Appendix A

City of Colusa – Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study

SANITARY SEWER FLOW MONITORING AND INFLOW / INFILTRATION STUDY

City of Colusa

April 2008

V&A

CITY OF COLUSA

Sanitary Sewer Flow Monitoring
and
Inflow / Infiltration Study

Prepared For:

ECO: LOGIC CONSULTING ENGINEERS
3875 Atherton Road
Rocklin, CA 94064

Prepared By:

V&A
Lake Merritt Plaza
1999 Harrison Street, Suite 975
Oakland, CA 94612

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1 EXECUTIVE SUMMARY

V&A Consulting Engineers (V&A) has completed sanitary sewer flow monitoring and inflow and infiltration (I/I) analysis at five locations within the City of Colusa (City) collection system. Flow monitoring was conducted over a 6-week period from February 14, 2008 to March 26, 2008. The flow monitoring sites are shown in Figure 2-1 on Page 4 of this report.

1.1 Flow Monitoring and I/I Results

Table 1-1 summarizes the flow monitoring results and infiltration and inflow results for each flow monitoring site. The infiltration and inflow (I/I) results shown in this table are taken from the rainfall event which occurred from February 23, 2008 to February 24, 2008. Figure 1-1 and Figure 1-2 summarize various infiltration, inflow and capacity results graphically.

Table 1-1
Flow Monitoring and I/I Results Summary

Site Name	ADWF* (MGD)	Estimated Total I/I (MGD)	R-Value (%)	I/I per ADWF Method	Peak Flow (MGD)	Peak I/I Rate (MGD)	Peak I/I to ADWF	Peaking Factor	d/D Ratio
Site 01	0.276	182,000	2.8%	0.87	0.769	0.386	1.40	2.79	0.47
Site 02	0.102	21,000	0.4%	0.28	0.208	0.059	0.58	2.05	0.64
Site 03	0.199	97,000	1.7%	0.65	0.379	0.139	0.70	1.90	0.48
Site 04	0.077	64,000	1.6%	1.09	0.158	0.060	0.78	2.04	0.60
Site 05	0.030	13,000	1.0%	0.56	0.097	0.055	1.82	3.18	0.24

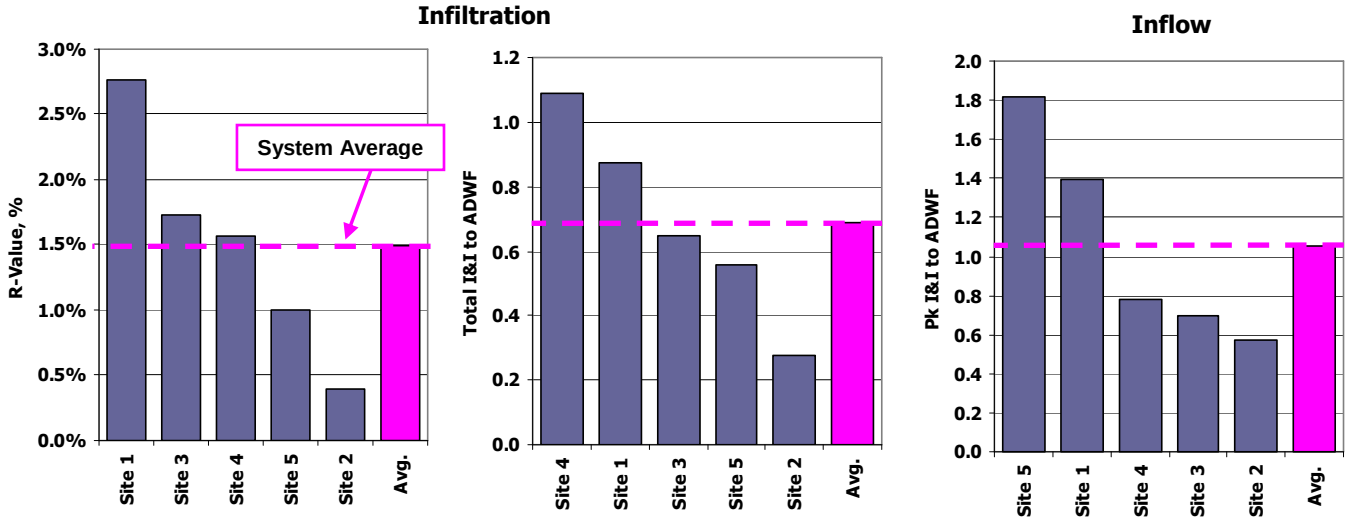


Figure 1-1. Site Rankings: I/I Factors by Site

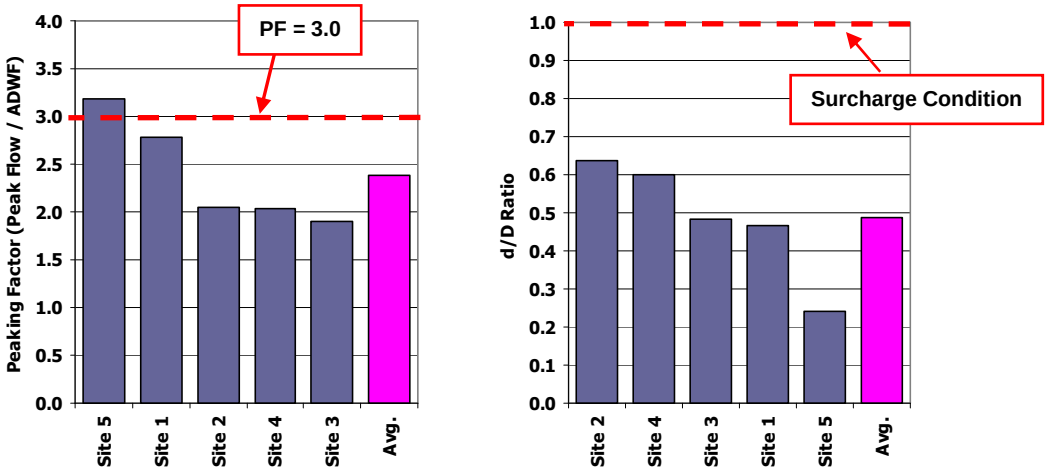


Figure 1-2. Site Rankings: Capacity Factors by Site

The following results from this project are noted:

- **Groundwater Infiltration:** Site 2 had min-to-baseline ratios that fell slightly outside of the typical min-to-baseline ratios as defined by WPCF. There may be slightly higher-than-normal groundwater infiltration occurring in the basins upstream from these sites during periods of dry weather flow.
- **Infiltration:** Sites 1, 3 and 4 had the highest ranked infiltration indicators (R-Value and I/I per ADWF Method). All sites had R-Values less than the 5% performance threshold during the February 23, 2008 to February 24, 2008 wet weather event.
- **Inflow:** Sites 1 and 5 had Peak I/I per ADWF Ratios that were greater than the system average.
- **Capacity**
  - **Peaking Factor:** All sites, except Site 5, were below the typical design threshold limit for peak flow to average dry weather flow ratio.
  - **d/D Ratio:** All sites, except Site 2, are below the typical design threshold limit for d/D ratio.
- **Additional Notes:** Site 2 appeared to be influenced by a sporadic back-flow condition as periodic jumps in level and dips in velocity were observed during rain-independent flows. There may be a hydraulic disturbance occurring downstream from Site 2 (i.e., influence by a larger line or pump station). This hydraulic backflow condition should be taken into consideration when reviewing capacity data at Site 2 versus the other flow monitoring locations

Synthetic hydrographs were developed for each site and were applied to a 10-year, 24-hour design storm event appropriate to this geographical location. Table 1-2 summarizes the results of this analysis.

Table 1-2
10-Year, 24-Hour Design Storm Response Summary

Monitoring Site	ADWF (MGD)	Peak Flow (MGD)	Peaking Factor	Infiltration
Site 01	0.27	2.27	8.34	825,000
Site 02	0.10	0.44	4.39	197,000
Site 03	0.20	0.80	3.95	208,000
Site 04	0.08	0.44	5.57	198,000
Site 05	0.03	0.20	6.74	104,000

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

1. **Determine I/I Reduction Program:** The City should examine its I/I reduction needs to determine a future I/I reduction program.
    a. If peak flows, sanitary sewer overflows, and pipeline capacity issues are of greater concern, then the program can be weighted to investigate and reduce sources of inflow within the basins with the greatest inflow problems.
    b. If total infiltration and general pipeline deterioration is of greater concern, then the program can be weighted to investigate and reduce sources of infiltration within the basins with the greatest infiltration problems.
2. **I/I Reduction Methods:** Potential I/I reduction methods include the following:
    a. smoke testing
    b. mini-basin flow monitoring
    c. night-time reconnaissance work to (1) investigate and determine direct point sources of inflow, and (2) determine the areas and/or pipe reaches responsible for high levels of infiltration contribution.
    d. CCTV inspection
3. **I/I Reduction Cost Effective Analysis:** The City should conduct a study to determine which is more cost-effective: (1) locating the sources of infiltration and inflow and systematically rehabilitating or replacing the faulty pipelines; or (2) continued treatment of the additional storm water I/I flow.

2 INTRODUCTION

V&A Consulting Engineers (V&A) has completed sanitary sewer flow monitoring and inflow and infiltration (I/I) analysis within the City of Colusa. Flow monitoring occurred over a 6-week period from February 14, 2008 to March 26, 2008 at five flow monitoring sites. The five flow monitoring sites are shown in Figure 2-1.

Detailed descriptions of the individual flow monitoring sites, including photographs, are included in *Appendix A*.

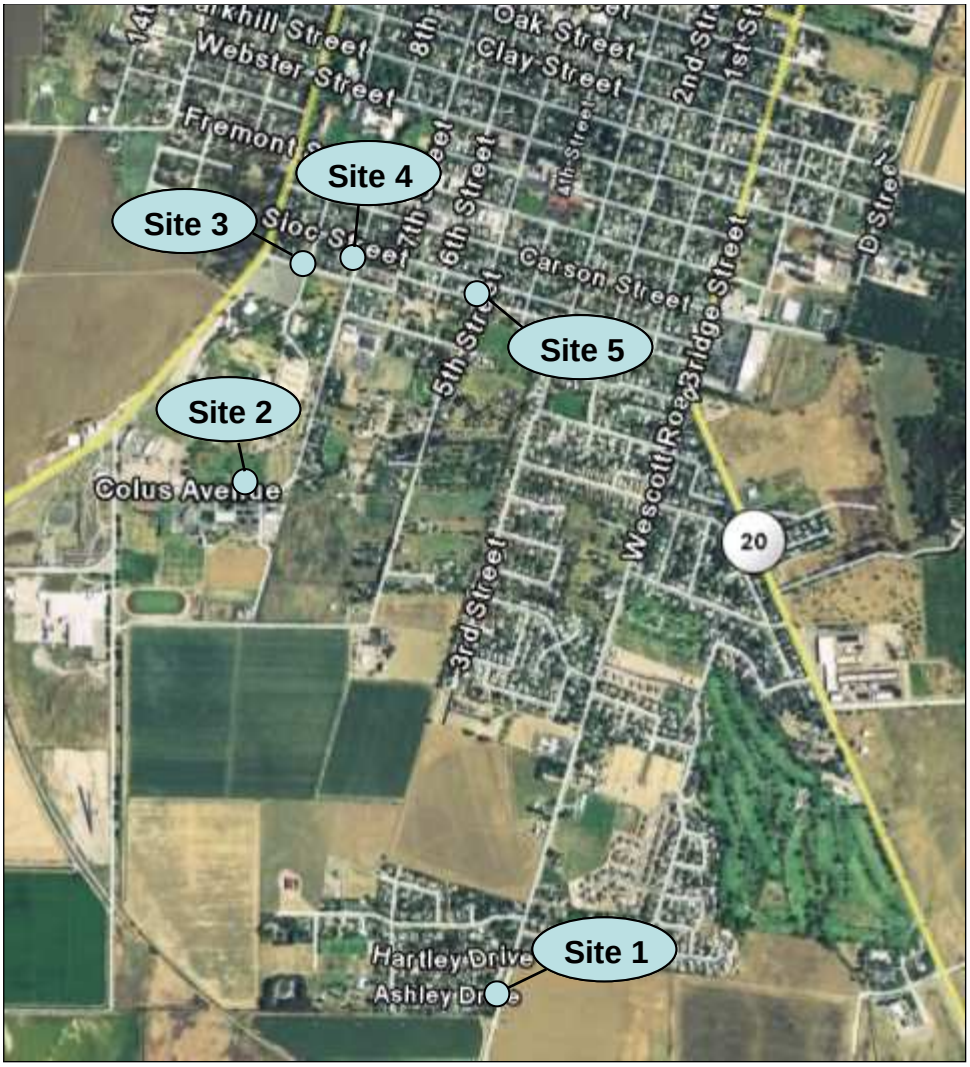


Figure 2-1. Vicinity Map of Flow Monitoring Locations

3 METHODS AND PROCEDURES

3.1 Confined Space Entry

A confined space (Photo 3.1) 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. Title 8, Section 5158 of the California Code of Regulations provides the guidelines and rules for working in these environments. 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 LEL levels. A typical confined space entry crew has at least three members: the entrant, the attendant and the supervisor. The entrant is the individual that will be performing the work. He is equipped with all of the necessary personal protective equipment needed to perform the job safely, including a personal 4-gas monitor (Photo 3.2). 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 entrant(s) to monitor the atmosphere on another 4-gas monitor and maintaining records of all entrants, if there is more than one. The supervisor develops the safe work plan for the job at hand.

Photo 3.1 – Confined Space Entry

Photo 3.2 – Typical Personal 4-Gas Monitor

3.2 Flow Meter Installation

Five Isco 2150 flow meters were installed by V&A in the sewer lines shown in Figure 2-1. Isco meters use a pressure transducer to collect depth readings, and ultrasonic Doppler sensors on the probe to determine the average fluid velocity.

Figure 3-1 shows a sketch of a typical flow meter installation.

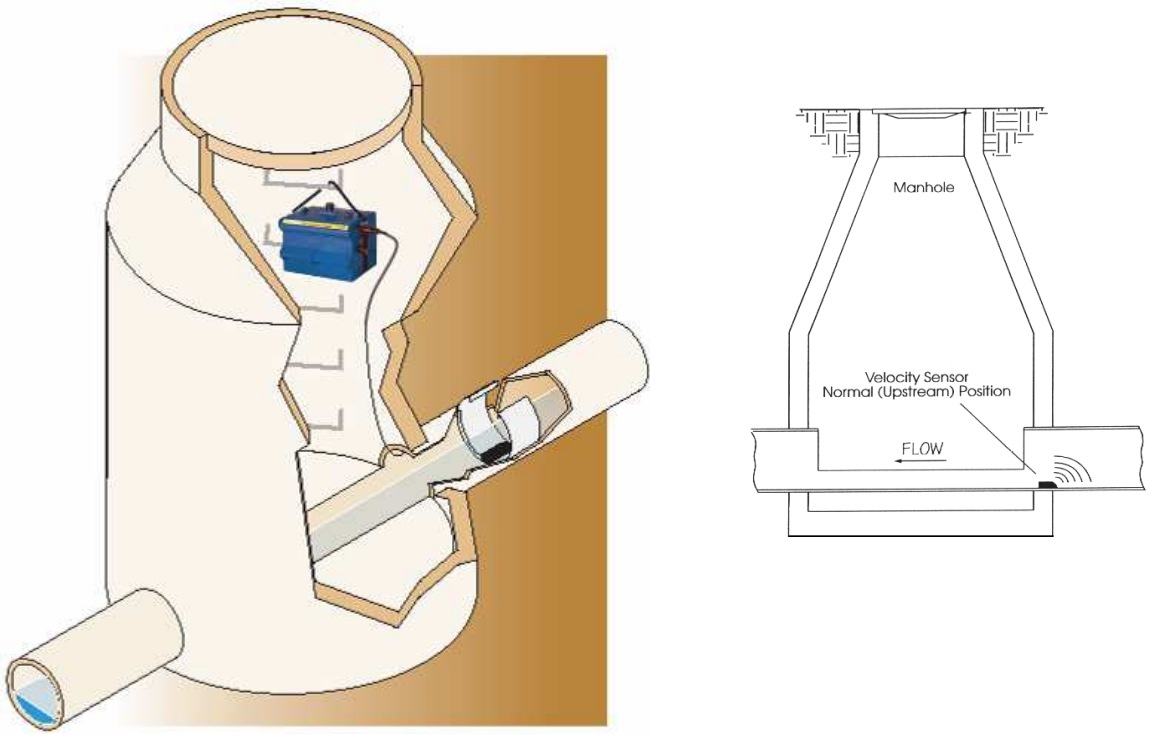


Figure 3-1. Typical Isco 2150 Installation

Continuous depth and velocity readings were recorded by the flow meters in 15-minute increments and downloaded into a computer spreadsheet program where the data could be analyzed and made report ready. Manual level and velocity readings were taken in the field during the flow meter installation and again when removed, and compared to the readings of the flow meters to ensure proper calibration and accuracy.

4 RAINFALL RESULTS

Rainfall information was taken from a local rain gauge within the City of Colusa. The rain gauge was utilized to capture the rain events over the course of this study. Most of the rain over the course of this study occurred between February 19, 2008 to February 25, 2008. The greatest I/I response occurred between February 23 and 25, 2008, and this time period was used for I/I analysis. Figure 4-1 graphically displays the rainfall events recorded over the flow monitoring period.

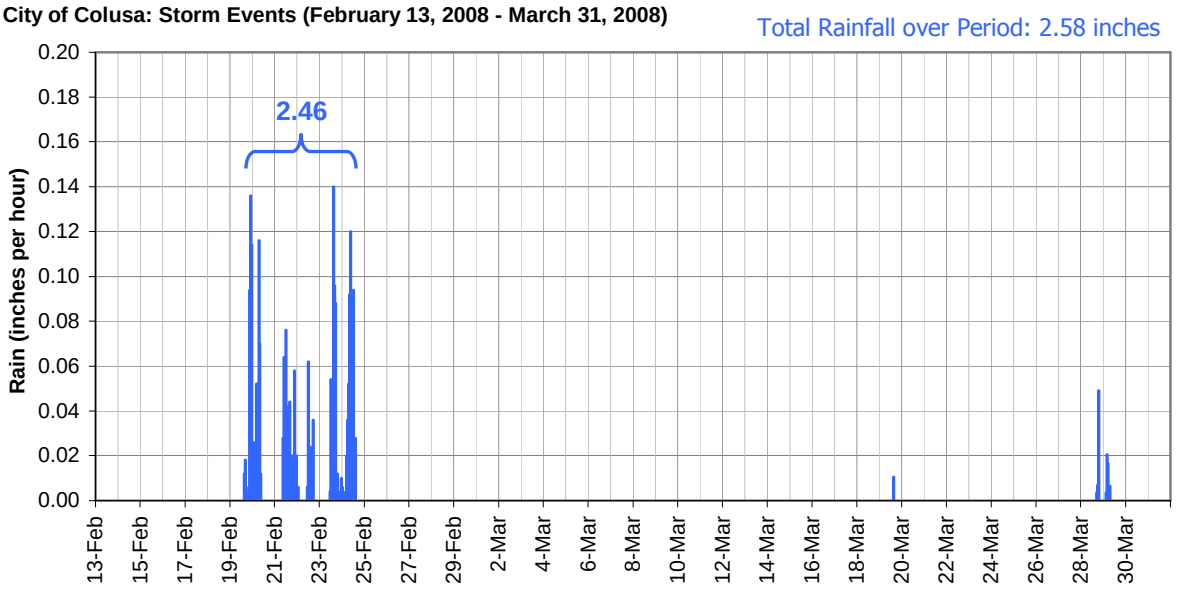


Figure 4-1. Rainfall Activity over Flow Monitoring Period

Figure 4-2 shows the rain accumulation plot of the rain gauge, as well as the historical average rainfall for the City during this project duration.

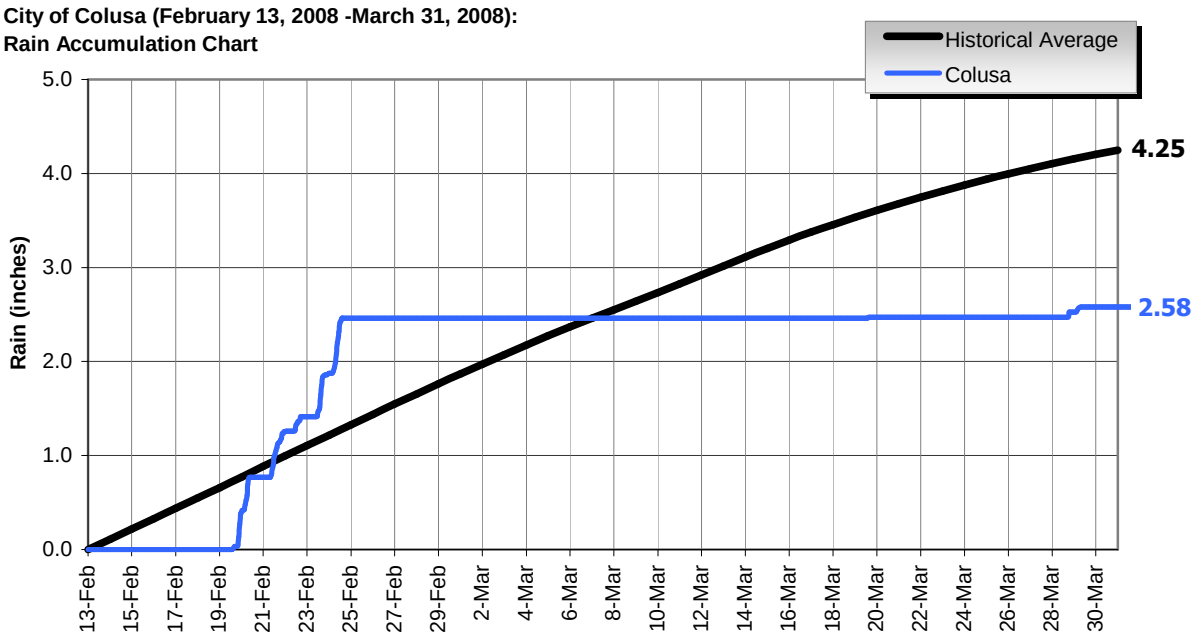


Figure 4-2. Rainfall Accumulation Plots

The historical average rainfall is shown for comparison to the rainfall that occurred over the course of the flow monitoring period (February 13, 2008 through March 31, 2008). The historical data was taken from the Western Regional Climate Center (WRCC) at Station 041948 in Colusa, California. Rainfall data from the years 1970 through 2000 were used to determine these averages. The historical average over the monitoring period is 4.25 inches. The rain gauge indicated a rainfall total of 2.58 inches, approximately 61% of normal level during this time period.

It is noted that significant storm events did occur in Colusa on January 3, 2008 through January 5, 2008 and January 21, 2008 through January 27, 2008. The soil conditions in Colusa may have been in a saturated state for the February 19, 2008 through February 25, 2008 rainfall event.

5 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[1]. Storm events are classified by intensity and duration. Based on historical data, frequency contour maps for given intensity and duration storm events 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[2] classifies a 10-year, 24-hour storm event in Colusa as 2.75 inches (Figure 5-1). This means that in any given year, there is a 10% chance (1/10) 2.75 inches of rain will fall in any 24-hour period.

Figure 5-1. NOAA Northern California Rainfall Frequency Map

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

From the NOAA frequency maps, the rainfall totals for Colusa 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 Colusa, shown in Figure 5-2.

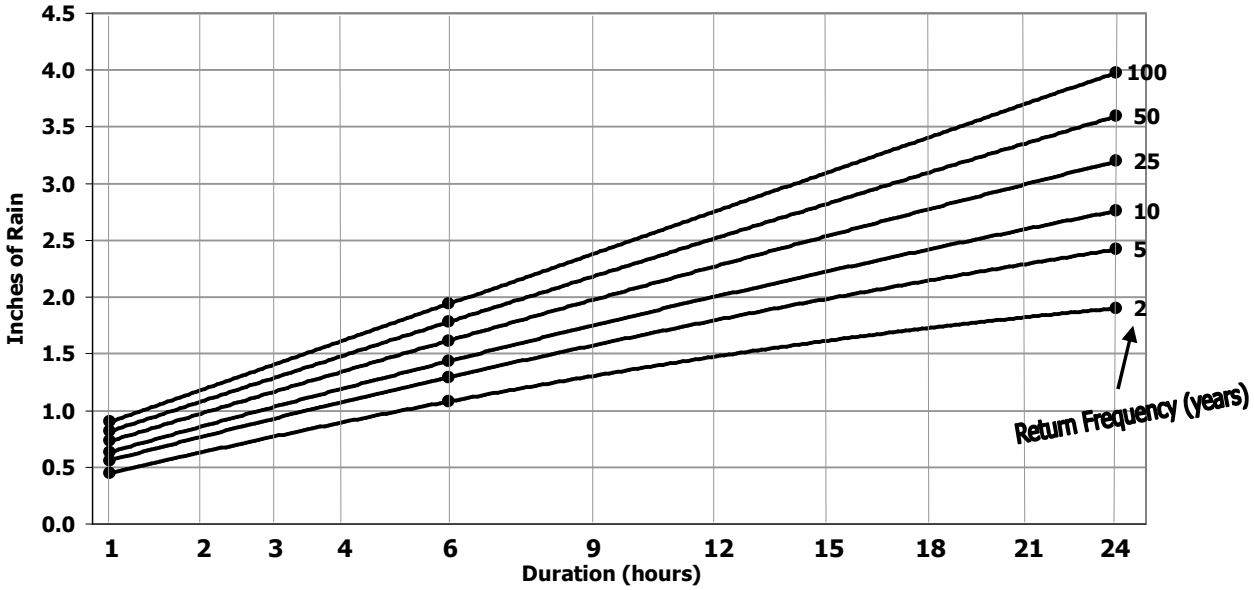


Figure 5-2. City of Colusa Storm Event Classification Chart

The highest rainfall in a 1-hour period was 0.17 inches, in any consecutive 6-hour period was 0.46 inches, and for any consecutive 12-hour period was 0.72 inches. Peak measured densities per hourly periods were calculated for the rainfall event, as summarized in Table 5-1. Superimposing the peak measured densities for the storm event on the Colusa Rainfall Storm Event Classification Chart will determine the classification of the storm event, shown in Figure 5-3.

Table 5-1
Peak Measured Rainfall Densities per Hourly Period (January 3-4, 2008)

Rainfall Duration	Total Rainfall (inches)
1 hr	0.14
3 hr	0.34
6 hr	0.48
12 hr	0.72
18 hr	0.76
24 hr	0.95

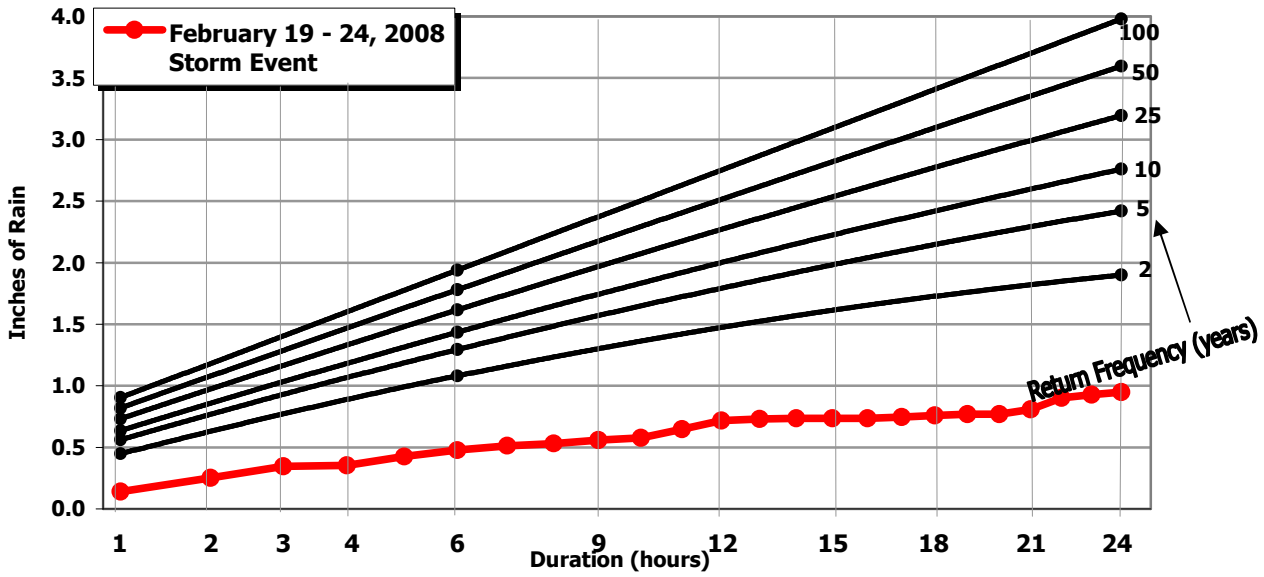


Figure 5-3. Project Storm Event Classification

The storm event is classified as less than a two year storm event.

6 FLOW MONITORING RESULTS

6.1 Dry Weather Flow Monitoring Results

Weekday and weekend flow patterns vary and must be separated when determining average dry weather flows. For this project, the following days were least affected by rainfall and were used to determine weekend and weekday average flows:

- Weekdays: March 10 – 14
- Weekends: March 8 – 9, 15 – 16

Figure 6-1 shows a sample of the average dry weather flow graph that was generated for each flow monitoring site. Graphs for each site are located in *Appendix A*.

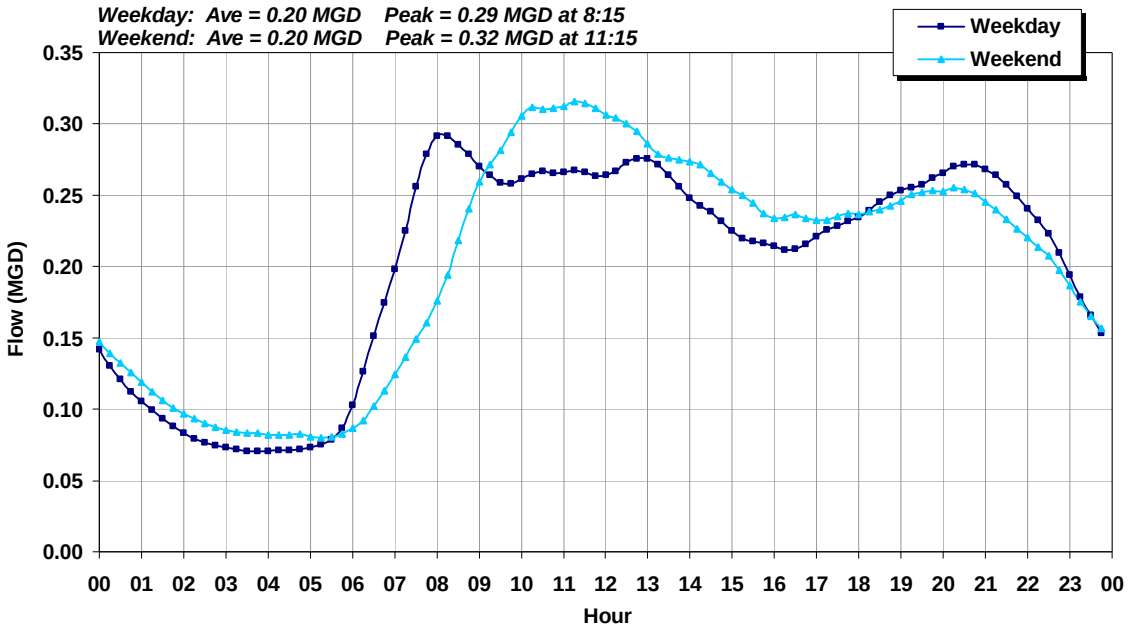


Figure 6-1. Site 3: Average Dry Weather Flow

Table 6-1 lists the average dry weather flow (ADWF) and average peak dry weather flows (PDWF) recorded during this study for the sites that were directly monitored.

Table 6-1

Dry Weather Flow Summary

Location	Average Dry Weather Flow (MGD)		Weekend/ Weekday Ratio	Average Peak Dry Weather Flow (MGD)		PDWF/ADWF Ratio	
	Weekday	Weekend		Weekday	Weekend	Weekday	Weekend
Site 01	0.272	0.287	1.05	0.399	0.460	1.47	1.60
Site 02	0.099	0.107	1.08	0.133	0.156	1.34	1.45
Site 03	0.202	0.193	0.96	0.291	0.306	1.44	1.59
Site 04	0.079	0.073	0.91	0.124	0.121	1.56	1.67
Site 05	0.030	0.030	0.99	0.048	0.054	1.56	1.80

6.2 Ground Water Infiltration Analysis

Dry weather (baseline) 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 peaks and lows fall into a predictable range when compared to the daily average flow. If a site has a large percentage of ground water infiltration occurring during the periods of dry weather flow measurement, the amplitudes of the peak and low flows will be dampened[3]. Figure 6-2 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 ground water infiltration.

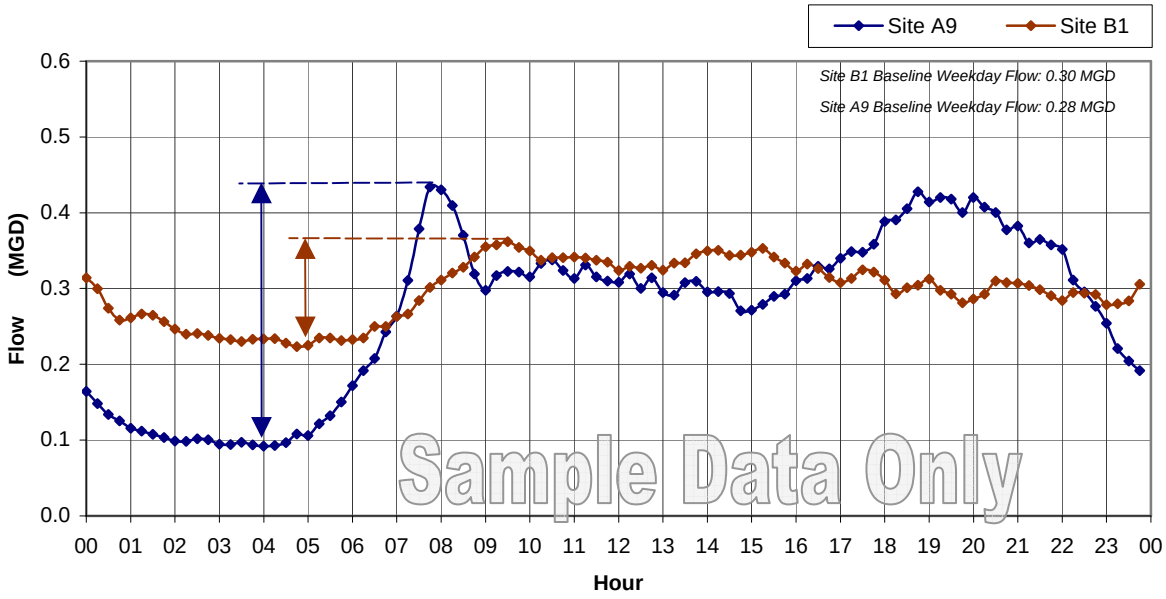


Figure 6-2. Ground Water Infiltration Sample Figure

It can be useful to compare the peak-to-baseline and low-to-baseline flow ratios for all 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 distinct possibility of higher levels of ground water infiltration in comparison to the rest of the collection system. Figure 6-3 plots the peak-to-baseline and min-to-baseline flow ratios against the baseline flows for all sites monitored during this study. The dotted line shows "typical" min-to-baseline flow ratios per the Water Pollution Control Federation[4]. There are no established peak-to-baseline ratios, but a system trendline has been drawn to better distinguish sites that fall outside the system trends. The min-to-baseline ratio should be taken with more weight as low flows during early morning hours are generally more predictable than peak flows.

[3] Theoretically imagining an extreme case, if there were 0.2 MGD of baseline flow and 2.0 MGD of groundwater infiltration, the peaks and lows would be barely recognizable; the baseline flow would be nearly a straight line.

[4] WPCF Manual of Practice No. 9 "Design and Construction of Sanitary and Storm Sewers"

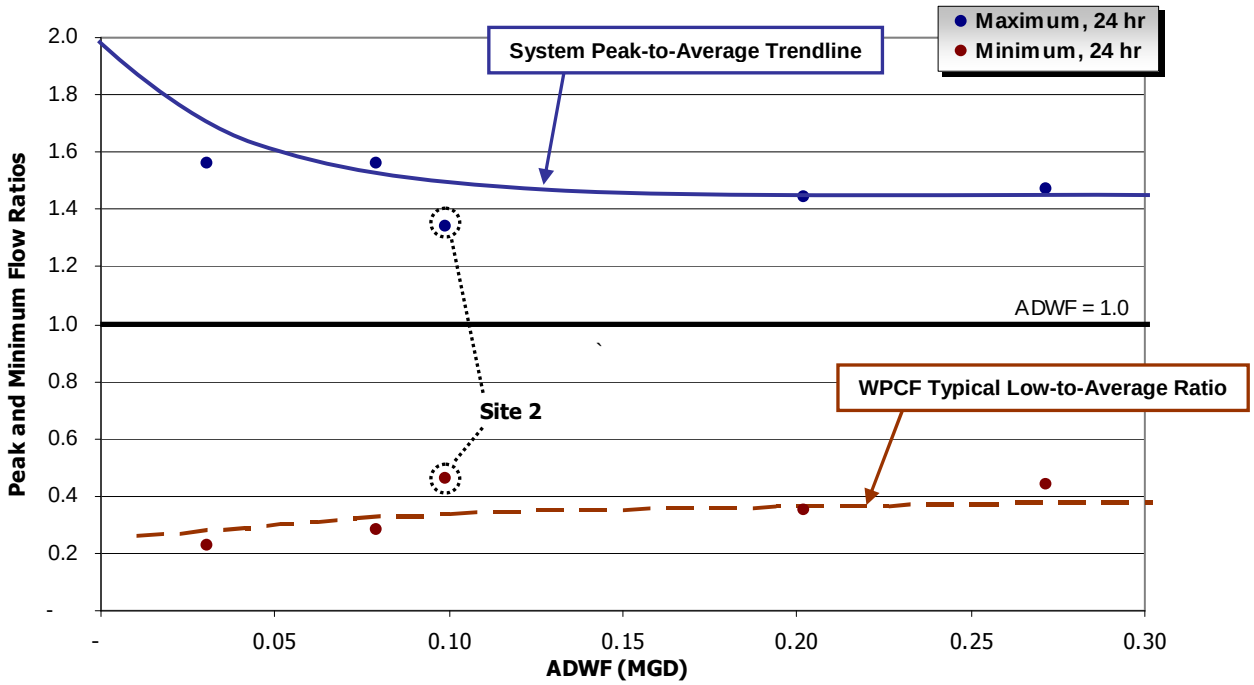


Figure 6-3. Peak and Minimum Flow Ratios vs. ADWF[5]

The following groundwater infiltration analysis results are noted:

- Site 2 had min-to-baseline ratios that fell slightly outside of the typical min-to-baseline ratios as defined by WPCF. There may be slightly higher-than-normal groundwater infiltration occurring in the basins upstream from this site during periods of dry weather flow.

[5] 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 typical and system trend lines slope closer to 1.0 as the ADWF increases, as shown in the figure.

6.3 Wet Weather Flow Monitoring Results

6.3.1 Inflow/Infiltration Methods

I/I Definitions

Infiltration/inflow (I/I) consists of storm water and groundwater which enters the sewer system through pipe defects and improper storm drainage connections, defined as follows:

Inflow

Definition: Storm water inflow (SWI) 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, together with RDI (explained below), 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: Compared to infiltration sources, SWI locations are usually less difficult to find and usually 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 SWI are low compared to potential benefits to public health and safety, or the costs of new facilities to transport the resulting peak flows.

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

Infiltration

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

Impact: Infiltration typically creates long-term annual **volumetric** problems, the major impact being 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 and/or manholes, and may include cracks, offset joints, root intrusion points, and broken pipes. The sources may be wide-spread 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 (Exception: RRI will graphically look more like SWI than infiltration.).

Infiltration can be further subdivided into components as follows:

- **Groundwater Infiltration** – Groundwater infiltration (GWI) depends on the depth of the

groundwater table above the pipelines as well as the percentage of the system submerged. The variation on groundwater levels and subsequent GWI are seasonal in nature. On a day-to-day basis, GWI rates are steady and will not fluctuate greatly.

- **Rainfall Dependent Infiltration (RDI)** – This component occurs as a result of storm water and enters the sewer system through pipe defects similar to GWI, but due to rapid response, affects the system by contributing to **peak** flows as well as to the **total I/I volume**. This component may be further categorized as being rainfall-responsive or rainfall-related.
  - **Rainfall responsive infiltration (RRI)** 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. RRI is independent of the groundwater table, and reaches defective sewers via the pipe trench in which the sewer is constructed, particularly if the pipe is placed in impermeable soil and bedded and backfilled with a granular material. In this case, the pipe trench serves as a conduit similar to a French drain, conveying storm drainage to defective joints and other openings in the system. Note: this type of infiltration can have a very quick response and graphically can look very similar to SWI.
  - **Rainfall related infiltration** is storm water that 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 depends on the soil permeability and saturation level.

Figure 6-4 illustrates the possible locations and components of I/I.

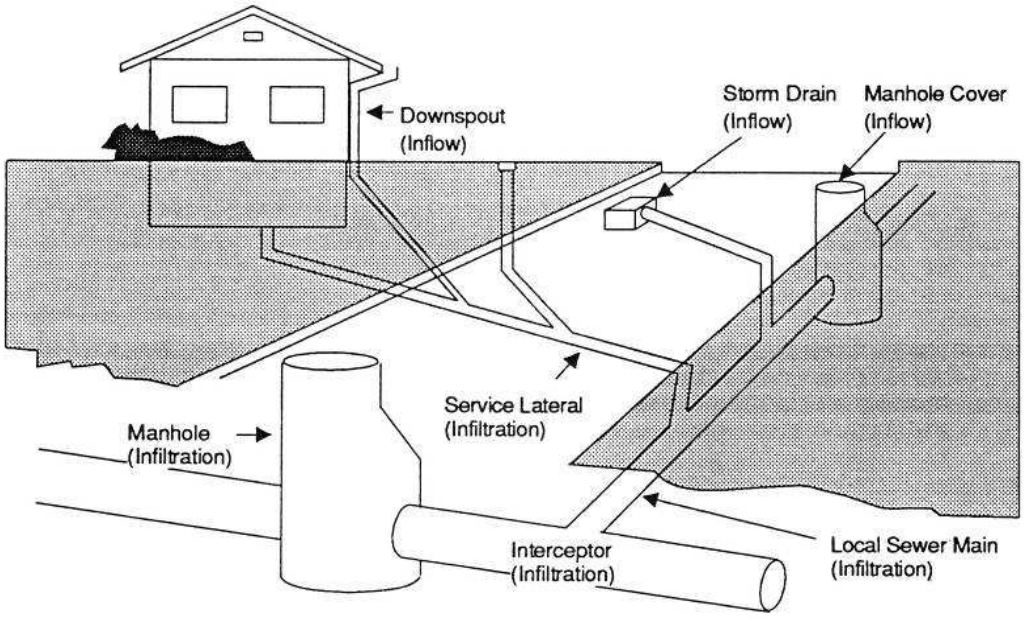


Figure 6-4. Infiltration / Inflow Locations and Components

Graphical Identification of I/I Components

Figure 6-5 shows sample graphs indicating the typical graphical response patterns for inflow and infiltration.

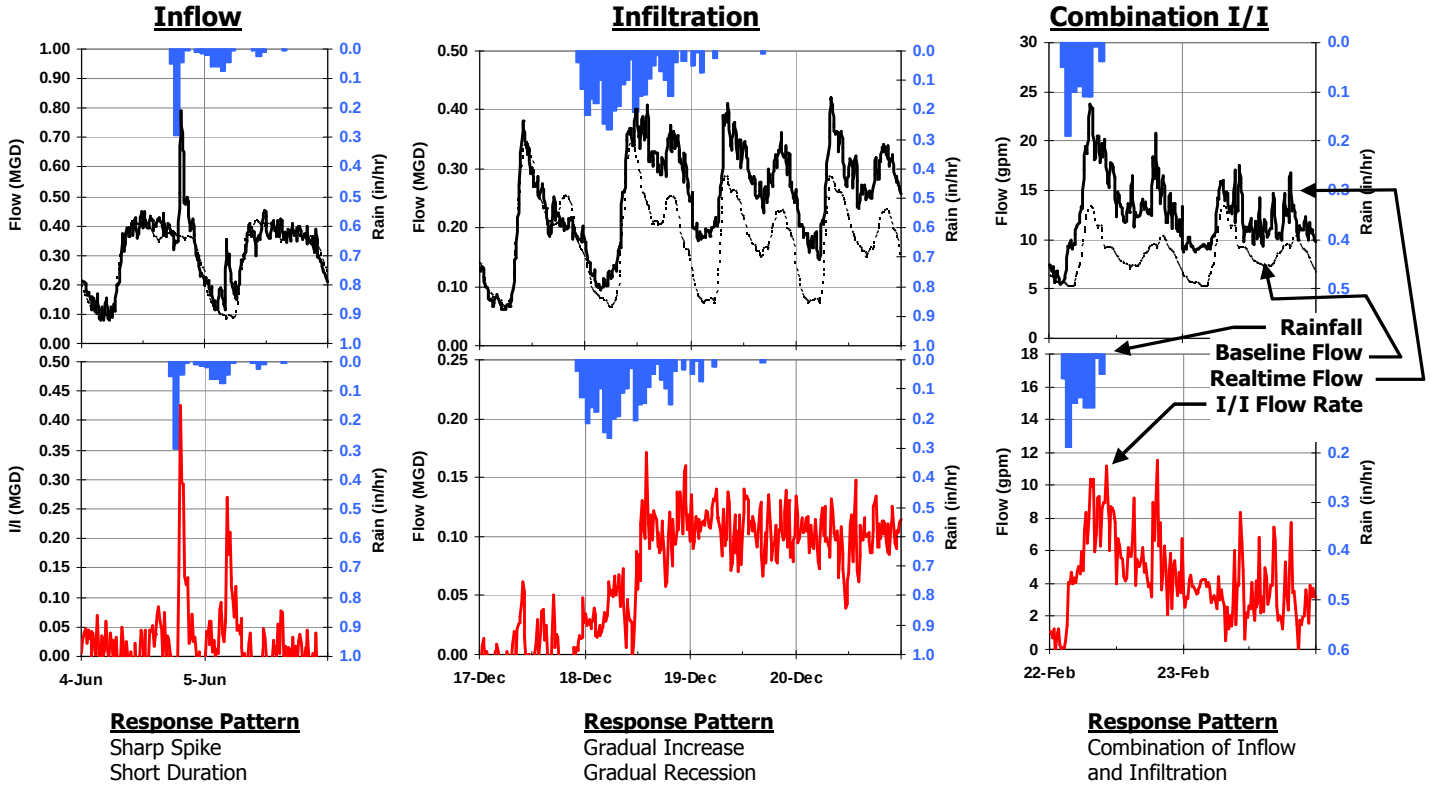


Figure 6-5. Infiltration/Inflow Graphical Response Patterns

6.3.2 I/I Analysis Techniques

After differentiating I/I flows from baseline flows, various calculations can be made to determine which I/I component is more prevalent at a particular site, and to compare the relative magnitude of the I/I components between drainage basins and between storm events, summarized as follows:

Infiltration Indicators

R-Value: Knowing the acreages of each basin and total I/I attributable to a storm event, the percentage of rainfall that permeates into each basin can be calculated and is called the R-Value. The R-Value method provides a means to compare the relative magnitude and severity of total I/I volume between different basins and different storm events. Systems with R-Values less than 5%[6] are often considered to be performing well and this criterion will be used for this study. Because the infiltration component is usually more predominant than the inflow component on a totalized I/I volume flow basis, R-Value is listed as an indicator of infiltration.

I/I per ADWF Method: Additionally, one can use the average dry weather flow (ADWF) as a means for normalizing between sites and between storm events. The I/I per ADWF method takes the total infiltration in gallons for a storm event, and divides that number by the strength of the storm event (inches of rain) and the ADWF in gallons per day. Because it is based on total I/I volume, it is predominantly an indicator of infiltration.

Inflow Indicators

Peak I/I Flow to ADWF Ratio: Peak I/I to ADWF Ratio is the peak measured I/I rate divided by ADWF. This ratio is a preferable comparative tool for I/I analysis to peaking factor because it strictly looks at I/I flow rates. Peaking factor (defined as peak flow divided by ADWF) can be skewed higher or lower depending on whether the storm event I/I response occurs during low flow or high flow hours. Peaking factor is a useful tool when looking at capacity issues (next section on *Capacity*).

Figure 6-6 below shows a sample I/I graph that illustrates and summarizes the I/I response and I/I calculations made per site per storm event. Similar graphs for each site and storm event and are located in *Appendix A*.

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

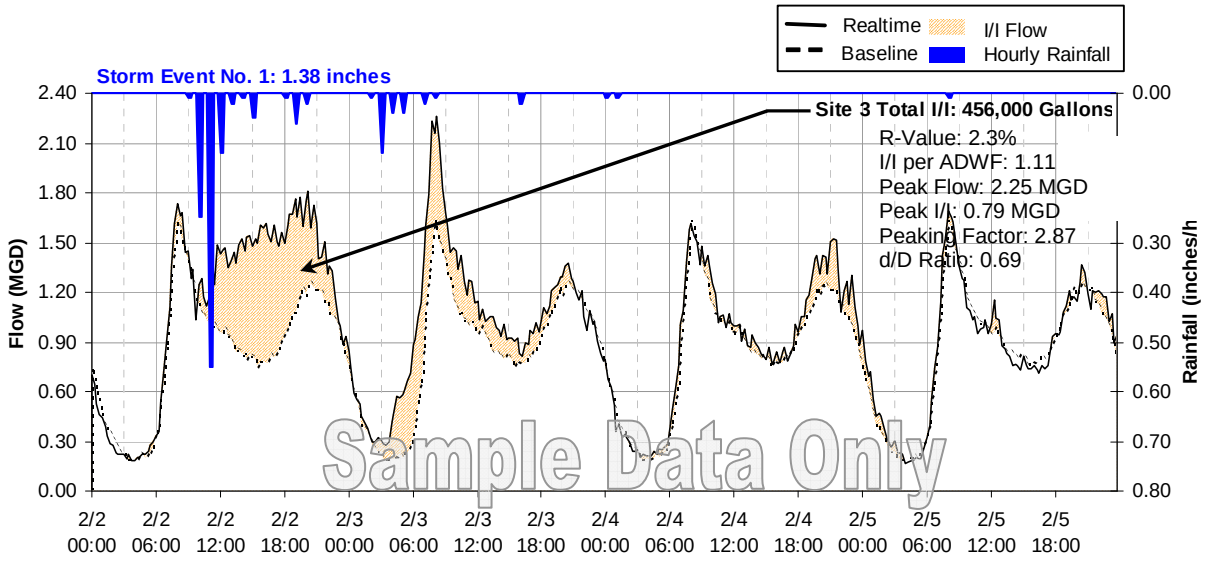


Figure 6-6. Sample I/I Flow Graph

6.3.3 I/I Results Summary

Table 6-2 summarizes the I/I data collected during the flow monitoring period, including estimated total I/I through each flow monitoring site for the Storm Event.

Table 6-2
Site I/I Summary

Site Name	ADWF* (MGD)	Estimated I/I Totals (gallons)	R-Value	I/I per ADWF Method	Peak Flow (MGD)	Peak I/I Rate (MGD)	Peak I/I to ADWF Ratio
Site 01	0.276	182,000	2.8%	0.87	0.769	0.386	1.40
Site 02	0.102	21,000	0.4%	0.28	0.208	0.059	0.58
Site 03	0.199	97,000	1.7%	0.65	0.379	0.139	0.70
Site 04	0.077	64,000	1.6%	1.09	0.158	0.060	0.78
Site 05	0.030	13,000	1.0%	0.56	0.097	0.055	1.82

*ADWF calculated as (5*weekday+2*weekend)/7

Figure 6-7 summarizes the I/I results graphically. The infiltration and inflow (I/I) results shown in this figure are taken from February 23, 2008 through February 28, 2008. This time period included the one significant storm event.

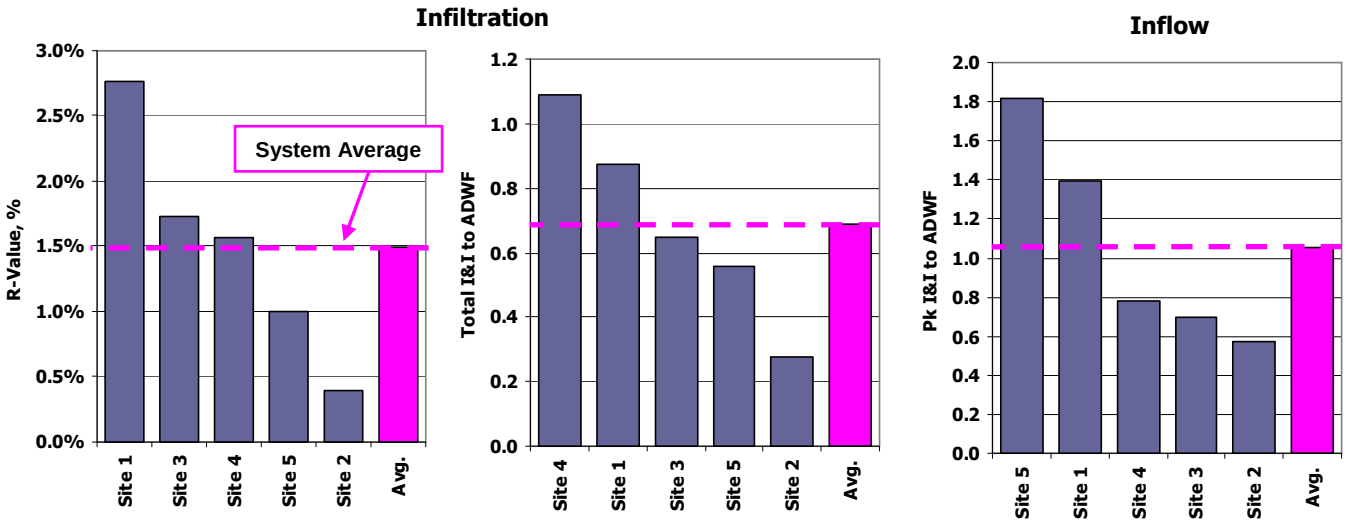


Figure 6-7. Infiltration and Inflow Rankings: I/I Factors by Site

The following I/I analysis results are noted:

- **Infiltration:** Sites 1, 3 and 4 had the highest ranked infiltration indicators (R-Value and I/I per ADWF Method). All sites had R-Values less than the 5% performance threshold during the February 23, 2008 to February 24, 2008 wet weather event.
- **Inflow:** Sites 1 and 5 had Peak I/I per ADWF Ratios that were greater than the system average.

6.4 Pipeline Capacity Analysis

Peaking Factor: Peaking Factor is defined as the Peak Wet Weather Flow divided by the Average Dry Weather Flow. 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 divided by the pipe diameter. A d/D ratio less than 0.75 is a common threshold value used for pipe design. The d/D ratio for each site was computed based on the maximum depth of flow during the storm event.

Table 6-3 summarizes the peak recorded d/D ratios and Peaking Factors per site during the February 23, 2008 to February 24, 2008 wet weather event.

Table 6-3
d/D Ratio Analysis Summary

Monitoring Site	Peaking Factor	d/D Ratio
Site 01	2.79	0.47
Site 02	2.05	0.64
Site 03	1.90	0.48
Site 04	2.04	0.60
Site 05	3.18	0.24

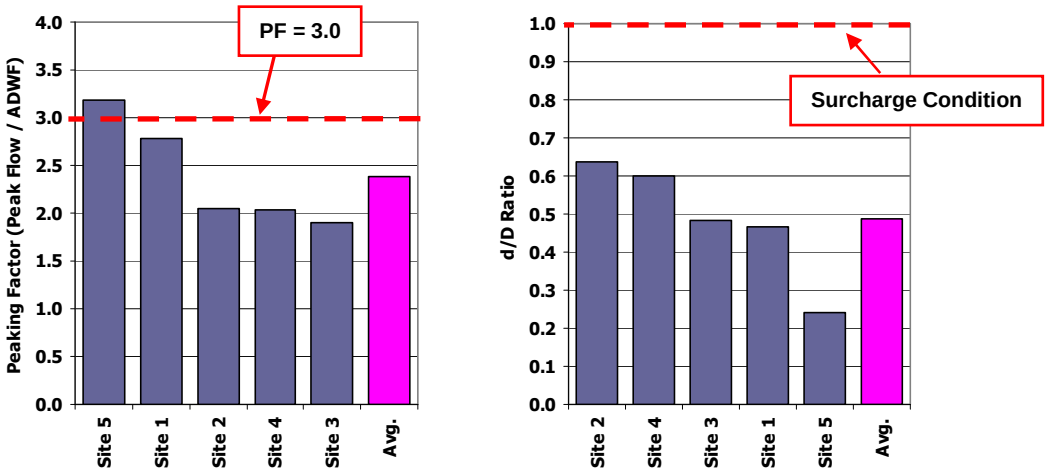


Figure 6-8. Capacity Rankings: Peaking Factor and d/D Ratio by Site

The following capacity analysis results are noted:

- **Peaking Factor**
  - All sites, except Site 5, were below the typical design threshold limit for peak flow to average dry weather flow ratio.
- **d/D Ratio**
  - All sites, except Site 2, are below the typical design threshold limit for d/D ratio.

It is noted that Site 2 appeared to be influenced by a sporadic back-flow condition as periodic jumps in level and dips in velocity were observed during rain-independent flows. There may be a hydraulic disturbance occurring downstream from Site 2 (i.e., influence by a larger line or pump station). This hydraulic backflow condition should be taken into consideration when reviewing capacity data at Site 2 versus the other flow monitoring locations.

6.5 Synthetic Hydrographs

In order to model design storms, synthetic hydrographs were developed to approximate the actual RDI/I hydrograph shape in terms of parameters representing time to the peak and the recession coefficient. The actual RDI/I hydrograph was best matched with a synthetic hydrograph by separating the synthetic hydrograph into seven volume components (R1, R2, R3, R4, R5, R6, 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. A sample synthetic hydrograph and its component hydrographs for the period of February 19 through February 25, 2008 for Site 3 is shown in Figure 6-9.

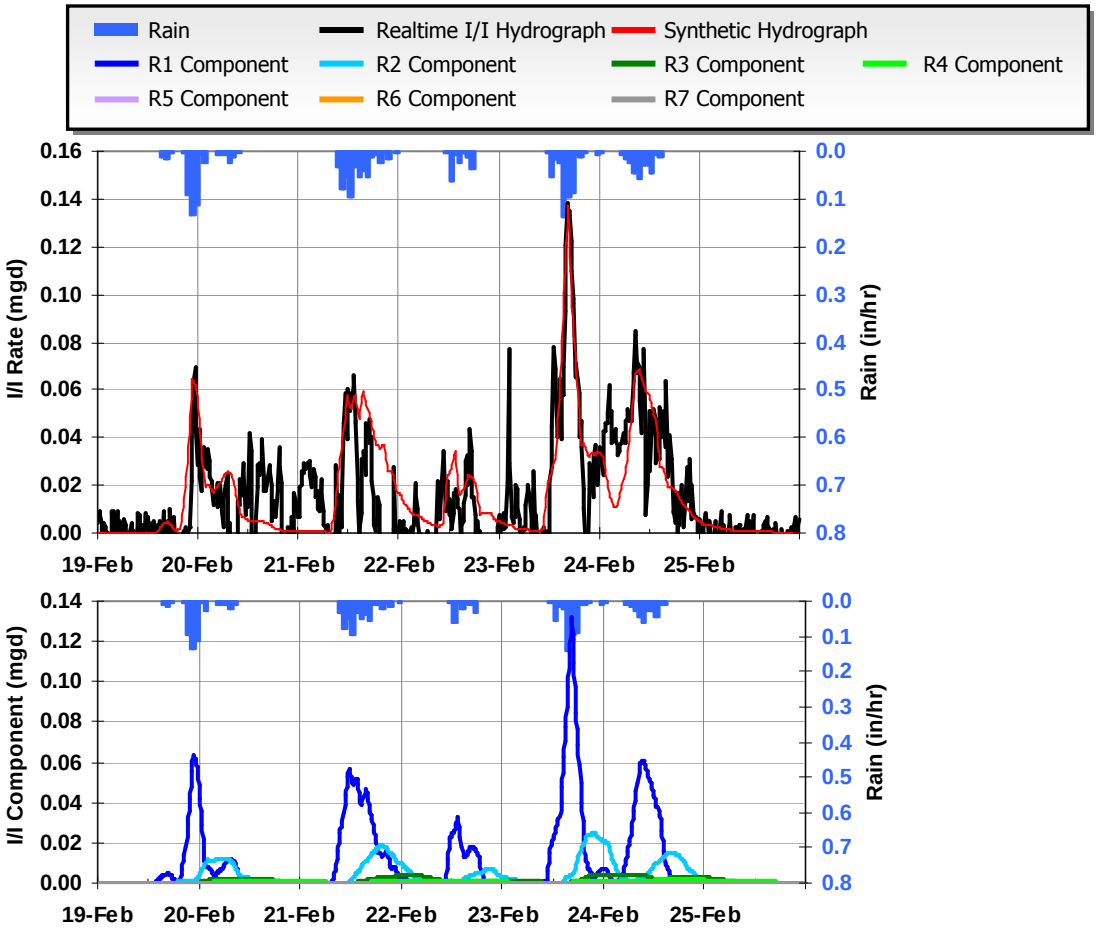


Figure 6-9. Site 3 Synthetic Hydrograph

6.6 Design Storm

Once the I/I components are defined, design storms can be applied and the resulting I/I flows can be predicted. The design storm used for this analysis was a 10-year storm event taken from the NOAA Western U.S. Precipitation Frequency Maps.

Figure 6-10 summarizes the design storms per hour and shows the storm profile for the 10-year event. This particular profile distribution also fits the criterion for a 2-hour, 6-hour and 24-hour event.

Hour	Rainfall (inches per hour)
1	0.01
2	0.02
3	0.19
4	0.11
5	0.04
6	0.01
7	0.15
8	0.09
9	0.12
10	0.04
11	0.02
12	0.01
13	0.08
14	0.22
15	0.03
16	0.12
17	0.12
18	0.30
19	0.55
20	0.23
21	0.12
22	0.06
23	0.11
24	0.03
Total:	**2.76**

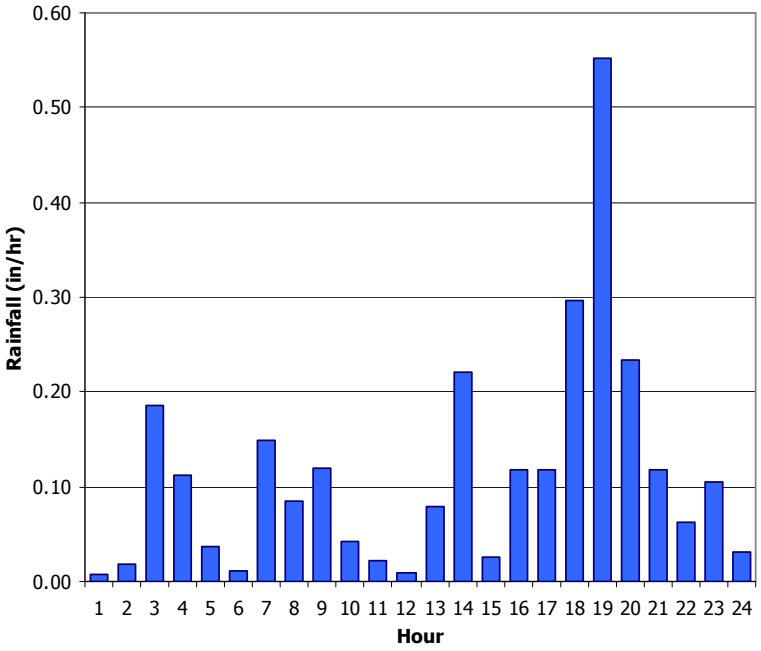


Figure 6-10. 10-Year, 24-Hour Design Storm Values

Figure 6-11 shows the synthetic hydrograph response for the 10-year event for Site 5. Table 6-4 summarizes the final results for each design storm on a site-by-site basis. 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.

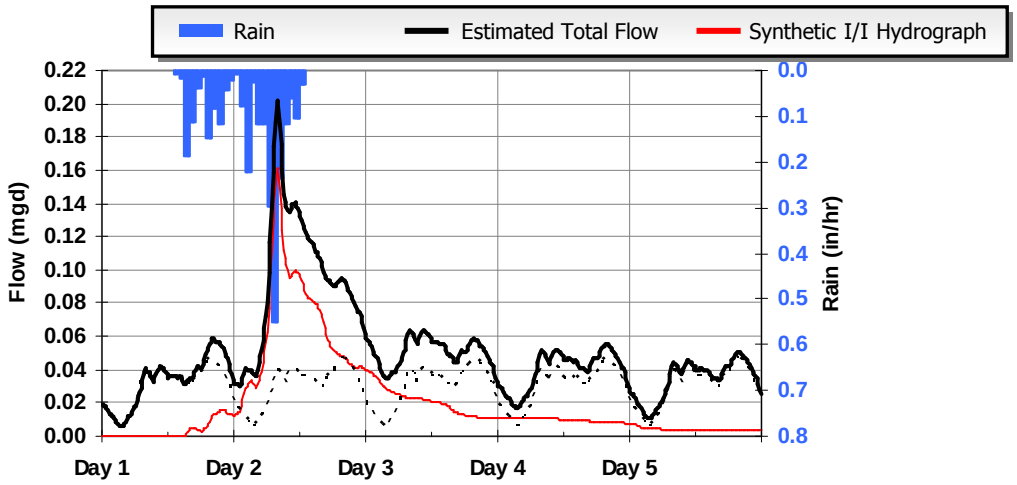


Figure 6-11. Site 5: 10-Year, 24-Hour Design Storm Synthetic Hydrograph

Table 6-4
10 Year, 24 Hour Design Storm Response Summary

Monitoring Site	ADWF (MGD)	Peak Flow (MGD)	Peaking Factor	Infiltration
Site 01	0.27	2.27	8.34	825,000
Site 02	0.10	0.44	4.39	197,000
Site 03	0.20	0.80	3.95	208,000
Site 04	0.08	0.44	5.57	198,000
Site 05	0.03	0.20	6.74	104,000

7 RECOMMENDATIONS

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

1. **Determine I/I Reduction Program:** The City should examine its I/I reduction needs to determine a future I/I reduction program.
    a. If peak flows, sanitary sewer overflows, and pipeline capacity issues are of greater concern, then the program can be weighted to investigate and reduce sources of inflow within the basins with the greatest inflow problems.
    b. If total infiltration and general pipeline deterioration is of greater concern, then the program can be weighted to investigate and reduce sources of infiltration within the basins with the greatest infiltration problems.
2. **I/I Reduction Methods:** Potential I/I reduction methods include the following:
    a. smoke testing
    b. mini-basin flow monitoring
    c. night-time reconnaissance work to (1) investigate and determine direct point sources of inflow, and (2) determine the areas and/or pipe reaches responsible for high levels of infiltration contribution.
    d. CCTV inspection
3. **I/I Reduction Cost Effective Analysis:** The City should conduct a study to determine which is more cost-effective: (1) locating the sources of infiltration and inflow and systematically rehabilitating or replacing the faulty pipelines; or (2) continued treatment of the additional storm water I/I flow.

Appendix A

Flow Monitoring Sites: Data, Graphs, Information

Temporary Flow Monitoring Study

Sanitary Sewer Collection System

Monitoring Site: Site 1

Manhole Address: Wescott Road at Ashley Drive

Size/Type of Line: 15-inch Sanitary Sewer Pipe

Data Summary Report

Site Information Report

Monitoring Site: Site 1

Location: Wescott Road at Ashley Drive

Diameter: 15 inches

Average Dry Weather Flow: 0.276 *MGD*

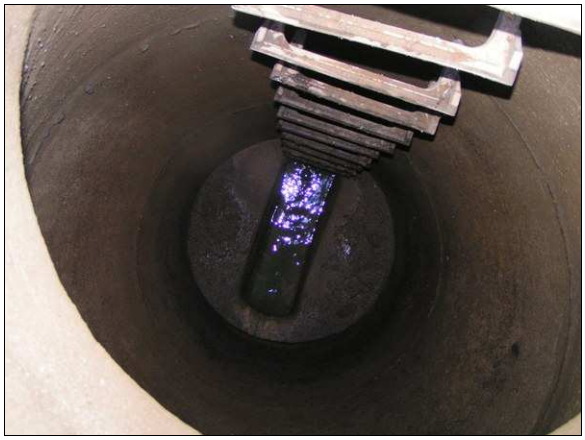
Peak Measured Flow: 0.769 *MGD*

Street-level photo:

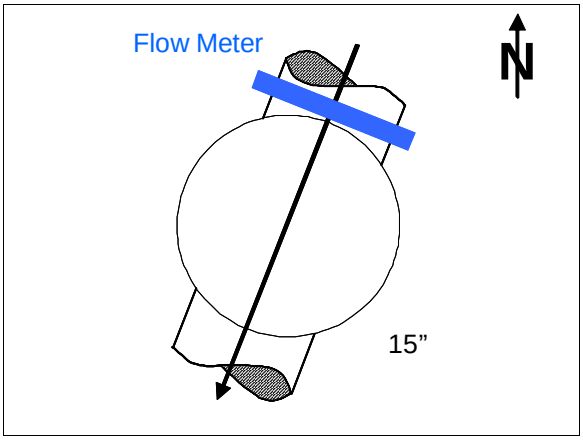
Street map:

Sanitary sewer map:

Plan view photo:



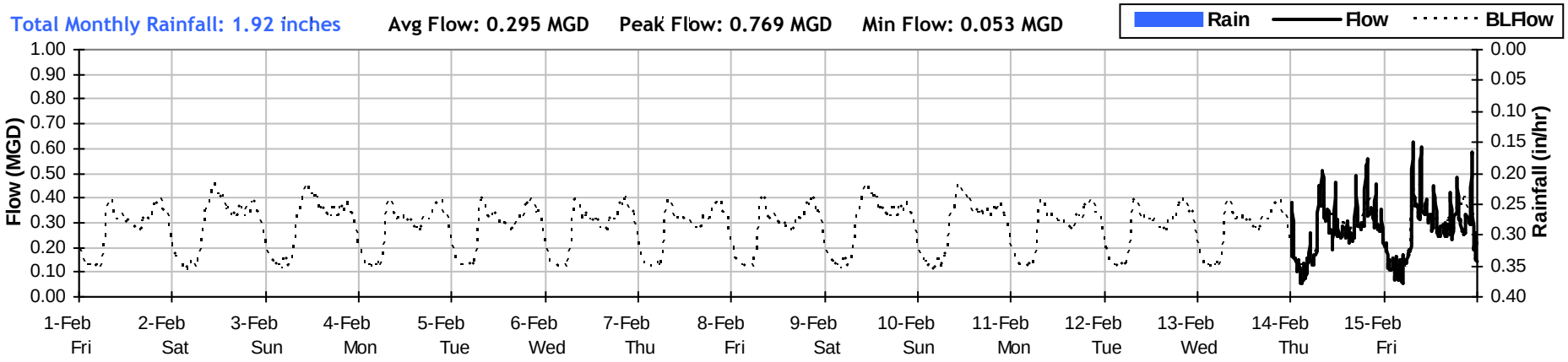
Flow sketch:

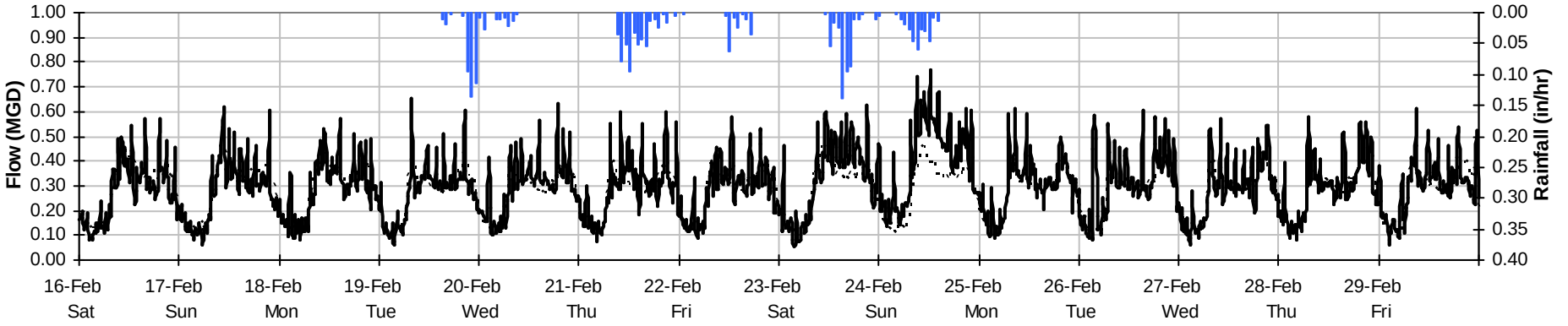


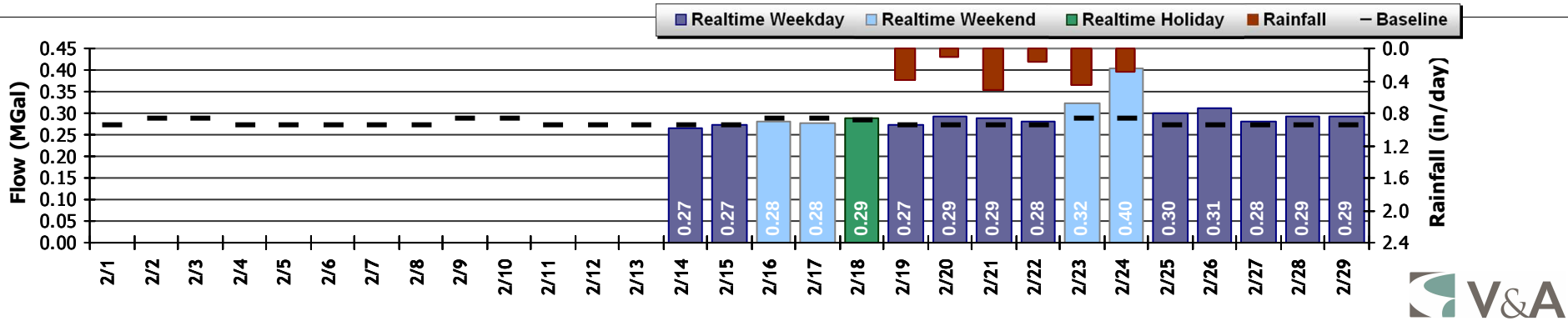
Monthly Flow Summary
February, 2008

Monitoring Site:
Site 1

Total Monthly Rainfall: 1.92 inches Avg Flow: 0.295 MGD Peak Flow: 0.769 MGD Min Flow: 0.053 MGD





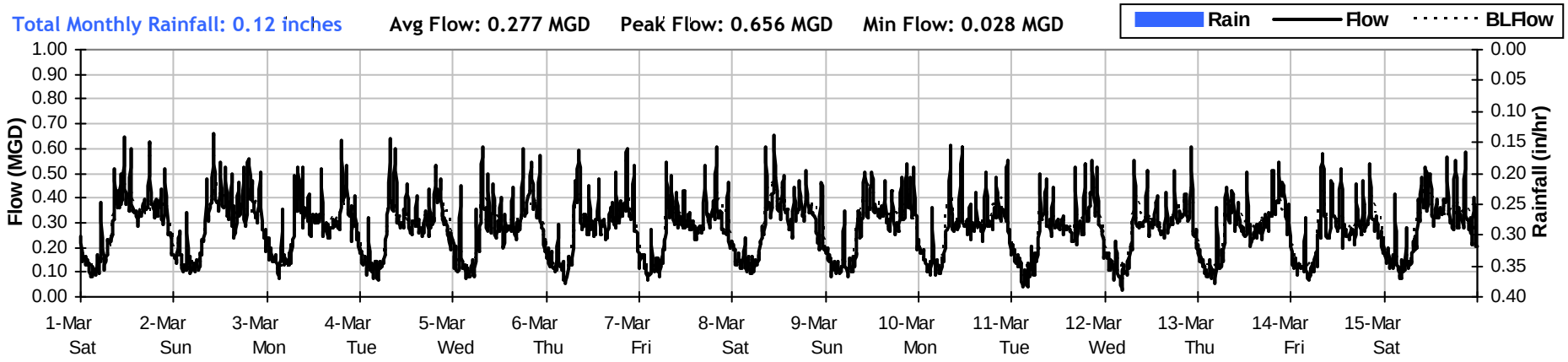


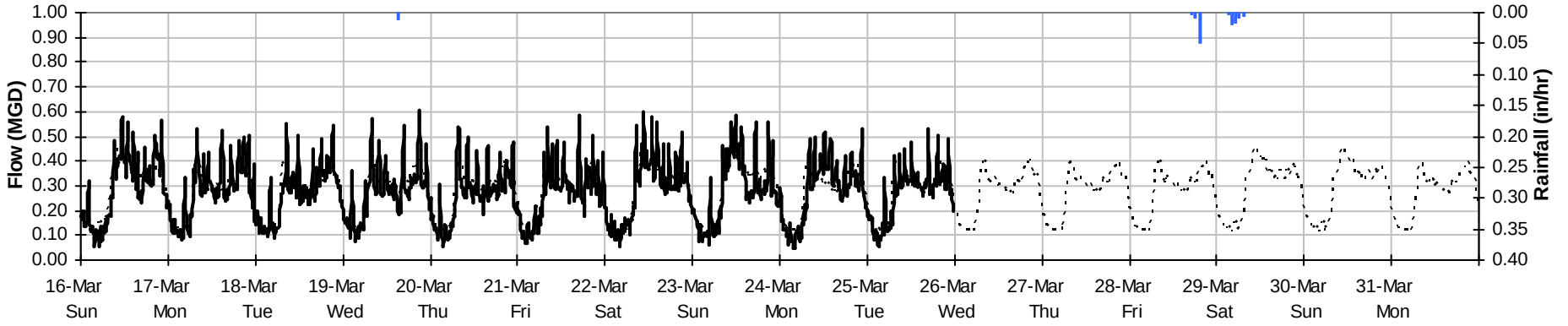
V&A

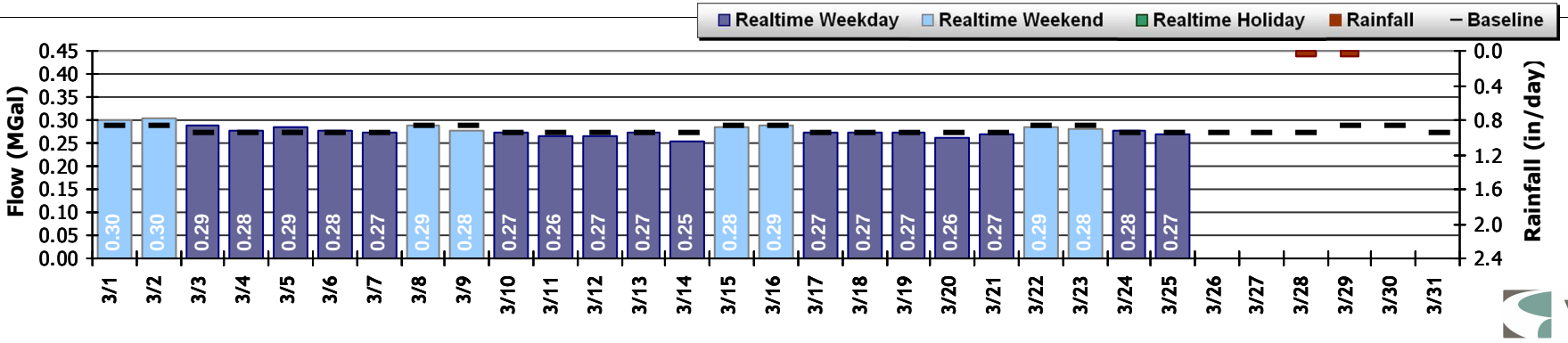
Monthly Flow Summary
March, 2008

Monitoring Site:
Site 1

Total Monthly Rainfall: 0.12 inches Avg Flow: 0.277 MGD Peak Flow: 0.656 MGD Min Flow: 0.028 MGD





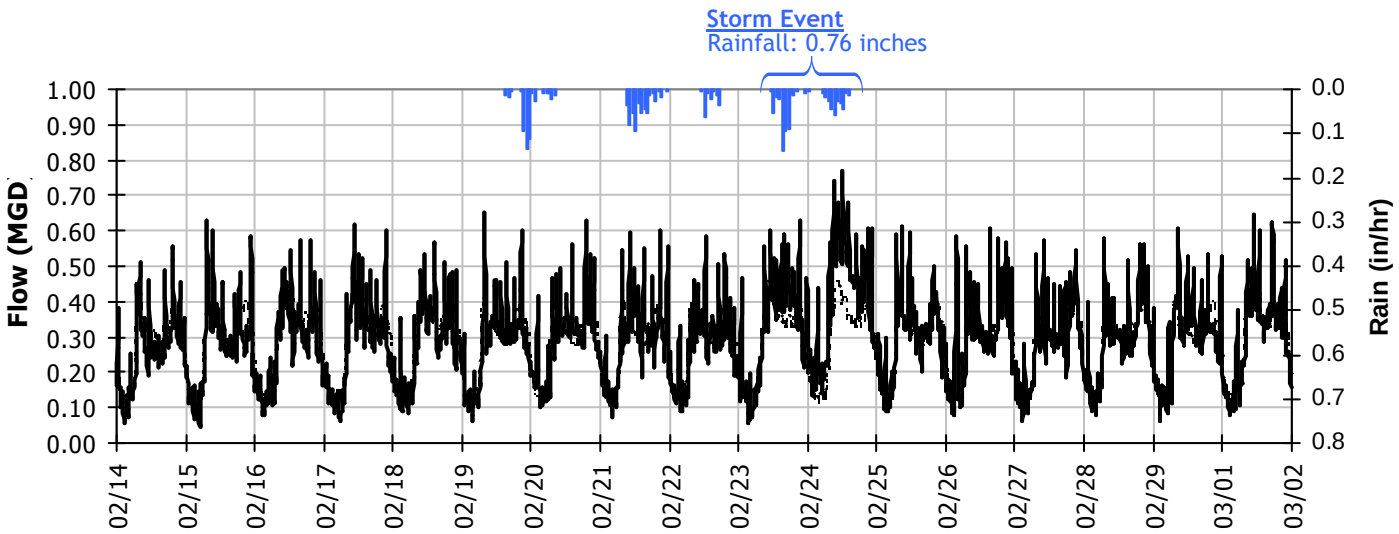


V&A

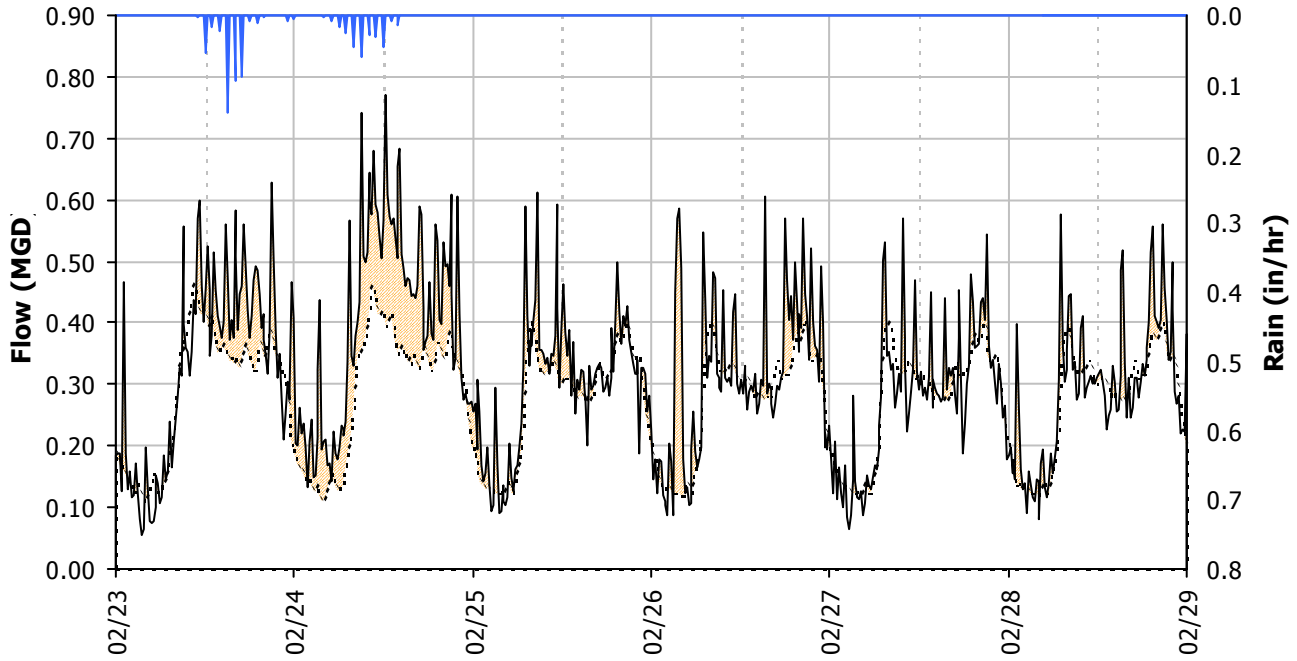
I/I Summary

Monitoring Site:
Site 1

Baseline, Realtime, and I/I Flows over Monitoring Period:



Storm Event #1 Detail I/I Graph

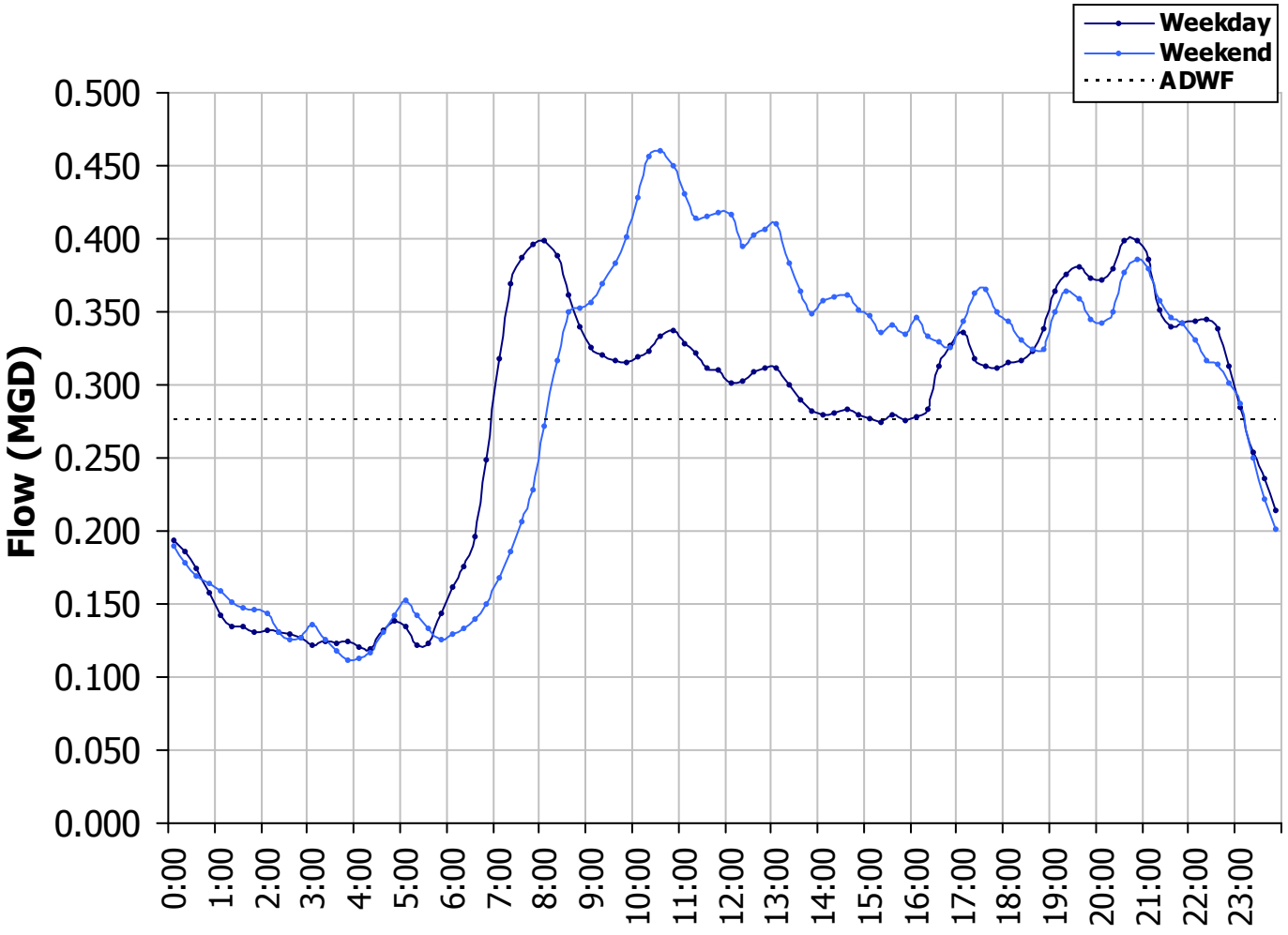


Storm Event #1 I/I Analysis

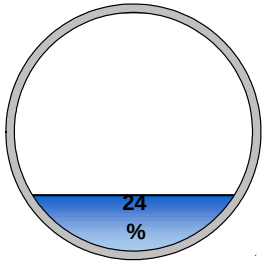
Rainfall:	0.76	*inches*		
Peak Flow:	0.769	*MGD*	**PF:**	2.79
Peak I/I Rate:	0.386	*MGD*	**Pk I/I:ADWF:**	1.40
Peak Level:	7.00	*inches*	**d/D Ratio:**	0.47
Total I/I:	182,000	*gallons*	**R-Value:**	2.8%
			I/I per ADWF:	0.87

Average Dry Weather Flow

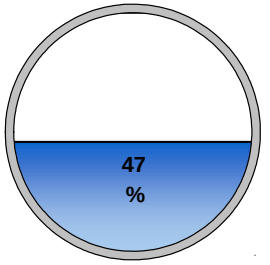
Monitoring Site:
Site 1



Average Dry Weather Flow:
0.276 *MGD*



Peak Measured Flow:
0.769 *MGD*



Peak measured flow shown on following pages in weekly flow data graphs

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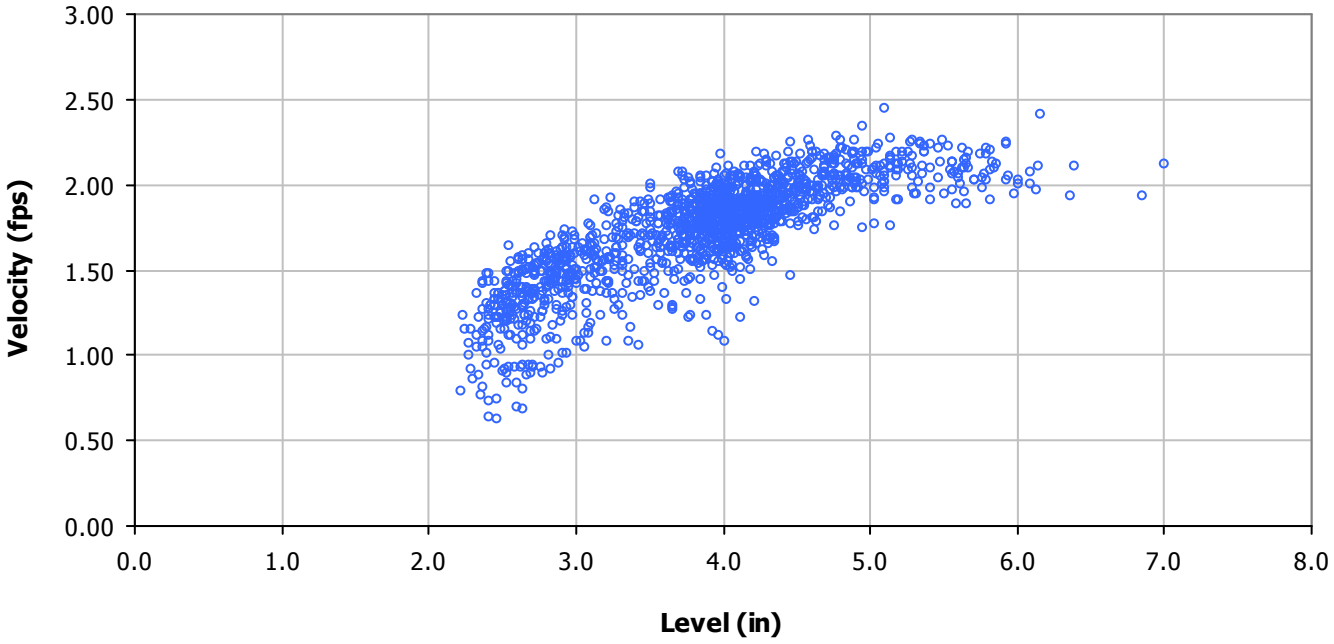
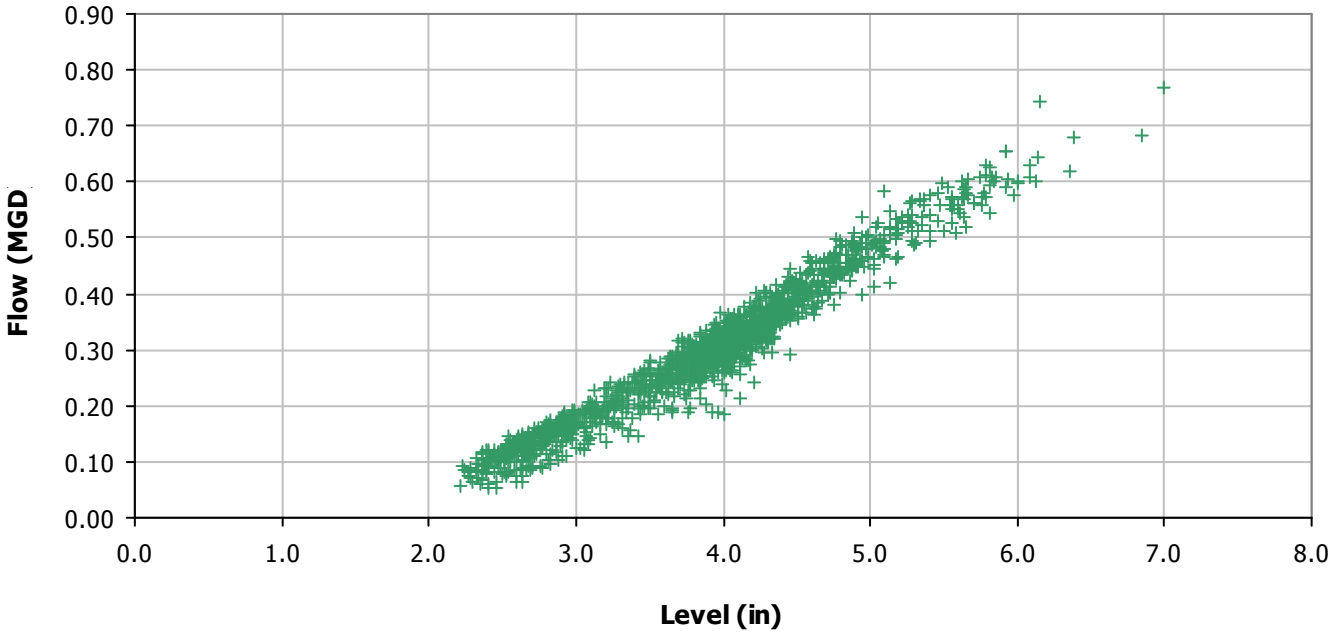
Scatter Plots
(Flow, Velocity vs. Depth)

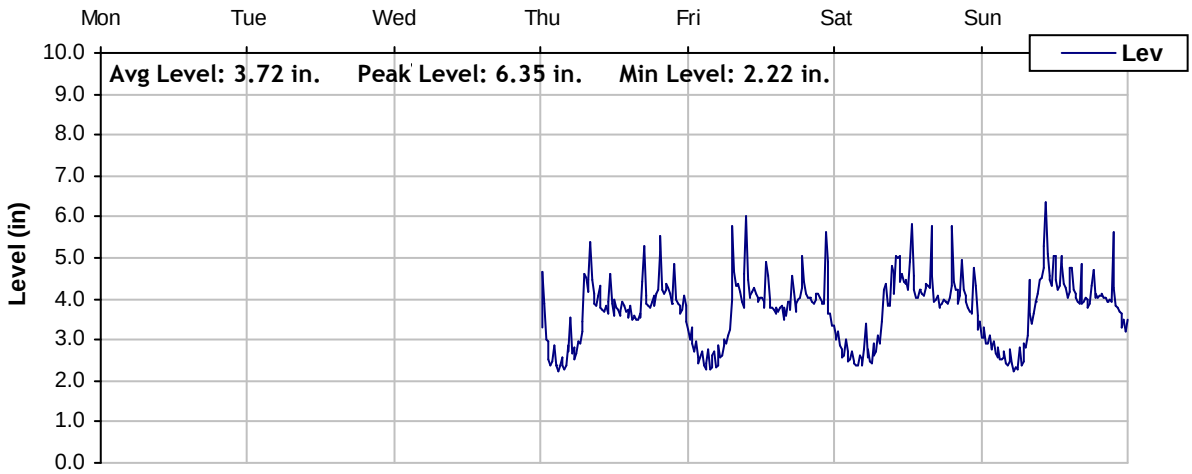
Monitoring Site:
Site 1

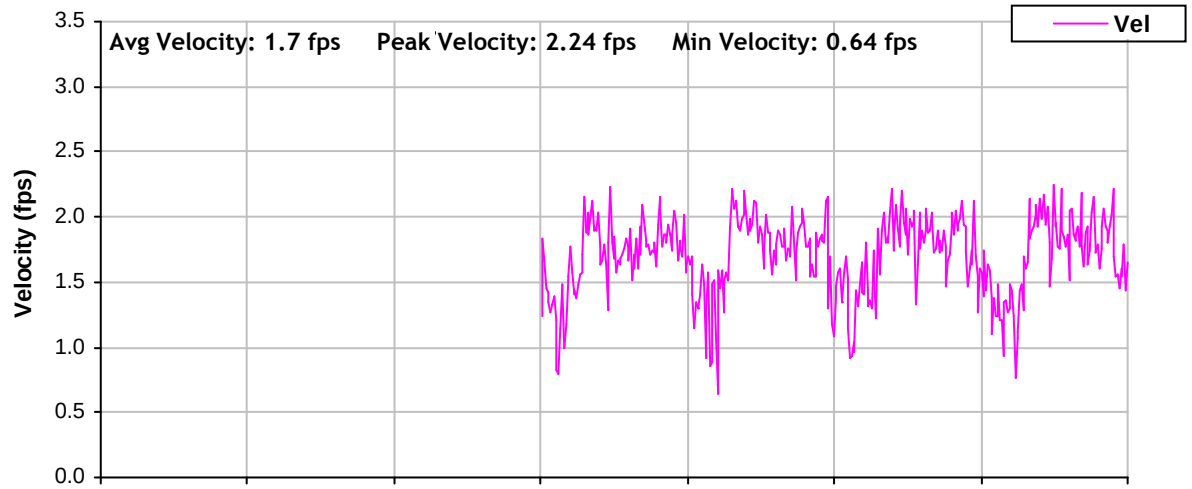


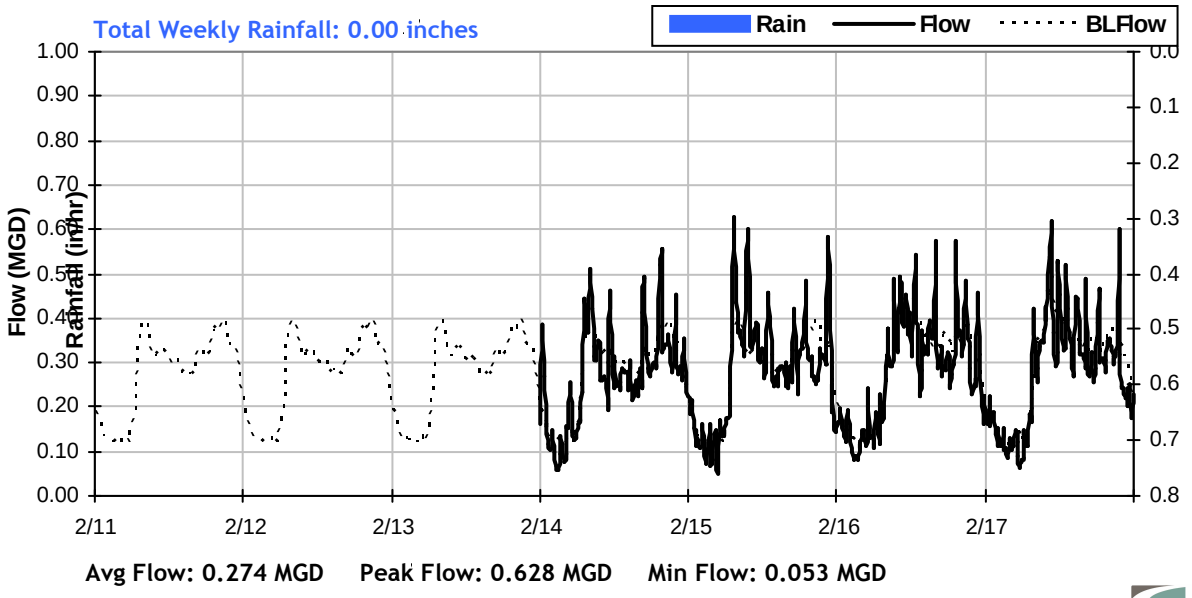


Level, Velocity and Flow
From 2/11/2008 to 2/18/2008

Monitoring Site:
Site 1



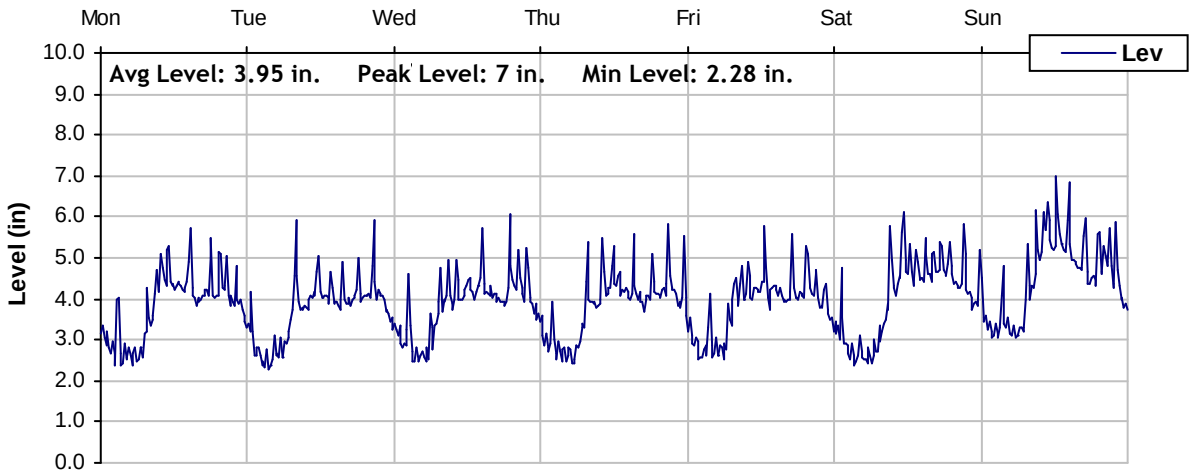


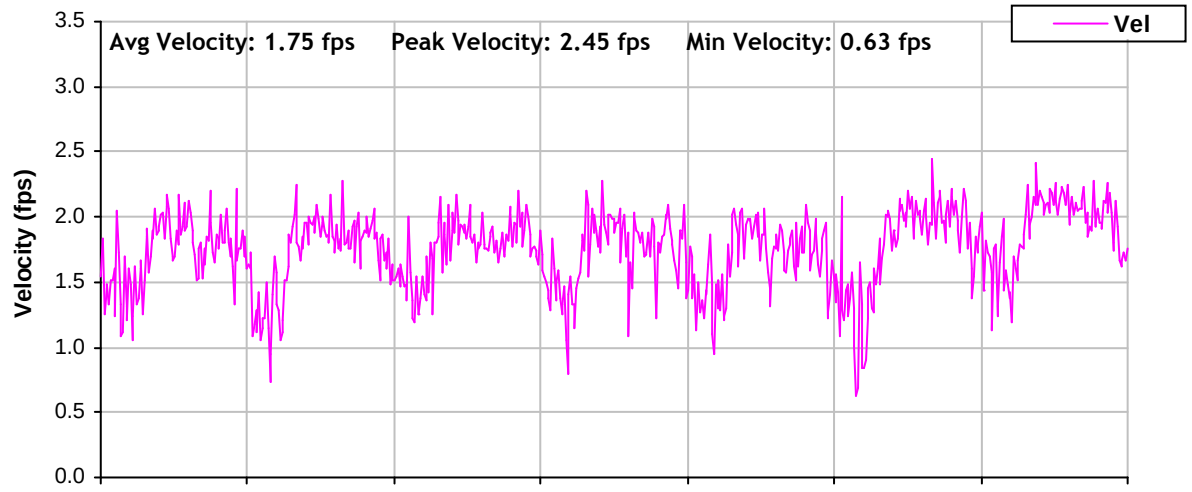


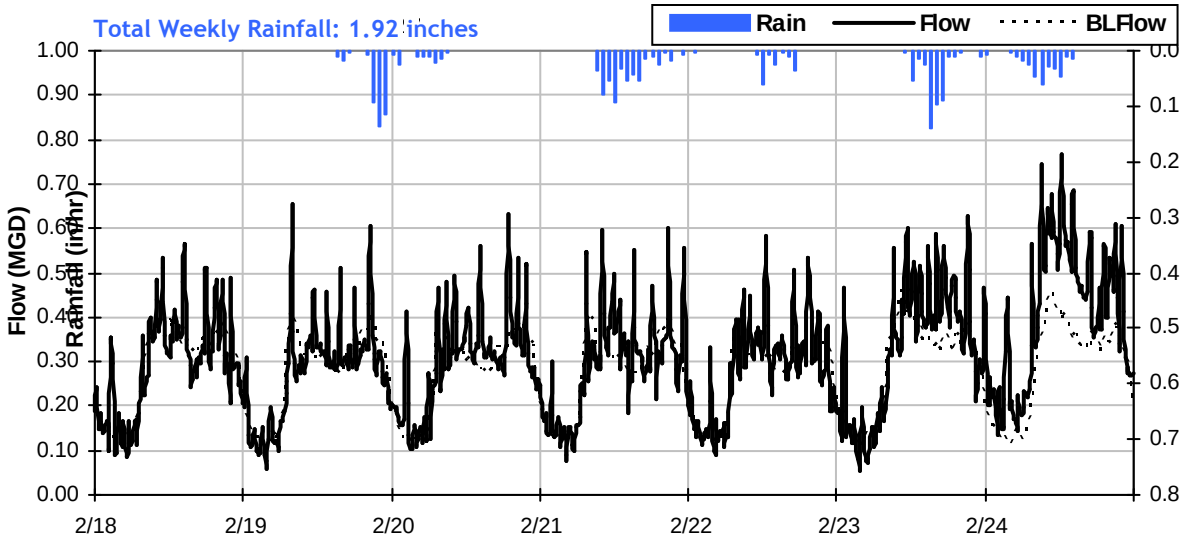
Avg Flow: 0.274 MGD Peak Flow: 0.628 MGD Min Flow: 0.053 MGD

Level, Velocity and Flow
From 2/18/2008 to 2/25/2008

Monitoring Site:
Site 1



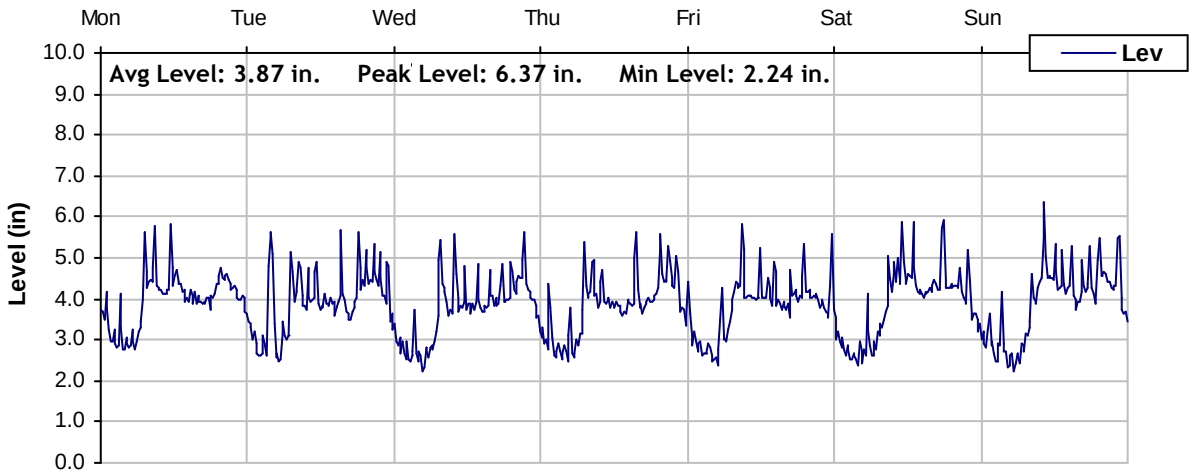


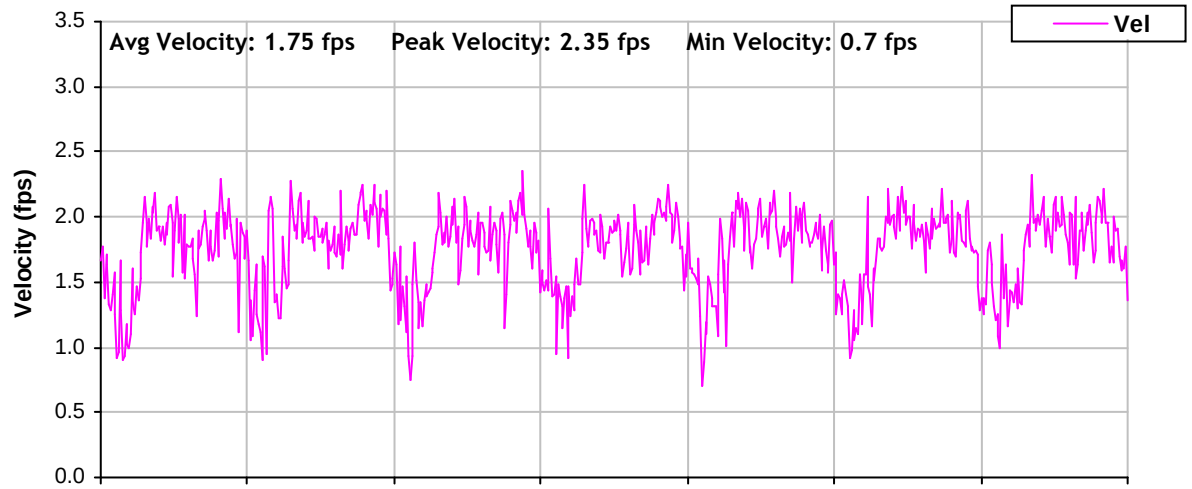


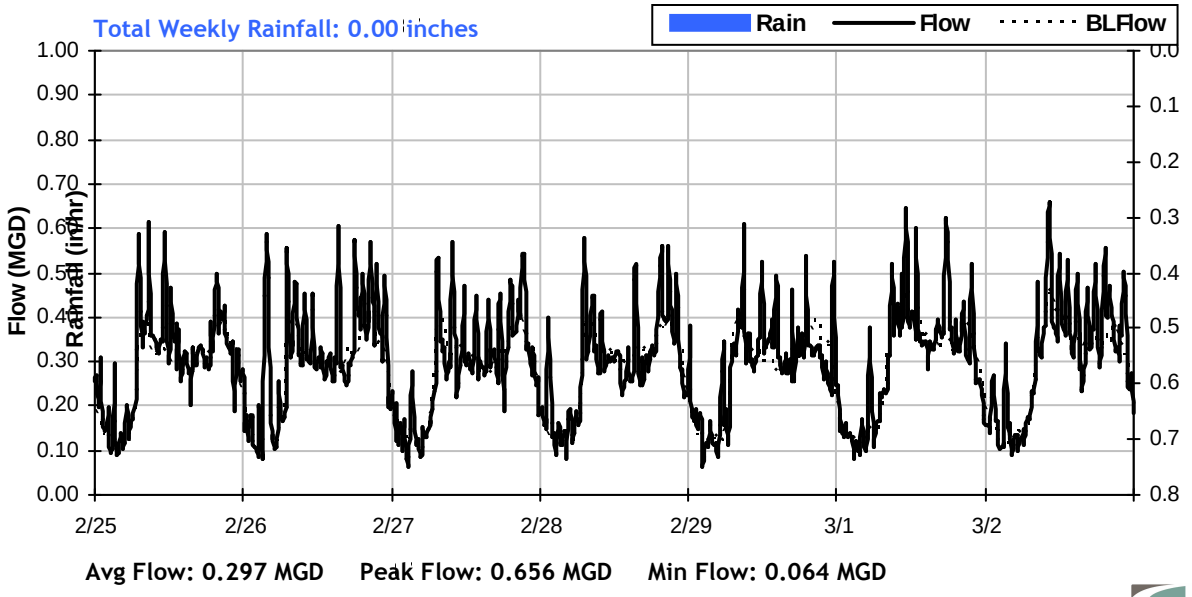
Avg Flow: 0.307 MGD Peak Flow: 0.769 MGD Min Flow: 0.054 MGD

Level, Velocity and Flow
From 2/25/2008 to 3/3/2008

Monitoring Site:
Site 1

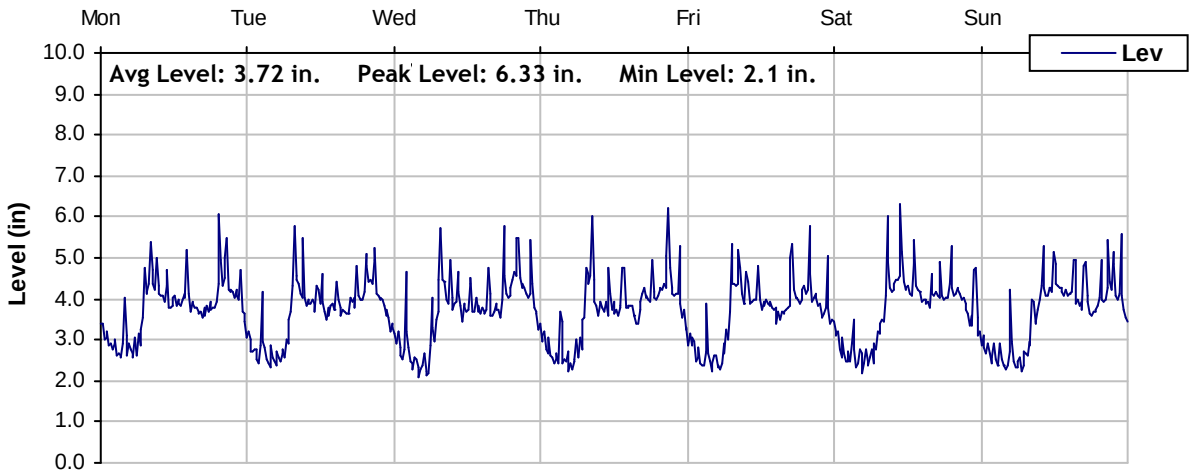


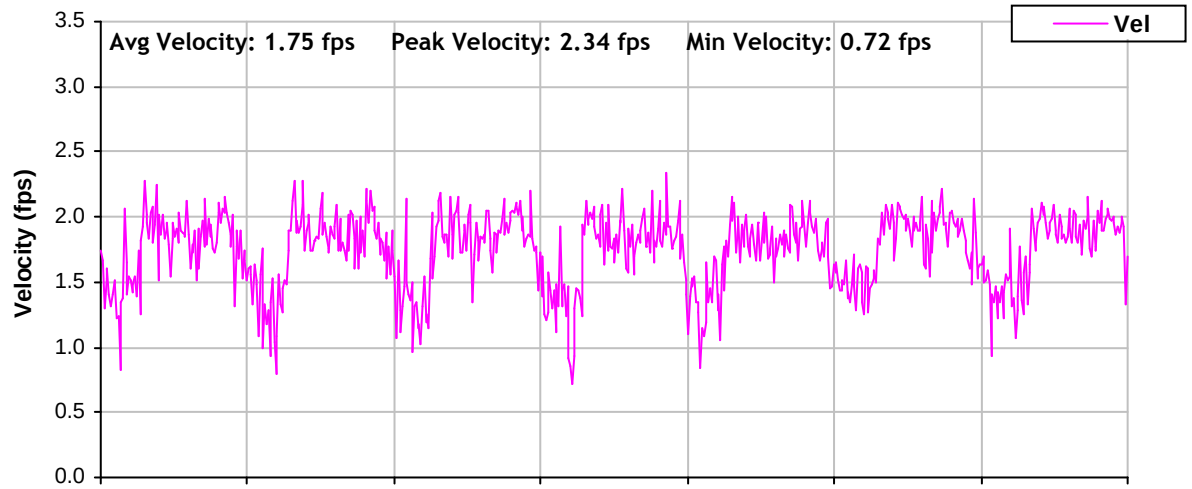


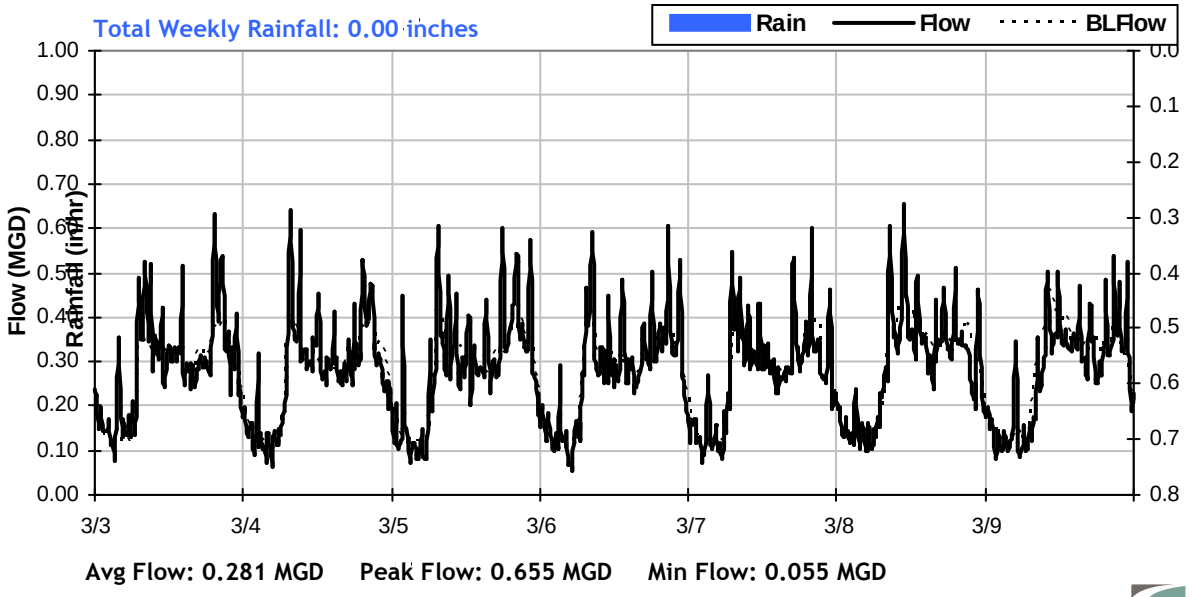


Level, Velocity and Flow
From 3/3/2008 to 3/10/2008

Monitoring Site:
Site 1

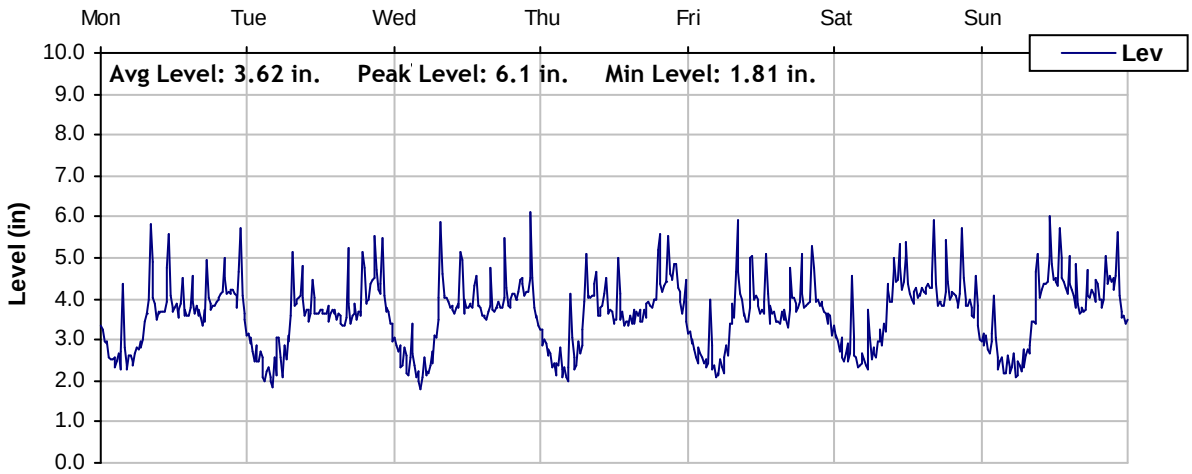


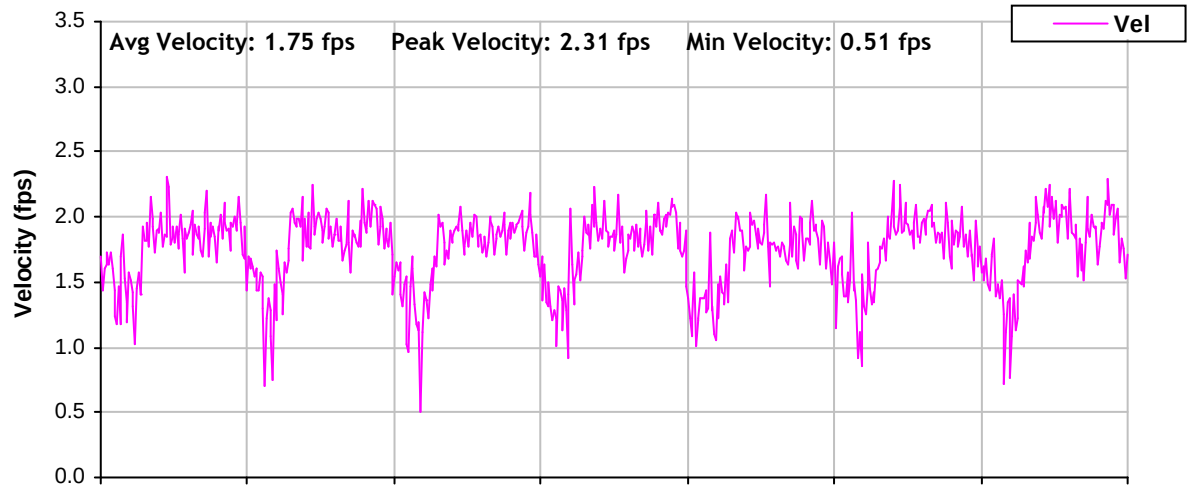


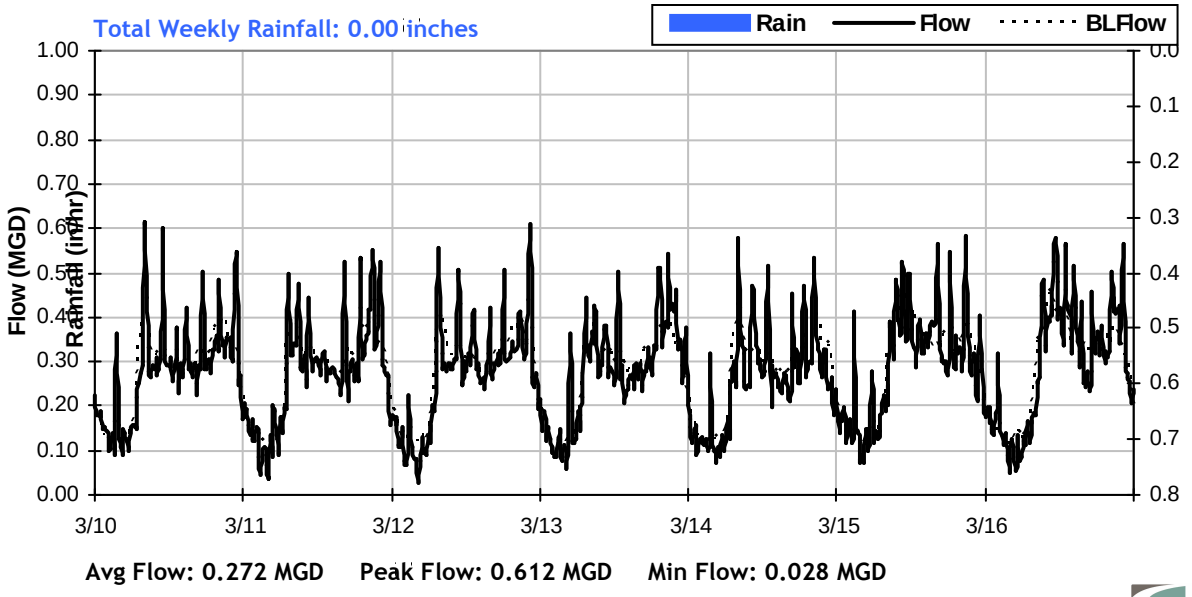


Level, Velocity and Flow
From 3/10/2008 to 3/17/2008

Monitoring Site:
Site 1

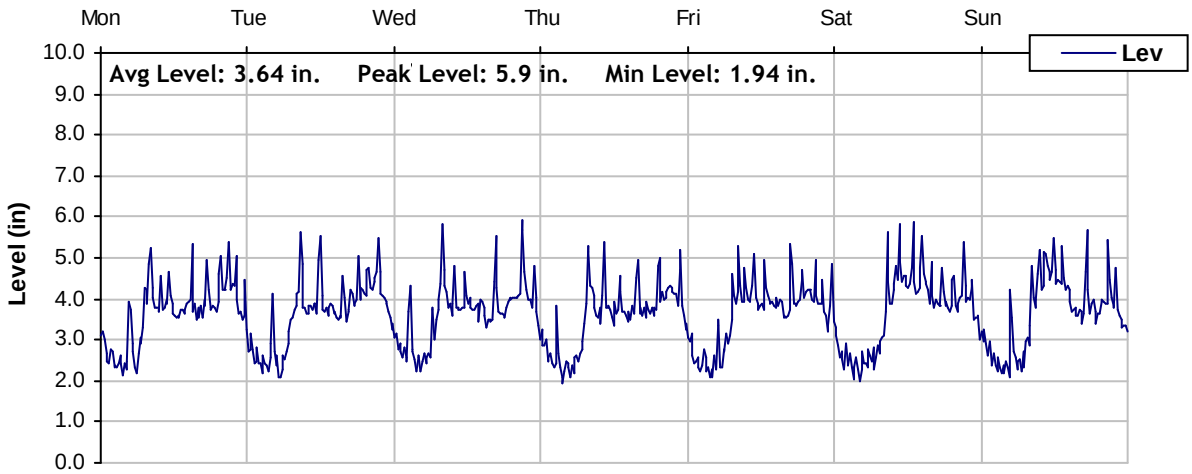


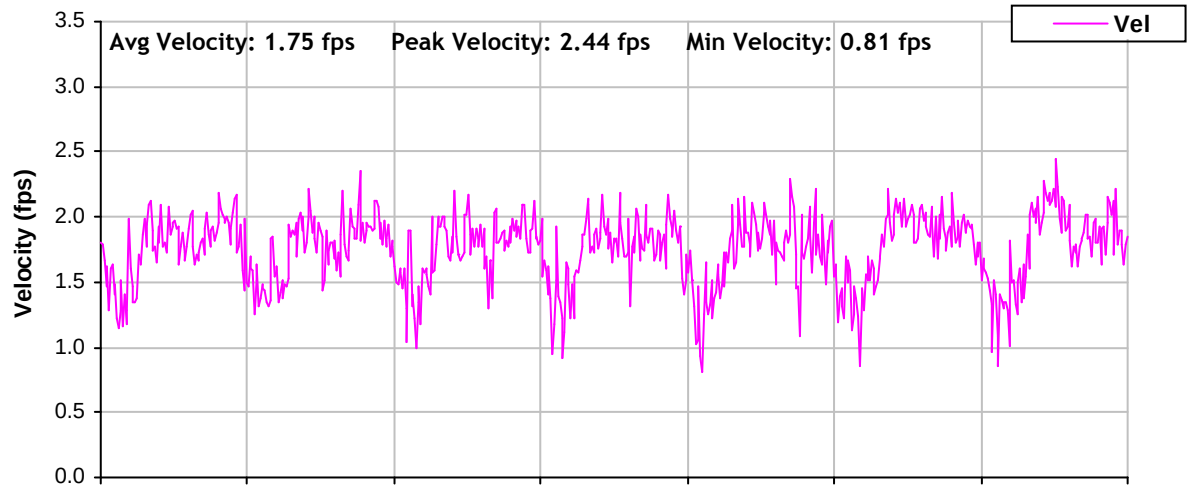


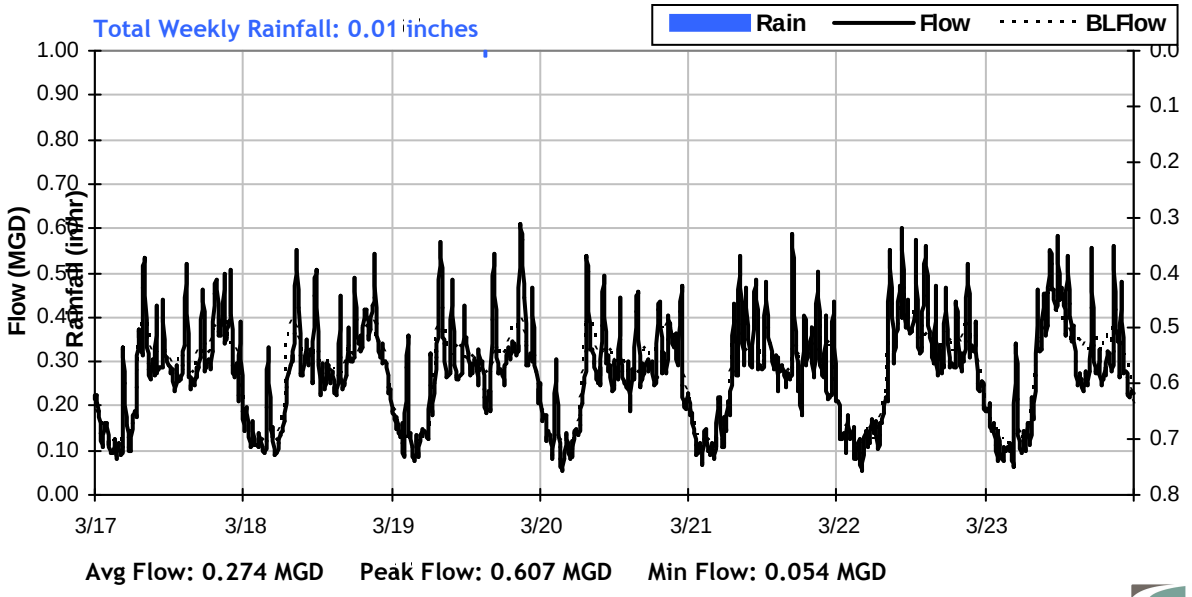


Level, Velocity and Flow
From 3/17/2008 to 3/24/2008

Monitoring Site:
Site 1



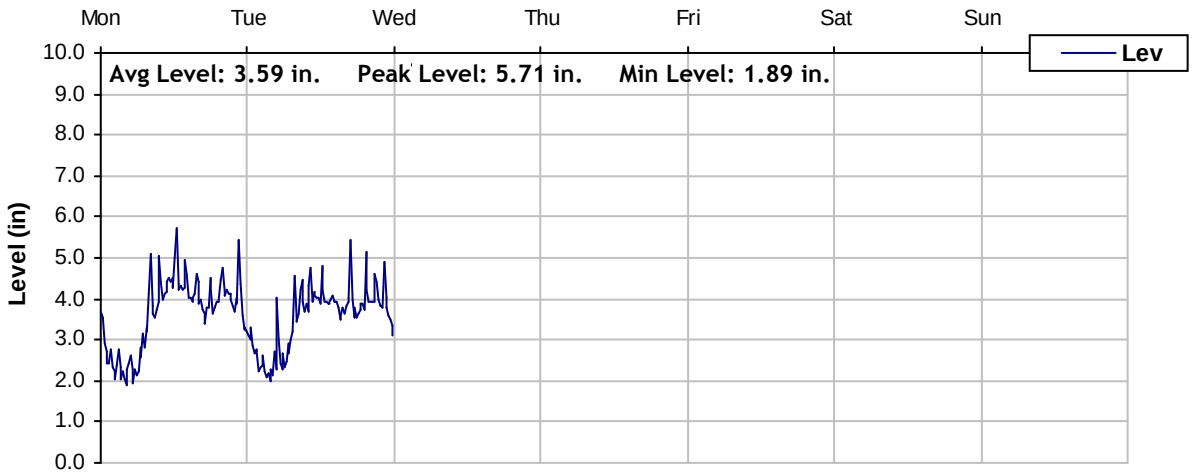


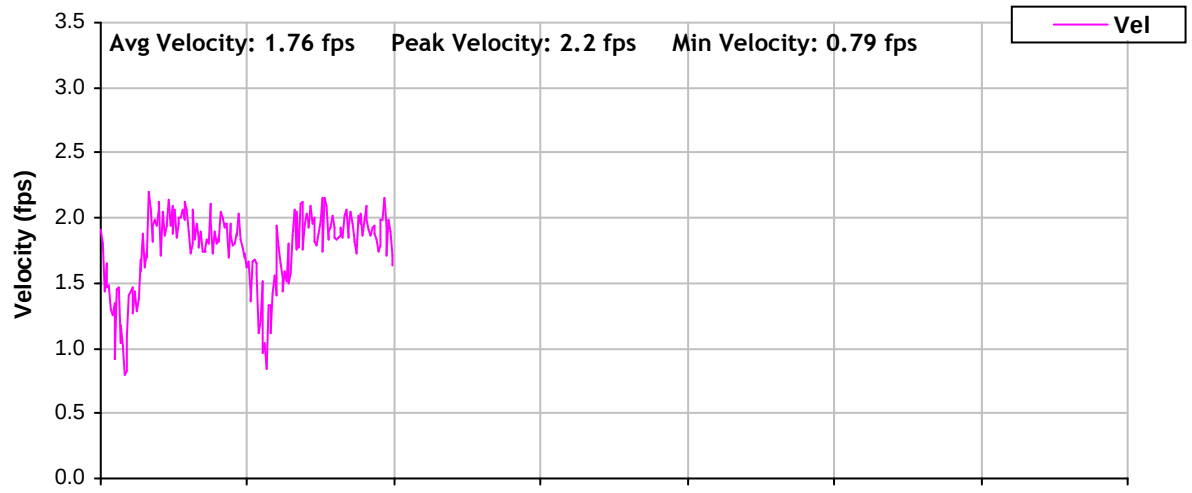


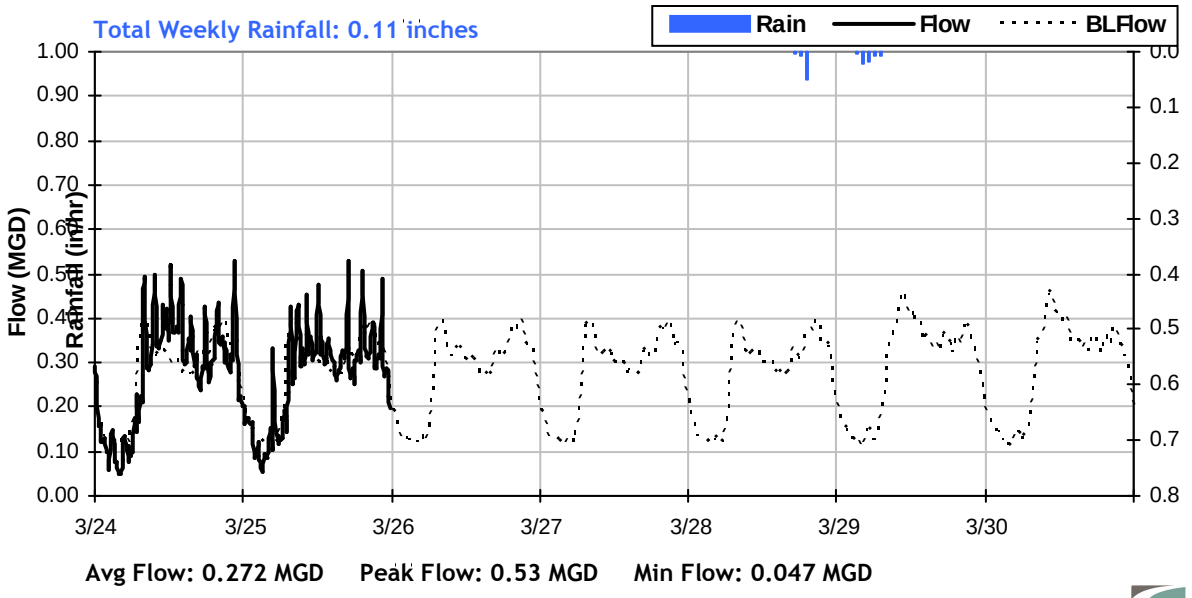
Avg Flow: 0.274 MGD Peak Flow: 0.607 MGD Min Flow: 0.054 MGD

Level, Velocity and Flow
From 3/24/2008 to 3/31/2008

Monitoring Site:
Site 1







Avg Flow: 0.272 MGD Peak Flow: 0.53 MGD Min Flow: 0.047 MGD

Temporary Flow Monitoring Study

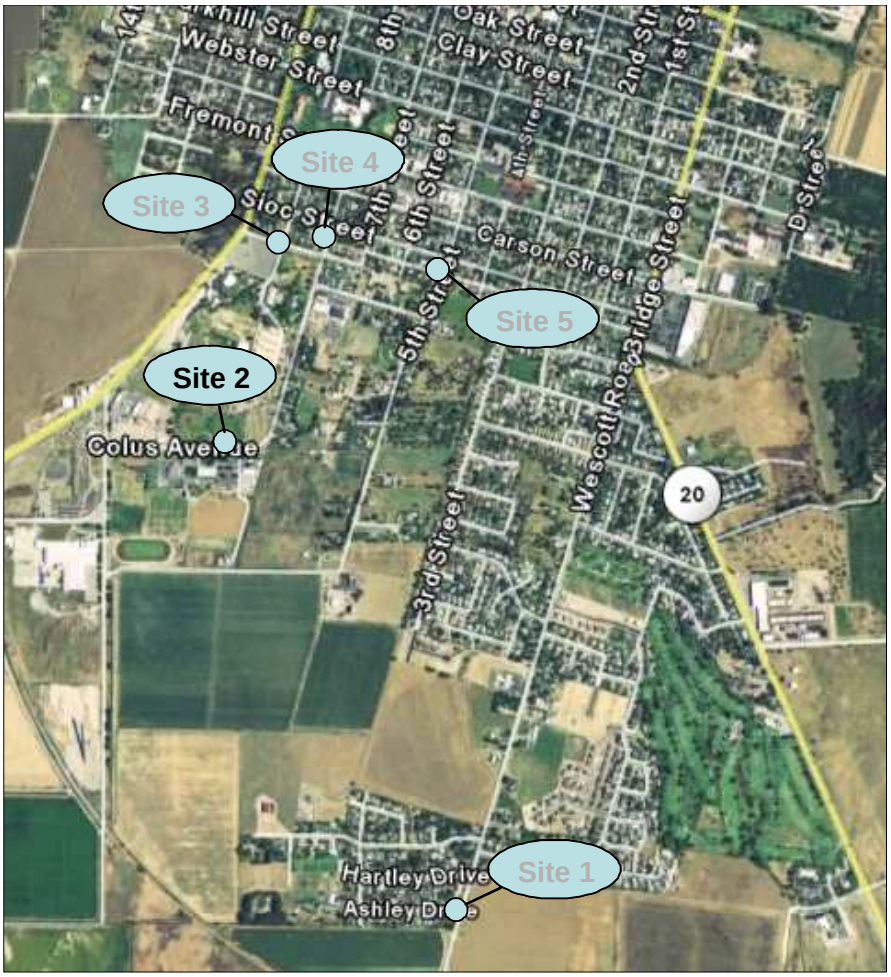
Sanitary Sewer Collection System

Monitoring Site: Site 2

Manhole Address: Colus Avenue, Colusa County Fairgrounds

Size/Type of Line: 12-inch Sanitary Sewer Pipe

Data Summary Report



Site Information Report

Monitoring Site: Site 2

Location: Colus Avenue, Colusa County Fairgrounds

Diameter: 12 inches

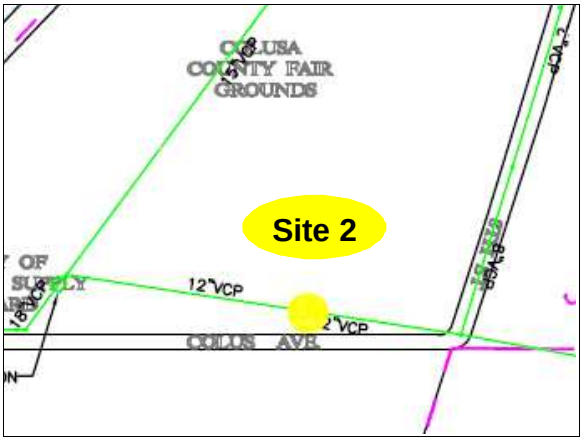
Average Dry Weather Flow: 0.102 *MGD*

Peak Measured Flow: 0.241 *MGD*

Street-level photo:

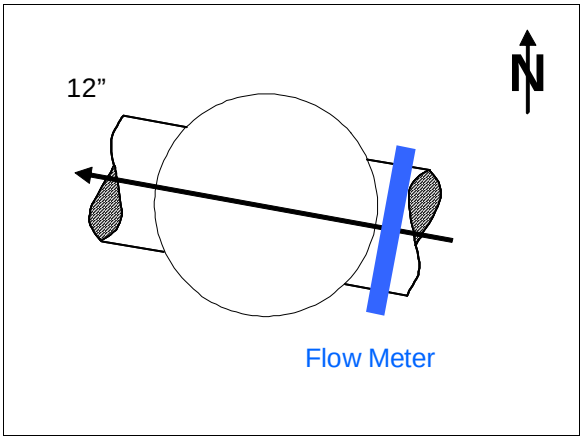
Street map:

Sanitary sewer map:



Plan view photo:

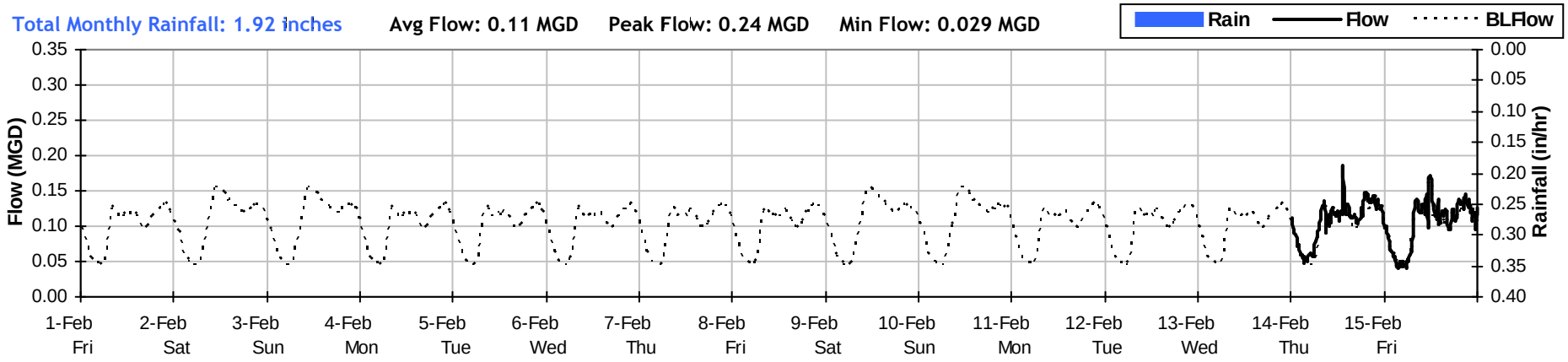
Flow sketch:

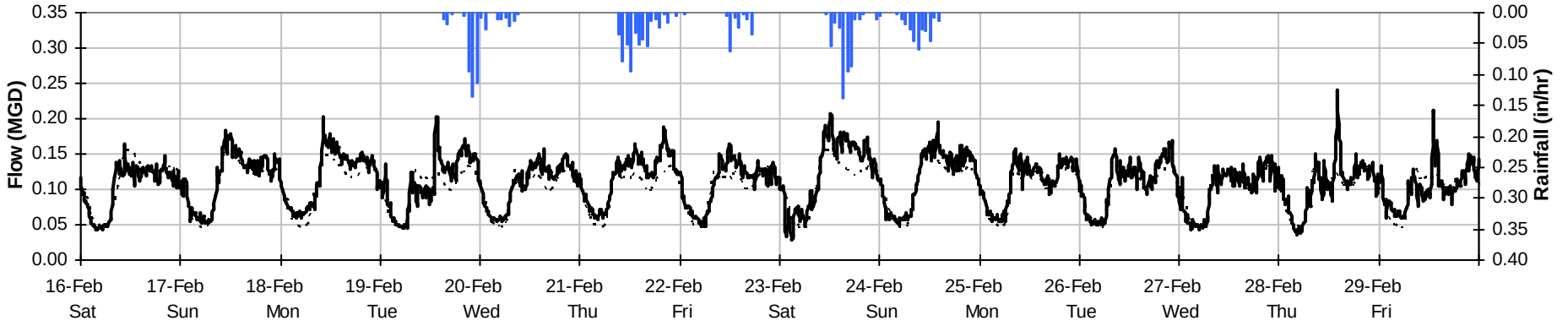


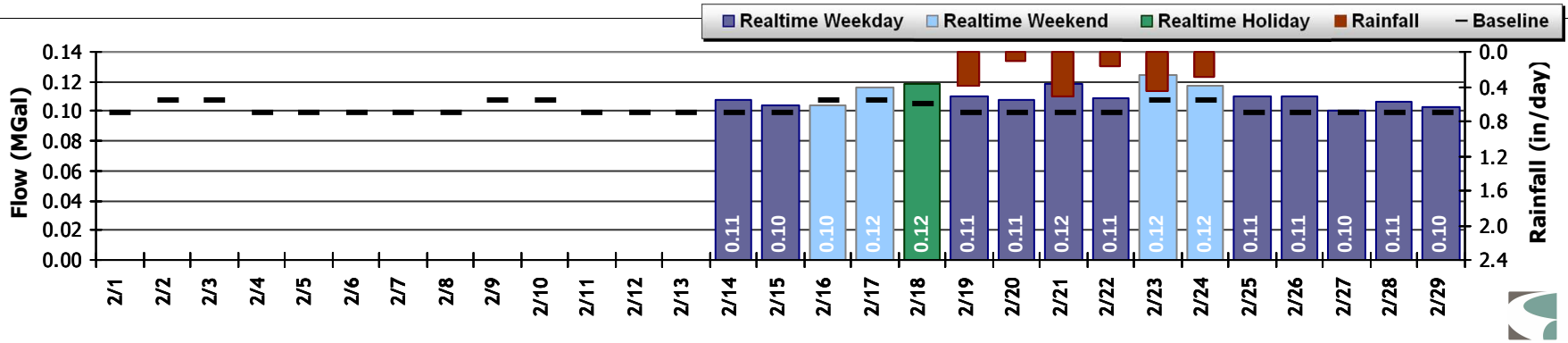
Monthly Flow Summary
February, 2008

Monitoring Site:
Site 2

Total Monthly Rainfall: 1.92 inches Avg Flow: 0.11 MGD Peak Flow: 0.24 MGD Min Flow: 0.029 MGD





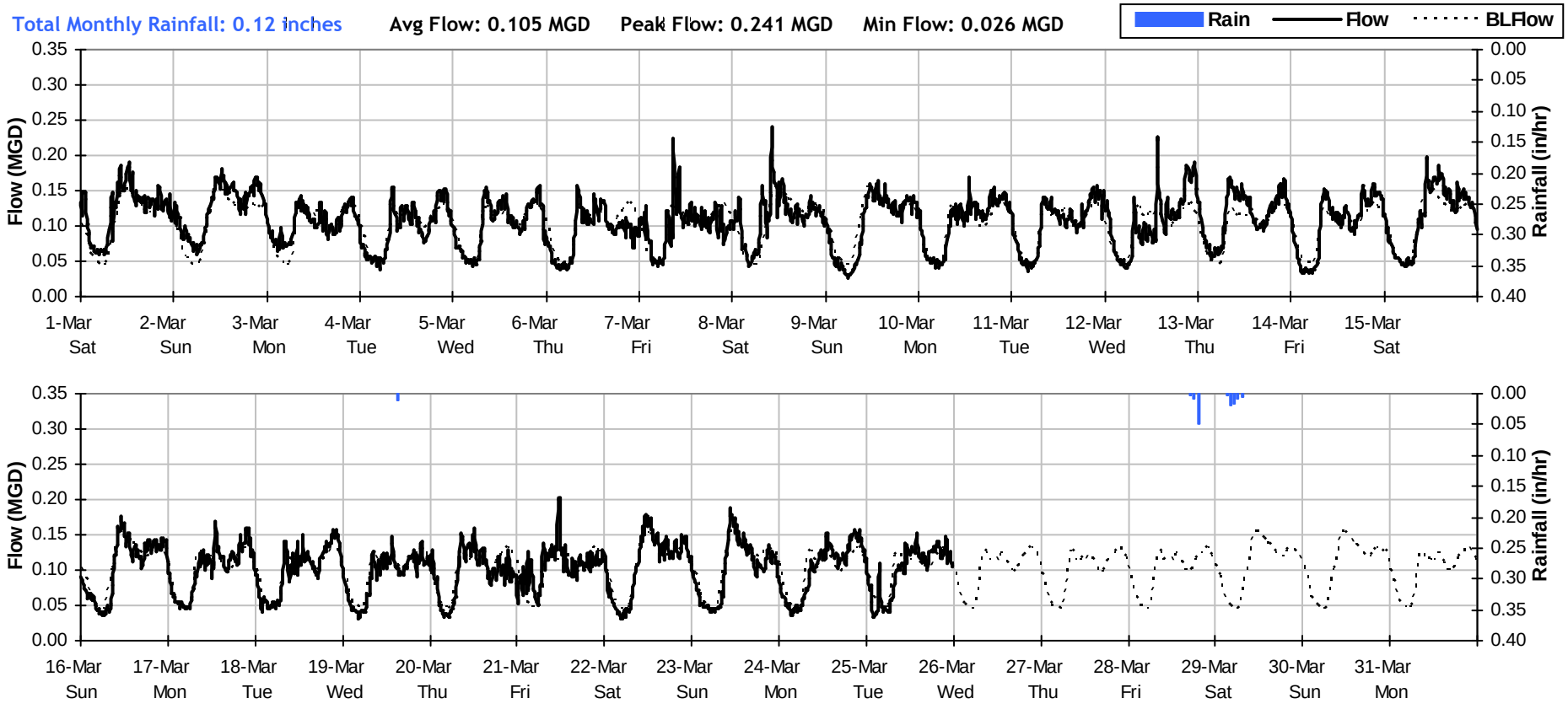


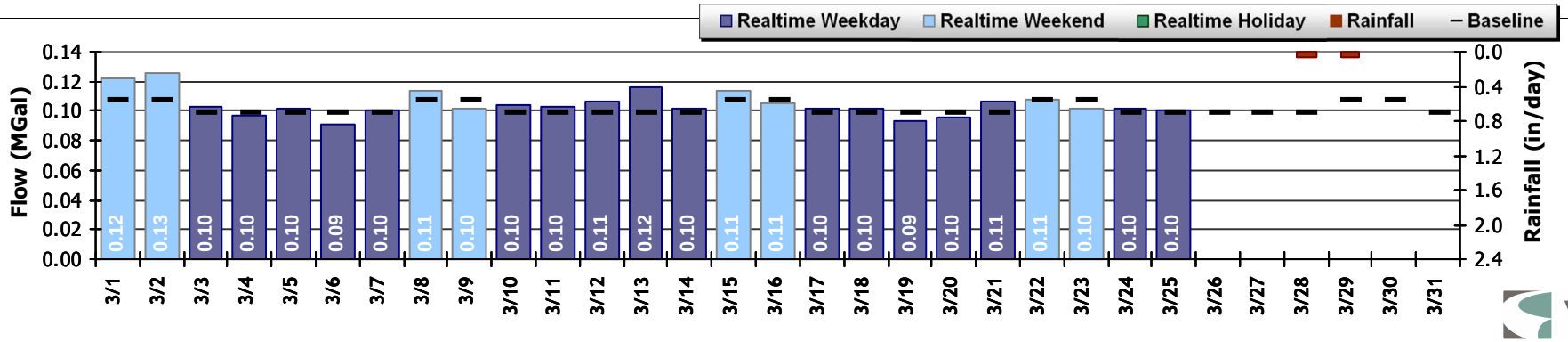
V&A

Monthly Flow Summary
March, 2008

Monitoring Site:
Site 2

Total Monthly Rainfall: 0.12 inches Avg Flow: 0.105 MGD Peak Flow: 0.241 MGD Min Flow: 0.026 MGD



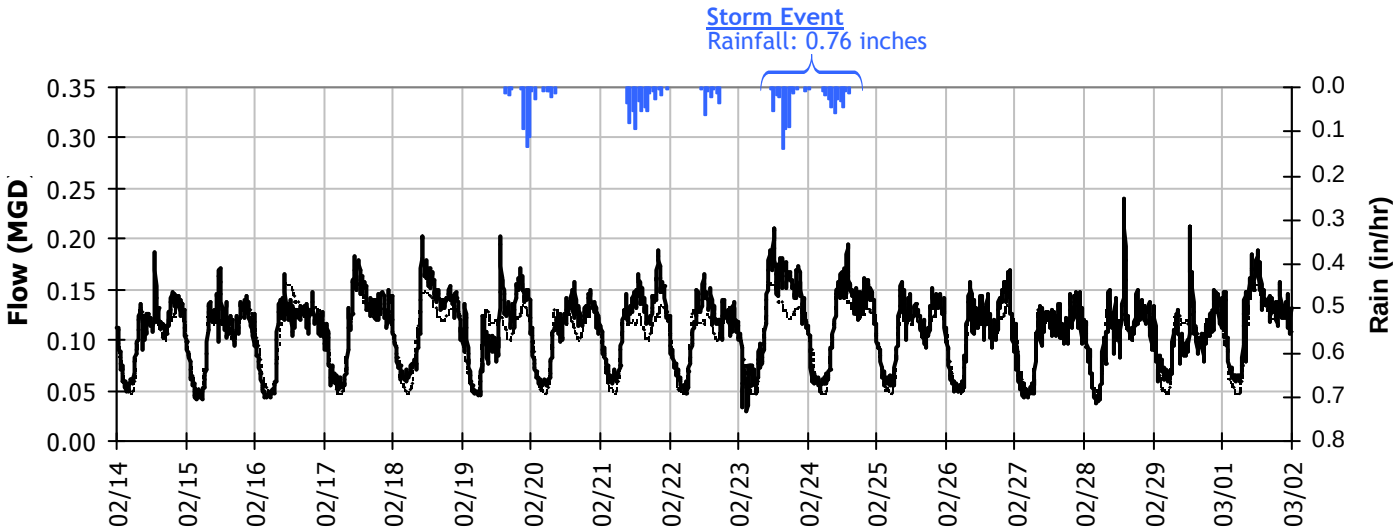


V&A

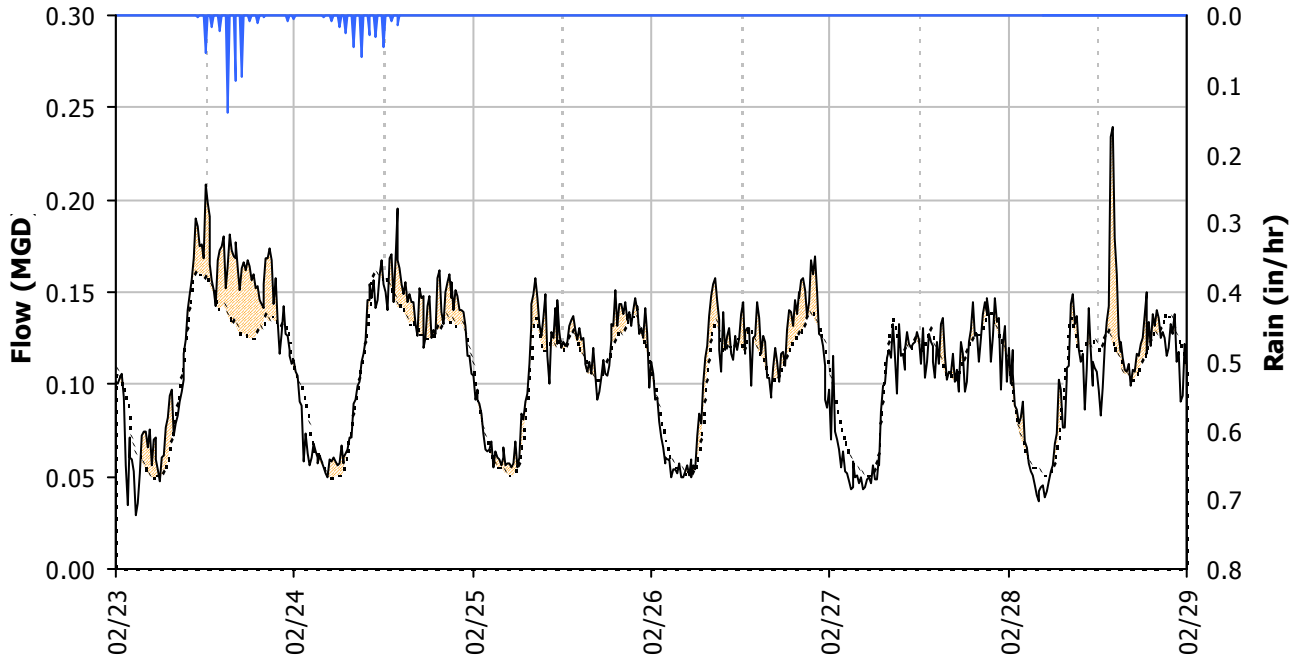
I/I Summary

Monitoring Site:
Site 2

Baseline, Realtime, and I/I Flows over Monitoring Period:



Storm Event #1 Detail I/I Graph

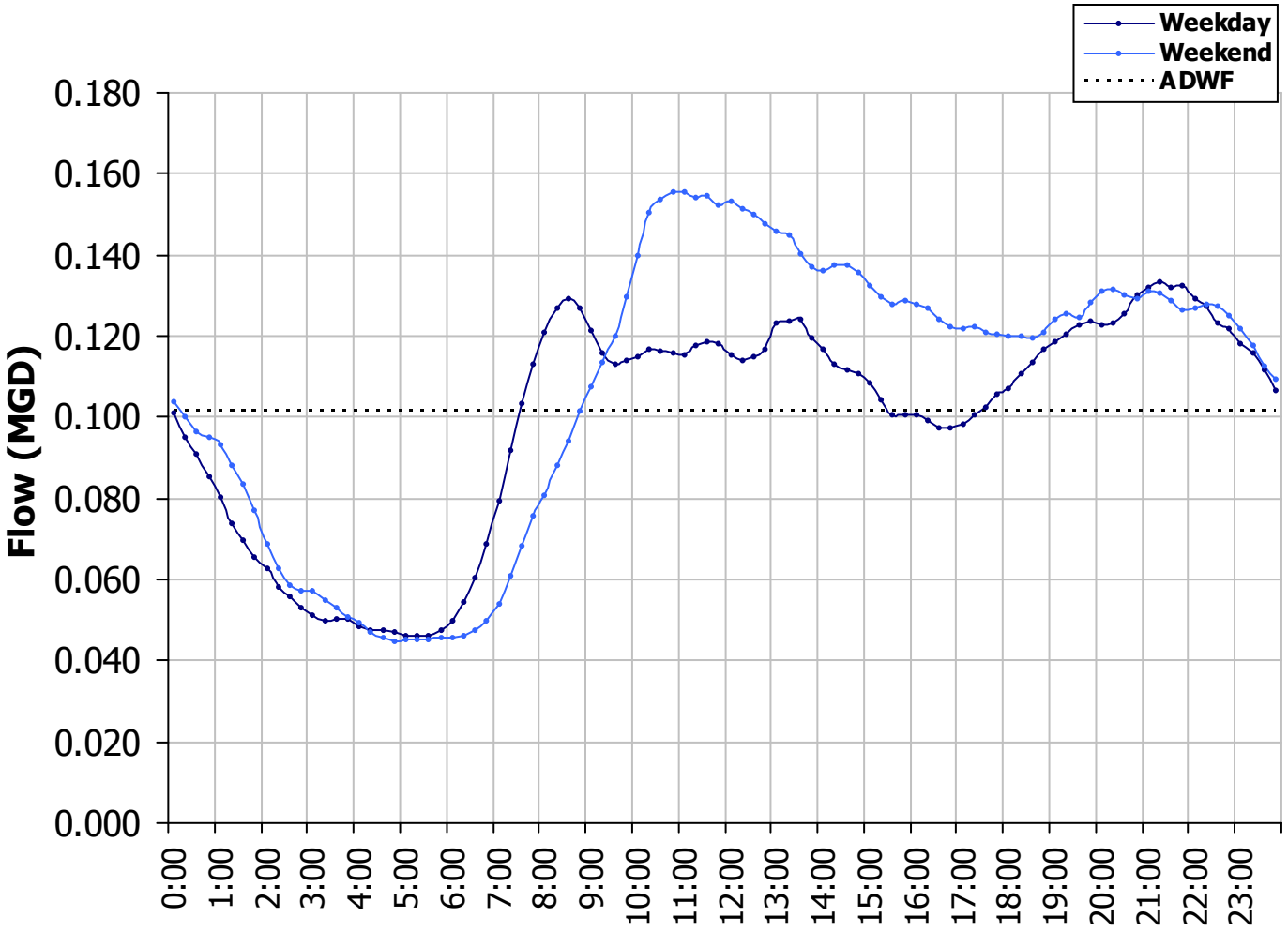


Storm Event #1 I/I Analysis

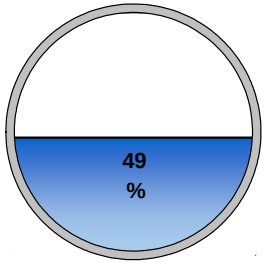
Rainfall:	0.76	*inches*		
Peak Flow:	0.208	*MGD*	**PF:**	2.05
Peak I/I Rate:	0.059	*MGD*	**Pk I/I:ADWF:**	0.58
Peak Level:	7.64	*inches*	**d/D Ratio:**	0.64
Total I/I:	21,000	*gallons*	**R-Value:**	0.4%
			I/I per ADWF:	0.28

Average Dry Weather Flow

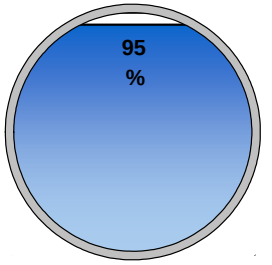
Monitoring Site:
Site 2



Average Dry Weather Flow:
0.102 *MGD*



Peak Measured Flow:
0.241 *MGD*

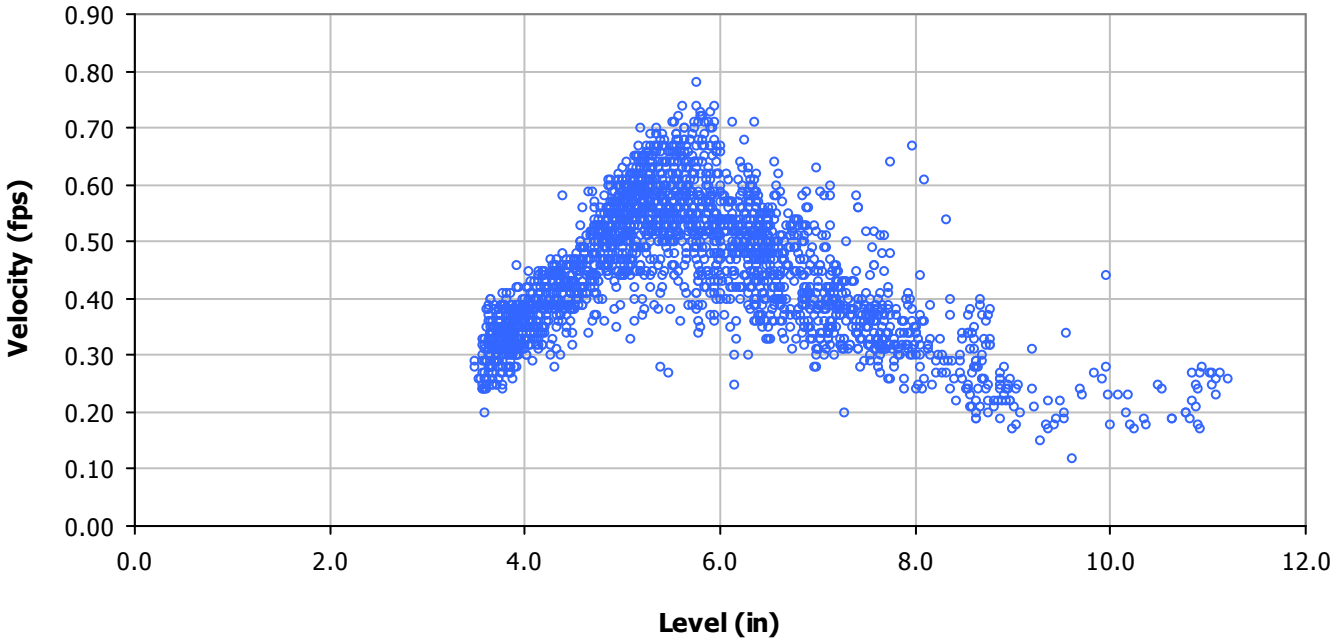


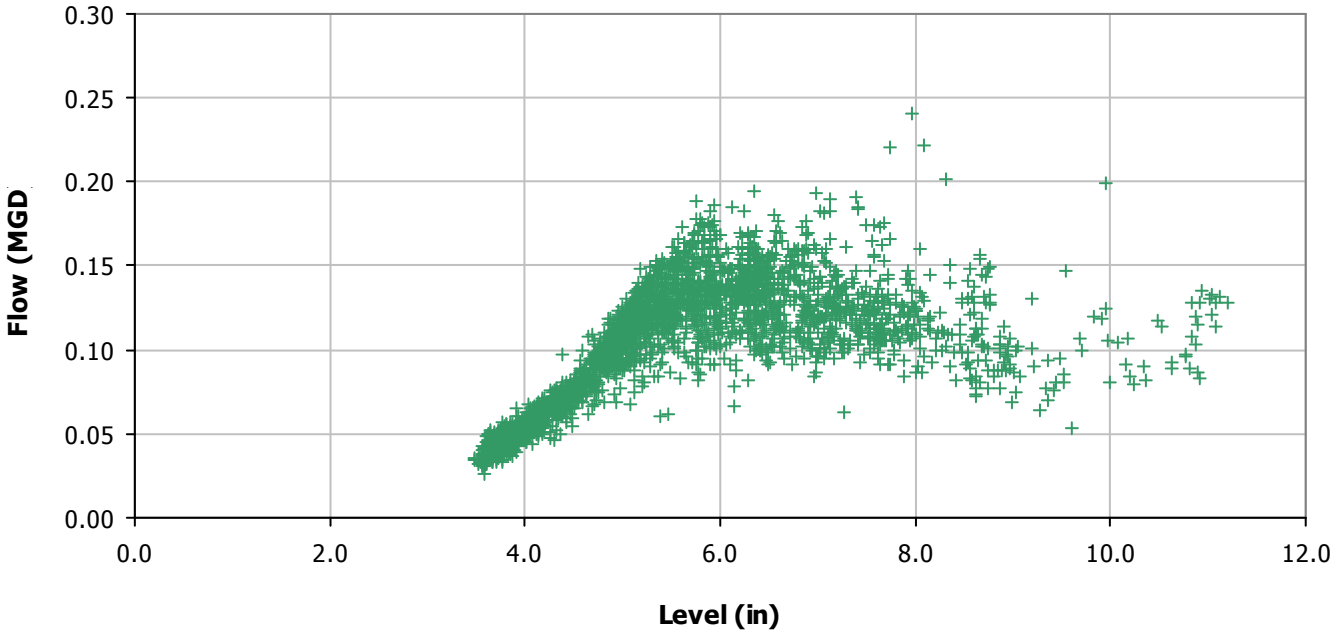
Peak measured flow shown on following pages in weekly flow data graphs

V&A

Scatter Plots (Flow, Velocity vs. Depth)

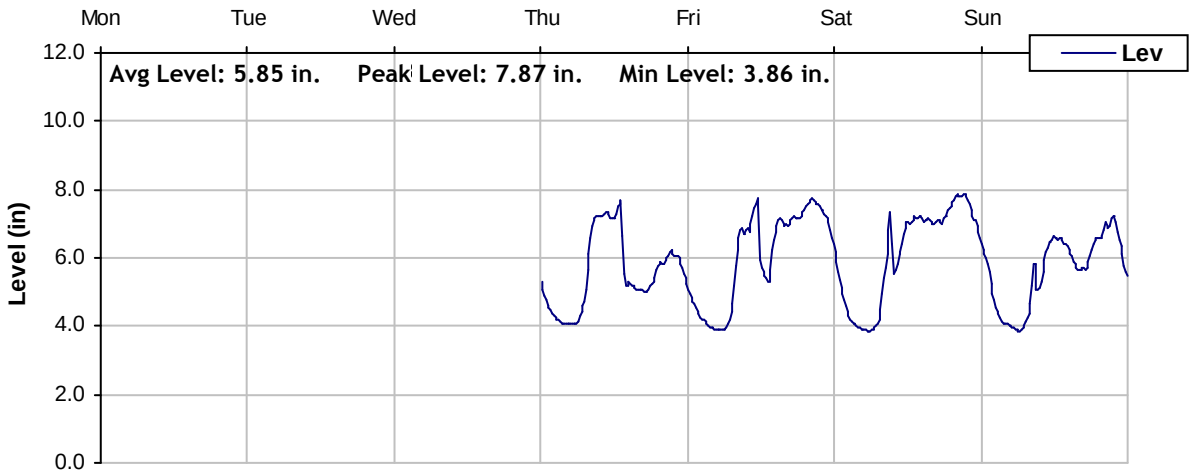
Monitoring Site: Site 2

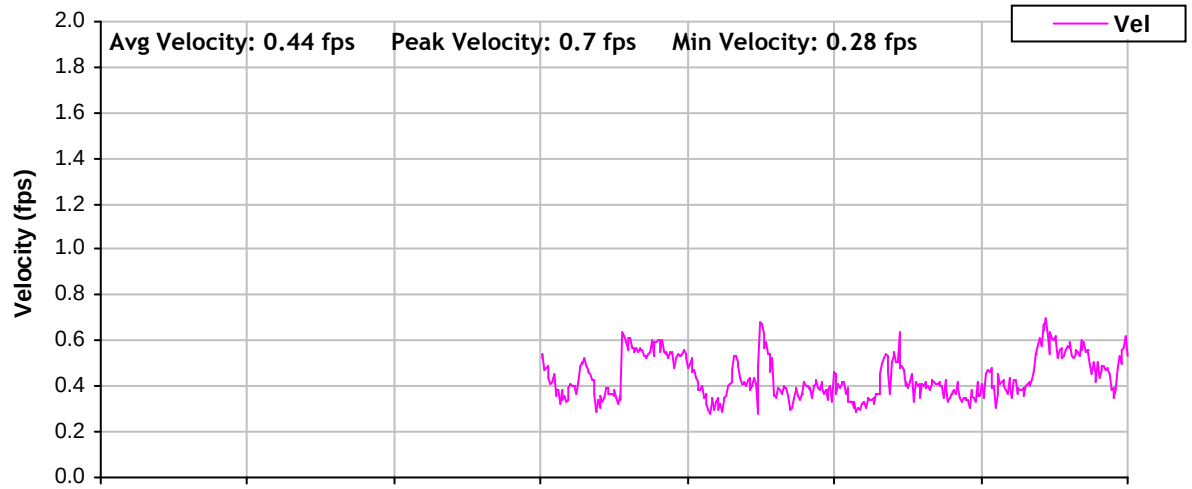


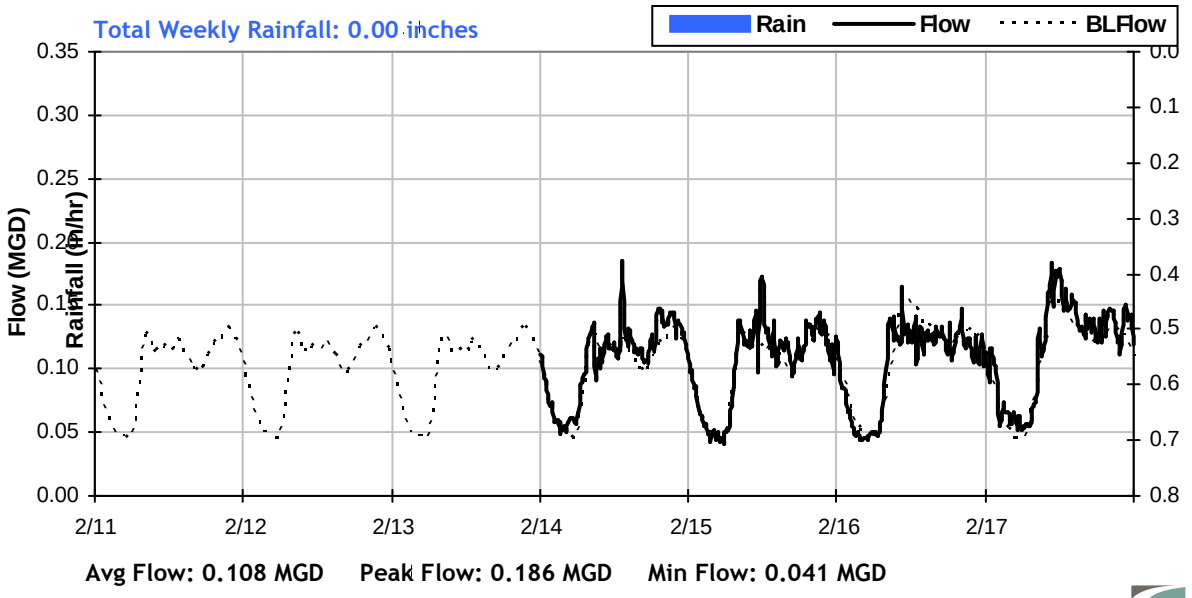


Level, Velocity and Flow
From 2/11/2008 to 2/18/2008

Monitoring Site:
Site 2



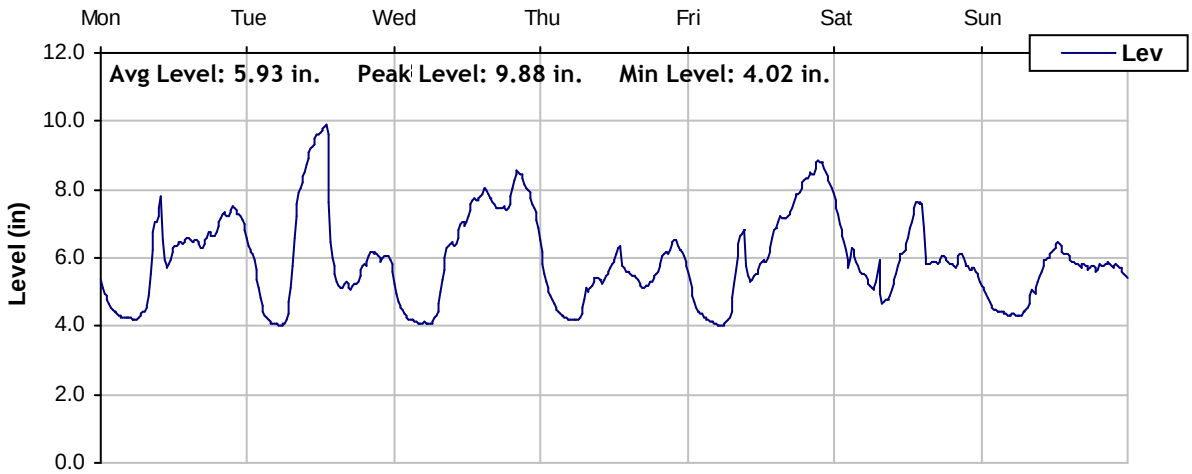


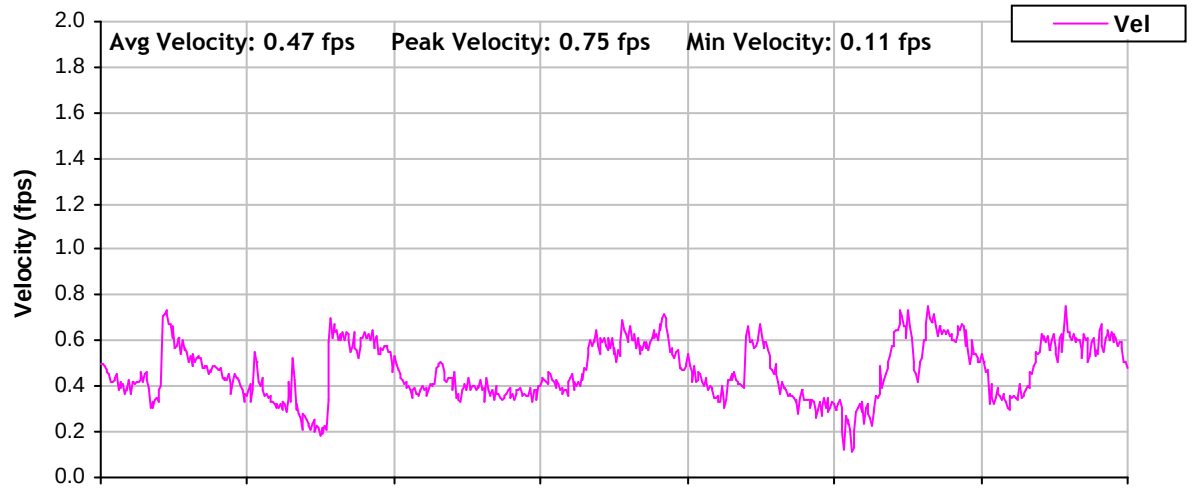


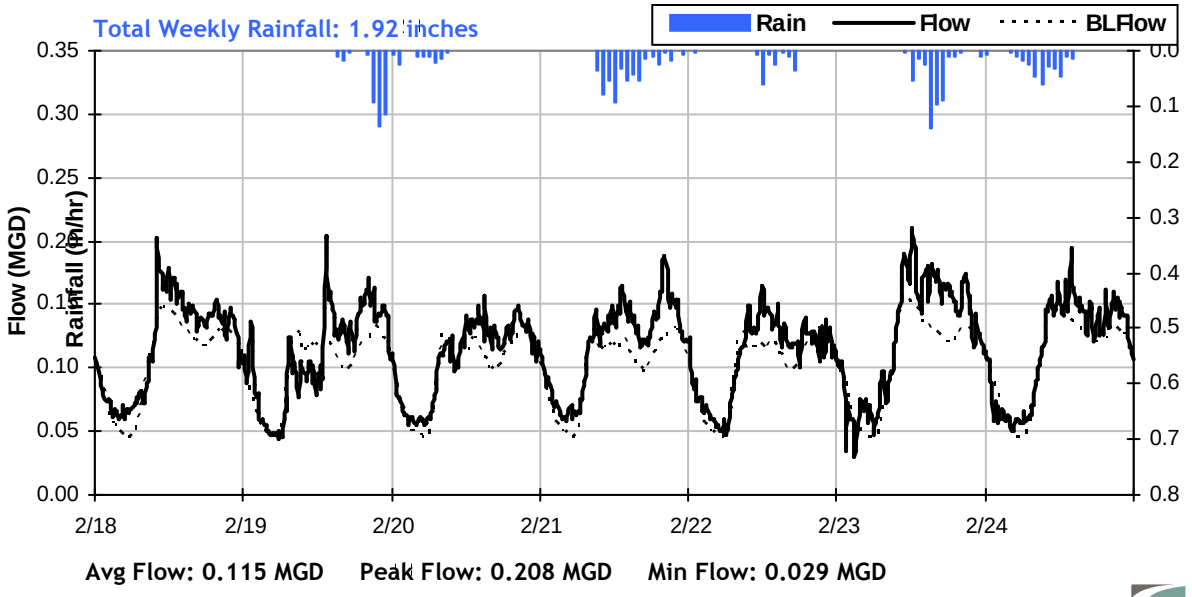
Avg Flow: 0.108 MGD Peak Flow: 0.186 MGD Min Flow: 0.041 MGD

Level, Velocity and Flow
From 2/18/2008 to 2/25/2008

Monitoring Site:
Site 2



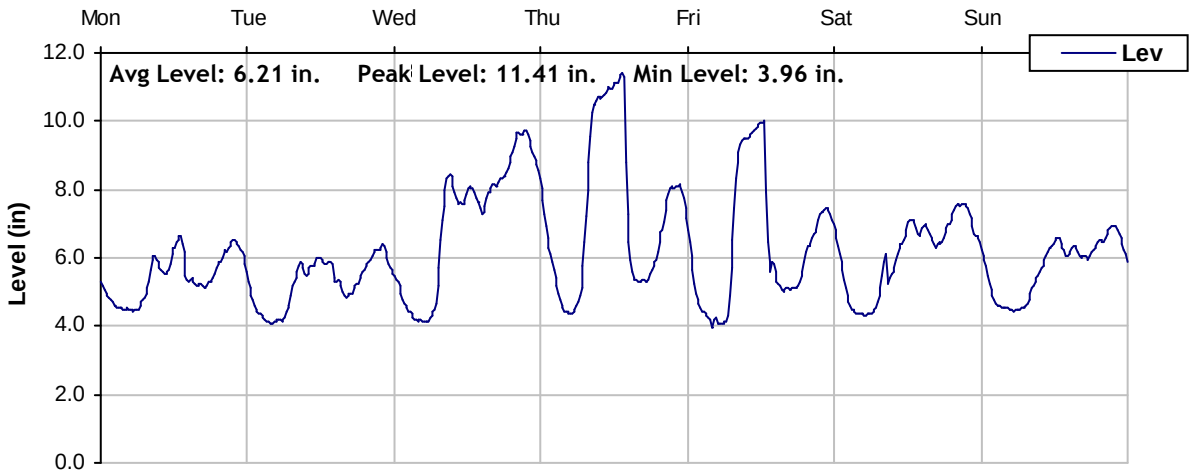


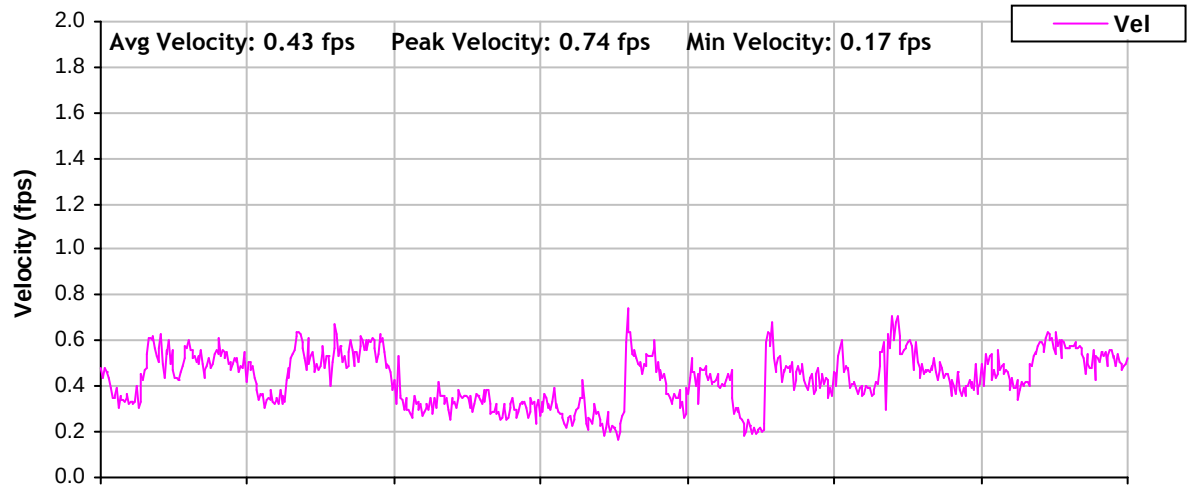


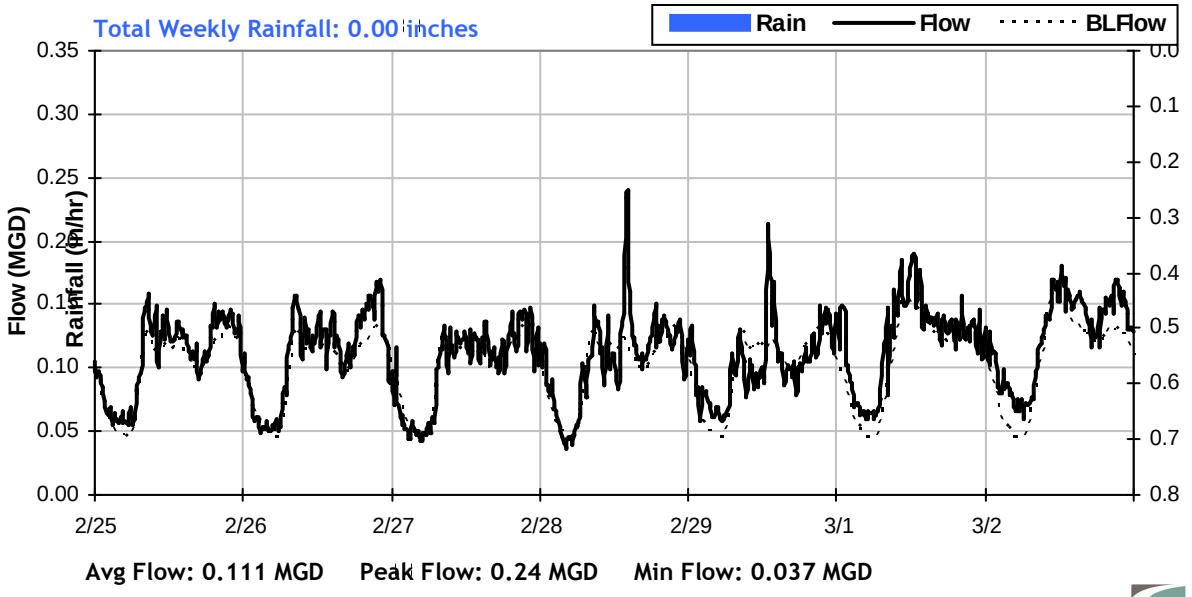
Avg Flow: 0.115 MGD Peak Flow: 0.208 MGD Min Flow: 0.029 MGD

Level, Velocity and Flow
From 2/25/2008 to 3/3/2008

Monitoring Site:
Site 2



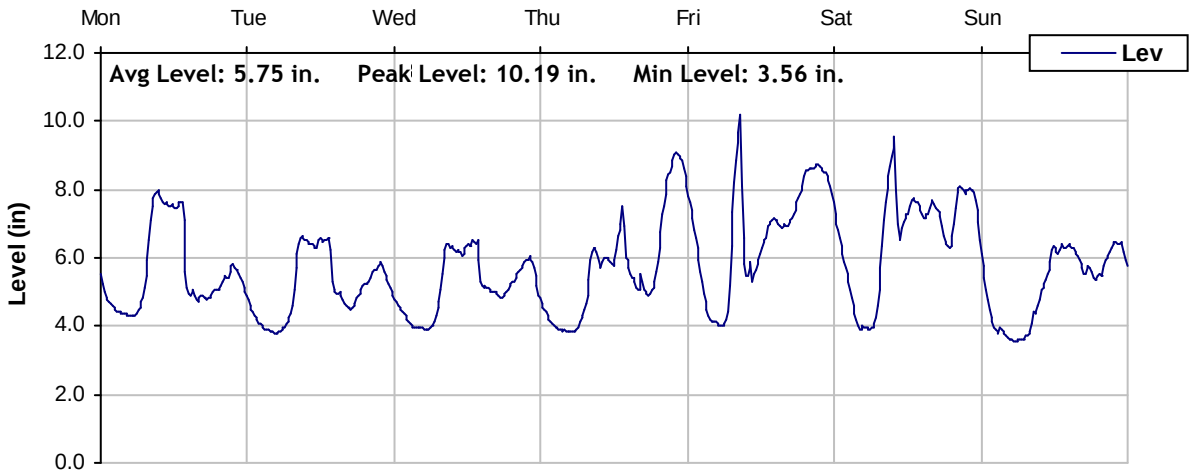


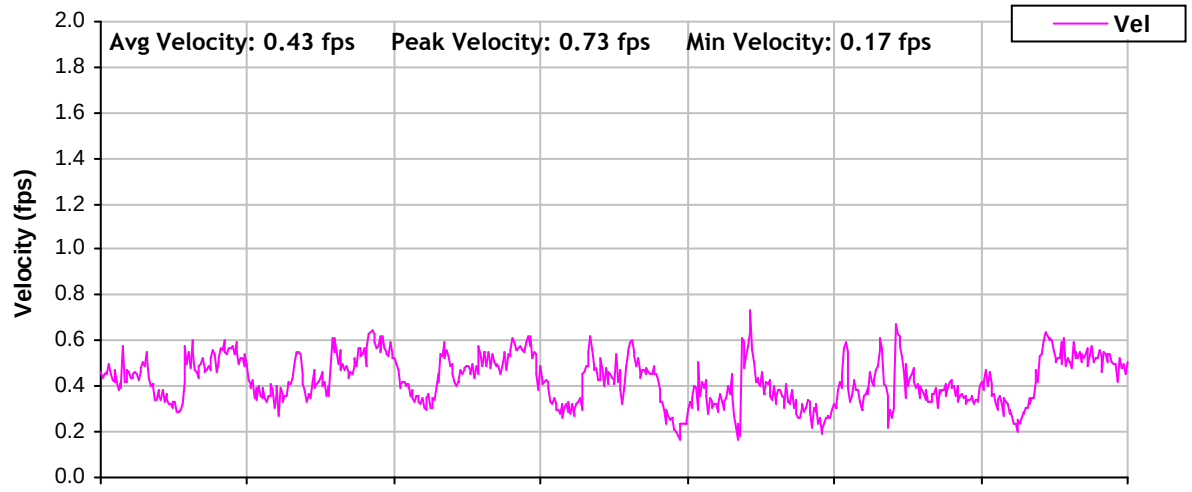


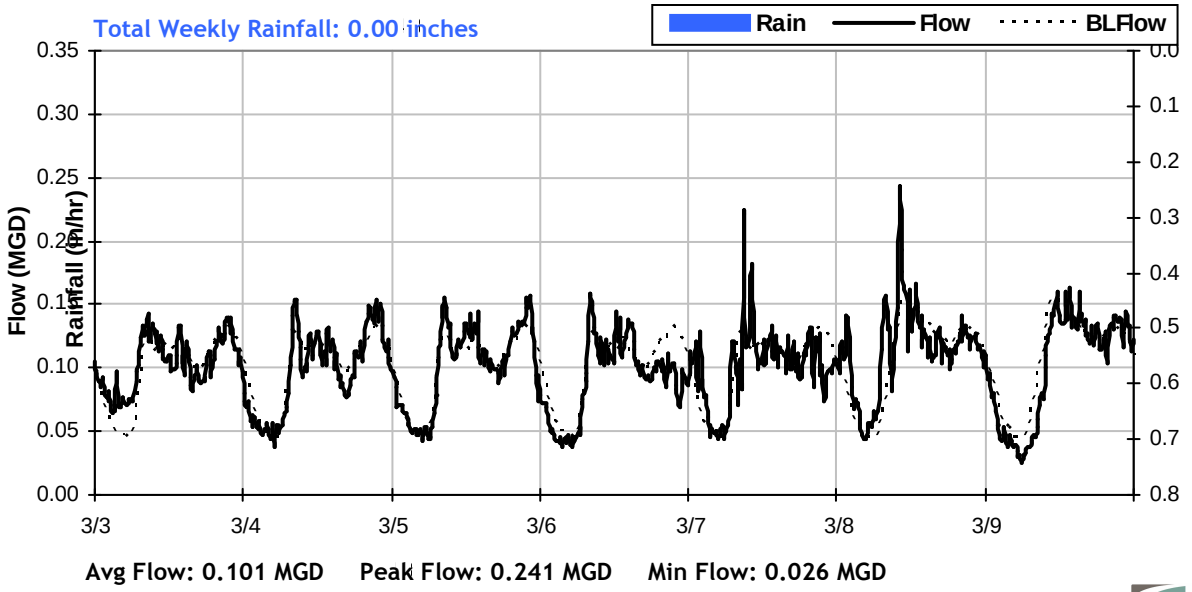
Avg Flow: 0.111 MGD Peak Flow: 0.24 MGD Min Flow: 0.037 MGD

Level, Velocity and Flow
From 3/3/2008 to 3/10/2008

Monitoring Site:
Site 2



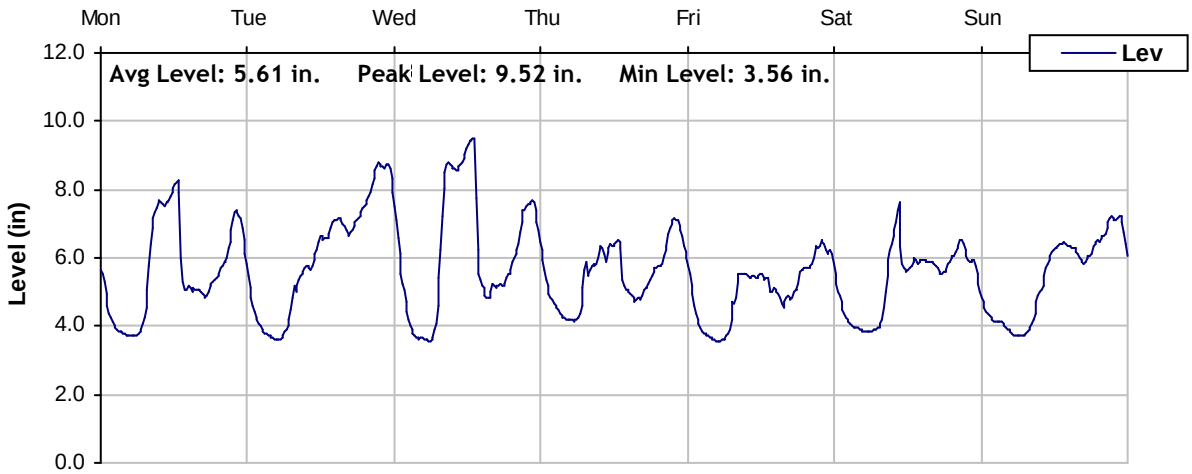


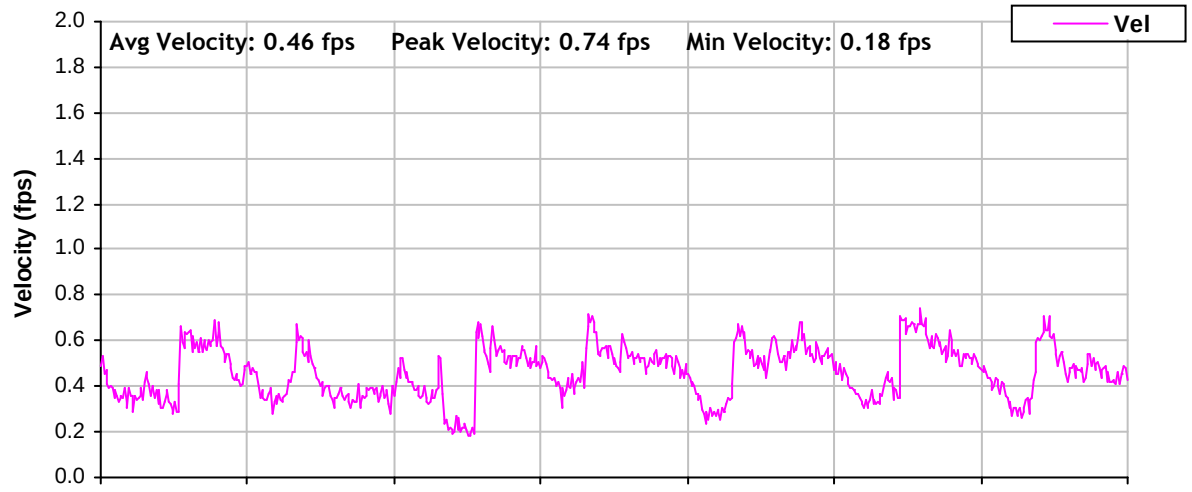


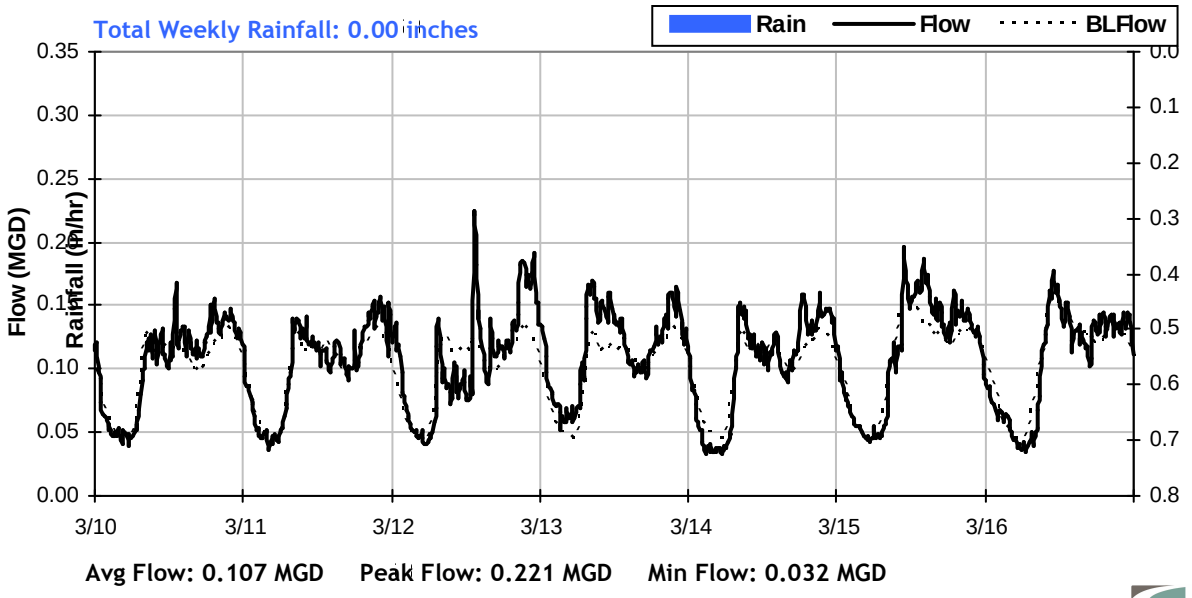
Avg Flow: 0.101 MGD Peak Flow: 0.241 MGD Min Flow: 0.026 MGD

Level, Velocity and Flow
From 3/10/2008 to 3/17/2008

Monitoring Site:
Site 2



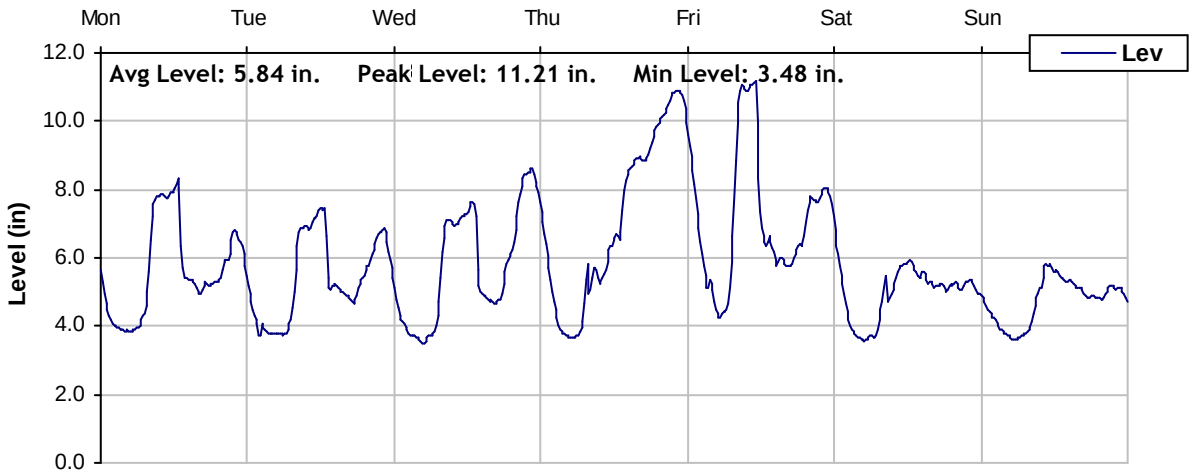


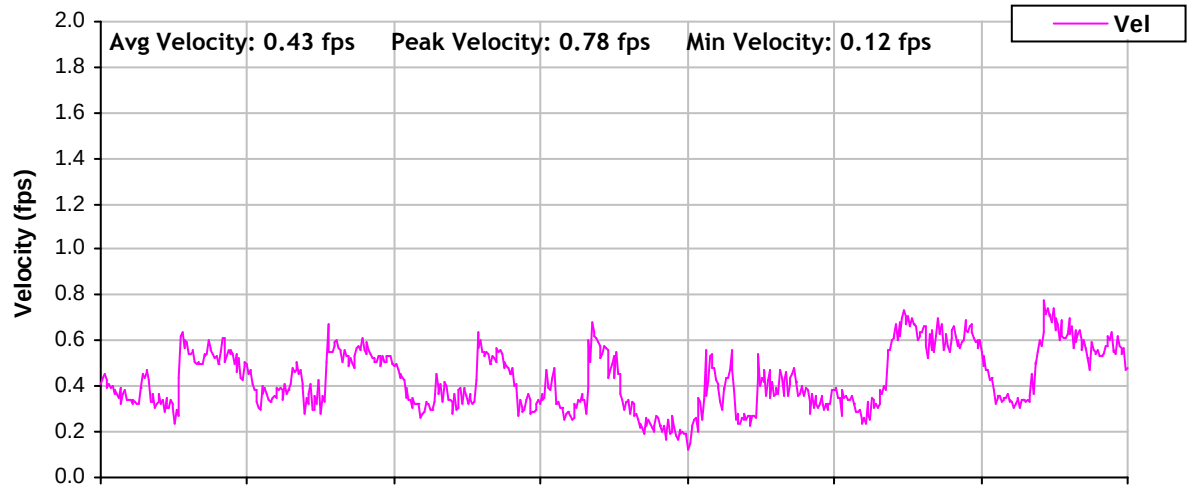


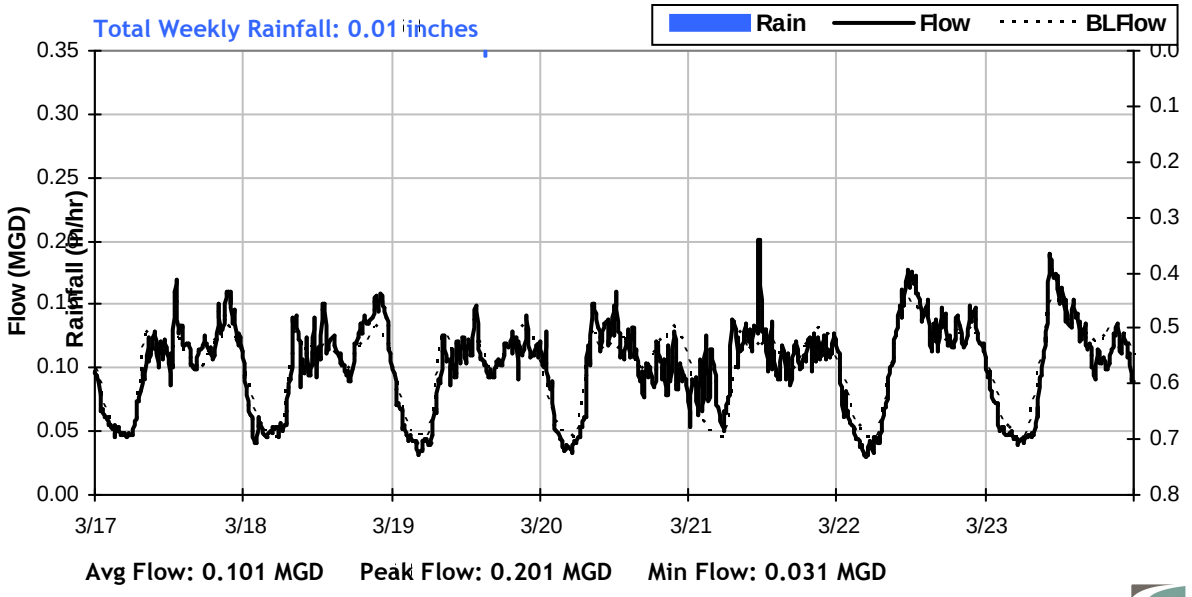
Avg Flow: 0.107 MGD Peak Flow: 0.221 MGD Min Flow: 0.032 MGD

Level, Velocity and Flow
From 3/17/2008 to 3/24/2008

Monitoring Site:
Site 2



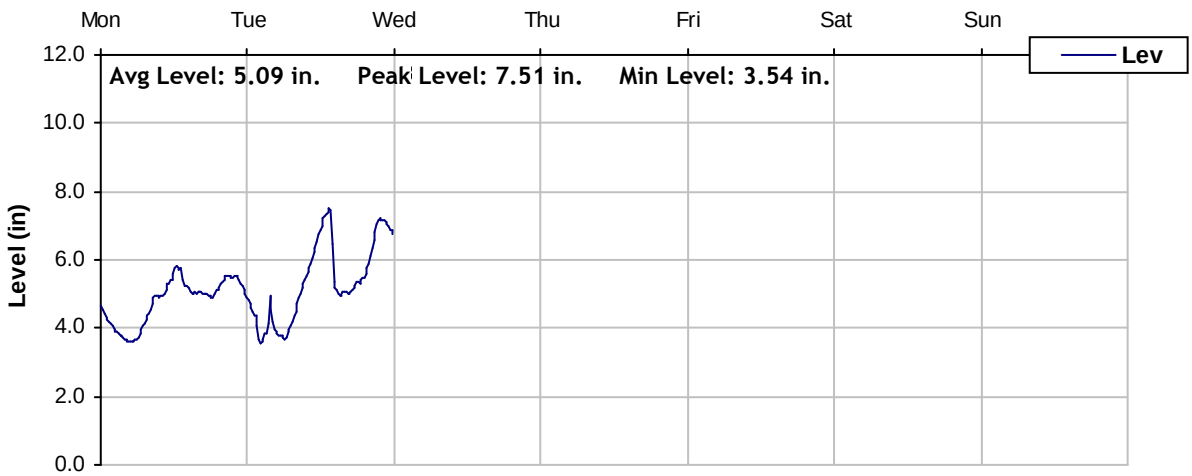


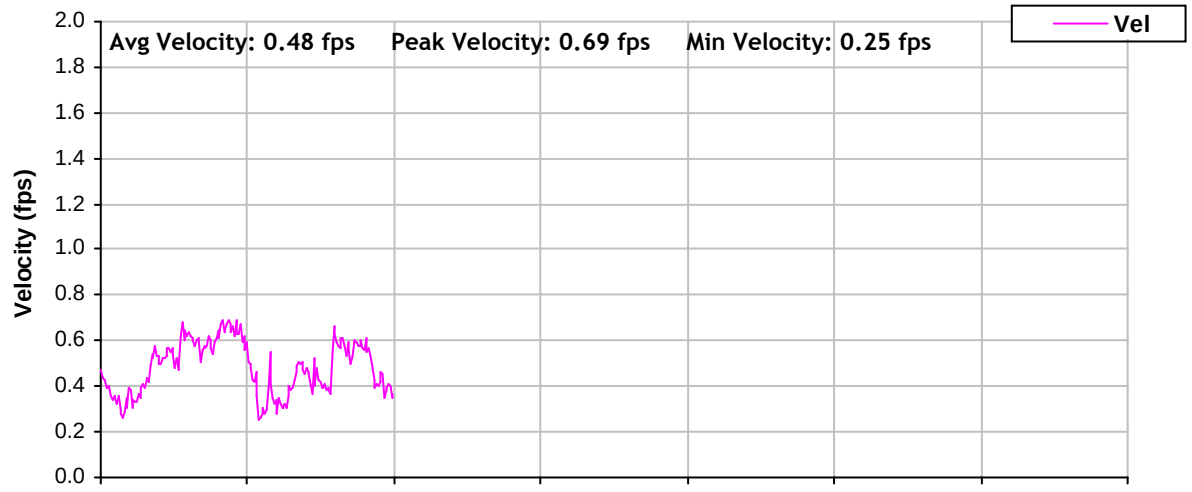


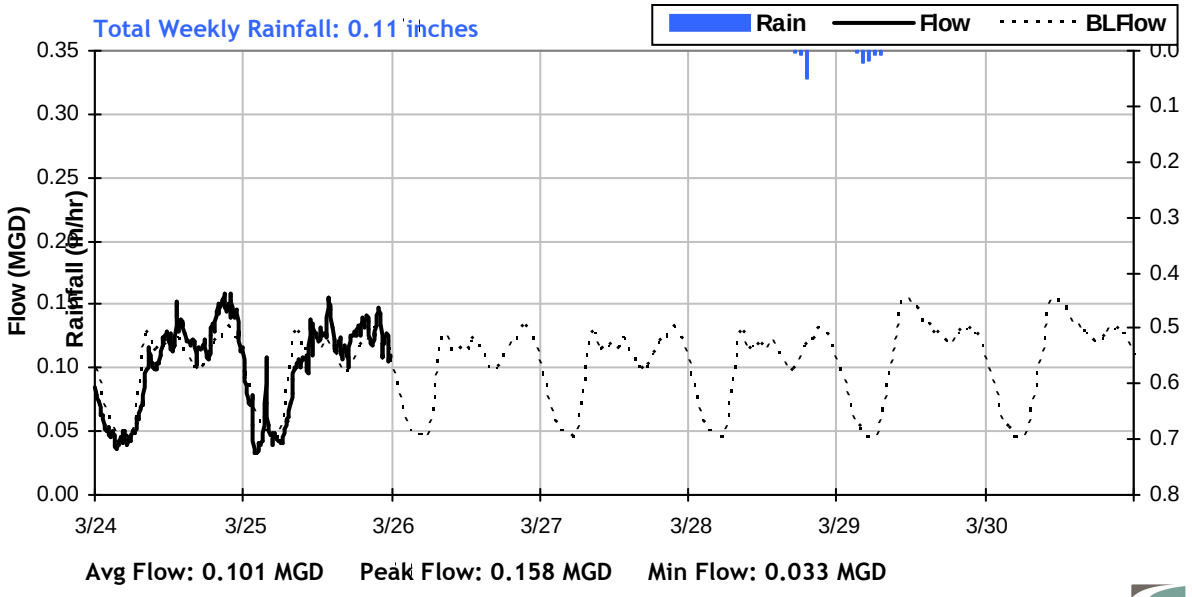
Avg Flow: 0.101 MGD Peak Flow: 0.201 MGD Min Flow: 0.031 MGD

Level, Velocity and Flow
From 3/24/2008 to 3/31/2008

Monitoring Site:
Site 2







Avg Flow: 0.101 MGD Peak Flow: 0.158 MGD Min Flow: 0.033 MGD

Temporary Flow Monitoring Study

Sanitary Sewer Collection System

Monitoring Site: Site 3

Manhole Address: 9th Street at Harris Street

Size/Type of Line: 12-inch Sanitary Sewer Pipe

Data Summary Report

Site Information Report

Monitoring Site: Site 3

Location: 9th Street at Harris Street

Diameter: 12 inches

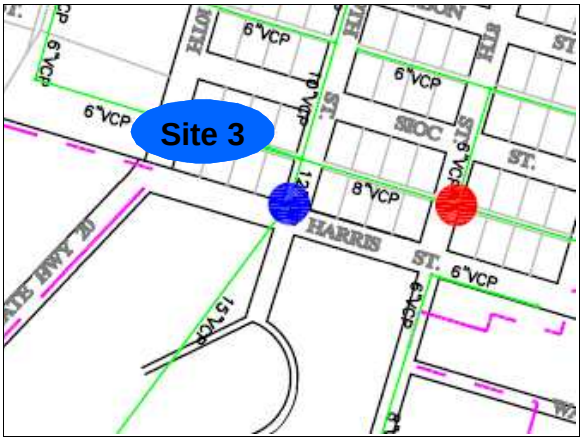
Average Dry Weather Flow: 0.199 *MGD*

Peak Measured Flow: 0.379 *MGD*

Street-level photo:

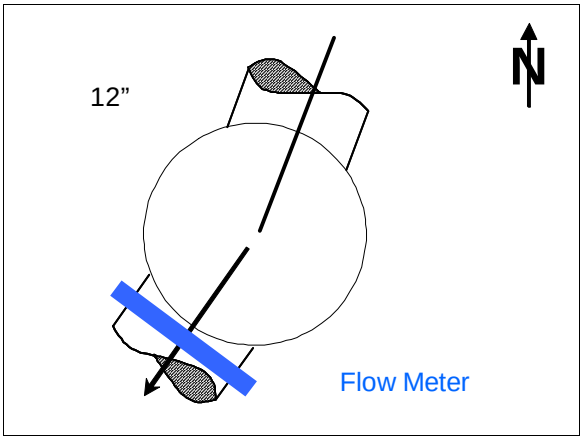
Street map:

Sanitary sewer map:



Plan view photo:

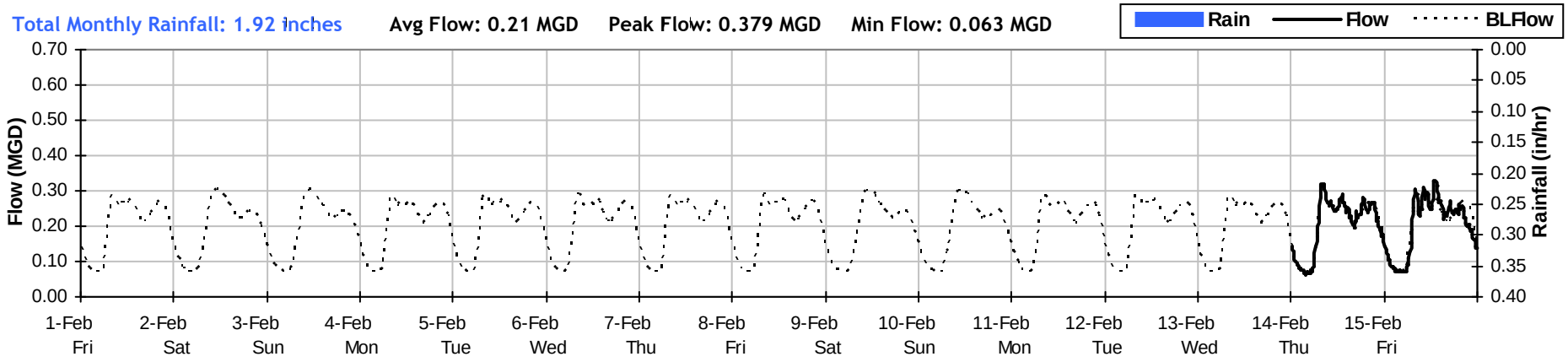
Flow sketch:

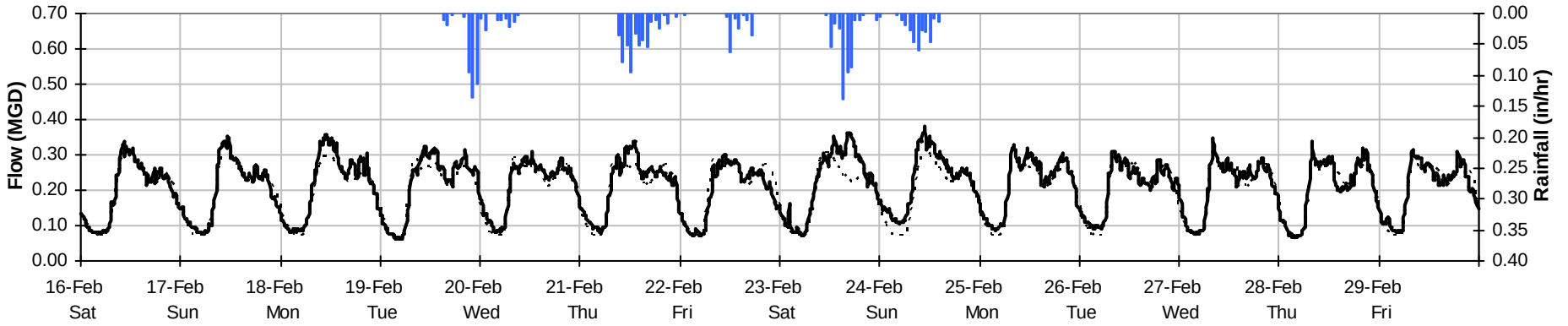


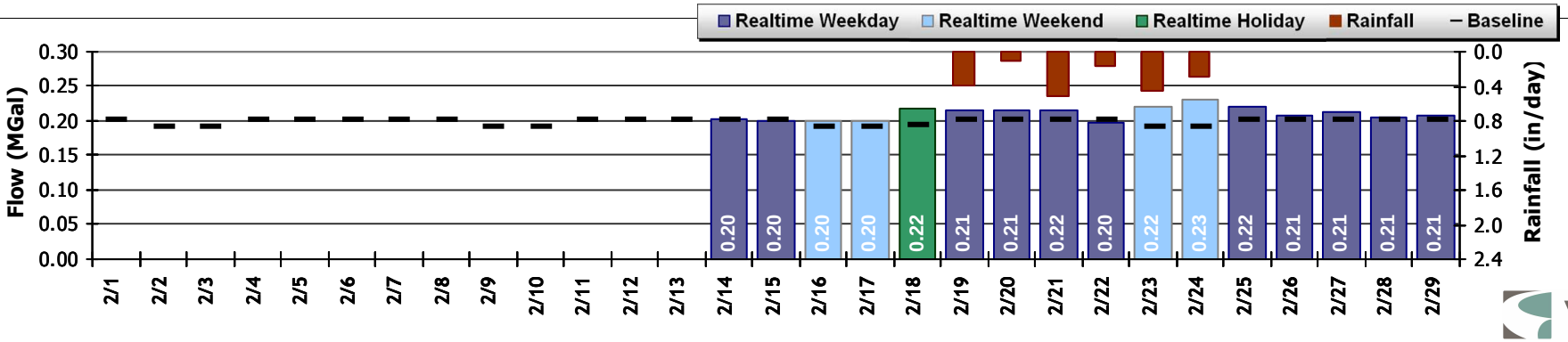
Monthly Flow Summary
February, 2008

Monitoring Site:
Site 3

Total Monthly Rainfall: 1.92 inches Avg Flow: 0.21 MGD Peak Flow: 0.379 MGD Min Flow: 0.063 MGD





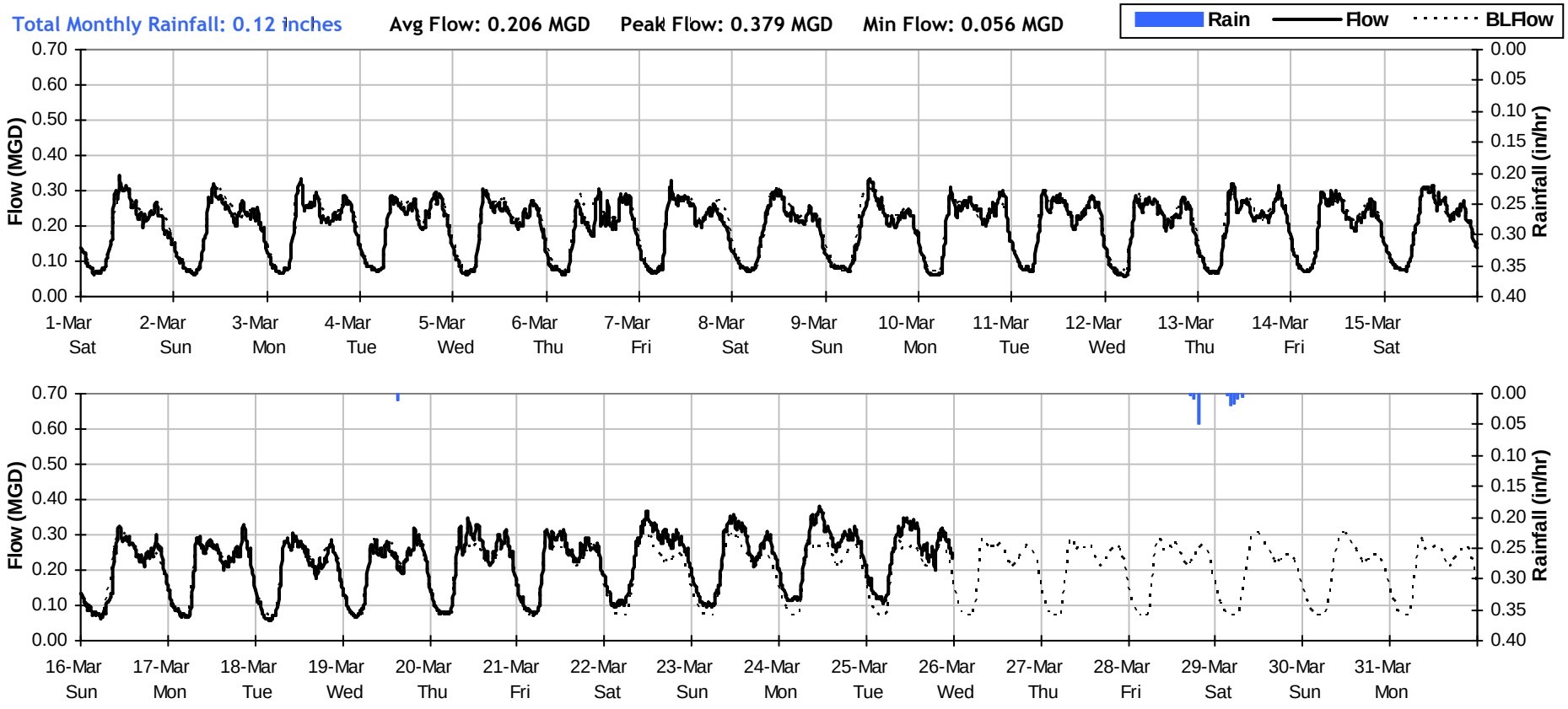


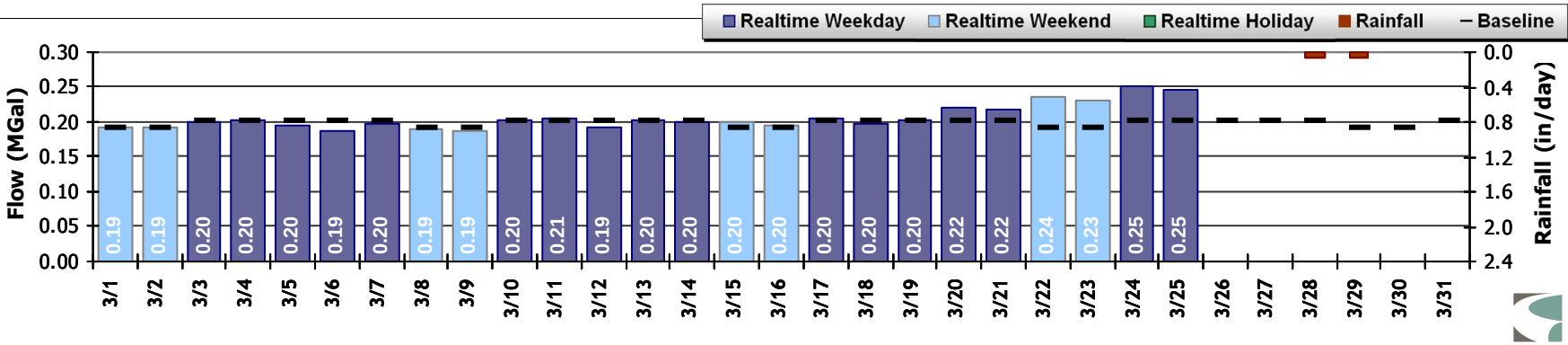
V&A

Monthly Flow Summary
March, 2008

Monitoring Site:
Site 3

Total Monthly Rainfall: 0.12 inches Avg Flow: 0.206 MGD Peak Flow: 0.379 MGD Min Flow: 0.056 MGD



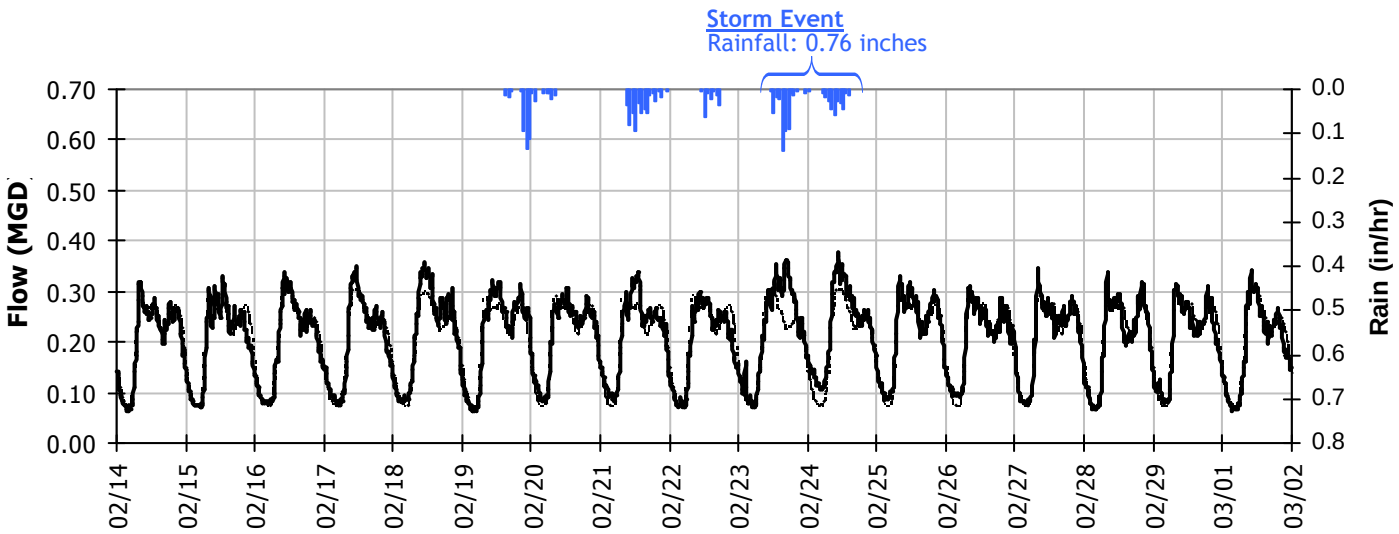


V&A

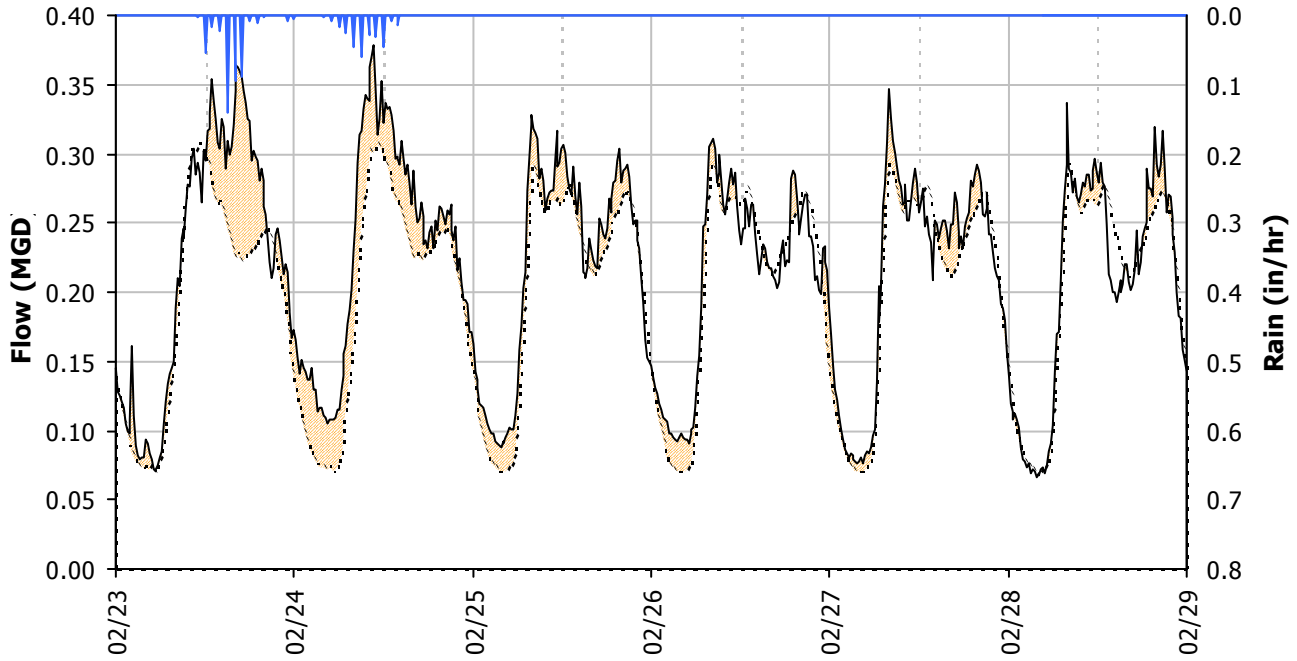
I/I Summary

Monitoring Site:
Site 3

Baseline, Realtime, and I/I Flows over Monitoring Period:



Storm Event #1 Detail I/I Graph

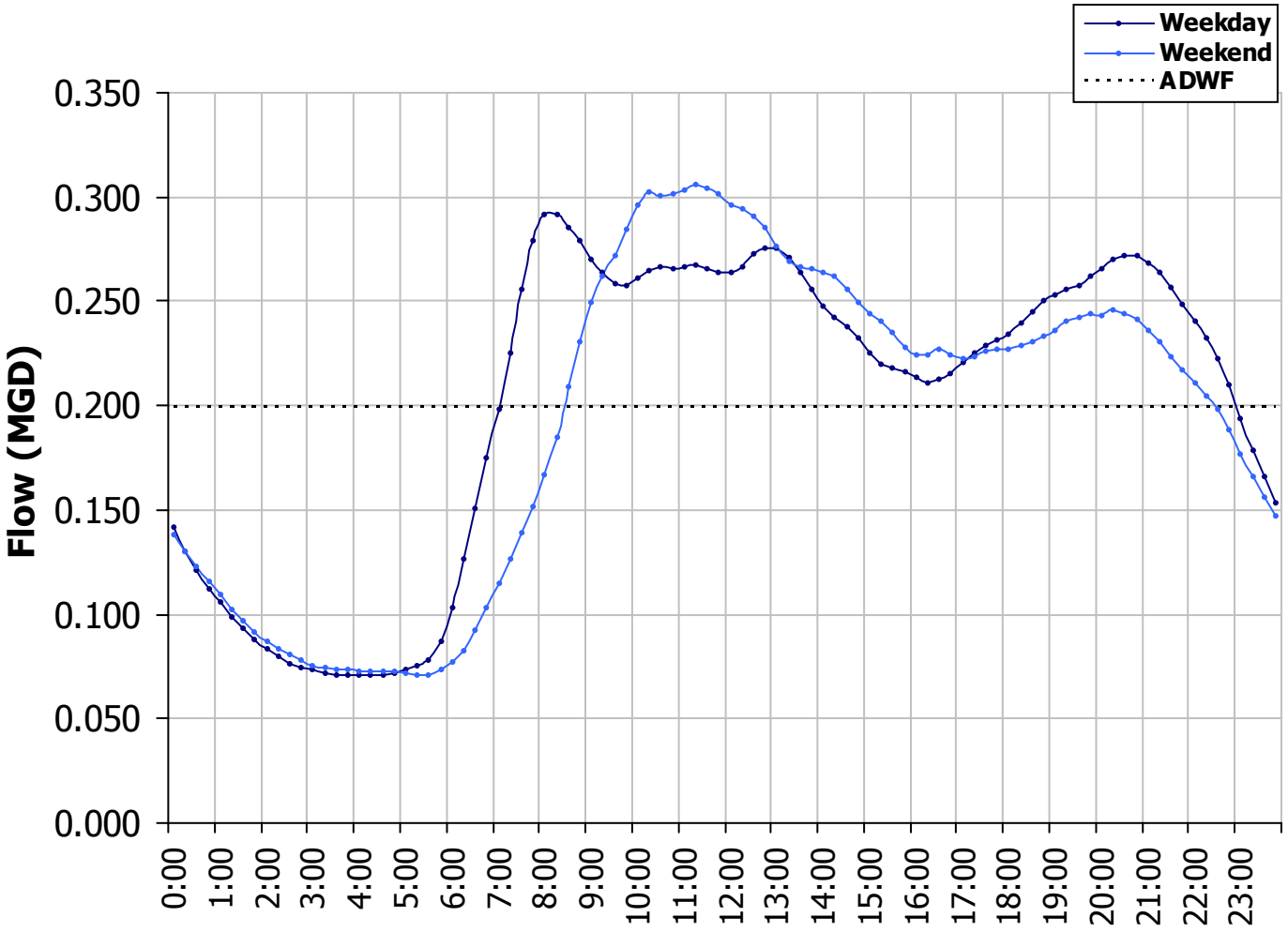


Storm Event #1 I/I Analysis

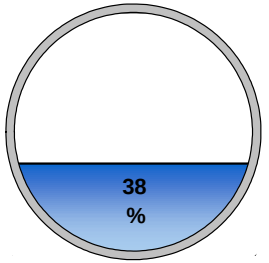
Rainfall:	0.76	*inches*		
Peak Flow:	0.379	*MGD*	**PF:**	1.90
Peak I/I Rate:	0.139	*MGD*	**Pk I/I:ADWF:**	0.70
Peak Level:	5.79	*inches*	**d/D Ratio:**	0.48
Total I/I:	97,000	*gallons*	**R-Value:**	1.7%
			I/I per ADWF:	0.65

Average Dry Weather Flow

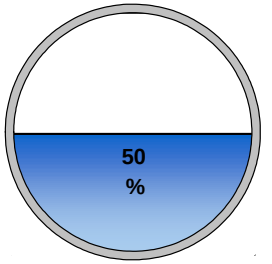
Monitoring Site:
Site 3



Average Dry Weather Flow:
0.199 *MGD*



Peak Measured Flow:
0.379 *MGD*

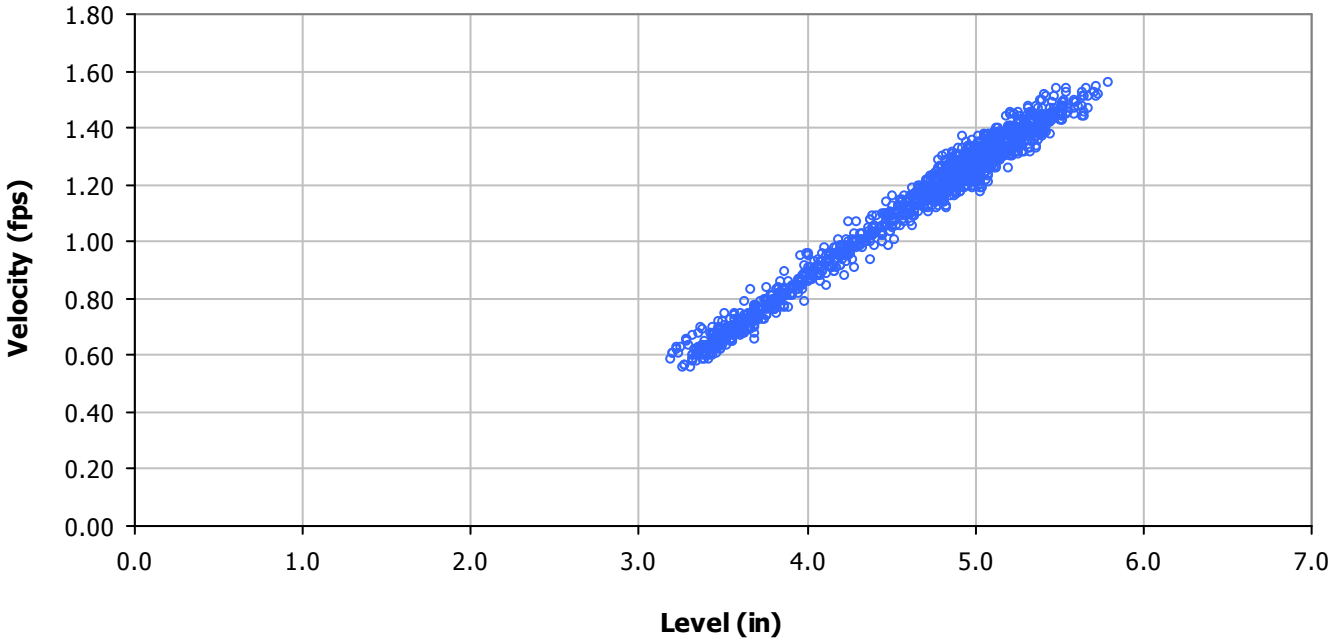


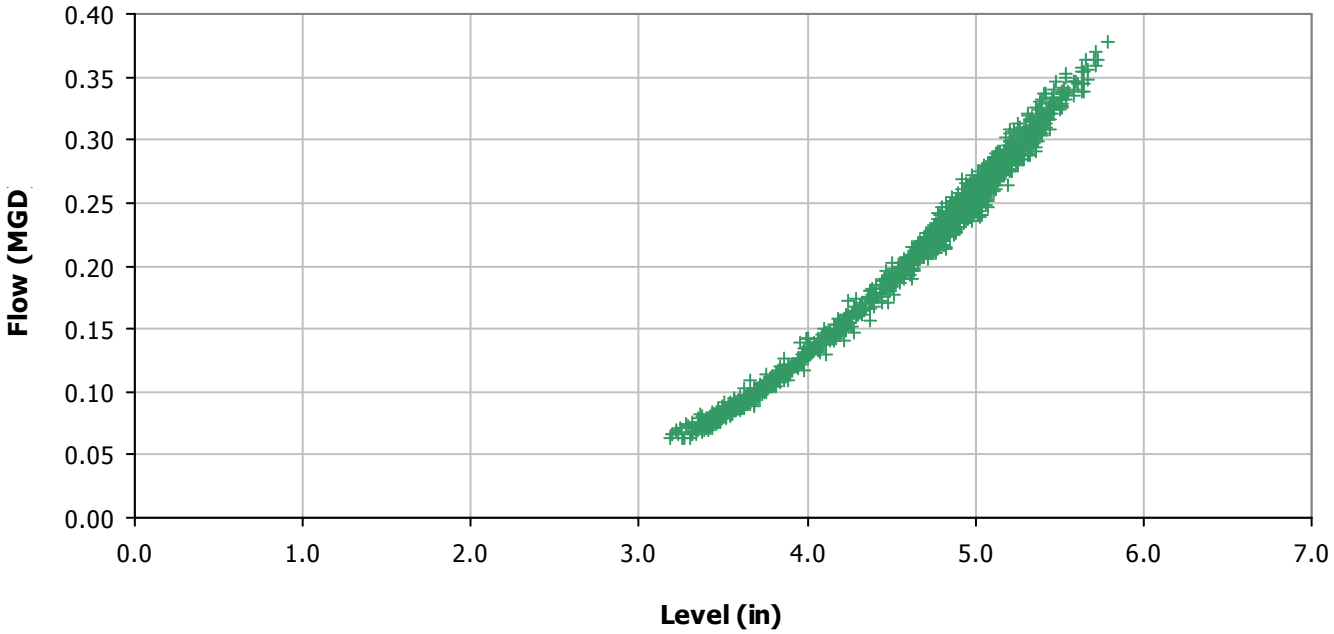
Peak measured flow shown on following pages in weekly flow data graphs

V&A

Scatter Plots
(Flow, Velocity vs. Depth)

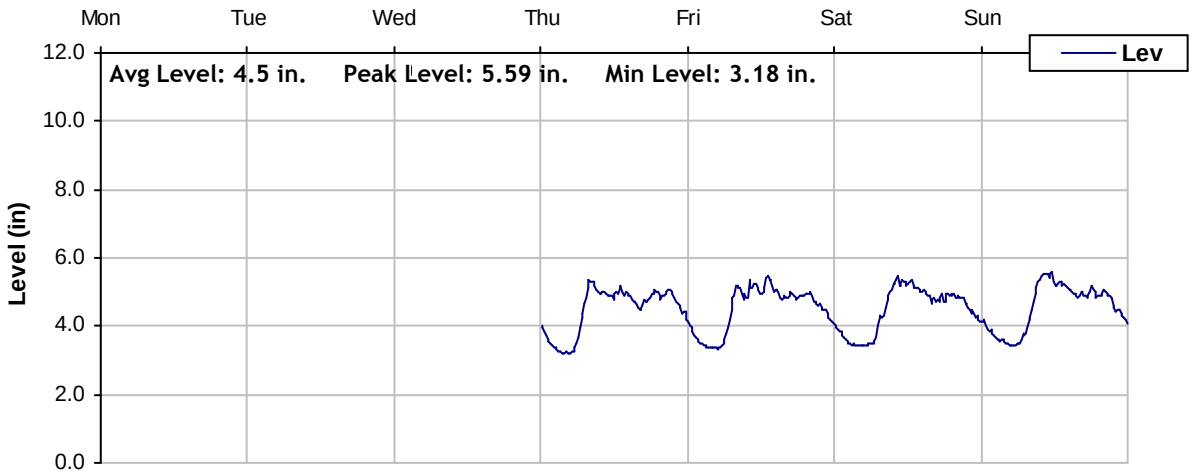
Monitoring Site:
Site 3

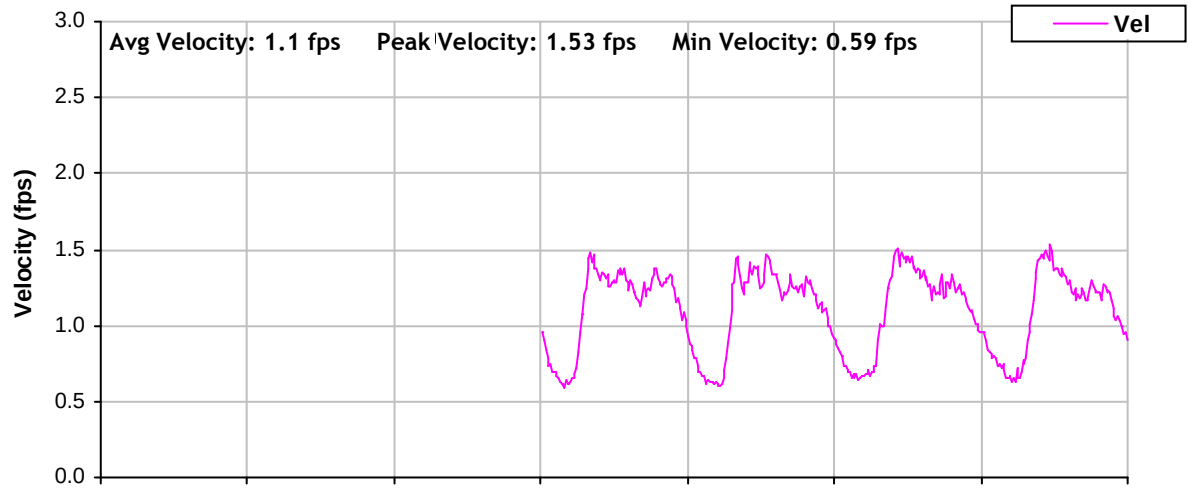


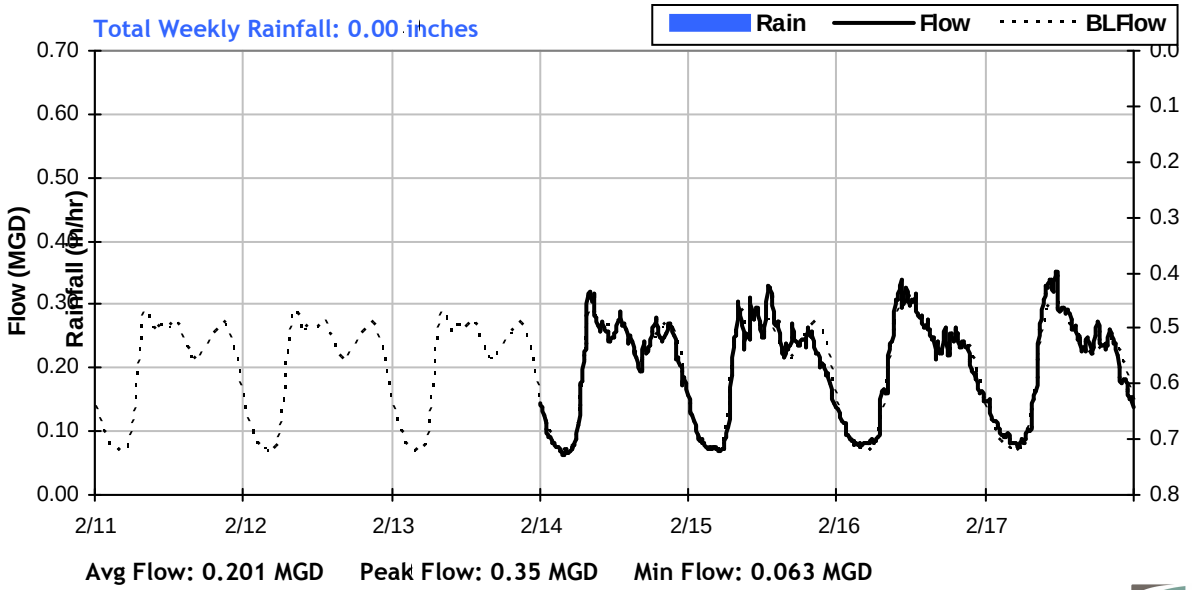


Level, Velocity and Flow
From 2/11/2008 to 2/18/2008

Monitoring Site:
Site 3



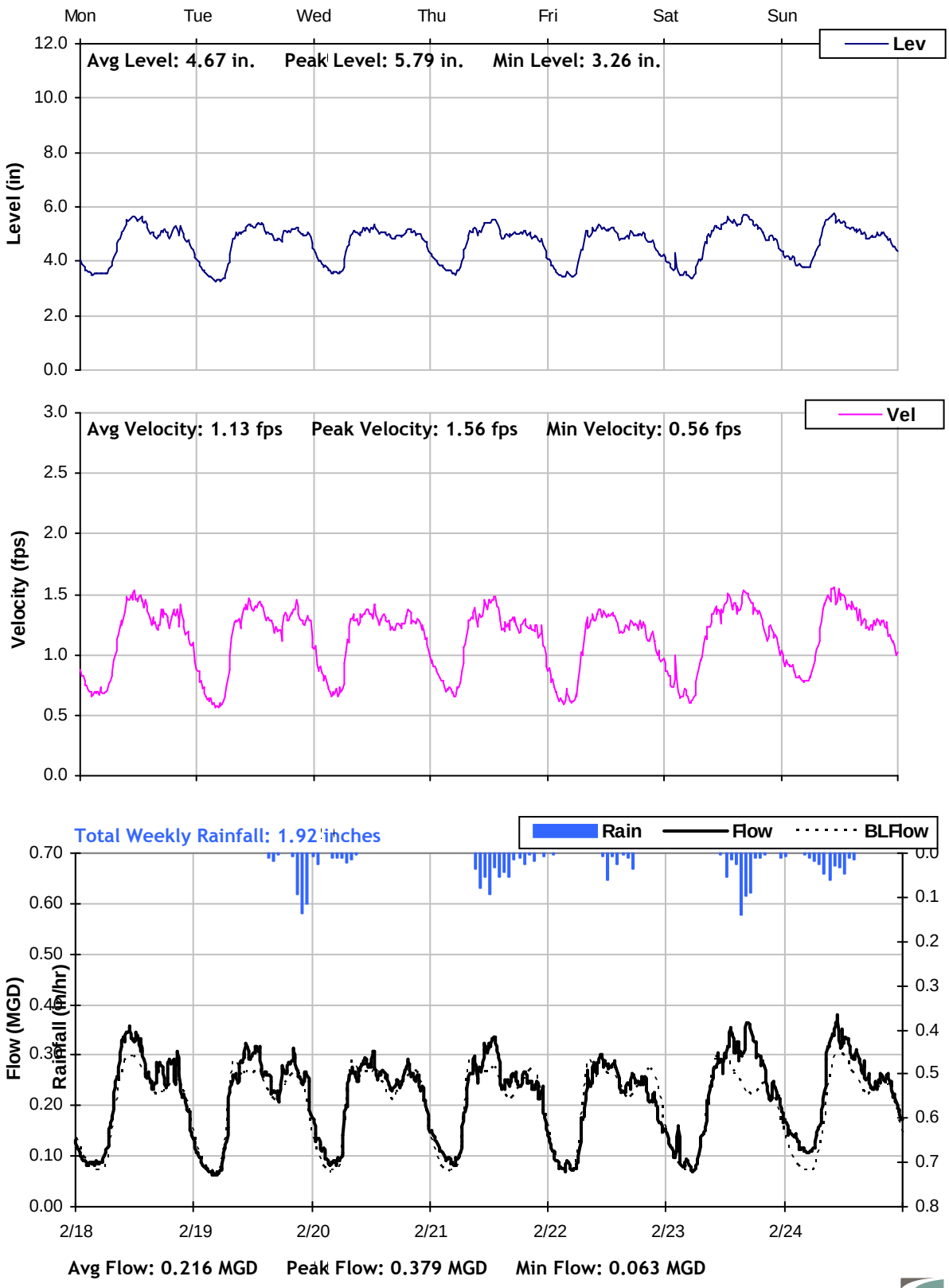




Avg Flow: 0.201 MGD Peak Flow: 0.35 MGD Min Flow: 0.063 MGD

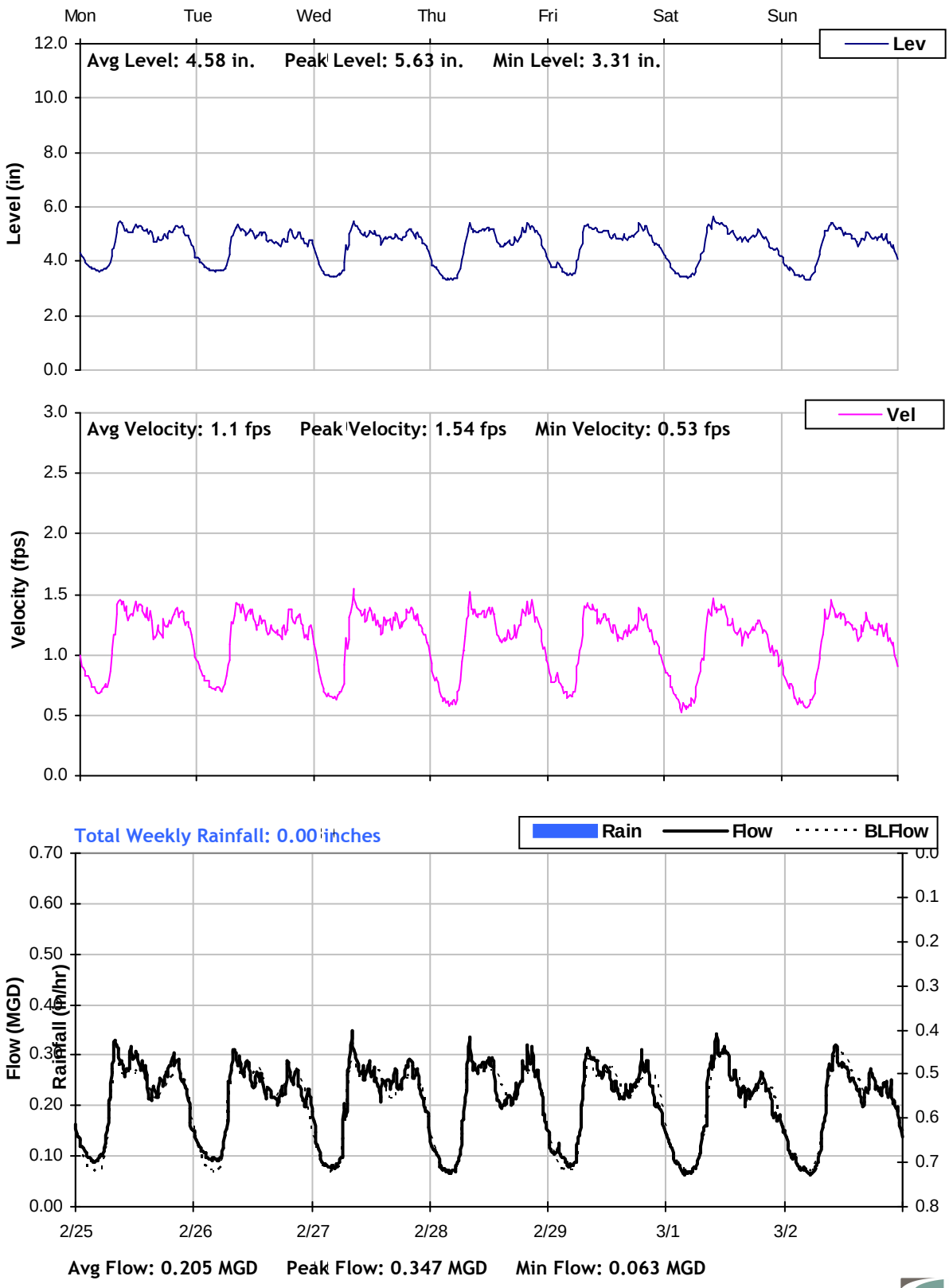
Level, Velocity and Flow
From 2/18/2008 to 2/25/2008

Monitoring Site:
Site 3



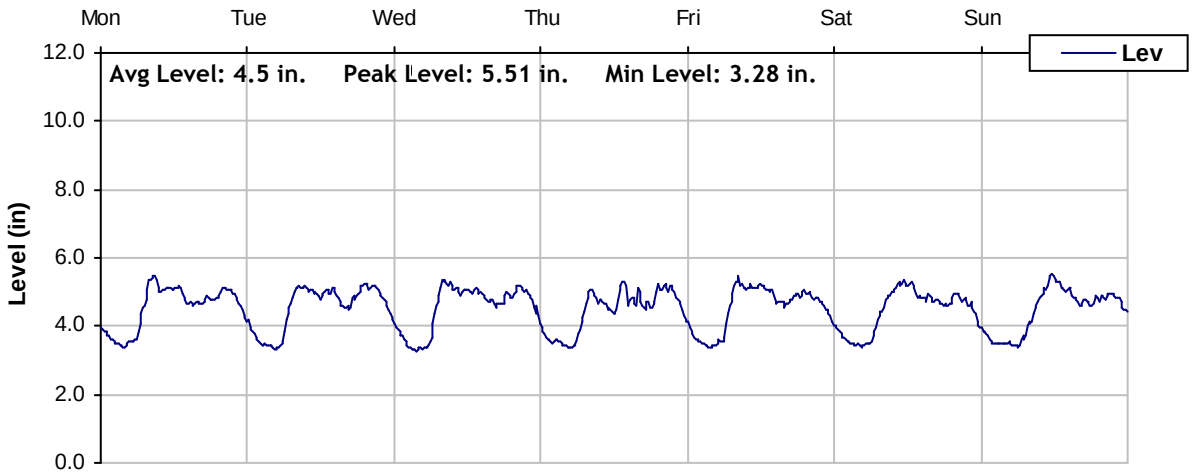
Level, Velocity and Flow
From 2/25/2008 to 3/3/2008

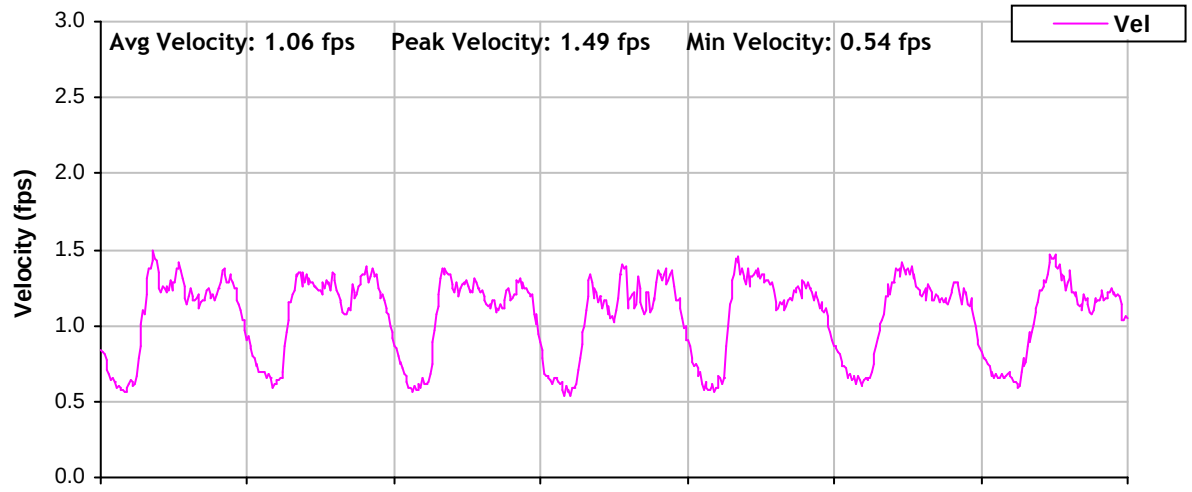
Monitoring Site:
Site 3

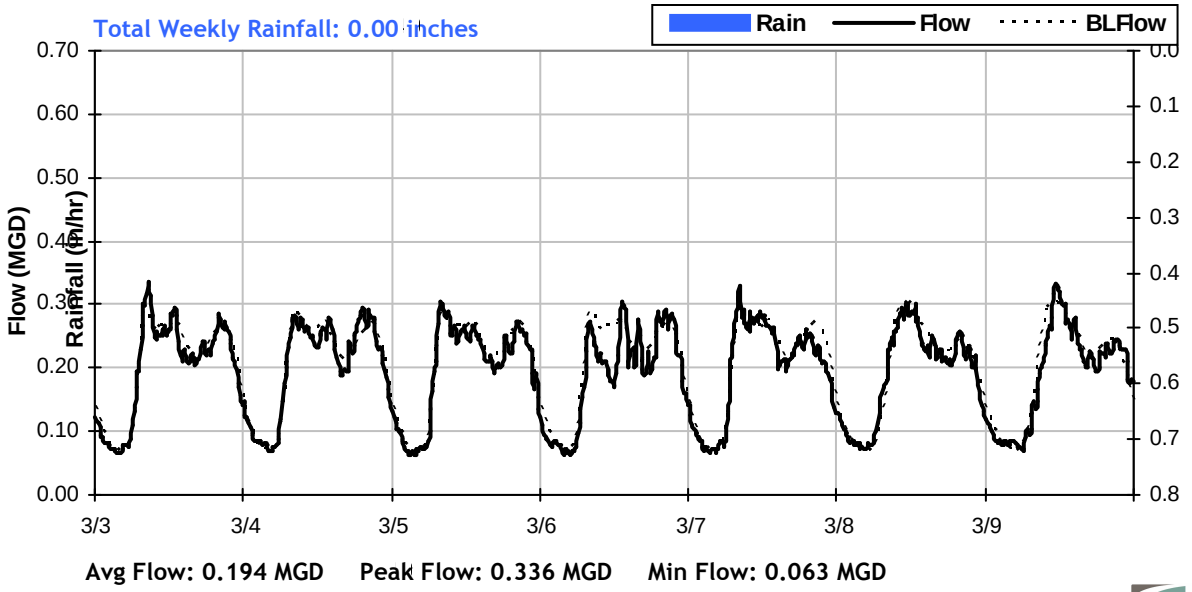


Level, Velocity and Flow
From 3/3/2008 to 3/10/2008

Monitoring Site:
Site 3







Level, Velocity and Flow
From 3/10/2008 to 3/17/2008

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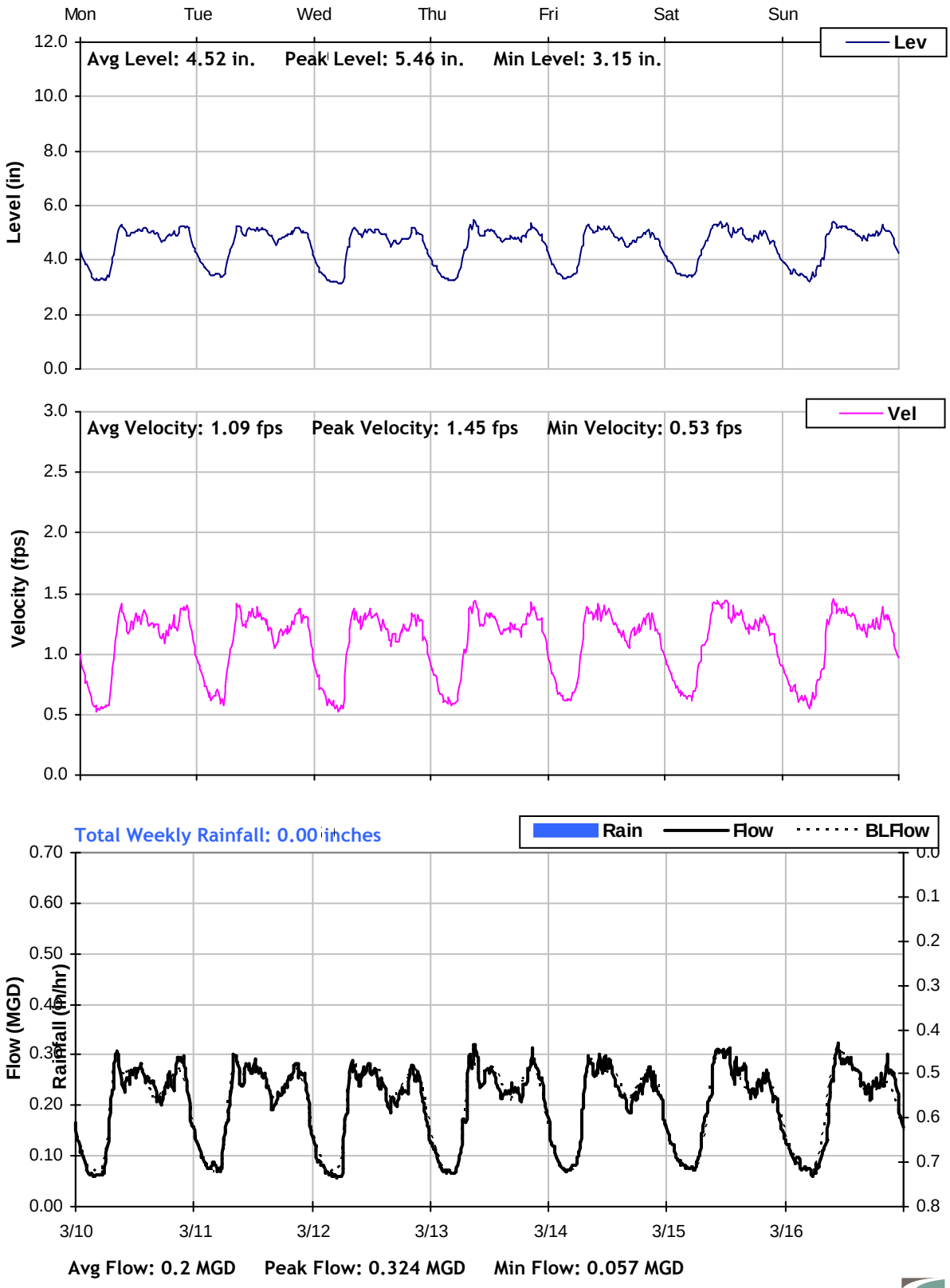
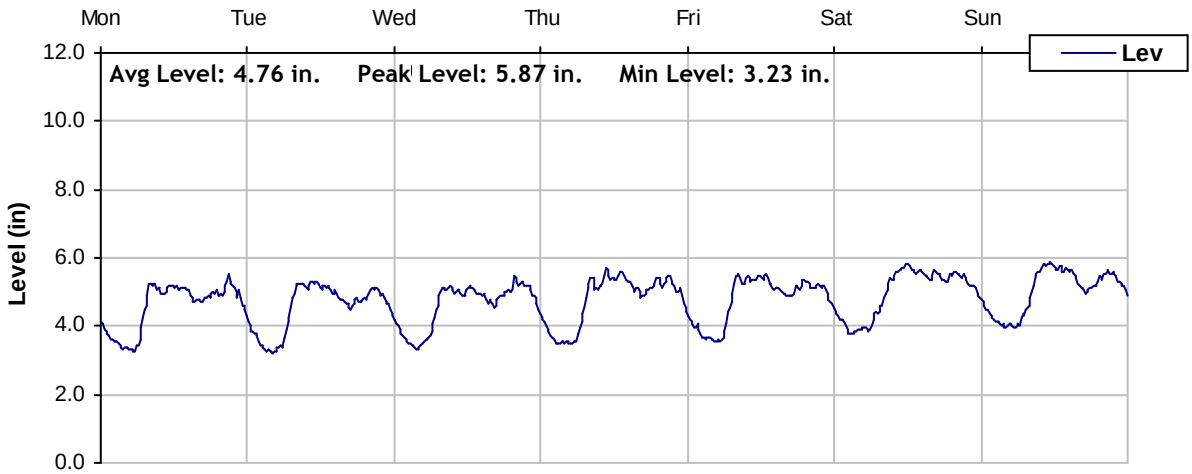
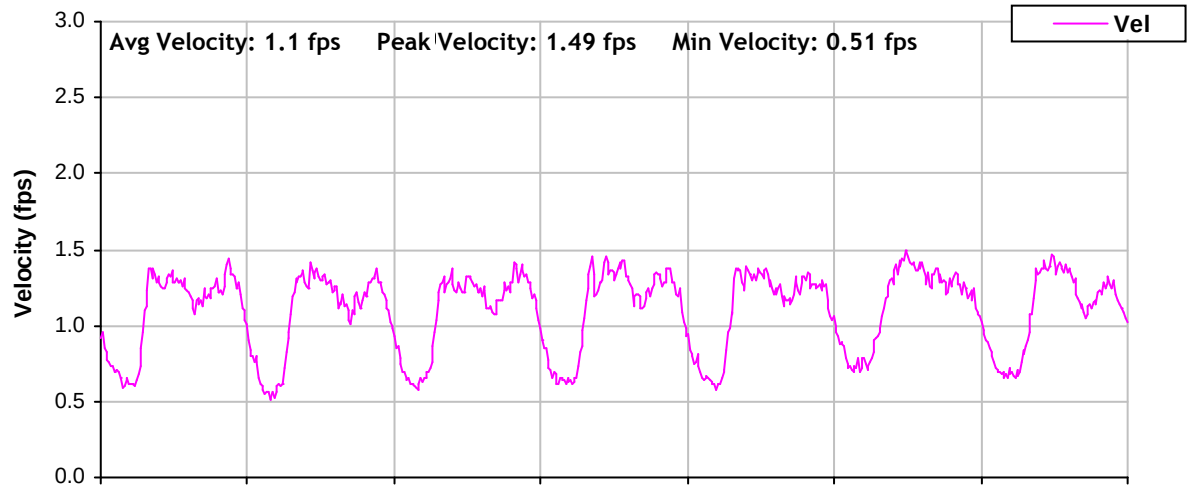
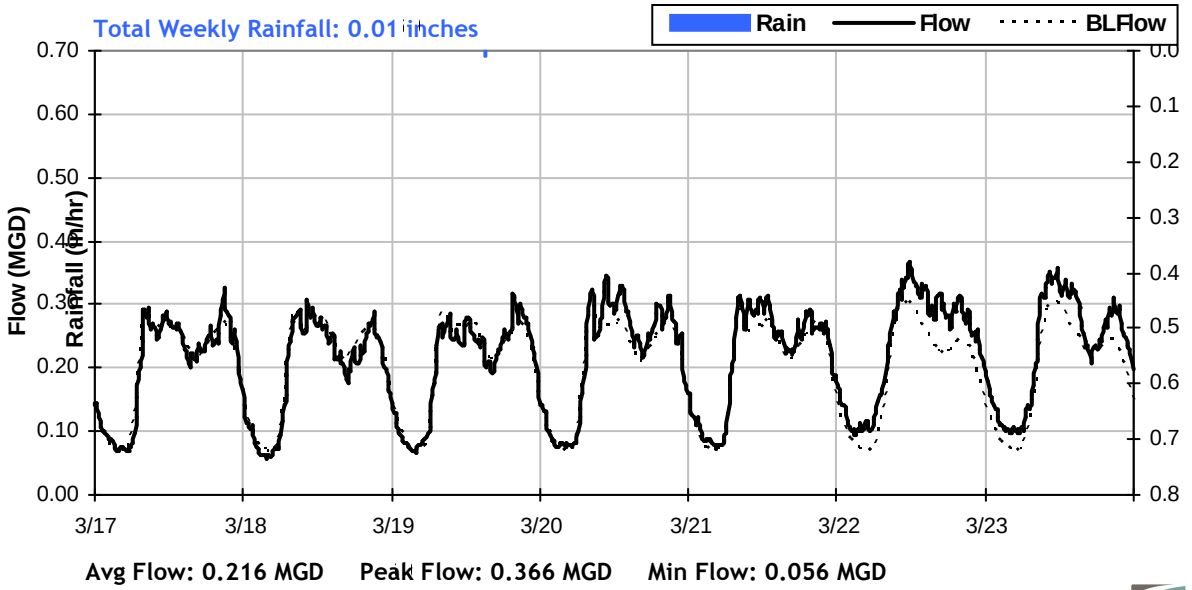


Level, Velocity and Flow
From 3/17/2008 to 3/24/2008

Monitoring Site:
Site 3

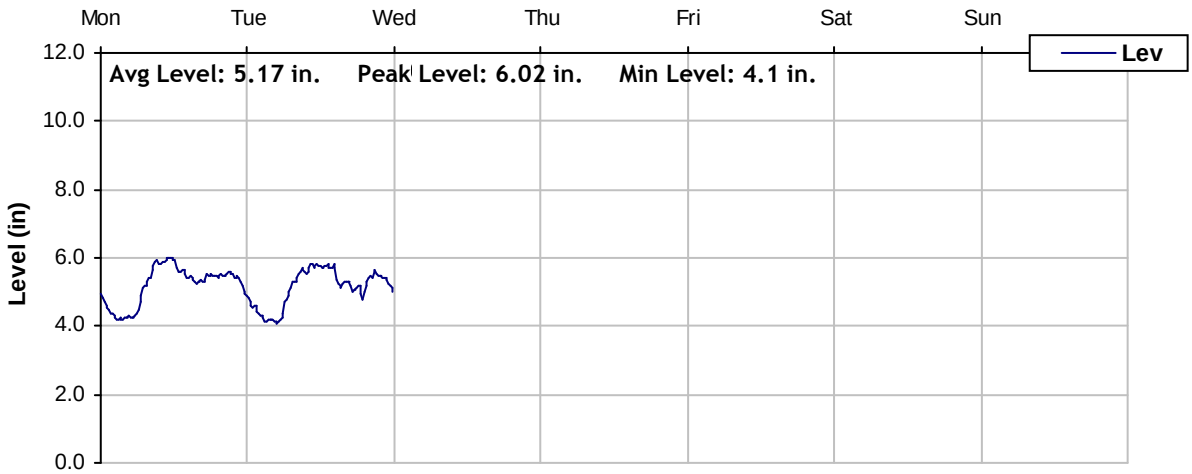


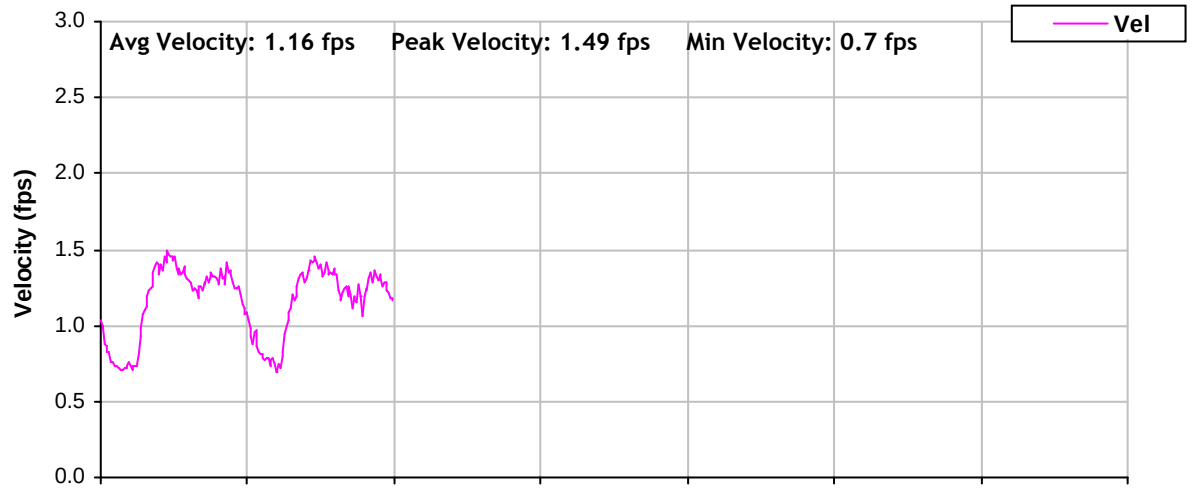


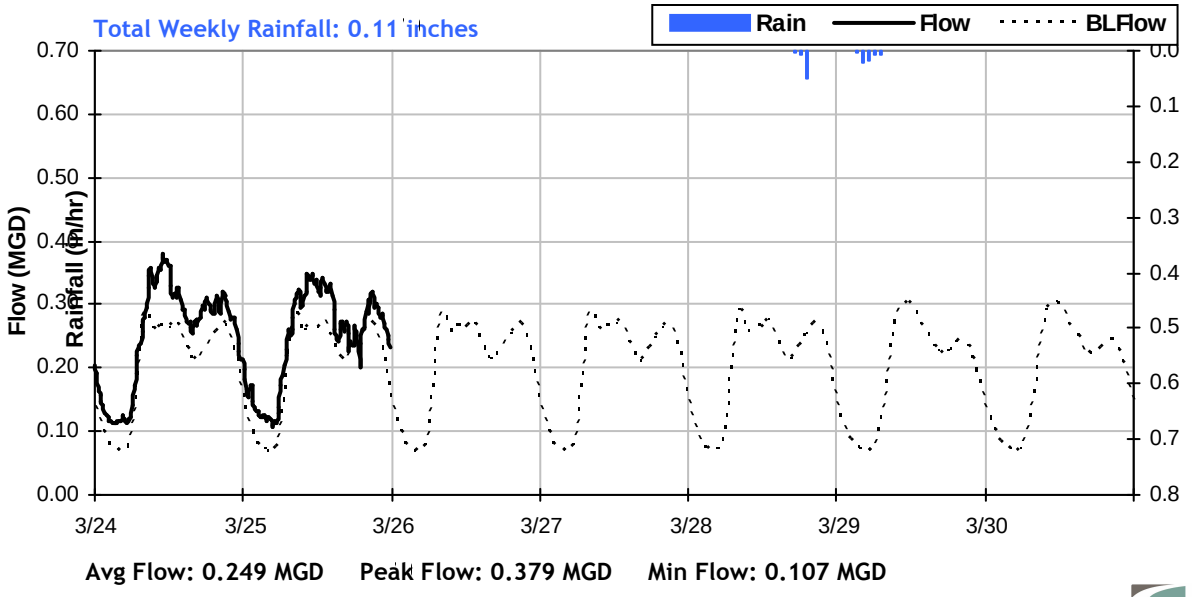


Level, Velocity and Flow
From 3/24/2008 to 3/31/2008

Monitoring Site:
Site 3







Temporary Flow Monitoring Study

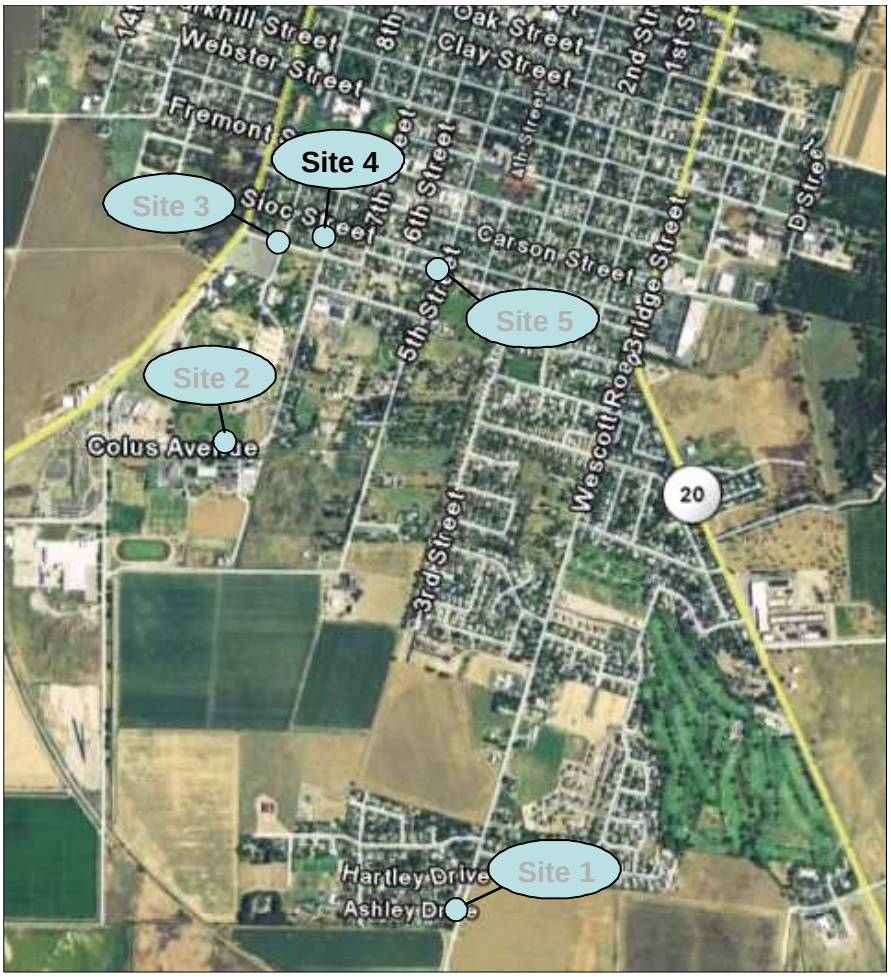
Sanitary Sewer Collection System

Monitoring Site: Site 4

Manhole Address: 8th Street at Tuttle Lane

Size/Type of Line: 8-inch Sanitary Sewer Pipe

Data Summary Report



Site Information Report

Monitoring Site: Site 4

Location: 8th Street at Tuttle Lane

Diameter: 8 inches

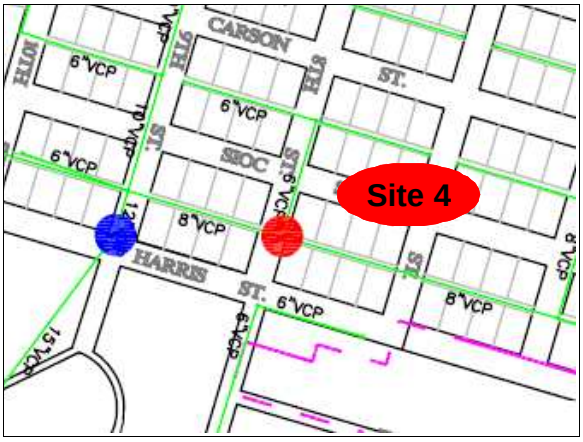
Average Dry Weather Flow: 0.077 *MGD*

Peak Measured Flow: 0.191 *MGD*

Street-level photo:

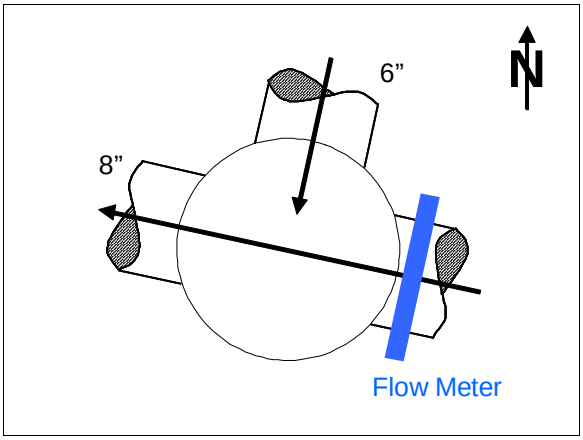
Street map:

Sanitary sewer map:



Plan view photo:

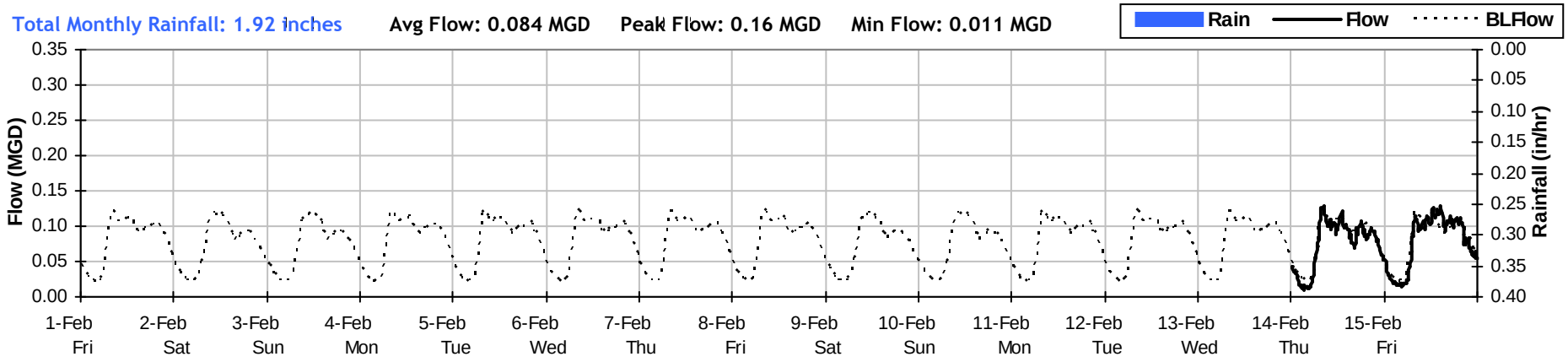
Flow sketch:

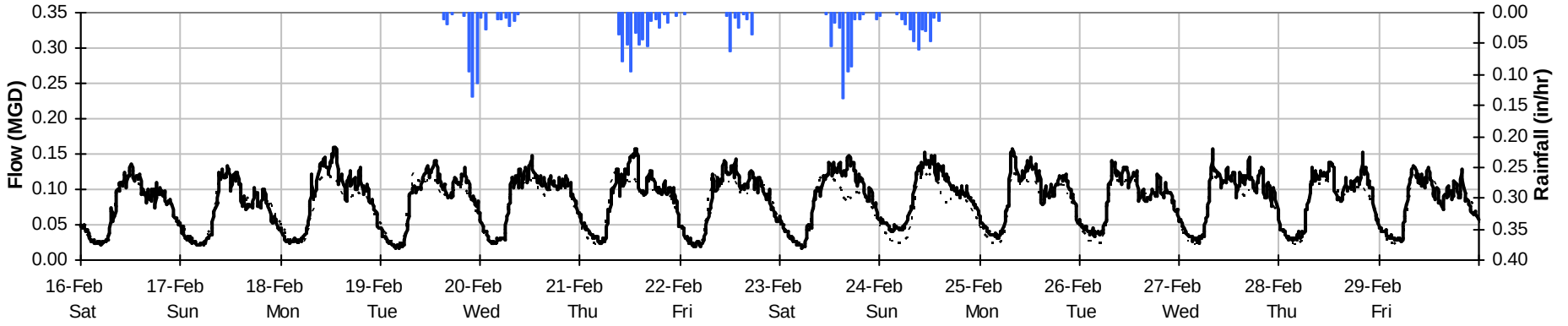


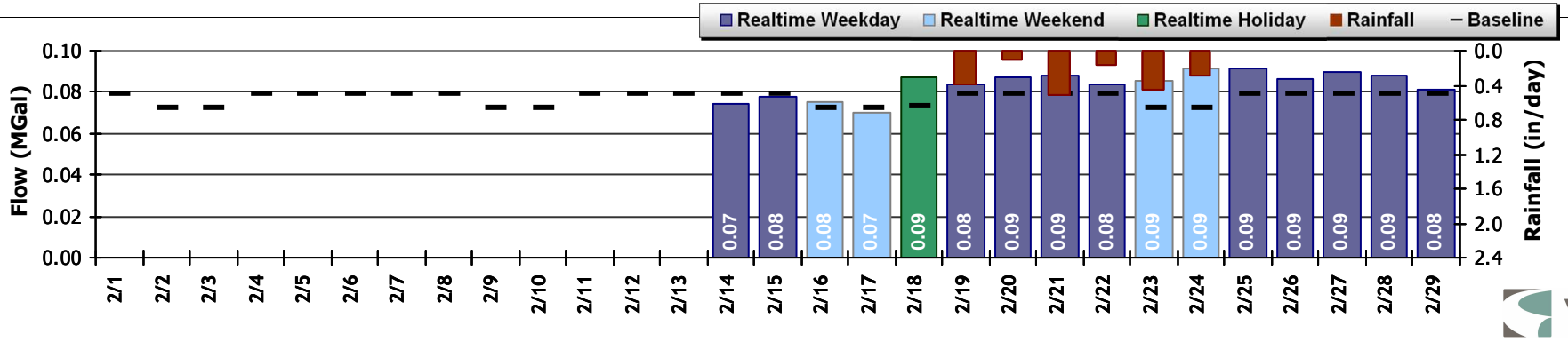
Monthly Flow Summary
February, 2008

Monitoring Site:
Site 4

Total Monthly Rainfall: 1.92 inches Avg Flow: 0.084 MGD Peak Flow: 0.16 MGD Min Flow: 0.011 MGD





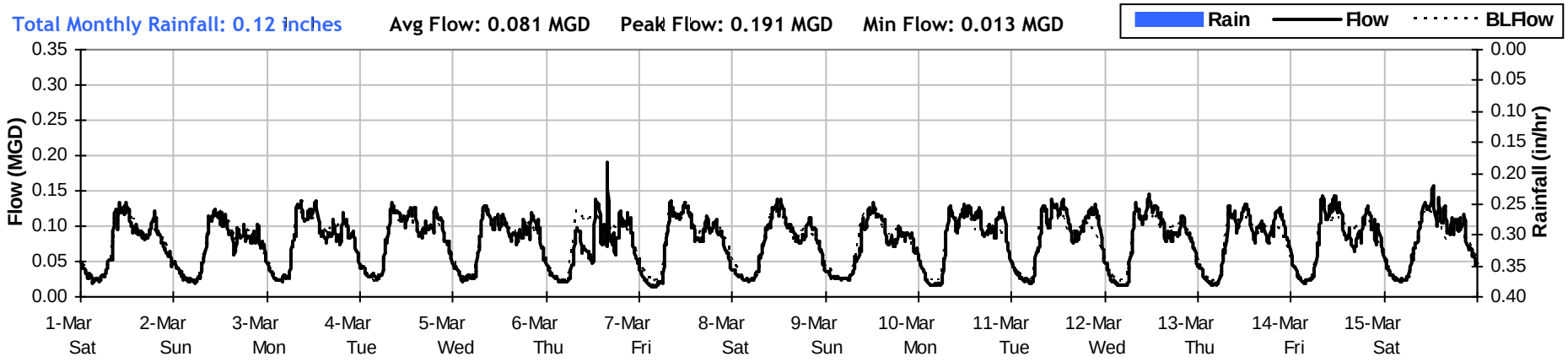


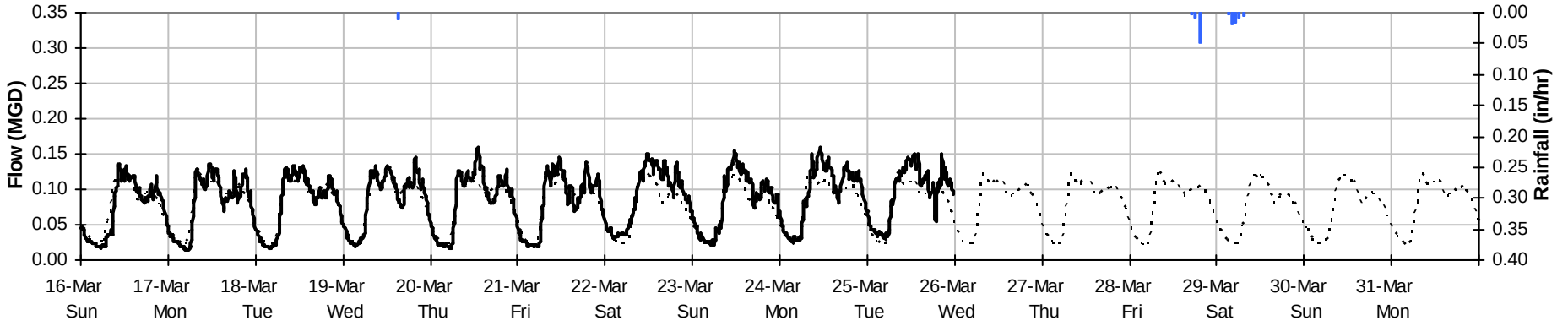
V&A

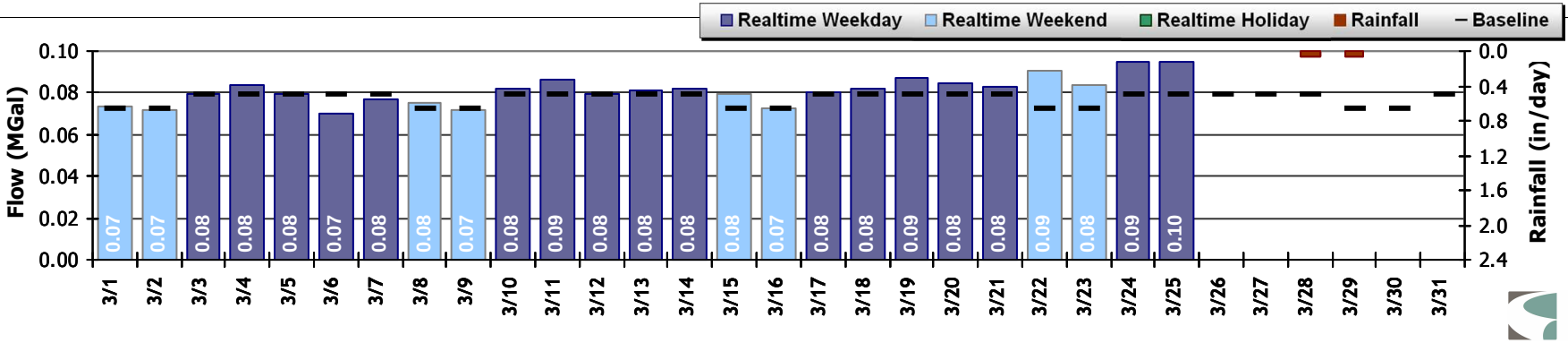
Monthly Flow Summary
March, 2008

Monitoring Site:
Site 4

Total Monthly Rainfall: 0.12 inches Avg Flow: 0.081 MGD Peak Flow: 0.191 MGD Min Flow: 0.013 MGD







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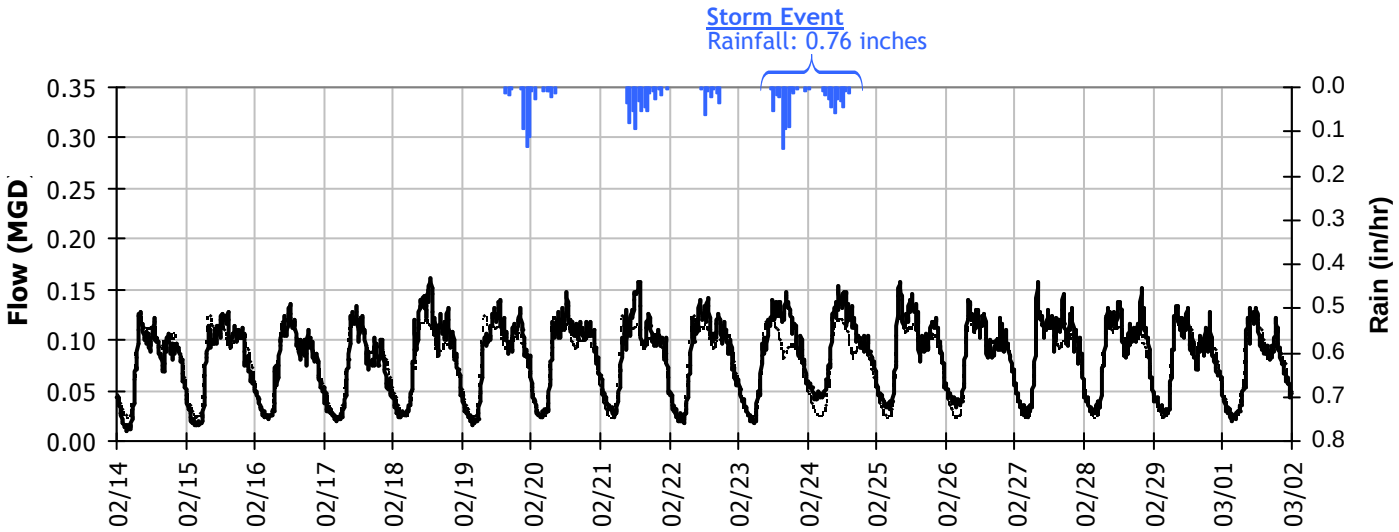
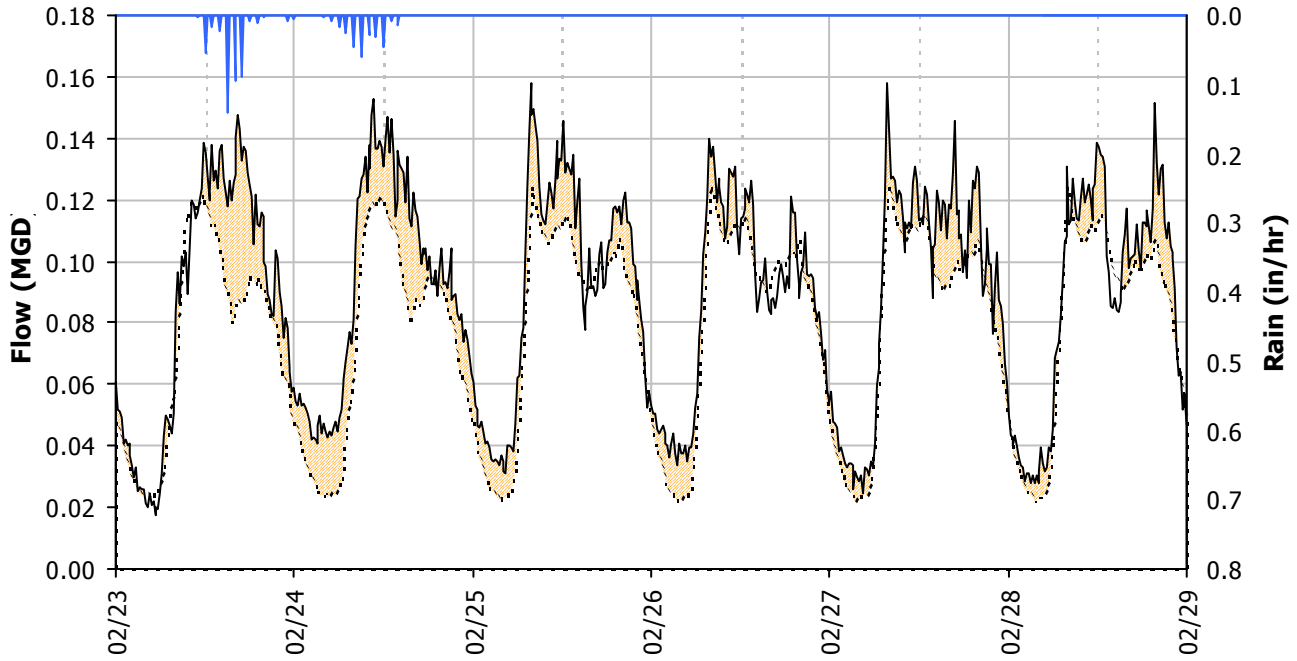
I/I Summary

Monitoring Site:
Site 4

Baseline, Realtime, and I/I Flows over Monitoring Period:



Storm Event #1 Detail I/I Graph

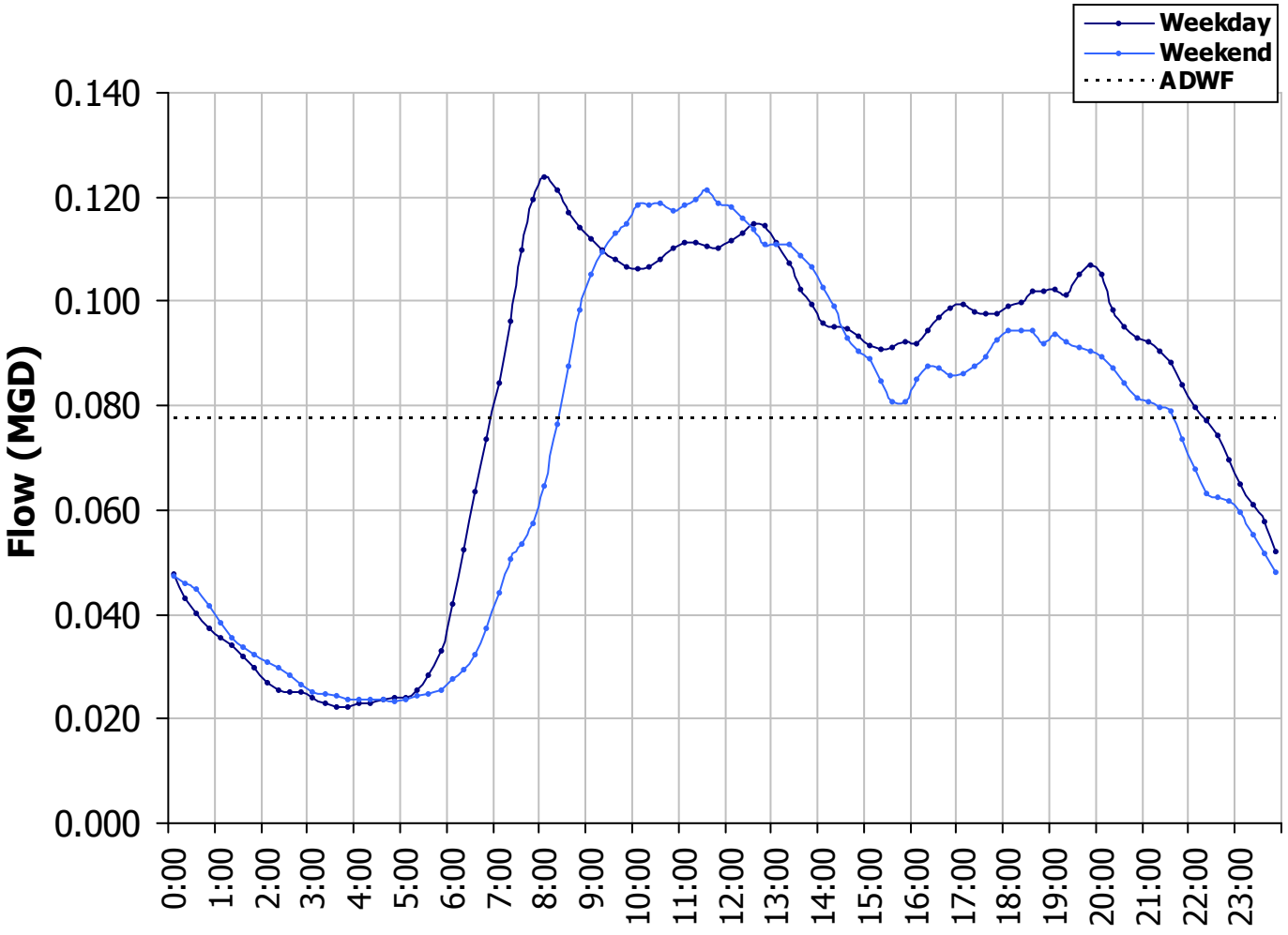


Storm Event #1 I/I Analysis

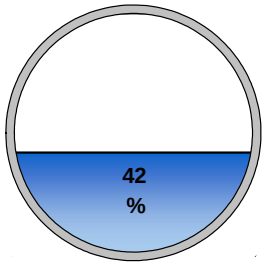
Rainfall:	0.76	*inches*		
Peak Flow:	0.158	*MGD*	**PF:**	2.04
Peak I/I Rate:	0.060	*MGD*	**Pk I/I:ADWF:**	0.78
Peak Level:	4.81	*inches*	**d/D Ratio:**	0.60
Total I/I:	64,000	*gallons*	**R-Value:**	1.6%
			I/I per ADWF:	1.09

Average Dry Weather Flow

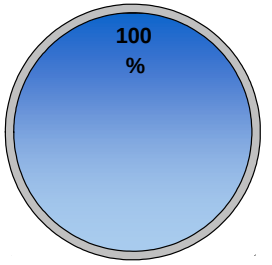
Monitoring Site:
Site 4



Average Dry Weather Flow:
0.077 *MGD*



Peak Measured Flow:
0.191 *MGD*

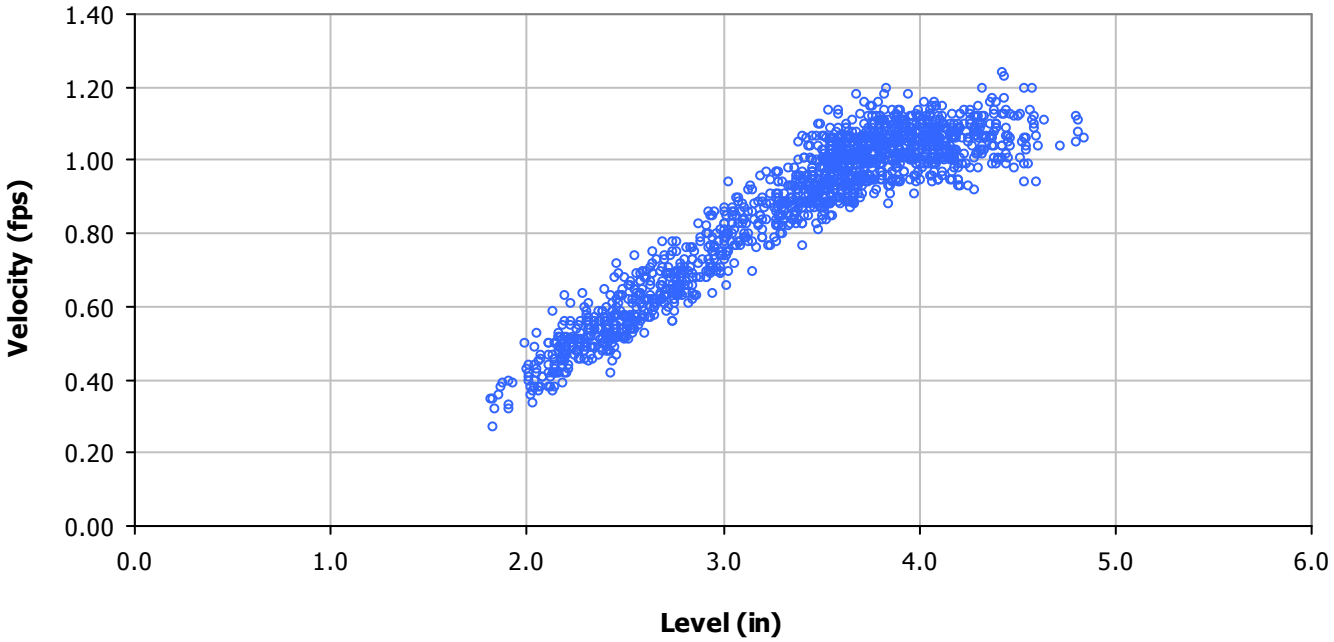


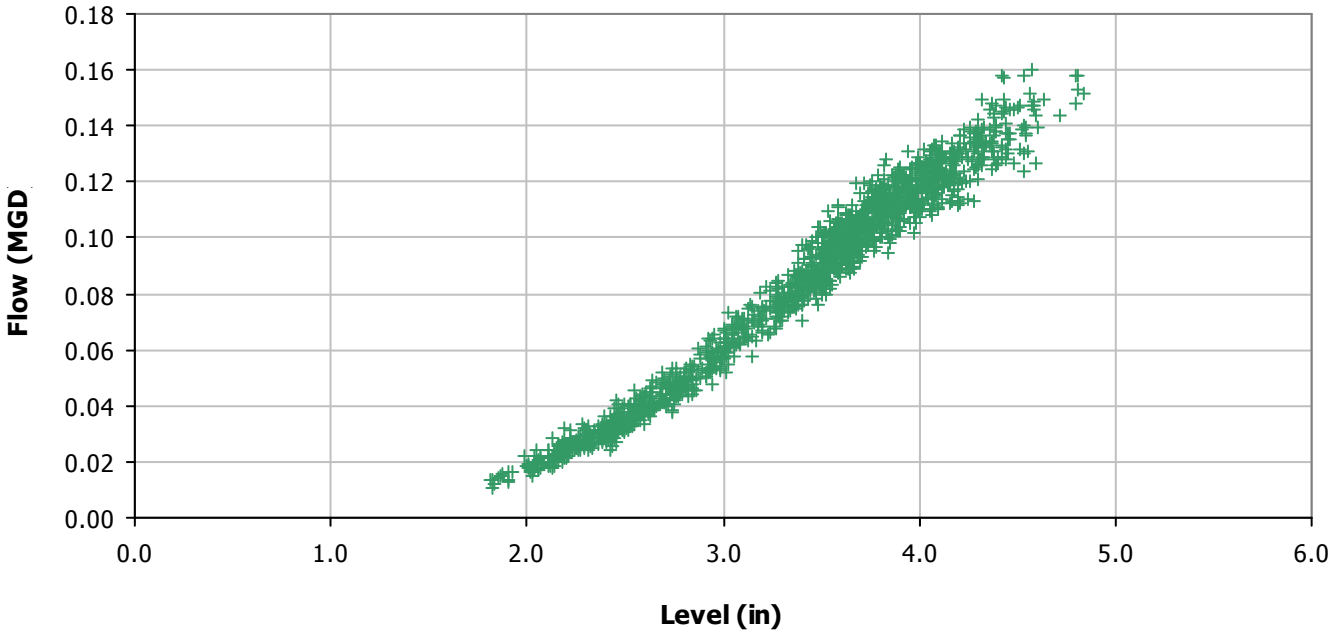
Peak measured flow shown on following pages in weekly flow data graphs

V&A

Scatter Plots (Flow, Velocity vs. Depth)

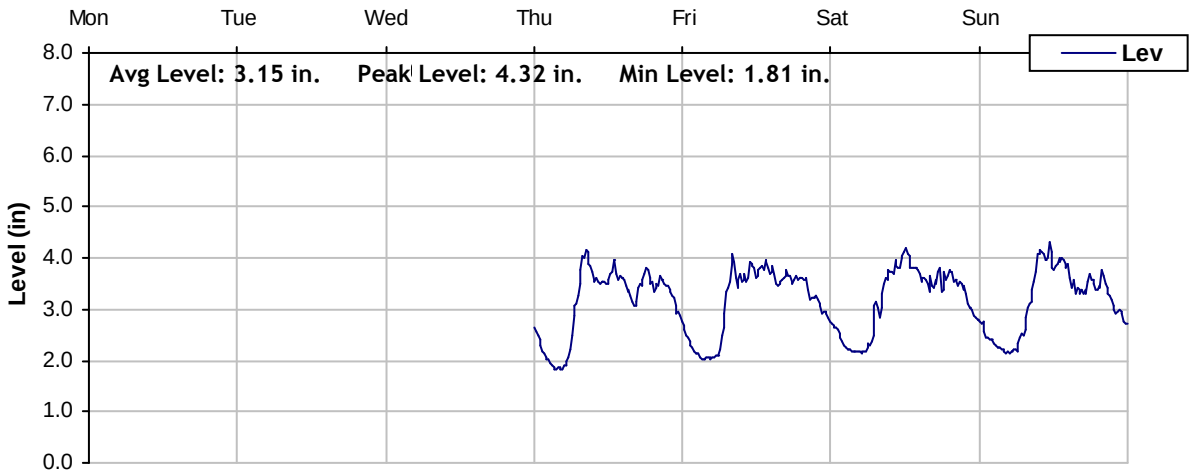
Monitoring Site: Site 4

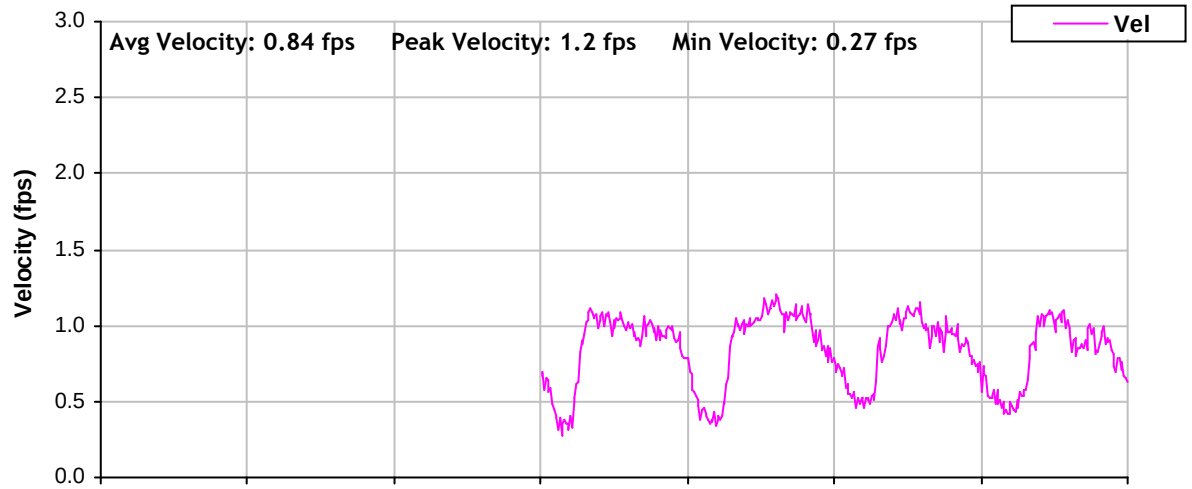


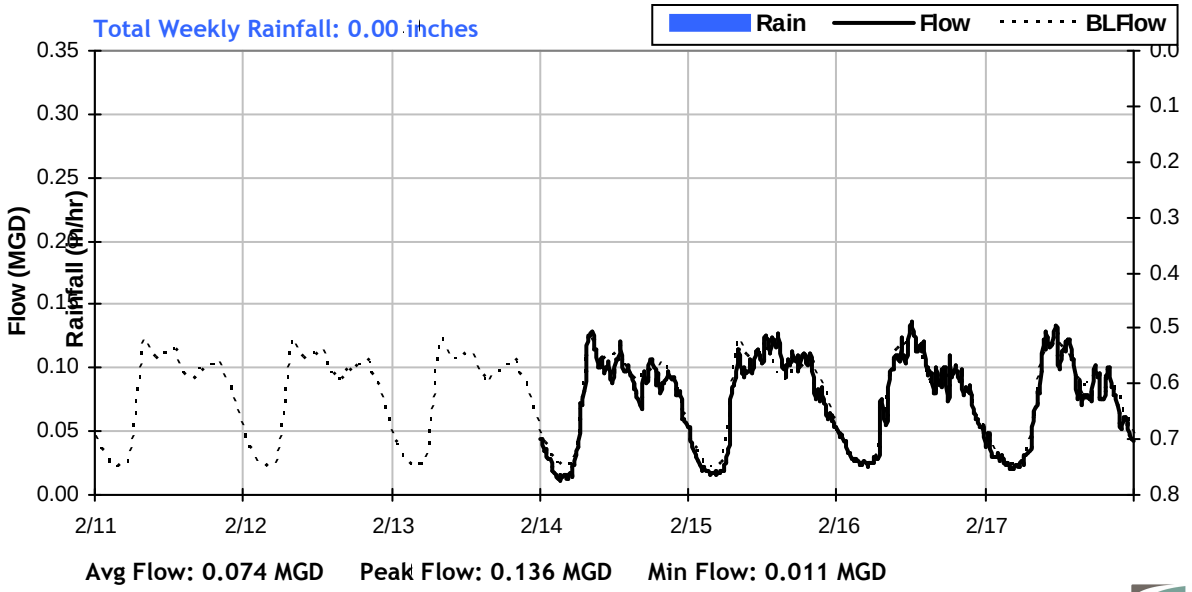


Level, Velocity and Flow
From 2/11/2008 to 2/18/2008

Monitoring Site:
Site 4

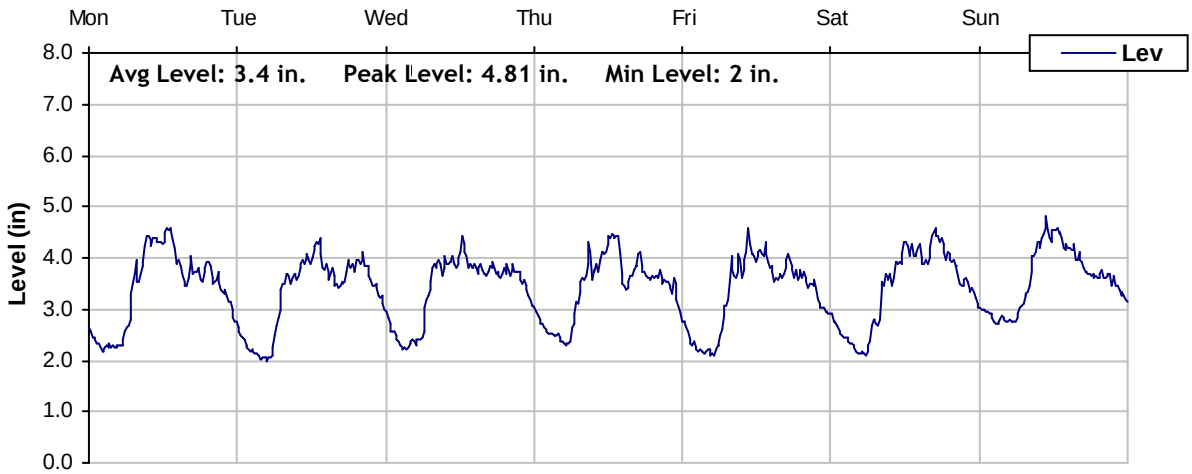


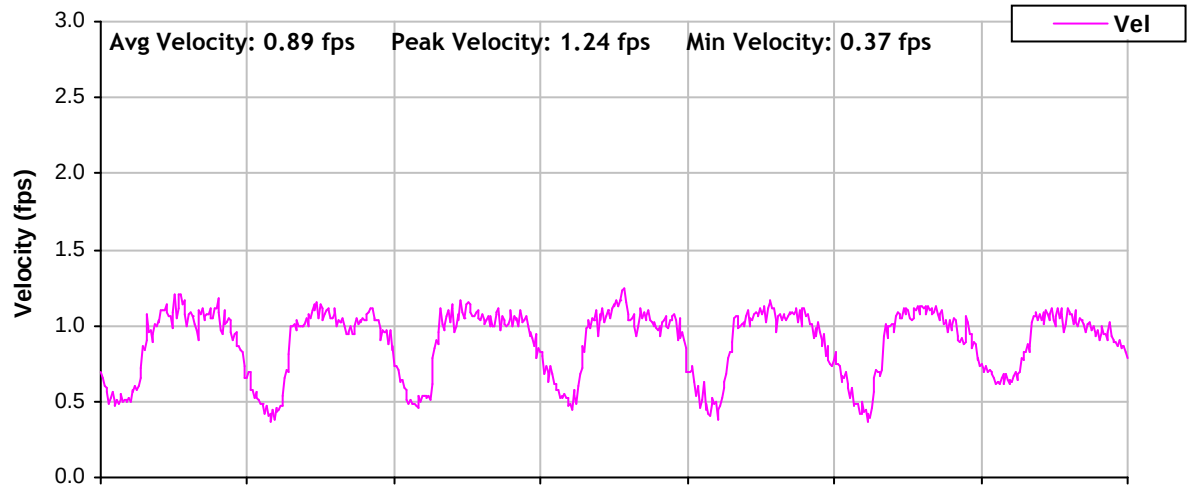


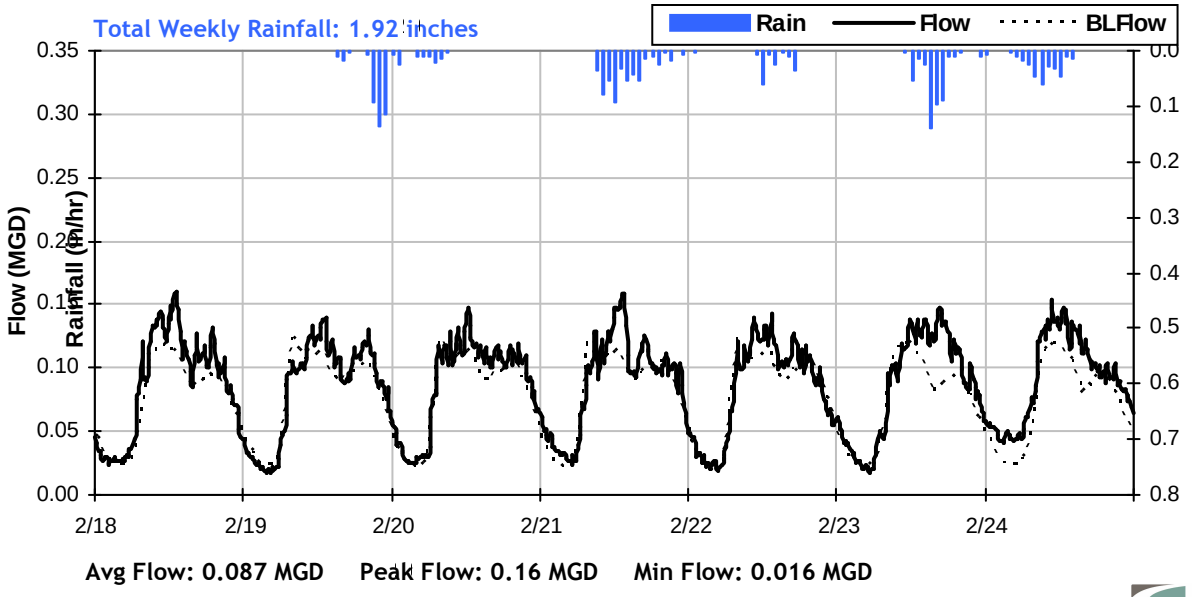


Level, Velocity and Flow
From 2/18/2008 to 2/25/2008

Monitoring Site:
Site 4

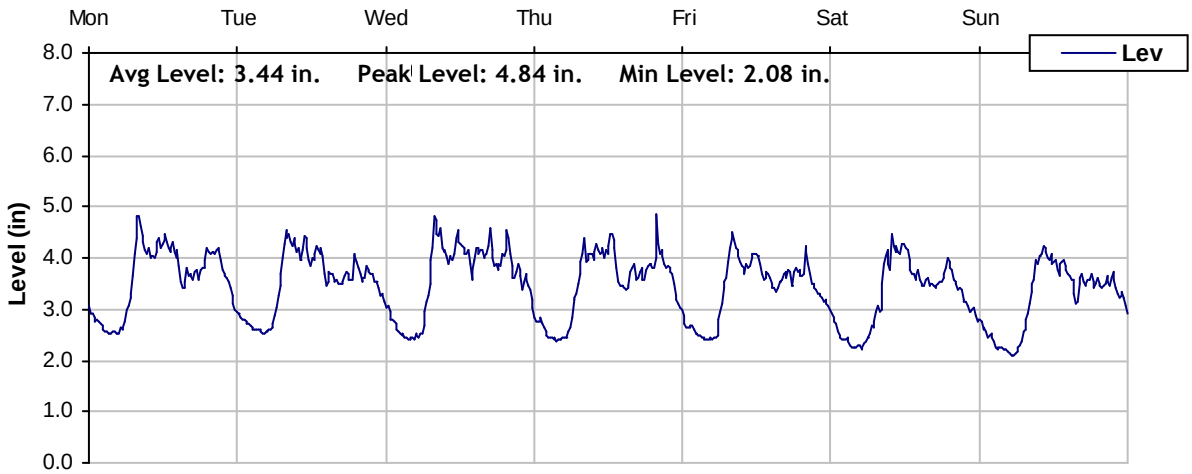


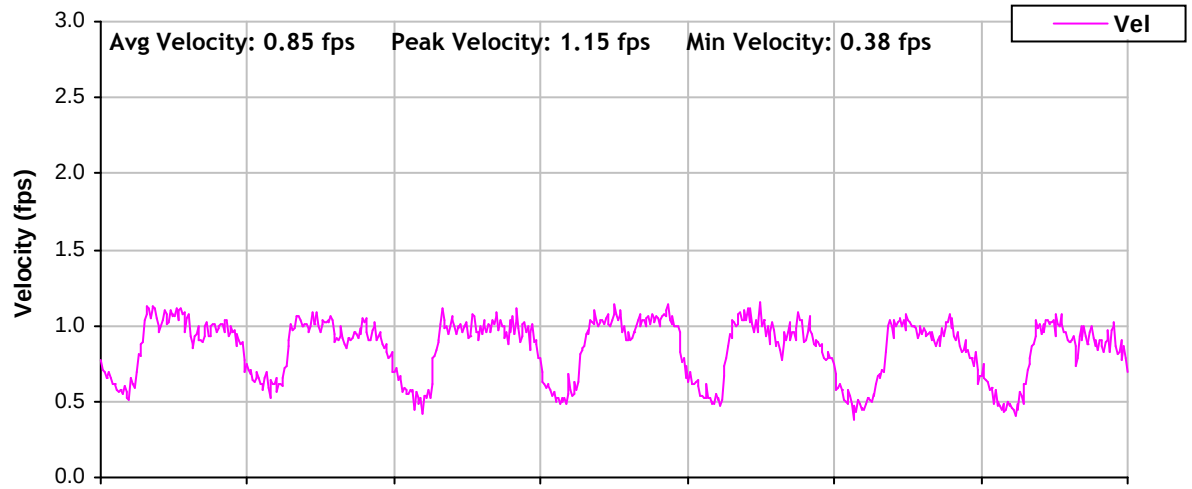


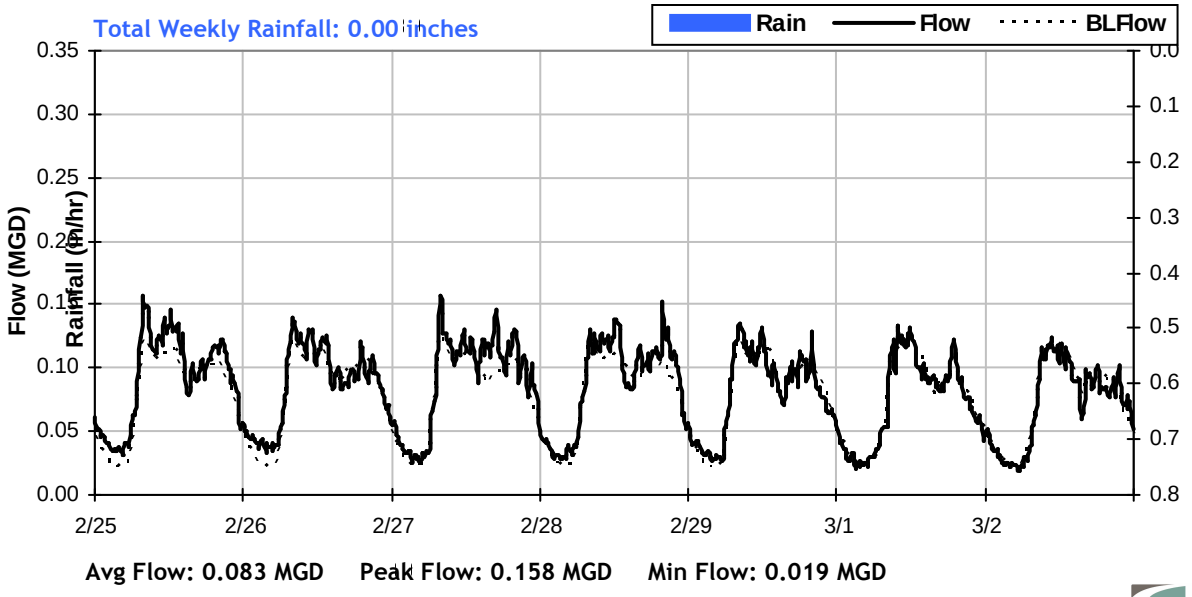


Level, Velocity and Flow
From 2/25/2008 to 3/3/2008

Monitoring Site:
Site 4

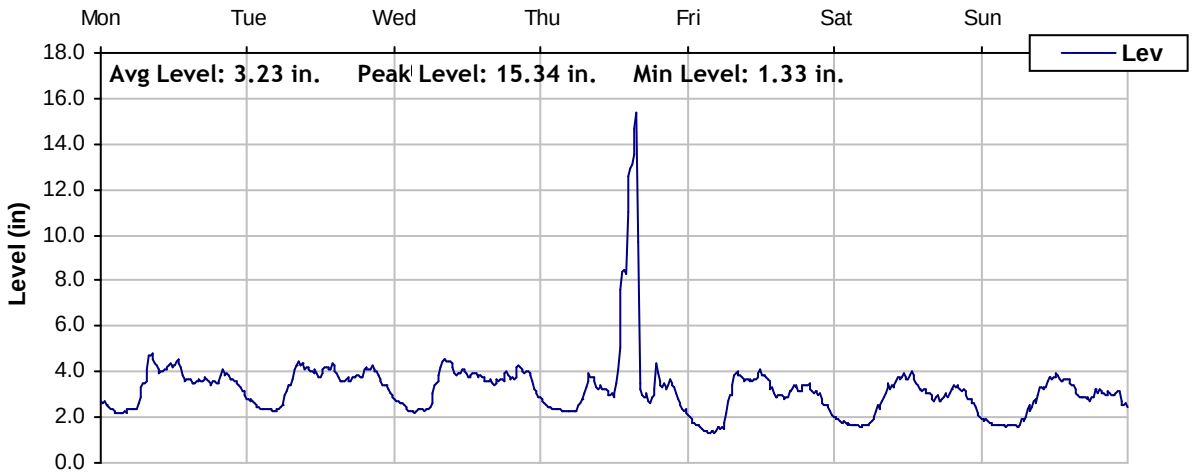


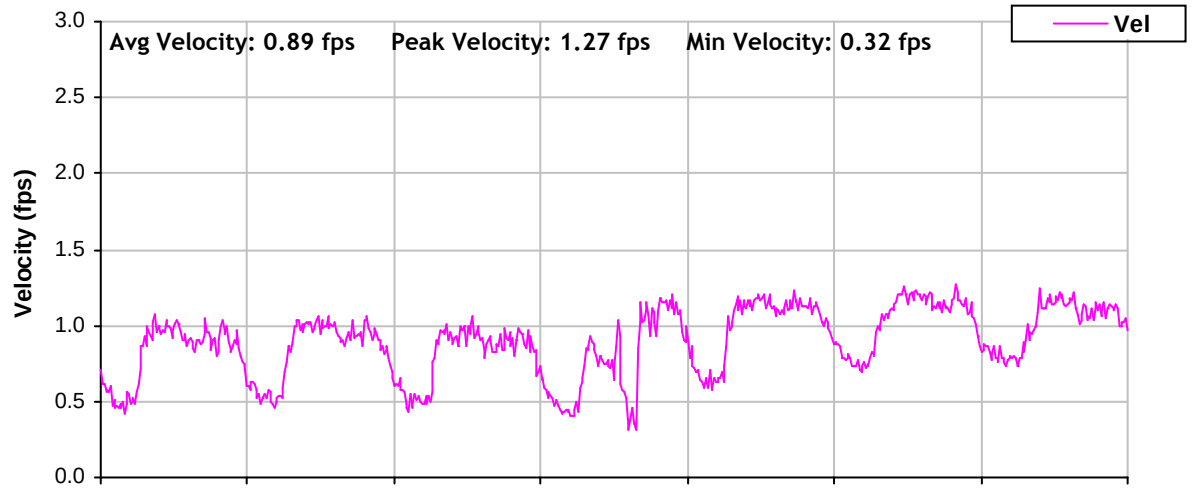


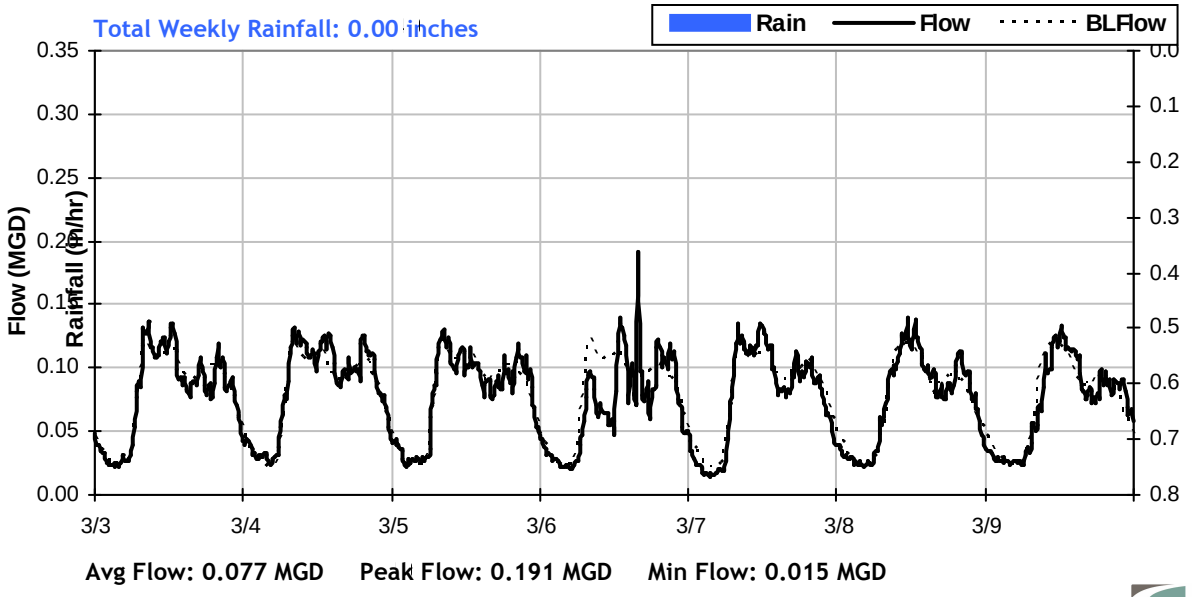


Level, Velocity and Flow
From 3/3/2008 to 3/10/2008

Monitoring Site:
Site 4



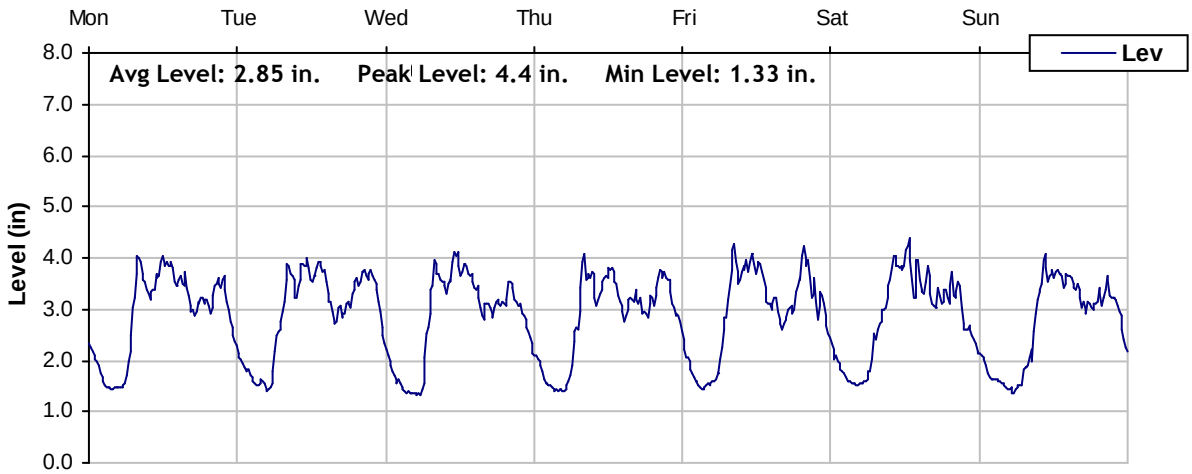


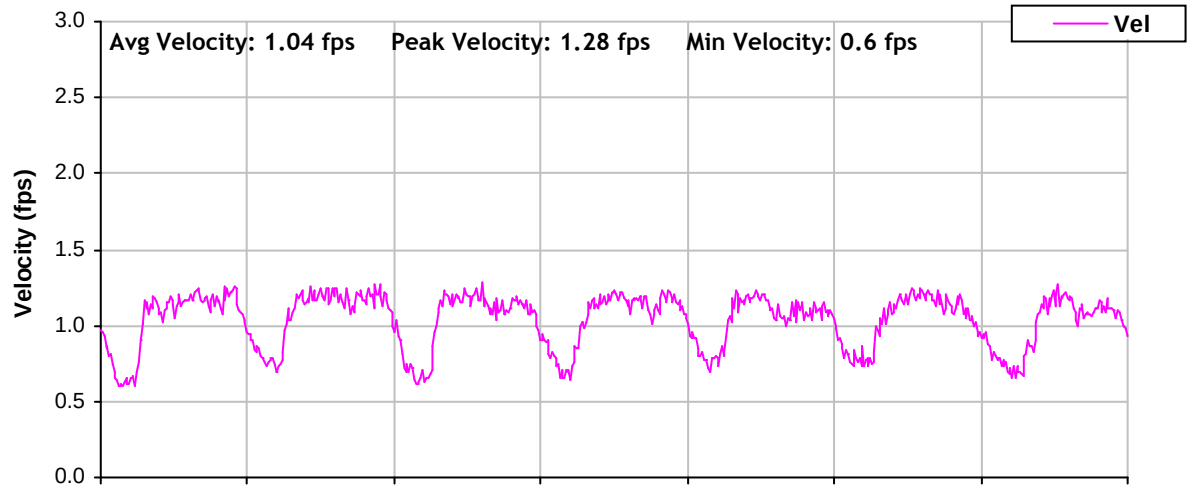


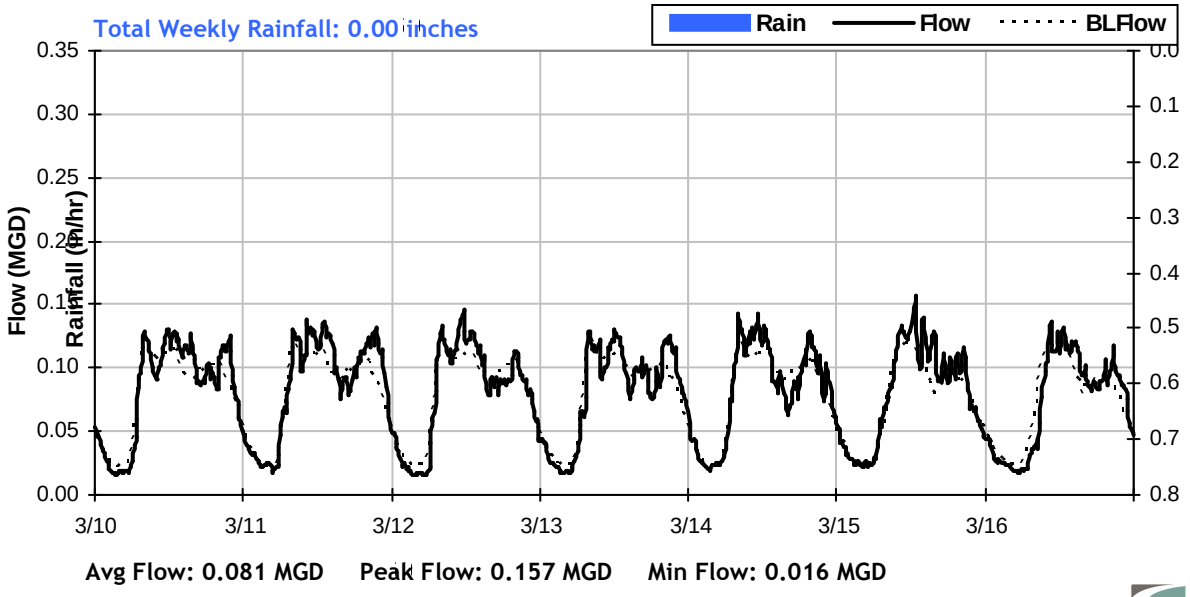
Avg Flow: 0.077 MGD Peak Flow: 0.191 MGD Min Flow: 0.015 MGD

Level, Velocity and Flow
From 3/10/2008 to 3/17/2008

Monitoring Site:
Site 4

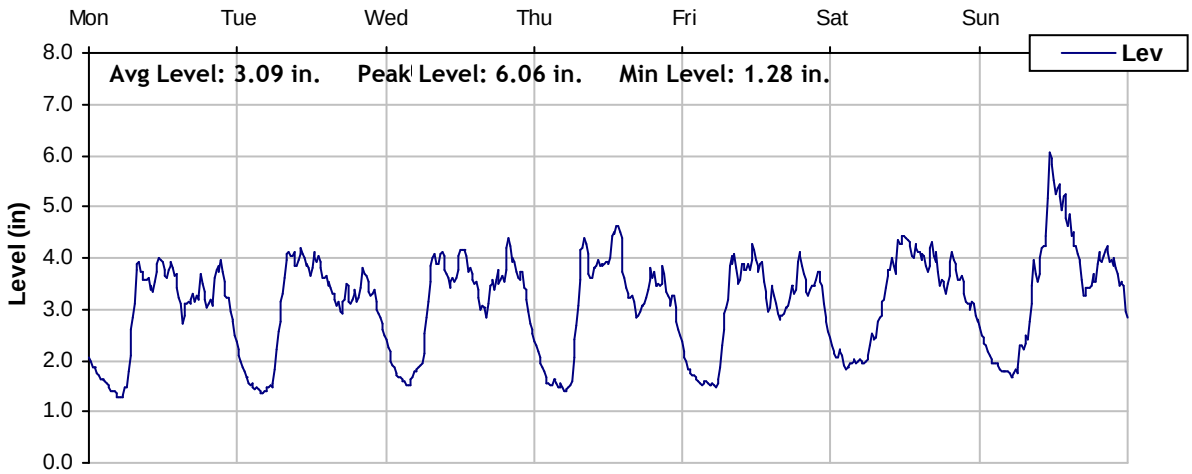


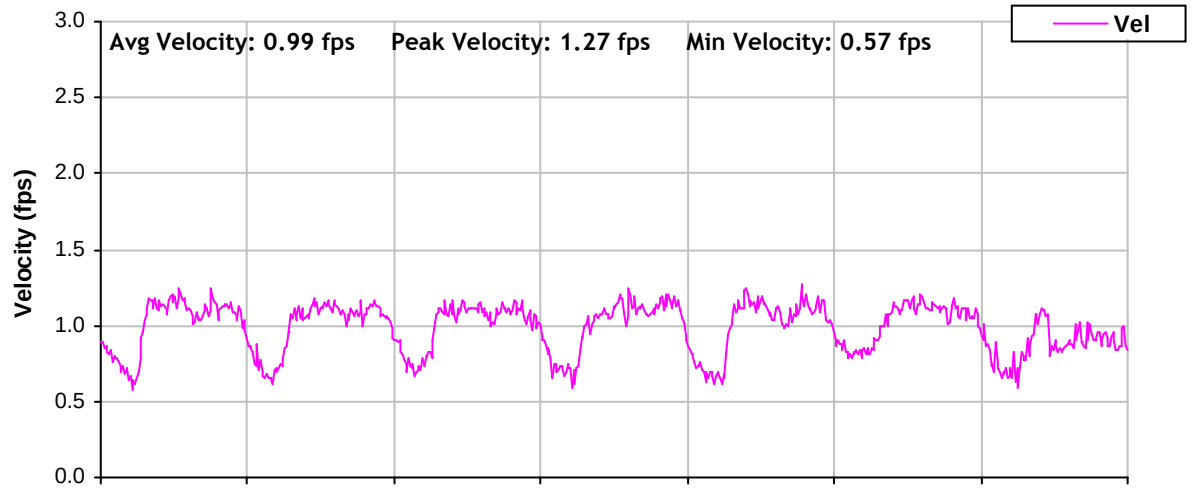


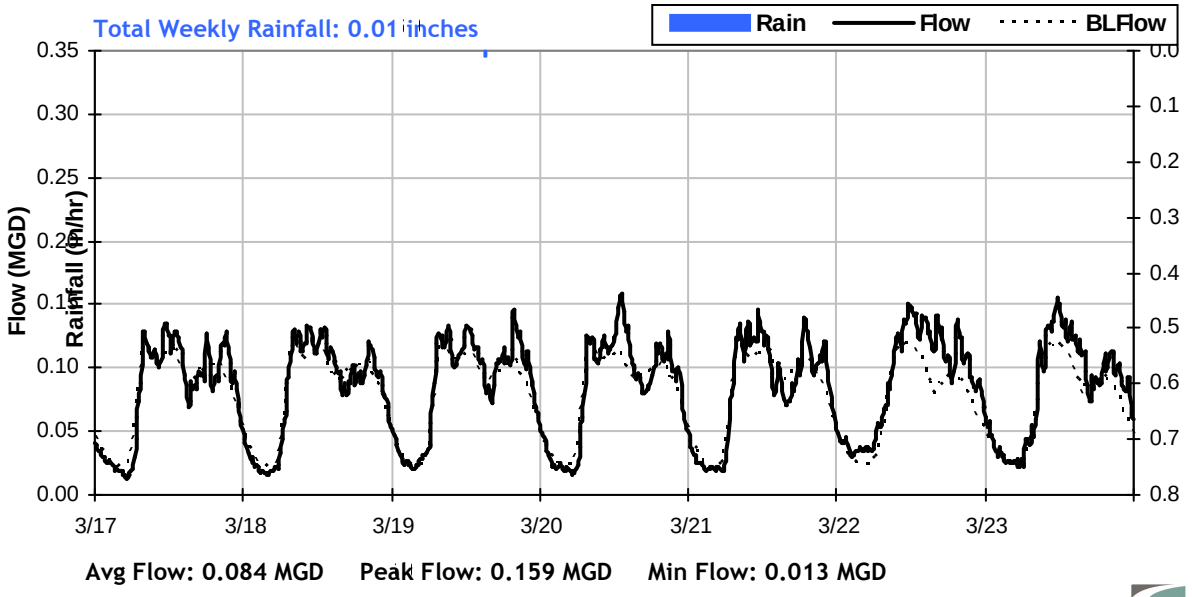


Level, Velocity and Flow
From 3/17/2008 to 3/24/2008

Monitoring Site:
Site 4

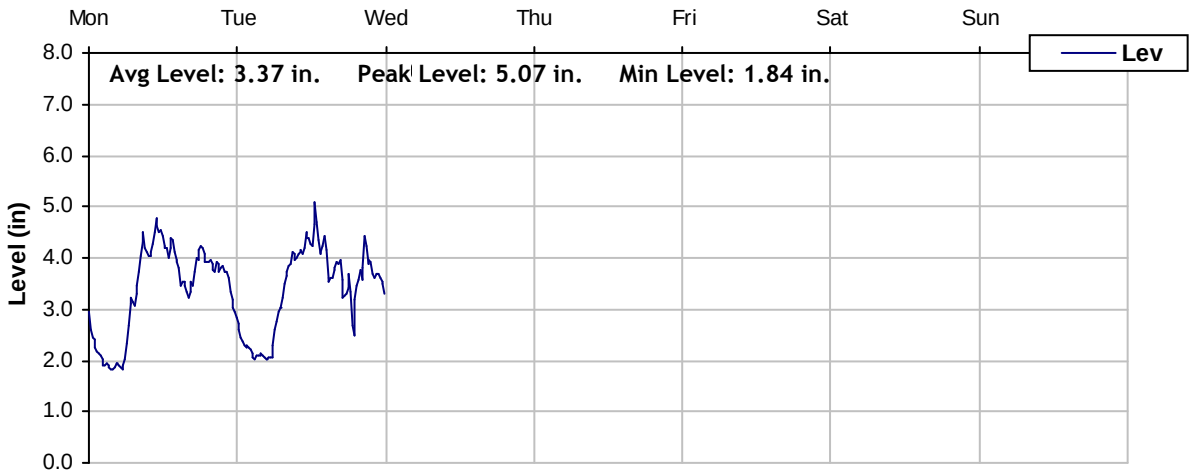


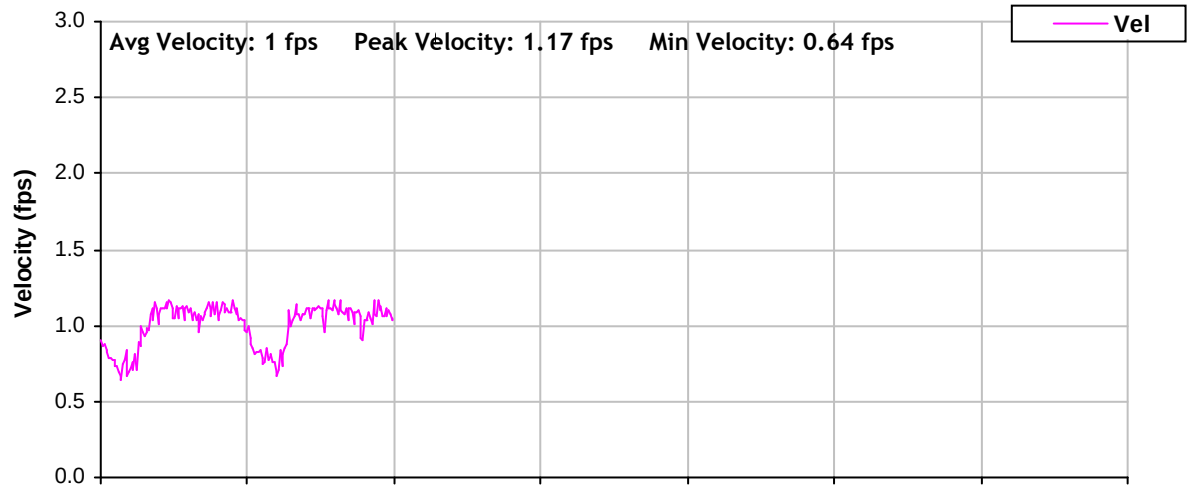


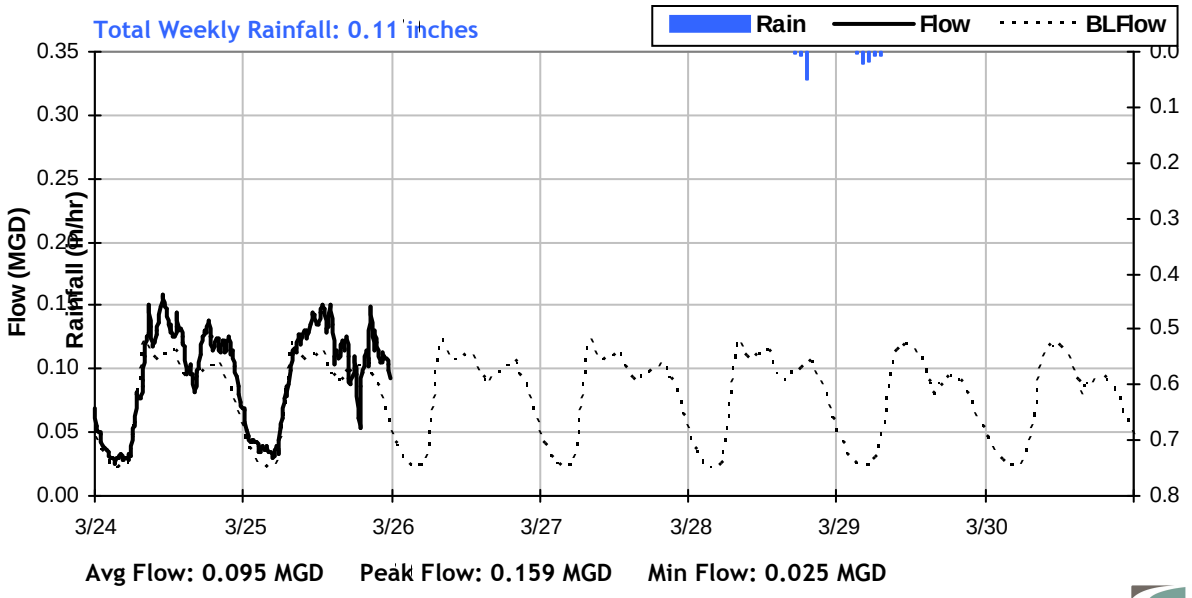


Level, Velocity and Flow
From 3/24/2008 to 3/31/2008

Monitoring Site:
Site 4







Temporary Flow Monitoring Study

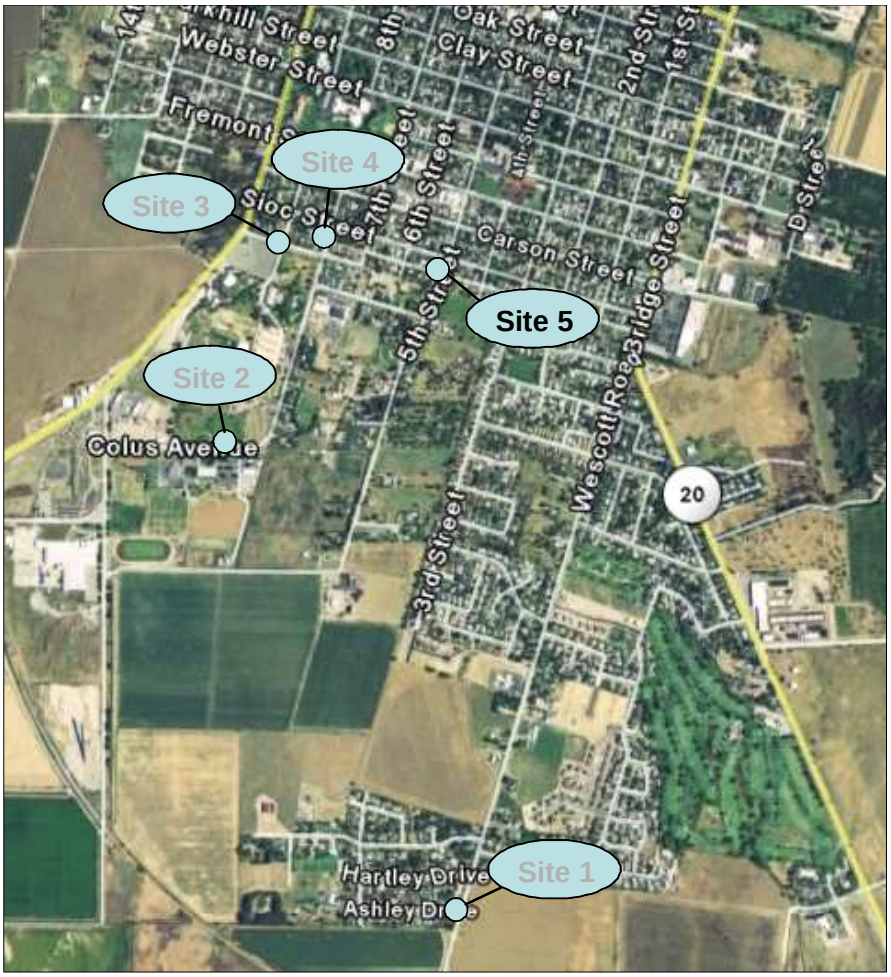
Sanitary Sewer Collection System

Monitoring Site: Site 5

Manhole Address: 5th Street at Tuttle Lane

Size/Type of Line: 8-inch Sanitary Sewer Pipe

Data Summary Report



Site Information Report

Monitoring Site: Site 5

Location: 5th Street at Tuttle Lane

Diameter: 8 inches

Average Dry Weather Flow: 0.030 *MGD*

Peak Measured Flow: 0.097 *MGD*

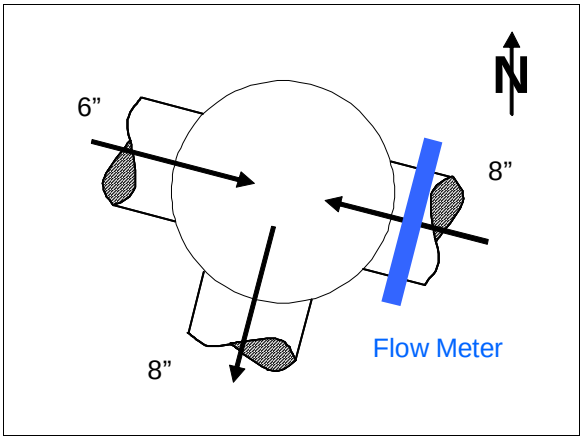
Street-level photo:

Street map:

Sanitary sewer map:

Plan view photo:

Flow sketch:

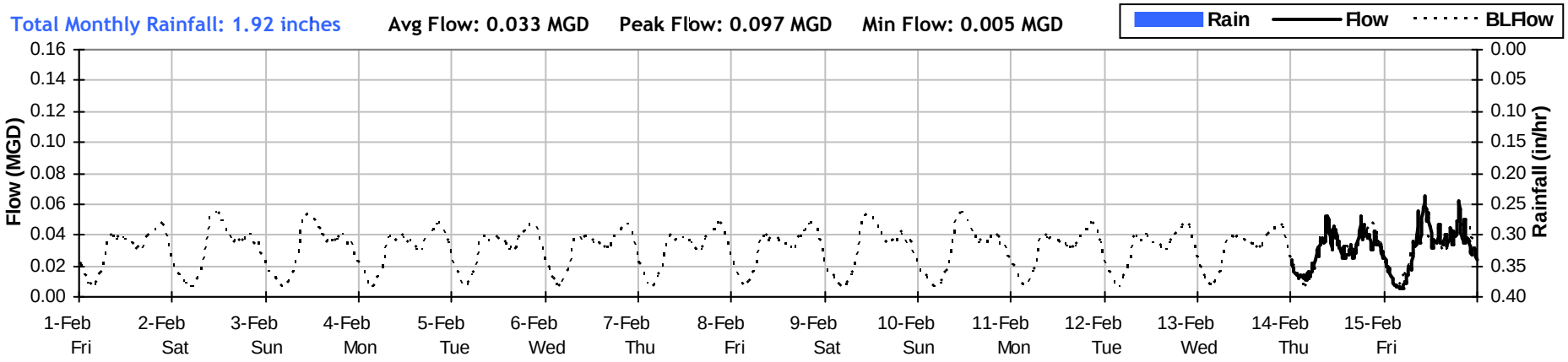


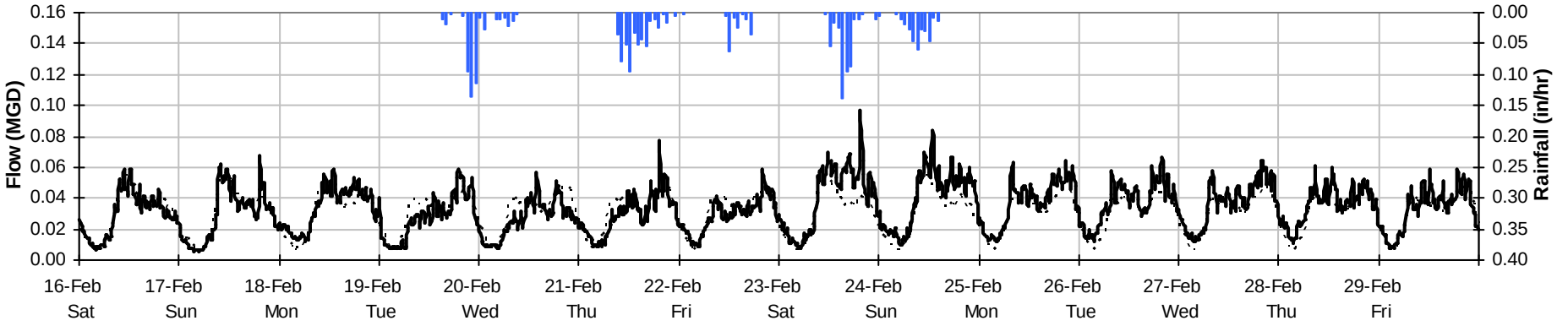
V&A

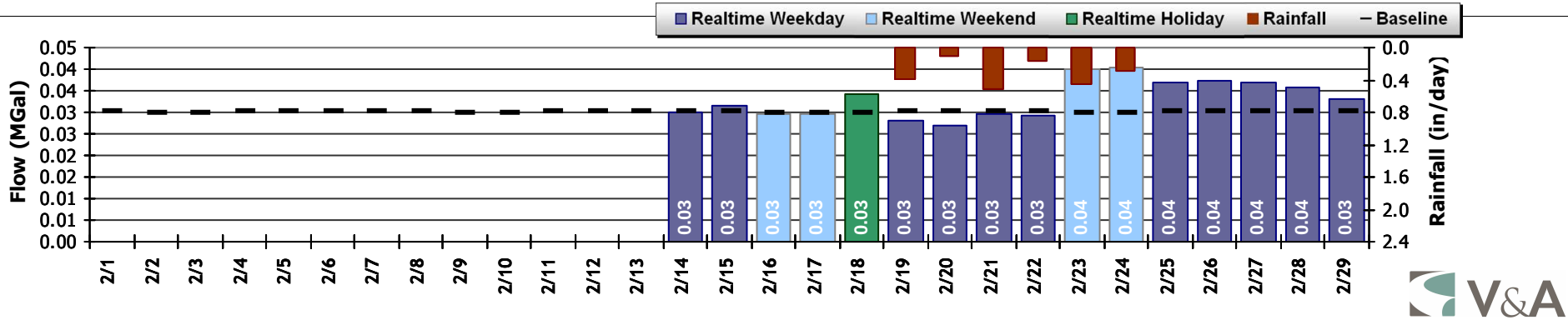
Monthly Flow Summary
February, 2008

Monitoring Site:
Site 5

Total Monthly Rainfall: 1.92 inches Avg Flow: 0.033 MGD Peak Flow: 0.097 MGD Min Flow: 0.005 MGD





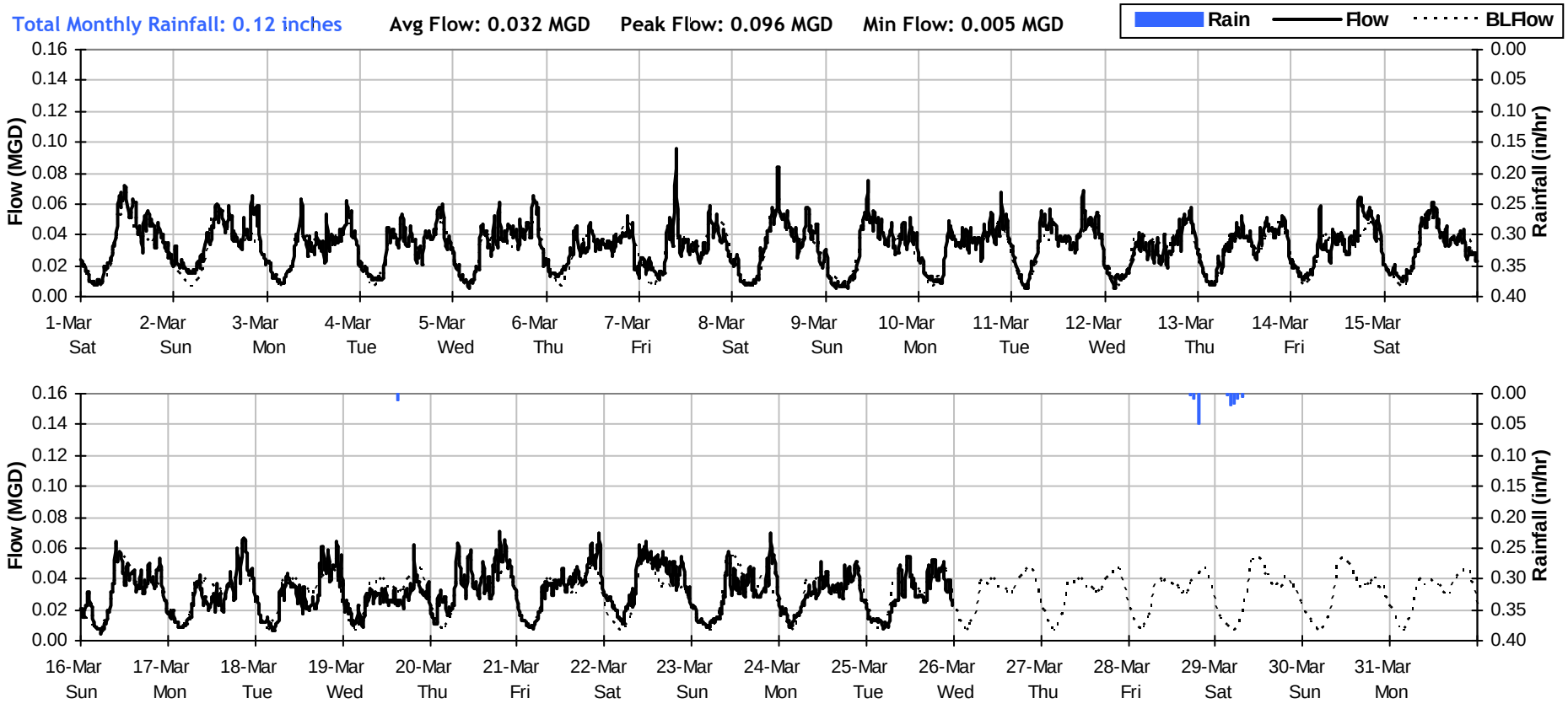


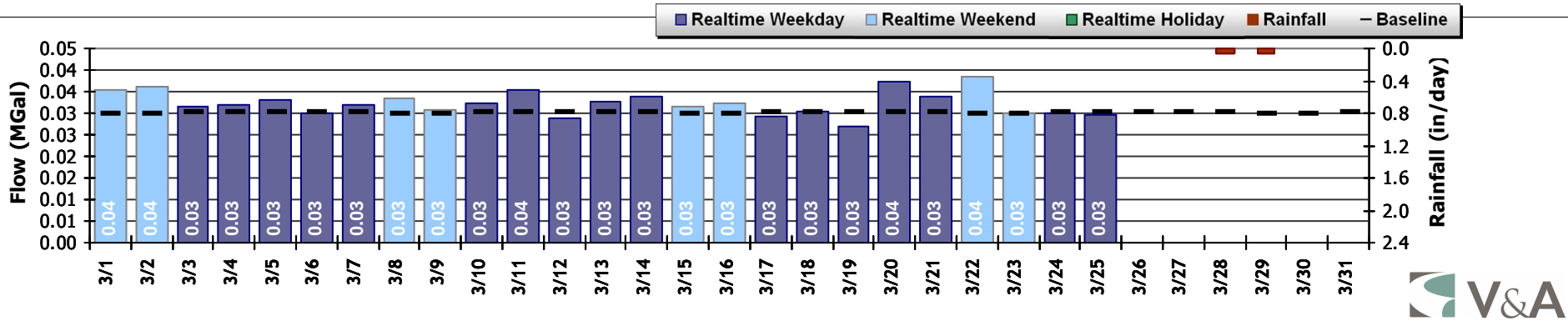
V&A

Monthly Flow Summary
March, 2008

Monitoring Site:
Site 5

Total Monthly Rainfall: 0.12 inches Avg Flow: 0.032 MGD Peak Flow: 0.096 MGD Min Flow: 0.005 MGD





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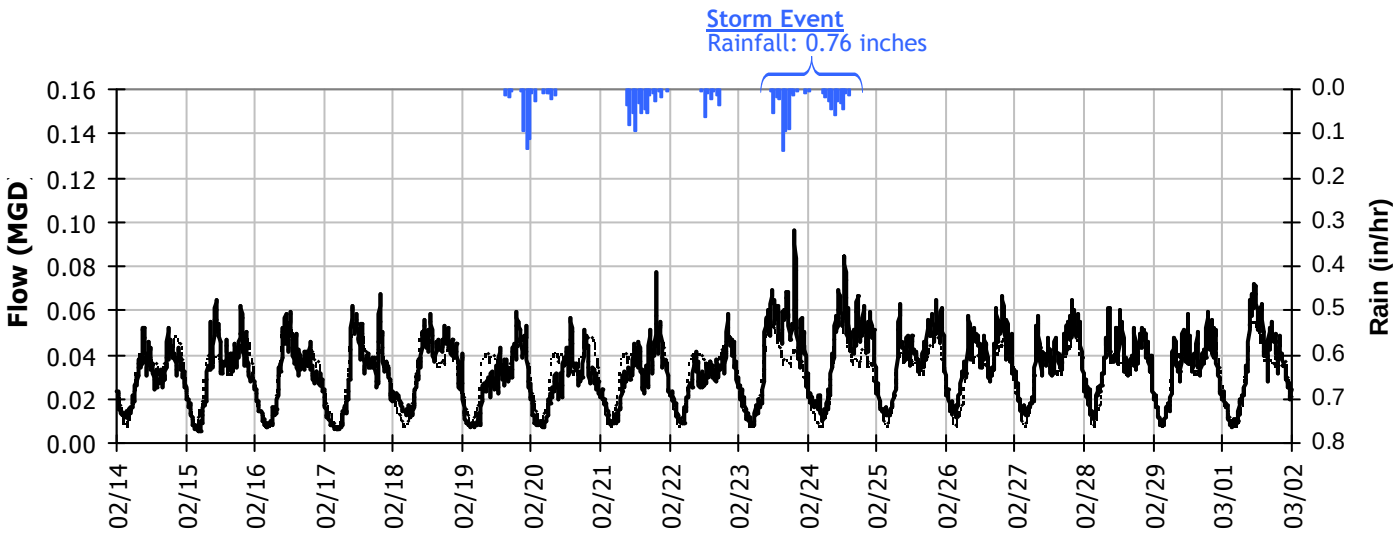
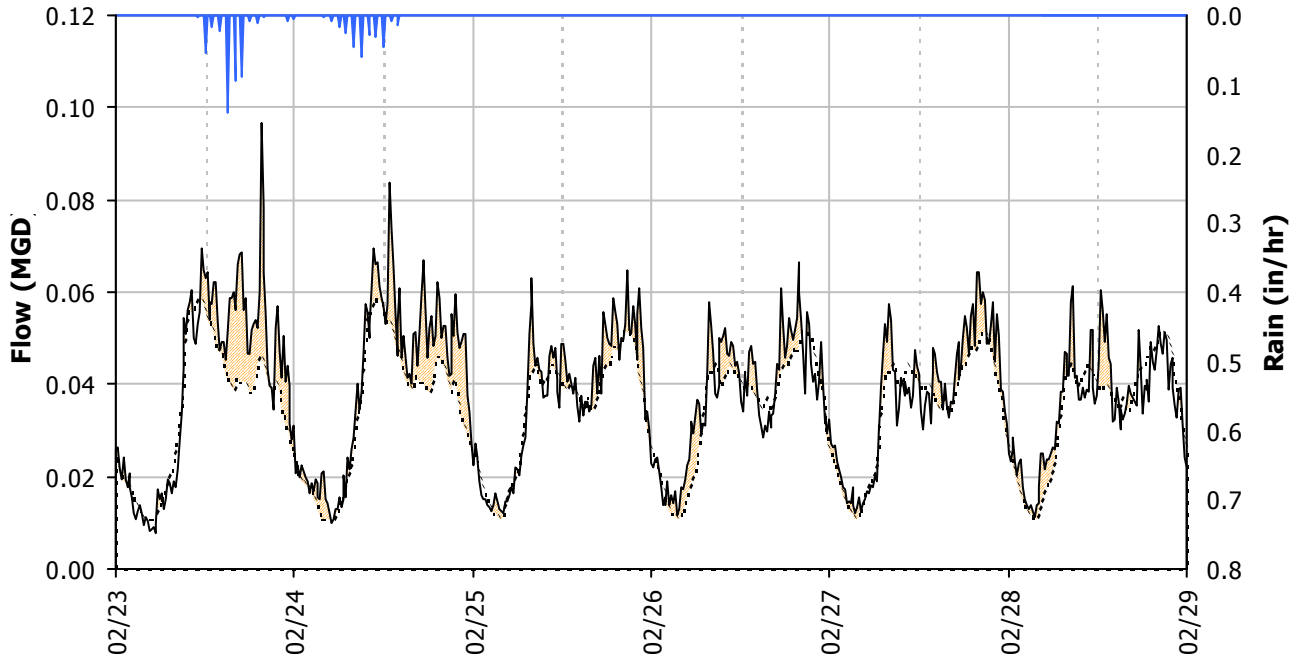
I/I Summary

Monitoring Site:
Site 5

Baseline, Realtime, and I/I Flows over Monitoring Period:



Storm Event #1 Detail I/I Graph

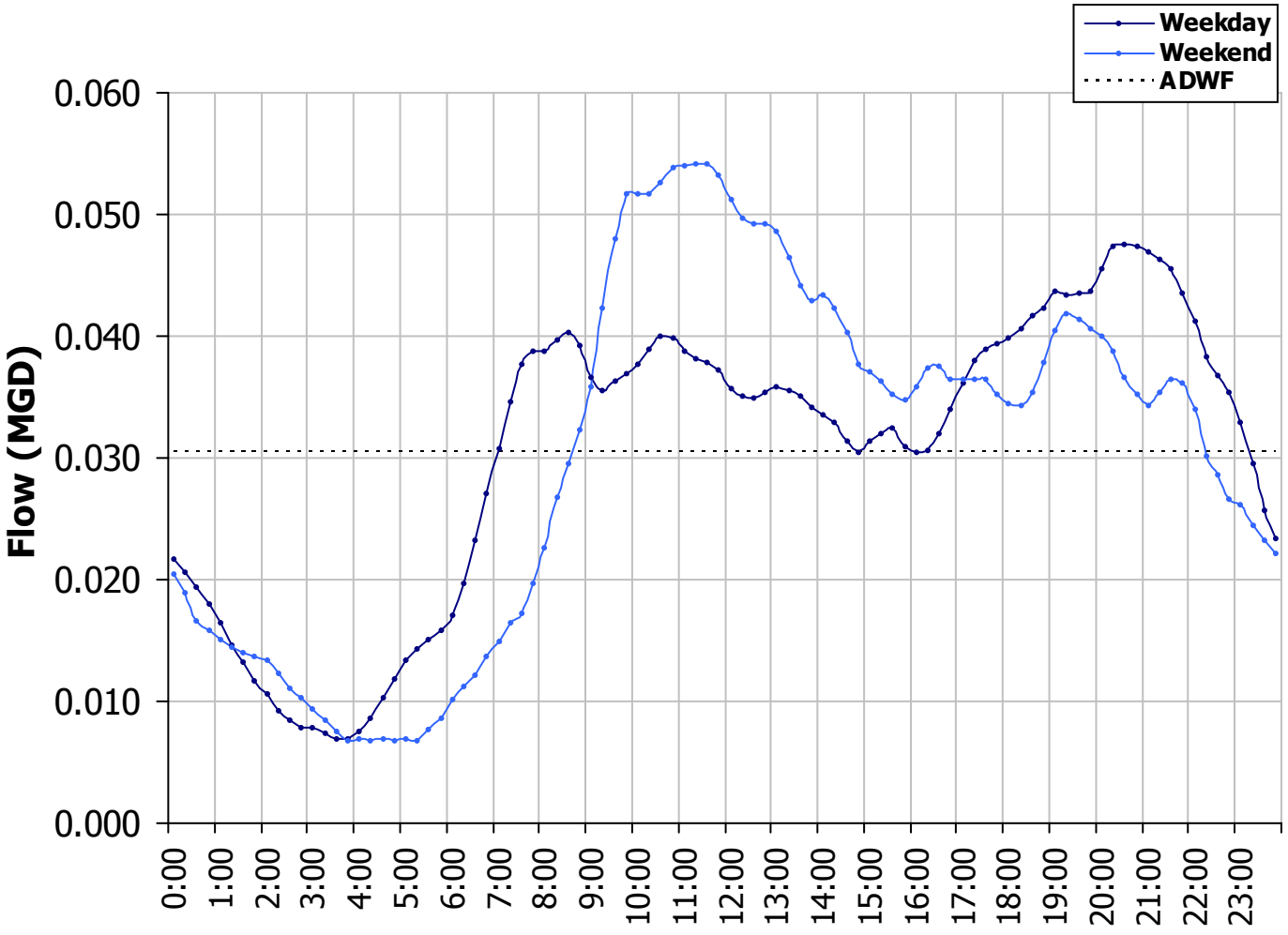


Storm Event #1 I/I Analysis

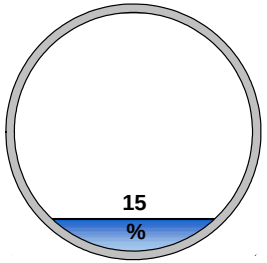
Rainfall:	0.76	*inches*		
Peak Flow:	0.097	*MGD*	**PF:**	3.18
Peak I/I Rate:	0.055	*MGD*	**Pk I/I:ADWF:**	1.82
Peak Level:	1.95	*inches*	**d/D Ratio:**	0.24
Total I/I:	13,000	*gallons*	**R-Value:**	1.0%
			I/I per ADWF:	0.56

Average Dry Weather Flow

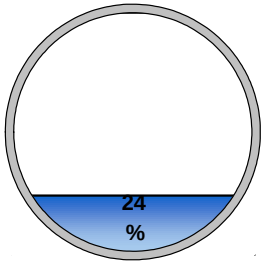
Monitoring Site:
Site 5



Average Dry Weather Flow:
0.030 *MGD*



Peak Measured Flow:
0.097 *MGD*



Peak measured flow shown on following pages in weekly flow data graphs

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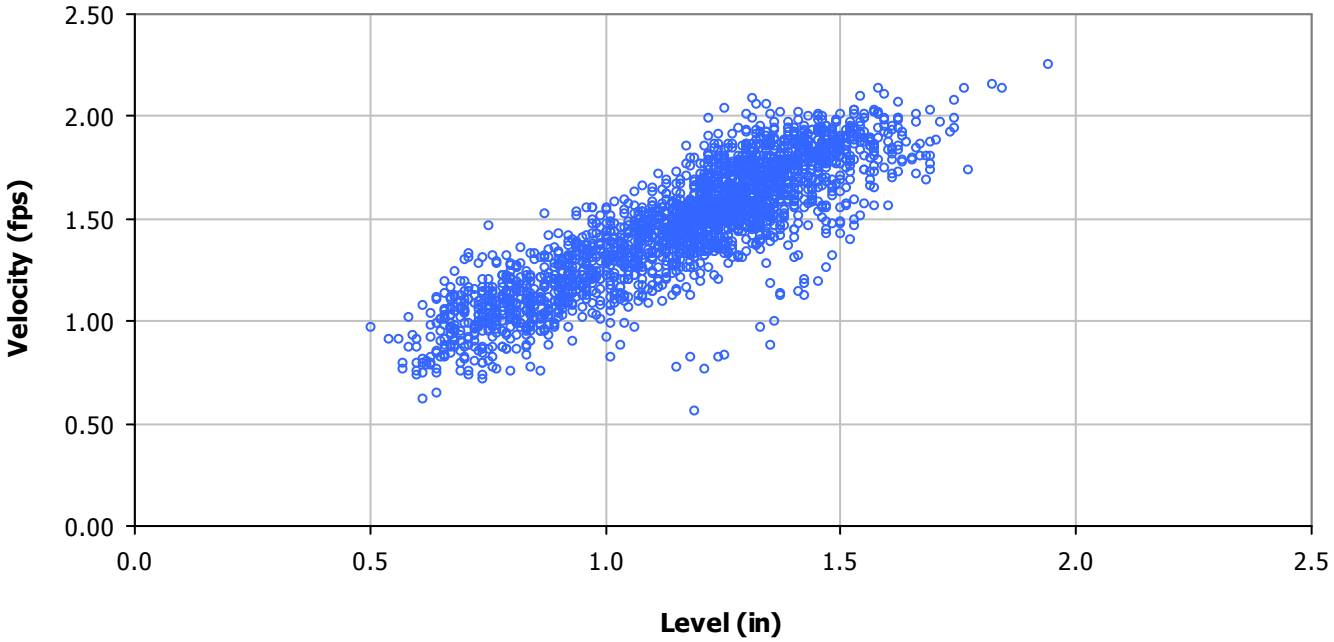
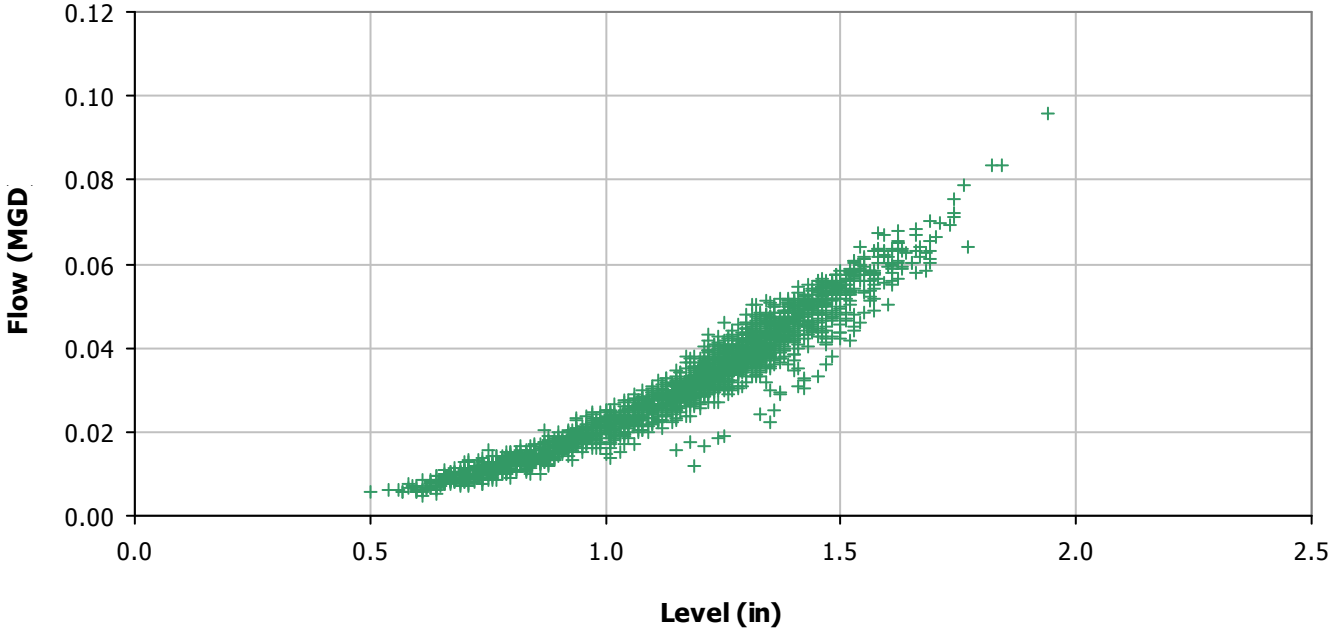
Scatter Plots
(Flow, Velocity vs. Depth)

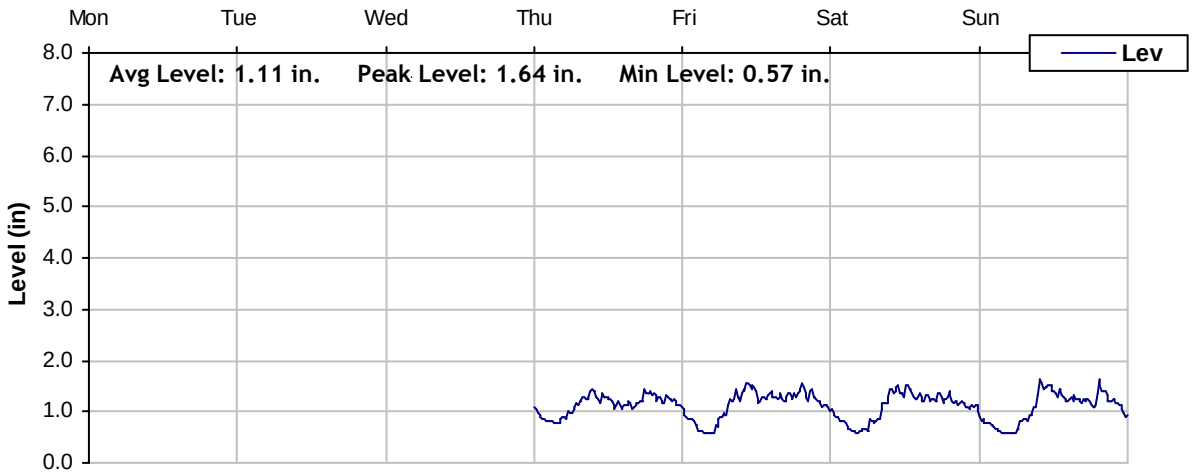
Monitoring Site:
Site 5

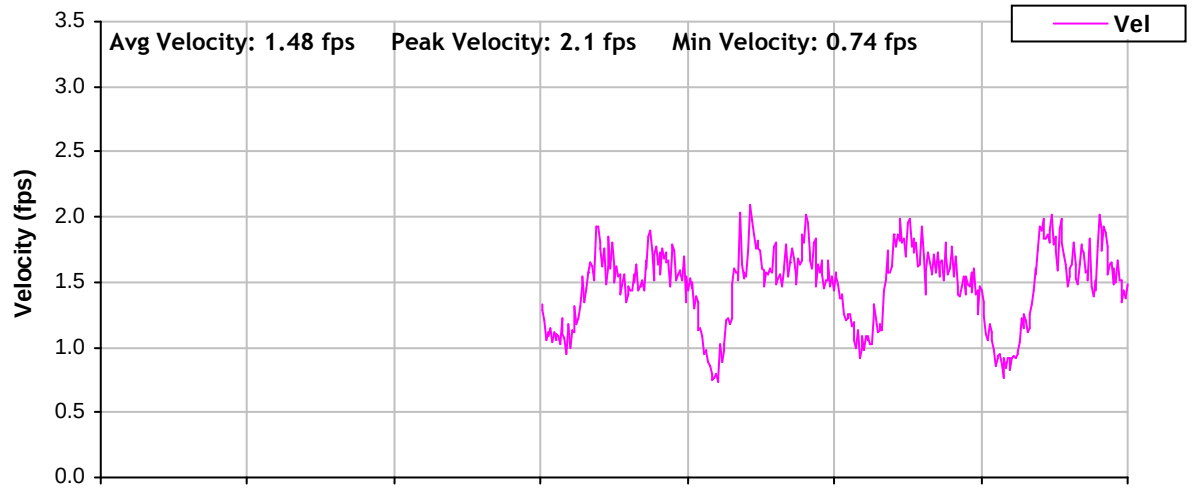


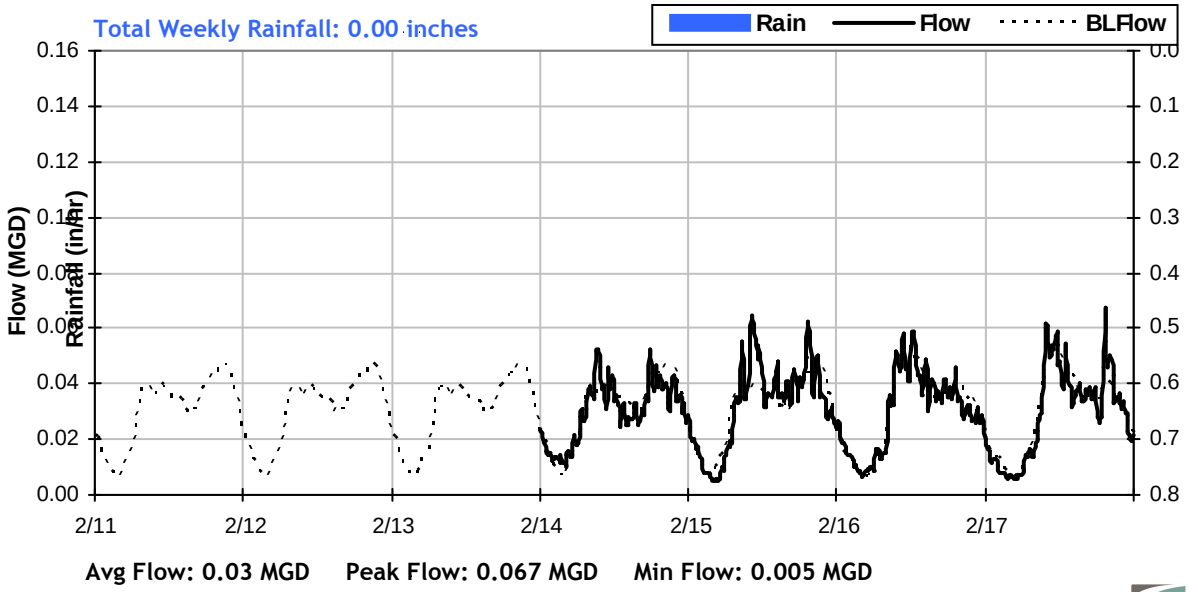


Level, Velocity and Flow
From 2/11/2008 to 2/18/2008

Monitoring Site:
Site 5







Avg Flow: 0.03 MGD Peak Flow: 0.067 MGD Min Flow: 0.005 MGD

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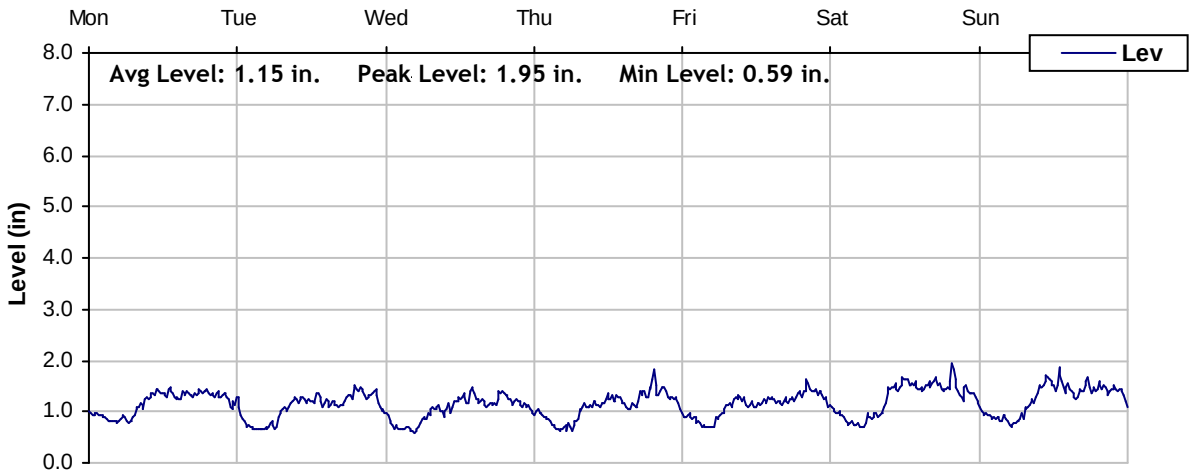
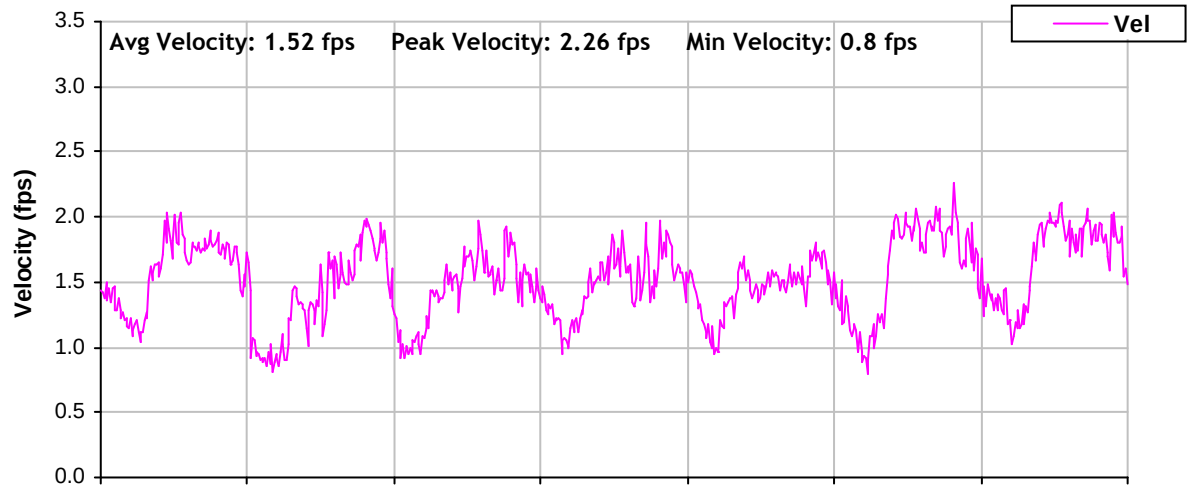
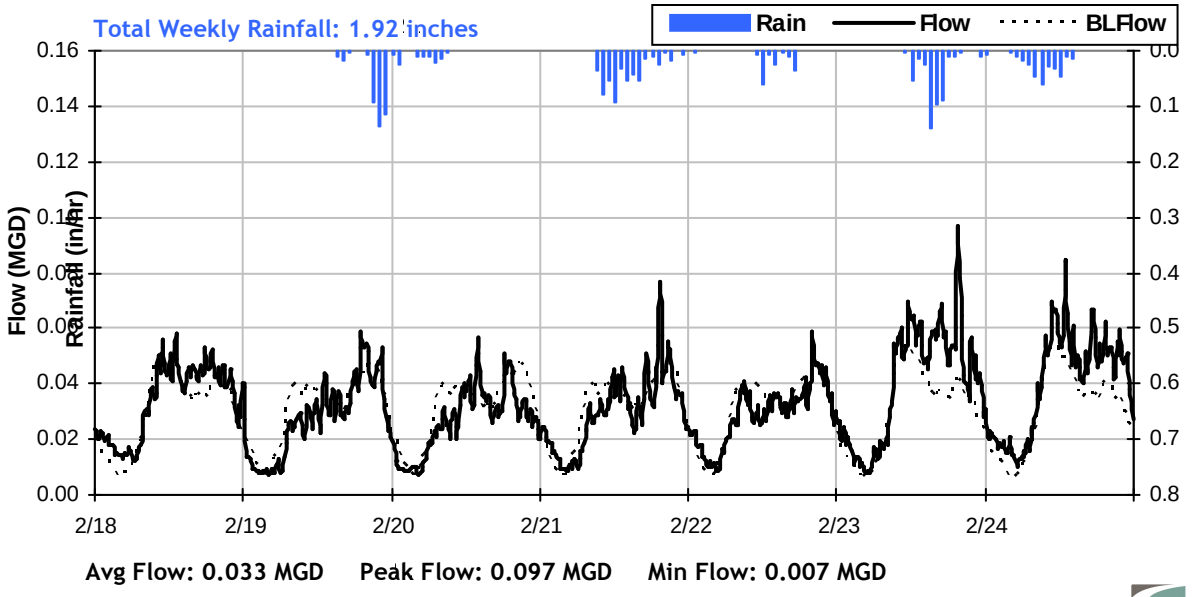
Level, Velocity and Flow
From 2/18/2008 to 2/25/2008

Monitoring Site:
Site 5



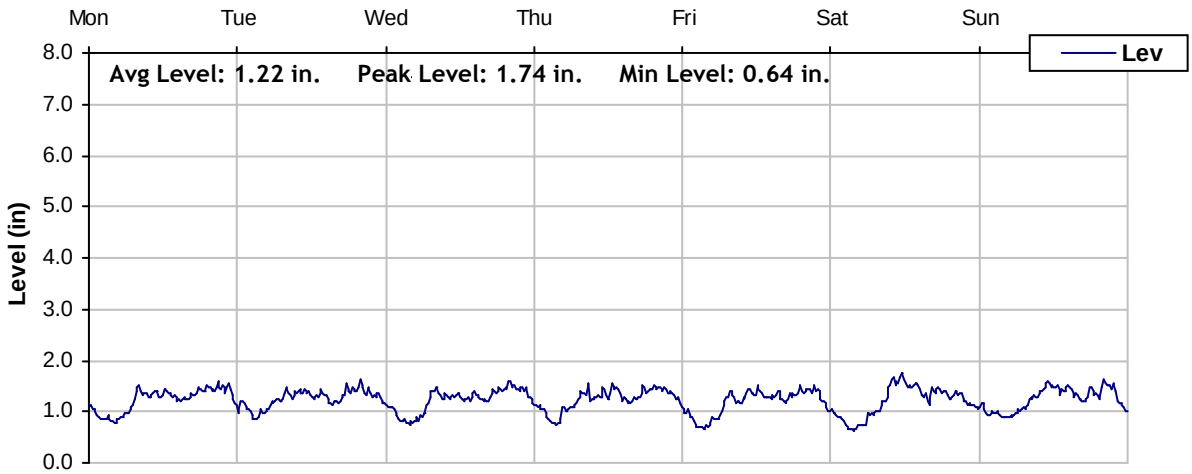


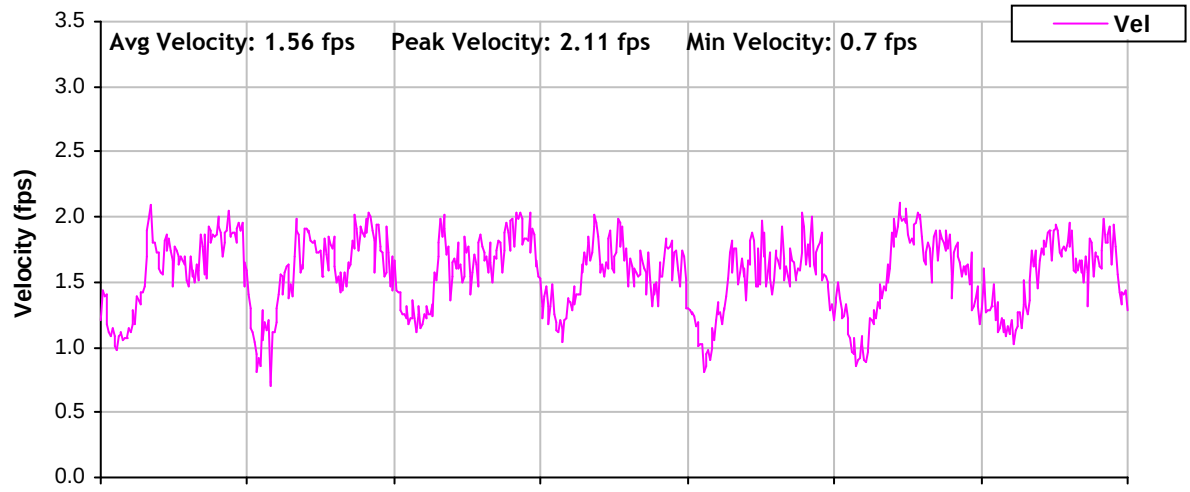


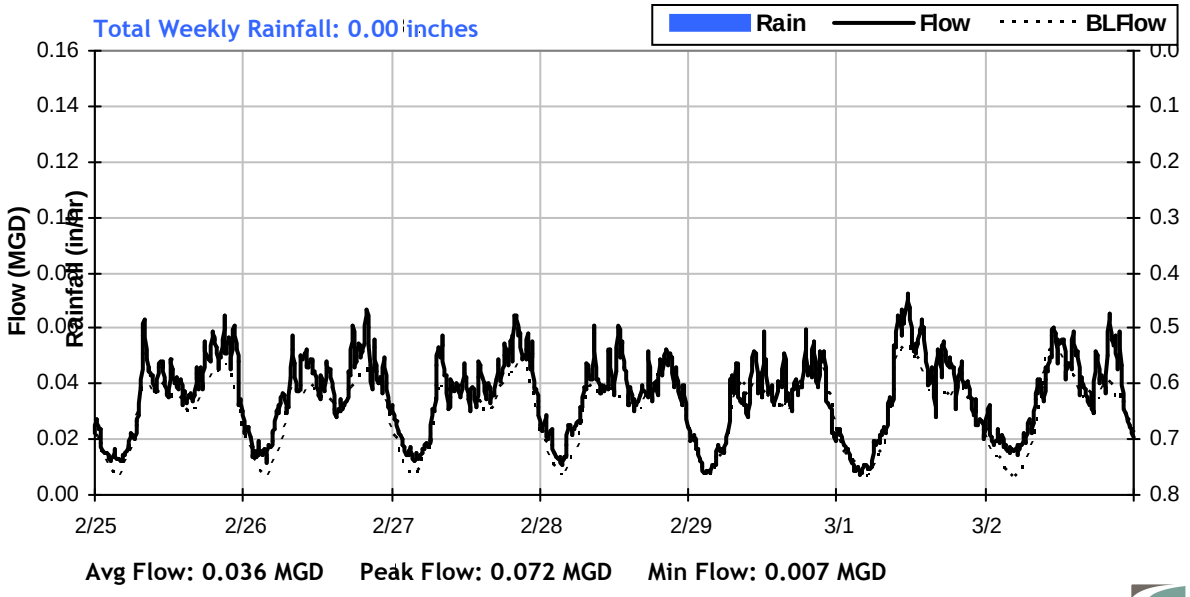
Avg Flow: 0.033 MGD Peak Flow: 0.097 MGD Min Flow: 0.007 MGD

Level, Velocity and Flow
From 2/25/2008 to 3/3/2008

Monitoring Site:
Site 5

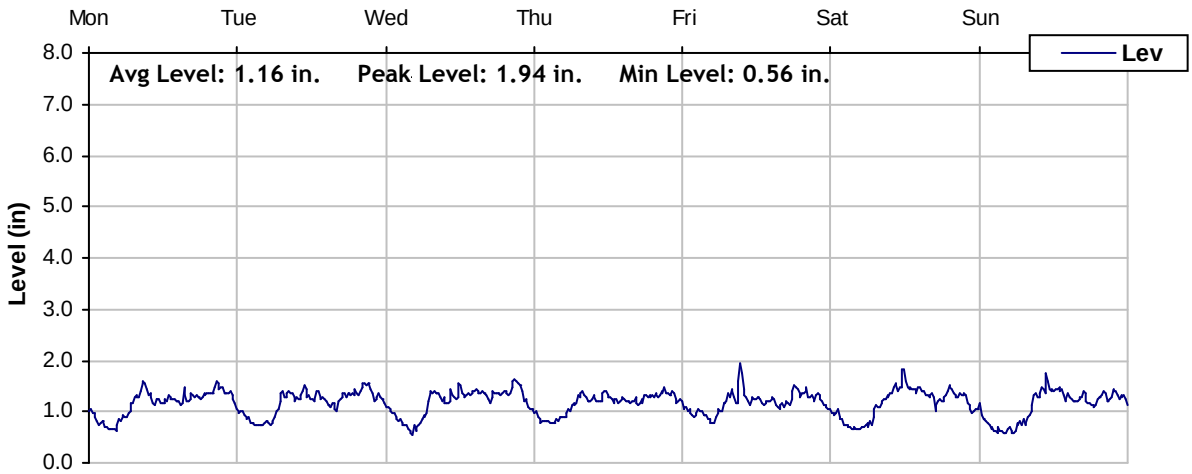


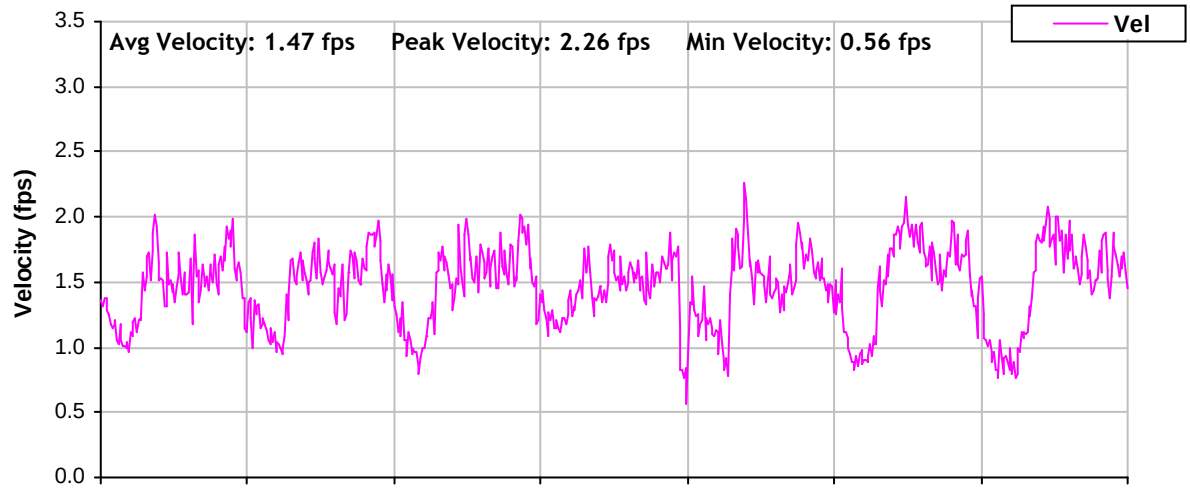


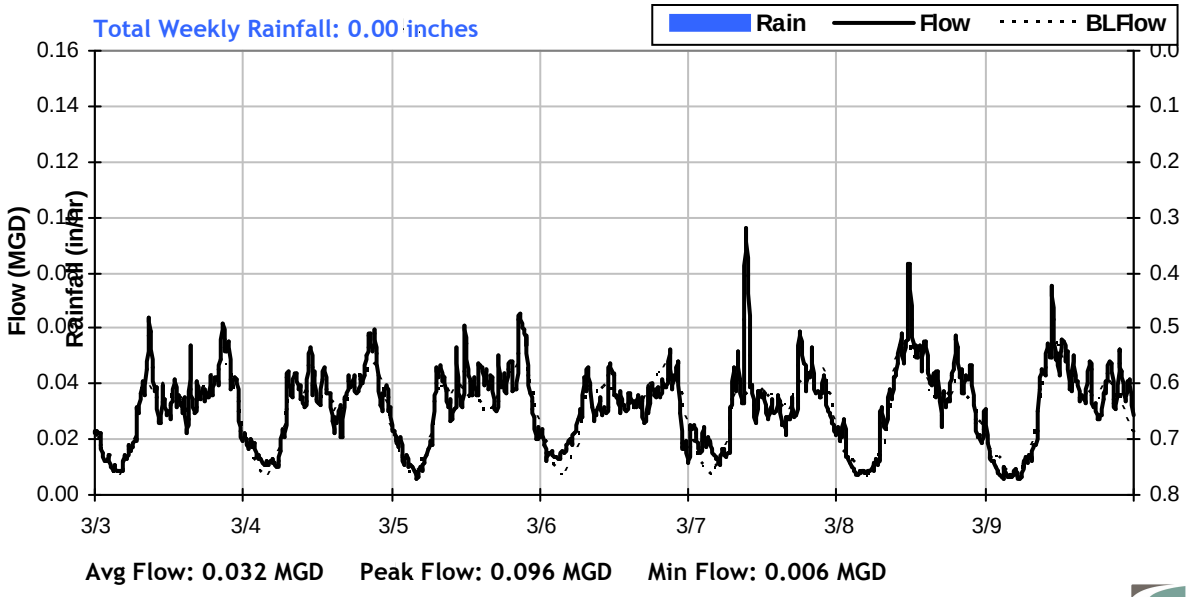


Level, Velocity and Flow
From 3/3/2008 to 3/10/2008

Monitoring Site:
Site 5







Avg Flow: 0.032 MGD Peak Flow: 0.096 MGD Min Flow: 0.006 MGD

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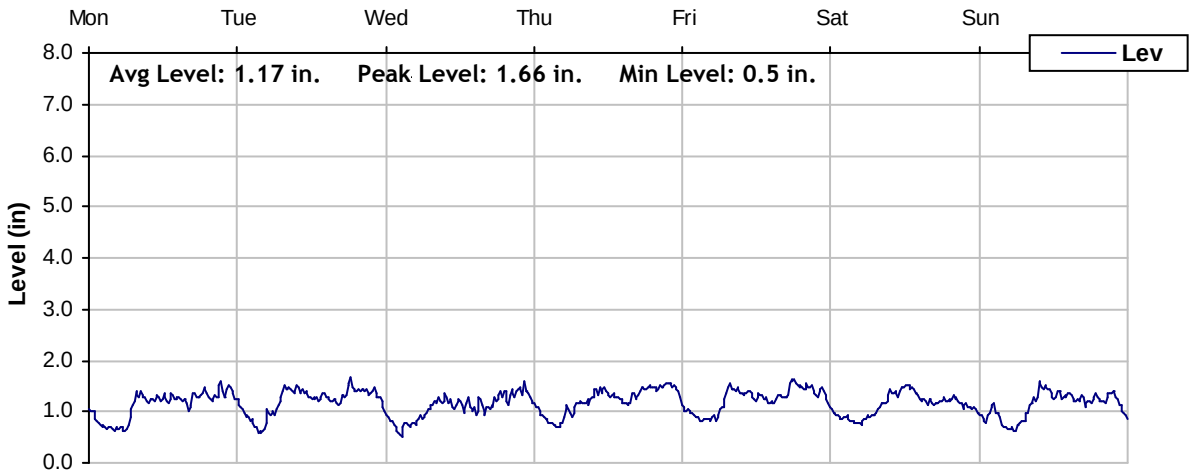
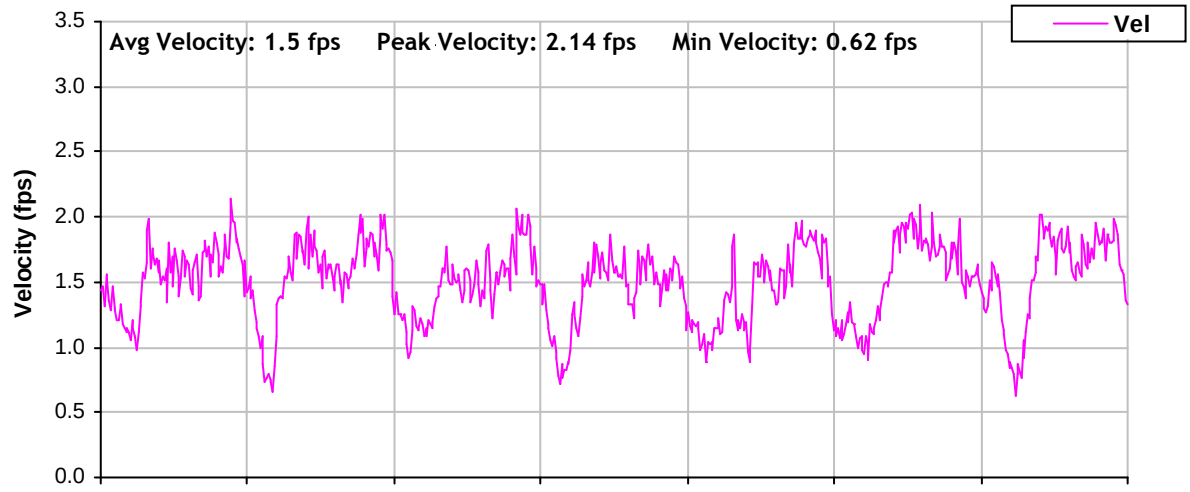
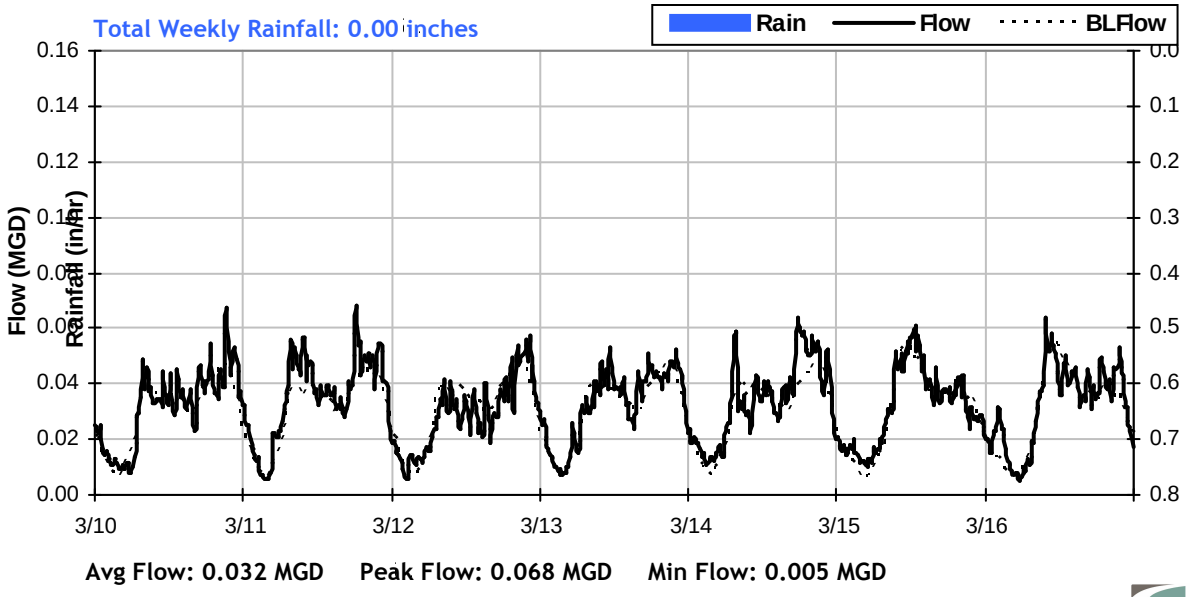
Level, Velocity and Flow
From 3/10/2008 to 3/17/2008

Monitoring Site:
Site 5

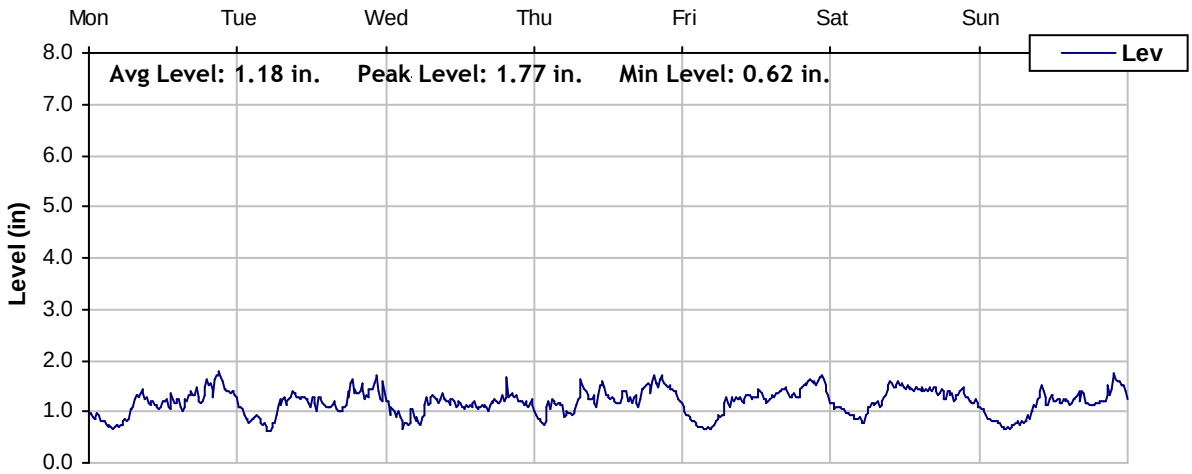


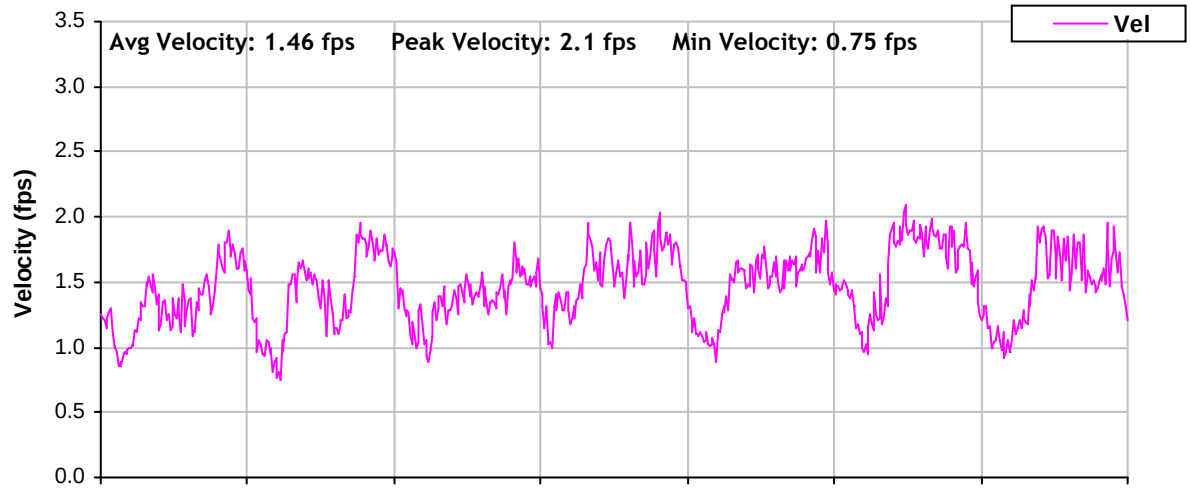


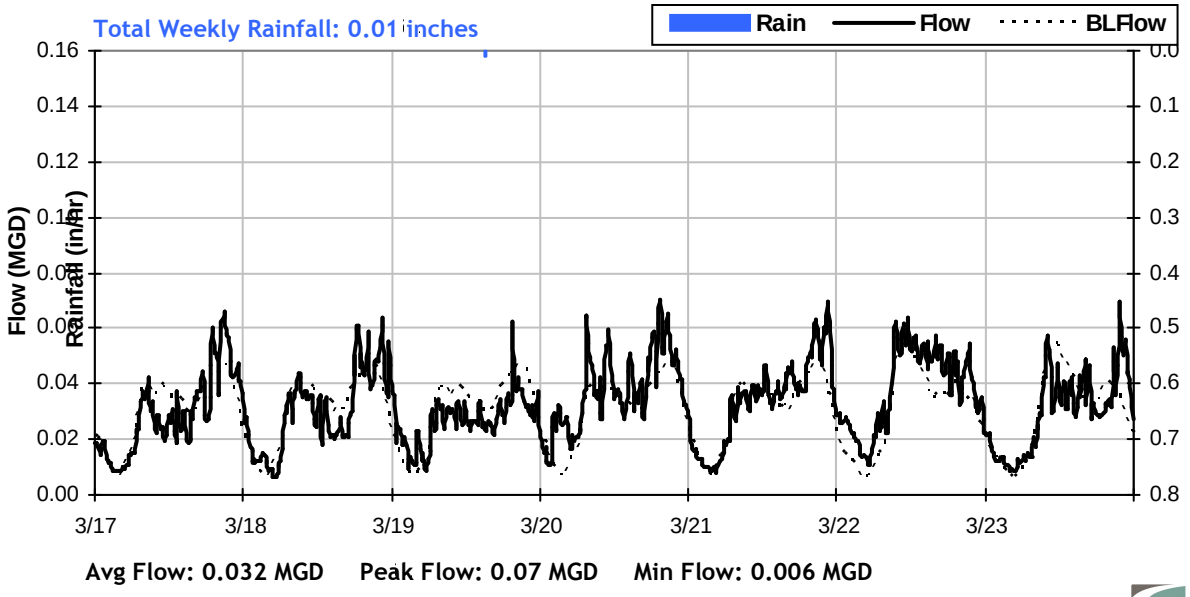


Level, Velocity and Flow
From 3/17/2008 to 3/24/2008

Monitoring Site:
Site 5

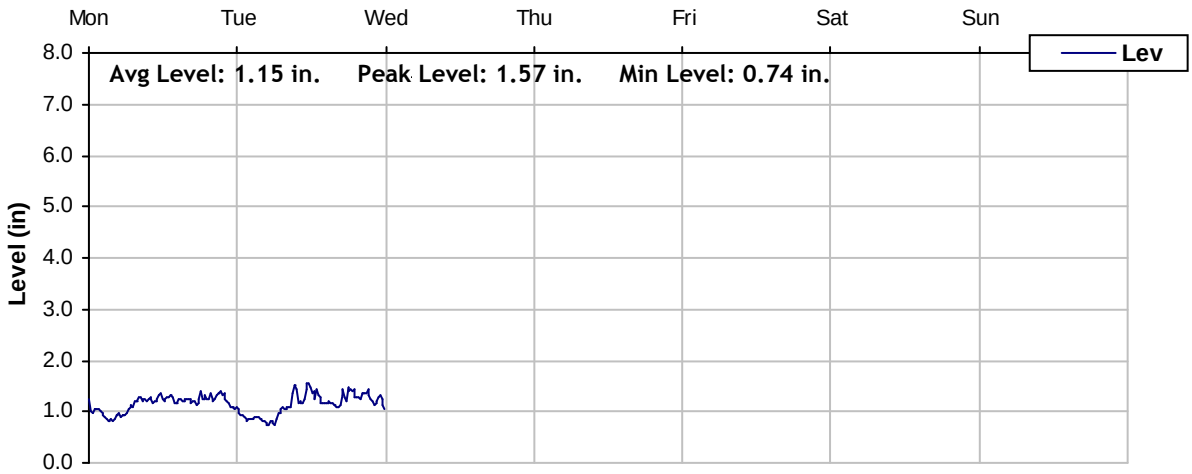


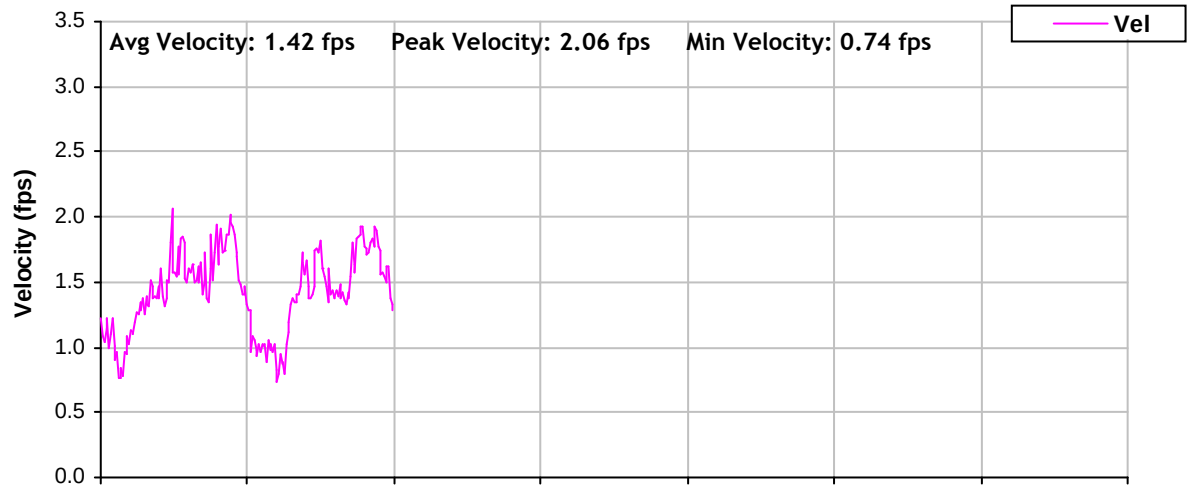


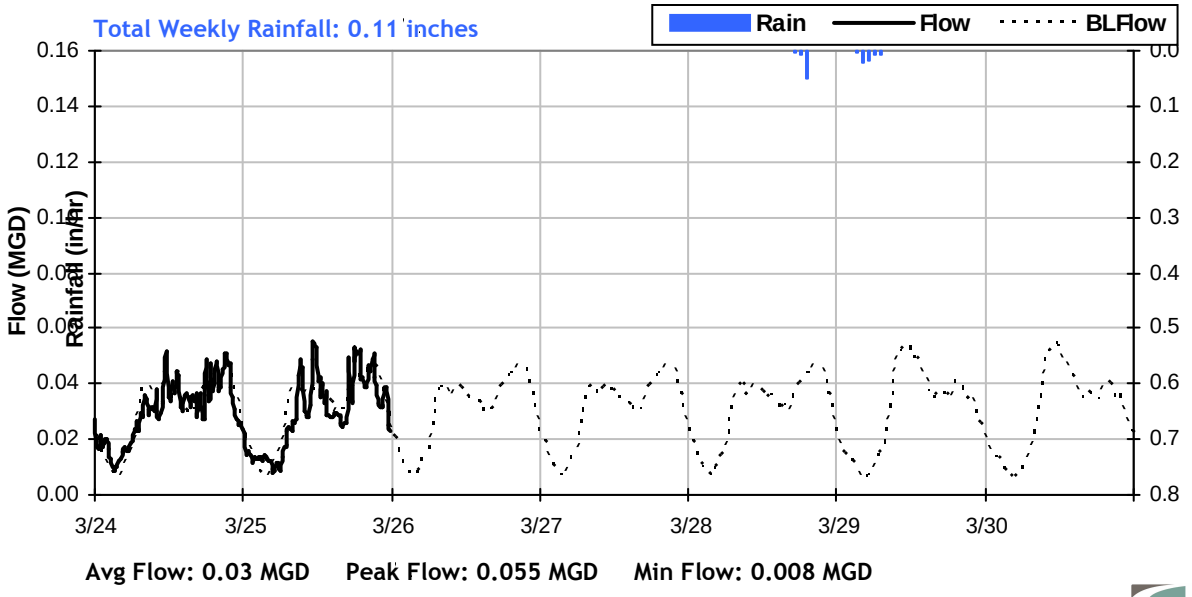


Level, Velocity and Flow
From 3/24/2008 to 3/31/2008

Monitoring Site:
Site 5







Avg Flow: 0.03 MGD Peak Flow: 0.055 MGD Min Flow: 0.008 MGD

V&A

Western Region
1999 Harrison Street, Suite 975
Oakland, CA 94612
510.903.6600 **Tel**
510.903.6601 **Fax**

Southwest Region
8291 Aero Place, Suite 110
San Diego, CA 92123
858.576.0226 **Tel**
858.576.0004 **Fax**

Northwest Region
14900 Interurban Avenue, Suite 268
Seattle, WA 96818
206.674.4560 **Tel**
206.674.4561 **Fax**

South Central Region
One Riverway, Suite 1700
Houston, TX 77056
713.840.6490 **Tel**
713.840.6491 **Fax**

vaengineering.com

Appendix B

Average Daily Dry Weather Flow Calibration Figures

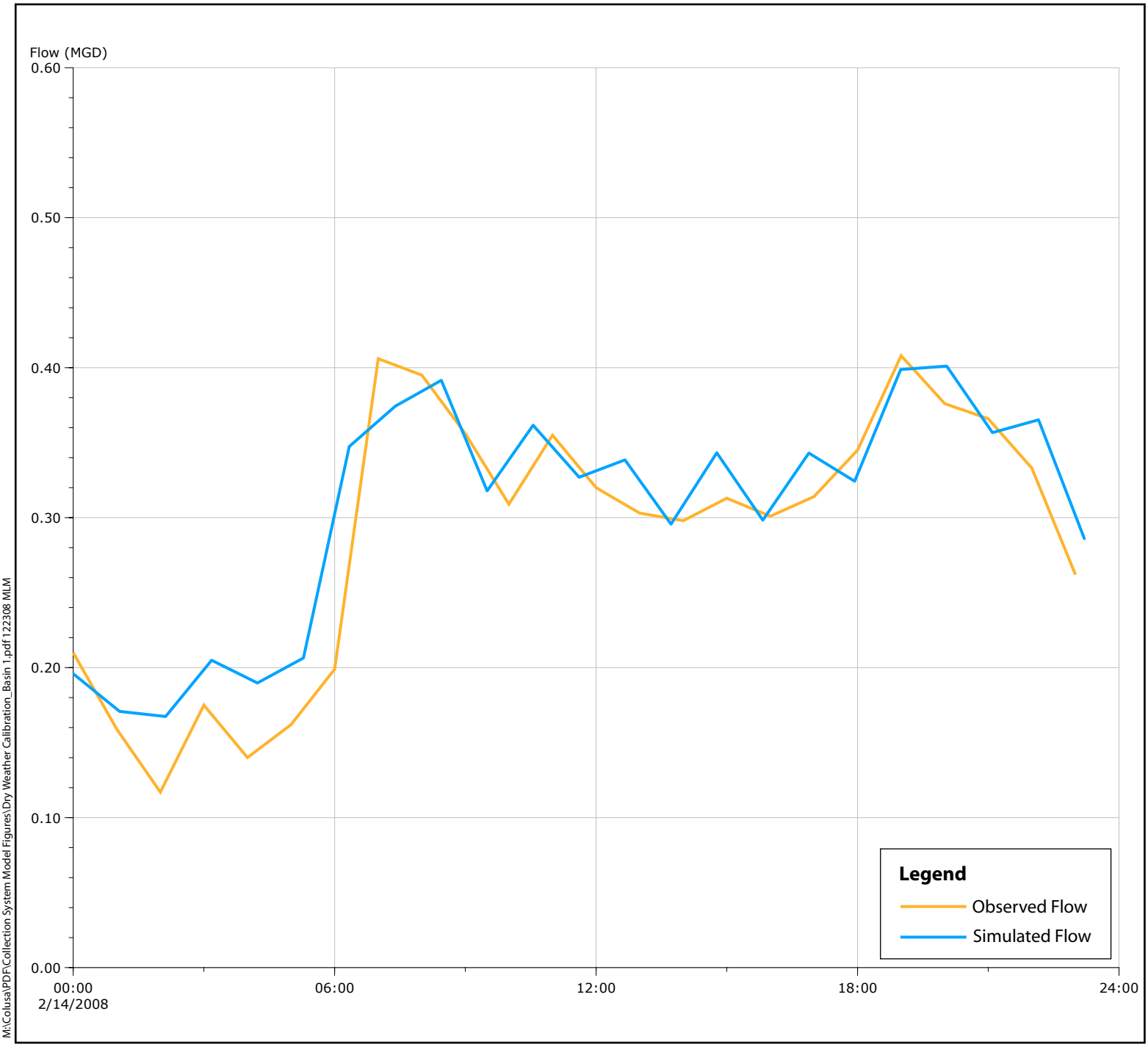


Figure B-1
Colusa Dry Weather Flow Calibration for Basin 1

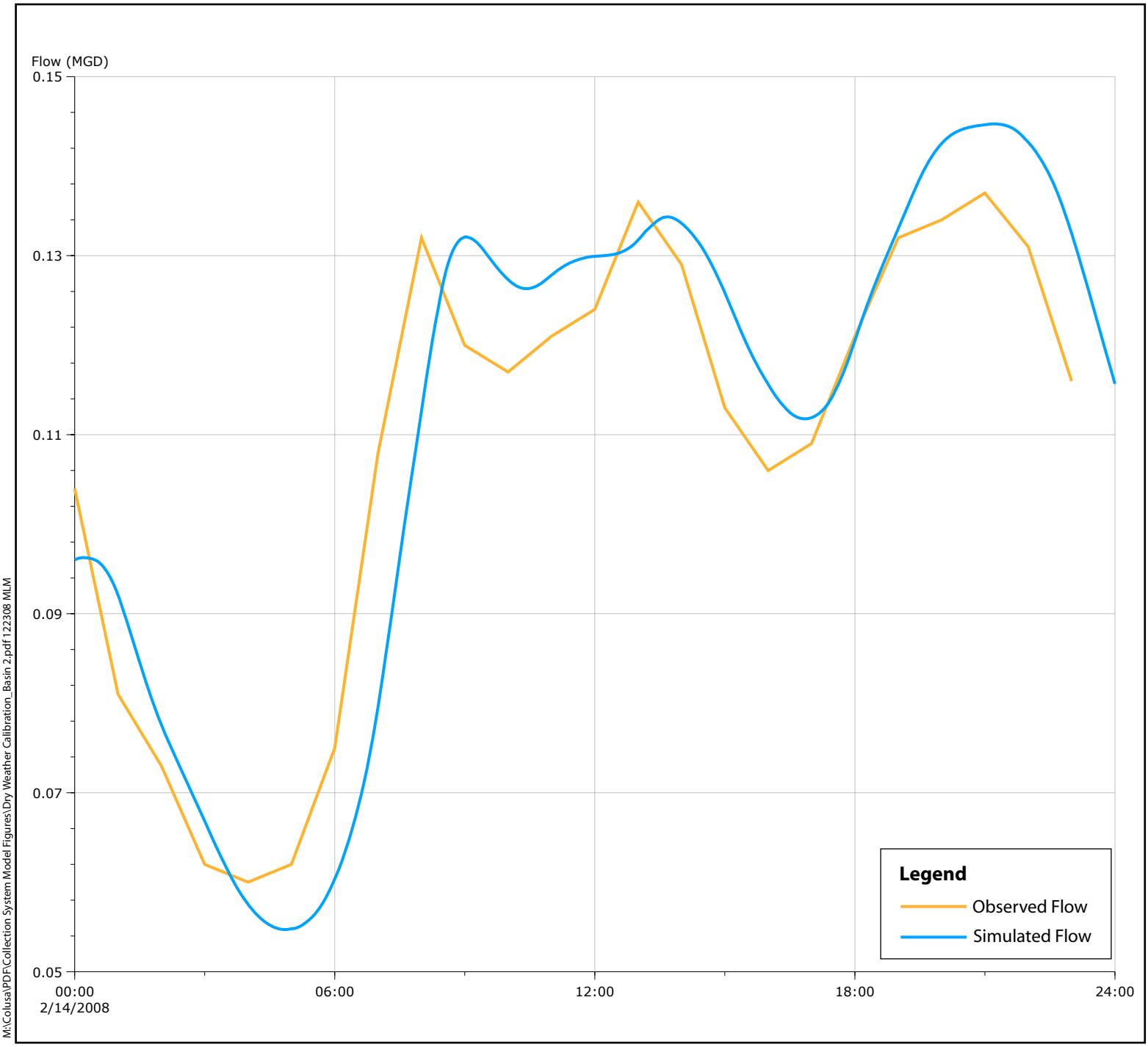


Figure B-2
Colusa Dry Weather Flow Calibration for Basin 2

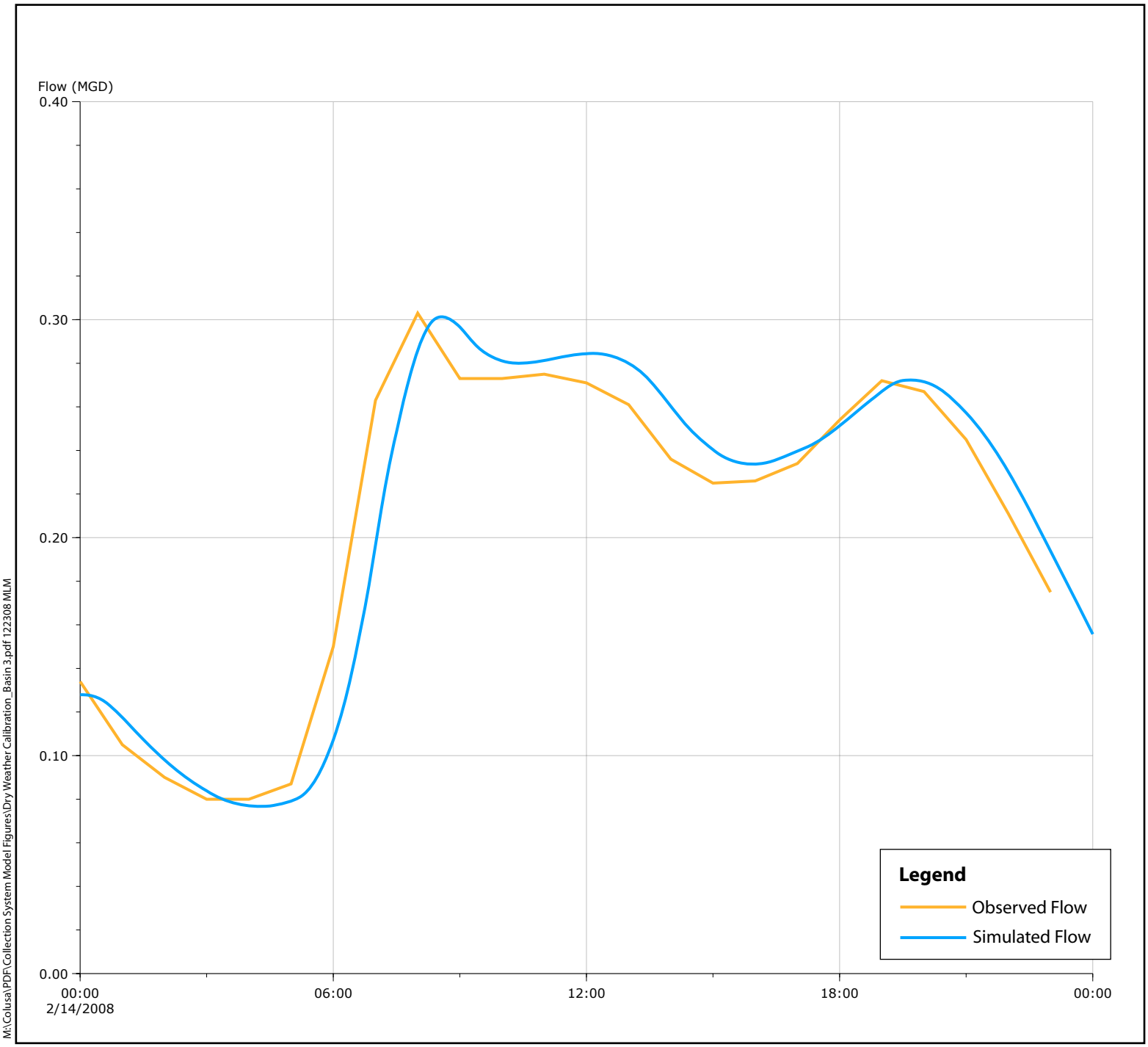
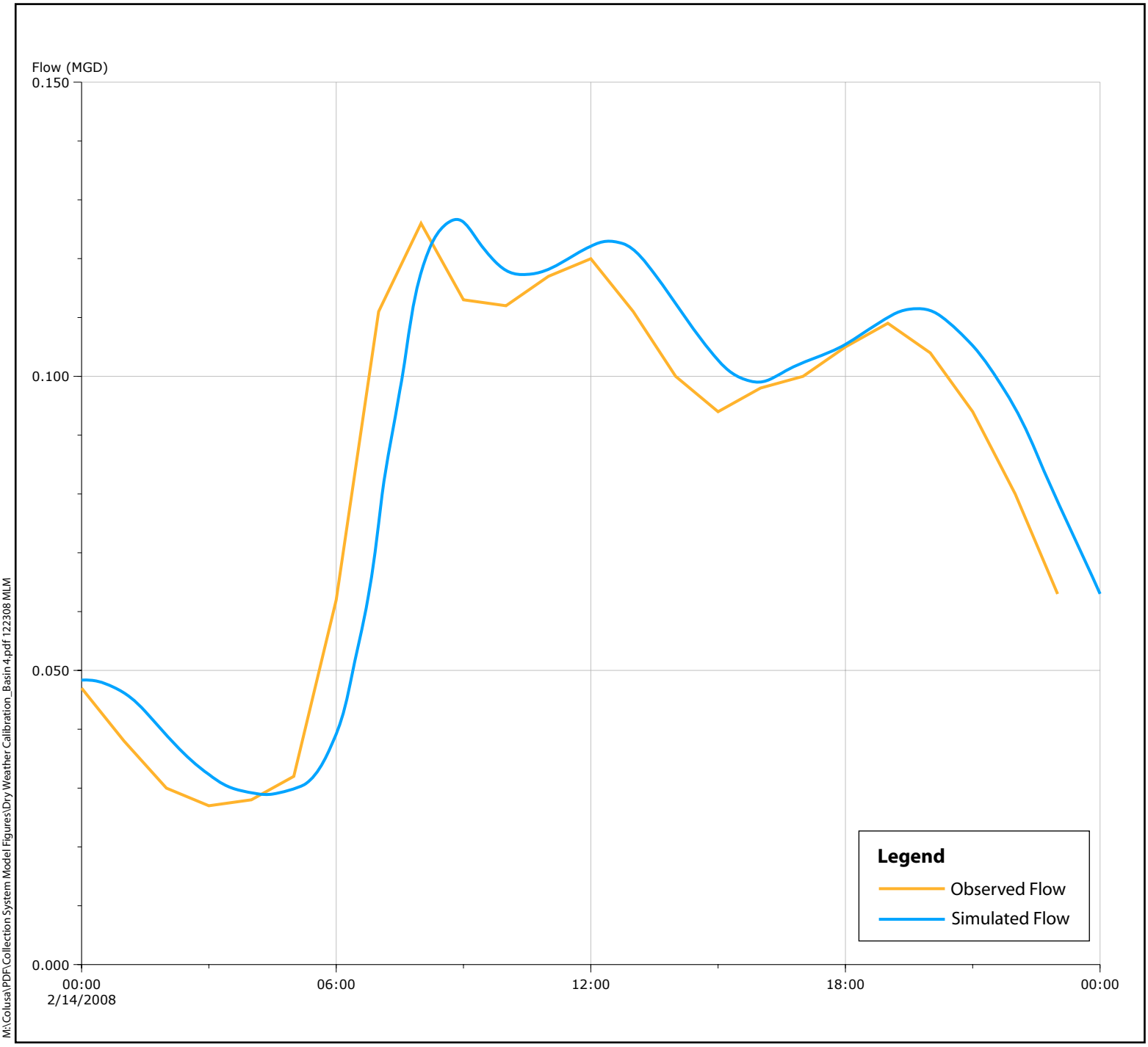


Figure B-3
Colusa Dry Weather Flow Calibration for Basin 3



M:\Colusa\PDF\Collection System Model Figures\Dry Weather Calibration_Basin 4.pdf 122308 MLM

Figure B-4
Colusa Dry Weather Flow Calibration for Basin 4

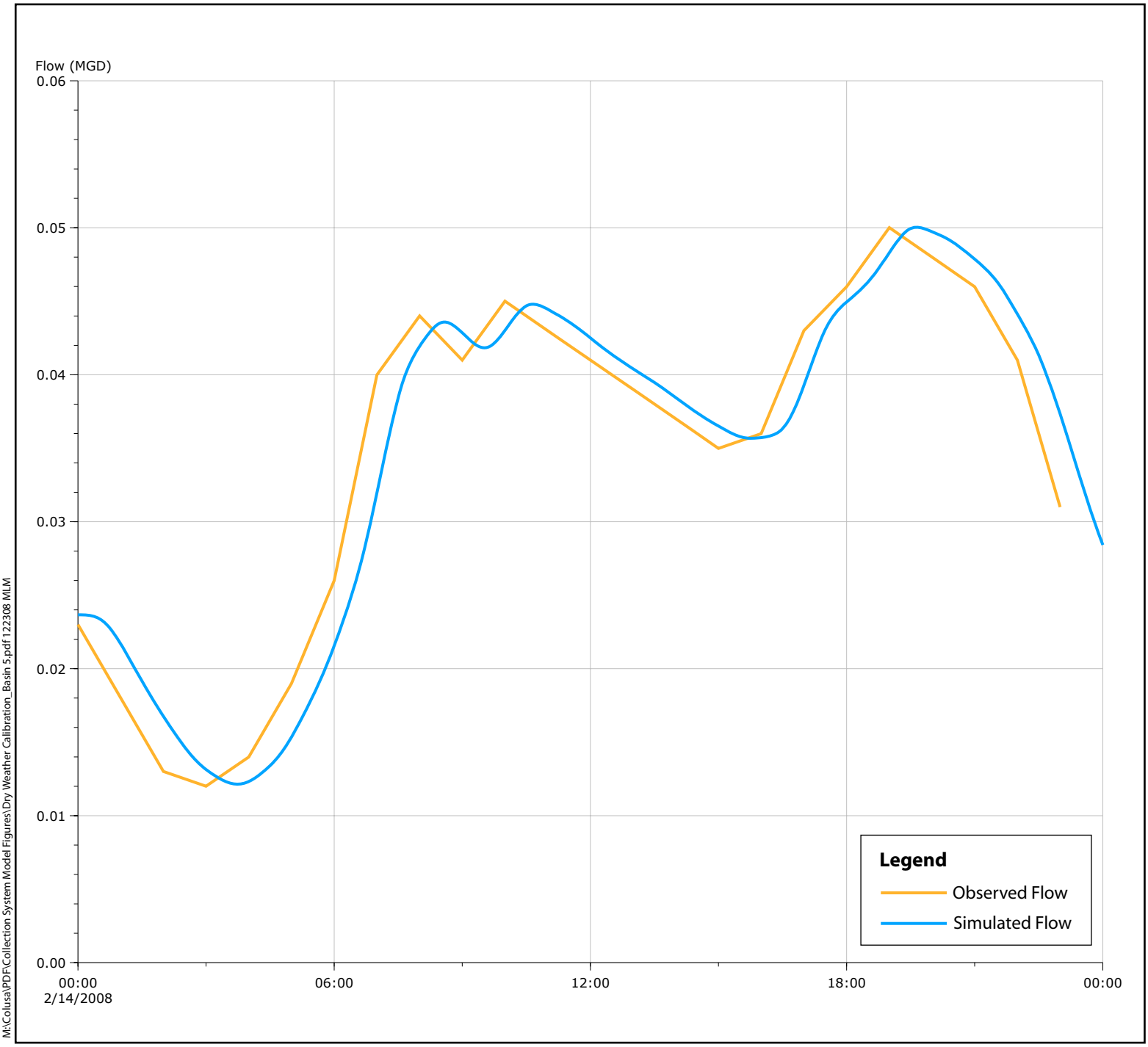


Figure B-5
Colusa Dry Weather Flow Calibration for Basin 5

Appendix C

Peak Hourly Wet Weather Flow Calibration Figures

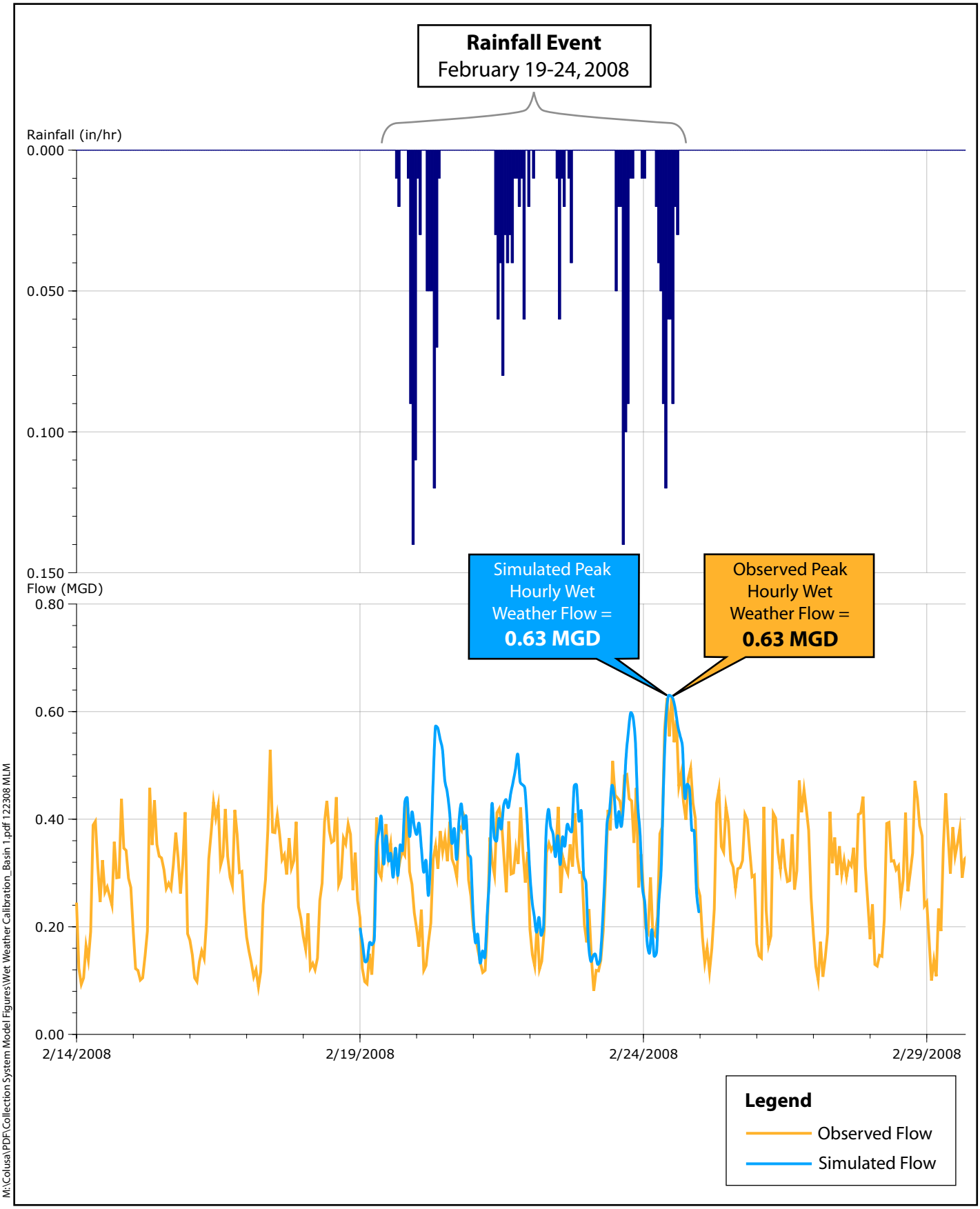


Figure C-1
Colusa Wet Weather Flow Calibration for Basin 1

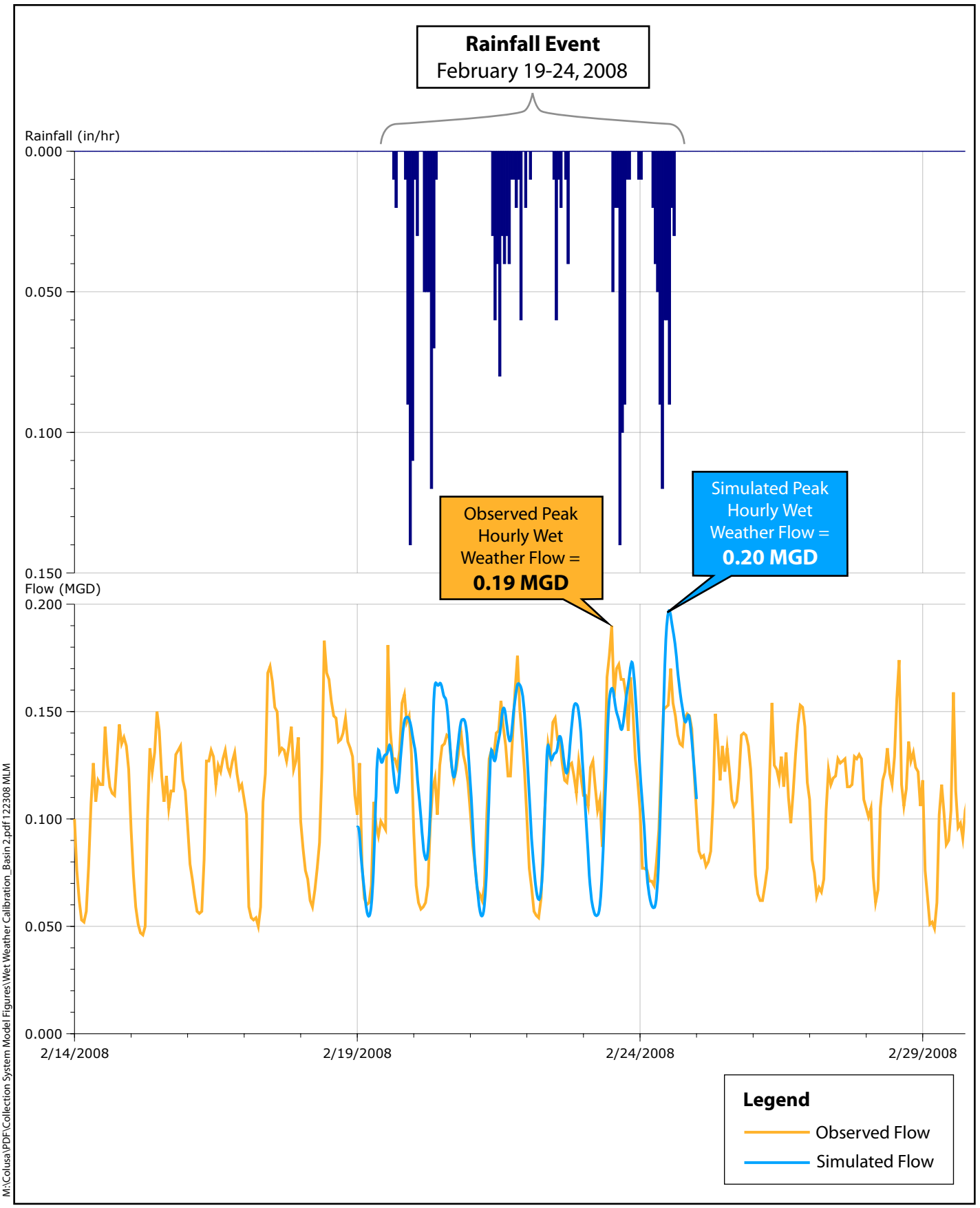


Figure C-2
Colusa Wet Weather Flow Calibration for Basin 2

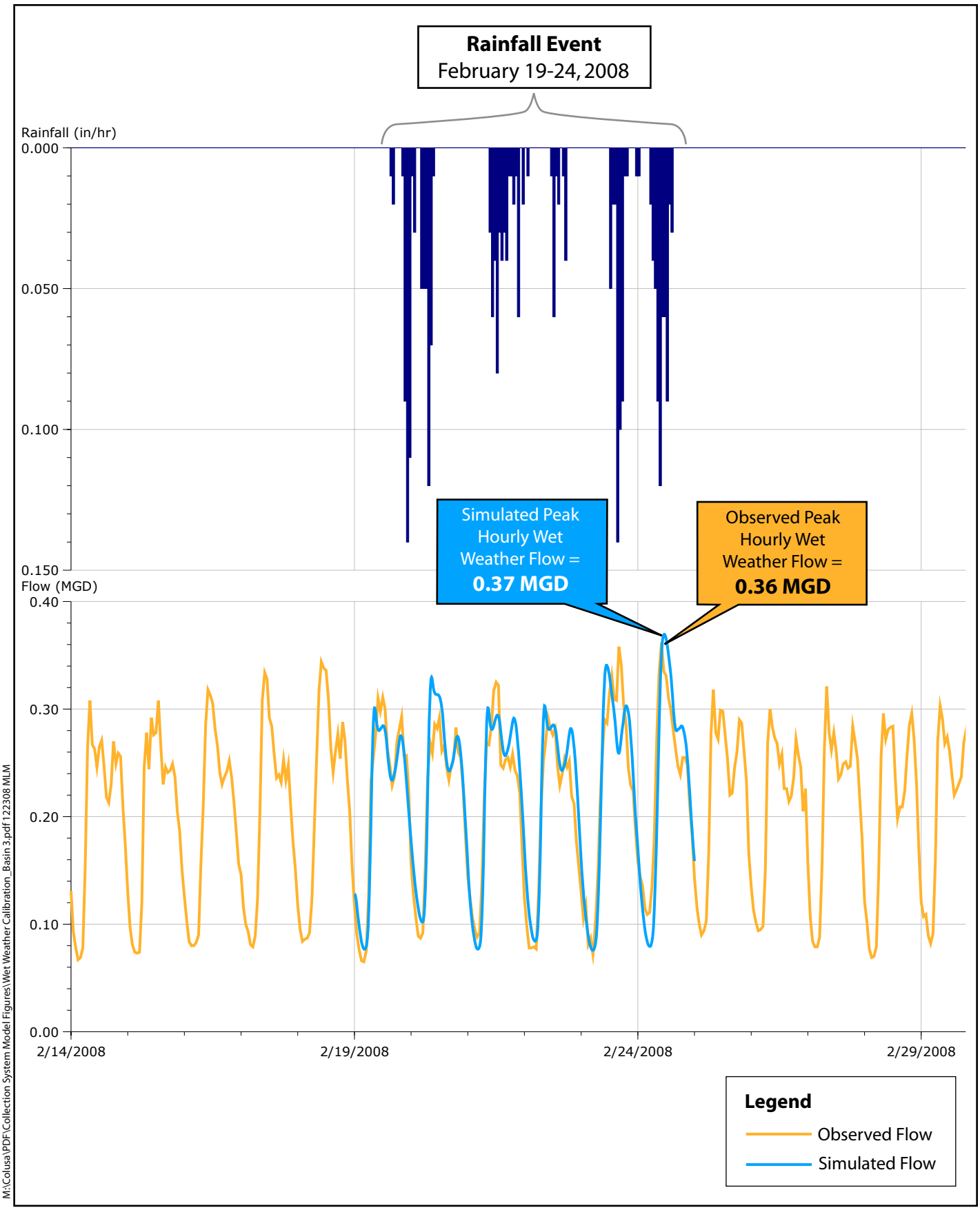


Figure C-3
Colusa Wet Weather Flow Calibration for Basin 3

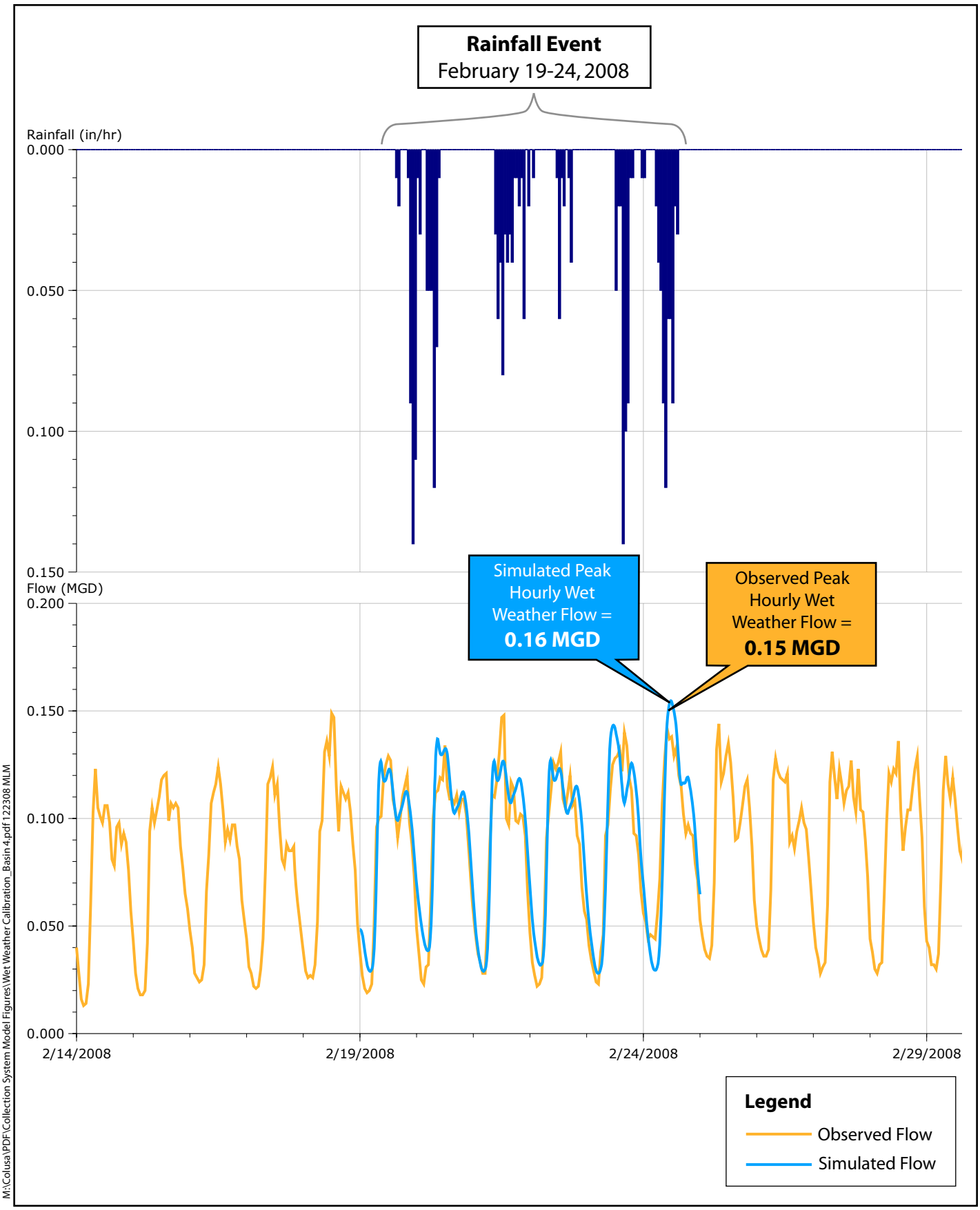


Figure C-4

Colusa Wet Weather Flow Calibration for Basin 4

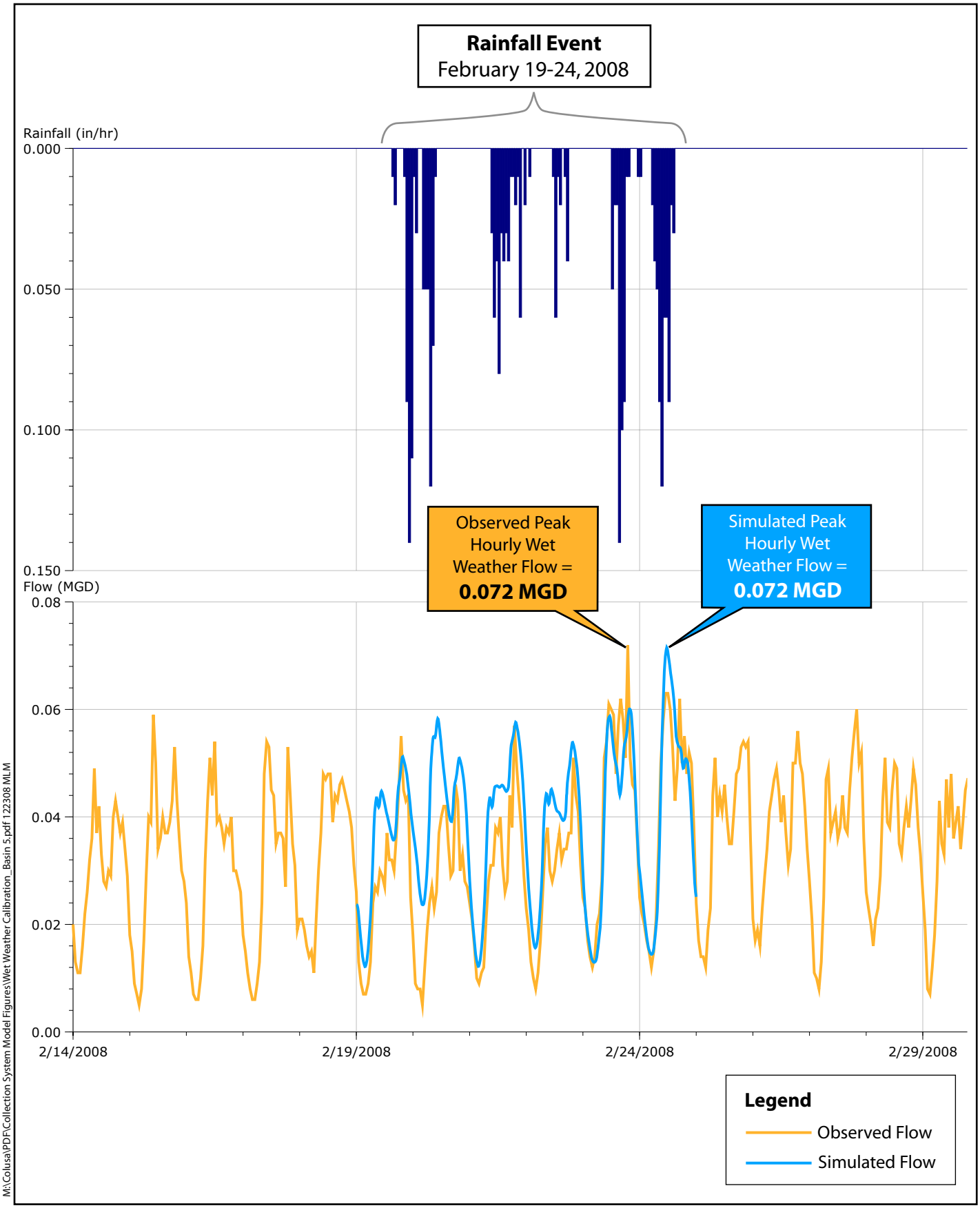


Figure C-5
Colusa Wet Weather Flow Calibration for Basin 5

Appendix D

Hydraulic Model Results

Table D-1
City of Colusa
Modeled Manhole Attributes [a]

MH ID	Rim Elev. (ft)	Floor Elev. (ft)	Max Water Level (ft) [b]
E04-004	60.43	53.26	53.36
E05-002	62.01	56.51	56.63
F04-000	56.93	50.36	50.72
F04-001	60.94	52.80	52.94
F04-005	60.95	52.64	52.78
F04-006	62.65	52.12	52.25
F04-017	61.11	51.70	51.90
F04-024	58.92	51.87	52.00
F04-025	58.96	51.25	51.48
F04-033	57.40	51.20	51.39
F04-034	57.62	50.47	50.94
F04-049	55.87	51.57	52.00
F04-050	57.40	52.60	52.92
F04-051	55.94	49.69	50.08
F05-001	59.92	56.03	56.19
F05-002	59.48	56.63	56.70
F05-003	60.44	57.51	57.58
F05-004	63.79	58.30	58.37
F05-006	59.52	55.68	55.92
F05-007	59.52	56.04	56.12
F05-008	60.51	57.12	57.19
F05-009	60.53	59.14	59.21
F05-011	58.69	55.09	55.41
F05-012	59.84	55.72	55.83
F05-013	60.26	56.44	56.53
F05-014	59.49	57.00	57.07
F05-016	58.76	54.62	54.90
F05-017	59.25	55.54	55.65
F05-018	59.15	56.12	56.22
F05-019	59.93	57.02	57.09
F05-021	58.38	53.90	54.34
F05-022	58.40	54.87	54.98
F05-023	58.60	55.57	55.66
F05-024	57.91	56.04	56.11
F05-025	59.01	53.15	53.52
F05-026	58.26	53.71	54.08
F05-027	57.75	54.33	54.45
F05-028	58.02	55.00	55.10
F05-029	57.31	55.52	55.59
G04-006	55.12	51.10	51.68
G04-008	55.06	50.52	50.63
G04-009	55.97	49.27	49.62
G04-011	54.55	50.99	51.36
G04-013	54.95	49.70	49.91
G04-014	56.08	48.63	49.07
G04-017	54.31	50.37	50.81

Table D-1
City of Colusa
Modeled Manhole Attributes [a]

MH ID	Rim Elev. (ft)	Floor Elev. (ft)	Max Water Level (ft) [b]
G04-018	54.73	49.04	49.27
G04-019	56.02	48.28	48.75
G04-020	54.61	50.69	50.87
G04-026	54.15	49.97	50.06
G04-027	53.13	47.74	48.22
G04-028	53.36	49.75	50.26
G04-030	52.50	48.49	48.61
G04-031	52.50	47.27	47.82
G04-037	53.15	49.11	49.70
G05-004	57.09	53.44	53.58
G05-005	57.59	55.71	55.78
G05-010	56.10	52.88	53.08
G05-011	57.09	53.45	53.52
G05-014	55.78	49.24	49.32
G05-018	56.23	51.23	51.31
G05-019	55.70	52.40	52.70
G05-020	55.73	52.89	52.96
G05-021	55.40	48.35	48.49
G05-022	55.96	49.41	49.54
G05-028	55.49	52.13	52.37
G05-029	56.31	50.31	50.38
G05-030	56.24	49.49	49.56
G05-031	55.11	47.55	47.71
G05-032	55.91	48.82	48.89
G05-033	55.14	48.12	48.19
G05-034	56.14	46.57	46.75
G05-035	55.08	47.65	47.73
G05-041	55.11	51.36	51.75
G06-001	58.79	50.34	50.41
H04-002	53.43	47.74	47.87
H04-003	52.80	47.35	47.50
H04-004	52.24	46.82	47.38
H04-005	52.00	47.48	47.99
H04-008	53.32	48.09	48.57
H04-009	53.57	48.69	49.17
H04-010	54.27	48.46	48.76
H04-011	52.09	46.42	47.23
H04-014	53.44	46.98	47.08
H04-015	56.72	47.58	47.90
H04-016	51.62	45.19	47.01
H04-017	56.55	46.96	47.30
H04-018	53.37	46.60	47.01
H04-019	54.58	46.00	47.00
H04-020	55.71	46.38	47.19
H04-021	54.97	45.22	47.00

Table D-1
City of Colusa
Modeled Manhole Attributes [a]

MH ID	Rim Elev. (ft)	Floor Elev. (ft)	Max Water Level (ft) [b]
H05-001	57.57	50.26	50.57
H05-003	55.93	50.60	50.98
H05-004	55.55	51.18	51.47
H05-005	55.28	44.51	44.71
H05-006	54.94	45.00	45.20
H05-009	57.32	38.65	41.75
H05-011	54.41	49.13	50.86
H05-012	54.87	48.57	50.85
H05-015	50.89	43.57	44.35
H05-016	54.07	43.43	44.24
H05-018	55.36	48.26	48.49
H05-019	54.02	48.56	48.81
H05-020	53.79	49.80	49.98
H05-021	54.26	49.80	50.34
H05-022	53.29	48.57	50.47
H05-023	53.78	47.59	50.76
H05-024	53.34	48.52	50.47
H05-027	55.00	46.77	47.01
H05-028	53.83	45.99	46.47
H05-029	53.36	47.22	47.49
H05-030	53.88	48.20	48.30
H05-031	53.70	46.52	50.59
H05-032	52.69	49.00	49.07
H05-033	52.51	48.93	50.46
H05-034	53.50	47.80	50.45
H05-035	53.43	47.80	50.42
H05-036	53.22	48.35	50.43
H05-037	52.67	48.81	50.44
H05-039	53.38	47.33	50.43
I04-001	55.32	44.47	47.09
I04-002	54.47	44.47	47.11
I04-003	55.38	44.43	46.99
I04-004	54.61	44.90	47.14
I04-005	52.19	44.14	46.90
I04-006	52.83	40.50	46.78
I04-008	53.46	47.02	47.73
I04-009	53.14	47.03	47.74
I04-010	51.81	46.88	47.54
I04-011	51.74	46.14	46.81
I04-013	51.67	46.02	46.70
I05-002	52.89	46.71	47.28
I05-006	53.25	45.20	50.42
I05-007	53.15	46.61	50.42
I05-008	53.38	47.33	50.42
I05-009	52.90	46.35	47.24

Table D-1
City of Colusa
Modeled Manhole Attributes [a]

MH ID	Rim Elev. (ft)	Floor Elev. (ft)	Max Water Level (ft) [b]
I05-010	52.80	46.61	47.25
I05-011	53.65	48.88	48.95
I05-012	52.74	47.40	50.43
I05-013	53.04	44.77	50.40
I05-014	52.55	47.89	50.44
I05-015	52.31	48.44	50.44
I05-016	53.18	49.18	49.25
I05-017	52.91	47.84	50.43
I05-018	52.89	47.30	47.56
I05-019	52.67	48.52	48.60
I05-020	51.48	42.15	49.57
I05-021	50.66	43.48	49.57
I05-022	52.51	49.18	50.44
I05-023	52.65	44.32	50.34
I05-024	52.59	41.16	50.30
I05-025	53.61	47.71	47.85
I05-030	52.47	46.95	50.31
I05-031	52.30	43.78	50.31
I05-032	51.49	46.98	49.71
I05-033	51.56	40.23	49.56
I05-036	52.16	44.40	52.13
I05-037	52.28	43.42	50.30
I05-038	51.78	46.11	50.31
I05-040	52.24	42.63	50.30
I05-041	52.28	46.30	49.40
I05-042	51.75	32.05	49.38
I05-043	50.89	37.10	49.40
I05-047	52.43	43.27	50.27
I05-048	52.53	43.23	50.26
I05-054	51.20	45.29	50.23
I05-055	51.29	46.24	50.20
I05-056	52.34	43.41	50.30
I05-057	52.08	44.38	50.30
I05-060	52.44	43.59	50.30
I05-062	51.93	46.91	50.18
I05-066	51.60	37.95	49.63
I05-067	51.49	46.24	49.86
I06-001	52.34	48.25	48.74
I06-005	52.64	49.15	49.59
Indian Oaks PS	50.80	30.90	50.20
J03-001	51.67	45.19	45.99
J03-002	51.67	45.05	45.85
J03-003	50.48	44.51	44.79
J03-004	50.17	43.46	44.32
J03-005	52.70	40.65	44.22

Table D-1
City of Colusa
Modeled Manhole Attributes [a]

MH ID	Rim Elev. (ft)	Floor Elev. (ft)	Max Water Level (ft) [b]
J03-006	51.00	45.08	45.78
J03-007	51.07	44.94	45.46
J05-001	53.26	44.60	50.29
J05-002	51.95	43.96	50.30
J05-003	51.99	42.72	50.20
J05-004	53.21	44.61	50.29
J05-007	51.78	42.70	50.19
J05-012	49.83	45.50	50.12
J05-014	50.75	38.84	49.86
J05-020	52.49	42.00	50.10
J05-026	51.47	43.91	50.07
J05-027	52.96	41.86	50.08
J05-028	49.52	44.40	50.01
J05-031	50.27	39.70	49.87
J05-033	53.51	41.37	50.02
J05-040	49.65	45.54	50.01
J05-041	49.87	40.36	49.87
J05-043	54.82	40.70	49.93
J05-045	49.82	46.09	50.02
J05-048	54.70	40.60	49.92
J05-049	49.48	41.03	49.87
J05-058	49.49	43.23	49.81
J05-061	54.12	40.11	49.85
J05-062	49.87	42.60	49.81
J05-063	49.96	45.34	49.97
J05-064	49.38	41.92	49.80
K05-001	53.48	39.75	49.81
K05-003	53.25	39.63	49.79
K05-004	49.98	40.94	49.79
K05-005	52.90	39.04	49.72
K05-006	52.29	38.43	49.61
K05-007	51.97	29.44	49.56
K05-012	53.23	39.58	49.78
L04-006	51.00	38.40	WWTP

[a] MH = manhole, WWTP = wastewater treatment plant.
[b] Model results of existing level of development at 10-year, 6-hour design storm.

Table D-2
City of Colusa
Modeled Sewer Line Attributes [a), (d)]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [(c)]	Max Velocity (fps) [(b), (c)]
E04-004	F04-001	379.2	6.0	0.013	53.26	52.80	0.0012	0.13	0.01	0.24
E05-002	F05-001	148.3	6.0	0.013	56.51	56.03	0.0032	0.21	0.02	0.52
F04-000	F04-051	339.4	10.0	0.013	50.36	49.99	0.0011	0.47	0.18	2.24
F04-001	F04-005	128.0	6.0	0.013	52.80	52.64	0.0013	0.13	0.02	0.60
F04-005	F04-006	400.8	6.0	0.013	52.64	52.12	0.0013	0.13	0.02	0.67
F04-006	F04-017	197.3	10.0	0.013	52.12	51.82	0.0015	0.55	0.02	0.89
F04-017	F04-025	359.9	10.0	0.013	51.70	51.25	0.0013	0.50	0.06	0.76
F04-024	F04-033	339.7	6.0	0.013	51.87	51.27	0.0018	0.15	0.02	0.85
F04-025	F04-034	339.8	10.0	0.013	51.25	50.67	0.0017	0.59	0.08	1.04
F04-033	F04-034	401.1	6.0	0.013	51.20	50.67	0.0013	0.13	0.03	0.62
F04-034	F04-000	340.5	10.0	0.013	50.47	50.46	0.0000	0.08	0.15	1.76
F04-049	G04-006	340.3	8.0	0.013	51.57	51.27	0.0009	0.23	0.17	1.37
F04-050	F04-049	383.2	8.0	0.013	52.60	51.74	0.0022	0.37	0.16	2.23
F04-051	G04-009	340.0	10.0	0.013	49.69	49.27	0.0012	0.50	0.22	1.53
F05-001	F05-006	191.7	8.0	0.013	56.03	55.68	0.0018	0.33	0.04	0.48
F05-002	F05-001	380.1	6.0	0.013	56.63	56.08	0.0015	0.14	0.00	0.06
F05-003	F05-002	398.8	6.0	0.013	57.51	56.69	0.0021	0.16	0.00	0.00
F05-004	F05-003	384.5	6.0	0.013	58.30	57.55	0.0020	0.16	0.00	0.00
F05-006	F05-011	360.1	8.0	0.013	55.68	55.20	0.0013	0.29	0.07	1.47
F05-007	F05-006	380.2	6.0	0.013	56.04	55.83	0.0006	0.09	0.00	0.22
F05-008	F05-007	400.0	6.0	0.013	57.12	56.10	0.0026	0.18	0.00	0.00
F05-009	F05-008	324.9	6.0	0.013	59.14	57.14	0.0062	0.28	0.00	0.00
F05-011	F05-016	339.4	8.0	0.013	55.09	54.79	0.0009	0.23	0.10	1.98
F05-012	F05-011	379.5	6.0	0.013	55.72	55.23	0.0013	0.13	0.01	0.43
F05-013	F05-012	400.5	6.0	0.013	56.44	55.74	0.0018	0.15	0.01	0.31
F05-014	F05-013	320.3	6.0	0.013	57.00	56.53	0.0015	0.14	0.00	0.00
F05-016	F05-021	340.6	8.0	0.013	54.62	53.90	0.0021	0.36	0.13	0.81
F05-017	F05-016	379.2	6.0	0.013	55.54	54.79	0.0020	0.16	0.01	0.77
F05-018	F05-017	400.8	6.0	0.013	56.12	55.60	0.0013	0.13	0.01	0.40
F05-019	F05-018	325.8	6.0	0.013	57.02	56.16	0.0026	0.19	0.00	0.00
F05-021	F05-026	339.9	8.0	0.013	53.90	53.71	0.0006	0.18	0.14	1.12
F05-022	F05-021	379.9	6.0	0.013	54.87	54.36	0.0013	0.13	0.01	0.55
F05-023	F05-022	400.3	6.0	0.013	55.57	54.95	0.0016	0.14	0.00	0.37

Table D-2
City of Colusa
Modeled Sewer Line Attributes [a), (d)]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [(c)]	Max Velocity (fps) [(b), (c)]
F05-024	F05-023	300.9	6.0	0.013	56.04	55.60	0.0015	0.14	0.00	0.00
F05-025	F04-050	398.2	8.0	0.013	53.15	52.64	0.0013	0.28	0.16	1.78
F05-026	F05-025	418.6	8.0	0.013	53.71	53.18	0.0013	0.28	0.16	1.35
F05-027	F05-026	380.2	6.0	0.013	54.33	53.97	0.0010	0.11	0.01	0.71
F05-028	F05-027	399.5	6.0	0.013	55.00	54.36	0.0016	0.15	0.01	0.46
F05-029	F05-028	324.7	6.0	0.013	55.52	55.02	0.0015	0.14	0.00	0.00
G04-006	G04-011	339.7	8.0	0.013	51.10	51.05	0.0002	0.09	0.18	1.80
G04-008	G04-013	340.2	6.0	0.013	50.52	49.70	0.0024	0.18	0.01	0.24
G04-009	G04-014	340.2	10.0	0.013	49.27	48.63	0.0019	0.61	0.22	1.15
G04-011	G04-017	340.1	8.0	0.013	50.99	50.37	0.0018	0.33	0.19	1.20
G04-013	G04-018	339.7	6.0	0.013	49.70	49.12	0.0017	0.15	0.05	1.48
G04-014	G04-019	340.4	10.0	0.013	48.63	48.36	0.0008	0.40	0.22	1.43
G04-017	G04-028	339.5	8.0	0.013	50.37	49.93	0.0013	0.28	0.22	2.30
G04-018	G04-019	399.1	6.0	0.013	49.04	48.36	0.0017	0.15	0.06	0.57
G04-019	G04-027	339.5	10.0	0.013	48.28	47.82	0.0014	0.52	0.31	1.84
G04-020	G04-017	380.3	6.0	0.013	50.69	50.37	0.0008	0.11	0.02	0.16
G04-026	G04-030	339.5	6.0	0.013	49.97	48.54	0.0042	0.24	0.01	0.51
G04-027	G04-031	340.9	10.0	0.013	47.74	47.27	0.0014	0.53	0.32	1.30
G04-028	G04-037	340.6	8.0	0.013	49.75	49.44	0.0009	0.24	0.23	2.56
G04-030	H04-002	331.8	6.0	0.013	48.49	47.90	0.0018	0.15	0.01	0.73
G04-031	H04-004	339.8	10.0	0.013	47.27	47.00	0.0008	0.40	0.32	2.51
G04-037	H04-009	340.0	8.0	0.013	49.11	48.89	0.0007	0.20	0.24	2.60
G05-004	G05-010	340.0	8.0	0.013	53.44	52.94	0.0015	0.30	0.02	0.67
G05-005	G05-004	346.9	6.0	0.013	55.71	53.57	0.0062	0.28	0.00	0.00
G05-010	G05-019	339.5	8.0	0.013	52.88	52.55	0.0010	0.24	0.04	1.27
G05-011	G05-010	347.2	6.0	0.013	53.45	52.94	0.0015	0.14	0.00	0.02
G05-014	G05-021	170.1	8.0	0.013	49.24	48.67	0.0034	0.45	0.01	0.37
G05-018	G04-020	258.8	6.0	0.013	51.23	50.73	0.0019	0.16	0.00	0.14
G05-019	G05-028	340.3	8.0	0.013	52.40	52.28	0.0004	0.15	0.07	1.76
G05-020	G05-019	347.3	6.0	0.013	52.89	52.55	0.0010	0.11	0.00	-0.01
G05-021	G05-031	338.7	10.0	0.013	48.35	47.55	0.0024	0.69	0.03	0.69
G05-022	G05-021	386.8	10.0	0.013	49.41	48.67	0.0019	0.62	0.03	0.99
G05-028	G05-041	340.4	8.0	0.013	52.13	51.52	0.0018	0.33	0.08	1.56

Table D-2
City of Colusa
Modeled Sewer Line Attributes [a), (d)]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [(c)]	Max Velocity (fps) [(b), (c)]
G05-029	G05-030	55.1	8.0	0.013	50.31	49.90	0.0074	0.67	0.00	0.00
G05-030	G05-032	241.4	8.0	0.013	49.49	49.03	0.0019	0.34	0.00	0.00
G05-031	G05-034	419.7	10.0	0.013	47.55	46.64	0.0022	0.66	0.04	1.32
G05-032	G05-033	207.2	8.0	0.013	48.82	48.27	0.0027	0.40	0.00	0.00
G05-033	G05-035	127.5	8.0	0.013	48.12	47.65	0.0037	0.47	0.00	0.00
G05-034	H05-006	559.9	10.0	0.013	46.57	45.59	0.0018	0.59	0.06	1.51
G05-035	G05-031	31.2	8.0	0.013	47.65	47.55	0.0032	0.44	0.00	0.00
G05-041	H05-004	340.1	8.0	0.013	51.36	51.26	0.0003	0.13	0.10	1.77
G06-001	G05-022	379.6	10.0	0.013	50.34	49.52	0.0022	0.66	0.00	0.00
H04-002	H04-003	342.0	6.0	0.013	47.74	47.35	0.0011	0.12	0.01	0.38
H04-003	H04-004	472.3	6.0	0.013	47.35	47.00	0.0007	0.10	0.02	0.15
H04-004	H04-011	126.5	12.0	0.013	46.82	46.50	0.0025	1.16	0.60	1.56
H04-005	H04-004	394.7	8.0	0.013	47.48	47.00	0.0012	0.27	0.25	2.35
H04-008	H04-005	425.1	8.0	0.013	48.09	47.48	0.0014	0.30	0.25	1.32
H04-009	H04-008	420.5	8.0	0.013	48.69	48.12	0.0014	0.29	0.24	1.52
H04-010	H04-015	446.0	8.0	0.013	48.46	47.63	0.0019	0.34	0.13	1.56
H04-011	H04-016	718.9	15.0	0.013	46.42	46.24	0.0003	0.66	0.60	2.95
H04-014	H04-018	123.6	8.0	0.013	46.98	46.60	0.0031	0.43	0.01	0.28
H04-015	H04-017	420.2	8.0	0.013	47.58	46.96	0.0015	0.30	0.13	1.15
H04-016	I04-006	1502.1	15.0	0.013	45.19	43.93	0.0008	1.21	0.57	2.86
H04-017	H04-020	479.3	8.0	0.013	46.96	46.39	0.0012	0.27	0.13	1.73
H04-018	H04-019	489.7	8.0	0.013	46.60	46.00	0.0012	0.27	0.04	0.71
H04-019	H04-021	494.3	8.0	0.013	46.00	45.22	0.0016	0.31	0.05	0.64
H04-020	I04-002	499.5	8.0	0.013	46.38	44.77	0.0032	0.44	0.13	1.31
H04-021	I04-003	505.3	8.0	0.013	45.22	44.65	0.0011	0.26	0.05	0.75
H05-001	H04-010	782.0	8.0	0.013	50.26	49.23	0.0013	0.28	0.12	2.07
H05-003	H05-001	402.8	8.0	0.013	50.60	50.38	0.0006	0.18	0.11	2.06
H05-004	H05-003	377.0	8.0	0.013	51.18	50.64	0.0014	0.30	0.11	0.94
H05-005	H05-009	187.6	10.0	0.013	44.51	43.22	0.0069	1.17	0.13	2.06
H05-006	H05-005	72.2	10.0	0.013	45.00	44.51	0.0068	1.17	0.13	2.06
H05-011	H05-022	442.7	8.0	0.013	49.13	48.89	0.0005	0.18	0.23	1.68
H05-011	H05-012	14.5	12.0	0.013	49.13	48.71	0.0289	3.92	0.82	9.06
H05-012	H05-023	434.4	12.0	0.013	48.57	47.59	0.0023	1.09	0.54	1.97

Table D-2
City of Colusa
Modeled Sewer Line Attributes [a), (d)]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [(c)]	Max Velocity (fps) [(b), (c)]
H05-015	H05-016	60.2	8.0	0.013	43.57	43.48	0.0015	0.30	0.32	1.36
H05-016	H05-009	328.3	8.0	0.013	43.43	43.22	0.0006	0.20	0.32	2.85
H05-018	H05-029	505.2	8.0	0.013	48.26	47.28	0.0019	0.34	0.08	1.37
H05-019	H05-018	215.7	8.0	0.013	48.56	48.28	0.0013	0.28	0.08	1.31
H05-020	H05-021	415.8	6.0	0.013	49.86	49.80	0.0001	0.04	-0.08	-0.72
H05-020	H05-019	242.8	8.0	0.013	49.80	48.63	0.0048	0.54	0.08	1.56
H05-021	H05-022	280.1	6.0	0.013	49.80	48.89	0.0033	0.21	-0.09	-0.63
H05-022	H05-024	37.0	12.0	0.013	48.57	48.52	0.0014	0.85	0.18	1.07
H05-023	H05-031	487.2	12.0	0.013	47.59	46.78	0.0017	0.94	0.49	2.90
H05-024	H05-034	474.7	12.0	0.013	48.52	47.80	0.0015	0.90	0.16	0.89
H05-027	H05-028	27.6	8.0	0.013	46.77	46.10	0.0243	1.22	0.31	3.06
H05-028	H05-015	1064.5	8.0	0.013	45.99	43.57	0.0023	0.37	0.32	1.36
H05-029	I05-002	331.5	8.0	0.013	47.22	46.71	0.0015	0.31	0.10	0.94
H05-030	H05-029	399.6	8.0	0.013	48.20	47.28	0.0023	0.37	0.01	0.66
H05-031	I05-006	497.2	12.0	0.013	46.52	45.20	0.0027	1.19	0.51	1.82
H05-032	H05-030	348.3	8.0	0.013	49.00	48.23	0.0022	0.37	0.00	0.00
H05-033	H05-034	375.5	8.0	0.013	48.93	48.36	0.0015	0.30	-0.05	-0.20
H05-034	H05-039	277.9	10.0	0.013	47.80	47.33	0.0017	0.58	0.14	1.54
H05-035	I05-008	477.1	8.0	0.013	47.80	47.71	0.0002	0.11	0.06	1.51
H05-036	H05-035	270.9	8.0	0.013	48.35	47.83	0.0019	0.34	0.04	0.52
H05-037	H05-036	413.8	8.0	0.013	48.81	48.35	0.0011	0.26	-0.04	0.41
H05-039	I05-007	197.7	12.0	0.013	47.33	46.61	0.0036	1.39	0.14	1.84
I04-001	I04-003	902.7	12.0	0.013	44.47	44.43	0.0000	0.15	0.26	0.72
I04-002	I04-001	202.3	12.0	0.013	44.63	44.47	0.0008	0.65	0.25	0.58
I04-003	I04-005	615.6	12.0	0.013	44.43	44.14	0.0005	0.50	0.33	0.81
I04-004	I04-002	248.1	10.0	0.013	44.90	44.77	0.0005	0.32	0.16	1.31
I04-005	I04-006	561.4	12.0	0.013	44.14	43.93	0.0004	0.45	0.38	2.61
I04-008	I04-010	193.3	18.0	0.013	47.02	46.92	0.0005	1.54	0.86	2.42
I04-009	I04-008	4.7	18.0	0.013	47.03	47.02	0.0021	3.14	0.98	3.17
I04-010	I04-011	738.8	18.0	0.013	46.88	46.14	0.0010	2.15	0.86	1.74
I04-011	I04-013	119.8	18.0	0.013	46.14	46.04	0.0008	1.96	0.86	1.81
I04-013	J03-001	752.1	18.0	0.013	46.02	45.32	0.0009	2.07	0.86	1.80
I05-002	I05-009	218.2	8.0	0.013	46.71	46.35	0.0017	0.32	0.11	0.74

Table D-2
City of Colusa
Modeled Sewer Line Attributes [a), (d)]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [(c)]	Max Velocity (fps) [(b), (c)]
I05-006	I05-013	176.8	15.0	0.013	45.20	44.77	0.0024	2.06	0.76	1.66
I05-007	I05-006	9.5	8.0	0.013	46.61	46.35	0.0274	1.29	0.19	3.32
I05-008	I05-006	22.2	8.0	0.013	47.33	46.67	0.0298	1.35	0.14	3.35
I05-009	I04-004	908.7	10.0	0.013	46.35	44.93	0.0016	0.56	0.16	0.86
I05-010	I05-009	113.1	8.0	0.013	46.61	46.35	0.0023	0.37	0.05	0.63
I05-011	I05-010	562.7	8.0	0.013	48.88	47.27	0.0029	0.42	0.00	0.00
I05-012	I05-008	172.6	8.0	0.013	47.40	47.33	0.0004	0.16	0.08	1.91
I05-013	I05-023	487.6	15.0	0.013	44.77	44.32	0.0009	1.27	0.77	1.92
I05-014	I05-012	270.1	8.0	0.013	47.89	47.40	0.0018	0.33	0.08	0.77
I05-015	I05-014	290.5	8.0	0.013	48.44	47.89	0.0019	0.34	0.06	0.89
I05-016	I05-019	231.6	8.0	0.013	49.18	48.70	0.0021	0.36	0.00	0.00
I05-017	I05-007	318.4	12.0	0.013	47.84	46.61	0.0039	1.43	0.08	0.75
I05-018	I05-010	331.9	8.0	0.013	47.30	47.27	0.0001	0.07	0.04	1.32
I05-019	I05-018	549.5	8.0	0.013	48.52	47.39	0.0021	0.35	0.00	0.12
I05-020	I05-033	484.4	8.0	0.013	42.15	40.23	0.0040	0.49	-0.11	1.09
I05-021	I05-020	294.9	8.0	0.013	43.48	42.22	0.0043	0.51	-0.09	1.22
I05-022	I05-017	346.8	8.0	0.013	49.18	47.84	0.0039	0.49	-0.03	-0.14
I05-023	I05-031	362.7	15.0	0.013	44.32	43.78	0.0015	1.61	1.02	2.48
I05-024	Indian Oaks PS	24.1	8.0	0.013	41.16	39.55	0.0669	2.02	0.75	8.00
I05-024	I05-023	13.7	8.0	0.013	46.87	46.45	0.0307	1.37	0.68	2.90
I05-025	I05-018	262.0	8.0	0.013	47.71	47.39	0.0012	0.27	0.02	0.62
I05-030	I05-038	251.2	8.0	0.013	46.95	46.15	0.0032	0.44	-0.10	1.45
I05-031	I05-037	126.7	15.0	0.013	43.78	43.42	0.0028	2.23	0.99	1.83
I05-032	I05-033	141.1	8.0	0.013	46.98	40.23	0.0479	1.71	0.26	1.71
I05-032	I05-067	198.7	8.0	0.013	46.98	46.27	0.0036	0.47	-0.27	-1.14
I05-033	I05-042	169.2	8.0	0.013	40.23	39.55	0.0040	0.50	0.26	2.51
I05-036	I05-037	13.6	4.0	0.013	44.40	44.36	0.0029	0.07	0.44	7.97
I05-037	I05-047	134.9	15.0	0.013	43.42	43.27	0.0011	1.39	1.18	2.26
I05-038	I05-040	228.7	8.0	0.013	46.11	45.38	0.0032	0.44	-0.12	1.59
I05-040	I05-024	512.4	8.0	0.013	42.63	41.16	0.0029	0.42	0.50	8.05
I05-041	I05-043	13.2	8.0	0.013	46.30	46.26	0.0030	0.43	-0.02	0.42
I05-043	I05-042	39.3	8.0	0.013	37.10	37.01	0.0023	0.37	0.41	3.07
I05-047	I05-048	37.9	15.0	0.013	43.27	43.23	0.0011	1.36	1.17	2.28

Table D-2
City of Colusa
Modeled Sewer Line Attributes [a), (d)]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [(c)]	Max Velocity (fps) [(b), (c)]
I05-048	J05-003	324.1	15.0	0.013	43.23	42.72	0.0016	1.66	1.08	2.18
I05-054	I05-048	371.3	8.0	0.013	45.29	43.85	0.0039	0.49	-0.17	1.42
I05-055	I05-054	300.2	8.0	0.013	46.24	45.31	0.0031	0.43	-0.19	-0.75
I05-056	I05-040	267.9	8.0	0.013	43.41	42.63	0.0029	0.42	0.35	1.82
I05-057	I05-060	266.4	8.0	0.013	44.38	43.66	0.0027	0.41	0.31	2.44
I05-060	I05-056	63.9	8.0	0.013	43.59	43.41	0.0028	0.41	0.33	2.01
I05-062	I05-055	176.4	8.0	0.013	46.91	46.25	0.0037	0.48	-0.19	-0.78
I05-062	J05-012	357.5	8.0	0.013	46.94	45.50	0.0040	0.50	0.19	0.79
I05-066	I05-043	393.1	8.0	0.013	37.95	37.10	0.0022	0.36	0.40	2.25
I05-067	I05-031	600.4	8.0	0.013	46.24	44.00	0.0037	0.48	-0.27	-1.04
I06-001	H05-027	1004.1	8.0	0.013	48.25	46.77	0.0015	0.30	0.26	2.66
I06-005	I06-001	439.5	8.0	0.013	49.15	48.27	0.0020	0.35	0.26	1.55
J03-001	J03-002	267.4	18.0	0.013	45.19	45.05	0.0005	1.55	0.86	1.39
J03-002	J03-003	989.9	18.0	0.013	45.05	44.58	0.0005	1.48	0.86	3.14
J03-003	J03-004	19.6	18.0	0.013	44.51	43.47	0.0529	15.62	0.86	2.59
J03-004	J03-005	113.6	18.0	0.013	43.46	43.15	0.0027	3.55	0.88	3.68
J03-006	J03-007	50.7	18.0	0.013	45.08	44.94	0.0028	3.57	1.13	3.39
J03-007	L04-006	2561.3	18.0	0.013	44.94	38.40	0.0026	3.43	0.86	3.12
J05-001	I05-057	121.7	6.0	0.013	44.60	44.57	0.0003	0.06	0.29	3.11
J05-002	I05-060	129.7	6.0	0.013	43.96	43.66	0.0023	0.17	-0.11	-0.87
J05-003	J05-007	22.7	15.0	0.013	42.72	42.70	0.0009	1.24	1.08	2.25
J05-004	J05-007	258.8	6.0	0.013	44.61	43.49	0.0043	0.24	-0.24	-1.60
J05-004	J05-001	18.1	6.0	0.013	44.61	44.60	0.0006	0.09	0.29	2.12
J05-007	J05-020	394.4	15.0	0.013	42.70	42.00	0.0018	1.76	0.97	2.09
J05-012	J05-026	267.1	8.0	0.013	45.50	44.01	0.0056	0.58	0.19	0.75
J05-014	I05-066	401.3	8.0	0.013	38.84	37.98	0.0021	0.36	0.41	1.92
J05-020	J05-027	104.8	15.0	0.013	42.00	41.86	0.0013	1.53	0.95	2.13
J05-026	J05-027	626.0	8.0	0.013	43.91	42.35	0.0025	0.39	-0.25	1.42
J05-027	J05-033	297.1	15.0	0.013	41.86	41.37	0.0017	1.70	0.97	2.10
J05-028	J05-026	258.1	8.0	0.013	44.40	44.01	0.0015	0.30	-0.43	-1.68
J05-031	J05-014	335.5	8.0	0.013	39.70	38.91	0.0024	0.38	0.16	1.67
J05-033	J05-043	400.9	15.0	0.013	41.37	40.79	0.0015	1.59	0.91	2.36
J05-040	J05-028	399.9	8.0	0.013	45.54	44.54	0.0025	0.39	0.06	1.41

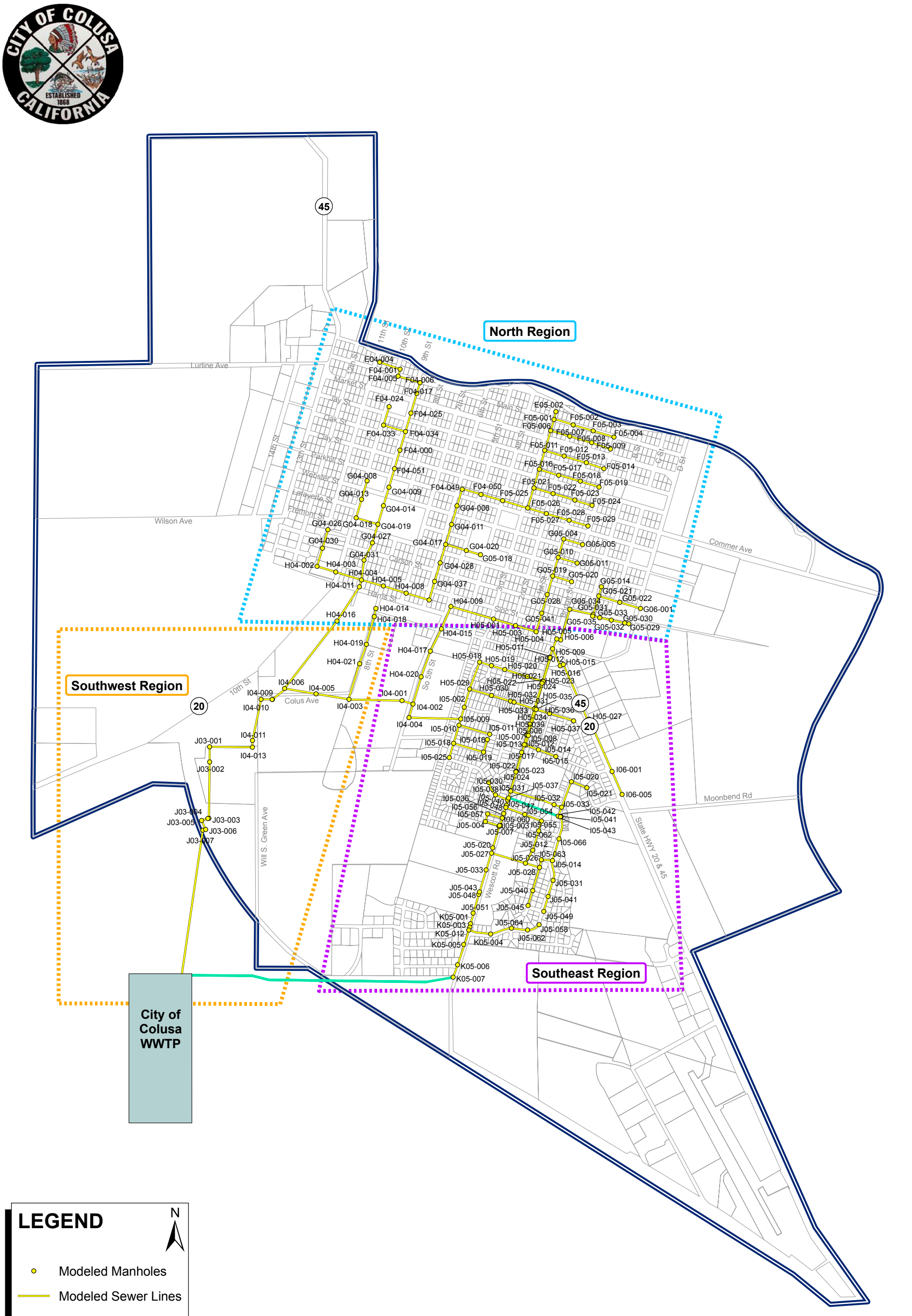
Table D-2
City of Colusa
Modeled Sewer Line Attributes [a], [d]

US MH ID	DS MH ID	Length (ft)	Diameter (in)	Roughness (n)	US Invert (ft)	DS Invert (ft)	Slope (ft/ft)	Full Pipe Capacity (MGD)	Max Flow (MGD) [c]	Max Velocity (fps) [b], [c]
J05-041	J05-031	291.6	8.0	0.013	40.36	39.83	0.0018	0.33	-0.15	1.32
J05-043	J05-048	61.9	15.0	0.013	40.70	40.60	0.0016	1.68	0.91	1.86
J05-045	J05-040	297.6	8.0	0.013	46.09	45.65	0.0015	0.30	0.05	1.22
J05-048	J05-061	309.6	15.0	0.013	40.60	40.26	0.0011	1.38	0.91	2.90
J05-049	J05-041	301.1	8.0	0.013	41.03	40.44	0.0020	0.35	-0.15	0.87
J05-058	J05-062	221.0	8.0	0.013	43.23	42.73	0.0023	0.37	0.05	1.19
J05-061	K05-001	196.3	15.0	0.013	40.11	39.85	0.0013	1.52	0.89	2.40
J05-062	J05-064	284.7	8.0	0.013	42.60	42.06	0.0019	0.34	0.06	1.54
J05-063	J05-028	139.3	8.0	0.013	45.34	44.54	0.0057	0.59	-0.47	-1.93
J05-063	J05-014	196.1	8.0	0.013	45.39	38.84	0.0334	1.43	0.45	1.73
J05-064	K05-004	387.4	8.0	0.013	41.92	40.99	0.0024	0.38	0.07	1.60
K05-001	K05-003	96.7	15.0	0.013	39.75	39.63	0.0012	1.47	0.87	1.98
K05-003	K05-012	46.5	15.0	0.013	39.63	39.58	0.0011	1.37	0.86	2.08
K05-004	K05-012	396.7	8.0	0.013	40.94	40.02	0.0023	0.38	0.09	1.56
K05-005	K05-006	420.9	15.0	0.013	39.04	38.43	0.0015	1.59	0.76	2.03
K05-006	K05-007	231.3	15.0	0.013	38.43	38.09	0.0015	1.60	0.71	3.08
K05-012	K05-005	224.0	15.0	0.013	39.58	39.20	0.0017	1.72	0.88	3.05

[a] US = upstream, DS = downstream, MH = manhole, MGD = million gallons per day, fps = feet per second.
[b] Max velocity does not necessarly correspond with max flow. The values of max flow and max velocity are the maximum flow and velocities calculated by the dynamic modeling software during the simulation under 10-year, 6-hour design storm conditions.
[c] Negative flows and negative velocities shown in particular pipe segments represent backflow due to downstream flow restrictions.
[d] Model results of existing level of development at 10-year, 6-hour design storm.

Appendix E

Manhole Reference IDs



M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Appendix E-1 Modeled Manholes - Labeleld

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City of Colusa Wastewater Collection System Master Plan

Figure E-1
City of Colusa Modeled Manholes - Labeled

M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Appendix E-2 Modeled Manholes (Labeled) - North Region

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City of Colusa Wastewater Collection System Master Plan

Figure E-2
City of Colusa Modeled Manholes - North Region

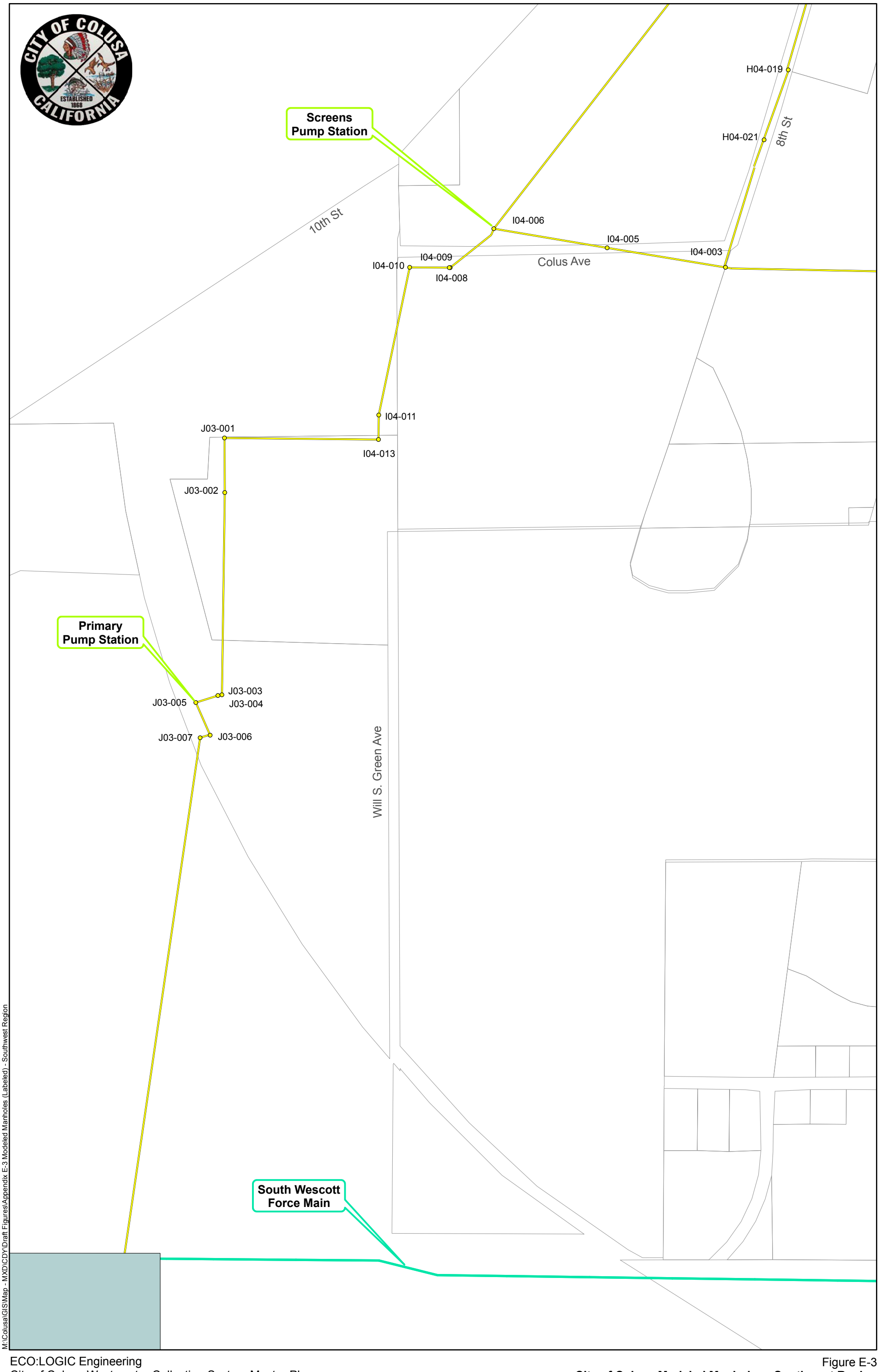
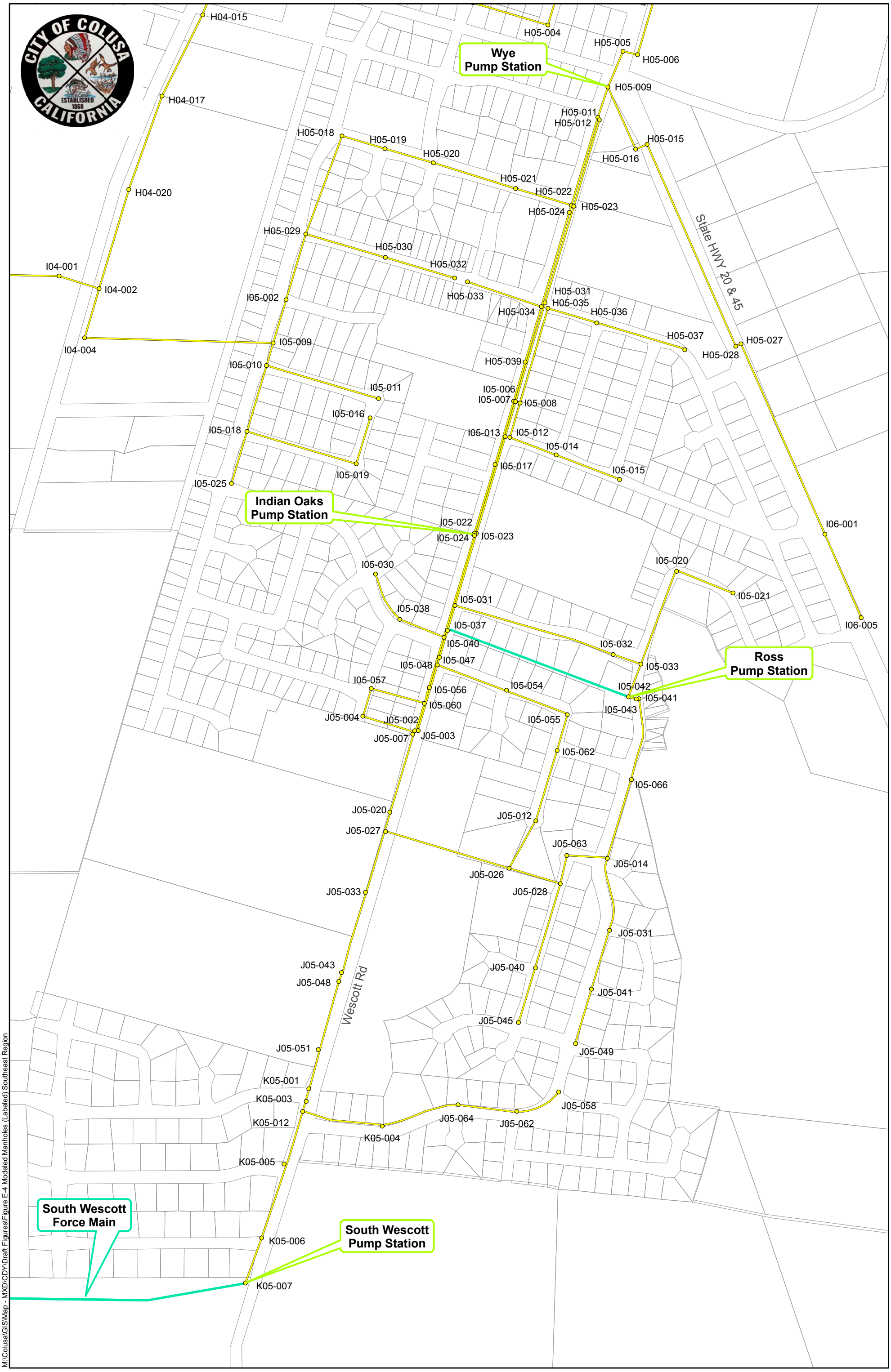
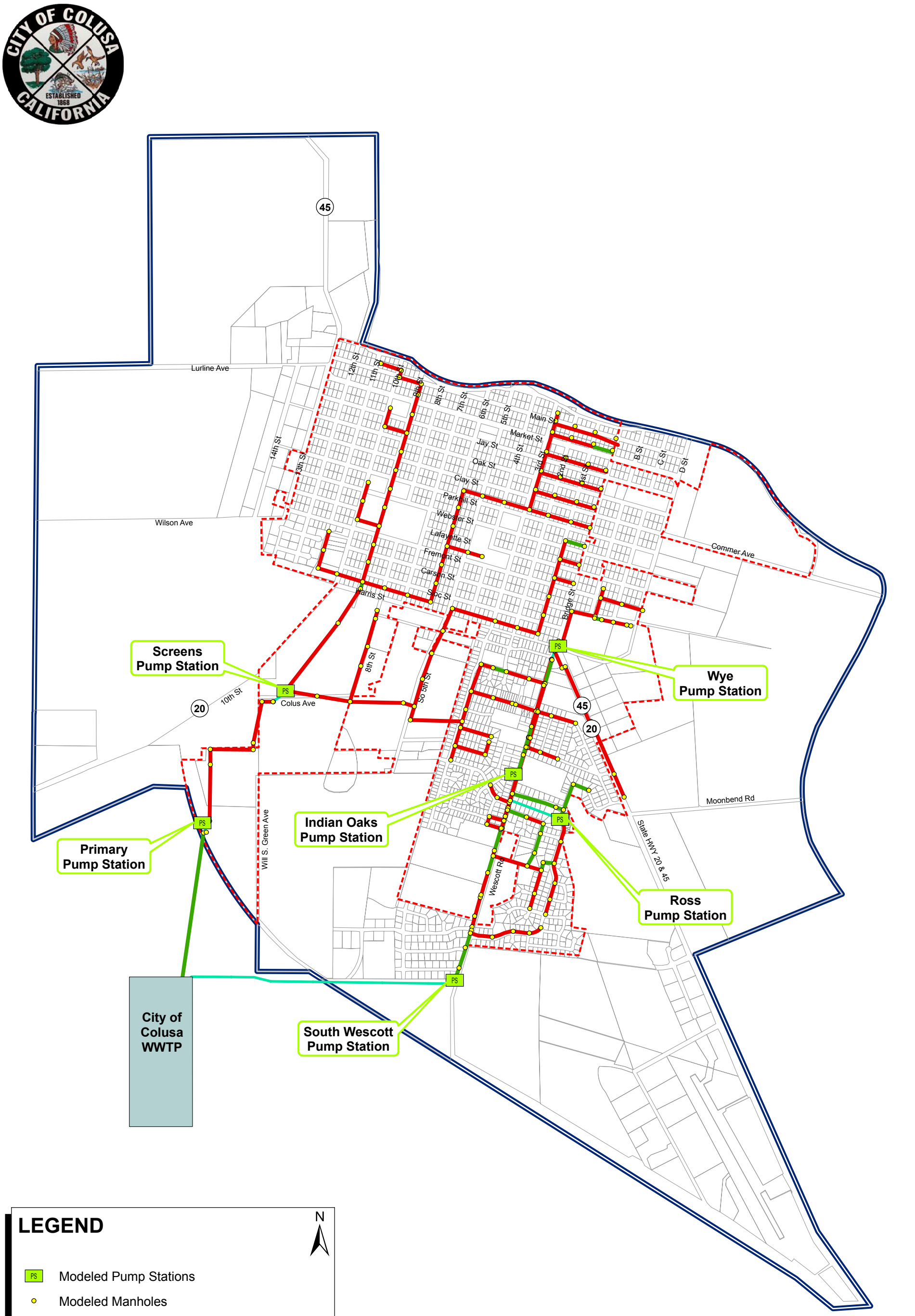


Figure E-3
City of Colusa Modeled Manholes - Southwest Region


H04-015
H04-017
H04-020
I04-001
I04-002
I04-004
H05-004
H05-005
H05-006
Wye
Pump Station
H05-009
H05-011
H05-012
H05-015
H05-016
H05-018
H05-019
H05-020
H05-021
H05-022
H05-023
H05-024
H05-029
H05-030
H05-032
H05-033
H05-031
H05-035
H05-034
H05-036
H05-037
H05-027
H05-028
H05-039
State HWY 20 & 45
I05-002
I05-009
I05-010
I05-011
I05-016
I05-018
I05-019
I05-025
I05-006
I05-007
I05-008
I05-013
I05-012
I05-014
I05-017
I05-015
Indian Oaks
Pump Station
I05-022
I05-024
I05-023
I06-001
I06-005
I05-030
I05-020
I05-021
I05-031
I05-038
I05-037
I05-040
I05-032
I05-033
I05-048
I05-047
Ross
Pump Station
I05-057
I05-056
I05-054
I05-042
I05-041
I05-060
I05-043
J05-004
J05-002
I05-055
J05-007
J05-003
I05-062
I05-066
J05-020
J05-012
J05-027
J05-063
J05-014
J05-026
J05-033
J05-028
J05-031
J05-043
J05-048
Wescott Rd
J05-040
J05-041
J05-045
J05-049
J05-051
K05-001
K05-003
J05-058
J05-064
J05-062
K05-012
K05-004
K05-005
South Wescott
Force Main
South Wescott
Pump Station
K05-006
K05-007
M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Figure E-4 Modeled Manholes (Labeled) Southeast Region

Appendix F

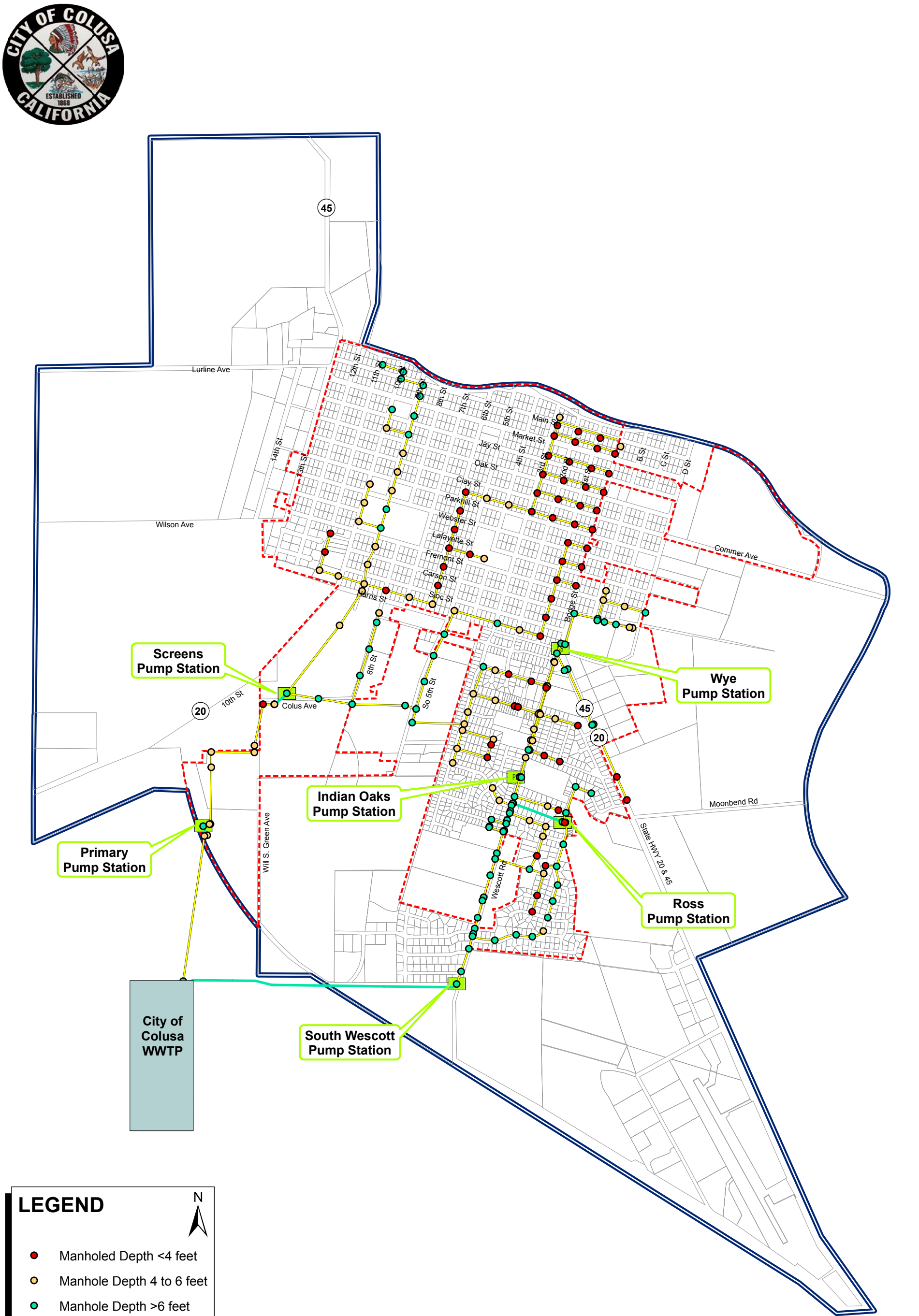
Minimum Sewer Line Gradients and Manhole Depths



M:\Colusa\GIS\Map - MXD\CDY\Draft Figures/Appendix F-1 Modeled Sewer Lines - Minimum Slope 02-20-09 MLM

ECO:LOGIC Engineering
City of Colusa Wastewater Collection System Master Plan

Figure F-1
City of Colusa Modeled Sewer Lines - Minimum Slope



M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Appendix F-2 Modeled Sewer Manholes - Minimum Depth 02-20-09 MLM

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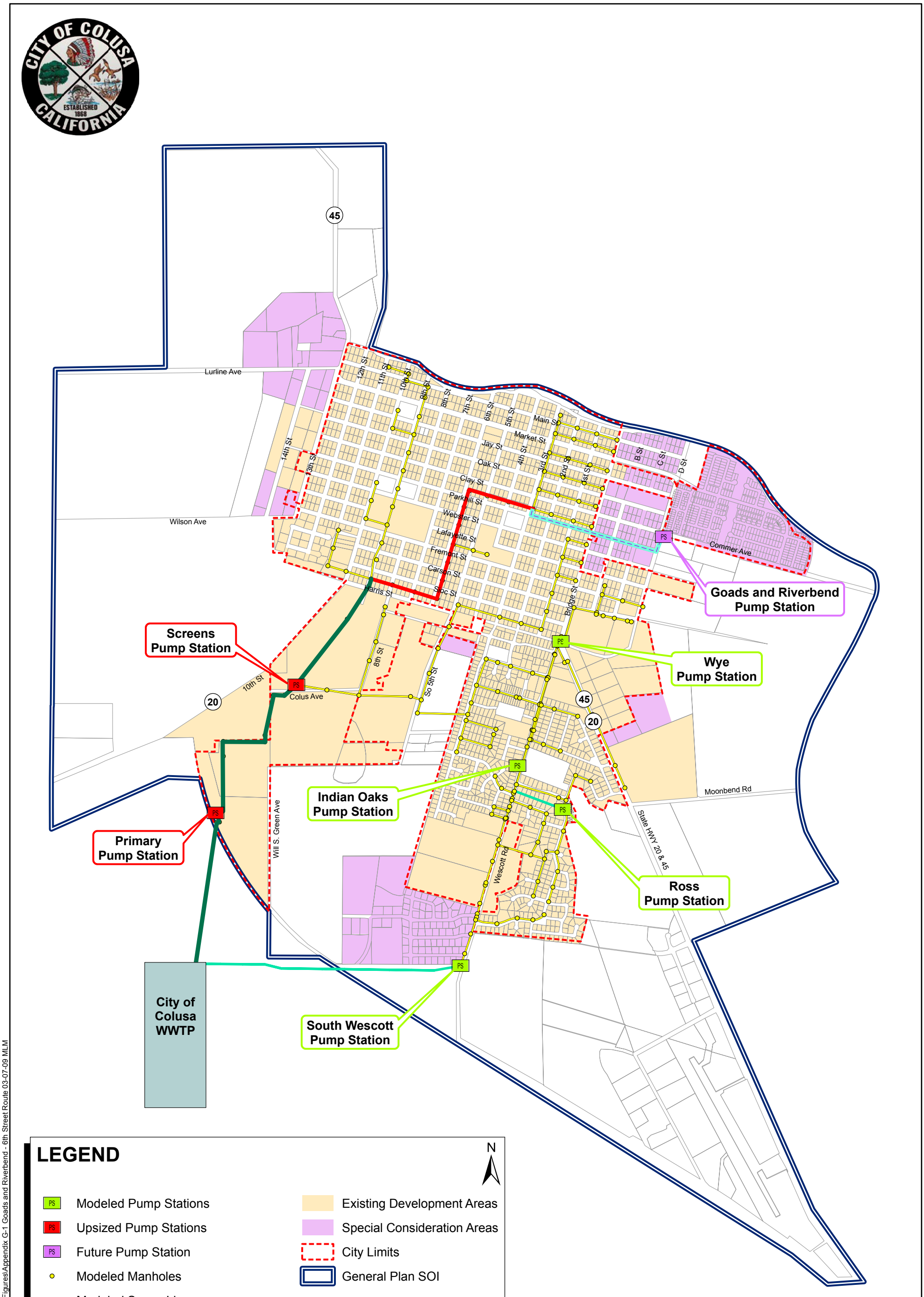
City of Colusa Wastewater Collection System Master Plan

Figure F-2
City of Colusa Modeled Sewer Manholes - Minimum Depth

Appendix G

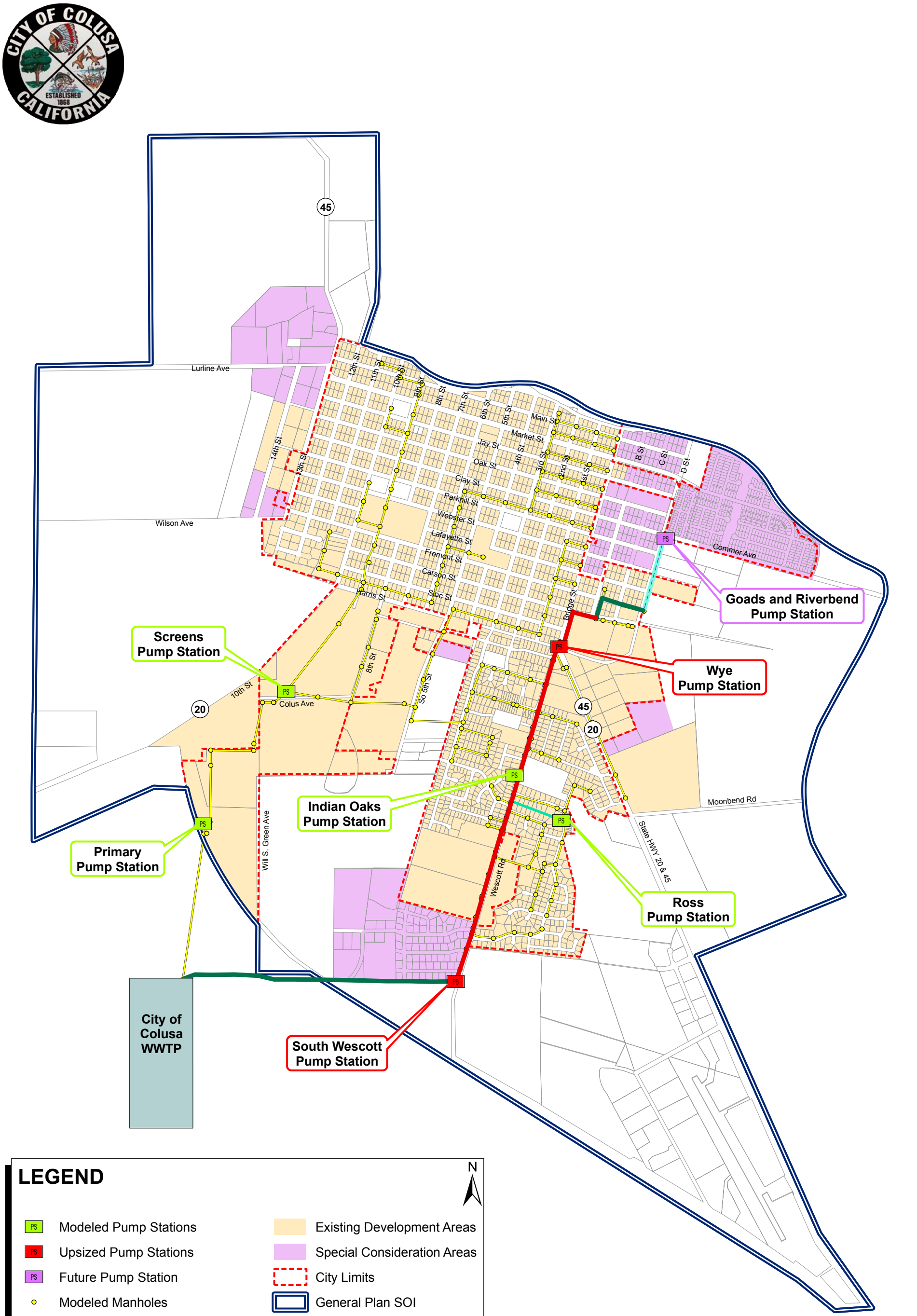
Future Wastewater Flow Routing Analysis for Goads and Riverbend Developments



M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Appendix G-1 Goads and Riverbend - 6th Street Route 03-07-09 MLM

ECO:LOGIC Engineering
City of Colusa Wastewater Collection System Master Plan

Figure G-1
City of Colusa Goads and Riverbend Developments - 6th Street Route



M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Appendix G-2 Goads and Riverbend - Wye Route 03-07-09 MLM

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City of Colusa Wastewater Collection System Master Plan

Figure G-2
City of Colusa Goads and Riverbend Developments - South Wescott Route

Table G-1
City of Colusa
Summary of Future Wastewater Flow Routing Analysis for Goads and Riverbend Developments [(a)]

	Current Capacity	Needed Capacity (in gpm) / Needed Improvements		
Component	**Existing System (gpm)**	**Existing Development**	**Future Development (Riverbend & Goads via 6th Street)**	**Future Development (Riverbend & Goads via South Wescott Trunk)**
Indian Oaks PS	310			
Primary PS	600	700	1,390	1,390
Ross PS	300			
South Wescott PS	450	900	1,530	2,085
Supply Yard/Screens PS	600	700	1,180	975
Wye PS	393			
South Wescott Force Main (4,600 ft)	900		New force main with 1,530 gpm total capacity	New force main with 2,085 gpm total capacity
South Wescott Trunk Sewer	1,115			Upsize: •1,250’ into Wye PS (from N) from 10” to 12” •15’ from Ross force main to Wescott from 4” to 10” •1,450’ South Wescott from 12” to 15” •4,500’ South Wescott from 15” to 18”
Other Pipelines			Upsize: •4,500’ of 6th St sewer from 8” to 12”	Upsize: •3,300’ of 6th St sewer from 8” to 10” •1,500’ into Wye PS (along Hwy 45/20) from 8” to 10”
Summary of Improvements due ONLY to Goads and Riverbend Developments			•Larger (or new) PS: Screens, Primary •1,200' ADDITIONAL upsizing of 6th St sewer •ALL 4,500' of 6th St sewer improvements upsized to 12" (instead of 10")	•Larger (or new) PS: Wye, South Wescott •Additional ~700 gpm capacity in South Wescott force main •Upsize 1,250' into Wye PS and 15' from Ross force main •Upsize 6,000' of South Wescott (to 15" and 18")

[(a)] gpm = gallons per minute, PS = pump station

Appendix H

Future Sewer System Collection Areas

Lurline Pump Station

Goads and Riverbend Pump Station

Colusa Crossings Pump Station

Screens Pump Station (To be abandoned)

Wye Pump Station

Indian Oaks Pump Station

New Primary Pump Station

Moonbend Pump Station

Ross Pump Station

New South Wescott Pump Station

City of Colusa WWTP

Lurline Ave
Wilson Ave
Colus Ave
Commer Ave
Moonbend Rd
Will S. Green Ave
Wescott Rd
State HWY 20 & 45
Bridge St
Main St
Market St
Jay St
Oak St
Clay St
Parkhill St
Webster St
Lafayette St
Fremont St
Carson St
Sloc St
Harris St
12th St
11th St
10th St
9th St
8th St
7th St
6th St
5th St
4th St
3rd St
2nd St
1st St
14th St
13th St
So 5th St
B St
C St
D St
45
20
PS

LEGEND

- Tributary to Lurline Pump Station
- Tributary to Colusa Crossings Pump Station
- Tributary to Goads and Riverbend Pump Station
- Tributary to Screens Pump Station
- Tributary to Primary Pump Station
- Tributary to Wye Pump Station
- Tributary to Indian Oaks Pump Station
- Tributary to Ross Pump Station
- Tributary to Moonbend Pump Station
- Tributary to South Wescott Pump Station
- Existing Pump Stations
- Future Pump Stations
- Goads and Riverbend Force Main
- Existing Manholes
- Existing Sewer Lines
- Build-out Trunk Sewers
- City Limits
- General Plan SOI

N

NOTE:

ROSS, INDIAN OAKS AND WYE PUMP STATIONS DISCHARGE TO SOUTH WESCOTT TRUNK.

0 0.25 0.5 1 Miles

M:\Colusa\GIS\Map - MXD\CDY\Draft Figures\Appendix H-1 Future Sewer System Collection Areas

ECO:LOGIC Engineering
City of Colusa Wastewater Collection System Master Plan

Figure H-1
City of Colusa Future Sewer System Collection Areas

Appendix I

New Gravity Sewer Information

City of Colusa
Sizing Assumptions for New Gravity Sewer

The proposed new gravity sewer infrastructure to serve unsewered portions of the City of Colusa's SOI at build-out was sized and routed based on the following assumptions:

1. The alignment of these new sewer lines follow future collector roads as identified in the General Plan's Circulation Diagram.

2. The minimum slope for each proposed diameter of new sewer is based on the City Design Standards.

3. The minimum pipe cover for trunk lines and minimum manhole depth is based on values established in the City Design Standards.

4. The minimum proposed diameter is 10-inches. Some smaller diameter trunk pipelines are shown (Figure 7-5) for clarity. However, it is assumed that the cost of these sewer pipes will be the responsibility of the developer.

5. Proposed new sewer pipelines were sized assuming 70% full as described in the City Design Standards. A peaking factor of 3.1 (as described in Section 4.2.2) was applied to dry weather flows from Future Developments – Phase II.

6. The roughness value, Manning's n, of 0.013 was used in sizing all new trunks.

Table I-1
City of Colusa
New Gravity Sewer Approximate Characteristics

Gravity Trunk	Ground Elevation (estimated) (ft)	Top of Pipe Elevation (ft) [(a)]	Pipe Starting Invert (ft)	End invert (ft)	Length of Trunk Sewer (ft)	Size of Pipeline (in)	Pipe slope
Colusa Crossing Trunk							
North SOI to Lurline Ave	56.5	50.5	49.8	34.6	4,350	8	0.0035
Lurline Ave to Colusa Crossing PS	56.0	50.0	49.3	39.7	2,750	8	0.0035
	--	--	39.7	37.2	1,000	10	0.0025
	--	--	37.2	35.1	1,050	12	0.0020
Colusa Crossing PS to New Primary PS	50.0	44.0	42.8	40.4	1,550	15	0.0015
	--	--	40.4	38.0	2,000	18	0.0012
MoonBend Trunk							
Commer Ave to Moonbend PS	55.0	49.0	48.0	42.0	3,050	12	0.0020
	--	--	42.0	37.6	2,950	15	0.0015
Moonbend PS to New South Wescott PS	52.0	46.0	44.8	30.9	9,250	15	0.0015

[(a)] Assumes 6 feet of ground cover, per City of Colusa design standards

Table I-2
City of Colusa
New Pump Station Approximate Ground and Floor Elevations

Pump Station	Ground Elevation (estimated) (ft)	Pump Station Wet Well Floor Elevation (ft)
Lurline Pump Station	56.5	34.5
Colusa Crossing Pump Station	50.0	35.0
New Primary Pump Station	52.5	37.5
Moonbend Pump Station	52.0	37.0
New Wescott Pump Station	52.0	30.0

Appendix J

Pump Station Cost Estimates

Table J-1
Pump Station Cost Estimates

Reliable Capacity (gpm)	**350**	**690**	**760**	**1040**	**1390**	**1740**	**2080**	**2430**	**2780**
Peak Flow (mgd)	**0.5**	**1.0**	**1.1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
Pump Station Equipment	120,000	200,000	200,000	300,000	300,000	360,000	400,000	450,000	490,000
Excavation and Backfilling	40,000	60,000	60,000	90,000	90,000	110,000	120,000	150,000	150,000
Shoring and Sheeting	60,000	90,000	100,000	140,000	150,000	180,000	200,000	220,000	250,000
Wet Well and Valve Box	60,000	100,000	110,000	150,000	170,000	200,000	220,000	250,000	270,000
Dewatering	50,000	50,000	50,000	80,000	80,000	90,000	100,000	110,000	120,000
Site Work	30,000	50,000	50,000	80,000	80,000	90,000	100,000	120,000	120,000
Site Piping	20,000	40,000	40,000	60,000	60,000	70,000	80,000	100,000	100,000
Odor Control	40,000	40,000	45,000	60,000	70,000	80,000	90,000	100,000	110,000
Generator and Control Building	25,000	25,000	25,000	40,000	40,000	40,000	50,000	60,000	60,000
Electrical and Instrumentation	120,000	200,000	200,000	300,000	300,000	360,000	400,000	450,000	490,000
Emergency Generator	30,000	50,000	50,000	80,000	80,000	90,000	100,000	120,000	120,000
Total Construction Costs	**600,000**	**910,000**	**930,000**	**1,380,000**	**1,420,000**	**1,670,000**	**1,860,000**	**2,130,000**	**2,280,000**
Engineering and Admin (15%)	90,000	140,000	140,000	210,000	210,000	250,000	280,000	300,000	340,000
Contingencies (30%)	180,000	270,000	280,000	410,000	430,000	500,000	560,000	600,000	680,000
Total Capital Costs	**870,000**	**1,320,000**	**1,350,000**	**2,000,000**	**2,060,000**	**2,420,000**	**2,700,000**	**3,030,000**	**3,300,000**
Total Capital Costs in $1000 (2009$)	870	1,320	1,350	2,000	2,060	2,420	2,700	3,030	3,300