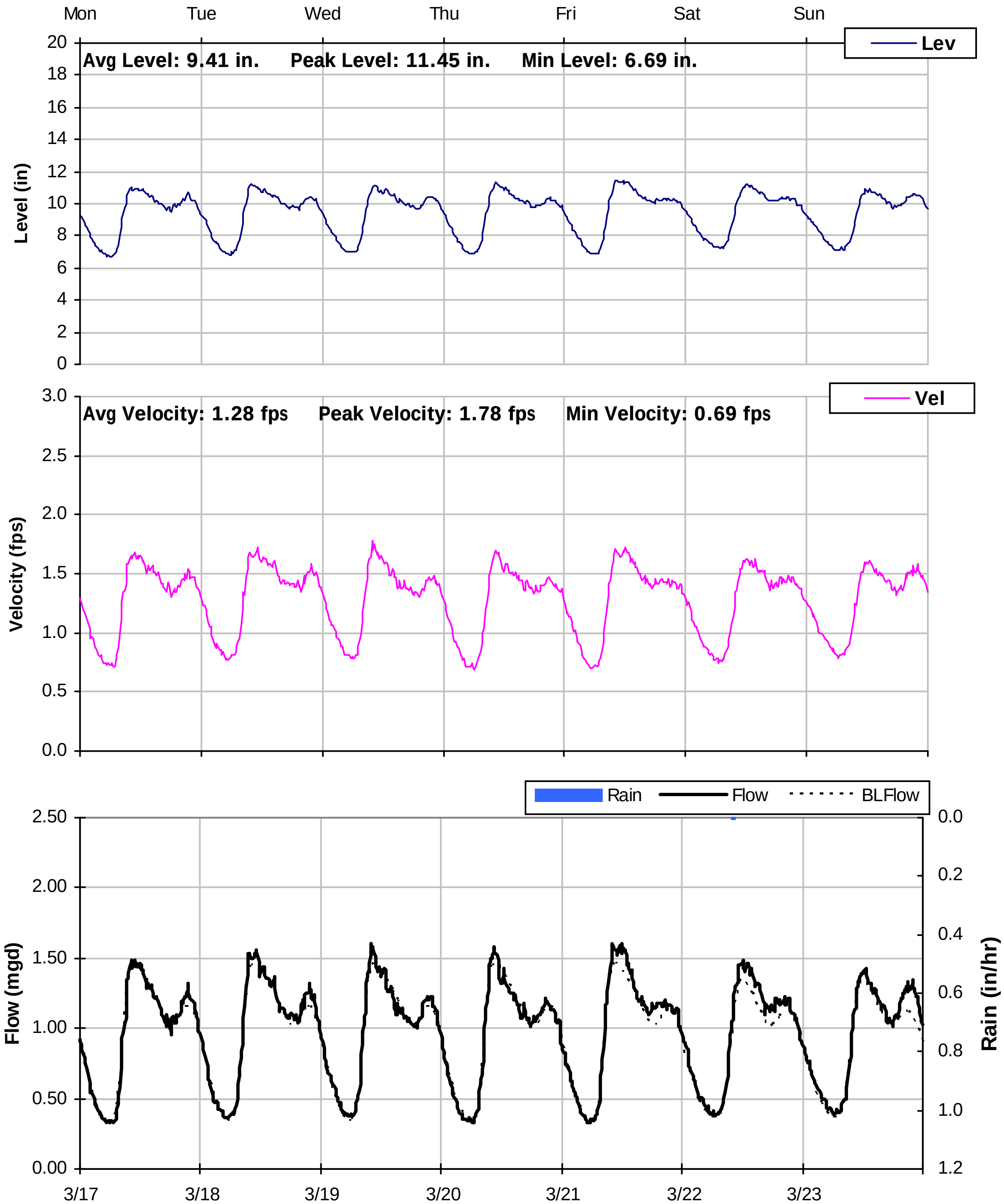
SITE 1

Weekly Level, Velocity and Flow Hydrographs

3/10/2014 to 3/17/2014

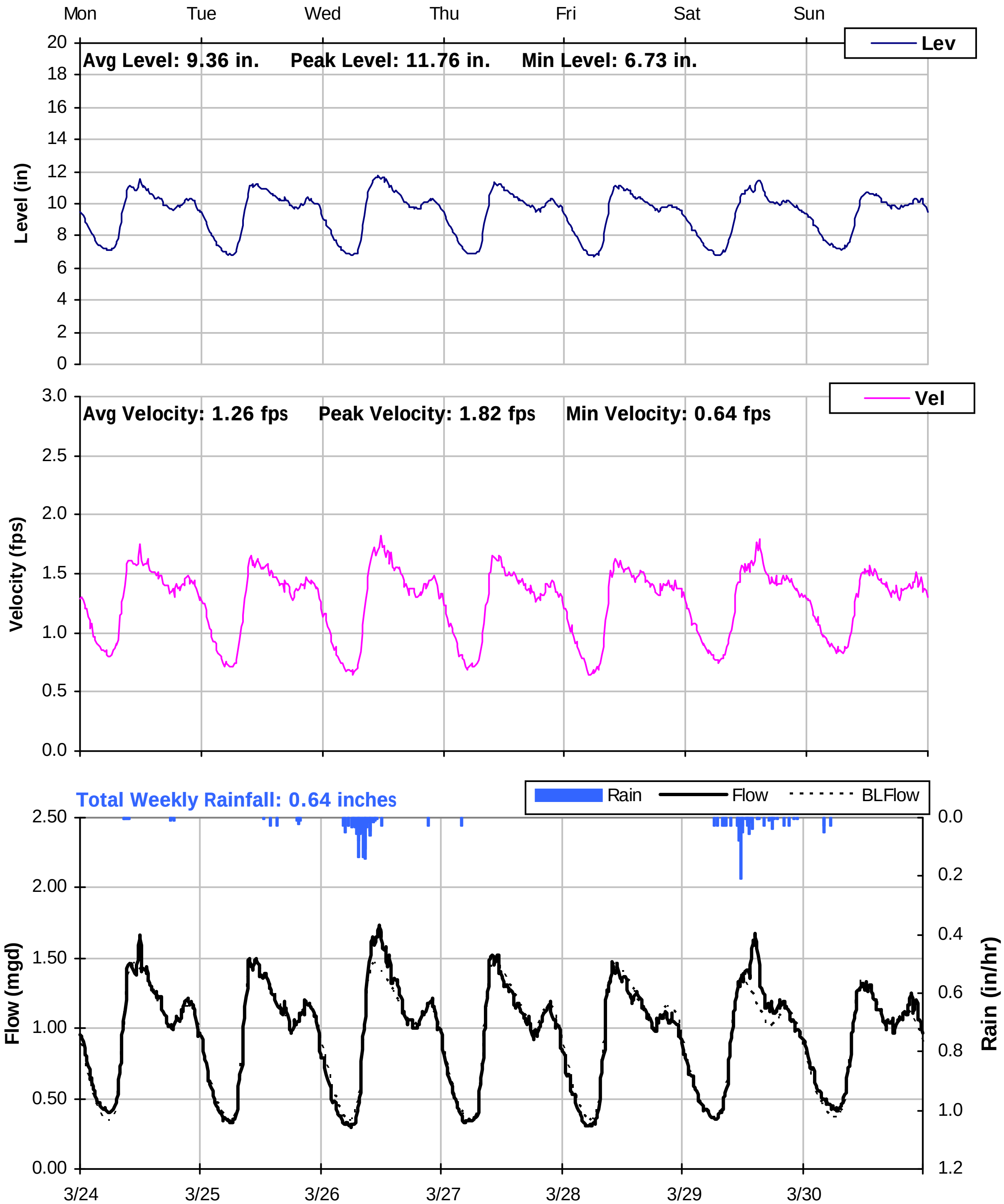


SITE 1
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



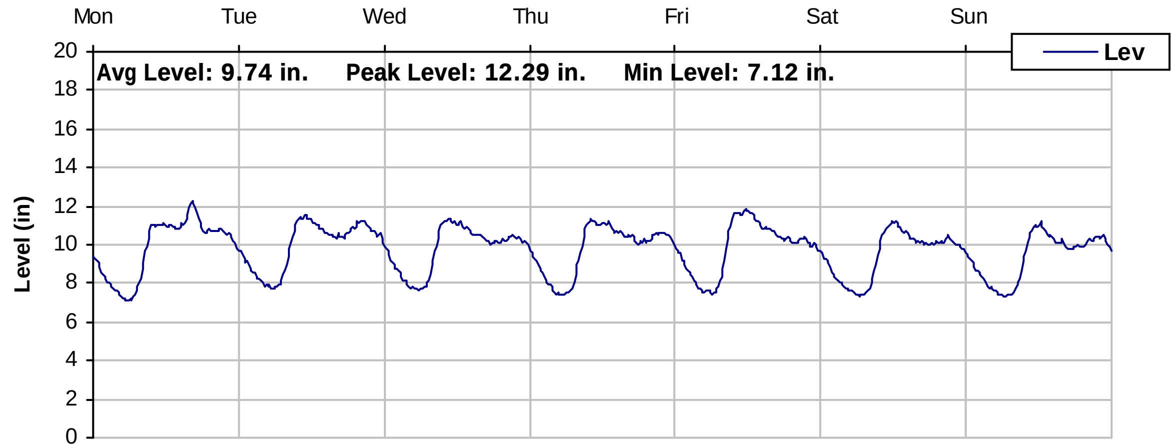
Avg Flow: 0.974 mgd Peak Flow: 1.608 mgd Min Flow: 0.331 mgd

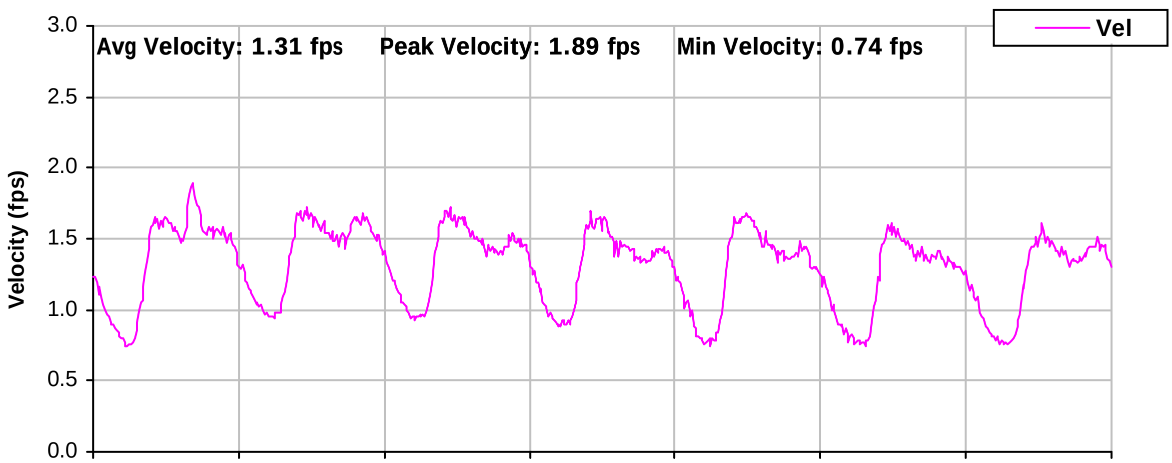
SITE 1
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

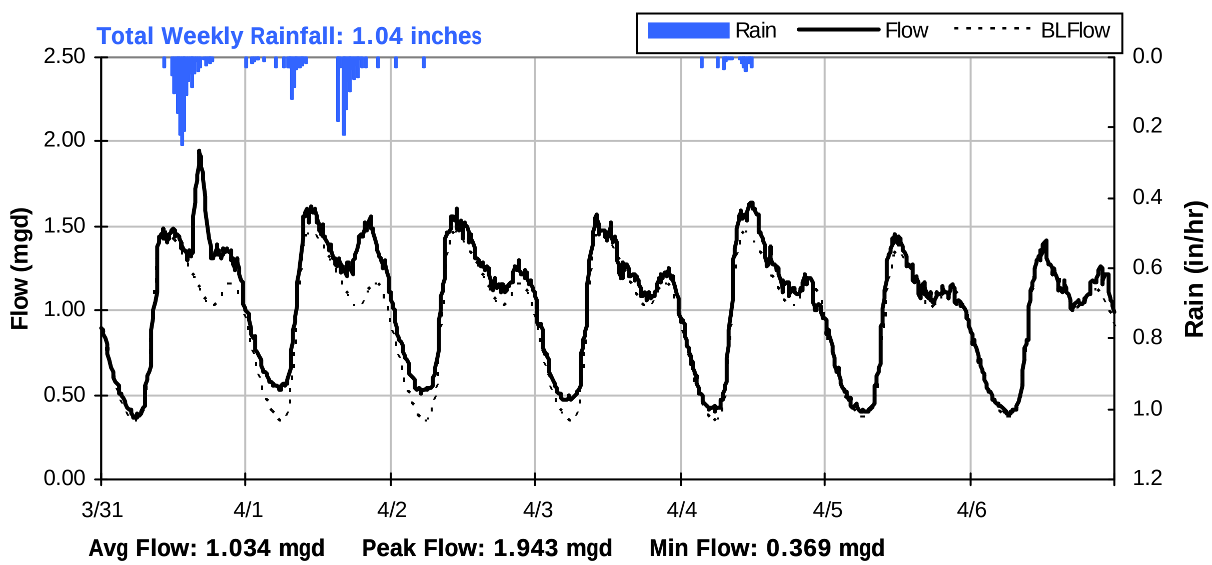


Avg Flow: 0.952 mgd **Peak Flow: 1.737 mgd** **Min Flow: 0.301 mgd**

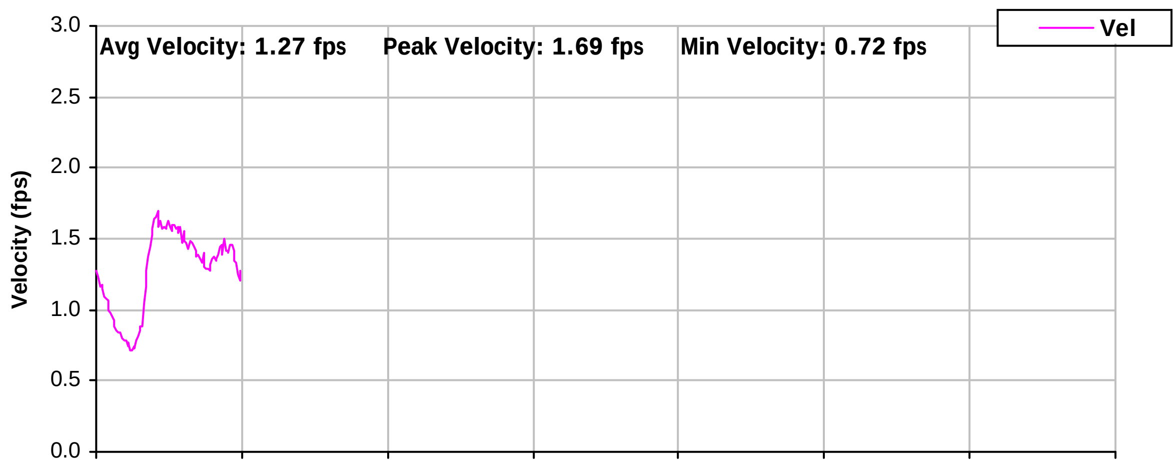
SITE 1
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014

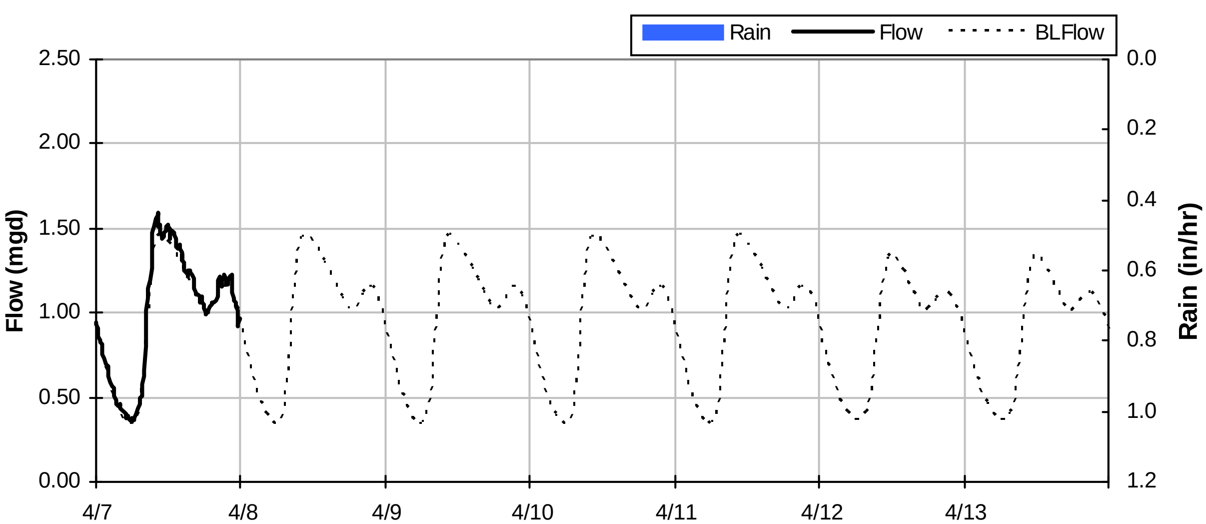






SITE 1
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014





Avg Flow: 1.000 mgd Peak Flow: 1.592 mgd Min Flow: 0.353 mgd

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 2

Location: Near bike path at Bayfront Park and Marsh Road

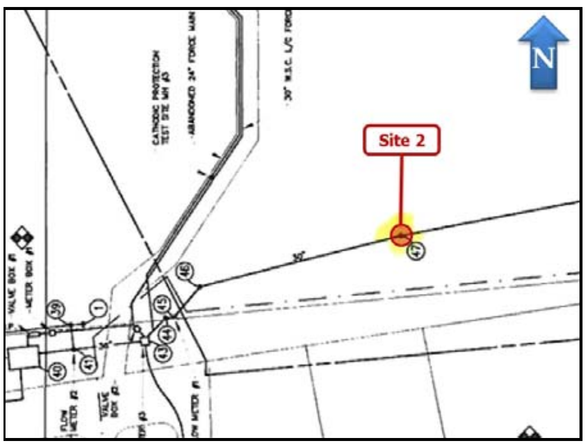
Data Summary Report

SITE 2

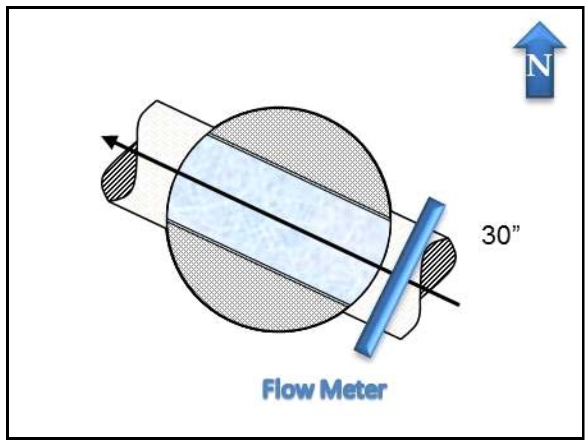
Site Information

Location:	Near bike path at Bayfront Park and Marsh Road
Coordinates:	122.1772° W, 37.4865° N
Rim Elevation:	8 feet
Pipe Diameter:	30 inches
Baseline Flow:	1.184 mgd
Peak Measured Flow:	2.378 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

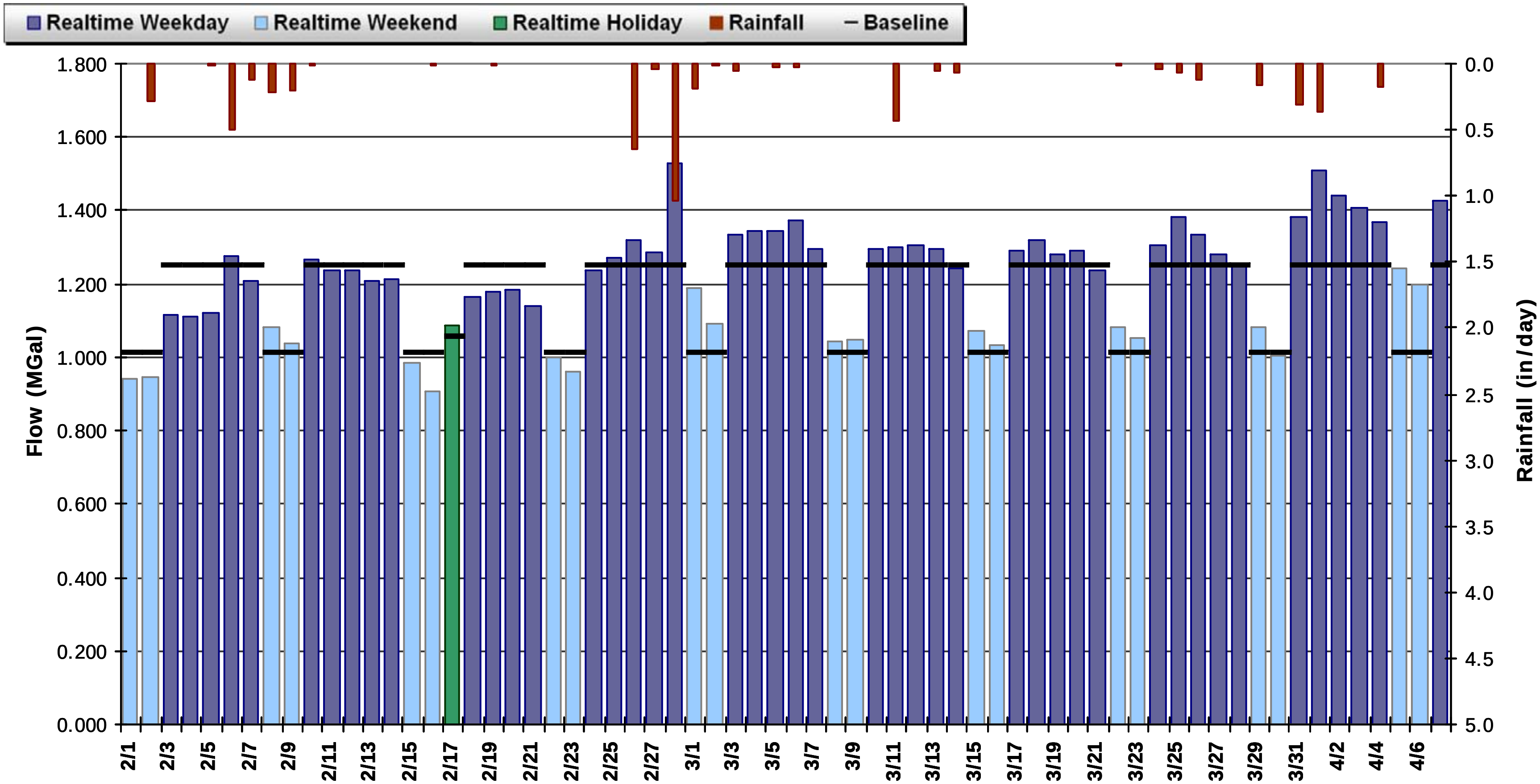
Plan View

SITE 2

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.213 MGal **Peak Daily Flow: 1.526 MGal** **Min Daily Flow: 0.909 MGal**

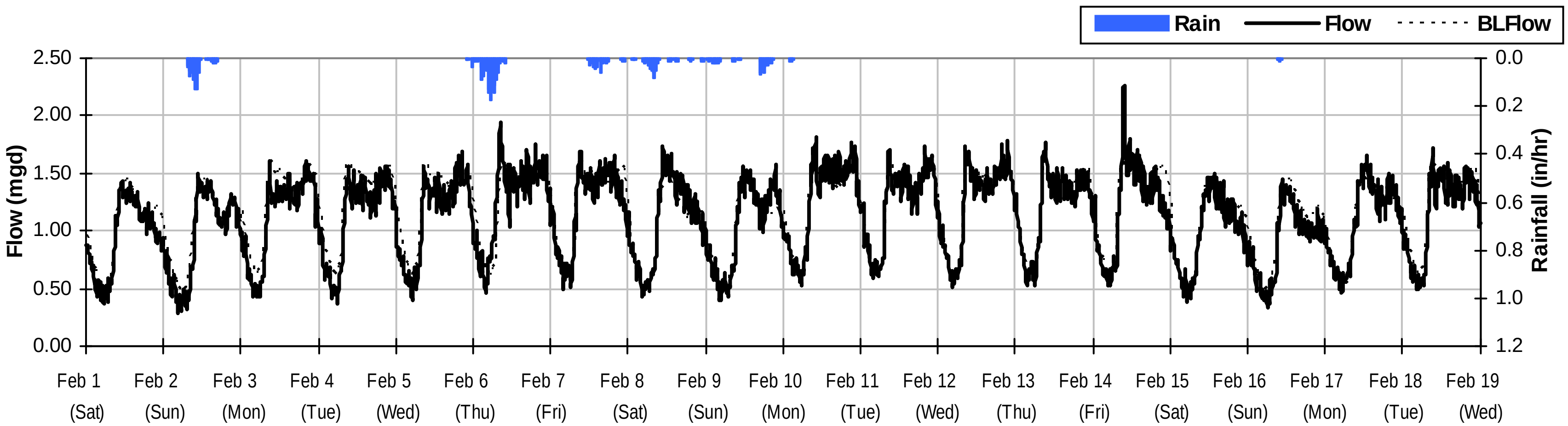
Total Period Rainfall: 5.22 inches

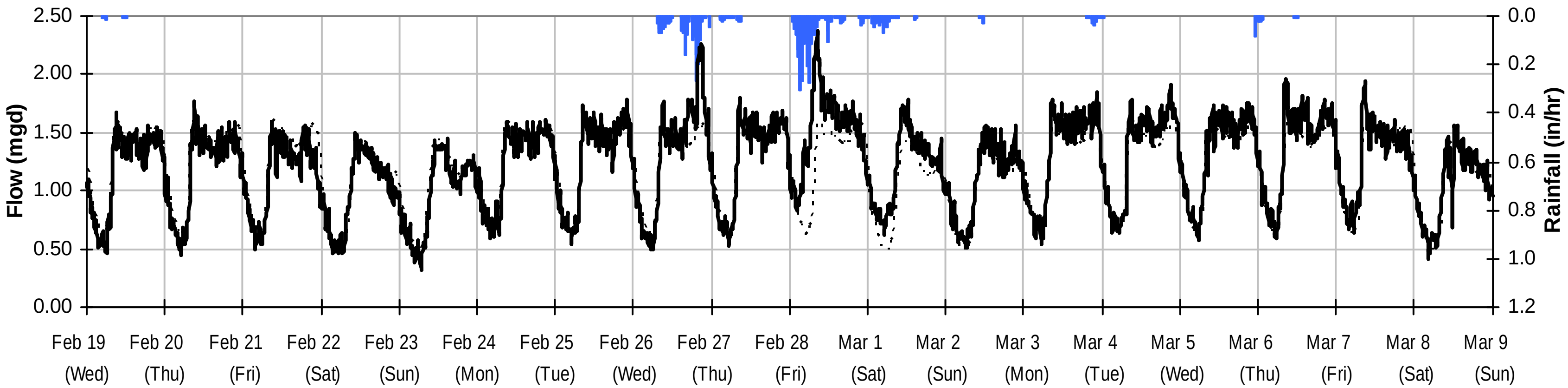


SITE 2

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 5.22 inches **Avg Flow: 1.213 mgd** **Peak Flow: 2.378 mgd** **Min Flow: 0.294 mgd**

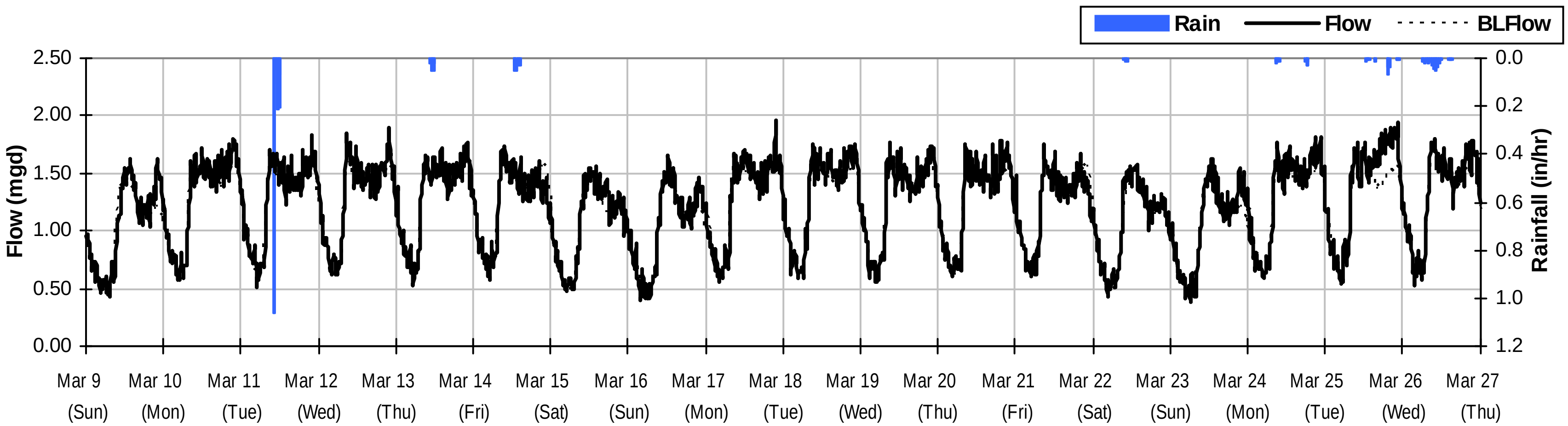


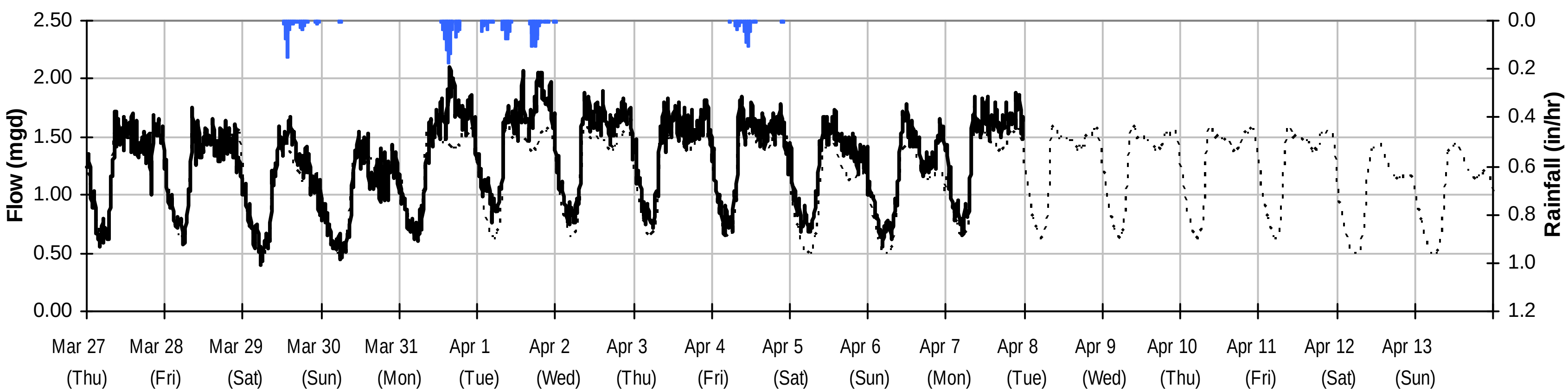


SITE 2

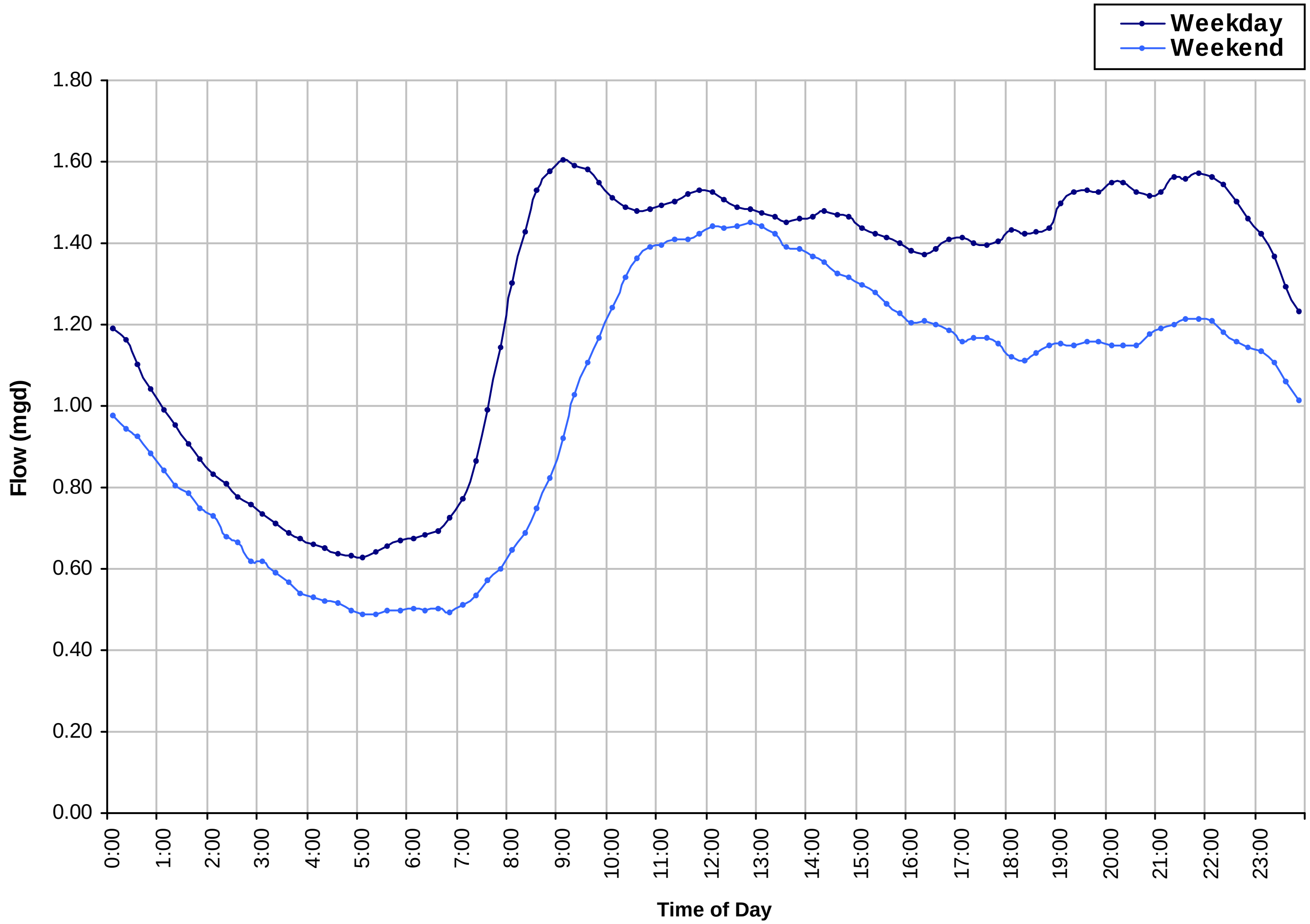
Period Flow Summary: March 9 to April 14, 2014

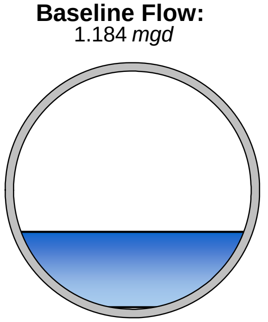
Total Monthly Rainfall: 5.22 inches **Avg Flow: 1.213 mgd** **Peak Flow: 2.378 mgd** **Min Flow: 0.294 mgd**





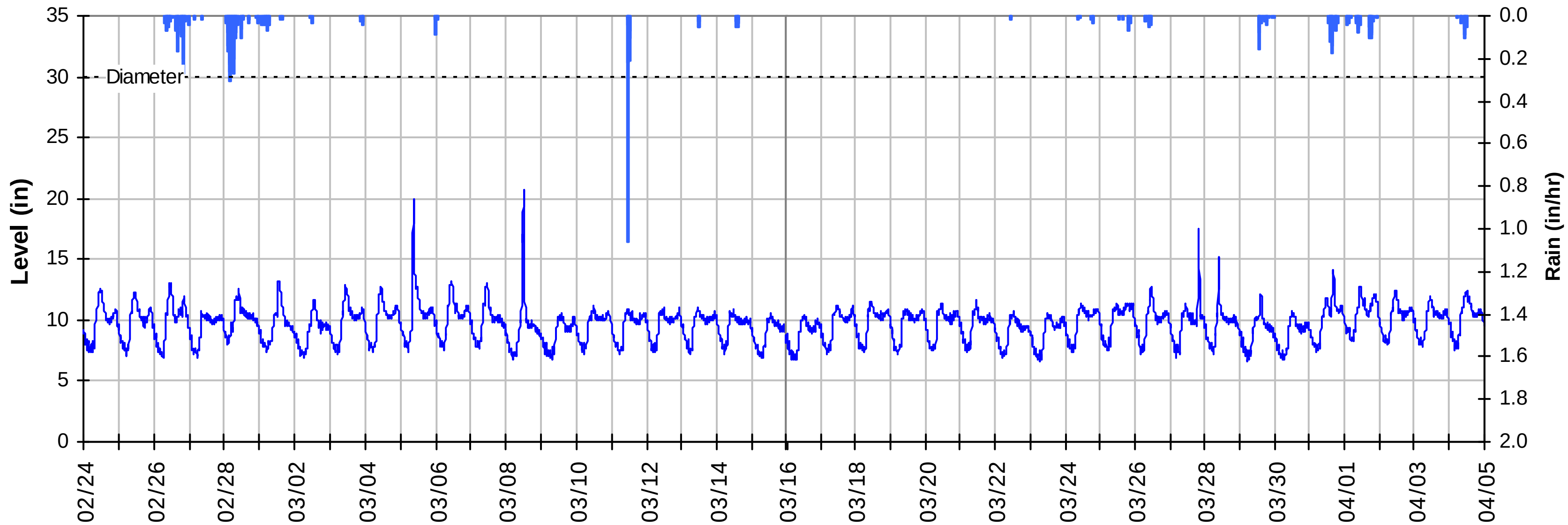
SITE 2
Baseline Flow Hydrographs

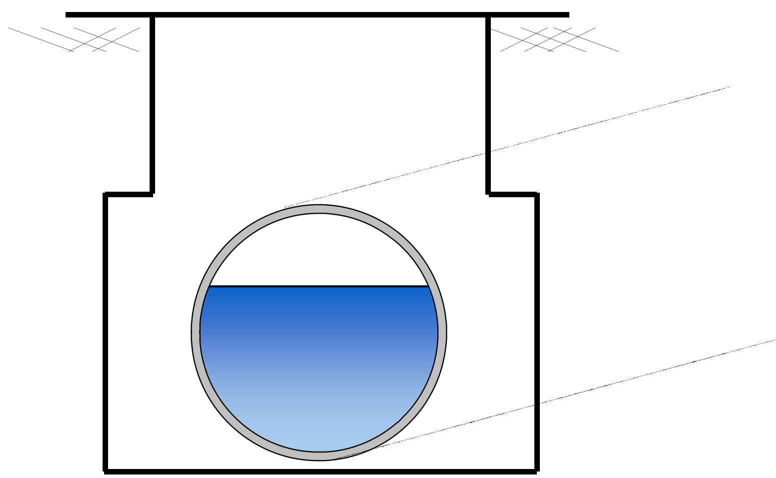




SITE 2
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





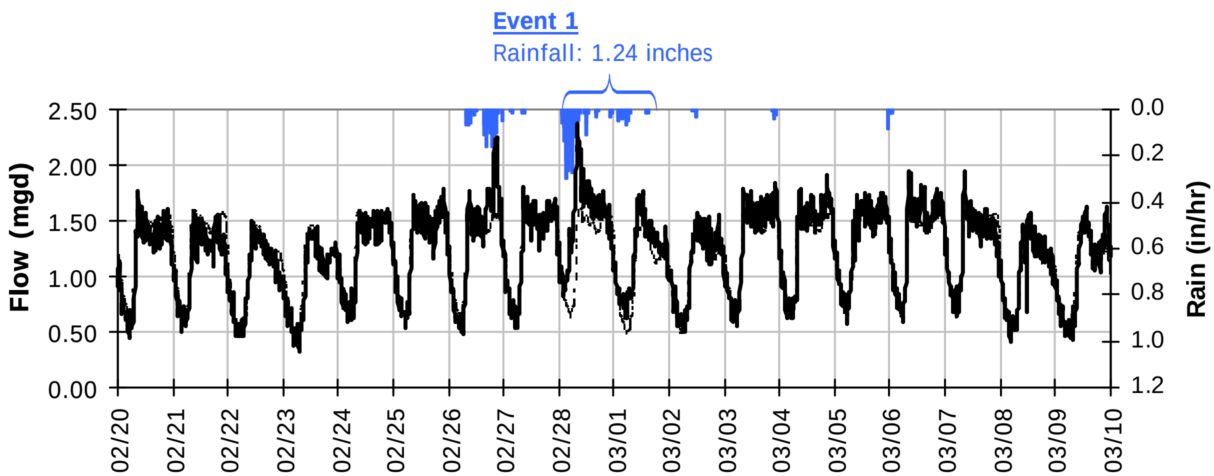
Pipe Diameter: 30 *inches*

Peak Measured Level: 20.5 *inches*

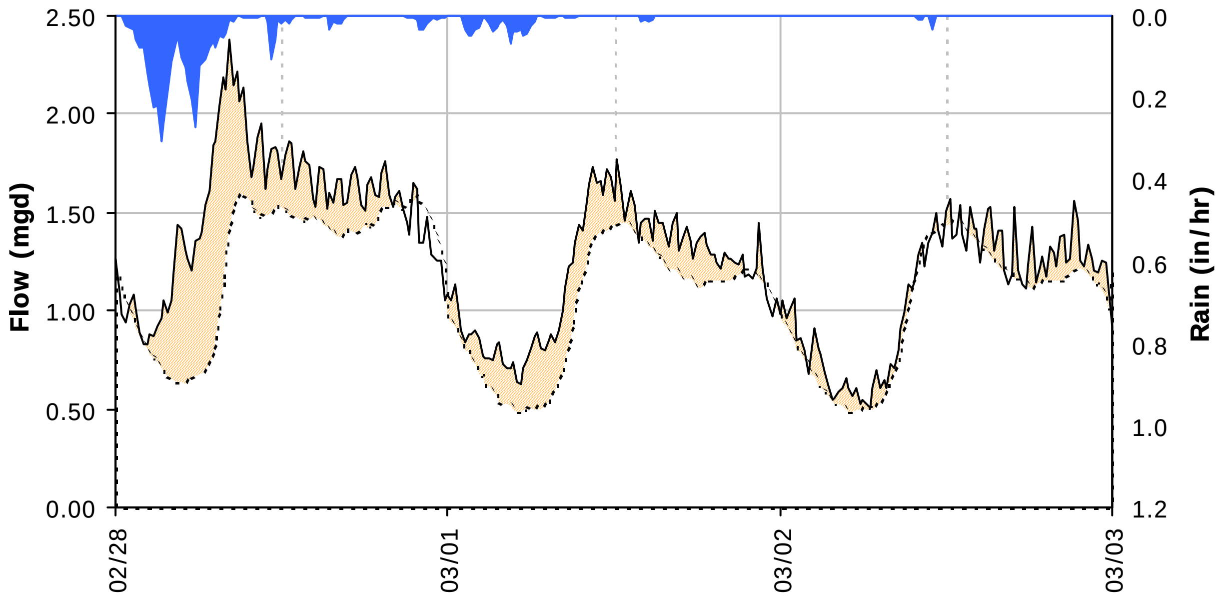
Peak d/D Ratio: 0.68

SITE 2
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

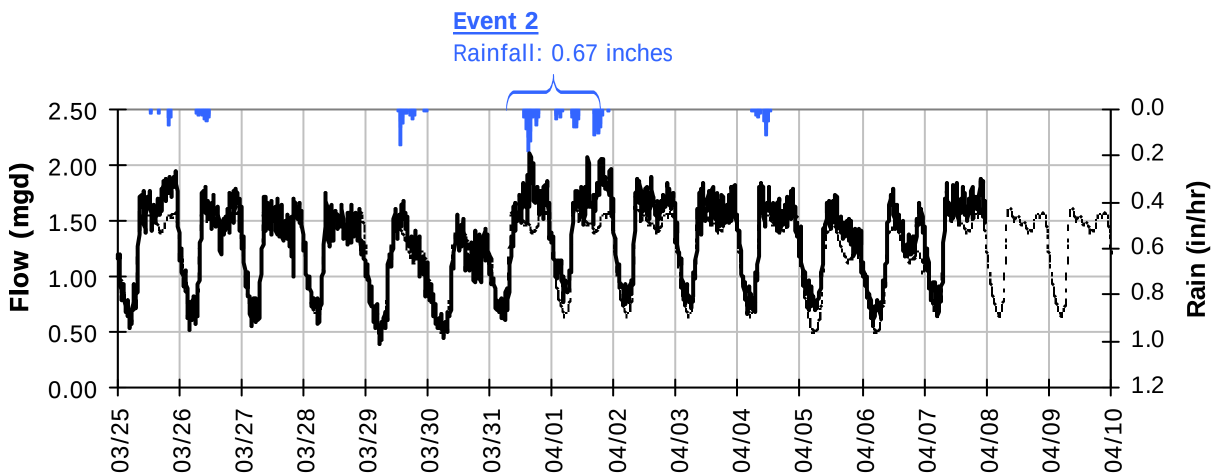


Storm Event I/I Analysis (Rain = 1.24 inches)

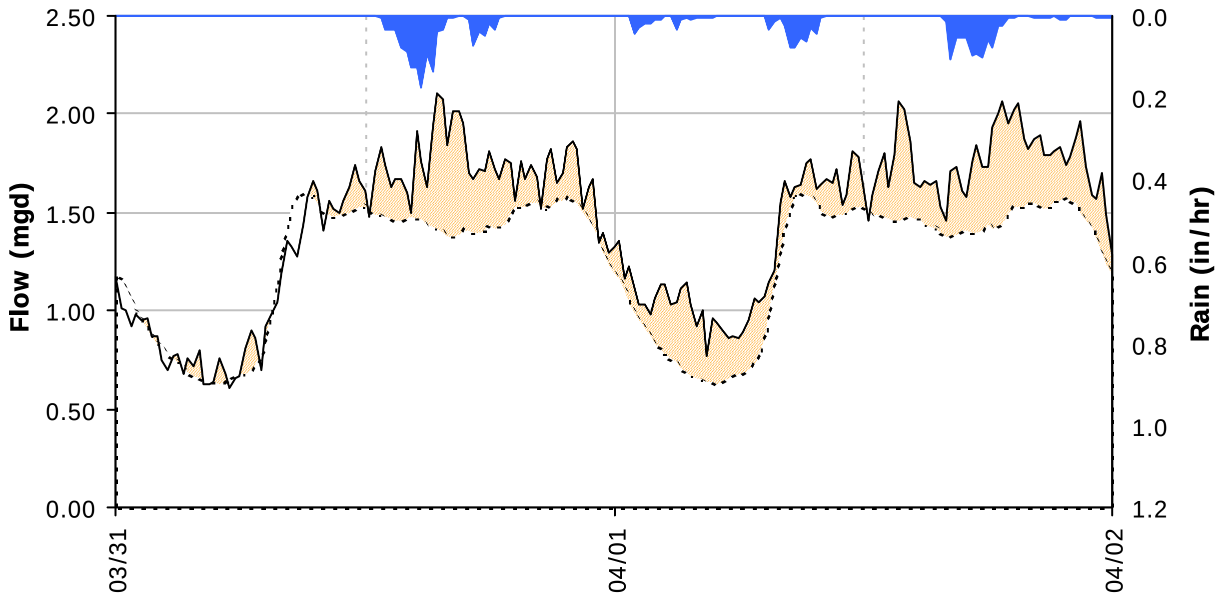
Capacity		Inflow / Infiltration	
Peak Flow:	2.38 *mgd*	**Peak I/I Rate:**	0.88 *mgd*
PF:	2.01	**Total I/I:**	529,000 *gallons*

SITE 2
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph



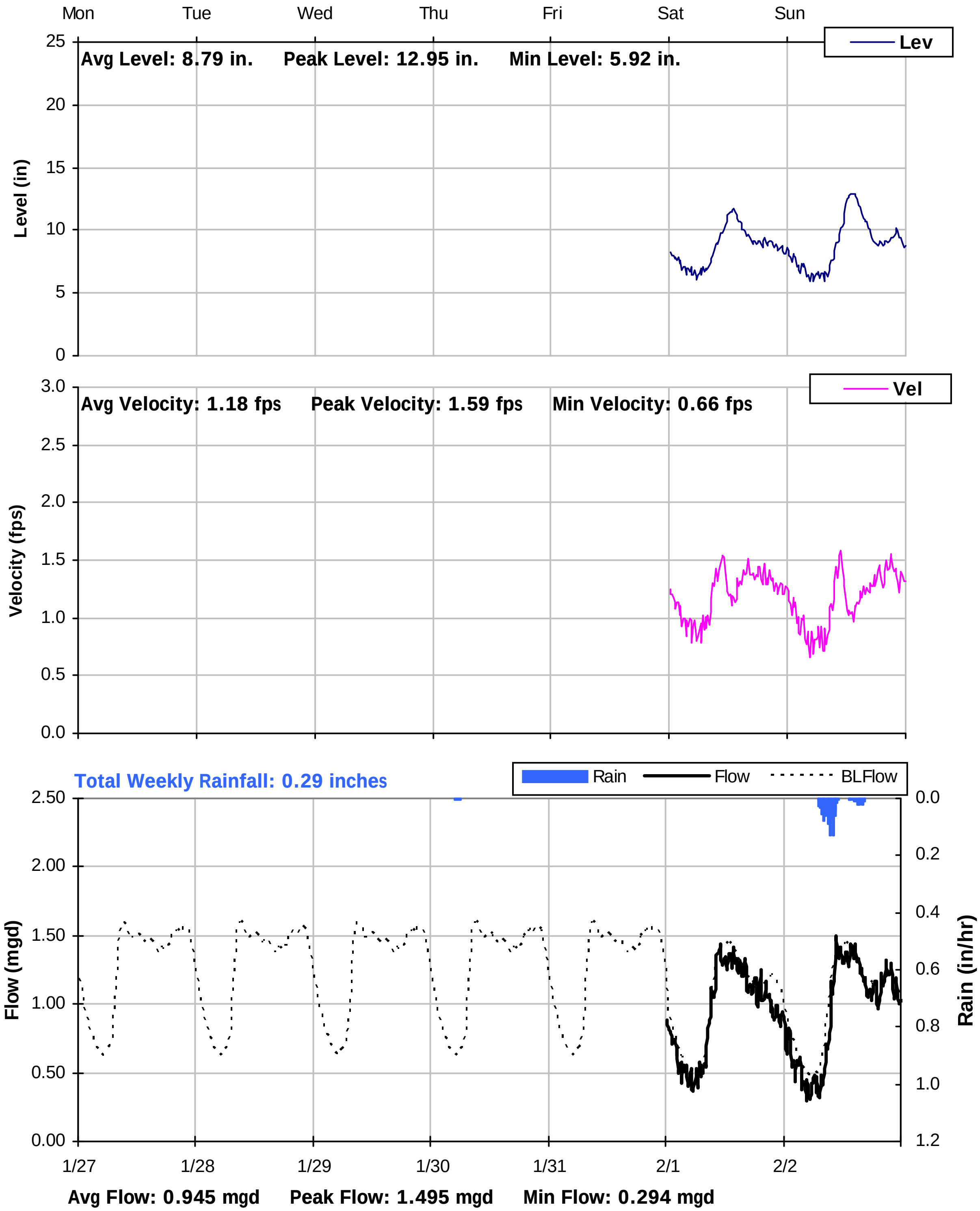
Storm Event I/I Analysis (Rain = 0.67 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	2.10 *mgd*	**Peak I/I Rate:**	0.69 *mgd*
PF:	1.78	**Total I/I:**	651,000 *gallons*

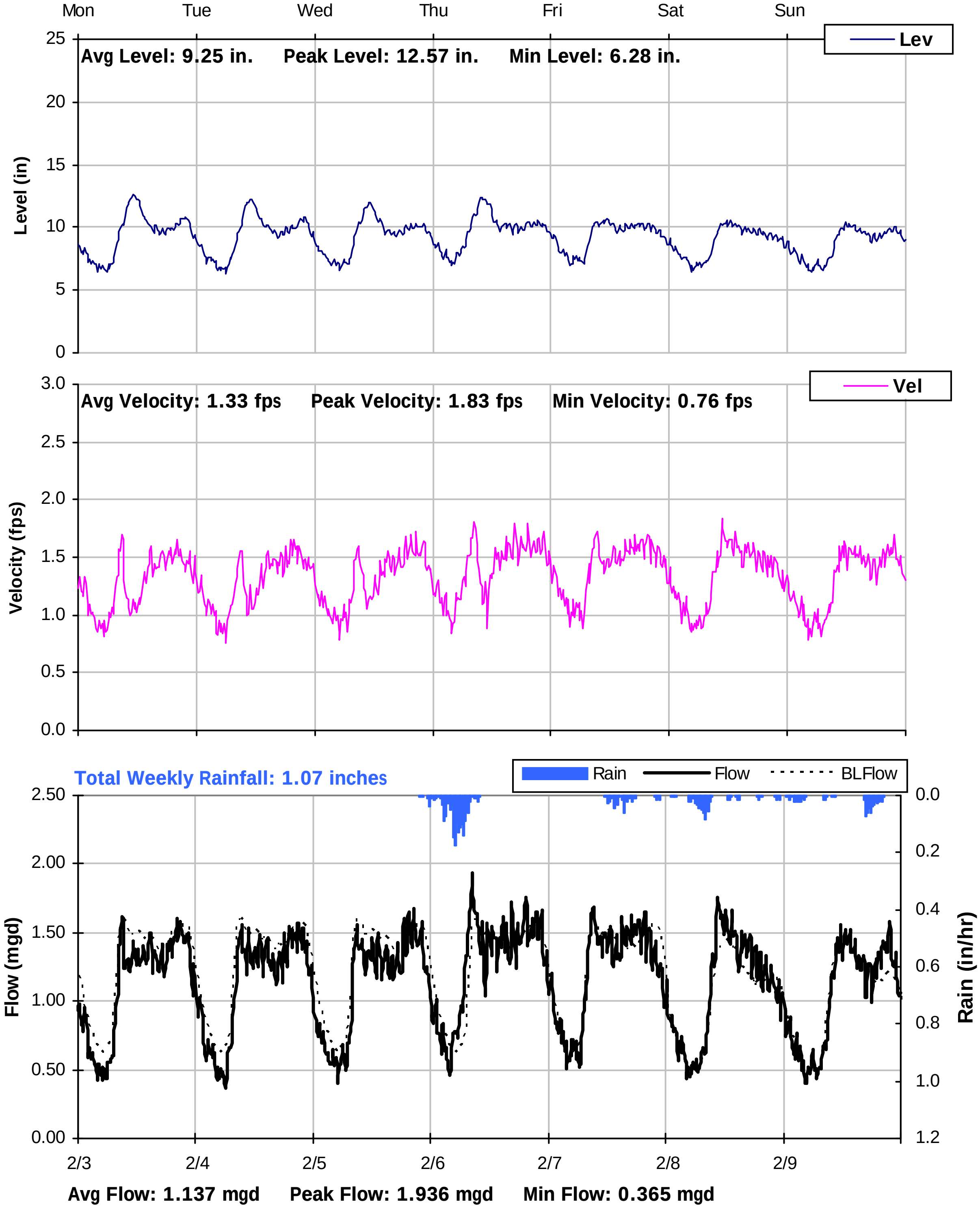
SITE 2

Weekly Level, Velocity and Flow Hydrographs

1/27/2014 to 2/3/2014

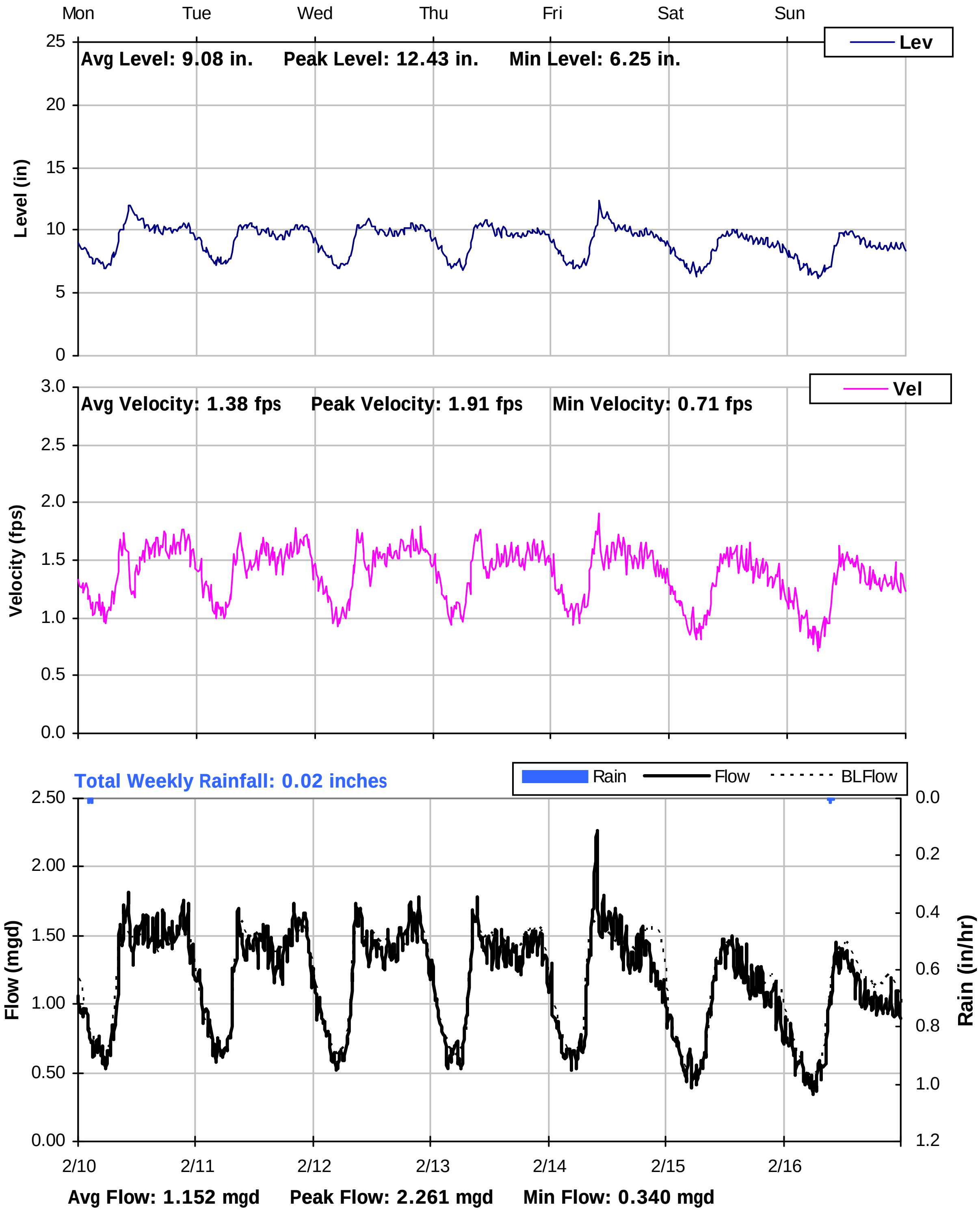


SITE 2
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

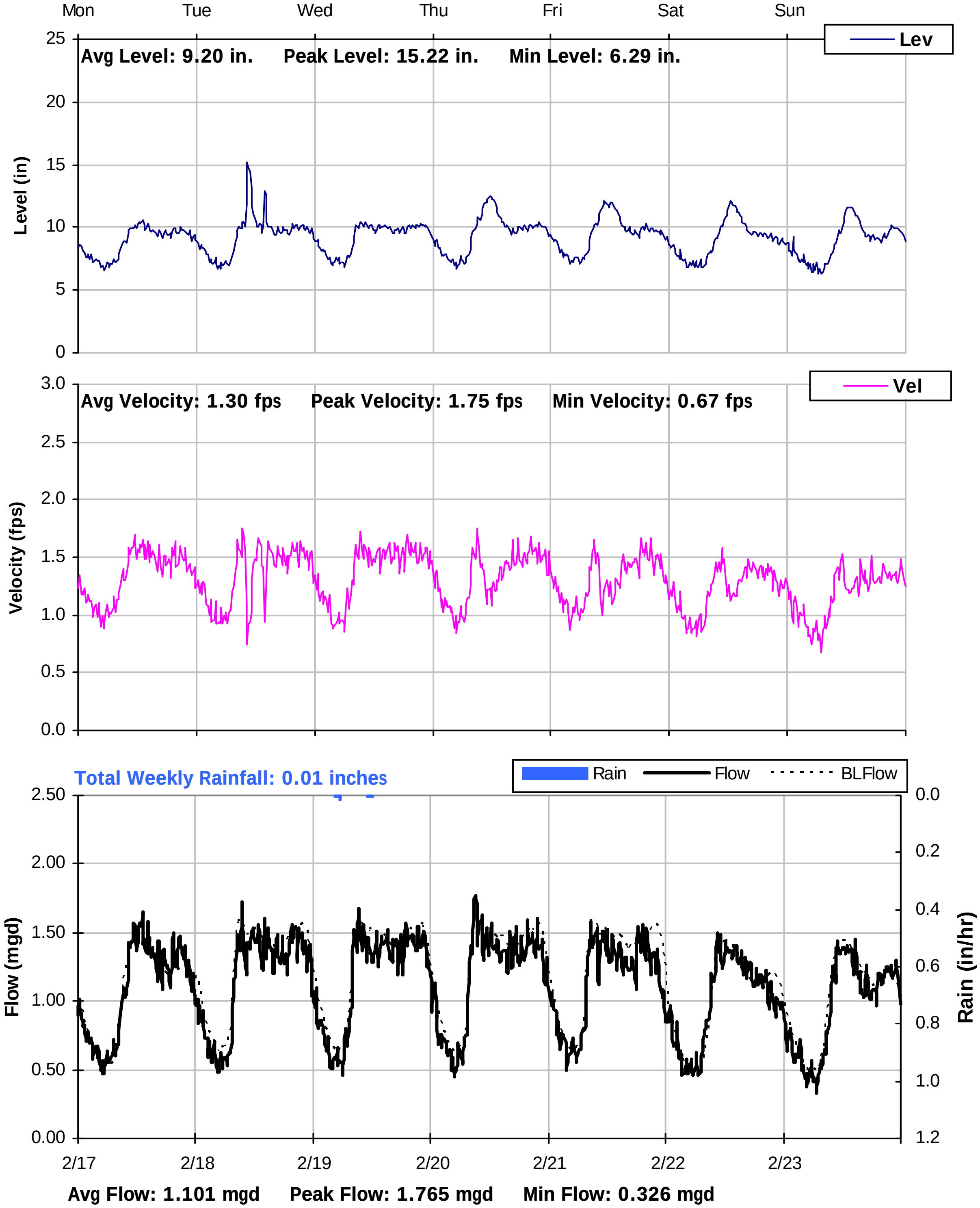


SITE 2

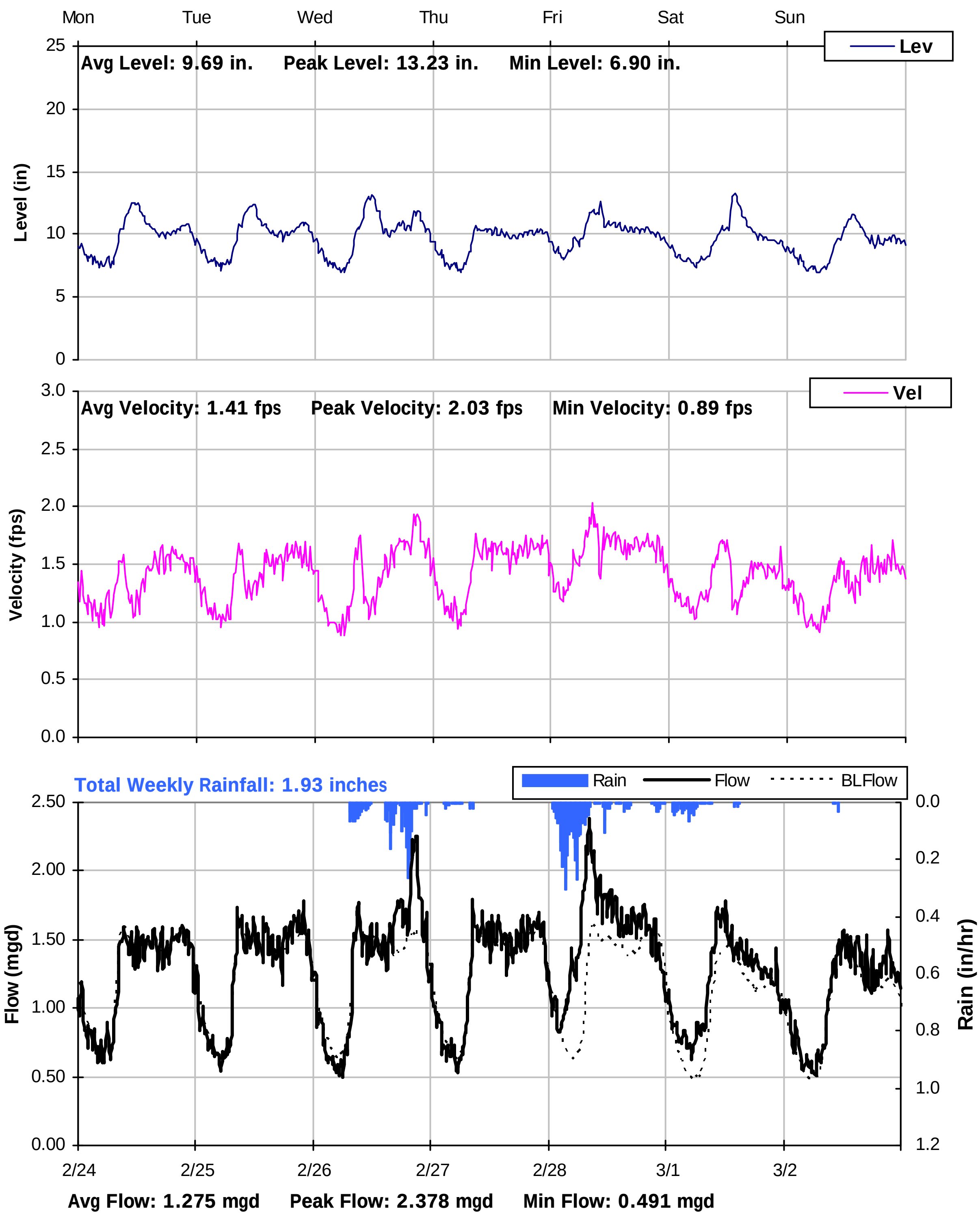
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



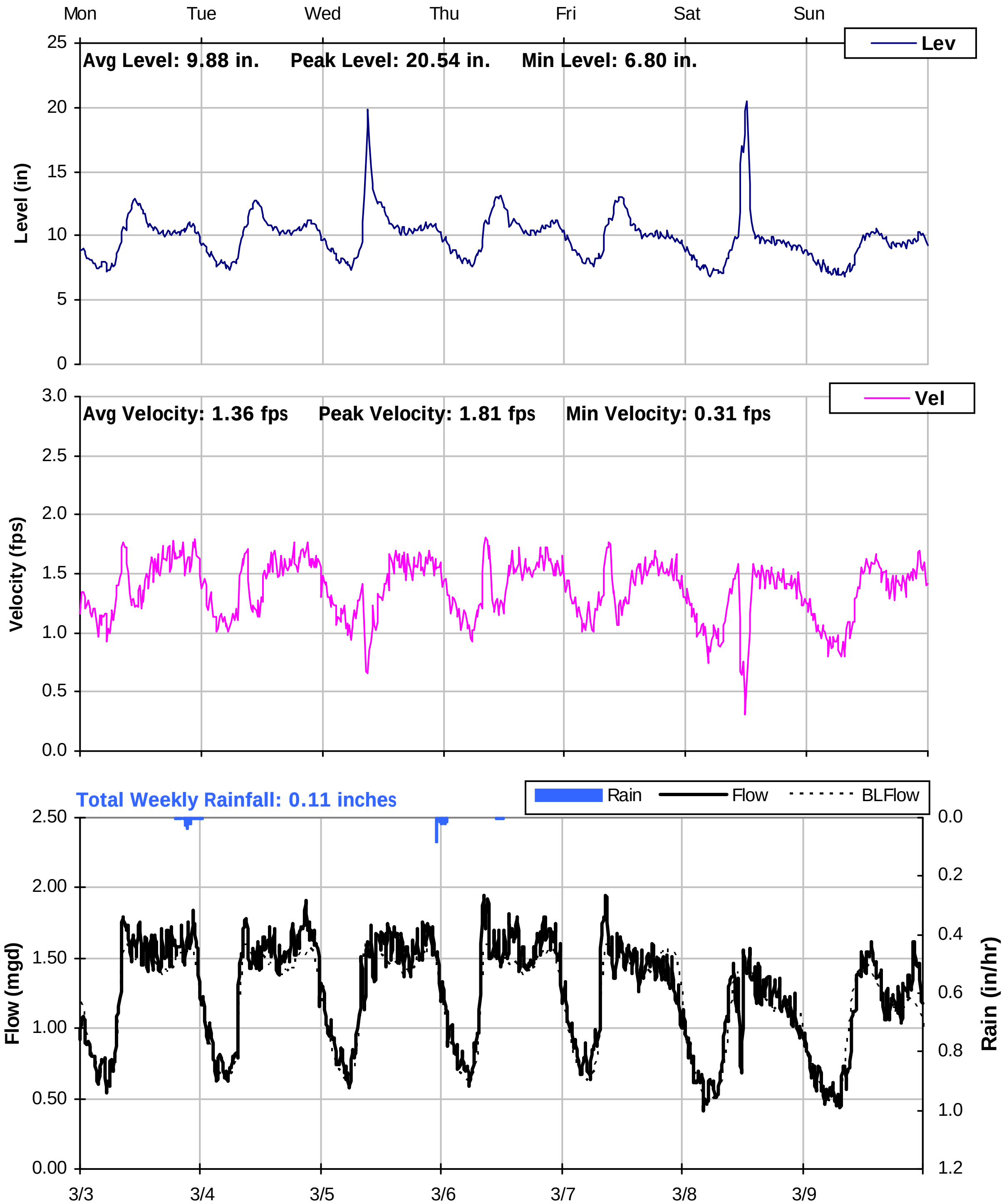
SITE 2
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014



SITE 2
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014

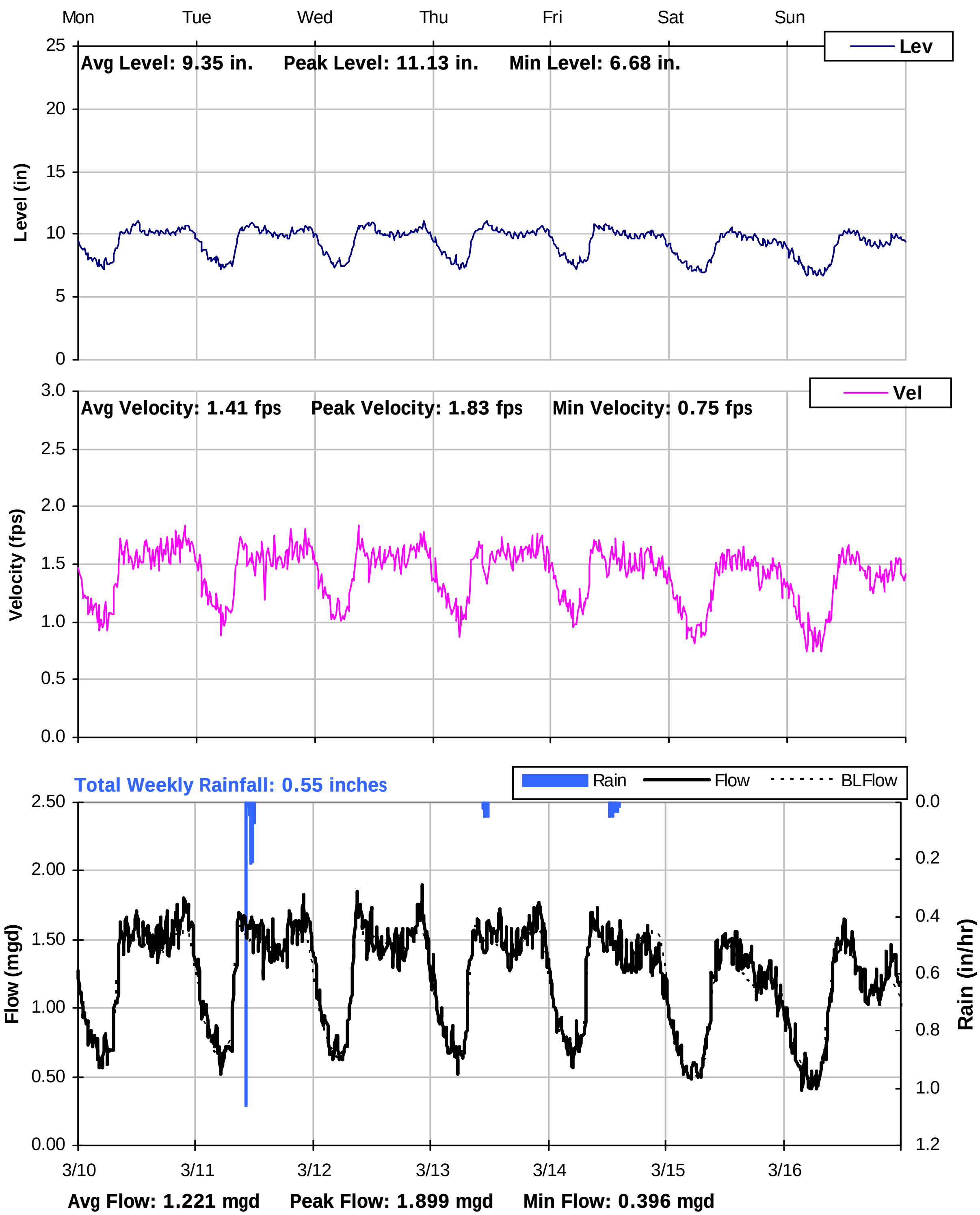


SITE 2
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

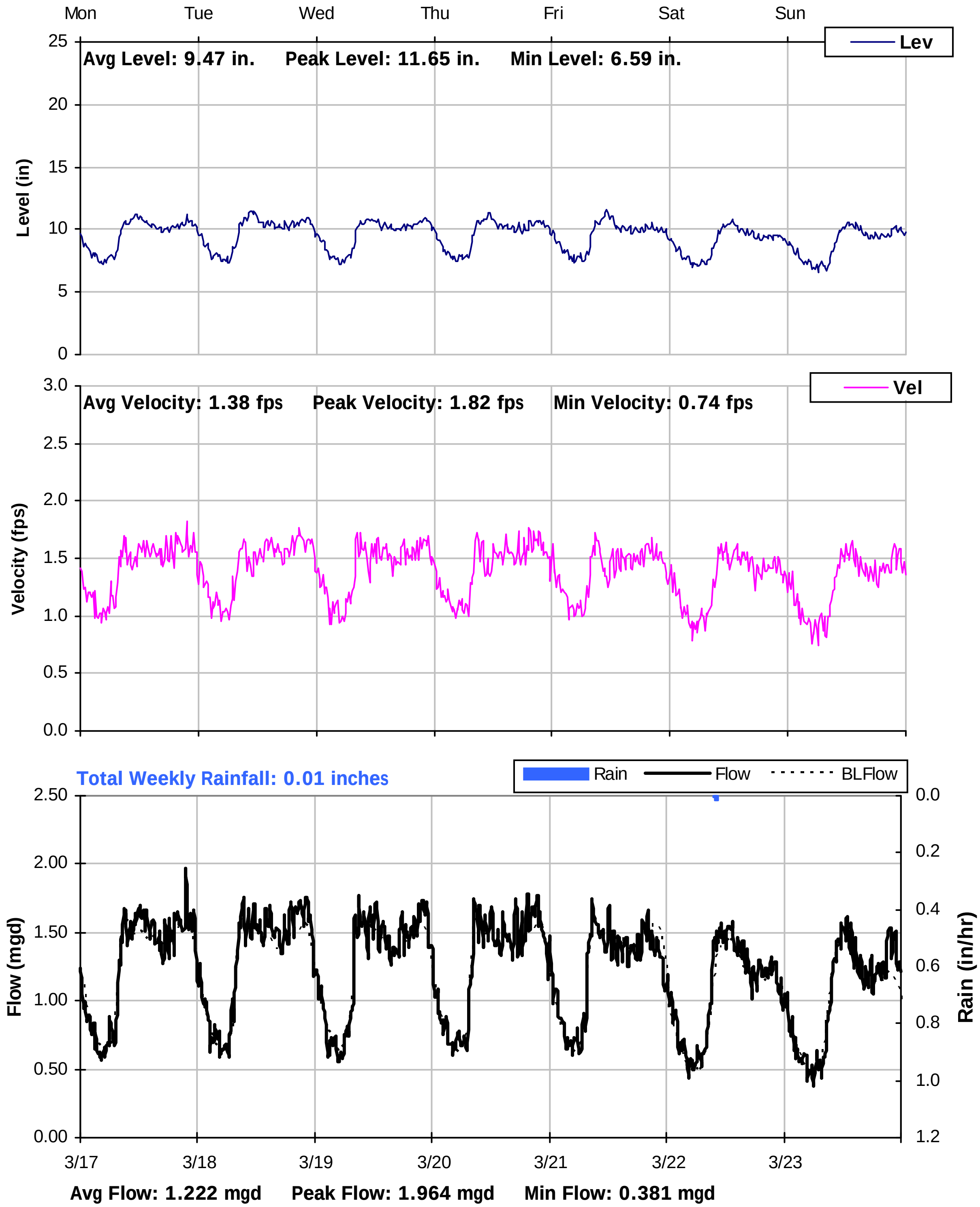


Avg Flow: 1.255 mgd **Peak Flow: 1.951 mgd** **Min Flow: 0.414 mgd**

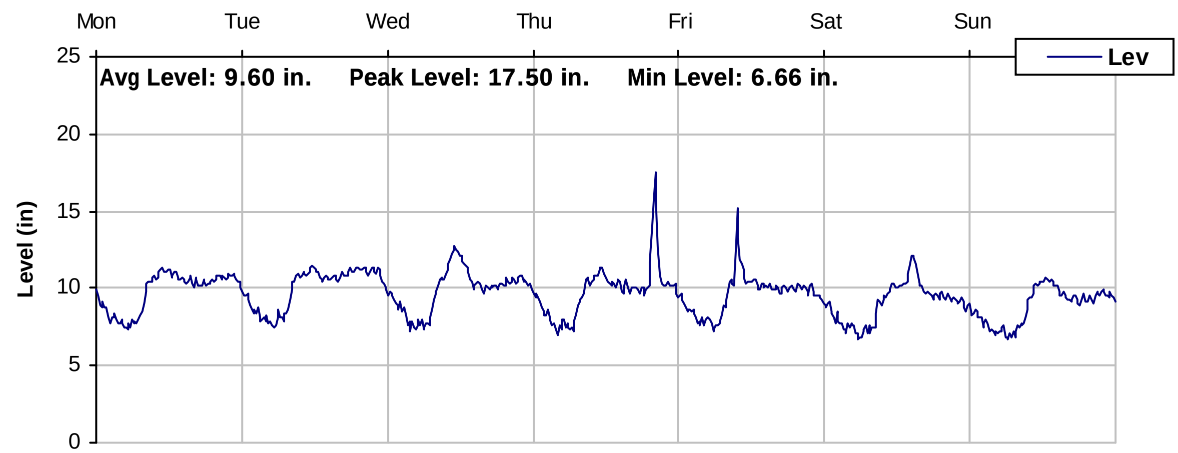
SITE 2
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014

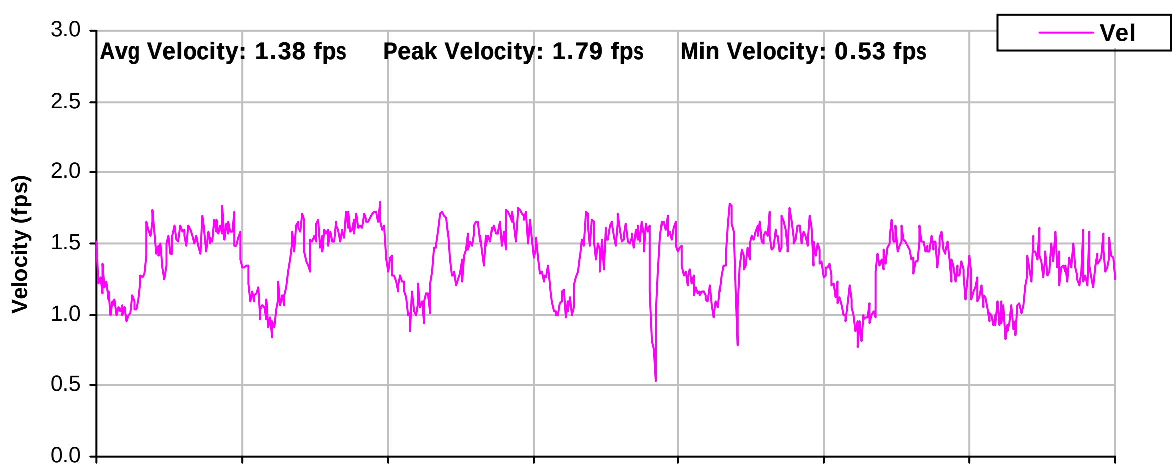


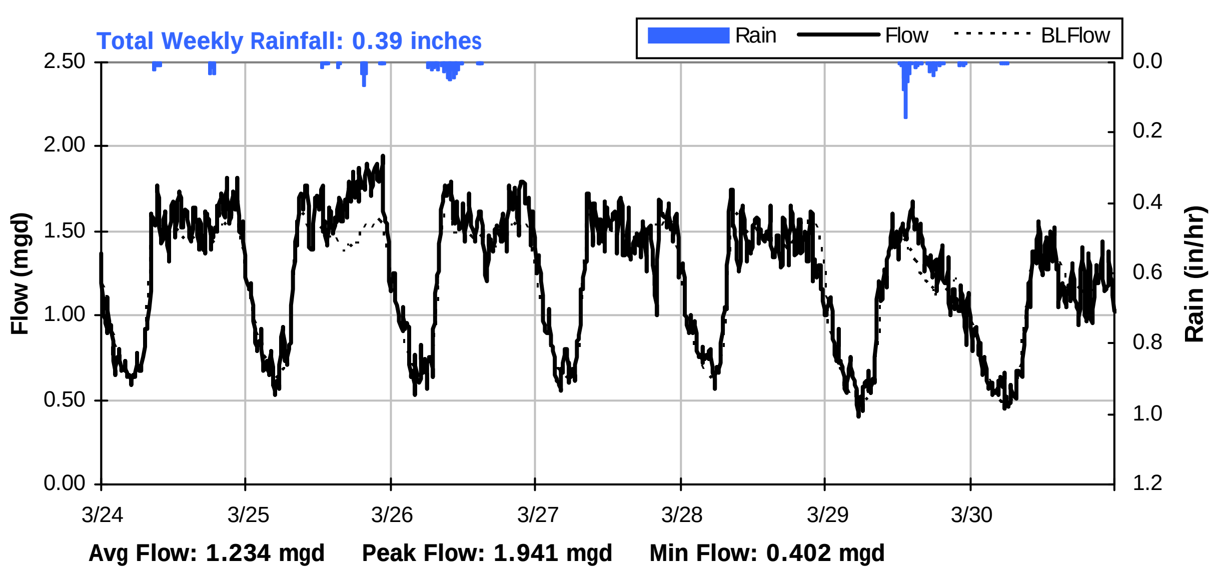
SITE 2
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



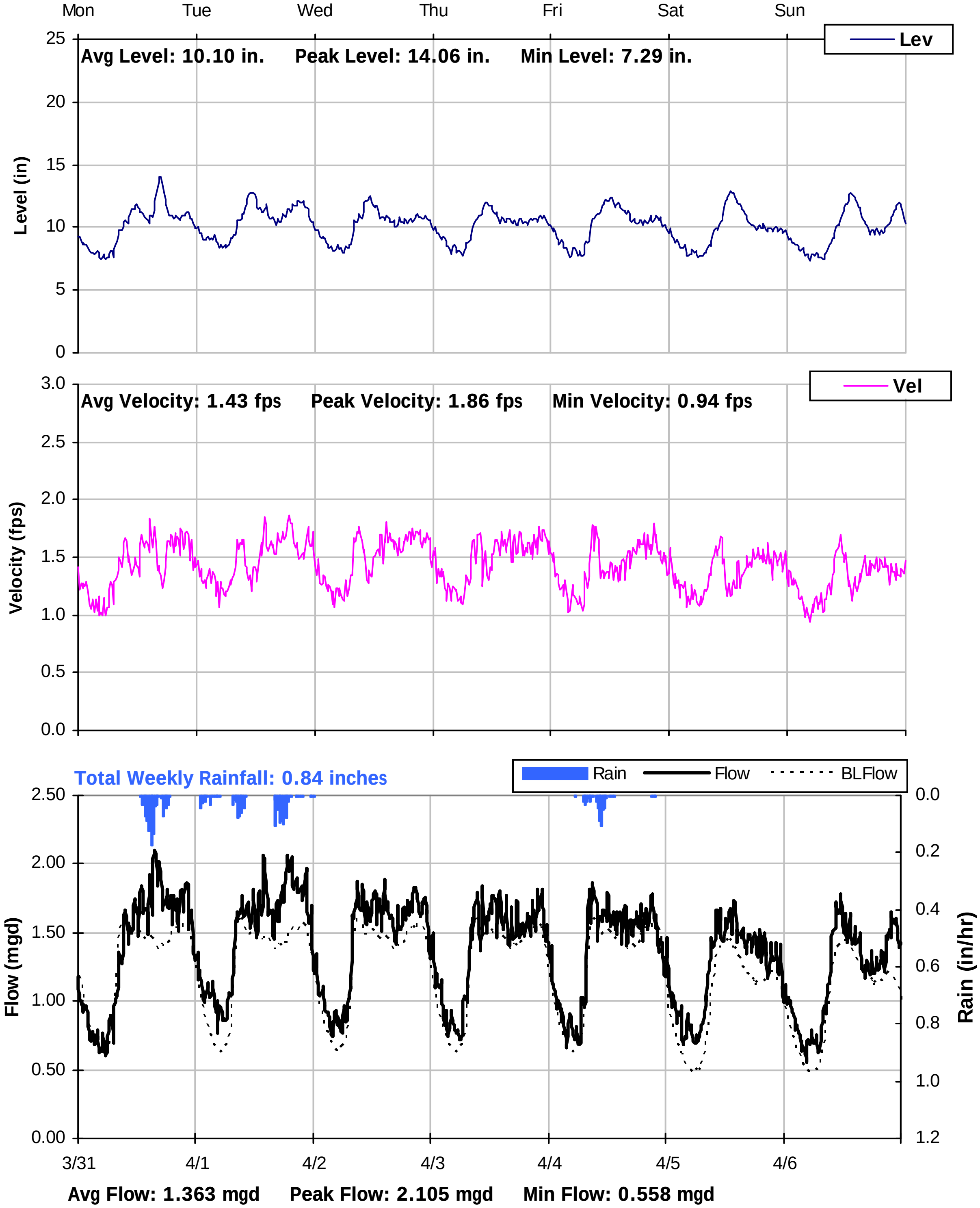
SITE 2
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



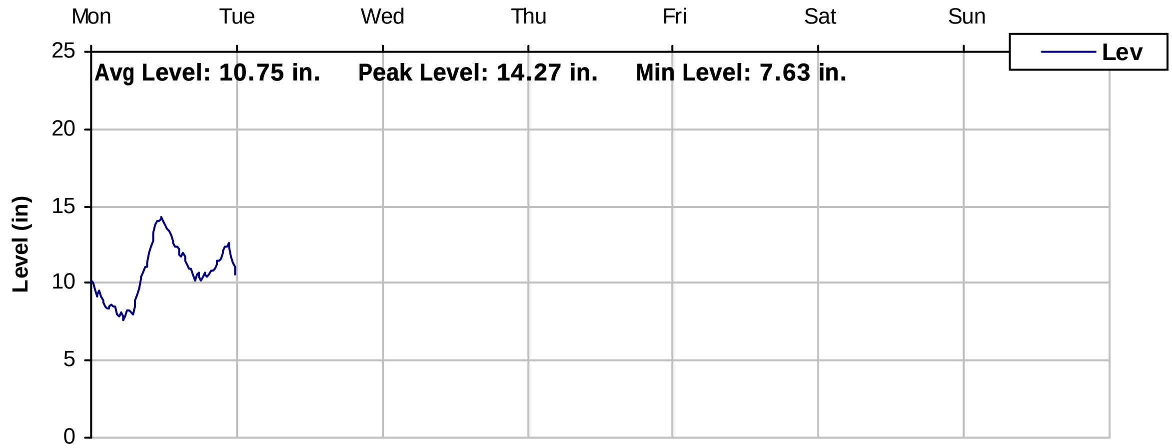


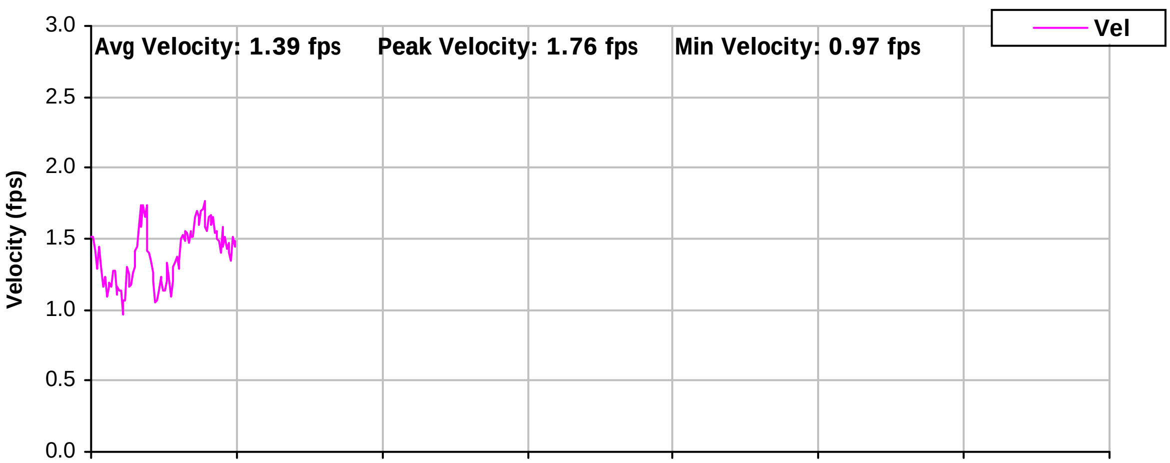


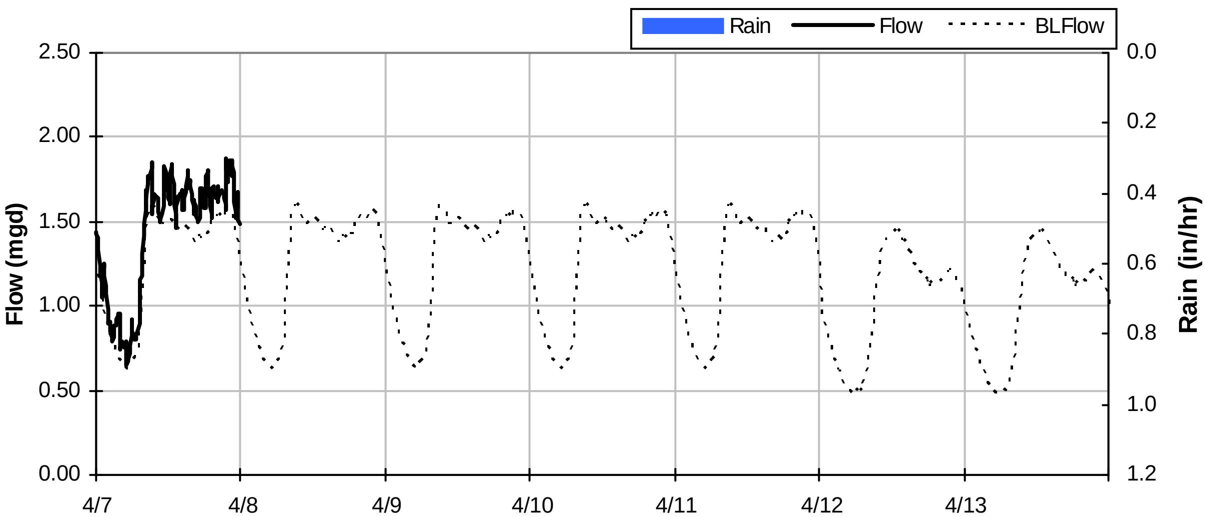
SITE 2
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 2
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014







Avg Flow: 1.425 mgd Peak Flow: 1.871 mgd Min Flow: 0.647 mgd

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 3

Location: Intersection of Hill Avenue and Hamilton Avenue

Data Summary Report

SITE 3

Site Information

Location: Intersection of Hill Avenue and Hamilton Avenue

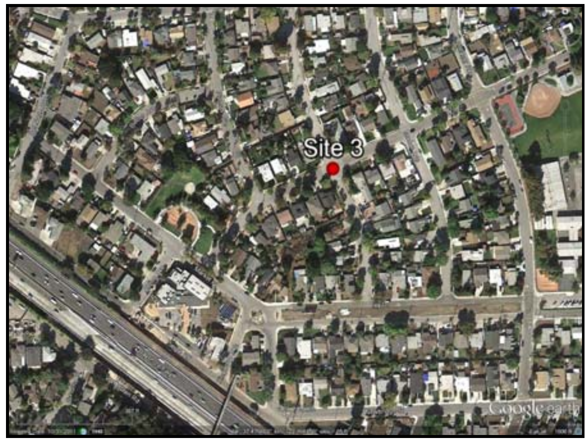
Coordinates: 122.1642° W, 37.4770° N

Rim Elevation: 13 feet

Pipe Diameter: 15 inches

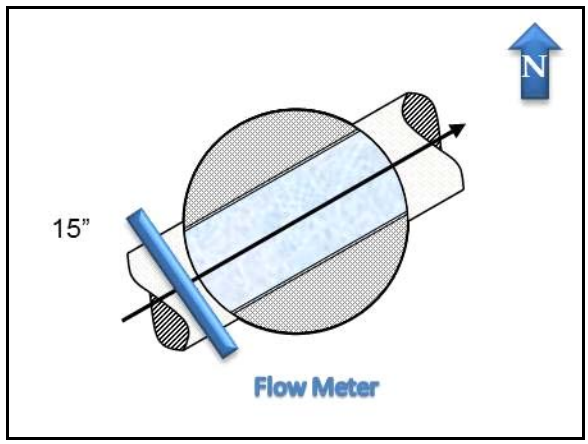
Baseline Flow: 0.089 mgd

Peak Measured Flow: 0.230 mgd



Satellite Map

Sanitary Sewer Map



Flow Sketch

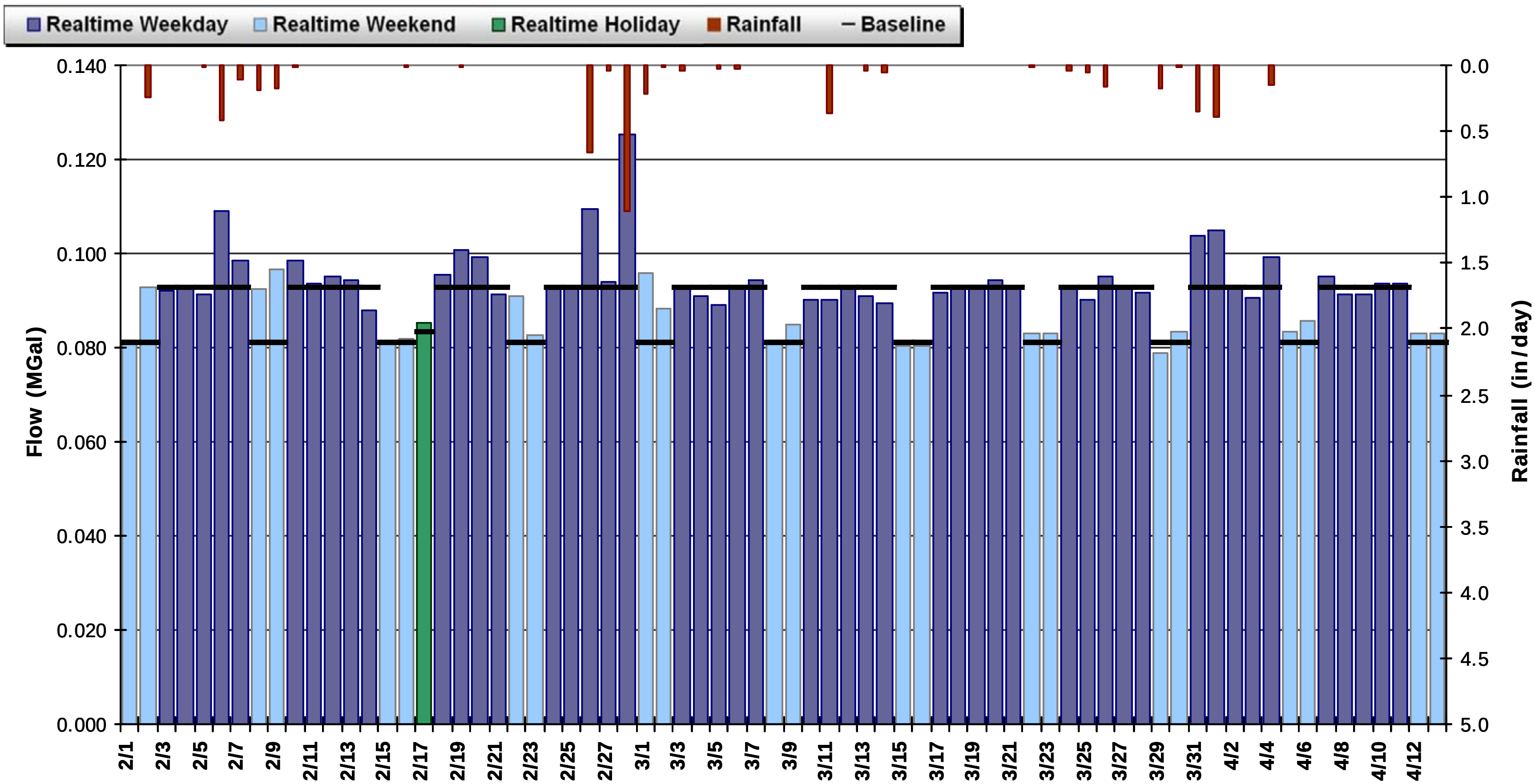
View from Street

Plan View

SITE 3
Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.092 MGal **Peak Daily Flow: 0.125 MGal** **Min Daily Flow: 0.079 MGal**

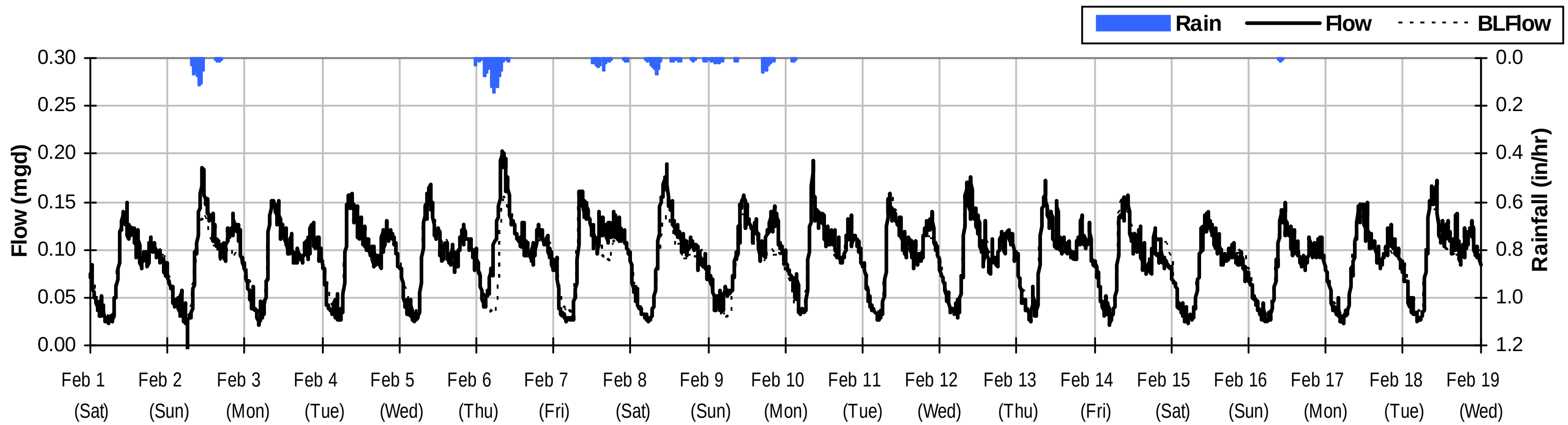
Total Period Rainfall: 5.11 inches

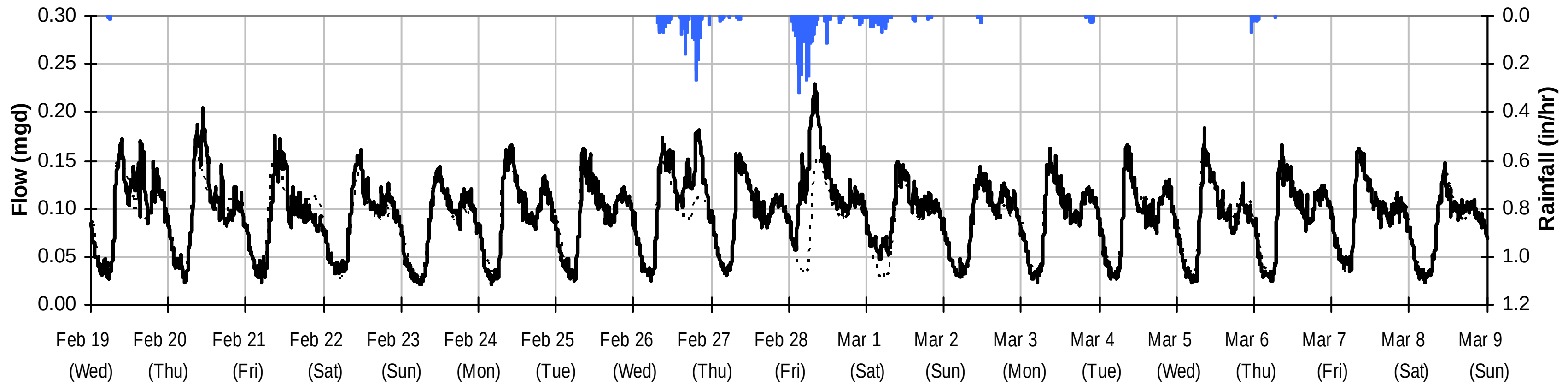


SITE 3

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 5.11 inches **Avg Flow: 0.092 mgd** **Peak Flow: 0.230 mgd** **Min Flow: -0.057 mgd**

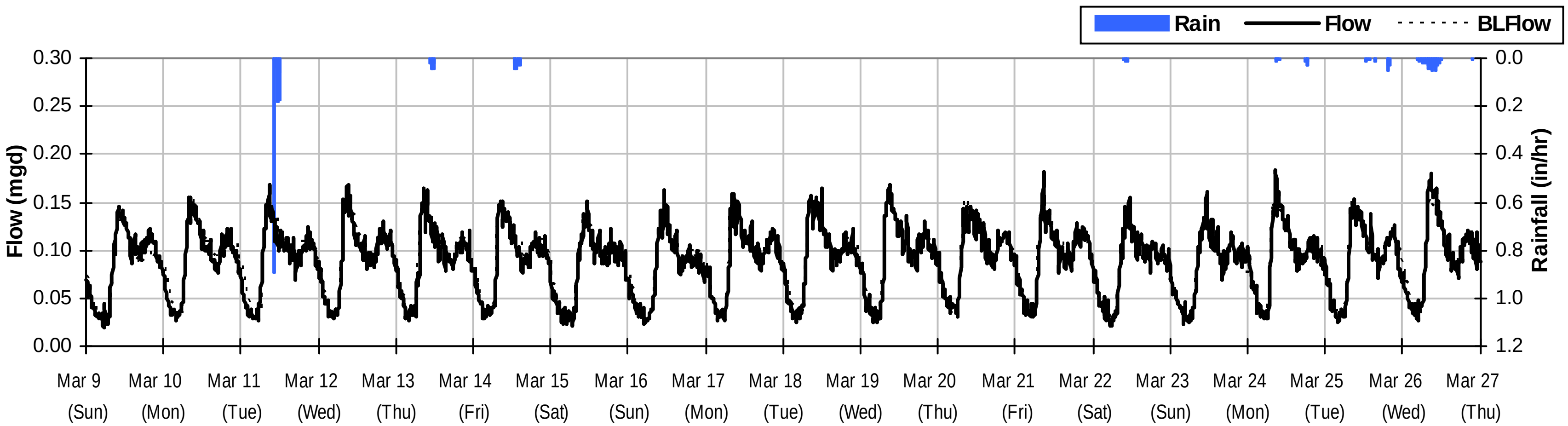


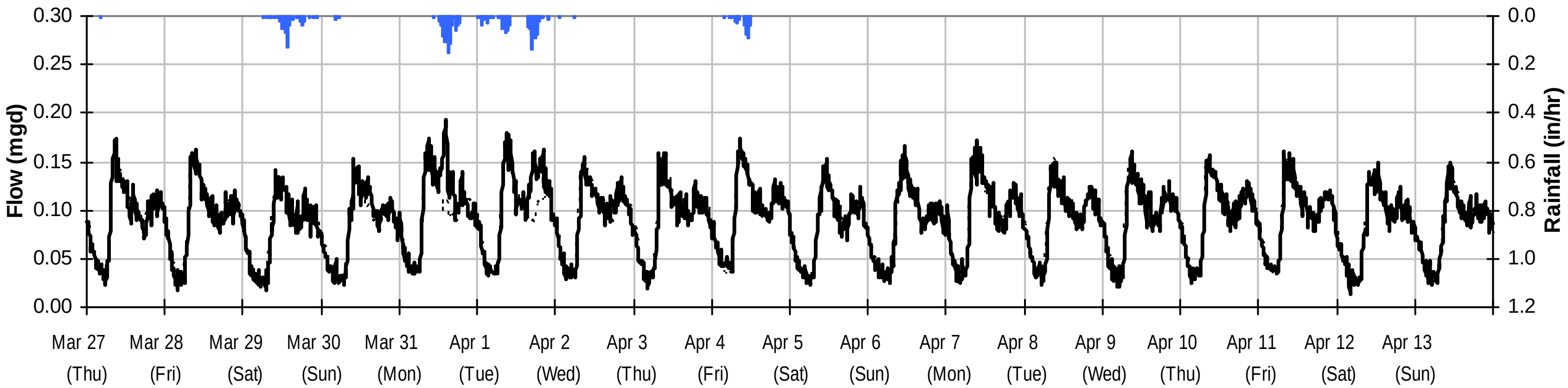


SITE 3

Period Flow Summary: March 9 to April 14, 2014

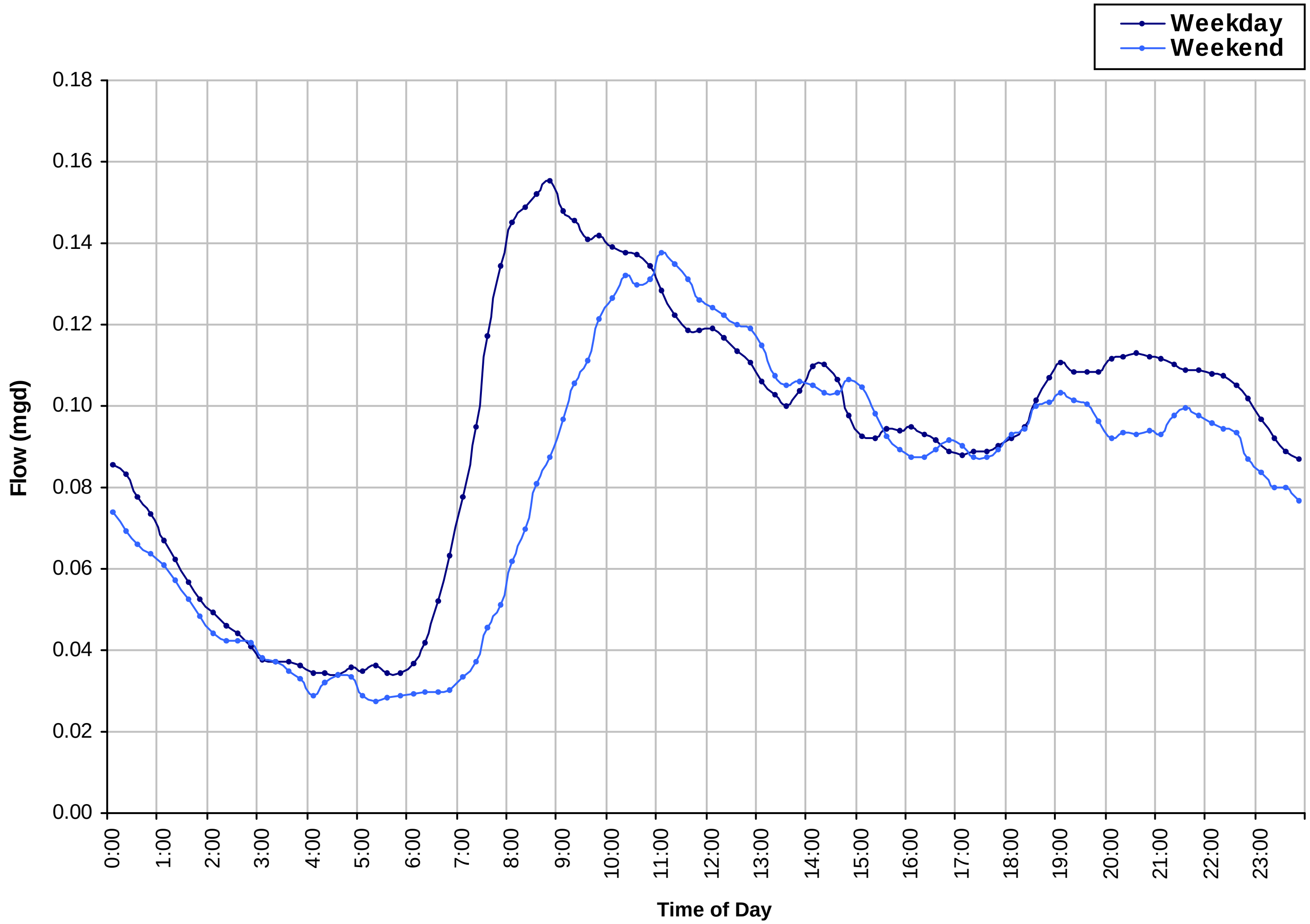
Total Monthly Rainfall: 5.11 inches **Avg Flow: 0.092 mgd** **Peak Flow: 0.230 mgd** **Min Flow: -0.057 mgd**

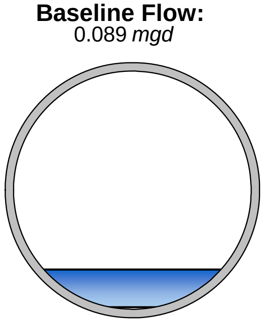




SITE 3

Baseline Flow Hydrographs

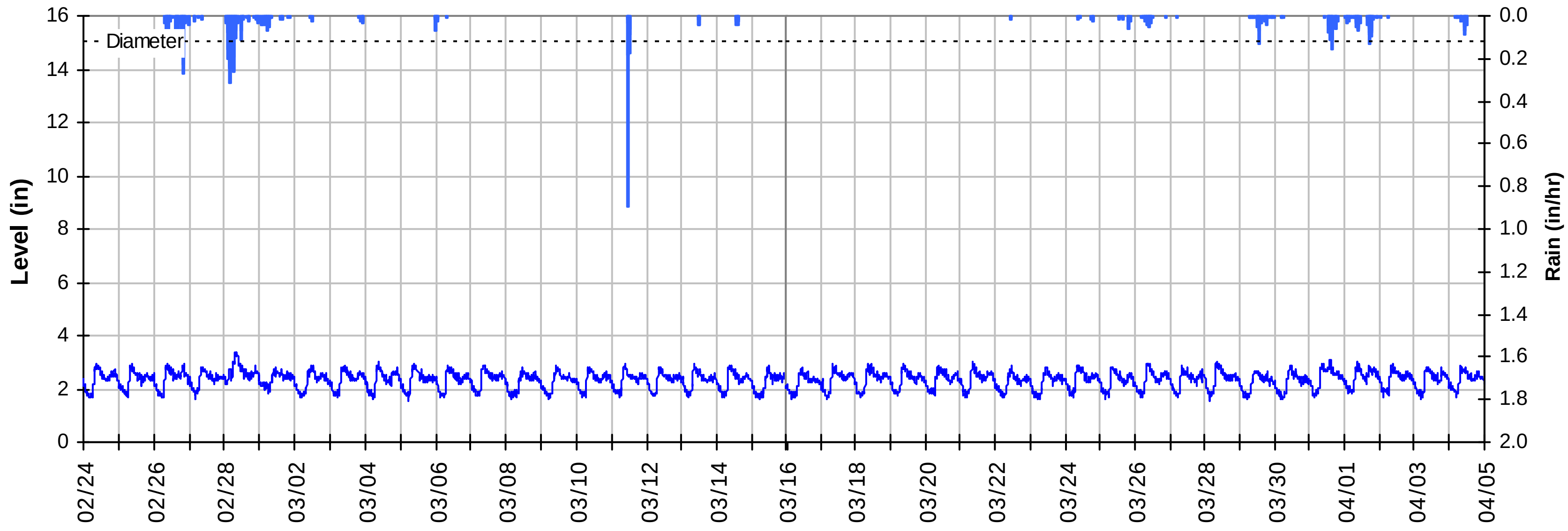


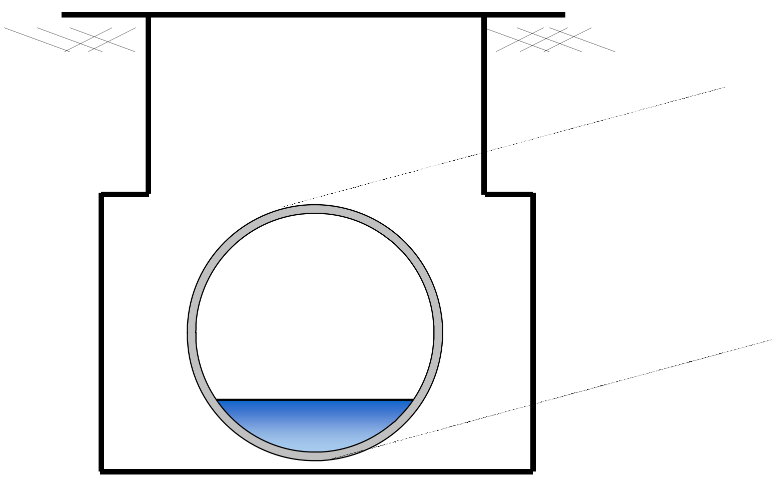


SITE 3

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

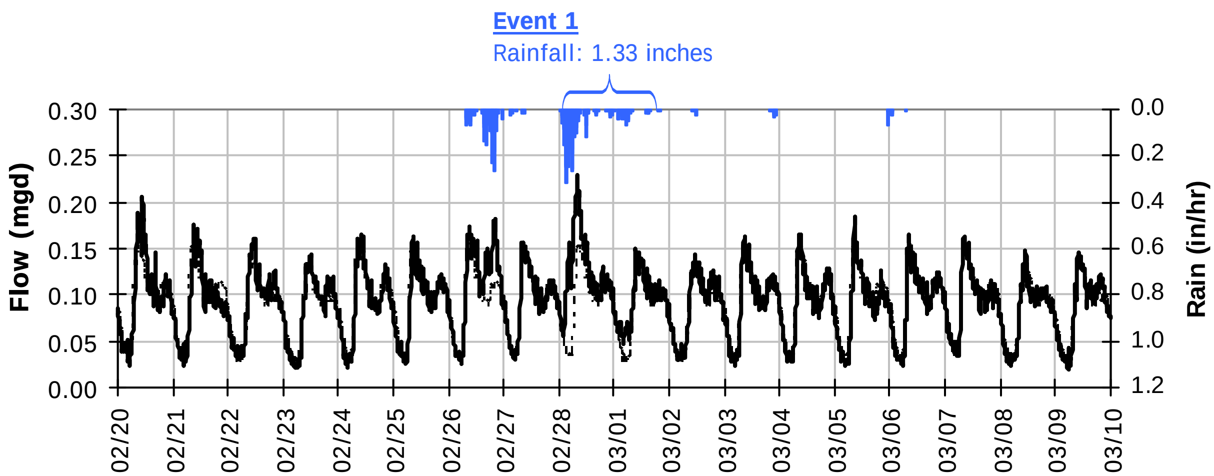




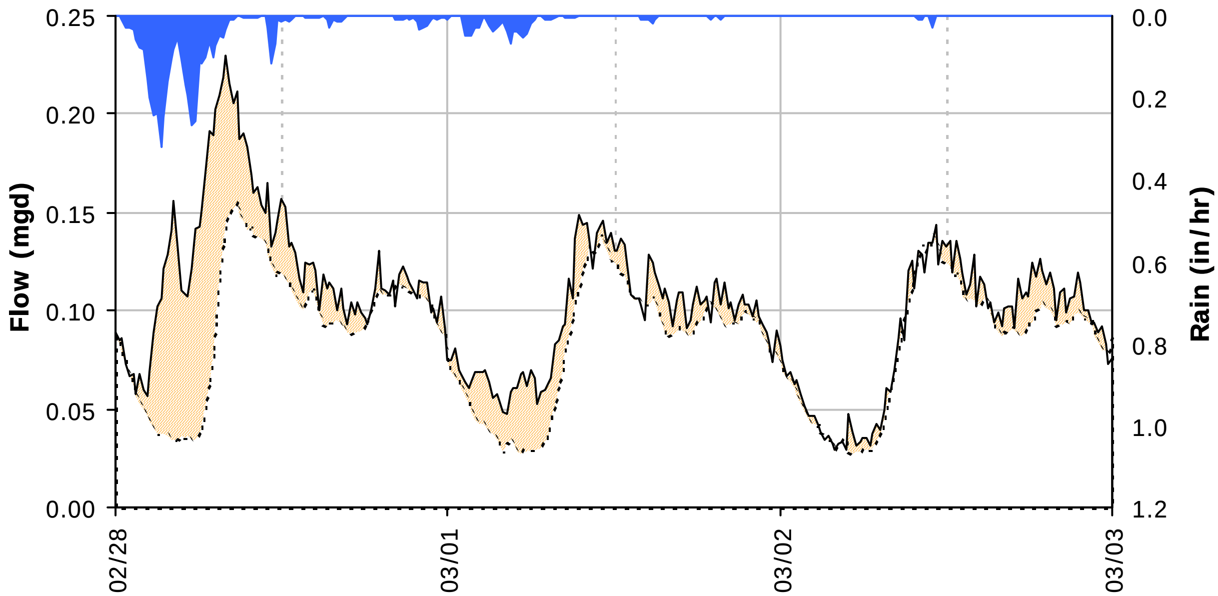
Pipe Diameter:	15	*inches*
Peak Measured Level:	3.37	*inches*
Peak d/D Ratio:	0.22	

SITE 3
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

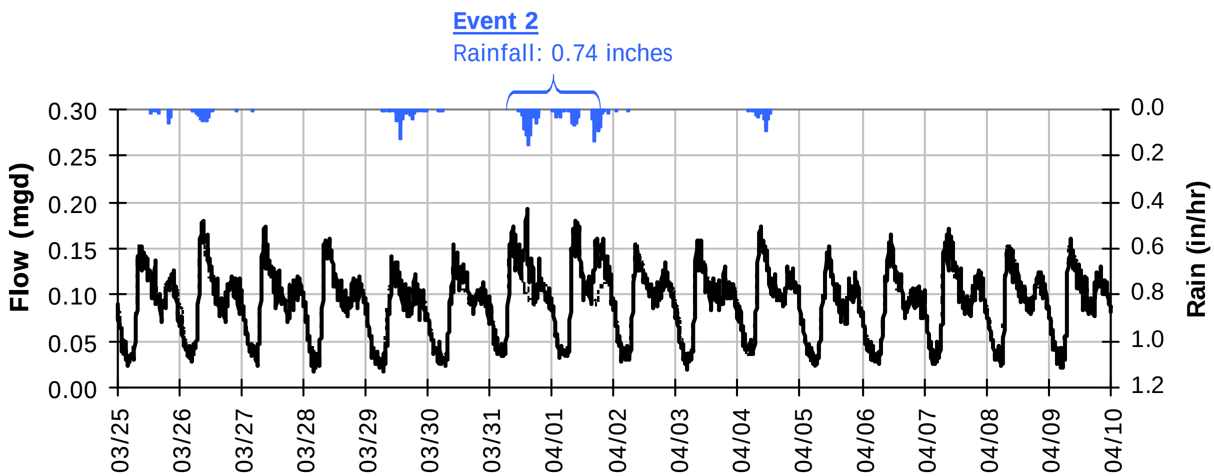


Storm Event I/I Analysis (Rain = 1.33 inches)

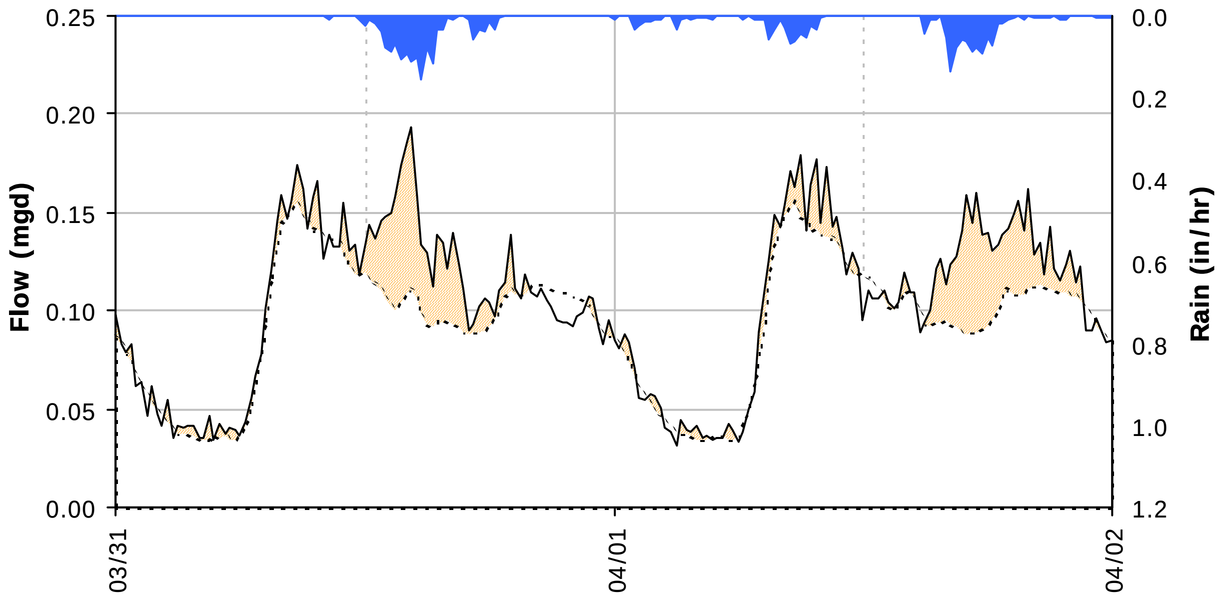
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.23 *mgd*	**Peak I/I Rate:**	0.11 *mgd*
PF:	2.57	**Total I/I:**	54,000 *gallons*

SITE 3
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



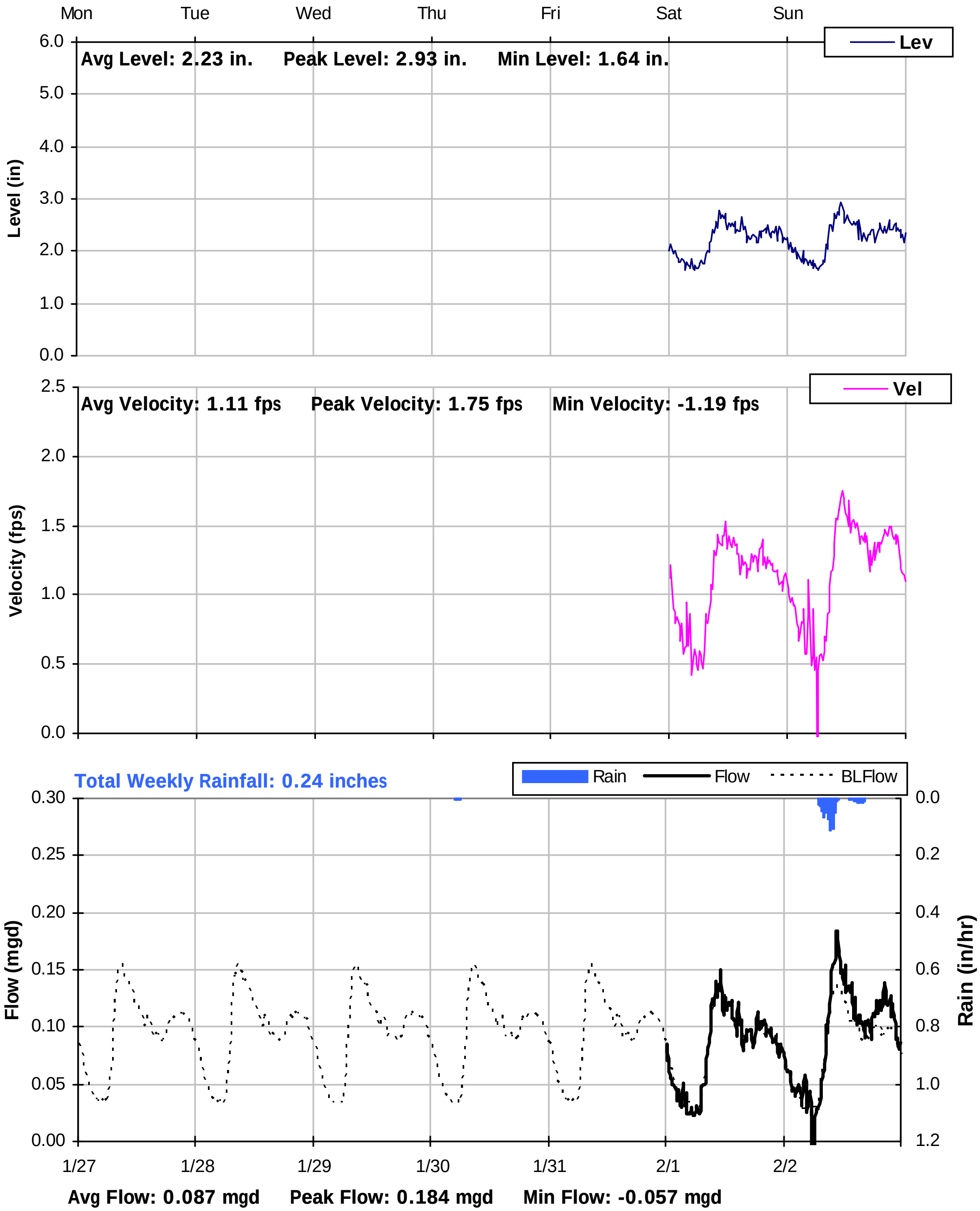
Event 2 Detail Graph



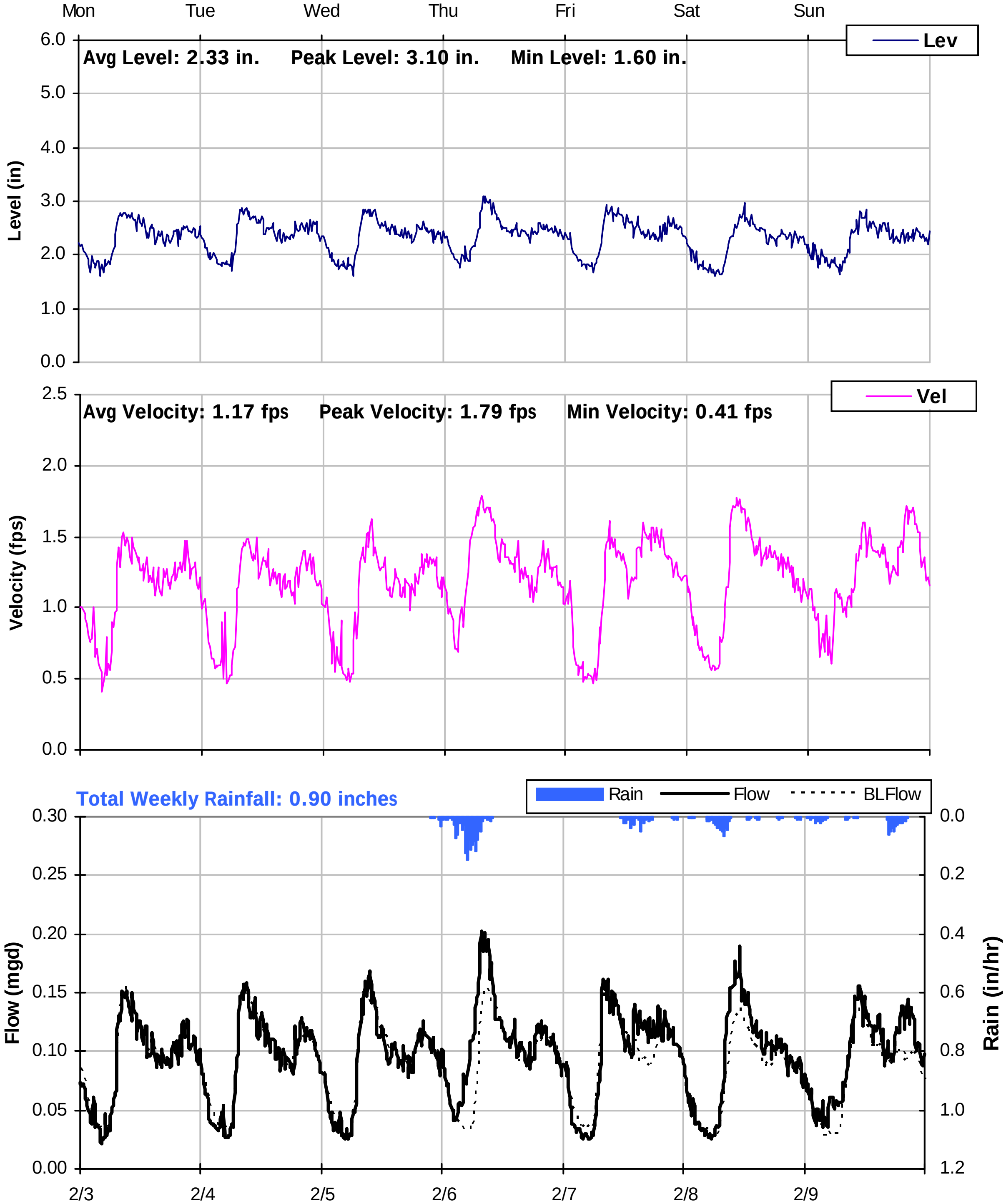
Storm Event I/I Analysis (Rain = 0.74 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	0.19 *mgd*	**Peak I/I Rate:**	0.08 *mgd*
PF:	2.16	**Total I/I:**	21,000 *gallons*

SITE 3
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

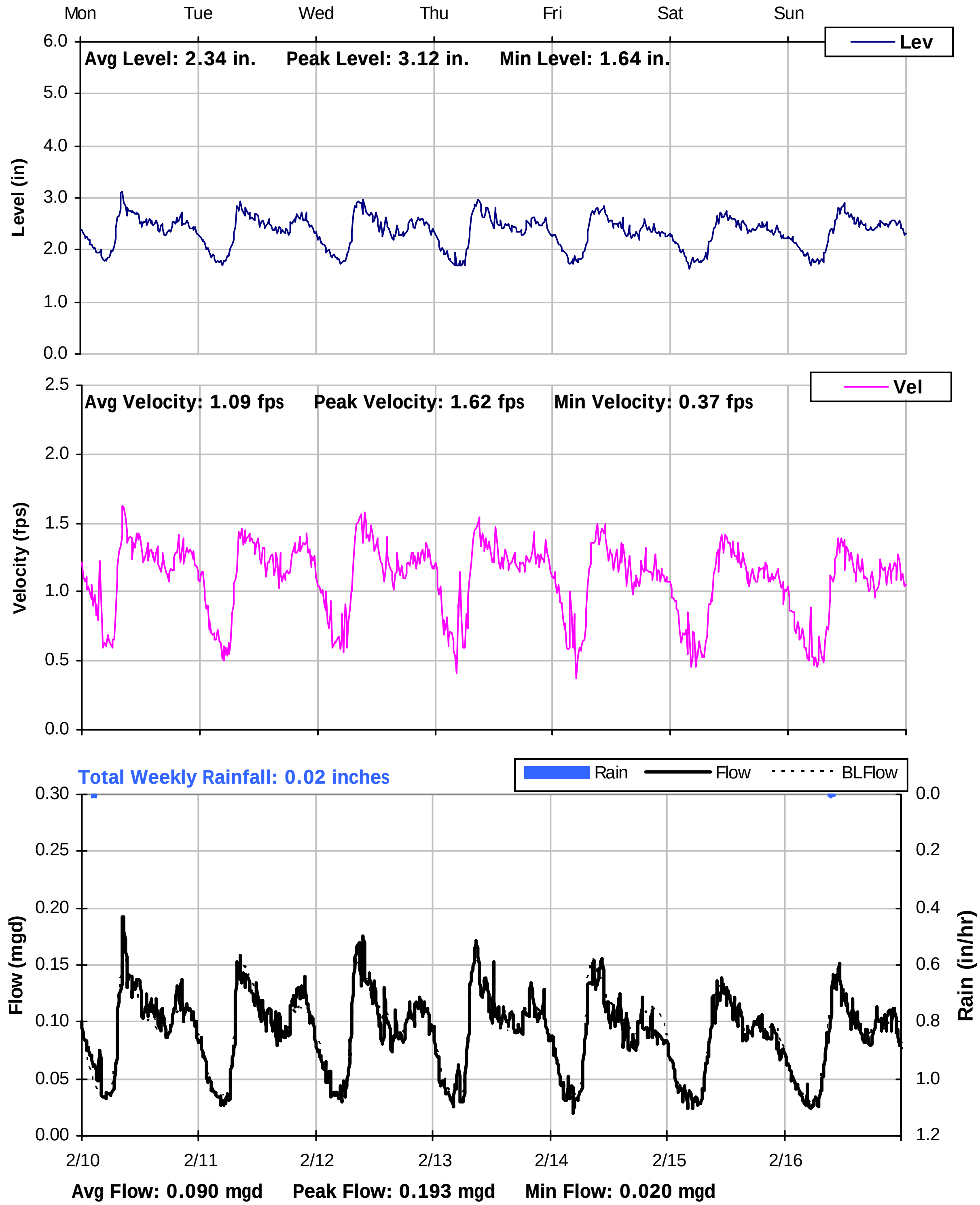


SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

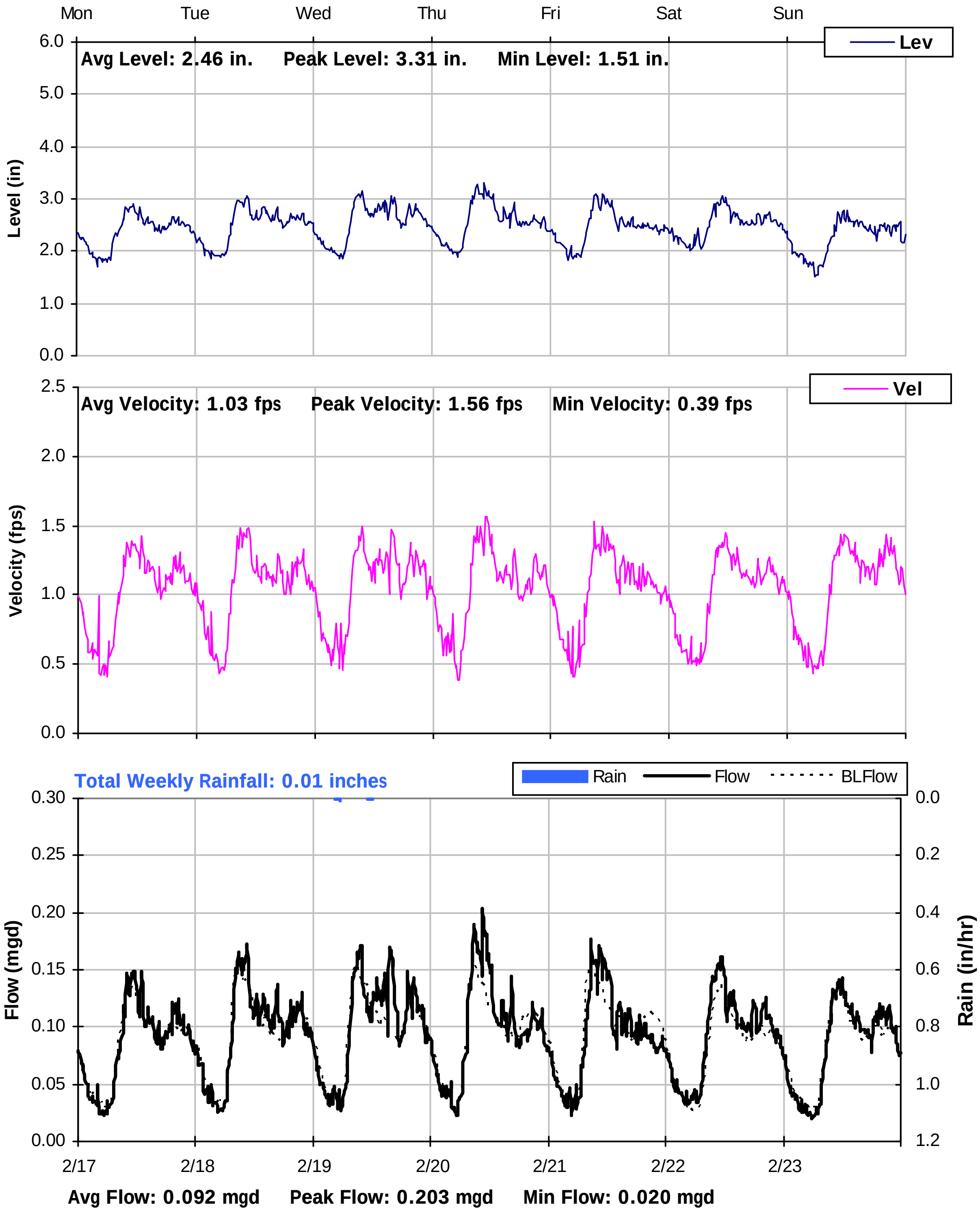


Avg Flow: 0.096 mgd **Peak Flow: 0.202 mgd** **Min Flow: 0.021 mgd**

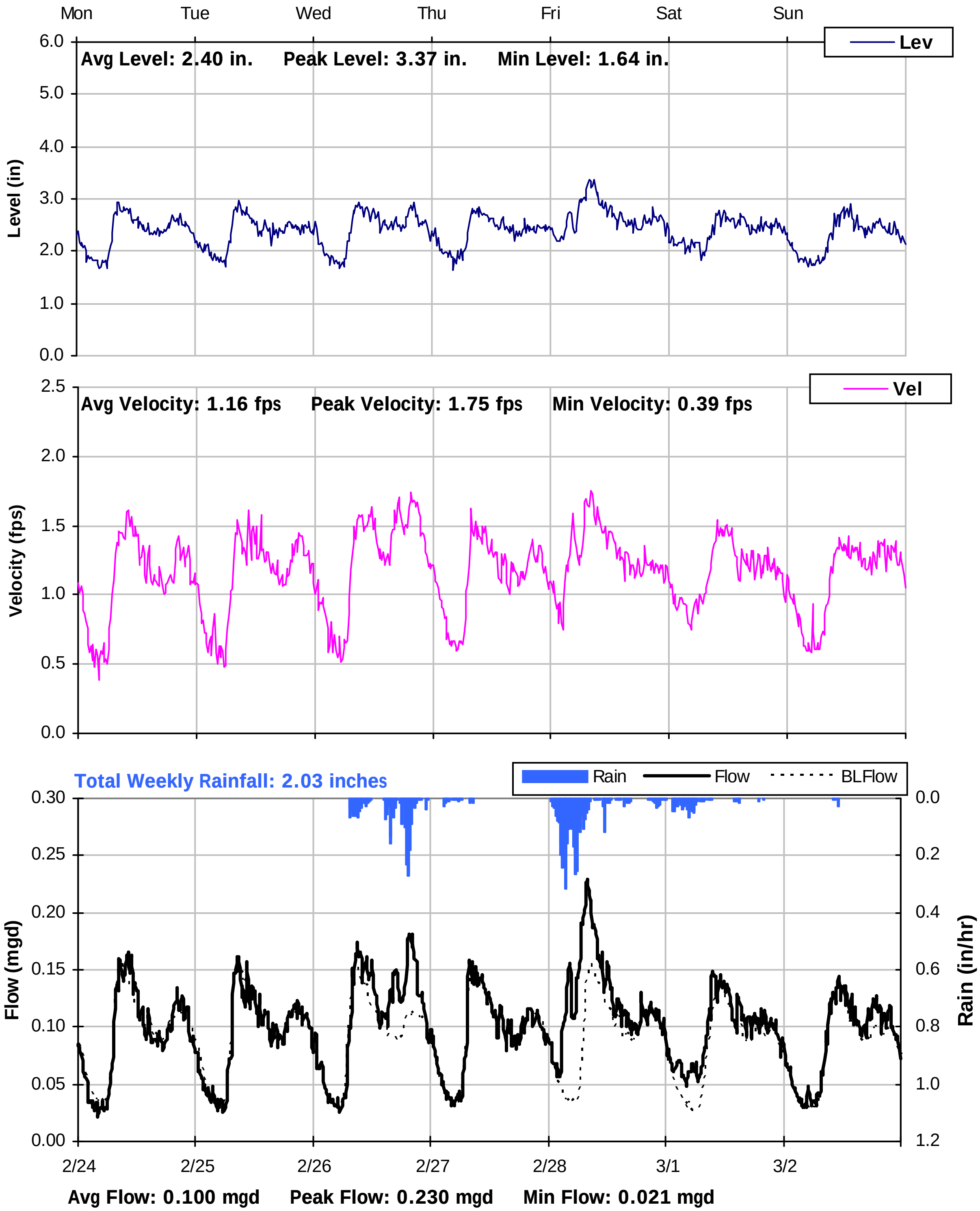
SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



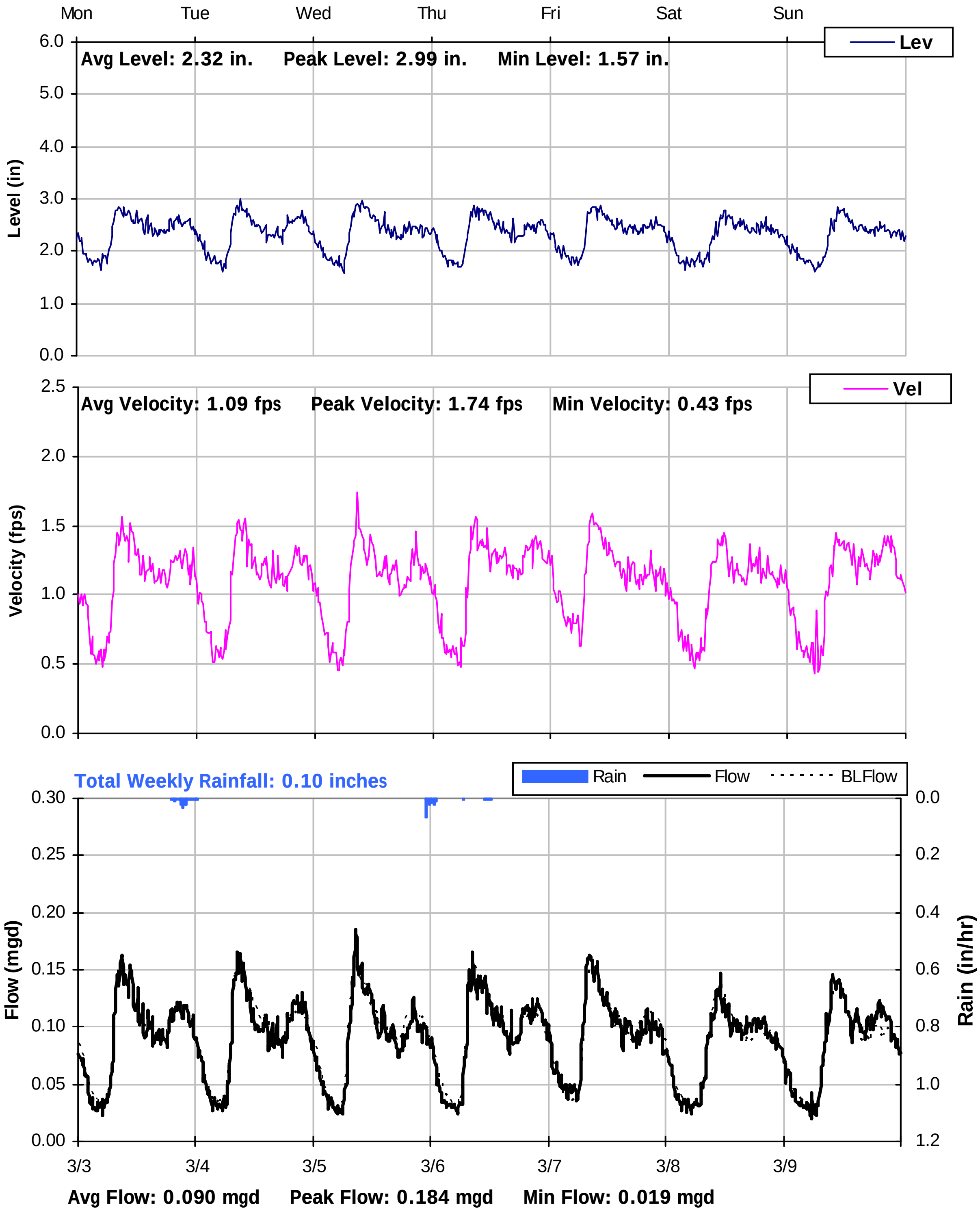
SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014



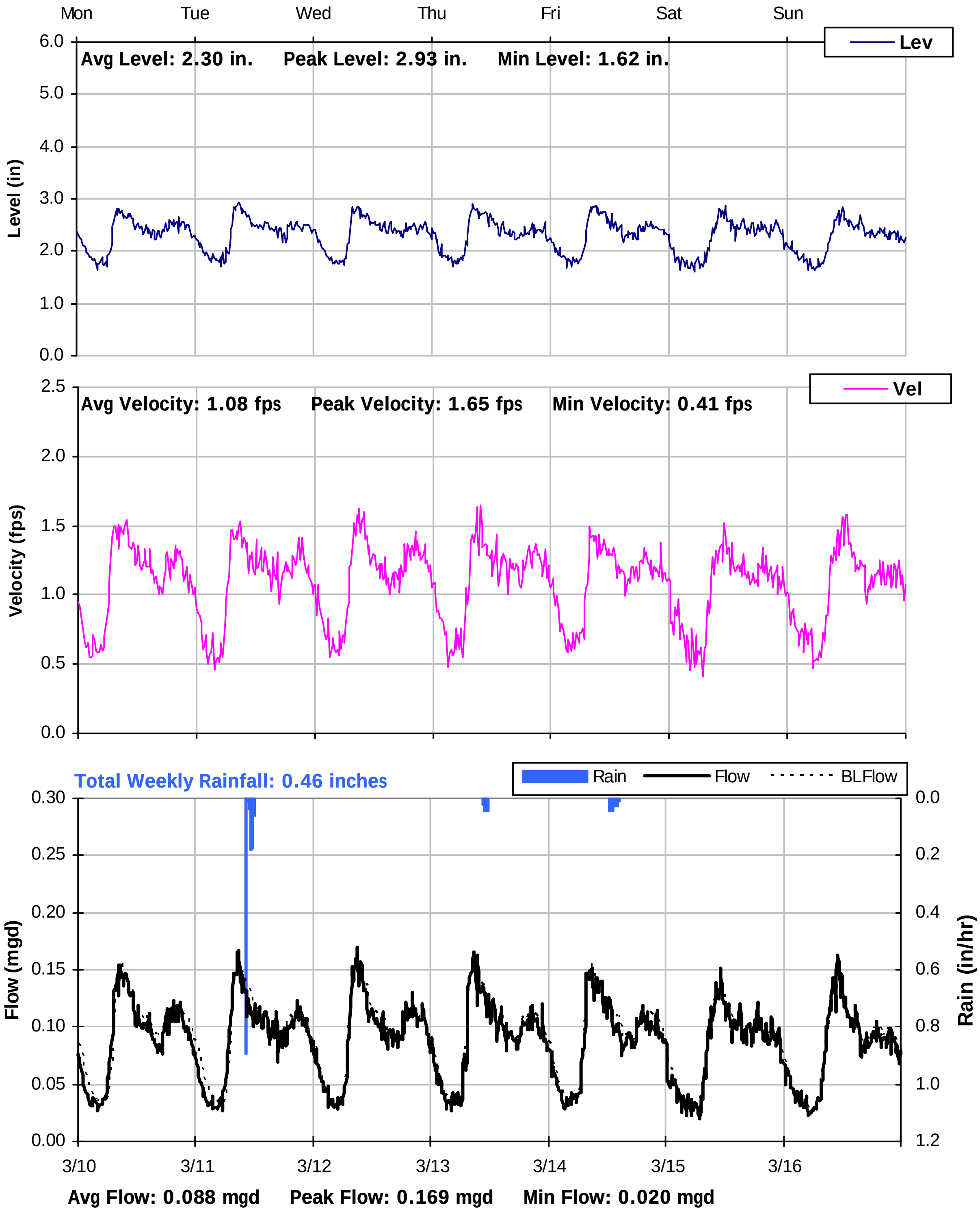
SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



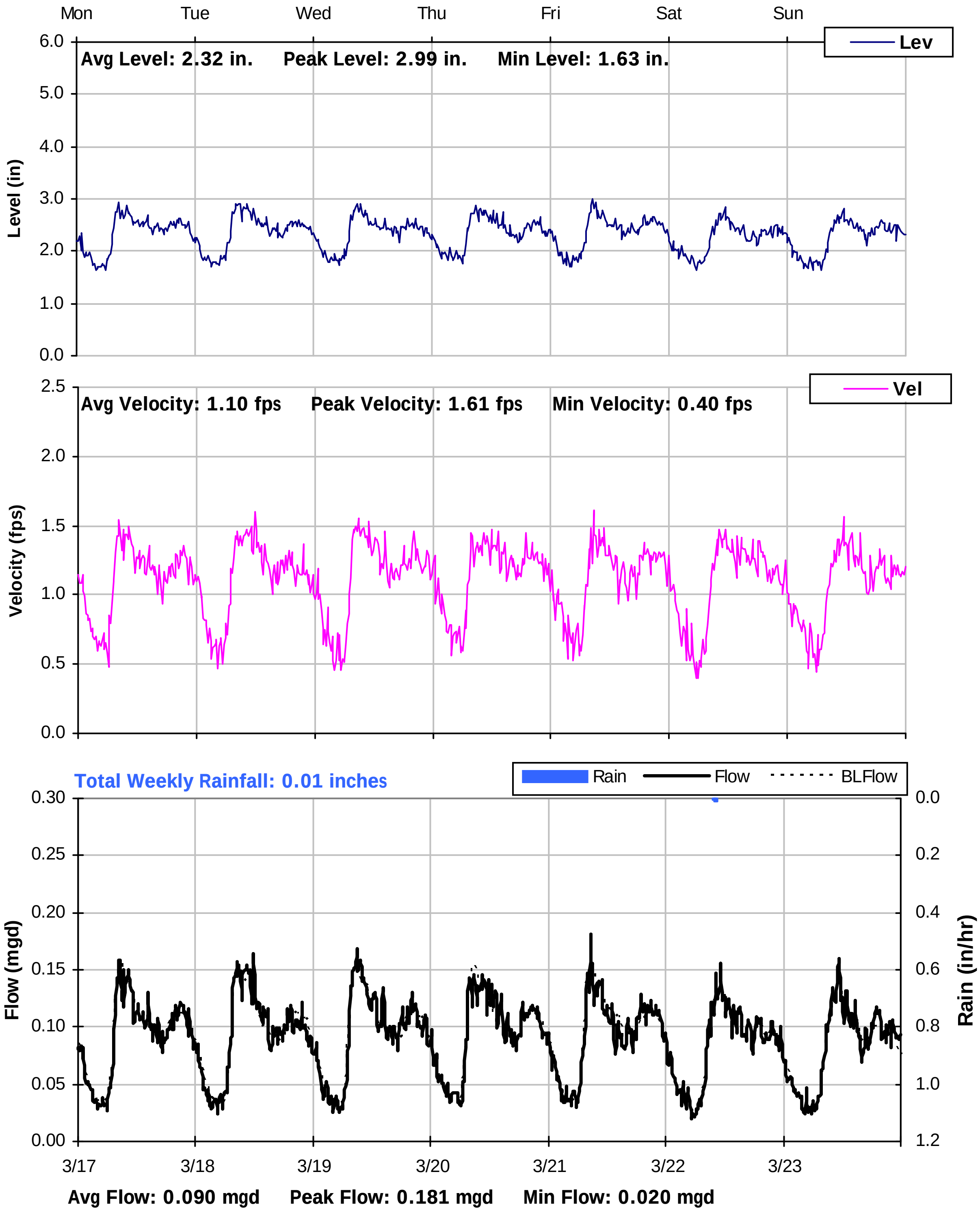
SITE 3
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



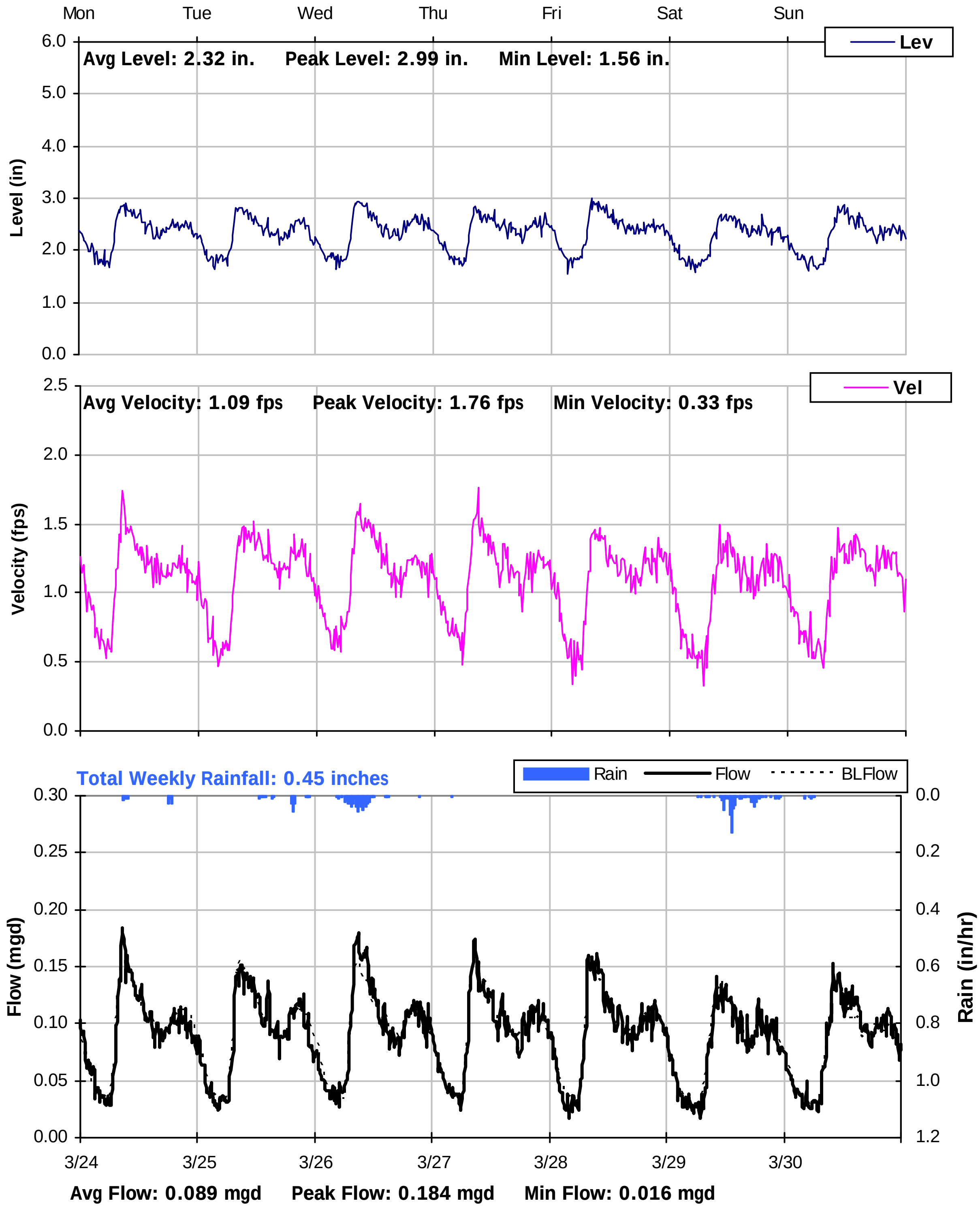
SITE 3
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



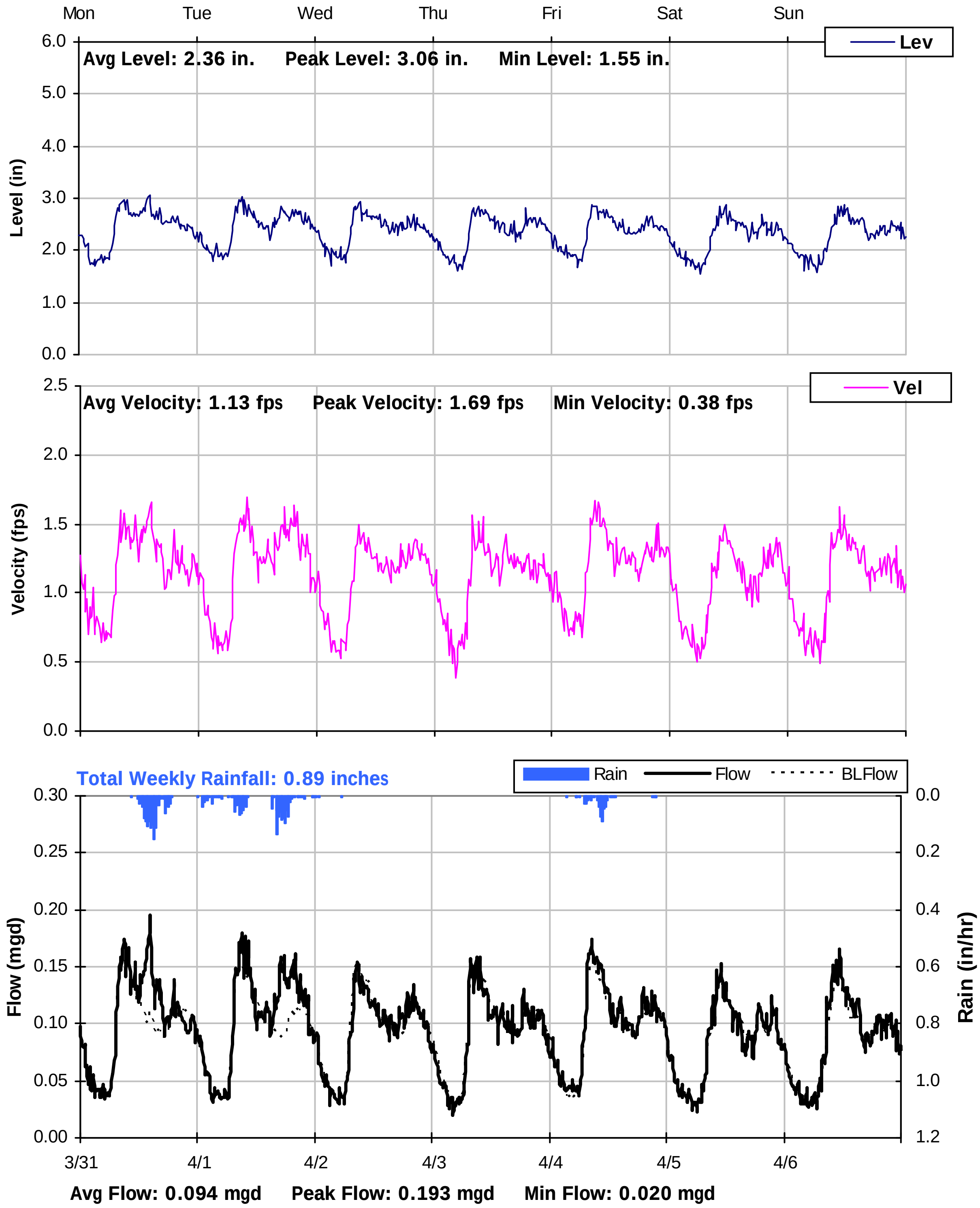
SITE 3
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



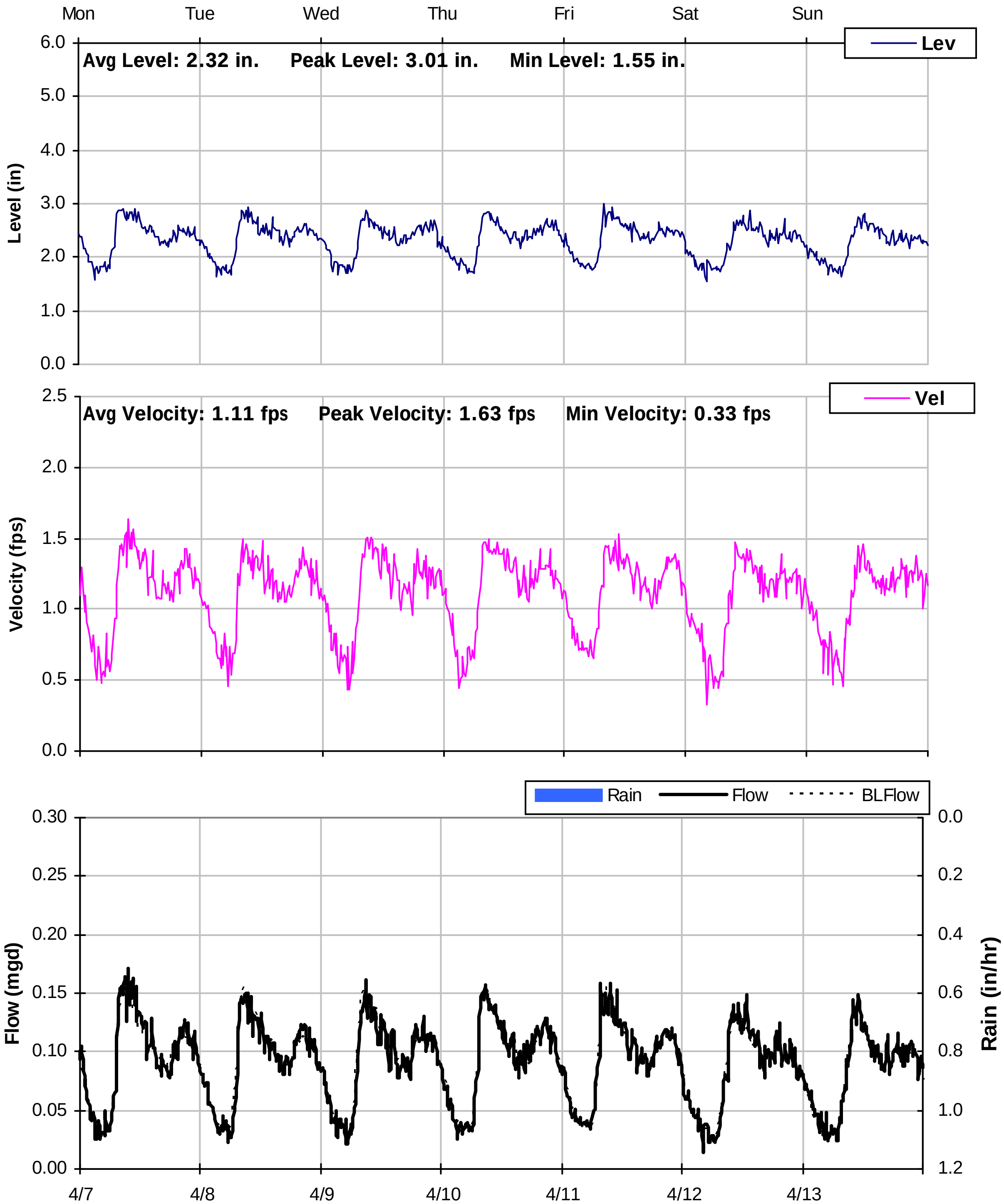
SITE 3
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



SITE 3
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 3
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 0.090 mgd **Peak Flow: 0.171 mgd** **Min Flow: 0.014 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 4

Location: Terminal Avenue, just east of Almanor Avenue

Data Summary Report

SITE 4

Site Information

Location: Terminal Avenue, just east of Almanor Avenue

Coordinates: 122.1624° W, 37.4787° N

Rim Elevation: 9 feet

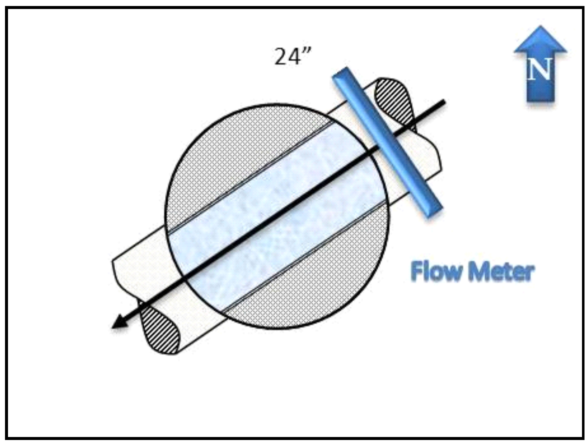
Pipe Diameter: 24 inches

Baseline Flow: 0.436 mgd

Peak Measured Flow: 1.028 mgd

Satellite Map

Sanitary Sewer Map



Flow Sketch

View from Street

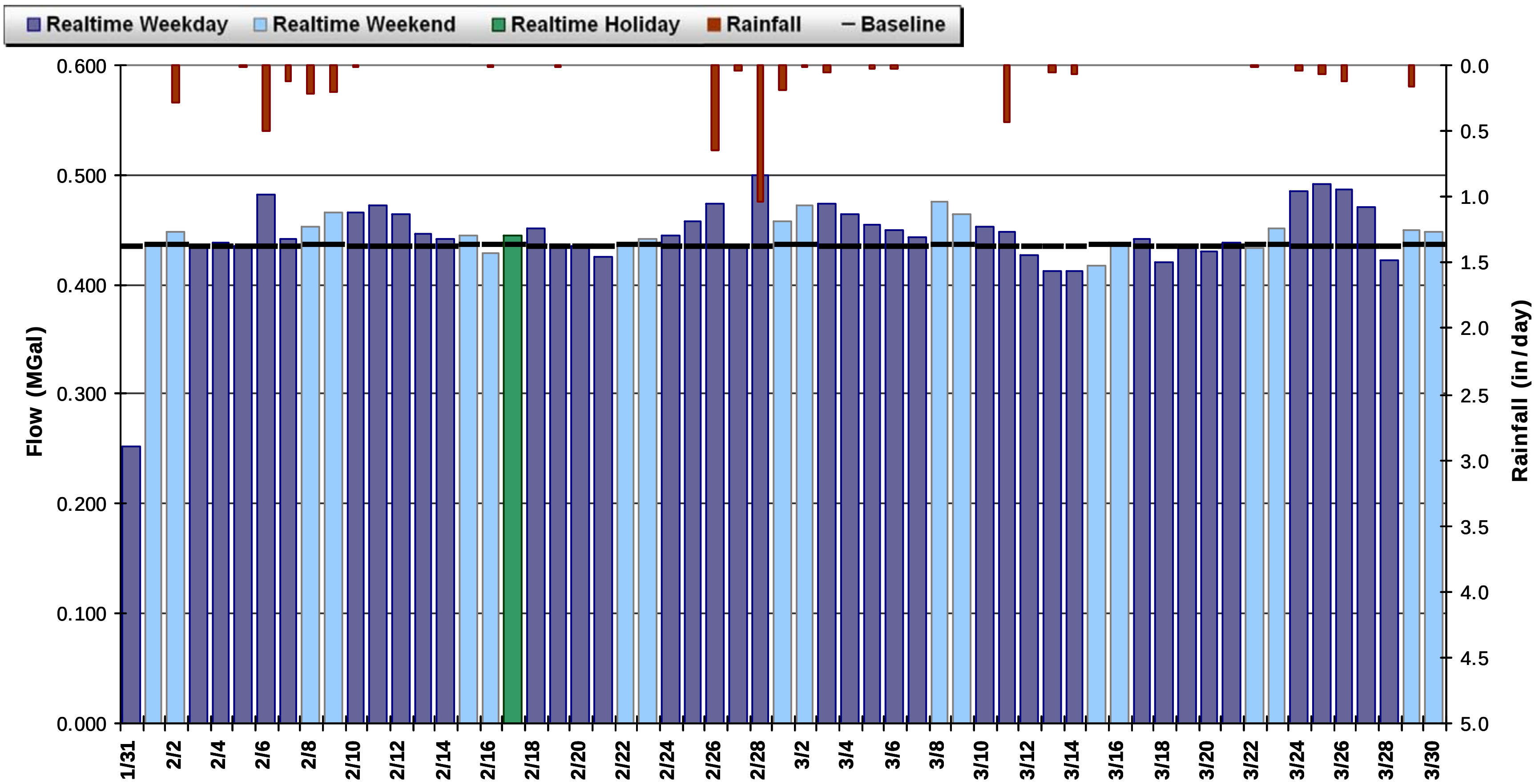
Plan View

SITE 4

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.446 MGal **Peak Daily Flow: 0.500 MGal** **Min Daily Flow: 0.252 MGal**

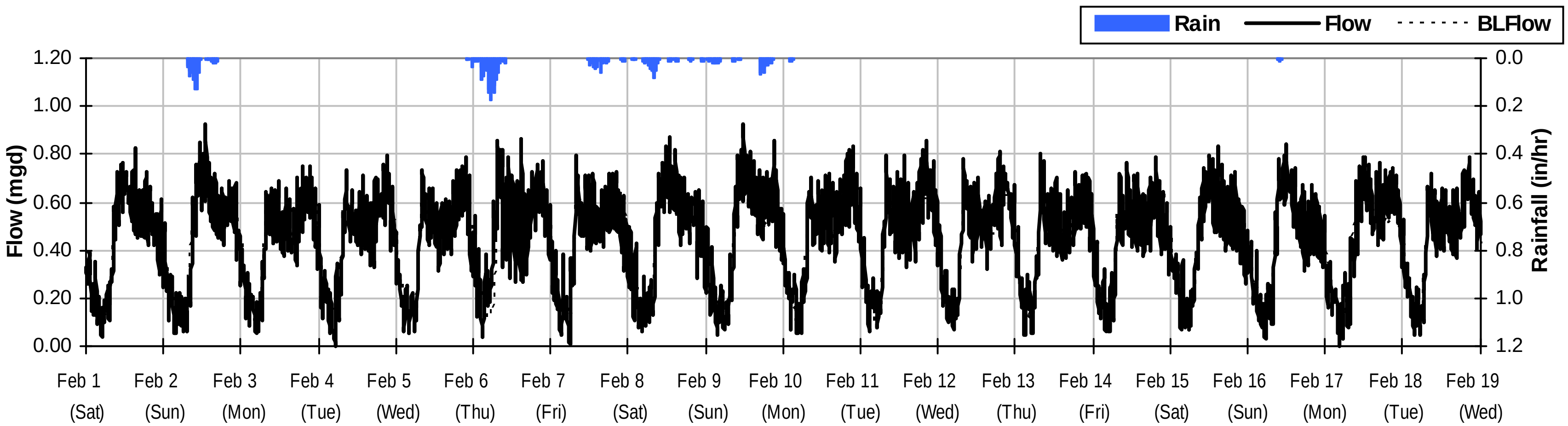
Total Period Rainfall: 4.38 inches

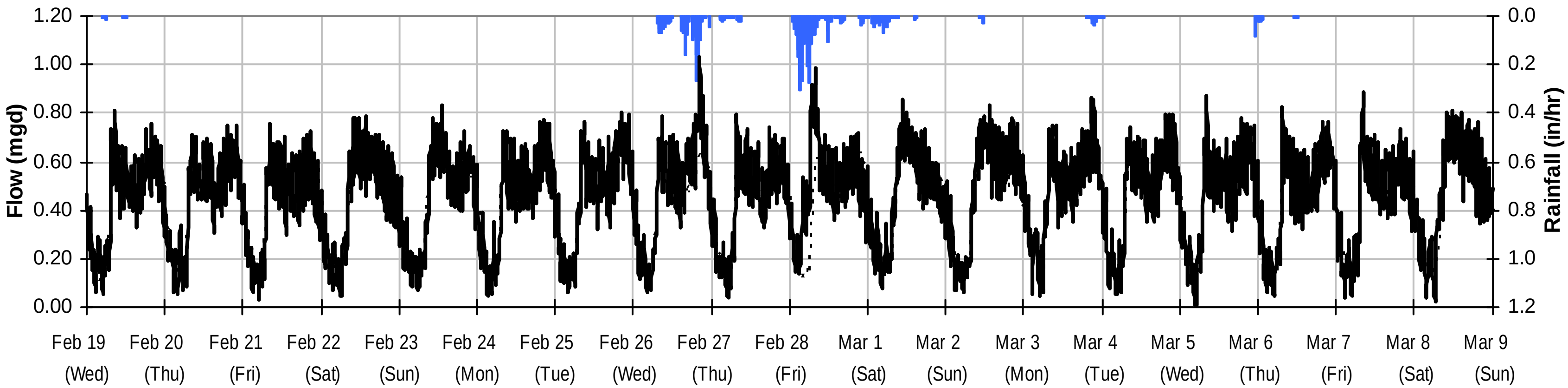


SITE 4

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 5.22 inches **Avg Flow: 0.446 mgd** **Peak Flow: 1.028 mgd** **Min Flow: 0.000 mgd**

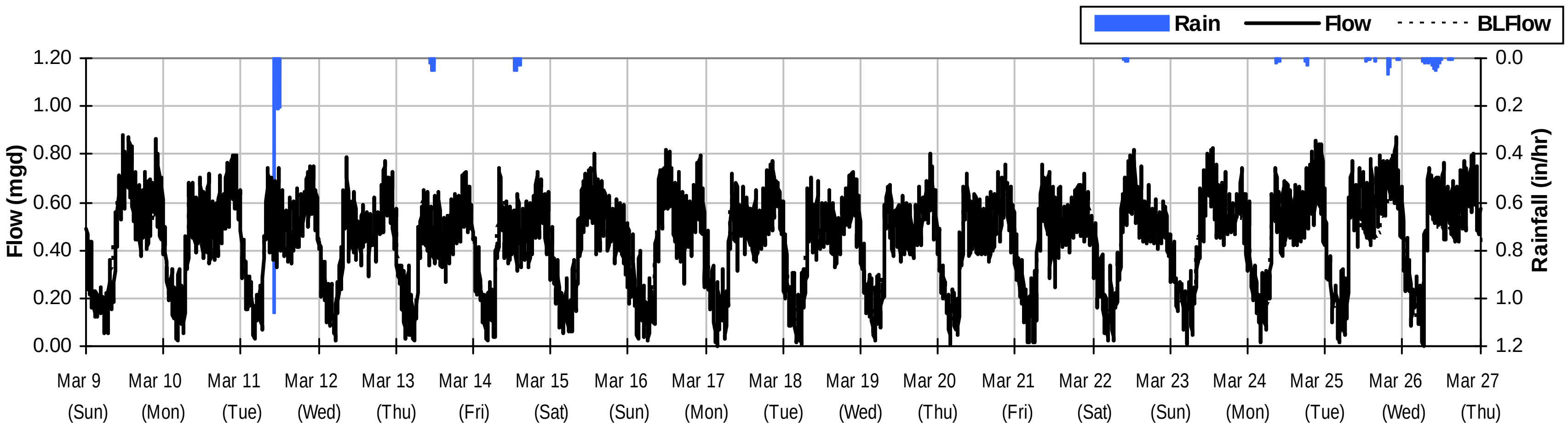


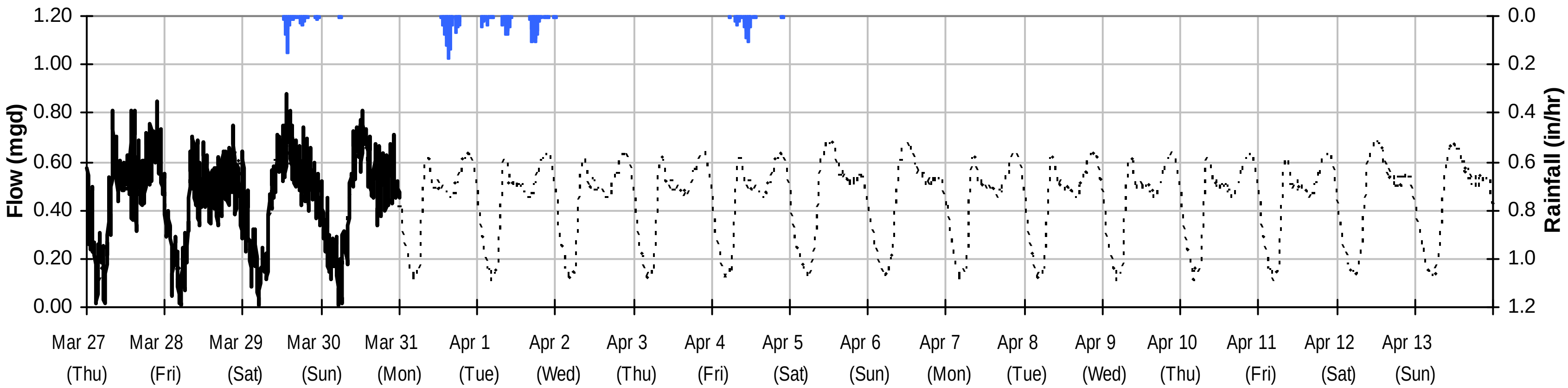


SITE 4

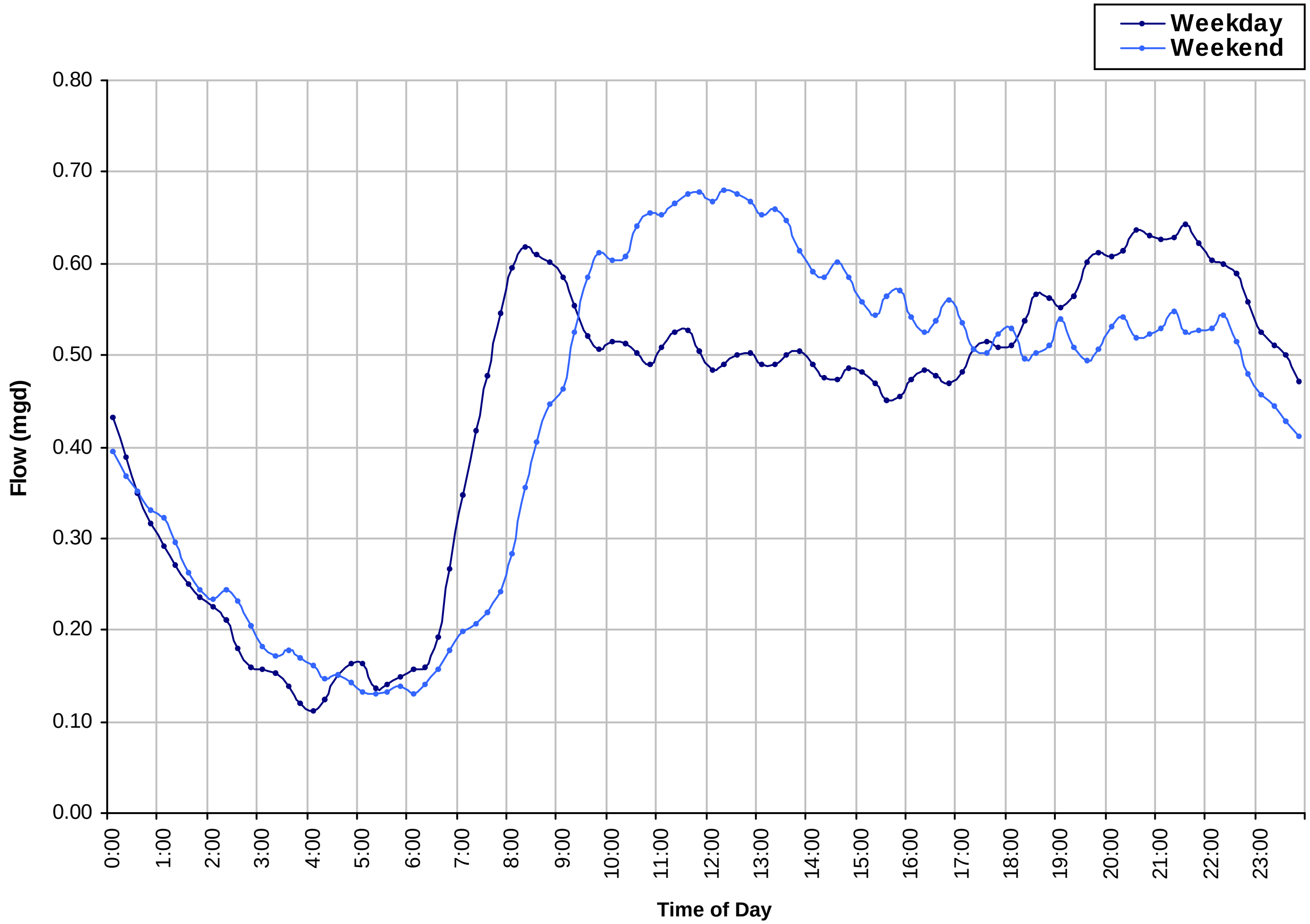
Period Flow Summary: March 9 to April 14, 2014

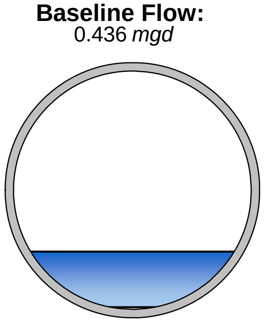
Total Monthly Rainfall: 5.22 inches **Avg Flow: 0.446 mgd** **Peak Flow: 1.028 mgd** **Min Flow: 0.000 mgd**





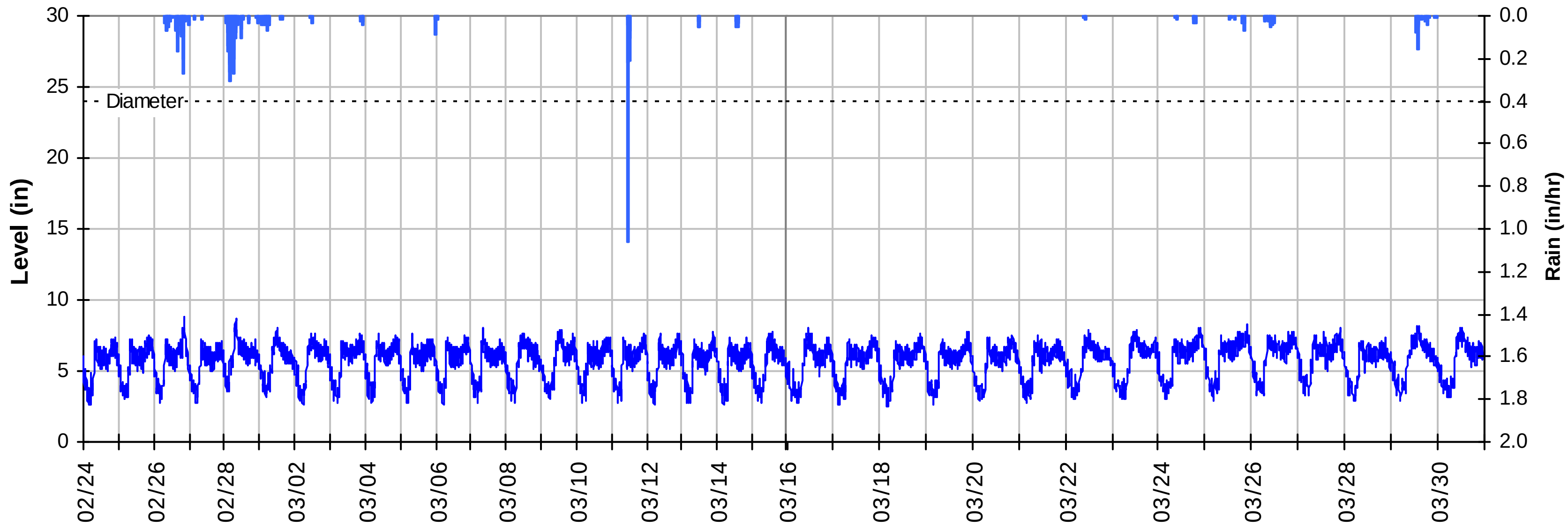
SITE 4
Baseline Flow Hydrographs

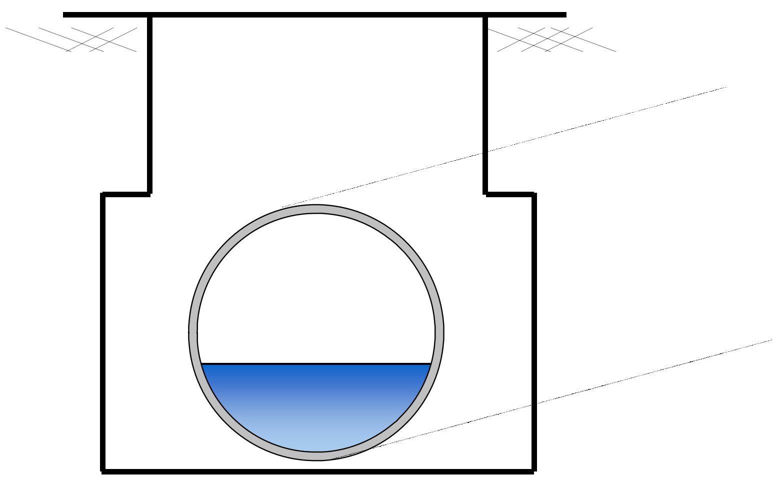




SITE 4
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





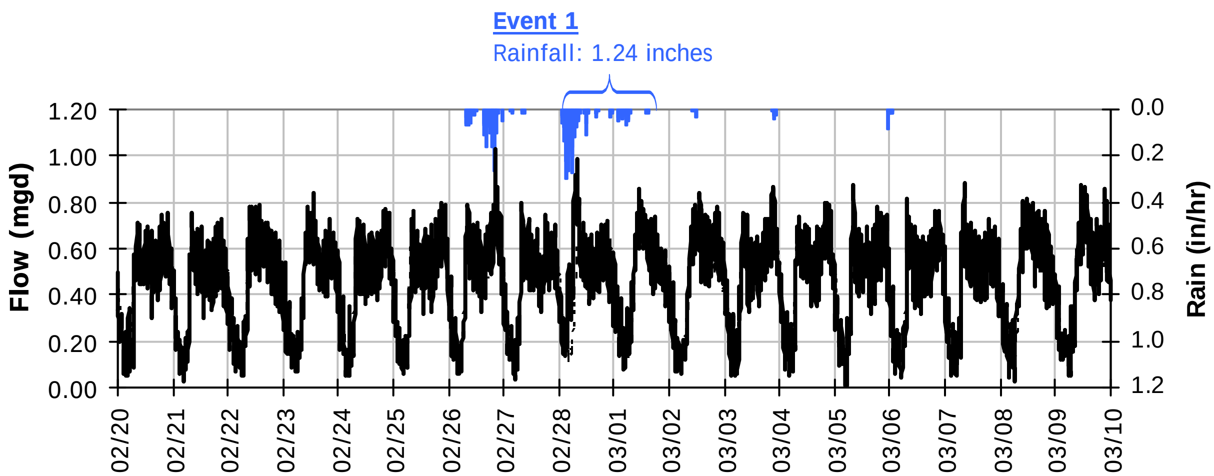
Pipe Diameter: 24 *inches*

Peak Measured Level: 8.77 *inches*

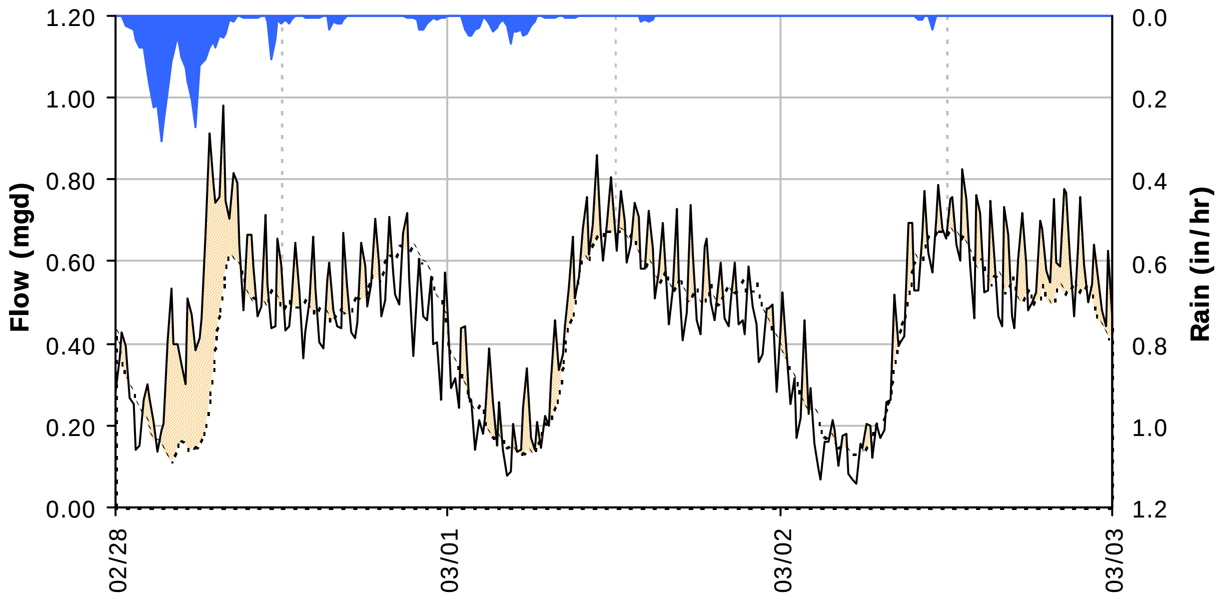
Peak d/D Ratio: 0.37

SITE 4
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



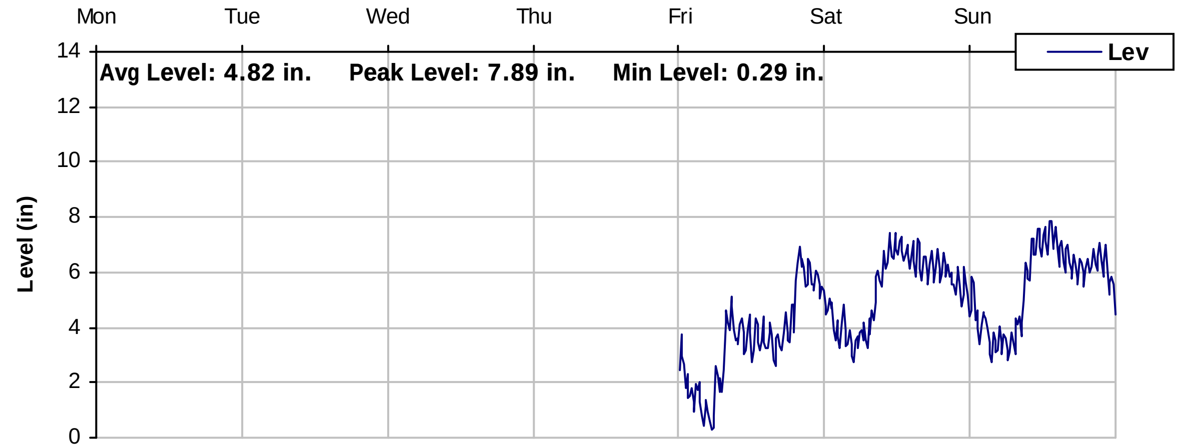
Event 1 Detail Graph

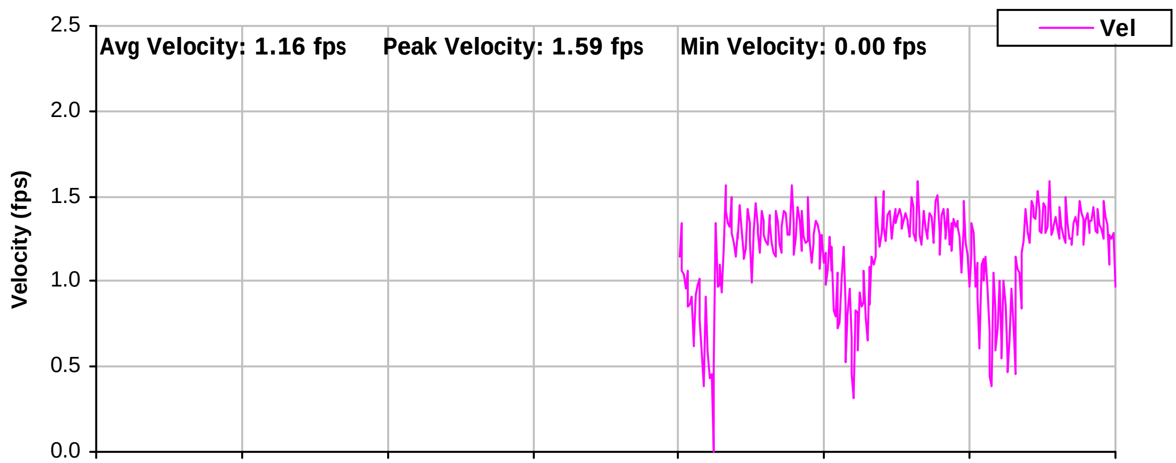


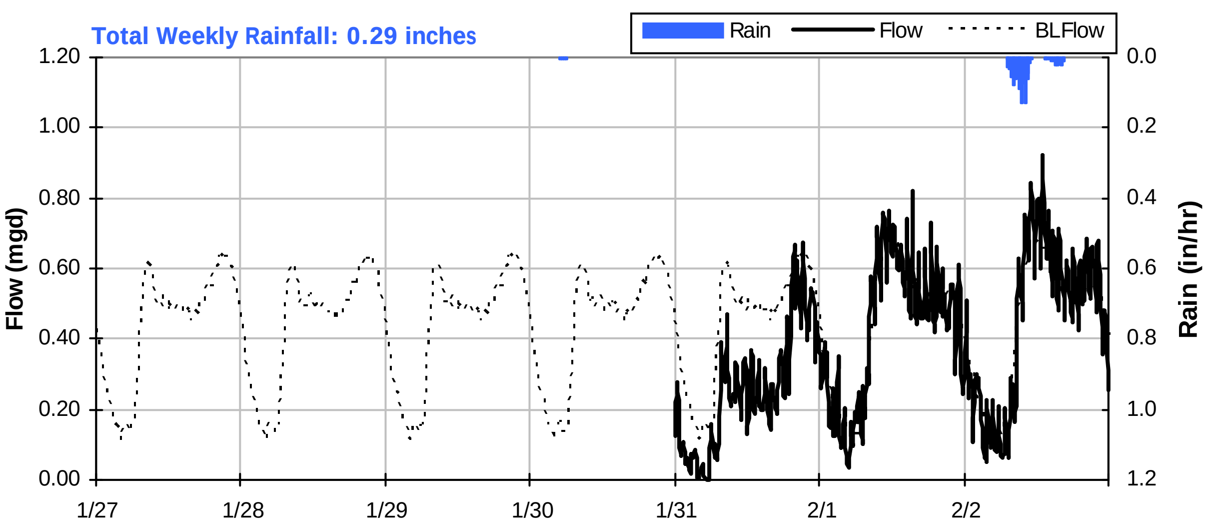
Storm Event I/I Analysis (Rain = 1.24 inches)

Capacity		Inflow / Infiltration	
Peak Flow:	0.98 *mgd*	**Peak I/I Rate:**	0.42 *mgd*
PF:	2.26	**Total I/I:**	123,000 *gallons*

SITE 4
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

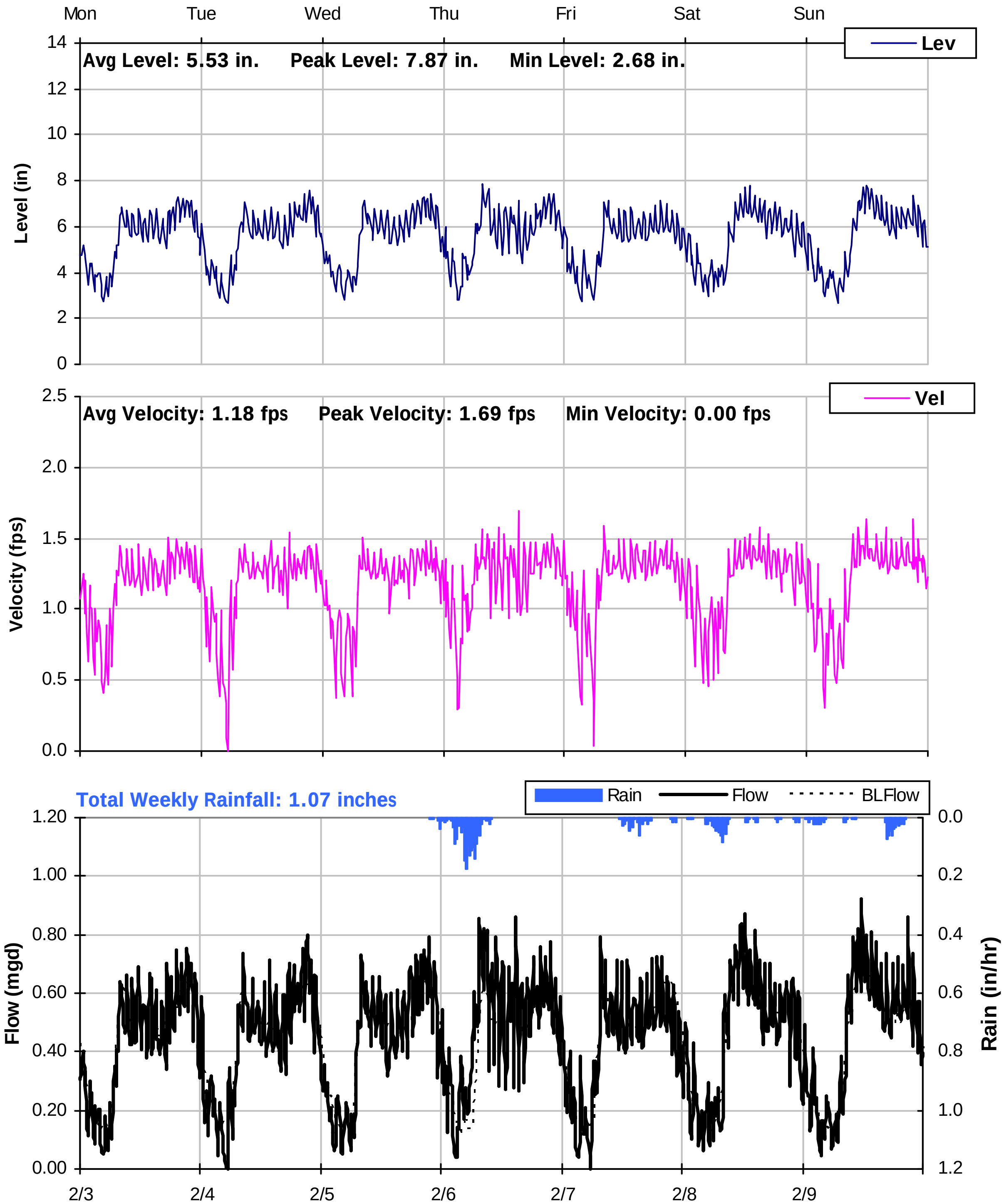






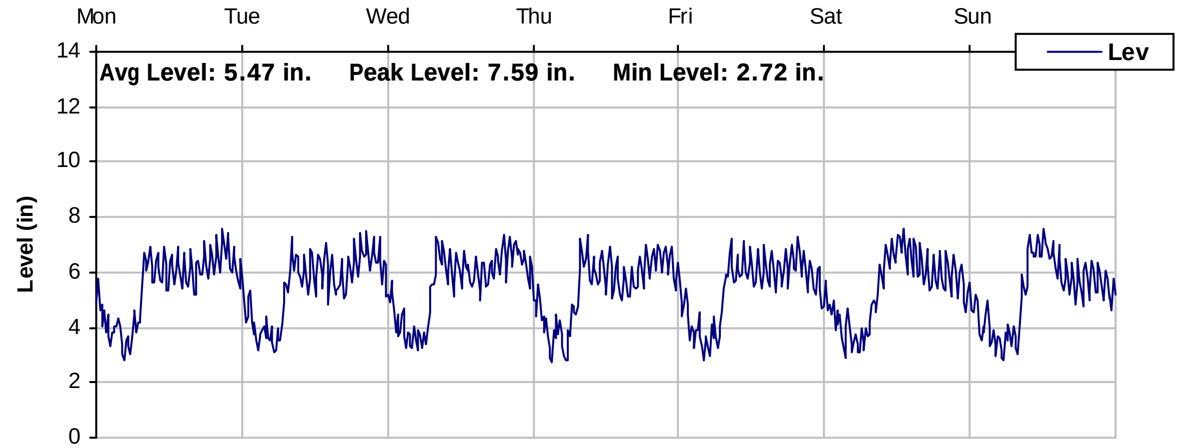
Avg Flow: 0.379 mgd **Peak Flow: 0.922 mgd** **Min Flow: 0.000 mgd**

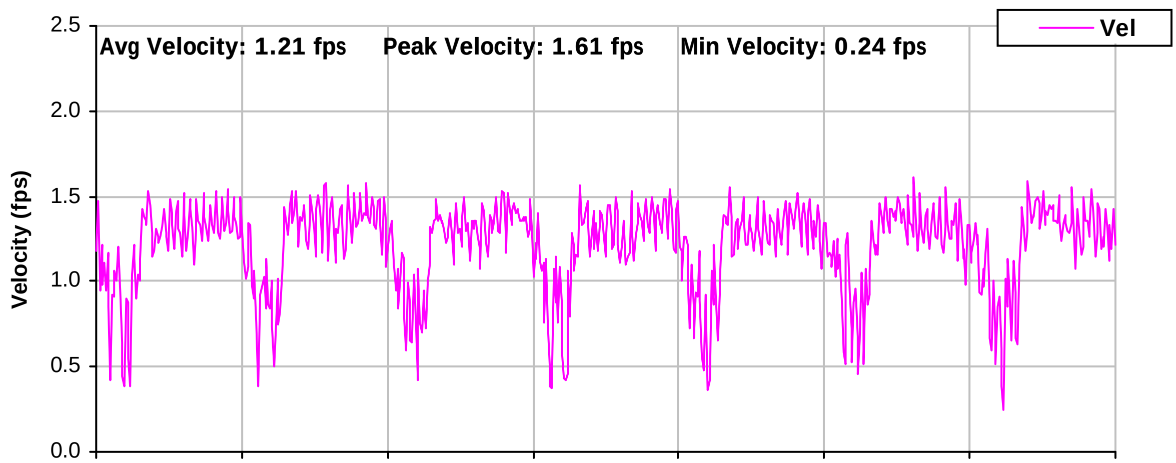
SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

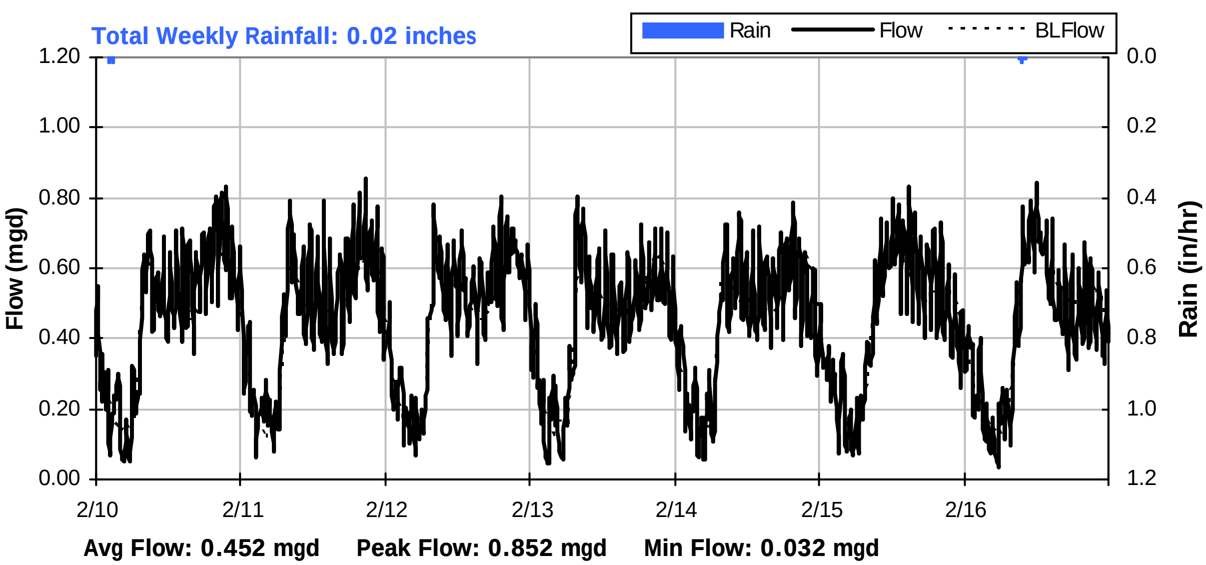


Avg Flow: 0.450 mgd   Peak Flow: 0.925 mgd   Min Flow: 0.000 mgd

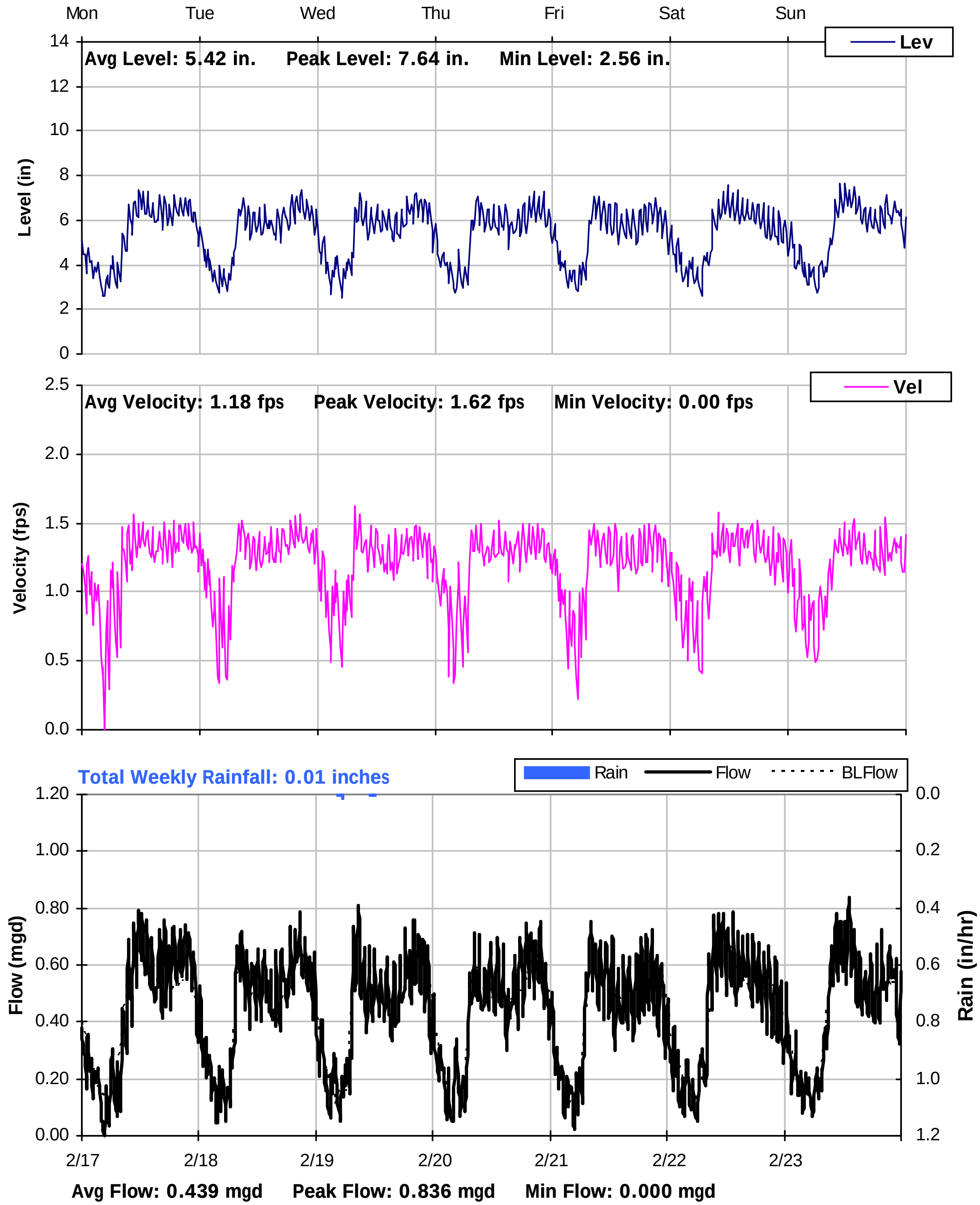
SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



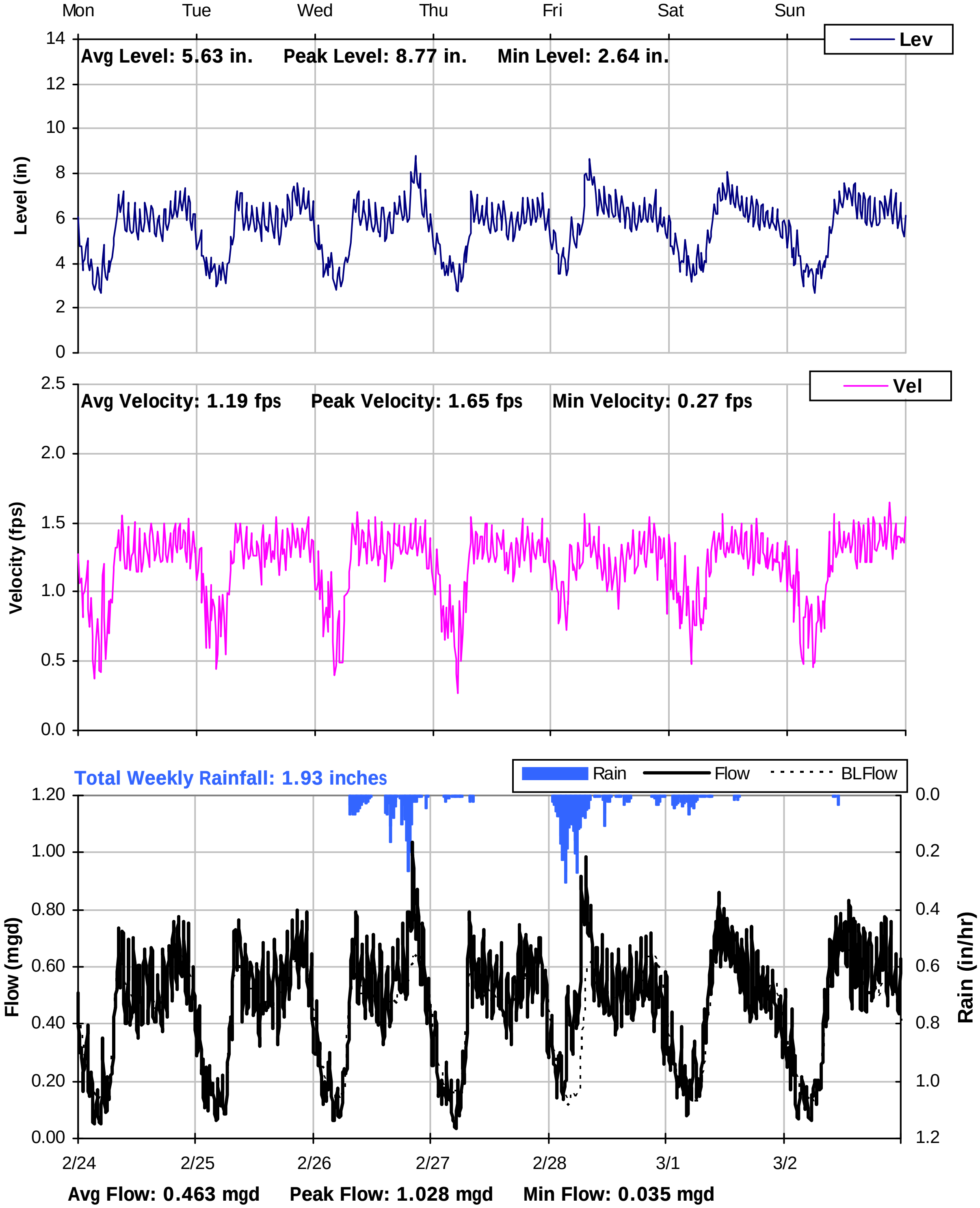




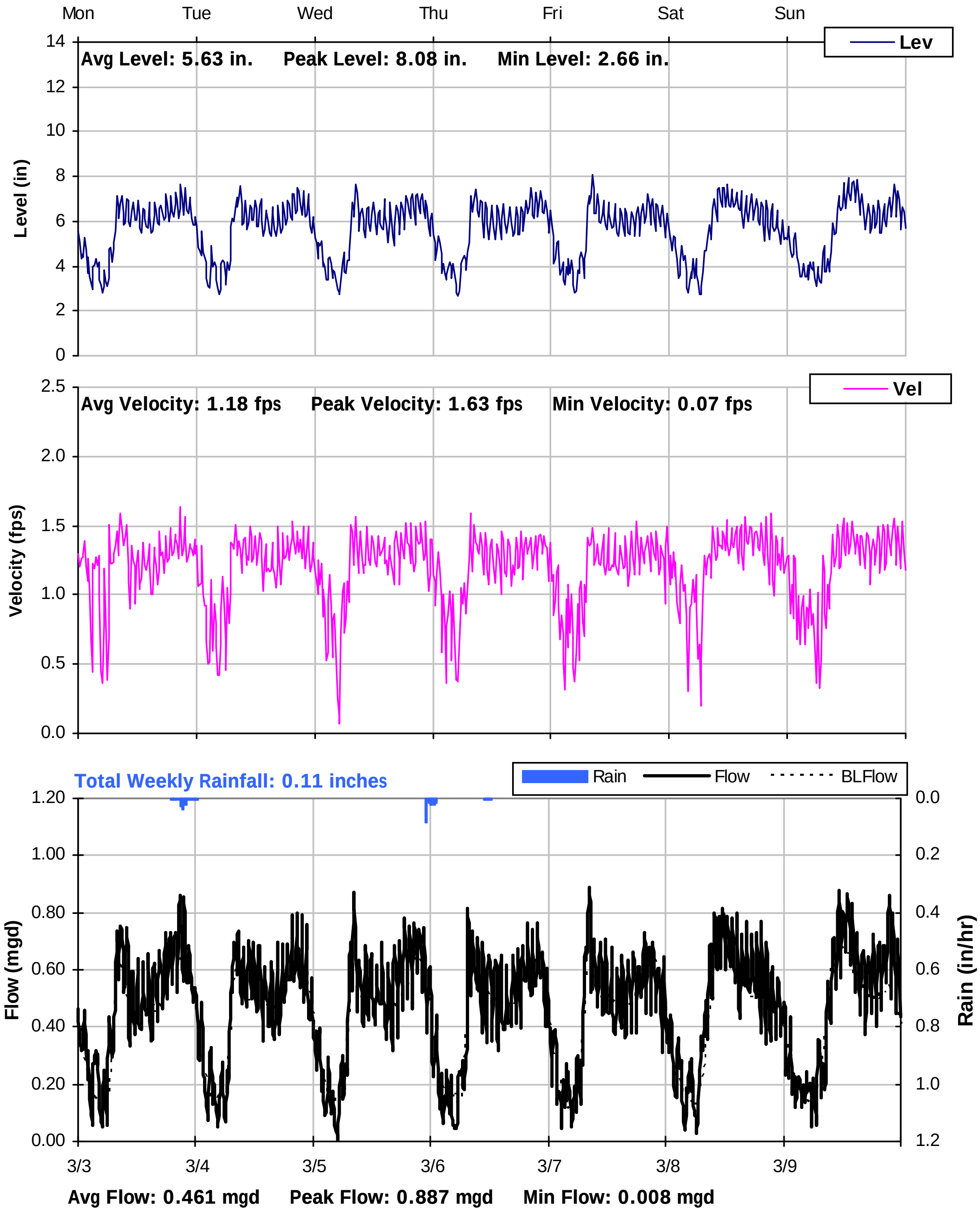
SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014



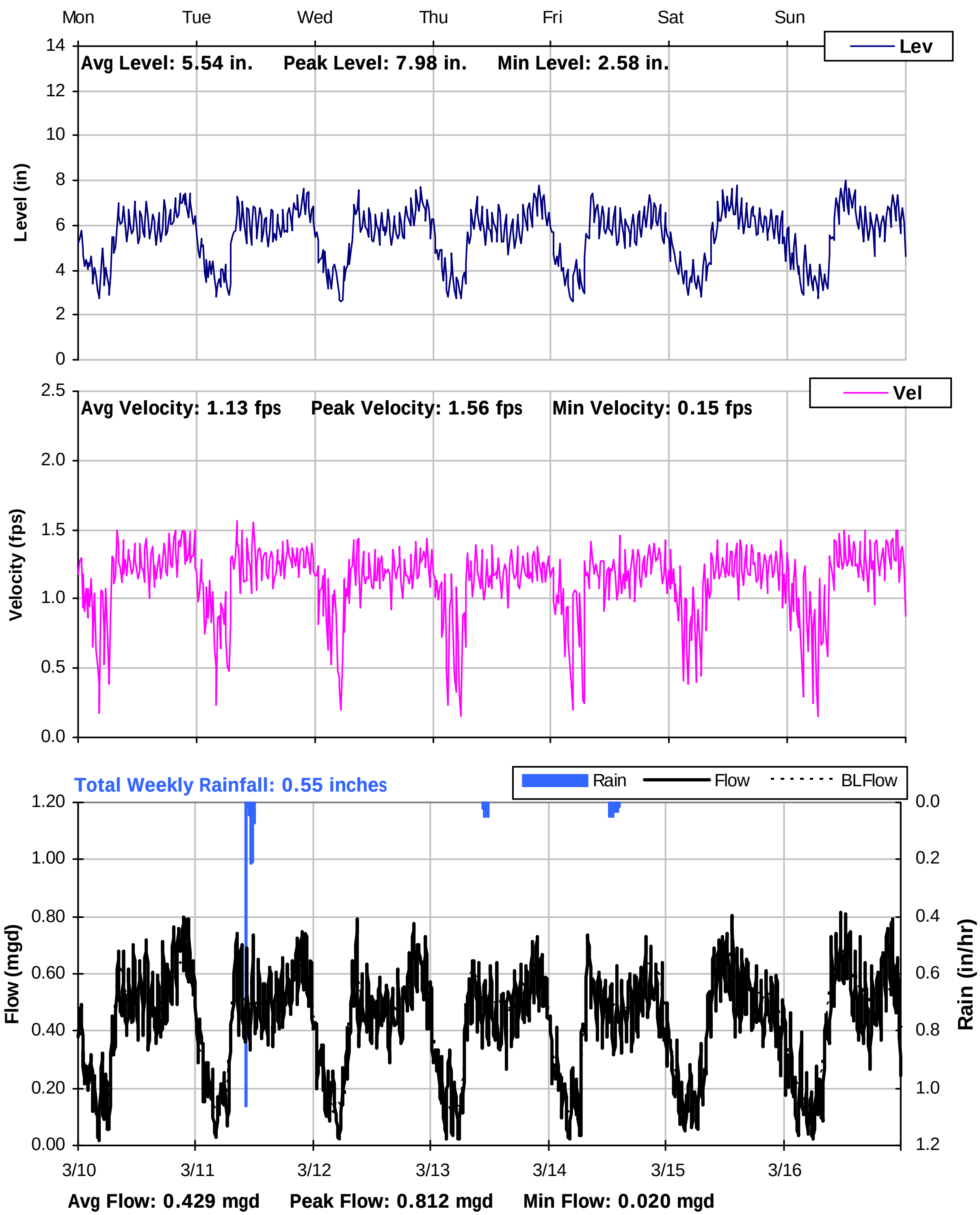
SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



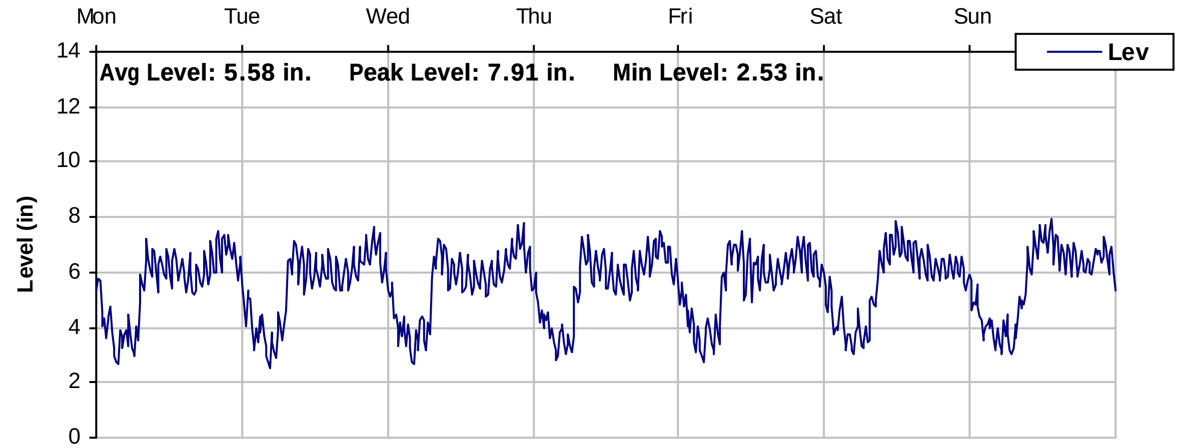
SITE 4
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

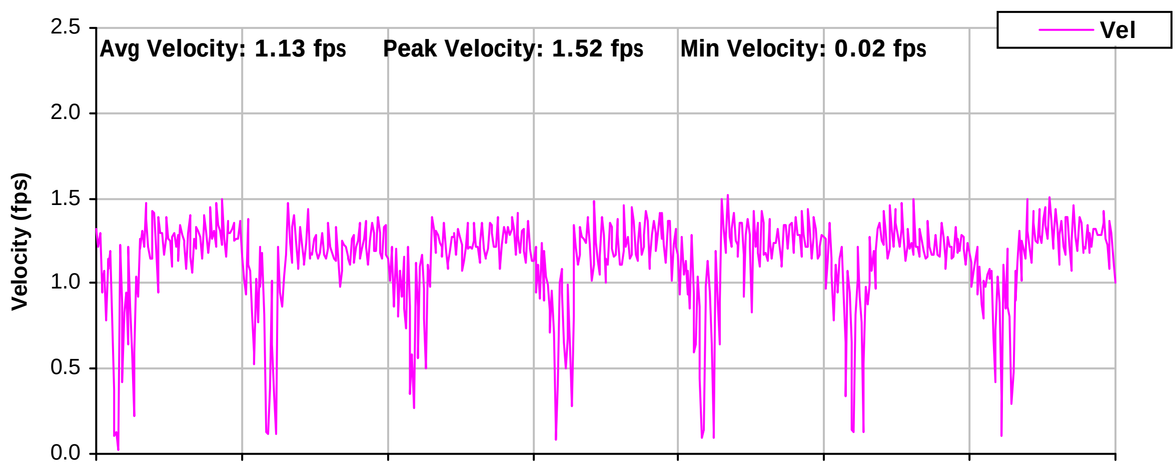


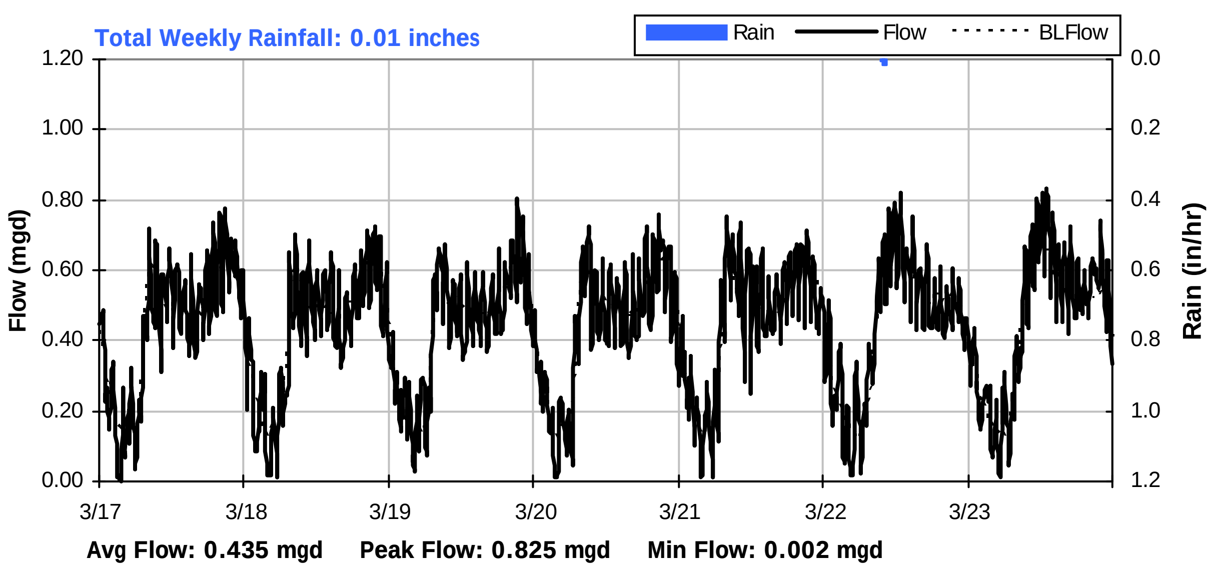
SITE 4
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



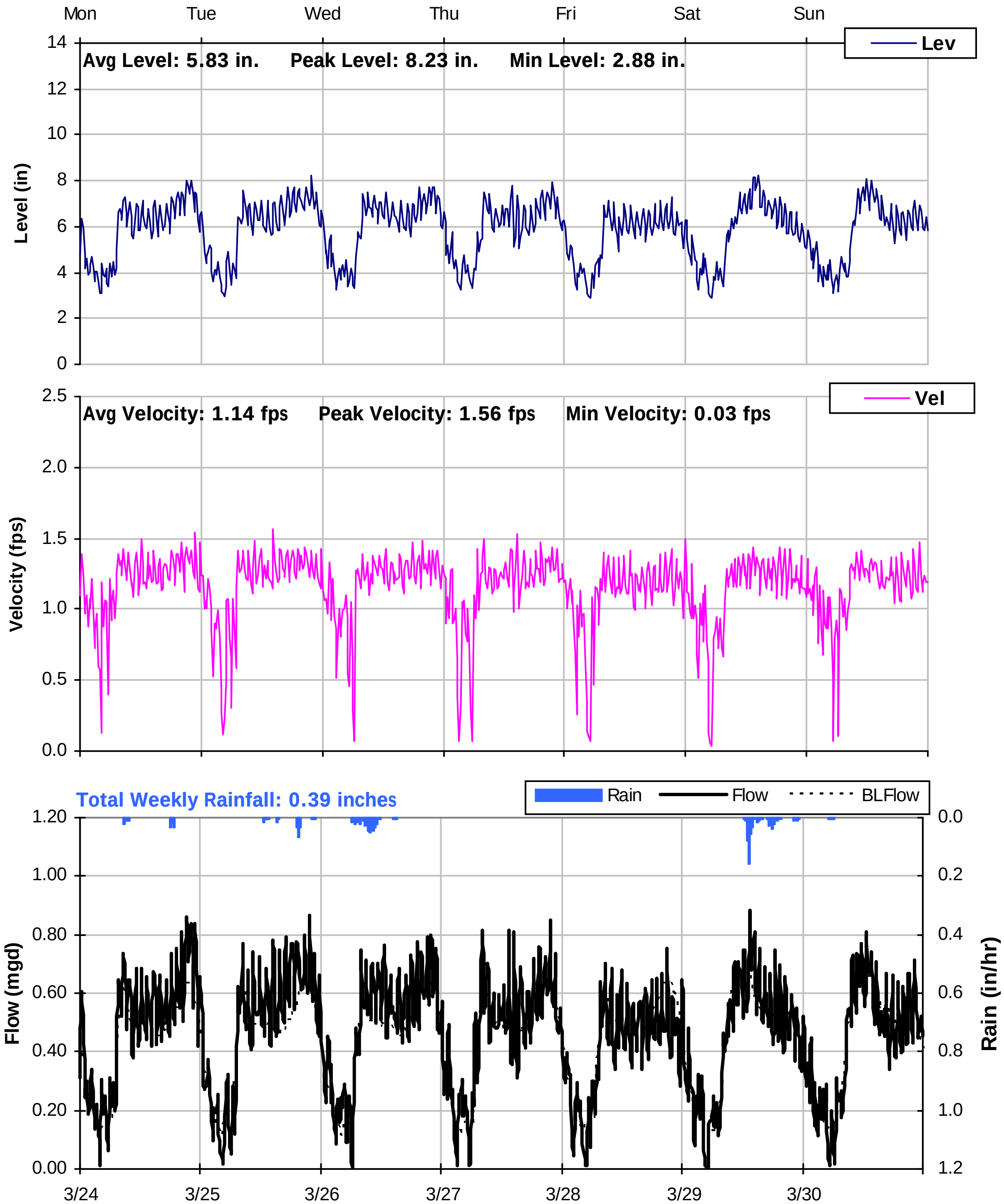
SITE 4
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014







SITE 4
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



Avg Flow: 0.465 mgd **Peak Flow: 0.875 mgd** **Min Flow: 0.005 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 5

Location: Hollyburne Avenue, south of Van Buren Road

Data Summary Report

SITE 5

Site Information

Location: Hollyburne Avenue, south of Van Buren Road

Coordinates: 122.1602° W, 37.4705° N

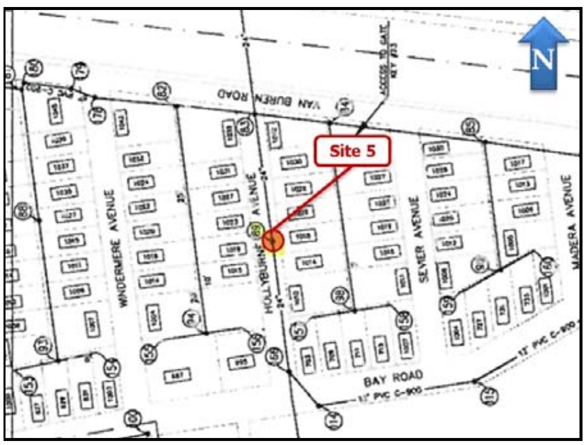
Rim Elevation: 24 feet

Pipe Diameter: 24.75 inches

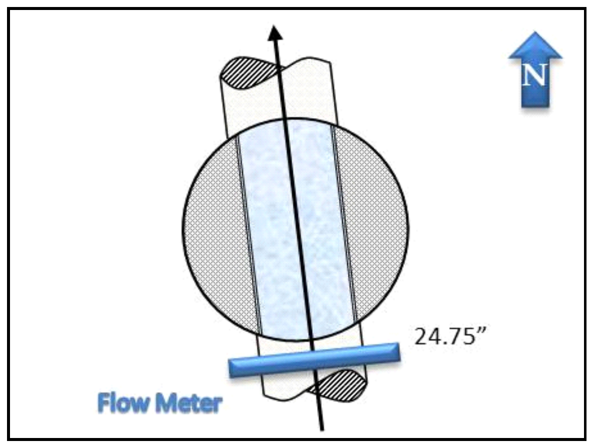
Baseline Flow: 1.426 mgd

Peak Measured Flow: 3.574 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

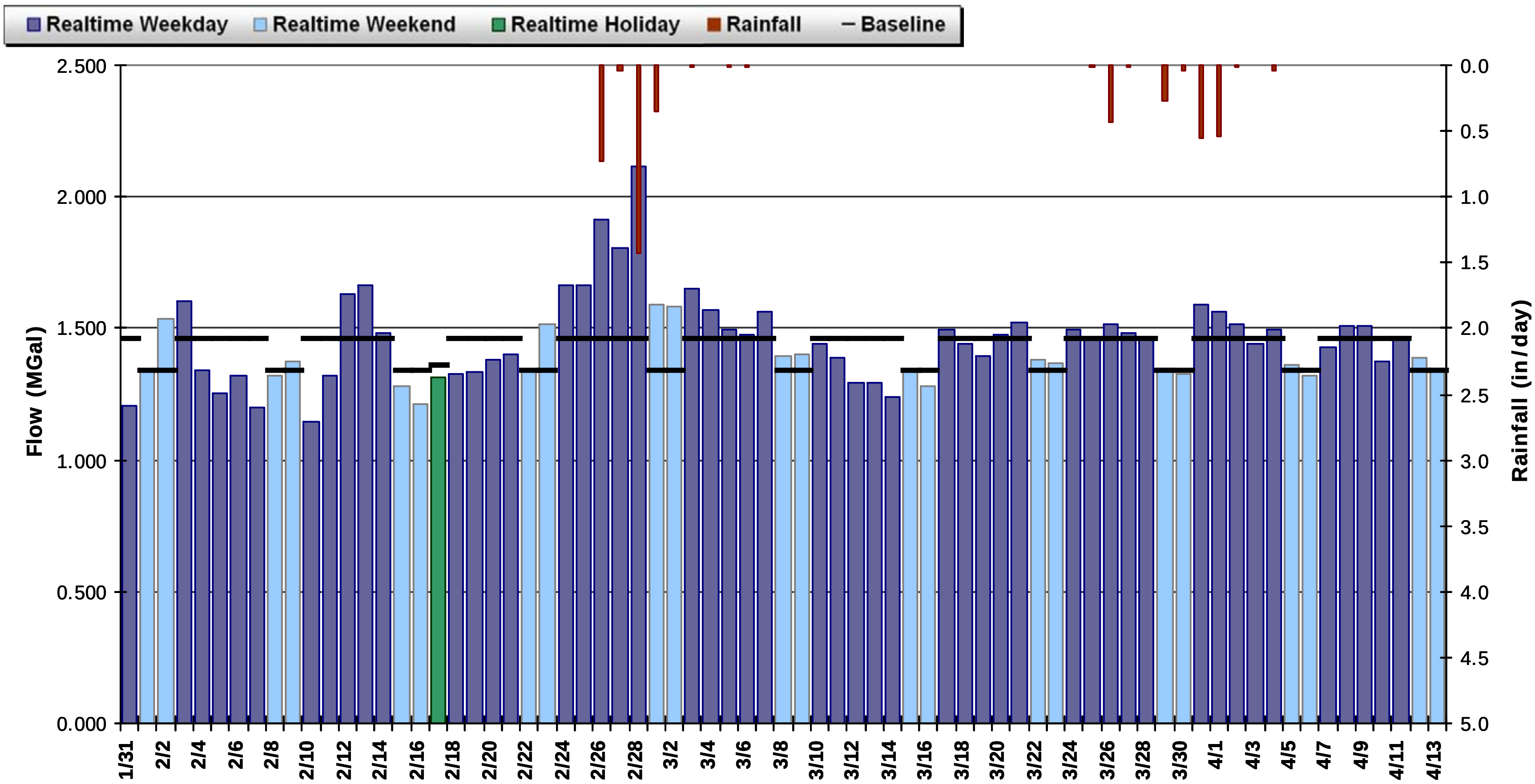
Plan View

SITE 5

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.445 MGal **Peak Daily Flow: 2.114 MGal** **Min Daily Flow: 1.144 MGal**

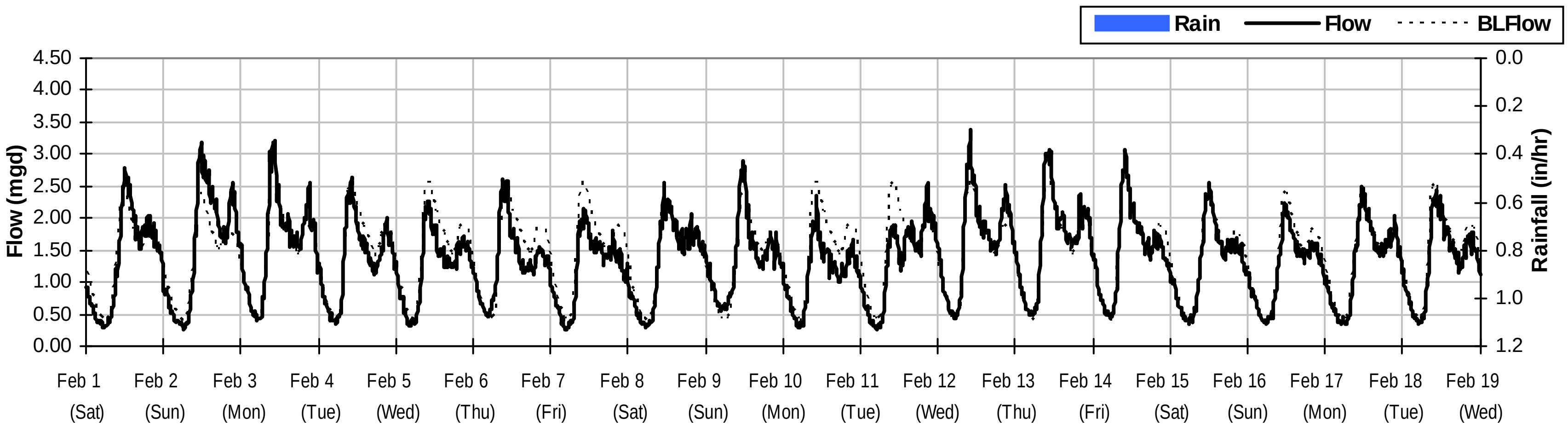
Total Period Rainfall: 4.53 inches

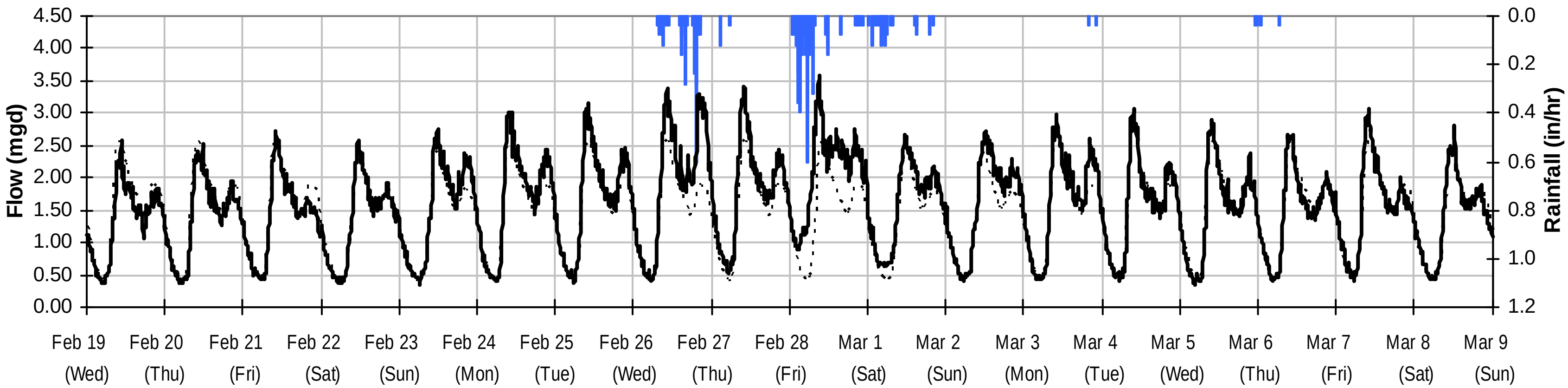


SITE 5

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.53 inches **Avg Flow: 1.445 mgd** **Peak Flow: 3.574 mgd** **Min Flow: 0.247 mgd**

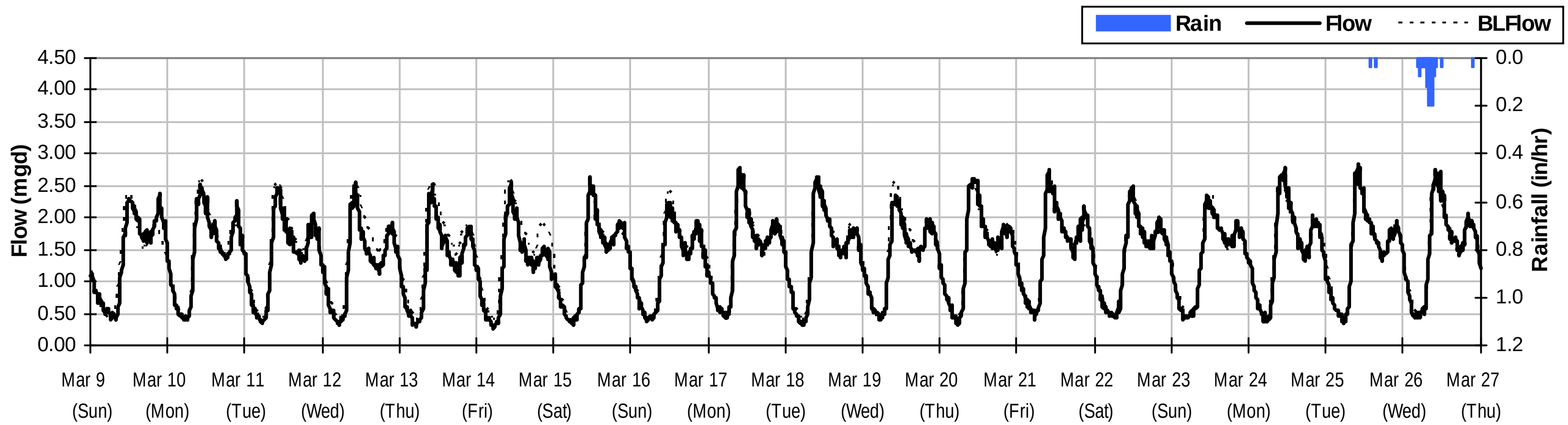


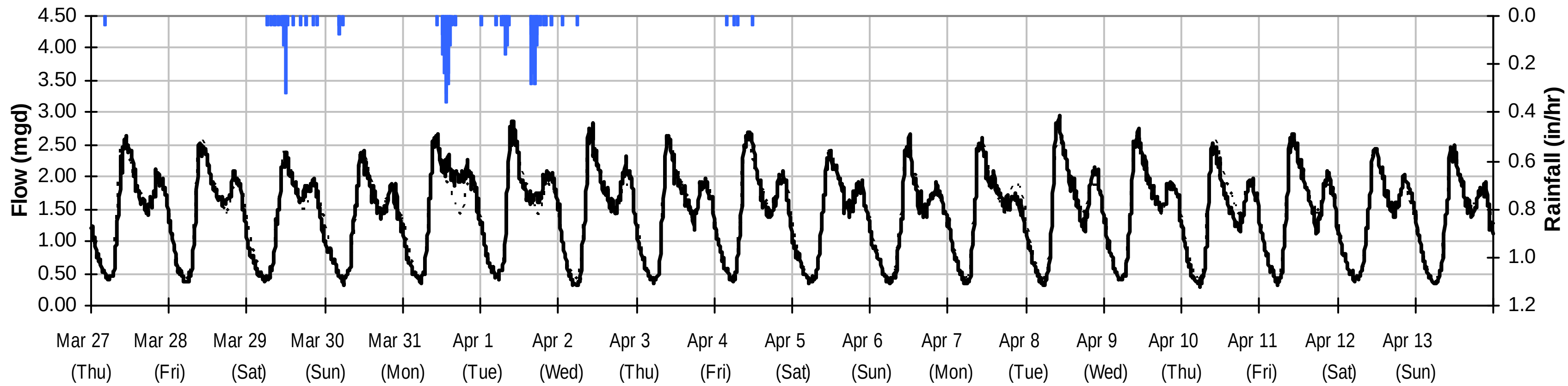


SITE 5

Period Flow Summary: March 9 to April 14, 2014

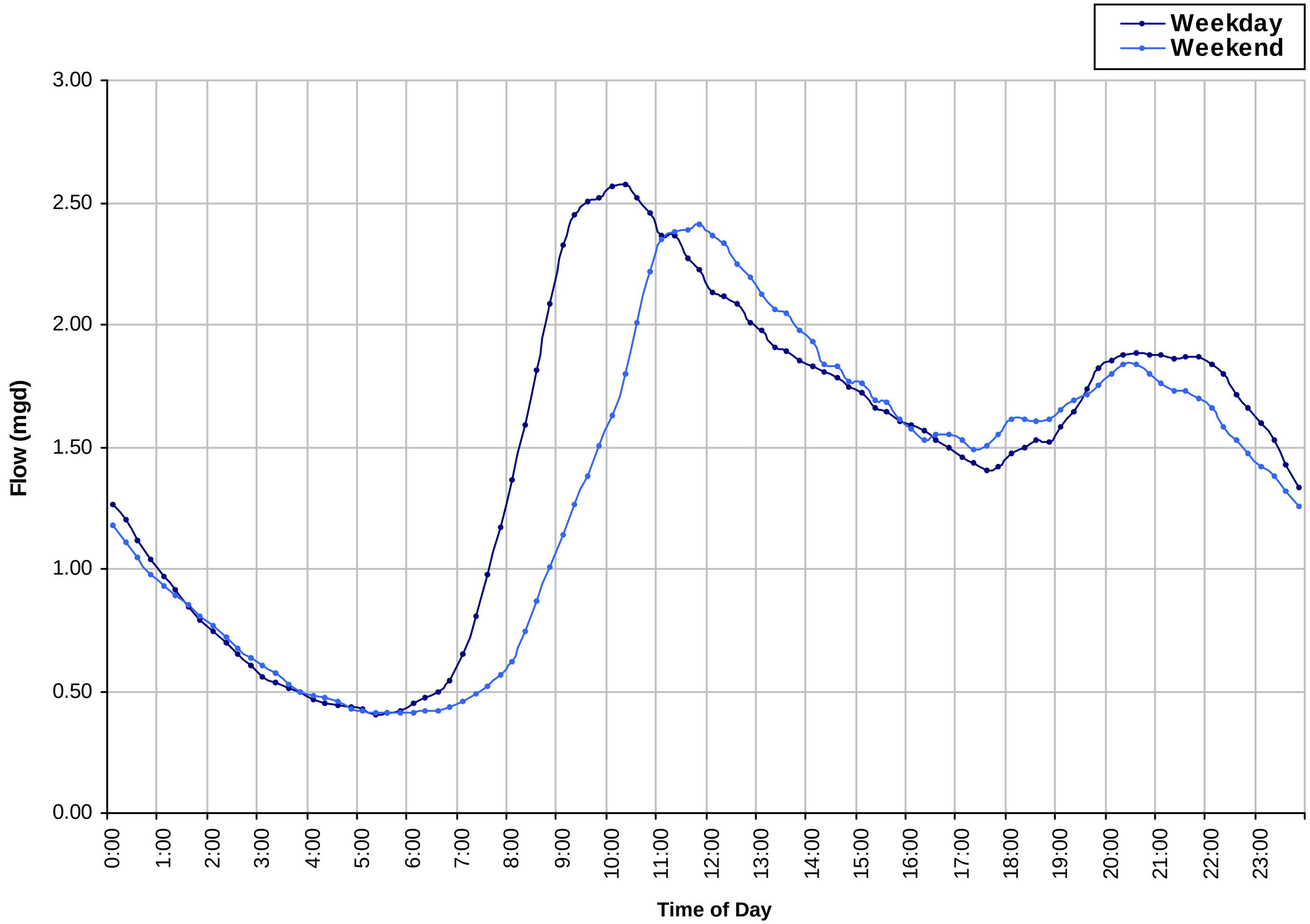
Total Monthly Rainfall: 4.53 inches **Avg Flow: 1.445 mgd** **Peak Flow: 3.574 mgd** **Min Flow: 0.247 mgd**



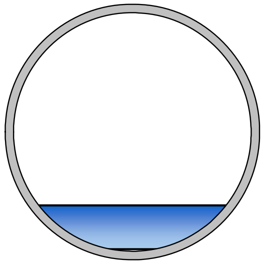


SITE 5

Baseline Flow Hydrographs

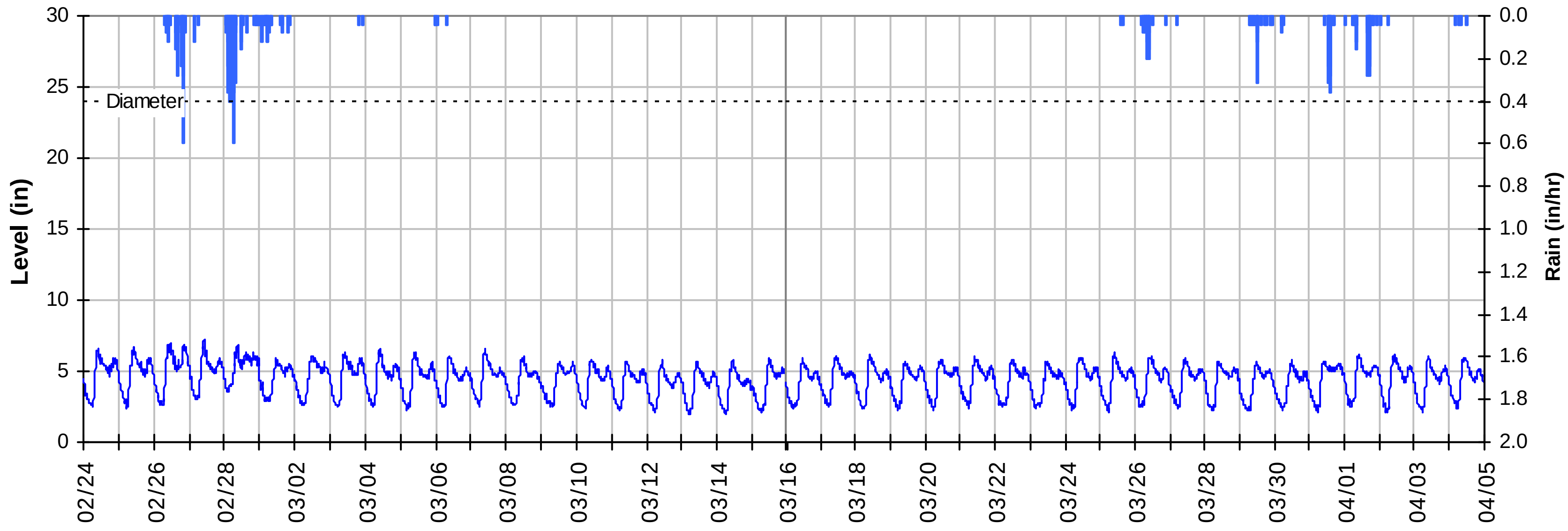


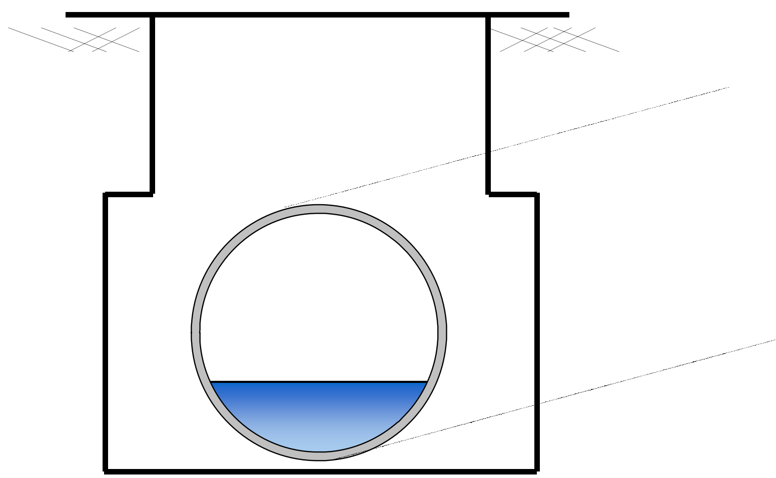
Baseline Flow:
1.426 *mgd*



SITE 5
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





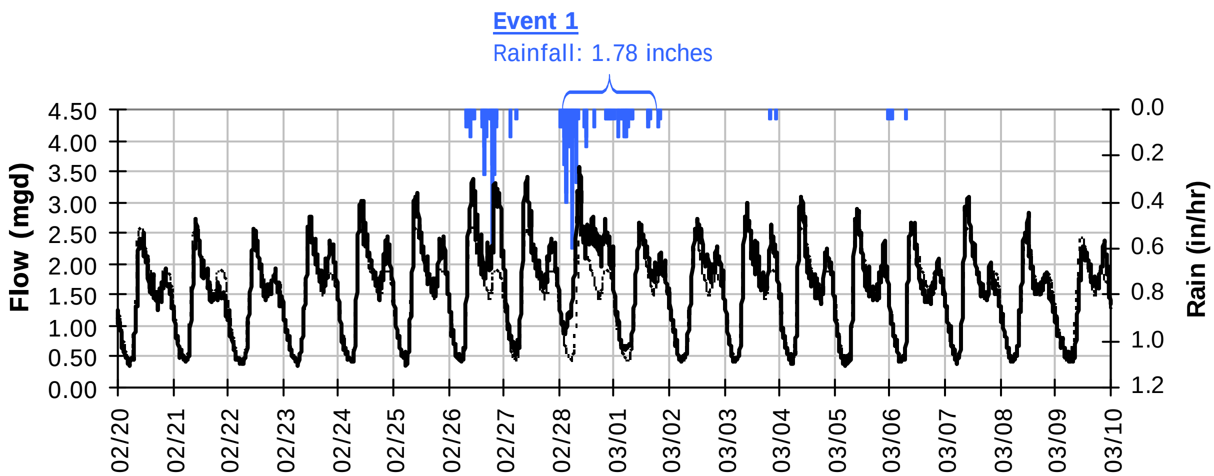
Pipe Diameter: 24.8 *inches*

Peak Measured Level: 7.21 *inches*

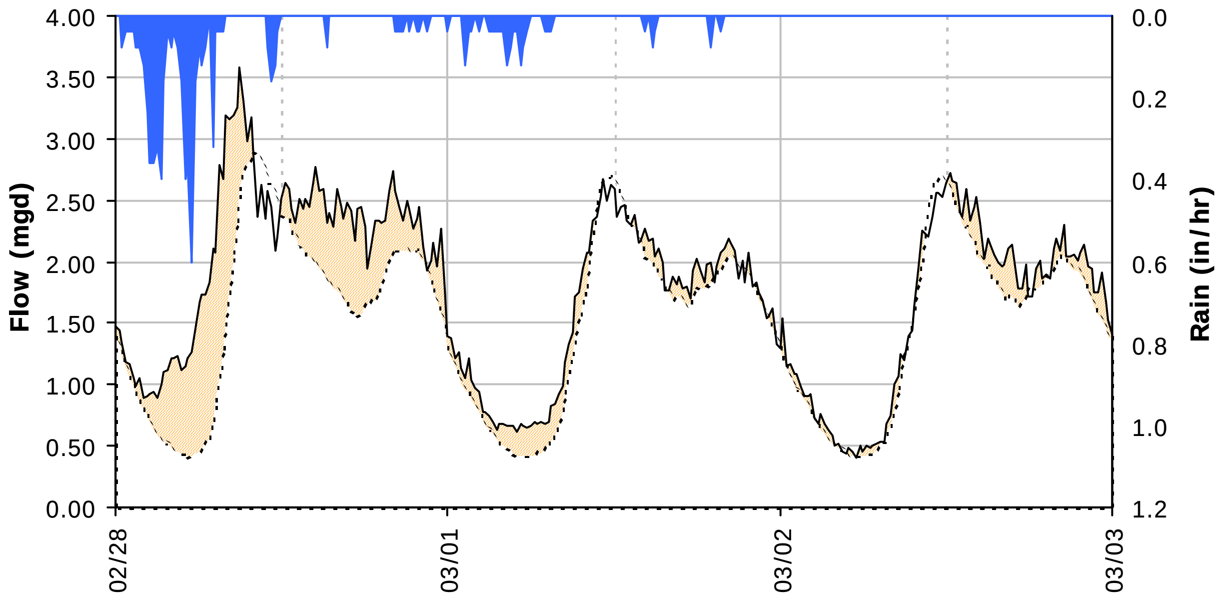
Peak d/D Ratio: 0.29

SITE 5
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

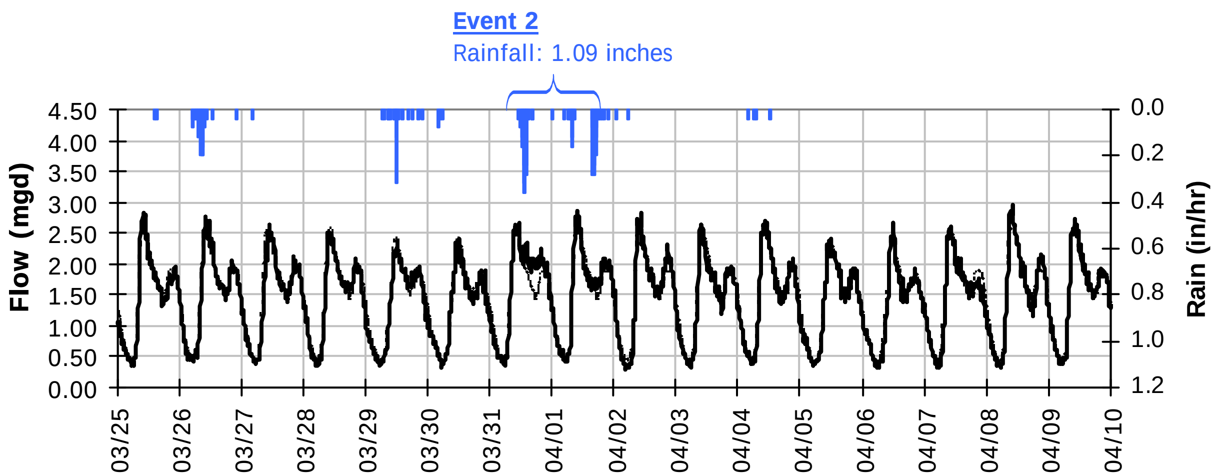


Storm Event I/I Analysis (Rain = 1.78 inches)

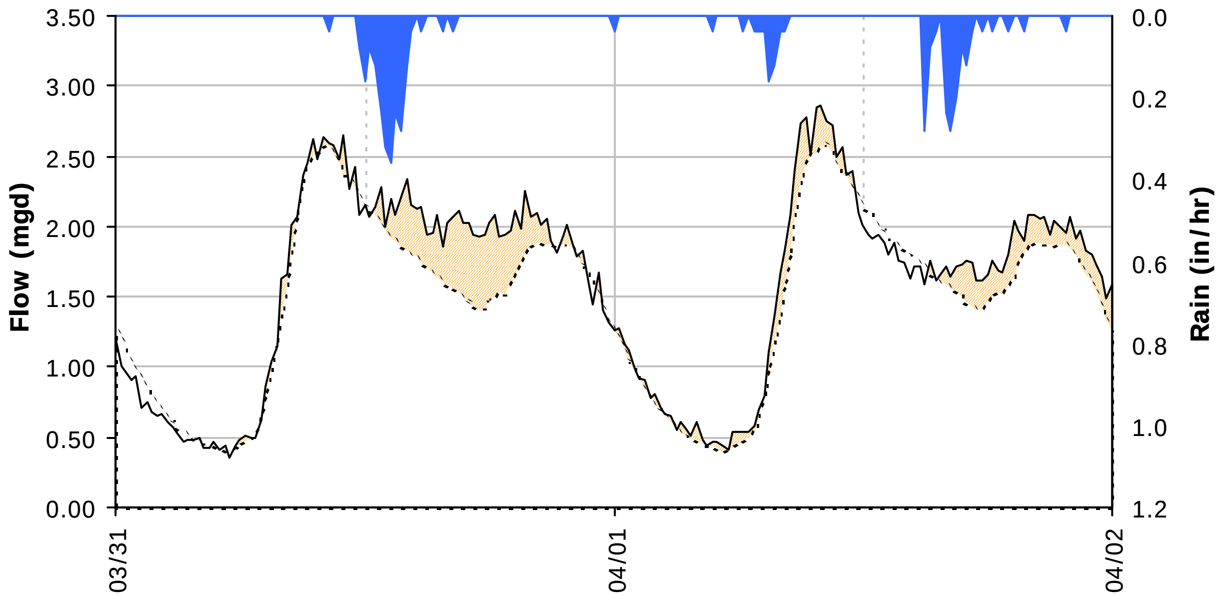
Capacity		**Inflow / Infiltration**	
Peak Flow:	3.57 *mgd*	**Peak I/I Rate:**	1.51 *mgd*
PF:	2.51	**Total I/I:**	719,000 *gallons*

SITE 5
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



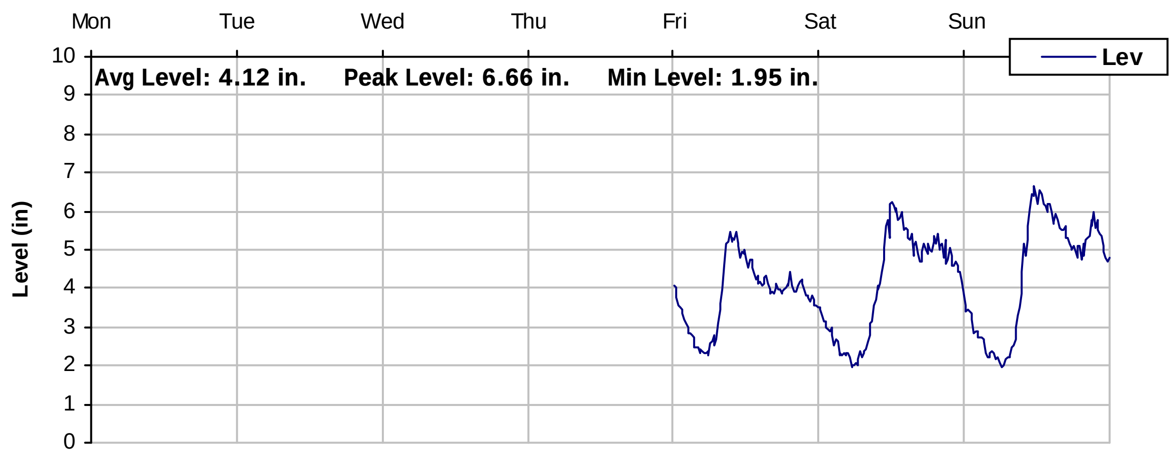
Event 2 Detail Graph

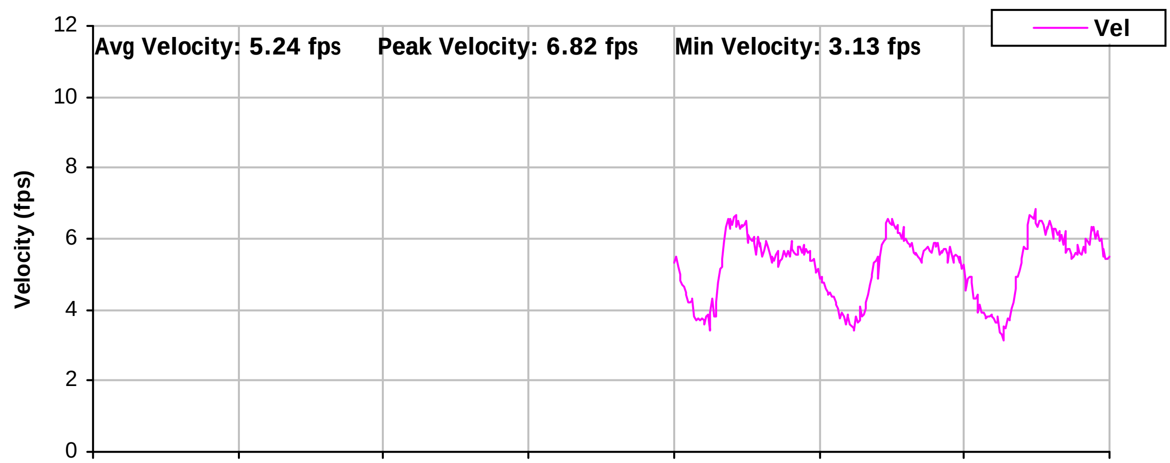


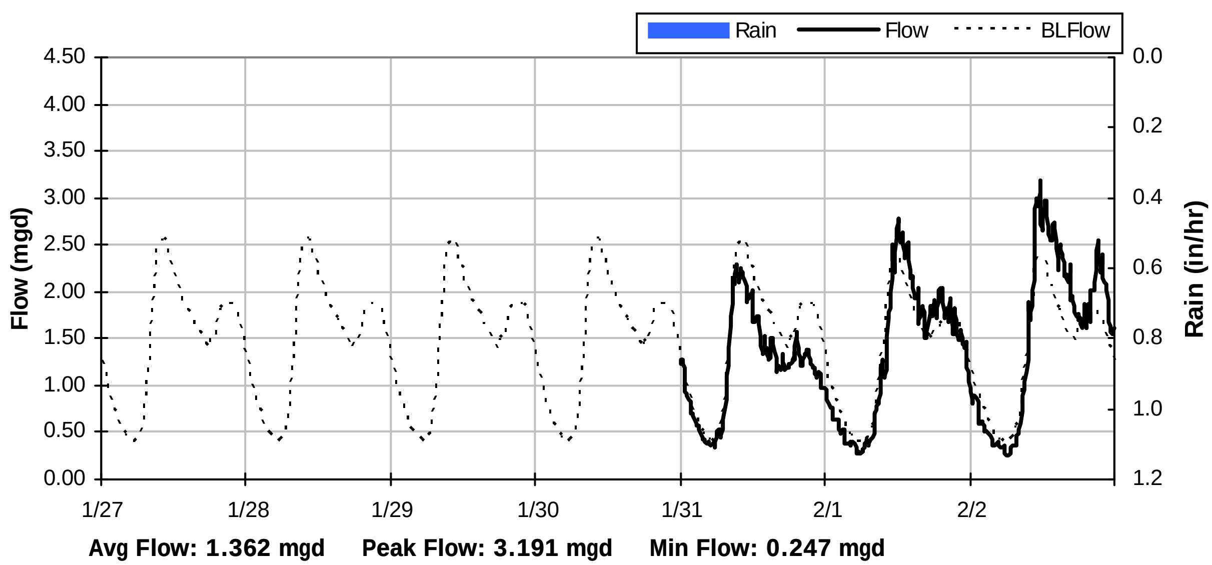
Storm Event I/I Analysis (Rain = 1.09 inches)

Capacity		Inflow / Infiltration	
Peak Flow:	2.86 *mgd*	**Peak I/I Rate:**	0.58 *mgd*
PF:	2.01	**Total I/I:**	268,000 *gallons*

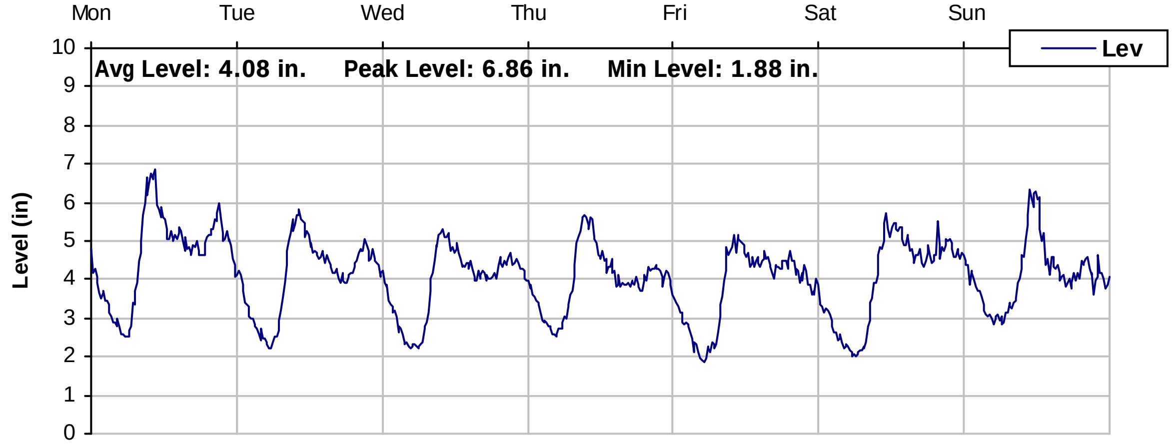
SITE 5
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

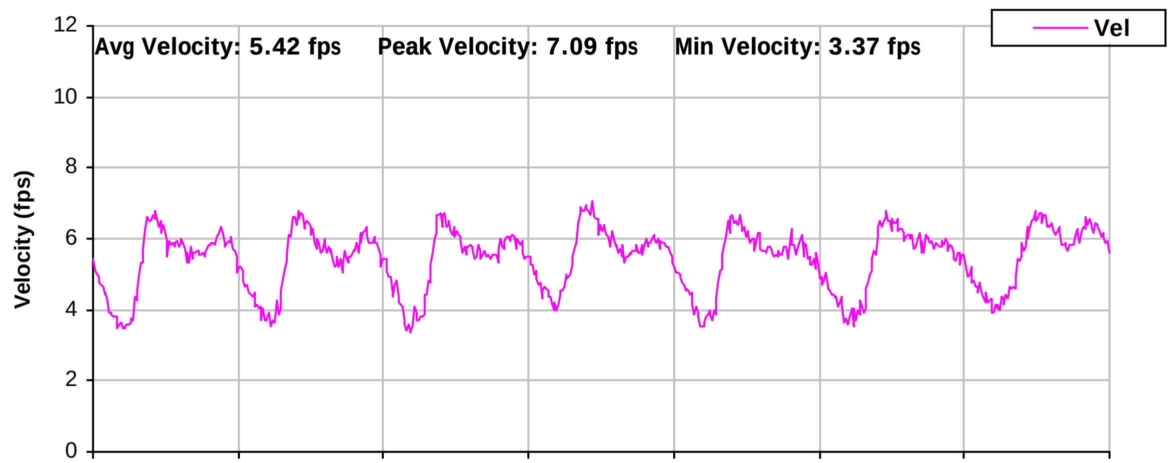


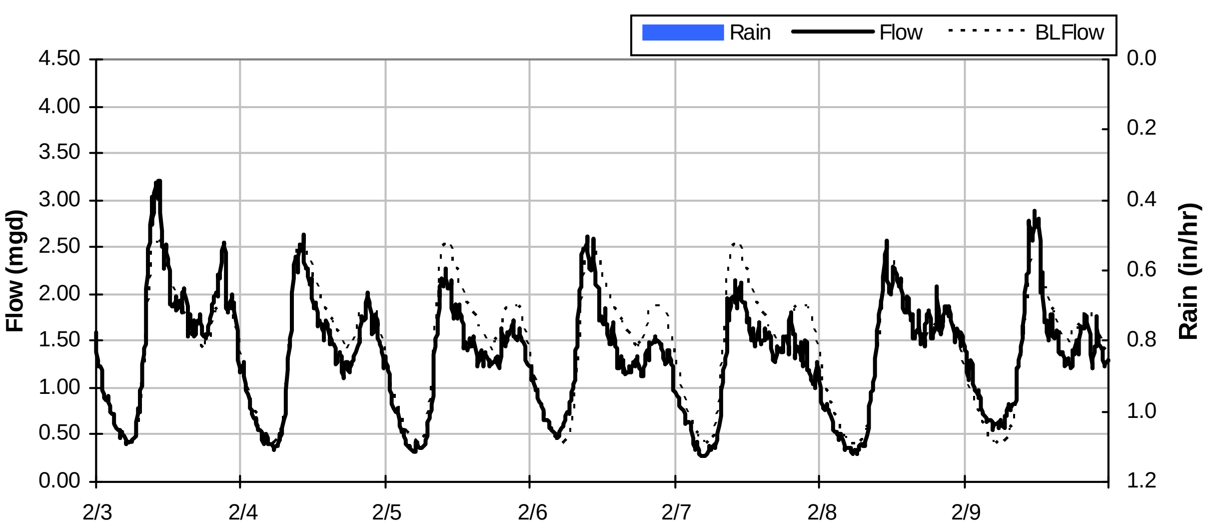




SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

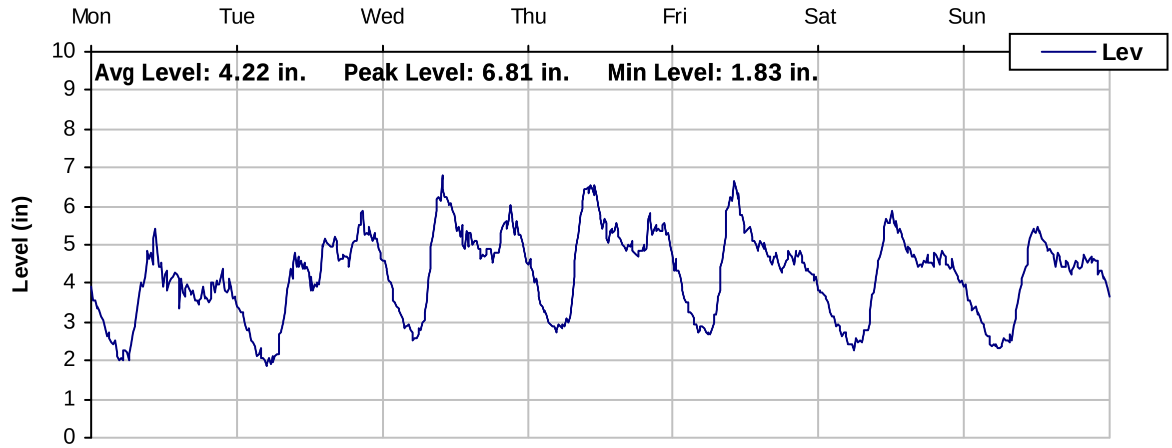


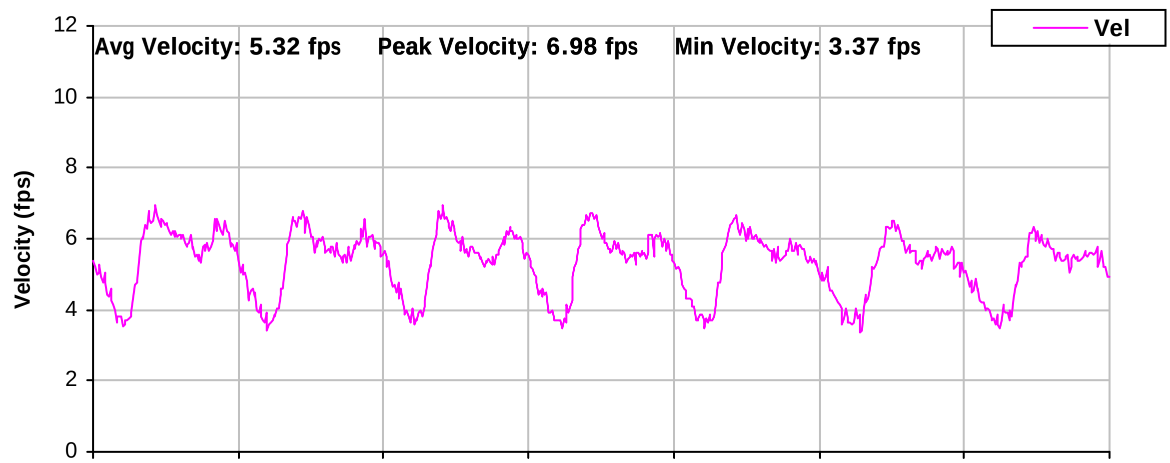


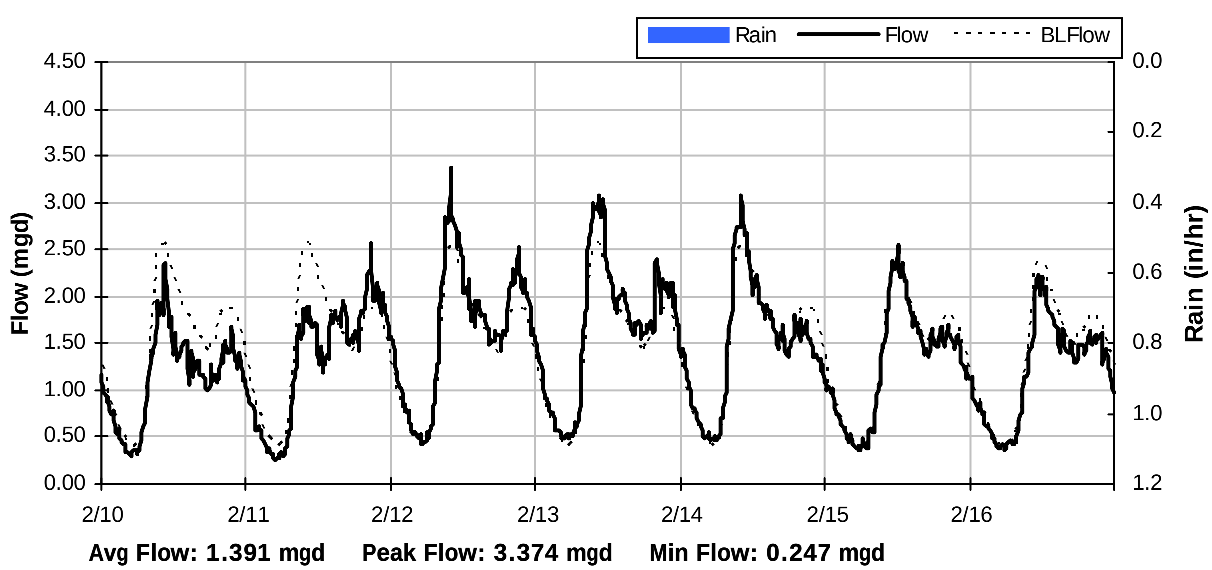


Avg Flow: 1.345 mgd **Peak Flow: 3.207 mgd** **Min Flow: 0.268 mgd**

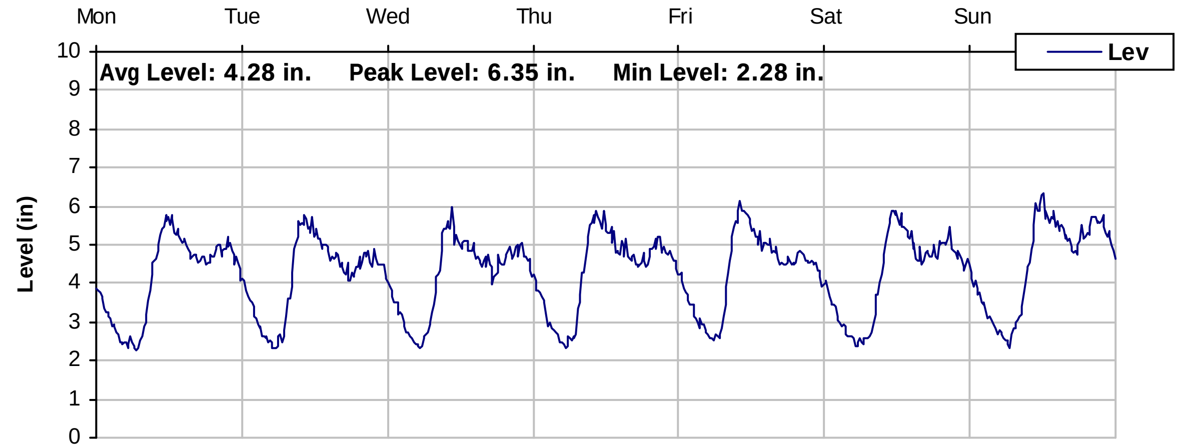
SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

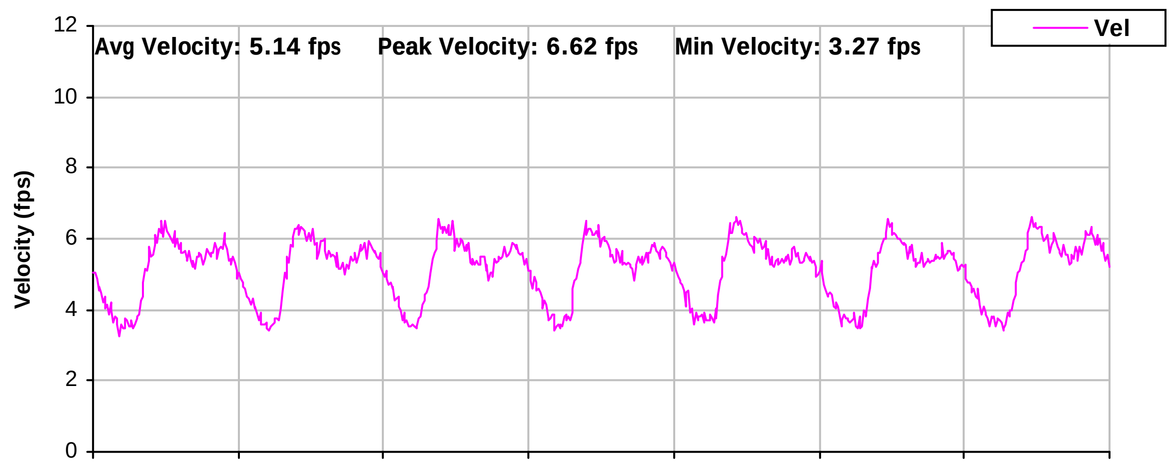


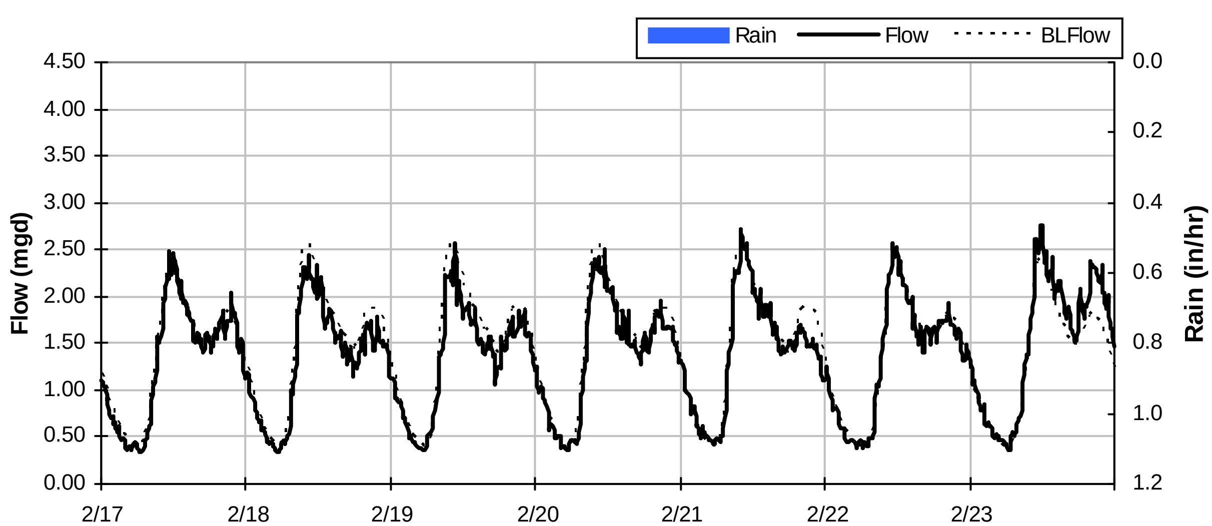




SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

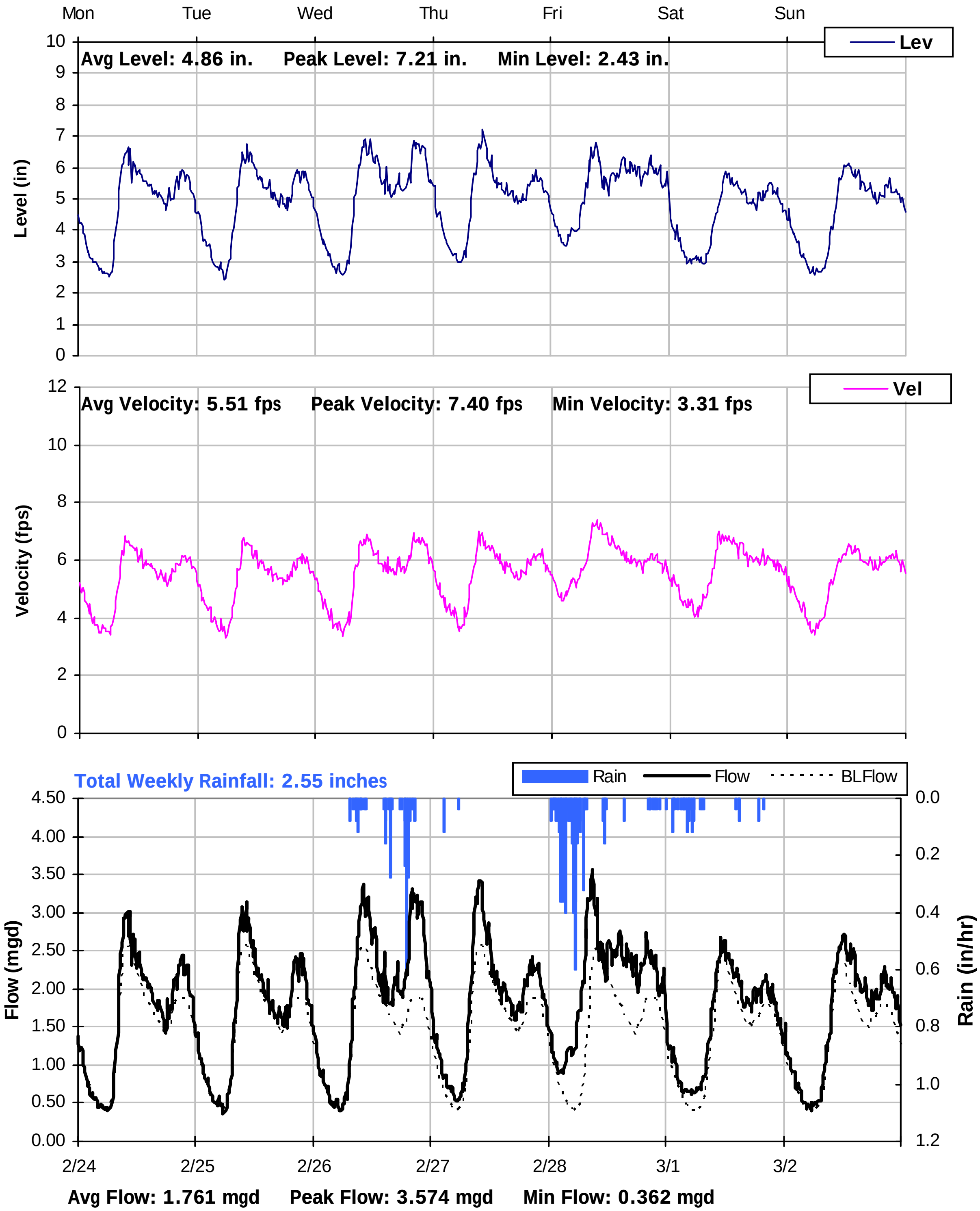




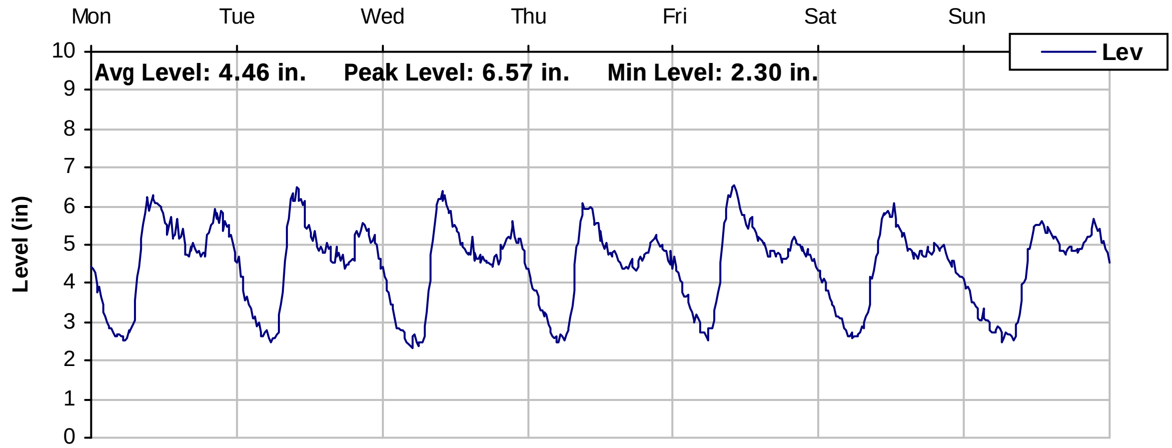


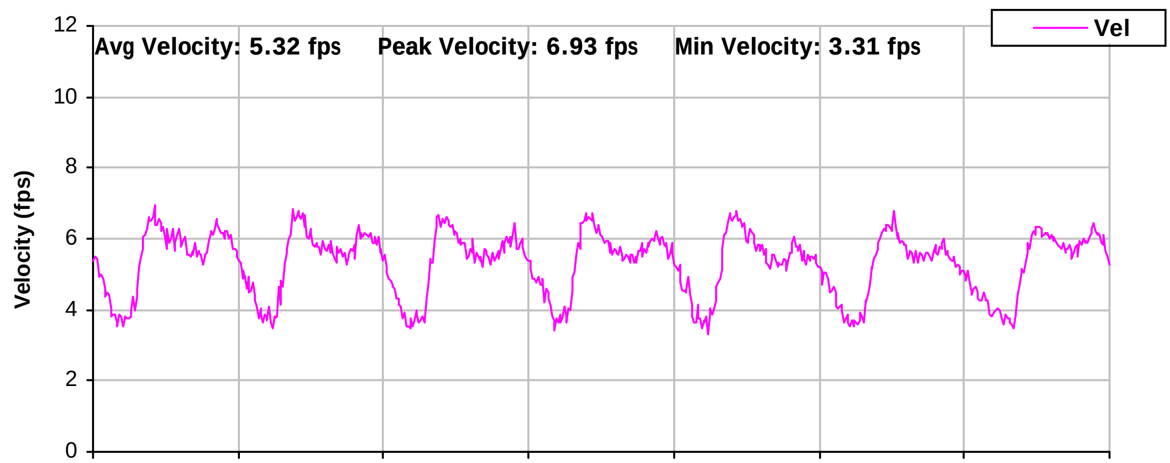
Avg Flow: 1.374 mgd **Peak Flow: 2.757 mgd** **Min Flow: 0.346 mgd**

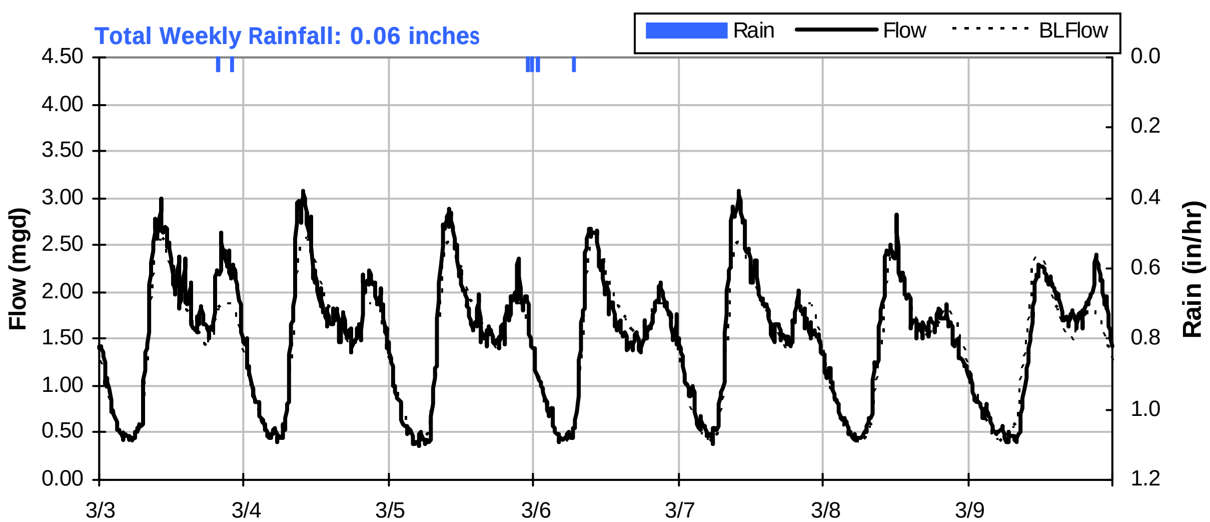
SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



SITE 5
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

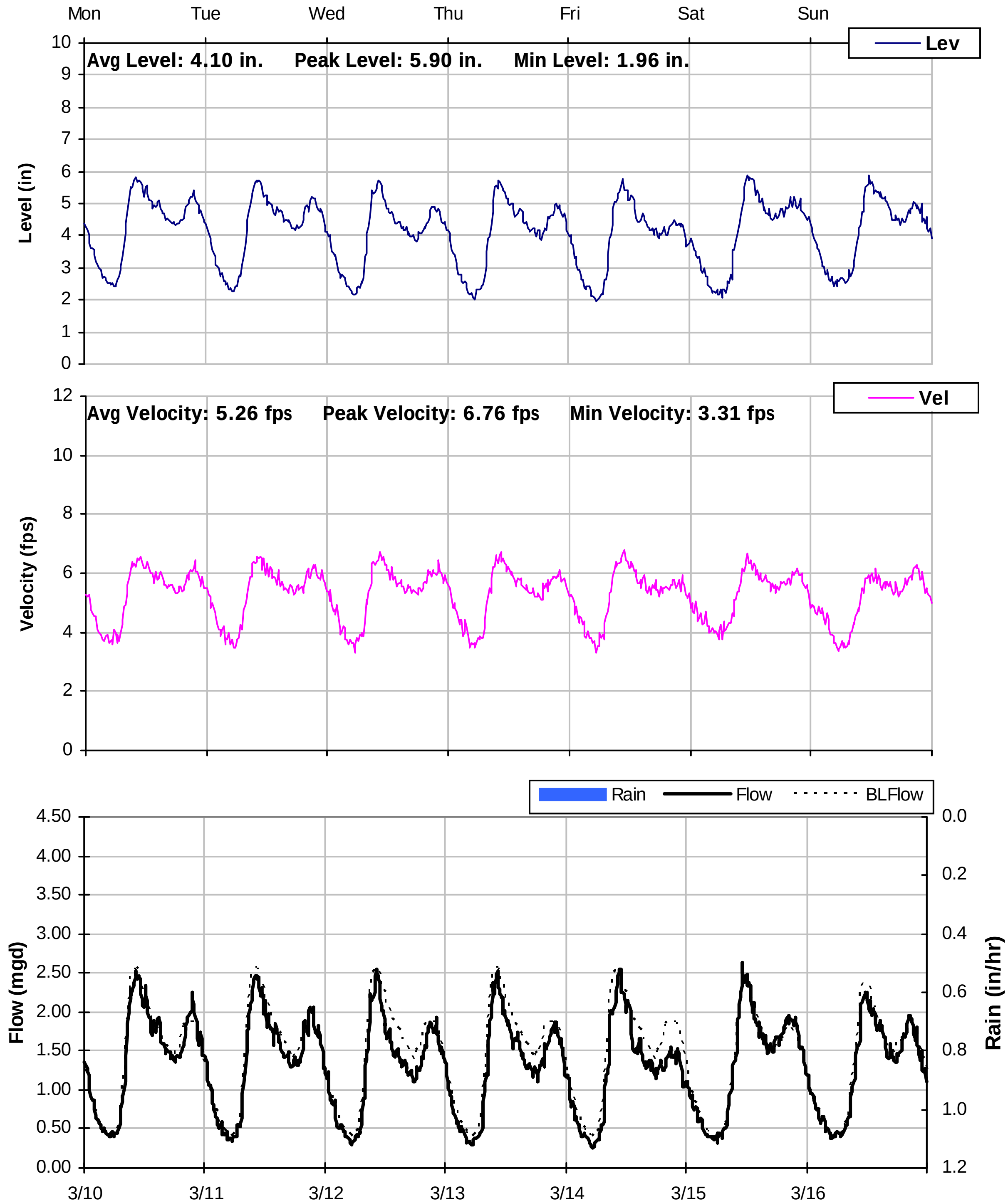






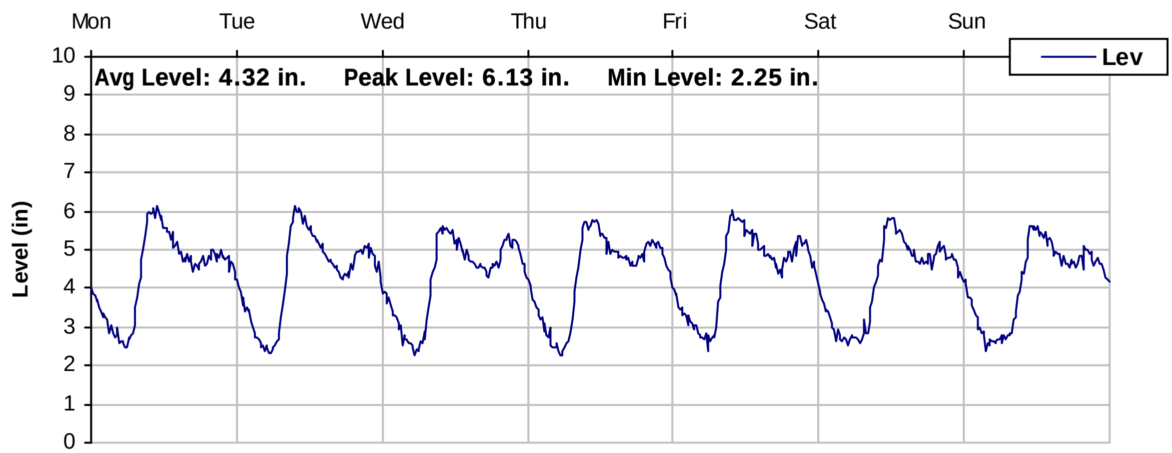
Avg Flow: 1.508 mgd Peak Flow: 3.080 mgd Min Flow: 0.356 mgd

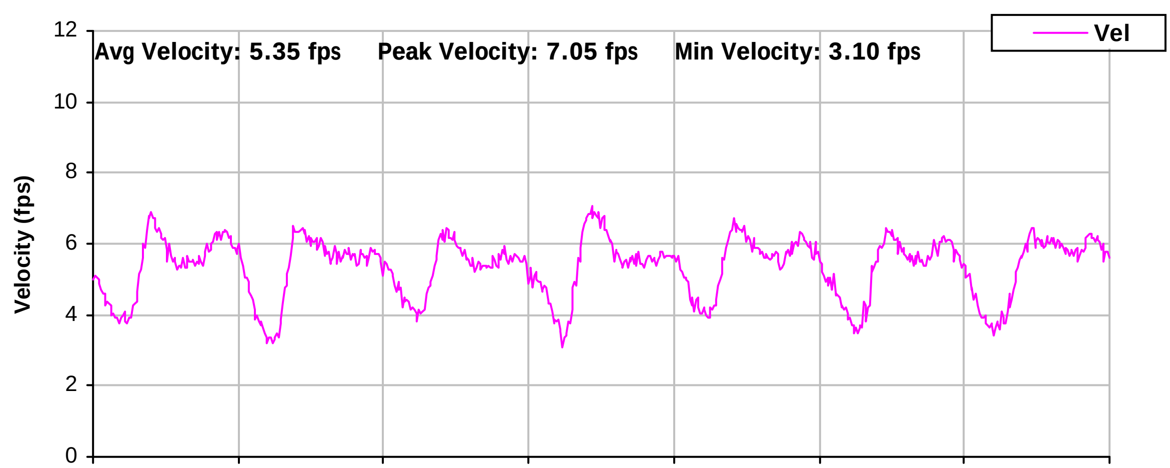
SITE 5
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014

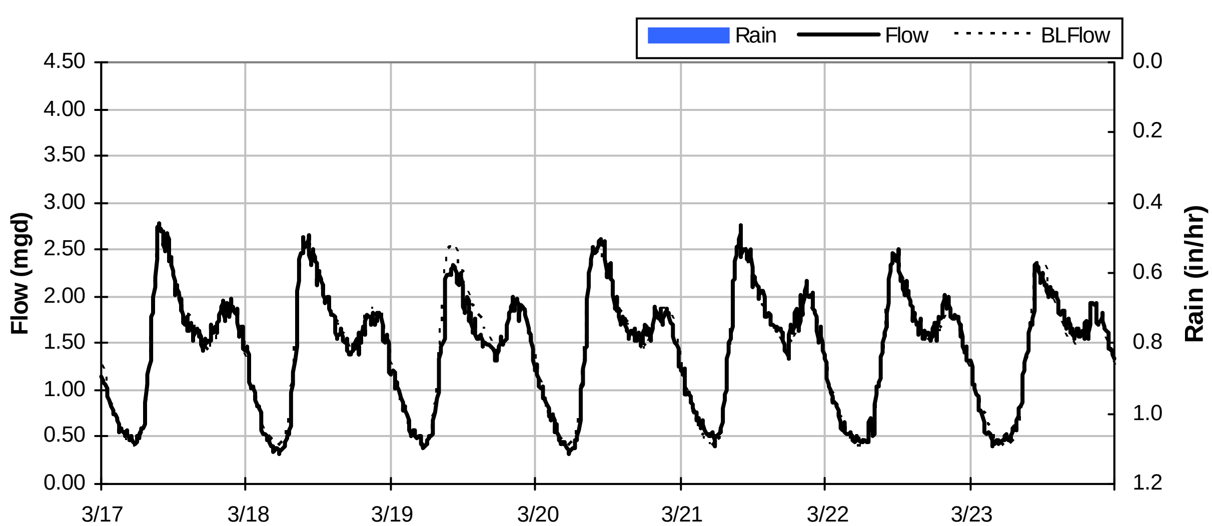


Avg Flow: 1.327 mgd **Peak Flow: 2.632 mgd** **Min Flow: 0.264 mgd**

SITE 5
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014

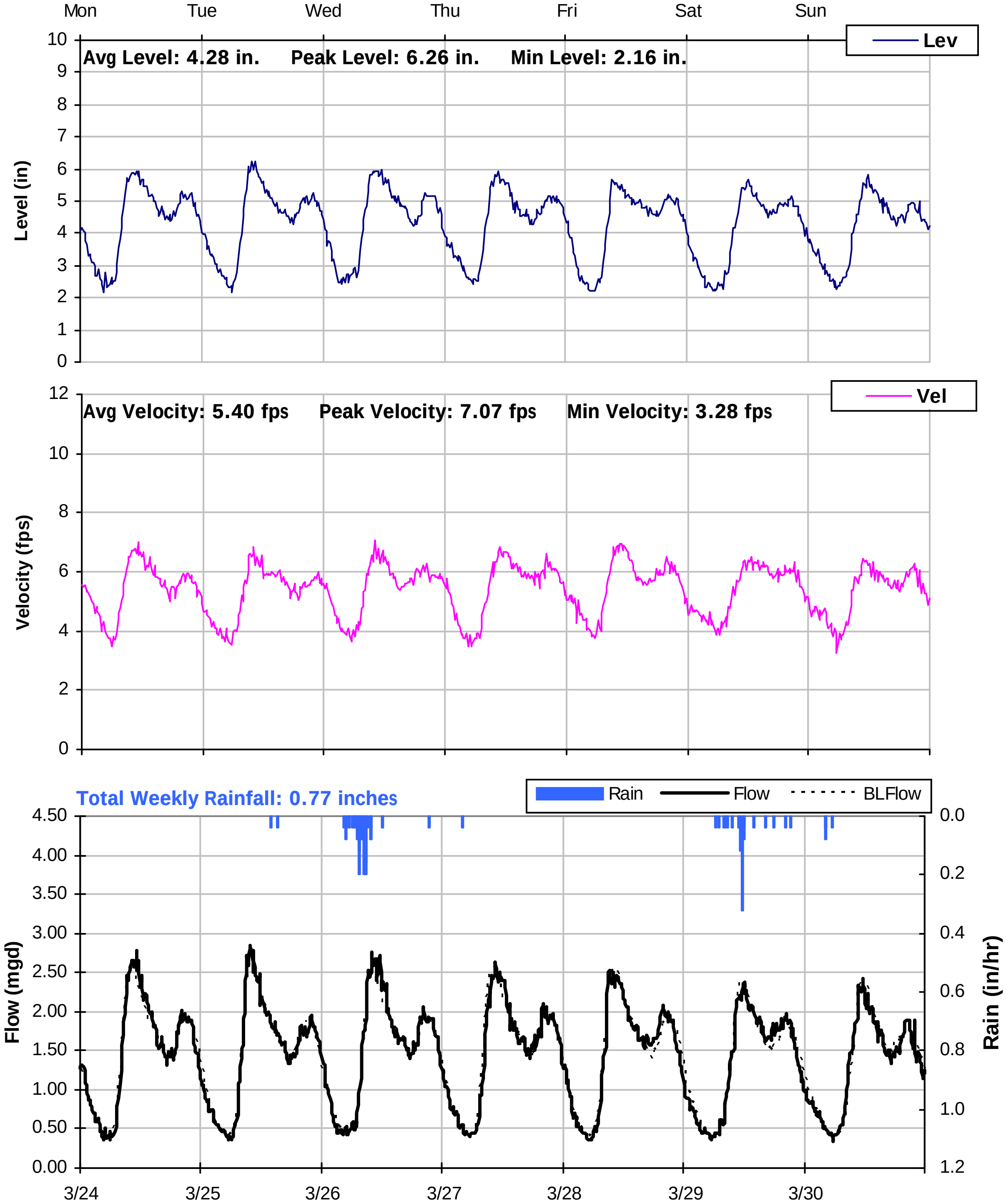






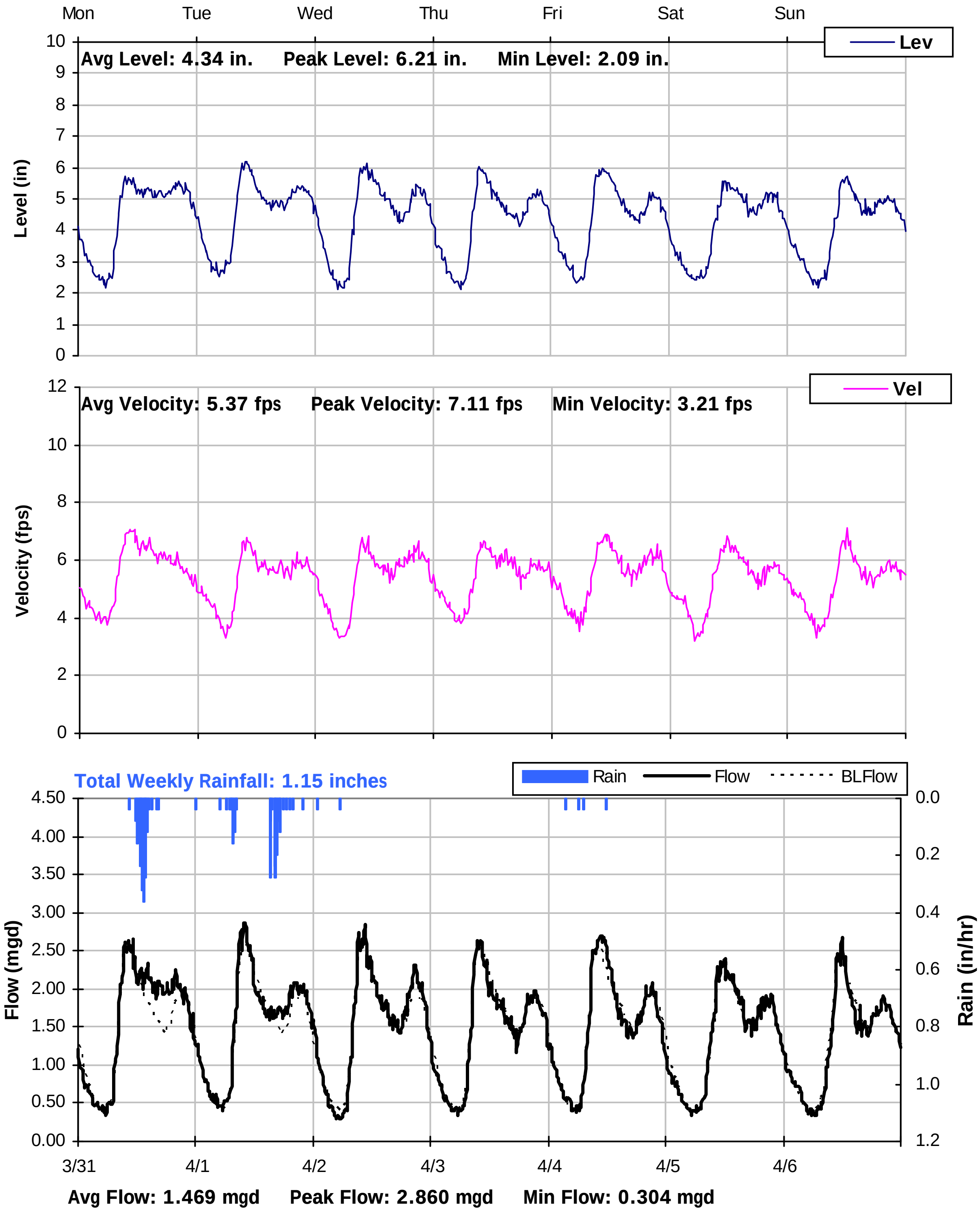
Avg Flow: 1.441 mgd **Peak Flow: 2.775 mgd** **Min Flow: 0.310 mgd**

SITE 5
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

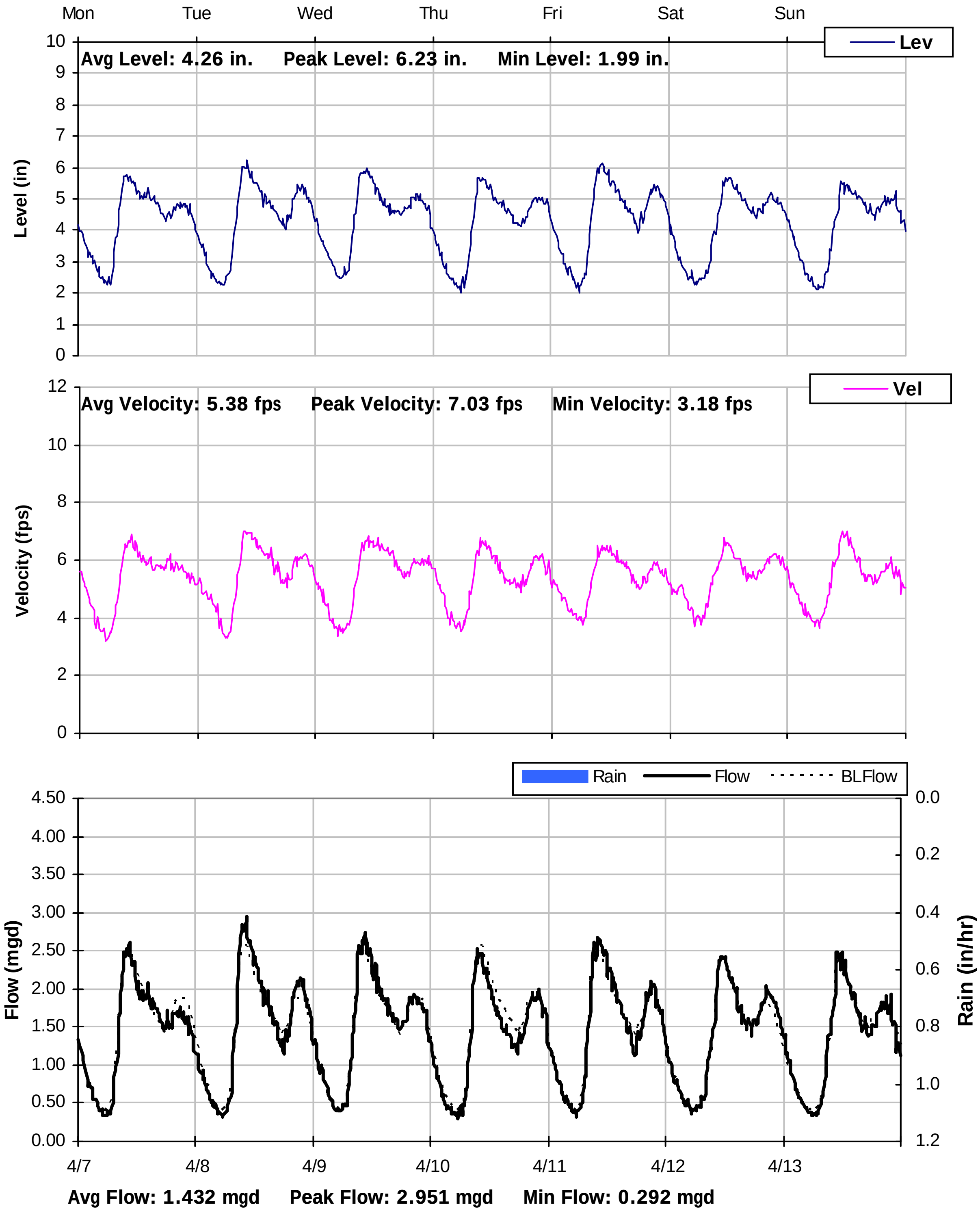


Avg Flow: 1.443 mgd **Peak Flow: 2.836 mgd** **Min Flow: 0.329 mgd**

SITE 5
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 5
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 6

Location: Willow Road, northeast of Alma Street

Data Summary Report

SITE 6

Site Information

Location: Willow Road, northeast of Alma Street

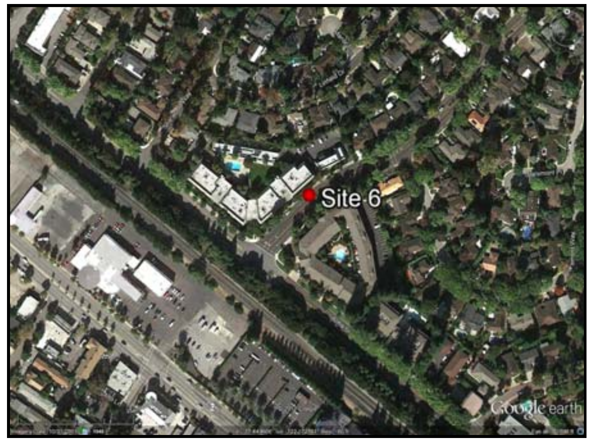
Coordinates: 122.1724° W, 37.4498° N

Rim Elevation: 60 feet

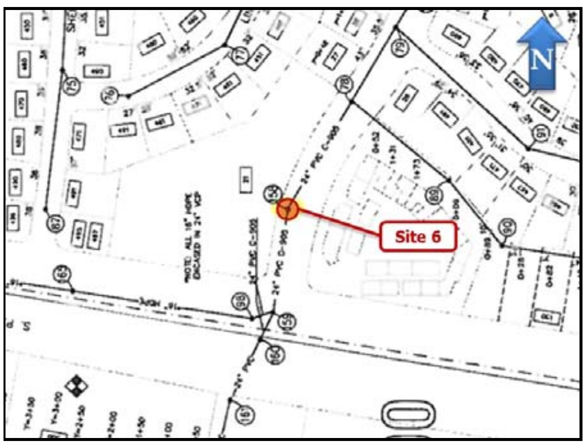
Pipe Diameter: 23.25 inches

Baseline Flow: 1.154 mgd

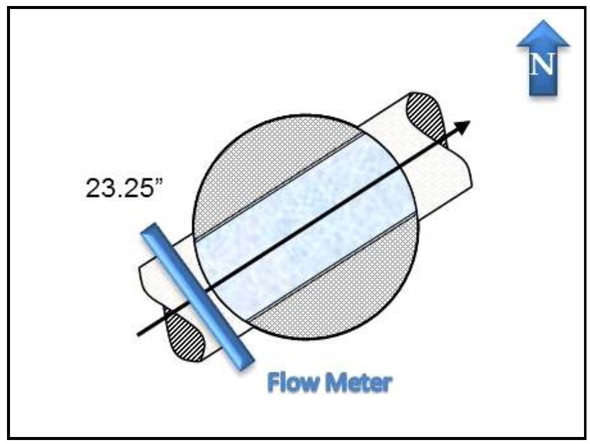
Peak Measured Flow: 2.849 mgd



Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

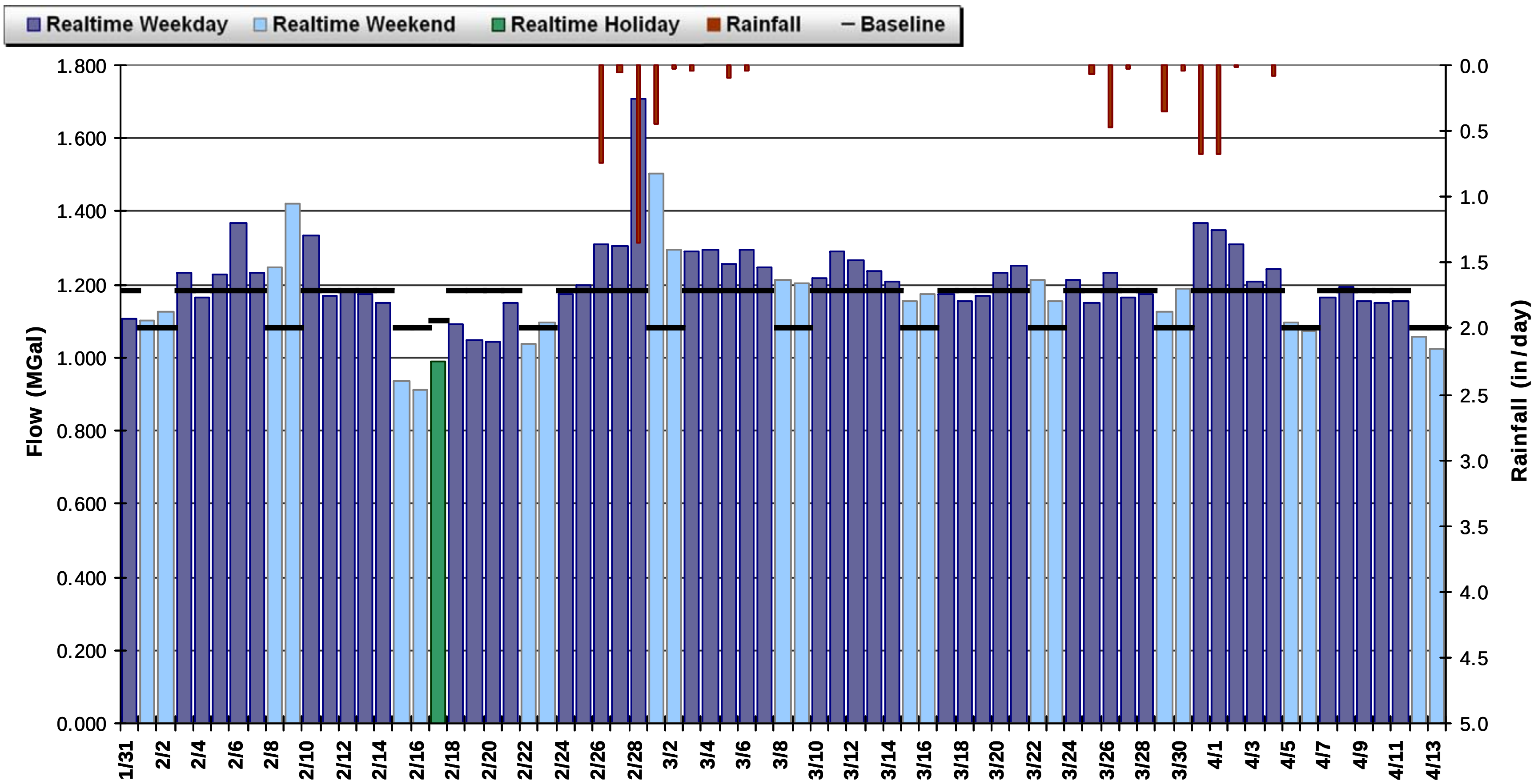
Plan View

SITE 6

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.199 MGal **Peak Daily Flow: 1.710 MGal** **Min Daily Flow: 0.910 MGal**

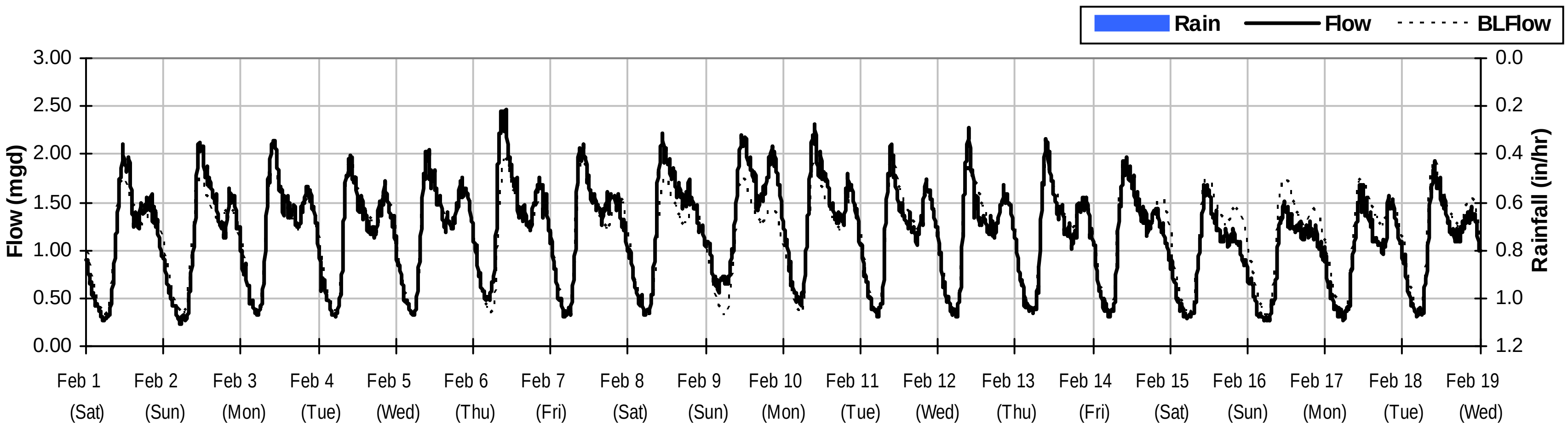
Total Period Rainfall: 5.18 inches

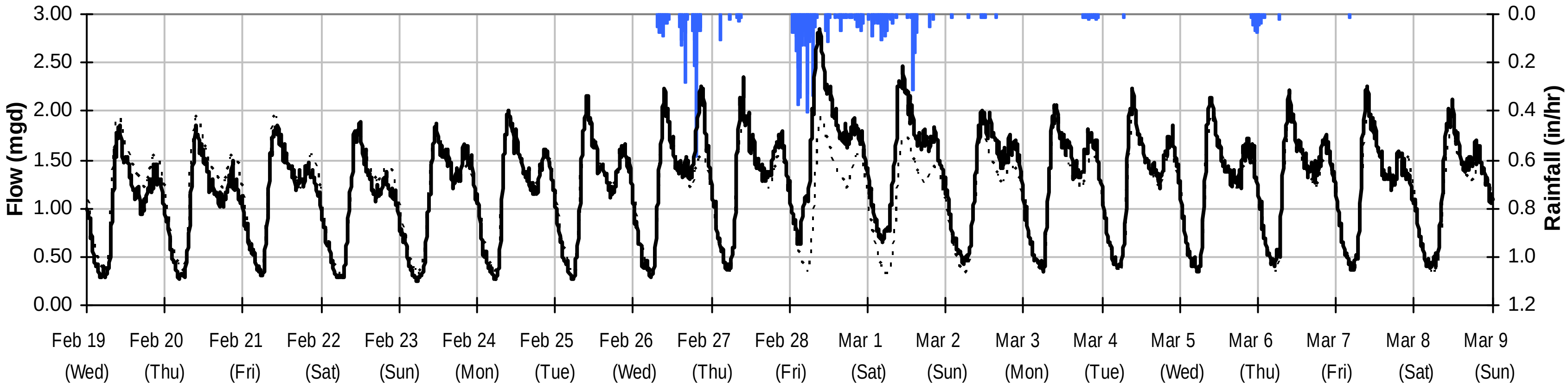


SITE 6

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 5.18 inches **Avg Flow: 1.199 mgd** **Peak Flow: 2.849 mgd** **Min Flow: 0.230 mgd**

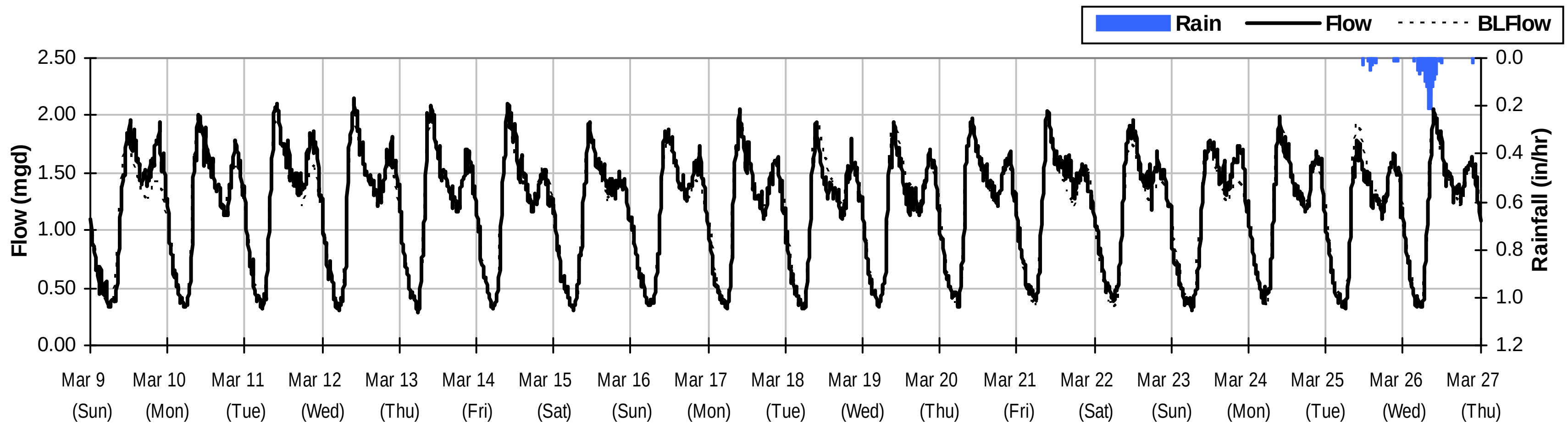


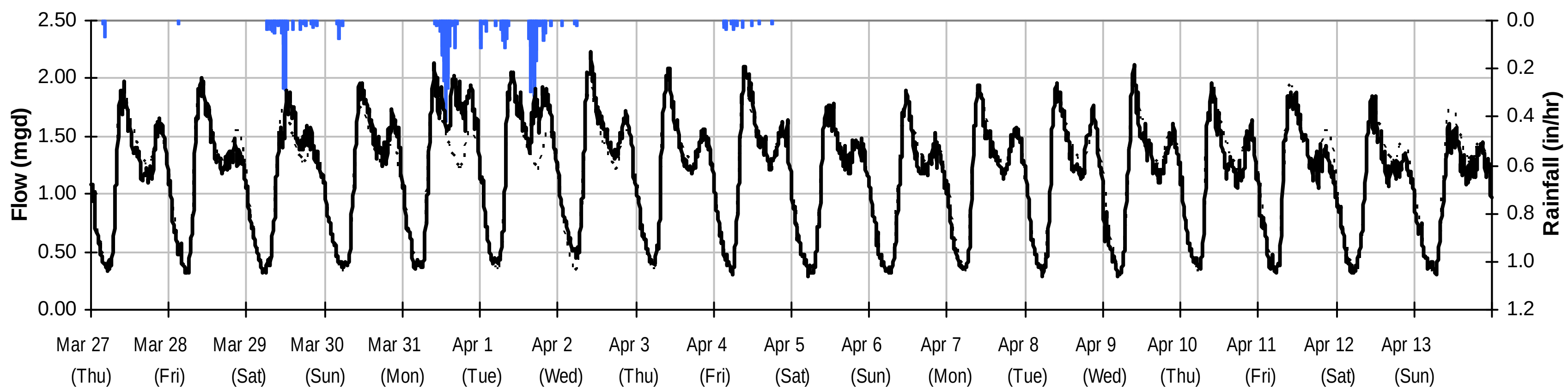


SITE 6

Period Flow Summary: March 9 to April 14, 2014

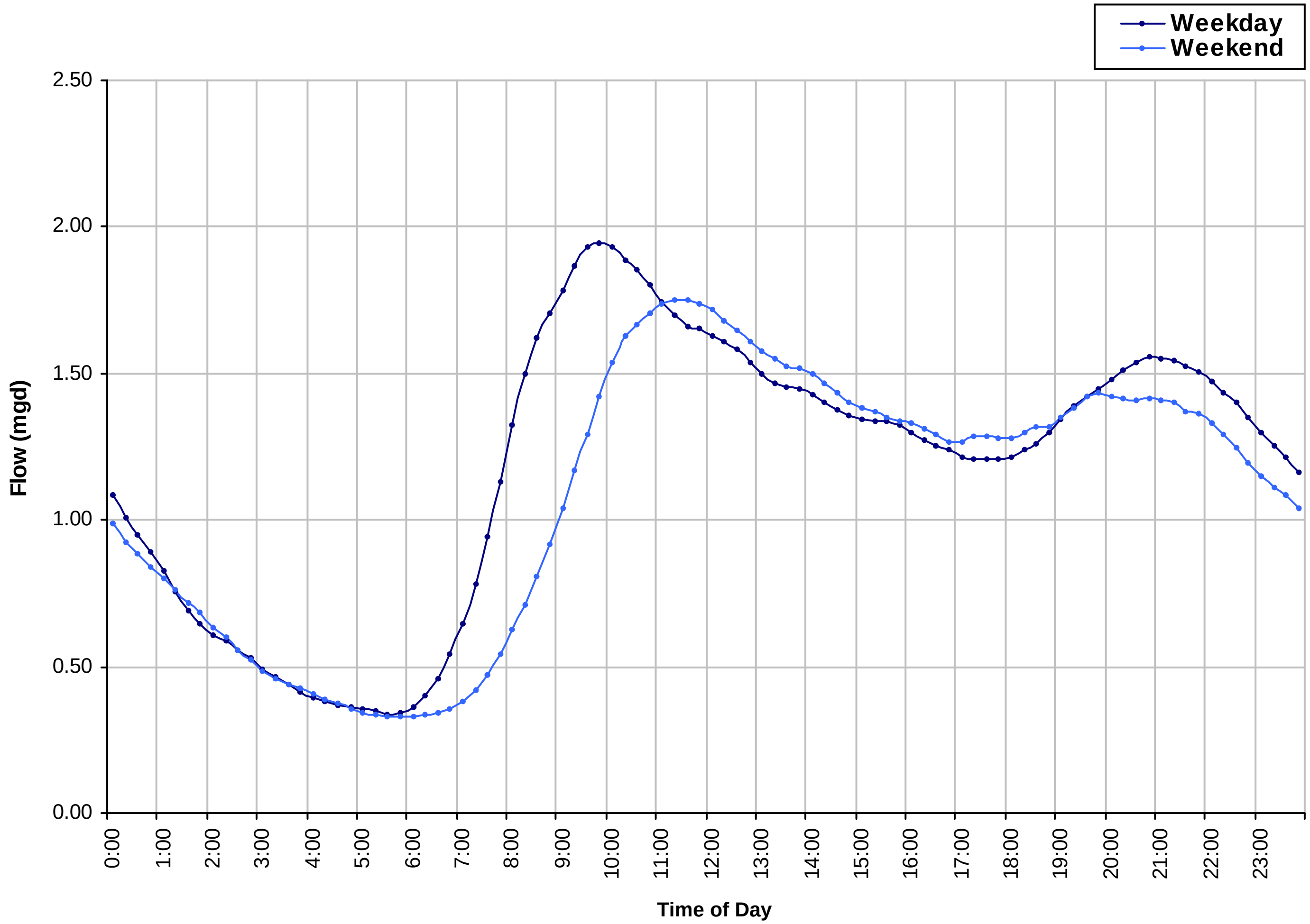
Total Monthly Rainfall: 5.18 inches **Avg Flow: 1.199 mgd** **Peak Flow: 2.849 mgd** **Min Flow: 0.230 mgd**



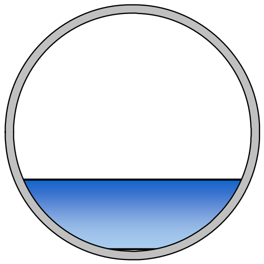


SITE 6

Baseline Flow Hydrographs

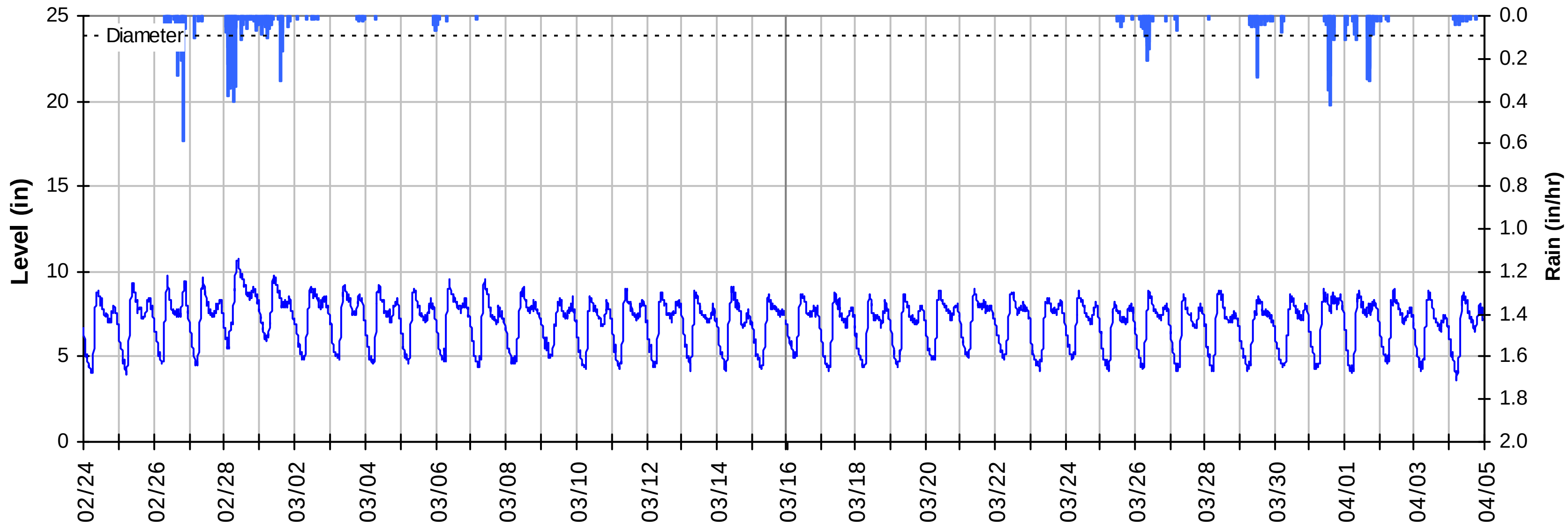


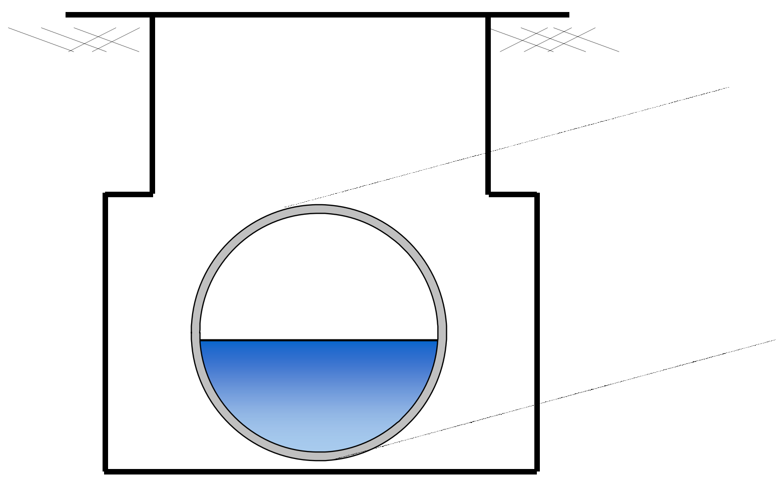
Baseline Flow:
1.154 *mgd*



SITE 6
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





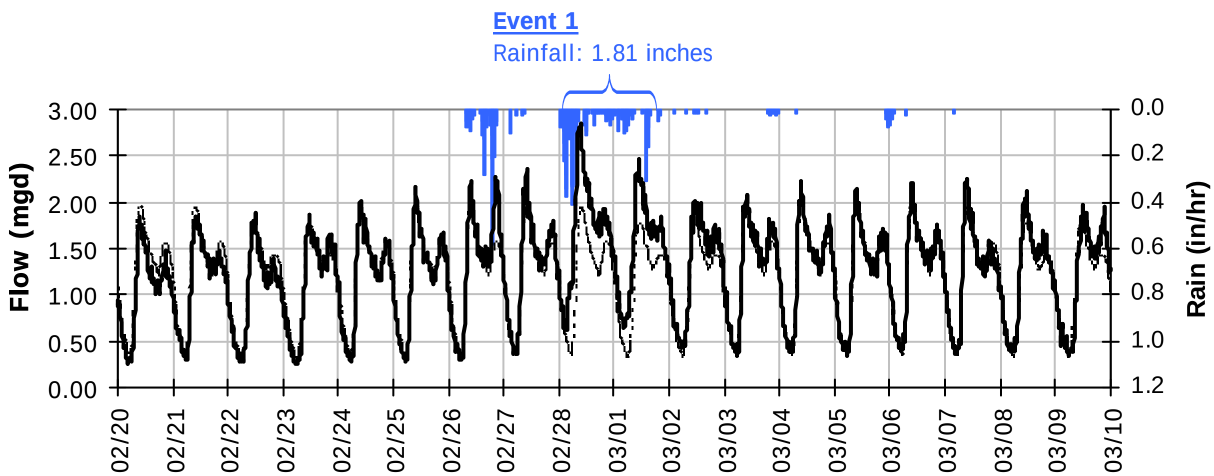
Pipe Diameter: 23.3 *inches*

Peak Measured Level: 10.8 *inches*

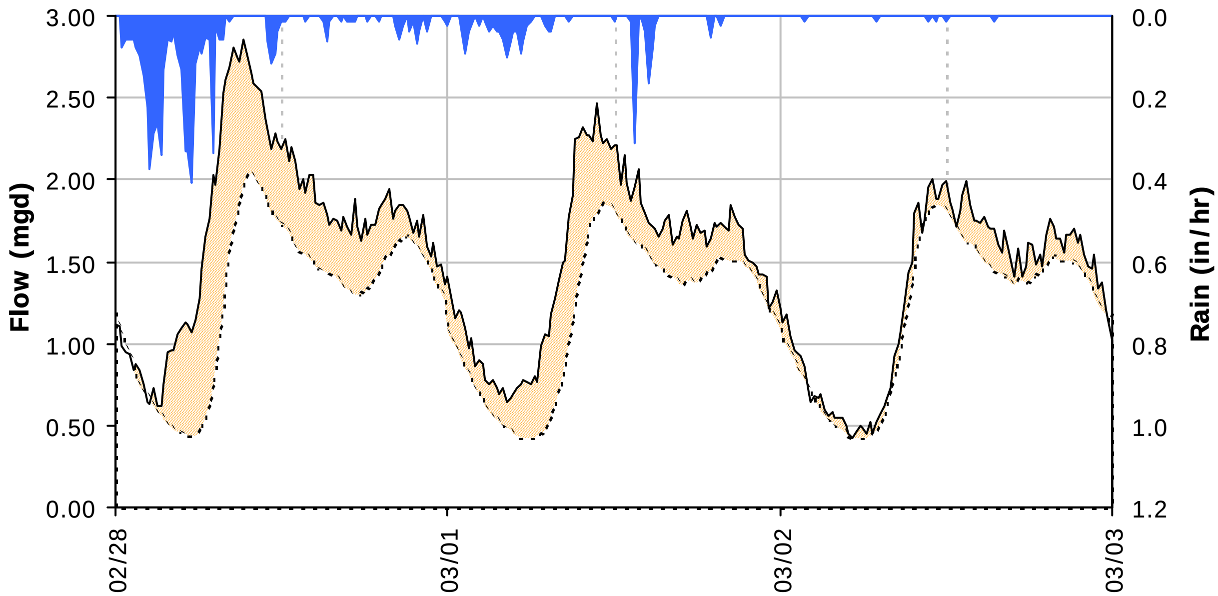
Peak d/D Ratio: 0.46

SITE 6
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

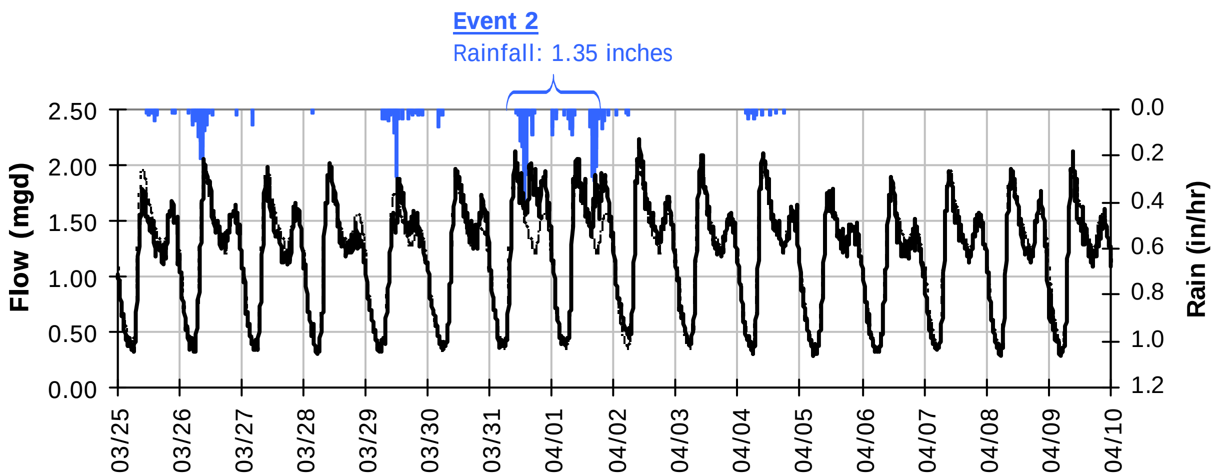


Storm Event I/I Analysis (Rain = 1.81 inches)

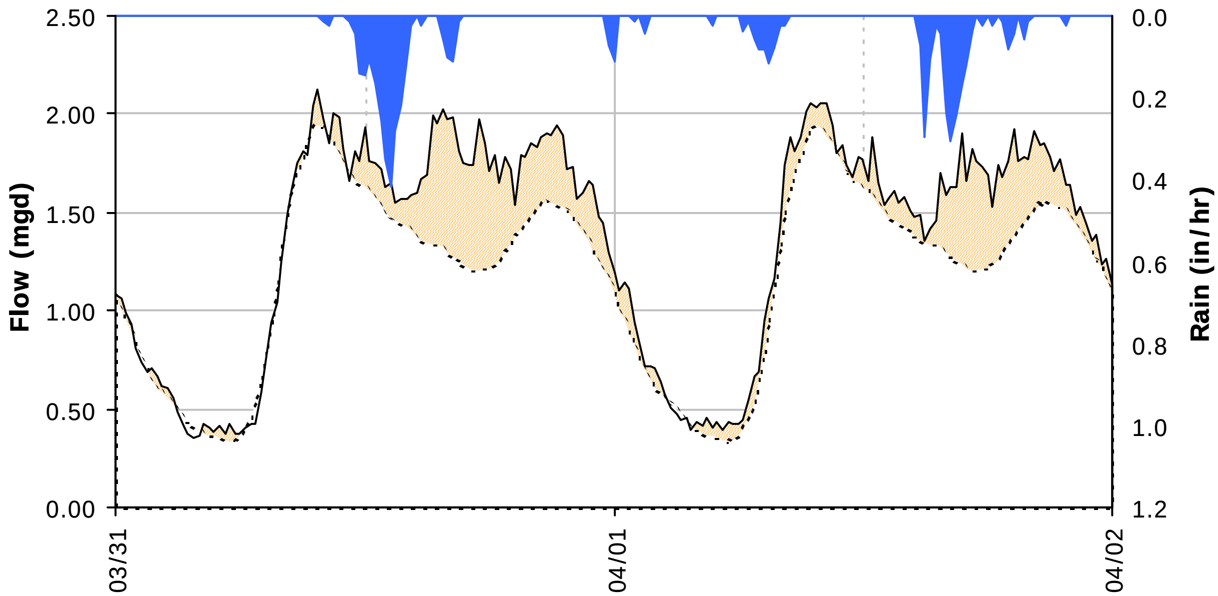
Capacity		**Inflow / Infiltration**	
Peak Flow:	2.85 *mgd*	**Peak I/I Rate:**	1.05 *mgd*
PF:	2.47	**Total I/I:**	692,000 *gallons*

SITE 6
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



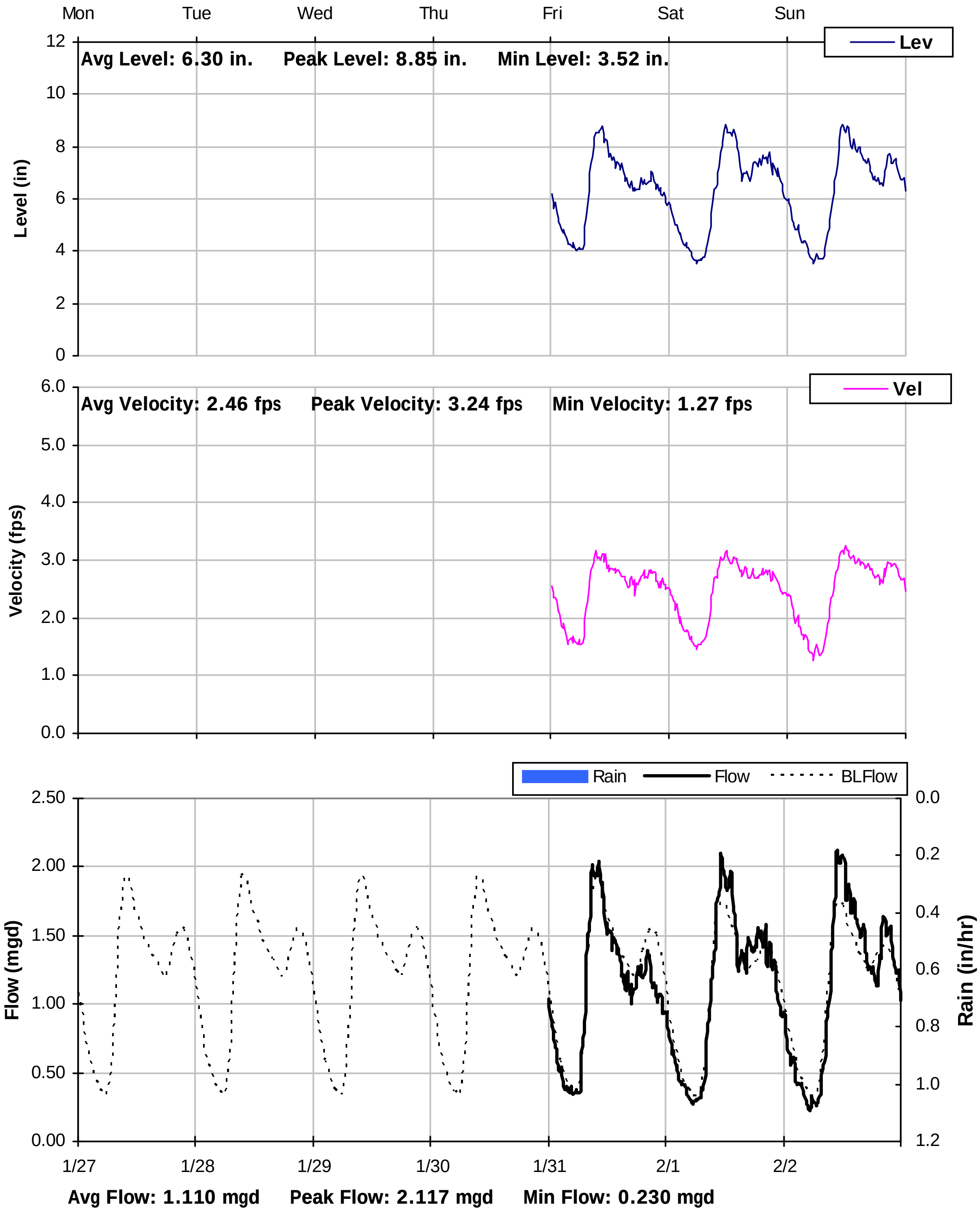
Event 2 Detail Graph



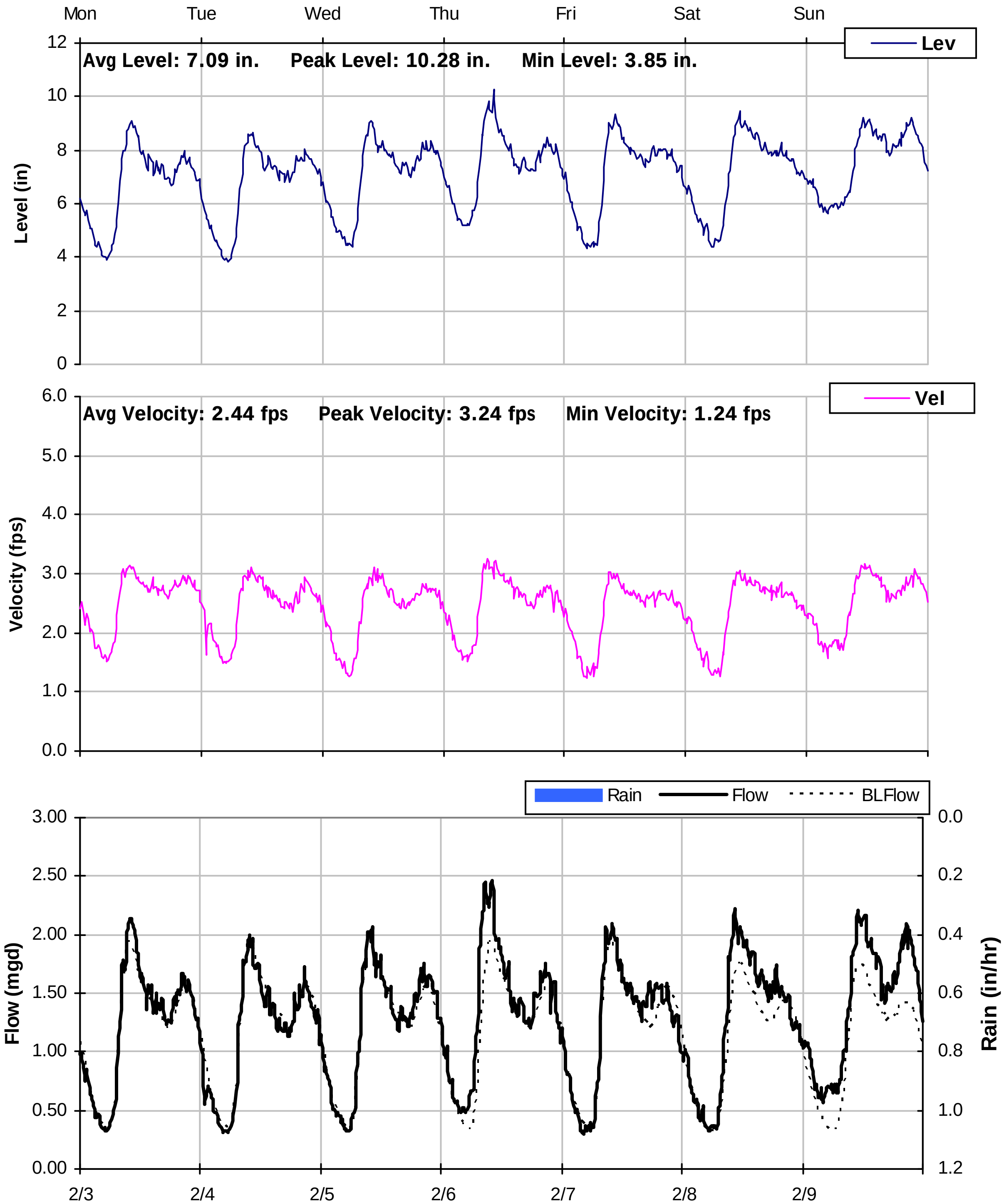
Storm Event I/I Analysis (Rain = 1.35 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	2.22 *mgd*	**Peak I/I Rate:**	0.76 *mgd*
PF:	1.93	**Total I/I:**	520,000 *gallons*

SITE 6
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

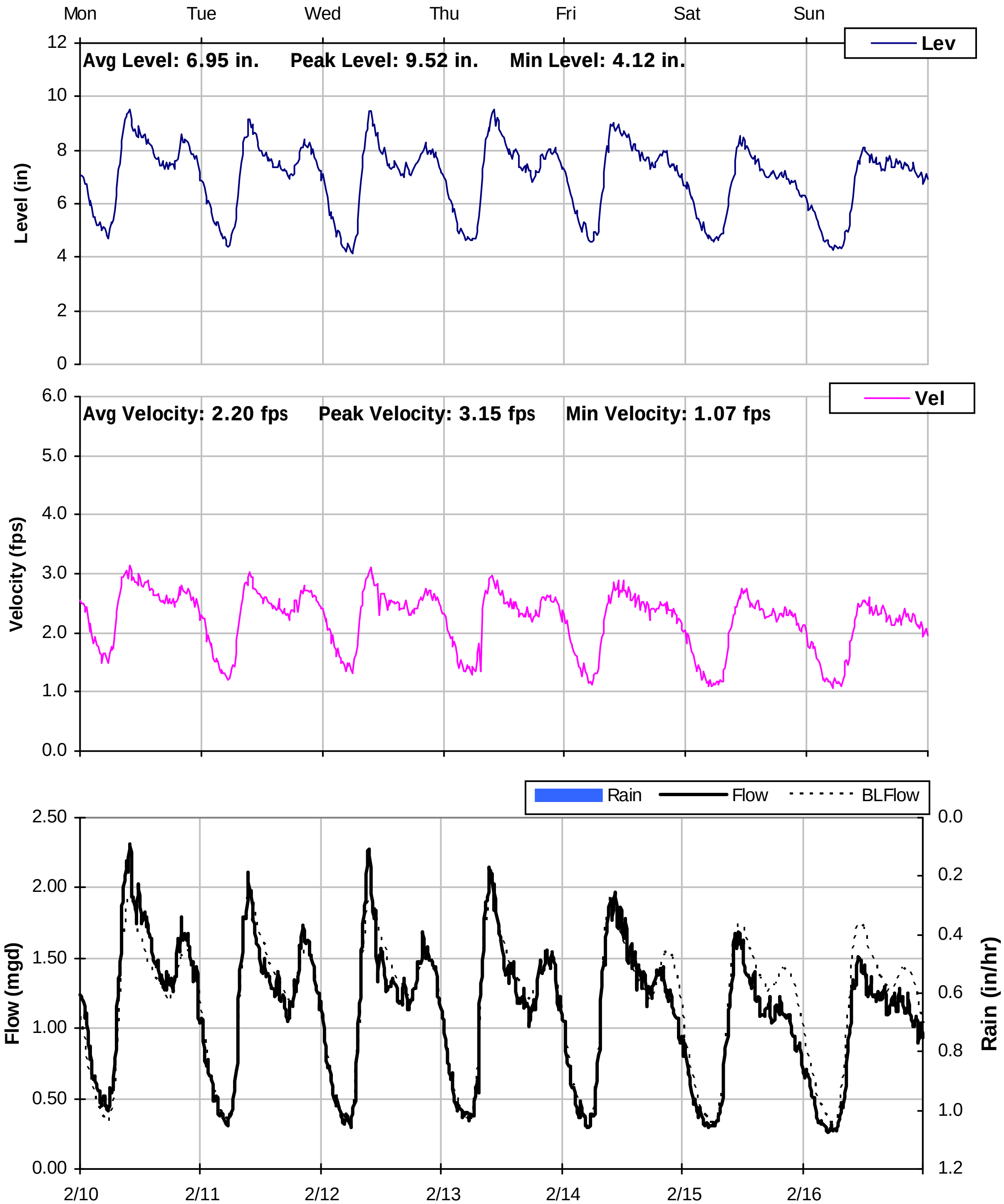


SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



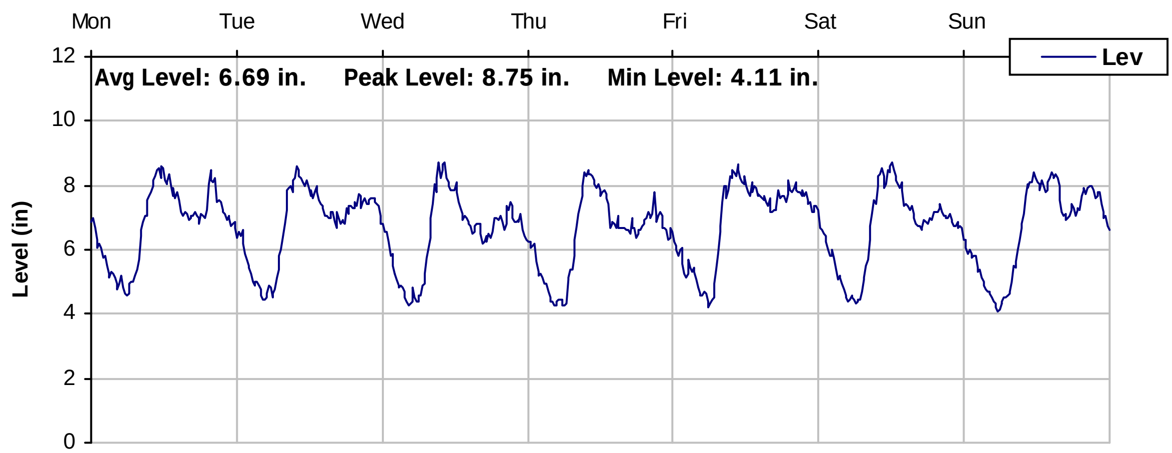
Avg Flow: 1.270 mgd **Peak Flow: 2.462 mgd** **Min Flow: 0.301 mgd**

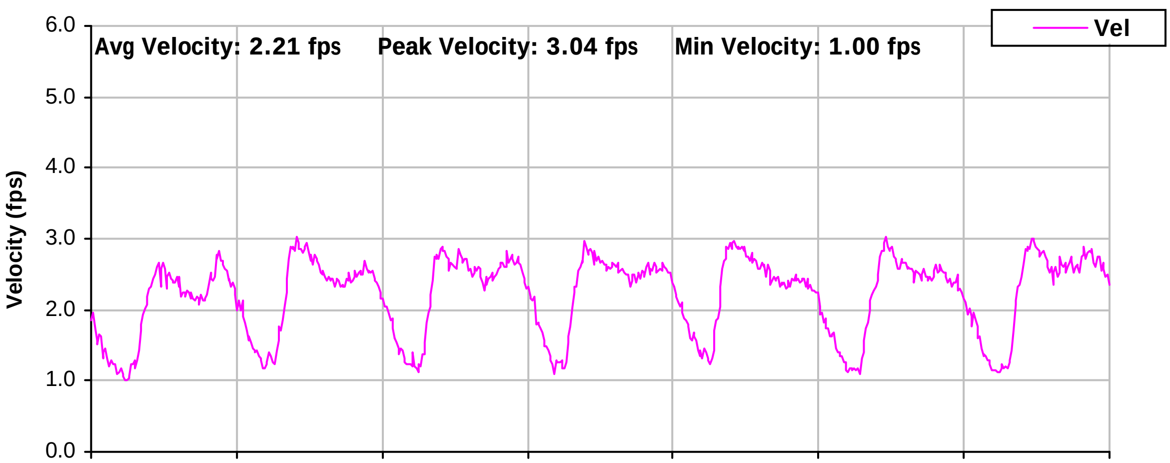
SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

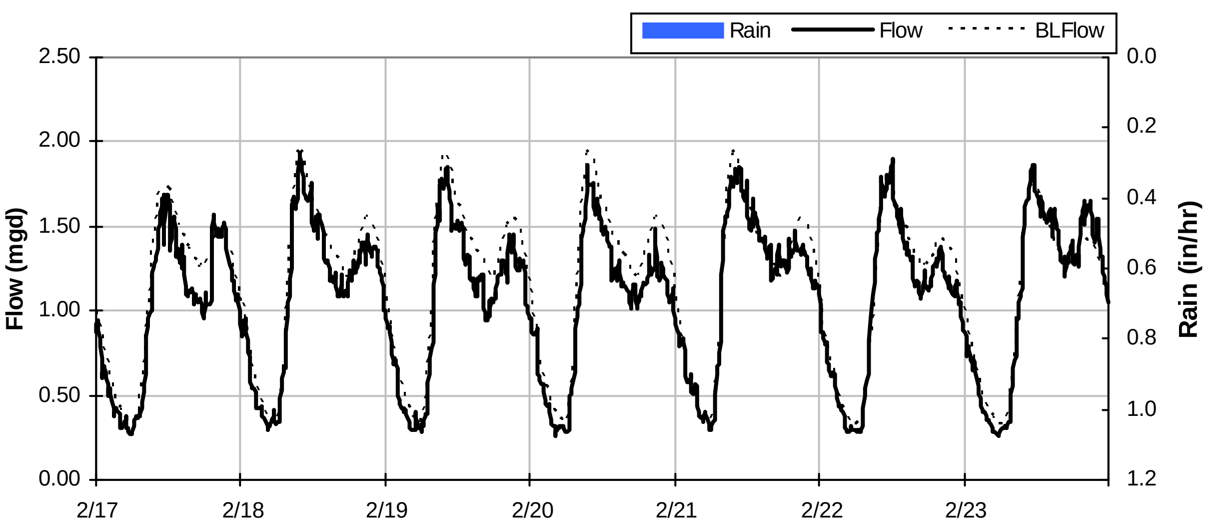


Avg Flow: 1.122 mgd **Peak Flow: 2.310 mgd** **Min Flow: 0.259 mgd**

SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

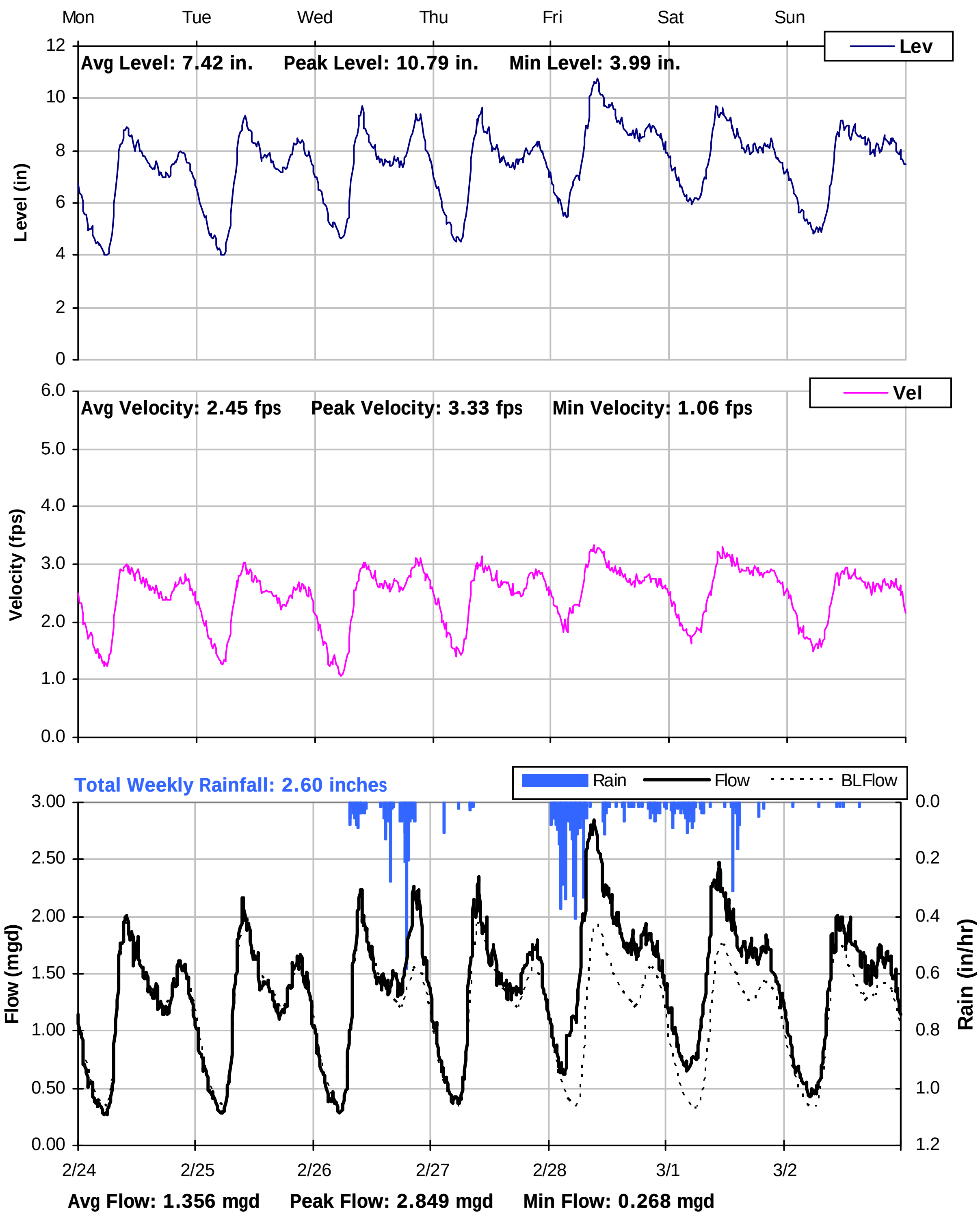




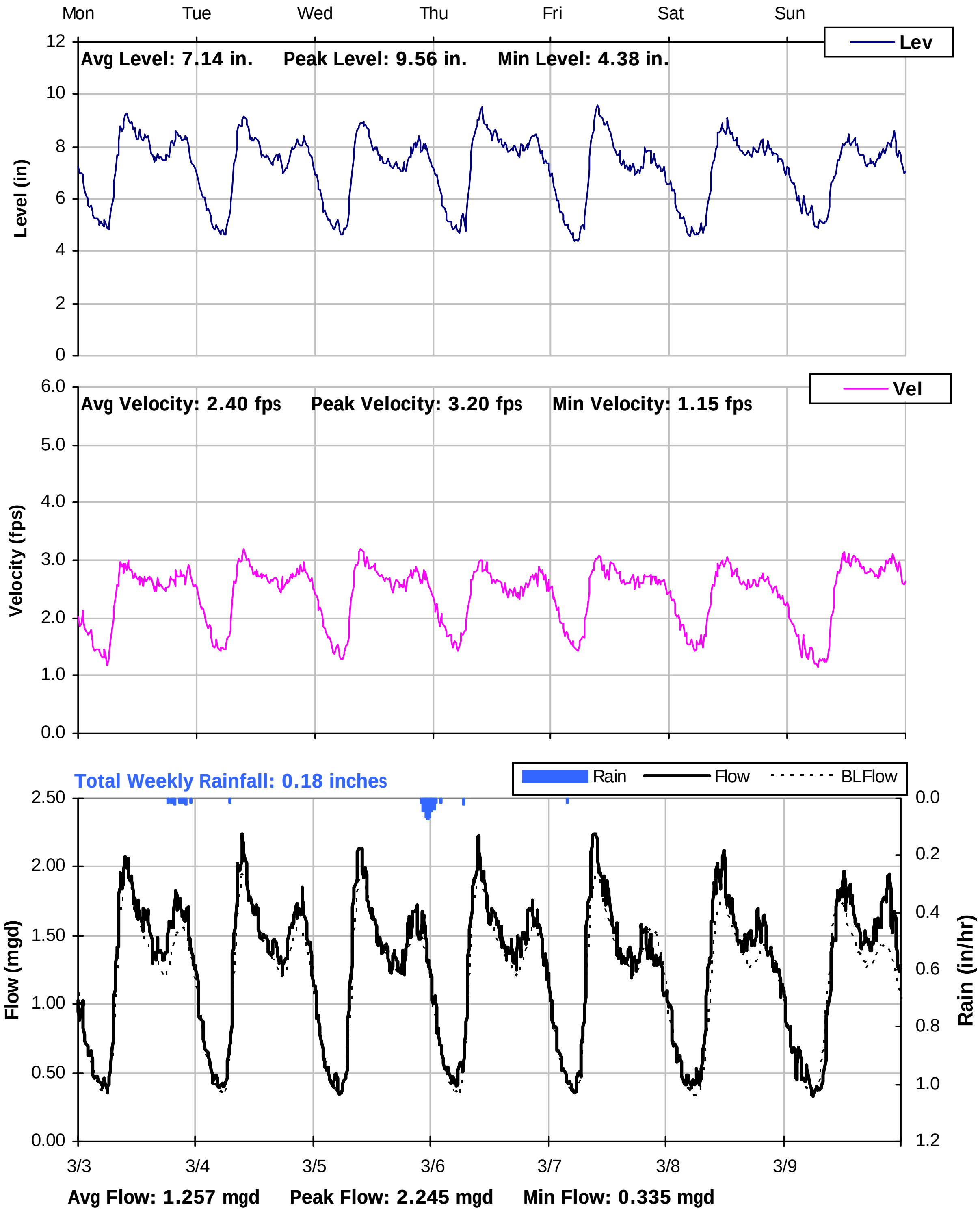


Avg Flow: 1.065 mgd **Peak Flow: 1.938 mgd** **Min Flow: 0.255 mgd**

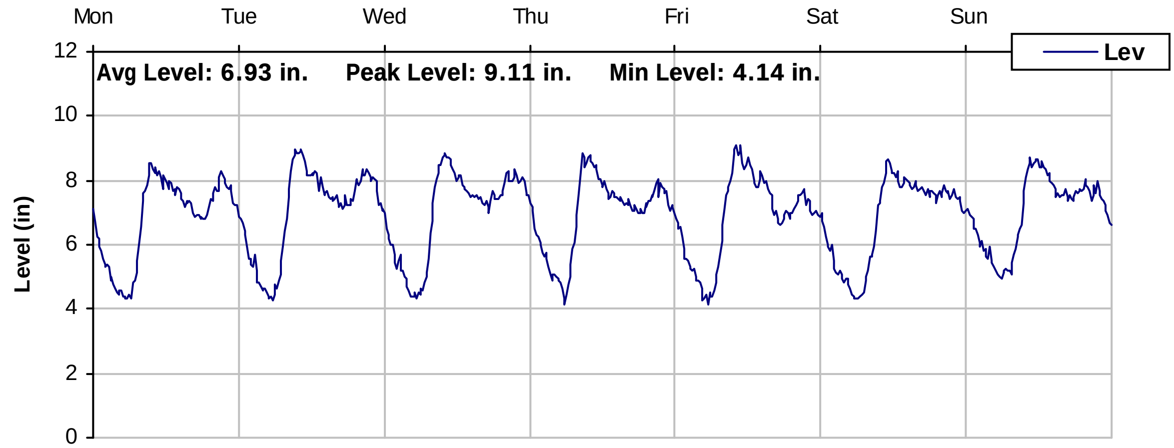
SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014

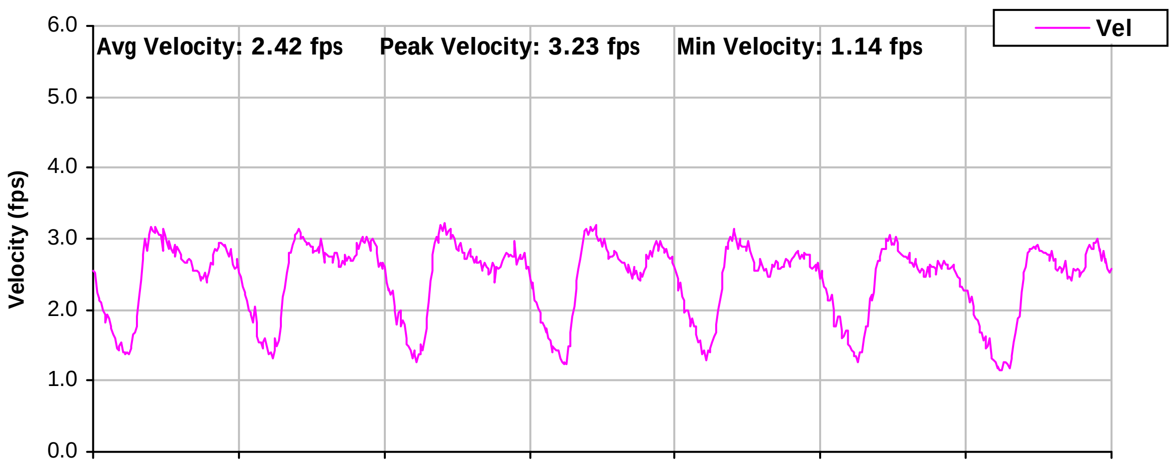


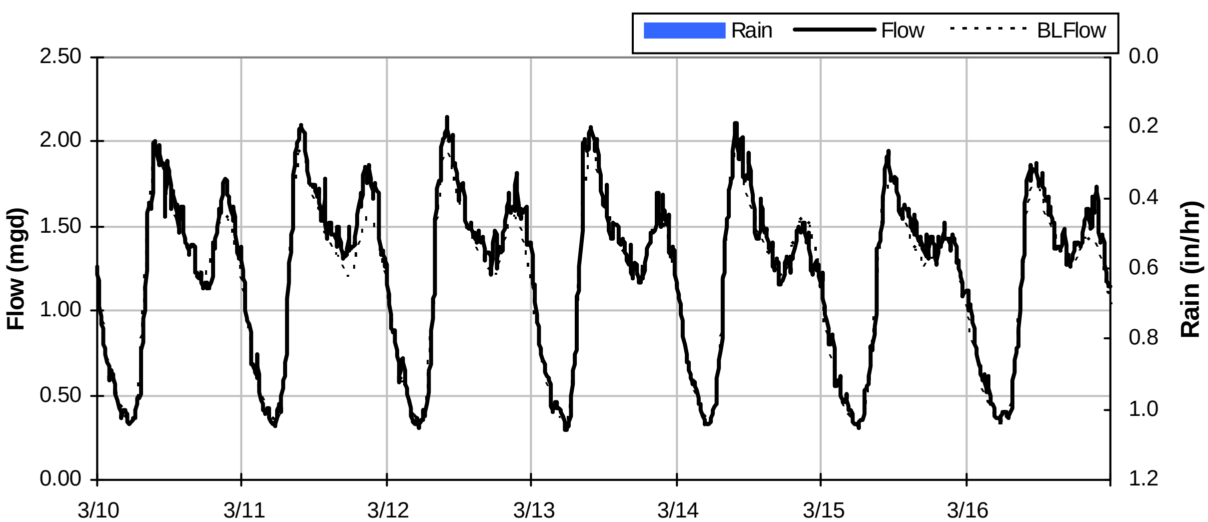
SITE 6
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



SITE 6
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014

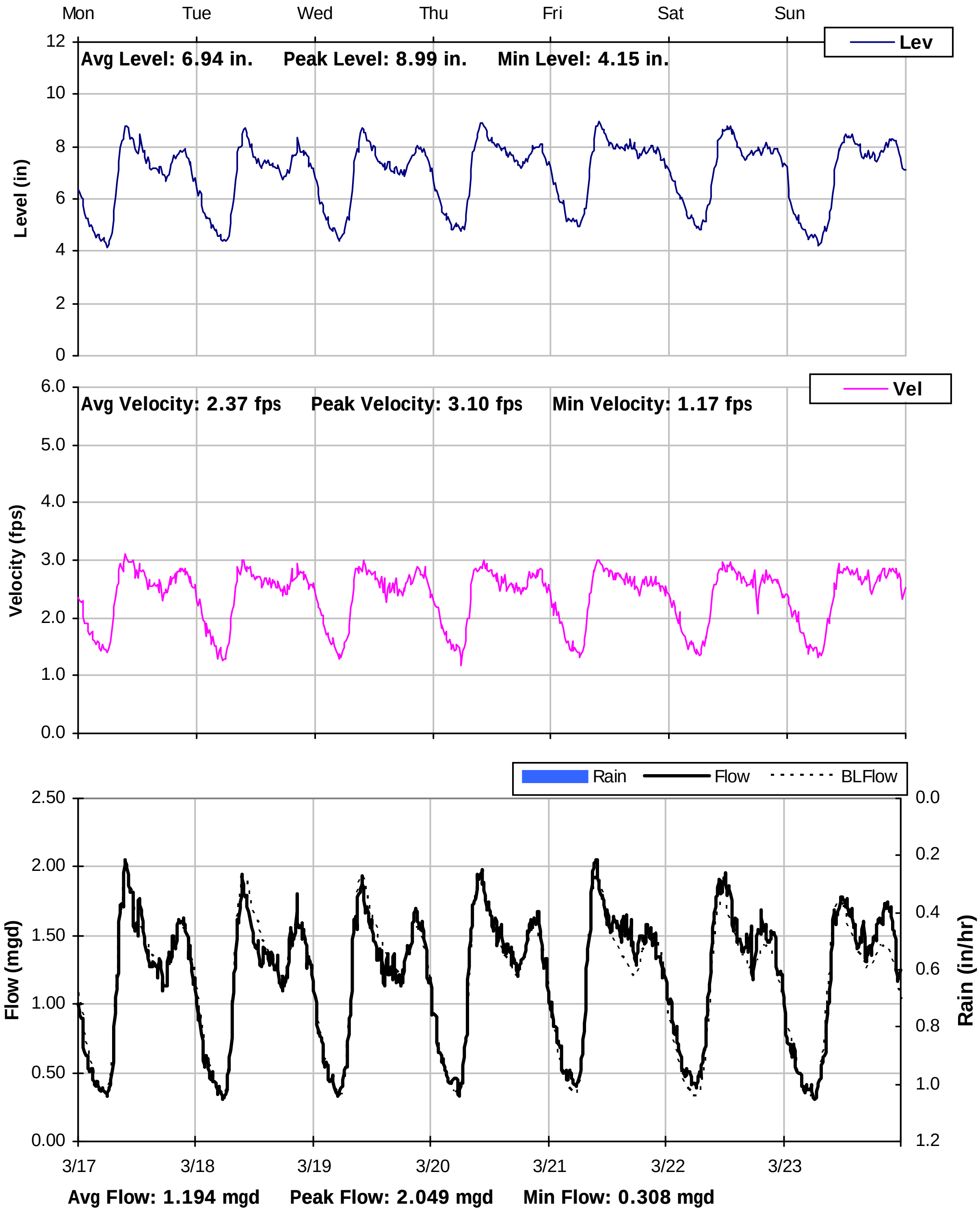




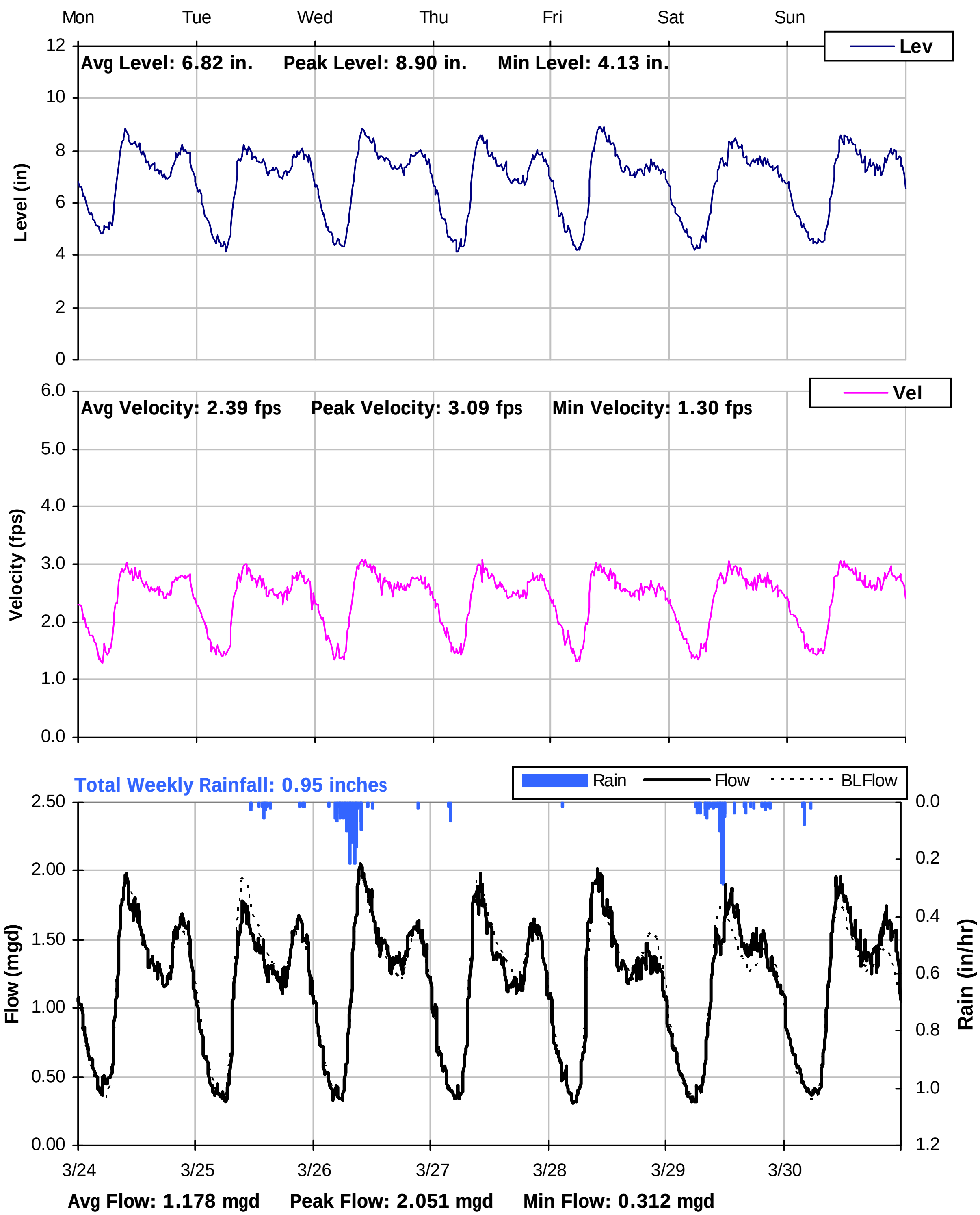


Avg Flow: 1.221 mgd **Peak Flow: 2.145 mgd** **Min Flow: 0.293 mgd**

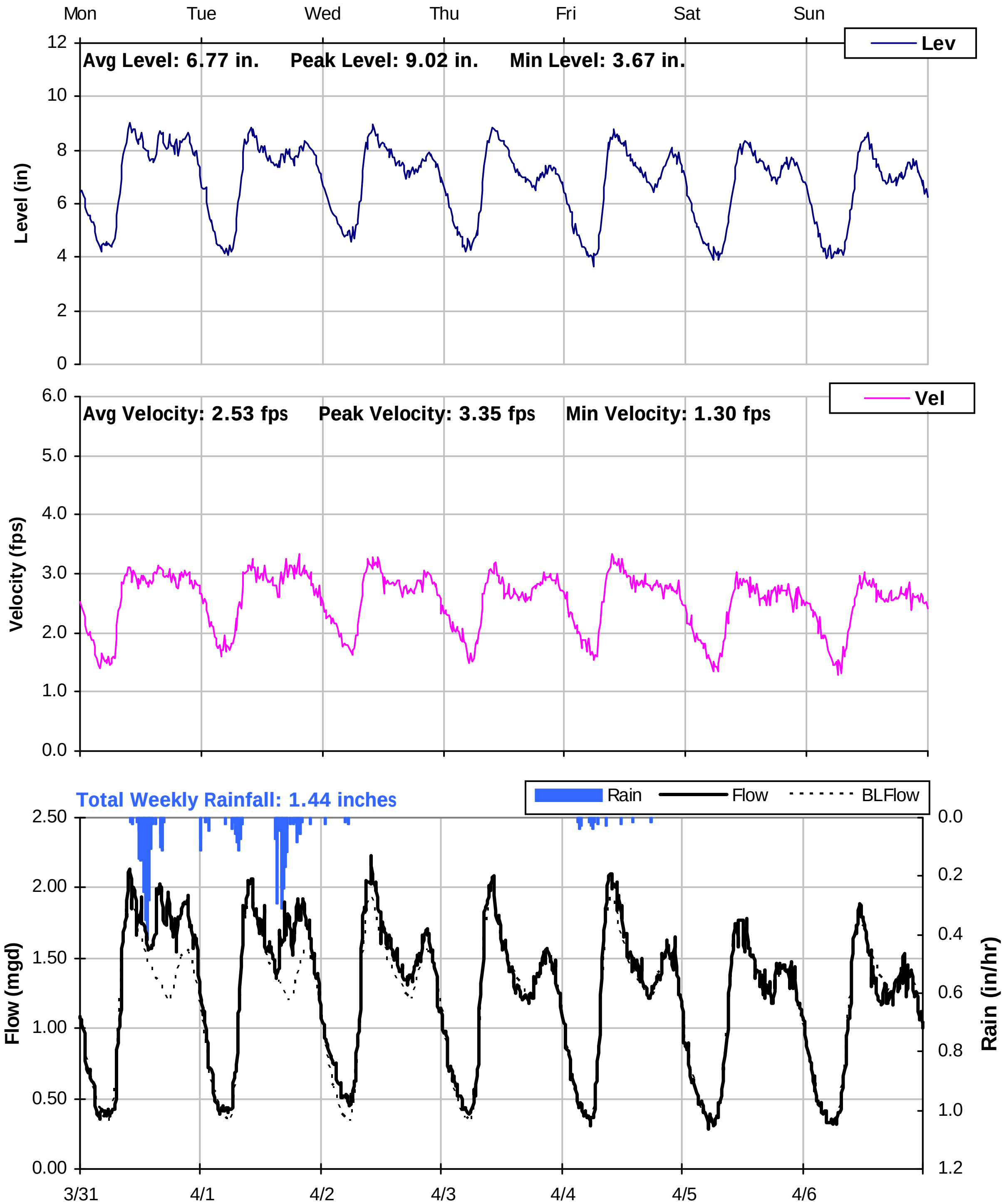
SITE 6
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



SITE 6
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

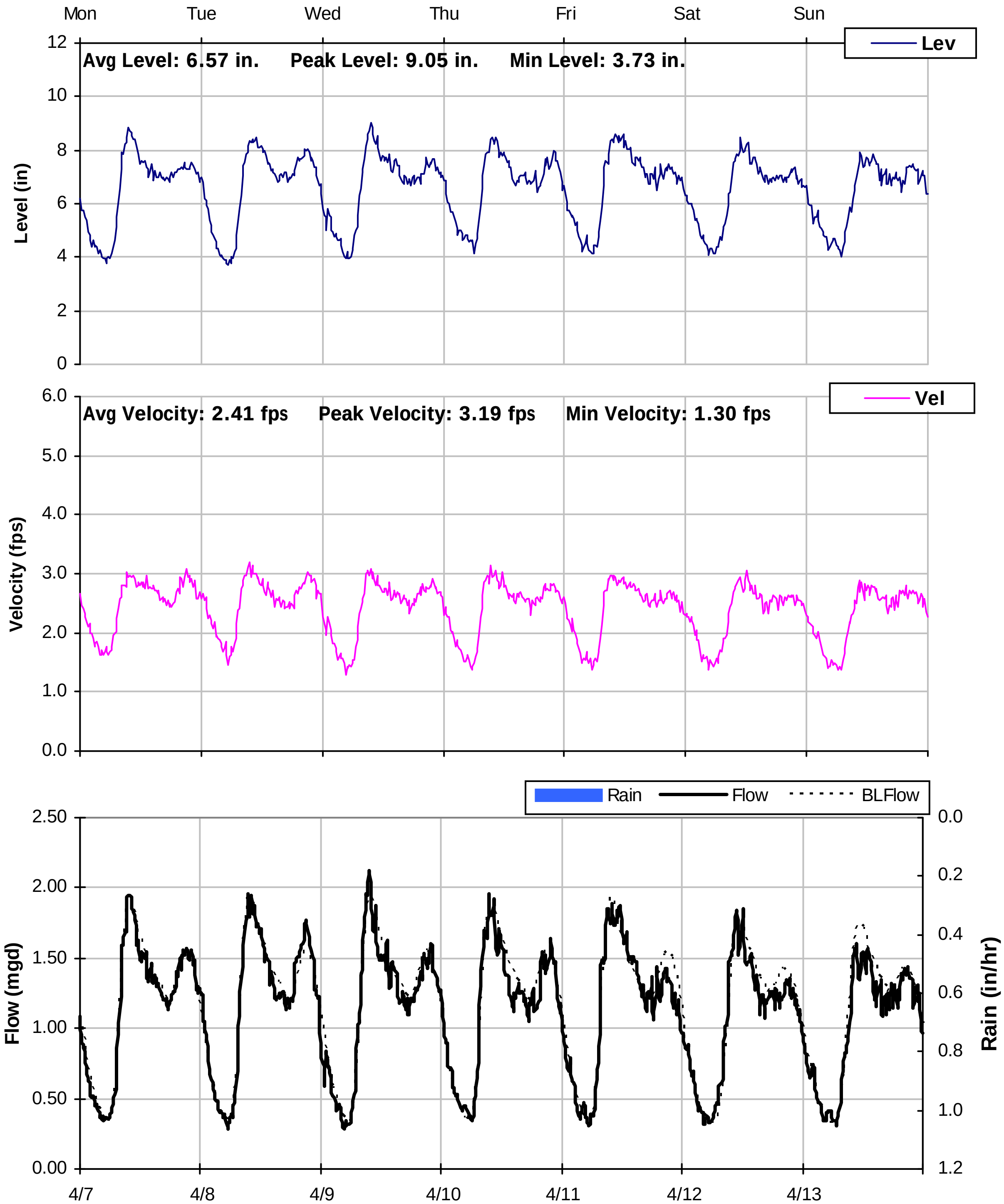


SITE 6
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



Avg Flow: 1.236 mgd **Peak Flow: 2.224 mgd** **Min Flow: 0.279 mgd**

SITE 6
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 1.128 mgd **Peak Flow: 2.121 mgd** **Min Flow: 0.280 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 7

Location: Alpine Road, north of Westridge Drive

Data Summary Report

SITE 7

Site Information

Location: Alpine Road, north of Westridge Drive

Coordinates: 122.1924° W, 37.3974° N

Rim Elevation: 274 feet

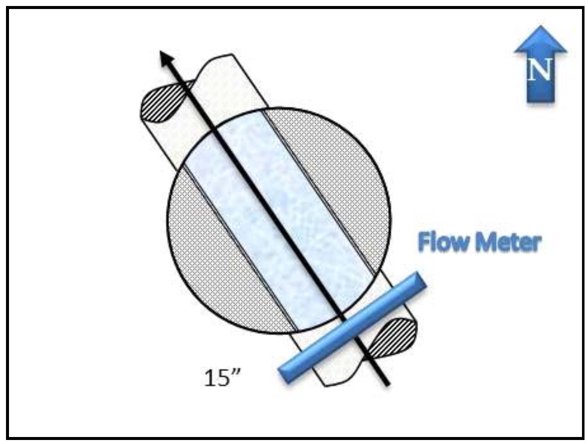
Pipe Diameter: 15 inches

Baseline Flow: 0.156 mgd

Peak Measured Flow: 0.825 mgd

Satellite Map

Sanitary Sewer Map



Flow Sketch

View from Street

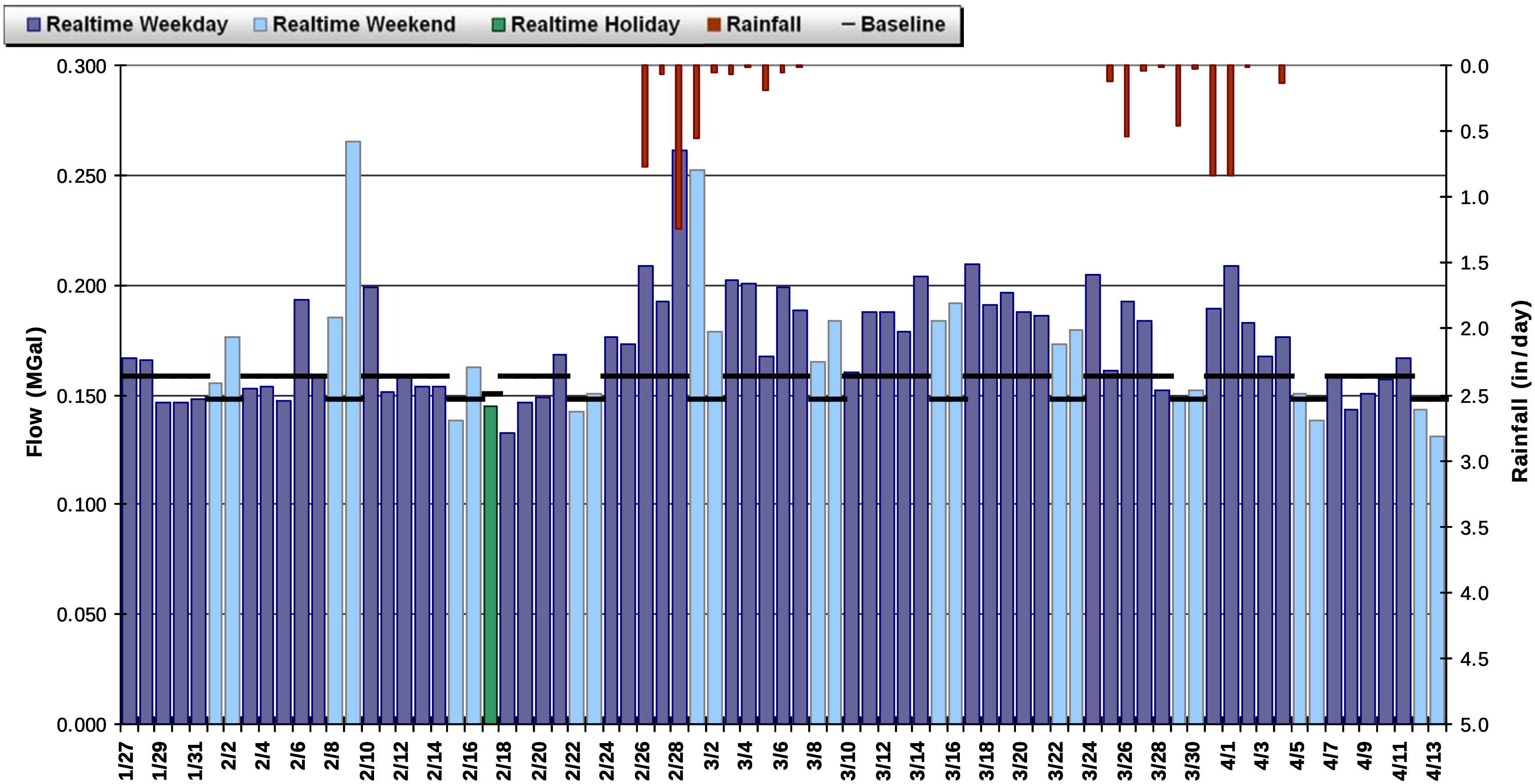
Plan View

SITE 7

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.173 MGal **Peak Daily Flow: 0.265 MGal** **Min Daily Flow: 0.131 MGal**

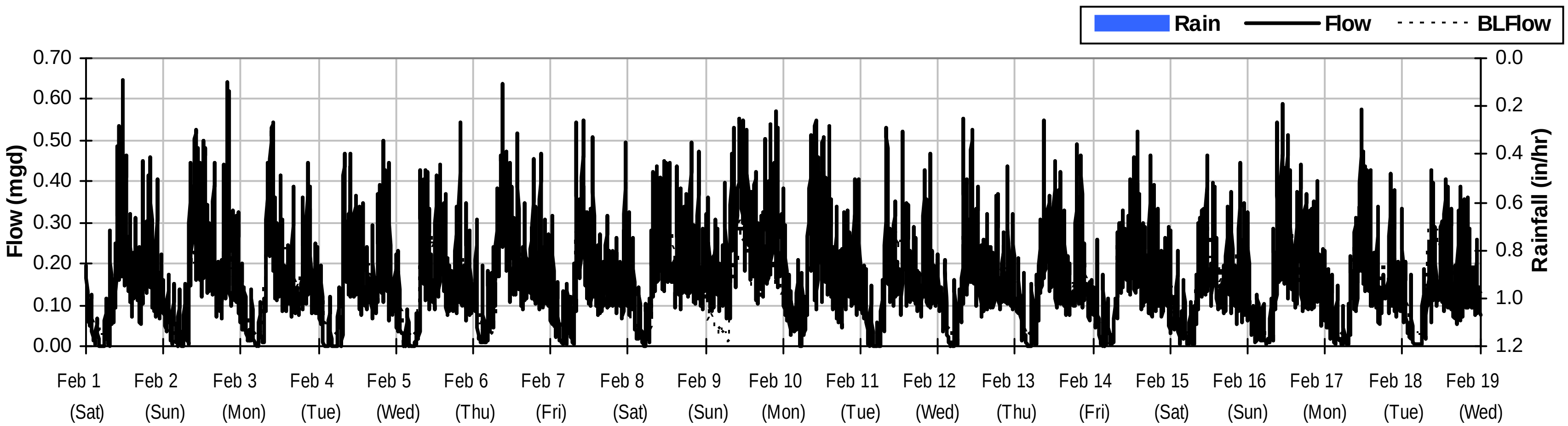
Total Period Rainfall: 6.00 inches

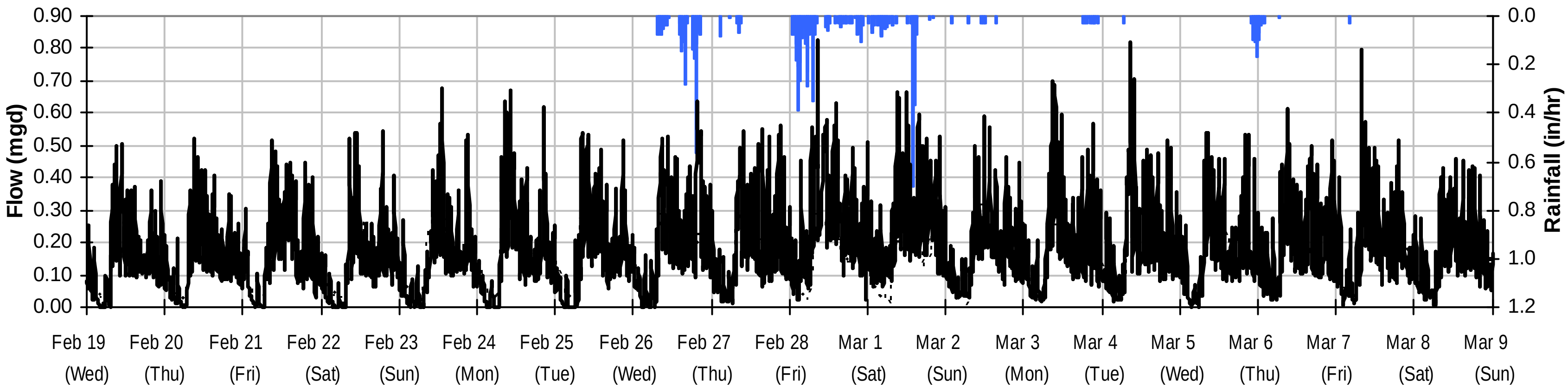


SITE 7

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 6 inches **Avg Flow: 0.173 mgd** **Peak Flow: 0.825 mgd** **Min Flow: 0.000 mgd**

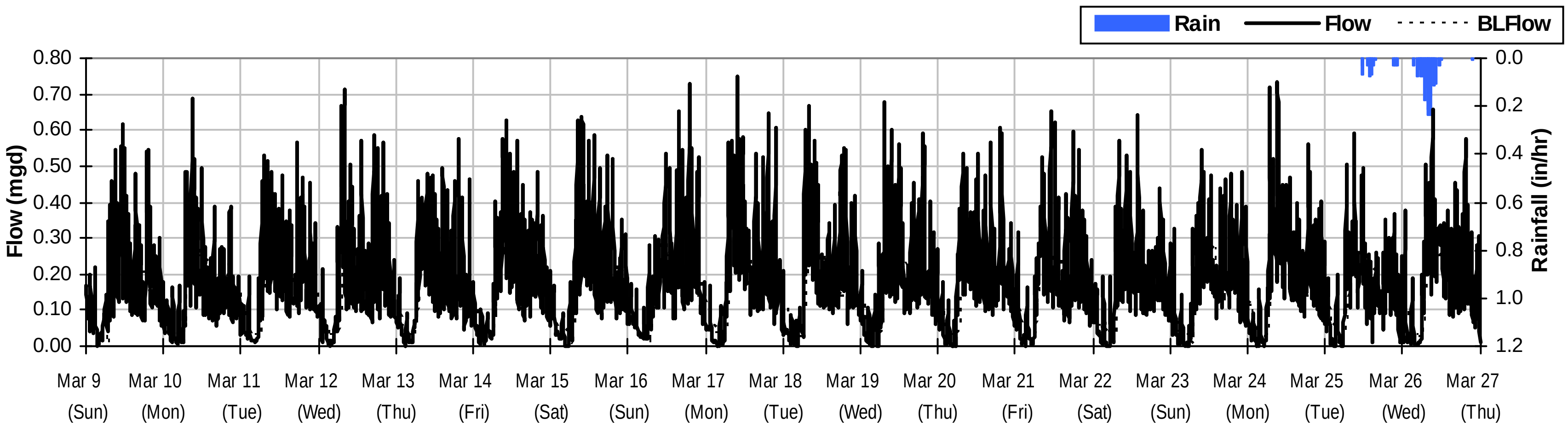


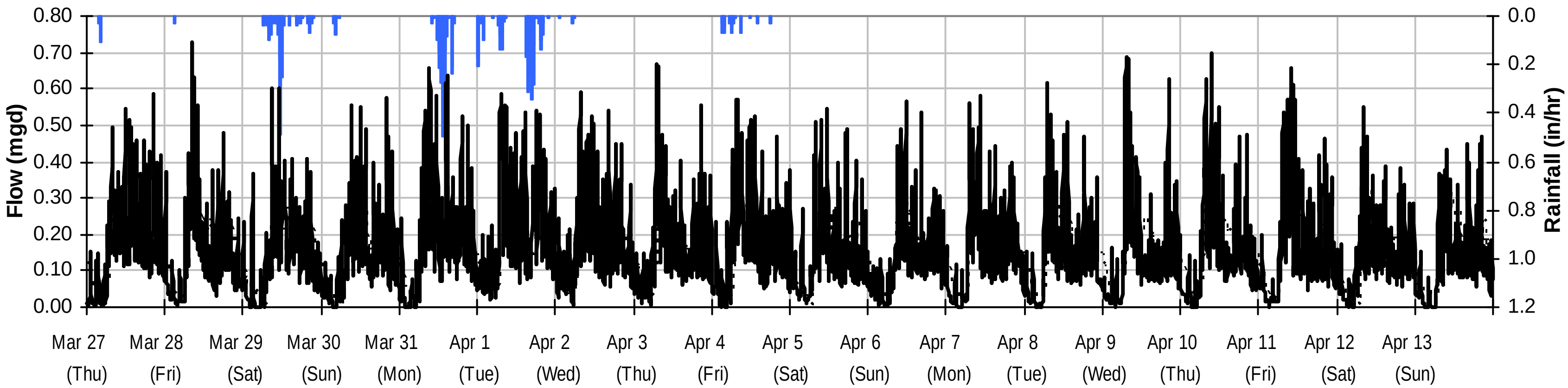


SITE 7

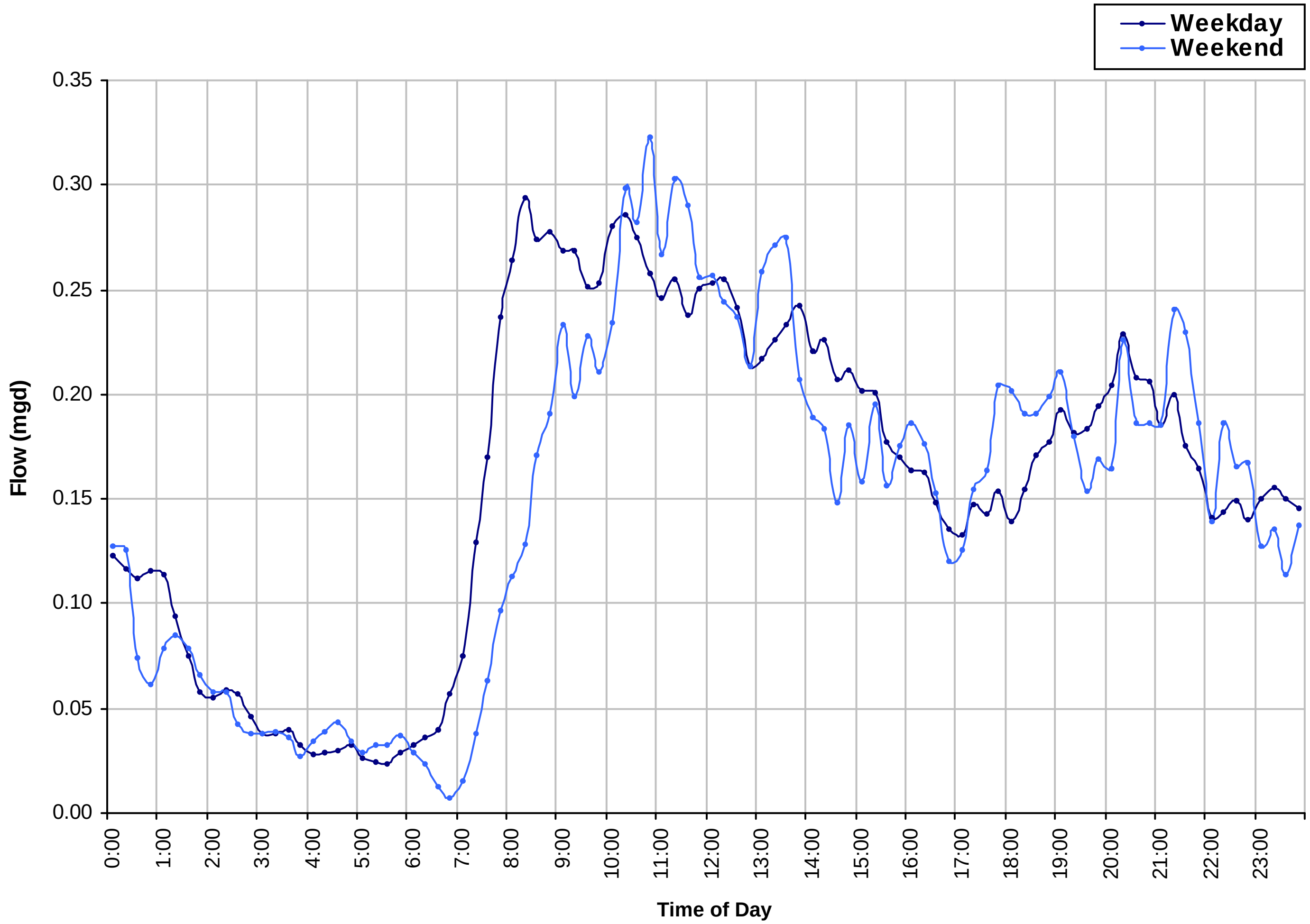
Period Flow Summary: March 9 to April 14, 2014

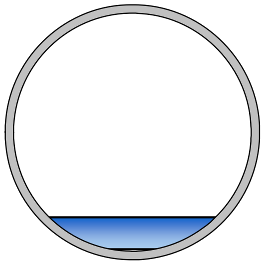
Total Monthly Rainfall: 6 inches **Avg Flow: 0.173 mgd** **Peak Flow: 0.825 mgd** **Min Flow: 0.000 mgd**





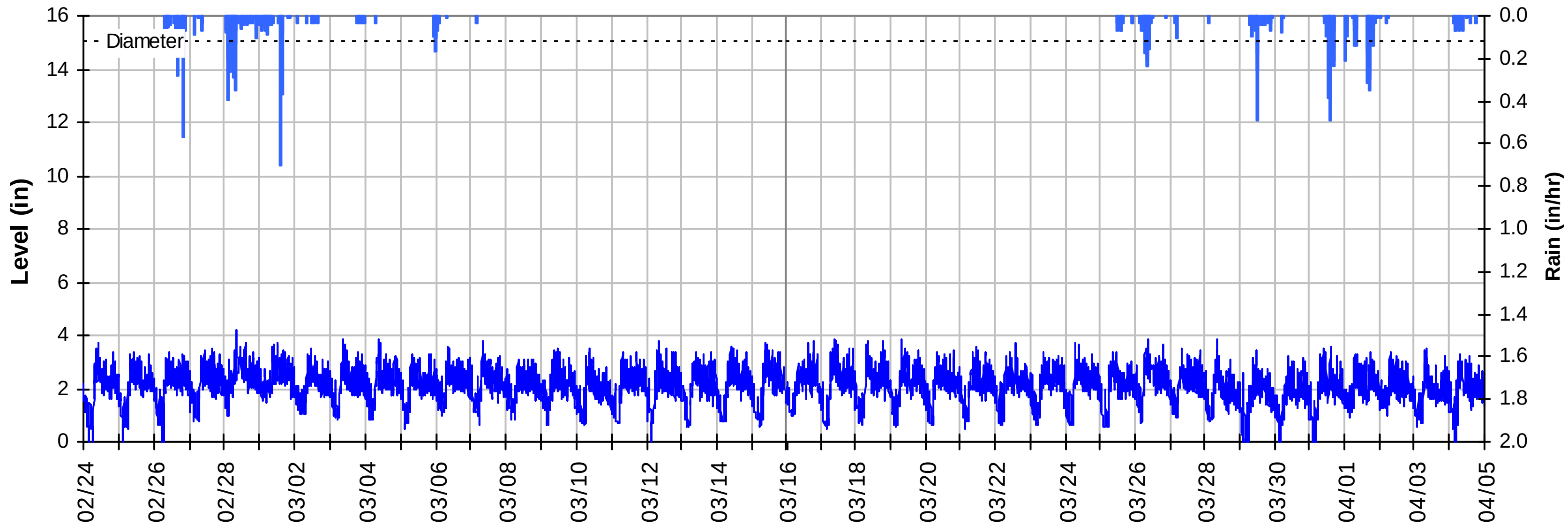
SITE 7
Baseline Flow Hydrographs

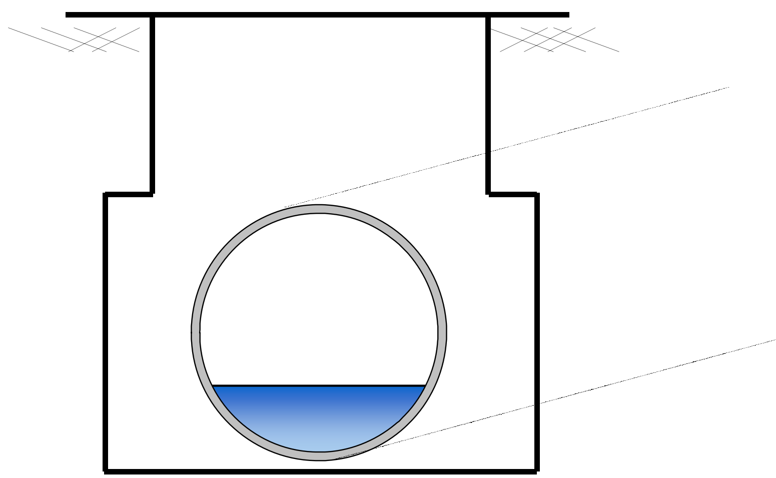




SITE 7
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





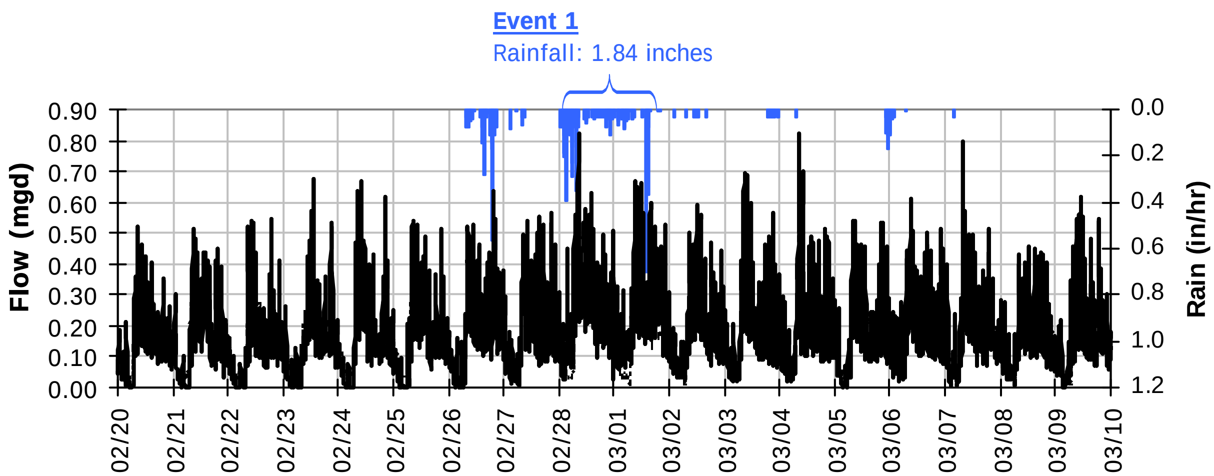
Pipe Diameter: 15 *inches*

Peak Measured Level: 4.18 *inches*

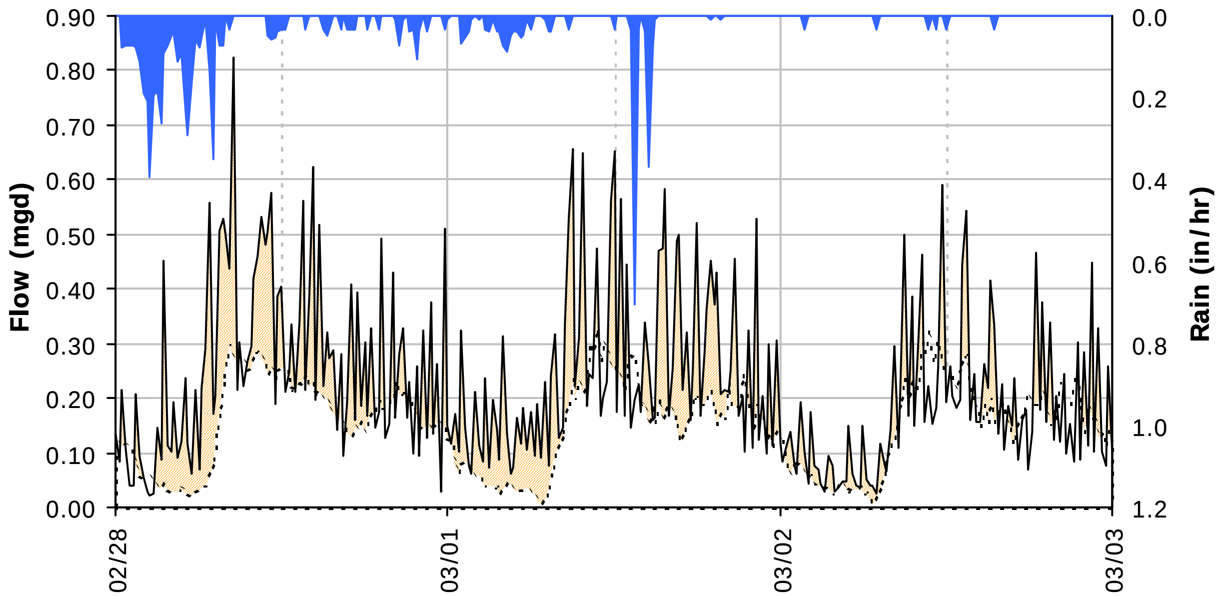
Peak d/D Ratio: 0.28

SITE 7
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

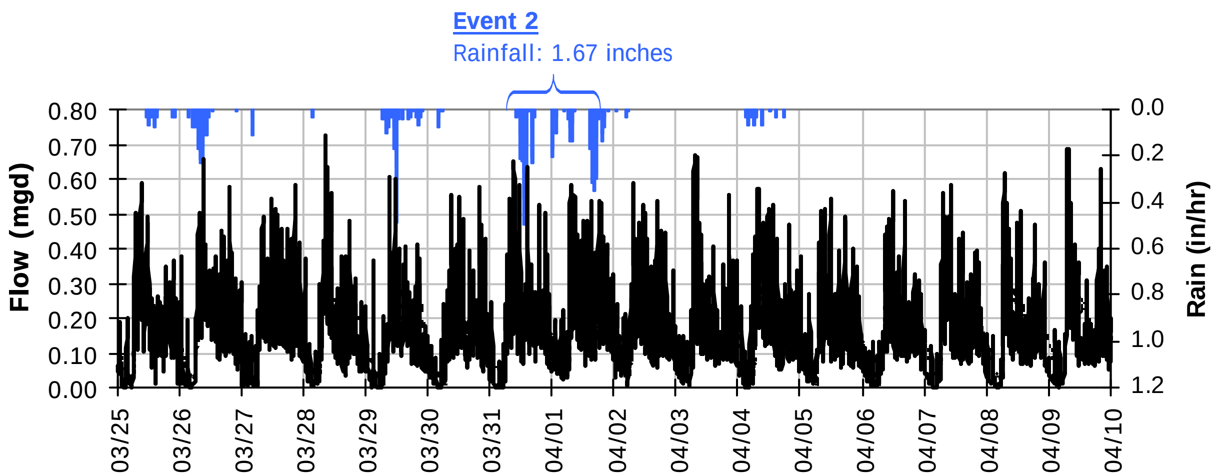


Storm Event I/I Analysis (Rain = 1.84 inches)

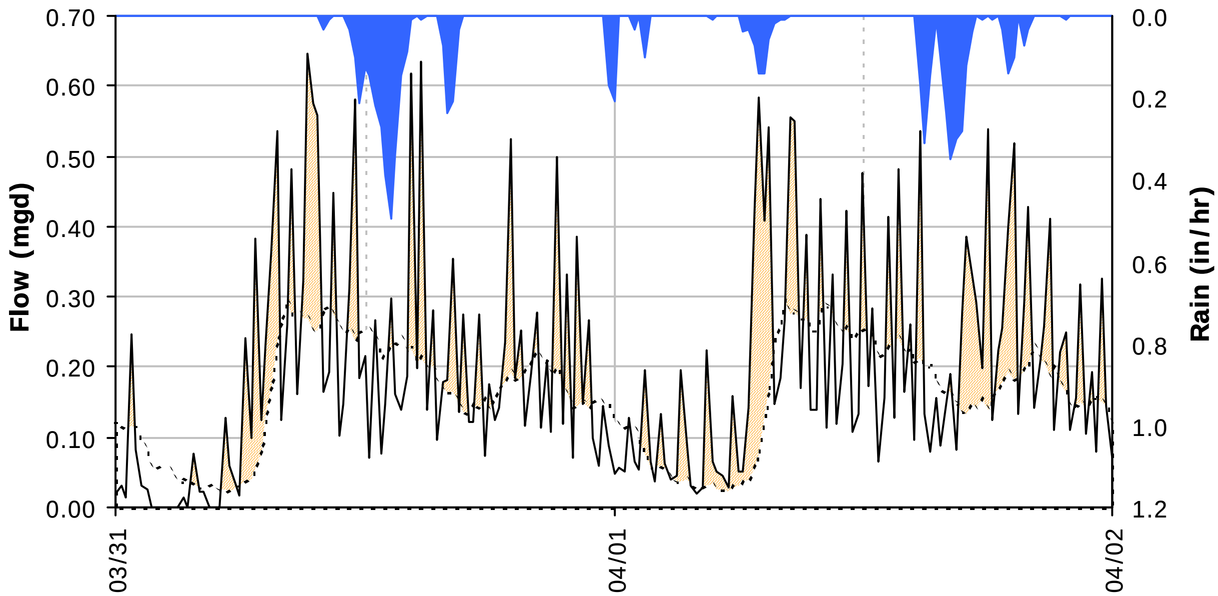
Capacity		Inflow / Infiltration	
Peak Flow:	0.82 *mgd*	**Peak I/I Rate:**	0.15 *mgd*
PF:	5.29	**Total I/I:**	236,000 *gallons*

SITE 7
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



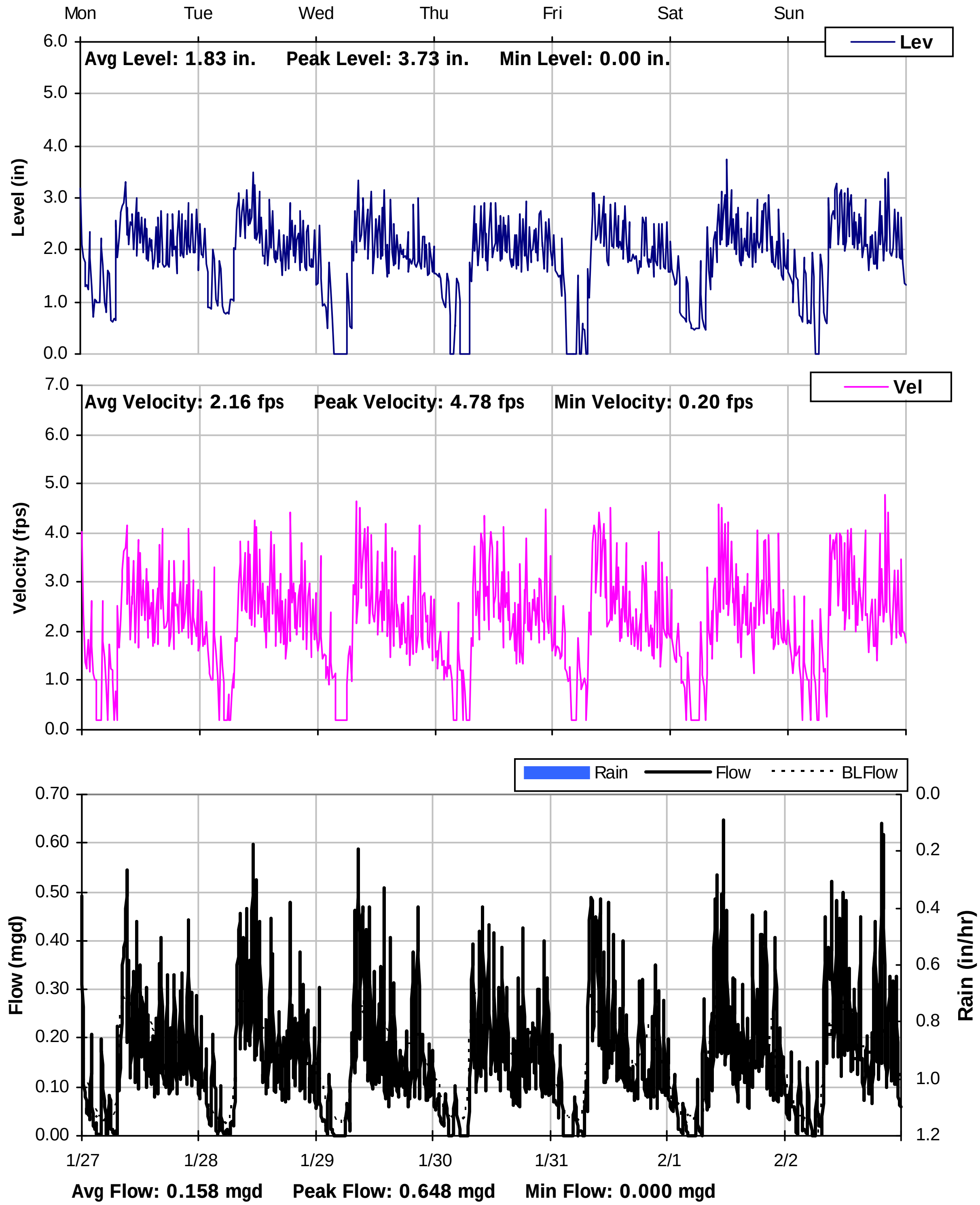
Event 2 Detail Graph



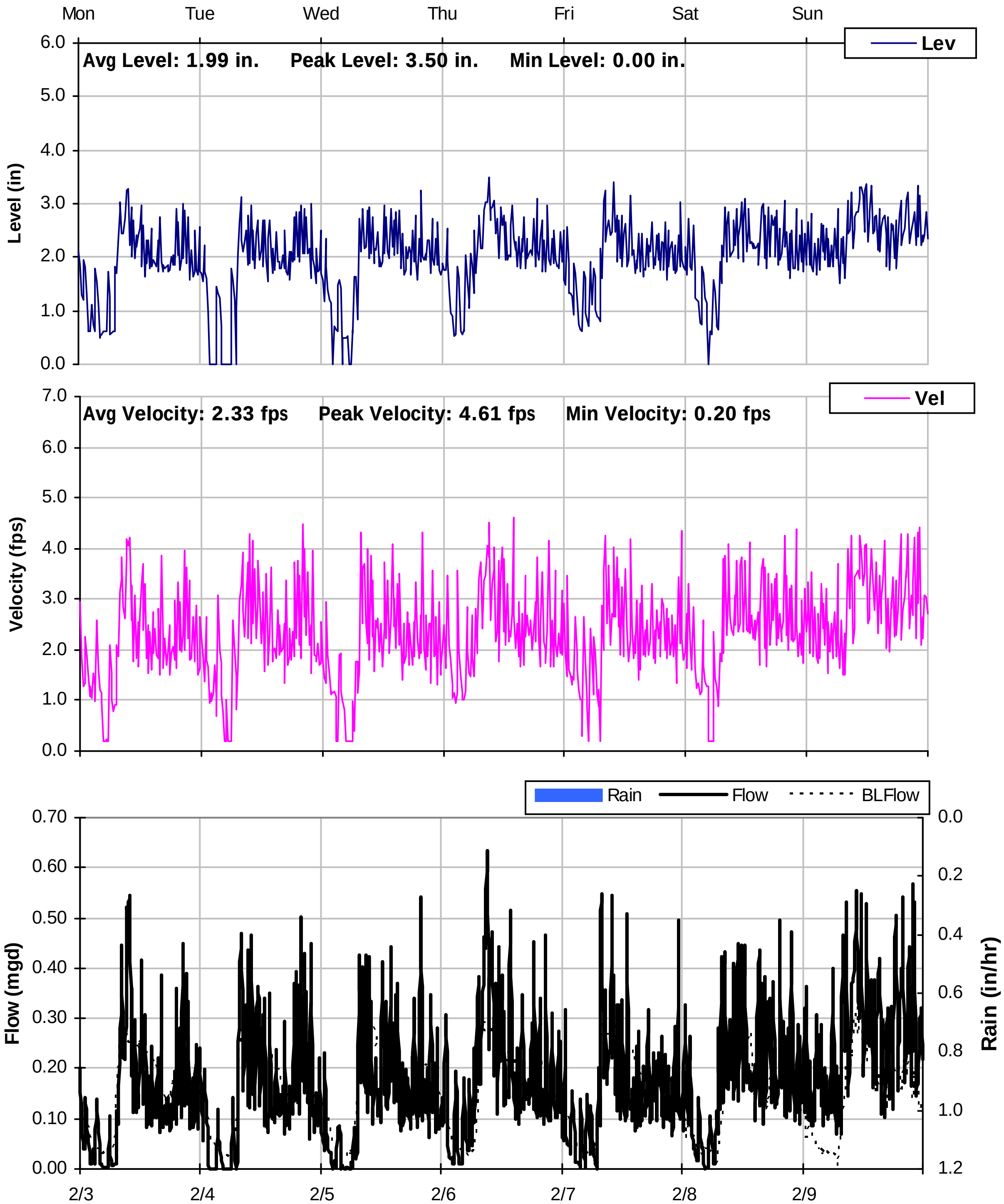
Storm Event I/I Analysis (Rain = 1.67 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	0.66 *mgd*	**Peak I/I Rate:**	0.58 *mgd*
PF:	4.24	**Total I/I:**	117,000 *gallons*

SITE 7
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

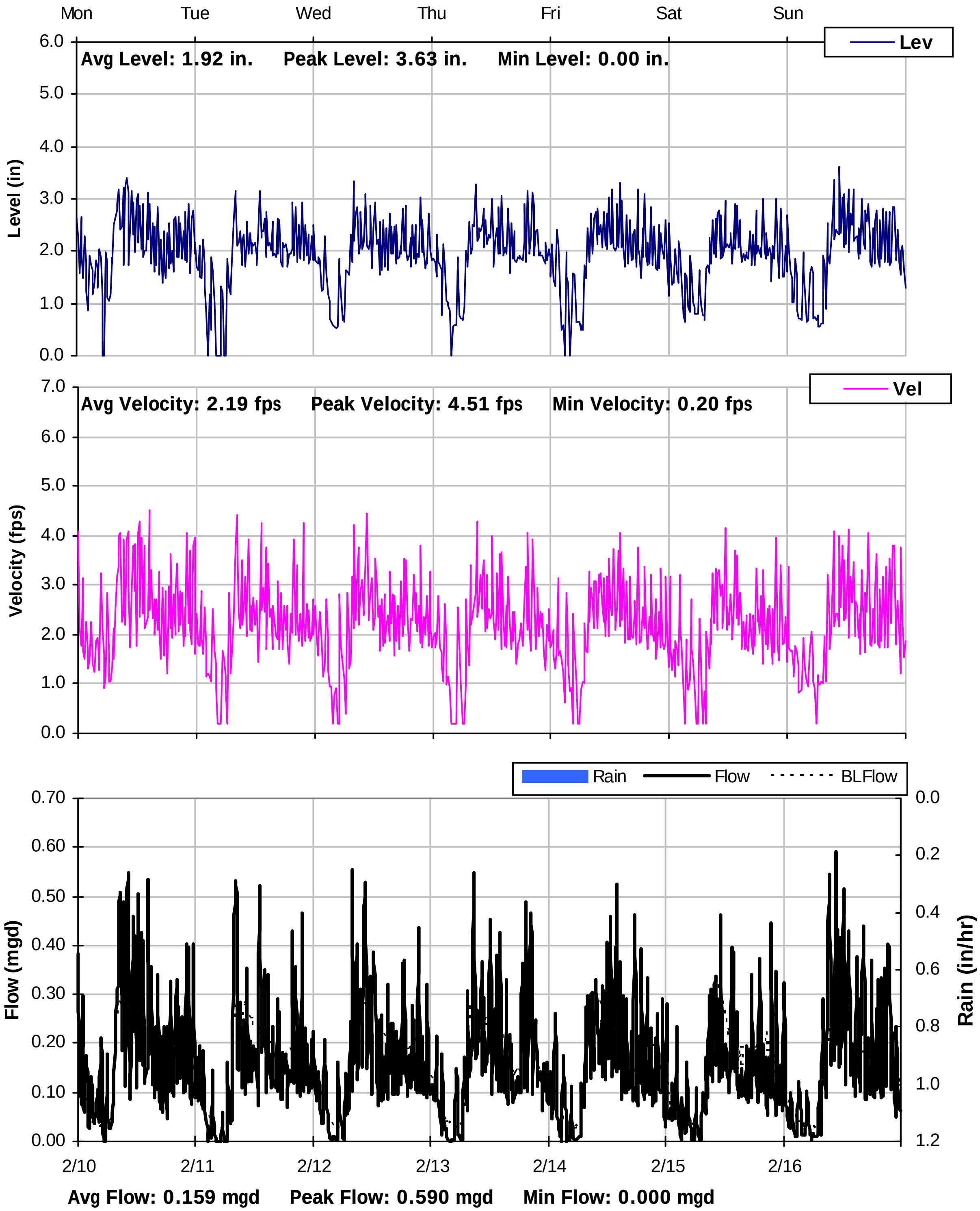


SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

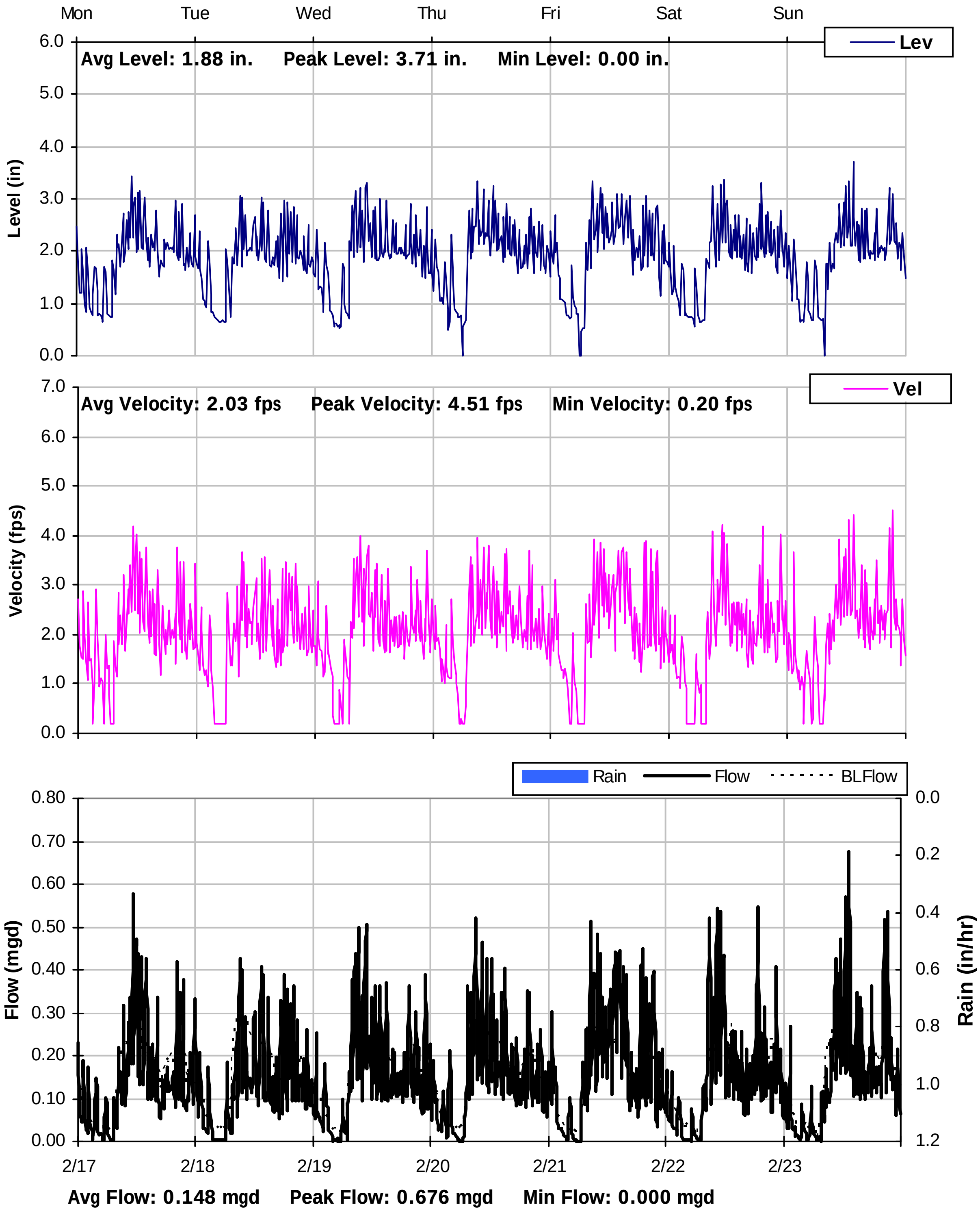


Avg Flow: 0.179 mgd **Peak Flow: 0.632 mgd** **Min Flow: 0.000 mgd**

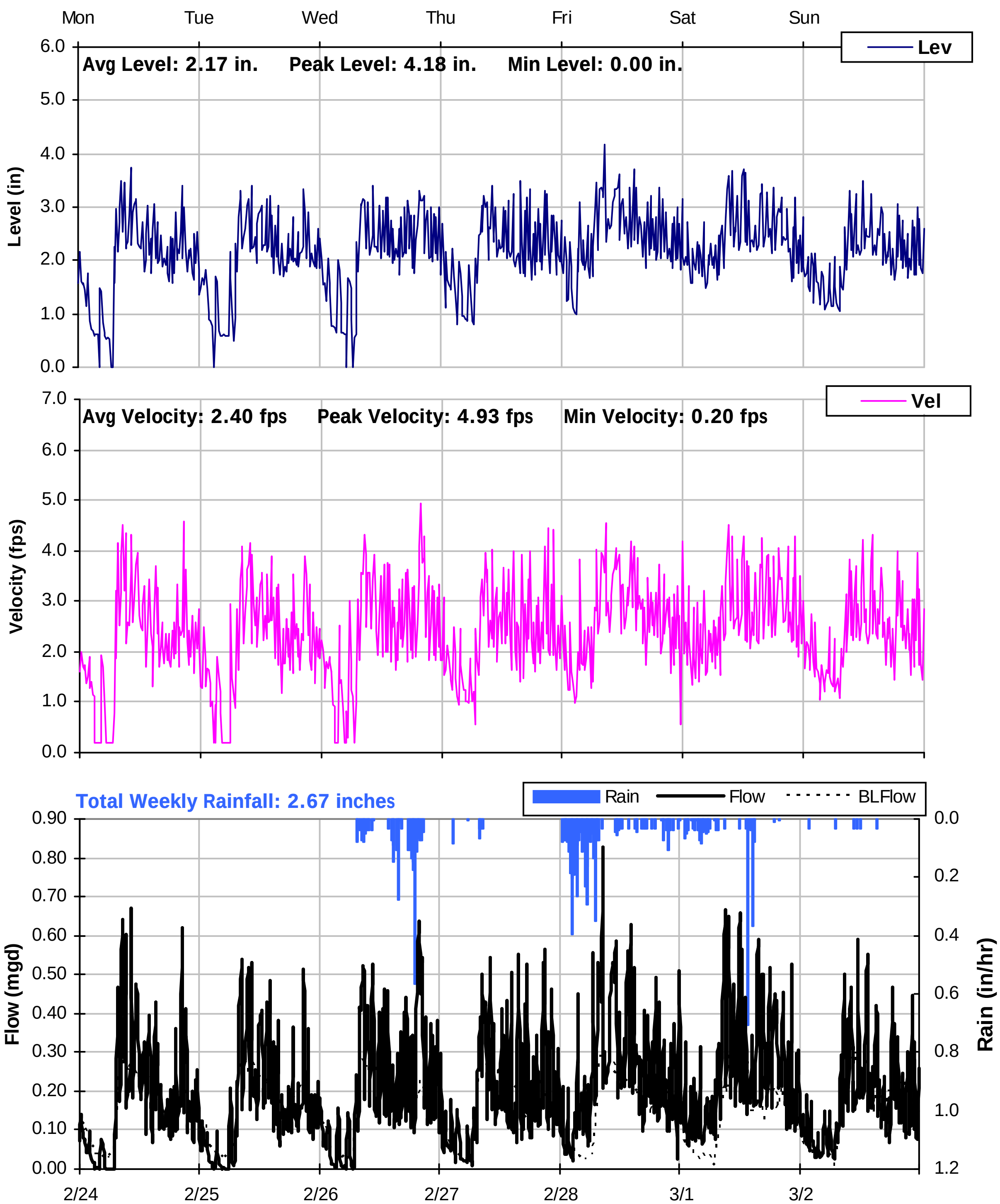
SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

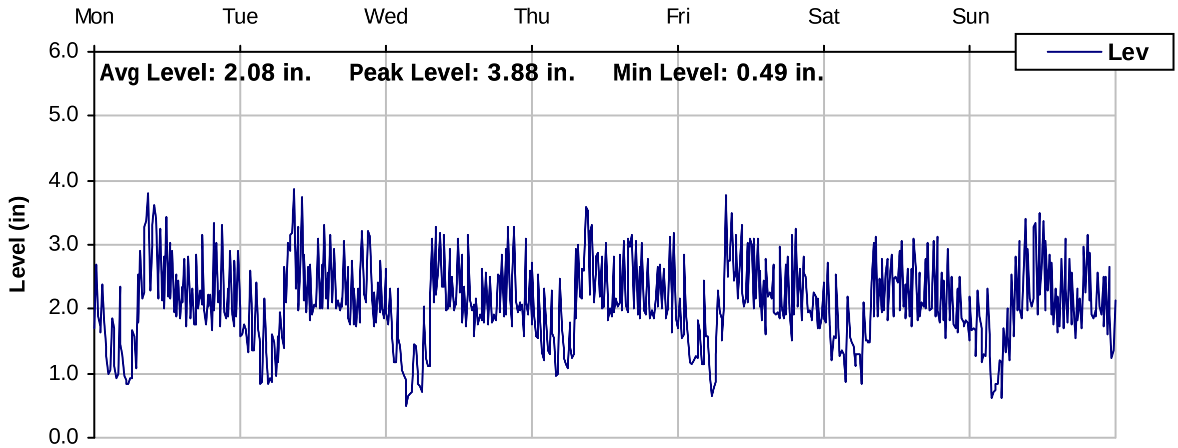


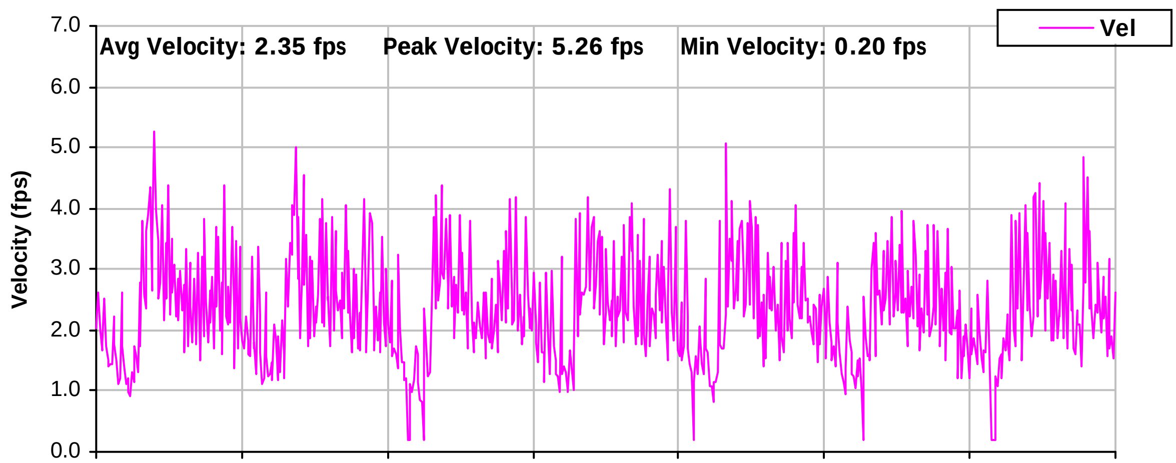
SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014

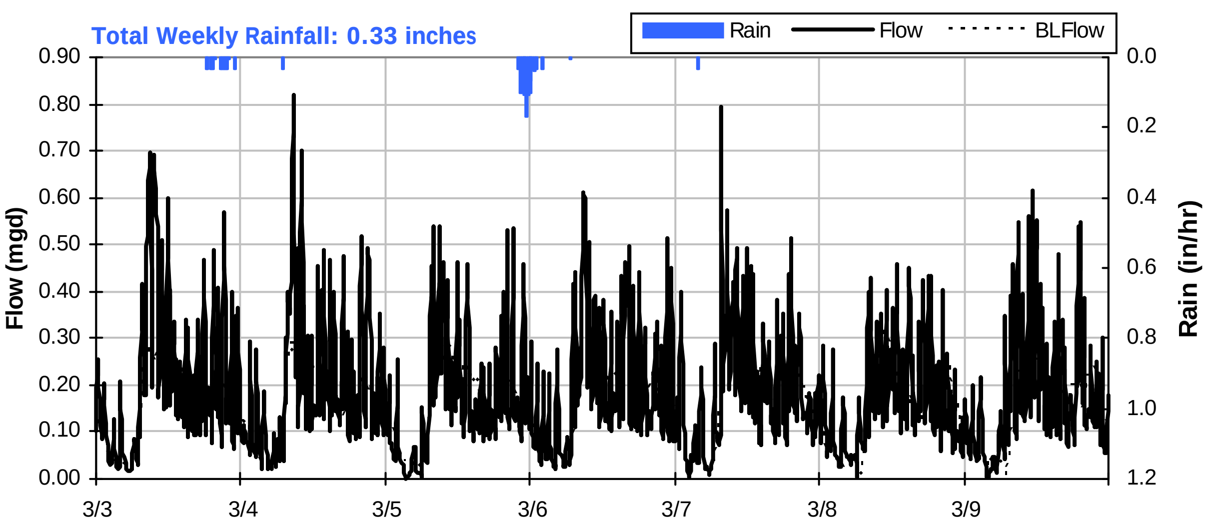


Avg Flow: 0.206 mgd **Peak Flow: 0.825 mgd** **Min Flow: 0.000 mgd**

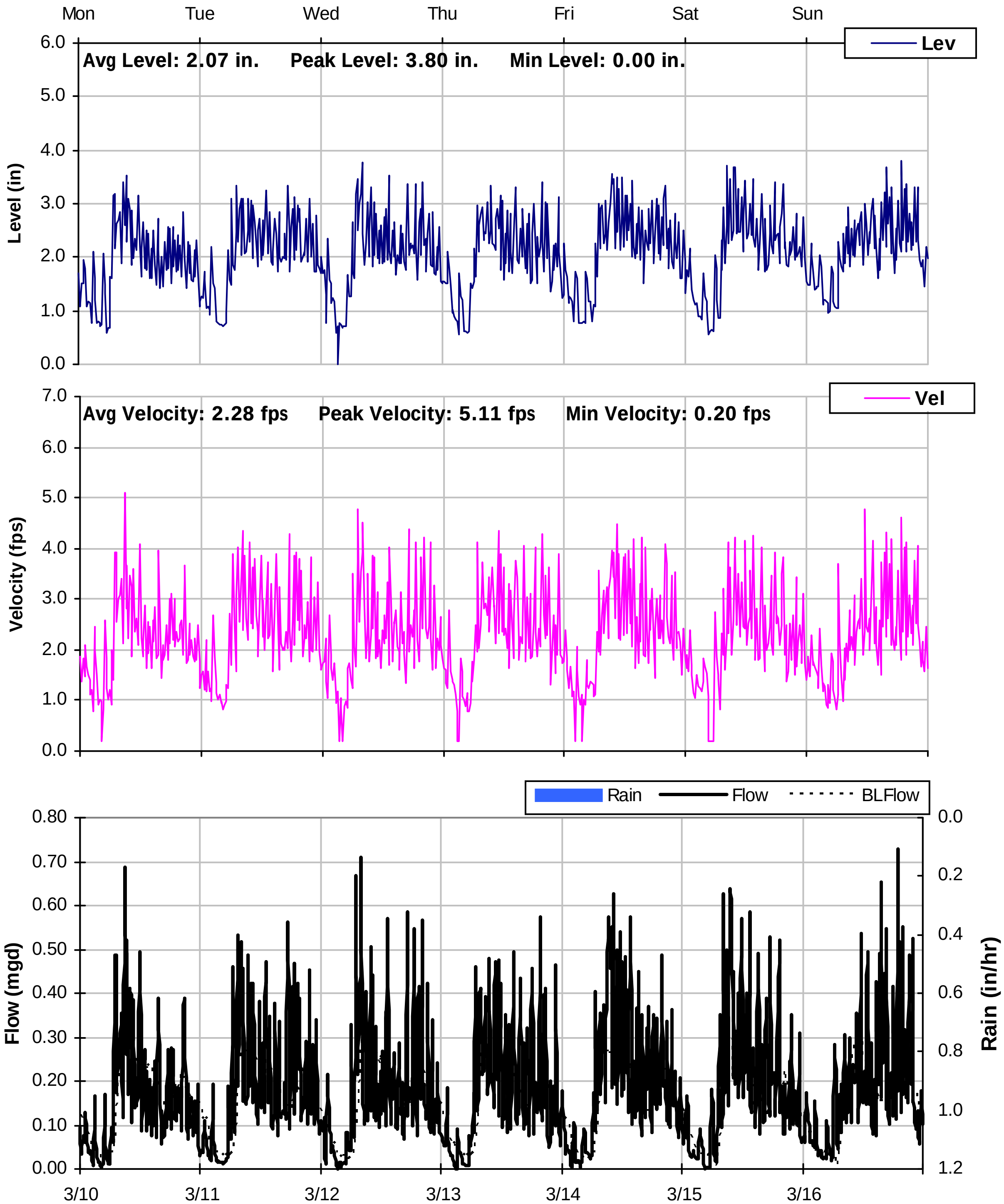
SITE 7
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014





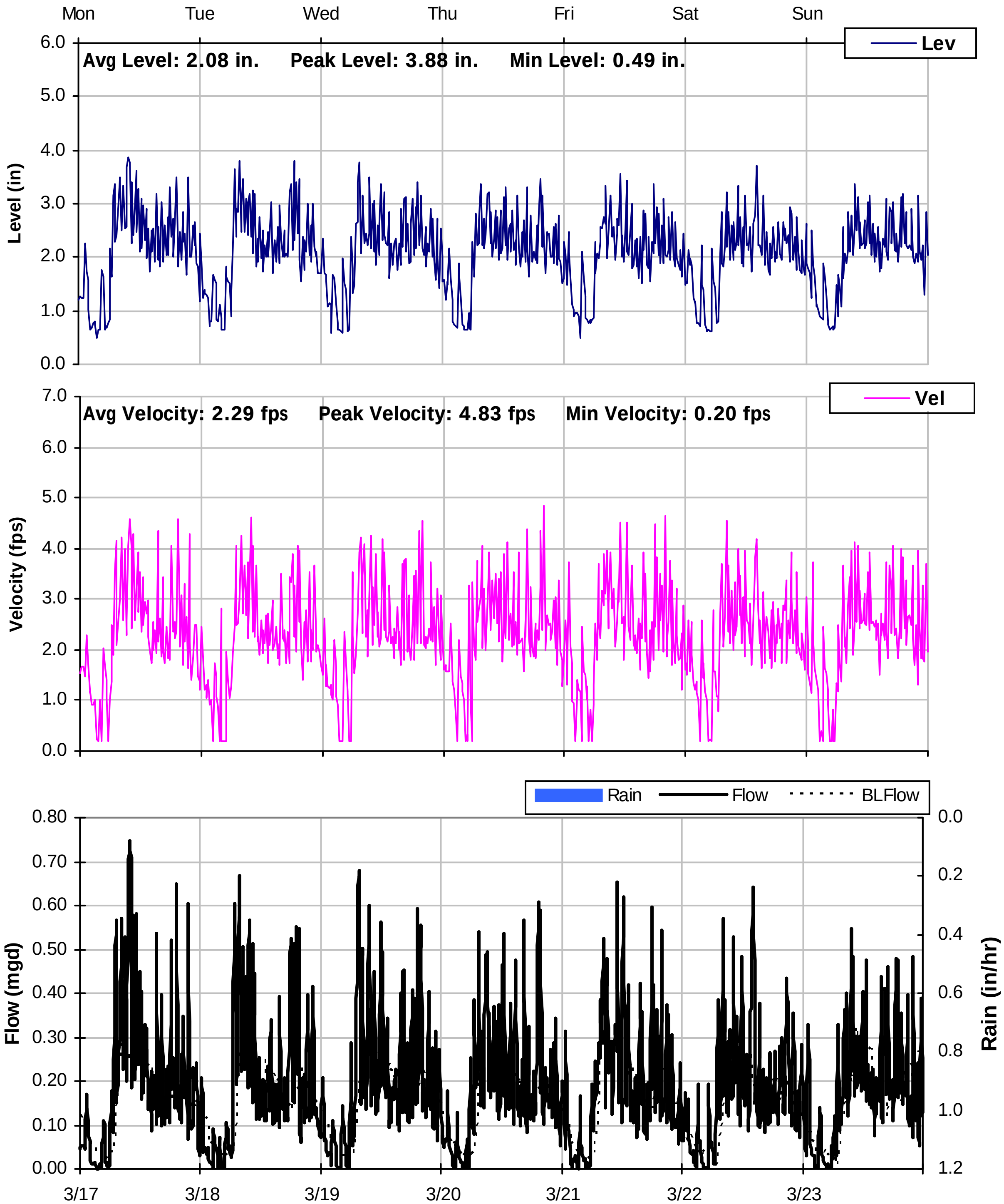


SITE 7
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



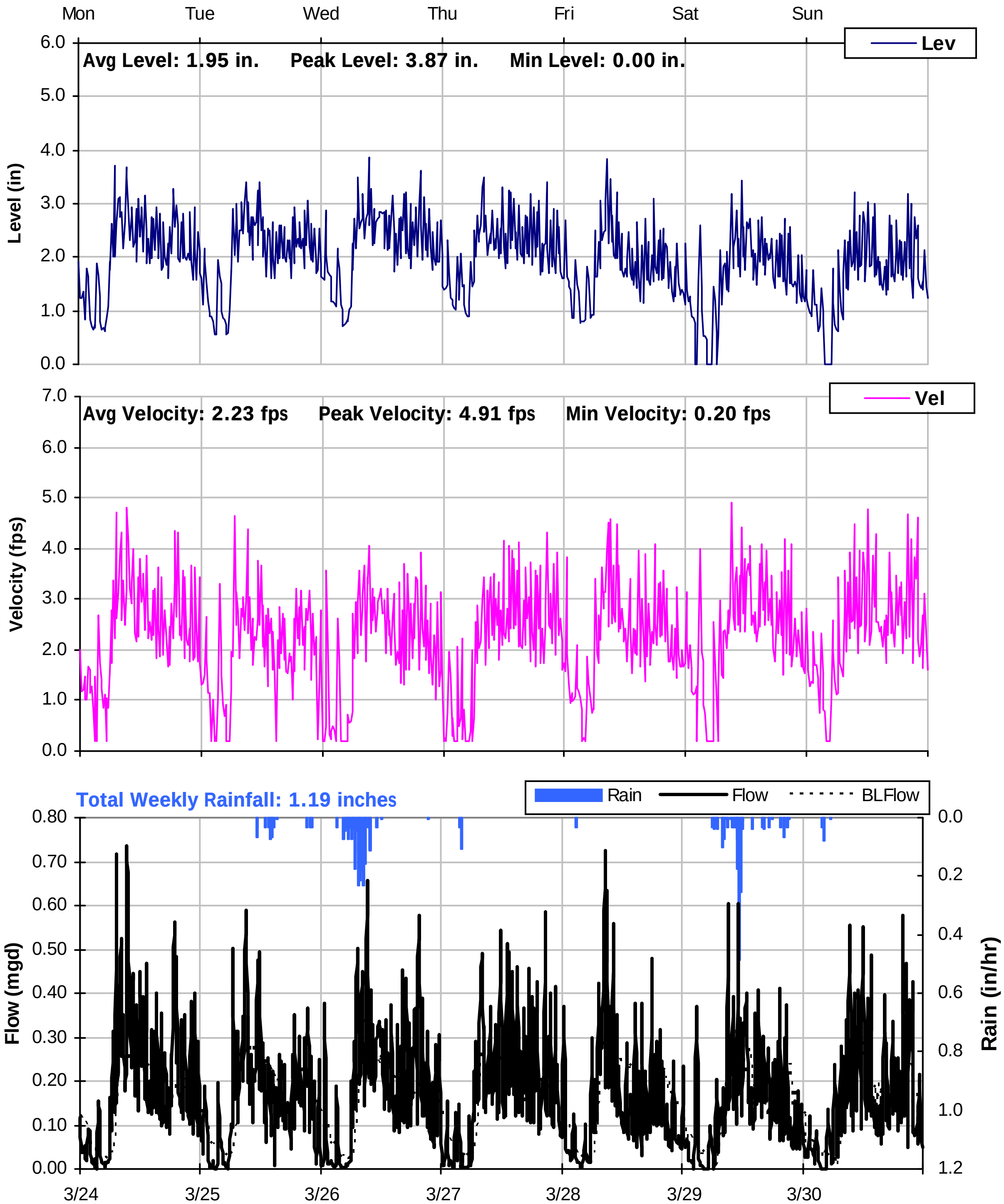
Avg Flow: 0.185 mgd **Peak Flow: 0.730 mgd** **Min Flow: 0.000 mgd**

SITE 7
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



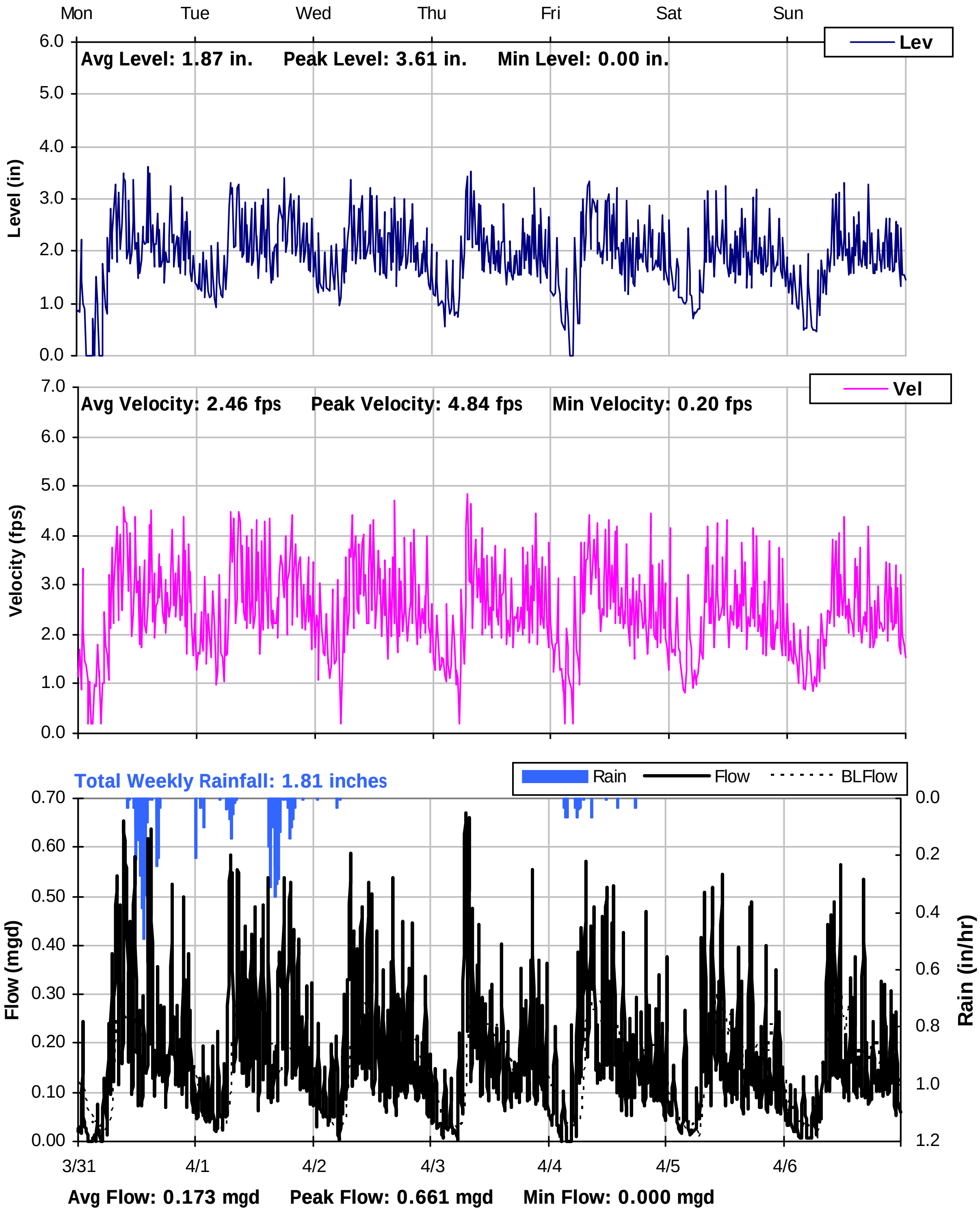
Avg Flow: 0.189 mgd Peak Flow: 0.747 mgd Min Flow: 0.002 mgd

SITE 7
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

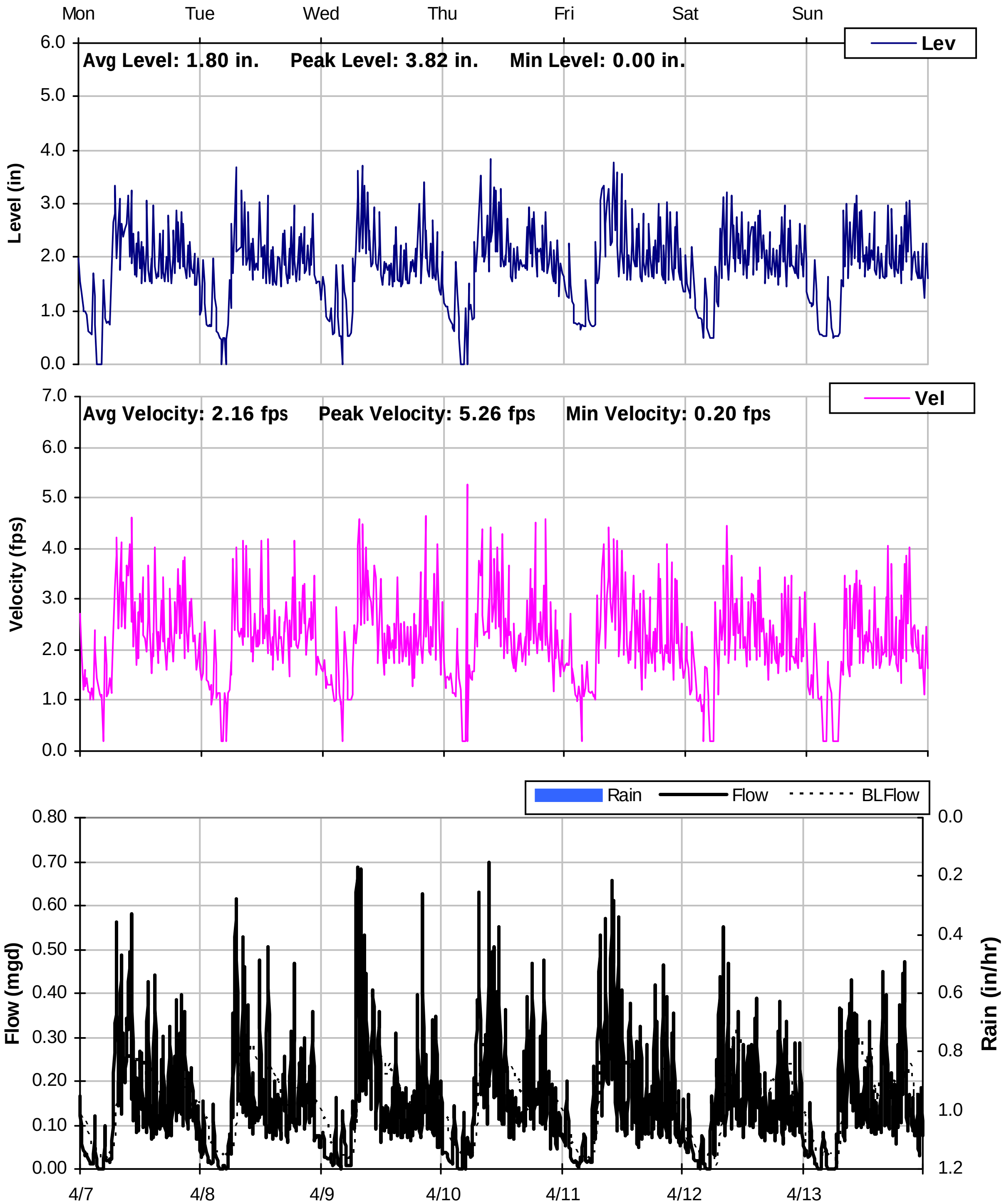


Avg Flow: 0.170 mgd **Peak Flow: 0.725 mgd** **Min Flow: 0.000 mgd**

SITE 7
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 7
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 0.150 mgd **Peak Flow: 0.699 mgd** **Min Flow: 0.000 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 8

Location: Alipne Road, north of Highway 280

Data Summary Report

SITE 8

Site Information

Location: Alipne Road, north of Highway 280

Coordinates: 122.1940° W, 37.4127° N

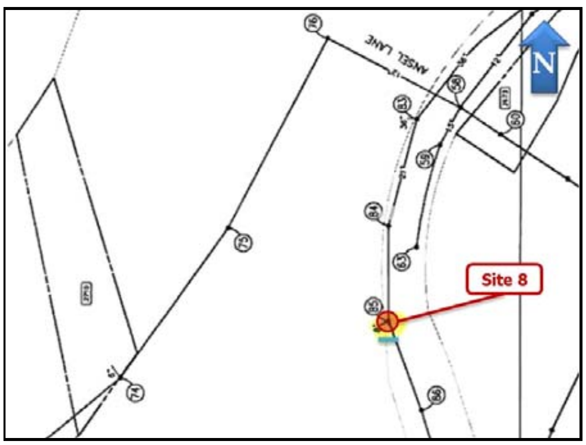
Rim Elevation: 163 feet

Pipe Diameter: 21 inches

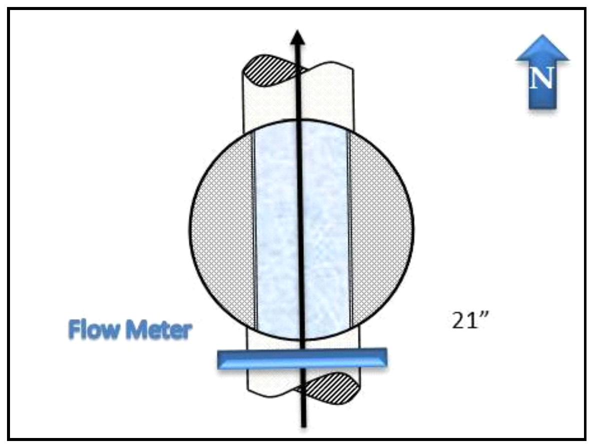
Baseline Flow: 0.233 mgd

Peak Measured Flow: 0.842 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

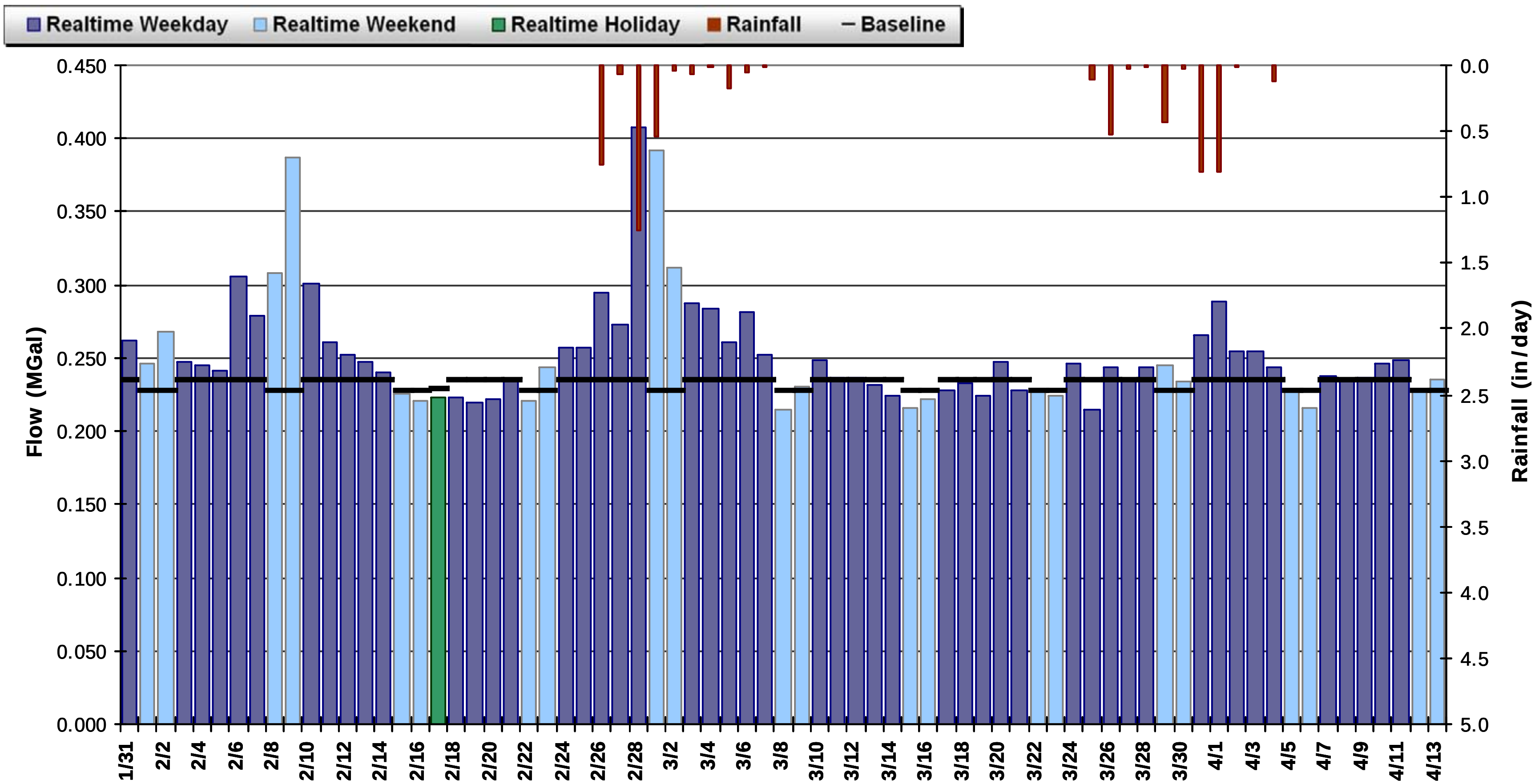
Plan View

SITE 8

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.253 MGal **Peak Daily Flow: 0.407 MGal** **Min Daily Flow: 0.214 MGal**

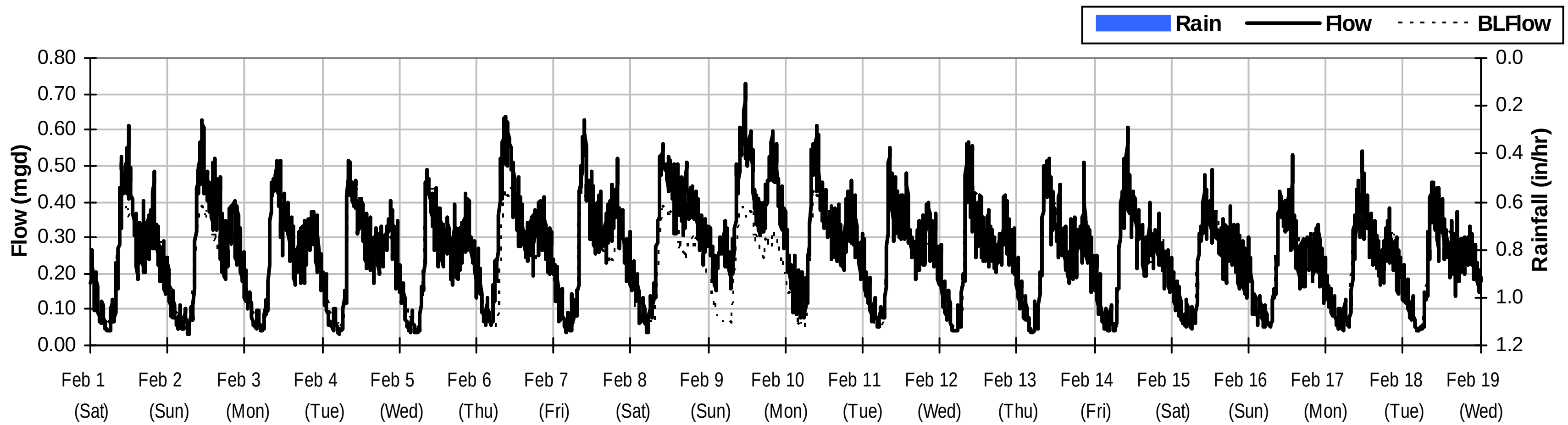
Total Period Rainfall: 5.86 inches

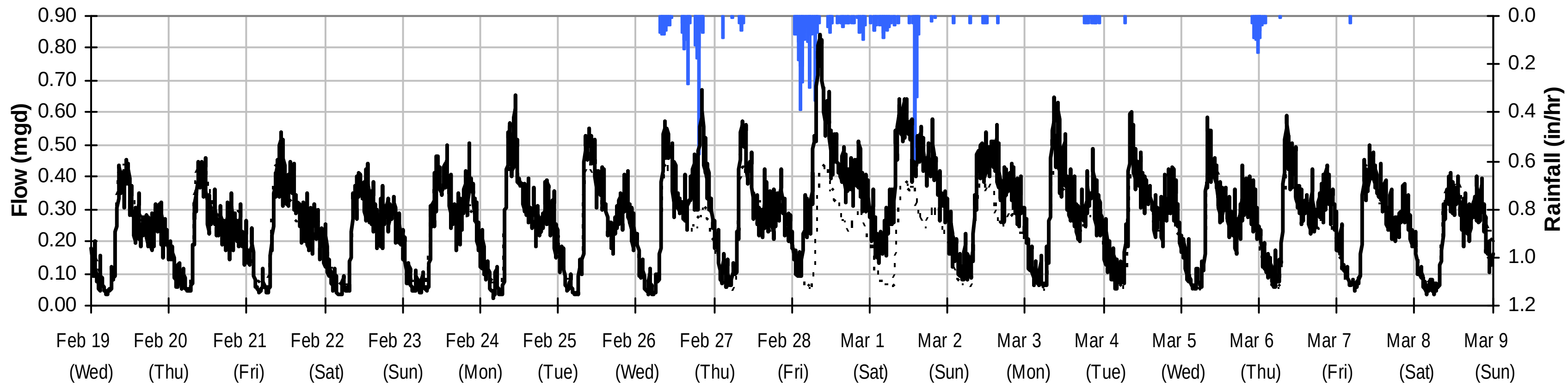


SITE 8

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 5.86 inches **Avg Flow: 0.253 mgd** **Peak Flow: 0.842 mgd** **Min Flow: 0.010 mgd**

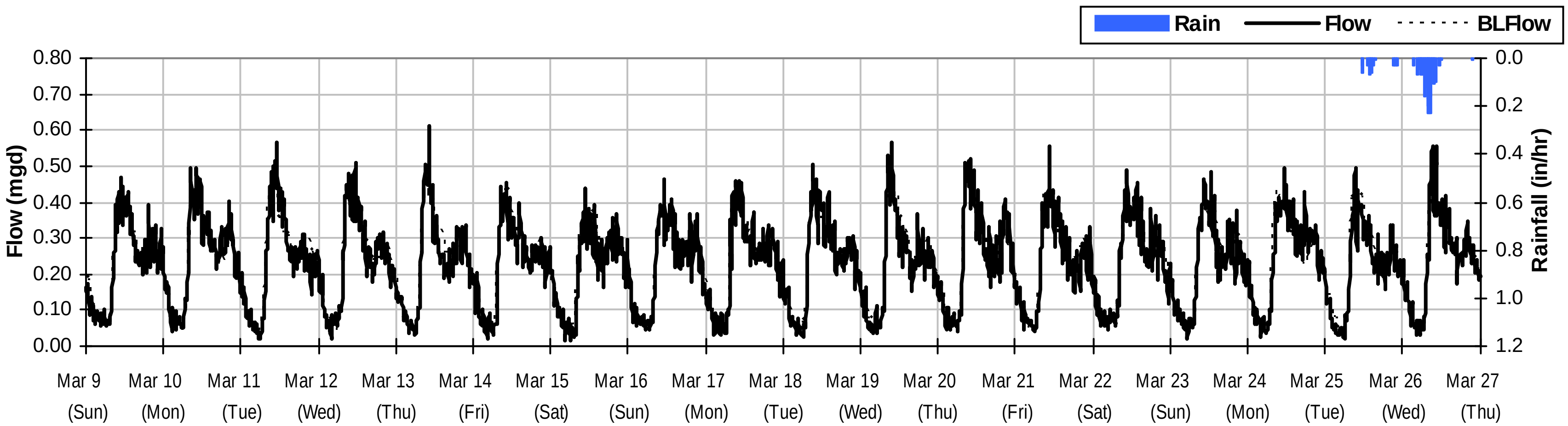


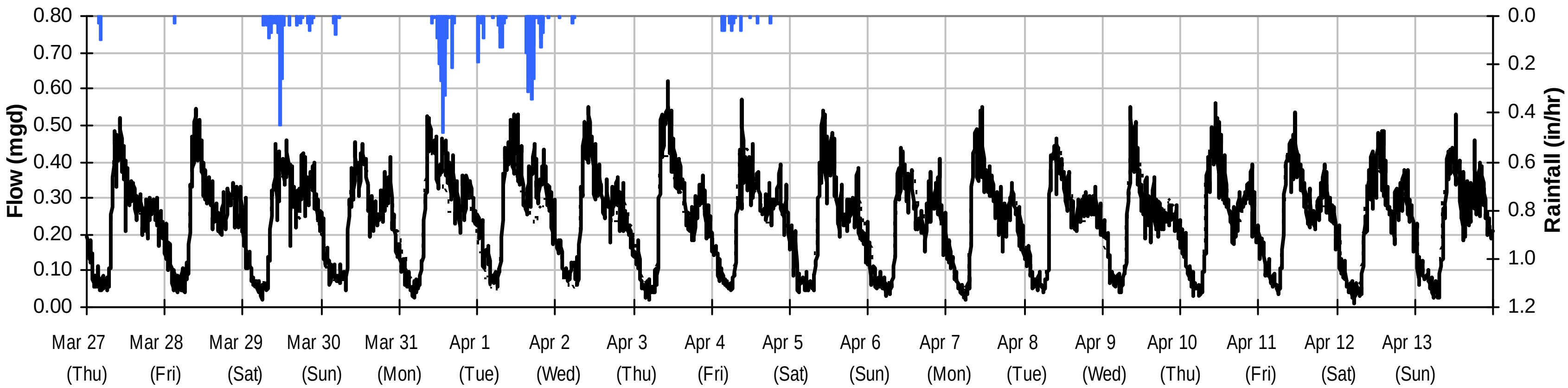


SITE 8

Period Flow Summary: March 9 to April 14, 2014

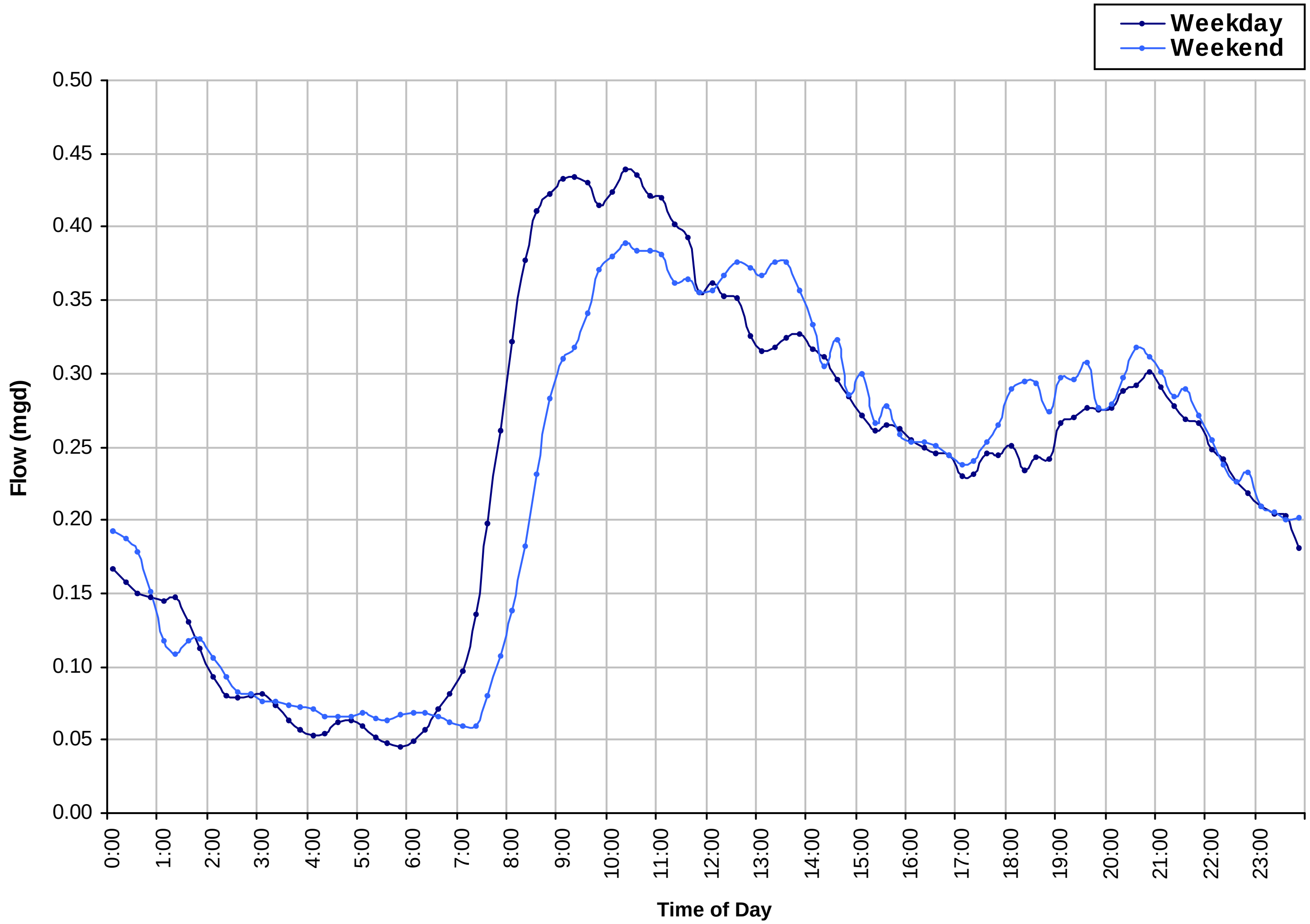
Total Monthly Rainfall: 5.86 inches **Avg Flow: 0.253 mgd** **Peak Flow: 0.842 mgd** **Min Flow: 0.010 mgd**

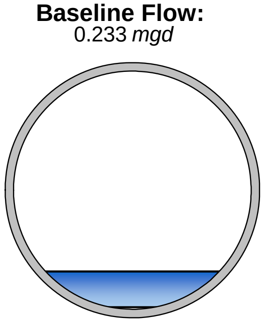




SITE 8

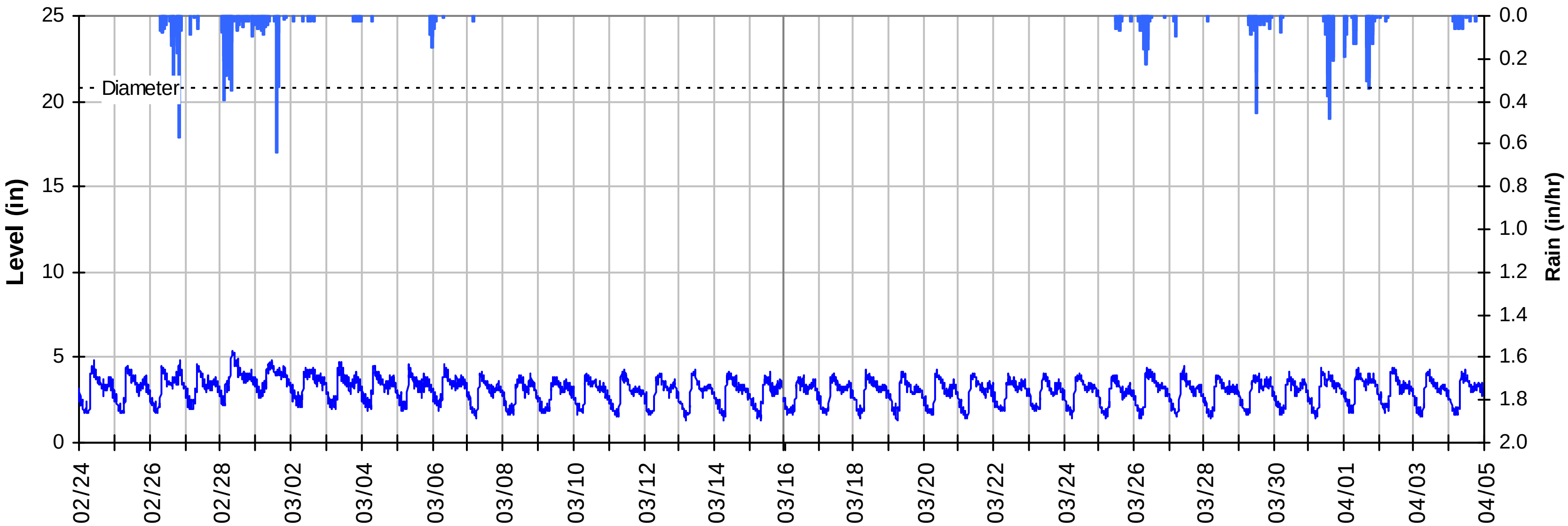
Baseline Flow Hydrographs

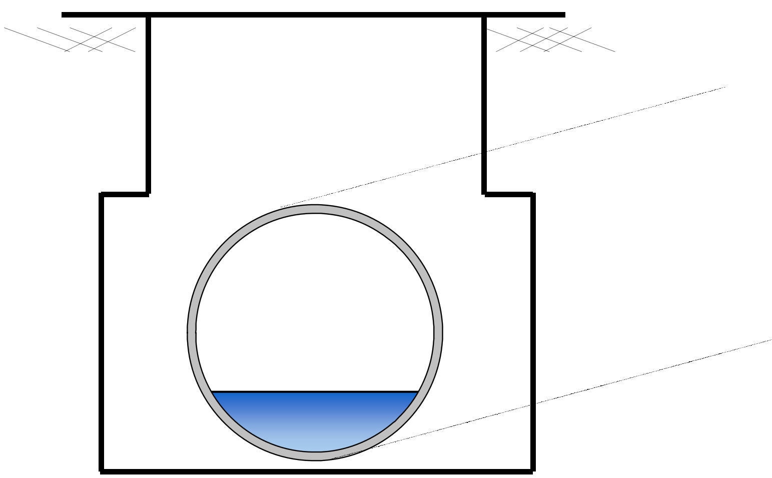




SITE 8
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

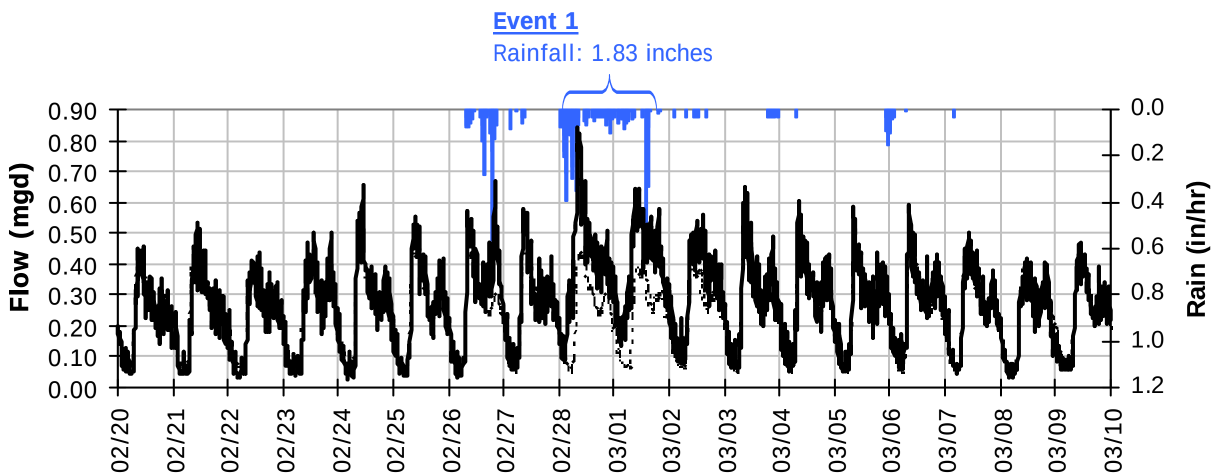




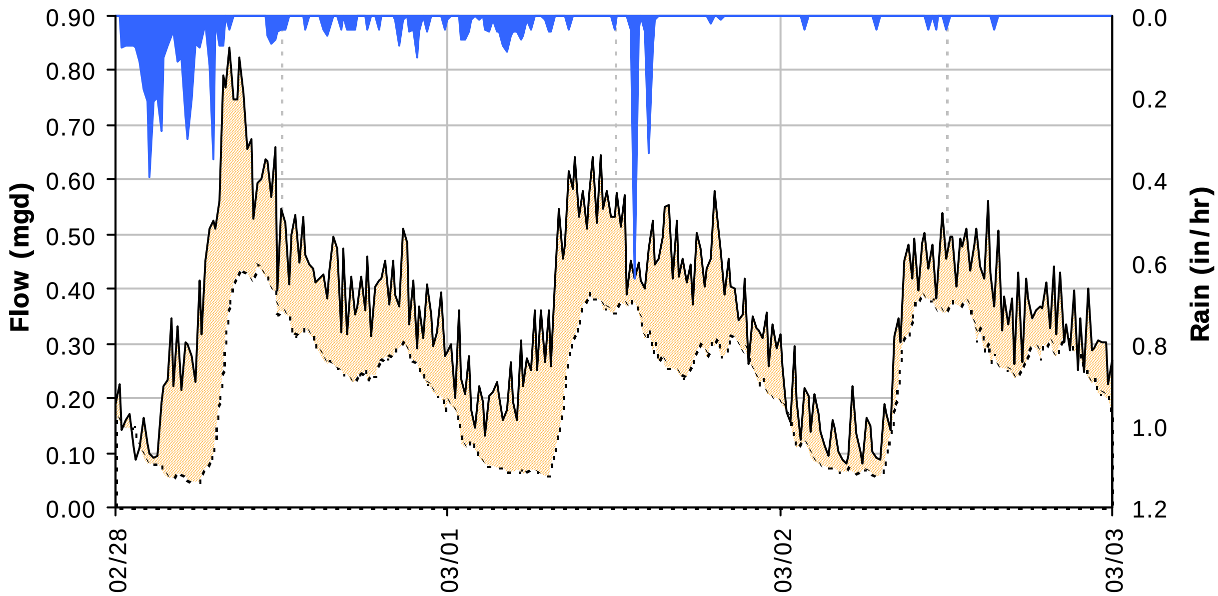
Pipe Diameter:	21 *inches*
Peak Measured Level:	5.37 *inches*
Peak d/D Ratio:	0.26

SITE 8
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

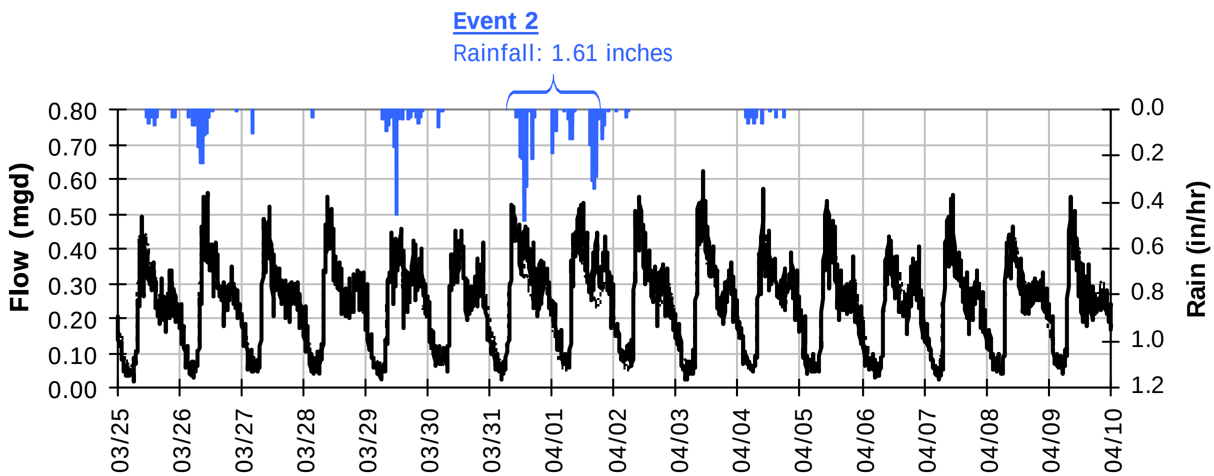


Storm Event I/I Analysis (Rain = 1.83 inches)

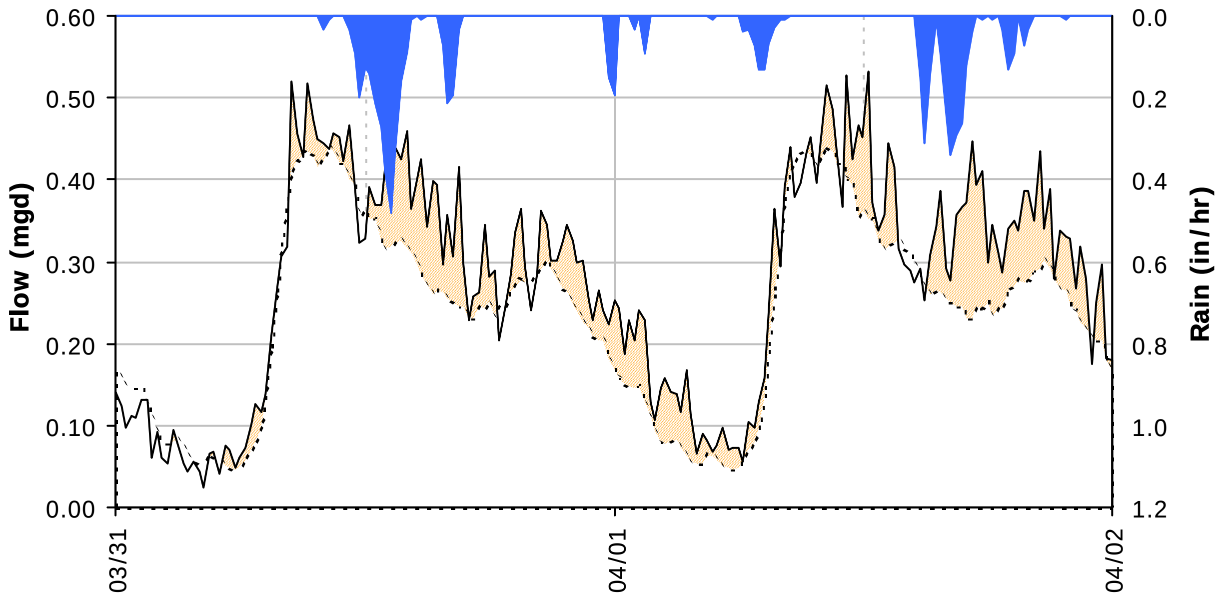
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.84 *mgd*	**Peak I/I Rate:**	0.40 *mgd*
PF:	3.61	**Total I/I:**	419,000 *gallons*

SITE 8
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



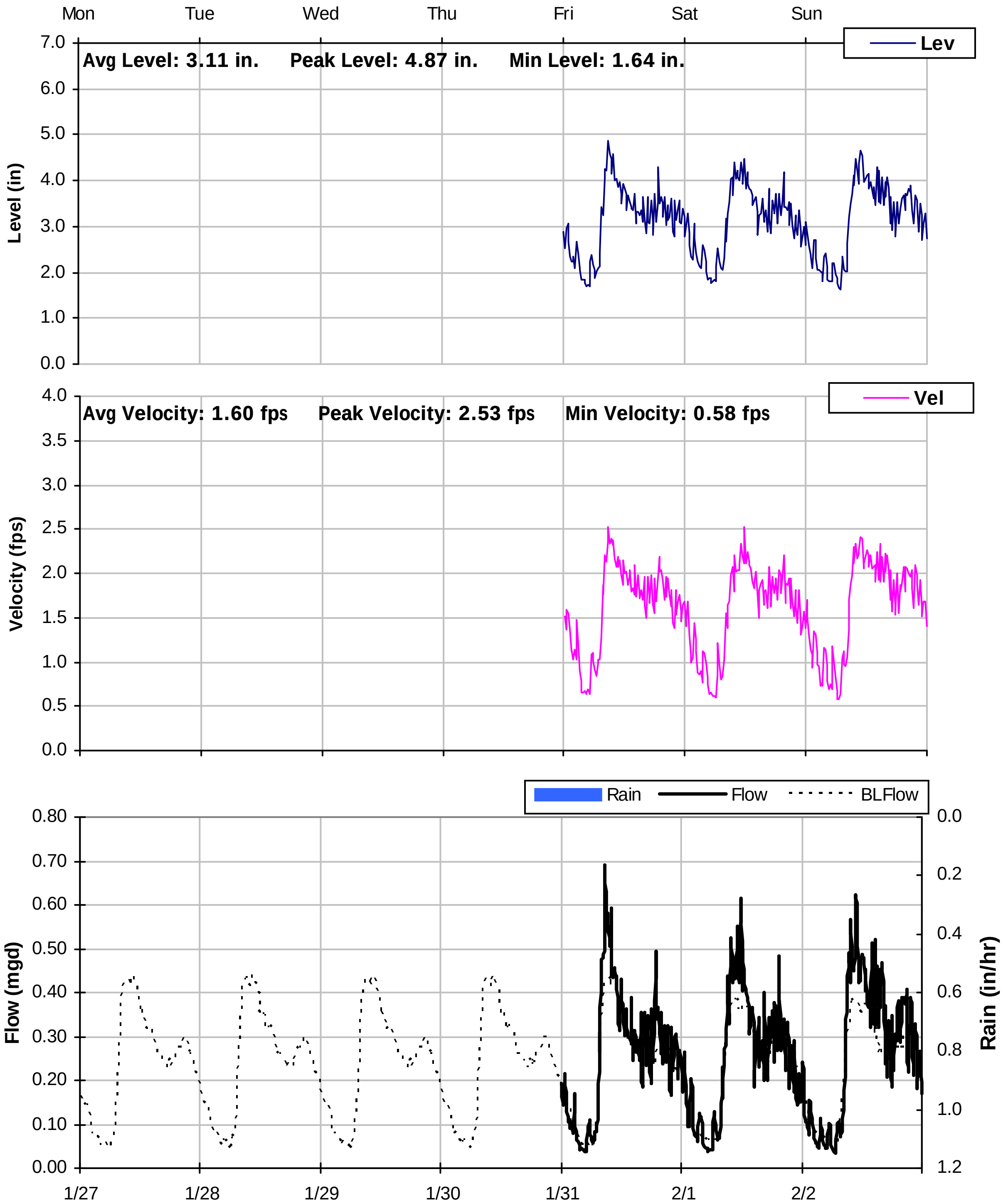
Event 2 Detail Graph



Storm Event I/I Analysis (Rain = 1.61 inches)

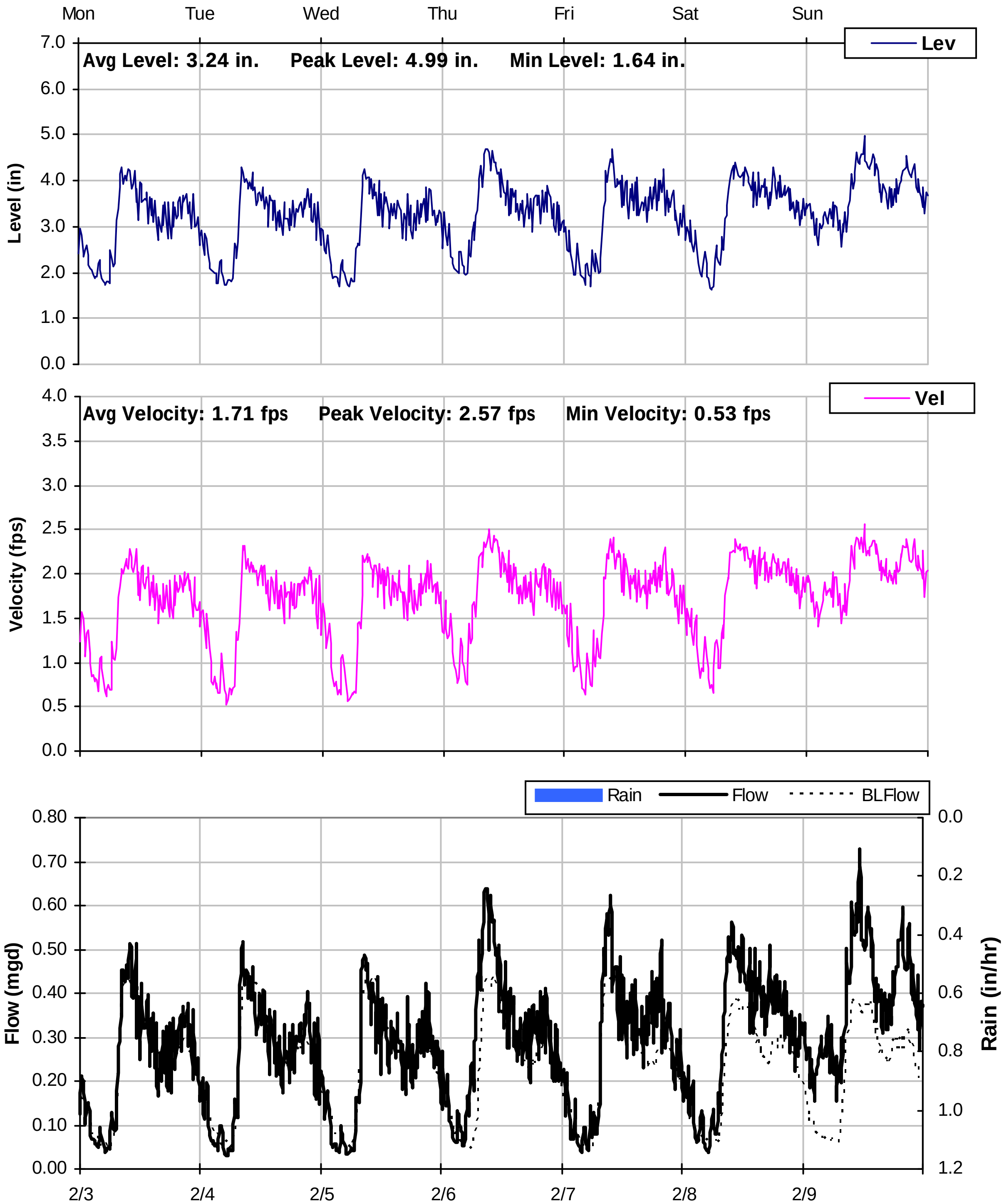
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.62 *mgd*	**Peak I/I Rate:**	0.22 *mgd*
PF:	2.66	**Total I/I:**	111,000 *gallons*

SITE 8
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014



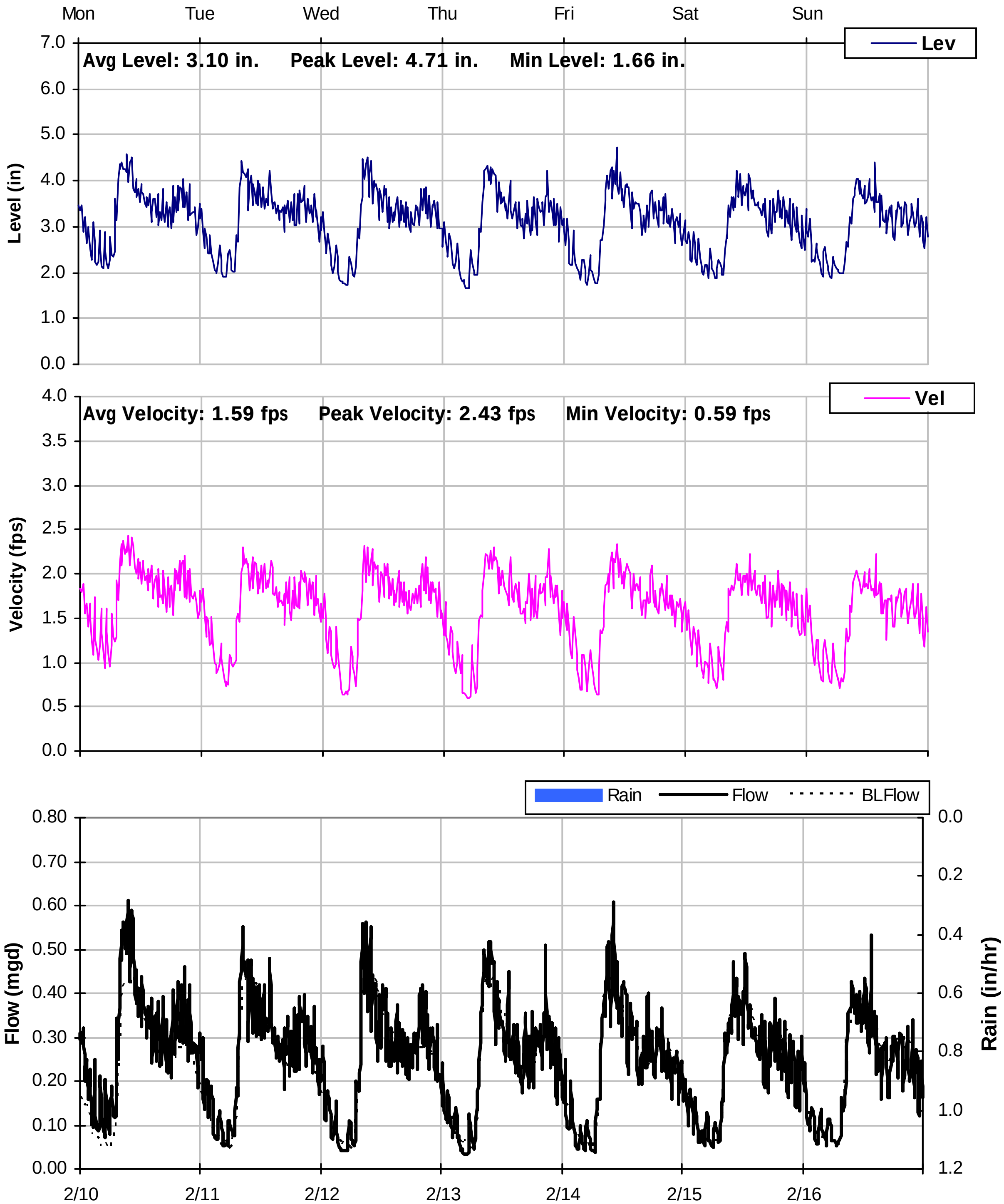
Avg Flow: 0.259 mgd **Peak Flow: 0.691 mgd** **Min Flow: 0.033 mgd**

SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



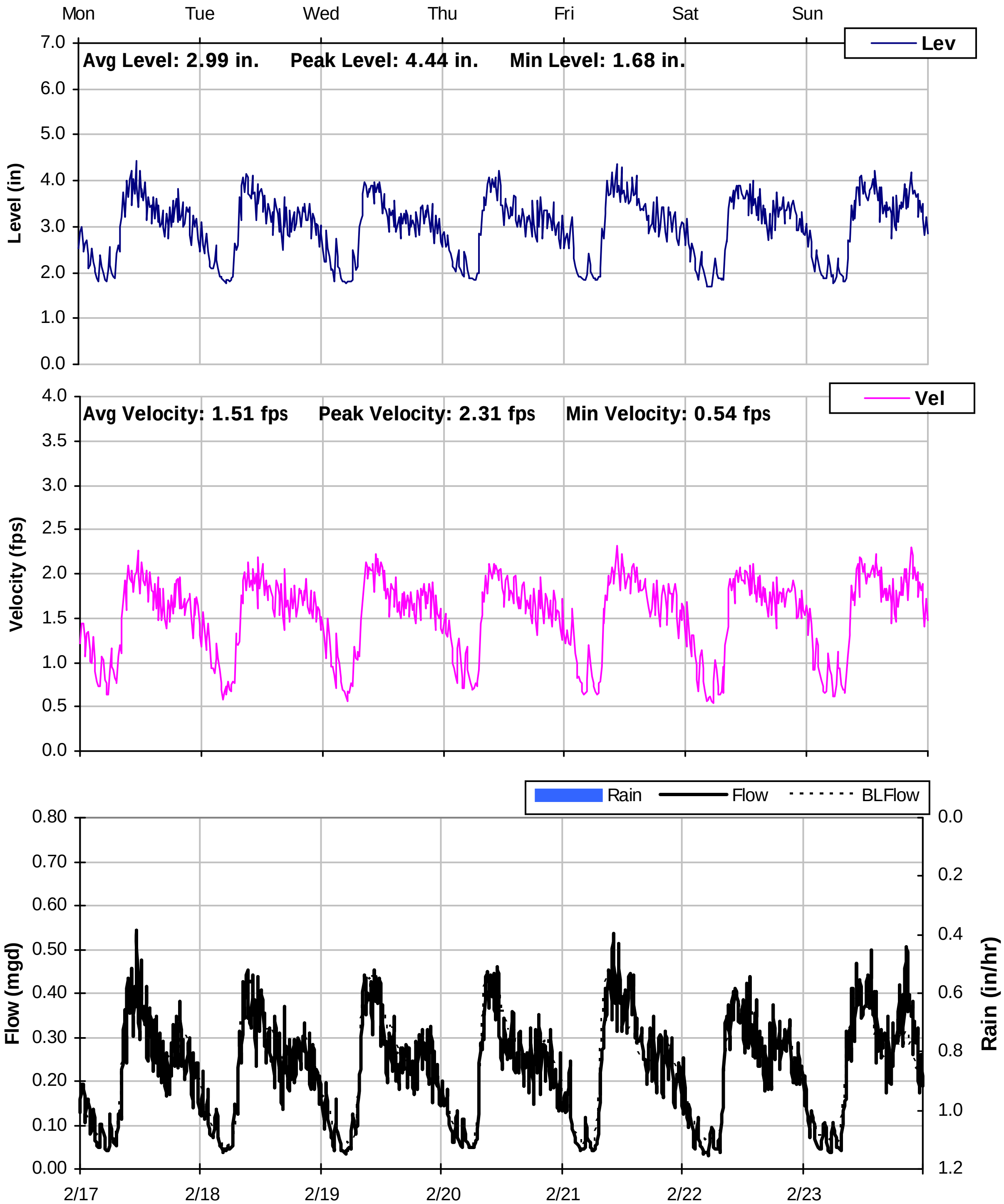
Avg Flow: 0.288 mgd **Peak Flow: 0.729 mgd** **Min Flow: 0.032 mgd**

SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



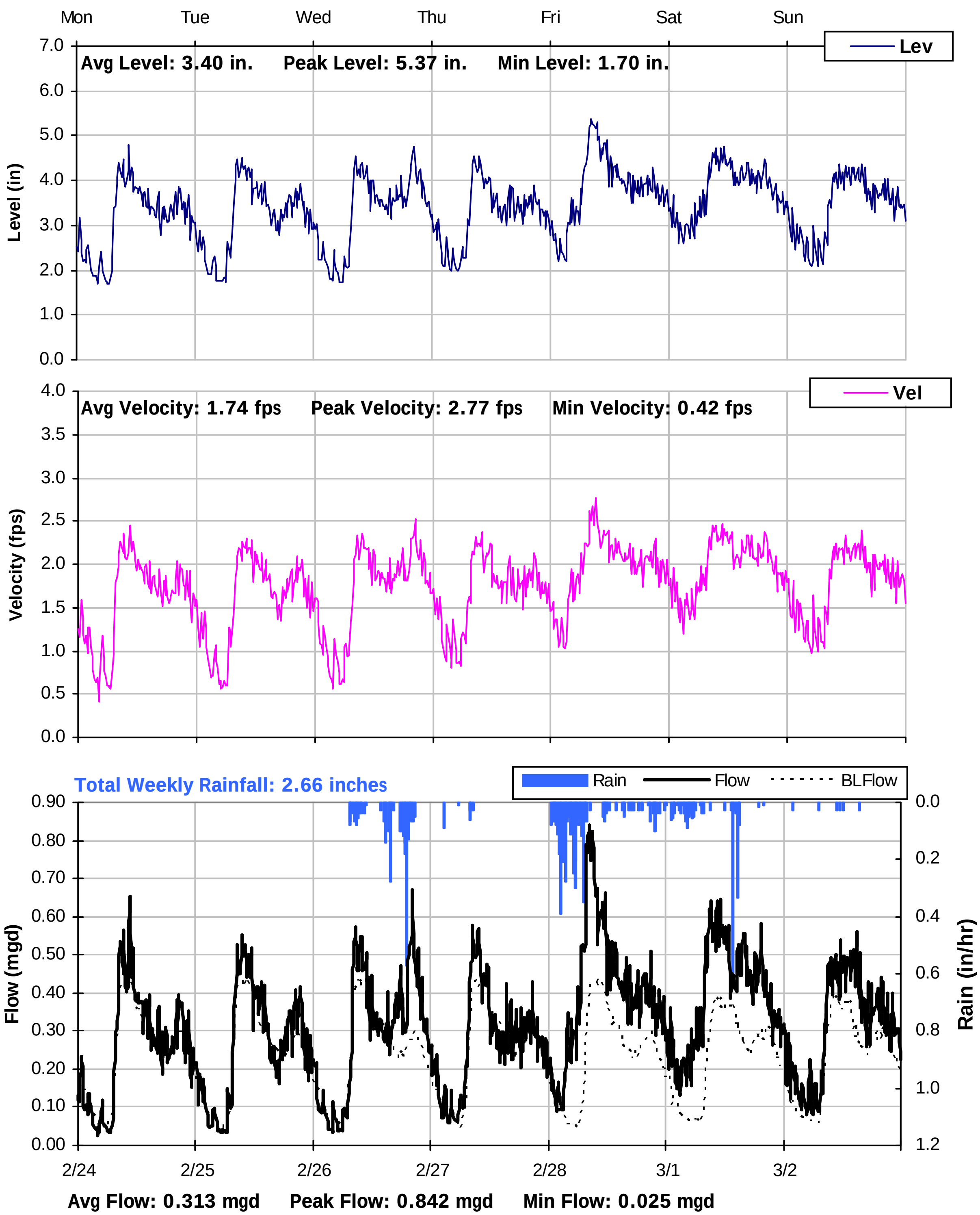
Avg Flow: 0.250 mgd　Peak Flow: 0.613 mgd　Min Flow: 0.034 mgd

SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

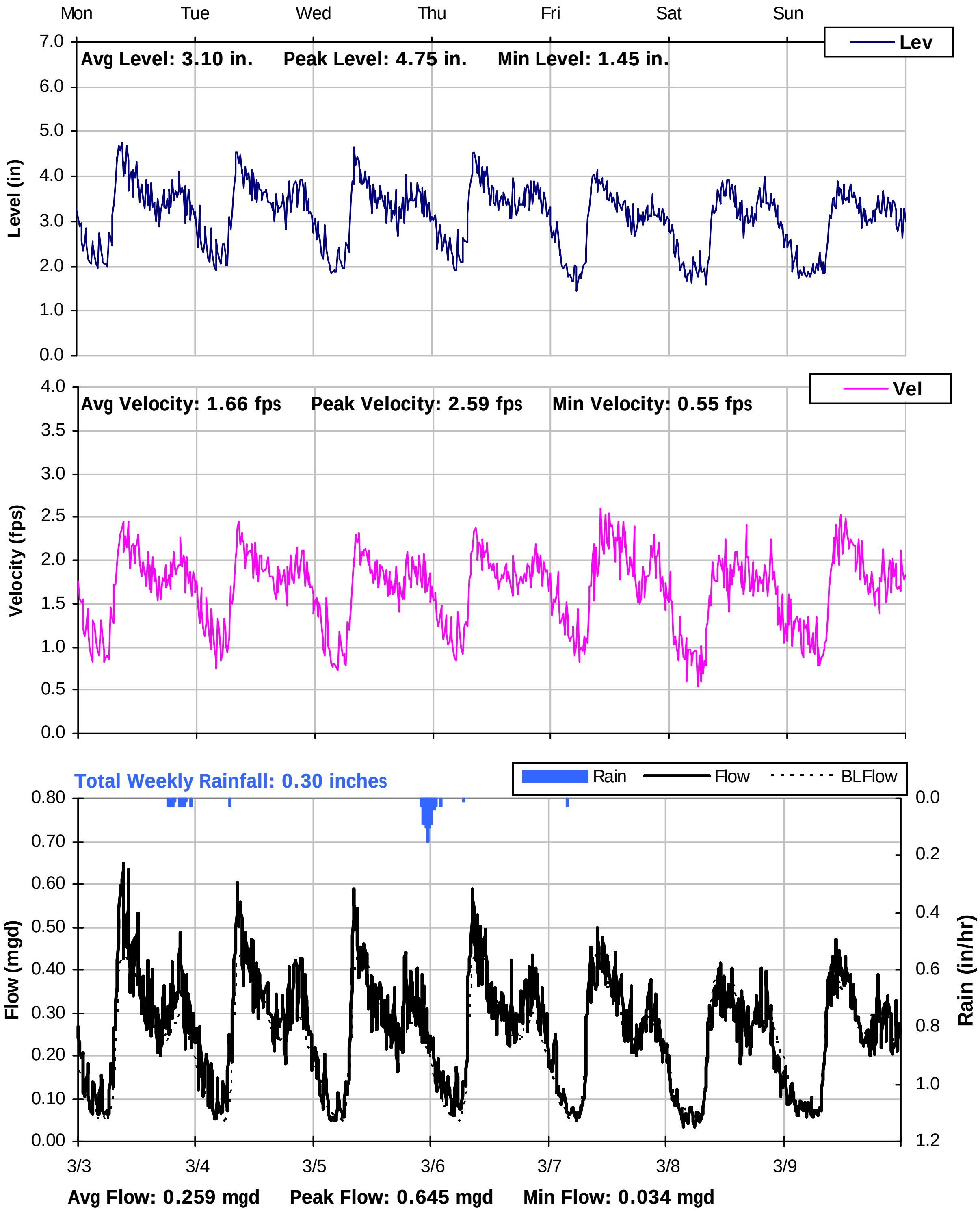


Avg Flow: 0.227 mgd Peak Flow: 0.542 mgd Min Flow: 0.032 mgd

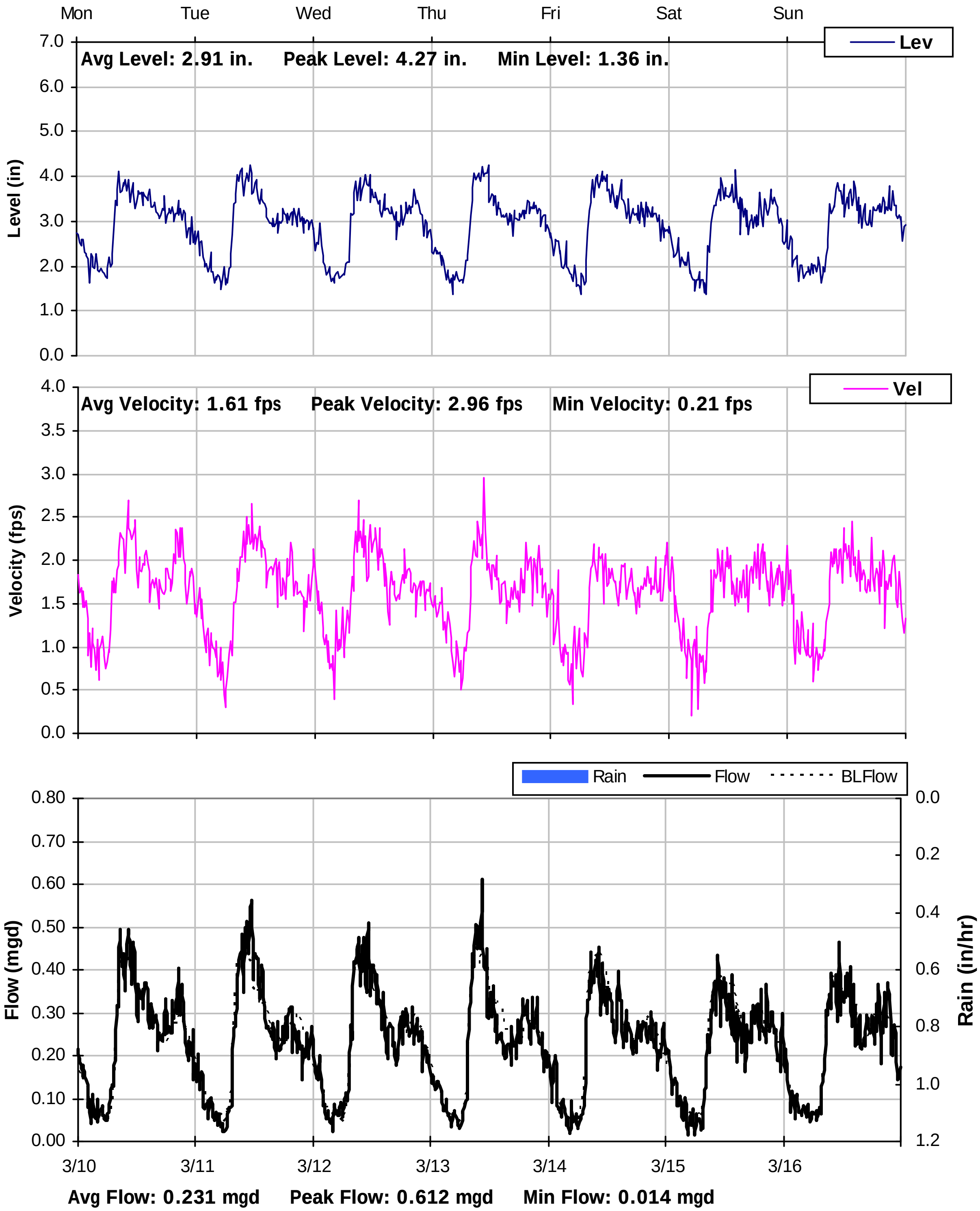
SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



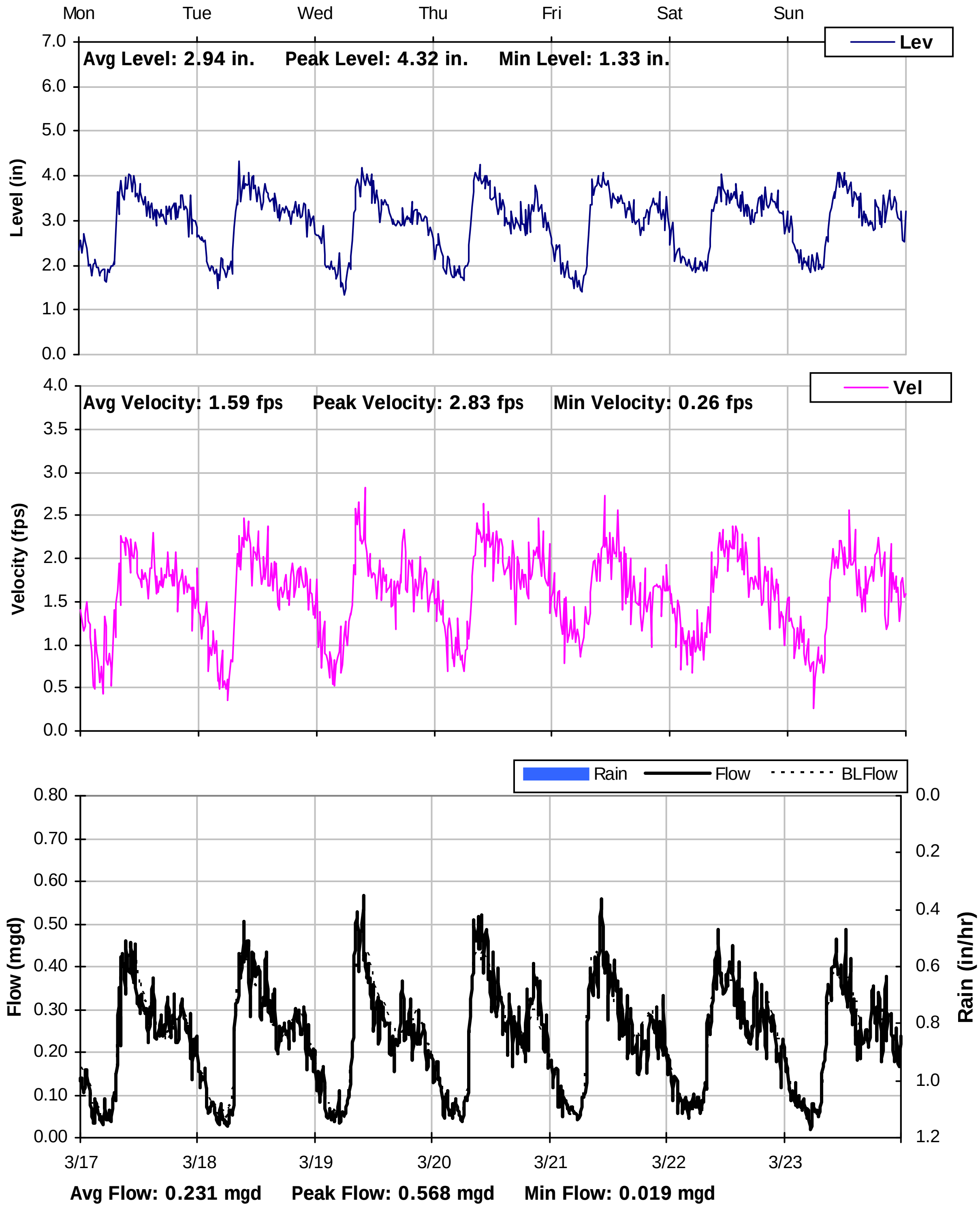
SITE 8
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



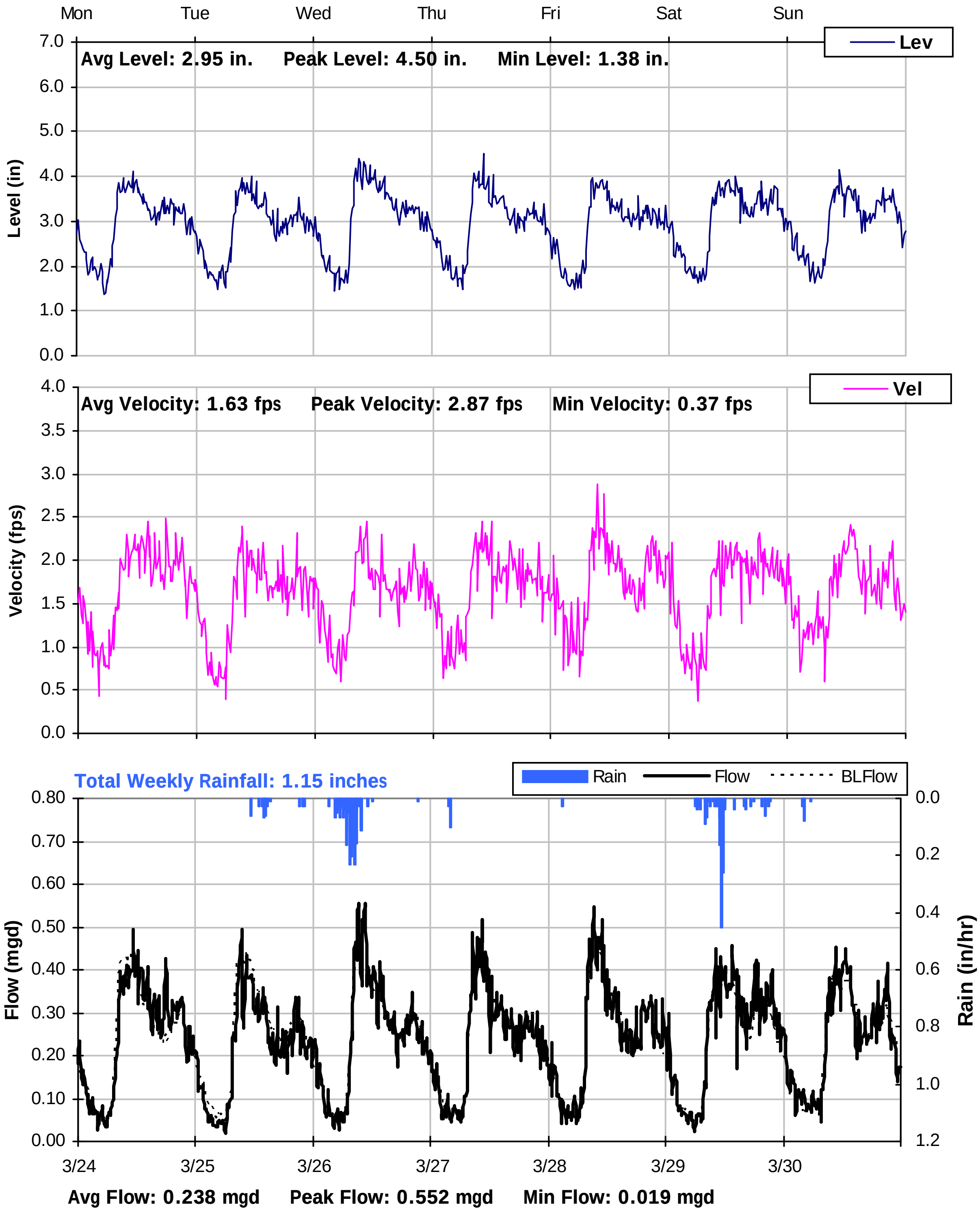
SITE 8
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



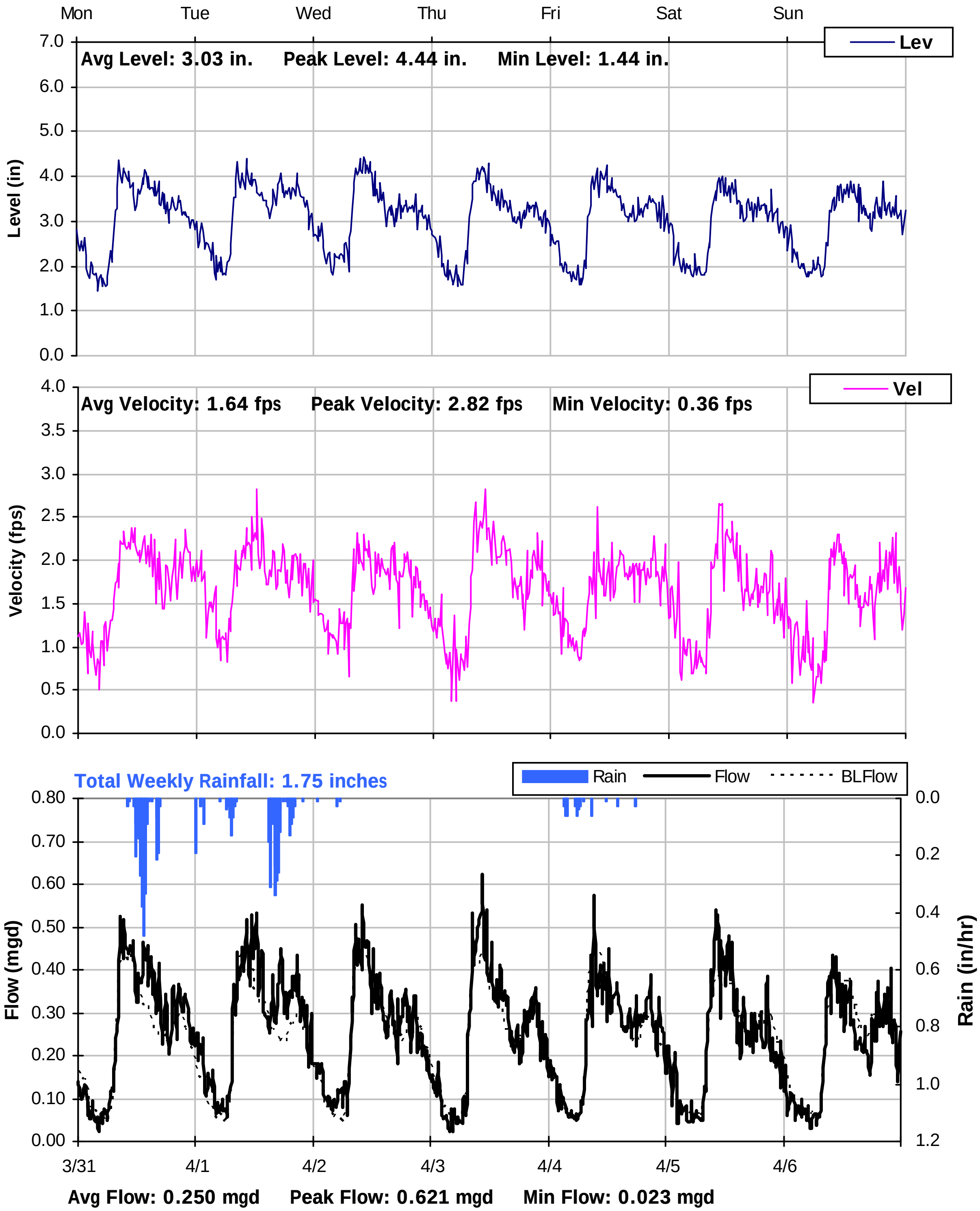
SITE 8
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



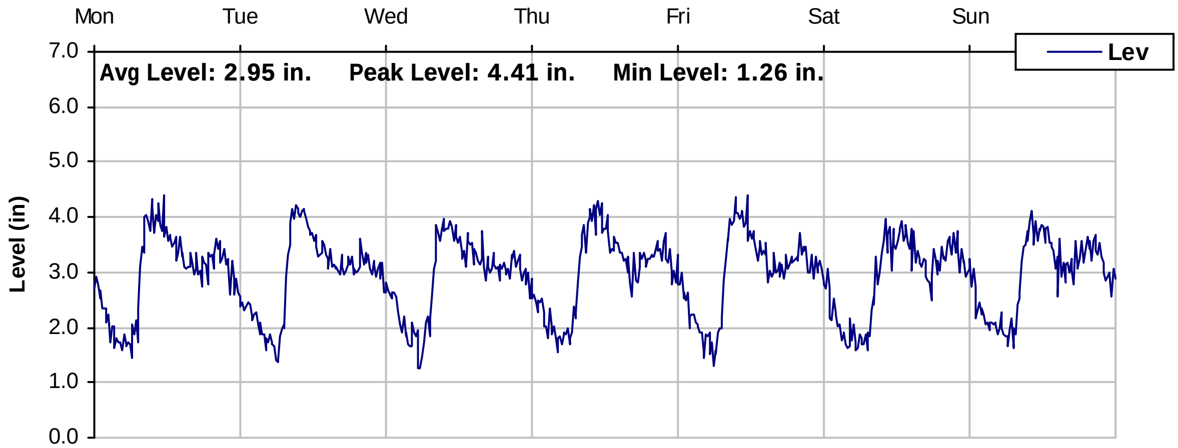
SITE 8
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

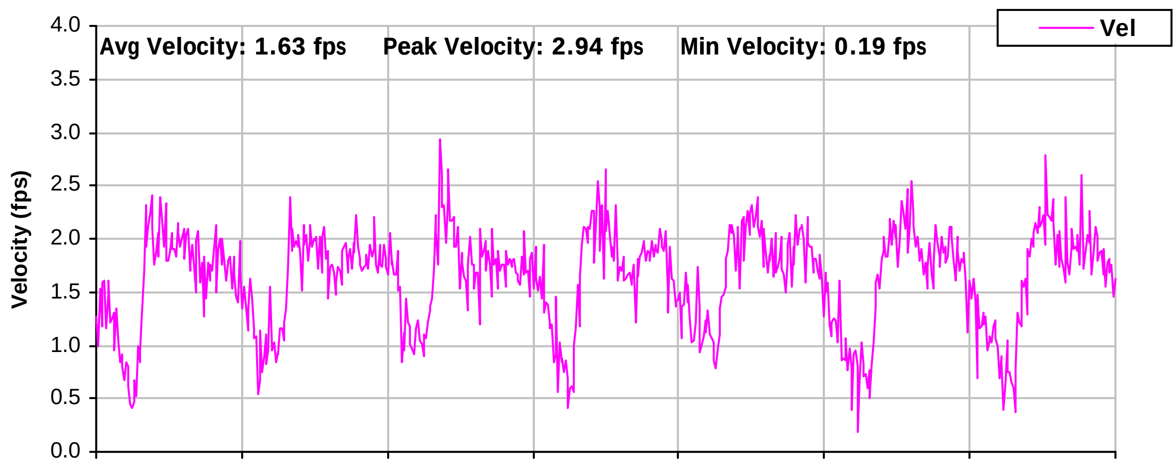


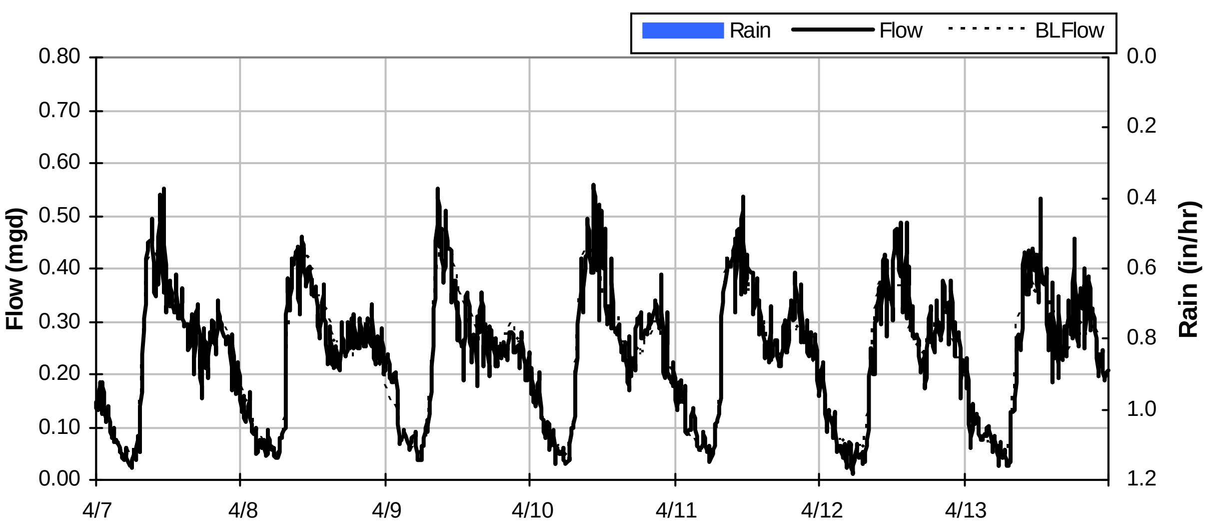
SITE 8
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 8
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014







Avg Flow: 0.238 mgd Peak Flow: 0.555 mgd Min Flow: 0.010 mgd

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 9

Location: Middlefield Road, southeast of Prior Lane

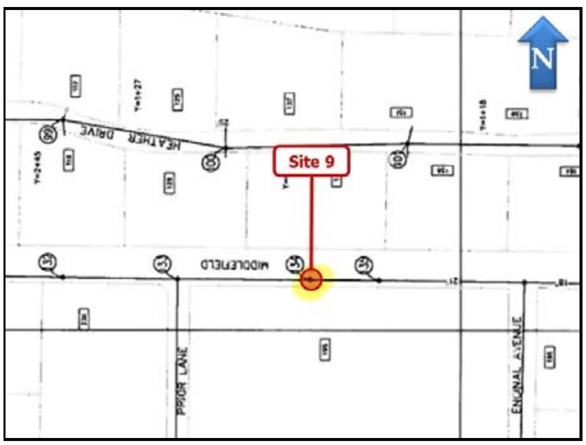
Data Summary Report

SITE 9

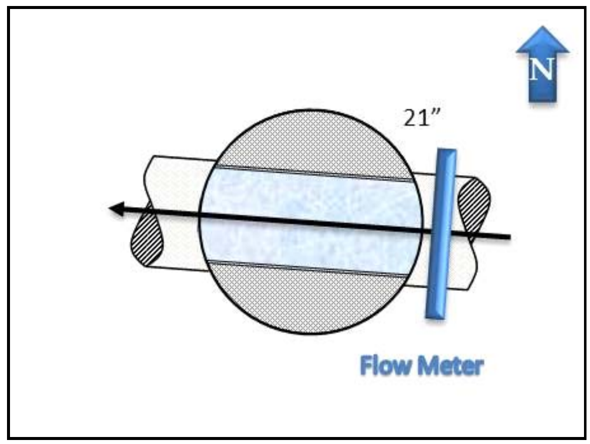
Site Information

Location:	Middlefield Road, southeast of Prior Lane
Coordinates:	122.1859° W, 37.4656° N
Rim Elevation:	45 feet
Pipe Diameter:	21 inches
Baseline Flow:	0.499 mgd
Peak Measured Flow:	1.332 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

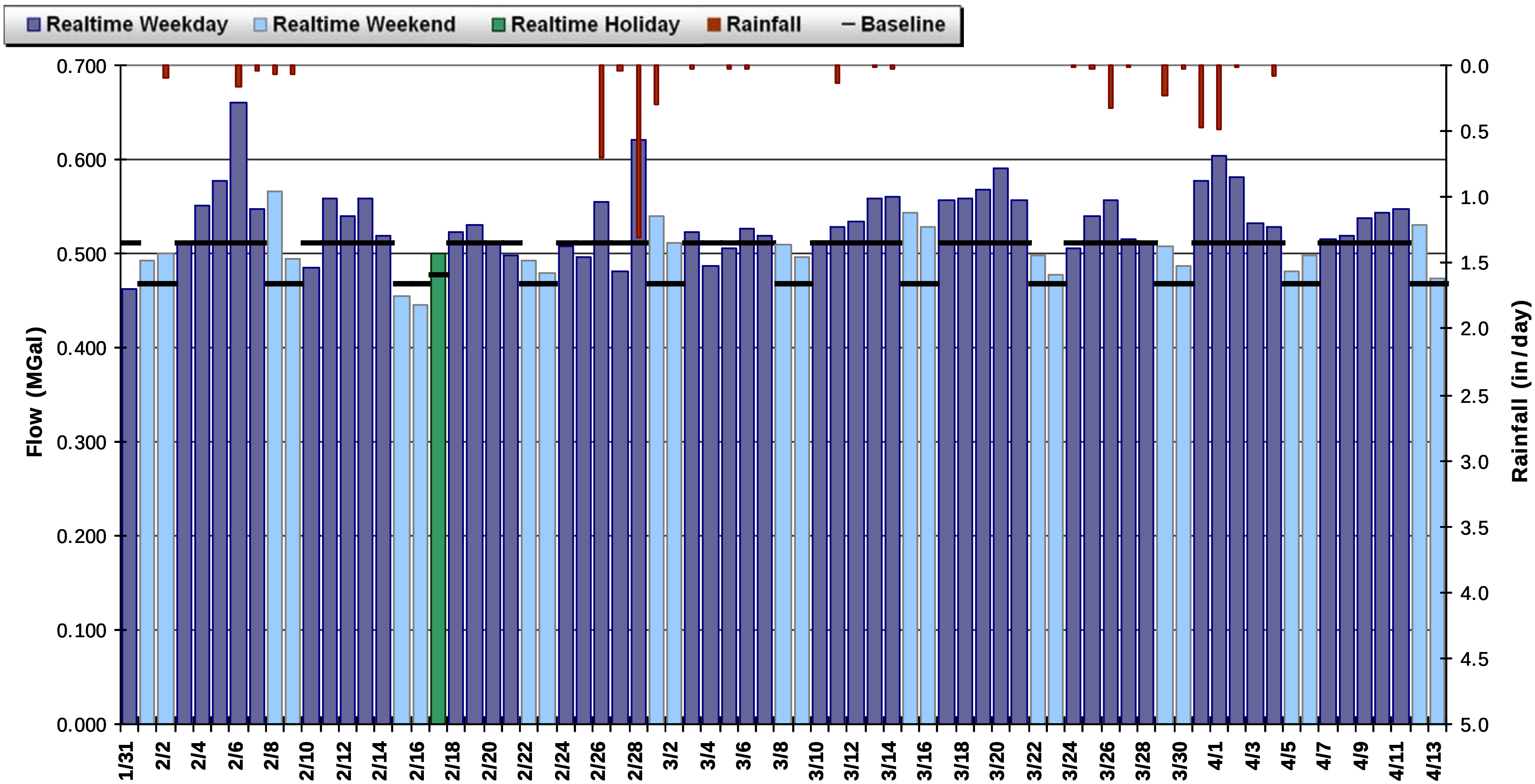
Plan View

SITE 9

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.526 MGal **Peak Daily Flow: 0.661 MGal** **Min Daily Flow: 0.446 MGal**

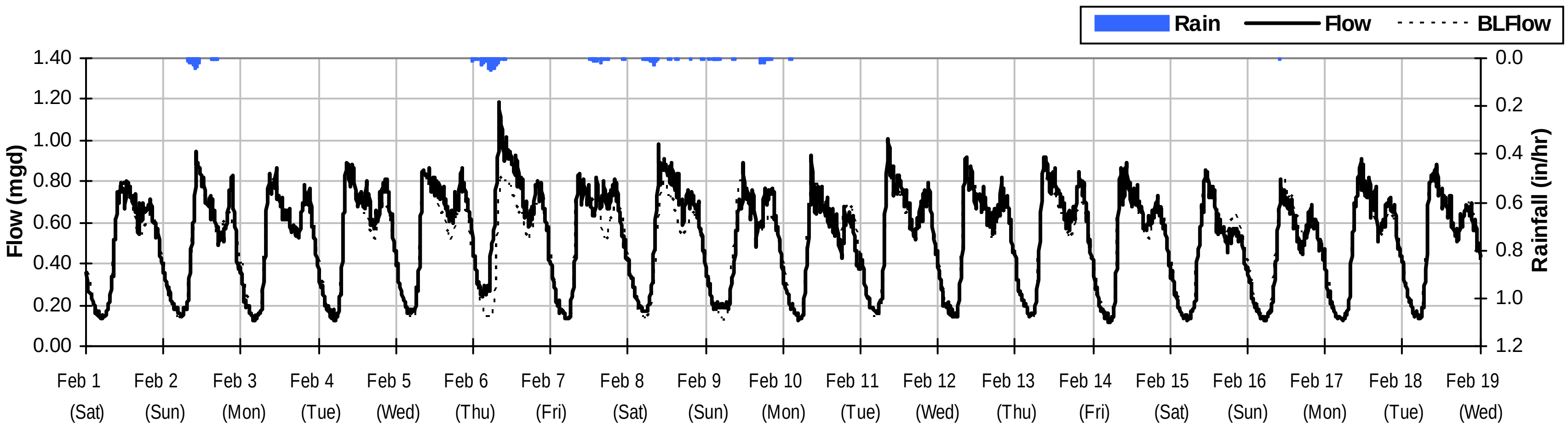
Total Period Rainfall: 4.75 inches

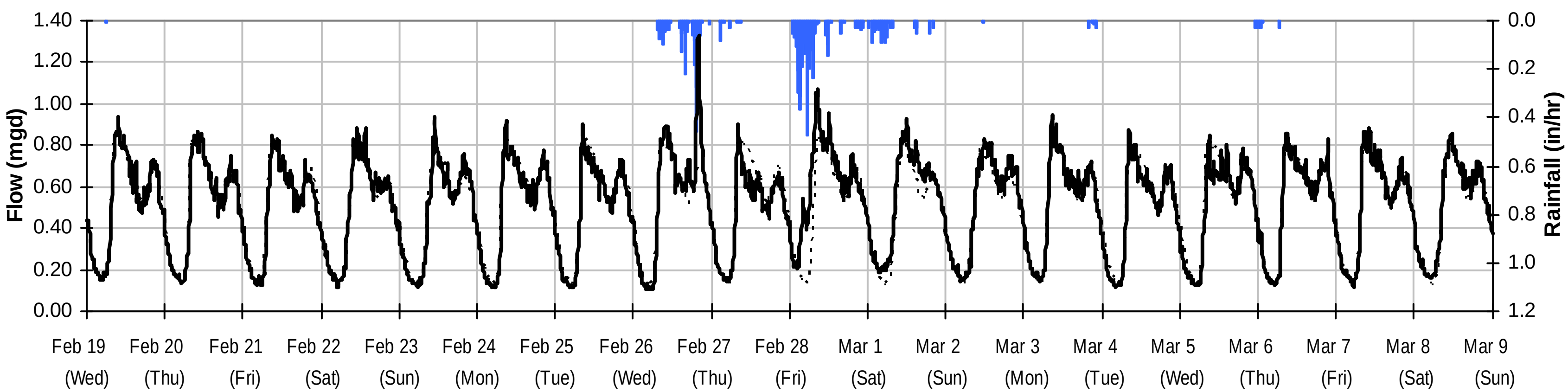


SITE 9

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.76 inches **Avg Flow: 0.526 mgd** **Peak Flow: 1.332 mgd** **Min Flow: 0.103 mgd**

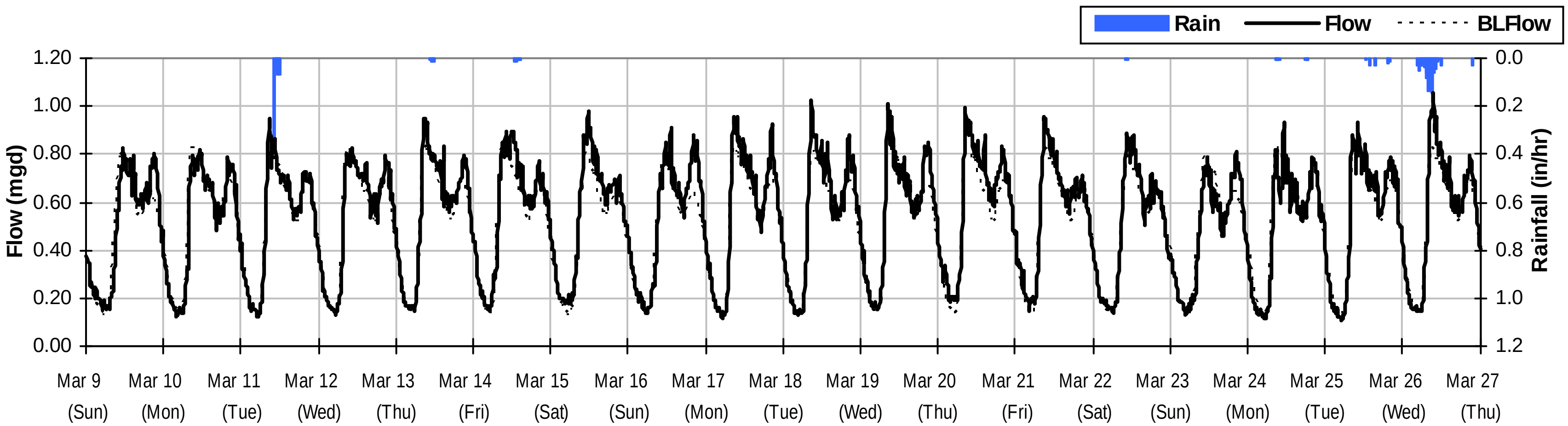


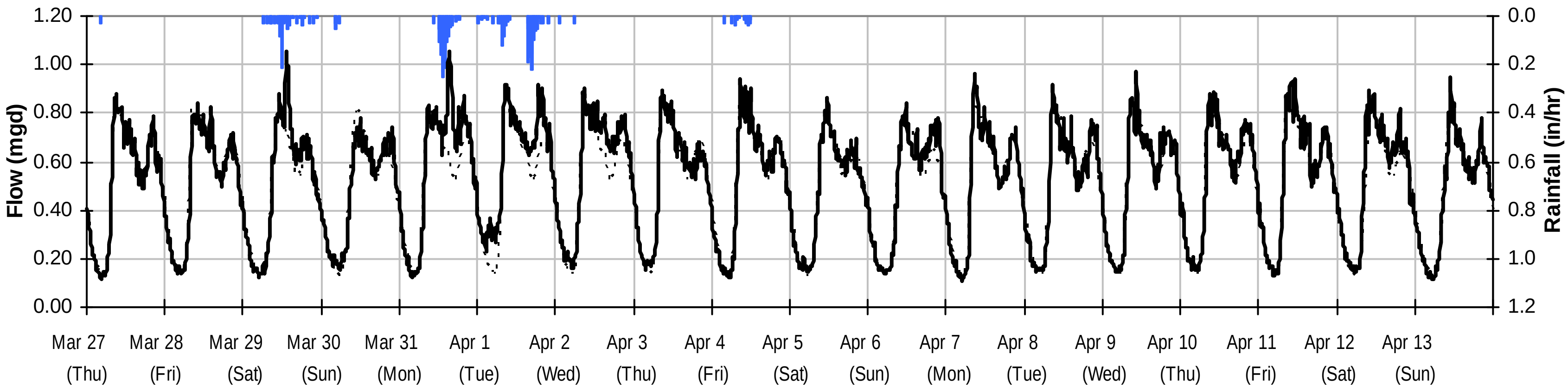


SITE 9

Period Flow Summary: March 9 to April 14, 2014

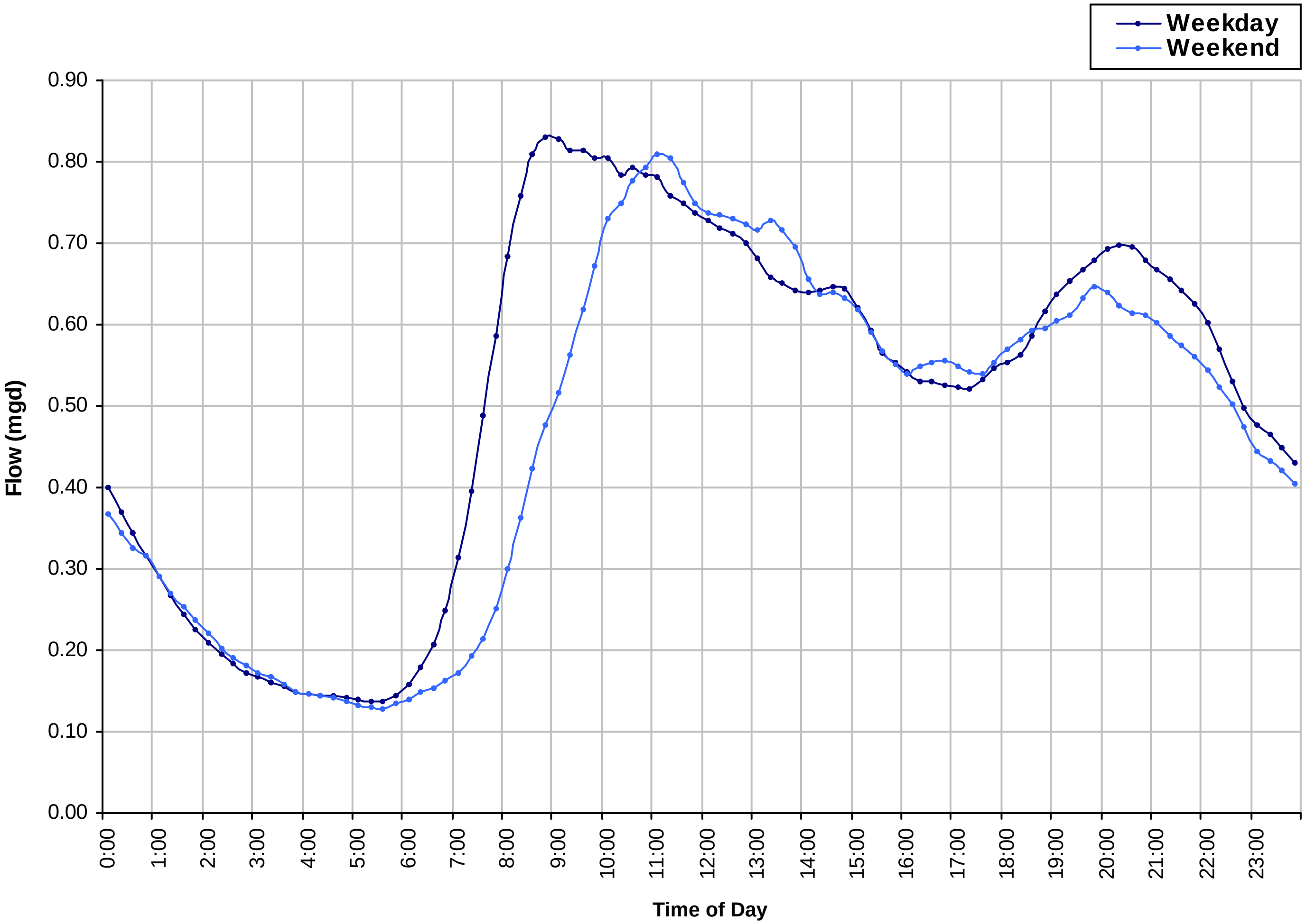
Total Monthly Rainfall: 4.76 inches **Avg Flow: 0.526 mgd** **Peak Flow: 1.332 mgd** **Min Flow: 0.103 mgd**



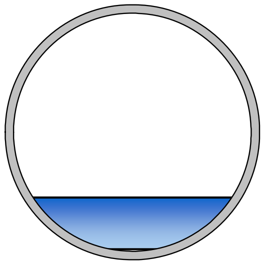


SITE 9

Baseline Flow Hydrographs

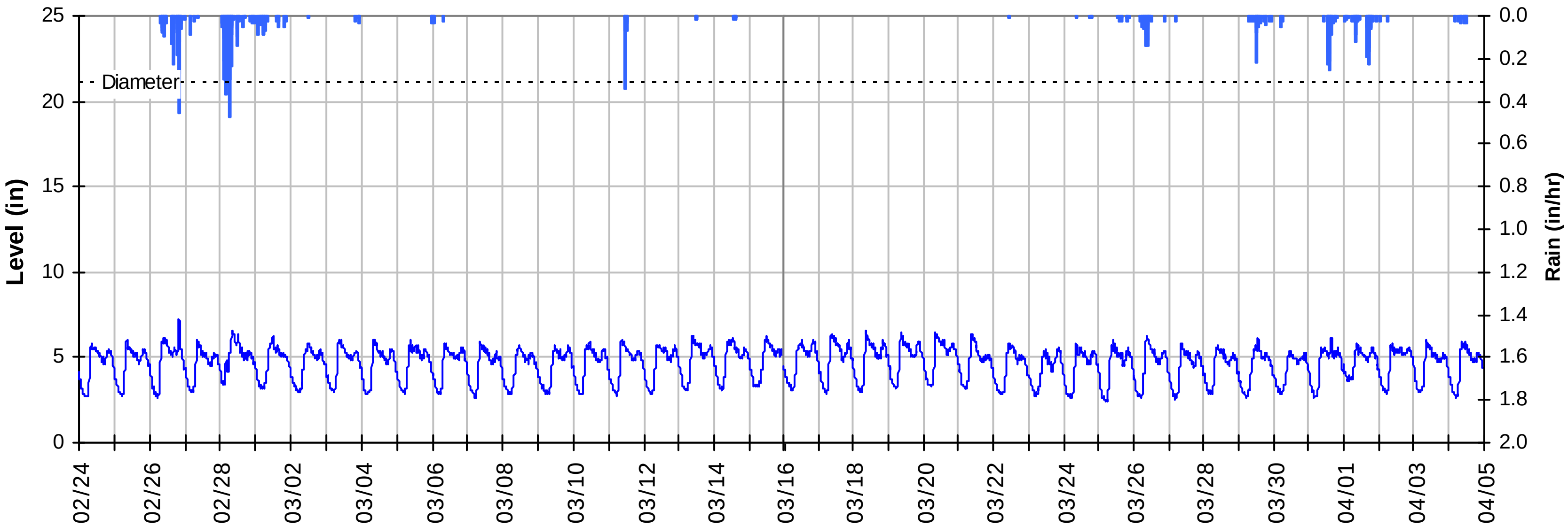


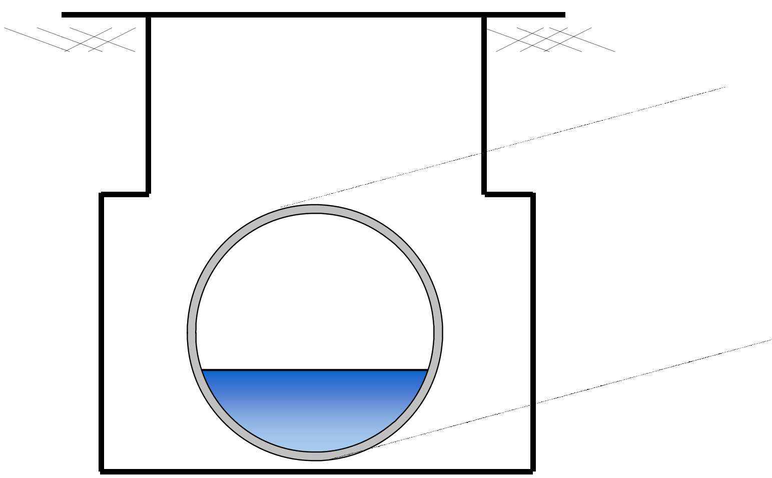
Baseline Flow:
0.499 *mgd*



SITE 9
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





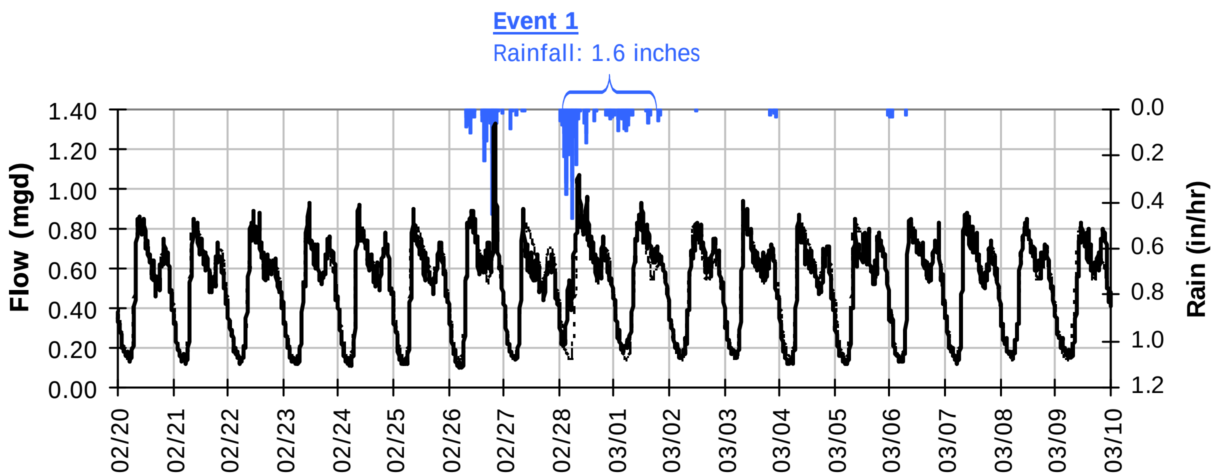
Pipe Diameter: 21 *inches*

Peak Measured Level: 7.2 *inches*

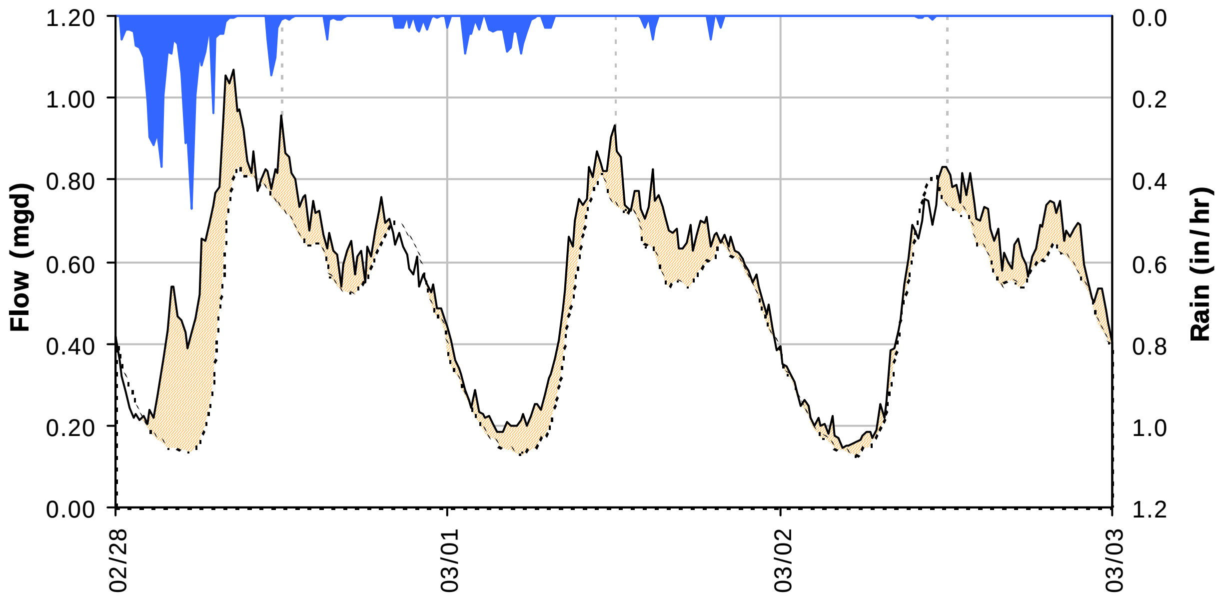
Peak d / D Ratio: 0.34

SITE 9
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

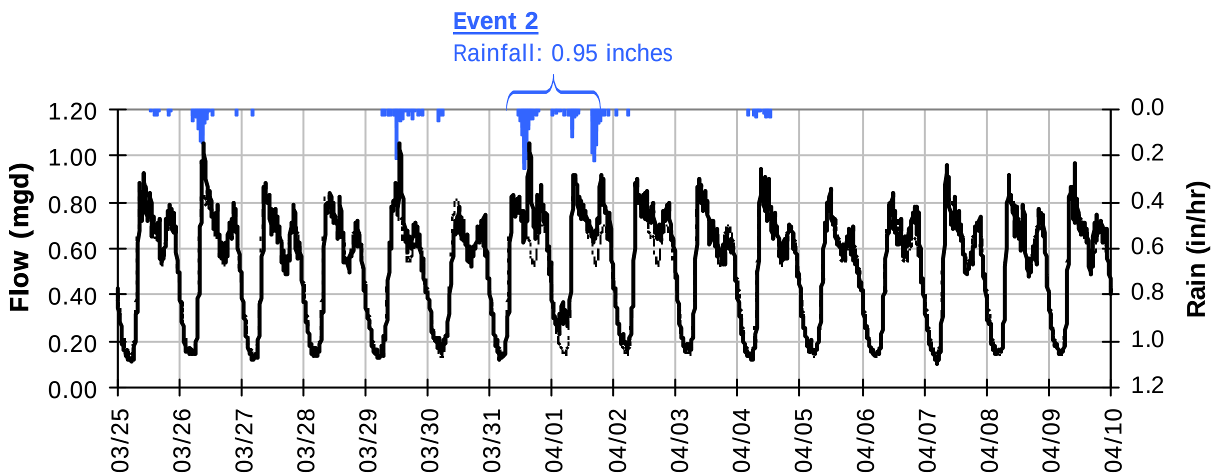


Storm Event I/I Analysis (Rain = 1.60 inches)

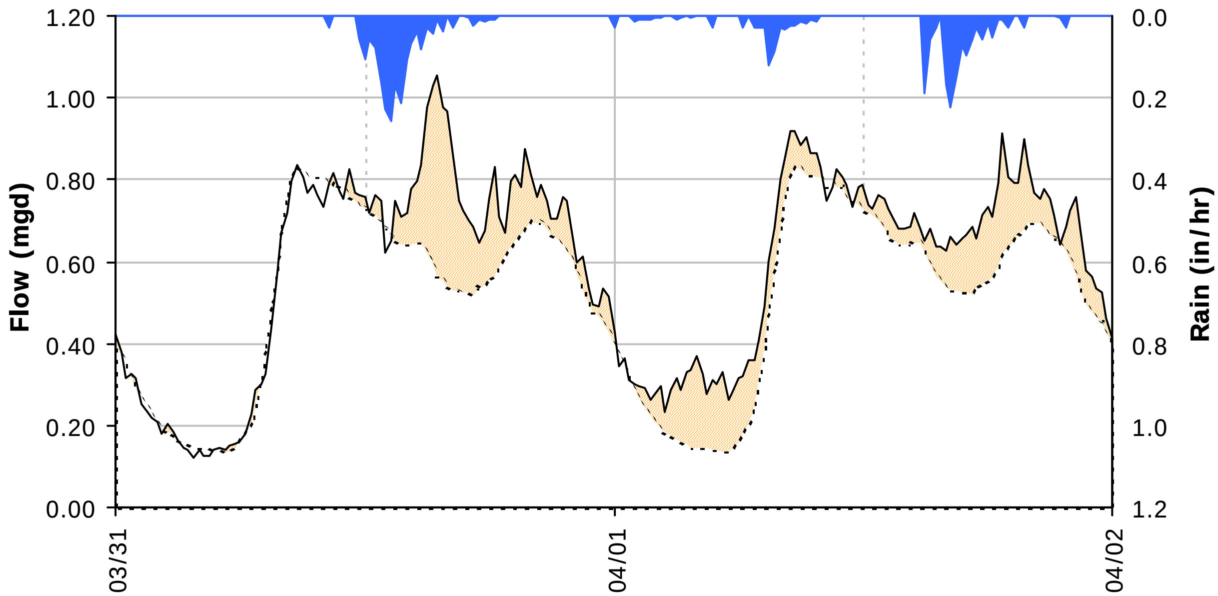
Capacity		**Inflow / Infiltration**	
Peak Flow:	1.07 *mgd*	**Peak I/I Rate:**	0.31 *mgd*
PF:	2.15	**Total I/I:**	225,000 *gallons*

SITE 9
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



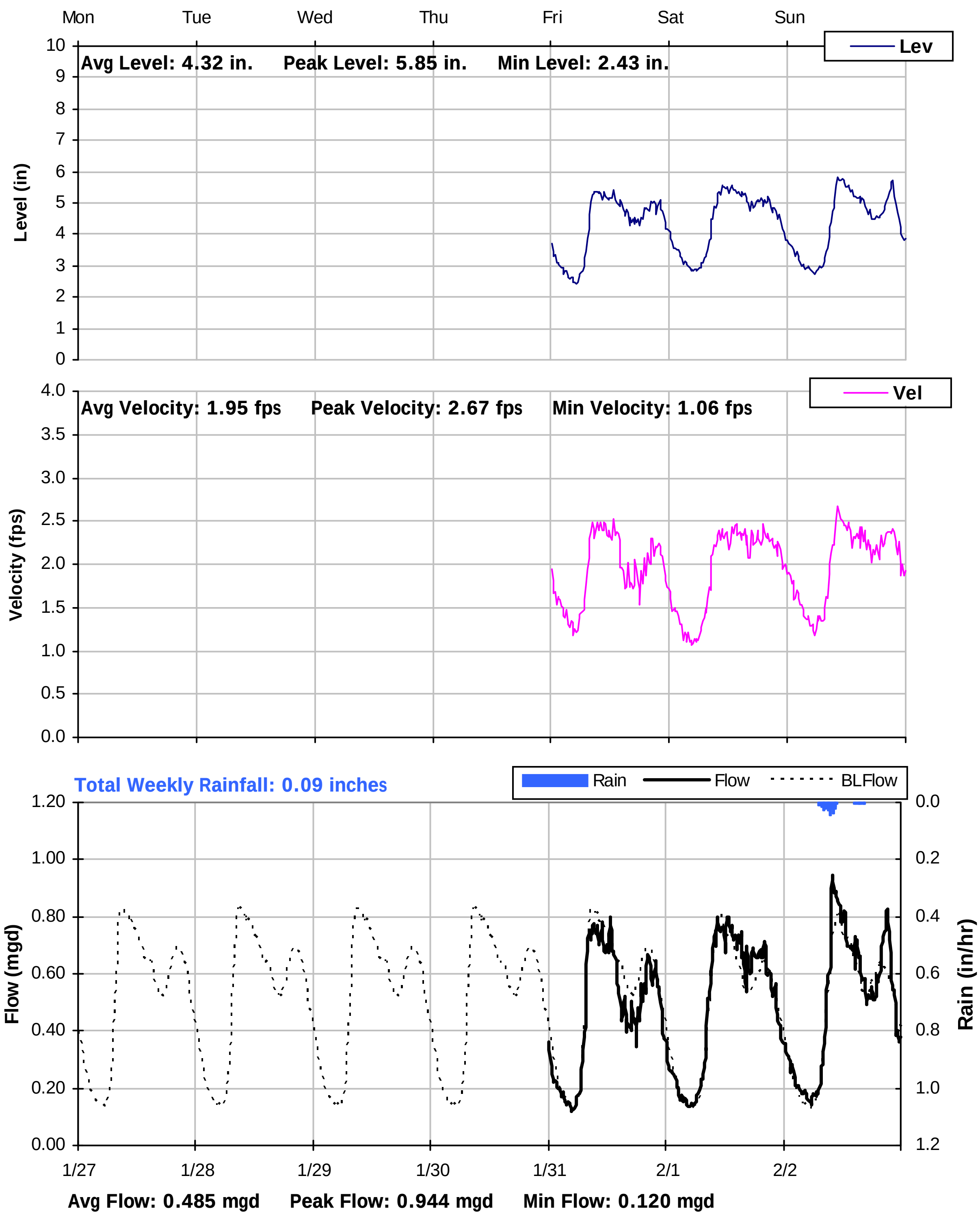
Event 2 Detail Graph



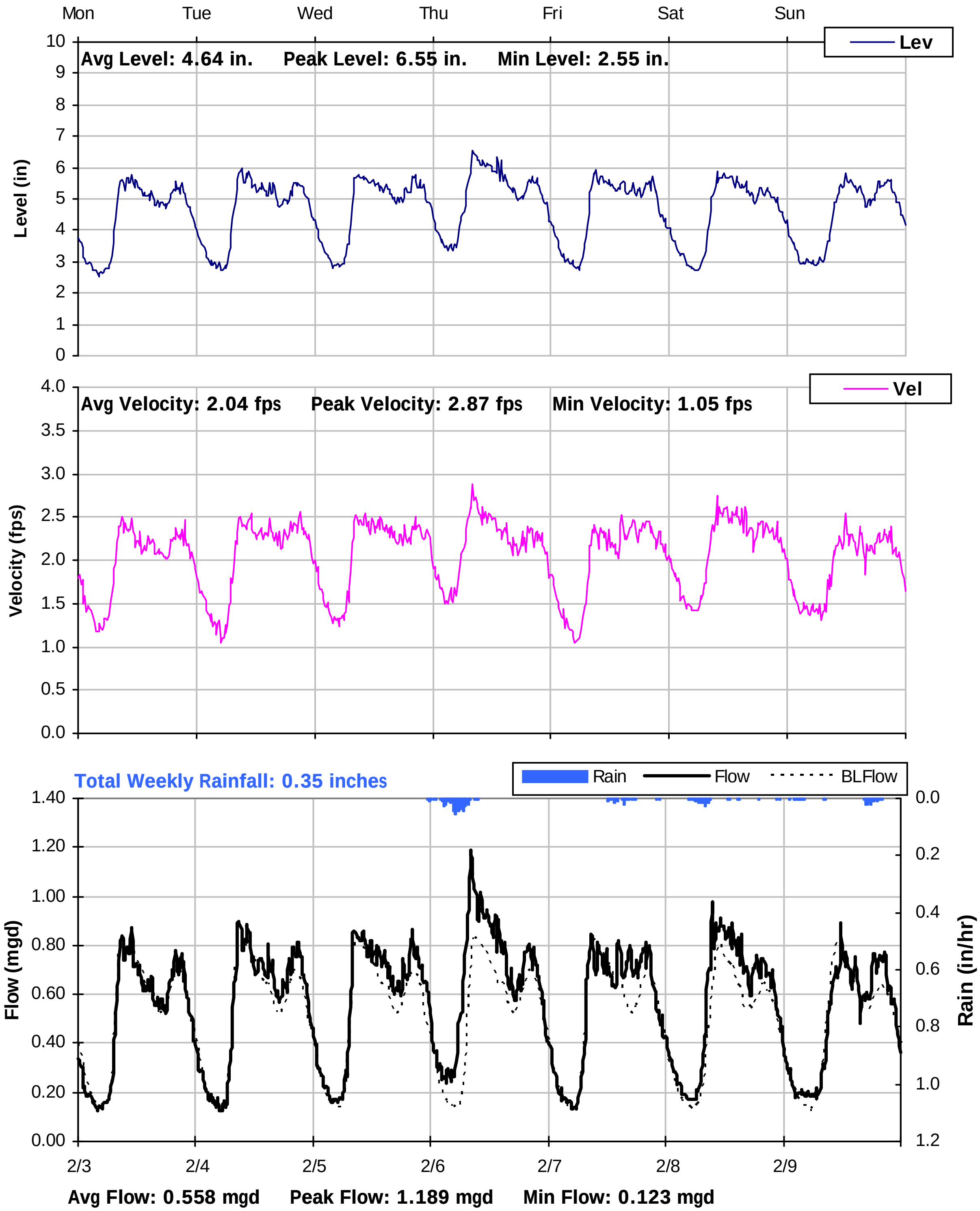
Storm Event I/I Analysis (Rain = 0.95 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	1.05 *mgd*	**Peak I/I Rate:**	0.49 *mgd*
PF:	2.11	**Total I/I:**	248,000 *gallons*

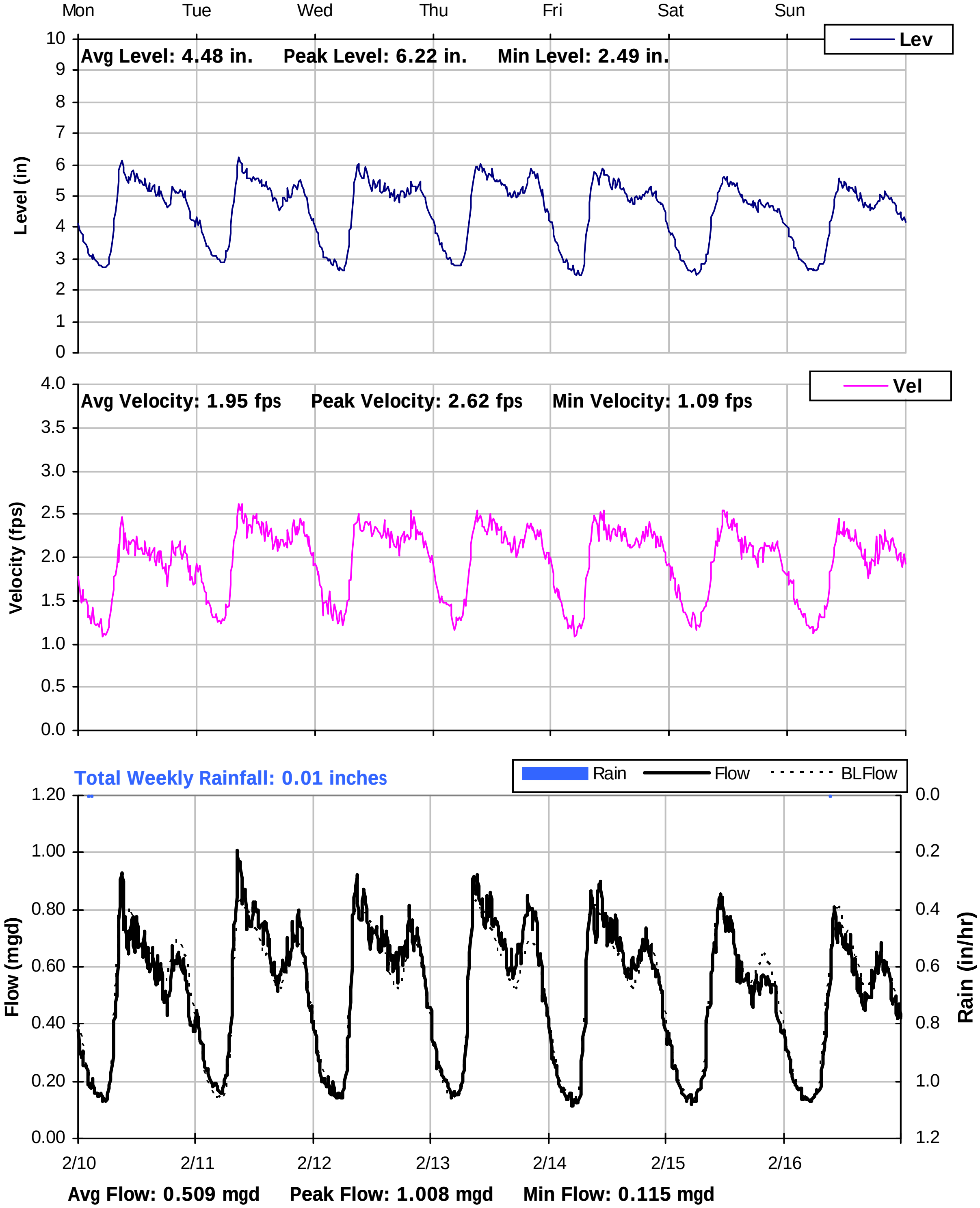
SITE 9
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014



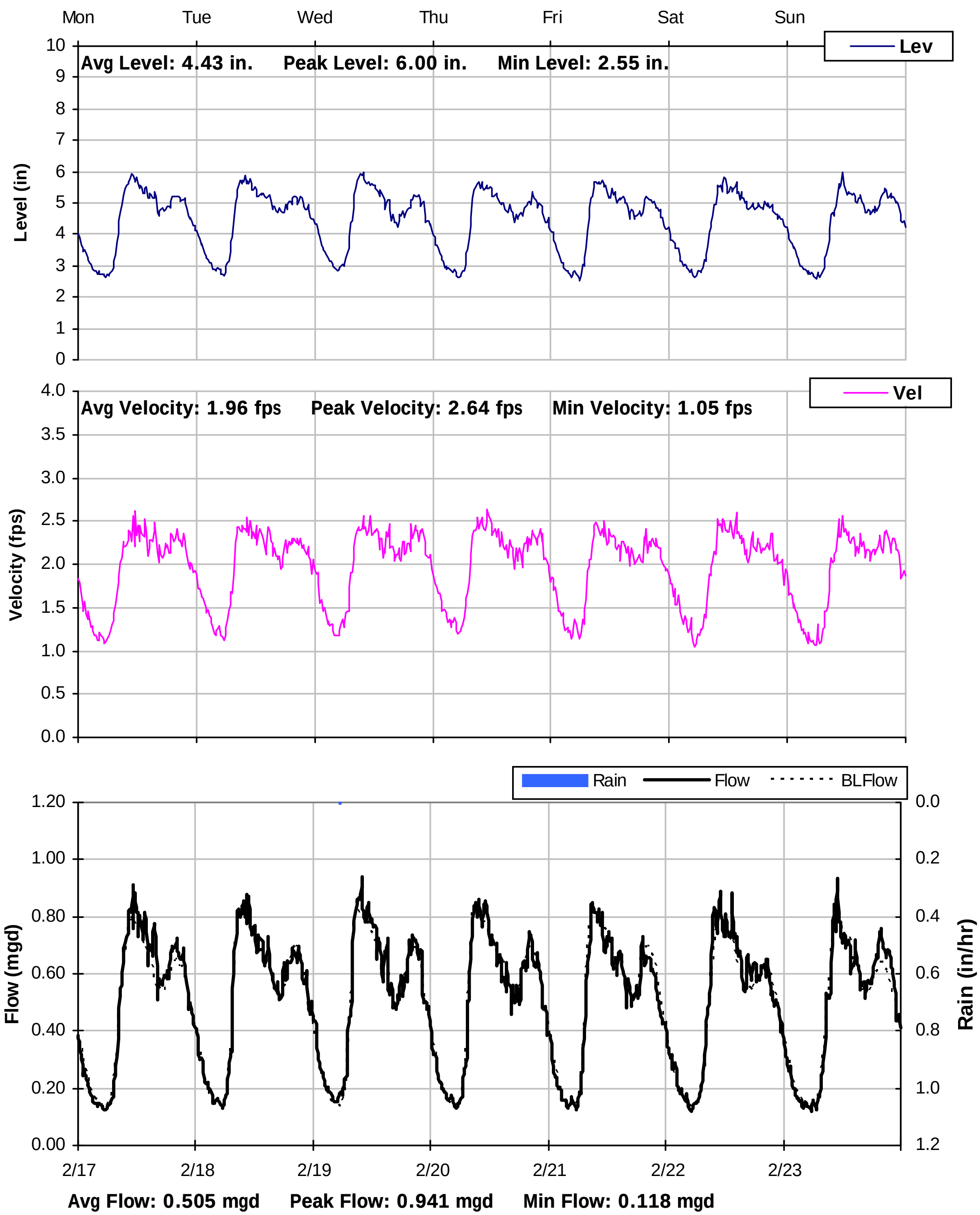
SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



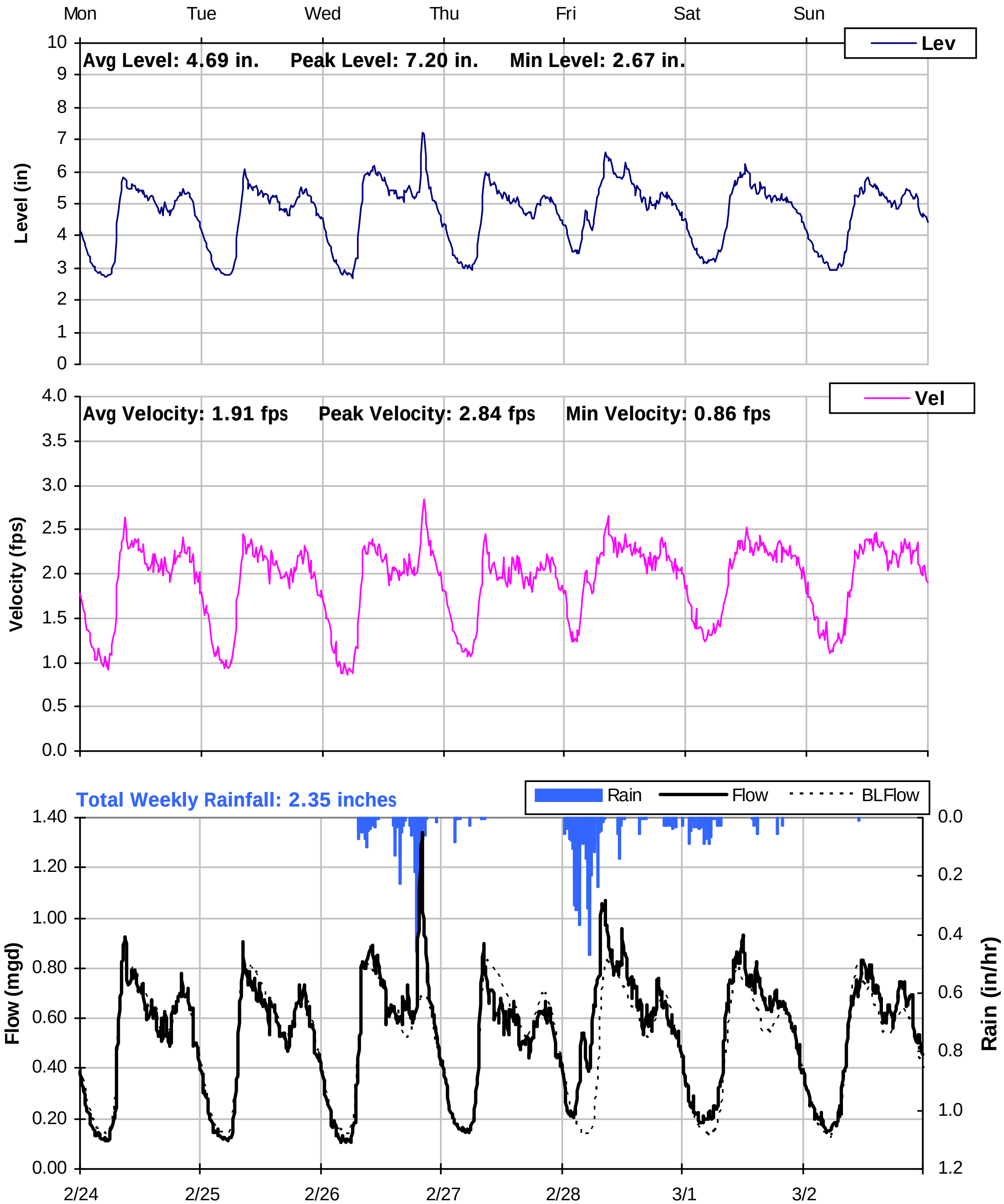
SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

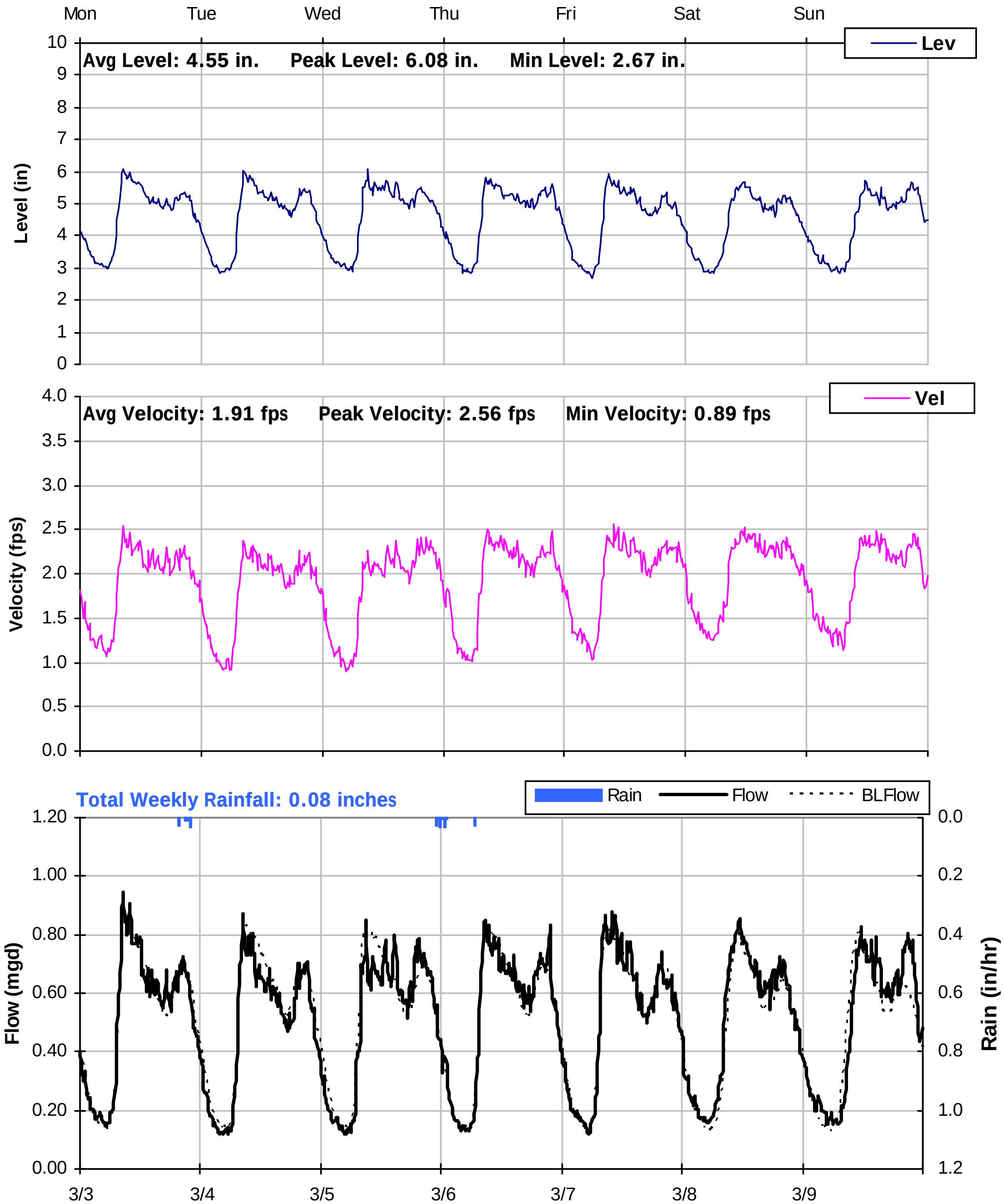


SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



Avg Flow: 0.530 mgd **Peak Flow: 1.332 mgd** **Min Flow: 0.103 mgd**

SITE 9
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

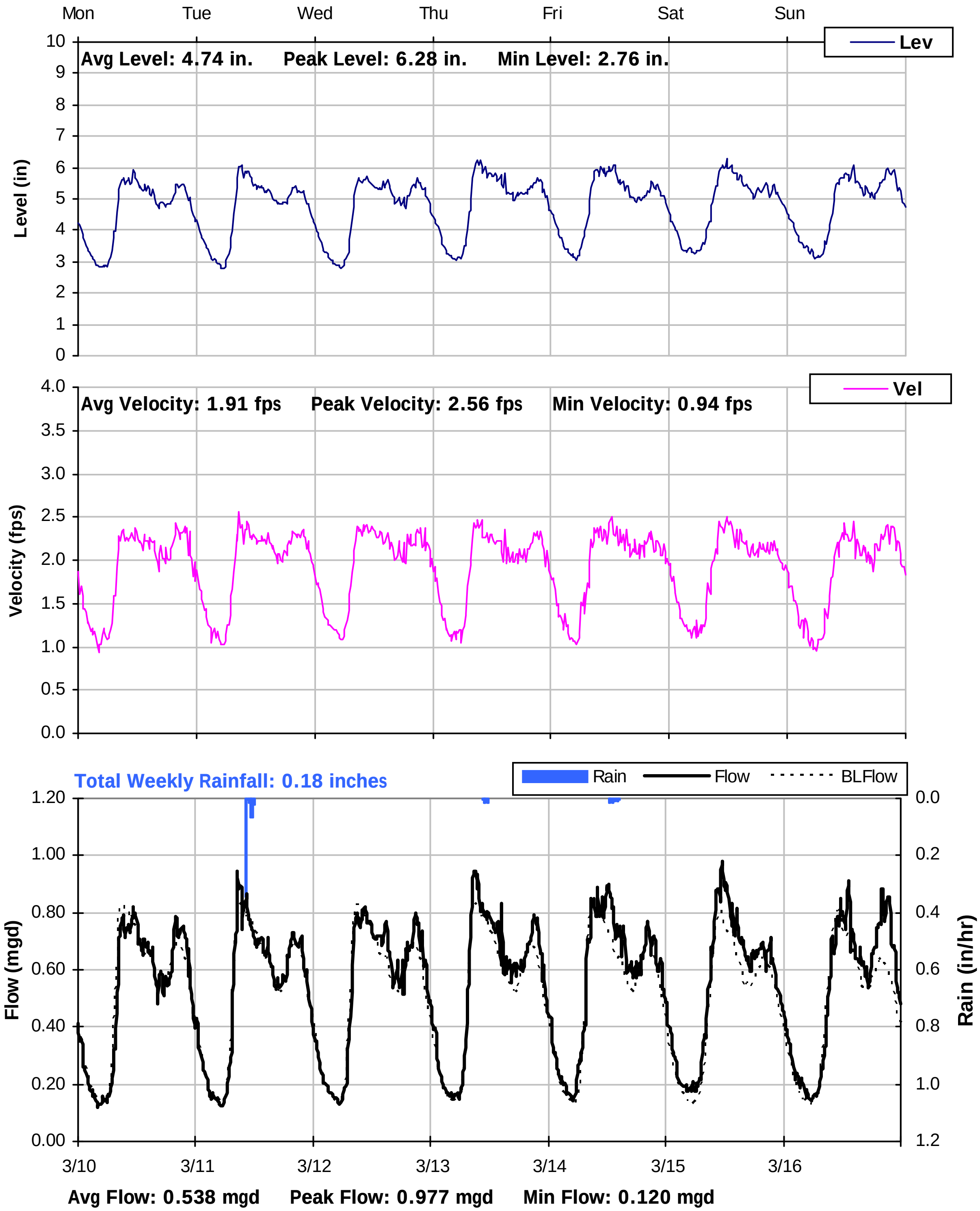


Avg Flow: 0.509 mgd Peak Flow: 0.944 mgd Min Flow: 0.118 mgd

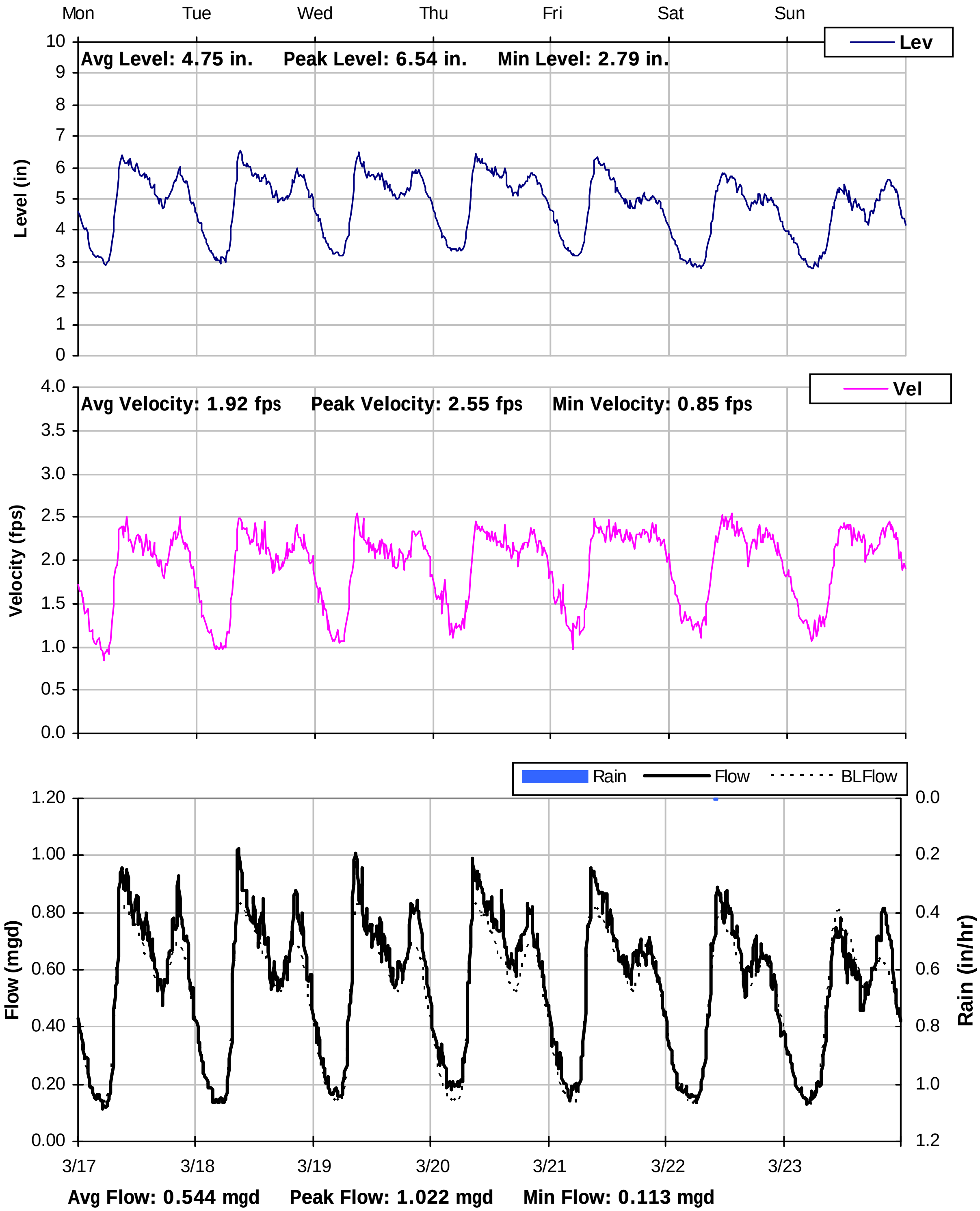
SITE 9

Weekly Level, Velocity and Flow Hydrographs

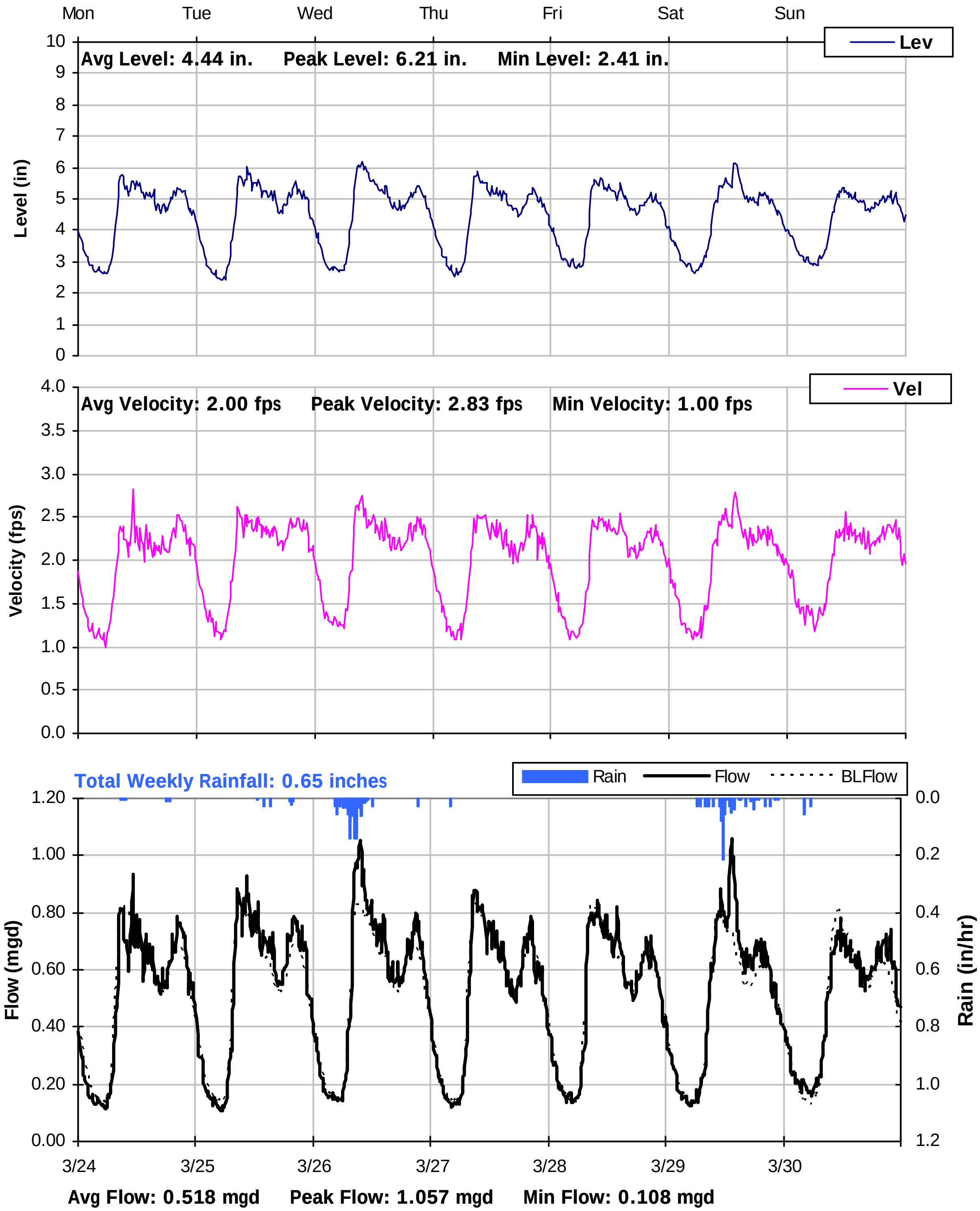
3/10/2014 to 3/17/2014



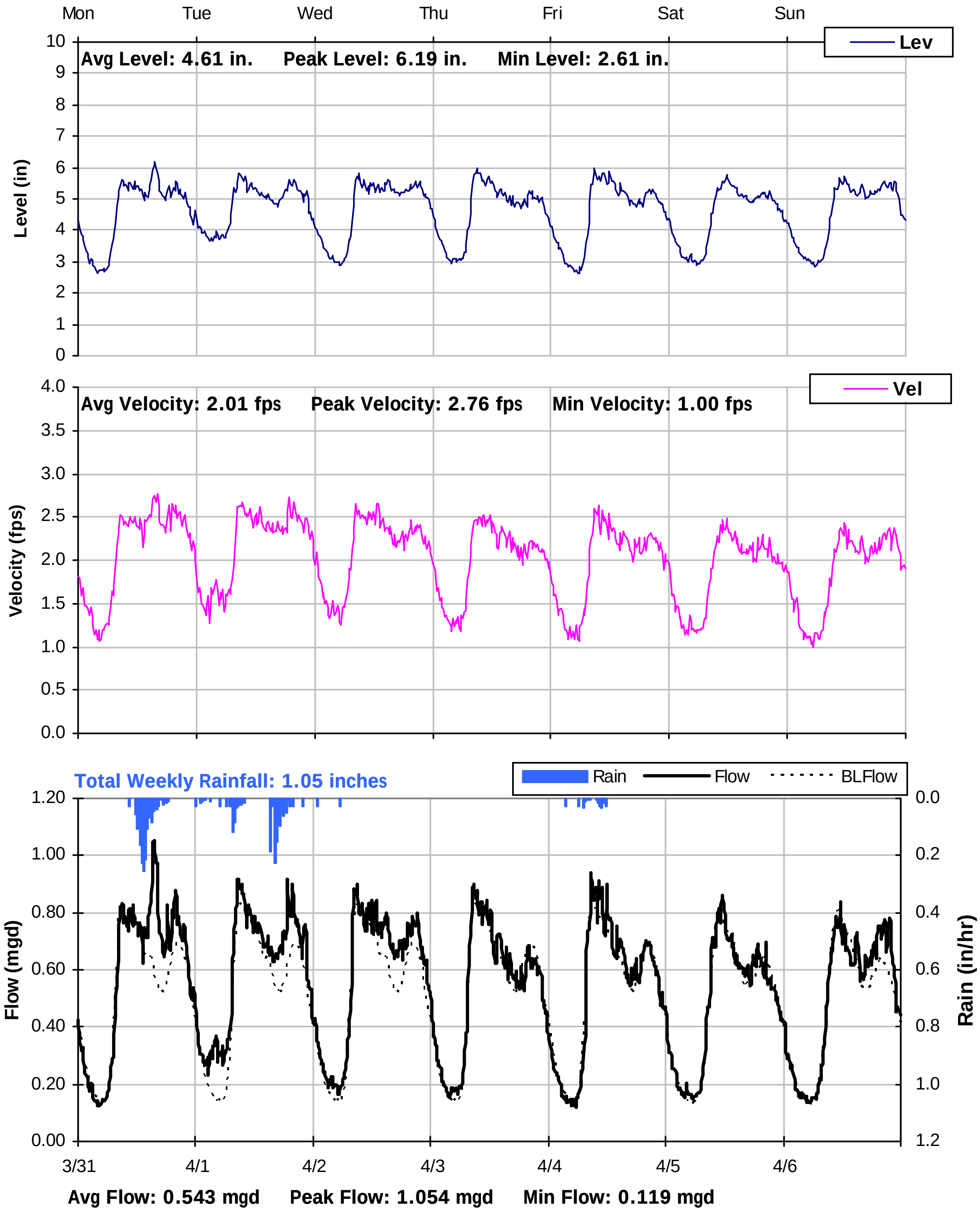
SITE 9
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



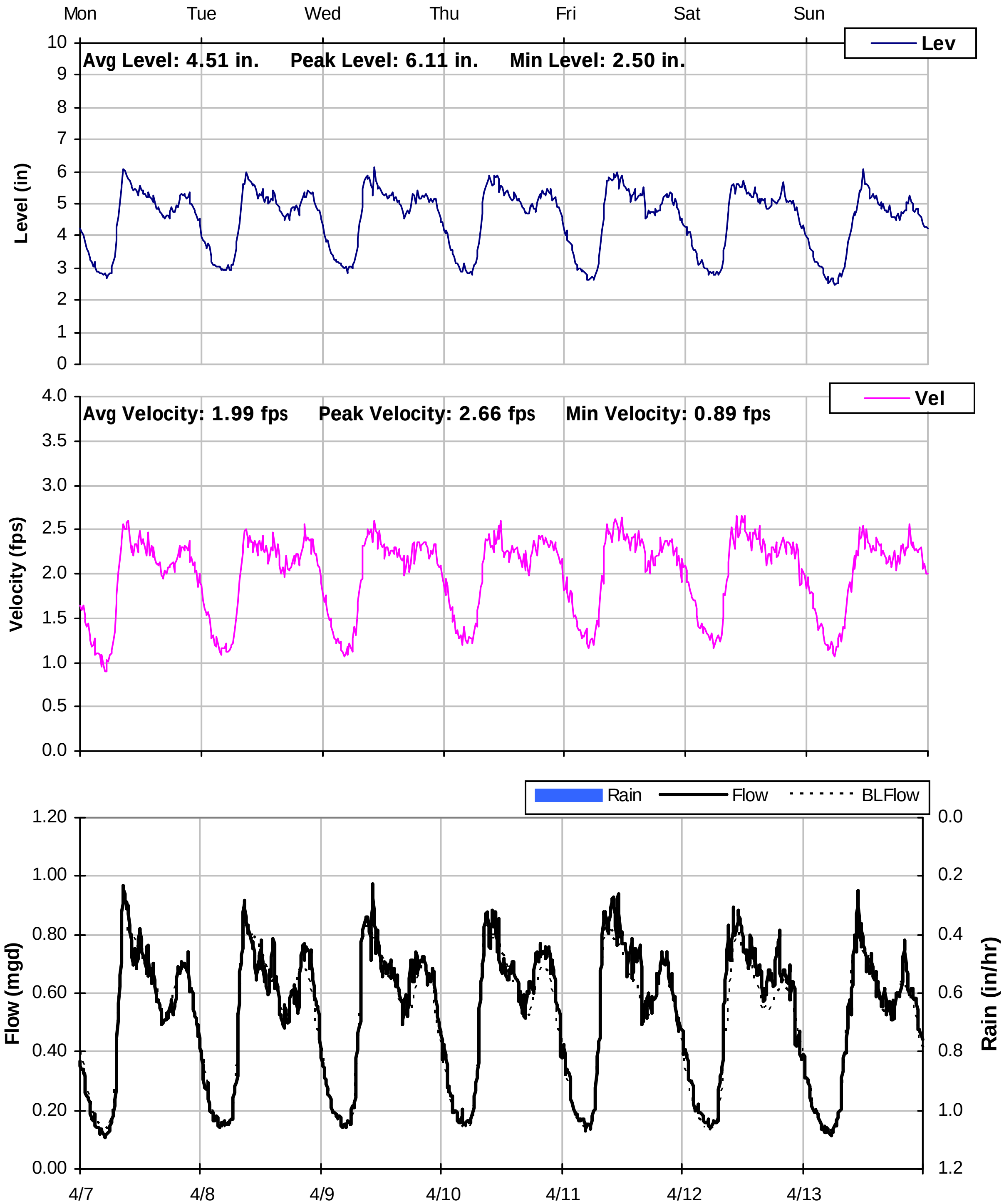
SITE 9
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



SITE 9
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 9
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 0.524 mgd **Peak Flow: 0.973 mgd** **Min Flow: 0.105 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 10

Location: On shoulder of El Camino Real, south of Atherton Avenue

Data Summary Report

SITE 10

Site Information

Location: On shoulder of El Camino Real, south of Atherton Avenue

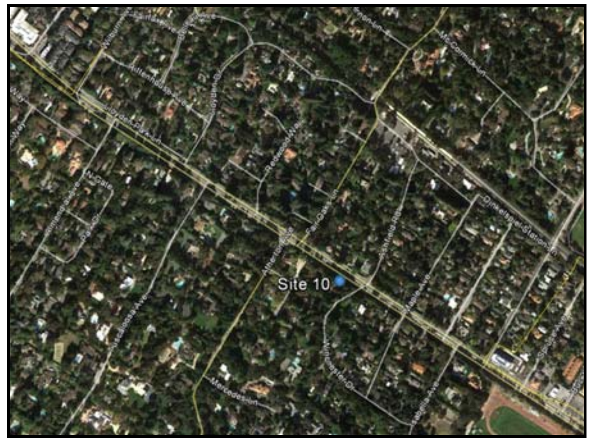
Coordinates: 122.1991° W, 37.4614° N

Rim Elevation: 56 feet

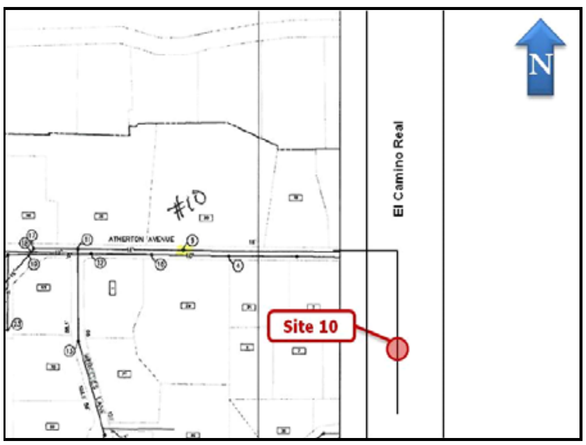
Pipe Diameter: 22.75 inches

Baseline Flow: 0.269 mgd

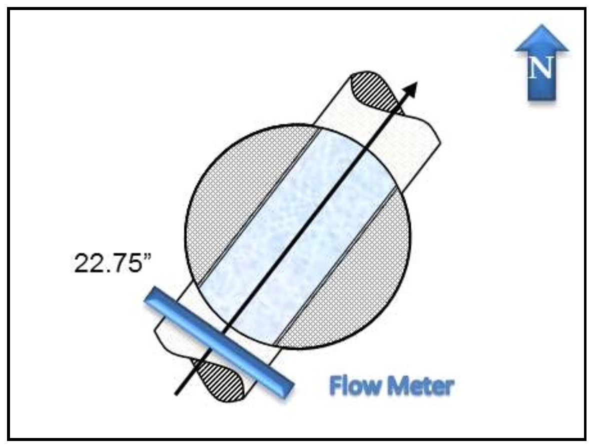
Peak Measured Flow: 0.913 mgd



Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

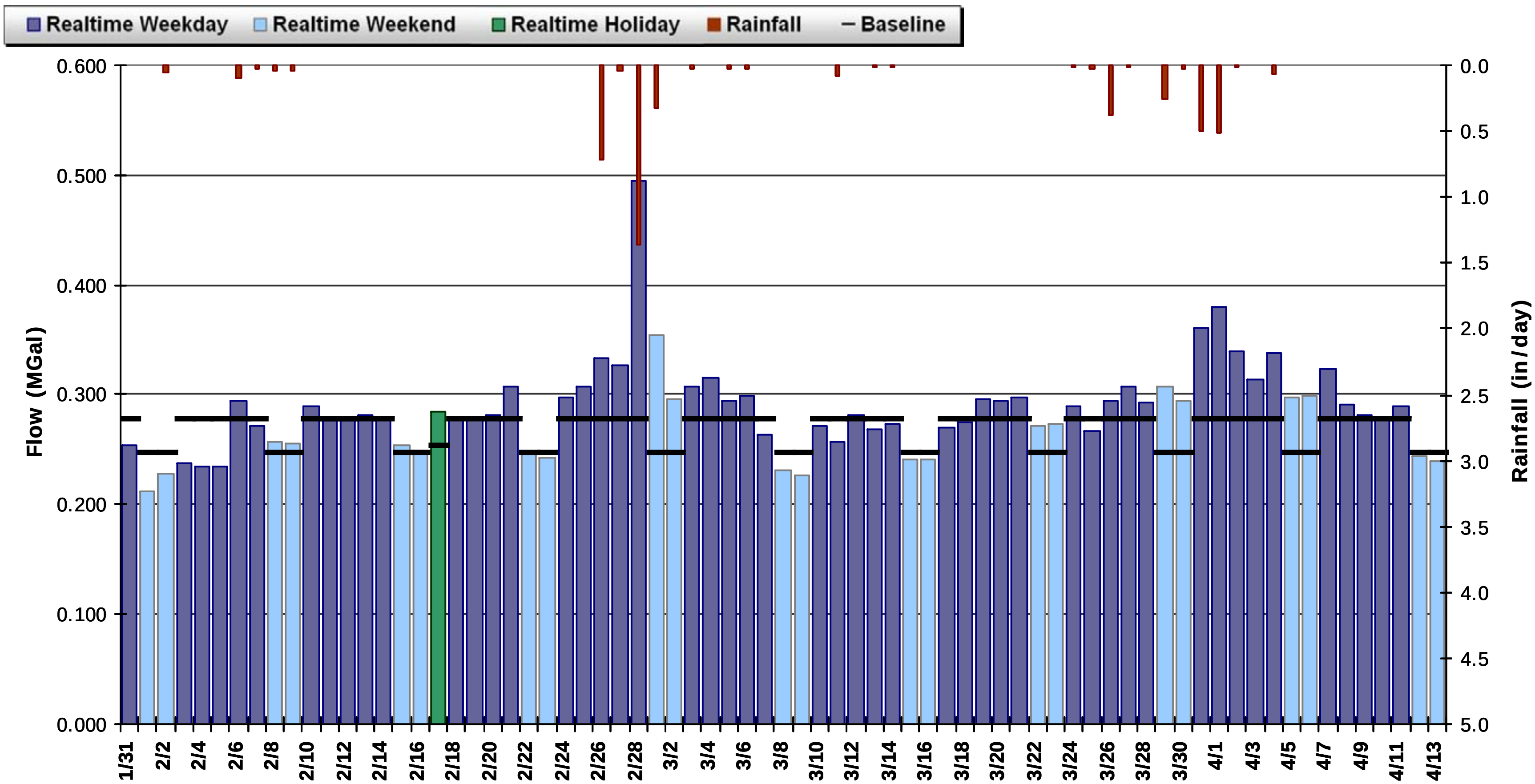
Plan View

SITE 10

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.285 MGal **Peak Daily Flow: 0.495 MGal** **Min Daily Flow: 0.212 MGal**

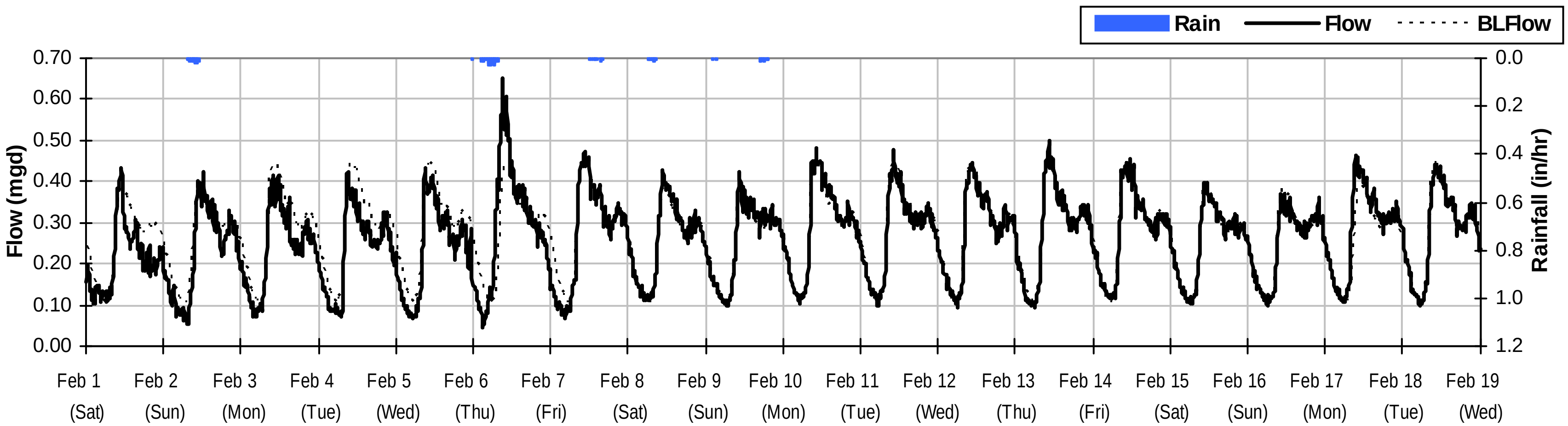
Total Period Rainfall: 4.66 inches

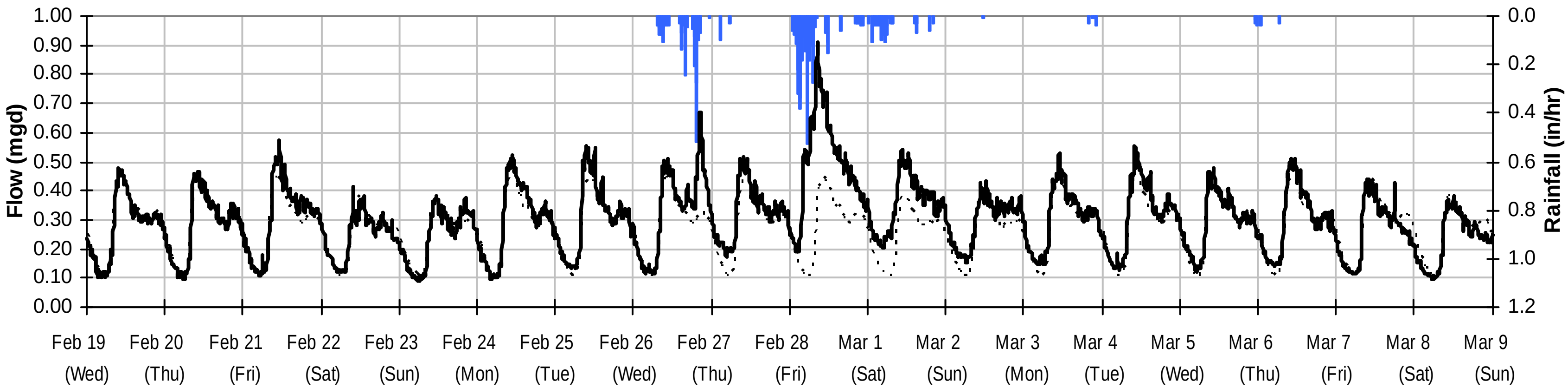


SITE 10

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.66 inches **Avg Flow: 0.285 mgd** **Peak Flow: 0.913 mgd** **Min Flow: 0.045 mgd**

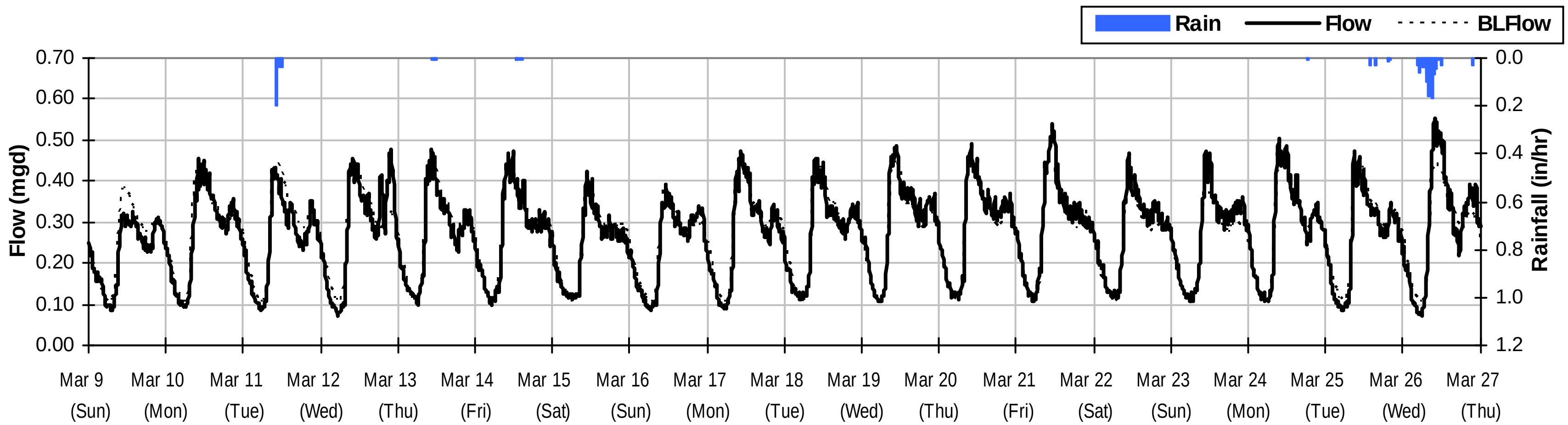


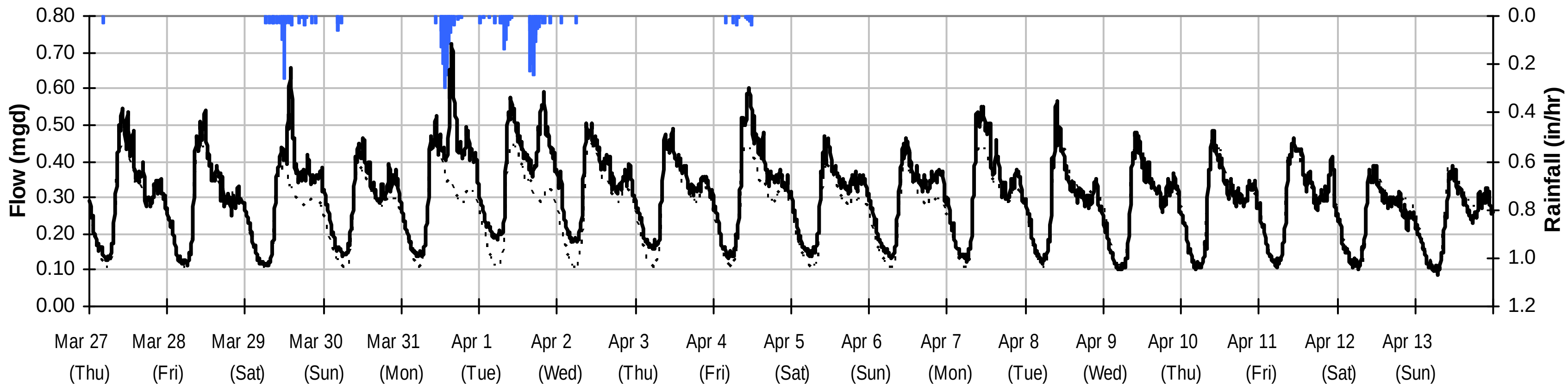


SITE 10

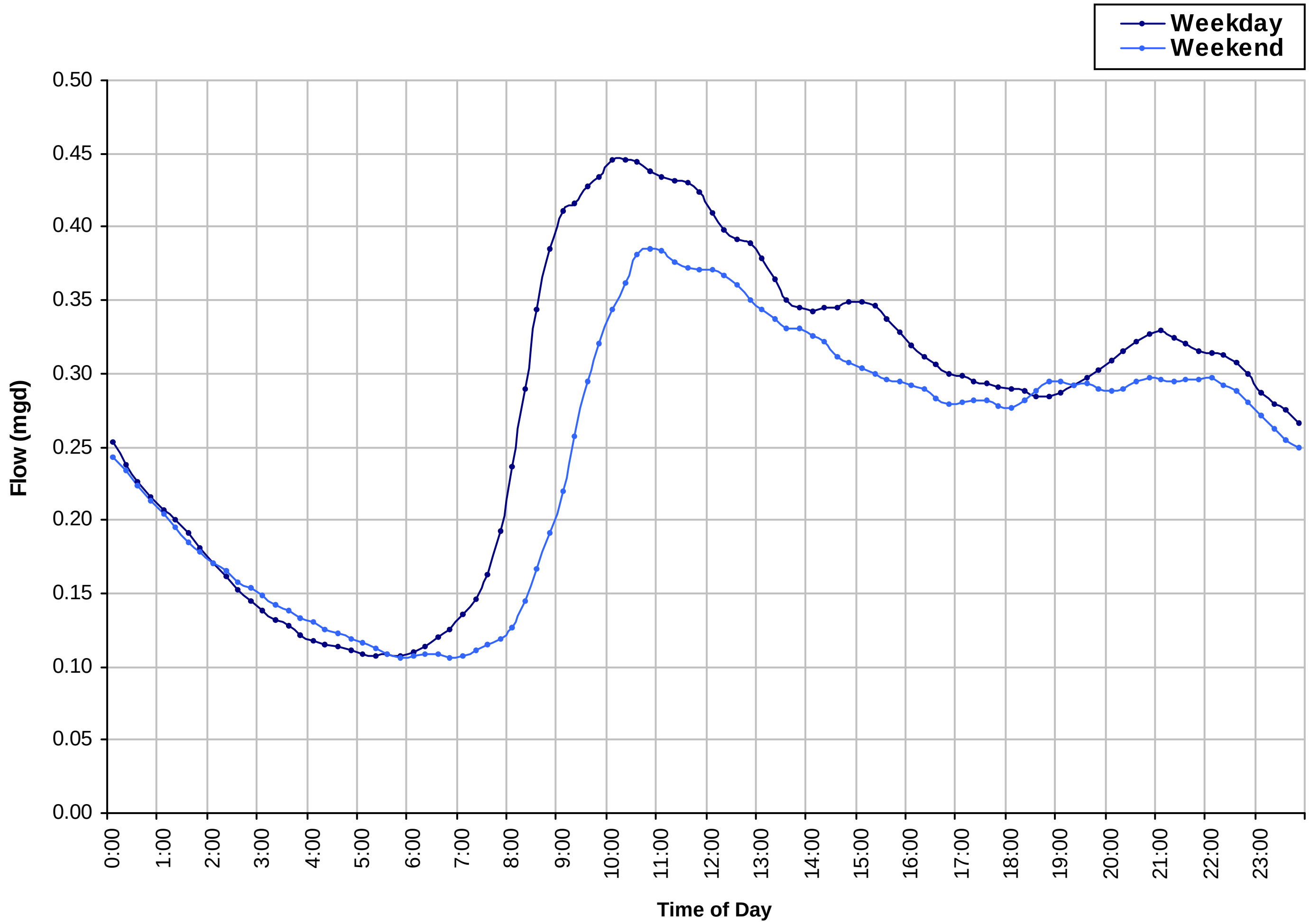
Period Flow Summary: March 9 to April 14, 2014

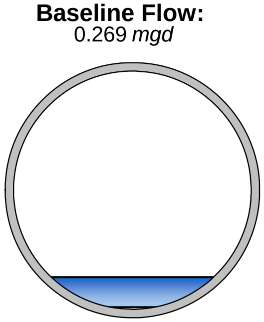
Total Monthly Rainfall: 4.66 inches **Avg Flow: 0.285 mgd** **Peak Flow: 0.913 mgd** **Min Flow: 0.045 mgd**





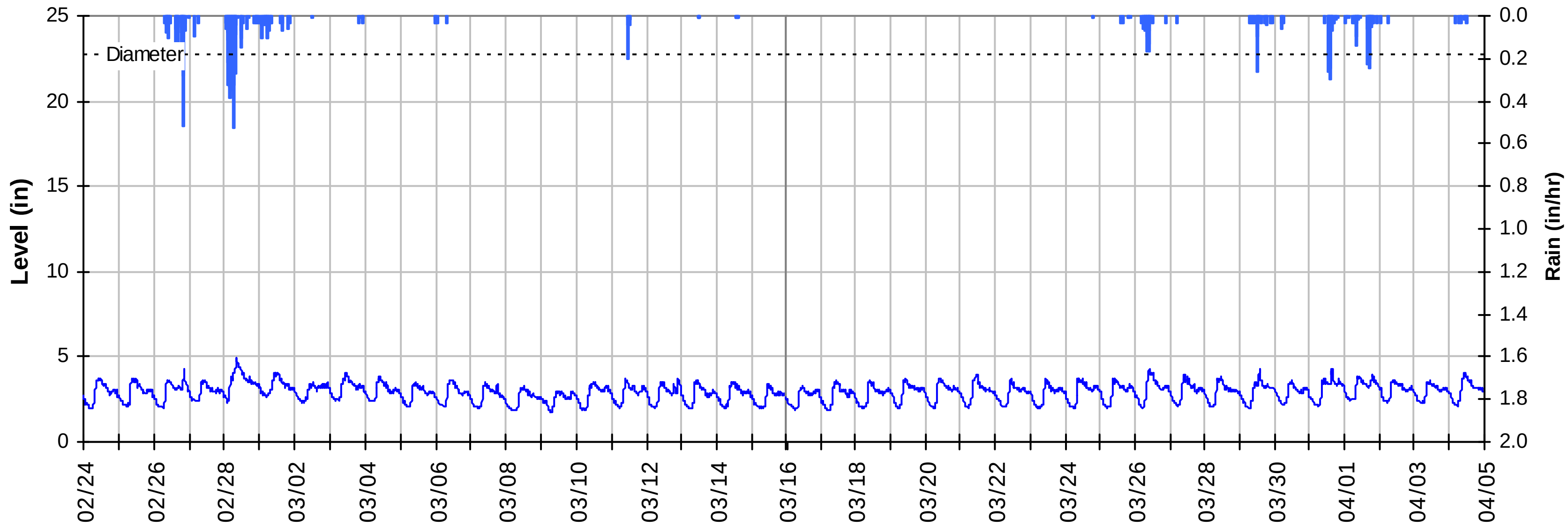
SITE 10
Baseline Flow Hydrographs

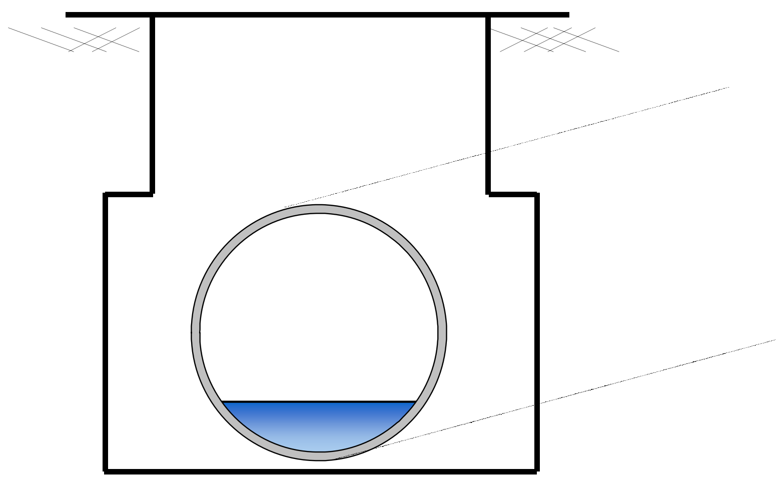




SITE 10
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





Pipe Diameter: 22.8 *inches*

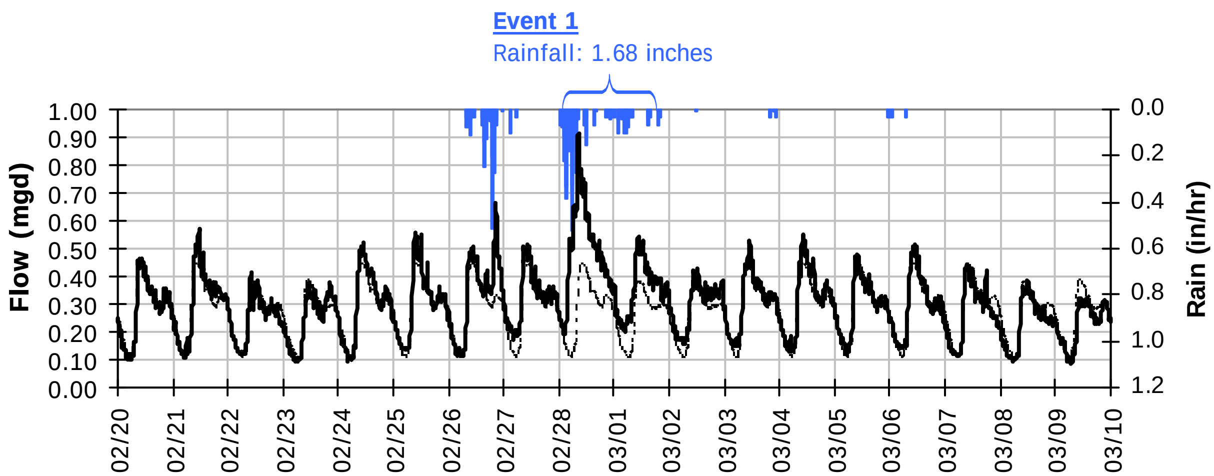
Peak Measured Level: 4.93 *inches*

Peak d/D Ratio: 0.22

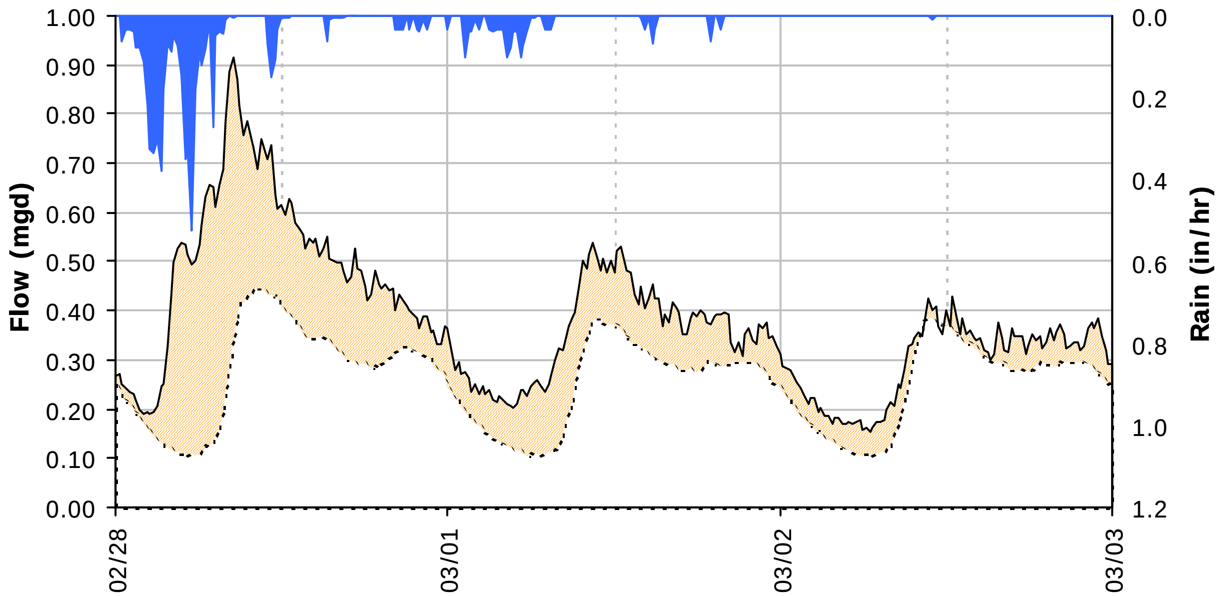
SITE 10

I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

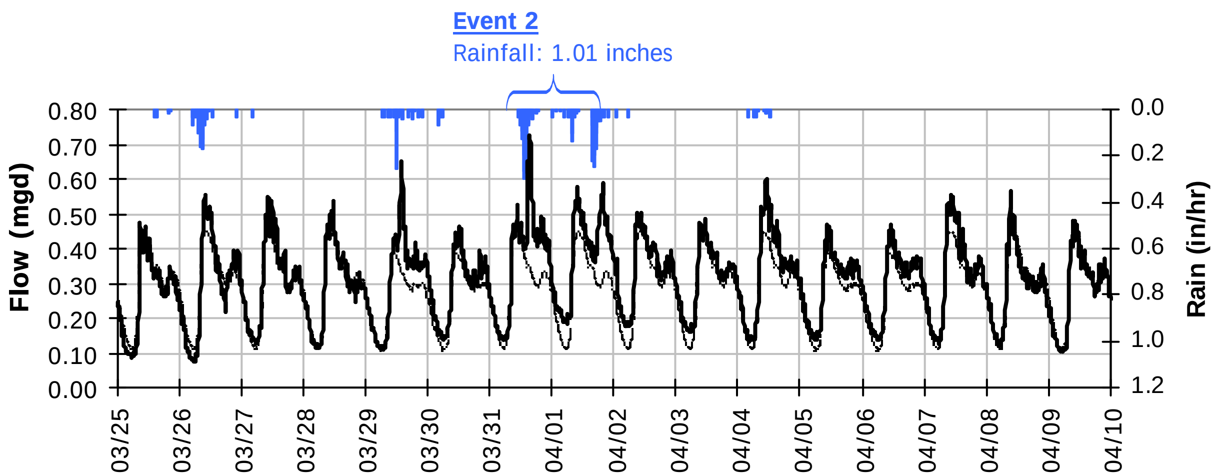


Storm Event I/I Analysis (Rain = 1.68 inches)

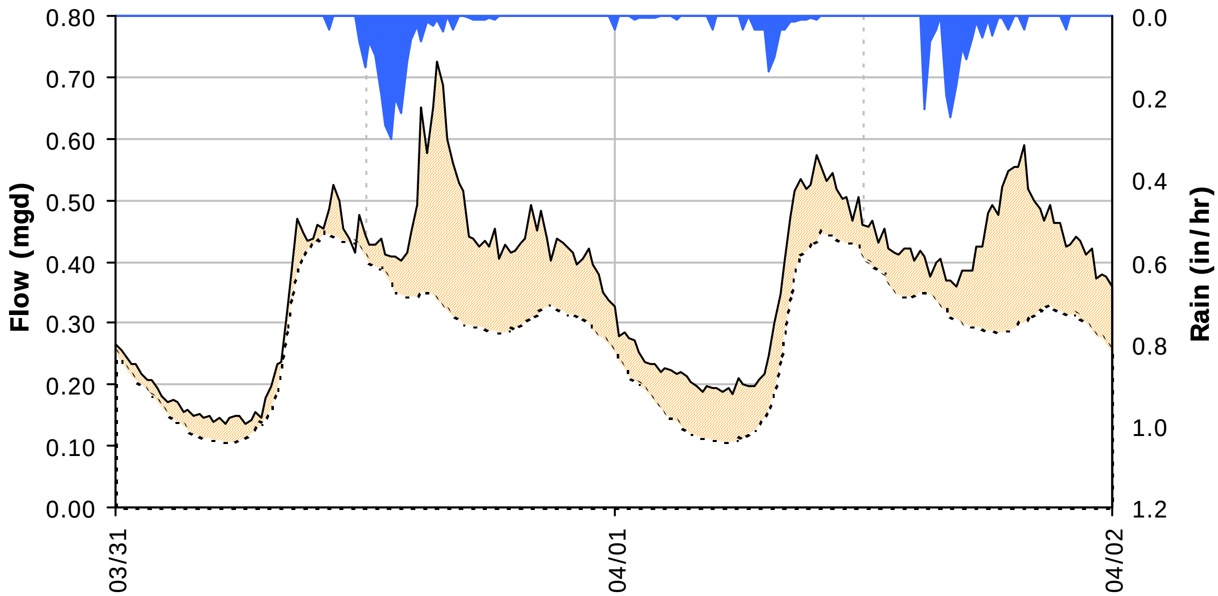
Capacity		Inflow / Infiltration	
Peak Flow:	0.91 *mgd*	**Peak I/I Rate:**	0.46 *mgd*
PF:	3.39	**Total I/I:**	371,000 *gallons*

SITE 10
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



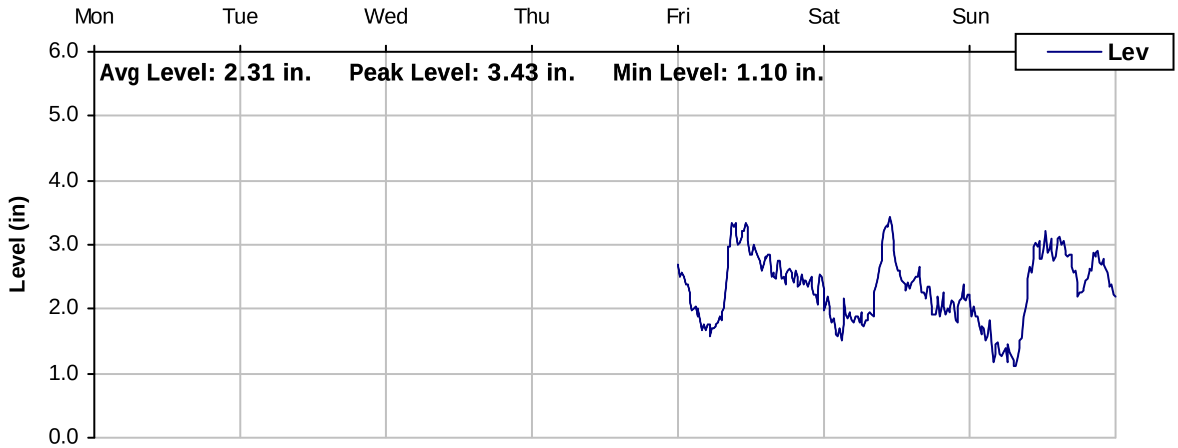
Event 2 Detail Graph

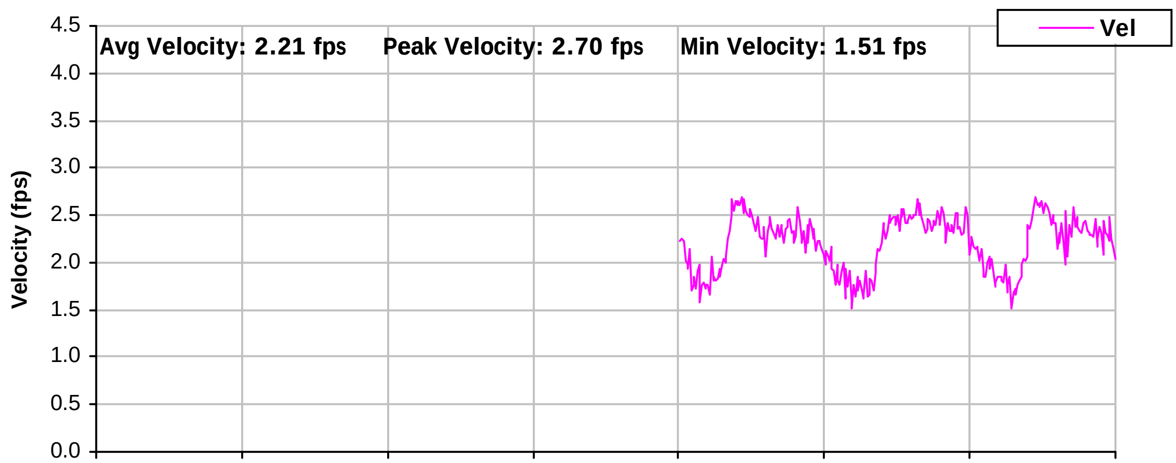


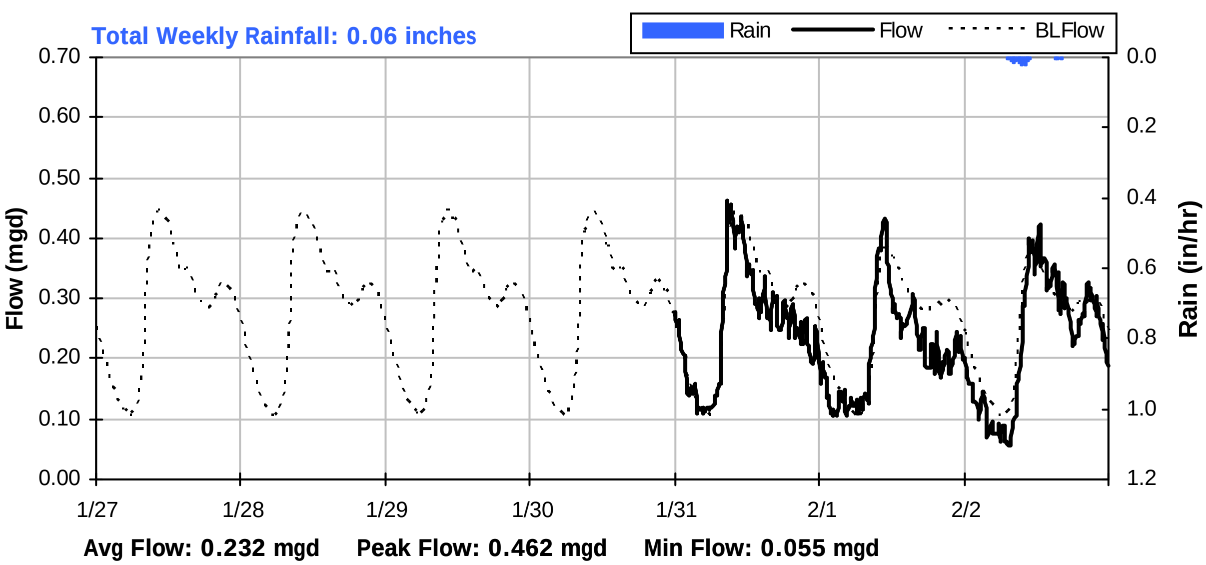
Storm Event I/I Analysis (Rain = 1.01 inches)

Capacity		Inflow / Infiltration	
Peak Flow:	0.73 *mgd*	**Peak I/I Rate:**	0.39 *mgd*
PF:	2.69	**Total I/I:**	266,000 *gallons*

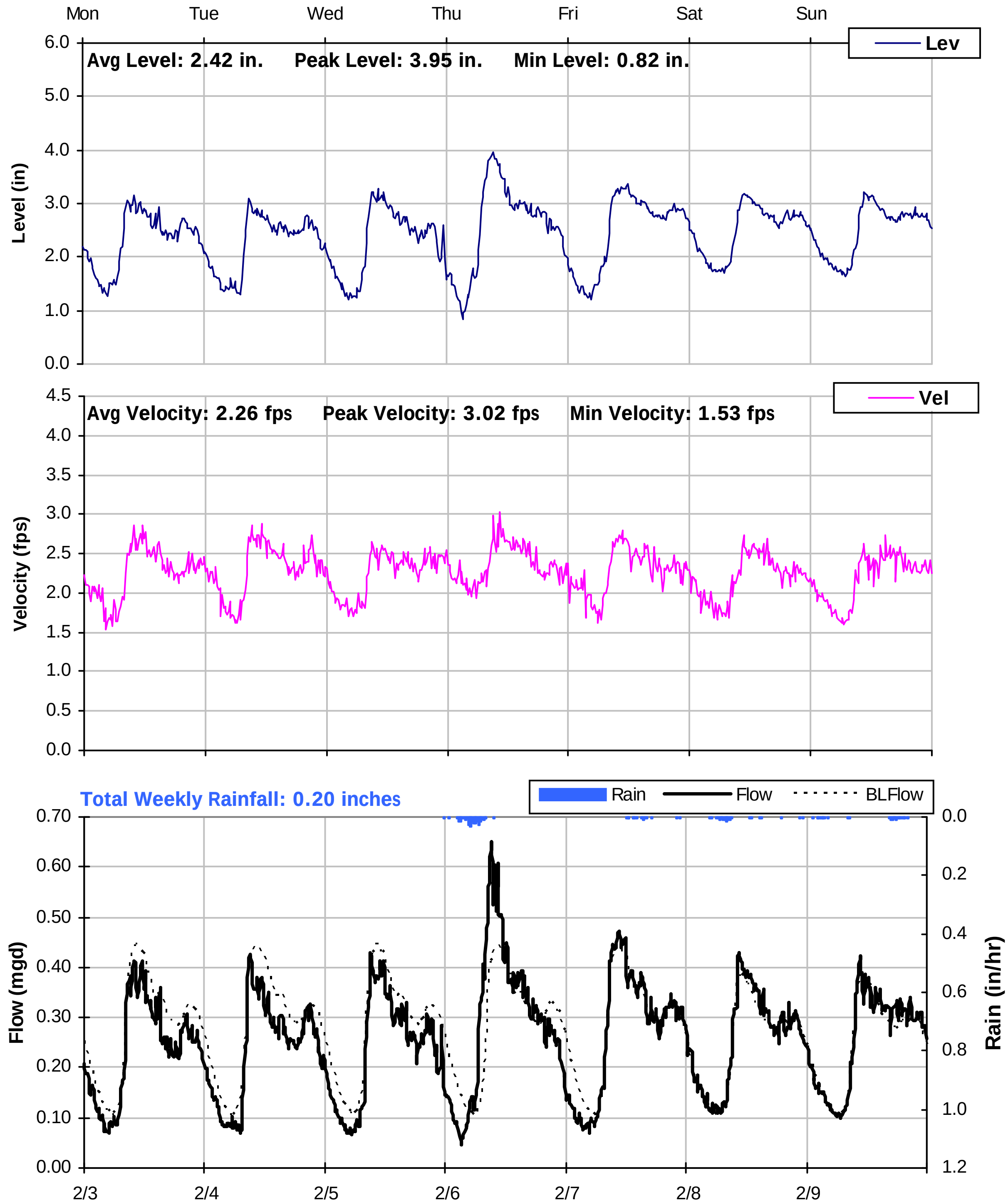
SITE 10
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014





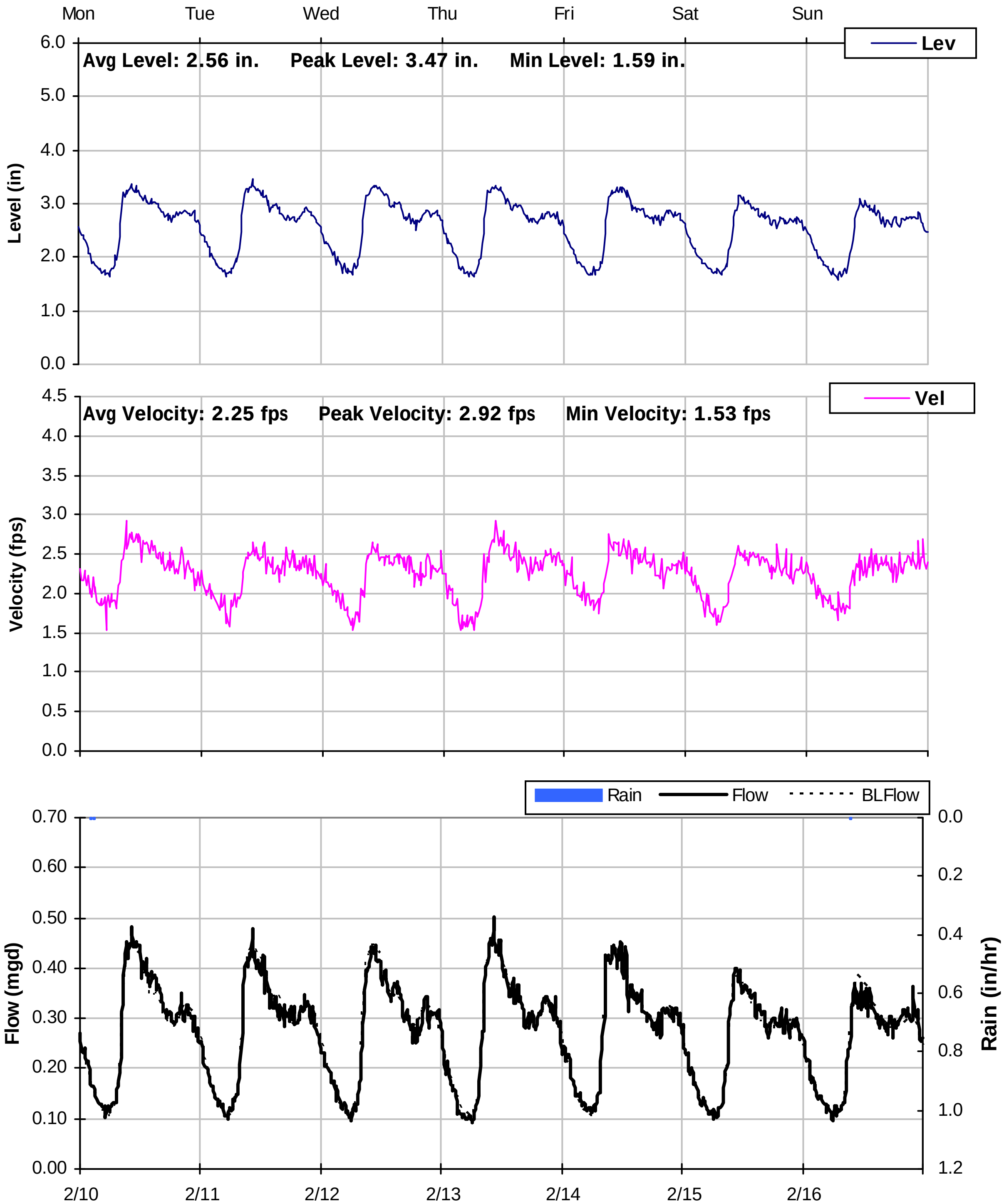


SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



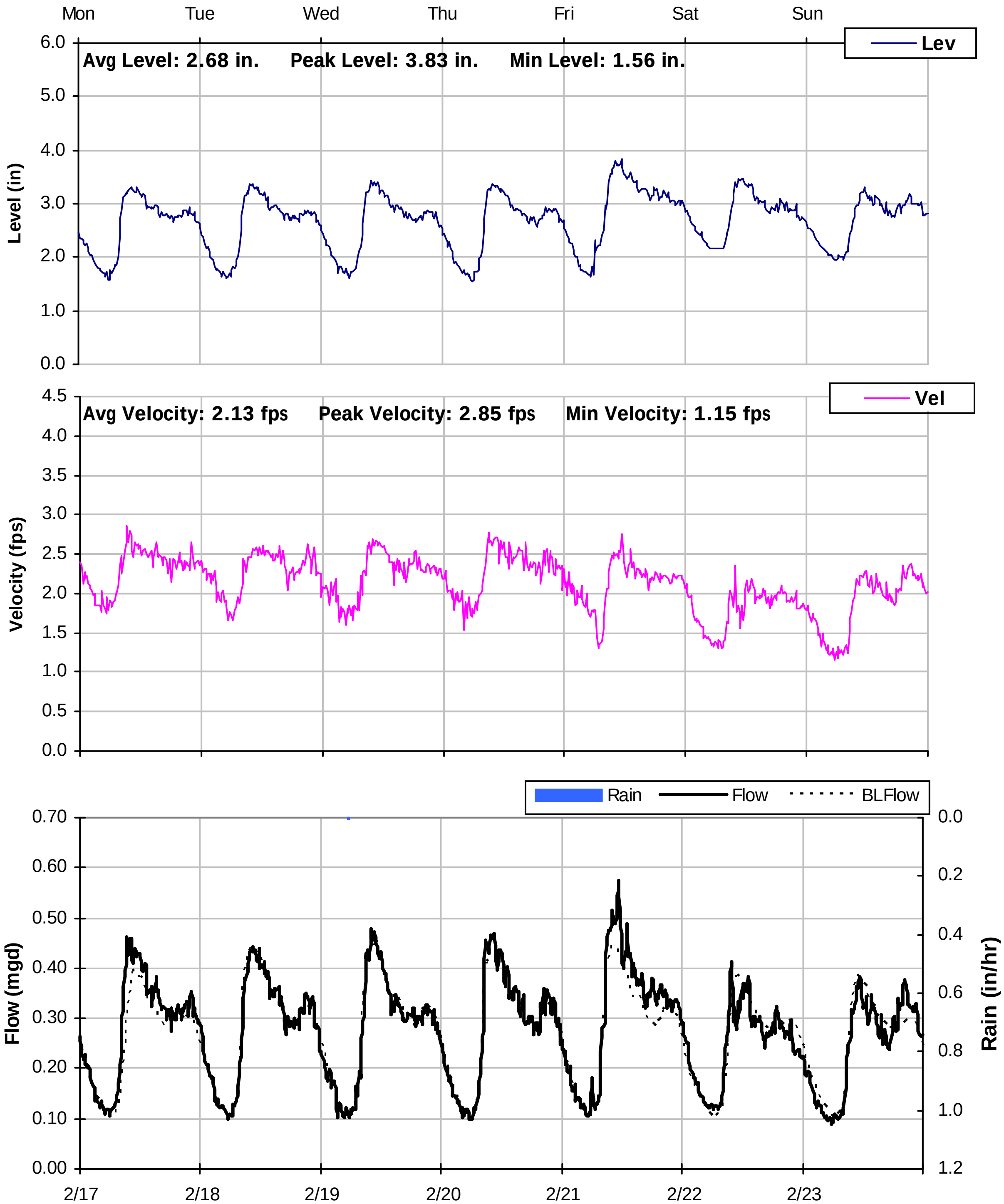
Avg Flow: 0.255 mgd **Peak Flow: 0.652 mgd** **Min Flow: 0.045 mgd**

SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



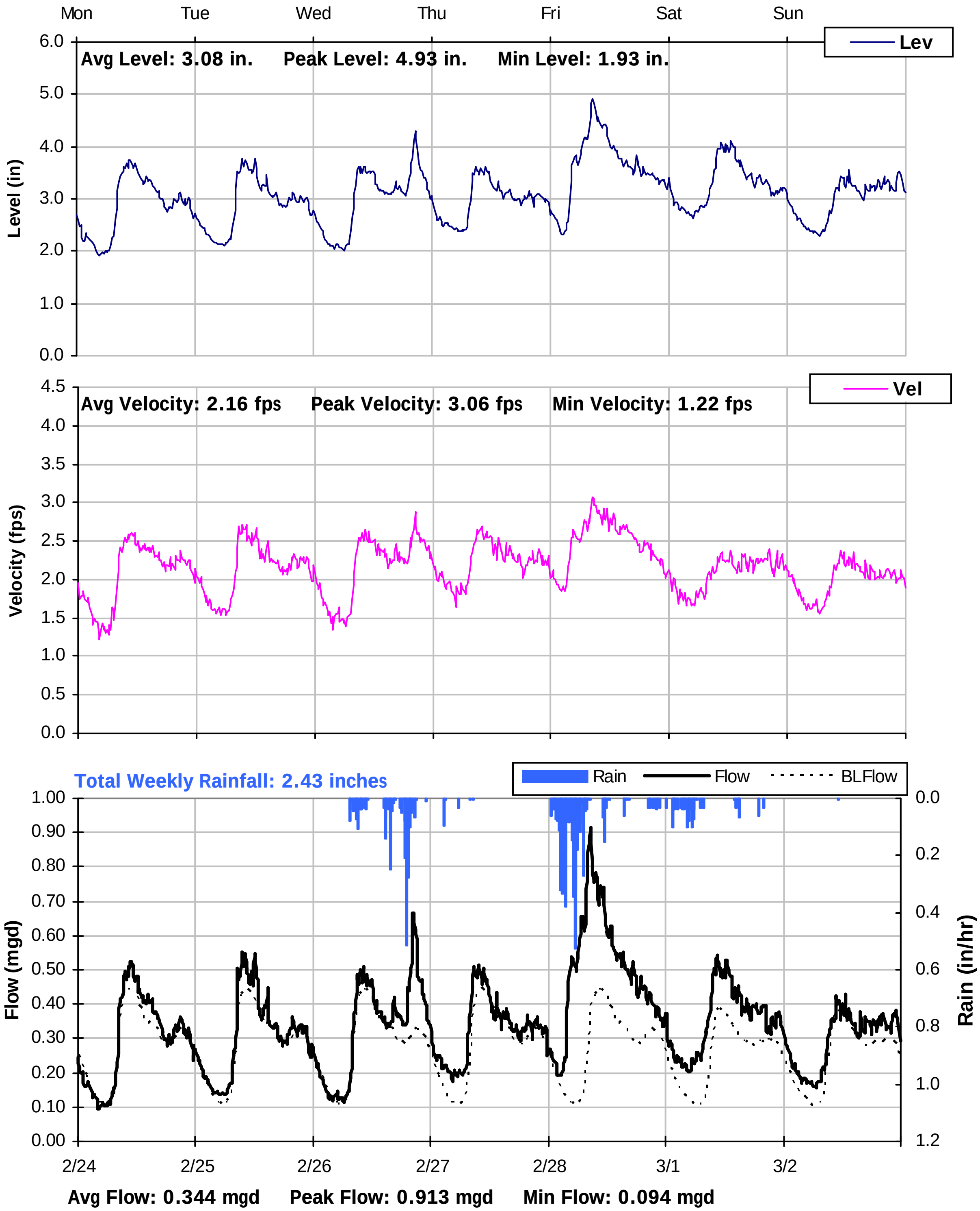
Avg Flow: 0.272 mgd **Peak Flow: 0.501 mgd** **Min Flow: 0.093 mgd**

SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

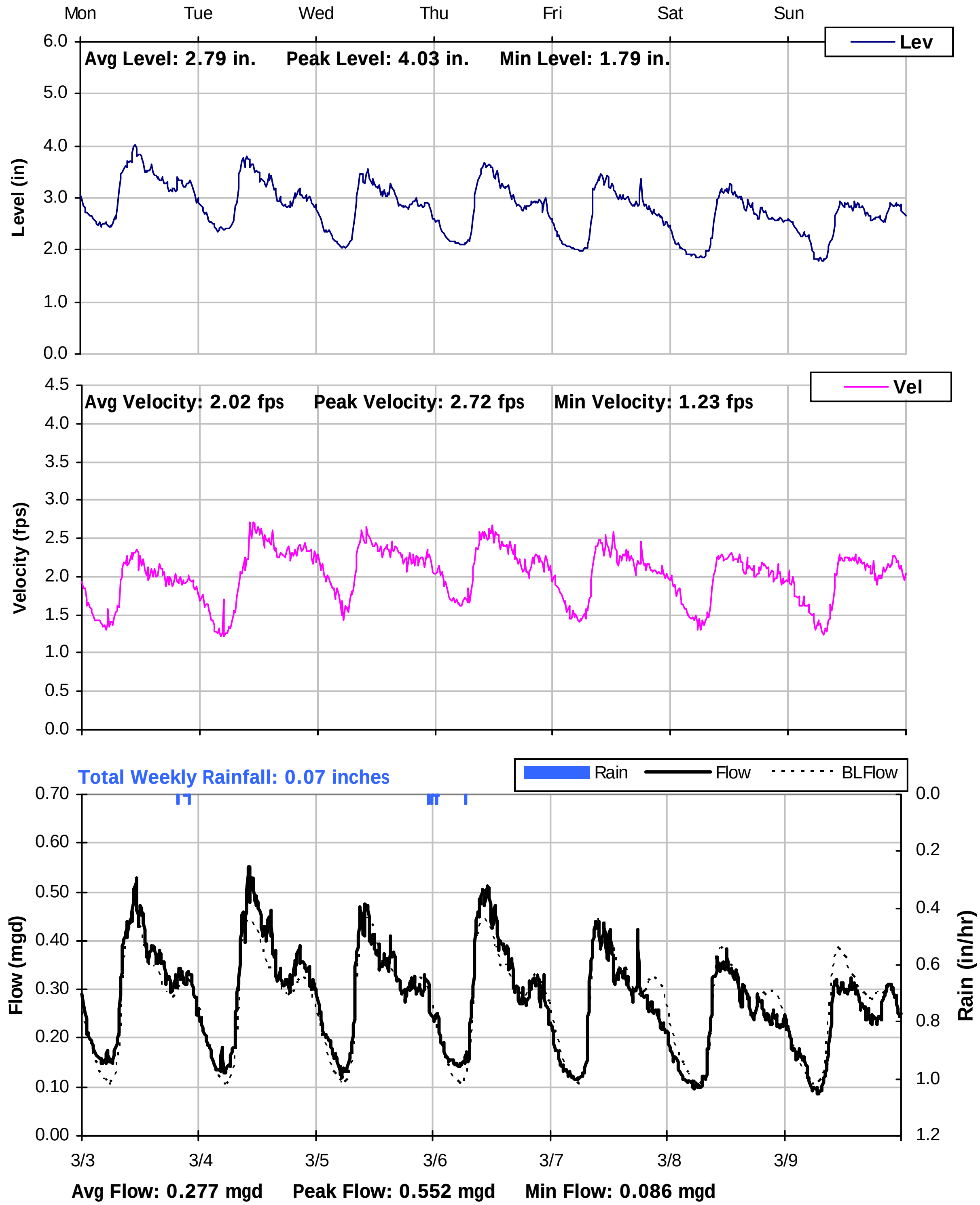


Avg Flow: 0.274 mgd **Peak Flow: 0.574 mgd** **Min Flow: 0.090 mgd**

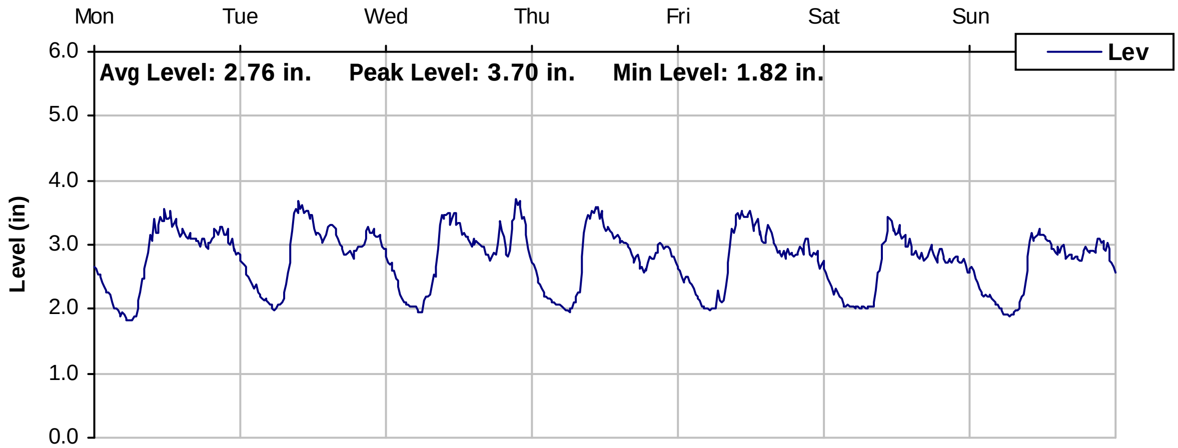
SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014

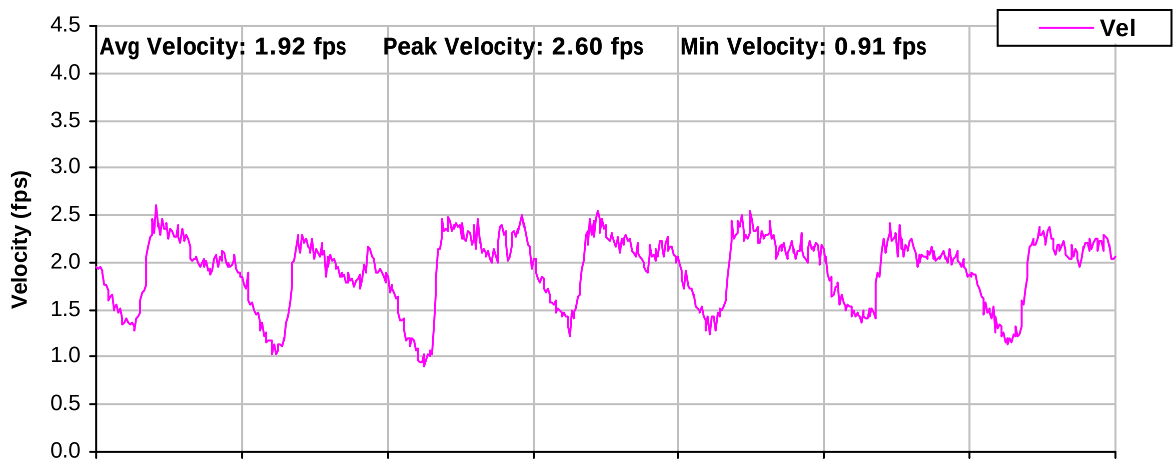


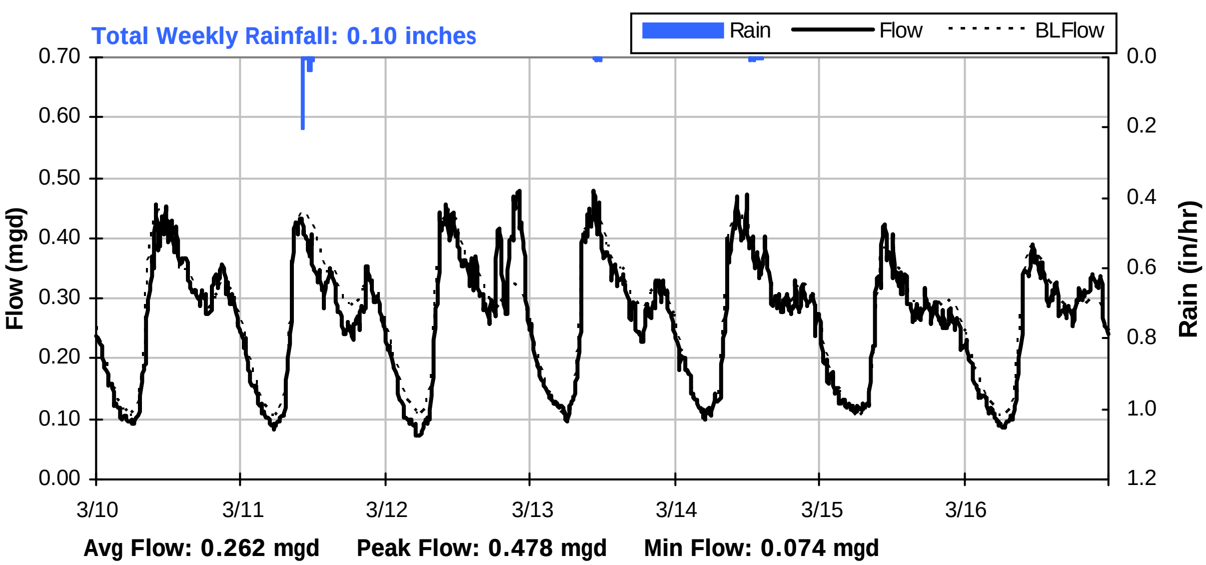
SITE 10
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



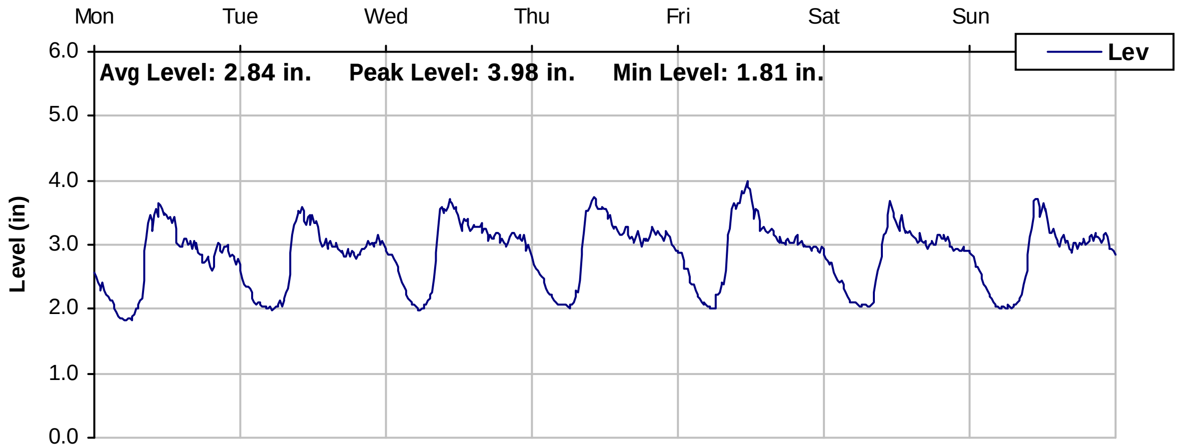
SITE 10
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014

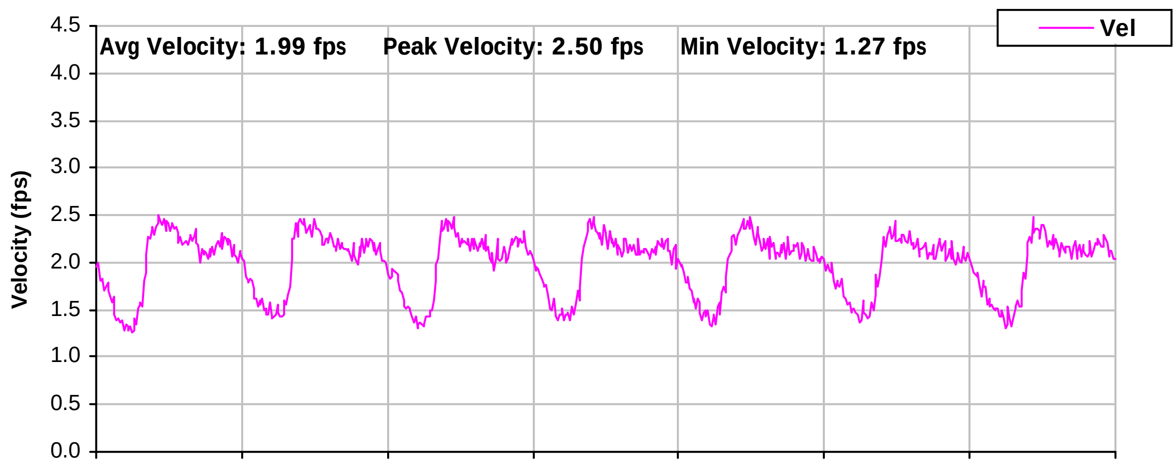


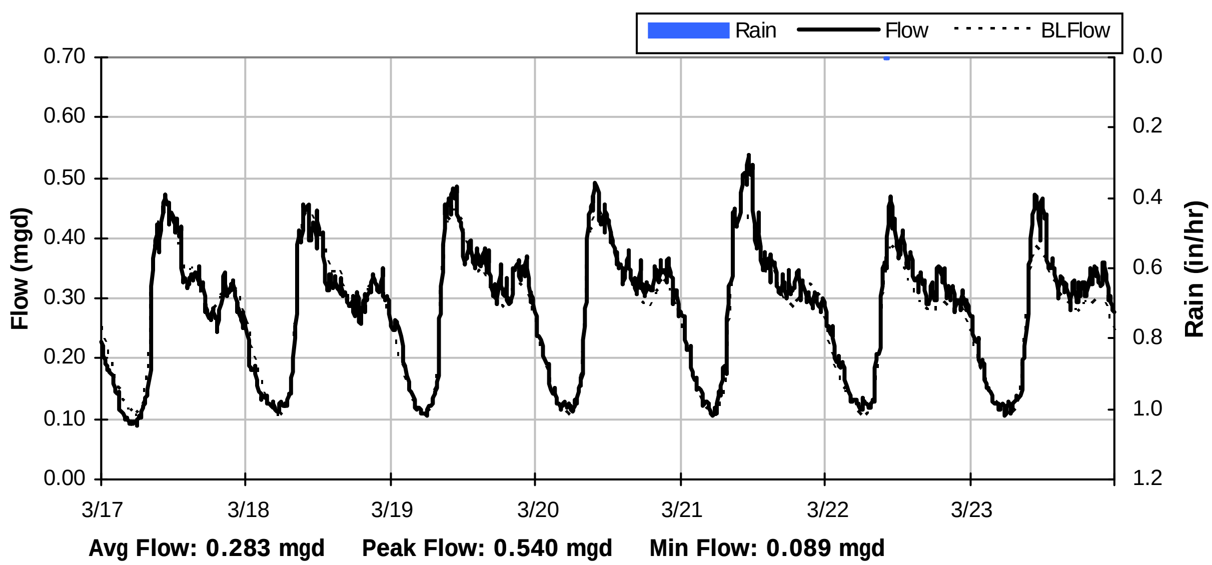




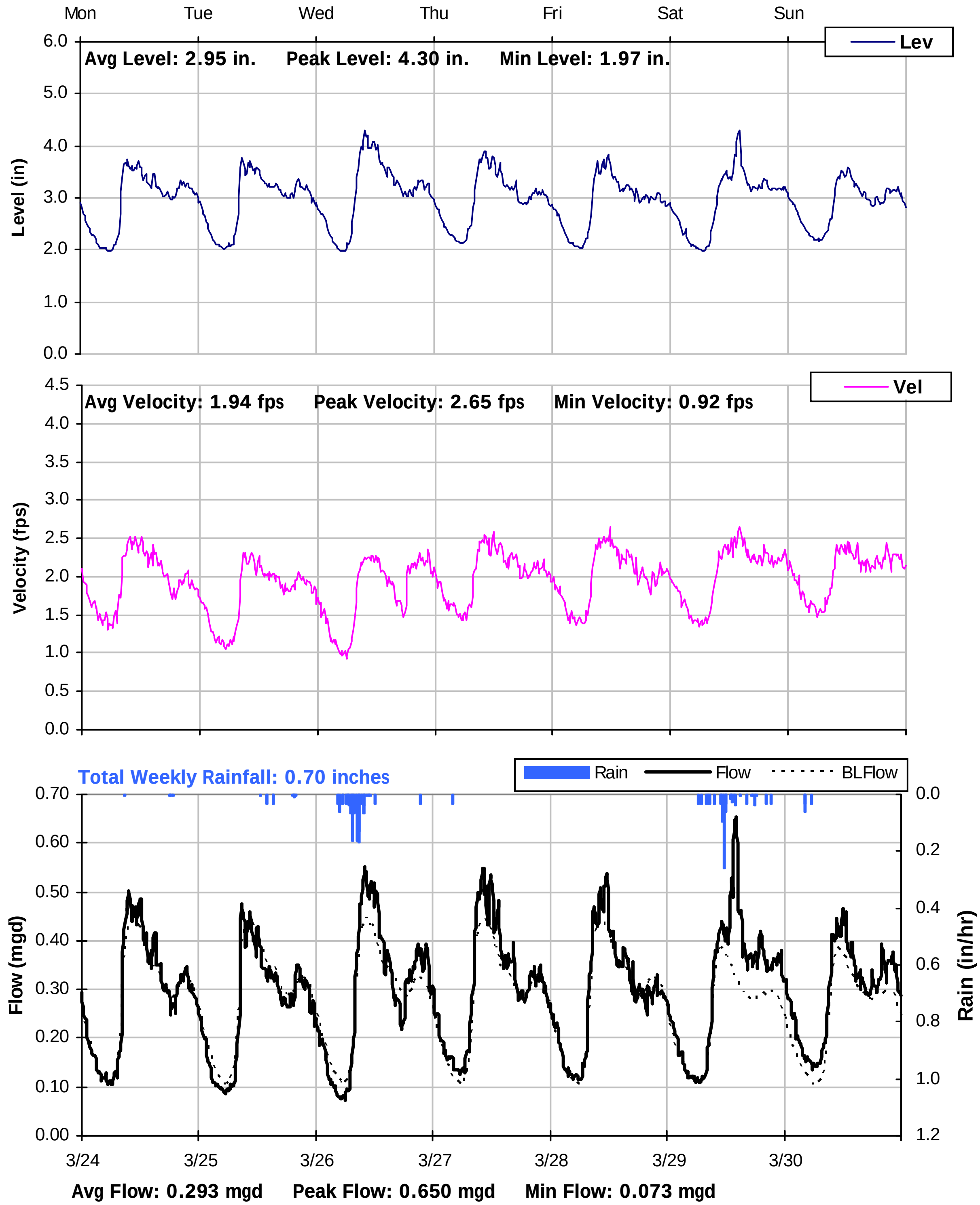
SITE 10
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



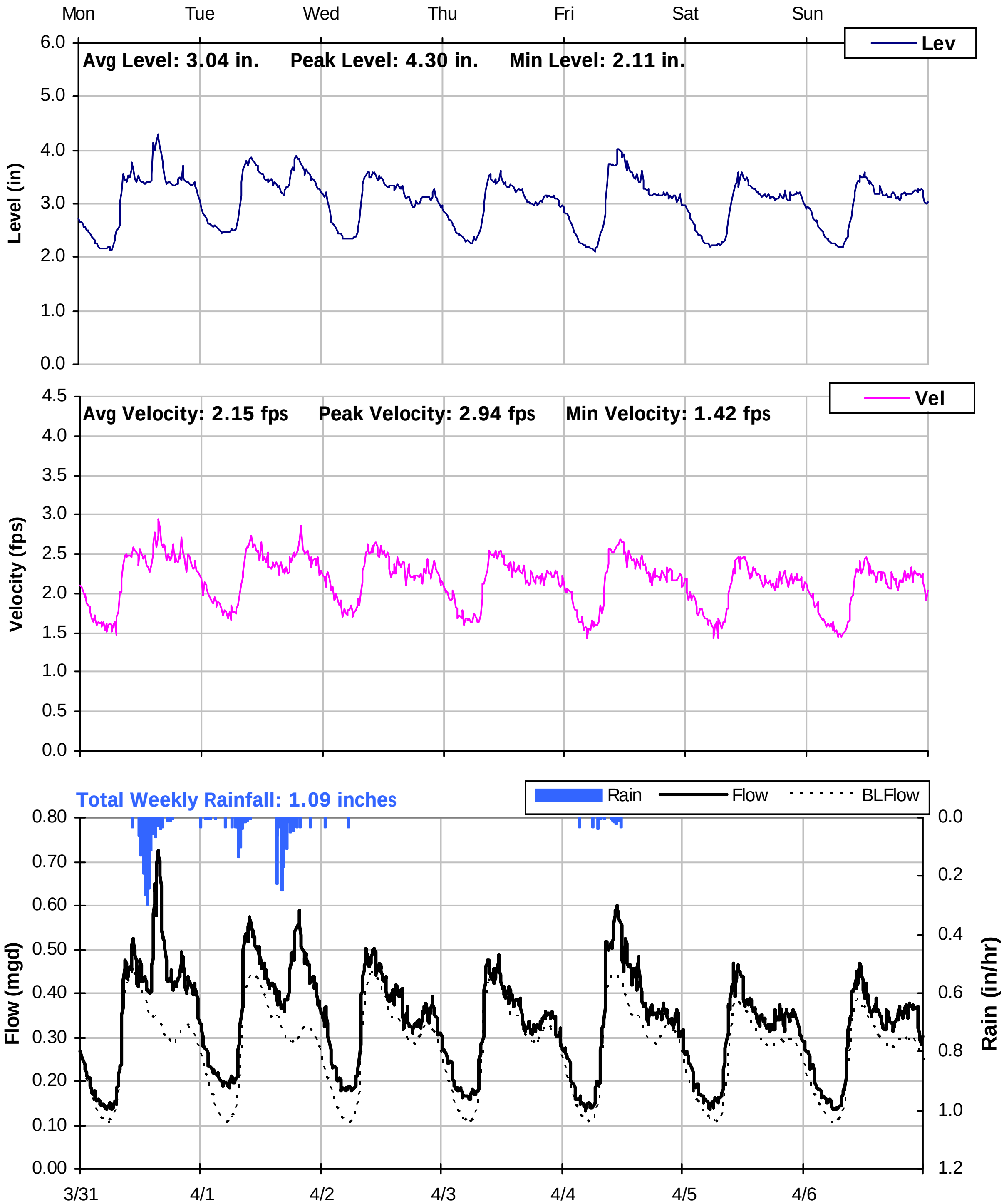




SITE 10
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

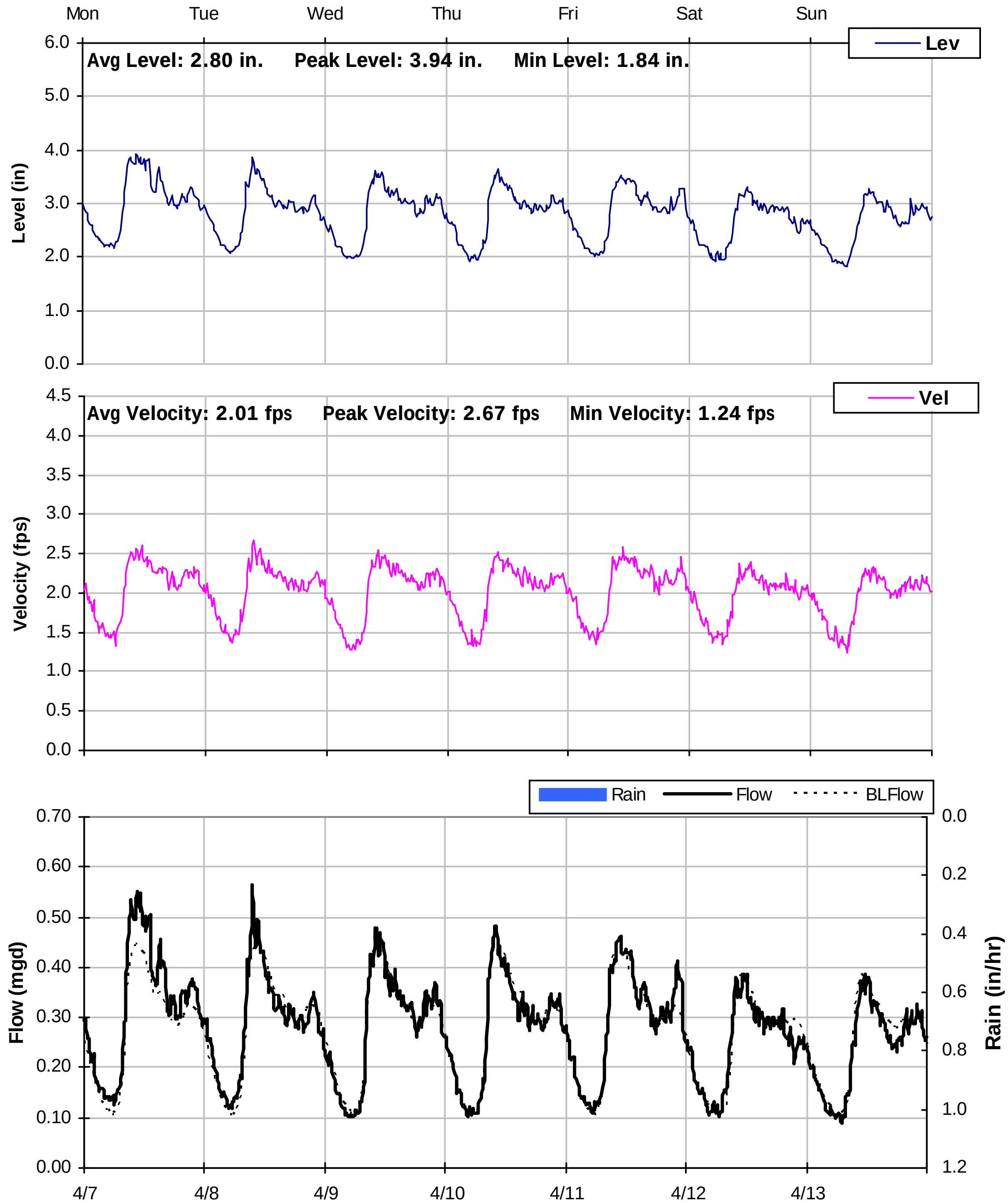


SITE 10
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



Avg Flow: 0.333 mgd **Peak Flow: 0.726 mgd** **Min Flow: 0.132 mgd**

SITE 10
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 0.278 mgd **Peak Flow: 0.566 mgd** **Min Flow: 0.088 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 11

Location: In field south of Independence Drive

Data Summary Report

SITE 11

Site Information

Location: In field south of Independence Drive

Coordinates: 122.1784° W, 37.4828° N

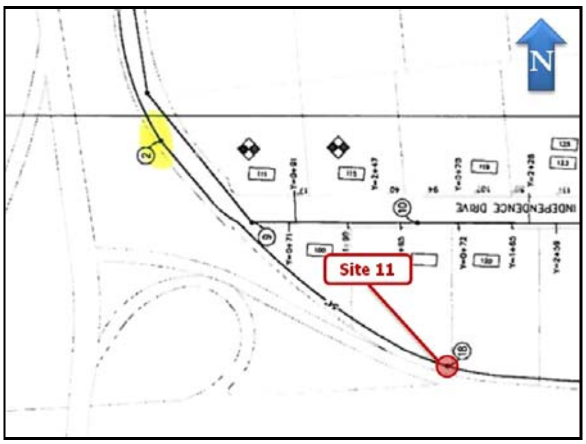
Rim Elevation: 11 feet

Pipe Diameter: 54 inches

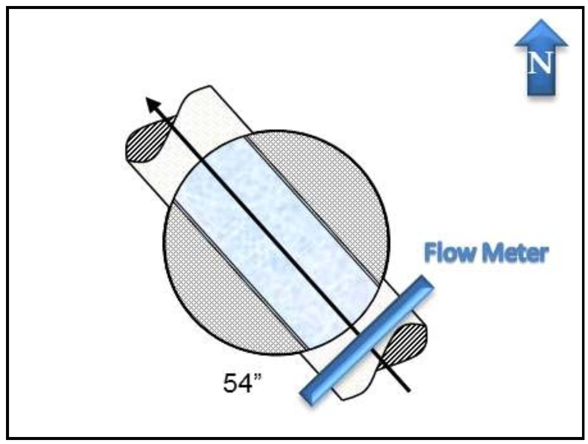
Baseline Flow: 1.733 mgd

Peak Measured Flow: 3.794 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch


View from Street

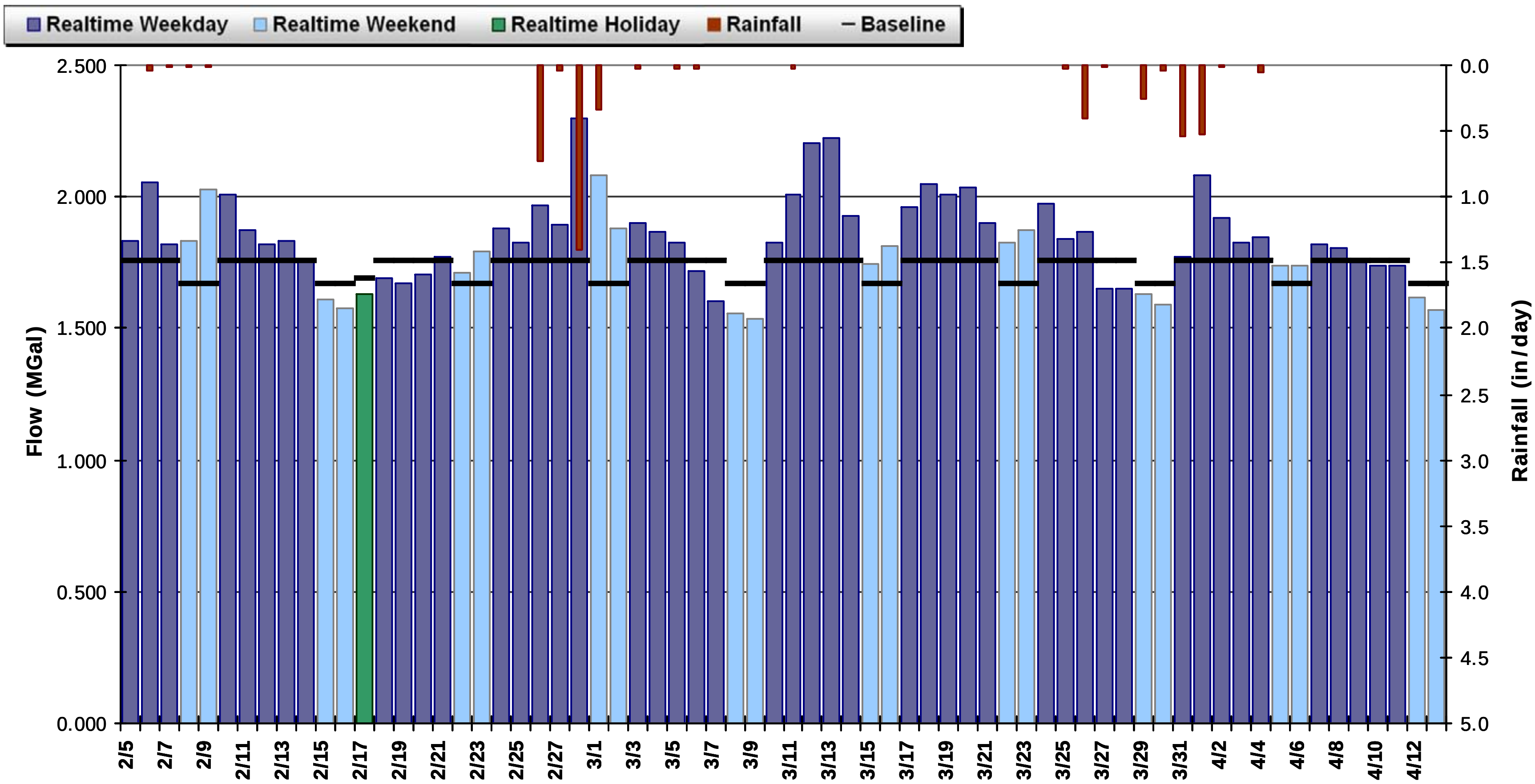

Plan View

SITE 11

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.830 MGal **Peak Daily Flow: 2.300 MGal** **Min Daily Flow: 1.535 MGal**

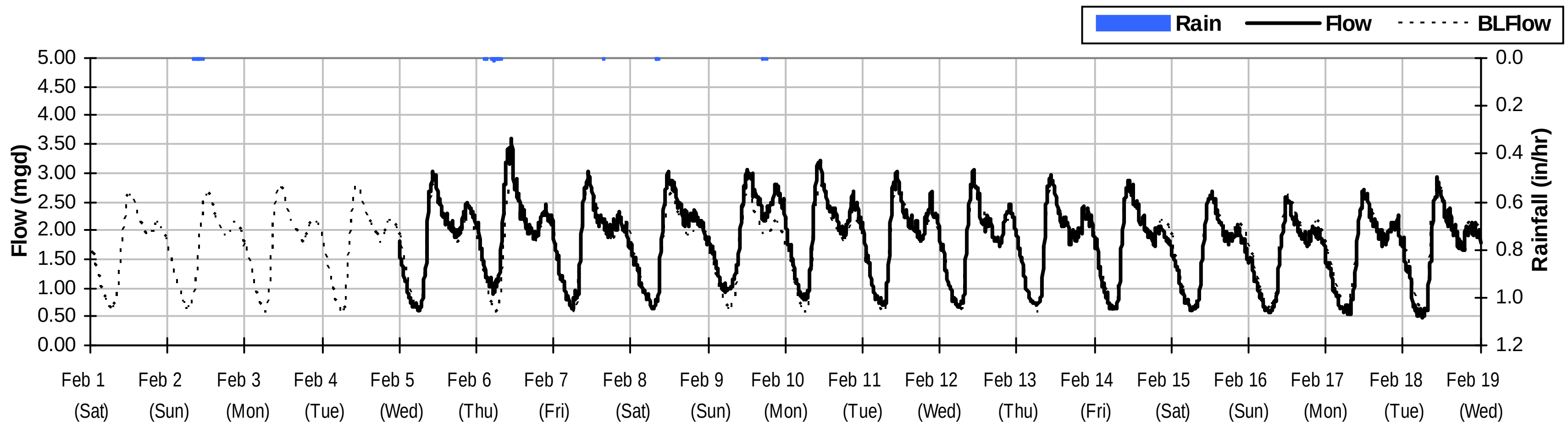
Total Period Rainfall: 4.56 inches

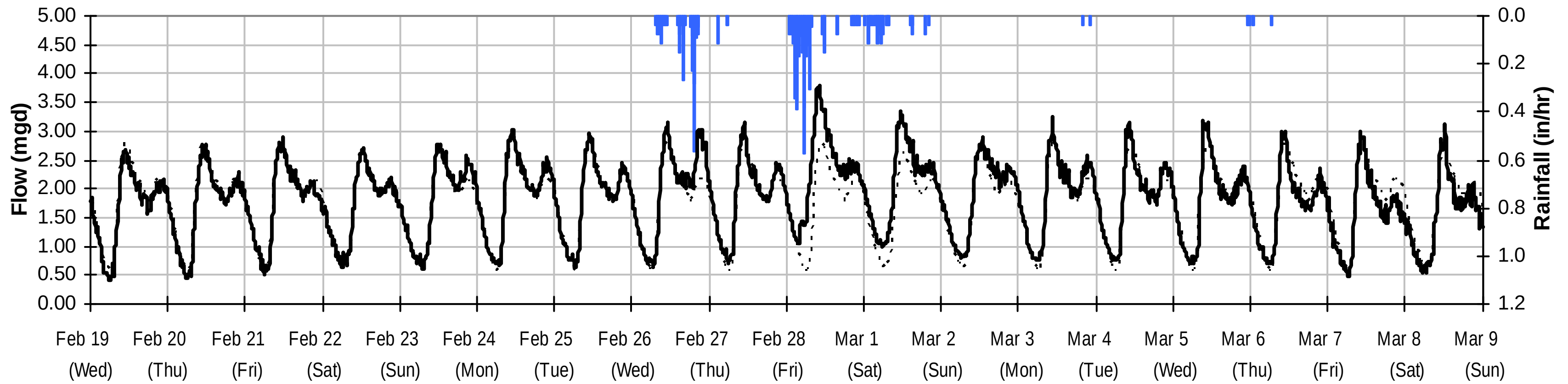


SITE 11

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.58 inches **Avg Flow: 1.830 mgd** **Peak Flow: 3.794 mgd** **Min Flow: 0.337 mgd**

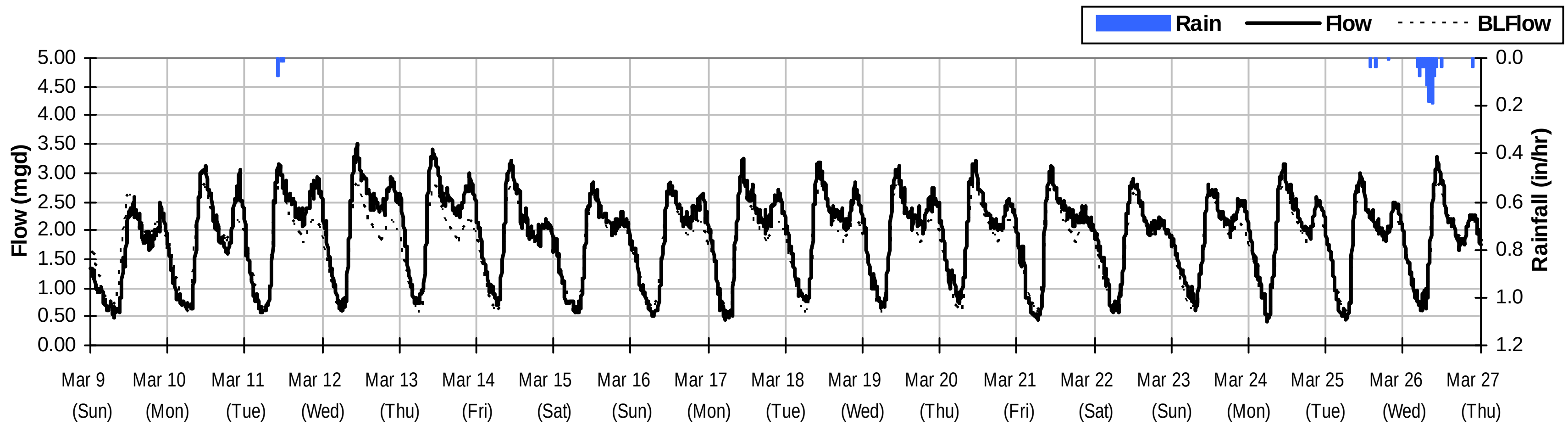


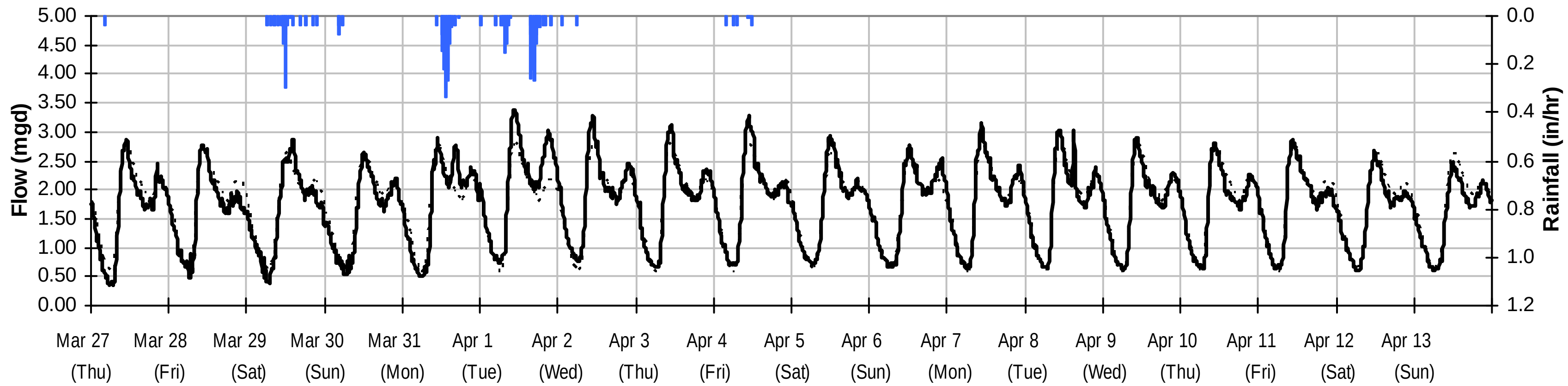


SITE 11

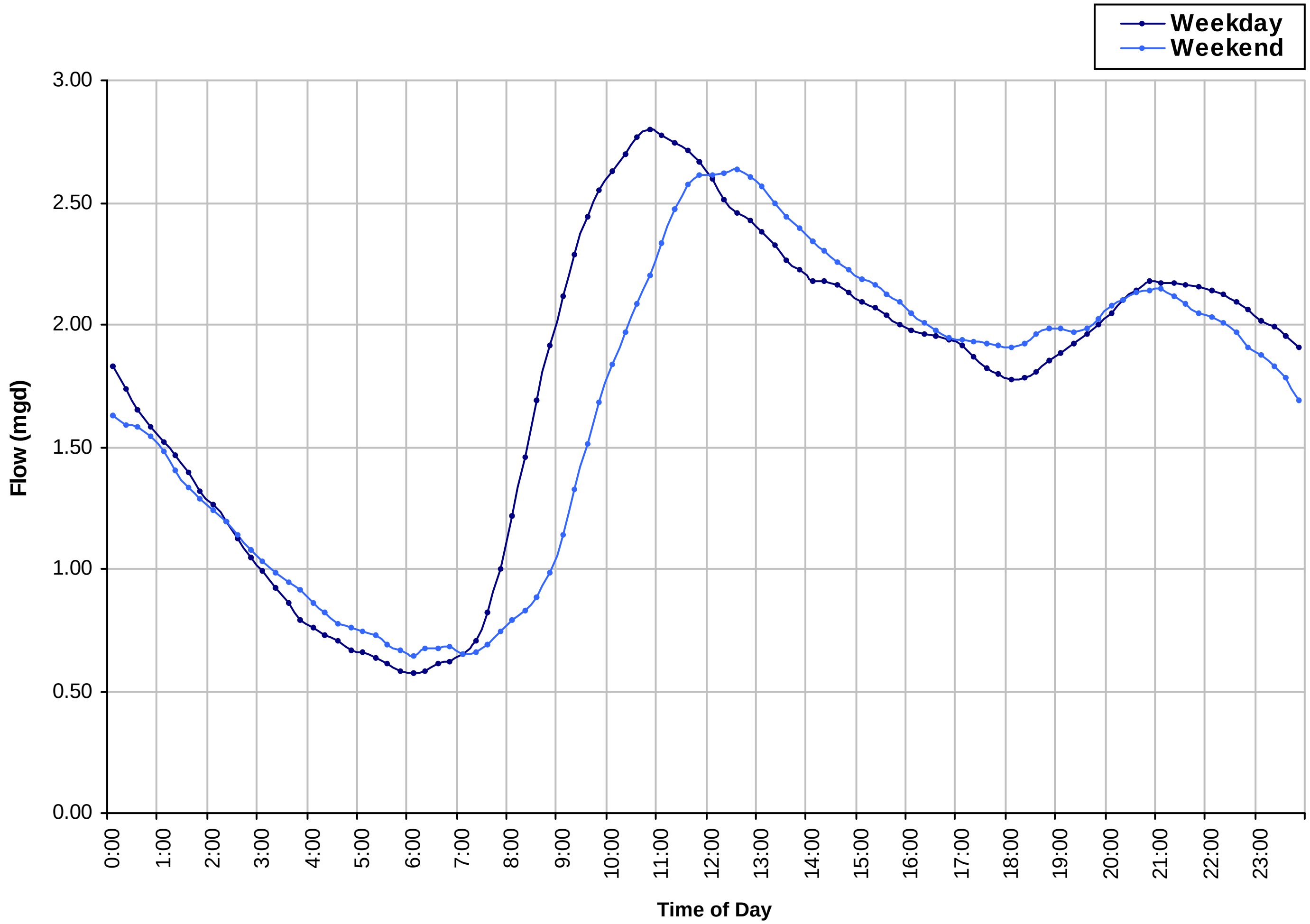
Period Flow Summary: March 9 to April 14, 2014

Total Monthly Rainfall: 4.58 inches **Avg Flow: 1.830 mgd** **Peak Flow: 3.794 mgd** **Min Flow: 0.337 mgd**

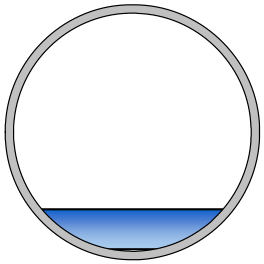




SITE 11
Baseline Flow Hydrographs

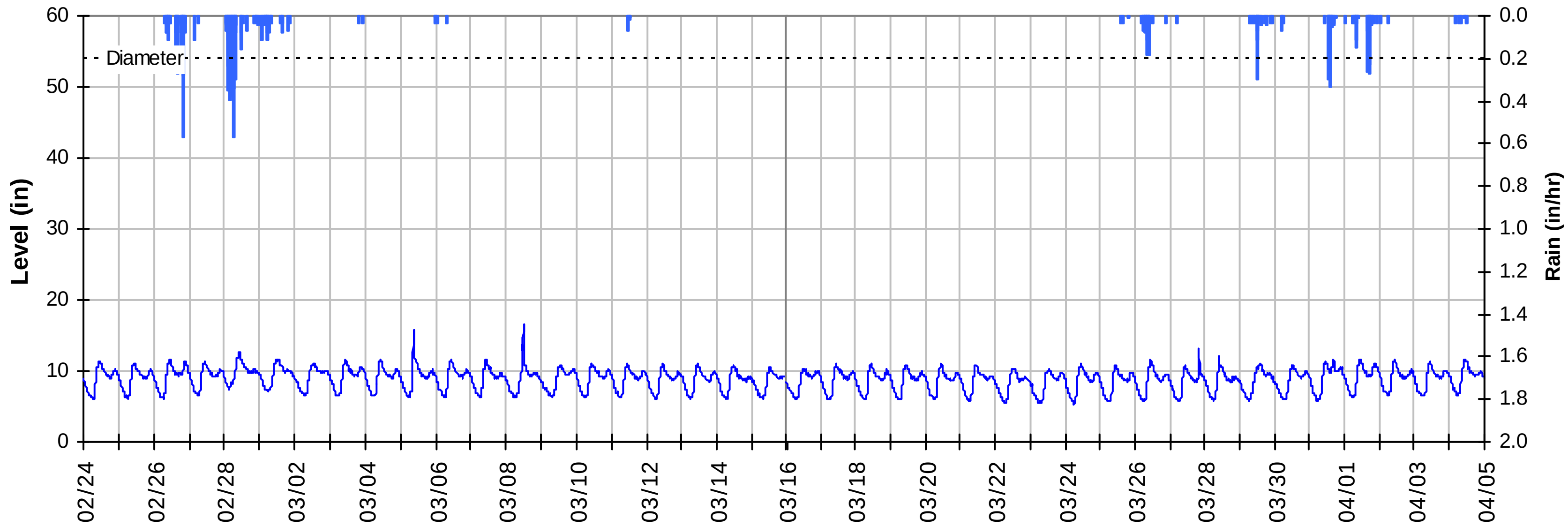


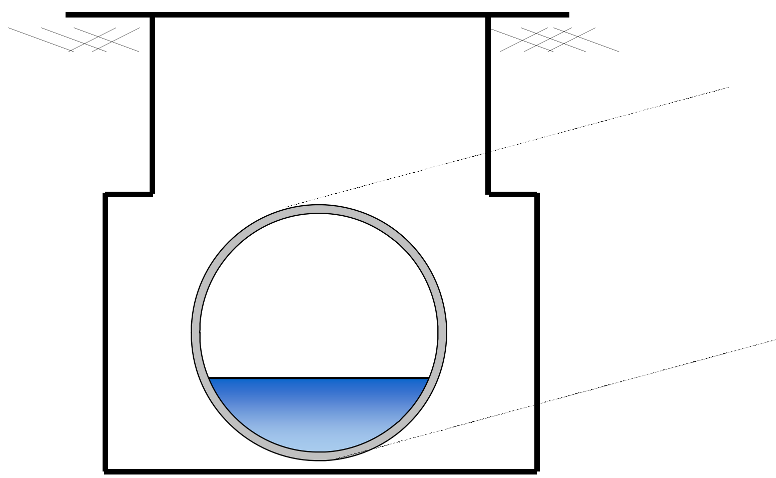
Baseline Flow:
1.733 *mgd*



SITE 11
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





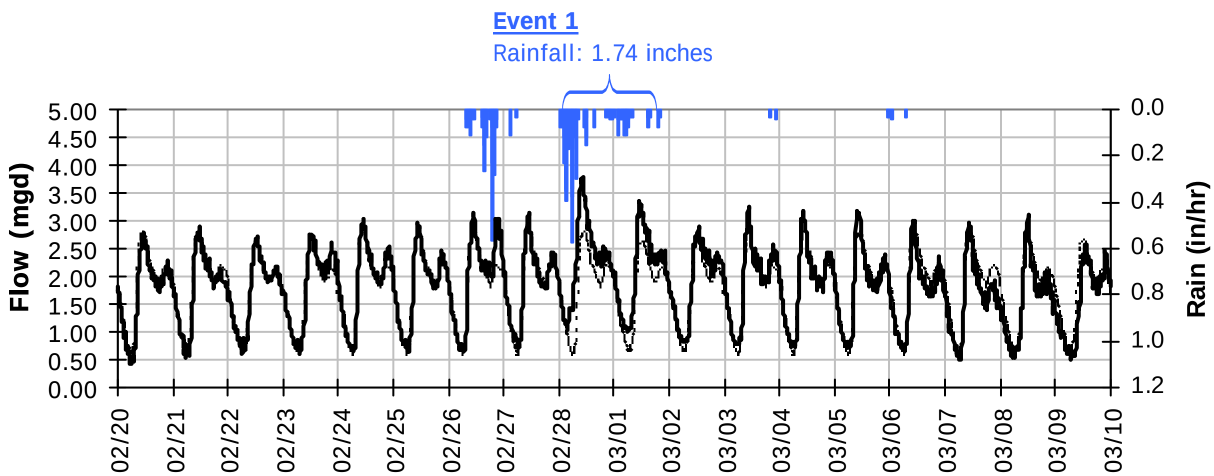
Pipe Diameter: 54 *inches*

Peak Measured Level: 16.6 *inches*

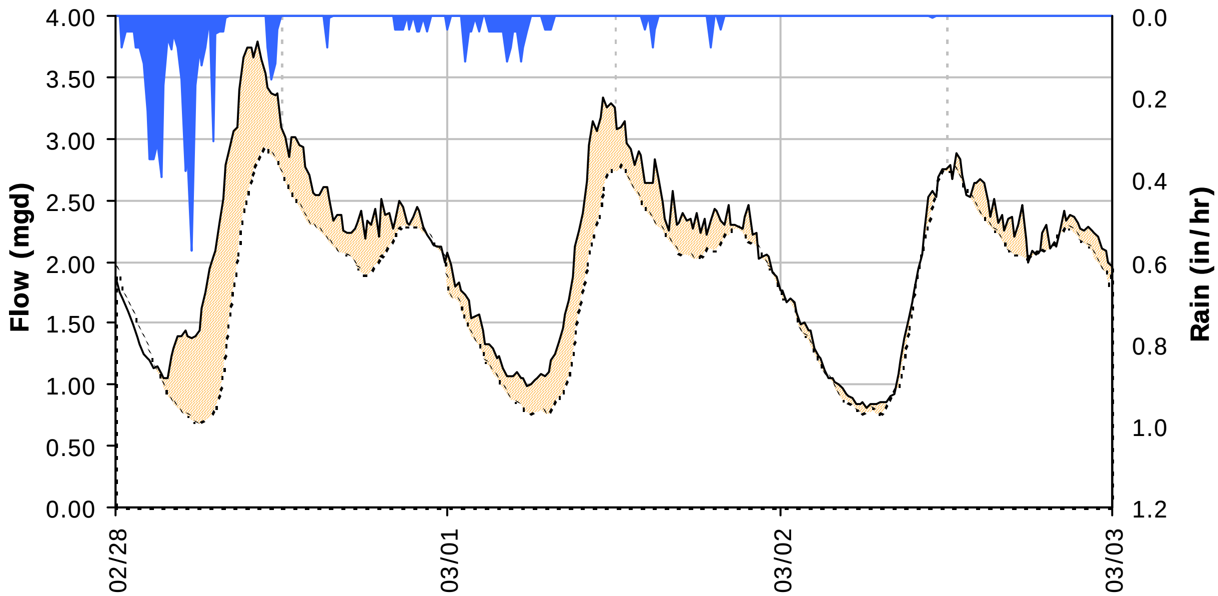
Peak d/D Ratio: 0.31

SITE 11
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

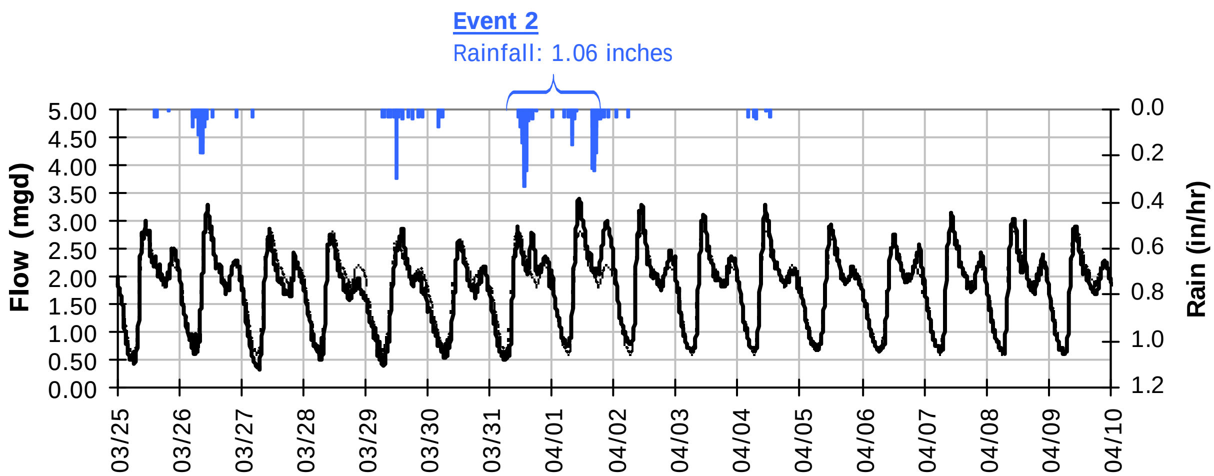


Storm Event I/I Analysis (Rain = 1.74 inches)

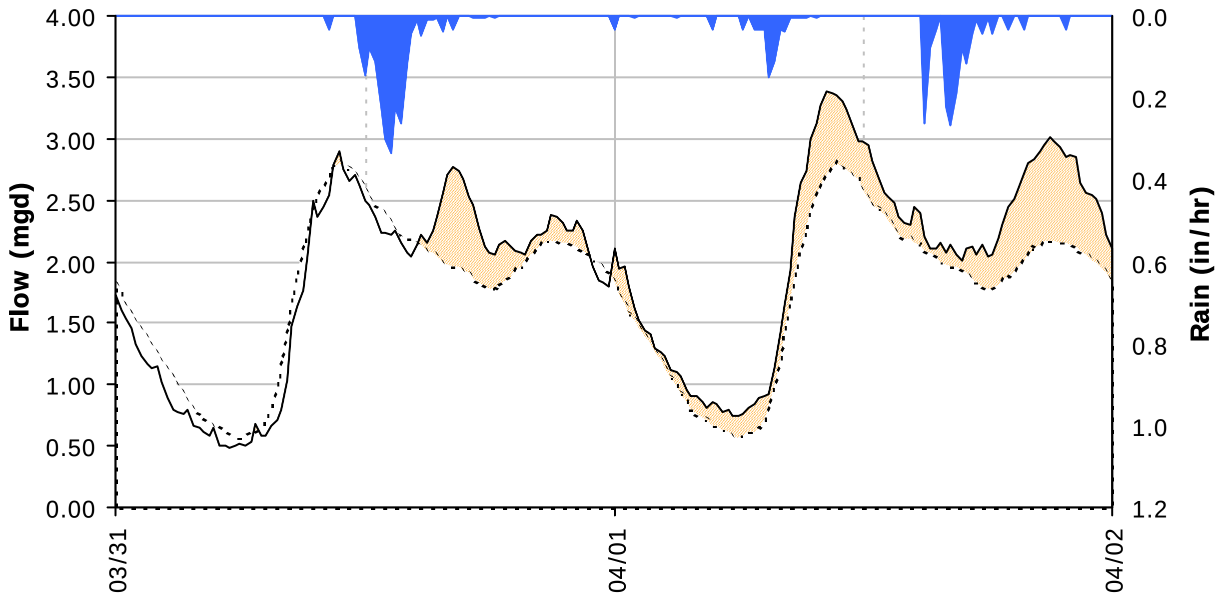
Capacity		Inflow / Infiltration	
Peak Flow:	3.79 *mgd*	**Peak I/I Rate:**	1.45 *mgd*
PF:	2.19	**Total I/I:**	810,000 *gallons*

SITE 11
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



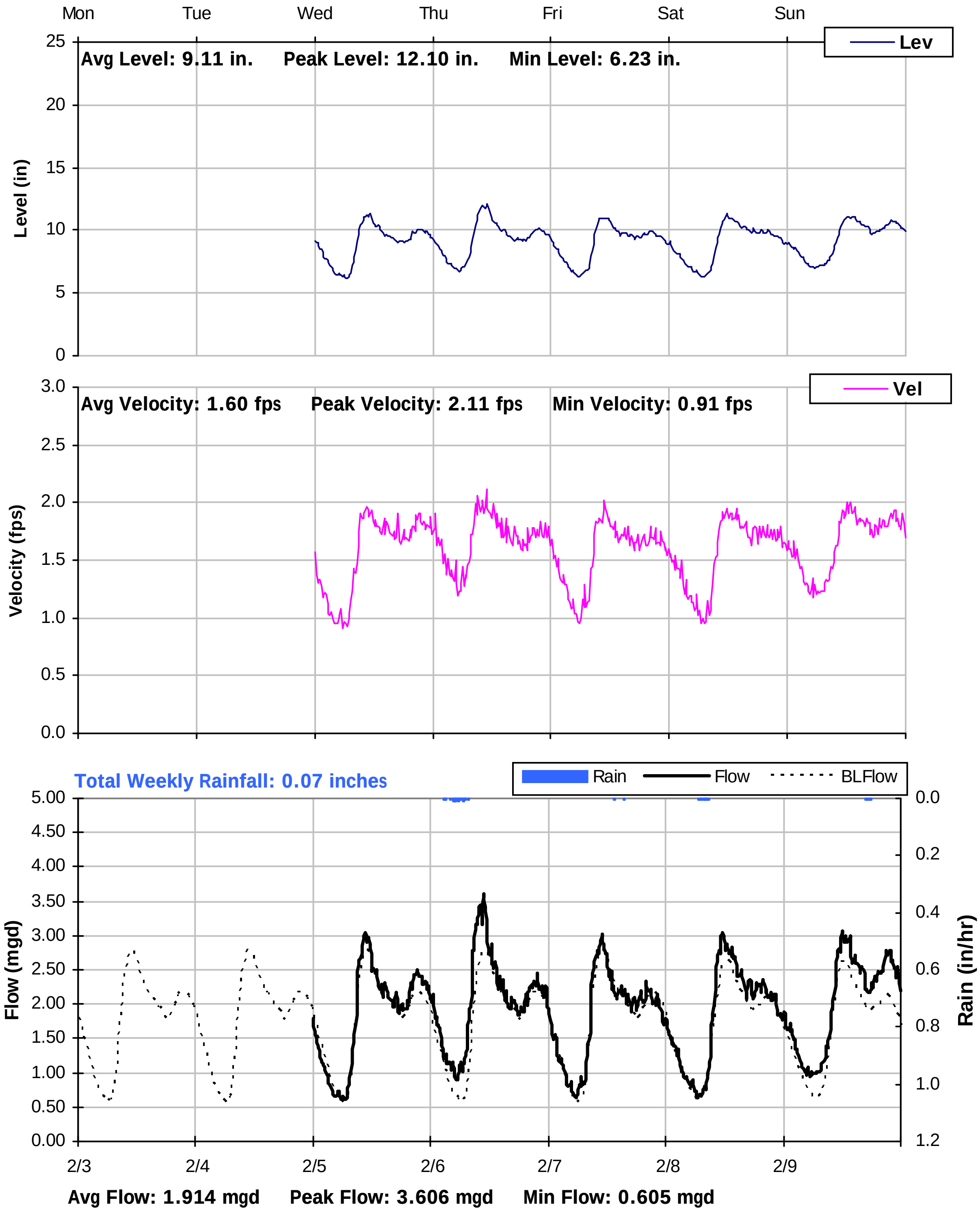
Event 2 Detail Graph



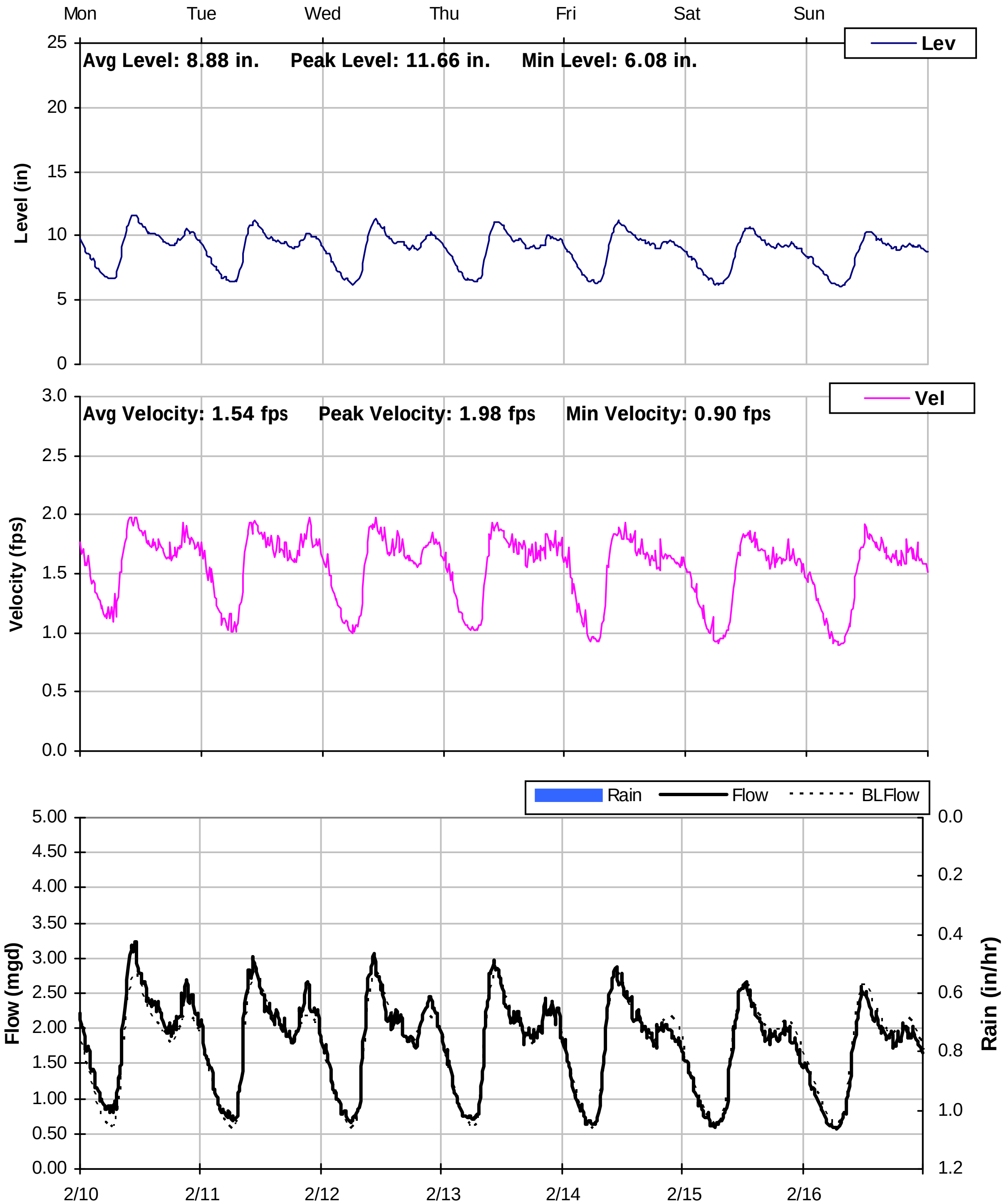
Storm Event I/I Analysis (Rain = 1.06 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	3.39 *mgd*	**Peak I/I Rate:**	0.85 *mgd*
PF:	1.96	**Total I/I:**	550,000 *gallons*

SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

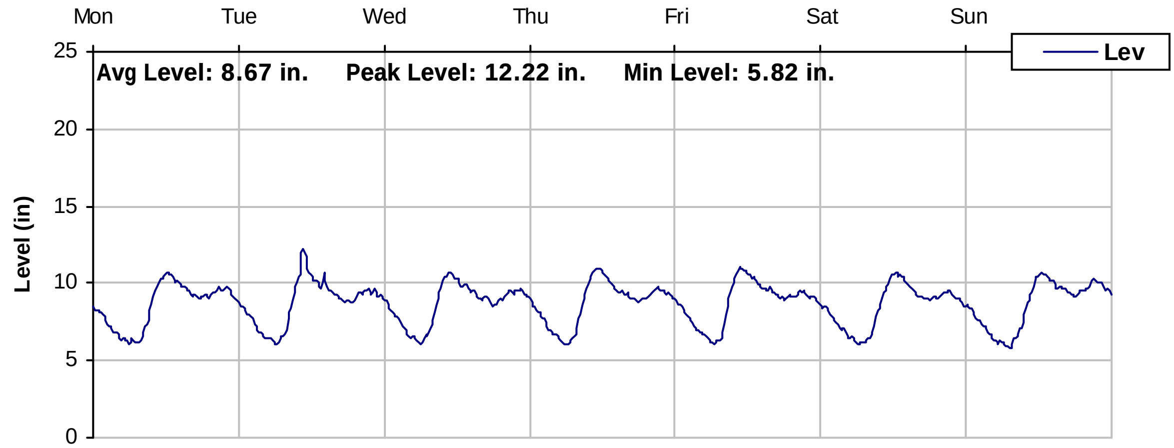


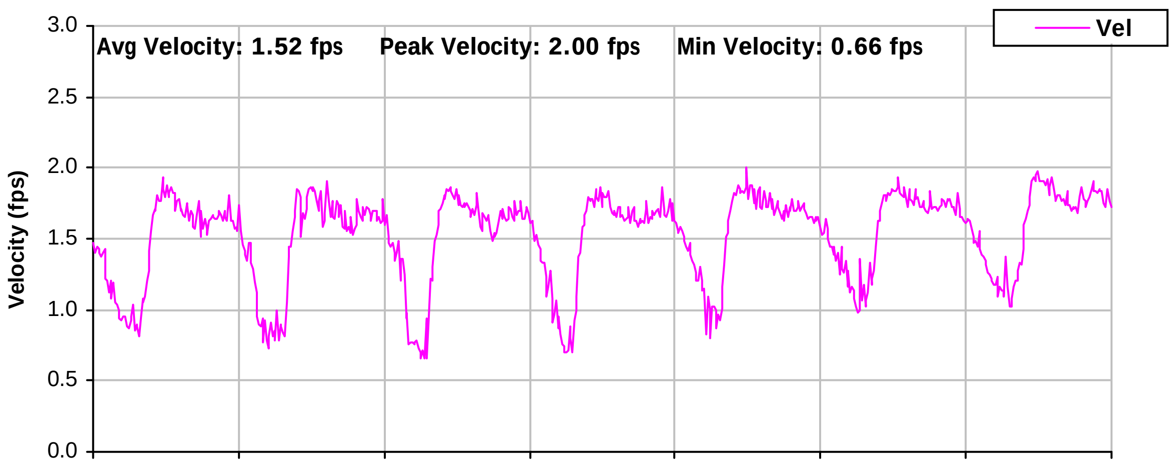
SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

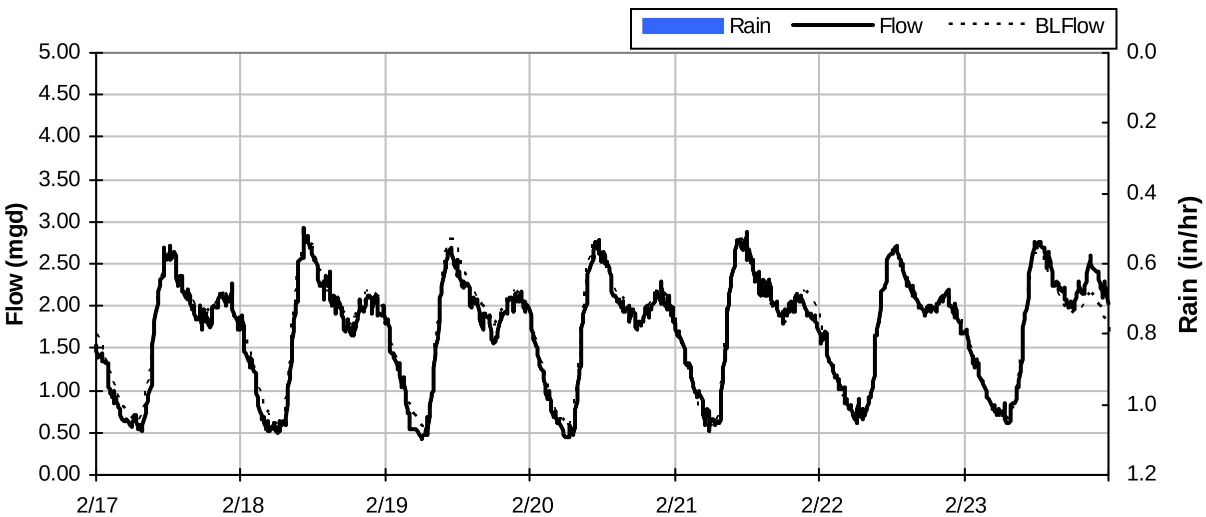


Avg Flow: 1.783 mgd **Peak Flow: 3.220 mgd** **Min Flow: 0.576 mgd**

SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

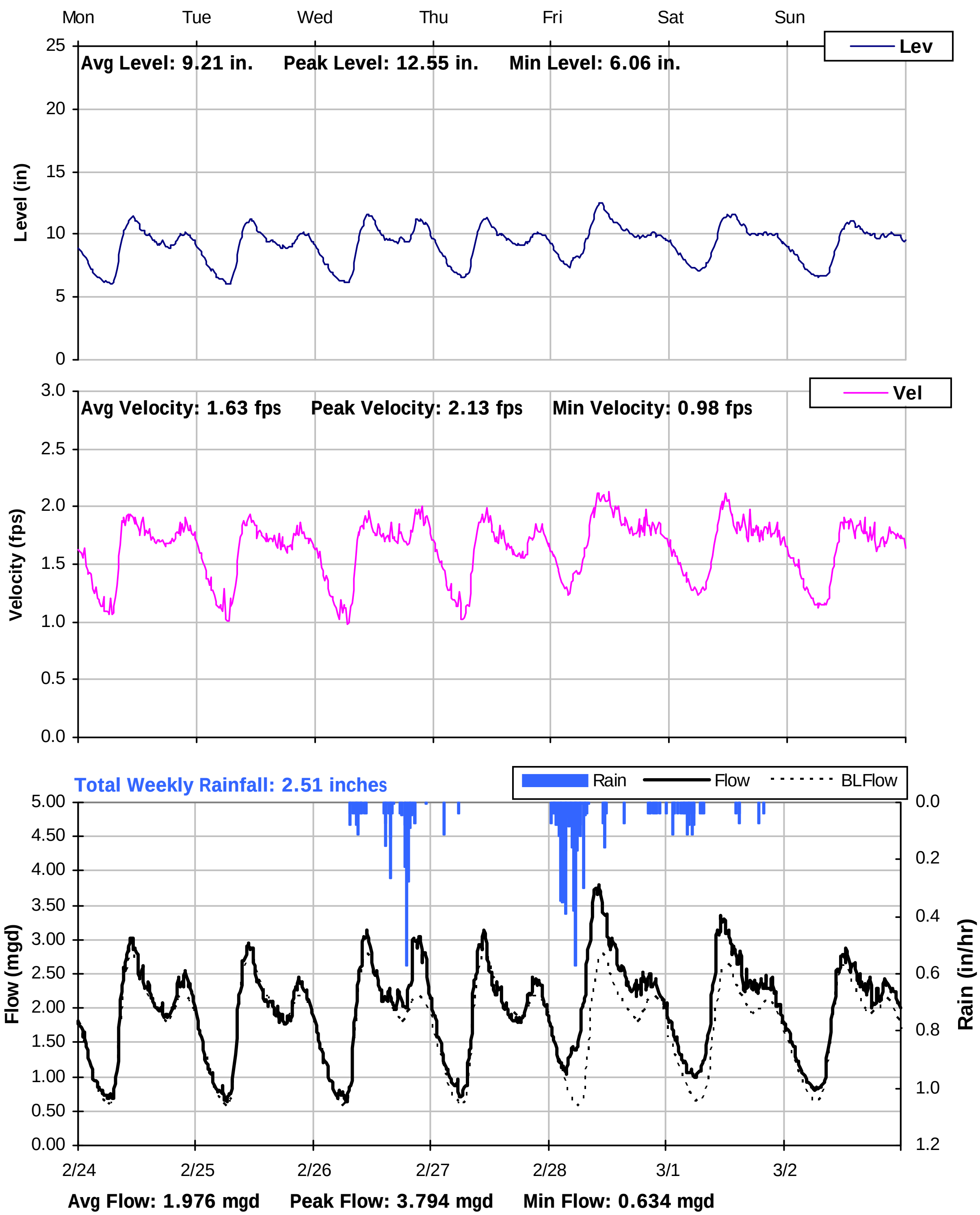




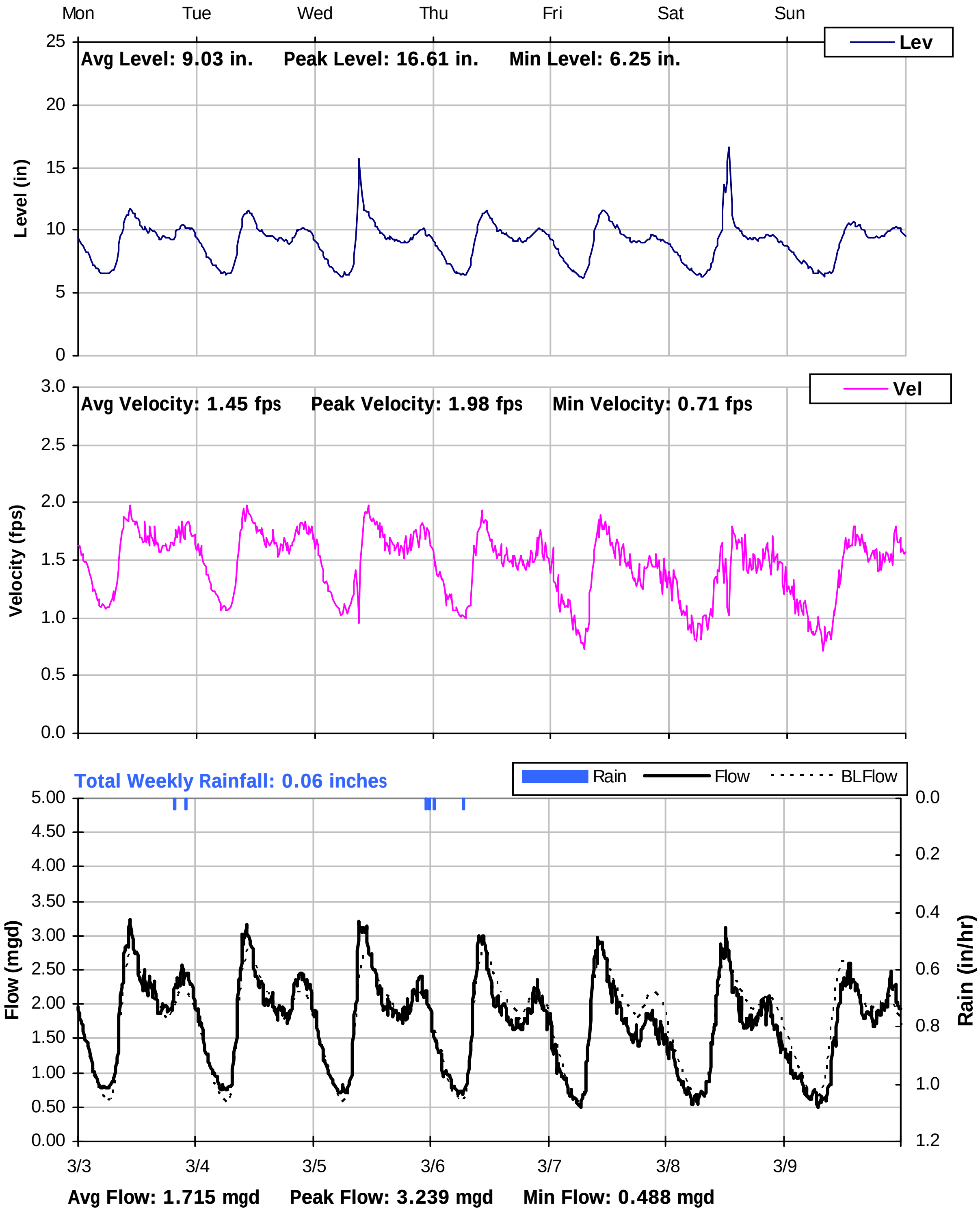


Avg Flow: 1.710 mgd **Peak Flow: 2.926 mgd** **Min Flow: 0.418 mgd**

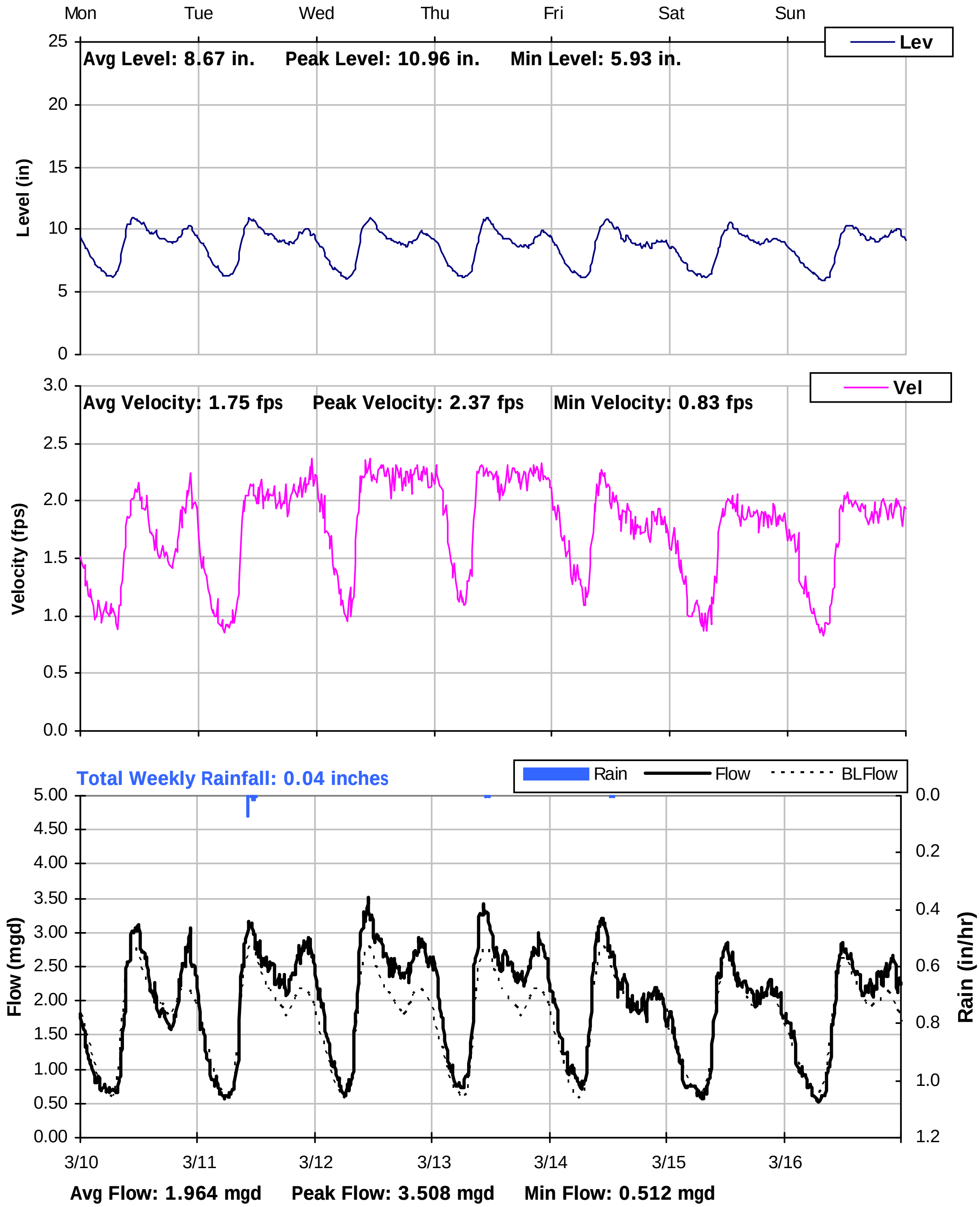
SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



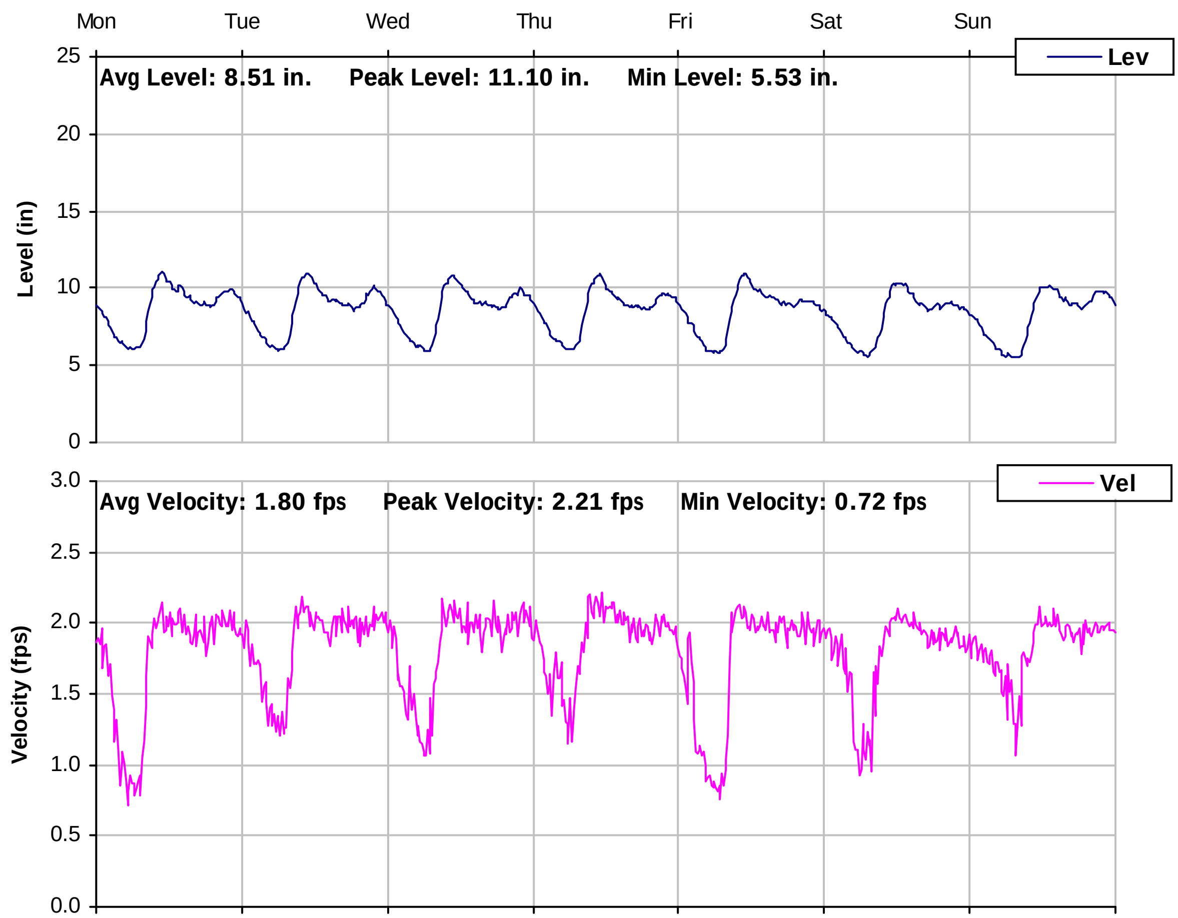
SITE 11
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

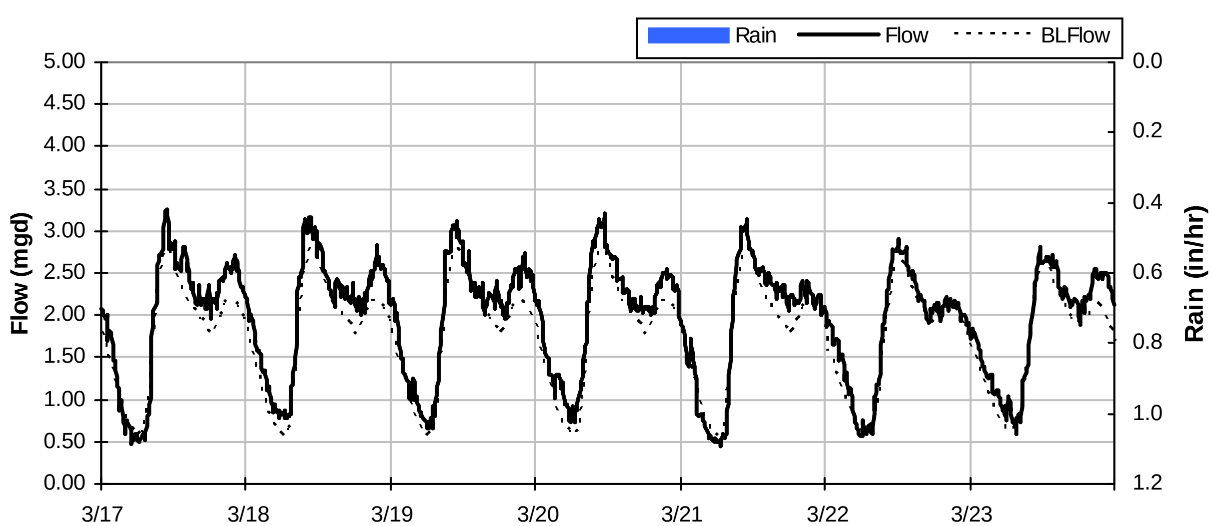


SITE 11
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



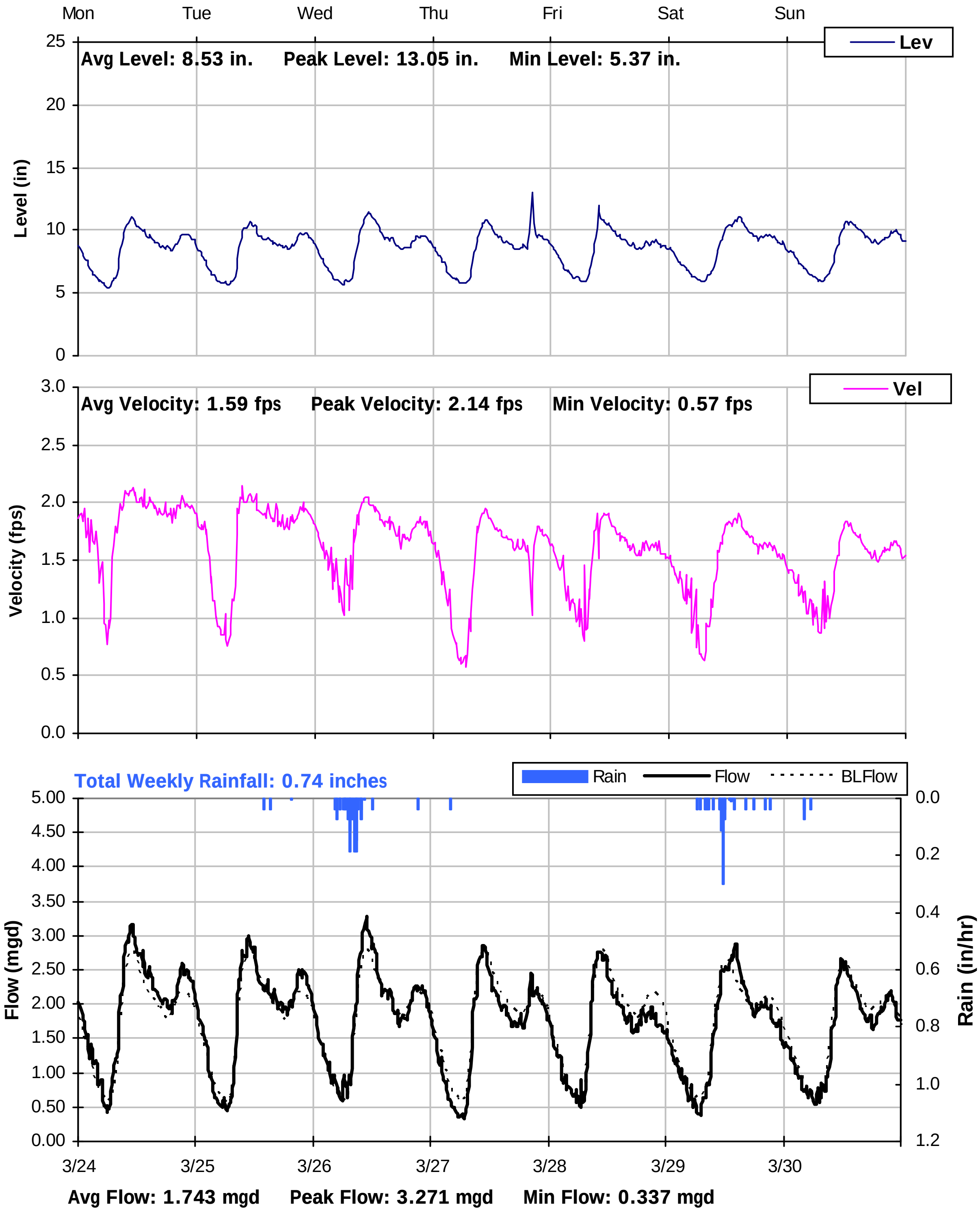
SITE 11
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



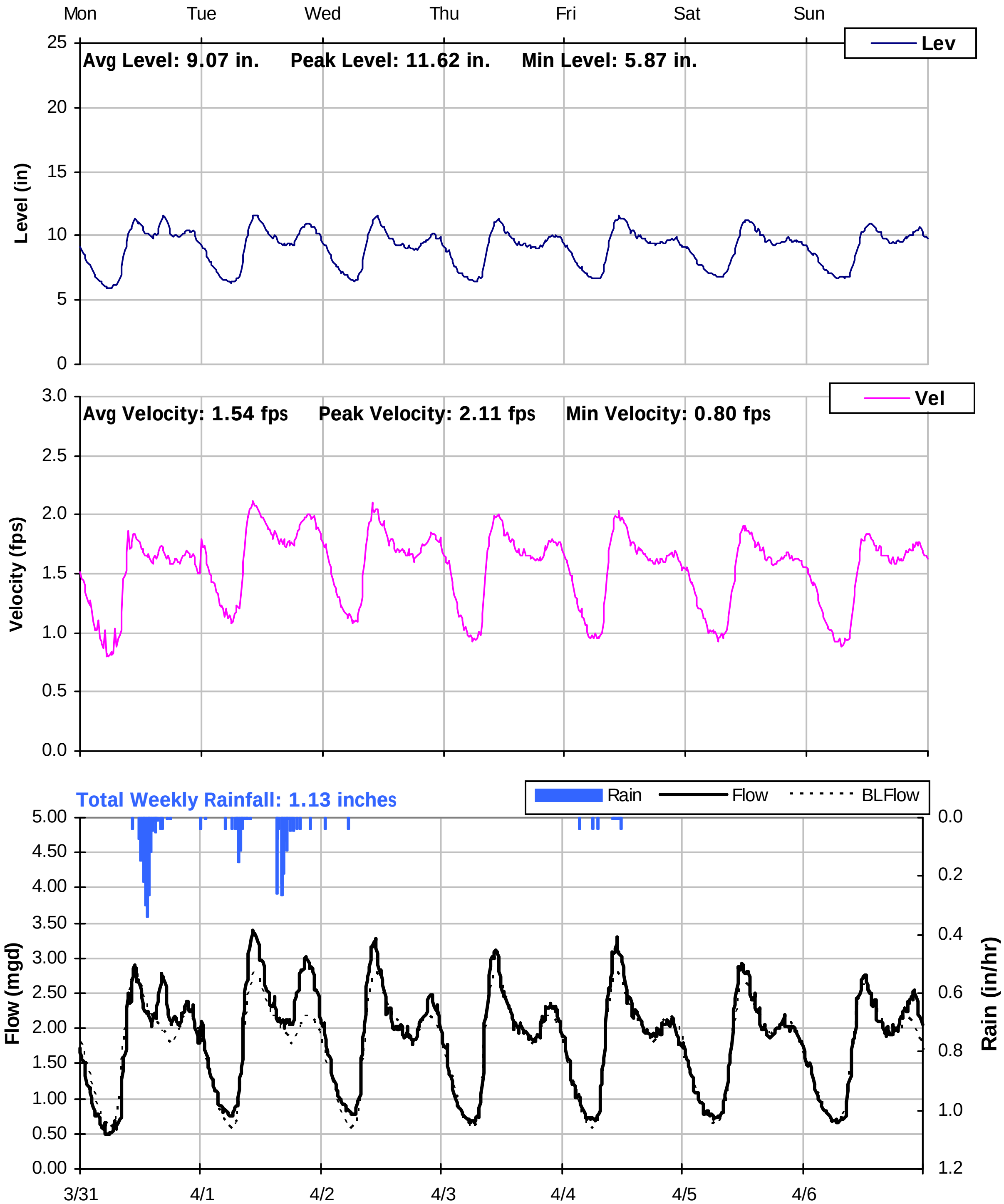


Avg Flow: 1.951 mgd **Peak Flow: 3.253 mgd** **Min Flow: 0.459 mgd**

SITE 11
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

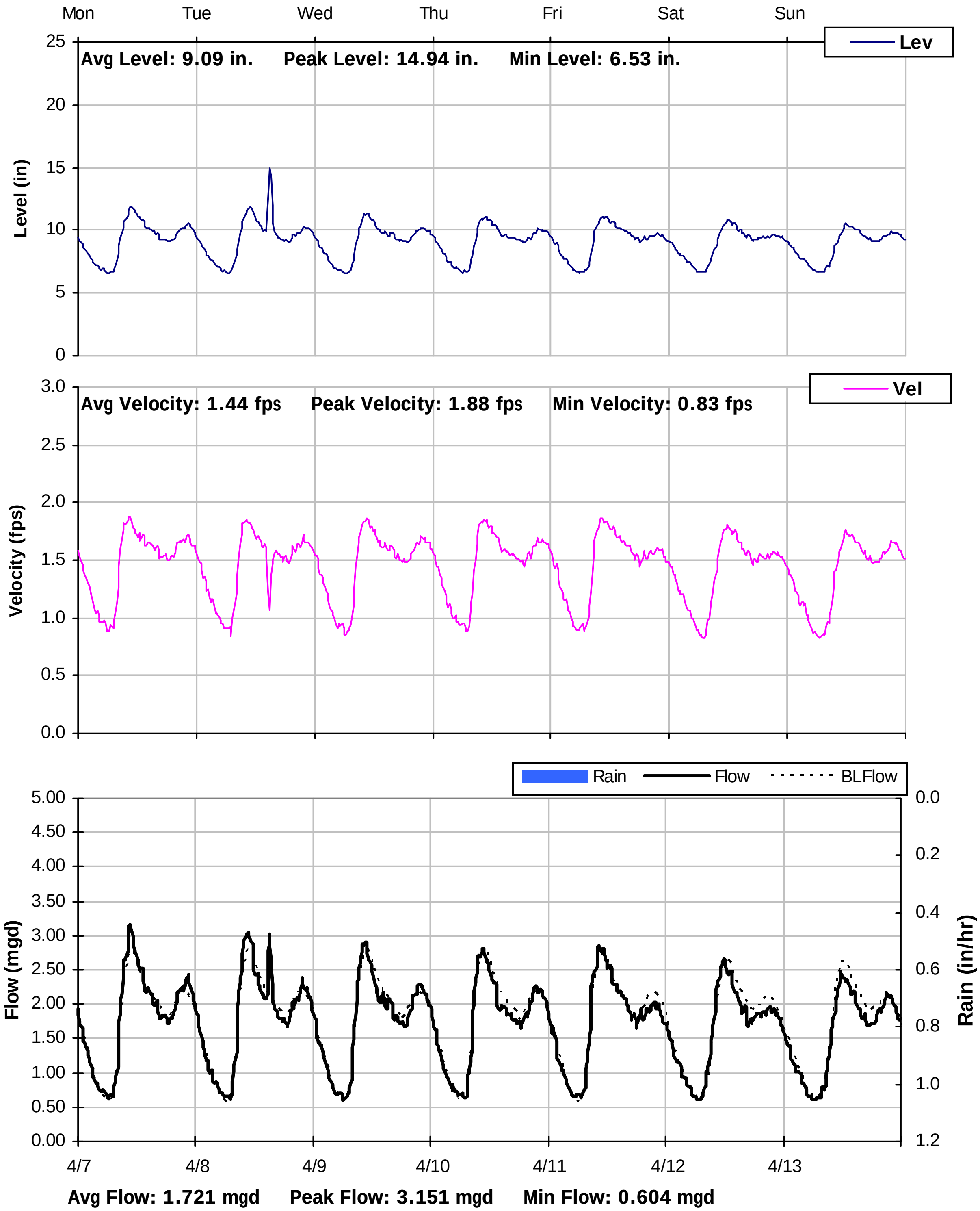


SITE 11
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



Avg Flow: 1.846 mgd Peak Flow: 3.391 mgd Min Flow: 0.494 mgd

SITE 11
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 12

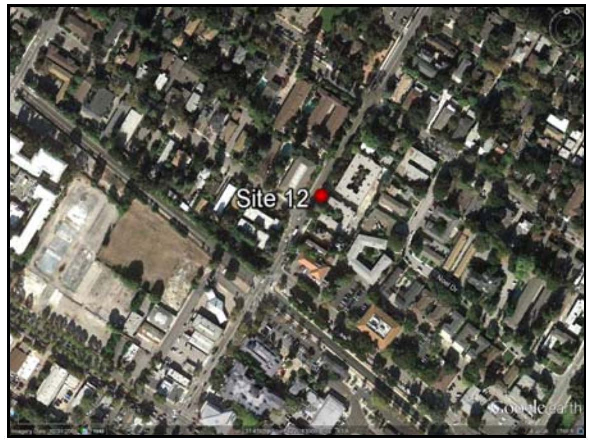
Location: Oak Grove Avenue, northeast of Mills Street

Data Summary Report

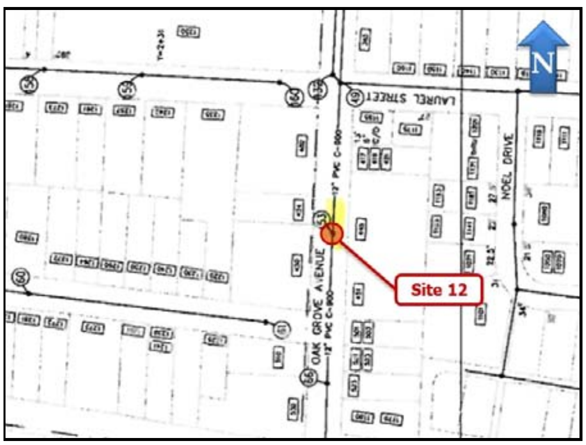
SITE 12

Site Information

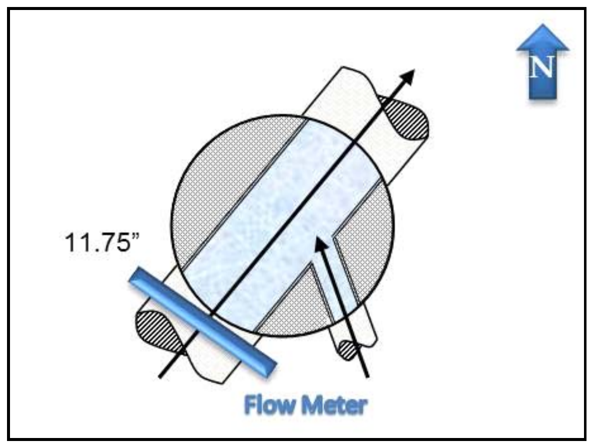
Location:	Oak Grove Avenue, northeast of Mills Street
Coordinates:	122.1827° W, 37.4563° N
Rim Elevation:	66 feet
Pipe Diameter:	11.75 inches
Baseline Flow:	0.090 mgd
Peak Measured Flow:	0.261 mgd



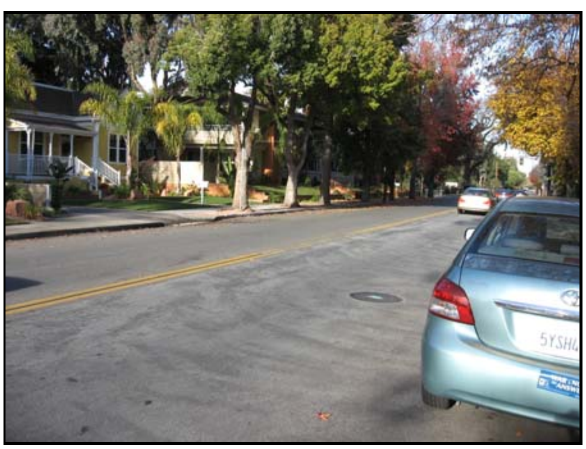
Satellite Map



Sanitary Sewer Map



Flow Sketch



View from Street

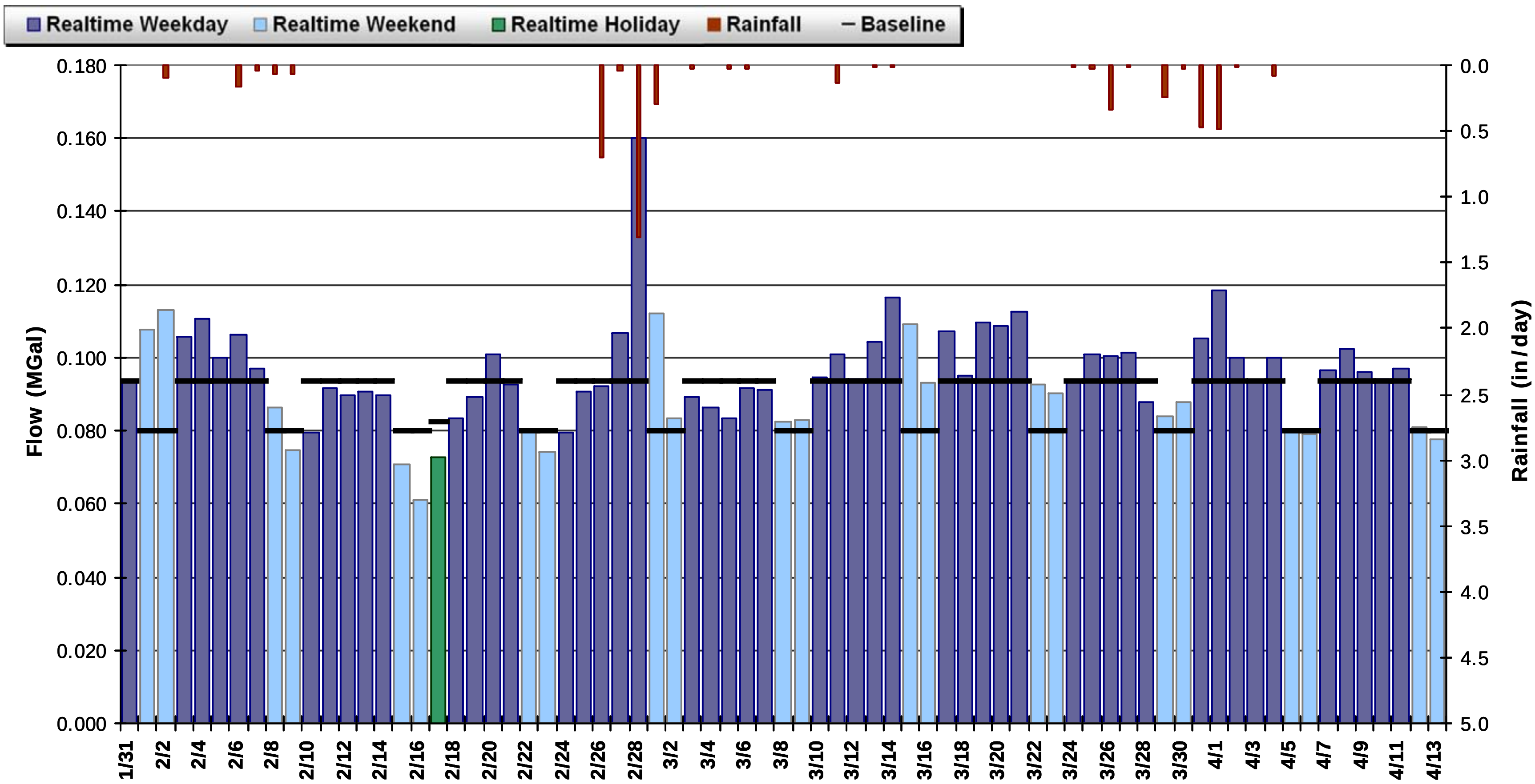
Plan View

SITE 12

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.095 MGal   Peak Daily Flow: 0.160 MGal   Min Daily Flow: 0.061 MGal

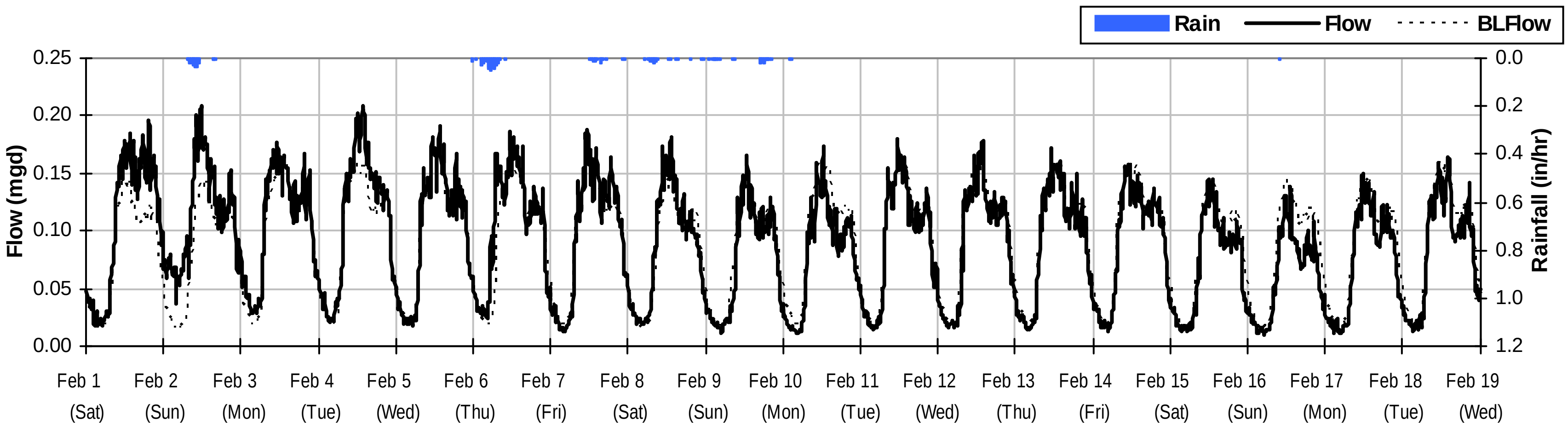
Total Period Rainfall: 4.74 inches

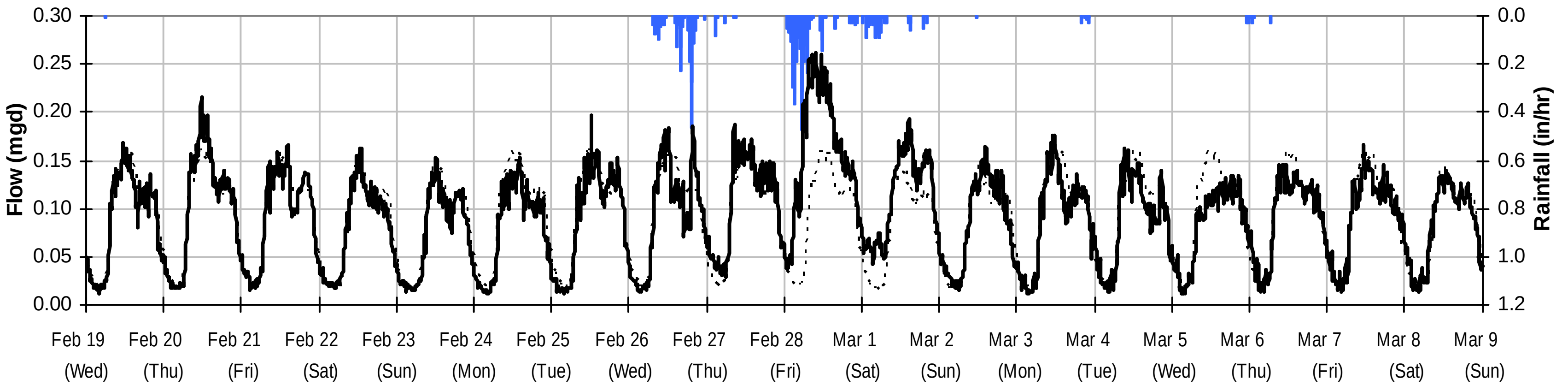


SITE 12

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.75 inches **Avg Flow: 0.095 mgd** **Peak Flow: 0.261 mgd** **Min Flow: 0.007 mgd**

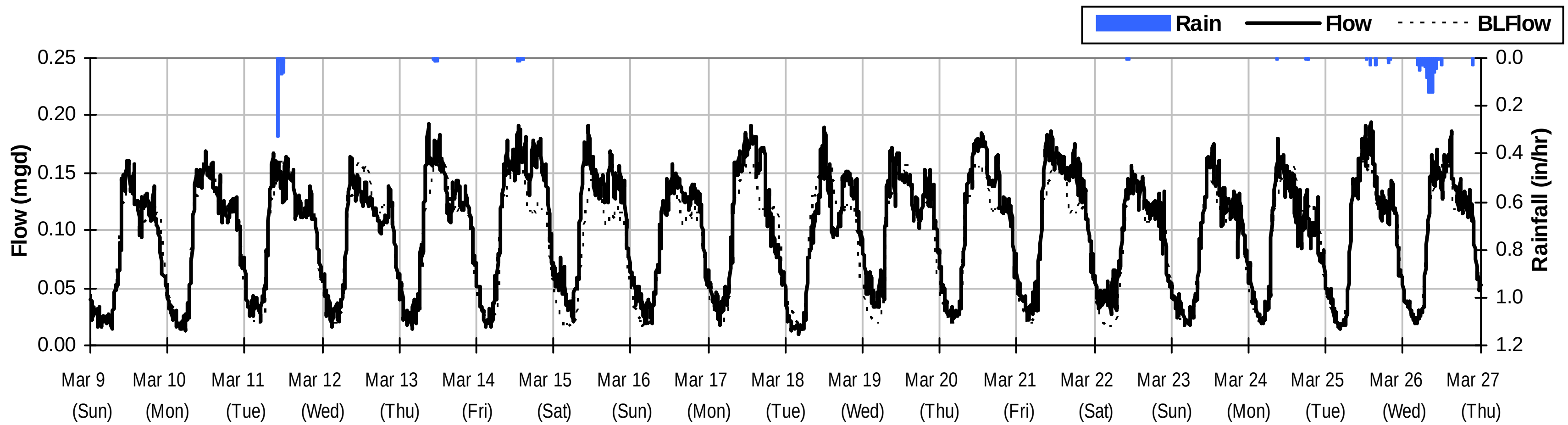


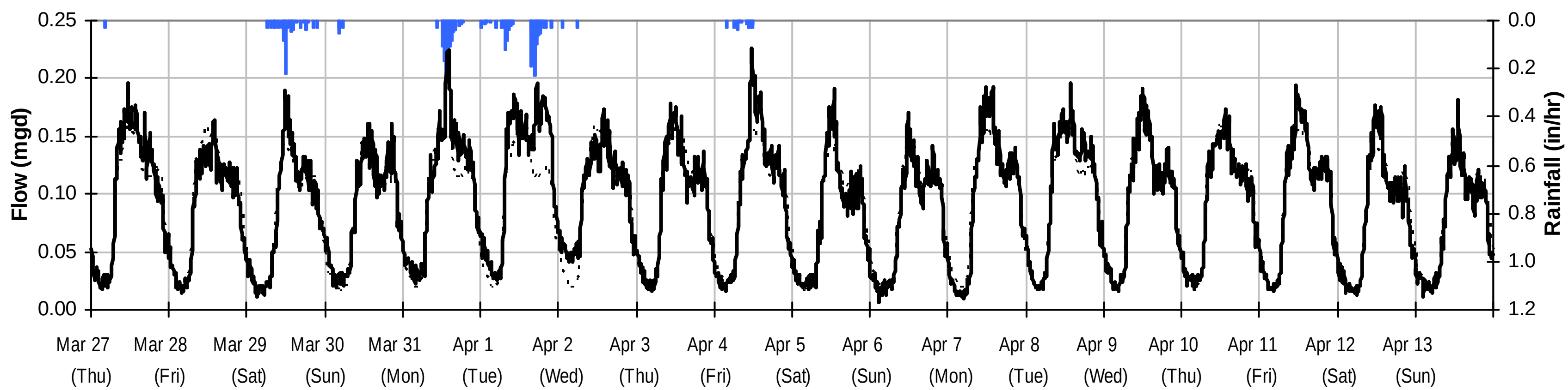


SITE 12

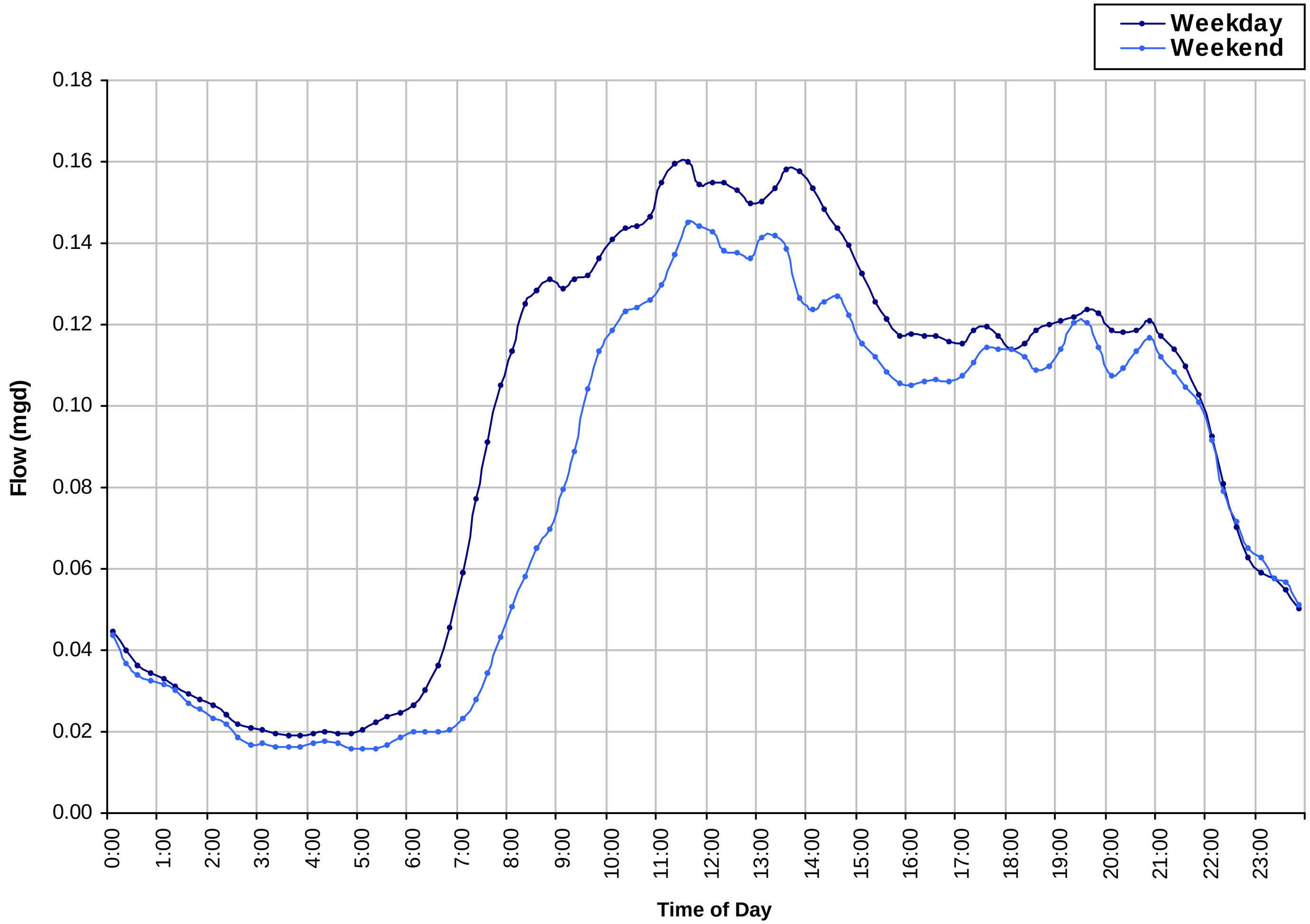
Period Flow Summary: March 9 to April 14, 2014

Total Monthly Rainfall: 4.75 inches **Avg Flow: 0.095 mgd** **Peak Flow: 0.261 mgd** **Min Flow: 0.007 mgd**

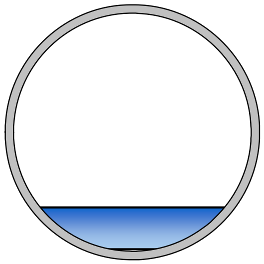




SITE 12
Baseline Flow Hydrographs

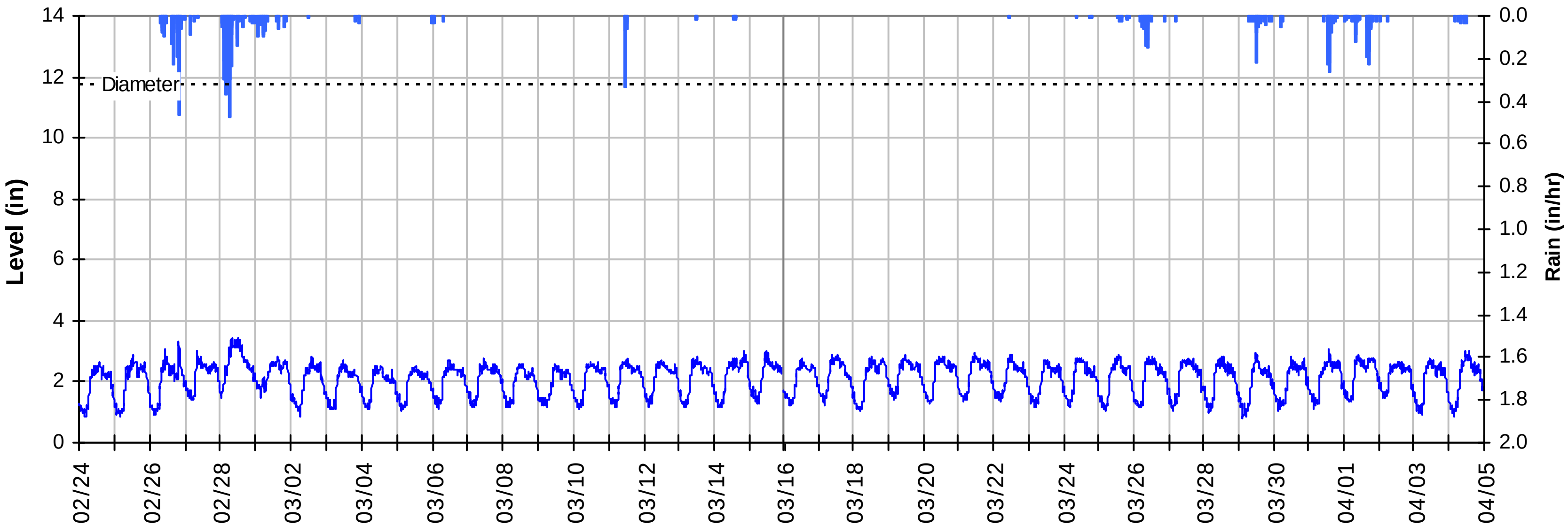


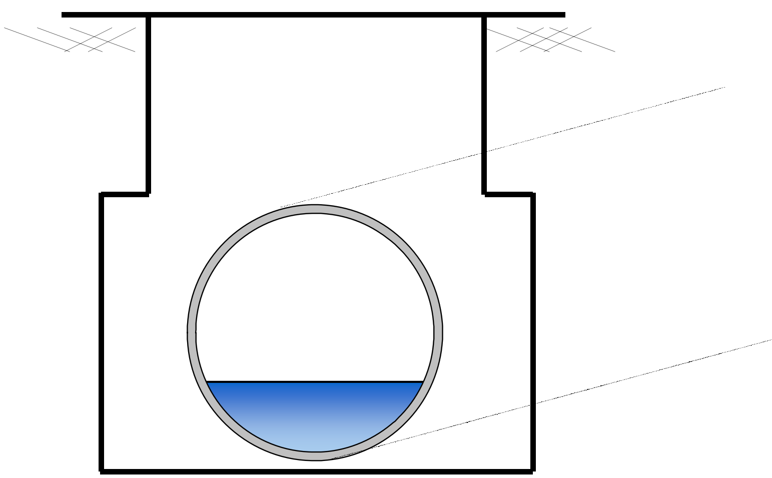
Baseline Flow:
0.090 *mgd*



SITE 12
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

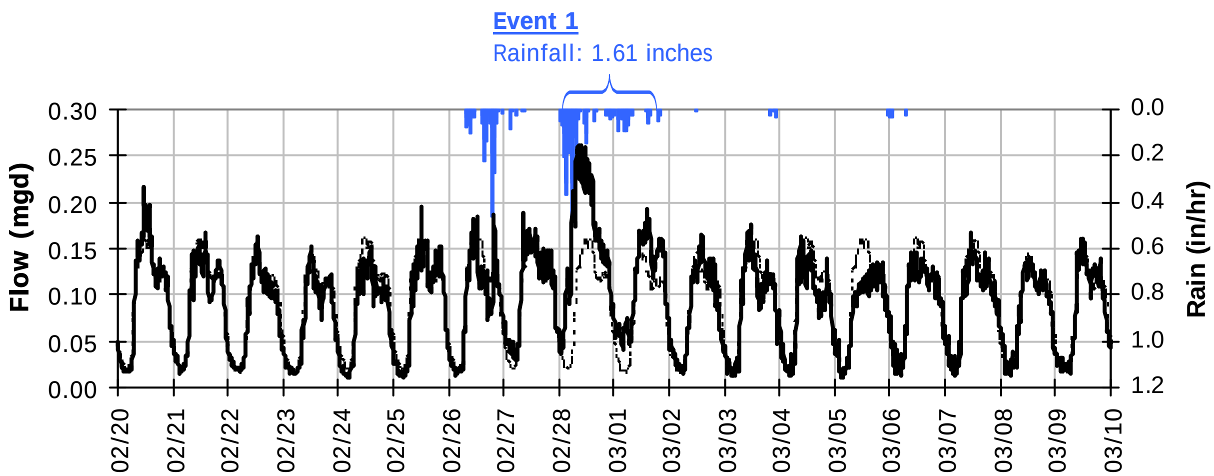




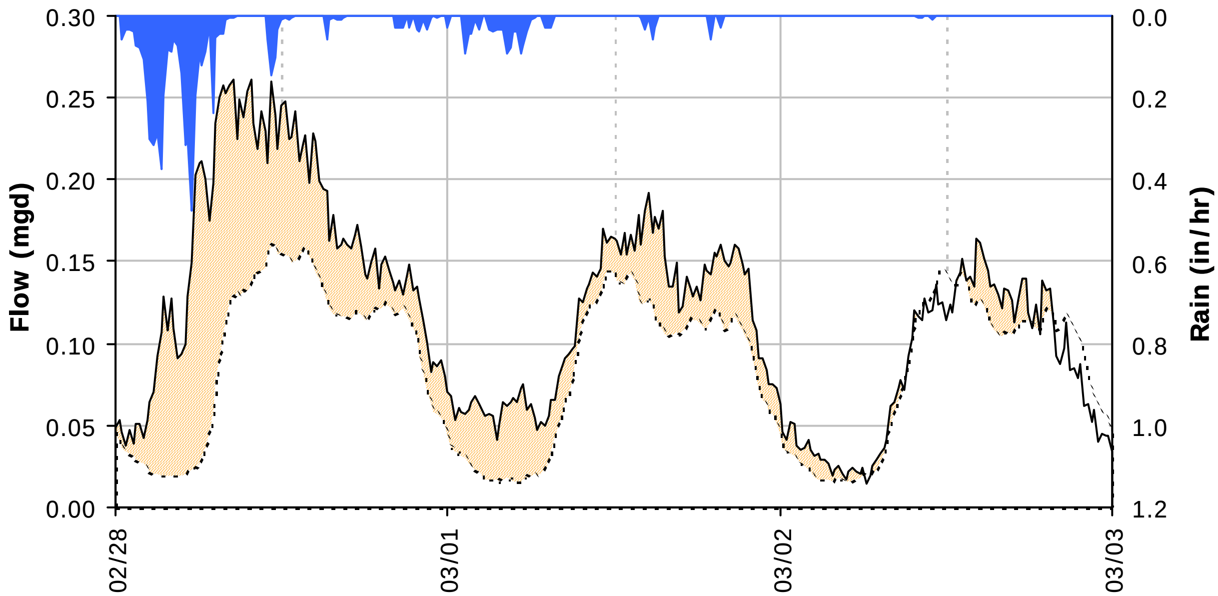
Pipe Diameter:	11.8 *inches*
Peak Measured Level:	3.46 *inches*
Peak d/D Ratio:	0.29

SITE 12
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

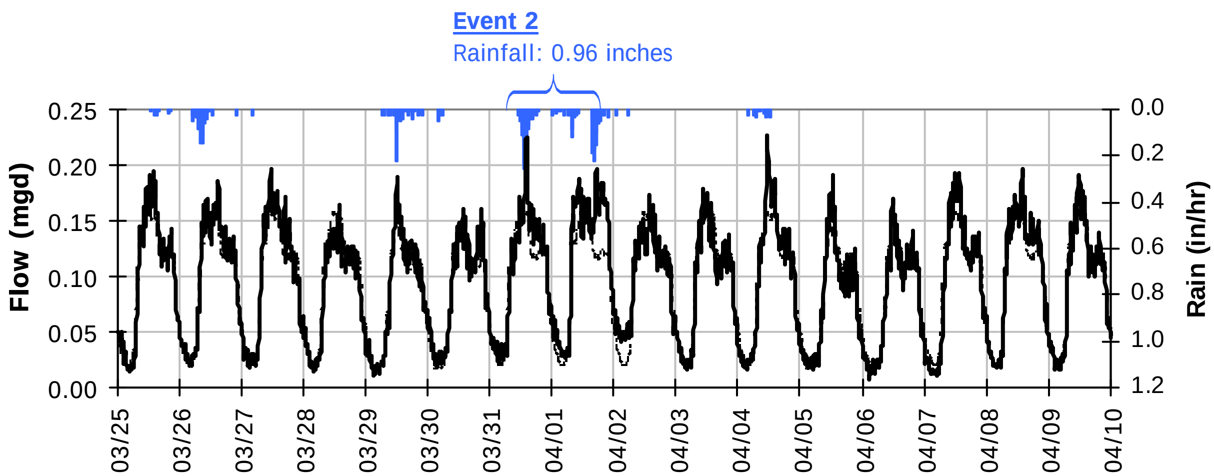


Storm Event I/I Analysis (Rain = 1.61 inches)

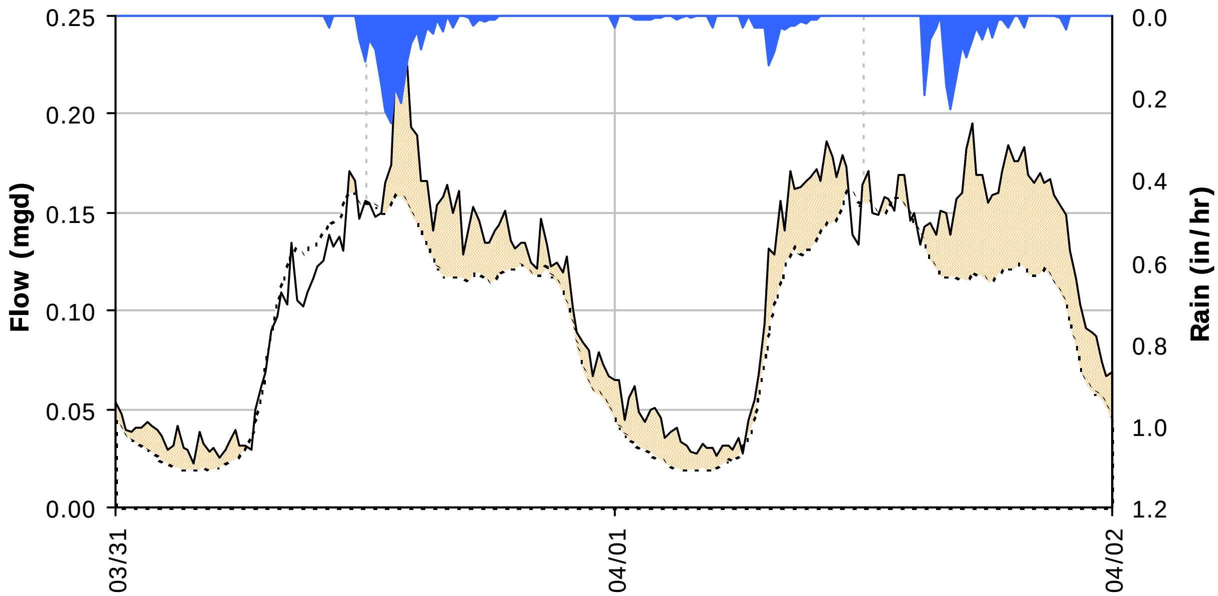
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.26 *mgd*	**Peak I/I Rate:**	0.16 *mgd*
PF:	2.91	**Total I/I:**	103,000 *gallons*

SITE 12
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



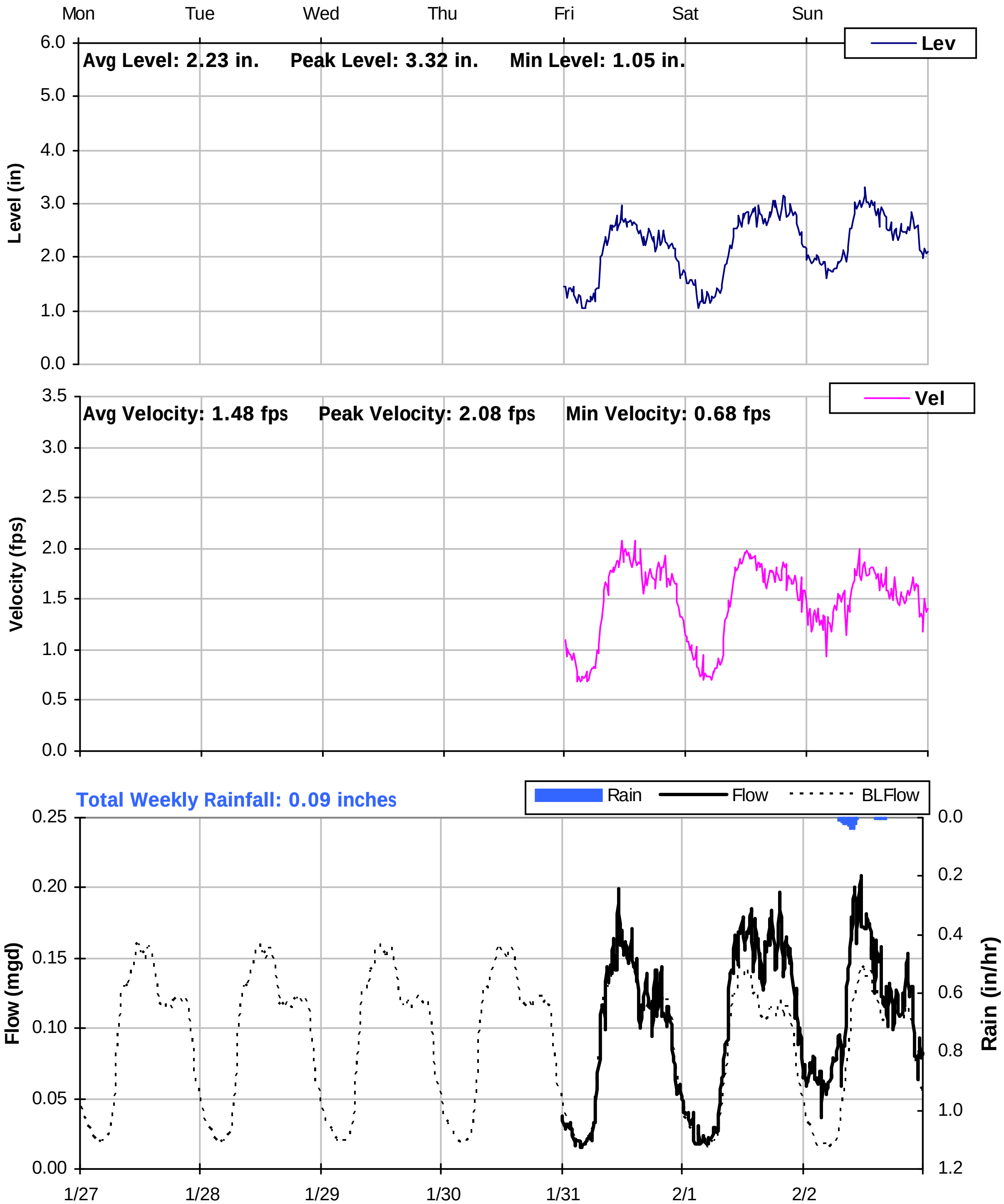
Event 2 Detail Graph



Storm Event I/I Analysis (Rain = 0.96 inches)

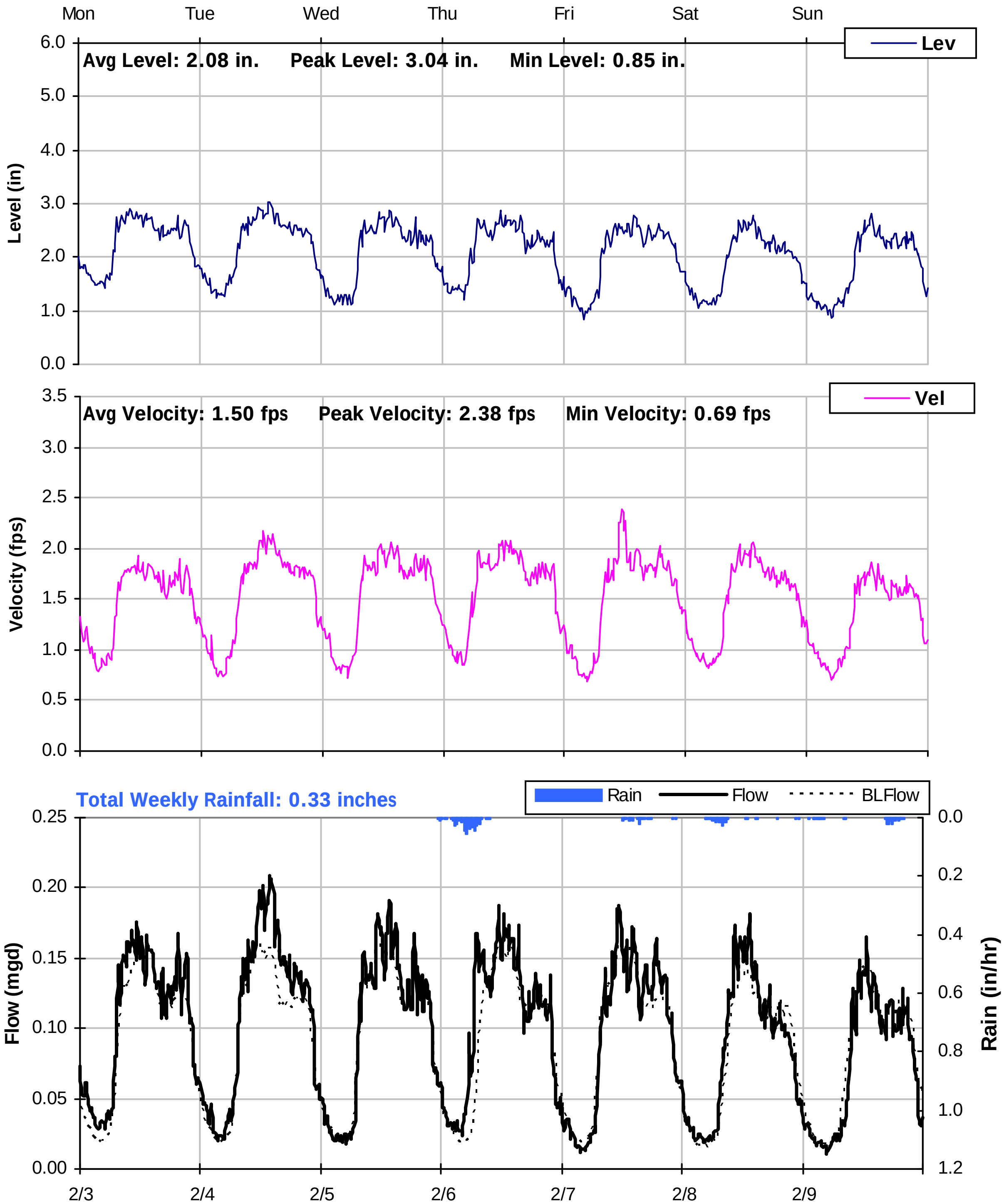
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.22 *mgd*	**Peak I/I Rate:**	0.08 *mgd*
PF:	2.51	**Total I/I:**	45,000 *gallons*

SITE 12
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014



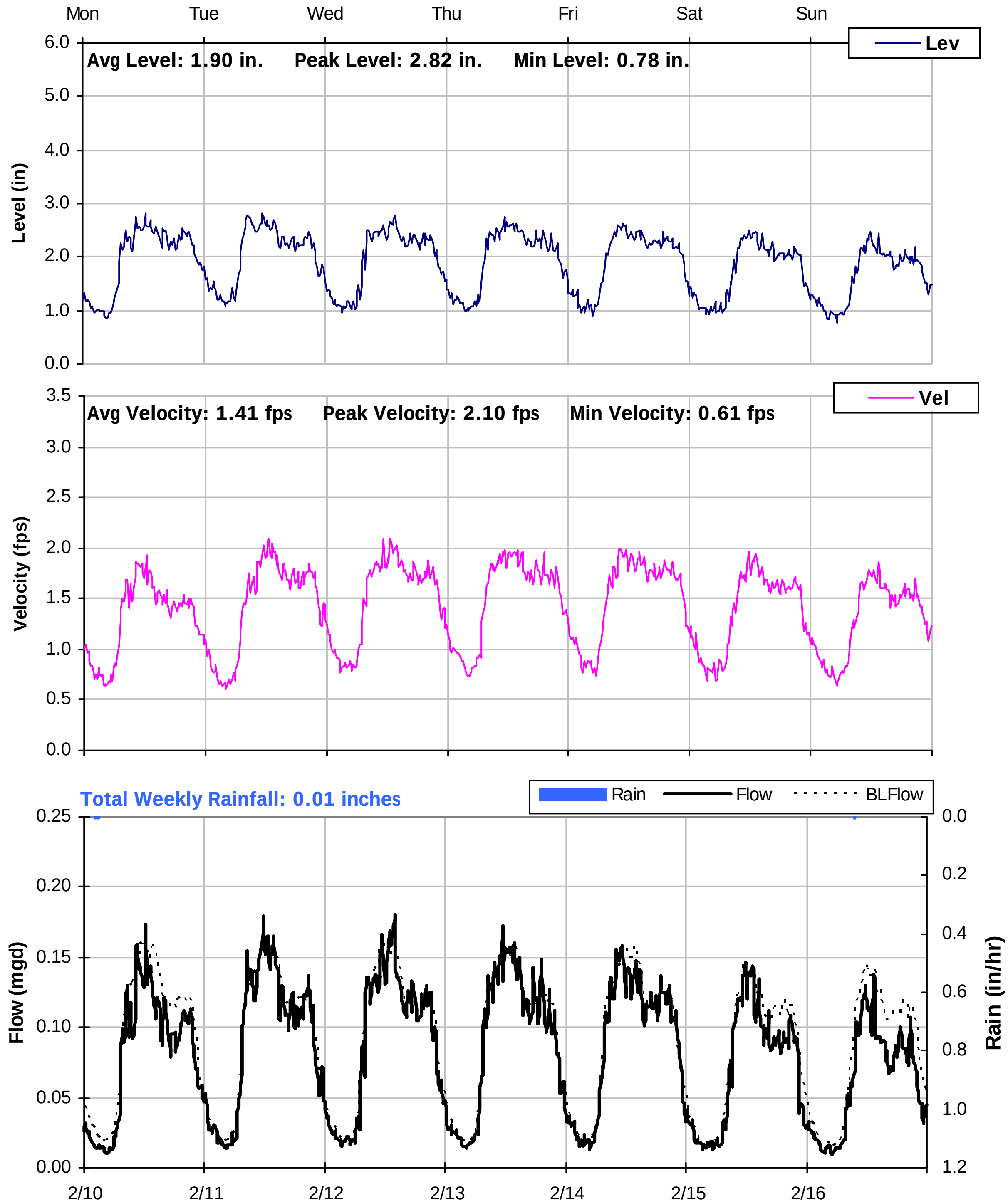
Avg Flow: 0.105 mgd Peak Flow: 0.207 mgd Min Flow: 0.016 mgd

SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



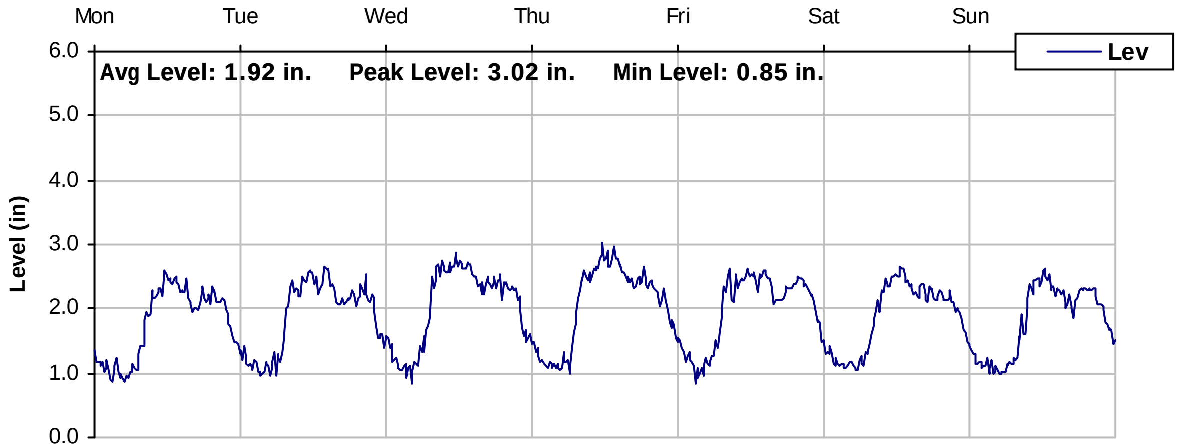
Avg Flow: 0.097 mgd Peak Flow: 0.209 mgd Min Flow: 0.011 mgd

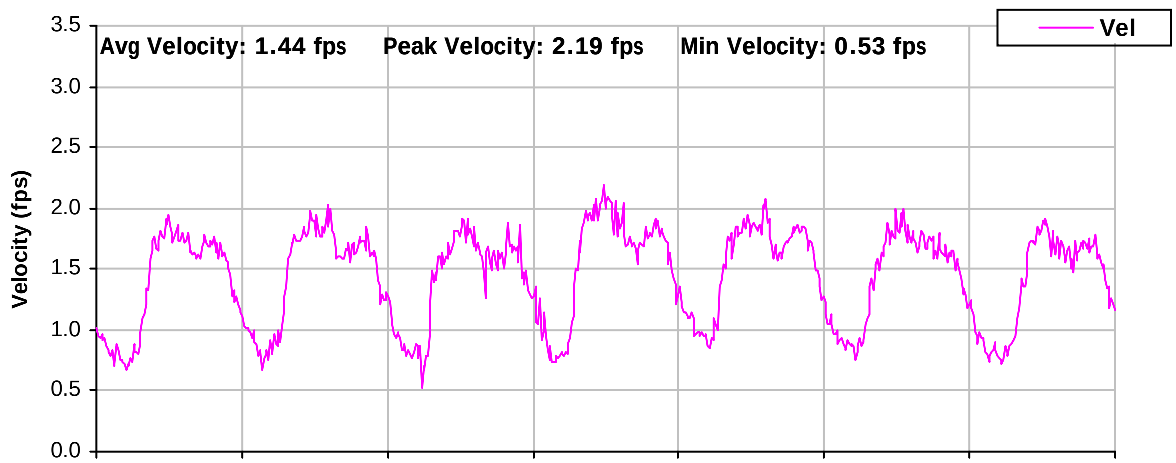
SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

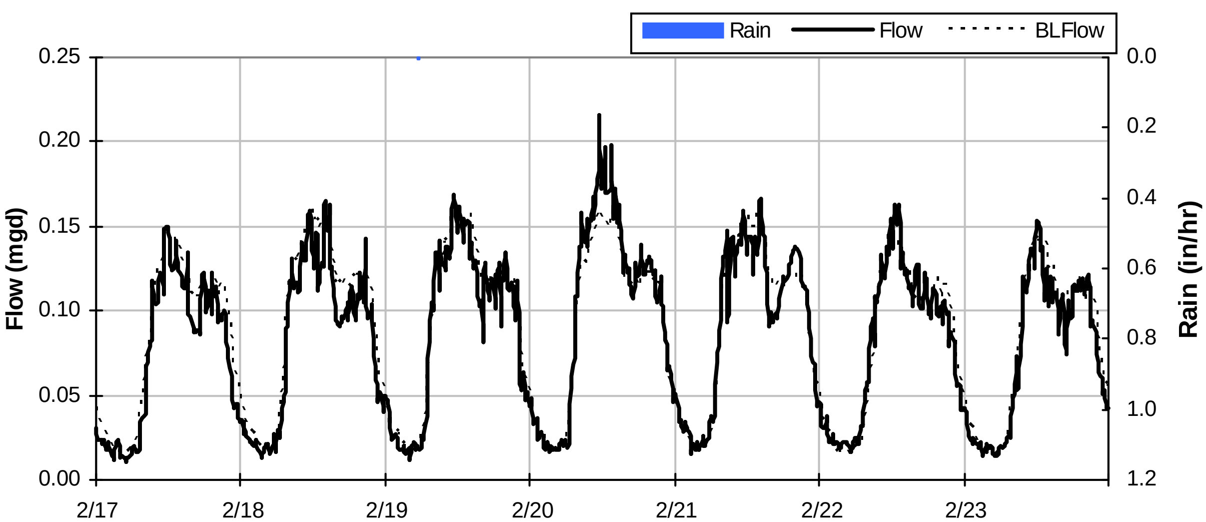


Avg Flow: 0.082 mgd **Peak Flow: 0.179 mgd** **Min Flow: 0.009 mgd**

SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

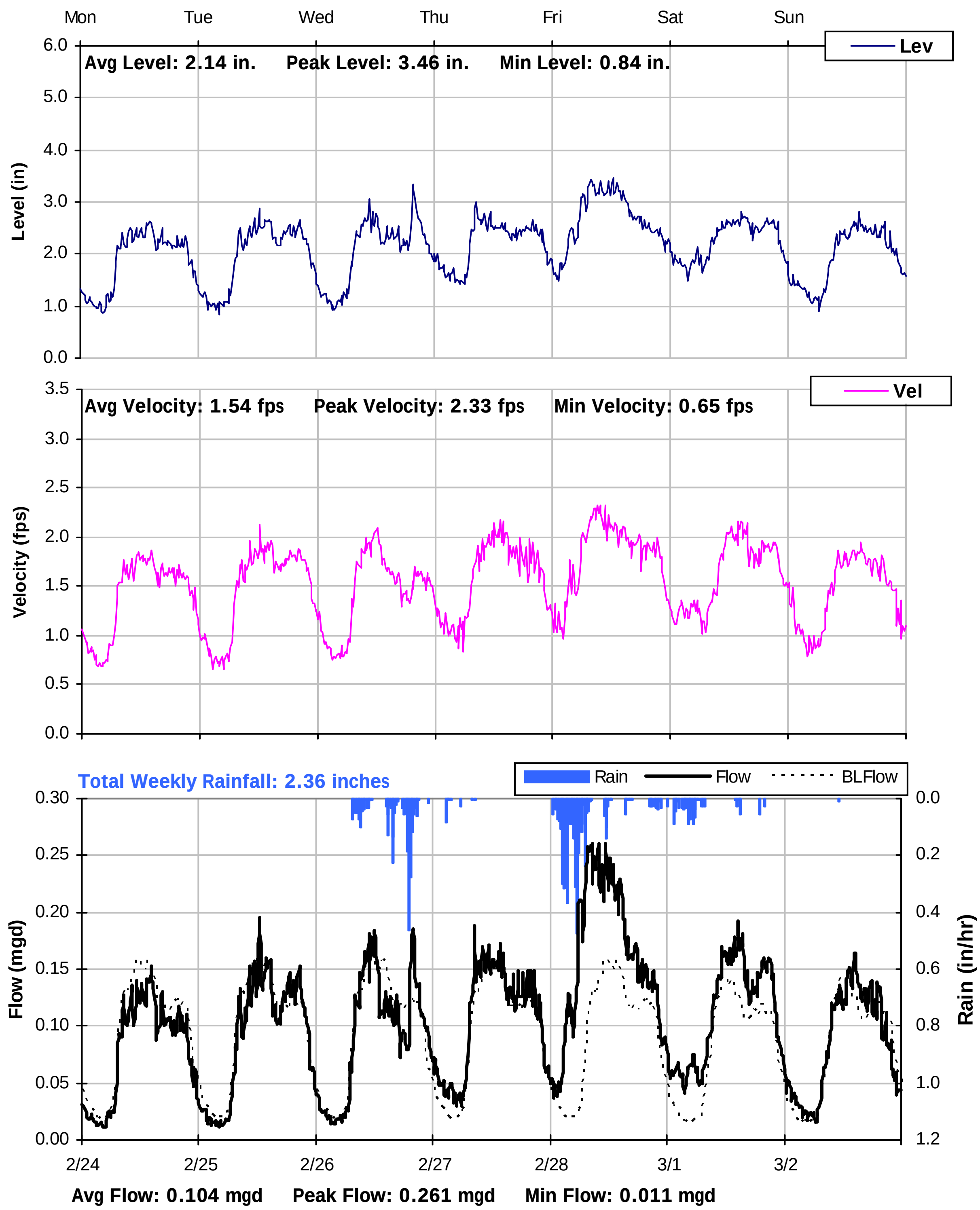




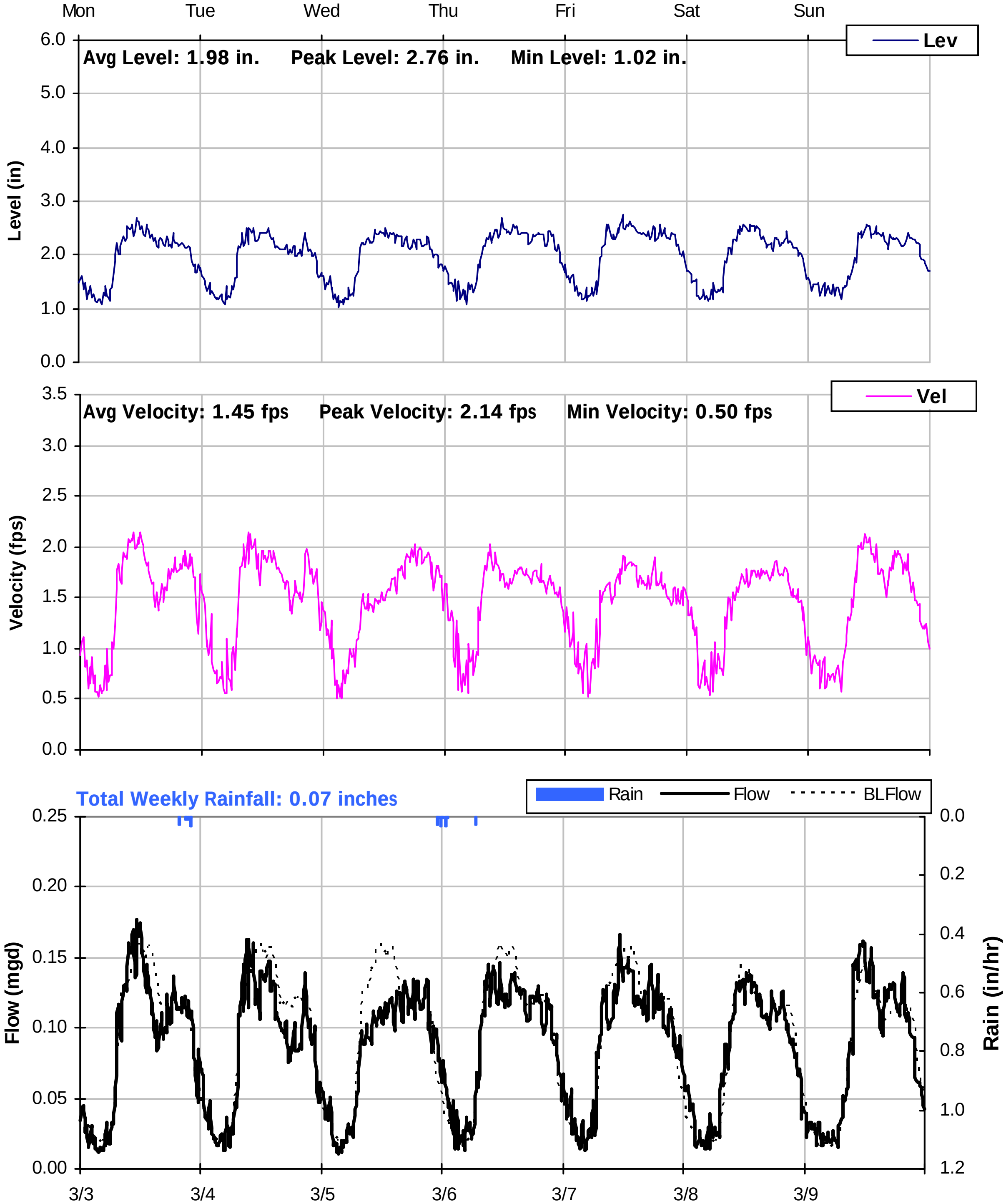


Avg Flow: 0.085 mgd **Peak Flow: 0.216 mgd** **Min Flow: 0.011 mgd**

SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014

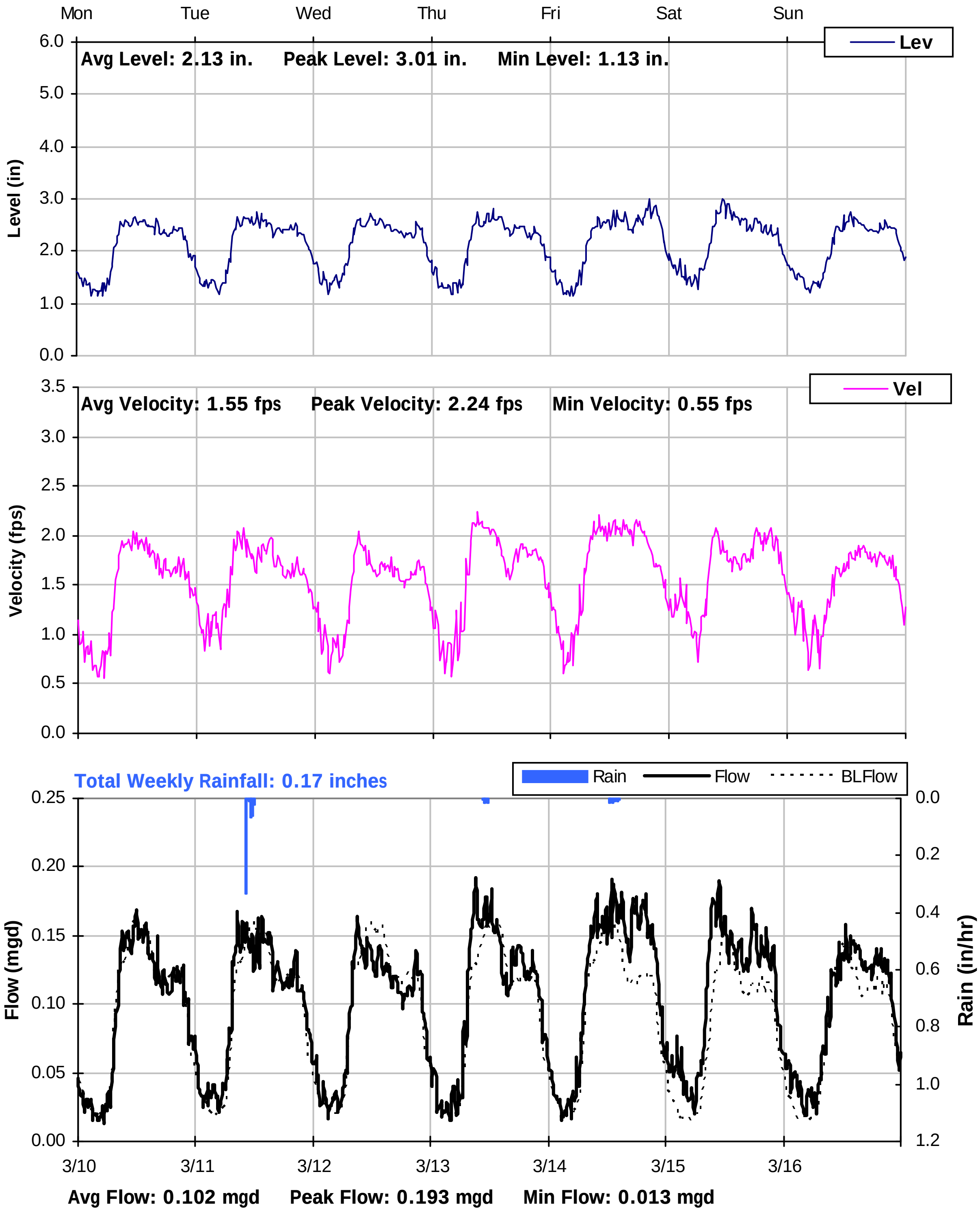


SITE 12
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

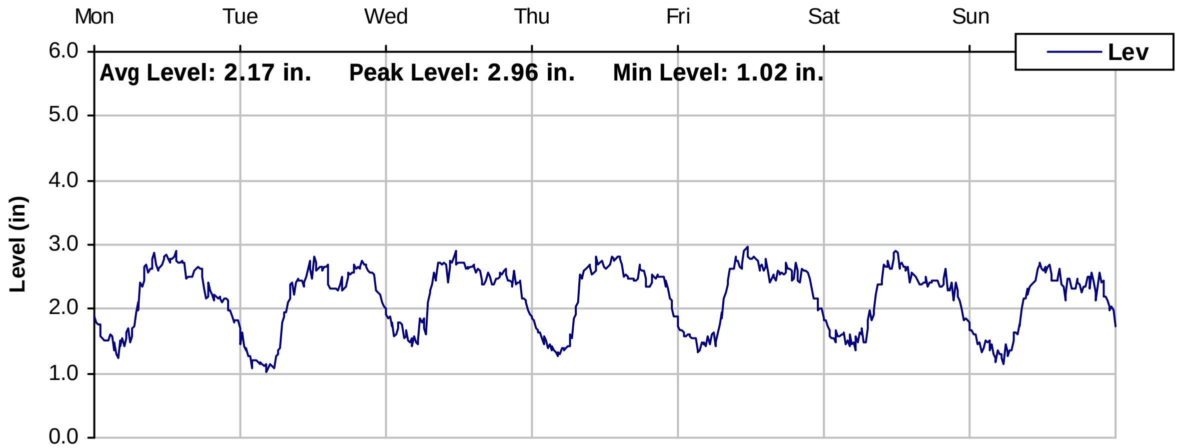


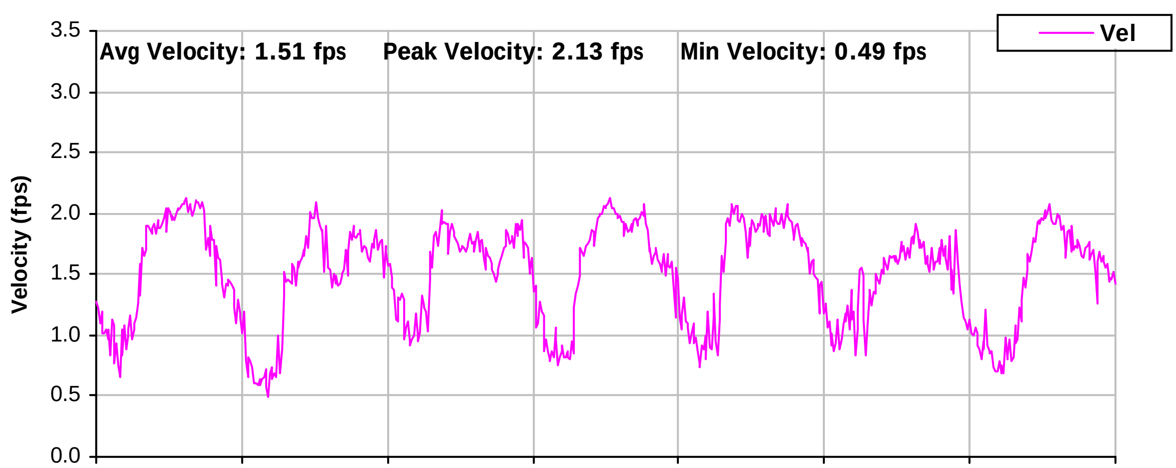
Avg Flow: 0.087 mgd **Peak Flow: 0.177 mgd** **Min Flow: 0.011 mgd**

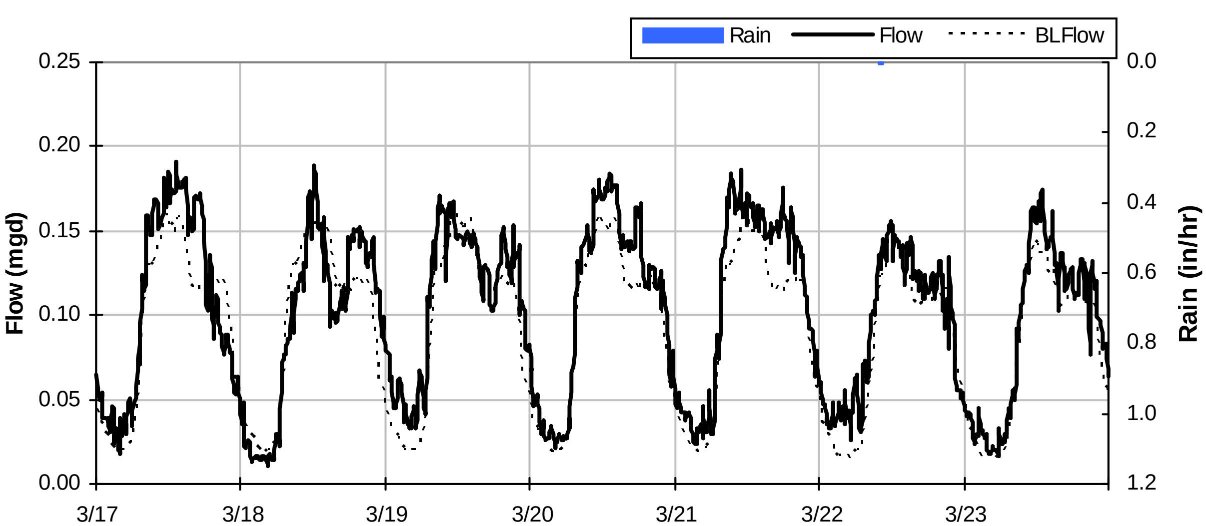
SITE 12
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



SITE 12
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014

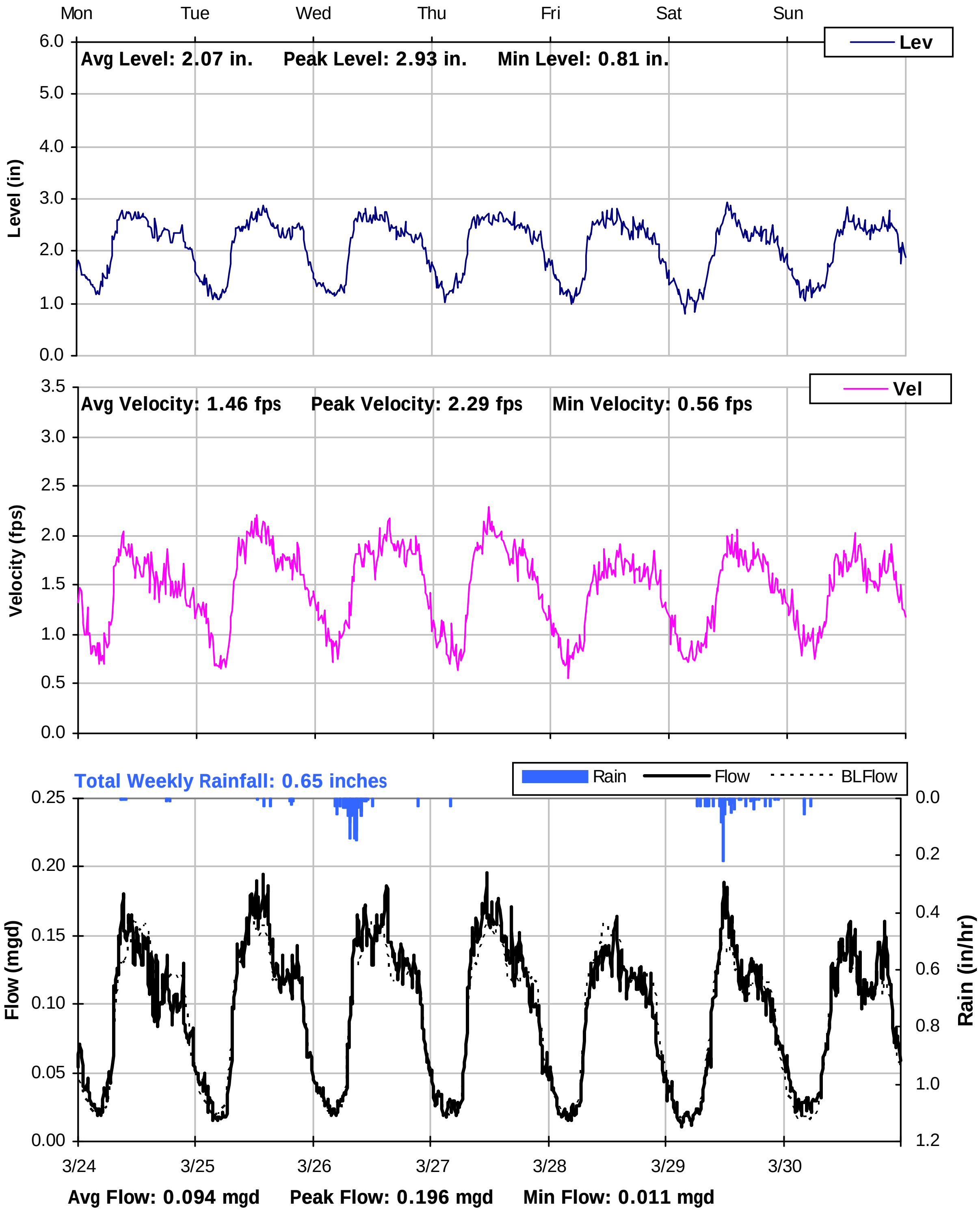




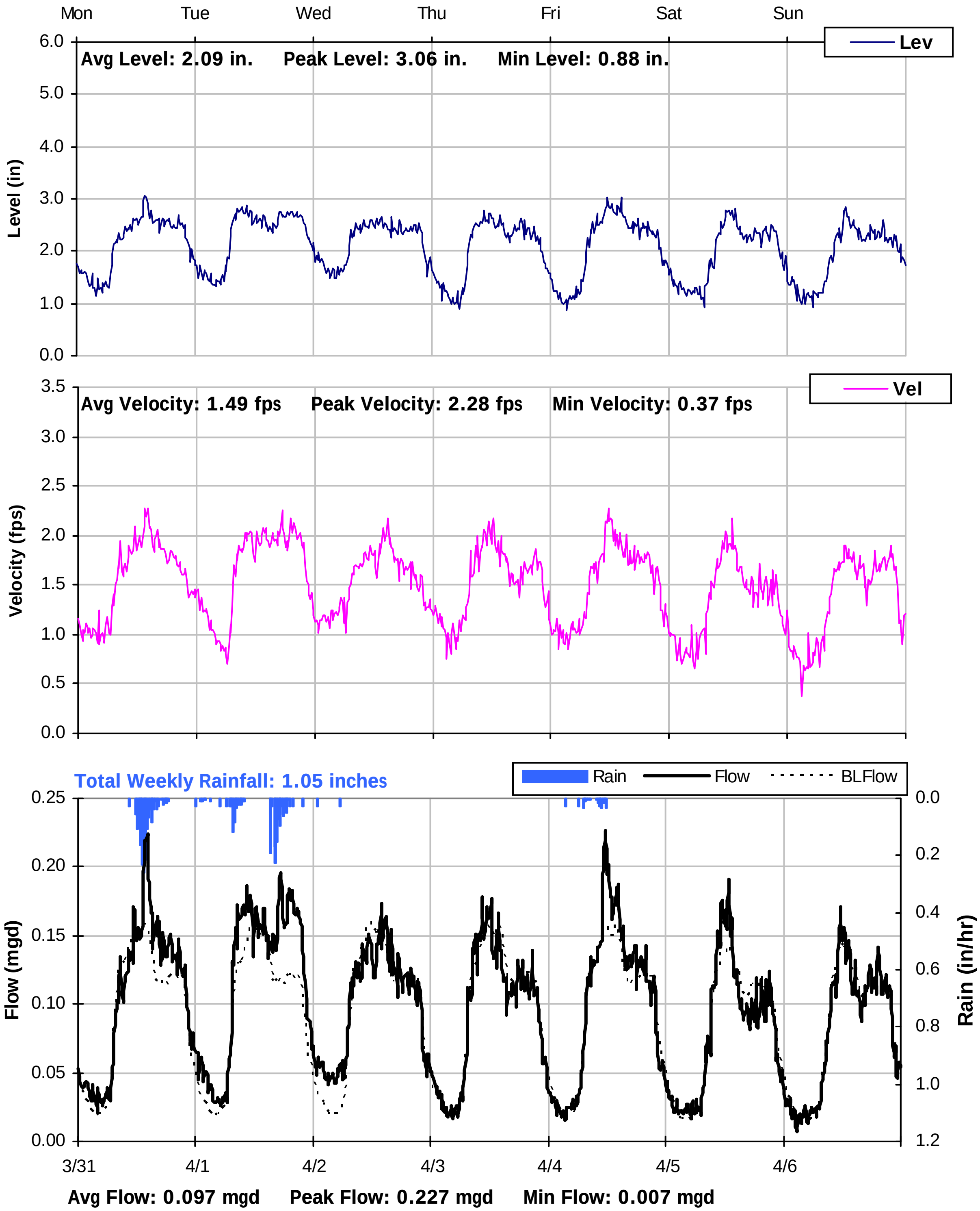


Avg Flow: 0.102 mgd Peak Flow: 0.191 mgd Min Flow: 0.010 mgd

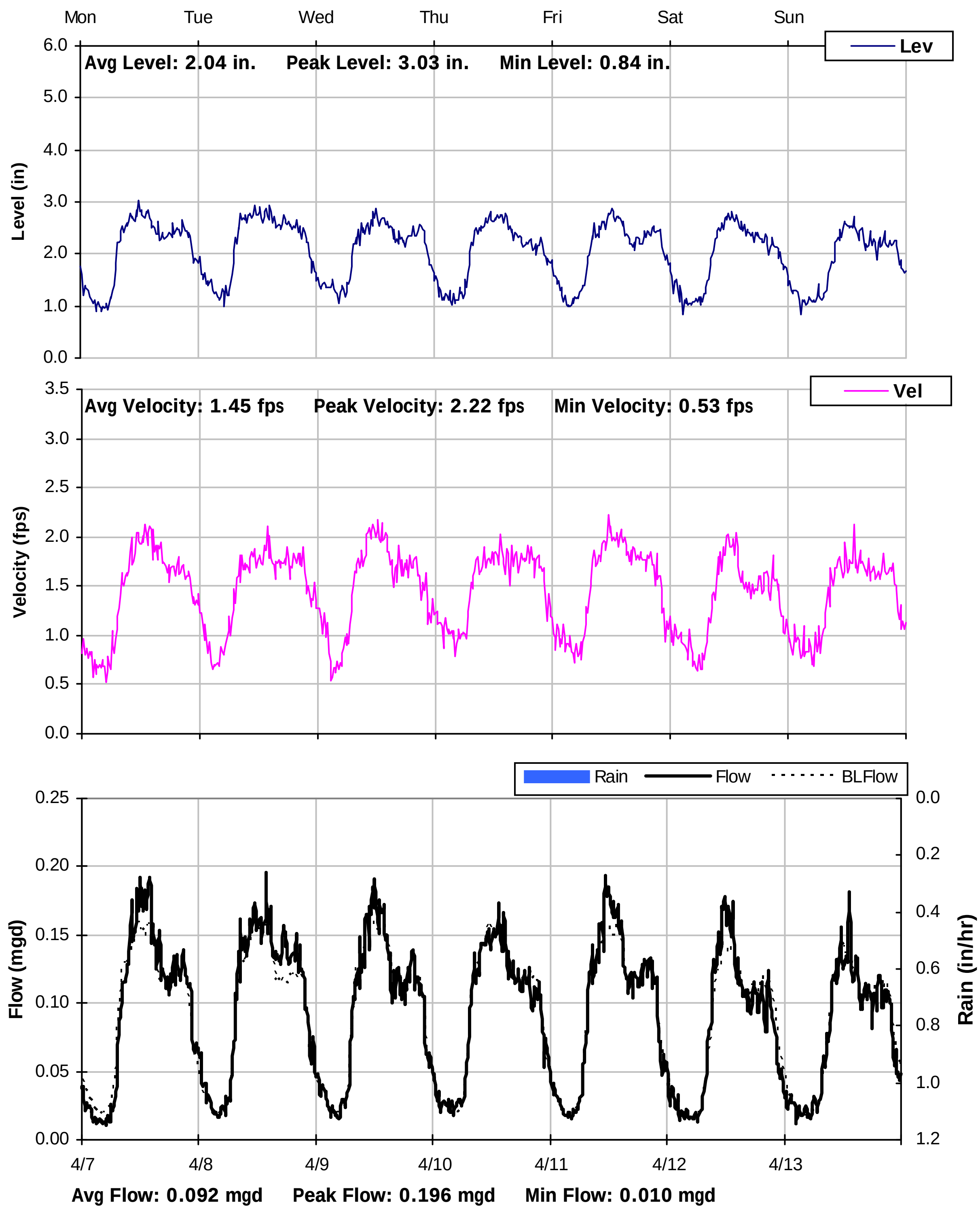
SITE 12
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



SITE 12
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 12
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 13

Location: Atherton Avenue, north of Alameda De Las Pulgas

Data Summary Report

SITE 13

Site Information

Location: Atherton Avenue, north of Alameda De Las Pulgas

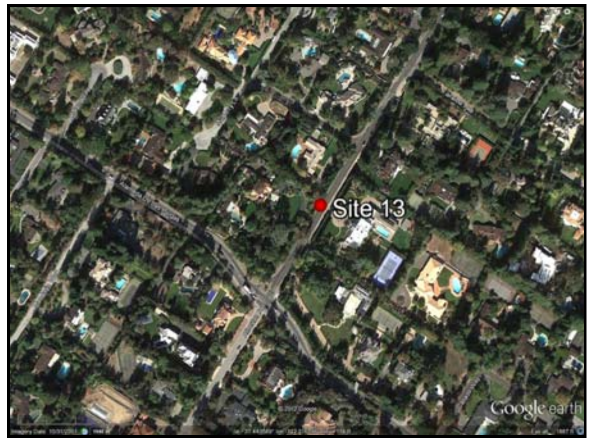
Coordinates: 122.2165° W, 37.4407° N

Rim Elevation: 112 feet

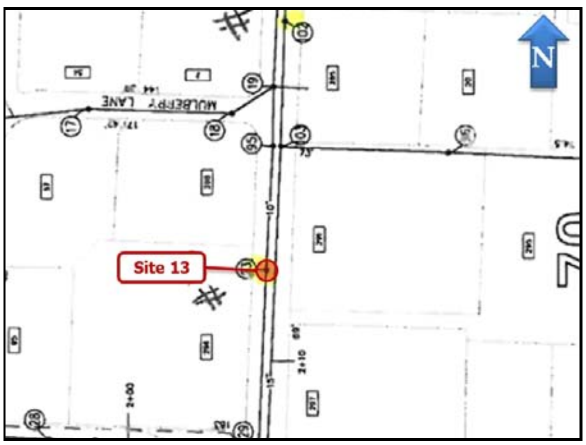
Pipe Diameter: 10 inches

Baseline Flow: 0.021 mgd

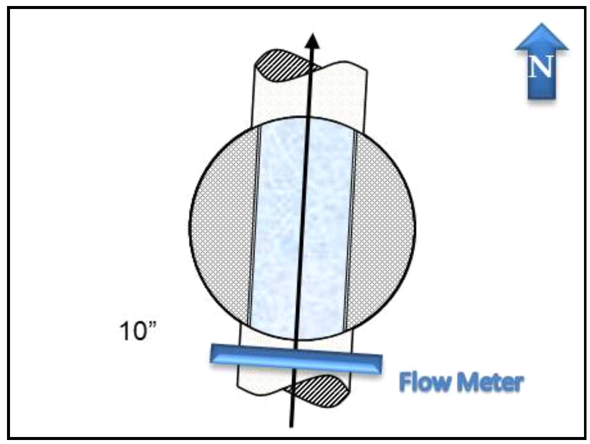
Peak Measured Flow: 0.194 mgd



Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

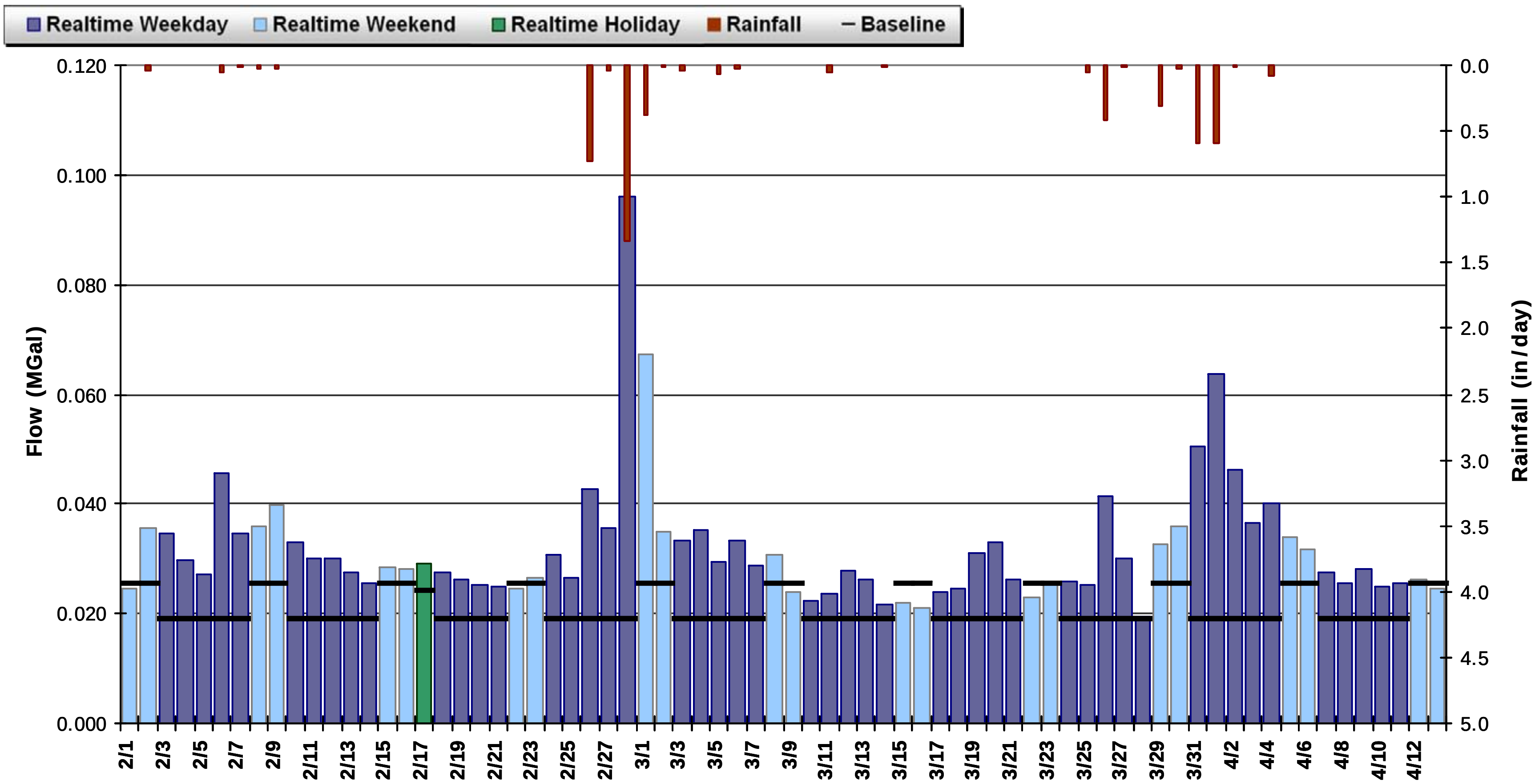
Plan View

SITE 13

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.032 MGal **Peak Daily Flow: 0.096 MGal** **Min Daily Flow: 0.019 MGal**

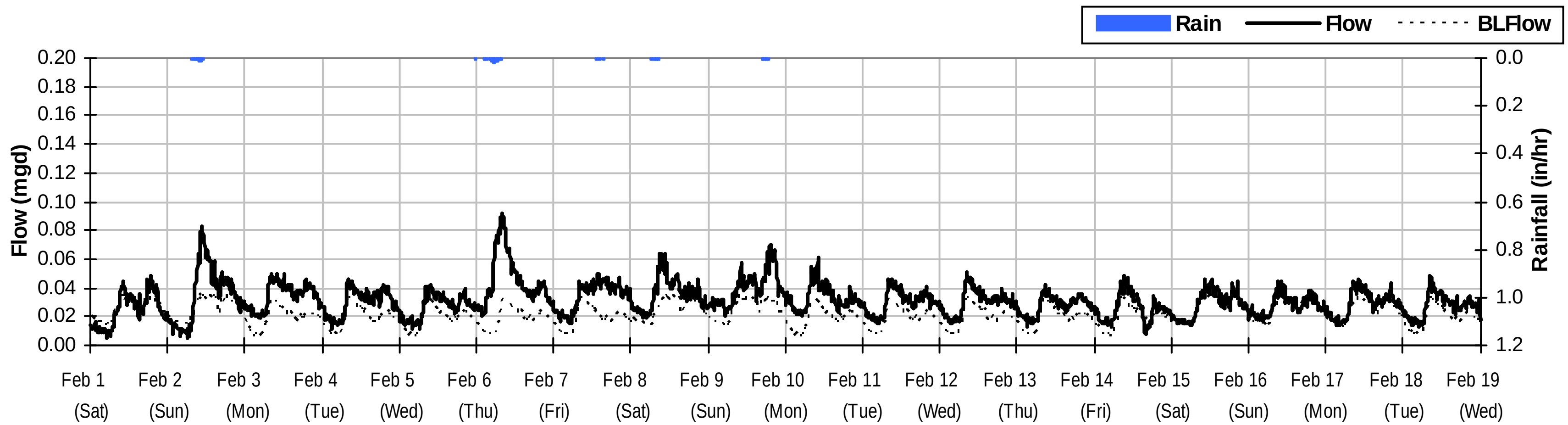
Total Period Rainfall: 4.98 inches

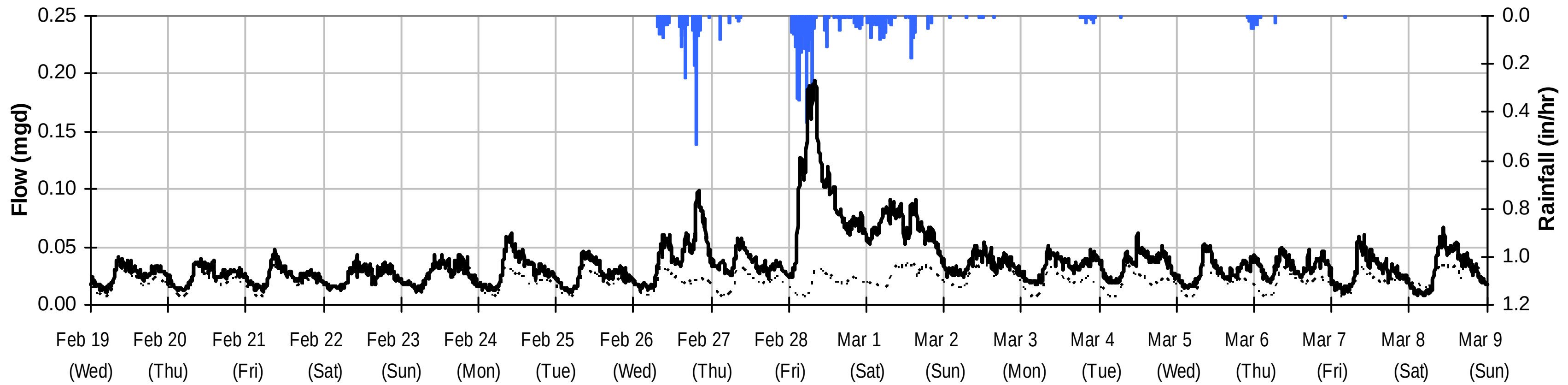


SITE 13

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.98 inches **Avg Flow: 0.032 mgd** **Peak Flow: 0.194 mgd** **Min Flow: 0.001 mgd**

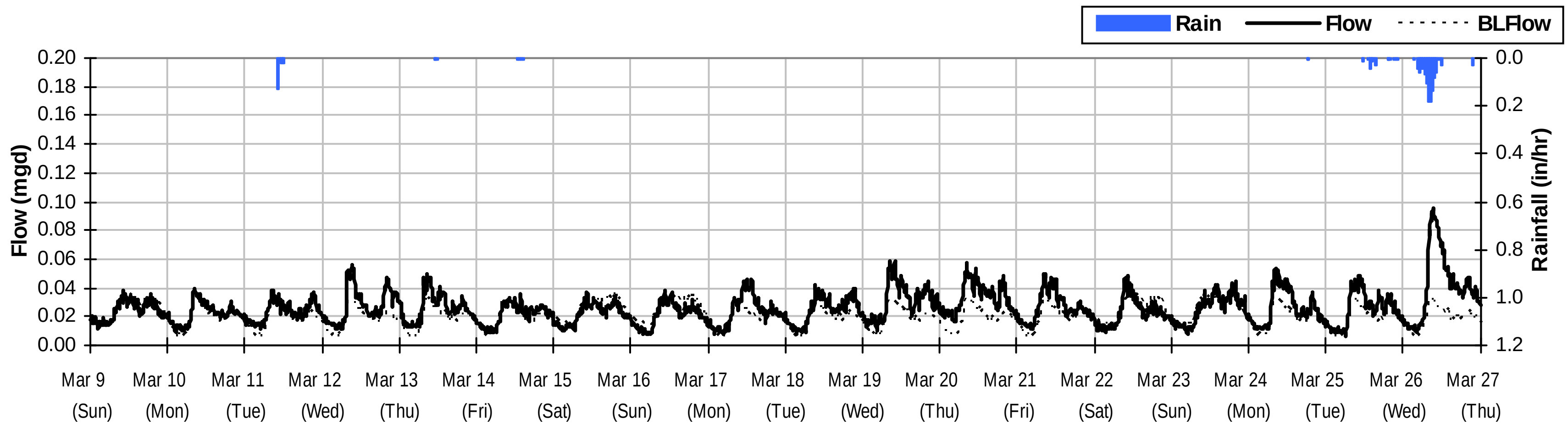


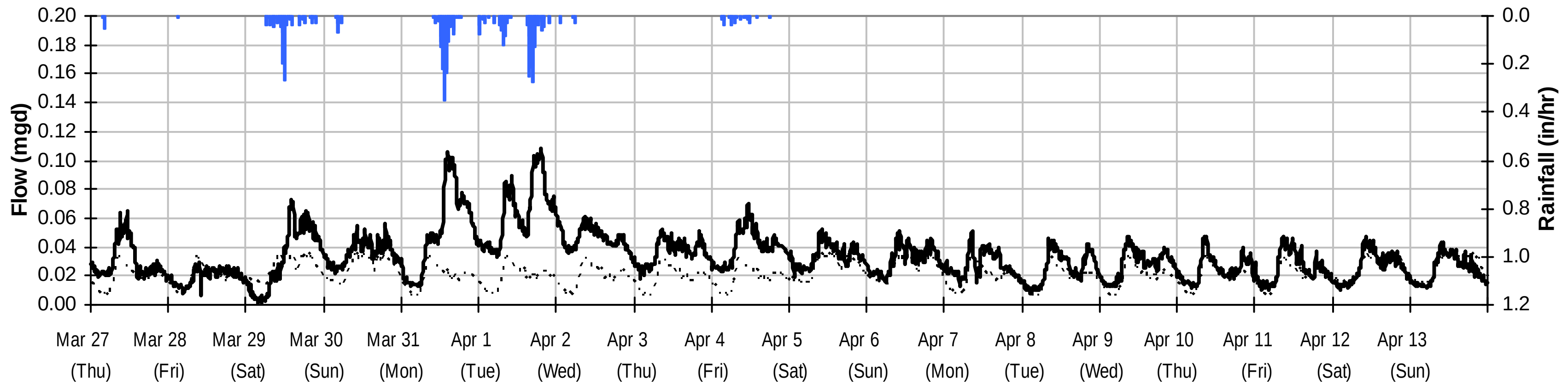


SITE 13

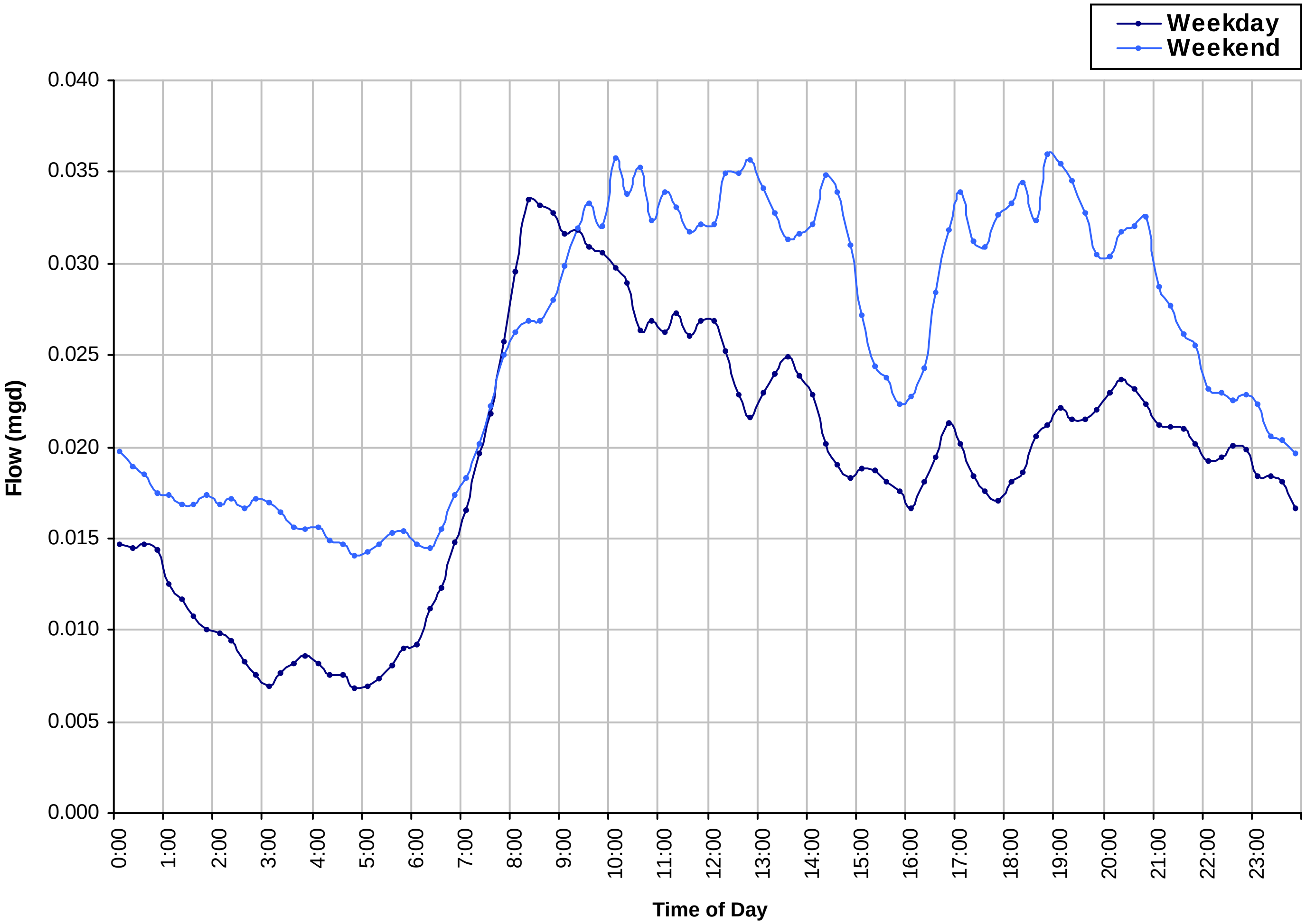
Period Flow Summary: March 9 to April 14, 2014

Total Monthly Rainfall: 4.98 inches **Avg Flow: 0.032 mgd** **Peak Flow: 0.194 mgd** **Min Flow: 0.001 mgd**

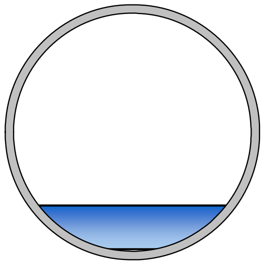




SITE 13
Baseline Flow Hydrographs

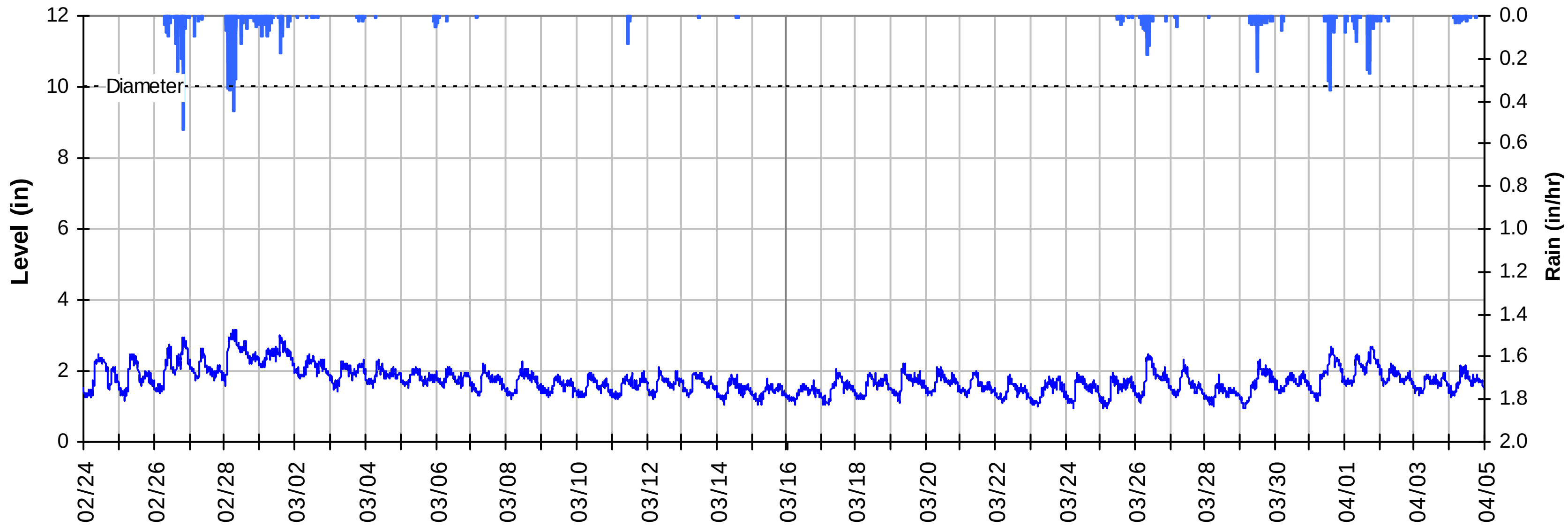


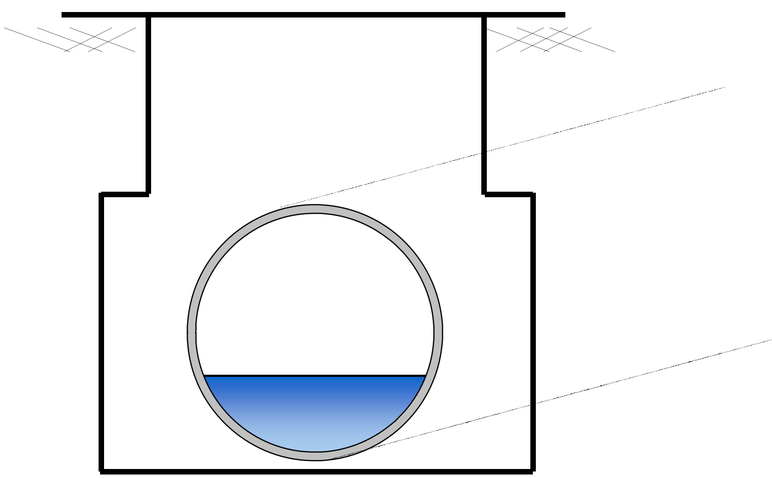
Baseline Flow:
0.021 *mgd*



SITE 13
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





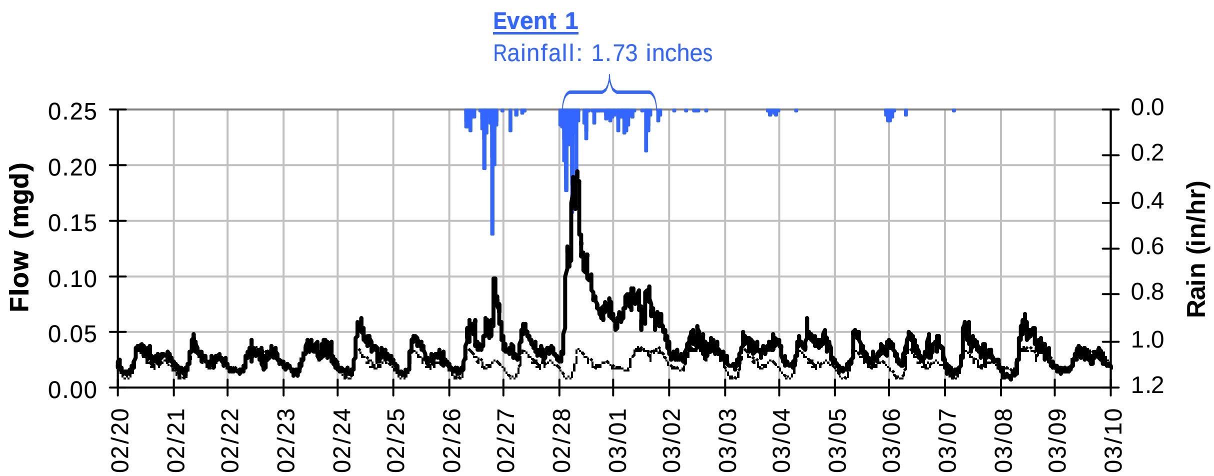
Pipe Diameter: 10 *inches*

Peak Measured Level: 3.18 *inches*

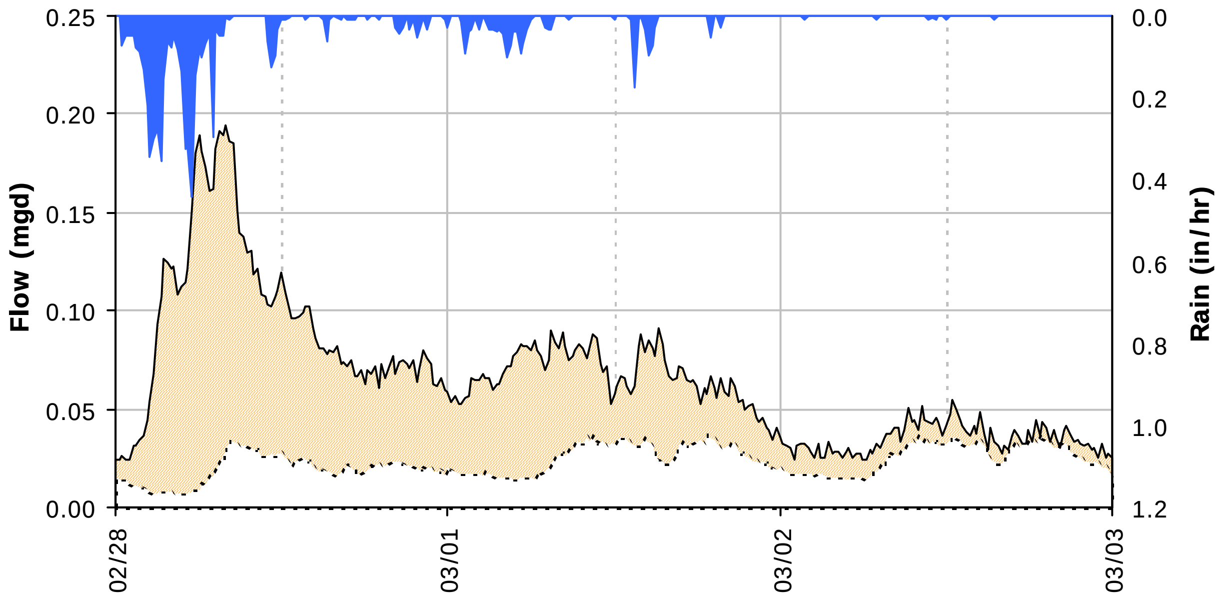
Peak d/D Ratio: 0.32

SITE 13
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

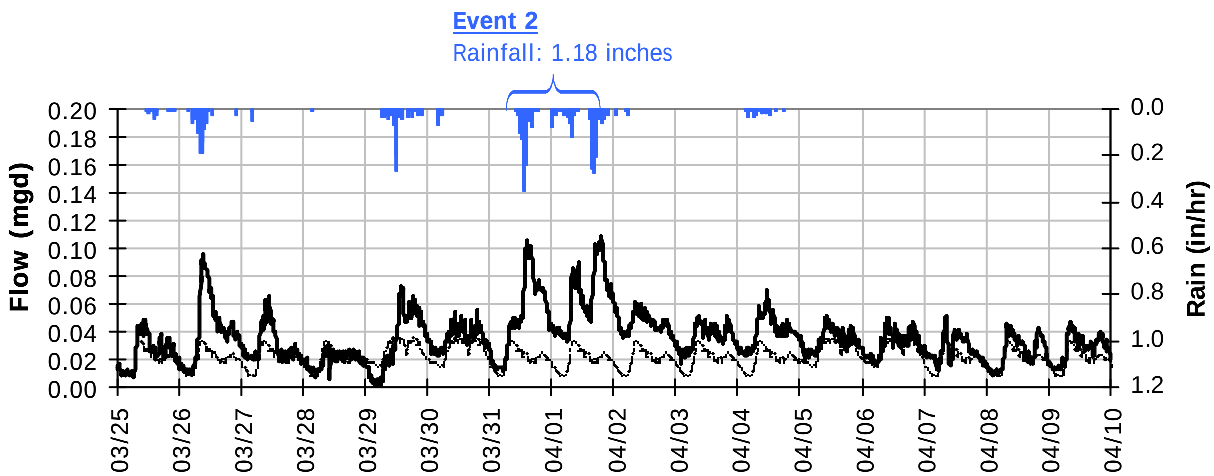


Storm Event I/I Analysis (Rain = 1.73 inches)

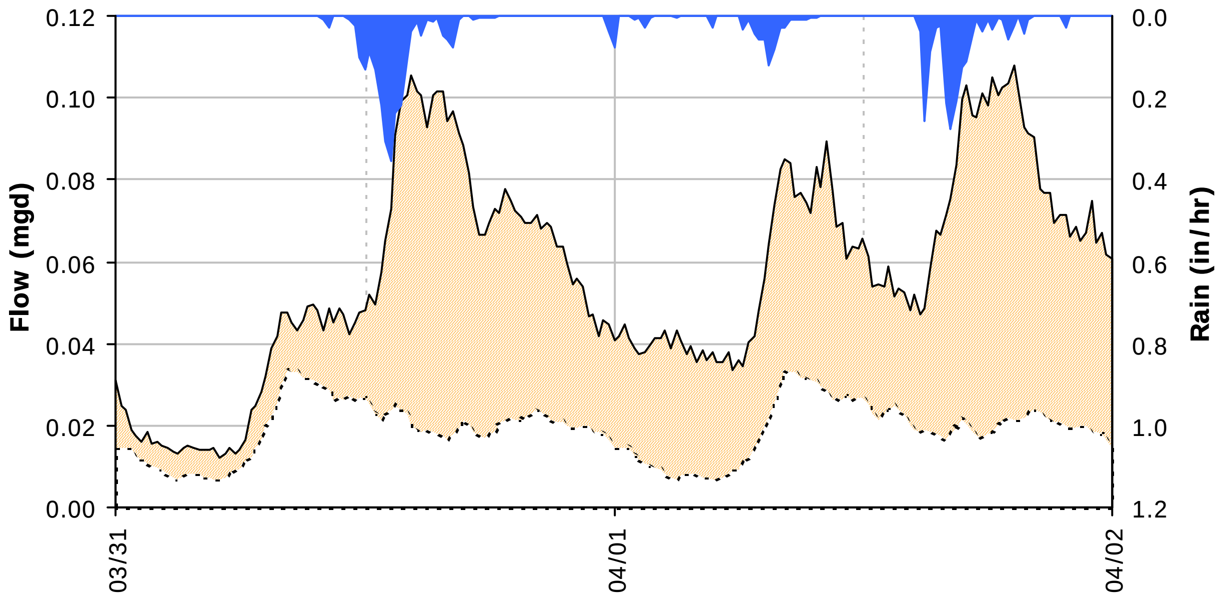
Capacity		Inflow / Infiltration	
Peak Flow:	0.19 *mgd*	**Peak I/I Rate:**	0.17 *mgd*
PF:	9.31	**Total I/I:**	128,000 *gallons*

SITE 13
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



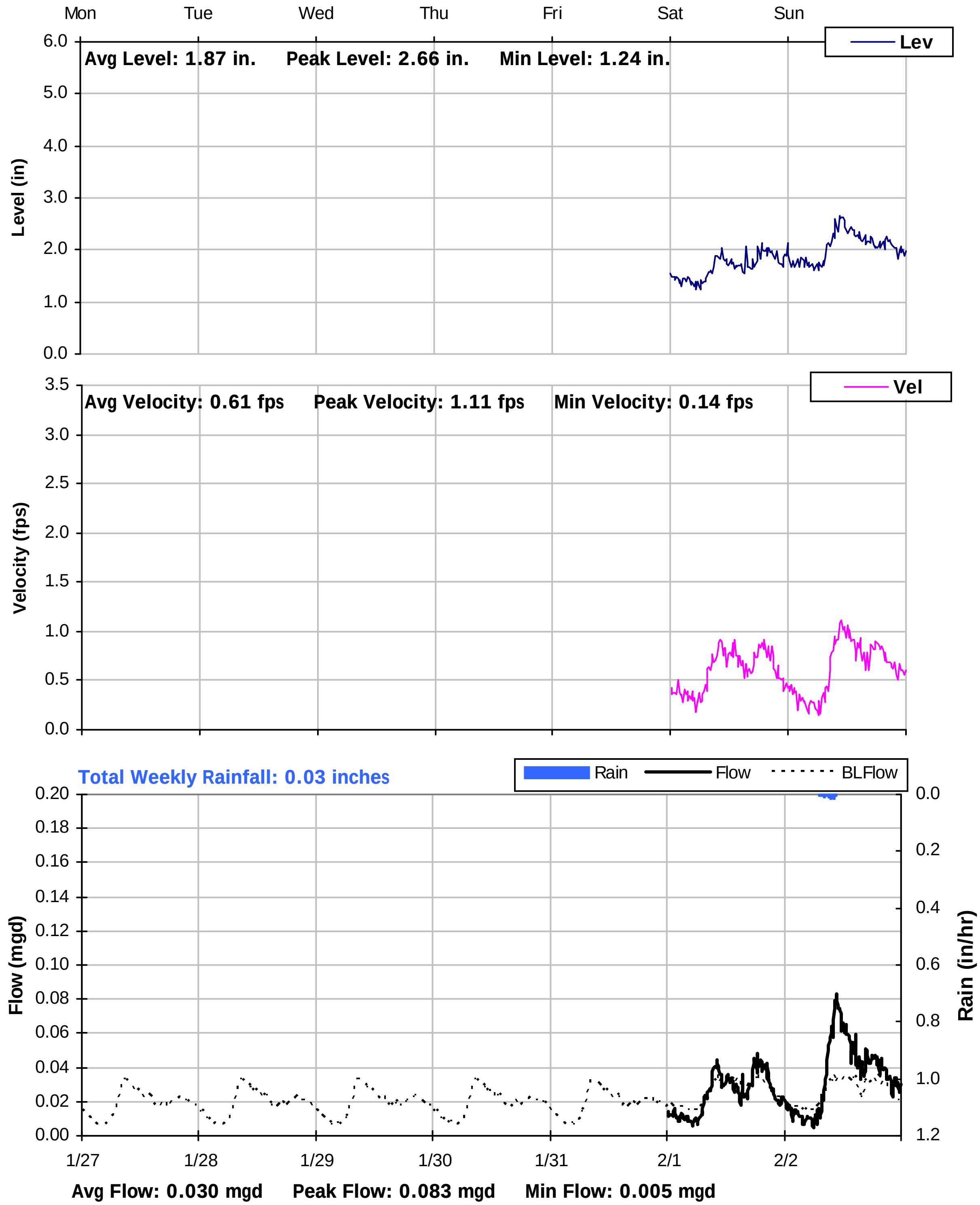
Event 2 Detail Graph



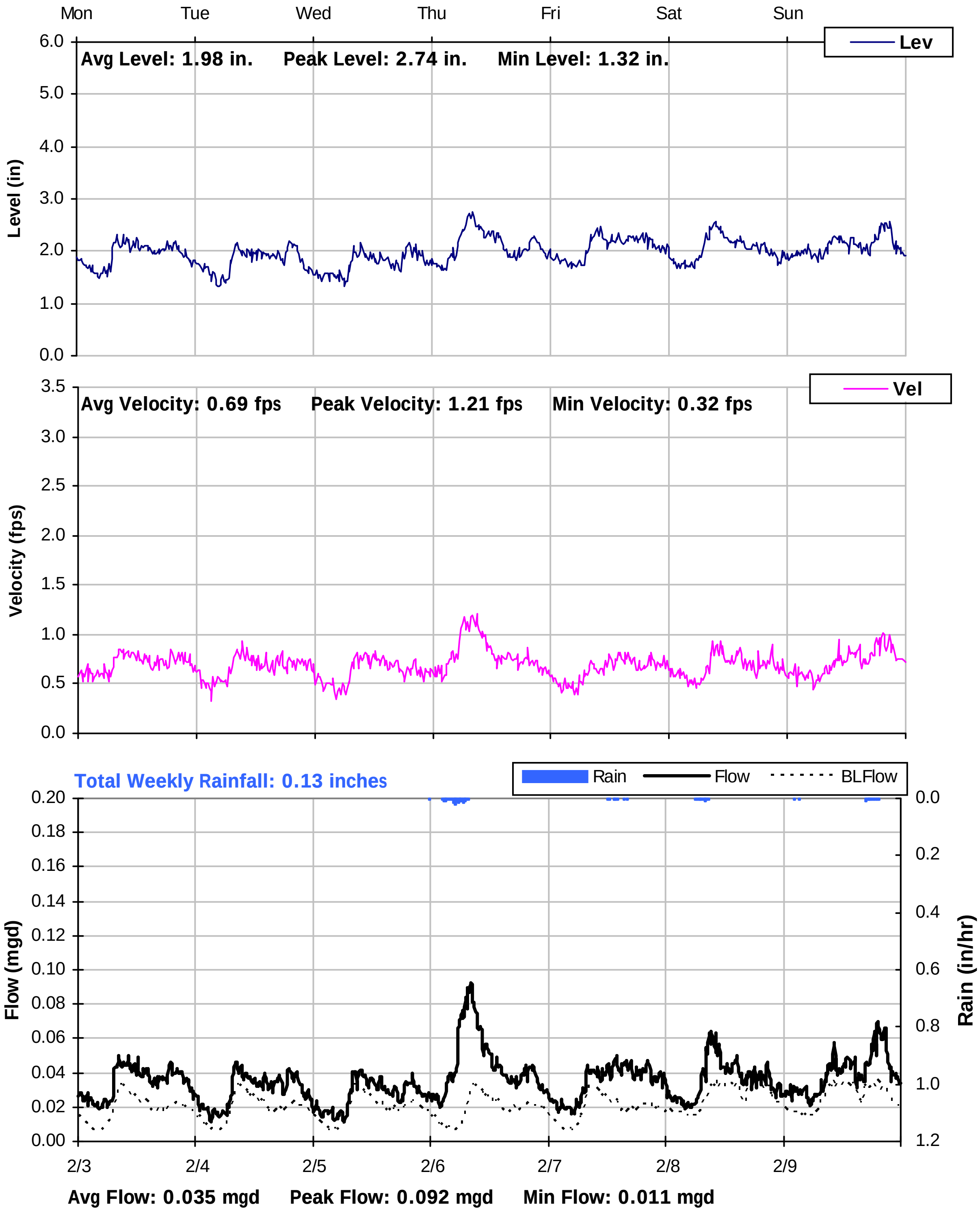
Storm Event I/I Analysis (Rain = 1.18 inches)

Capacity		Inflow / Infiltration	
Peak Flow:	0.11 *mgd*	**Peak I/I Rate:**	0.09 *mgd*
PF:	5.18	**Total I/I:**	112,000 *gallons*

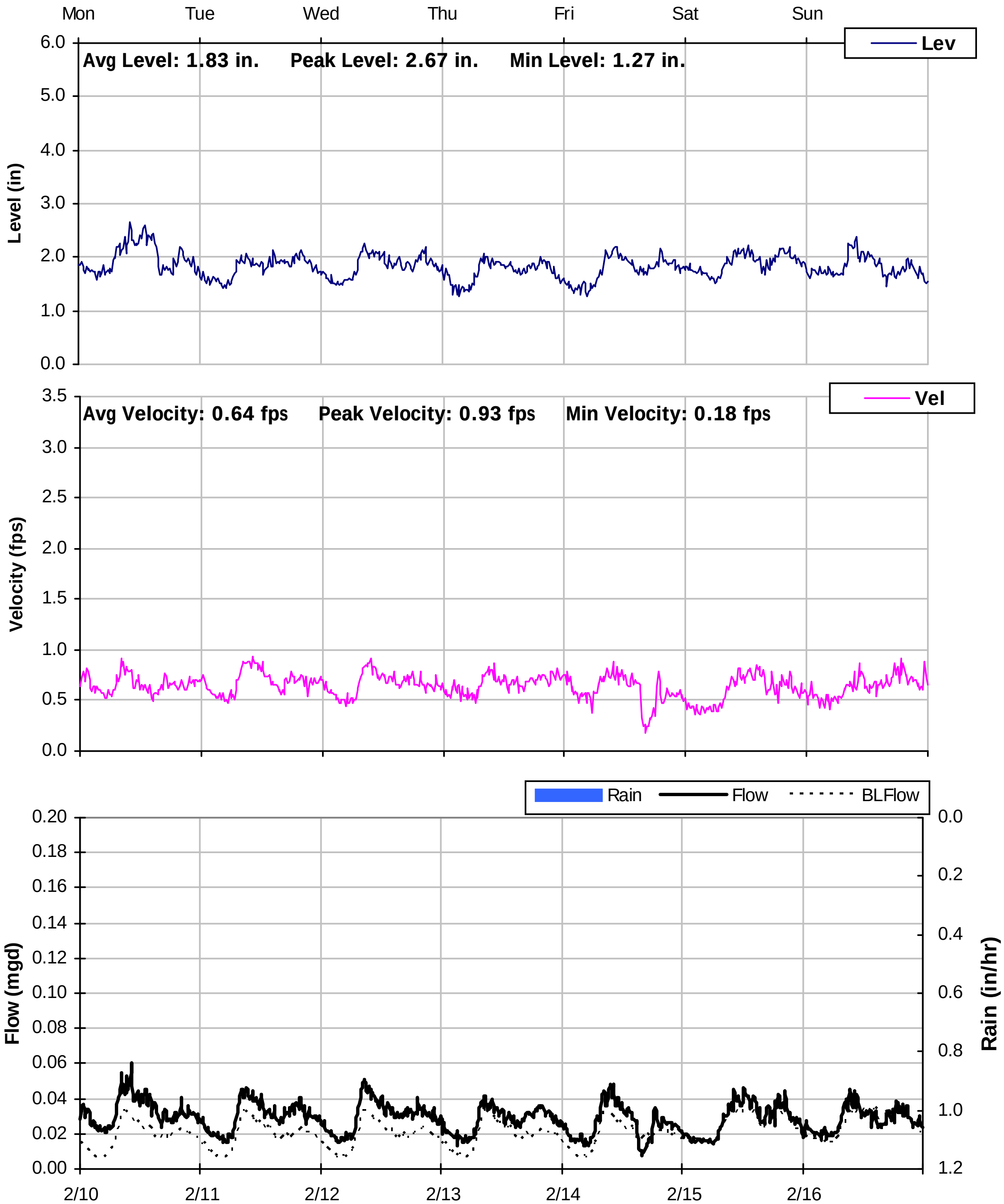
SITE 13
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014



SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

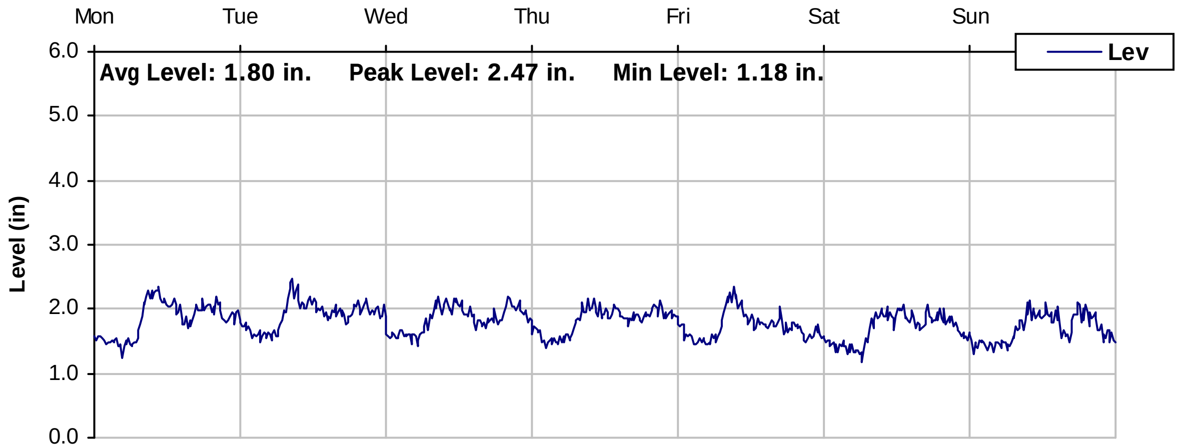


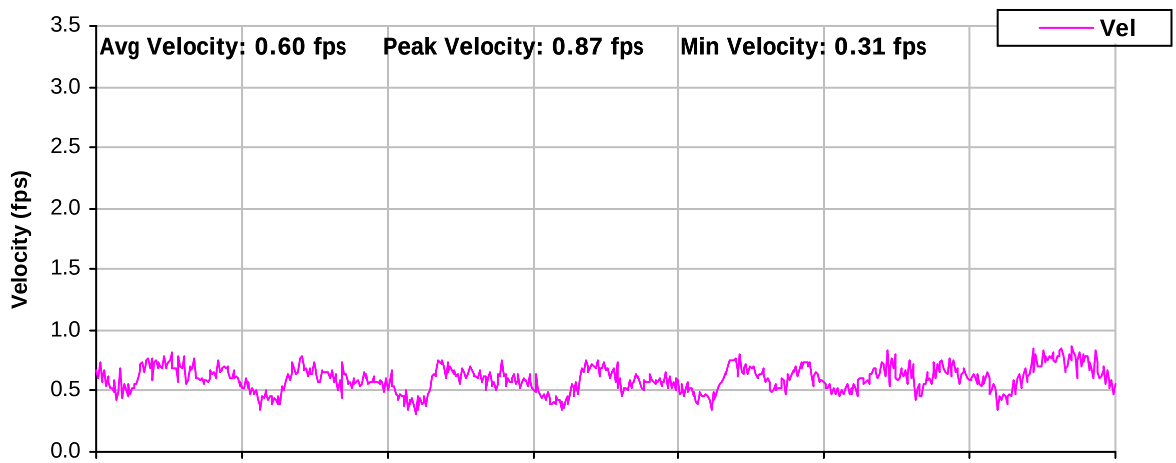
SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

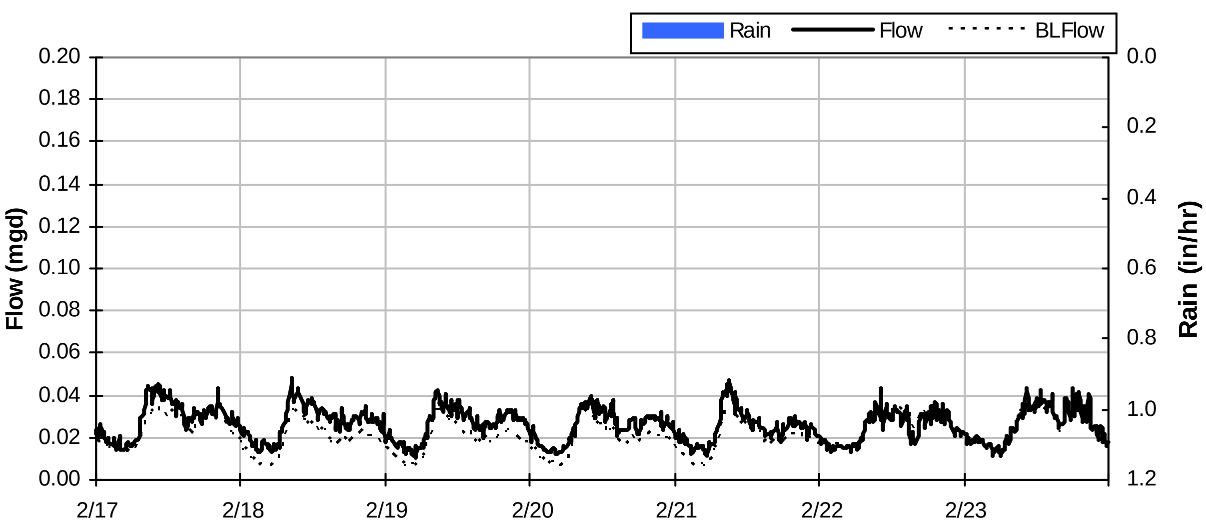


Avg Flow: 0.029 mgd **Peak Flow: 0.061 mgd** **Min Flow: 0.007 mgd**

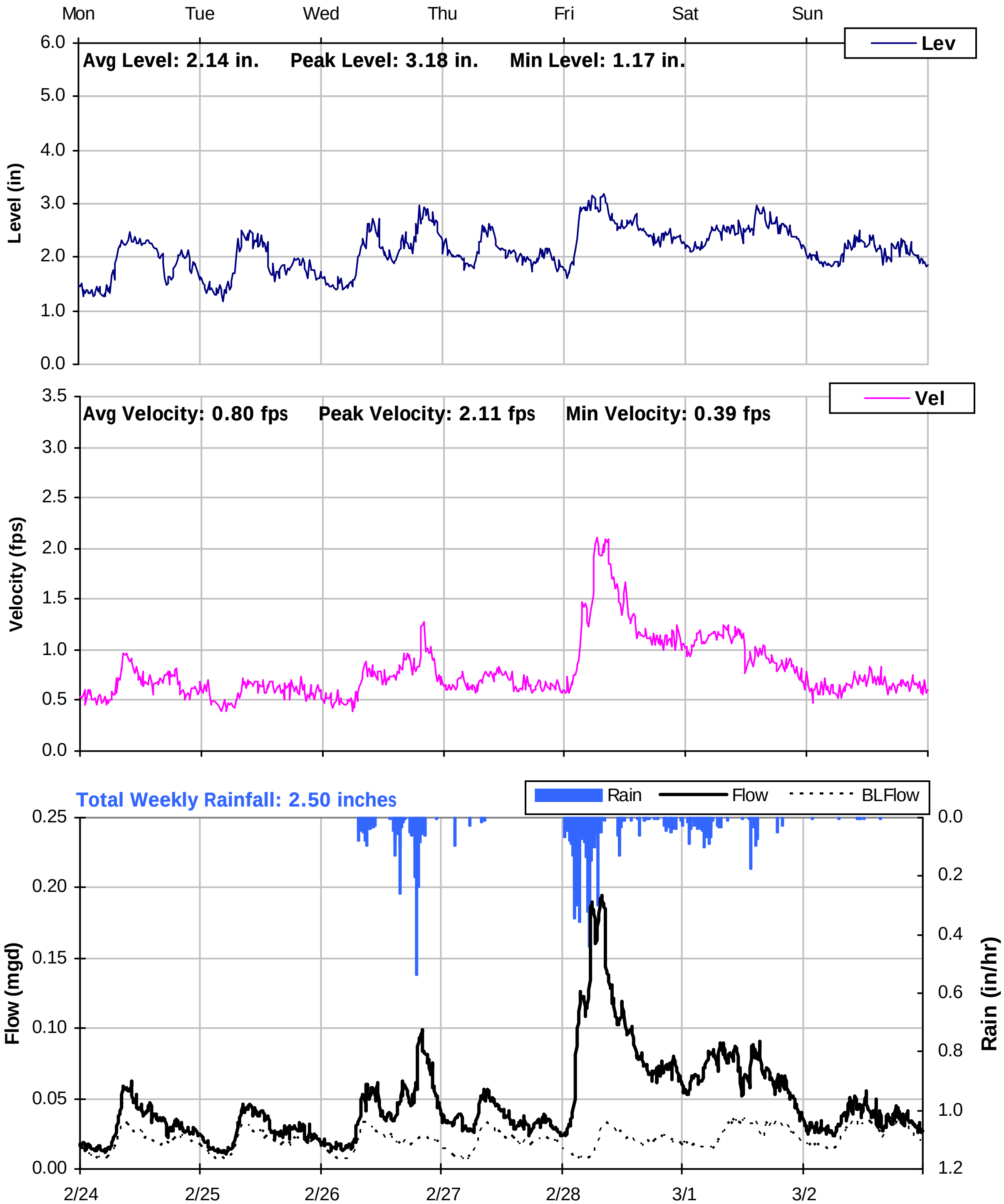
SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014





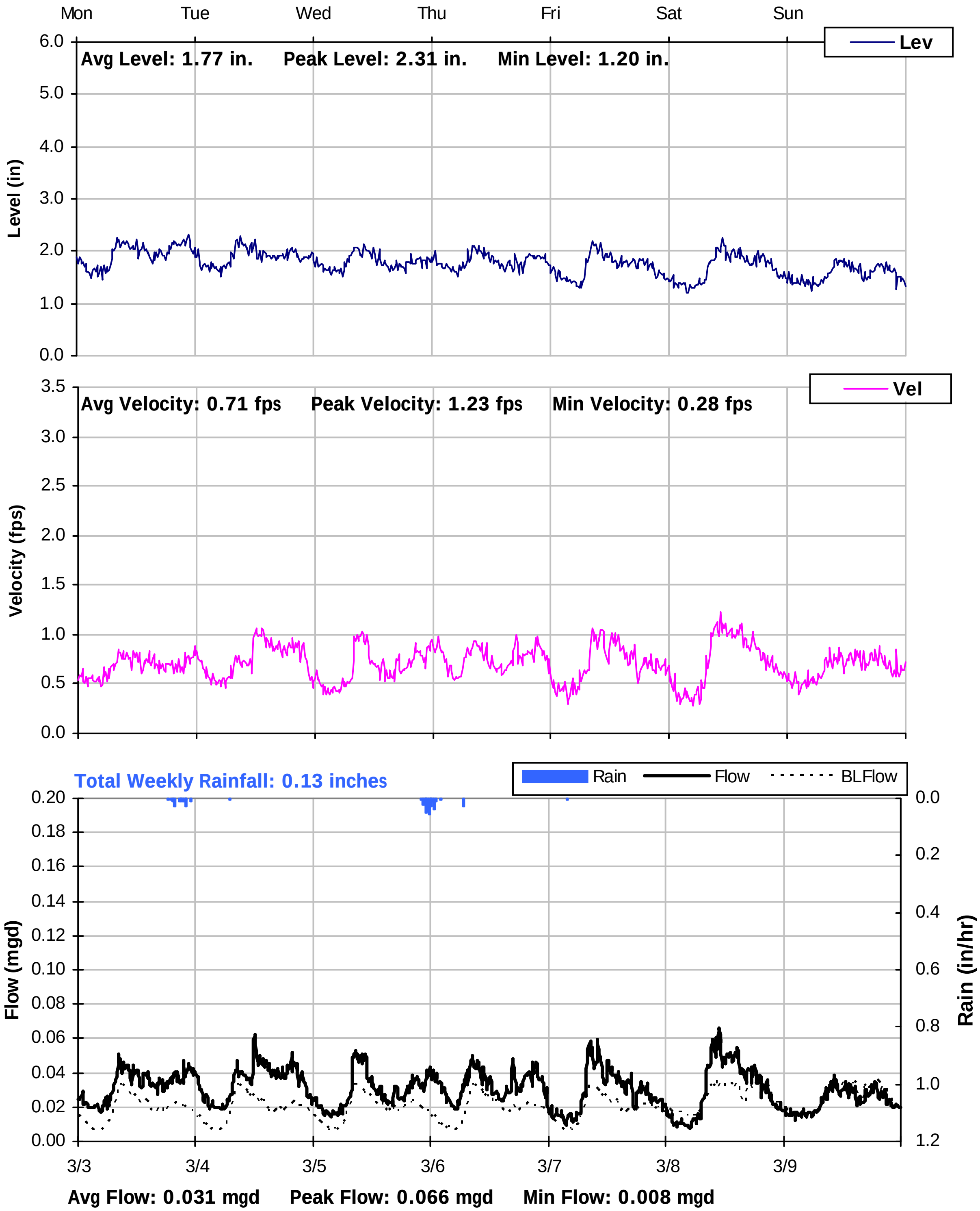


SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014

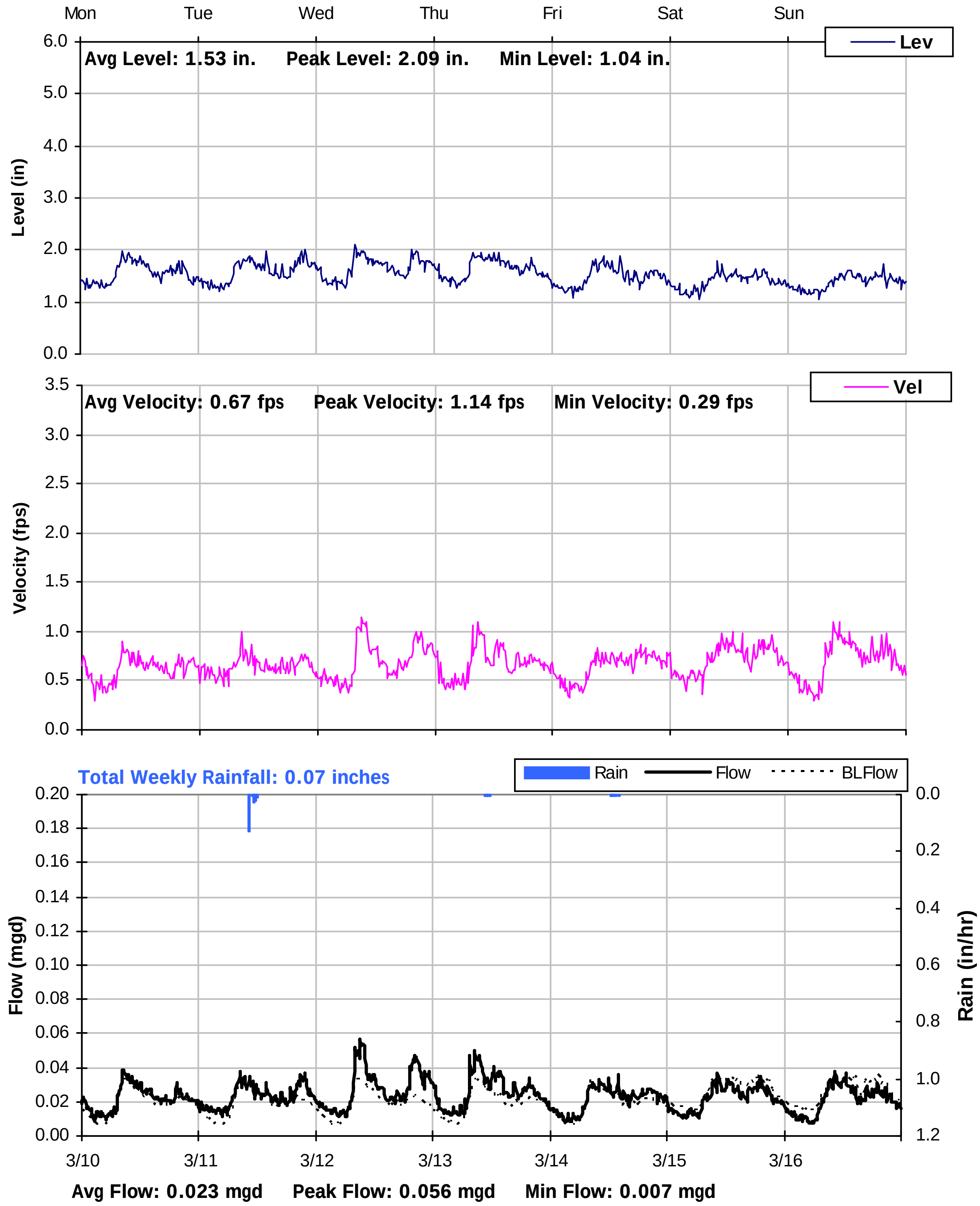


Avg Flow: 0.048 mgd **Peak Flow: 0.194 mgd** **Min Flow: 0.011 mgd**

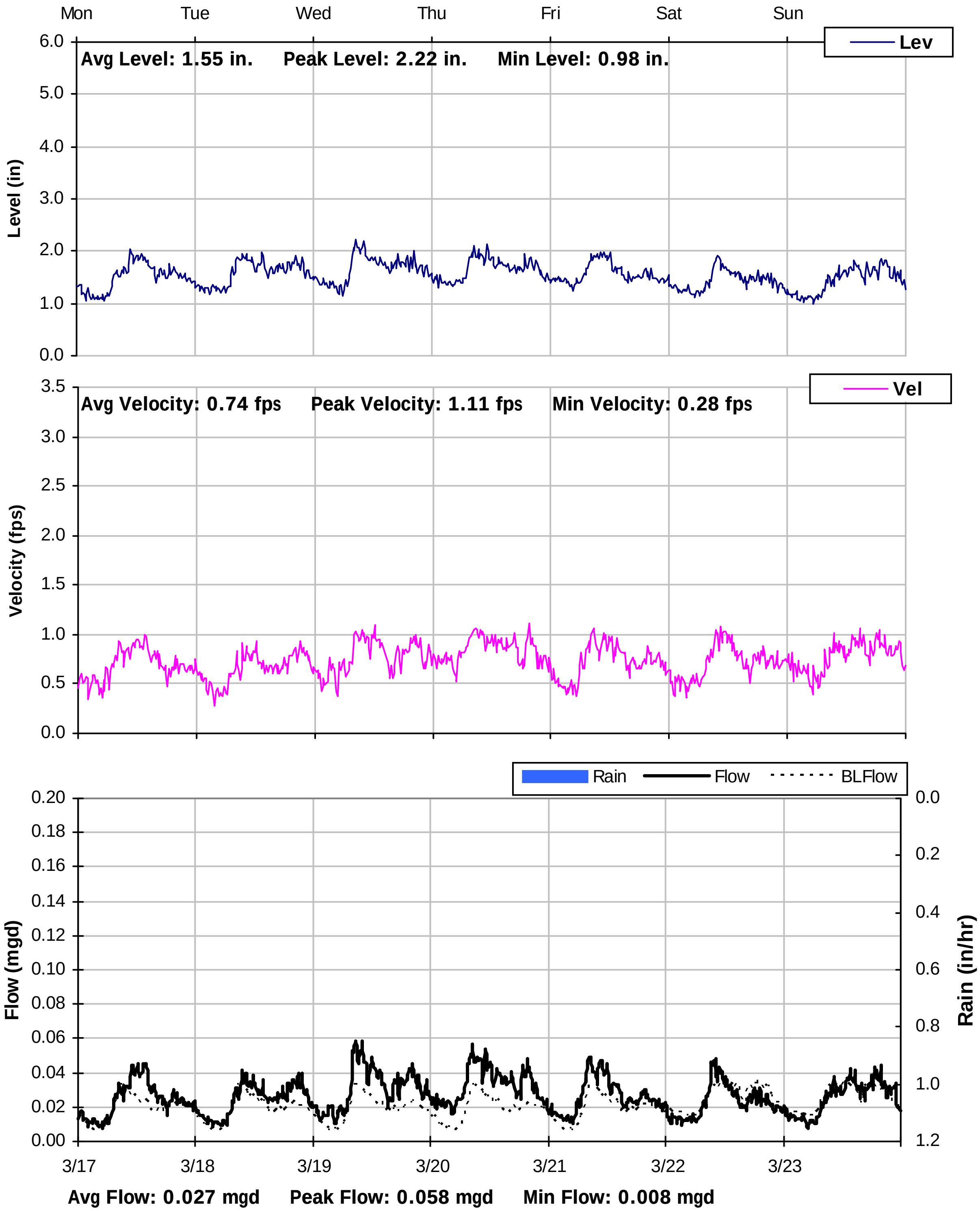
SITE 13
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



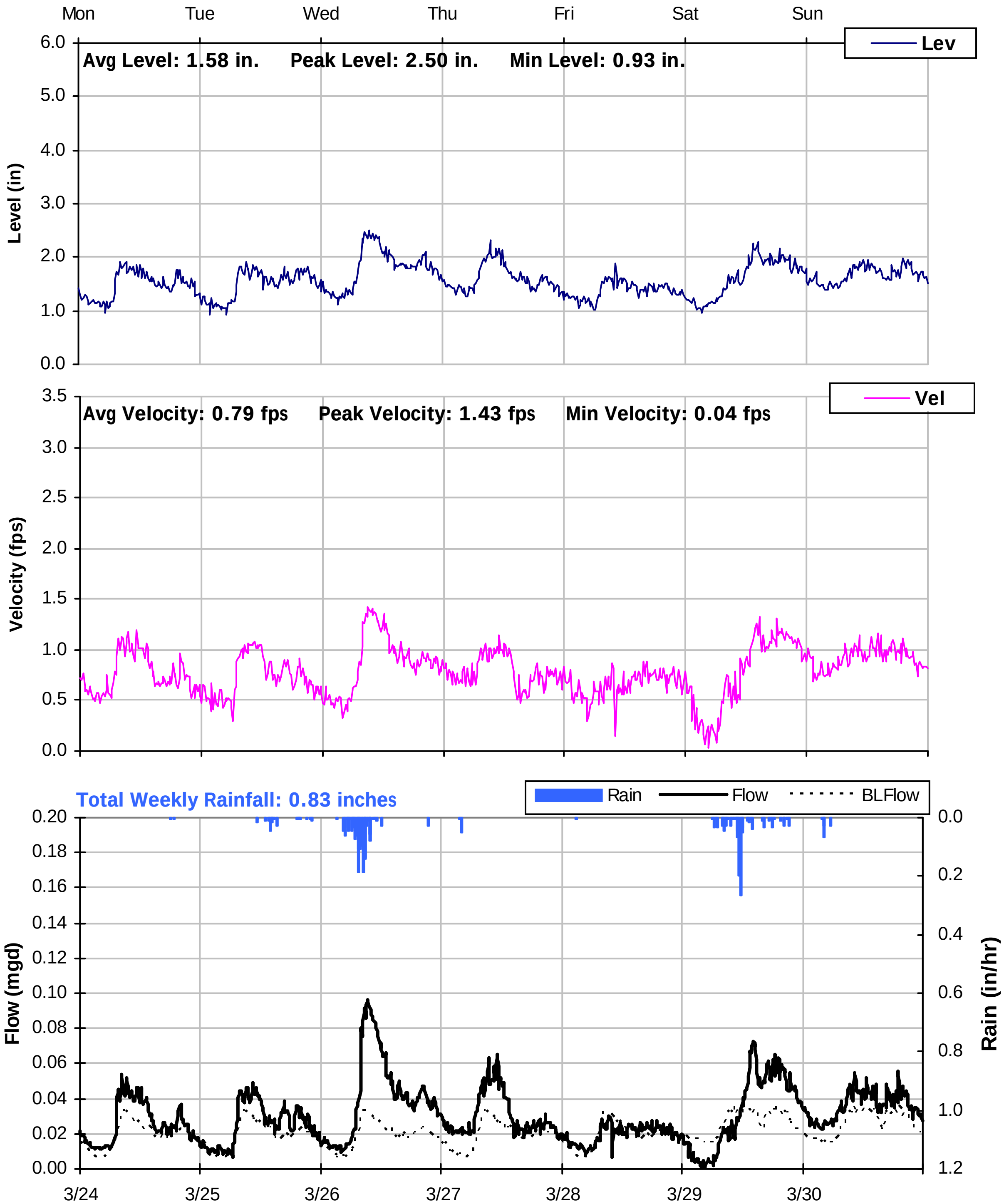
SITE 13
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014



SITE 13
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



SITE 13
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014

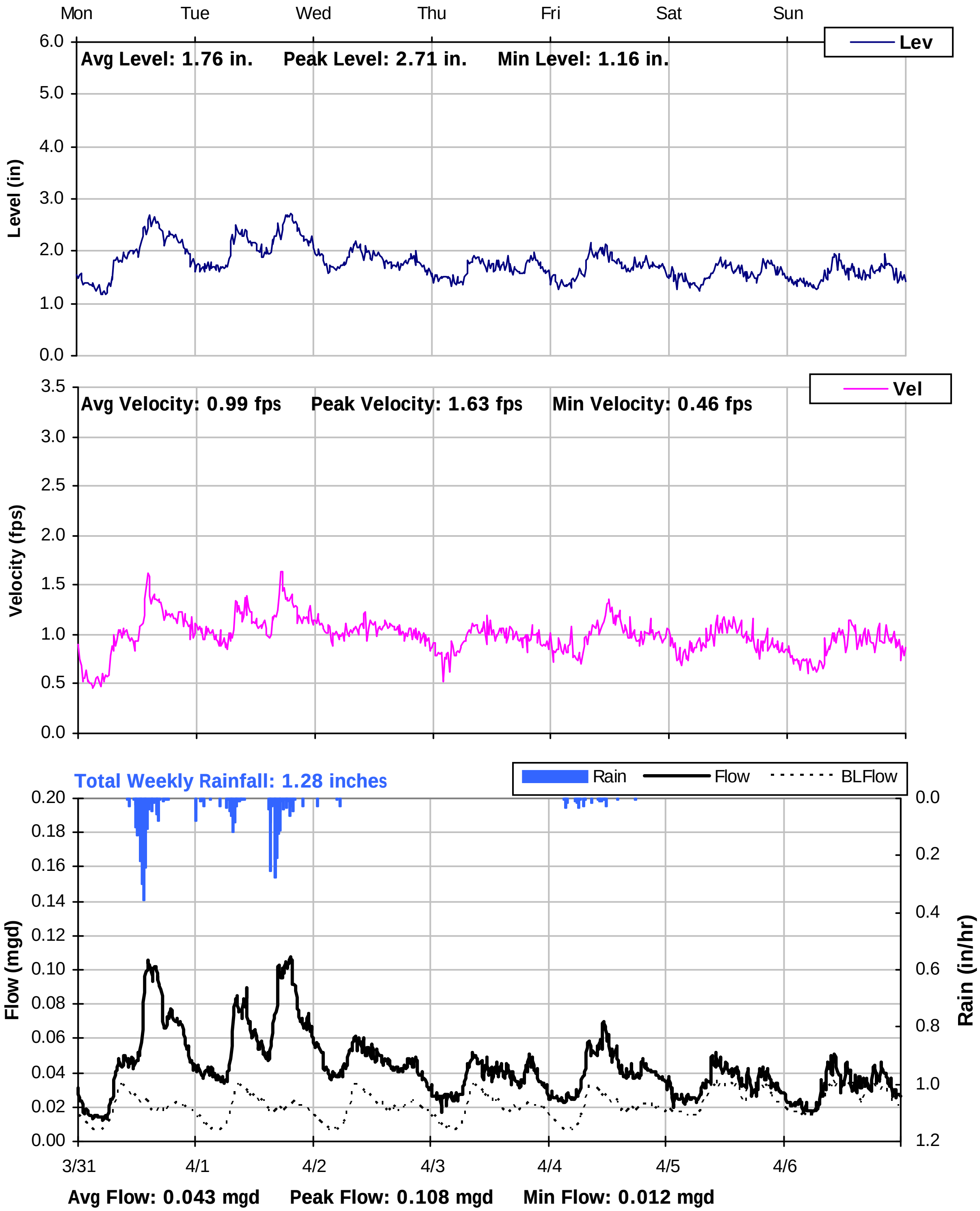


Avg Flow: 0.030 mgd **Peak Flow: 0.096 mgd** **Min Flow: 0.001 mgd**

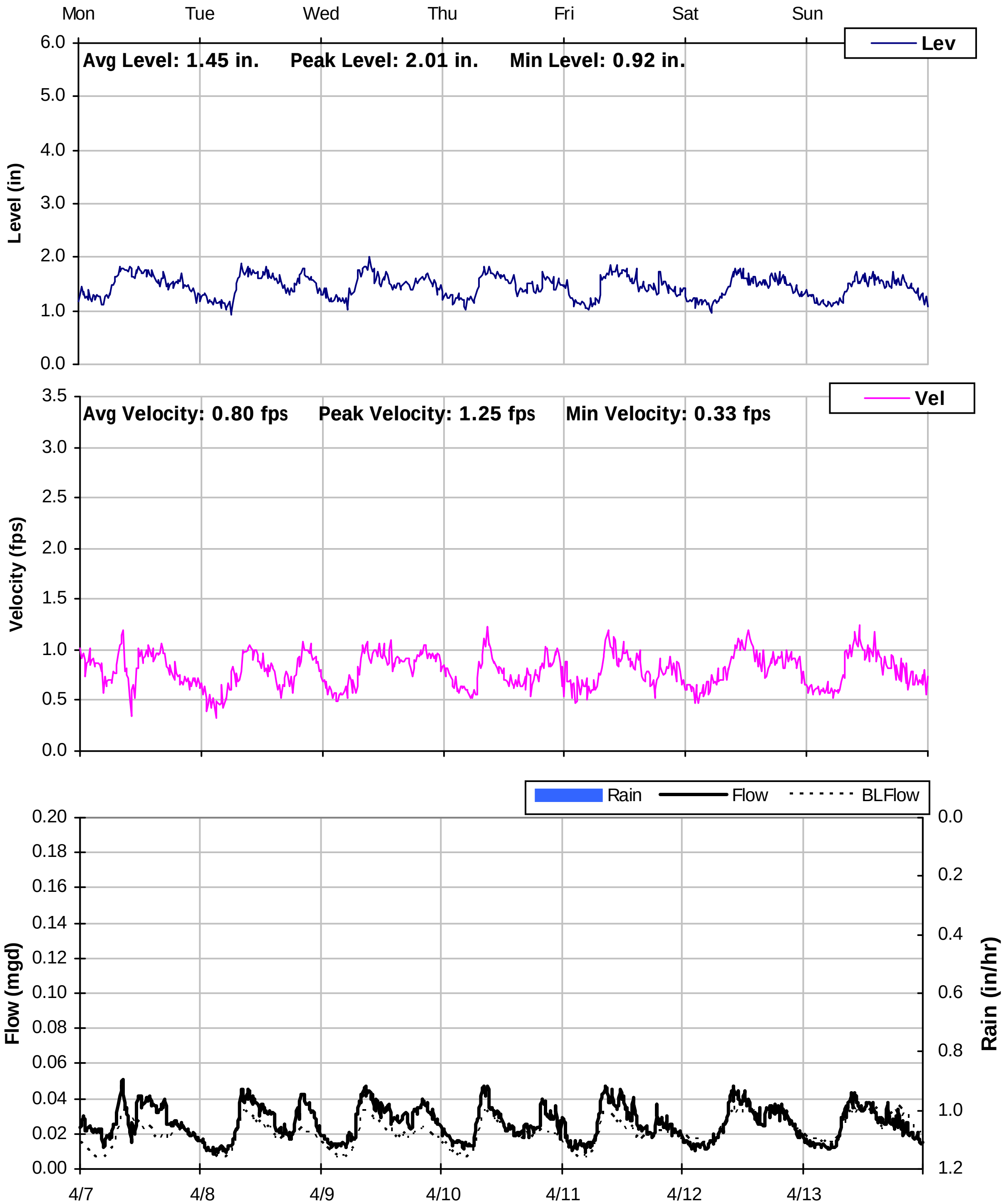
SITE 13

Weekly Level, Velocity and Flow Hydrographs

3/31/2014 to 4/7/2014



SITE 13
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 0.026 mgd **Peak Flow: 0.051 mgd** **Min Flow: 0.008 mgd**

West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 14

Location: Atherton Avenue, north of Mulberry Lane

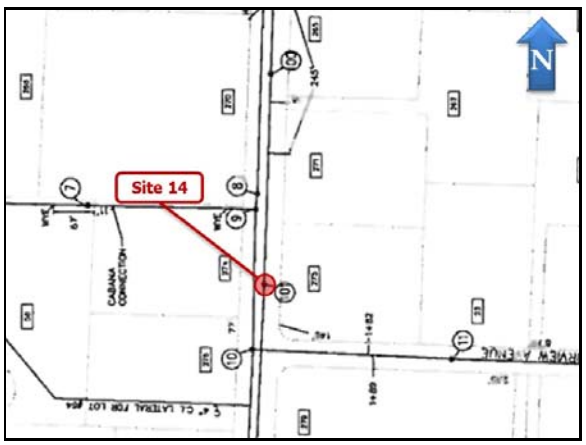
Data Summary Report

SITE 14

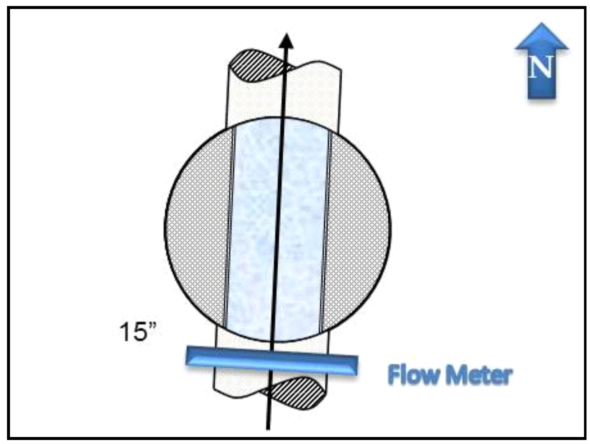
Site Information

Location:	Atherton Avenue, north of Mulberry Lane
Coordinates:	122.2152° W, 37.4423° N
Rim Elevation:	105 feet
Pipe Diameter:	15 inches
Baseline Flow:	0.103 mgd
Peak Measured Flow:	0.346 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

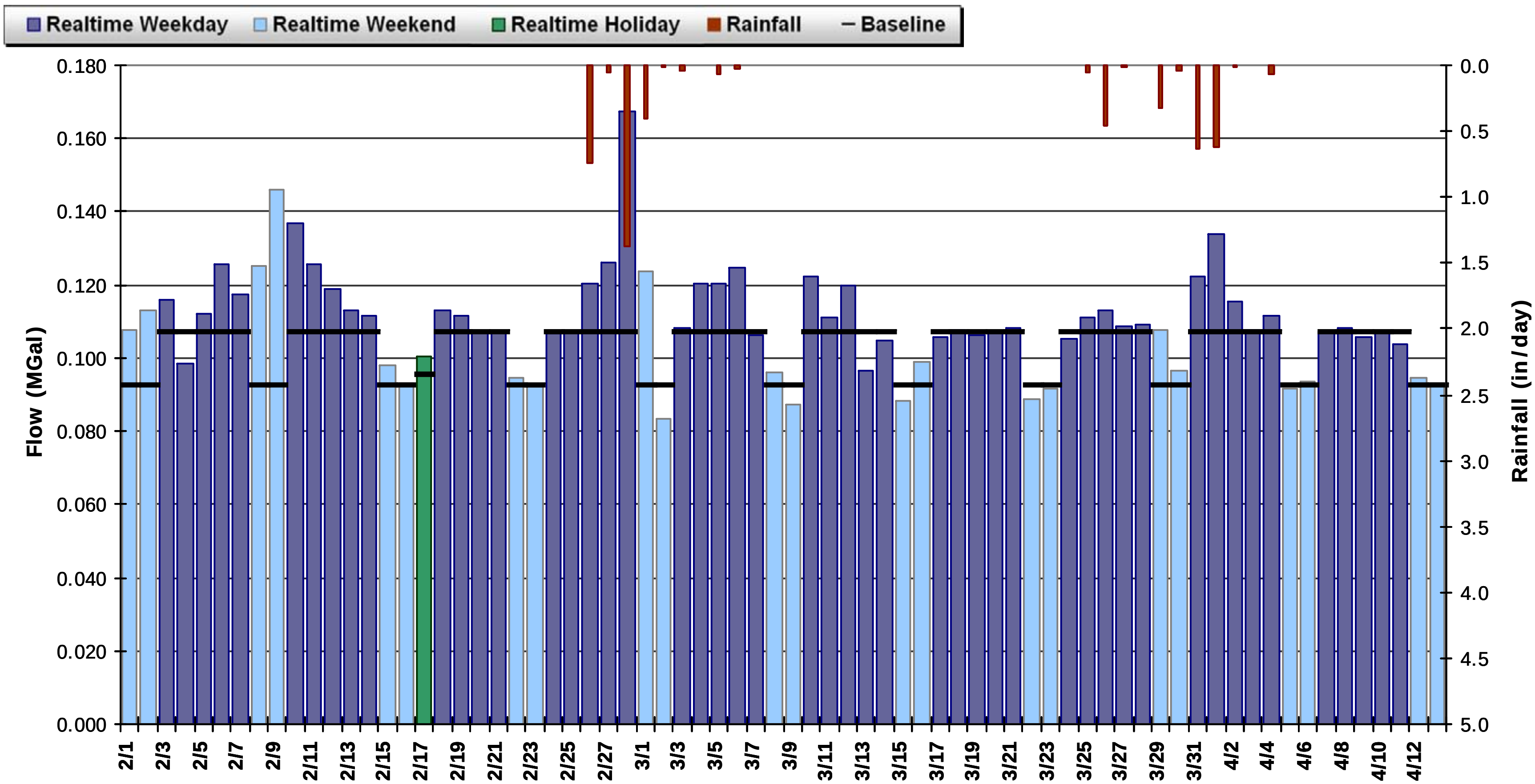
Plan View

SITE 14

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.110 MGal **Peak Daily Flow: 0.167 MGal** **Min Daily Flow: 0.083 MGal**

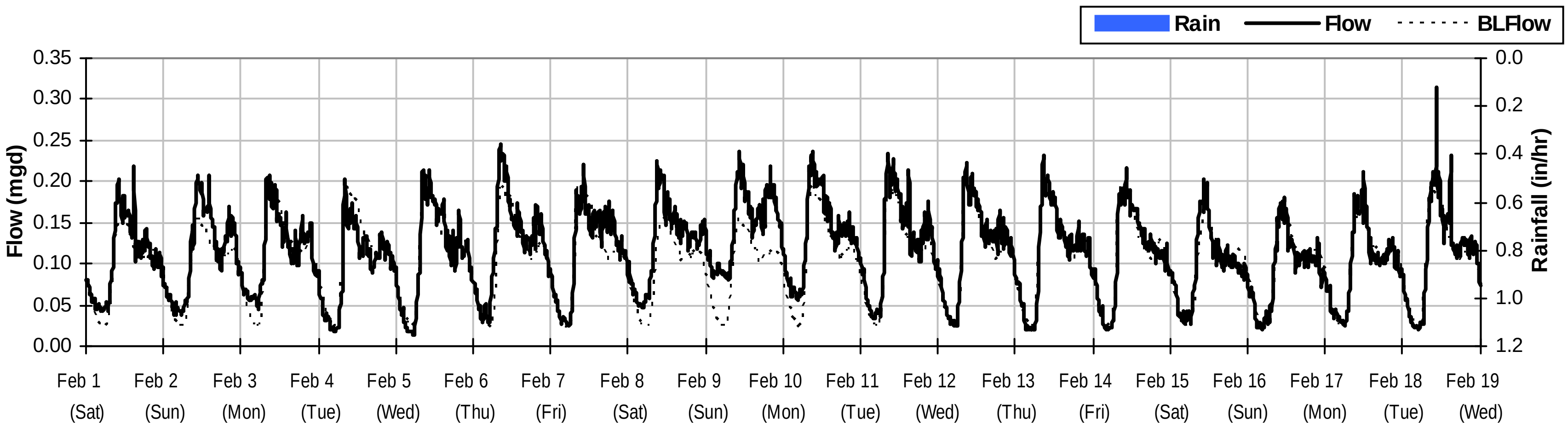
Total Period Rainfall: 4.95 inches

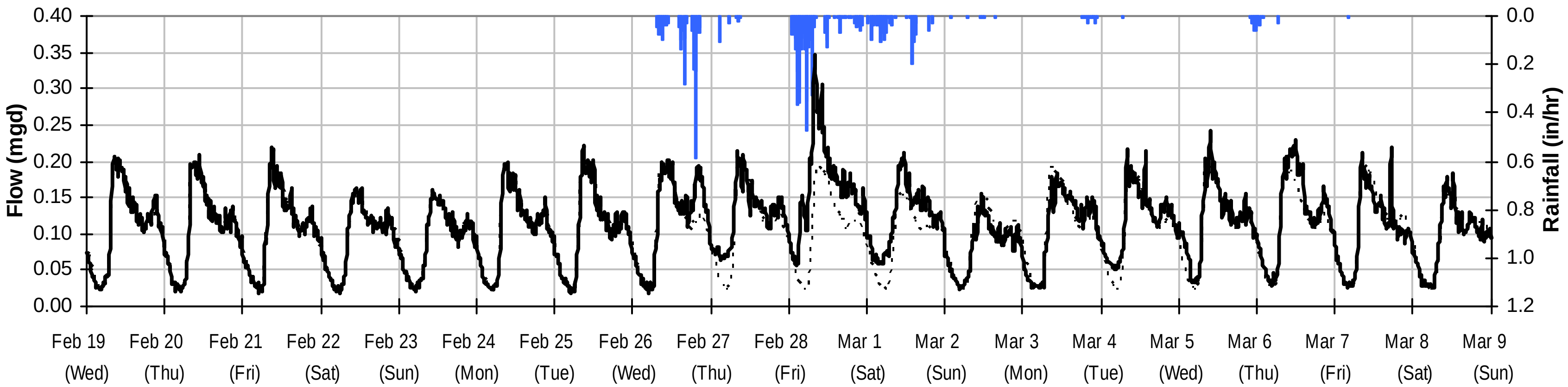


SITE 14

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.95 inches **Avg Flow: 0.110 mgd** **Peak Flow: 0.346 mgd** **Min Flow: 0.008 mgd**

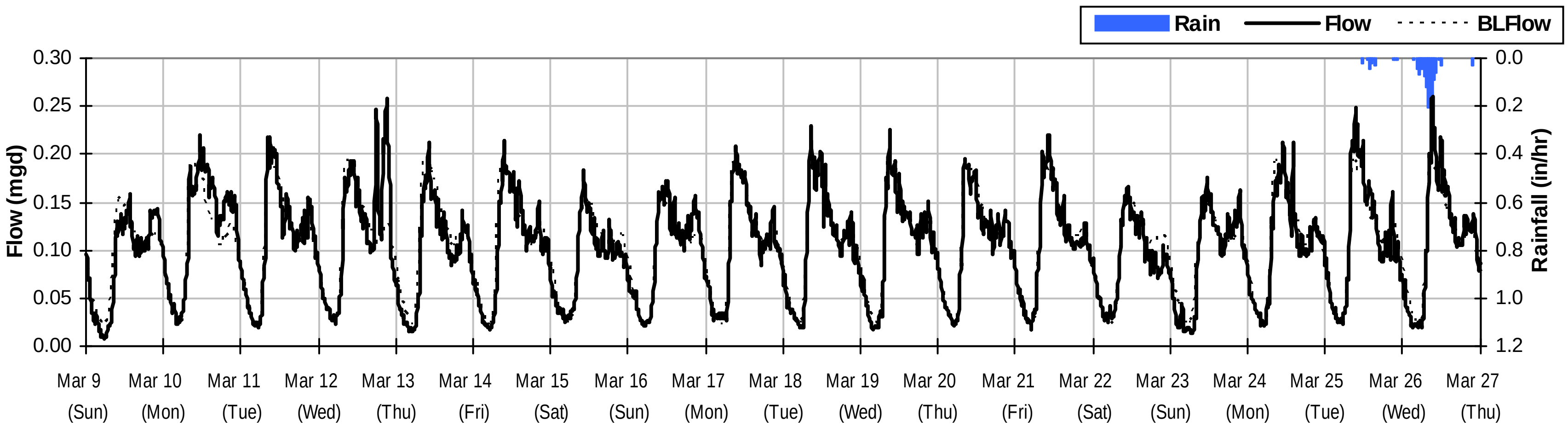


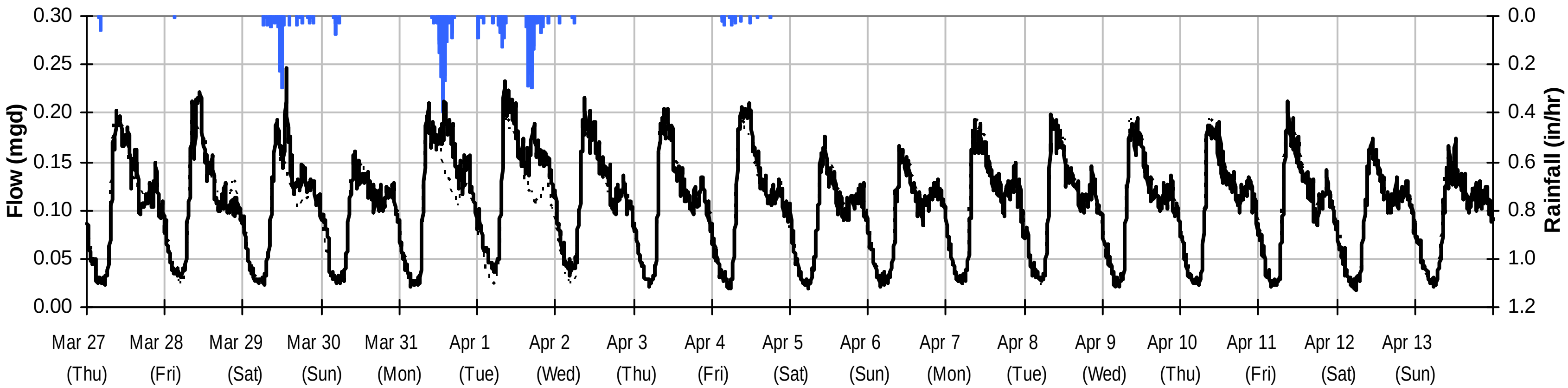


SITE 14

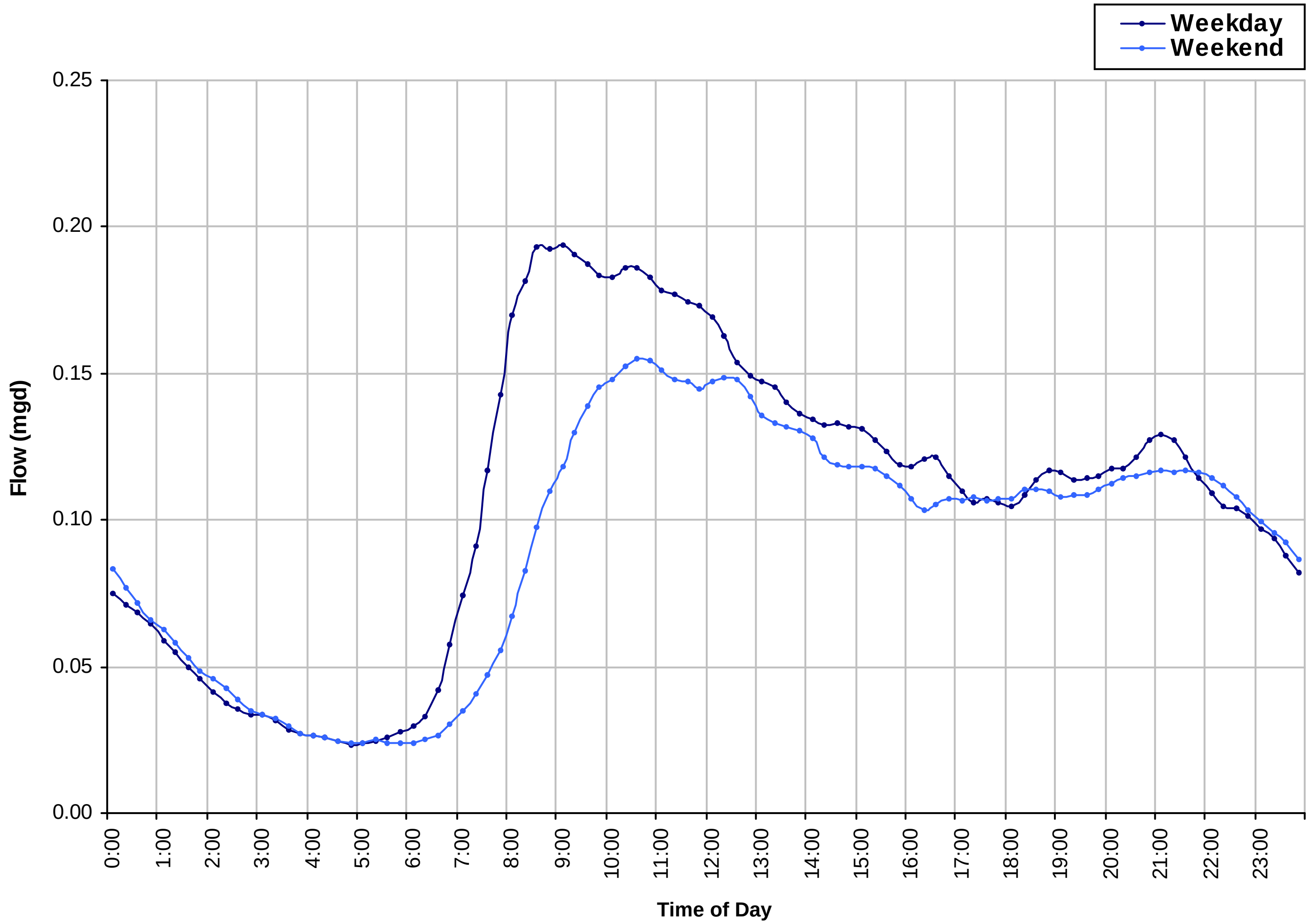
Period Flow Summary: March 9 to April 14, 2014

Total Monthly Rainfall: 4.95 inches **Avg Flow: 0.110 mgd** **Peak Flow: 0.346 mgd** **Min Flow: 0.008 mgd**

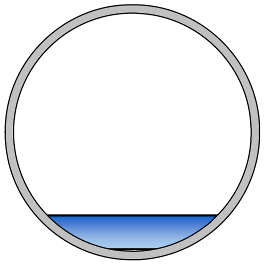




SITE 14
Baseline Flow Hydrographs

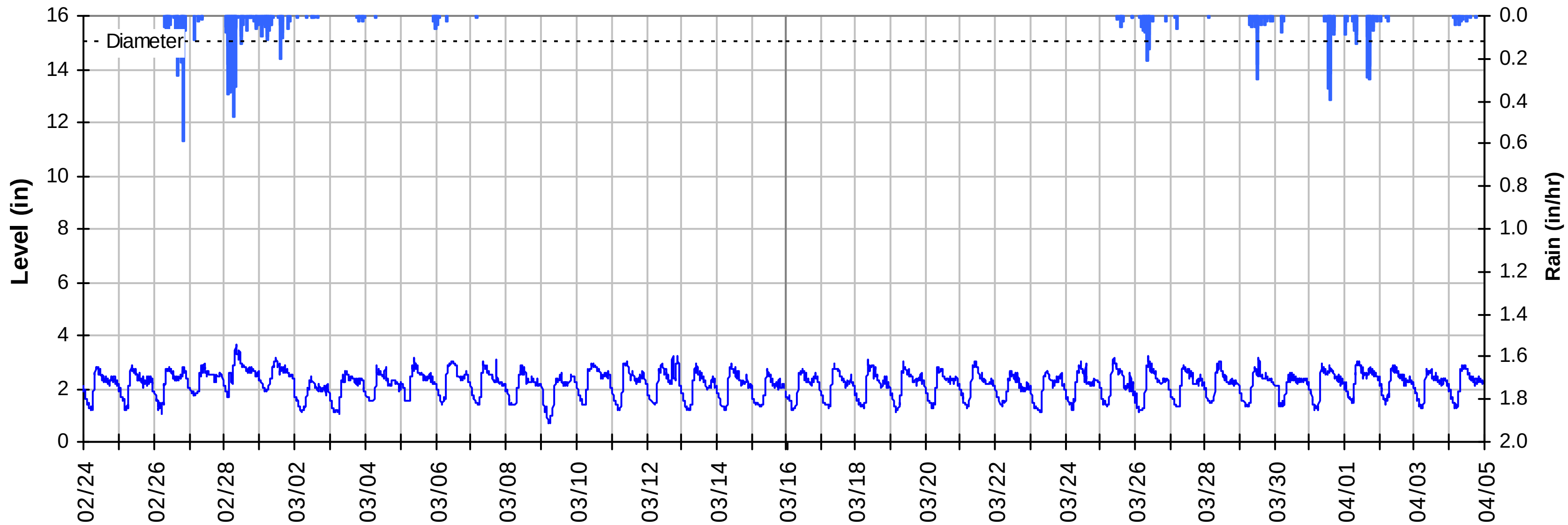


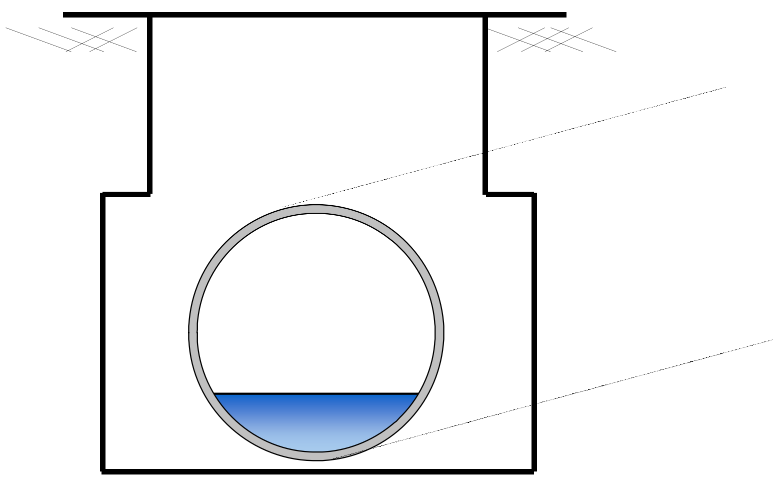
Baseline Flow:
0.103 *mgd*



SITE 14
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

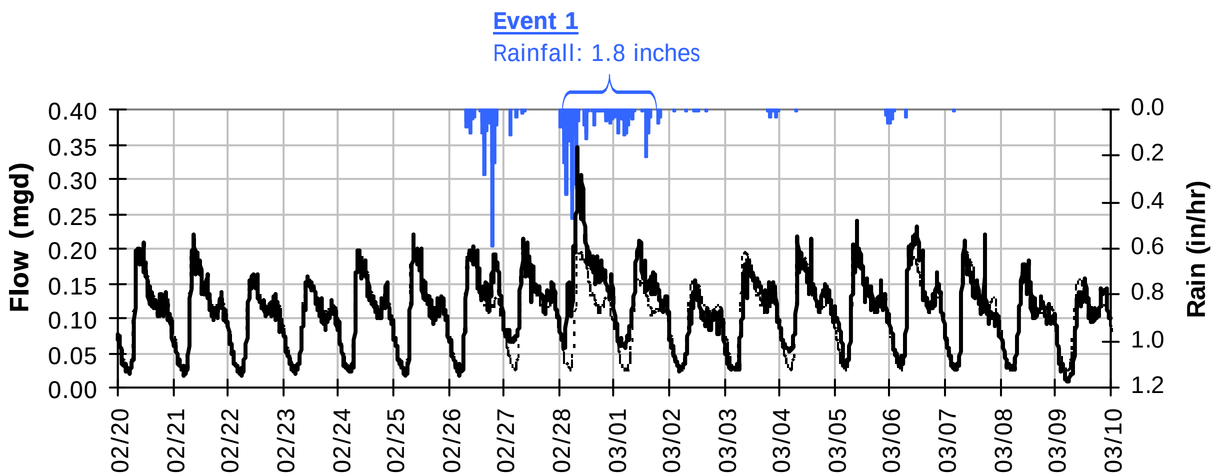




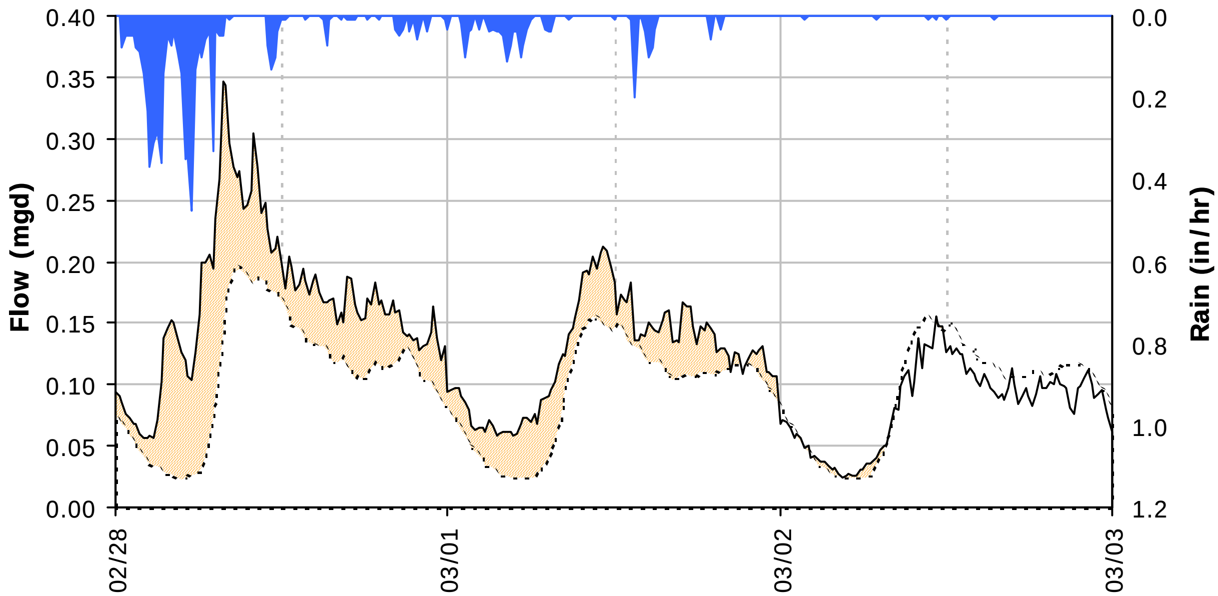
Pipe Diameter:	15	*inches*
Peak Measured Level:	3.67	*inches*
Peak d/D Ratio:	0.24	

SITE 14
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

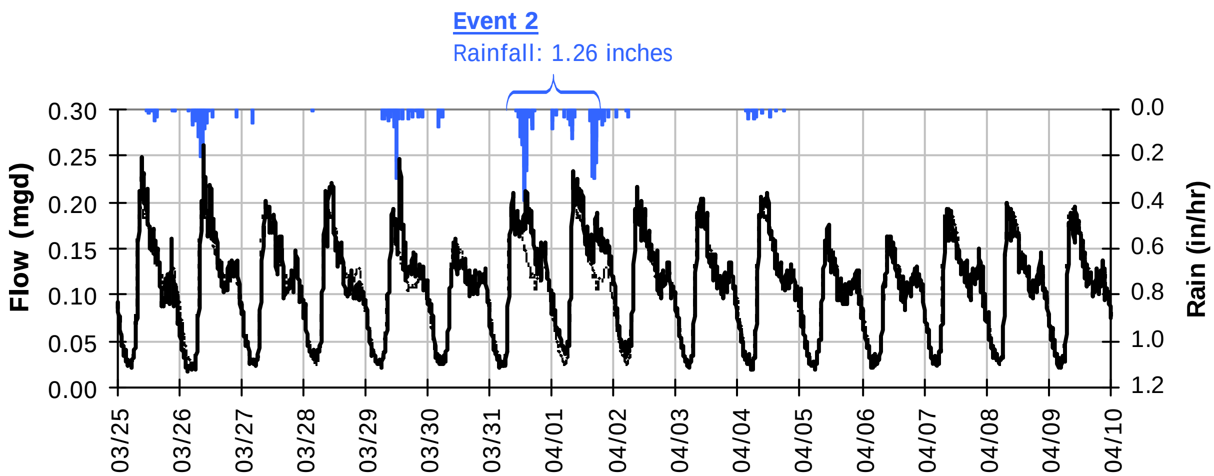


Storm Event I/I Analysis (Rain = 1.80 inches)

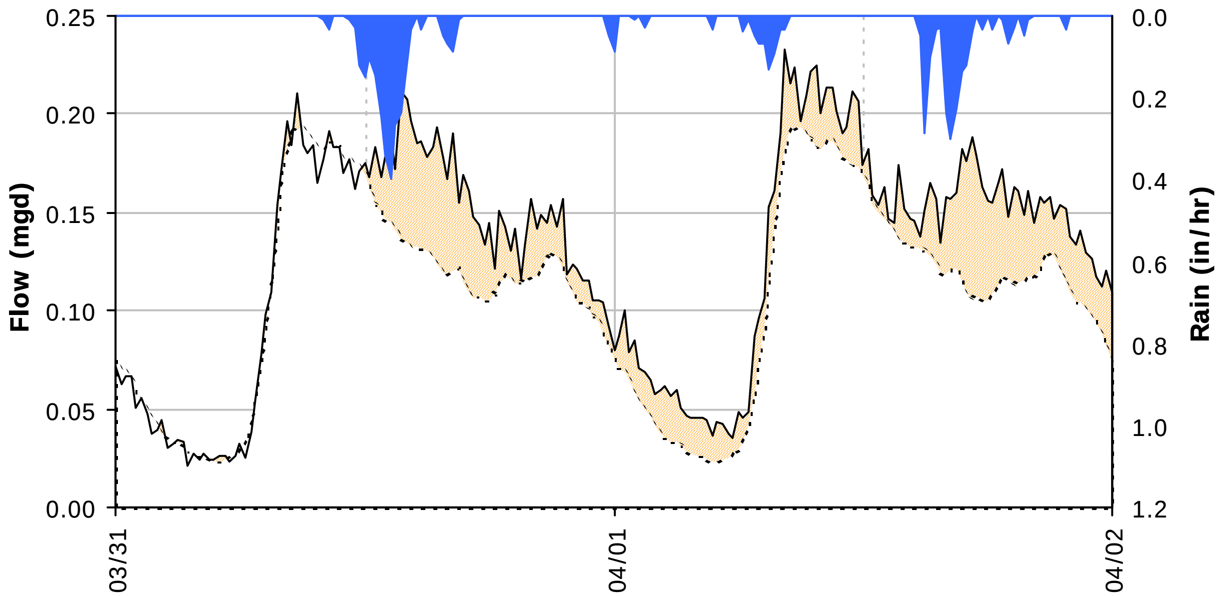
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.35 *mgd*	**Peak I/I Rate:**	0.17 *mgd*
PF:	3.36	**Total I/I:**	82,000 *gallons*

SITE 14
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



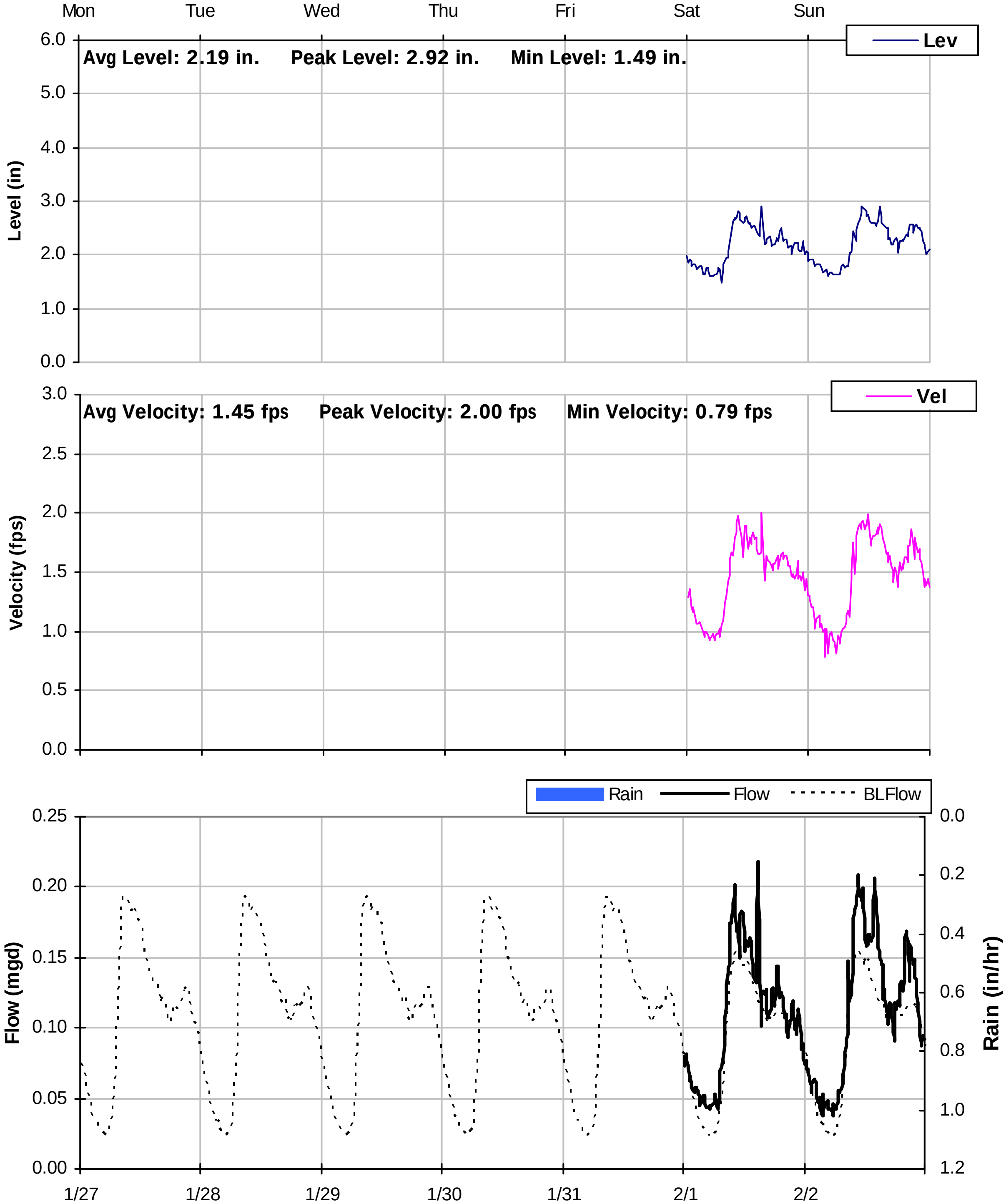
Event 2 Detail Graph



Storm Event I/I Analysis (Rain = 1.26 inches)

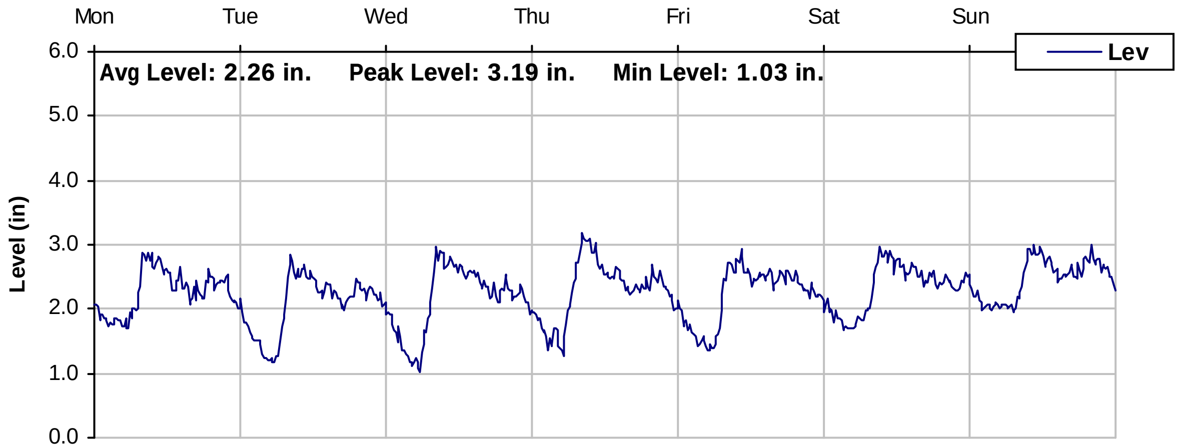
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.23 *mgd*	**Peak I/I Rate:**	0.08 *mgd*
PF:	2.26	**Total I/I:**	52,000 *gallons*

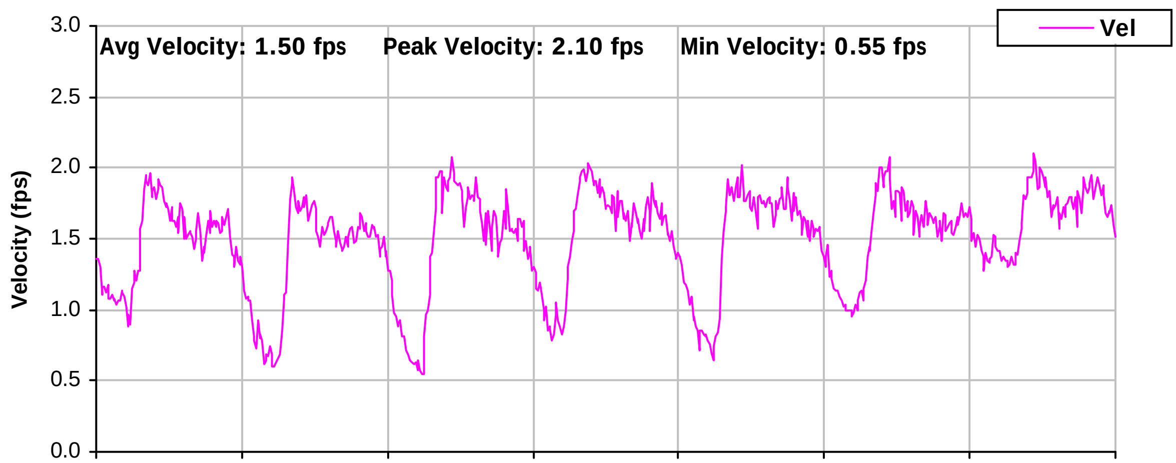
SITE 14
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

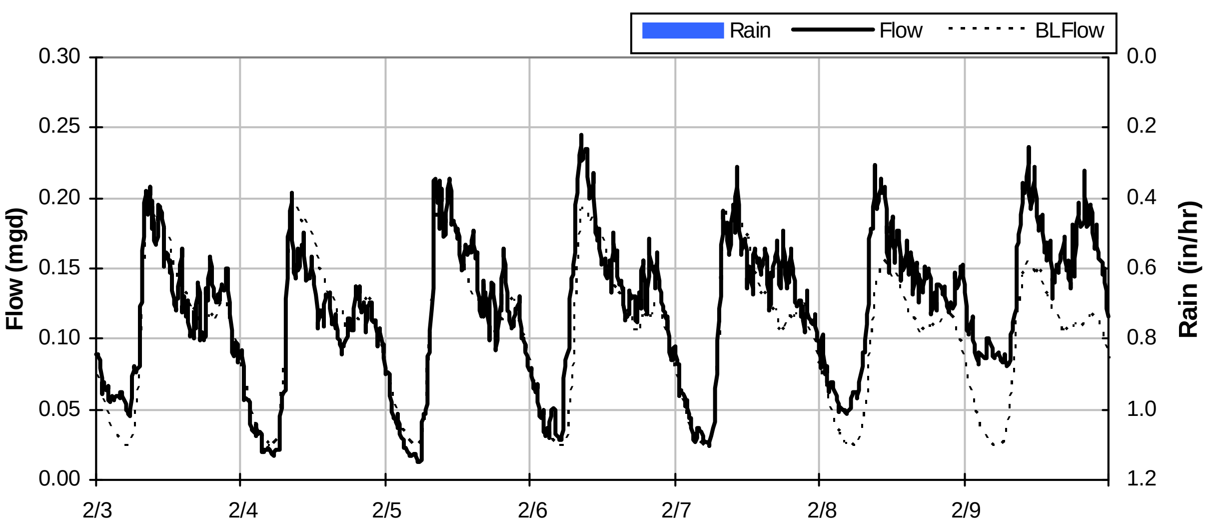


Avg Flow: 0.110 mgd **Peak Flow: 0.218 mgd** **Min Flow: 0.037 mgd**

SITE 14
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014

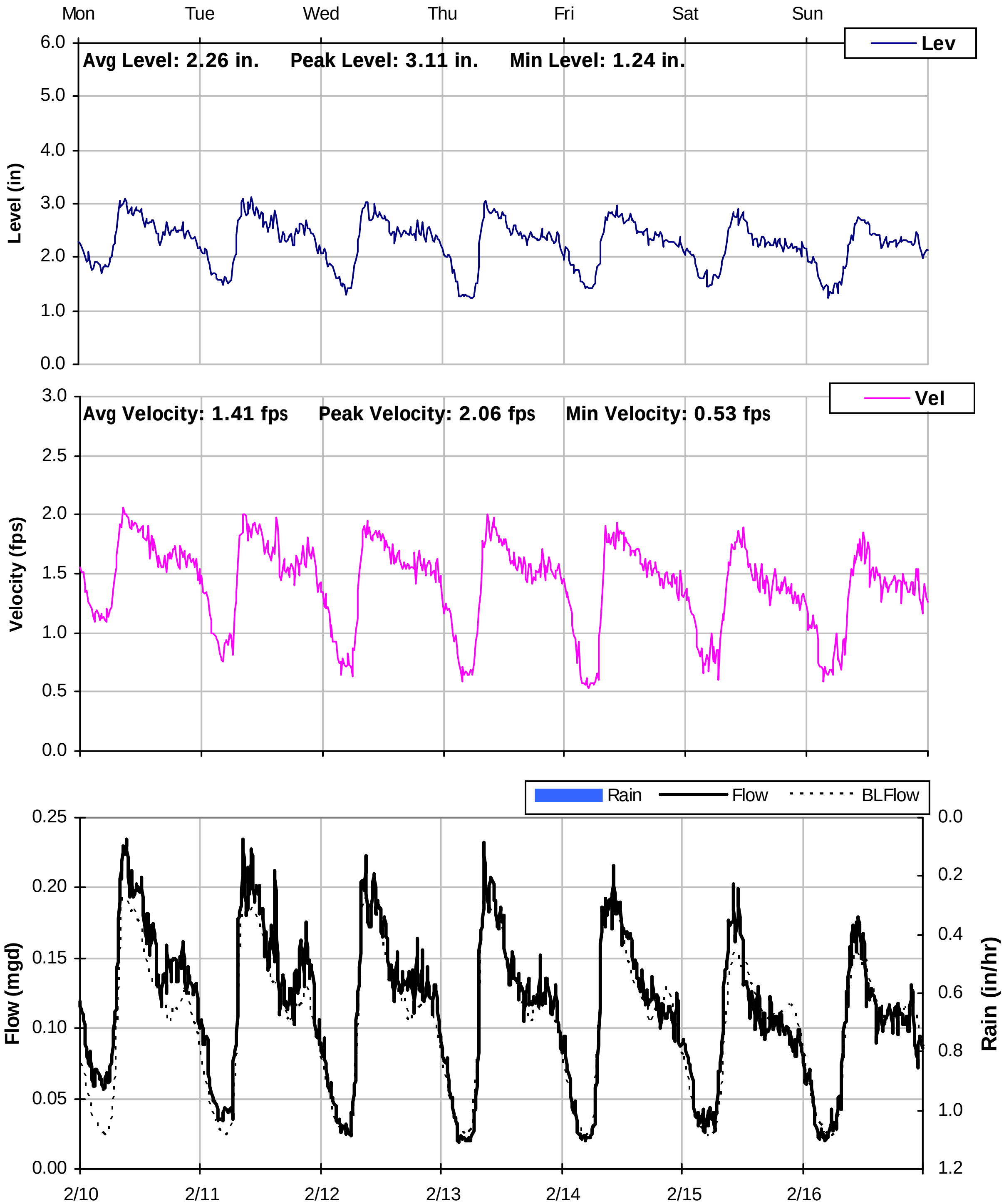






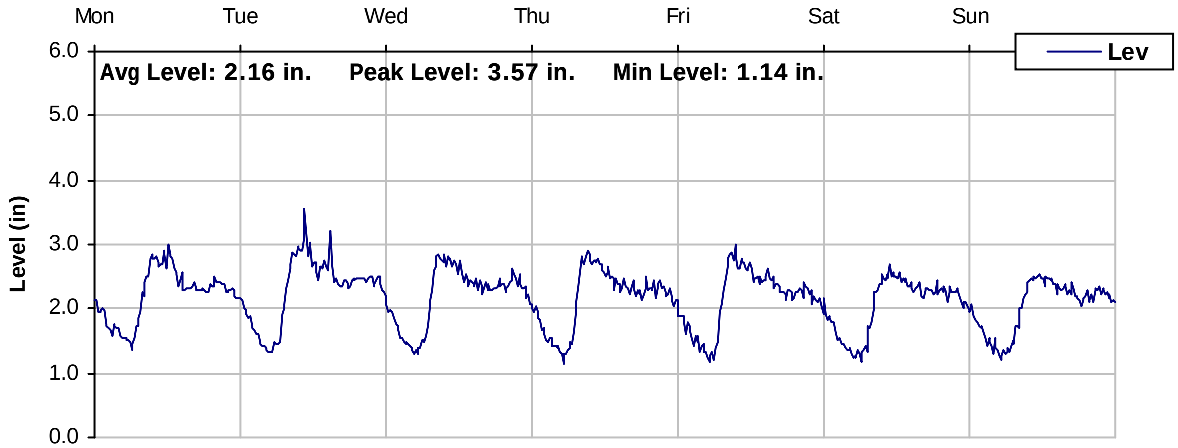
Avg Flow: 0.120 mgd **Peak Flow: 0.245 mgd** **Min Flow: 0.013 mgd**

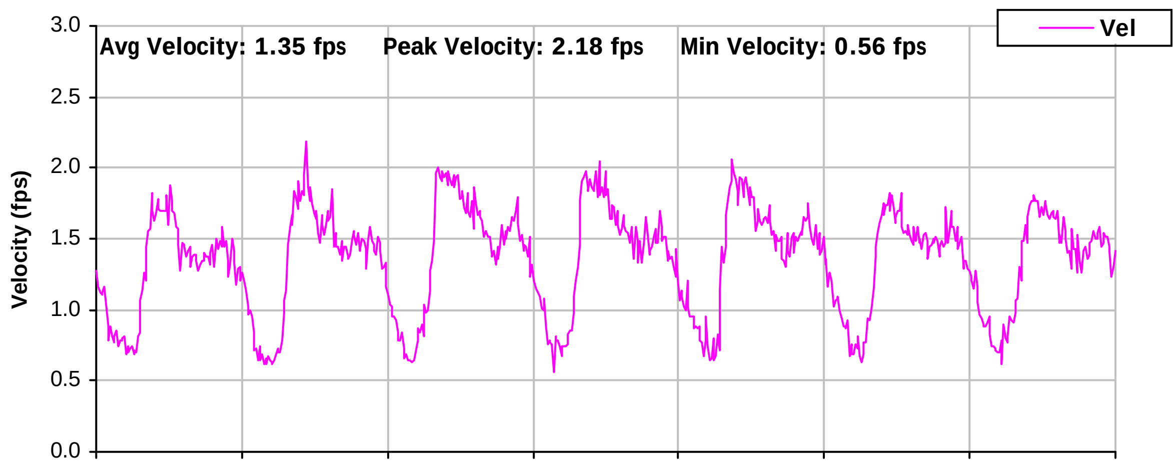
SITE 14
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014

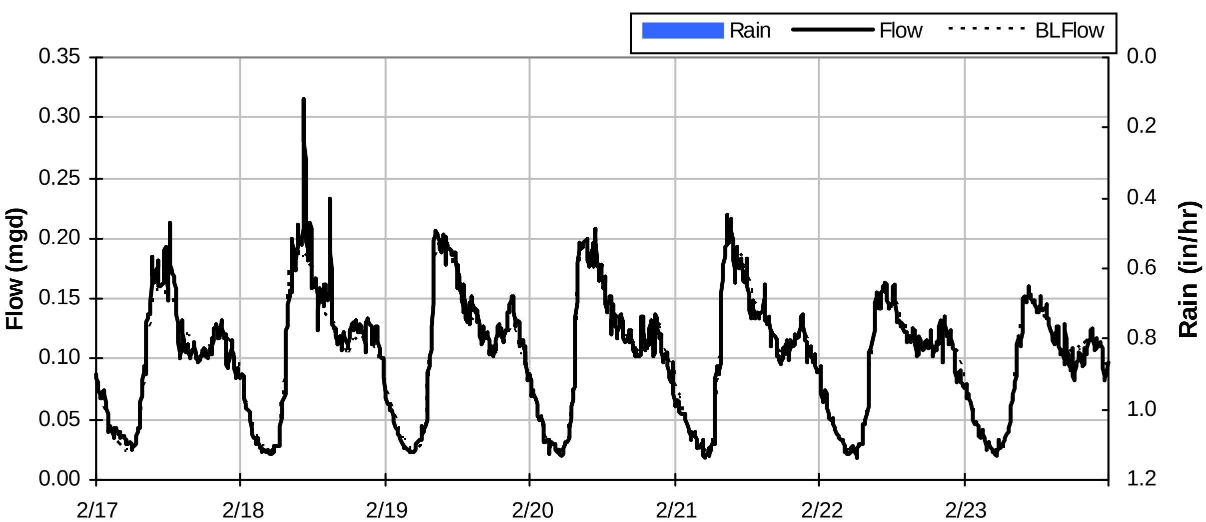


Avg Flow: 0.114 mgd **Peak Flow: 0.235 mgd** **Min Flow: 0.019 mgd**

SITE 14
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

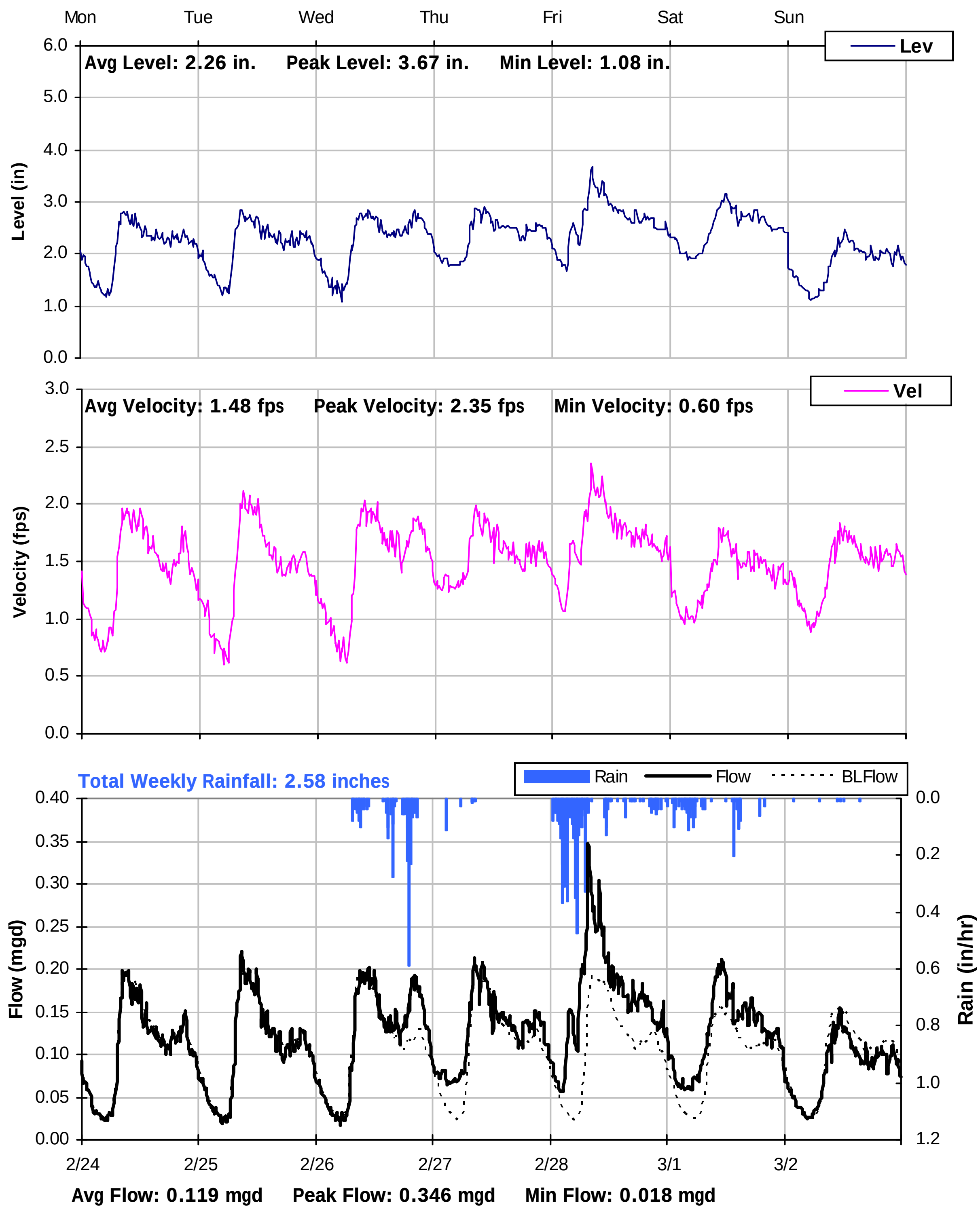




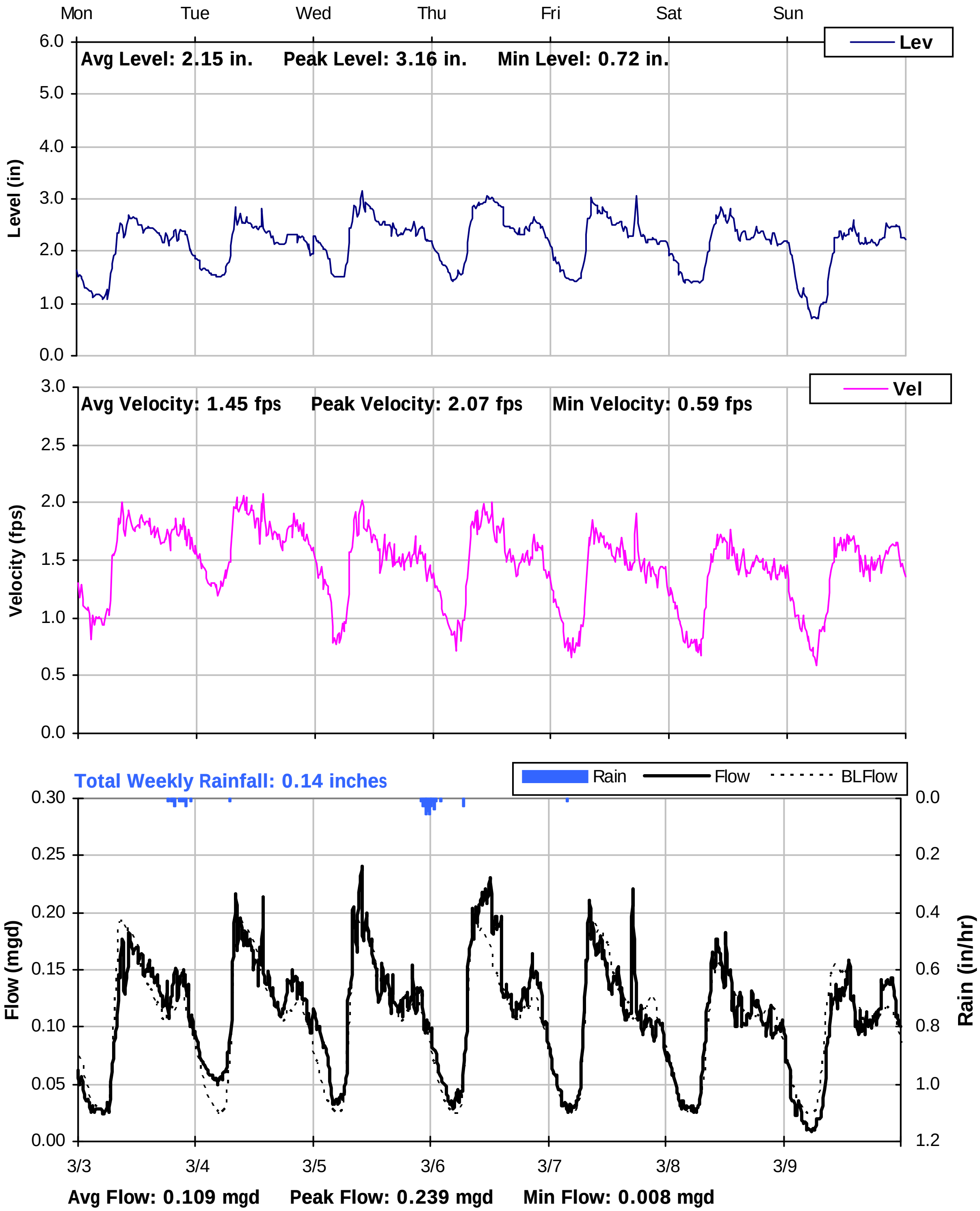


Avg Flow: 0.104 mgd Peak Flow: 0.315 mgd Min Flow: 0.018 mgd

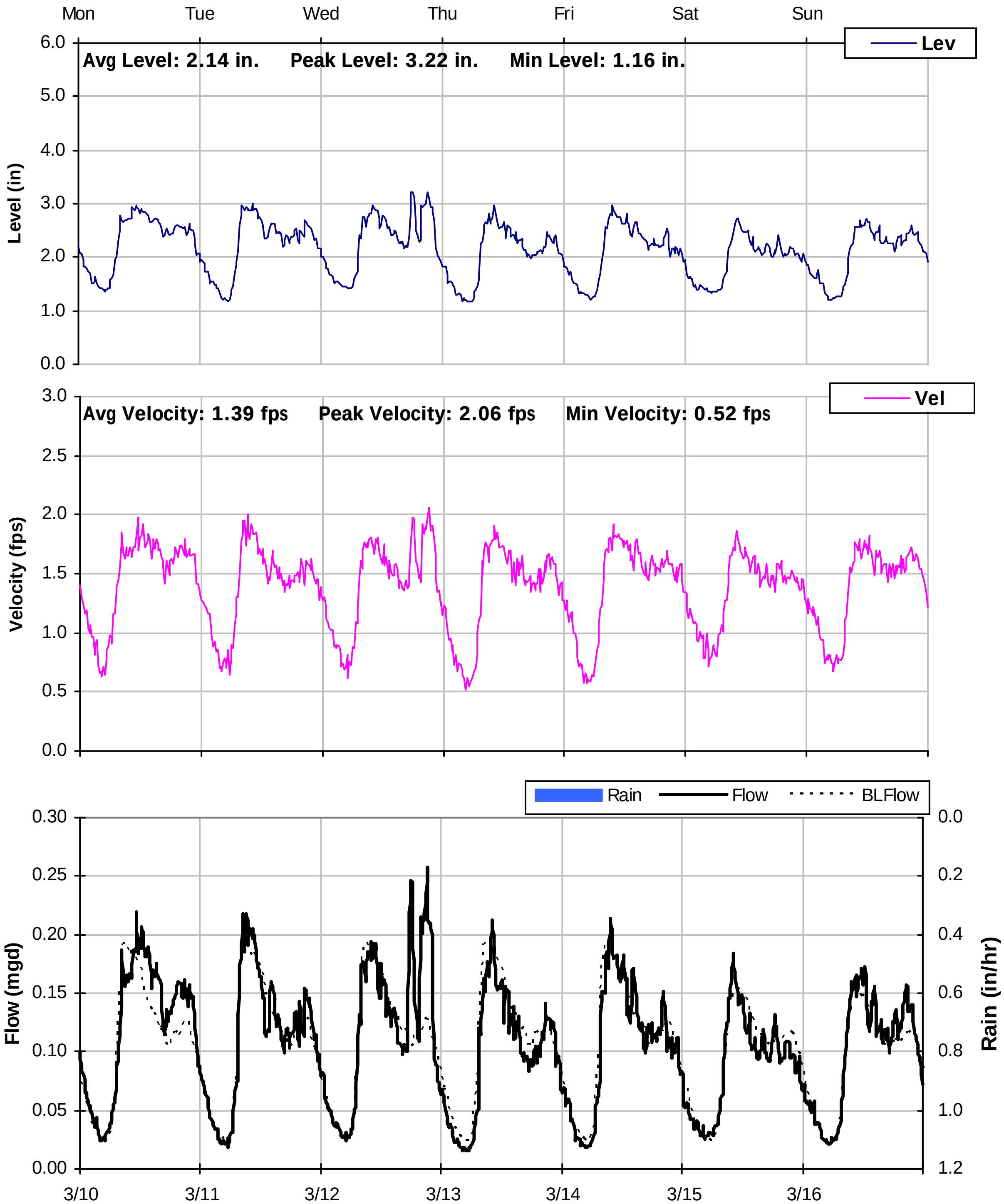
SITE 14
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



SITE 14
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014

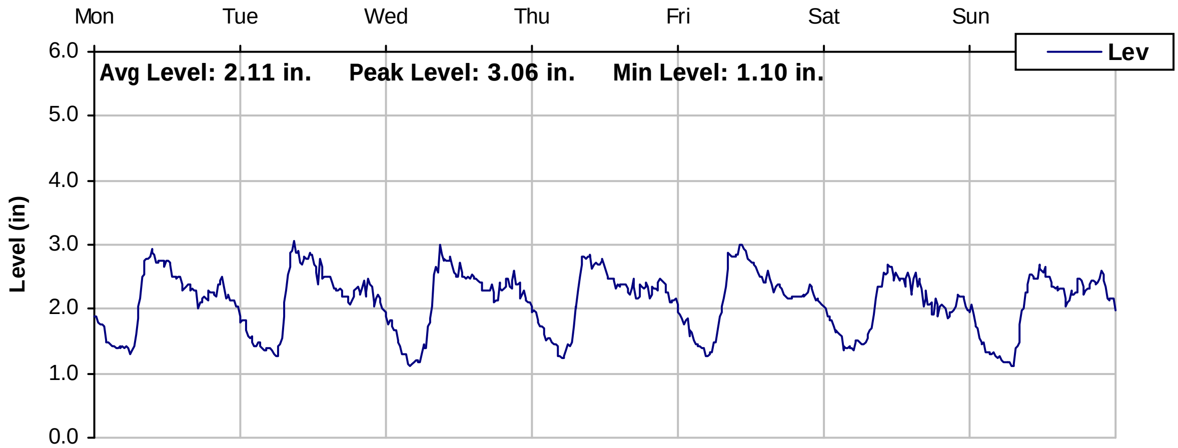


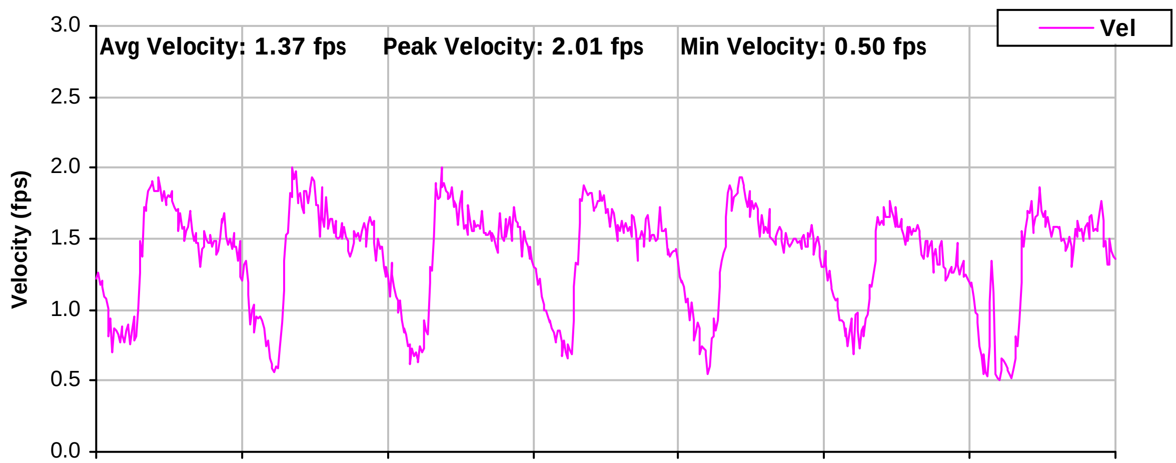
SITE 14
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014

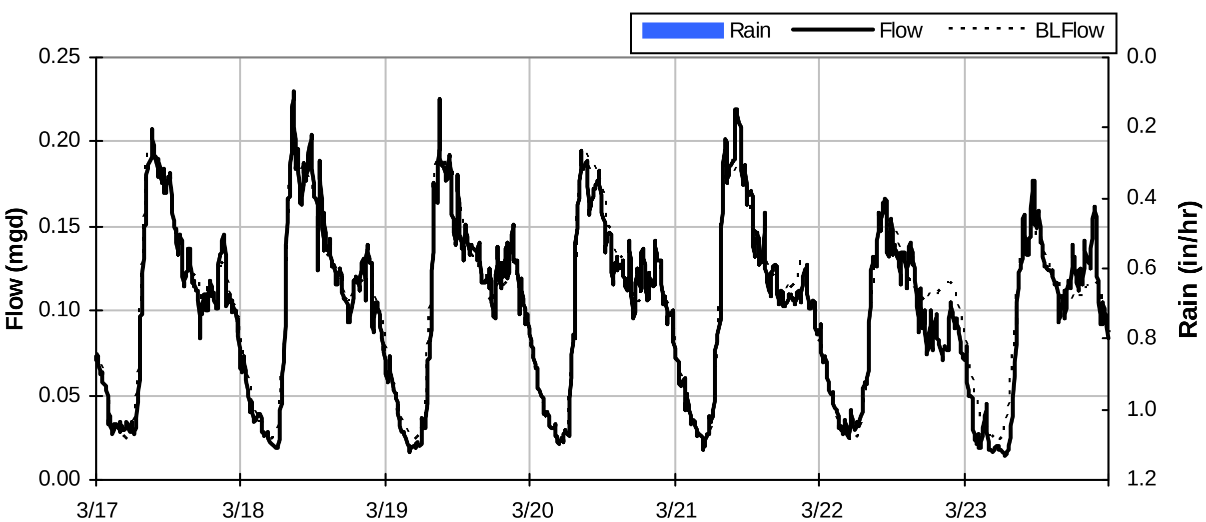


Avg Flow: 0.106 mgd **Peak Flow: 0.258 mgd** **Min Flow: 0.015 mgd**

SITE 14
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014

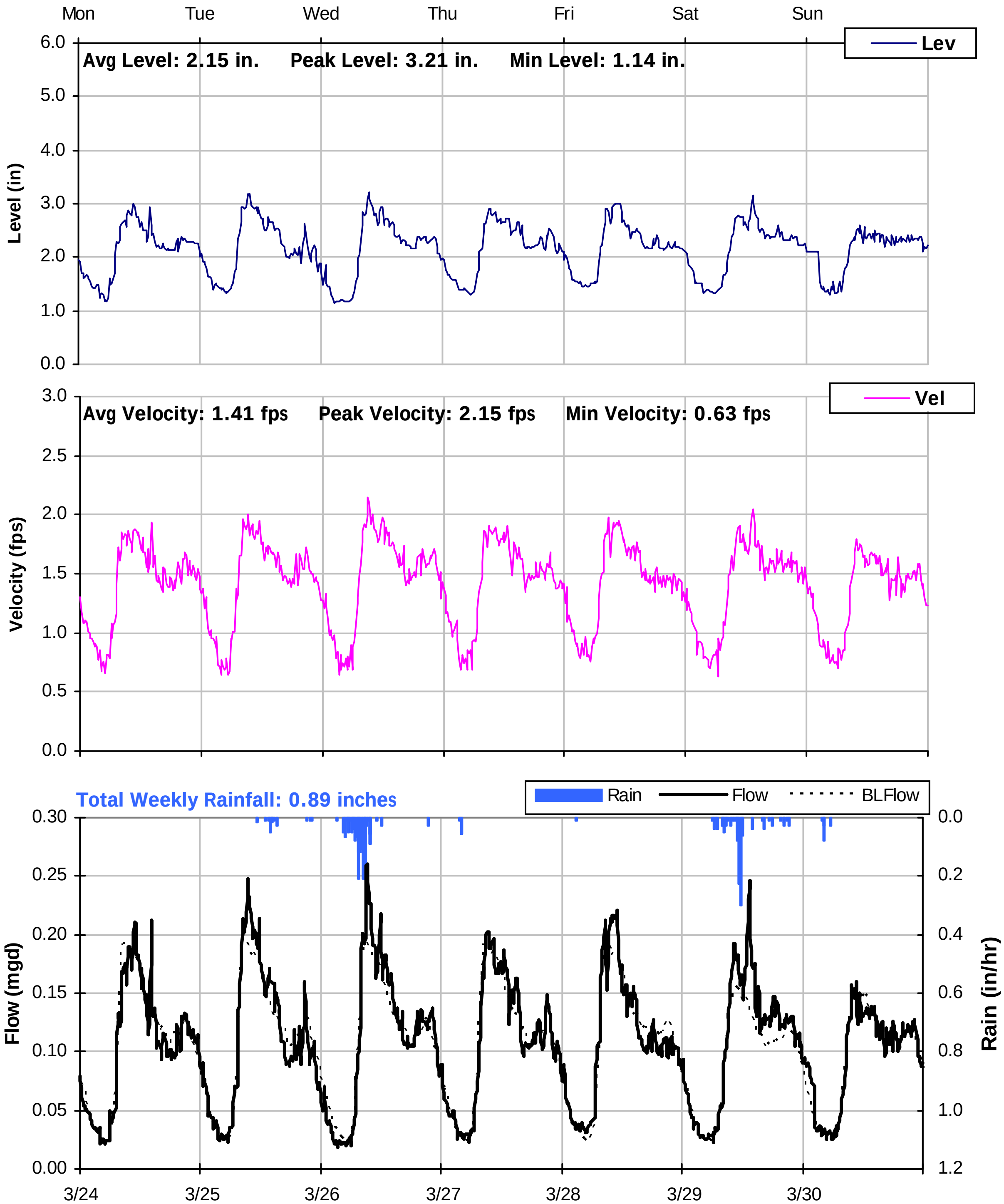






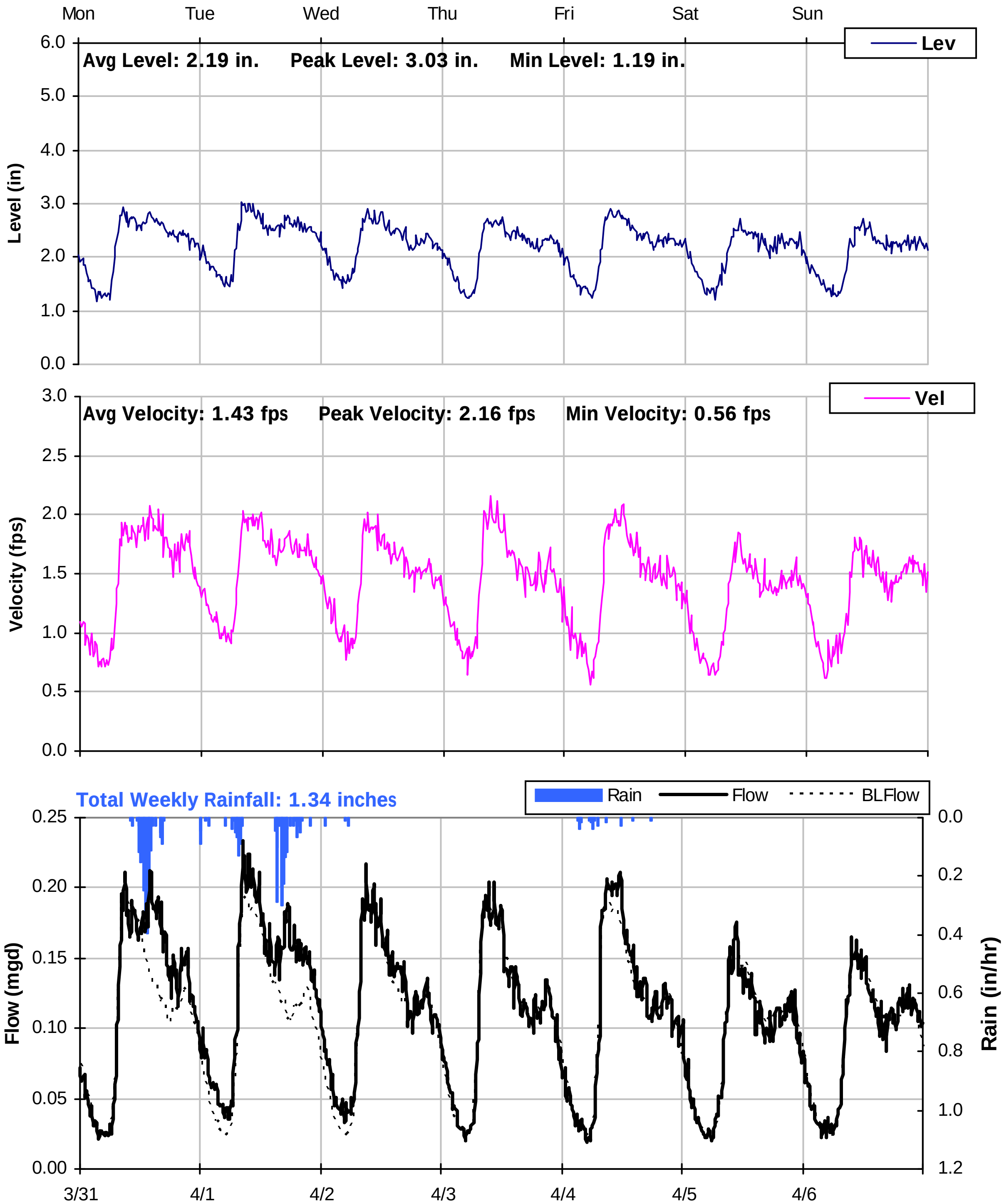
Avg Flow: 0.102 mgd **Peak Flow: 0.229 mgd** **Min Flow: 0.014 mgd**

SITE 14
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



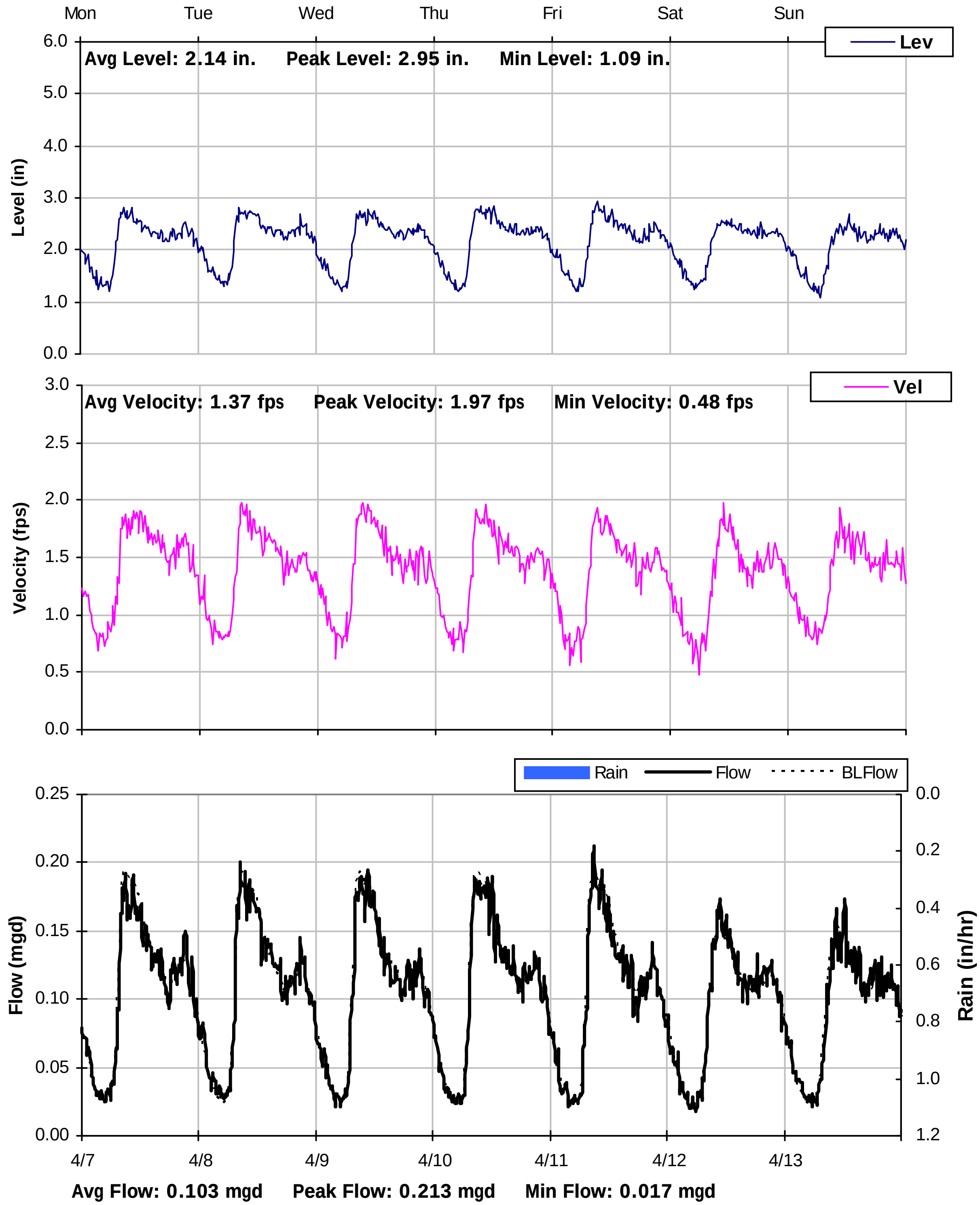
Avg Flow: 0.107 mgd **Peak Flow: 0.261 mgd** **Min Flow: 0.018 mgd**

SITE 14
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



Avg Flow: 0.111 mgd **Peak Flow: 0.233 mgd** **Min Flow: 0.019 mgd**

SITE 14
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 15

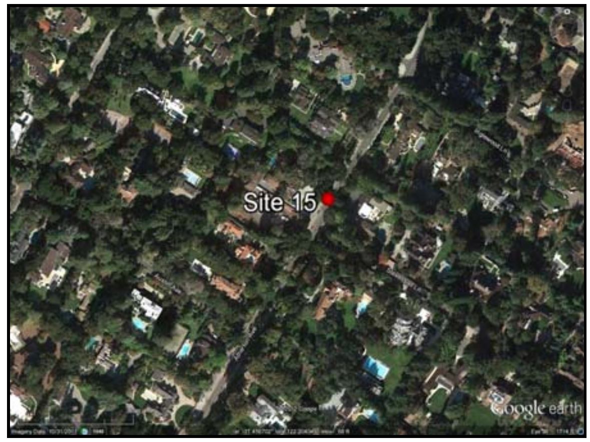
Location: Atherton Avenue, northeast of Stevenson Lane

Data Summary Report

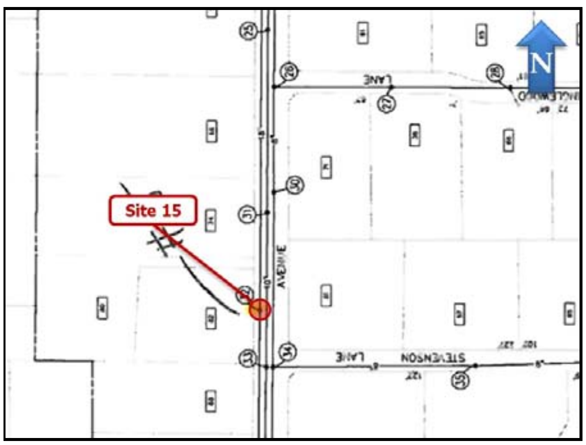
SITE 15

Site Information

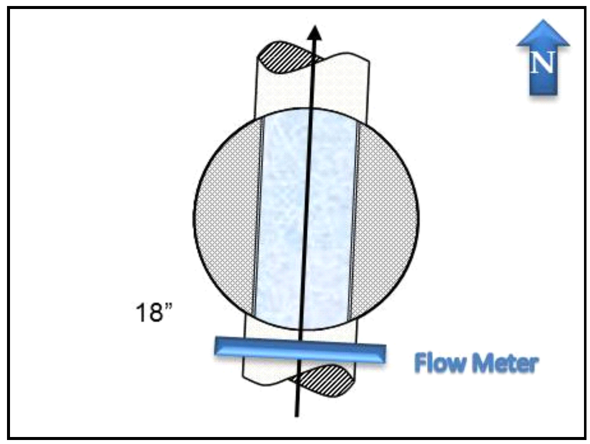
Location:	Atherton Avenue, northeast of Stevenson Lane
Coordinates:	122.2037° W, 37.4569° N
Rim Elevation:	69 feet
Pipe Diameter:	18 inches
Baseline Flow:	0.237 mgd
Peak Measured Flow:	0.825 mgd



Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

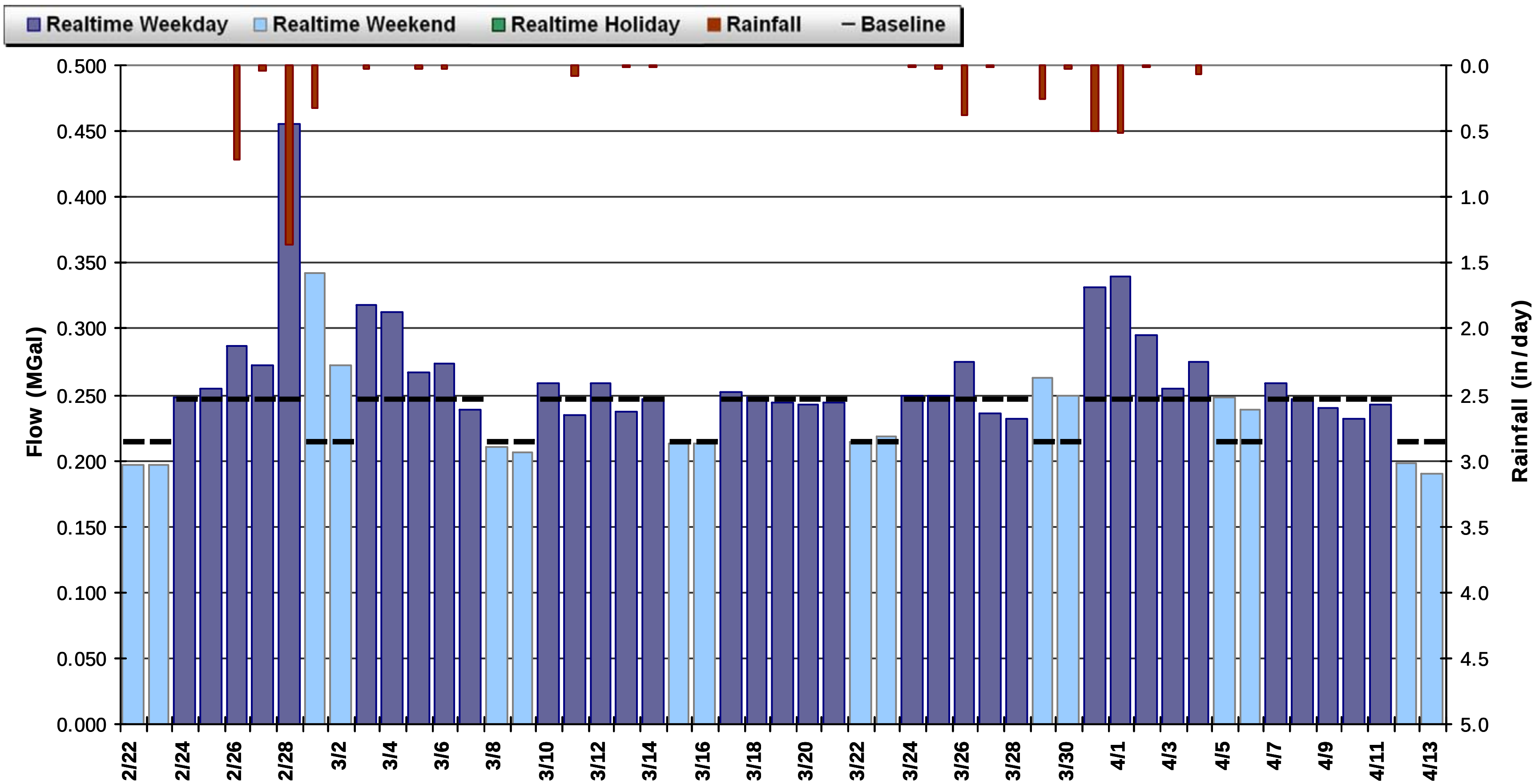
Plan View

SITE 15

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.255 MGal **Peak Daily Flow: 0.455 MGal** **Min Daily Flow: 0.190 MGal**

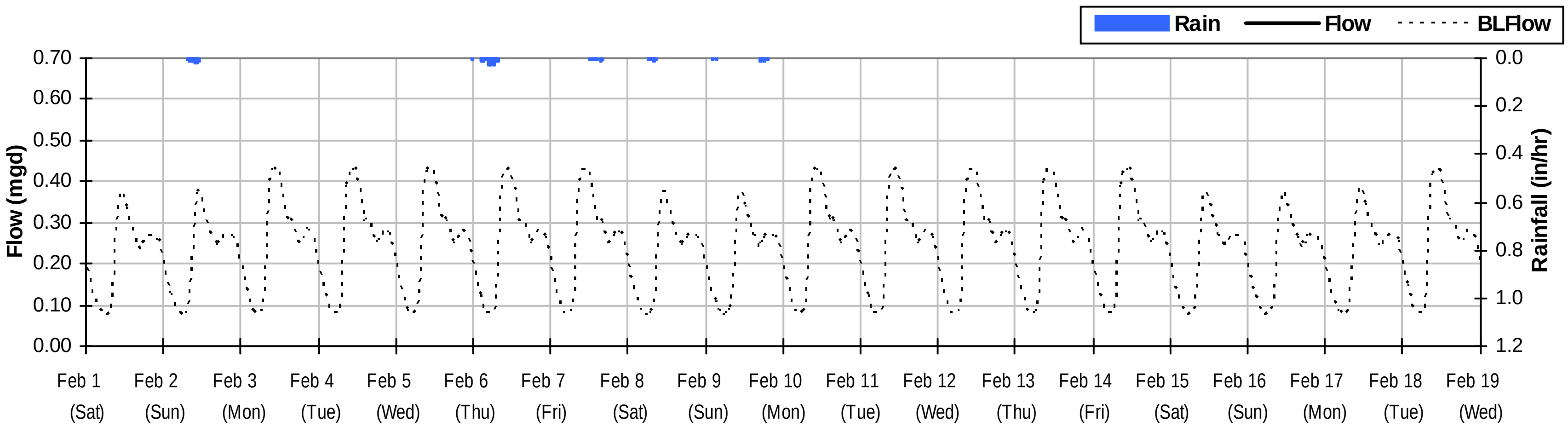
Total Period Rainfall: 4.40 inches

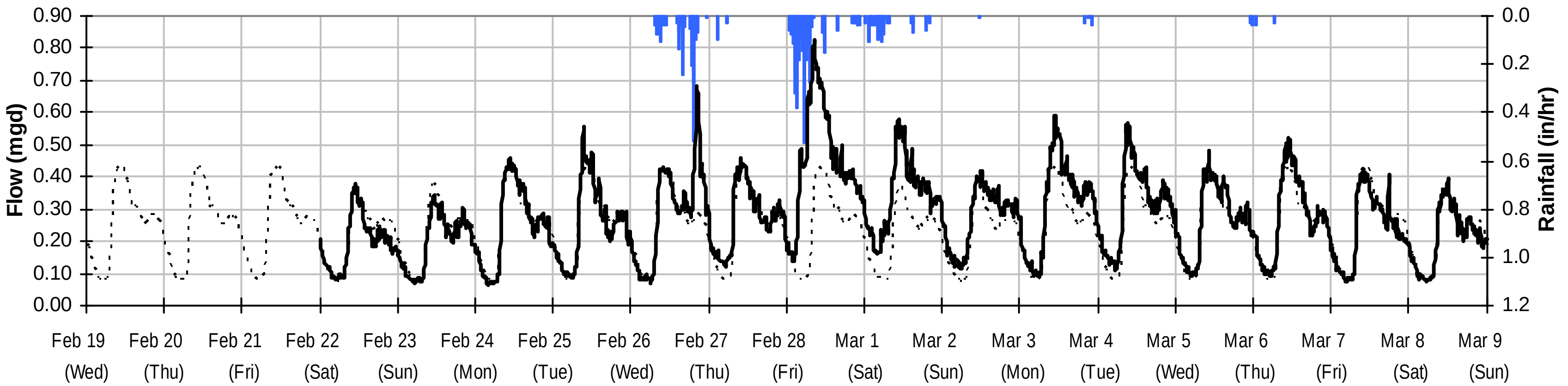


SITE 15

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.66 inches **Avg Flow: 0.255 mgd** **Peak Flow: 0.825 mgd** **Min Flow: 0.043 mgd**

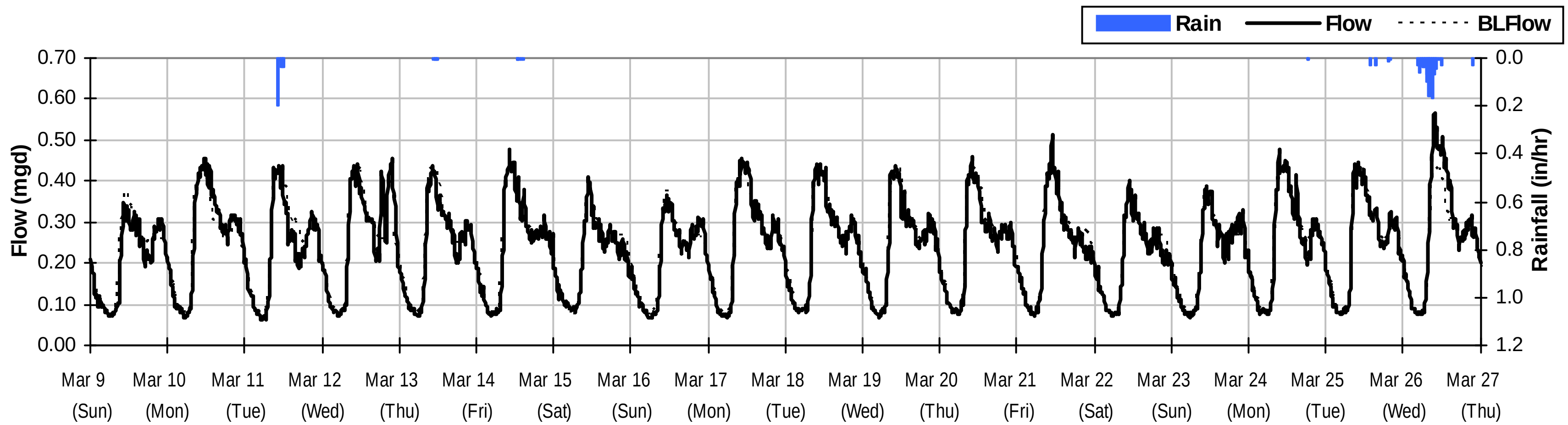


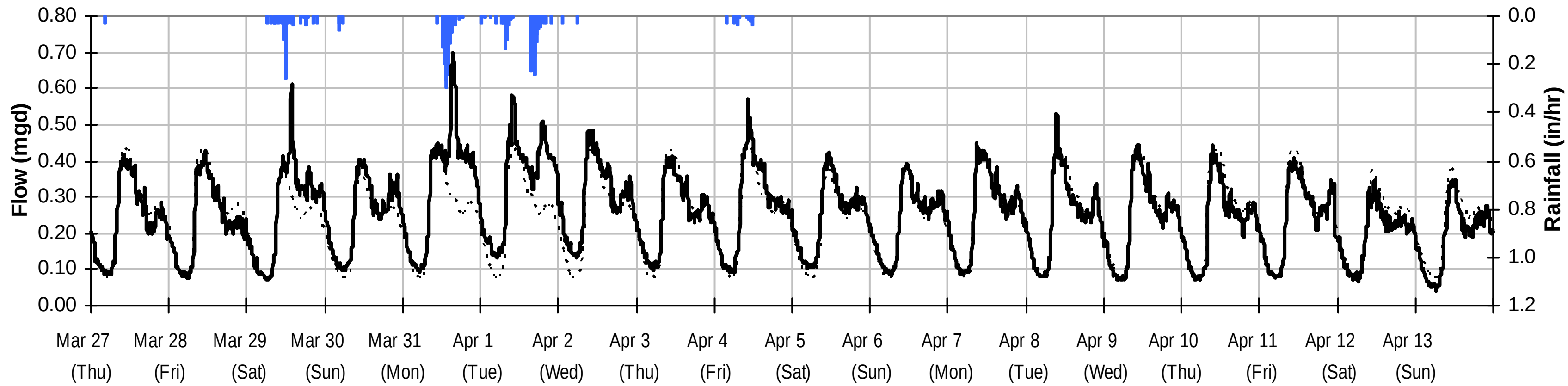


SITE 15

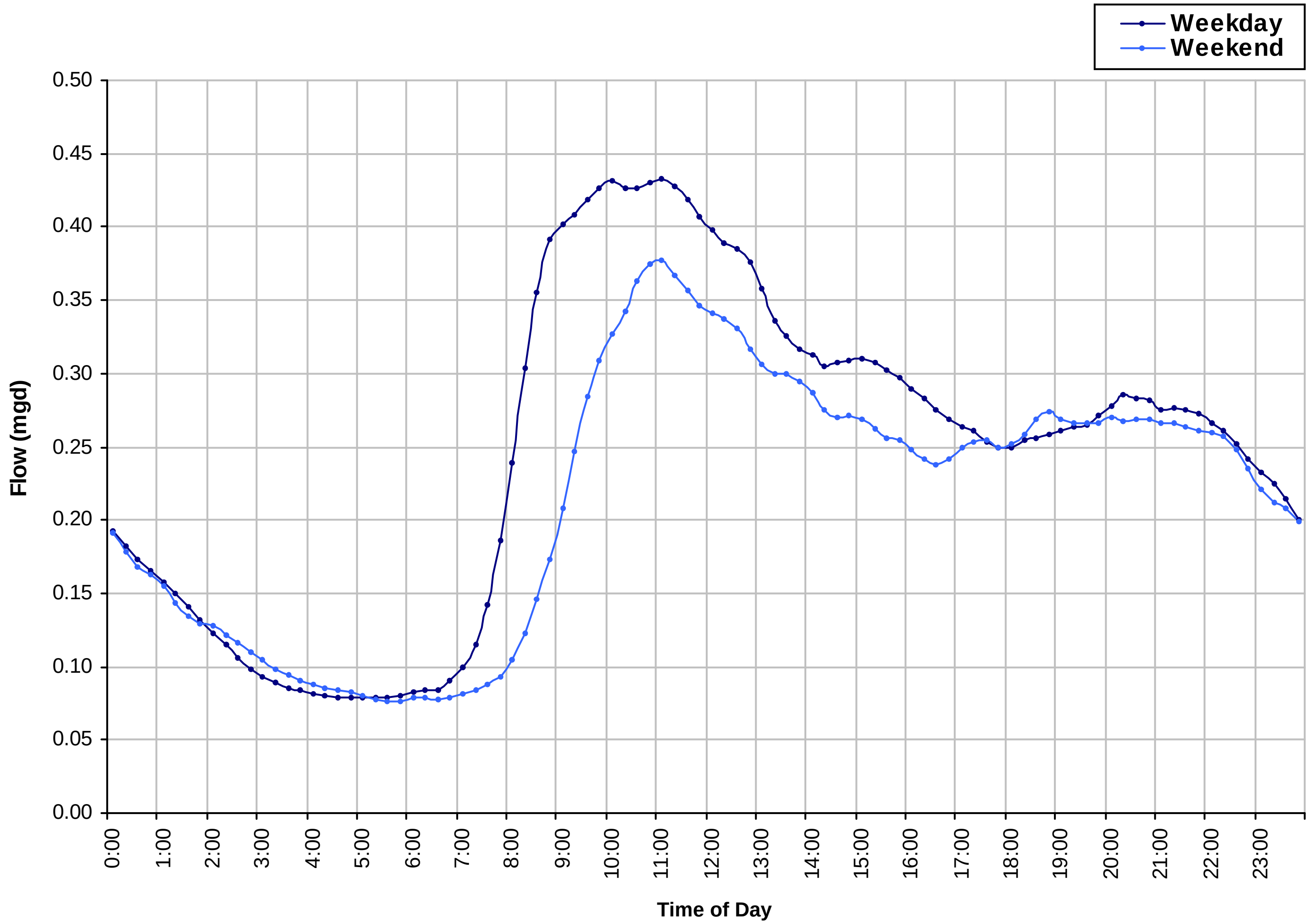
Period Flow Summary: March 9 to April 14, 2014

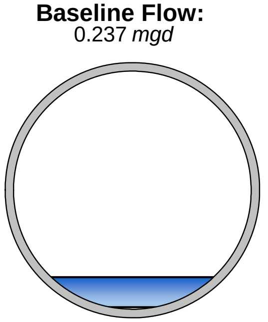
Total Monthly Rainfall: 4.66 inches **Avg Flow: 0.255 mgd** **Peak Flow: 0.825 mgd** **Min Flow: 0.043 mgd**





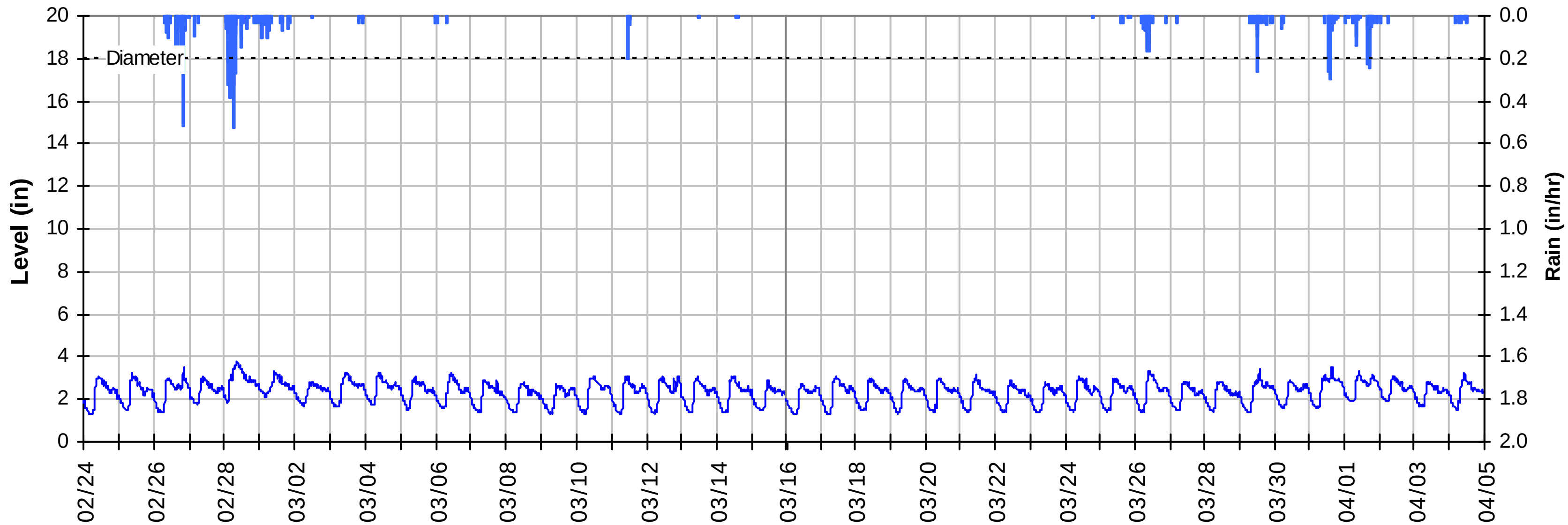
SITE 15
Baseline Flow Hydrographs

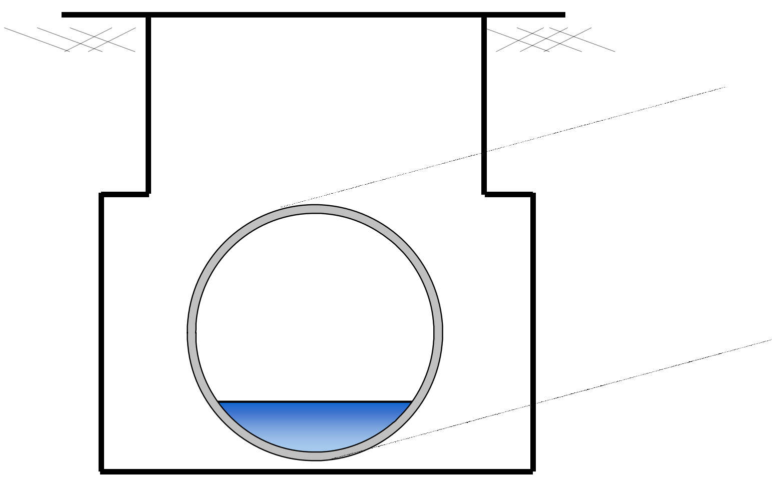




SITE 15
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





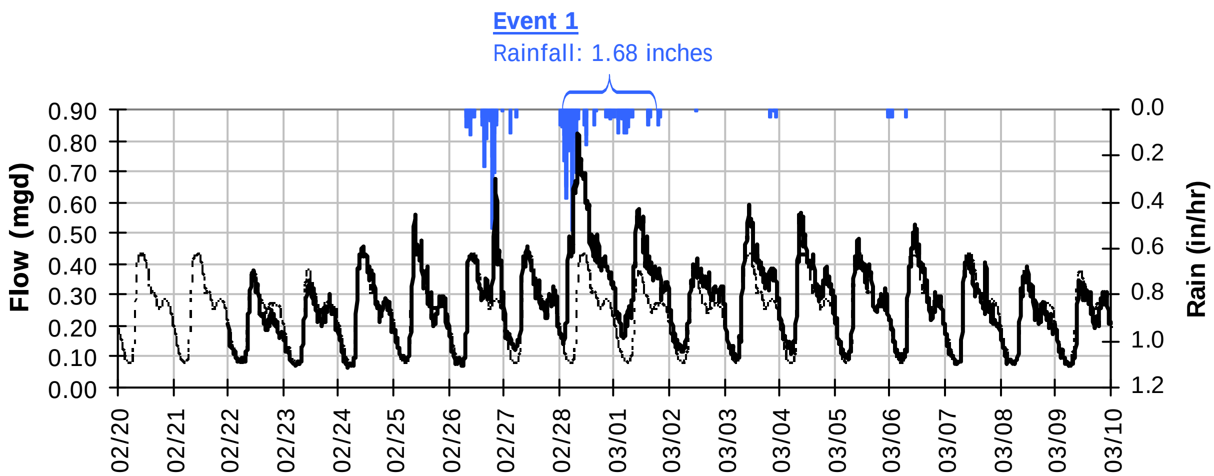
Pipe Diameter: 18 *inches*

Peak Measured Level: 3.81 *inches*

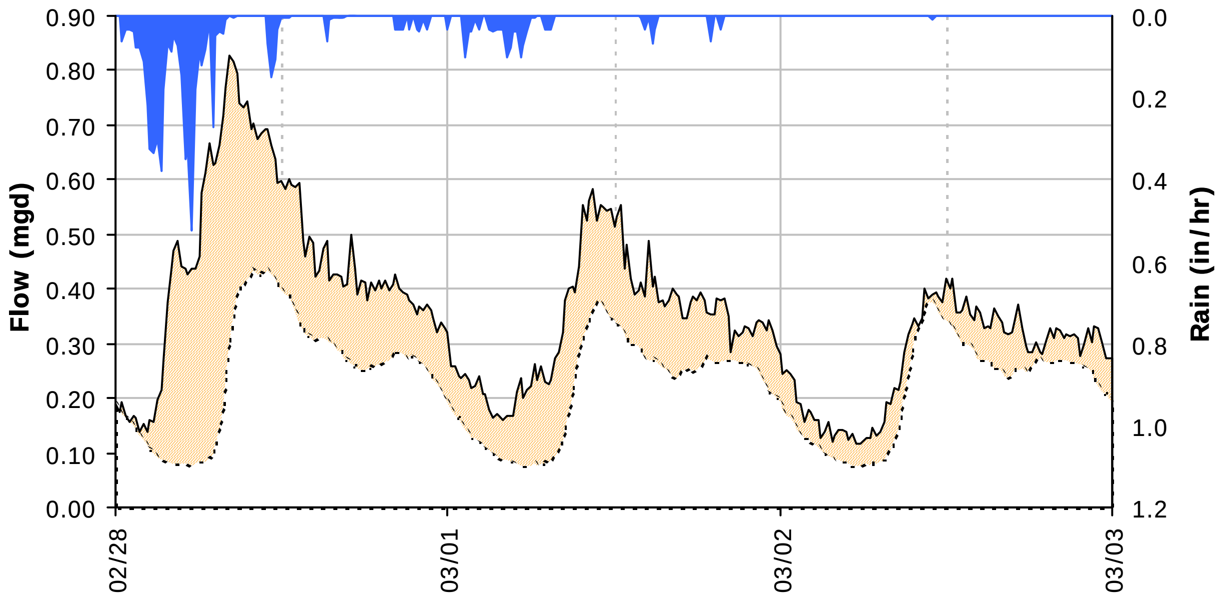
Peak d/D Ratio: 0.21

SITE 15
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

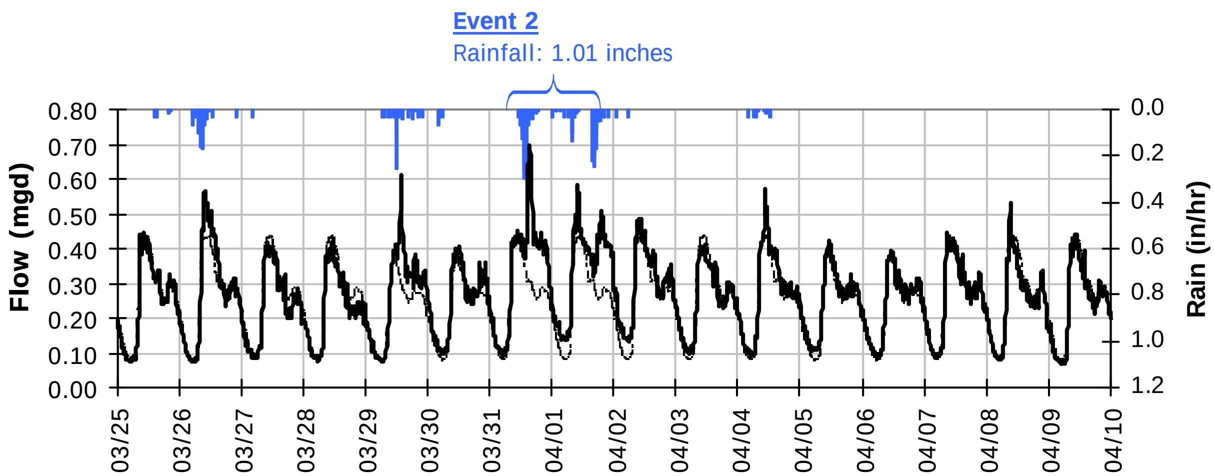


Storm Event I/I Analysis (Rain = 1.68 inches)

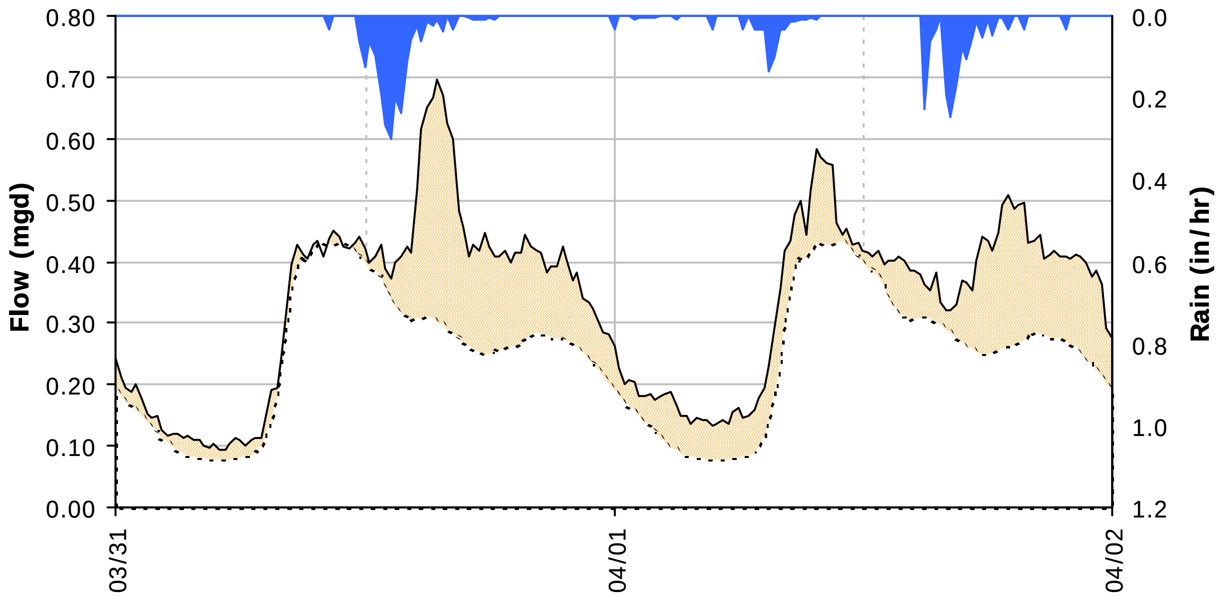
Capacity		Inflow / Infiltration	
Peak Flow:	0.83 *mgd*	**Peak I/I Rate:**	0.52 *mgd*
PF:	3.48	**Total I/I:**	393,000 *gallons*

SITE 15
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



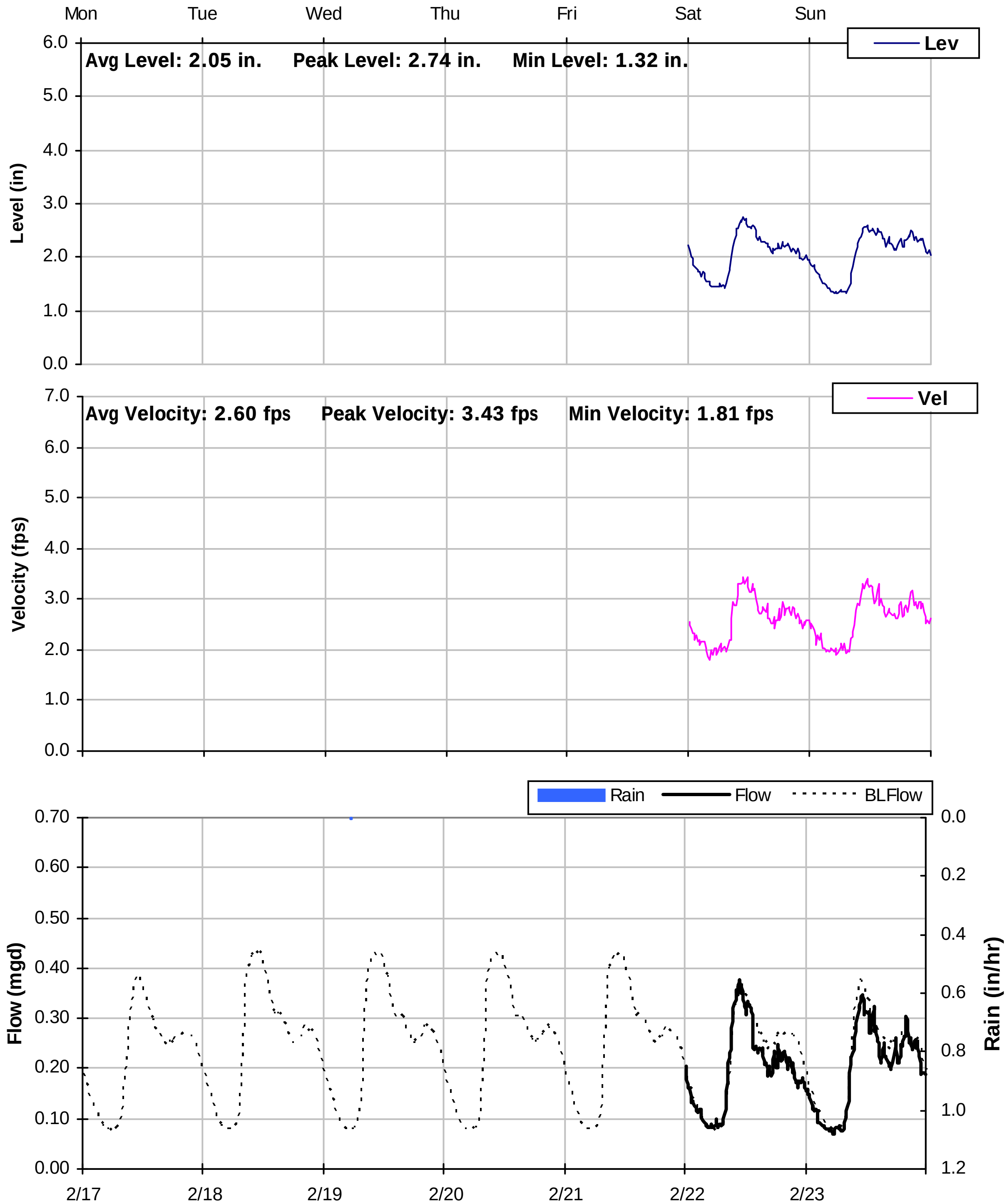
Event 2 Detail Graph



Storm Event I/I Analysis (Rain = 1.01 inches)

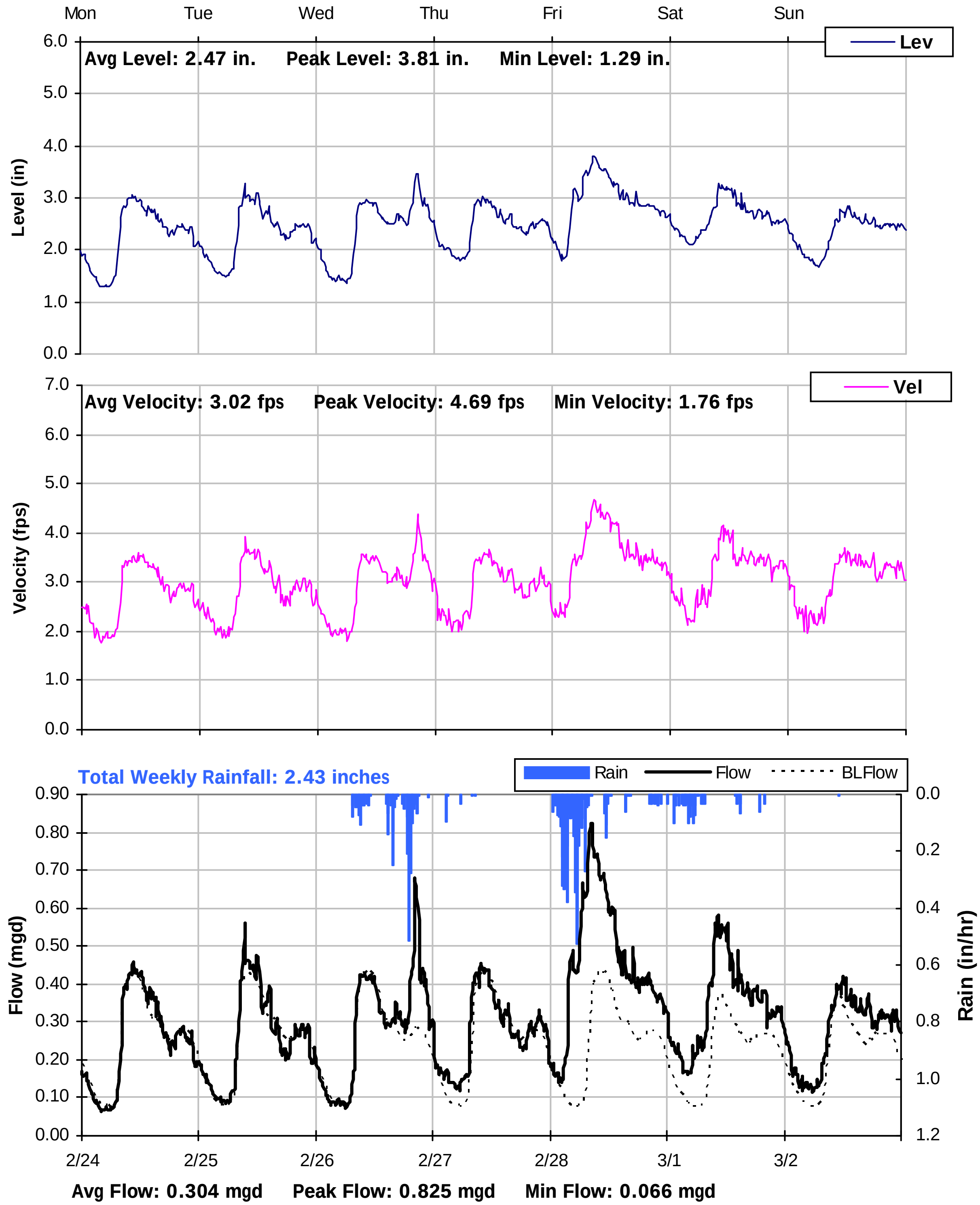
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.70 *mgd*	**Peak I/I Rate:**	0.40 *mgd*
PF:	2.94	**Total I/I:**	235,000 *gallons*

SITE 15
Weekly Level, Velocity and Flow Hydrographs
2/17/2014 to 2/24/2014

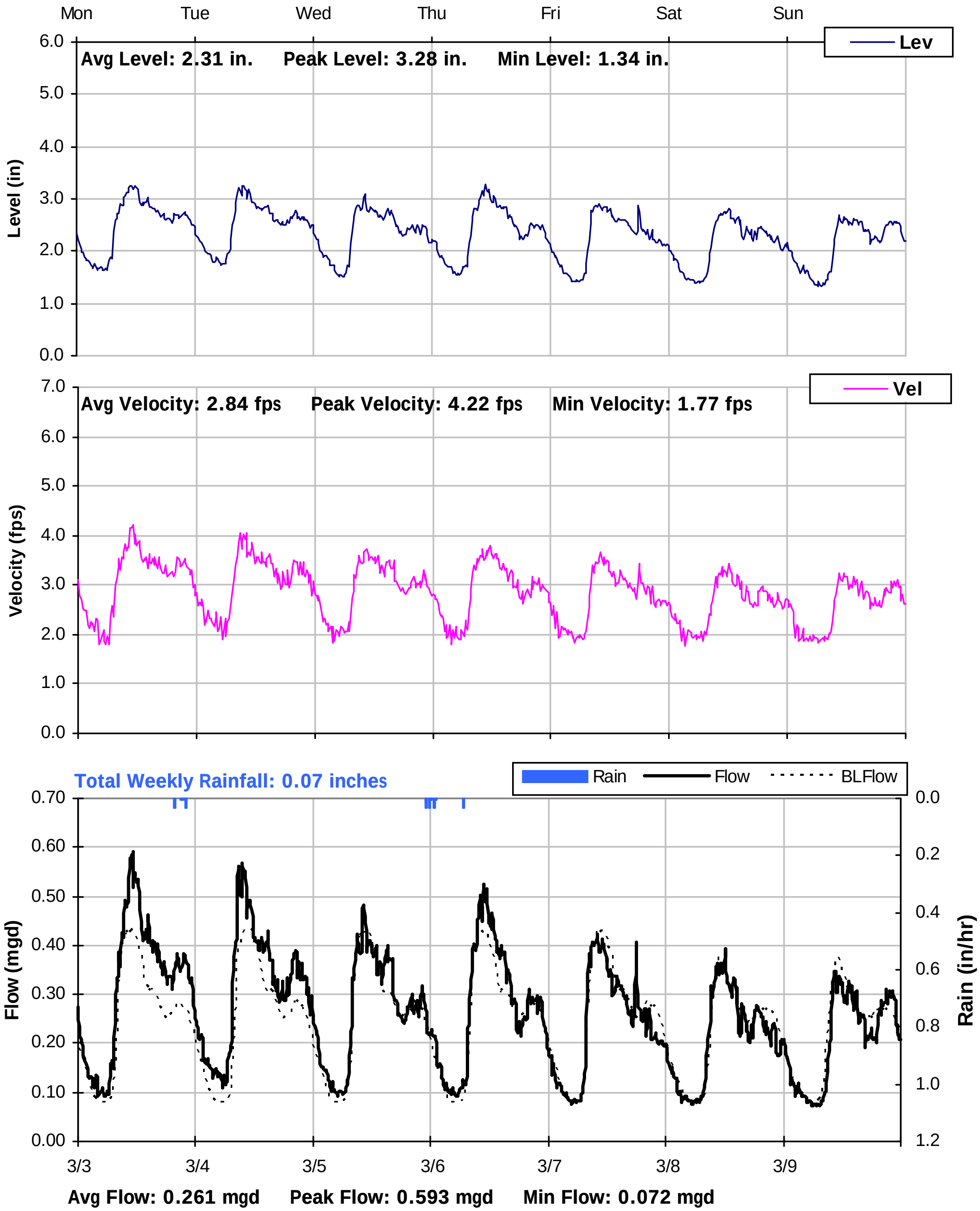


Avg Flow: 0.197 mgd **Peak Flow: 0.377 mgd** **Min Flow: 0.071 mgd**

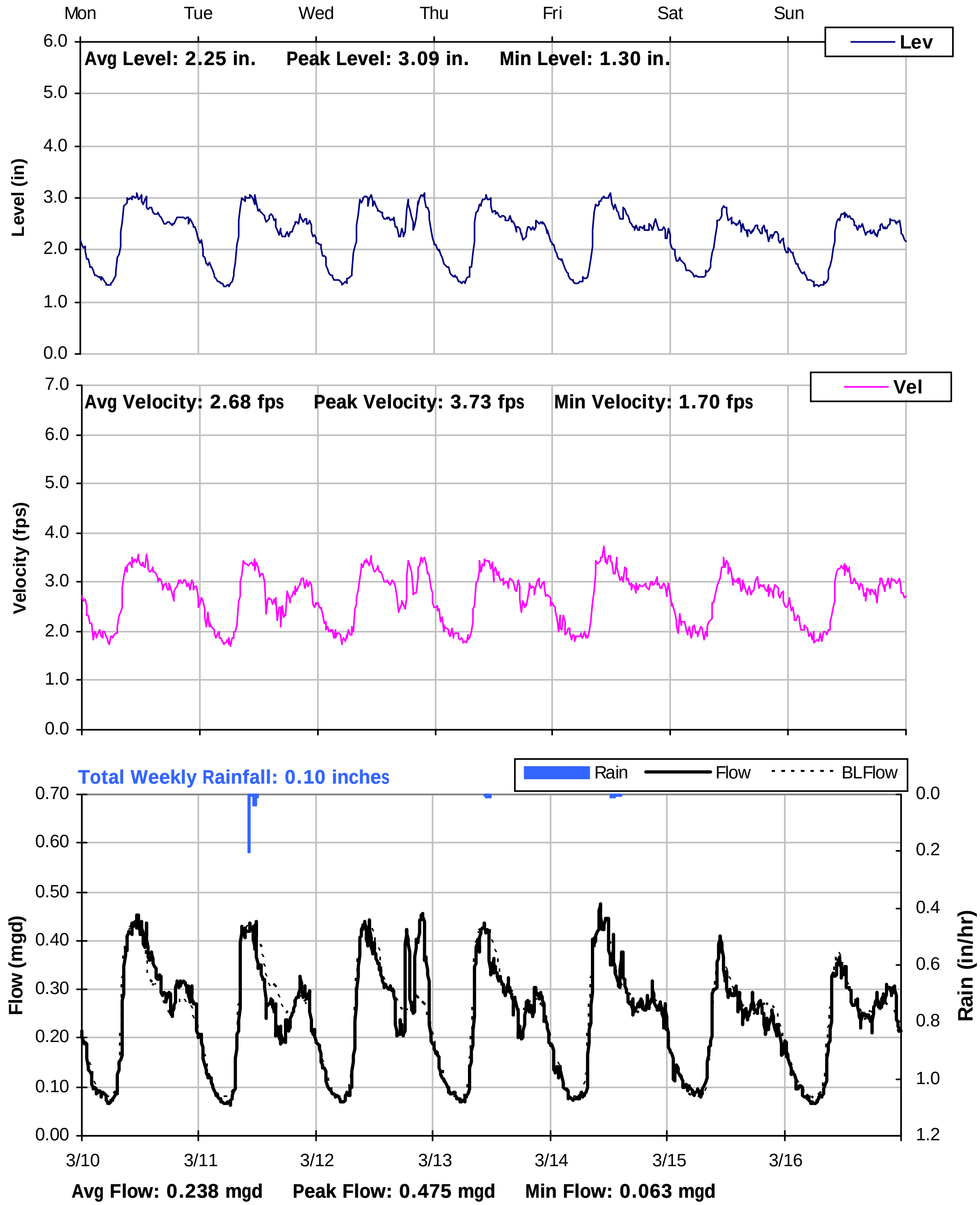
SITE 15
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



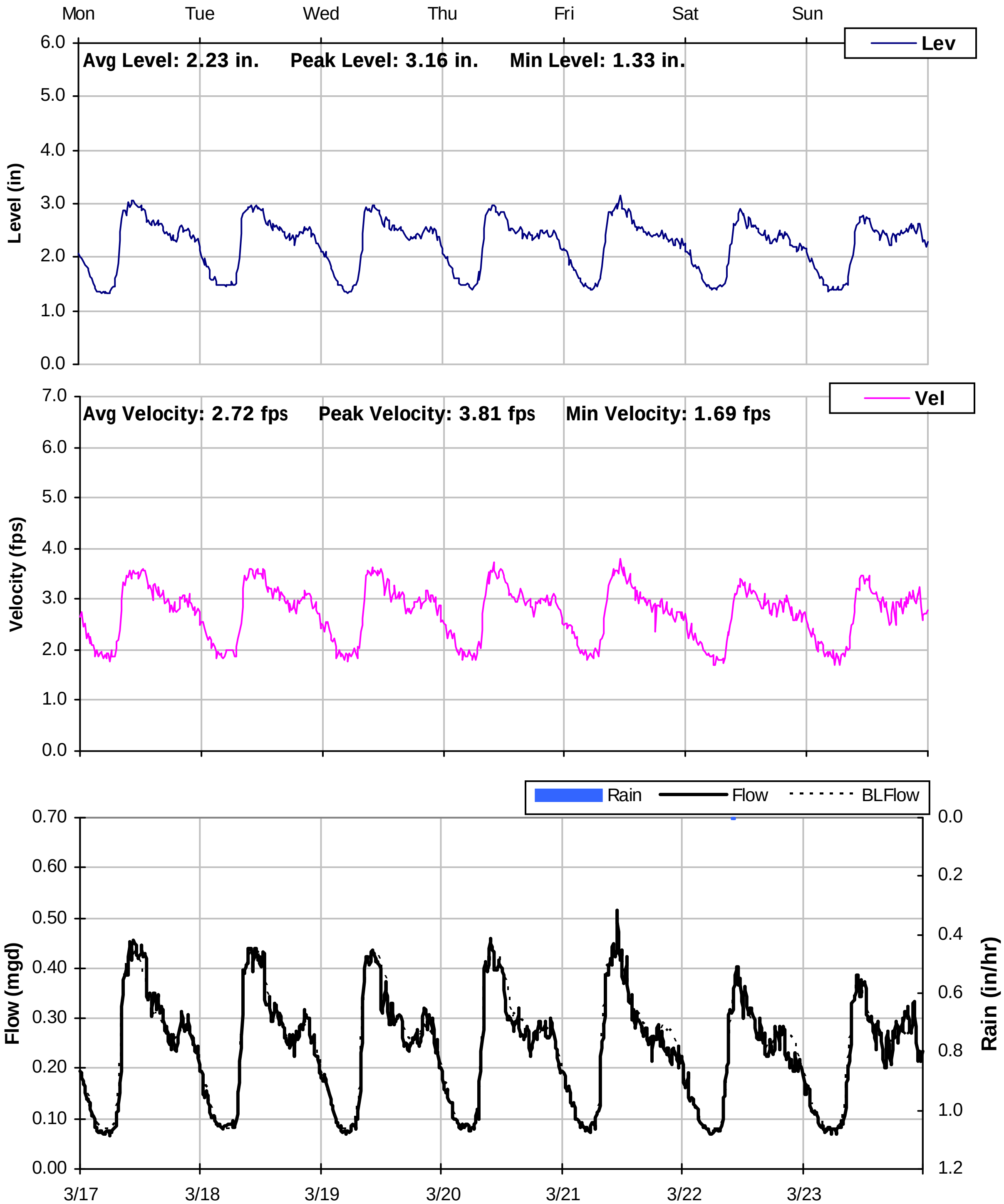
SITE 15
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



SITE 15
Weekly Level, Velocity and Flow Hydrographs
3/10/2014 to 3/17/2014

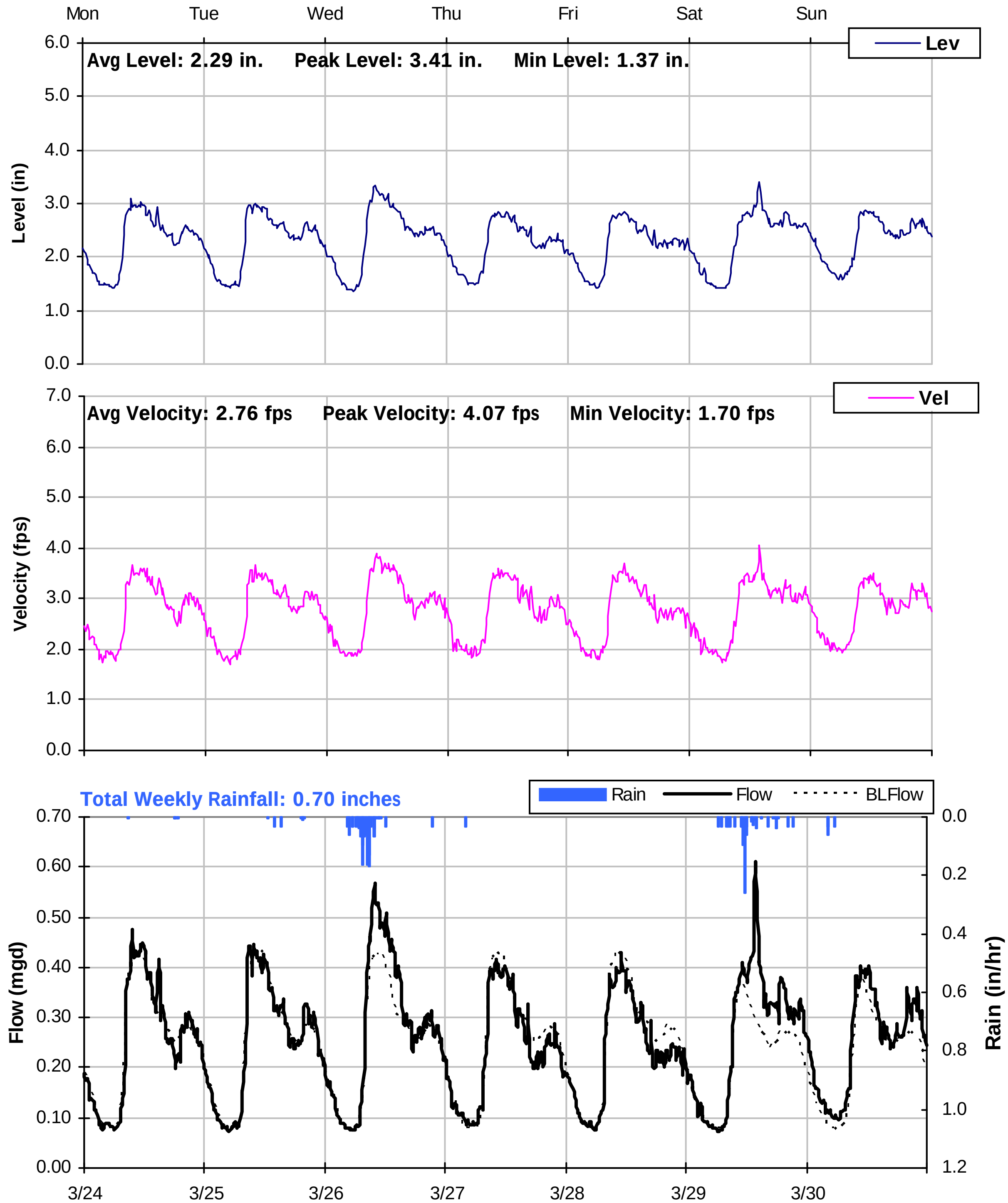


SITE 15
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



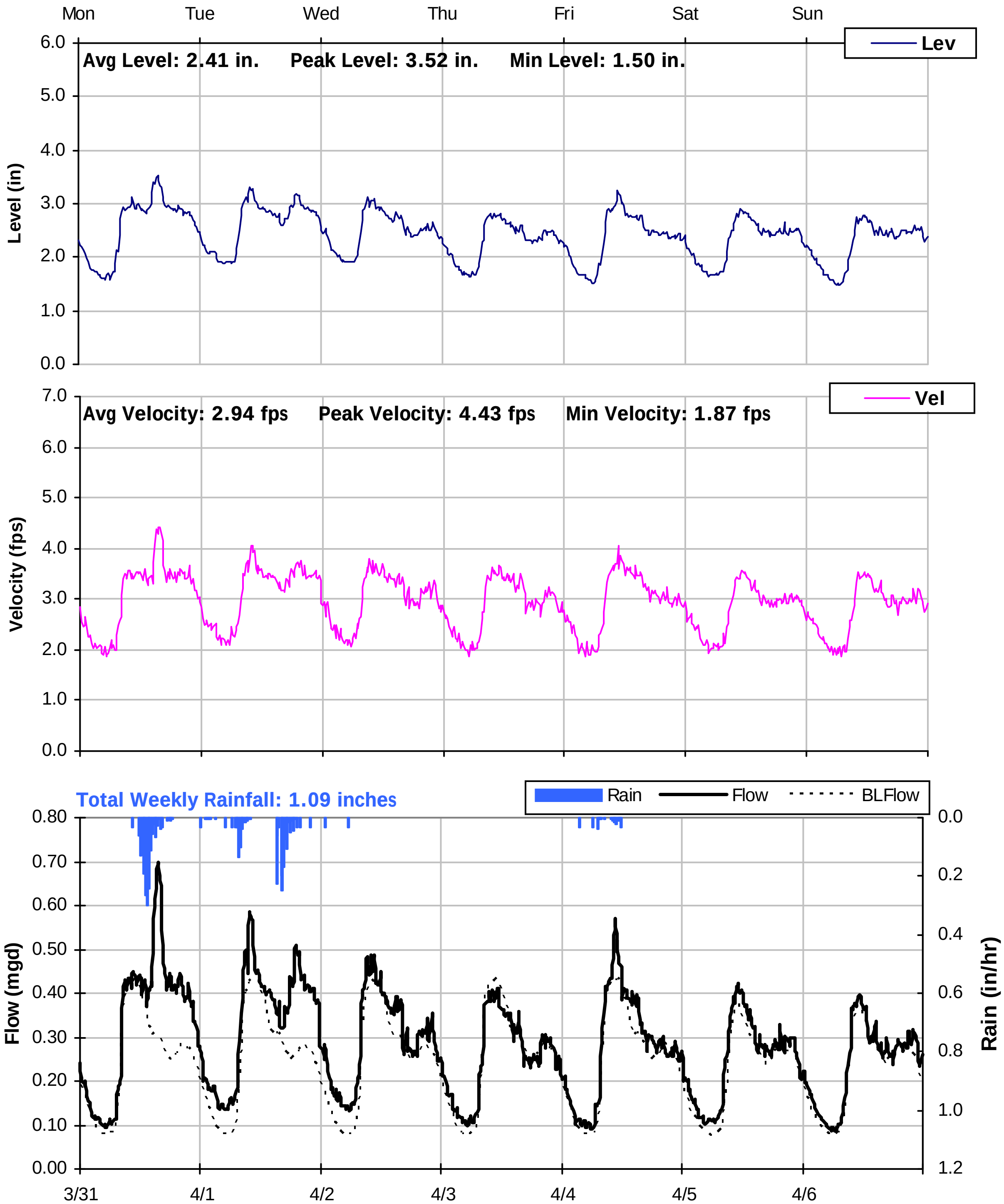
Avg Flow: 0.238 mgd **Peak Flow: 0.514 mgd** **Min Flow: 0.067 mgd**

SITE 15
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



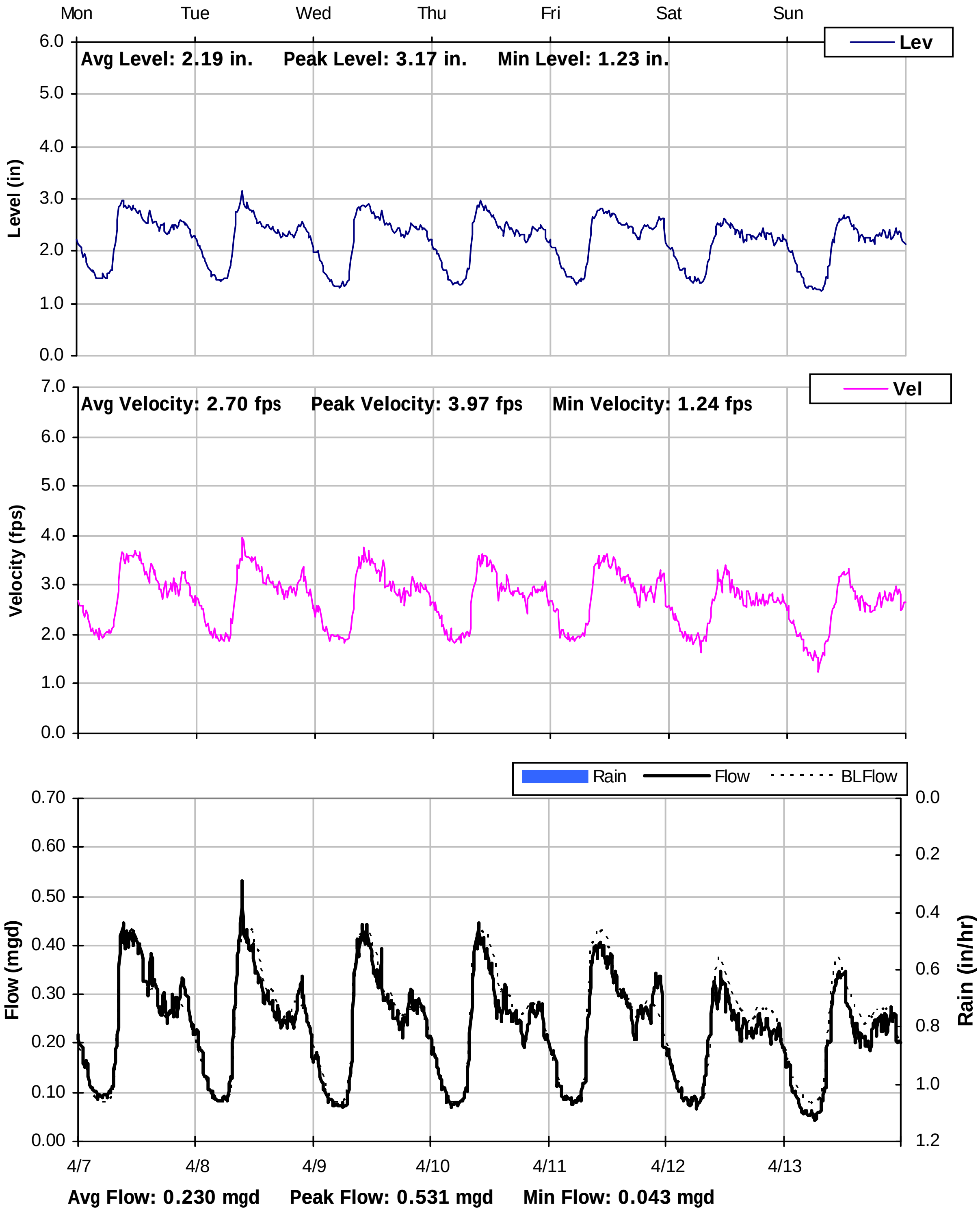
Avg Flow: 0.251 mgd **Peak Flow: 0.612 mgd** **Min Flow: 0.073 mgd**

SITE 15
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



Avg Flow: 0.283 mgd **Peak Flow: 0.698 mgd** **Min Flow: 0.086 mgd**

SITE 15
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



West Bay Sanitary District

Sanitary Sewer Flow Monitoring Study

January 17 to April 13, 2014

Monitoring Site: Site 16

Location: Atherton Avenue, northeast of Austin Avenue

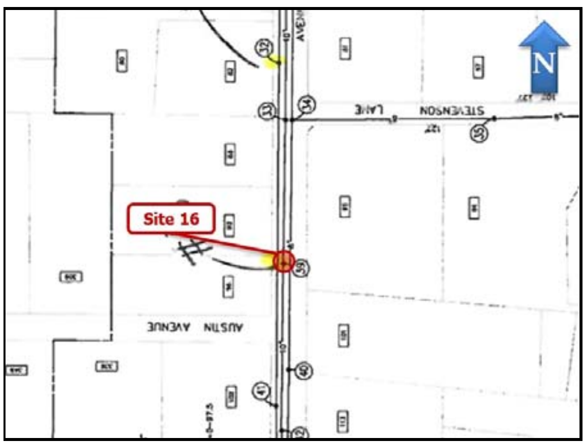
Data Summary Report

SITE 16

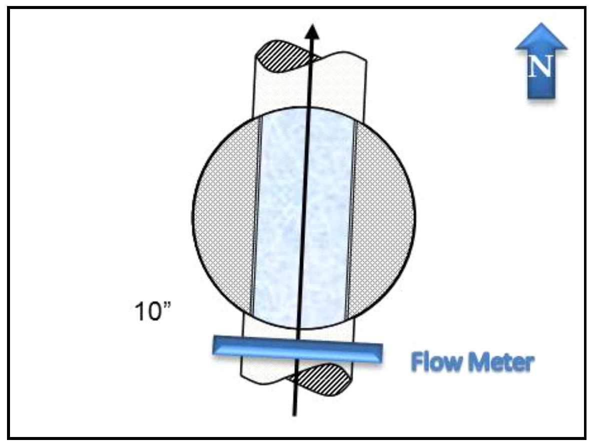
Site Information

Location:	Atherton Avenue, northeast of Austin Avenue
Coordinates:	122.2045° W, 37.4559° N
Rim Elevation:	67 feet
Pipe Diameter:	10 inches
Baseline Flow:	0.008 mgd
Peak Measured Flow:	0.092 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

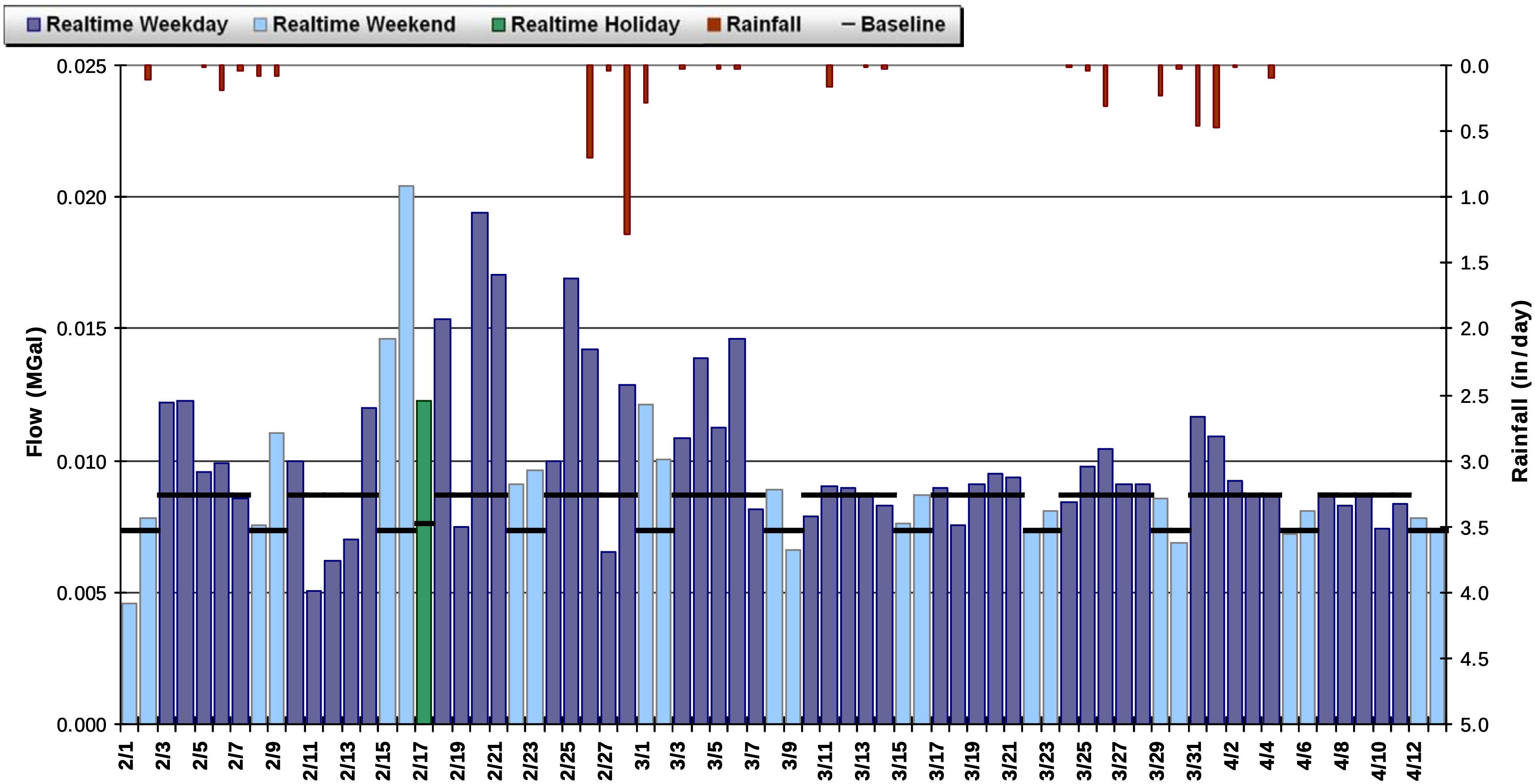
Plan View

SITE 16

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.010 MGal **Peak Daily Flow: 0.020 MGal** **Min Daily Flow: 0.005 MGal**

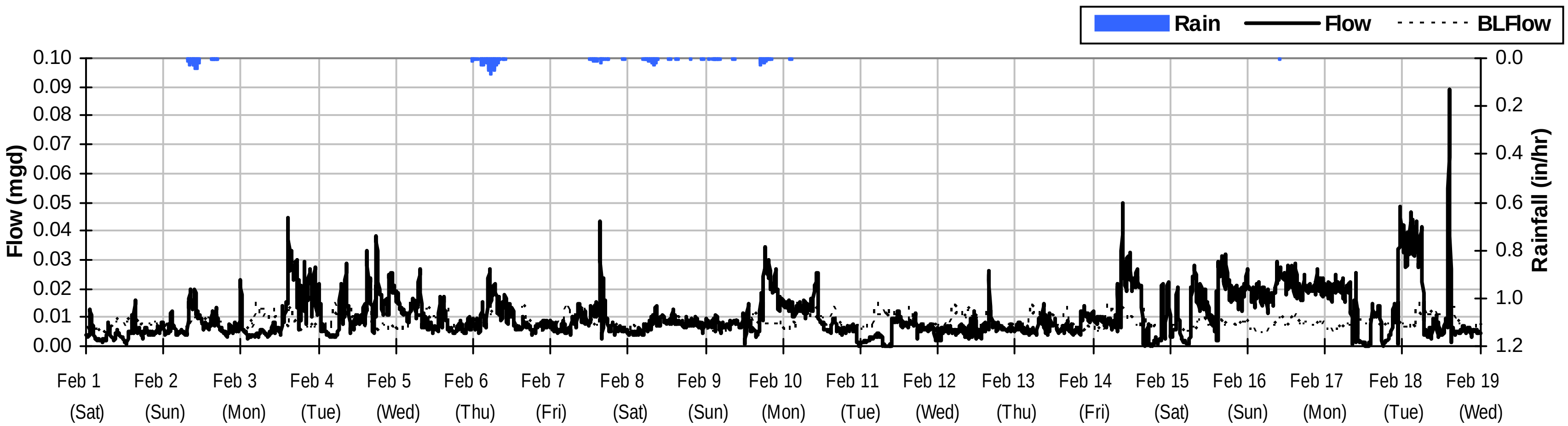
Total Period Rainfall: 4.79 inches

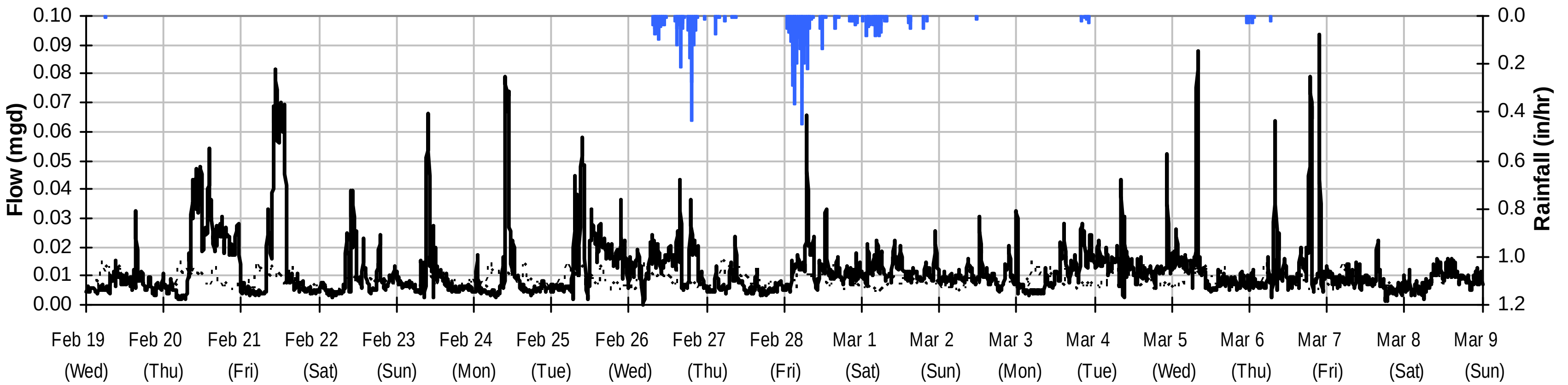


SITE 16

Period Flow Summary: February 1 to March 9, 2014

Total Monthly Rainfall: 4.79 inches **Avg Flow: 0.010 mgd** **Peak Flow: 0.092 mgd** **Min Flow: 0.000 mgd**

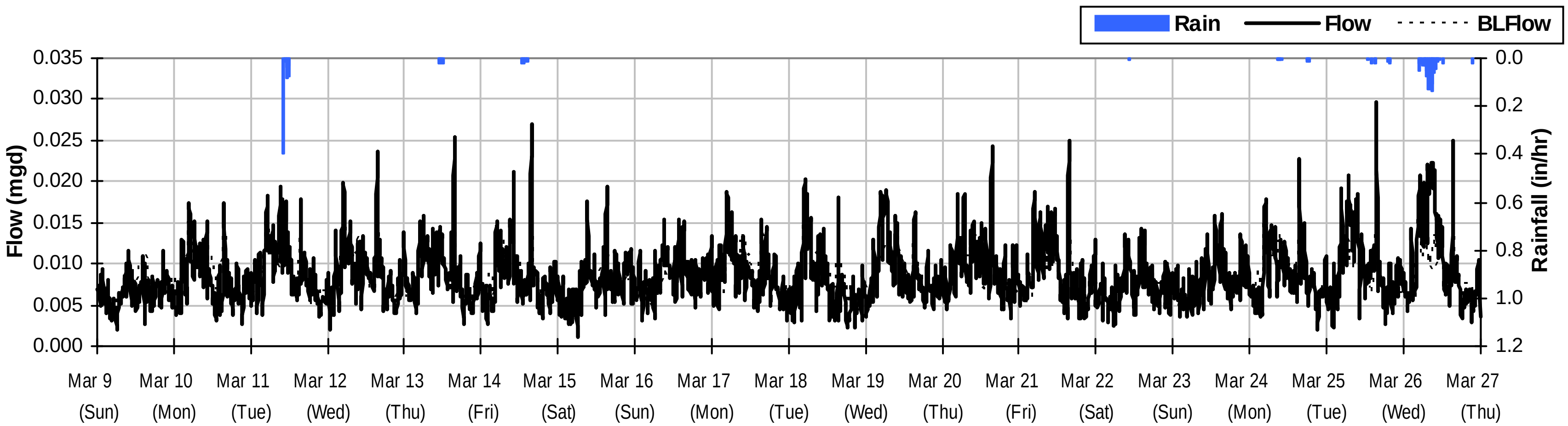


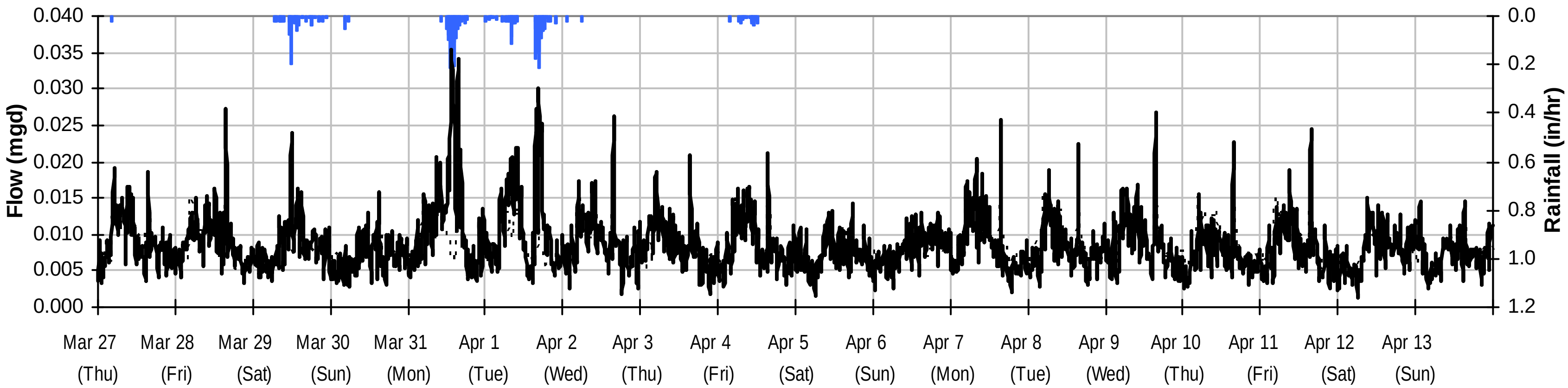


SITE 16

Period Flow Summary: March 9 to April 14, 2014

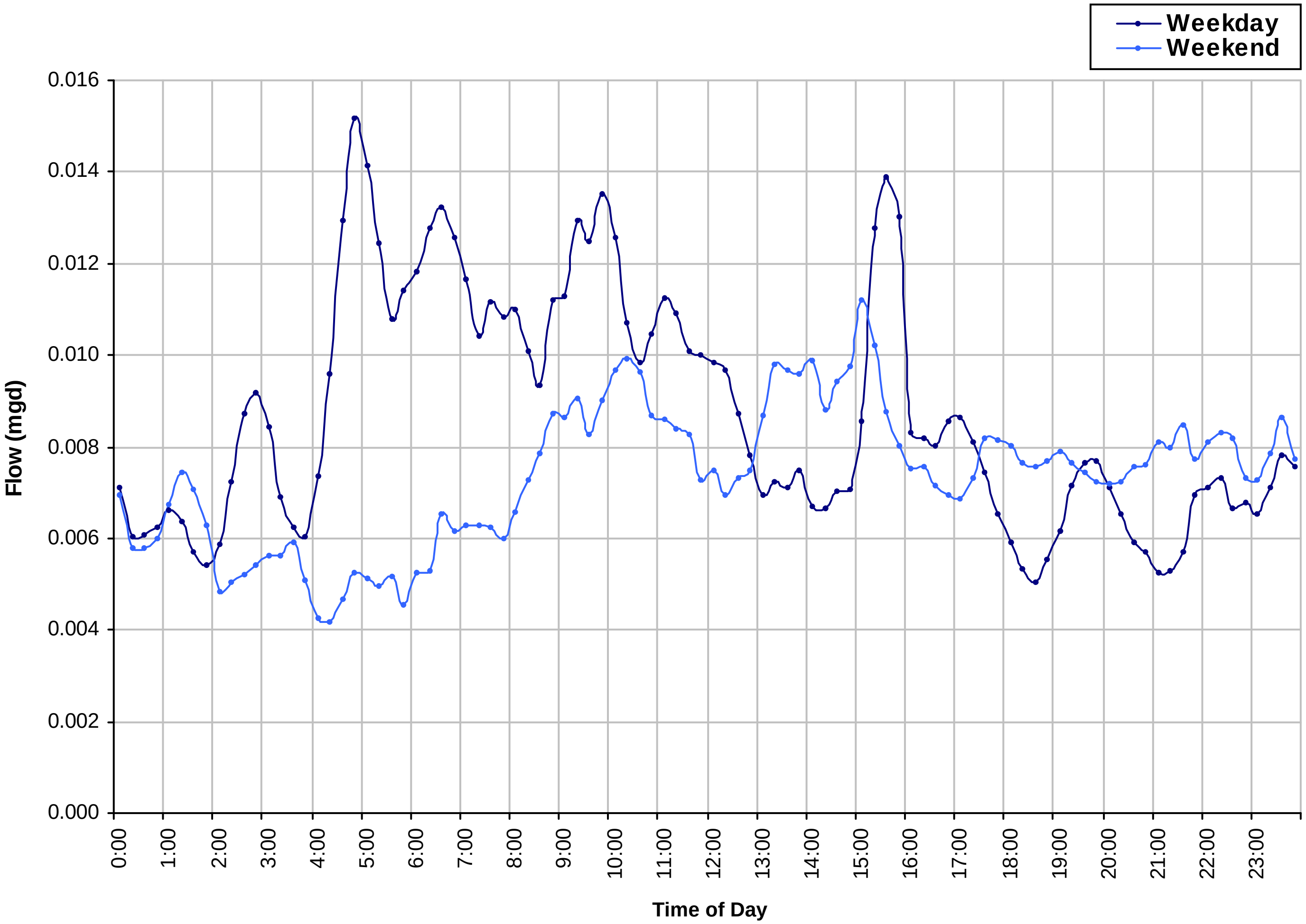
Total Monthly Rainfall: 4.79 inches **Avg Flow: 0.010 mgd** **Peak Flow: 0.092 mgd** **Min Flow: 0.000 mgd**



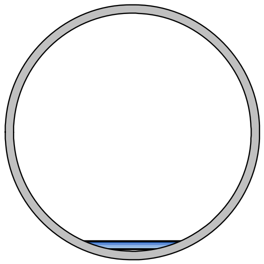


SITE 16

Baseline Flow Hydrographs

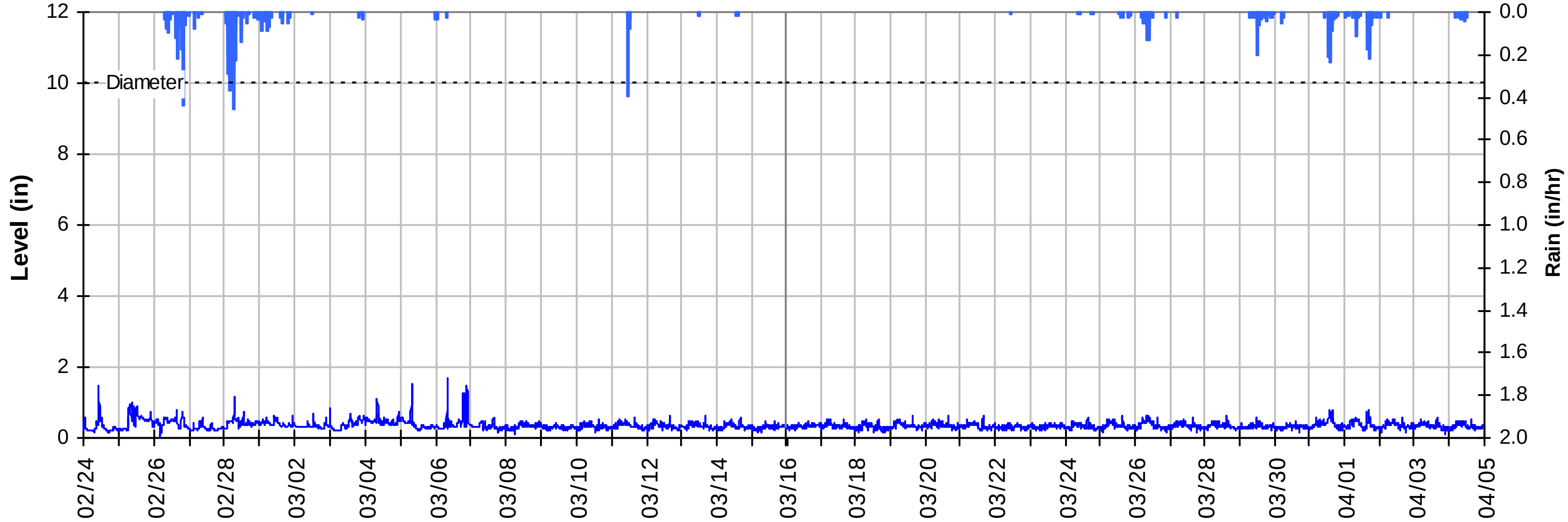


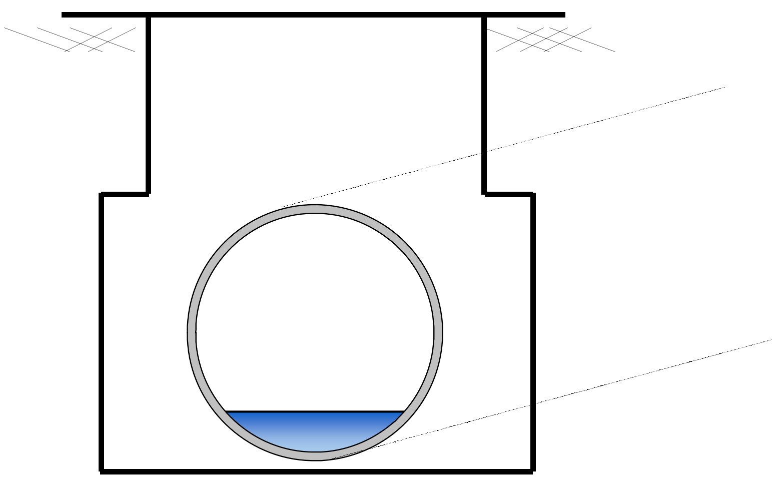
Baseline Flow:
0.008 *mgd*



SITE 16
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

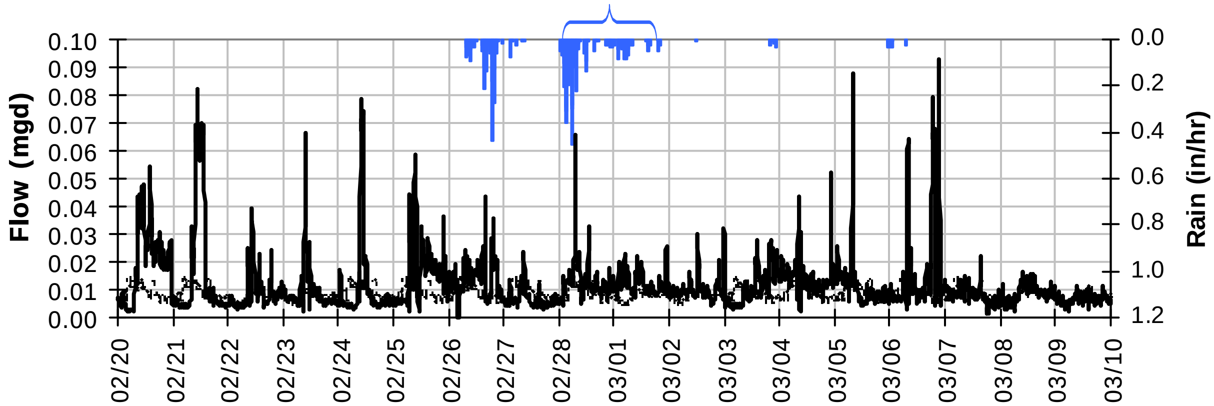




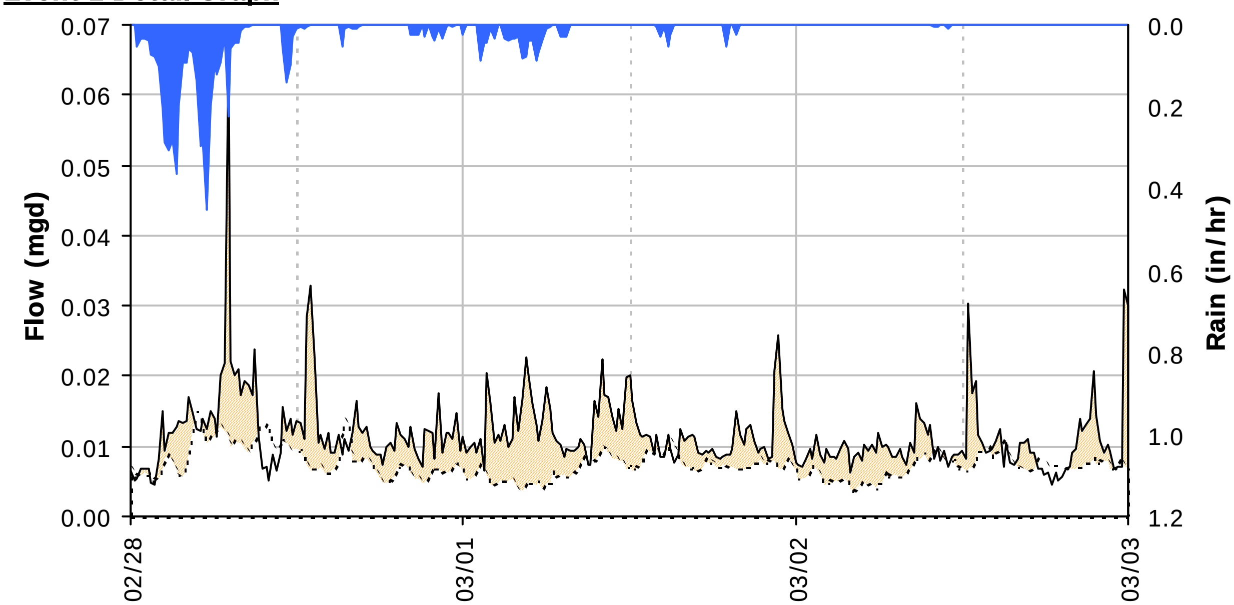
Pipe Diameter:	10	*inches*
Peak Measured Level:	1.7	*inches*
Peak d/D Ratio:	0.17	

SITE 16
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

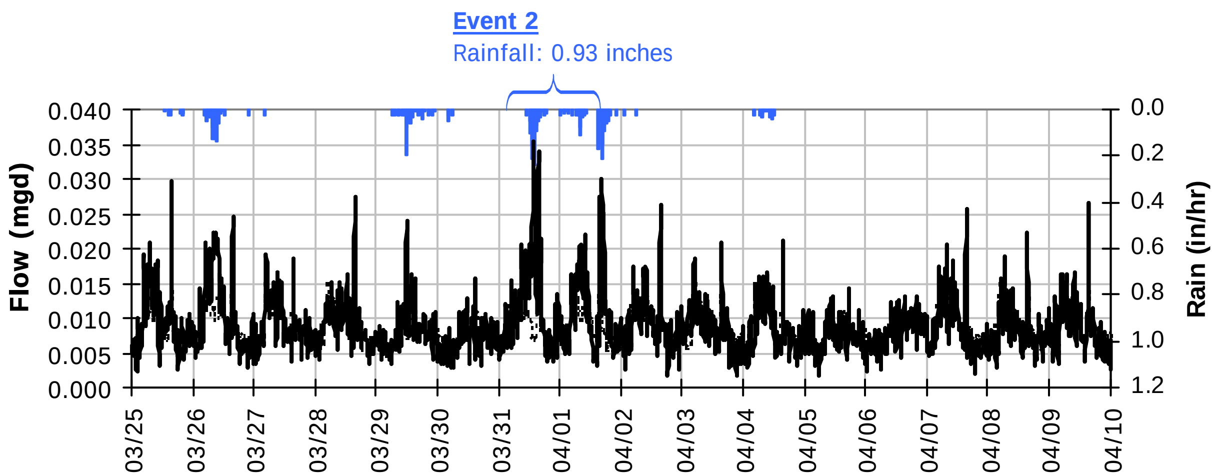


Storm Event I/I Analysis (Rain = 1.58 inches)

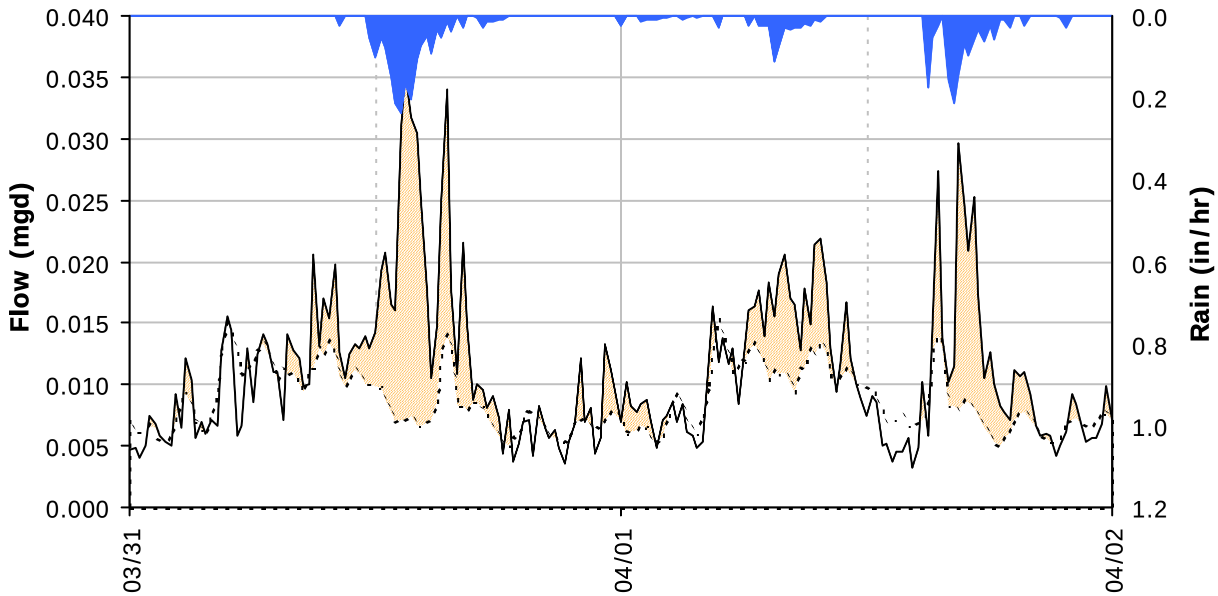
Capacity		**Inflow / Infiltration**	
Peak Flow:	0.07 *mgd*	**Peak I/I Rate:**	0.05 *mgd*
PF:	7.93	**Total I/I:**	13,000 *gallons*

SITE 16
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



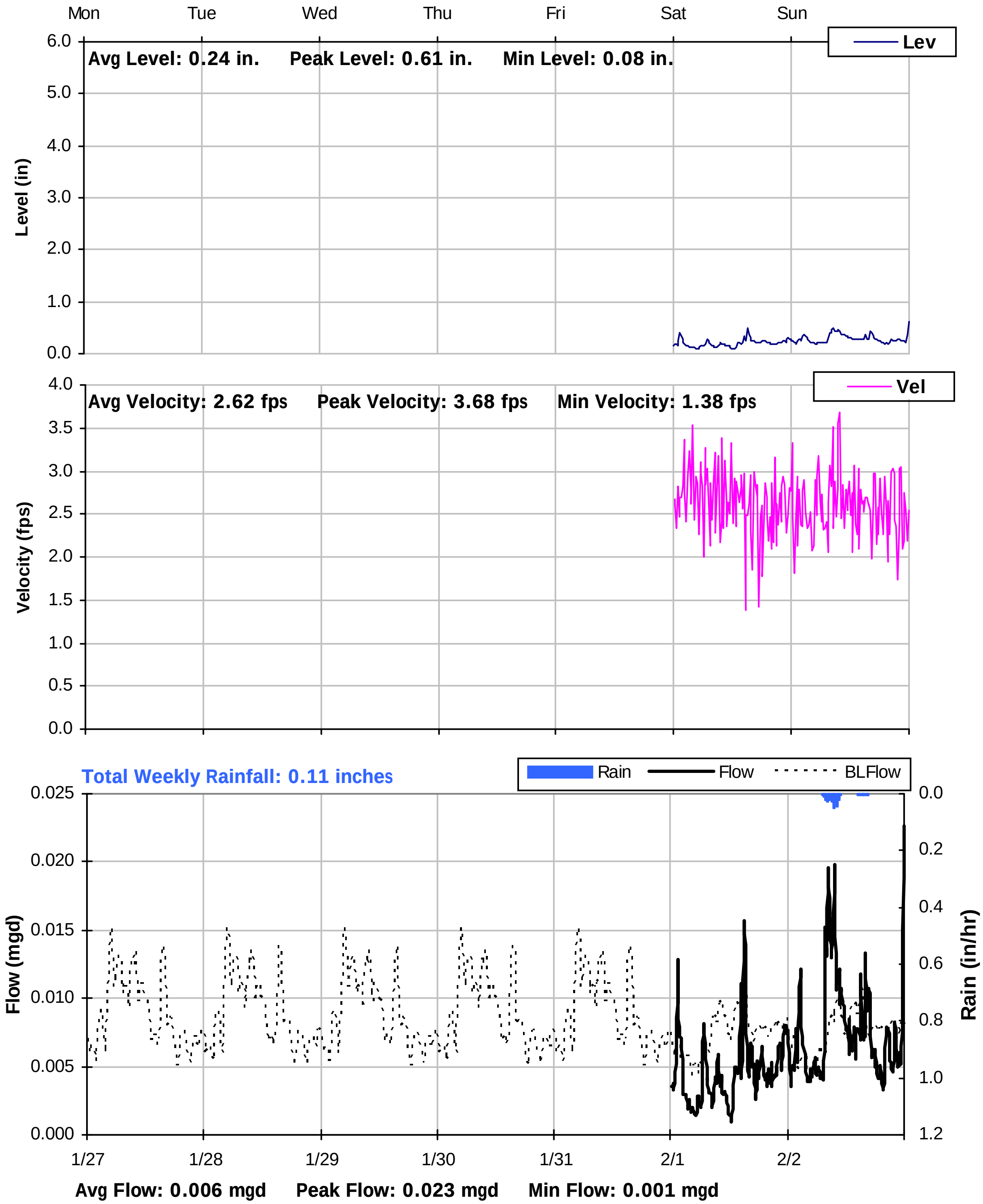
Event 2 Detail Graph



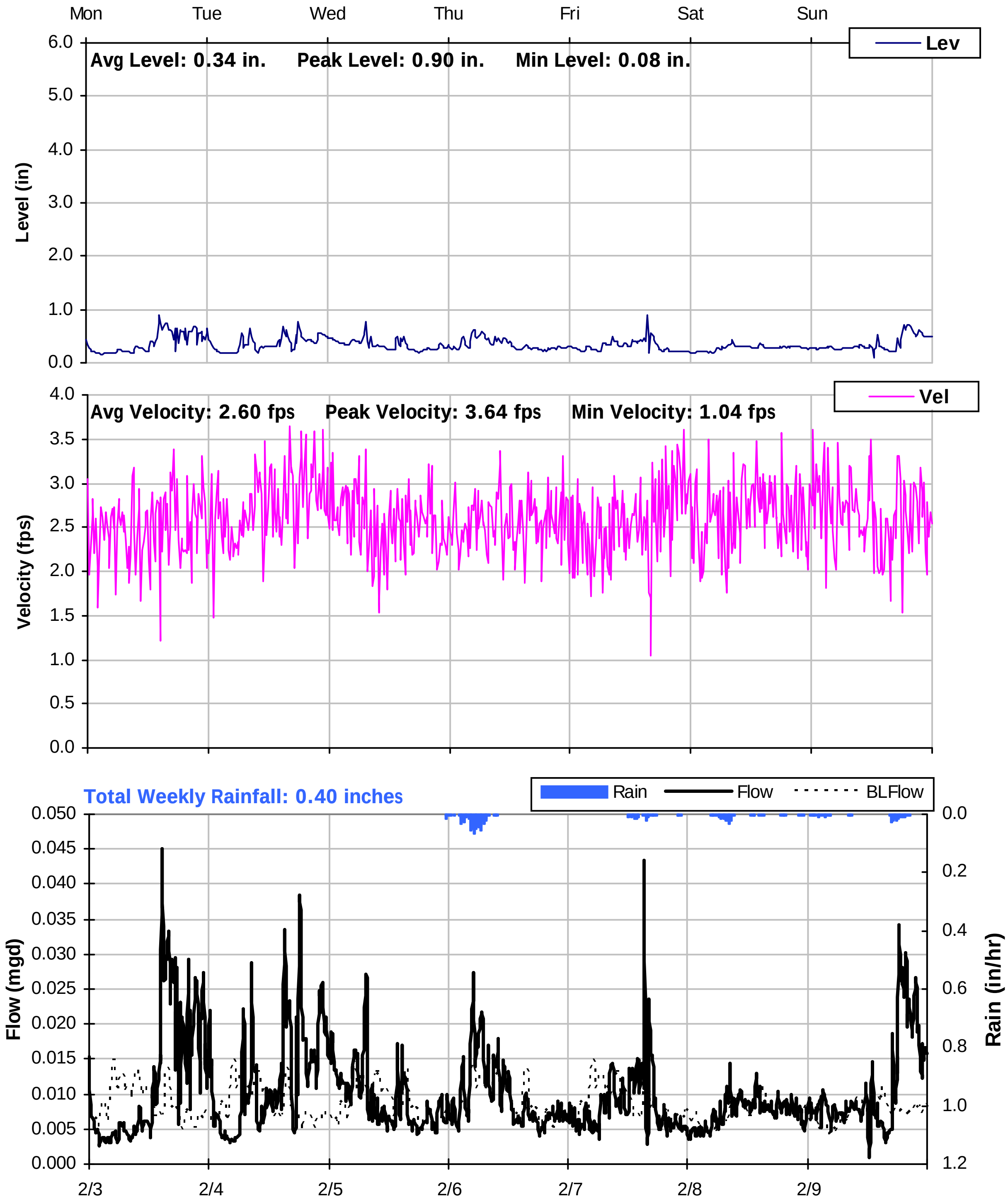
Storm Event I/I Analysis (Rain = 0.93 inches)

Capacity		**Inflow / Infiltration**	
Peak Flow:	0.04 *mgd*	**Peak I/I Rate:**	0.03 *mgd*
PF:	4.26	**Total I/I:**	6,000 *gallons*

SITE 16
Weekly Level, Velocity and Flow Hydrographs
1/27/2014 to 2/3/2014

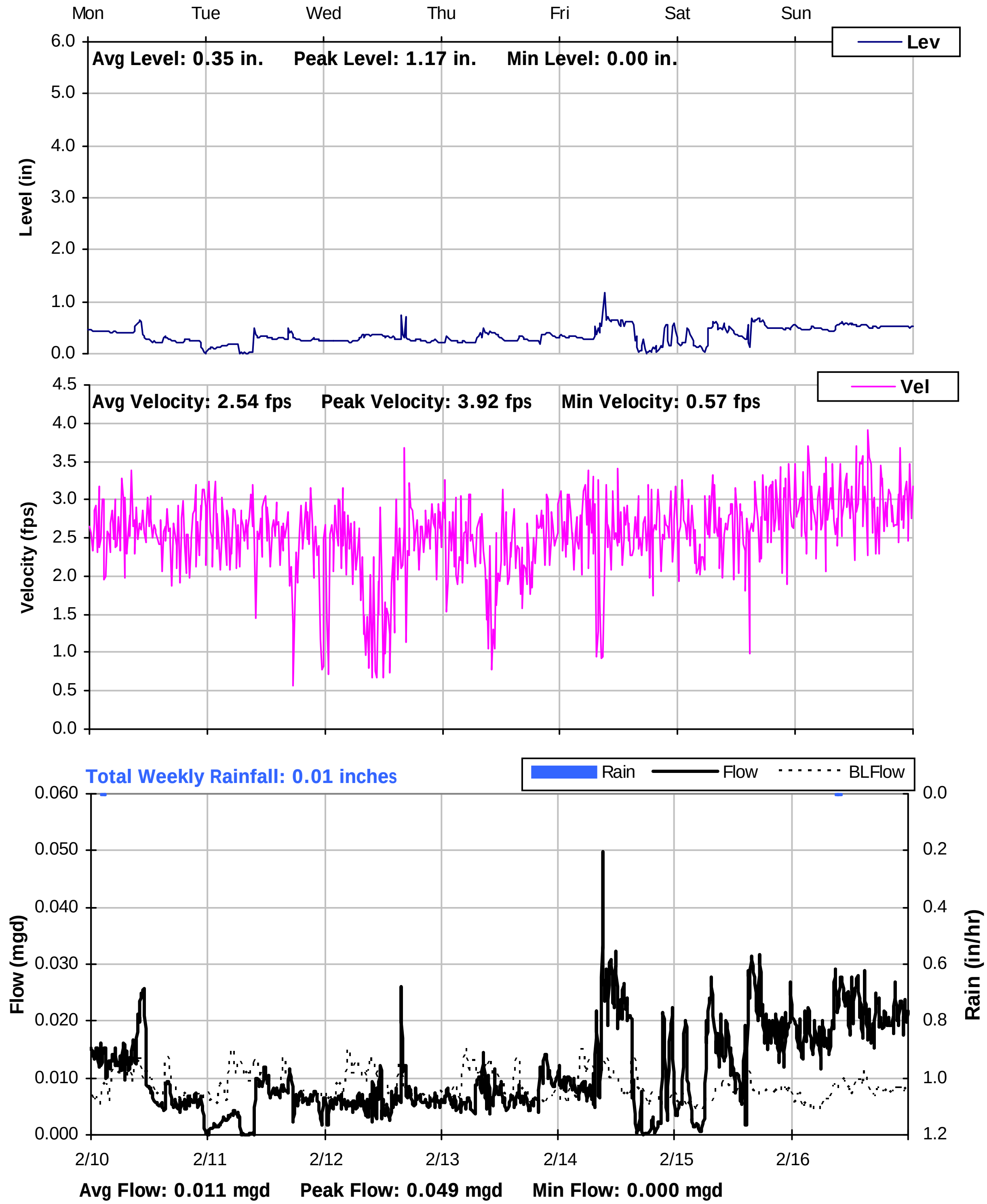


SITE 16
Weekly Level, Velocity and Flow Hydrographs
2/3/2014 to 2/10/2014



Avg Flow: 0.010 mgd **Peak Flow: 0.045 mgd** **Min Flow: 0.001 mgd**

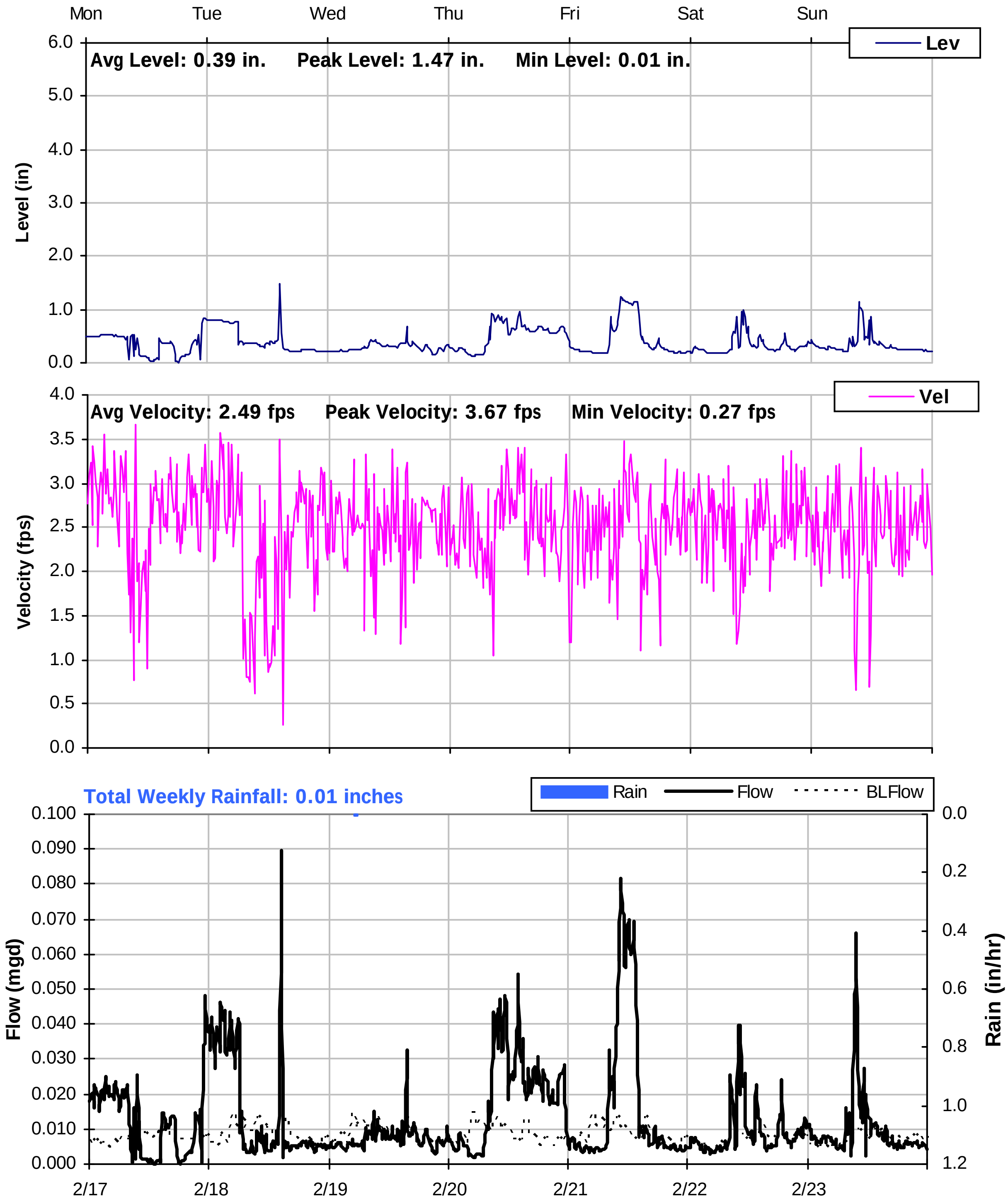
SITE 16
Weekly Level, Velocity and Flow Hydrographs
2/10/2014 to 2/17/2014



SITE 16

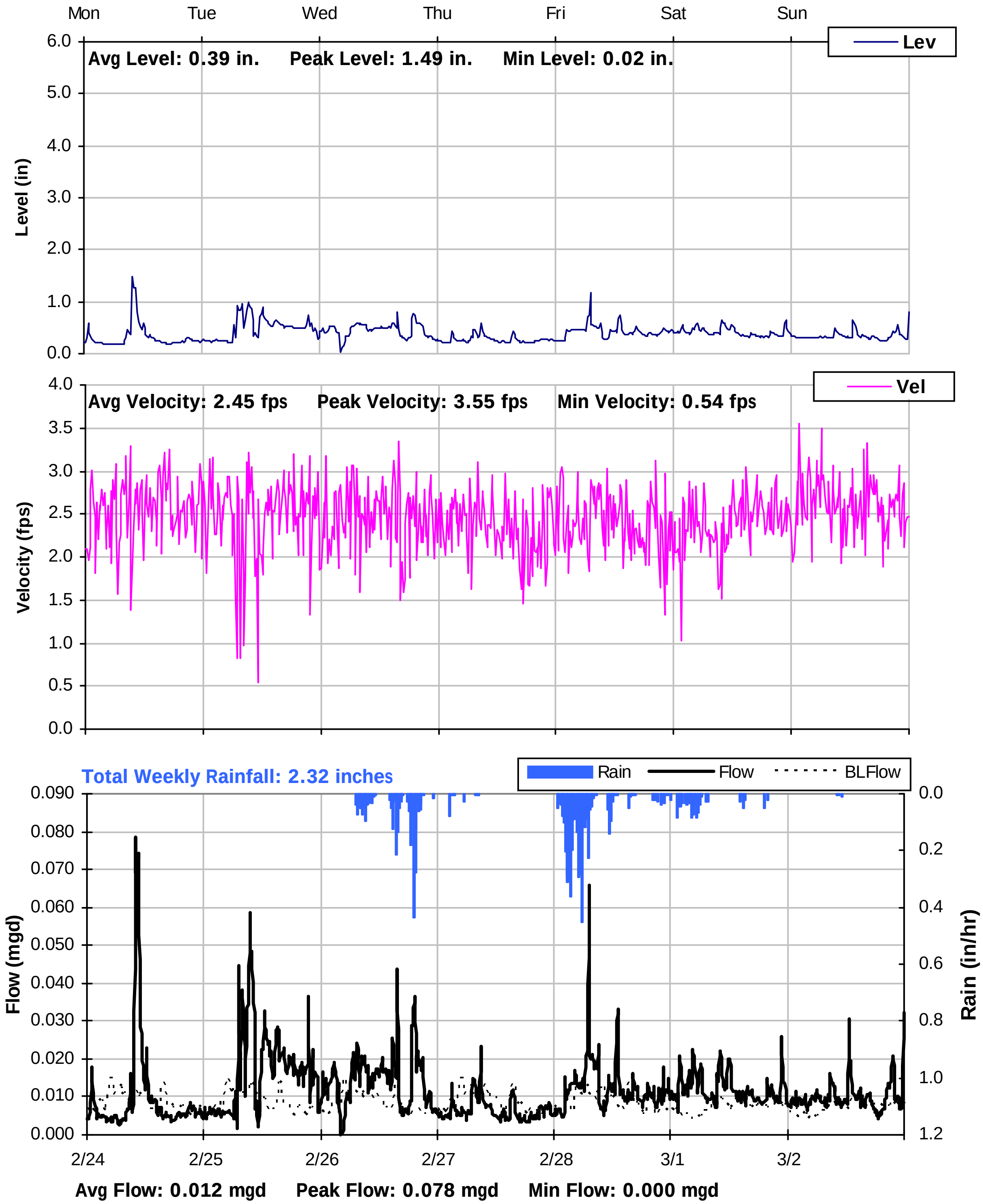
Weekly Level, Velocity and Flow Hydrographs

2/17/2014 to 2/24/2014

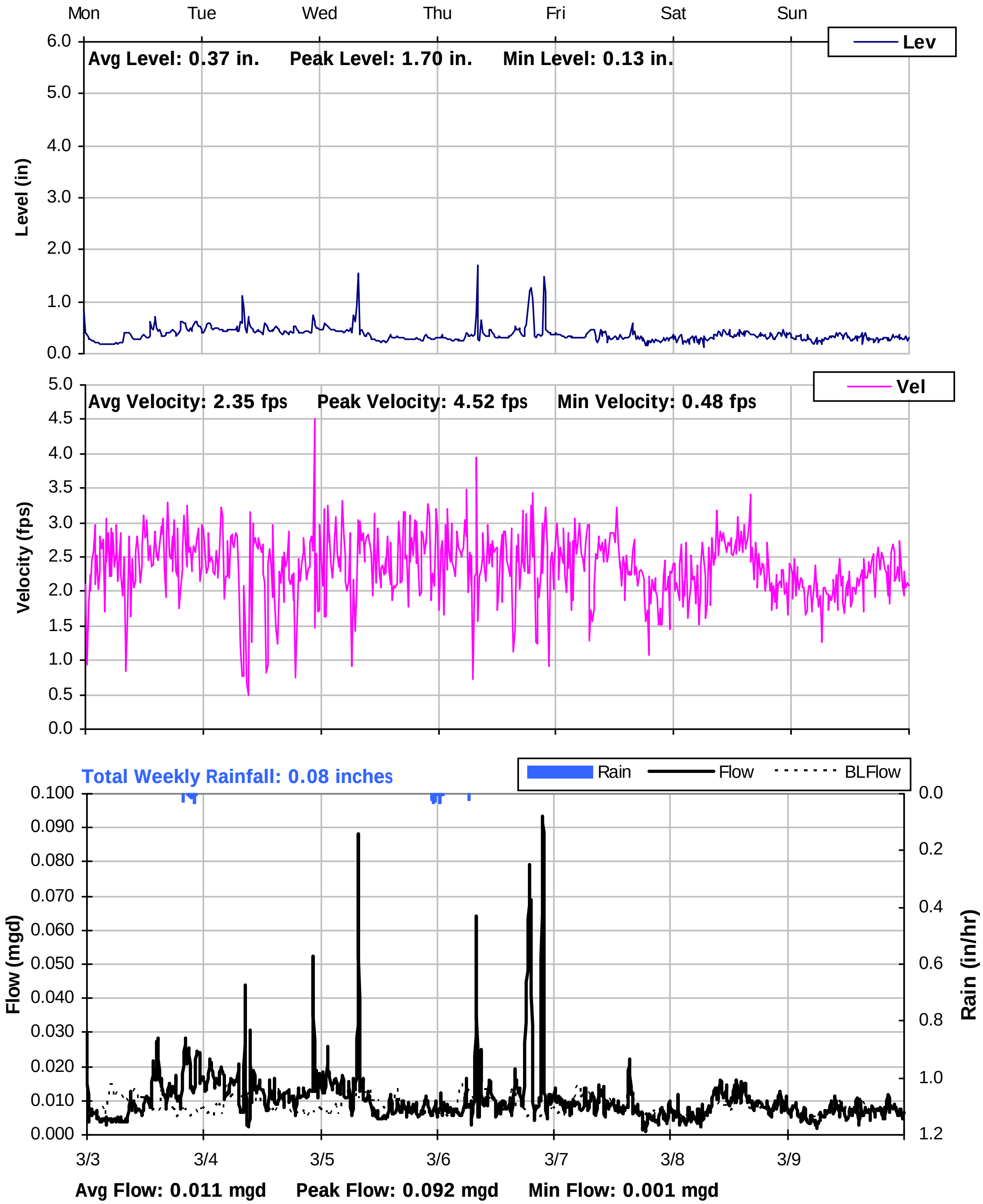


Avg Flow: 0.013 mgd **Peak Flow: 0.089 mgd** **Min Flow: 0.000 mgd**

SITE 16
Weekly Level, Velocity and Flow Hydrographs
2/24/2014 to 3/3/2014



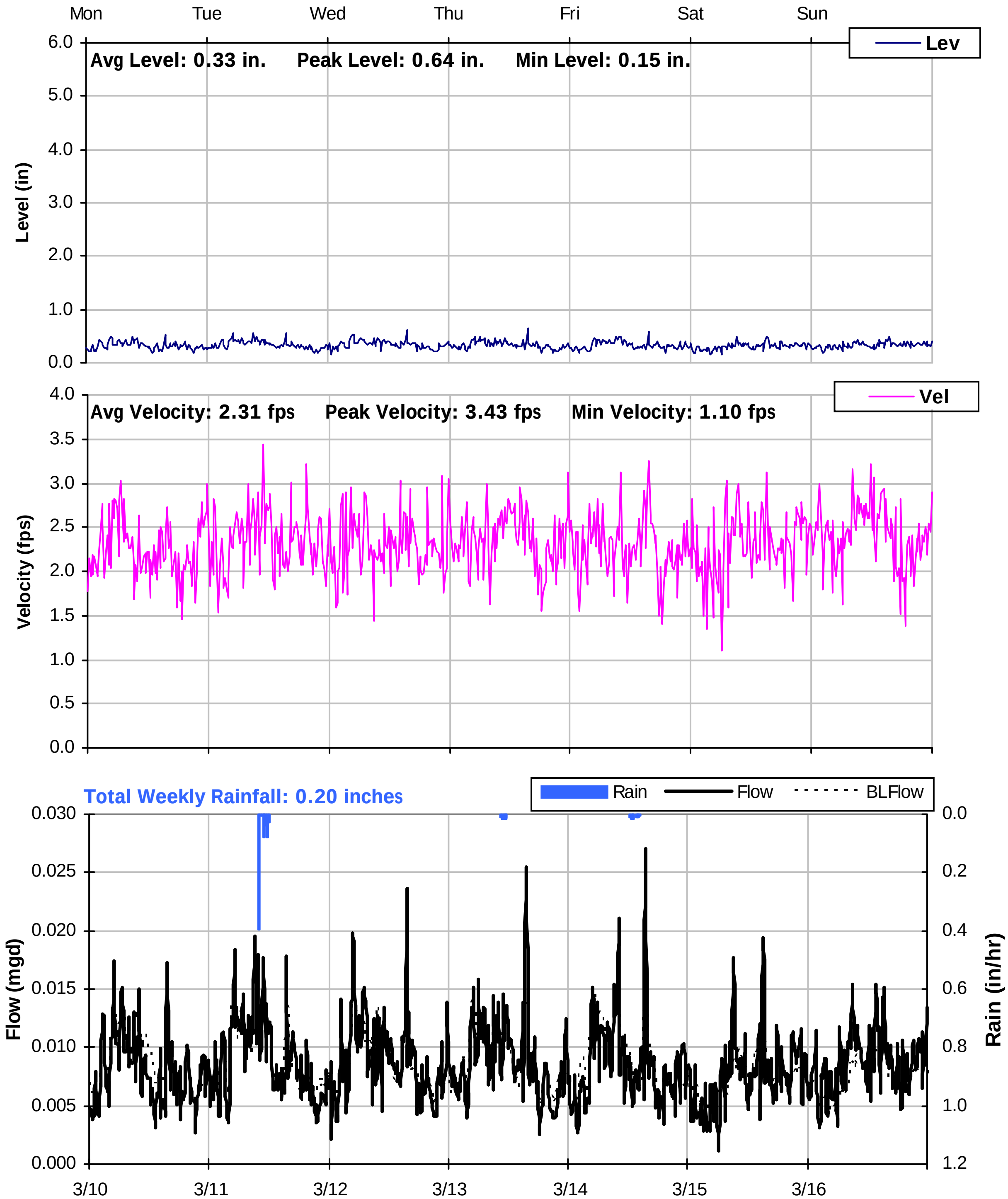
SITE 16
Weekly Level, Velocity and Flow Hydrographs
3/3/2014 to 3/10/2014



SITE 16

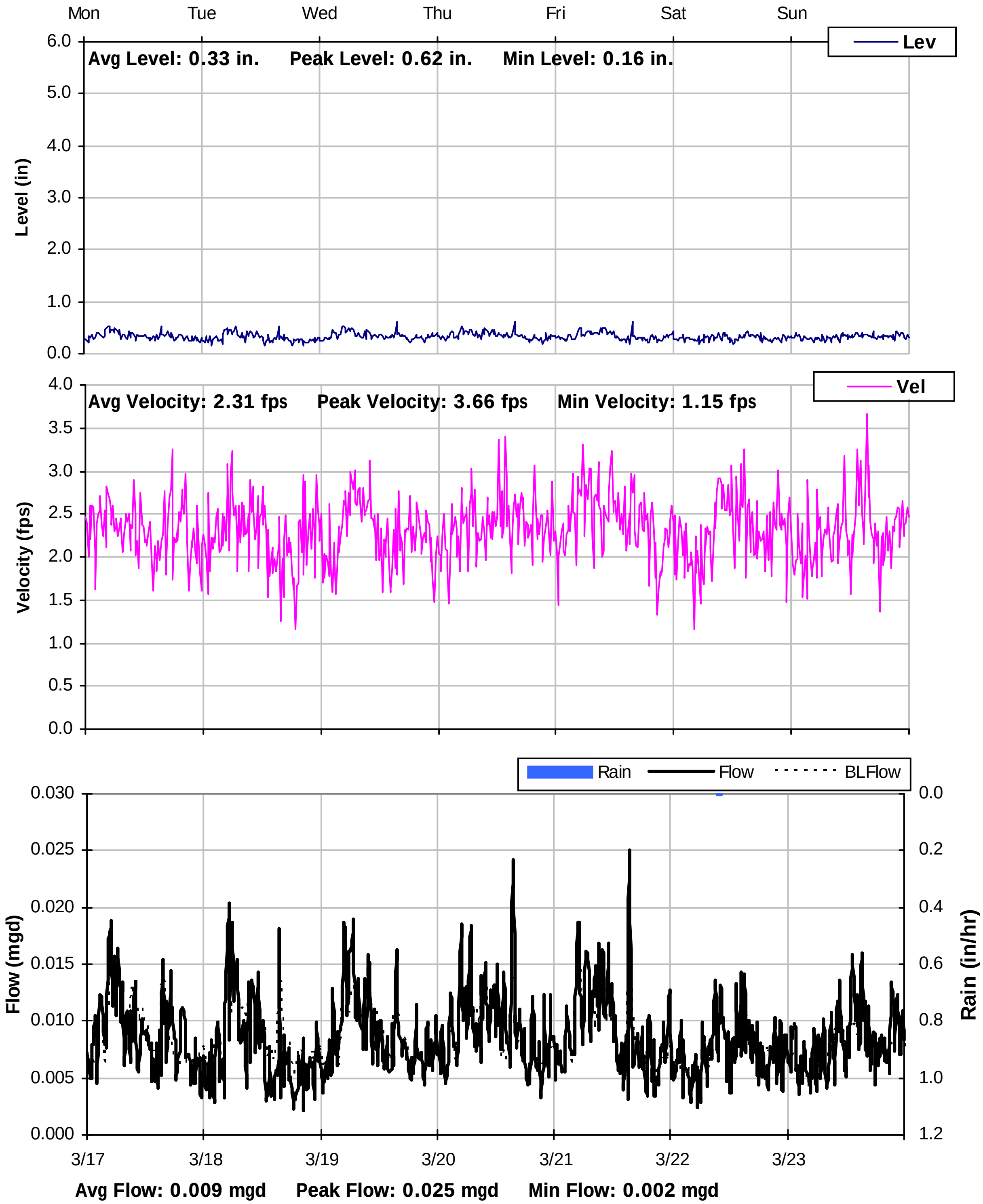
Weekly Level, Velocity and Flow Hydrographs

3/10/2014 to 3/17/2014

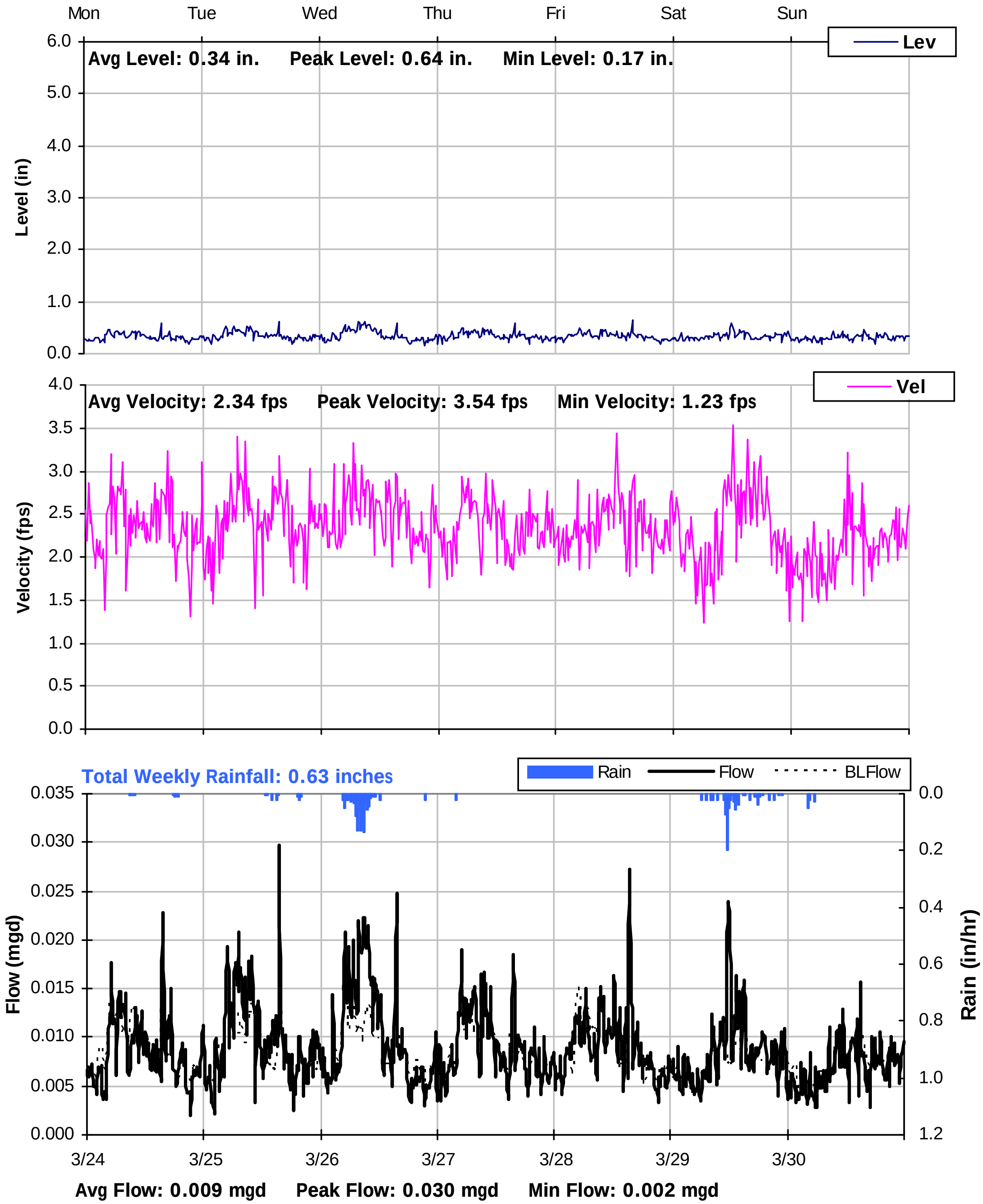


Avg Flow: 0.008 mgd **Peak Flow: 0.027 mgd** **Min Flow: 0.001 mgd**

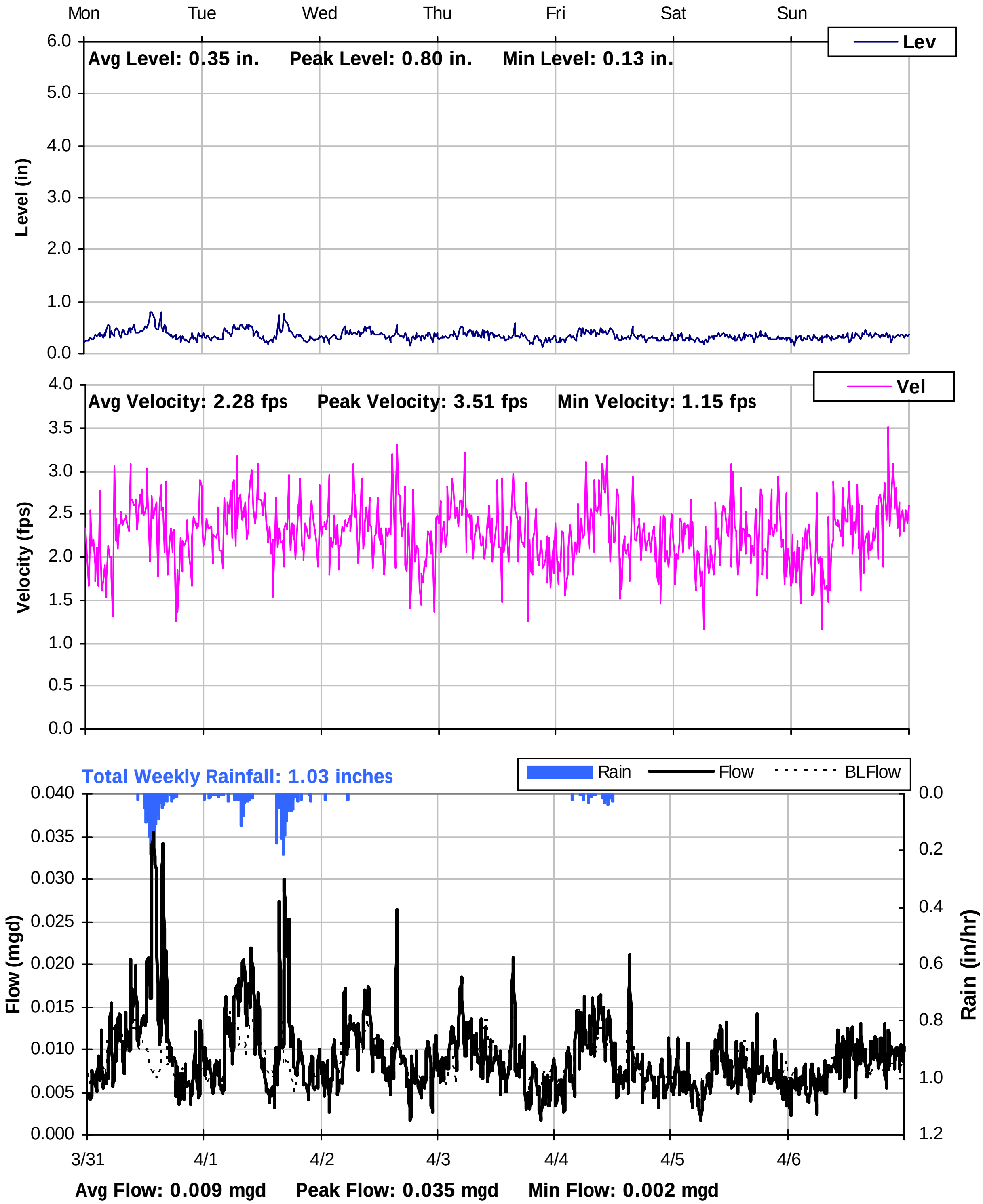
SITE 16
Weekly Level, Velocity and Flow Hydrographs
3/17/2014 to 3/24/2014



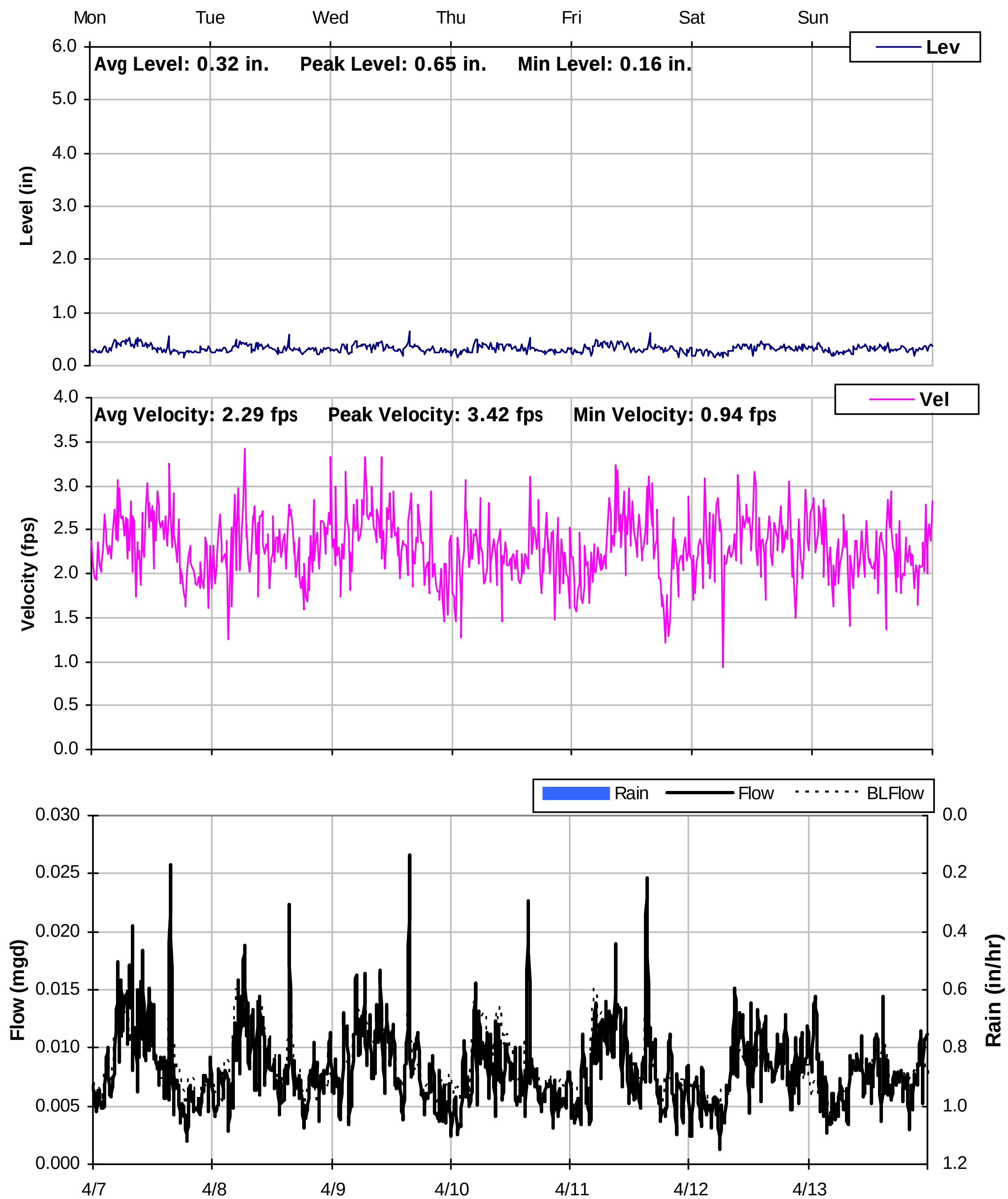
SITE 16
Weekly Level, Velocity and Flow Hydrographs
3/24/2014 to 3/31/2014



SITE 16
Weekly Level, Velocity and Flow Hydrographs
3/31/2014 to 4/7/2014



SITE 16
Weekly Level, Velocity and Flow Hydrographs
4/7/2014 to 4/14/2014



Avg Flow: 0.008 mgd **Peak Flow: 0.027 mgd** **Min Flow: 0.001 mgd**

V&A

Oakland
155 Grand Avenue, Suite 700
Oakland, CA 94612
510.903.6600 **Tel**
510.903.6601 **Fax**

San Diego
11011 Via Frontera, Suite C
San Diego, CA 92127
858.576.0226 **Tel**

Houston
8220 Jones Road, Suite 500
Houston, TX 77065
713.568.9067 **Tel**

Las Vegas
3430 East Russell Road, Suite 316
Las Vegas, NV 89120
702.522.7967 **Tel**
702.553.4694 **Fax**

vaengineering.com