APPENDIX E – TM - MODEL DEVELOPMENT AND CALIBRATION AND V&A SANITARY SEWER FLOW MONITORING AND INFLOW/INFILTRATION STUDY

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MAY 13, 2008
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EXPIRES: 06·30·13

CITY OF GRANTS PASS

FLOW MONITORING AND HYDRAULIC MODELING UPDATE

TECHNICAL MEMORANDUM
MODEL DEVELOPMENT AND CALIBRATION

FINAL
July 2012

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MODEL DEVELOPMENT AND CALIBRATION

1.0 INTRODUCTION

The City of Grants Pass (City) owns and operates a sanitary sewage collection system (collection system) that serves an existing area of approximately 8,860 acres and a population of approximately 52,000.[1] The collection system includes approximately 162.7 miles of gravity mains, 0.2 miles of siphon pipelines, 9.7 miles of force mains, and five sewage pump stations.

The sewage collection system serving the existing City of Grants Pass Urban Growth Boundary (UGB) is a combination of three collection systems:

- City of Grants Pass sewer collection system.
- Fruitdale-Harbeck Sewer District collection system.
- Redwood Sanitary Sewer Service District (RSSSD) collection system.

Management of the RSSSD was transferred to the City in approximately 2000, and a petition was approved in 2010 to dissolve the Fruitdale-Harbeck system and make it a part of the City's collection system. The combined collection system discharges to the City of Grants Pass Water Restoration Plant (WRP), located centrally within the City and adjacent to the Rouge River. Treated effluent is ultimately discharged to the Rouge River.

This technical memorandum (TM) describes the development and calibration of the City's collection system hydraulic model.

2.0 MODELED COLLECTION SYSTEM

An existing hydraulic model of the City's collection system was available, which ran using a software platform called Hydra. The Hydra model included approximately 1,130 pipelines (approximately 61 miles of pipelines) and two pump stations. The Hydra model represented a skeletonized version of the City's collection system, and included a portion of the 8-inch diameter sewers and all larger interceptors.

For the hydraulic model update, the Hydra model was converted to H2OMap SWMM (described in Section 3.1), and expanded to include pipelines 8-inches and larger plus force mains. The expanded SWMM model included the addition of 2,895 pipelines, for a total model size of approximately 4,025 pipelines. The updated modeled collection system consists of approximately 172.6 miles of sanitary sewer pipelines. Gravity sewers range in

[1] Source: Population for existing service area (2012) interpolated from population projections in the City of Grants Pass Collection System Master Plan (2004).

diameter from 6-inches to 48-inches, force mains range in diameter from 4-inches to 14-inches, and the system includes five sewage pump stations.

Table 1 presents a summary of the modeled sewer system by diameter and length of pipe. Figure 1 shows the extent of the system included in the City's original Hydra model, and the expanded system included in the hydraulic model update.

Table 1 Modeled Sewer System Pipeline Summary
Model Development and Calibration
City of Grants Pass

Diameter (inch)	Length (feet)	Diameter (inch)	Length (feet)
4	1,956	18	19,939
6	14,342	21	4,771
8	673,791	24	16,348
10	57,542	27	5,668
12	89,202	30	6,286
14	1,081	36	181
15	20,189	48	22
		Total	**911,319**

2.1 Collection System Sewer Basins

Evaluation of the system by sewer tributary area facilitates understanding of system connectivity and relation of the flow monitoring data to actual conditions. The City's sanitary sewage collection system consists of 23 sewer tributary areas, referred to as "sewer basins," which are labeled A through Z. The sewer basins represent distinct collection tributaries throughout the City, all of which flow to the WRP. The collection basins also correspond to the naming convention of the manholes and pipe junctions throughout the system. Figure 2 shows the boundaries of the sewer basins throughout the service area.

2.2 Sewage Pump Stations and Force Mains

There are five pump stations within the City's collection system service area, all of which were included in the City's hydraulic computer model. Table 2 lists the modeled pump stations and the sewer basins from which they receive flow. Pump curves were available for the Redwood and Darneille Pump Stations, and pump operation set points were available for the Redwood, Darneille, and Bridge Street Pump Stations. Three-point pump curves based on the pump station capacities[2] were developed to model pump operations of the Bridge Street, Webster No. 1, and Webster No. 2 Pump Stations. Set point operation was also assumed from the Webster No. 1 and No. 2 Pump Stations. In addition, specific

[2] Source: Pump station capacities were taken from 'Table 4-4. Pump Station Data,' from the City of Grants Pass 2004 Collection System Master Plan.

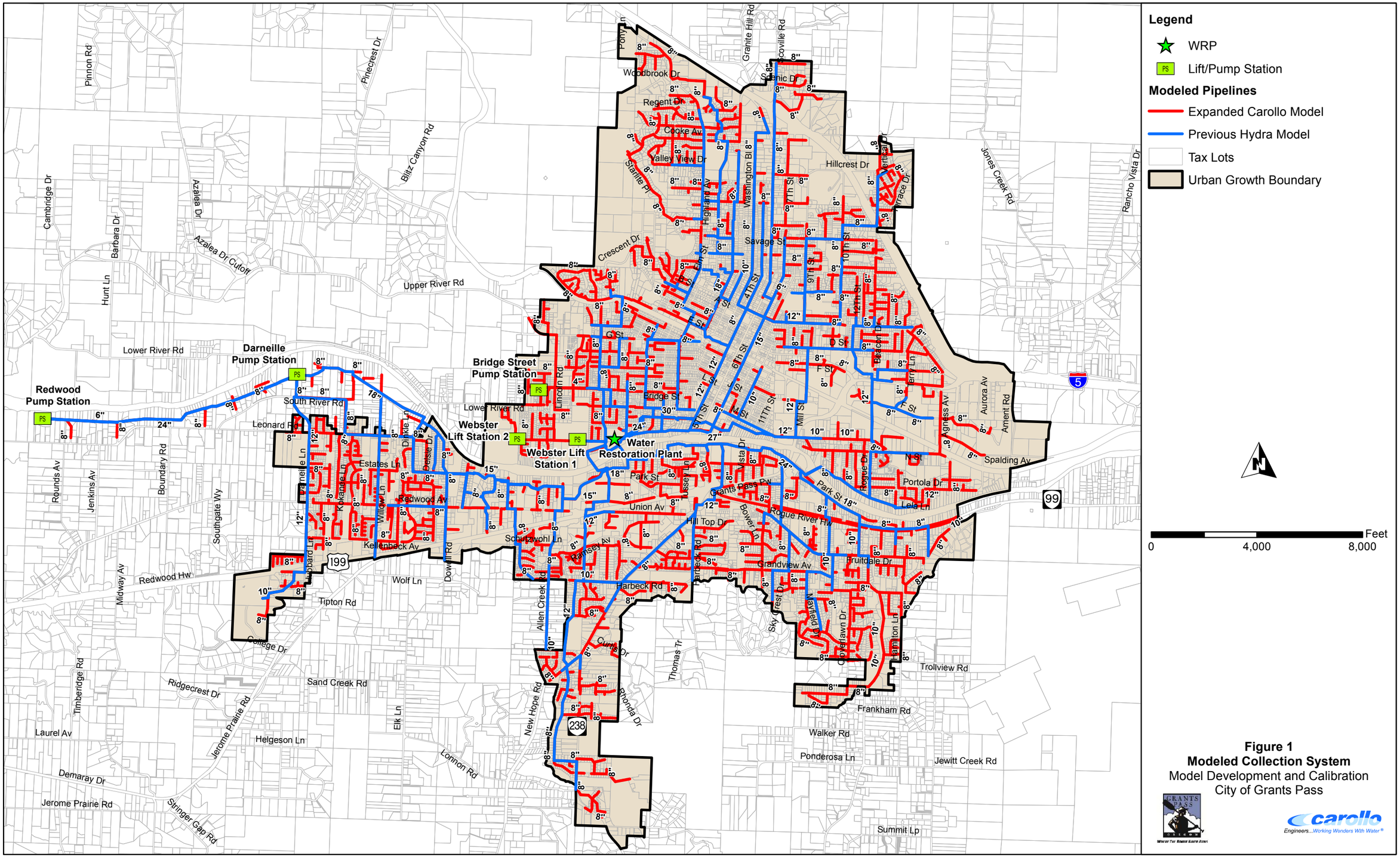
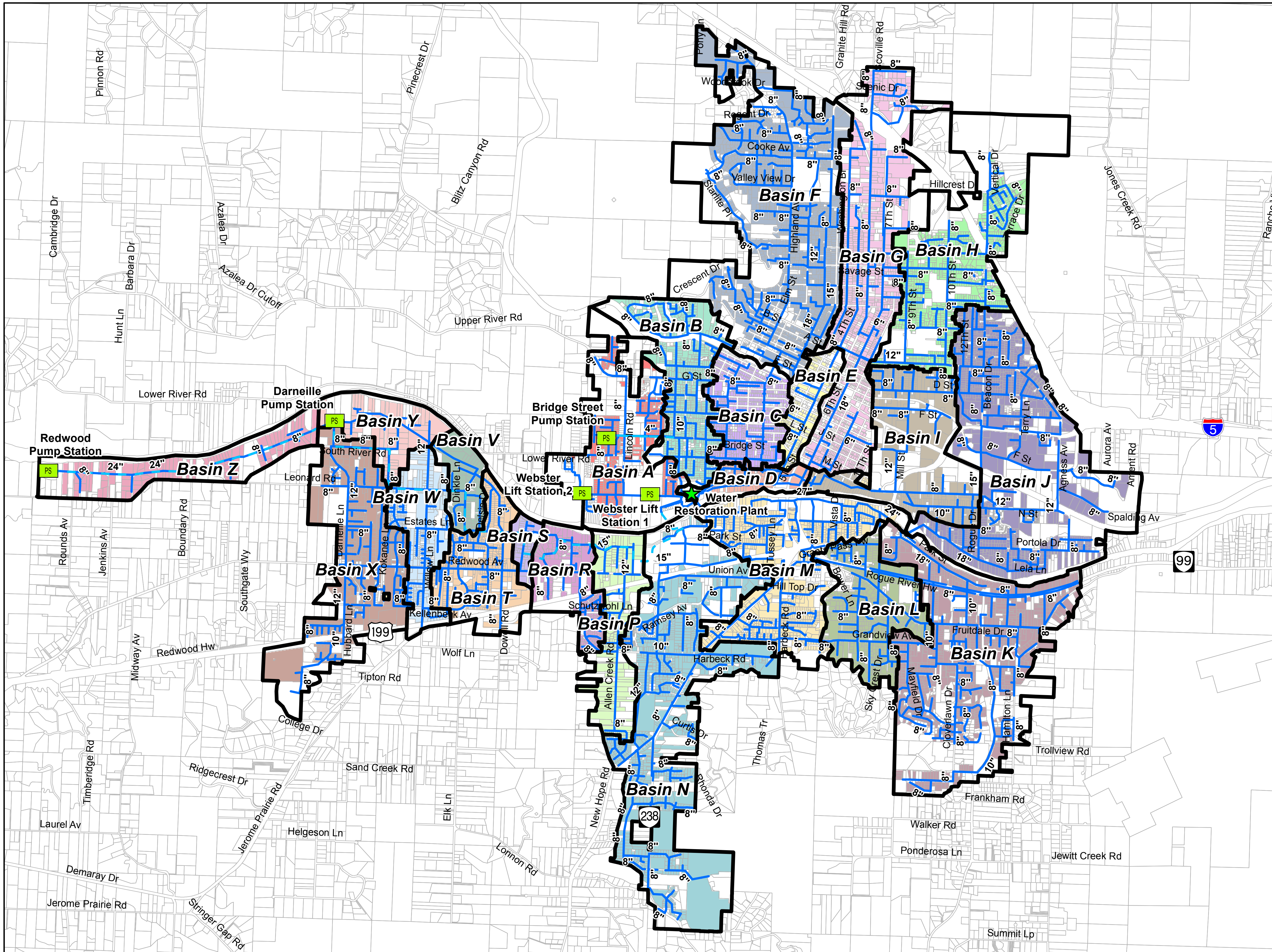


Figure 1
Modeled Collection System
Model Development and Calibration
City of Grants Pass



Legend

WRP

Lift/Pump Station

Pipelines

Gravity Mains

Force Mains

Tax Lots

Collection System Sewer Basins

Sewer Accounts by Collection System Sewer Basin

Basin A	Basin M
Basin B	Basin N
Basin C	Basin P
Basin D	Basin R
Basin E	Basin S
Basin F	Basin T
Basin G	Basin V
Basin H	Basin W
Basin I	Basin X
Basin J	Basin Y
Basin K	Basin Z
Basin L	

0 4,000 8,000 Feet

Figure 2
Collection System Sewer Basins
Model Development and Calibration
City of Grants Pass

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Table 2	Modeled Sewage Pump Stations Model Development and Calibration City of Grants Pass	
Pump Station Name	**Location[1]**	**Influent Sewer Basins**
Webster No. 1	Eastern edge of Roguelea Estates	A
Webster No. 2	All Sports Park	A
Bridge Street	Bridge Street and Tami Court	A
Darneille[2]	3100 South River Road	P, R, S, T, V, W, X, Y
Redwood[2]	4960 Leonard Road	Z

Notes:
(1) Source: City of Grants Pass 2004 Collection System Master Plan, Table 4-4.
(2) Pump Stations located in the Redwood Sanitary Sewer Service District (RSSSD), currently managed by Grants Pass.

information regarding the dimensions of the pump station wet well was only available for the Redwood and Bridge Street Pump Stations. The wet well dimensions for the Darneille Pump Station was assumed to be similar to that of the Redwood Pump Station, while the dimensions for the Webster No. 1 and No. 2 Pump Stations were assumed to be similar to Bridge Street Pump Station.

The Webster No. 1, Webster No. 2, and Bridge Street Pump Stations all pump water from low-lying areas in Collection Basin A to gravity pipelines that convey flow to the WRP. The force mains associated with these pump stations are small and serve to lift the wastewater relatively short distances. The force mains associated with the Darneille and Redwood Pump Stations are significant. The force main conveying flow from the Redwood Pump Station conveys flow to the Darneille Pump Station wet well with a 2.0-mile 6-inch diameter force main. The Darneille Pump Station conveys flow to the WRP through dual 12-inch diameter force mains that are each approximately 3.4 miles long. At least one of the Darneille 12-inch force mains is open year-round, though the second is typically opened during the rainy season to accommodate increased seasonal flows.

3.0 SEWER SYSTEM HYDRAULIC MODEL

A wastewater collection system model is a simplified representation of the real sewer system. Sewer system models can assess the conveyance capacity for a collection system. Sewer system models can also perform “what if” scenarios to assess the impacts of future developments and land use changes.

This section summarizes the selected hydraulic modeling software, the elements within the hydraulic model, and the hydraulic model development process.

3.1 Selected Hydraulic Modeling Software

There is an abundance of sewer analysis software in the marketplace today, with a variety of features and capabilities. The selection of a particular model generally depends on user preferences, software costs, and the complexity of the sewer system.

It was agreed that H2OMap SWMM, by Innovyze (formerly MWH Soft), would be used to assemble the City's hydraulic model. H2OMap SWMM is a fully dynamic, geospatial wastewater and stormwater modeling and management software application that runs within the Environmental Systems Research Institute (ESRI) geographical information systems (GIS) software platform . The hydraulic modeling engine for the H2OMap SWMM software package uses the Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM), which is widely used throughout the world for planning, analysis, and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems. Version 10.0 of H2OMap SWMM was used to assemble the hydraulic model.

3.2 Elements of the Hydraulic Model

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

- **Junctions.** Sewer manholes, cleanouts, as well as other locations where pipe sizes change or where pipelines intersect are represented by junctions in the hydraulic model. Required inputs for junctions include rim elevation, invert elevation, and surcharge depth (used to represent pressurized systems).

- **Pipes.** Gravity sewers and force mains are represented as pipes in the hydraulic model. Input parameters for pipes include length, friction factor (e.g., Manning's n for gravity mains, Hazen Williams C for force mains), invert elevations, diameter, and whether or not the pipe is a force main.

- **Storage Nodes.** For sewer system modeling, storage nodes typically are used to represent pump station wet wells (although other storage basins, etc. can be modeled as storage nodes). Input parameters for storage nodes include invert elevation, wet well depth, and wet well cross section.

- **Pumps.** Pumps are included in the hydraulic model as links. Input parameters for pumps include pump curves and operational controls.

- **Outfalls.** Outfalls represent areas where flow leaves the system. For sewer system modeling, an outfall typically represents the connection to the influent pump station at a wastewater treatment plant. For Grants Pass, an outfall was used to represent connections to the WRP.

- **Rain Gauges.** Rain gauges are input into the hydraulic model to simulate historical or theoretical hourly rainfall events.

- **Inflows.** The following are the three types of inflow sources that can be injected into individual model junctions (and storage nodes):
  - External: External inflows can represent any number of flows into the collection system, such as metered flow data or groundwater inflow. External inflows are applied to a specific model junction by applying a baseline flow value and a pattern that varies the flow by hour, day, or month of the year.
  - Dry Weather: Dry weather inflows simulate base sanitary wastewater flows and represent the average flow. The dry weather flows can be multiplied by up to four patterns that vary the flow by month, day, hour, and day of the week (e.g., weekday or weekend). The dry weather diurnal patterns are adjusted during the dry weather calibration process.
  - RDII: Rainfall Derived Infiltration and Inflows (RDII) are applied in the model by assigning a unit hydrograph and a corresponding tributary area to a given junction. The unit hydrographs consists of several parameters that are used to adjust the volume of RDII that enters the system at a given location. These parameters are adjusted during the wet weather calibration process.

3.3 Wastewater Load Allocation

Baseline wastewater loads were allocated (assigned to specific nodes) in the hydraulic model based on water billing records provided by the City for customers located within the City's sewer system service area, as described below:

- Step 1 – The City's service area was broken up into 3,968 individual loading polygons. Each loading polygon represents the geographic area that contributes flows into a single model node (i.e., trunk system manhole). Non-sewered areas such as parks were not included in the service area polygon calculations.

- Step 2 – The winter water demand was calculated for each customer within the City service area, excluding dedicated irrigation meters and other known non-sewered water uses. Winter demands are used for this process because irrigation water usage is minimal during this period, and so the water demands will more closely represent the base wastewater flows.

- Step 3 – The individual customer water demands were assigned to the appropriate sewer loading polygon using GIS software and a total water demand for each loading polygon was calculated and assigned to the appropriate model node.

- Step 4 – The baseline water demands were adjusted as necessary during the dry weather flow calibration process (see Section 5.2) to closely match the actual measured dry weather flows recorded during the flow monitoring period.

3.4 Hydraulic Model Construction

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

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

- Step 1 - The City's existing Hydra collection system model and digital geographic information system (GIS) shape files for the sewer collection system were obtained from the City;
- Step 2 - The Hydra model was converted to H2OMap SWMM;
- Step 3 - GIS data were reviewed and formatted to allow easy import into the H2OMap SWMM modeling platform;
- Step 4 - The collection system pipeline and facility data were imported into the modeling software and verified. Certain physical and operational data for the City's wastewater collection facilities was not available from the GIS data. This type of data, such as wet well dimensions, pump stations, and other special features (e.g., diversion structures to the Redwood Interceptor), were input manually into the model based on available information. In addition, pipelines and junctions with missing inverts or invert discrepancies were reviewed and manually input or modified based on City records, field reconnaissance, and engineering judgment.

  Once all the relevant data was input into the hydraulic model, the model was reviewed to verify that the data was input correctly and that the flow direction and size of the modeled pipelines were logical.
- Step 5 - The existing dry weather wastewater flows were allocated to the model junctions using the City's water consumption records. These flows were scaled up or down, as necessary, to match the dry weather flows recorded during the flow monitoring period.
- Step 6 - The hydraulic model contains certain run parameters that need to be set by the user at the beginning of the project. These include run dates, time steps, reporting parameters, output units, and flow routing method. Once the run parameters were established, the model was debugged to ensure that it ran without errors or critical warnings.

4.0 FLOW MONITORING PROGRAM

Temporary flow monitoring was conducted to assist in the development of design flow criteria, and to correlate actual sewer system flows to the hydraulic model predicted flows.

Flow monitoring data are used to calibrate the wastewater collection system hydraulic model for dry weather and wet weather flow.

Temporary flow monitoring was performed by the City during the 2011/2012 wet weather season. These flow monitoring programs, which began in October 2011 and continued through the beginning of February 2012, were used as part of this study to characterize both dry weather and wet weather flows in the City service area.

4.1 Flow Monitoring Program

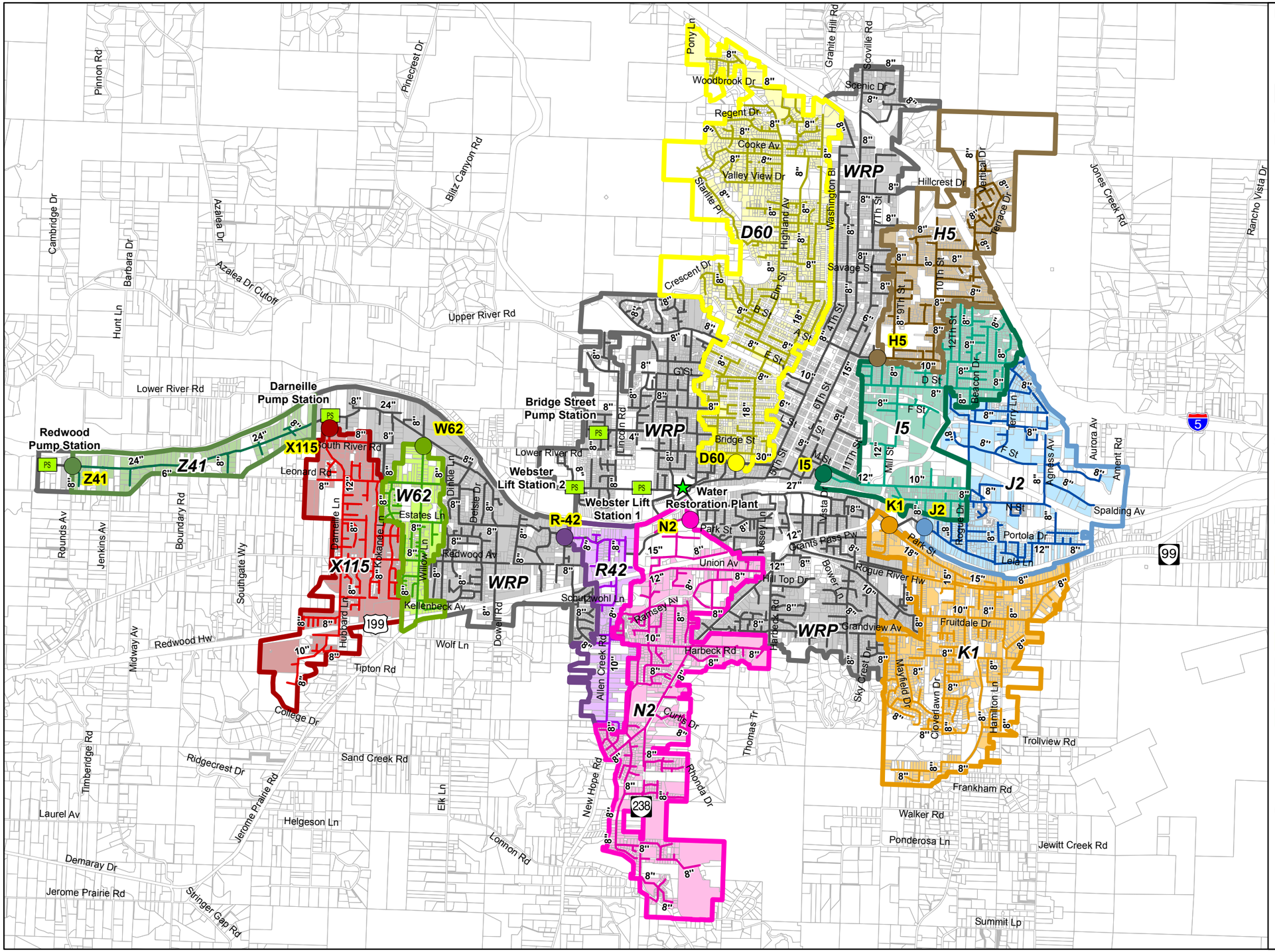
Carollo Engineers contracted with V&A Consulting Engineers (V&A) to conduct a temporary flow monitoring program at 10 monitoring sites within the City collection system. The meter sites were selected to best model the sewer areas and multiple sub-areas within the City's collection system. Figure 3 shows the location of the City flow monitoring sites. Table 3 summarizes the influent sewer basins for each flow meter. Some flow meters received all the influent flow from a particular sewer basin, while others received only a portion of flow from sewer basins due to their location in the system.

In addition to monitoring data from the 10 V&A flow meters, flow data was also available for the WRP for a portion of the flow monitoring period. Therefore, measured data from 11 total sites was available for use with model calibration.

The V&A flow monitoring and inflow/infiltration report for the 11 sites where measured data was available is included in Appendix A. The following sections provide a summary of the flow monitoring program and the application of the monitored data for model calibration procedures.

4.1.1 Dry Weather Flow

During the flow monitoring period, flow, depth, and velocity data were recorded by V&A at 15-minute intervals for each meter. The 15-minute data were then aggregated to hourly data for the model calibration effort. Characteristic dry weather 24-hour diurnal flow patterns for each site were developed by V&A at 15-minute intervals for both weekday and weekend flows. The 15-minute dry weather flow data were converted to hourly flow data and then used to calibrate the hydraulic model for average day flow. For this study, both the weekday and weekend flow averages and diurnal patterns were used for calibration and analysis. Table 4 provides the weekday and weekend average and peak flow rates measured for each flow meter over the course of the flow monitoring period. The magnitude of the flows depends on the tributary area and land use categories in each flow meter basin. Wet weather flows are described in the following sections.



Legend

- WRP
- Lift/Pump Station
- Tax Lots

Flow Monitoring Basins

Flow Monitor Site	Pipelines
D60	D60
H5	H5
I5	I5
J2	J2
K1	K1
N2	N2
R42	R42
W62	W62
X115	WRP
Z41	X115
	Z41

Sewer Accounts	Basin Boundary
D60	D60
H5	H5
I5	I5
J2	J2
K1	K1
N2	R42
R42	N2
W62	W62
WRP	WRP
X115	X115
Z41	Z41

N

0 4,000 8,000 Feet

Figure 3
Flow Monitoring Sites
Model Development and Calibration
City of Grants Pass

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Table 3	Flow Meter Influent Sewer Basin(s) Model Development and Calibration City of Grants Pass	
No.	**Flow Meter**	**Influent Sewer Basin(s)**
1	D60	C, F
2	H5	H
3	I5	I, J
4	J2	J
5	K1	K
6	N2	N
7	R42	P, R
8	W62	W
9	X115	X
10	Z41	Z
11	WRP	All Basins

Table 4 Dry Weather Flow Summary
Model Development and Calibration
City of Grants Pass

Flow Meter	Pipe Diameter (in)	Weekday		Weekend	
		Average Flow (mgd)	Peak Flow (mgd)	Average Flow (mgd)	Peak Flow (mgd)
D60	21	0.61	0.80	0.61	0.89
H5	12	0.26	0.36	0.27	0.38
I5	15	0.31	0.41	0.29	0.39
J2	18	0.33	0.47	0.33	0.50
K1	18	0.26	0.34	0.27	0.40
N2	18	0.21	0.31	0.19	0.31
R42	15	0.18	0.26	0.18	0.29
W62	12	0.09	0.12	0.09	0.15
X115	12	0.14	0.20	0.14	0.22
Z41	24	0.02	0.02	0.02	0.02
WRP	48	4.35	5.56	4.31	6.17

Notes:

(1) Source: V&A Flow Monitoring data for the City of Grants Pass over the course of the flow monitoring period.

4.1.2 Rainfall Data

V&A set up five temporary rain gauges throughout the City to capture rainfall events over the course of the flow monitoring period, and provided 15-minute rainfall data with the flow monitoring results. Estimates of the rainfall experienced in each flow meter tributary area were determined by using the weighted average rainfall for each flow meter location based on proximity to each rain gauge. Of the five rain gauges utilized in this study, gauge "Grant 4" measured the median total rainfall of the five rain gauges in this study. Table 5 provides a summary of the rainfall events captured by Grant 4 over the course of the flow monitoring period.

Table 5 Rainfall Event Summary (Grant 4 Rain Gauge)
Model Development and Calibration
City of Grants Pass

Storm Event	Event Date(s)	Total Rainfall Volume (in)	Number of Hours	Peak Rainfall Intensity (in/hr)
1	11/5/11-11/6/11	0.96	24.50	0.28
2	11/17/11-11/18/11	0.54	20.75	0.16
3	11/21/11-11/22/11	0.87	17.00	0.12
4	11/23/2011	0.84	11.50	0.20
5	12/30/2011	0.86	14.50	0.21
6	1/18/12-1/20/12	2.37	46.50	0.17
7	1/20/12-1/21/12	1.06	14.75	0.38
8	1/22/2012	0.69	10.00	0.29

As shown in Table 5, there were eight prominent storm events that occurred over the flow monitoring period. Storm durations ranged from 10 hours to 46.5 hours, and peak intensities ranged from 0.12 inches/hour (in/hr) to 0.38 in/hr. While storm durations and intensities varied, all eight measured rainfall events were classified as less than 2-year, 24-hour storm events. Classification is based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14 isopluvial (rainfall total contours) map of Oregon, applied to the Natural Resources Conservation Service (NRCS) Type 1A rainfall distribution curve.

Although all eight storms were classified as less than the 2-year, 24-hour characteristic storm for the Grants Pass area, the storms did present valuable variation in terms of total rainfall, duration, and intensity. As described in the V&A flow monitoring report in Appendix A, the variation in storm events provided for a more detailed analysis of inflow and infiltration into the sanitary sewer system. Capturing variable rainfall events further allowed for more precise hydraulic model calibration for determining wet weather flows, described in Section 5.0.

4.1.3 Wet Weather Flow

Wet weather flows are characterized as the flows through the sewer during wet weather events and for an indeterminate amount of time after rainfall while inflow and infiltration (I/I) still contribute flows to the system. For each of the rainfall events summarized in Table 5, a measureable amount of I/I occurred based on the intensity and duration of the storms. I/I is also dependent on saturation of the soil and groundwater surface elevations, which can vary throughout the rainy season. Table 6 provides a summary of the I/I measured at each flow meter during wet weather events, indicating the extent of the impact of rainfall events within each meter tributary area. A complete analysis of the I/I for each flow meter is provided in Appendix A, which includes a description of the magnitude of I/I and the classification of the City's I/I compared to Water Environment Federation (WEF) standards. Several of the flow meters indicated that certain areas in the City experience excessive groundwater infiltration, above typically allowable rates.

Table 6 also lists the R-Values that were calculated using the results from the flow monitoring program. The R-Value provides a means by which to quantify the magnitude of the I/I response for each basin. The R-Value is the percentage of the rainfall that enters into the collection system. Typically, R-Values over 5 percent represent a significant I/I response. As can be seen in Table 6, the R-Values ranged from 1.2 percent to 8.5 percent with basin I5 showing the highest R-Value and thus the worst I/I response.

The wet weather flow monitoring data was used to evaluate how each flow meter tributary basin and the overall collection system responded to wet weather events. Comparing the monitored flows for each of the rainfall events, the storm event with the greatest infiltration and inflow (I/I) response was observed in the system for a group of several back-to-back storms that occurred in late January 2012. For this reason, the period of January 17 through January 30, 2012 was selected for the wet weather calibration. In addition, the highest peak flows during the flow monitoring period occurred during this period.

Table 6	Wet Weather Flow Summary Model Development and Calibration City of Grants Pass						
Flow Meter	**Pipe Diameter (in)**	**Peak I/I Rate (mgd)**	**Peak I/I: ADWF (mgd)**	**Combined I/I (gallons)**	**Total I/I: ADWF (per in-rain)**	**d/D Ratio**	**R-Value (%)**
D60	21	1.83	2.99	11,782,000	3.47	0.32	4.3
H5	12	1.00	3.78	5,478,000	3.79	1.64	6.4
I5	15	0.84	2.75	4,579,000	2.82	0.57	8.5
J2	18	1.16	3.50	4,460,000	2.53	0.58	3.7
K1	18	0.51	1.96	3,046,000	2.17	0.34	2.6
N2	18	0.90	4.49	4,361,000	3.91	0.42	3.4
R42	15	1.01	5.61	3,344,000	3.27	0.31	6.5
W62	12	0.22	2.41	1,681,000	3.40	0.32	5.8
X115	12	0.57	3.98	3,422,000	4.36	0.73	4.7
Z41	24	1.16	74.53	1,400,000	16.39	1.28	1.2
WRP	48	13.35	3.08	63,842,000	2.81	-	5.1

Notes:

(1) Source: V&A Flow Monitoring data for the City of Grants Pass over the course of the flow monitoring period.

5.0 HYDRAULIC MODEL CALIBRATION

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

For this project, both dry and wet weather calibration were conducted. Dry weather flow (DWF) calibration ensures an accurate depiction of base wastewater flow generated within the study area. The wet weather flow (WWF) calibration consists of calibrating the hydraulic model to a specific storm event or events to simulate the peak and volume of infiltration/inflow (I/I) into the sewer system. The amount of I/I is essentially the difference between the WWF and DWF components.

5.1 Calibration Standards

Proper calibration requires an assessment of the precision and accuracy of modeled variables compared to measured variables. In this case, flows are the primary variable used for calibration. The goal of calibration depends on the specific use of the model. The model needs to be accurately calibrated to flow volume, peaks, and hydrograph shape.

The model was calibrated in accordance with international modeling standards. The Wastewater Planning Users Group (WaPUG), a section of the Chartered Institution of Water and Environmental Management, has established principles for model verification that have been generally agreed-upon. The wet weather calibration for this project focused on meeting the recommendations on model verification contained in the "Code of Practice for the Hydraulic Modeling of Sewer Systems," version 3.001, published by the WaPUG.

The WaPUG criteria for hydraulic model calibration are summarized below:

- **Dry Weather Flow Calibration.** The DWF hydrographs should closely follow each other in shape and magnitude, and meet the following criteria as a general guide:
  - Timing of flow peaks and troughs should be within one hour.
  - The peak flow rate should be in the range of ±10 percent.
  - The volume of flow (or average flow) should be in the range of ±10 percent, with care taken to exclude periods of missing or inaccurate data.
- **Wet Weather Flow Calibration.** The WWF hydrographs should closely follow each other in shape and magnitude until the flow has substantially returned to the dry weather flow rates, and meet the following criteria as a general guide:
  - Timing of flow peaks and troughs should be similar having regard to the duration of the event.
  - The peak flow rate should be in the range of +25 percent to -15 percent.
  - The volume of flow (or average flow) should be in the range of +20 percent to -10 percent, with care taken to exclude periods of missing or inaccurate data.

5.2 Dry Weather Flow Calibration

The DWF calibration consists of several elements: 1) dividing the sewer system into areas tributary to each of the flow meter stations; 2) defining the flow volumes within each area; and 3) creating diurnal patterns to match the temporal distribution of flow. The diurnal curve is a pattern of hourly multipliers that are applied to the base flow to simulate the variation in flow that occurs throughout the day.

The first step in the calibration process was to divide the City service area into flow meter tributary areas. One tributary area was created for each flow meter. The next step was to define the flow volumes within each area, which was accomplished in the flow-allocation step discussed in Section 3.3. Two diurnal curves based on the flow monitoring data were created for nodes tributary to a specific flow meter, one representing weekday flows and the

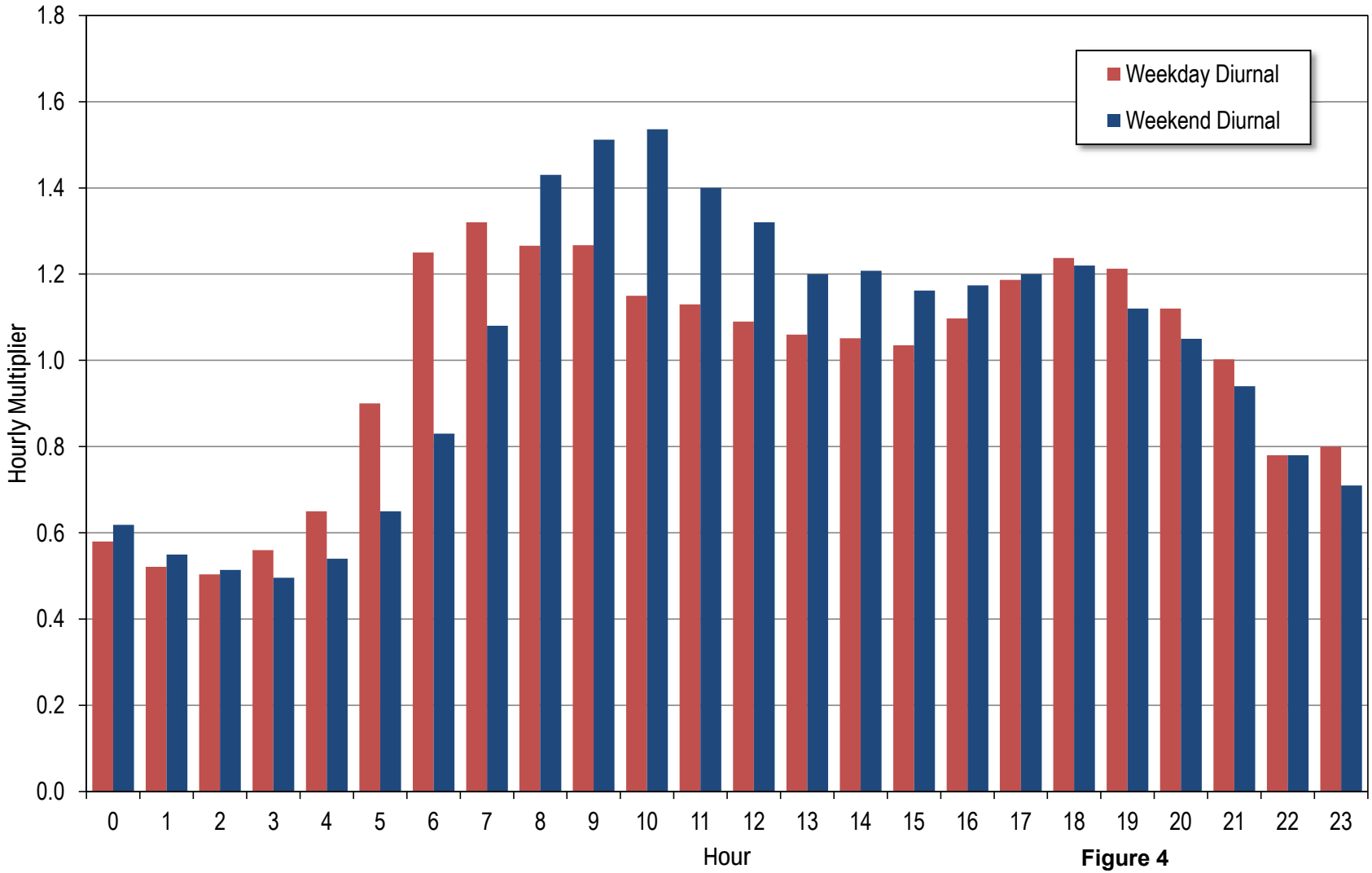

Figure 4
Meter K1 Diurnal Patterns
Model Development and Calibration
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other representing weekend flows. Figure 4 displays the weekday and weekend diurnal curves for the area tributary to Meter K1. Similar diurnal curves were developed for each of the meters and its tributary area. These additional curves are available in Appendix B.

The calibration process compared the meter data with the model output. Comparisons were made for the peak and average flows as well as the temporal distribution of flow. The modeled flow velocities (ft/s) and depths (in) of water were also calibrated to measured values, though there is no standard for calibration for these parameters. For the purposes of the calibration of this study, an acceptable percent error for velocity and depth for dry weather flow was assumed to be ten percent.

Table 7 provides a summary table with the DWF calibration using peak and average flow results, as well as average velocities and levels. For each of the 11 flow meters, the percent difference between modeled and measured flows, velocities, and levels met the WaPUG dry weather flow calibration standards. All measured versus modeled results had percent errors of less than 10 percent, while most meters showed calibration to less than 5 percent error.

During the calibration process, the order of operations generally begins with calibration of modeled flows, followed by calibration of modeled velocities and levels. Once flow rates were adjusted to match measured flows to the extent possible, reasonable adjustments were made to model parameters to calibrate to measured values for velocity and flow depth. In cases were pipe invert data was originally interpolated, minor adjustments to pipe slopes could be made to result in better correlation to measured velocities and depths.

A sample of the DWF calibration for flow meter K1 is presented in Figure 5. This figure shows the measured flow at the meter versus the model predicted flows for both weekday and weekend periods. The remaining DWF calibration plots for flow, velocity, and level for each meter are provided in Appendix B. Based on the calibration results in Appendix B and Figure 5, the model showed good correlation between the measured flows and simulated flows, and met the WaPUG standards for dry weather calibration.

Table 7 Dry Weather Flow Calibration Summary
Model Development and Calibration
City of Grants Pass

		Weekday Dry Weather Flow												Weekend Dry Weather Flow												Average Dry Weather Flow[4]		
		Measured Data[1]				Modeled Data[2]				Percent Error[3]				Measured Data[1]				Modeled Data[2]				Percent Error[3]						
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Measured ADWF (mgd)	Modeled ADWF (mgd)	Percent Difference (%)
D60	20.5	0.611	0.802	3.80	3.4	0.620	0.835	3.74	3.4	1.5%	4.1%	-1.7%	0.7%	0.609	0.886	3.82	3.3	0.626	0.927	3.74	3.4	2.8%	4.6%	-2.3%	1.6%	0.611	0.622	1.9%
H5	12	0.264	0.360	2.13	3.5	0.266	0.370	2.07	3.6	0.7%	2.8%	-2.8%	2.6%	0.268	0.376	2.12	3.5	0.269	0.374	2.07	3.6	0.2%	-0.6%	-2.4%	2.1%	0.265	0.267	0.5%
I5	15	0.312	0.408	1.70	4.3	0.317	0.407	1.77	4.1	1.3%	-0.2%	4.2%	-4.0%	0.288	0.392	1.68	4.1	0.292	0.395	1.73	3.9	1.3%	0.6%	2.9%	-3.8%	0.305	0.309	1.3%
J2	18	0.333	0.466	1.34	5.1	0.331	0.463	1.37	4.6	-0.4%	-0.6%	2.1%	-8.5%	0.328	0.503	1.32	5.0	0.329	0.497	1.36	4.6	0.2%	-1.2%	2.9%	-8.5%	0.331	0.331	-0.2%
K1	18	0.258	0.336	1.71	3.4	0.262	0.347	1.81	3.3	1.5%	3.3%	5.8%	-4.9%	0.266	0.404	1.71	3.5	0.267	0.403	1.81	3.3	0.1%	-0.2%	5.6%	-5.7%	0.261	0.263	1.1%
N2	18	0.205	0.305	1.53	3.0	0.207	0.299	1.42	3.2	0.7%	-2.1%	-7.4%	8.5%	0.188	0.309	1.50	2.8	0.191	0.306	1.38	3.1	1.3%	-0.9%	-7.6%	9.2%	0.200	0.202	0.9%
R42	15	0.180	0.260	2.89	1.8	0.179	0.258	2.73	2.0	-0.2%	-0.6%	-5.8%	9.0%	0.179	0.292	2.78	1.9	0.178	0.290	2.70	2.0	-0.4%	-0.6%	-3.2%	4.5%	0.180	0.179	-0.3%
W62	12	0.089	0.121	1.29	2.3	0.090	0.126	1.31	2.3	1.6%	3.9%	1.1%	0.6%	0.093	0.148	1.39	2.3	0.094	0.148	1.31	2.3	1.0%	-0.3%	-5.3%	-0.3%	0.090	0.091	1.4%
X115	12	0.144	0.200	1.49	3.2	0.144	0.207	1.40	3.0	0.2%	3.5%	-6.4%	-6.3%	0.140	0.223	1.46	3.1	0.139	0.226	1.37	2.9	-0.6%	1.4%	-6.0%	-5.1%	0.143	0.143	0.0%
Z41	24	0.016	0.018	0.60	1.0	0.016	0.018	0.58	1.0	0.5%	1.2%	-4.6%	-0.2%	0.016	0.020	0.59	0.9	0.016	0.019	0.58	1.0	-0.3%	-2.6%	-2.1%	8.3%	0.016	0.016	0.2%
WRP	48	4.345	5.565	-	-	4.139	5.425	-	-	-4.7%	-2.5%	-	-	4.314	6.166	-	-	4.114	6.107	-	-	-4.6%	-1.0%	-	-	4.336	4.132	-4.7%

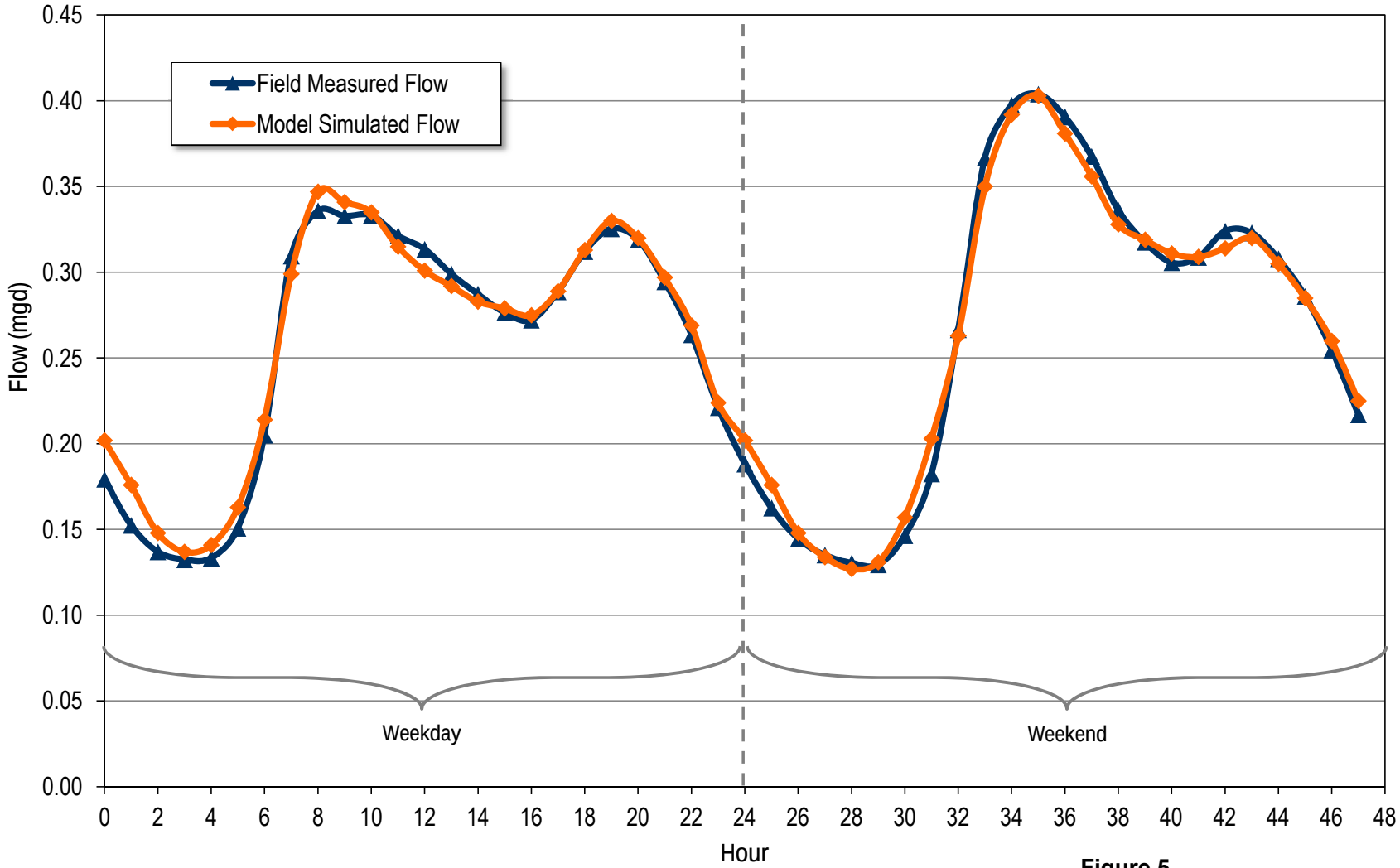

Figure 5
Meter K1 Dry Weather Flow Calibration
Model Development and Calibration
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5.3 Wet Weather Flow Calibration

The WWF calibration enables the hydraulic model to accurately simulate I/I entering a sewer system during a wet weather event. WWF calibration consists of two steps: 1) determining the rainfall events that characterize the most significant impact on the sewer system facilities, preferably during wet antecedent soil moisture conditions; and 2) creating a database of I/I parameters for these rainfall event that simulate an accurate and precise system response to wet weather for a variety of rainfall events. I/I parameters are developed such that the model will accurately simulate the system's response to wet weather for any rainfall and/or soil moisture conditions.

For WWF calibration, it is necessary to calibrate flows against two or more rainfall events. For example, model parameters for I/I are adjusted for one event so that projected flows align with measured flows. These same parameters are then used to project flows for a second measured event. If both events provide an accurate and precise estimate of the independent measured flow events, the model is calibrated.

The collection system I/I response was greatest during the late January 2012 rainfall events, between January 17 to January 31, 2012. During this time, approximately three significant storms occurred that varied in terms of their intensity and length. Calibrating the model to this type and duration of rainfall is ideal because it represents variable wet weather situations in the presence of high soil saturation. Therefore, the hydraulic model was calibrated to three rainfall events that occurred over a 14-day period between January 17 and January 31, 2012.

The wet weather calibration process involves creating custom RDII unit hydrographs for each flow meter tributary area using the "RTK Method." The RDII unit hydrograph is the summation of three separate triangular hydrographs (short-term, medium-term, and long-term), which are each defined by three parameters: R, T, and K. R represents the fraction of the rainfall over the watershed that enters the sanitary sewer system; T represents the time to peak; and K represents the ratio of the time to recession to the time to peak. Therefore, there are a total of nine variables for each RDII unit hydrograph Figure 6 shows an example RDII hydrograph. In addition to the RDII unit hydrograph, there are nine initial abstraction parameters that can be specified in the hydraulic model (three each for the short-term, medium-term, and long--term hydrographs). Initial abstractions represent potential rainfall losses that occur before rainfall becomes part of RDII. Therefore, in order for rainfall to become an RDII, it must first satisfy the initial abstraction losses. Values can be specified for maximum depth, recovery rate, and initial depth. Maximum depth is the maximum initial abstraction loss possible; rainfall in excess of the maximum depth would be converted to an RDII according to the defined RTK parameters. Recovery rate represents the rate at which the initial abstraction loss recovers during the dry period between two rain events. Initial depth represents the depth of the abstraction losses that are already satisfied at the beginning of the simulation. For several of the flow meters in this study, maximum depth parameters were used to simulate the delayed flow response to a rainfall event.

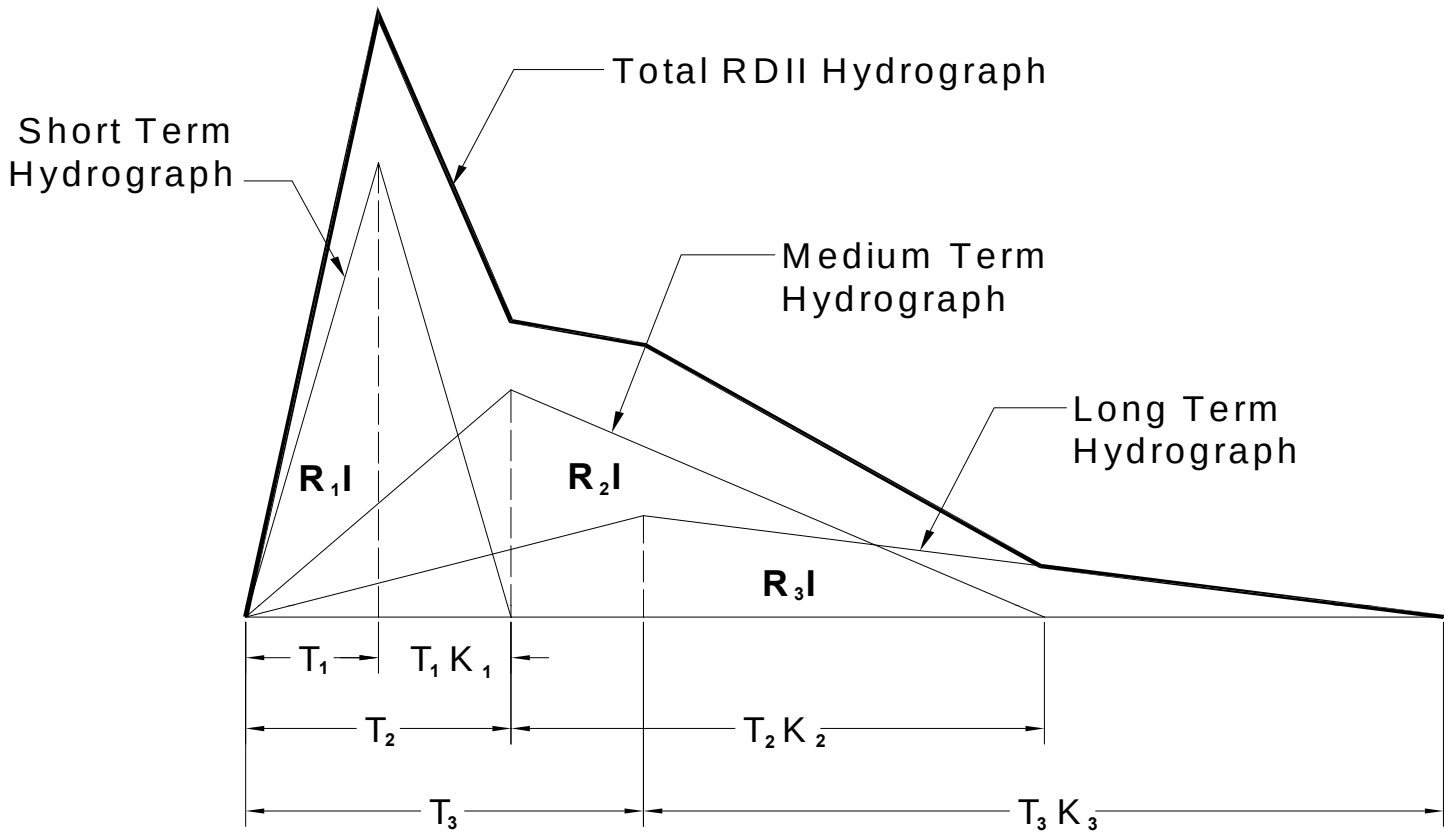

Figure 6
Example RDII Hydrograph
Model Development and Calibration
City of Grants Pass

Adjustment of this parameter mimics the affect of the moisture content in the soil; zero indicates soil saturation, a lower value indicates high moisture, and a high value indicates low moisture.

The WWF calibration process consists of adjusting the eighteen variables in the RDII hydrographs for each flow meter until the peak I/I rate measured during the flow monitoring program are simulated for each of the series of rainfall events. Figure 7 illustrates the results for the wet weather calibration for meter K1. The remaining WWF calibration plots are provided in Appendix C. As shown in Appendix C and Figure 7, the model showed good correlation between the measured flow and simulated flow, and met the WaPUG standards for wet weather calibration.

Similar to the DWF calibration plots, comparisons were made for peak and average flows as well as the temporal distribution of flow. Table 8 provides a summary table with the WWF calibration peak and average flow results. The modeled flow velocities (ft/s) and depths (in) of water were also recorded during the flow calibration process, though there is no calibration standard for these parameters for wet weather flow calibration. Since no standard exists for levels and depths for wet weather flow calibration, the percent errors for these parameters was not included in Table 8. However, the individual wet weather calibration sheets in Appendix C show graphical calibration results for flow, velocity, and level for each flow meter.

The WaPUG calibration standards specify that the hydraulic model must be calibrated to meet the percent error requirements for two out of three storm events. Therefore, each of the 11 flow meters met the WaPUG wet weather flow calibration standards. For two out of three storm events, all measured versus modeled flows had percent errors within the desire range. Appendix C contains a summary table and flow meter calibration sheets for the WWF calibration.

For flow meter Z41, special operation of the Darneille Pump Station during the Storm 1 event resulted in the relatively high percent error for the wet weather calibration. According to operations staff, only one of the two Darneille Pump Station force mains was initially open when the first storm event occurred. The reduced force main capacity and high flow rates at the Darneille Pump Station caused an overflow of the Darneille wet well to the Redwood Interceptor, which conveys flows to the Redwood Pump Station. As shown on the wet weather calibration sheets in Appendix C, the initial peak flow during Storm 1 represents the time at which the overflow to the Redwood Interceptor occurred. Even though the system operators opened the second force main at the Darneille pump station around this same time, it took almost 24 hours with water being circulated between the Darneille and Redwood Pump Stations for the pumps to catch up to the storm flows.

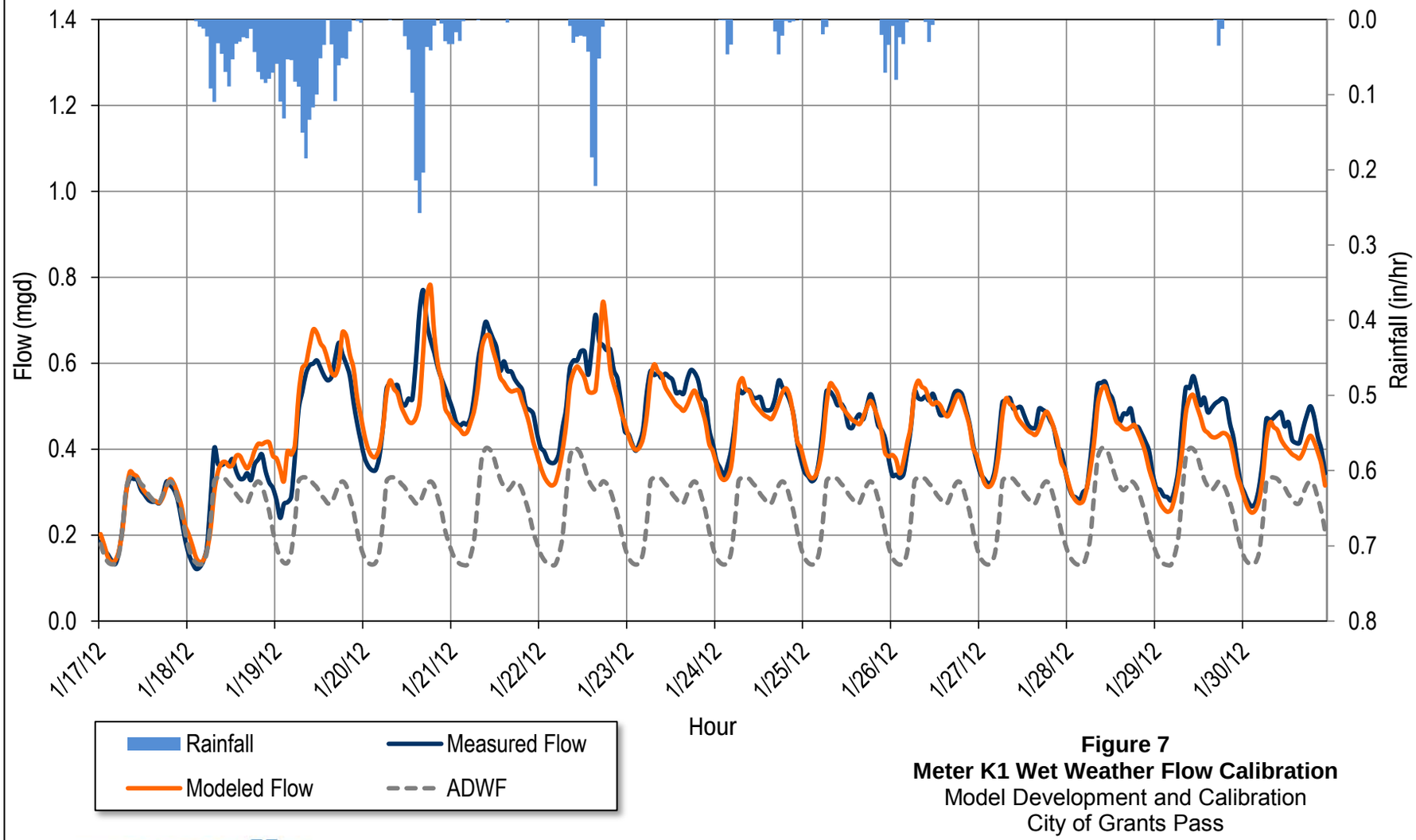

Figure 7
Meter K1 Wet Weather Flow Calibration
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Table 8 Wet Weather Flow Calibration Summary
Model Development and Calibration
City of Grants Pass

		Storm 1 (1/18/12-1/20/12)						Storm 2 (1/20/12-1/21/12)						Storm 3 (1/22/12-1/22/12)					
		Measured Data[1]		Modeled Data[2]		Percent Error[3]		Measured Data[1]		Modeled Data[2]		Percent Error[3]		Measured Data[1]		Modeled Data[2]		Percent Error[3]	
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)
D60	20.5	1.163	2.173	1.158	2.158	-0.5%	-0.7%	1.773	2.397	1.741	2.529	-1.8%	5.5%	1.607	2.065	1.620	2.352	0.8%	13.9%
H5	12	0.593	1.130	0.611	1.124	3.1%	-0.5%	0.905	1.271	0.862	1.323	-4.7%	4.1%	0.752	1.014	0.718	1.060	-4.6%	4.5%
I5	15	0.569	1.039	0.570	0.998	0.2%	-4.0%	0.784	1.159	0.754	1.068	-3.9%	-7.8%	0.697	0.906	0.701	0.997	0.5%	10.0%
J2	18	0.536	1.103	0.591	1.222	10.2%	10.8%	0.862	1.457	0.866	1.485	0.4%	1.9%	0.771	1.136	0.792	1.372	2.7%	20.8%
K1	18	0.365	0.647	0.394	0.678	8.0%	4.7%	0.541	0.770	0.529	0.781	-2.2%	1.5%	0.524	0.712	0.494	0.742	-5.8%	4.1%
N2	18	0.432	0.928	0.452	0.936	4.5%	0.9%	0.590	1.107	0.568	1.023	-3.8%	-7.6%	0.526	0.770	0.539	0.890	2.5%	15.5%
R42	15	0.377	1.038	0.402	0.927	6.5%	-10.7%	0.790	1.123	0.809	1.196	2.4%	6.5%	0.550	0.690	0.583	0.838	6.1%	21.5%
W62	12	0.157	0.279	0.159	0.279	1.3%	-0.1%	0.219	0.309	0.218	0.324	-0.5%	4.9%	0.206	0.267	0.212	0.297	2.9%	11.0%
X115	12	0.333	0.658	0.331	0.648	-0.8%	-1.5%	0.488	0.678	0.479	0.732	-1.7%	8.0%	0.441	0.619	0.443	0.640	0.4%	3.4%
Z41	24	0.124	0.569	0.093	0.293	*-25.4%*	*-48.5%*	0.238	0.378	0.220	0.335	-7.4%	-11.3%	0.139	0.173	0.143	0.207	2.4%	19.7%
WRP	48	8.029	16.162	7.804	15.868	-2.8%	-1.8%	12.291	17.595	11.749	18.131	-4.4%	3.0%	10.581	13.973	10.279	15.327	-2.9%	9.7%

Notes:
1. Average flow values are calculated from weekday/weekend dry weather flow monitoring data. Maximum flow values are hourly peaks corresponding to either weekend or weekday confitions, as appropriate.
2. Percent Difference = (Modeled - Measured)/Measured*100.
3. Average Dry Weather Flow = (5*Weekday Dry Weather Flow + 2*Weekend Dry Weather Flow)/7

The overflow connecting the Darneille wet well to the Redwood Interceptor exists to provide temporary storage when an event like Storm 1 occurs or similar operating conditions at the Darneille Pump Station exist. It is difficult to represent flows when operating variables such as those experienced during Storm 1 are introduced. However, while the model did not mimic observed flow for Storm 1, Storms 2 and 3 were calibrated to within the acceptable WaPUG limits for flow meter Z41.

APPENDIX A – FLOW MONITORING REPORT

SANITARY SEWER FLOW MONITORING AND INFLOW / INFILTRATION STUDY

City of Grants Pass, Oregon

June 2012

V&A

SANITARY SEWER FLOW MONITORING AND INFLOW / INFILTRATION STUDY

City of Grants Pass, Oregon

Prepared for

carollo

Engineers...Working Wonders With Water™

Prepared by

V&A

June 2012

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APPENDIX

Appendix A: Flow Monitoring Sites: Data, Graphs, Information

ABBREVIATIONS, TERMS AND DEFINITIONS USED IN THIS REPORT

Table i.
Abbreviations

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

Table ii.
Terms and Definitions

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

Term	Definition
	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 in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Overflows are often attributable to high inflow rates.
Normalization	To run an "apples-to-apples" comparison amongst different basins, calculated metrics must be **normalized**. Individual basins will have different runoff areas, pipe lengths and sanitary flows. There are three common methods of normalization. Depending on the information available, one or all methods can be applied to a given project: Pipe Length: The metric is divided by the length of pipe in the upstream basin expressed in units of inch-diameter-mile (IDM). Basin Area: The metric is divided by the estimated drainage area of the basin in acres. ADWF: The metric is divided by the average dry weather sanitary flow (ADWF).
Normalization, *inflow*	The peak I/I flow rate is used to quantify inflow. Although the instantaneous flow monitoring data will typically show an inflow peak, the inflow response is measured from the I/I flow rate (in excess of baseline flow). This removes the effect of sanitary flow variations and measures only the I/I response: Pipe Length: The peak I/I flow rate is divided by the length of pipe (IDM) in the upstream basin. The result is expressed in gallons per day (gpd) per IDM (gpd/IDM). Basin Area: The peak I/I flow rate is divided by the geographic area of the upstream basin. The result is expressed in gpd per acre. ADWF: The peak I/I flow rate is divided by the average dry weather flow (ADWF). This is a ratio and is expressed without units.
Normalization, *GWI*	The estimated GWI rates are compared to acceptable GWI rates, as defined by the Water Environment Federation, and are used to identify basins with high GWI: Pipe Length: The GWI flow rate is divided by the length of pipe (IDM) in the upstream basin. The result is expressed in gallons per day (gpd) per IDM (gpd/IDM). Basin Area: The GWI flow rate is divided by the geographic area of the upstream basin. The result is expressed in gpd per acre. ADWF: The GWI flow rate is divided by the average dry weather flow (ADWF). This

Term	Definition
	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.
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 City of Grants Pass, Oregon (City). Flow and rainfall monitoring was performed over a 17 week period at ten open-channel flow monitoring sites throughout the City. Sanitary flow monitoring was conducted at ten locations from October 17, 2011 to February 3, 2012. The purpose of this study was to measure sanitary sewer flows at the flow monitoring sites, estimate available sewer capacity and conduct analyses pertaining to 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 flow level (depth) at peak flow times are important factors to consider in understanding the capacity of the flow monitoring system. Table 1 summarizes the peak recorded flows, levels, d/D ratios and peaking factors per site during the flow monitoring period. Note: capacity analysis data represents the hydraulic conditions only at the point site location. Hydraulic conditions in other areas of the collection system will differ.

Table 1.
Capacity Analysis Summary[2]

Site	ADWF (mgd)	Peak Measured Flow (mgd)	Peaking Factor	Diameter (in)	Peak Level (in)	*d/D* Ratio	Level Surcharged above Crown (ft)
D60	0.611	2.534	4.2	20.5	6.6	0.32	-
H5	0.265	1.296	4.9	12	19.6	1.64	0.64
I5	0.305	1.191	3.9	15	8.5	0.57	-
J2	0.331	1.566	4.7	18	10.5	0.58	-
K1	0.261	0.790	3.0	18	6.1	0.34	-
N2	0.200	1.143	5.7	18	7.6	0.42	-
R42	0.180	1.233	6.9	15	4.6	0.31	-
W62	0.090	0.322	3.6	12	3.8	0.32	-
X115	0.143	0.722	5.1	12	8.7	0.73	-
Z41	0.016	1.180	75.7	24	30.7	1.28	0.56

The following capacity analysis results are noted:

- **Peaking Factor:** All sites had peaking factors that exceeded typical design threshold limits for peak flow to average dry weather flow ratio. Sites Z41, R42, X115 and N2 had the highest peaking factors recorded for this study. It should be noted that the peaking factor for site Z41 may be skewed high due to both low ADWF and pump station operations.

[2] Notes: (a) ADWF = average dry weather flow. (b) Peak flow as measured during entire flow monitoring period. (c) PF = Peaking Factor = Peak Measured Flow / ADWF. (d) d/D Ratio = peak measured depth / pipe diameter. Values shown are the highest d/D ratios as measured during entire flow monitoring period.

- ***d/D* Ratio:** Two sites had *d/D* ratios that exceeded common threshold values for *d/D* ratio. Sites H5 and Z41 surcharged approximately 0.6 feet above the pipe crown during this study

Figure 1 shows bar graphs of the capacity results. Figure 2 shows a schematic diagram of the peak measured flows with peak flow levels.

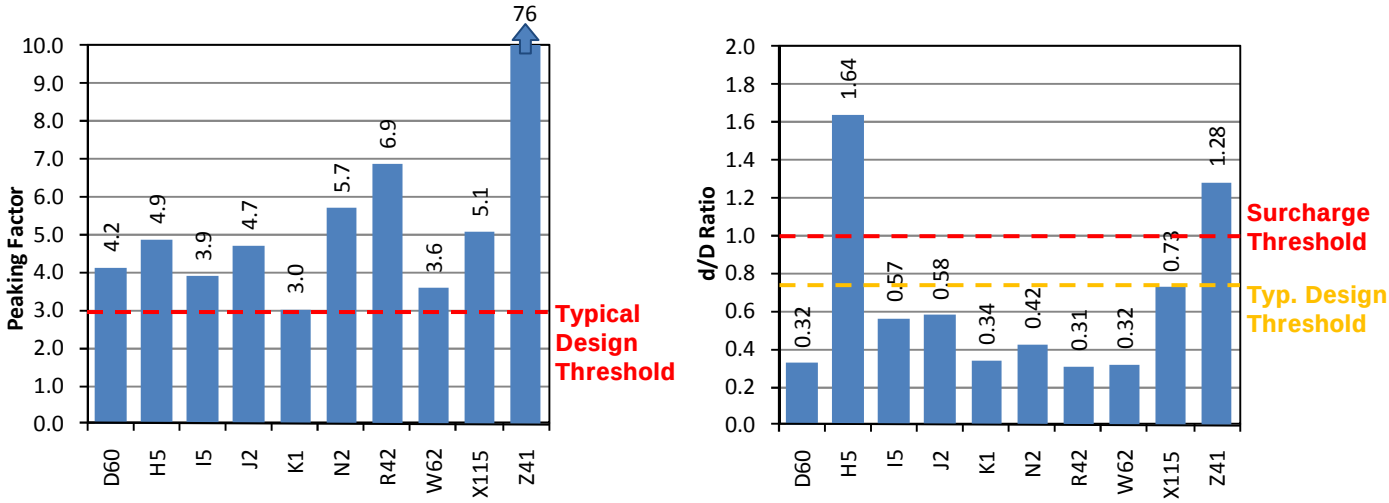

Figure 1. Capacity Summary Bar Graphs: Peaking Factors and *d/D* Ratios

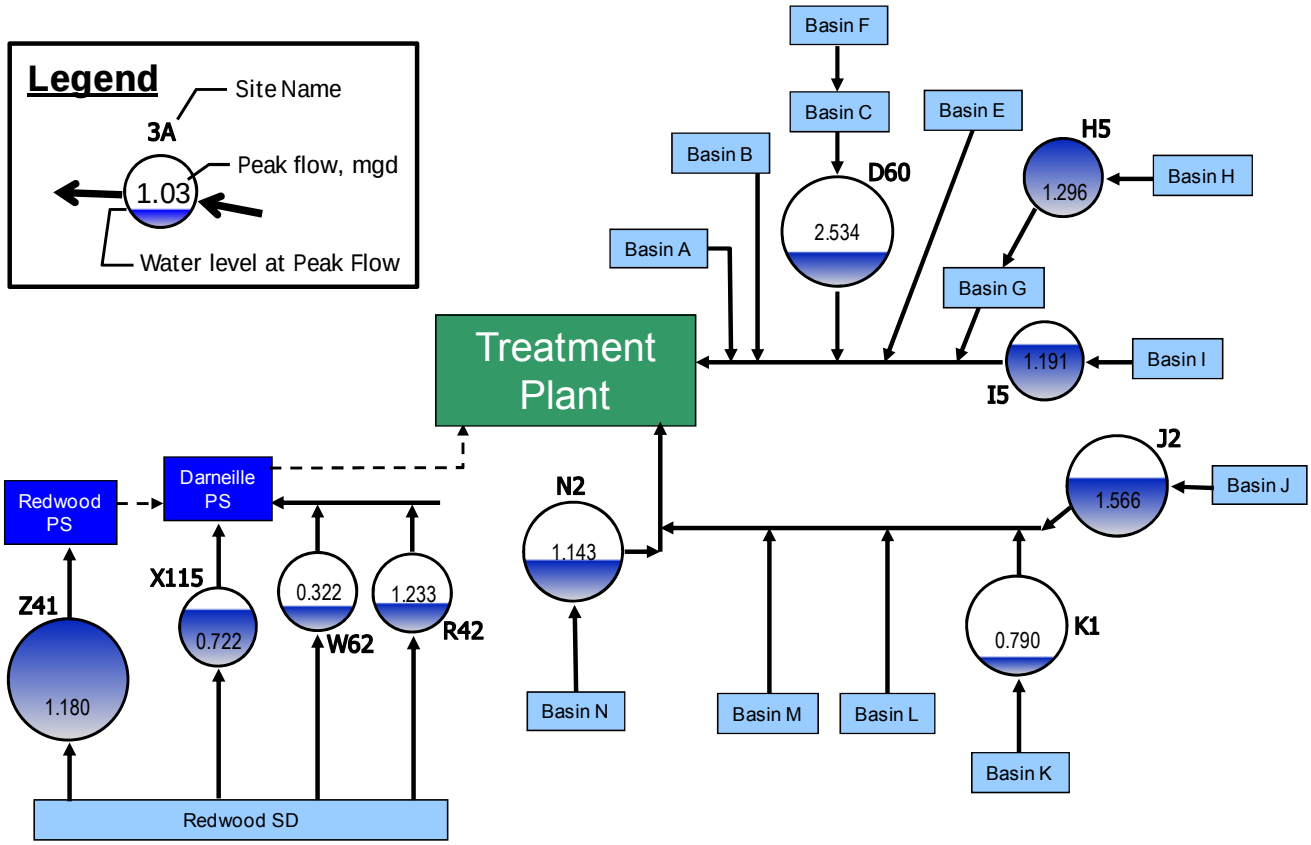

Figure 2. Peak Measured Flow (Flow Schematic)

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 10 represents the least. The final I/I values and I/I analysis data were taken from the January 18 – February 2, 2012 rainfall event. Please refer to the *I/I Methods* section for more information on inflow analysis methods. Figure 3, Figure 4, Figure 5 and Figure 6 show temperature basin maps of the overall inflow and infiltration rankings. Figure 7 shows an illustrative map summary of the "Top 3" ranked basins for each I/I Analysis component.

Table 2.
I/I Analysis Summary

Basin	ADWF (mgd)	Peak I/I Rate (mgd)	Inflow Ranking	RDI Ranking	Evidence of High GWI?	Combined I/I Ranking
D60	0.611	1.829	9	6	-	6
H5	0.265	1.003	3	3	Yes	2
I5	0.305	0.839	2	1	Yes	1
J2	0.331	1.161	5	9	-	8
K1	0.261	0.510	10	7	Yes	10
N2	0.200	0.900	7	5	-	7
R42	0.180	1.008	1	10	-	3
W62	0.090	0.217	8	2	Yes	5
X115	0.143	0.567	6	4	-	4
Z41	0.016	1.162	4	8	Yes	9
Grants Pass:	1.973	6.129				
Redwood:	0.428	2.054				
WWTP:	4.336	13.345				

Ranking of 1 represents most inflow after normalization.

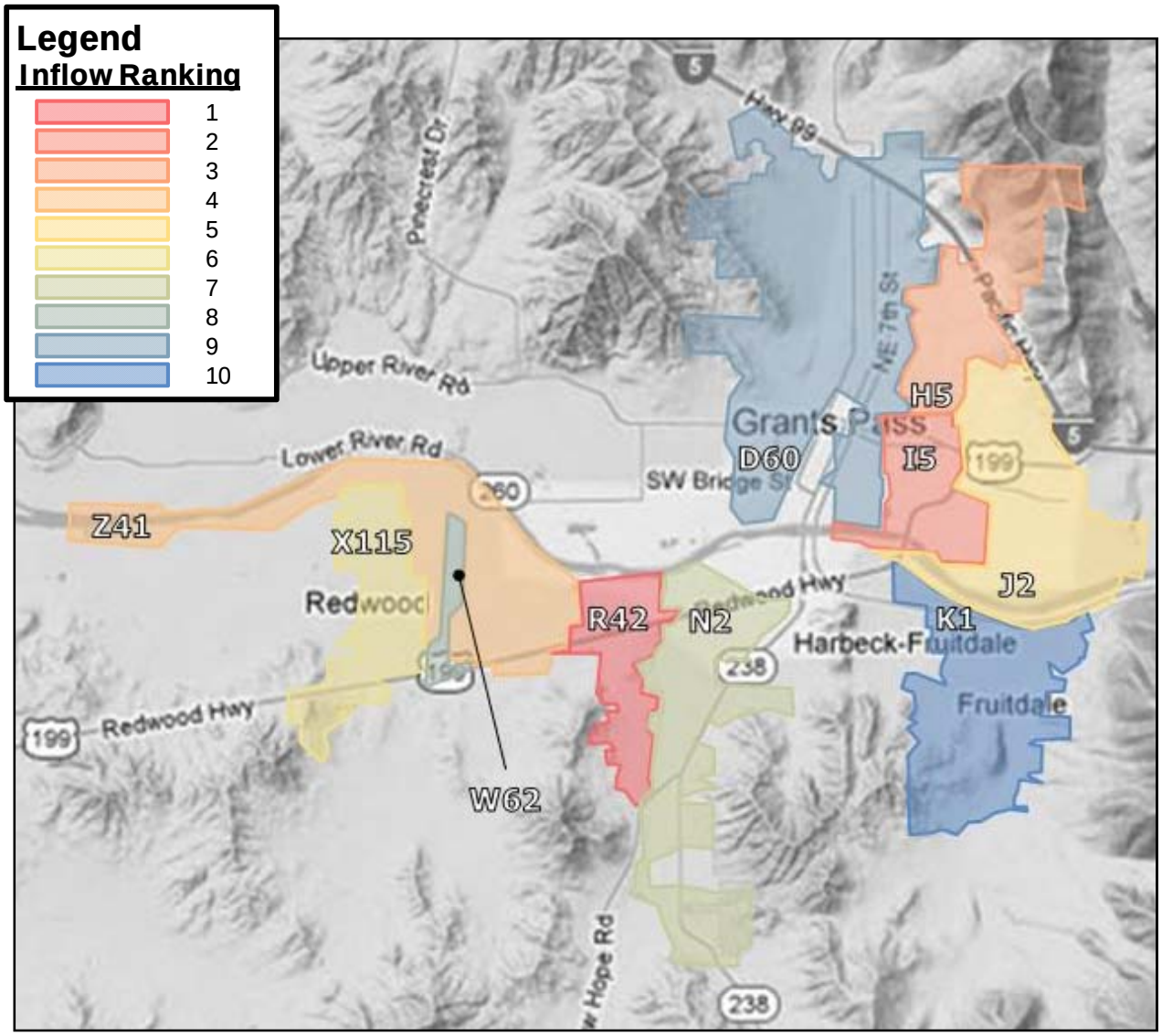

Figure 3. Inflow Temperature Map (by Rank)

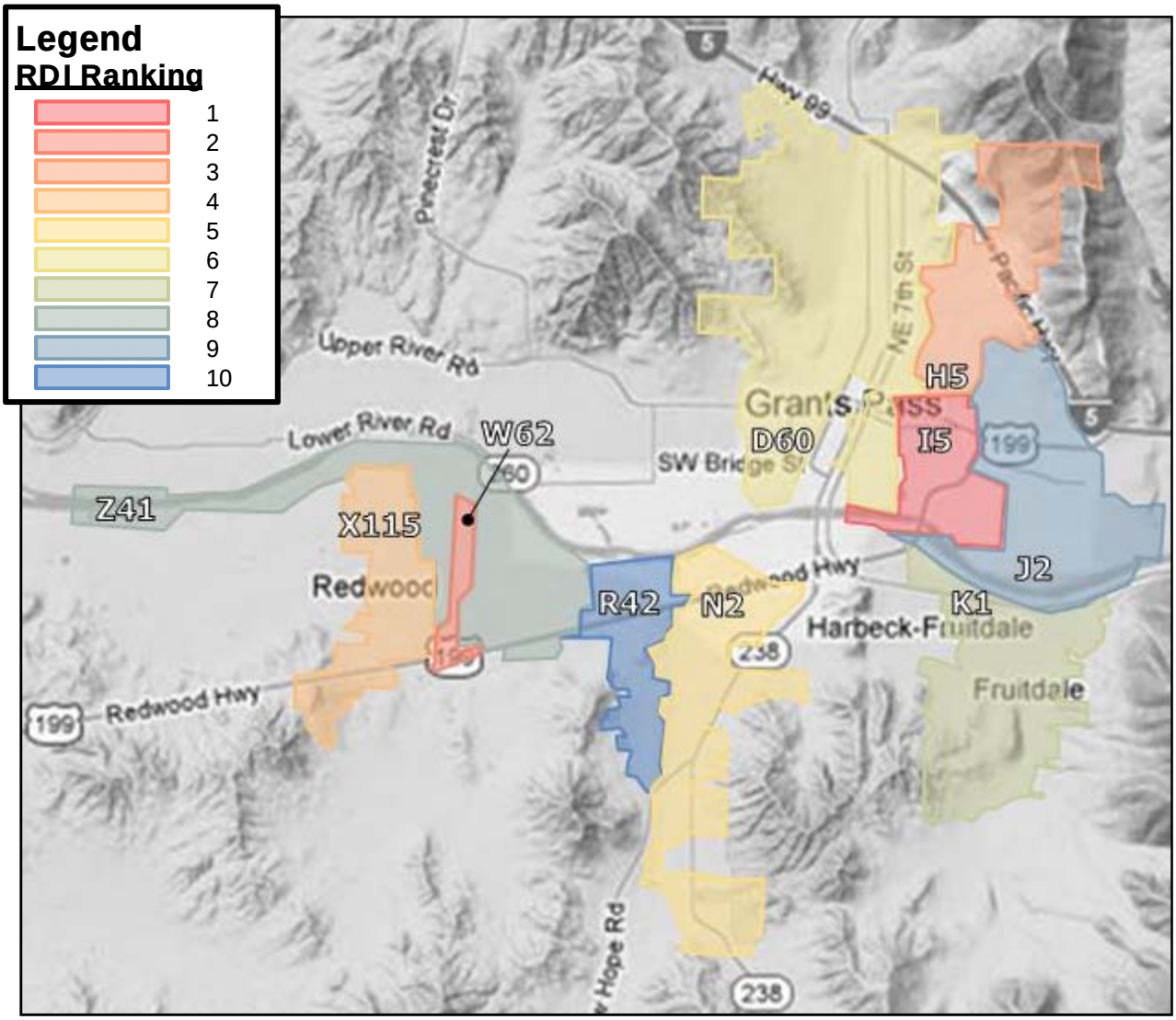

Figure 4. RDI Temperature Map (by Rank)

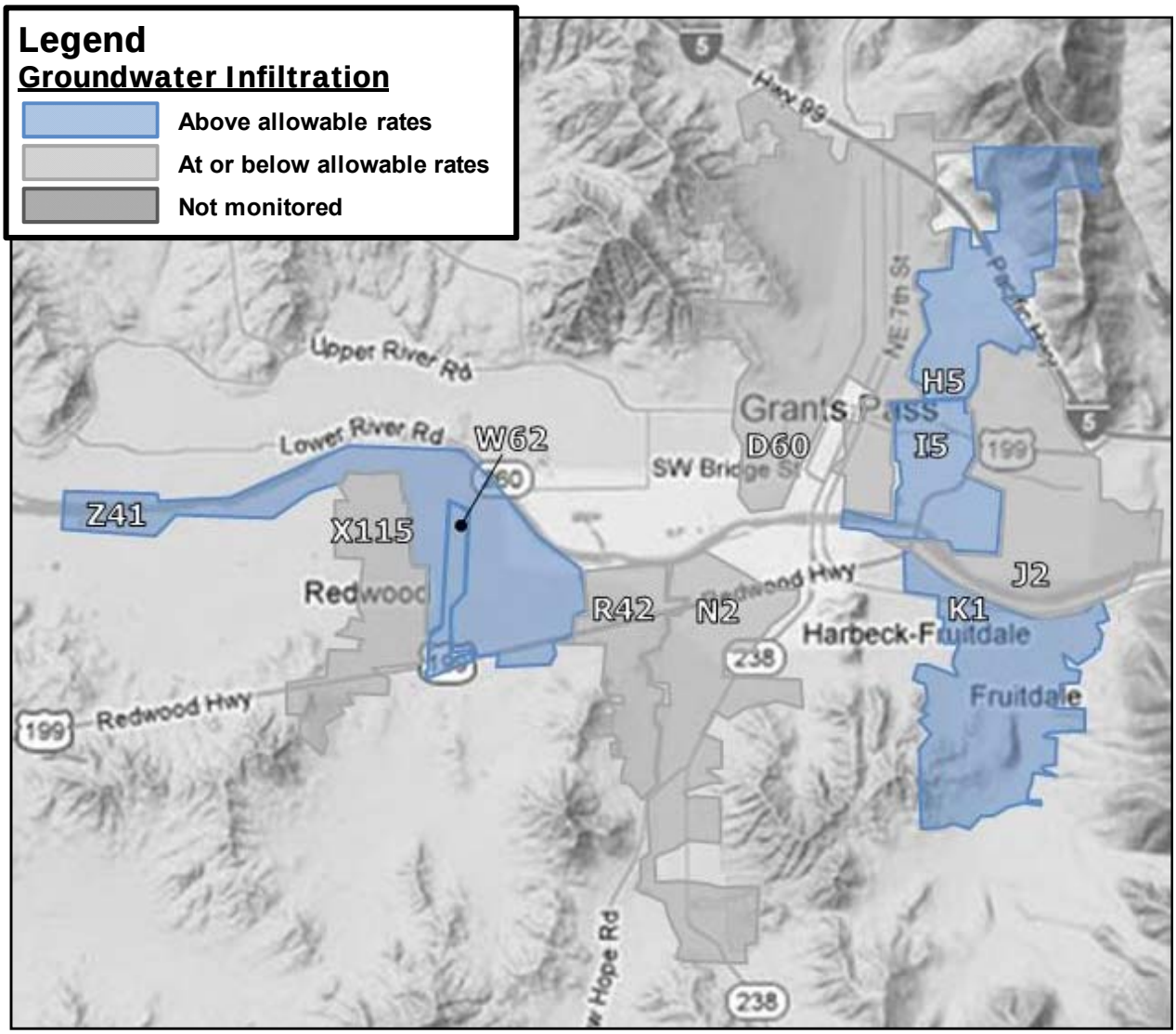

Figure 5. Basins with Groundwater Infiltration

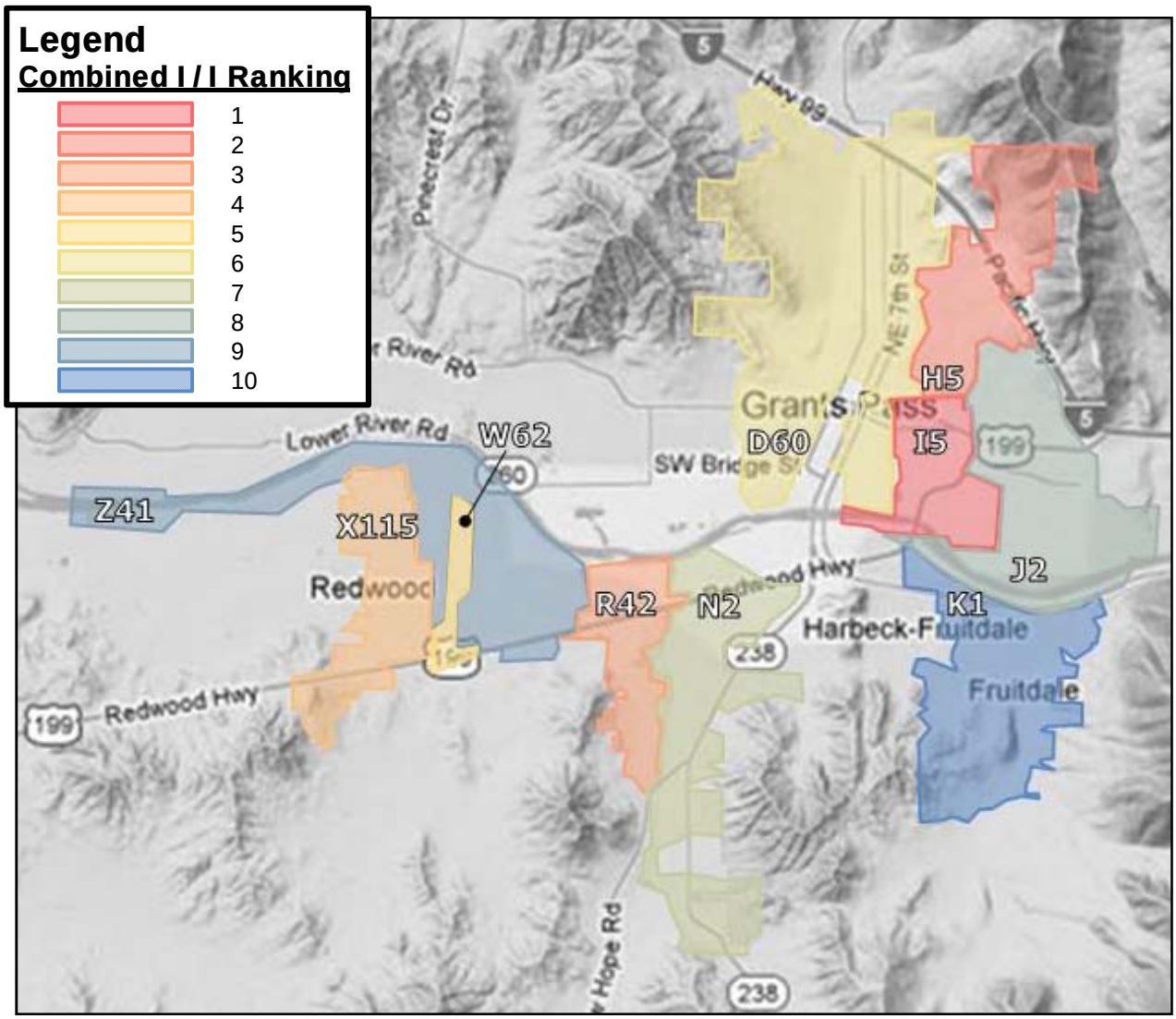

Figure 6. Combined I/I Temperature Map (by Rank)

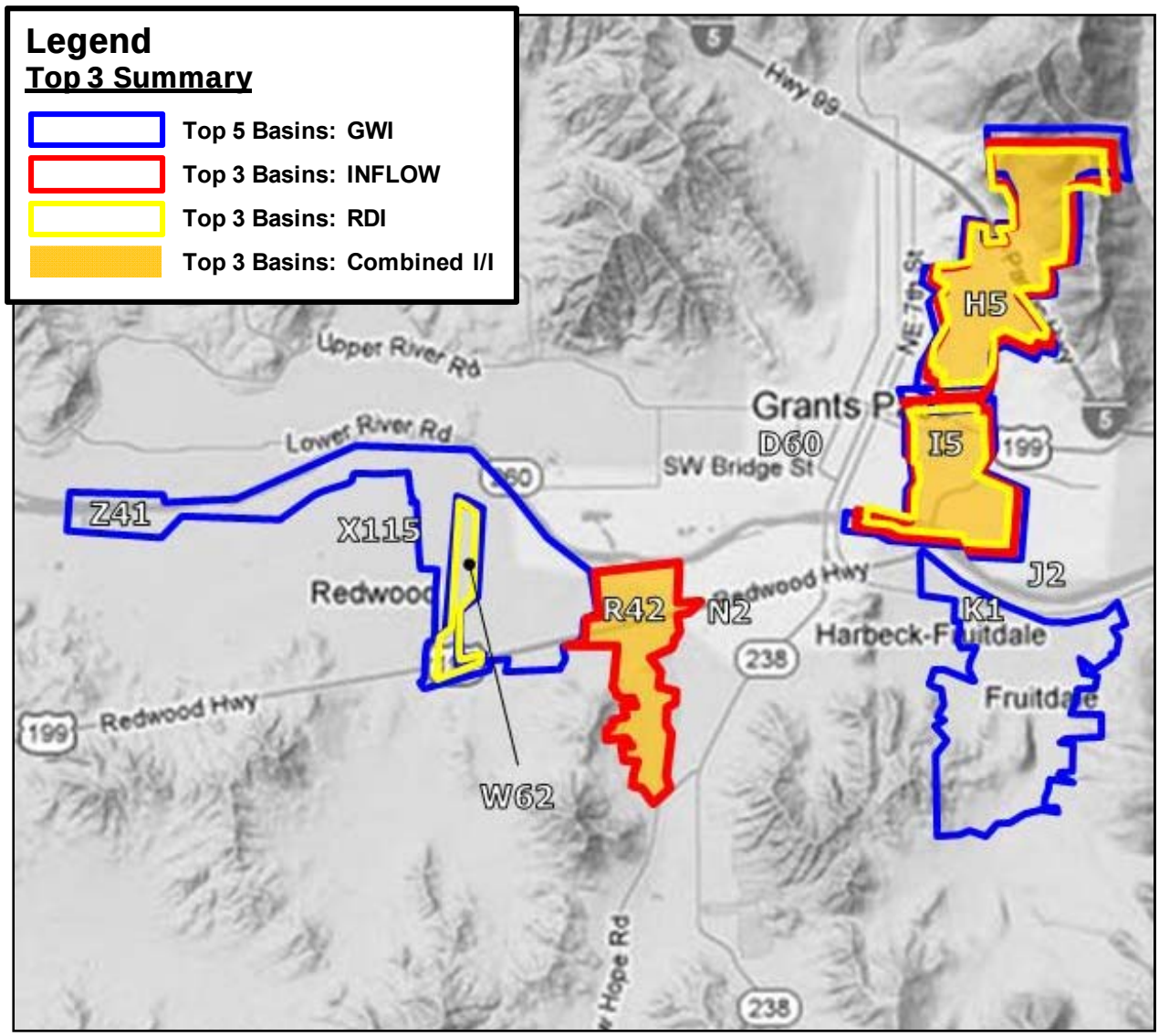

Figure 7. Temperature Map Summary: Top Three Basins, All I/I Analyses

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 H5, I5, and R42.
   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 Basin I5. The highest groundwater infiltration was occurring in Basins Z41, I5 and H5.
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

Preface

Situated near the Rogue River, the Grants Pass Water Restoration Plant serves the City, the Harbeck-Fruitdale area and the Redwood area. The City of Grants Pass Wastewater Collection Department collects wastewater from approximately 10,000 homes and businesses in the city and urban growth boundary via 164 miles of piping, two lift stations and three force main pump stations.

The Wastewater Treatment Plant is an activated sludge secondary treatment plant, with ultra violet disinfection. Average dry weather flows are 5.5 mgd (million gallons per day), and peak wet weather flows are 30 mgd[3].

Scope and Purpose

V&A has completed sanitary sewer flow monitoring, rainfall monitoring, and inflow and infiltration (I/I) analysis within the City of Grants Pass, Oregon (City). Flow and rainfall monitoring was performed over a 17 week period at 10 open-channel flow monitoring sites throughout the City from October 18, 2011 to February 2, 2012. 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

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[4]. Capacity and flow rate information is presented on a site-by-site basis.

Flow Monitoring Basins

Flow monitoring basins are localized areas of a sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. The basin refers to the ground surface area near and enclosed by the pipelines[5]. A basin may refer to the entire collection system upstream from a flow meter or may exclude separately monitored basins upstream. I/I analysis in this report will be conducted on a basin-by-basin basis.

Rain Gauges

Rain data was obtained from a rain gauge installed by V&A and located at the Grants Pass wastewater treatment facility. Four other rain gauges maintained by local weather enthusiasts were used to supplement V&A's rainfall data.

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[3] Preface information taken from the City of Grants Pass website (http://www.grantspassoregon.gov).

[4] 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%.

[5] Data for the basin areas (in acres) and basin pipe lengths (in IDM) were provided by Carollo Engineers.

Table 3 summarizes the flow monitoring sites and associated basins that were analyzed for this project. Figure 8 and Figure 9 illustrate the flow monitoring locations and associated basins, respectively.

Table 3.
List of Flow Monitoring Sites and Flow Drainage Basins

City Manhole ID	Pipe Size (in)	Location	Size (acres)	Pipe Length (IDM[6])
D60	21	Intersection of Southwest Central Avenue and SW Oak Street	2.84	359.43
H5	12	518 Northeast A Street, East of Northeast Dean Drive	0.90	68.34
I5	15	505 Southeast M Street	0.58	53.20
J2	18	1064 Southeast Belle Aire Drive	1.30	134.45
K1	18	Intersection of Gold River Lane and Gold River Lane	1.24	137.14
N2	18	West Park Street, West of Evergreen Avenue	1.32	133.34
R42	15	Shady Lane by mailboxes at end of paved road	0.52	46.80
W62	12	Schroeder Lane, South of Eggers Lane	0.30	38.93
X115	12	Private Drive North of South River Road and Darneille Lane	0.76	77.87
Z41	24	Private Drive Northeast of Leonard Road and Rounds Avenue	1.26	155.09

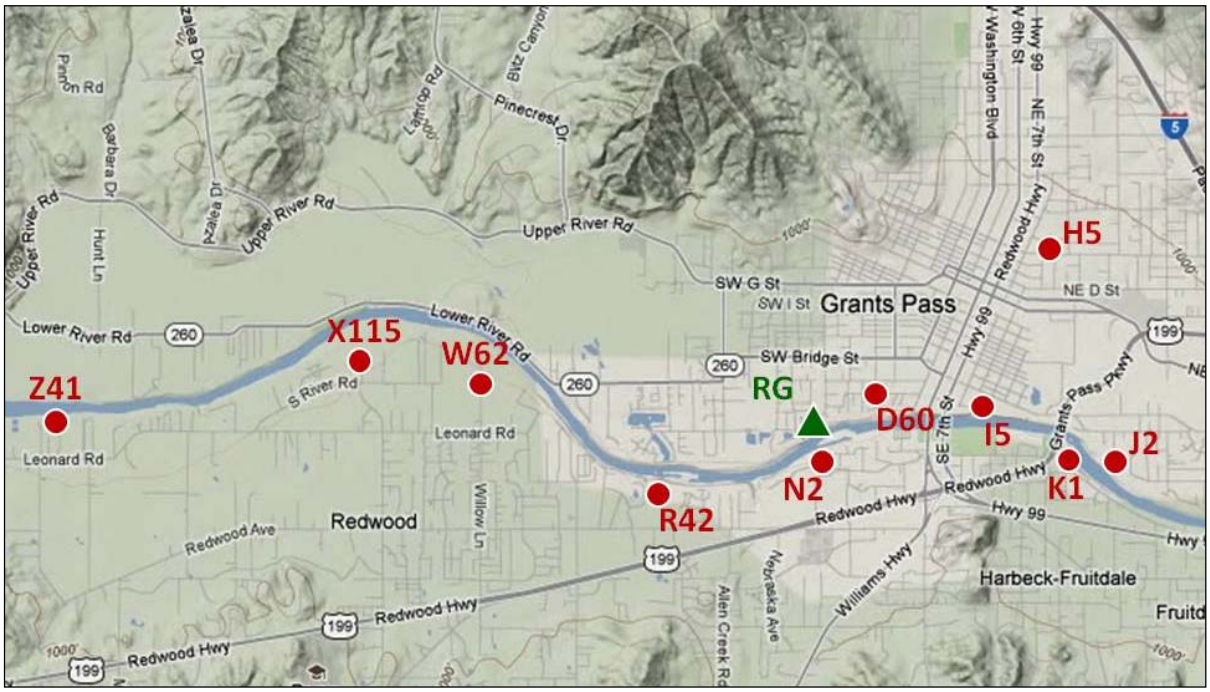


Figure 8. Flow Monitoring Site Map

[6] Inch-diameter-mile (miles of pipeline multiplied by the diameter of the pipeline in inches). This is the industry standard unit of measurement for stating length of pipe within a sanitary drainage basin.

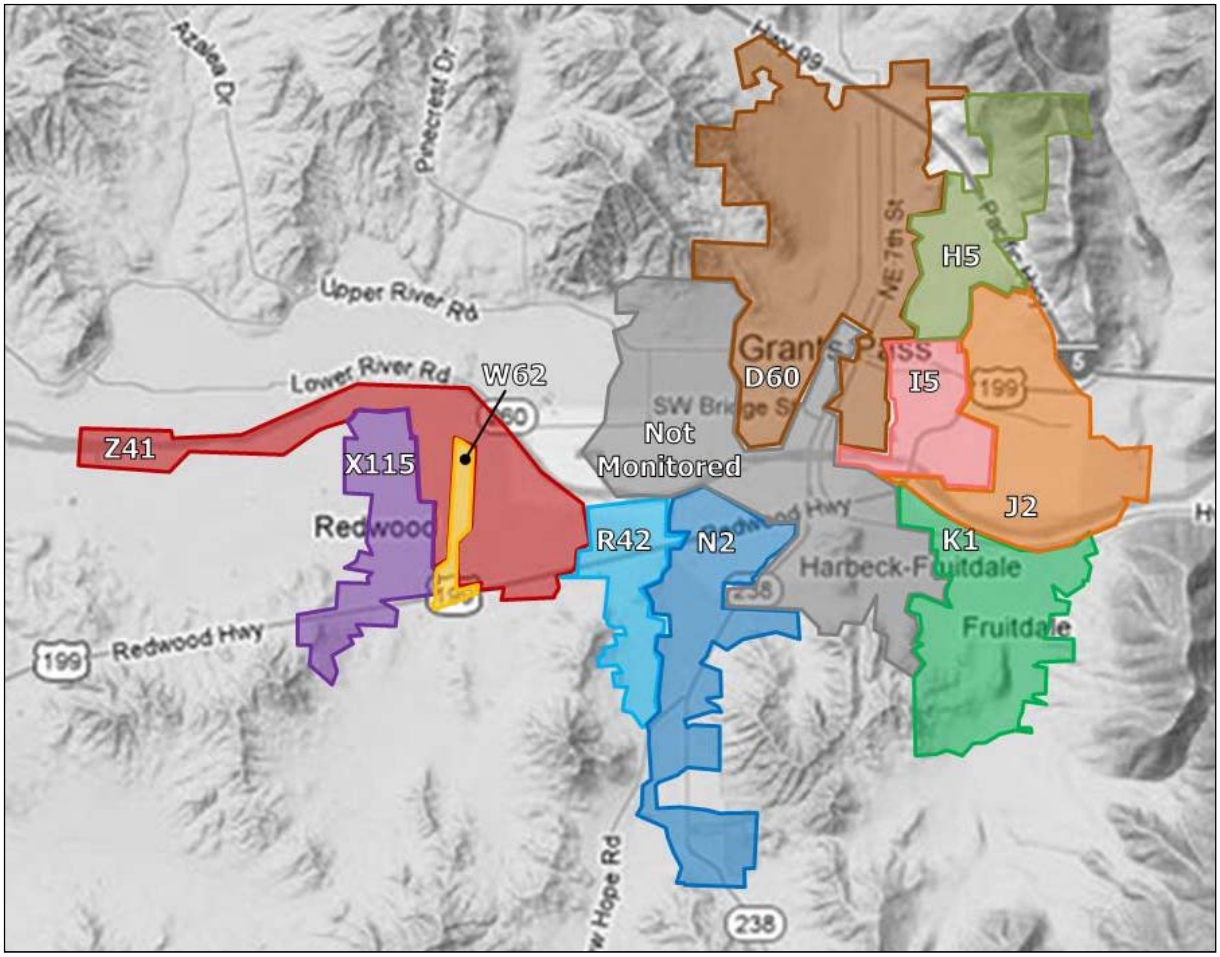


Figure 9. Flow Monitoring Basin Map

Treatment Plant Data / Regional Analysis

In addition to the sites that were monitored, V&A was provided influent flow data for the wastewater treatment plant. With this information, it made sense to regionalize the overall collection system. For I/I analysis, this allowed for smaller individual basins to be compared to general overall trends within general areas of the collection system. Regions were separated as follows:

- **WWTP:** Using the influent flow data provided for the wastewater treatment plant, I/I analysis will determine the complete system response.
- **Redwood Sanitary District:** The sum of the flow monitoring sites X115, Z41, W62 and R42, nearly all of the Redwood Sanitary District was monitored during this study.
- **City of Grants Pass:** The sum of the flow monitoring sites N2, D60, H5, I5, J2 and K1, a significant and representative portion of the City collection system was monitored during this study.

Figure 10 illustrates the Regions that were utilized in this project. The areas not monitored for this study are also shown.

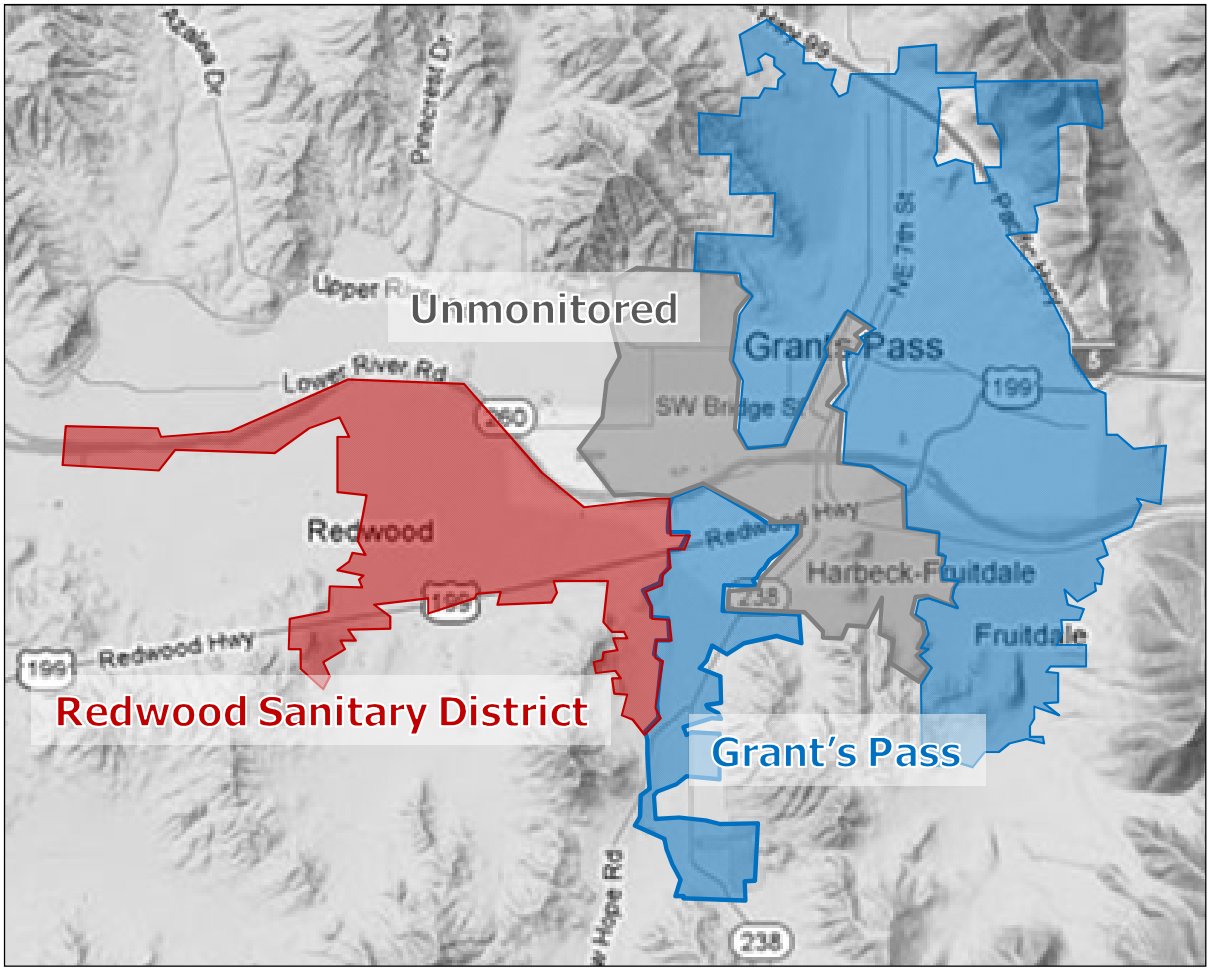


Figure 10. Regions in Grants Pass Area

METHODS AND PROCEDURES

Confined Space Entry

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

Ten Teledyne Isco 2150 meters were installed by V&A in the sewer lines 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 (500 kHz) 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. Figure 11 shows a typical installation for a flow meter with a submerged sensor.

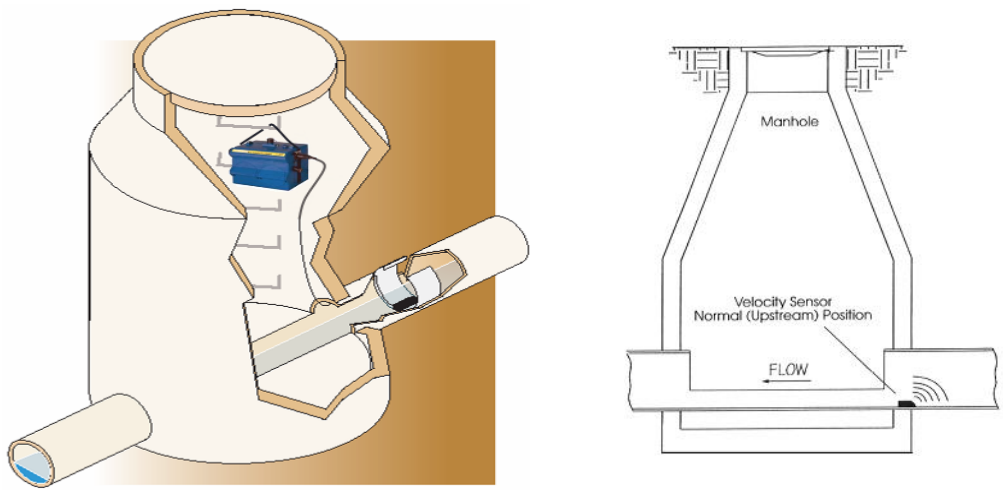


Figure 11. Typical Installation for Flow Meter with Submerged Sensor

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

<u>Flow Calculation</u>

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.

RESULTS AND ANALYSIS

Rainfall: Rain Gauge Locations

V&A installed one rain gauge at the Grants Pass wastewater treatment facility. V&A also used data from four rain gauges located throughout the Grants Pass area that were maintained by local weather enthusiasts. While V&A performed QA/QC analysis to ensure, as best possible, the quality of the rainfall data from these four additional sites, it is noted that V&A has no direct control over those gauges. Figure 12 illustrates the rain gauge locations.

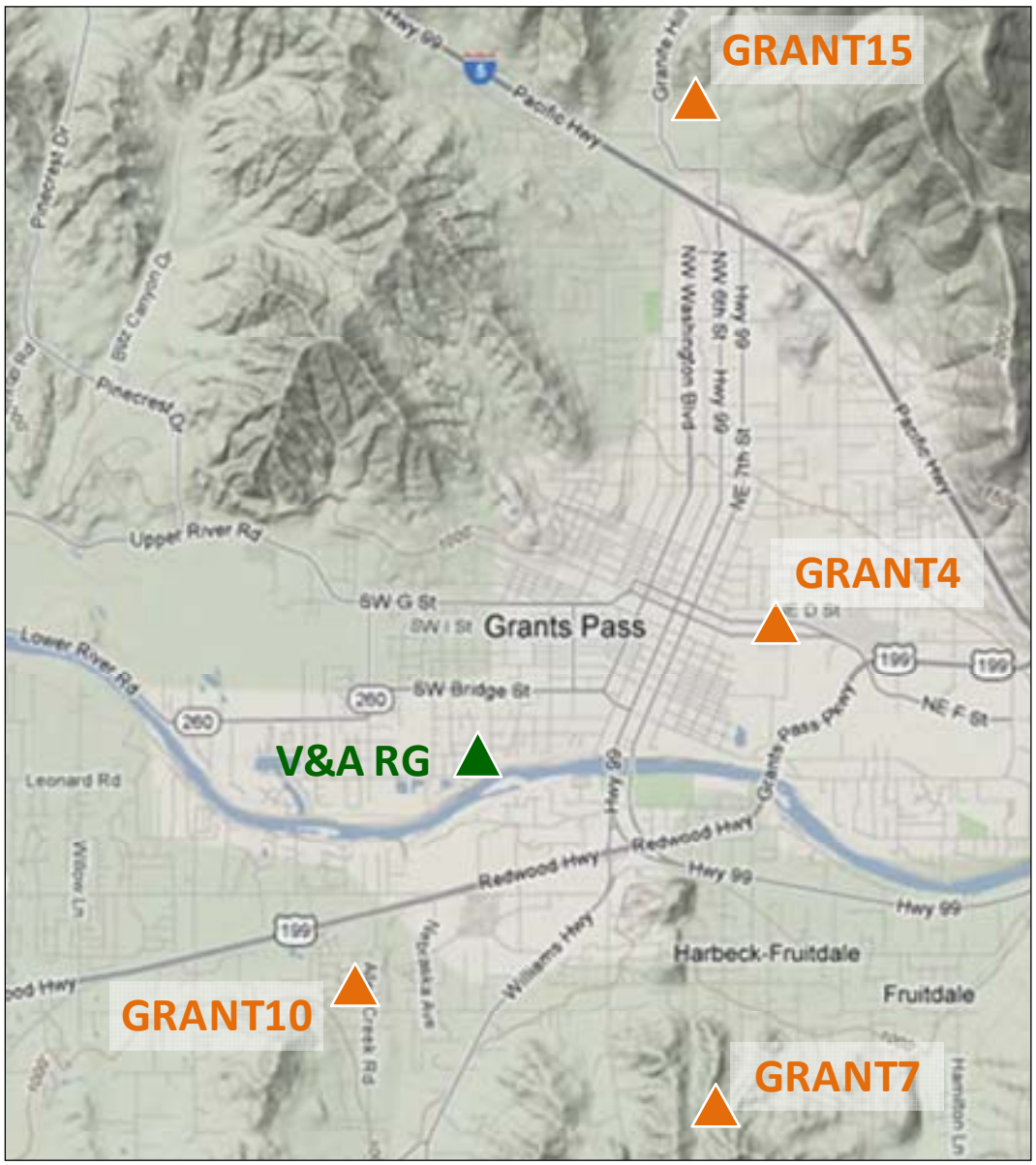


Figure 12. Rain Gauge Locations

Rainfall: Rain Gauge Data

There were three main rainfall events that were initially used for infiltration and inflow analysis for this study, as summarized in Table 4. Figure 13 graphically displays the rainfall activity recorded over the flow monitoring period (data shown is for the V&A Rain Gauge located at the treatment facility). Figure 14 shows the rain accumulation plot of the period rainfall, as well as the historical average rainfall[7] in Grants Pass during this project duration. Rainfall totals for Grants Pass were approximately 64% (using average of five rain gauge locations) below the historical normal levels during this time period.

Table 4.
Rainfall Events Used for I/I Analysis

Rainfall Event	V&A Gauge (in)	GRANT4 Gauge (in)	GRANT7 Gauge (in)	GRANT10 Gauge (in)	GRANT15 Gauge (in)
Event 1: November 5 – 8, 2011	0.87	0.96	0.96	0.77	1.07
Event 2: November 21 – 29, 2011:	2.13	2.12	2.27	1.88	2.29
Event 3: January 18 – Feb 2, 2012:	5.20	5.31	5.42	5.70	6.06
Total over Period:	*10.50*	*10.70*	*11.08*	*10.31*	*12.04*

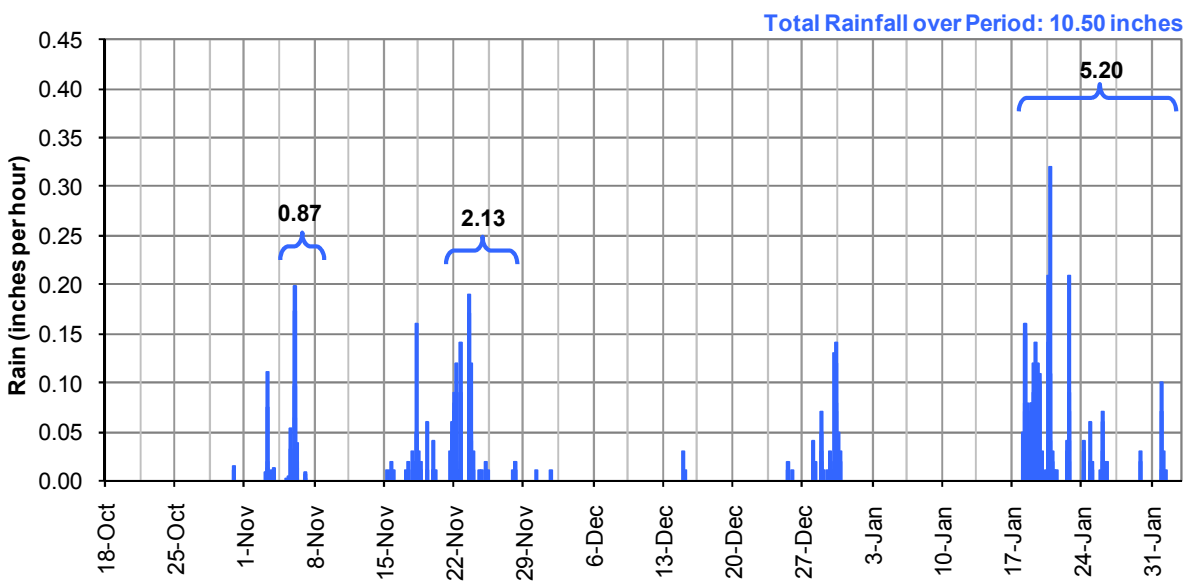


Figure 13. Rainfall Activity over Flow Monitoring Period (V&A Rain Gauge)

[7] Historical data taken from the WRCC (Station 047902 in Grants Pass): http://www.wrcc.dri.edu/summary/climsmnca.html

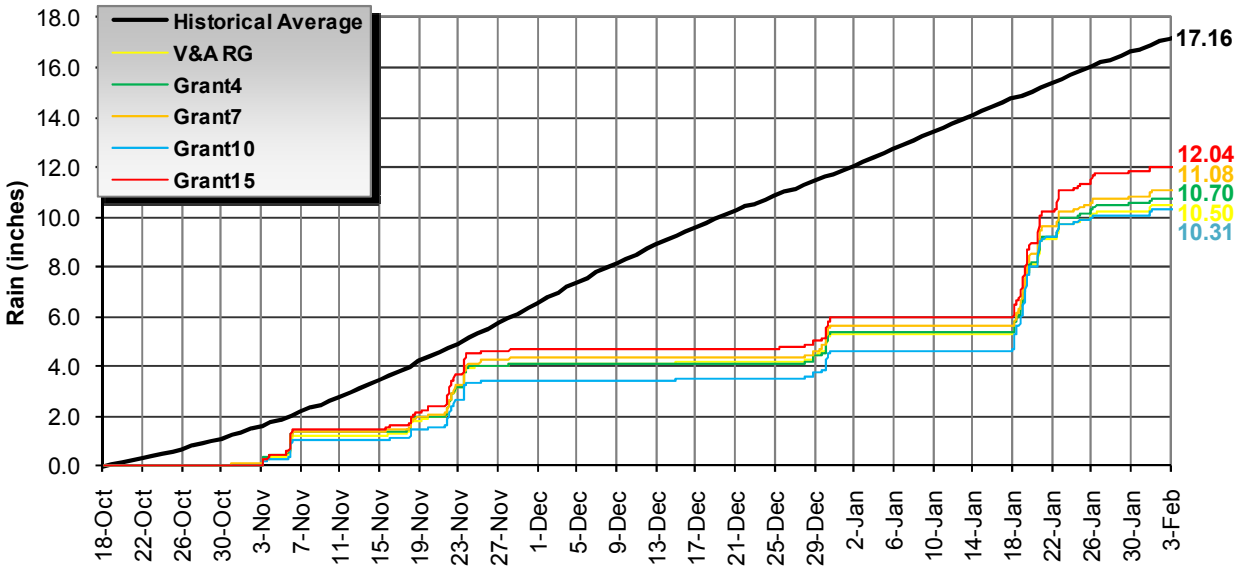


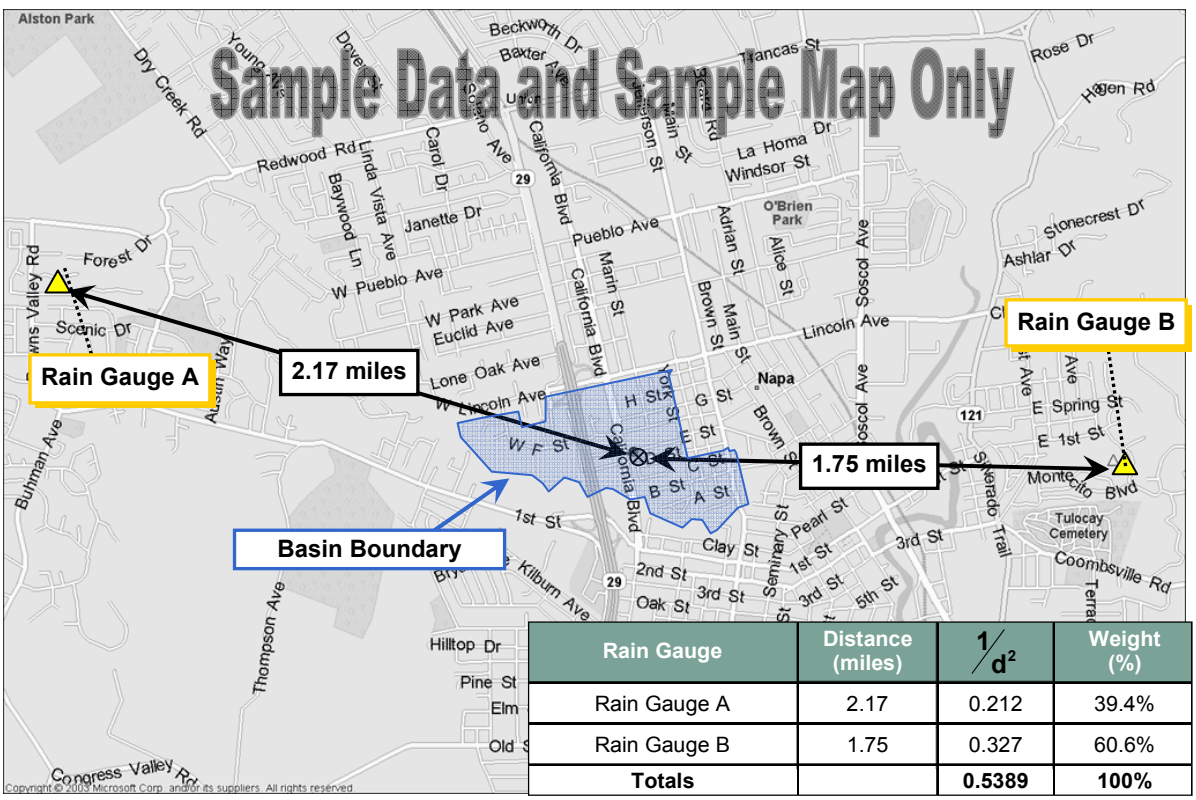
Figure 14. Rainfall Accumulation Plot

Rainfall: Rain Gauge Triangulation

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

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

The value of p is user defined. The most common choice for hydrological studies of watershed areas is $p = 2$. Figure 15 illustrates the IDW method (sample data). The rain gauge distribution as calculated for each flow monitoring site is shown in Table 5.



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 5.
Rain Gauge Distribution by Basin

Monitoring Site	VA Rain Gauge	GRANT4	GRANT7	GRANT10	GRANT15
MH D60	21.7%	40.7%	-	-	37.6%
MH H5	7.9%	71.3%	-	-	20.8%
MH I5	12.5%	73.3%	9.2%	5.0%	-
MH J2	5.8%	85.0%	6.2%	3.1%	-
MH K1	7.4%	12.2%	80.5%	-	-
MH N2	12.7%	3.1%	20.9%	63.2%	-
MH R42	0.1%	-	0.1%	99.8%	-
MH W62	33.4%	7.3%	-	59.2%	-
MH X115	32.7%	8.8%	-	58.4%	-
MH Z41	37.2%	9.1%	-	53.6%	-

Rainfall: Storm Event Classification

It is important to classify the relative size of the major storm event that occurs over the course of a flow monitoring period[8]. 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[9] classifies a 10-year, 24-hour storm event in Grants Pass as 3.8 inches (Figure 16). This means that in any given year, there is a 10% chance that 3.8 inches of rain will fall in any 24-hour period.

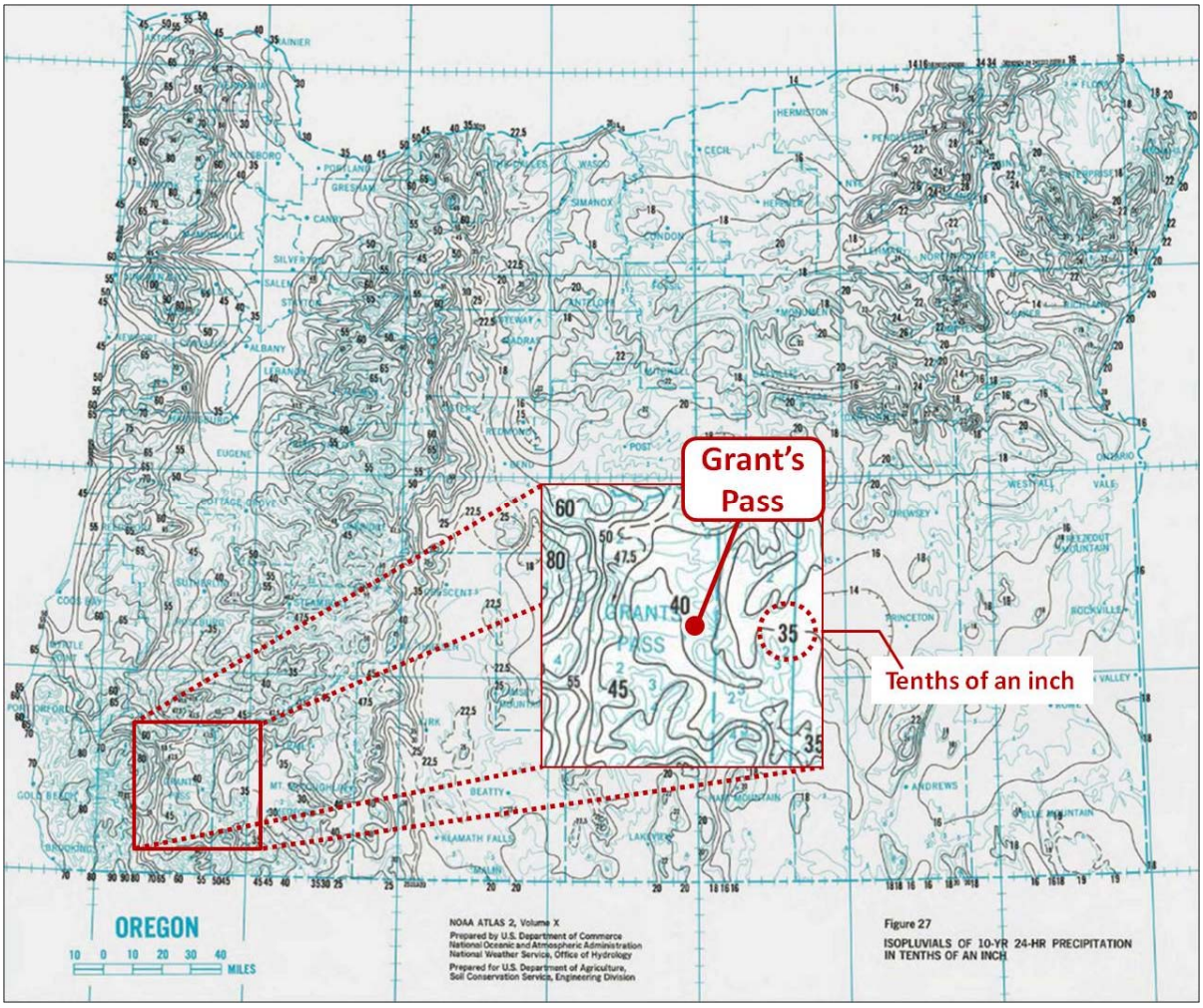


Figure 16. NOAA Oregon Rainfall Frequency Map

From the NOAA frequency maps, the rainfall totals for 1-hour, 6-hour and 24-hour period durations, and 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year period intensities, were plotted to develop a rain event frequency map specific to the rainfall monitoring site. Event 3 was the largest event of the flow

[8] Sanitary sewers are often designed to withstand I/I contribution to sanitary flows for specific-sized "design" storm events.
[9] NOAA Western U.S. Precipitation Frequency Maps Atlas 2, 1973: http://www.wrcc.dri.edu/pcpnfreq.html

monitoring period; peak measured densities per hourly periods were calculated for each rain gauge location for all rain events. Superimposing the peak measured densities for the storm events on the rain event frequency plot determines the classification of the storm event, as shown for the V&A Rain Gauge for each event in Figure 17.

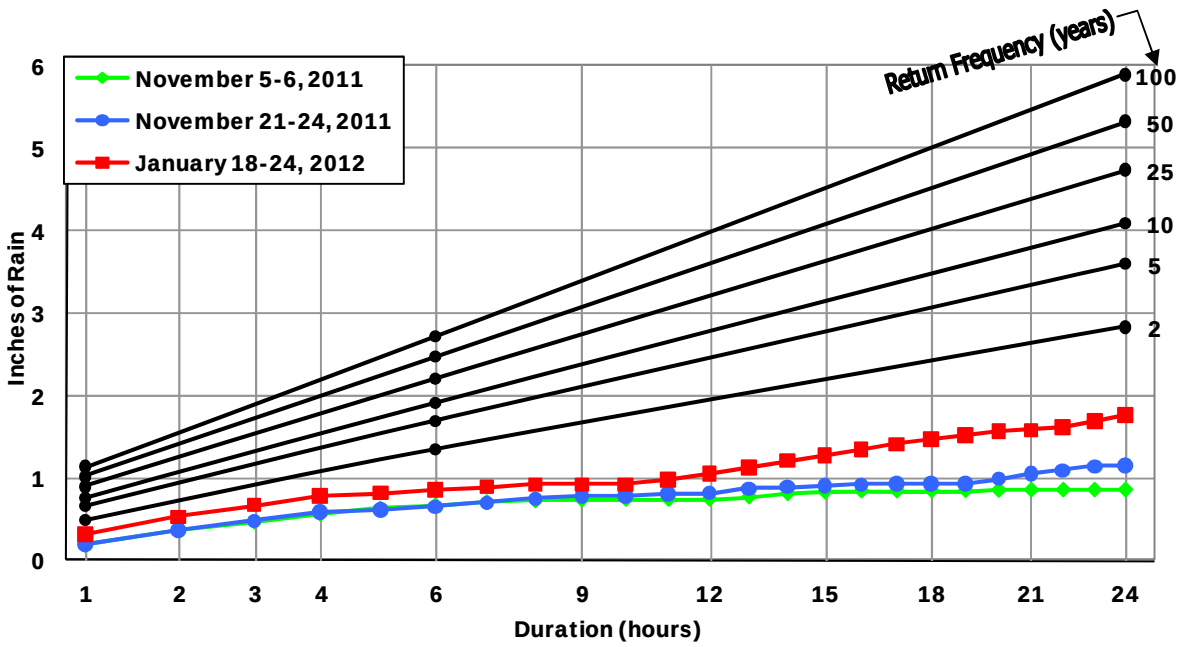


Figure 17. Storm Event Classification: V&A Rain Gauge

All of the storm events at all of the rain gauges throughout the study were classified as less than 2-year events.

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 6 lists the average dry weather flow (ADWF) recorded during this study for the flow monitoring sites. Figure 18 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 6.
Dry Weather Flow Summary

Monitoring Site	Weekday ADWF (mgd)	Weekend ADWF (mgd)	Overall ADWF (mgd)	Weekend/ Weekday Ratio
D60	0.611	0.609	0.611	1.00
H5	0.264	0.268	0.265	1.02
I5	0.312	0.288	0.305	0.92
J2	0.333	0.328	0.331	0.99
K1	0.258	0.266	0.261	1.03
N2	0.205	0.188	0.200	0.92
R42	0.180	0.179	0.180	1.00
W62	0.089	0.093	0.090	1.05
X115	0.144	0.140	0.143	0.97
Z41	0.016	0.016	0.016	1.02

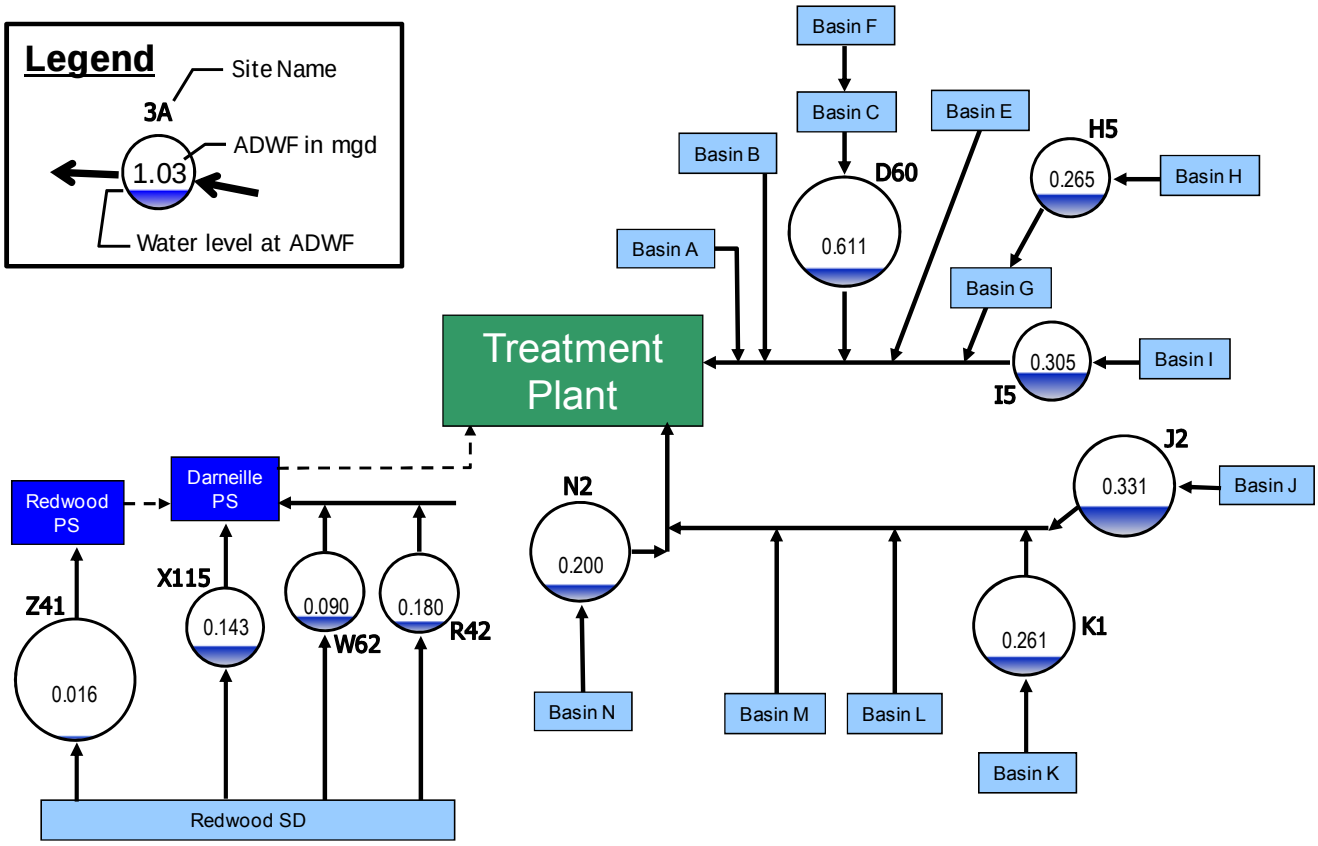


Figure 18. Average Dry Weather Flow (Flow Schematic)

Flow Monitoring: Peak Measured Flows and Pipeline Capacity Analysis

Peak measured flows and the flow level (depth) at the peak flow is important to understand the capacity of the flow monitoring system. The peak flows and flow levels reported are from the peak measurements as taken across the entirety of the flow monitoring period and may or may not correspond to a rainfall event. It did not appear that there were any elevated flow levels due to blockages, grease or roots during the flow monitoring study. However, there were backflow conditions due to capacity constraints and the inability of the local collection system to handle peak wet weather flows.

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 7 summarizes the peak recorded flows, levels, d/D ratios and peaking factors per site during the flow monitoring period. Note: capacity analysis data represents the hydraulic conditions only at the point site location. Hydraulic conditions in other areas of the collection system will differ.

Table 7.
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)
D60	0.611	2.534	4.2	33	6.6	0.32	-
H5	0.265	1.296	4.9	12	19.6	1.64	0.64
I5	0.305	1.191	3.9	15	8.5	0.57	-
J2	0.331	1.566	4.7	18	10.5	0.58	-
K1	0.261	0.790	3.0	18	6.1	0.34	-
N2	0.200	1.143	5.7	18	7.6	0.42	-
R42	0.180	1.233	6.9	15	4.6	0.31	-
W62	0.090	0.322	3.6	12	3.8	0.32	-
X115	0.143	0.722	5.1	12	8.7	0.73	-
Z41	0.016	1.180	75.7	24	30.7	1.28	0.56

The following capacity analysis results are noted:

- **Peaking Factor:** All sites had peaking factors that exceeded typical design threshold limits for peak flow to average dry weather flow ratio. Sites Z41, R42, X115 and N2 had the highest peaking factors recorded for this study. It should be noted that the peaking factor for site Z41 may be skewed high due to both low ADWF and pump station operations.

- ***d/D* Ratio:** Two sites had *d/D* ratios that exceeded common threshold values for *d/D* ratio. Sites H5 and Z41 surcharged approximately 0.6 feet above the pipe crown during this study

Figure 19 shows bar graphs of the capacity results. Figure 20 shows a schematic diagram of the peak measured flows with peak flow levels.

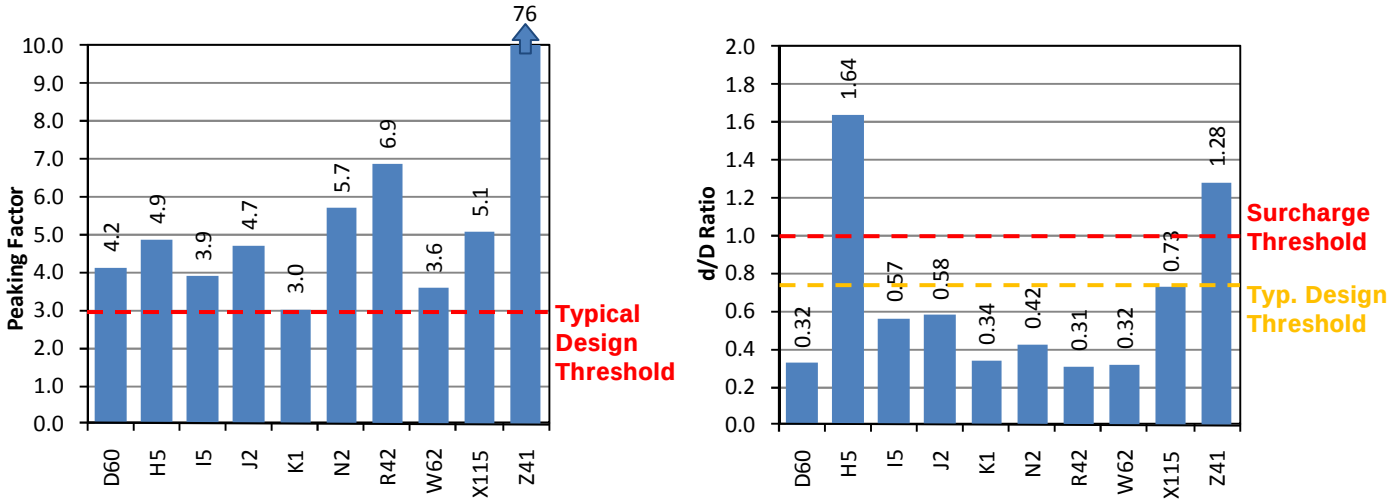


Figure 19. Capacity Summary Bar Graphs: Peaking Factors and *d/D* Ratios

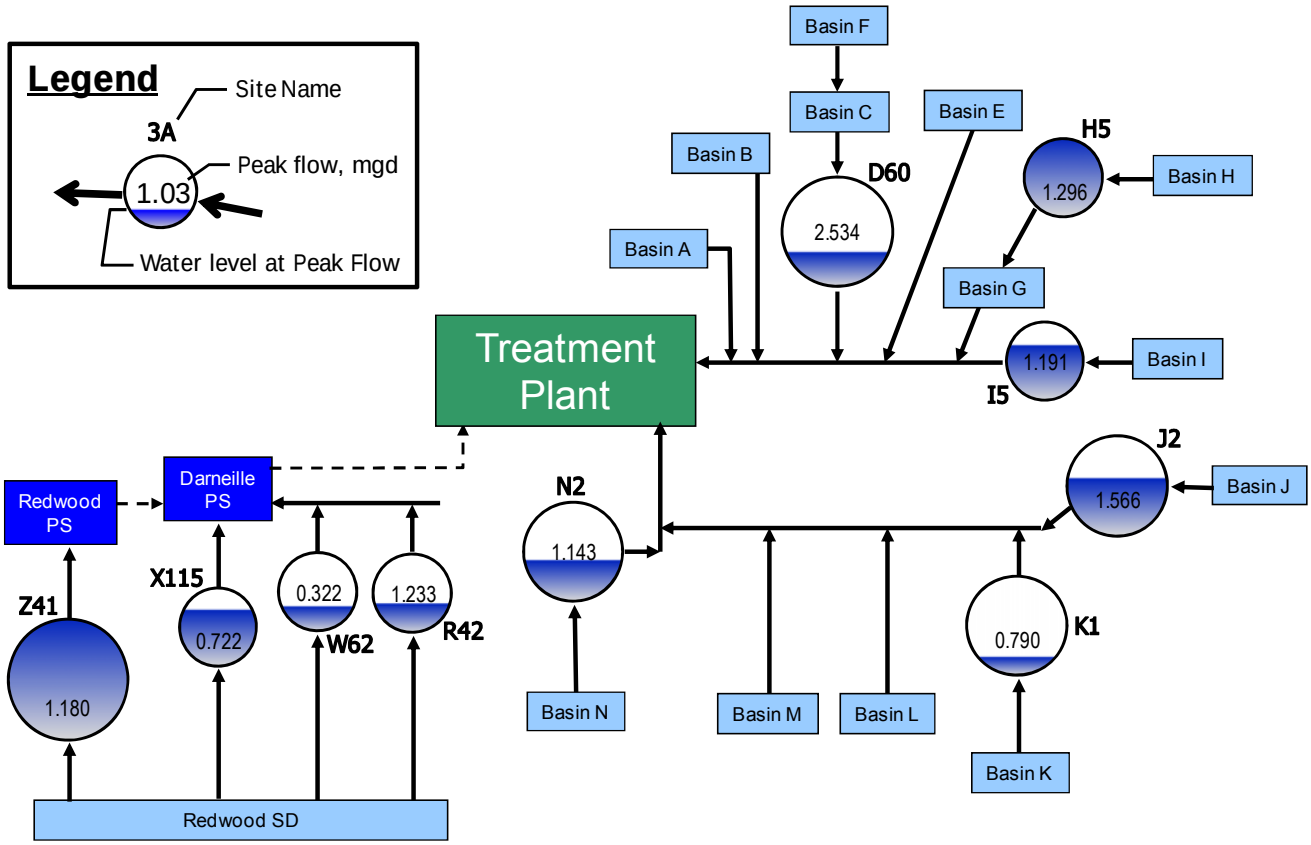


Figure 20. Peak Measured Flow (Flow Schematic)

Inflow / Infiltration Analysis: Definitions and Identification

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:

Inflow Definition

Definition: 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.

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.

Graphical Identification: Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event.

Infiltration Definition

Definition: Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes.

Impact: Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).

Cost of Source Detection and Removal: Infiltration sources are usually harder to find and more expensive to correct than inflow sources. Infiltration sources include defects in deteriorated sewer pipes or manholes that may be widespread throughout a sanitary sewer system.

Graphical Identification: Infiltration is often recognized graphically by a gradual increase in flow after a wet-weather event. The increased flow typically sustains for a period after rainfall has stopped and then gradually drops off as soils become less saturated and as groundwater levels recede to normal levels.

Figure 21 shows sample graphs indicating the typical graphical response patterns for inflow and infiltration.

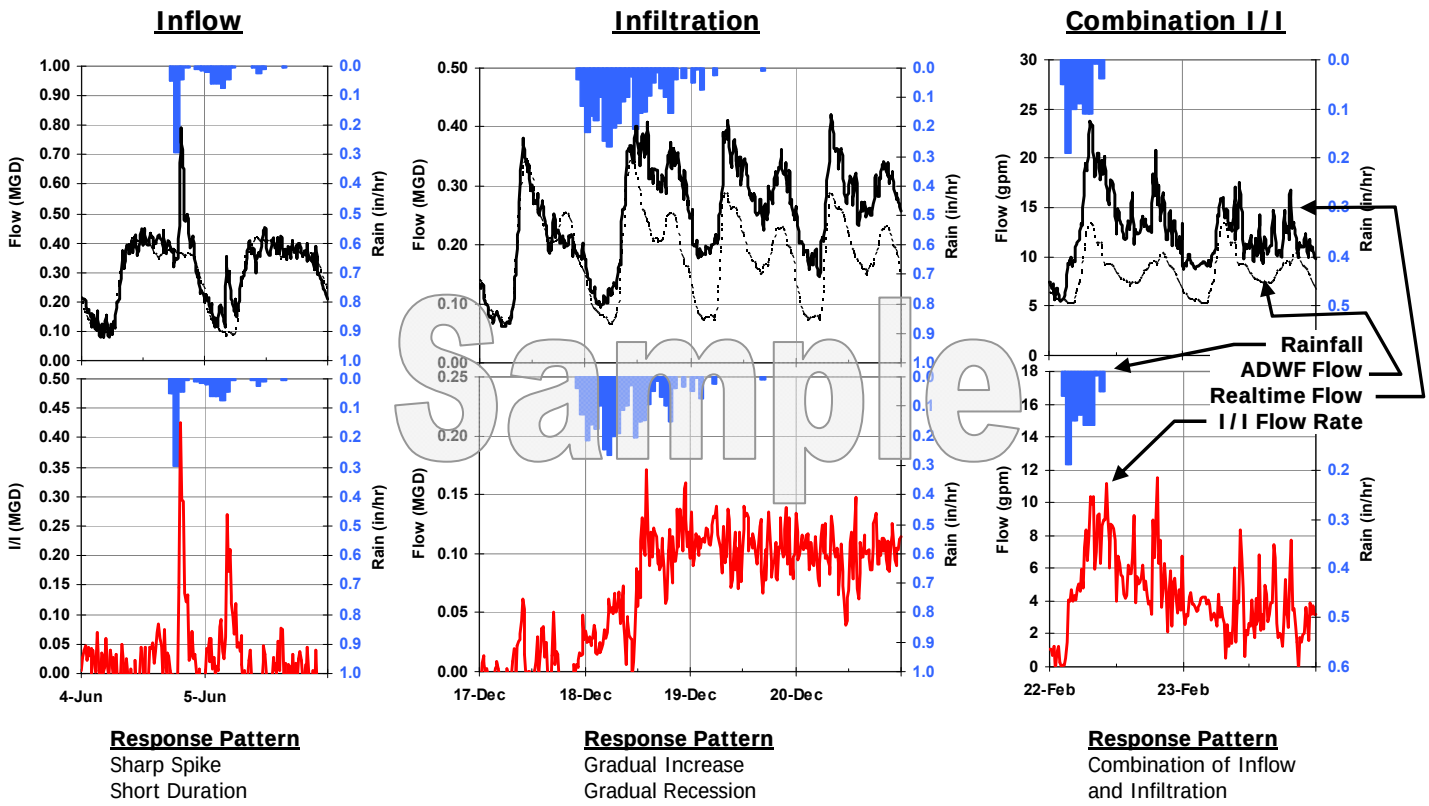


Figure 21. Inflow and Infiltration: Graphical Response Patterns

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.

Figure 22 illustrates the possible sources and components of I/I.

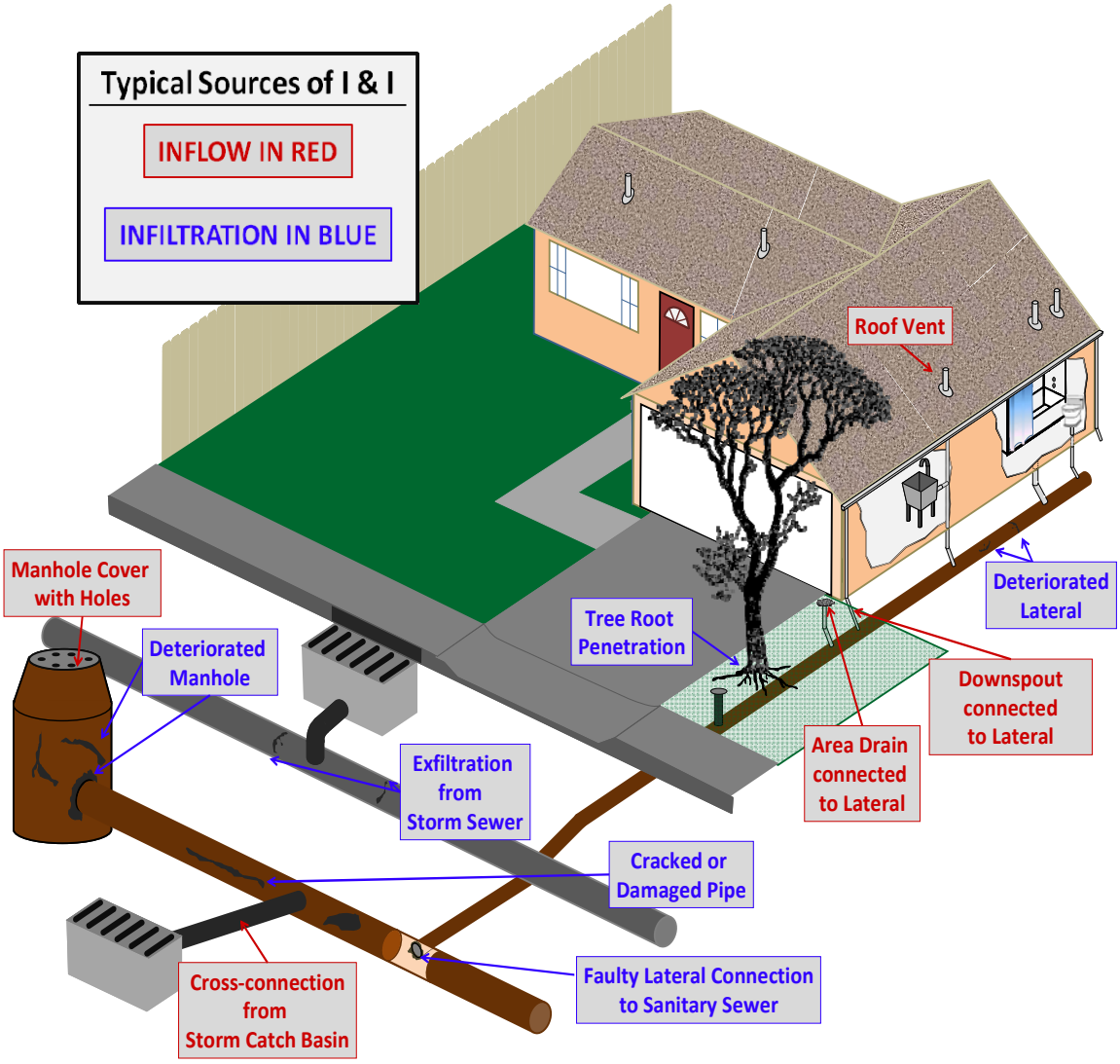


Figure 22. Typical Sources of Infiltration and Inflow

Inflow / Infiltration: 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

Peak I/I Flow Rate: Inflow is characterized by sharp, direct spikes occurring during a rainfall event. Peak I/I rates are used for inflow analysis[10]. 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.

Peak I/I Flow Rate to ADWF Ratio: Peak measured I/I rate divided by average dry weather flow (ADWF). This is a ratio and is expressed without units.

Infiltration Indicators

Dry Weather Groundwater Infiltration: GWI analysis is conducted by looking at minimum dry weather flow to average dry weather flow ratios and comparing them to established standards to quantify the rate of excess groundwater infiltration. 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.

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.

Combined I/I Indicators

Total Infiltration: The total inflow and infiltration is measured in gallons per site and per storm event. Because it is based on total I/I volume, it is an indicator of combined inflow and infiltration and is used to identify the overall volumetric influence of I/I within the monitoring basin. As with inflow, pipe length, basin area, and dry weather flow are used to normalize combined I/I for basin comparison:

[10] 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.

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%[11] 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.

Realtime flows were plotted against ADWF flows to analyze the I/I response to rainfall events. Figure 23 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*.

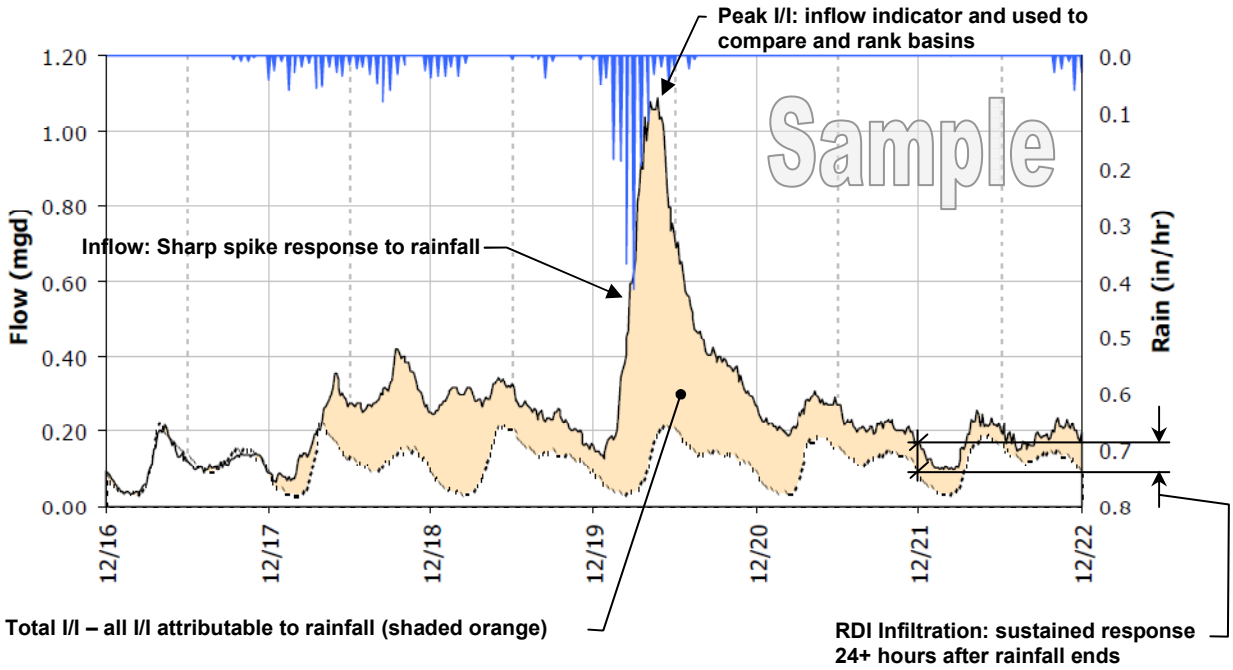


Figure 23. Sample Infiltration and Inflow Isolation Graph

The infiltration and inflow indicators were normalized by the per-IDM, per-ACRE and per-ADWF methods in this report. Final rankings were determined by weighting the per-IDM, per-ACRE and per-ADWF normalization methods by 50%, 25% and 25%, respectively, with ties broken by the per-IDM method. The per-IDM method is given a higher weight including the tie-break because, for this study, future I/I rehabilitation and/or reduction efforts are typically budgeted per unit length of pipe. Additionally, the IDM measurement typically has a higher level of accuracy than drainage watershed area and low-flow ADWF.

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

Inflow and Infiltration: Results

Inflow Results Summary

Inflow is storm water discharged into the sewer system through direct connections such as downspouts, area drains, cross-connections to catch basins, etc. These sources transport rain water directly into the sewer system and the corresponding flow rates are tied closely to the intensity of the storm. This component of I/I often causes a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows.

Table 8 summarizes the peak measured I/I flows and inflow analysis results for the storm events that occurred during the monitoring period (refer to the *I/I Methods* section for more information on inflow analysis methods and ranking procedures). Figure 24, Figure 25 and Figure 26 show bar graph summaries of the inflow analysis, and Figure 27 shows a temperature map summary of the inflow analysis results per basin. Inflow results were taken from Event 3 (January 18 – February 2, 2012).

Table 8.
Basins Inflow Analysis Summary

Basin	ADWF (mgd)	Peak I/I Rate (mgd)	Peak I/I per IDM (gpd/IDM)	Peak I/I per Acre (GPAD)	Peak I/I per ADWF	Inflow Ranking
D60	0.611	1.829	5,100	1,010	3.0	9
H5	0.265	1.003	14,700	1,740	3.8	3
I5	0.305	0.839	15,800	2,250	2.7	2
J2	0.331	1.161	8,600	1,390	3.5	5
K1	0.261	0.510	3,700	640	2.0	10
N2	0.200	0.900	6,700	1,070	4.5	7
R42	0.180	1.008	21,500	3,040	5.6	1
W62	0.090	0.217	5,600	1,120	2.4	8
X115	0.143	0.567	7,300	1,170	4.0	6
Z41	0.016	1.162	7,500	1,440	74.5	4
Grants Pass:	1.973	6.129	6,900	1,170	3.1	
Redwood:	0.428	2.054	6,400	1,130	4.8	
WWTP:	4.336	13.345	8,000	1,520	3.1	

Ranking of 1 represents most inflow after normalization.

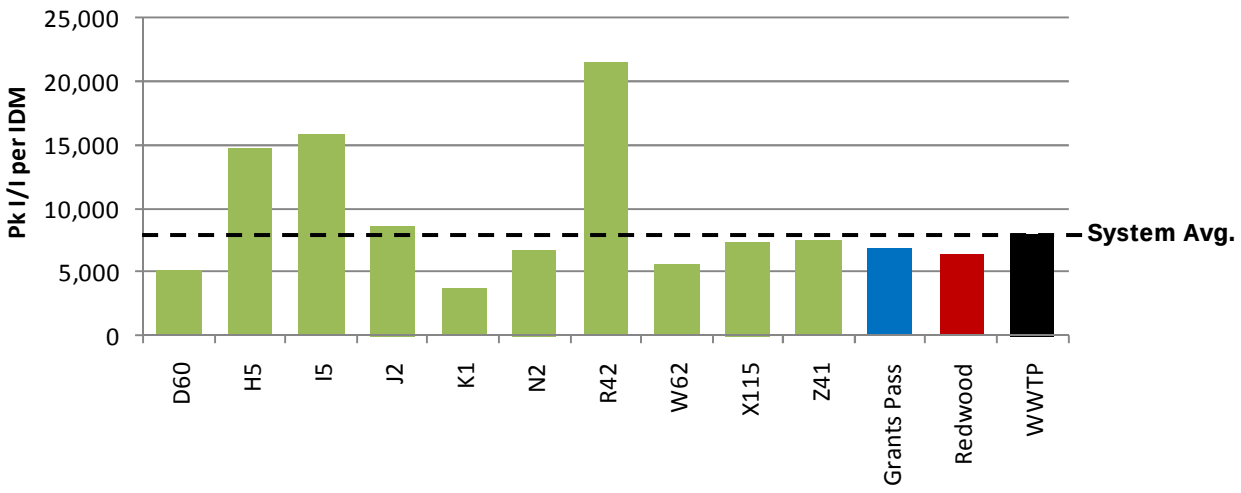


Figure 24. Bar Graphs: Inflow Analysis Summary – Peak I/I to IDM

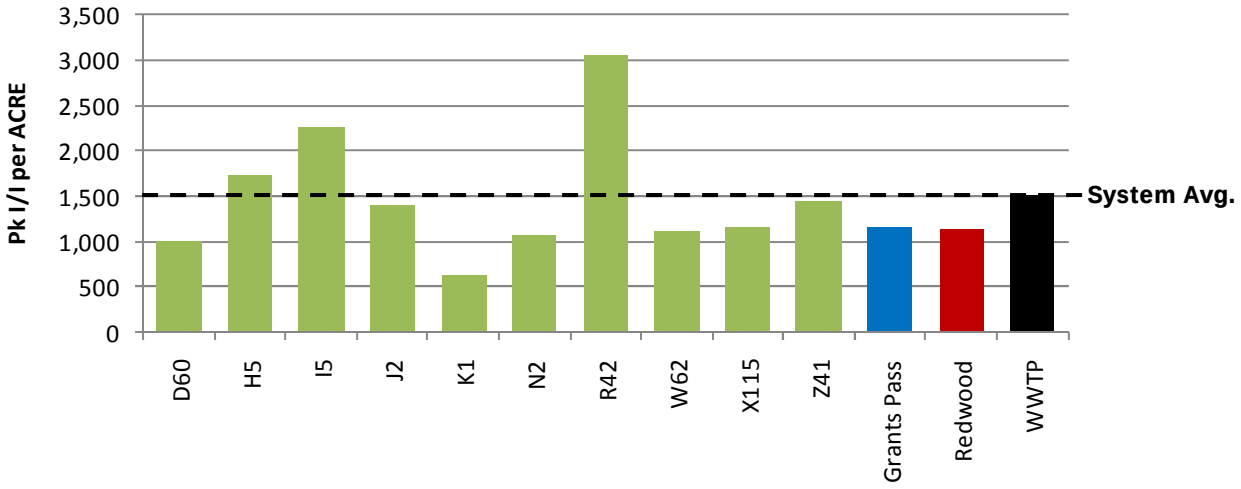


Figure 25. Bar Graphs: Inflow Analysis Summary – Peak I/I to ACRE

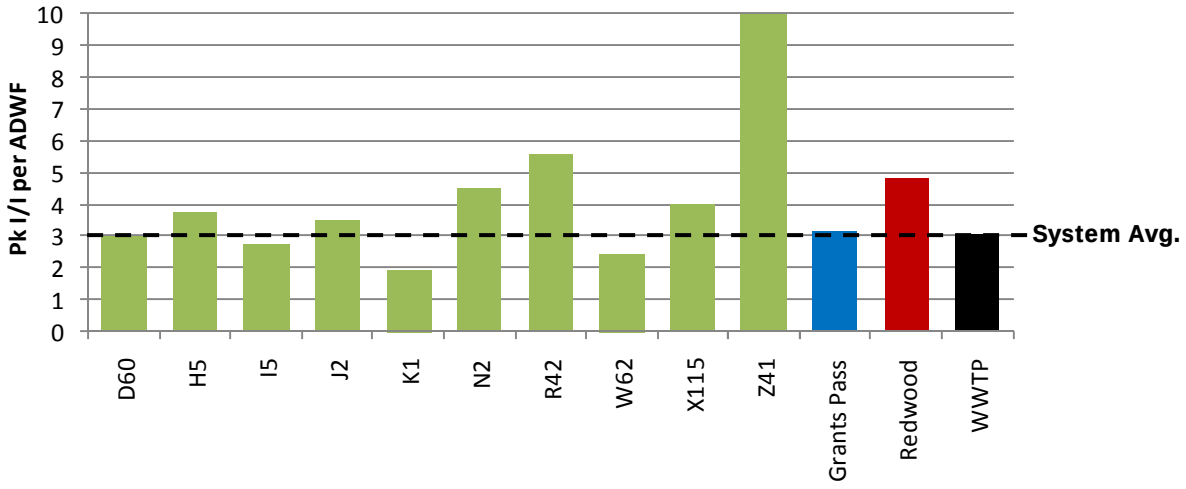


Figure 26. Bar Graphs: Inflow Analysis Summary – Peak I/I to ADWF

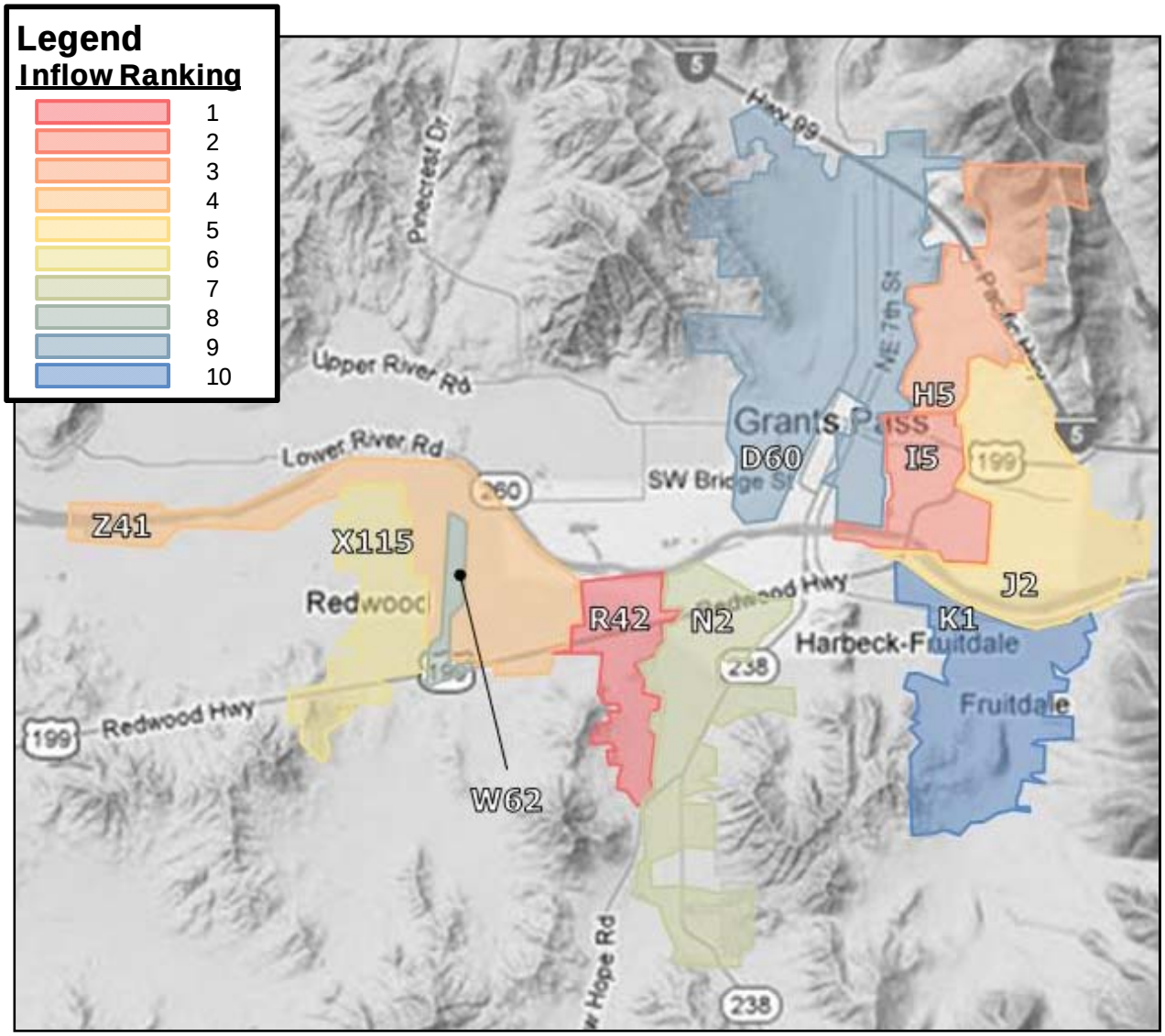


Figure 27. Inflow Temperature Map (by Rank)

Infiltration Results Summary

Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes. Increased flows into the sanitary sewer system are usually tied to groundwater levels and soil saturation levels. Infiltration sources transport rain water into the system *indirectly*; flow levels in the sanitary system increase gradually, are typically sustained for a period after rainfall has stopped, and then gradually drop off as soils become less saturated and as groundwater levels recede to normal. Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).

Table 9 summarizes the calculated RDI flow rates for a design storm event (refer to the *I/I Methods* section for more information on infiltration analysis methods and ranking procedures). RDI was taken as the average I/I rate on January 30, approximately 72 hours after the majority of the rain occurring in Event 3. Figure 28, Figure 29 and Figure 30 shows bar graph summaries of the RDI analysis, and a temperature map by overall ranking is shown in Figure 31.

Table 9.
Basins RDI Analysis Summary

Basin	ADWF (mgd)	RDI Rate (mgd)	RDI to IDM (gpd/IDM)	RDI per Acre (GPAD)	RDI per ADWF	RDI Ranking
D60	0.611	0.601	1,670	330	99%	6
H5	0.265	0.200	2,920	350	76%	3
I5	0.305	0.218	4,110	590	70%	1
J2	0.331	0.140	1,040	170	42%	9
K1	0.261	0.148	1,080	190	57%	7
N2	0.200	0.226	1,700	270	111%	5
R42	0.180	0.021	440	60	12%	10
W62	0.090	0.093	2,390	480	105%	2
X115	0.143	0.166	2,140	340	116%	4
Z41	0.016	0.056	360	70	359%	8
Grants Pass:	1.973	1.533	1,730	290	77%	
Redwood:	0.428	0.334	1,050	180	78%	
WWTP:	4.336	2.492	1,500	280	57%	

Ranking of 1 represents most inflow after normalization.

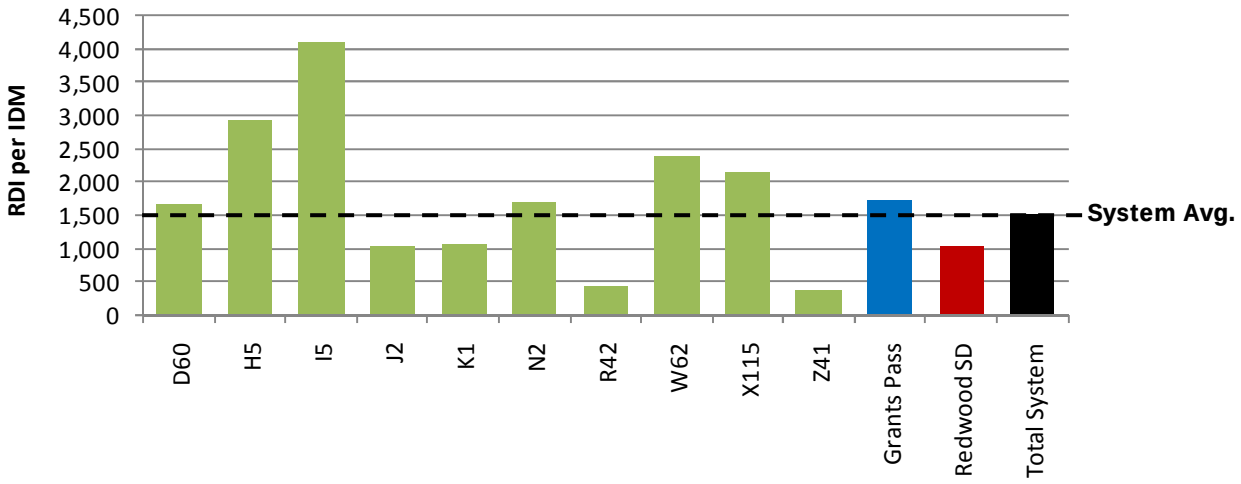


Figure 28. Bar Graphs: RDI Analysis Summary – RDI to IDM

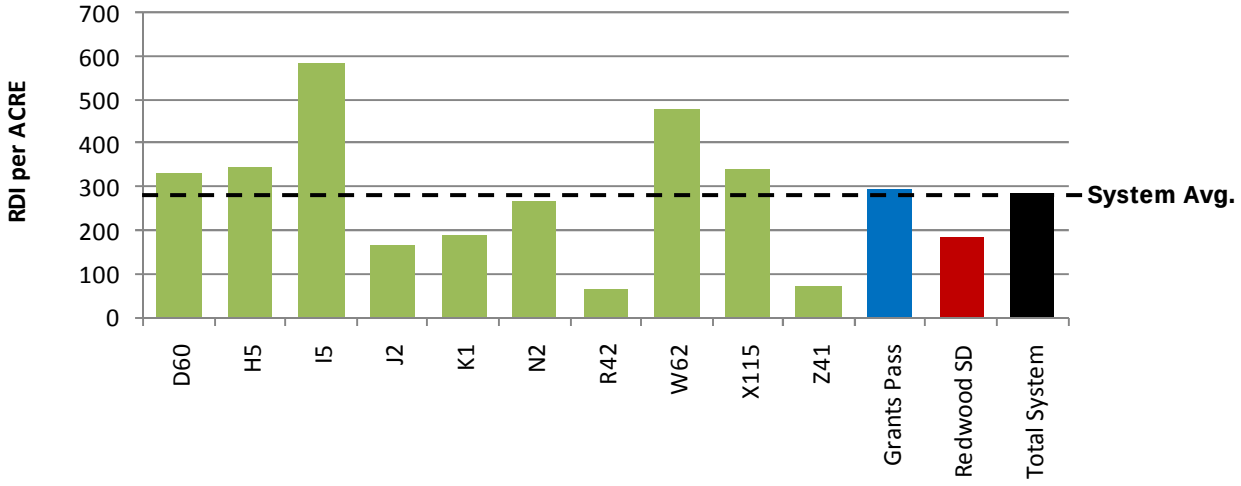


Figure 29. Bar Graphs: RDI Analysis Summary – RDI to ACRE

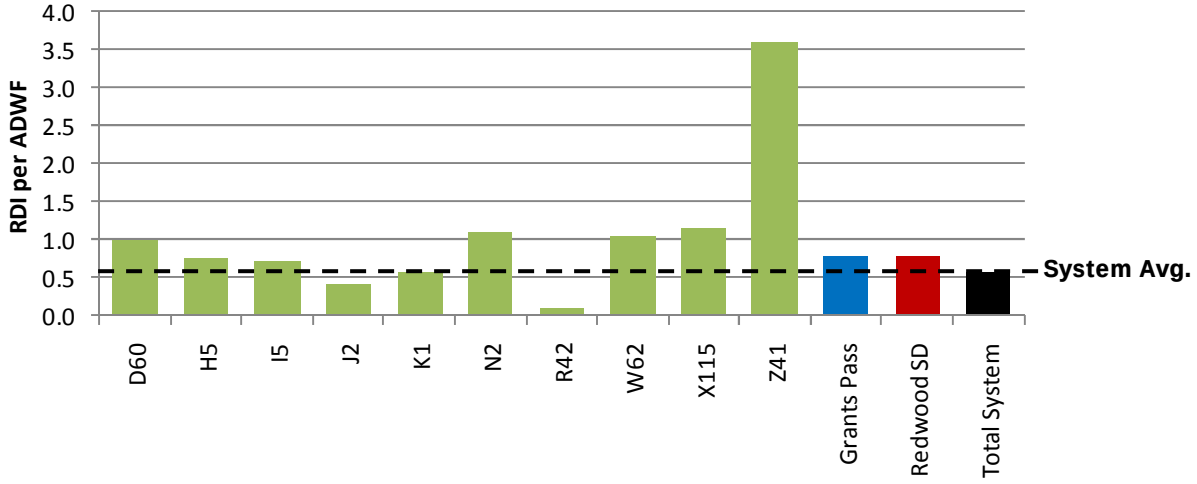


Figure 30. Bar Graphs: RDI Analysis Summary – RDI to ADWF

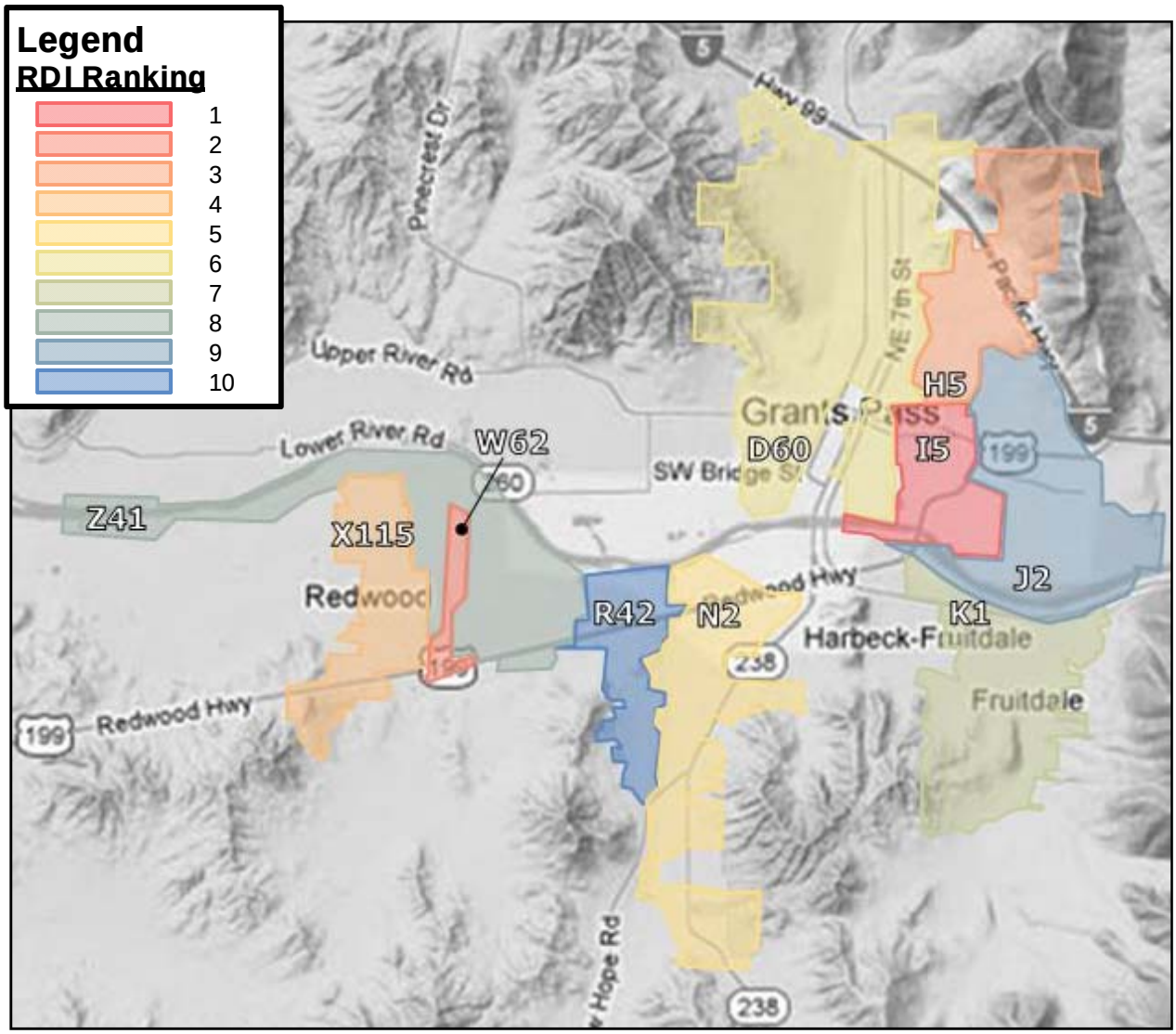


Figure 31. RDI Temperature Map (by Rank)

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[12]. Figure 32 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.

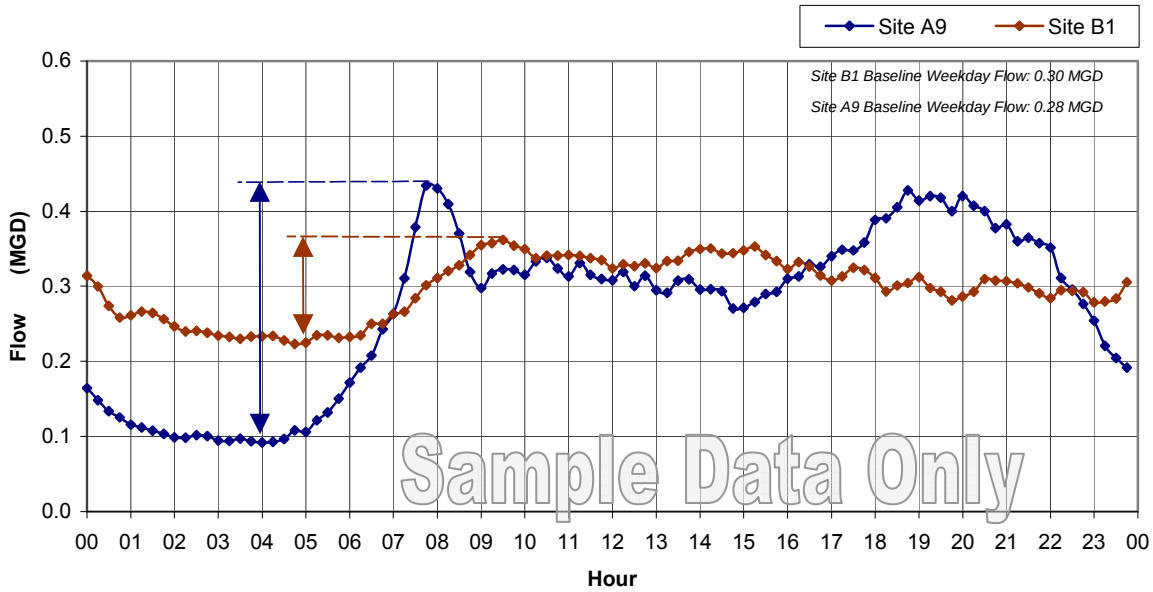


Figure 32. Groundwater Infiltration Sample Figure

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 reasons 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 33 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)[13]. The following GWI results are noted:

Basins Z41, H5, I5, K1 and W62 have GWI rates that were **above** the WEF typical Low-to-Average Ratio, indicating excessive groundwater infiltration.

Figure 34 shows a color-coded map of the basins with rates of groundwater infiltration above typical groundwater infiltration standards (as set forth by WEF).

[12] 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.

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

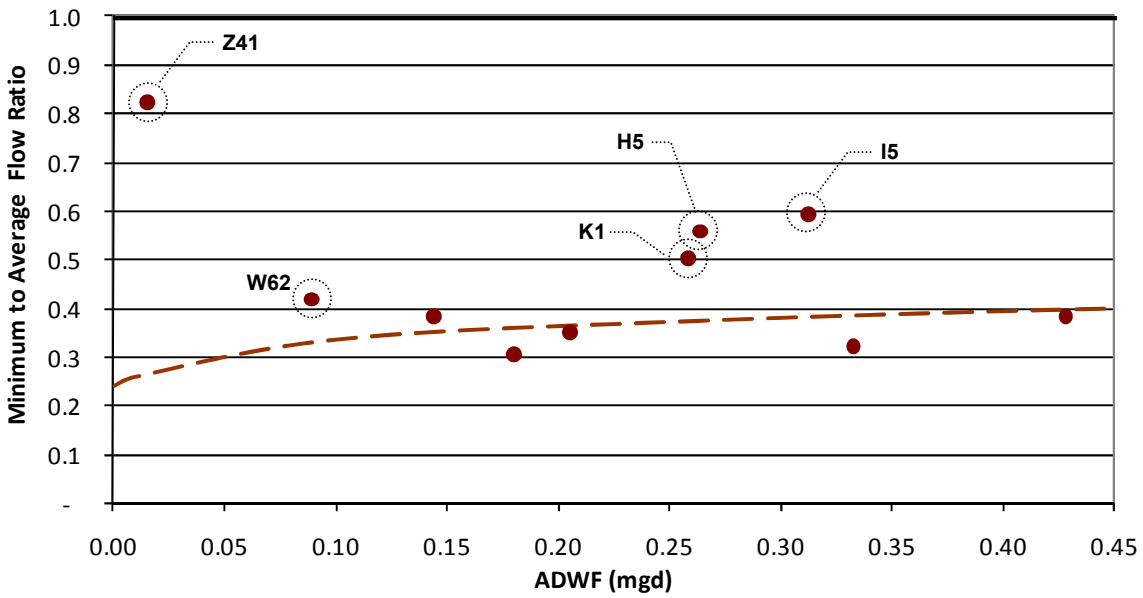


Figure 33. Minimum Flow Ratios vs. ADWF[14]

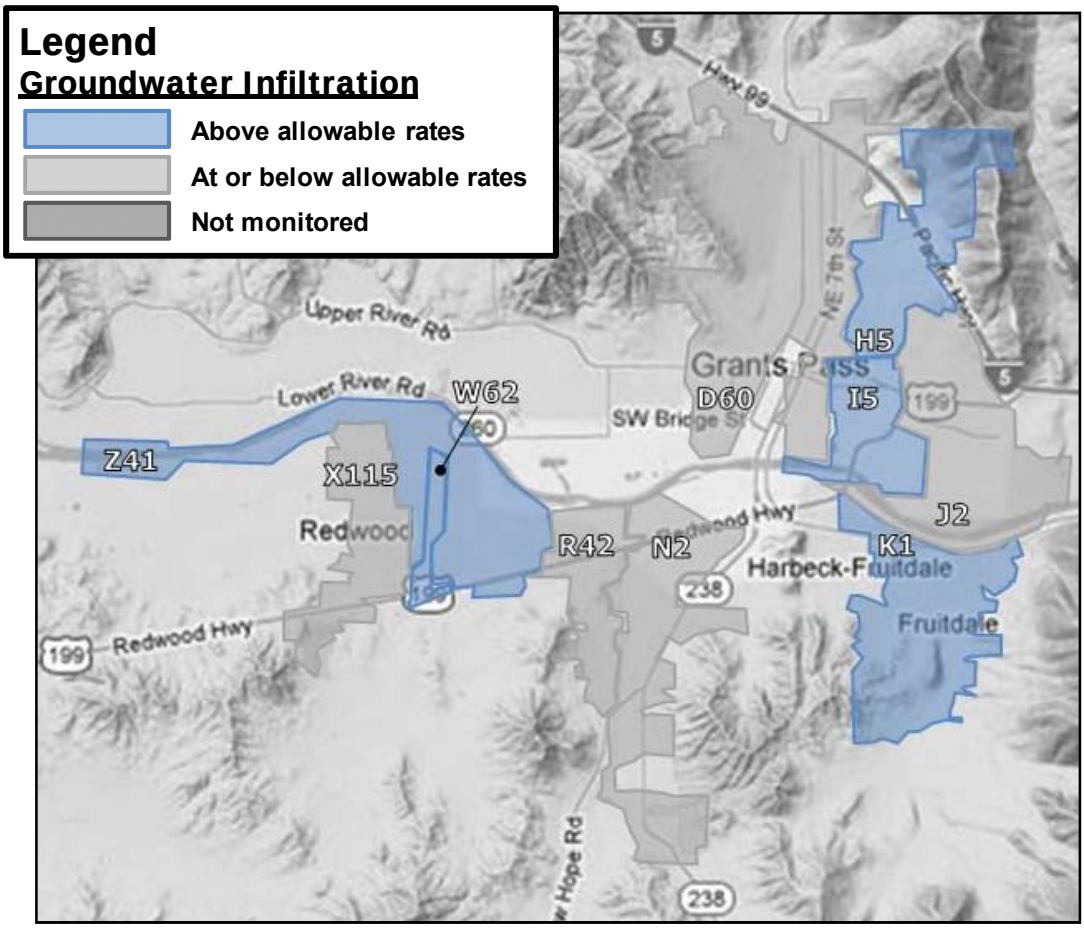


Figure 34. Basins with Groundwater Infiltration

[14] Due to attenuation, it should be expected that sites with larger flow volumes should not have quite the peak-to-average and low-to-average flow ratios as sites with lesser flow volumes, which is why the WEF typical trend lines slope closer to 1.0 as the ADWF increases, as shown in the figure.

Combined I/I Results Summary

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

Table 10 summarizes the combined I/I flow results for a design storm event (refer to the *I/I Methods* section for more information on I/I analysis methods and ranking procedures). Figure 35, Figure 36 and Figure 37 show bar graph summaries of the combined I/I analysis, and Figure 38 shows a temperature map summary of the combined I/I analysis results per basin. Combined I/I results were taken from Event 3 (January 18 – February 2, 2012).

Table 10.
Basins Combined I/I Analysis Summary

Basin	ADWF (mgd)	Total I/I (gallons)	Total I/I per IDM	R-Value (%)	Total I/I per ADWF	Combined I/I Ranking
D60	0.611	11,782,000	5,900	4.3%	3.5	6
H5	0.265	5,478,000	14,700	6.4%	3.8	2
I5	0.305	4,579,000	16,200	8.5%	2.8	1
J2	0.331	4,460,000	6,200	3.7%	2.5	8
K1	0.261	3,046,000	4,100	2.6%	2.2	10
N2	0.200	4,361,000	5,900	3.4%	3.9	7
R42	0.180	3,344,000	12,500	6.5%	3.3	3
W62	0.090	1,681,000	7,900	5.8%	3.4	5
X115	0.143	3,422,000	8,000	4.7%	4.4	4
Z41	0.016	1,400,000	1,600	1.2%	16.4	9
Grants Pass:	1.973	34,028,000	7,200	4.5%	3.2	
Redwood:	0.428	10,180,000	5,800	3.7%	4.3	
WWTP:	4.336	63,842,000	7,300	5.1%	2.8	

Ranking of 1 represents most inflow after normalization.

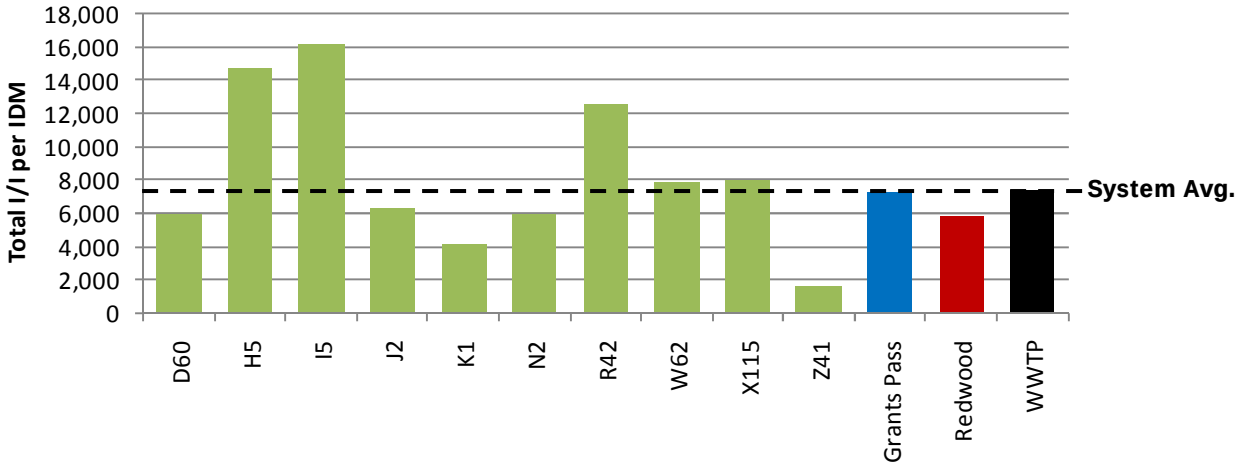


Figure 35. Bar Graphs: Combined I/I Analysis Summary – Total I/I to IDM

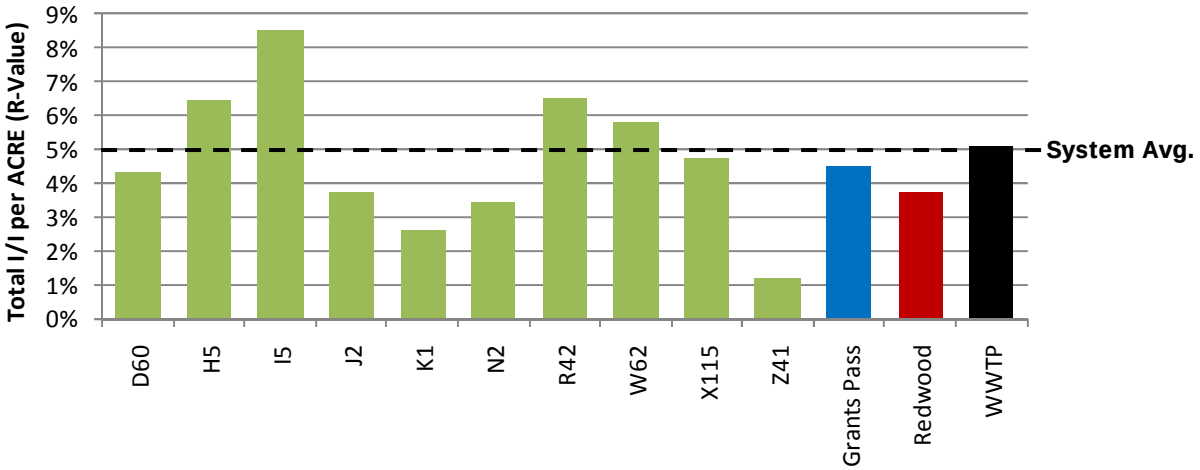


Figure 36. Bar Graphs: Combined I/I Analysis Summary – Total I/I to ACRE (R-Value)

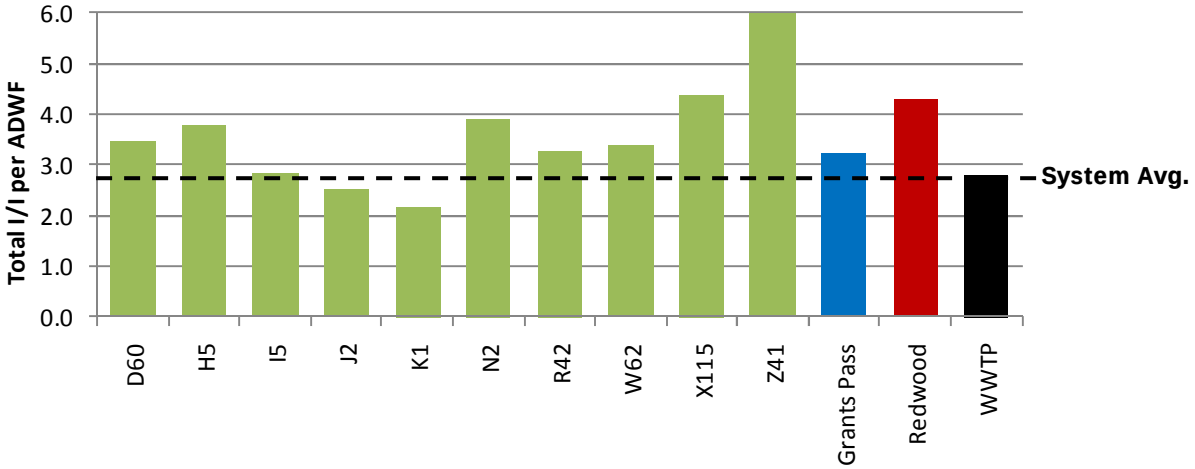


Figure 37. Bar Graphs: Combined I/I Analysis Summary – Total I/I to ADWF

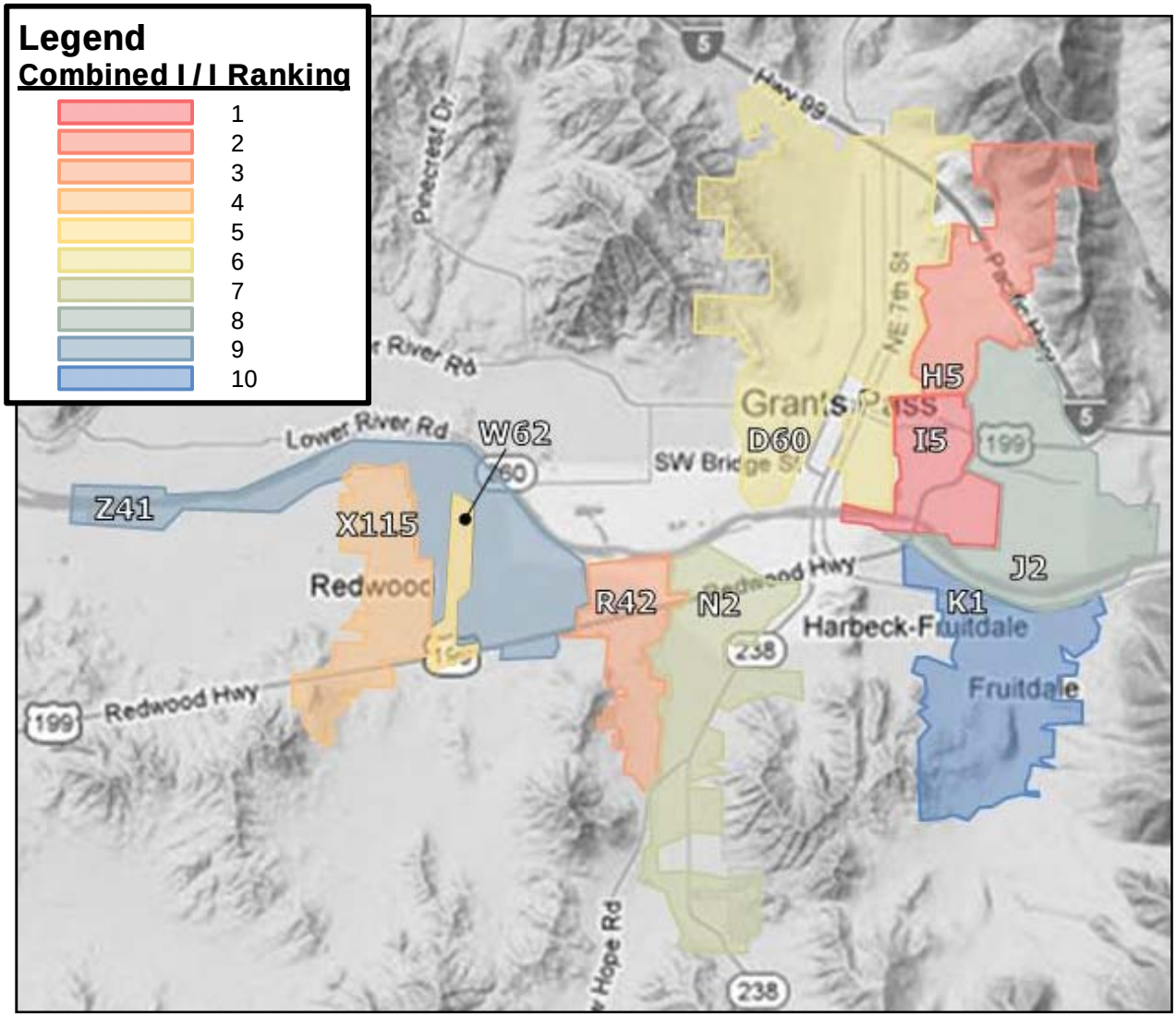


Figure 38. Combined I/I Temperature Map (by Rank)

Synthetic Hydrographs

In order to model design storms, synthetic hydrographs were developed to approximate the actual RDI hydrograph shape in terms of the time to the peak and the recession coefficient. The actual RDI hydrograph was best matched with a synthetic hydrograph by separating the synthetic hydrograph into seven volume components (R1 through R7). The seven components represent different response times to the rainfall event and, therefore, different infiltration or inflow paths into the sewer system. R1 is characterized by a short response time and is assumed to consist of mainly inflow. R7 represents slower response and longer recession times and consists of mostly infiltration. Levels of soil saturation are also considered. Using synthetic hydrograph analysis, appropriate time and recession parameters were estimated by a trial-and-error procedure until a good match was obtained. For example, the hydrograph and its component hydrographs for the period of January 17 to 27, 2012, for Site H5 is shown in Figure 39.

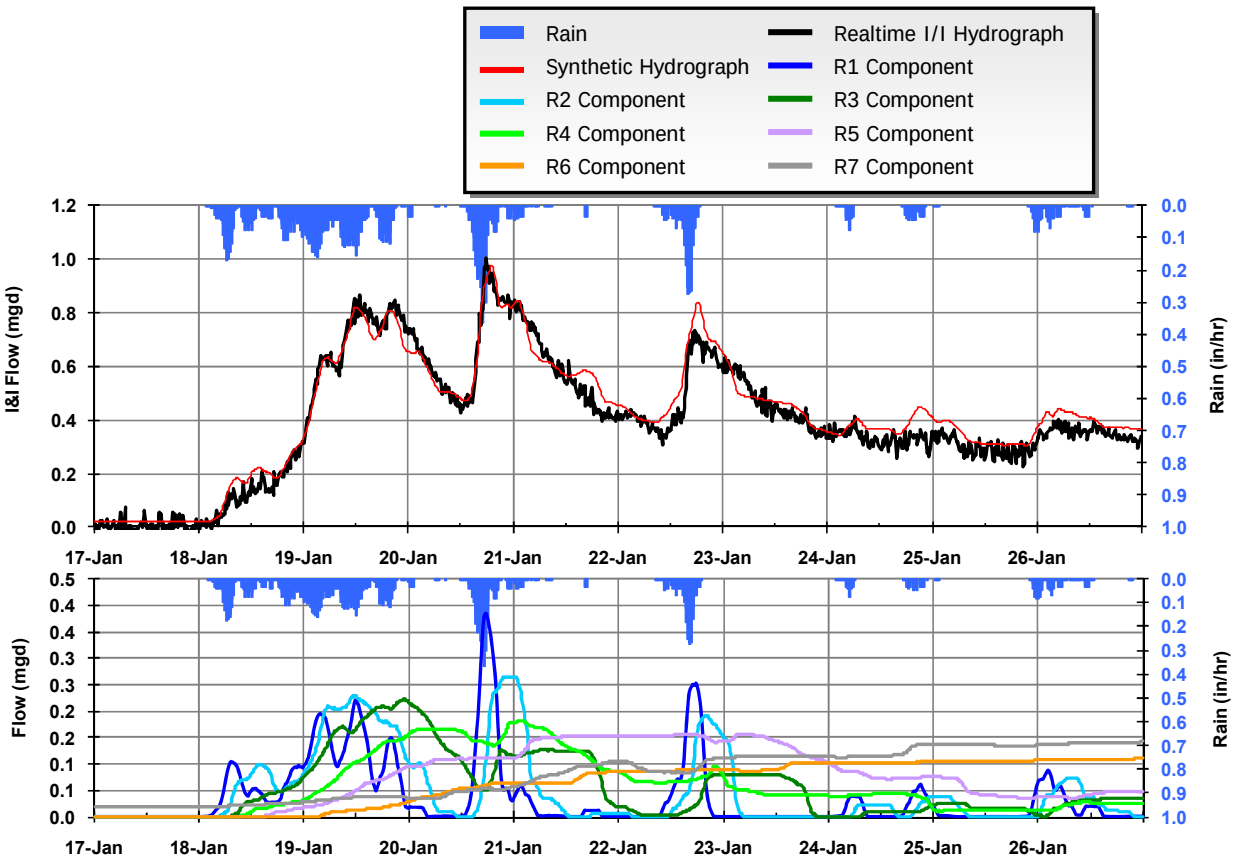


Figure 39. Site H5: Synthetic Hydrograph

Design Storm Development

With the I/I response modeled by a synthetic hydrograph, design storms can be applied. This serves two functions: (a) predicted flows are based on the same storm event and are therefore normalized to each other, making for easier and better comparisons, and (b) the resulting I/I flows can be predicted for a design storm event. This helps to calibrate modeling efforts that will determine if the collection system has adequate capacity to handle very large storm events.

V&A used a 10-year, 24-hour design storm for this analysis. Storm events were taken from the NOAA Precipitation-Frequency Atlas of the Western United States. Figure 40 summarizes the design storm magnitude and profile. This particular profile distribution also fits the NOAA criterion for 2-hour and 6-hour durations, in addition to the 24-hour duration.

10-Year, 24-hour Design Storm	
Hour	Inches of Rain
1	0.01
2	0.04
3	0.36
4	0.22
5	0.07
6	0.02
7	0.29
8	0.17
9	0.23
10	0.08
11	0.04
12	0.02
13	0.16
14	0.43
15	0.05
16	0.29
17	0.30
18	0.59
19	1.10
20	0.59
21	0.29
22	0.12
23	0.21
24	0.06
Total:	**5.74**

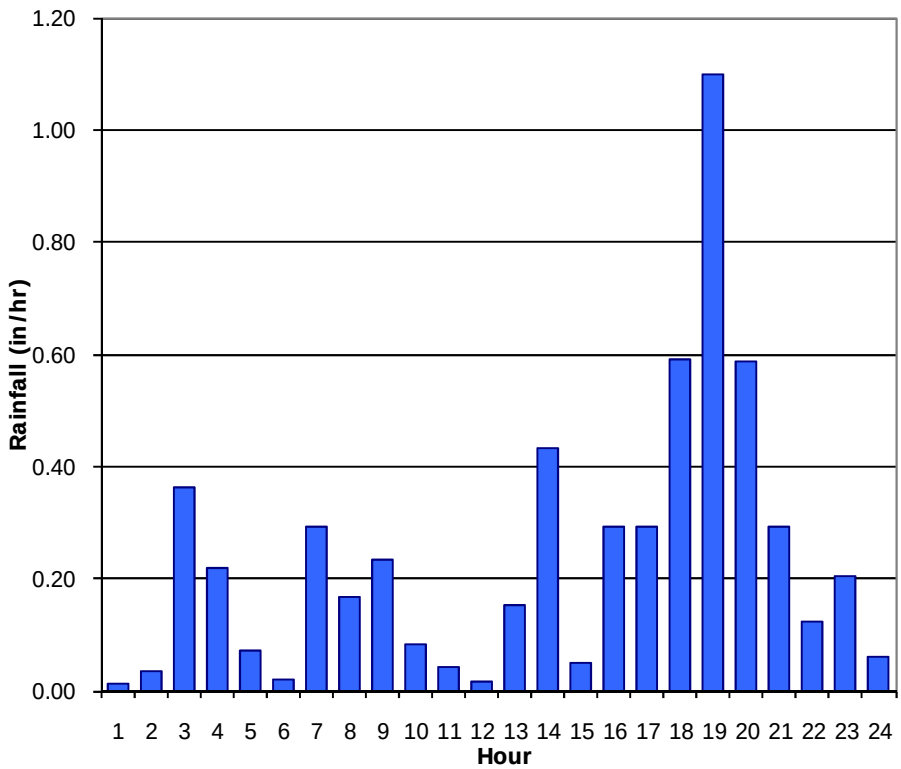


Figure 40. 10-Year, 24-Hour Design Storm Values and Profile

Design Storm Response Summary

The 10-year, 24-hour storm event was applied to the synthetic I/I hydrograph components developed for each flow monitoring site. This method produces the best estimated response to the design storm events. These results assume full ground saturation, and the peak I/I flows from the design storm coincide with peak dry weather flows to get a "worst-case" scenario of peak wet weather flows. Table 11 summarizes the final results for each design storm on a site-by-site basis. Figure 41 shows the synthetic hydrograph response for the design storm event at Site H5.

Table 11.
Design Storm I/I Analysis Summary

Basin	Peak Dry Weather Flow (mgd)	Peak I/I Rate (mgd)	Peak Flow (mgd)	Total I/I (gallons)
D60	0.895	3.34	4.23	5,046,000
H5	0.381	1.77	2.15	2,728,000
I5	0.401	1.55	1.96	2,143,000
J2	0.511	1.95	2.46	2,330,000
K1	0.408	0.90	1.31	1,181,000
N2	0.315	1.80	2.11	1,565,000
R42	0.301	1.72	2.02	2,335,000
W62	0.151	0.38	0.53	487,000
X115	0.227	1.01	1.23	1,466,000
Z41	0.020	0.65	0.67	938,000

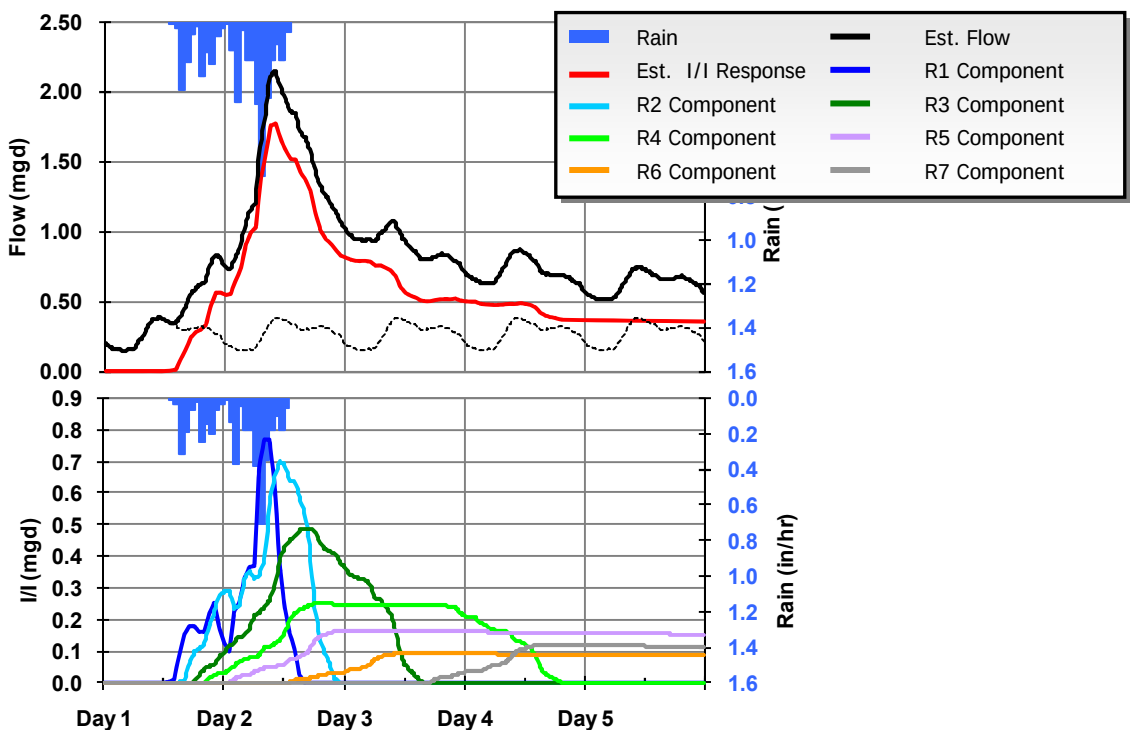


Figure 41. 10-Year, 24-Hour Design Storm: Estimated I/I Response at Site D60

RECOMMENDATIONS

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

4. **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 H5, I5, and R42.
   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 Basin I5. The highest groundwater infiltration was occurring in Basins Z41, I5 and H5.
5. **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.
6. **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

City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

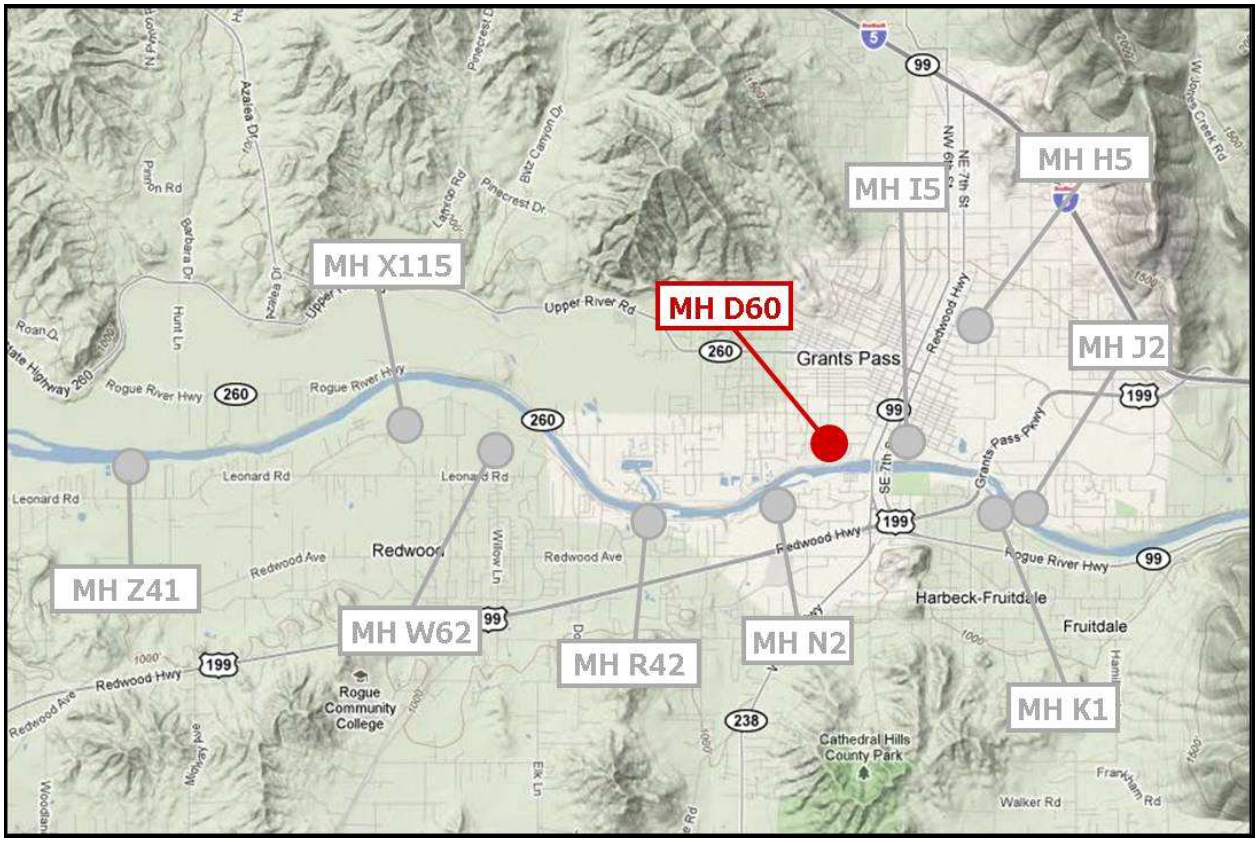
Year 2011/2012

Monitoring Site: D60

Location: Intersection of Southwest Central Avenue and Southwest Oak Street

Data Summary Report

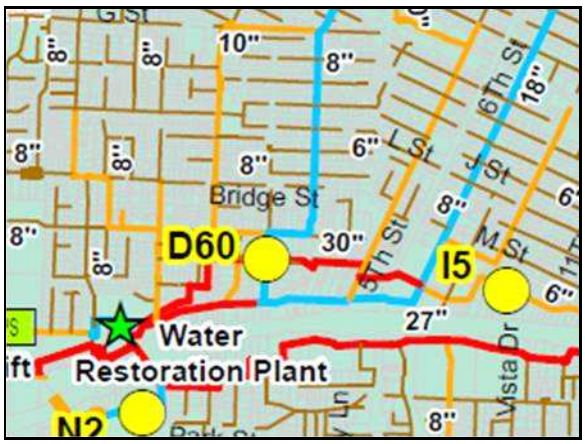
Vicinity Map:



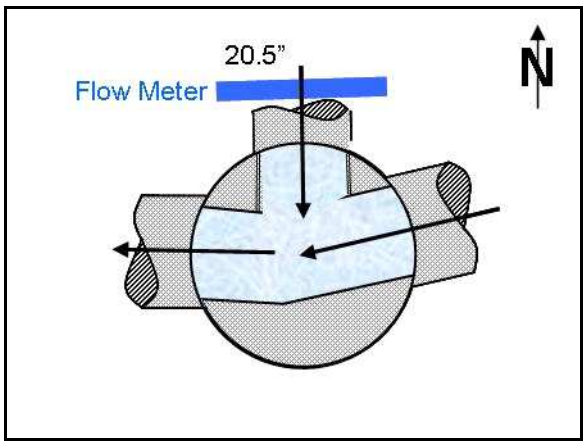
D60
Site Information Report

Location:	Intersection of Southwest Central Avenue and Southwest Oak Street
Coordinates:	123.3370°W, 42.4324°N
Elevation:	923 feet
Diameter:	20.5 inches
Baseline Flow:	0.611 mgd
Peak Measured Flow:	2.534 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

D60
Additional Site Photos

Effluent Pipe

East Influent Pipe

D60
Additional Site Photos

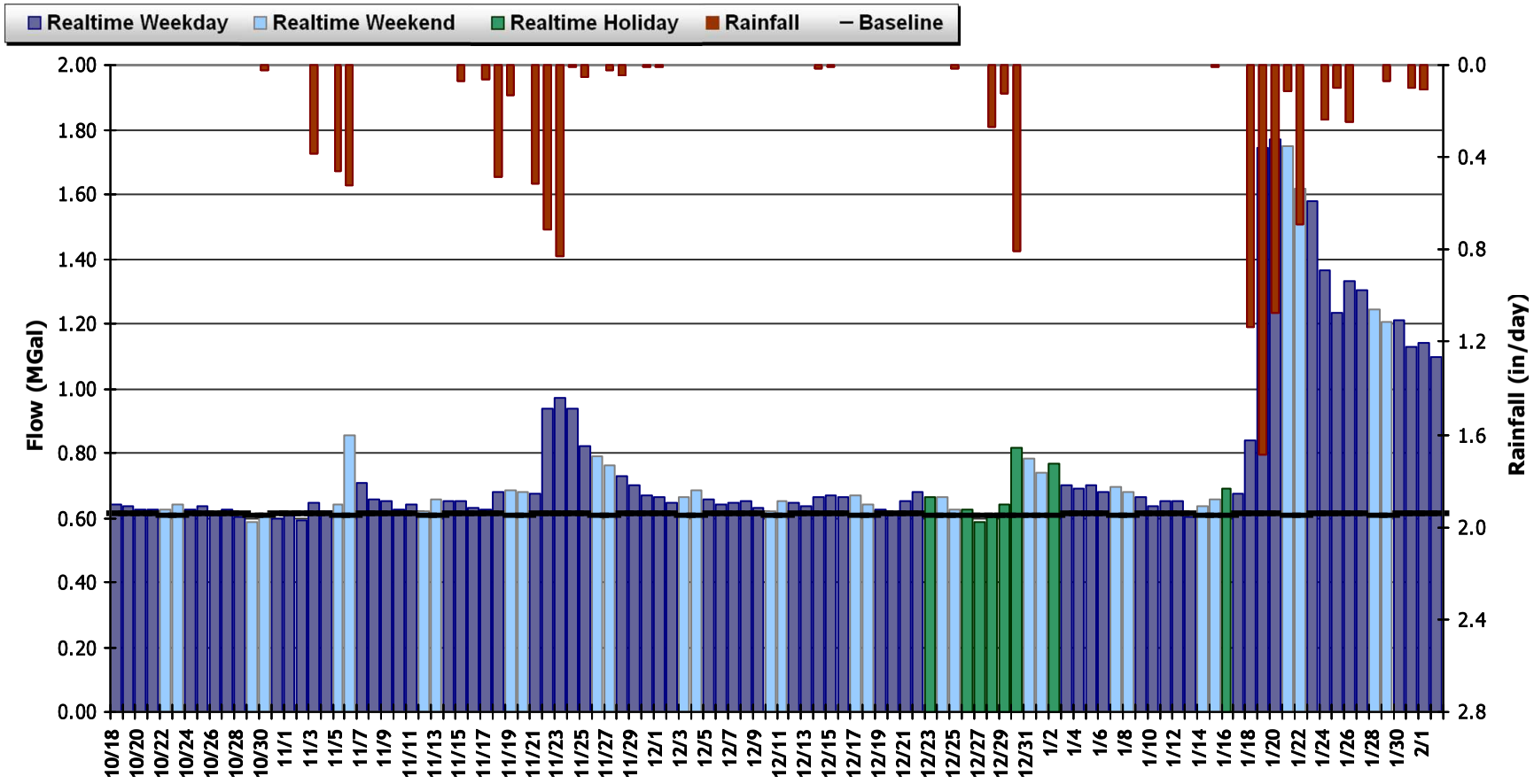
North Influent Pipe

D60

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.769 MGal Peak Daily Flow: 1.77 MGal Min Daily Flow: 0.587 MGal

Total Period Rainfall: 11.15 inches

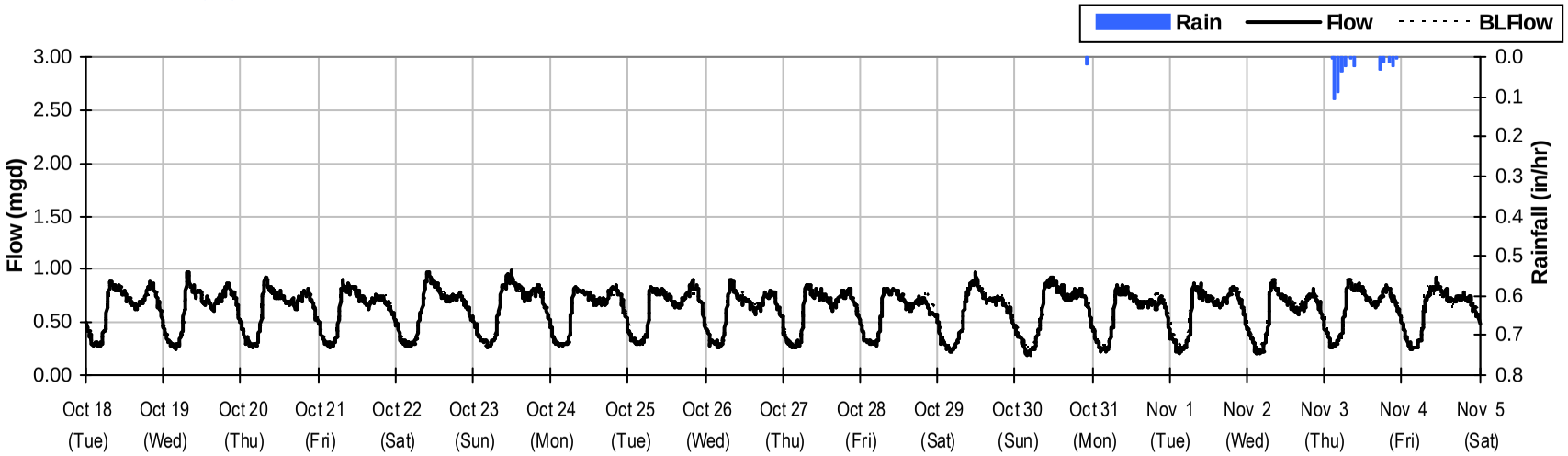


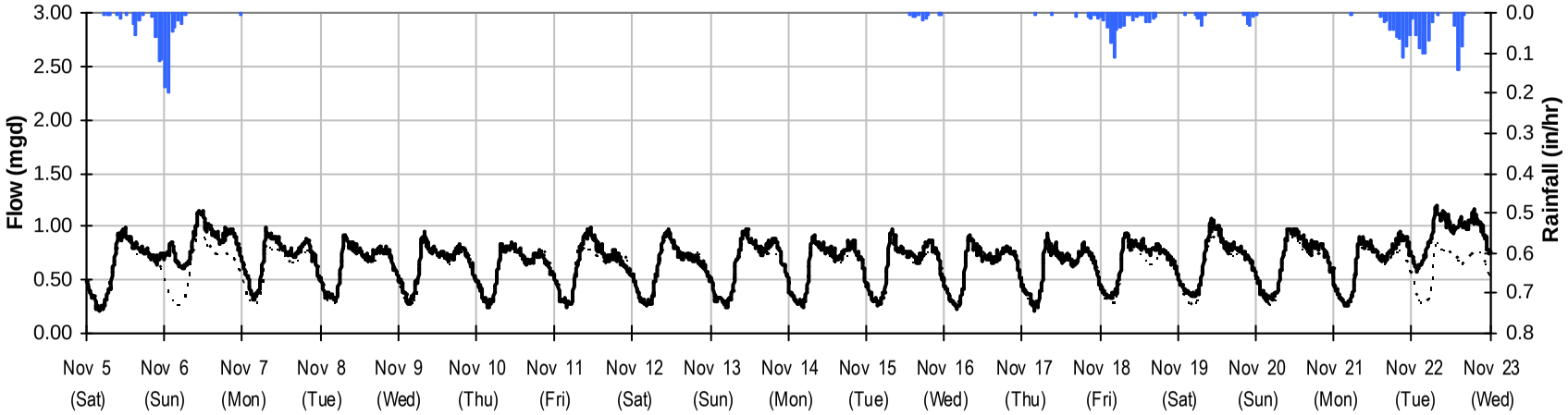
D60

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.651 mgd Peak Flow: 1.196 mgd Min Flow: 0.19 mgd

Total Period Rainfall: 3.36 inches



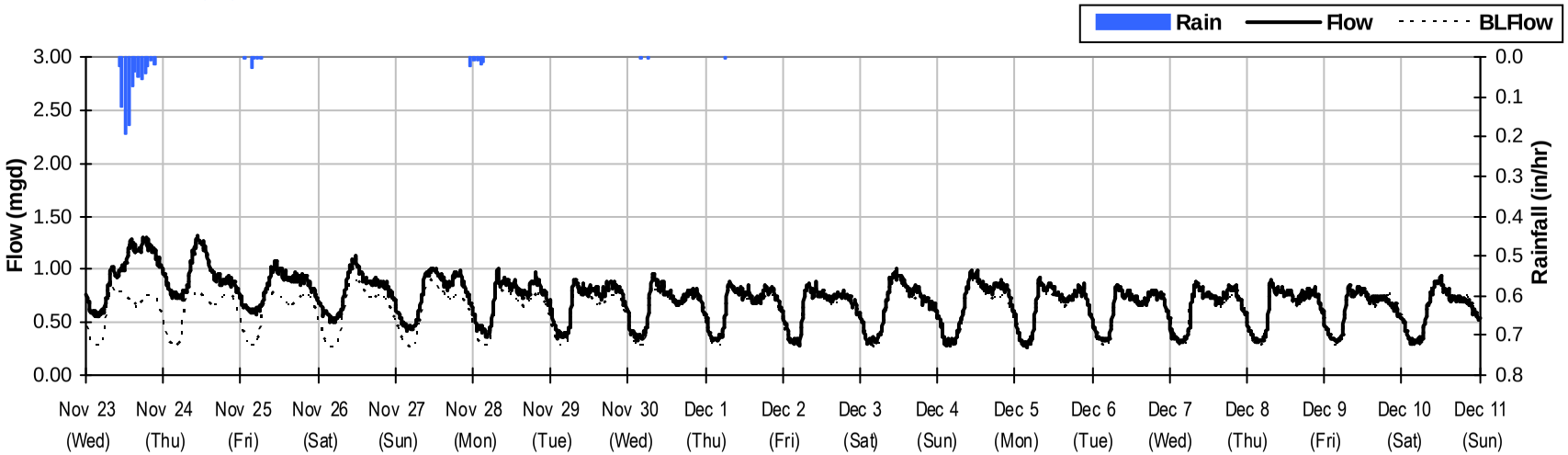


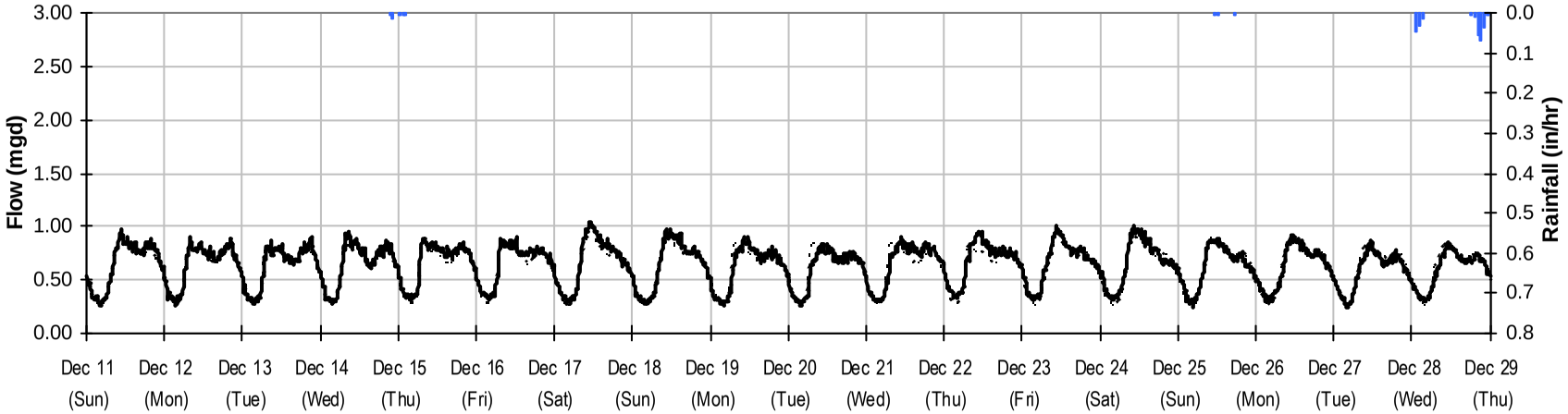
D60

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.68 mgd Peak Flow: 1.325 mgd Min Flow: 0.238 mgd

Total Period Rainfall: 1.29 inches



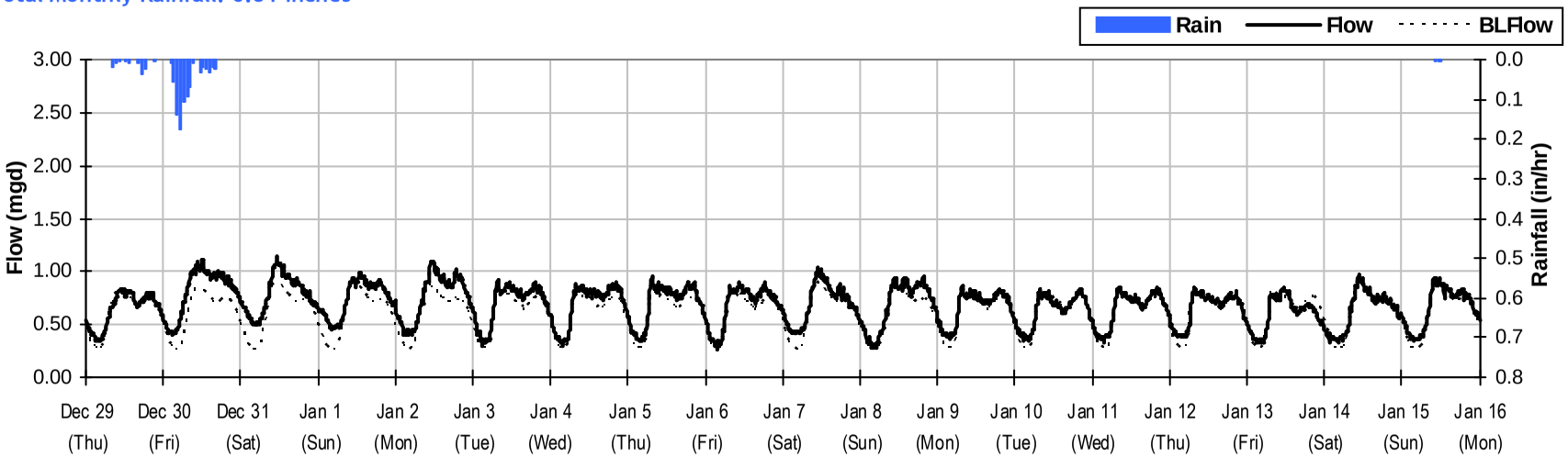


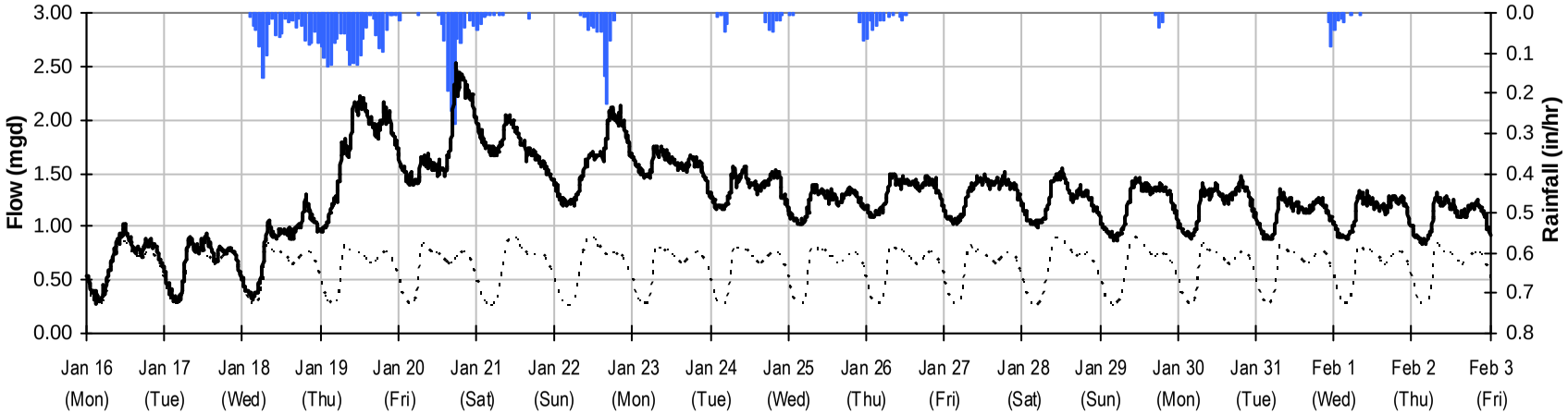
D60

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.98 mgd Peak Flow: 2.53 mgd Min Flow: 0.27 mgd

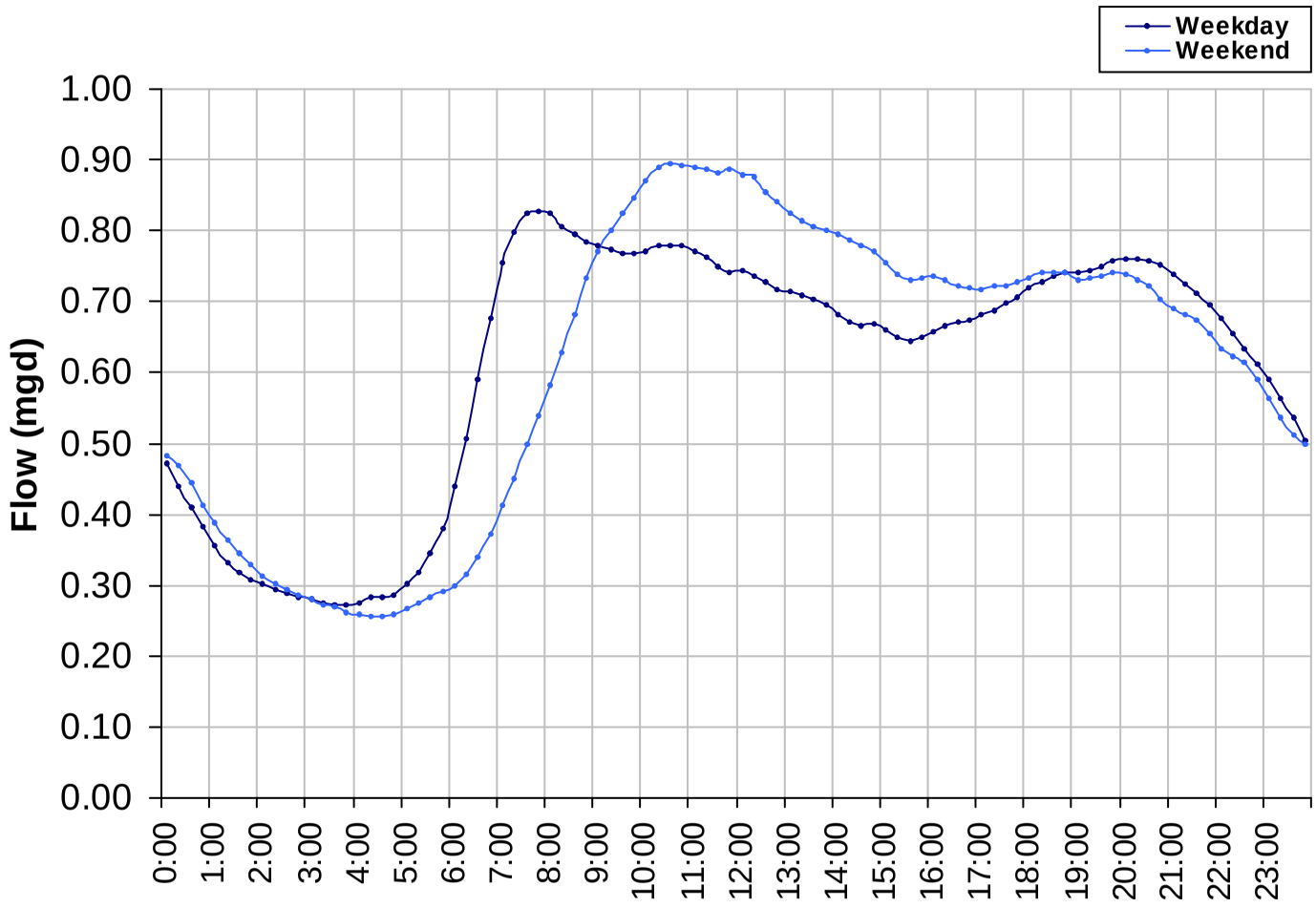
Total Monthly Rainfall: 6.51 inches





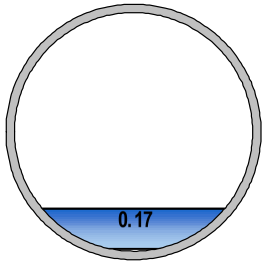
D60

Baseline Flow Hydrographs



Baseline Flow:

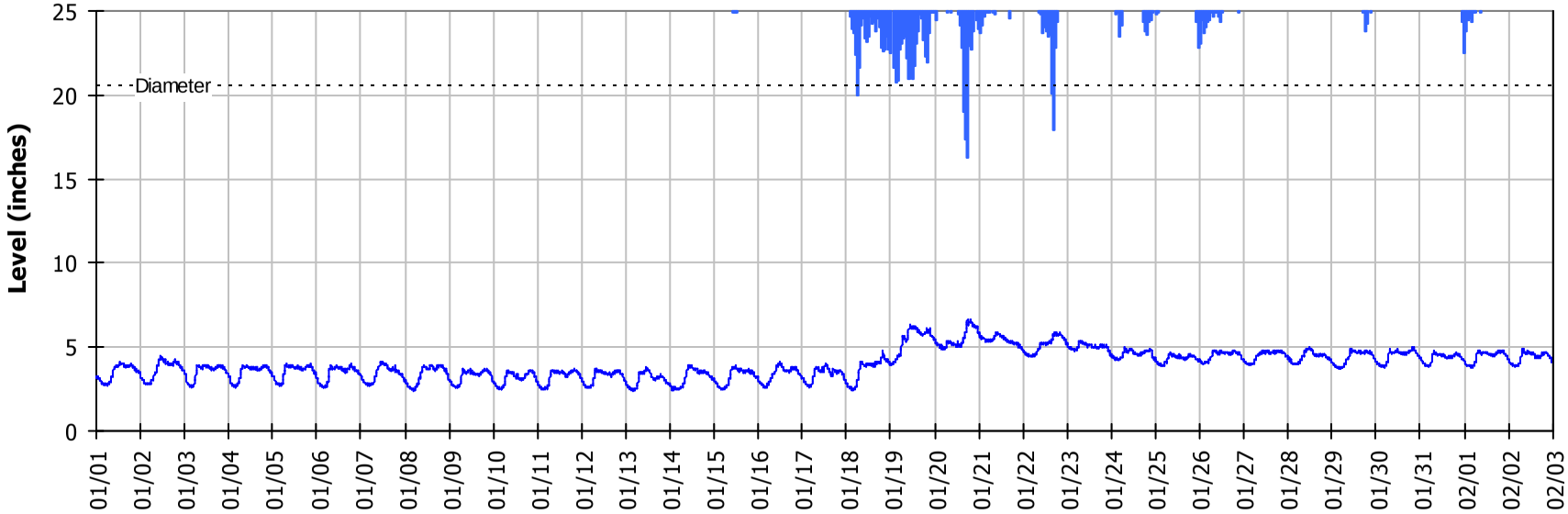
0.611 *mgd*

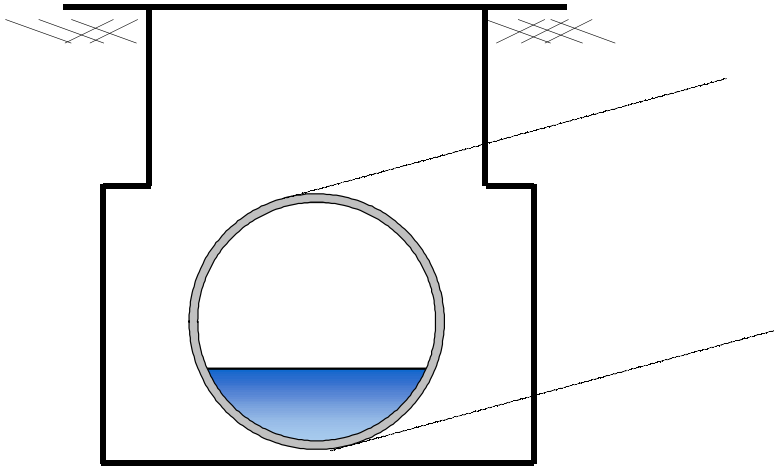


D60

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

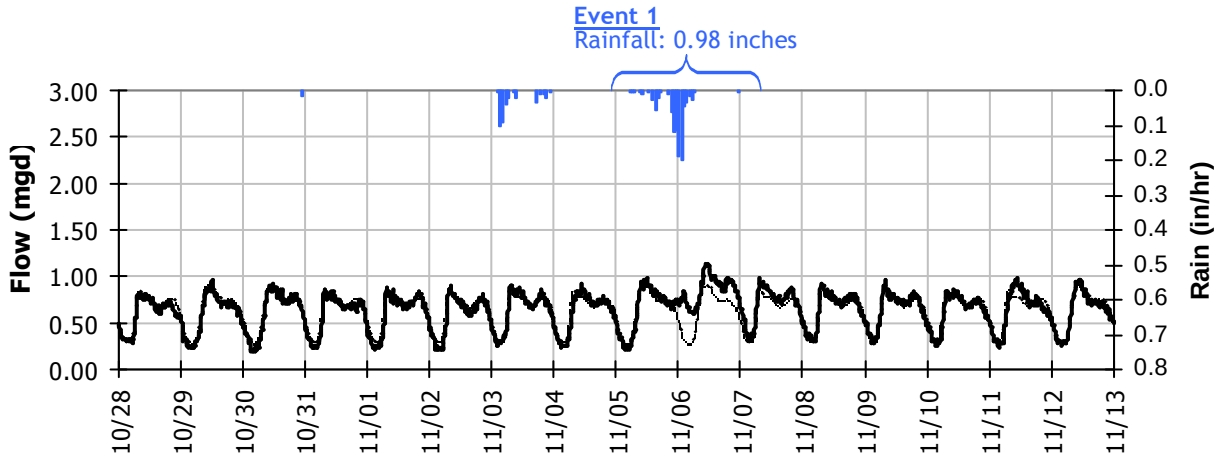




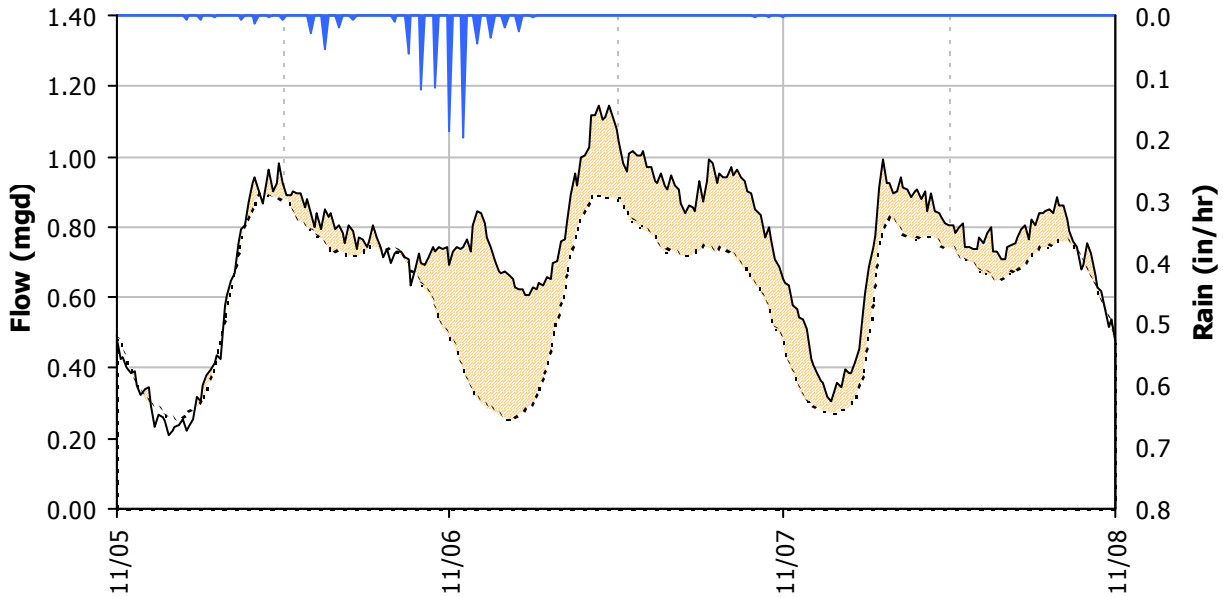
Pipe Diameter:	20.5 *inches*
Peak Measured Level	6.63 *inches*
Peak d/D Ratio:	0.32

SITE D60
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

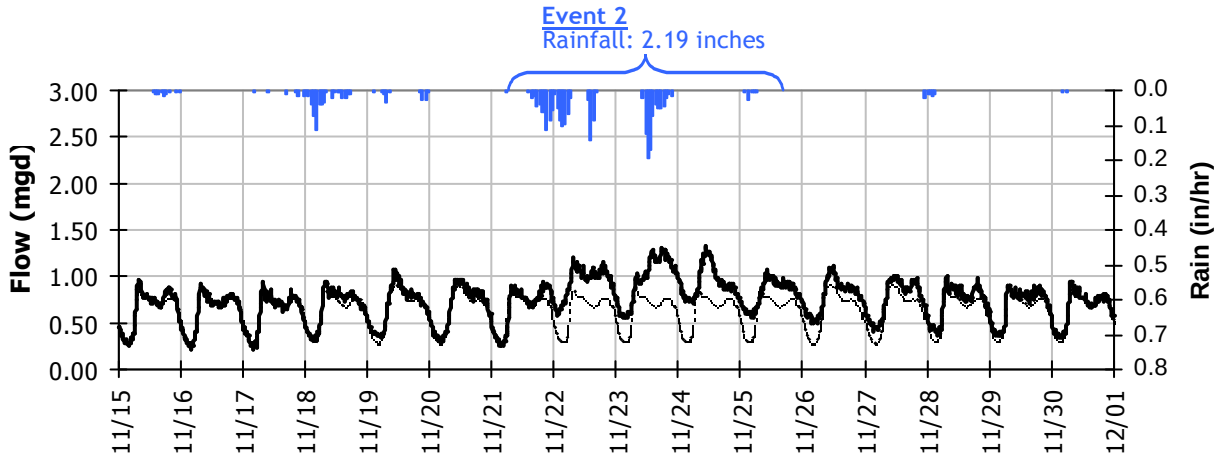


Storm Event I/I Analysis (Rain = 0.98 inches)

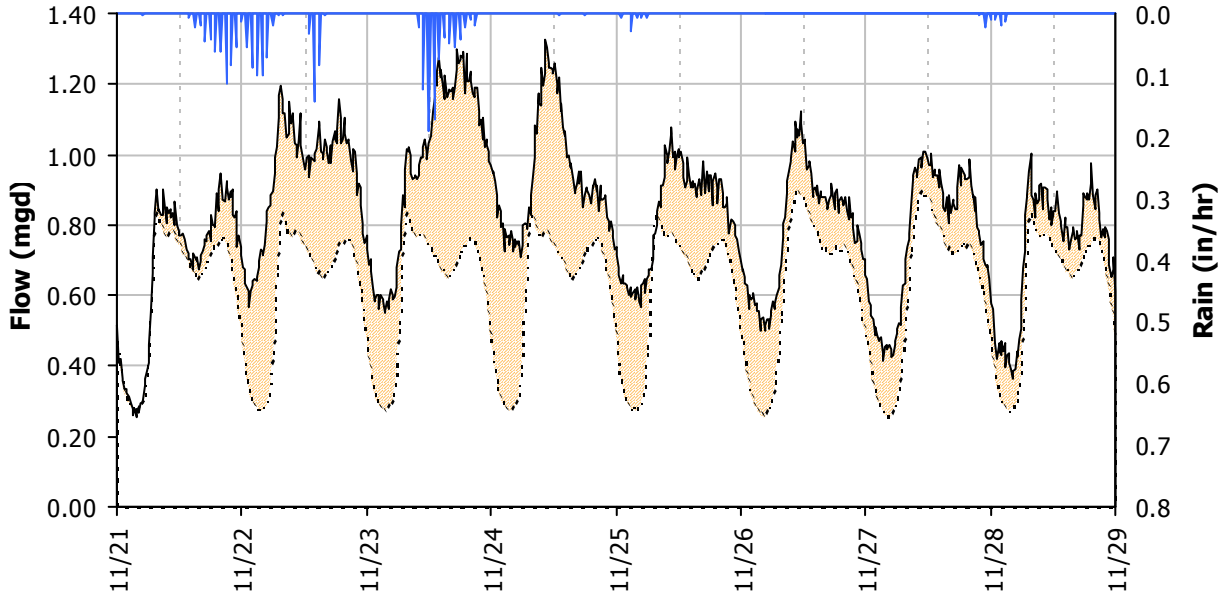
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	1.15 *mgd*	Peak I/I Rate:	0.54 *mgd*	Infiltration Rate: (11/7/2011)	0.094 *mgd*	Total I/I:	371,000 *gallons*
PF:	1.88	PkI/I:IDM:	1,499 *gpd/IDM*	RDI:IDM:	261 *gpd/IDM*	Total I/I:IDM:	1,048 *gal/IDM/in*
Peak Level:	4.48 *in*	PkI/I:Acre:	296 *gpd/acre*	RDI:Acre:	52 *gpd/acre*	R-Value:	0.8%
d/D Ratio:	0.22	Pk I/I:ADWF:	0.88	RDI (% of BL):	15%	Total I/I:ADWF:	0.62 *per in-rain*

SITE D60
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

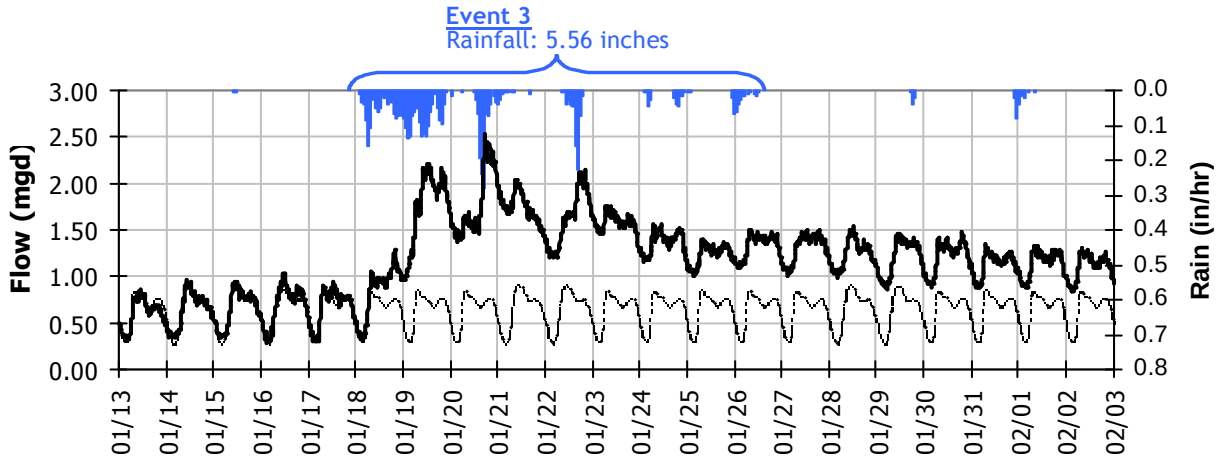


Storm Event I/I Analysis (Rain = 2.19 inches)

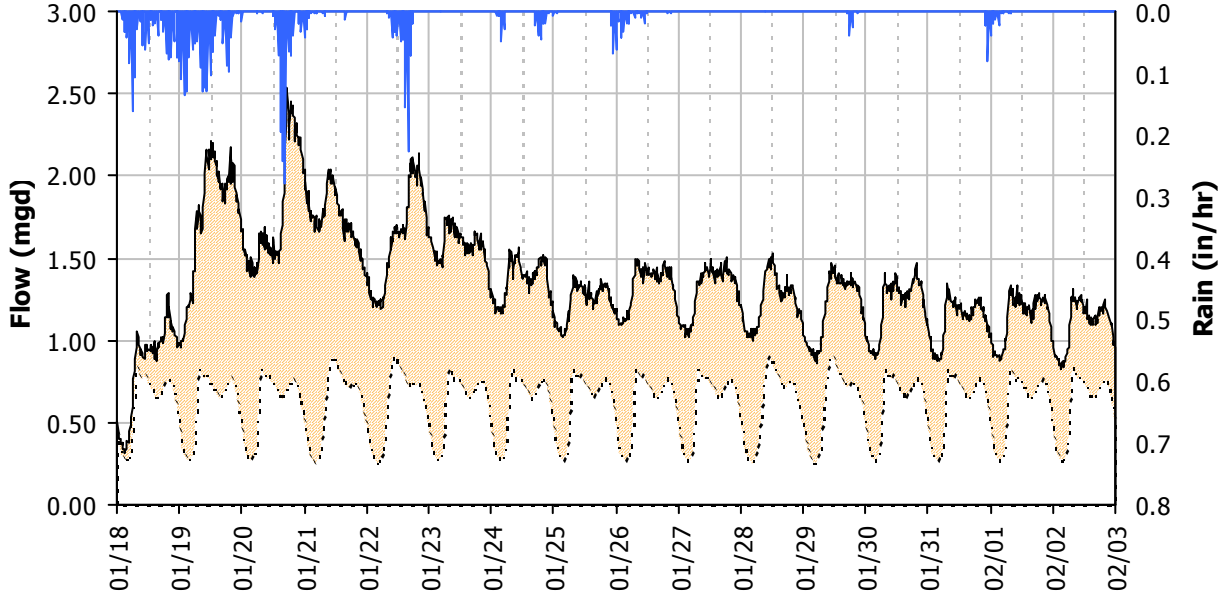
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	1.33 *mgd*	Peak I/I Rate:	0.60 *mgd*	Infiltration Rate: (11/26/2011)	0.182 *mgd*	Total I/I:	1,740,000 *gallons*
PF:	2.17	PkI/I:IDM:	1,670 *gpd/IDM*	RDI:IDM:	505 *gpd/IDM*	Total I/I:IDM:	2,214 *gal/IDM/in*
Peak Level:	4.96 *in*	PkI/I:Acre:	330 *gpd/acre*	RDI:Acre:	100 *gpd/acre*	R-Value:	1.6%
d/D Ratio:	0.24	Pk I/I:ADWF:	0.98	RDI (% of BL):	30%	Total I/I:ADWF:	1.30 *per in-rain*

SITE D60
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

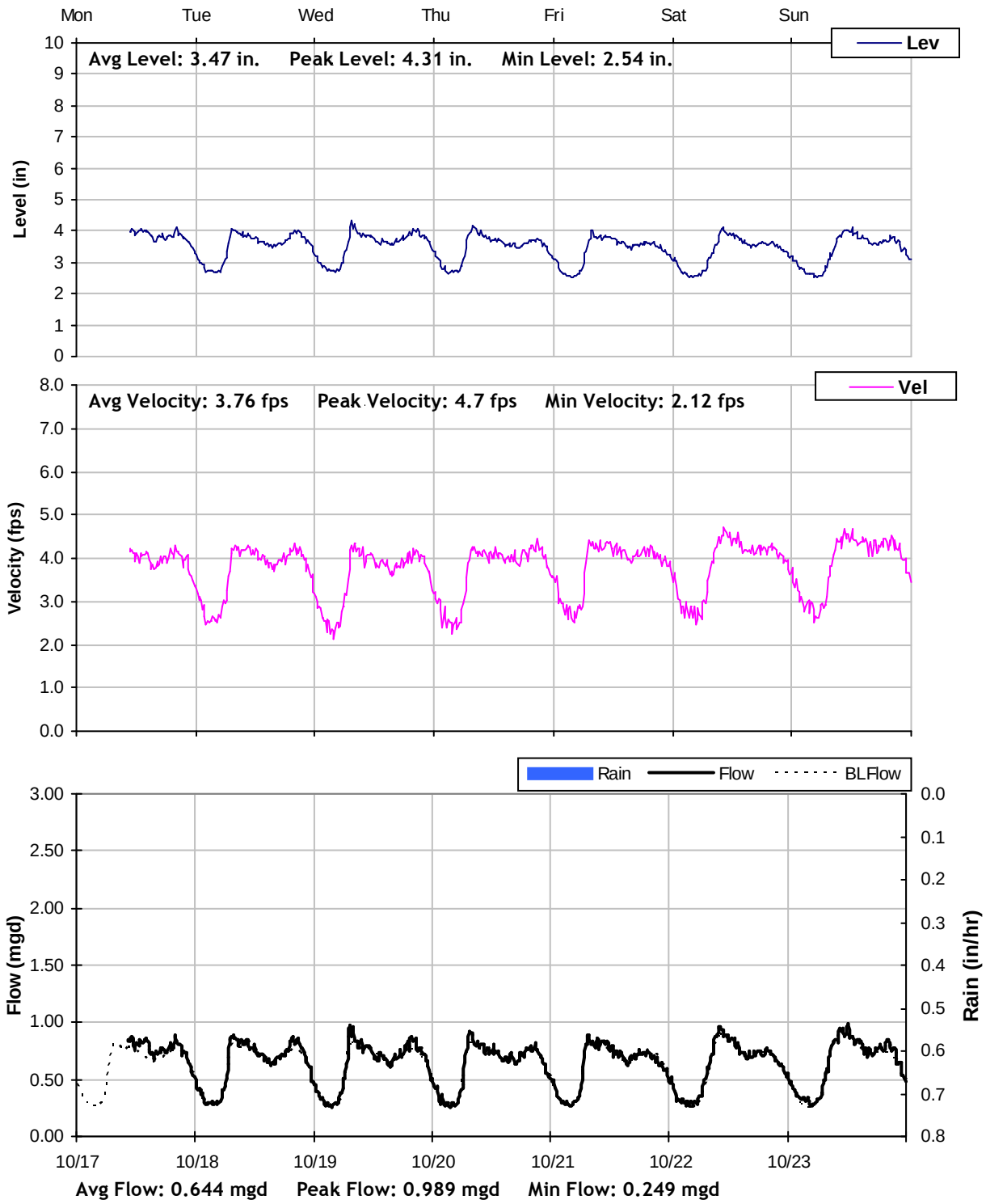


Storm Event I/I Analysis (Rain = 5.56 inches)

Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	2.53 *mgd*	Peak I/I Rate:	1.83 *mgd*	Infiltration Rate: (1/30/2012)	0.601 *mgd*	Total I/I:	11,782,000 *gallons*
PF:	4.15	PkI/I:IDM:	5,087 *gpd/IDM*	RDI:IDM:	1,673 *gpd/IDM*	Total I/I:IDM:	5,891 *gal/IDM/in*
Peak Level:	6.63 *in*	PkI/I:Acre:	1,006 *gpd/acre*	RDI:Acre:	331 *gpd/acre*	R-Value:	4.3%
d/D Ratio:	0.32	Pk I/I:ADWF:	2.99	RDI (% of BL):	99%	Total I/I:ADWF:	3.47 *per in-rain*

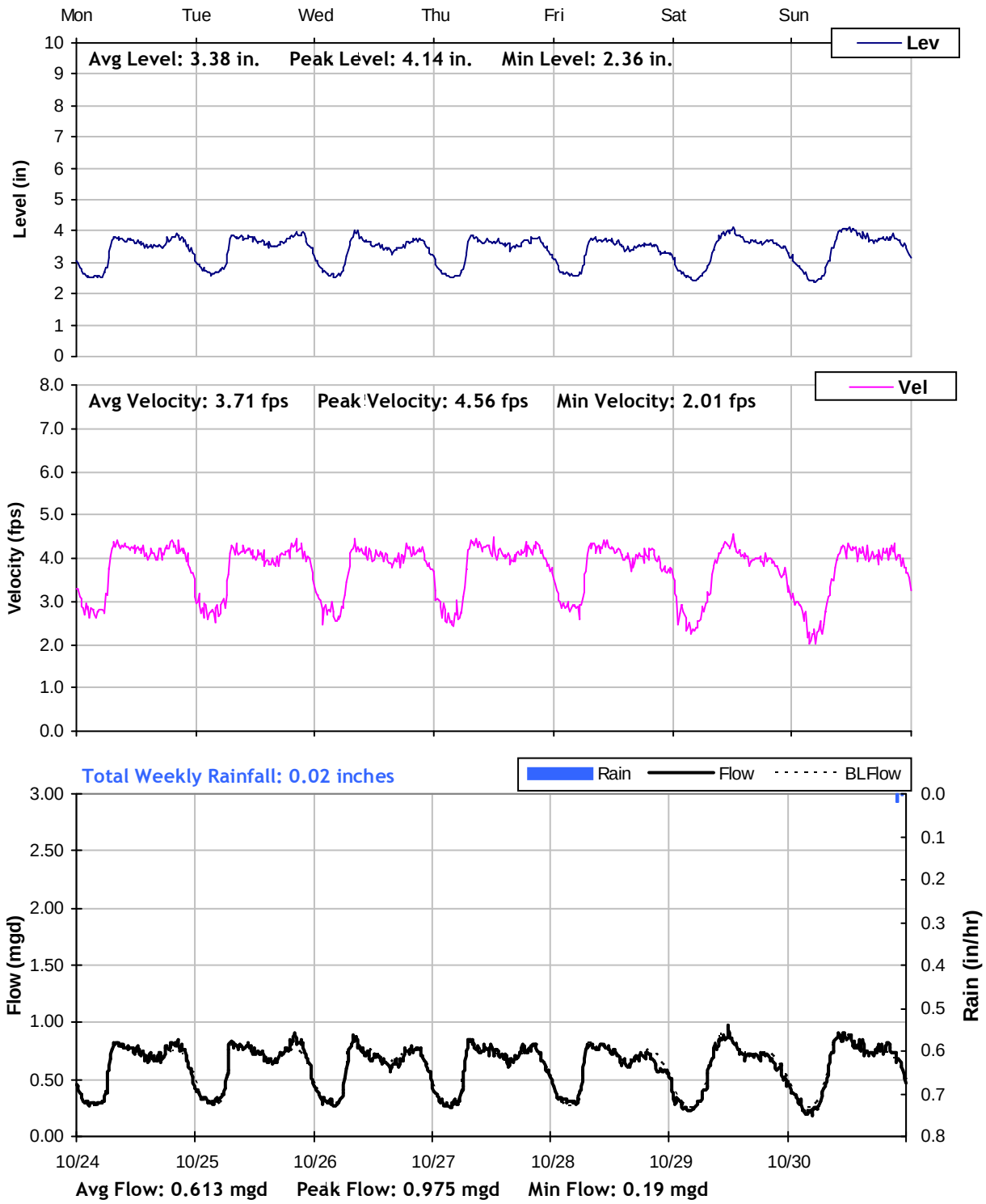
D60

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



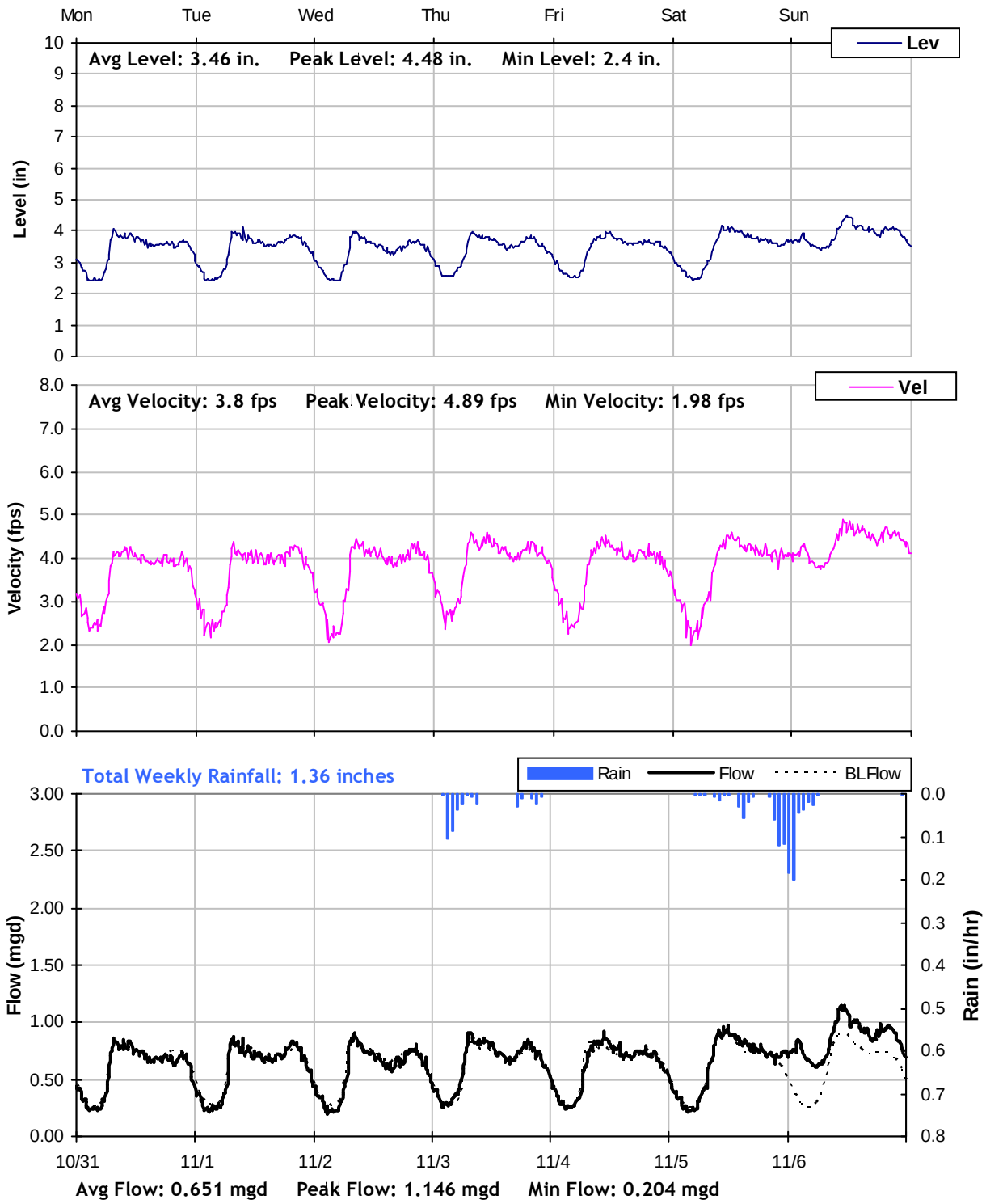
D60

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



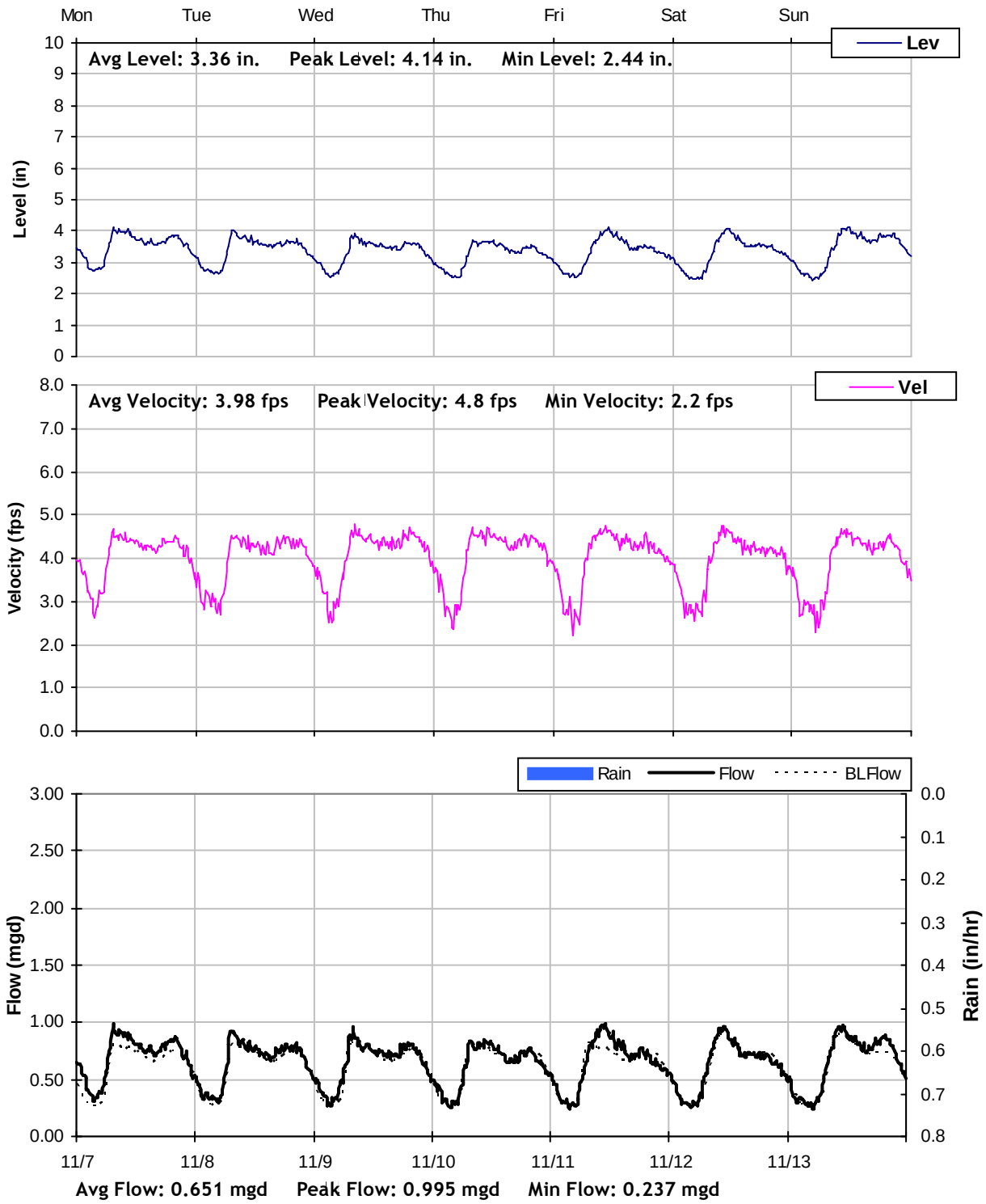
D60

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



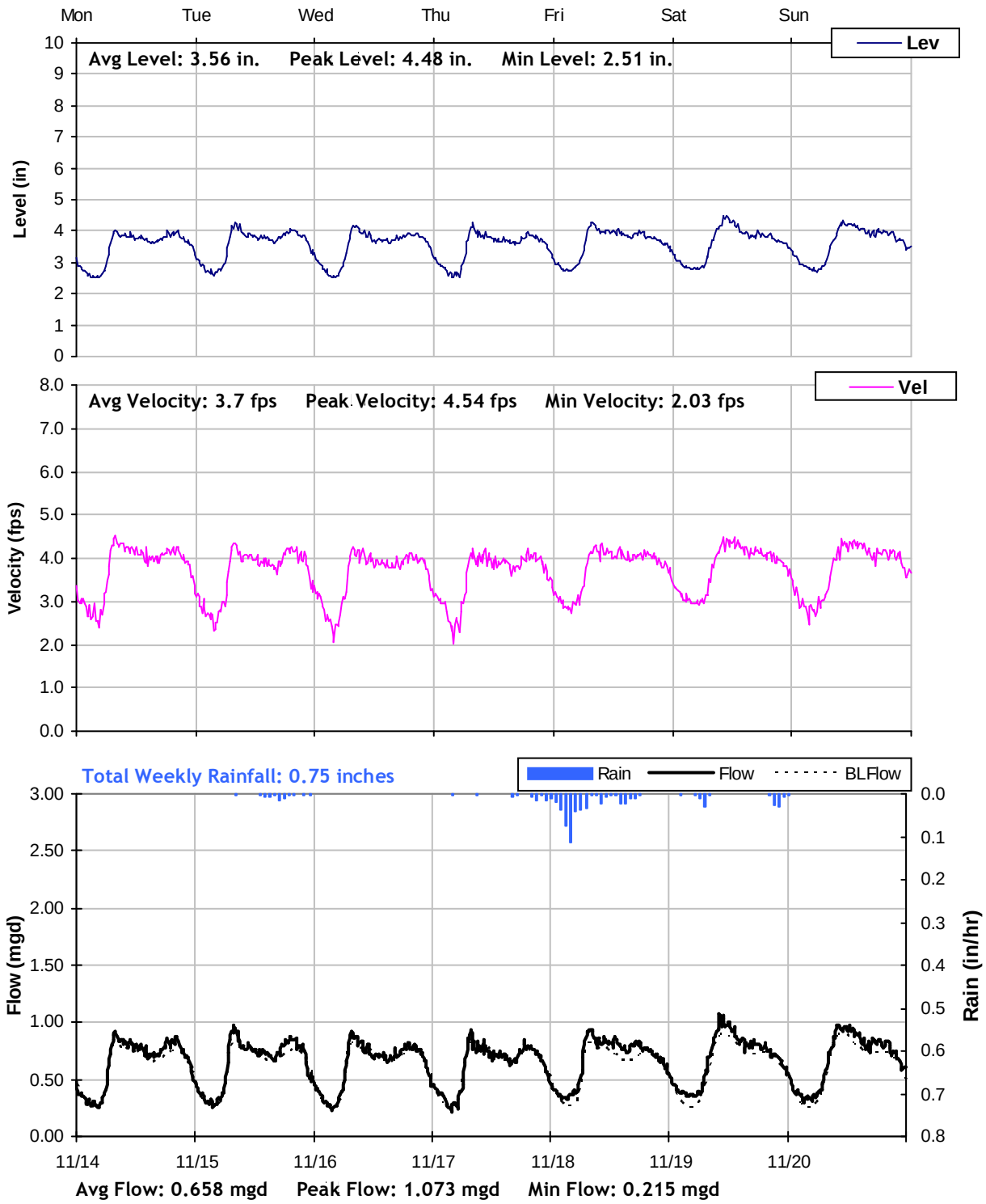
D60

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



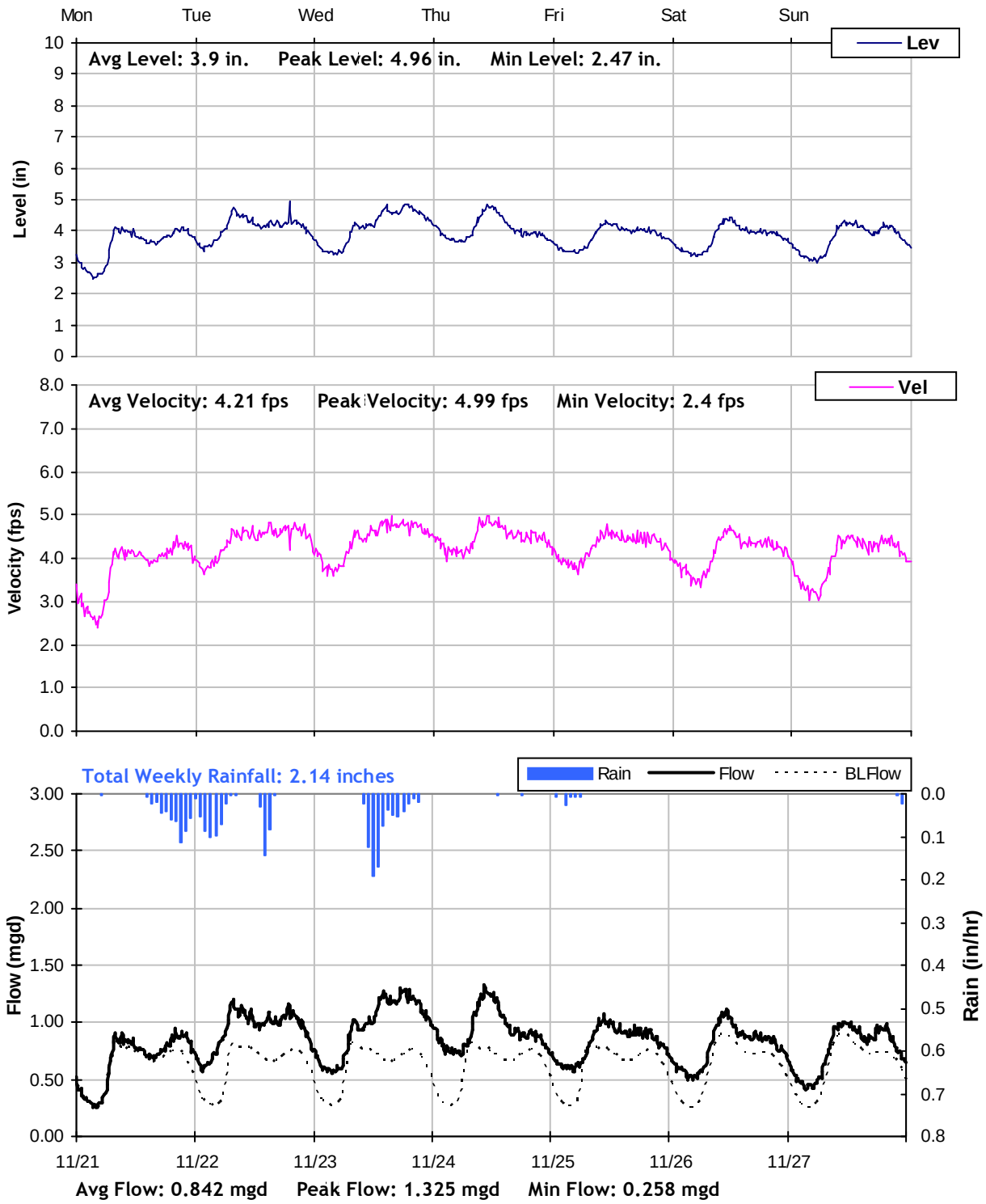
D60

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



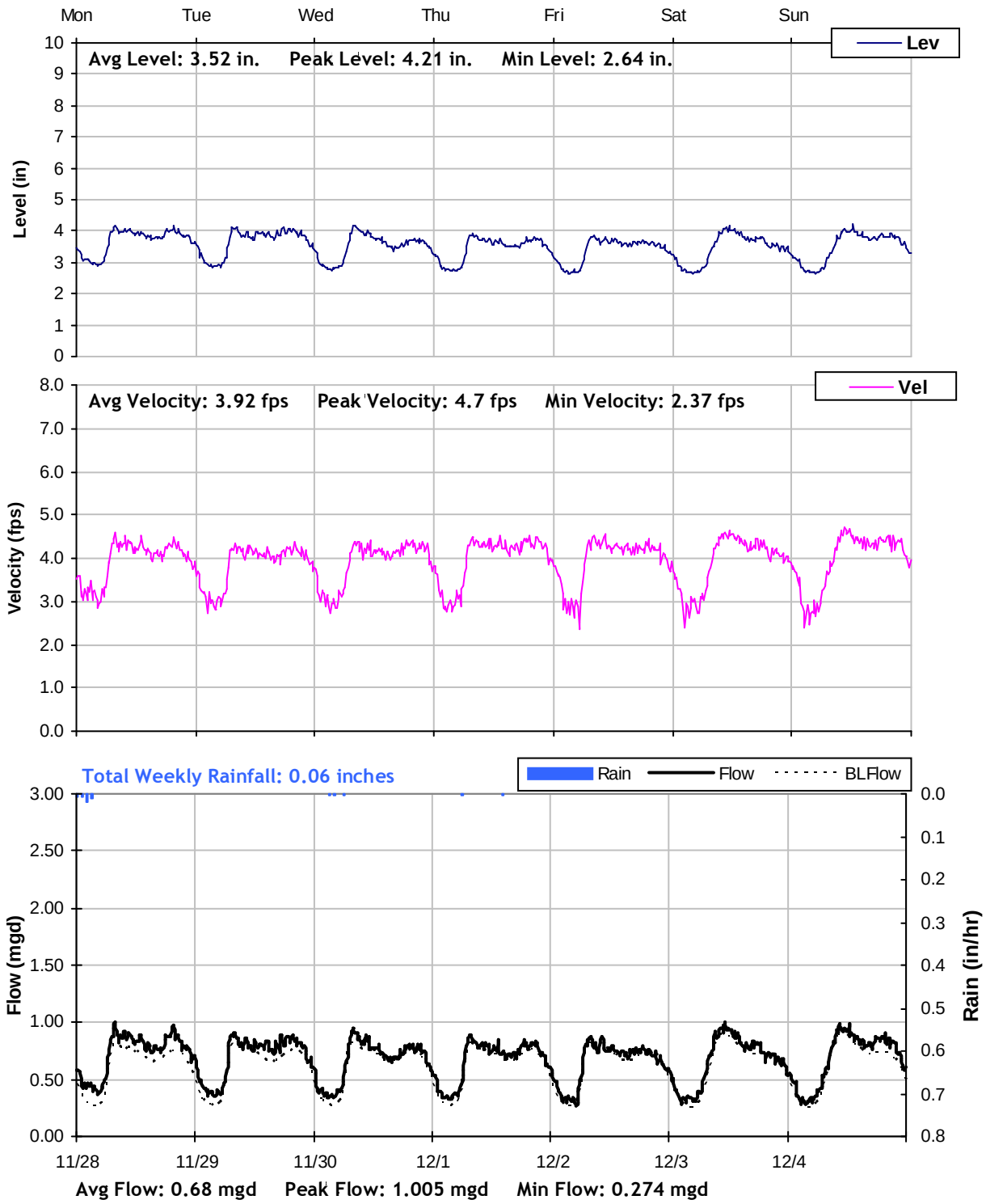
D60

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



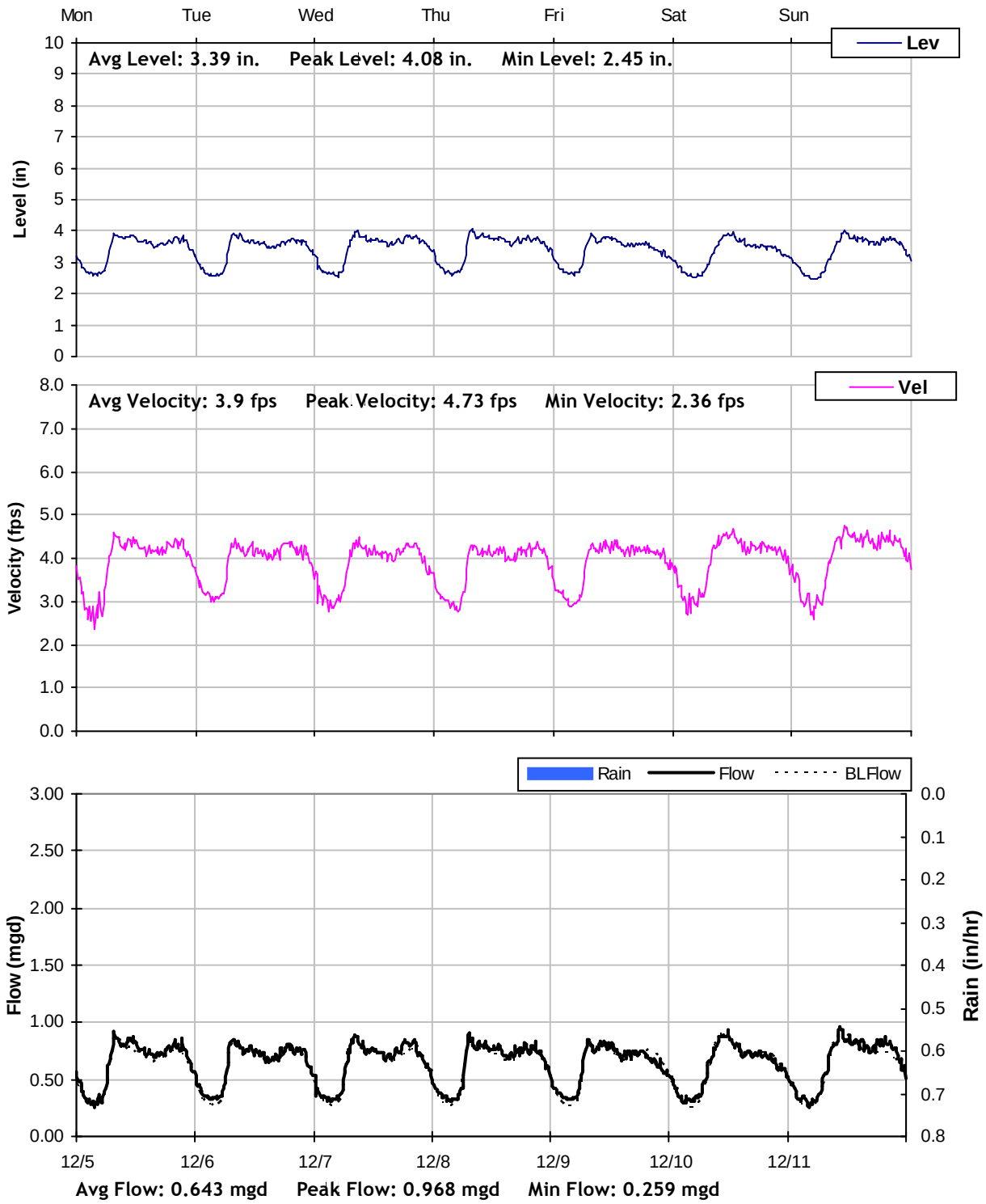
D60

Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



D60

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



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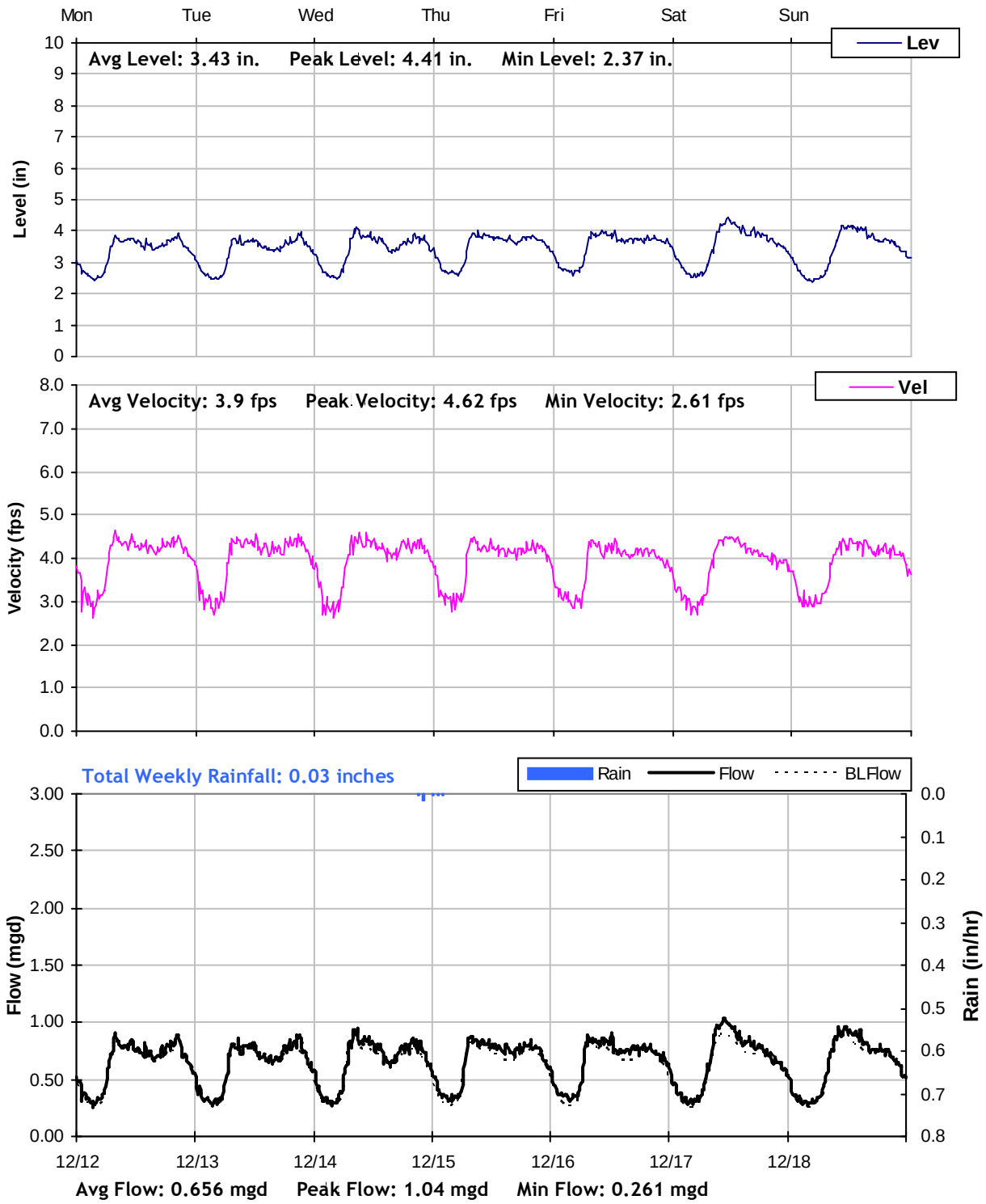
Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



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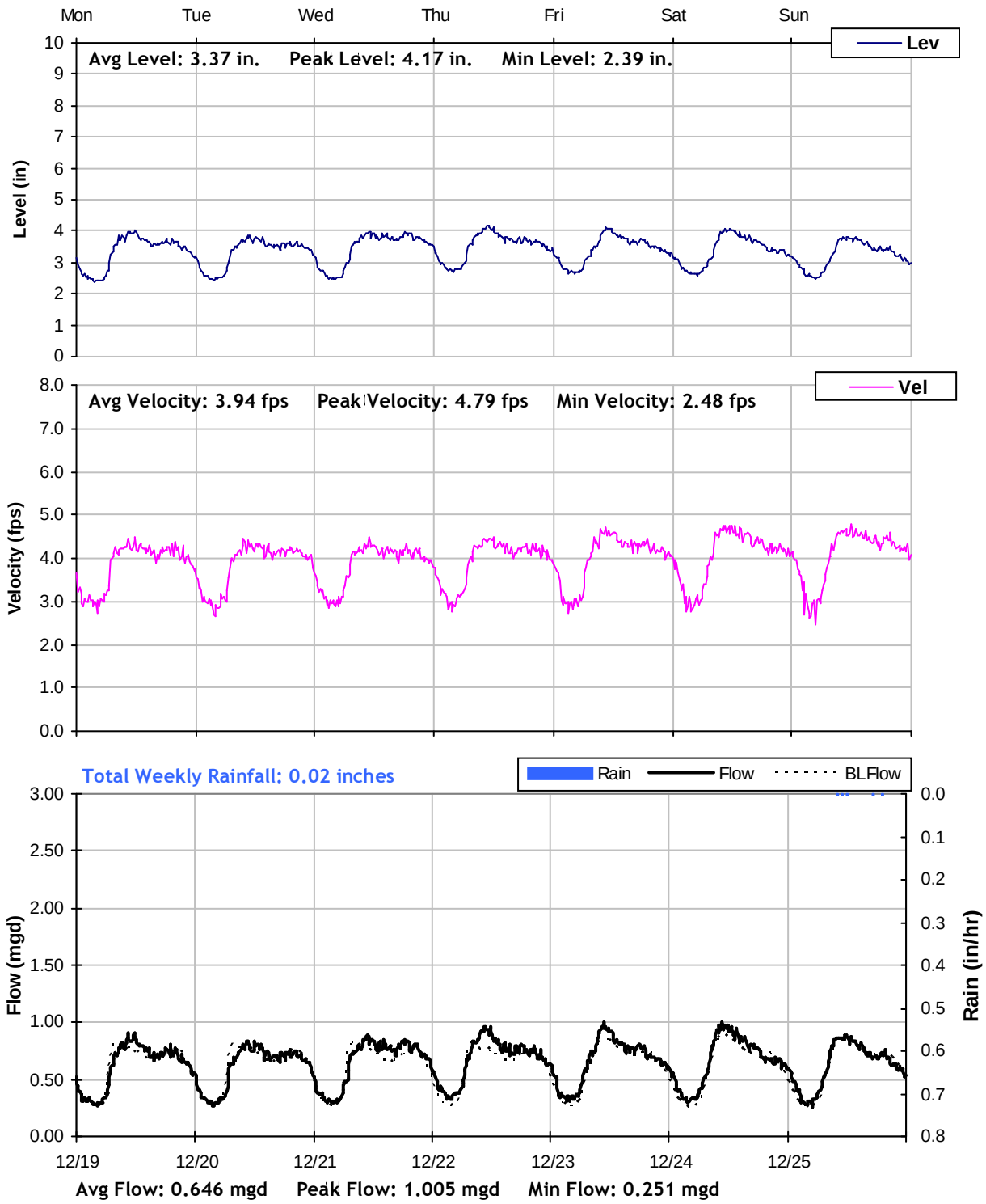
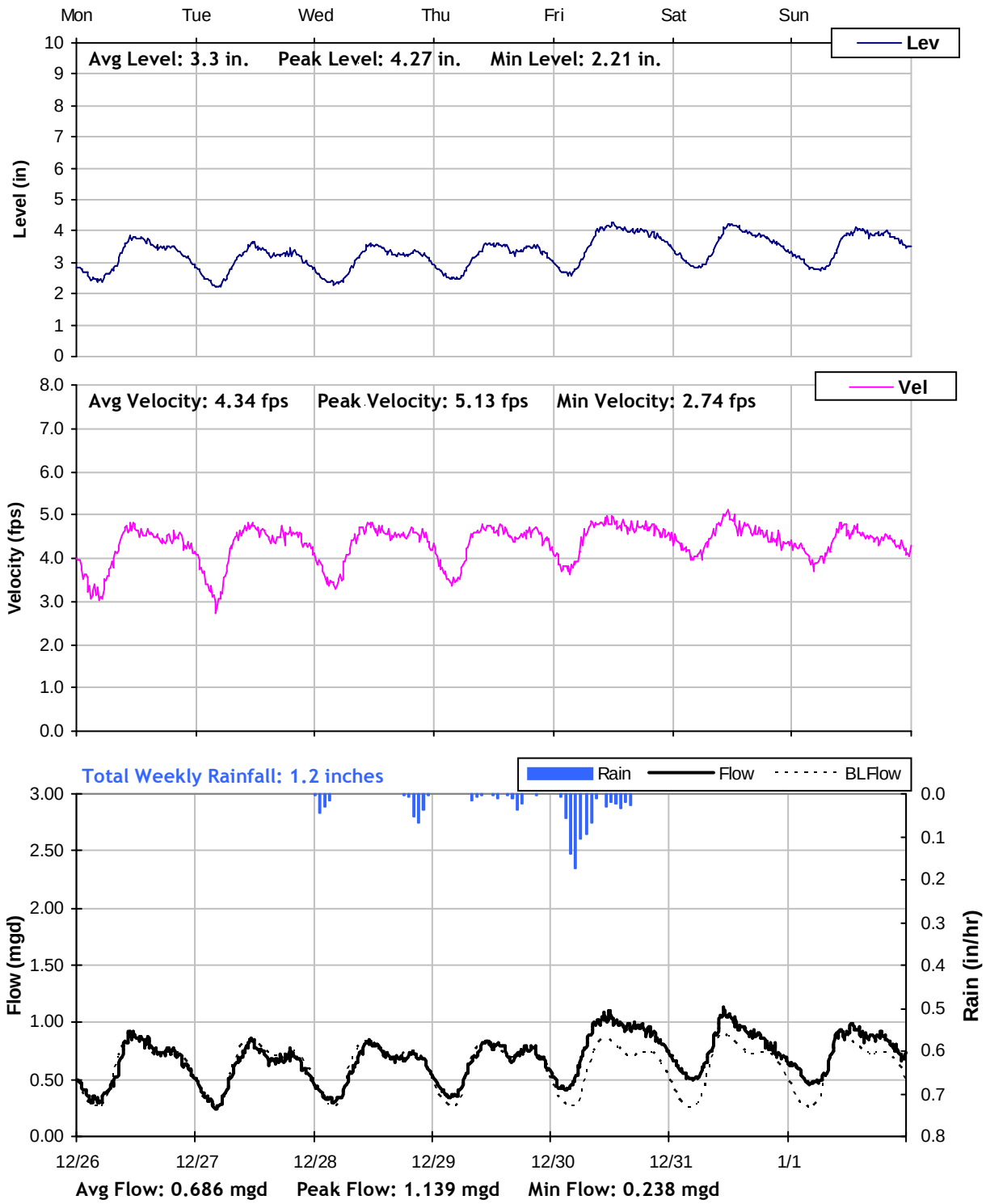
Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



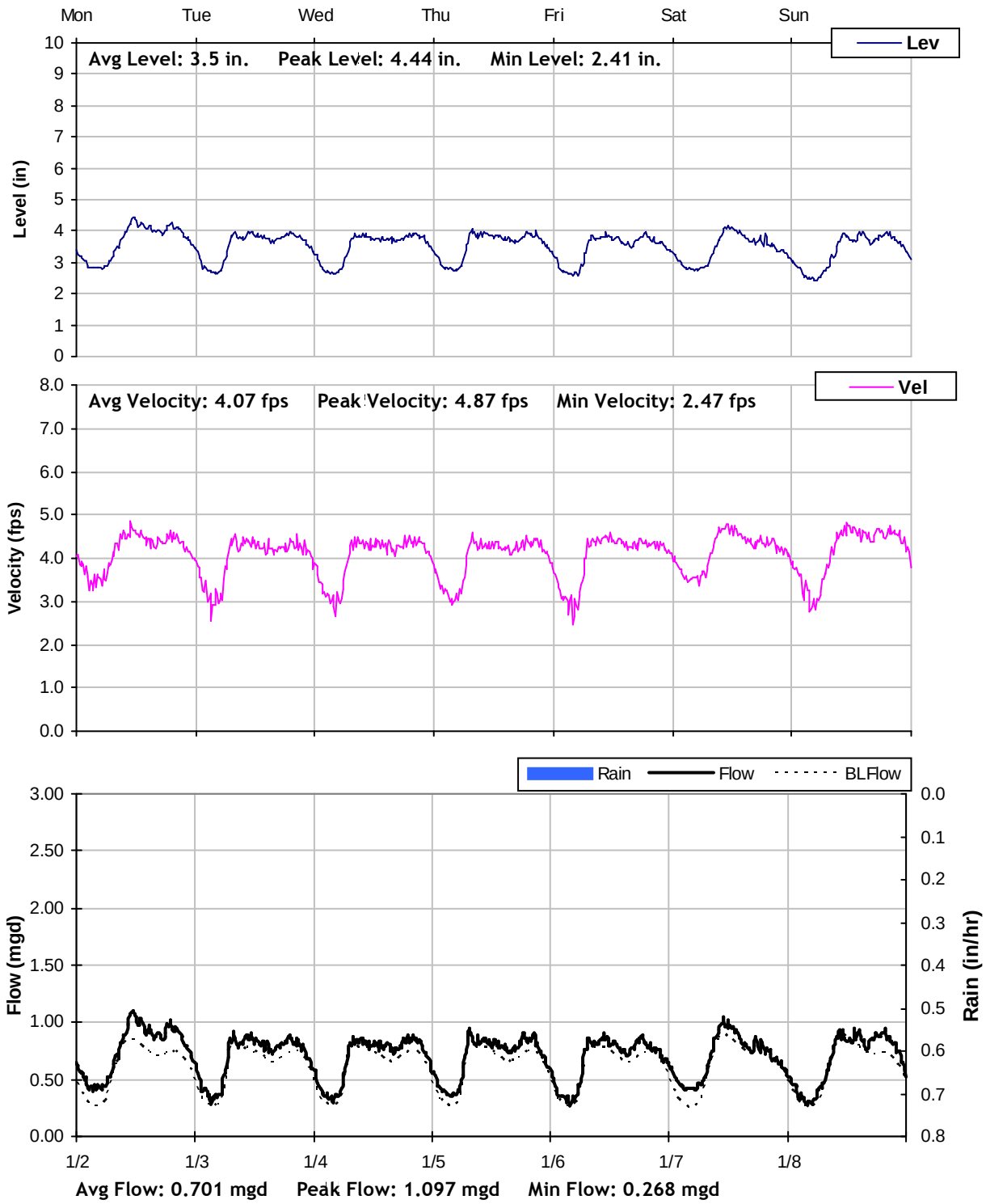
D60

Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



D60

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



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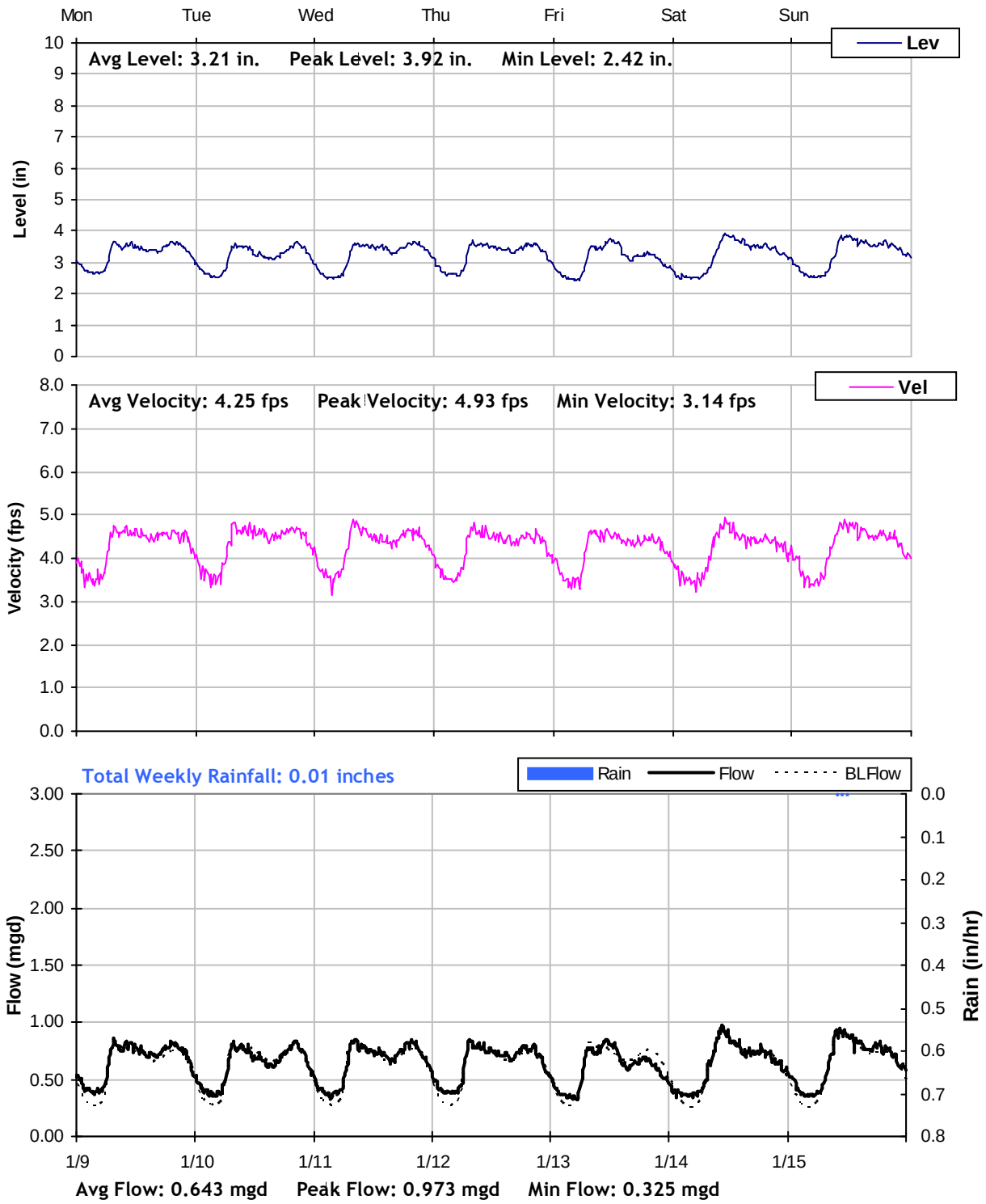
Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



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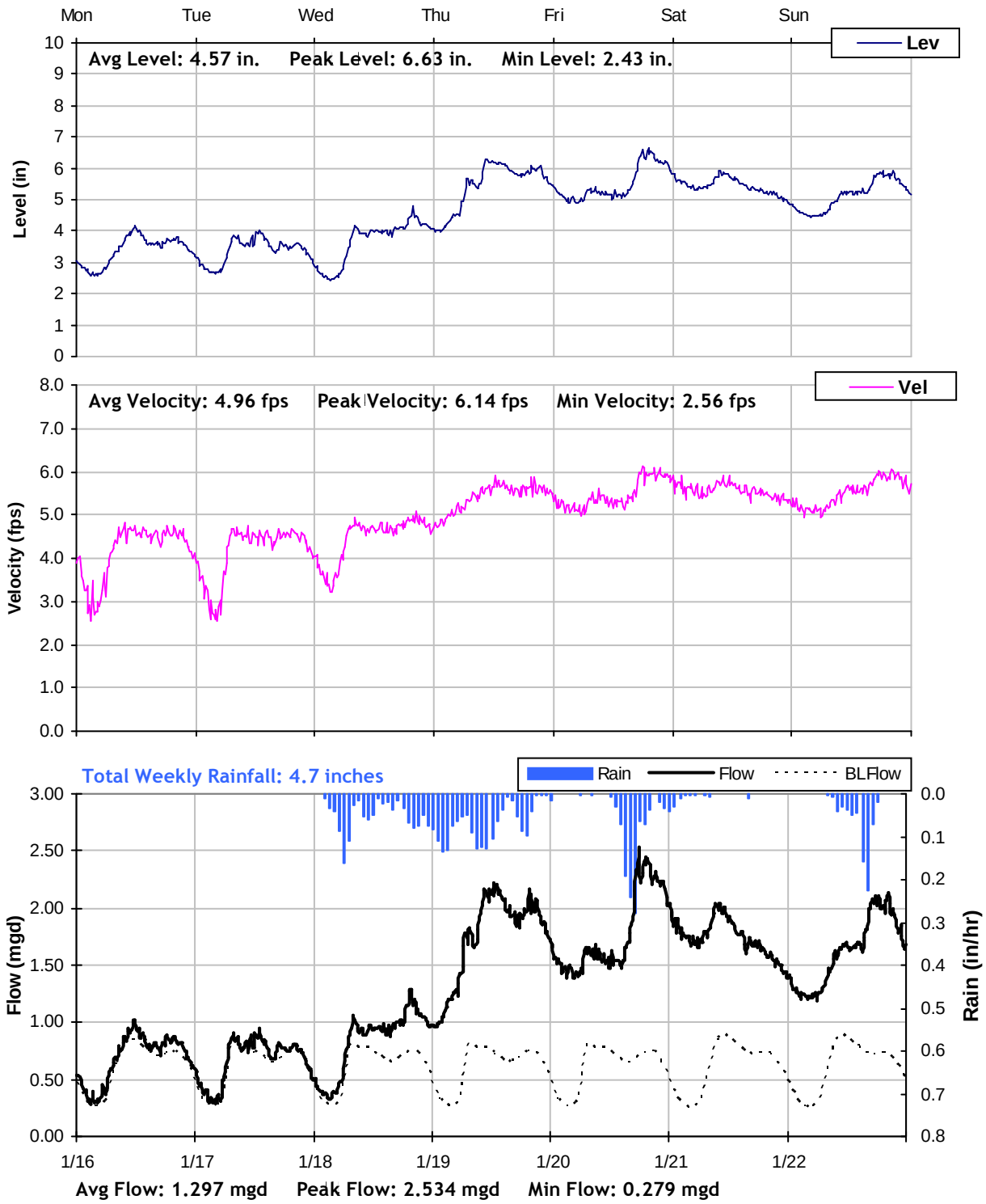
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



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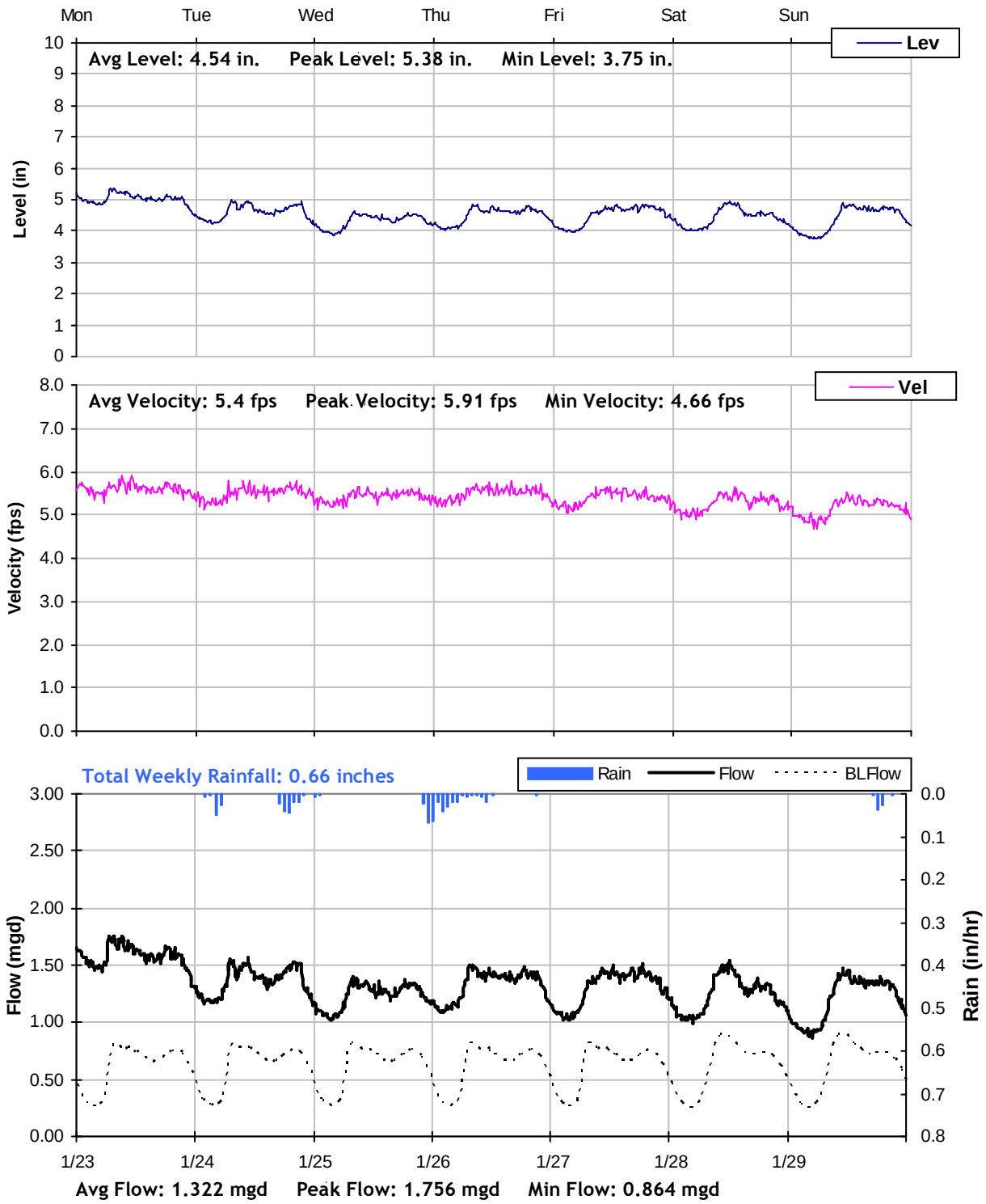
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



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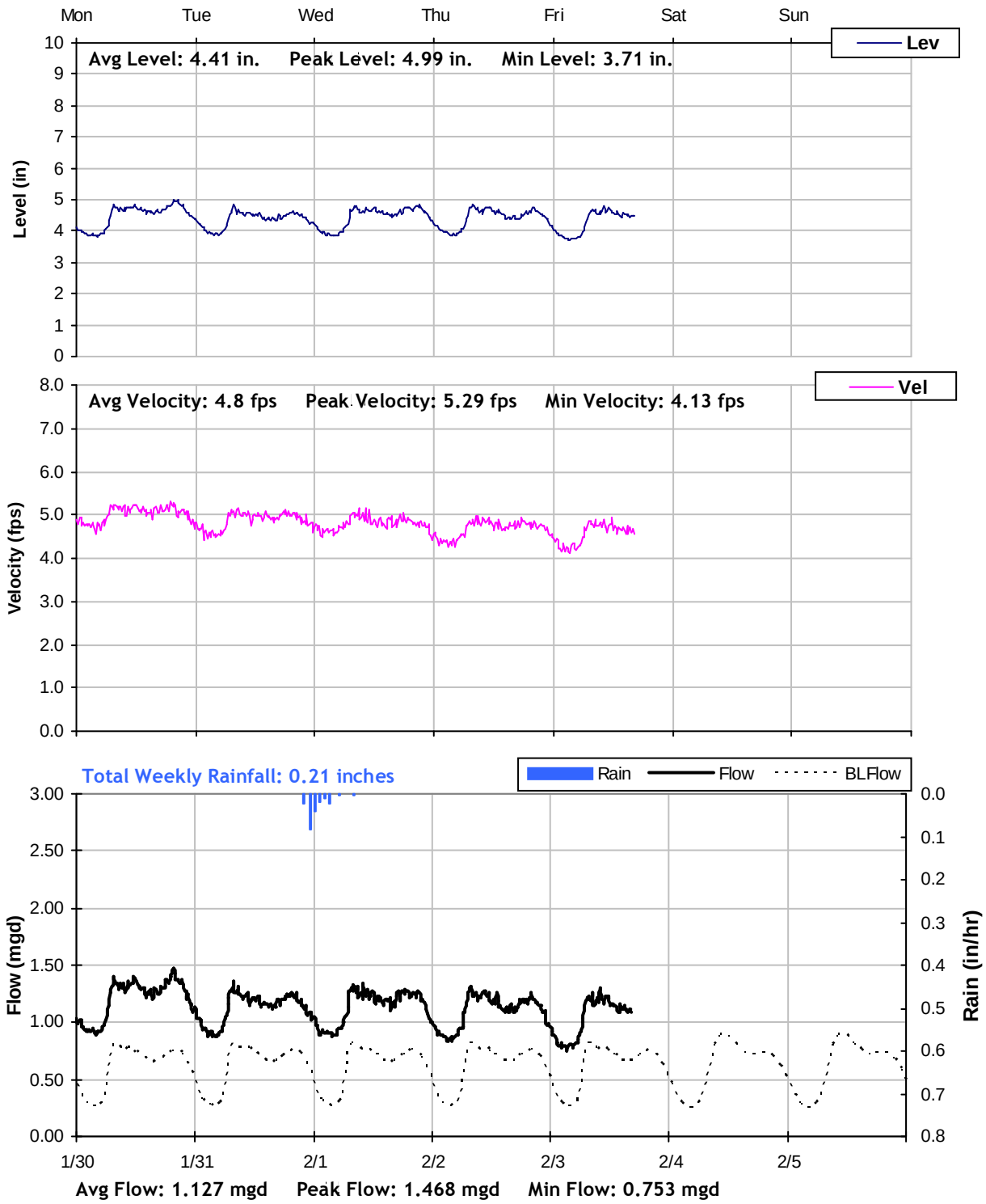
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

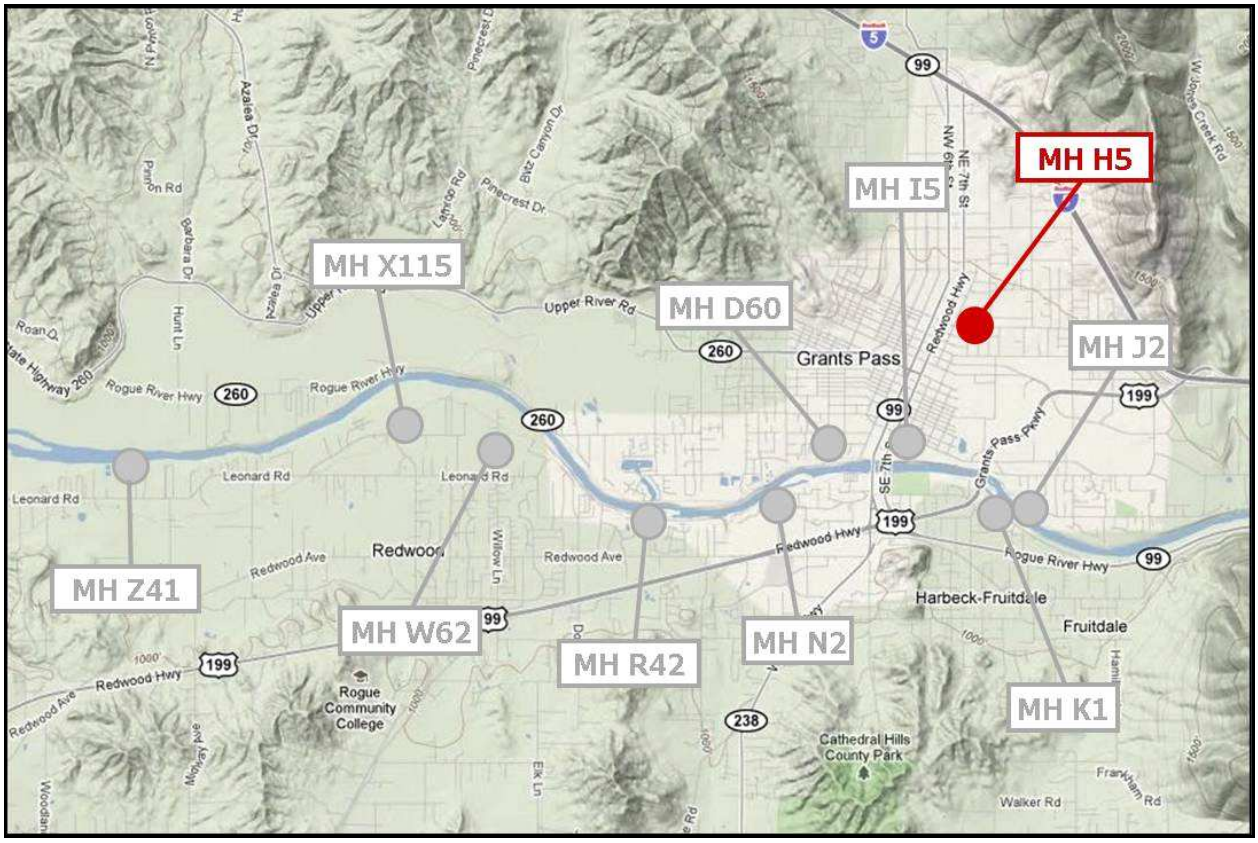
Year 2011/2012

Monitoring Site: H5

Location: 518 Northeast A Street, East of Northeast Dean Drive

Data Summary Report

Vicinity Map:

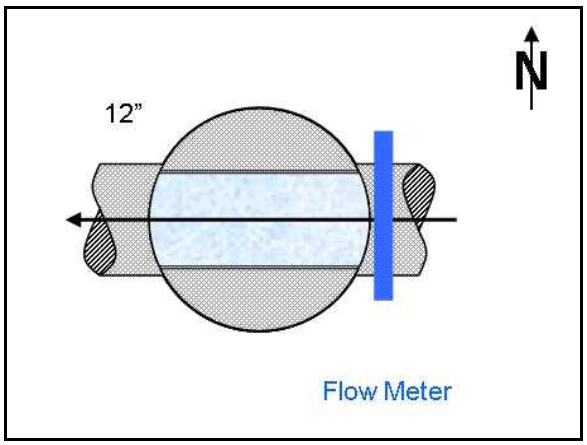


H5
Site Information Report

Location:	518 Northeast A Street, East of Northeast Dean Drive
Coordinates:	123.3196°W, 42.4427°N
Elevation:	961 feet
Diameter:	12 inches
Baseline Flow:	0.265 mgd
Peak Measured Flow:	1.296 mgd

Satellite Map

Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

H5
Additional Site Photos

Effluent Pipe

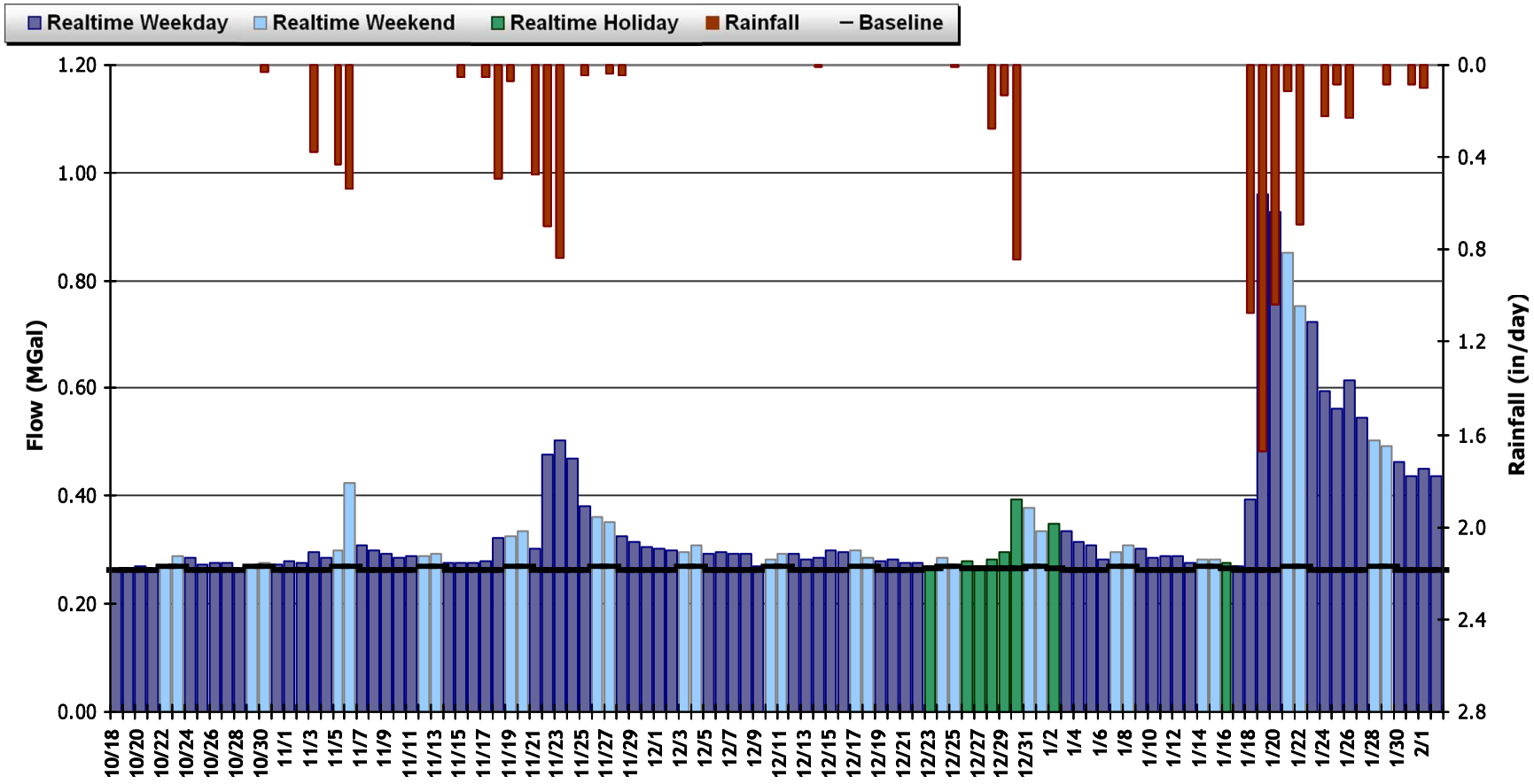
Main Influent Pipe

H5

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.347 MGal Peak Daily Flow: 0.959 MGal Min Daily Flow: 0.26 MGal

Total Period Rainfall: 10.85 inches

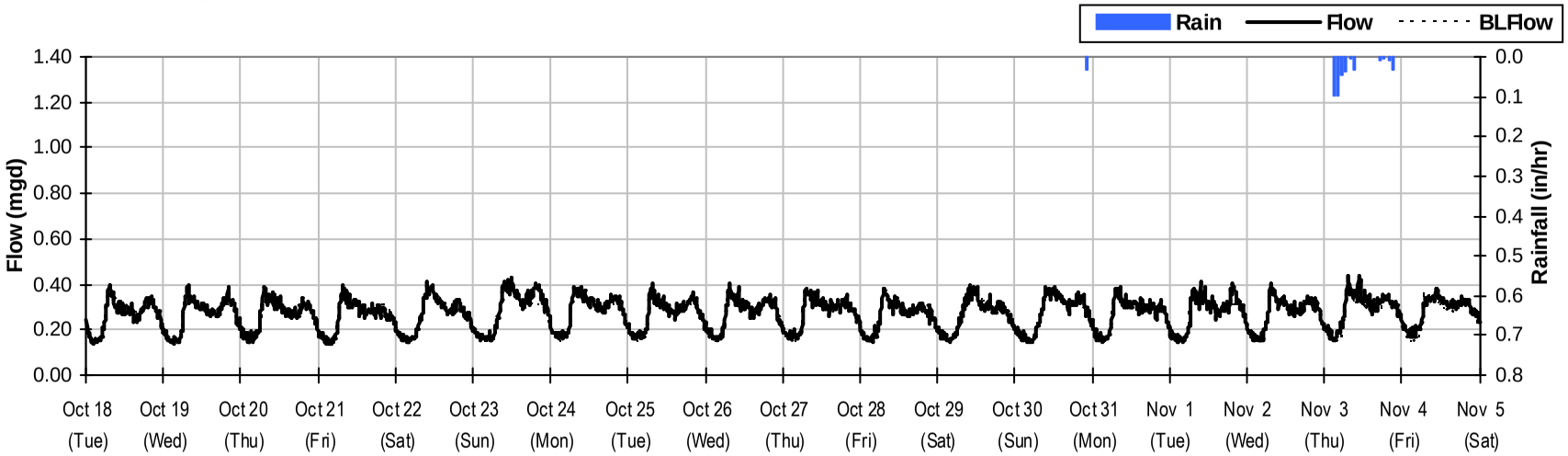


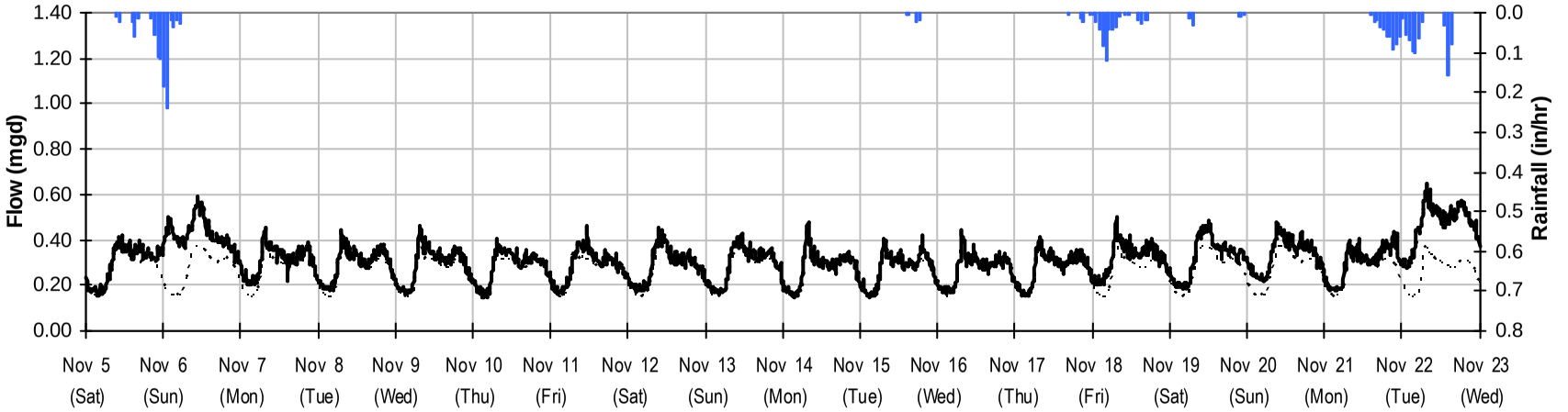
H5

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.294 mgd Peak Flow: 0.65 mgd Min Flow: 0.135 mgd

Total Period Rainfall: 3.22 inches



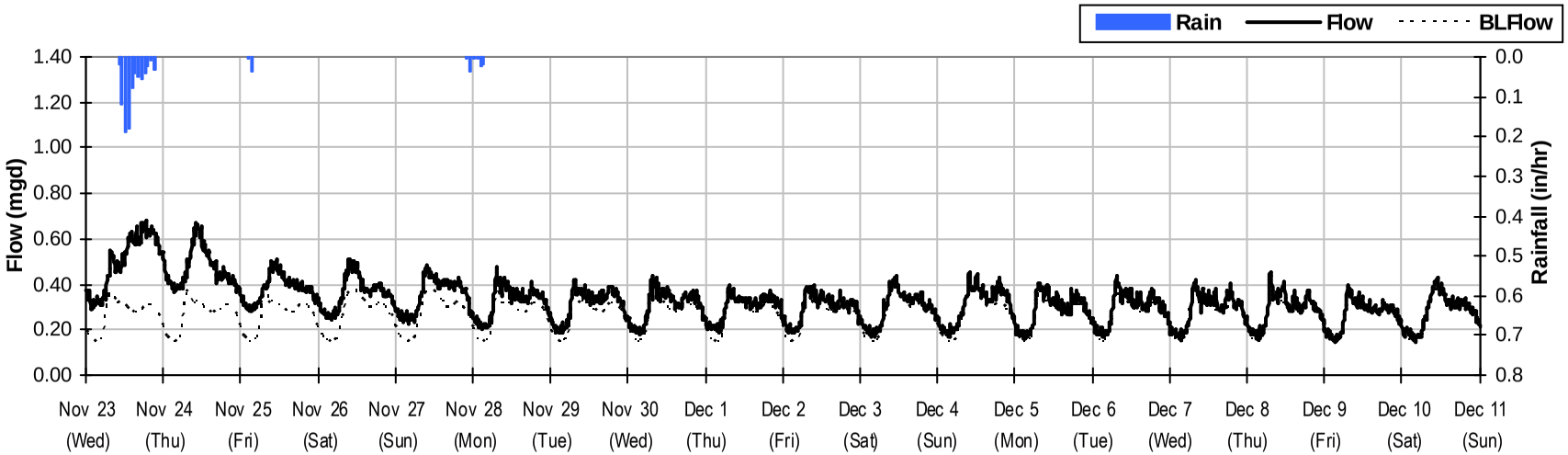


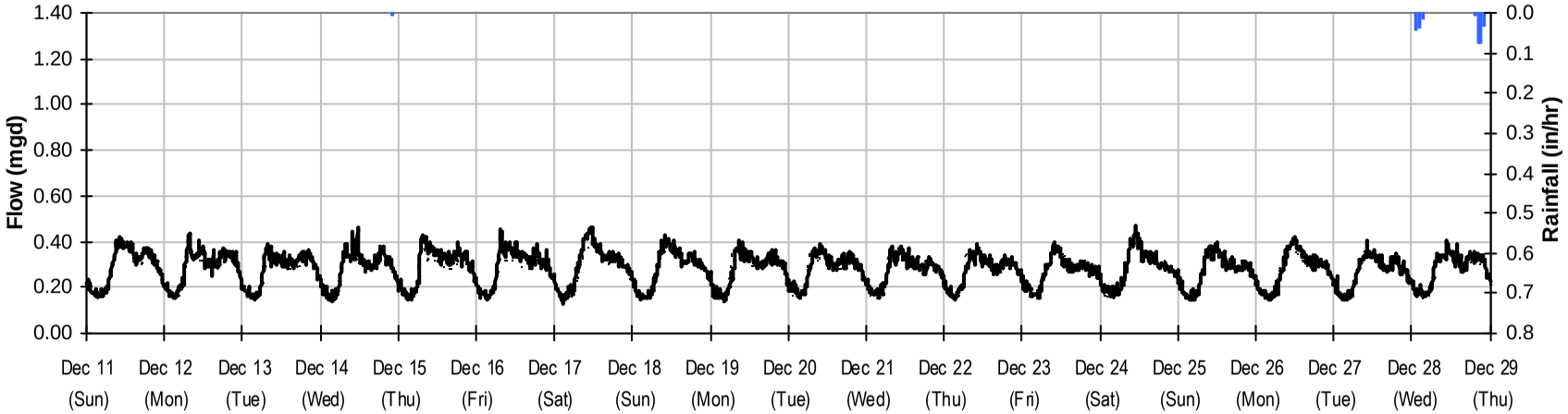
H5

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.307 mgd Peak Flow: 0.678 mgd Min Flow: 0.129 mgd

Total Period Rainfall: 1.26 inches



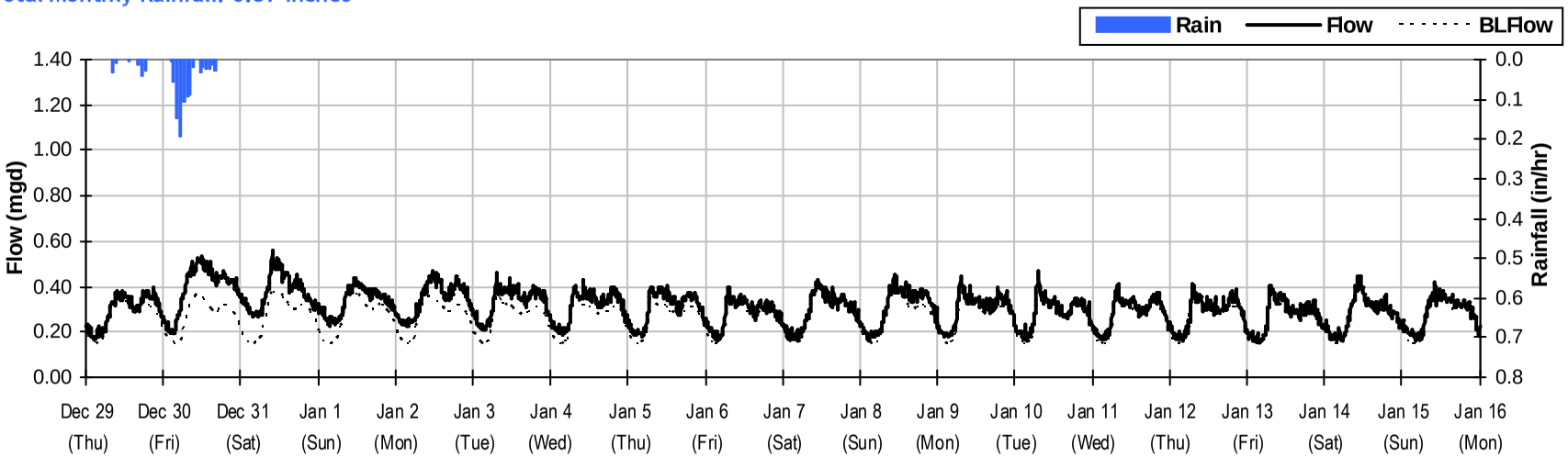


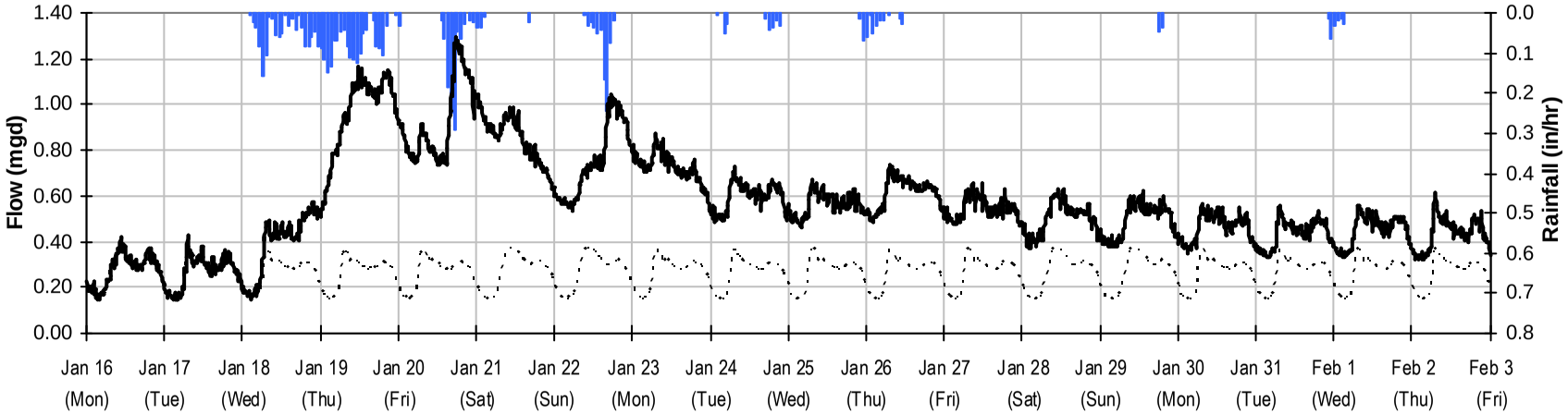
H5

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.44 mgd Peak Flow: 1.3 mgd Min Flow: 0.14 mgd

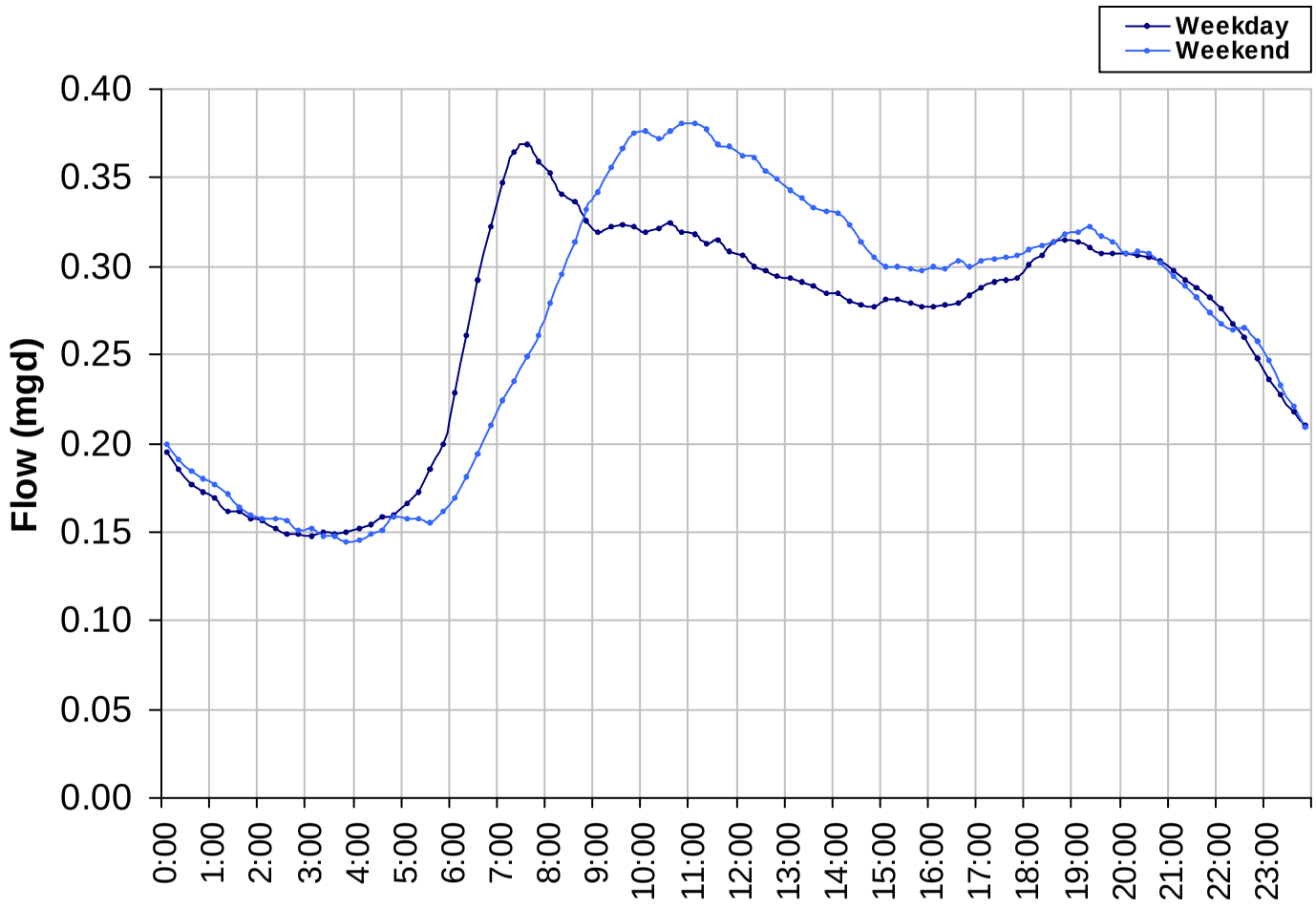
Total Monthly Rainfall: 6.37 inches





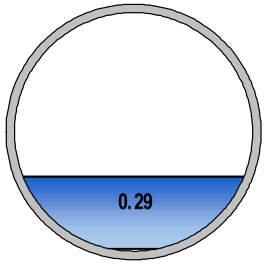
H5

Baseline Flow Hydrographs



Baseline Flow:

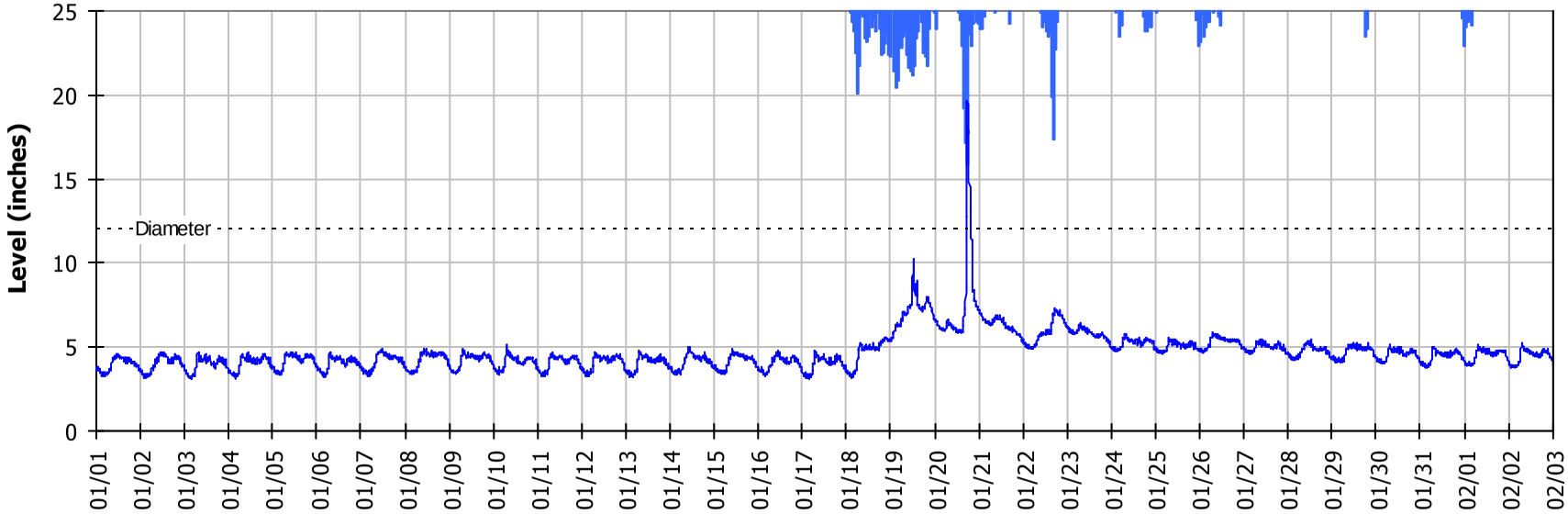
0.265 *mgd*

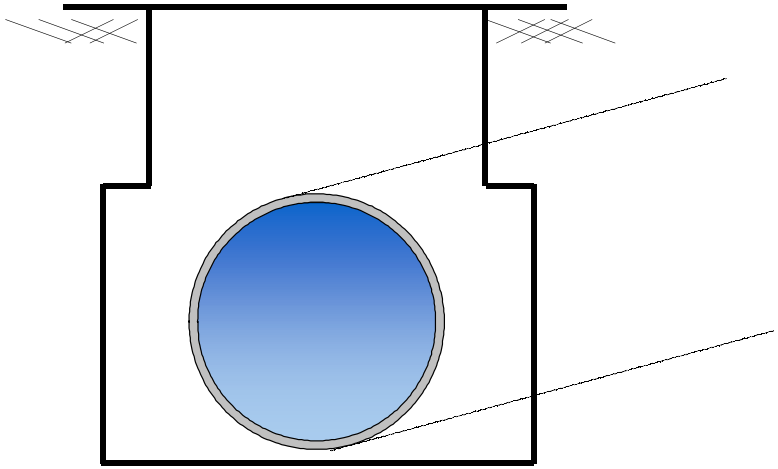


H5

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period



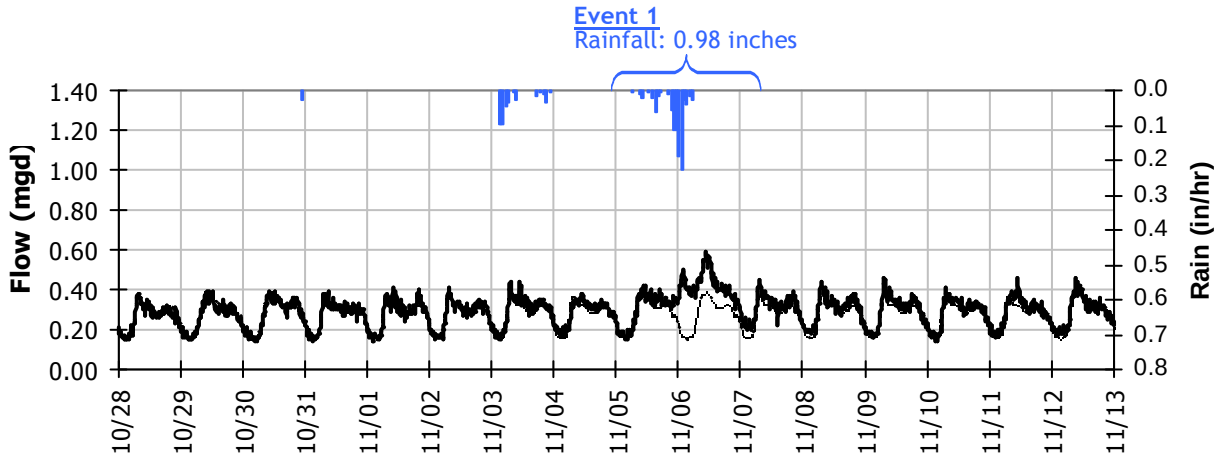


Pipe Diameter:	12	*inches*
Peak Measured Level	19.6	*inches*
Peak d/D Ratio:	1.64	

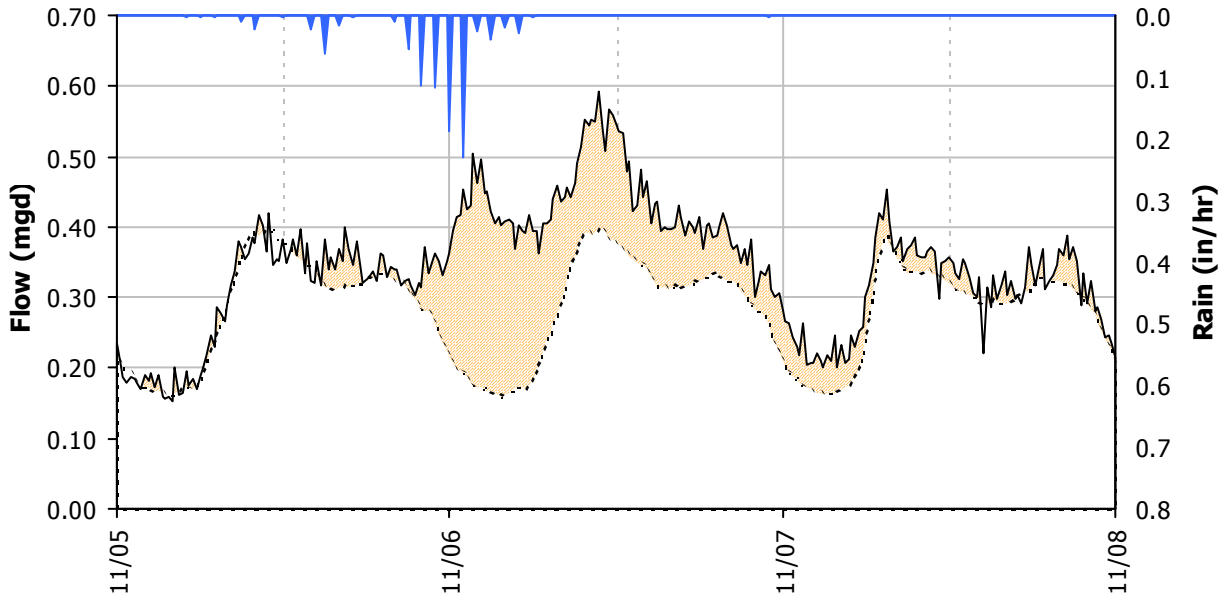
Surcharged 7.6 inches over crown

SITE H5
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

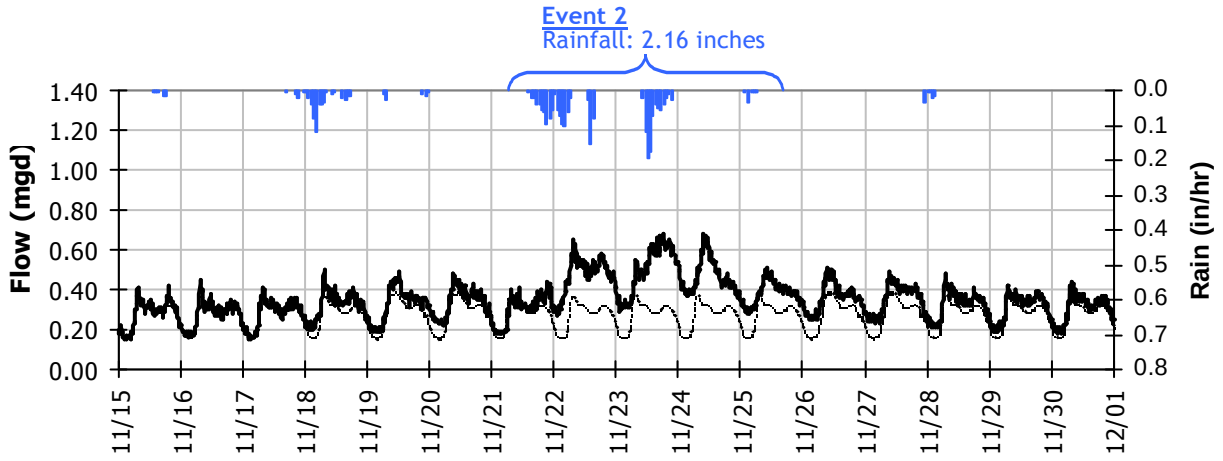


Storm Event I/I Analysis (Rain = 0.98 inches)

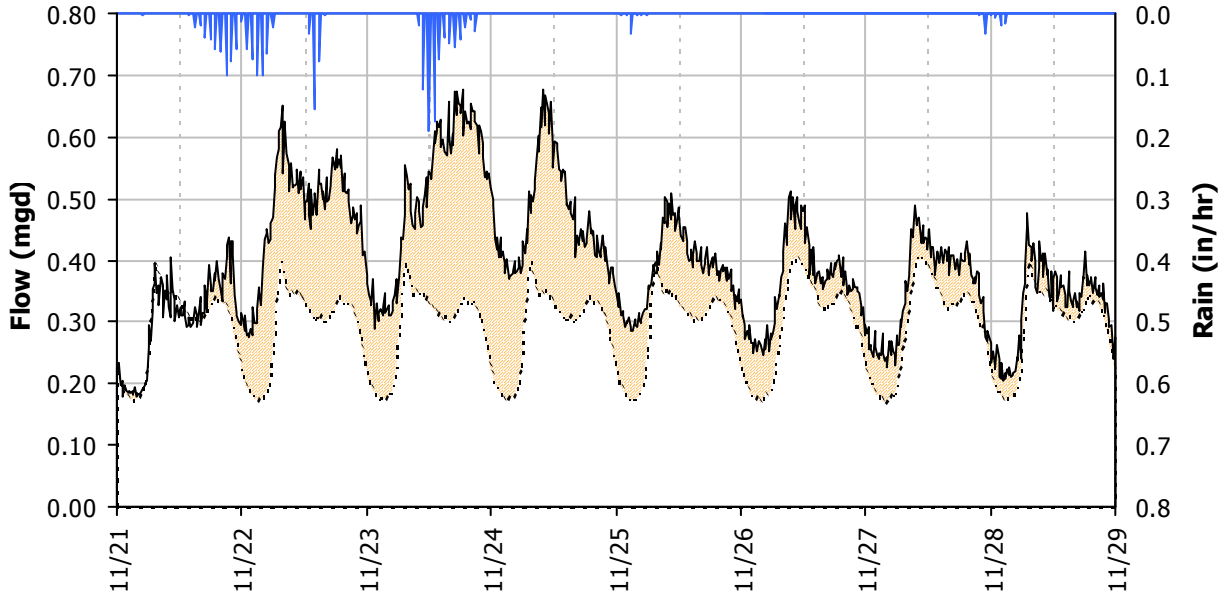
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.59 *mgd*	Peak I/I Rate:	0.35 *mgd*	Infiltration Rate: (11/7/2011)	0.045 *mgd*	Total I/I:	186,000 *gallons*
PF:	2.23	PkI/I:IDM:	5,049 *gpd/IDM*	RDI:IDM:	658 *gpd/IDM*	Total I/I:IDM:	2,788 *gal/IDM/in*
Peak Level:	5.23 *in*	PkI/I:Acre:	599 *gpd/acre*	RDI:Acre:	78 *gpd/acre*	R-Value:	1.2%
d/D Ratio:	0.44	Pk I/I:ADWF:	1.30	RDI (% of BL):	17%	Total I/I:ADWF:	0.72 *per in-rain*

SITE H5
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

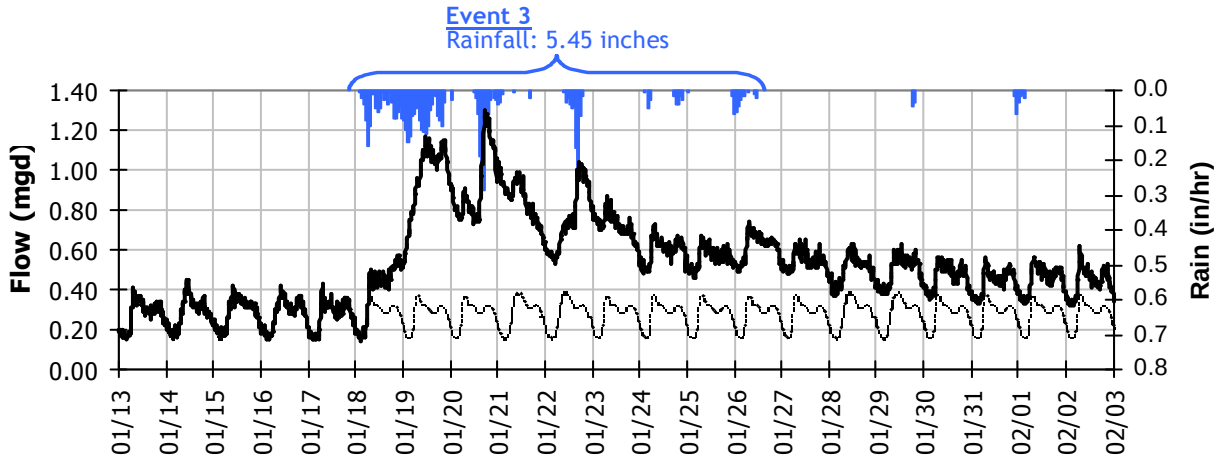


Storm Event I/I Analysis (Rain = 2.16 inches)

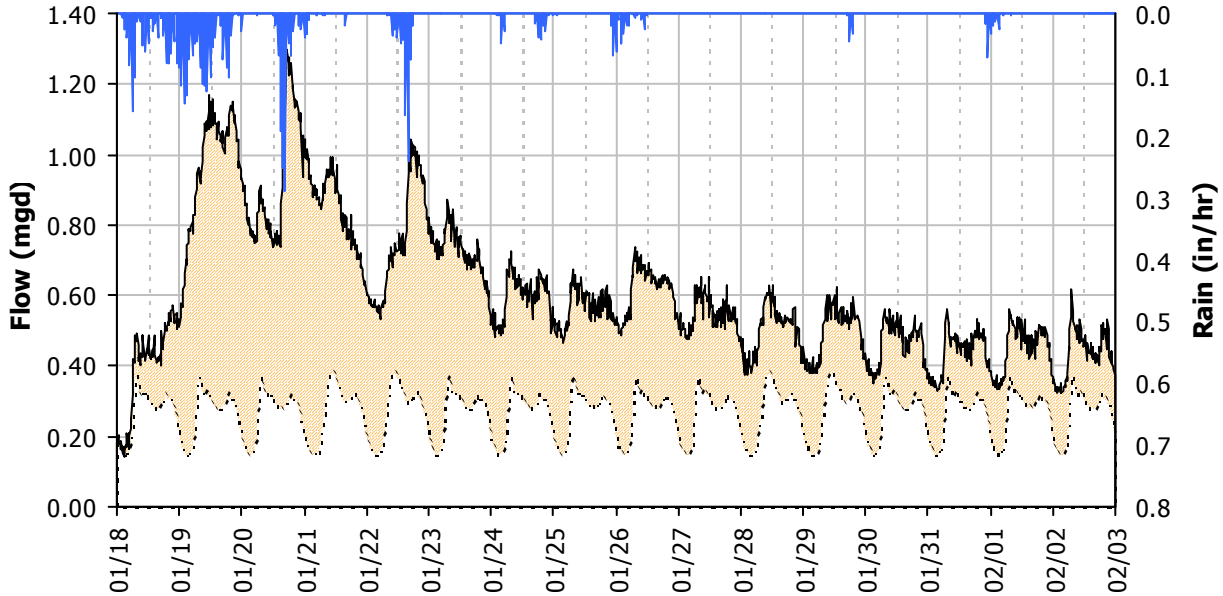
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.68	*mgd*	Peak I/I Rate:	0.39	*mgd*	Infiltration Rate: (11/26/2011)	0.093	*mgd*	Total I/I:	853,000	*gallons*
PF:	2.56		PkI/I:IDM:	5,644	*gpd/IDM*	RDI:IDM:	1,356	*gpd/IDM*	Total I/I:IDM:	5,793	*gal/IDM/in*
Peak Level:	5.57	*in*	PkI/I:Acre:	670	*gpd/acre*	RDI:Acre:	161	*gpd/acre*	R-Value:	2.5%	
d/D Ratio:	0.46		Pk I/I:ADWF:	1.45		RDI (% of BL):	35%		Total I/I:ADWF:	1.49	*per in-rain*

SITE H5
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

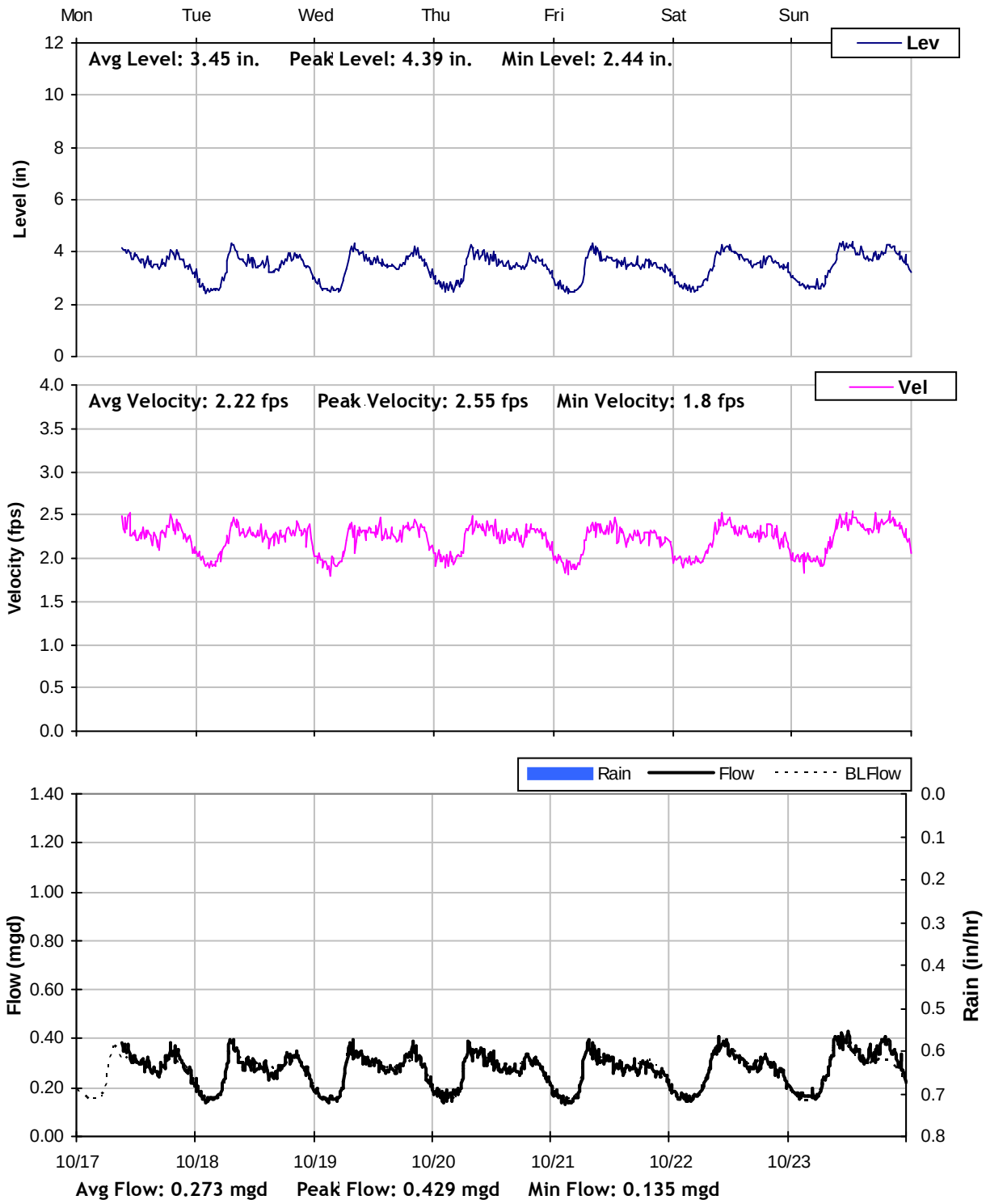


Storm Event I/I Analysis (Rain = 5.45 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	1.30	*mgd*	Peak I/I Rate:	1.00	*mgd*	Infiltration Rate: (1/30/2012)	0.200	*mgd*	Total I/I:	5,478,000	*gallons*
PF:	4.89		PkI/I:IDM:	14,676	*gpd/IDM*	RDI:IDM:	2,923	*gpd/IDM*	Total I/I:IDM:	14,700	*gal/IDM/in*
Peak Level:	19.63	*in*	PkI/I:Acre:	1,742	*gpd/acre*	RDI:Acre:	347	*gpd/acre*	R-Value:	6.4%	
d/D Ratio:	1.64		Pk I/I:ADWF:	3.78		RDI (% of BL):	76%		Total I/I:ADWF:	3.79	*per in-rain*

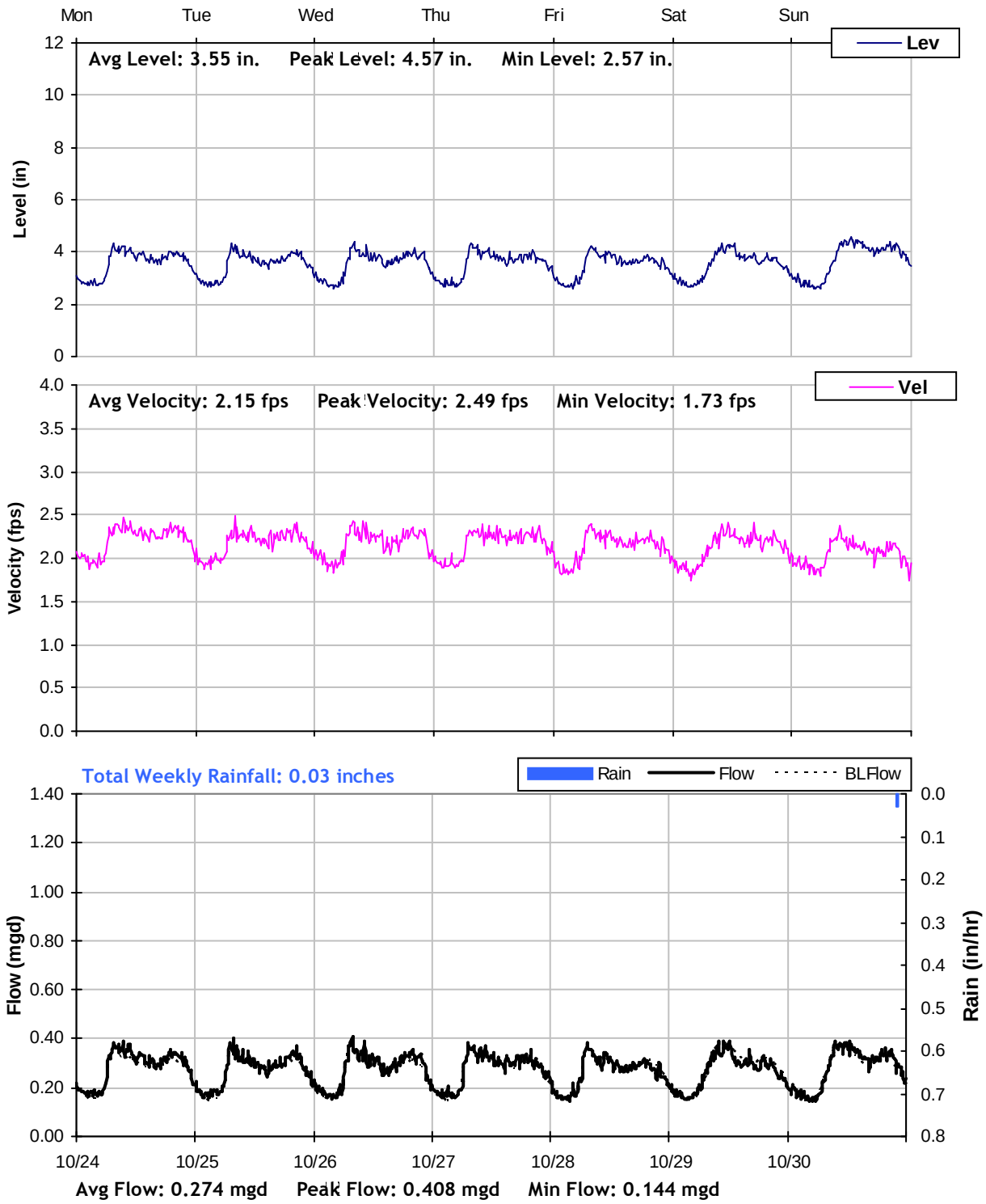
H5

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



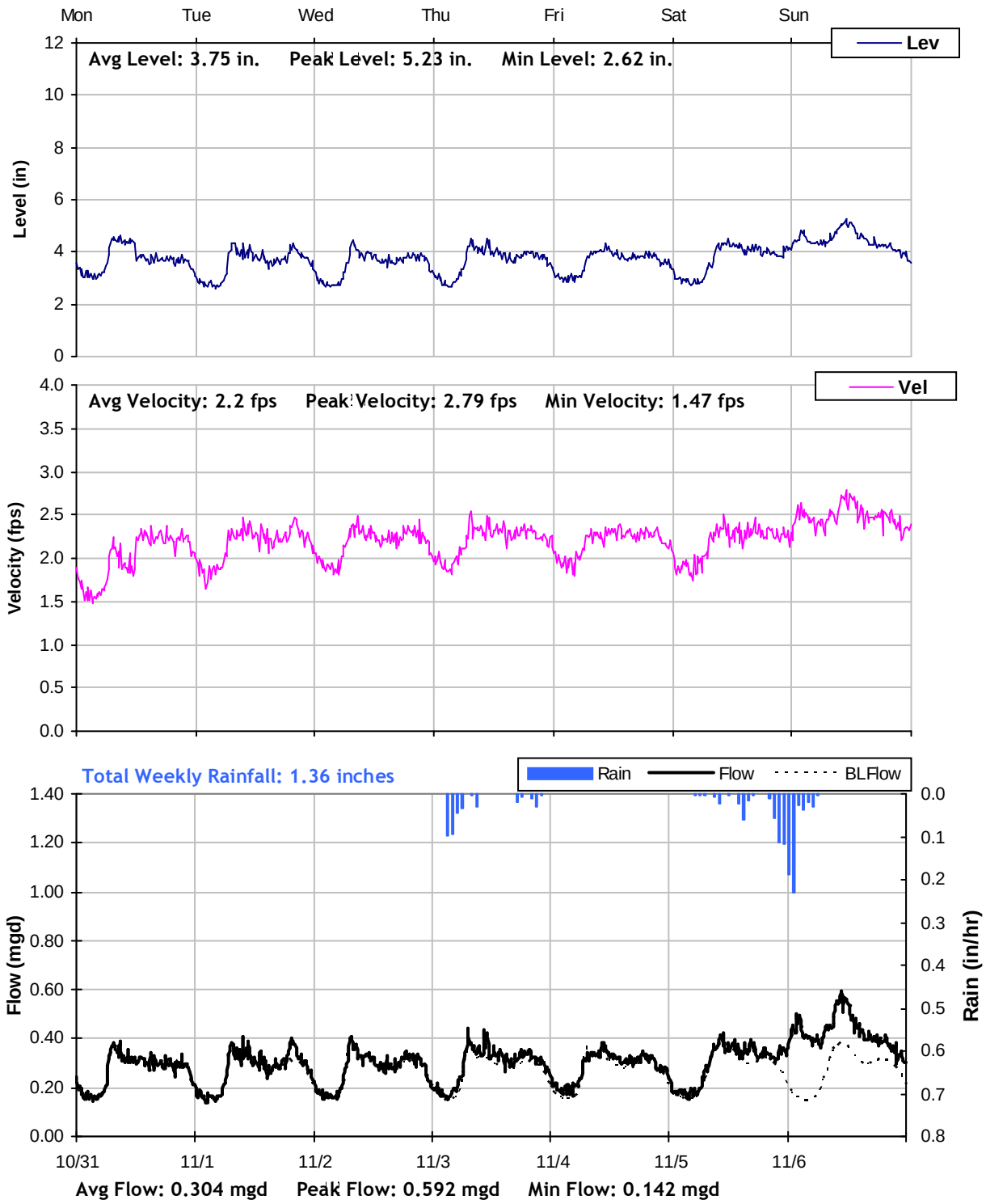
H5

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



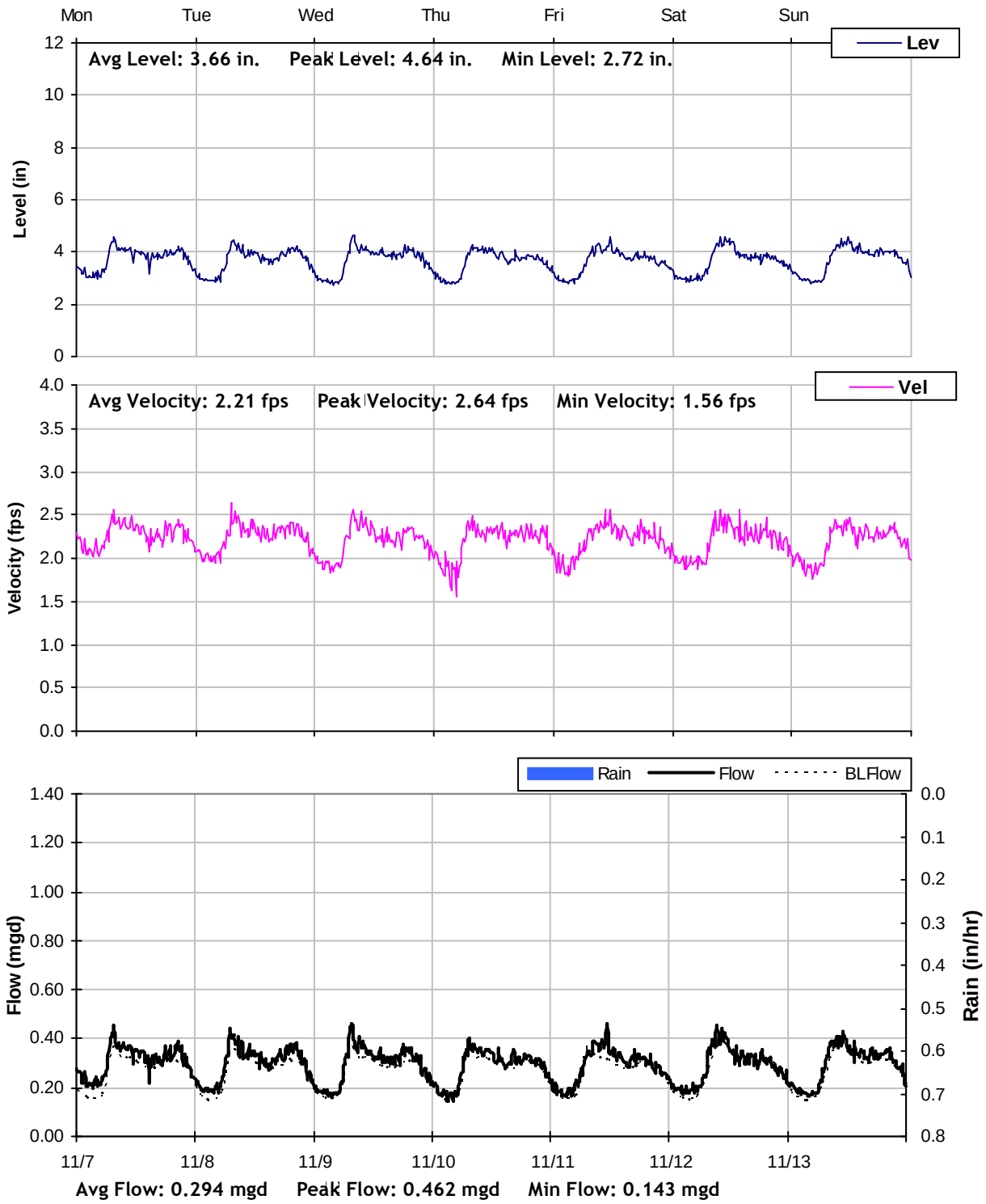
H5

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



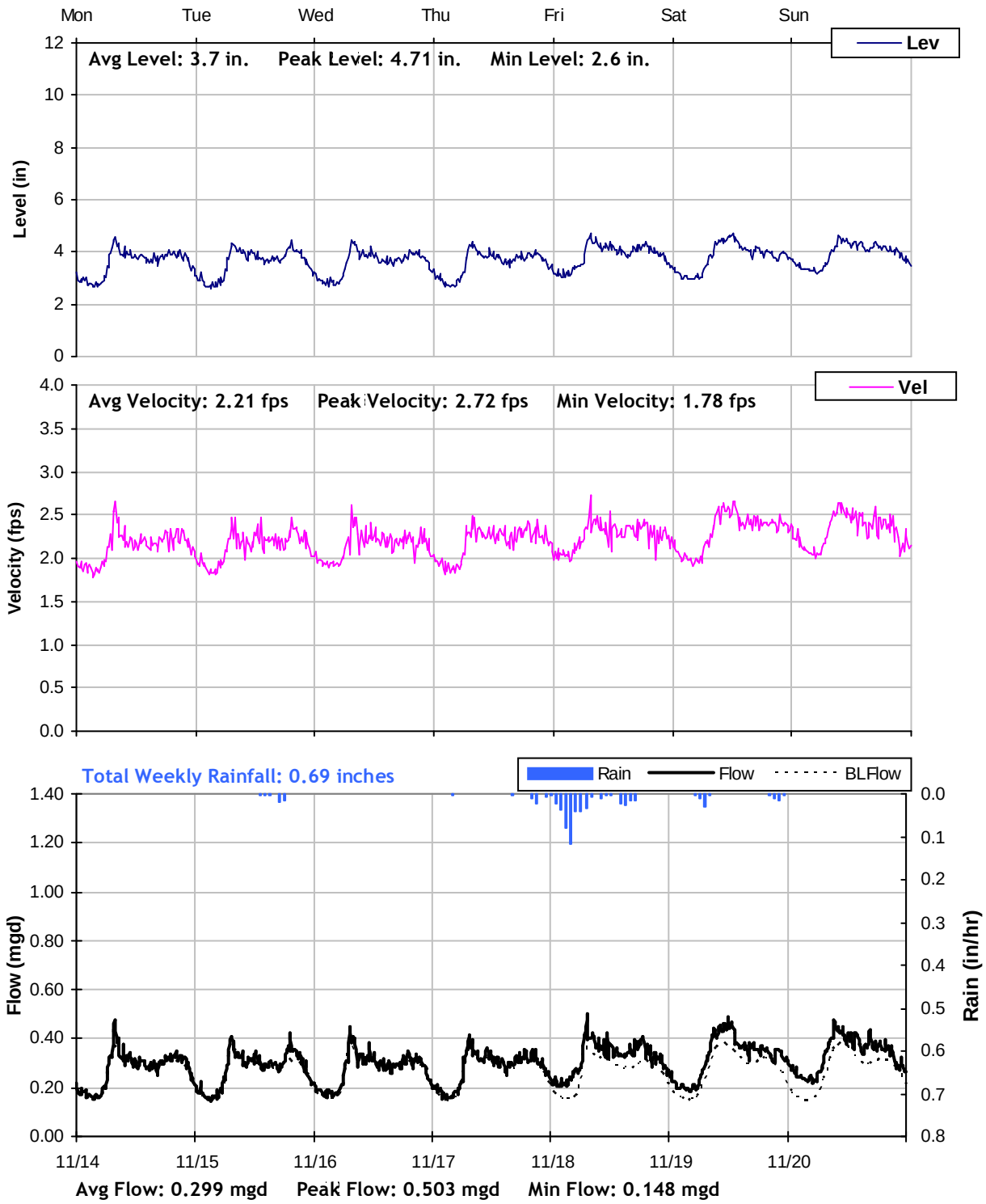
H5

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



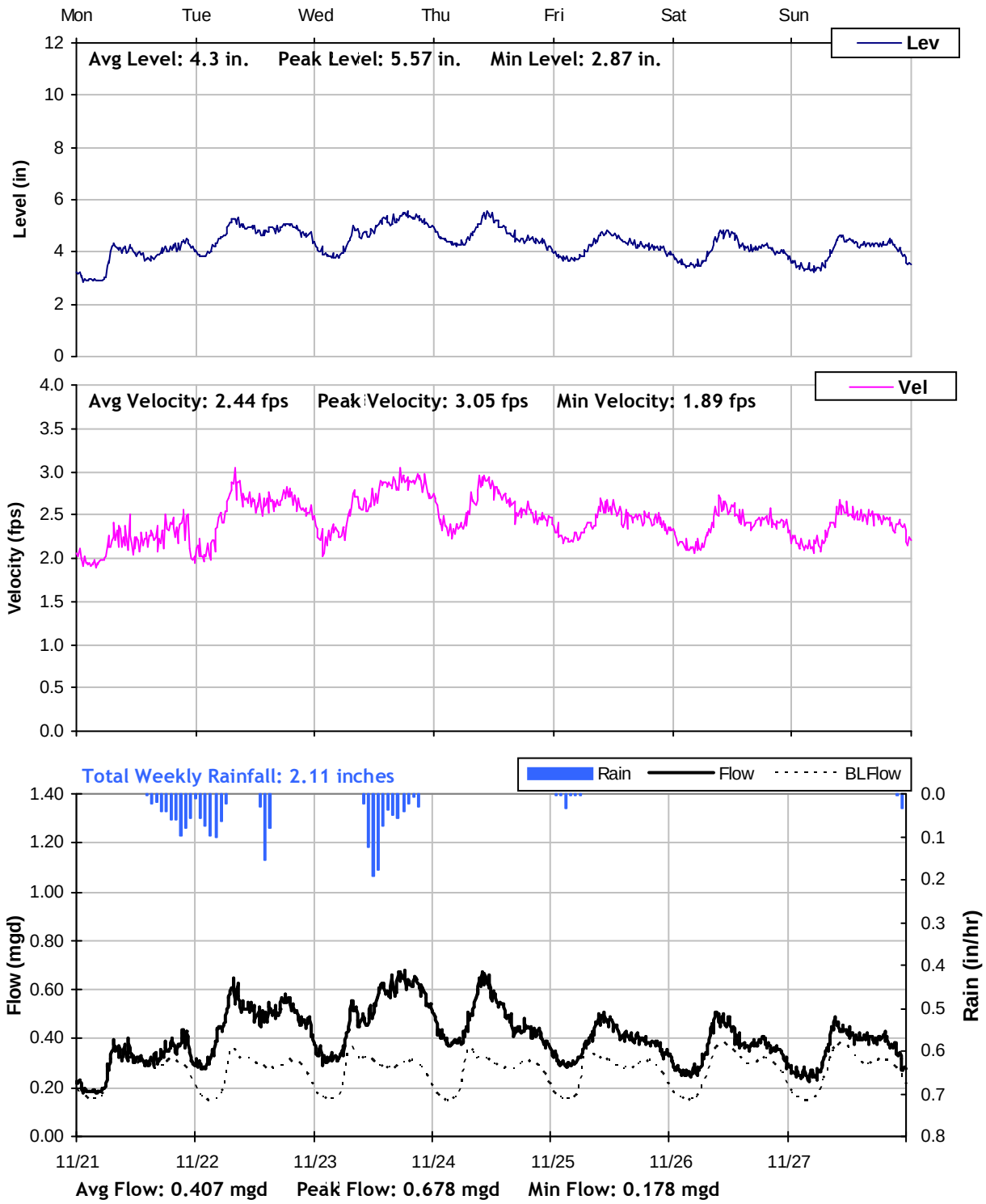
H5

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



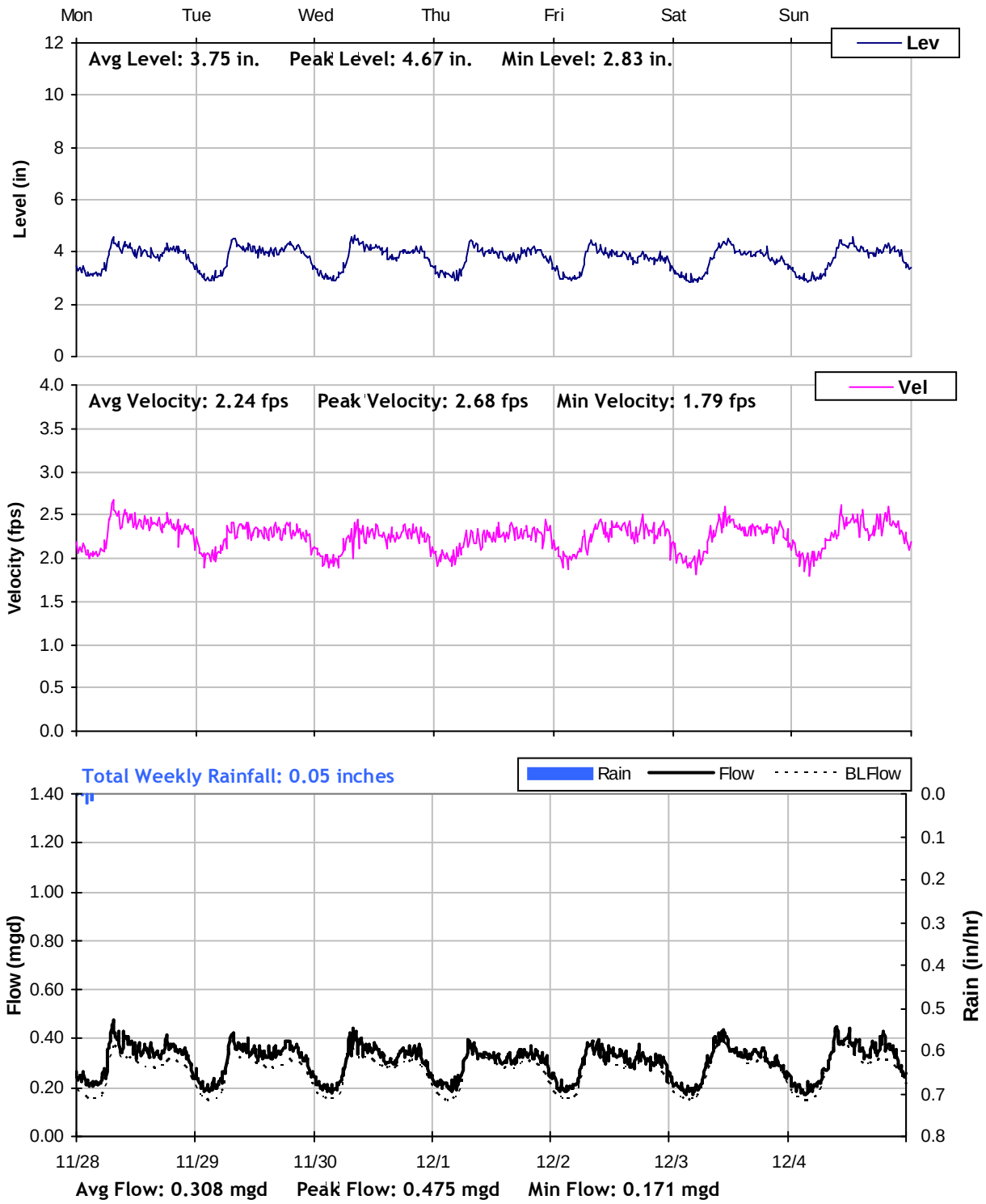
H5

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



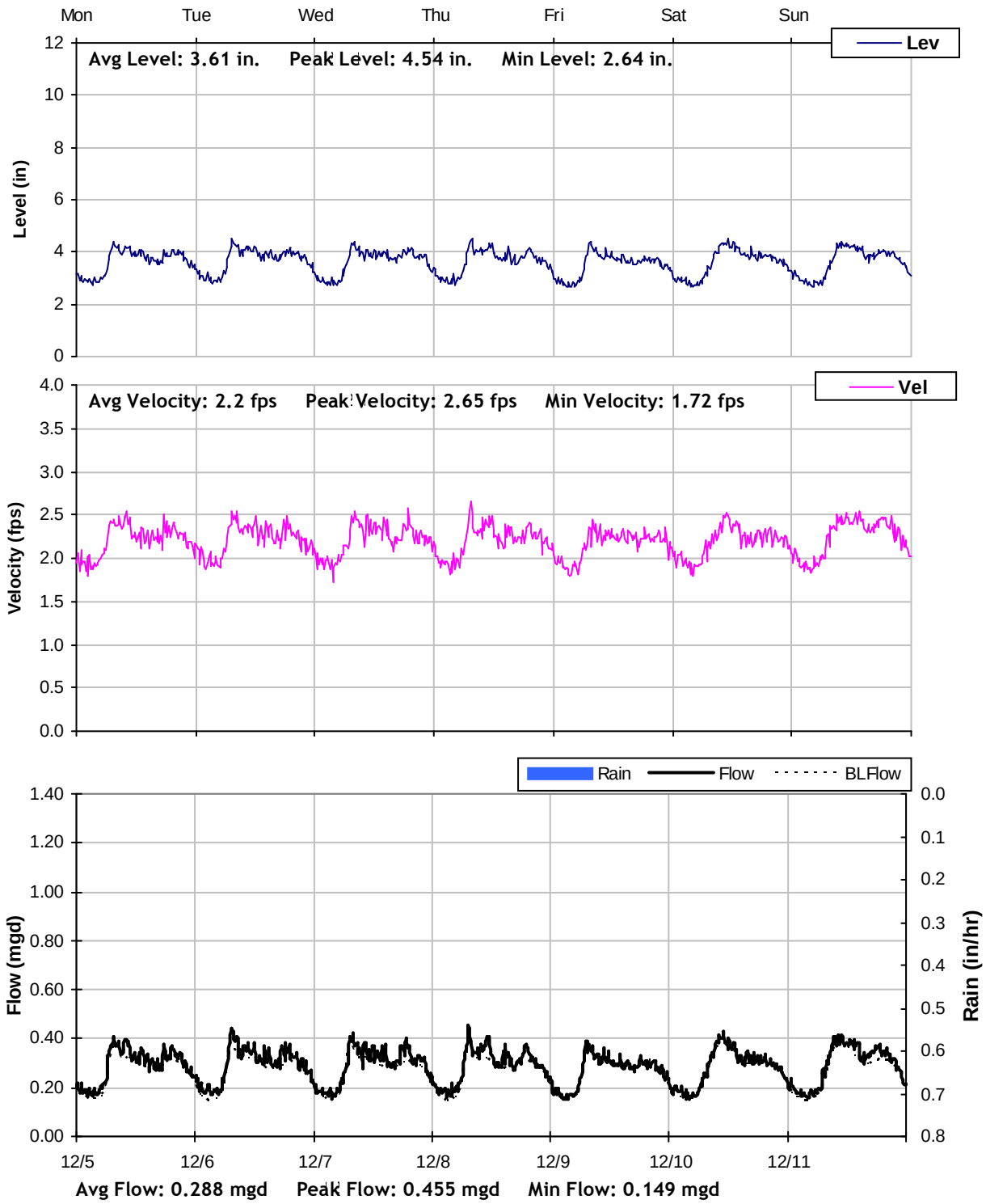
H5

Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



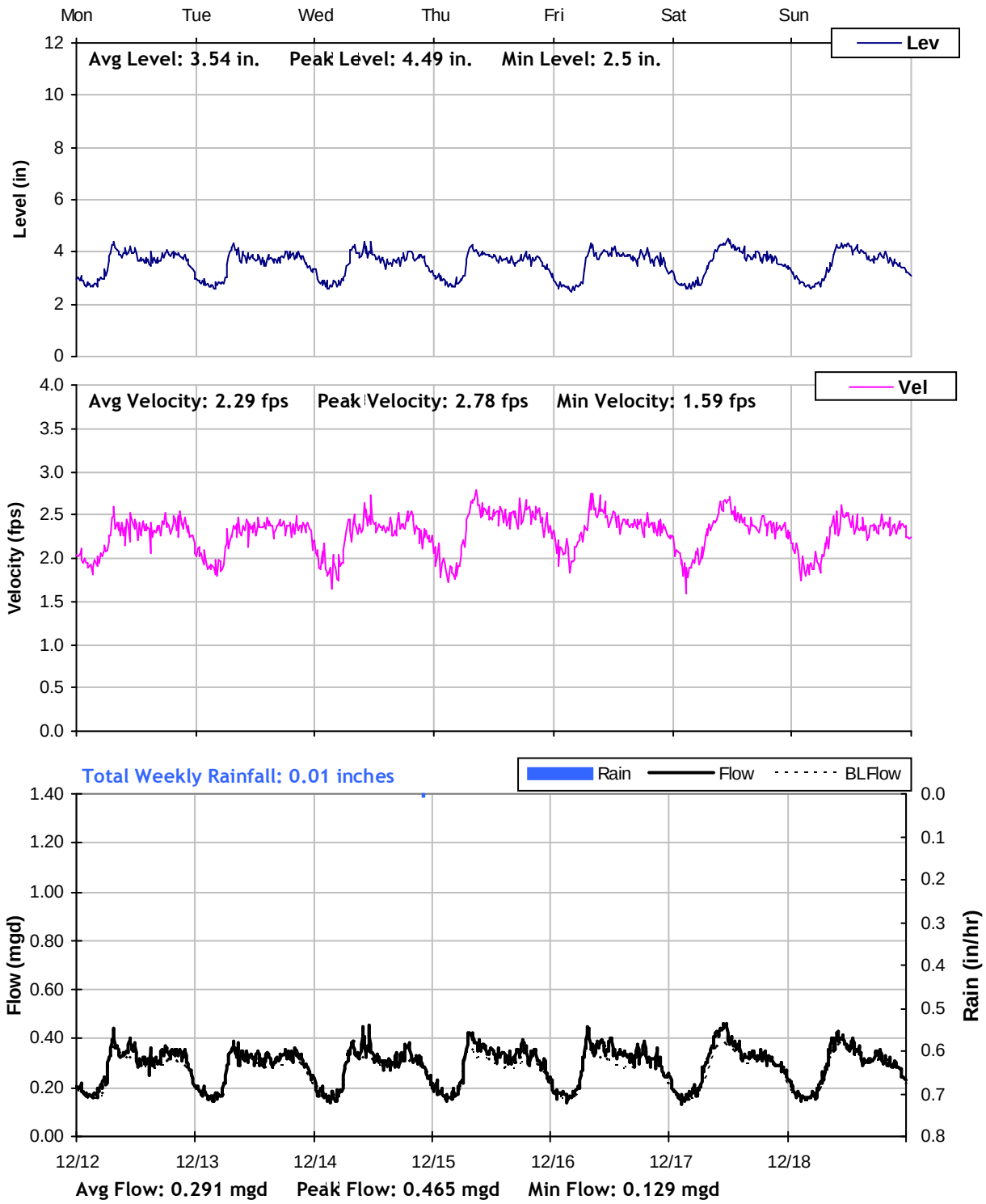
H5

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



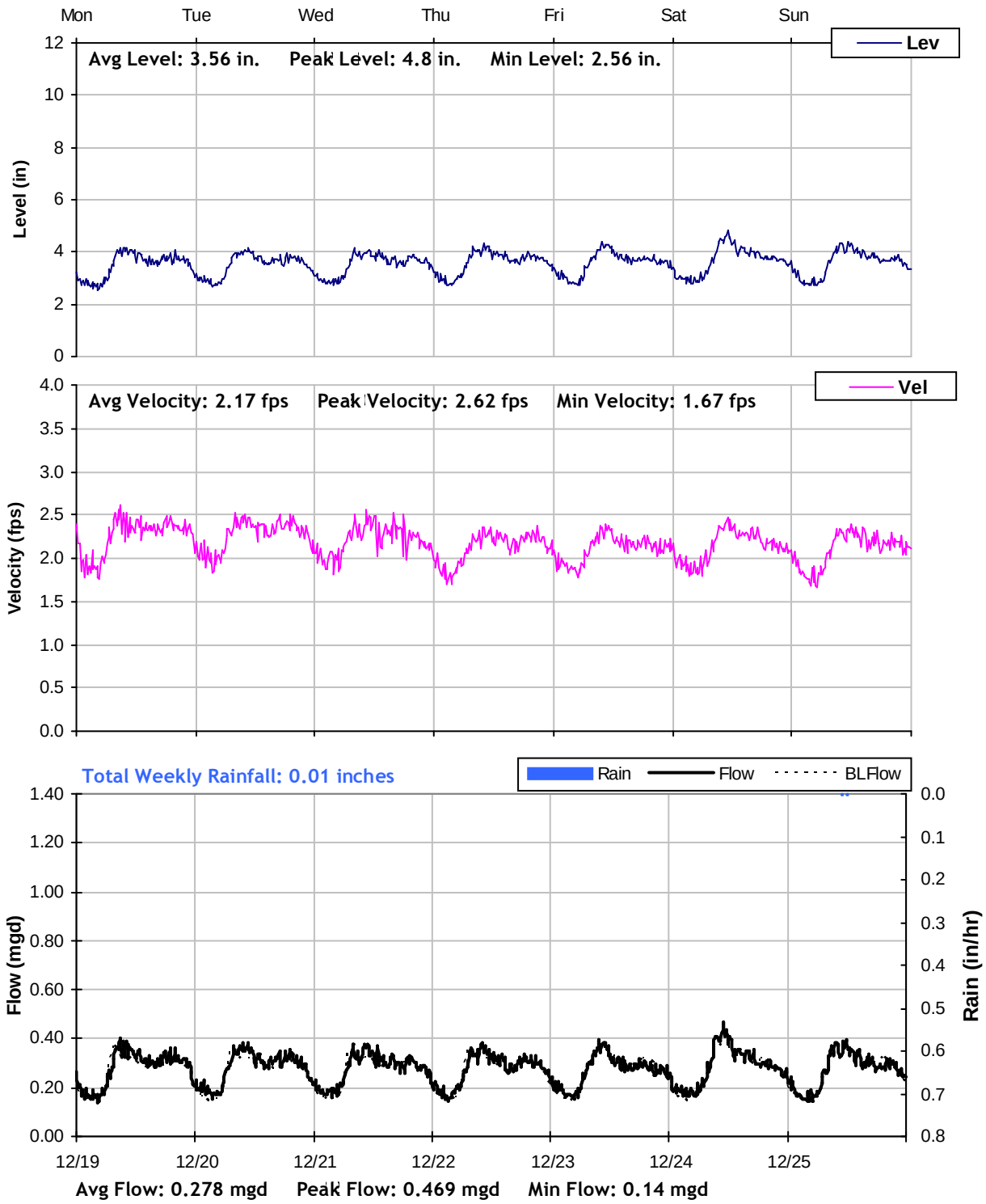
H5

Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



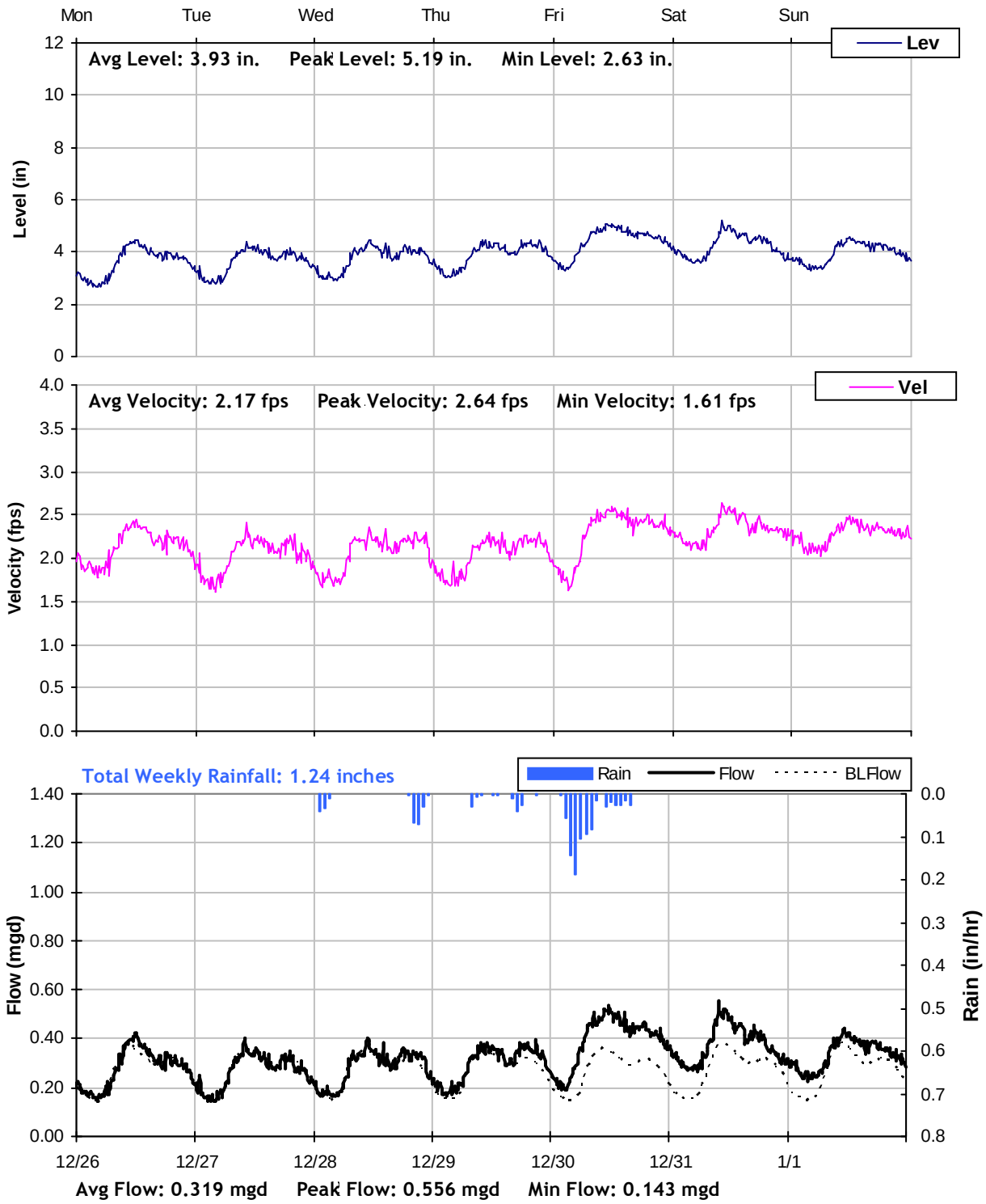
H5

Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



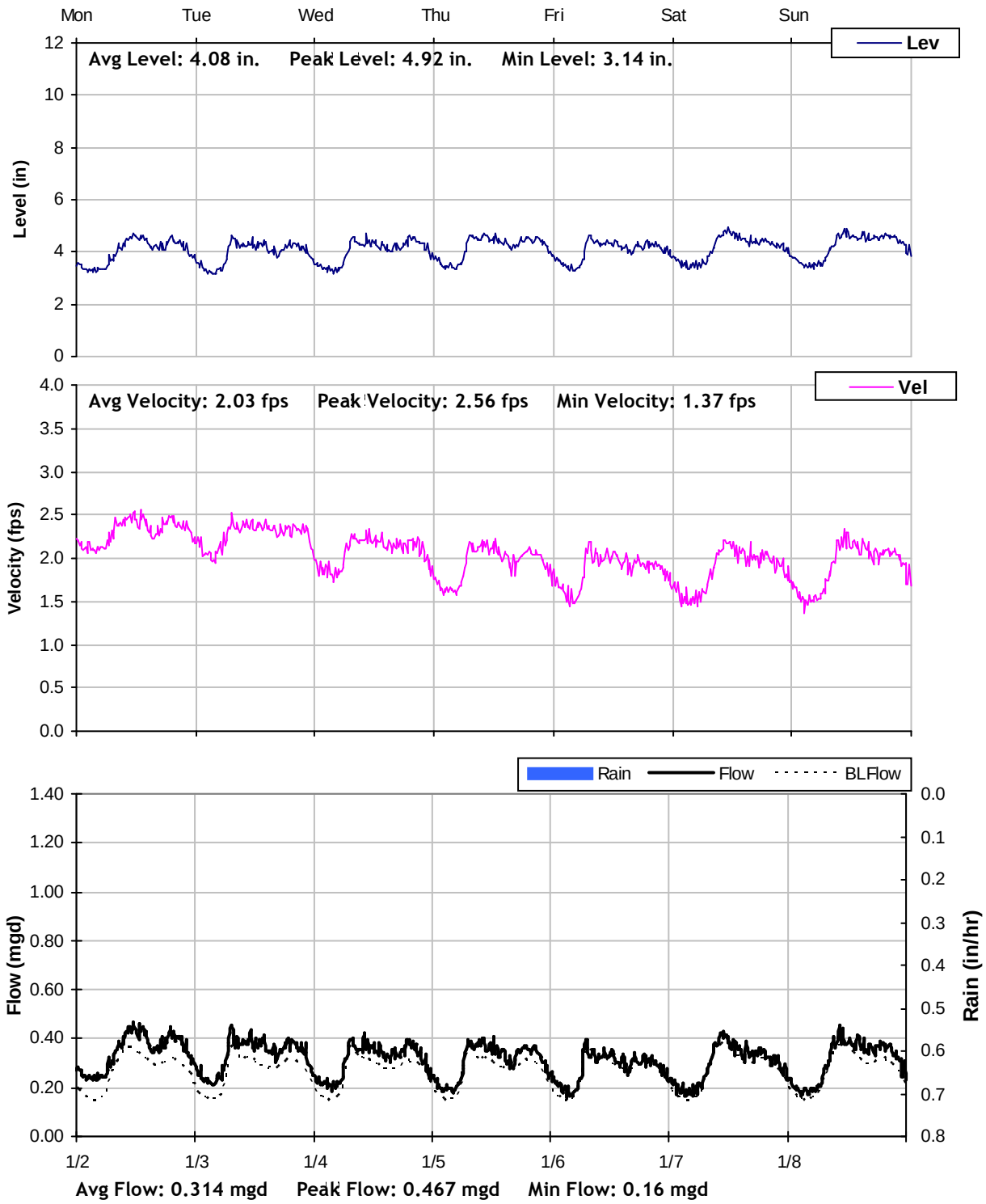
H5

Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



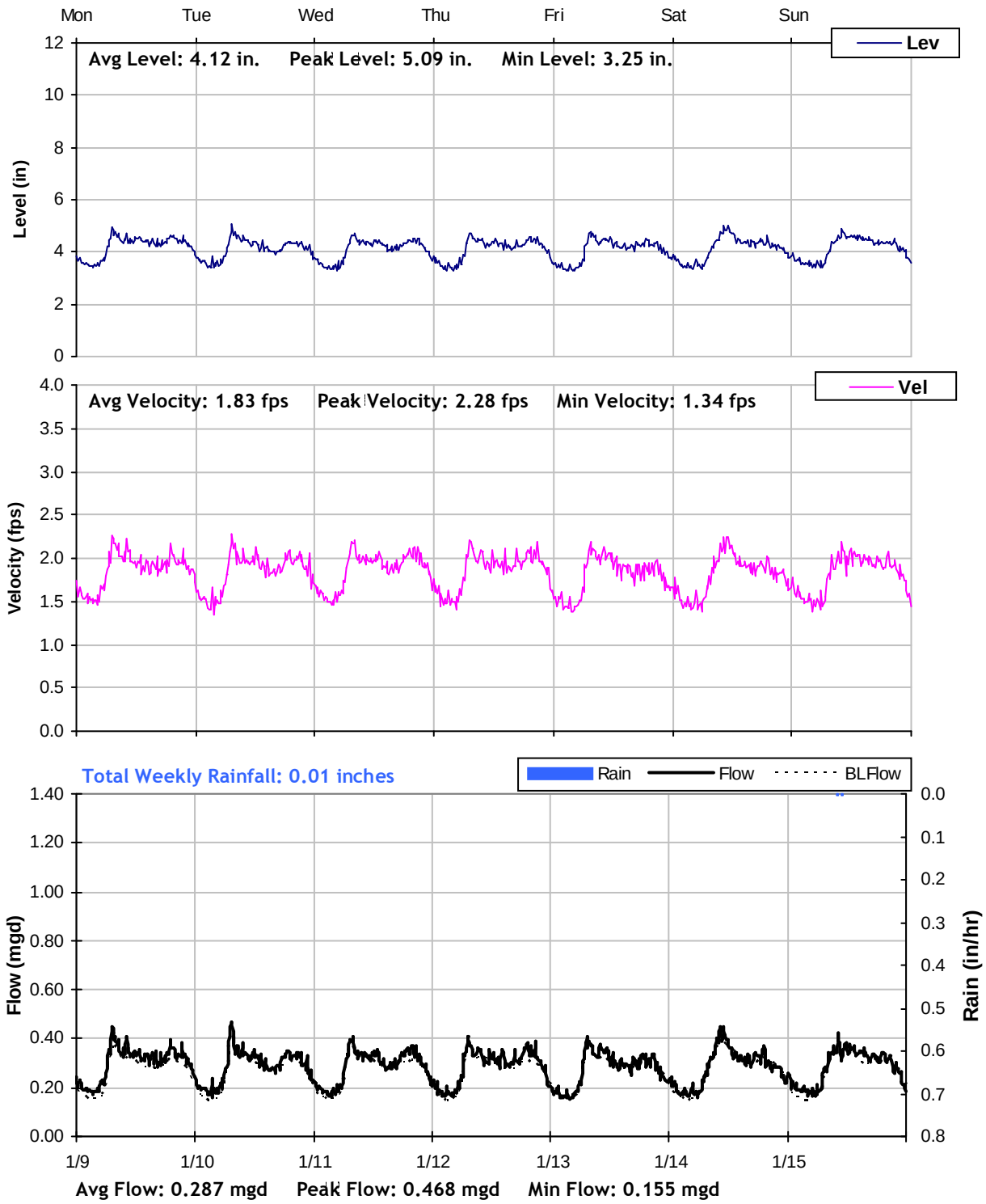
H5

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



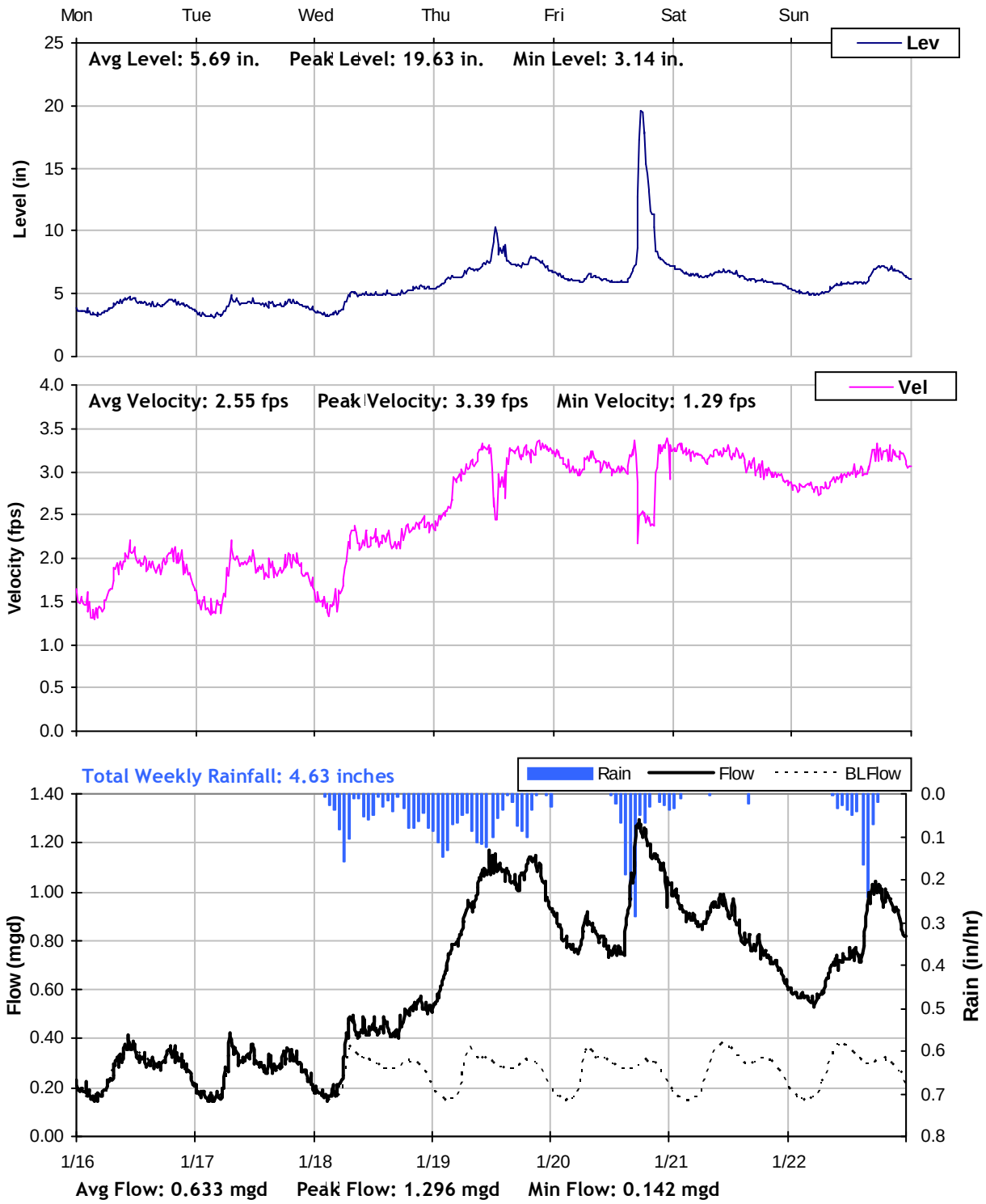
H5

Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



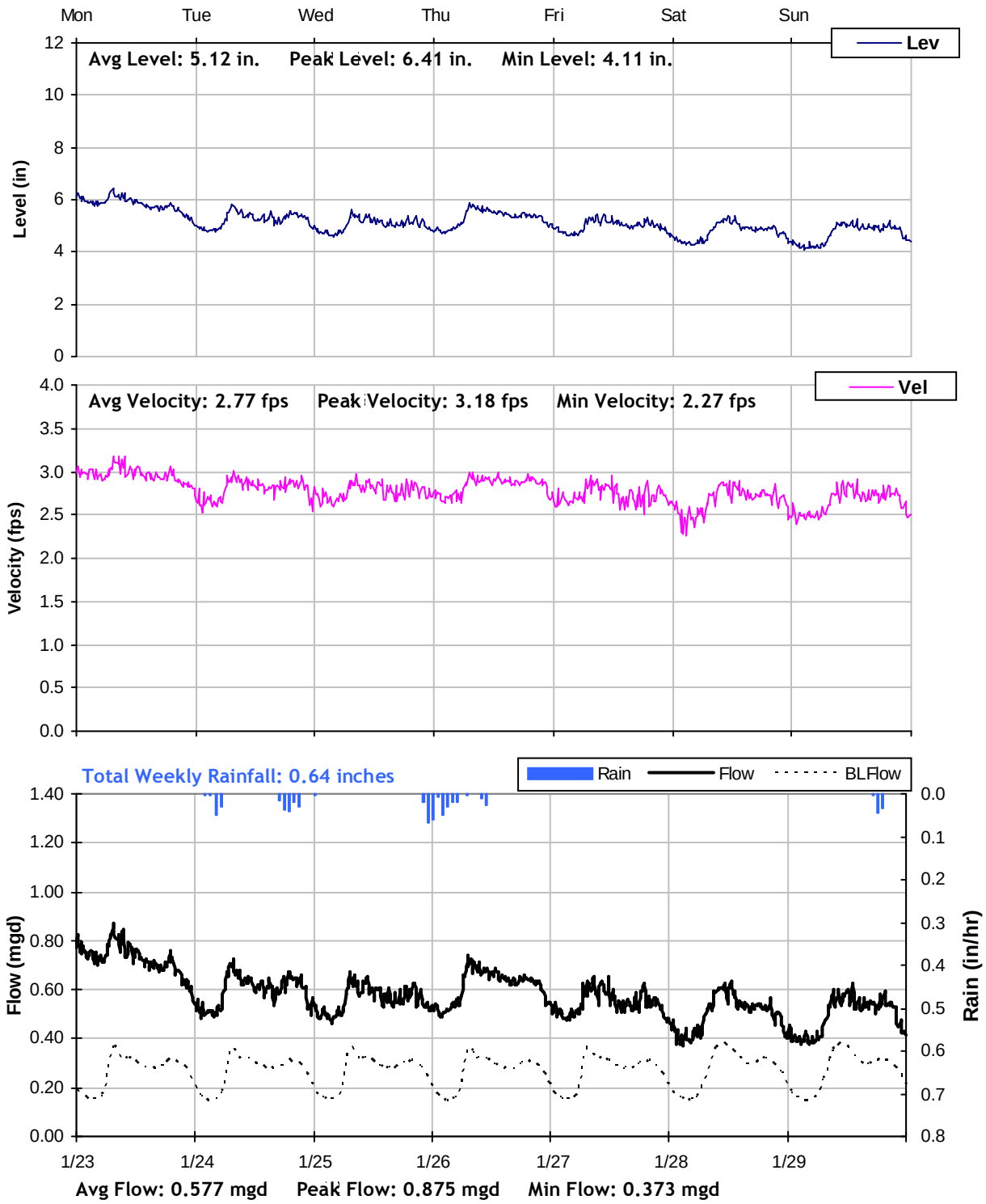
H5

Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



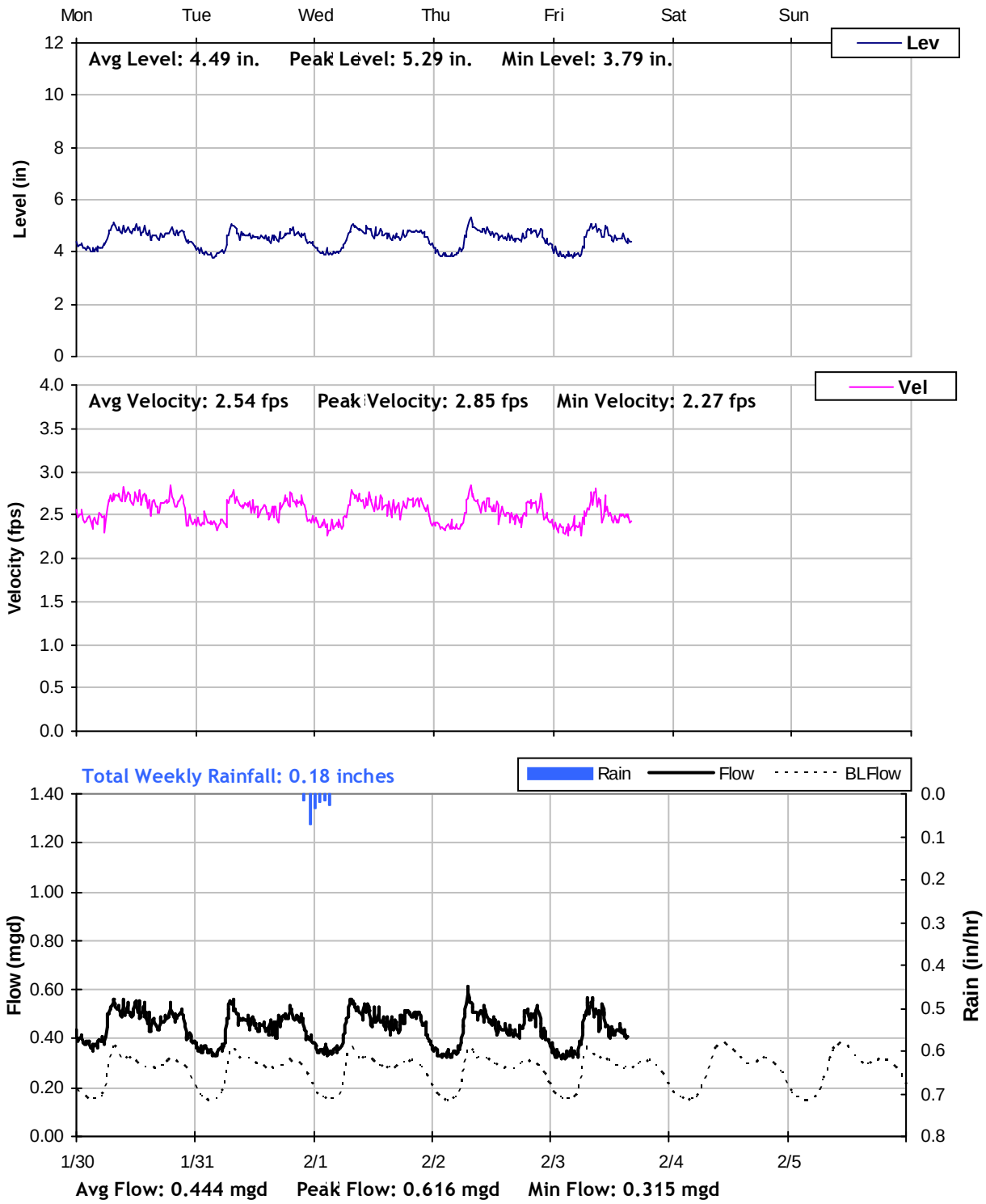
H5

Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



H5

Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

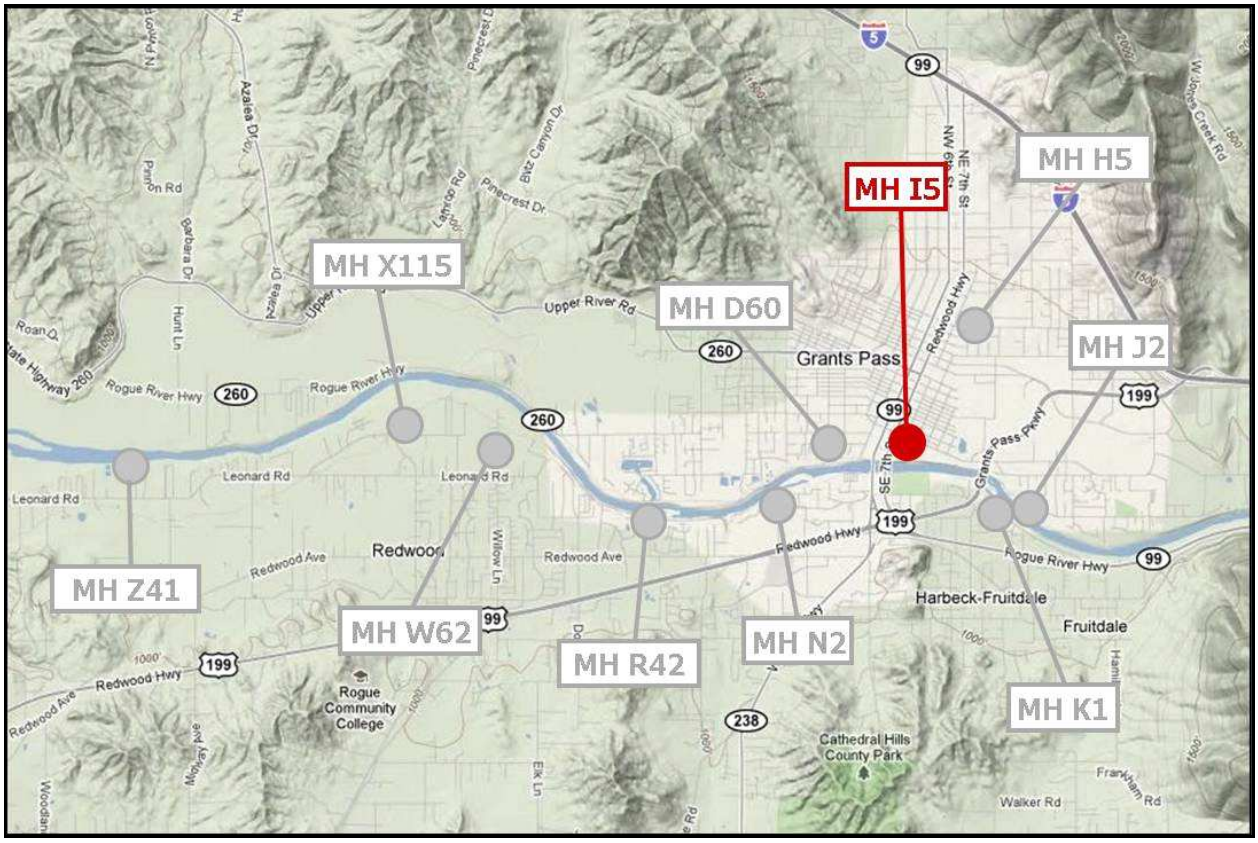
Year 2011/2012

Monitoring Site: I5

Location: 505 Southeast M Street

Data Summary Report

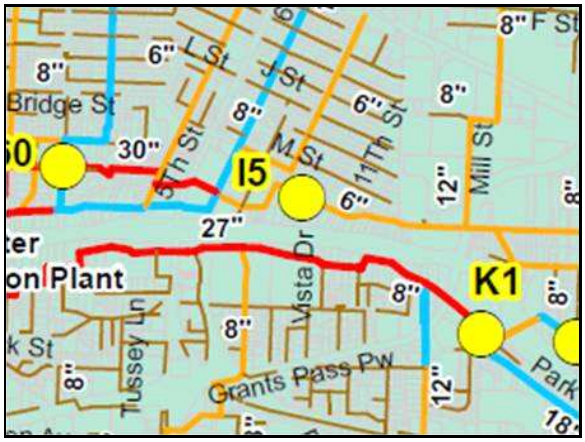
Vicinity Map:



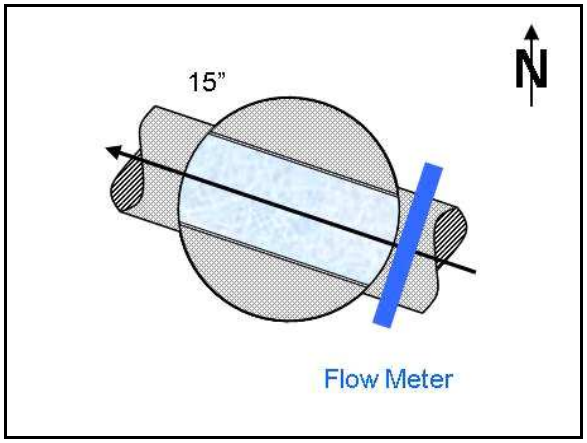
I5
Site Information Report

Location:	505 Southeast M Street
Coordinates:	123.3259°W, 42.4317°N
Elevation:	926 feet
Diameter:	15 inches
Baseline Flow:	0.305 mgd
Peak Measured Flow:	1.191 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

I5
Additional Site Photos

Effluent Pipe

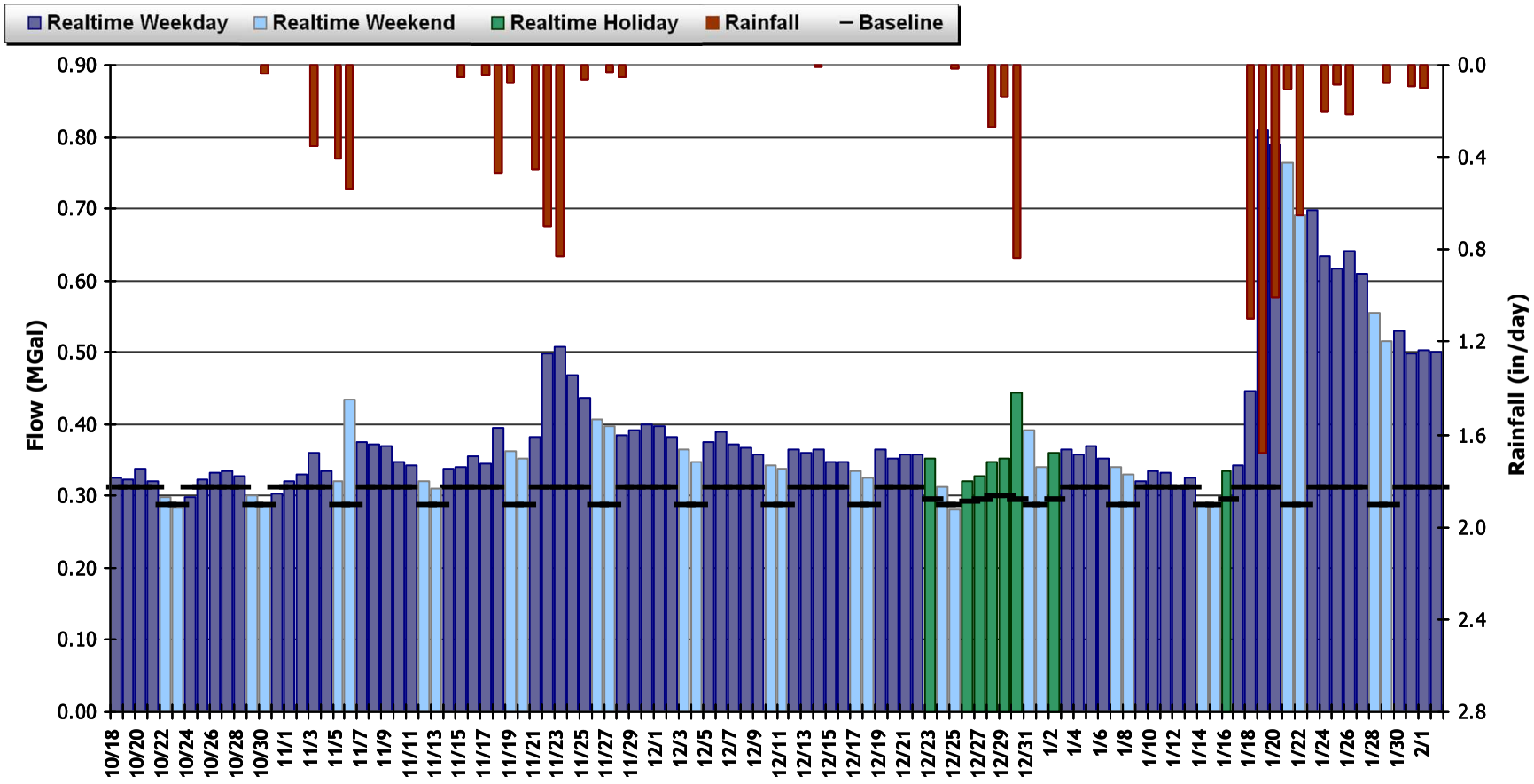
Main Influent Pipe

I5

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.39 MGal Peak Daily Flow: 0.81 MGal Min Daily Flow: 0.282 MGal

Total Period Rainfall: 10.7 inches

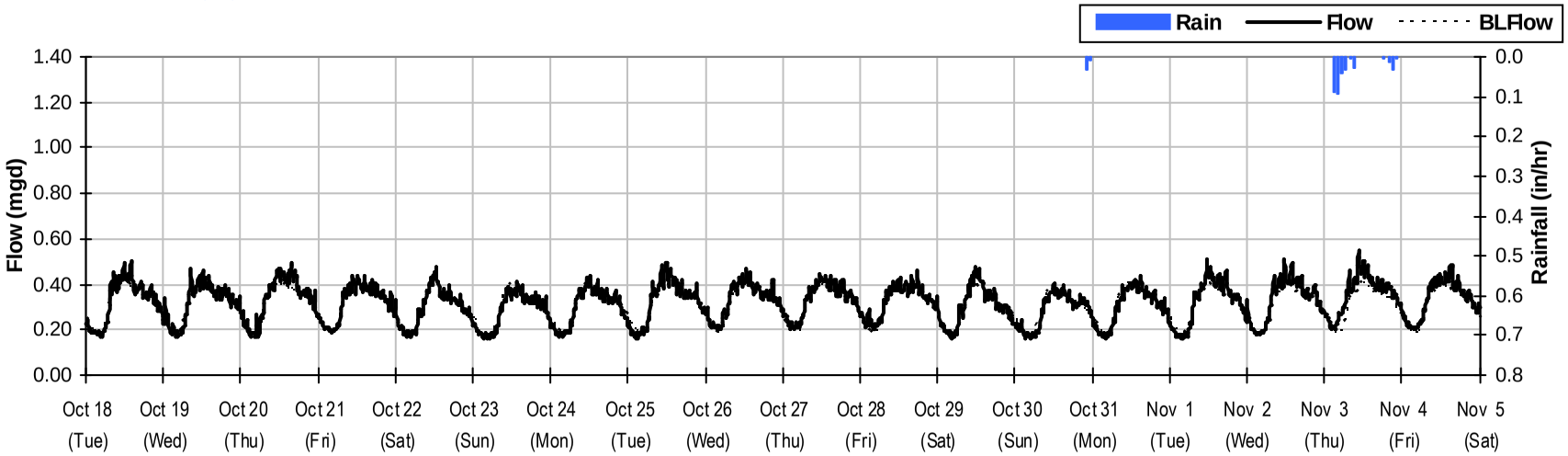


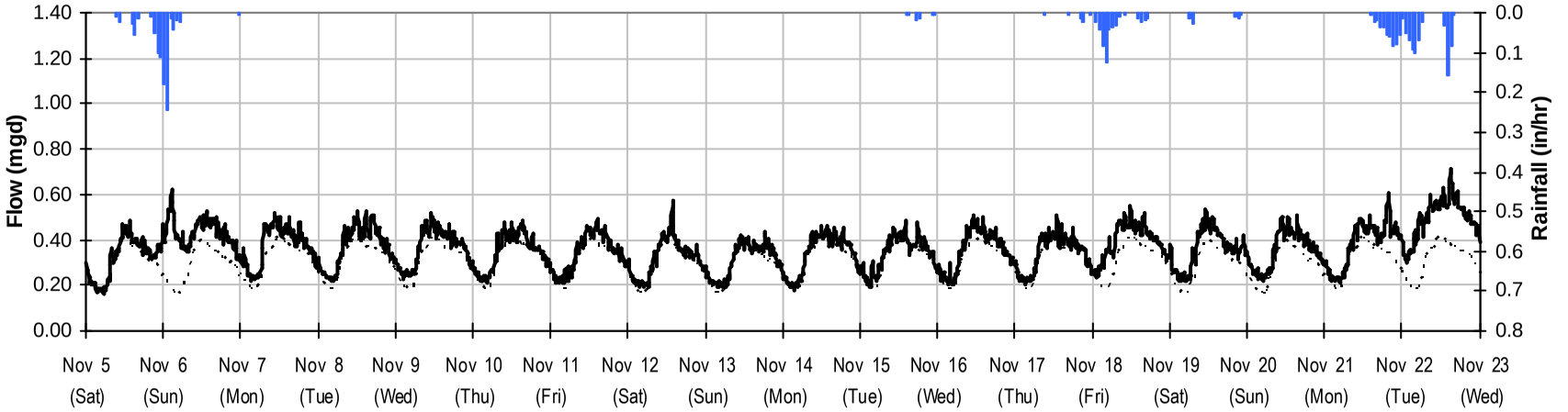
I5

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.342 mgd Peak Flow: 0.715 mgd Min Flow: 0.16 mgd

Total Period Rainfall: 3.13 inches



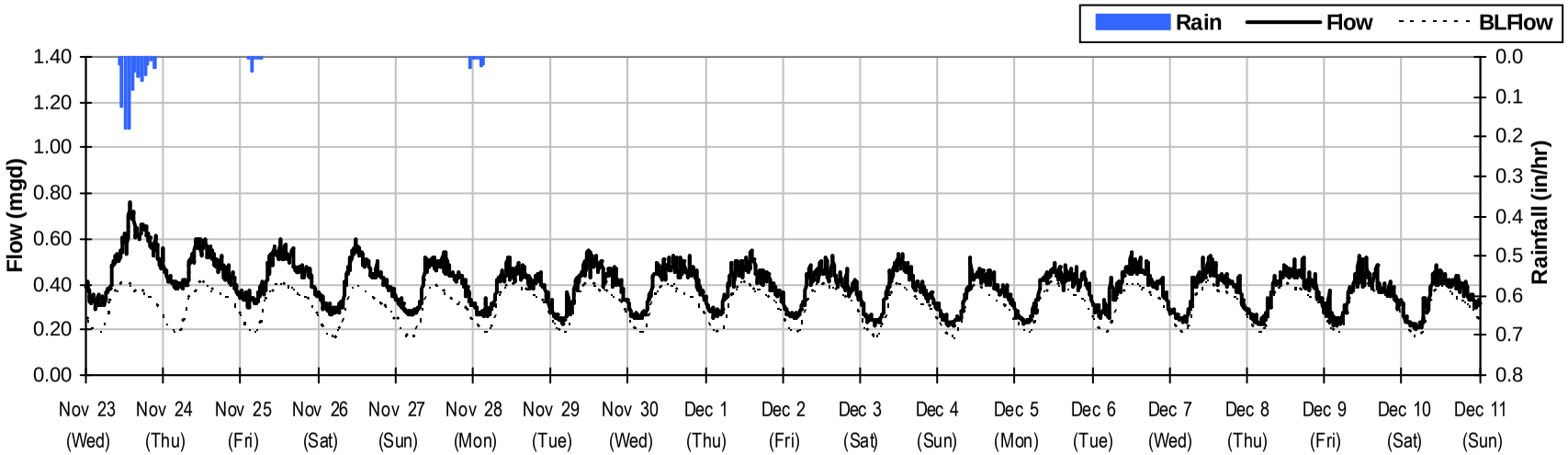


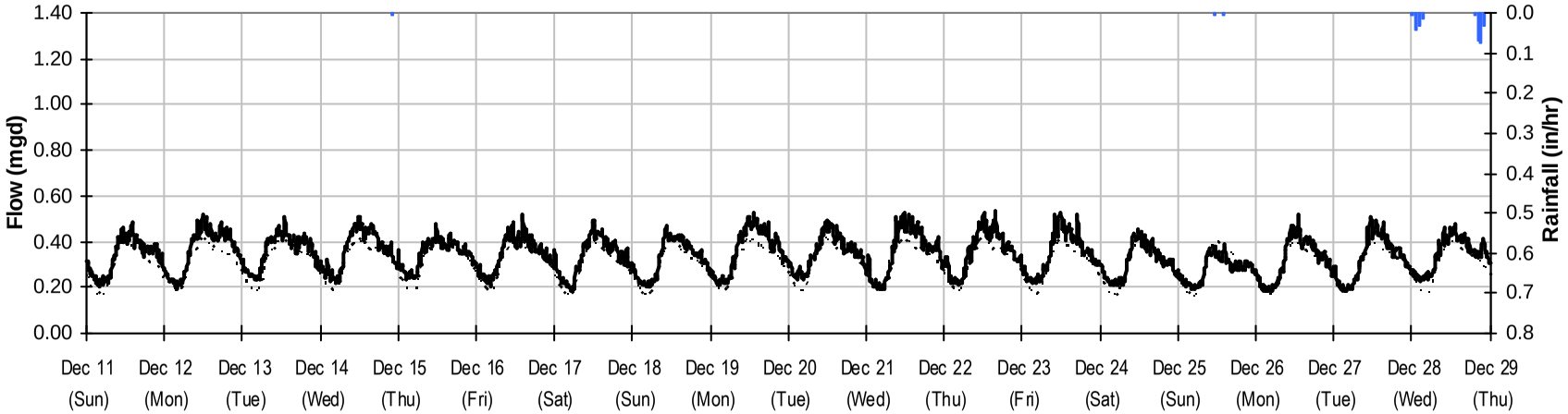
I5

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.368 mgd Peak Flow: 0.763 mgd Min Flow: 0.183 mgd

Total Period Rainfall: 1.27 inches



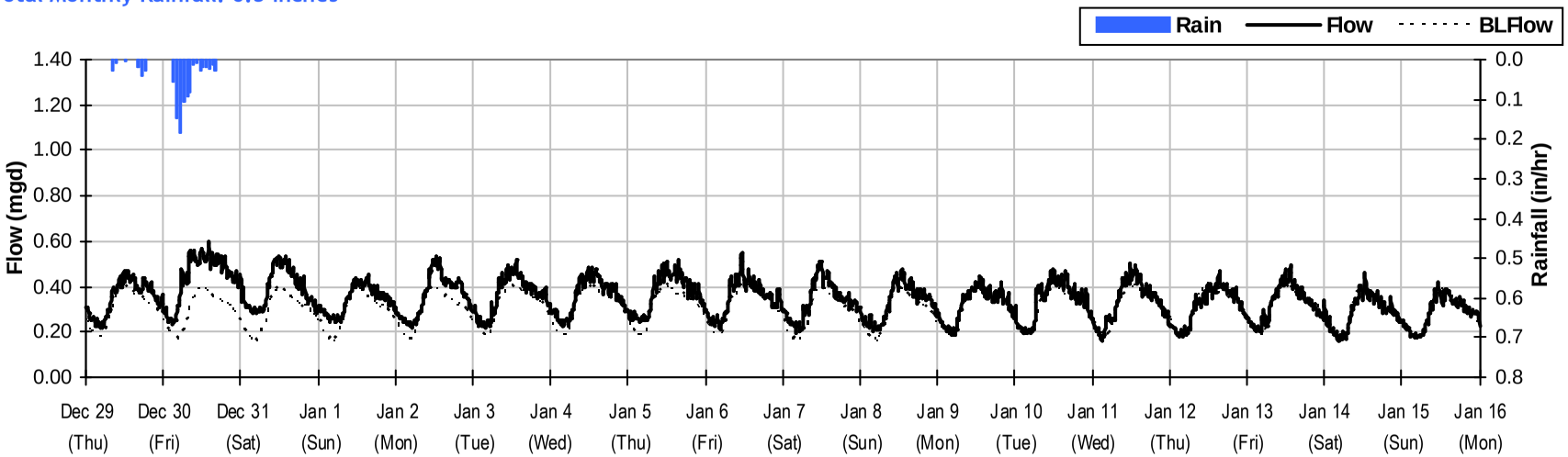


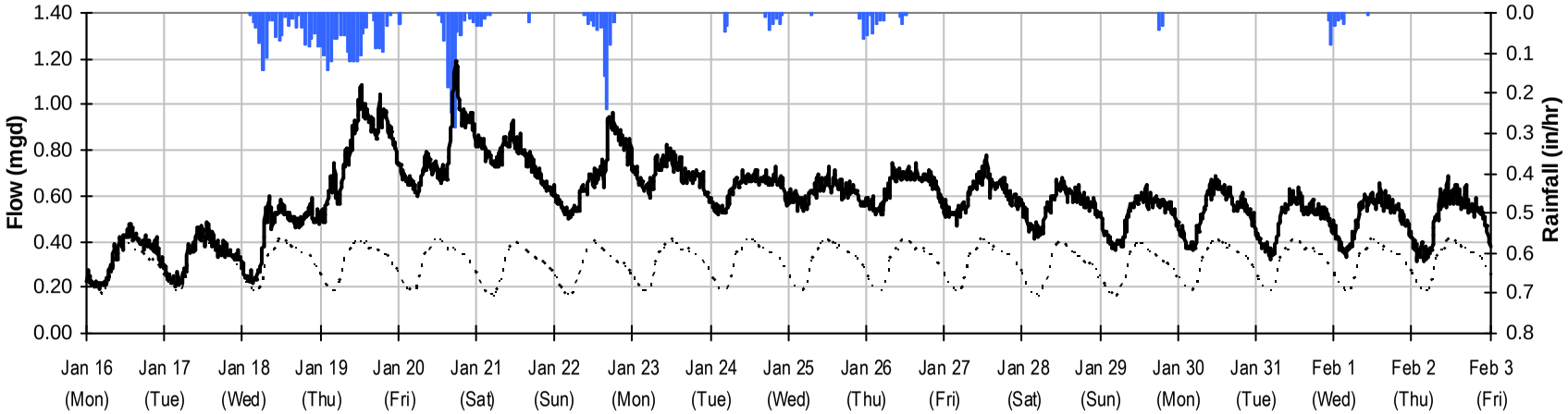
I5

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.46 mgd Peak Flow: 1.19 mgd Min Flow: 0.16 mgd

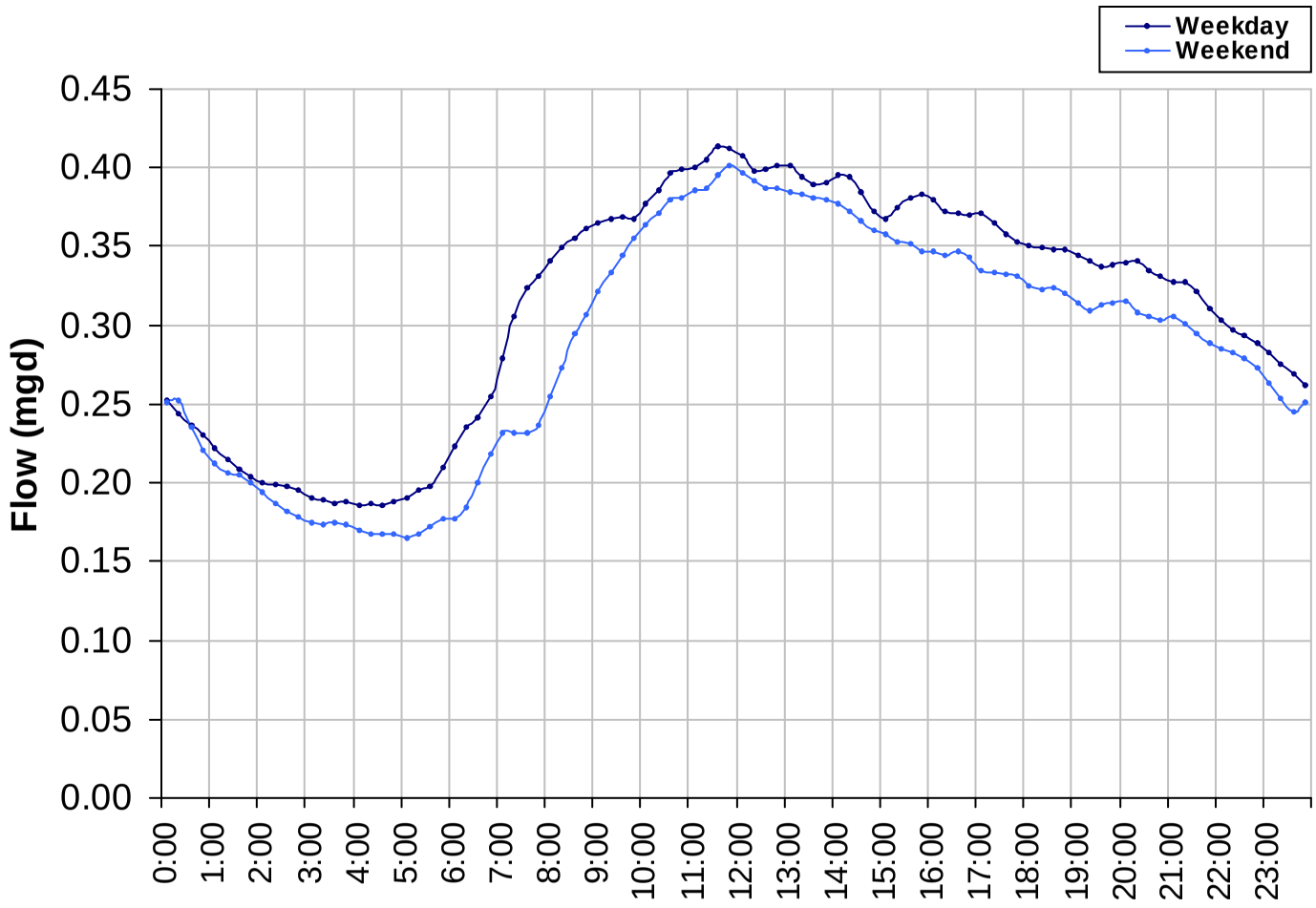
Total Monthly Rainfall: 6.3 inches





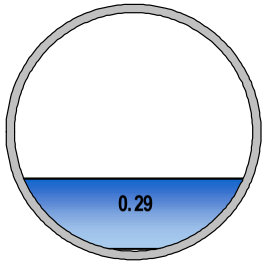
I5

Baseline Flow Hydrographs



Baseline Flow:

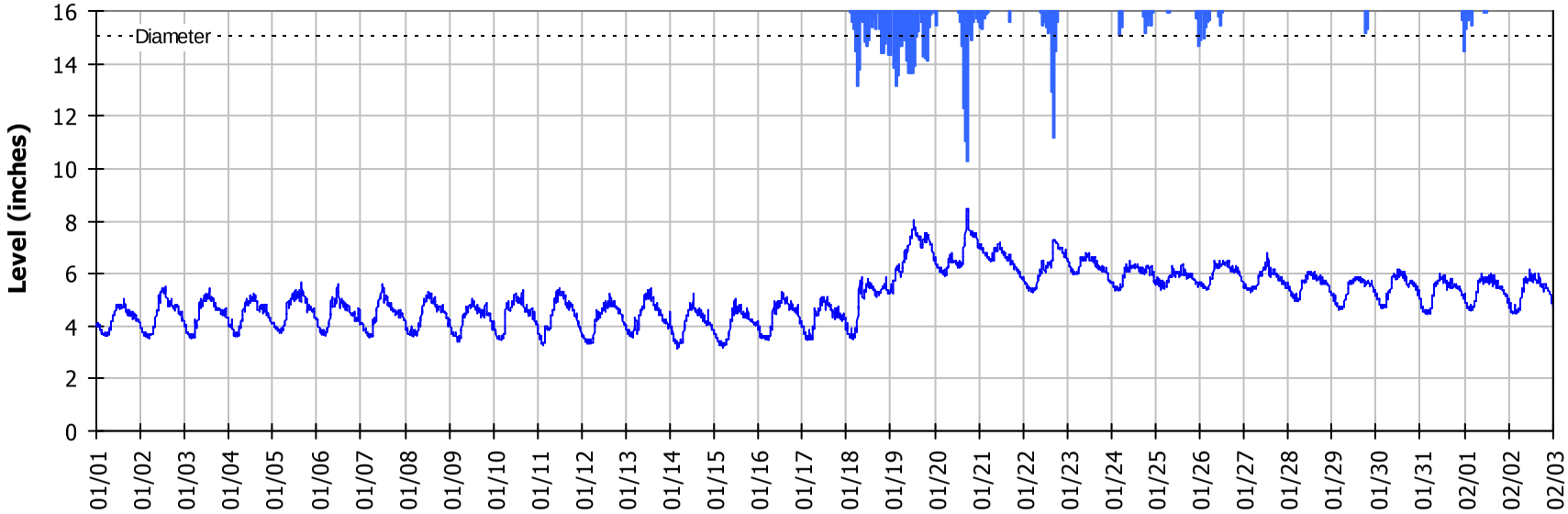
0.305 *mgd*

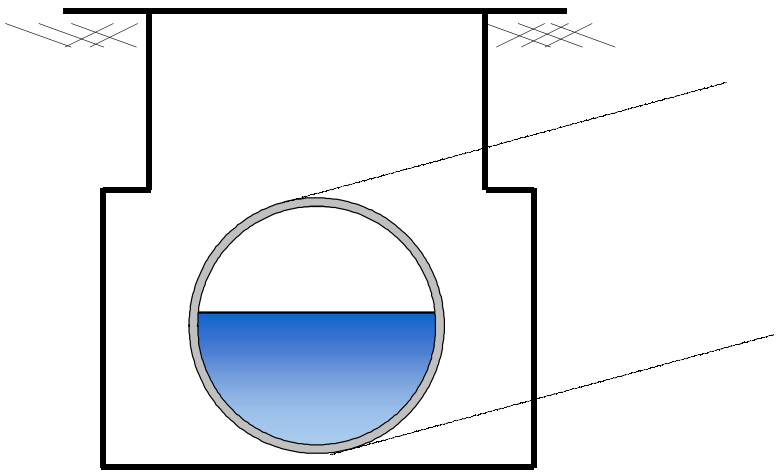


I5

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

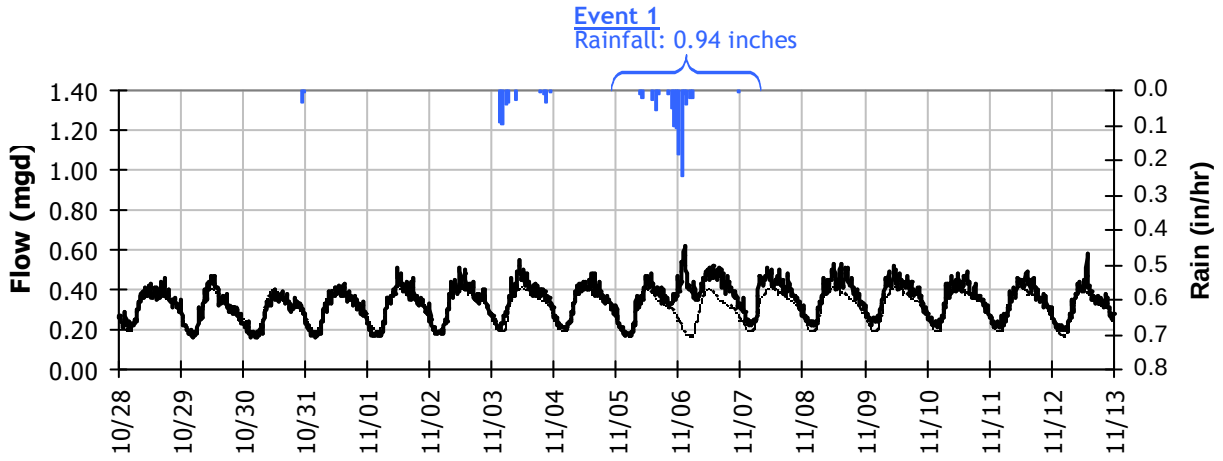




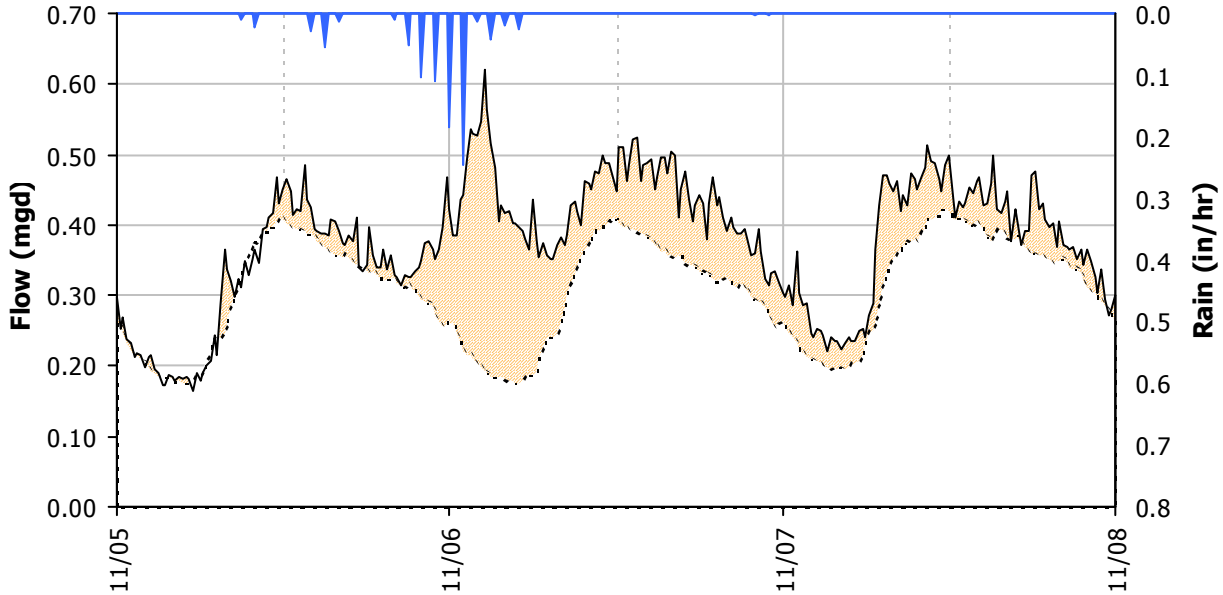
Pipe Diameter:	15	*inches*
Peak Measured Level	8.48	*inches*
Peak d/D Ratio:	0.57	

SITE I5
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

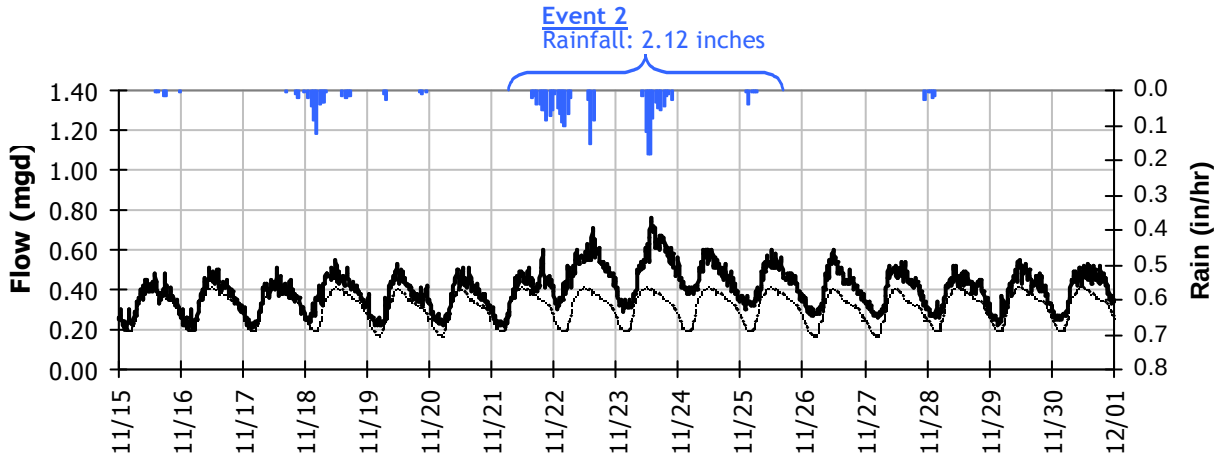


Storm Event I/I Analysis (Rain = 0.94 inches)

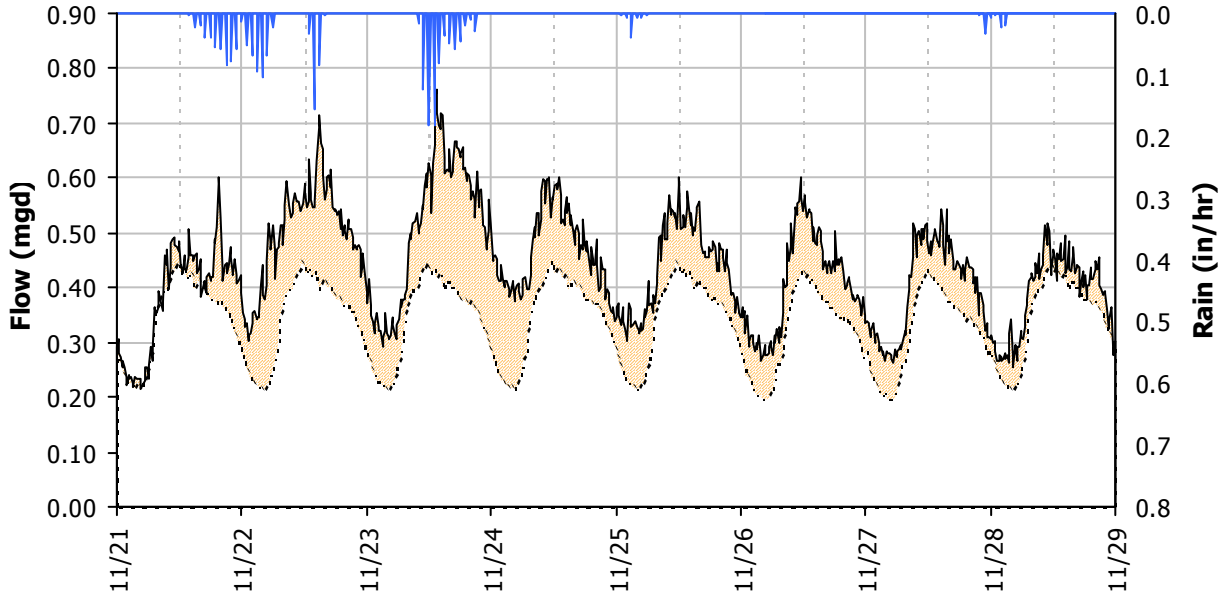
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.62 *mgd*	Peak I/I Rate:	0.44 *mgd*	Infiltration Rate: (11/7/2011)	0.061 *mgd*	Total I/I:	208,000 *gallons*
PF:	2.03	PkI/I:IDM:	8,255 *gpd/IDM*	RDI:IDM:	1,153 *gpd/IDM*	Total I/I:IDM:	4,148 *gal/IDM/in*
Peak Level:	6.05 *in*	PkI/I:Acre:	1,178 *gpd/acre*	RDI:Acre:	165 *gpd/acre*	R-Value:	2.2%
d/D Ratio:	0.40	Pk I/I:ADWF:	1.44	RDI (% of BL):	20%	Total I/I:ADWF:	0.72 *per in-rain*

SITE I5
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

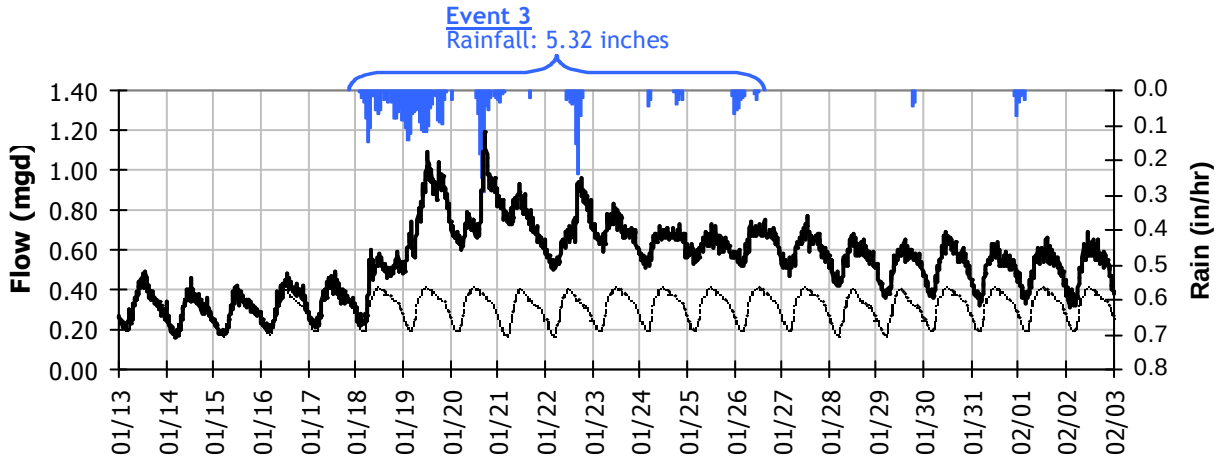


Storm Event I/I Analysis (Rain = 2.12 inches)

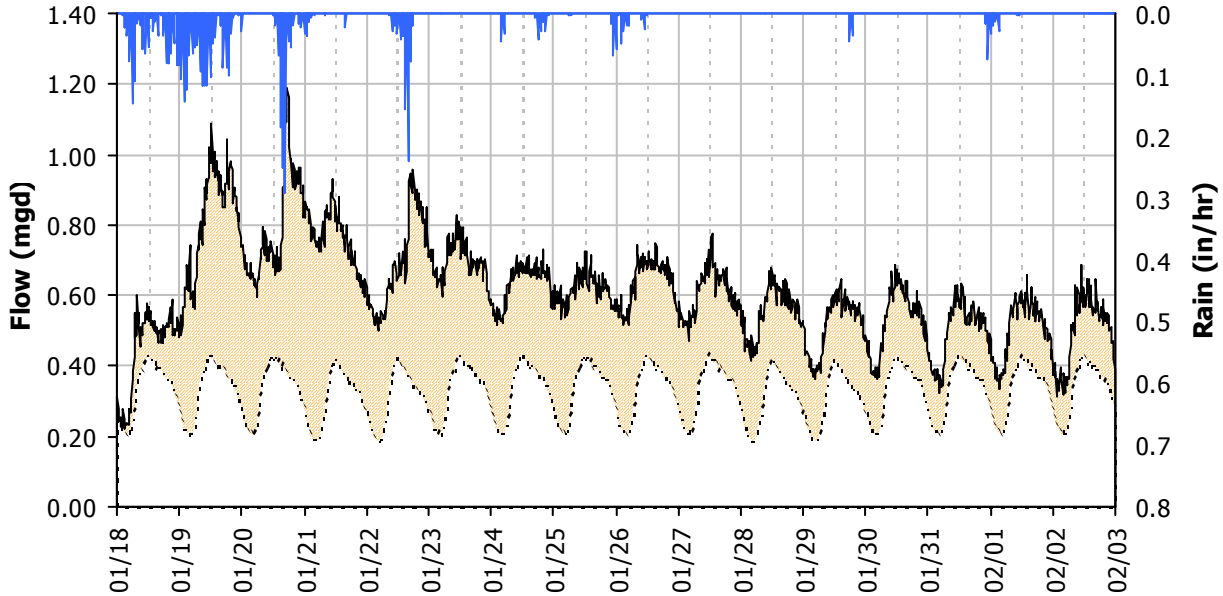
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.76 *mgd*	Peak I/I Rate:	0.37 *mgd*	Infiltration Rate: (11/26/2011)	0.119 *mgd*	Total I/I:	792,000 *gallons*
PF:	2.50	PkI/I:IDM:	7,024 *gpd/IDM*	RDI:IDM:	2,240 *gpd/IDM*	Total I/I:IDM:	7,017 *gal/IDM/in*
Peak Level:	6.71 *in*	PkI/I:Acre:	1,002 *gpd/acre*	RDI:Acre:	320 *gpd/acre*	R-Value:	3.7%
d/D Ratio:	0.45	Pk I/I:ADWF:	1.22	RDI (% of BL):	41%	Total I/I:ADWF:	1.22 *per in-rain*

SITE I5
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

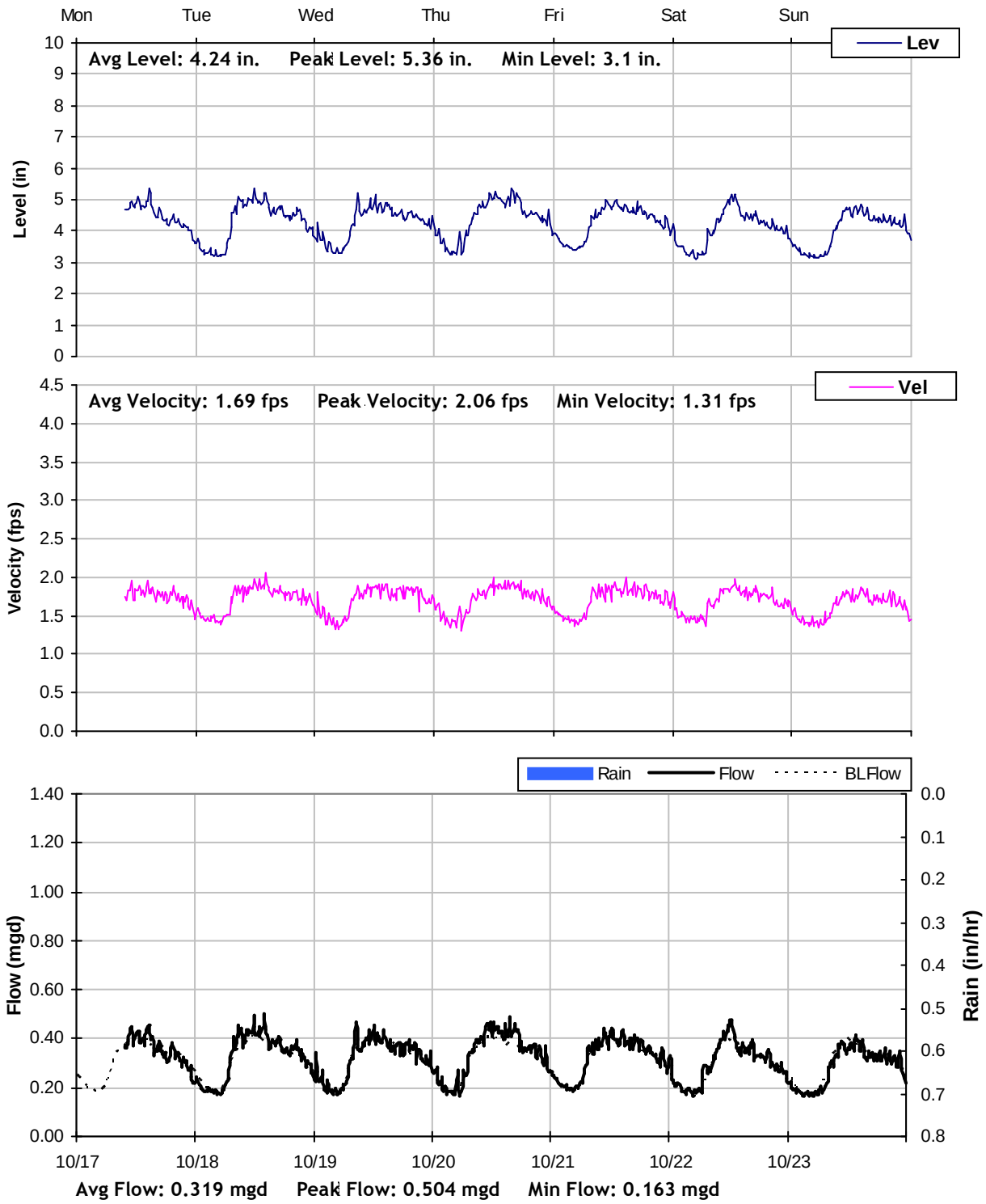


Storm Event I/I Analysis (Rain = 5.32 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	1.19	*mgd*	Peak I/I Rate:	0.84	*mgd*	Infiltration Rate: (1/30/2012)	0.218	*mgd*	Total I/I:	4,579,000	*gallons*
PF:	3.90		PkI/I:IDM:	15,768	*gpd/IDM*	RDI:IDM:	4,105	*gpd/IDM*	Total I/I:IDM:	16,175	*gal/IDM/in*
Peak Level:	8.48	*in*	PkI/I:Acre:	2,250	*gpd/acre*	RDI:Acre:	586	*gpd/acre*	R-Value:	8.5%	
d/D Ratio:	0.57		Pk I/I:ADWF:	2.75		RDI (% of BL):	70%		Total I/I:ADWF:	2.82	*per in-rain*

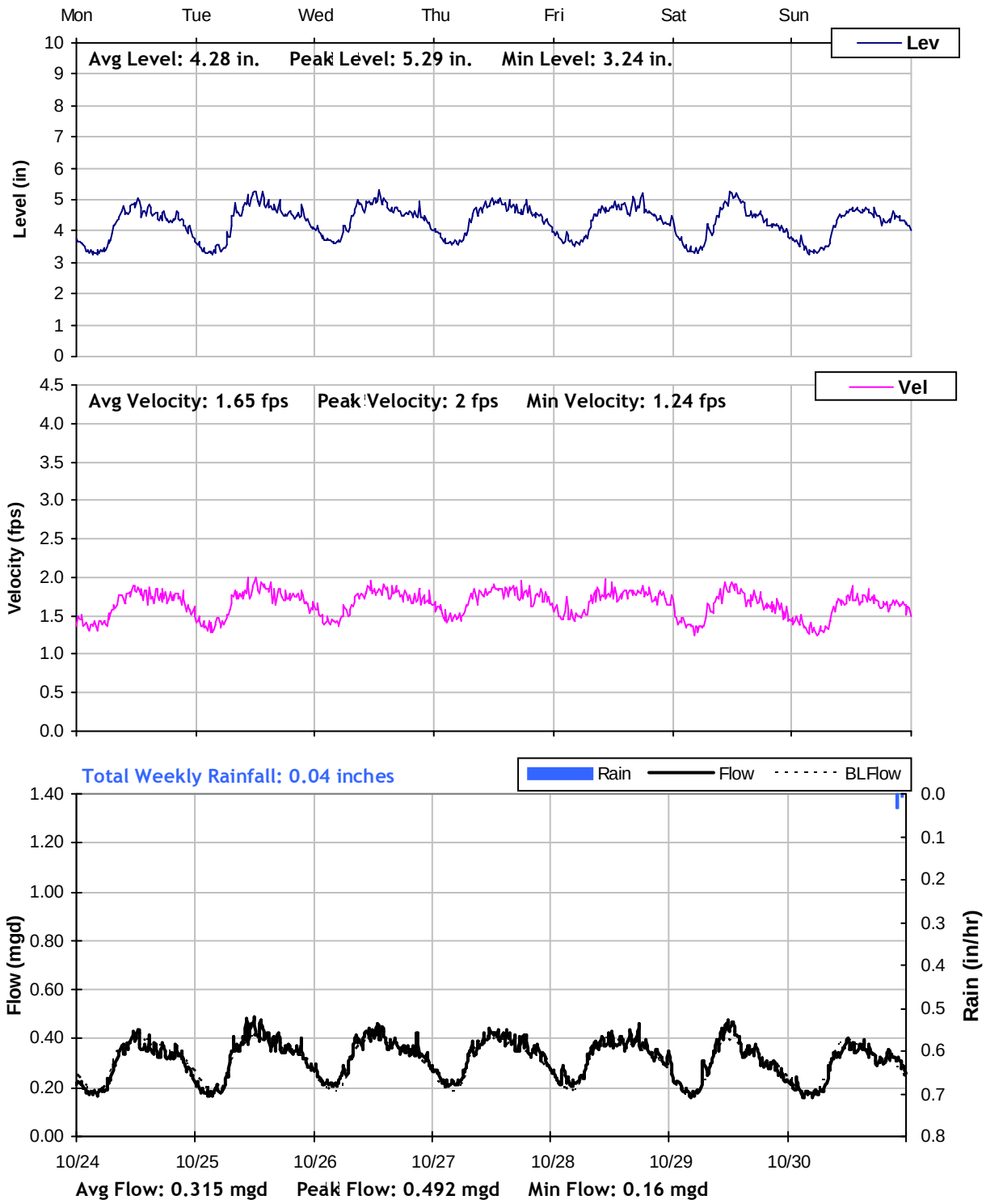
I5

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



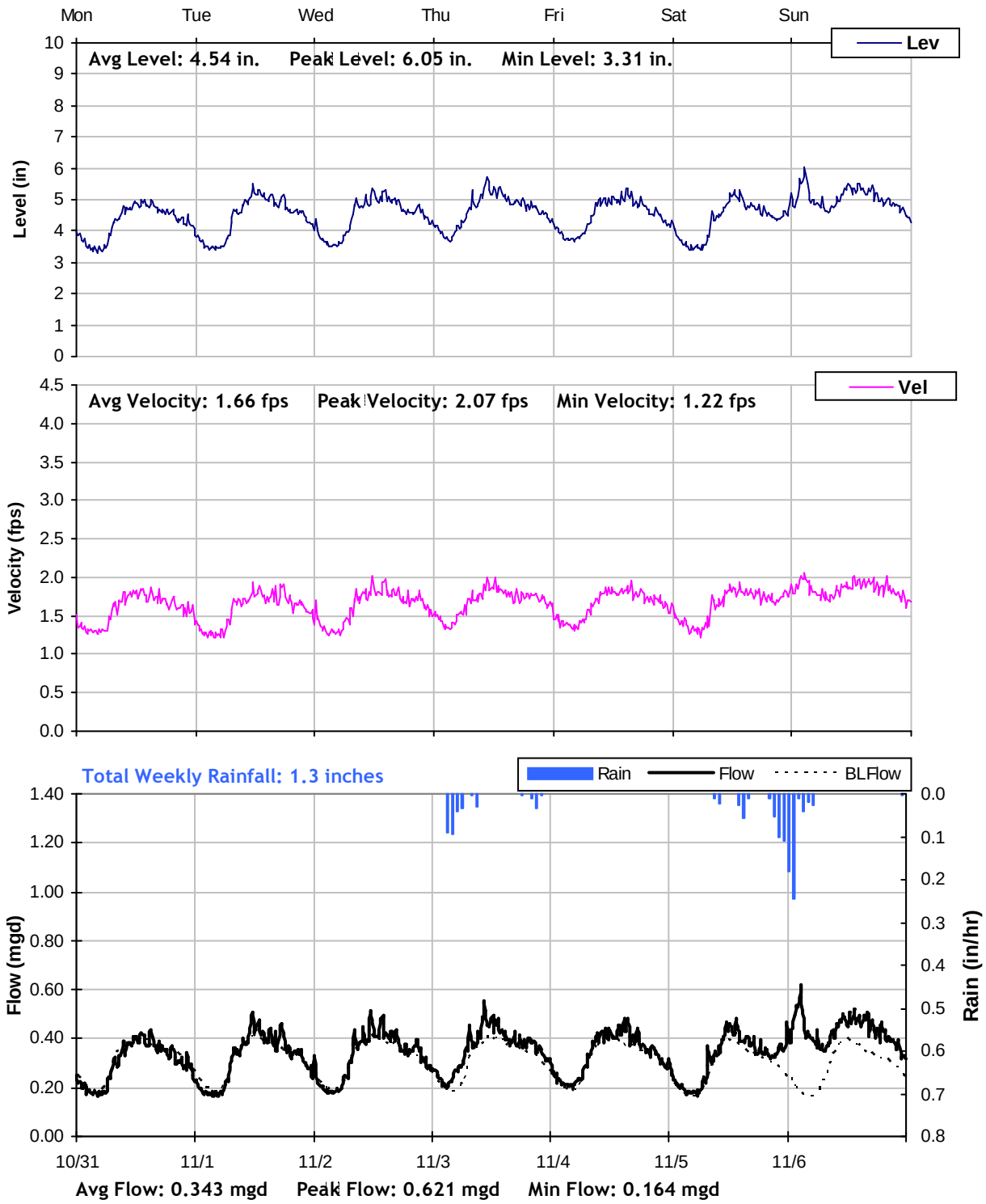
I5

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



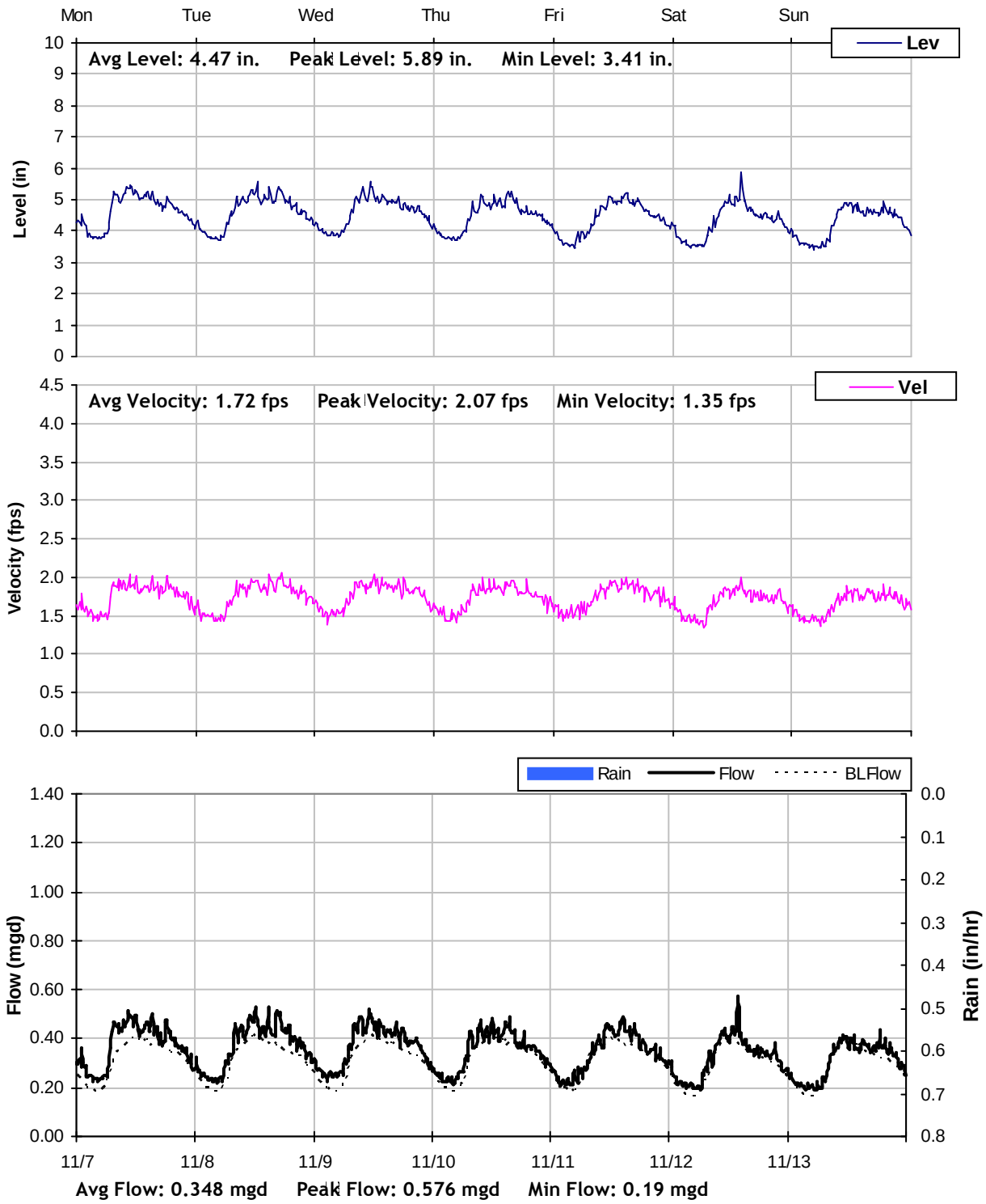
I5

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



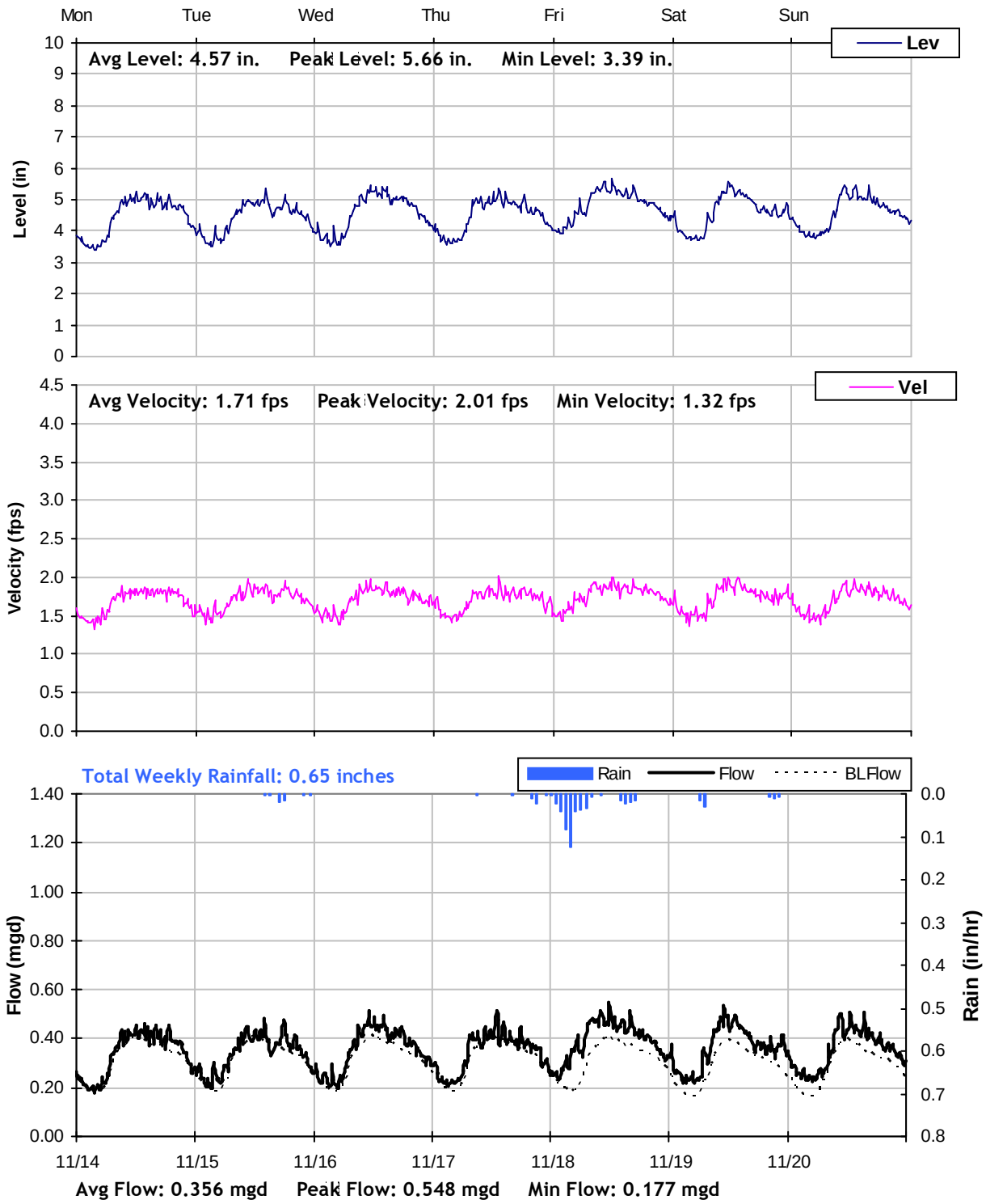
I5

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



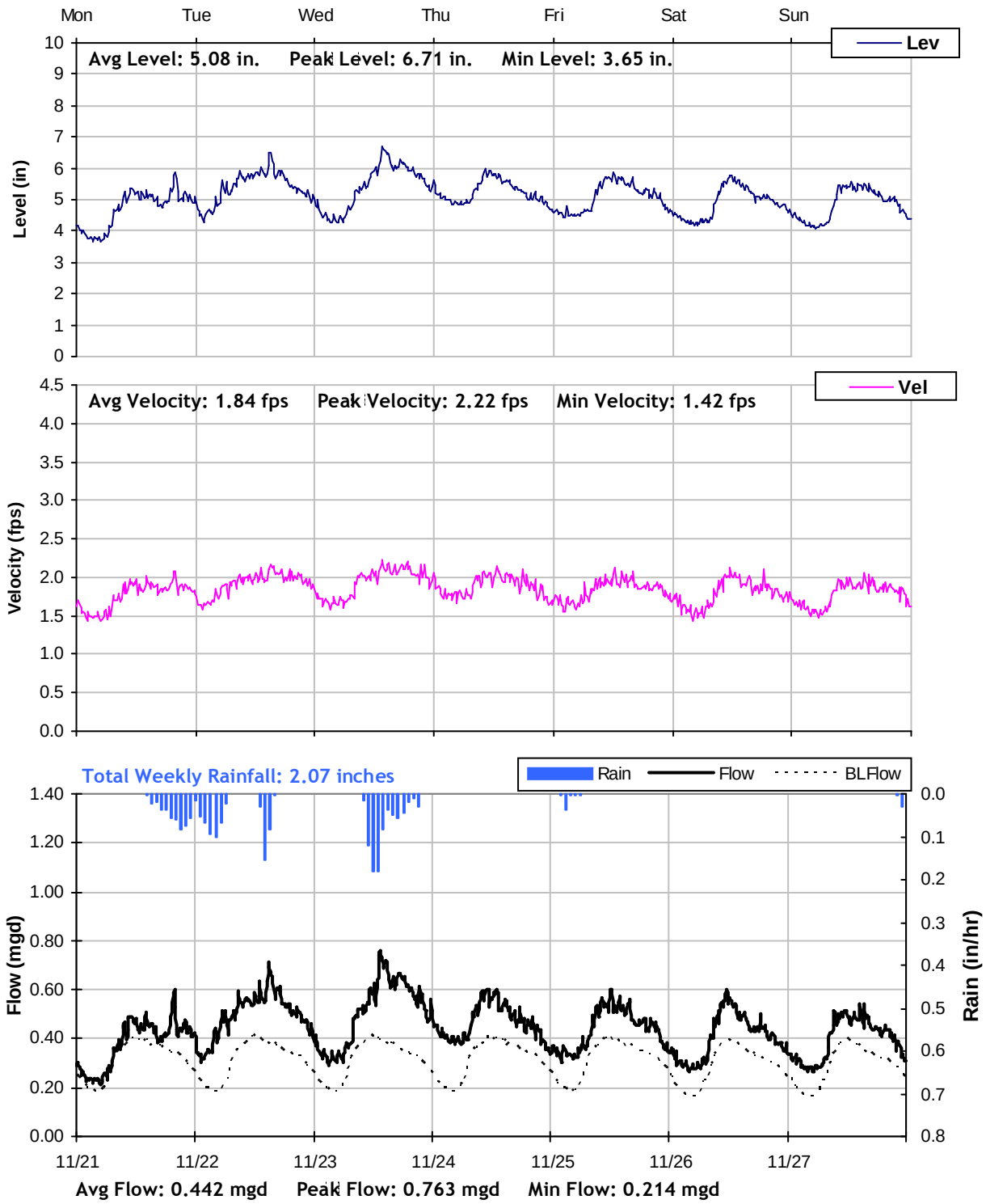
I5

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



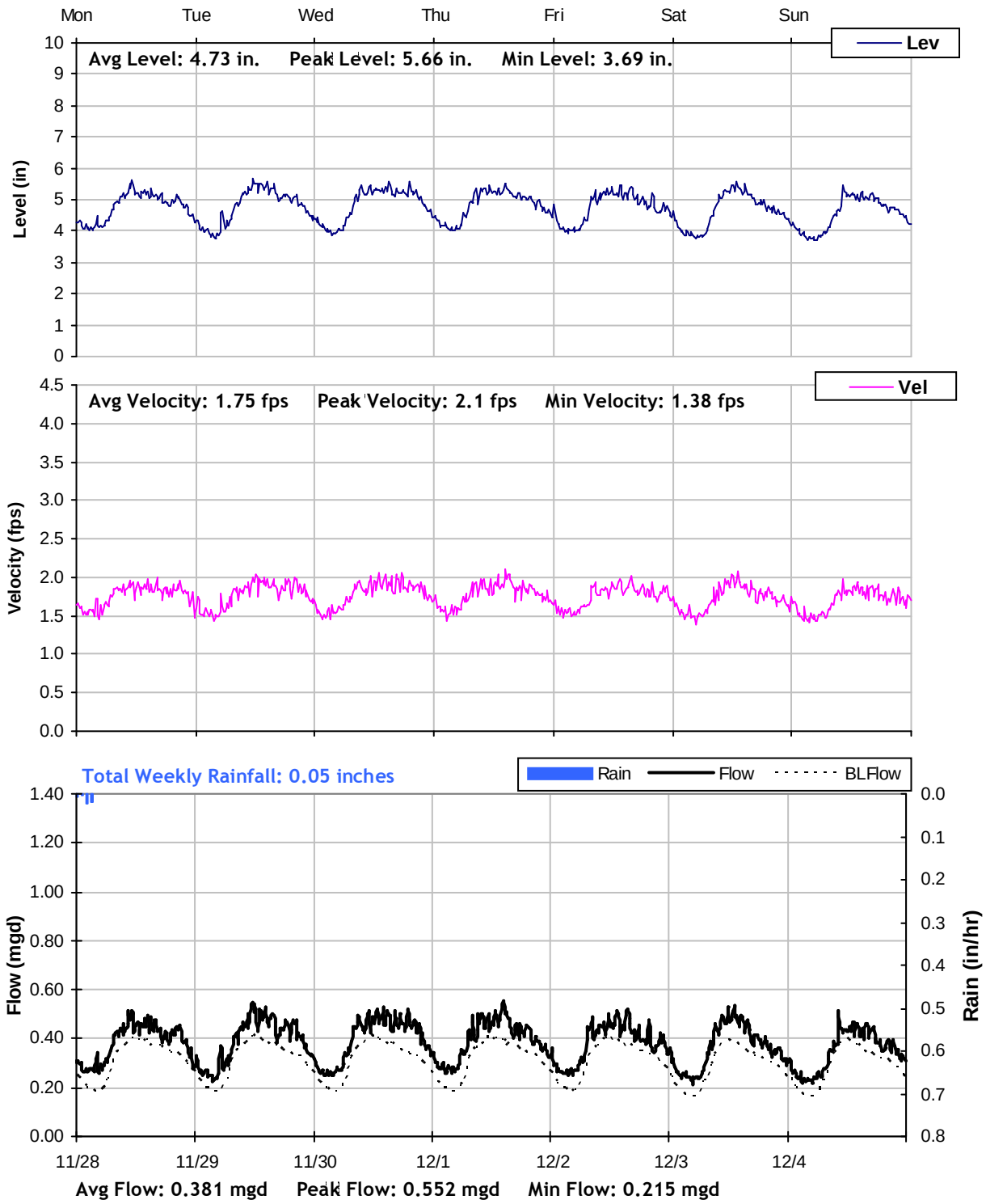
I5

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



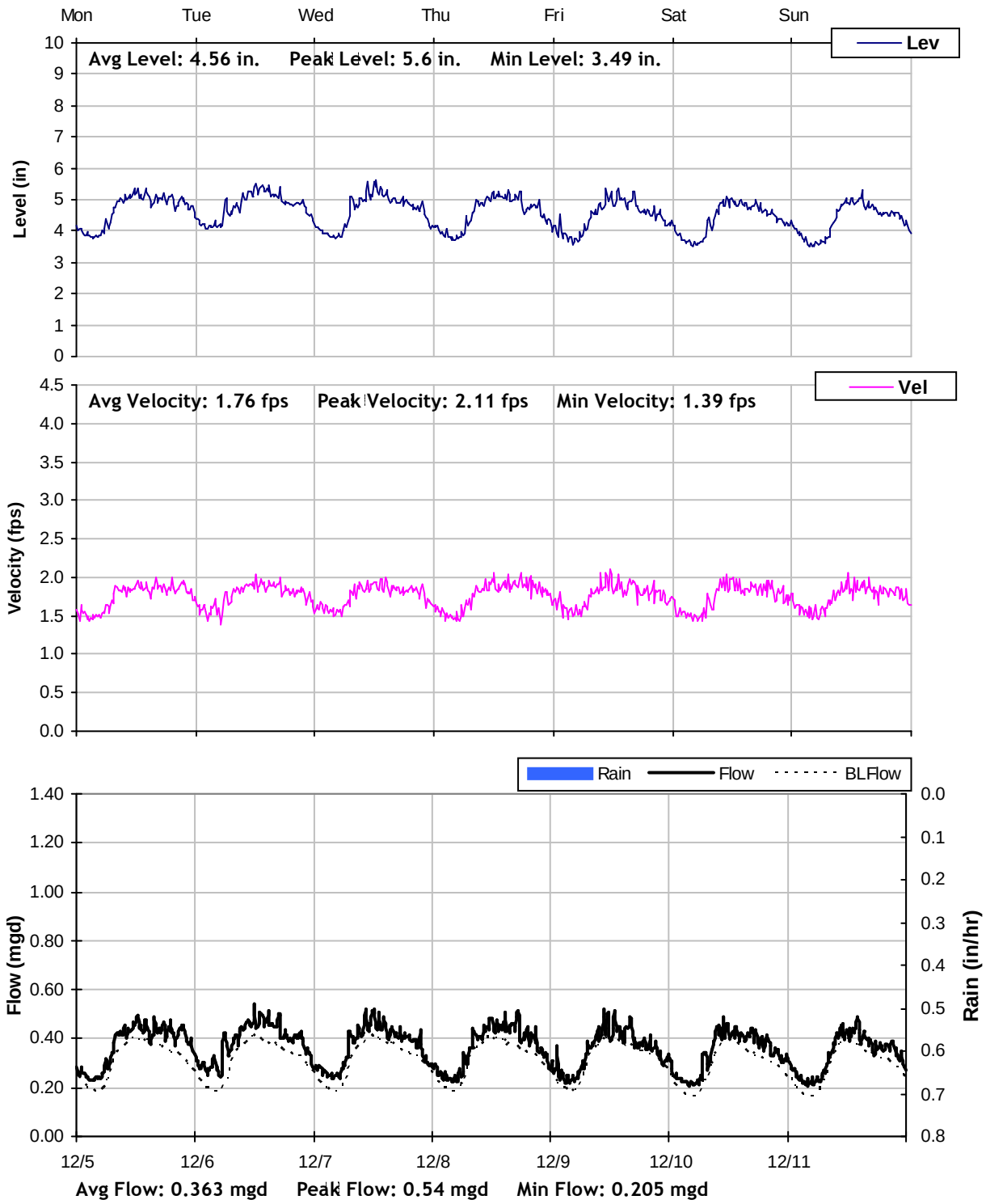
I5

Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



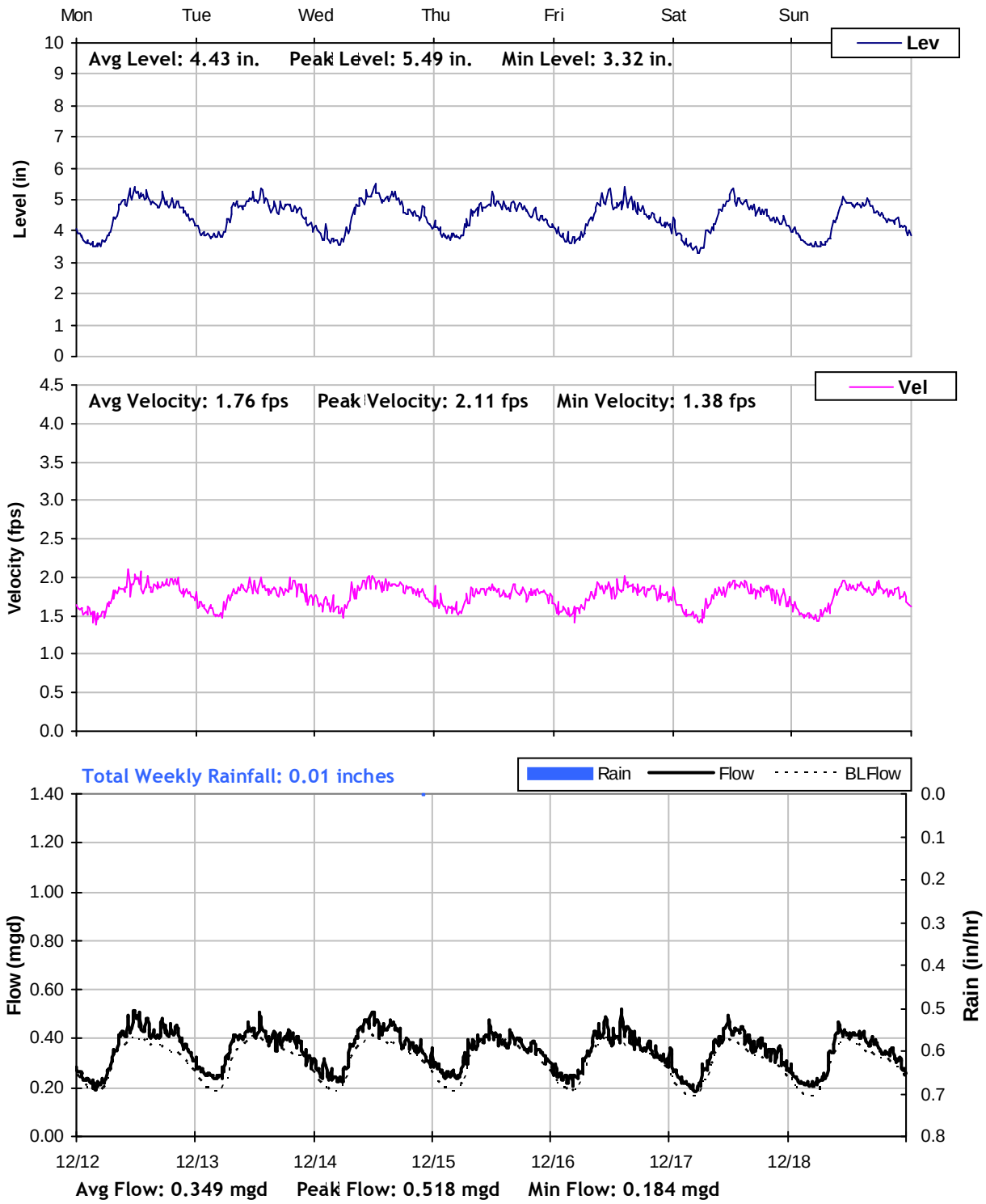
I5

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



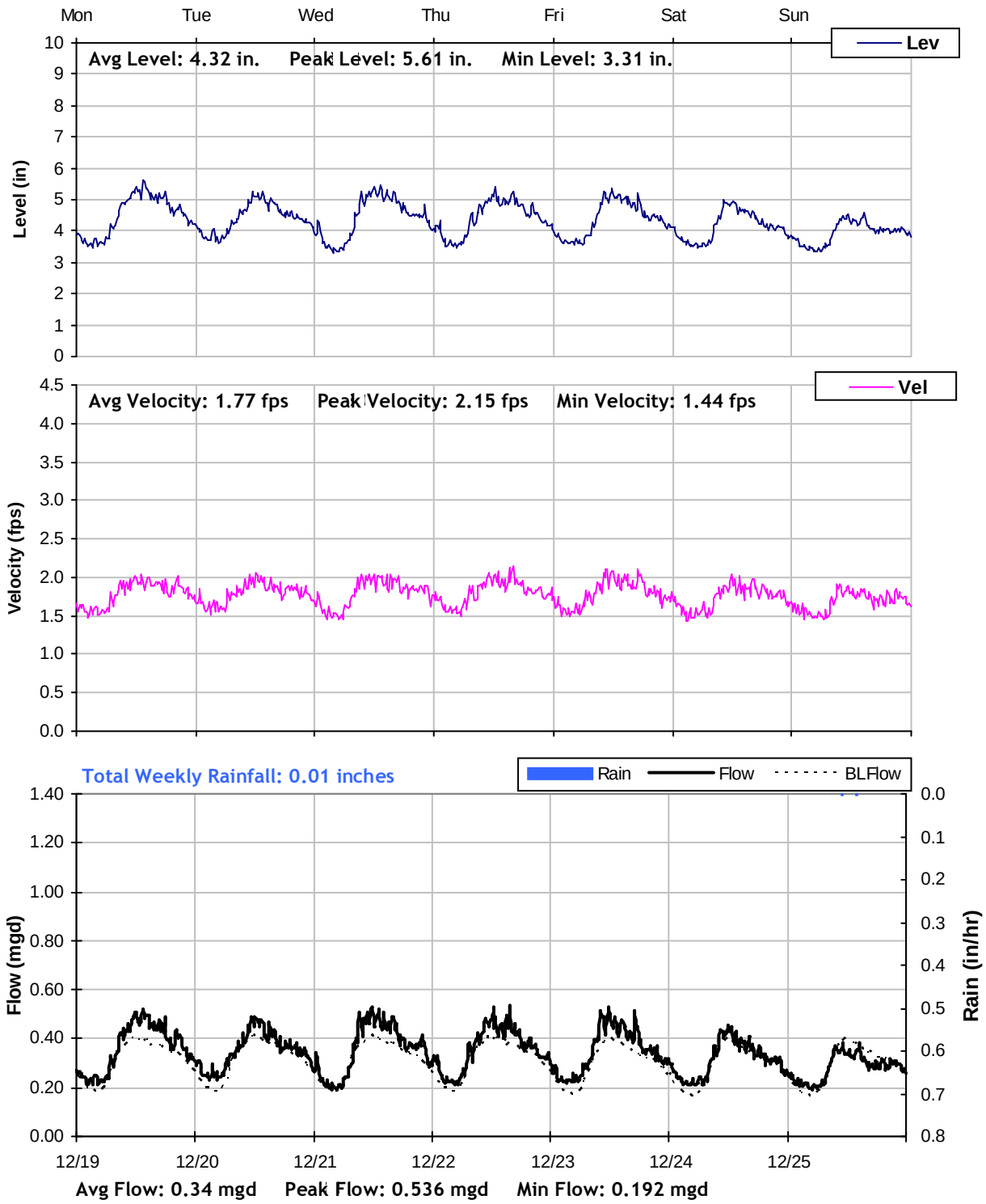
I5

Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



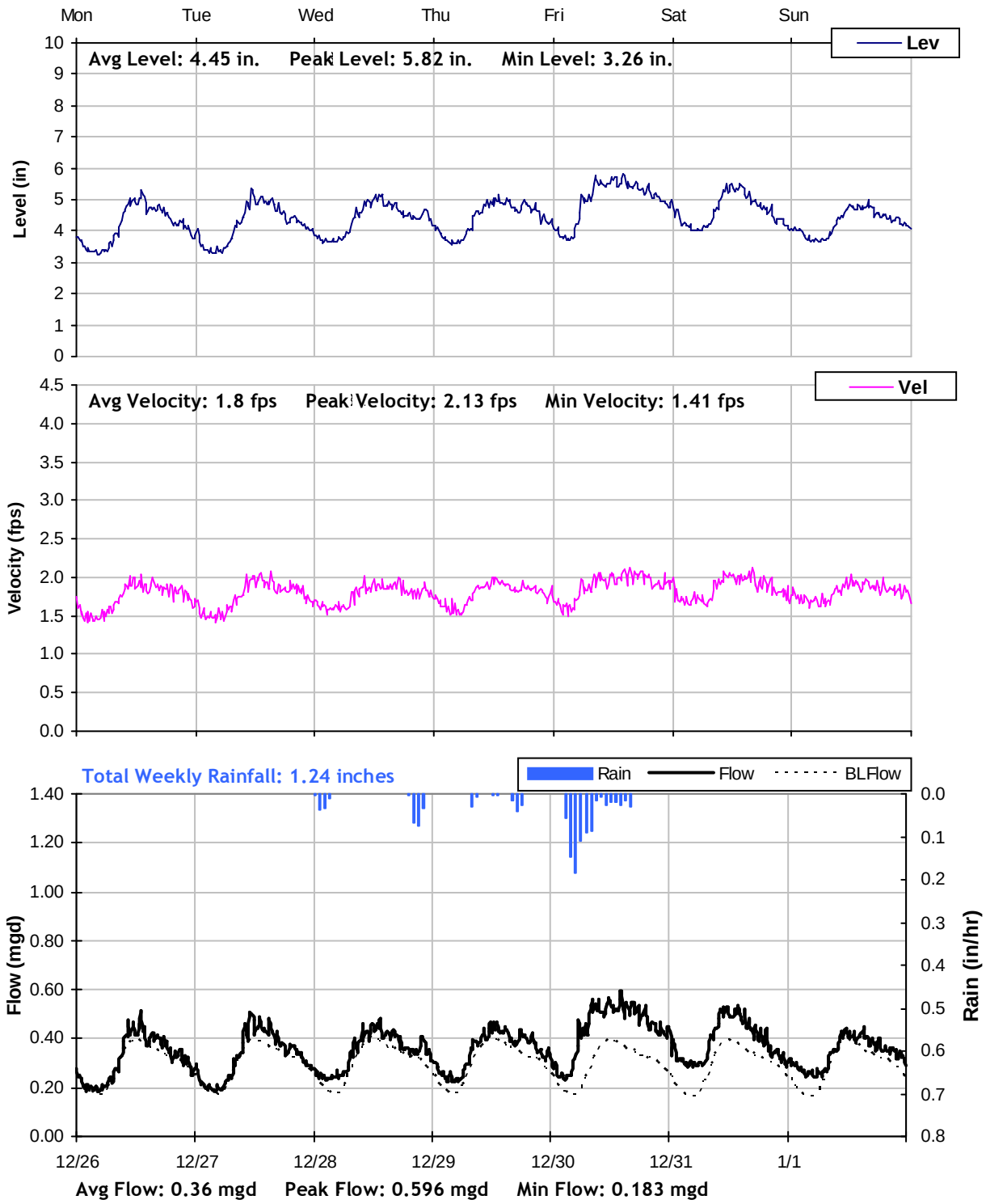
I5

Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



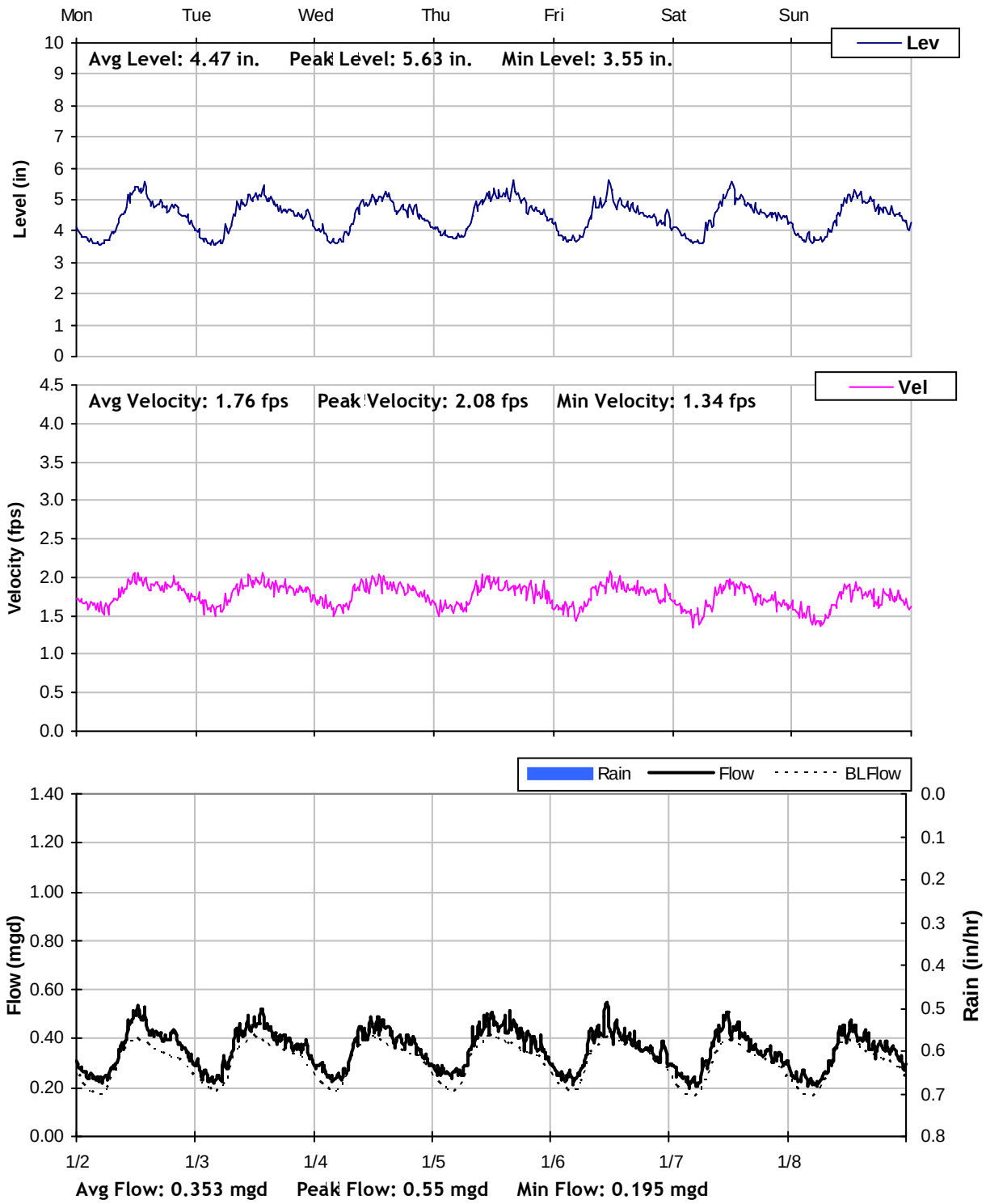
I5

Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



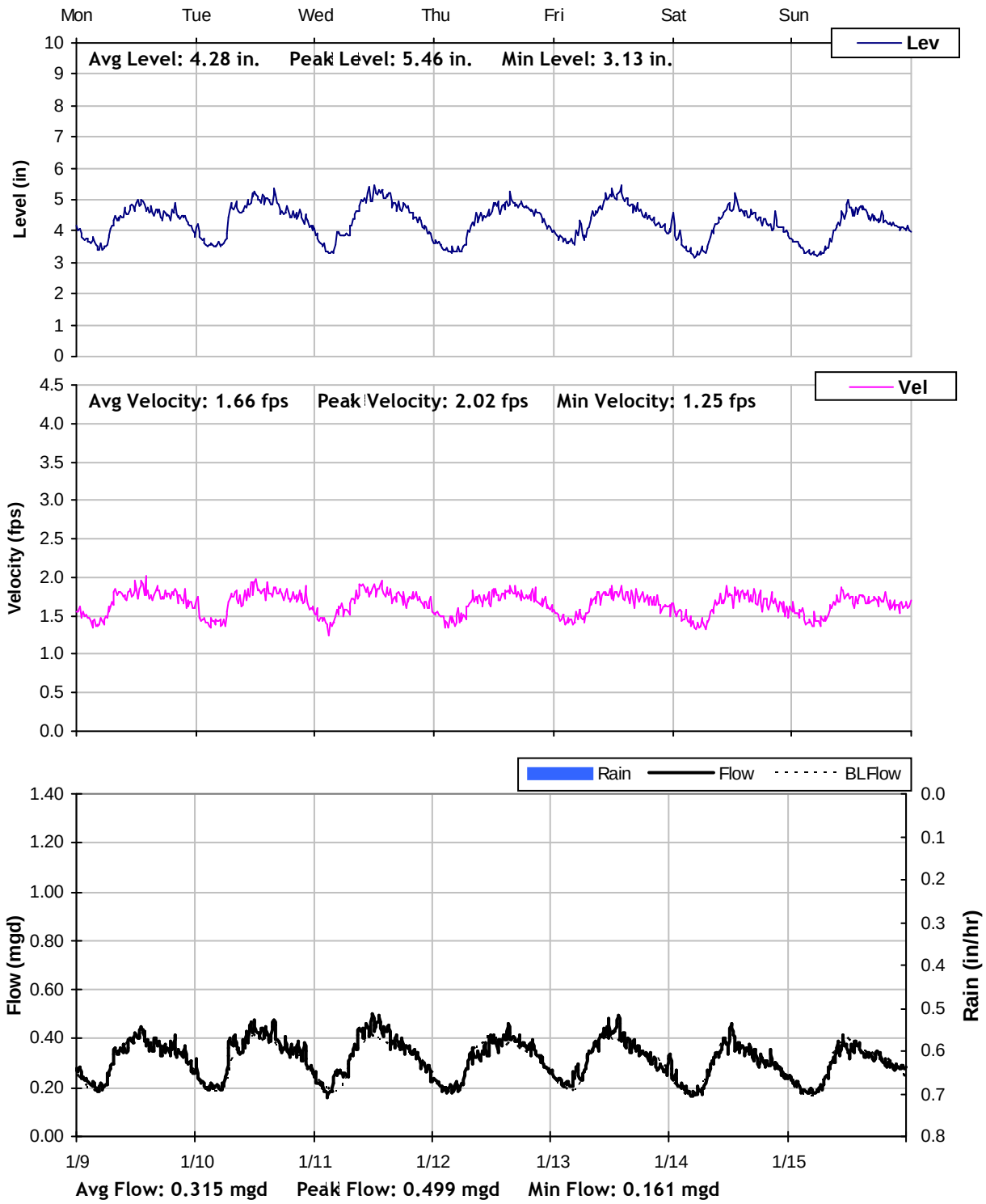
I5

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



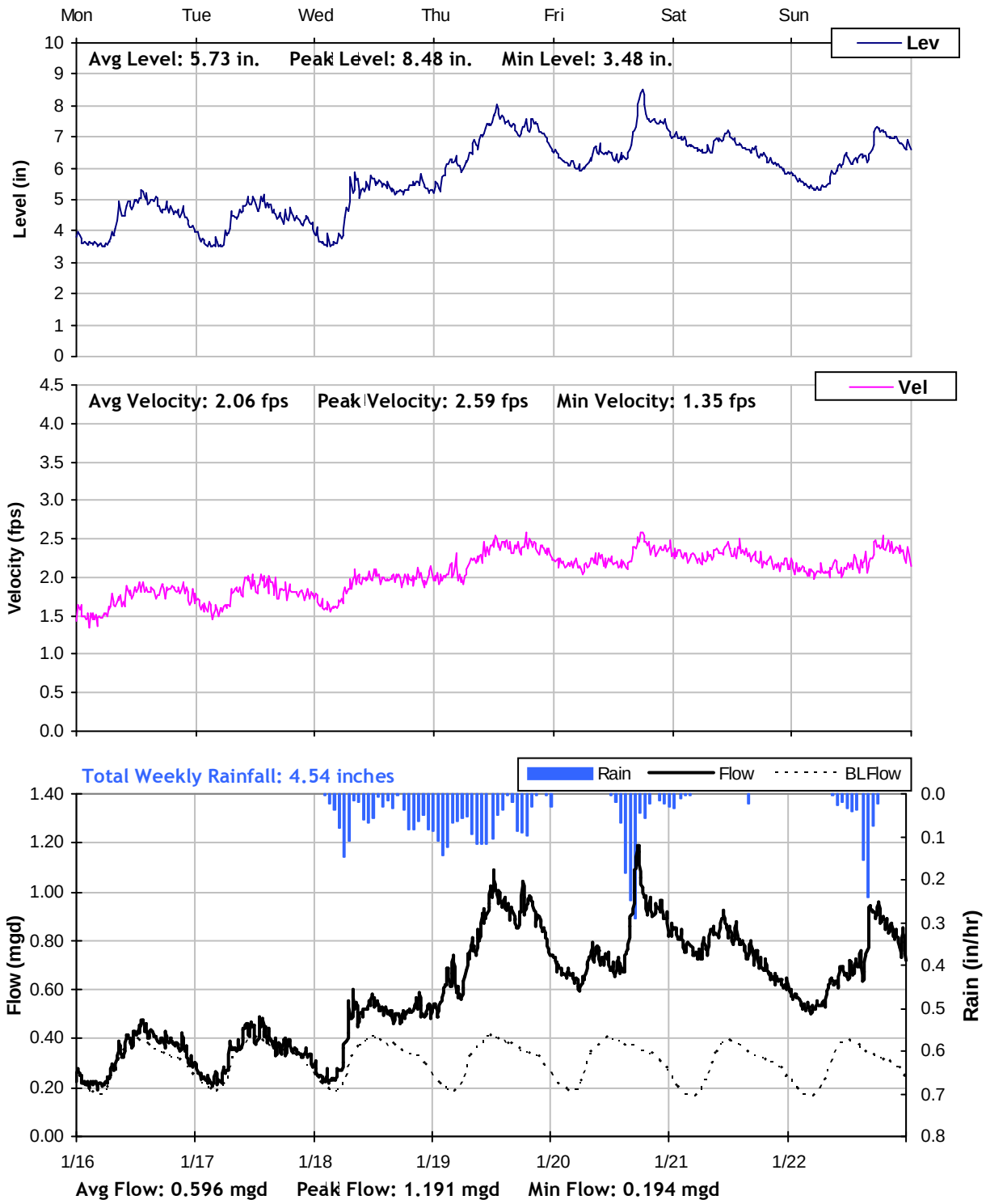
I5

Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



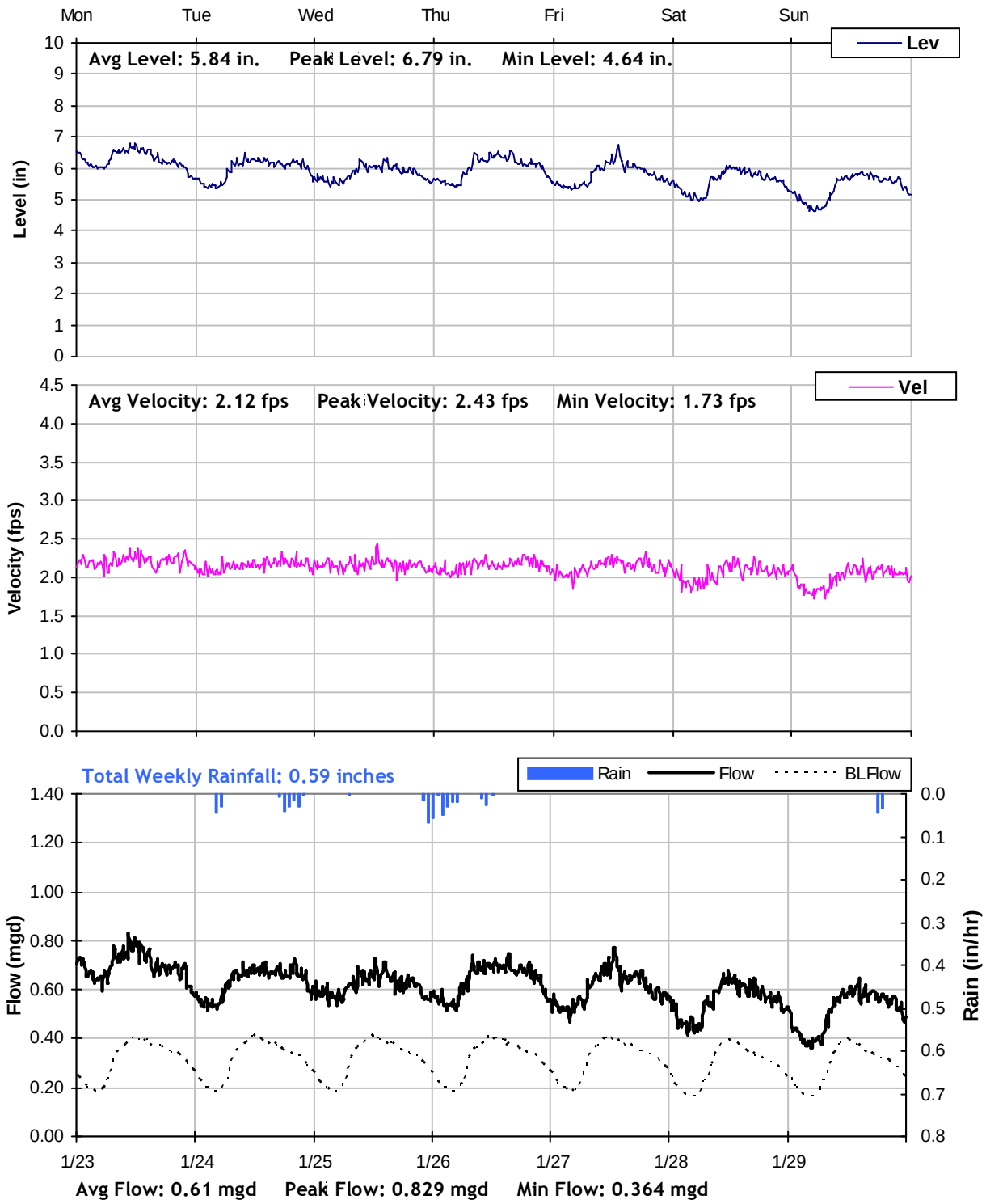
I5

Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



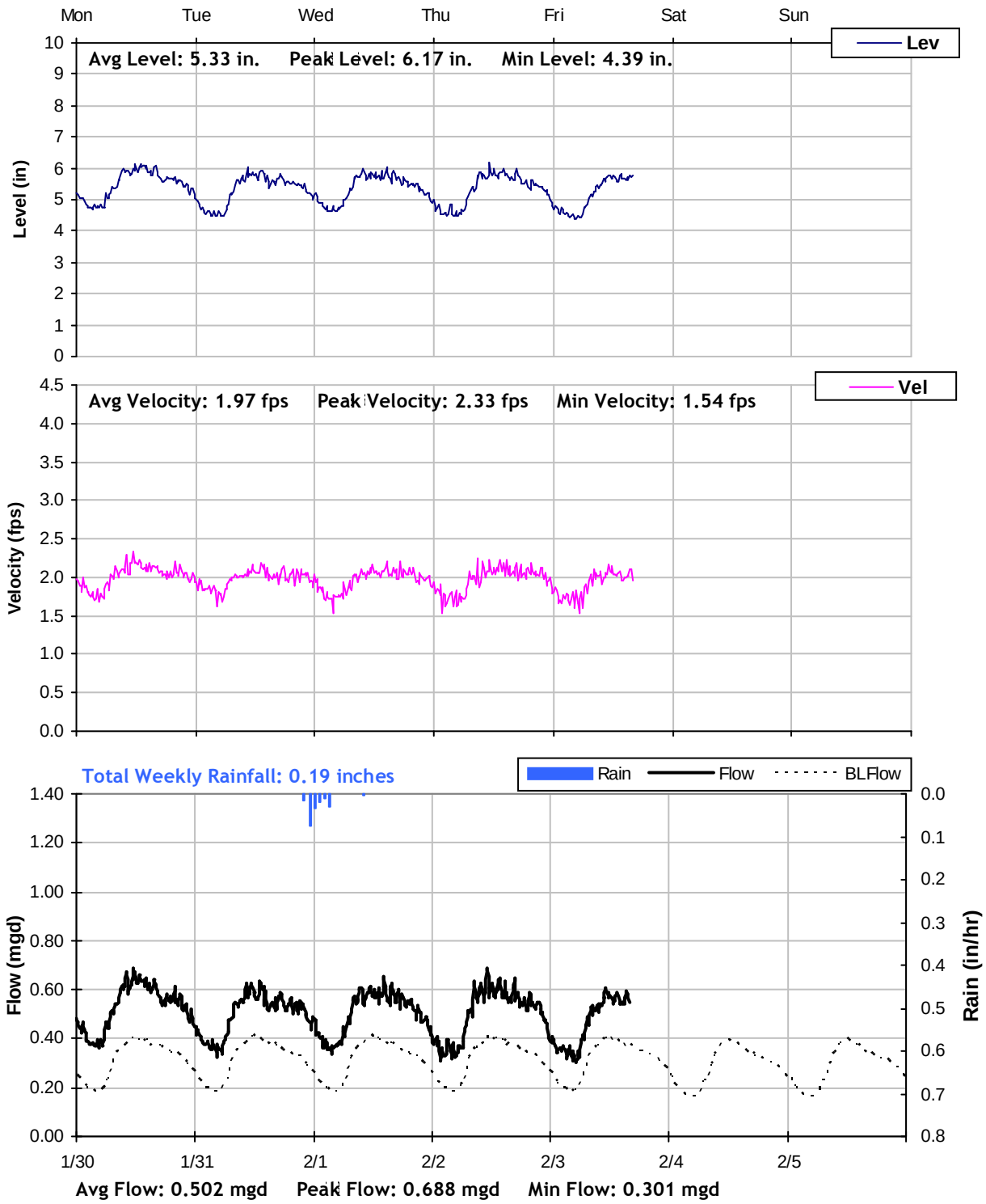
I5

Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



I5

Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

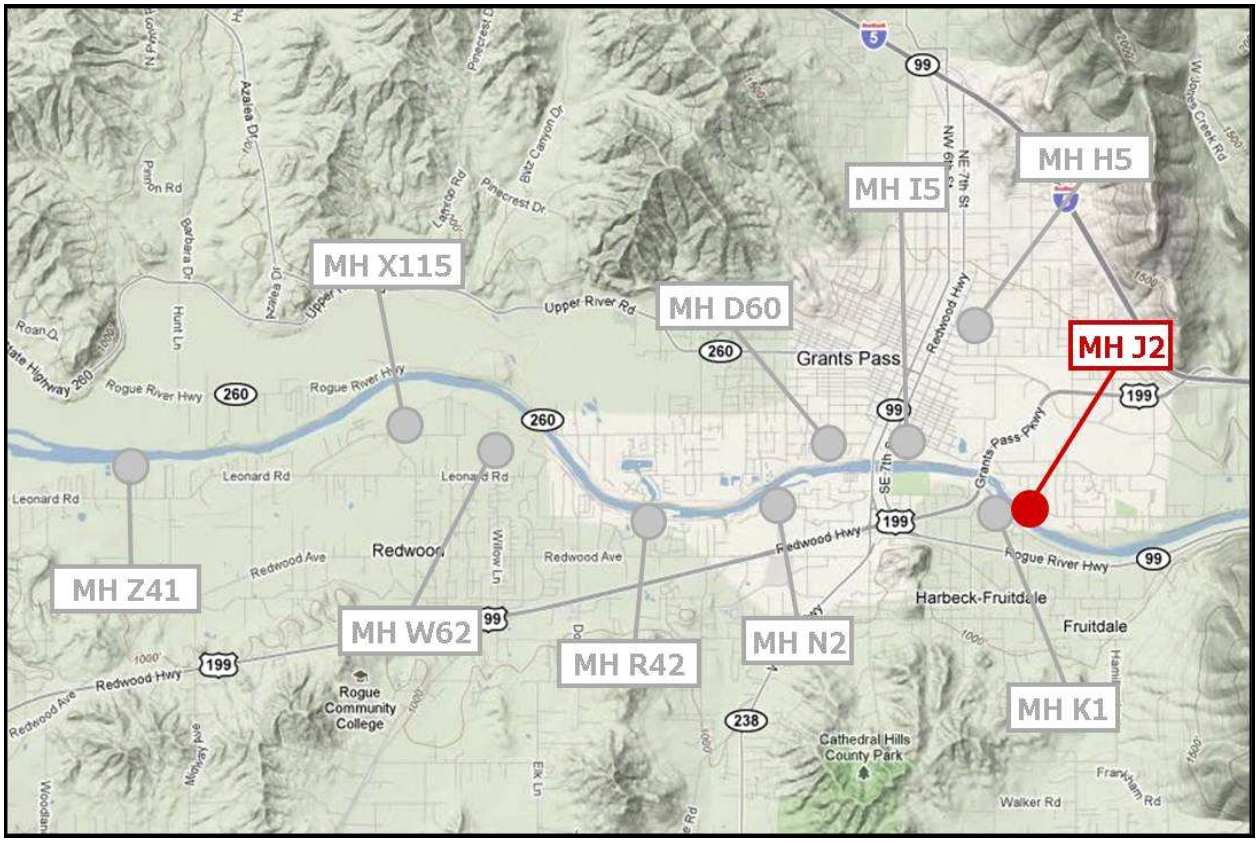
Year 2011/2012

Monitoring Site: J2

Location: 1064 Southeast Belle Aire Drive

Data Summary Report

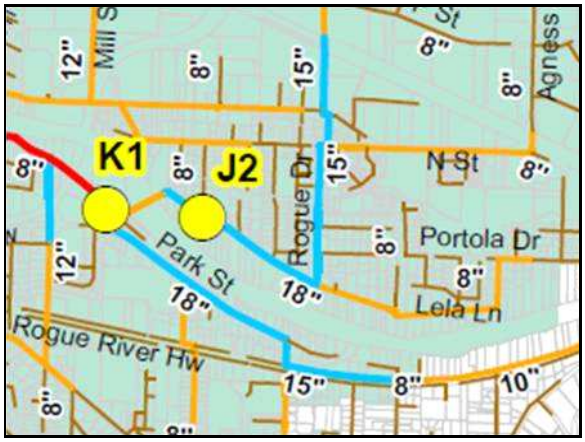
Vicinity Map:



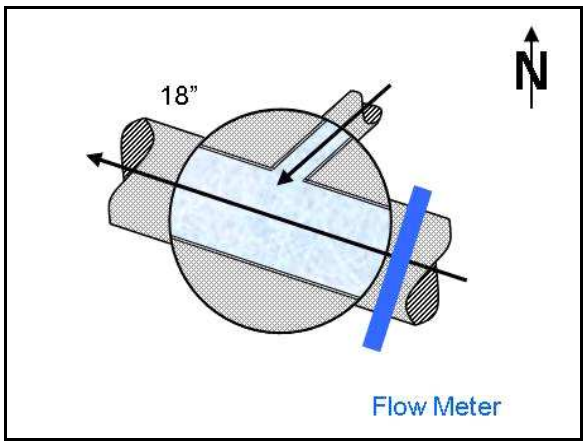
J2
Site Information Report

Location:	1064 Southeast Belle Aire Drive
Coordinates:	123.3129°W, 42.4270°N
Elevation:	926 feet
Diameter:	18 inches
Baseline Flow:	0.331 mgd
Peak Measured Flow:	1.566 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

J2
Additional Site Photos

Effluent Pipe

Main Influent Pipe

J2
Additional Site Photos

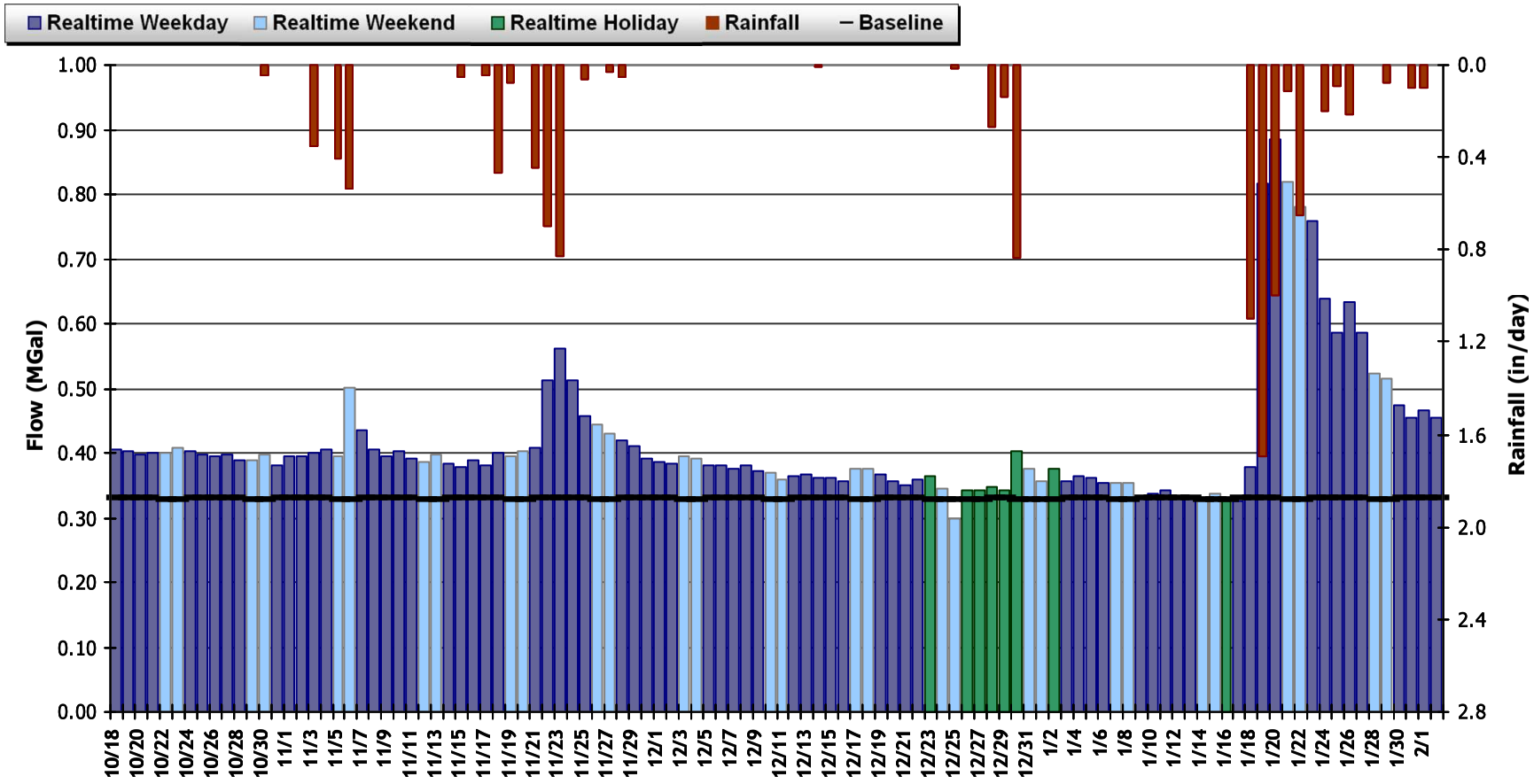
North Influent Pipe

J2

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.417 MGal Peak Daily Flow: 0.886 MGal Min Daily Flow: 0.298 MGal

Total Period Rainfall: 10.71 inches

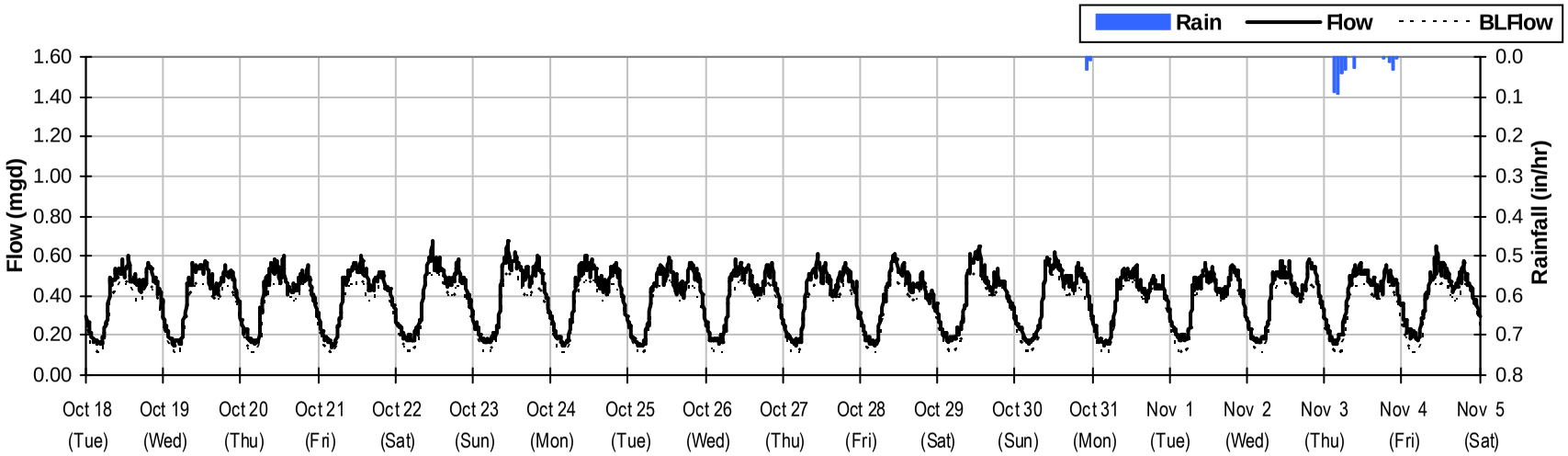


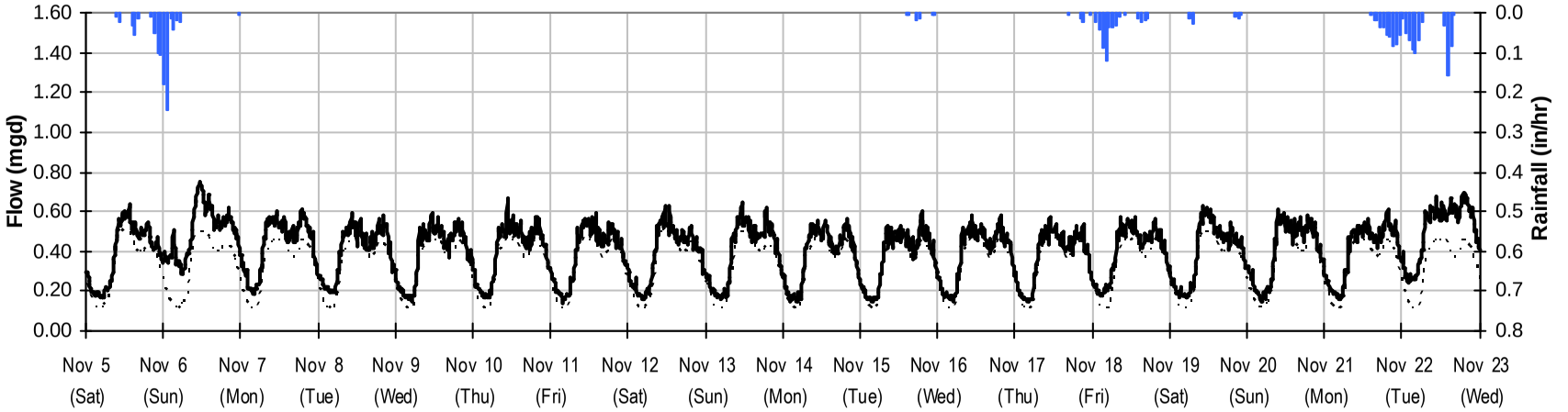
J2

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.403 mgd Peak Flow: 0.751 mgd Min Flow: 0.142 mgd

Total Period Rainfall: 3.13 inches



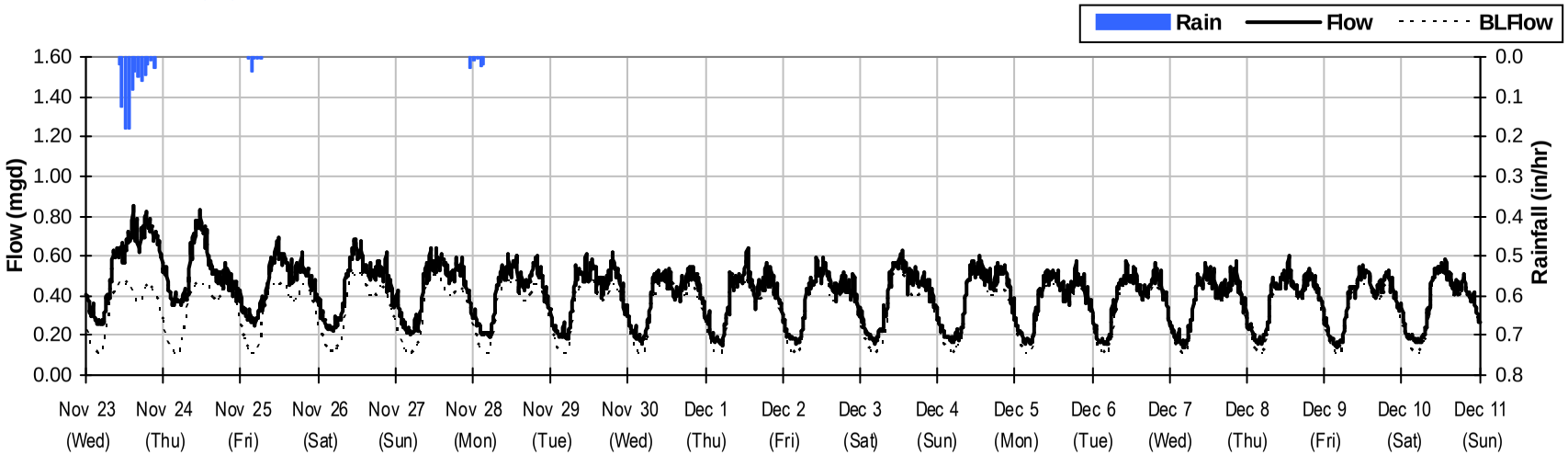


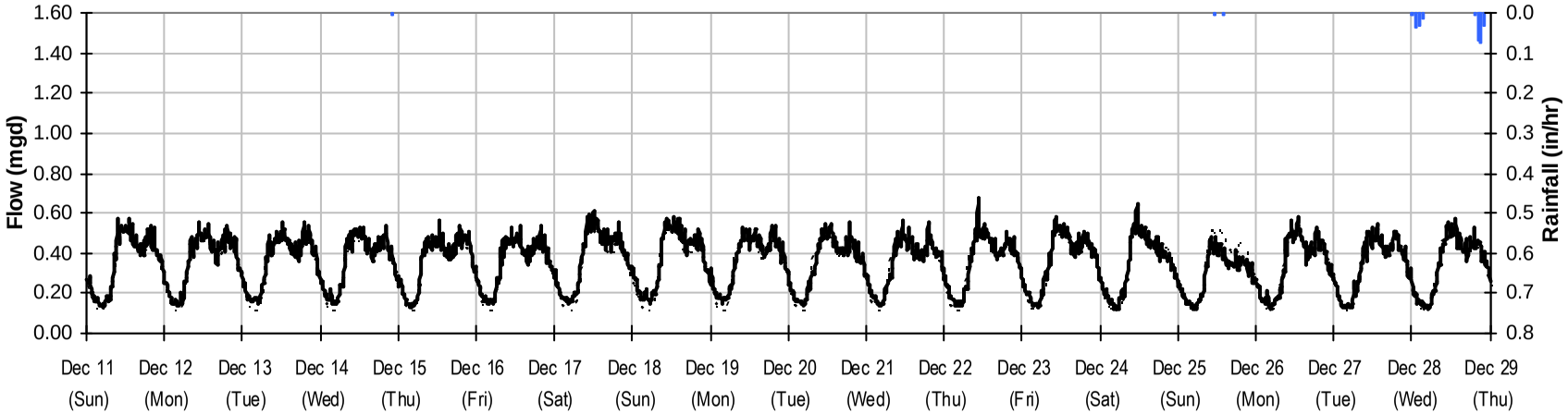
J2

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.384 mgd Peak Flow: 0.847 mgd Min Flow: 0.12 mgd

Total Period Rainfall: 1.27 inches



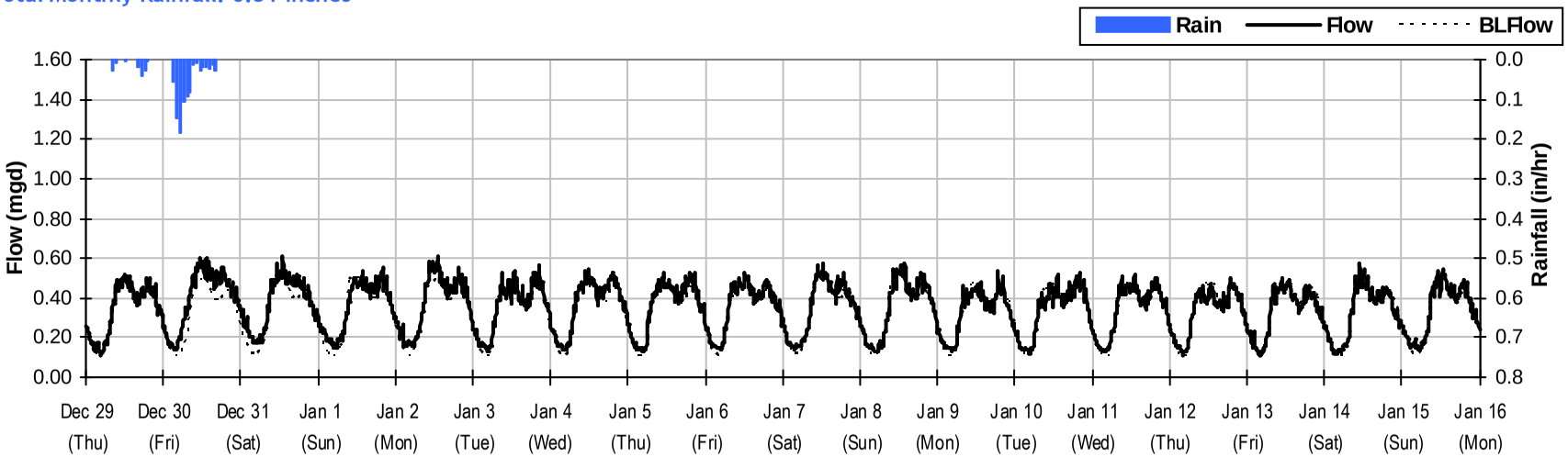


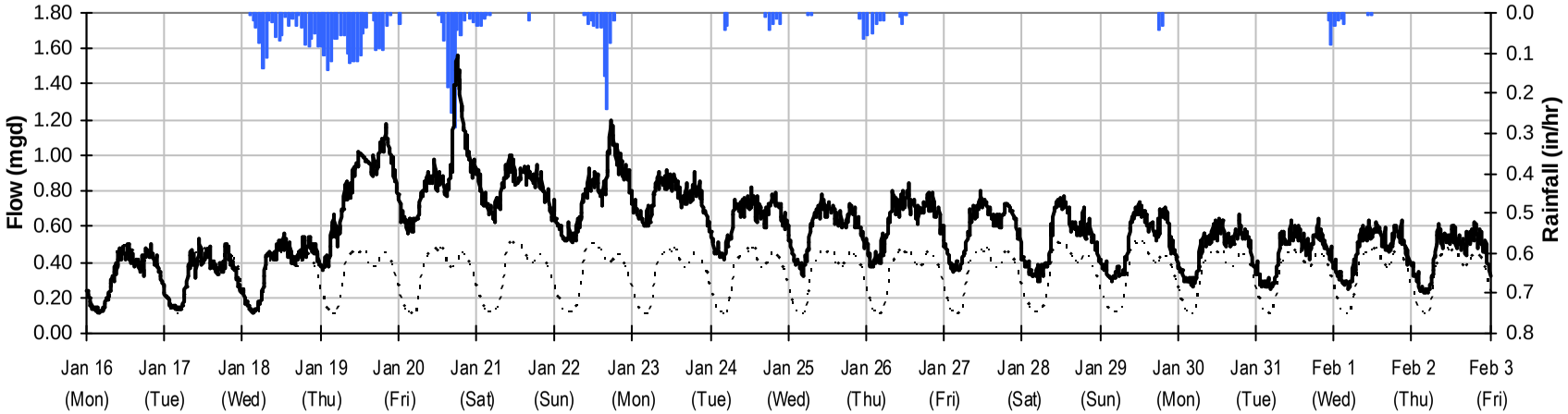
J2

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.47 mgd Peak Flow: 1.57 mgd Min Flow: 0.11 mgd

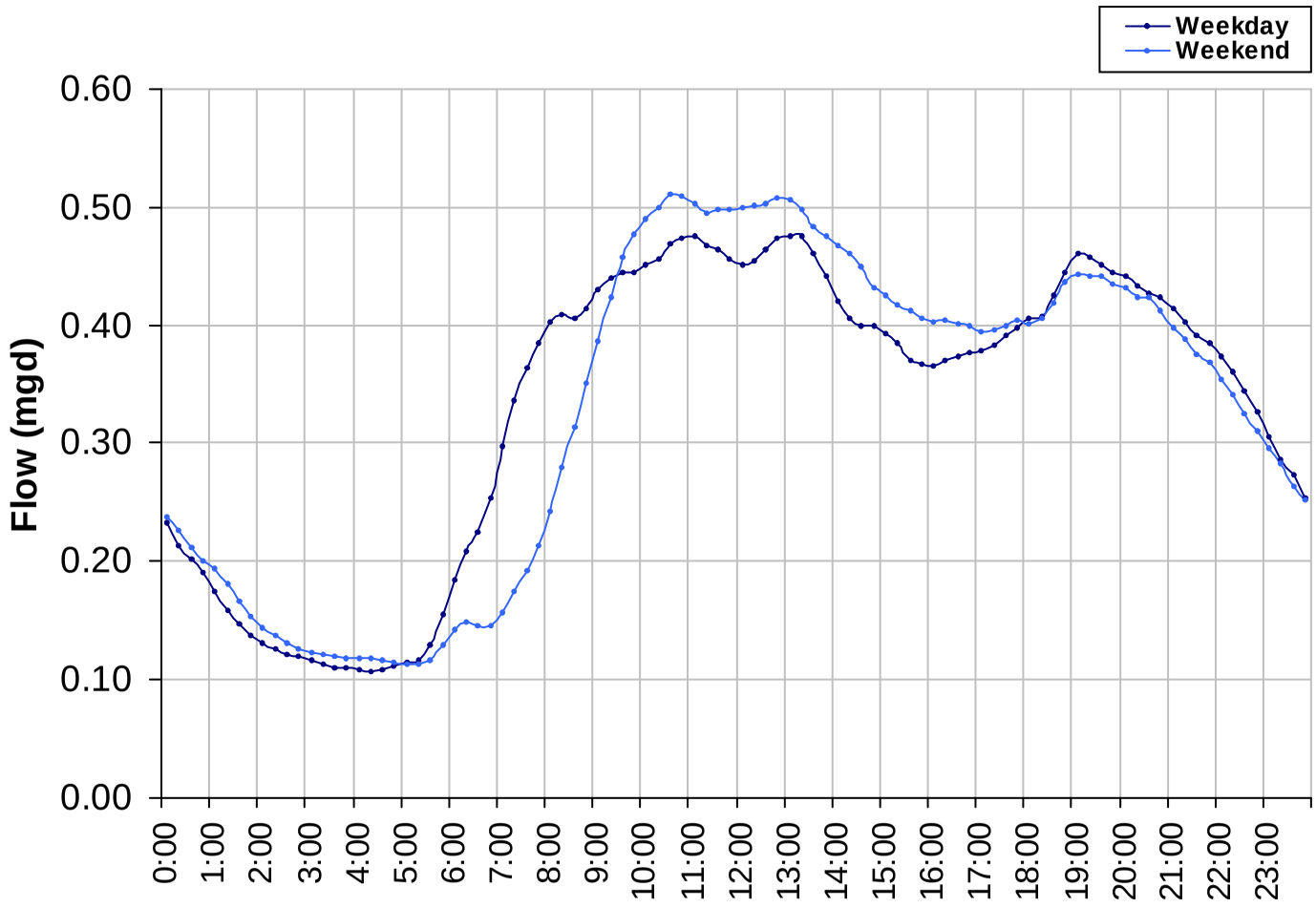
Total Monthly Rainfall: 6.31 inches





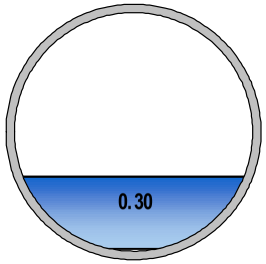
J2

Baseline Flow Hydrographs



Baseline Flow:

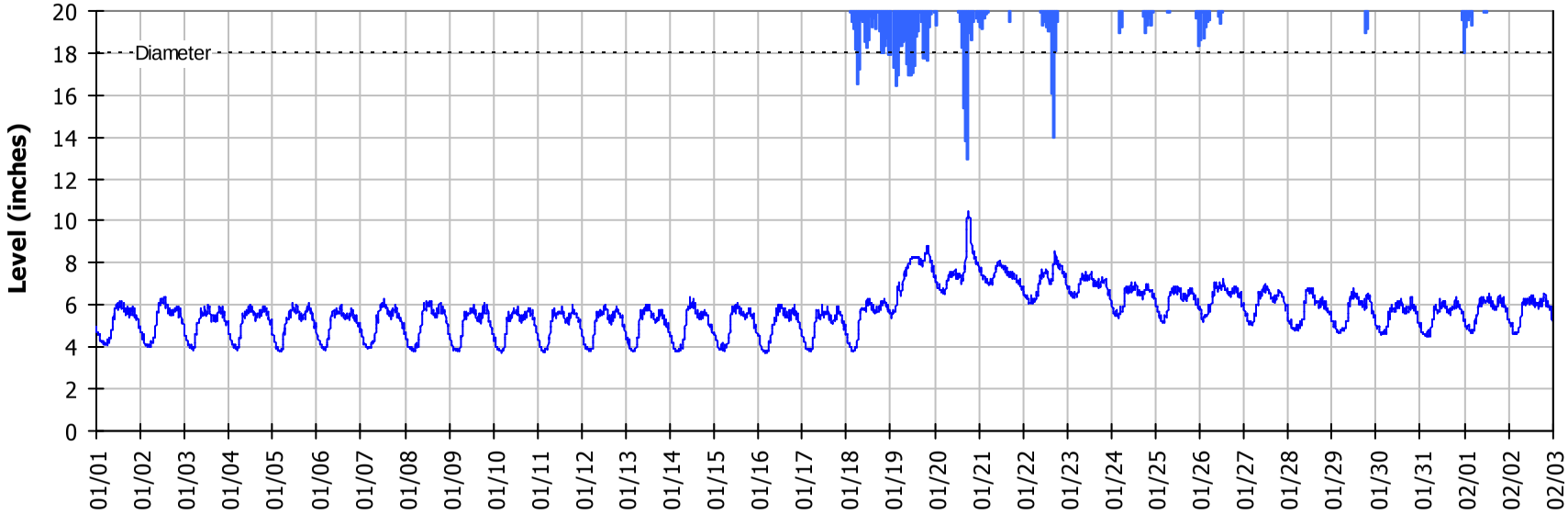
0.331 *mgd*

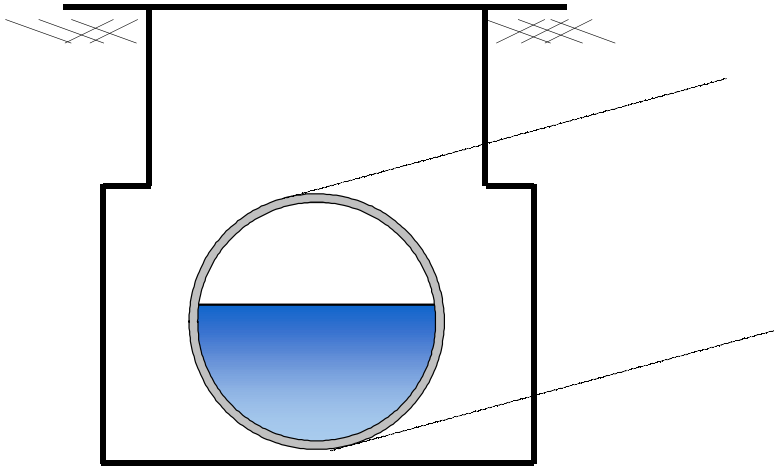


J2

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

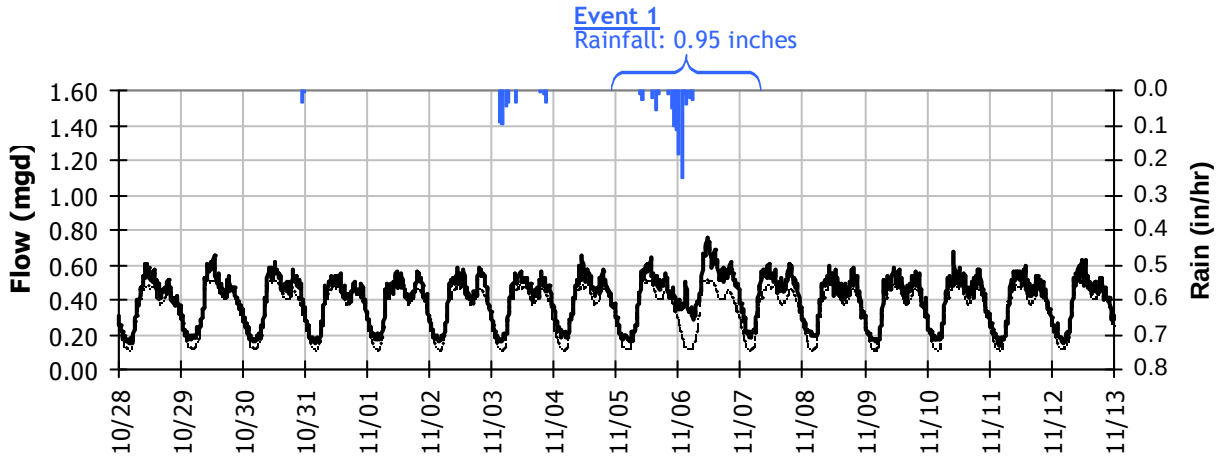




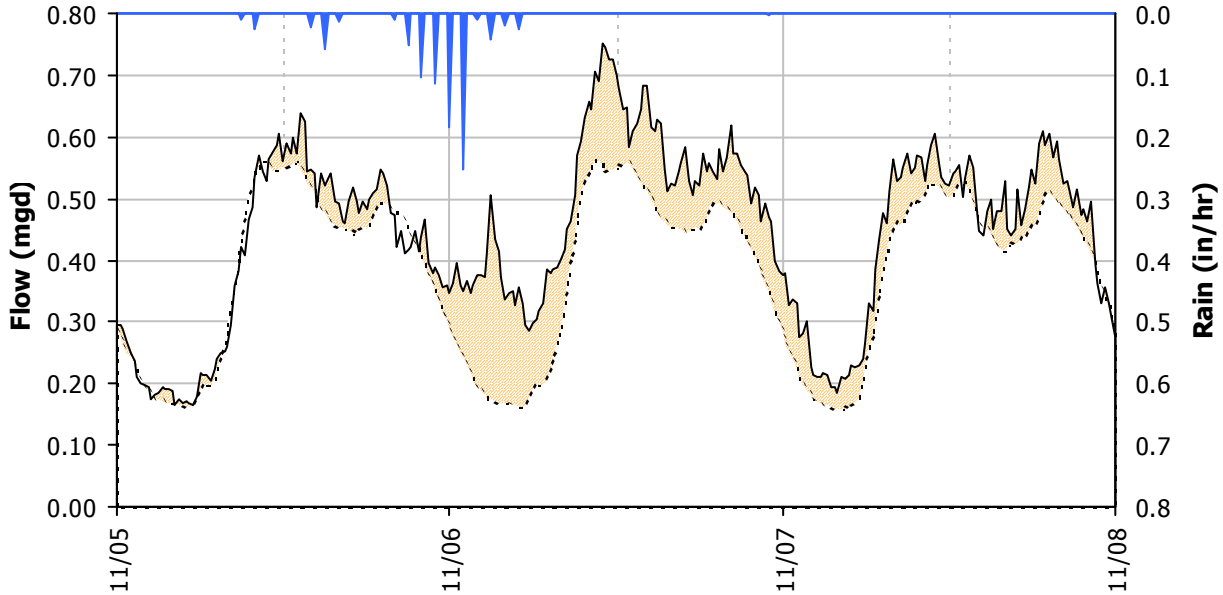
Pipe Diameter:	18	*inches*
Peak Measured Level	10.5	*inches*
Peak d/D Ratio:	0.58	

SITE J2
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

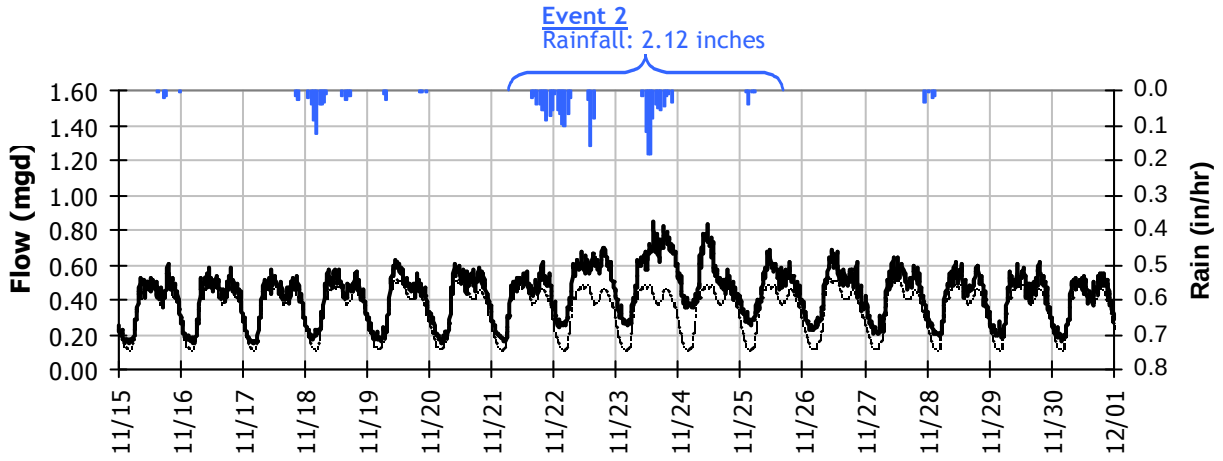


Storm Event I/I Analysis (Rain = 0.95 inches)

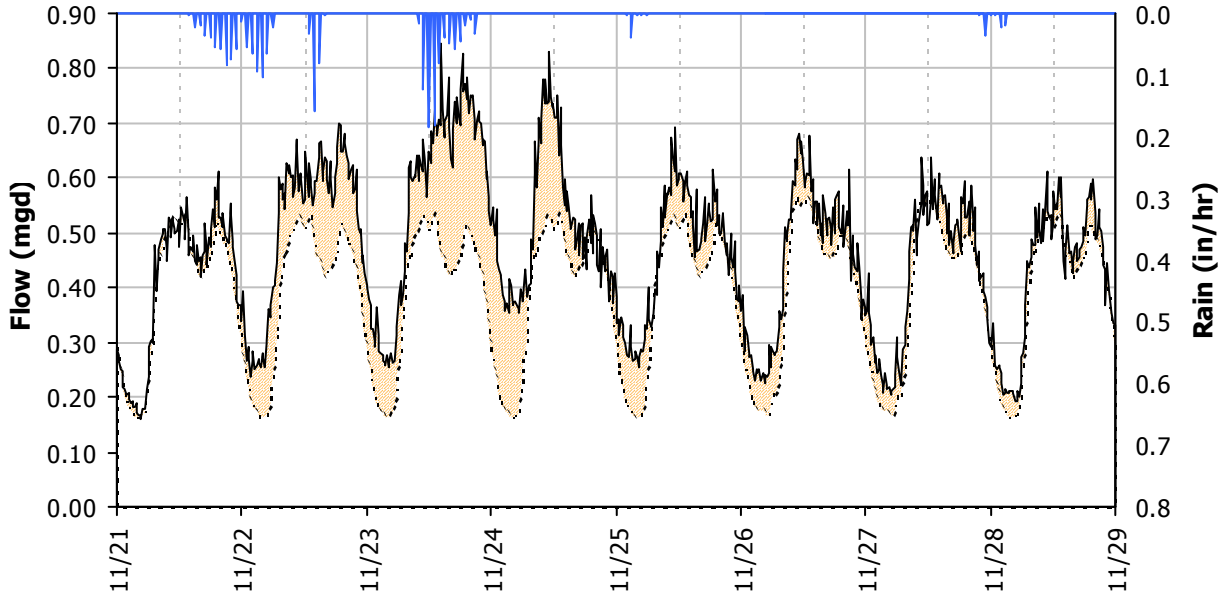
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.75 *mgd*	Peak I/I Rate:	0.38 *mgd*	Infiltration Rate: (11/7/2011)	0.101 *mgd*	Total I/I:	189,000 *gallons*
PF:	2.26	PkI/I:IDM:	2,839 *gpd/IDM*	RDI:IDM:	754 *gpd/IDM*	Total I/I:IDM:	1,478 *gal/IDM/in*
Peak Level:	7.03 *in*	PkI/I:Acre:	458 *gpd/acre*	RDI:Acre:	122 *gpd/acre*	R-Value:	0.9%
d/D Ratio:	0.39	Pk I/I:ADWF:	1.15	RDI (% of BL):	31%	Total I/I:ADWF:	0.60 *per in-rain*

SITE J2
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

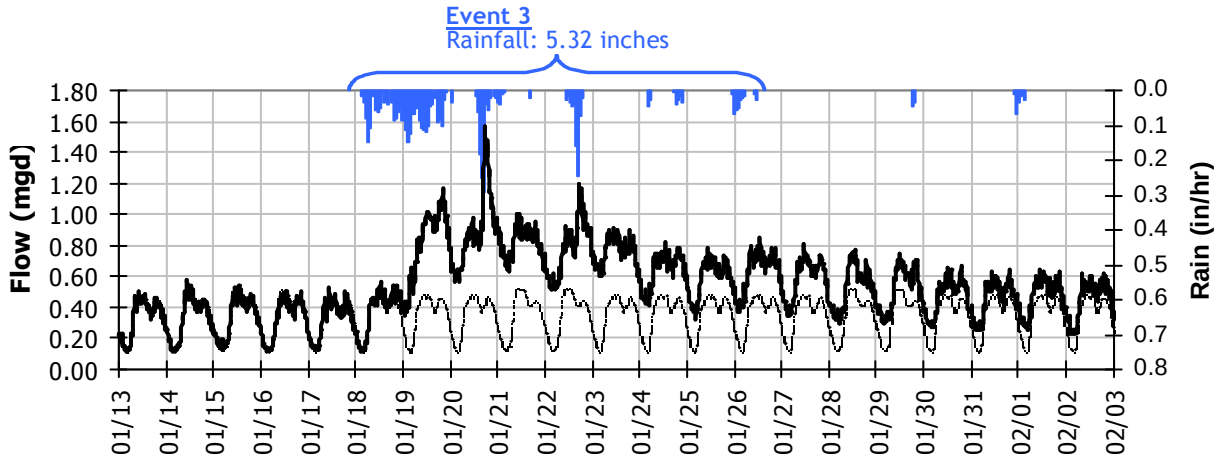


Storm Event I/I Analysis (Rain = 2.12 inches)

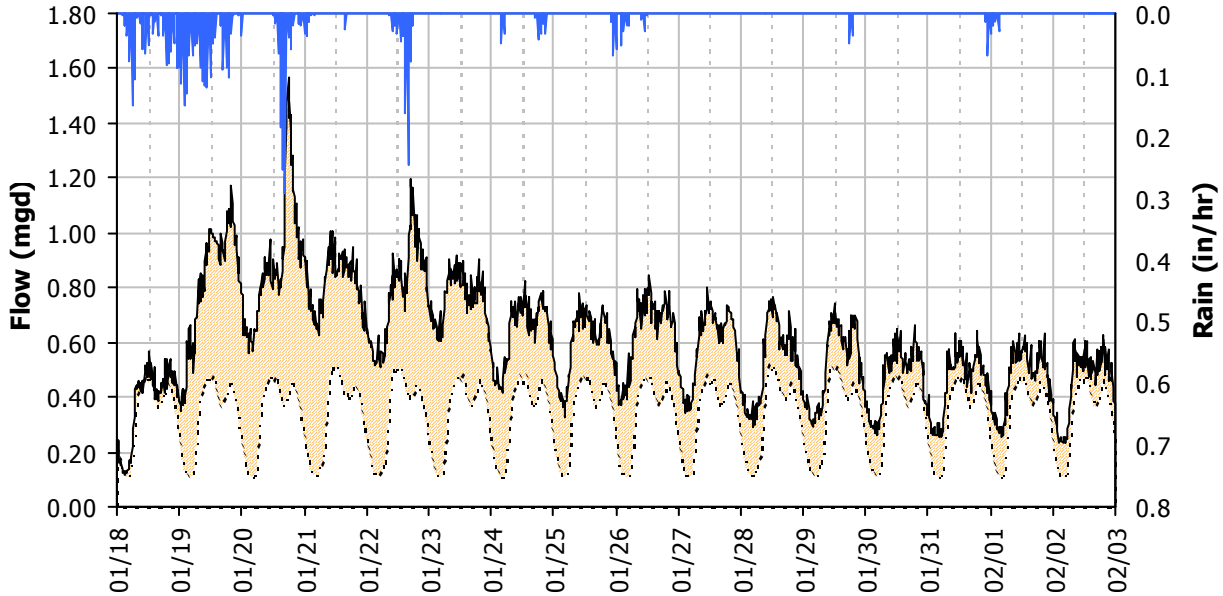
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.85 *mgd*	Peak I/I Rate:	0.45 *mgd*	Infiltration Rate: (11/26/2011)	0.117 *mgd*	Total I/I:	653,000 *gallons*
PF:	2.56	PkI/I:IDM:	3,326 *gpd/IDM*	RDI:IDM:	869 *gpd/IDM*	Total I/I:IDM:	2,290 *gal/IDM/in*
Peak Level:	7.44 *in*	PkI/I:Acre:	536 *gpd/acre*	RDI:Acre:	140 *gpd/acre*	R-Value:	1.4%
d/D Ratio:	0.41	Pk I/I:ADWF:	1.35	RDI (% of BL):	36%	Total I/I:ADWF:	0.93 *per in-rain*

SITE J2
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

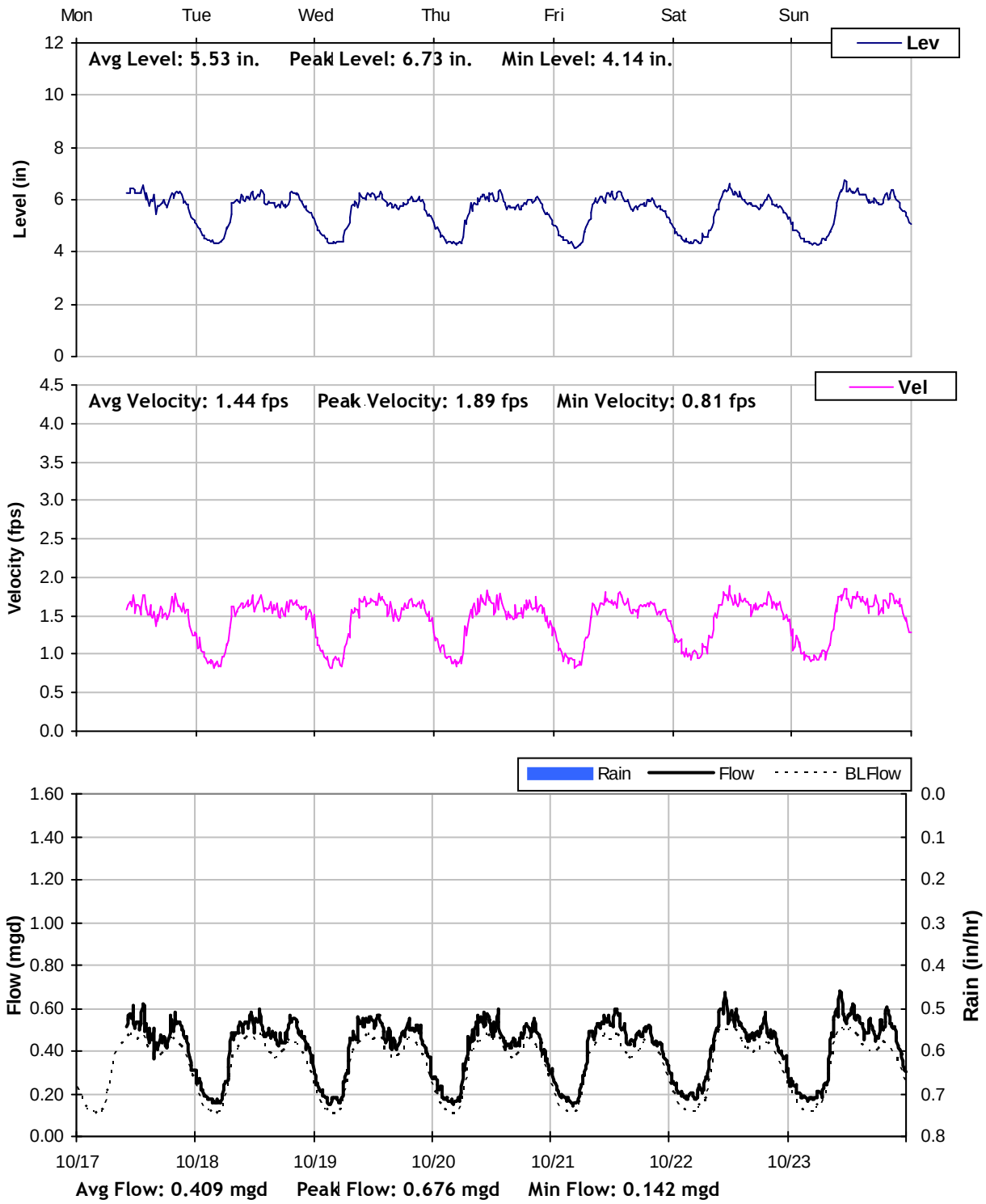


Storm Event I/I Analysis (Rain = 5.32 inches)

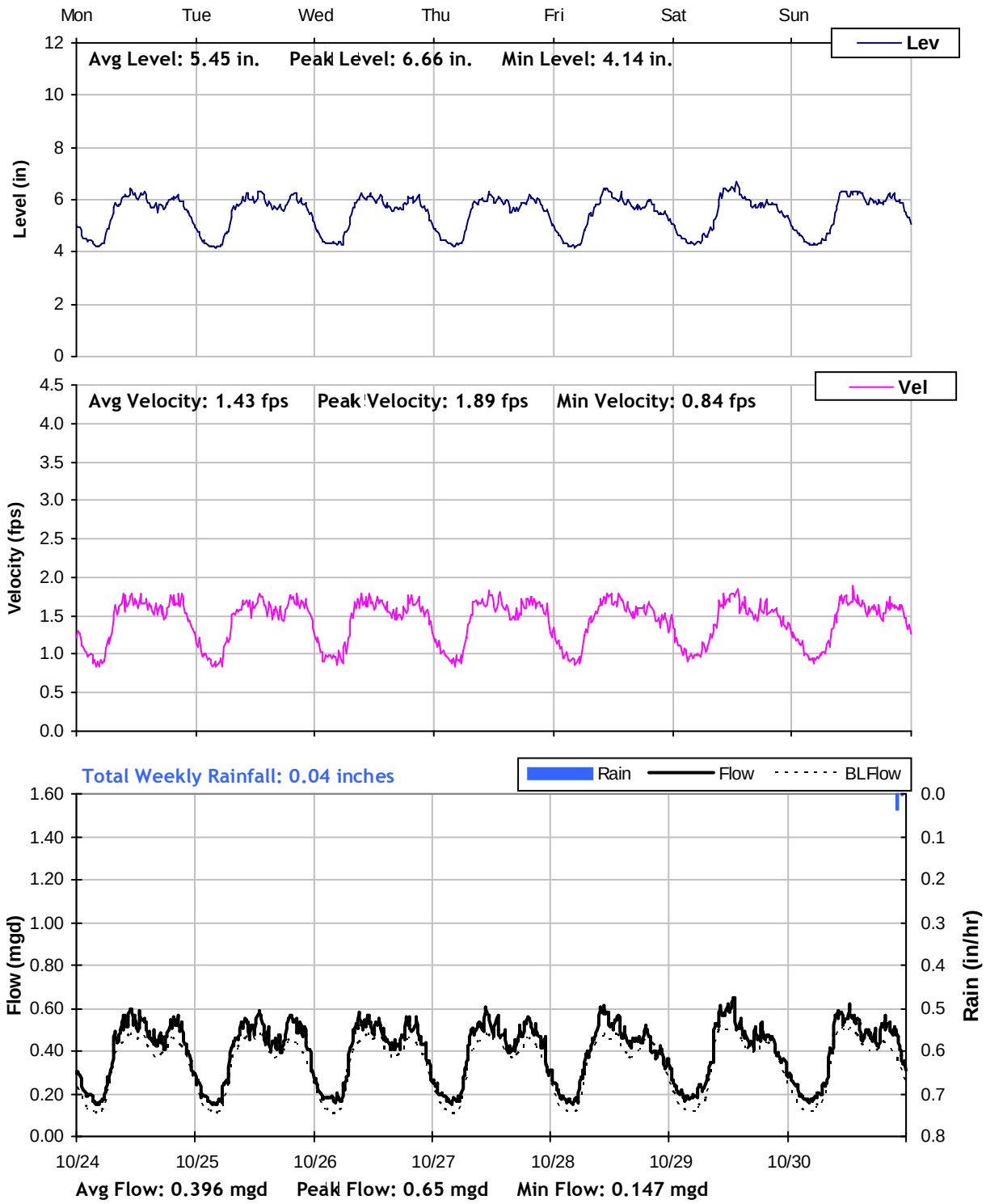
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	1.57 *mgd*	Peak I/I Rate:	1.16 *mgd*	Infiltration Rate: (1/30/2012)	0.140 *mgd*	Total I/I:	4,460,000 *gallons*
PF:	4.72	PkI/I:IDM:	8,631 *gpd/IDM*	RDI:IDM:	1,038 *gpd/IDM*	Total I/I:IDM:	6,239 *gal/IDM/in*
Peak Level:	10.45 *in*	PkI/I:Acre:	1,392 *gpd/acre*	RDI:Acre:	167 *gpd/acre*	R-Value:	3.7%
d/D Ratio:	0.58	Pk I/I:ADWF:	3.50	RDI (% of BL):	42%	Total I/I:ADWF:	2.53 *per in-rain*

J2

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011

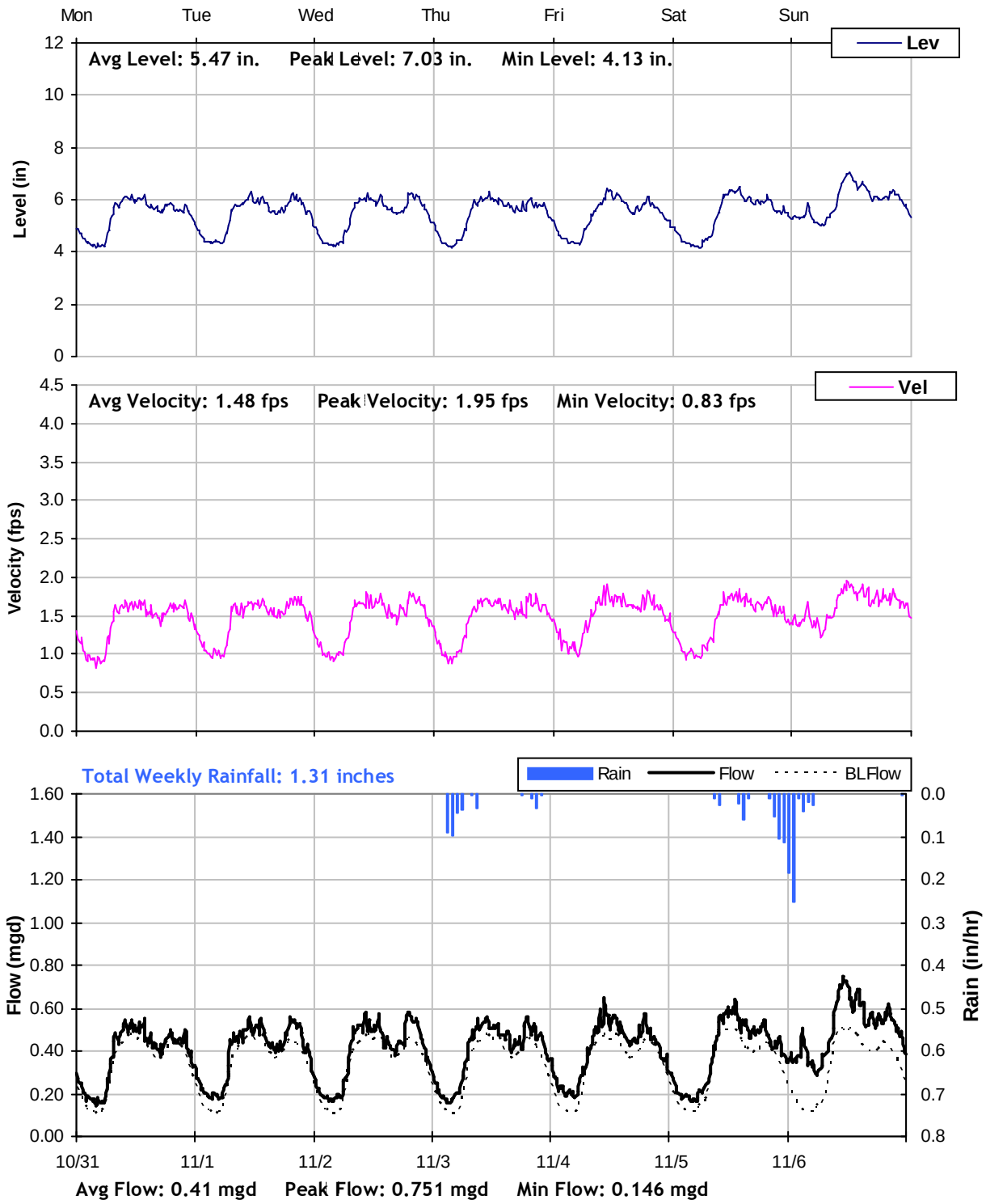


J2
Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



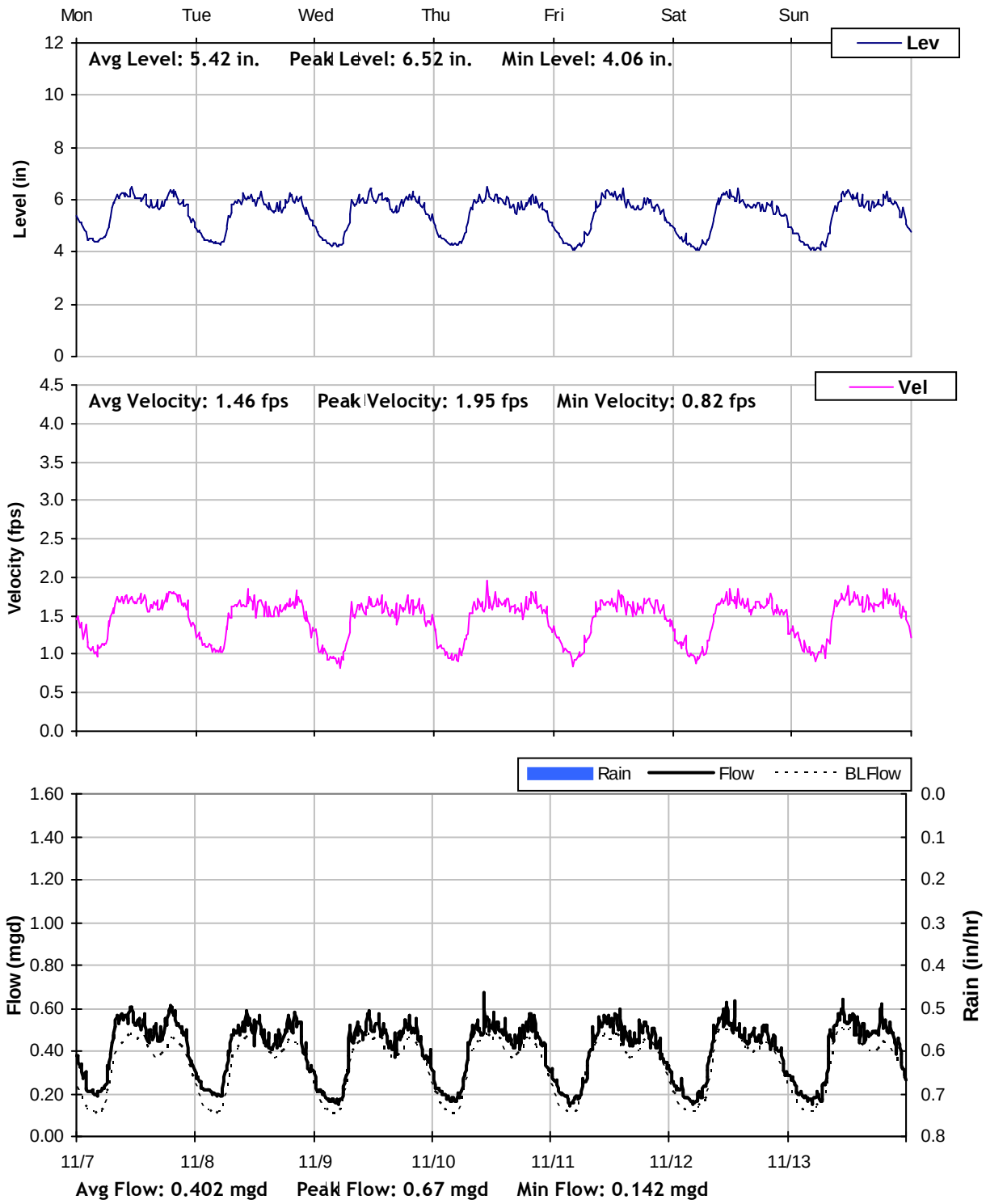
J2

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011

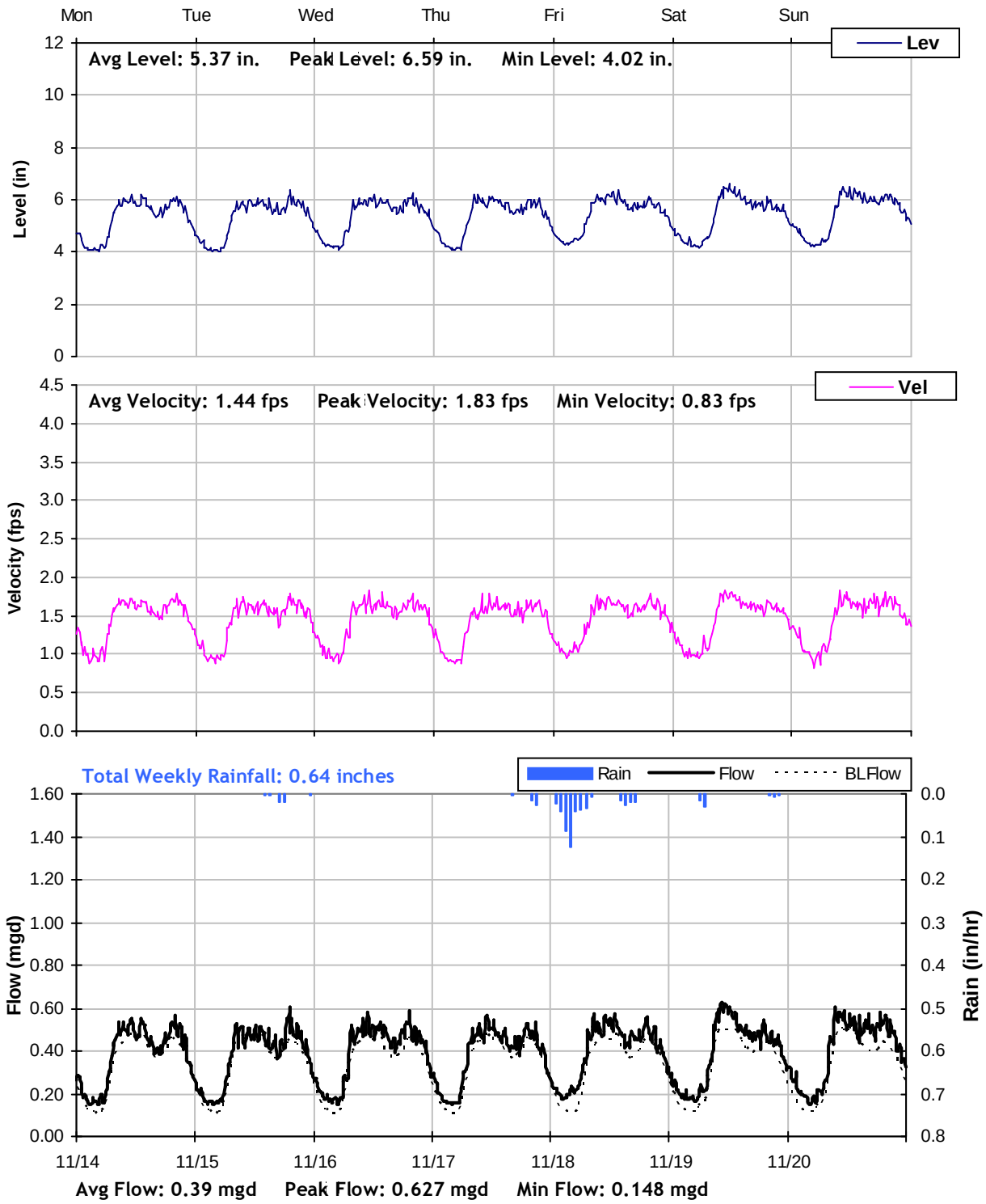


J2

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011

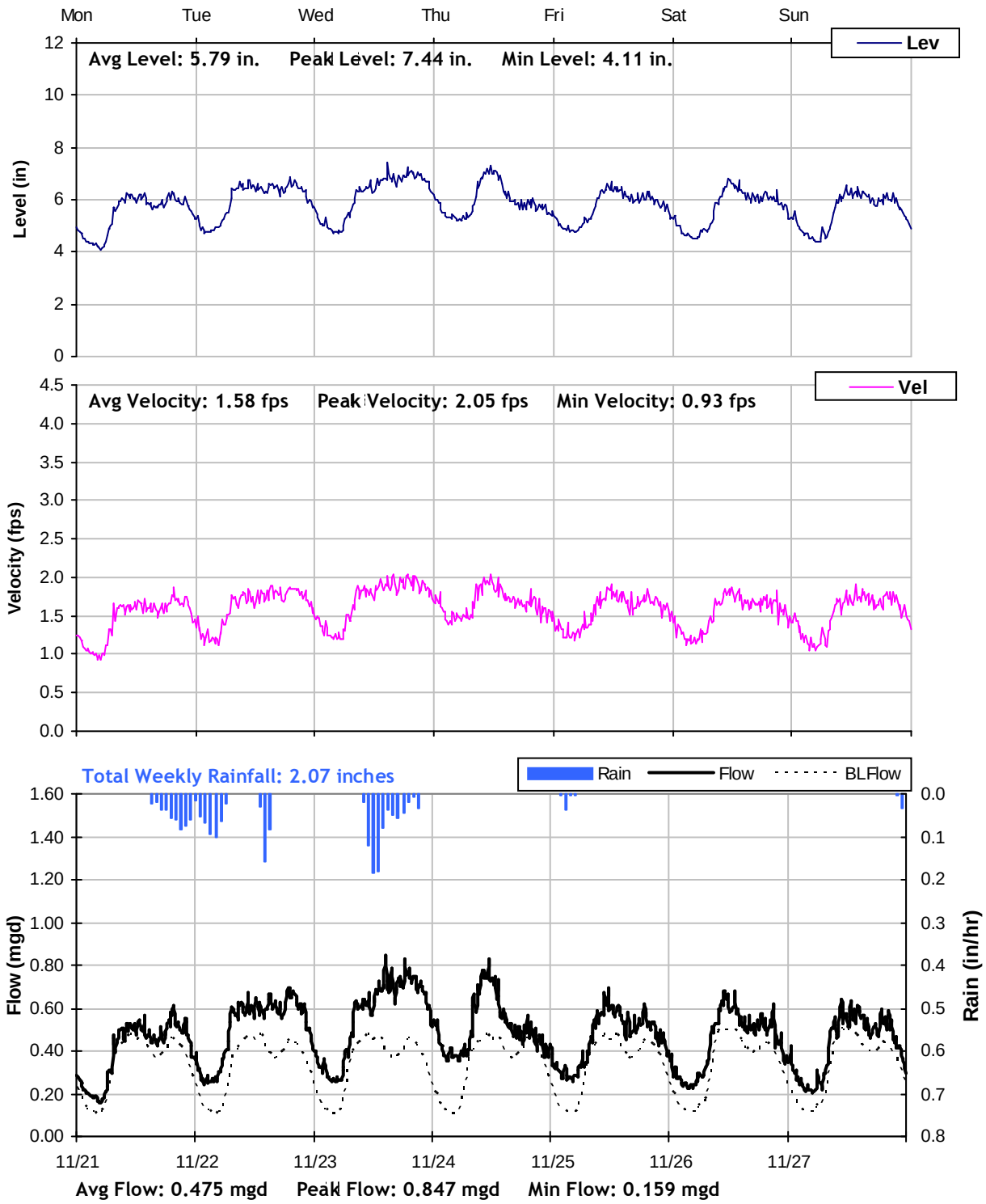


J2
Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



J2

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



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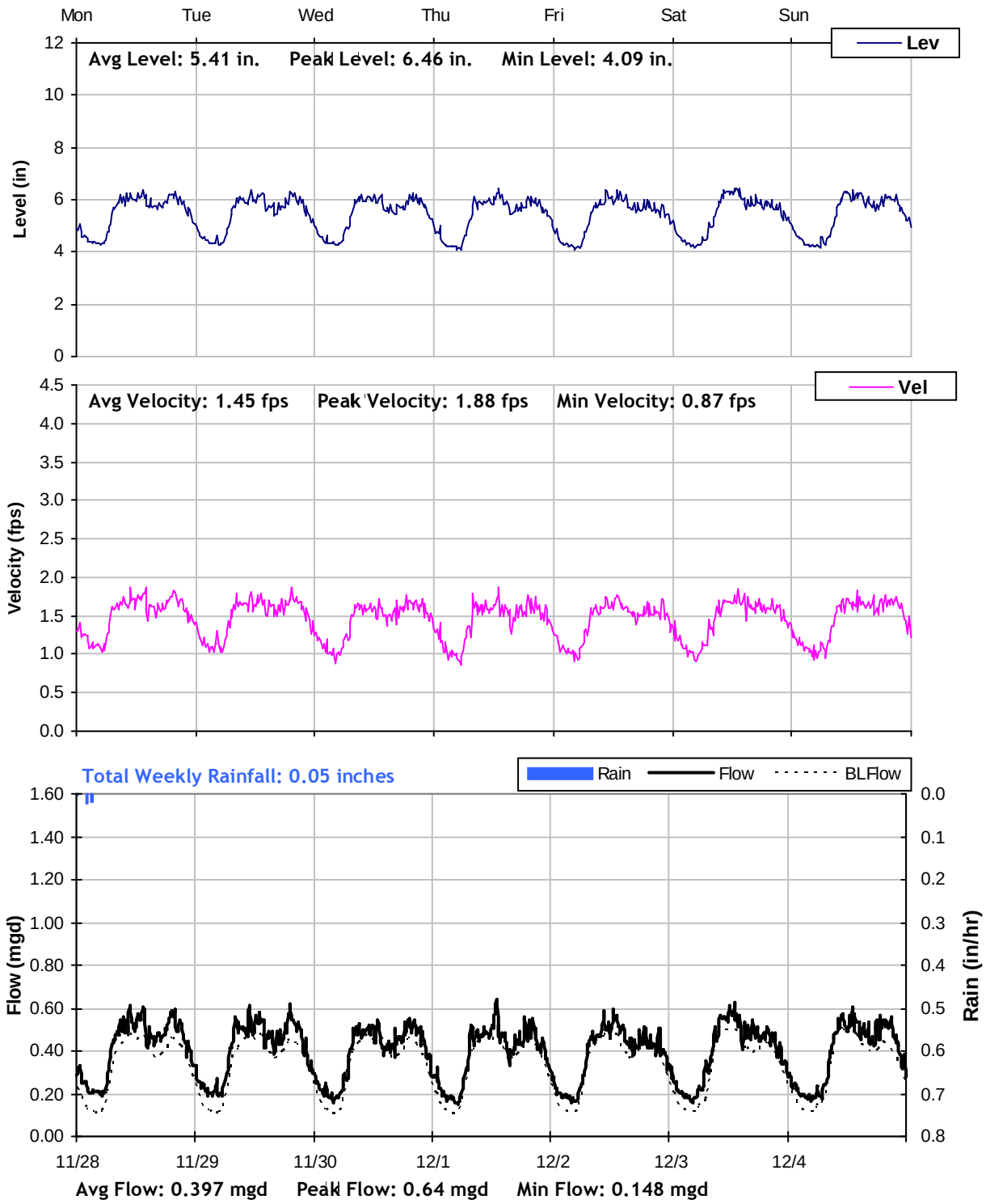
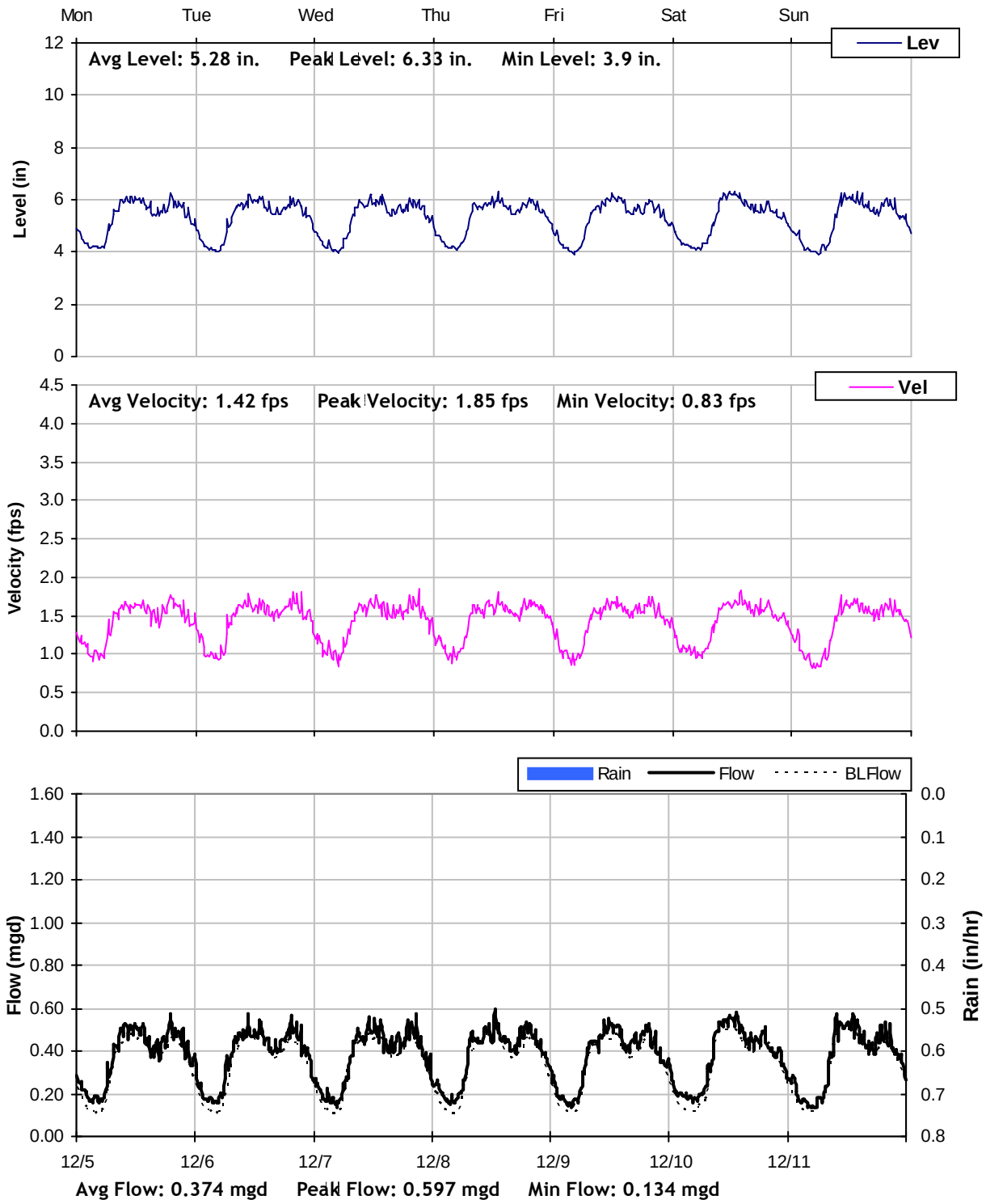
Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



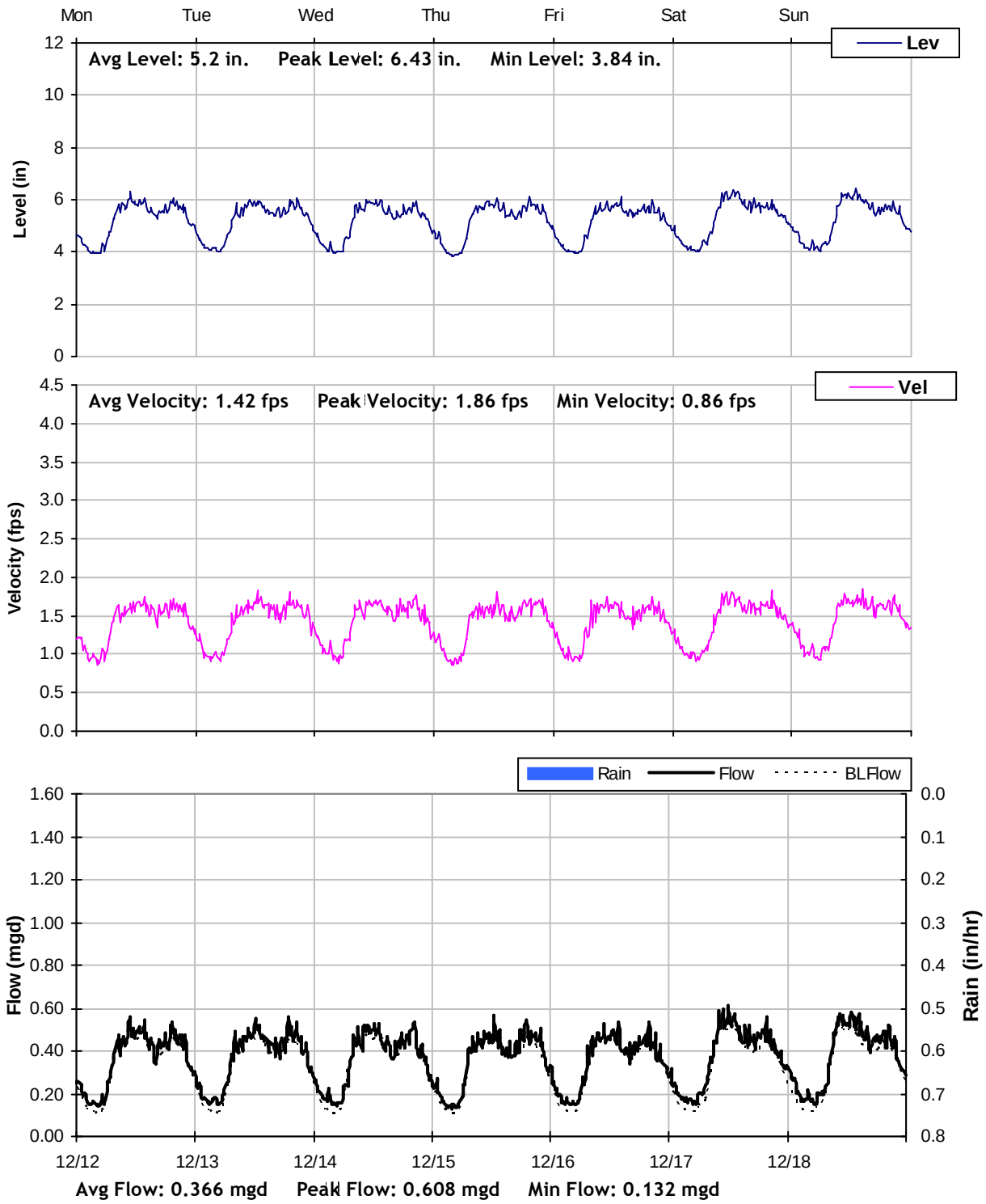
J2

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



J2

Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



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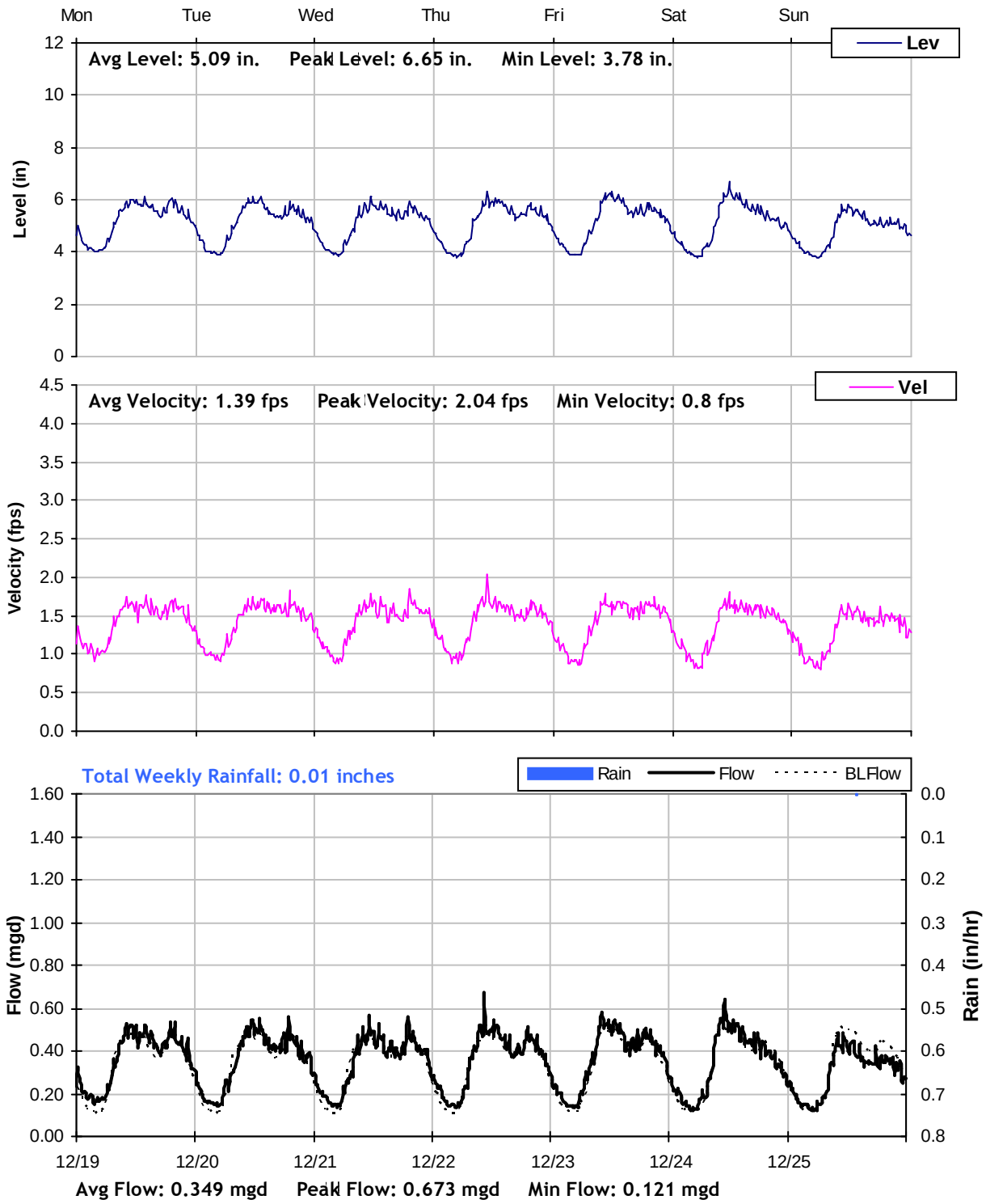
Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



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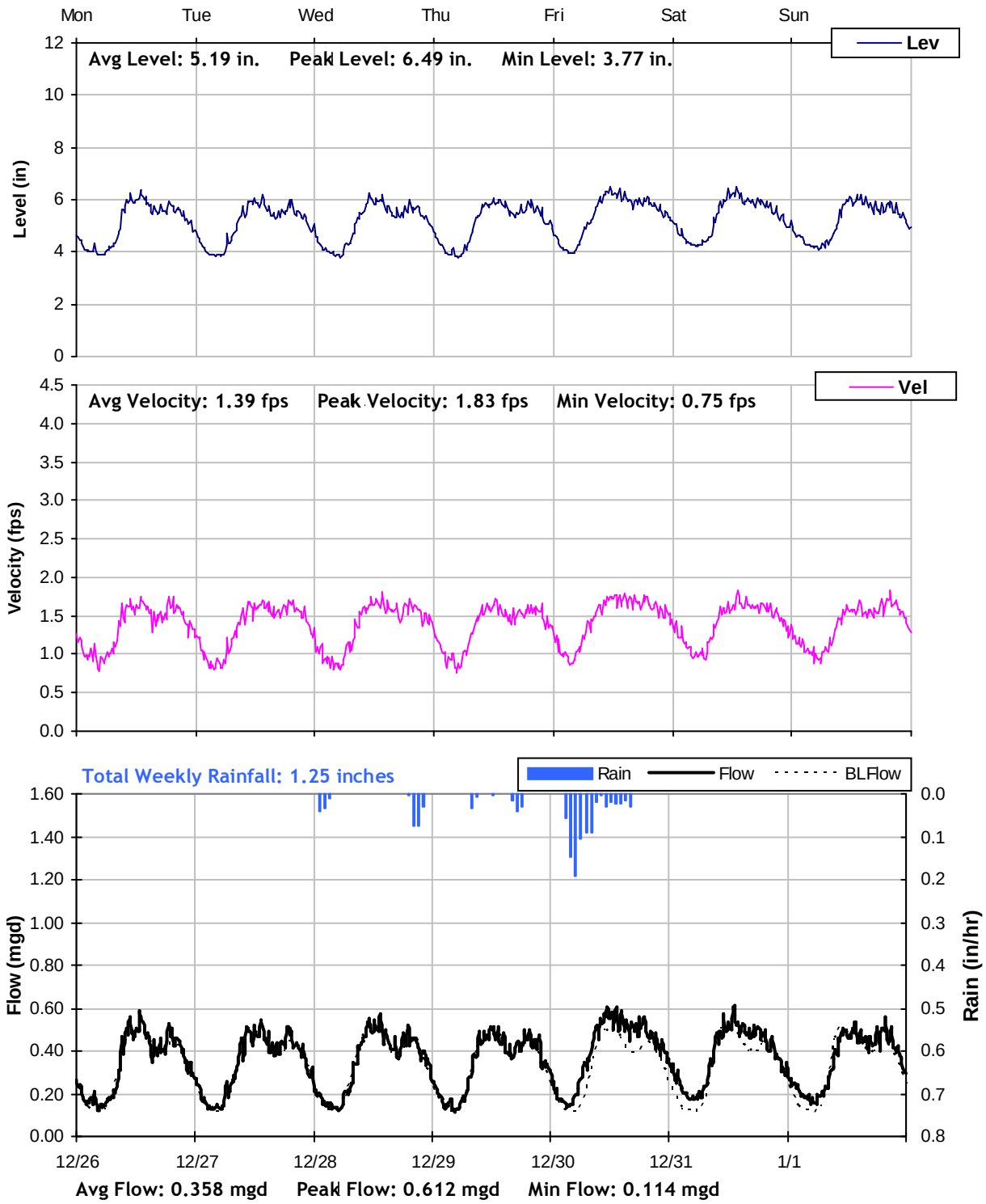
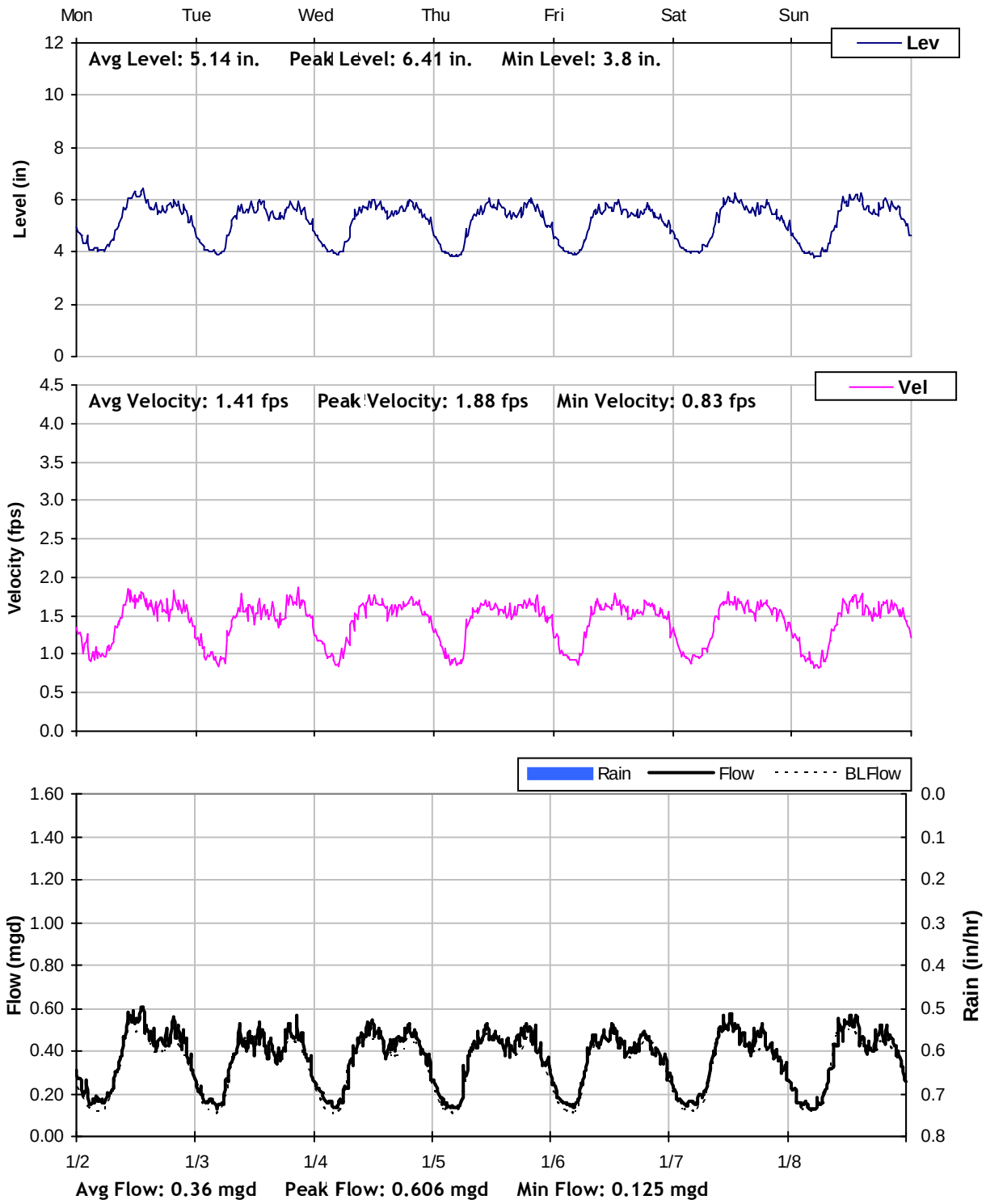
Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



J2
Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



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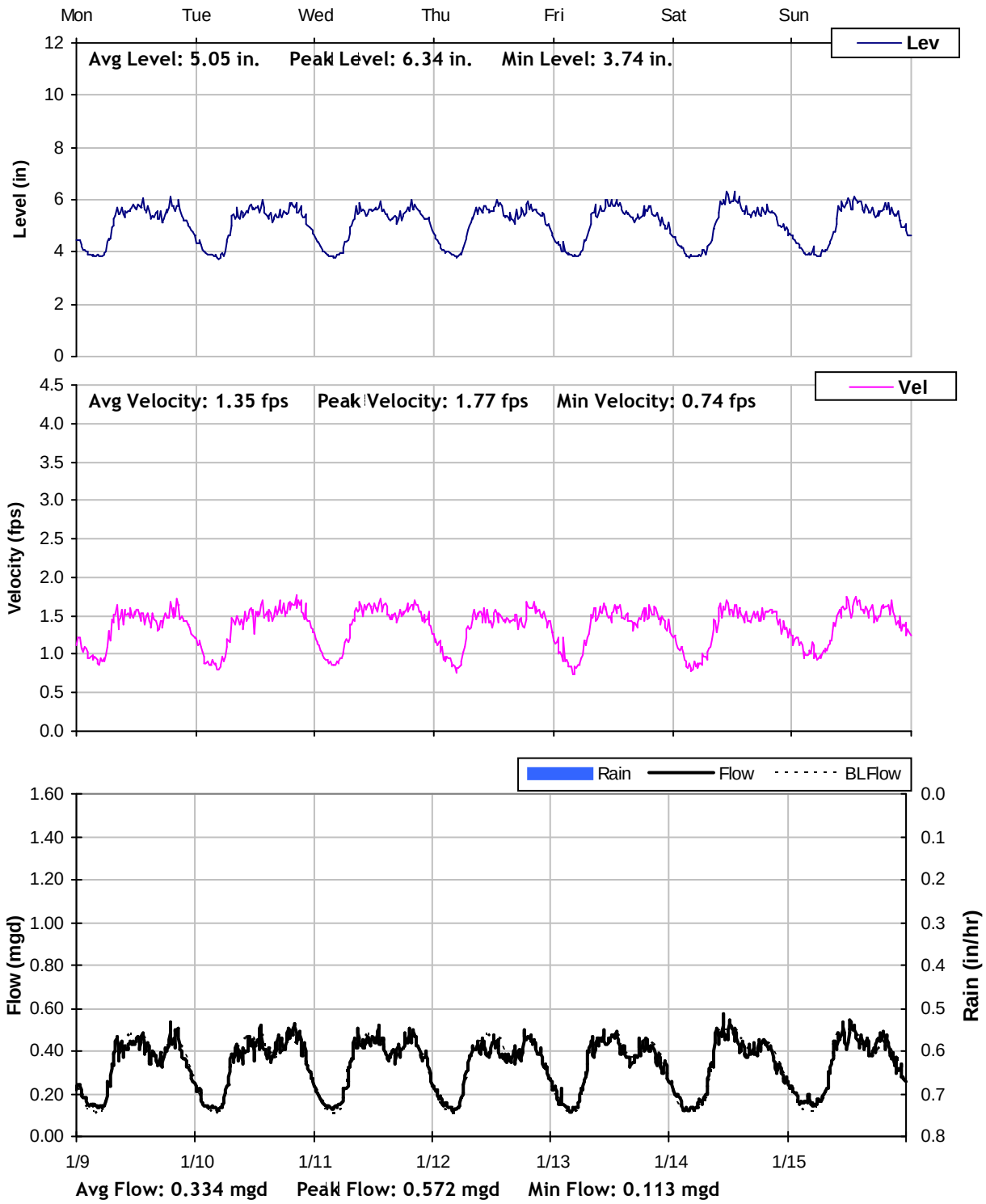
Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



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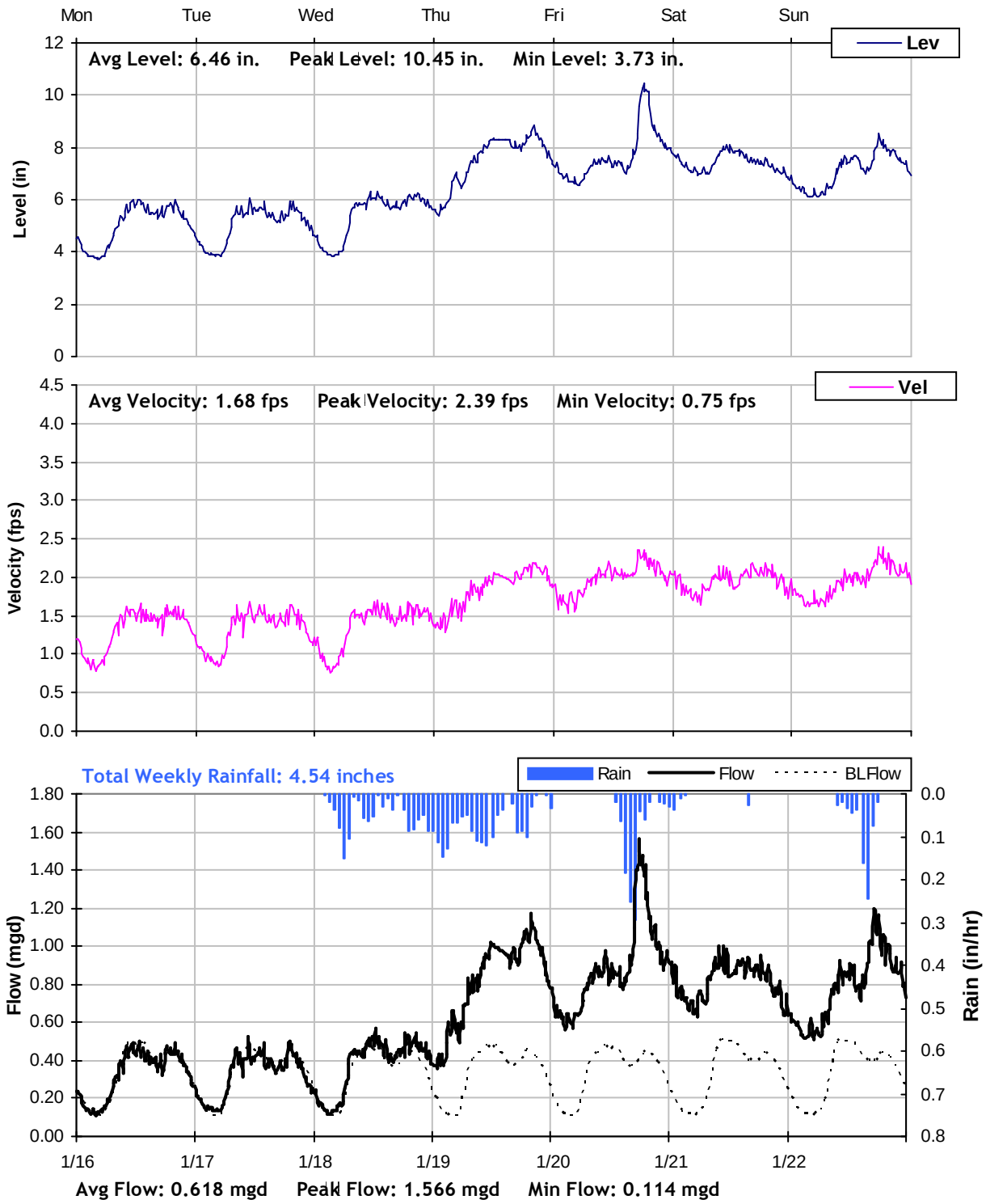
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



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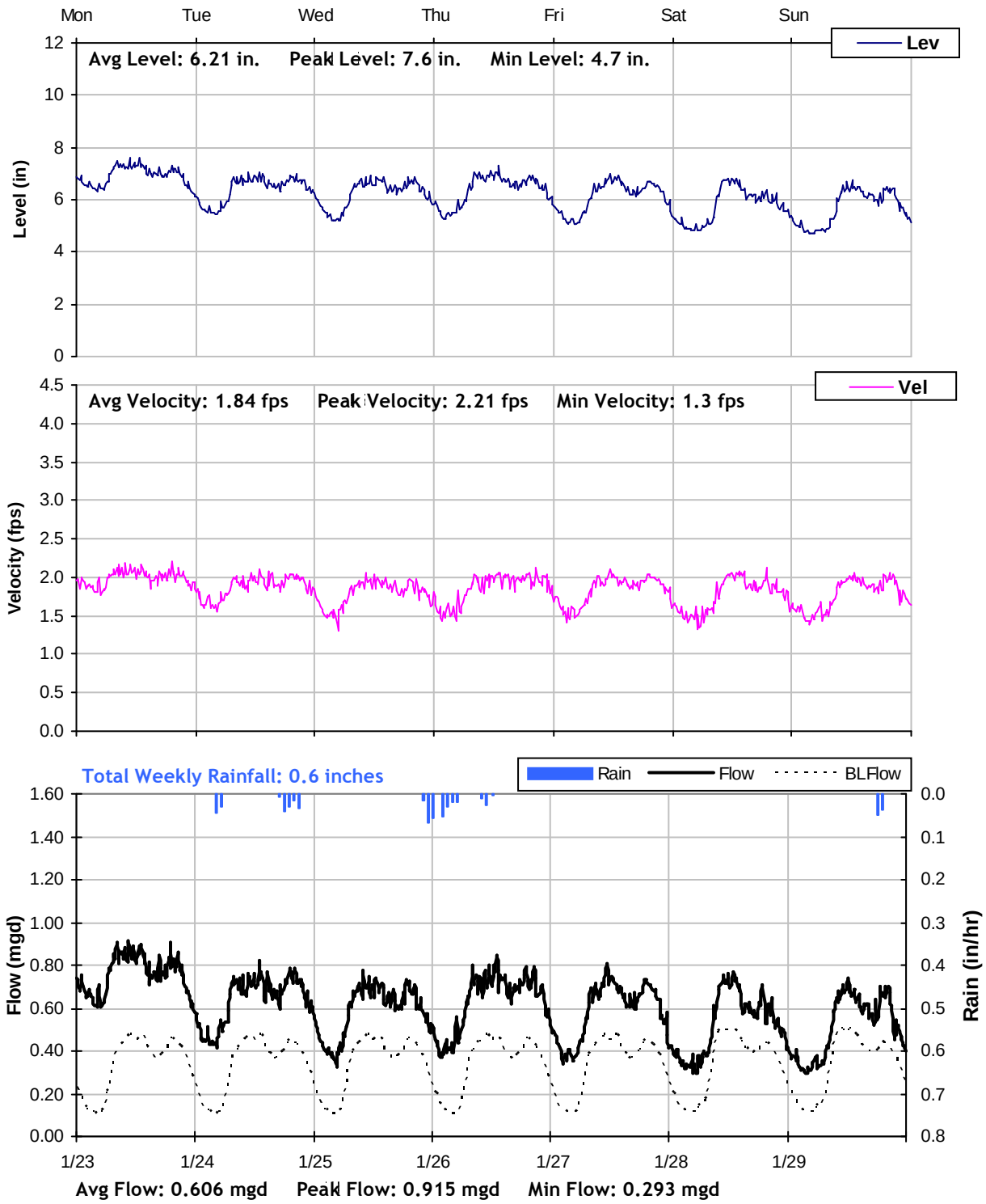
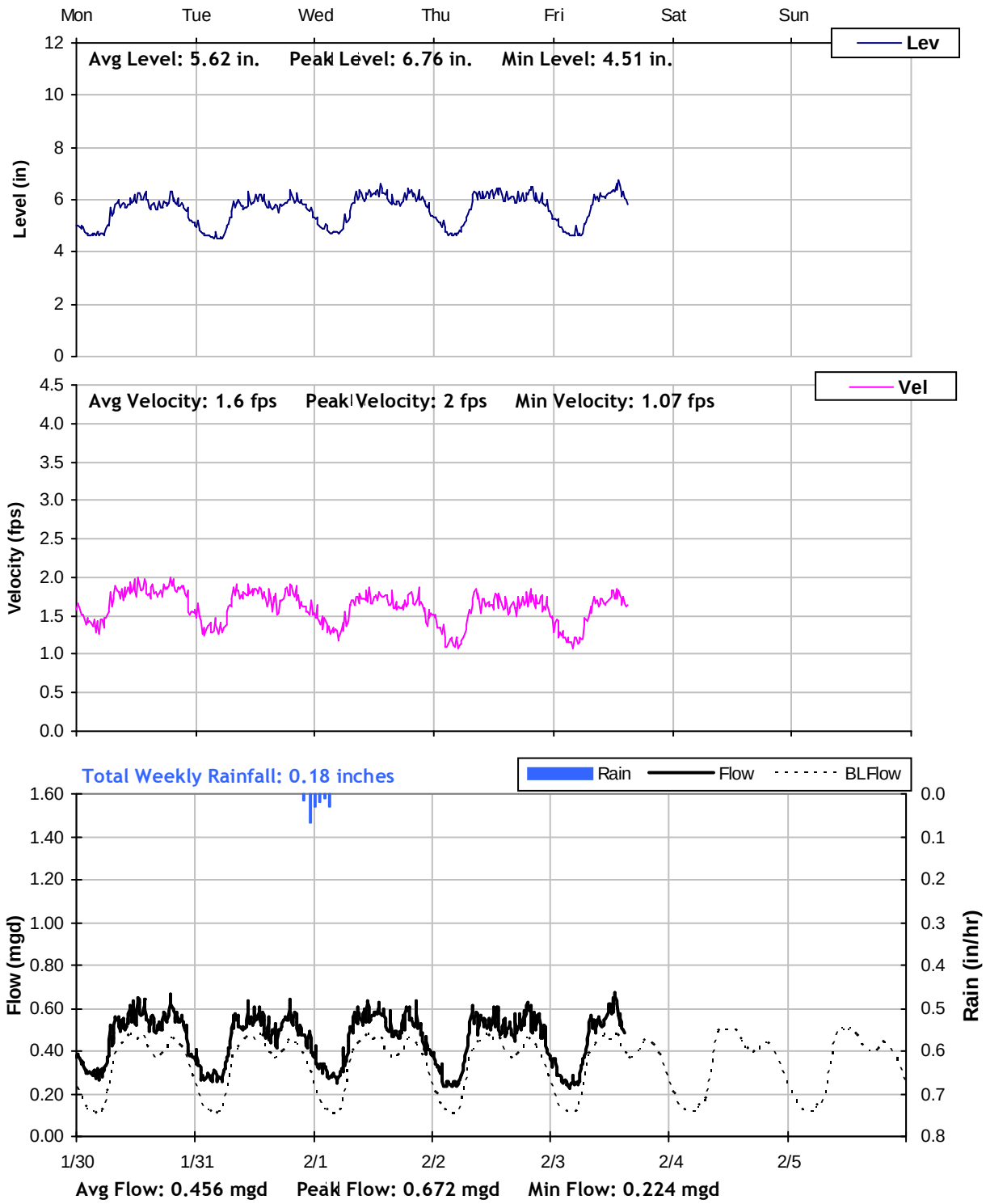
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



J2

Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

Year 2011/2012

Monitoring Site: K1

Location: Intersection of Gold River Lane and Gold River Lane

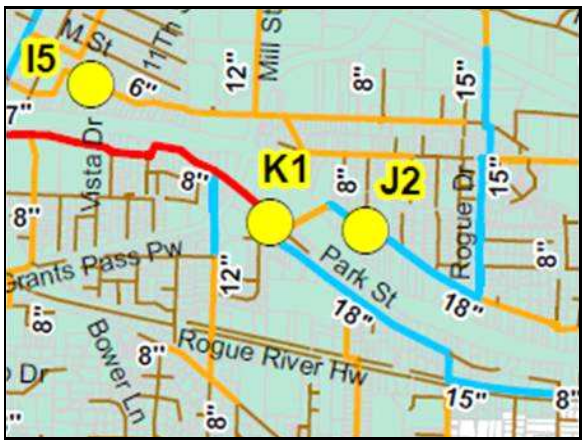
Data Summary Report

Vicinity Map:

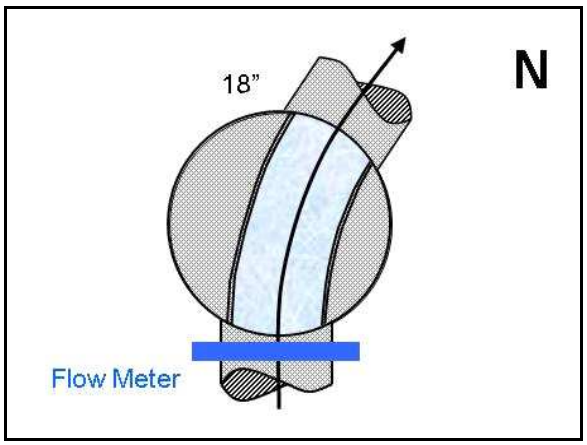
K1
Site Information Report

Location:	Intersection of Gold River Lane and Gold River Lane
Coordinates:	123.3174°W, 42.4271°N
Elevation:	925 feet
Diameter:	18 inches
Baseline Flow:	0.261 mgd
Peak Measured Flow:	0.79 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

K1
Additional Site Photos

Effluent Pipe

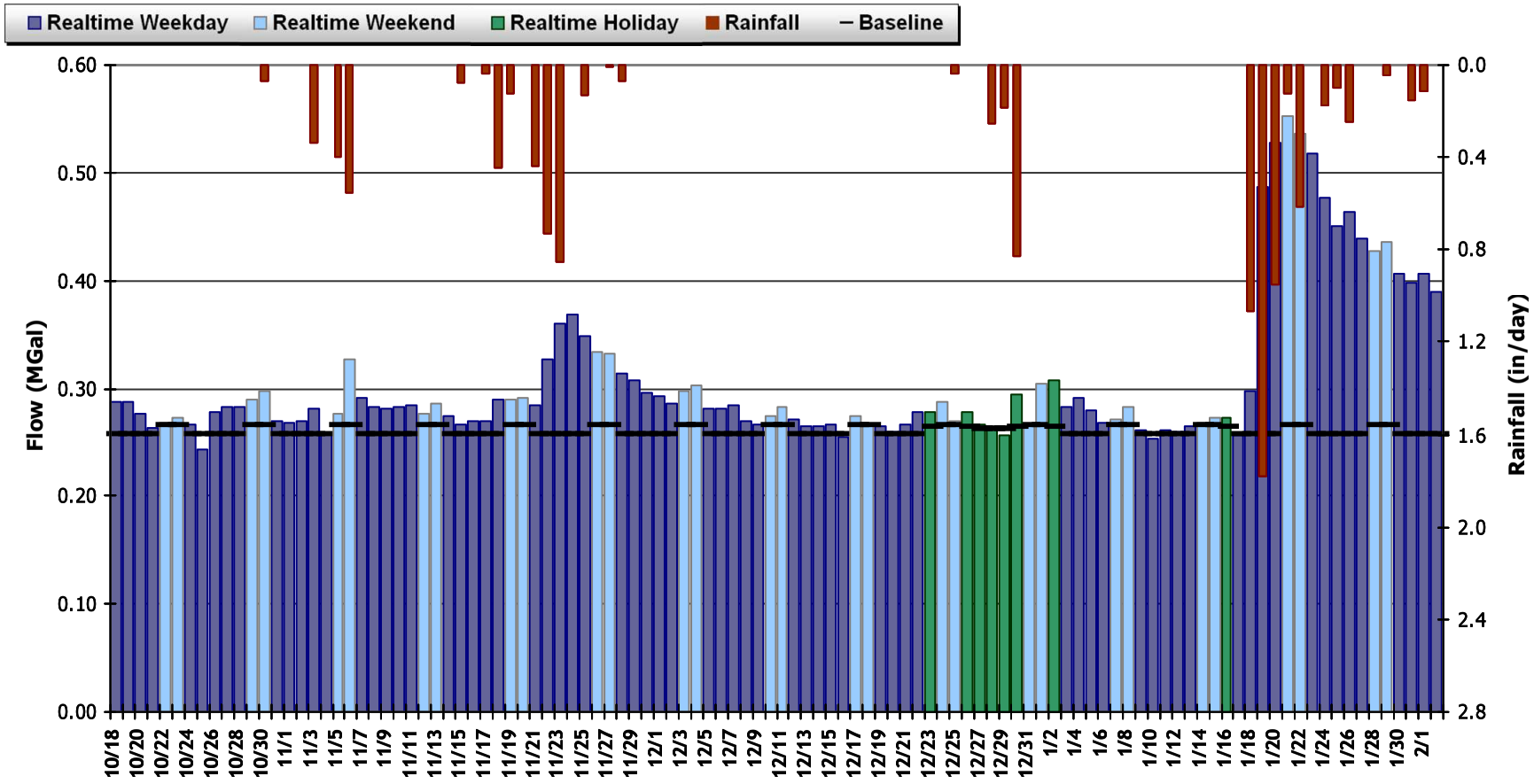
Main Influent Pipe

K1

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.306 MGal Peak Daily Flow: 0.553 MGal Min Daily Flow: 0.243 MGal

Total Period Rainfall: 10.97 inches

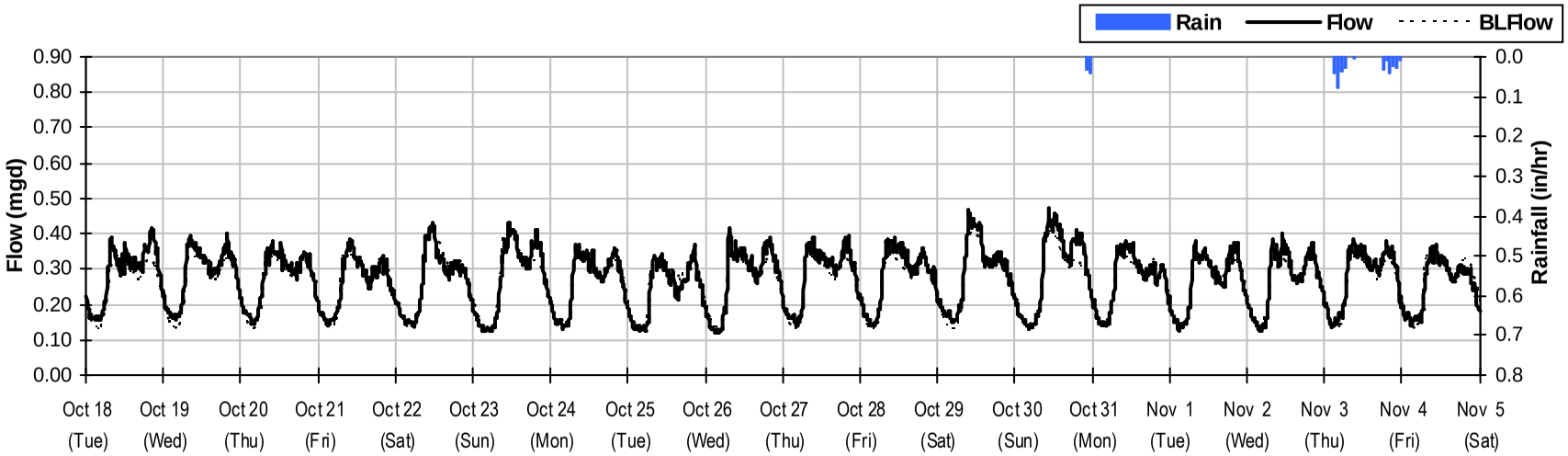


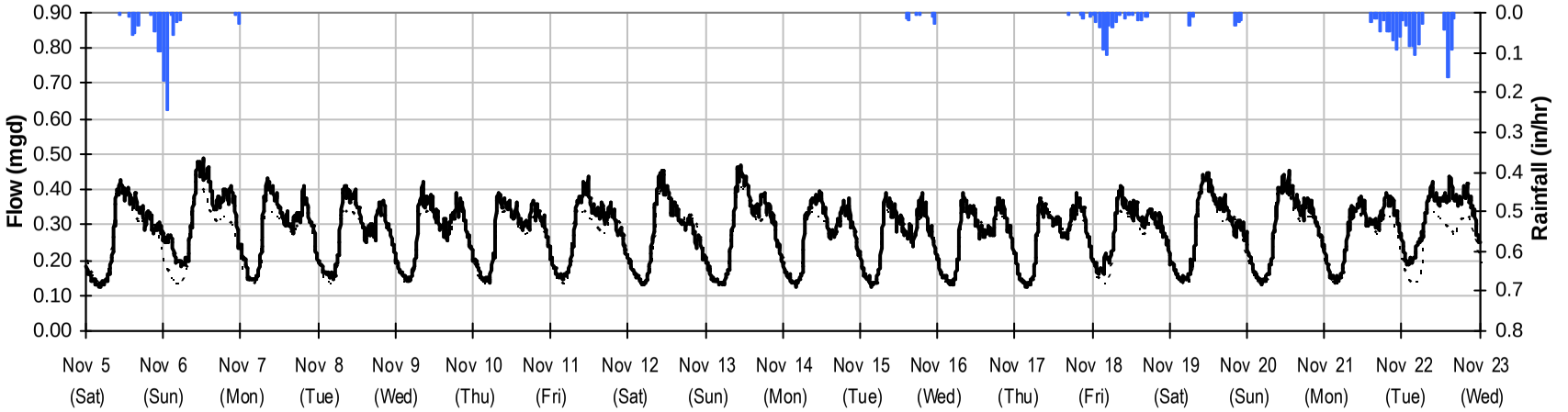
K1

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.28 mgd Peak Flow: 0.49 mgd Min Flow: 0.118 mgd

Total Period Rainfall: 3.21 inches



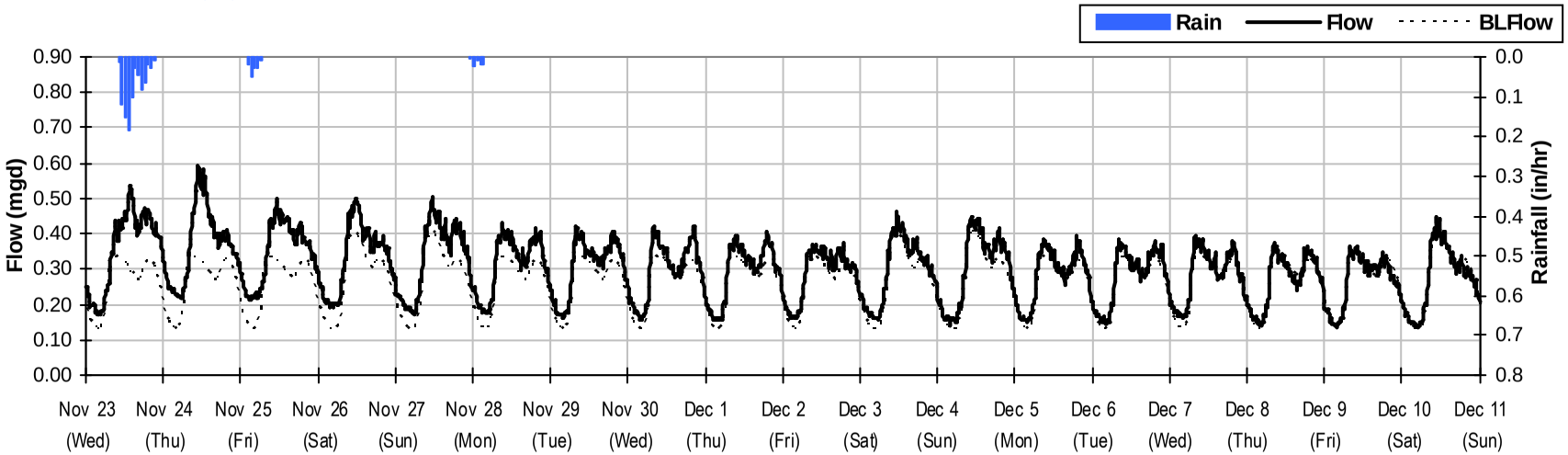


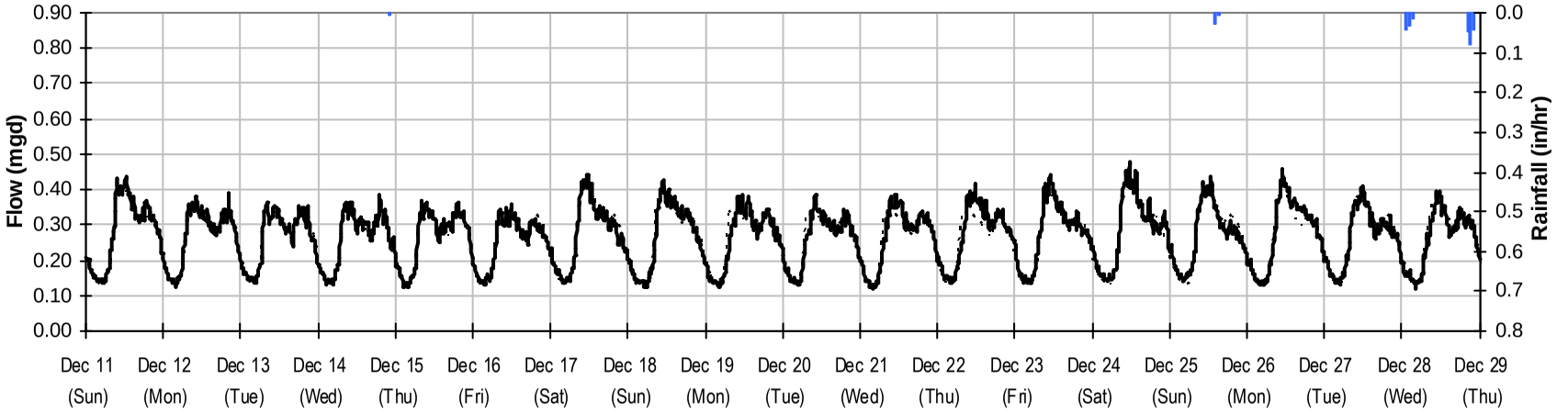
K1

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.288 mgd Peak Flow: 0.591 mgd Min Flow: 0.12 mgd

Total Period Rainfall: 1.36 inches



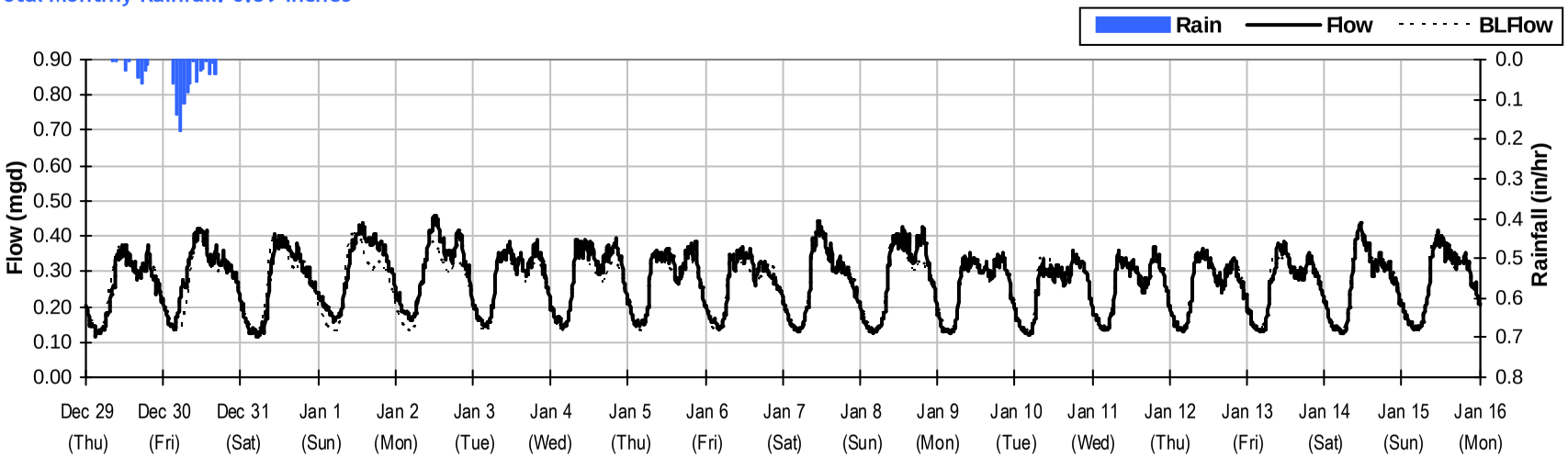


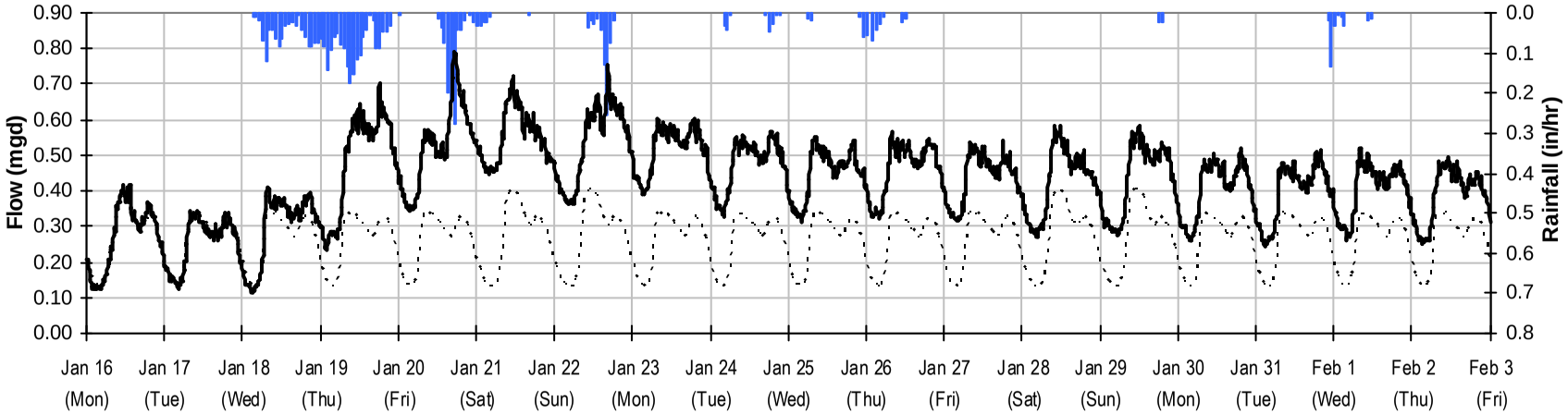
K1

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.35 mgd Peak Flow: 0.79 mgd Min Flow: 0.11 mgd

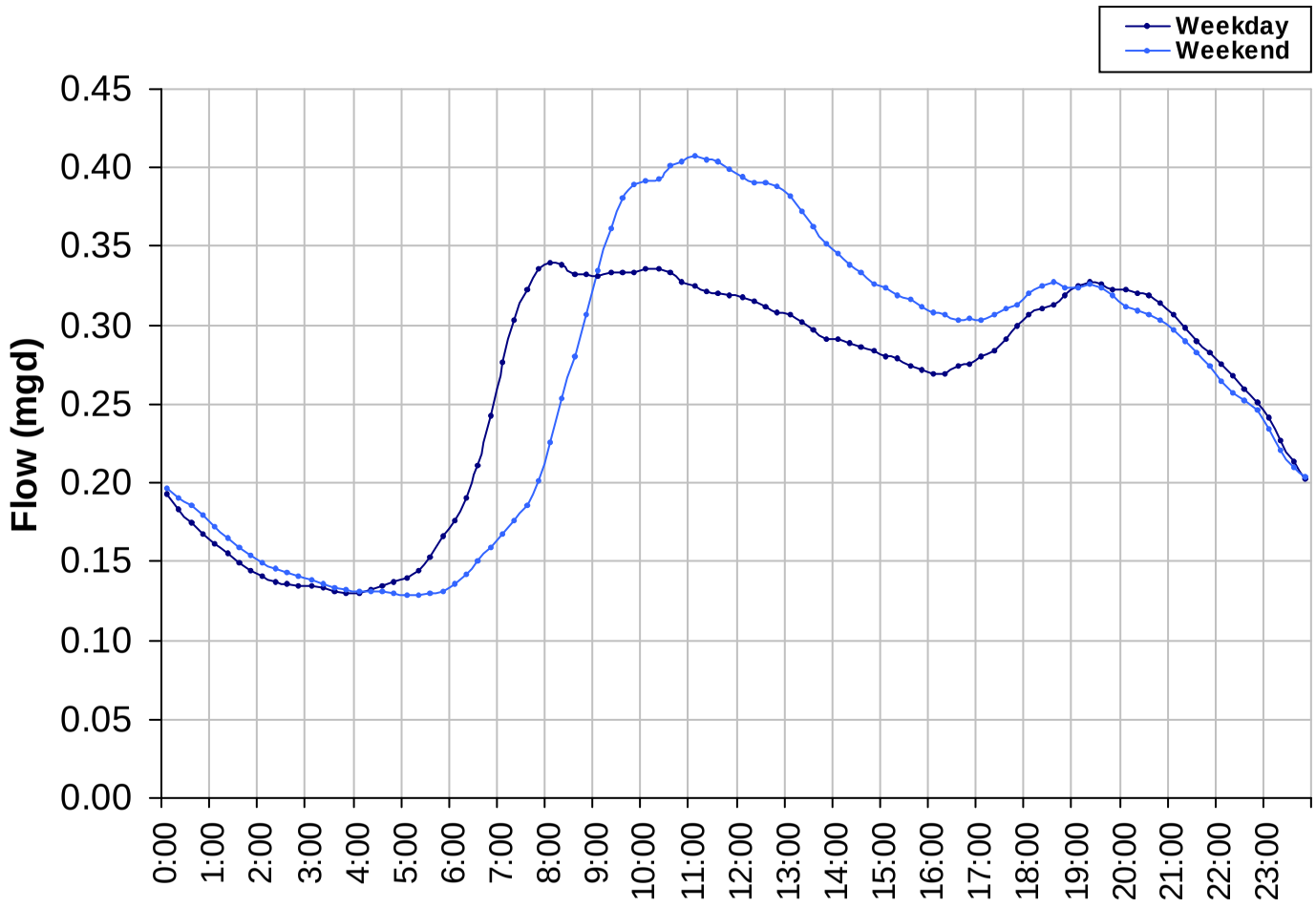
Total Monthly Rainfall: 6.39 inches





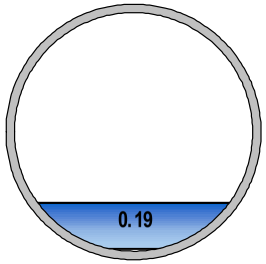
K1

Baseline Flow Hydrographs



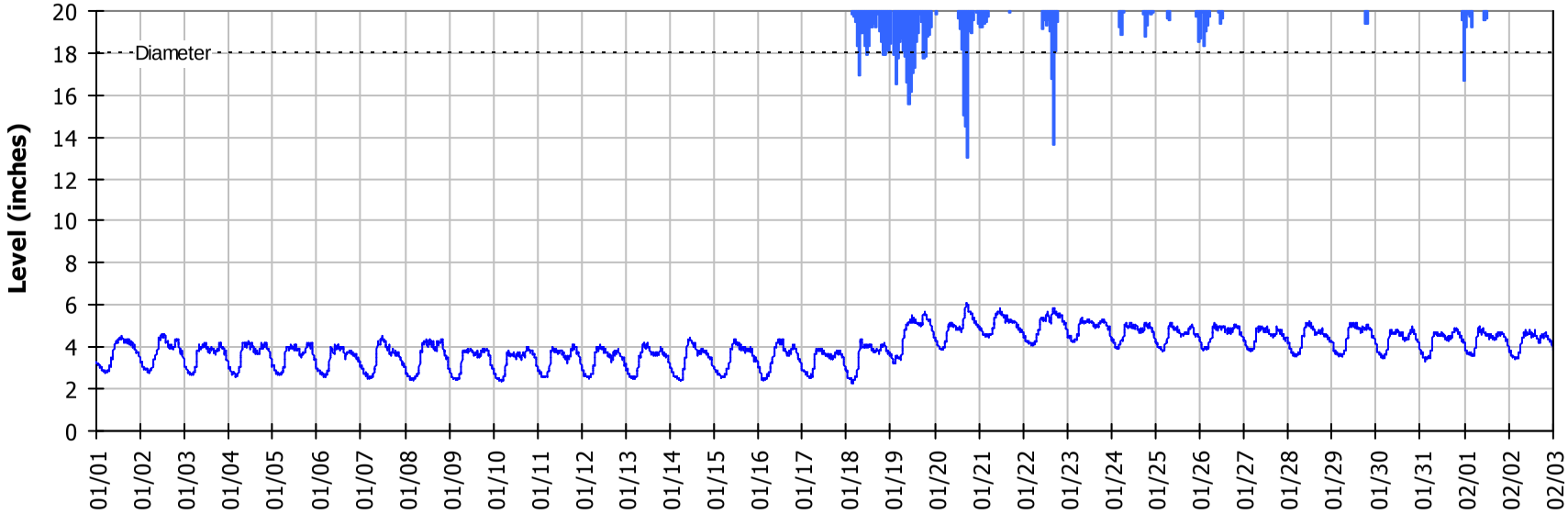
Baseline Flow:

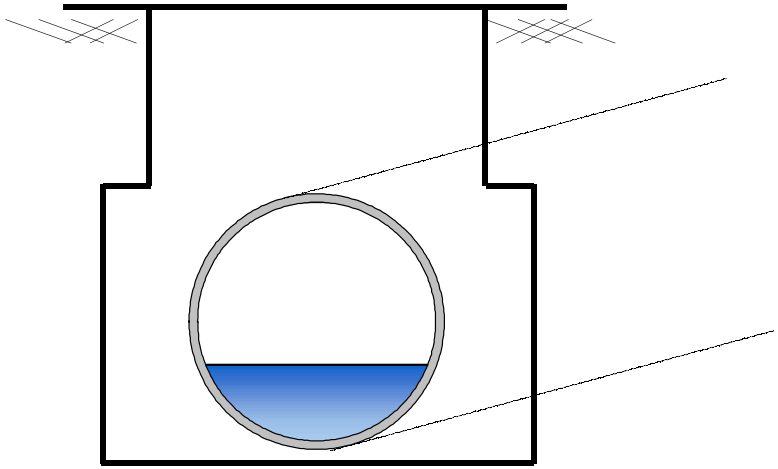
0.261 *mgd*



K1
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

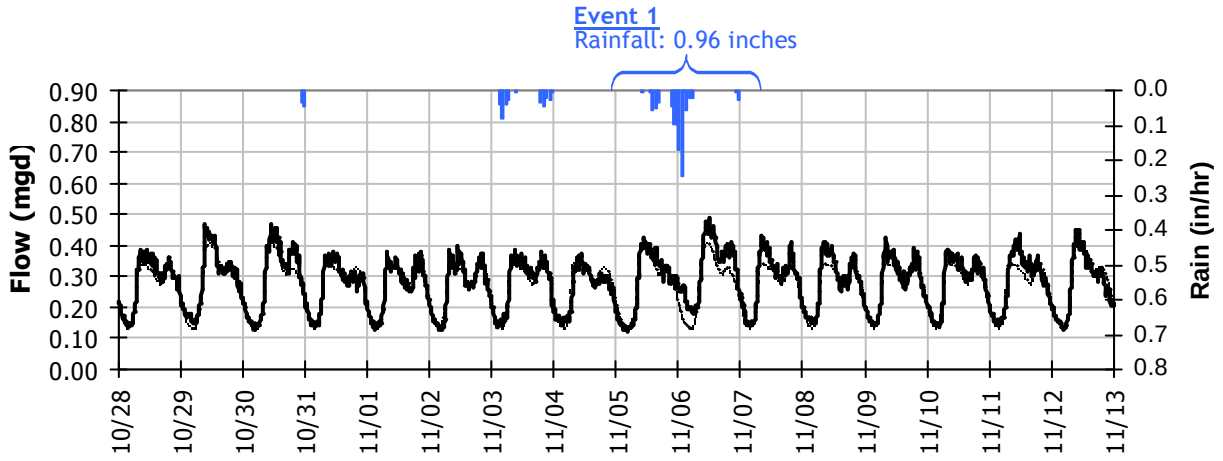




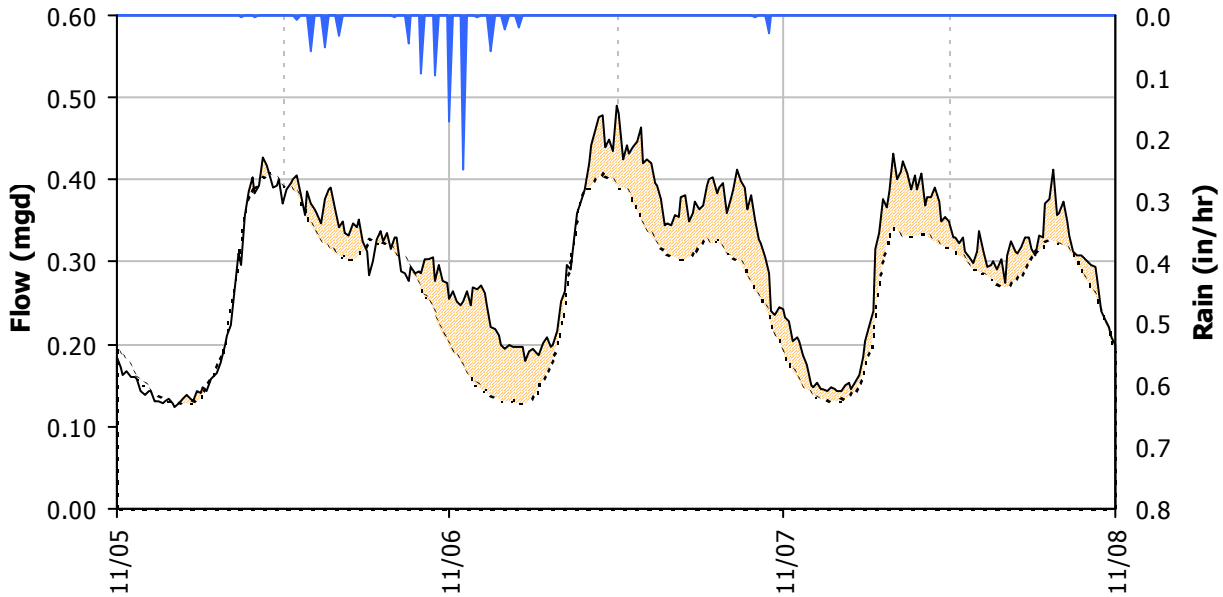
Pipe Diameter:	18	*inches*
Peak Measured Level	6.12	*inches*
Peak d/D Ratio:	0.34	

SITE K1
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

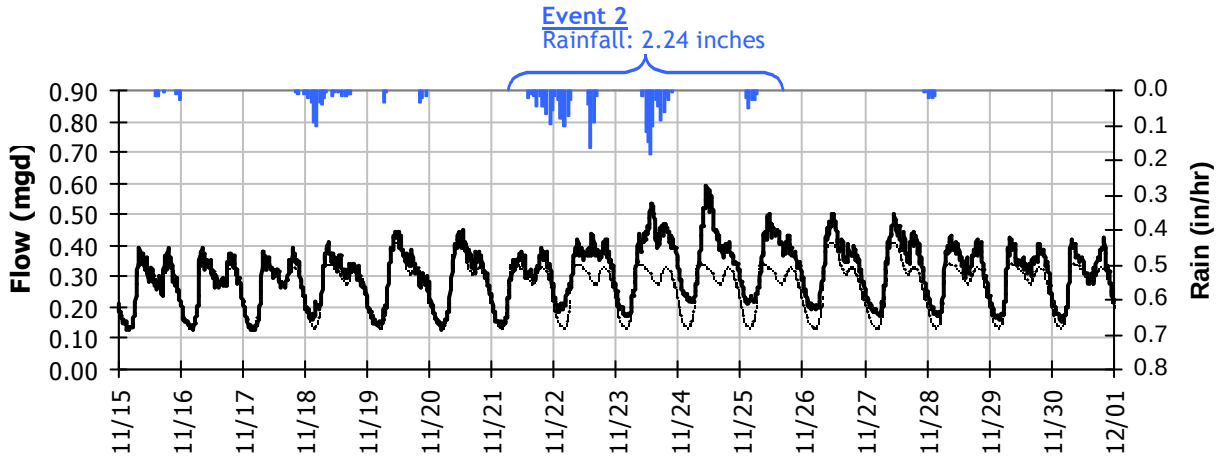


Storm Event I/I Analysis (Rain = 0.96 inches)

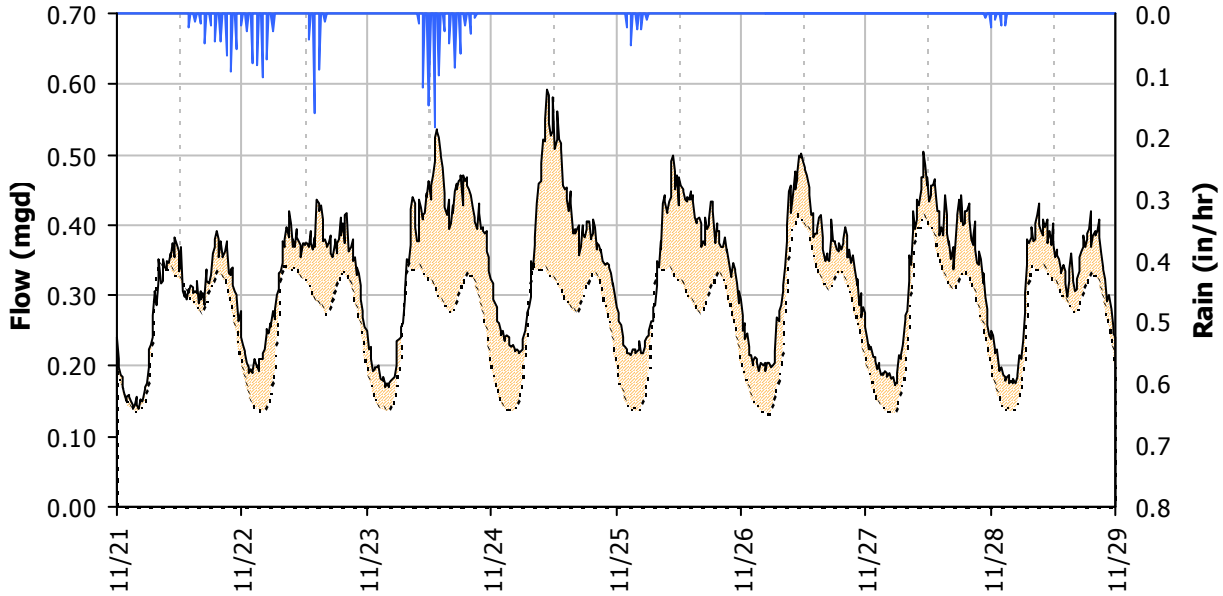
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.49	*mgd*	Peak I/I Rate:	0.13	*mgd*	Infiltration Rate: (11/7/2011)	0.032	*mgd*	Total I/I:	104,000	*gallons*
PF:	1.88		PkI/I:IDM:	927	*gpd/IDM*	RDI:IDM:	234	*gpd/IDM*	Total I/I:IDM:	795	*gal/IDM/in*
Peak Level:	4.85	*in*	PkI/I:Acre:	160	*gpd/acre*	RDI:Acre:	40	*gpd/acre*	R-Value:	0.5%	
d/D Ratio:	0.27		Pk I/I:ADWF:	0.49		RDI (% of BL):	12%		Total I/I:ADWF:	0.42	*per in-rain*

SITE K1
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

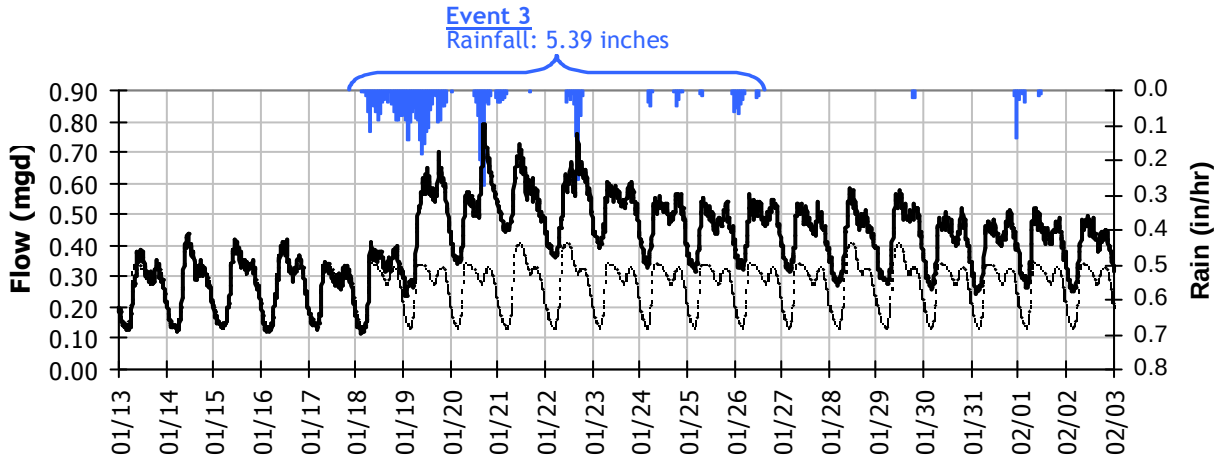


Storm Event I/I Analysis (Rain = 2.24 inches)

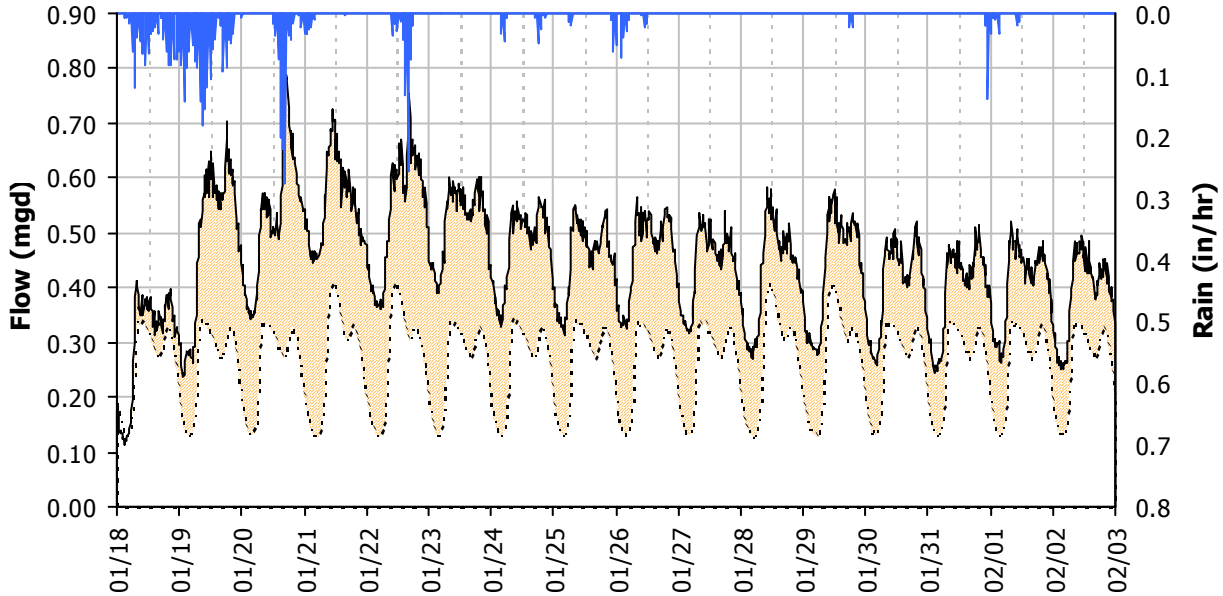
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.59 *mgd*	Peak I/I Rate:	0.26 *mgd*	Infiltration Rate: (11/26/2011)	0.068 *mgd*	Total I/I:	547,000 *gallons*
PF:	2.27	PkI/I:IDM:	1,920 *gpd/IDM*	RDI:IDM:	494 *gpd/IDM*	Total I/I:IDM:	1,780 *gal/IDM/in*
Peak Level:	5.45 *in*	PkI/I:Acre:	332 *gpd/acre*	RDI:Acre:	85 *gpd/acre*	R-Value:	1.1%
d/D Ratio:	0.30	Pk I/I:ADWF:	1.01	RDI (% of BL):	26%	Total I/I:ADWF:	0.94 *per in-rain*

SITE K1
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

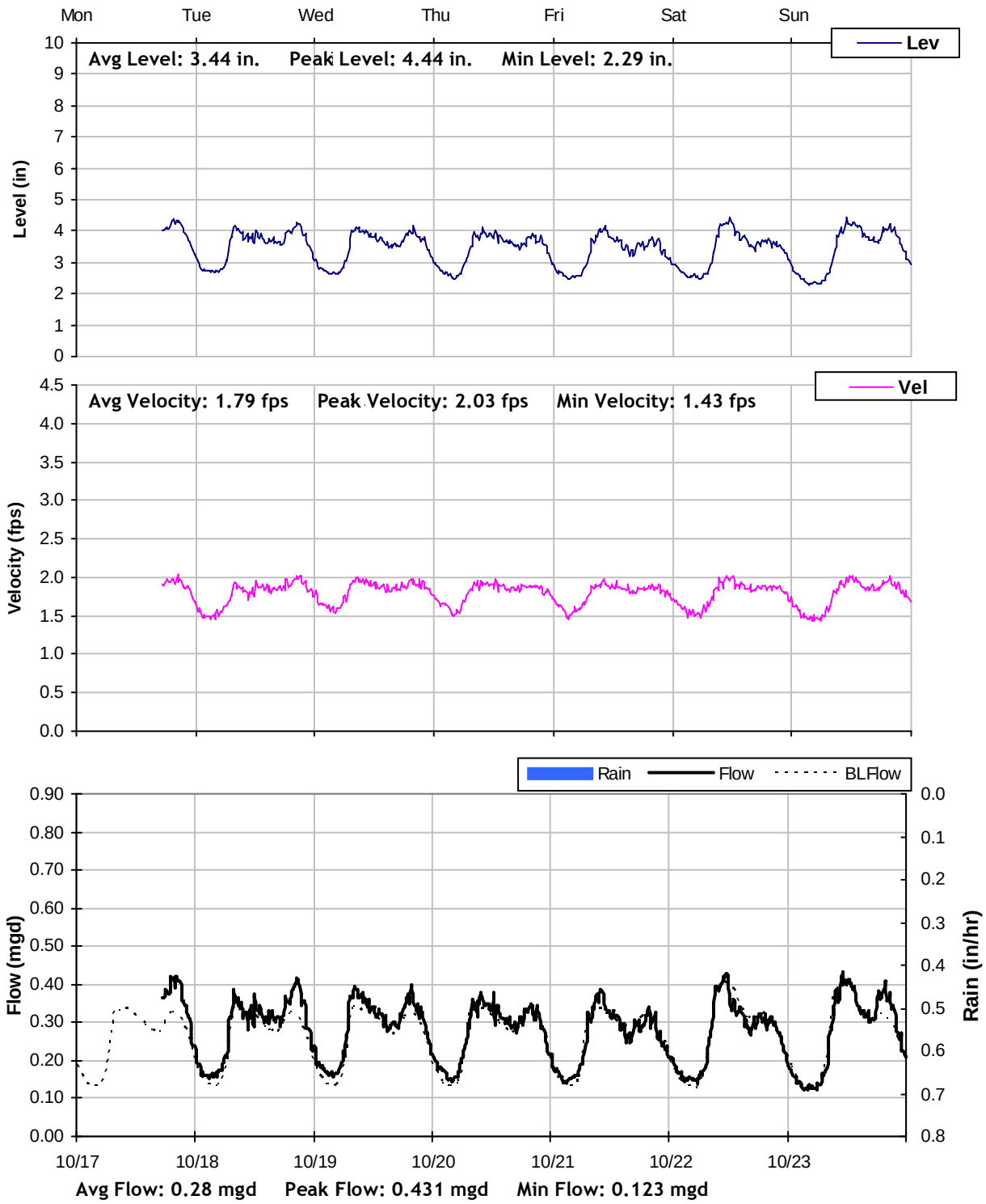


Storm Event I/I Analysis (Rain = 5.39 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.79	*mgd*	Peak I/I Rate:	0.51	*mgd*	Infiltration Rate: (1/30/2012)	0.148	*mgd*	Total I/I:	3,046,000	*gallons*
PF:	3.03		PkI/I:IDM:	3,717	*gpd/IDM*	RDI:IDM:	1,078	*gpd/IDM*	Total I/I:IDM:	4,121	*gal/IDM/in*
Peak Level:	6.12	*in*	PkI/I:Acre:	642	*gpd/acre*	RDI:Acre:	186	*gpd/acre*	R-Value:	2.6%	
d/D Ratio:	0.34		Pk I/I:ADWF:	1.96		RDI (% of BL):	57%		Total I/I:ADWF:	2.17	*per in-rain*

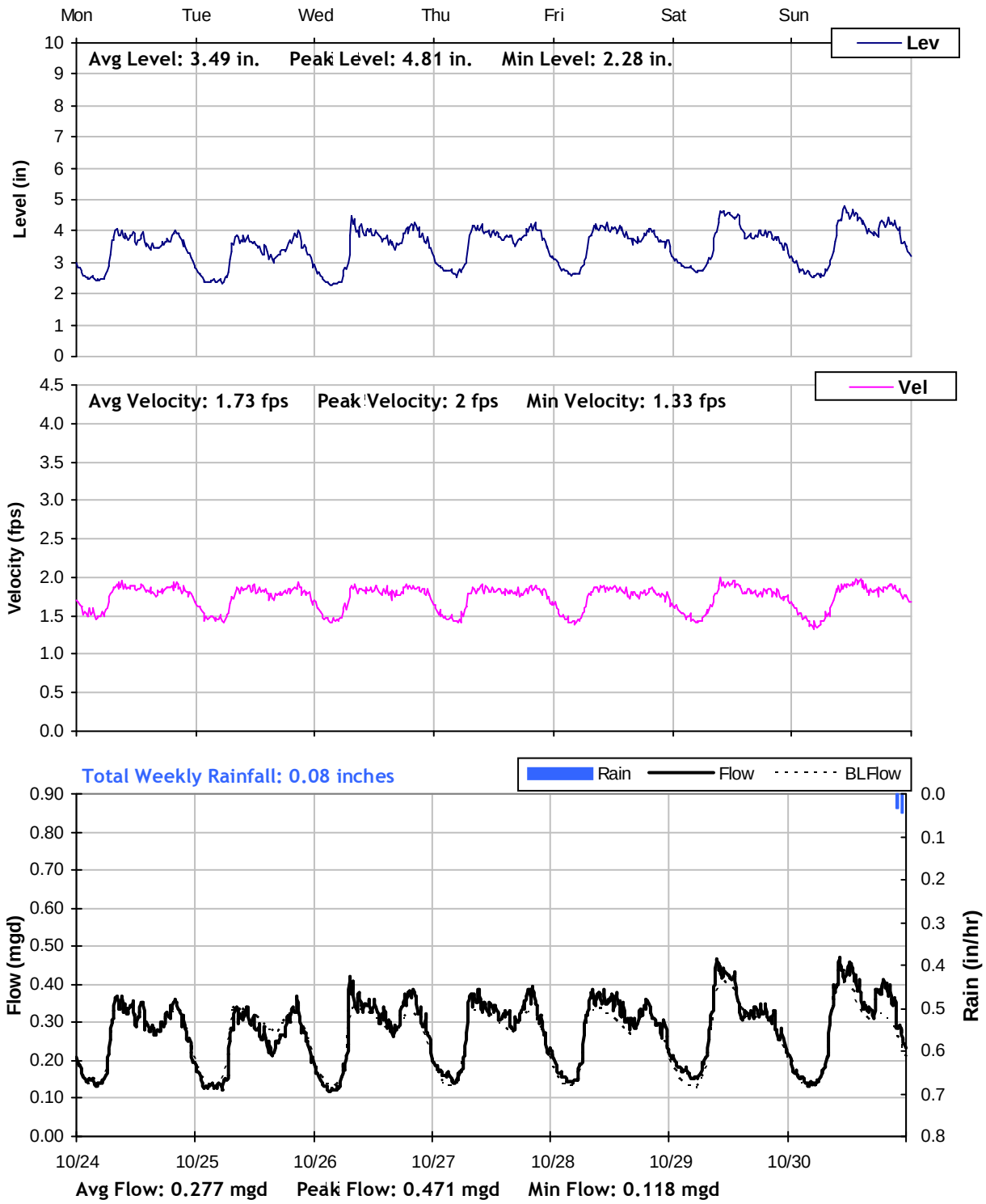
K1

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



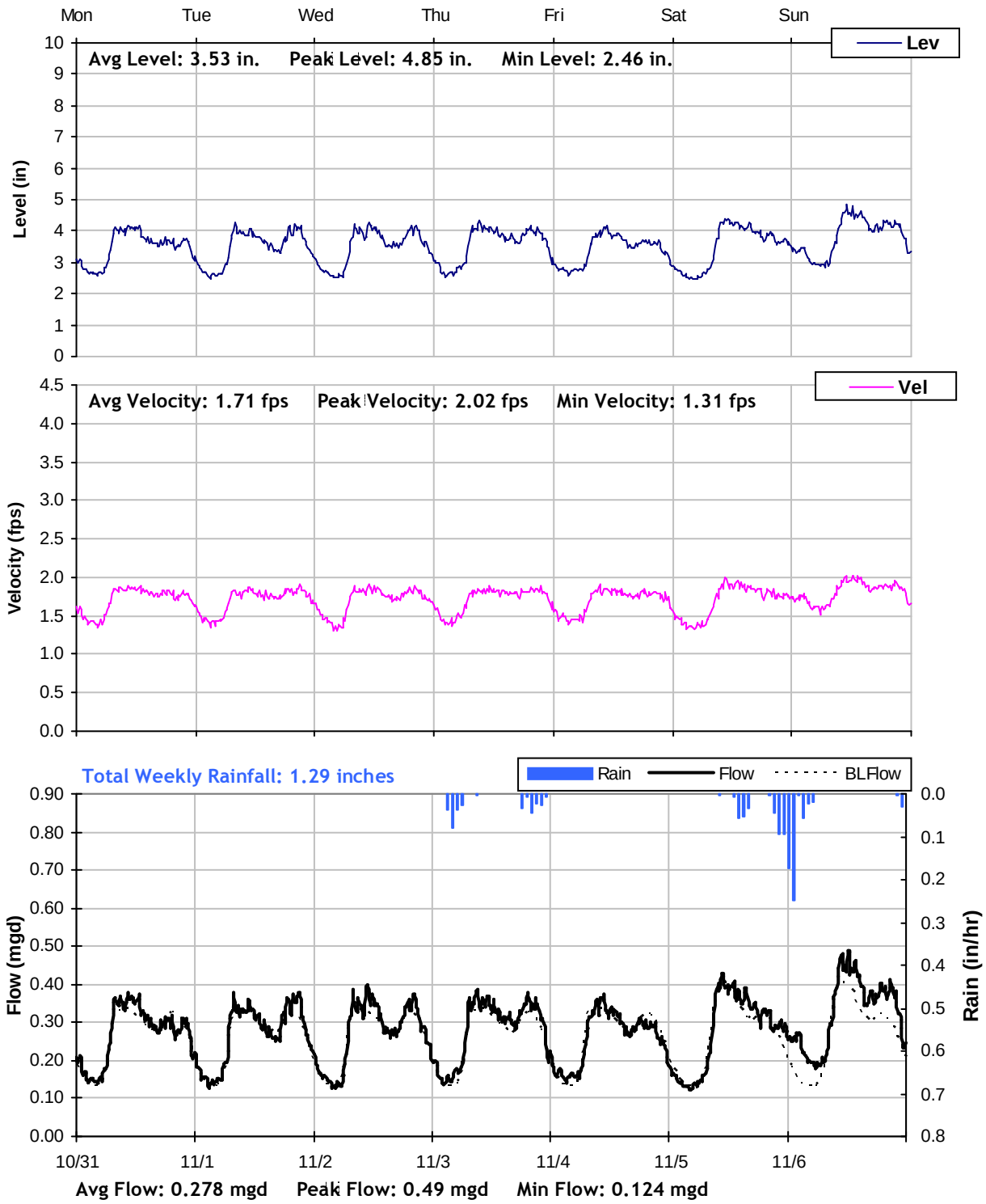
K1

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



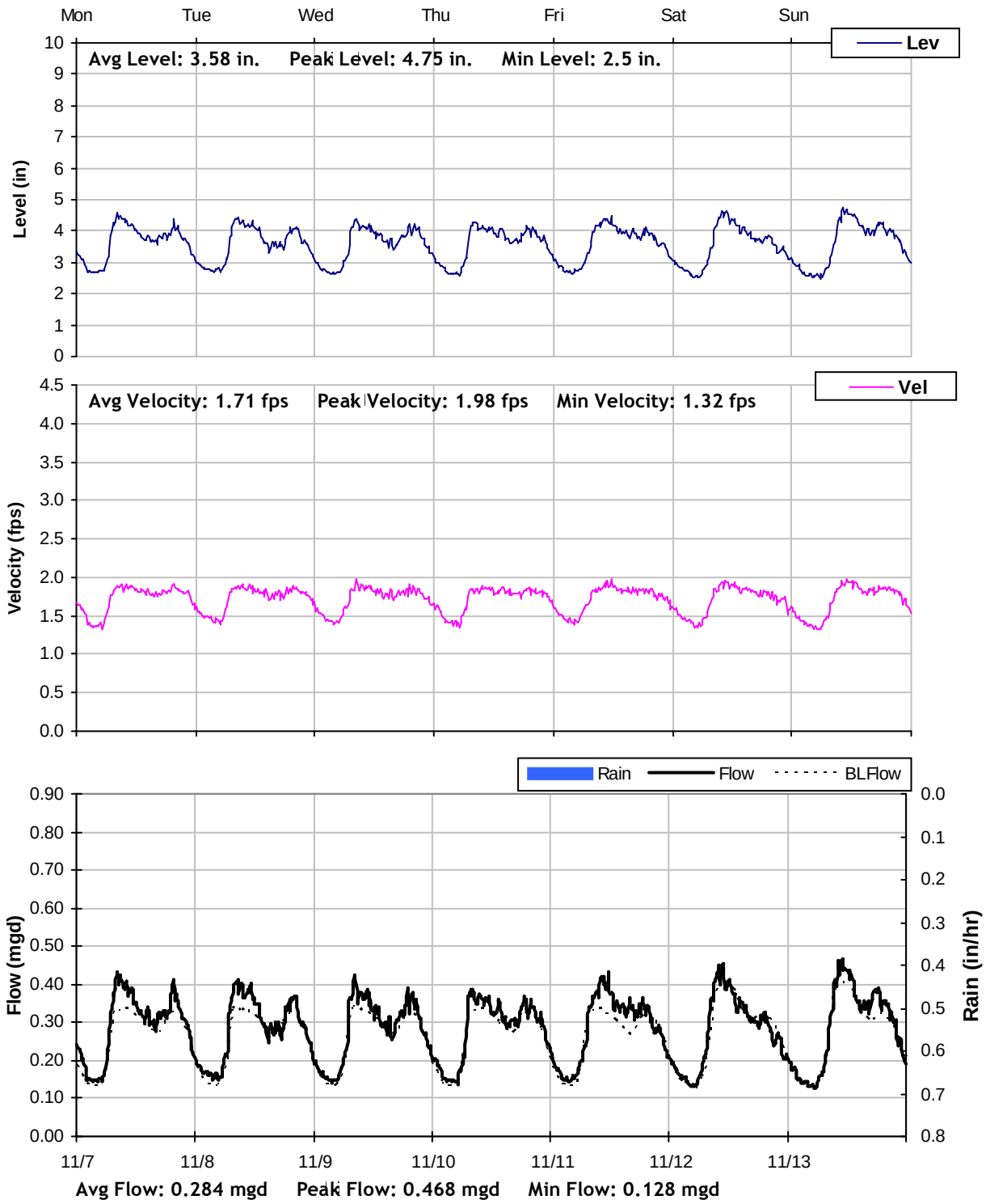
K1

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



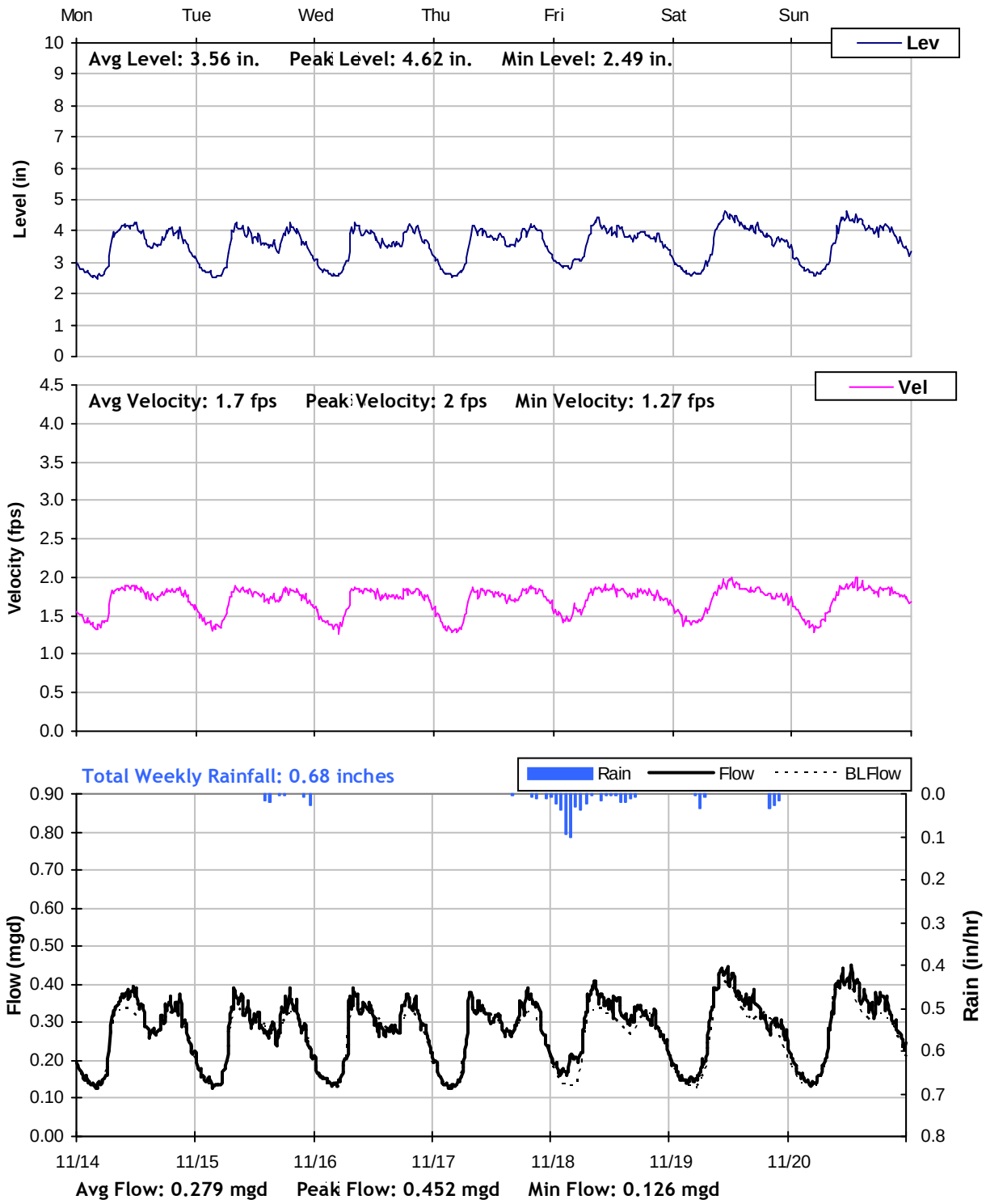
K1

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



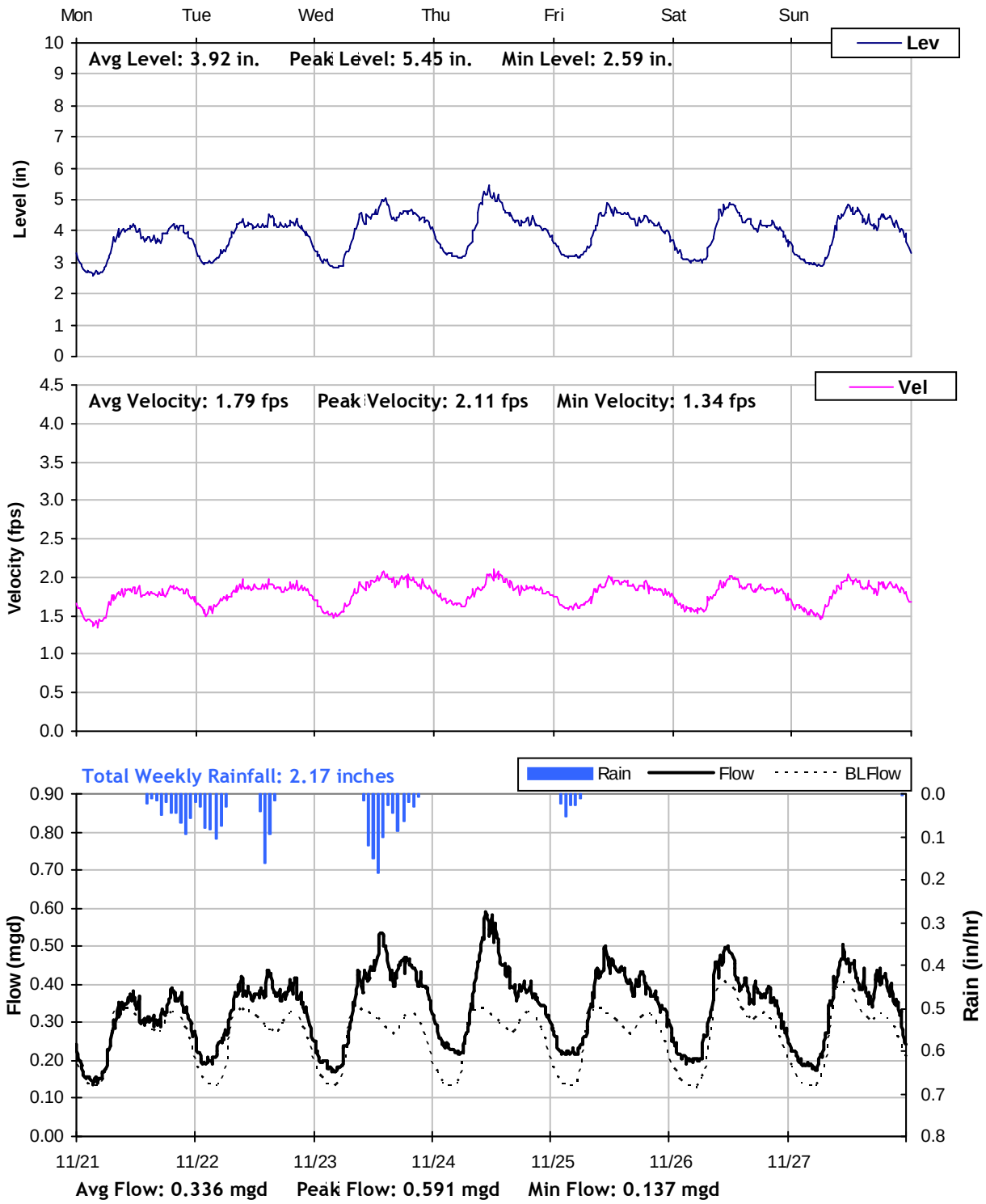
K1

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



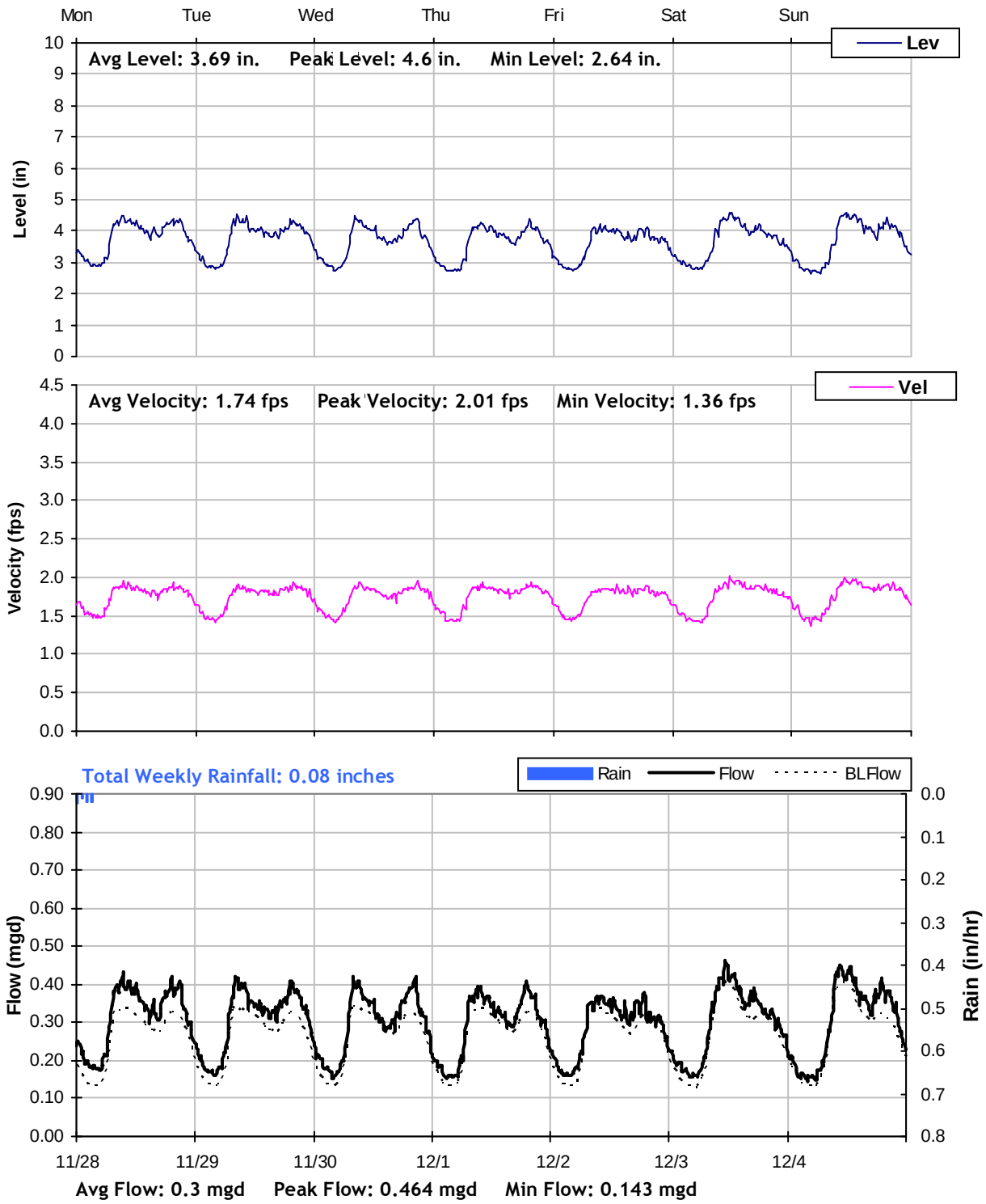
K1

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



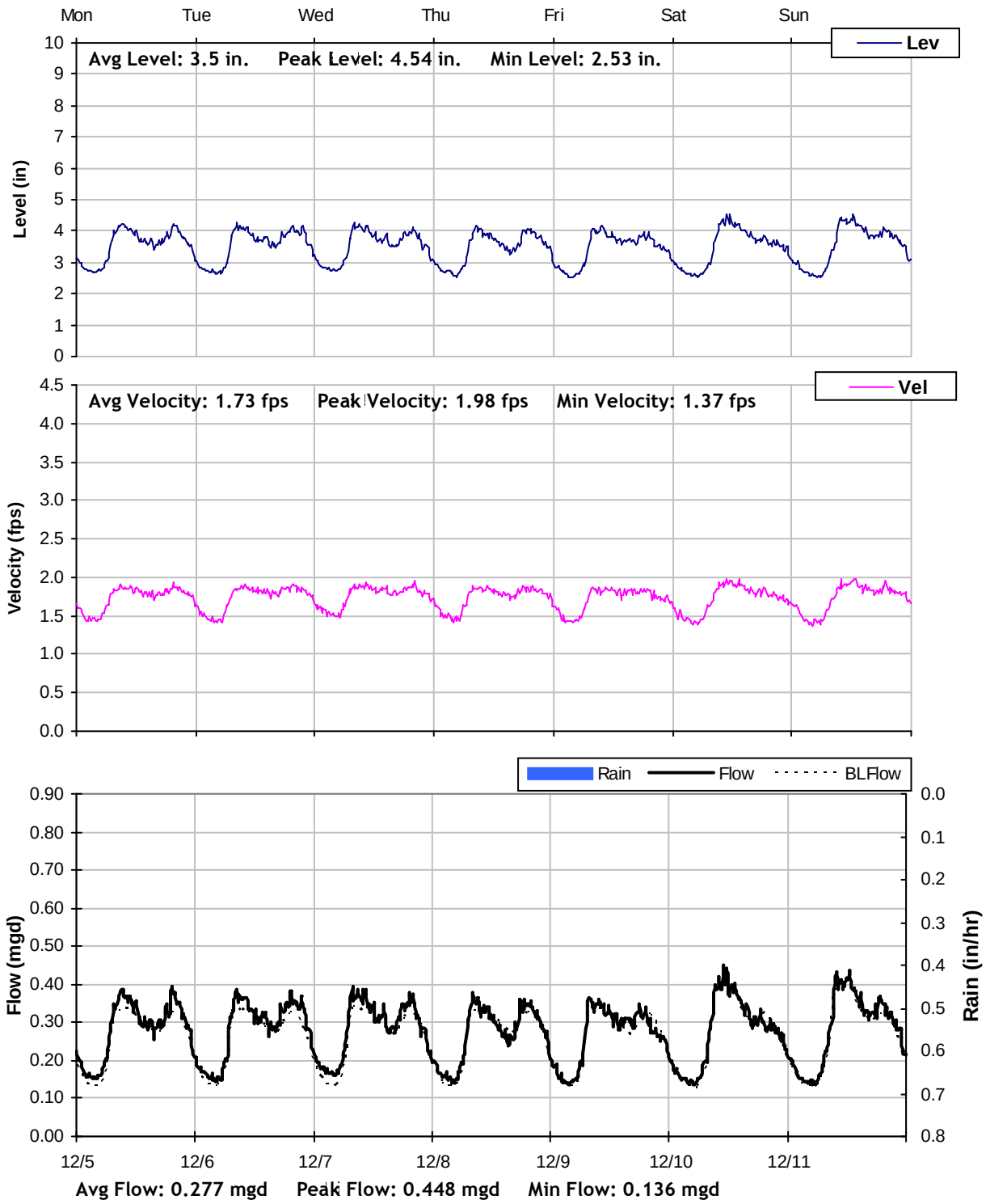
K1

Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



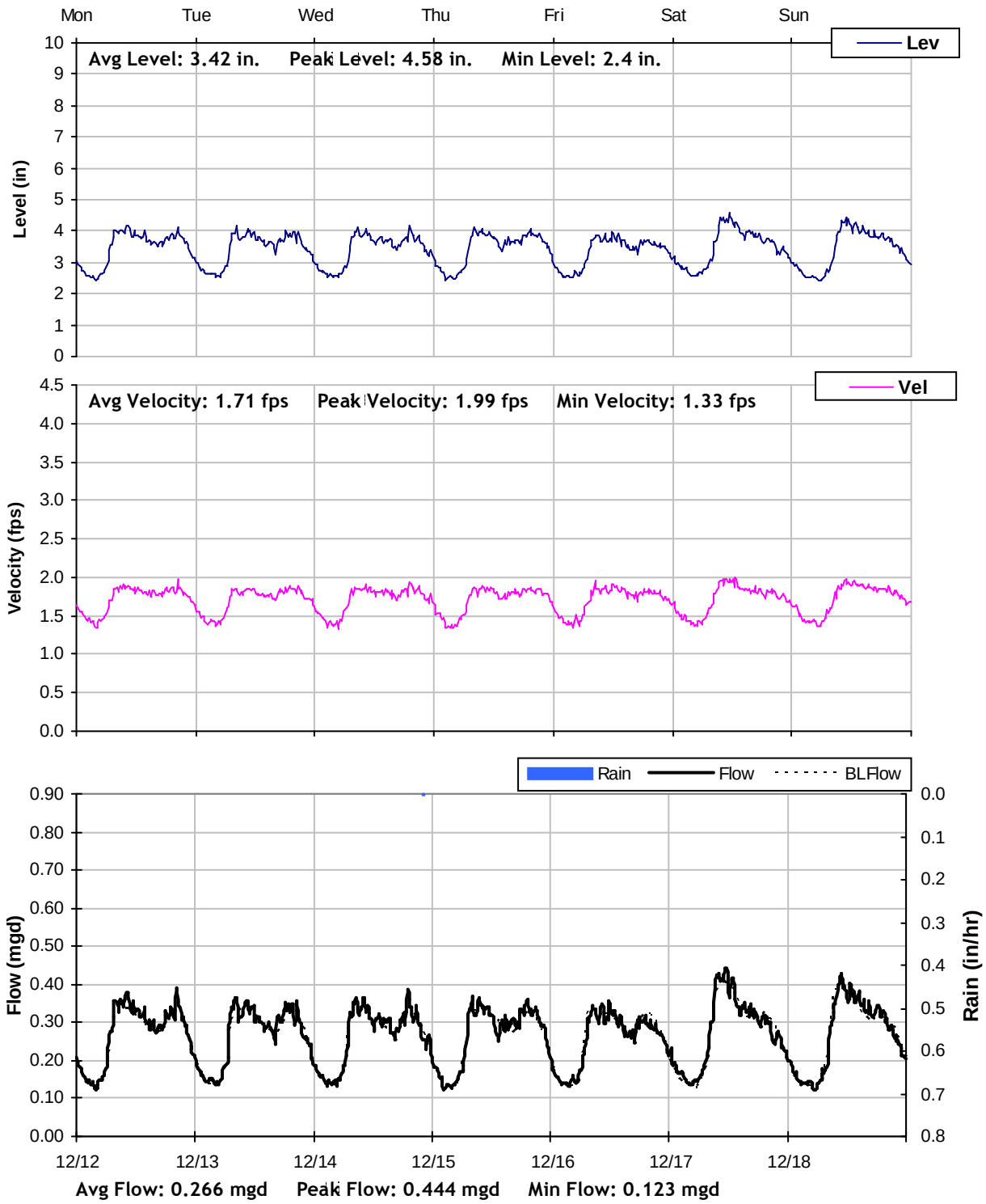
K1

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



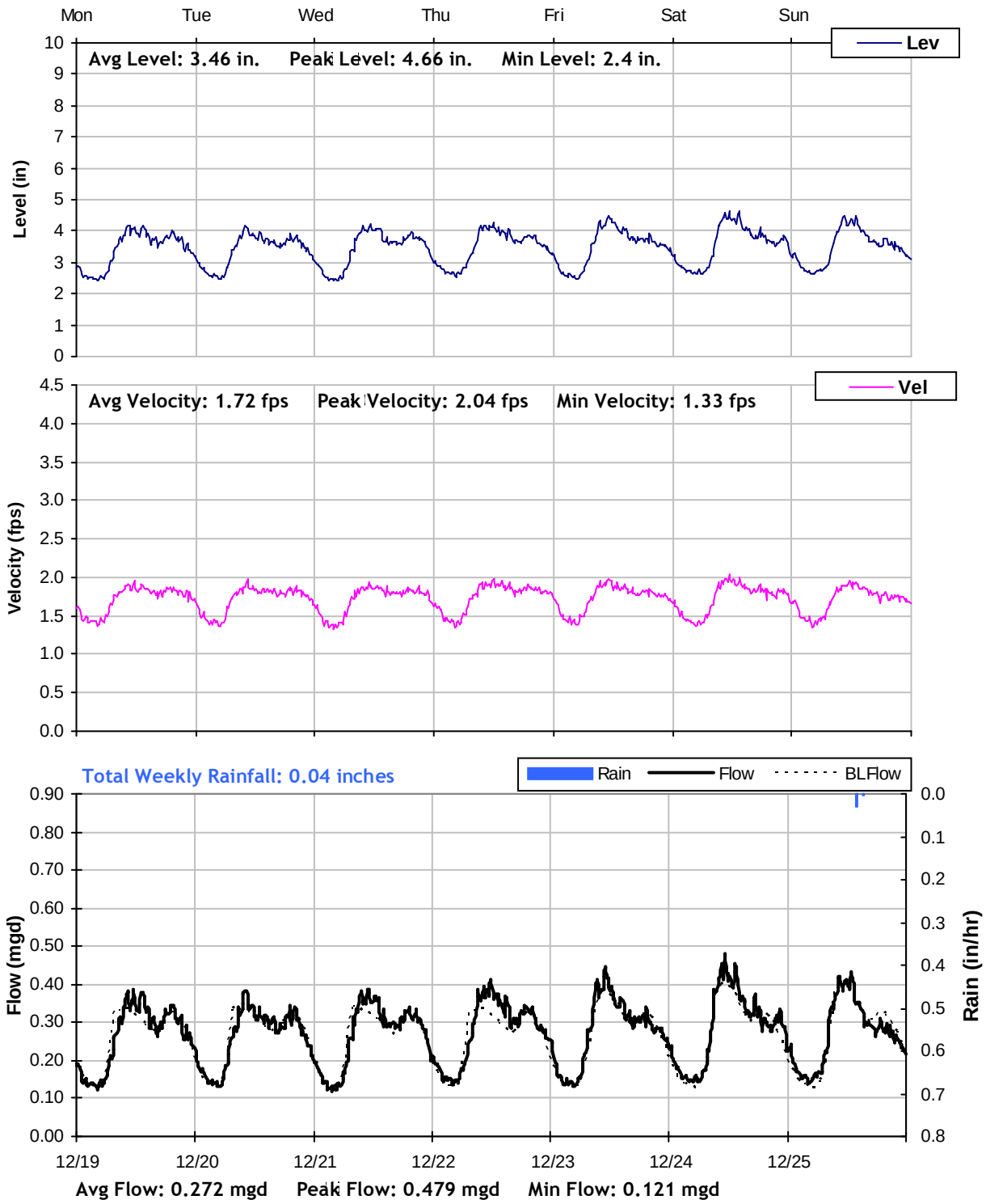
K1

Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



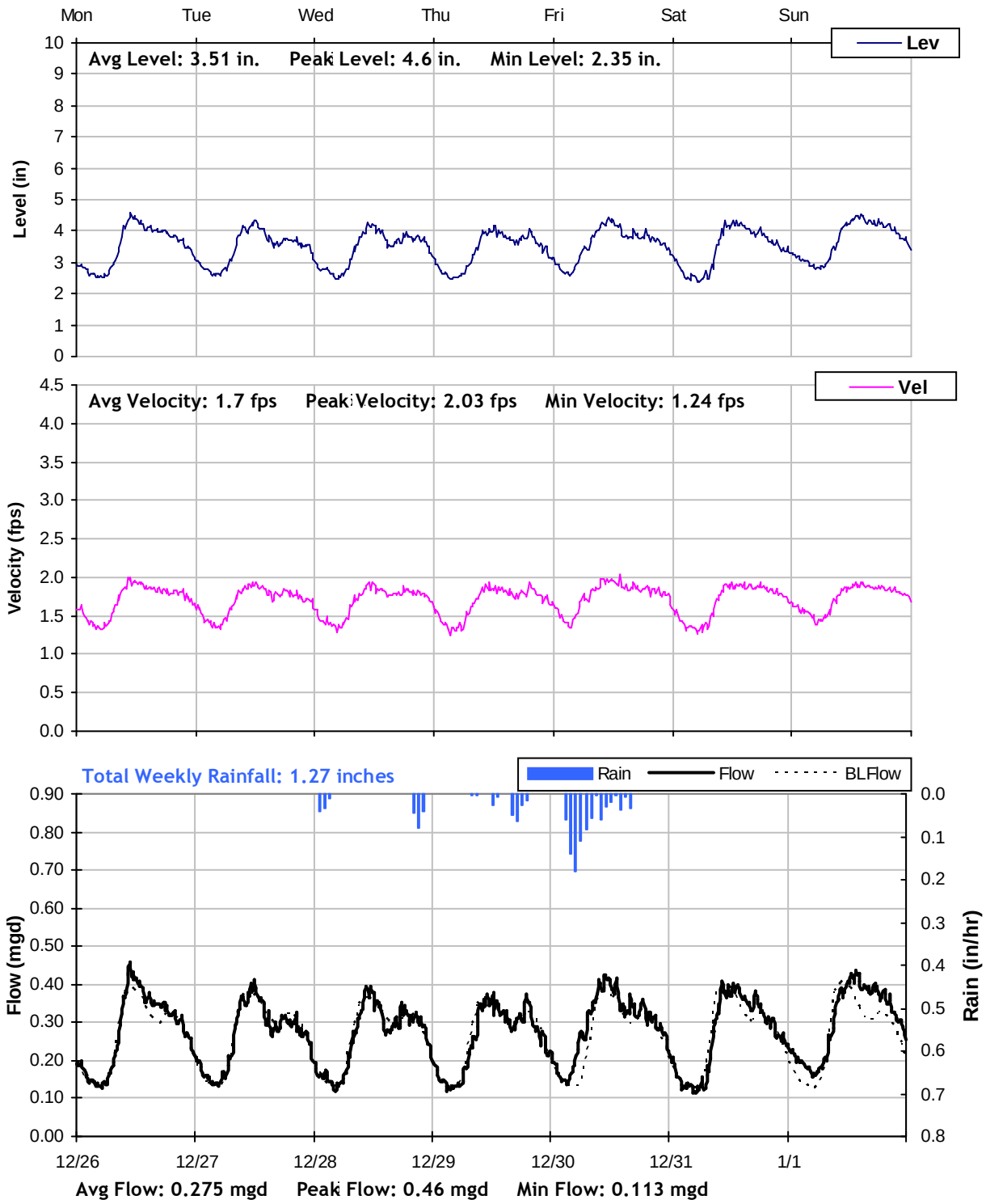
K1

Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



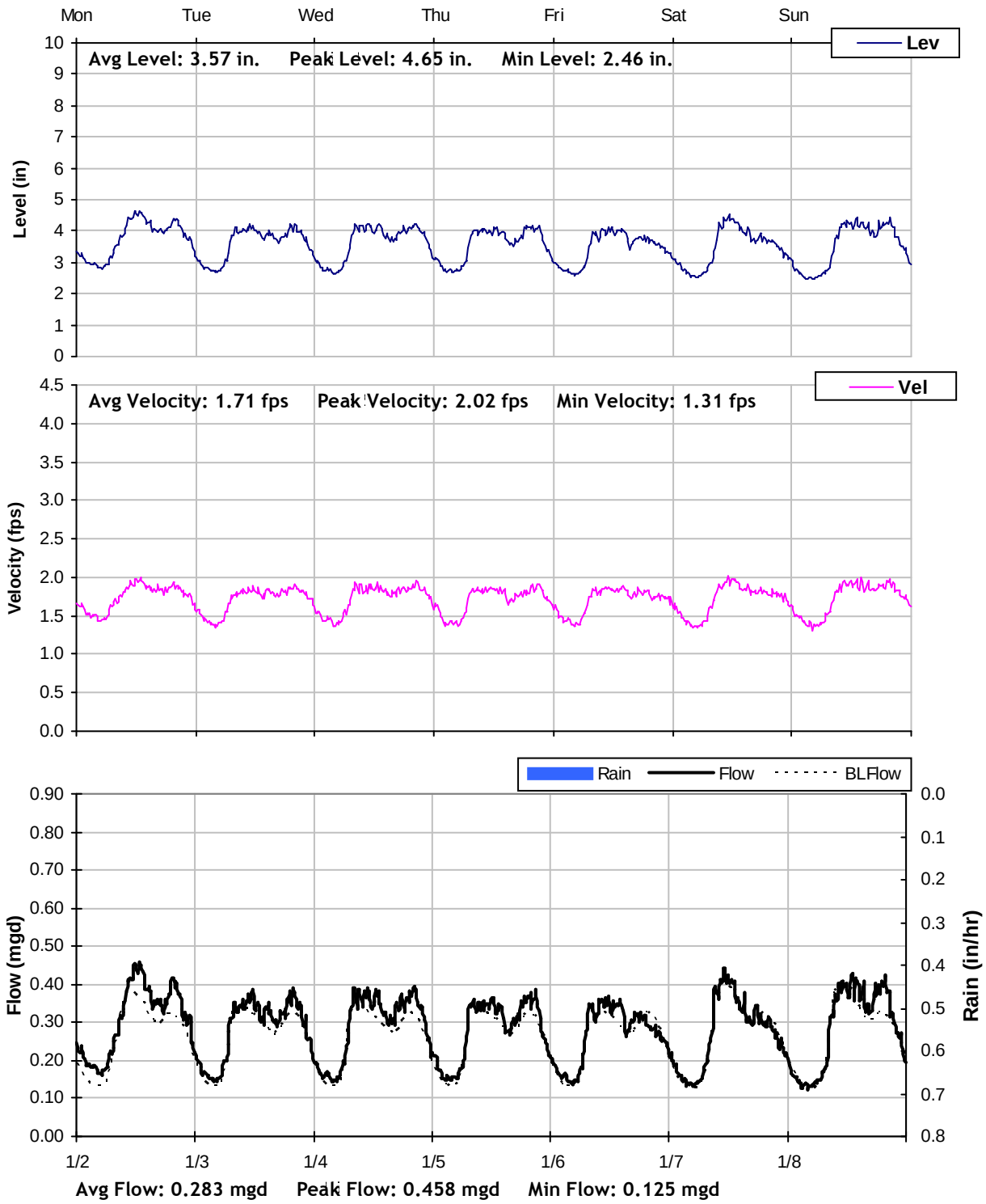
K1

Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



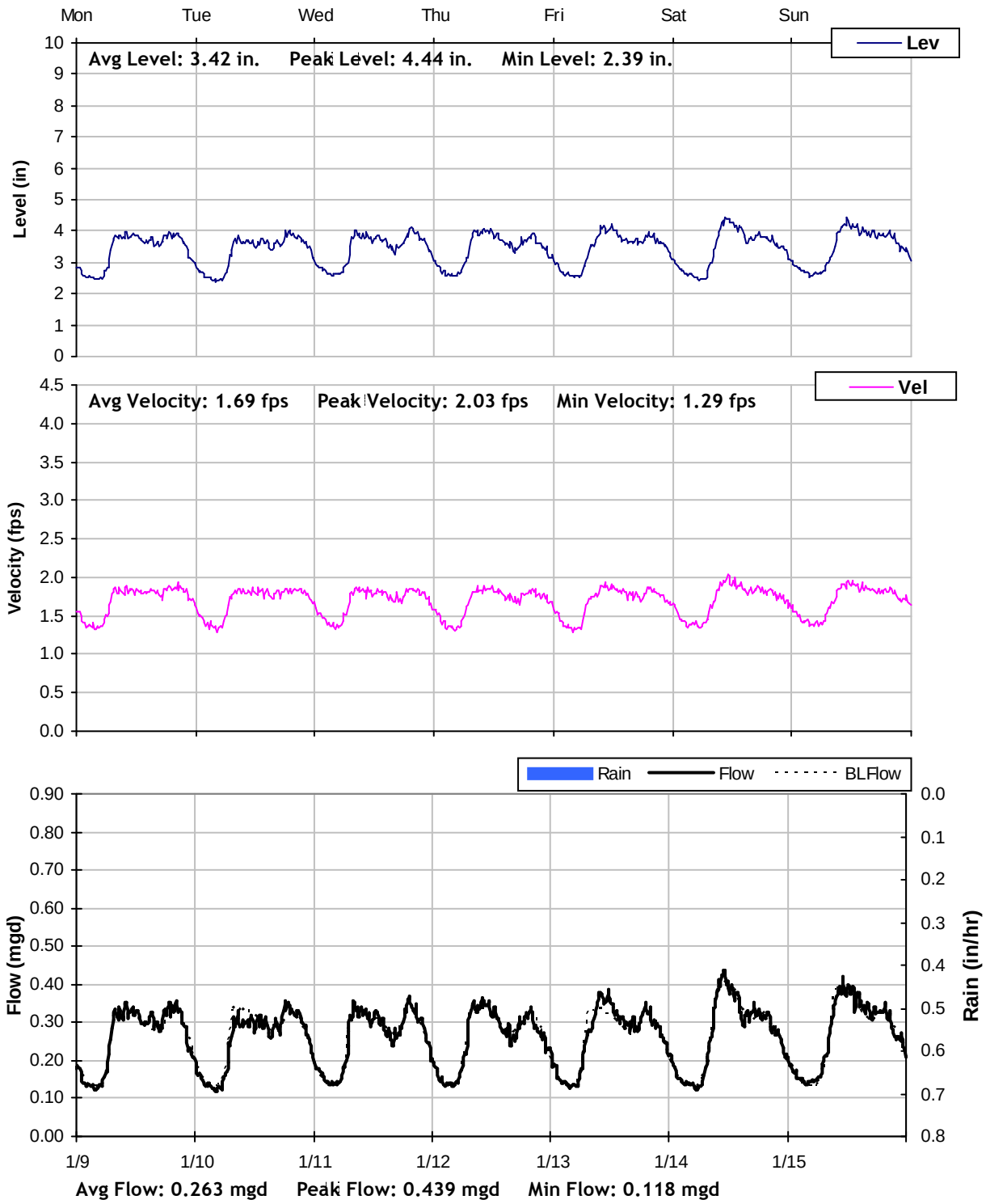
K1

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



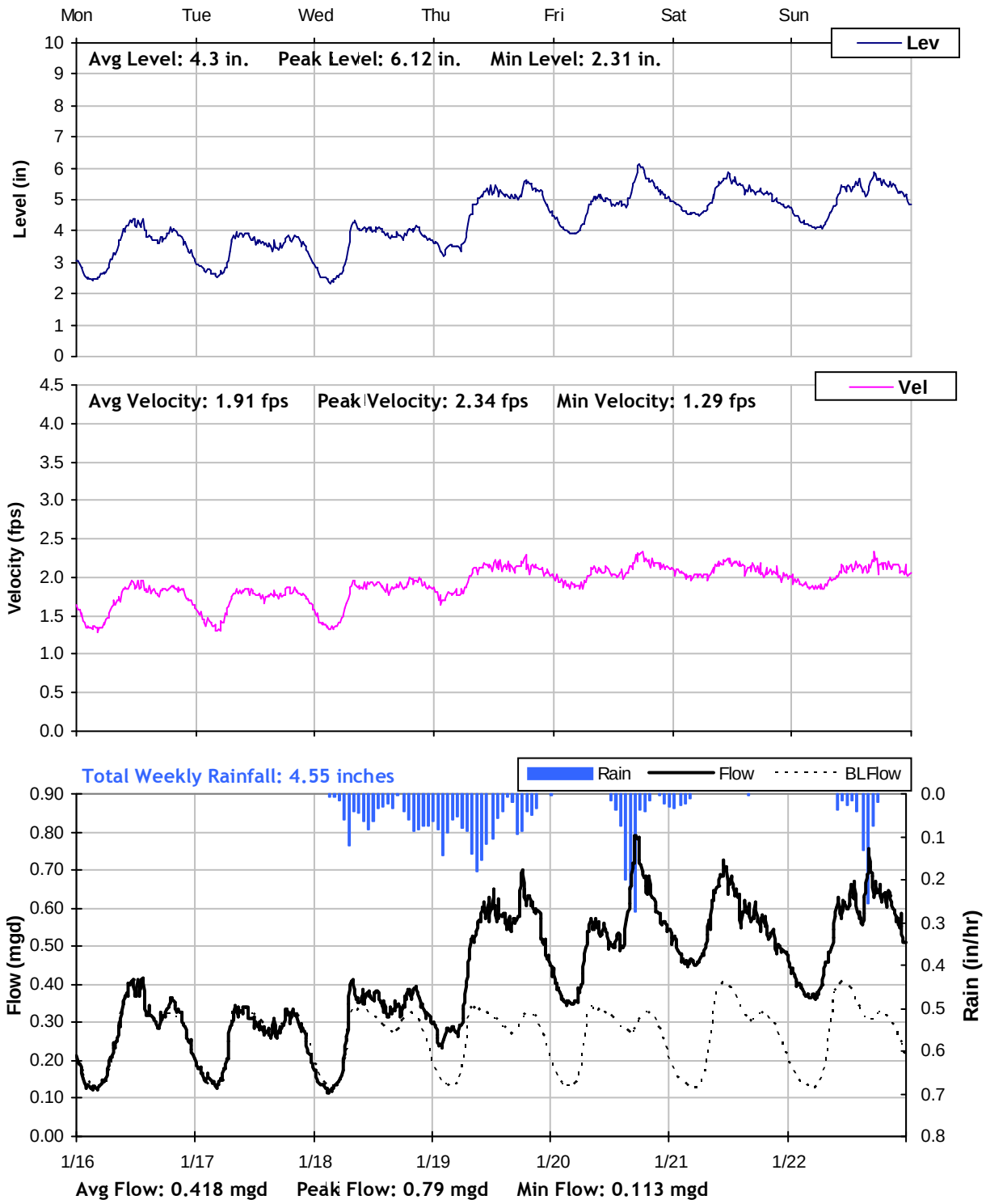
K1

Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



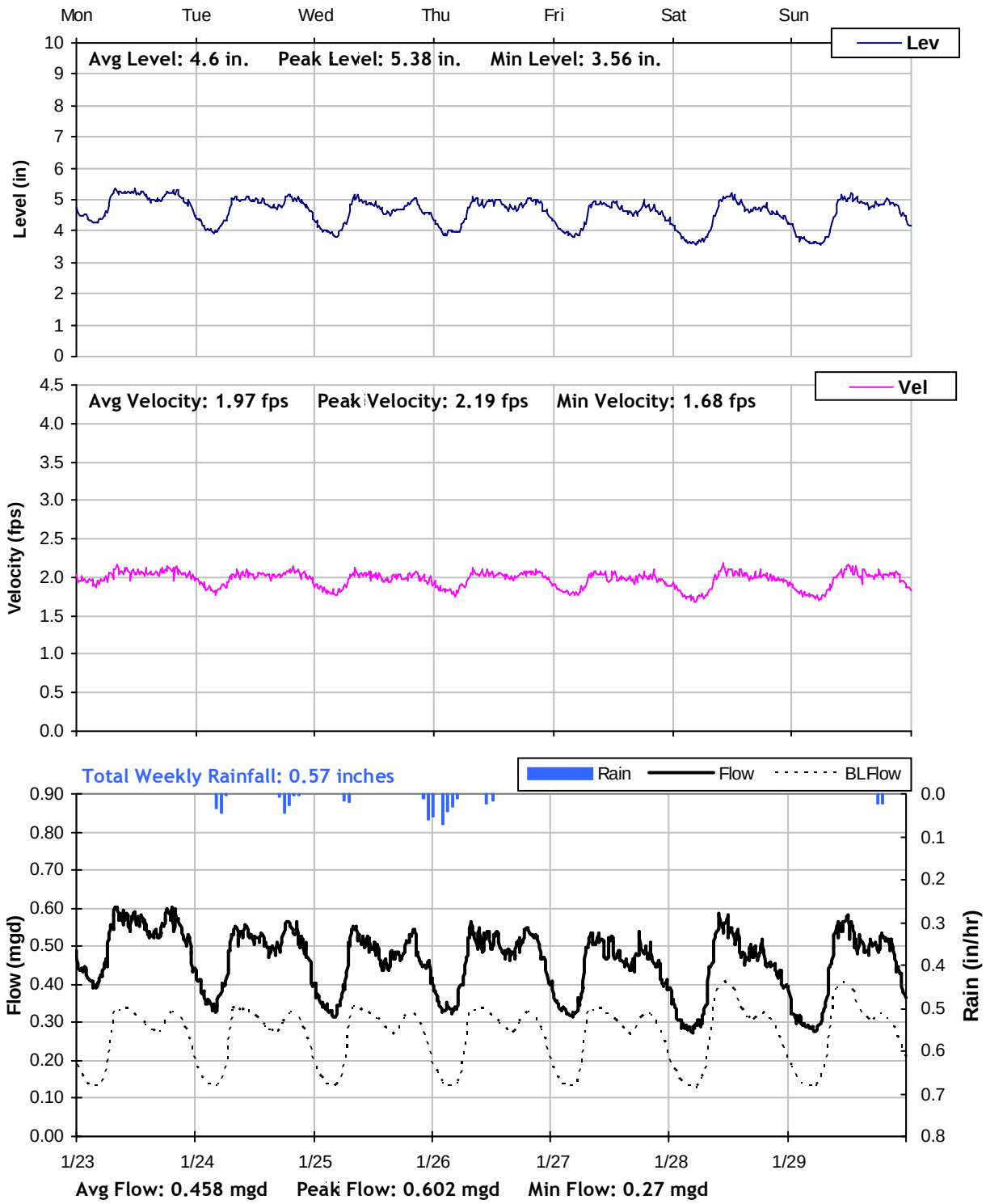
K1

Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



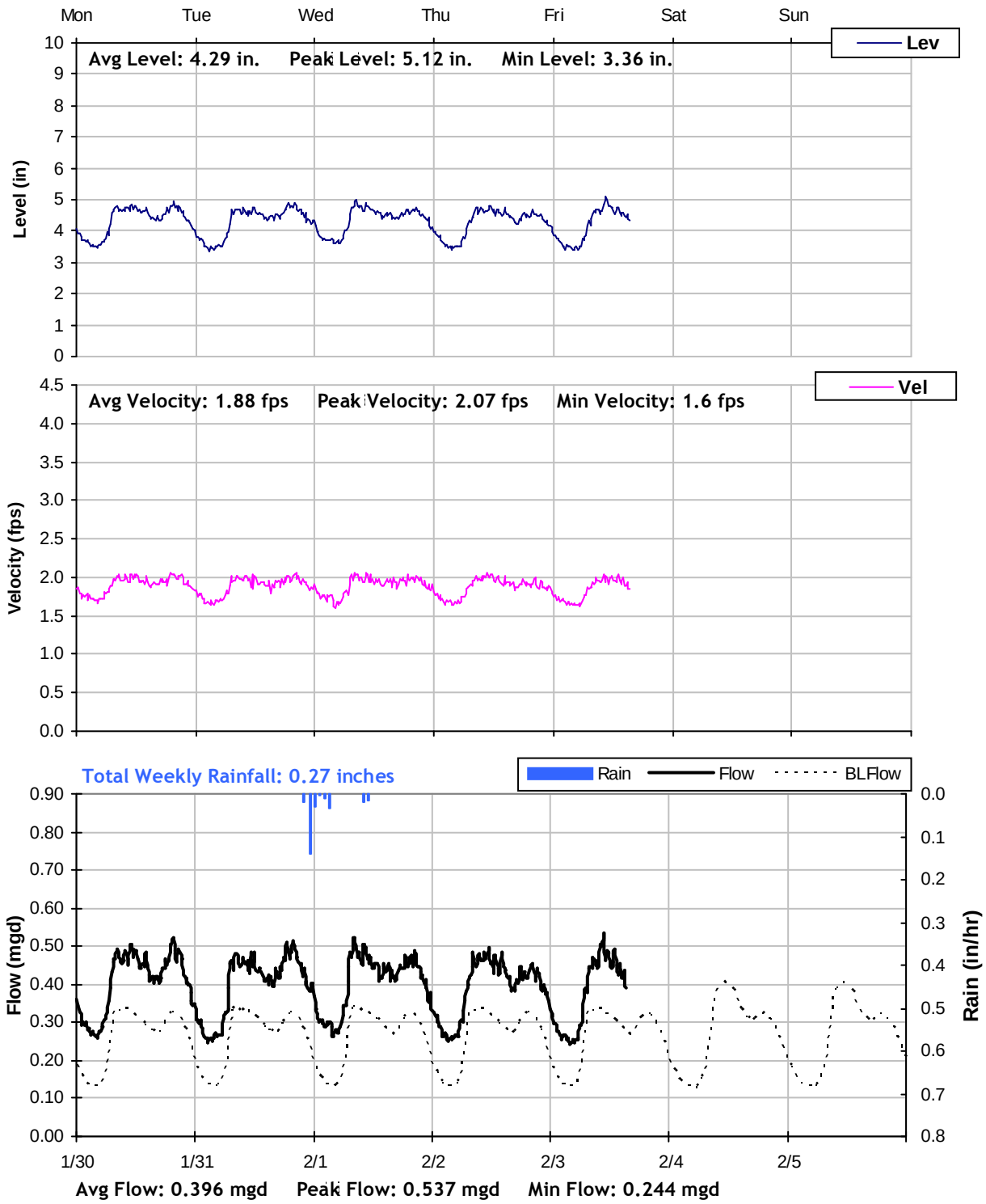
K1

Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



K1

Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

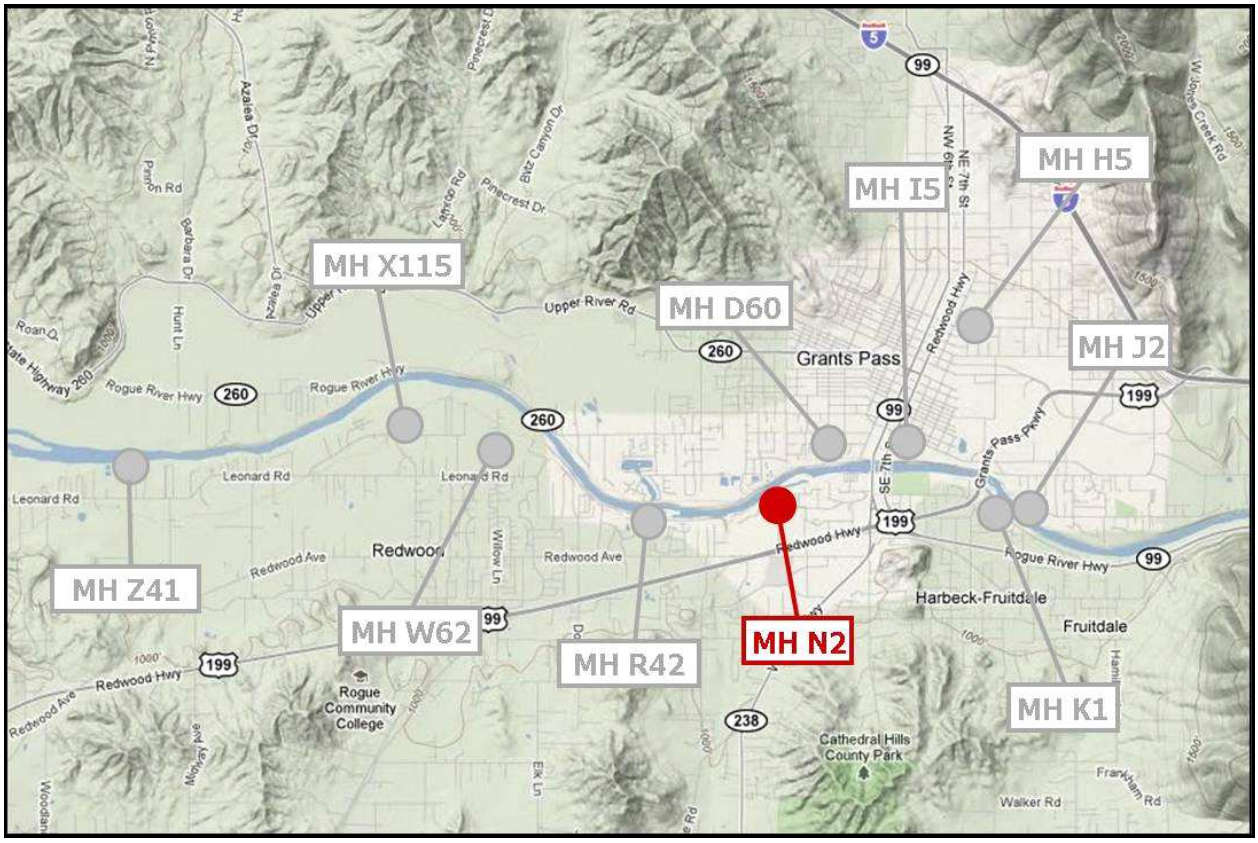
Year 2011/2012

Monitoring Site: N2

Location: West Park Street, West of Evergreen Avenue

Data Summary Report

Vicinity Map:

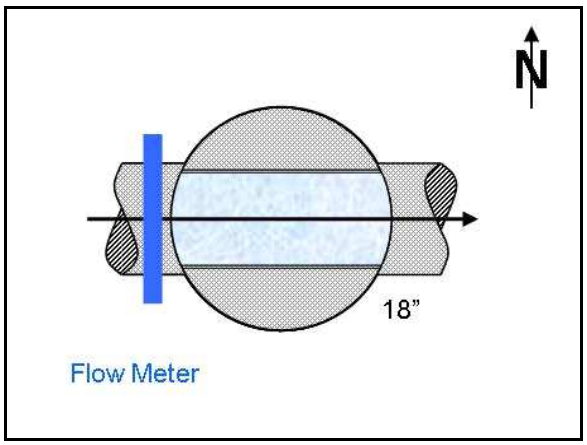


N2
Site Information Report

Location:	West Park Street, West of Evergreen Avenue
Coordinates:	123.3425°W, 42.4270°N
Elevation:	913 feet
Diameter:	18 inches
Baseline Flow:	0.2 mgd
Peak Measured Flow:	1.143 mgd

Satellite Map

Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

N2
Additional Site Photos

Effluent Pipe

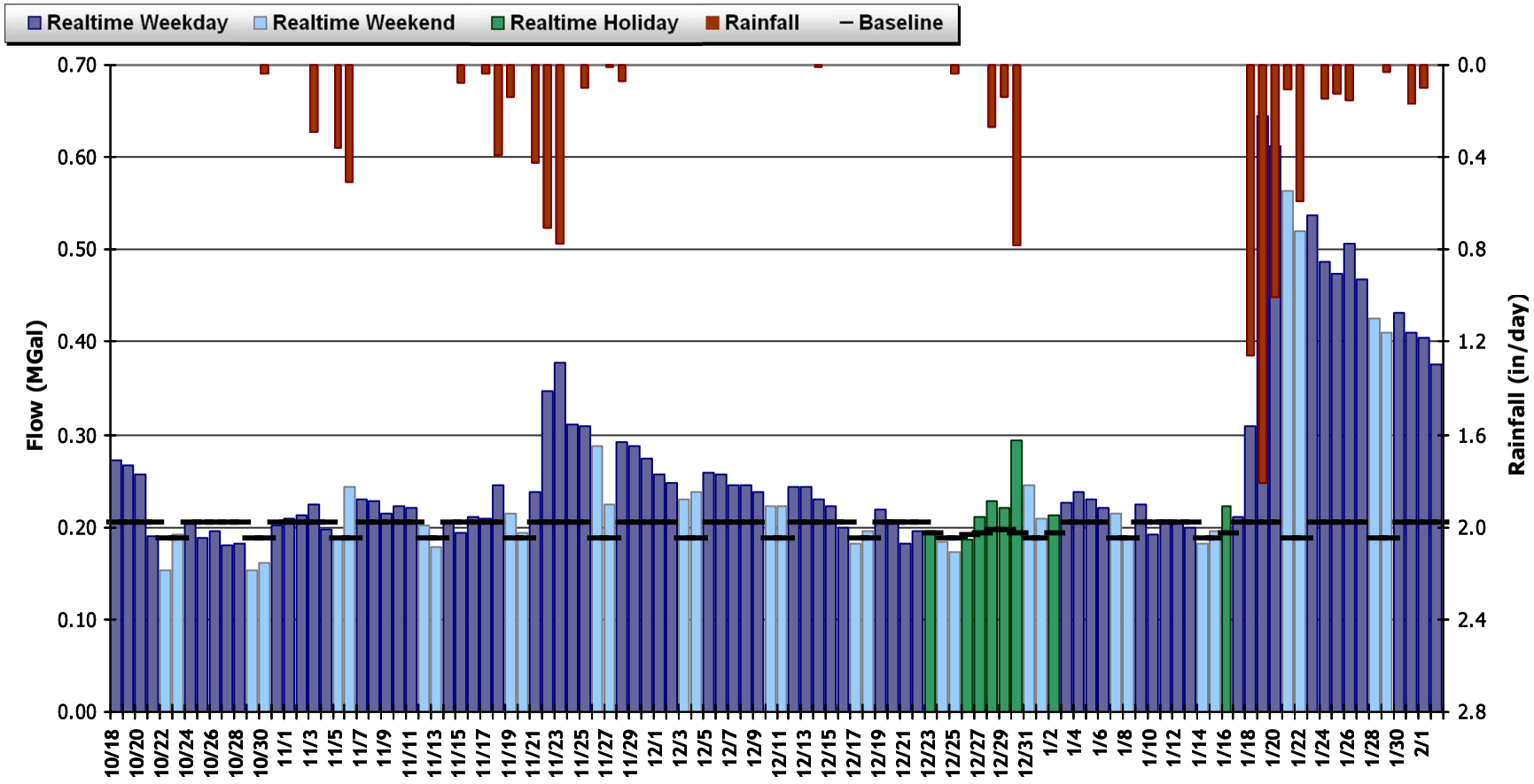
Main Influent Pipe

N2

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.259 MGal Peak Daily Flow: 0.645 MGal Min Daily Flow: 0.153 MGal

Total Period Rainfall: 10.66 inches

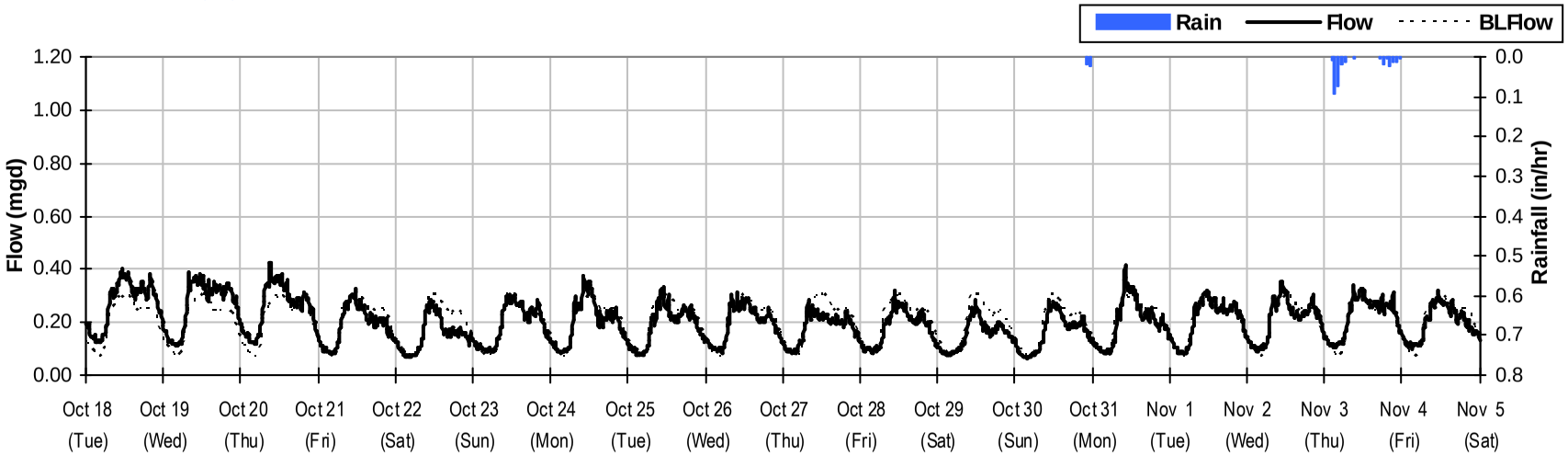


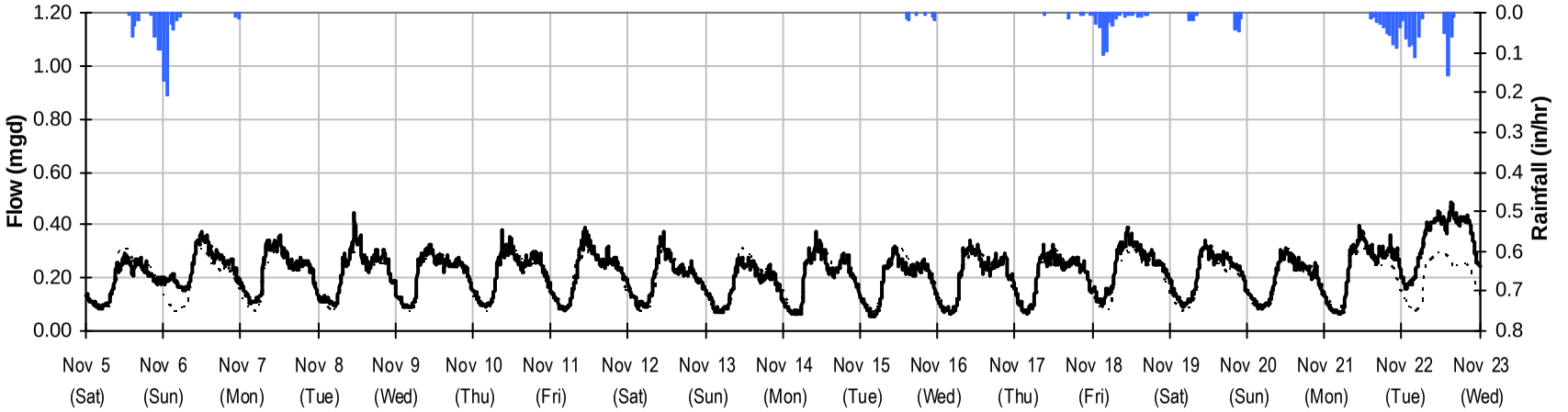
N2

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.212 mgd Peak Flow: 0.488 mgd Min Flow: 0.052 mgd

Total Period Rainfall: 2.97 inches



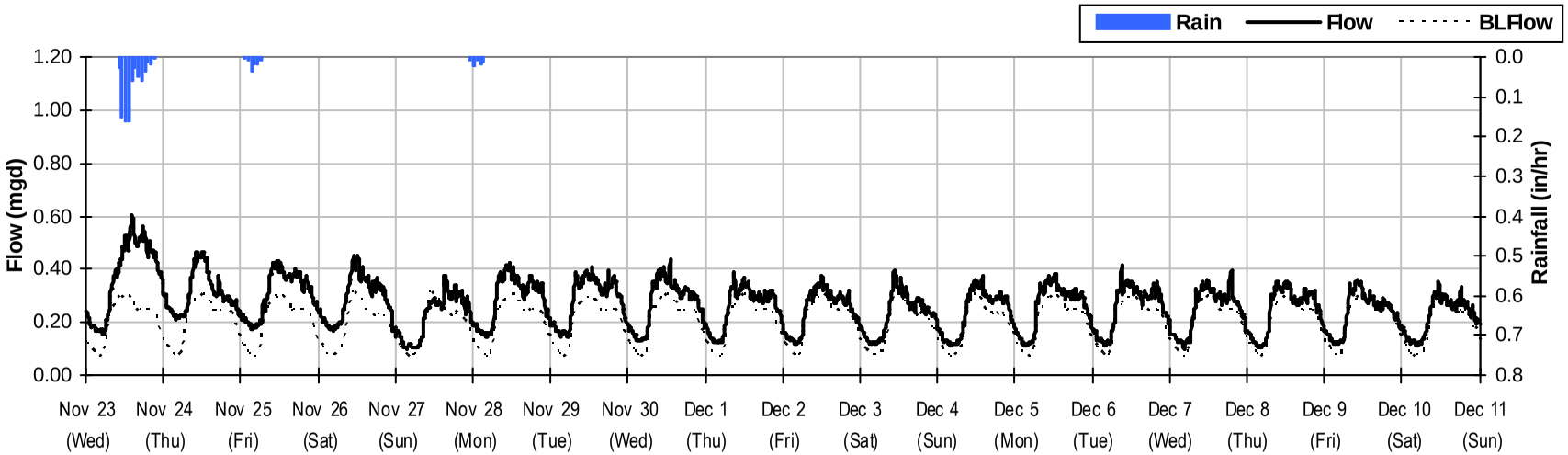


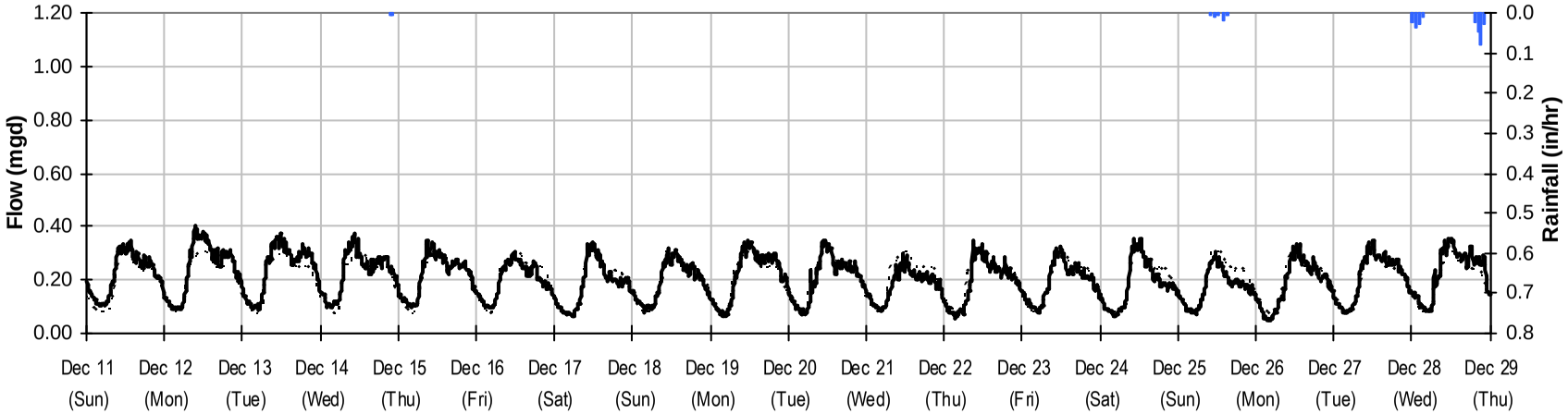
N2

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.237 mgd Peak Flow: 0.605 mgd Min Flow: 0.05 mgd

Total Period Rainfall: 1.28 inches



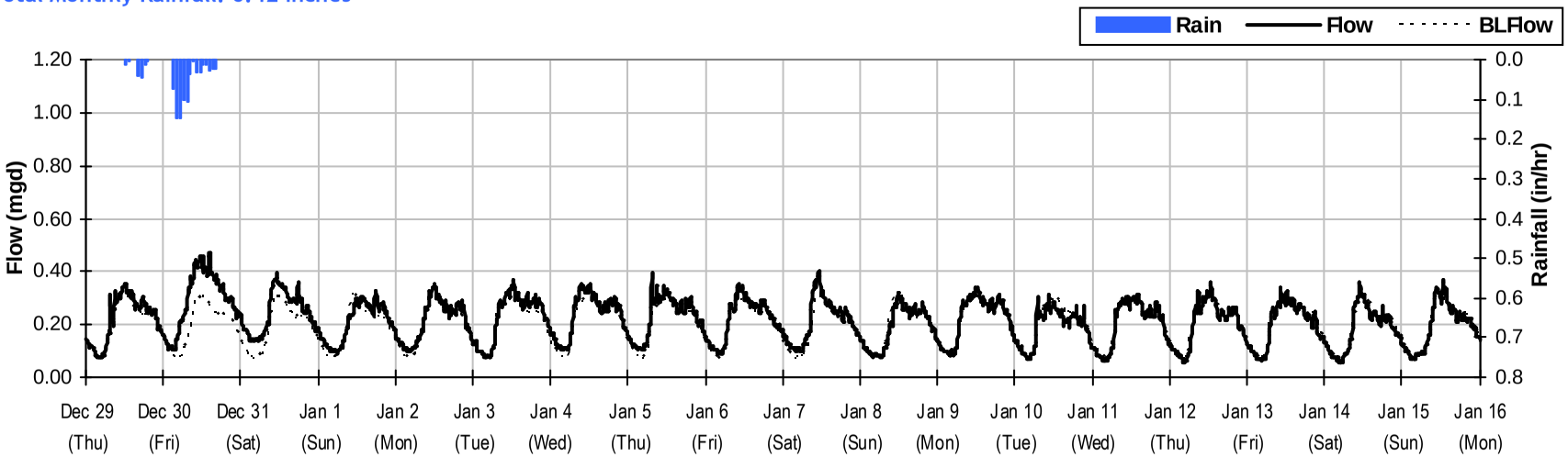


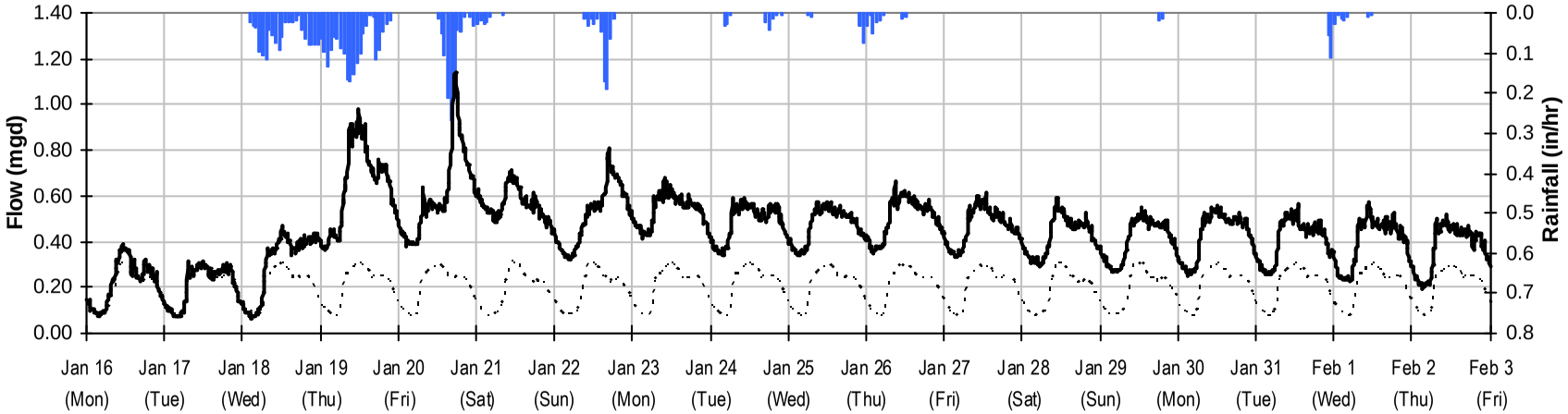
N2

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.33 mgd Peak Flow: 1.14 mgd Min Flow: 0.05 mgd

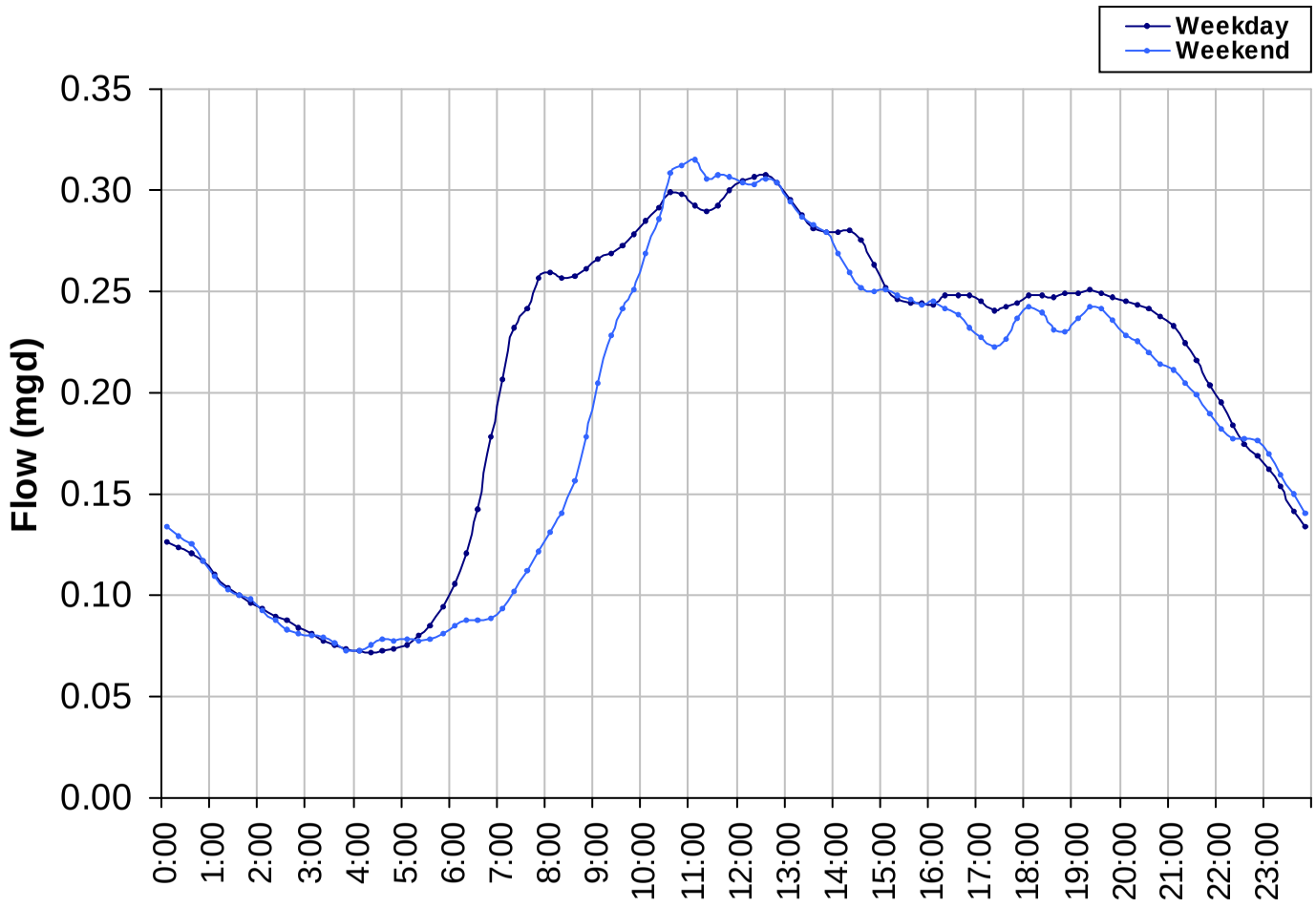
Total Monthly Rainfall: 6.42 inches





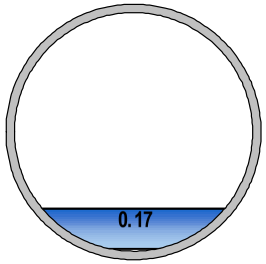
N2

Baseline Flow Hydrographs



Baseline Flow:

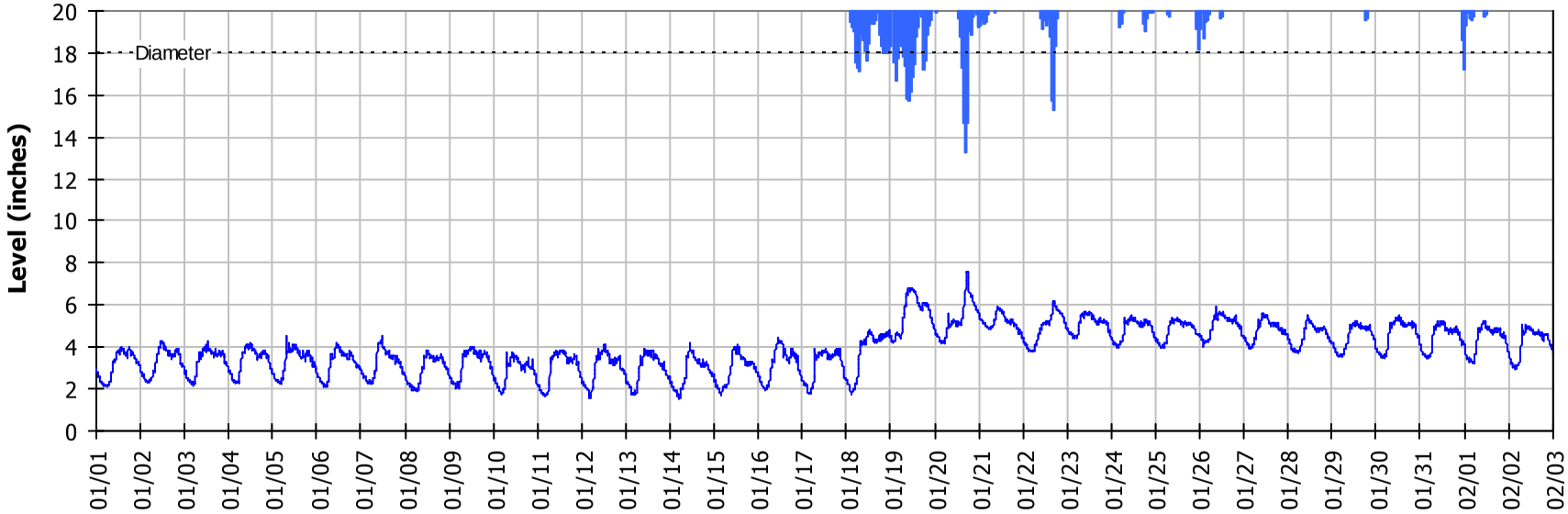
0.200 *mgd*

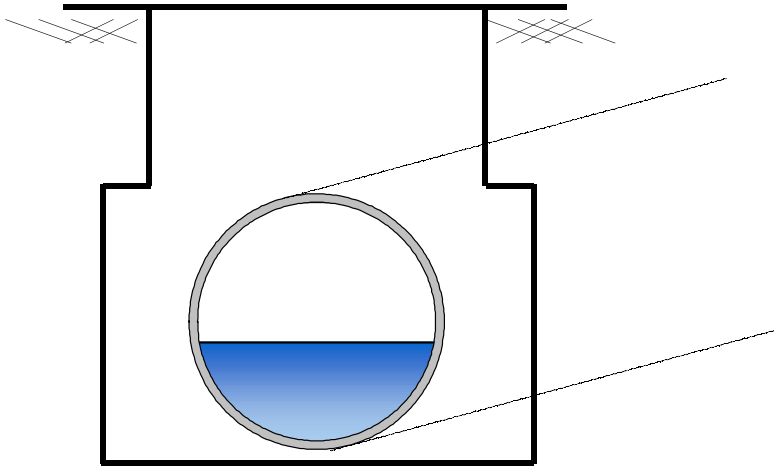


N2

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

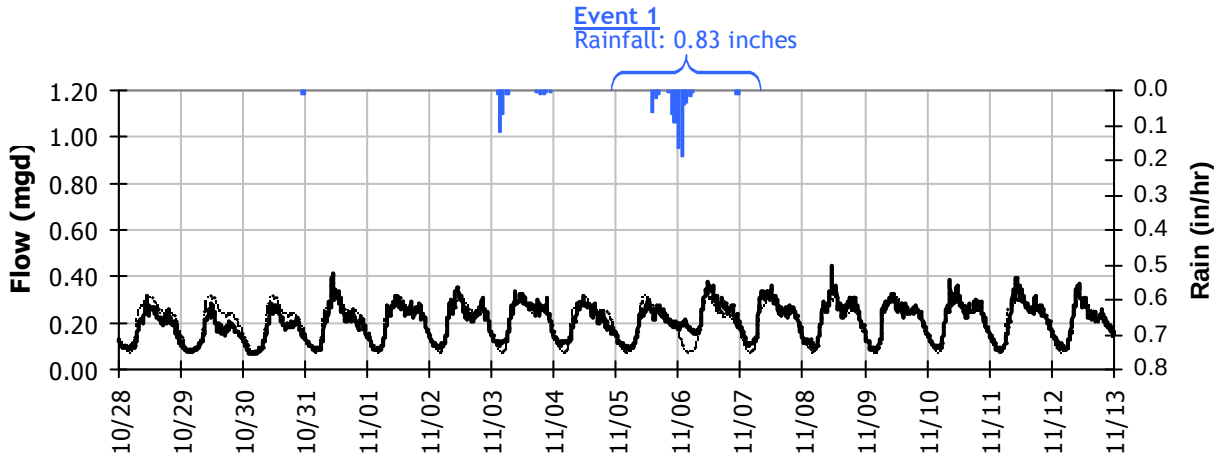




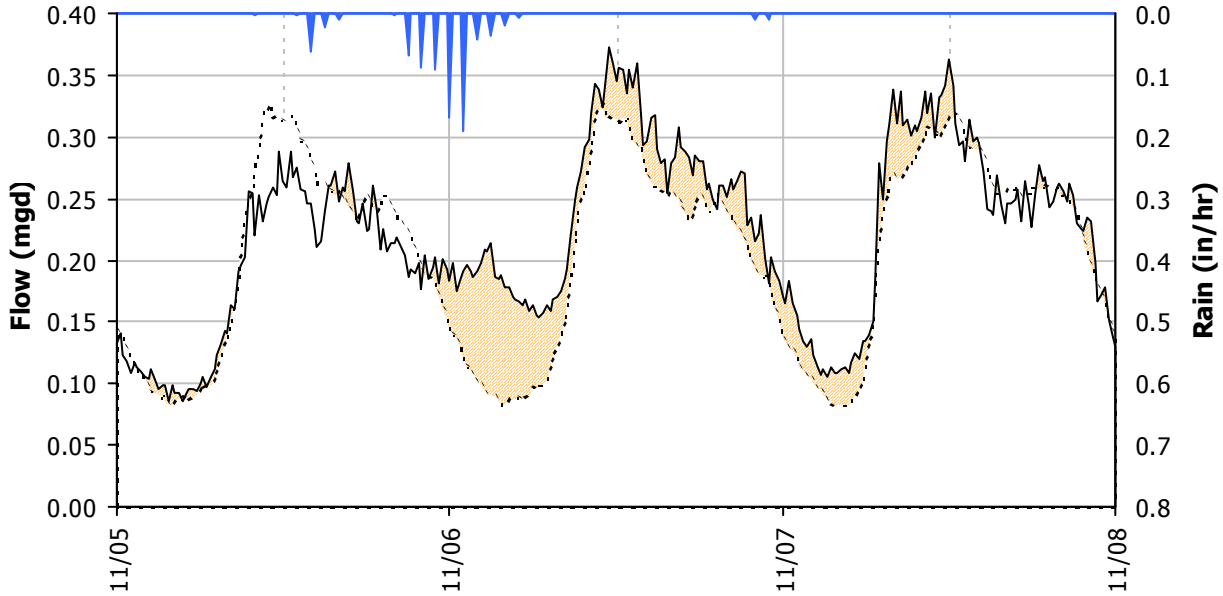
Pipe Diameter:	18	*inches*
Peak Measured Level	7.64	*inches*
Peak d/D Ratio:	0.42	

SITE N2
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

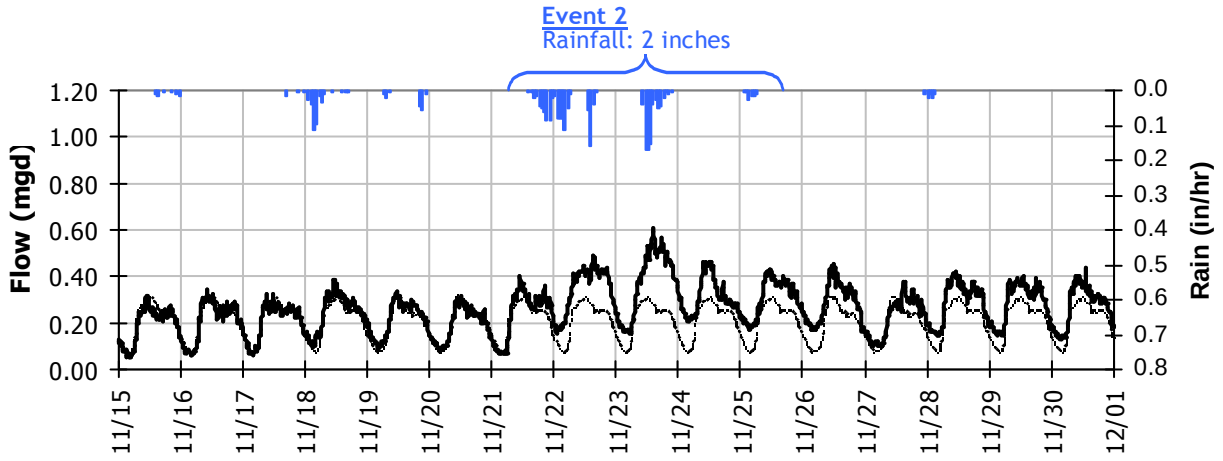


Storm Event I/I Analysis (Rain = 0.83 inches)

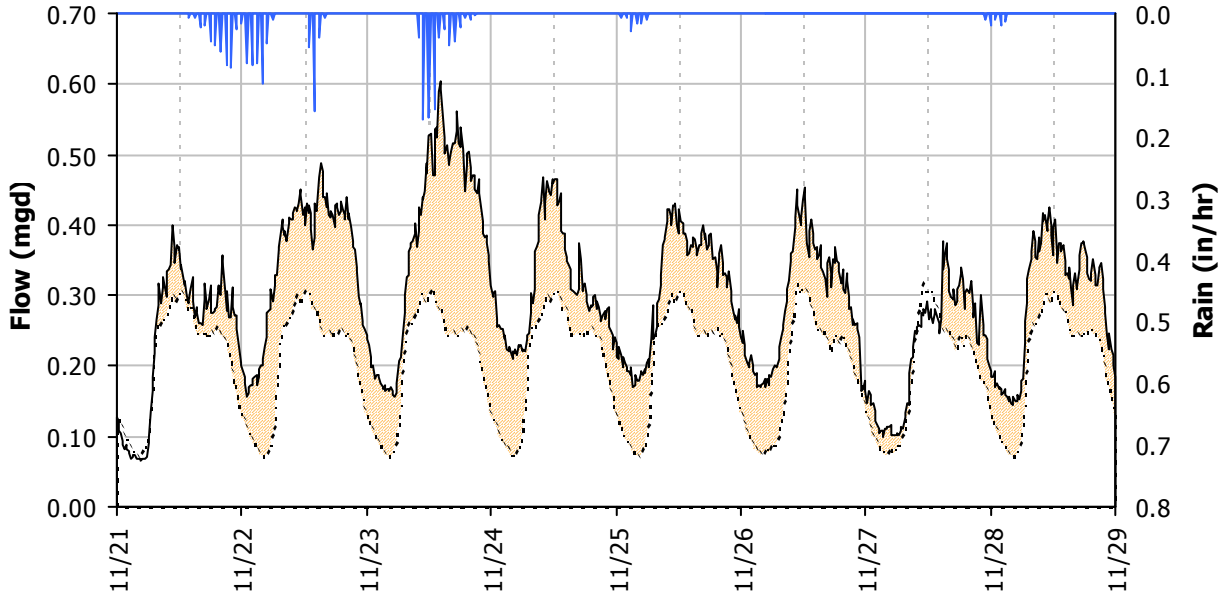
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.37 *mgd*	Peak I/I Rate:	0.13 *mgd*	Infiltration Rate: (11/7/2011)	0.024 *mgd*	Total I/I:	61,000 *gallons*
PF:	1.86	PkI/I:IDM:	997 *gpd/IDM*	RDI:IDM:	180 *gpd/IDM*	Total I/I:IDM:	549 *gal/IDM/in*
Peak Level:	4.21 *in*	PkI/I:Acre:	157 *gpd/acre*	RDI:Acre:	28 *gpd/acre*	R-Value:	0.3%
d/D Ratio:	0.23	Pk I/I:ADWF:	0.66	RDI (% of BL):	12%	Total I/I:ADWF:	0.37 *per in-rain*

SITE N2
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

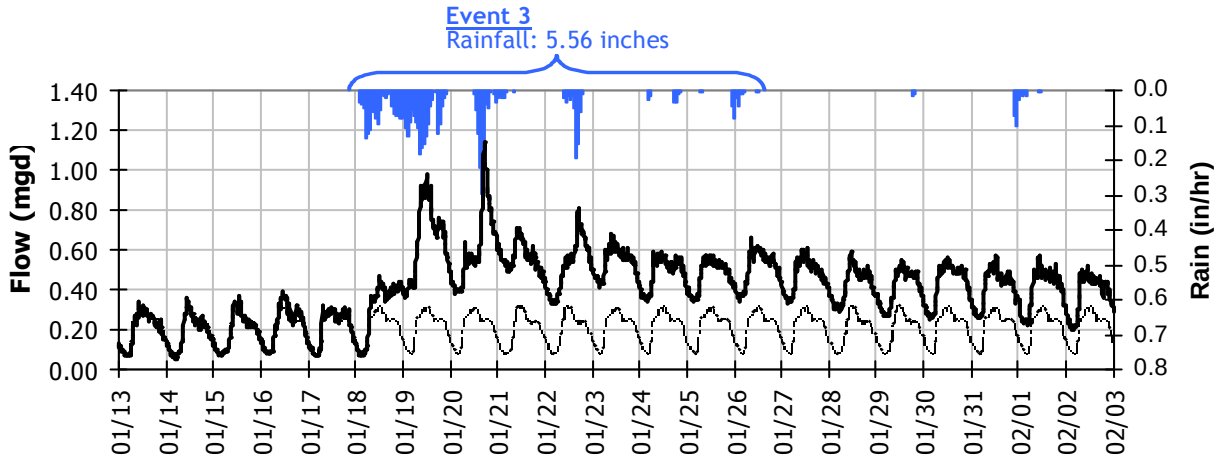


Storm Event I/I Analysis (Rain = 2 inches)

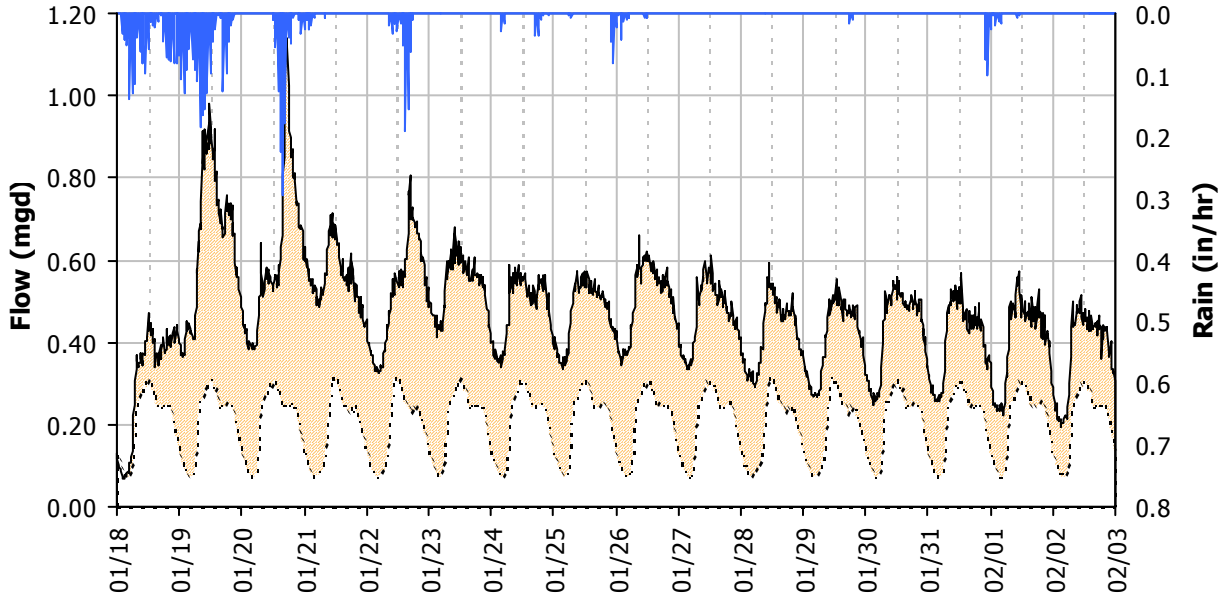
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.60	*mgd*	Peak I/I Rate:	0.33	*mgd*	Infiltration Rate: (11/26/2011)	0.098	*mgd*	Total I/I:	776,000	*gallons*
PF:	3.02		PkI/I:IDM:	2,437	*gpd/IDM*	RDI:IDM:	734	*gpd/IDM*	Total I/I:IDM:	2,910	*gal/IDM/in*
Peak Level:	5.47	*in*	PkI/I:Acre:	385	*gpd/acre*	RDI:Acre:	116	*gpd/acre*	R-Value:	1.7%	
d/D Ratio:	0.30		Pk I/I:ADWF:	1.62		RDI (% of BL):	52%		Total I/I:ADWF:	1.94	*per in-rain*

SITE N2
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

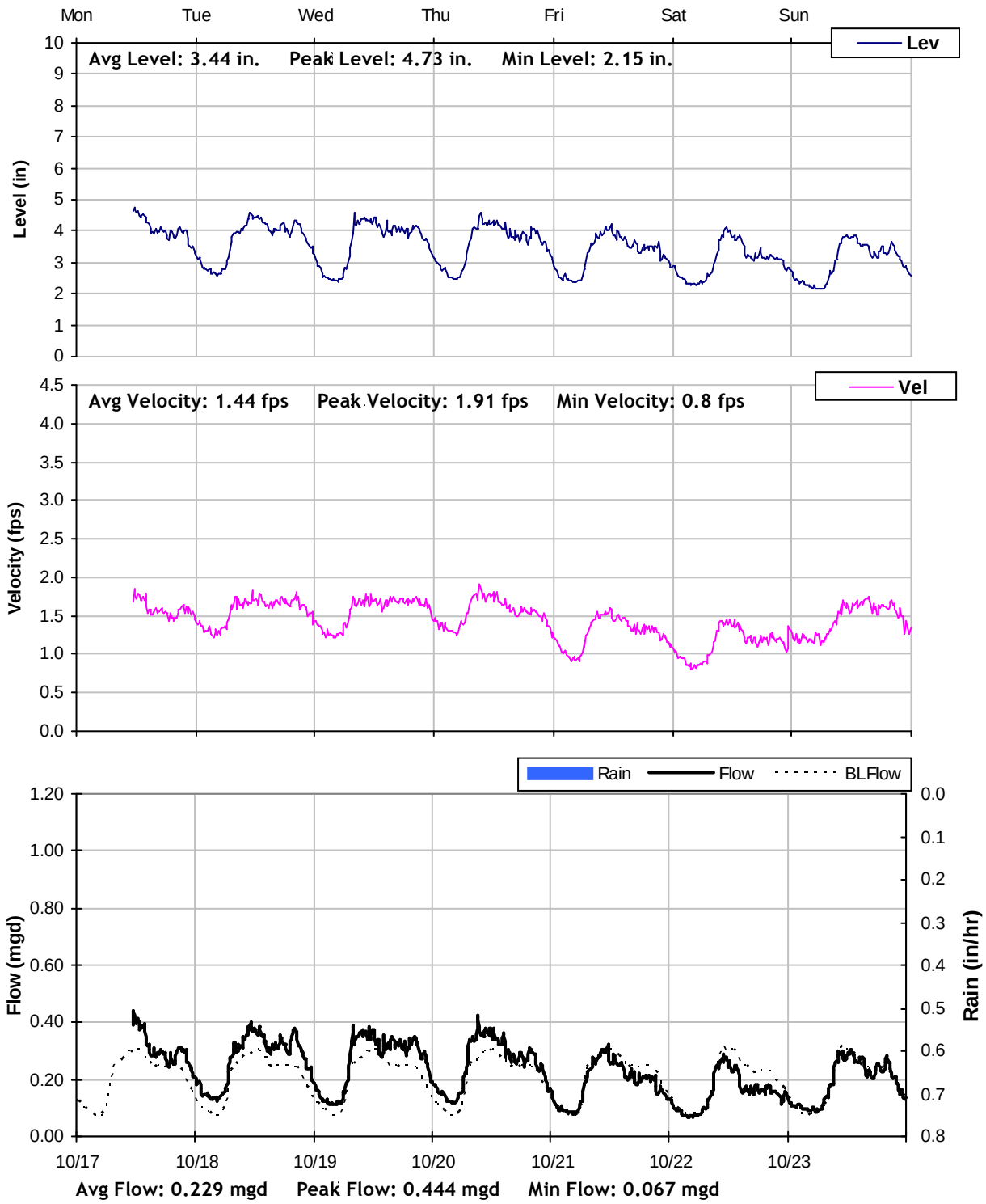


Storm Event I/I Analysis (Rain = 5.56 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	1.14	*mgd*	Peak I/I Rate:	0.90	*mgd*	Infiltration Rate: (1/30/2012)	0.226	*mgd*	Total I/I:	4,361,000	*gallons*
PF:	5.70		PkI/I:IDM:	6,749	*gpd/IDM*	RDI:IDM:	1,696	*gpd/IDM*	Total I/I:IDM:	5,880	*gal/IDM/in*
Peak Level:	7.64	*in*	PkI/I:Acre:	1,066	*gpd/acre*	RDI:Acre:	268	*gpd/acre*	R-Value:	3.4%	
d/D Ratio:	0.42		Pk I/I:ADWF:	4.49		RDI (% of BL):	111%		Total I/I:ADWF:	3.91	*per in-rain*

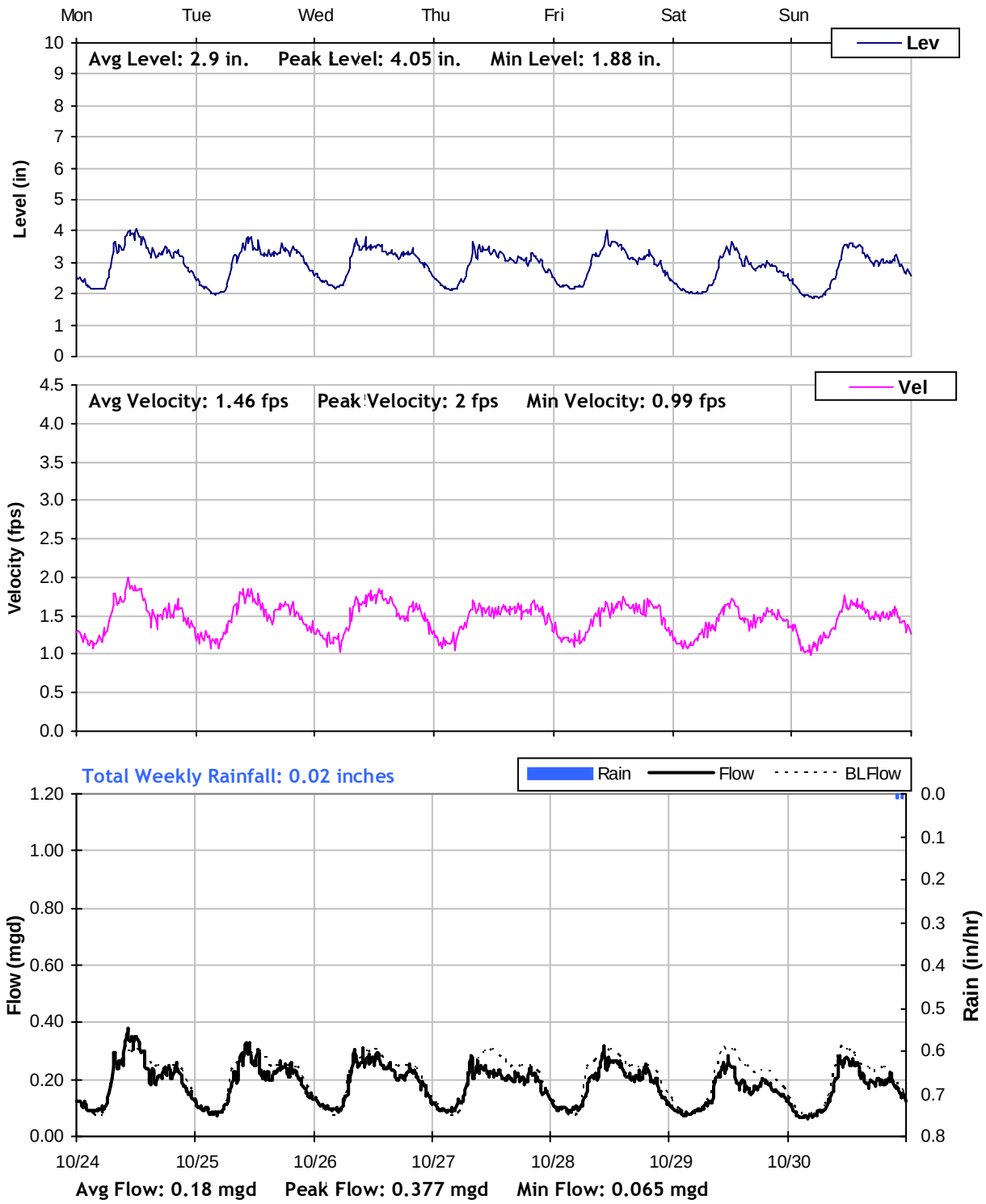
N2

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



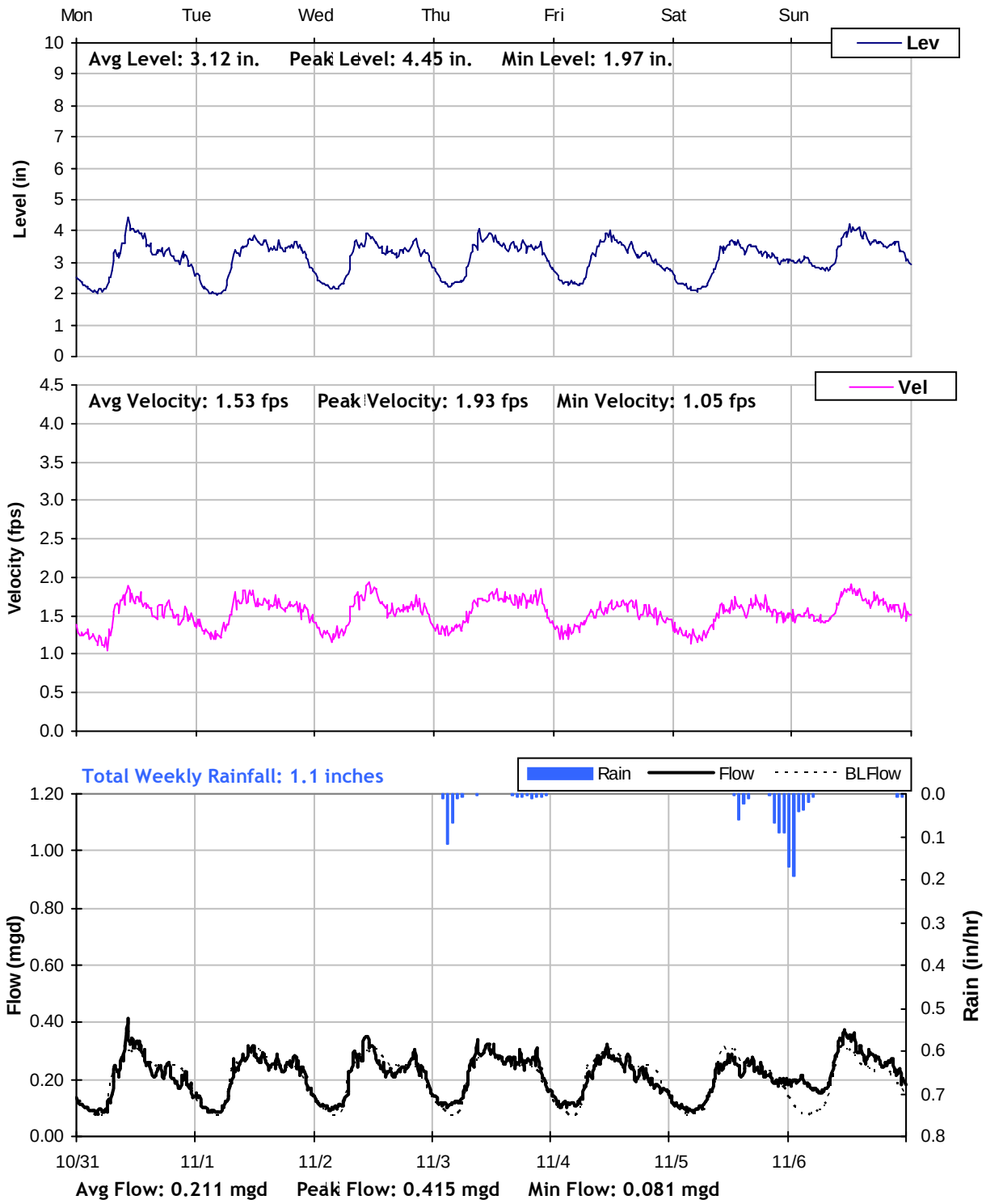
N2

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



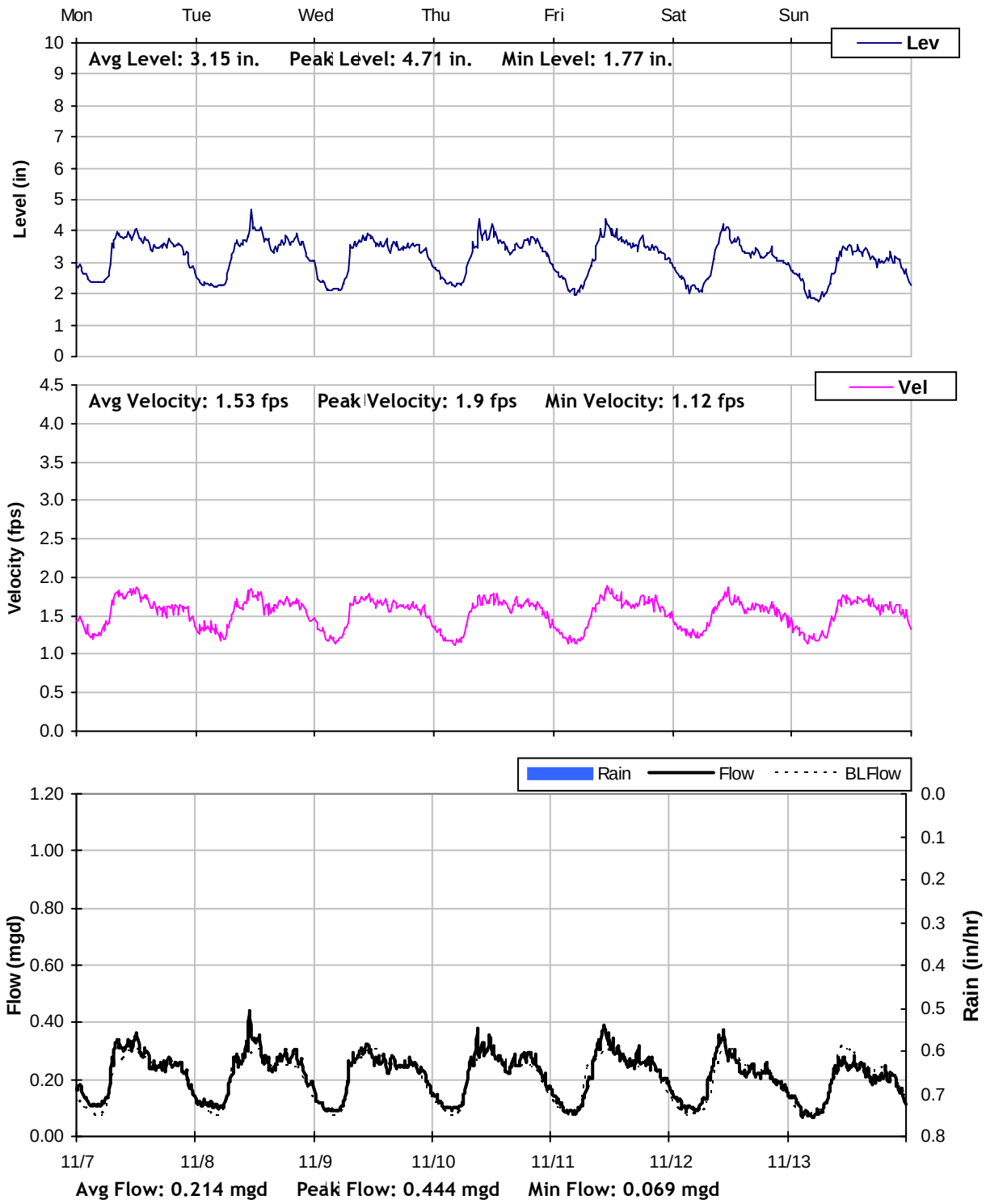
N2

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



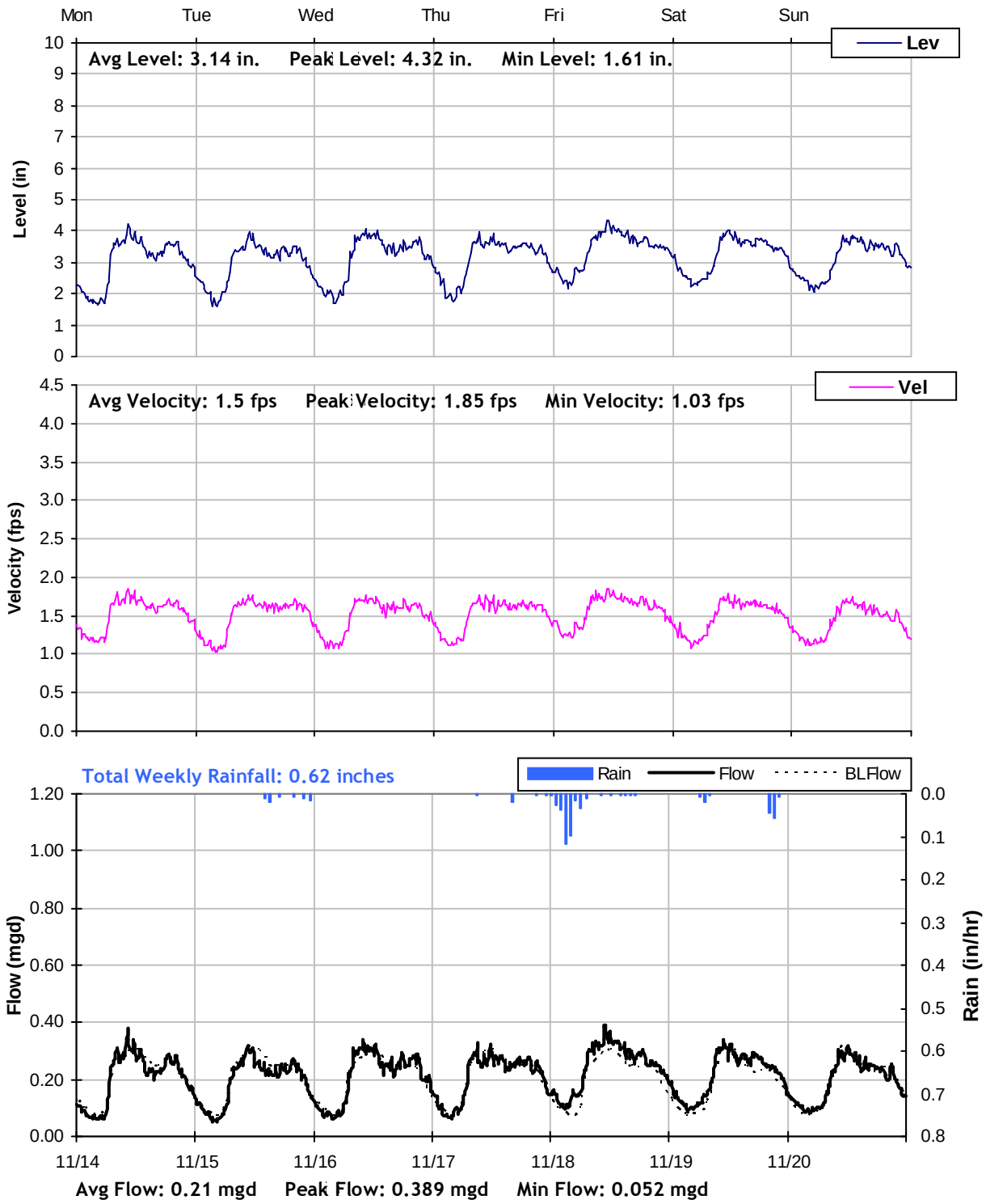
N2

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



N2

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



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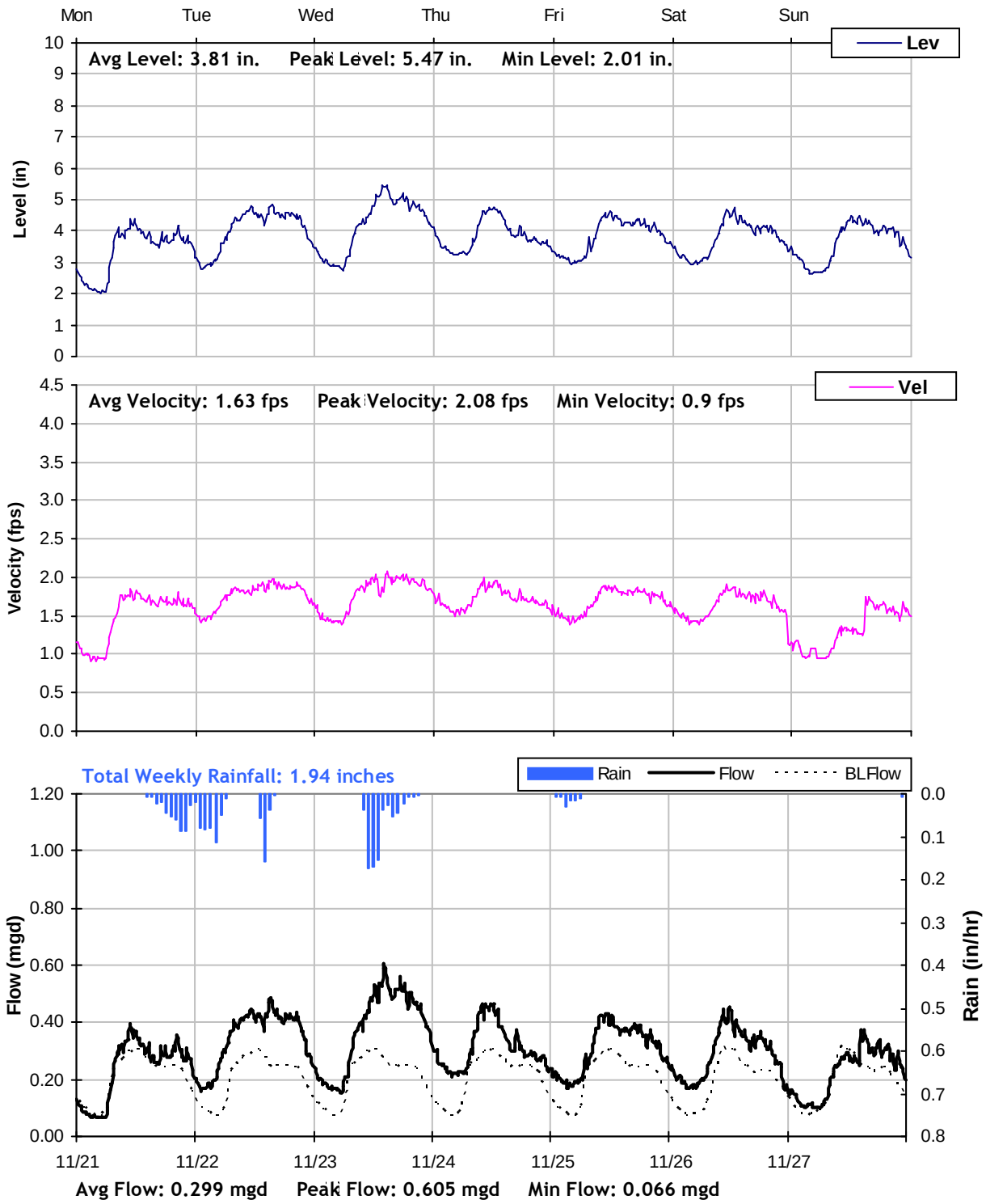
Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



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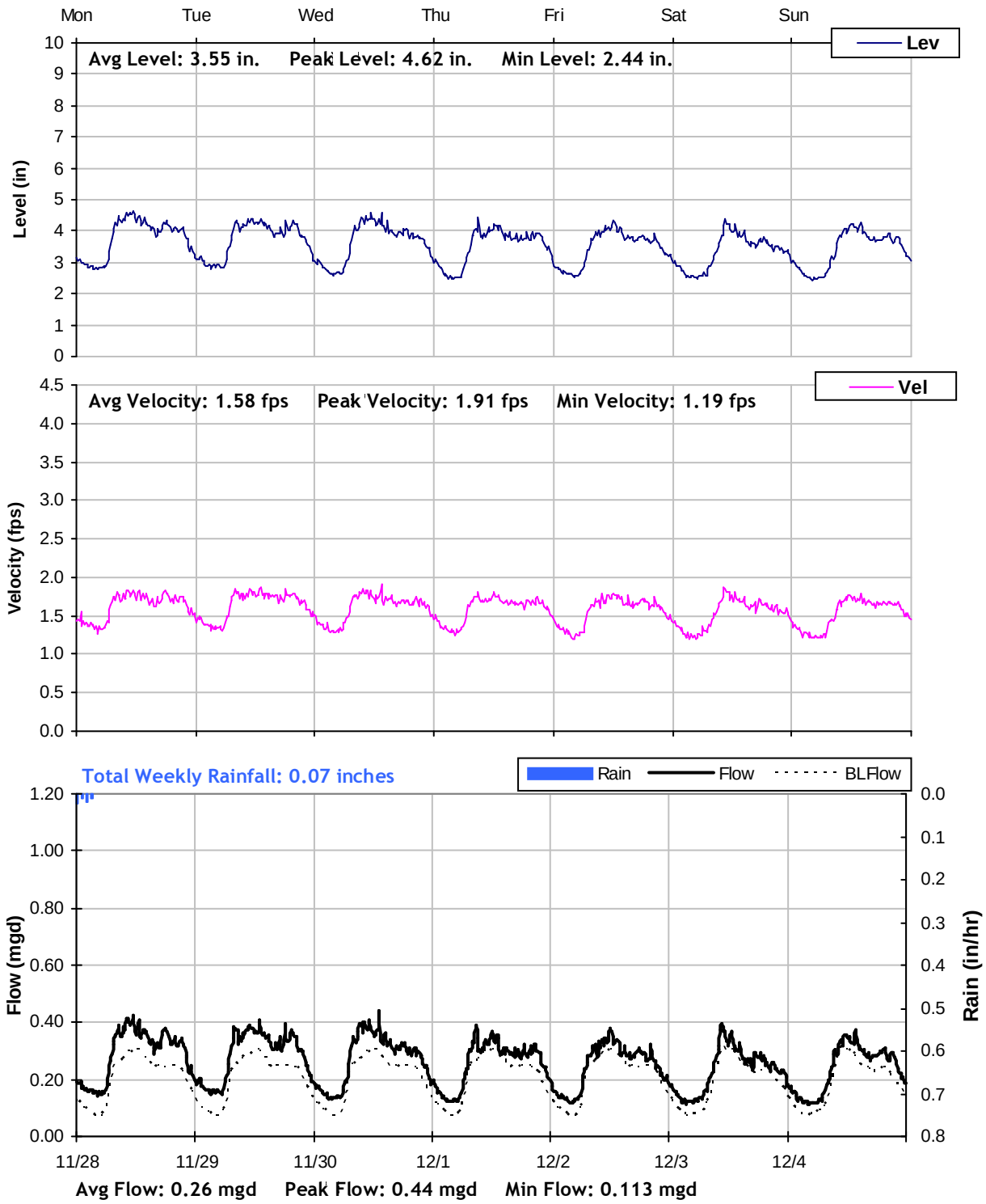
Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



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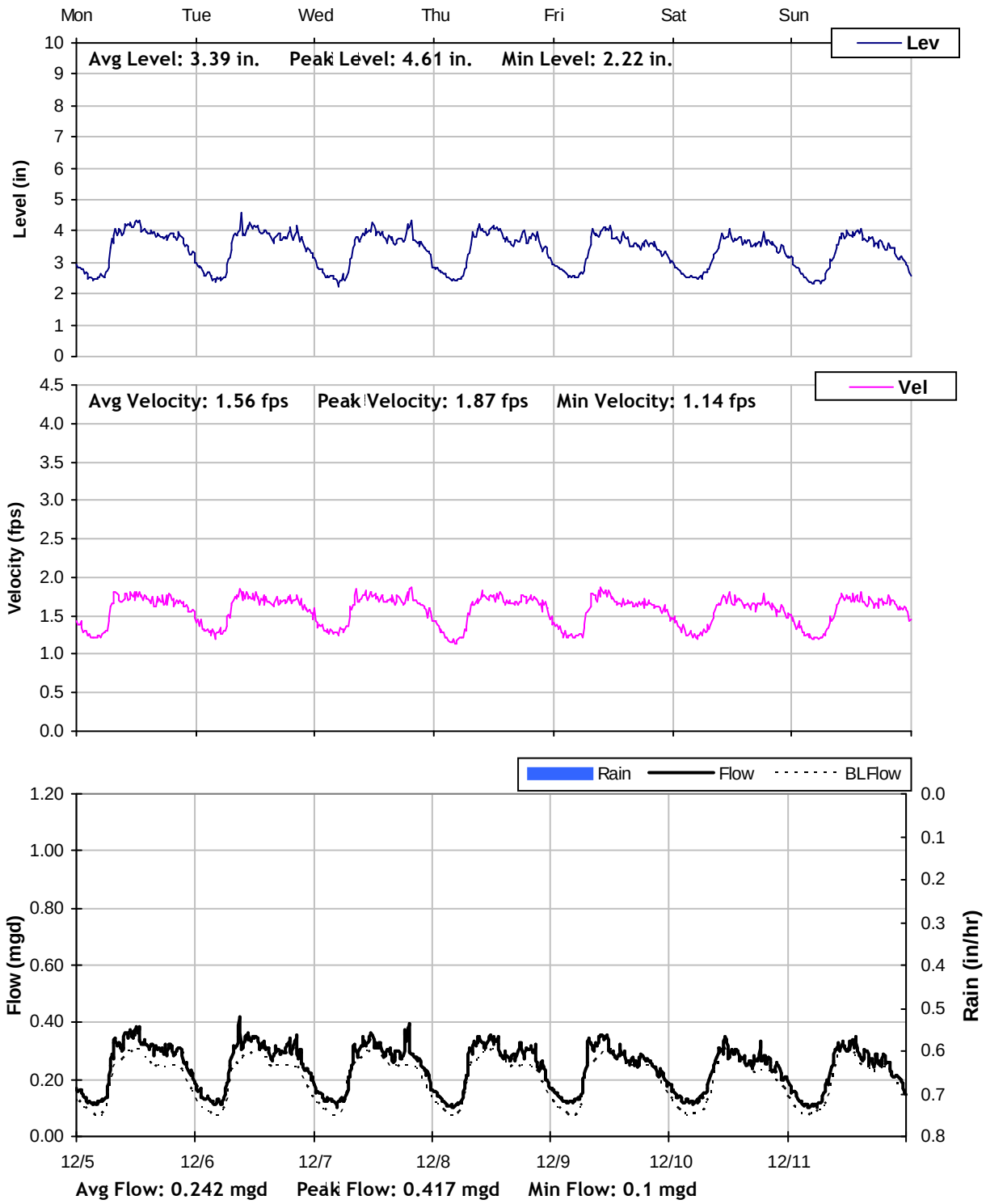
Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



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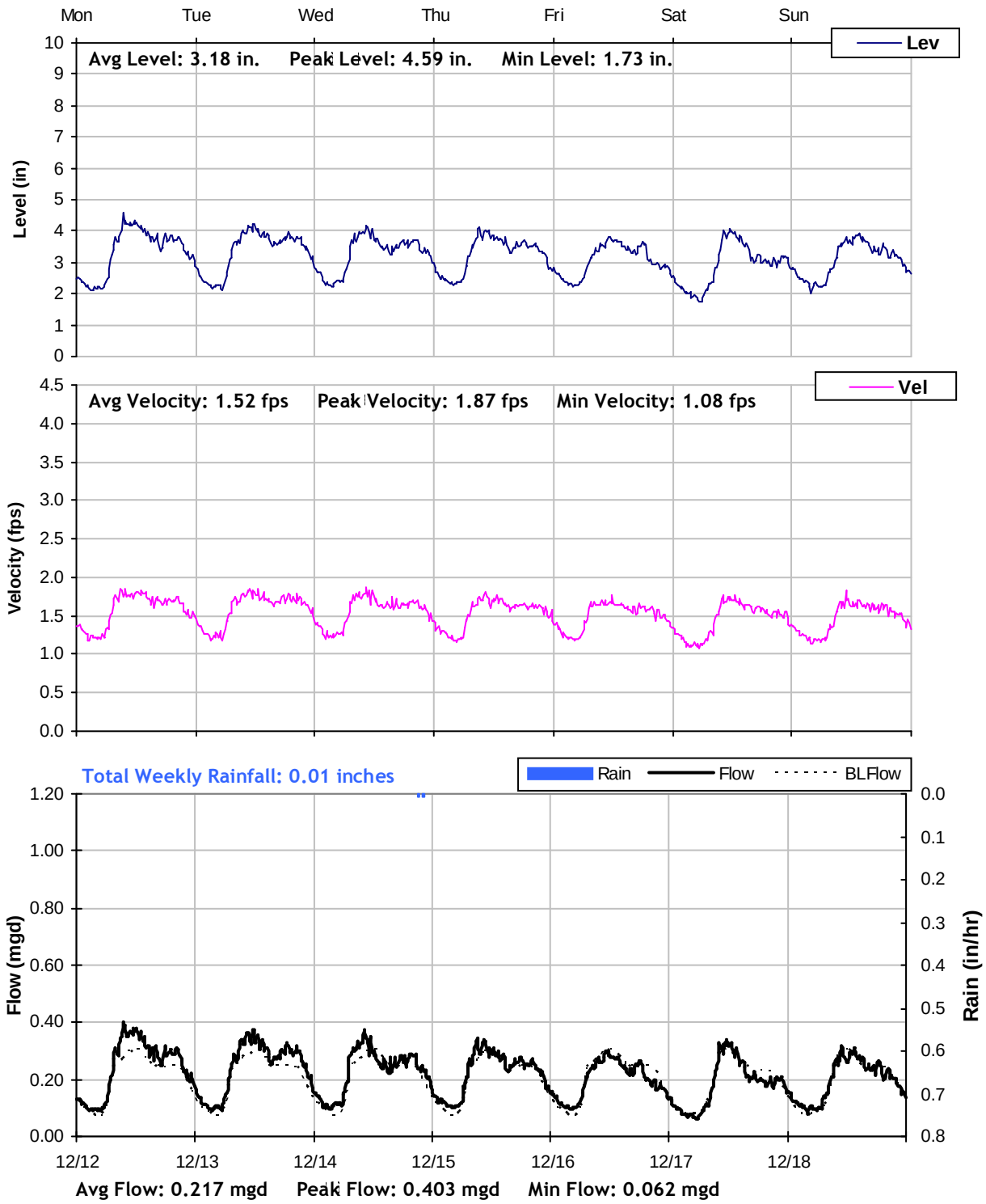
Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



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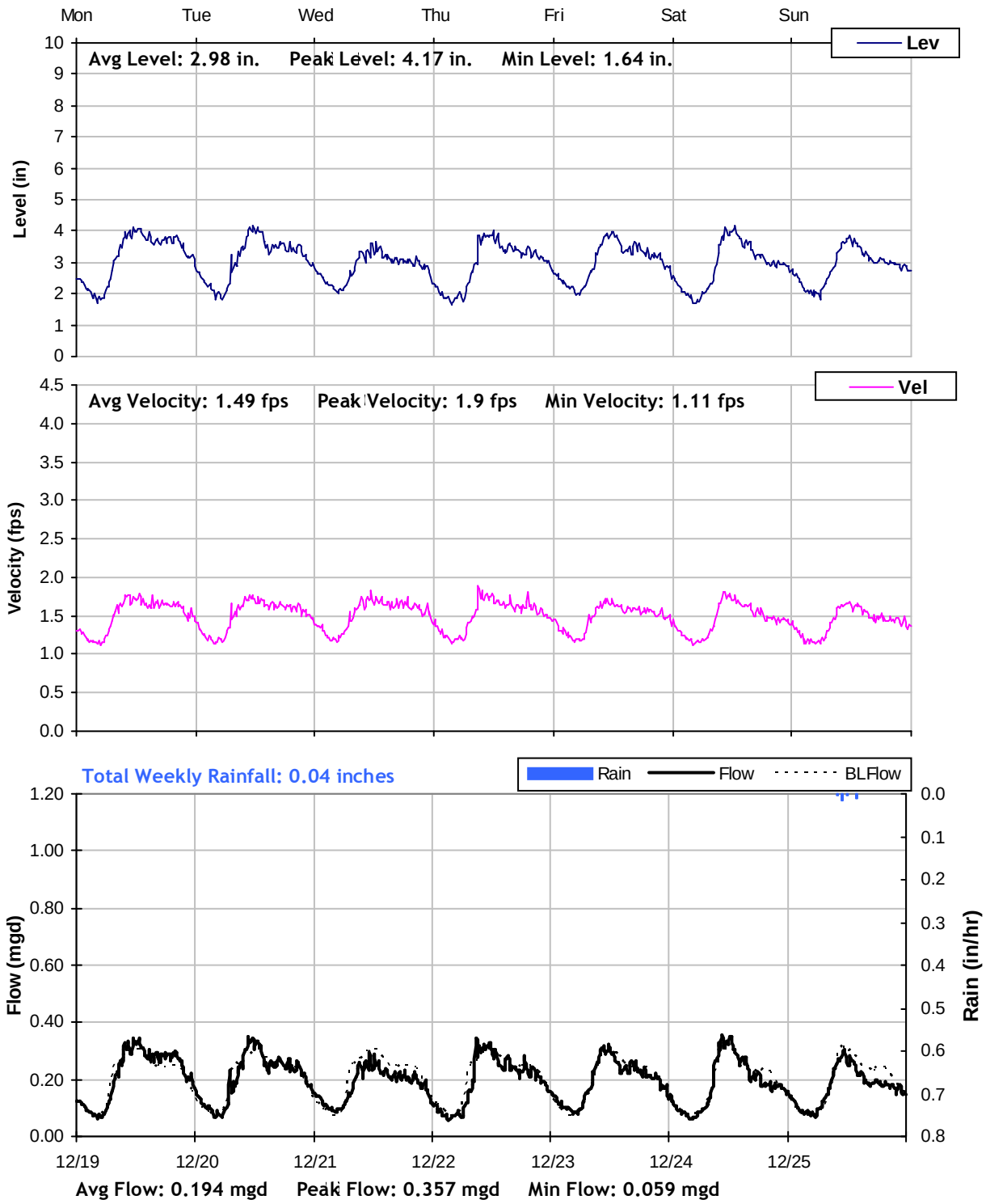
Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



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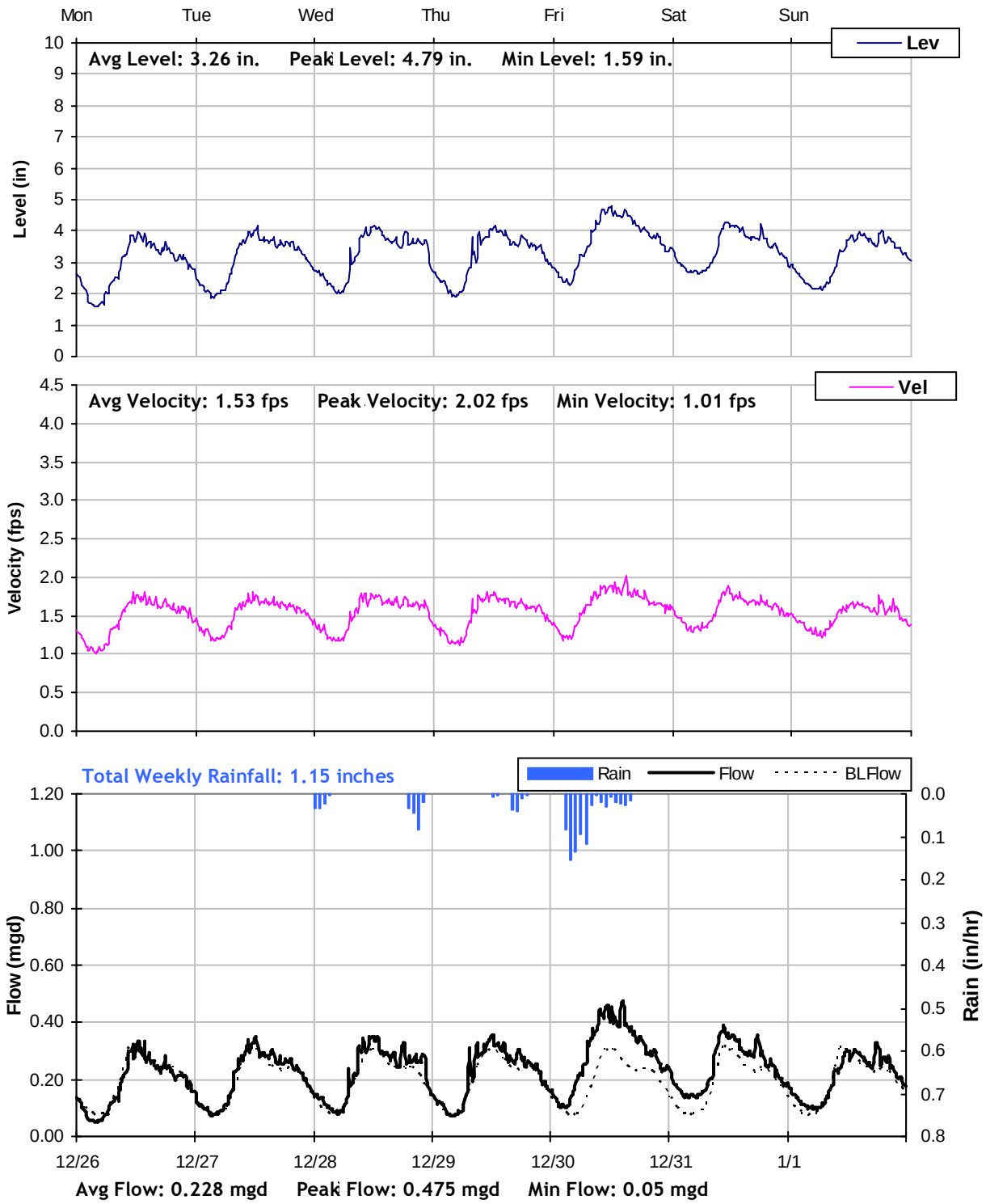
Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



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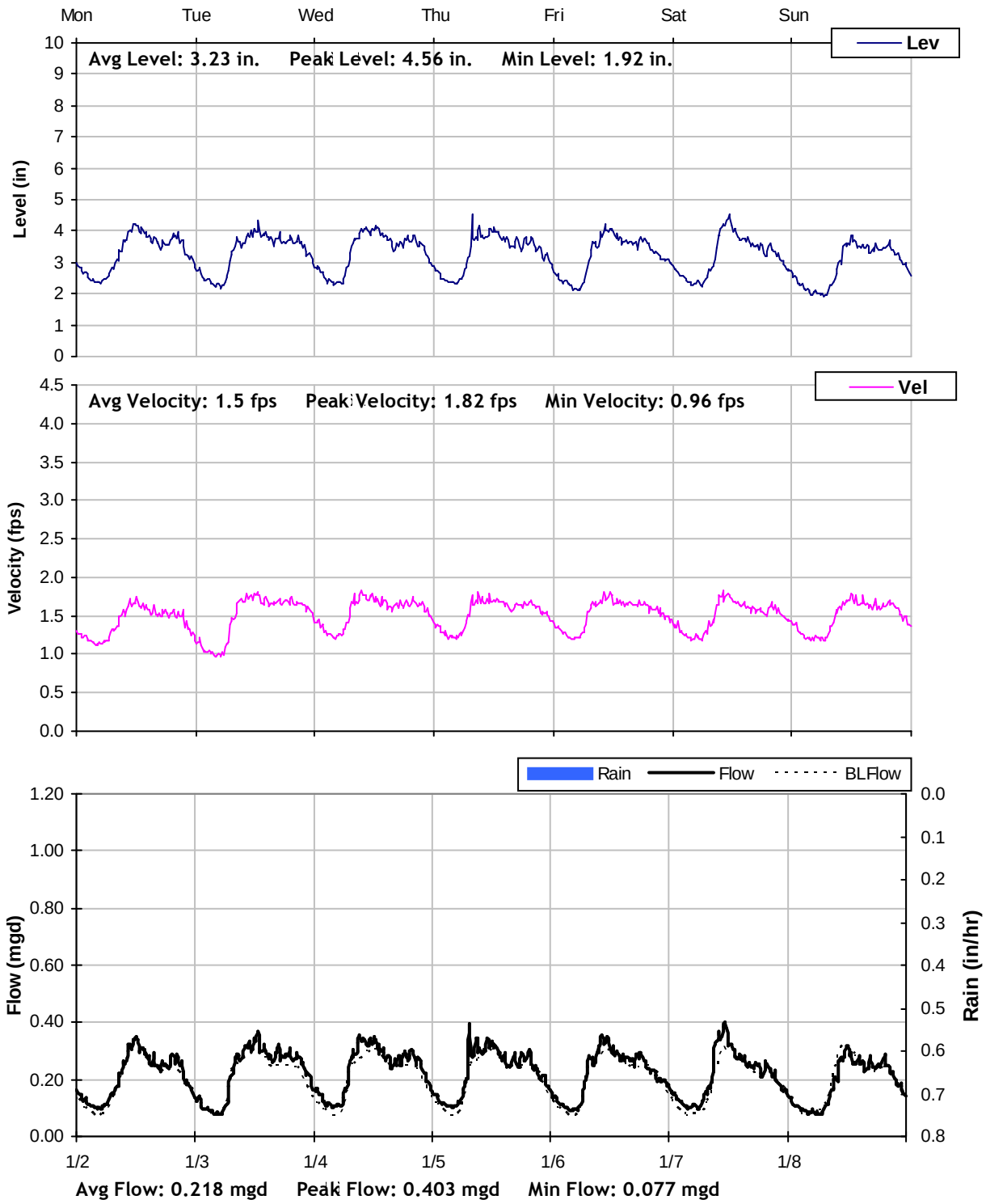
Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



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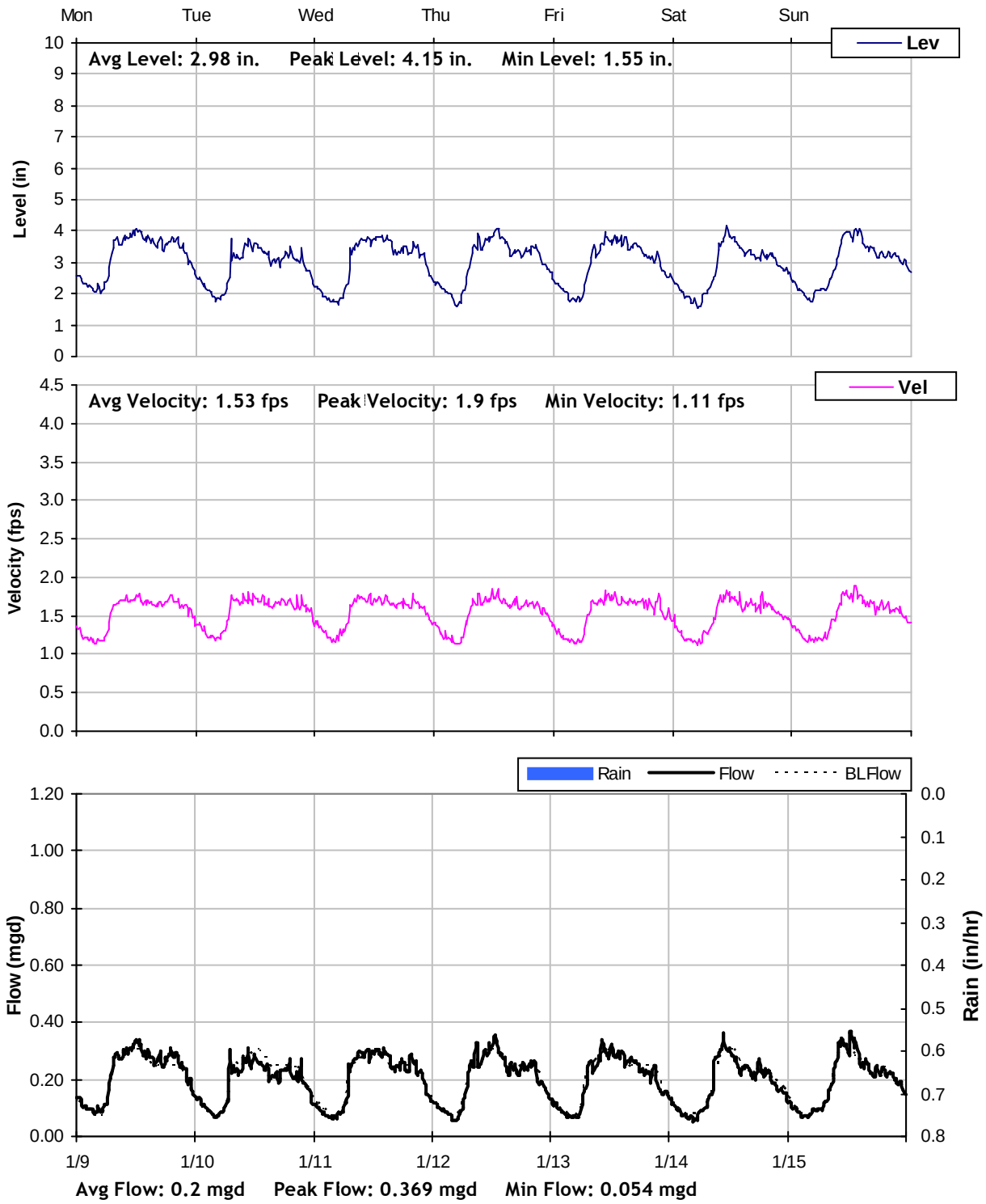
Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



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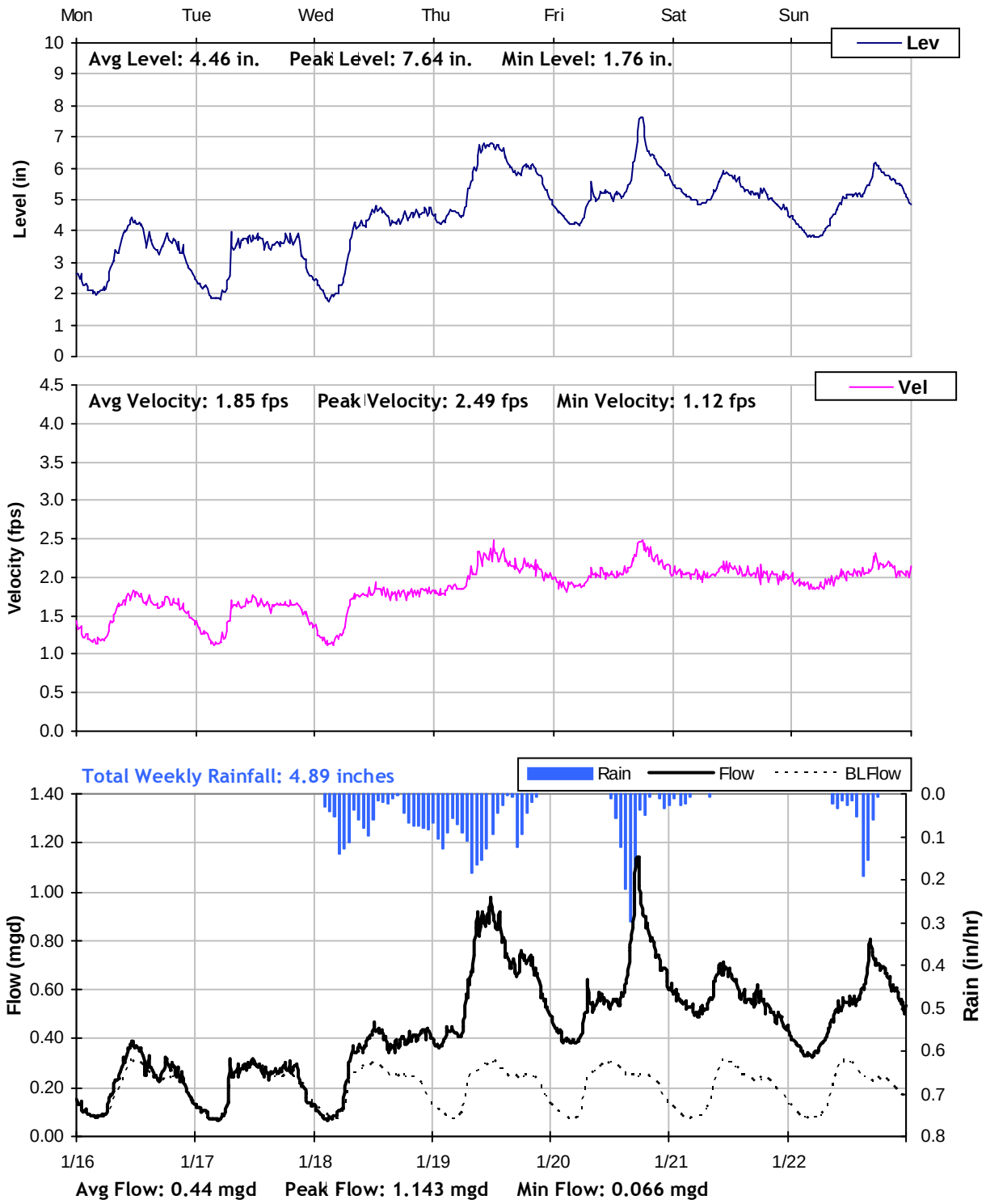
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



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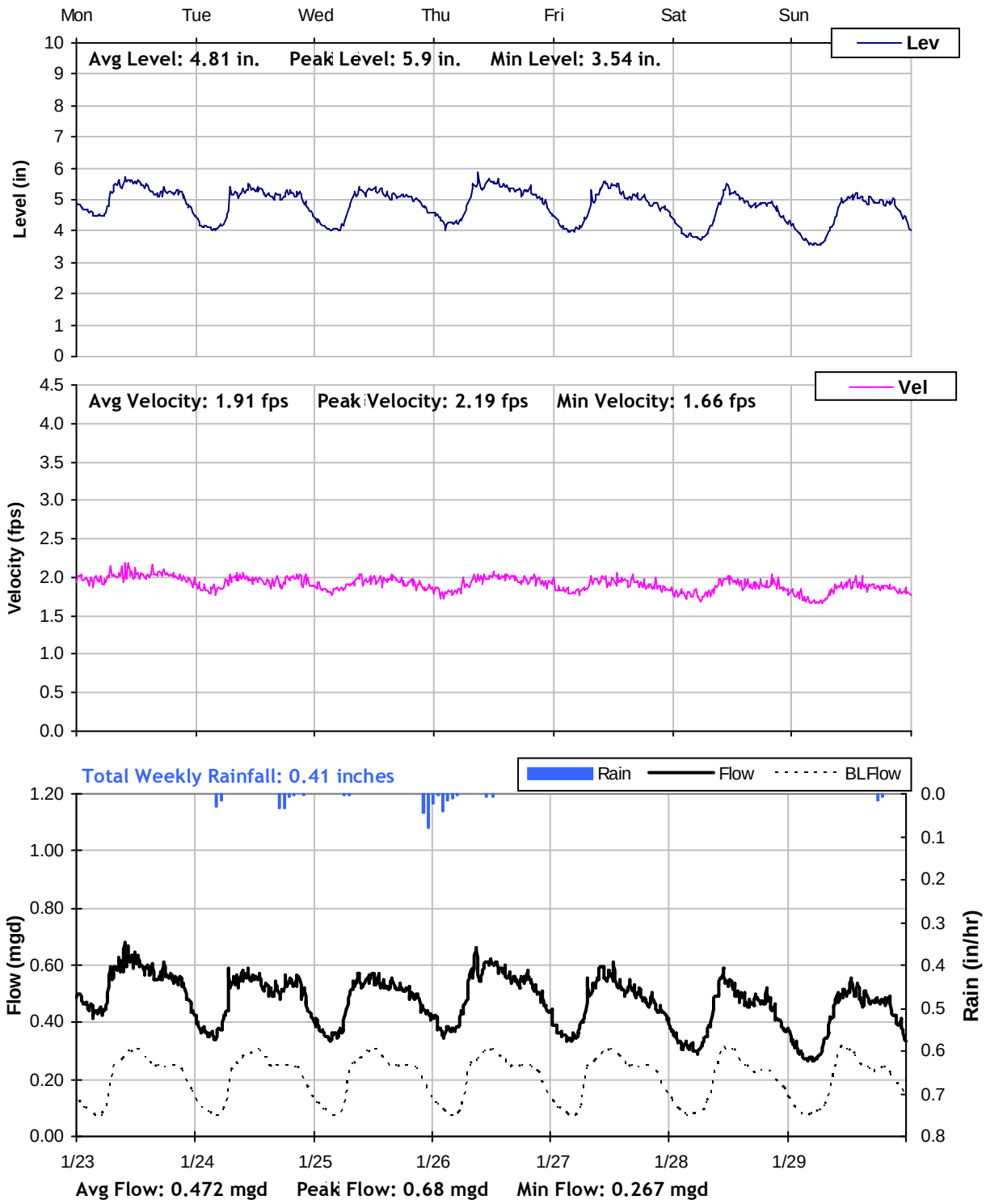
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



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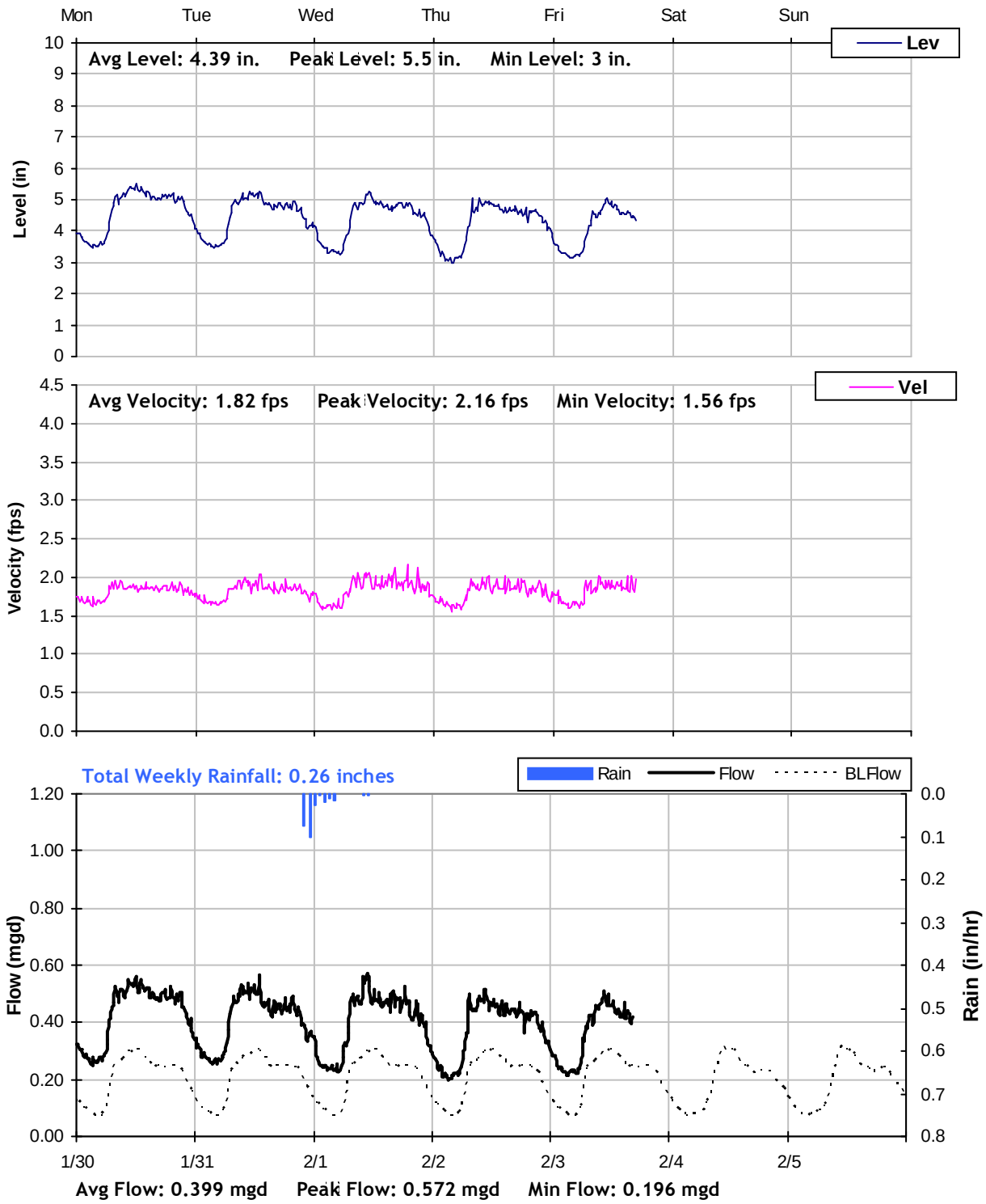
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

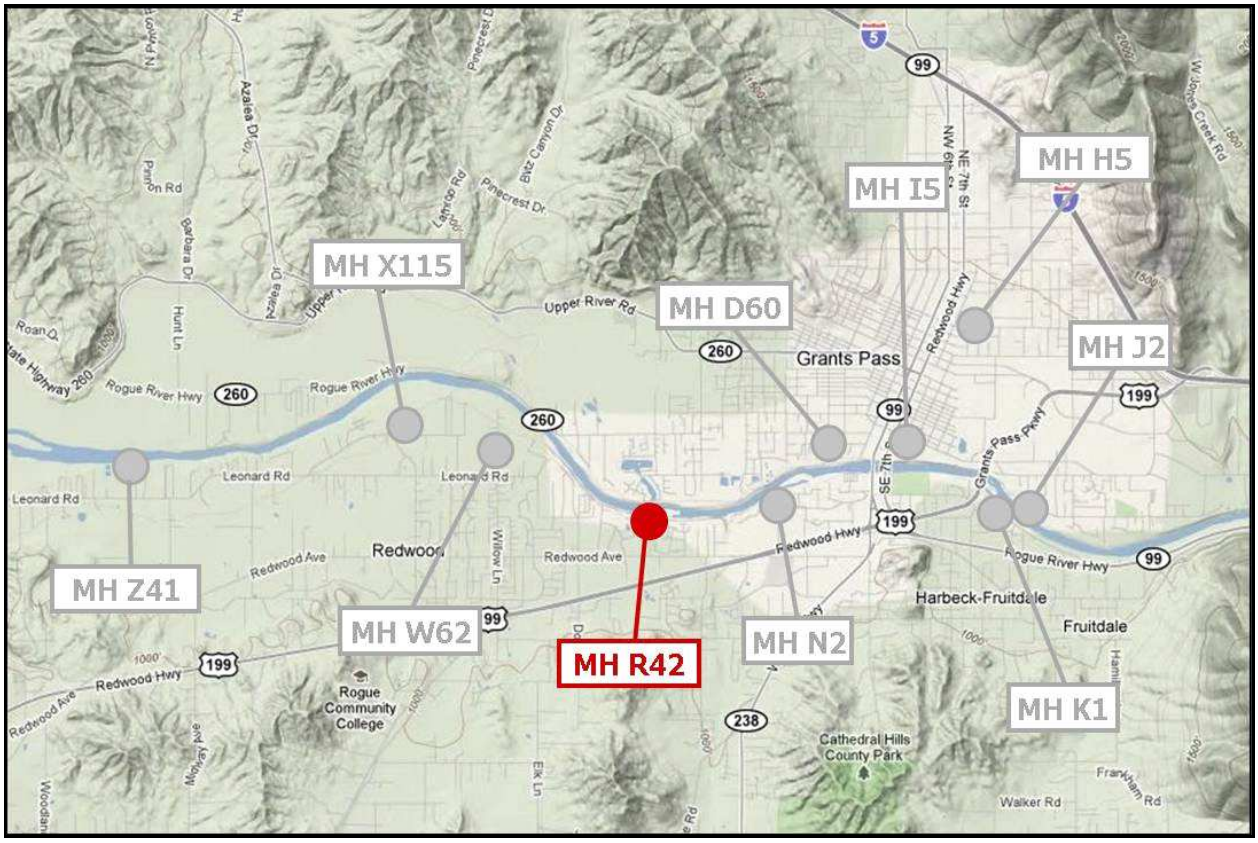
Year 2011/2012

Monitoring Site: R42

Location: Shady Lane by mailboxes at end of paved road

Data Summary Report

Vicinity Map:

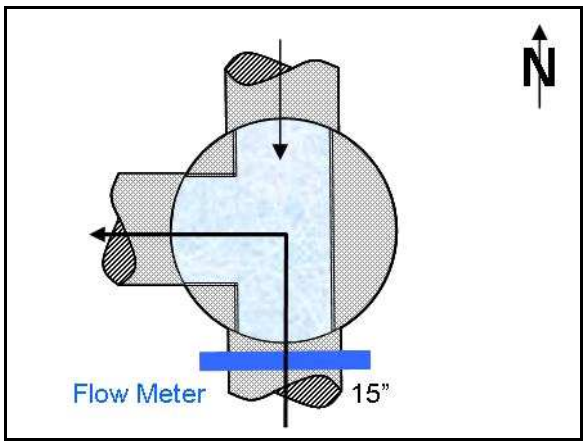


R42
Site Information Report

Location:	Shady Lane by mailboxes at end of paved road
Coordinates:	123.3583°W, 42.4253°N
Elevation:	928 feet
Diameter:	15 inches
Baseline Flow:	0.18 mgd
Peak Measured Flow:	1.233 mgd

Satellite Map

Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

R42
Additional Site Photos

Effluent Pipe

Main Influent Pipe

R42
Additional Site Photos

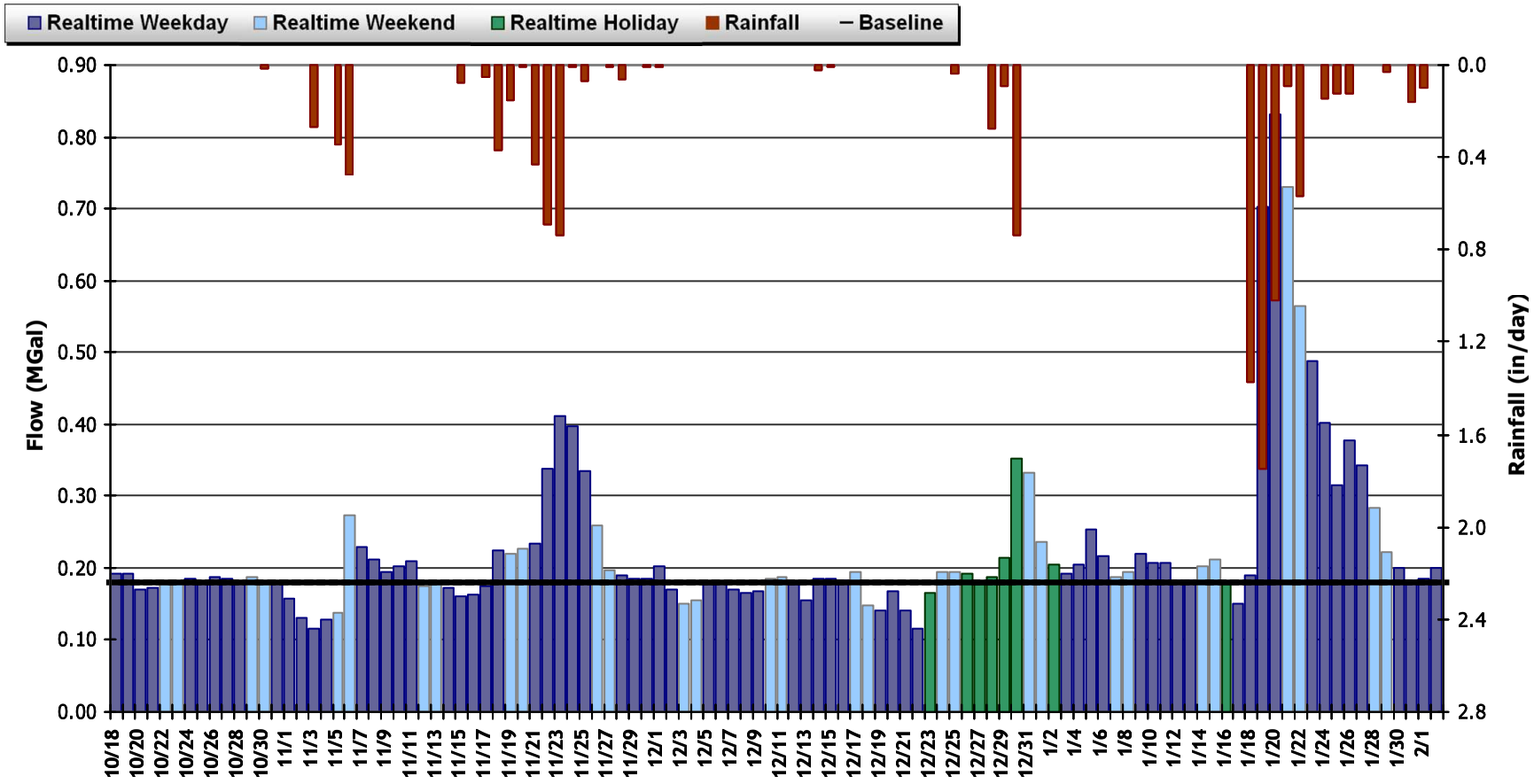
North Influent Pipe

R42

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.224 MGal Peak Daily Flow: 0.832 MGal Min Daily Flow: 0.086 MGal

Total Period Rainfall: 10.43 inches

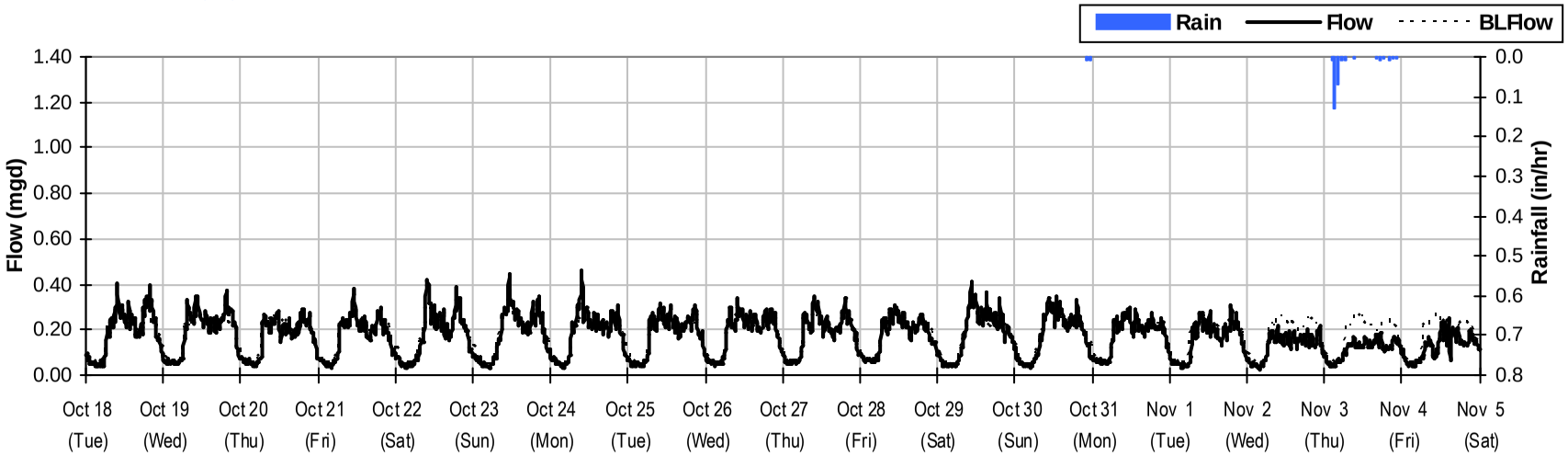


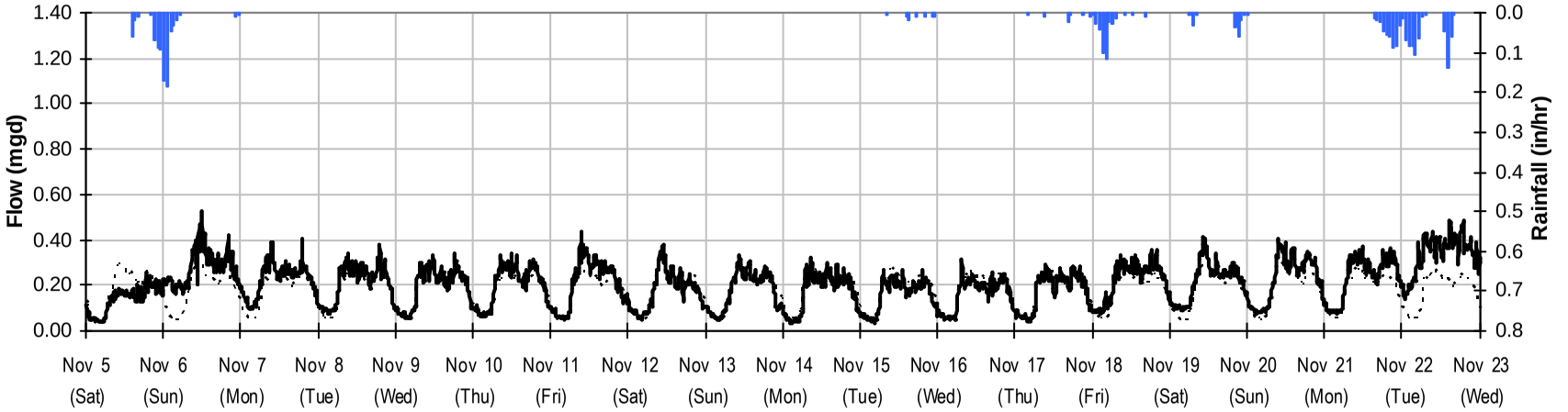
R42

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.189 mgd Peak Flow: 0.525 mgd Min Flow: 0.028 mgd

Total Period Rainfall: 2.88 inches



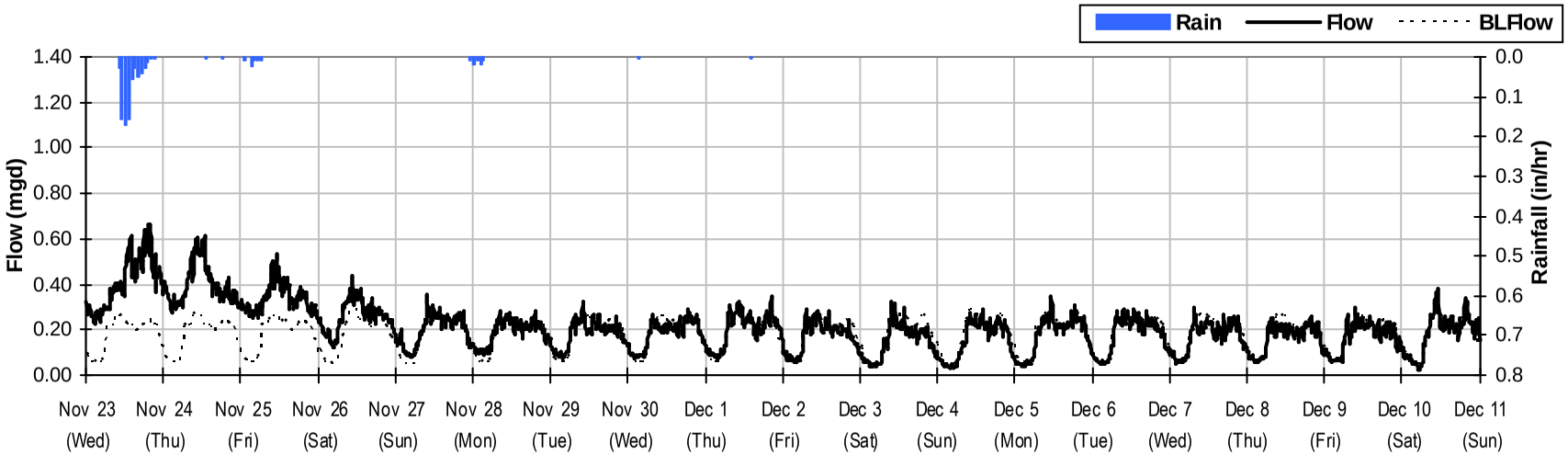


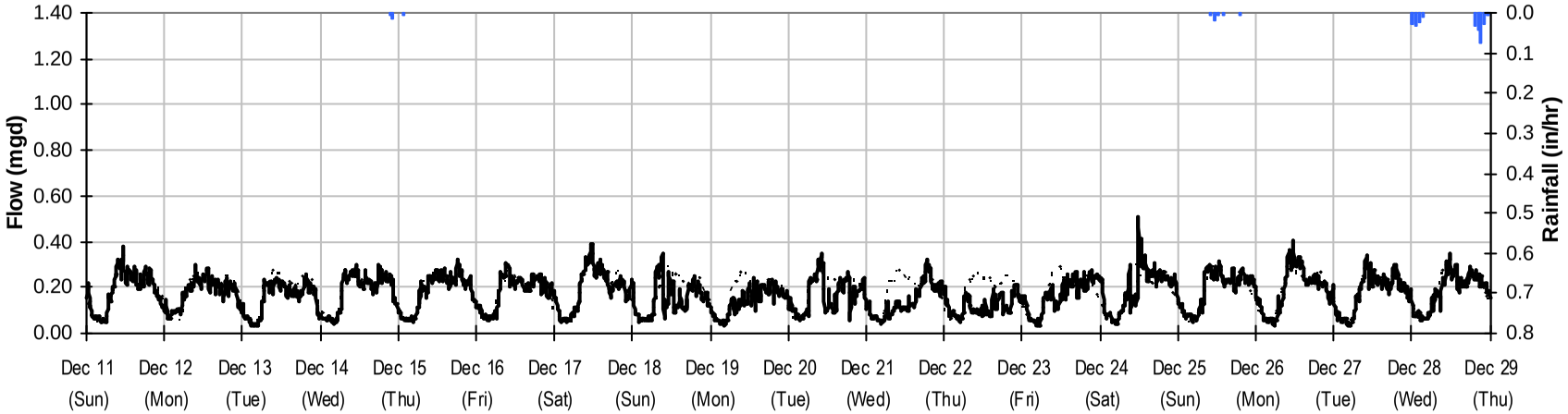
R42

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.194 mgd Peak Flow: 0.663 mgd Min Flow: 0.025 mgd

Total Period Rainfall: 1.23 inches



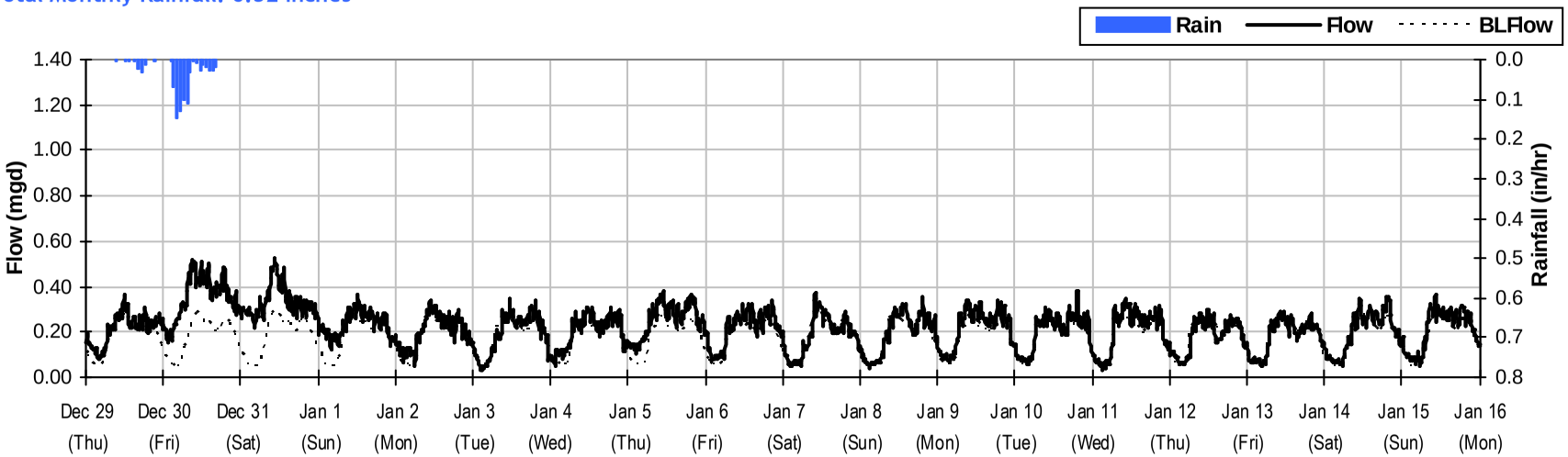


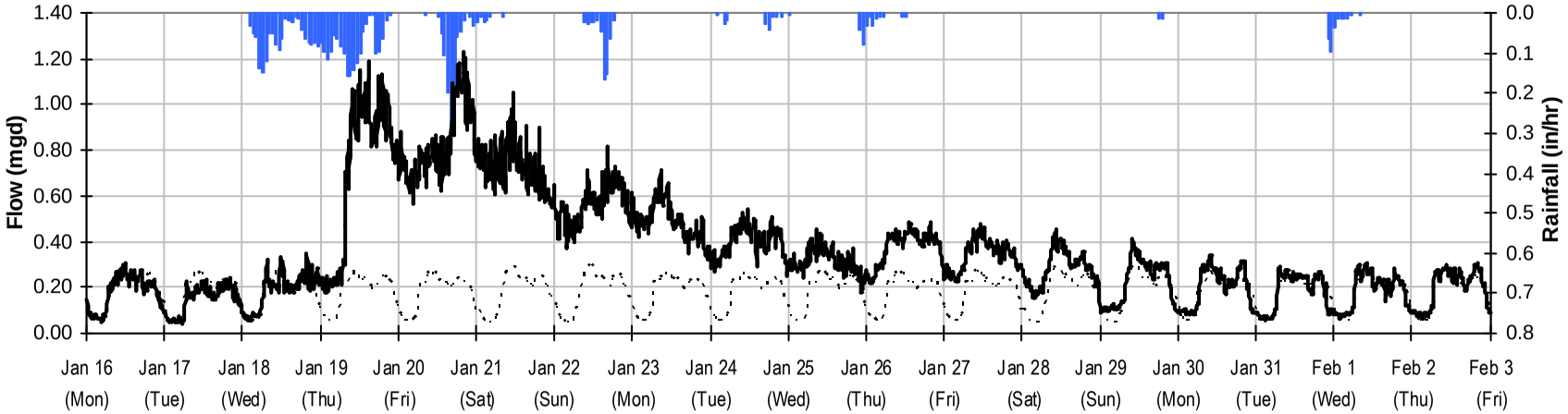
R42

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.29 mgd Peak Flow: 1.23 mgd Min Flow: 0.03 mgd

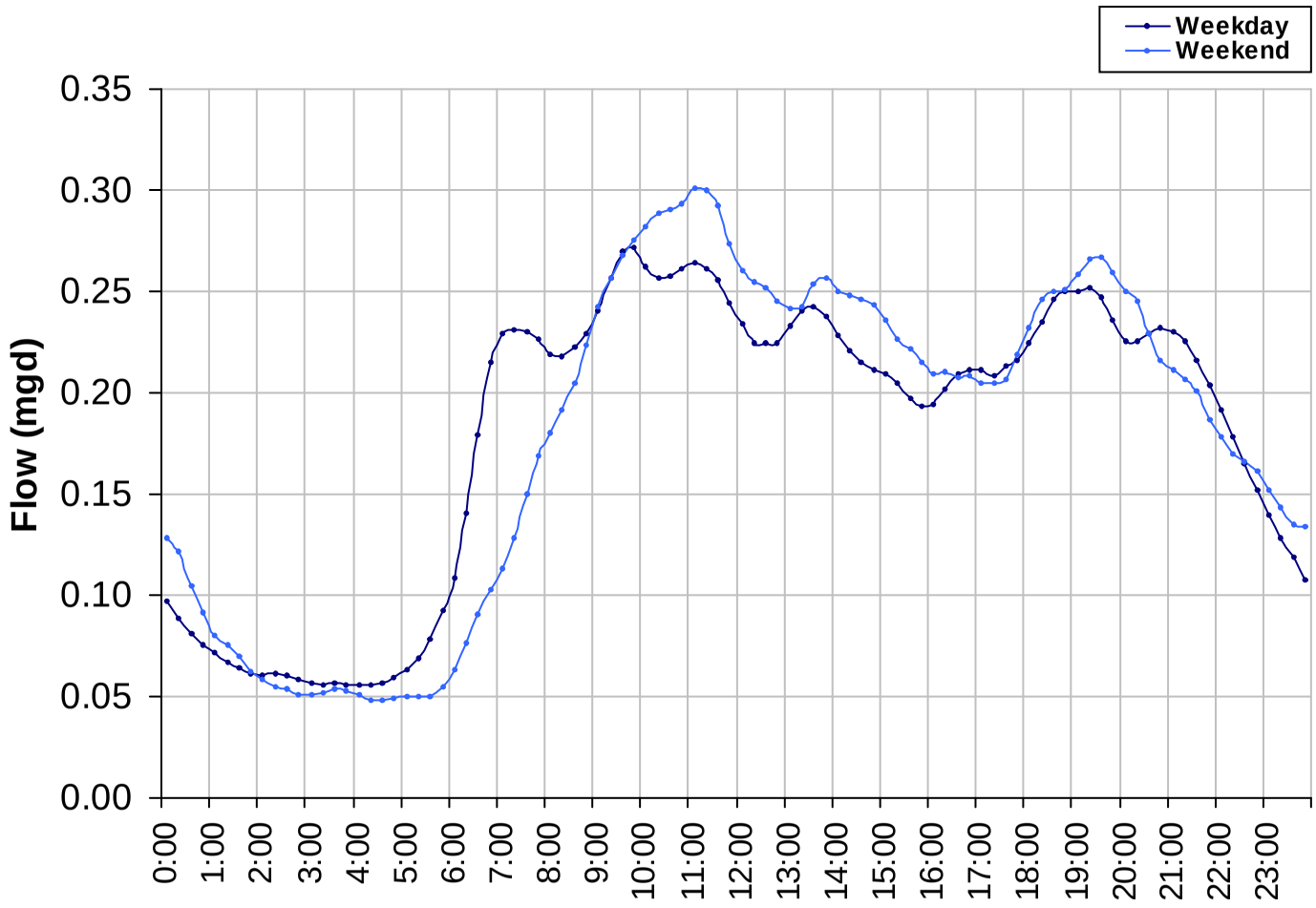
Total Monthly Rainfall: 6.32 inches





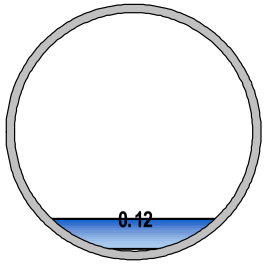
R42

Baseline Flow Hydrographs



Baseline Flow:

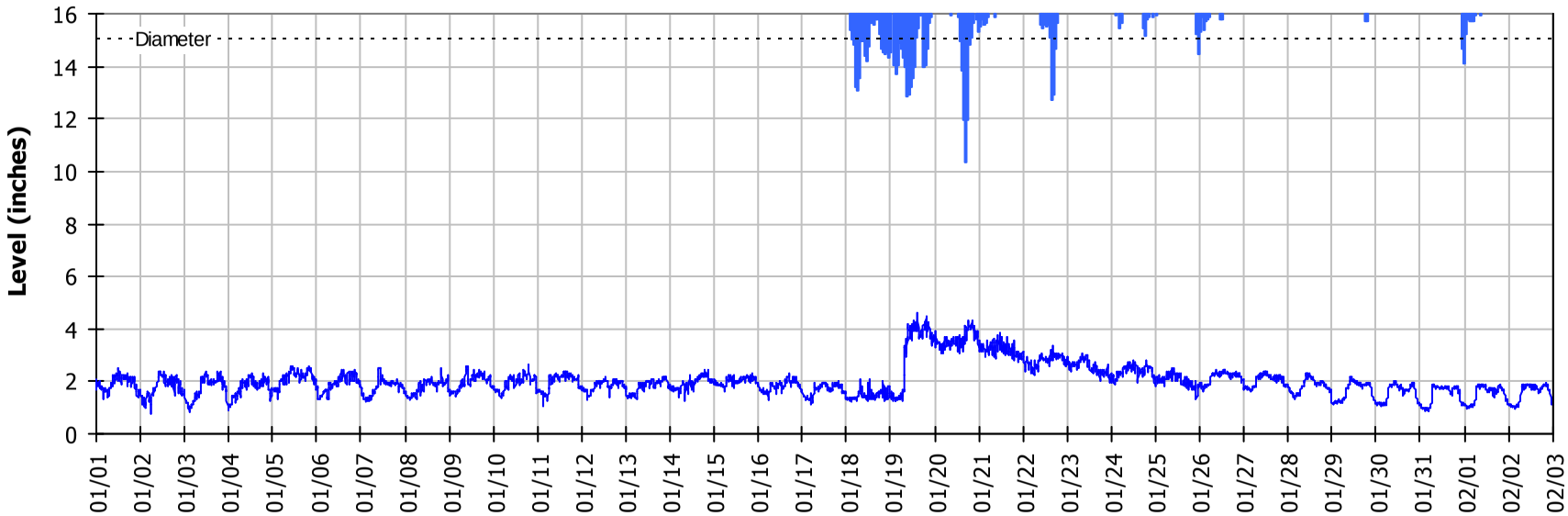
0.180 *mgd*

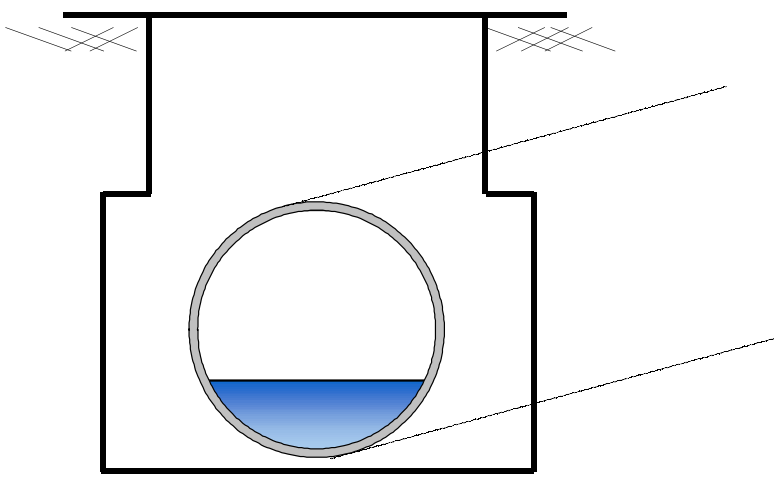


R42

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

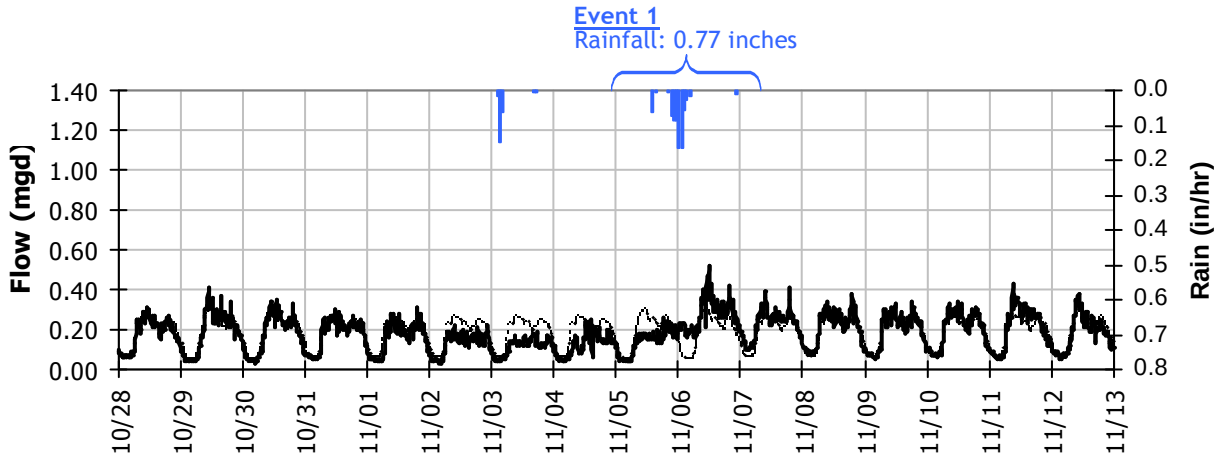




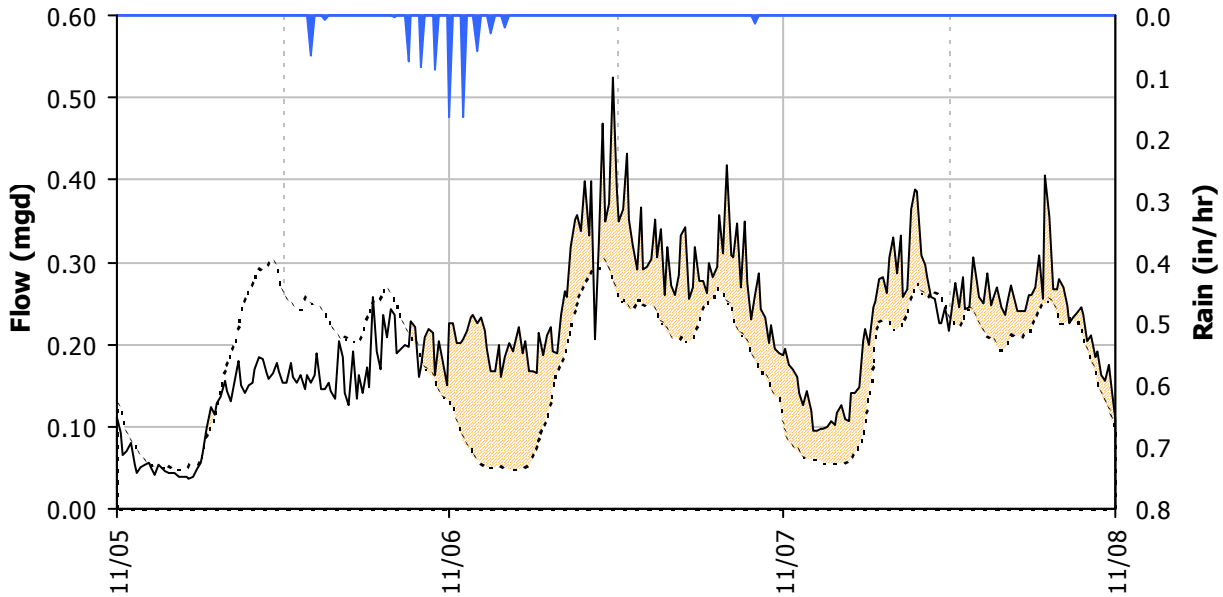
Pipe Diameter:	15	*inches*
Peak Measured Level	4.61	*inches*
Peak d/D Ratio:	0.31	

SITE R42
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

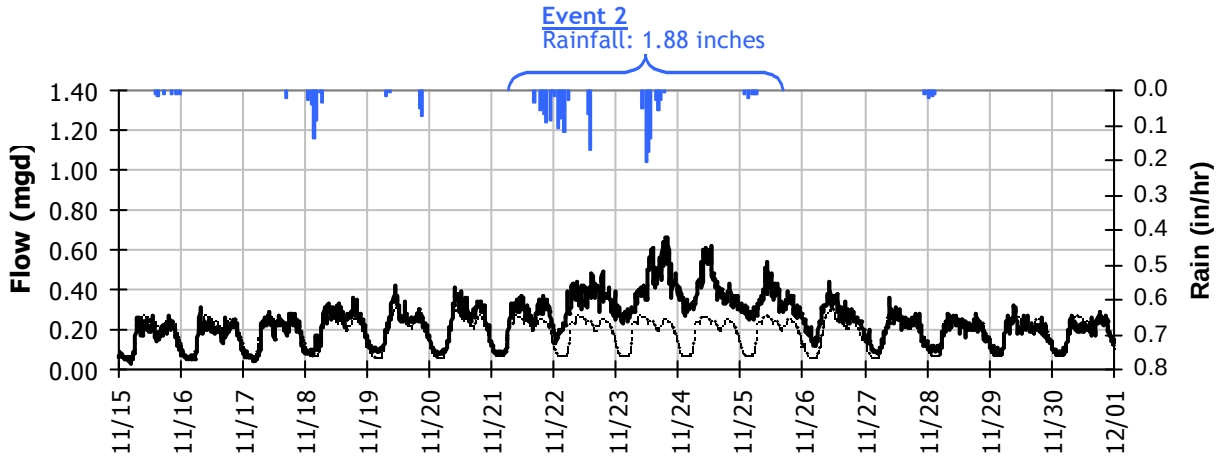


Storm Event I/I Analysis (Rain = 0.77 inches)

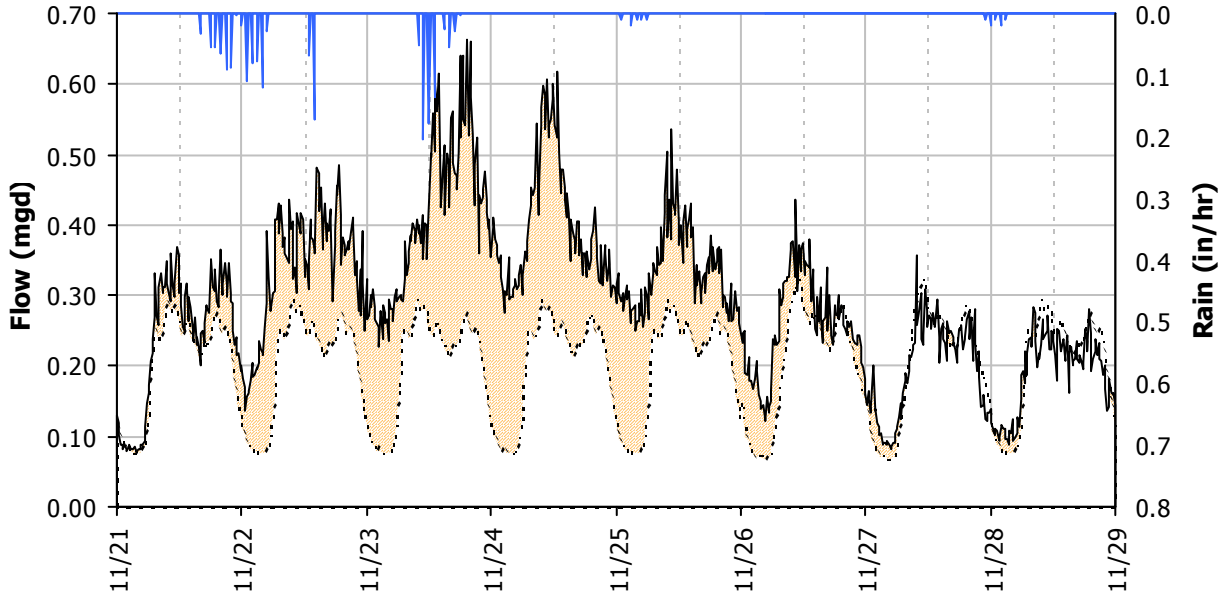
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.52	*mgd*	Peak I/I Rate:	0.25	*mgd*	Infiltration Rate: (11/7/2011)	0.048	*mgd*	Total I/I:	146,000	*gallons*
PF:	2.92		PkI/I:IDM:	5,357	*gpd/IDM*	RDI:IDM:	1,026	*gpd/IDM*	Total I/I:IDM:	4,034	*gal/IDM/in*
Peak Level:	2.89	*in*	PkI/I:Acre:	757	*gpd/acre*	RDI:Acre:	145	*gpd/acre*	R-Value:	2.1%	
d/D Ratio:	0.19		Pk I/I:ADWF:	1.40		RDI (% of BL):	27%		Total I/I:ADWF:	1.05	*per in-rain*

SITE R42
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

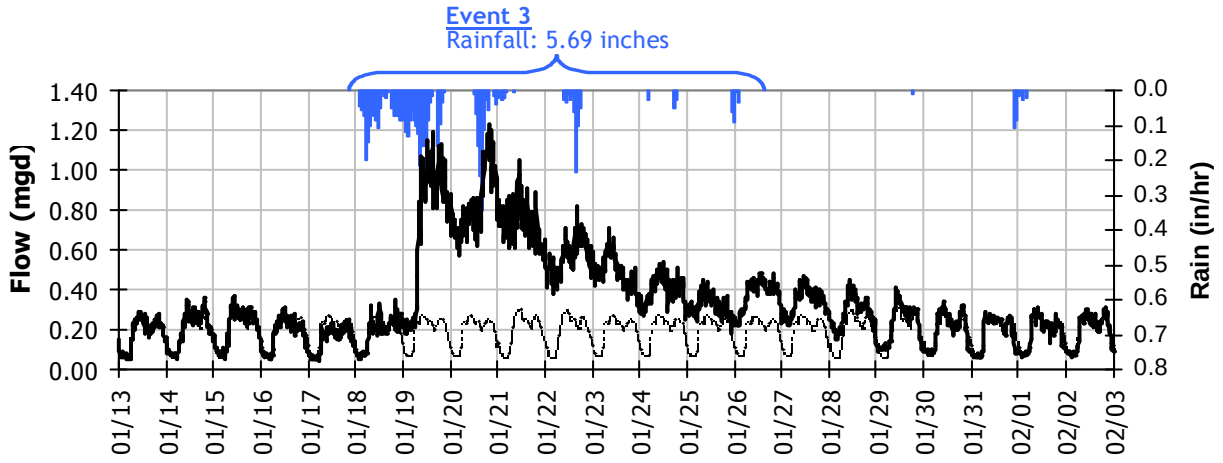


Storm Event I/I Analysis (Rain = 1.88 inches)

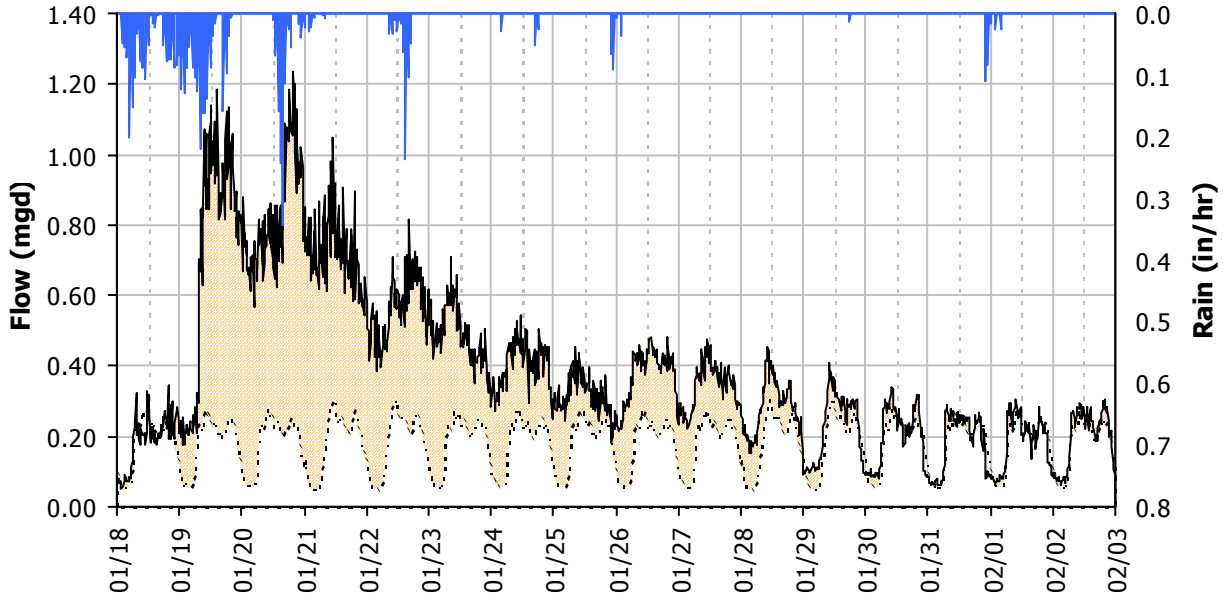
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.66	*mgd*	Peak I/I Rate:	0.44	*mgd*	Infiltration Rate: (11/26/2011)	0.078	*mgd*	Total I/I:	764,000	*gallons*
PF:	3.69		PkI/I:IDM:	9,308	*gpd/IDM*	RDI:IDM:	1,674	*gpd/IDM*	Total I/I:IDM:	8,701	*gal/IDM/in*
Peak Level:	3.34	*in*	PkI/I:Acre:	1,315	*gpd/acre*	RDI:Acre:	237	*gpd/acre*	R-Value:	4.5%	
d/D Ratio:	0.22		Pk I/I:ADWF:	2.42		RDI (% of BL):	44%		Total I/I:ADWF:	2.27	*per in-rain*

SITE R42
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

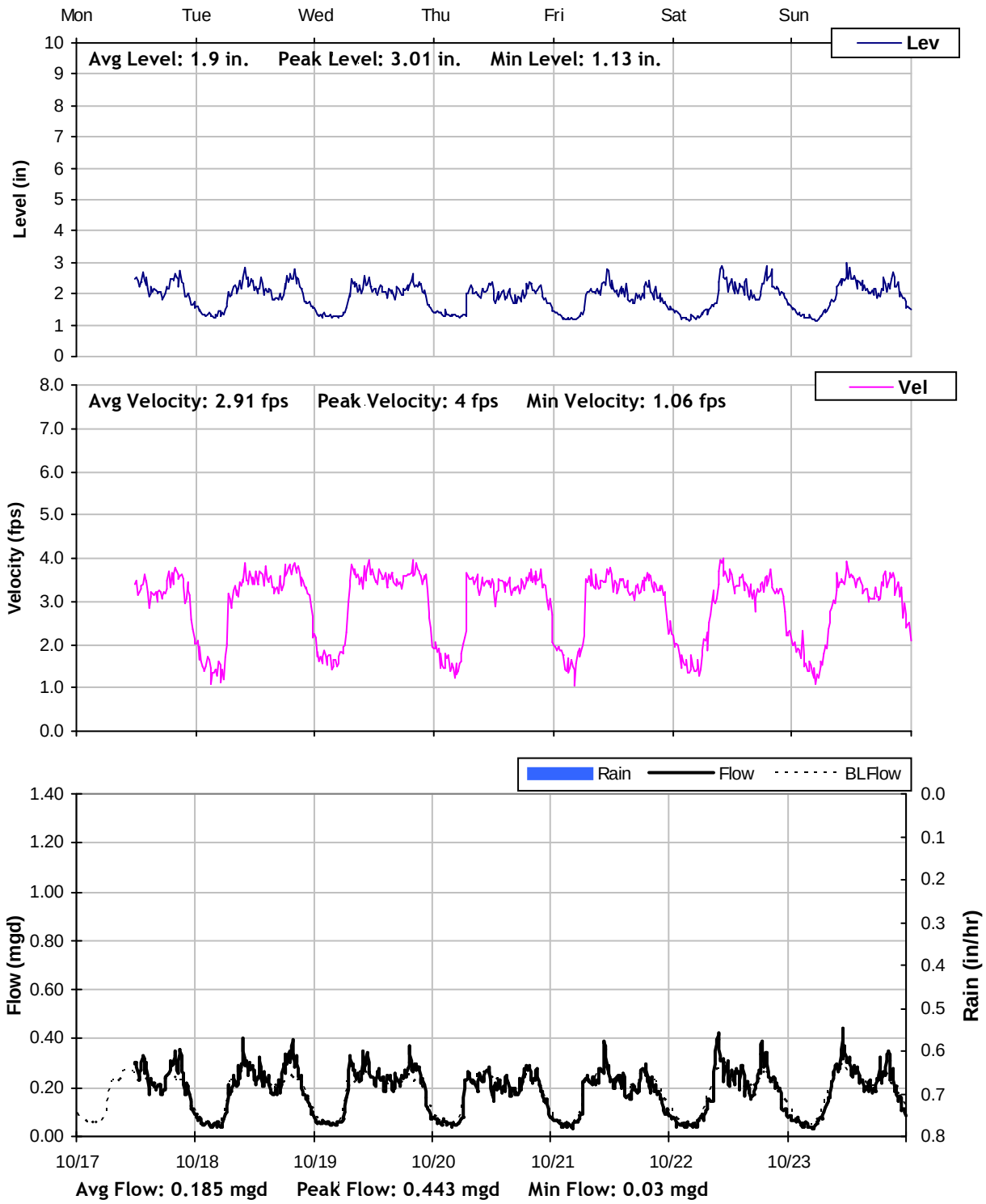


Storm Event I/I Analysis (Rain = 5.69 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	1.23	*mgd*	Peak I/I Rate:	1.01	*mgd*	Infiltration Rate: (1/30/2012)	0.021	*mgd*	Total I/I:	3,344,000	*gallons*
PF:	6.86		PkI/I:IDM:	21,532	*gpd/IDM*	RDI:IDM:	441	*gpd/IDM*	Total I/I:IDM:	12,549	*gal/IDM/in*
Peak Level:	4.61	*in*	PkI/I:Acre:	3,042	*gpd/acre*	RDI:Acre:	62	*gpd/acre*	R-Value:	6.5%	
d/D Ratio:	0.31		Pk I/I:ADWF:	5.61		RDI (% of BL):	12%		Total I/I:ADWF:	3.27	*per in-rain*

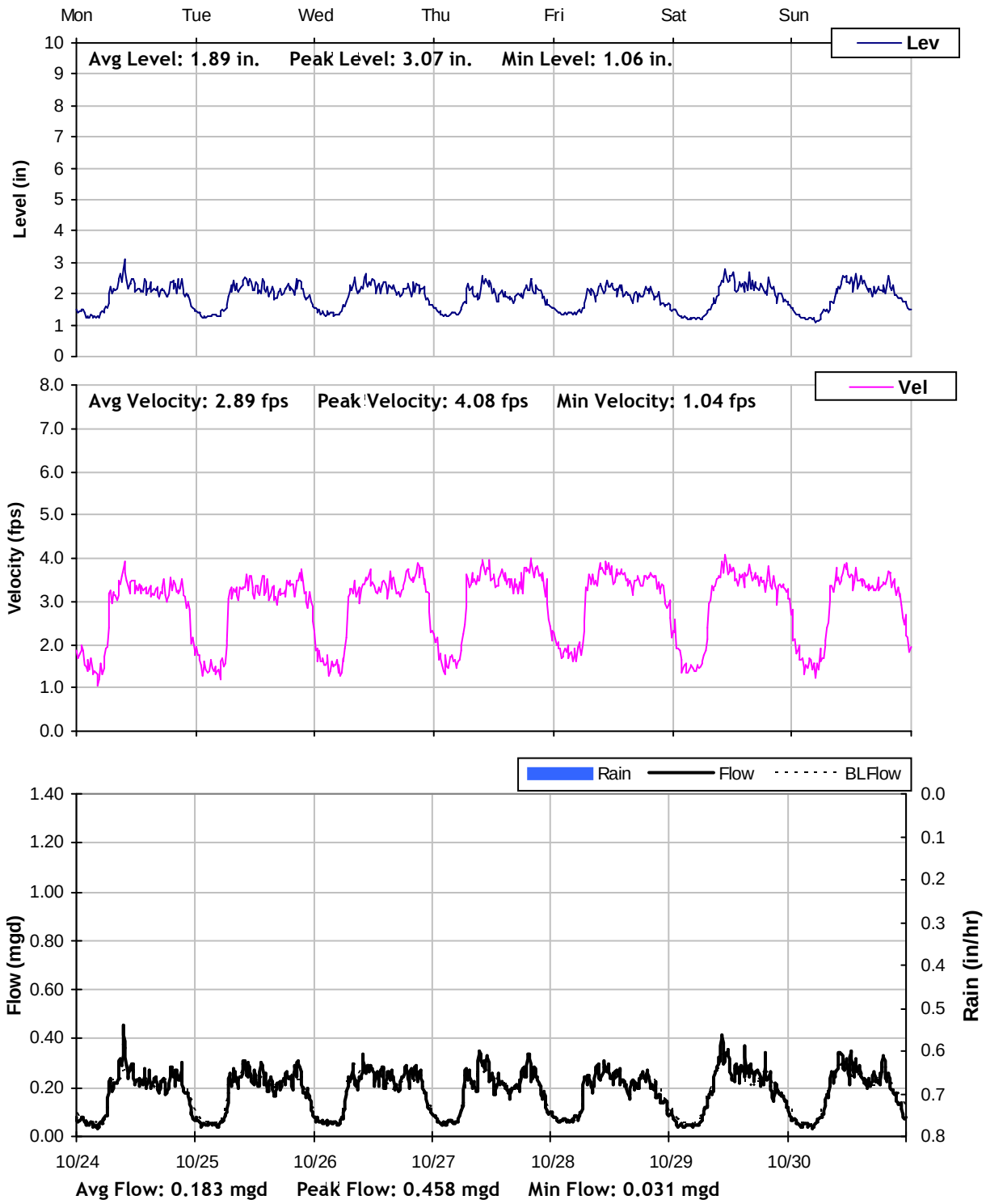
R42

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



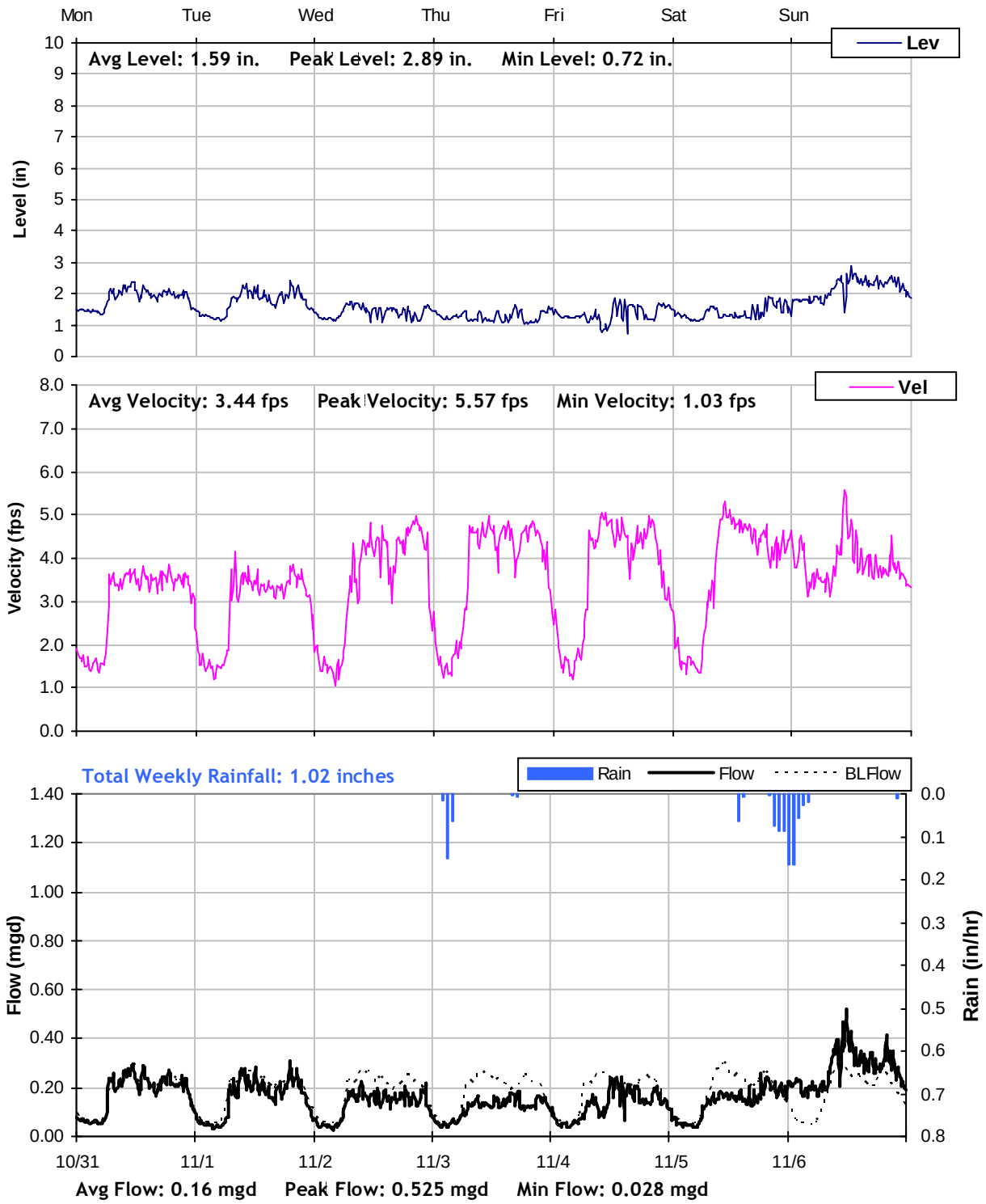
R42

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



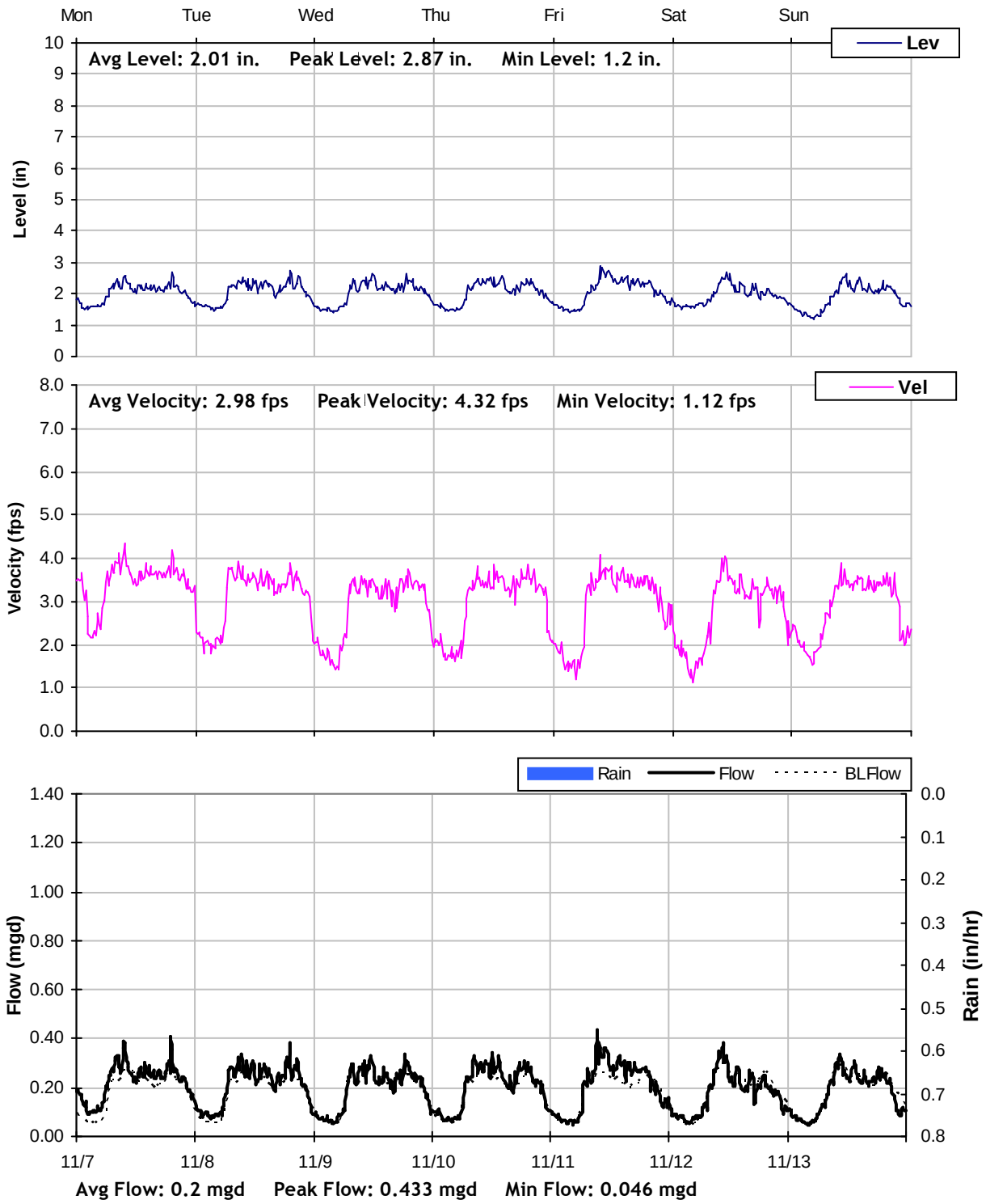
R42

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



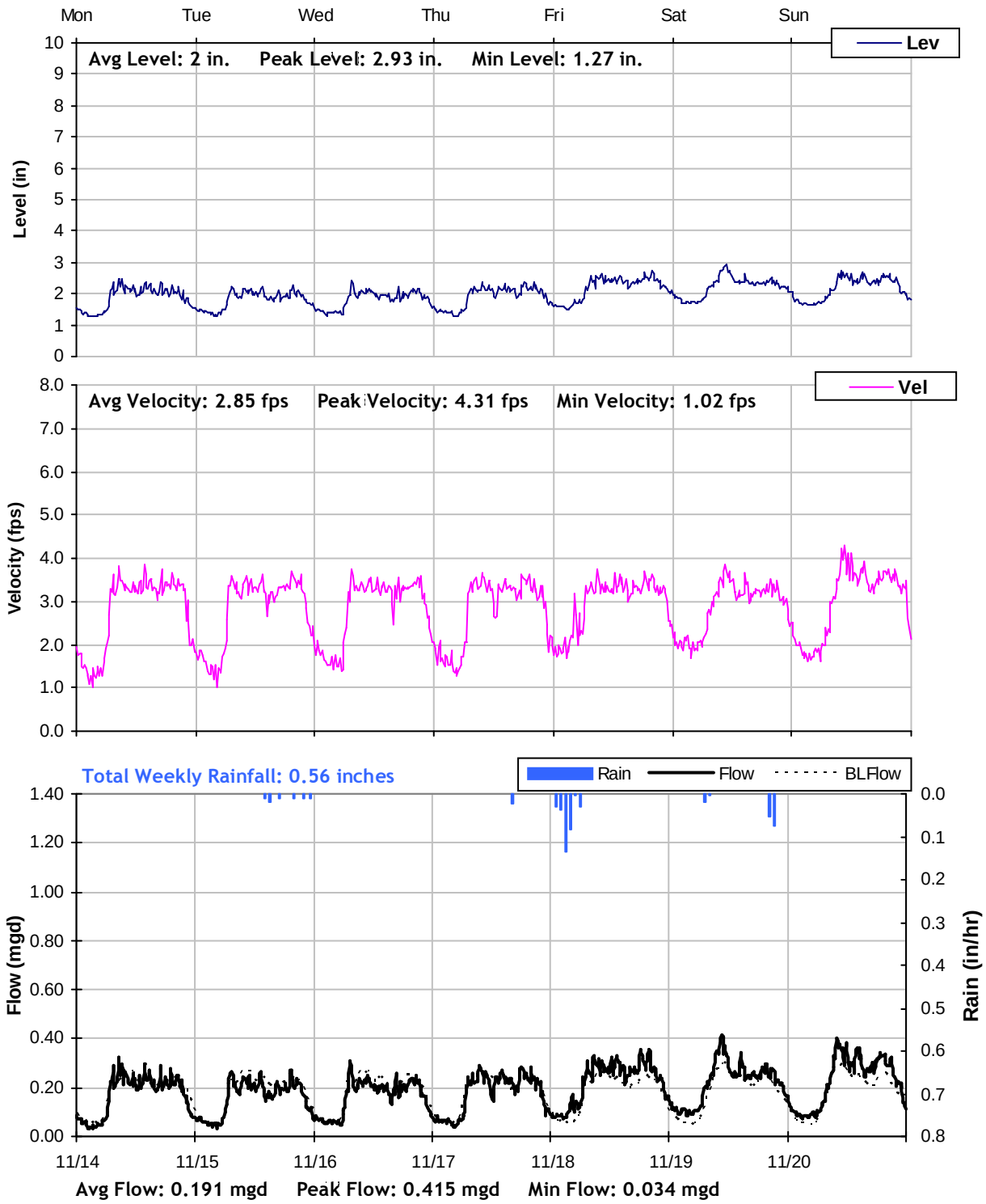
R42

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



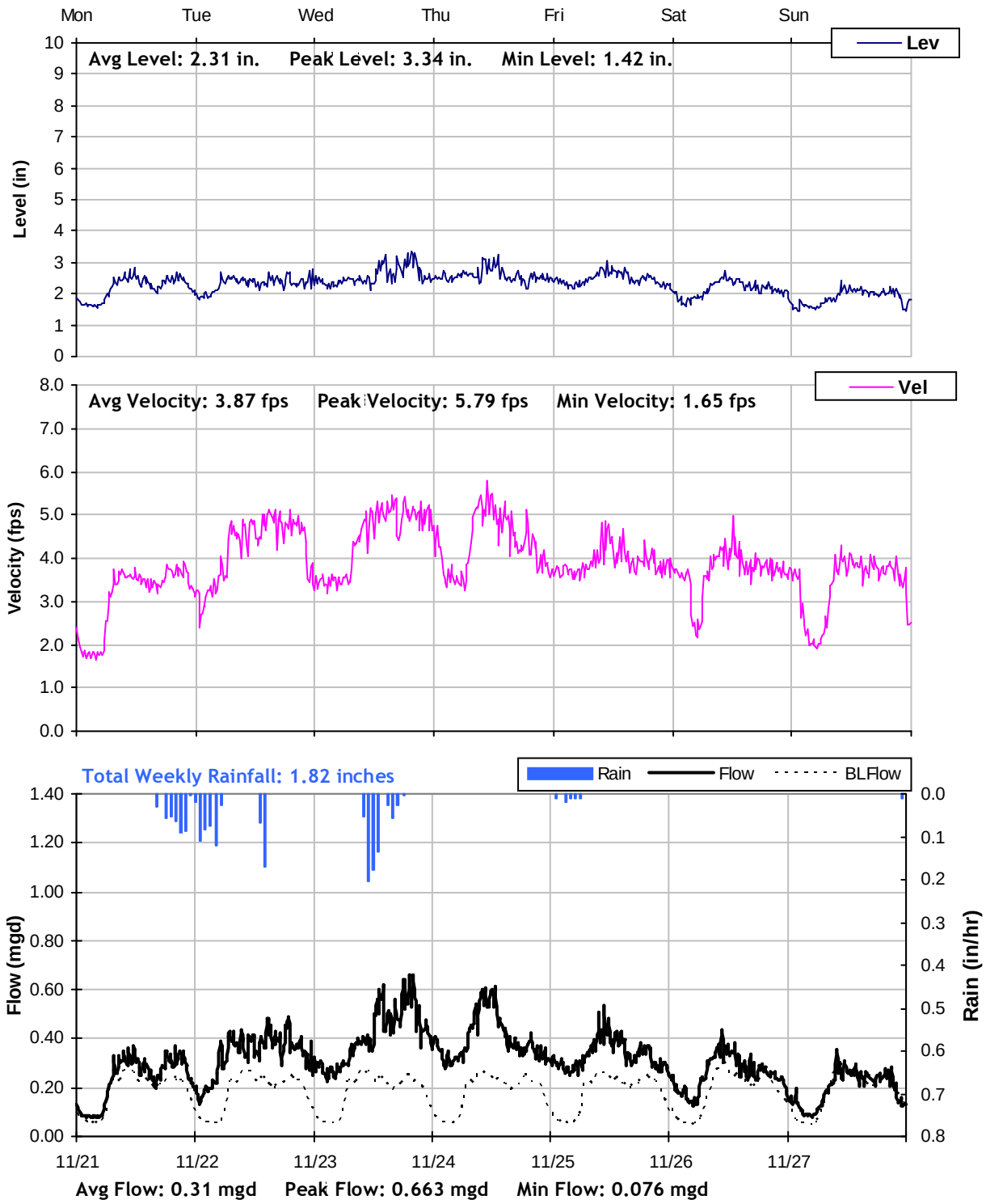
R42

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



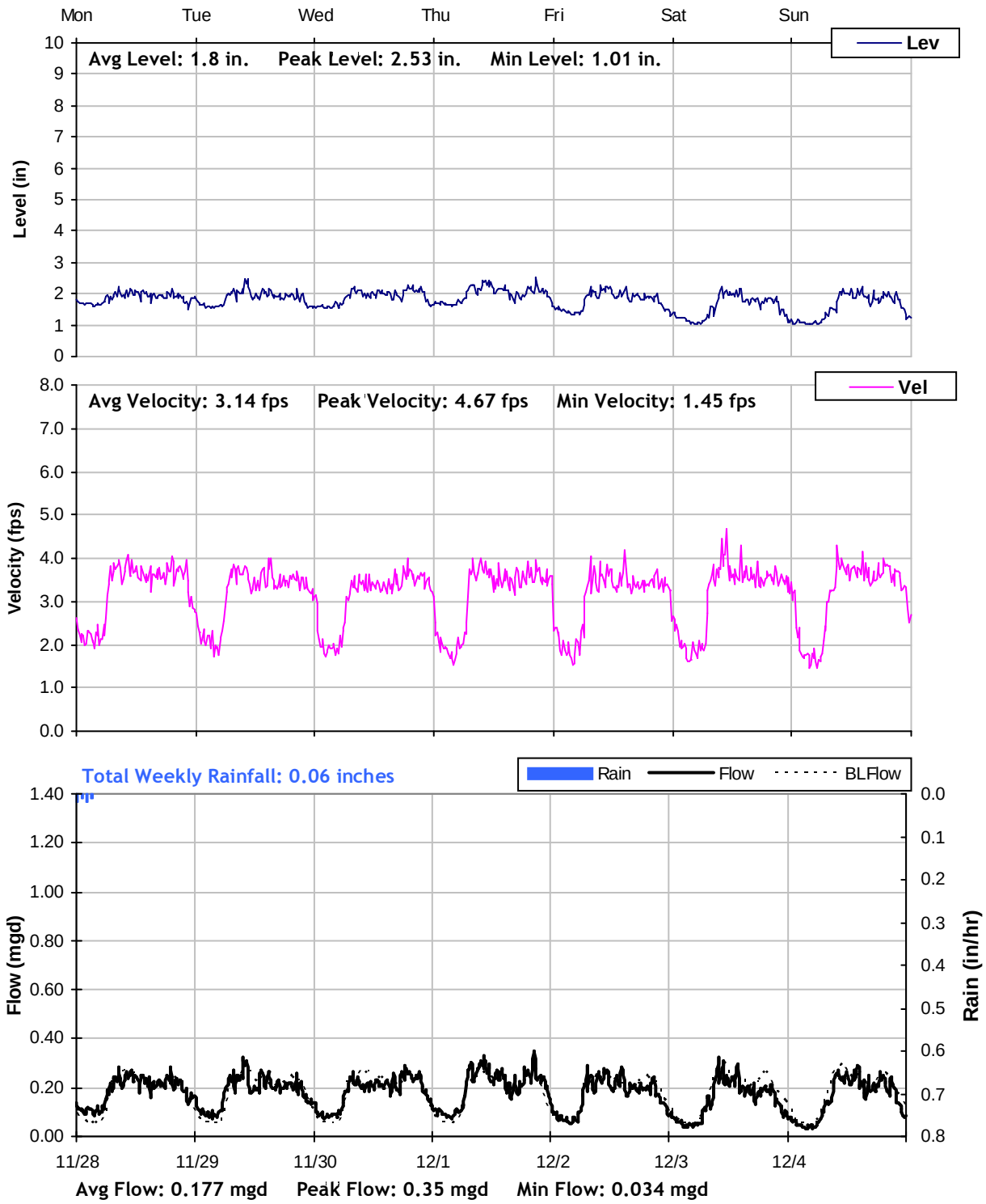
R42

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



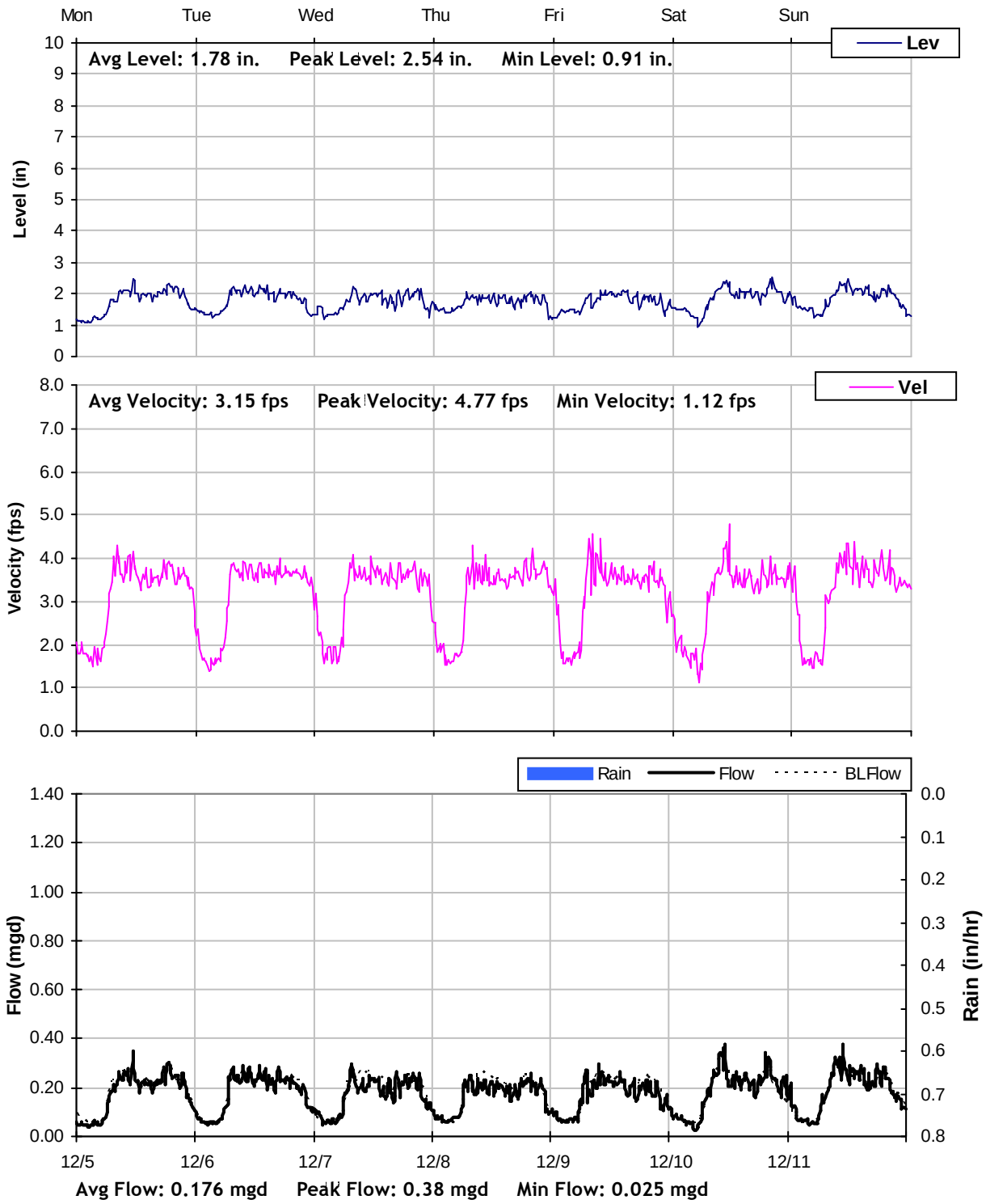
R42

Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



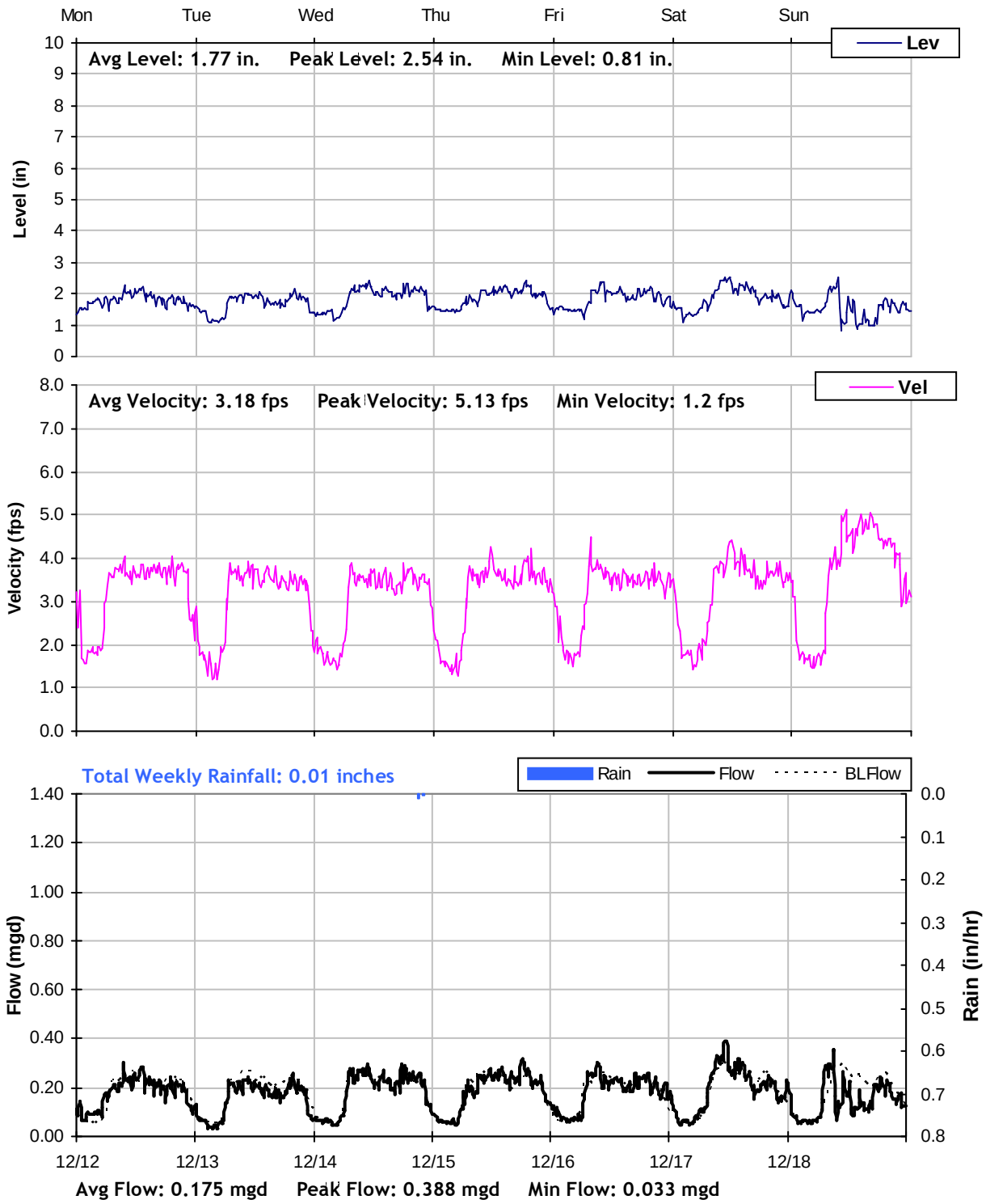
R42

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



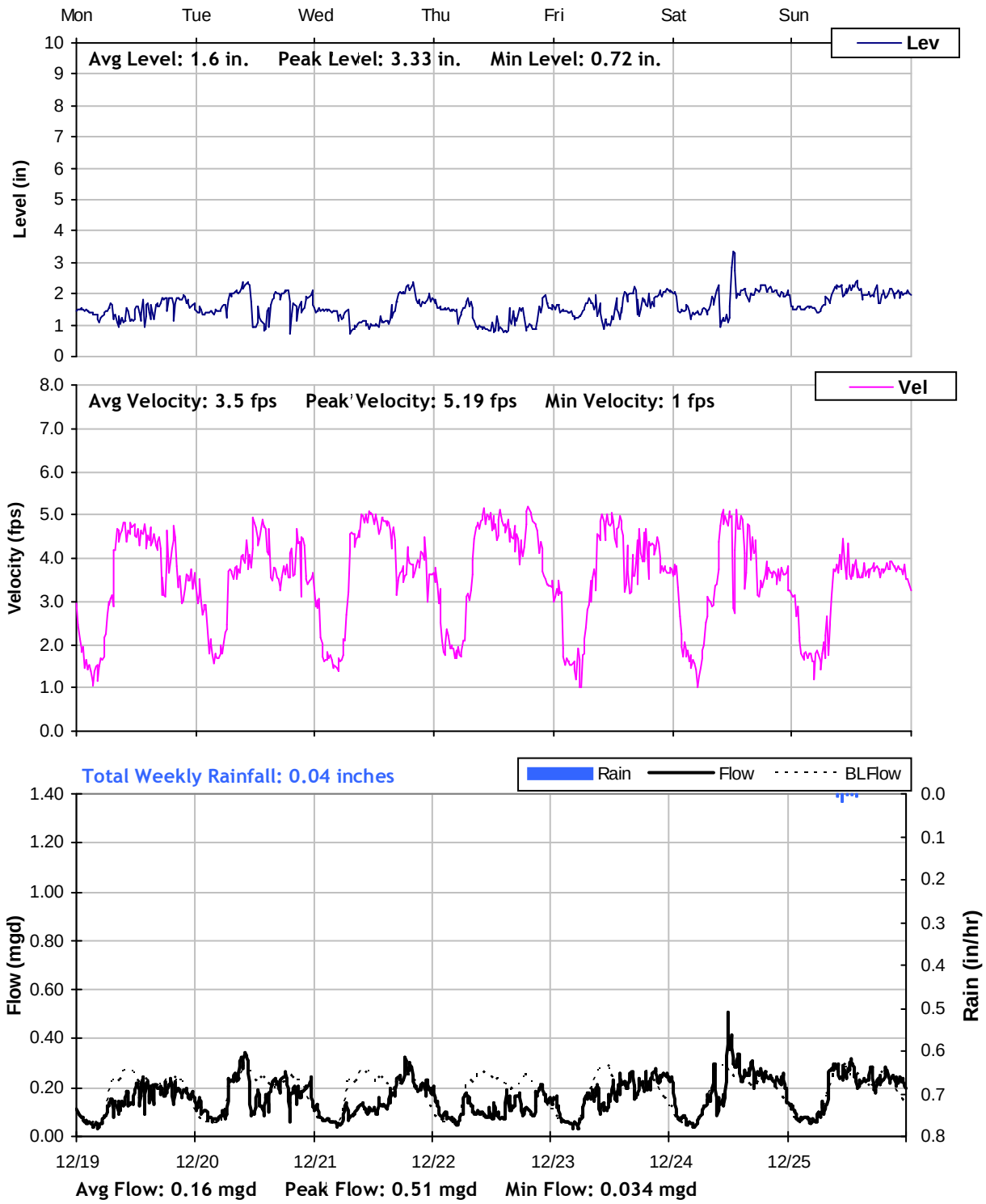
R42

Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



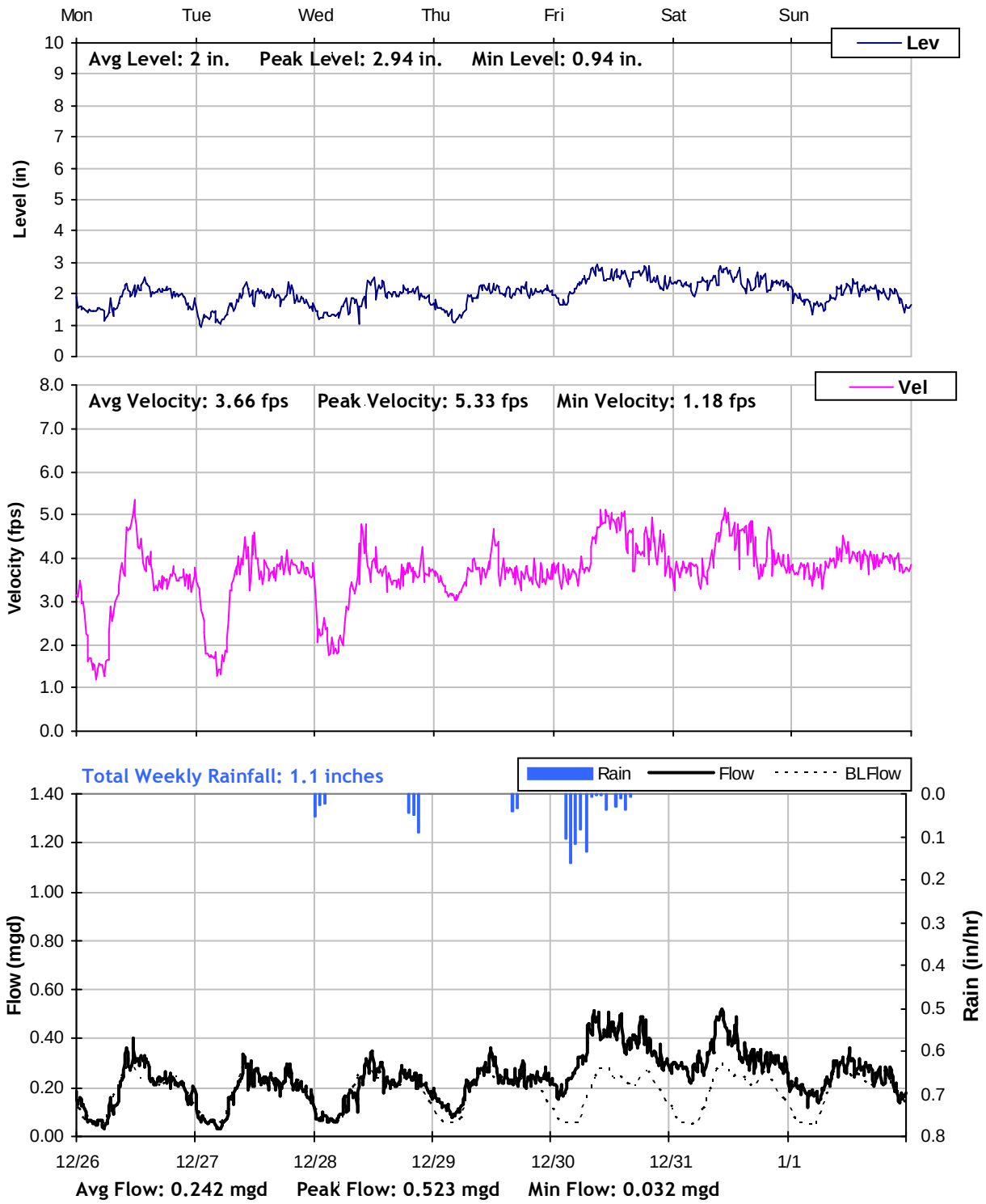
R42

Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



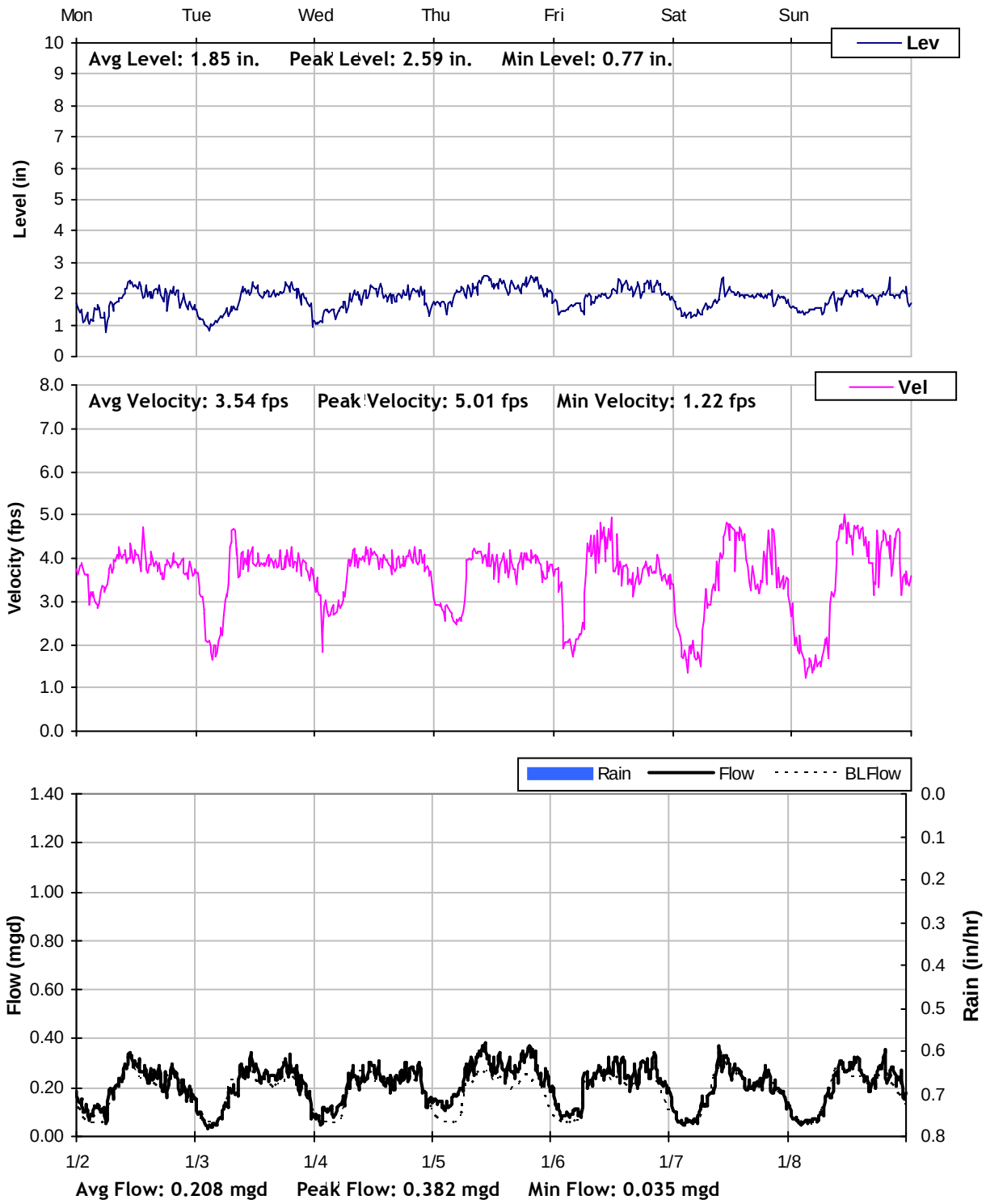
R42

Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



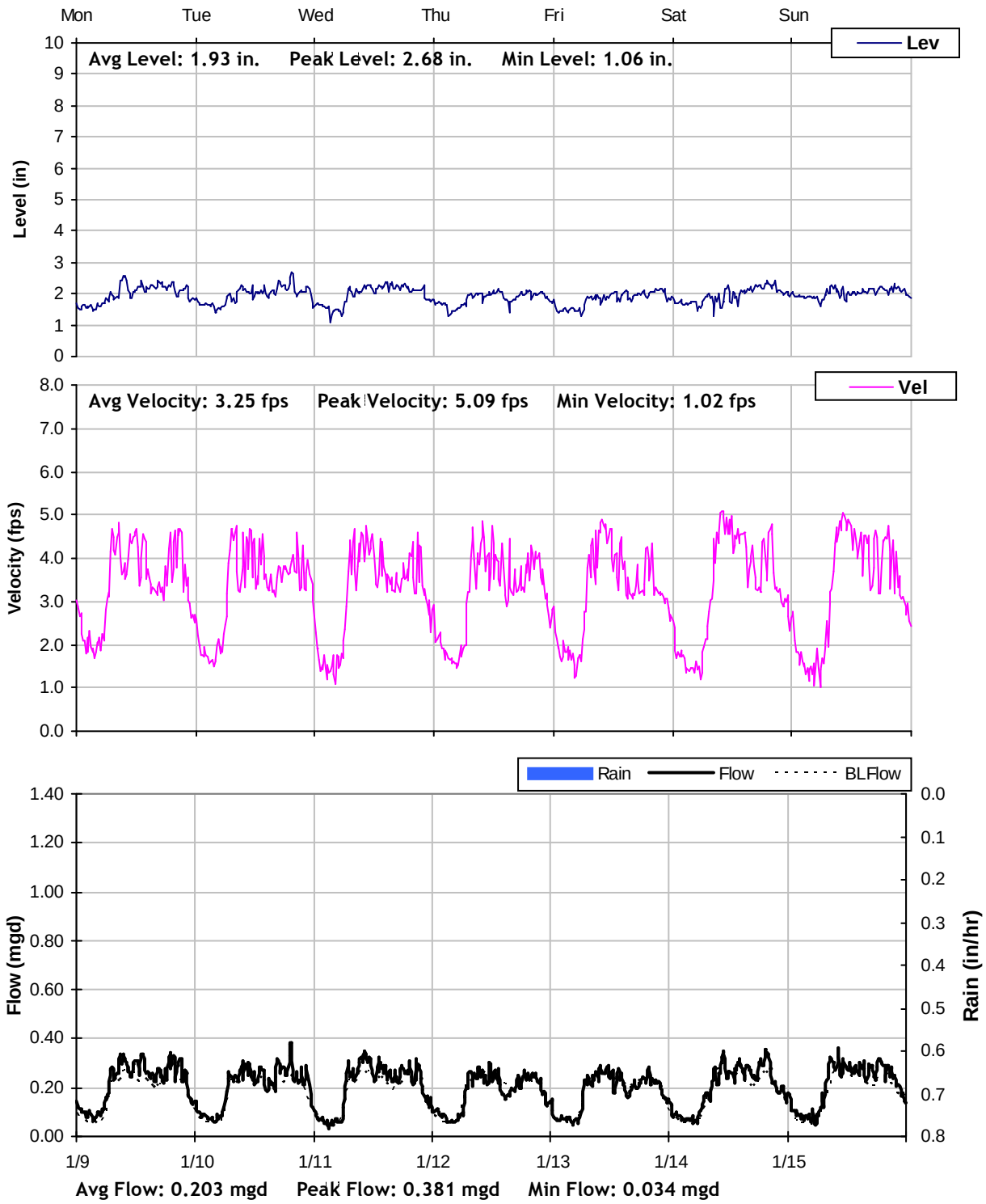
R42

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



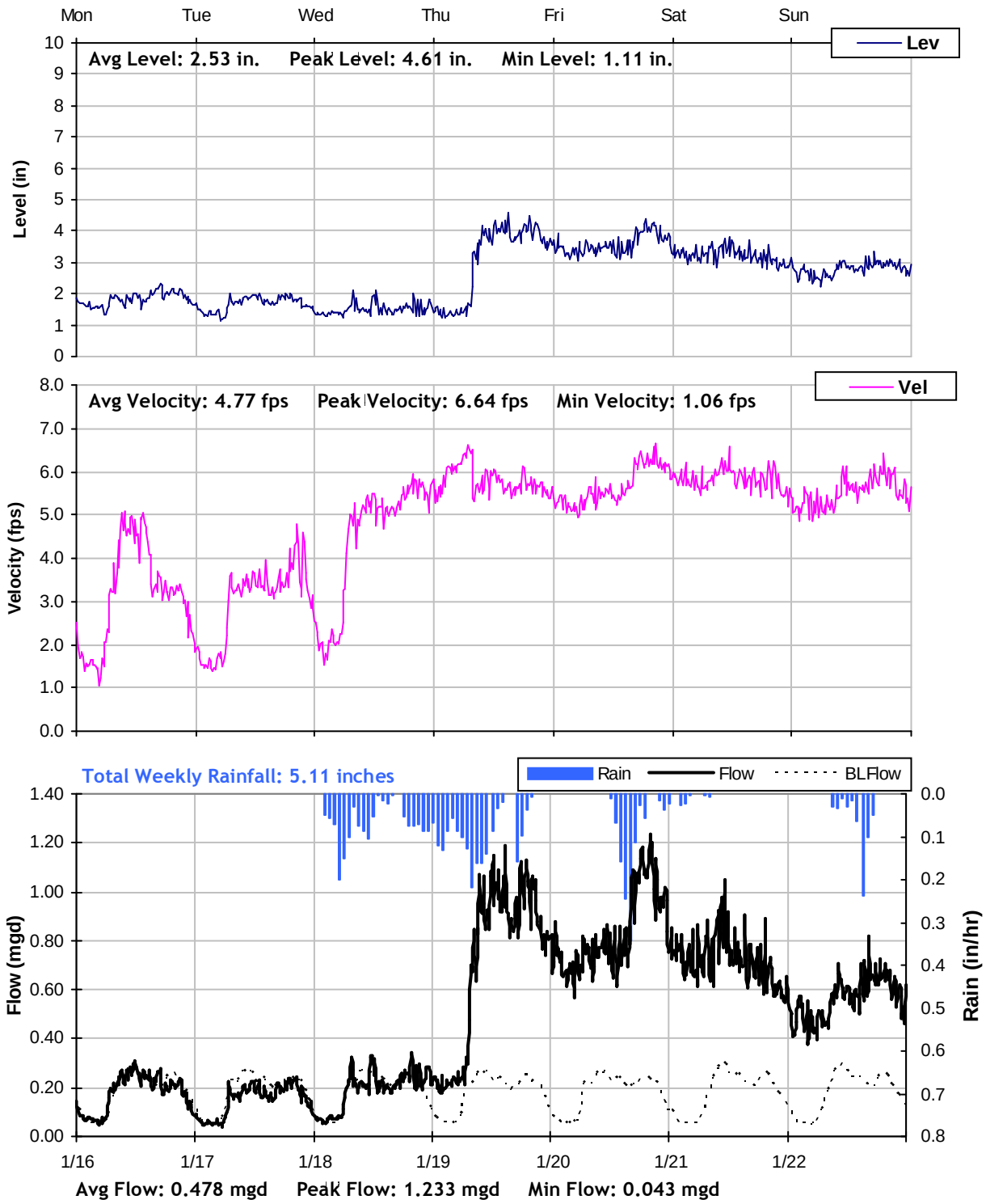
R42

Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



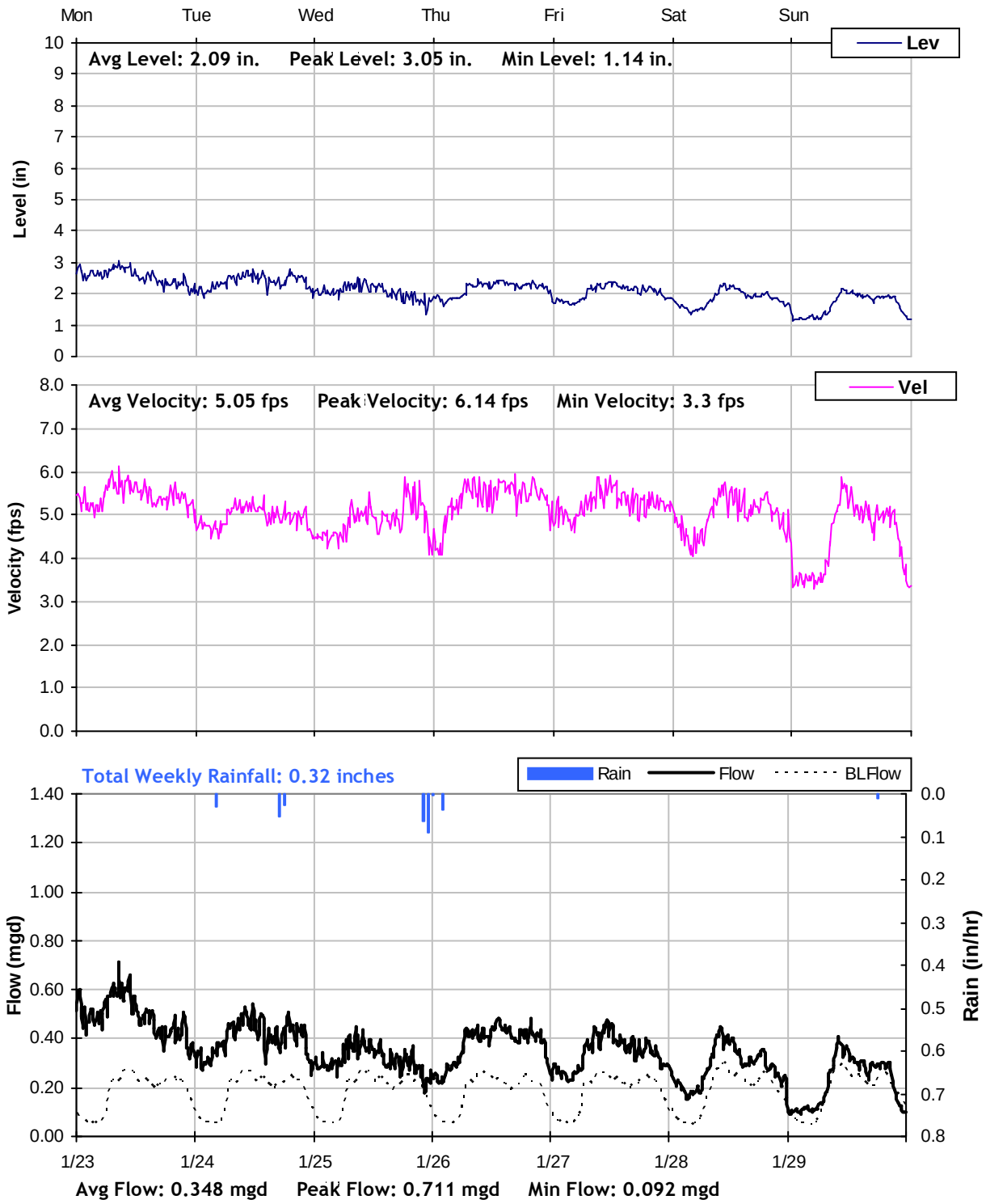
R42

Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



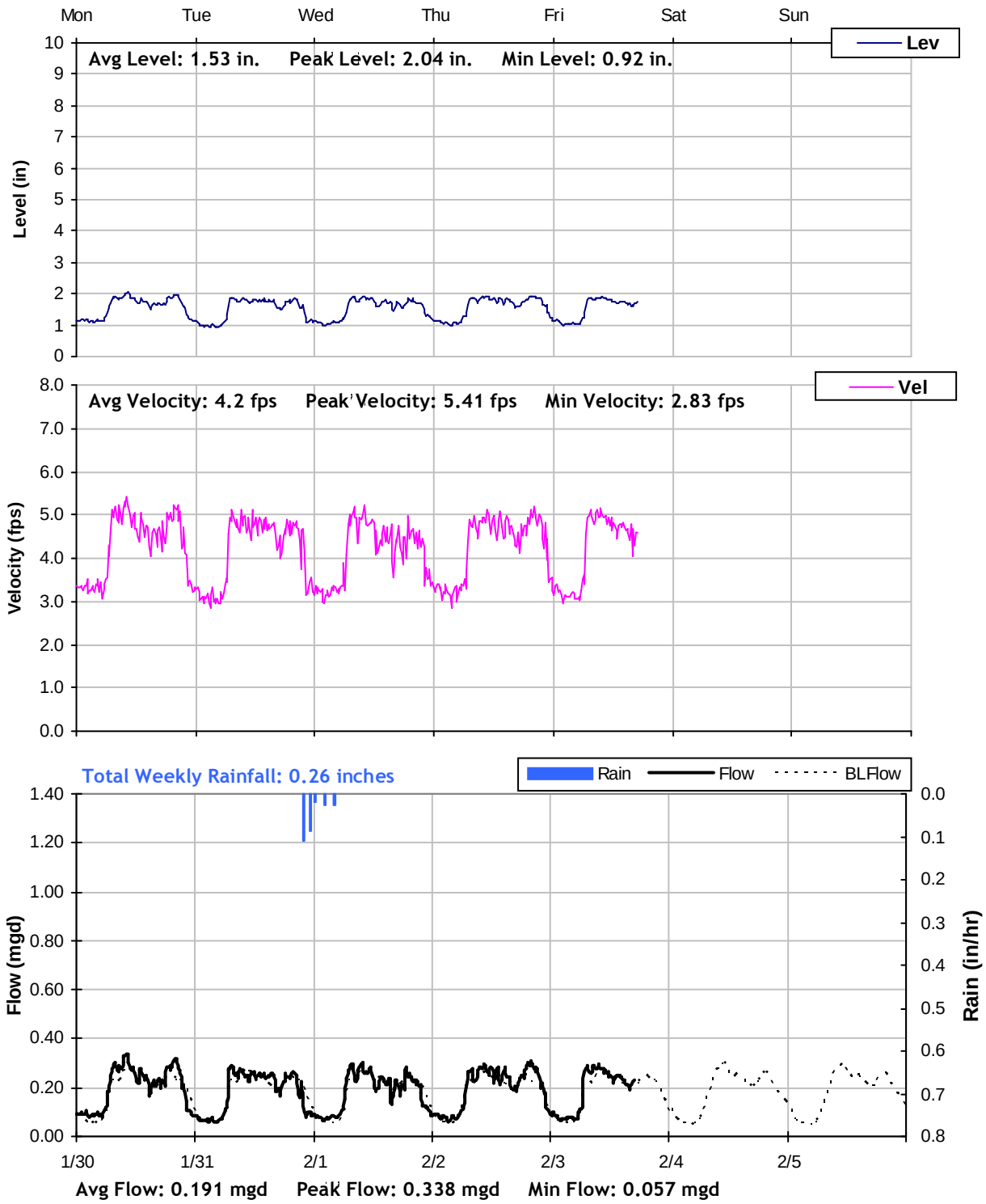
R42

Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



R42

Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

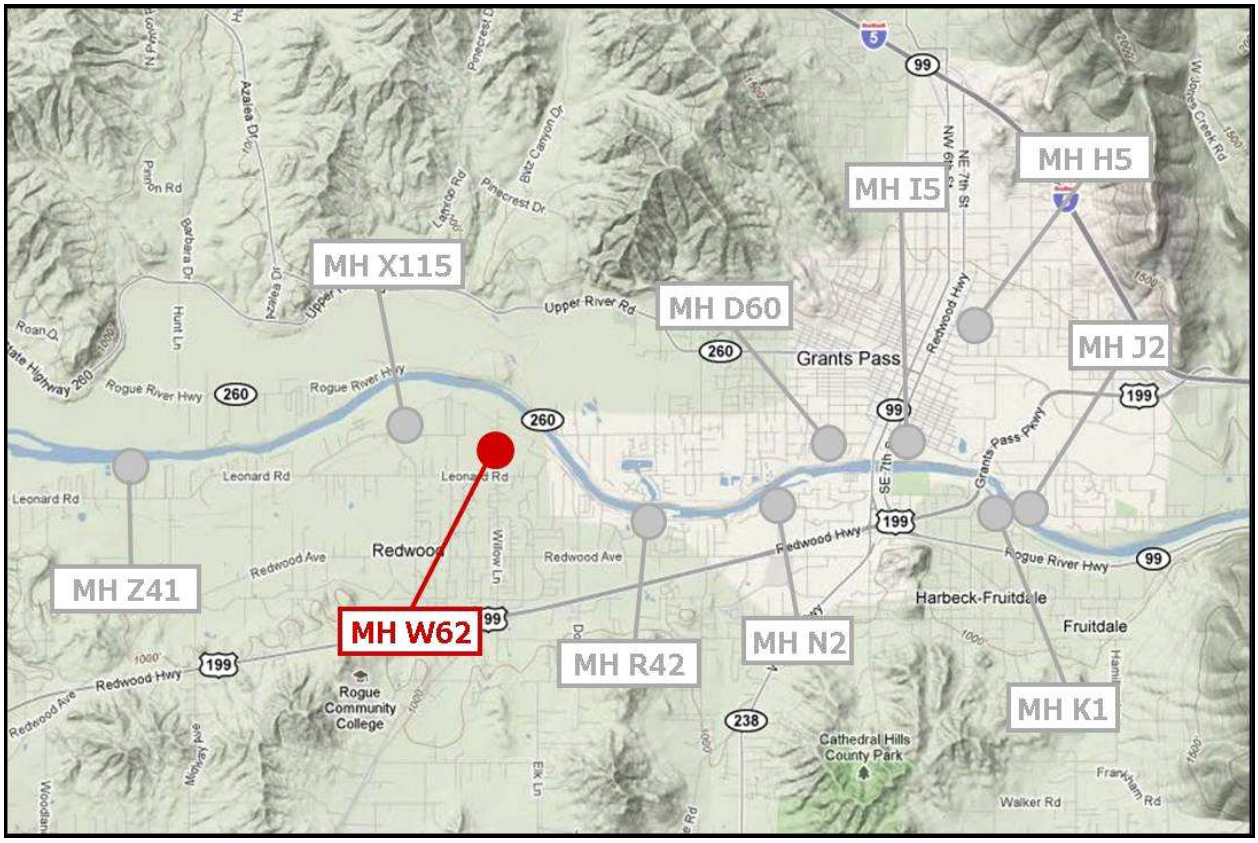
Year 2011/2012

Monitoring Site: W62

Location: Schroeder Lane, South of Eggers Lane

Data Summary Report

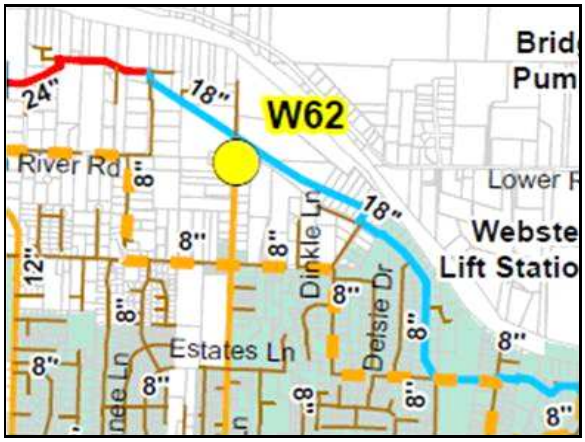
Vicinity Map:



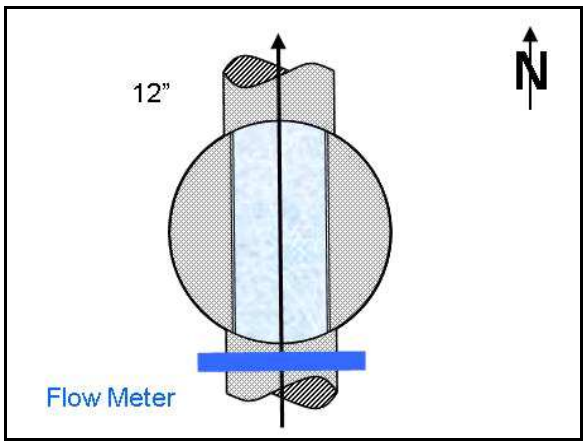
W62
Site Information Report

Location:	Schroeder Lane, South of Eggers Lane
Coordinates:	123.3765°W, 42.4331°N
Elevation:	906 feet
Diameter:	12 inches
Baseline Flow:	0.09 mgd
Peak Measured Flow:	0.322 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

W62
Additional Site Photos

Effluent Pipe

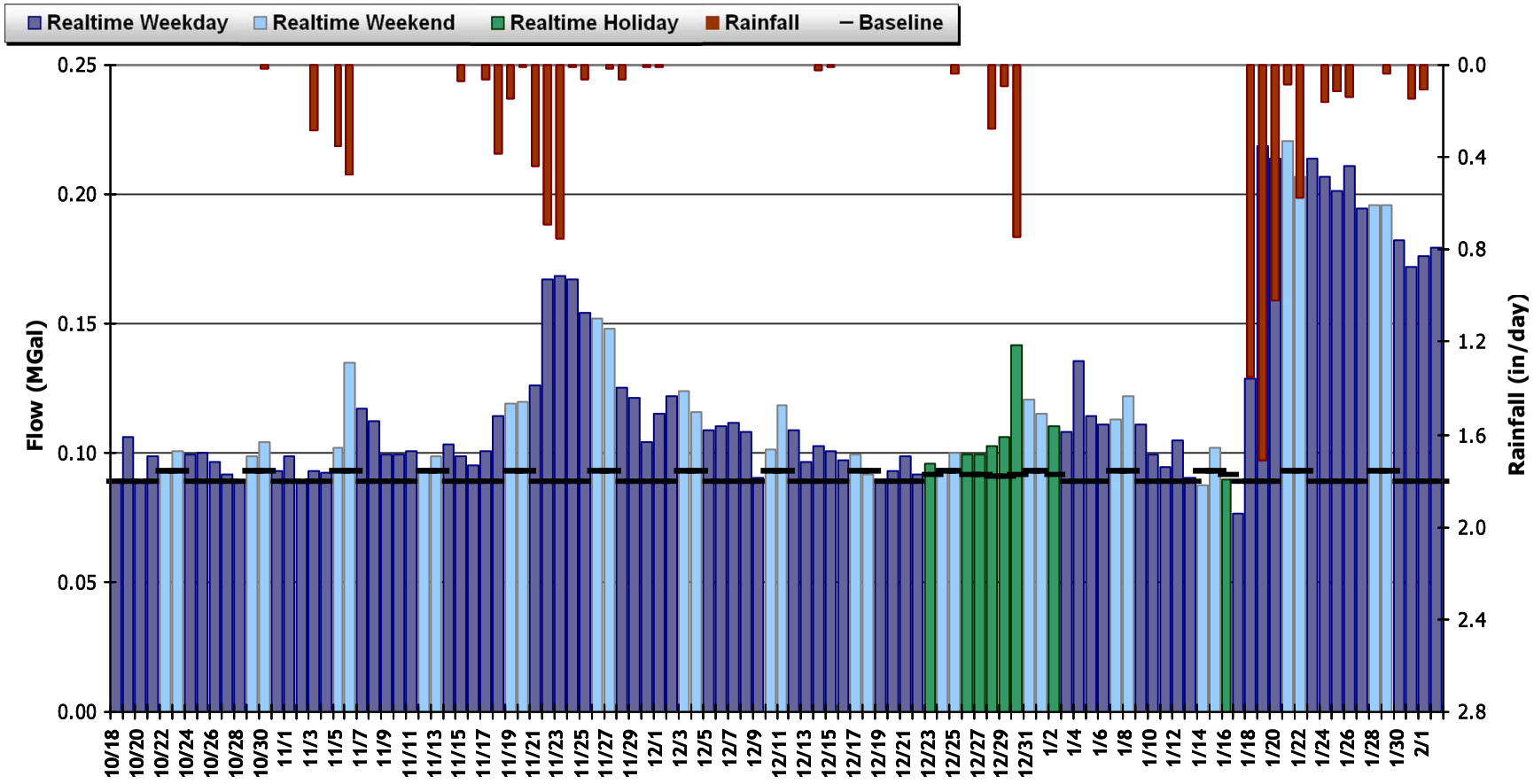
Main Influent Pipe

W62

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.12 MGal Peak Daily Flow: 0.22 MGal Min Daily Flow: 0.077 MGal

Total Period Rainfall: 10.43 inches

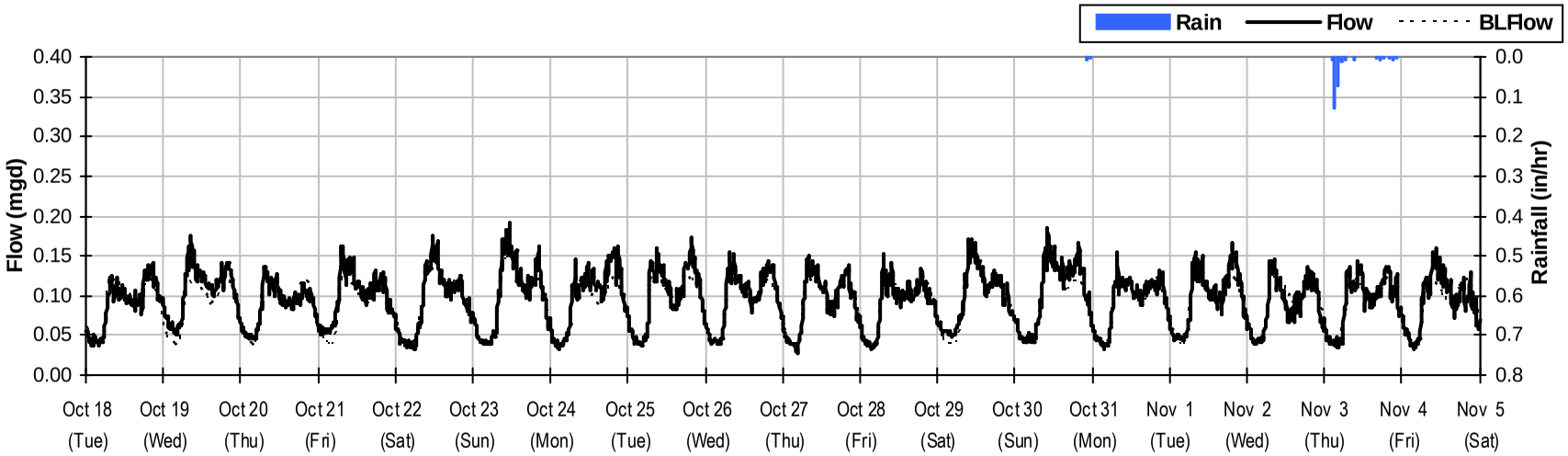


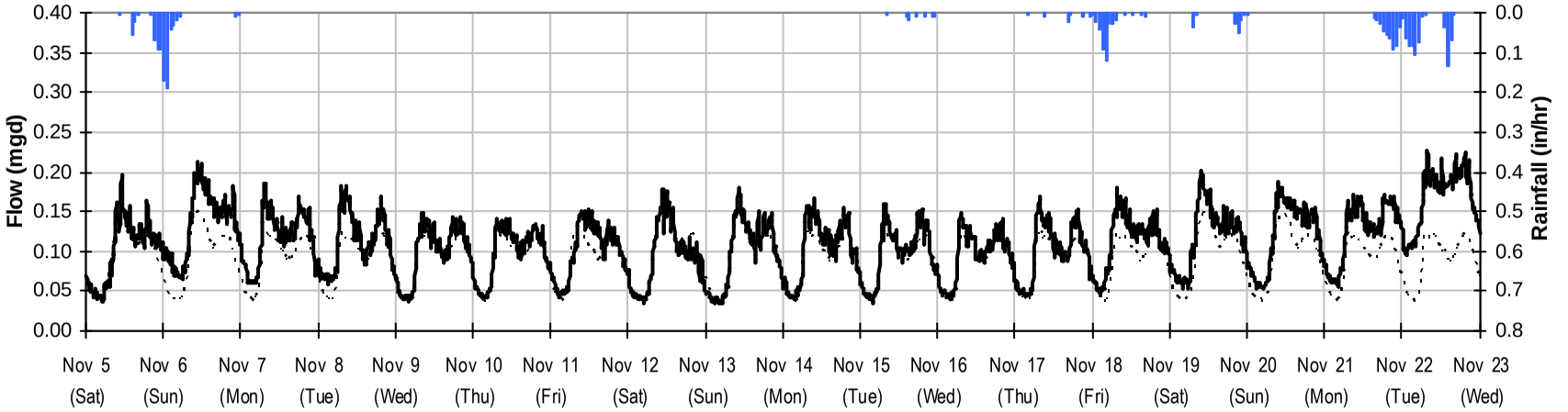
W62

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.103 mgd Peak Flow: 0.225 mgd Min Flow: 0.028 mgd

Total Period Rainfall: 2.92 inches



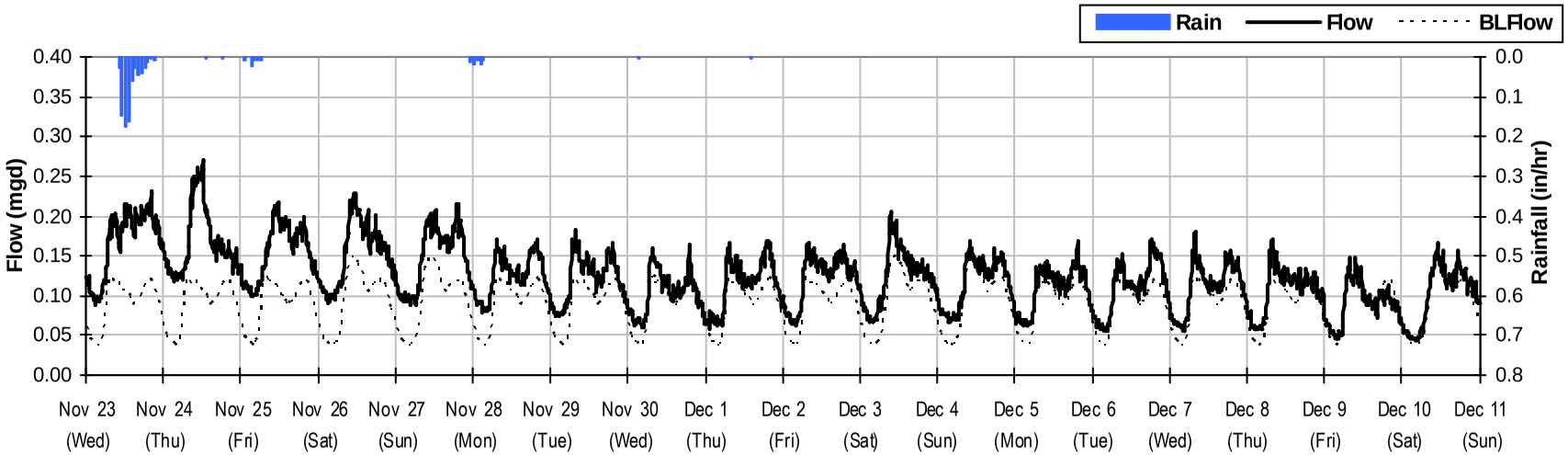


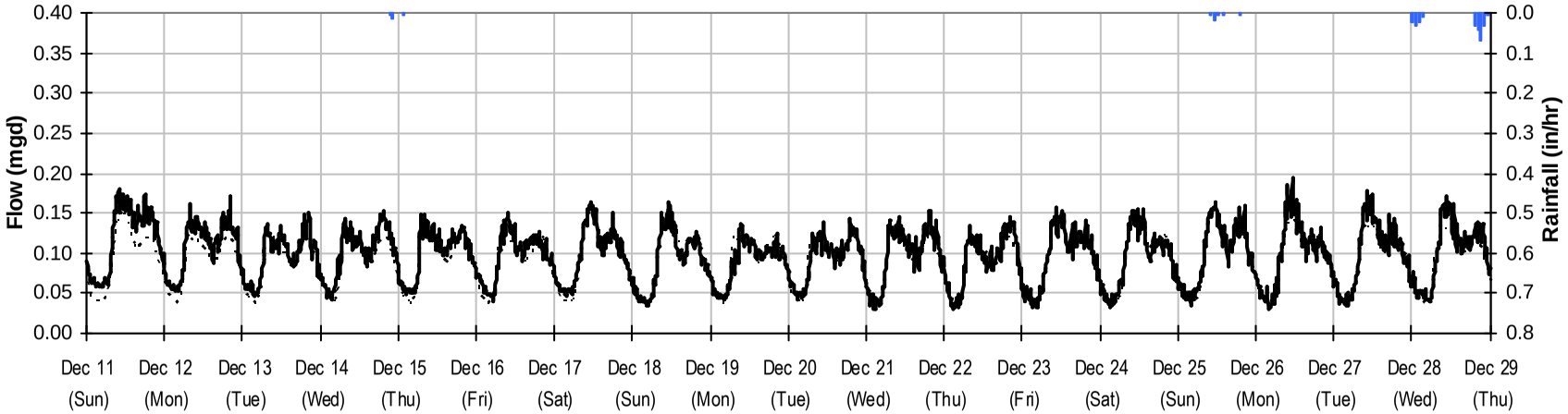
W62

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.112 mgd Peak Flow: 0.27 mgd Min Flow: 0.029 mgd

Total Period Rainfall: 1.23 inches



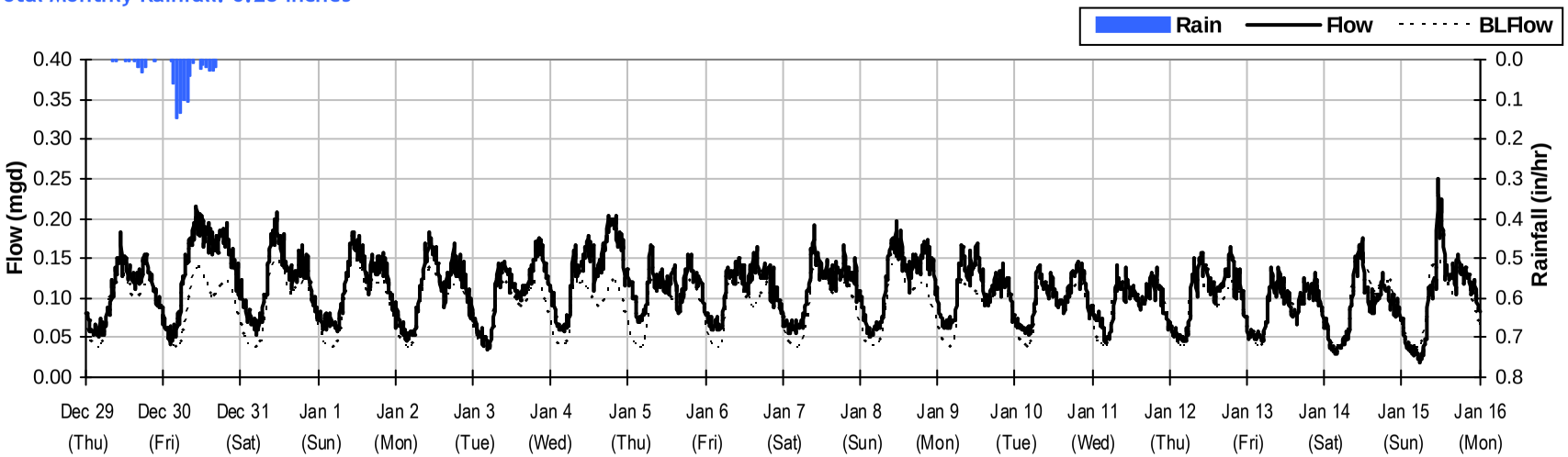


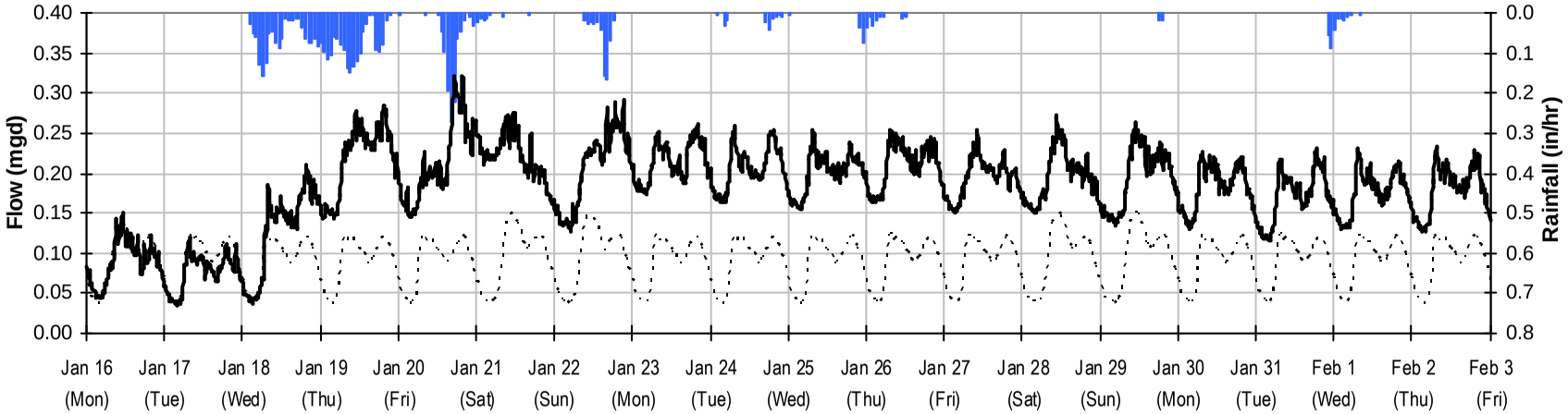
W62

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.15 mgd Peak Flow: 0.32 mgd Min Flow: 0.02 mgd

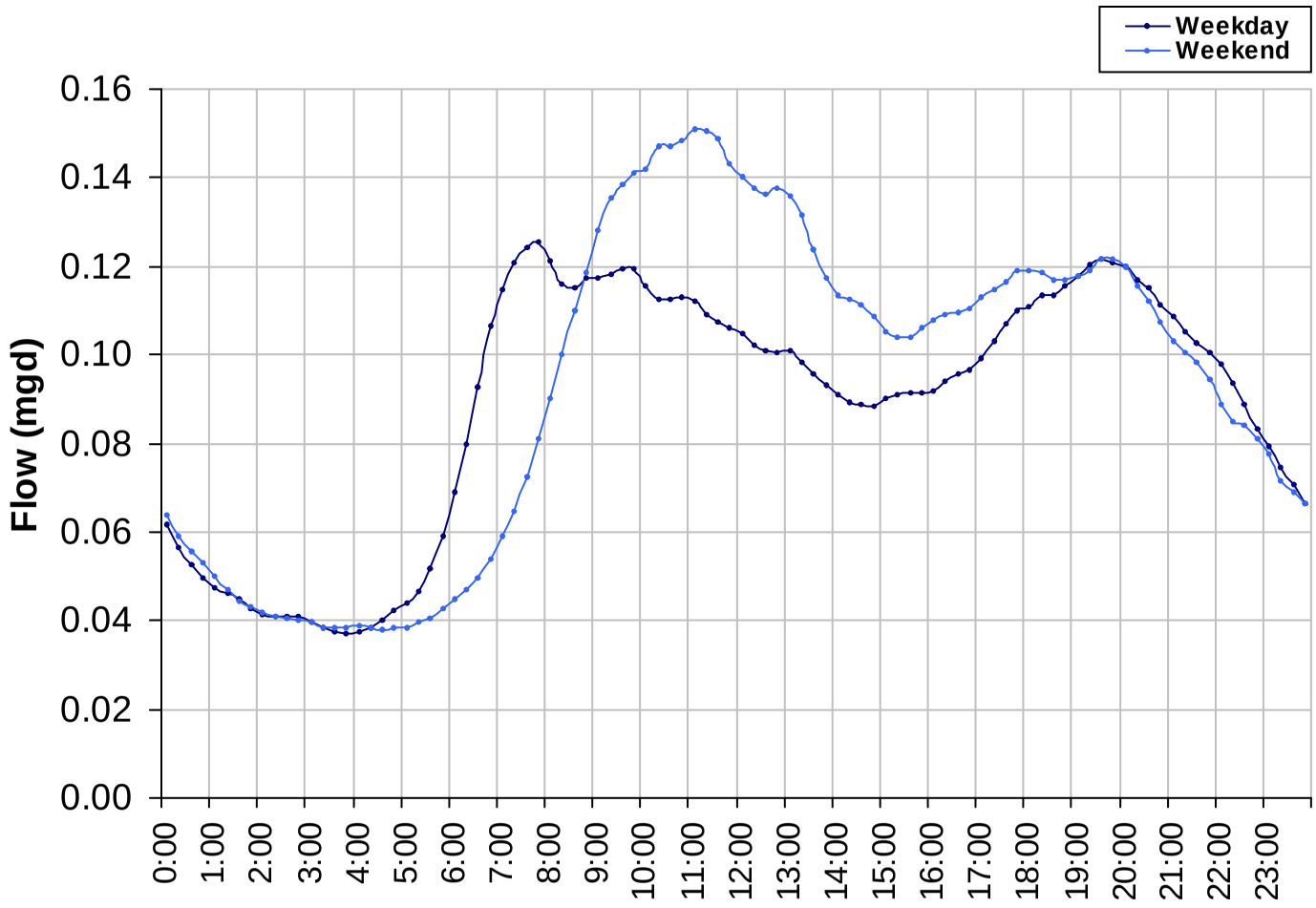
Total Monthly Rainfall: 6.28 inches





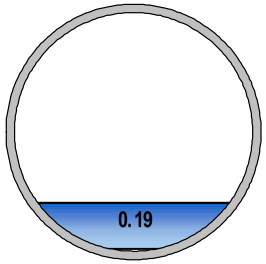
W62

Baseline Flow Hydrographs



Baseline Flow:

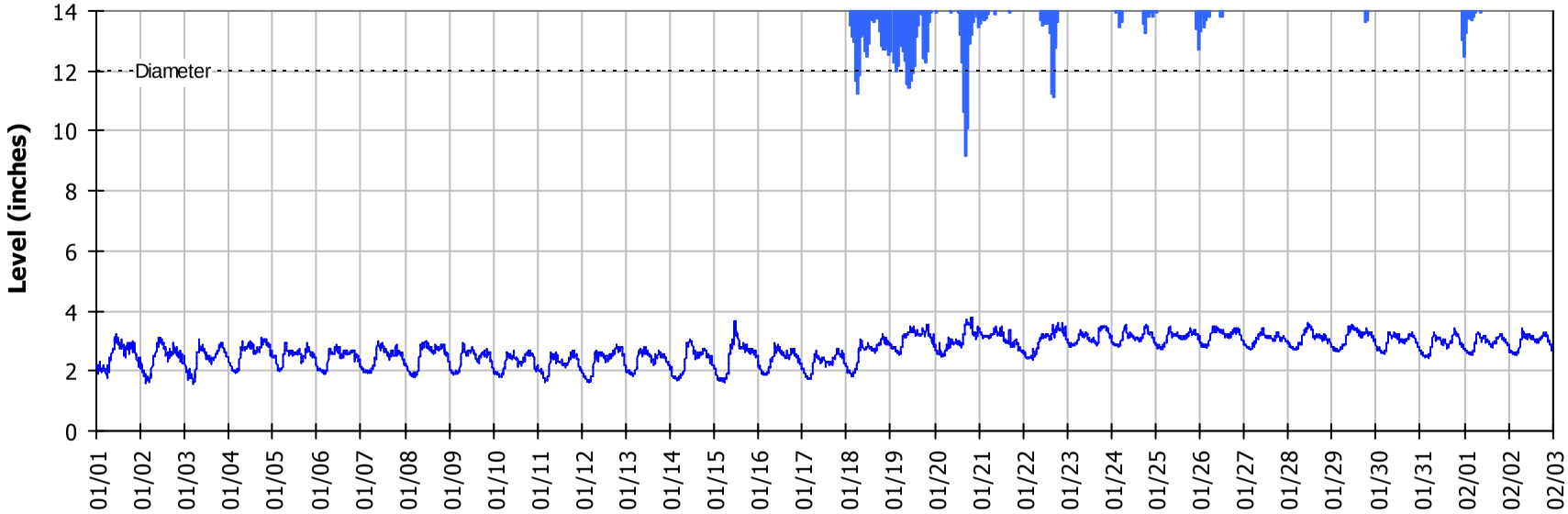
0.090 *mgd*

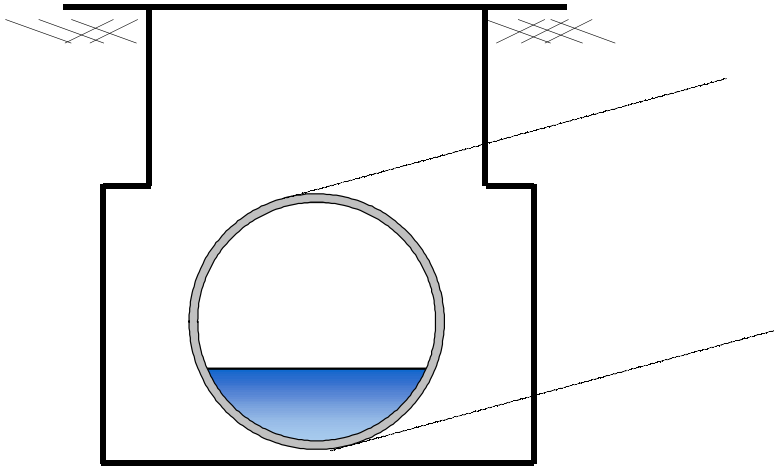


W62

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

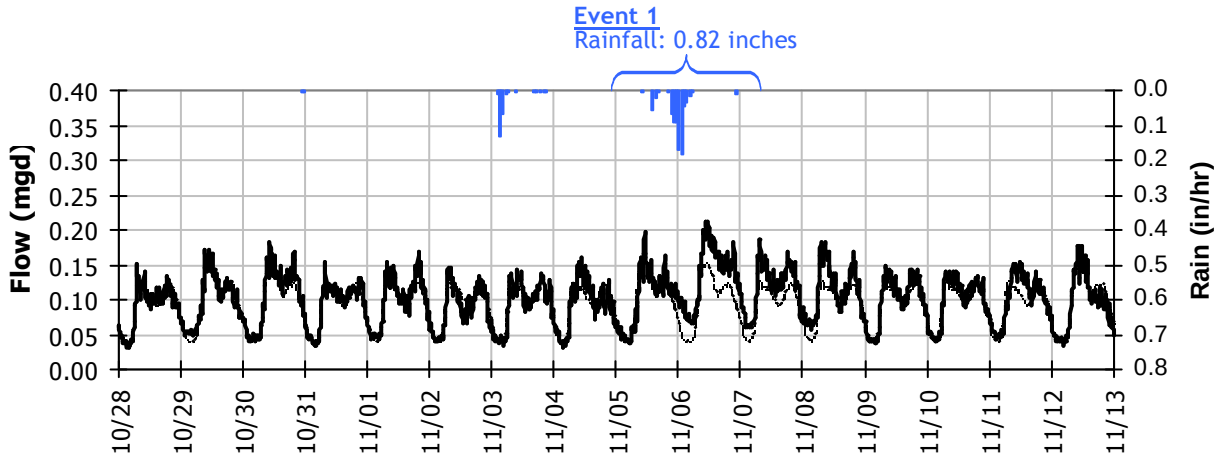




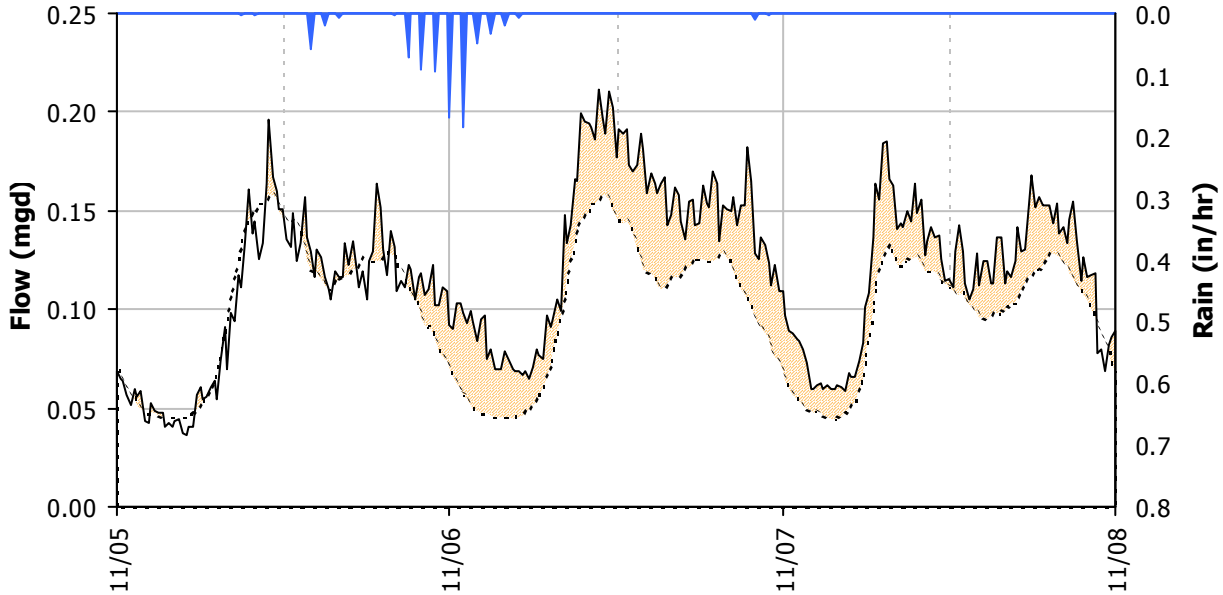
Pipe Diameter:	12	*inches*
Peak Measured Level	3.82	*inches*
Peak d/D Ratio:	0.32	

SITE W62
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

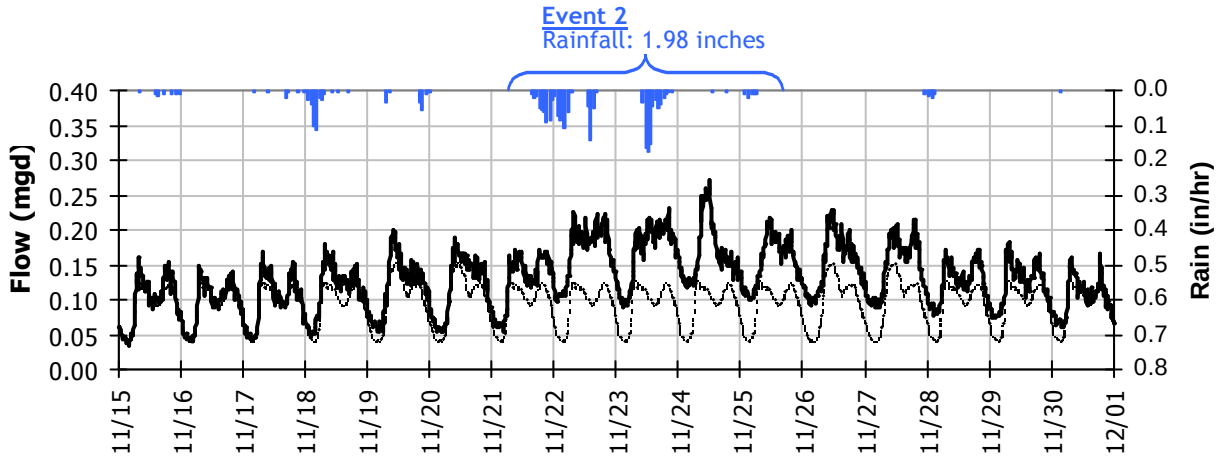


Storm Event I/I Analysis (Rain = 0.82 inches)

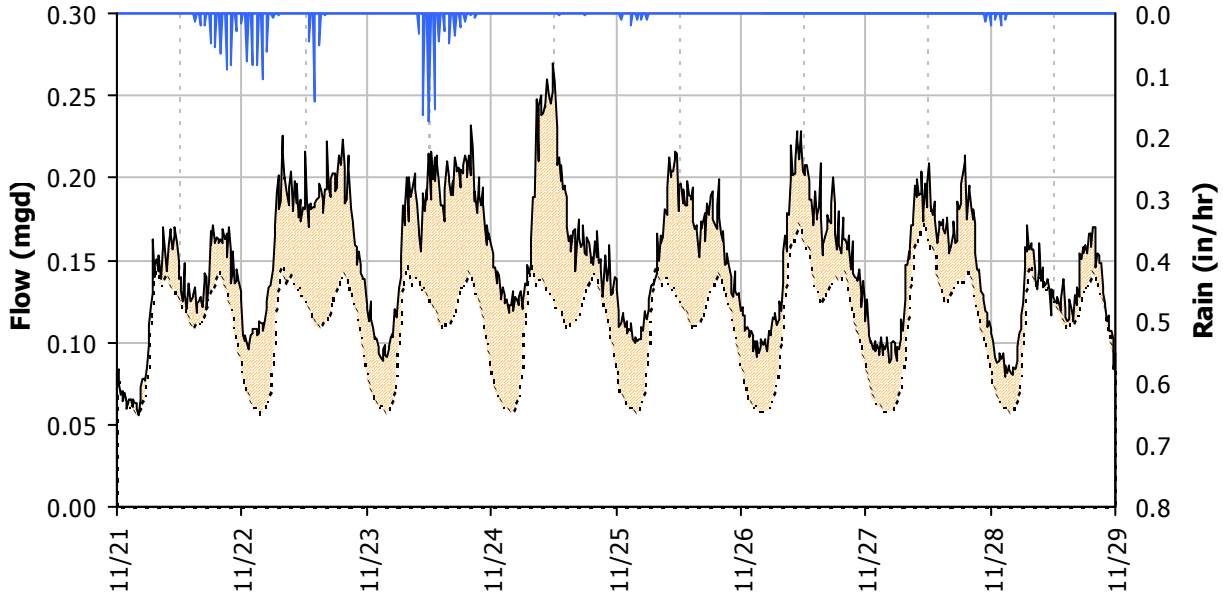
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.21	*mgd*	Peak I/I Rate:	0.08	*mgd*	Infiltration Rate: (11/7/2011)	0.028	*mgd*	Total I/I:	60,000	*gallons*
PF:	2.36		PkI/I:IDM:	2,153	*gpd/IDM*	RDI:IDM:	728	*gpd/IDM*	Total I/I:IDM:	1,881	*gal/IDM/in*
Peak Level:	3.30	*in*	PkI/I:Acre:	430	*gpd/acre*	RDI:Acre:	146	*gpd/acre*	R-Value:	1.4%	
d/D Ratio:	0.28		Pk I/I:ADWF:	0.93		RDI (% of BL):	32%		Total I/I:ADWF:	0.81	*per in-rain*

SITE W62
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

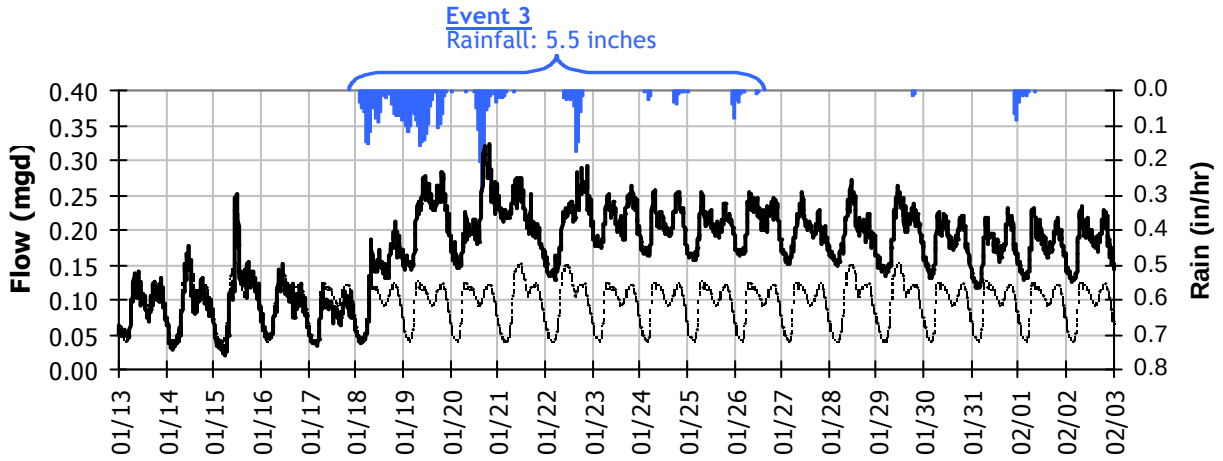


Storm Event I/I Analysis (Rain = 1.98 inches)

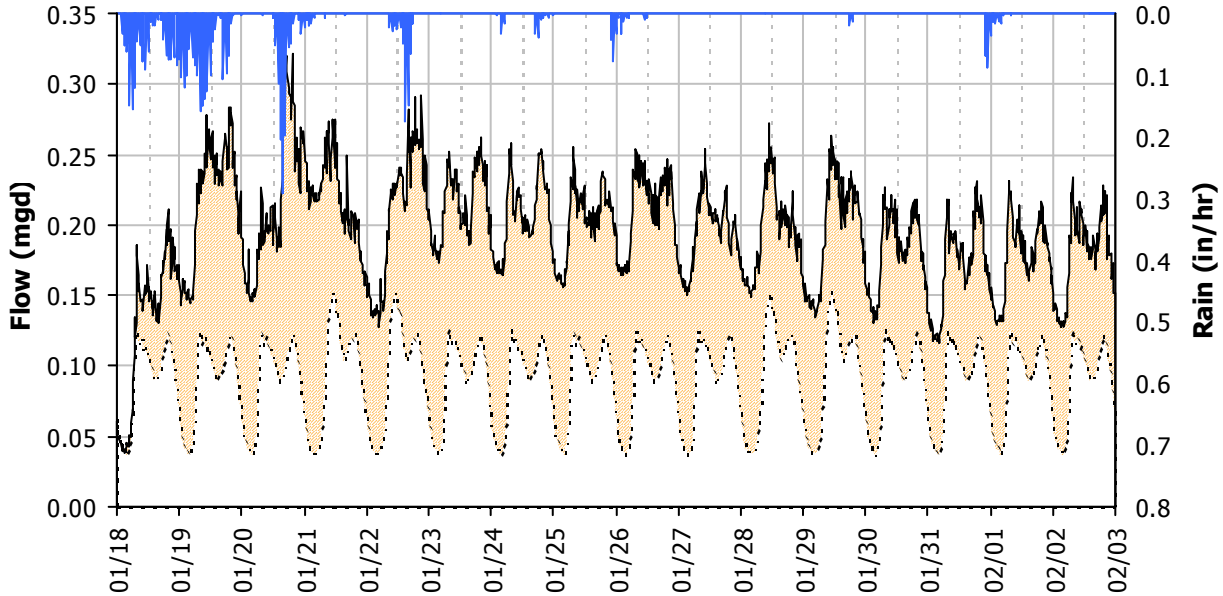
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.27	*mgd*	Peak I/I Rate:	0.17	*mgd*	Infiltration Rate: (11/26/2011)	0.059	*mgd*	Total I/I:	330,000	*gallons*
PF:	3.00		PkI/I:IDM:	4,252	*gpd/IDM*	RDI:IDM:	1,522	*gpd/IDM*	Total I/I:IDM:	4,278	*gal/IDM/in*
Peak Level:	3.74	*in*	PkI/I:Acre:	850	*gpd/acre*	RDI:Acre:	304	*gpd/acre*	R-Value:	3.2%	
d/D Ratio:	0.31		Pk I/I:ADWF:	1.84		RDI (% of BL):	64%		Total I/I:ADWF:	1.85	*per in-rain*

SITE W62
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



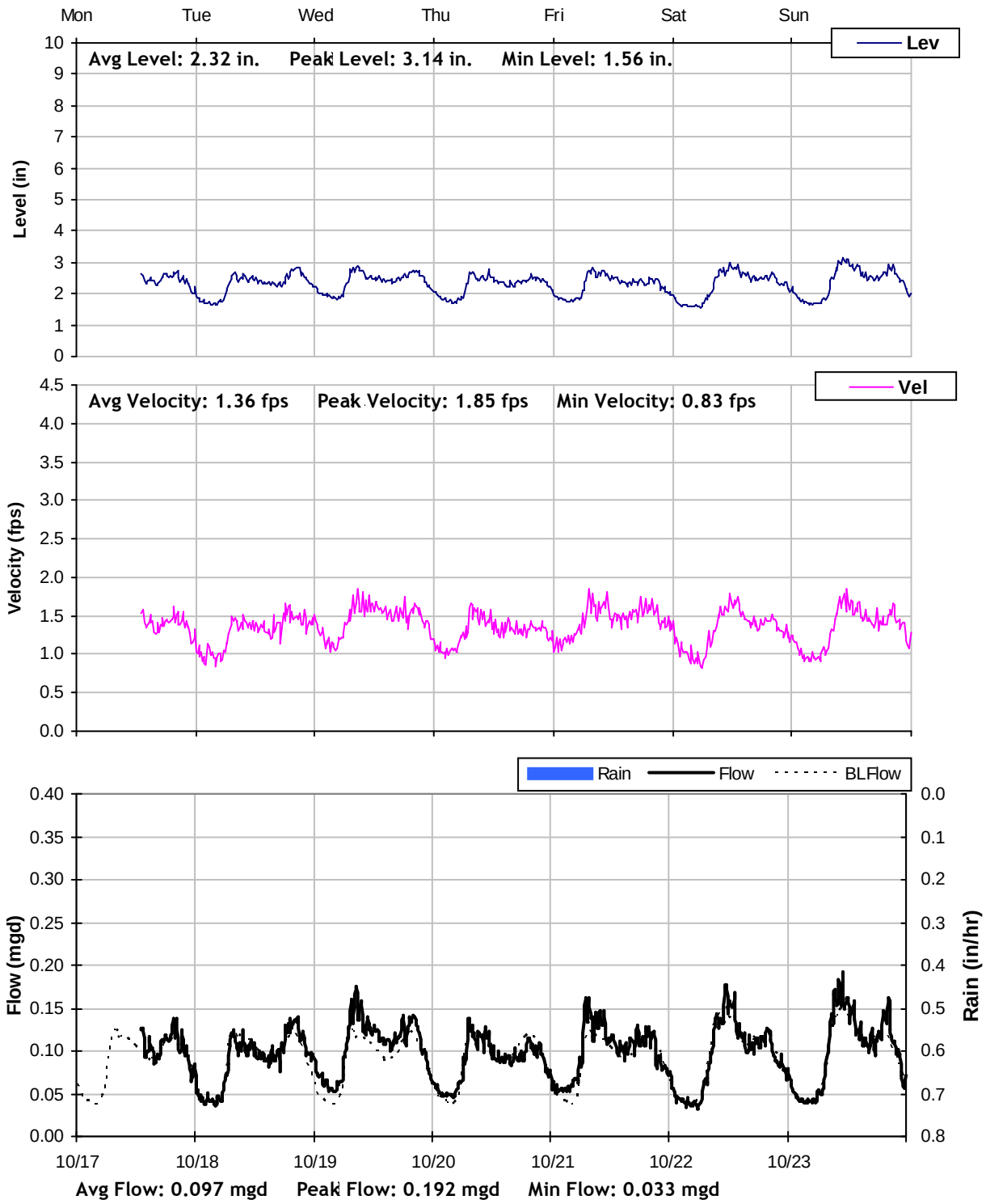
Event 3 Detail Graph



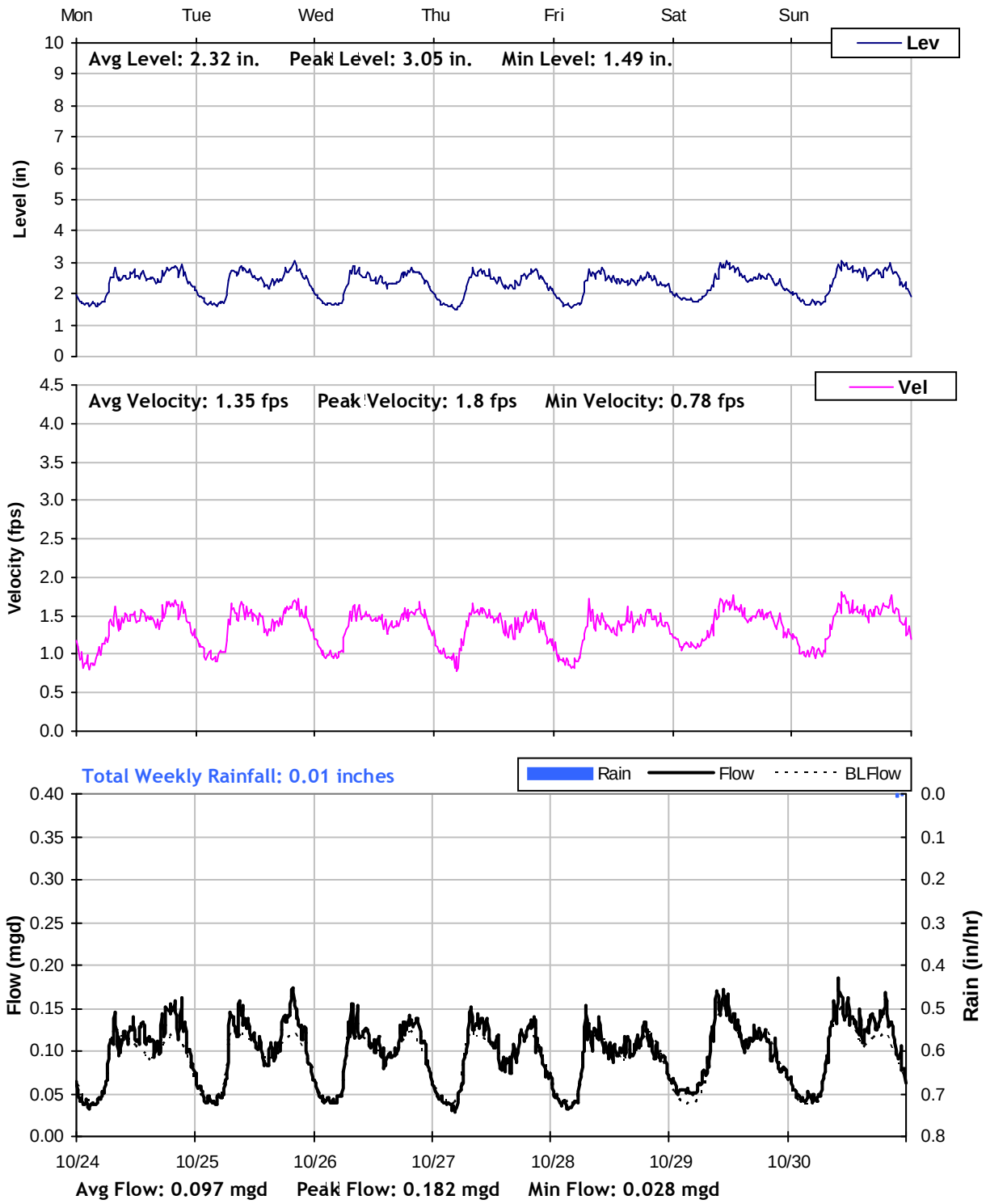
Storm Event I/I Analysis (Rain = 5.5 inches)

Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.32 *mgd*	Peak I/I Rate:	0.22 *mgd*	Infiltration Rate: (1/30/2012)	0.093 *mgd*	Total I/I:	1,681,000 *gallons*
PF:	3.58	PkI/I:IDM:	5,580 *gpd/IDM*	RDI:IDM:	2,394 *gpd/IDM*	Total I/I:IDM:	7,851 *gal/IDM/in*
Peak Level:	3.82 *in*	PkI/I:Acre:	1,116 *gpd/acre*	RDI:Acre:	479 *gpd/acre*	R-Value:	5.8%
d/D Ratio:	0.32	Pk I/I:ADWF:	2.41	RDI (% of BL):	105%	Total I/I:ADWF:	3.40 *per in-rain*

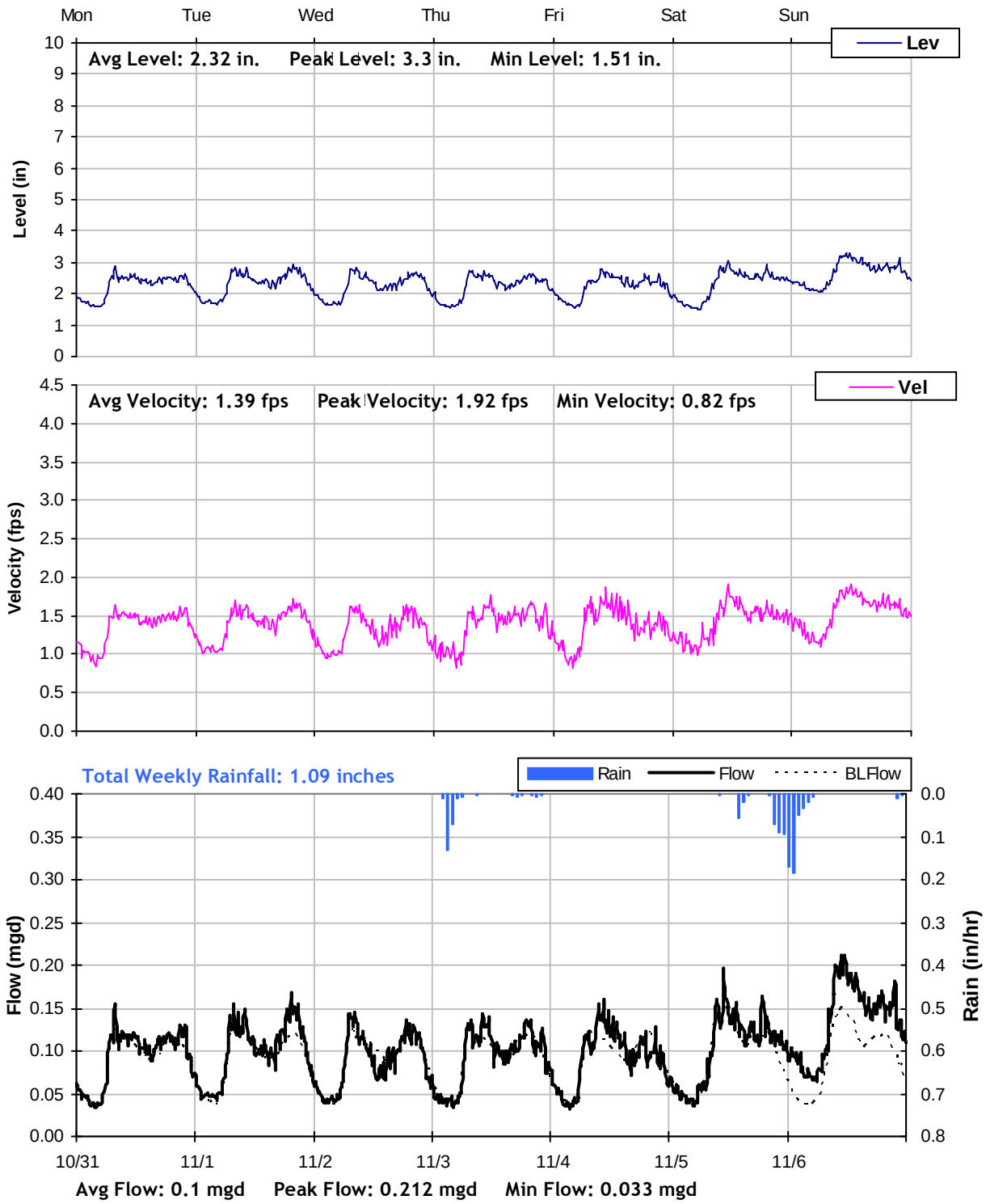
W62
Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



W62
Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011

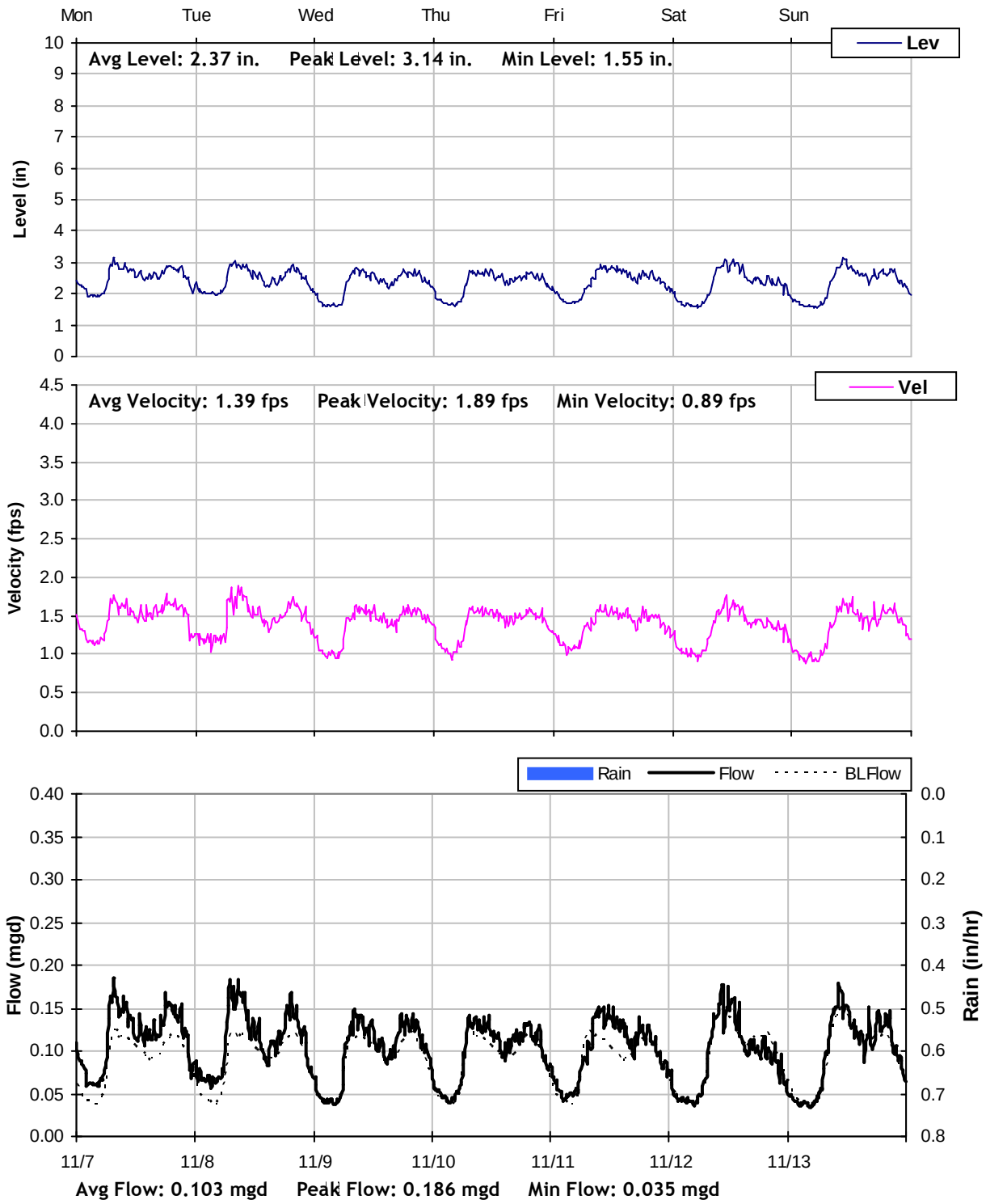


W62
Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011

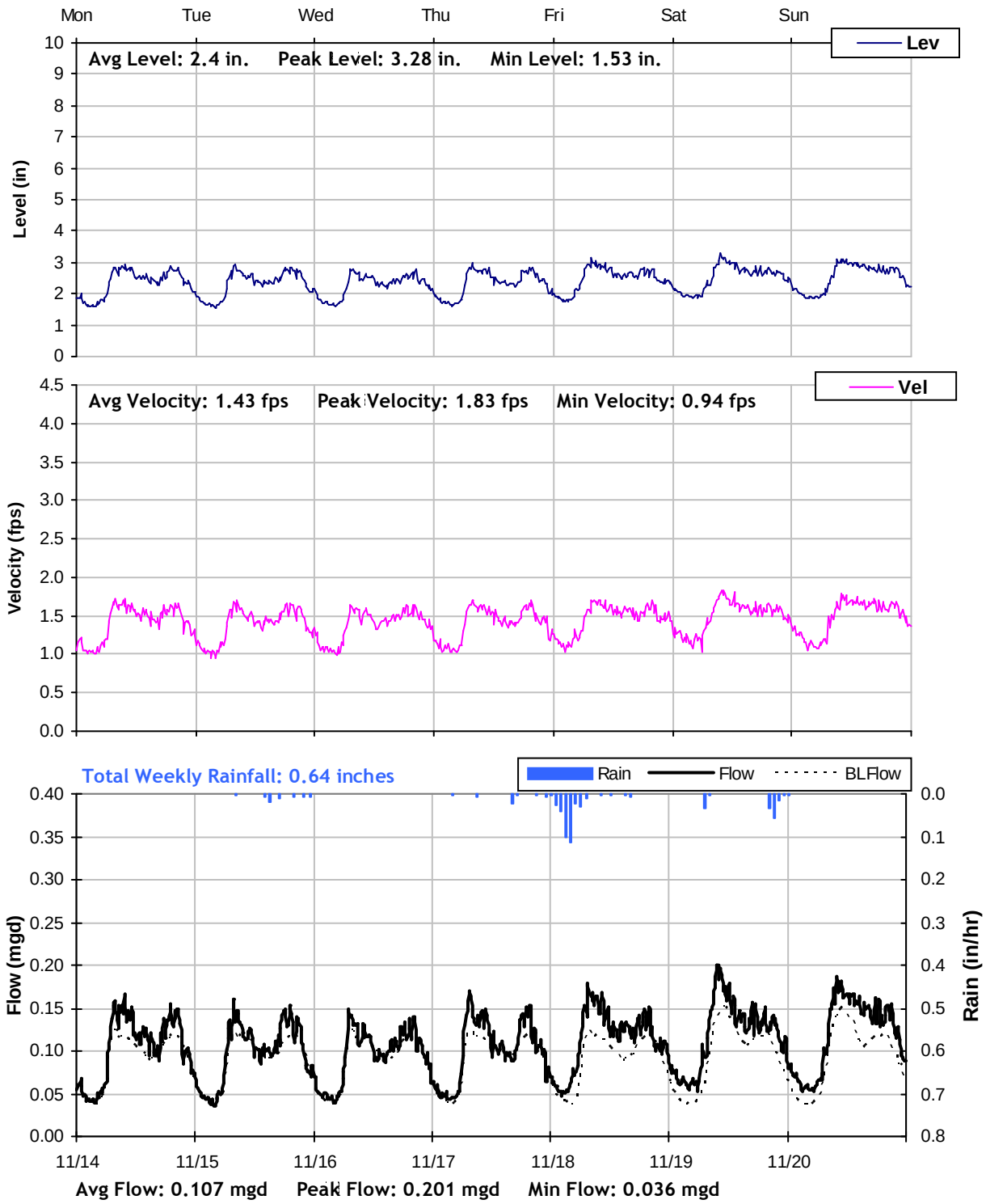


W62

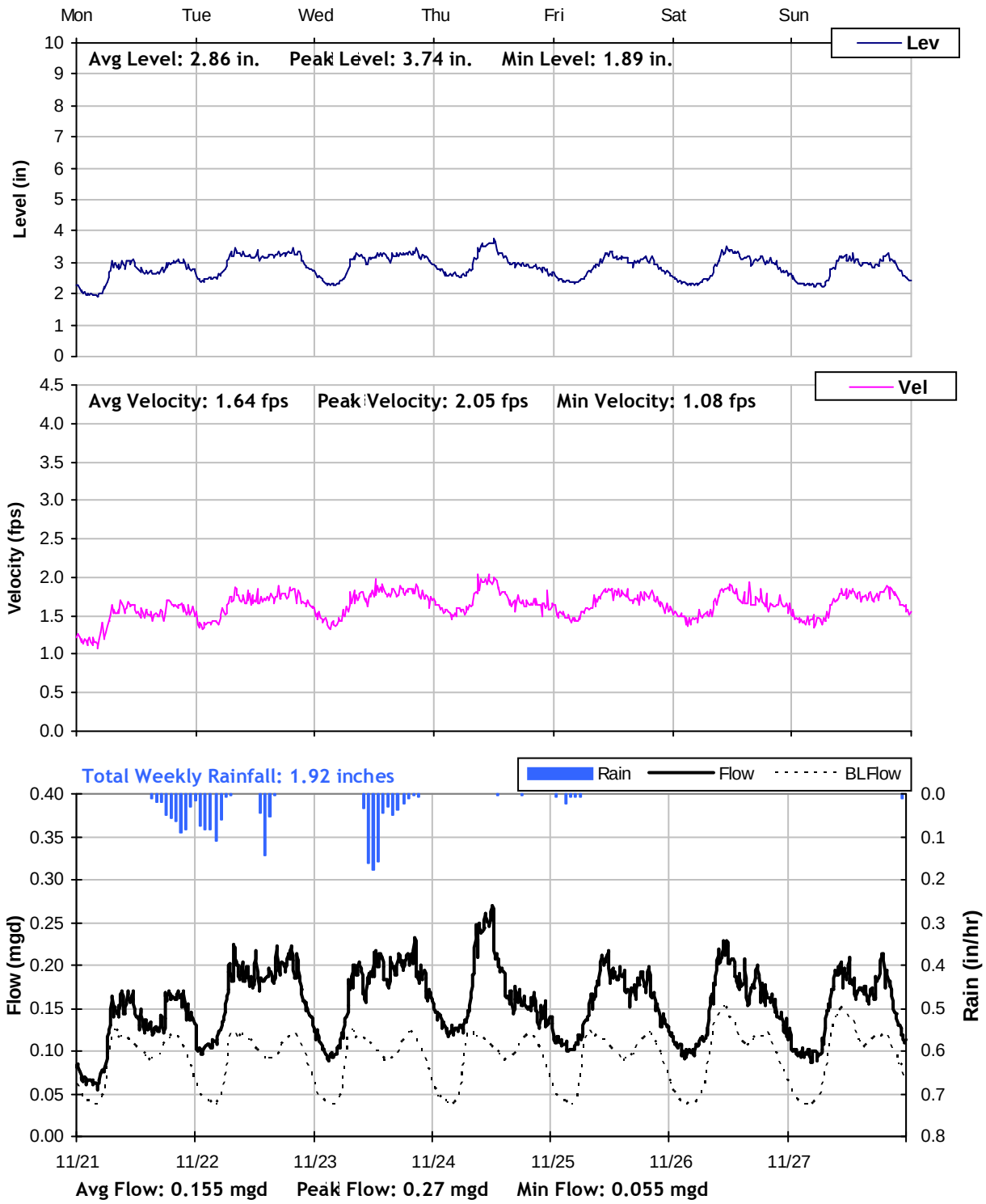
Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



W62
Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



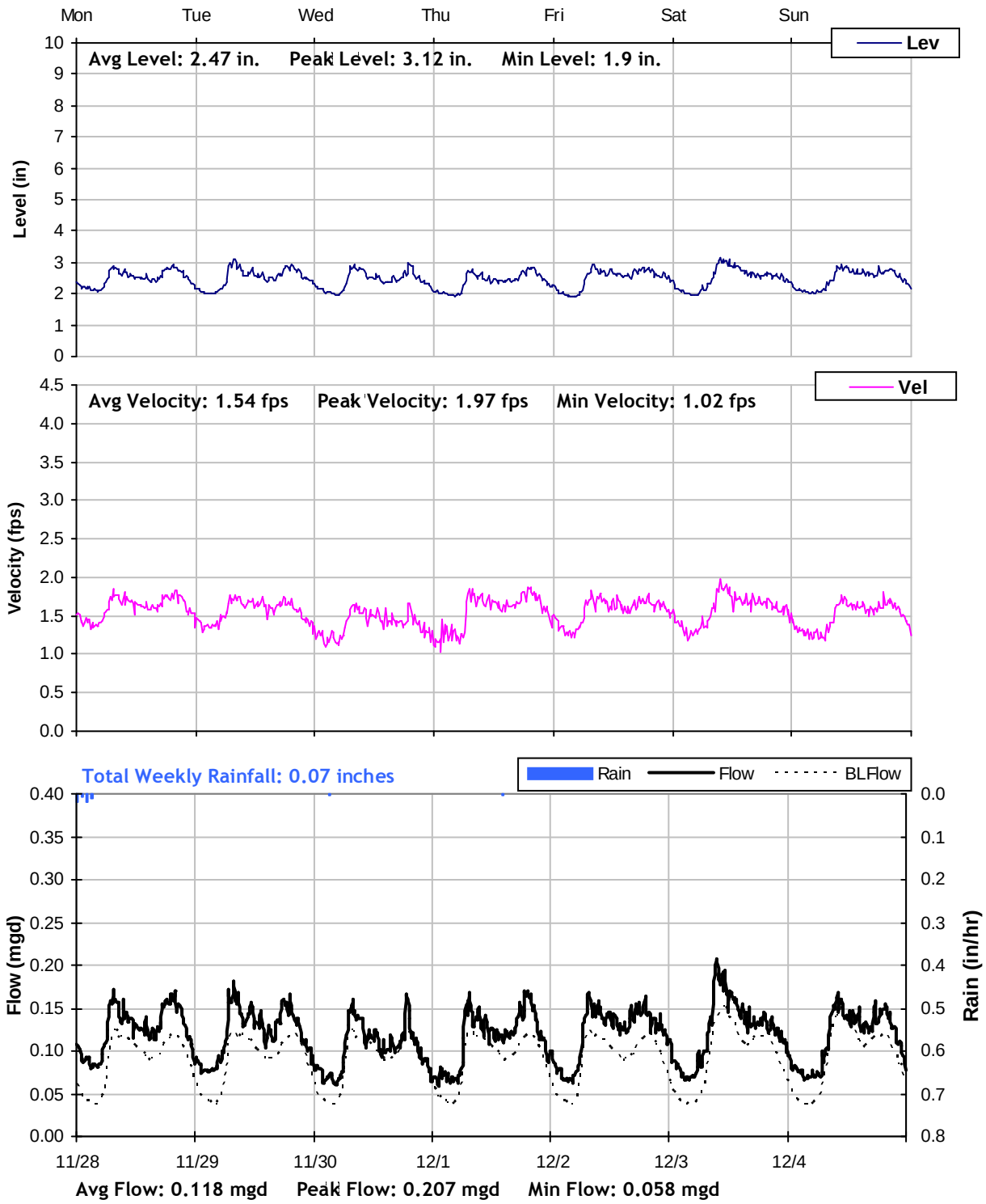
W62
Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



W62

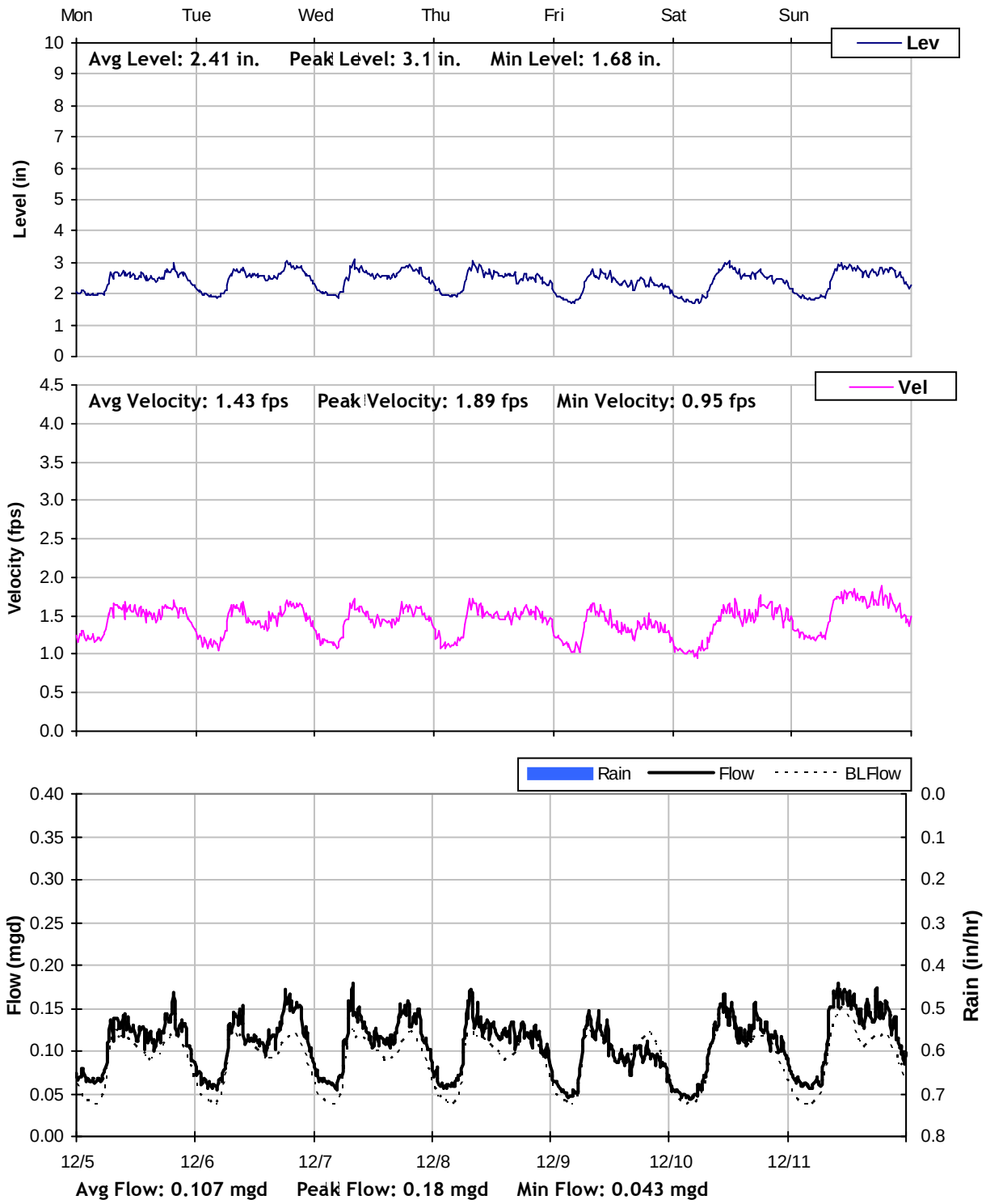
Weekly Level, Velocity and Flow Hydrographs

11/28/2011 to 12/5/2011



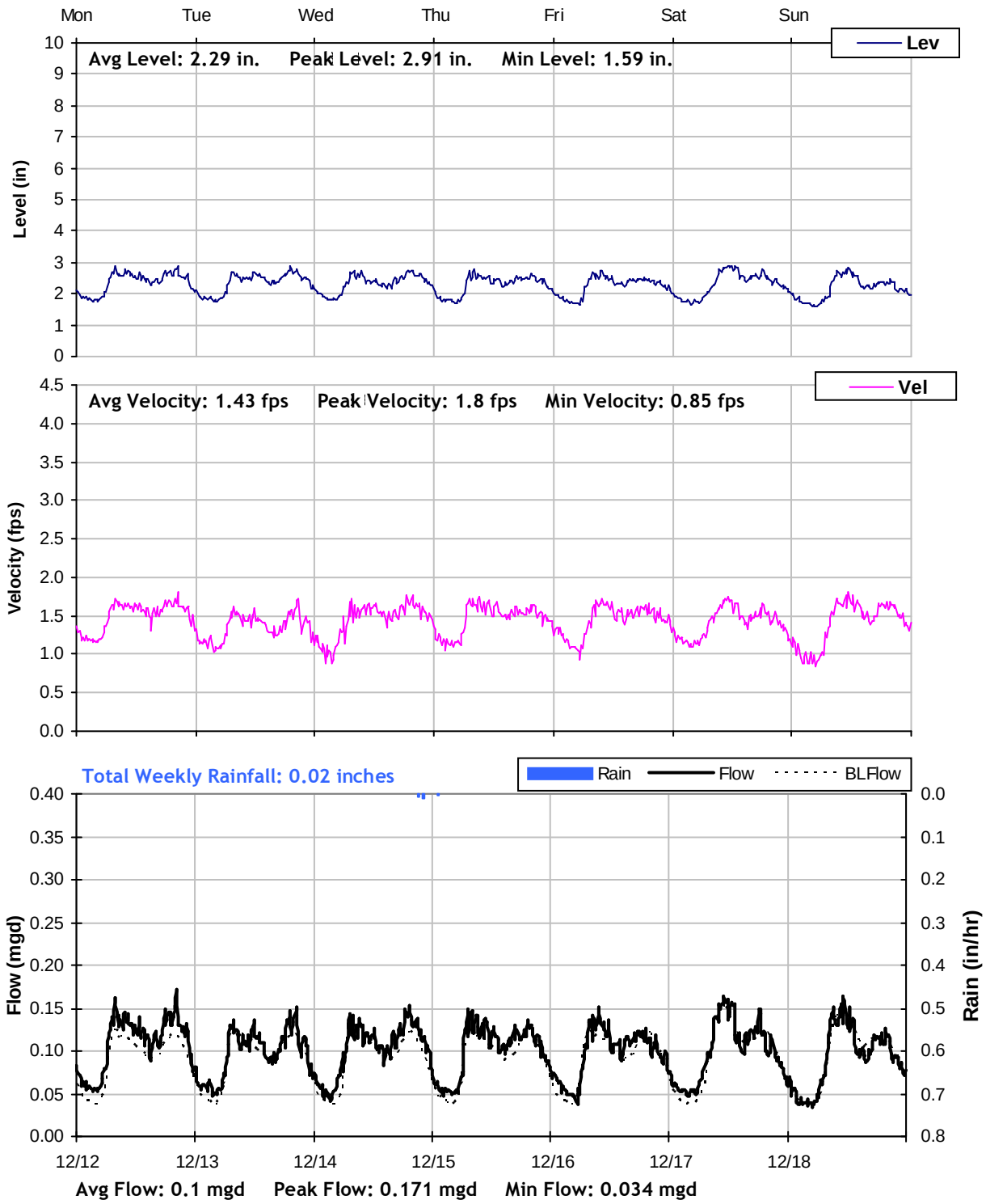
W62

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011

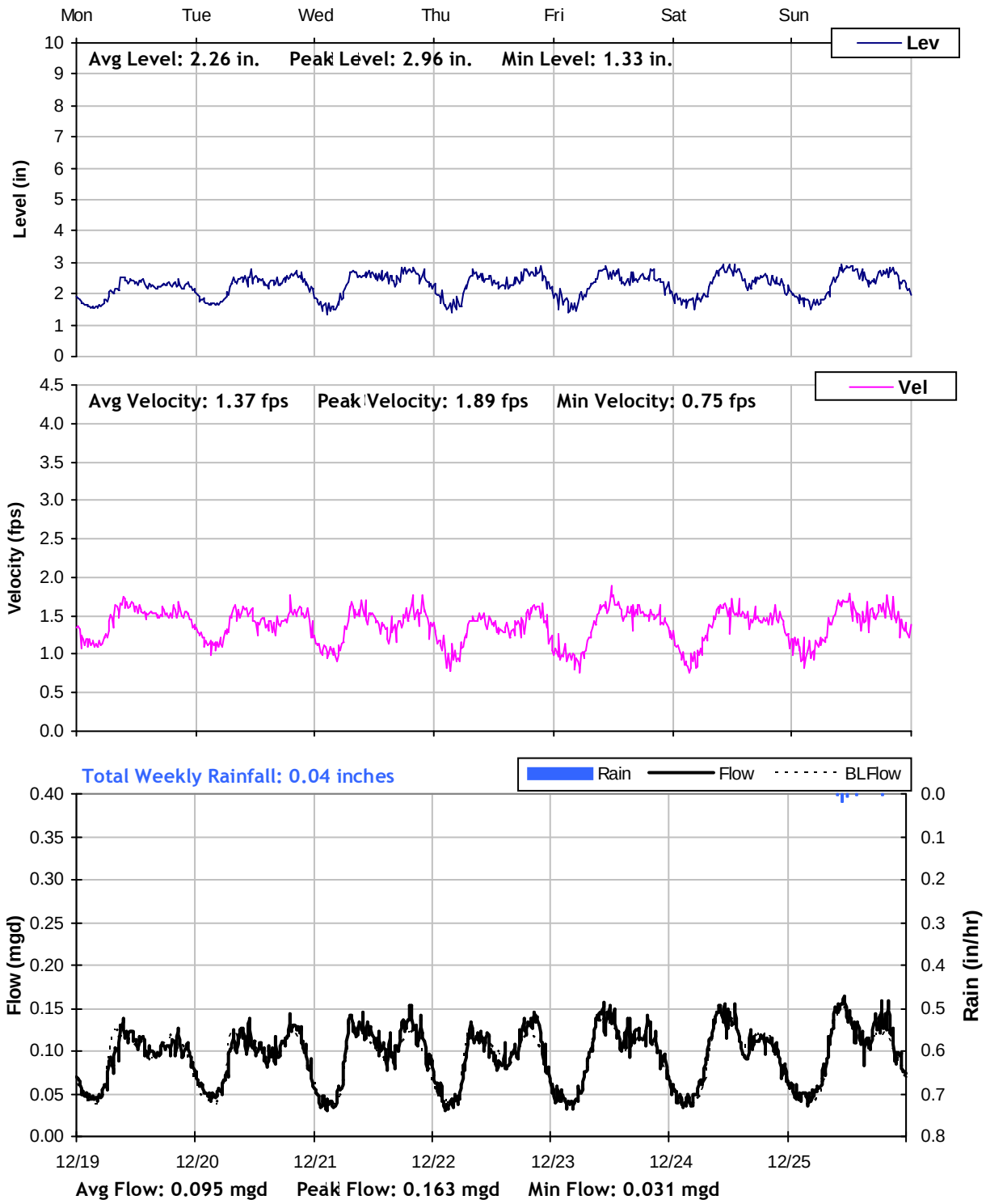


W62

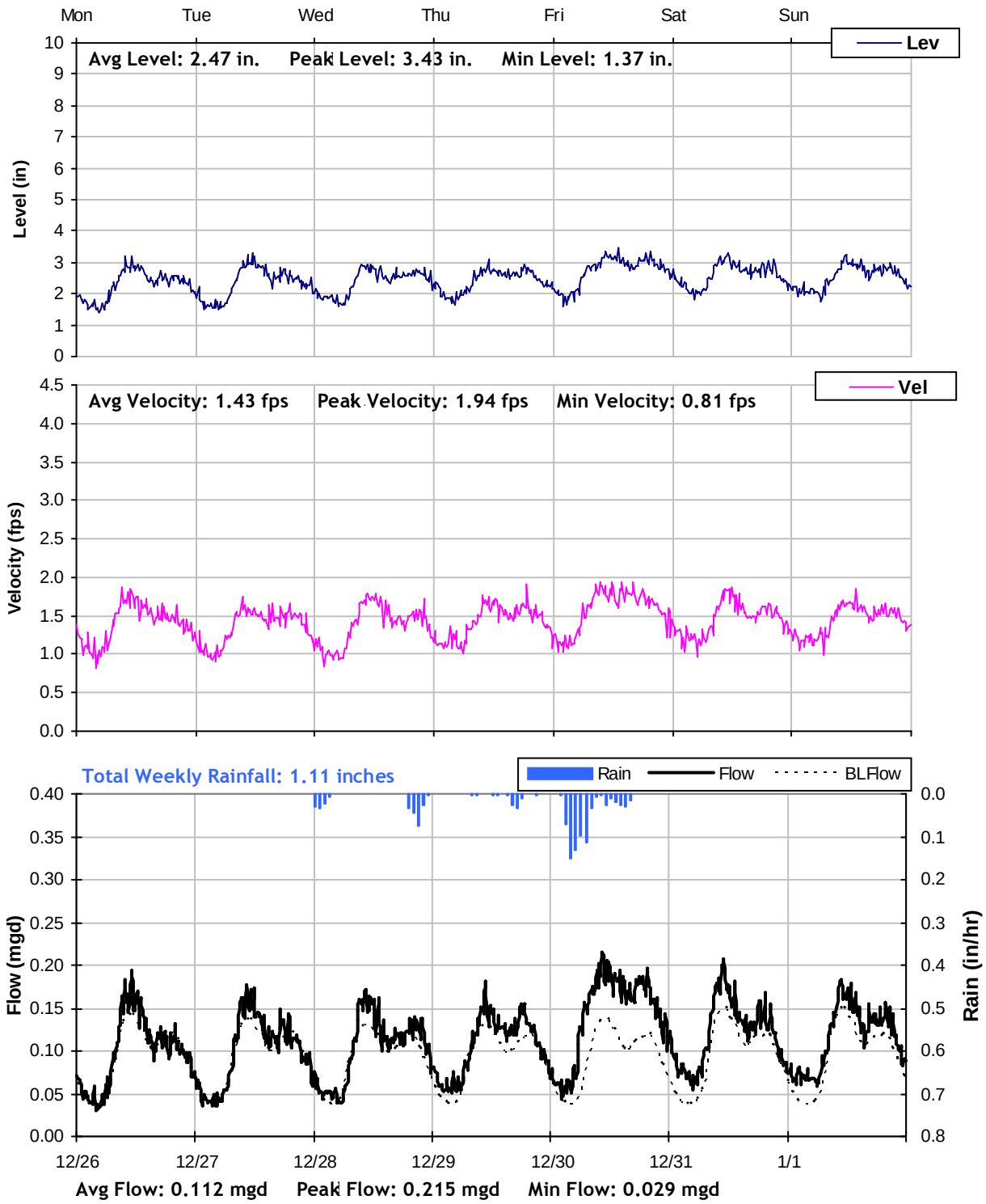
Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



W62
Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011

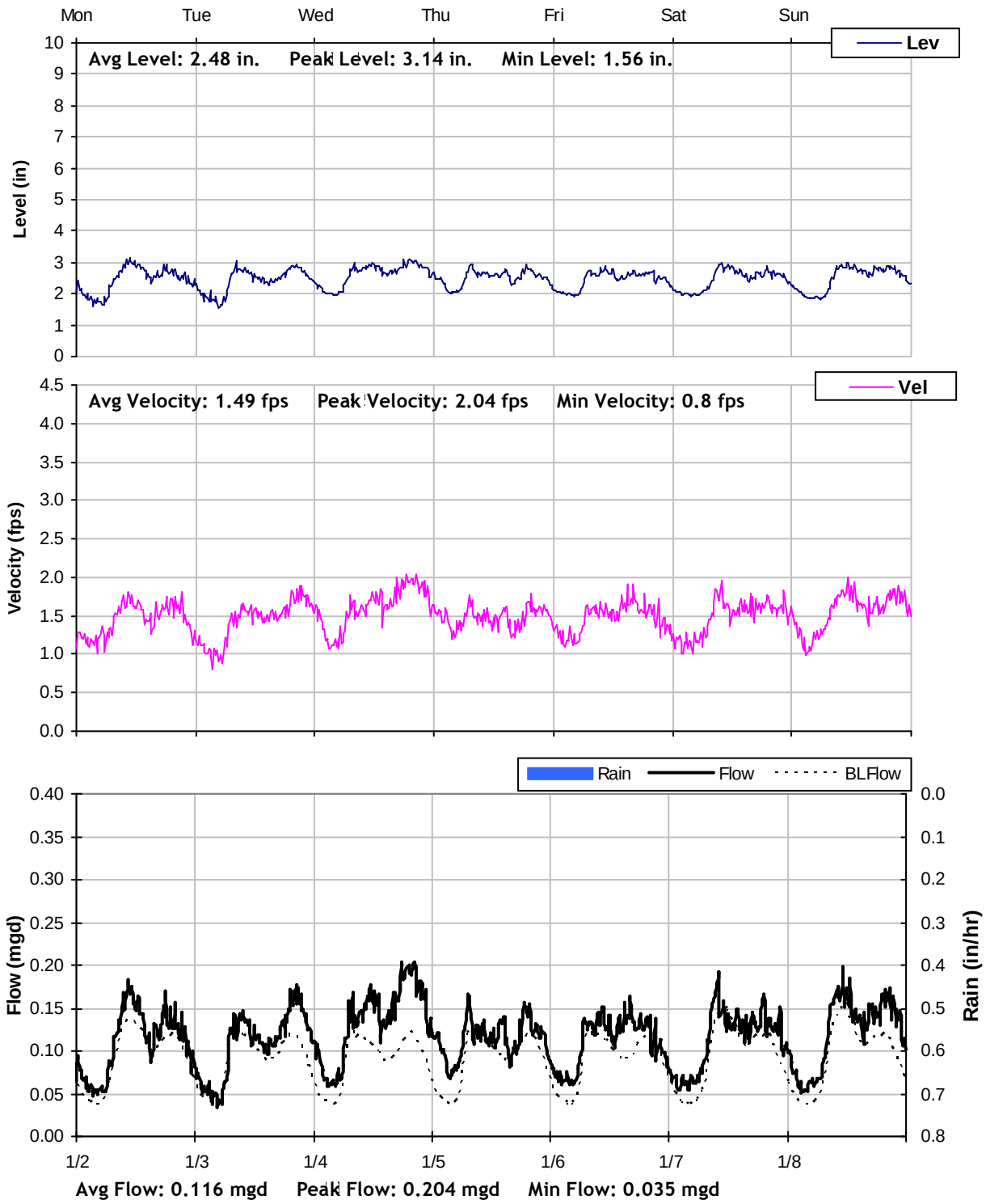


W62
Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012

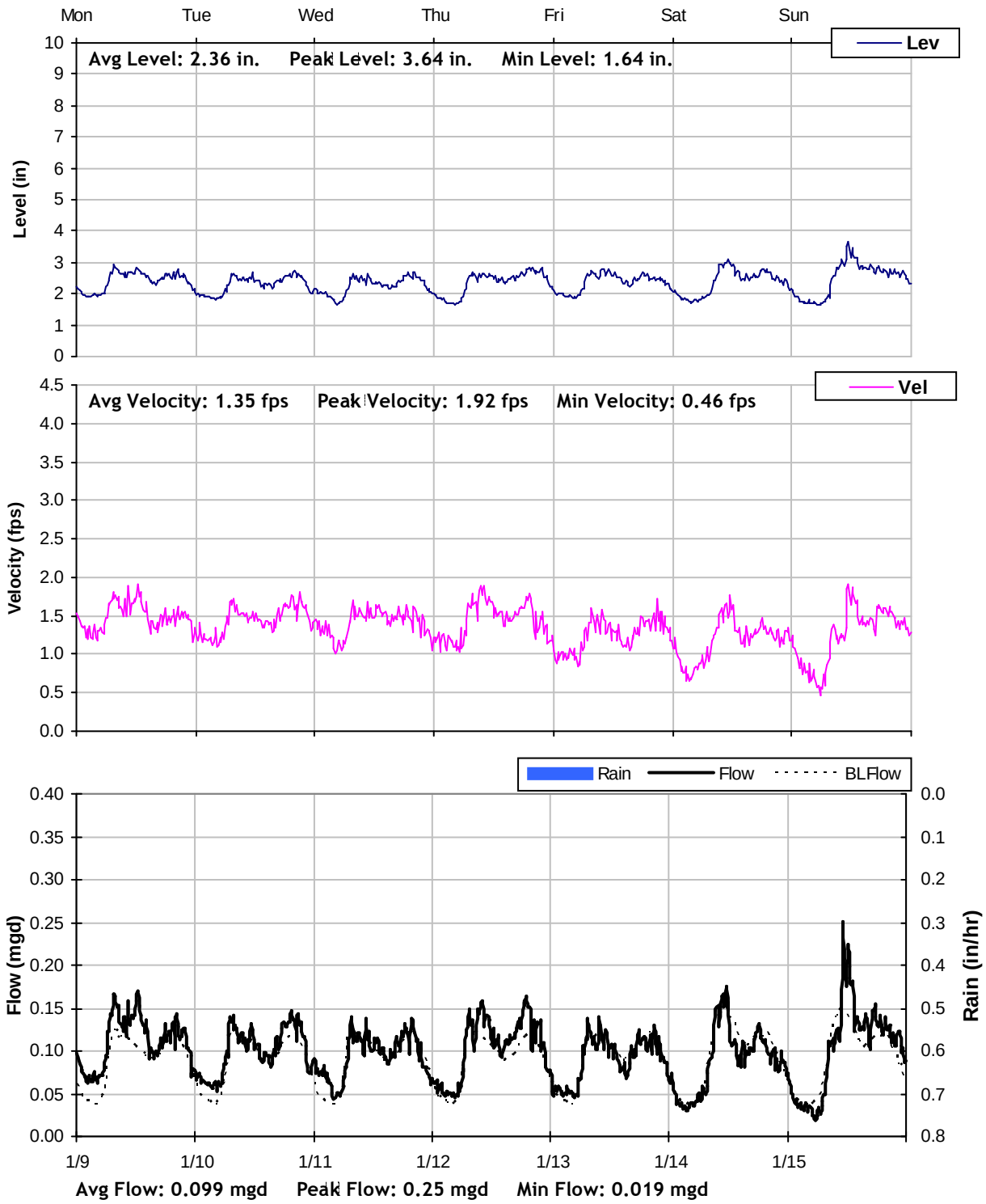


W62

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012

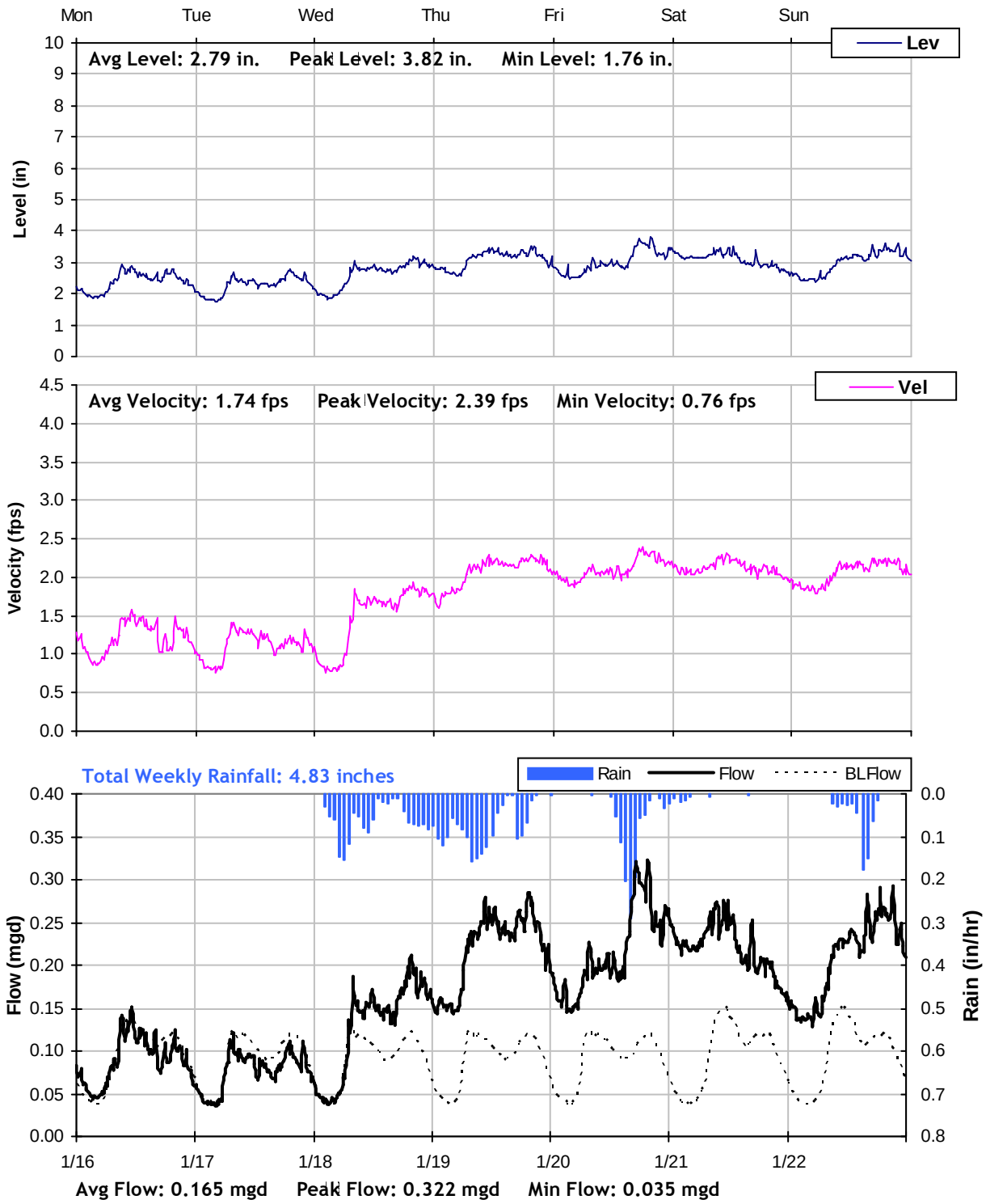


W62
Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



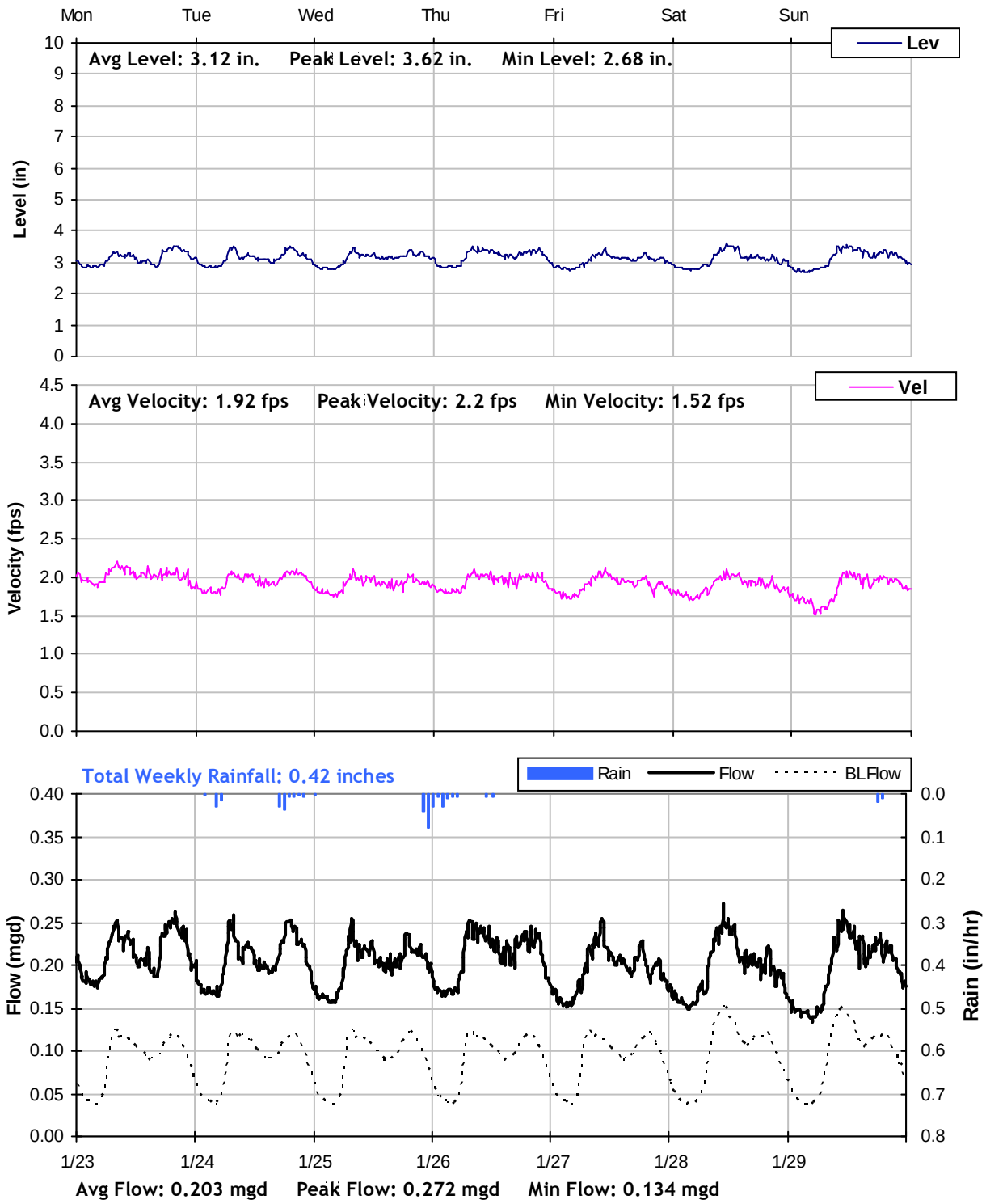
W62

Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012

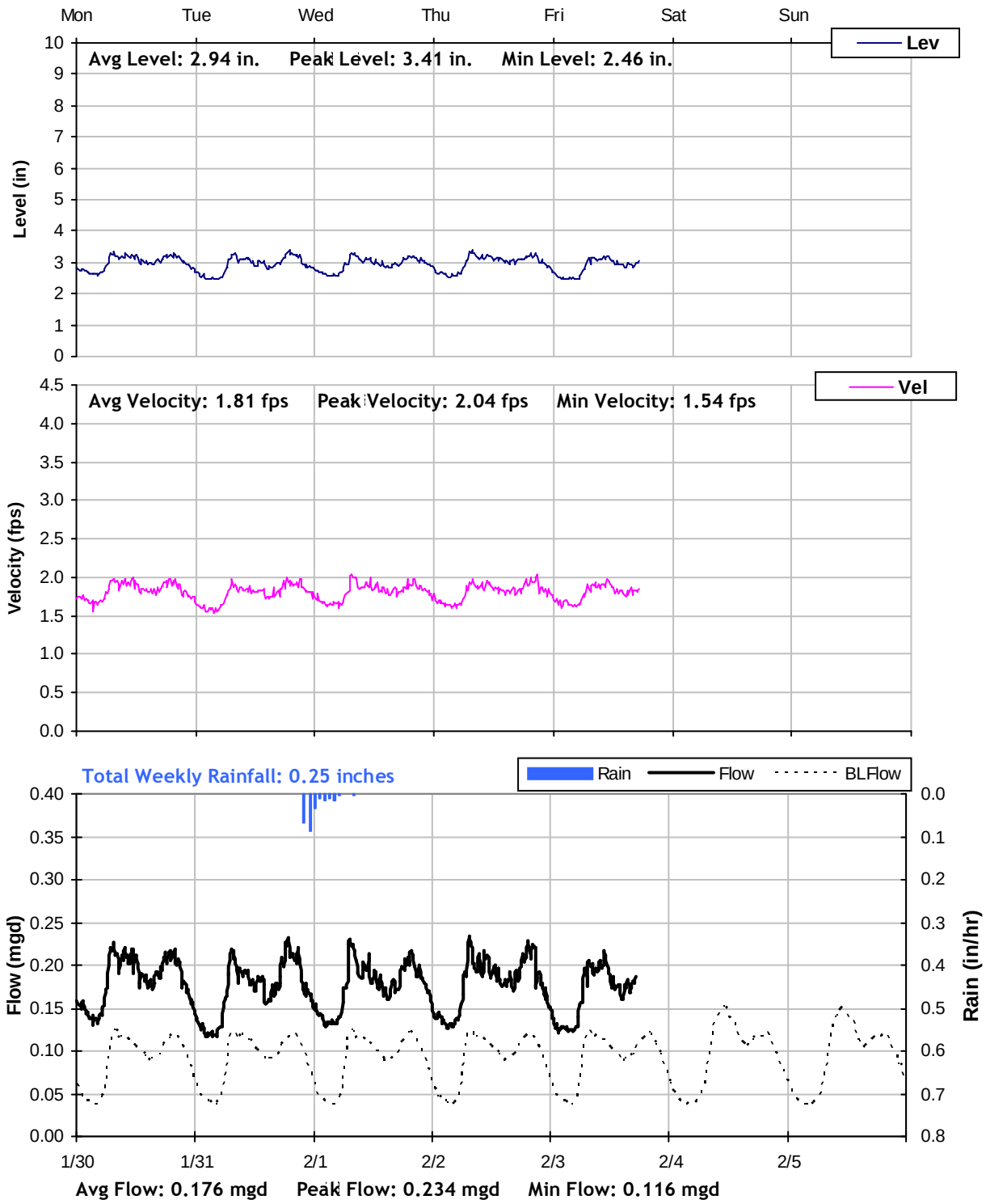


W62

Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



W62
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

Year 2011/2012

Monitoring Site: X115

Location: Private Drive North of South River Road and Darneille Lane

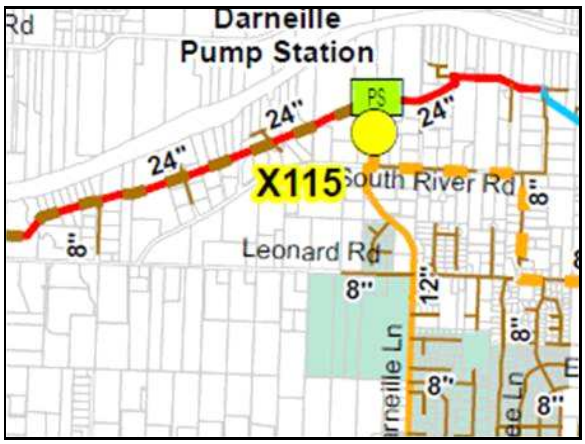
Data Summary Report

Vicinity Map:

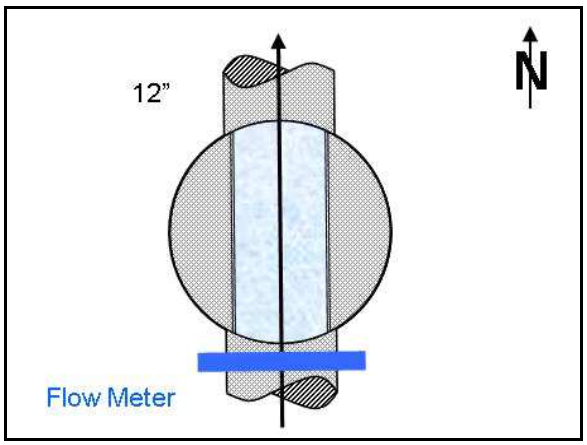
X115
Site Information Report

Location:	Private Drive North of South River Road and Darneille Lane
Coordinates:	123.3884°W, 42.4344°N
Elevation:	899 feet
Diameter:	12 inches
Baseline Flow:	0.143 mgd
Peak Measured Flow:	0.722 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

X115
Additional Site Photos

Effluent Pipe

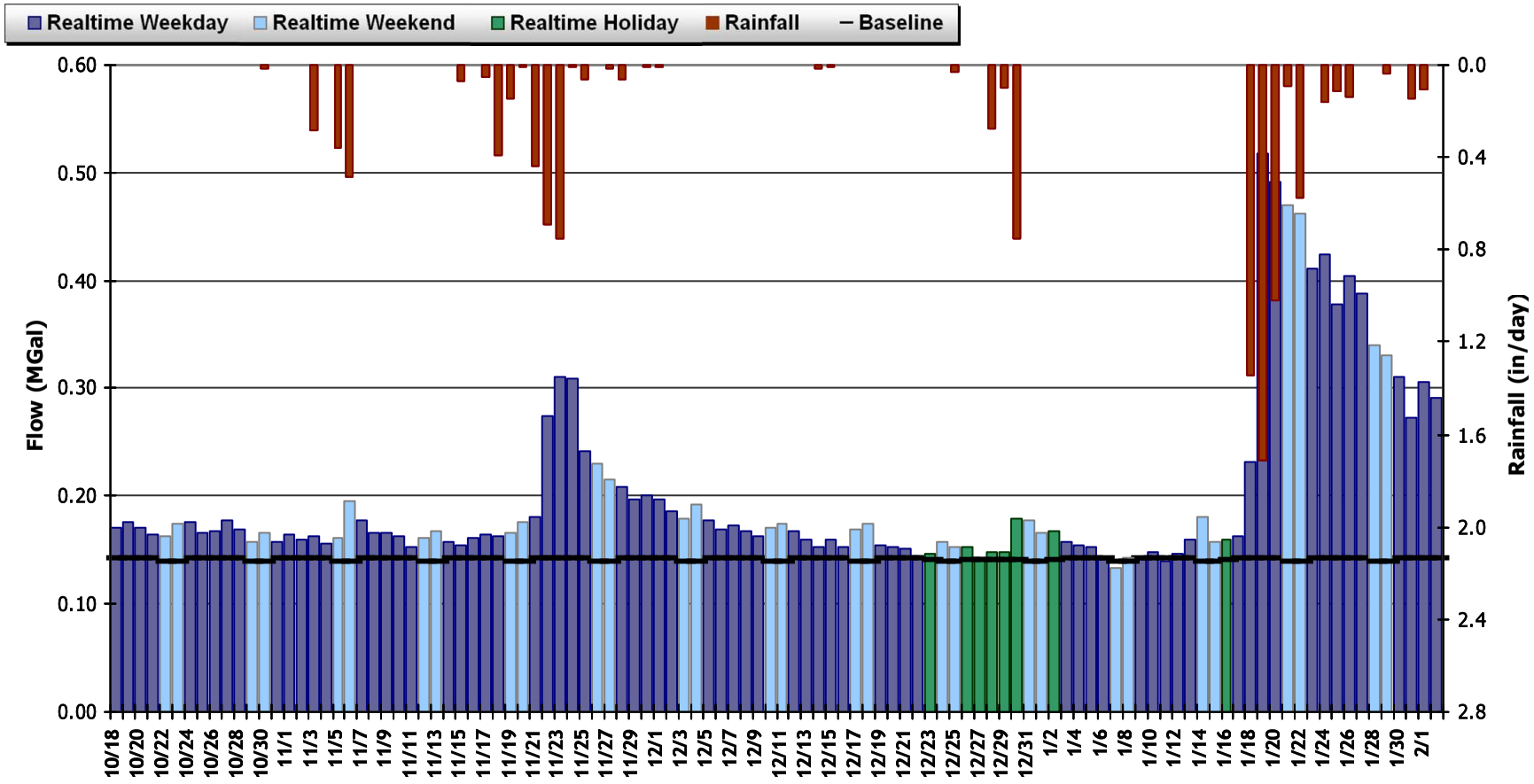
Main Influent Pipe

X115

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.201 MGal Peak Daily Flow: 0.517 MGal Min Daily Flow: 0.134 MGal

Total Period Rainfall: 10.44 inches

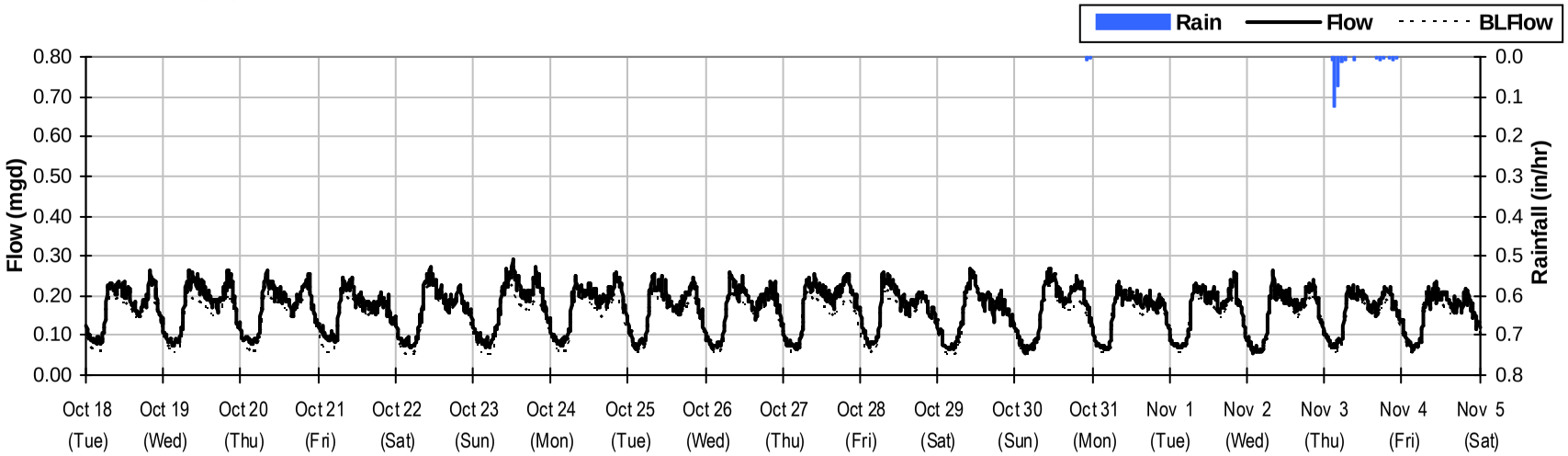


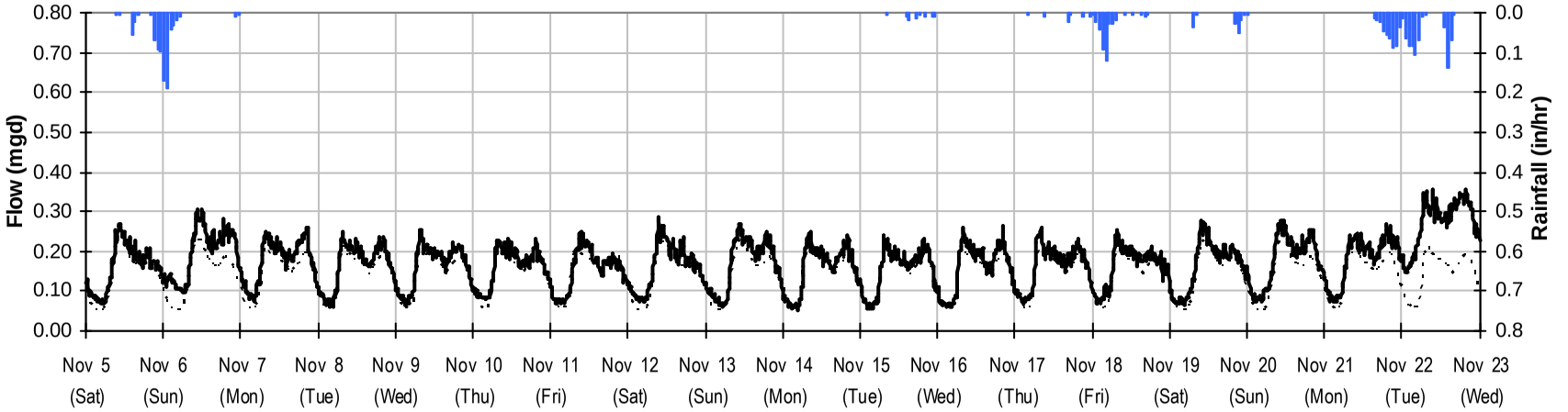
X115

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.17 mgd Peak Flow: 0.357 mgd Min Flow: 0.052 mgd

Total Period Rainfall: 2.92 inches



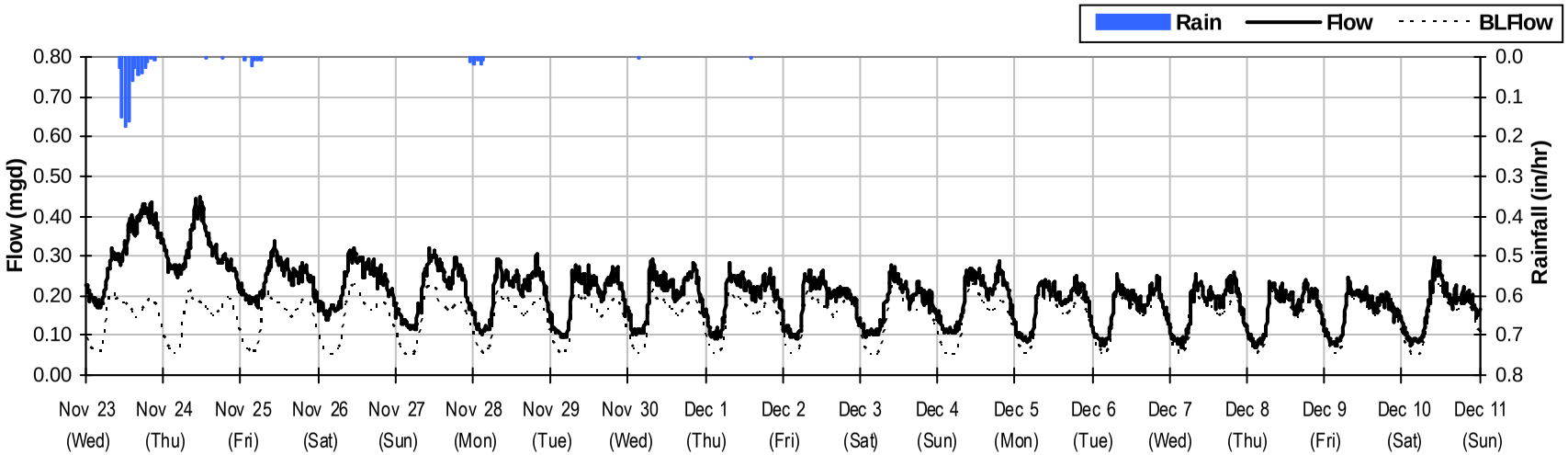


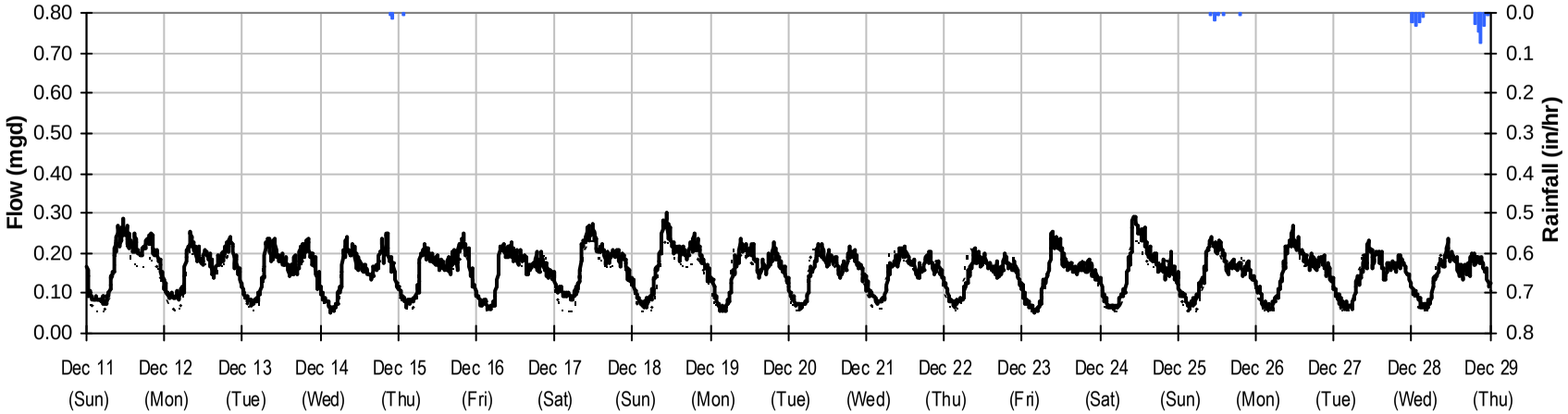
X115

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.181 mgd Peak Flow: 0.448 mgd Min Flow: 0.053 mgd

Total Period Rainfall: 1.23 inches



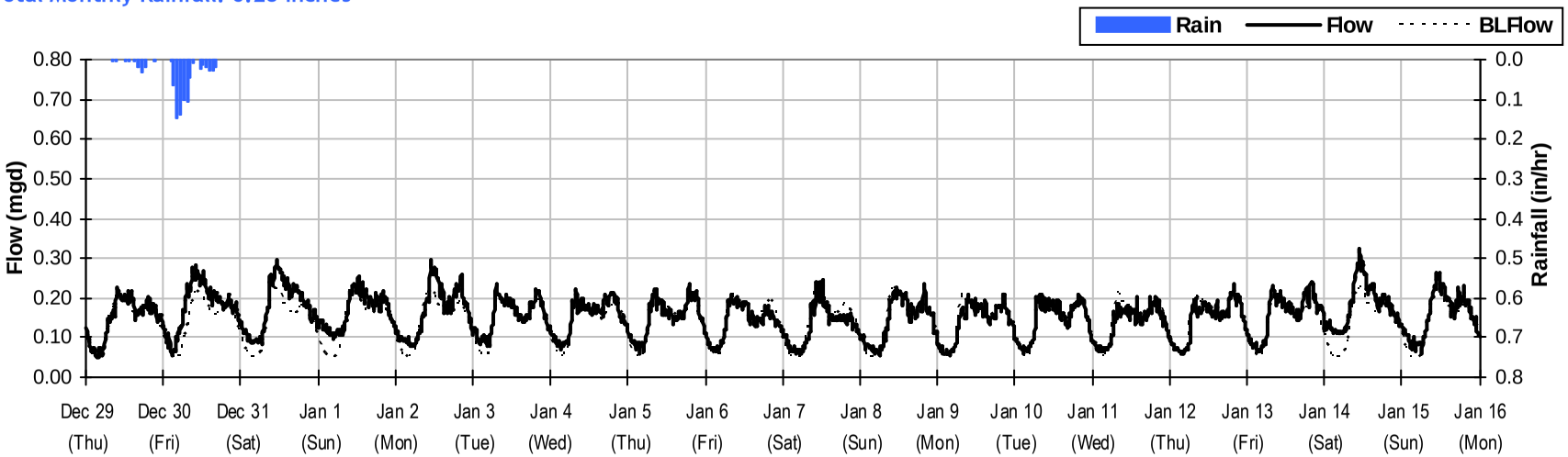


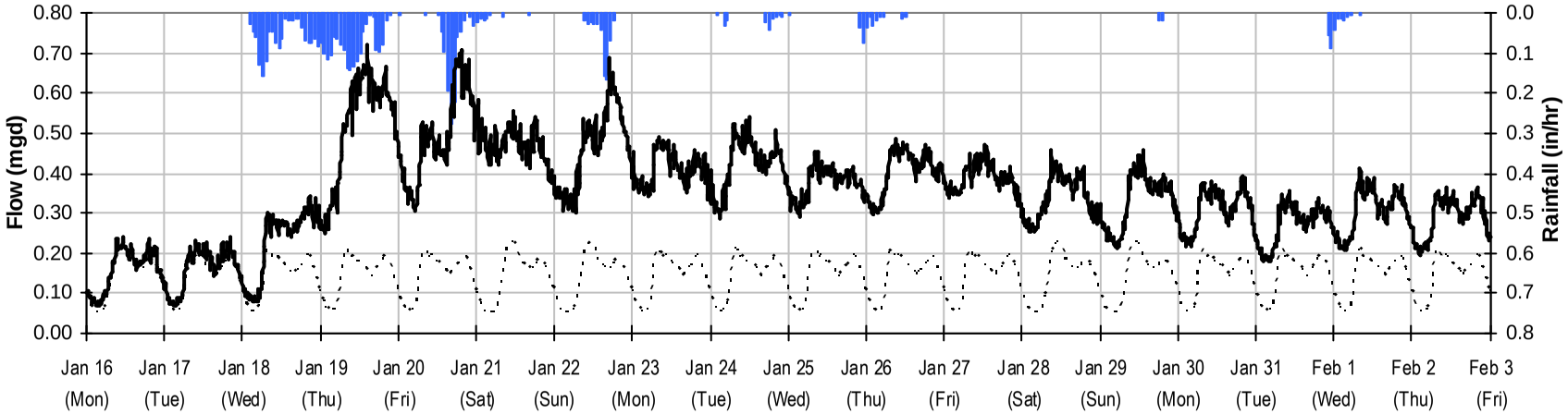
X115

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.25 mgd Peak Flow: 0.72 mgd Min Flow: 0.05 mgd

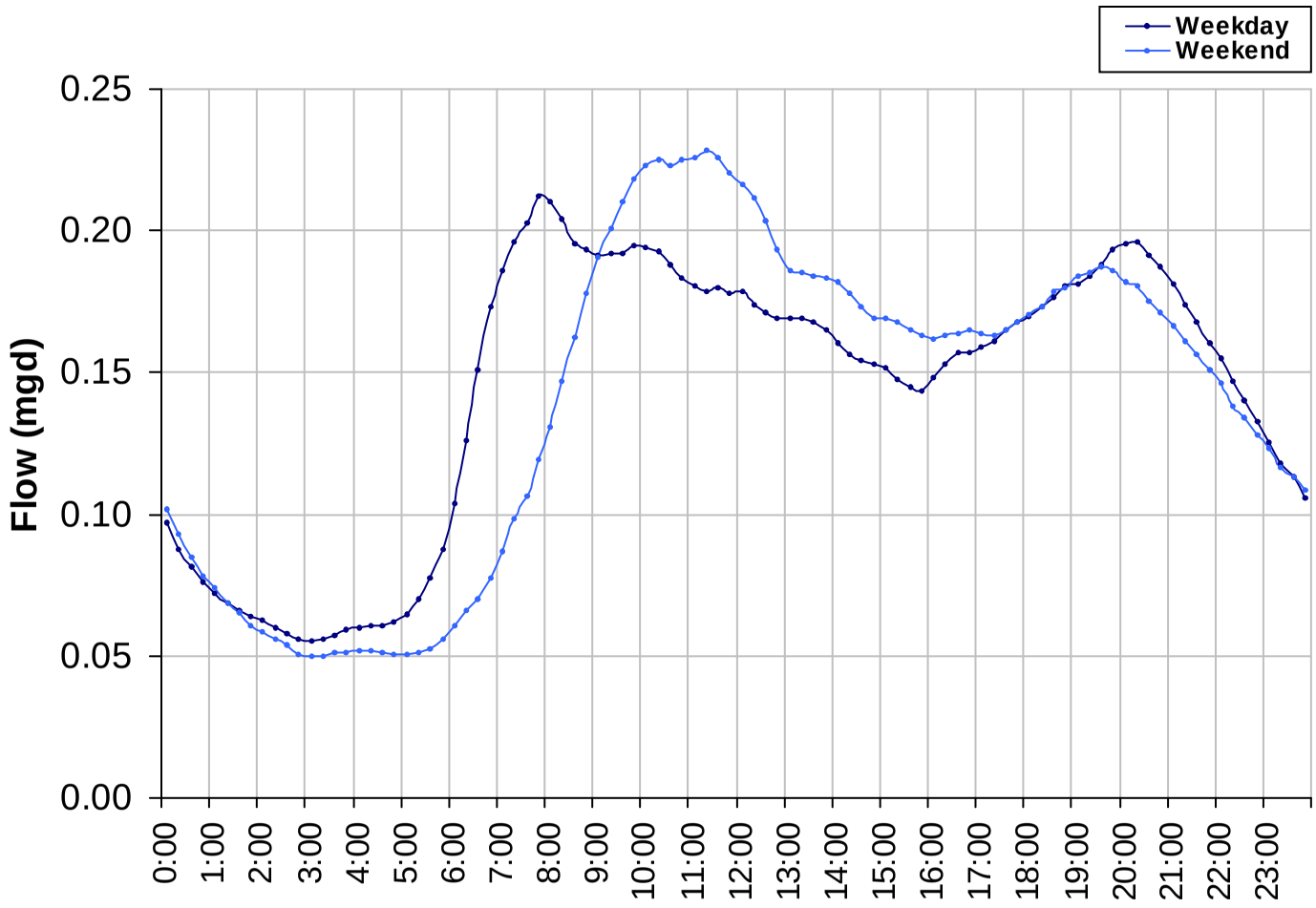
Total Monthly Rainfall: 6.28 inches





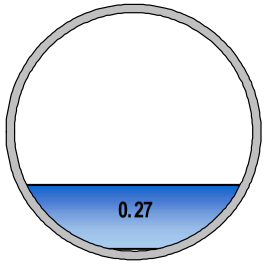
X115

Baseline Flow Hydrographs



Baseline Flow:

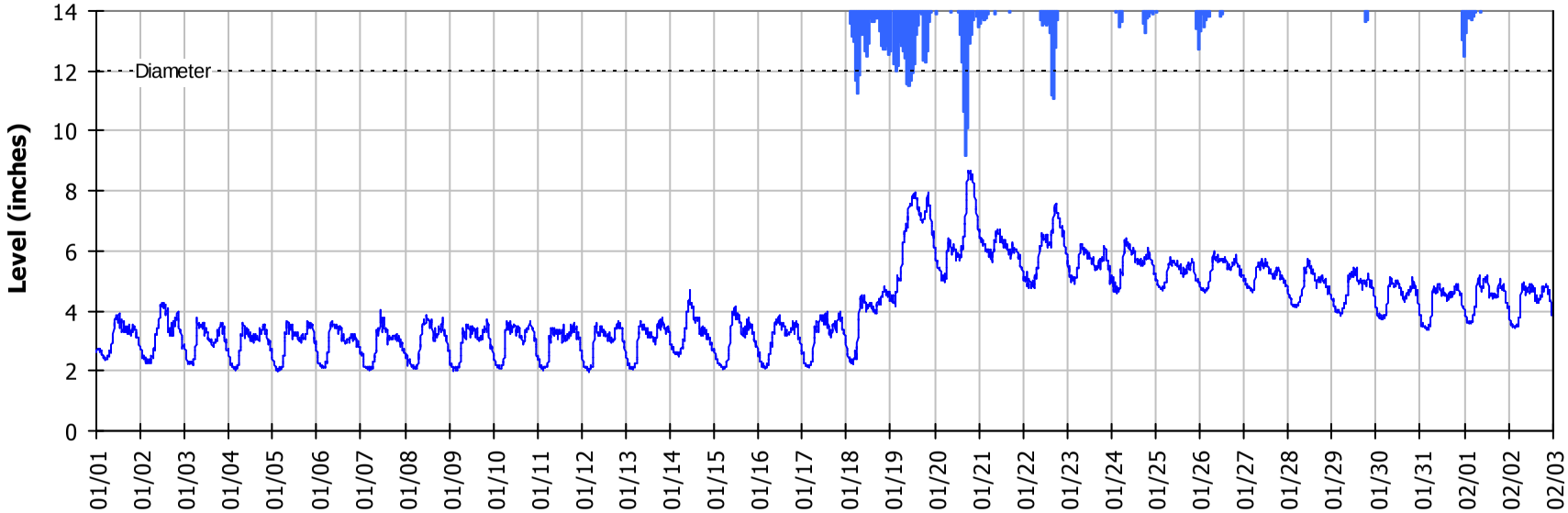
0.143 *mgd*

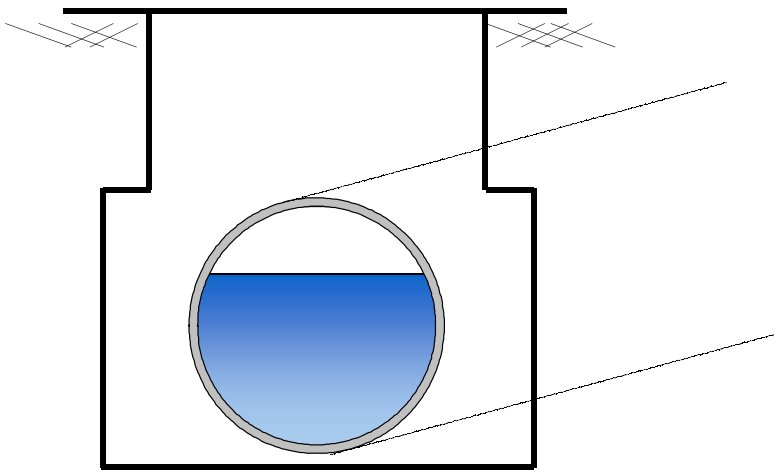


X115

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

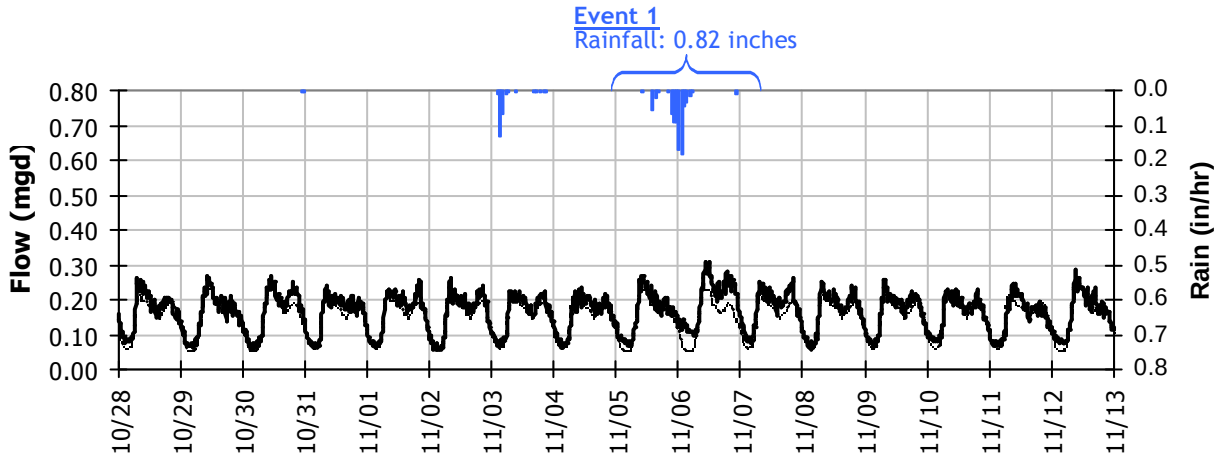




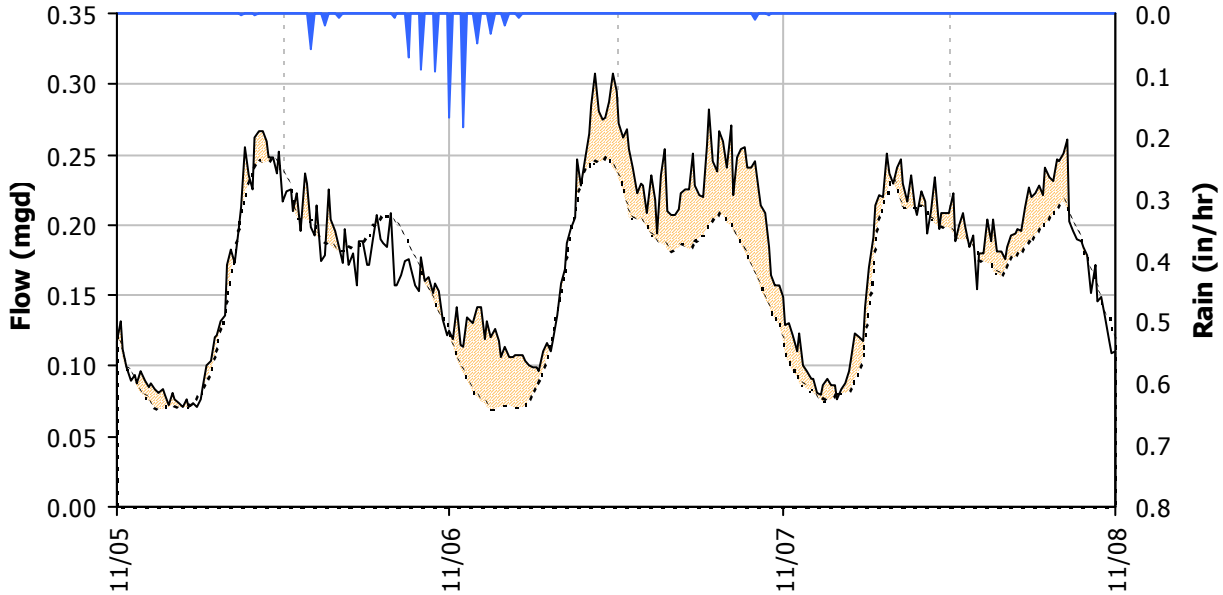
Pipe Diameter:	12	*inches*
Peak Measured Level	8.7	*inches*
Peak d/D Ratio:	0.73	

SITE X115
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

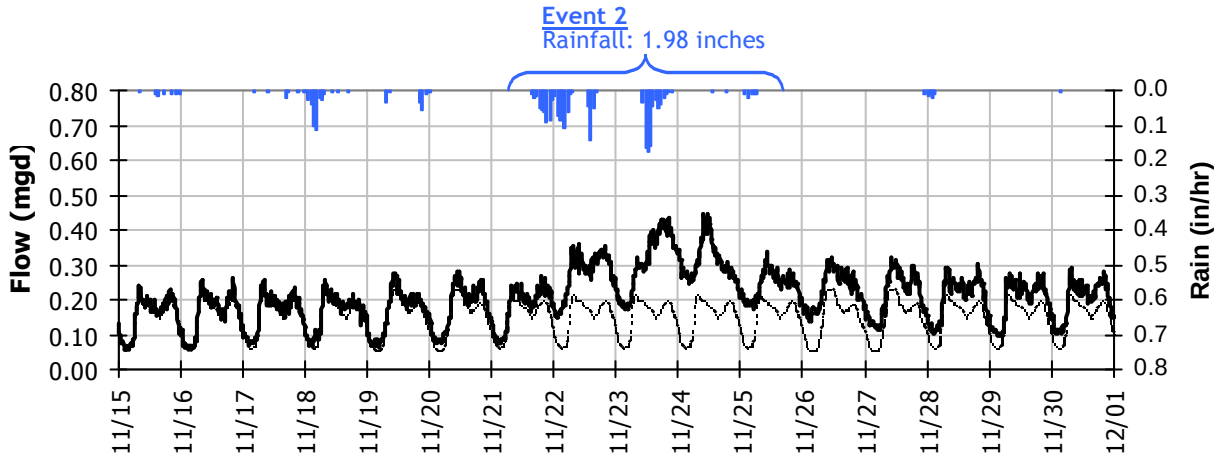


Storm Event I/I Analysis (Rain = 0.82 inches)

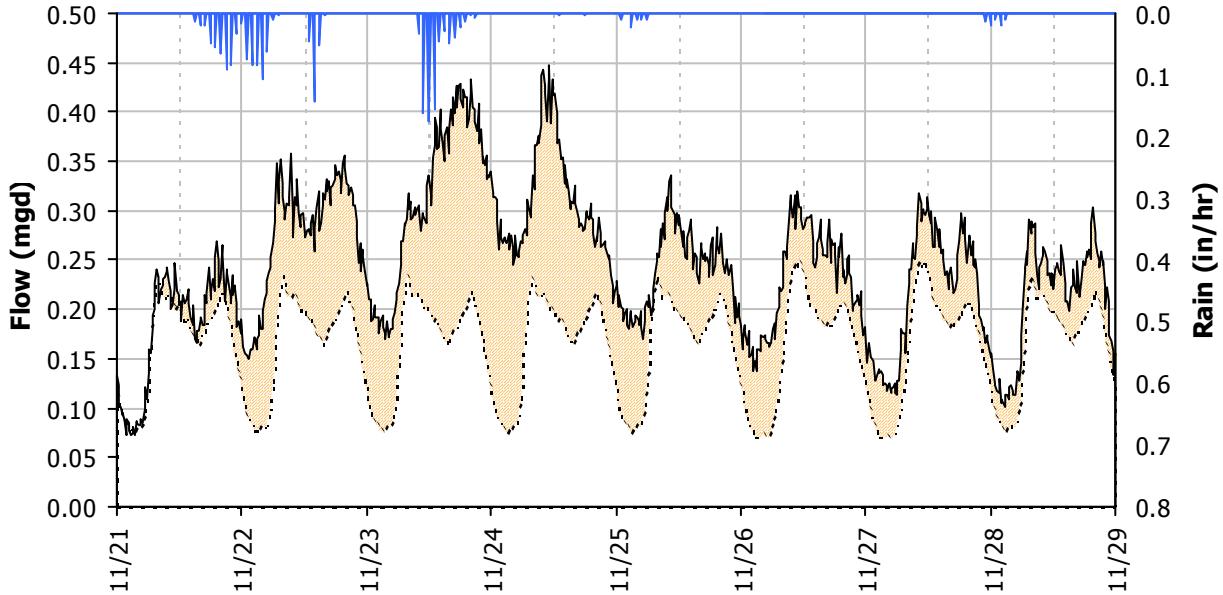
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.31 *mgd*	Peak I/I Rate:	0.10 *mgd*	Infiltration Rate: (11/7/2011)	0.033 *mgd*	Total I/I:	47,000 *gallons*
PF:	2.15	PkI/I:IDM:	1,306 *gpd/IDM*	RDI:IDM:	425 *gpd/IDM*	Total I/I:IDM:	737 *gal/IDM/in*
Peak Level:	4.53 *in*	PkI/I:Acre:	209 *gpd/acre*	RDI:Acre:	68 *gpd/acre*	R-Value:	0.4%
d/D Ratio:	0.38	Pk I/I:ADWF:	0.71	RDI (% of BL):	23%	Total I/I:ADWF:	0.40 *per in-rain*

SITE X115
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

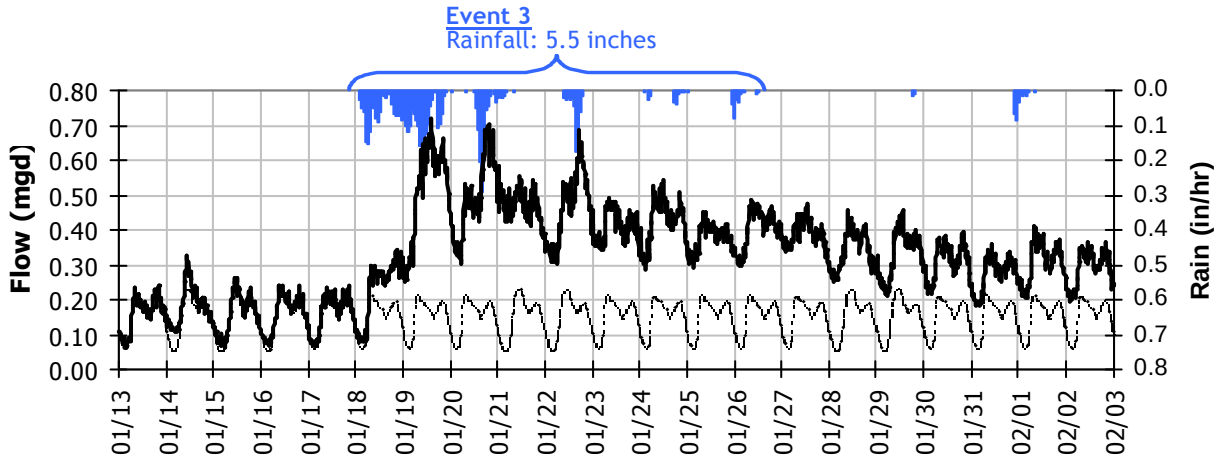


Storm Event I/I Analysis (Rain = 1.98 inches)

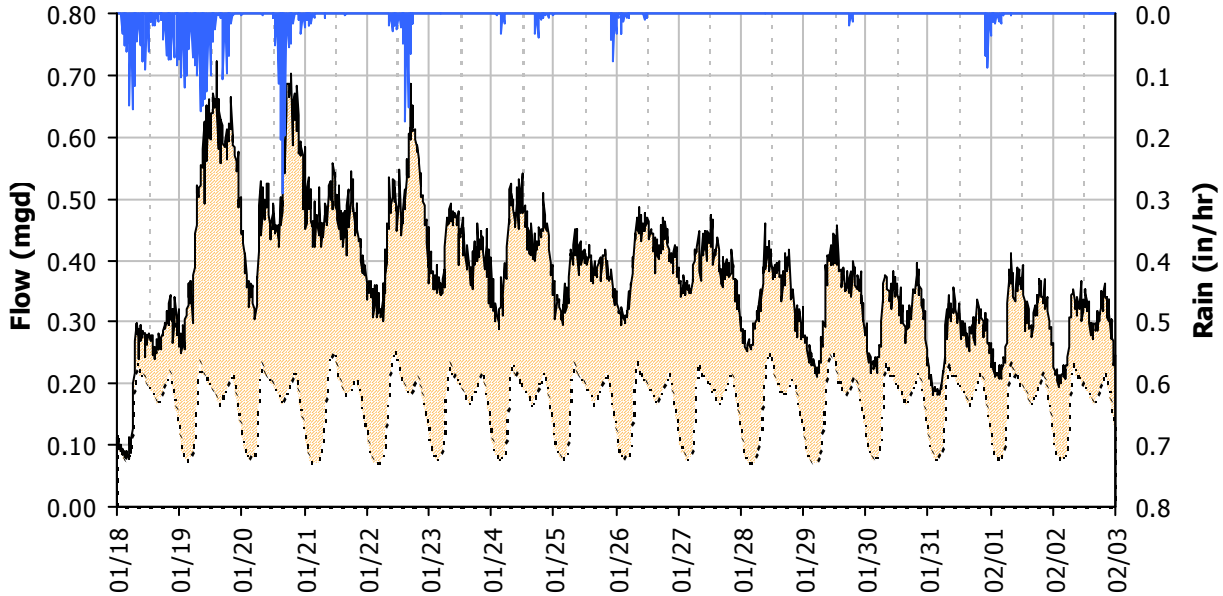
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.45	*mgd*	Peak I/I Rate:	0.27	*mgd*	Infiltration Rate: (11/26/2011)	0.090	*mgd*	Total I/I:	669,000	*gallons*
PF:	3.14		PkI/I:IDM:	3,457	*gpd/IDM*	RDI:IDM:	1,150	*gpd/IDM*	Total I/I:IDM:	4,334	*gal/IDM/in*
Peak Level:	5.89	*in*	PkI/I:Acre:	553	*gpd/acre*	RDI:Acre:	184	*gpd/acre*	R-Value:	2.6%	
d/D Ratio:	0.49		Pk I/I:ADWF:	1.89		RDI (% of BL):	64%		Total I/I:ADWF:	2.37	*per in-rain*

SITE X115
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



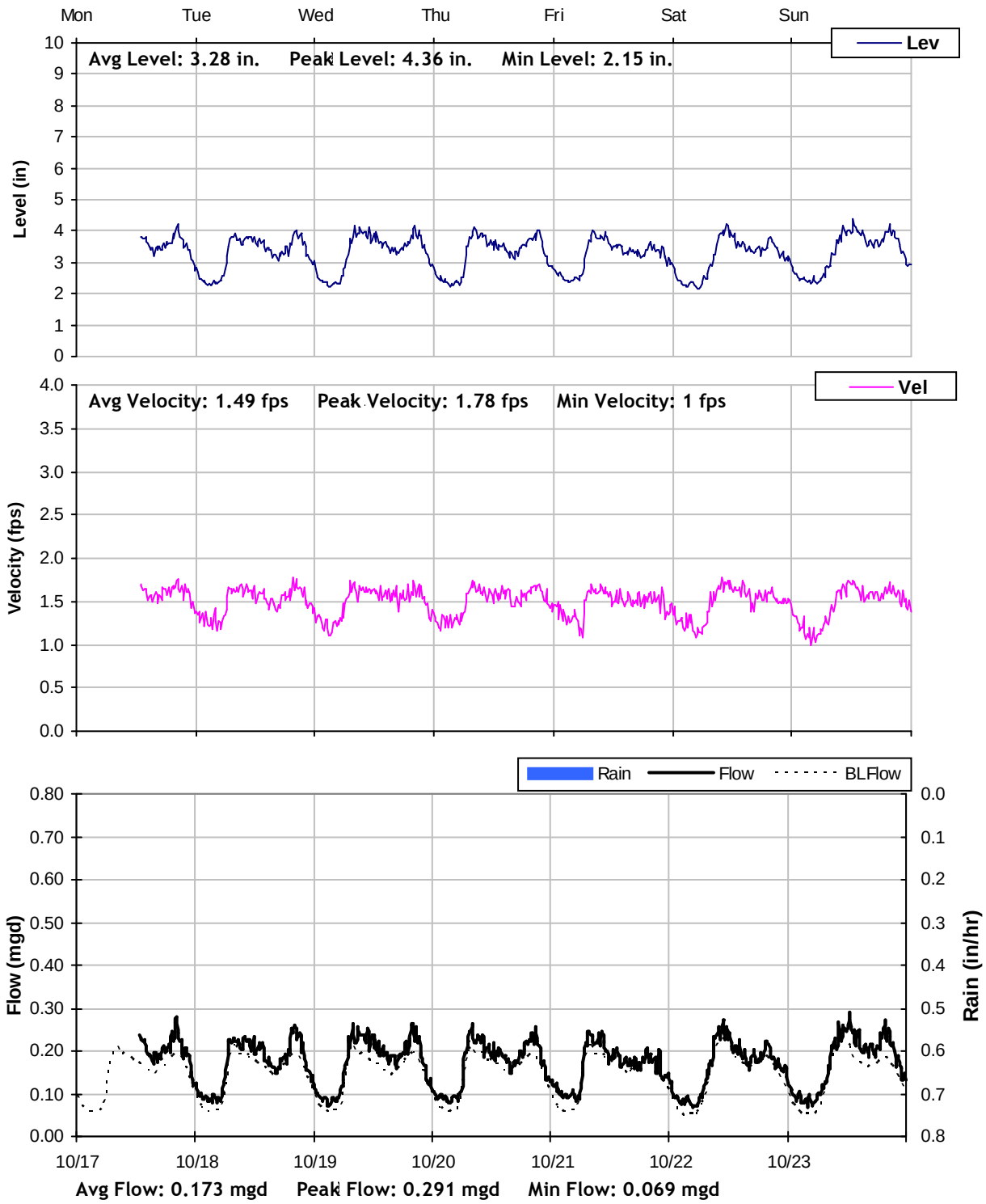
Event 3 Detail Graph



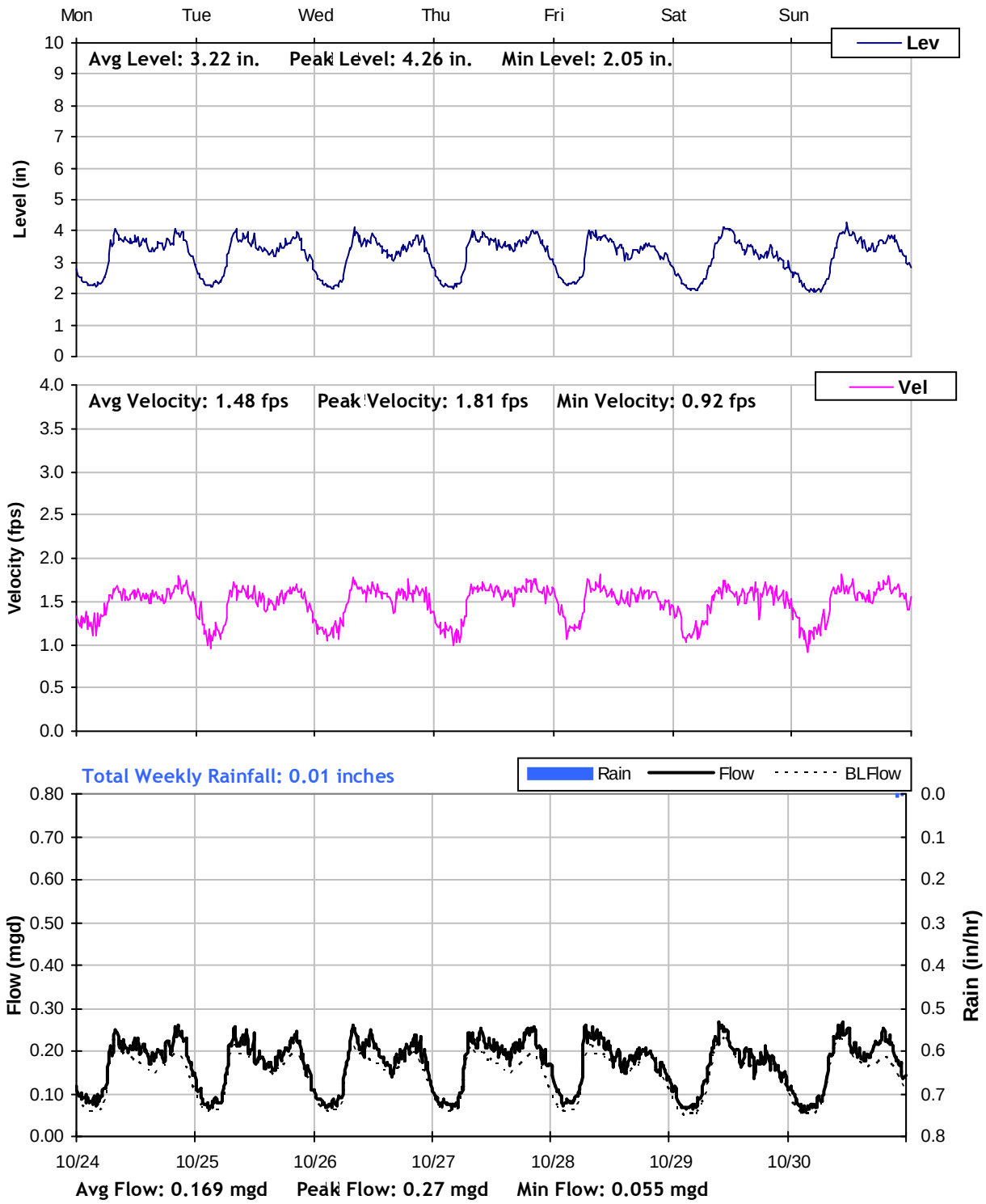
Storm Event I/I Analysis (Rain = 5.5 inches)

Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.72 *mgd*	Peak I/I Rate:	0.57 *mgd*	Infiltration Rate: (1/30/2012)	0.166 *mgd*	Total I/I:	3,422,000 *gallons*
PF:	5.06	PkI/I:IDM:	7,287 *gpd/IDM*	RDI:IDM:	2,137 *gpd/IDM*	Total I/I:IDM:	7,993 *gal/IDM/in*
Peak Level:	8.70 *in*	PkI/I:Acre:	1,166 *gpd/acre*	RDI:Acre:	342 *gpd/acre*	R-Value:	4.7%
d/D Ratio:	0.73	Pk I/I:ADWF:	3.98	RDI (% of BL):	116%	Total I/I:ADWF:	4.36 *per in-rain*

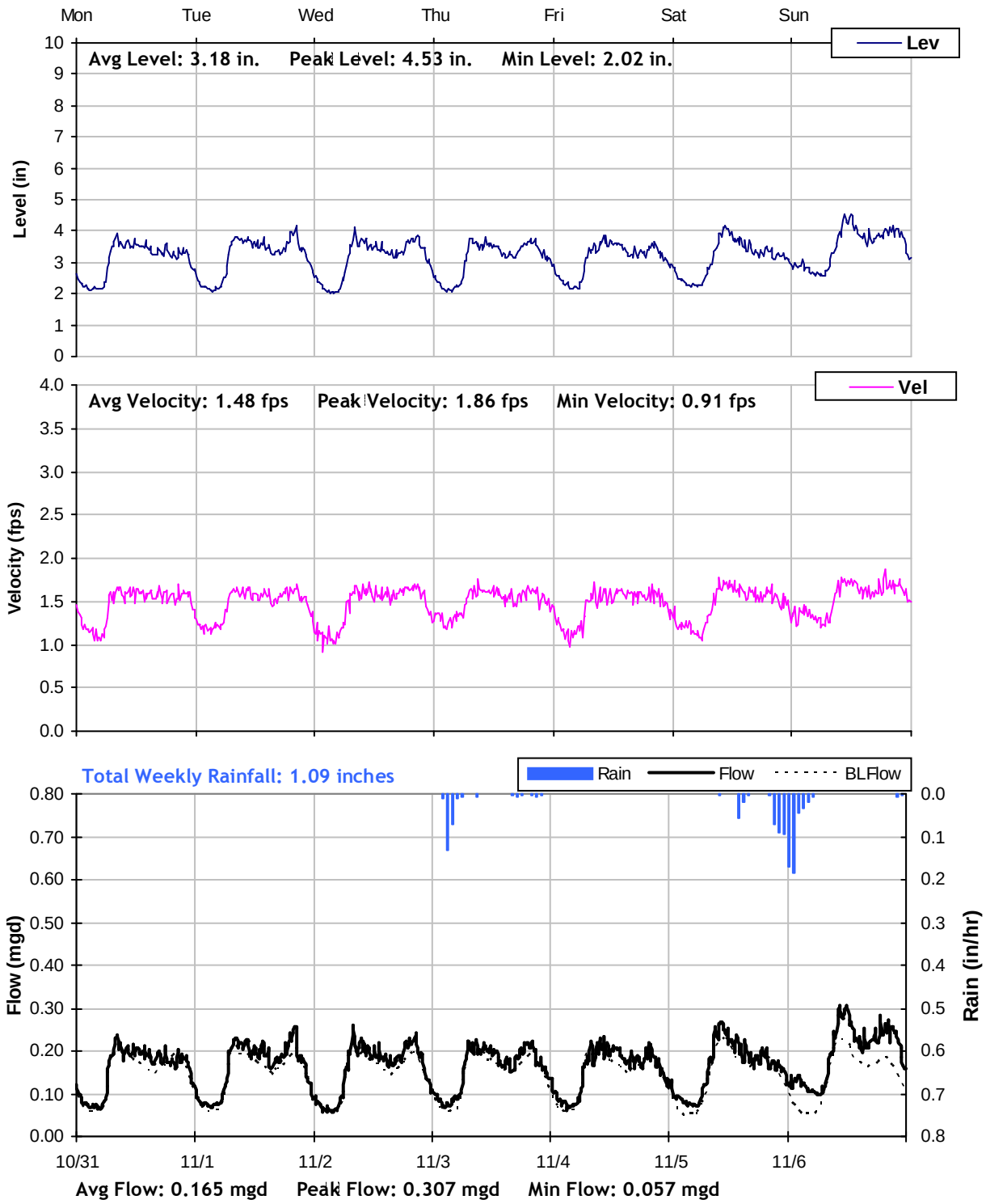
X115
Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



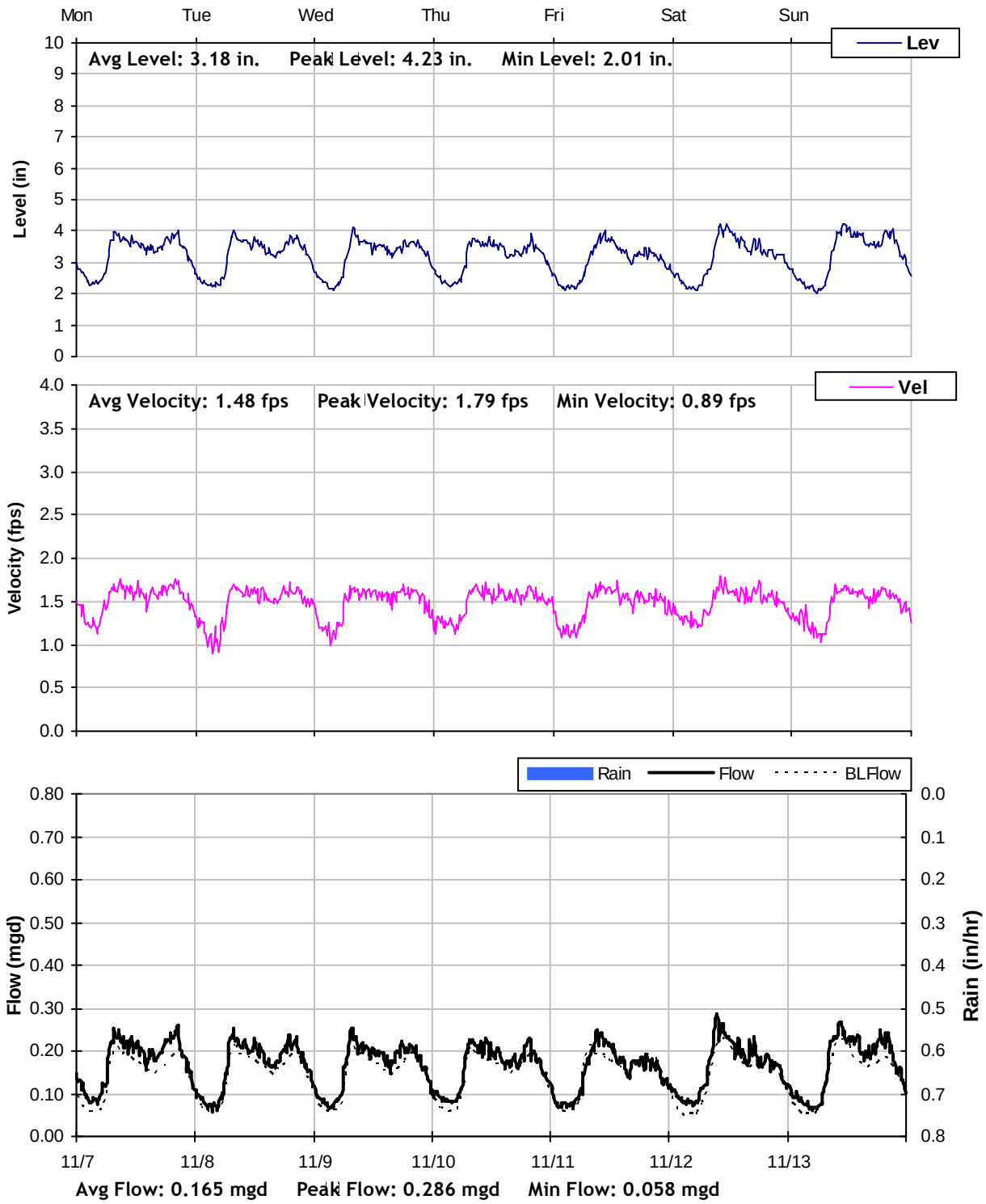
X115
Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



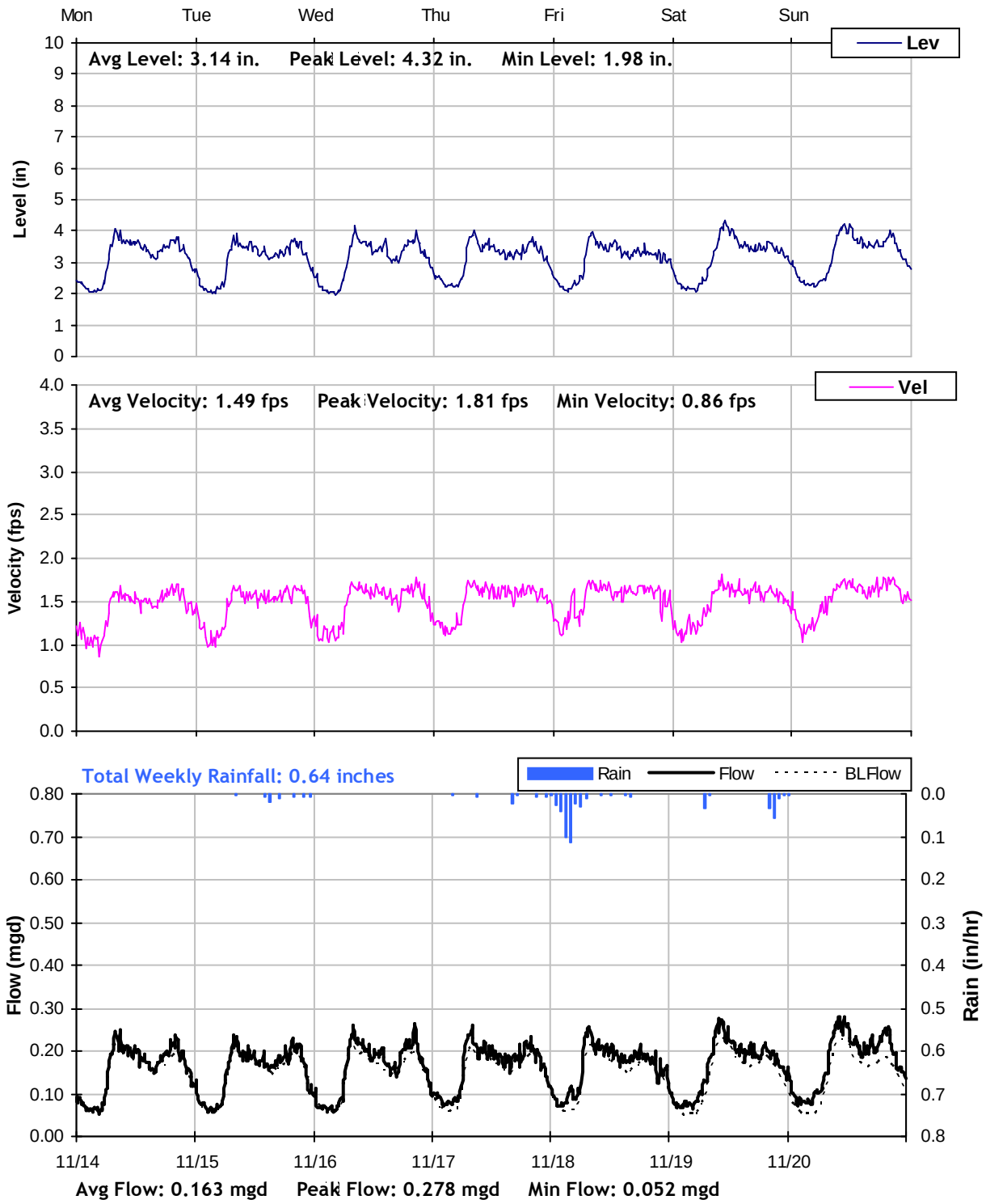
X115
Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



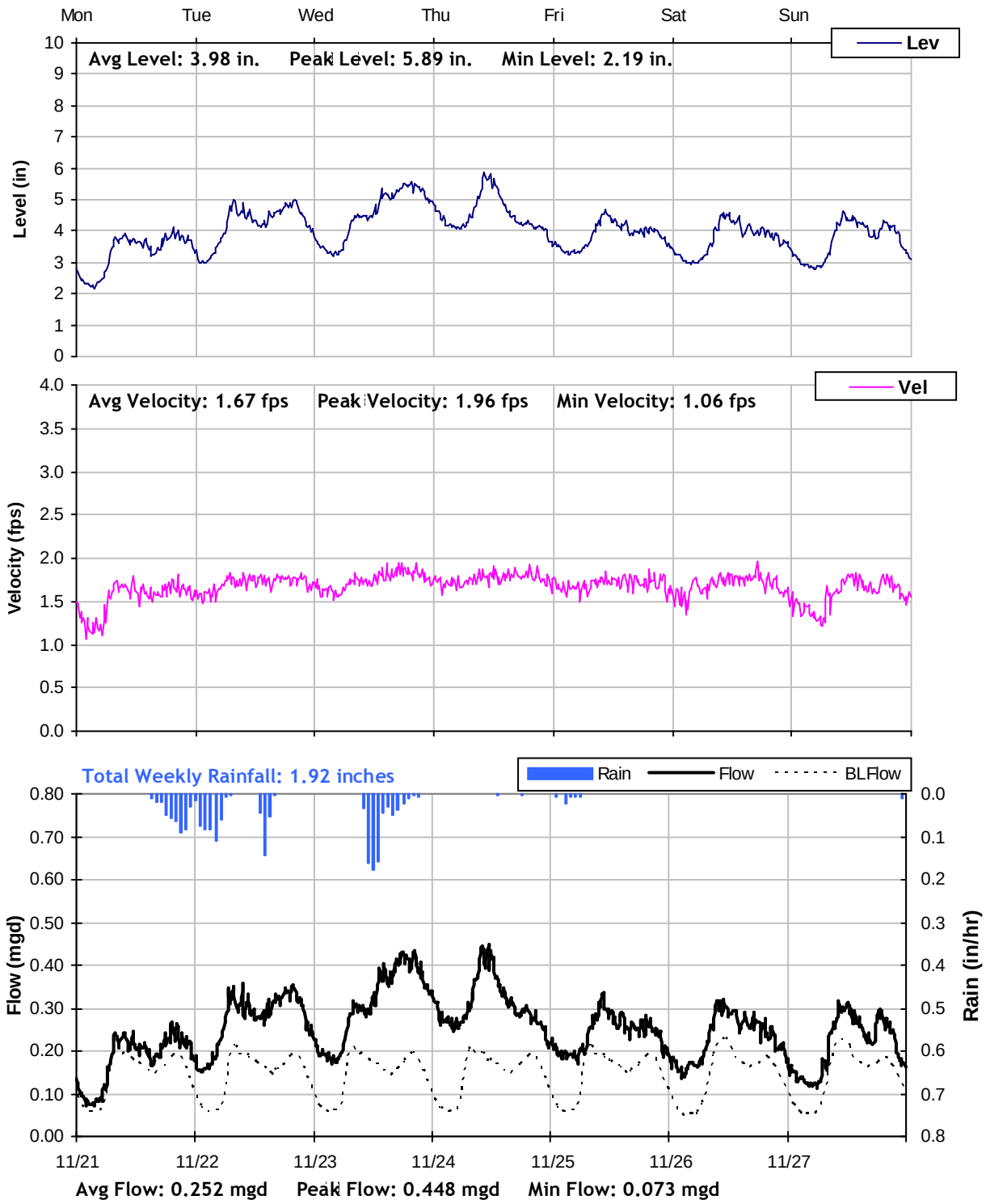
X115
Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



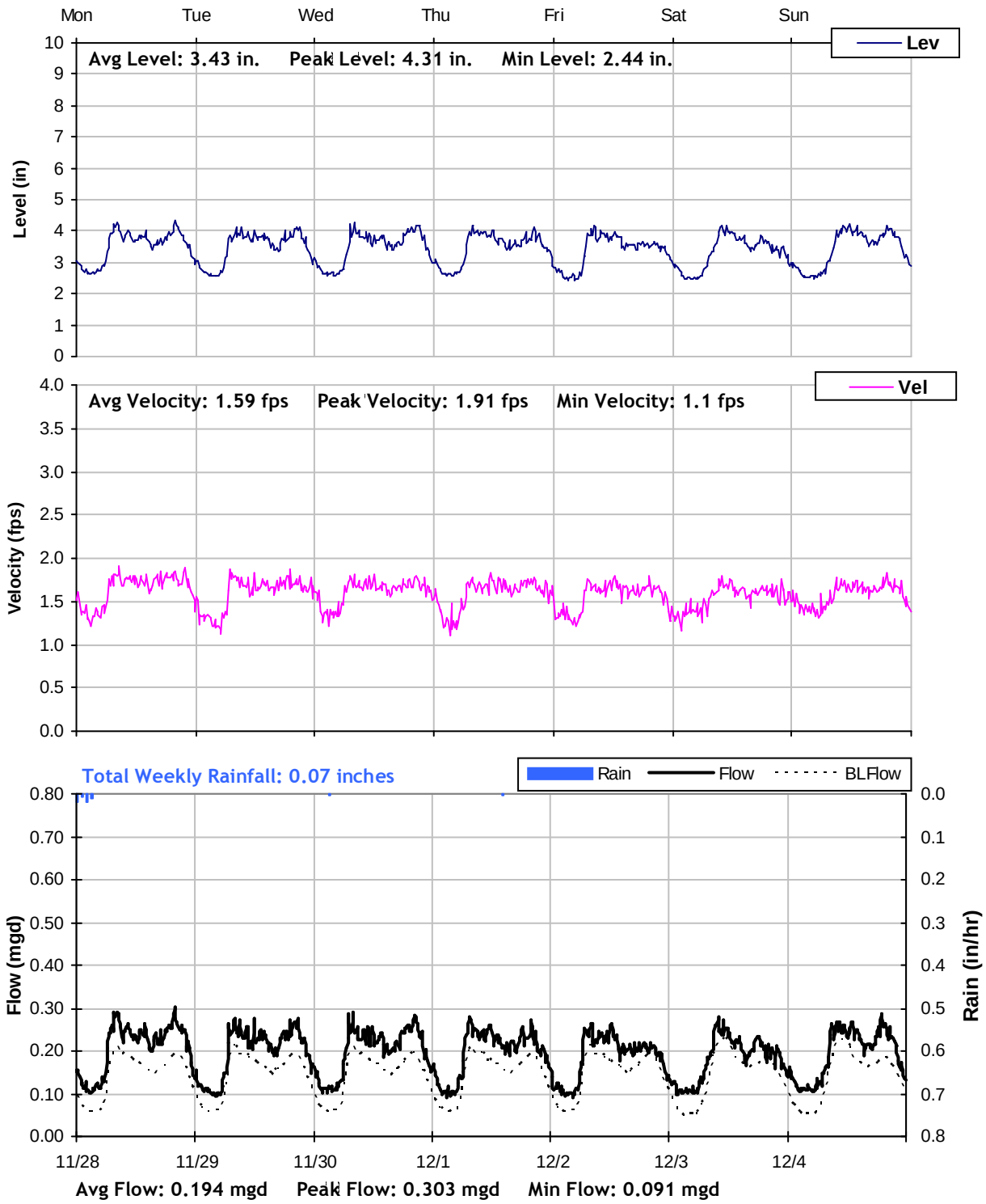
X115
Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



X115
Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



X115
Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



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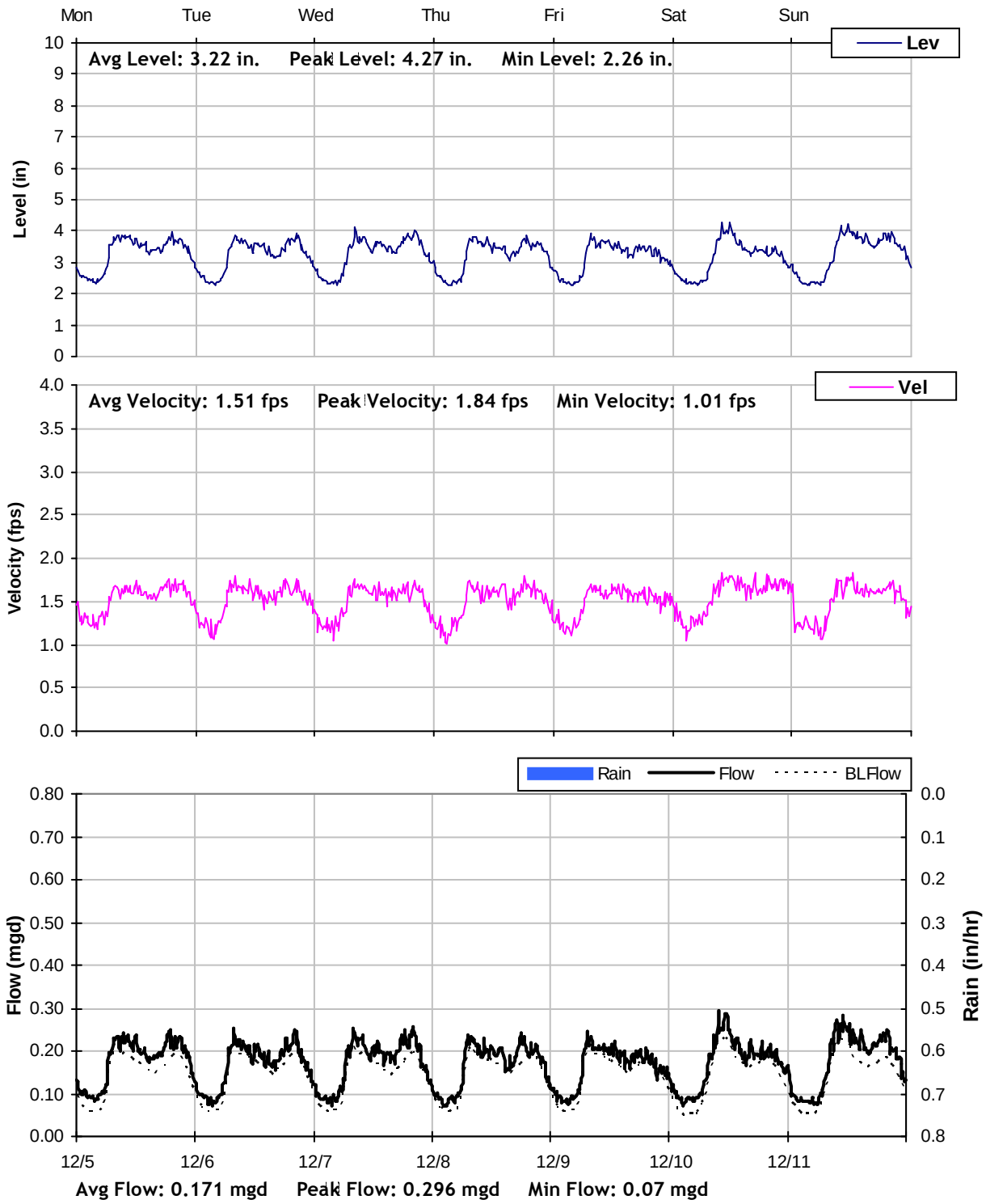
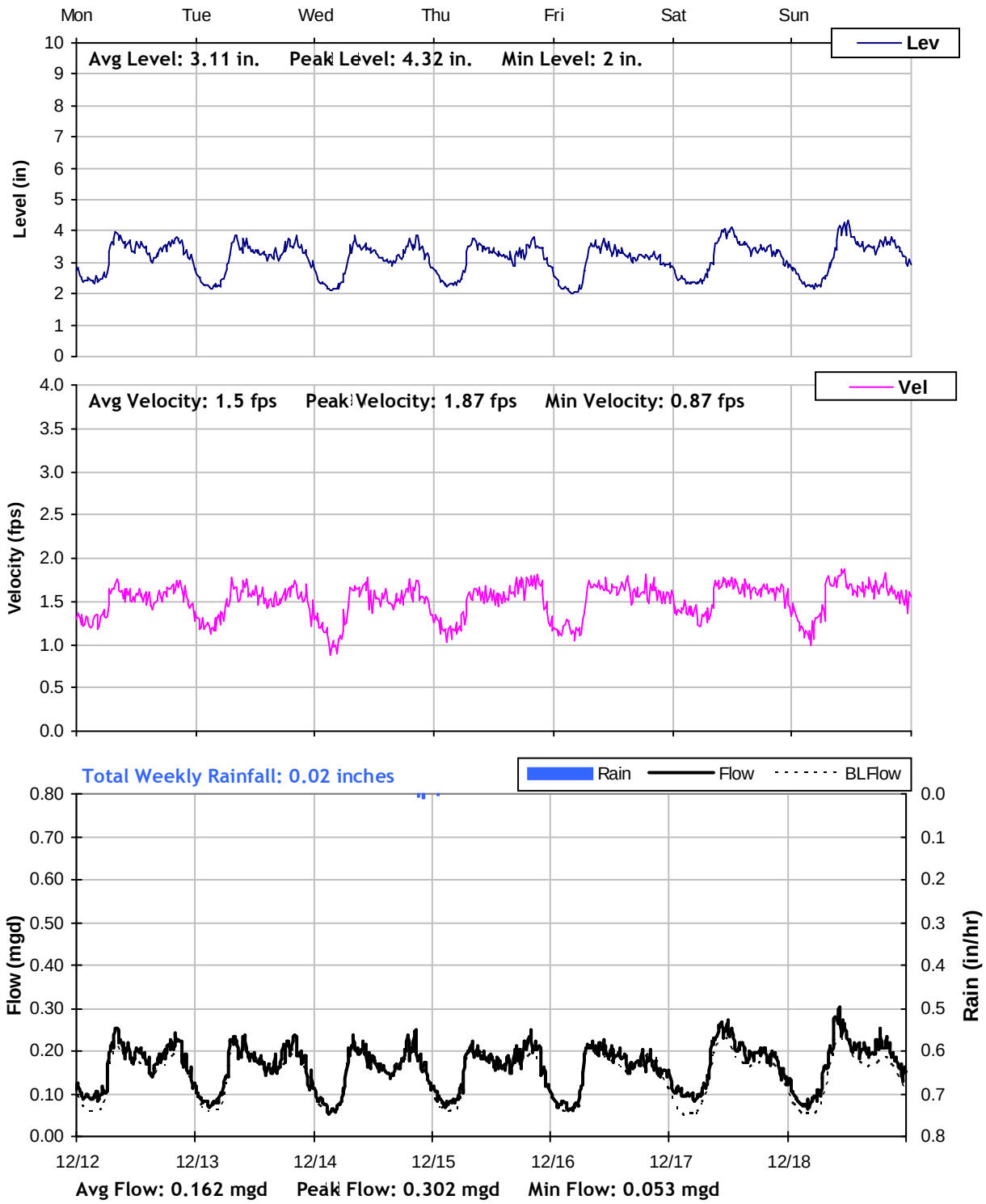
Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



X115
Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



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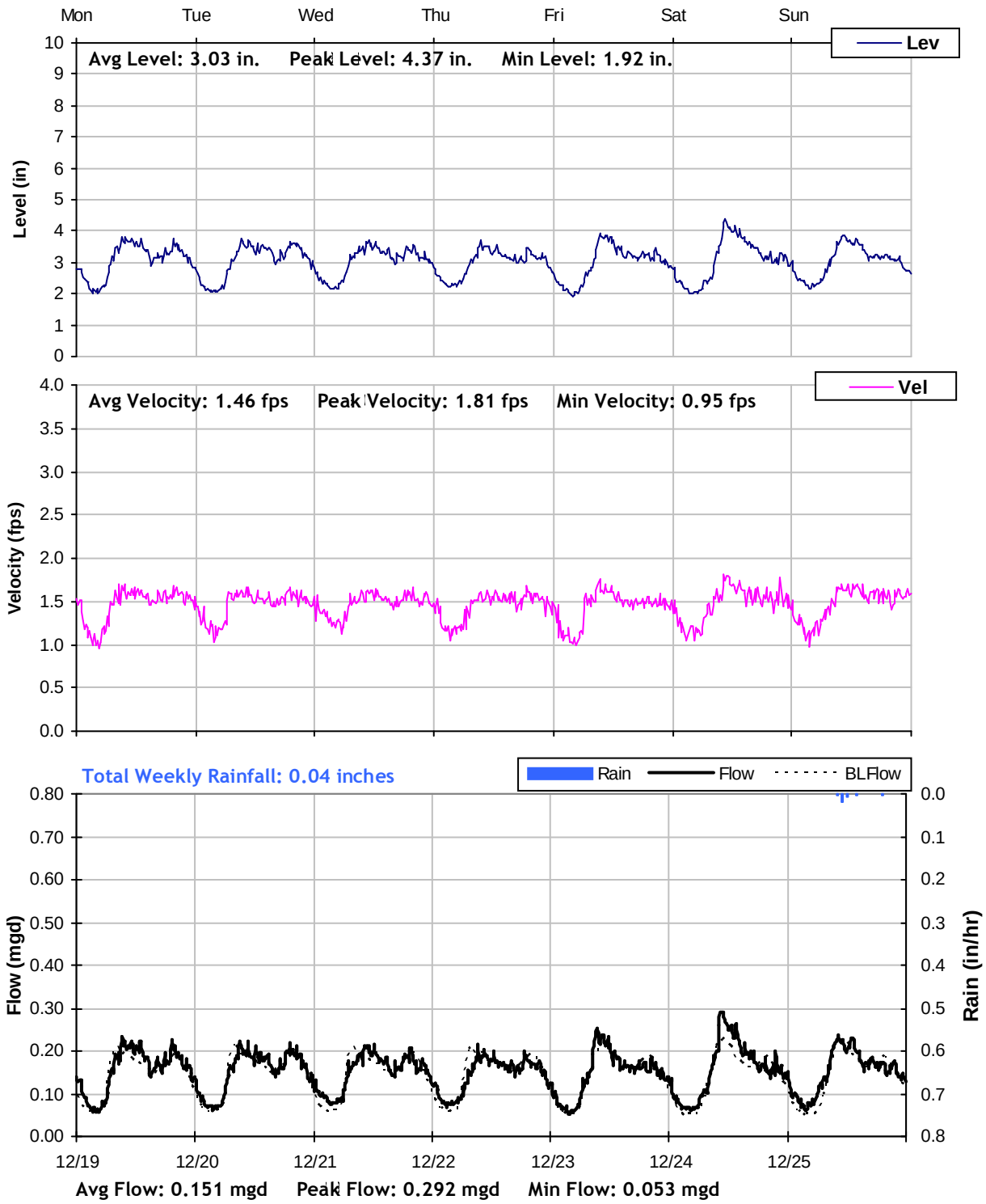
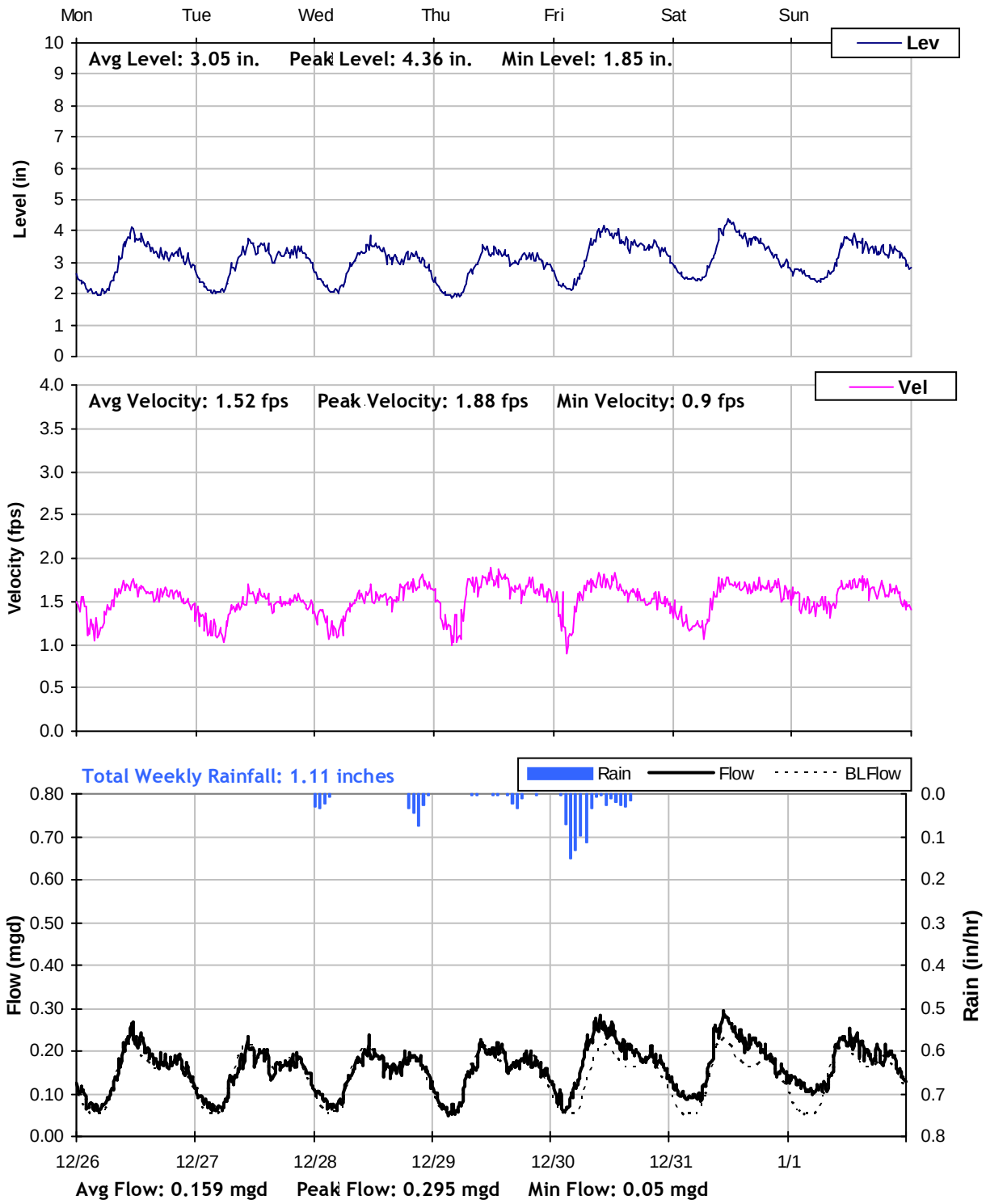
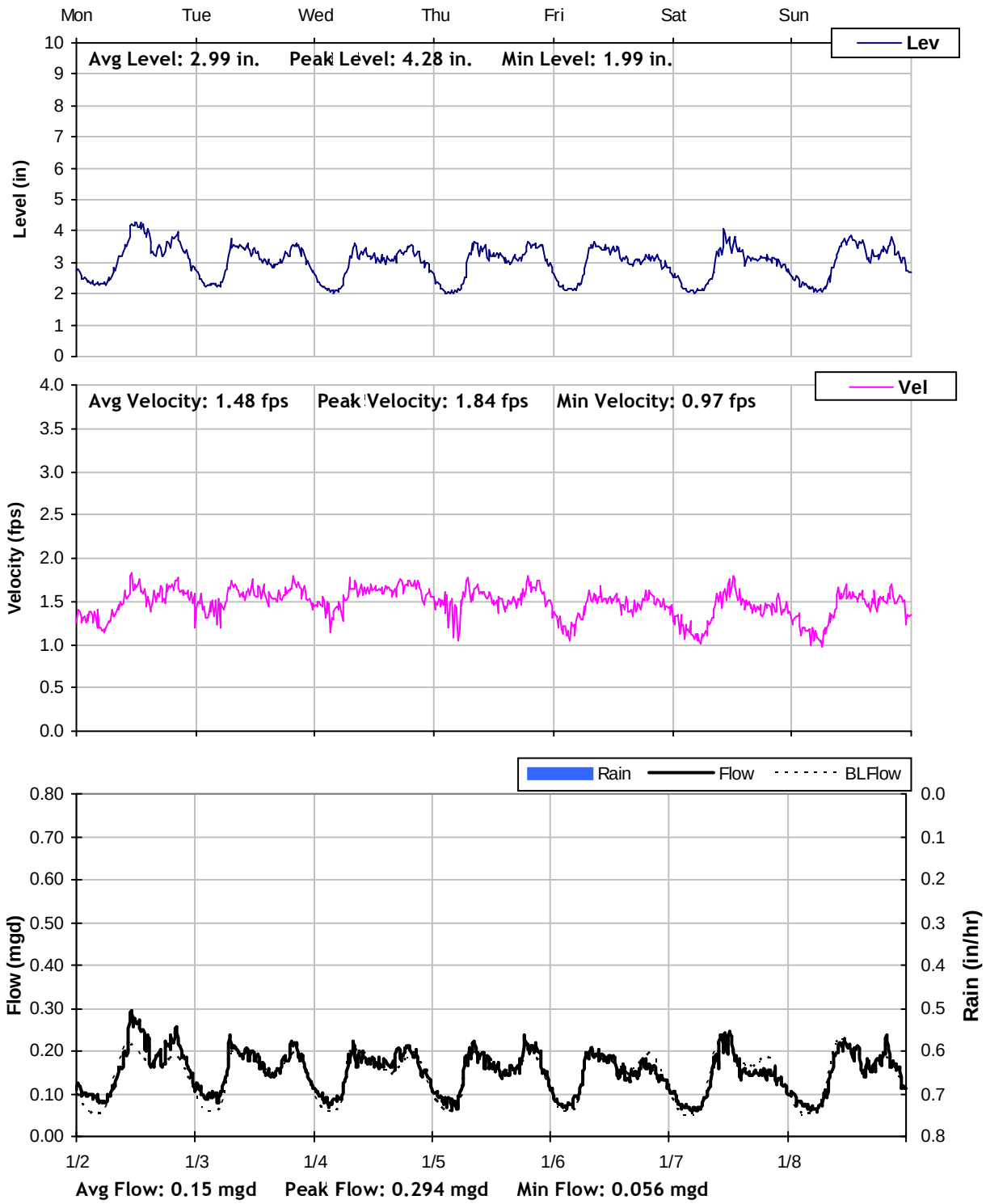
Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



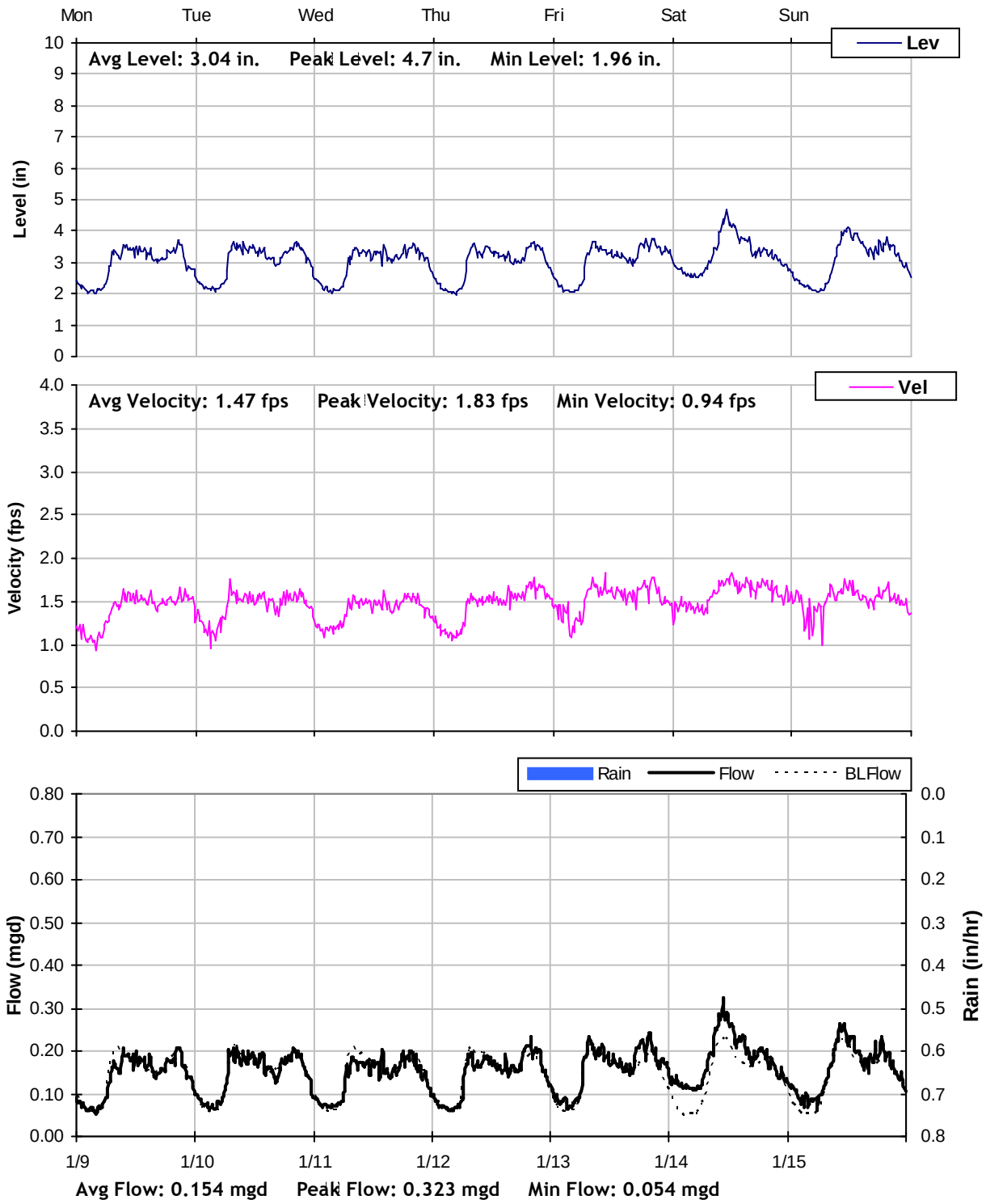
X115
Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



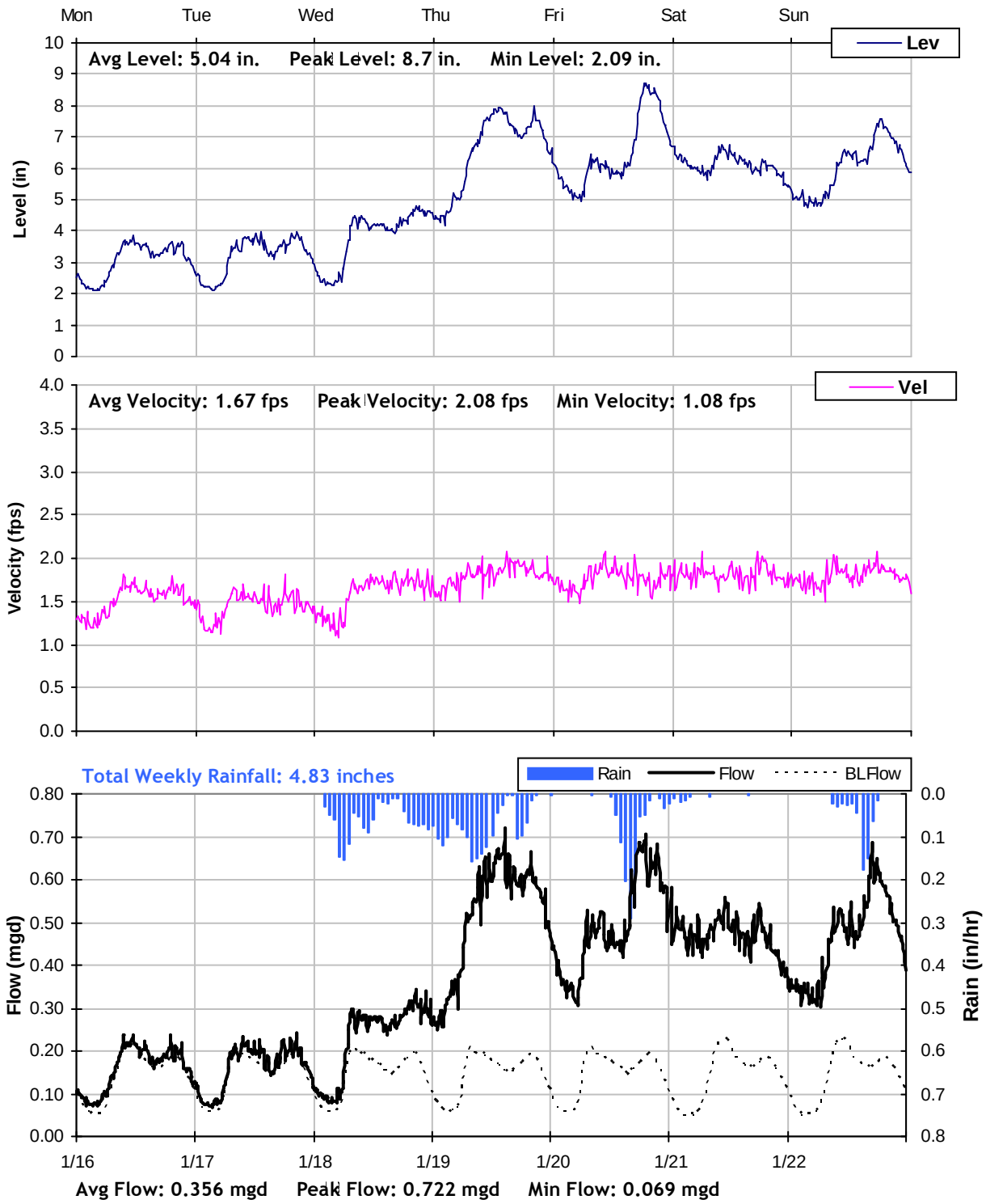
X115
Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



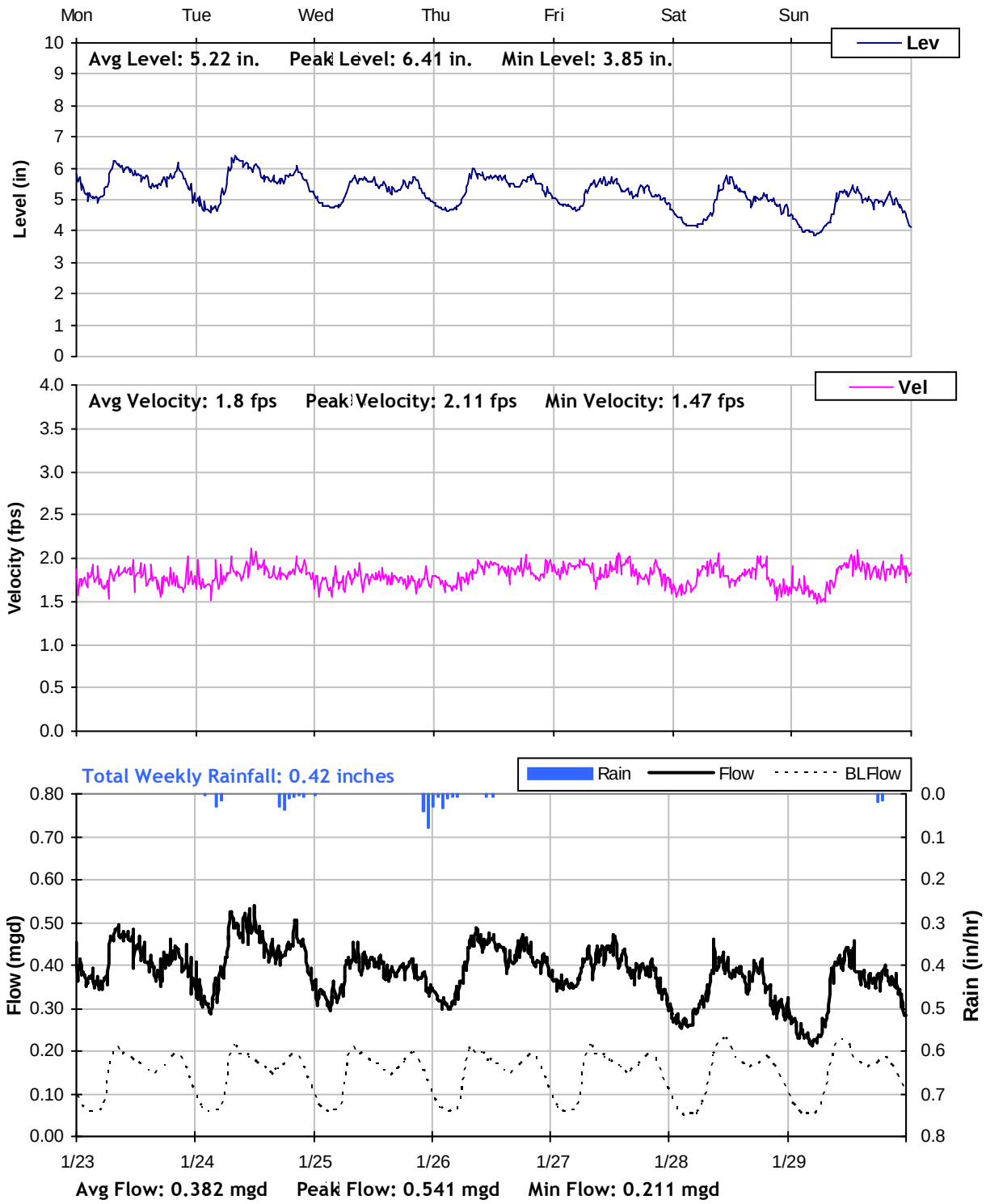
X115
Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



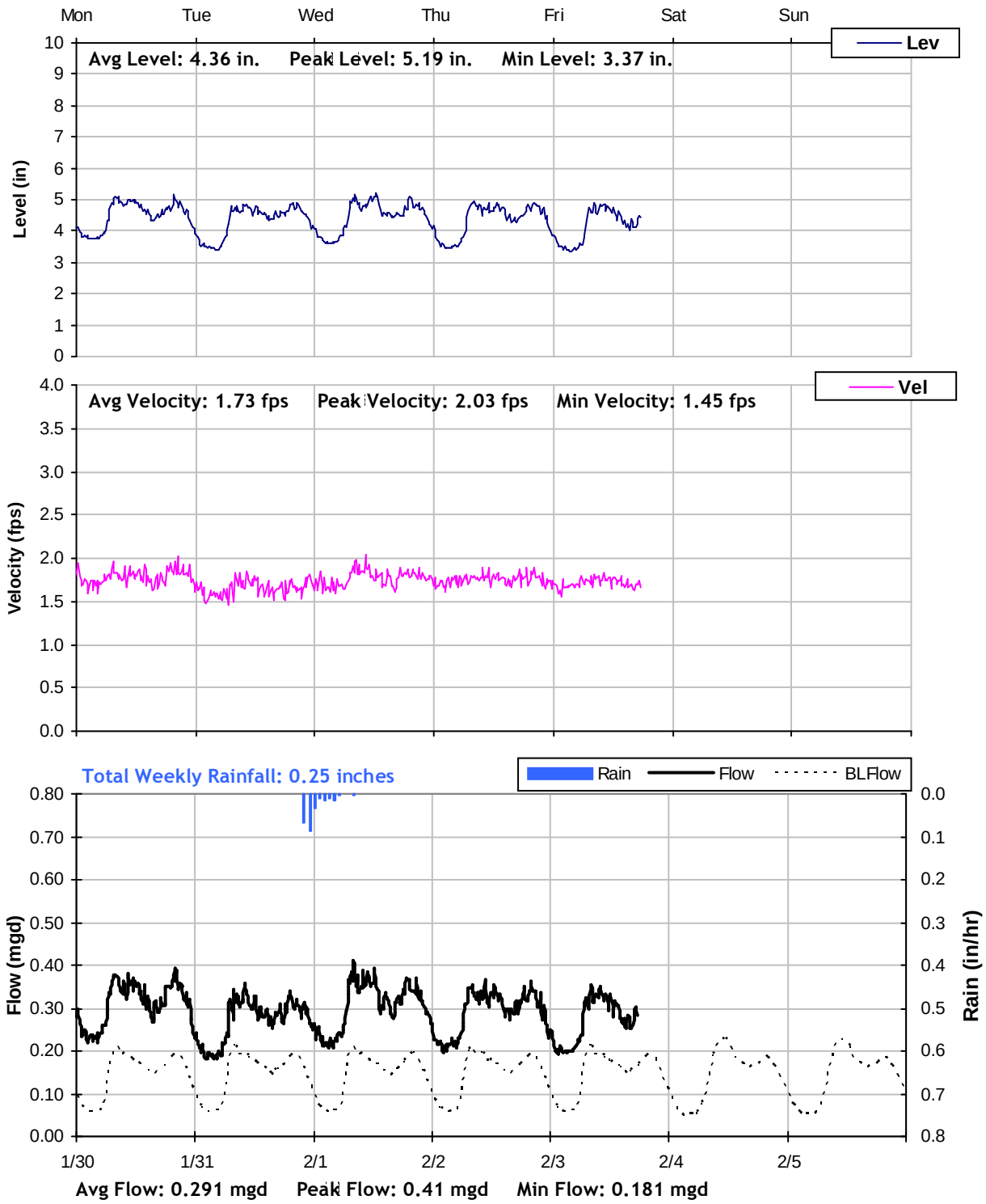
X115
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



X115
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



X115
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



City of Grants Pass

Master Plan Sanitary Sewer Flow Monitoring

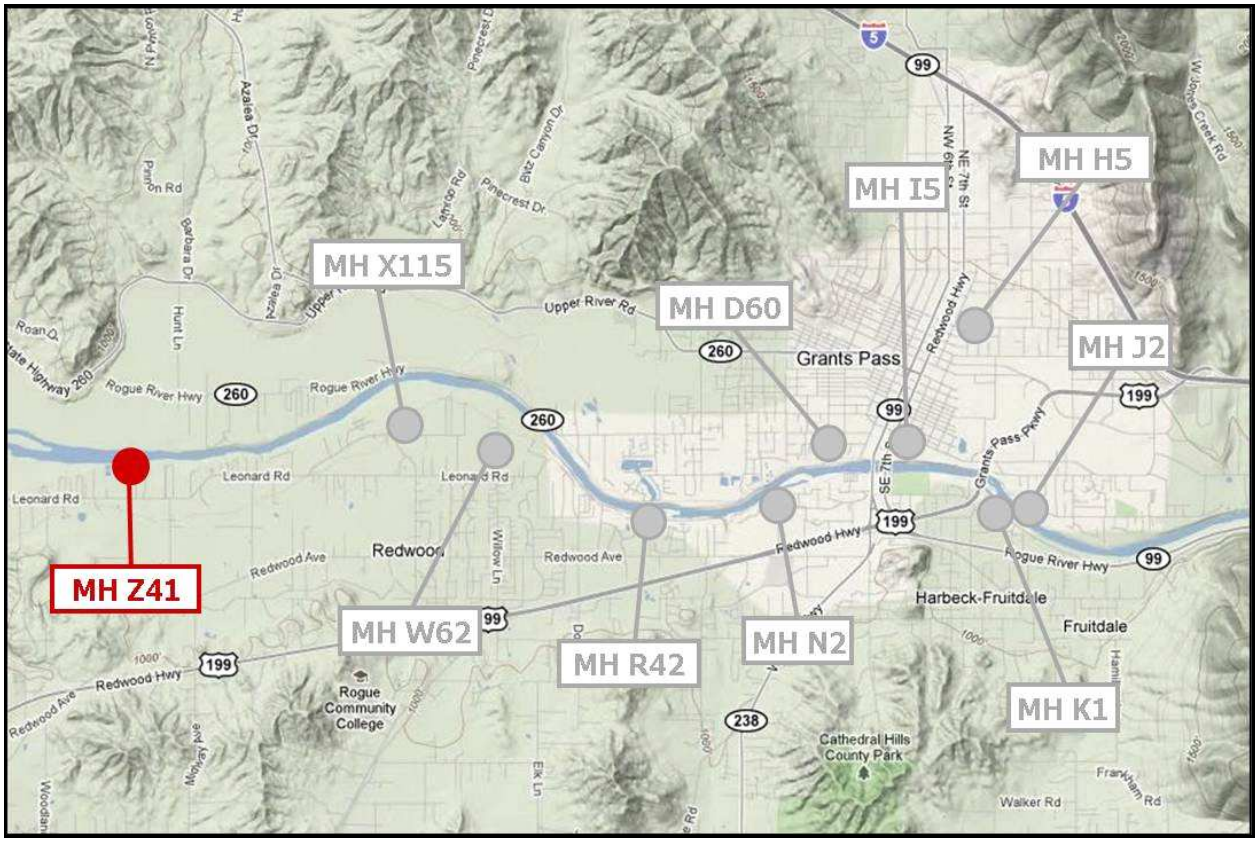
Year 2011/2012

Monitoring Site: Z41

Location: Private Drive Northeast of Leonard Road and Rounds Avenue

Data Summary Report

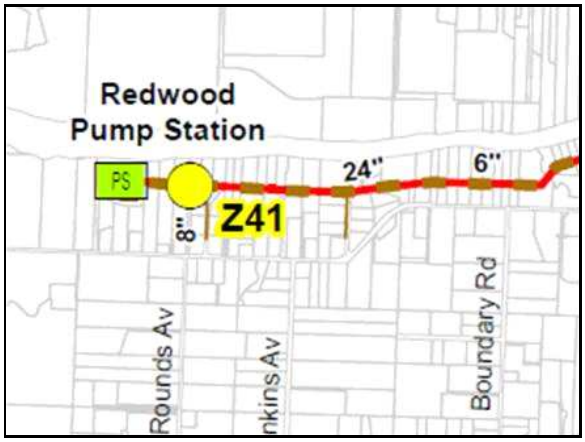
Vicinity Map:



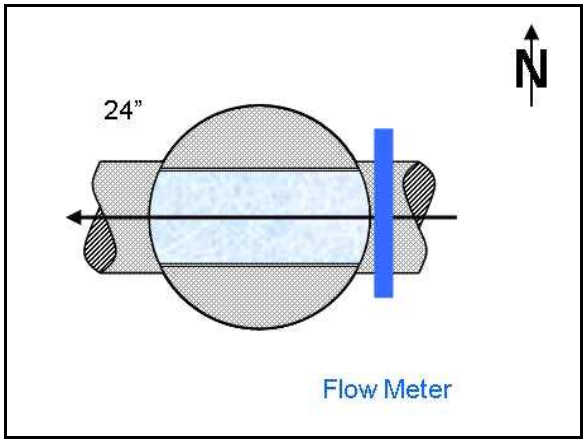
Z41
Site Information Report

Location:	Private Drive Northeast of Leonard Road and Rounds Avenue
Coordinates:	123.4207°W, 42.4300°N
Elevation:	870 feet
Diameter:	24 inches
Baseline Flow:	0.016 mgd
Peak Measured Flow:	1.18 mgd

Satellite Map



Sanitary Sewer Map



Flow Sketch

View from Street

Plan View

Z41
Additional Site Photos

Effluent Pipe

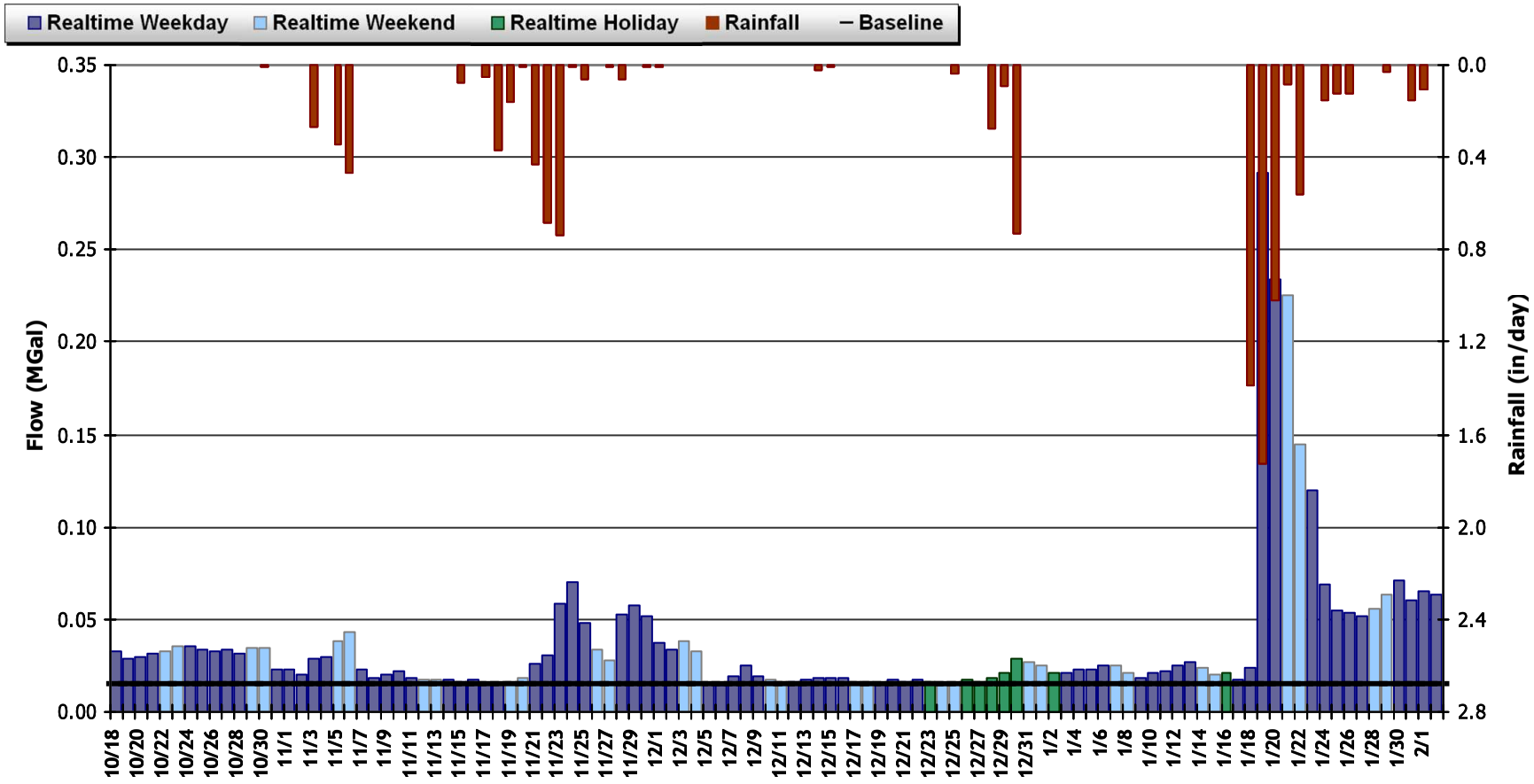
Main Influent Pipe

Z41

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.037 MGal Peak Daily Flow: 0.291 MGal Min Daily Flow: 0.014 MGal

Total Period Rainfall: 10.4 inches

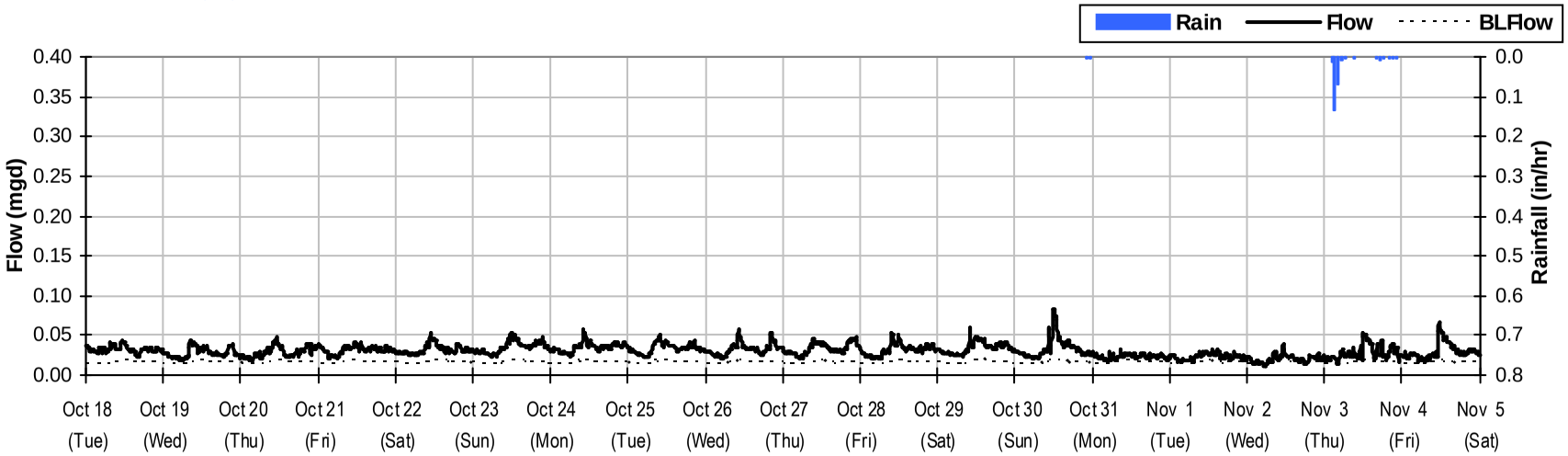


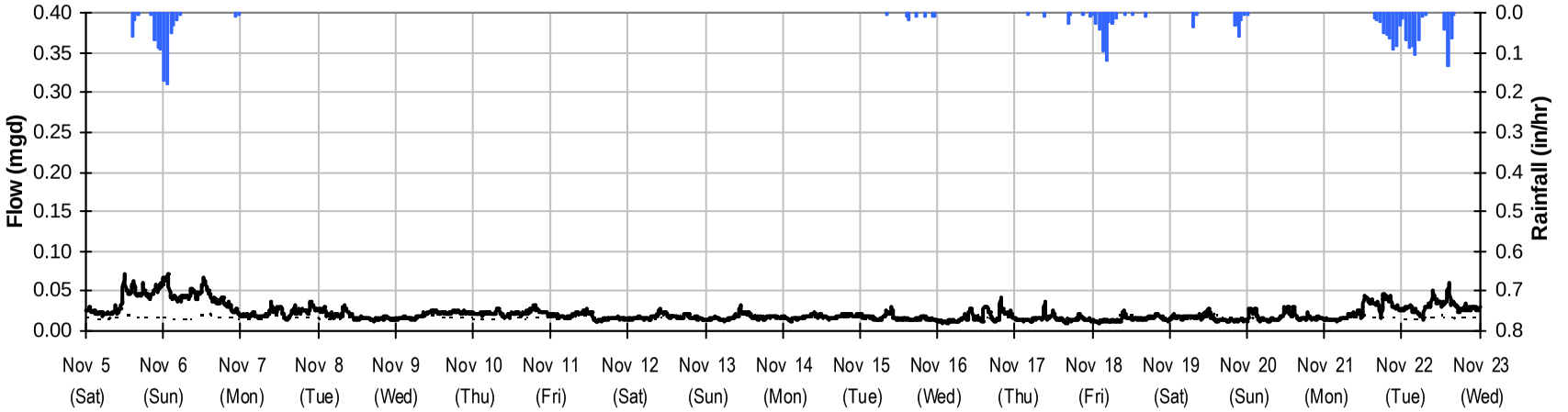
Z41

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.026 mgd Peak Flow: 0.083 mgd Min Flow: 0.009 mgd

Total Period Rainfall: 2.88 inches



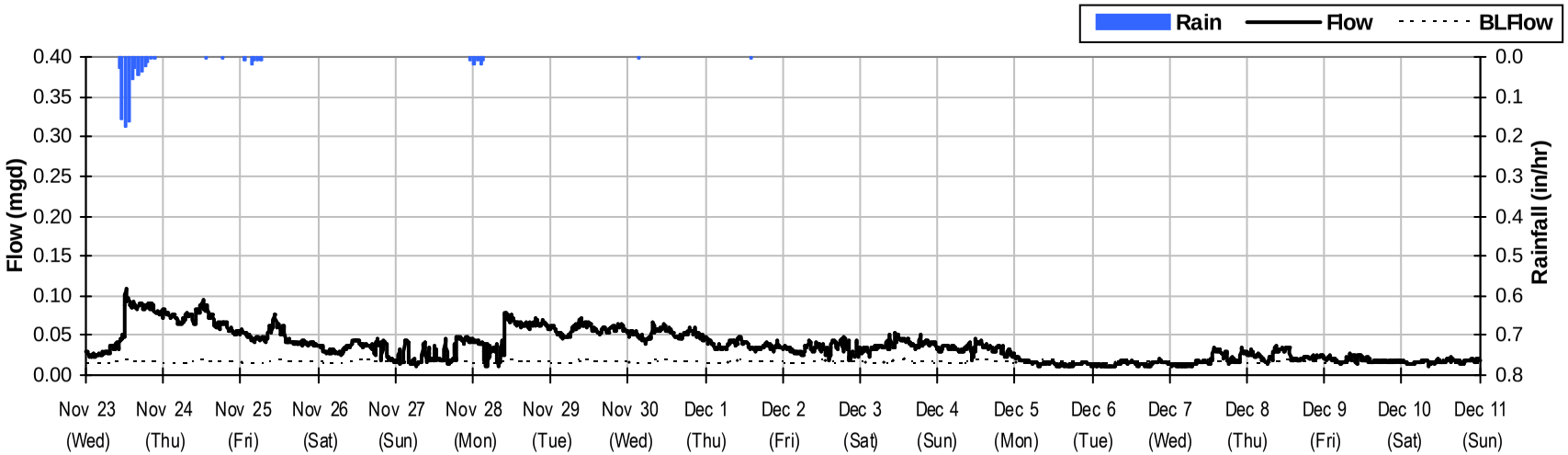


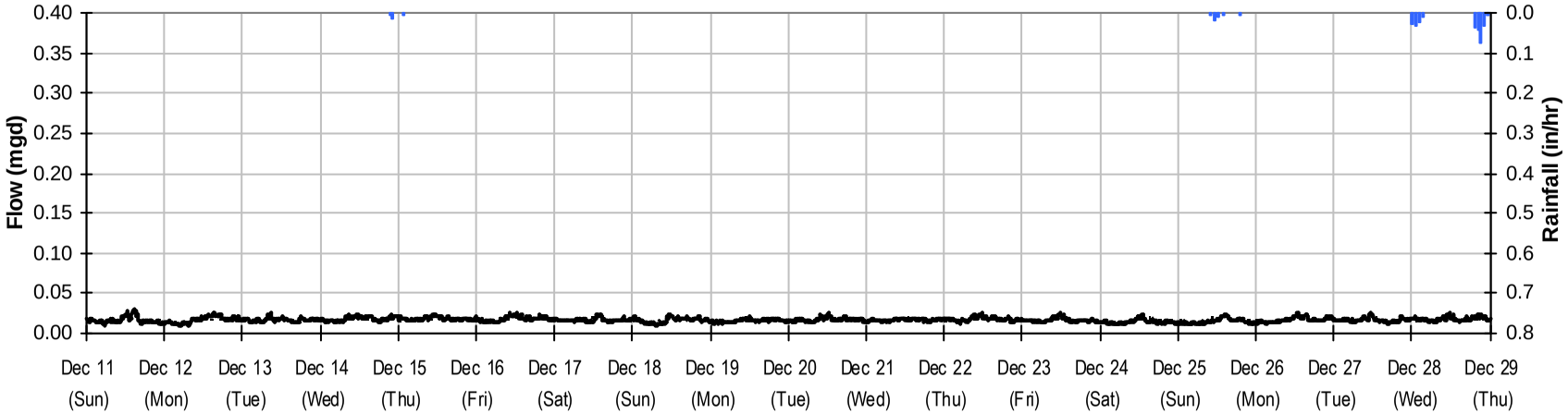
Z41

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.026 mgd Peak Flow: 0.109 mgd Min Flow: 0.009 mgd

Total Period Rainfall: 1.22 inches



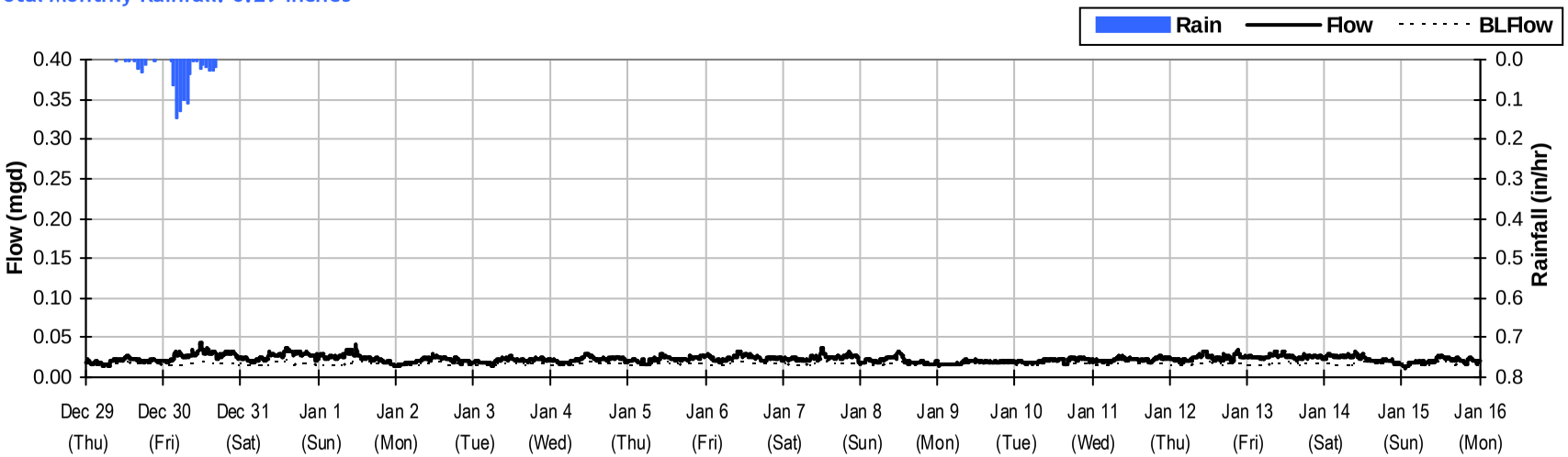


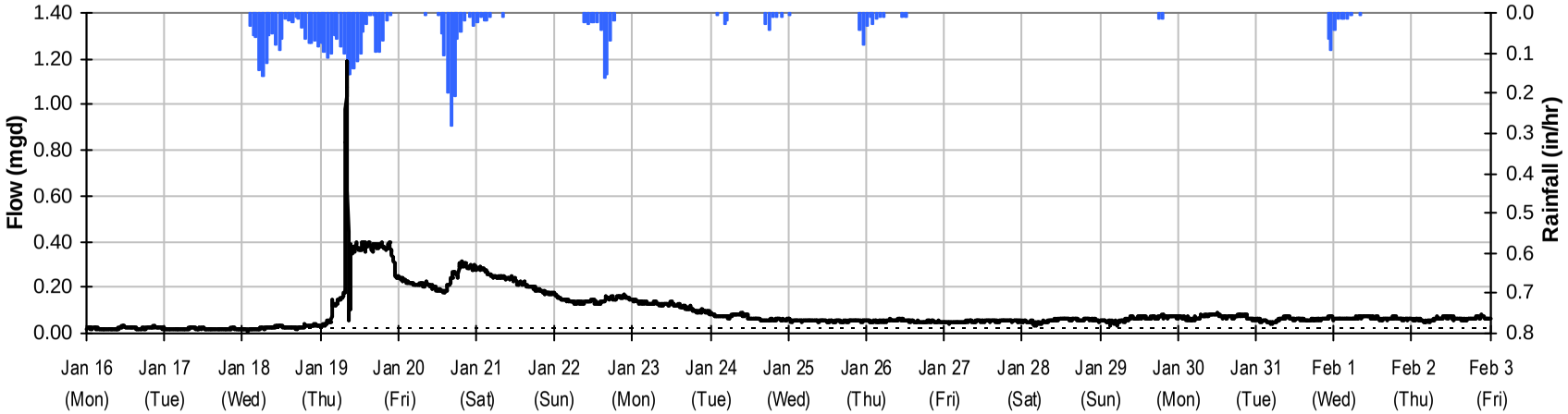
Z41

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.06 mgd Peak Flow: 1.18 mgd Min Flow: 0.01 mgd

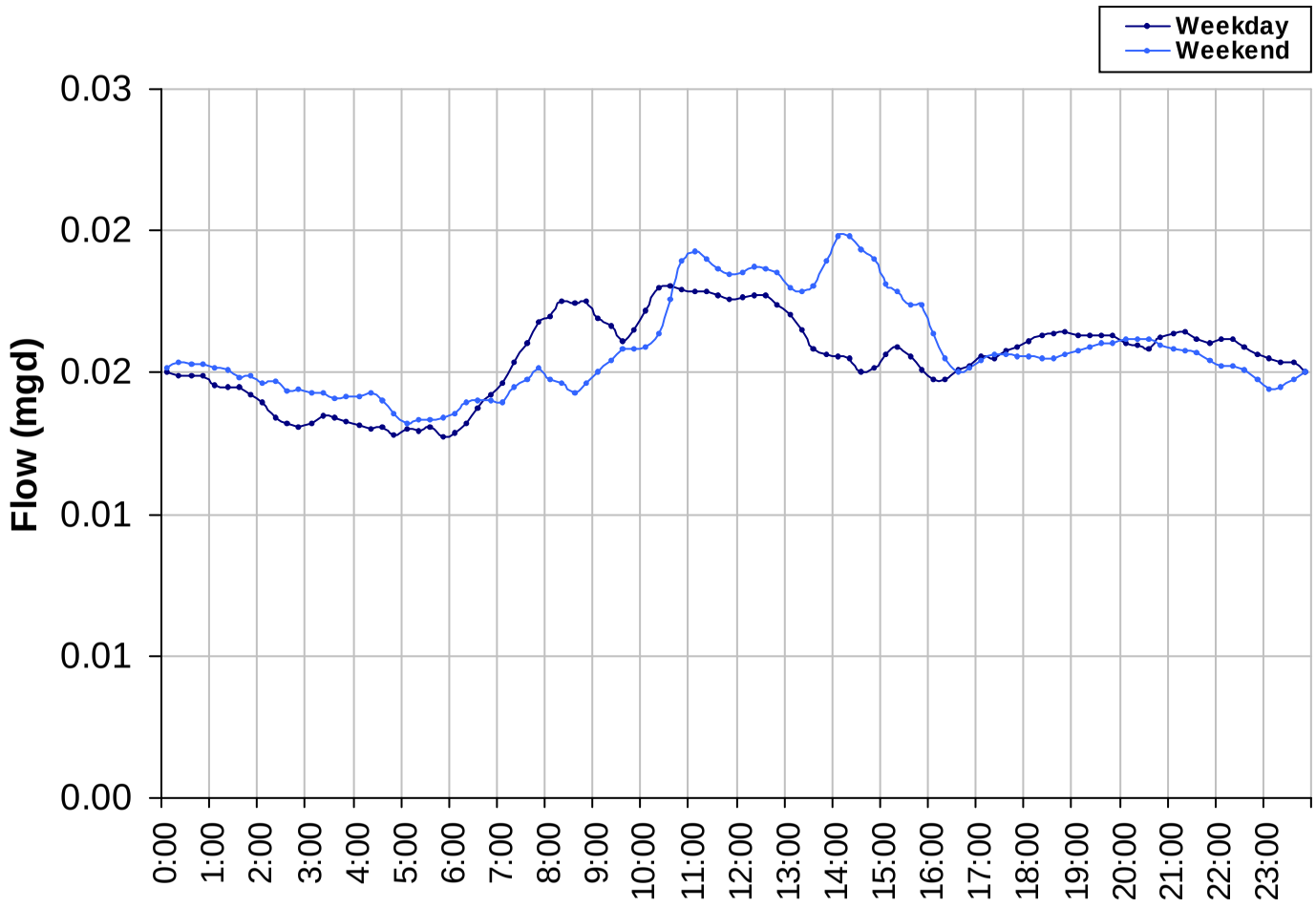
Total Monthly Rainfall: 6.29 inches





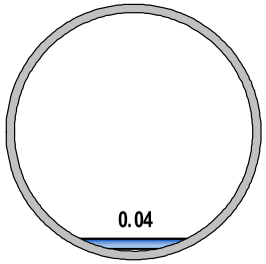
Z41

Baseline Flow Hydrographs



Baseline Flow:

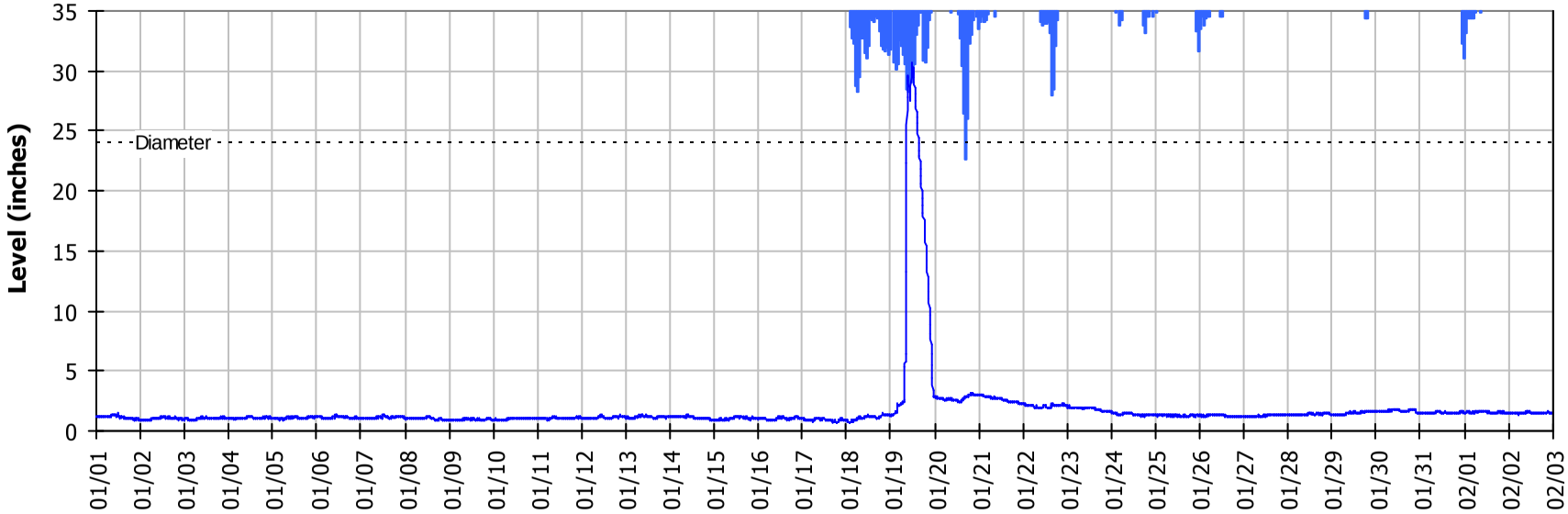
0.016 *mgd*

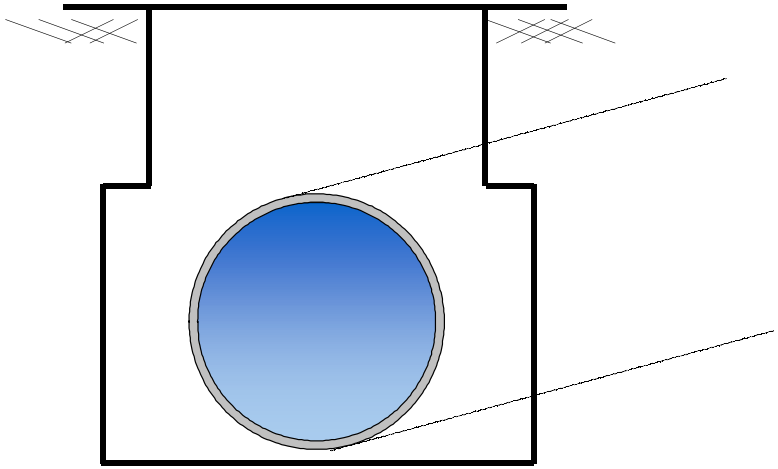


Z41

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period



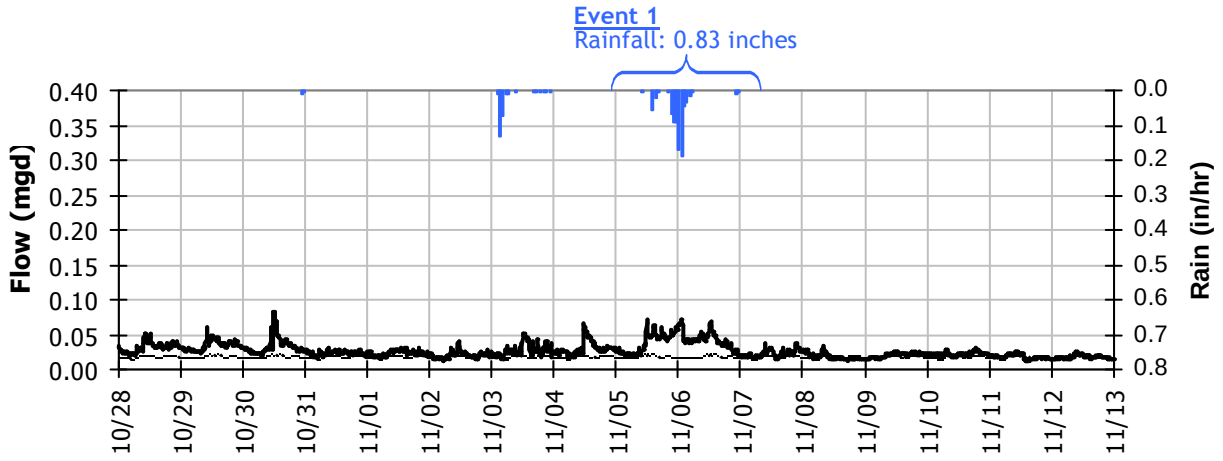


Pipe Diameter:	24	*inches*
Peak Measured Level	30.7	*inches*
Peak d/D Ratio:	1.28	

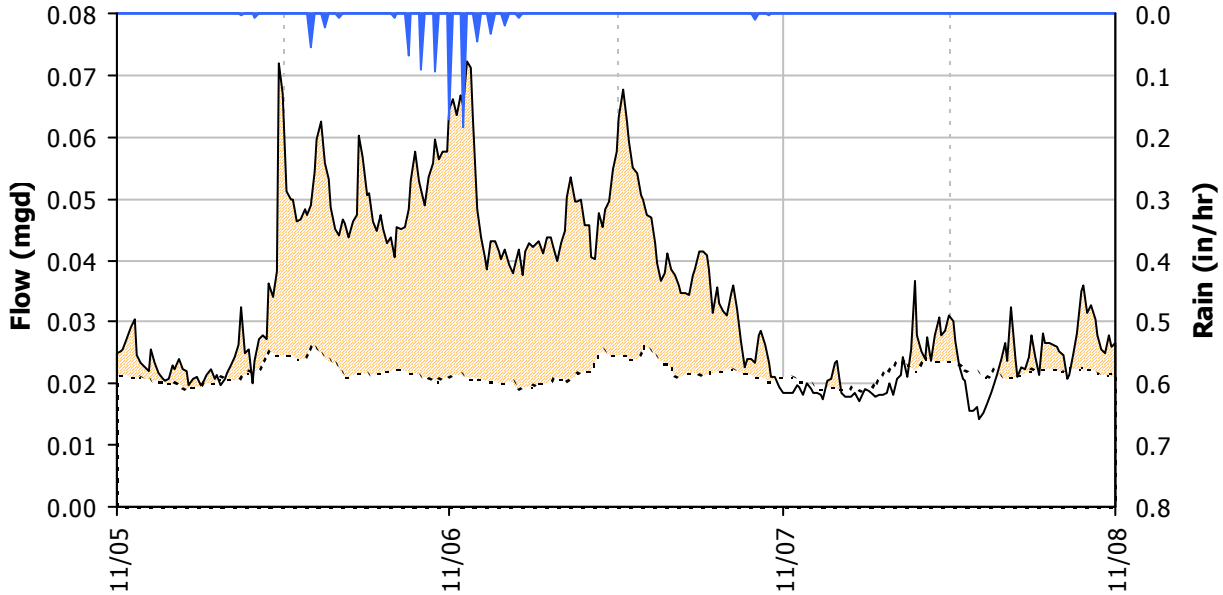
Surcharged 6.7 inches over crown

SITE Z41
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph

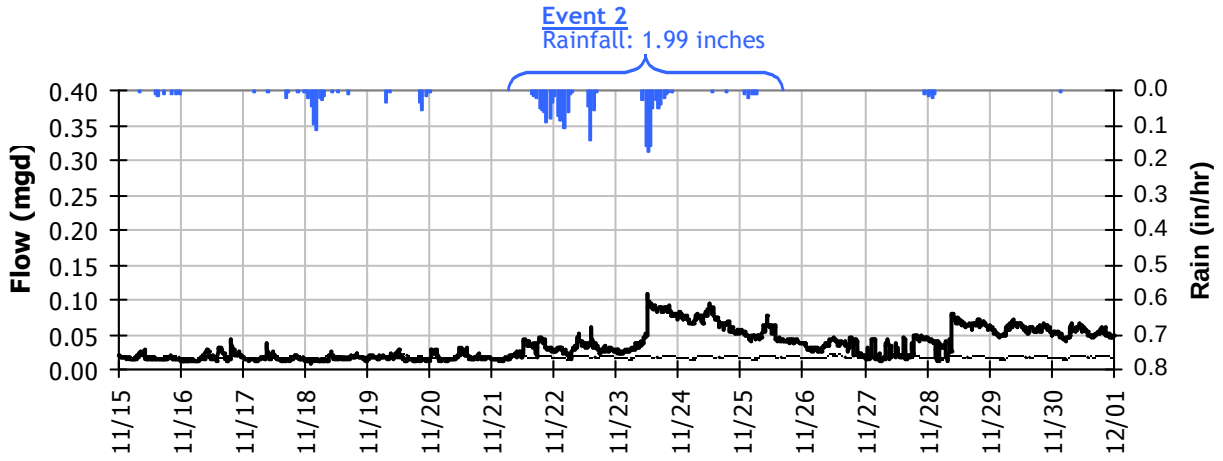


Storm Event I/I Analysis (Rain = 0.83 inches)

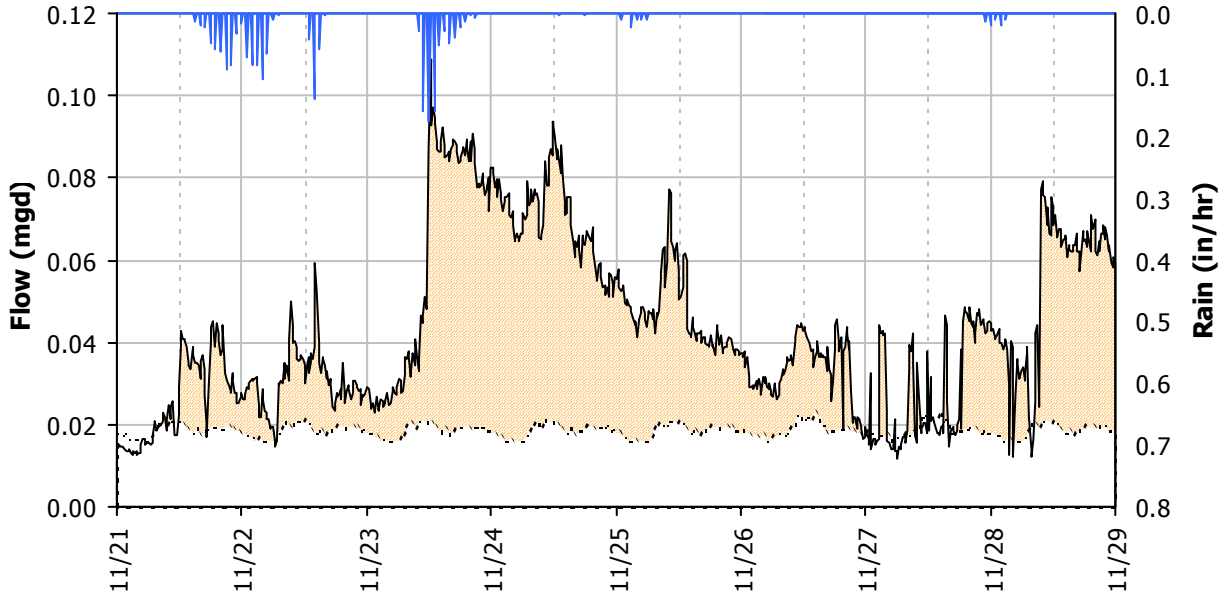
Capacity		Inflow		RDI (infiltration)		Combined I/I	
Peak Flow:	0.07 *mgd*	Peak I/I Rate:	0.06 *mgd*	Infiltration Rate: (11/7/2011)	0.007 *mgd*	Total I/I:	36,000 *gallons*
PF:	4.63	PkI/I:IDM:	368 *gpd/IDM*	RDI:IDM:	48 *gpd/IDM*	Total I/I:IDM:	284 *gal/IDM/in*
Peak Level:	2.25 *in*	PkI/I:Acre:	71 *gpd/acre*	RDI:Acre:	9 *gpd/acre*	R-Value:	0.2%
d/D Ratio:	0.09	Pk I/I:ADWF:	3.66	RDI (% of BL):	48%	Total I/I:ADWF:	2.82 *per in-rain*

SITE Z41
I/I Summary: Event 2

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 2 Detail Graph

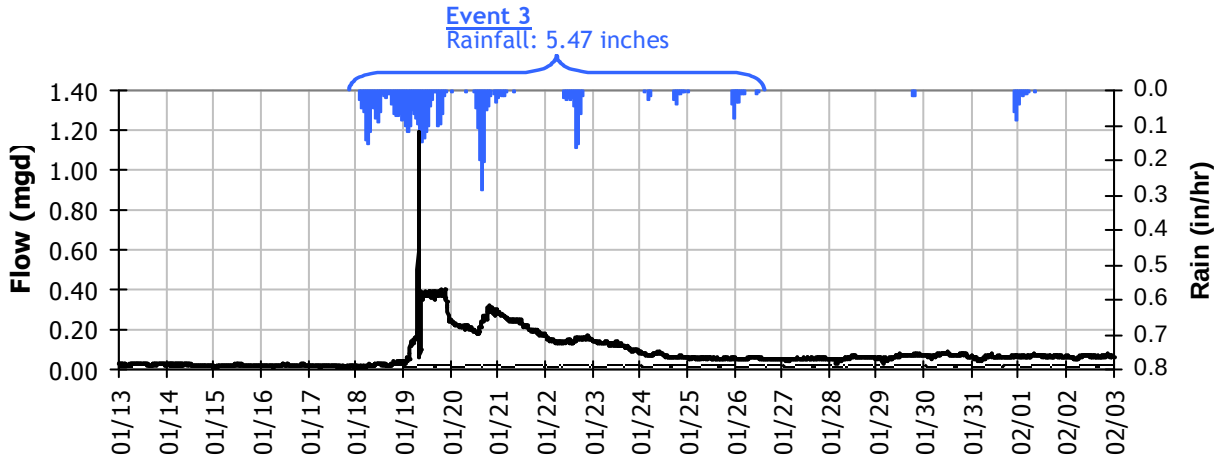


Storm Event I/I Analysis (Rain = 1.99 inches)

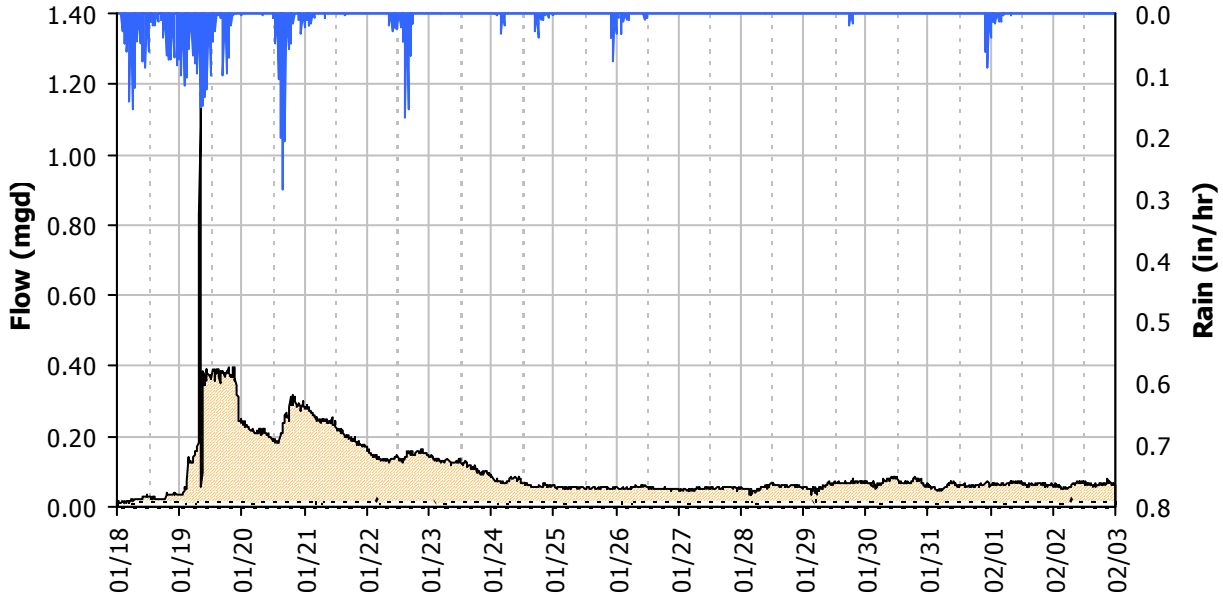
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	0.11	*mgd*	Peak I/I Rate:	0.09	*mgd*	Infiltration Rate: (11/26/2011)	0.018	*mgd*	Total I/I:	198,000	*gallons*
PF:	6.97		PkI/I:IDM:	587	*gpd/IDM*	RDI:IDM:	113	*gpd/IDM*	Total I/I:IDM:	642	*gal/IDM/in*
Peak Level:	2.05	*in*	PkI/I:Acre:	112	*gpd/acre*	RDI:Acre:	22	*gpd/acre*	R-Value:	0.5%	
d/D Ratio:	0.09		Pk I/I:ADWF:	5.84		RDI (% of BL):	111%		Total I/I:ADWF:	6.39	*per in-rain*

SITE Z41
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph

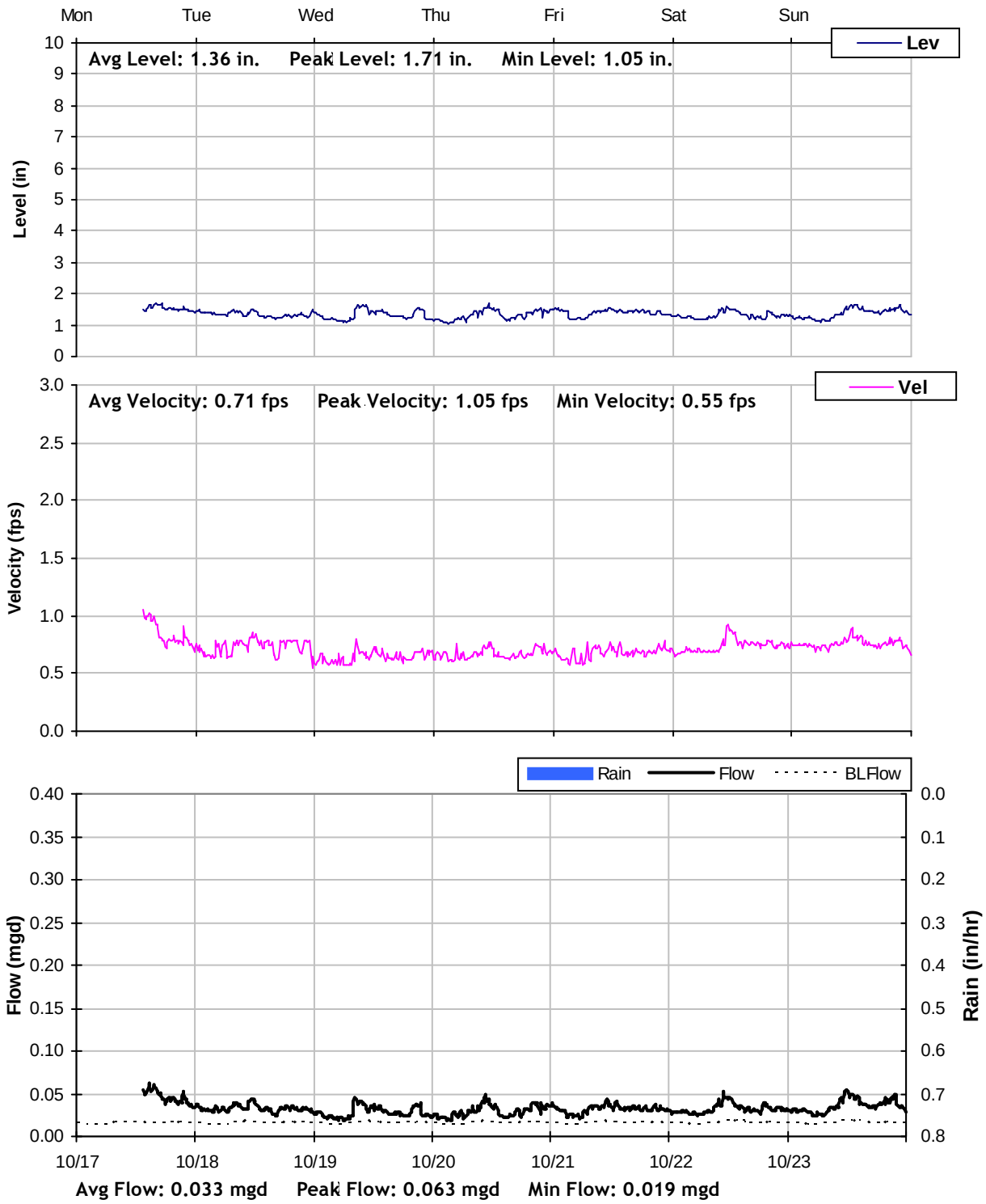


Storm Event I/I Analysis (Rain = 5.47 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	1.18	*mgd*	Peak I/I Rate:	1.16	*mgd*	Infiltration Rate: (1/30/2012)	0.056	*mgd*	Total I/I:	1,400,000	*gallons*
PF:	75.65		PkI/I:IDM:	7,494	*gpd/IDM*	RDI:IDM:	359	*gpd/IDM*	Total I/I:IDM:	1,648	*gal/IDM/in*
Peak Level:	30.72	*in*	PkI/I:Acre:	1,436	*gpd/acre*	RDI:Acre:	69	*gpd/acre*	R-Value:	1.2%	
d/D Ratio:	1.28		Pk I/I:ADWF:	74.53		RDI (% of BL):	359%		Total I/I:ADWF:	16.39	*per in-rain*

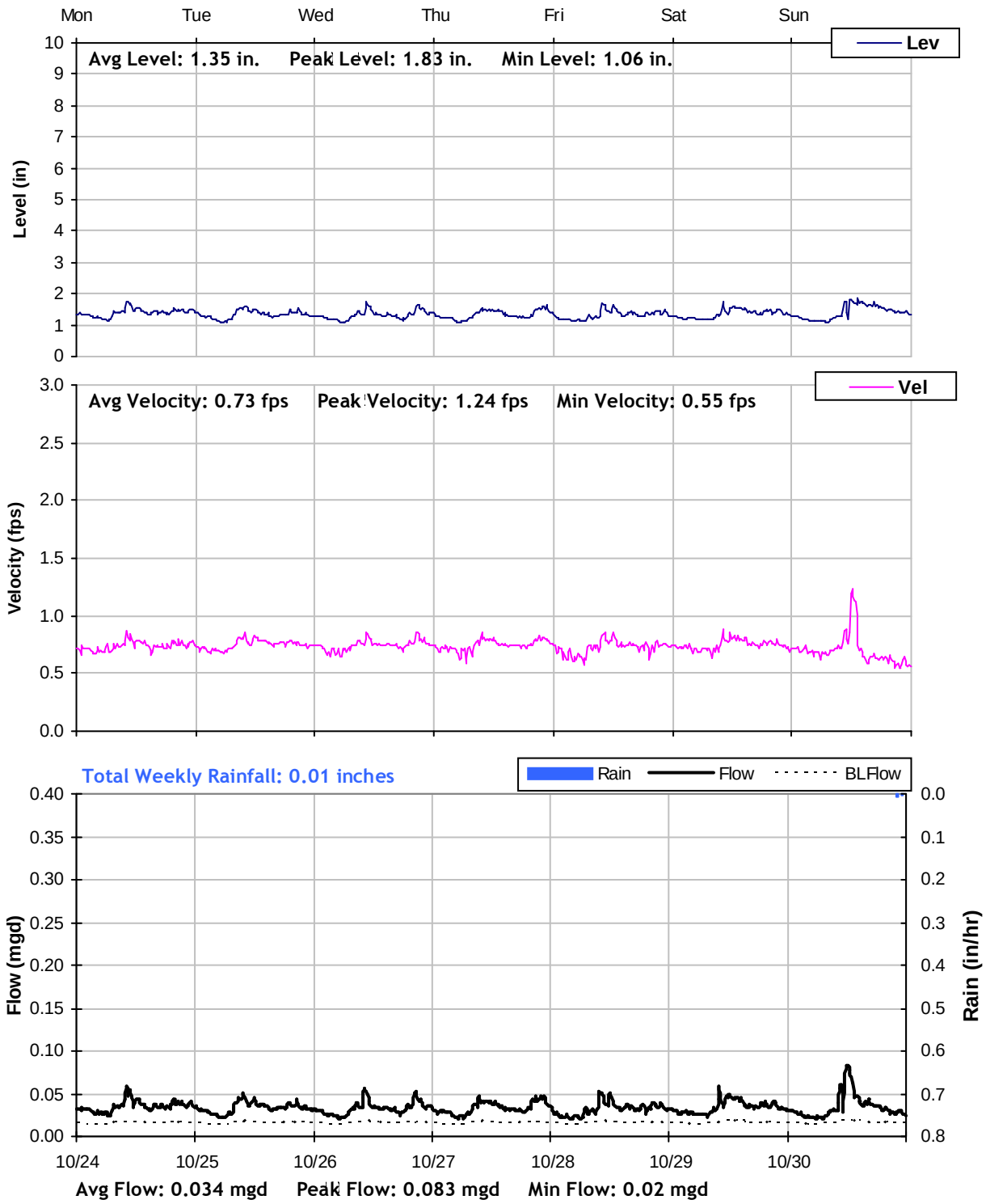
Z41

Weekly Level, Velocity and Flow Hydrographs
10/17/2011 to 10/24/2011



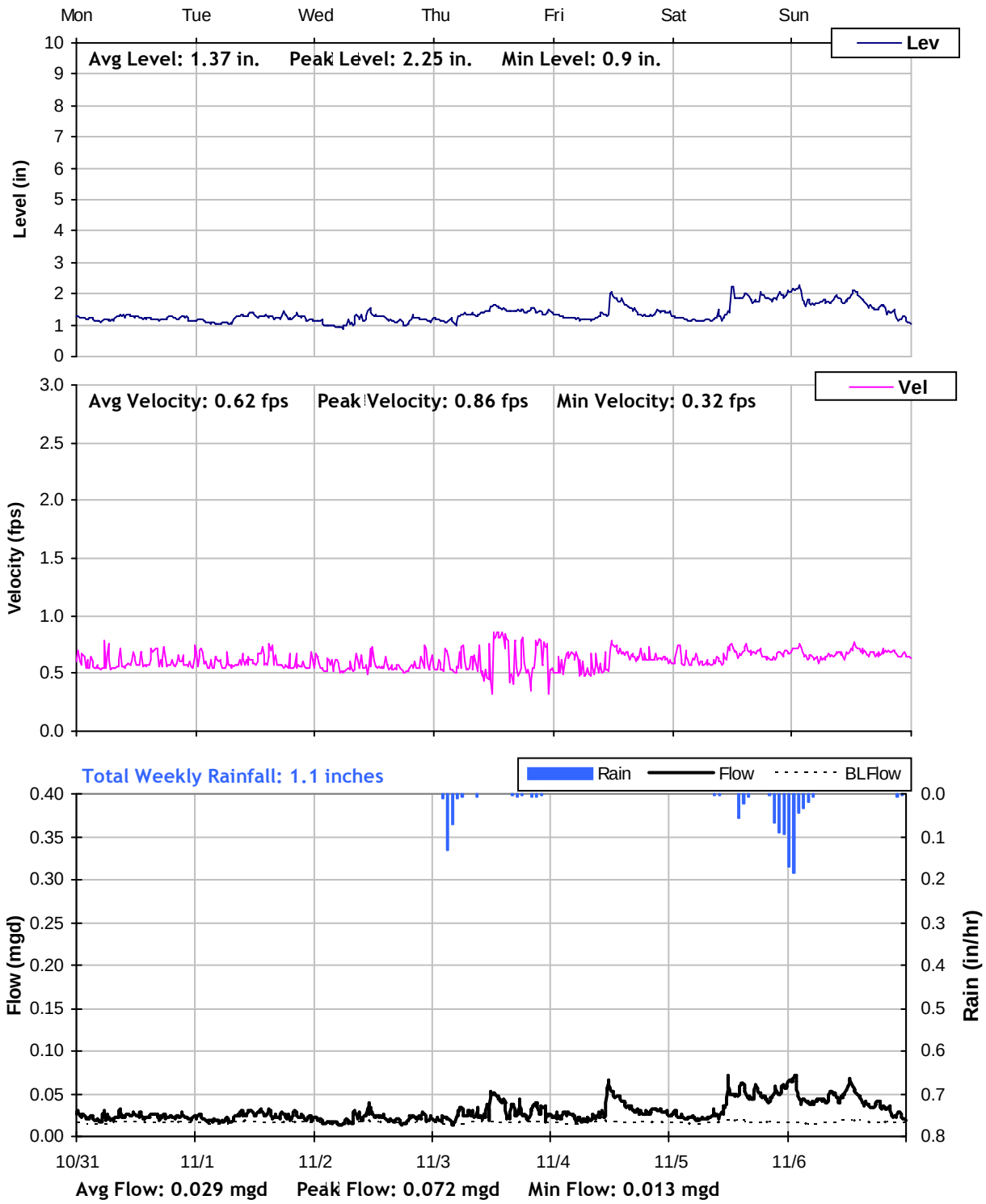
Z41

Weekly Level, Velocity and Flow Hydrographs
10/24/2011 to 10/31/2011



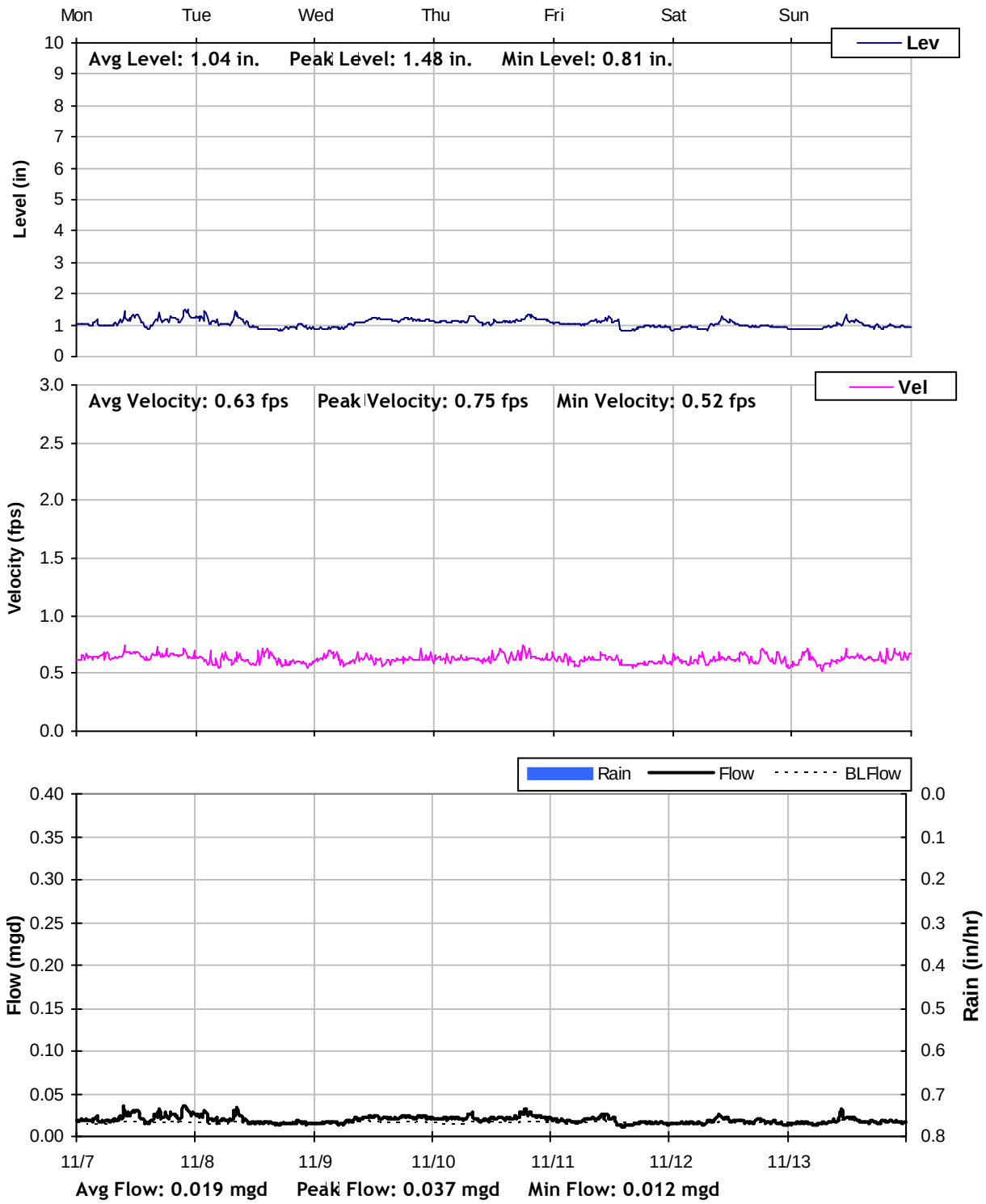
Z41

Weekly Level, Velocity and Flow Hydrographs
10/31/2011 to 11/7/2011



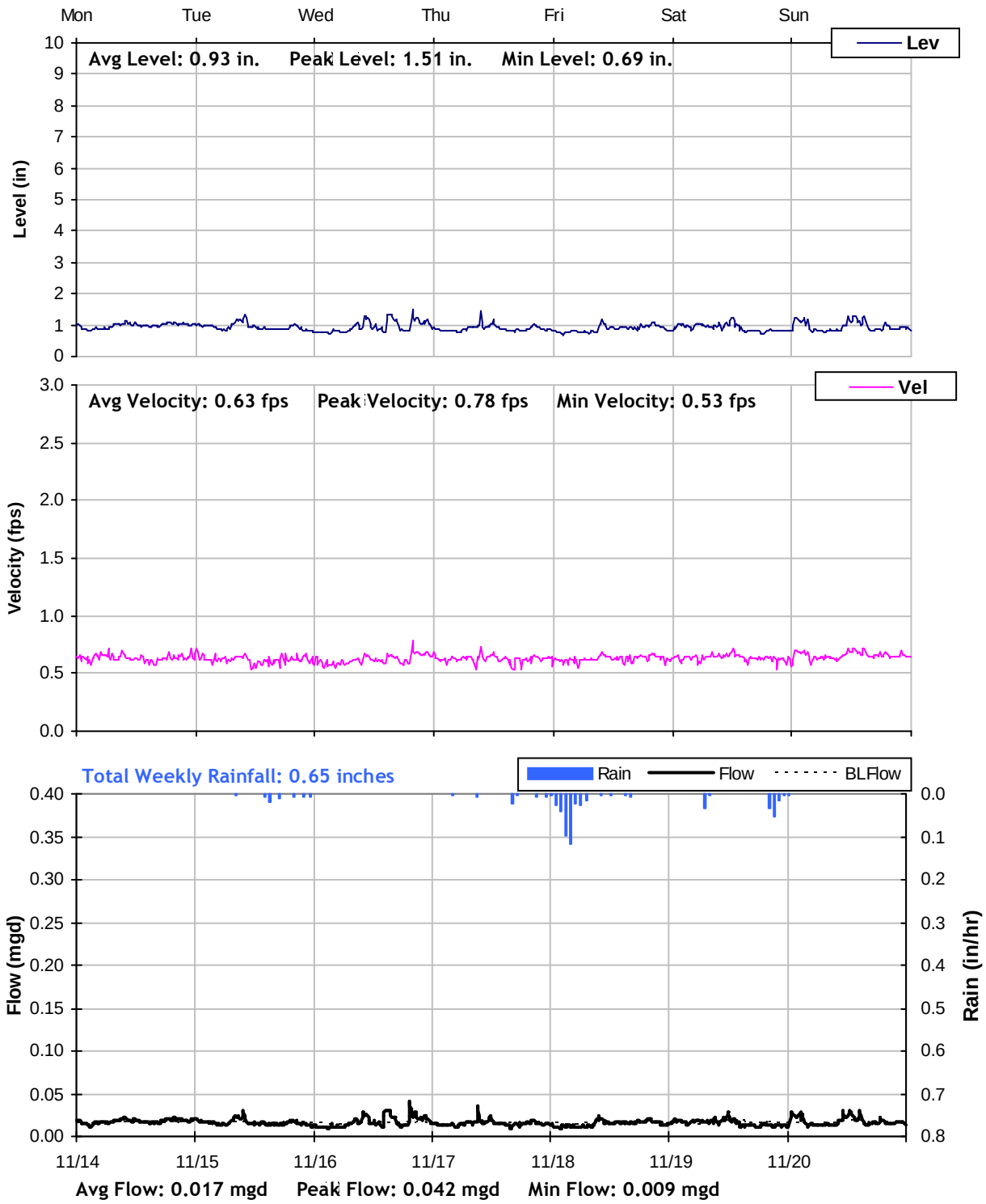
Z41

Weekly Level, Velocity and Flow Hydrographs
11/7/2011 to 11/14/2011



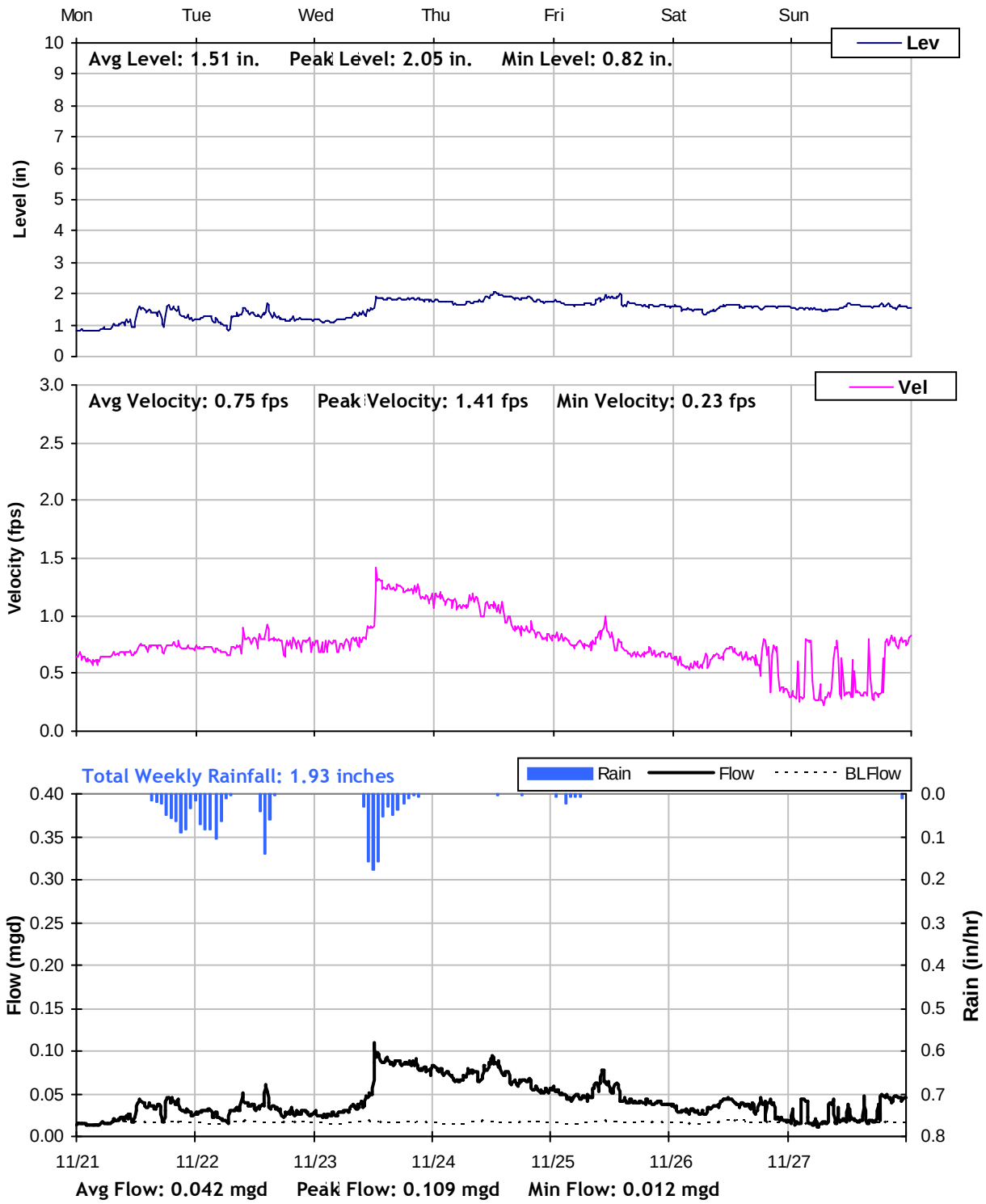
Z41

Weekly Level, Velocity and Flow Hydrographs
11/14/2011 to 11/21/2011



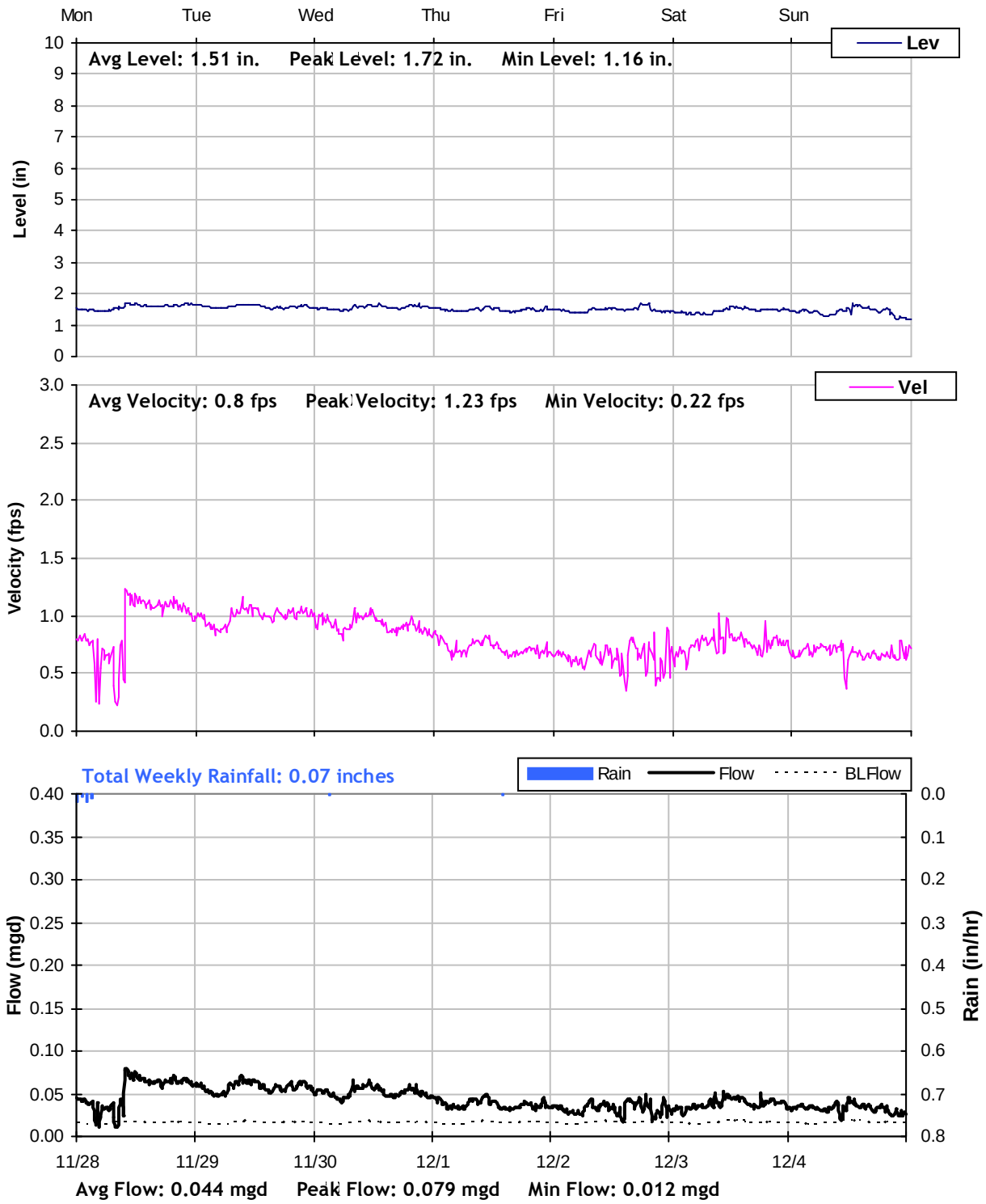
Z41

Weekly Level, Velocity and Flow Hydrographs
11/21/2011 to 11/28/2011



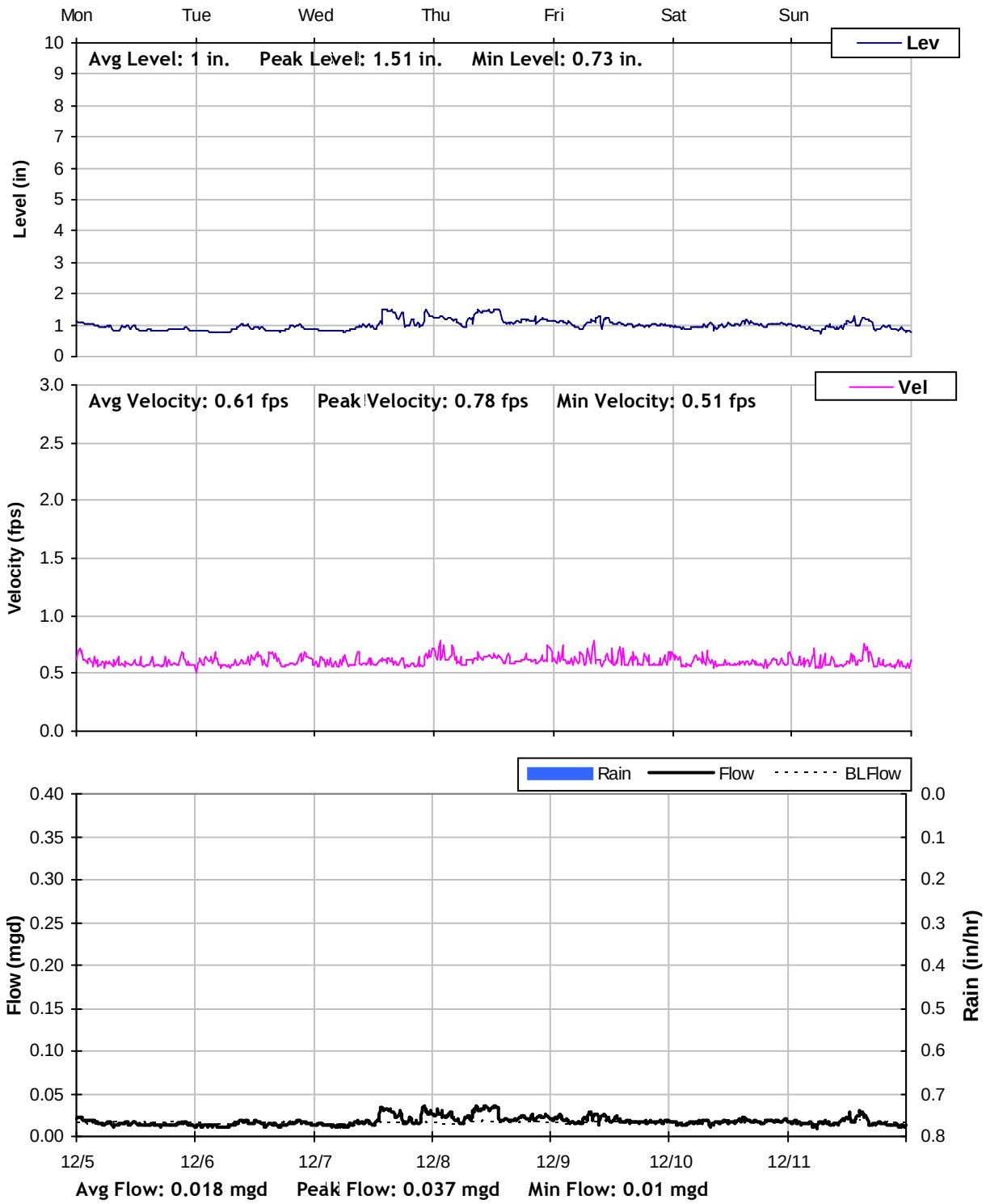
Z41

Weekly Level, Velocity and Flow Hydrographs
11/28/2011 to 12/5/2011



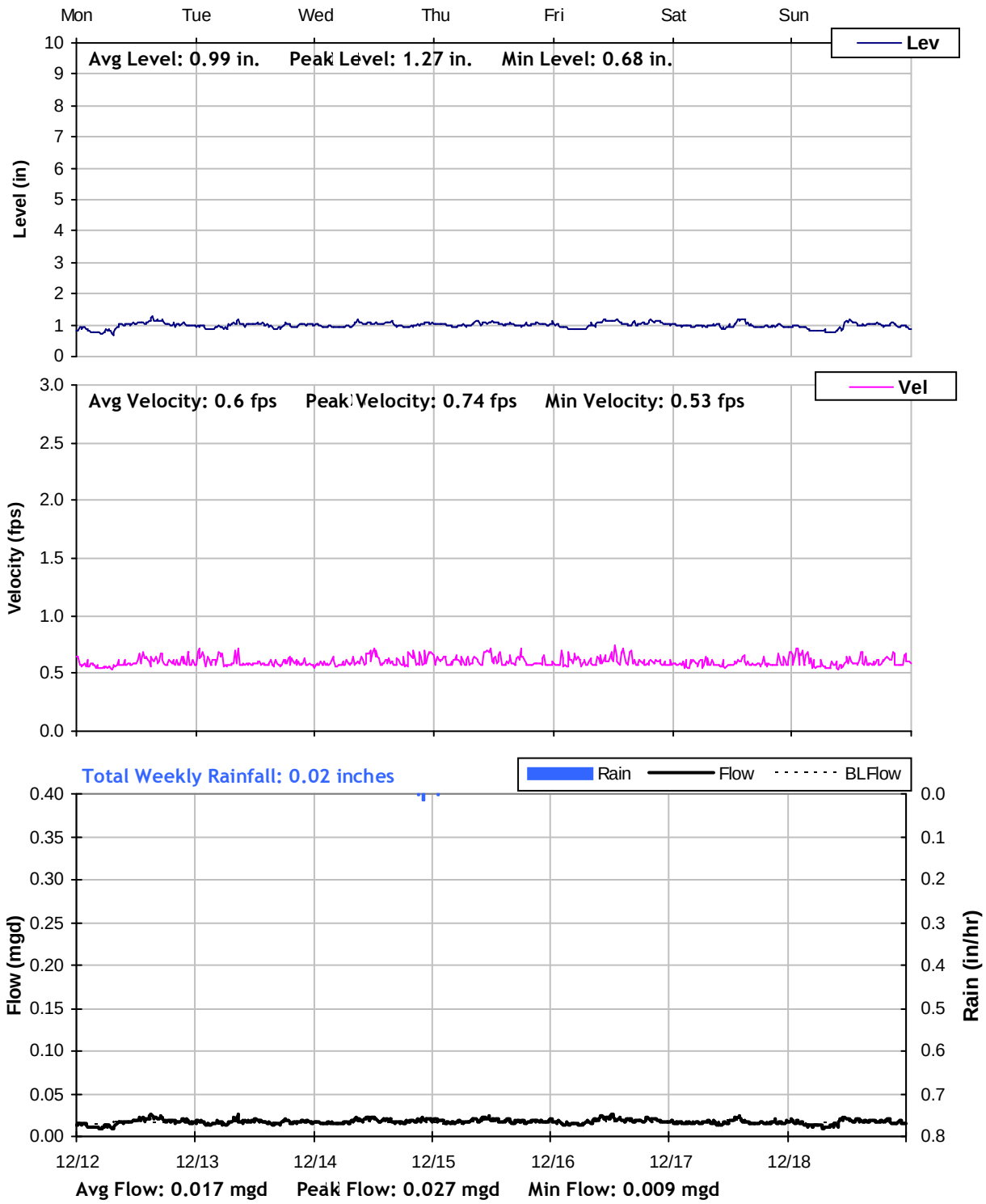
Z41

Weekly Level, Velocity and Flow Hydrographs
12/5/2011 to 12/12/2011



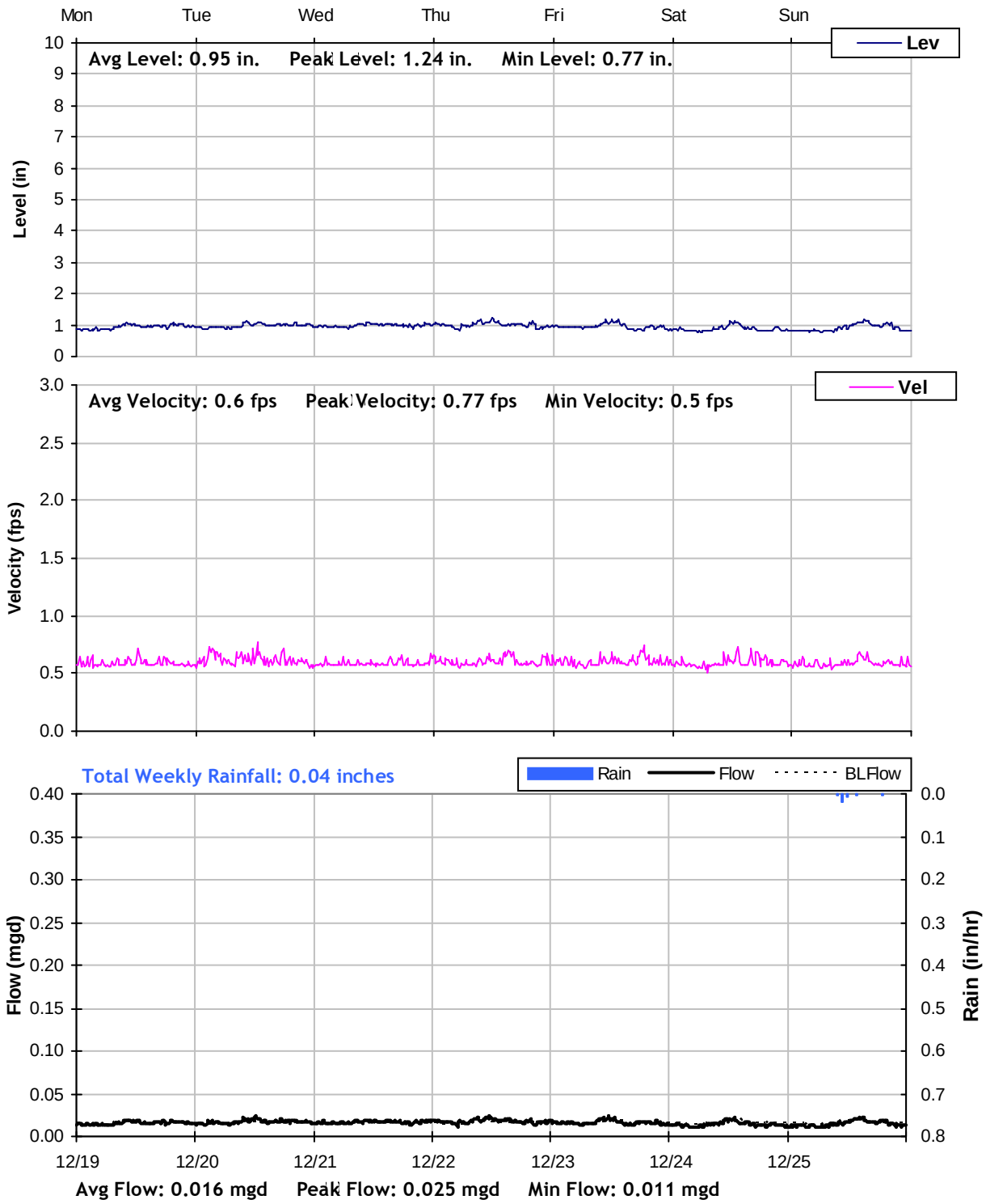
Z41

Weekly Level, Velocity and Flow Hydrographs
12/12/2011 to 12/19/2011



Z41

Weekly Level, Velocity and Flow Hydrographs
12/19/2011 to 12/26/2011



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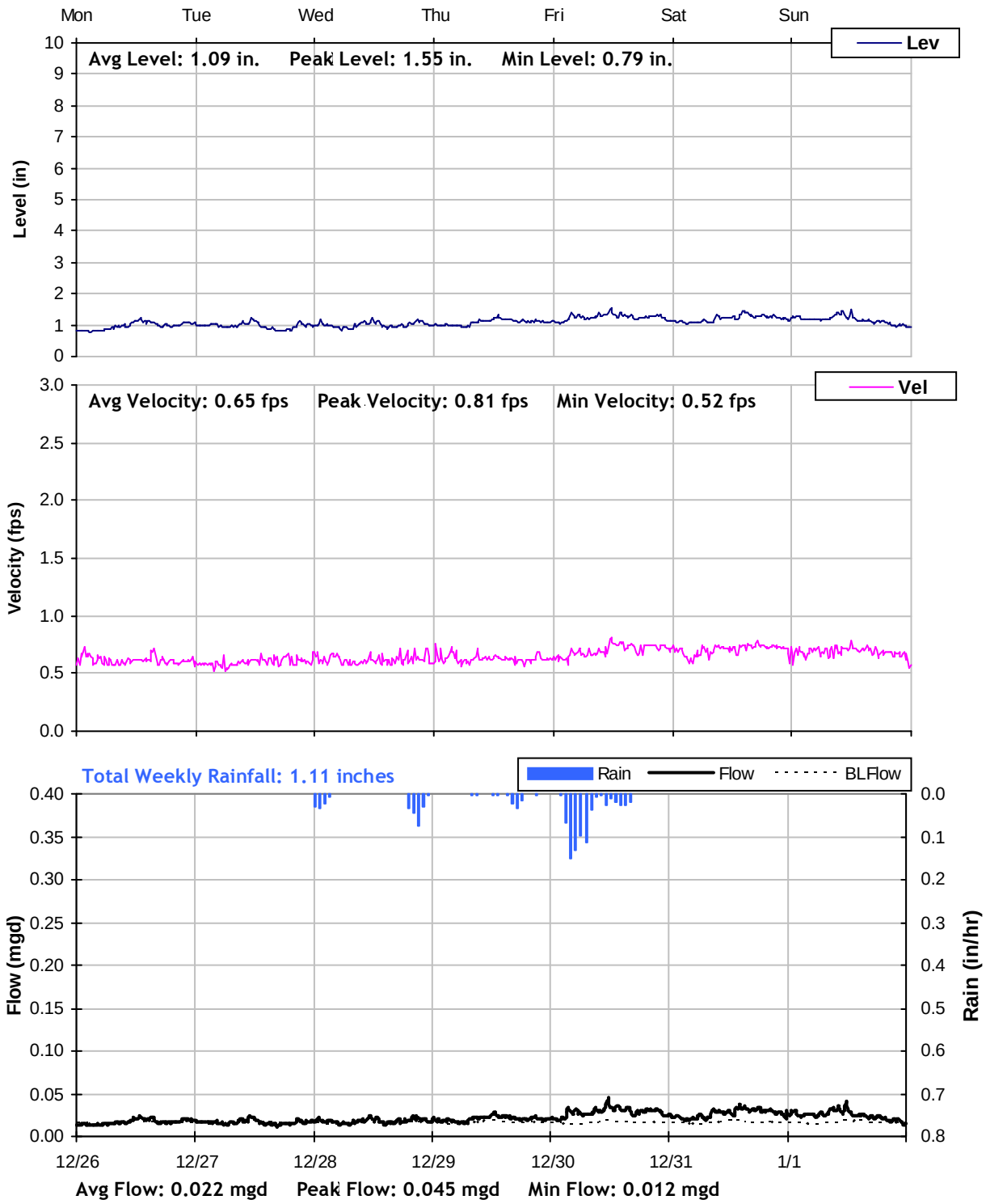
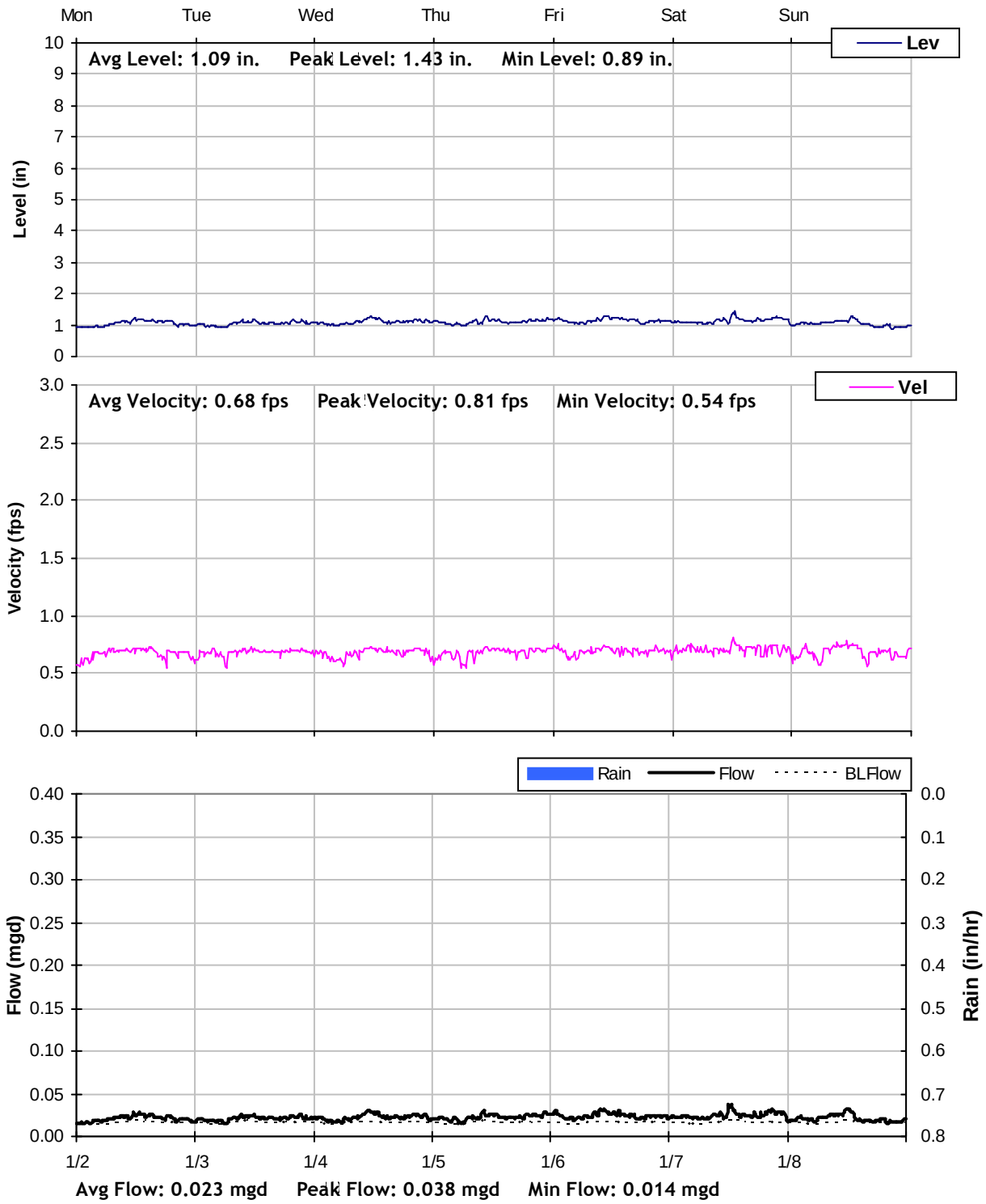
Weekly Level, Velocity and Flow Hydrographs
12/26/2011 to 1/2/2012



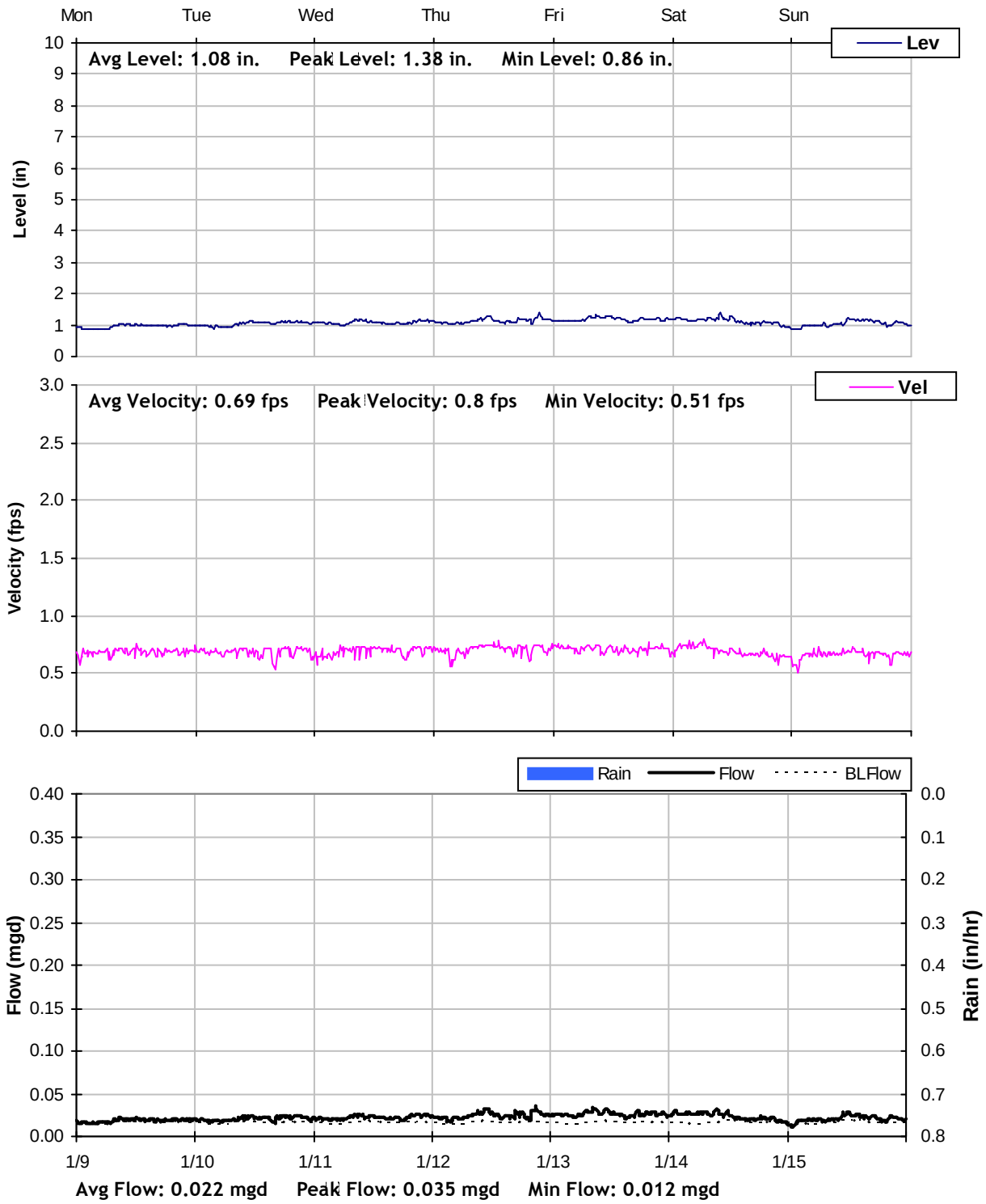
Z41

Weekly Level, Velocity and Flow Hydrographs
1/2/2012 to 1/9/2012



Z41

Weekly Level, Velocity and Flow Hydrographs
1/9/2012 to 1/16/2012



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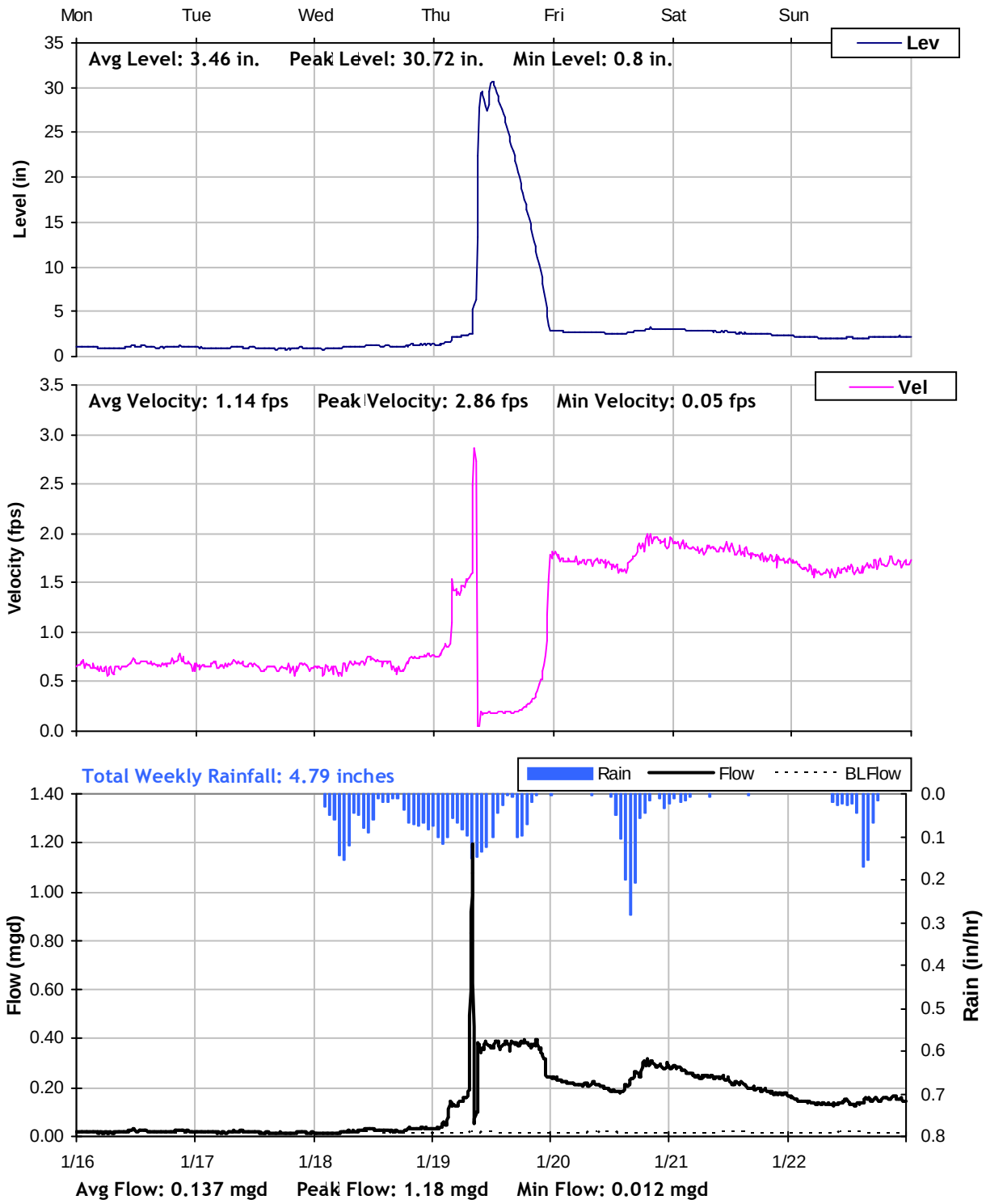
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



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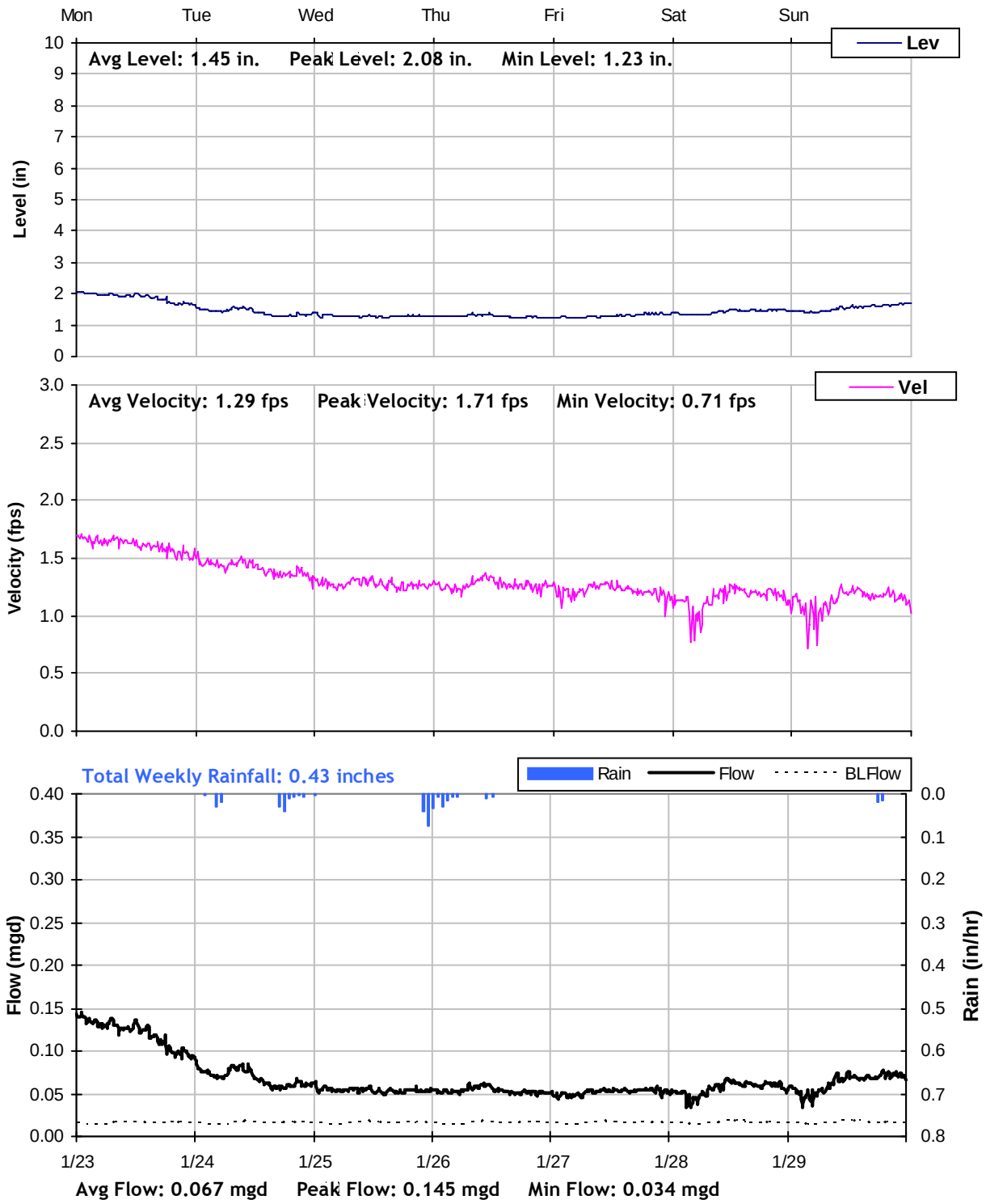
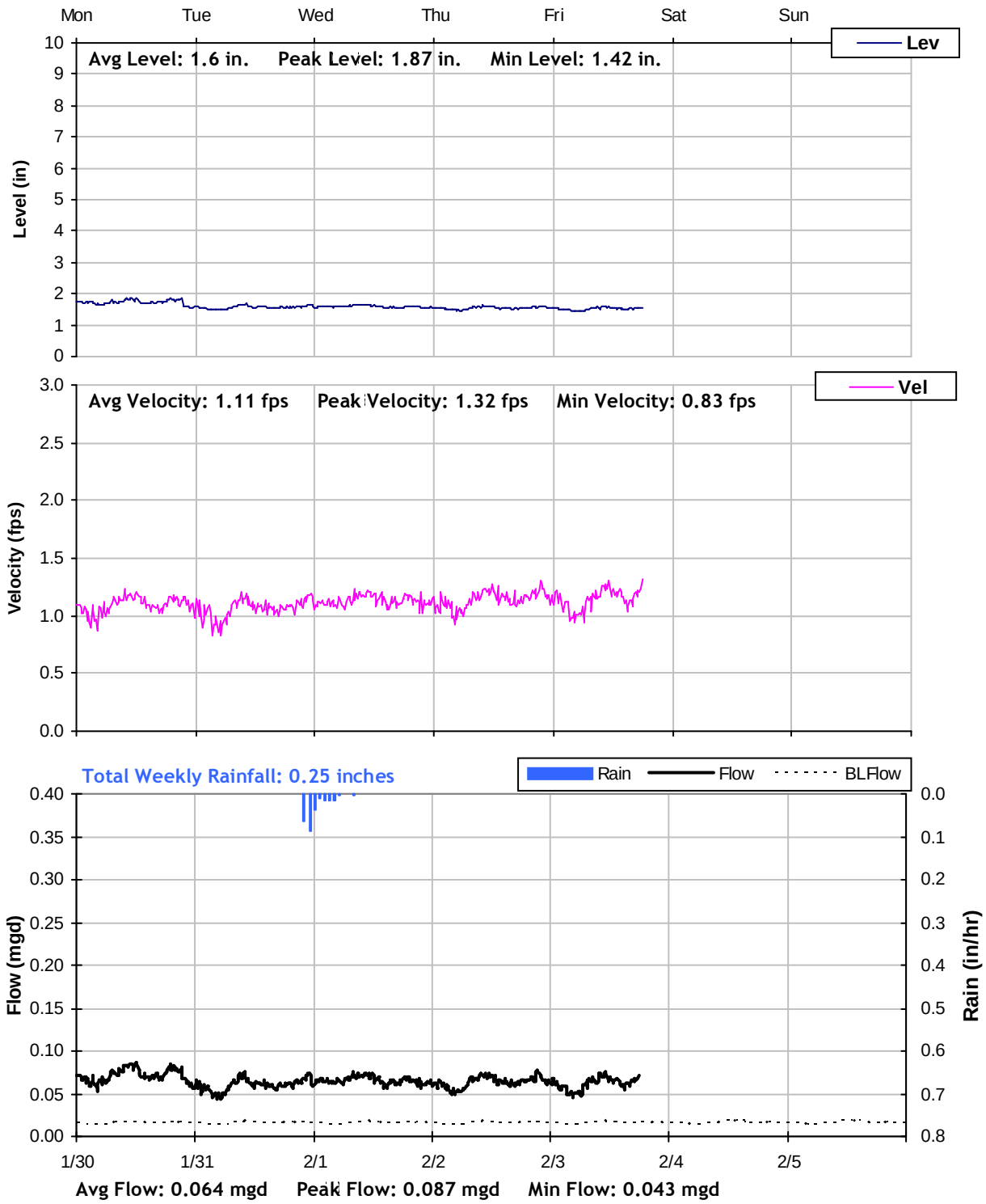
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



Z41

Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012

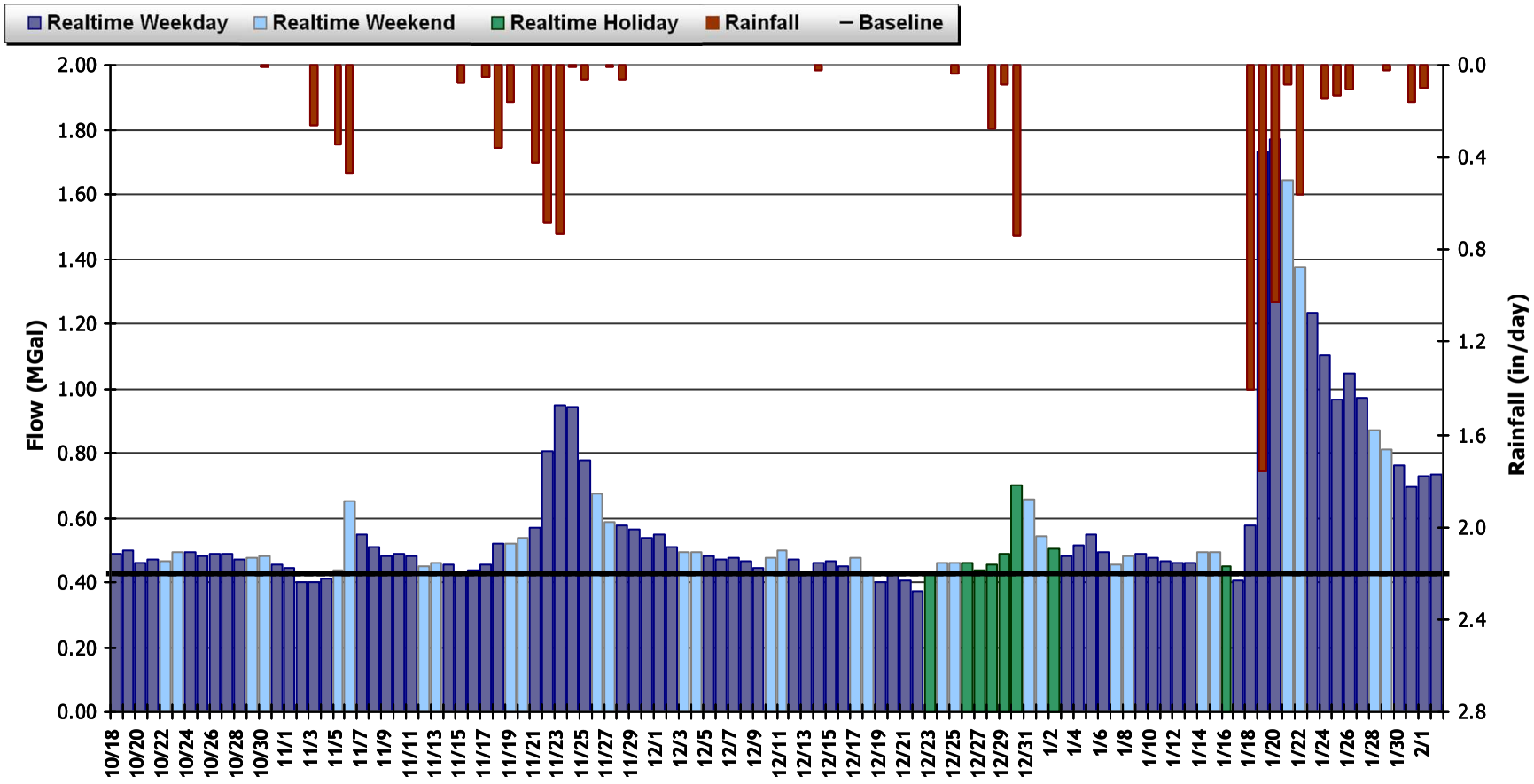


REDWOOD SD

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 0.583 MGal Peak Daily Flow: 1.77 MGal Min Daily Flow: 0.372 MGal

Total Period Rainfall: 10.38 inches

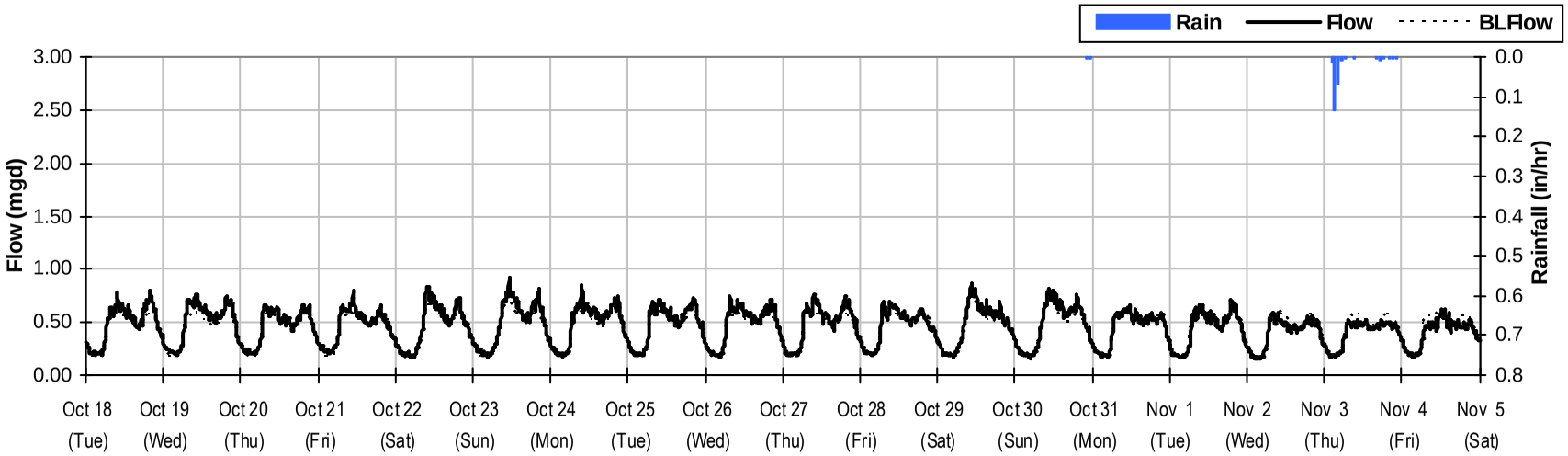


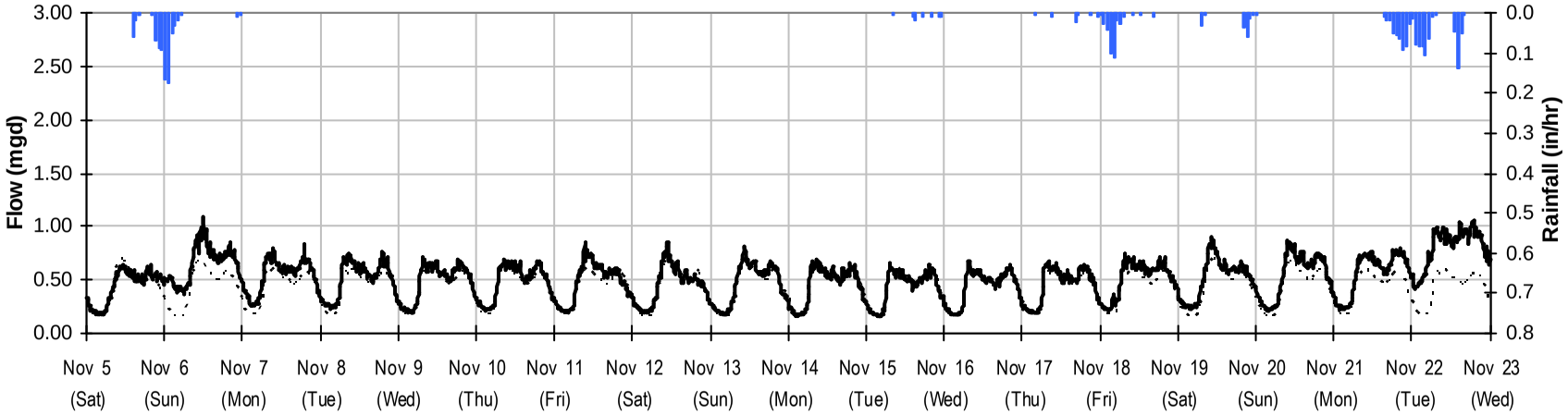
REDWOOD SD

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 0.489 mgd Peak Flow: 1.091 mgd Min Flow: 0.15 mgd

Total Period Rainfall: 2.84 inches



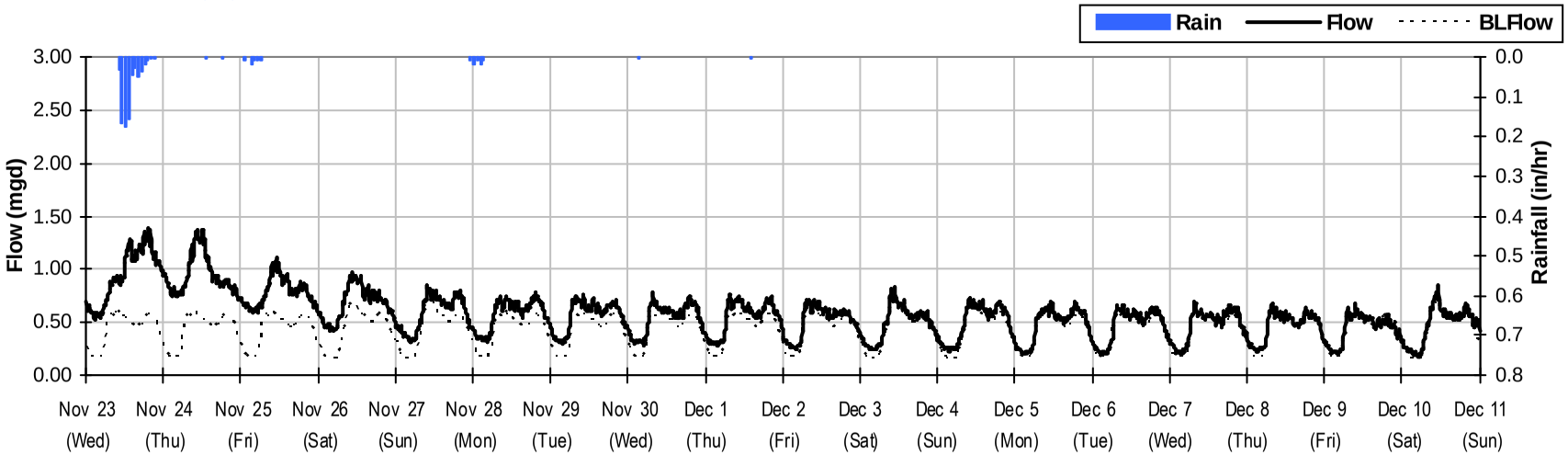


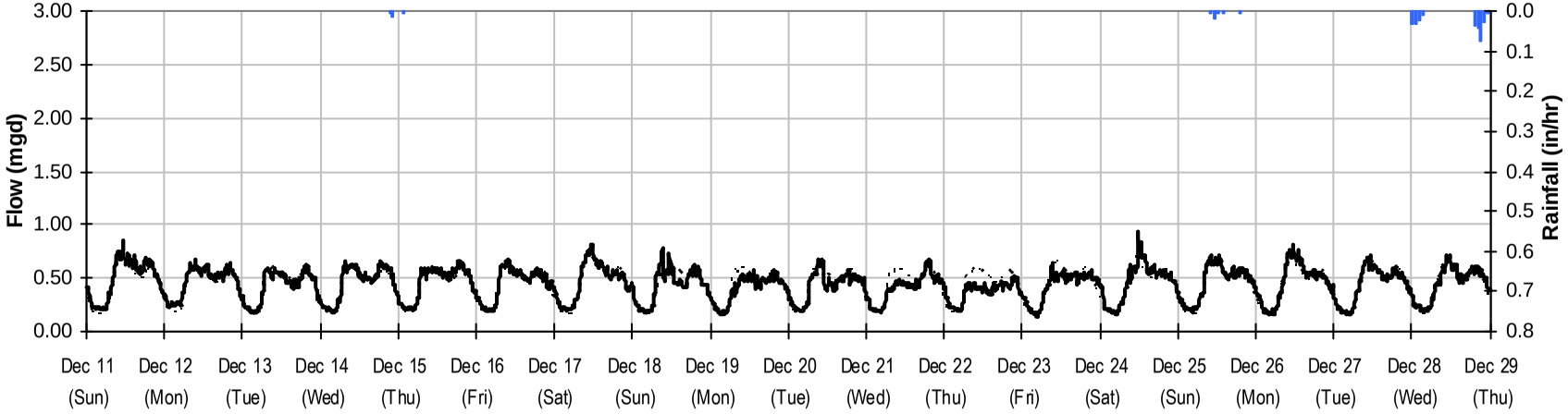
REDWOOD SD

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 0.512 mgd Peak Flow: 1.384 mgd Min Flow: 0.143 mgd

Total Period Rainfall: 1.21 inches



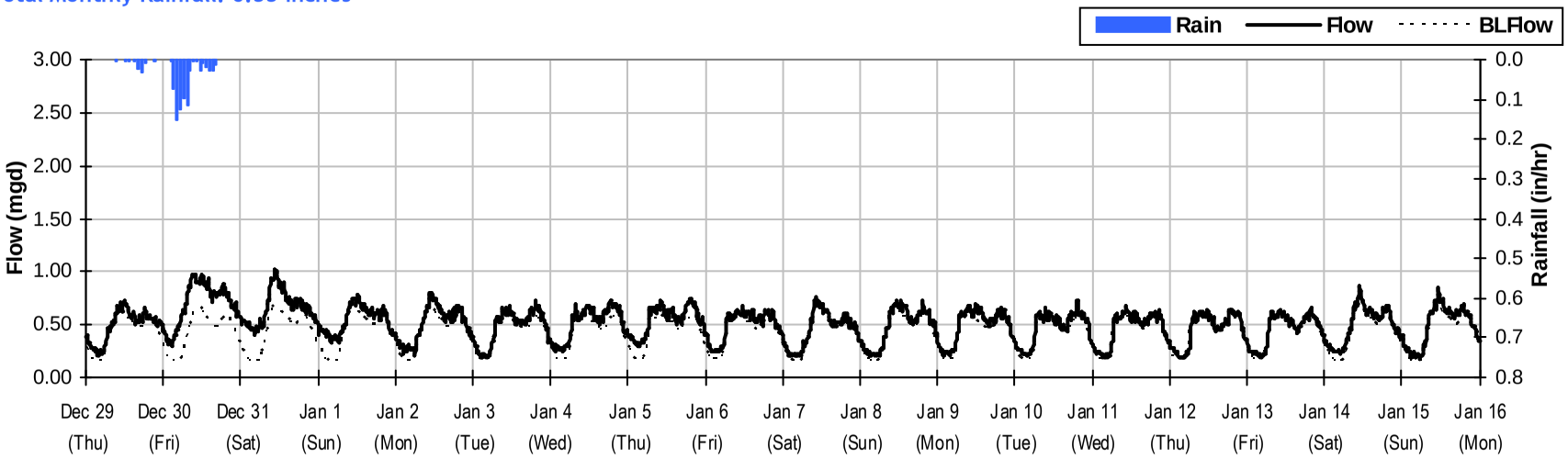


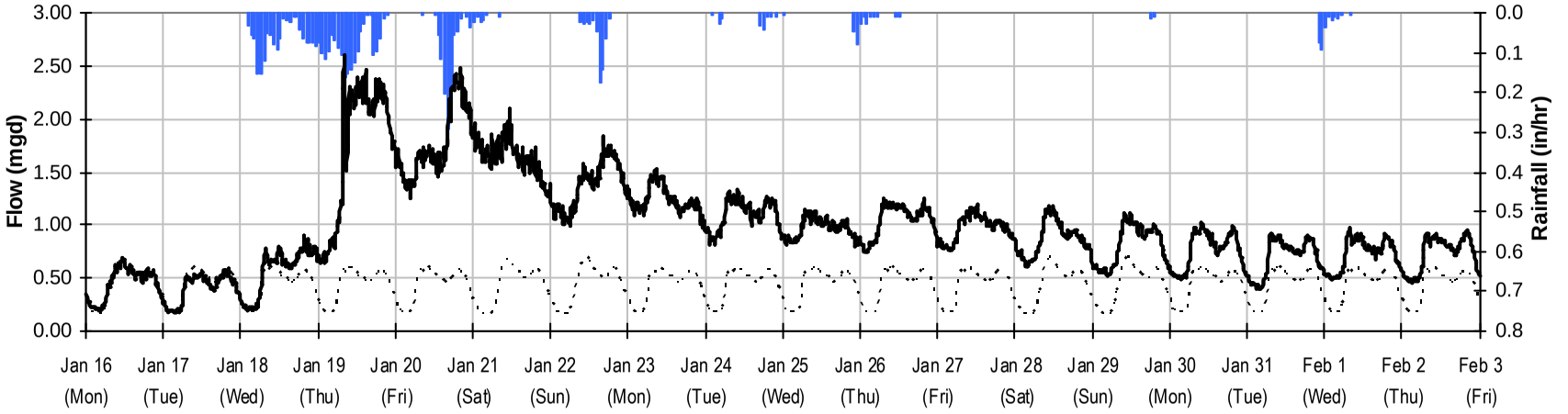
REDWOOD SD

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 0.75 mgd Peak Flow: 2.61 mgd Min Flow: 0.17 mgd

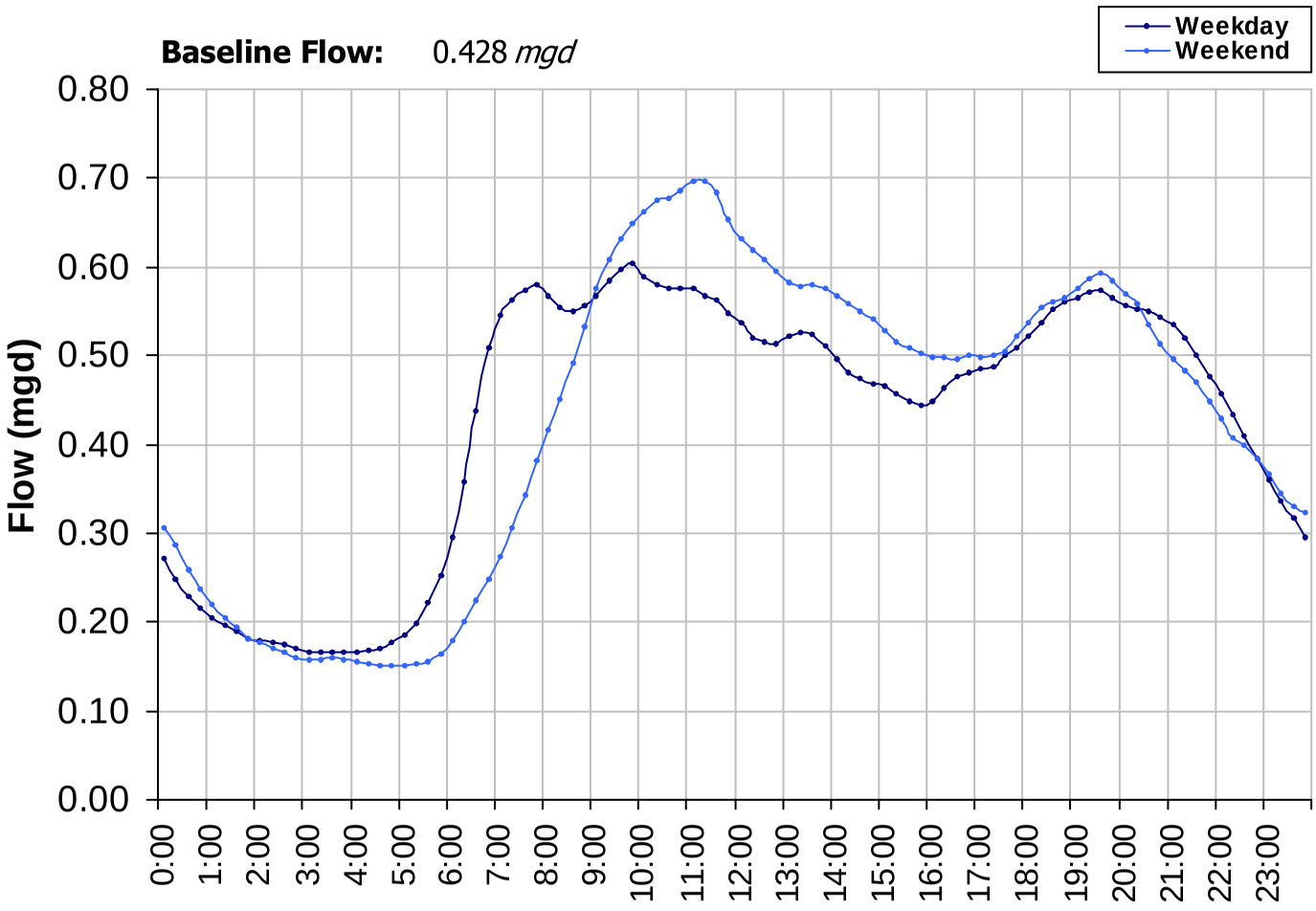
Total Monthly Rainfall: 6.33 inches





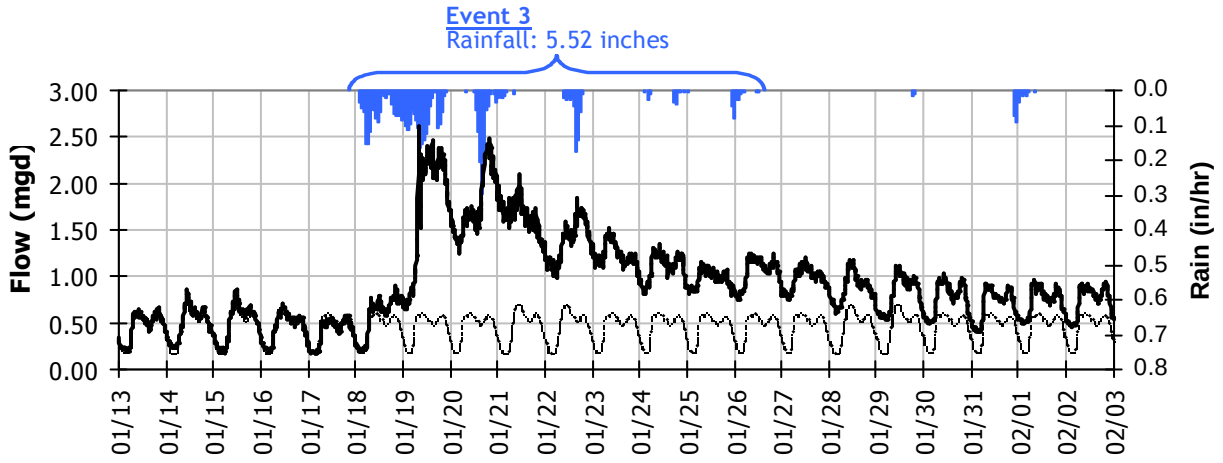
REDWOOD SD

Baseline Flow Hydrographs

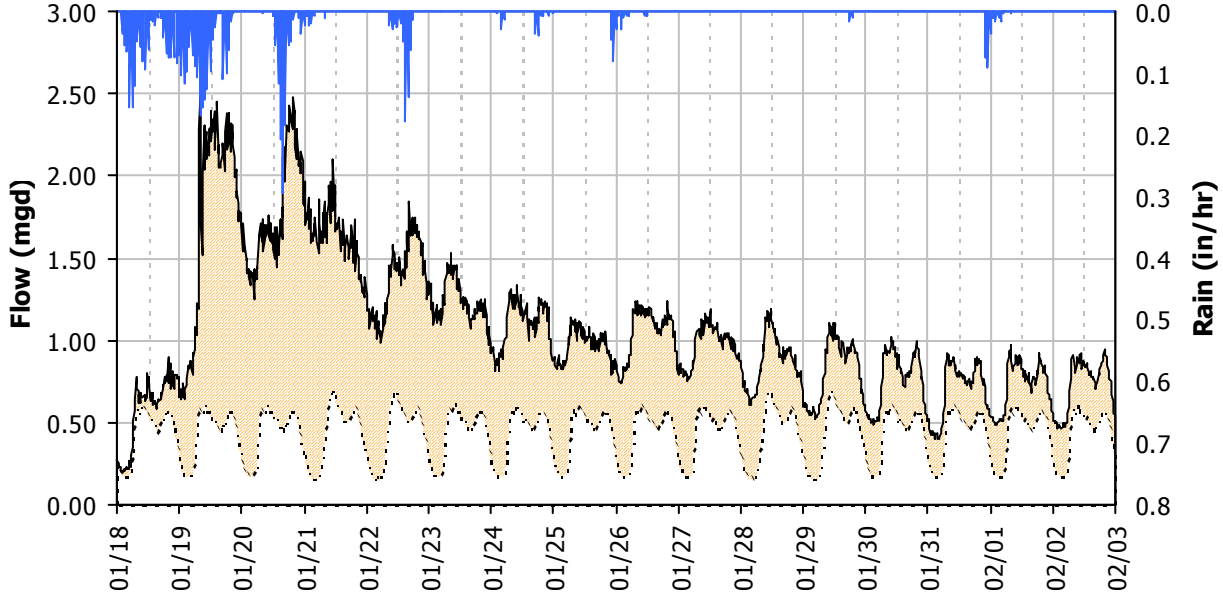


SITE REDWOOD SD
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph



Storm Event I/I Analysis (Rain = 5.52 inches)

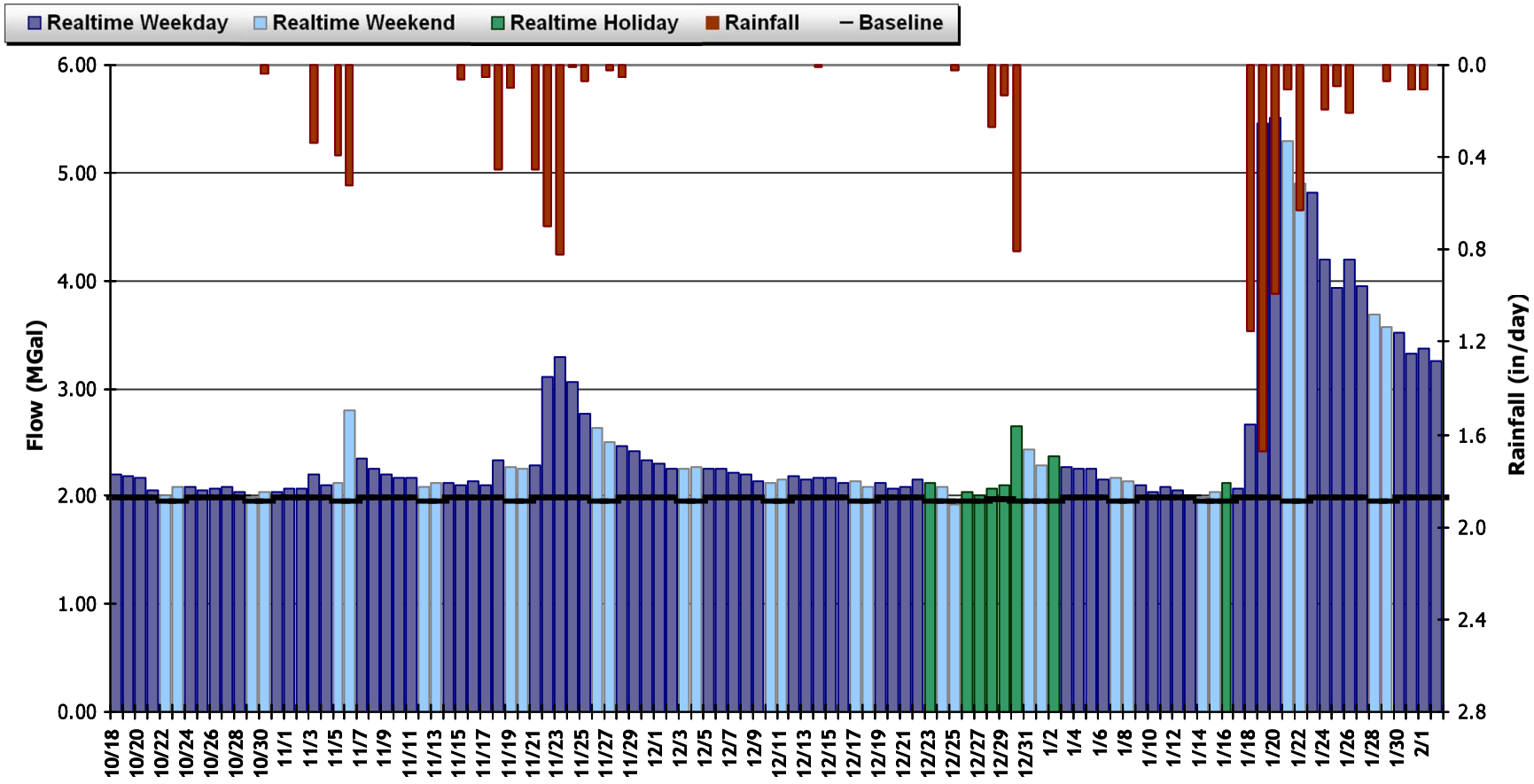
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	2.61	*mgd*	Peak I/I Rate:	2.05	*mgd*	Infiltration Rate: (1/30/2012)	0.334	*mgd*	Total I/I:	10,180,000	*gallons*
PF:	6.10		PkI/I:IDM:	6,444	*gpd/IDM*	RDI:IDM:	1,047	*gpd/IDM*	Total I/I:IDM:	5,784	*gal/IDM/in*
Peak Level:		*in*	PkI/I:Acre:	1,127	*gpd/acre*	RDI:Acre:	183	*gpd/acre*	R-Value:	3.7%	
d/D Ratio:			Pk I/I:ADWF:	4.80		RDI (% of BL):	78%		Total I/I:ADWF:	4.31	*per in-rain*

GRANTS PASS

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 2.488 MGal Peak Daily Flow: 5.51 MGal Min Daily Flow: 1.922 MGal

Total Period Rainfall: 10.66 inches

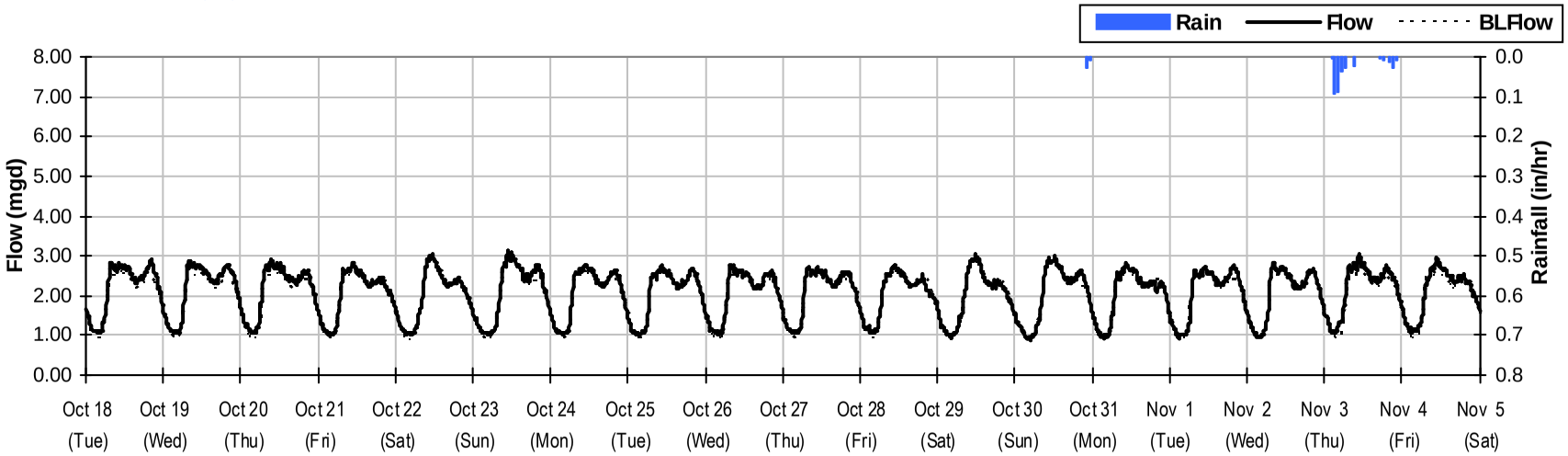


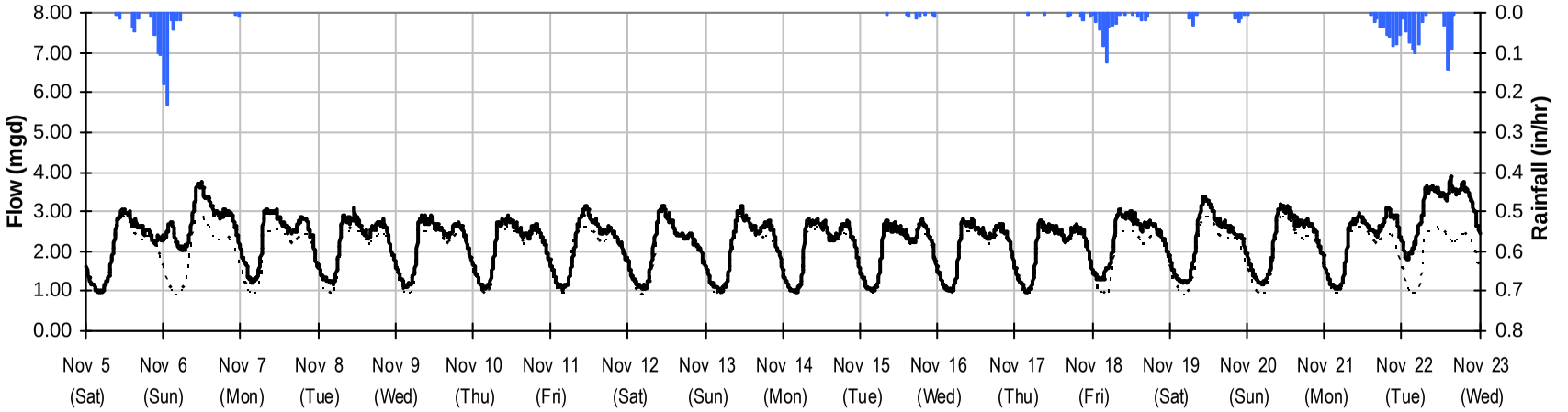
GRANTS PASS

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: 2.182 mgd Peak Flow: 3.882 mgd Min Flow: 0.888 mgd

Total Period Rainfall: 3.12 inches



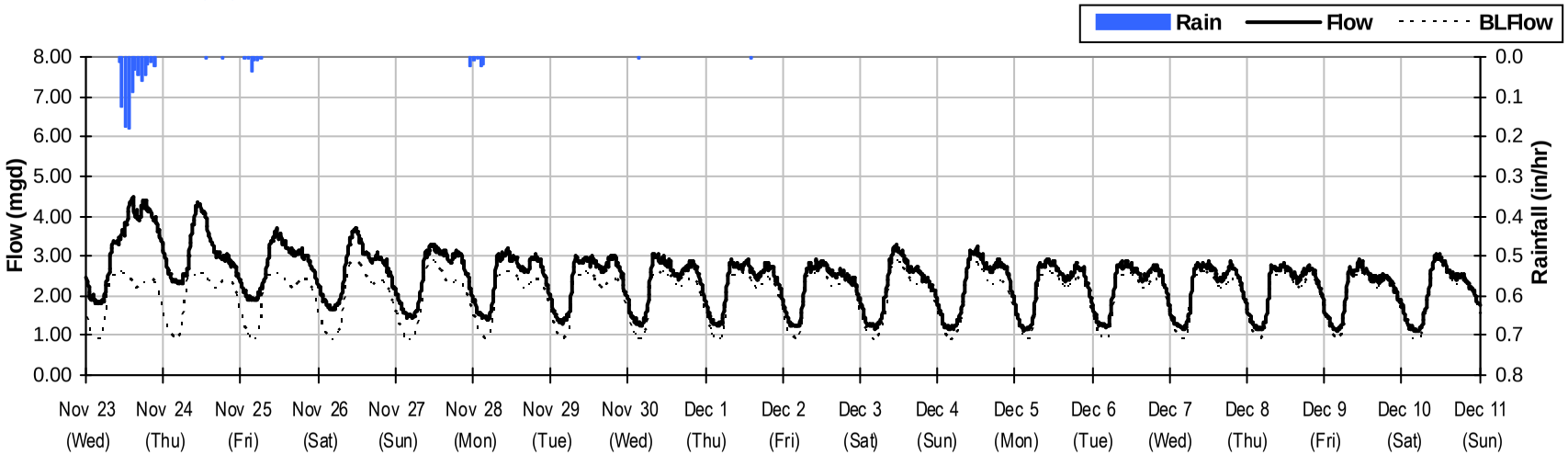


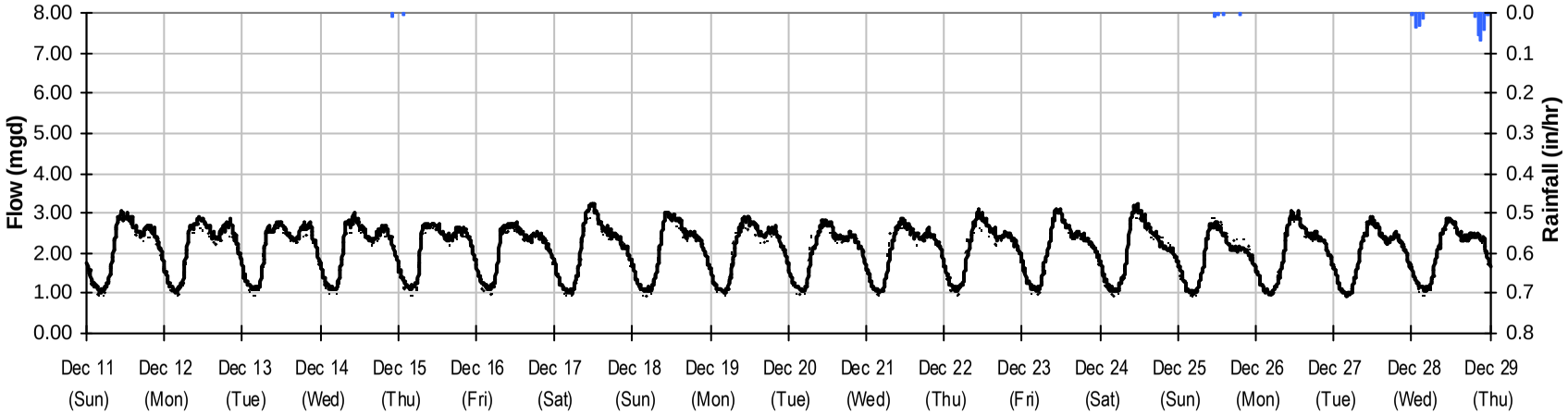
GRANTS PASS

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: 2.263 mgd Peak Flow: 4.481 mgd Min Flow: 0.92 mgd

Total Period Rainfall: 1.28 inches



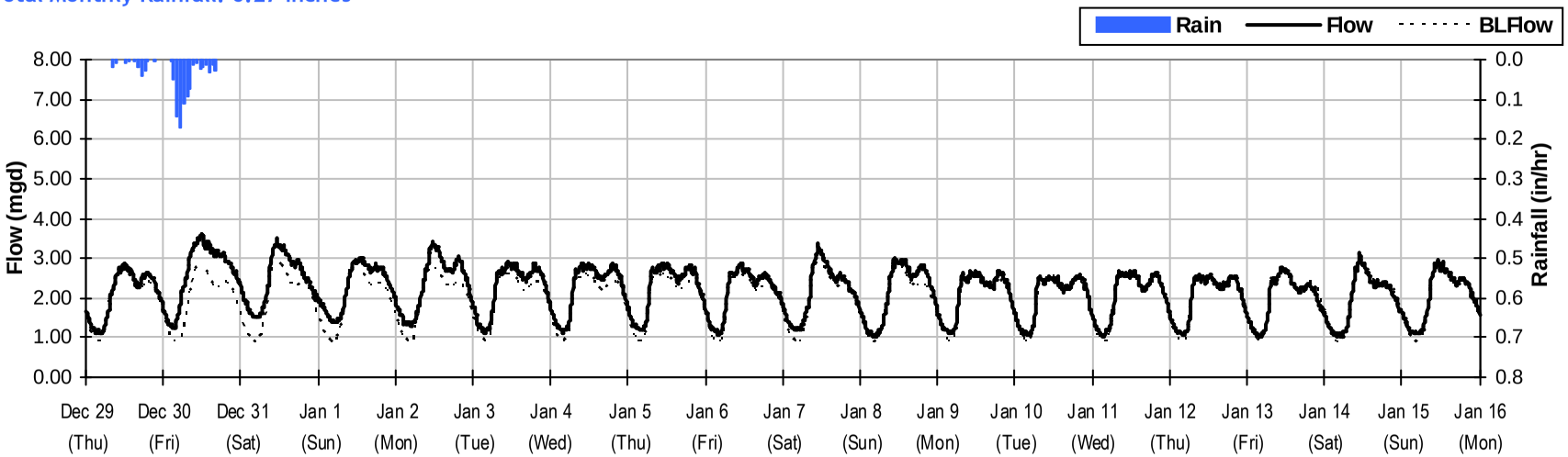


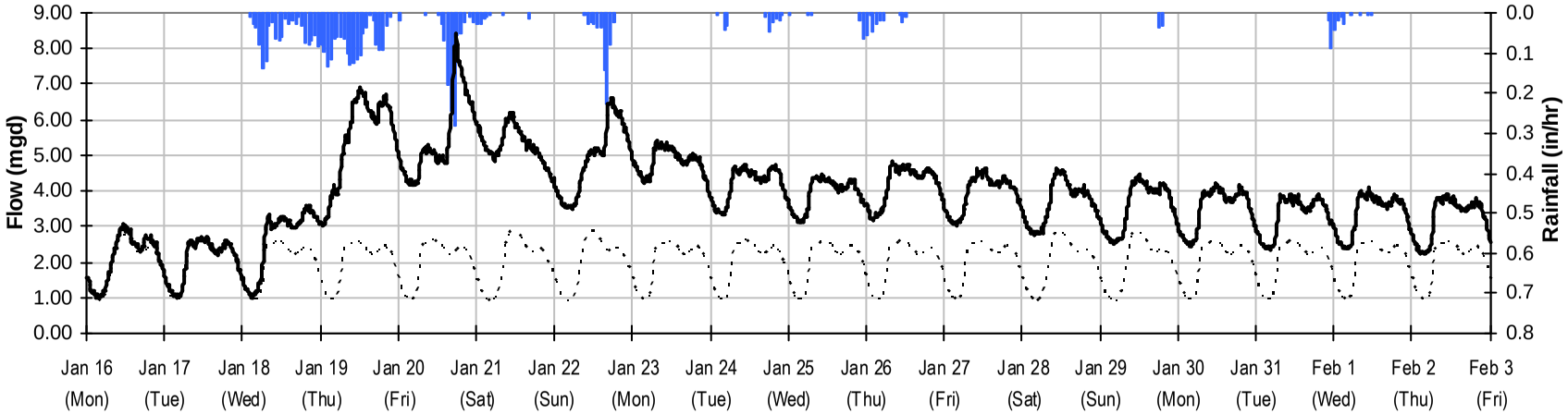
GRANTS PASS

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 3.03 mgd Peak Flow: 8.42 mgd Min Flow: 0.97 mgd

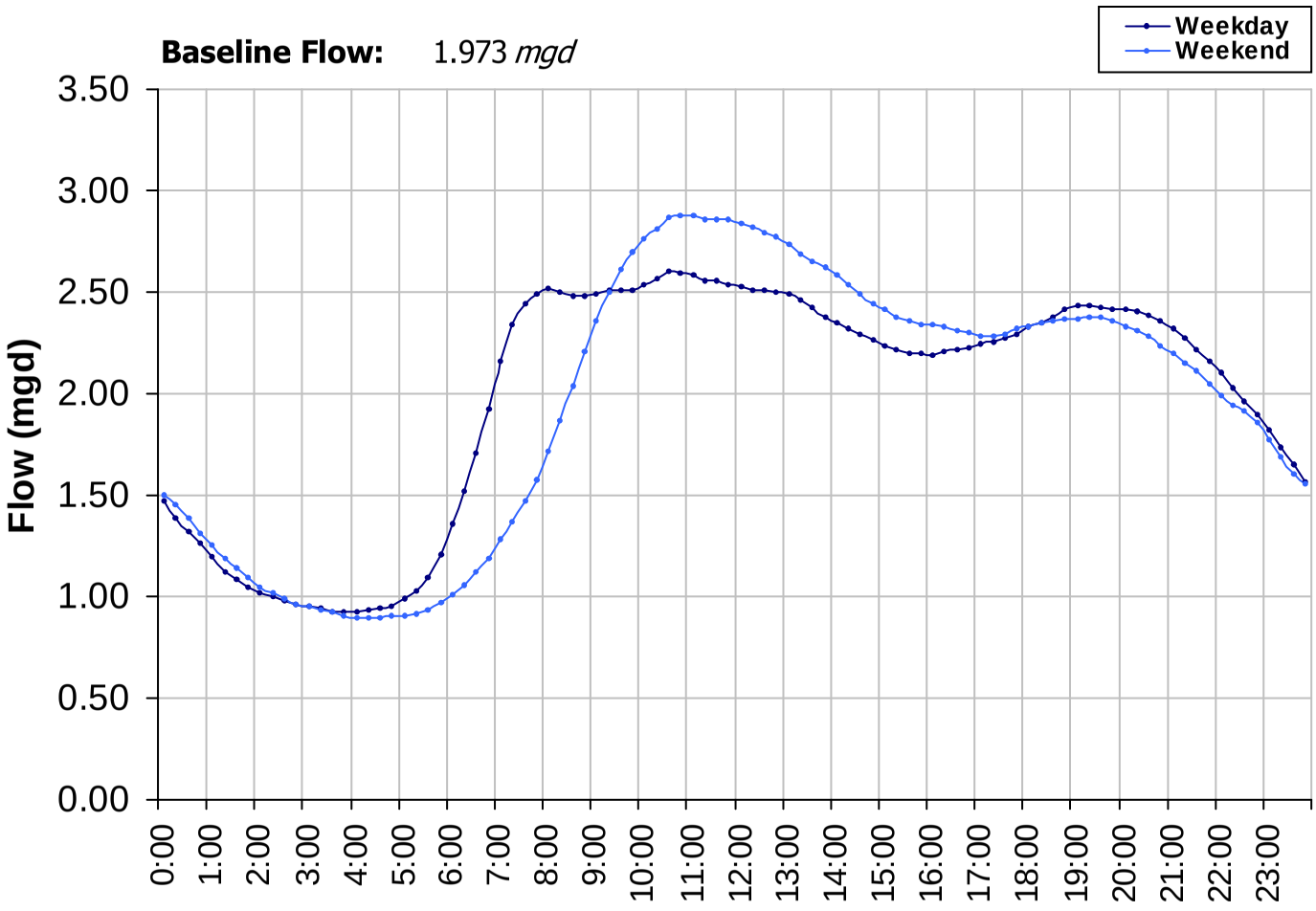
Total Monthly Rainfall: 6.27 inches





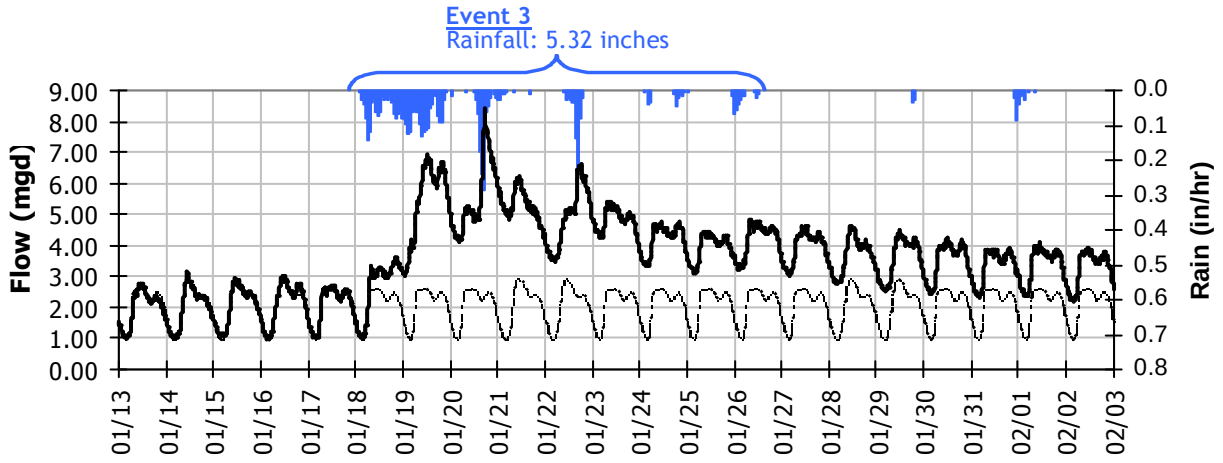
GRANTS PASS

Baseline Flow Hydrographs

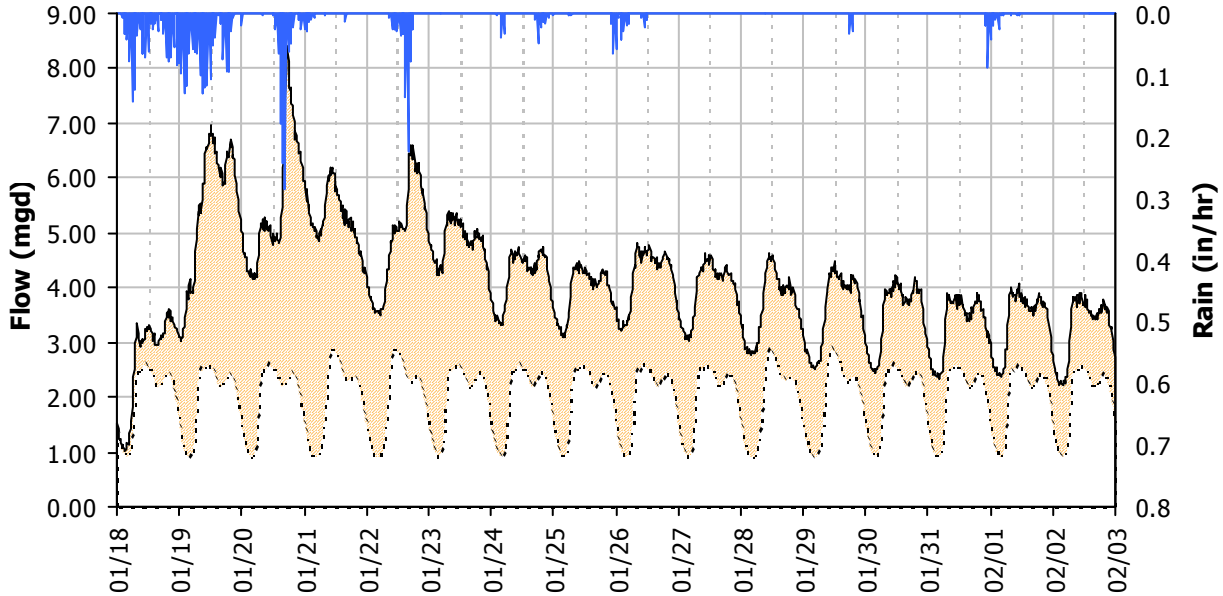


SITE GRANTS PASS
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph



Storm Event I/I Analysis (Rain = 5.32 inches)

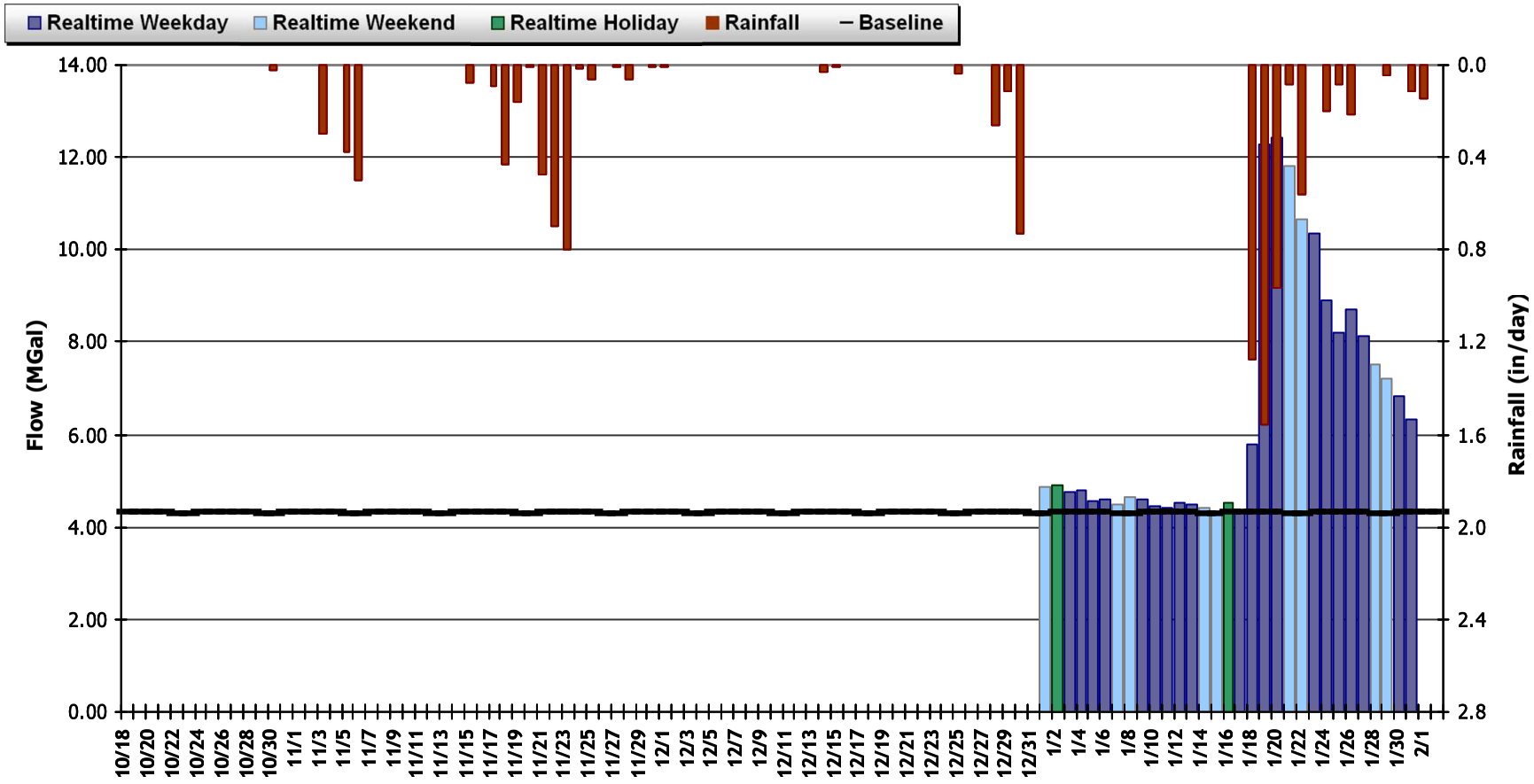
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	8.42	*mgd*	Peak I/I Rate:	6.13	*mgd*	Infiltration Rate: (1/30/2012)	1.533	*mgd*	Total I/I:	34,028,000	*gallons*
PF:	4.27		PkI/I:IDM:	6,919	*gpd/IDM*	RDI:IDM:	1,730	*gpd/IDM*	Total I/I:IDM:	7,223	*gal/IDM/in*
Peak Level:		*in*	PkI/I:Acre:	1,170	*gpd/acre*	RDI:Acre:	293	*gpd/acre*	R-Value:	4.5%	
d/D Ratio:			Pk I/I:ADWF:	3.11		RDI (% of BL):	77%		Total I/I:ADWF:	3.24	*per in-rain*

TOTAL SYSTEM

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 6.543 MGal Peak Daily Flow: 12.441 MGal Min Daily Flow: 4.315 MGal

Total Period Rainfall: 10.53 inches

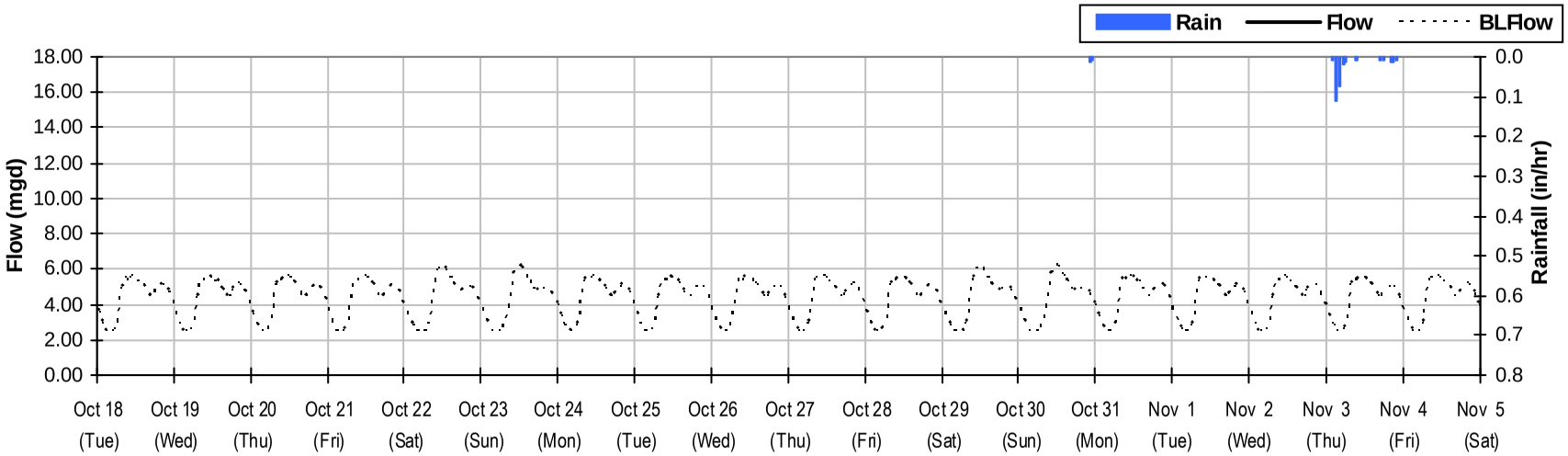


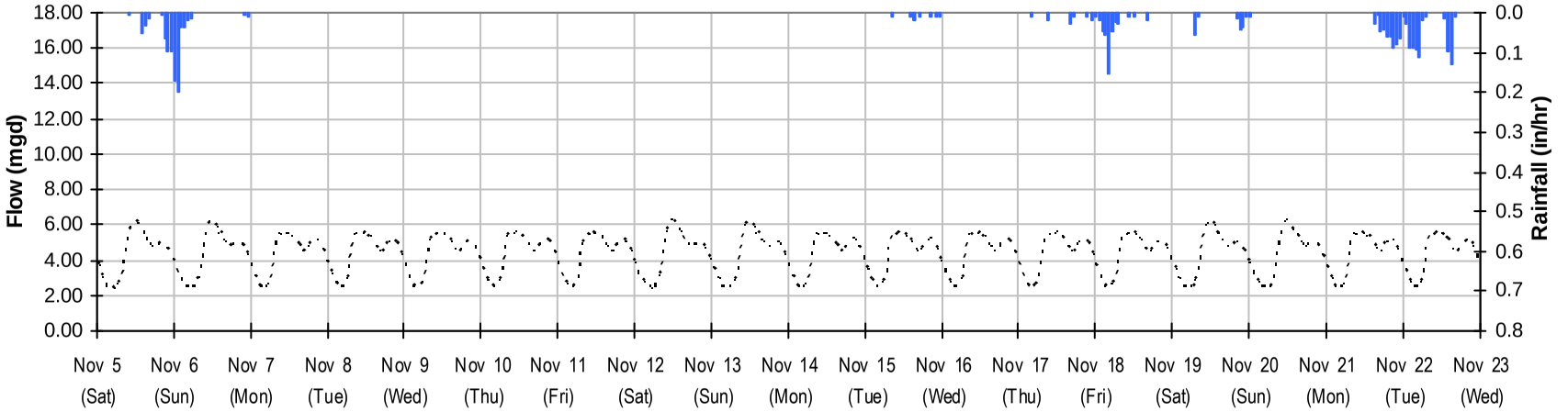
TOTAL SYSTEM

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: mgd Peak Flow: mgd Min Flow: mgd

Total Period Rainfall: 3.15 inches



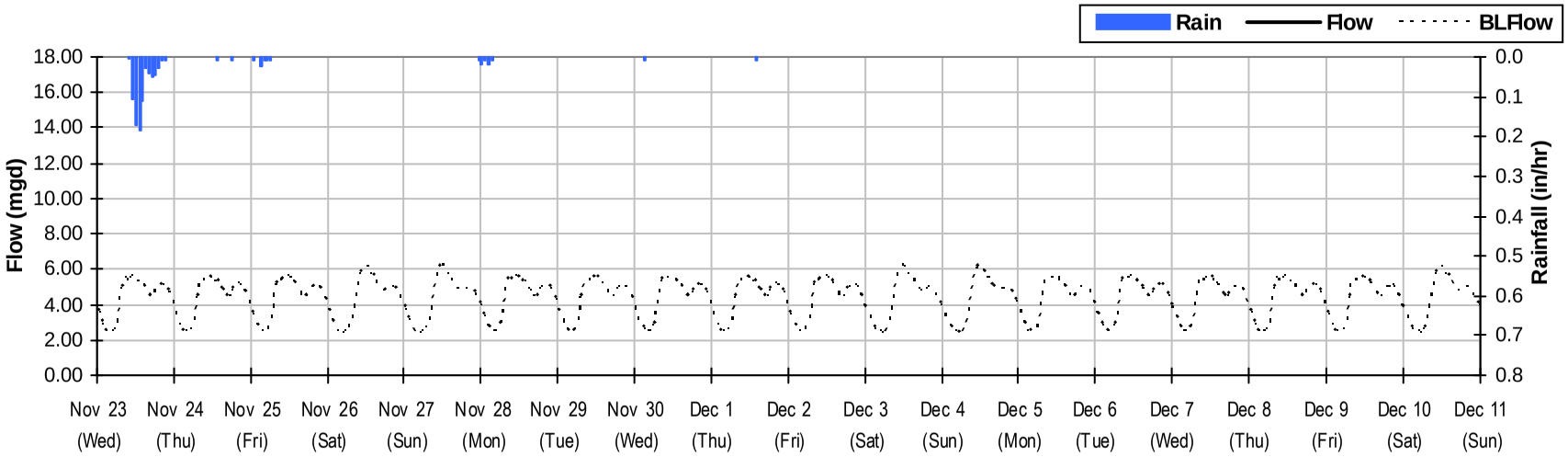


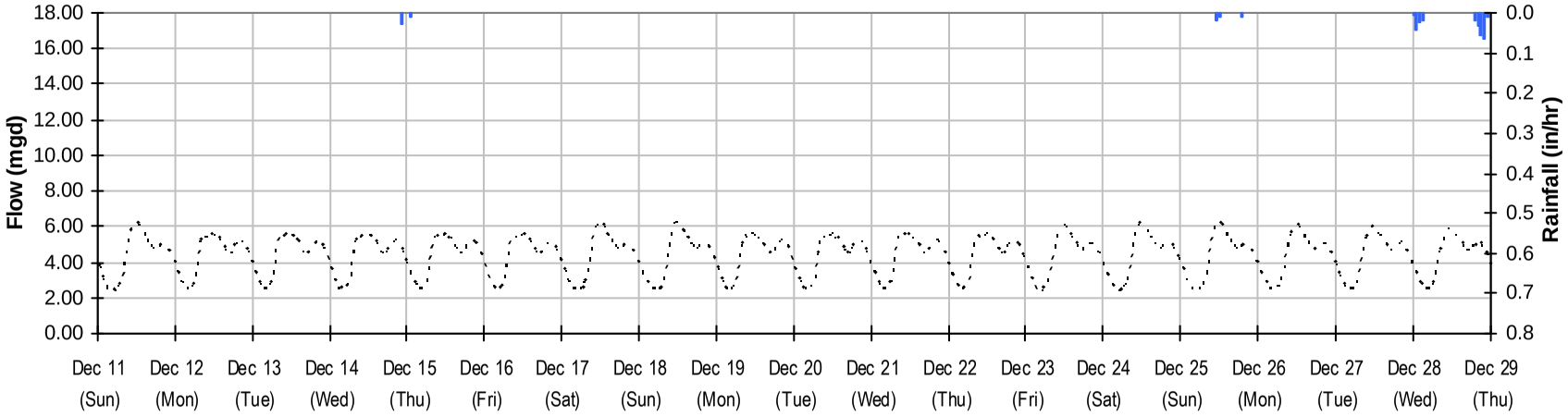
TOTAL SYSTEM

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: mgd Peak Flow: mgd Min Flow: mgd

Total Period Rainfall: 1.3 inches



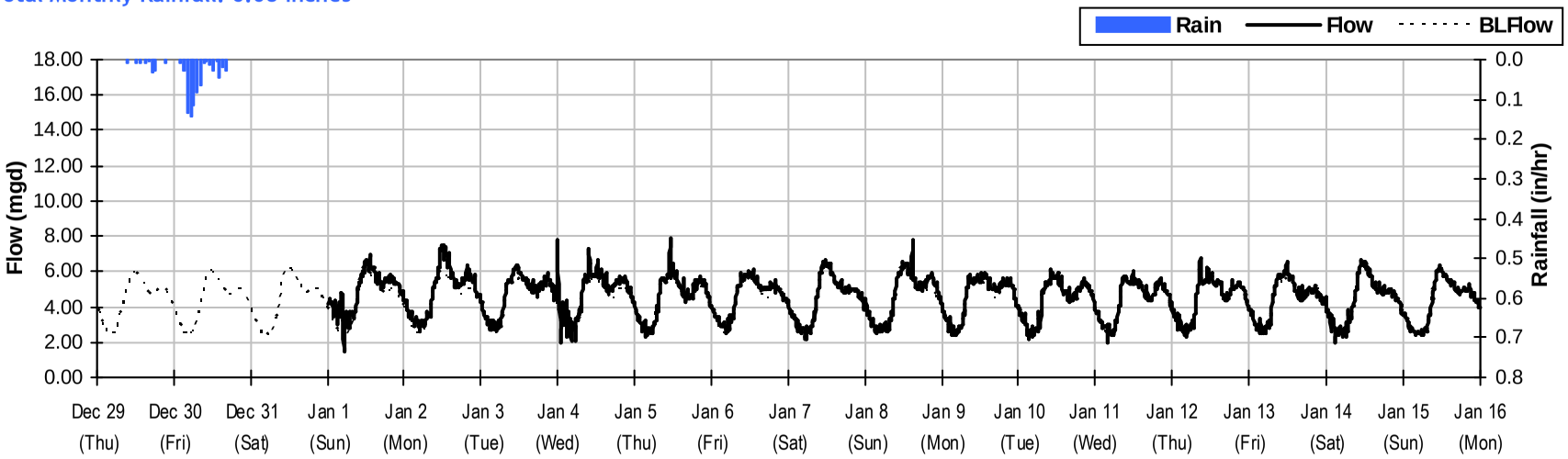


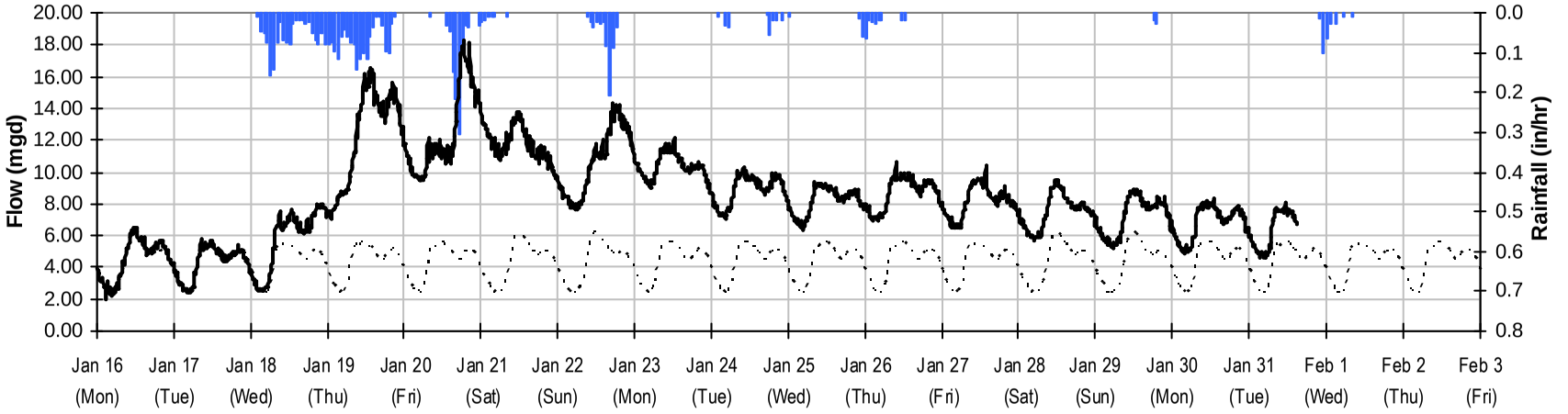
TOTAL SYSTEM

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 6.55 mgd Peak Flow: 18.23 mgd Min Flow: 1.49 mgd

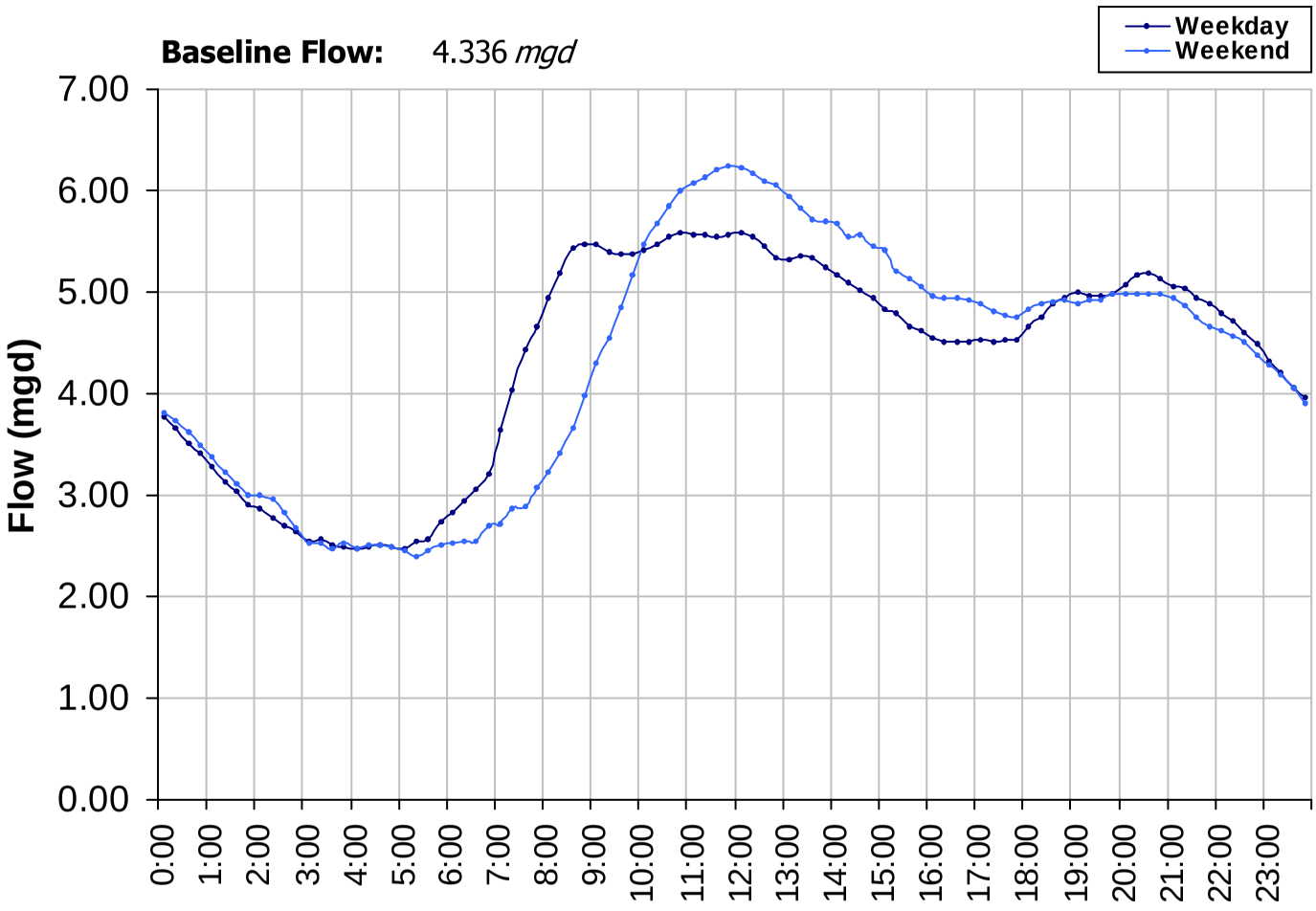
Total Monthly Rainfall: 6.08 inches





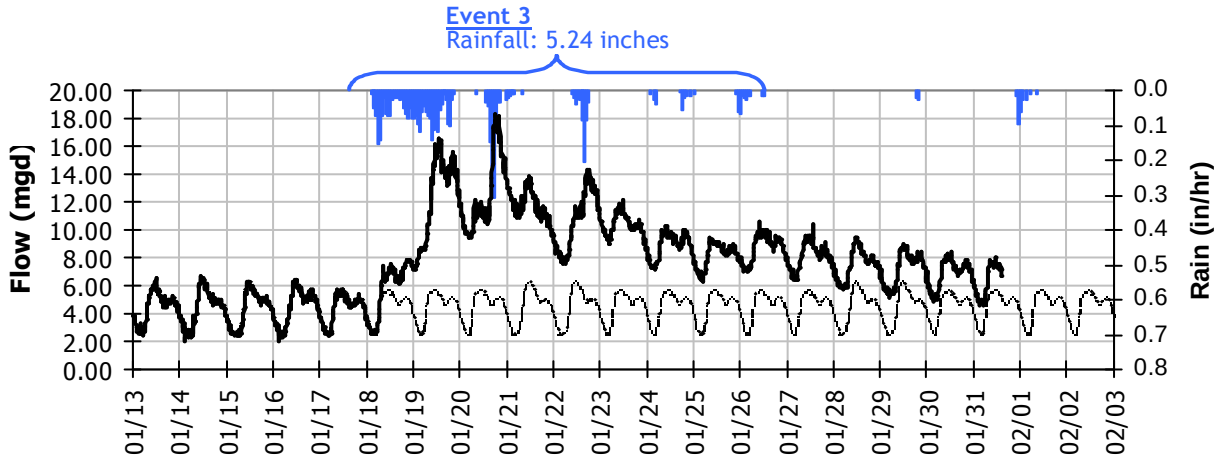
TOTAL SYSTEM

Baseline Flow Hydrographs

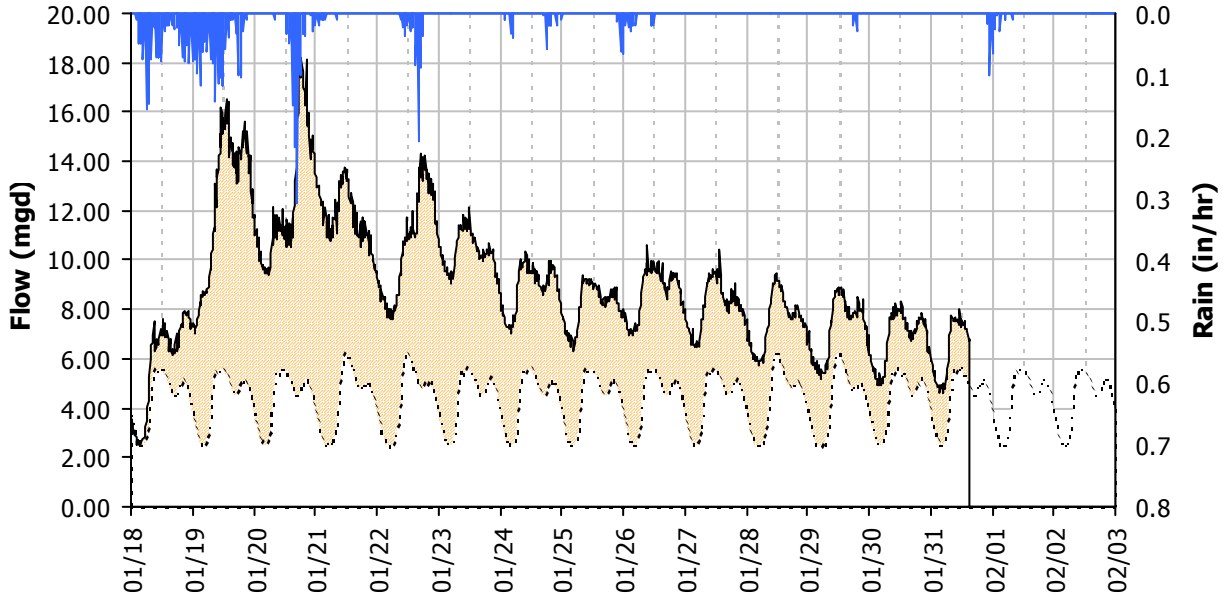


SITE TOTAL SYSTEM
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 3 Detail Graph



Storm Event I/I Analysis (Rain = 5.24 inches)

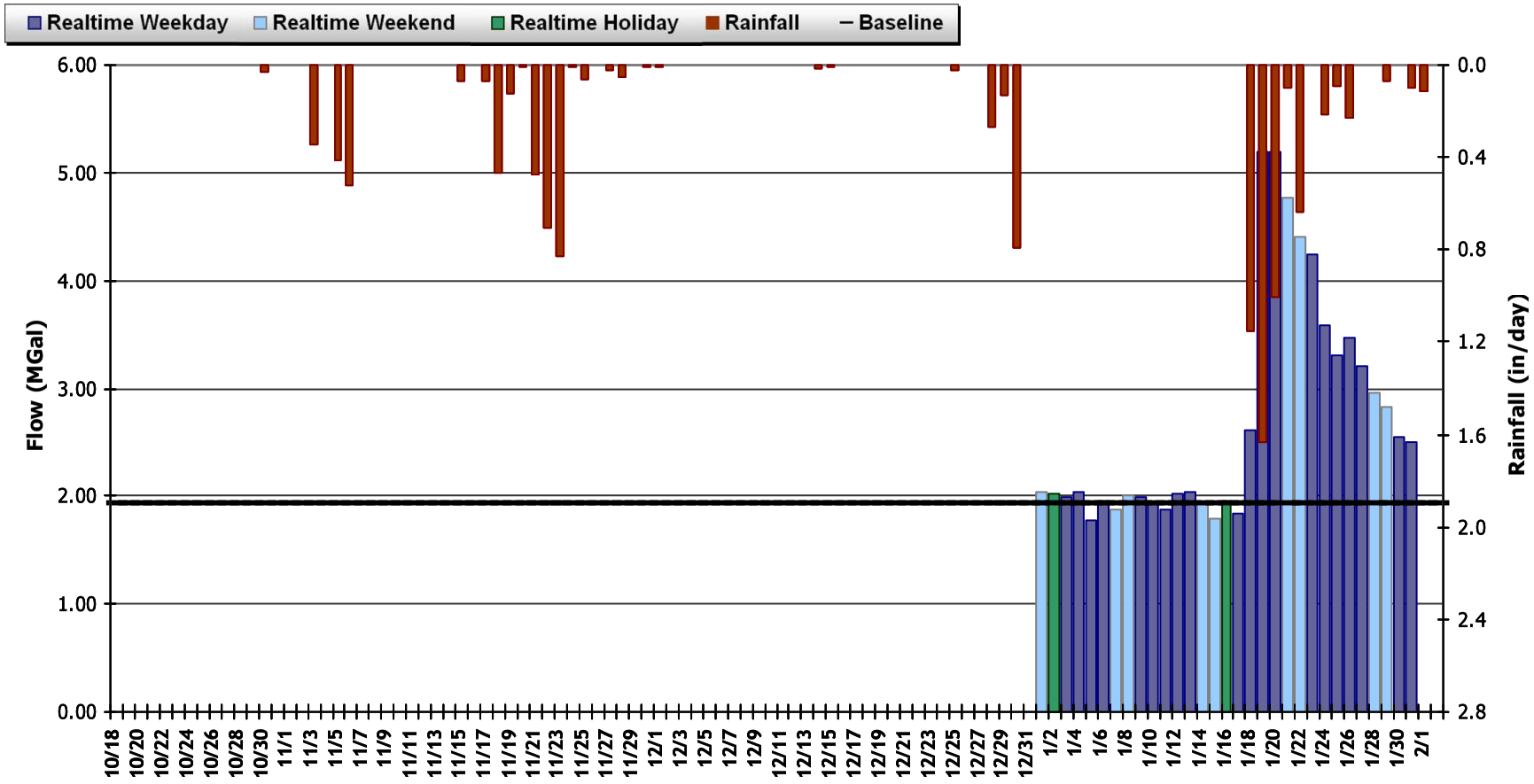
Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	18.23	*mgd*	Peak I/I Rate:	13.35	*mgd*	Infiltration Rate: (1/30/2012)	2.492	*mgd*	Total I/I:	63,842,000	*gallons*
PF:	4.20		PkI/I:IDM:	8,046	*gpd/IDM*	RDI:IDM:	1,503	*gpd/IDM*	Total I/I:IDM:	7,343	*gal/IDM/in*
Peak Level:		*in*	PkI/I:Acre:	1,517	*gpd/acre*	RDI:Acre:	283	*gpd/acre*	R-Value:	5.1%	
d/D Ratio:			Pk I/I:ADWF:	3.08		RDI (% of BL):	57%		Total I/I:ADWF:	2.81	*per in-rain*

UNMONITORED BASINS

Period Flow Summary: Daily Flow Totals

Avg Daily Flow: 2.706 MGal Peak Daily Flow: 5.197 MGal Min Daily Flow: 1.775 MGal

Total Period Rainfall: 10.8 inches

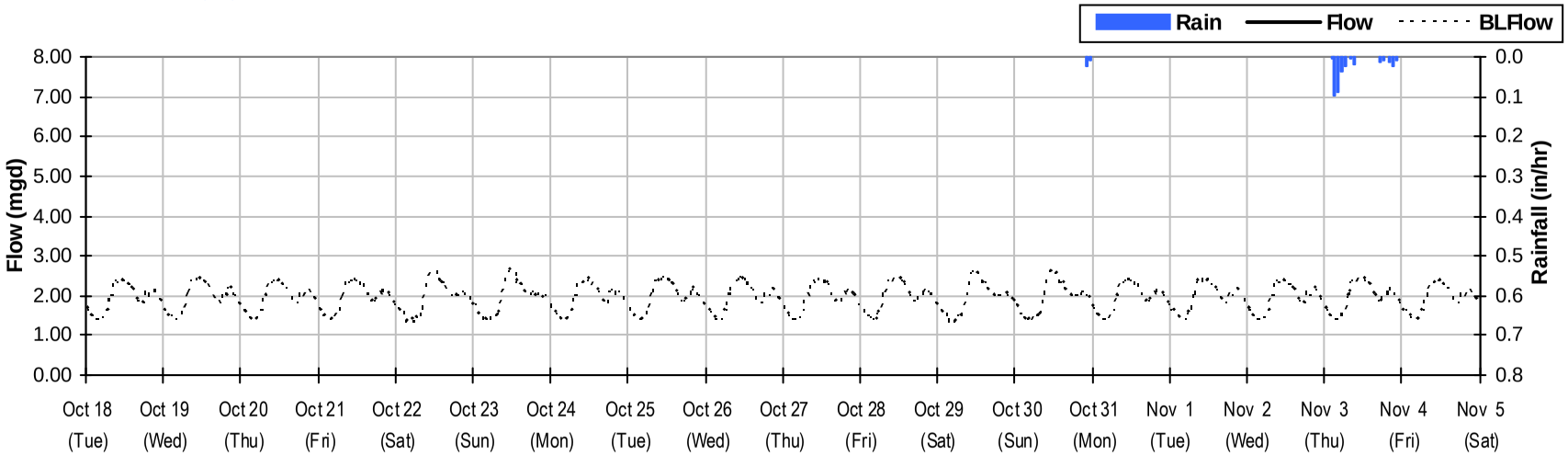


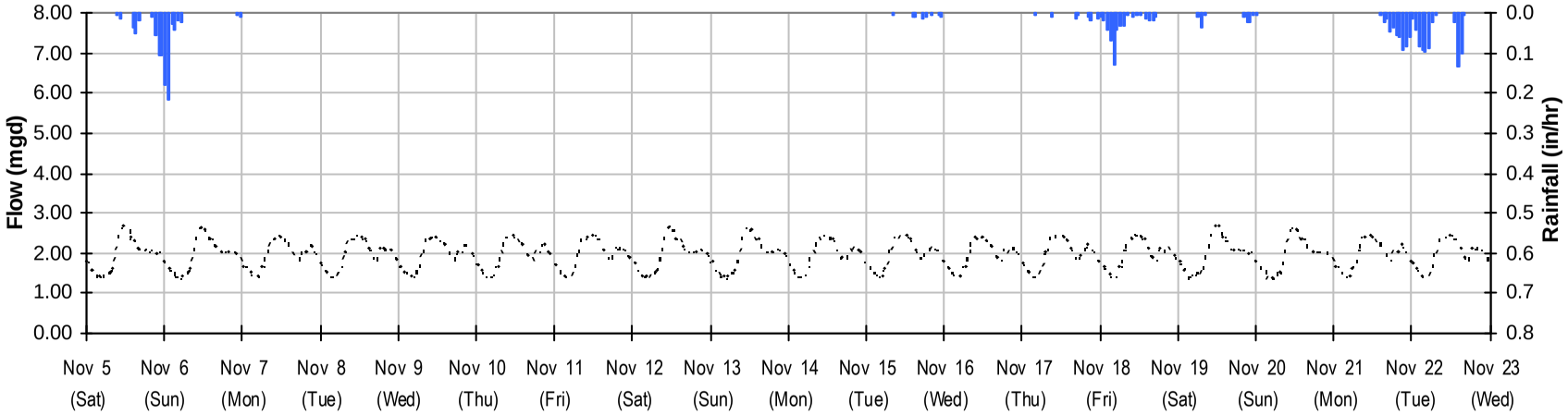
UNMONITORED BASINS

Period Flow Summary: October 18 to November 22, 2011

Avg Flow: mgd Peak Flow: mgd Min Flow: mgd

Total Period Rainfall: 3.23 inches



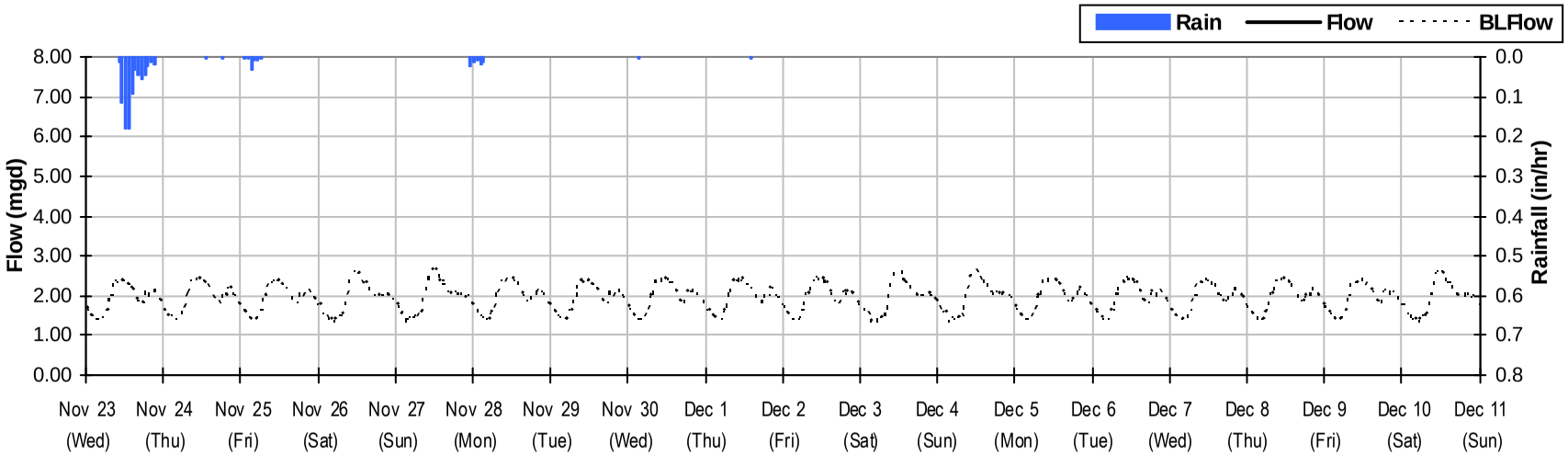


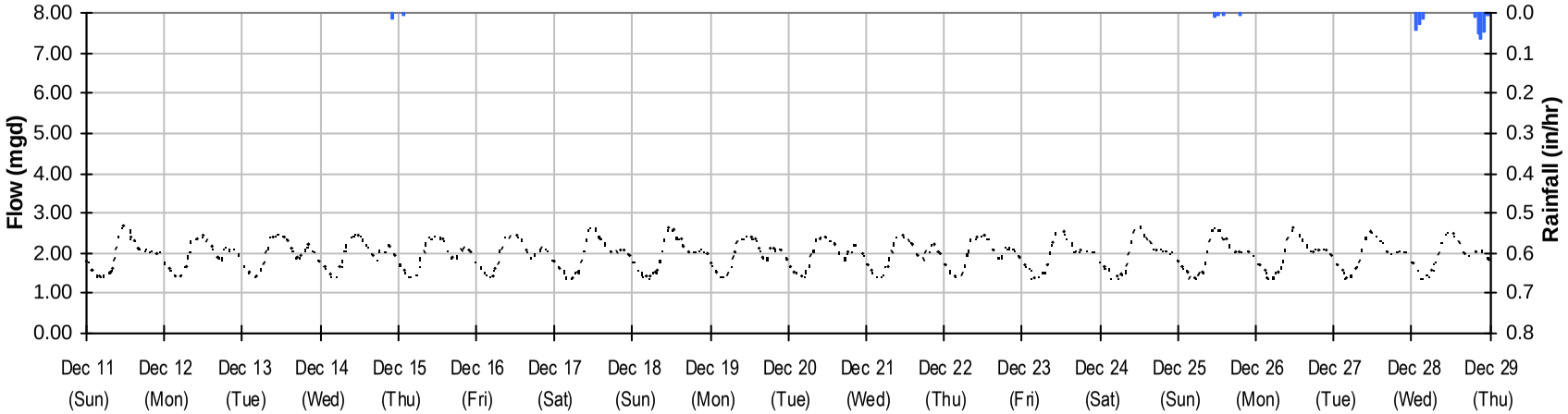
UNMONITORED BASINS

Period Flow Summary: November 23 to December 29, 2011

Avg Flow: mgd Peak Flow: mgd Min Flow: mgd

Total Period Rainfall: 1.29 inches



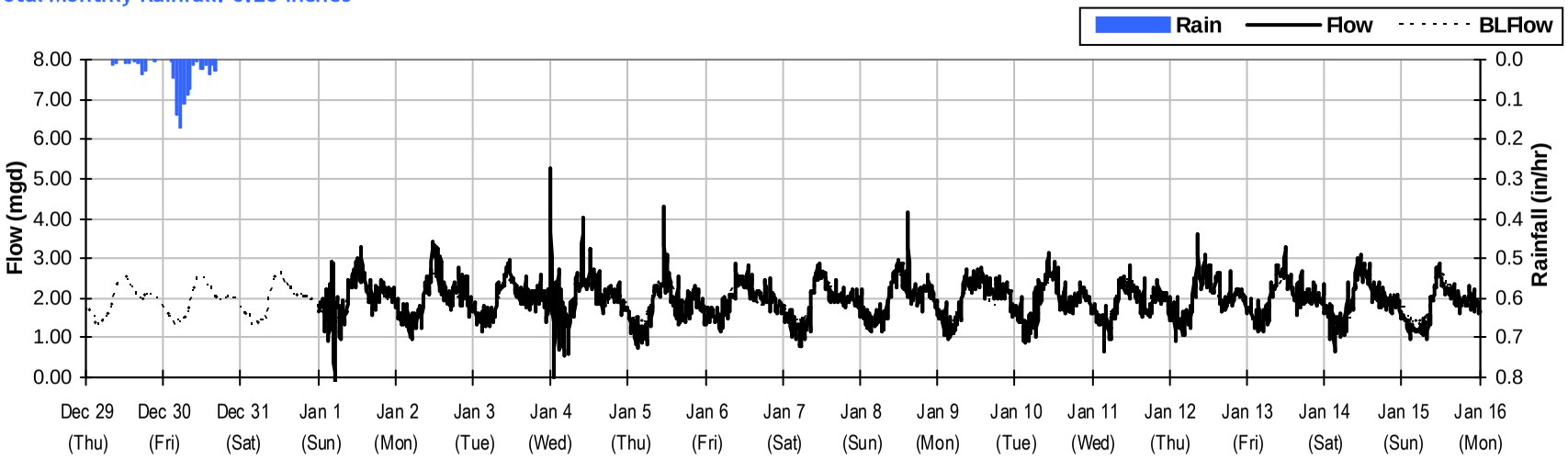


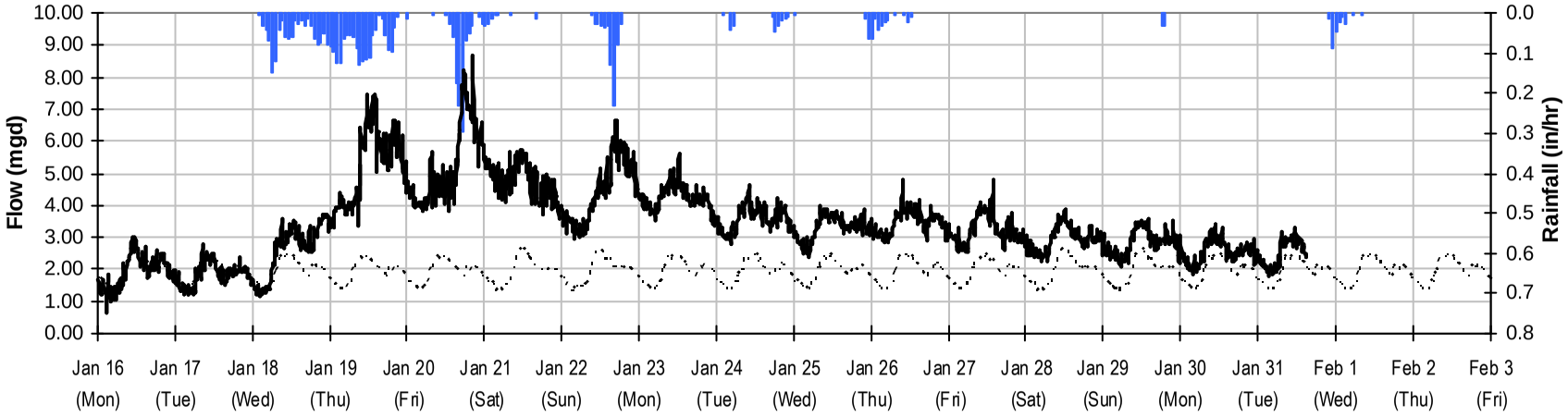
UNMONITORED BASINS

Period Flow Summary: December 29, 2011 to February 3, 2012

Avg Flow: 2.71 mgd Peak Flow: 8.66 mgd Min Flow: -0.27 mgd

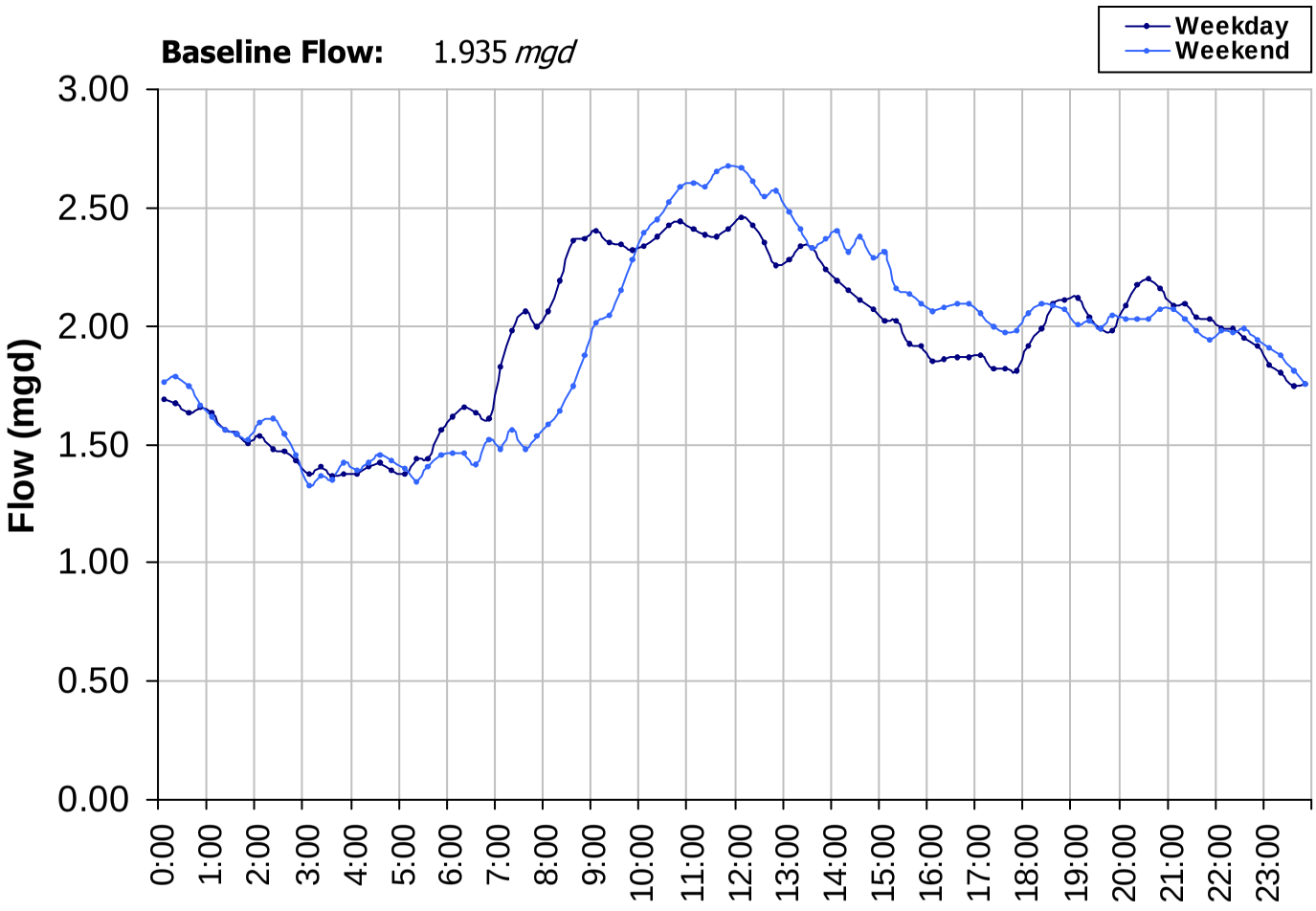
Total Monthly Rainfall: 6.28 inches





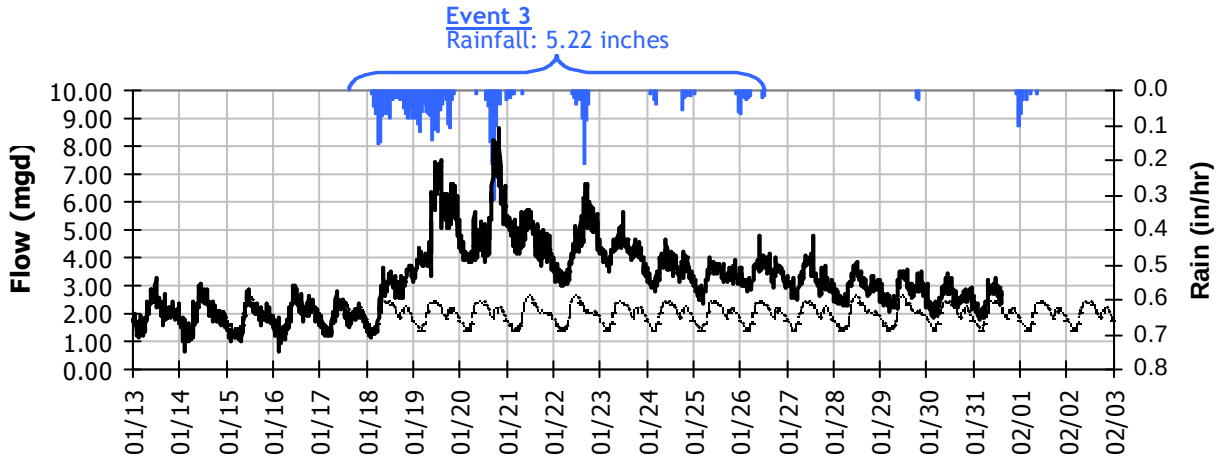
UNMONITORED BASINS

Baseline Flow Hydrographs

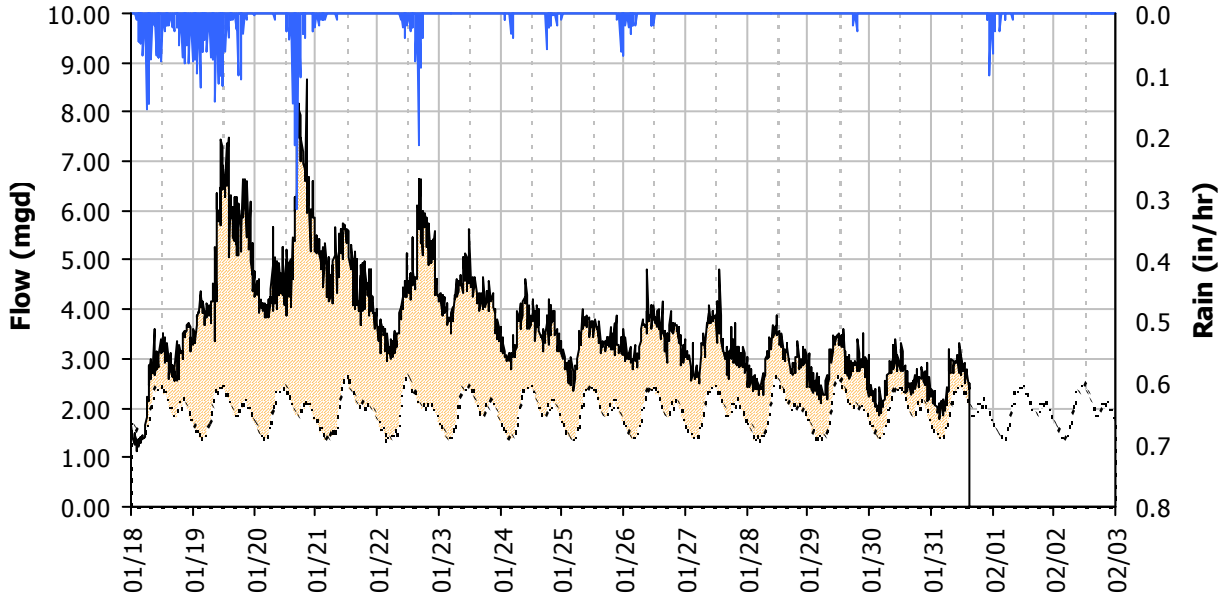


SITE UNMONITORED BASINS
I/I Summary: Event 3

Baseline and Realtime Flows with Rainfall Data over Monitoring Period

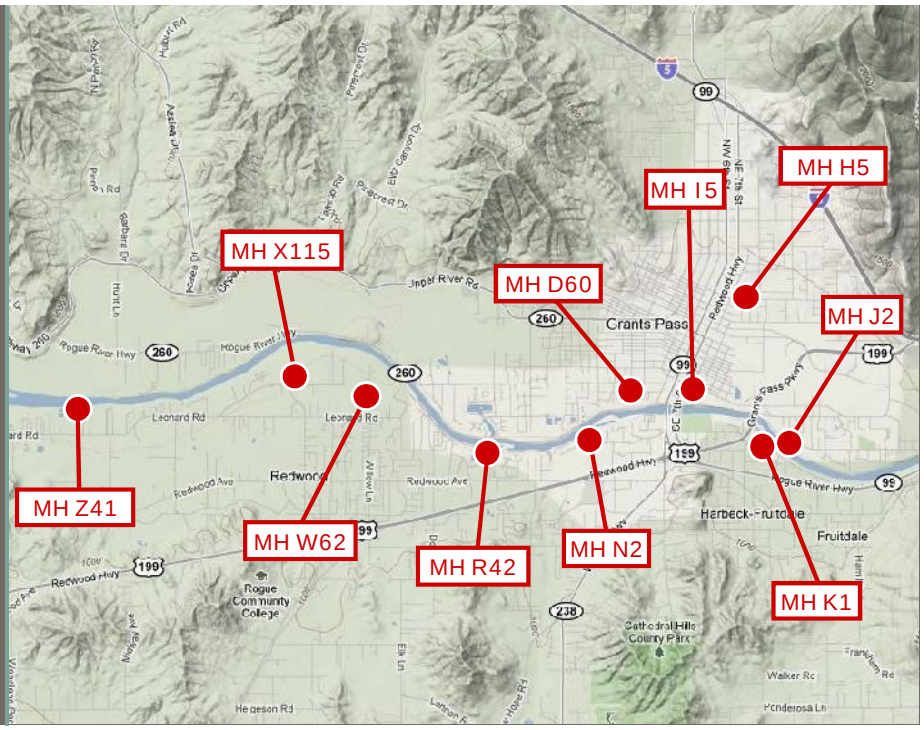


Event 3 Detail Graph



Storm Event I/I Analysis (Rain = 5.22 inches)

Capacity			Inflow			RDI (infiltration)			Combined I/I		
Peak Flow:	8.66	*mgd*	Peak I/I Rate:	6.46	*mgd*	Infiltration Rate: (1/30/2012)	0.621	*mgd*	Total I/I:	23,542,000	*gallons*
PF:	4.47		PkI/I:IDM:	14,221	*gpd/IDM*	RDI:IDM:	1,368	*gpd/IDM*	Total I/I:IDM:	9,925	*gal/IDM/in*
Peak Level:		*in*	PkI/I:Acre:	3,715	*gpd/acre*	RDI:Acre:	357	*gpd/acre*	R-Value:	9.5%	
d/D Ratio:			Pk I/I:ADWF:	3.34		RDI (% of BL):	32%		Total I/I:ADWF:	2.33	*per in-rain*



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APPENDIX B – DRY WEATHER FLOW CALIBRATION

Table 1 Dry Weather Flow Calibration Results
Flow Monitoring Program and Hydraulic Model Update
City of Grants Pass

		Weekday Dry Weather Flow												Weekend Dry Weather Flow												Average Dry Weather Flow[4]		
		Measured Data[1]				Modeled Data[2]				Percent Error[3]				Measured Data[1]				Modeled Data[2]				Percent Error[3]						
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Measured ADWF (mgd)	Modeled ADWF (mgd)	Percent Difference (%)
D60	20.5	0.611	0.802	3.80	3.4	0.620	0.835	3.74	3.4	1.5%	4.1%	-1.7%	0.7%	0.609	0.886	3.82	3.3	0.626	0.927	3.74	3.4	2.8%	4.6%	-2.3%	1.6%	0.611	0.622	1.9%
H5	12	0.264	0.360	2.13	3.5	0.266	0.370	2.07	3.6	0.7%	2.8%	-2.8%	2.6%	0.268	0.376	2.12	3.5	0.269	0.374	2.07	3.6	0.2%	-0.6%	-2.4%	2.1%	0.265	0.267	0.5%
I5	15	0.312	0.408	1.70	4.3	0.317	0.407	1.77	4.1	1.3%	-0.2%	4.2%	-4.0%	0.288	0.392	1.68	4.1	0.292	0.395	1.73	3.9	1.3%	0.6%	2.9%	-3.8%	0.305	0.309	1.3%
J2	18	0.333	0.466	1.34	5.1	0.331	0.463	1.37	4.6	-0.4%	-0.6%	2.1%	-8.5%	0.328	0.503	1.32	5.0	0.329	0.497	1.36	4.6	0.2%	-1.2%	2.9%	-8.5%	0.331	0.331	-0.2%
K1	18	0.258	0.336	1.71	3.4	0.262	0.347	1.81	3.3	1.5%	3.3%	5.8%	-4.9%	0.266	0.404	1.71	3.5	0.267	0.403	1.81	3.3	0.1%	-0.2%	5.6%	-5.7%	0.261	0.263	1.1%
N2	18	0.205	0.305	1.53	3.0	0.207	0.299	1.42	3.2	0.7%	-2.1%	-7.4%	8.5%	0.188	0.309	1.50	2.8	0.191	0.306	1.38	3.1	1.3%	-0.9%	-7.6%	9.2%	0.200	0.202	0.9%
R42	15	0.180	0.260	2.89	1.8	0.179	0.258	2.73	2.0	-0.2%	-0.6%	-5.8%	9.0%	0.179	0.292	2.78	1.9	0.178	0.290	2.70	2.0	-0.4%	-0.6%	-3.2%	4.5%	0.180	0.179	-0.3%
W62	12	0.089	0.121	1.29	2.3	0.090	0.126	1.31	2.3	1.6%	3.9%	1.1%	0.6%	0.093	0.148	1.39	2.3	0.094	0.148	1.31	2.3	1.0%	-0.3%	-5.3%	-0.3%	0.090	0.091	1.4%
X115	12	0.144	0.200	1.49	3.2	0.144	0.207	1.40	3.0	0.2%	3.5%	-6.4%	-6.3%	0.140	0.223	1.46	3.1	0.139	0.226	1.37	2.9	-0.6%	1.4%	-6.0%	-5.1%	0.143	0.143	0.0%
Z41	24	0.016	0.018	0.60	1.0	0.016	0.018	0.58	1.0	0.5%	1.2%	-4.6%	-0.2%	0.016	0.020	0.59	0.9	0.016	0.019	0.58	1.0	-0.3%	-2.6%	-2.1%	8.3%	0.016	0.016	0.2%
WRP	48	4.345	5.565	-	-	4.139	5.425	-	-	-4.7%	-2.5%	-	-	4.314	6.166	-	-	4.114	6.107	-	-	-4.6%	-1.0%	-	-	4.336	4.132	-4.7%

City of Grants Pass

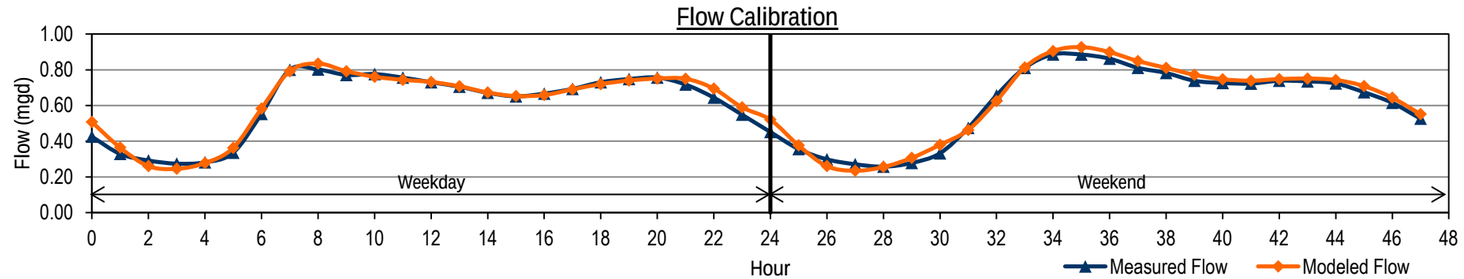
Flow Monitoring Program and Hydraulic Model Update

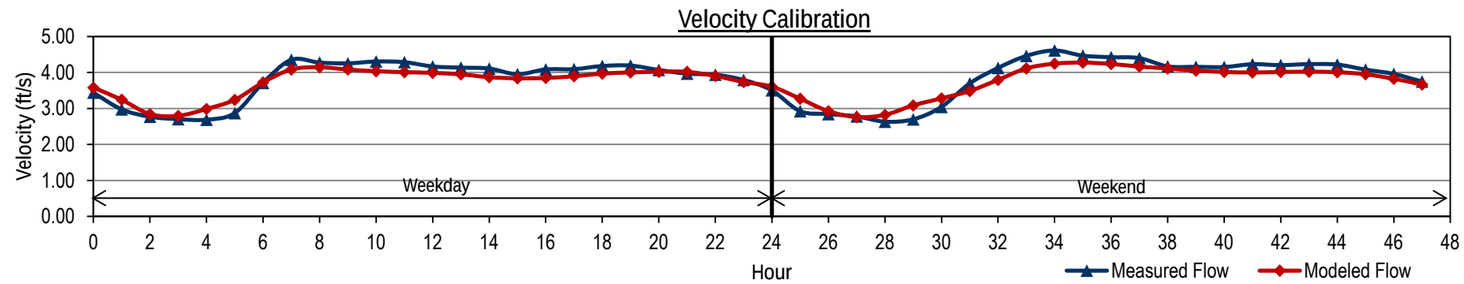
FLOW MONITORING SITE D60 DRY WEATHER FLOW CALIBRATION

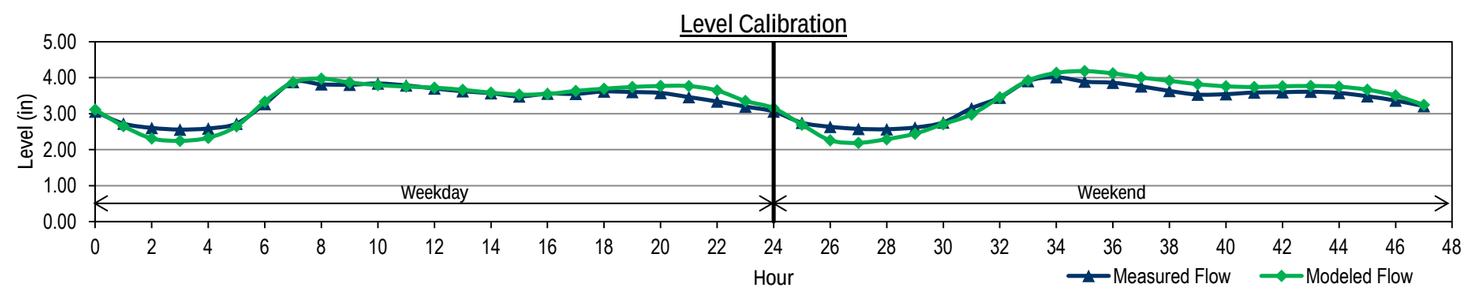
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.426	3.44	3.1	0.508	3.58	3.1	0.54	0.40	0.40
	1	0.329	2.98	2.7	0.365	3.24	2.7	0.48	0.38	0.38
	2	0.292	2.77	2.6	0.261	2.84	2.3	0.45	0.42	0.42
	3	0.275	2.70	2.6	0.246	2.79	2.2	0.46	0.50	0.50
	4	0.282	2.69	2.6	0.278	2.98	2.3	0.55	0.70	0.70
	5	0.336	2.87	2.7	0.363	3.24	2.6	0.91	1.15	1.15
	6	0.553	3.71	3.3	0.583	3.72	3.3	1.31	1.38	1.38
	7	0.801	4.35	3.9	0.792	4.08	3.9	1.31	1.35	1.35
	8	0.802	4.28	3.8	0.835	4.14	4.0	1.26	1.25	1.25
	9	0.771	4.26	3.8	0.792	4.08	3.9	1.27	1.23	1.23
	10	0.776	4.31	3.8	0.761	4.03	3.8	1.24	1.20	1.20
	11	0.757	4.29	3.8	0.744	4.01	3.8	1.20	1.19	1.19
	12	0.731	4.17	3.7	0.732	3.99	3.7	1.16	1.13	1.13
	13	0.706	4.14	3.6	0.708	3.95	3.7	1.10	1.07	1.07
	14	0.672	4.11	3.6	0.673	3.87	3.6	1.07	1.06	1.06
	15	0.651	3.95	3.5	0.653	3.84	3.5	1.09	1.08	1.08
	16	0.667	4.09	3.6	0.659	3.85	3.5	1.14	1.15	1.15
	17	0.693	4.09	3.6	0.690	3.89	3.6	1.20	1.19	1.19
	18	0.731	4.18	3.6	0.720	3.97	3.7	1.23	1.22	1.22
	19	0.749	4.19	3.6	0.740	4.00	3.7	1.24	1.23	1.23
	20	0.757	4.07	3.6	0.751	4.02	3.8	1.18	1.19	1.19
	21	0.718	3.97	3.5	0.750	4.02	3.8	1.06	1.05	1.05
	22	0.645	3.94	3.3	0.695	3.90	3.6	0.90	0.85	0.85
	23	0.549	3.79	3.2	0.590	3.73	3.4	0.70	0.80	0.80
Weekend	24	0.452	3.51	3.1	0.521	3.60	3.2	0.58	0.40	0.40
	25	0.356	2.93	2.7	0.377	3.27	2.7	0.49	0.35	0.35
	26	0.299	2.84	2.6	0.261	2.92	2.3	0.44	0.38	0.38
	27	0.271	2.78	2.6	0.235	2.76	2.2	0.42	0.45	0.45
	28	0.258	2.63	2.6	0.256	2.82	2.3	0.46	0.55	0.55
	29	0.278	2.70	2.6	0.307	3.08	2.4	0.54	0.68	0.68
	30	0.332	3.04	2.8	0.380	3.28	2.7	0.78	0.80	0.80
	31	0.475	3.70	3.2	0.463	3.48	3.0	1.07	1.15	1.15
	32	0.656	4.13	3.4	0.625	3.79	3.5	1.33	1.40	1.40
	33	0.811	4.46	3.9	0.813	4.11	3.9	1.45	1.47	1.47
	34	0.886	4.61	4.0	0.905	4.24	4.1	1.45	1.48	1.48
	35	0.886	4.47	3.9	0.927	4.27	4.2	1.41	1.40	1.40
	36	0.863	4.43	3.9	0.899	4.24	4.1	1.33	1.32	1.32
	37	0.811	4.40	3.8	0.849	4.16	4.0	1.28	1.27	1.27
	38	0.783	4.17	3.6	0.811	4.11	3.9	1.21	1.20	1.20
	39	0.739	4.16	3.5	0.772	4.05	3.8	1.19	1.18	1.18
	40	0.727	4.15	3.5	0.747	4.01	3.8	1.18	1.17	1.17
	41	0.723	4.23	3.6	0.739	4.00	3.7	1.21	1.20	1.20
	42	0.739	4.21	3.6	0.748	4.01	3.8	1.20	1.19	1.19
	43	0.735	4.23	3.6	0.751	4.02	3.8	1.19	1.18	1.18
	44	0.724	4.22	3.6	0.743	4.01	3.8	1.11	1.10	1.10
	45	0.675	4.08	3.5	0.709	3.95	3.7	1.01	0.97	0.97
	46	0.615	3.96	3.4	0.644	3.82	3.5	0.86	0.80	0.80
	47	0.527	3.75	3.2	0.552	3.67	3.2	0.74	0.68	0.68
Average										
Weekday		0.611	3.80	3.4	0.620	3.74	3.4	1.00	1.01	1.01
Weekend		0.609	3.82	3.3	0.626	3.74	3.4	1.00	0.99	0.99
ADWF[1]		0.611	3.81	3.4	0.622	3.74	3.4	1.00	1.00	1.00
% Error										
Weekday					1.5%	-1.7%	0.7%			
Weekend					2.8%	-2.3%	1.6%			

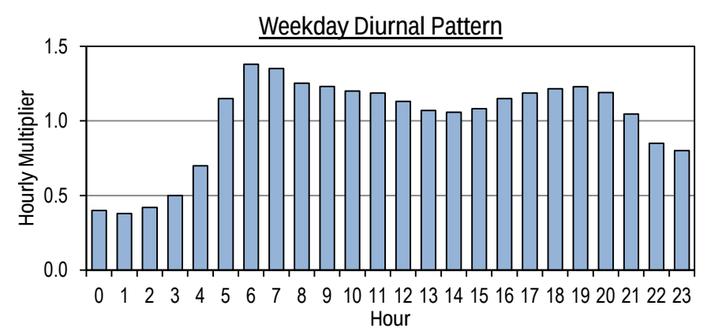
Note:

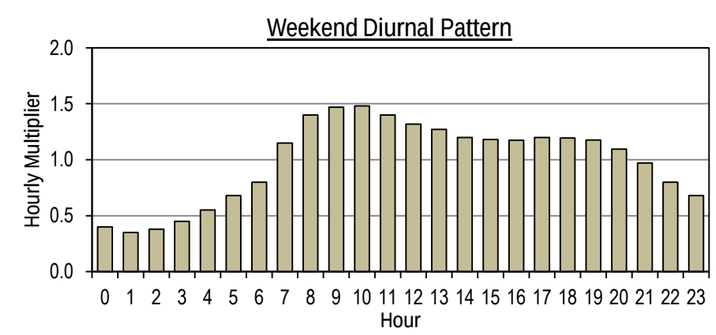
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

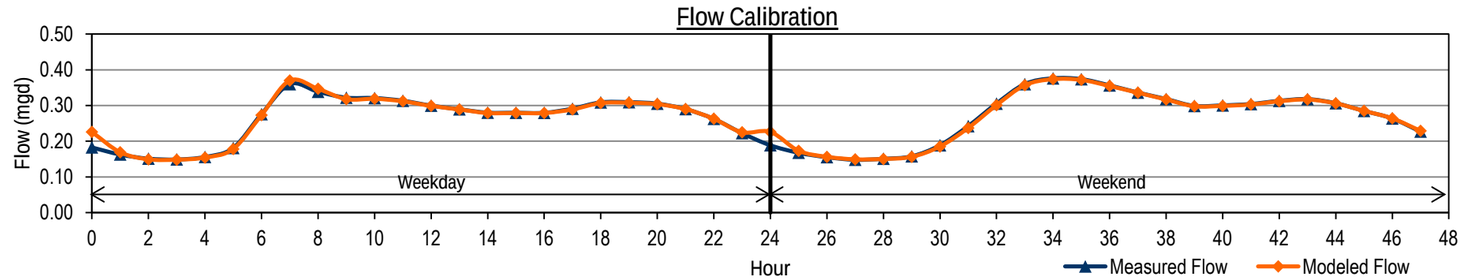
Flow Monitoring Program and Hydraulic Model Update

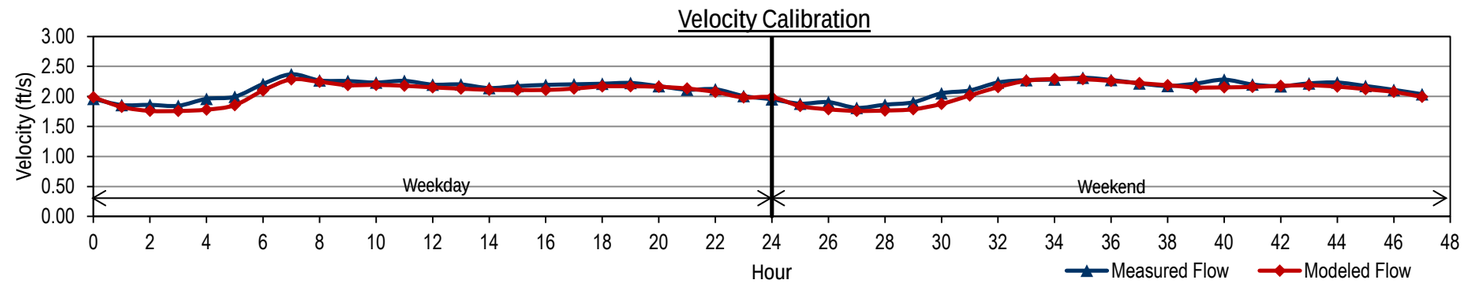
FLOW MONITORING SITE H5 DRY WEATHER FLOW CALIBRATION

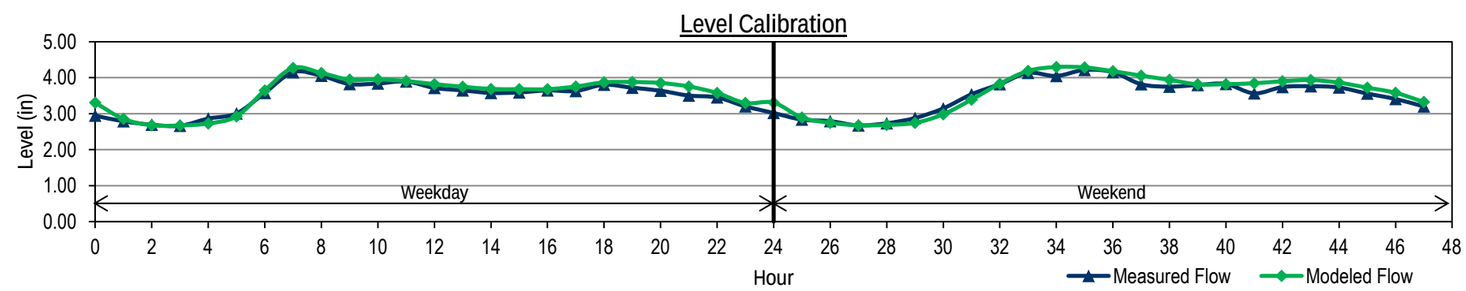
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.183	1.96	2.9	0.226	1.99	3.3	0.61	0.61	0.61
	1	0.163	1.86	2.8	0.169	1.83	2.9	0.57	0.55	0.55
	2	0.151	1.86	2.7	0.149	1.76	2.7	0.56	0.56	0.56
	3	0.149	1.85	2.7	0.148	1.76	2.7	0.59	0.58	0.58
	4	0.156	1.96	2.9	0.154	1.78	2.7	0.68	0.68	0.68
	5	0.181	2.00	3.0	0.178	1.86	2.9	1.04	1.05	1.05
	6	0.276	2.21	3.6	0.273	2.10	3.6	1.36	1.40	1.40
	7	0.360	2.37	4.2	0.370	2.29	4.3	1.28	1.30	1.30
	8	0.339	2.27	4.1	0.347	2.24	4.1	1.21	1.19	1.19
	9	0.322	2.26	3.8	0.318	2.19	3.9	1.21	1.20	1.20
	10	0.321	2.23	3.8	0.319	2.19	4.0	1.18	1.17	1.17
	11	0.313	2.26	3.9	0.312	2.18	3.9	1.13	1.12	1.12
	12	0.300	2.20	3.7	0.299	2.15	3.8	1.09	1.08	1.08
	13	0.289	2.20	3.6	0.289	2.13	3.7	1.06	1.05	1.05
	14	0.280	2.14	3.6	0.279	2.11	3.7	1.06	1.05	1.05
	15	0.280	2.17	3.6	0.279	2.11	3.7	1.05	1.04	1.04
	16	0.280	2.19	3.6	0.279	2.11	3.7	1.10	1.09	1.09
	17	0.291	2.20	3.6	0.289	2.13	3.8	1.16	1.15	1.15
	18	0.309	2.21	3.8	0.307	2.17	3.9	1.17	1.16	1.16
	19	0.309	2.23	3.7	0.308	2.17	3.9	1.15	1.14	1.14
	20	0.305	2.17	3.6	0.304	2.16	3.9	1.09	1.08	1.08
	21	0.290	2.11	3.5	0.290	2.13	3.8	0.99	0.98	0.98
	22	0.263	2.12	3.5	0.263	2.08	3.6	0.84	0.83	0.83
	23	0.223	2.01	3.2	0.225	1.98	3.3	0.69	0.85	0.85
Weekend	24	0.189	1.95	3.0	0.226	1.99	3.3	0.63	0.63	0.63
	25	0.168	1.88	2.8	0.173	1.84	2.9	0.59	0.58	0.58
	26	0.156	1.91	2.8	0.156	1.79	2.7	0.56	0.55	0.55
	27	0.148	1.81	2.7	0.149	1.76	2.7	0.57	0.56	0.56
	28	0.151	1.86	2.7	0.150	1.77	2.7	0.60	0.59	0.59
	29	0.158	1.90	2.9	0.156	1.79	2.7	0.71	0.71	0.71
	30	0.189	2.05	3.1	0.185	1.88	3.0	0.91	0.91	0.91
	31	0.242	2.10	3.5	0.237	2.02	3.4	1.15	1.14	1.14
	32	0.305	2.23	3.8	0.301	2.16	3.8	1.36	1.34	1.34
	33	0.360	2.27	4.1	0.357	2.26	4.2	1.42	1.41	1.41
	34	0.376	2.28	4.0	0.374	2.29	4.3	1.41	1.40	1.40
	35	0.374	2.31	4.2	0.372	2.29	4.3	1.34	1.33	1.33
	36	0.356	2.28	4.2	0.355	2.26	4.2	1.27	1.26	1.26
	37	0.336	2.22	3.8	0.336	2.22	4.1	1.20	1.19	1.19
	38	0.318	2.18	3.8	0.317	2.19	3.9	1.13	1.12	1.12
	39	0.299	2.22	3.8	0.298	2.15	3.8	1.13	1.12	1.12
	40	0.300	2.28	3.8	0.299	2.15	3.8	1.15	1.14	1.14
	41	0.304	2.20	3.6	0.303	2.16	3.8	1.18	1.17	1.17
	42	0.313	2.17	3.7	0.312	2.18	3.9	1.20	1.19	1.19
	43	0.318	2.22	3.8	0.317	2.19	3.9	1.16	1.15	1.15
	44	0.307	2.23	3.7	0.306	2.17	3.9	1.07	1.06	1.06
	45	0.285	2.18	3.6	0.285	2.12	3.7	0.99	0.99	0.99
	46	0.264	2.11	3.4	0.264	2.08	3.6	0.86	0.85	0.85
	47	0.227	2.04	3.2	0.229	1.99	3.3	0.71	0.71	0.71
Average										
Weekday		0.264	2.13	3.5	0.266	2.07	3.6	1.00	1.00	1.00
Weekend		0.268	2.12	3.5	0.269	2.07	3.6	1.01	1.00	1.00
ADWF[1]		0.265	2.12	3.5	0.267	2.07	3.6	1.00	1.00	1.00
% Error										
Weekday					0.7%	-2.8%	2.6%			
Weekend					0.2%	-2.4%	2.1%			

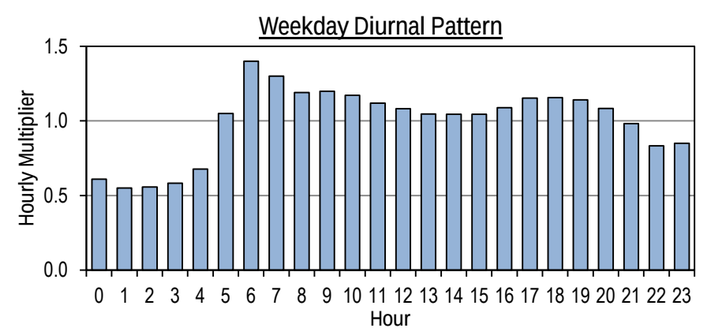
Note:

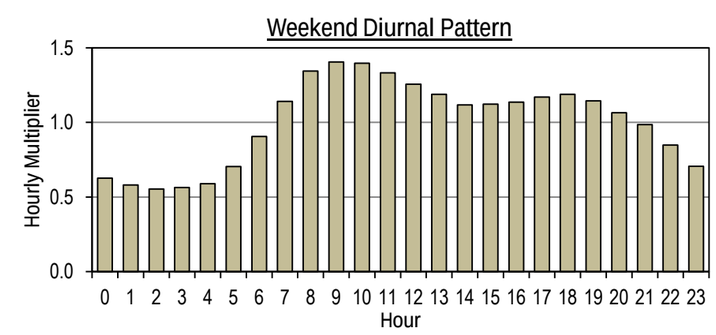
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

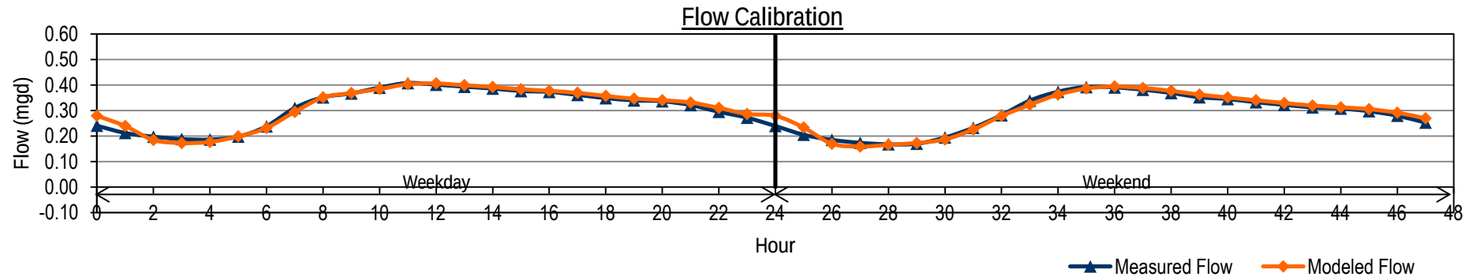
Flow Monitoring Program and Hydraulic Model Update

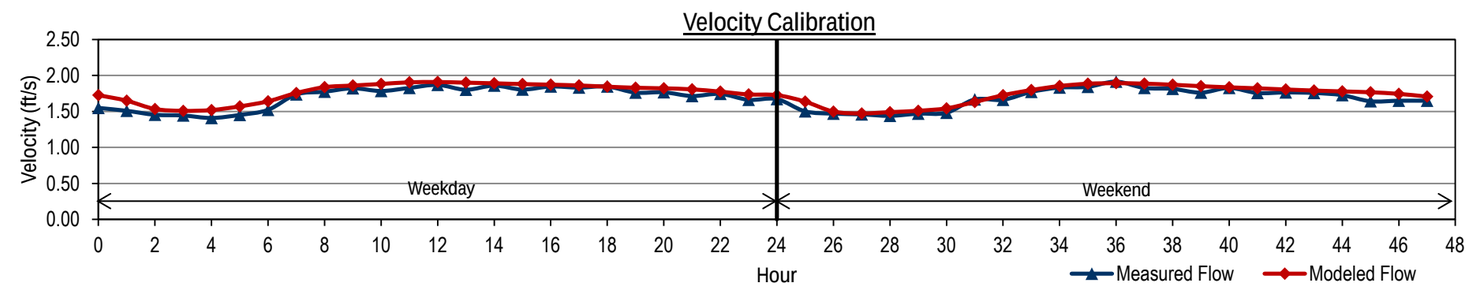
FLOW MONITORING SITE I5 DRY WEATHER FLOW CALIBRATION

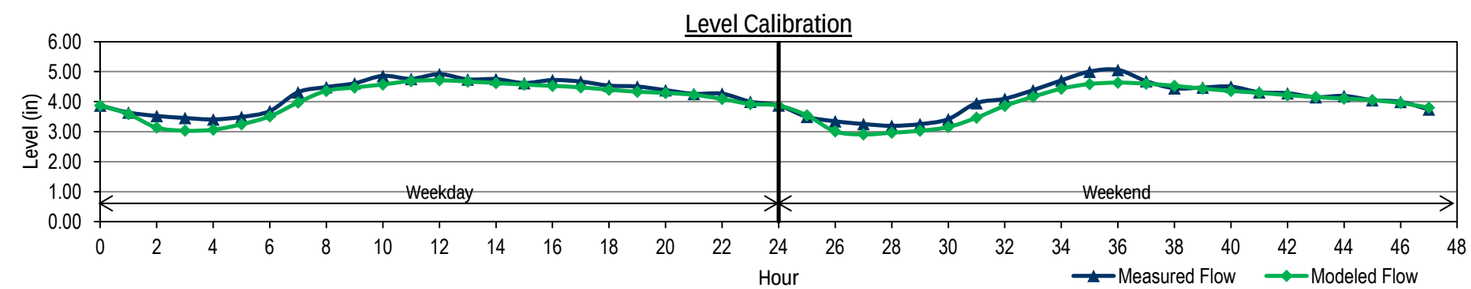
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.241	1.55	3.9	0.280	1.73	3.9	0.70	0.60	0.60
	1	0.213	1.51	3.6	0.240	1.65	3.6	0.65	0.56	0.56
	2	0.198	1.46	3.5	0.185	1.53	3.1	0.62	0.55	0.55
	3	0.189	1.45	3.5	0.173	1.51	3.0	0.61	0.61	0.61
	4	0.187	1.41	3.4	0.177	1.52	3.1	0.65	0.70	0.70
	5	0.198	1.45	3.5	0.199	1.57	3.2	0.78	0.82	0.82
	6	0.238	1.52	3.7	0.232	1.64	3.5	1.02	1.10	1.10
	7	0.310	1.74	4.3	0.295	1.76	4.0	1.15	1.17	1.17
	8	0.352	1.78	4.5	0.352	1.84	4.4	1.20	1.21	1.21
	9	0.367	1.82	4.6	0.369	1.86	4.5	1.28	1.27	1.27
	10	0.390	1.79	4.9	0.385	1.88	4.6	1.34	1.33	1.33
	11	0.408	1.83	4.8	0.404	1.91	4.7	1.31	1.31	1.31
	12	0.402	1.87	4.9	0.407	1.91	4.7	1.29	1.28	1.28
	13	0.394	1.80	4.7	0.400	1.90	4.7	1.27	1.26	1.26
	14	0.386	1.86	4.7	0.393	1.89	4.6	1.23	1.23	1.23
	15	0.377	1.81	4.6	0.384	1.88	4.6	1.22	1.22	1.22
	16	0.373	1.85	4.7	0.378	1.87	4.5	1.18	1.18	1.18
	17	0.362	1.83	4.7	0.370	1.86	4.5	1.14	1.14	1.14
	18	0.349	1.85	4.5	0.358	1.85	4.4	1.11	1.11	1.11
	19	0.340	1.76	4.5	0.347	1.83	4.3	1.10	1.10	1.10
	20	0.337	1.77	4.4	0.341	1.82	4.3	1.05	1.05	1.05
	21	0.322	1.72	4.3	0.332	1.81	4.2	0.97	0.96	0.96
	22	0.295	1.75	4.3	0.311	1.78	4.1	0.89	0.89	0.89
	23	0.272	1.66	4.0	0.287	1.74	3.9	0.79	0.92	0.92
Weekend	24	0.240	1.67	3.9	0.280	1.73	3.9	0.67	0.55	0.55
	25	0.206	1.50	3.5	0.234	1.64	3.5	0.61	0.50	0.50
	26	0.186	1.47	3.3	0.170	1.50	3.0	0.57	0.53	0.53
	27	0.174	1.46	3.3	0.159	1.47	2.9	0.55	0.55	0.55
	28	0.168	1.44	3.2	0.166	1.49	3.0	0.56	0.58	0.58
	29	0.170	1.47	3.3	0.173	1.51	3.0	0.64	0.65	0.65
	30	0.195	1.48	3.4	0.187	1.54	3.2	0.76	0.85	0.85
	31	0.233	1.67	4.0	0.226	1.63	3.5	0.92	0.96	0.96
	32	0.282	1.66	4.1	0.279	1.73	3.9	1.11	1.12	1.12
	33	0.339	1.77	4.4	0.323	1.80	4.2	1.22	1.22	1.22
	34	0.374	1.83	4.7	0.363	1.85	4.4	1.29	1.28	1.28
	35	0.392	1.84	5.0	0.387	1.89	4.6	1.28	1.27	1.27
	36	0.391	1.92	5.1	0.395	1.89	4.6	1.25	1.24	1.24
	37	0.382	1.83	4.7	0.389	1.89	4.6	1.21	1.20	1.20
	38	0.369	1.82	4.4	0.378	1.87	4.5	1.15	1.15	1.15
	39	0.352	1.76	4.5	0.363	1.85	4.4	1.13	1.12	1.12
	40	0.345	1.83	4.5	0.352	1.84	4.4	1.09	1.08	1.08
	41	0.333	1.76	4.3	0.341	1.82	4.3	1.06	1.05	1.05
	42	0.323	1.77	4.3	0.330	1.81	4.2	1.02	1.02	1.02
	43	0.313	1.76	4.1	0.320	1.79	4.2	1.01	1.00	1.00
	44	0.308	1.73	4.2	0.313	1.78	4.1	0.97	0.97	0.97
	45	0.298	1.64	4.1	0.306	1.77	4.1	0.92	0.91	0.91
	46	0.280	1.65	4.0	0.292	1.75	4.0	0.83	0.82	0.82
	47	0.253	1.65	3.7	0.270	1.71	3.8	0.79	0.78	0.78
Average										
Weekday		0.312	1.70	4.3	0.317	1.77	4.1	1.02	1.02	1.02
Weekend		0.288	1.68	4.1	0.292	1.73	3.9	0.94	0.93	0.93
ADWF[1]		0.305	1.70	4.2	0.309	1.76	4.0	1.00	1.00	1.00
% Error										
Weekday					1.3%	4.2%	-4.0%			
Weekend					1.3%	2.9%	-3.8%			

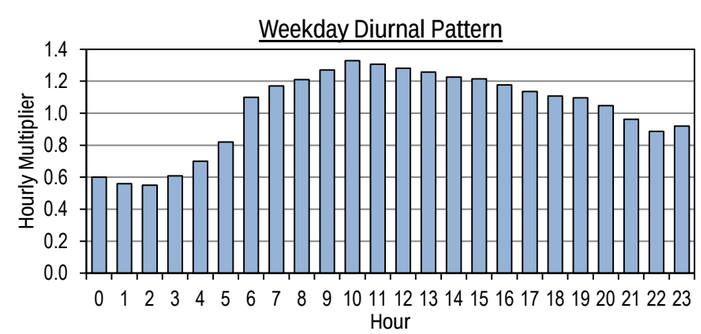
Note:

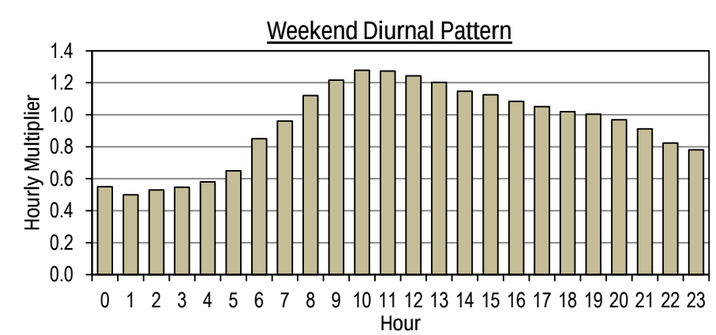
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

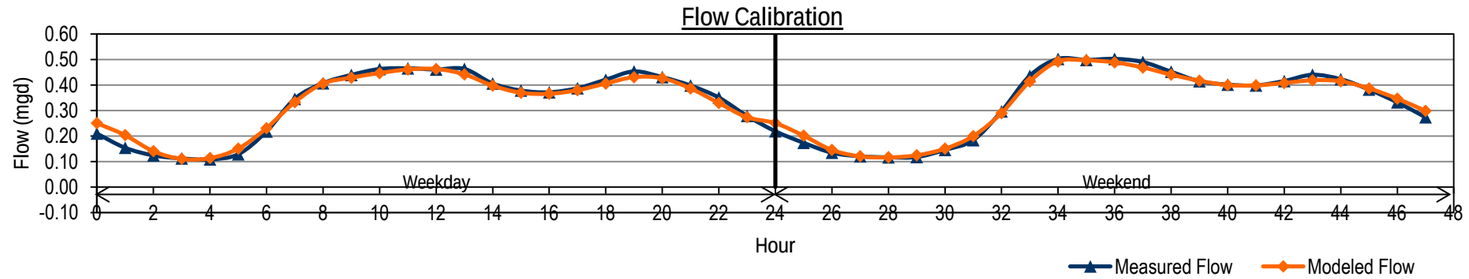
Flow Monitoring Program and Hydraulic Model Update

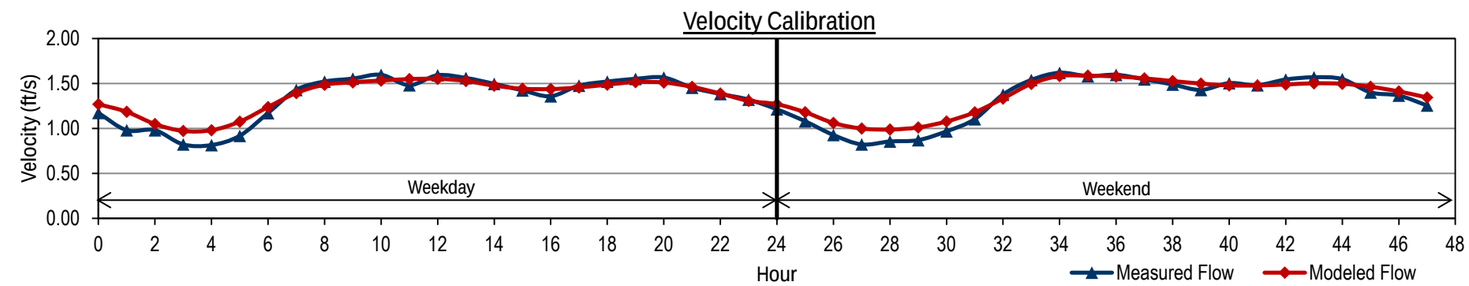
FLOW MONITORING SITE J2 DRY WEATHER FLOW CALIBRATION

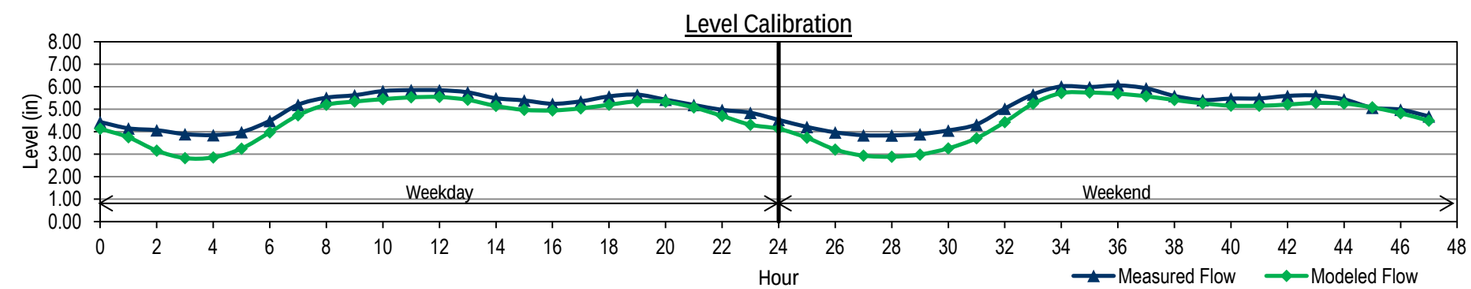
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.210	1.17	4.4	0.251	1.27	4.1	0.47	0.40	0.40
	1	0.154	0.98	4.1	0.204	1.19	3.8	0.38	0.28	0.28
	2	0.124	0.98	4.1	0.141	1.05	3.2	0.34	0.29	0.29
	3	0.112	0.82	3.9	0.111	0.97	2.8	0.33	0.38	0.38
	4	0.109	0.82	3.8	0.114	0.98	2.9	0.39	0.58	0.58
	5	0.129	0.92	4.0	0.151	1.08	3.2	0.66	0.89	0.89
	6	0.218	1.17	4.5	0.231	1.24	4.0	1.04	1.19	1.19
	7	0.346	1.43	5.2	0.333	1.39	4.7	1.23	1.30	1.30
	8	0.407	1.52	5.5	0.406	1.49	5.2	1.33	1.33	1.33
	9	0.440	1.55	5.6	0.429	1.51	5.3	1.40	1.40	1.40
	10	0.463	1.60	5.8	0.447	1.53	5.4	1.41	1.42	1.42
	11	0.466	1.48	5.8	0.461	1.55	5.5	1.39	1.41	1.41
	12	0.461	1.59	5.8	0.463	1.55	5.5	1.40	1.30	1.30
	13	0.464	1.56	5.7	0.442	1.53	5.4	1.23	1.12	1.12
	14	0.406	1.50	5.5	0.398	1.48	5.1	1.14	1.09	1.09
	15	0.379	1.42	5.4	0.370	1.44	5.0	1.12	1.10	1.10
	16	0.372	1.36	5.2	0.366	1.44	4.9	1.17	1.18	1.18
	17	0.388	1.48	5.3	0.380	1.46	5.0	1.27	1.28	1.28
	18	0.421	1.52	5.6	0.406	1.49	5.2	1.37	1.36	1.36
	19	0.454	1.55	5.6	0.431	1.52	5.4	1.30	1.29	1.29
	20	0.431	1.57	5.4	0.427	1.51	5.3	1.20	1.10	1.10
	21	0.398	1.45	5.2	0.387	1.46	5.1	1.06	0.90	0.90
	22	0.351	1.38	5.0	0.330	1.39	4.7	0.84	0.72	0.72
	23	0.279	1.32	4.8	0.274	1.31	4.3	0.63	0.75	0.75
Weekend	24	0.219	1.21	4.5	0.251	1.27	4.1	0.52	0.38	0.38
	25	0.174	1.08	4.2	0.202	1.18	3.7	0.41	0.35	0.35
	26	0.135	0.93	4.0	0.146	1.06	3.2	0.36	0.32	0.32
	27	0.121	0.82	3.8	0.121	1.00	2.9	0.35	0.35	0.35
	28	0.117	0.86	3.8	0.117	0.99	2.9	0.36	0.40	0.40
	29	0.118	0.87	3.9	0.125	1.01	3.0	0.44	0.54	0.54
	30	0.146	0.97	4.0	0.151	1.08	3.3	0.56	0.72	0.72
	31	0.184	1.10	4.3	0.200	1.18	3.7	0.90	1.09	1.09
	32	0.297	1.38	5.0	0.290	1.33	4.4	1.32	1.45	1.45
	33	0.436	1.54	5.7	0.414	1.50	5.2	1.52	1.60	1.60
	34	0.503	1.62	6.0	0.493	1.58	5.7	1.50	1.51	1.51
	35	0.499	1.58	6.0	0.497	1.59	5.7	1.52	1.50	1.50
	36	0.503	1.60	6.1	0.489	1.58	5.7	1.48	1.40	1.40
	37	0.491	1.55	5.9	0.469	1.56	5.6	1.37	1.31	1.31
	38	0.453	1.49	5.6	0.441	1.53	5.4	1.25	1.24	1.24
	39	0.415	1.43	5.4	0.417	1.50	5.3	1.21	1.20	1.20
	40	0.402	1.50	5.5	0.400	1.48	5.2	1.20	1.23	1.23
	41	0.399	1.48	5.5	0.399	1.48	5.2	1.25	1.27	1.27
	42	0.416	1.54	5.6	0.408	1.49	5.2	1.33	1.31	1.31
	43	0.440	1.57	5.6	0.419	1.50	5.3	1.28	1.26	1.26
	44	0.423	1.55	5.4	0.415	1.50	5.3	1.15	1.14	1.14
	45	0.383	1.40	5.1	0.387	1.46	5.1	1.00	0.99	0.99
	46	0.333	1.37	5.0	0.347	1.41	4.8	0.83	0.82	0.82
	47	0.274	1.26	4.7	0.299	1.34	4.5	0.66	0.65	0.65
Average										
Weekday		0.333	1.34	5.1	0.331	1.37	4.6	1.00	1.00	1.00
Weekend		0.328	1.32	5.0	0.329	1.36	4.6	0.99	1.00	1.00
ADWF[1]		0.331	1.33	5.0	0.331	1.36	4.6	1.00	1.00	1.00
% Error										
Weekday					-0.4%	2.1%	-8.5%			
Weekend					0.2%	2.9%	-8.5%			

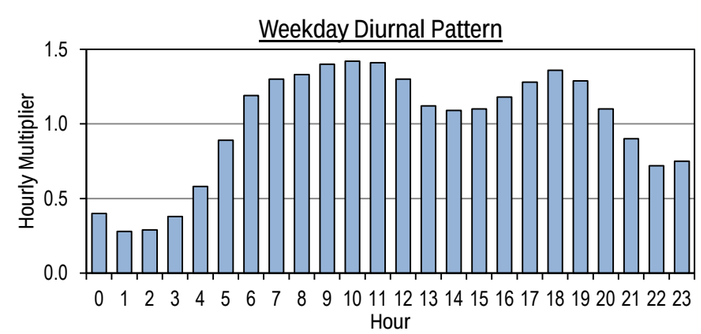
Note:

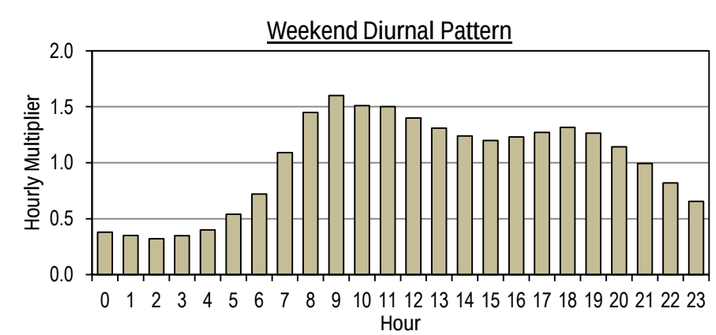
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

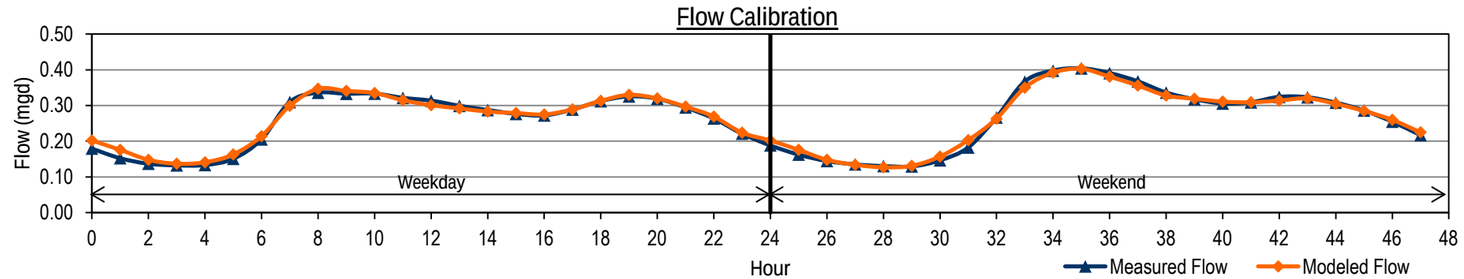
Flow Monitoring Program and Hydraulic Model Update

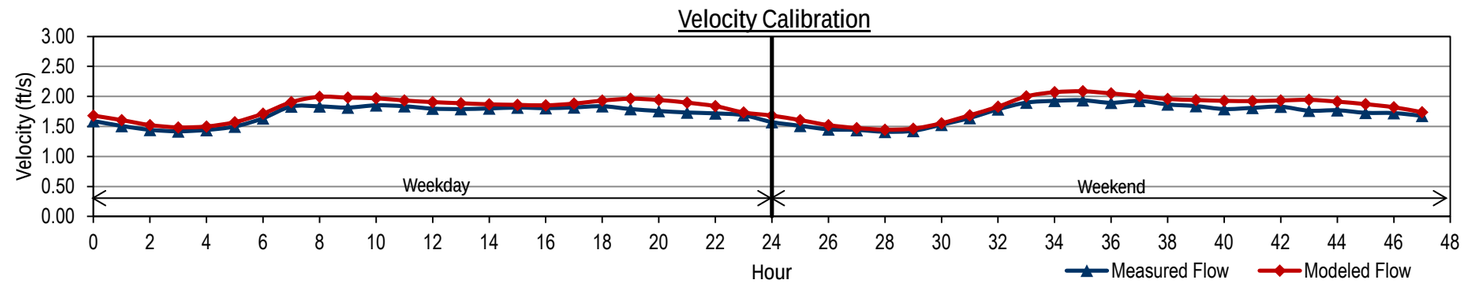
FLOW MONITORING SITE K1 DRY WEATHER FLOW CALIBRATION

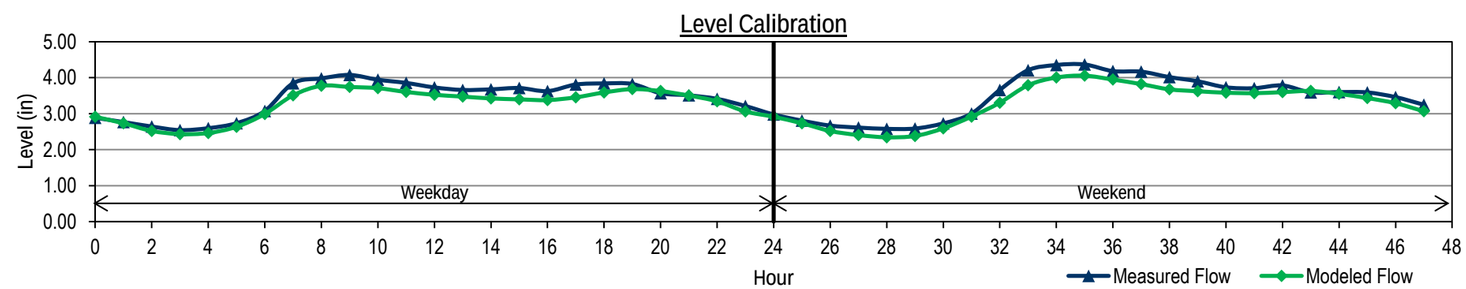
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.179	1.59	2.9	0.202	1.68	2.9	0.59	0.58	0.58
	1	0.152	1.51	2.8	0.176	1.61	2.7	0.53	0.52	0.52
	2	0.137	1.44	2.6	0.148	1.52	2.5	0.51	0.50	0.50
	3	0.132	1.42	2.5	0.137	1.48	2.4	0.51	0.56	0.56
	4	0.133	1.44	2.6	0.141	1.50	2.5	0.58	0.68	0.65
	5	0.151	1.50	2.7	0.163	1.57	2.6	0.79	0.93	0.90
	6	0.205	1.64	3.1	0.214	1.71	3.0	1.19	1.28	1.25
	7	0.310	1.83	3.8	0.299	1.91	3.5	1.29	1.35	1.32
	8	0.336	1.84	4.0	0.347	1.99	3.8	1.28	1.27	1.27
	9	0.333	1.82	4.1	0.341	1.98	3.7	1.28	1.27	1.27
	10	0.333	1.85	3.9	0.335	1.97	3.7	1.23	1.15	1.15
	11	0.321	1.84	3.9	0.315	1.93	3.6	1.20	1.13	1.13
	12	0.314	1.80	3.7	0.301	1.91	3.5	1.15	1.09	1.09
	13	0.299	1.79	3.7	0.292	1.89	3.5	1.10	1.06	1.06
	14	0.287	1.80	3.7	0.283	1.87	3.4	1.06	1.05	1.05
	15	0.276	1.82	3.7	0.279	1.86	3.4	1.04	1.03	1.03
	16	0.272	1.81	3.6	0.275	1.85	3.4	1.11	1.13	1.10
	17	0.289	1.82	3.8	0.289	1.88	3.5	1.20	1.22	1.19
	18	0.312	1.84	3.8	0.313	1.93	3.6	1.25	1.27	1.24
	19	0.325	1.79	3.8	0.330	1.96	3.7	1.22	1.18	1.21
	20	0.319	1.76	3.6	0.320	1.94	3.6	1.13	1.09	1.12
	21	0.295	1.73	3.5	0.297	1.90	3.5	1.01	0.97	1.00
	22	0.264	1.72	3.4	0.269	1.84	3.3	0.85	0.75	0.78
	23	0.221	1.69	3.2	0.224	1.73	3.1	0.69	0.76	0.80
Weekend	24	0.188	1.57	3.0	0.202	1.68	2.9	0.62	0.58	0.62
	25	0.163	1.51	2.8	0.176	1.61	2.7	0.55	0.52	0.55
	26	0.145	1.45	2.7	0.148	1.52	2.5	0.52	0.48	0.51
	27	0.135	1.44	2.6	0.134	1.47	2.4	0.50	0.47	0.50
	28	0.130	1.41	2.6	0.127	1.45	2.3	0.50	0.52	0.54
	29	0.129	1.43	2.6	0.131	1.46	2.4	0.56	0.68	0.65
	30	0.147	1.53	2.7	0.157	1.55	2.6	0.70	0.86	0.83
	31	0.182	1.64	3.0	0.203	1.69	2.9	1.02	1.11	1.08
	32	0.267	1.79	3.7	0.263	1.83	3.3	1.41	1.46	1.43
	33	0.367	1.90	4.2	0.350	2.00	3.8	1.53	1.51	1.51
	34	0.398	1.93	4.4	0.392	2.07	4.0	1.55	1.54	1.54
	35	0.404	1.94	4.4	0.403	2.09	4.1	1.50	1.40	1.40
	36	0.391	1.90	4.2	0.381	2.05	4.0	1.41	1.32	1.32
	37	0.368	1.93	4.2	0.356	2.01	3.8	1.29	1.20	1.20
	38	0.336	1.87	4.0	0.328	1.96	3.7	1.22	1.21	1.21
	39	0.318	1.84	3.9	0.319	1.94	3.6	1.17	1.16	1.16
	40	0.306	1.79	3.7	0.311	1.93	3.6	1.19	1.17	1.17
	41	0.309	1.81	3.7	0.309	1.92	3.6	1.24	1.20	1.20
	42	0.324	1.83	3.8	0.314	1.93	3.6	1.24	1.22	1.22
	43	0.323	1.76	3.6	0.320	1.94	3.6	1.18	1.12	1.12
	44	0.308	1.77	3.6	0.305	1.91	3.6	1.10	1.05	1.05
	45	0.286	1.73	3.6	0.285	1.87	3.4	0.98	0.94	0.94
	46	0.255	1.72	3.5	0.260	1.82	3.3	0.83	0.78	0.78
	47	0.217	1.68	3.3	0.225	1.74	3.1	0.72	0.71	0.71
Average										
Weekday		0.258	1.71	3.4	0.262	1.81	3.3	0.99	0.99	0.99
Weekend		0.266	1.71	3.5	0.267	1.81	3.3	1.02	1.01	1.01
ADWF[1]		0.261	1.71	3.5	0.263	1.81	3.3	1.00	1.00	1.00
% Error										
Weekday					1.5%	5.8%	-4.9%			
Weekend					0.1%	5.6%	-5.7%			

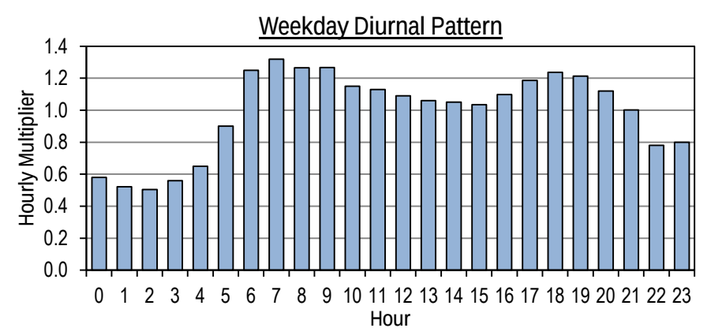
Note:

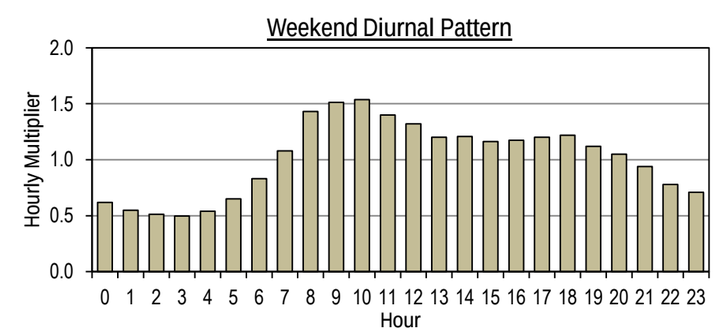
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

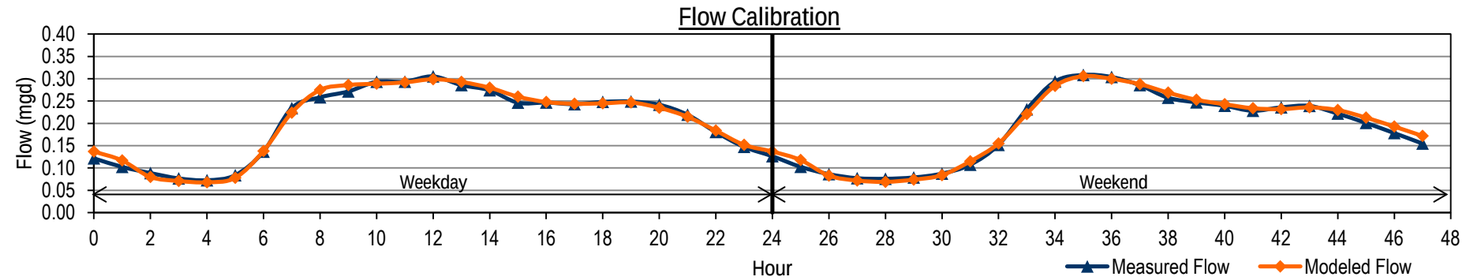
Flow Monitoring Program and Hydraulic Model Update

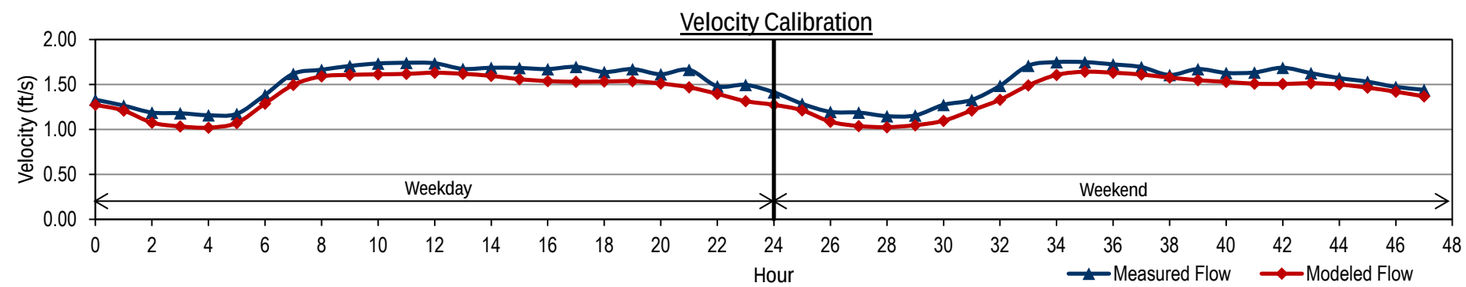
FLOW MONITORING SITE N2 DRY WEATHER FLOW CALIBRATION

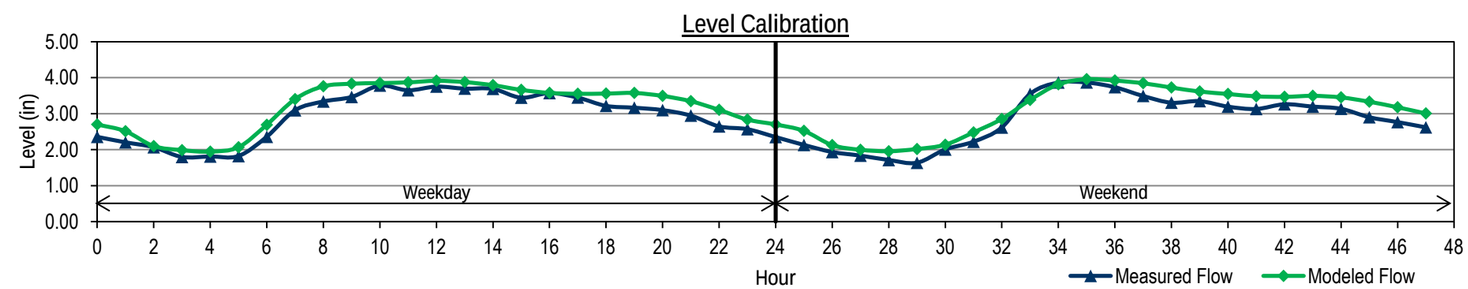
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.122	1.33	2.4	0.137	1.27	2.7	0.51	0.30	0.30
	1	0.103	1.27	2.2	0.117	1.21	2.5	0.44	0.35	0.35
	2	0.089	1.19	2.1	0.080	1.08	2.1	0.38	0.33	0.33
	3	0.077	1.18	1.8	0.071	1.03	2.0	0.36	0.35	0.35
	4	0.073	1.16	1.8	0.068	1.02	1.9	0.42	0.62	0.62
	5	0.084	1.17	1.8	0.078	1.07	2.1	0.68	1.02	1.02
	6	0.137	1.38	2.4	0.138	1.29	2.7	1.17	1.33	1.33
	7	0.234	1.62	3.1	0.224	1.49	3.4	1.29	1.44	1.44
	8	0.258	1.66	3.3	0.275	1.59	3.8	1.36	1.41	1.41
	9	0.272	1.71	3.5	0.286	1.61	3.8	1.46	1.45	1.45
	10	0.293	1.73	3.8	0.289	1.61	3.9	1.46	1.45	1.45
	11	0.293	1.74	3.7	0.292	1.62	3.9	1.52	1.51	1.51
	12	0.305	1.74	3.8	0.299	1.63	3.9	1.43	1.41	1.41
	13	0.286	1.67	3.7	0.293	1.62	3.9	1.37	1.35	1.35
	14	0.274	1.69	3.7	0.280	1.60	3.8	1.23	1.22	1.22
	15	0.246	1.68	3.4	0.260	1.56	3.7	1.23	1.22	1.22
	16	0.247	1.67	3.6	0.248	1.54	3.6	1.21	1.20	1.20
	17	0.243	1.70	3.4	0.244	1.53	3.6	1.24	1.23	1.23
	18	0.248	1.64	3.2	0.245	1.53	3.6	1.24	1.23	1.23
	19	0.249	1.67	3.2	0.247	1.54	3.6	1.21	1.10	1.10
	20	0.242	1.61	3.1	0.235	1.51	3.5	1.10	1.00	1.00
	21	0.220	1.66	2.9	0.215	1.47	3.3	0.90	0.75	0.75
	22	0.181	1.48	2.6	0.184	1.40	3.1	0.74	0.65	0.65
	23	0.148	1.50	2.6	0.152	1.31	2.8	0.61	0.68	0.68
Weekend	24	0.127	1.41	2.4	0.137	1.27	2.7	0.51	0.32	0.32
	25	0.103	1.29	2.1	0.118	1.21	2.5	0.43	0.35	0.35
	26	0.086	1.20	1.9	0.083	1.09	2.1	0.39	0.33	0.33
	27	0.077	1.19	1.8	0.072	1.04	2.0	0.38	0.37	0.37
	28	0.076	1.15	1.7	0.069	1.02	2.0	0.39	0.39	0.39
	29	0.079	1.16	1.6	0.074	1.05	2.0	0.44	0.58	0.58
	30	0.087	1.27	2.0	0.084	1.10	2.1	0.54	0.72	0.72
	31	0.107	1.33	2.2	0.115	1.21	2.5	0.76	0.94	0.94
	32	0.152	1.49	2.6	0.155	1.33	2.9	1.16	1.34	1.34
	33	0.231	1.71	3.5	0.221	1.49	3.4	1.47	1.52	1.52
	34	0.294	1.75	3.9	0.284	1.61	3.8	1.54	1.53	1.53
	35	0.309	1.75	3.9	0.306	1.64	4.0	1.52	1.45	1.45
	36	0.304	1.72	3.7	0.300	1.63	3.9	1.43	1.40	1.40
	37	0.286	1.69	3.5	0.288	1.61	3.8	1.29	1.27	1.27
	38	0.258	1.61	3.3	0.269	1.58	3.7	1.23	1.22	1.22
	39	0.247	1.67	3.3	0.253	1.55	3.6	1.20	1.18	1.18
	40	0.240	1.63	3.2	0.243	1.53	3.5	1.14	1.13	1.13
	41	0.228	1.63	3.1	0.234	1.51	3.5	1.18	1.17	1.17
	42	0.236	1.69	3.3	0.232	1.51	3.5	1.19	1.18	1.18
	43	0.239	1.63	3.2	0.236	1.51	3.5	1.11	1.10	1.10
	44	0.222	1.57	3.1	0.230	1.50	3.5	1.00	0.99	0.99
	45	0.201	1.53	2.9	0.213	1.46	3.3	0.89	0.88	0.88
	46	0.178	1.47	2.8	0.193	1.42	3.2	0.77	0.76	0.76
	47	0.155	1.44	2.6	0.172	1.37	3.0	0.63	0.62	0.62
Average										
Weekday		0.205	1.53	3.0	0.207	1.42	3.2	1.02	1.02	1.02
Weekend		0.188	1.50	2.8	0.191	1.38	3.1	0.94	0.95	0.95
ADWF[1]		0.200	1.52	2.9	0.202	1.41	3.2	1.00	1.00	1.00
% Error										
Weekday					0.7%	-7.4%	8.5%			
Weekend					1.3%	-7.6%	9.2%			

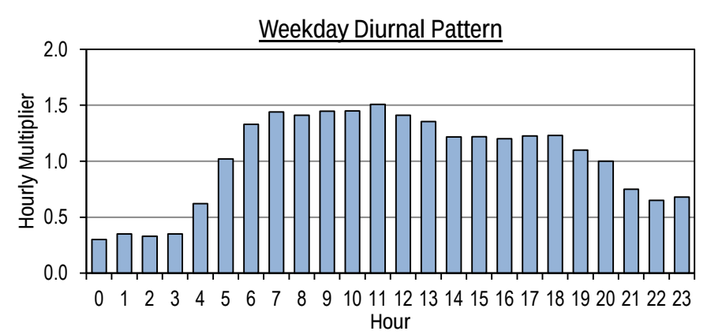
Note:

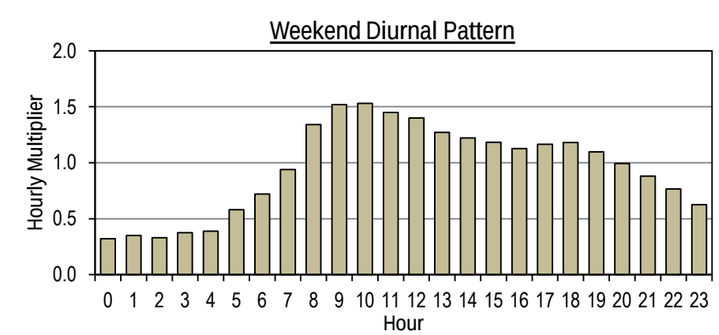
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

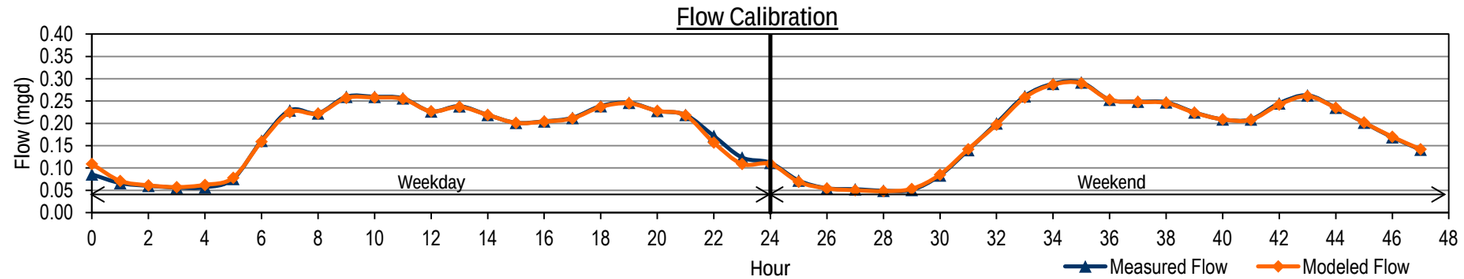
Flow Monitoring Program and Hydraulic Model Update

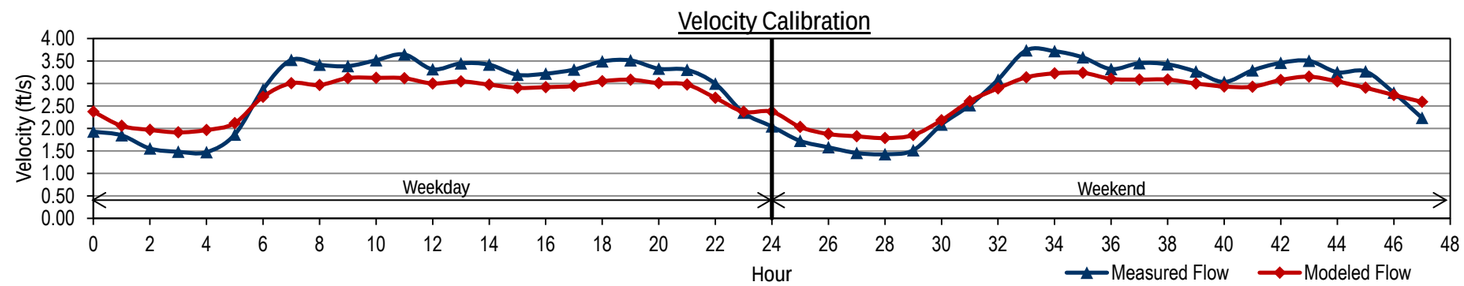
FLOW MONITORING SITE R42 DRY WEATHER FLOW CALIBRATION

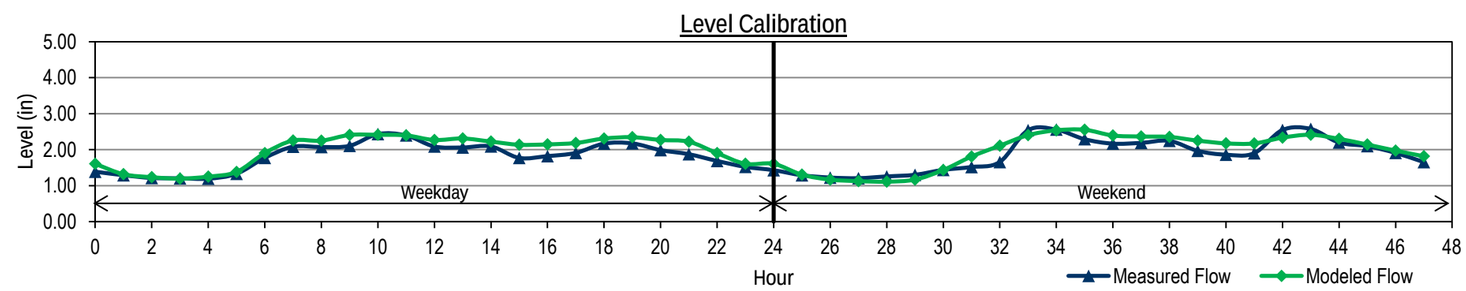
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.086	1.93	1.4	0.109	2.37	1.6	0.37	0.36	0.36
	1	0.066	1.85	1.3	0.071	2.06	1.3	0.33	0.33	0.33
	2	0.060	1.56	1.2	0.061	1.97	1.2	0.31	0.31	0.31
	3	0.056	1.49	1.2	0.057	1.92	1.2	0.32	0.35	0.35
	4	0.057	1.48	1.2	0.062	1.97	1.3	0.42	0.44	0.44
	5	0.076	1.87	1.3	0.078	2.12	1.4	0.90	0.90	0.90
	6	0.161	2.87	1.8	0.159	2.70	1.9	1.27	1.25	1.25
	7	0.229	3.53	2.1	0.225	3.01	2.3	1.24	1.22	1.22
	8	0.222	3.42	2.1	0.222	2.97	2.3	1.44	1.42	1.42
	9	0.260	3.39	2.1	0.257	3.12	2.4	1.44	1.42	1.42
	10	0.259	3.52	2.4	0.258	3.13	2.4	1.43	1.40	1.40
	11	0.256	3.65	2.4	0.255	3.12	2.4	1.26	1.24	1.24
	12	0.227	3.32	2.1	0.227	3.00	2.3	1.33	1.31	1.31
	13	0.238	3.45	2.1	0.237	3.05	2.3	1.22	1.20	1.20
	14	0.219	3.42	2.1	0.219	2.97	2.2	1.12	1.10	1.10
	15	0.201	3.20	1.8	0.201	2.90	2.1	1.14	1.12	1.12
	16	0.204	3.22	1.8	0.204	2.92	2.1	1.18	1.16	1.16
	17	0.212	3.31	1.9	0.211	2.95	2.2	1.33	1.31	1.31
	18	0.239	3.49	2.2	0.237	3.05	2.3	1.37	1.35	1.35
	19	0.246	3.52	2.2	0.245	3.08	2.3	1.27	1.25	1.25
	20	0.228	3.33	2.0	0.228	3.01	2.3	1.22	1.20	1.20
	21	0.219	3.31	1.9	0.218	2.98	2.2	0.96	0.85	0.85
	22	0.172	3.00	1.7	0.157	2.68	1.9	0.69	0.58	0.58
	23	0.123	2.35	1.5	0.109	2.37	1.6	0.48	0.60	0.60
Weekend	24	0.112	2.05	1.4	0.109	2.37	1.6	0.40	0.35	0.35
	25	0.072	1.73	1.3	0.069	2.04	1.3	0.30	0.28	0.28
	26	0.054	1.59	1.2	0.054	1.88	1.2	0.29	0.27	0.27
	27	0.052	1.46	1.2	0.050	1.83	1.1	0.27	0.26	0.26
	28	0.049	1.43	1.3	0.048	1.79	1.1	0.28	0.30	0.30
	29	0.051	1.52	1.3	0.053	1.85	1.2	0.46	0.49	0.49
	30	0.083	2.09	1.4	0.085	2.18	1.4	0.78	0.80	0.80
	31	0.140	2.52	1.5	0.142	2.61	1.8	1.11	1.10	1.10
	32	0.200	3.09	1.7	0.197	2.89	2.1	1.45	1.43	1.43
	33	0.261	3.74	2.5	0.258	3.14	2.4	1.61	1.58	1.58
	34	0.289	3.72	2.6	0.287	3.22	2.5	1.62	1.60	1.60
	35	0.292	3.58	2.3	0.290	3.24	2.6	1.41	1.39	1.39
	36	0.253	3.32	2.2	0.253	3.10	2.4	1.38	1.36	1.36
	37	0.249	3.45	2.2	0.248	3.09	2.4	1.38	1.35	1.35
	38	0.247	3.43	2.2	0.246	3.09	2.4	1.25	1.23	1.23
	39	0.225	3.27	2.0	0.224	3.00	2.3	1.16	1.14	1.14
	40	0.209	3.04	1.9	0.209	2.93	2.2	1.16	1.14	1.14
	41	0.209	3.29	1.9	0.208	2.93	2.2	1.36	1.34	1.34
	42	0.245	3.46	2.5	0.242	3.08	2.3	1.46	1.44	1.44
	43	0.263	3.51	2.6	0.261	3.15	2.4	1.31	1.29	1.29
	44	0.235	3.25	2.2	0.235	3.05	2.3	1.12	1.11	1.11
	45	0.202	3.27	2.1	0.202	2.91	2.1	0.94	0.93	0.93
	46	0.169	2.80	1.9	0.170	2.74	2.0	0.79	0.77	0.77
	47	0.141	2.24	1.7	0.142	2.59	1.8	0.62	0.61	0.61
Average										
Weekday		0.180	2.89	1.8	0.179	2.73	2.0	1.00	0.99	0.99
Weekend		0.179	2.78	1.9	0.178	2.70	2.0	1.00	0.98	0.98
ADWF[1]		0.180	2.86	1.8	0.179	2.72	2.0	1.00	0.99	0.99
% Error										
Weekday					-0.2%	-5.8%	9.0%			
Weekend					-0.4%	-3.2%	4.5%			

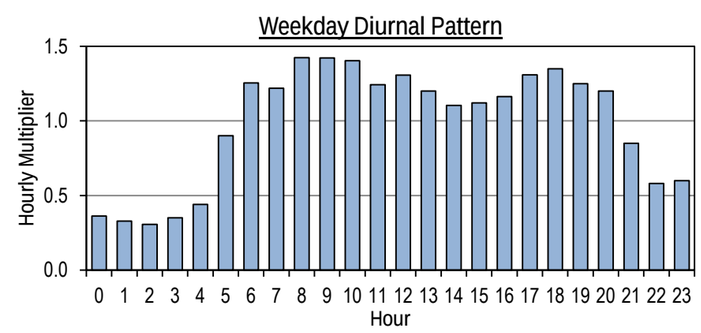
Note:

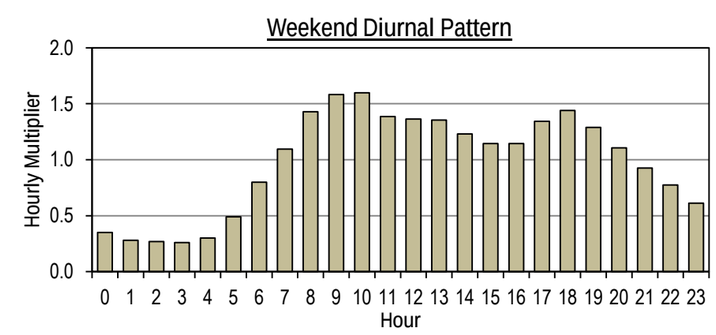
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

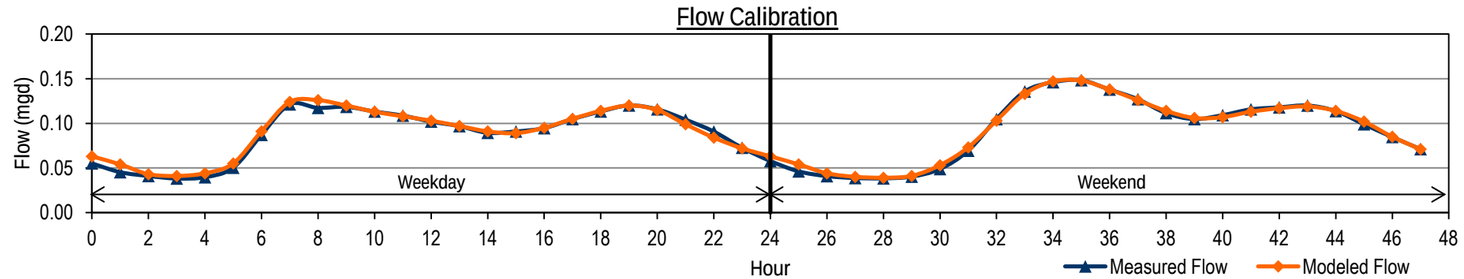
Flow Monitoring Program and Hydraulic Model Update

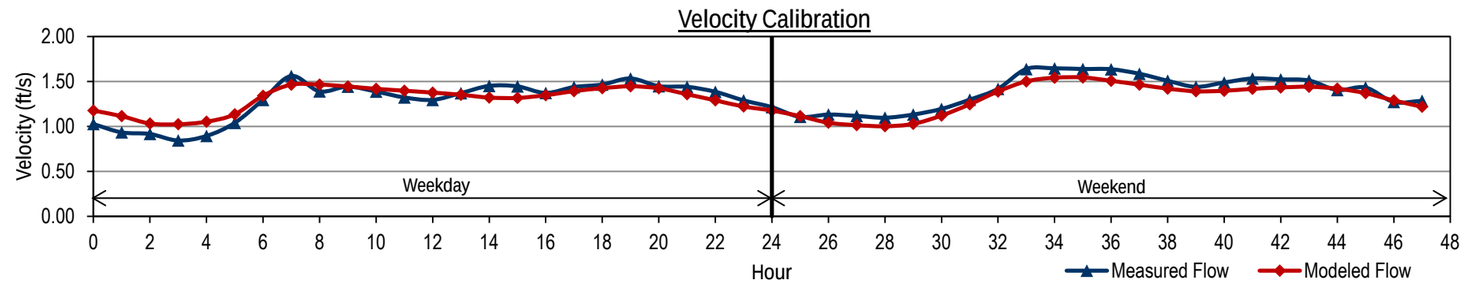
FLOW MONITORING SITE W62 DRY WEATHER FLOW CALIBRATION

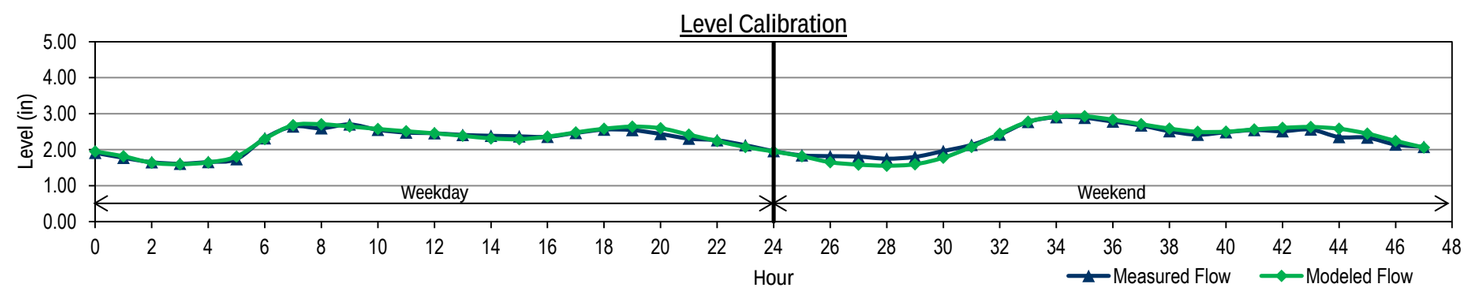
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.055	1.03	1.9	0.063	1.18	2.0	0.50	0.48	0.48
	1	0.045	0.94	1.8	0.054	1.12	1.8	0.46	0.42	0.42
	2	0.041	0.92	1.7	0.043	1.03	1.6	0.42	0.49	0.49
	3	0.038	0.85	1.6	0.041	1.03	1.6	0.44	0.50	0.50
	4	0.040	0.90	1.7	0.044	1.05	1.6	0.56	0.75	0.75
	5	0.050	1.04	1.7	0.055	1.14	1.8	0.97	1.26	1.26
	6	0.087	1.30	2.3	0.091	1.34	2.3	1.35	1.44	1.44
	7	0.121	1.56	2.6	0.124	1.46	2.7	1.30	1.35	1.35
	8	0.117	1.39	2.6	0.126	1.47	2.7	1.32	1.30	1.30
	9	0.119	1.44	2.7	0.120	1.44	2.6	1.26	1.21	1.21
	10	0.113	1.39	2.6	0.113	1.42	2.6	1.21	1.17	1.17
	11	0.109	1.32	2.5	0.108	1.40	2.5	1.13	1.10	1.10
	12	0.102	1.30	2.5	0.103	1.38	2.5	1.08	1.04	1.04
	13	0.097	1.37	2.4	0.097	1.35	2.4	0.99	0.96	0.96
	14	0.089	1.45	2.4	0.091	1.32	2.3	1.01	1.00	1.00
	15	0.091	1.45	2.4	0.089	1.32	2.3	1.05	1.09	1.09
	16	0.095	1.37	2.4	0.095	1.35	2.4	1.17	1.22	1.22
	17	0.105	1.44	2.5	0.105	1.39	2.5	1.26	1.29	1.29
	18	0.113	1.47	2.6	0.114	1.43	2.6	1.33	1.34	1.34
	19	0.120	1.53	2.5	0.120	1.45	2.6	1.29	1.22	1.22
	20	0.116	1.45	2.4	0.115	1.42	2.6	1.16	0.99	0.99
	21	0.104	1.44	2.3	0.099	1.36	2.4	1.01	0.87	0.87
	22	0.091	1.39	2.3	0.084	1.29	2.2	0.81	0.70	0.70
	23	0.073	1.29	2.1	0.072	1.22	2.1	0.61	0.68	0.68
Weekend	24	0.058	1.22	2.0	0.063	1.18	2.0	0.51	0.48	0.48
	25	0.046	1.11	1.8	0.054	1.12	1.8	0.45	0.45	0.45
	26	0.041	1.13	1.8	0.044	1.04	1.7	0.43	0.43	0.43
	27	0.039	1.12	1.8	0.040	1.02	1.6	0.43	0.42	0.42
	28	0.038	1.10	1.8	0.039	1.00	1.6	0.45	0.51	0.51
	29	0.040	1.13	1.8	0.041	1.03	1.6	0.54	0.70	0.70
	30	0.049	1.20	2.0	0.053	1.12	1.8	0.77	0.94	0.94
	31	0.069	1.30	2.1	0.073	1.25	2.1	1.16	1.30	1.30
	32	0.105	1.42	2.4	0.103	1.39	2.4	1.51	1.58	1.58
	33	0.136	1.64	2.8	0.133	1.50	2.8	1.62	1.64	1.64
	34	0.146	1.65	2.9	0.147	1.54	2.9	1.65	1.63	1.63
	35	0.148	1.64	2.9	0.148	1.54	2.9	1.53	1.46	1.46
	36	0.138	1.64	2.8	0.138	1.51	2.8	1.41	1.34	1.34
	37	0.127	1.59	2.7	0.126	1.46	2.7	1.24	1.20	1.20
	38	0.112	1.51	2.5	0.114	1.42	2.6	1.17	1.15	1.15
	39	0.105	1.44	2.4	0.106	1.39	2.5	1.21	1.20	1.20
	40	0.109	1.49	2.5	0.107	1.40	2.5	1.29	1.27	1.27
	41	0.116	1.53	2.5	0.113	1.42	2.6	1.31	1.30	1.30
	42	0.118	1.52	2.5	0.117	1.43	2.6	1.33	1.32	1.32
	43	0.120	1.51	2.6	0.119	1.44	2.6	1.26	1.21	1.21
	44	0.114	1.41	2.4	0.114	1.42	2.6	1.10	1.05	1.05
	45	0.099	1.43	2.3	0.102	1.37	2.4	0.94	0.82	0.82
	46	0.085	1.27	2.1	0.085	1.29	2.2	0.79	0.73	0.73
	47	0.071	1.29	2.1	0.071	1.22	2.1	0.64	0.56	0.56
Average										
Weekday		0.089	1.29	2.3	0.090	1.31	2.3	0.99	0.99	0.99
Weekend		0.093	1.39	2.3	0.094	1.31	2.3	1.03	1.03	1.03
ADWF[1]		0.090	1.32	2.3	0.091	1.31	2.3	1.00	1.00	1.00
% Error										
Weekday					1.6%	1.1%	0.6%			
Weekend					1.0%	-5.3%	-0.3%			

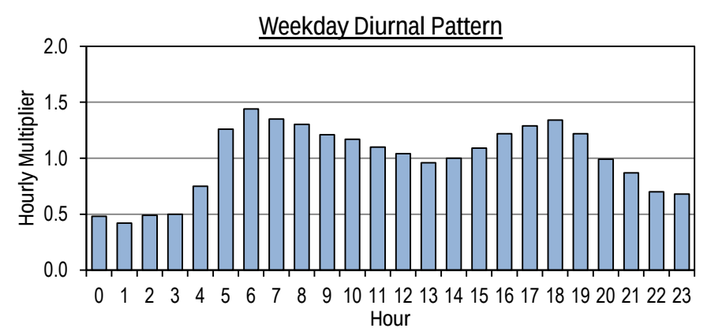
Note:

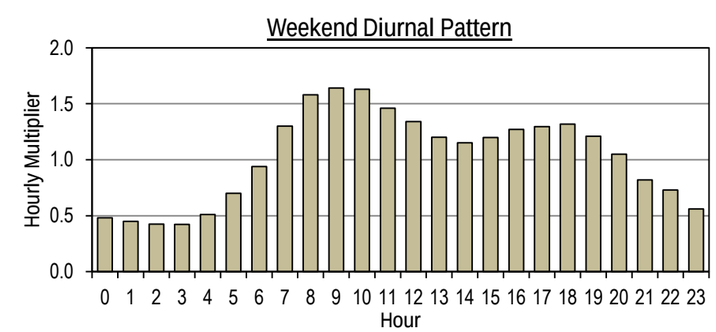
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

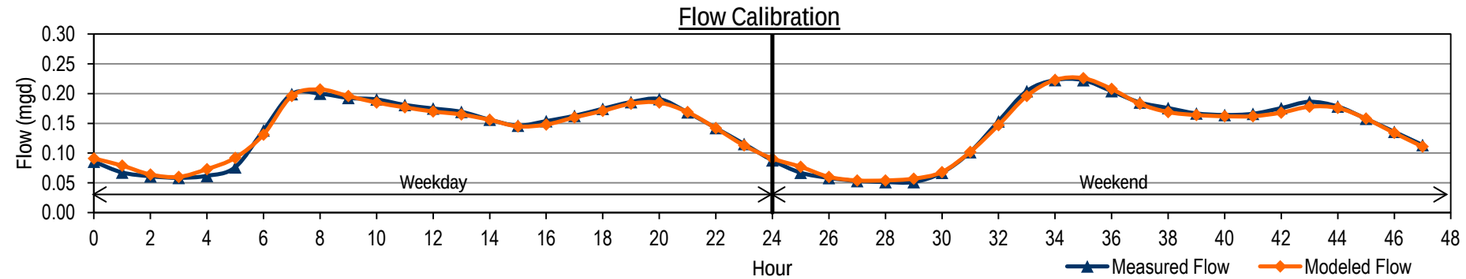
Flow Monitoring Program and Hydraulic Model Update

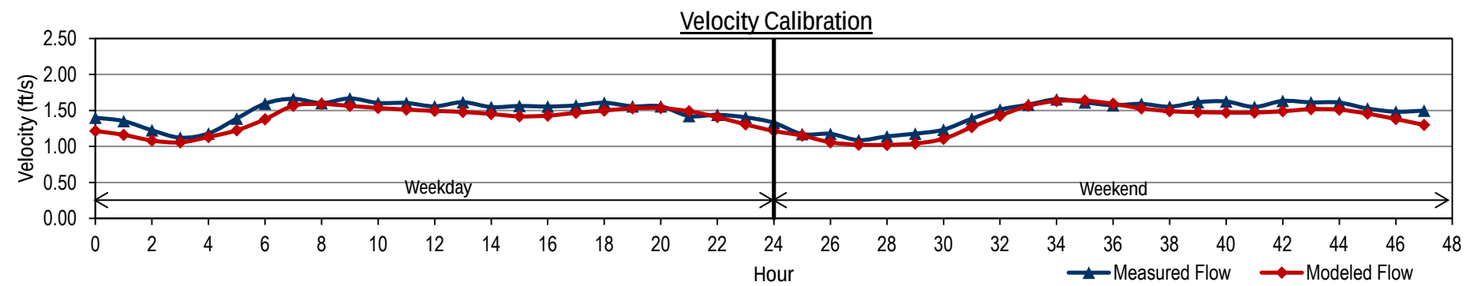
FLOW MONITORING SITE X115 DRY WEATHER FLOW CALIBRATION

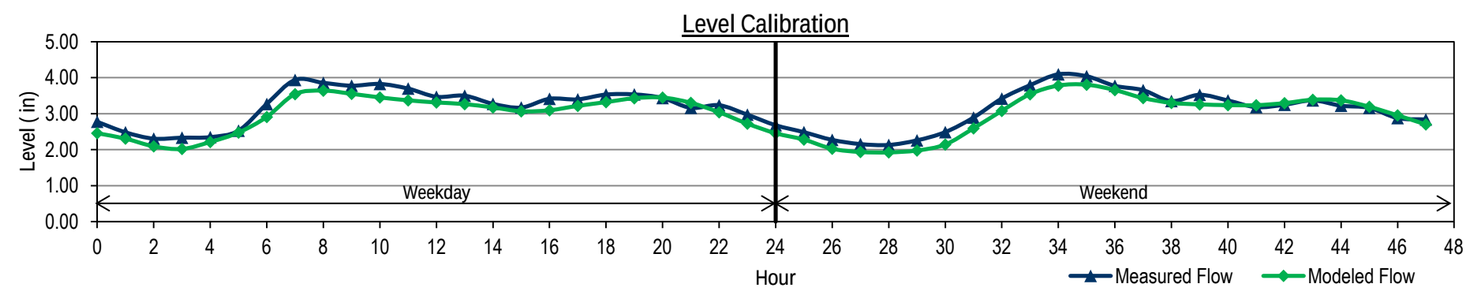
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.086	1.40	2.8	0.091	1.22	2.5	0.47	0.45	0.45
	1	0.067	1.35	2.5	0.079	1.16	2.3	0.43	0.39	0.39
	2	0.061	1.23	2.3	0.064	1.08	2.1	0.41	0.47	0.47
	3	0.058	1.12	2.3	0.060	1.06	2.0	0.43	0.65	0.65
	4	0.062	1.18	2.3	0.073	1.13	2.2	0.53	0.68	0.68
	5	0.076	1.39	2.5	0.092	1.22	2.5	0.97	1.27	1.27
	6	0.138	1.60	3.3	0.131	1.38	2.9	1.40	1.48	1.48
	7	0.199	1.66	3.9	0.196	1.57	3.5	1.40	1.43	1.43
	8	0.200	1.60	3.9	0.207	1.59	3.6	1.35	1.34	1.34
	9	0.193	1.67	3.8	0.196	1.56	3.5	1.33	1.27	1.27
	10	0.190	1.61	3.8	0.185	1.54	3.4	1.27	1.21	1.21
	11	0.181	1.61	3.7	0.177	1.51	3.4	1.23	1.18	1.18
	12	0.175	1.56	3.5	0.170	1.49	3.3	1.19	1.14	1.14
	13	0.169	1.62	3.5	0.165	1.48	3.3	1.10	1.04	1.04
	14	0.156	1.55	3.3	0.156	1.45	3.2	1.02	0.99	0.99
	15	0.146	1.56	3.2	0.145	1.42	3.1	1.08	1.10	1.10
	16	0.154	1.56	3.4	0.148	1.43	3.1	1.14	1.16	1.16
	17	0.163	1.57	3.4	0.160	1.47	3.2	1.22	1.25	1.25
	18	0.174	1.61	3.5	0.171	1.50	3.3	1.30	1.32	1.32
	19	0.186	1.56	3.5	0.183	1.53	3.4	1.34	1.28	1.28
	20	0.191	1.56	3.4	0.185	1.53	3.4	1.18	1.09	1.09
	21	0.169	1.42	3.2	0.169	1.49	3.3	1.00	0.88	0.88
	22	0.142	1.44	3.2	0.142	1.41	3.0	0.81	0.64	0.64
	23	0.115	1.41	3.0	0.113	1.31	2.7	0.60	0.60	0.60
Weekend	24	0.088	1.33	2.7	0.091	1.22	2.5	0.47	0.40	0.40
	25	0.067	1.17	2.5	0.077	1.15	2.3	0.41	0.38	0.38
	26	0.058	1.18	2.3	0.060	1.06	2.0	0.37	0.37	0.37
	27	0.053	1.09	2.2	0.054	1.02	1.9	0.36	0.40	0.40
	28	0.051	1.14	2.1	0.054	1.02	1.9	0.36	0.42	0.42
	29	0.051	1.18	2.3	0.057	1.04	2.0	0.47	0.64	0.64
	30	0.067	1.23	2.5	0.068	1.11	2.1	0.71	0.90	0.90
	31	0.102	1.39	2.9	0.102	1.27	2.6	1.08	1.21	1.21
	32	0.153	1.51	3.4	0.147	1.43	3.1	1.43	1.53	1.53
	33	0.204	1.58	3.8	0.196	1.57	3.5	1.56	1.60	1.60
	34	0.223	1.66	4.1	0.223	1.63	3.8	1.56	1.58	1.58
	35	0.223	1.61	4.0	0.226	1.64	3.8	1.43	1.37	1.37
	36	0.204	1.57	3.8	0.208	1.59	3.7	1.30	1.21	1.21
	37	0.185	1.59	3.7	0.183	1.53	3.4	1.23	1.16	1.16
	38	0.176	1.55	3.4	0.169	1.49	3.3	1.17	1.15	1.15
	39	0.167	1.62	3.5	0.164	1.48	3.3	1.15	1.13	1.13
	40	0.164	1.63	3.4	0.162	1.47	3.2	1.16	1.15	1.15
	41	0.166	1.55	3.2	0.162	1.47	3.2	1.23	1.22	1.22
	42	0.176	1.63	3.2	0.168	1.49	3.3	1.31	1.29	1.29
	43	0.186	1.61	3.4	0.178	1.52	3.4	1.25	1.19	1.19
	44	0.178	1.61	3.2	0.176	1.51	3.4	1.11	1.01	1.01
	45	0.158	1.53	3.2	0.158	1.46	3.2	0.95	0.84	0.84
	46	0.136	1.48	2.9	0.134	1.38	3.0	0.80	0.67	0.67
	47	0.114	1.50	2.8	0.111	1.30	2.7	0.62	0.50	0.50
Average										
Weekday		0.144	1.49	3.2	0.144	1.40	3.0	1.01	1.01	1.01
Weekend		0.140	1.46	3.1	0.139	1.37	2.9	0.98	0.97	0.97
ADWF[1]		0.143	1.48	3.2	0.143	1.39	3.0	1.00	1.00	1.00
% Error										
Weekday					0.2%	-6.4%	-6.3%			
Weekend					-0.6%	-6.0%	-5.1%			

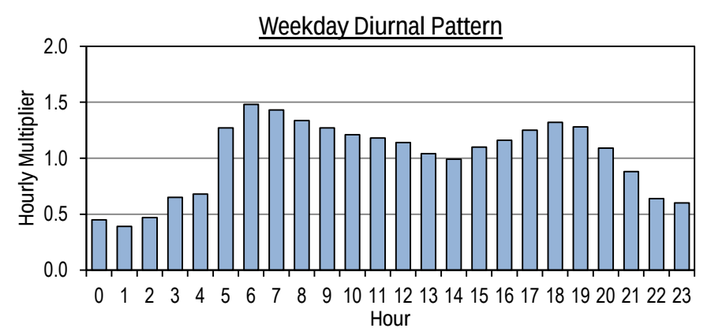
Note:

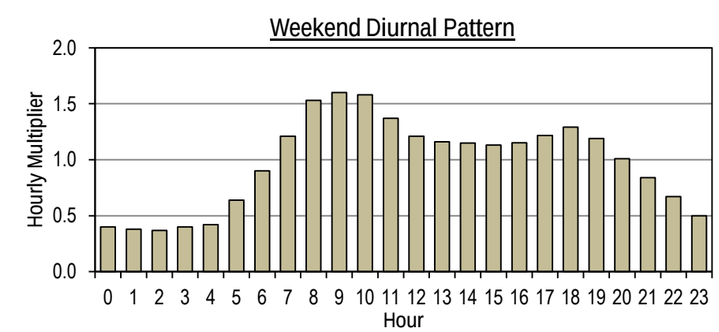
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

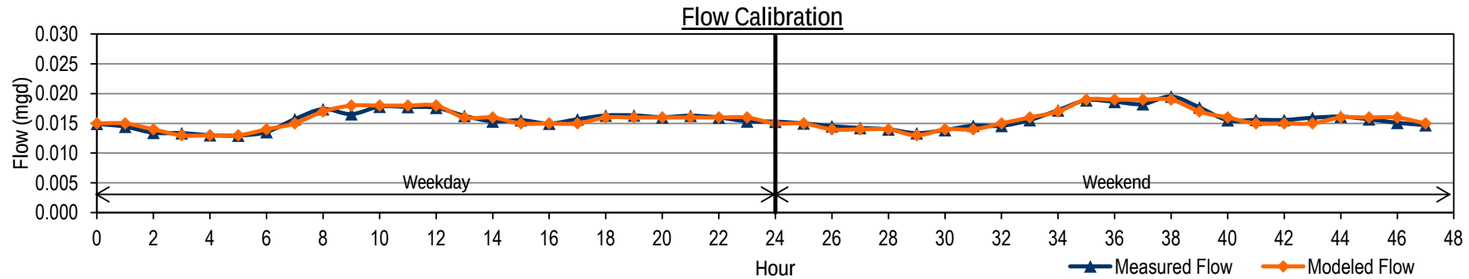
Flow Monitoring Program and Hydraulic Model Update

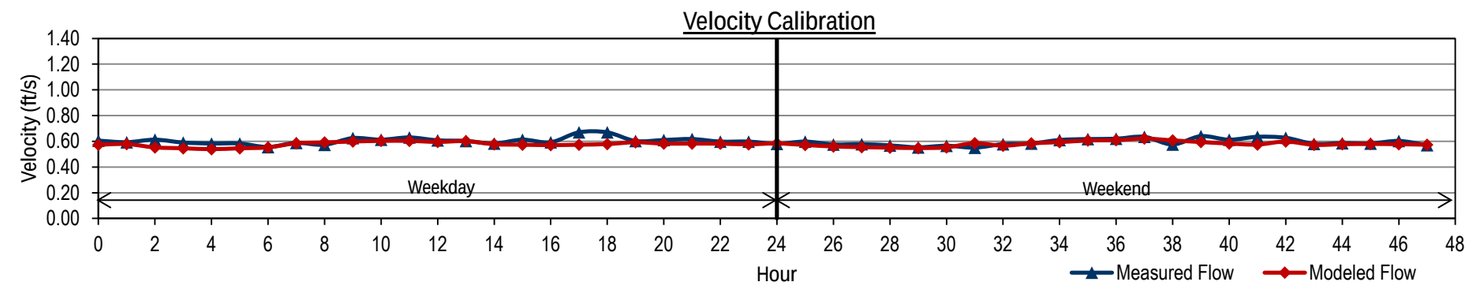
FLOW MONITORING SITE Z41 DRY WEATHER FLOW CALIBRATION

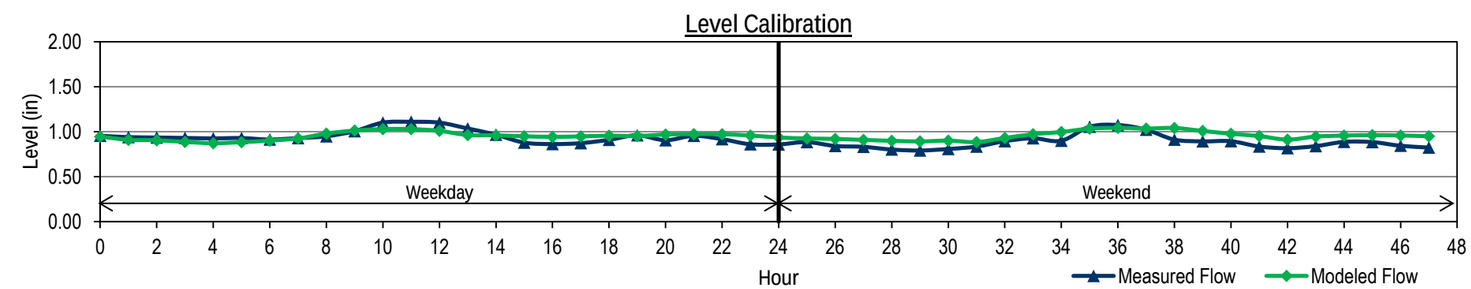
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Velocity (ft/s)	Level (in)	Flow (mgd)	Velocity (ft/s)	Level (in)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.015	0.61	1.0	0.015	0.57	0.9	0.93	0.85	0.85
	1	0.014	0.59	0.9	0.015	0.58	0.9	0.86	0.79	0.79
	2	0.013	0.61	0.9	0.014	0.55	0.9	0.86	0.80	0.80
	3	0.013	0.59	0.9	0.013	0.55	0.9	0.83	0.78	0.78
	4	0.013	0.58	0.9	0.013	0.54	0.9	0.83	0.95	0.95
	5	0.013	0.58	0.9	0.013	0.55	0.9	0.87	0.96	0.96
	6	0.014	0.56	0.9	0.014	0.55	0.9	1.01	1.13	1.13
	7	0.016	0.59	0.9	0.015	0.58	0.9	1.11	1.21	1.21
	8	0.017	0.57	0.9	0.017	0.59	1.0	1.06	1.20	1.20
	9	0.017	0.63	1.0	0.018	0.60	1.0	1.14	1.18	1.18
	10	0.018	0.61	1.1	0.018	0.60	1.0	1.14	1.14	1.14
	11	0.018	0.63	1.1	0.018	0.60	1.0	1.13	1.02	1.02
	12	0.018	0.61	1.1	0.018	0.60	1.0	1.04	0.92	0.92
	13	0.016	0.60	1.0	0.016	0.60	1.0	0.98	0.96	0.96
	14	0.015	0.58	1.0	0.016	0.58	1.0	1.00	0.99	0.99
	15	0.016	0.61	0.9	0.015	0.57	0.9	0.96	0.96	0.96
	16	0.015	0.59	0.9	0.015	0.57	0.9	1.01	1.00	1.00
	17	0.016	0.67	0.9	0.015	0.57	0.9	1.05	1.04	1.04
	18	0.016	0.67	0.9	0.016	0.58	1.0	1.05	1.05	1.05
	19	0.016	0.60	1.0	0.016	0.59	1.0	1.03	1.03	1.03
	20	0.016	0.61	0.9	0.016	0.58	1.0	1.04	1.04	1.04
	21	0.016	0.62	1.0	0.016	0.58	1.0	1.02	1.02	1.02
	22	0.016	0.60	0.9	0.016	0.58	1.0	0.98	0.92	0.92
	23	0.015	0.60	0.9	0.016	0.58	1.0	0.96	0.94	0.94
Weekend	24	0.015	0.58	0.9	0.015	0.58	0.9	0.96	0.89	0.89
	25	0.015	0.60	0.9	0.015	0.57	0.9	0.93	0.88	0.88
	26	0.015	0.58	0.8	0.014	0.56	0.9	0.91	0.85	0.85
	27	0.014	0.58	0.8	0.014	0.55	0.9	0.90	0.84	0.84
	28	0.014	0.57	0.8	0.014	0.55	0.9	0.86	0.84	0.84
	29	0.013	0.55	0.8	0.013	0.55	0.9	0.89	0.95	0.95
	30	0.014	0.57	0.8	0.014	0.55	0.9	0.94	0.97	0.97
	31	0.015	0.55	0.8	0.014	0.59	0.9	0.93	0.99	0.99
	32	0.015	0.58	0.9	0.015	0.57	0.9	1.00	1.23	1.23
	33	0.016	0.58	0.9	0.016	0.58	1.0	1.10	1.17	1.17
	34	0.017	0.61	0.9	0.017	0.59	1.0	1.21	1.30	1.30
	35	0.019	0.62	1.1	0.019	0.61	1.0	1.19	1.19	1.19
	36	0.019	0.62	1.1	0.019	0.61	1.0	1.17	1.20	1.20
	37	0.018	0.64	1.0	0.019	0.62	1.0	1.25	1.18	1.18
	38	0.020	0.58	0.9	0.019	0.61	1.0	1.13	0.95	0.95
	39	0.018	0.64	0.9	0.017	0.59	1.0	1.00	0.90	0.90
	40	0.016	0.61	0.9	0.016	0.58	1.0	1.00	0.95	0.95
	41	0.016	0.64	0.8	0.015	0.57	1.0	1.00	1.00	1.00
	42	0.016	0.63	0.8	0.015	0.60	0.9	1.02	1.02	1.02
	43	0.016	0.58	0.8	0.015	0.57	0.9	1.03	1.03	1.03
	44	0.016	0.59	0.9	0.016	0.58	1.0	1.01	1.00	1.00
	45	0.016	0.58	0.9	0.016	0.58	1.0	0.97	0.97	0.97
	46	0.015	0.60	0.8	0.016	0.58	1.0	0.94	0.94	0.94
	47	0.015	0.57	0.8	0.015	0.57	0.9	0.98	0.98	0.98
Average										
Weekday		0.016	0.60	1.0	0.016	0.58	1.0	0.99	1.00	1.00
Weekend		0.016	0.59	0.9	0.016	0.58	1.0	1.01	1.01	1.01
ADWF[1]		0.016	0.60	0.9	0.016	0.58	1.0	1.00	1.00	1.00
% Error										
Weekday					0.5%	-4.6%	-0.2%			
Weekend					-0.3%	-2.1%	8.3%			

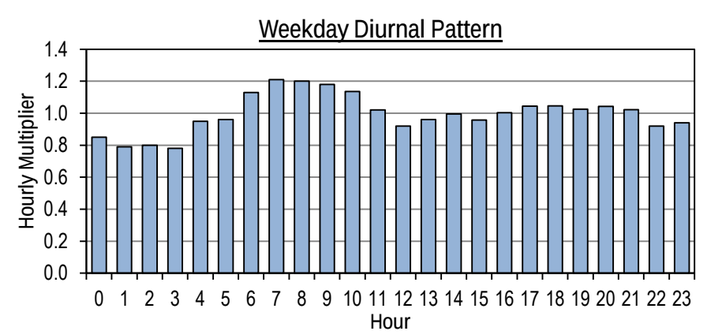
Note:

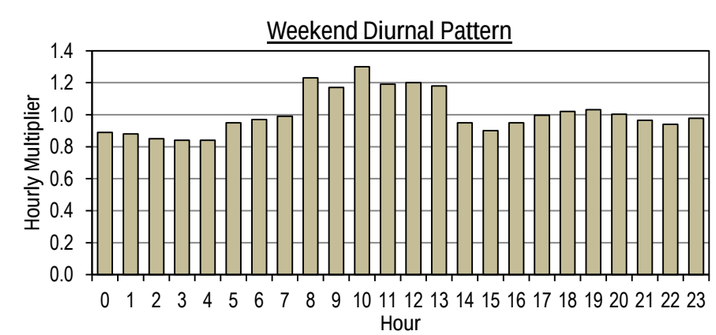
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Grants Pass

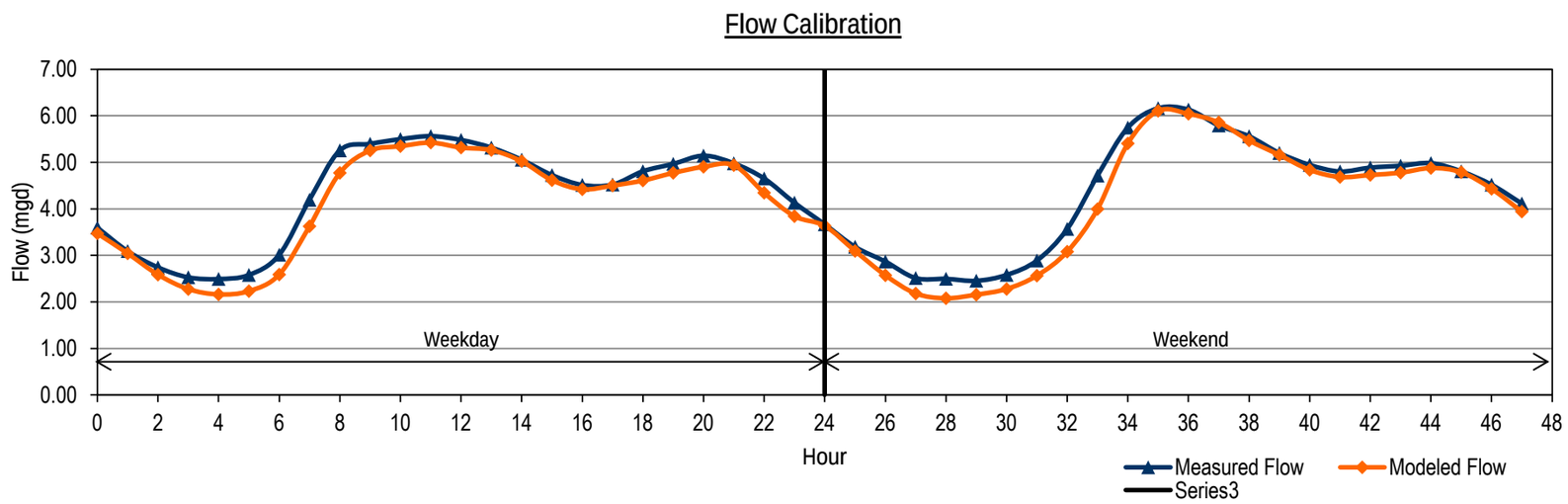
Flow Monitoring Program and Hydraulic Model Update

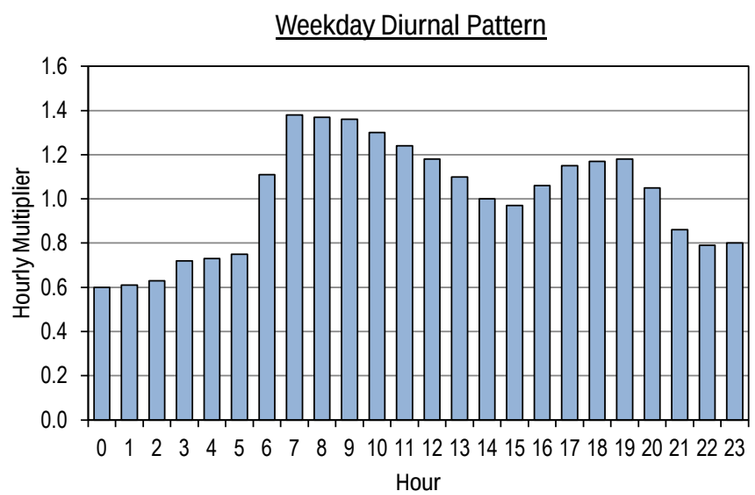
FLOW MONITORING SITE WRP DRY WEATHER FLOW CALIBRATION

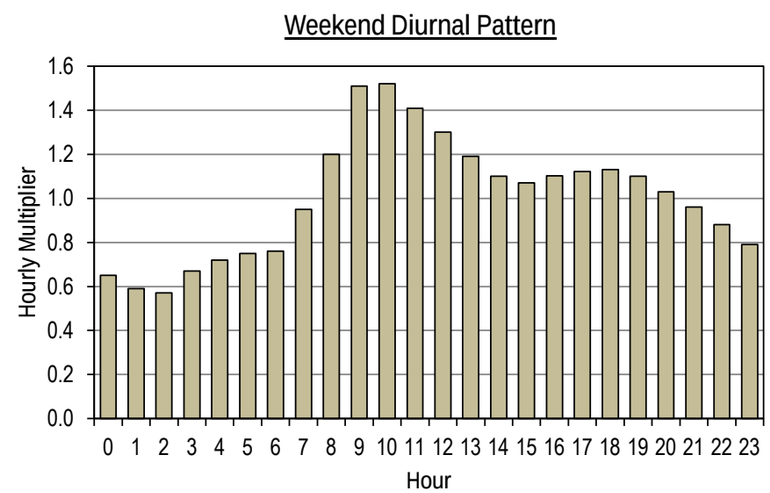
	Hour	Measured Data Flow (mgd)	Modeled Data Flow (mgd)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	3.597	3.471	0.71	0.60	0.60
	1	3.093	3.042	0.63	0.61	0.61
	2	2.744	2.585	0.58	0.63	0.63
	3	2.529	2.274	0.58	0.72	0.72
	4	2.494	2.160	0.59	0.73	0.73
	5	2.580	2.230	0.69	0.75	0.75
	6	3.013	2.587	0.97	1.11	1.11
	7	4.195	3.625	1.21	1.38	1.38
	8	5.258	4.773	1.25	1.37	1.37
	9	5.400	5.255	1.27	1.36	1.36
	10	5.501	5.348	1.28	1.30	1.30
	11	5.565	5.425	1.26	1.24	1.24
	12	5.483	5.317	1.23	1.18	1.18
	13	5.318	5.264	1.17	1.10	1.10
	14	5.057	5.024	1.09	1.00	1.00
	15	4.728	4.616	1.04	0.97	0.97
	16	4.515	4.420	1.04	1.06	1.06
	17	4.523	4.501	1.11	1.15	1.15
	18	4.810	4.609	1.15	1.17	1.17
	19	4.969	4.773	1.19	1.18	1.18
	20	5.145	4.904	1.15	1.05	1.05
	21	4.980	4.939	1.07	0.86	0.86
	22	4.654	4.345	0.95	0.79	0.79
	23	4.133	3.842	0.83	0.80	0.80
Weekend	24	3.668	3.633	0.73	0.65	0.65
	25	3.184	3.094	0.66	0.59	0.59
	26	2.868	2.571	0.58	0.57	0.57
	27	2.514	2.179	0.58	0.67	0.67
	28	2.497	2.077	0.57	0.72	0.72
	29	2.455	2.154	0.60	0.75	0.75
	30	2.581	2.276	0.67	0.76	0.76
	31	2.890	2.563	0.82	0.95	0.95
	32	3.569	3.079	1.09	1.20	1.20
	33	4.717	3.995	1.33	1.51	1.51
	34	5.748	5.406	1.42	1.52	1.52
	35	6.166	6.107	1.41	1.41	1.41
	36	6.134	6.044	1.34	1.30	1.30
	37	5.793	5.858	1.28	1.19	1.19
	38	5.562	5.471	1.20	1.10	1.10
	39	5.202	5.159	1.14	1.07	1.07
	40	4.946	4.838	1.11	1.10	1.10
	41	4.805	4.685	1.13	1.12	1.12
	42	4.889	4.729	1.14	1.13	1.13
	43	4.928	4.778	1.15	1.10	1.10
	44	4.984	4.878	1.11	1.03	1.03
	45	4.808	4.788	1.04	0.96	0.96
	46	4.521	4.431	0.95	0.88	0.88
	47	4.115	3.941	0.85	0.79	0.79
Average						
Weekday		4.345	4.139	1.00	1.00	1.00
Weekend		4.314	4.114	0.99	1.00	1.00
ADWF[1]		4.336	4.132	1.00	1.00	1.00
% Error						
Weekday			-4.7%			
Weekend			-4.6%			

Note:

1. ADWF = (5xWeekday Average + 2xWeekend Average)/7







APPENDIX C – WET WEATHER FLOW CALIBRATION

Table 1 Wet Weather Flow Calibration Results
Flow Monitoring and Hydraulic Modeling Update
City of Grants Pass

		Storm 1 (1/18/12-1/20/12)						Storm 2 (1/20/12-1/21/12)						Storm 3 (1/22/12-1/22/12)					
		Measured Data[1]		Modeled Data[2]		Percent Error[3]		Measured Data[1]		Modeled Data[2]		Percent Error[3]		Measured Data[1]		Modeled Data[2]		Percent Error[3]	
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)
D60	20.5	1.163	2.173	1.158	2.158	-0.5%	-0.7%	1.773	2.397	1.741	2.529	-1.8%	5.5%	1.607	2.065	1.620	2.352	0.8%	13.9%
H5	12	0.593	1.130	0.611	1.124	3.1%	-0.5%	0.905	1.271	0.862	1.323	-4.7%	4.1%	0.752	1.014	0.718	1.060	-4.6%	4.5%
I5	15	0.569	1.039	0.570	0.998	0.2%	-4.0%	0.784	1.159	0.754	1.068	-3.9%	-7.8%	0.697	0.906	0.701	0.997	0.5%	10.0%
J2	18	0.536	1.103	0.591	1.222	10.2%	10.8%	0.862	1.457	0.866	1.485	0.4%	1.9%	0.771	1.136	0.792	1.372	2.7%	20.8%
K1	18	0.365	0.647	0.394	0.678	8.0%	4.7%	0.541	0.770	0.529	0.781	-2.2%	1.5%	0.524	0.712	0.494	0.742	-5.8%	4.1%
N2	18	0.432	0.928	0.452	0.936	4.5%	0.9%	0.590	1.107	0.568	1.023	-3.8%	-7.6%	0.526	0.770	0.539	0.890	2.5%	15.5%
R42	15	0.377	1.038	0.402	0.927	6.5%	-10.7%	0.790	1.123	0.809	1.196	2.4%	6.5%	0.550	0.690	0.583	0.838	6.1%	21.5%
W62	12	0.157	0.279	0.159	0.279	1.3%	-0.1%	0.219	0.309	0.218	0.324	-0.5%	4.9%	0.206	0.267	0.212	0.297	2.9%	11.0%
X115	12	0.333	0.658	0.331	0.648	-0.8%	-1.5%	0.488	0.678	0.479	0.732	-1.7%	8.0%	0.441	0.619	0.443	0.640	0.4%	3.4%
Z41	24	0.124	0.569	0.093	0.293	*-25.4%*	*-48.5%*	0.238	0.378	0.220	0.335	-7.4%	-11.3%	0.139	0.173	0.143	0.207	2.4%	19.7%
WRP	48	8.029	16.162	7.804	15.868	-2.8%	-1.8%	12.291	17.595	11.749	18.131	-4.4%	3.0%	10.581	13.973	10.279	15.327	-2.9%	9.7%

Notes:

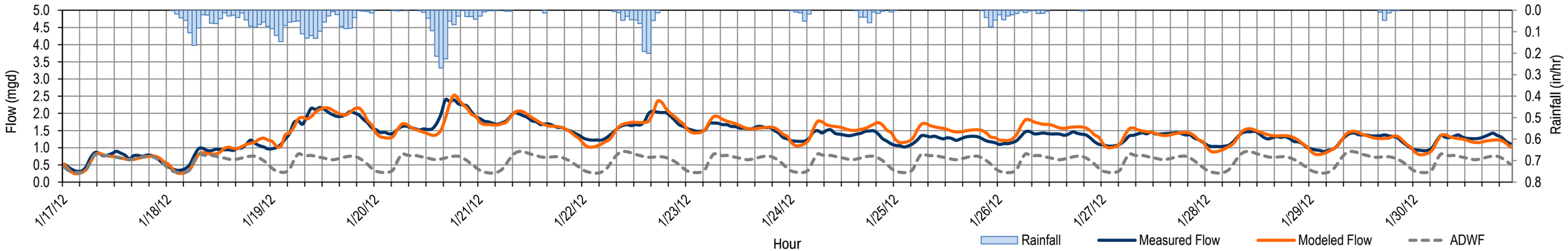
1. Average flow values are calculated from weekday/weekend dry weather flow monitoring data. Maximum flow values are hourly peaks corresponding to either weekend or weekday confitions, as appropriate.
2. Percent Difference = (Modeled - Measured)/Measured*100.
3. Average Dry Weather Flow = (5*Weekday Dry Weather Flow + 2*Weekend Dry Weather Flow)/7

City of Grants Pass

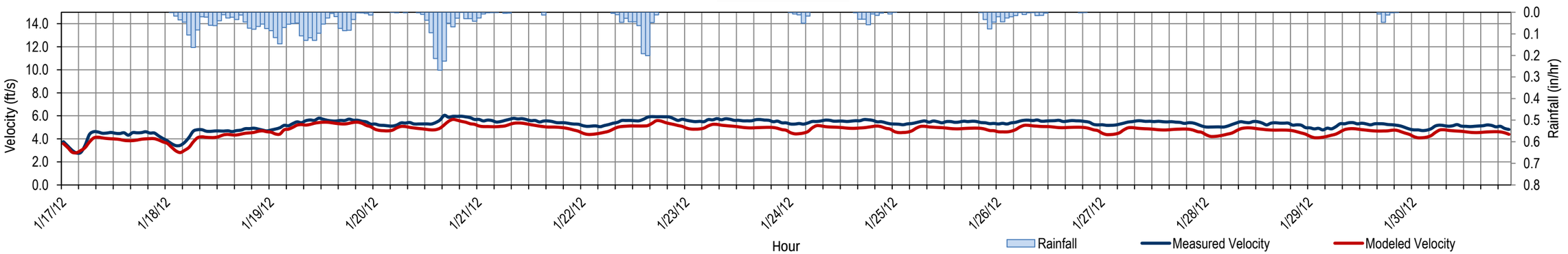
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE D60 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

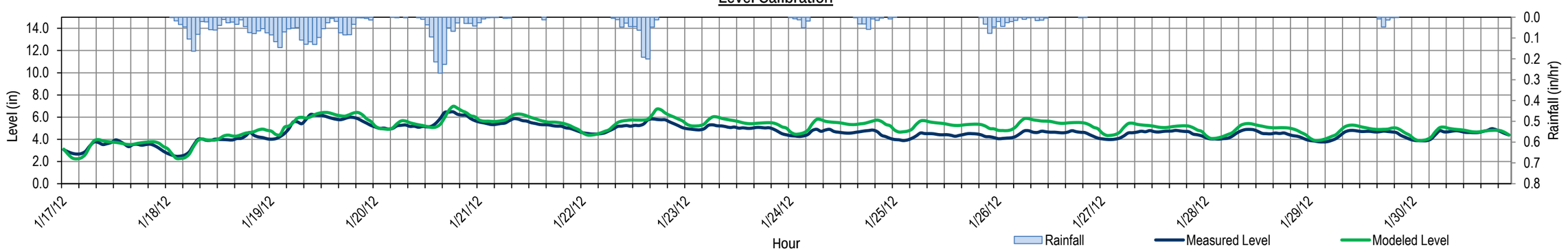
Flow Calibration



Velocity Calibration



Level Calibration

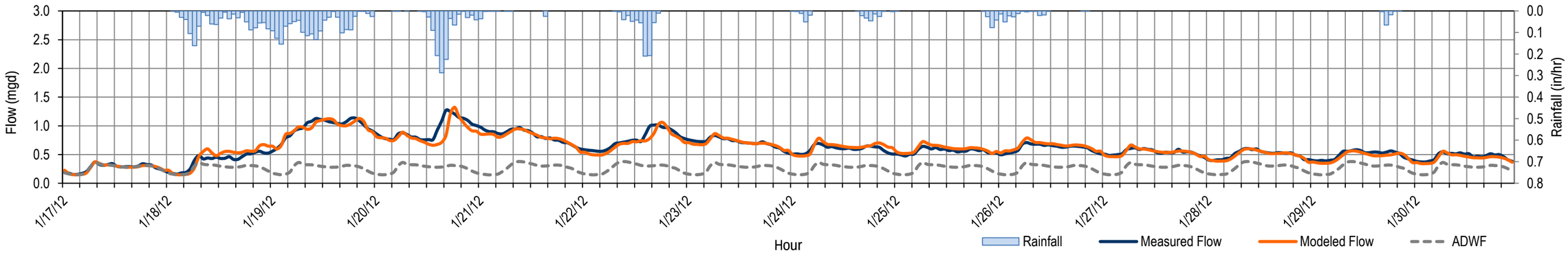


City of Grants Pass

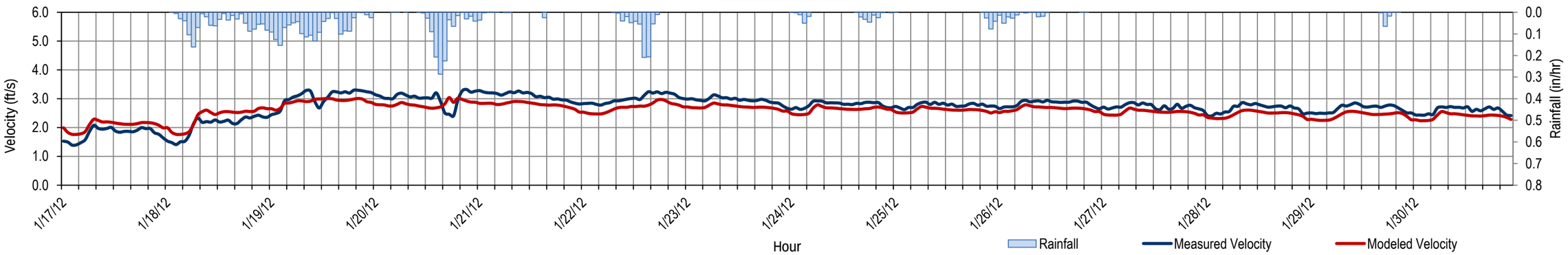
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE H5 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

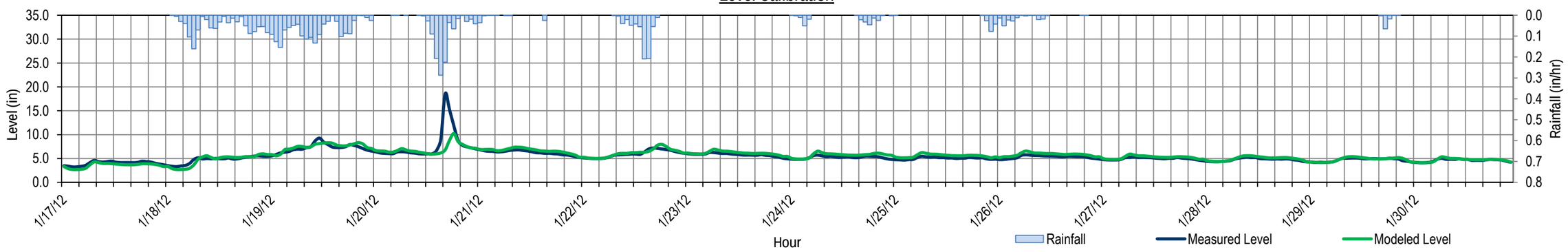
Flow Calibration



Velocity Calibration



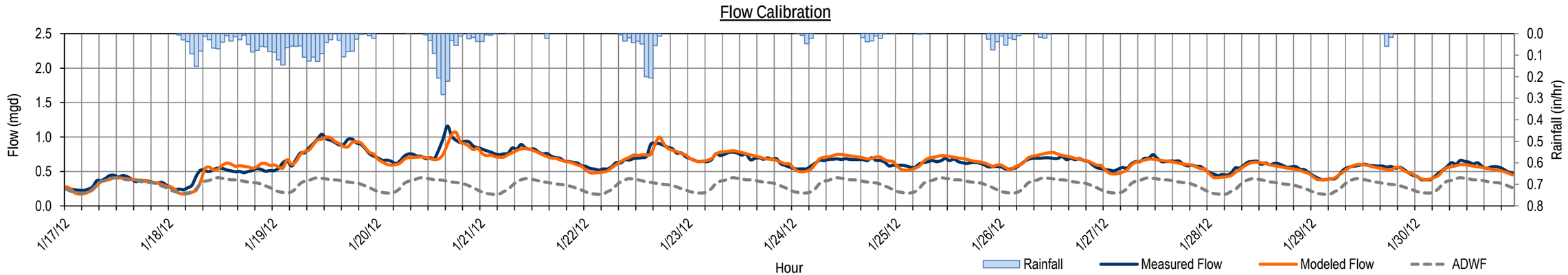
Level Calibration

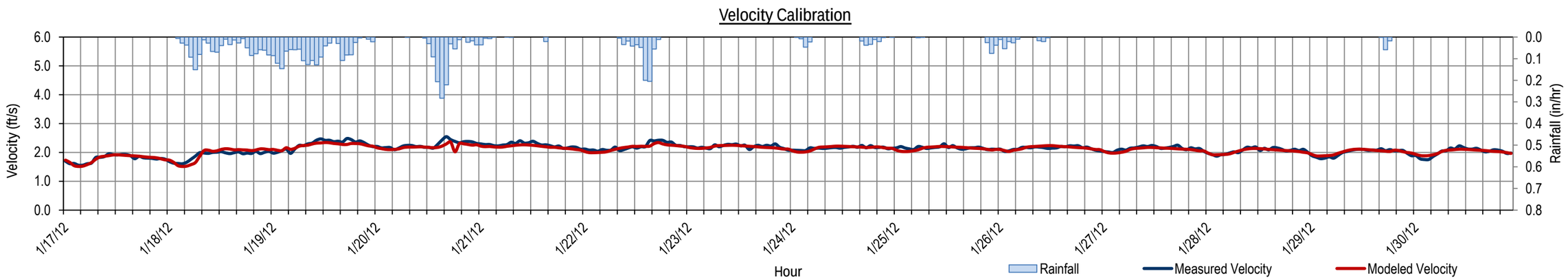


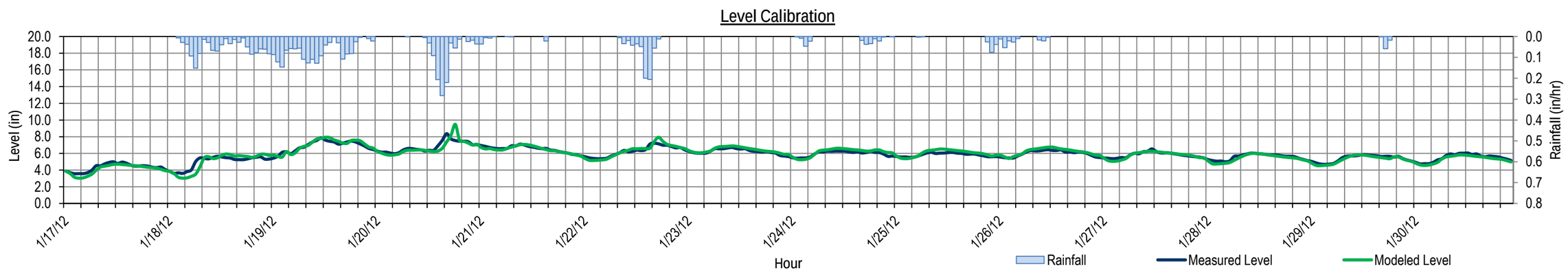
City of Grants Pass

Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE I5 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)



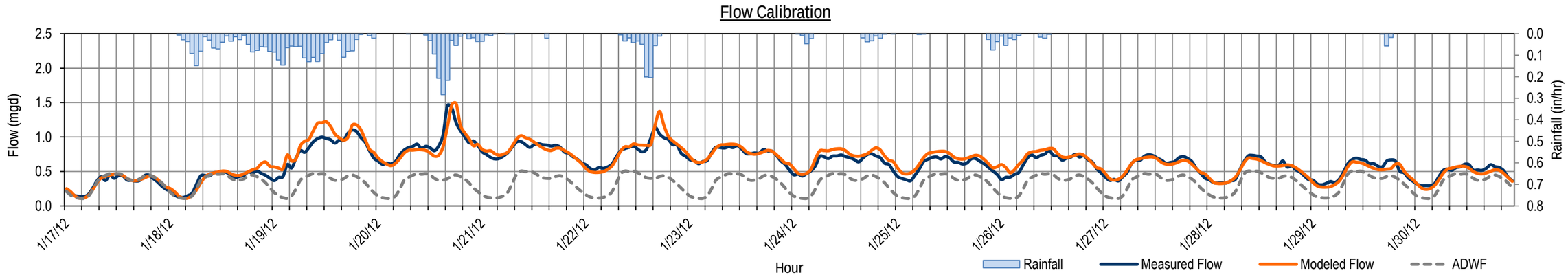


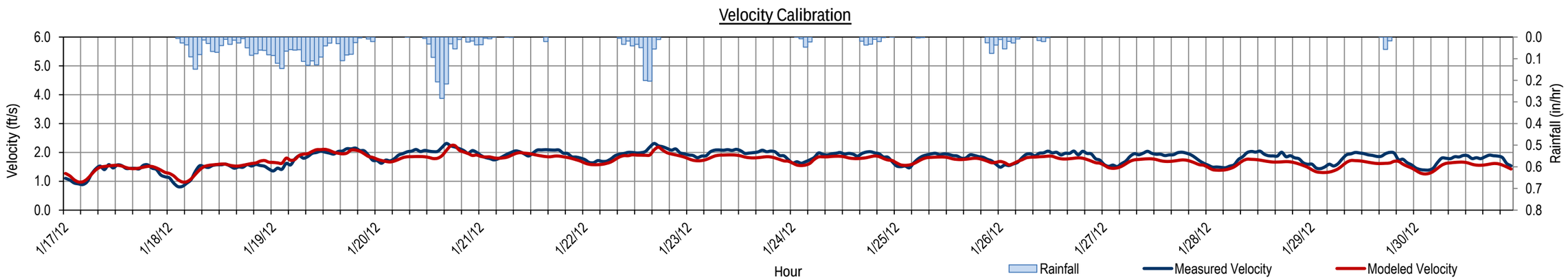


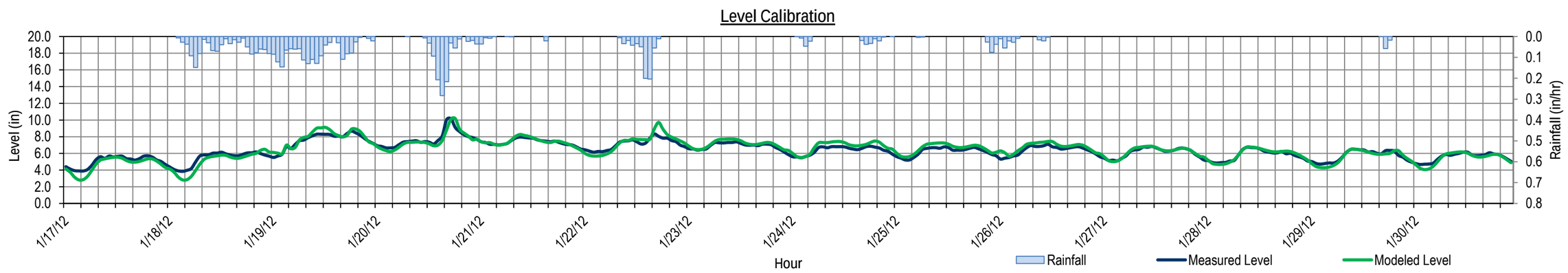
City of Grants Pass

Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE J2 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)





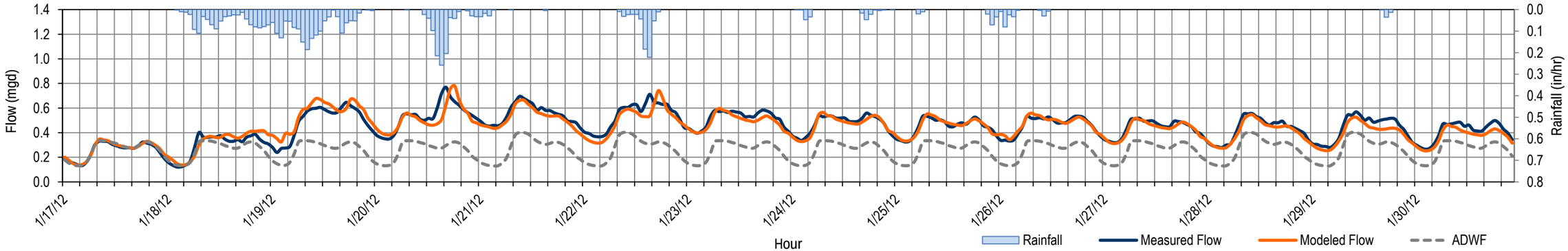


City of Grants Pass

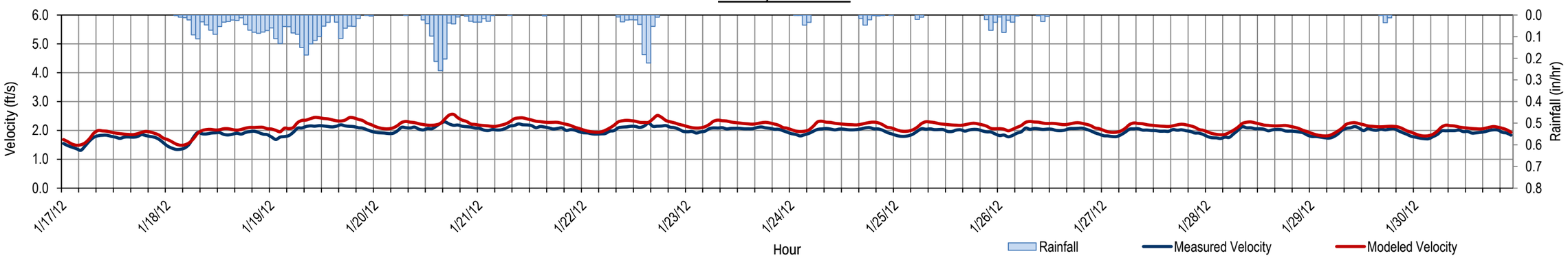
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE K1 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

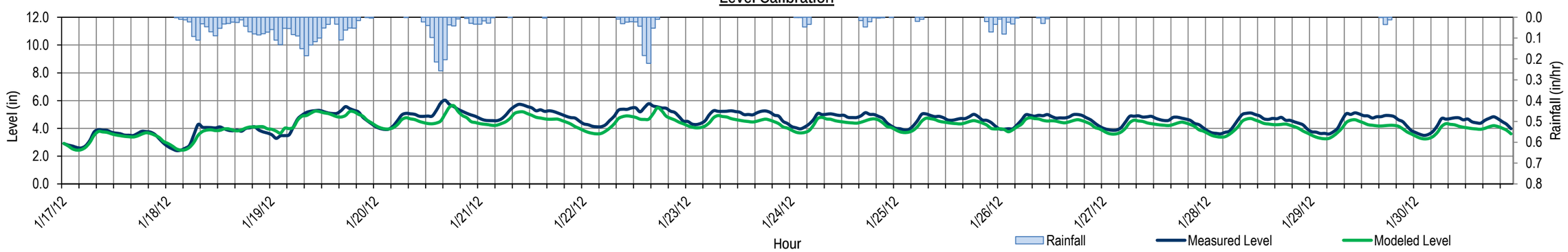
Flow Calibration



Velocity Calibration



Level Calibration

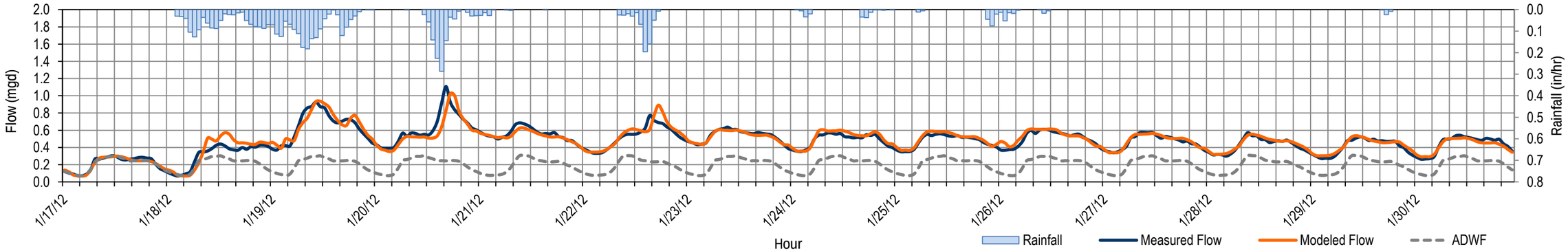


City of Grants Pass

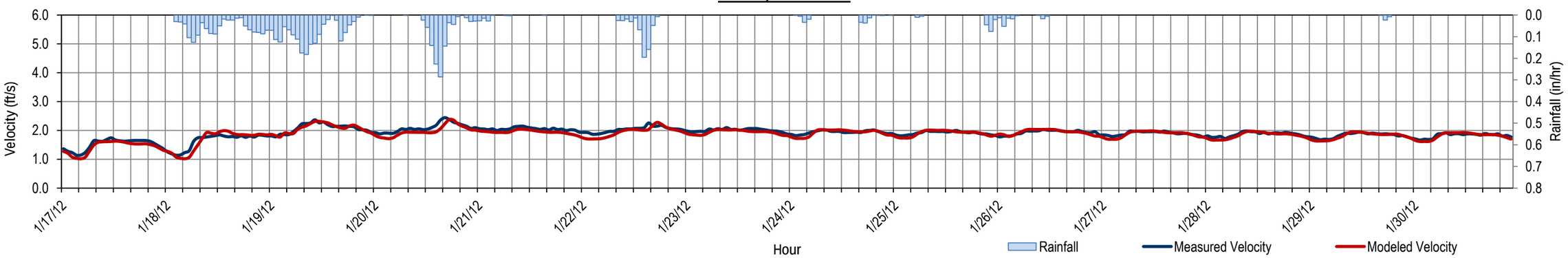
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE N2 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

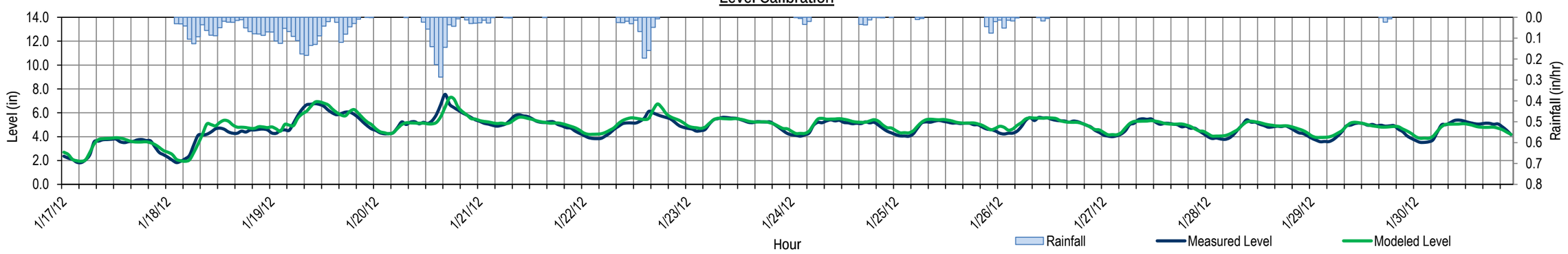
Flow Calibration



Velocity Calibration



Level Calibration

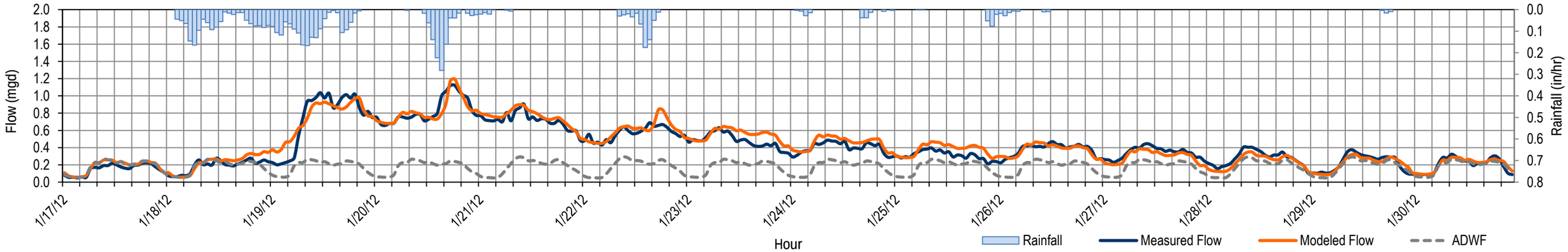


City of Grants Pass

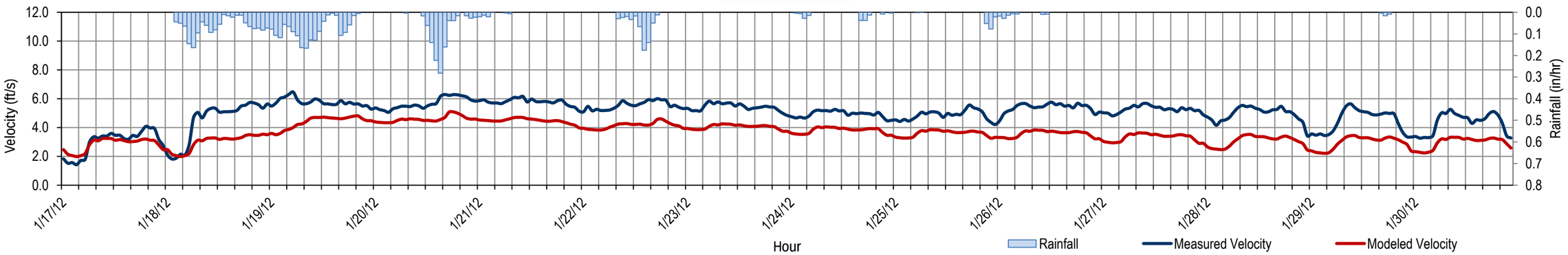
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE R42 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

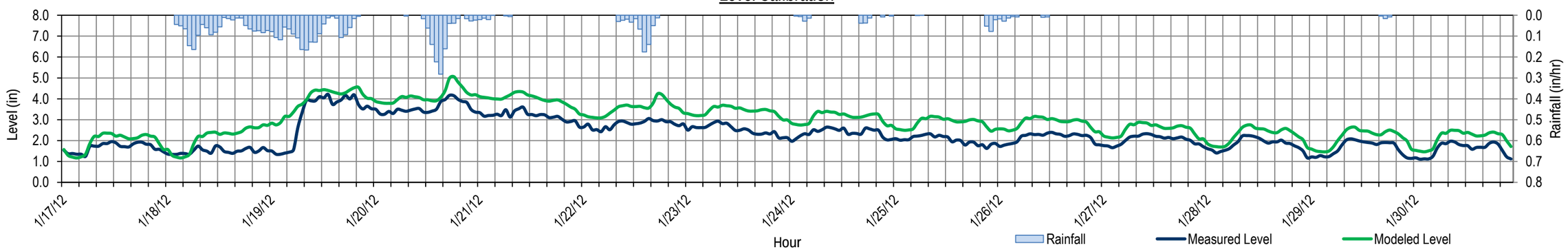
Flow Calibration



Velocity Calibration



Level Calibration

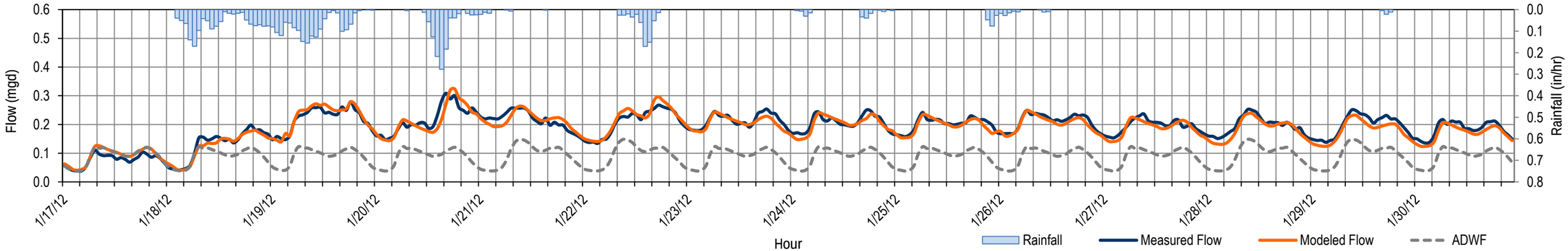


City of Grants Pass

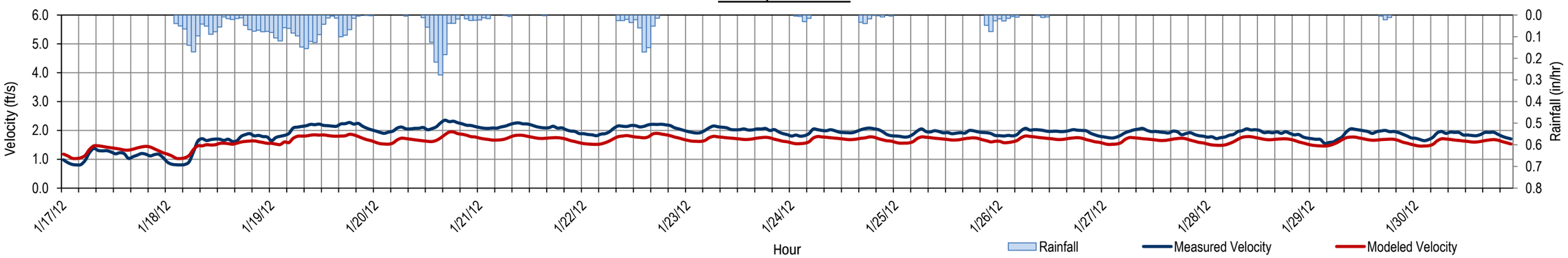
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE W62 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

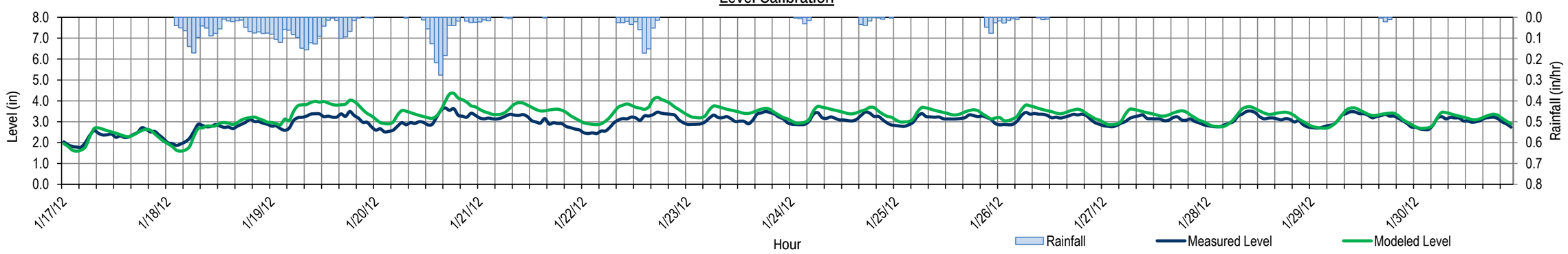
Flow Calibration



Velocity Calibration



Level Calibration



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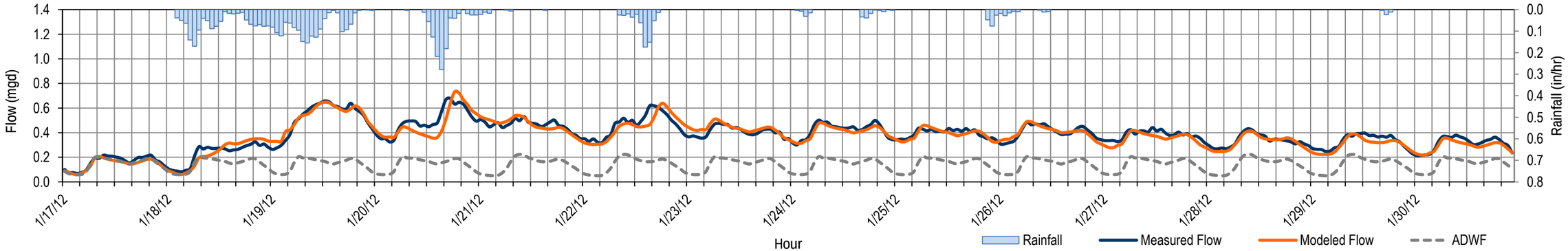
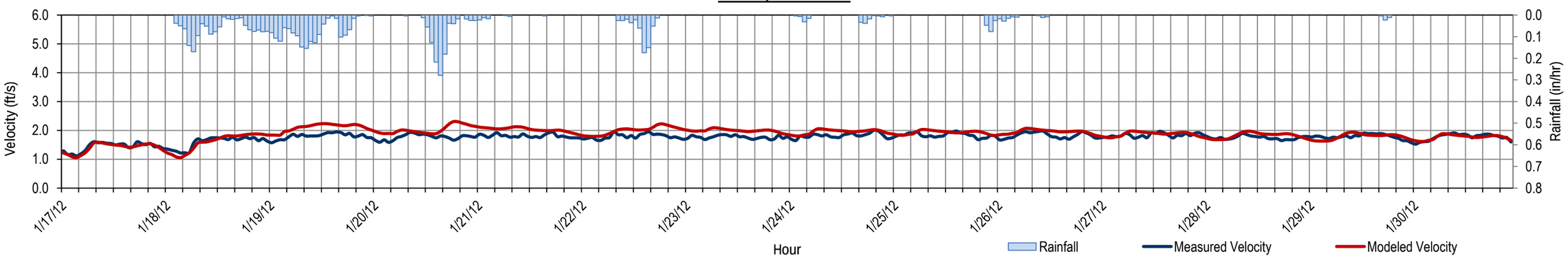
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE X115 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)

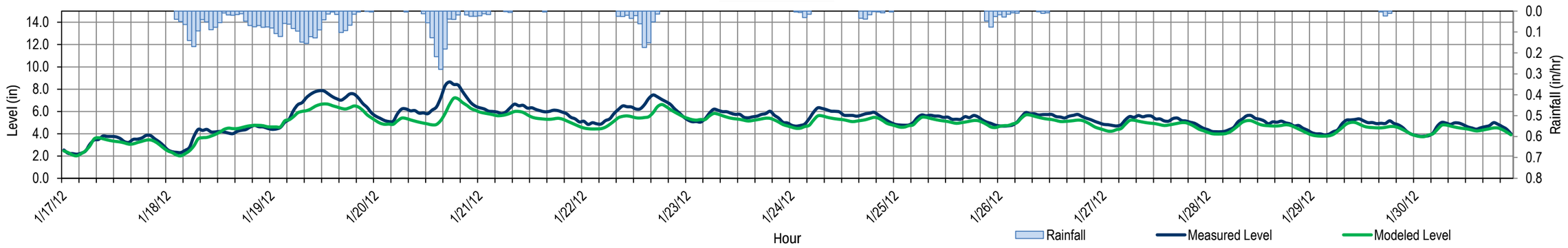
Flow Calibration



Velocity Calibration



Level Calibration



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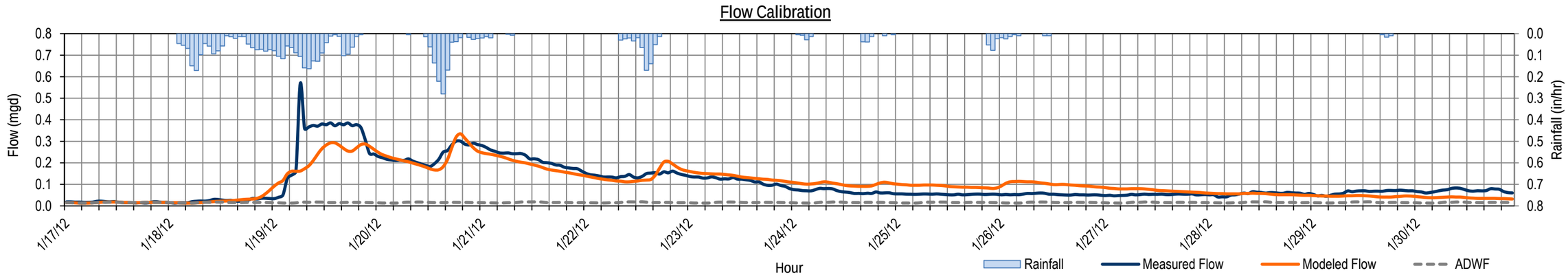
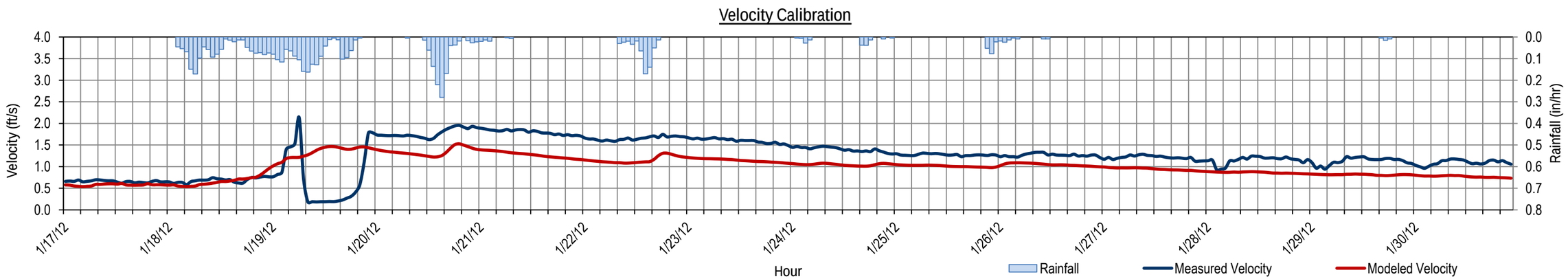
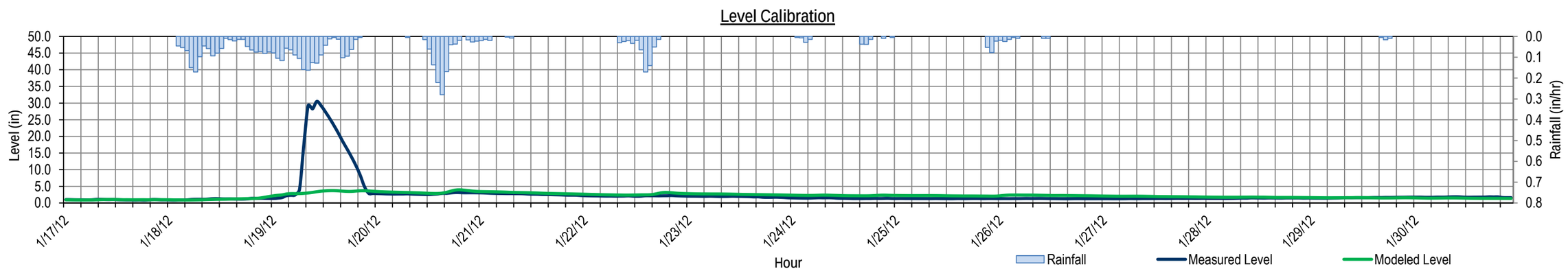
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE Z41 WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)







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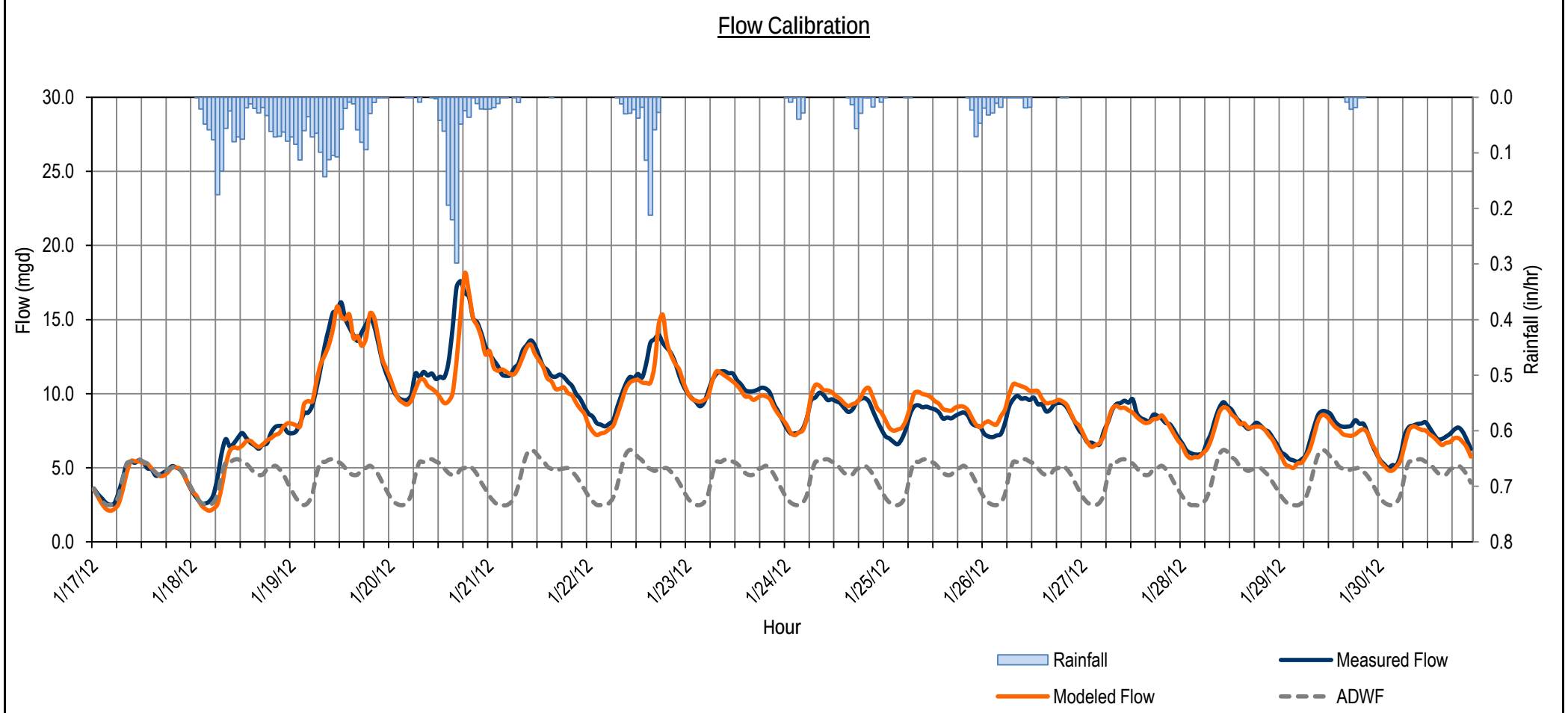
Flow Monitoring and Hydraulic Modeling Update

FLOW MONITORING SITE WRP WET WEATHER FLOW CALIBRATION (1/17/12-1/30/12)