Agenda Report

Subject: **Draft Report – Sanitary Sewer Evaluation Survey**

Prepared By: Steven M. Saunders, Director of Public Works/Village Engineer

Date: July 12, 2012

On February 21, 2012, the Village Council awarded a contract to Strand Associates to complete a flow monitoring analysis of the Village's sanitary sewer system to identify areas of the Village subject to inflow and infiltration (I/I). I/I is stormwater or groundwater that enters the Village's separate sanitary sewer system, which is designed and intended to handle solely wastewater. Excessive I/I in the sanitary sewer system can lead to basement backups.

Flow Monitoring

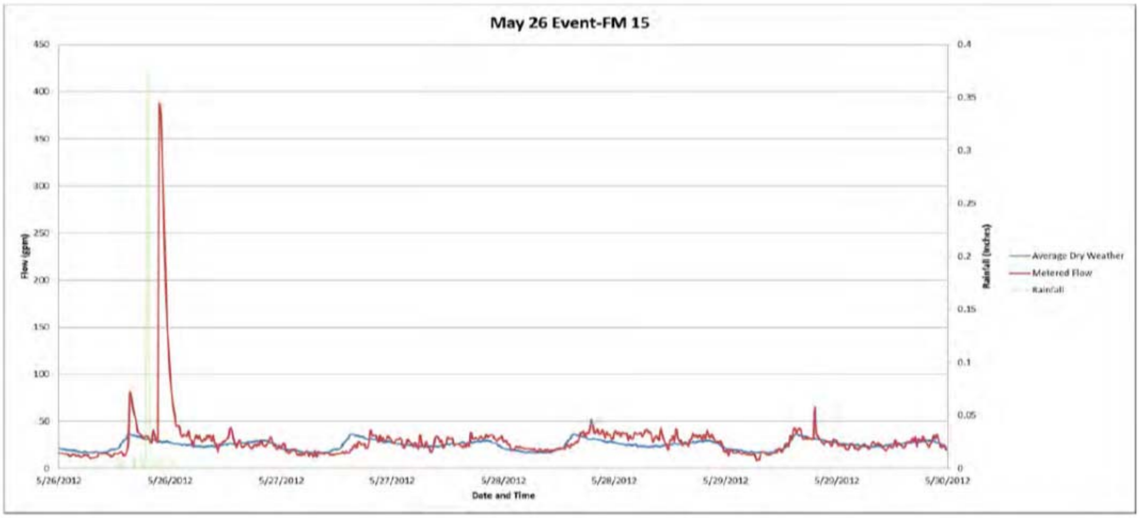
30 flow meters were installed in the Village's sanitary sewer system, allowing flow information to be developed for the majority of the Village's system. Some portions of the system were not metered, either because the sub-basins to be metered were so small that the meters would not be capable of accurately measuring dry-weather flow volumes, or because the configuration of the Village's system did not present a suitable meter insertion location. A schematic of the Village's sanitary sewer system and the 30 meter locations is shown in figure 2.02-1 of the draft report. The shaded basins show the extent of the area monitored under this program.

Flow monitoring took place for the period April 9 to June 8, 2012. While the summer has been exceptionally dry, we did experience 8 rainfall events during the metering period. Three of these events were of sufficient magnitude to cause the system to respond, and for I/I to be recorded by the flow meters. These three rainfall events occurred on April 15, May 26, and May 31, and are summarized on page 3-1 of the report.

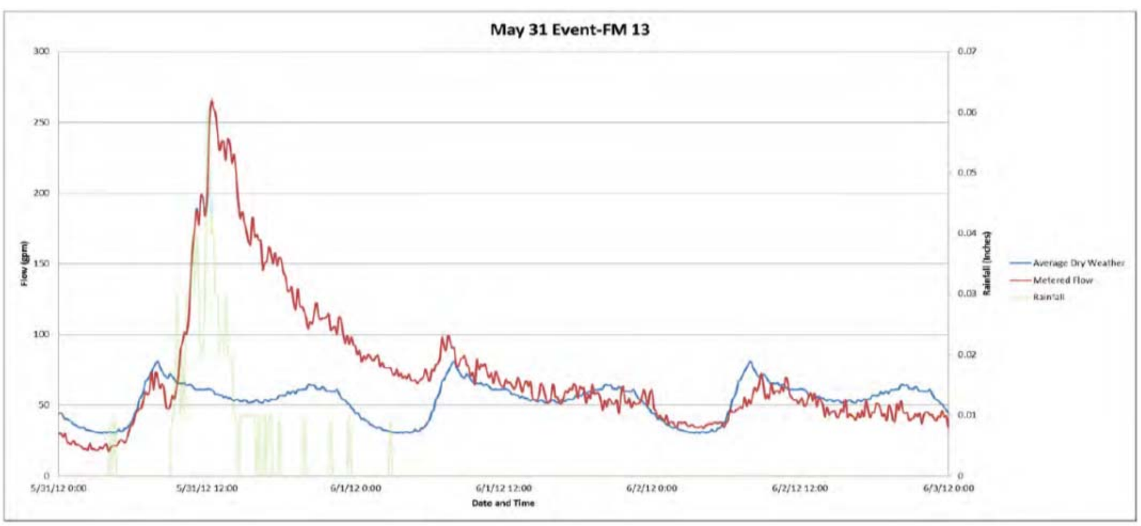
Data Analysis

Following completion of the flow monitoring work, Strand Associates compiled and analyzed the data, and drafted Sections 1 through 3 of their report, attached. These sections of the report detail the project scope and methodology, analysis of the data, and some preliminary recommendations on prioritizing basins for detailed study and analysis. Recall that the purpose of this flow monitoring study was to develop empirical data about the location and magnitude of I/I in the Village's sanitary sewer system. This information is intended to be used to help the Village identify which sanitary sewer basins should be the highest priority for detailed investigations into particular and specific sources of I/I such as poor manhole seals, leaking pipes (public and private) illegal downspout and drain connections, and other sources.

Strand's data analysis, simply put, consists of identifying average dry-weather flow as a baseline, and calculating the observed increases between wet-weather flow and dry-weather flow during and immediately after a measured rain event. Inflow is characterized in metering data by a rapid and sizable "spike" in flow that is closely timed to the occurrence of rainfall. This can be observed in the plot below, showing data from meter #15 for the May 26 storm.



Infiltration, which is groundwater entering the system through open joints and cracks in pipes, is a longer, slower, less intense occurrence. Infiltration is characterized in metering data by a long, sloping return of flow from a wet-weather peak back to the dry-weather flow regime. This can be seen in the plot below, showing data from meter #13 for the May 31 event.



Inflow and infiltration data were evaluated, quantified and tabulated for each of the 30 metering basins. A discussion of the methods used to quantify and compare data is contained in Section 3 of the draft report.

In summary, inflow was characterized by two methods. In the first method, a ratio of wet-weather flow to dry-weather flow, known as "peaking factor", was calculated for each metering location. The higher the peaking factor, the more susceptible the metering basin is to inflow. In the second method, inflow for the entire system was calculated , and each basin was ranked based on the percentage of inflow it contributed to the entire system.

Infiltration for each basin was calculated using the flow volume beginning 30 minutes after the conclusion of a each rainfall event and ending when the flow volume returned to the baseline dry weather flow. Infiltration was "normalized" across basins by factoring in the length of sewer in each basin to equalize large and small basins.

Preliminary Basin Ranking

Strand provided some preliminary recommendations on how to rank basins for prioritizing future actions, based on a data-driven, empirical evaluation of the system. These recommendations are summarized in Table 3.06-4 on page 3-20 of the report. Figure 3.07-1 shows Strand's preliminary empirical recommendations for the highest priority basins to be addressed first (shown in green), and the remaining basins to be evaluated (shown in blue). These basins are overlaid with the responses that indicated sanitary sewer backups from the September 2011 flood survey. It is readily apparent that some areas that exhibited clusters of basement flooding, notably in metering basins 23, 24, and 25 in the southeast portion of the Village, occur in basins that did not exhibit signs of excessive I/I. Why would this be the case?

Recall that the flood survey data relates to a particular storm of historic proportions, July 22-23 2011. During this event, there were conditions that occurred which were not duplicated during the flow monitoring period, such as interceptor surcharging and widespread overland flooding. While the flow monitoring data is of good quality, and confirms the presence of I/I to varying degrees throughout the system, the data is not ideal, in the sense that the observed rainstorms were sufficient to cause the system to respond, but not sufficient to cause flooding, or backups from the MWRD's interceptor systems.

Such conditions likely contributed to significant surcharging of the Village's sanitary sewers that would not be observable except in cases of extreme flooding. For example, many streets and intersections were inundated beneath two to three feet or more of standing water at the height of the flooding. In many of these locations, sanitary manholes were located in flooded areas, and anything but the most perfectly sealed or elevated manhole would allow significant amounts of floodwater to enter the system under such conditions. In addition, it can be seen that many of the clusters of reported sanitary sewer backups are within a block or two of a connection to the MWRD's intercepting sewers. It is highly likely that surcharging of these interceptors contributed to basement flooding in these areas.

Data Reconciliation

There are a couple of ways to reconcile the flow metering data with the observed flooding data from July 2011 so that the resultant detailed investigation program recognizes both realities. One way would simply be to add the metering basins with significant flooding clusters to the high priority list for detailed I/I investigations. This would be relatively fast and would not carry any significant upfront cost, however it would add to the cost of the higher-priority investigations, with no empirical indication that significant I/I sources or reductions would be identified.

A second way to reconcile these two realities would be to engage Strand Associates to reinstall meters in select locations in the hope (??) of experiencing a larger storm that may induce interceptor backups or other conditions that more closely approximate the July 2011 flood. This would entail an additional up-front metering expenditure, but may be an effective way to ascertain to a greater degree an appropriate priority ranking for these metering basins that reconciles empirical data with the flood survey data.

Strand Associates will be present at the Village Council meeting on July 17 to present and discuss the draft report with the Council. This will be an opportunity for the Council to discuss and provide comments and policy direction on the draft report. The most important point for discussion is identifying the right methodology – for Winnetka – to evaluate the empirical flow monitoring data and rank the metering basins in context with the reported flooding data from the July 23, 2011 storm.

Actions to Complete Project

After Council input is received on the ranking methodology, Strand Associates will complete Sections 4 and 5 of the report, consisting of detailed recommendations for future investigations, and a timeline and budget for these investigations, and present a final recommendation for consideration by the Council, likely at the August 21 Council meeting.

Recommendation:

1. Review draft report.
2. Discuss and develop consensus on methodology to be used to rank sewer basins for further detailed I/I analysis.

Attachments:

Sanitary Sewer Evaluation Survey – Draft Report
Sanitary Sewer Evaluation Survey – Draft Report Appendices

DRAFT-07/12/12

Professional

Engineering

Services

Sanitary Sewer Evaluation Survey

Report

Village of

Winnetka, IL

July 2012

STRAND ASSOCIATES®

Report for
Village of Winnetka, IL

Sanitary Sewer Evaluation Survey

Prepared by:

STRAND ASSOCIATES, INC.®
IDFPR No. 184-001273
1170 South Houbolt Road
Joliet, IL 60431
www.strand.com
July 2012

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SECTION 1
INTRODUCTION

1.01 PURPOSE

The Village of Winnetka, Illinois (Village) owns and maintains its own sanitary sewer system. Sewerage from the Village's local sanitary sewer system flows into the interceptor sewer system owned and maintained by the Metropolitan Water Reclamation District of Great Chicago (MWRDGC) and transported to the North Side Wastewater Treatment Plant (WWTP).

Over the years the Village has experienced a number of large rainfall events resulting in significant surface flooding and backup of the sanitary sewer system into basements. One particular event occurred on July 23, 2011, when over 6 inches of rain fell in less than three hours. In response to the July 23 event the Village performed a survey of all residents to determine the extent of flooding and basement backups. Of the responses received, 276 residents indicated they experienced a basement backup. While the July 23 event was an extreme event, the results of the survey suggest the presence of sanitary sewer infiltration and inflow (I/I) prompting development of a sanitary sewer evaluation survey (SSES).

The purpose of a SSES study is to identify locations of I/I into the sanitary sewer system and determine means for reducing I/I. Infiltration is groundwater that enters the sanitary sewer system because of high ground or surface waters. Infiltration is groundwater that enters the sanitary sewer system through defective sewer joints, cracked or broken sewers, or manhole walls. Inflow is surface water directly entering the sanitary sewer system because of rainfall or surface runoff through roof drains, yard or area drains, foundation drains, manhole covers, and cross connections with storm sewers. Excessive I/I into the sewer system can exceed the sewer's capacity and result in system backups.

The purpose of this flow monitoring study was to analyze the dry and wet weather flow characteristics of the Village's sanitary sewer system, isolate the areas within the system where I/I is most prolific, and provide the Village with recommendations on moving forward with future investigations to pinpoint and reduce the sources of I/I.

1.02 SCOPE

The scope of the SSES includes the following:

1. Division of the Village into 30 flow metering basins and installation of flow meters for a period of seven weeks from April 16 to June 8.

2. Installation of one rain gauge to supplement the existing Illinois State Water Survey (ISWS) rain gauge within the Village to collect simultaneous rainfall data over the flow metering period.

3. Analysis of the flow monitoring data for sanitary sewer system I/I characteristics in each flow metering basin.

4. Prioritization of the flow metering basins based on I/I characteristics.

5. Recommendations for continued investigations to pinpoint and reduce sources of I/I.

1.03 ABBREVIATIONS

Village	Village of Winnetka
FM	flow meter
gpm	gallons per minute
I/I	infiltration and inflow
in	inch
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
RG	rain gauge
WWTP	wastewater treatment plant
ISWS	Illinois State Water Survey
SSES	sanitary sewer evaluation study
SSO	sanitary sewer overflow

SECTION 2
FLOW MONITORING PROGRAM

2.01 EXISTING COLLECTION SYSTEM

The Village currently owns, operates, and maintains a sanitary sewer system that serves residential, commercial, and public users. These sewers were designed to convey wastewater for the existing users and also for future growth. The Village-owned sewers flow into MWRDGC-owned interceptor sewers that convey flow to MWRDGC's North Side WWTP.

The Village's sanitary system is a separate sanitary sewer system. A separate sanitary sewer system is a two-pipe system where wastewater flows through one network of pipes and storm water flows through a separate network of pipes. However, because of the grade separation at the railroad tracks along Green Bay Road storm sewers are prevented from crossing the tracks. As a result, some of the separate storm sewers on the west side of the village ultimately discharge directly into the MWRDGC interceptors.

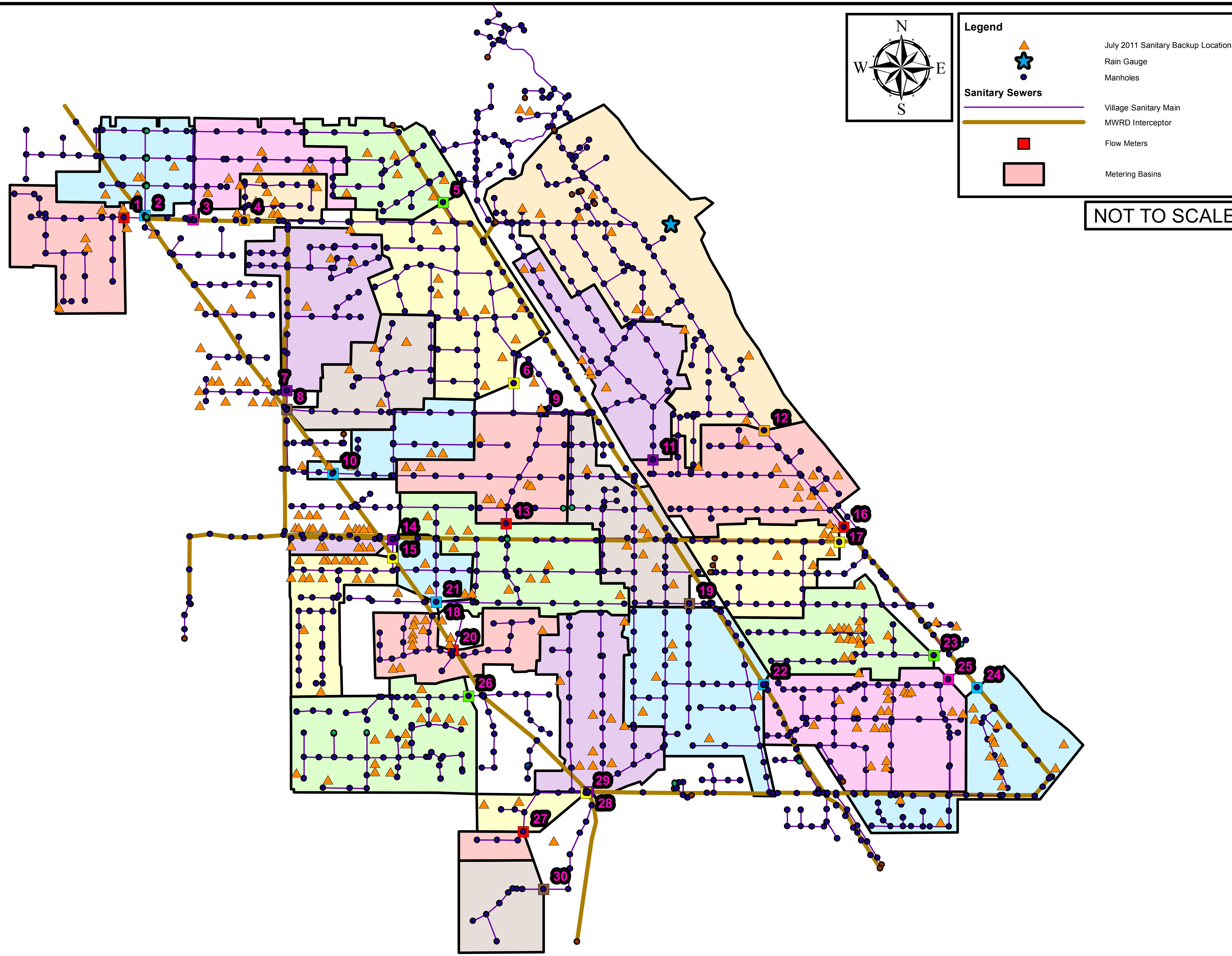
2.02 BASIN DELINEATION AND FLOW METERING LOCATIONS

The Village's sanitary sewer system is unique in that there is an excess of 40 points of discharge into the MWRDGC interceptor sewer system. This made developing a metering program challenging and resulted in having a much higher number of flow meters than normally would be required for a system of similar size.

Ultimately, a total of 30 flow meters were installed in the Village's sanitary sewer system creating 30 sewershed basins with each basin monitored by a flow meter. The flow meters were maintained and data collected over a seven-week monitoring period from April 16 through June 8. Table 2.02-1 provides an inventory of the flow metering locations and the upstream pipe sizes (flow meter sizes). Figure 2.02-1 shows the locations of each flow meter and the resulting metered areas or sewershed basins.

The Village conducted a flooding survey in September 2011 in response to the rainfall event that occurred on July 23, 2011, producing over 6 inches of rain in less than 3 hours. The purpose of the survey was to identify how many residents and at what locations basement backups occurred. The results of this survey are presented in Figure 2.02-1.

The flow metering program was developed to monitor as much of the system as practically possible, especially the areas that experienced basement backups according to the Village survey. However, a few areas of the Village were not metered, either because there was not a manhole suitable for meter installation, or because the tributary areas were too small to allow for reliable data collection. Areas not metered under this program include small local sewers west of Hibbard Road along Sunview Lane, Hackberry Lane, Westmoor Trail, Trapp Lane, and Bell Lane. Other areas omitted because of basin size include the sewer along Spruce Street between Berkeley Avenue and Hibbard Road, areas between Hibbard Road and Glendale Avenue, and some areas south of Willow Road. Some of these areas reported basement backups, which was taken into consideration in making recommendations for future investigations.



FLOW METERING BASINS

SANITARY SEWER EVALUATION SURVEY
VILLAGE OF WINNETKA
WINNETKA, IL

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FIGURE 2.02-1

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There is a large unmetered area located east of the railroad tracks north of Basin 12. This area was left unmetered because it was tributary to a lift station and there was not a suitable location for a single flow meter. As a result, it would require an additional meter increasing the project cost. After discussions with Village personnel, it was determined that the increase in cost did not provide much added benefit because the results of the Village survey indicated there were very few basement backups that occurred in this area. Therefore, it was omitted for future investigation.

TABLE 2.02-1

FLOW METER LOCATIONS AND SIZES

Meter	Meter Location	Sewer Size (inches)
M01	In the westbound lane of Tower Road just east of Boar Parkway	8
M02	At the intersection of Tower Road and Greenwood Avenue	10
M03	In the parkway south of the intersection of Tower Road and Vernon Avenue	15
M04	In the eastbound lane of Tower Road between Bell Lane and Forest Glen Drive	8
M05	Green Bay Road just north of Tower Road	12
M06	East parkway of Blackthorn Road north of Pine Street	15
M07	Northbound lane of Hibbard Avenue just north of Pine Street	10
M08	At the intersection of Hibbard Avenue and Pine Street	15
M09	North parkway of Pine Street between Provident Avenue and Walden Road	18
M10	Westbound lane of Elm Street east of Hibbard Avenue	10
M11	In the middle of Lincoln Avenue north of Elm Street	15
M12	In the middle of Sheridan Road between Pine and Spruce Street	27 x 18 Egg Shape
M13	Northbound lane of Provident Avenue between Oak and Cherry Street	15
M14	At the intersection of Ash Street and Glendale Avenue	10
M15	In the southbound lane of Glendale south of Ash Street	15
M16	In the middle of Sheridan Road between Cherry and Oak Street	36 x 24 Egg Shape
M17	Just west of the intersection of Cherry Street and Sheridan Road	32 x 21 Egg Shape
M18	Intersection of Rosewood Avenue and Willow Road (Same MH as M21)	15
M19	Intersection of Willow Road and Forest Street	27 x 18 Egg Shape
M20	Just north of Locust Road and Mt. Pleasant Street	10
M21	Intersection of Rosewood Avenue and Willow Road (Same MH as M18)	8
M22	Outside northbound lane of Green Bay Road between Sunset Street and Church Road	18
M23	In the middle of Hawthorn Lane just West of Sheridan Road	18
M24	In the middle of Sheridan Road between Elder Lane and Fuller Lane	27 x 20 Egg Shape
M25	In the middle of Elder Lane between Sheridan and Essex Road	28 x 21 Egg Shape
M26	The intersection of Sunset and De Windt Road	12
M27	Northbound Lane of Fox Lane south of Hill Road	12
M28	MWRDGC manhole at the intersection of Hill and N. Indian Hill Road	10
M29	Just west of the intersection of Hill and N. Indian Hill Road	15
M30	Front yard of 40 Indian Hill Road	8

Figure 2.02-2 shows a schematic of the flow meters in the conveyance system. This figure provides perspective on how the meters were interconnected.

Infiltration is groundwater entering the sanitary sewer system through sewer defects and is directly related to sewer length and diameter. It is expected that a large sewershed basin with large diameter pipes will have a higher volume of infiltration than a small basin with small diameter pipes. However, a larger total infiltration volume does not necessarily indicate a larger infiltration problem. To equalize basin size and pipe diameter variables between the basins, each basin was separated into inch-miles of sewer. Table 2.02-2 is a summary of this quantification. A detailed quantification is included in Appendix A.

In Table 2.02-2 there is no quantification for Basins 09, 27, and 30. FM 09 was installed to measure any overflows from Basin 13. As a result, there was no associated basin with a network of pipes that required quantification.

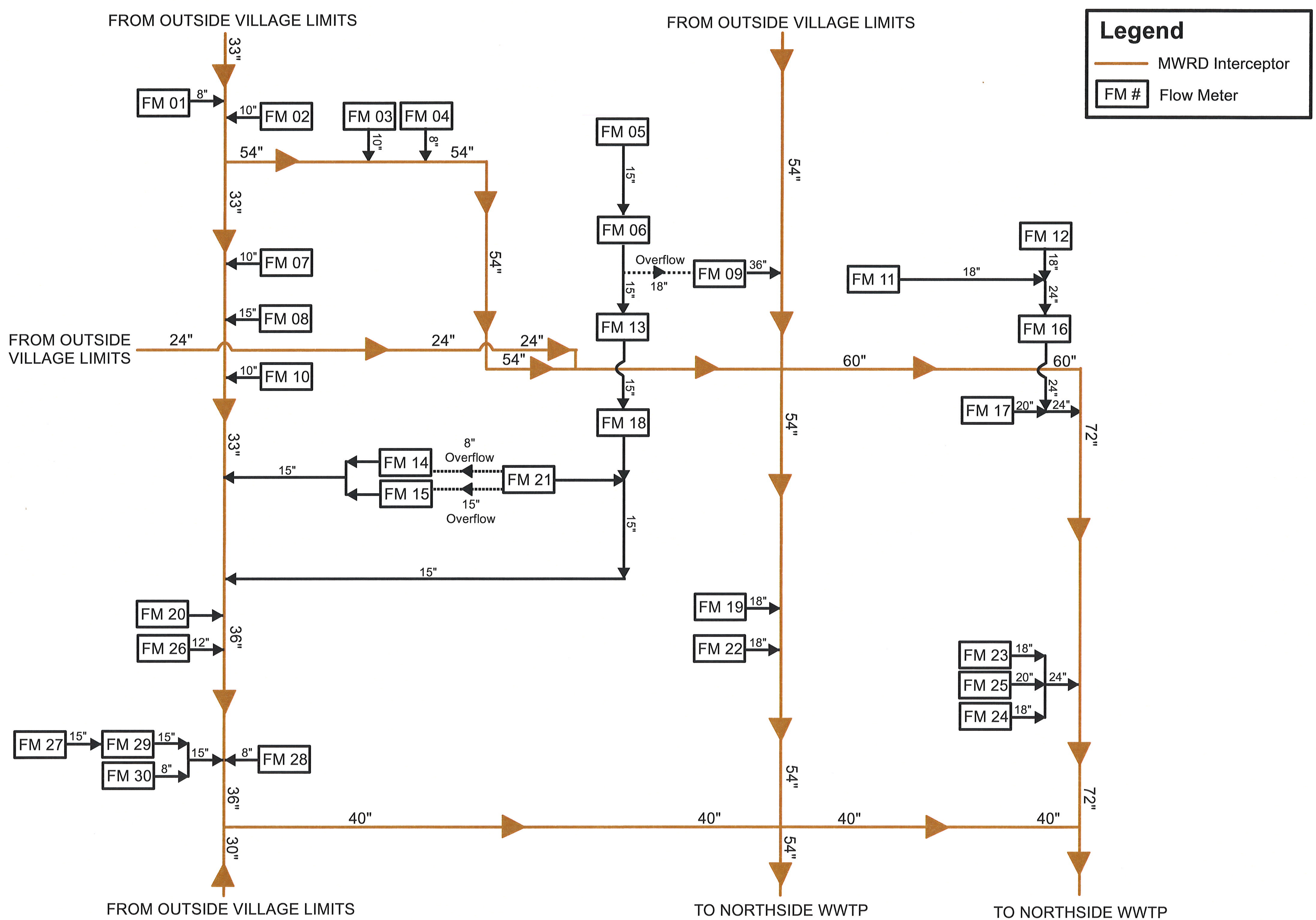
Flow meters 27 and 30 were installed to measure and quantify the flow that enters the Village's system from an unincorporated portion of Cook County serviced by the Woodley Road Sanitary District located west of Locust Road. Since it is not part of the Village system, the details of the basins were unknown at the time of this report and were not studied in this report.

Metering Basin	Length of Sewer		Equivalent Sewer Length
	(feet)	(miles)	(inch dia-mile)
M 01	5,440	1.03	8.24
M 02	4,768	0.90	7.52
M 03	5,819	0.94	11.24
M 04	2,594	0.49	3.93
M 05	5,899	1.12	9.98
M 06	14,240	2.11	25.93
M 07	10,881	2.06	16.88
M 08	4,708	0.89	10.27
M 09			
M 10	5,207	0.99	9.87
M 11	7,023	1.33	13.87
M 12	18,261	3.46	33.95
M 13	8,050	1.52	15.43
M 14	1,413	0.27	2.42
M 15	5,391	1.02	10.23
M 16	8,494	1.49	20.96
M 17	6,061	1.15	14.81
M 18	11,571	2.19	20.35
M 19	5,308	1.01	22.04
M 20	4,514	0.85	7.25
M 21	2,437	0.46	3.69
M 22	11,152	2.07	20.22
M 23	4,636	0.88	14.96
M 24	6,592	1.25	16.06
M 25	13,668	2.34	31.43
M 26	10,147	1.92	16.88
M 27			
M 28	7,017	1.33	10.64
M 29	1,604	0.30	4.03
M 30			

Table 2.02-2 Breakdown of Flow Metering Basins

2.03 RAIN GAUGE LOCATIONS

Rainfall data was collected from two rain gauges located within the Village. Rain Gauge 1 (RG 1) is an existing ISWS-maintained rain gauge located in the southwest corner of the Village. The data from RG 1 was collected, maintained, and made available via the internet by the ISWS during the flow monitoring period.



SYSTEM SCHEMATIC

SANITARY SEWER EVALUATION SURVEY
VILLAGE OF WINNETKA
WINNETKA, IL

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FIGURE 2.02-2

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The second rain gauge, Rain Gauge 2 (RG 2), was installed for the flow monitoring period at the Village's electric plant located at the intersection of Tower Road and Sheridan Road along the lakeshore.

The rain gauges collected rainfall over the seven-week period. The data collected was used to develop a relationship between rainfall totals, rainfall intensity, and wastewater flows in the collection system.

2.04 FLOW MONITORING OPERATIONS

The flow monitoring operations began with the installation of 30 ISCO 2150 area-velocity flow meters and one ISCO 675 tipping-bucket rain gauge between April 9, 2012 and April 13, 2012. Figures 2.04-1 and 2.04-2 show photographs of the equipment used. The flow meters used a pressure transducer to detect water level and Doppler radar to detect velocity of the sewer flow over the top of sensor which is set at or near the bottom of the sewer pipe entering a selected flow metering manhole. The diameter and shape of the sewer were programmed into the flow meter and the level reading was converted within the flow meter into a cross-sectional area of flow. Flow was calculated by multiplying the velocity readings by the flow meter's calculated flow area. Figure 2.04-3 shows a typical installation.

Figure 2.04-1 ISCO 2150 Flow Meter

Figure 2.04-2 ISCO Tipping Bucket Rain Gauge

Figure 2.04-3 Flow Meter Installation

After the initial installation, each of the flow meters and the rain gauge were monitored on a weekly basis. The stored data was downloaded from the meters and gauge to a laptop and a visual check of the data and site conditions was made to verify the meters were operating correctly. A manhole entry was made to correct any problems detected with the flow meters. Figure 2.04-4 shows a photograph of downloading data.

Following each week's data collection, a more thorough evaluation of the data was performed. This evaluation included a mass balance of flows comparing upstream and downstream data to confirm meters were working properly relative to each other.

The meters were removed June 7 and 8, 2012.

Figure 2.04-4 Flow Meter Data Download

SECTION 3
FLOW MONITORING DATA ANALYSIS

3.01 RAINFALL DATA ANALYSIS

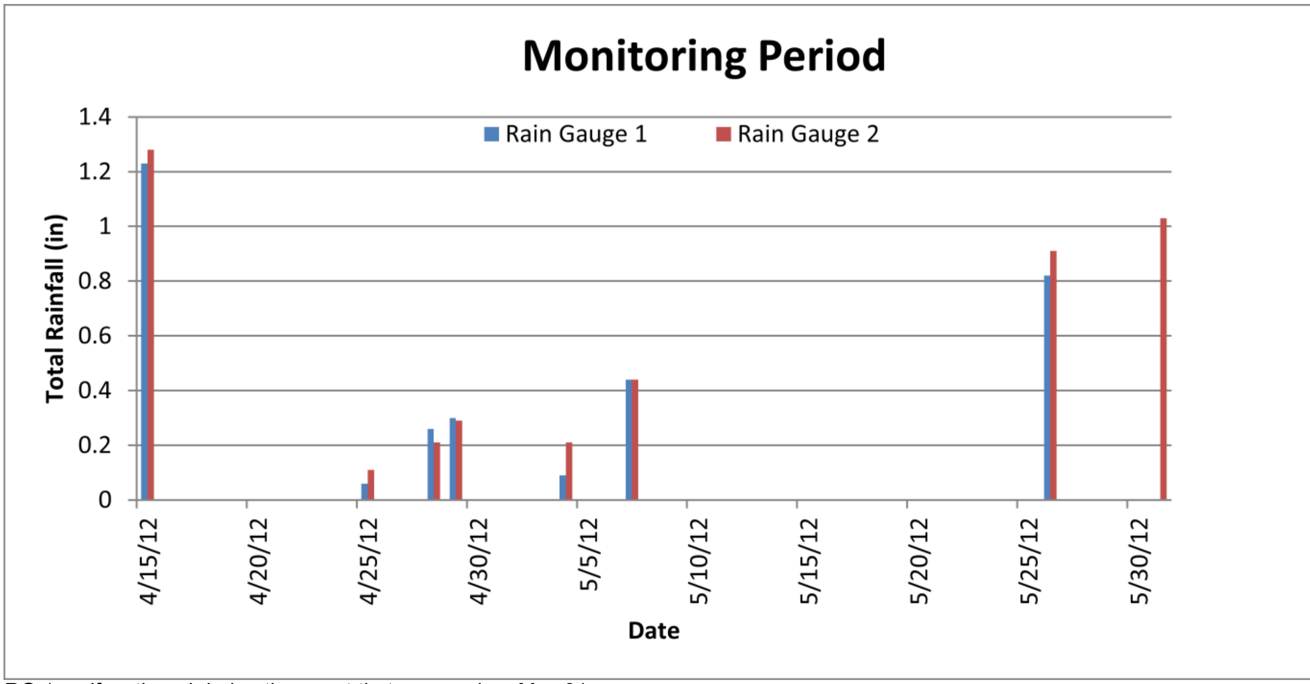
There were eight individual rainfall events considered over the seven week flow monitoring period. There were additional smaller events during the study period, but for an event to be considered more than 0.10 inch of rain was required. The eight rainfall events are detailed in Table 3.01-1. The rainfall distribution over the monitoring period is shown in Figure 3.01-1.

Date	Rain Gauge 1				Rain Gauge 2			
	Total Rainfall (in)	Total Duration (hrs)	Maximum Rainfall Intensity	Maximum Rainfall Recurrence Interval	Total Rainfall (in)	Total Duration (hrs)	Maximum Rainfall Intensity	Maximum Rainfall Recurrence Interval
4/15	1.23	24	.78 in/3 hour	<2 months, 3 hour	1.28	24	.37 in/1 hour	<2 months, 1 hour
4/25	0.06	9	.02 in/10 min	<2 months, 10 min	0.11	8.5	.04 in/1 hour	<2 months, 1 hour
4/28	0.26	1.67	.19 in/30 min	<2 months, 30 min	0.21	2	.11 in/1 hour	<2 months, 1 hour
4/29	0.3	5	.11 in/30 min	<2 months, 30 min	0.29	4.33	.12 in/30 min	<2 months, 30 min
5/4	0.09	2	.02 in/10 min	<2 months, 10 min	0.21	2.67	.13 in/30 min	<2 months, 30 min
5/7	0.44	2.5	.26 in/1 hour	<2 months, 1 hour	0.44	3	.2 in/30 min	<2 months, 30 min
5/26	0.82	1.5	.55 in/10 min	1.2 year, 10 min	0.91	1	.59 in/10 min	1.25 year, 10 min
5/31					1.03	8.5	.44 in/2 hour	<2 months, 2 hour

The shaded light gray indicates the events chosen for analysis.
The shaded dark gray indicates a period when the associated rain gauge was not working properly.

Table 3.01-1 Rainfall Event Details

The data collected at each rain gauge was used to analyze each rainfall event. The rainfall intensity for the most intense portion of the rainfall event was used to estimate a recurrence interval in accordance with the *Rainfall Frequency Atlas of the Midwest* by Huff and Angel. Rainfall recurrence intervals consider both the magnitude and the duration of a rainfall event and are based on a statistical analysis representing the probability that the given event will be equaled or exceeded in any given year. For example, in any given year statistically there is a 1 in 2 chance that 0.67 inches of rain will fall in 10 minutes in the Village. Thus, an event where 0.67 inches of rain falls in 10 minutes is said to have a 2-year recurrence interval. Furthermore, according to Huff and Angel, in any given year statistically there is a 1 in 1 chance that 0.55 inches of rain will fall in 10 minutes. This is considered to have a 1-year recurrence interval. On May 26, according to the data collected by RG 2, 0.59 inches of rain fell in 10 minutes. Since this amount of rainfall, is between the 1- and 2-year recurrence interval storms for a 10-minute duration, we need to interpolate to estimate the recurrence interval of the event. The resulting estimated recurrence interval was a 1.25-year recurrence interval.



RG 1 malfunctioned during the event that occurred on May 31.

Figure 3.01-1 Rainfall Events

A rainfall event used for data analysis would ideally be uniform across the Village. A uniform event would result in approximately equal rain gauge data at each gauge location. If the data collected at each rain gauge is approximately equal, it can be inferred that the rainfall between the rain gauges was also approximately equal. This allows us to assume that sewershed basins not next to a rain gauge received approximately the same rainfall observed at a rain gauge which in turn allows for a more equal comparison between basins when evaluating the severity of I/I into the system. Each sewershed basin was assigned to one of the two rain gauges.

The most significant events observed during the monitoring period occurred on April 15, May 26, and May 31. The April 15 and May 31 events were characterized by long low-intensity soaking events. While these two events had recurrence intervals less than two months, over 1 inch of rain fell and the flow monitoring data suggest they impacted flow characteristics in the sanitary sewer system.

The May 26 event was a short, but intense event that occurred after a prolonged period of dry weather. This type of event is a good indicator of sources of inflow in the system because the long period of dry weather before the event most likely resulted in more absorption by the dry soils and may have reduced the impacts of infiltration. With the impact of infiltration reduced, the increase in flows observed as a result of this event was most likely inflow. This inference seems to be supported by the data collected.

3.02 FLOW METERING EVALUATIONS

On a weekly basis over the flow monitoring period, the flow metering data was compiled and evaluated to determine two things: (1) the quality of the data collected at each individual flow metering location and (2) how the meters were working relative to each other.

To determine the quality of the data collected, a scatter graph was created for each flow meter each week. The scatter graphs consisted of plotting the velocity data vs. the level data on the same graph. The shape and pattern of the scatter graph provided valuable insight into how the flow meter was functioning and the quality of the data it was collecting as well as how the hydraulic conditions in the sewers were changing during rain events. Figure 3.02-1 shows an example scatter graph created for data evaluation. As should be expected, the data points generally fall into a relatively tight line. This scatter graph suggests the flow meter is collecting good data and the sewer did not surcharge during the month of April.

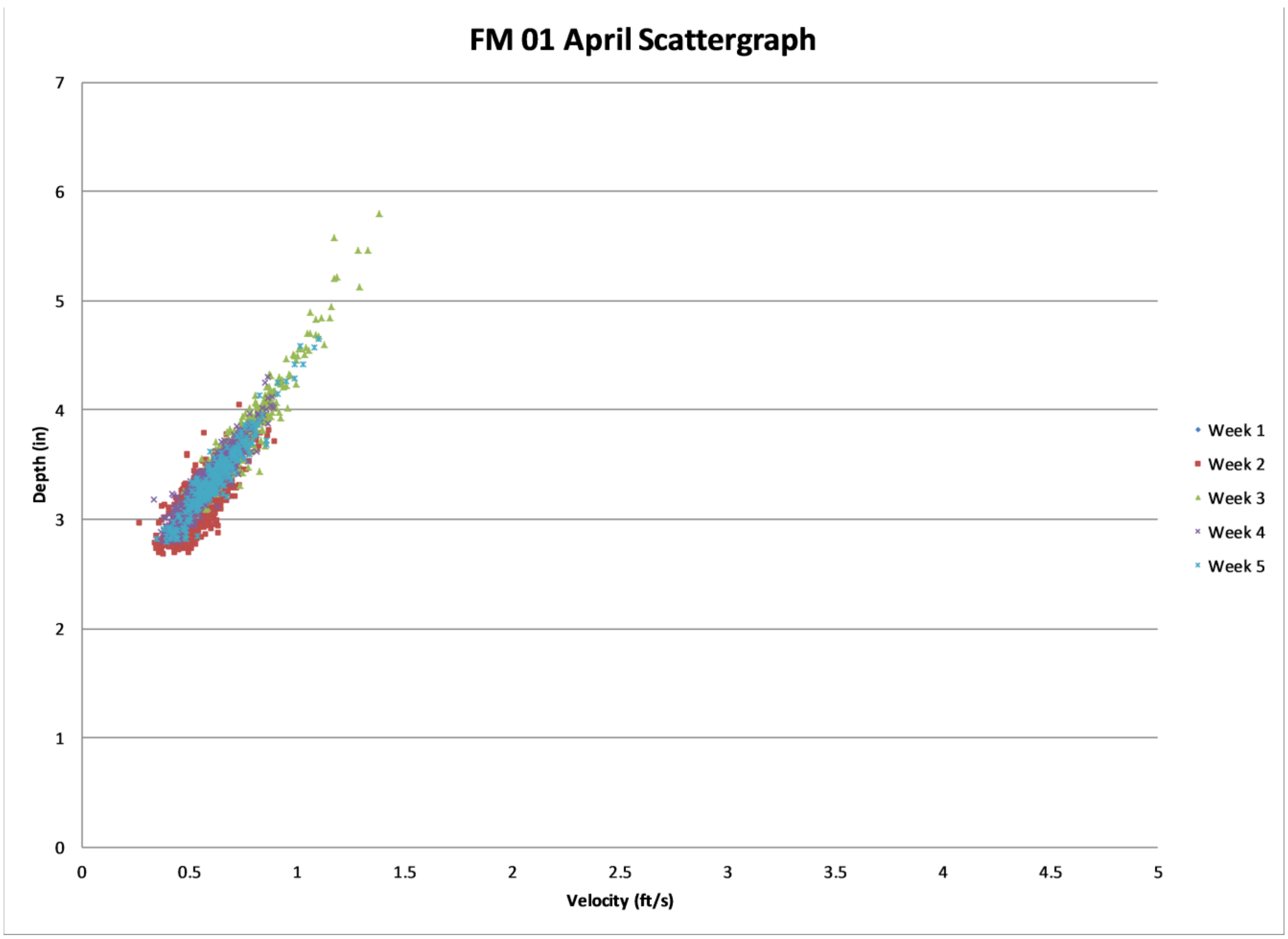


Figure 3.02-1 Example Scatter Graph

To determine how the meters were working relative to each other, a mass balance was calculated between certain flow meters. A mass balance analysis is a comparison between downstream flow data and flow data collected directly upstream. While most flow meters were installed directly upstream of the MWRDGC intercepting sewers, there were some meters upstream of other meters. In these situations flow meter data was evaluated by removing the influence of upstream meters by subtracting the upstream flow meter data from the downstream data, taking time of travel into account. In theory, any flow generated in an upstream basin should be measured at the flow meter location downstream. Furthermore, additional sewerage collected from within the downstream basin should also be measured at the downstream flow meter. This means that the flow rates observed at the downstream meter should always be higher than the flows observed at the upstream meter.

If the results of the data evaluation suggested a flow meter was not working properly, either a specific maintenance trip was made to correct the flow meter in question, or the meter was adjusted during the next weekly download.

Appendix B discusses the flow meter data evaluation in more detail providing a narrative description of each flow metering location and the quality of data collected, specifically during the three study events. Appendix B also provides flow response graphs for each flow metering location during each of the three study rainfall events.

3.03 DRY WEATHER FLOW ANALYSIS

A dry weather flow analysis was performed to determine the baseline flow characteristics of each sewershed basin.

To determine the baseline flow at each meter, dry weather flow values collected at 10-minute intervals over each dry weather day were averaged to create a 24-hour baseline flow consisting of 144 data points for each basin. For a day to be considered a “dry weather” day, it had to satisfy two criteria: (1) it had to have less than 0.10 inches of rain, and (2) there had to be at least 48 hours of dry weather preceding it. Table 3.03-1 shows the results of the dry weather or baseline flow analysis.

Flow Meter	Baseline Flow (gpm)		
	Minimum	Average	Maximum
FM 01	21.5	32.7	47.2
FM 02	27.1	46.4	83.8
FM 03	6.8	12.5	20.9
FM 04	8.5	16.2	31.7
FM 05	29.2	46.0	60.9
FM 06	8.6	24.8	48.6
FM 07	6.6	8.2	12.2
FM 08	48.7	62.2	83.8
FM 09	27.6	43.2	65.8
FM 10	13.6	16.5	21.0
FM 11	25.9	47.5	69.2
FM 12	55.2	114.0	172.5
FM 13	11.5	25.7	43.2
FM 14	19.1	29.8	51.0
FM 15	16.9	25.2	36.6
FM 16	18.4	72.6	111.3
FM 17	29.1	43.2	70.7
FM 18	36.8	56.5	92.4
FM 19	64.9	89.5	110.9
FM 20	36.2	47.4	56.8
FM 21	13.3	16.6	22.4
FM 22	82.6	122.9	162.1
FM 23	39.0	60.0	91.0
FM 24	48.5	61.8	77.2
FM 25	16.0	24.0	35.5
FM 26	43.1	61.2	87.3
FM 27	95.0	108.9	127.1
FM 28	15.3	28.4	48.9
FM 29	12.6	26.2	61.0
FM 30	46.8	57.2	69.9

Table 3.03-1 Baseline Flow Analysis

The flows presented in Table 3.03-1 represent the baseline flow characteristics for each individual sewershed basin and were used for the wet weather analyses in the next section.

3.04 WET WEATHER FLOW ANALYSIS

A wet weather flow analysis was performed for each sewershed basin for each of the three rain events that occurred on April 15, May 26, and May 31. There were two analyses performed on each basin.

A. Inflow Analysis

The inflow analysis employed two techniques. The first technique determined the peaking factor for each basin by taking the peak flow observed during the rain event and divided it by the baseline flow value that occurred at the same time of day. For example, if the peak flow occurred at 2:20 A.M. then the peaking factor was determined by taking the peak flow value and dividing by the baseline flow value at 2:20 A.M. as calculated in the baseline flow analysis. Peaking factor is generally a good analysis of inflow because it quantifies the quick response observed within the system directly caused by rainfall. When there are inflow problems, it tends to cause flows to peak quickly to multiple times higher than the baseline dry weather flows. Table 3.04-1 and Figure 3.04-1 show the results of the peaking factor analysis.

The second technique analyzing how much of the overall system inflow rate was contributed by each individual basin. This analysis entailed adding the peak inflow flow rate from each basin to determine a theoretical total system peak inflow rate. A percentage of the total system inflow rate was calculated for each basin by taking the individual peak inflow flow rate for each basin and dividing it by the total peak inflow rate for the system. This percentage represents the proportion of the total inflow for the system from an individual sewershed basin. This analysis provided a comparison of basins by quantifying the impact each basin had on the total system. Table 3.04-2 and Figures 3.04-2, 3.04-3, and 3.04-4 show the results of this analysis.

TABLE 3.04-1

INFLOW ANALYSIS–PEAKING FACTORS

Metered Basin	Baseline Flow (gpm)	April 15, 2012		May 26, 2012		May 31, 2012	
		Peak Flow (gpm)	Peaking Factor	Peak Flow (gpm)	Peaking Factor	Peak Flow (gpm)	Peaking Factor
1	33	168	7.44	203	5.75	166	4.89
2	46	321	11.43	529	9.19	233	5.05
3	10	203	28.07	221	14.92	113	8.61
4	16	244	26.3	436	20.56	173	9.6
5	46	635	20.46	960	18.35	387	7.34
6	25	221	12.98	1289	33.16	576	22.04
7	8	31	3.18	90	8.68	31	3.45
8	62	448	8.85	496	7.19	413	6.43
9	43	406	12.47	549	10.22	441	7.58
10	16	113	6.06	277	16.11	176	11.98
11	47	349	12.86	498	7.83	298	4.95
12	114	894	13.96	1459	9.75	721	5.39
13	26			208	7.83	442	13.23
14	30	364	18.52	355	11.07	323	10.21
15	25	394	22.72	387	13.22	317	12.12
16	73	397	4.88	413	6.14	757	8.42
17	43	280	9.47	254	5.2	283	6.42
18	57	577	4.39	644	9.91	678	11.6
19	90	564	8.32	1428	13.78	516	5.16
20	47	404	10.86	207	3.91	399	7.62
21	17	122	8.92	117	6.62	127	7.6
22	123	785	9.43	450	3.26	653	4.96
23	60	435	10.96	468	6.95	438	6.77
24	62	245	4.98	152	2.25	219	3.37
25	24	134	8.23	56	2.12	133	5.31
26	61	359	8.28	234	3.34	408	6
27	109	375	2.96	323	2.96	515	4.45
28	28	259	15.67	258	7.88	391	13.02
29	26	131	2.23	33	4.32	58	5.31
30	57	168	4.14	108	1.75	192	3.32

FIGURE 3.04-1

PEAKING FACTORS AT FLOW METERS

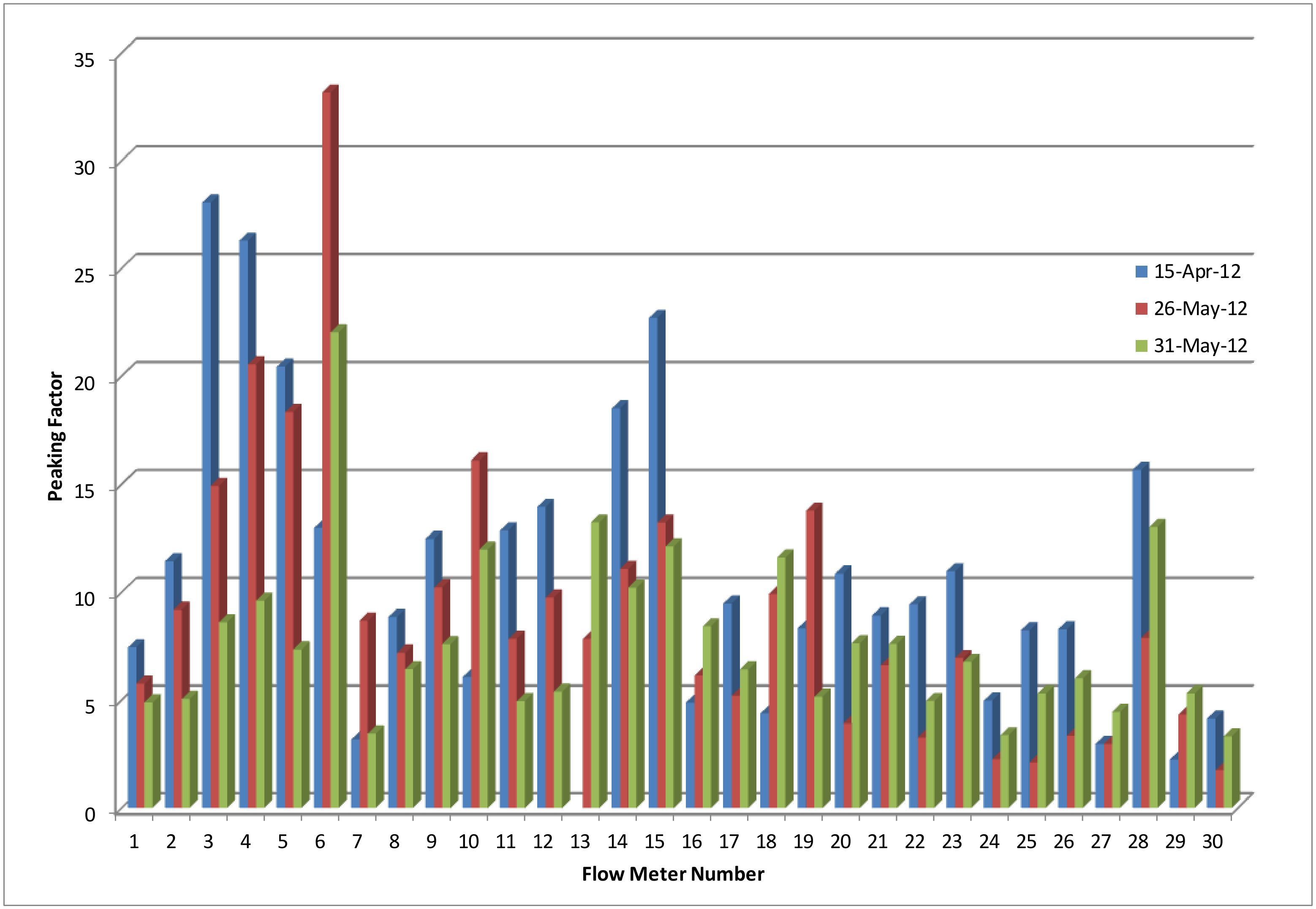


TABLE 3.04-2

INFLOW ANALYSIS–OVERALL SYSTEM CONTRIBUTION

	April 15, 2012				May 26, 2012				May 31, 2012			
Metering Basin	Max Metered Flow (gpm)	Corresponding Average Dry Weather Flow (gpm)	Max Inflow Volume (gpm)	Percentage of Total System Inflow	Max Metered Flow (gpm)	Corresponding Average Dry Weather Flow (gpm)	Max Inflow Volume (gpm)	Percentage of Total System Inflow	Max Metered Flow (gpm)	Corresponding Average Dry Weather Flow (gpm)	Max Inflow Volume (gpm)	Percentage of Total System Inflow
1	168	23	145	1.71%	203	35	168	1.52%	166	34	132	1.53%
2	321	28	293	3.45%	529	58	471	4.29%	233	46	187	2.16%
3	203	7	196	2.31%	221	15	206	1.87%	113	13	100	1.16%
4	244	9	235	2.76%	436	21	415	3.77%	173	18	155	1.79%
5	635	31	604	7.11%	960	52	908	8.25%	387	53	334	3.87%
6	221	17	204	2.40%	1,289	39	1,250	11.37%	576	26	550	6.36%
7	31	10	21	0.25%	90	10	80	0.72%	31	9	22	0.25%
8	448	51	397	4.68%	496	69	427	3.88%	413	64	349	4.03%
10	113	19	94	1.11%	277	17	260	2.36%	176	15	161	1.87%
11	349	27	322	3.79%	498	64	434	3.95%	298	60	238	2.75%
12	894	64	830	9.77%	1,459	150	1,309	11.90%	721	134	587	6.79%
13					208	27	181	1.65%	442	33	409	4.73%
14	364	20	344	4.05%	355	32	323	2.94%	323	32	291	3.37%
15	394	17	377	4.44%	387	29	358	3.25%	317	26	291	3.37%
16	397	81	316	3.72%	413	67	346	3.14%	757	90	667	7.72%
17	280	30	250	2.95%	254	49	205	1.87%	283	44	239	2.76%
18	577	131	446	5.25%	644	65	579	5.26%	678	58	620	7.17%
19	564	68	496	5.84%	1,428	104	1,324	12.04%	516	100	416	4.81%
20	404	37	367	4.32%	207	53	154	1.40%	399	52	347	4.01%
21	122	14	108	1.27%	117	18	99	0.90%	127	17	110	1.28%
22	785	83	702	8.26%	450	138	312	2.84%	653	132	521	6.03%
23	435	40	395	4.66%	468	67	401	3.64%	438	65	373	4.32%
24	245	49	196	2.31%	152	68	84	0.77%	219	65	154	1.78%
25	134	16	118	1.39%	56	26	30	0.27%	133	25	108	1.25%
26	359	43	316	3.72%	234	70	164	1.49%	408	68	340	3.93%
27	375	96	279	3.28%	323	109	214	1.94%	515	116	399	4.62%
28	259	17	242	2.85%	258	33	225	2.05%	391	30	361	4.18%
29	131	59	72	0.85%	33	8	25	0.23%	58	11	47	0.54%
30	168	41	127	1.50%	108	62	46	0.42%	192	58	134	1.55%
Totals	**9,620**	**1,127**	**8,493**	**100.00%**	**12,553**	**1,554**	**10,999**	**100.00%**	**10,136**	**1,494**	**8,642**	**100.00%**

FIGURE 3.04-2

OVERALL SYSTEM INFLOW CONTRIBUTION FOR EACH FLOW METER-APRIL 15, 2012 EVENT

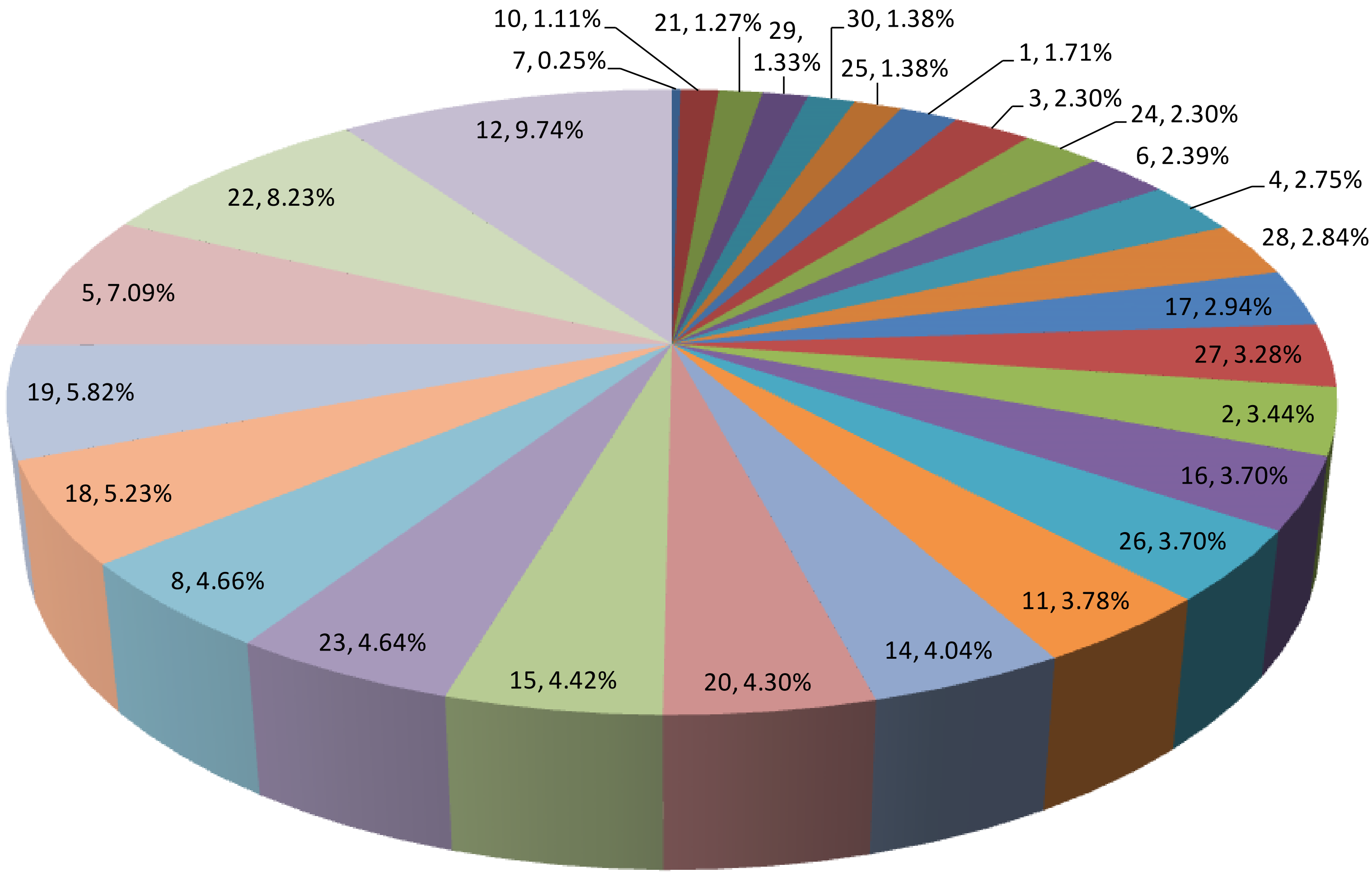


FIGURE 3.04-3

OVERALL SYSTEM INFLOW CONTRIBUTION FOR EACH FLOW METER-MAY 26, 2012 EVENT

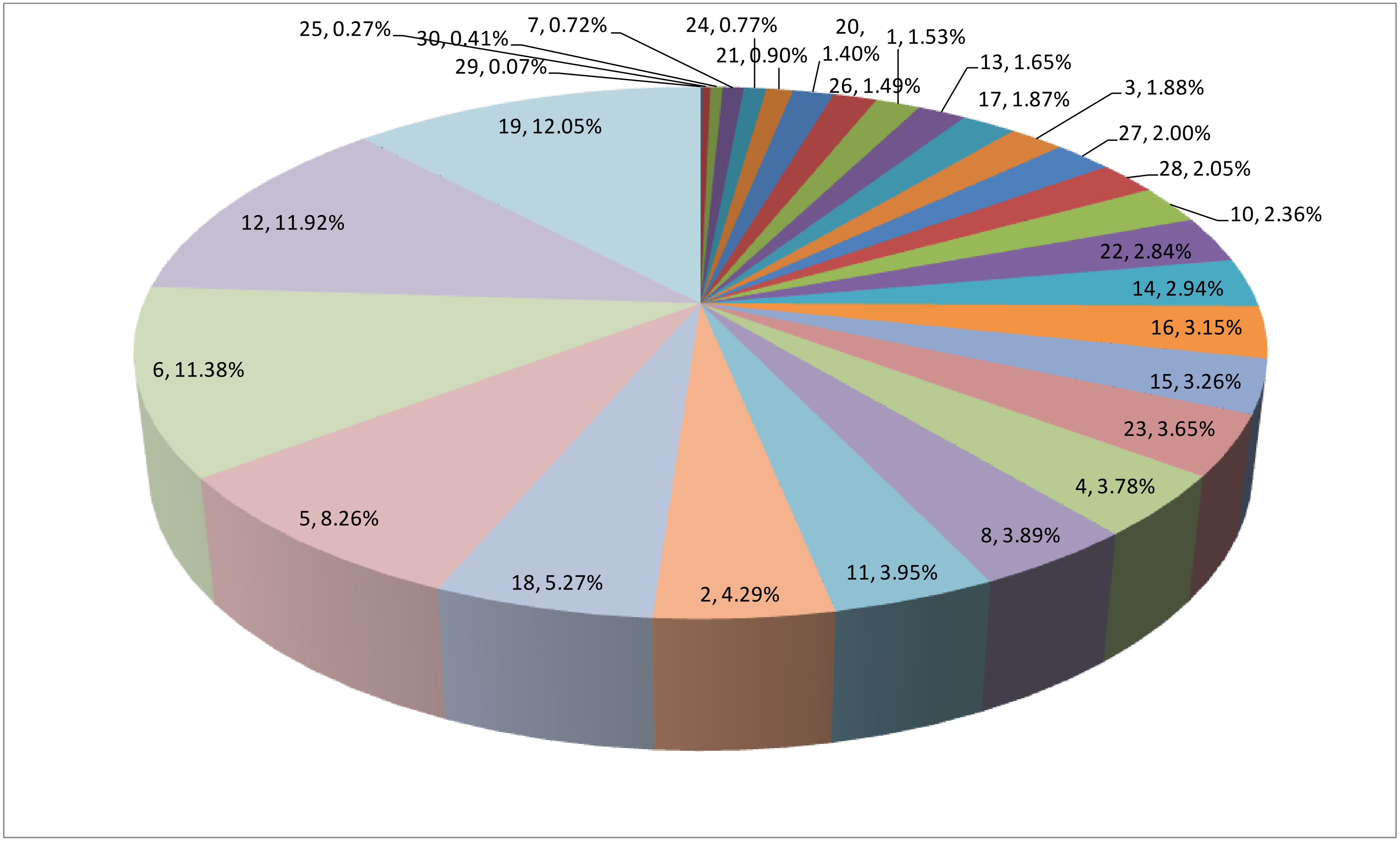
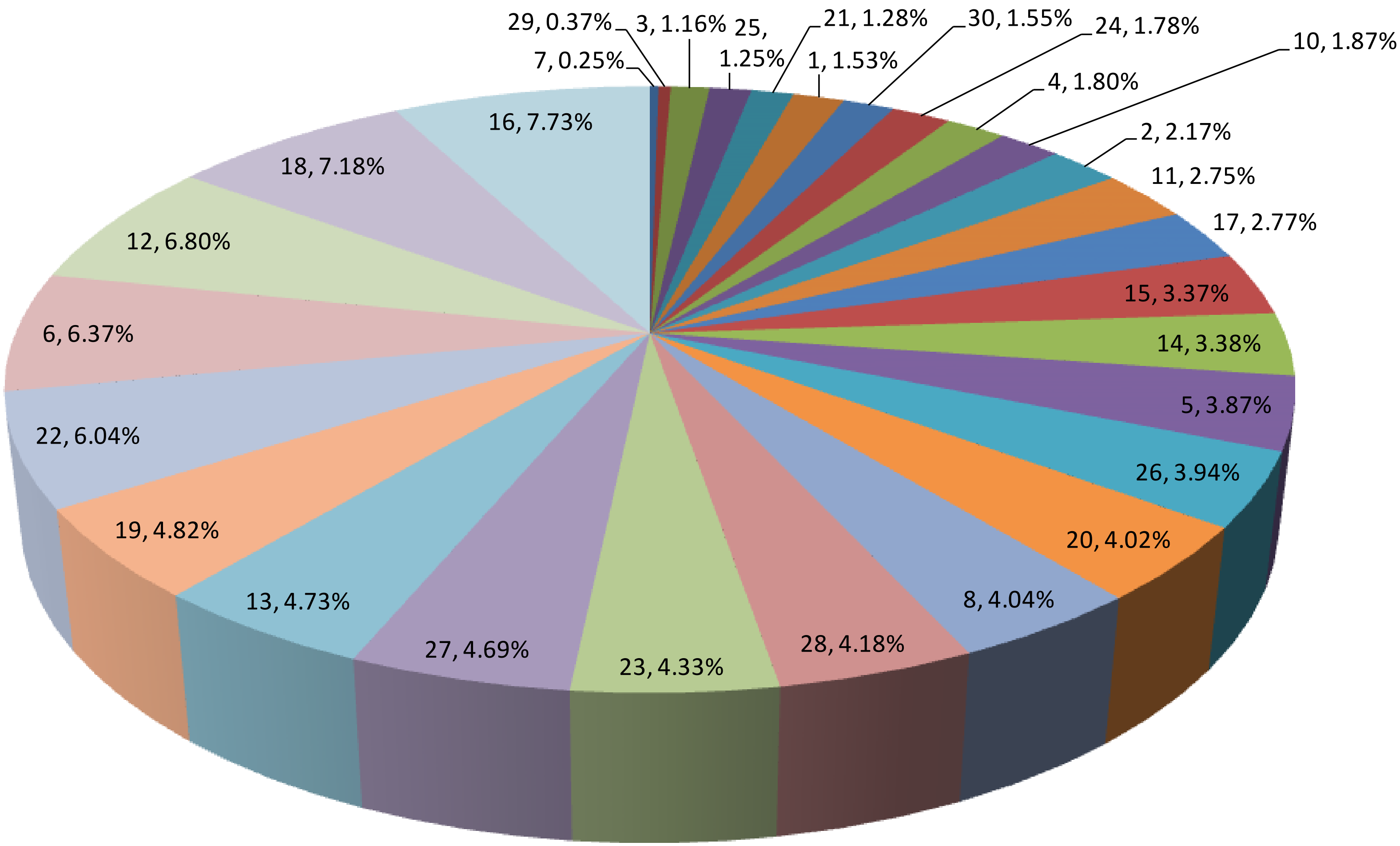


FIGURE 3.04-4

OVERALL SYSTEM INFLOW CONTRIBUTION FOR EACH FLOW METER-MAY 31, 2012 EVENT



B. Infiltration Analysis

The infiltration analysis looked at the elevated flows in the system over a period of time following the rainfall event and involved calculating an infiltration volume for each sewershed basin for each wet weather event and normalizing the volume based on inch-diameter-mile of sewer in each basin. .
The volume of infiltration for each basin was determined by calculating the flow volume starting 30 minutes after the conclusion of the rainfall event until the flow in the sewer returned to baseline flow levels and then subtracting the baseline volume over the same period of time. The reason for waiting 30 minutes after the rainfall event was to isolate the infiltration portion of the sewer flow response. If the analysis was performed starting at the beginning of the event it would include the effects of inflow into the system. A 30-minute delay was used because most of the sewershed basin areas are small enough that surface flow and run off, which represents inflow, would have enough time to get into the system and not skew the results of the analysis. Furthermore, the shapes of the hydrographs presented in Appendix B show a majority of the peak flows have significantly dropped off after approximately 30 minutes suggesting the delay appropriately isolates the sources of infiltration.

The final step of the analysis took the volume calculated as described above and dividing by the inch diameter-miles calculated for each basin presented in Table 2.02-2. Table 3.04-3 and Figure 3.04-5 show the results of this analysis.

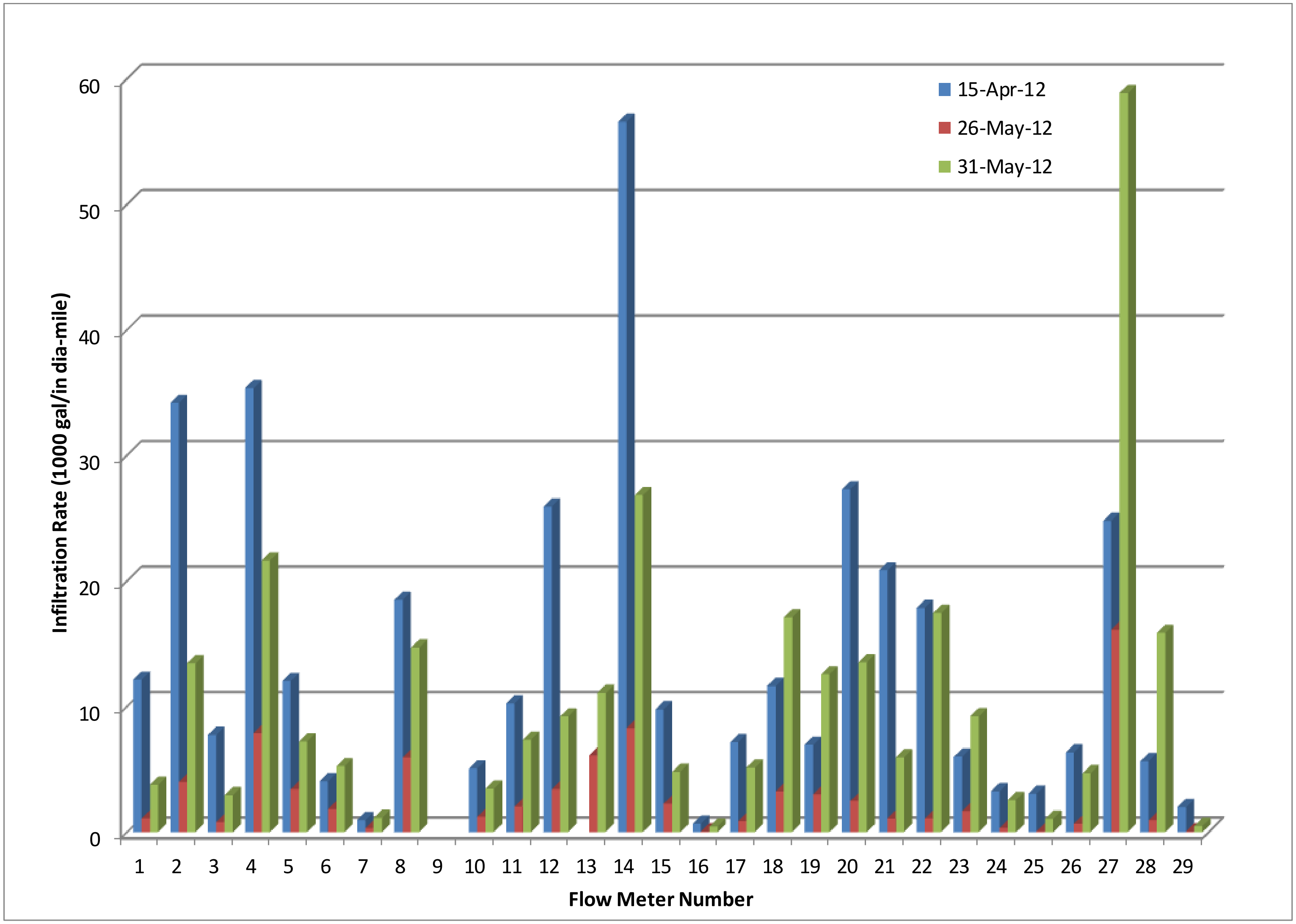
TABLE 3.04-3

INFILTRATION ANALYSIS

Metered Basin	April 15, 2012		May 26, 2012		May 31, 2012	
	Infiltration Volume (1000 gal)	Infiltration Rate (1000 gal/ inch dia-mile)	Infiltration Volume (1000 gal)	Infiltration Rate (1000 gal/ inch dia-mile)	Infiltration Volume (1000 gal)	Infiltration Rate (1000 gal/ inch dia-mile)
1	100	12.13	9	1.09	31	3.76
2	257	34.19	30	3.99	101	13.44
3	87	7.74	9	0.80	33	2.94
4	139	35.37	31	7.89	85	21.63
5	120	12.03	34	3.41	72	7.22
6	105	4.05	47	1.81	136	5.25
7	16	0.95	5	0.30	19	1.13
8	190	18.50	61	5.94	151	14.70
10	50	5.07	12	1.22	34	3.44
11	142	10.23	28	2.02	102	7.35
12	880	25.92	116	3.42	313	9.22
13			94	6.09	171	11.08
14	137	56.57	20	8.26	65	26.84
15	100	9.78	23	2.25	49	4.79
16	14	0.67	1	0.05	9	0.43
17	106	7.16	13	0.88	76	5.13
18	416	11.63	66	3.24	348	17.10
19	153	6.94	66	2.99	277	12.57
20	198	27.30	18	2.48	98	13.51
21	77	20.85	4	1.08	22	5.96
22	361	17.85	22	1.09	353	17.45
23	90	6.01	25	1.67	138	9.22
24	52	3.24	5	0.31	41	2.55
25	96	3.05	2	0.06	33	1.05
26	107	6.34	11	0.65	79	4.68
27	40	24.79	26	16.11	95	58.87
28	60	5.64	10	0.94	169	15.88
29	8	1.98	0.17	0.04	1.94	0.48

FIGURE 3.04-5

INFILTRATION RATES AT FLOW METERS



3.05 ANALYSIS ANOMALIES

Overall, the data collected by the flow meters was generally of good quality and analyses of I/I were successful for all of the sewershed basins. However, as evident from the tables and figures presented in Sections 3.03 and 3.04, there were a few basins not included in the analyses or the results of the analyses yielded impossible results. This section provides an explanation for the reasons why data was omitted from the analyses.

A. FM 09

Flow meter number 9 (FM 09) was unique in that it was installed in a relief sewer that acted as an overflow from Basin 13 (see Figure 2.02-2). As a result, the data collected from FM 09 was used to supplement the data collected at FM 13 and FM 18. The flow recorded at FM 09 had to be added to the data collected at FM 13 and FM 18 to quantify the actual flow rates generated within those sewershed basins because it overflowed from the basin before being recorded by the respective flow meters.

Since this flow meter was installed strictly as a supplement to other meters, it was not analyzed directly. However, the data was incorporated for both the I/I analyses for Basins 13 and 18.

B. FM 13

All the flow metering equipment was calibrated and certified by the manufacturer before the beginning to the flow metering program. However, as sometimes happens with electrical equipment, an error occurred at flow metering number 13 (FM 13) shortly after this meter was installed on April 9 causing it to not record data. The error was discovered and addressed during recalibration of the meter on April 11, and verified to be working properly during data download on April 14. Unfortunately, the meter once again had a failure and did not record data during the April 15 wet weather event. Eventually the meter was replaced and worked properly for the remainder of the flow metering period.

Since we were not able to collect data for the April 15 event at FM 13, that basin was not analyzed for the April 15 event. Instead for the analyses of the April 15 event Basin 18 was expanded to include Basin 13.

C. FM 27, FM 29, and 30

These meters were unique in that they were installed to monitor the flow into the Village system from an unicorporated development outside the Village limits served by the Woodley Road Sanitary District. They were installed to quantify the outside impacts to the Village's system. These basins were included in the inflow analysis but not the infiltration analysis because information regarding the length and size of pipes within these basins was not available.

3.06 CONCLUSIONS

The reports of basement backups July 23, 2011, storm event suggest the presence of I/I into the Village's sanitary sewer system that could have contributed to the basement backups. While none of the metered rainfall events between April 16, 2012, and June 8, 2012, were large enough to mirror the conditions that occurred during the July 23, 2011 event, the flow metering data collected during this study affirms the presence of I/I within the system. Additionally, the data presented in the figures from Section 3.04 suggest the sources of inflow and infiltration are widespread throughout most of the system.

Ideally the flow monitoring data would identify a group of specific basins where the sources of I/I are significantly more pronounced than the rest of the basins making it clear which basins are priorities for further investigations and focused attention on reduction of I/I. In Winnetka's case, this identification is not as clear cut. So a ranking methodology was used to quantify the relative magnitude of I/I produced in each sewershed basin.

A. Ranking Methodology

To rank the basins, the results of the I/I analyses were used. Each basin was given a score of 1 through 29 (Basin 09 was not included in the ranking) with the basin having the highest peaking factor receiving a score of 1 and the lowest peaking factor receiving a score of 29. The same was done using the inflow contribution analysis results. Each basin was then given a score of 1 through 27 (Basins 09, 27, and 30 were not included in the ranking) with the basin having the highest infiltration rate receiving a score of 1 and the basin with the lowest infiltration rate receiving a score of 27.

Once scores were given for each basin for each analysis for each event, an overall score was calculated by taking an average of all six individual scores. The basins were then ranked based on the overall average score.

As previously noted, Basin 13 was not functioning during the April 15 event. Therefore, the overall score for Basin 13 was based on four individual scores rather than six.

B. Ranking Results

Tables 3.06-1, 3.06-2, 3.06-3, and 3.06-4 show the results of the four sets of rankings. Table 3.06-1 shows rankings based on the peaking factor analysis. Table 3.06-2 shows rankings based on the overall system inflow contribution analysis. Table 3.06-3 shows the rankings based on the infiltration analysis. Table 3.06-4 is the overall basin rankings taking into account both the I/I analyses.

TABLE 3.06-1

PEAKING FACTOR RANKINGS

Rank	Flow Metering Basin	Average Score	April 15, 2012		May 26, 2012		May 31, 2012	
			Peaking Factor	Score	Peaking Factor	Score	Peaking Factor	Score
1	6	3.33	12.98	8	33.16	1	22.04	1
2	4	4	26.3	2	20.56	2	9.6	8
3	15	4.67	22.72	3	13.22	7	12.12	4
4	3	5	28.07	1	14.92	5	8.61	9
5	14	6.67	18.52	5	11.07	8	10.21	7
6	5	7	20.46	4	18.35	3	7.34	14
7	28	7.67	15.67	6	7.88	14	13.02	3
8	13	8.5			7.83	15	13.23	2
9	10	10.33	6.06	22	16.11	4	11.98	5
10	9	10.67	12.47	10	10.22	9	7.58	13
11	12	12.33	13.96	7	9.75	11	5.39	19
12	18	13.67	4.39	25	9.91	10	11.6	6
13	23	15	10.96	12	6.95	18	6.77	15
14	19	15.33	8.32	18	13.78	6	5.16	22
14	2	15.33	11.43	11	9.19	12	5.05	23
16	21	15.67	8.92	16	6.62	19	7.6	12
17	20	16	10.86	13	3.91	24	7.62	11
18	11	16.33	12.86	9	7.83	15	4.95	25
19	8	16.67	8.85	17	7.19	17	6.43	16
20	17	17.67	9.47	14	5.2	22	6.42	17
21	16	18	4.88	24	6.14	20	8.42	10
22	26	20.67	8.28	19	3.34	25	6	18
23	22	21.67	9.43	15	3.26	26	4.96	24
24	1	22.67	7.44	21	5.75	21	4.89	26
24	7	22.67	3.18	27	8.68	13	3.45	28
26	25	23	8.23	20	2.12	29	5.31	20
27	29	24	2.23	29	4.32	23	5.31	20
28	24	26.67	4.98	23	2.25	28	3.37	29
29	27	27.33	2.96	28	2.96	27	4.45	27
30	30	28.67	4.14	26	1.75	30	3.32	30

TABLE 3.06-2

OVERALL SYSTEM INFLOW CONTRIBUTION RANKINGS

Rank	Flow Metering Basin	Average Score	April 15, 2012		May 26, 2012		May 31, 2012	
			Inflow Percentage	Score	Inflow Percentage	Score	Inflow Percentage	Score
1	12	2	9.77%	1	11.90%	2	6.79%	3
2	19	3.67	5.84%	4	12.04%	1	4.81%	6
3	18	4	5.25%	5	5.26%	5	7.17%	2
4	5	7	7.11%	3	8.25%	4	3.87%	14
4	22	7	8.26%	2	2.84%	14	6.03%	5
6	8	8.33	4.68%	6	3.88%	8	4.03%	11
7	6	8.67	2.40%	19	11.37%	3	6.36%	4
7	16	8.67	3.72%	13	3.14%	12	7.72%	1
7	23	8.67	4.66%	7	3.64%	10	4.32%	9
10	15	11.67	4.44%	8	3.25%	11	3.37%	16
11	11	12	3.79%	11	3.95%	7	2.75%	18
12	14	12.67	4.05%	10	2.94%	13	3.37%	15
13	2	13	3.45%	14	4.29%	6	2.16%	19
14	27	13.33	3.28%	15	1.94%	17	4.62%	8
15	13	13.5			1.65%	20	4.73%	7
16	28	14.33	2.85%	17	2.05%	16	4.18%	10
17	20	14.67	4.32%	9	1.40%	23	4.01%	12
18	26	15.67	3.72%	12	1.49%	22	3.93%	13
19	4	16	2.76%	18	3.77%	9	1.79%	21
20	17	17.33	2.95%	16	1.87%	19	2.76%	17
21	10	20.33	1.11%	26	2.36%	15	1.87%	20
22	3	22	2.31%	21	1.87%	18	1.16%	27
23	1	22.33	1.71%	22	1.52%	21	1.53%	24
23	24	22.33	2.31%	20	0.77%	25	1.78%	22
25	30	24.33	1.50%	23	0.42%	27	1.55%	23
26	21	24.67	1.27%	25	0.90%	24	1.28%	25
27	25	26	1.39%	24	0.27%	28	1.25%	26
28	7	27.67	0.25%	28	0.72%	26	0.25%	29
29	29	28	0.85%	27	0.23%	29	0.54%	28

TABLE 3.06-3

INFILTRATION ANALYSIS RANKINGS

Rank	Flow Metering Basin	Average Score	April 15, 2012		May 26, 2012		May 31, 2012	
			Infiltration Rate	Score	Infiltration Rate	Score	Infiltration Rate	Score
1	14	1	56.57	1	8.26	1	26.84	1
2	4	2	35.37	2	7.89	2	21.63	2
3	2	5.33	34.19	3	3.99	5	13.44	8
4	8	5.67	18.5	7	5.94	4	14.7	6
5	13	6.5			6.09	3	11.08	10
6	20	7	27.3	4	2.48	10	13.51	7
7	12	7.33	25.92	5	3.42	6	9.22	11
8	18	7.67	11.63	11	3.24	8	17.1	4
9	22	9	17.85	8	1.09	16	17.45	3
10	5	10.33	12.03	10	3.41	7	7.22	14
11	19	11.33	6.94	16	2.99	9	12.57	9
12	11	12.33	10.23	12	2.02	12	7.35	13
13	21	13	20.85	6	1.08	18	5.96	15
14	15	14	9.78	13	2.25	11	4.79	18
15	23	14.33	6.01	18	1.67	14	9.22	11
15	28	14.33	5.64	19	0.94	19	15.88	5
17	1	15	12.13	9	1.09	16	3.76	20
18	6	16.67	4.05	21	1.81	13	5.25	16
19	17	17.33	7.16	15	0.88	20	5.13	17
20	10	18.67	5.07	20	1.22	15	3.44	21
21	3	19	7.74	14	0.8	21	2.94	22
22	26	19.33	6.34	17	0.65	22	4.68	19
23	24	22.67	3.24	22	0.31	23	2.55	23
24	7	24.33	0.95	25	0.3	24	1.13	24
24	25	24.33	3.05	23	0.06	25	1.05	25
26	29	25.67	1.98	24	0.04	27	0.48	26
27	16	26.33	0.67	26	0.05	26	0.43	27

TABLE 3.06-4

OVERALL BASIN RANKINGS

Rank	Flow Metering Basin	Overall Score	Peaking Factor Average Score	Inflow Percentage Average Score	Infiltration Rate Average Score
1	14	20.34	6.67	12.67	1
2	12	21.66	12.33	2	7.33
3	4	22	4	16	2
4	5	24.33	7	7	10.33
5	18	25.34	13.67	4	7.67
6	13	28.5	8.5	13.5	6.5
7	6	28.67	3.33	8.67	16.67
8	19	30.33	15.33	3.67	11.33
9	15	30.34	4.67	11.67	14
10	8	30.67	16.67	8.33	5.67
11	2	33.66	15.33	13	5.33
12	28	36.33	7.67	14.33	14.33
13	22	37.67	21.67	7	9
13	20	37.67	16	14.67	7
15	23	38	15	8.67	14.33
16	11	40.66	16.33	12	12.33
17	3	46	5	22	19
18	10	49.33	10.33	20.33	18.67
19	17	52.33	17.67	17.33	17.33
20	16	53	18	8.67	26.33
21	21	53.34	15.67	24.67	13
22	26	55.67	20.67	15.67	19.33
23	1	60	22.67	22.33	15
24	24	71.67	26.67	22.33	22.67
25	25	73.33	23	26	24.33
26	7	74.67	22.67	27.67	24.33
27	29	77.67	24	28	25.67

3.07 BASIN PRIORITIZATION

Table 3.06-4 presents overall basin rankings solely based on the I/I observed during the flow monitoring period. However, there are other factors that contribute to prioritization of the basins that can not necessarily be quantified with data analysis. One such factor is the results of the flooding survey presented in Figure 2.02-1. In addition, sources of inflow are traditionally both easier and less expensive to locate and repair. As a result, the ranking system combined with engineering judgment accounting for the flooding survey results and potential future costs, help determine the prioritization and schedule for future investigations.

A. Highest Priority Basins

Figure 3.07-1 shows the basins given the highest priority for future investigations. Following is a discussion as to why each basin was chosen.

Basin 14 exhibited high values of both inflow and infiltration and was ranked highest in the ranking system, and it also showed significant flooding according to the flood survey results.

Basin 15 was prioritized because it is a top ten basin according to the rankings, but more importantly the flooding survey suggests extensive flooding in this area. Also, its proximity to Basin 14 makes it an logical basin for future investigation.

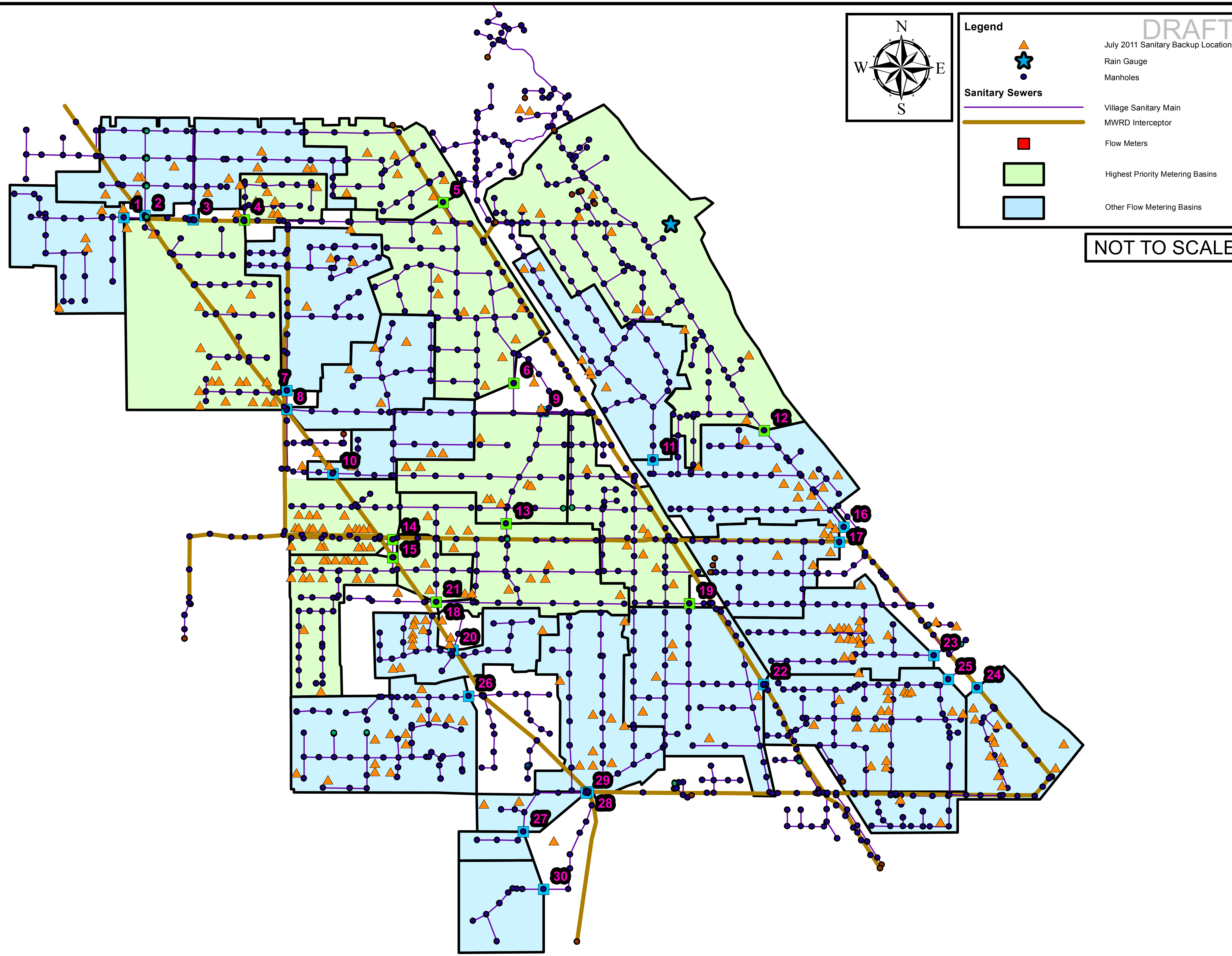
Basins 05, 06, 13, and 18 were included in the highest priority group because each basin ranked high in the overall rankings and the inflow rankings. In addition, flooding was reported in each of those basins according to the survey results. Most importantly however, these basins interact very closely because they are in series (see Figure 2.02-2). Furthermore, the presence of a relief sewer from Basin 13 which also relieves Basin 18 suggest that excess flow has historically been an issue throughout these basins.

Basin 21 was included as a high priority basin not because the rankings suggest that this basin is subject to extensive I/I, but because it includes an overflow to Basins 14 and 15. Since future investigations appear warranted throughout this area, it makes sense to include it.

Basin 04 was included as a high priority because of how high it ranked based on the data collected during the flow metering period supported by the flooding reported as a result of the July 23, 2011 event.

Basin 19 was included as a high priority basin because it ranked high in the top 10 of the overall rankings including number two in the overall inflow rankings and is just adjacent to Basin 18.

Basin 12 was included as a high priority basin because it ranked high in the overall rankings. While the risk of basement backups in this area appears low because of the topography of the basin and relatively few basement backups indicated in the flood survey, removing the excess flow would provide added capacity downstream and could benefit Basin 16. According to the flow metering data, Basin 16 does not appear to be a basin with high I/I, however, the flooding survey suggests there is a problem with basement backups along the main sewer on Sheridan Road. This could be because I/I from Basin



Path: S:\JOL\1600--1699\1619\005\Data\GIS\Sanitary System Map with Priority Basins.mxd User: KyleC Date: 7/10/2012 Time: 4:35:23 PM

HIGHEST PRIORITY BASINS

SANITARY SEWER EVALUATION SURVEY
VILLAGE OF WINNETKA
WINNETKA, IL

STRAND ASSOCIATES®

FIGURE 3.07-1

12 is reducing the capacity of the sewers within Basin 16 and it is the lack of capacity causing the reported problems in Basin 16.

There were several areas of the Village that were not metered that reported basement backups in the flood survey, specifically the areas west of Basin 07 and north of Basin 14. We recommend these areas be included as high priority areas also.

B. Remaining Basins

Certainly the flood survey report and the results of the flow metering analyses indicate there are other areas of the Village that have concerns with I/I and potential for basement backups. The intention of the highest priority basin ranking is not to exclude these other areas, but to give the Village focus on where to start their further investigations. As discussed in Section 4, these other areas will be addressed in the future following the further investigations and follow up evaluations of I/I removal success.

APPENDIX A
BREAKDOWN OF SANITARY SUBBASINS

APPENDIX A

BREAKDOWN OF SANITARY SUBBASINS

Meter	Sewer Diameter	Length of Sewer		Equivalent Sewer Length
	(in)	(ft)	(miles)	inch-mile
1	8	5440	1.03	8.24
Total		**5440**	**1.03**	**8.24**
Acreage		50.7		
2	8	3998	0.76	6.06
	10	770	0.15	1.46
Total		**4768**	**0.90**	**7.52**
Acreage		43.6		
3	8	959	0.18	1.45
	10	4013	0.76	7.60
	12	384	0.07	0.87
	15	463	0.09	1.32
Total		**5819**	**0.94**	**11.24**
Acreage		42.0		
4	8	2594	0.49	3.93
Total		**2594**	**0.49**	**3.93**
Acreage		17.4		
5	8	3969	0.75	6.01
	10	1118	0.21	2.12
	12	812	0.15	1.85
Total		**5899**	**1.12**	**9.98**
Acreage		45.8		
6	8	8970	1.70	13.59
	10	2159	0.41	4.09
	12	1036	0.20	2.35
	15	2075	0.39	5.89
Total		**14240**	**2.11**	**25.93**
Acreage		94.7		
7	8	9841	1.86	14.91
	10	1040	0.20	1.97
Total		**10881**	**2.06**	**16.88**
Acreage		67.2		
8	8	1934	0.37	2.93
	10	152	0.03	0.29
	12	696	0.13	1.58
	15	1926	0.36	5.47
Total		**4708**	**0.89**	**10.27**
Acreage		47.1		

Meter	Sewer Diameter	Length of Sewer		Equivalent Sewer Length
	(in)	(ft)	(miles)	inch-mile
9	Overflow for Basin 13			
10	8	1232	0.23	1.87
	10	2720	0.52	5.15
	12	1255	0.24	2.85
Total		**5207**	**0.99**	**9.87**
Acreage		33.4		
11	8	3036	0.58	4.60
	10	1928	0.37	3.65
	12	398	0.08	0.90
	15	1661	0.31	4.72
Total		**7023**	**1.33**	**13.87**
Acreage		66.3		
12	6	337	0.06	0.38
	8	10624	2.01	16.10
	10	2712	0.51	5.14
	12	2986	0.57	6.79
	15	1602	0.30	4.55
	18	291	0.06	0.99
Total		**18261**	**3.46**	**33.95**
Acreage		184.2		
13	8	5613	1.06	8.50
	15	2437	0.46	6.92
Total		**8050**	**1.52**	**15.43**
Acreage		47.8		
14	8	672	0.13	1.02
	10	741	0.14	1.40
Total		**1413**	**0.27**	**2.42**
Acreage		7.4		
15	8	455	0.09	`
	10	4008	0.76	7.59
	15	928	0.18	2.64
Total		**5391**	**1.02**	**10.23**
Acreage		39.4		

Meter	Sewer Diameter	Length of Sewer		Equivalent Sewer Length
	(in)	(ft)	(miles)	inch-mile
16	6	131	0.02	0.15
	8	3016	0.57	4.57
	10	1025	0.19	1.94
	15	2025	0.38	5.75
	18	1669	0.32	5.69
	24	628	0.12	2.85
Total		**8494**	**1.49**	**20.96**
Acreage		76.0		
17	8	2481	0.47	3.76
	10	1326	0.25	2.51
	20	2254	0.43	8.54
Total		**6061**	**1.15**	**14.81**
Acreage		47.5		
18	8	9233	1.75	13.99
	12	503	0.10	1.14
	15	1835	0.35	5.21
Total		**11571**	**2.19**	**20.35**
Acreage		72.8		
19	8	4383	0.83	6.64
	10	954	0.18	1.81
	12	448	0.08	1.02
	15	1305	0.25	3.71
	18	2601	0.49	8.87
Total		**5308**	**1.01**	**22.04**
Acreage		56.9		
20	8	3424	0.65	5.19
	10	1090	0.21	2.06
Total		**4514**	**0.85**	**7.25**
Acreage		41.6		
21	8	2437	0.46	3.69
Total		**2437**	**0.46**	**3.69**
Acreage		17.9		

Meter	Sewer Diameter	Length of Sewer		Equivalent Sewer Length
	(in)	(ft)	(miles)	inch-mile
22	8	6145	1.16	9.31
	9	703	0.13	1.20
	10	2044	0.39	3.87
	12	1220	0.23	2.77
	15	834	0.16	2.37
	18	206	0.04	0.70
Total		**11152**	**2.07**	**20.22**
Acreage		86.6		
23	8	1926	0.36	2.92
	10	393	0.07	0.74
	12	2581	0.49	5.87
	15	407	0.08	1.16
	18	1255	0.24	4.28
Total		**4636**	**0.88**	**14.96**
Acreage		54.0		
24	8	971	0.18	1.47
	9	1518	0.29	2.59
	10	1911	0.36	3.62
	12	2116	0.40	4.81
	18	1047	0.20	3.57
Total		**6592**	**1.25**	**16.06**
Acreage		65.9		
25	6	116	0.02	0.13
	8	6222	1.18	9.43
	12	2871	0.54	6.53
	15	599	0.11	1.70
	18	2571	0.49	8.76
	20	1289	0.24	4.88
Total		**13668**	**2.34**	**31.43**
Acreage		91.7		
26	8	8166	1.55	12.37
	12	1981	0.38	4.50
Total		**10147**	**1.92**	**16.88**
Acreage		85.5		
27	12	710	0.13	1.61
Total		**710**	**0.13**	**1.61**
Acreage		9.0		

Meter	Sewer Diameter	Length of Sewer		Equivalent Sewer Length
	(in)	(ft)	(miles)	inch-mile
28	8	6985	1.32	10.58
	10	32	0.01	0.06
Total		**7017**	**1.33**	**10.64**
Acreage		67.5		
29	12	925	0.18	2.10
	15	679	0.13	1.93
Total		**1604**	**0.30**	**4.03**
Acreage		14.9		
30	8	1563	0.30	2.37
Total		**1563**	**0.30**	**2.37**
Acreage		34.3		

APPENDIX B
FLOW METERING EVALUATIONS

B.01 FLOW METERING BASIN DESCRIPTIONS

The following evaluation provides a summary of each metering location, the data collected, and concerns identified based on the three study rainfall events. The information presented is best considered in conjunction with the dry and wet weather flow analyses presented in Section 3.

A. <u>FM 01</u>

This basin was approximately 50.7 acres in area. It collected flow from most northwest portion of the Village. The flow meter collected good data throughout the monitoring period. The sewerage from this basin flowed directly into the MWRDGC interceptor system.

B. <u>FM 02</u>

This basin was approximately 43.6 acres in area north of Tower Road between Grove Street and Vernon Avenue. This flow meter collected good data throughout the monitoring period. The sewerage from this basin flowed directly into the MWRDGC interceptor system.

C. <u>FM 03</u>

This basin was unique among some of the other basins in that it had a relief sewer located within it. There are two sewers that travel from north to south along Vernon Avenue. The eastern most line collects flow from the collector sewers along Scott and Asbury Avenues. However, there exists three overflow pipes connecting the eastern line to the western line. The inverts of these overflow pipes are set higher than the invert of the downstream sewers. When flows get too high and the water level rises it would reach the invert of the overflow sewers and flow into the adjacent sewer line. An analysis of the data and physical observations, such as the presence of debris in the overflow pipe flowline both before and after rainfall events, suggest that none of the events that occurred during the monitoring period caused an overflow.

This basin was 42 acres in area and the data collected was of good quality. The connection to the MWRDGC interceptor is located directly downstream.

D. <u>FM 04</u>

This basin was approximately 17.4 acres in area north of Tower Road and collecting sewerage from the Forest Glen area. The meter functioned well during the monitoring period and the basin flows directly to the MWRDGC interceptor.

E. <u>FM 05</u>

The flow metering data collected by FM 05 was good. The basin was 45.8 acres in area encompassing the area north of Tower Road, west of the railroad tracks and East of Euclid Avenue. Sewerage from this flow meter continued downstream to Basin 06.

F. FM 06

As stated above FM 06 received flow from the Basin 05 as well as sewerage from an 94.7 acre area. The data collected at this metering location was good throughout the metering period. Basin 06 was tributary to Basin 13.

G. FM 07

This flow meter had some sediment issues that caused some data dropouts to occur. When velocities are low within sewers it causes solids to settle out. When these solids deposit on top of the flow meter sensor it prevents the meter from collecting a velocity reading. To combat this, every week during the data download process we made sure to clean this location. The diligent cleaning program for this metering location ensured that the data collected at this location was generally good.

This basin had an area of 67.2 acres and was directly upstream of an MWRDGC interceptor.

H. FM 08

This flow meter collected good data. However, during the middle of the night during low flows the meter was having difficulty collecting data because the flow level was too low. We made a maintenance visit to this location during the monitoring period to push the meter further into the pipe and this solved the problem. Since the flow level was elevated during rainfall events, this did not affect any of the wet weather data collected.

This basin was 47.1 acres in size and was directly upstream of the MWRDGC interceptor.

I. FM 09

This flow meter was installed in an 18 inch relief sewer designed to offload a small portion of dry weather and a significant portion of the wet weather flows from the Basin 13 towards an MWRDGC interceptor. All data collected at this flow meter actually represented flow generated upstream in Basins 13, 06, and 05. The data was used to adjust the data collected by FM 13. As a result, the wet weather analyses described later in this section was not applied to Basin 09. This is described further in Section 3.05.

The dry weather flows at this metering location were fairly low since it was monitoring a relief sewer. This resulted in solid depositing on the flow metering sensor. This was another site that required cleaning every time the data was downloaded. The data collected at this location was generally good despite the solids deposits.

J. FM 10

FM 10 presented problems throughout the flow monitoring period. Firstly, the velocities within the sewer were very low resulting in severe solids depositing. We explored the option of moving the meter. However, the next manhole upstream was a junction point of two sewers which would required the installation of an additional meter. Rather than moving the meter and increasing the cost, we were diligent in cleaning the solids deposits during each data download.

Despite the heavy solids deposits, the meter was functional during all of the rainfall events and provided generally good data throughout the monitoring period. The MWRDGC interceptor was directly downstream of this metering location.

The flow response graph at this location suggested that a backup occurred during the April 15 and May 26 events as evidenced by the negative flow observed during the event. It is unclear based on the flow metering data whether the backup was caused by the capacity of the sewer being exceeded or as a result of downstream influence from the MWRDGC intercepting sewer.

K. FM 11

This meter was located east of the railroad tracks in the downtown area north of Elm Street. It's tributary area was 66.3 acres and the data collected at this location was good. Basin 11 was tributary to Basin 16.

L. FM 12

This basin encompassed the northeastern portion of the Village and had the largest basin area at 184.2 acres. This flow metering location was unique in that the sewer was an egg-shaped brick sewer. The shape of the sewer was accounted for to accurately calculate flow rates.

The data collected at this location was good and this meter was also tributary to Basin 16.

M. FM 13

This flow meter experienced a mechanical error and did not collect data during portions of the first few weeks of the monitoring period. Due to the meter malfunction this meter was not operational during the April 15 event. This is discussed in further detail in Section 3.05. Once the meter was replaced, it collected good data during the rest of the monitoring period including the final two study rainfall events.

This basin was 47.8 acres in size and was located downstream of Basin 06 and upstream of Basin 18. As discussed previously, the data collected at Basin 13 was adjusted using the data collected by FM 09.

N. FM 14

This flow meter provided generally good data during the monitoring period, especially during the study rainfall events. A maintenance trip was required early on in the monitoring period to push the flow meter deeper into the pipe to reduce turbulence. This resulted in better data the rest of the monitoring period.

This basin contained an overflow relief sewer from Basin 21. The flow metering data and physical observations, such as the presence of debris in the overflow pipe flow line both before and after rainfall events, suggest an overflow did not occur during the flow monitoring period.

This flow metering basin was 7.4 acres and was directly tributary to the MWRDGC interceptor system.

O. FM 15

This flow meter provided good data throughout the monitoring period. The basin was 39.4 acres. This basin also contains an overflow from Basin 21 and similar to Basin 14 the data and physical observations suggest an overflow did not occur during the metering event.

P. FM 16

This flow meter was installed in a brick egg-shaped sewer. As a result, similar metering adjustments were required as described under FM 12. This meter collected the sewerage from Basin 11 and Basin 12. The data collected here was good throughout the period. This basin was 76 acres in area and was tributary to the MWRDGC interceptor system.

Q. FM 17

This flow meter was also installed in a brick egg-shaped sewer and required the adjustments described above. Overall the data collected at this location was good. The basin area was 47.5 acres and was directly connected to the MWRDGC interceptor system.

R. FM 18

This flow meter was located downstream of Basin 13. The data collected at this location was good and it flowed to the MWRDGC interceptor system.

S. FM 19

This flow meter was located in an egg-shaped brick sewer and the metering was adjusted accordingly. This location experienced severe solids deposition resulting in some lost data during dry weather. However, this was one location that was cleaned during each data download and therefore was fully operational for each study rainfall event. This basin was 56.9 acres in area and was directly upstream of the MWRDGC interceptor.

T. FM 20

This basin was 41.6 acres in area and the data collected was good throughout the flow monitoring period.

U. FM 21

This basin was 17.9 acres in area and was directly upstream of the MWRDGC interceptor. However, this metering basin has two overflows into other basins as described above (Basin 14 and Basin 15). Despite the presence of the overflow pipes, the data suggest there were no overflows during the flow monitoring period. We were able to make this determination by analyzing the level and flow data collected by the meter. If an overflow occurred upstream the level data collected at this location would have leveled off at the elevation of the overflow pipes. Similarly, the shape of the flow curve found in Appendix B would show evidence of an overflow.

V. FM 22

Basin 22 was 86.6 acres in size. The flow meter at this location collected generally good data throughout the flow monitoring period. There were a few times some obstructions caused a loss in velocity data, however this did not occur during any of the study wet weather events. This meter was directly upstream of the connection to the MWRDGC interceptor.

W. FM 23

This flow meter collected good data throughout the metering period. The basin had an area of 54 acres and was directly tributary to the MWRDGC interceptor system.

X. FM 24

This flow meter collected good data throughout the monitoring period. This meter was also installed in an egg-shaped sewer and the metering was adjusted to account for that. The basin had an area of 65.9 acres. This basin was directly upstream of the MWRDGC connection.

Y. FM 25

This flow meter was the last meter installed in an egg-shaped sewer and required adjustment for that reason. It was located directly upstream of the MWRDGC interceptor and collected good data throughout the monitoring period. The basin had an area of 91.7 acres.

Z. FM 26

This flow meter collected sewerage from the southwest portion of the Village. The data collected was good for all three study events and throughout the monitoring period. This basin was 85.5 acres and was directly tributary to the MWRDGC interceptor system.

AA. FM 27

This flow meter along with FM 30 were unique among the other meters in that, it was installed to monitor flow entering the Village of Winnetka system from the Woodley Road Sanitary District. This is described in more detail in Section 3.05. The size of the tributary area to this flow meter is unknown because mapping information for this area was unavailable. The data collected at this location was generally good, however, on two occasions the meter needed to be cleaned free of rags. Neither incident affected any of the three study rainfall events.

AB. FM 28

This meter was installed in a Village of Winnetka sewer that was directly connected to an MWRDGC owned manhole requiring a confined space entry. Before entering the MWRDGC manhole, however, we needed to receive permission.

Strand Associates and Village of Winnetka personnel met at the MWRDGC offices downtown on April 4, 2012. The purpose of the meeting was to inform the MWRDGC of the intent and goals of the project and to receive permission to access their manhole. The result of the meeting was positive and we were able to install the flow meter.

This basin had an area of 67.5 acres.

AC. FM 29

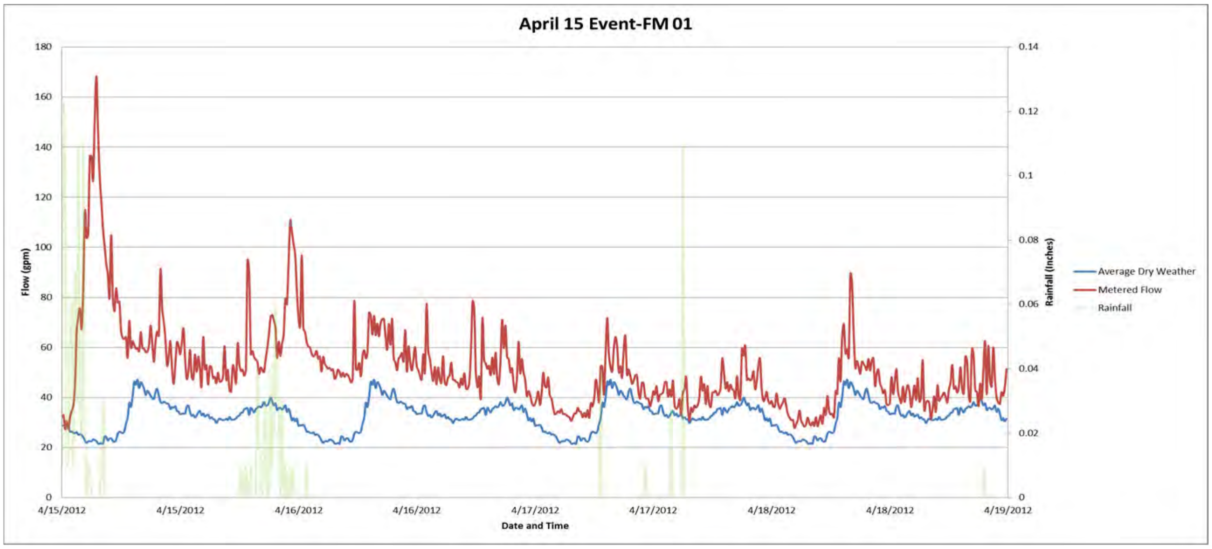
This basin was downstream of Basin 27. The data appeared to be good based on the quality control checks performed on the data. This basin was 14.9 acres and directly upstream of the MWRDGC interceptor system.

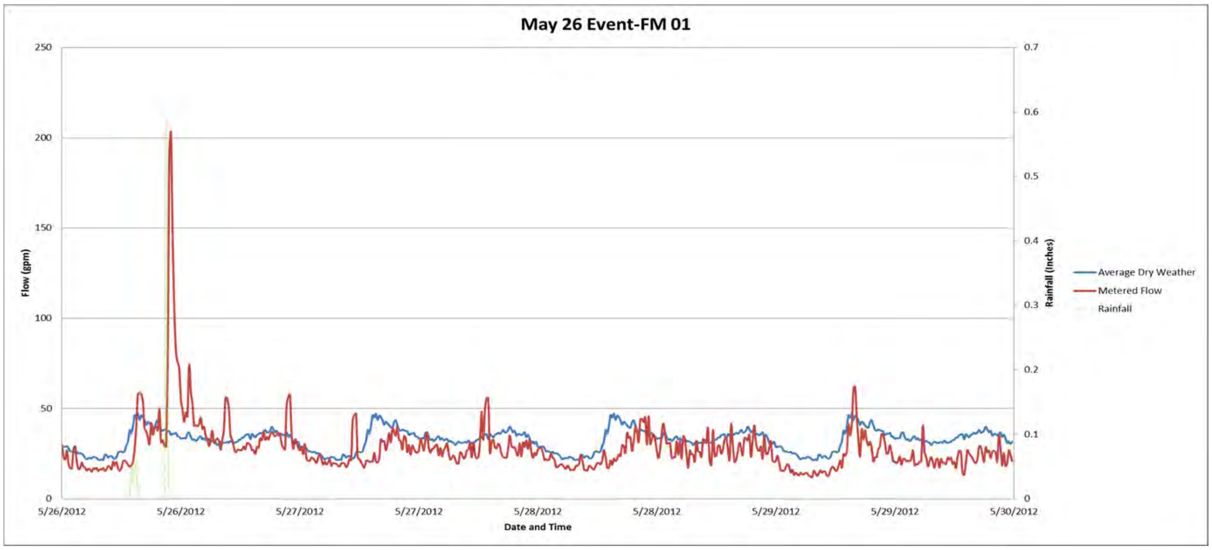
AD. FM 30

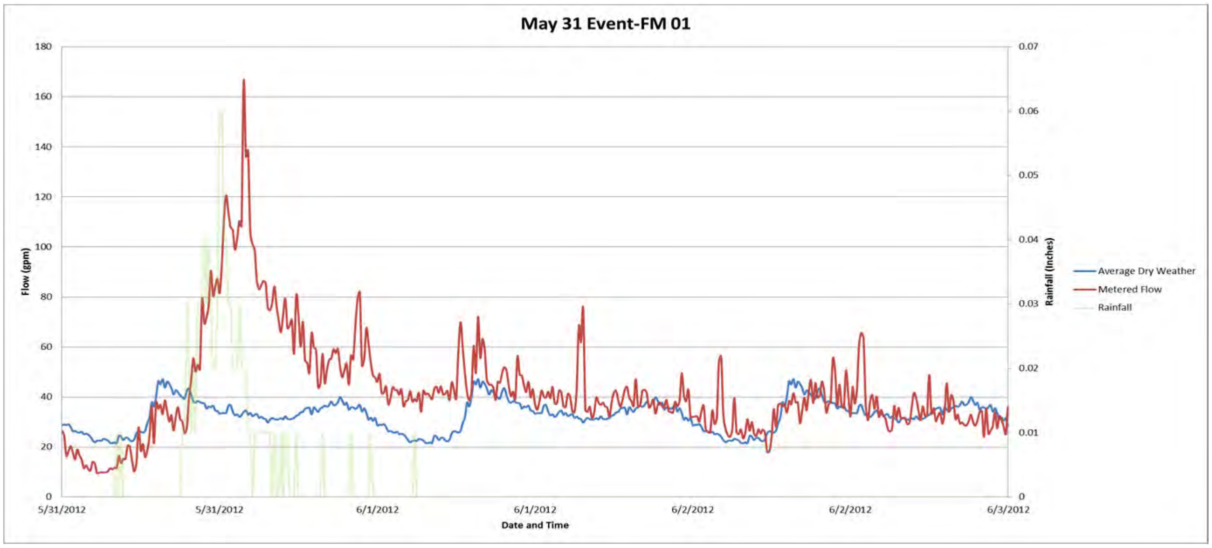
This basin was similar to Basin 27. It was installed to monitor flows into the Village from the Woodley Road Sanitary District. This meter collected generally good data, although there were times when rags collected on the probe and caused erroneous data. This did not affect any of the study events, however. As was the case with Basin 27, the actual size of this basin is unknown because mapping was unavailable at the time of this report. See Section 3.05 for further details regarding this basin.

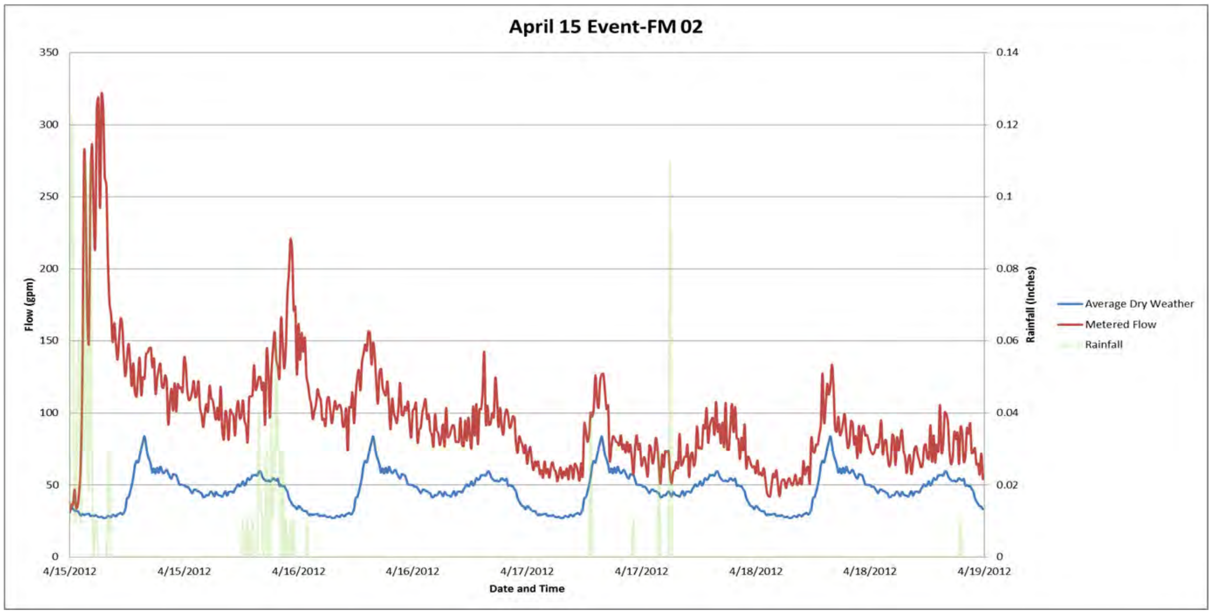
B.02 WET WEATHER FLOW RESPONSES

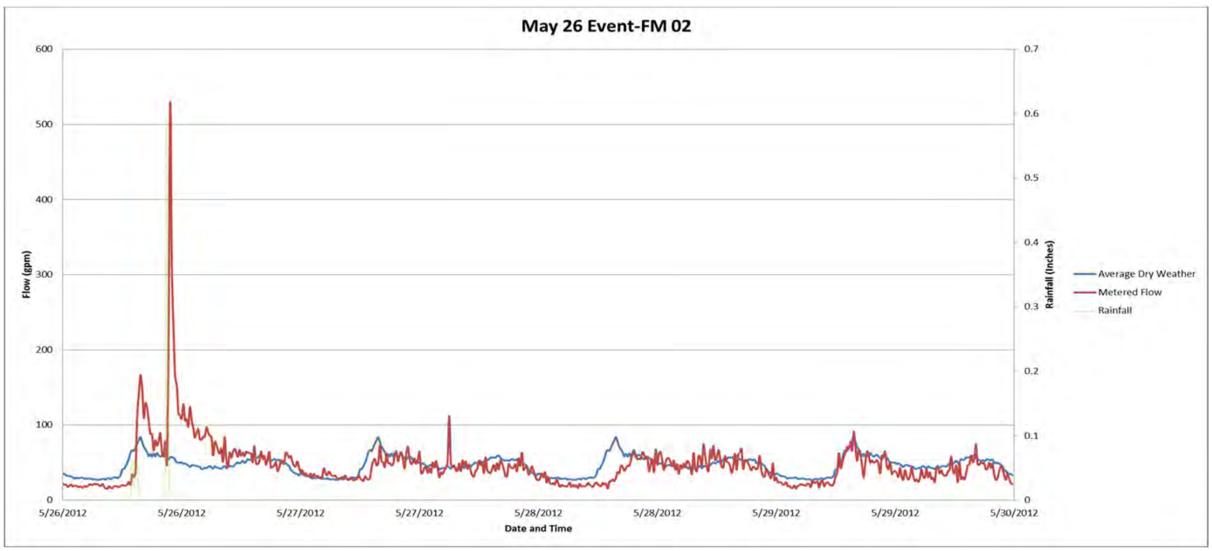
The following graphs represent the flow response at each metering location that occurred during the three study events that occurred on April 15, May 26, and May 31.

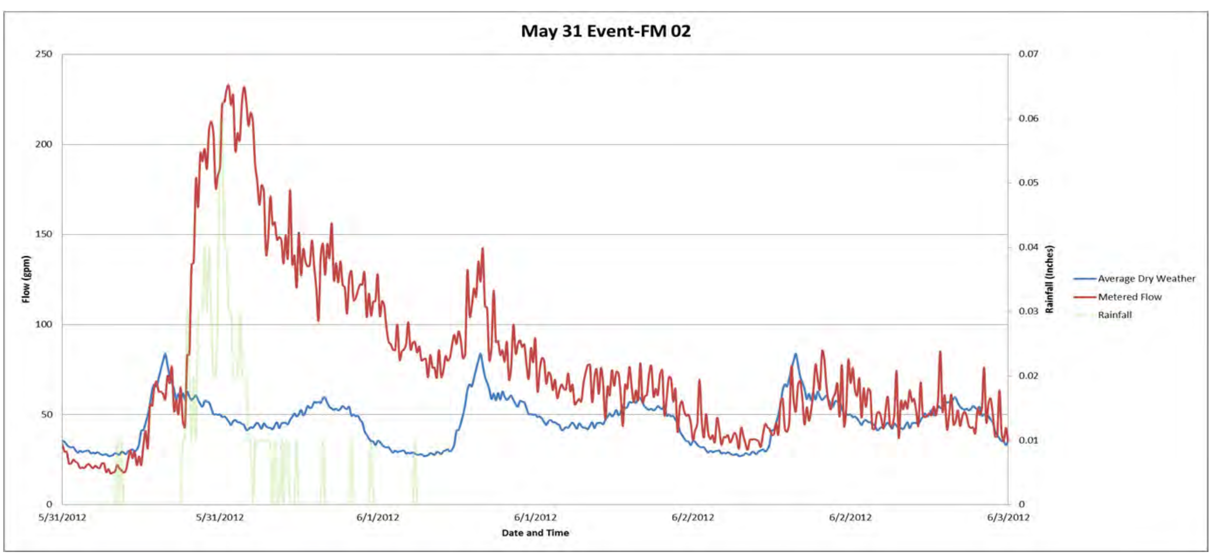

April 15 Event-FM 01
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

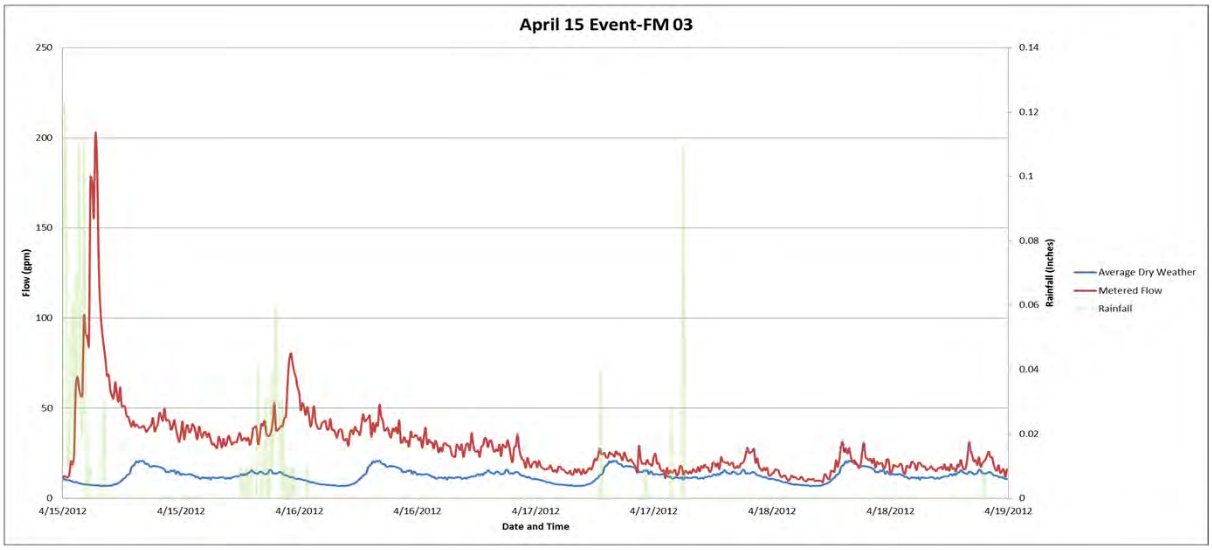

May 26 Event-FM 01
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

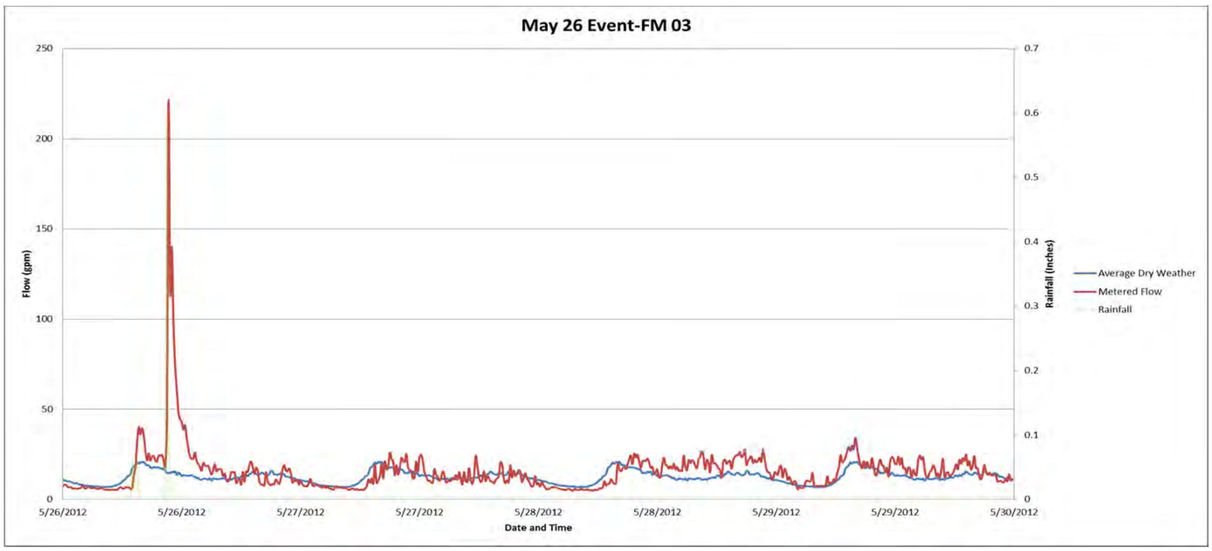

May 31 Event-FM 01
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

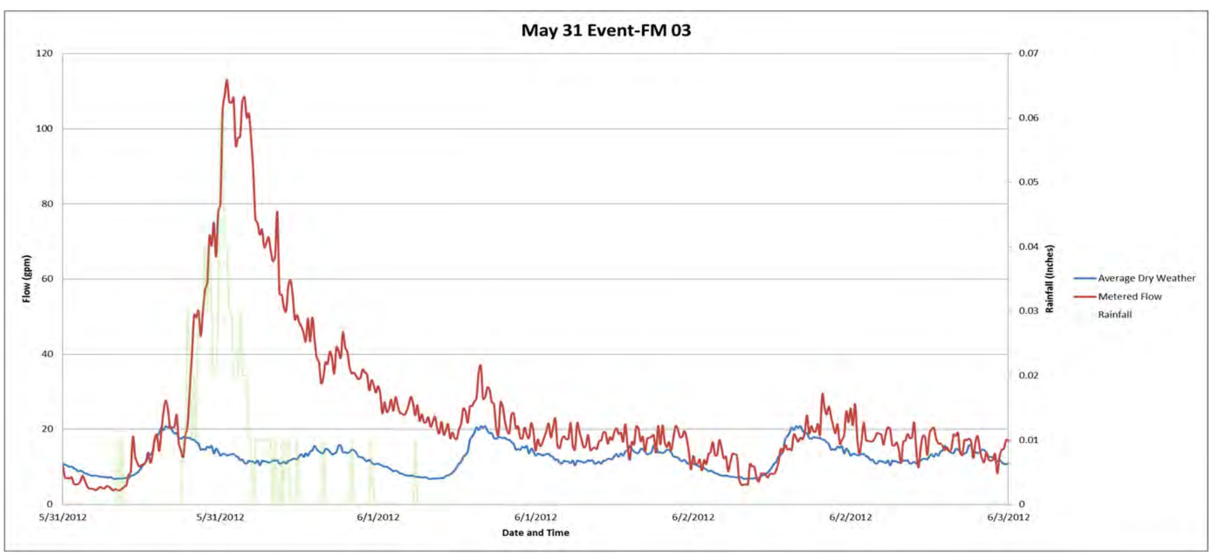

April 15 Event-FM 02
Flow (gpm)
Rainfall (Inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

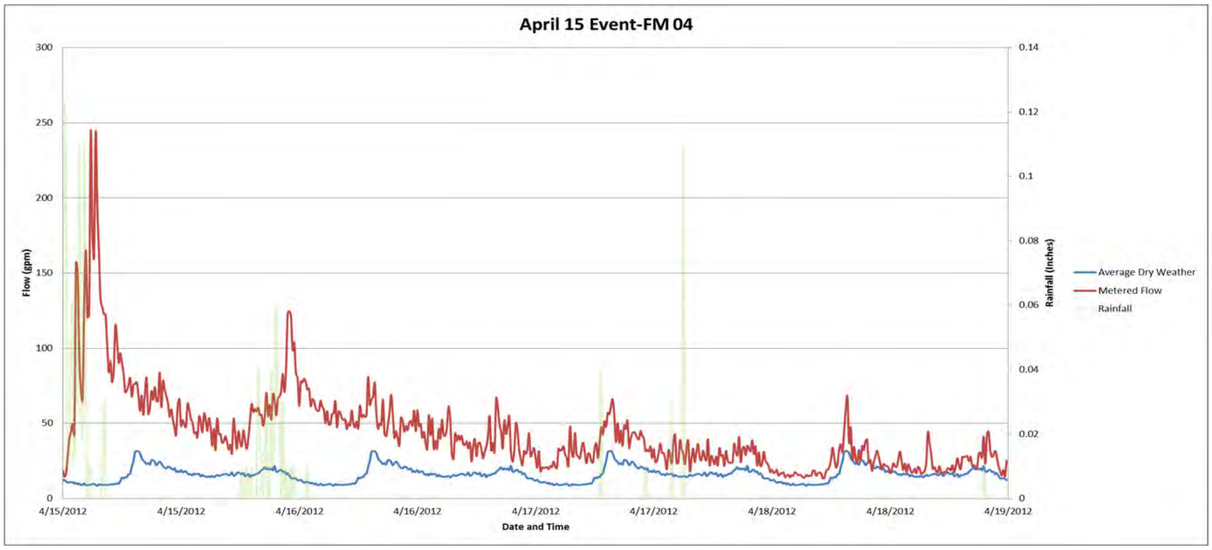

May 26 Event-FM 02
Flow (gpm)
Rainfall (Inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

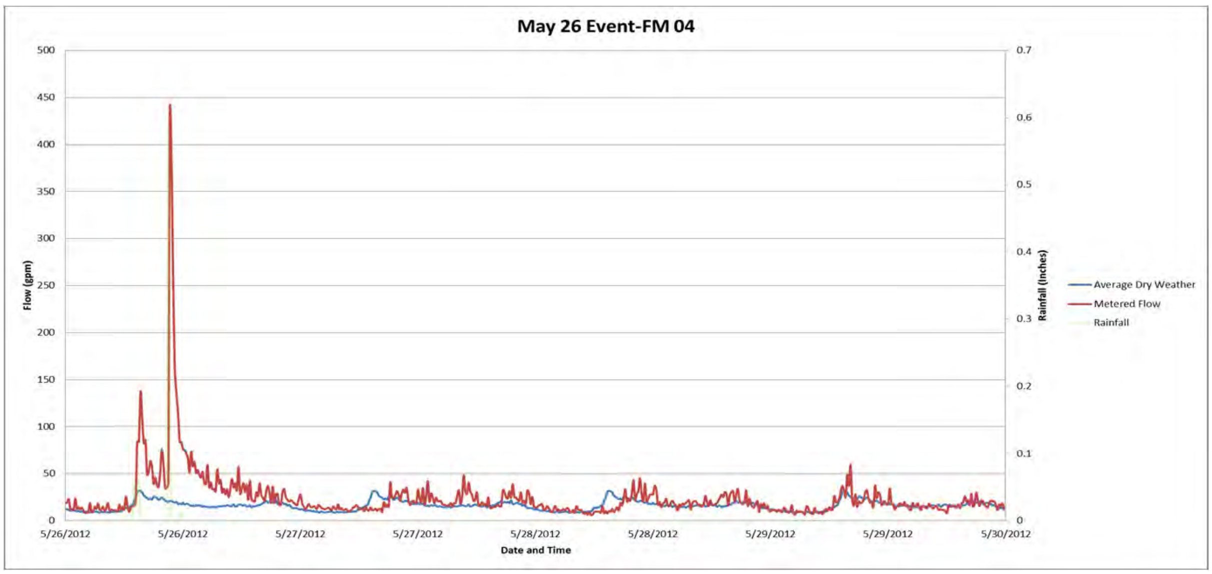

May 31 Event-FM 02
Flow (gpm)
Rainfall (Inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

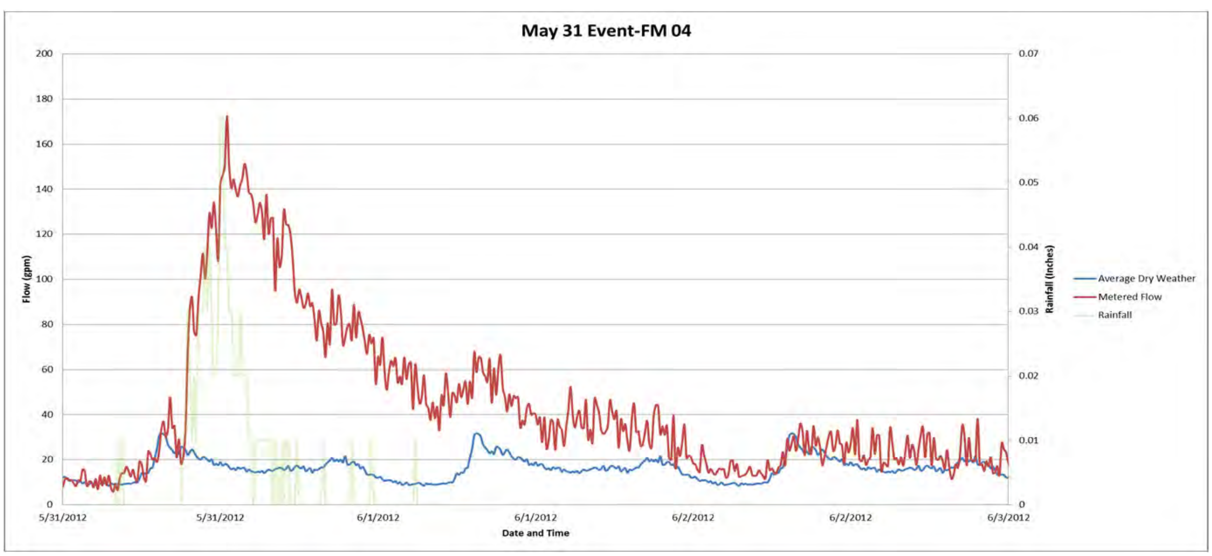

April 15 Event-FM 03
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

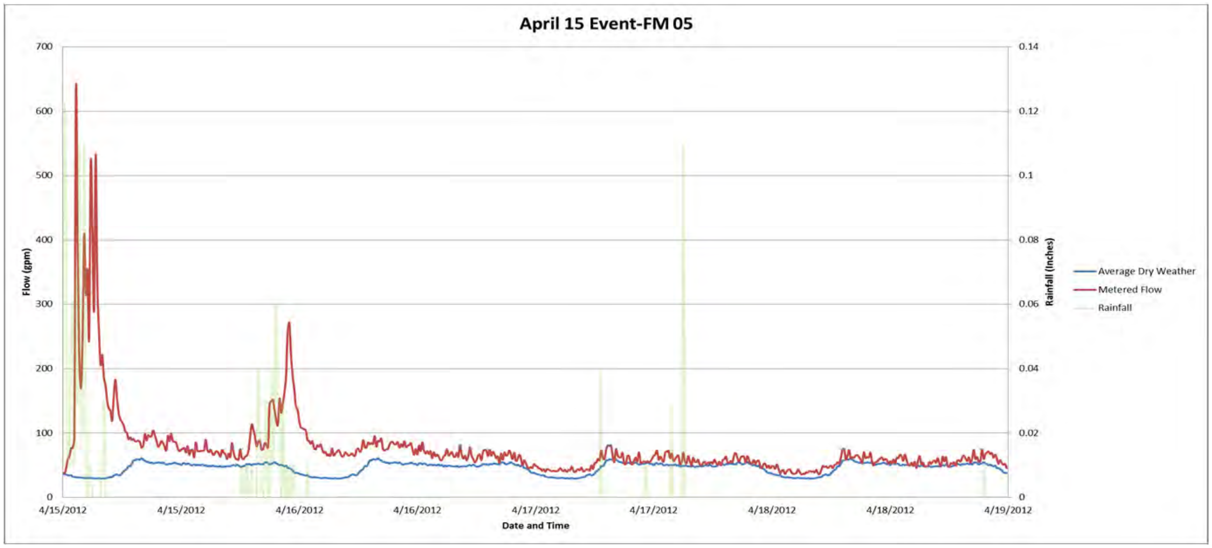

May 26 Event-FM 03
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

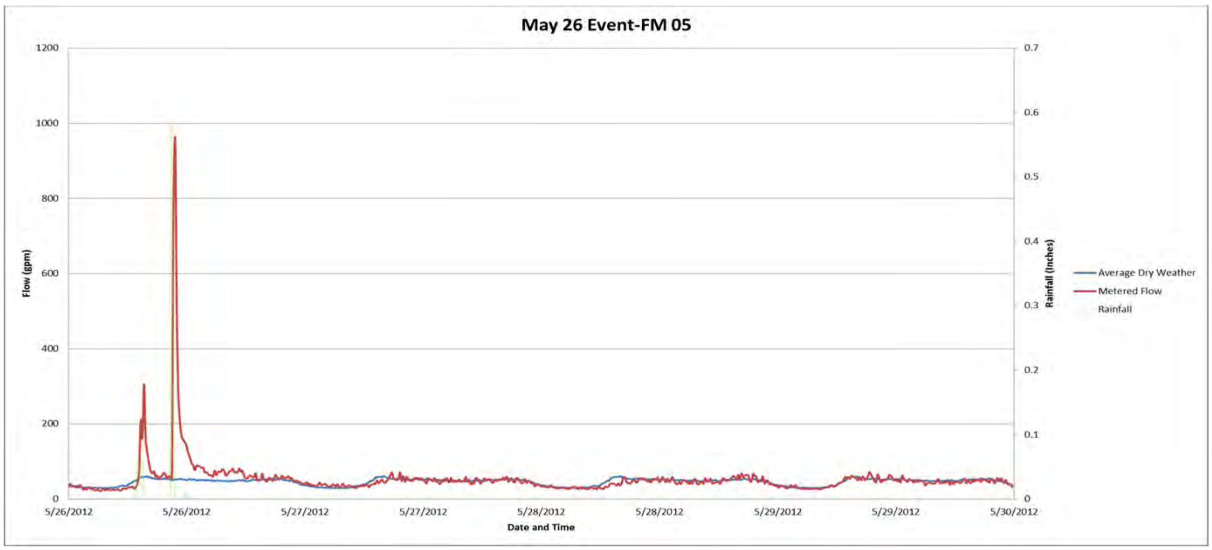

May 31 Event-FM 03
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

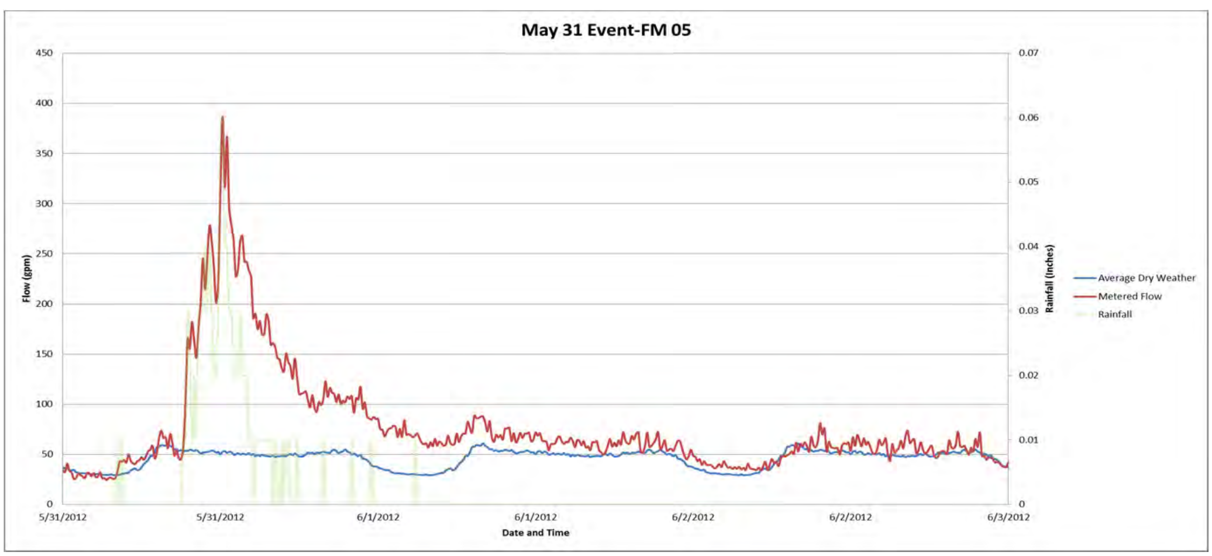

April 15 Event-FM 04
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

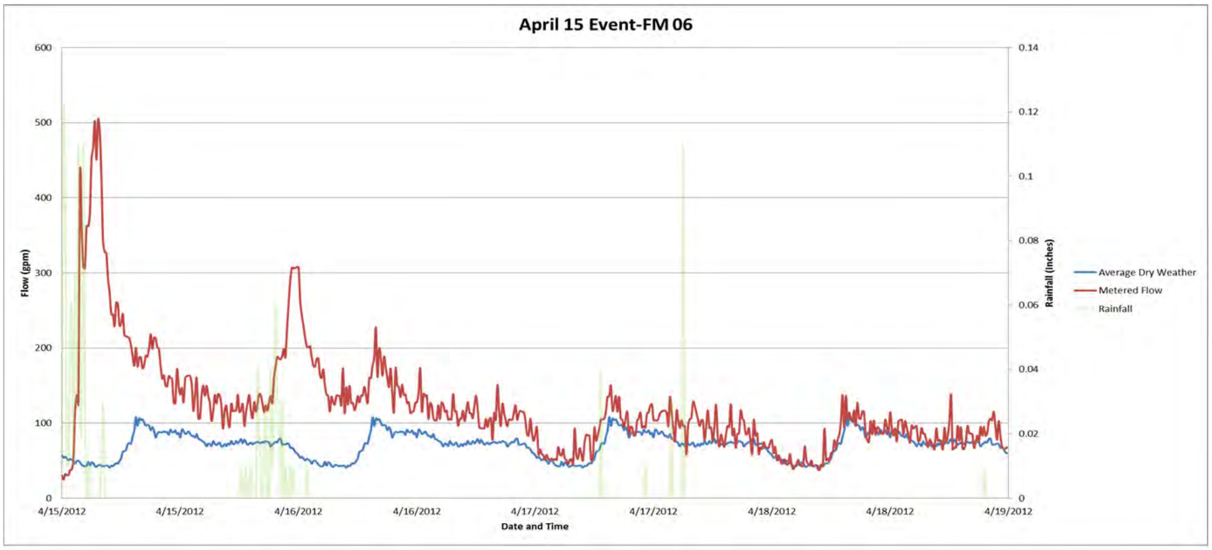

May 26 Event-FM 04
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

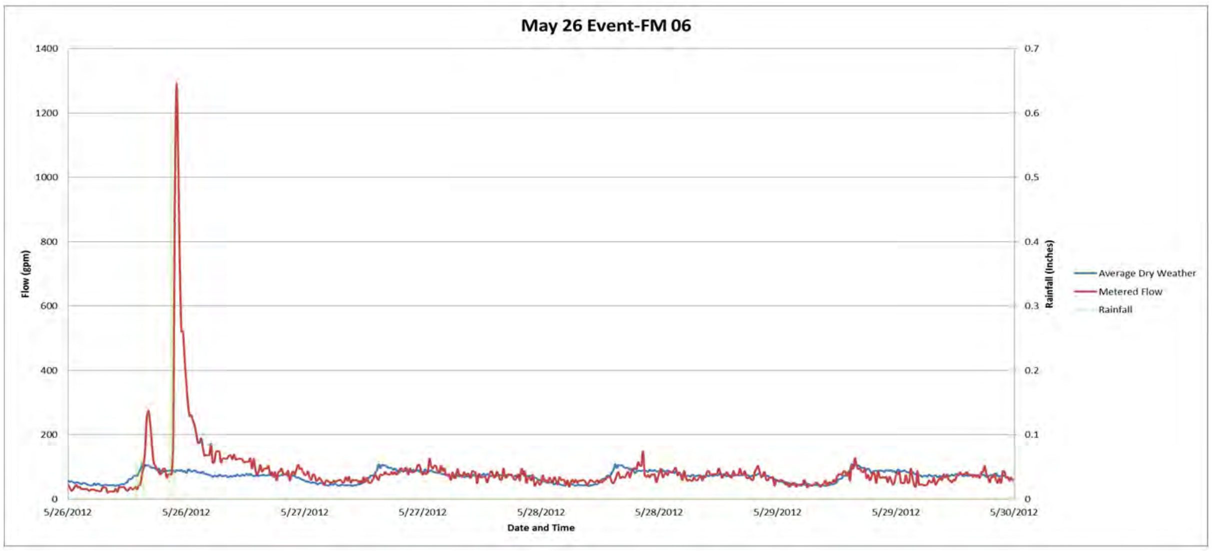

May 31 Event-FM 04
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

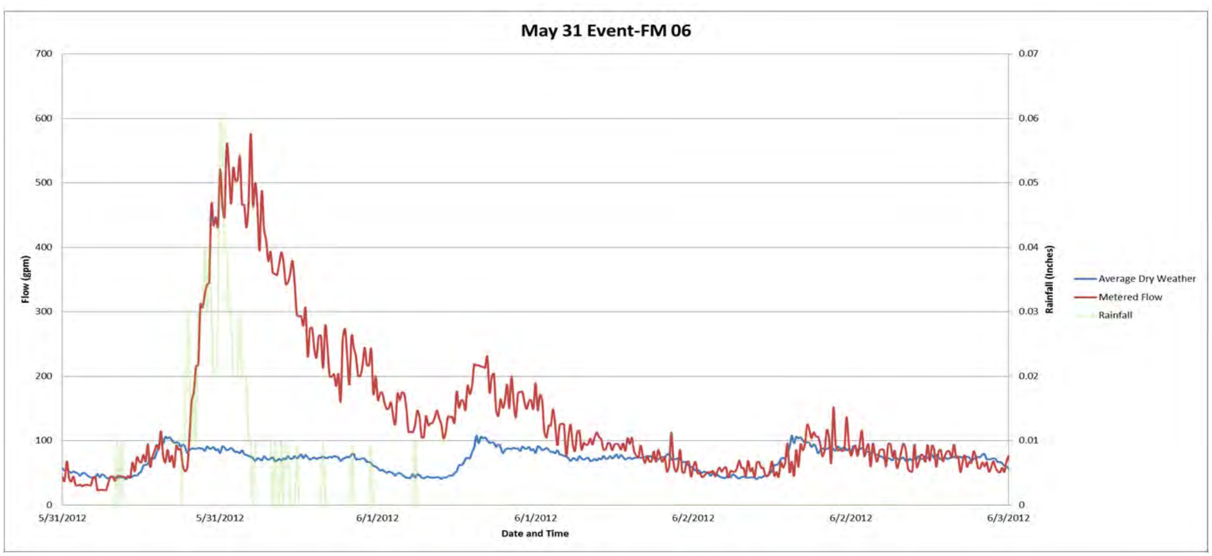

April 15 Event-FM 05
Flow (gpm)
Rainfall (inches)
Date and Time
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012
Average Dry Weather
Metered Flow
Rainfall

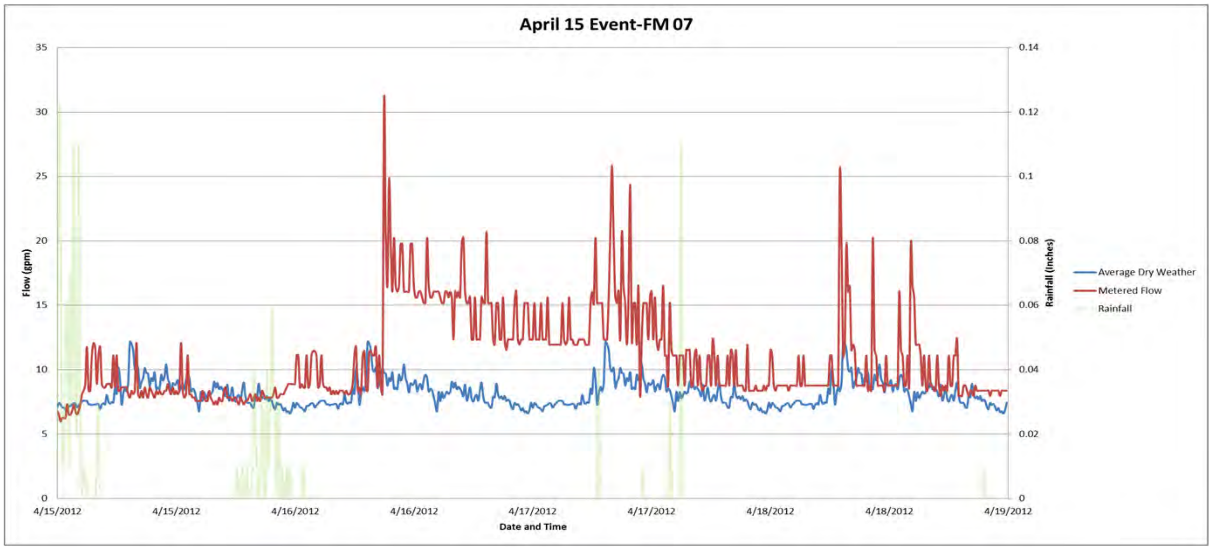

May 26 Event-FM 05
Flow (gpm)
Rainfall (inches)
Date and Time
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012
Average Dry Weather
Metered Flow
Rainfall

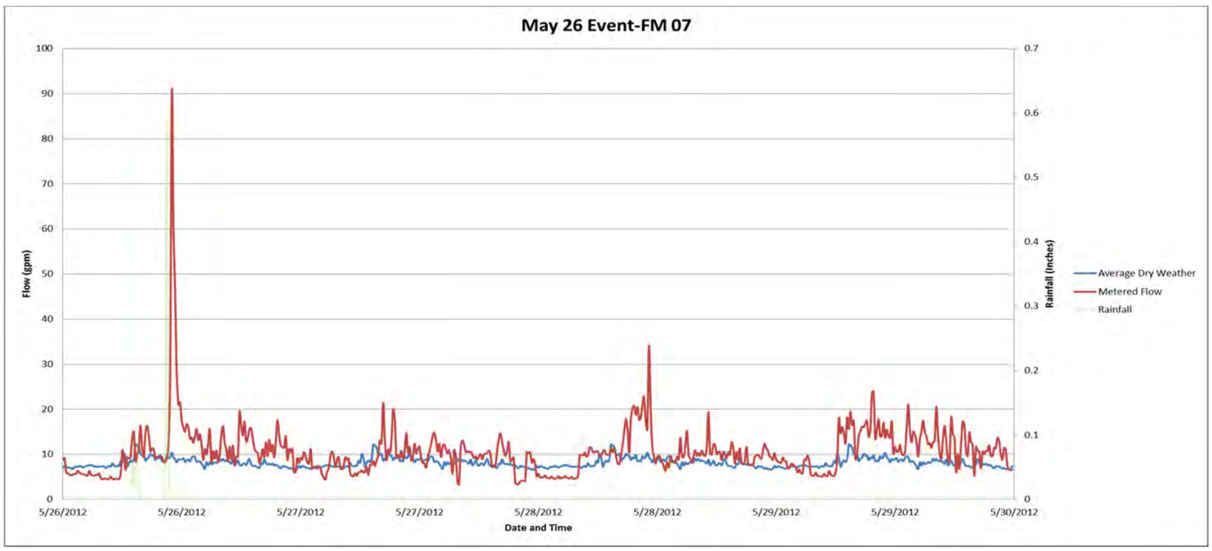

May 31 Event-FM 05
Flow (gpm)
Rainfall (inches)
Date and Time
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012
Average Dry Weather
Metered Flow
Rainfall

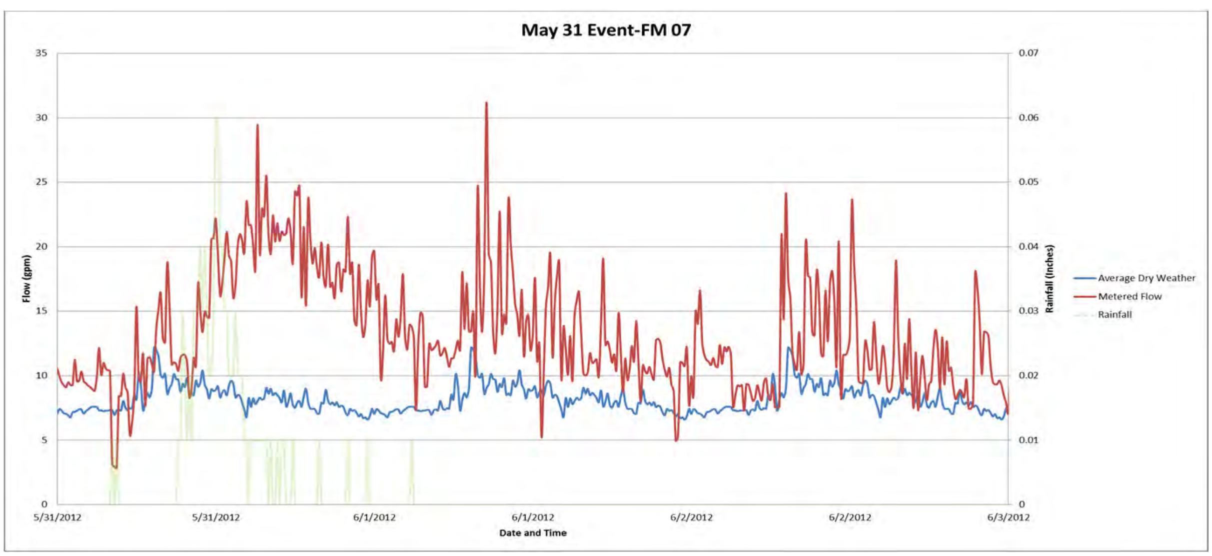

April 15 Event-FM 06
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

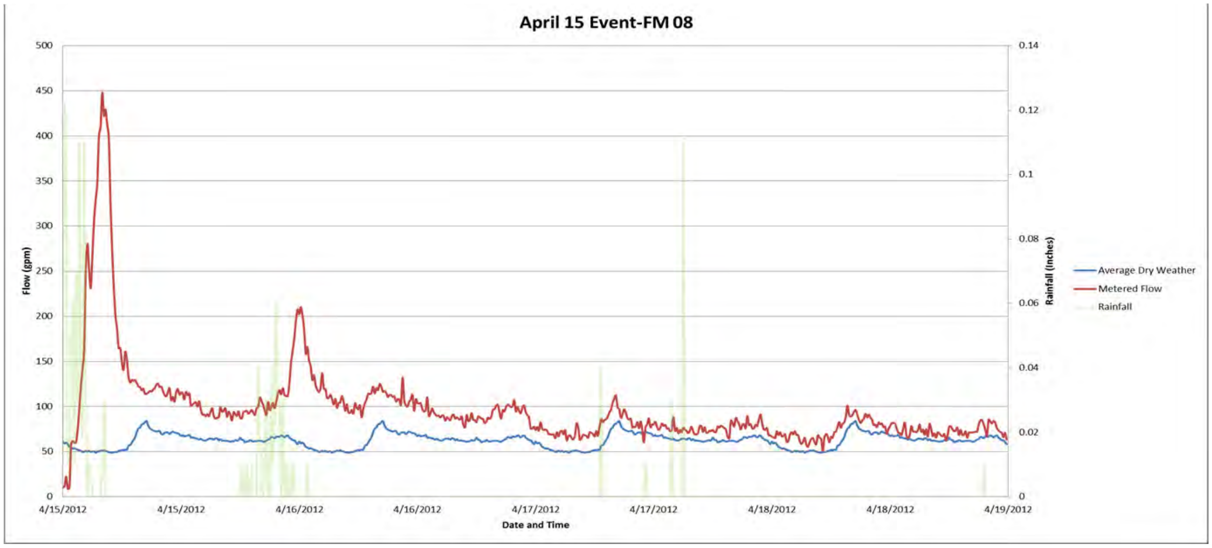

May 26 Event-FM 06
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

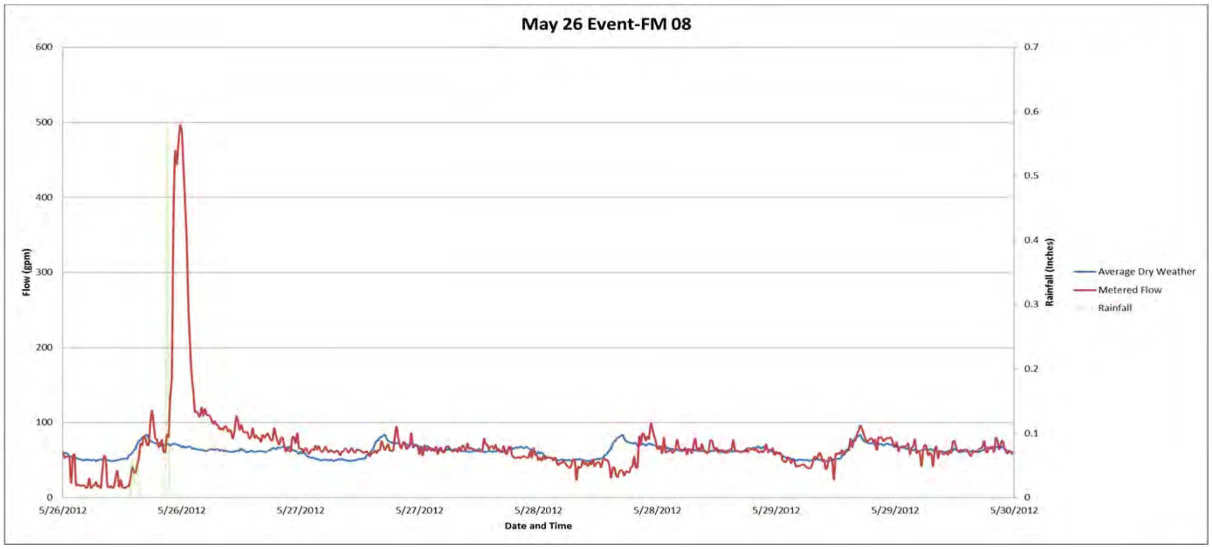

May 31 Event-FM 06
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

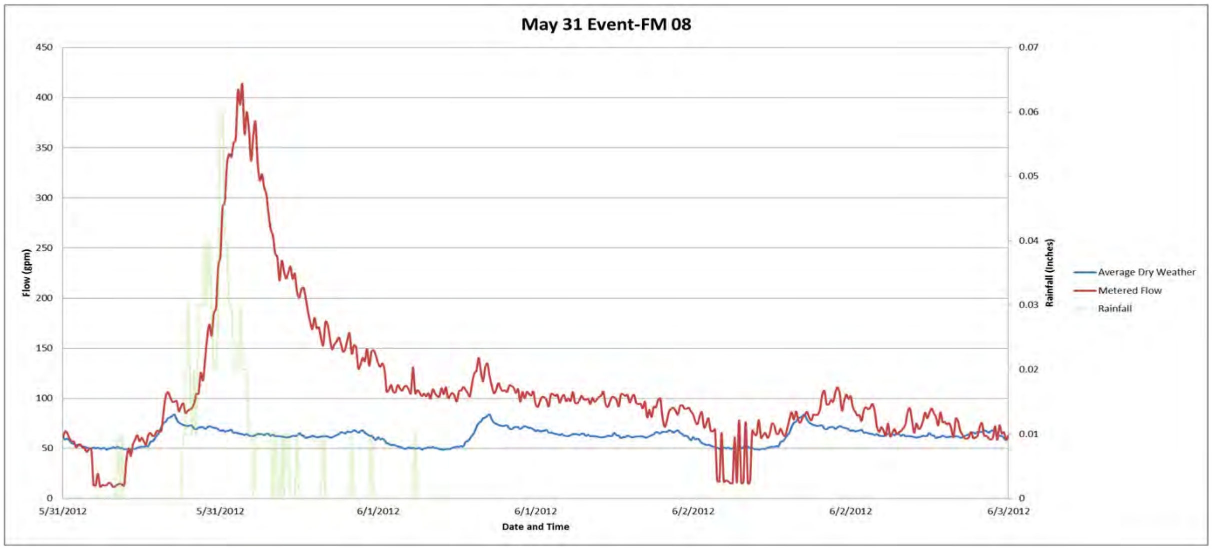

April 15 Event-FM 07
Flow (gpm)
Rainfall (inches)
Date and Time
0
5
10
15
20
25
30
35
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012
Average Dry Weather
Metered Flow
Rainfall

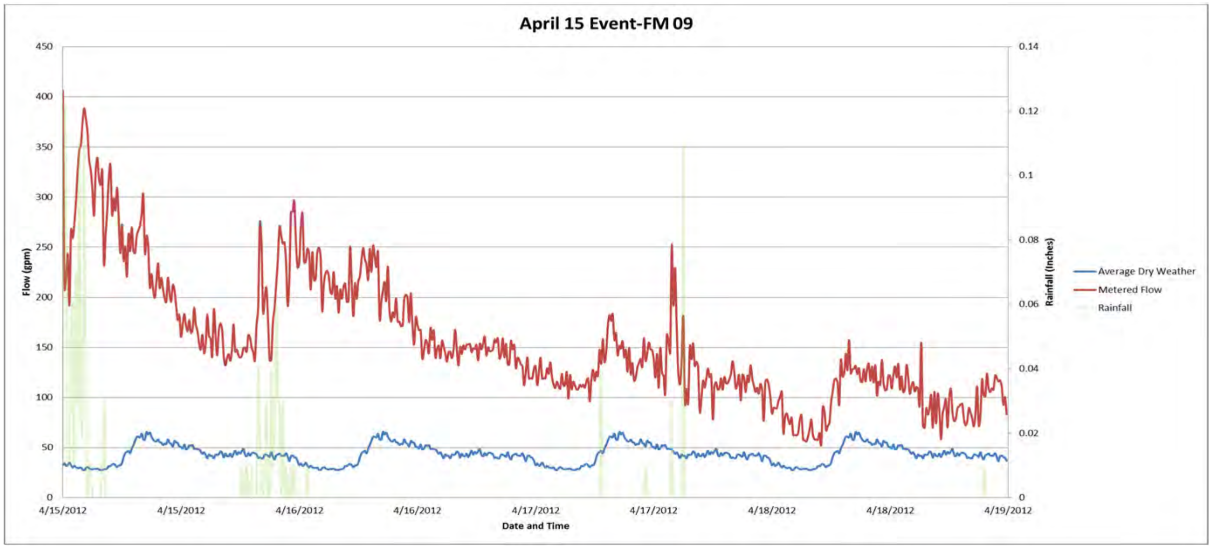

May 26 Event-FM 07
Flow (gpm)
Rainfall (inches)
Date and Time
0
10
20
30
40
50
60
70
80
90
100
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012
Average Dry Weather
Metered Flow
Rainfall

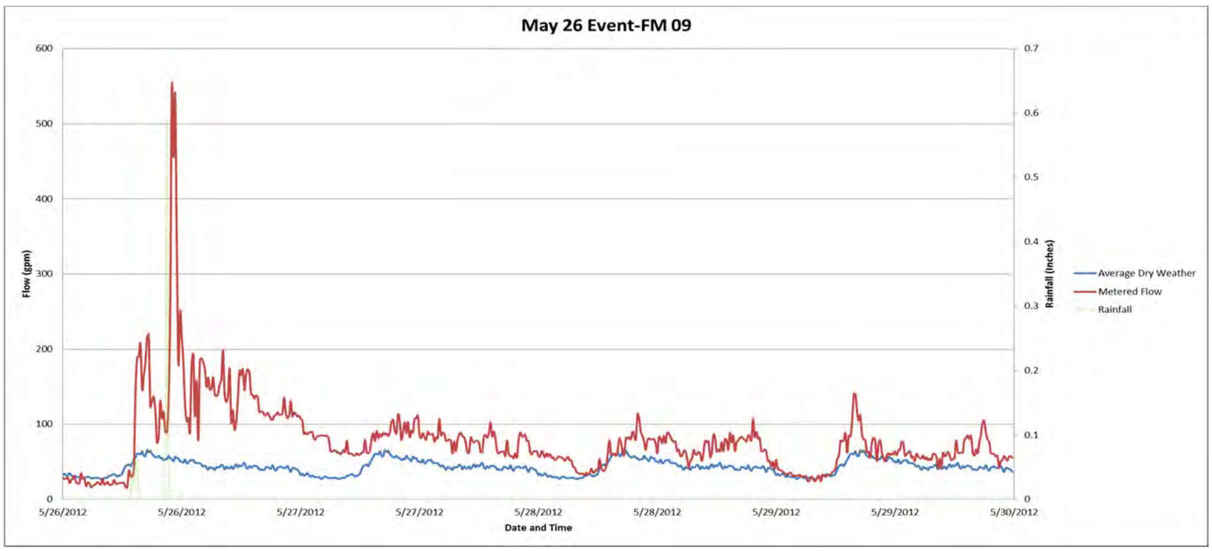

May 31 Event-FM 07
Flow (gpm)
Rainfall (inches)
Date and Time
0
5
10
15
20
25
30
35
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012
Average Dry Weather
Metered Flow
Rainfall

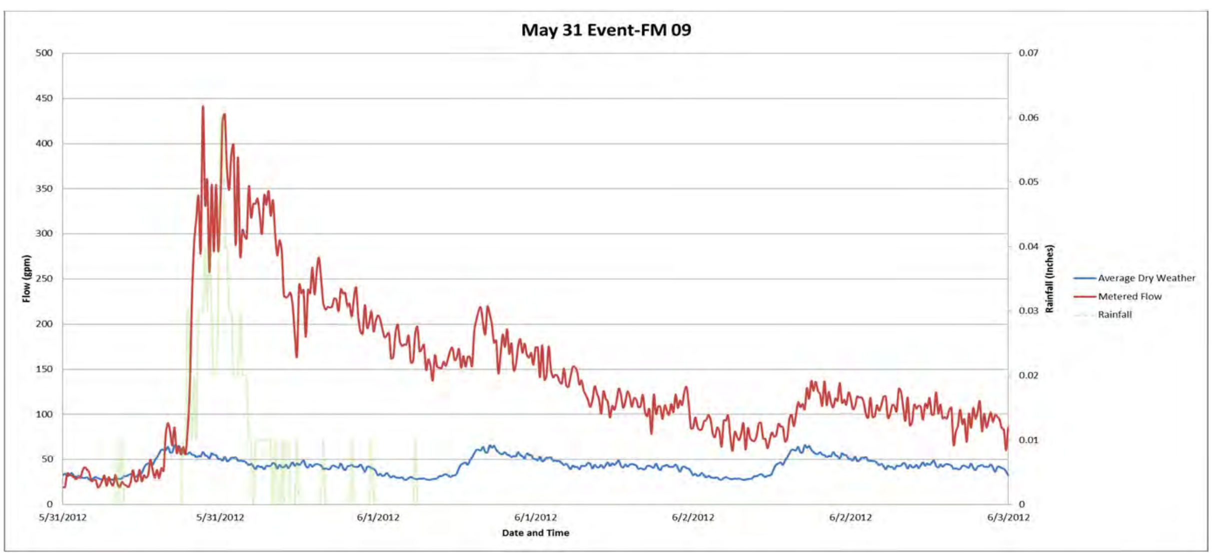

April 15 Event-FM 08
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

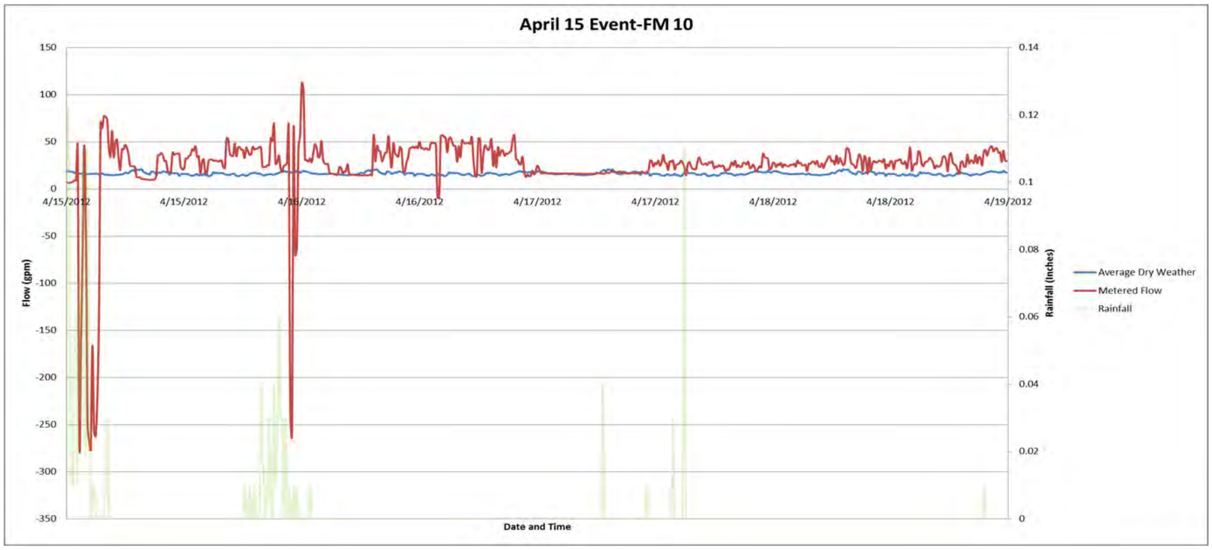

May 26 Event-FM 08
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

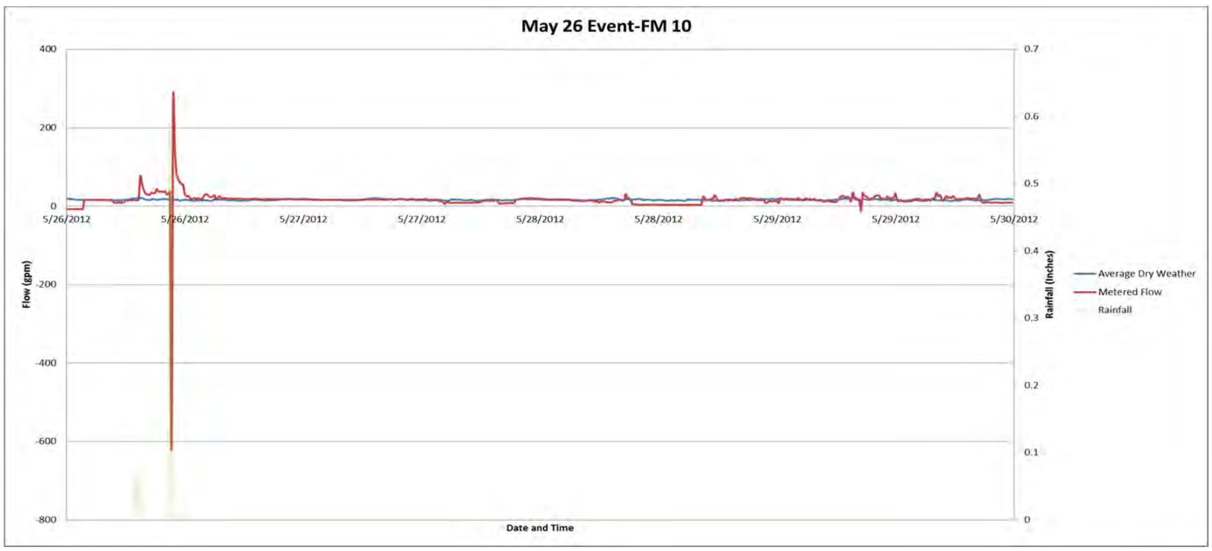

May 31 Event-FM 08
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

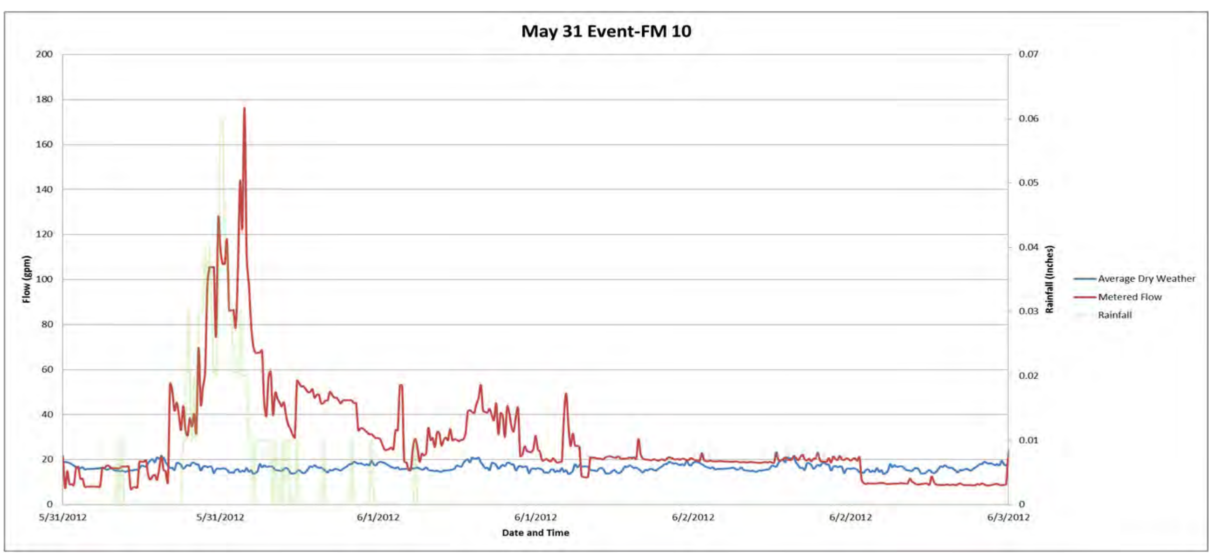

April 15 Event-FM 09
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

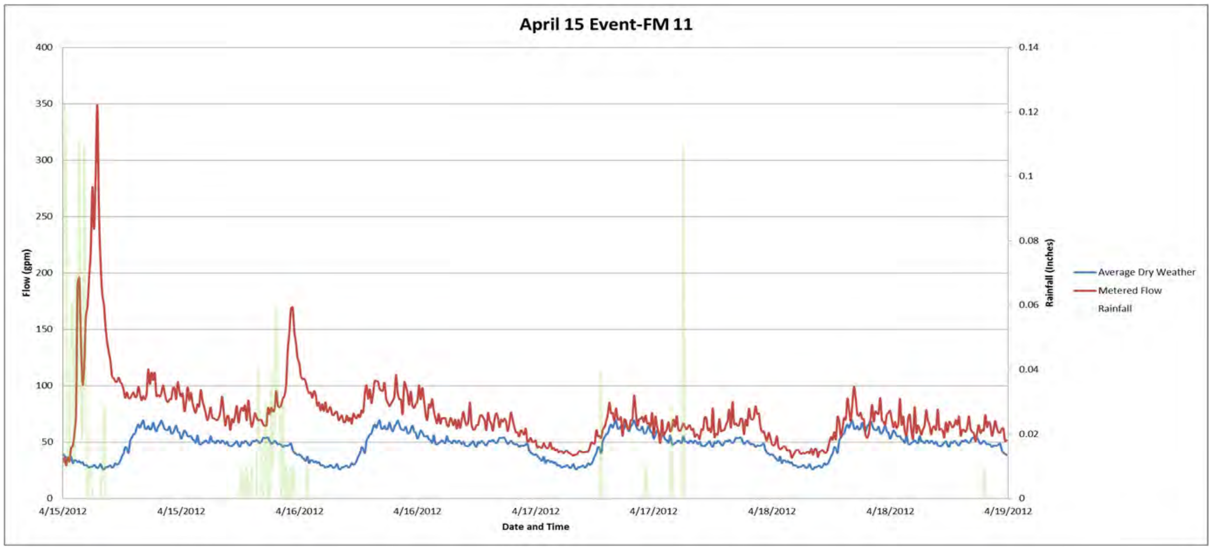

May 26 Event-FM 09
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

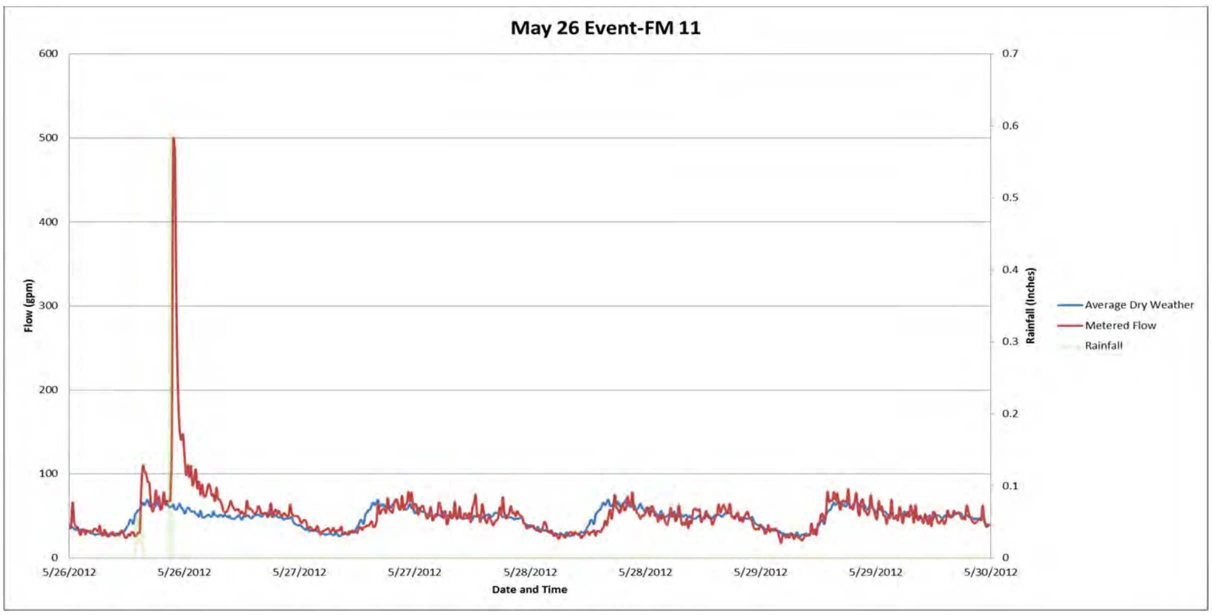

May 31 Event-FM 09
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

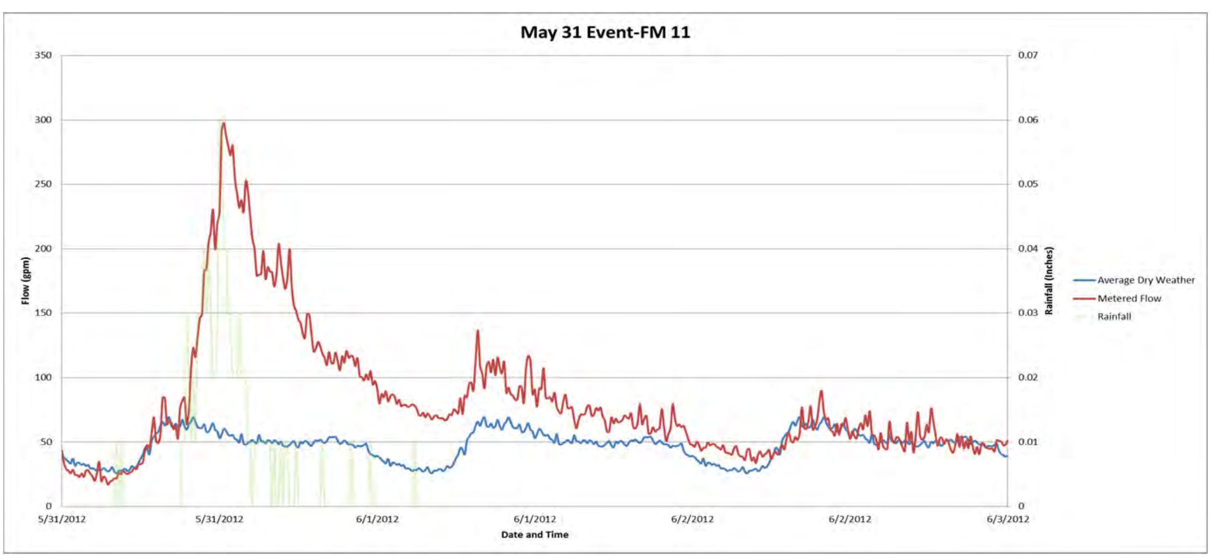

April 15 Event-FM 10
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

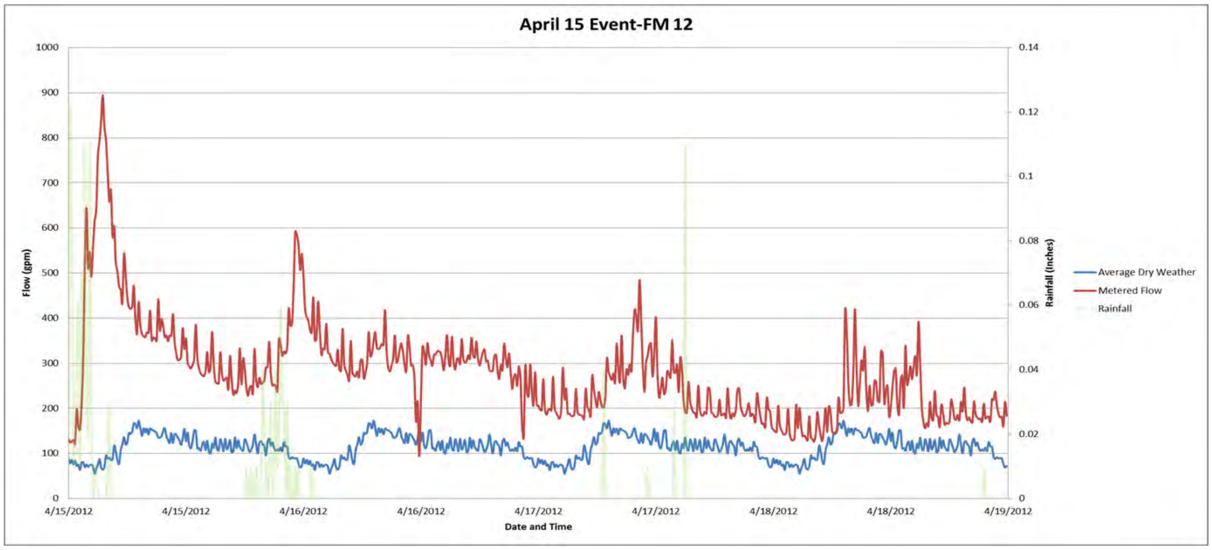

May 26 Event-FM 10
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

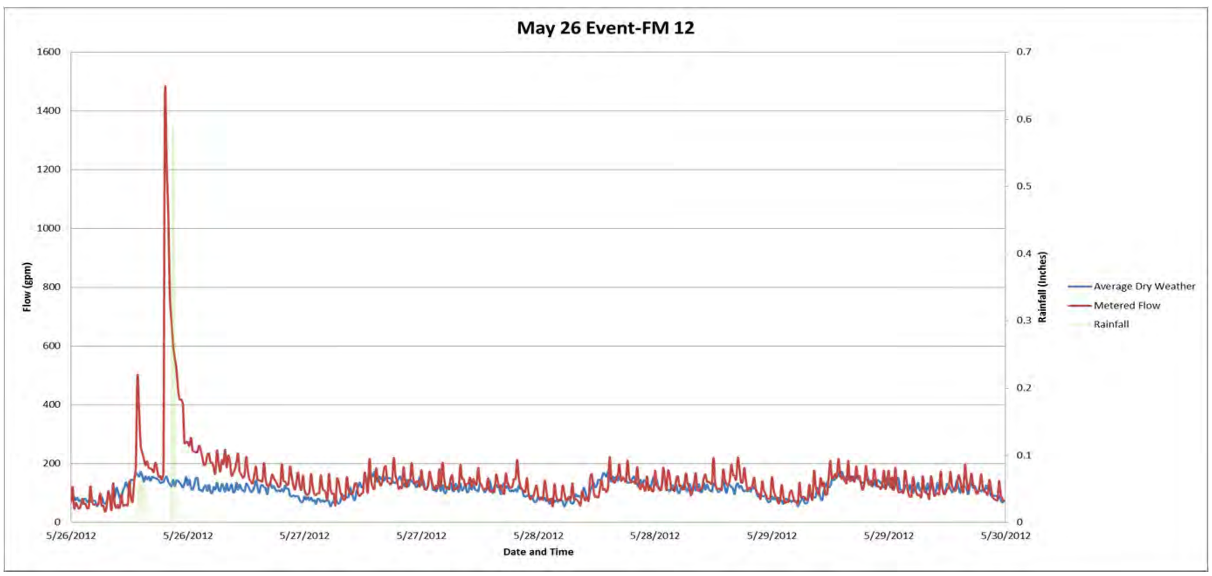

May 31 Event-FM 10
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

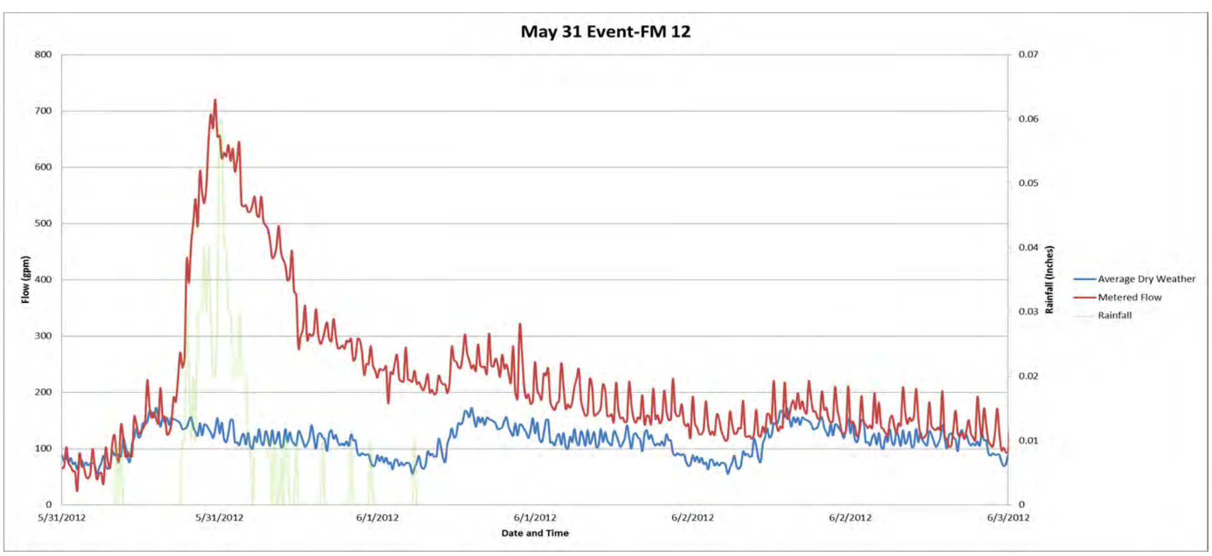

April 15 Event-FM 11
400
350
300
250
200
150
100
50
0
Flow (gpm)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Rainfall (inches)
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012
Date and Time
Average Dry Weather
Metered Flow
Rainfall

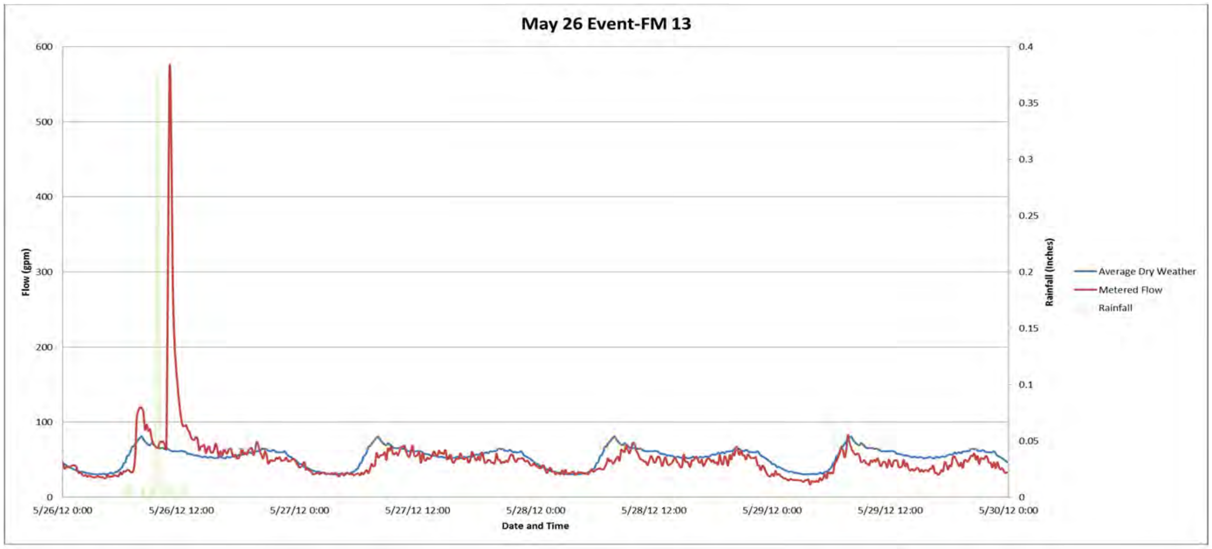

May 26 Event-FM 11
600
500
400
300
200
100
0
Flow (gpm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rainfall (inches)
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012
Date and Time
Average Dry Weather
Metered Flow
Rainfall


May 31 Event-FM 11
350
300
250
200
150
100
50
0
Flow (gpm)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Rainfall (inches)
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012
Date and Time
Average Dry Weather
Metered Flow
Rainfall


April 15 Event-FM 12
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012


May 26 Event-FM 12
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012


May 31 Event-FM 12
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012


May 26 Event-FM 13
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/12 0:00
5/26/12 12:00
5/27/12 0:00
5/27/12 12:00
5/28/12 0:00
5/28/12 12:00
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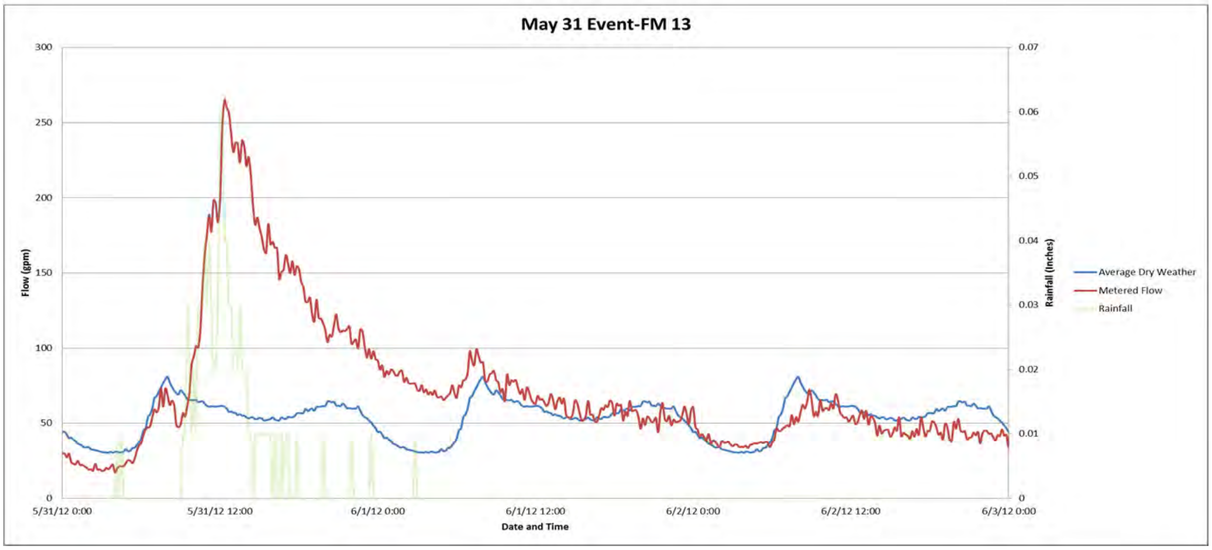
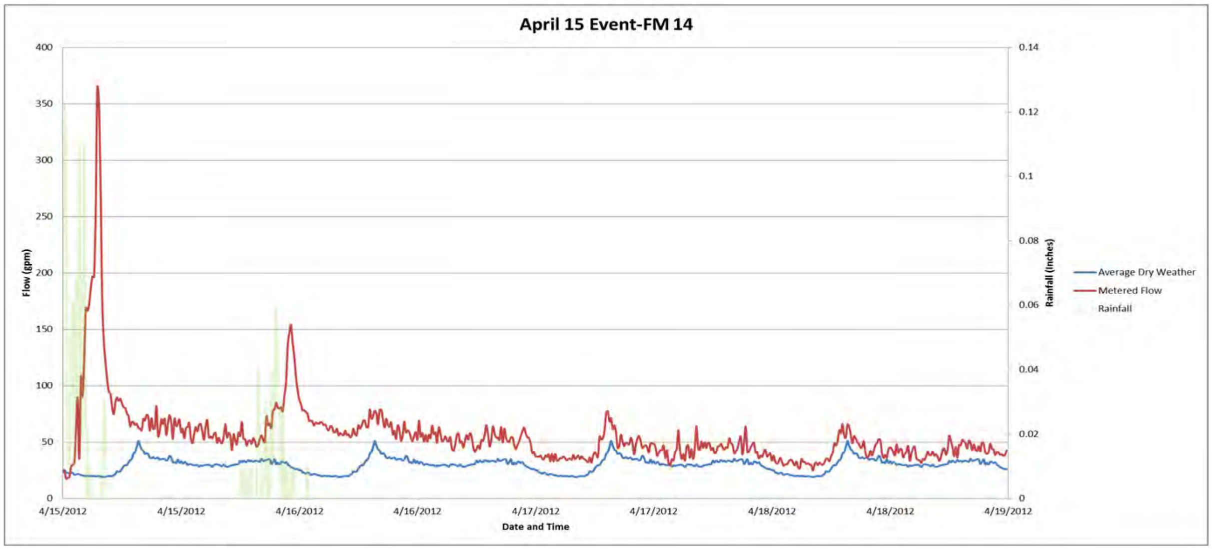
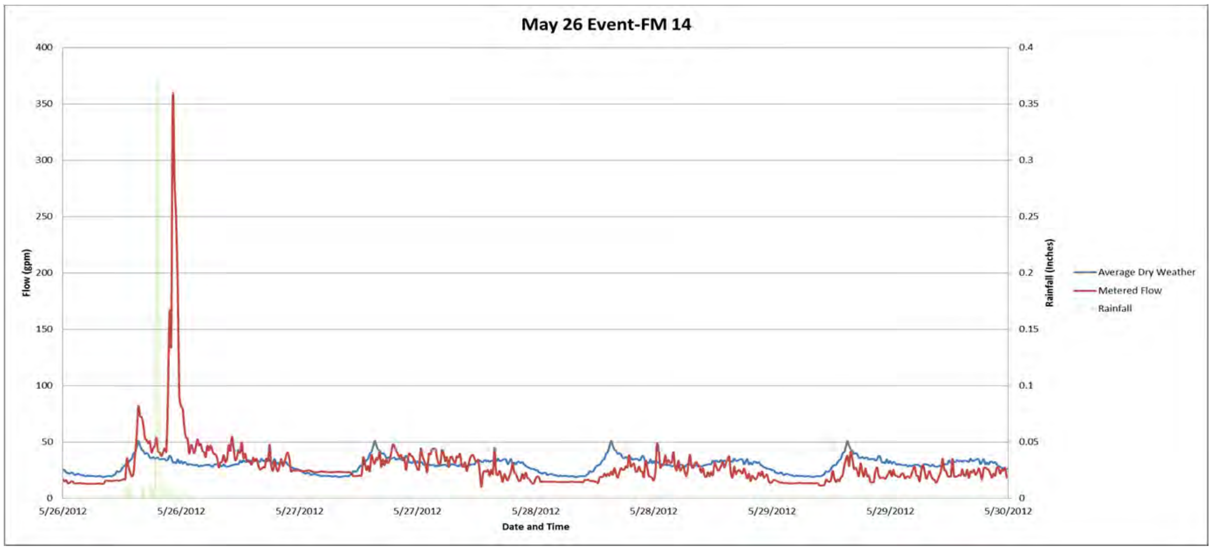
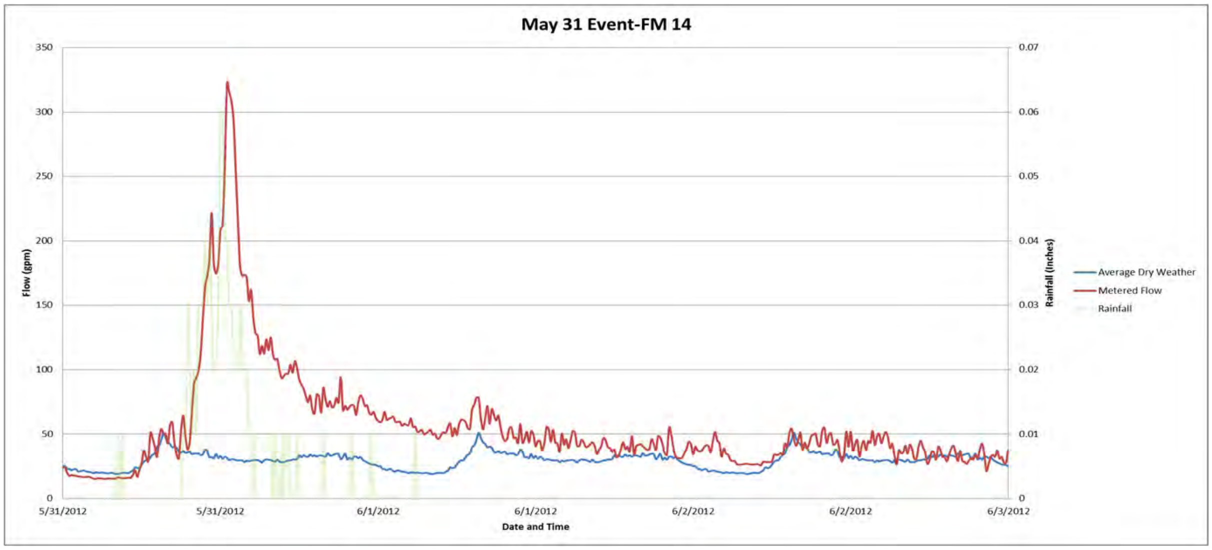
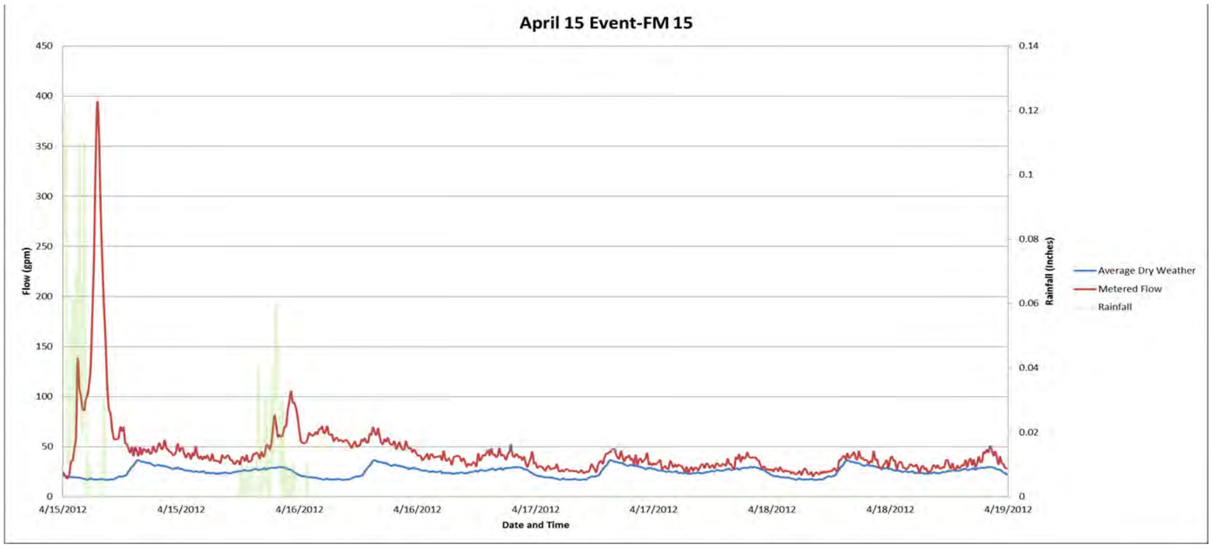
5/30/12 0:00

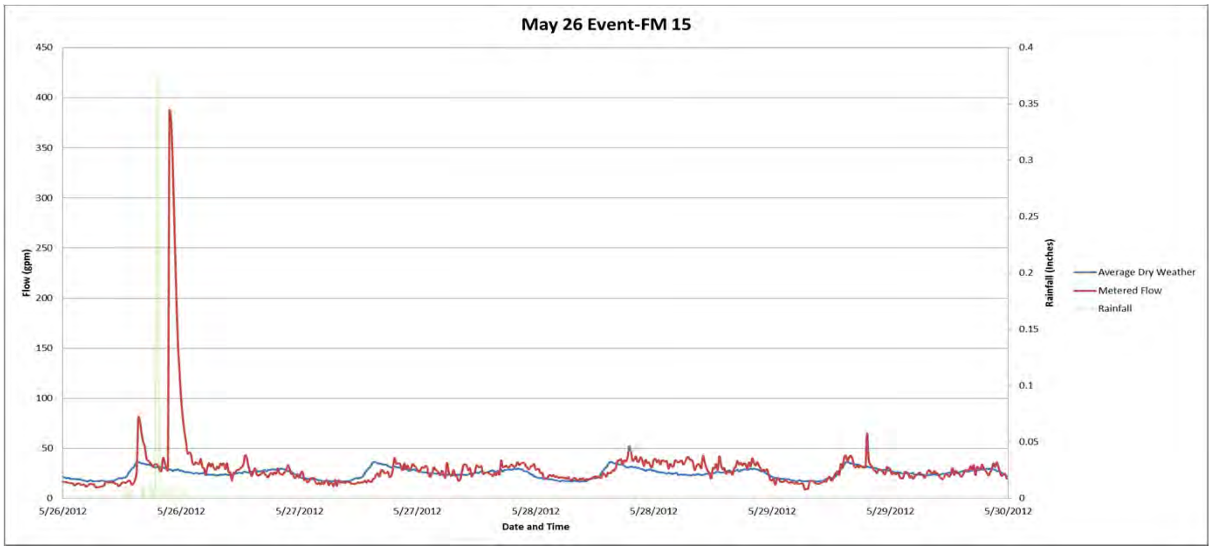

May 31 Event-FM 13
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/12 0:00
5/31/12 12:00
6/1/12 0:00
6/1/12 12:00
6/2/12 0:00
6/2/12 12:00
6/3/12 0:00

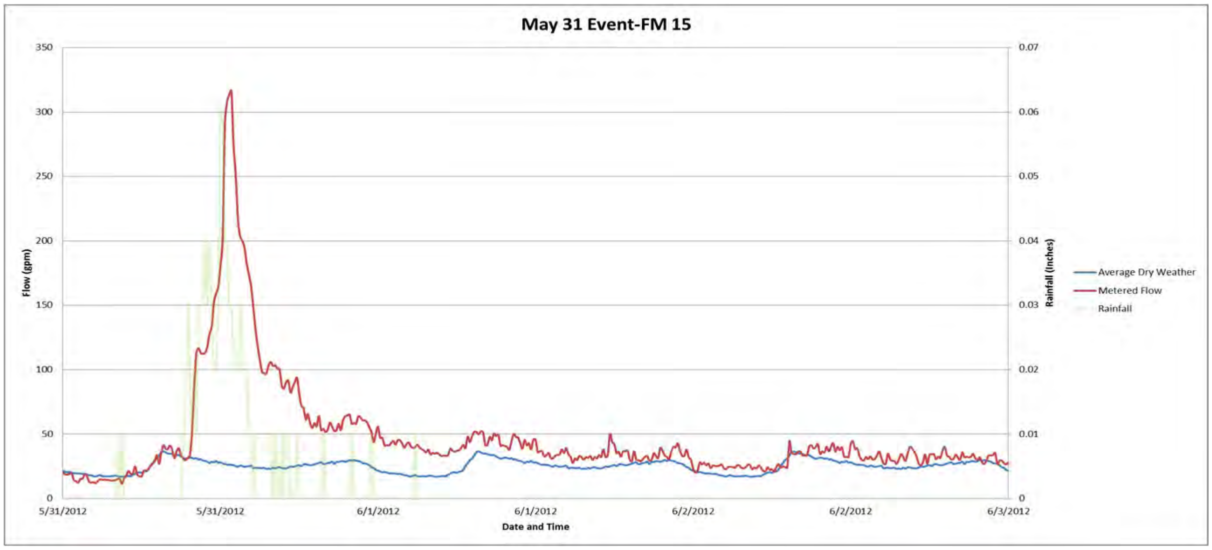

April 15 Event-FM 14
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

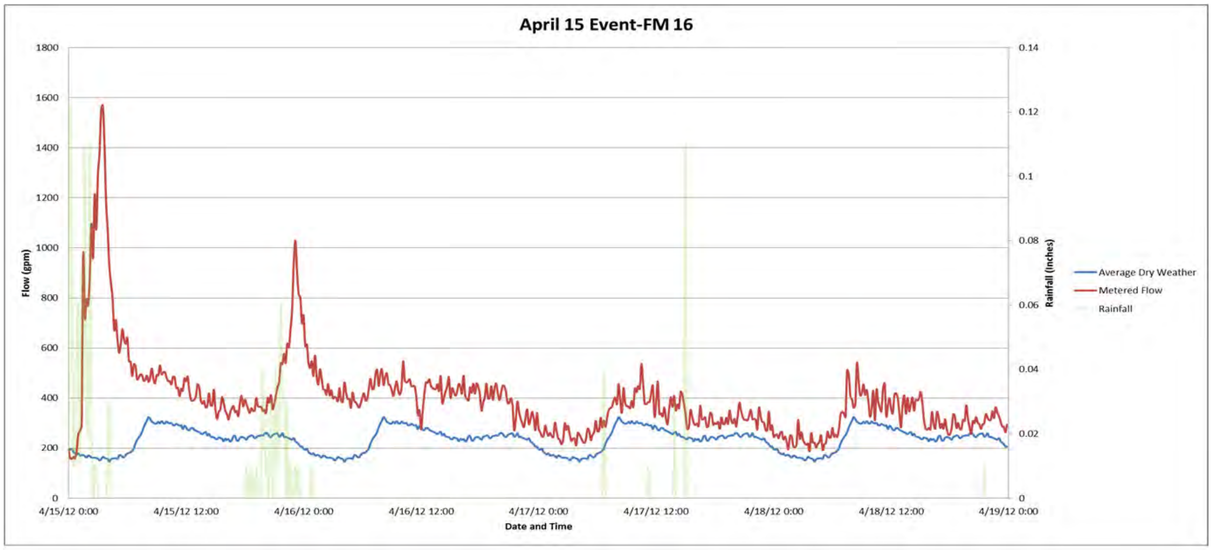

May 26 Event-FM 14
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

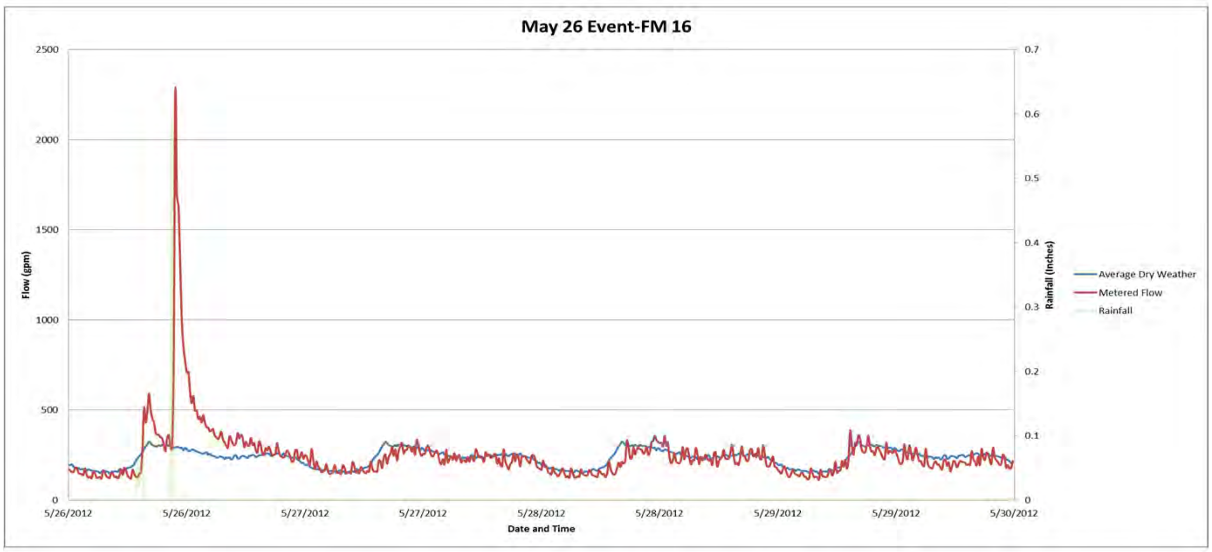

May 31 Event-FM 14
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

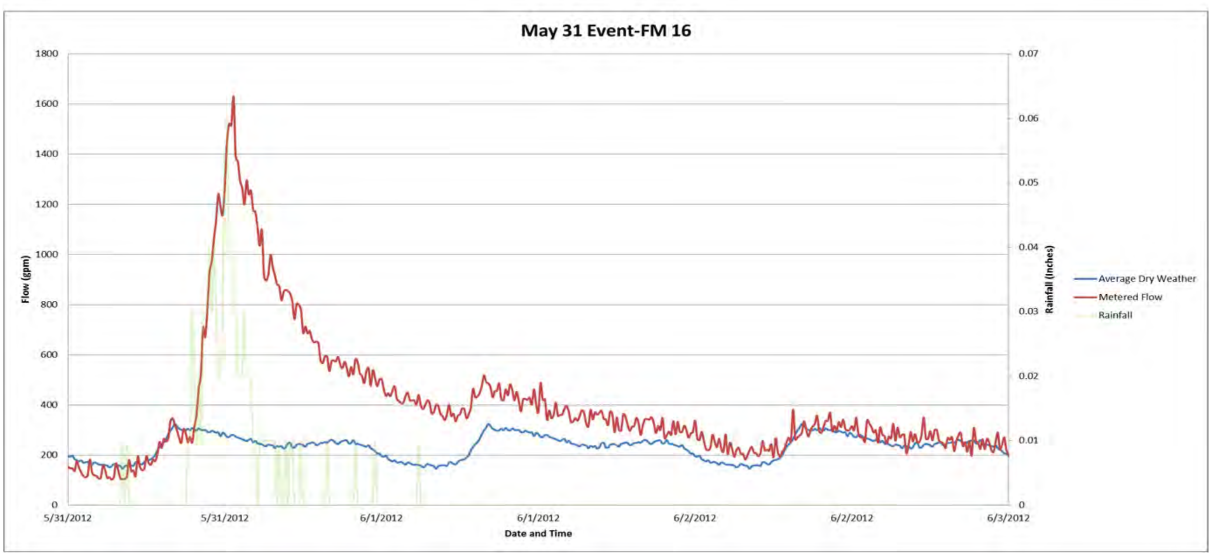

April 15 Event-FM 15
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

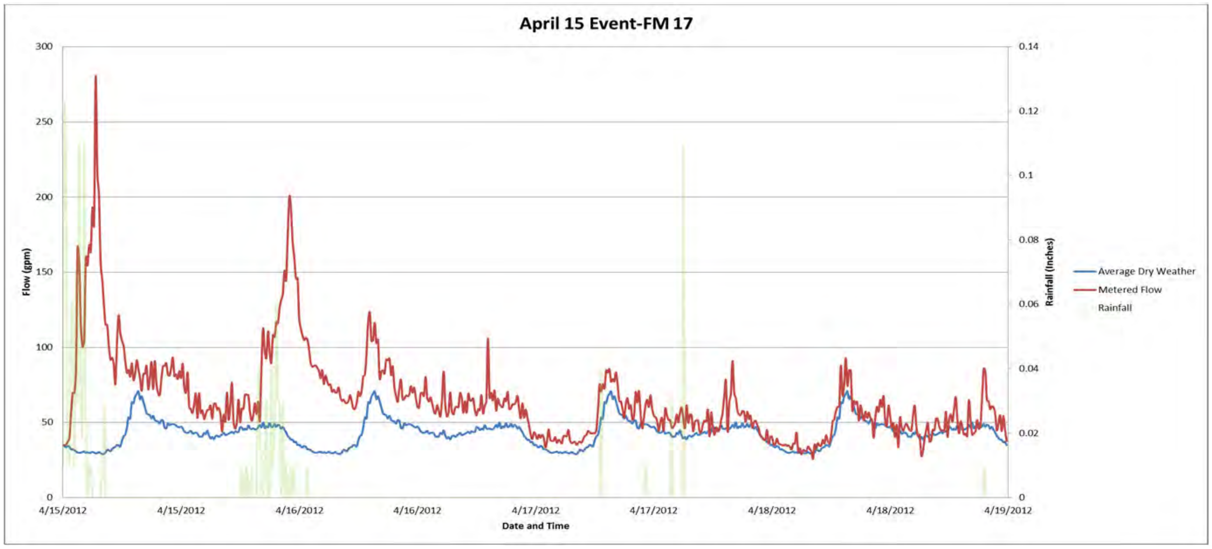

May 26 Event-FM 15
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

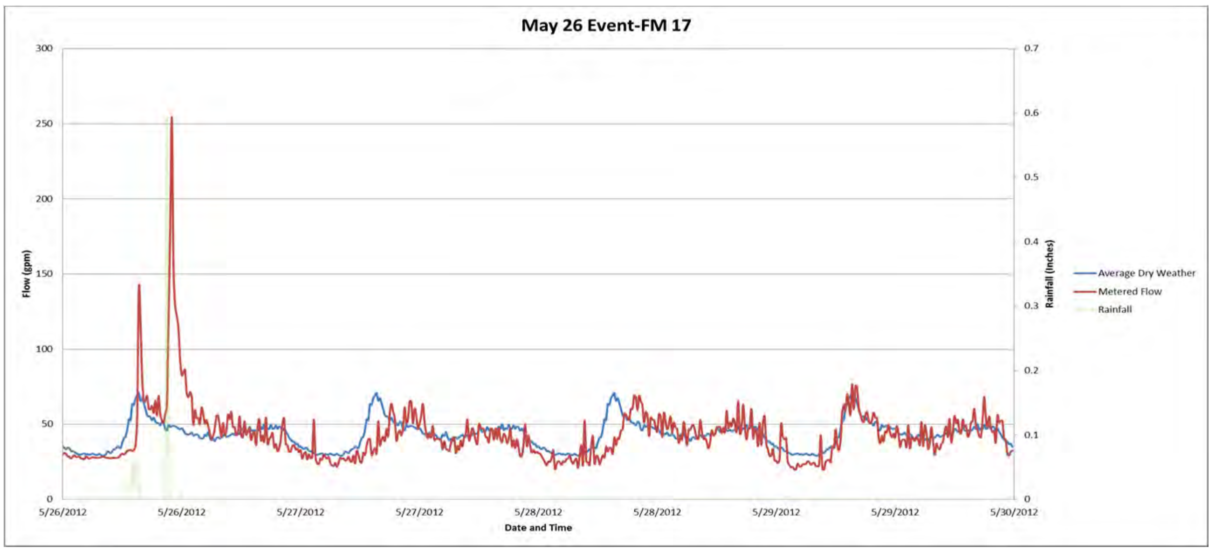

May 31 Event-FM 15
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

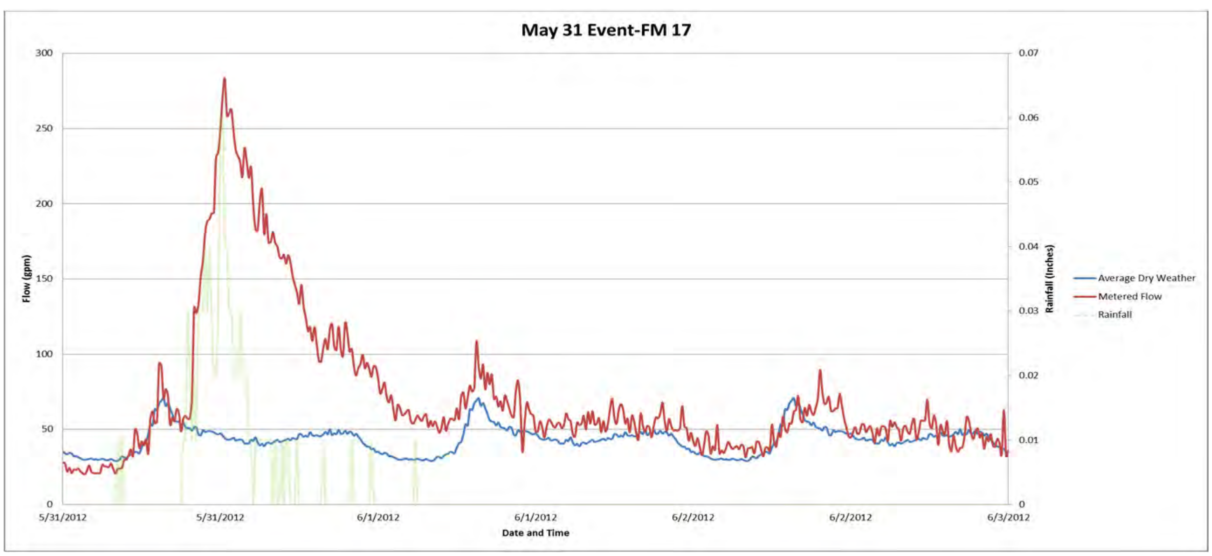

April 15 Event-FM 16
Flow (gpm)
Rainfall (Inches)
Date and Time
4/15/12 0:00
4/15/12 12:00
4/16/12 0:00
4/16/12 12:00
4/17/12 0:00
4/17/12 12:00
4/18/12 0:00
4/18/12 12:00
4/19/12 0:00
Average Dry Weather
Metered Flow
Rainfall

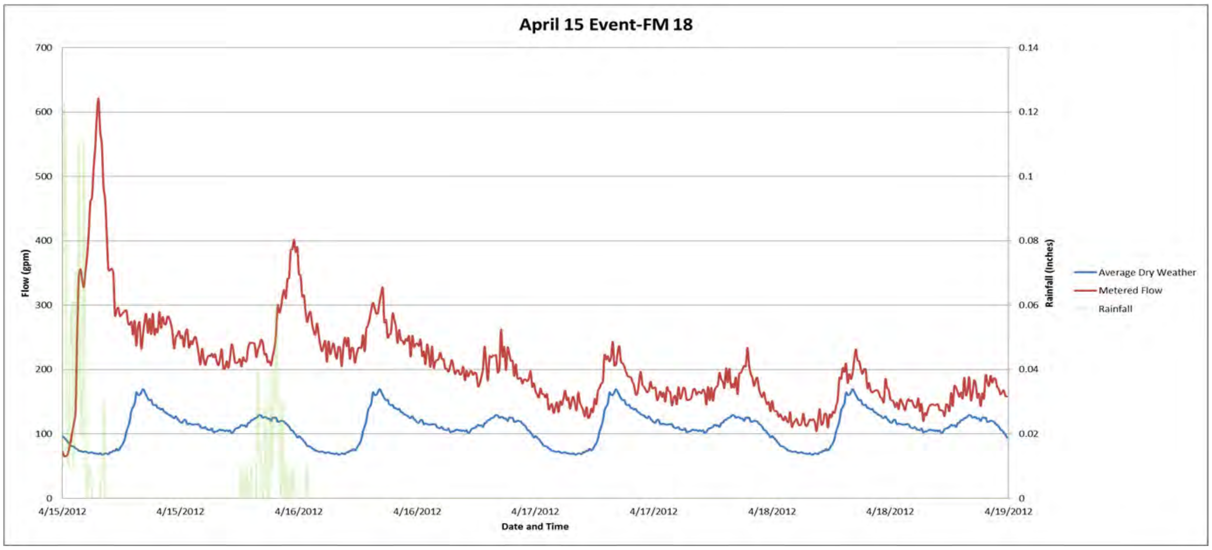

May 26 Event-FM 16
Flow (gpm)
Rainfall (Inches)
Date and Time
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012
Average Dry Weather
Metered Flow
Rainfall

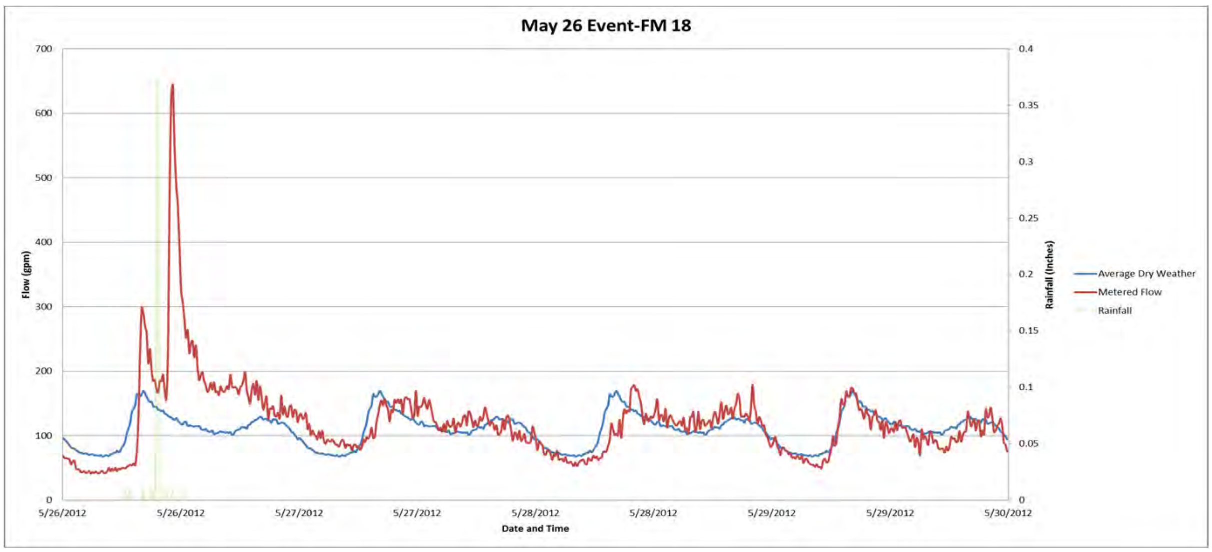

May 31 Event-FM 16
Flow (gpm)
Rainfall (Inches)
Date and Time
5/31/2012
6/1/2012
6/2/2012
6/3/2012
Average Dry Weather
Metered Flow
Rainfall

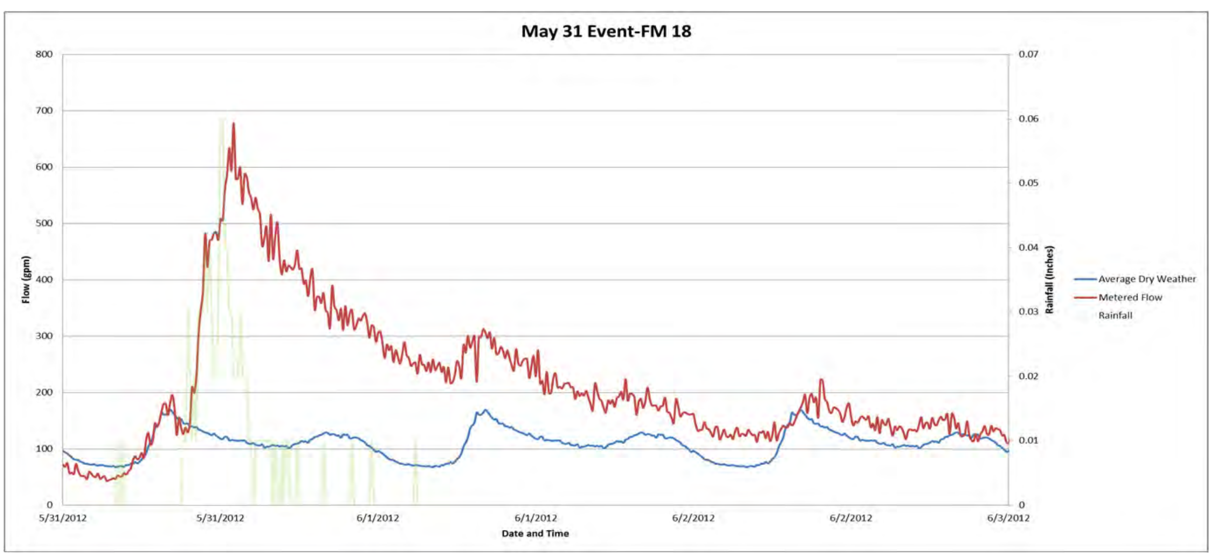

April 15 Event-FM 17
Flow (gpm)
Rainfall (inches)
Date and Time
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012
Average Dry Weather
Metered Flow
Rainfall

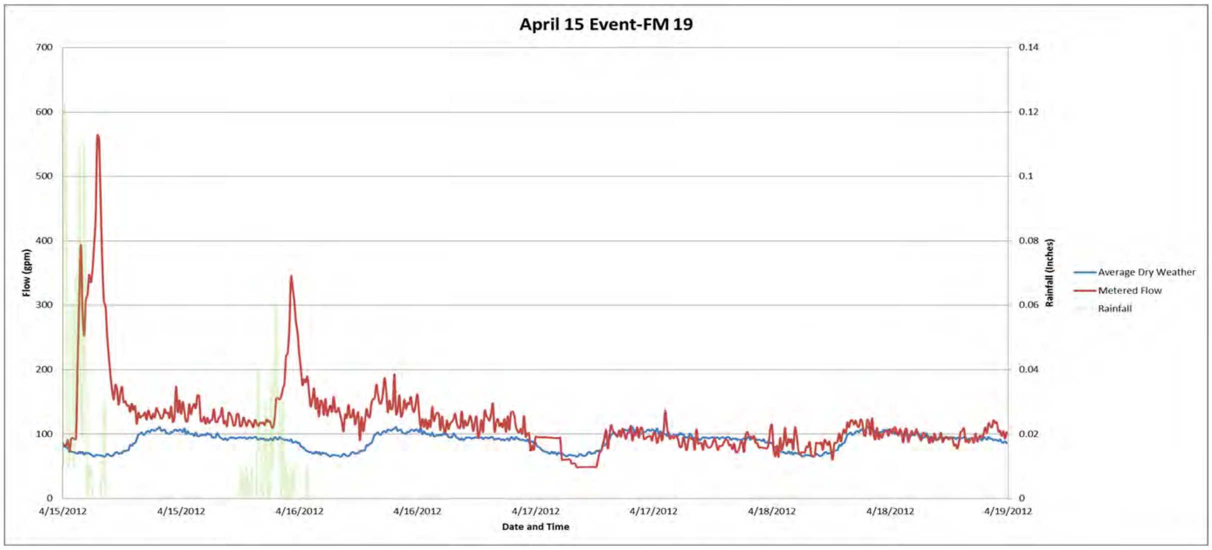

May 26 Event-FM 17
Flow (gpm)
Rainfall (inches)
Date and Time
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012
Average Dry Weather
Metered Flow
Rainfall

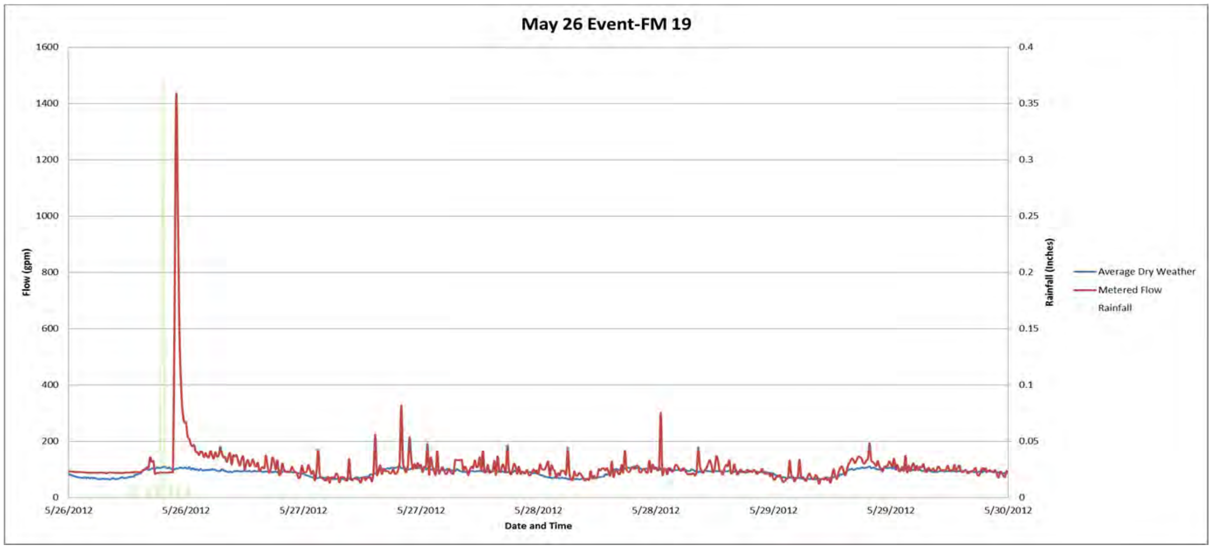

May 31 Event-FM 17
Flow (gpm)
Rainfall (inches)
Date and Time
5/31/2012
6/1/2012
6/2/2012
6/3/2012
Average Dry Weather
Metered Flow
Rainfall

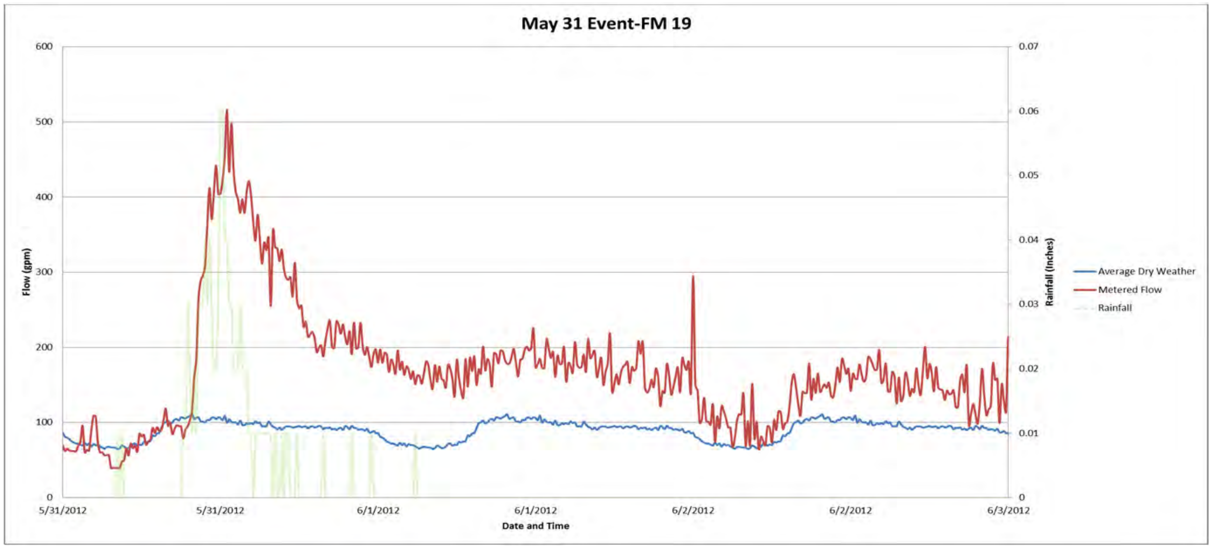

April 15 Event-FM 18
Flow (gpm)
Rainfall (inches)
Date and Time
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012
Average Dry Weather
Metered Flow
Rainfall

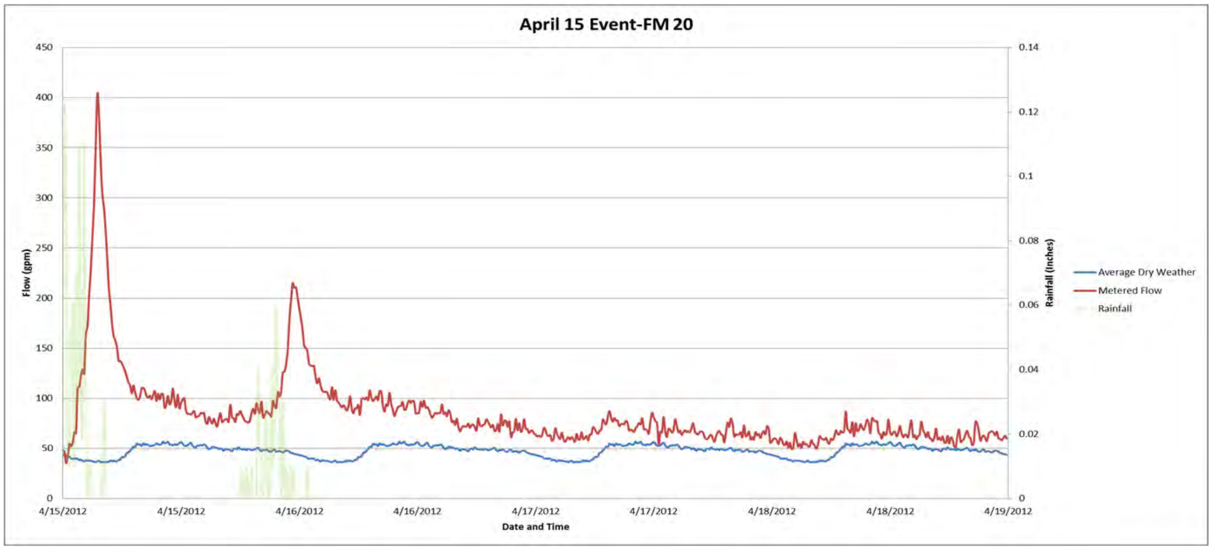

May 26 Event-FM 18
Flow (gpm)
Rainfall (inches)
Date and Time
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012
Average Dry Weather
Metered Flow
Rainfall

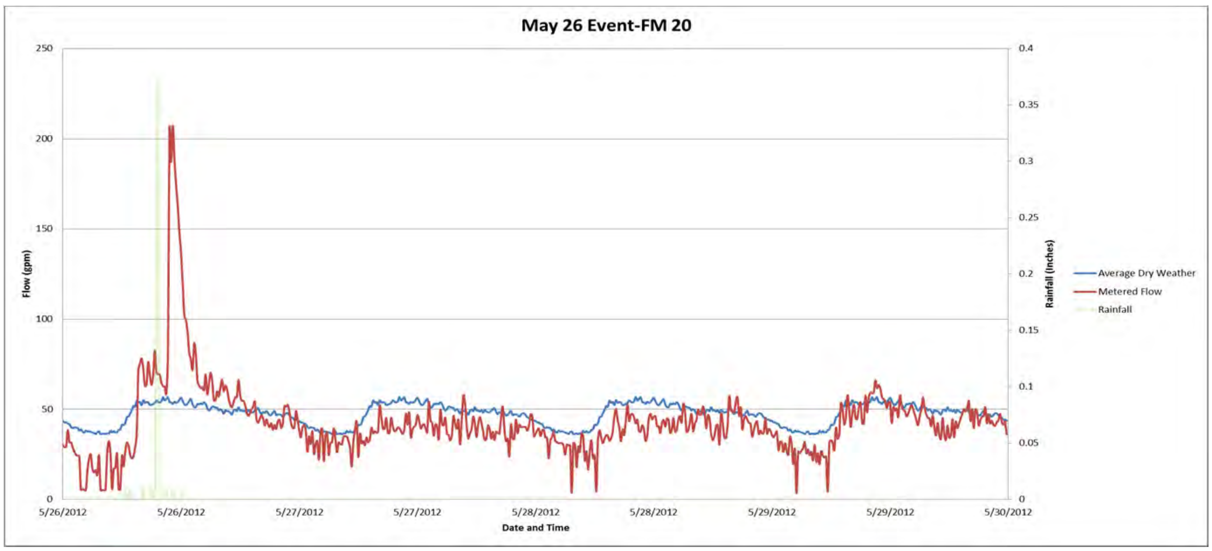

May 31 Event-FM 18
Flow (gpm)
Rainfall (inches)
Date and Time
5/31/2012
6/1/2012
6/2/2012
6/3/2012
Average Dry Weather
Metered Flow
Rainfall

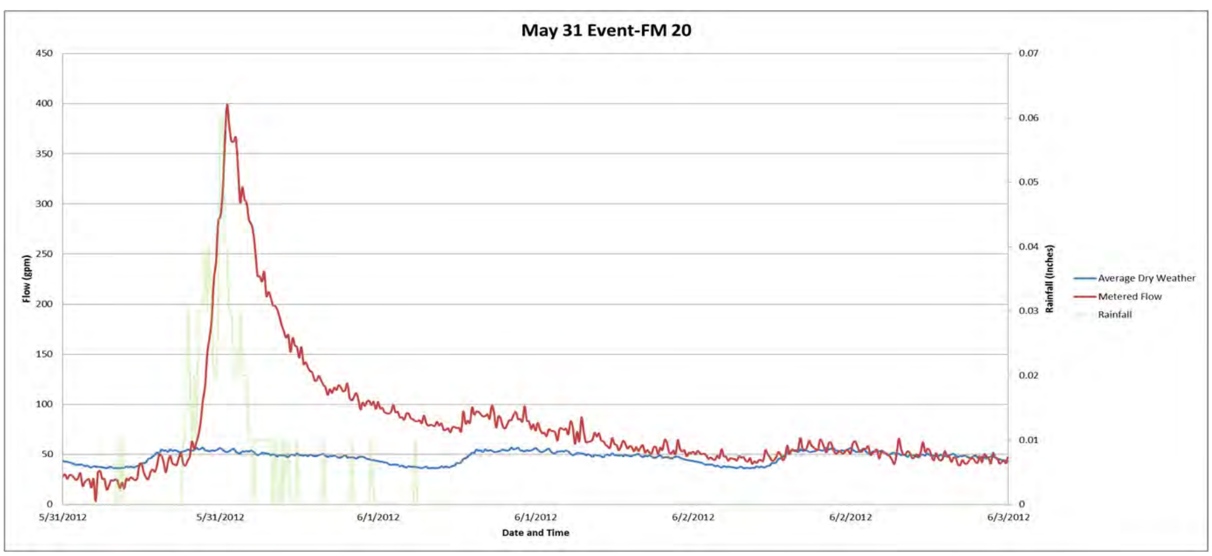

April 15 Event-FM 19
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

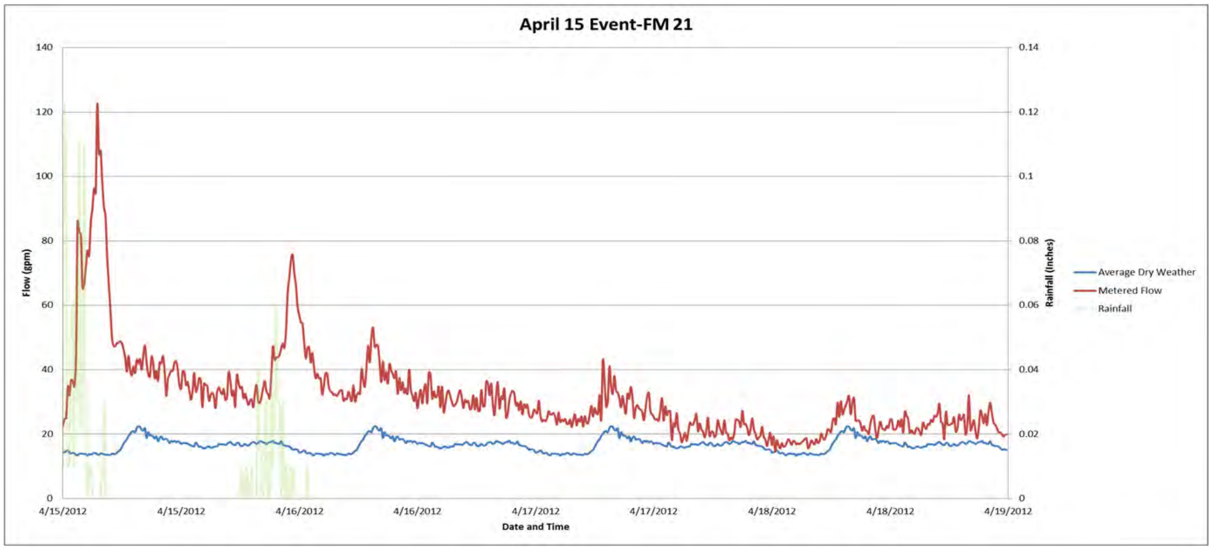

May 26 Event-FM 19
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

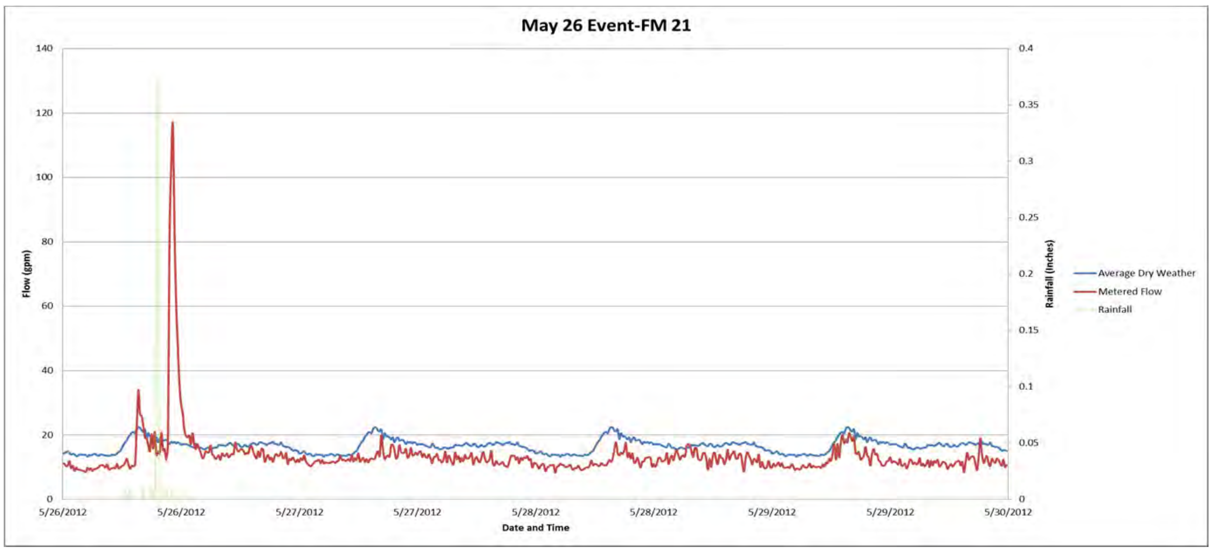

May 31 Event-FM 19
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

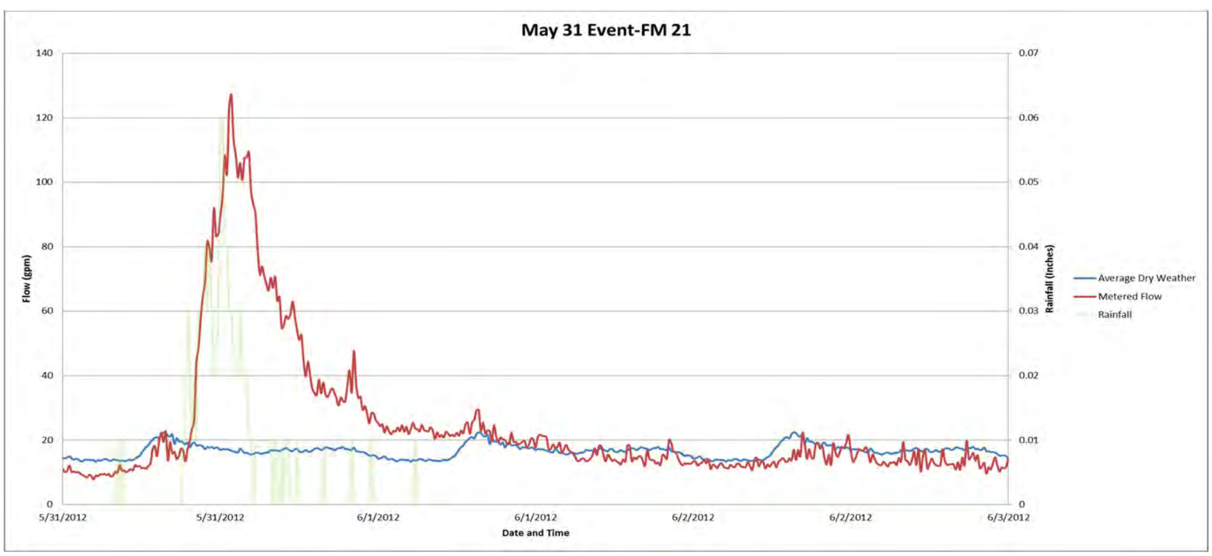

April 15 Event-FM 20
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

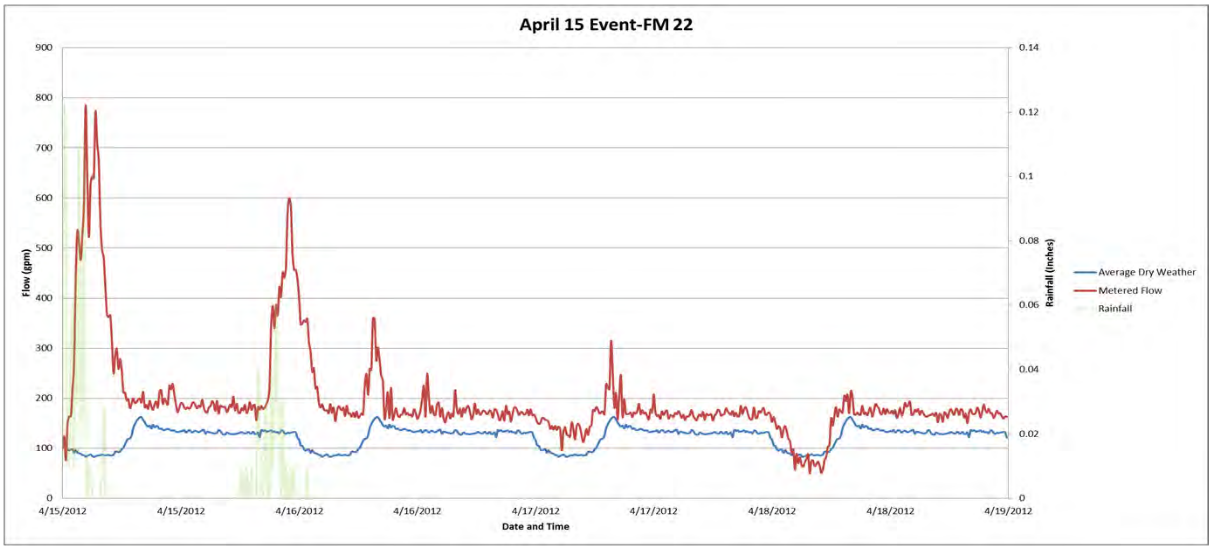

May 26 Event-FM 20
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

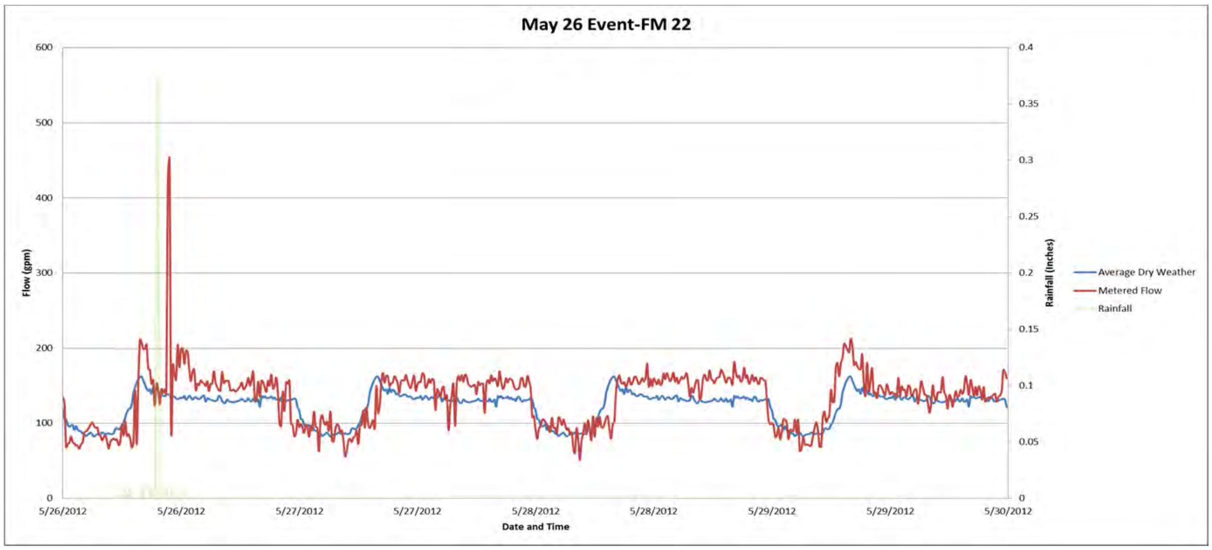

May 31 Event-FM 20
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

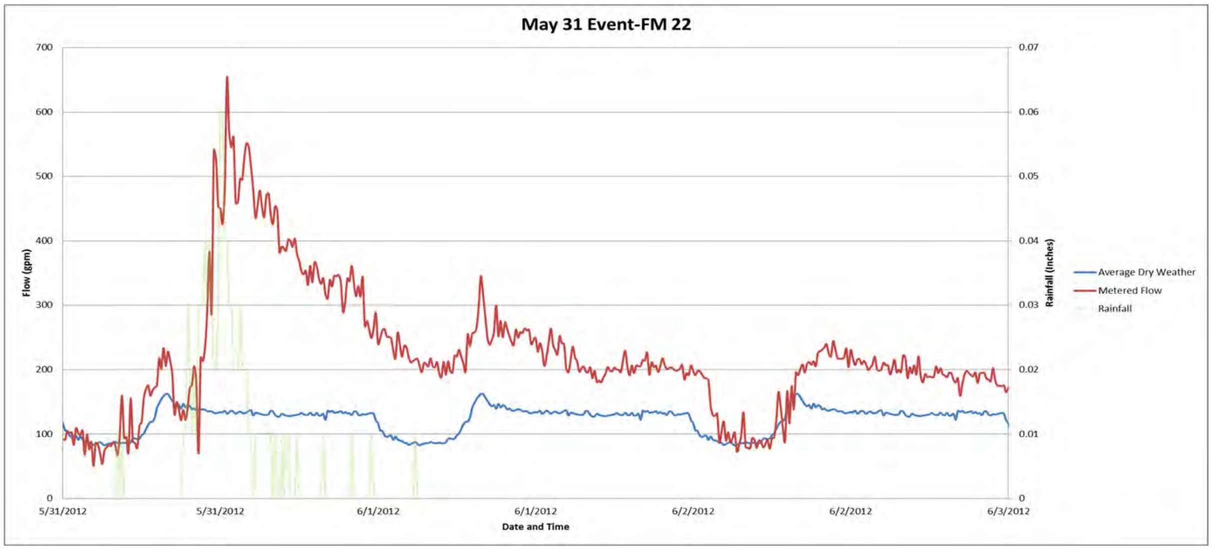

April 15 Event-FM 21
Flow (gpm)
Rainfall (inches)
140
120
100
80
60
40
20
0
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012
Date and Time
Average Dry Weather
Metered Flow
Rainfall

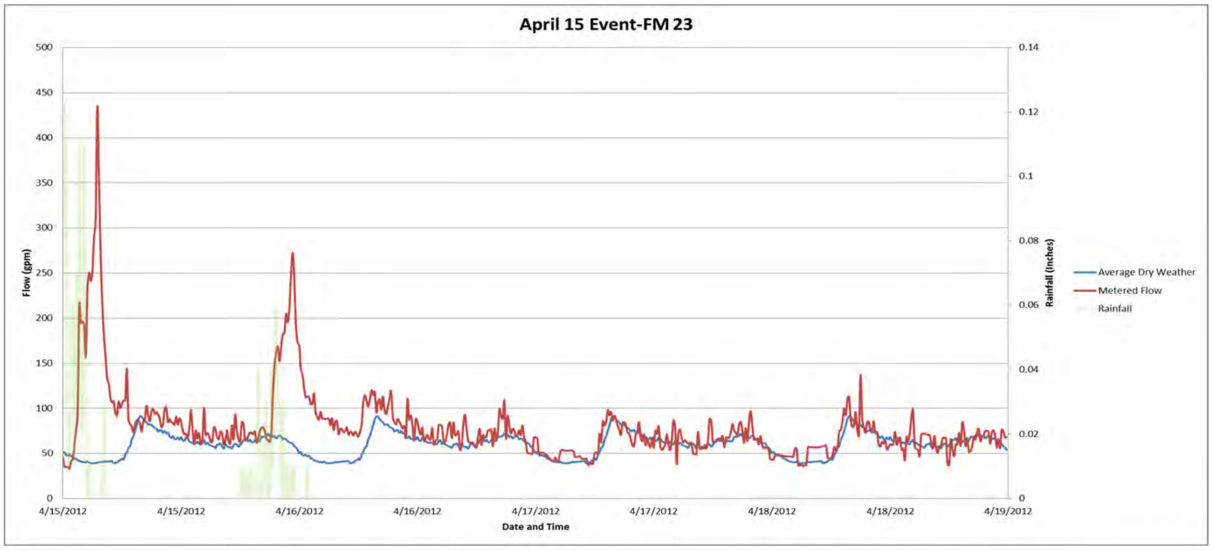

May 26 Event-FM 21
Flow (gpm)
Rainfall (inches)
140
120
100
80
60
40
20
0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012
Date and Time
Average Dry Weather
Metered Flow
Rainfall


May 31 Event-FM 21
Flow (gpm)
Rainfall (inches)
140
120
100
80
60
40
20
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012
Date and Time
Average Dry Weather
Metered Flow
Rainfall

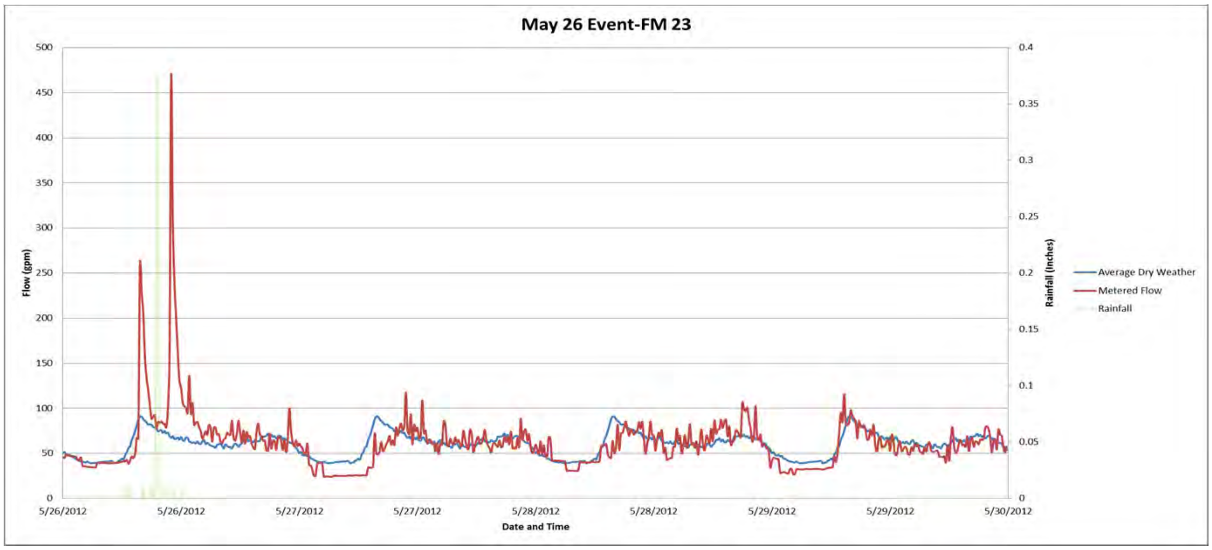

April 15 Event-FM 22
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall


May 26 Event-FM 22
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

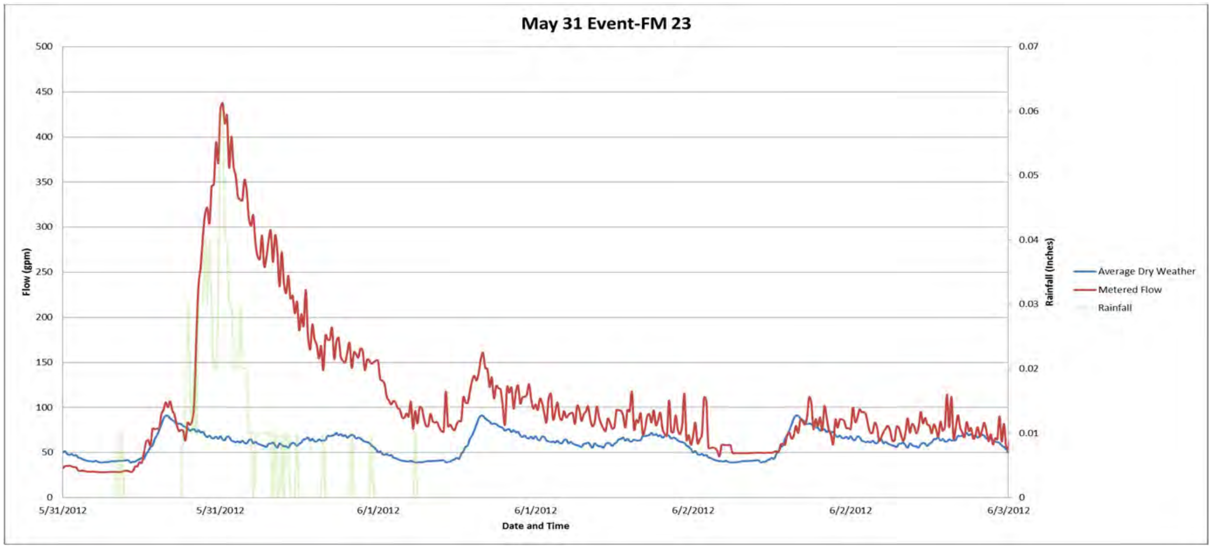

May 31 Event-FM 22
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall



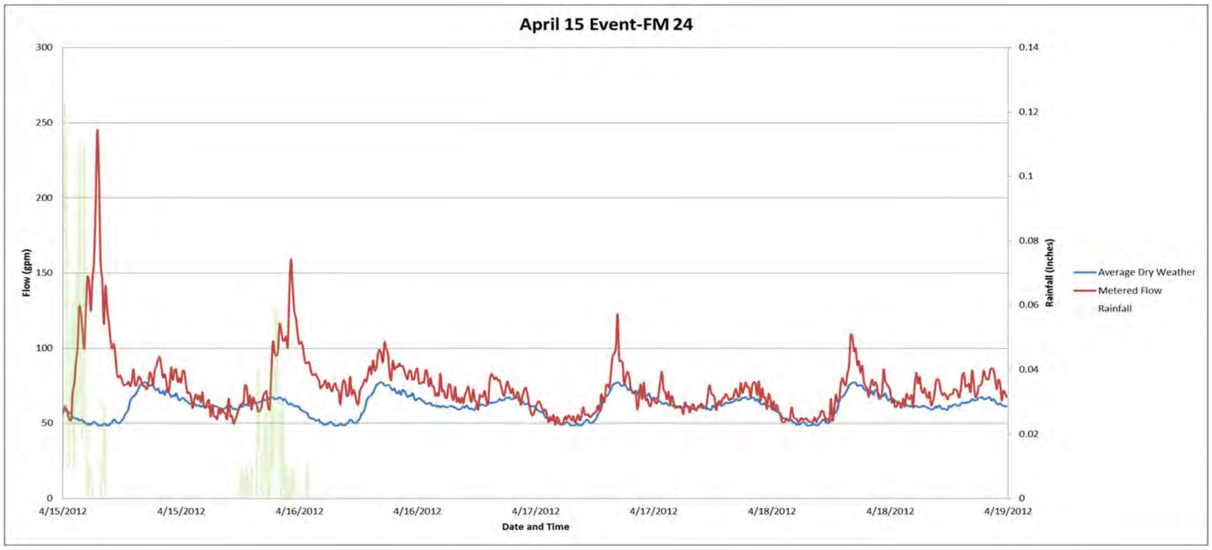
April 15 Event-FM 23
Flow (gpm)
Rainfall (inches)
Date and Time
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012
Average Dry Weather
Metered Flow
Rainfall

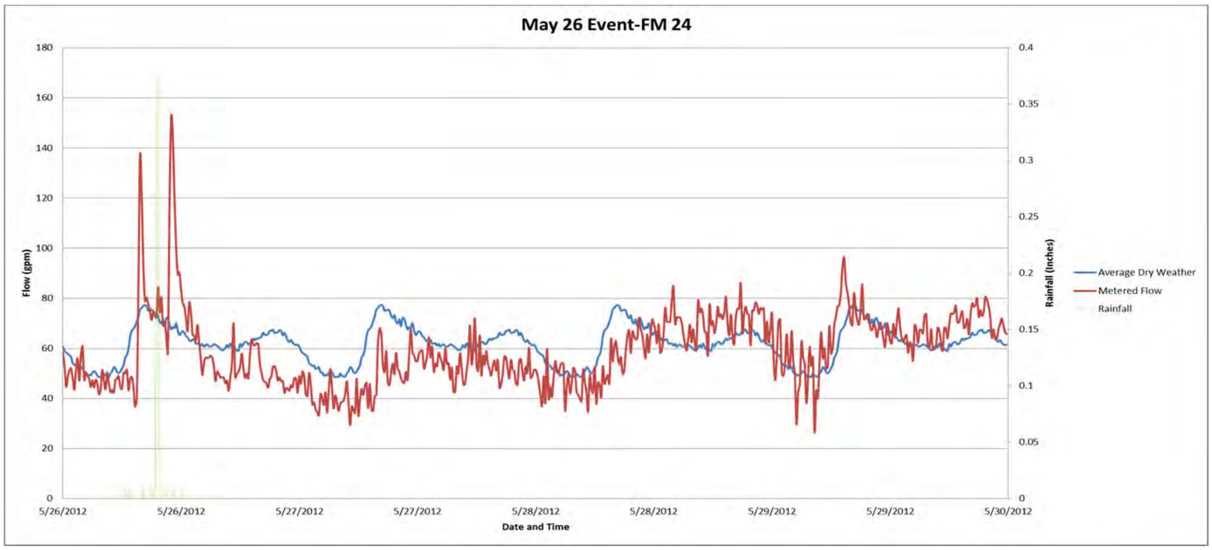


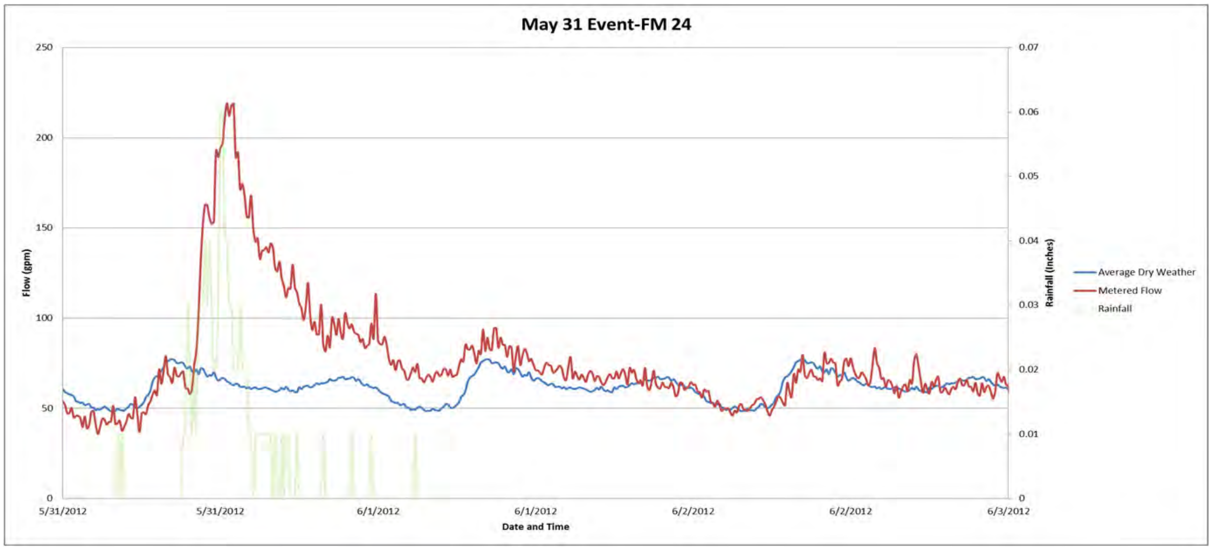
May 26 Event-FM 23
Flow (gpm)
Rainfall (inches)
Date and Time
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012
Average Dry Weather
Metered Flow
Rainfall

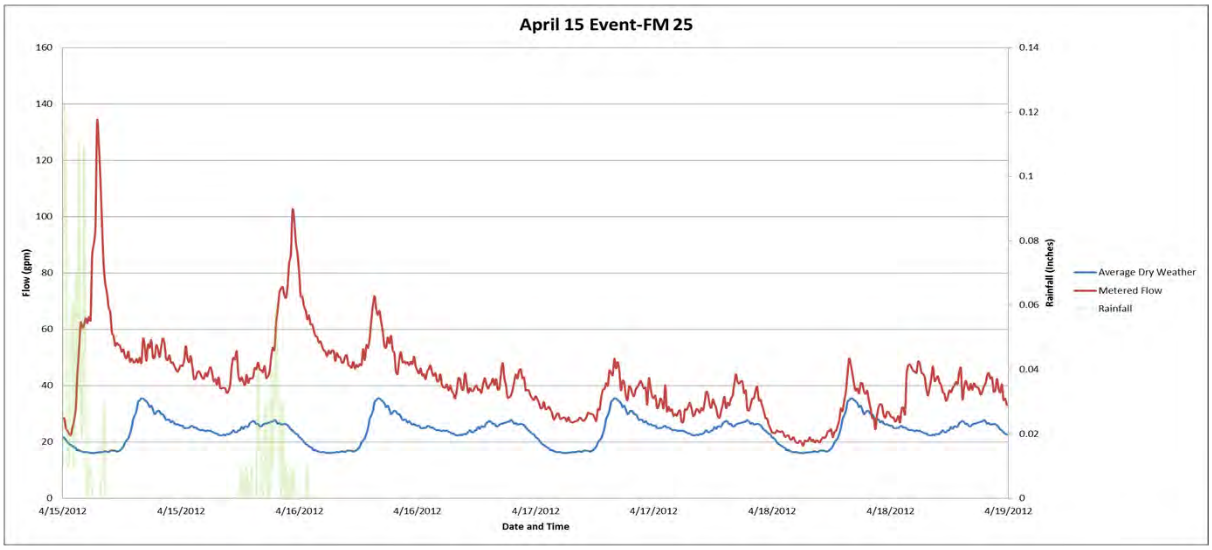


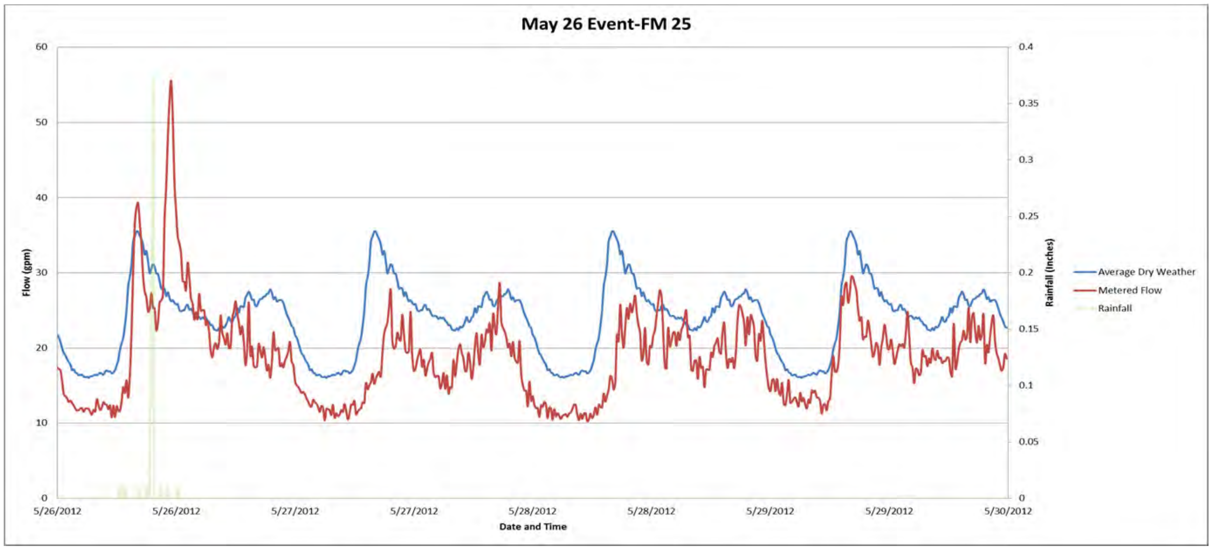
May 31 Event-FM 23
Flow (gpm)
Rainfall (inches)
Date and Time
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012
Average Dry Weather
Metered Flow
Rainfall

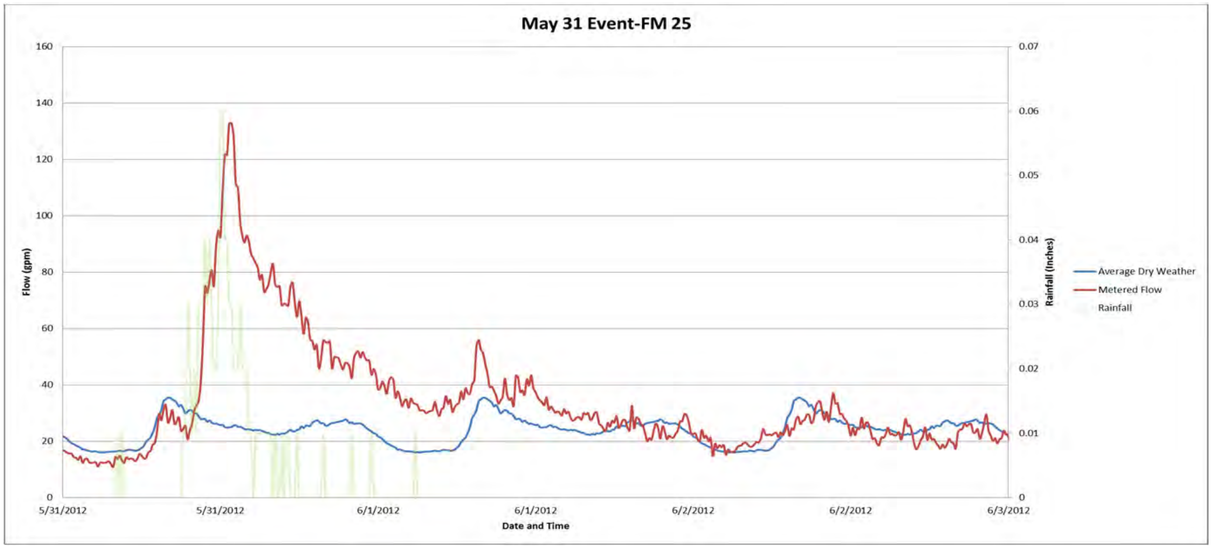

April 15 Event-FM 24
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
300
250
200
150
100
50
0
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012

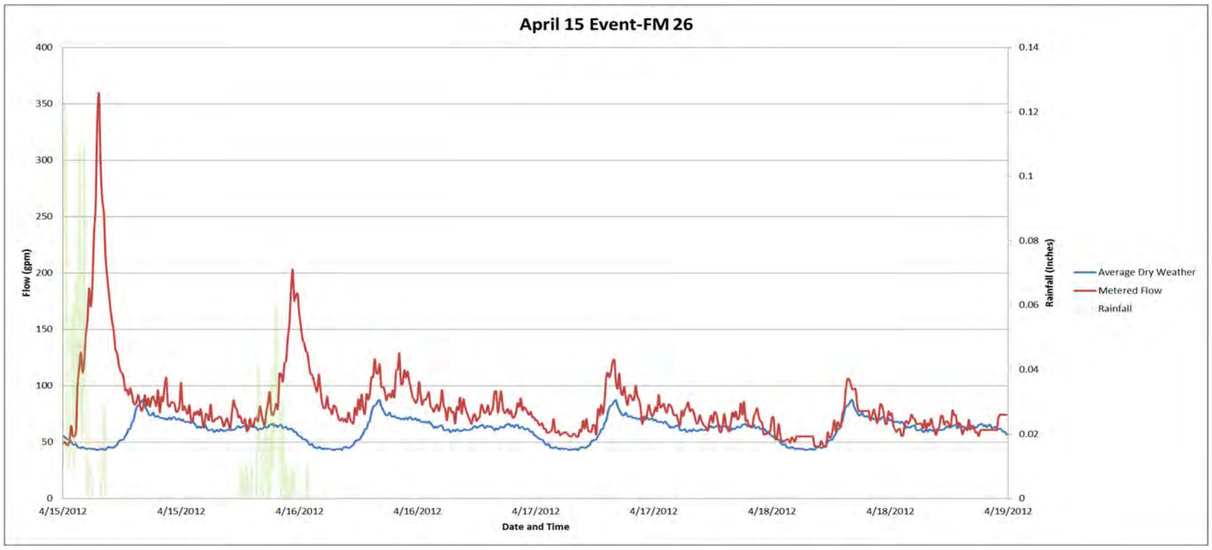

May 26 Event-FM 24
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
180
160
140
120
100
80
60
40
20
0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012

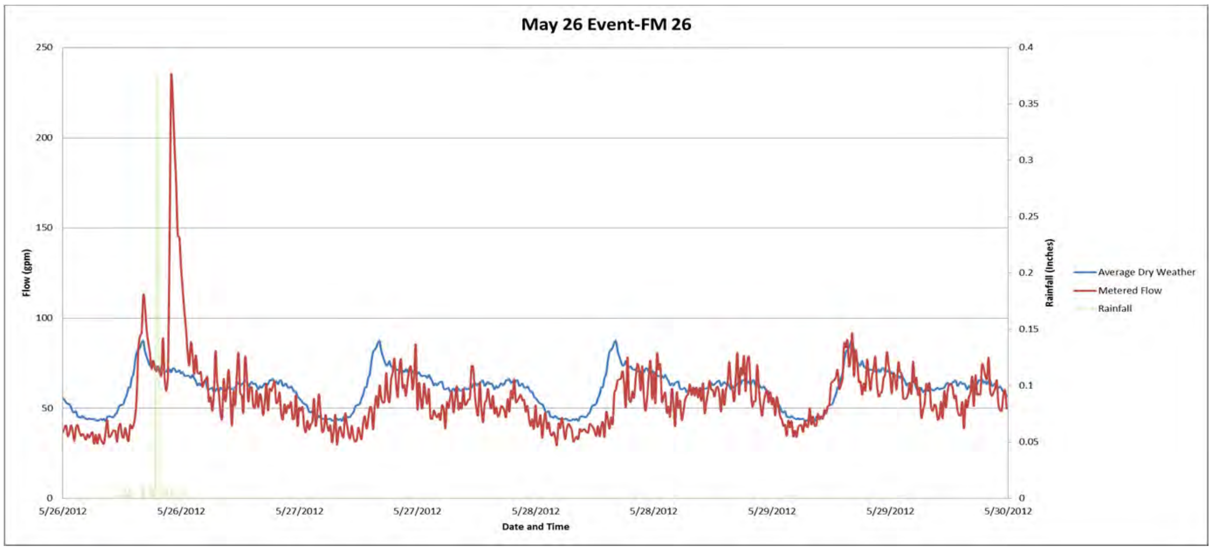

May 31 Event-FM 24
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
250
200
150
100
50
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012

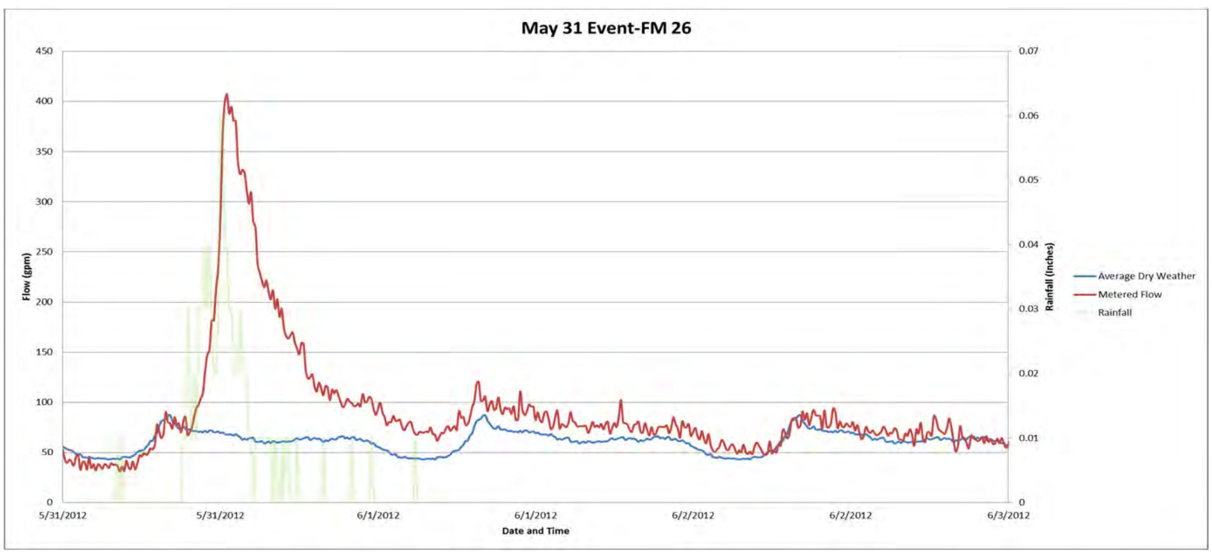

April 15 Event-FM 25
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

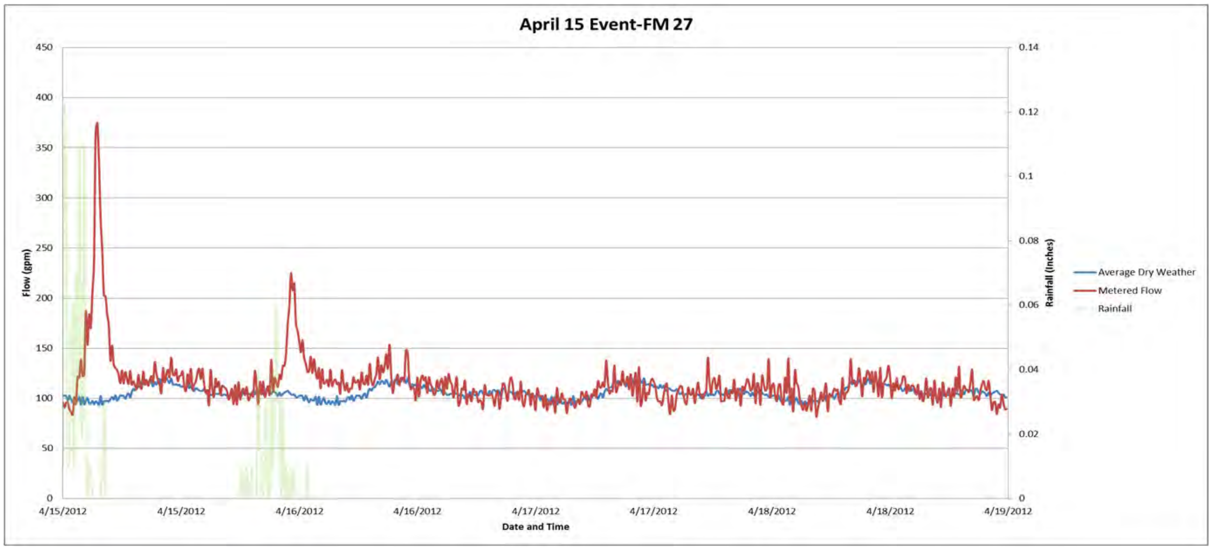

May 26 Event-FM 25
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

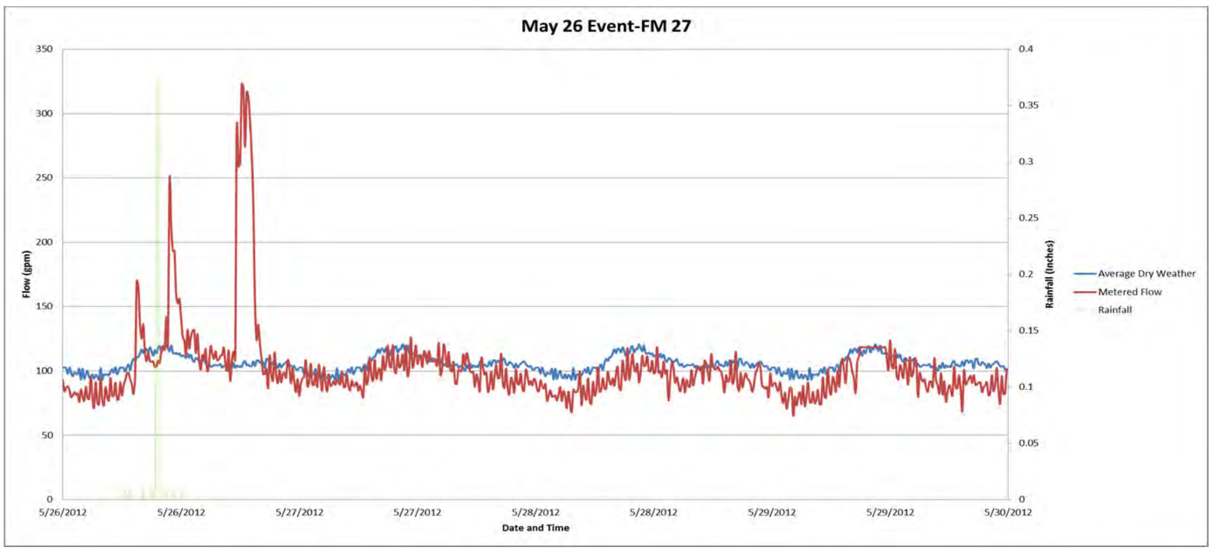

May 31 Event-FM 25
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall

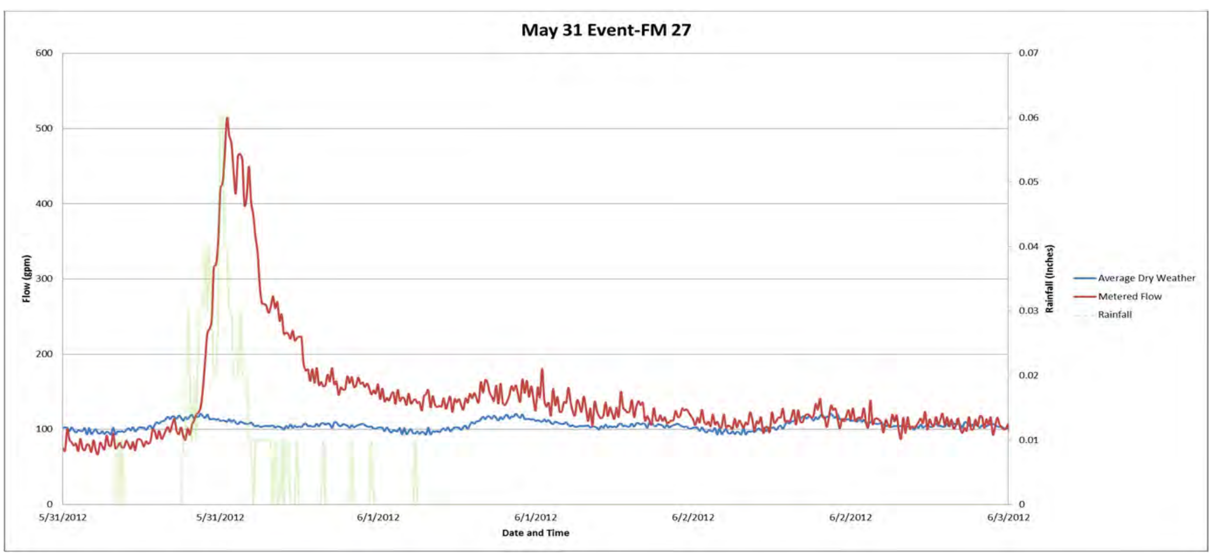

April 15 Event-FM 26
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

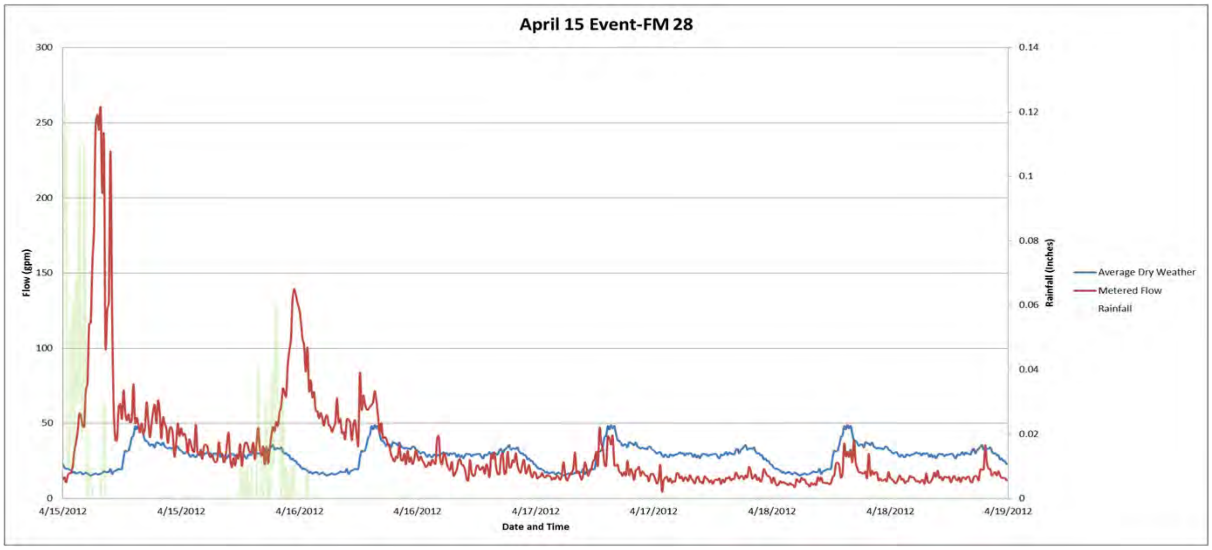

May 26 Event-FM 26
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

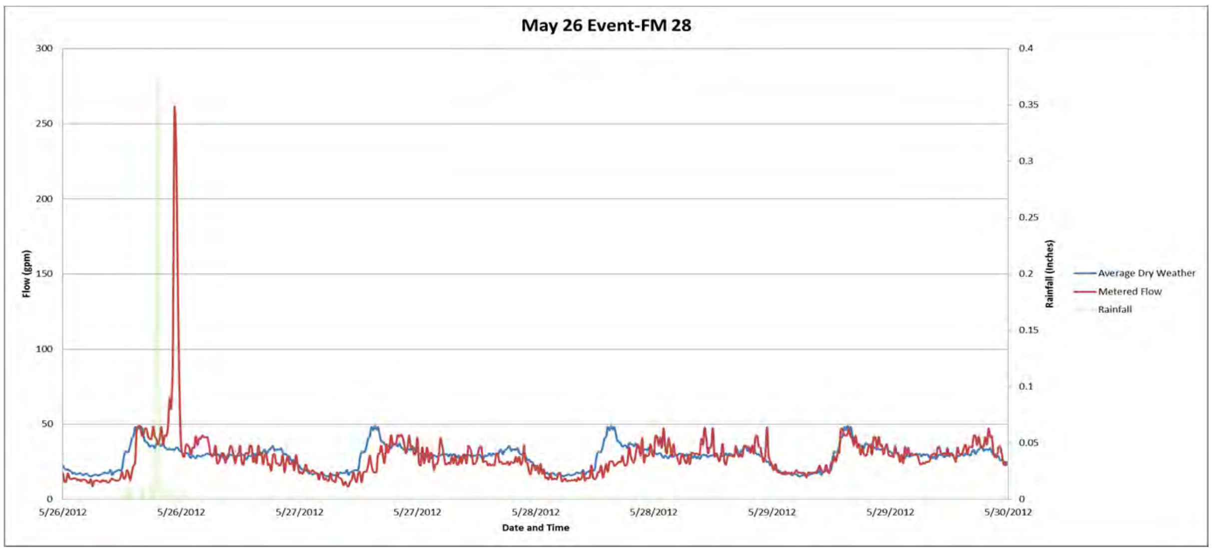

May 31 Event-FM 26
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

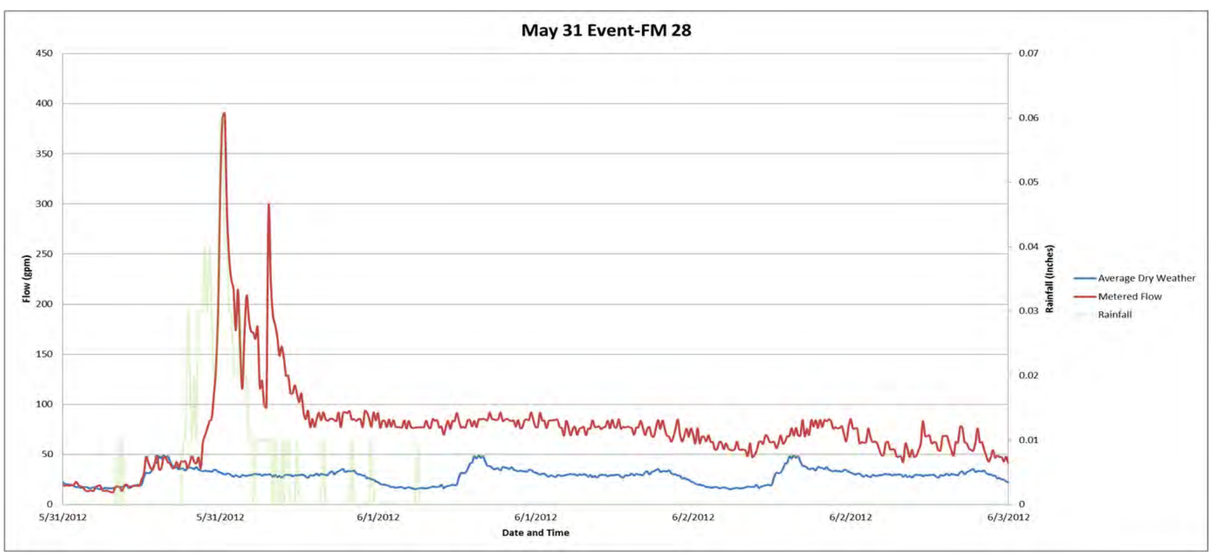

April 15 Event-FM 27
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
4/15/2012
4/16/2012
4/17/2012
4/18/2012
4/19/2012

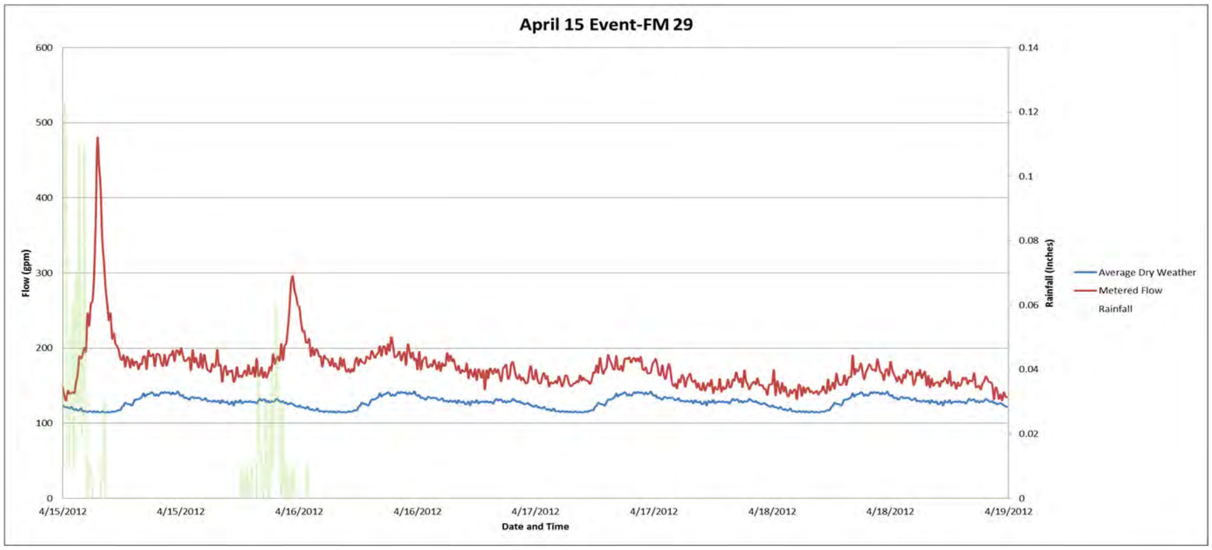

May 26 Event-FM 27
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/26/2012
5/27/2012
5/28/2012
5/29/2012
5/30/2012

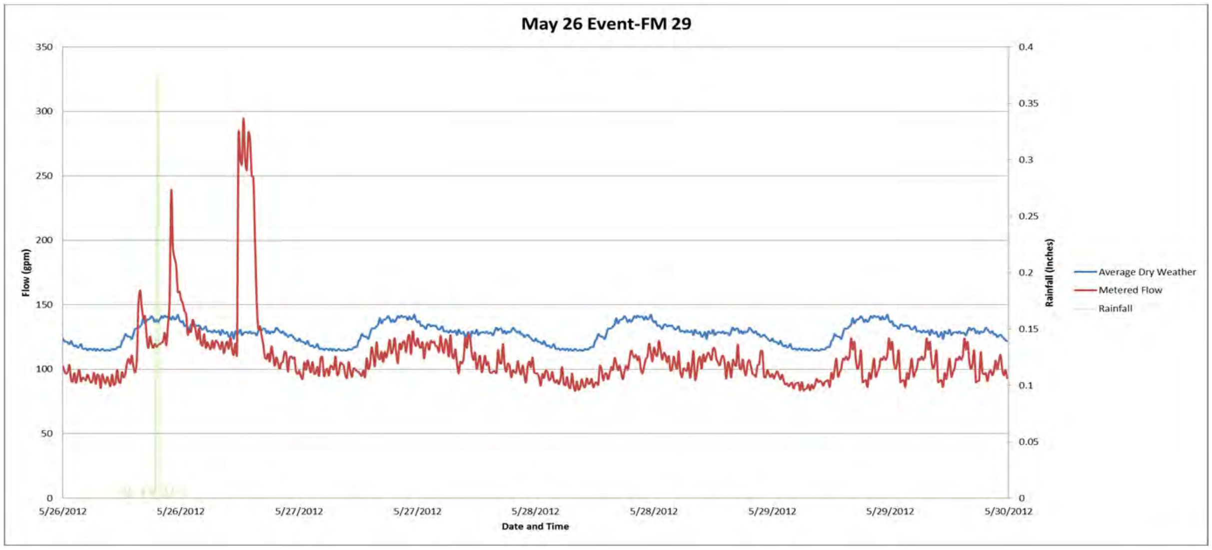

May 31 Event-FM 27
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
5/31/2012
6/1/2012
6/2/2012
6/3/2012

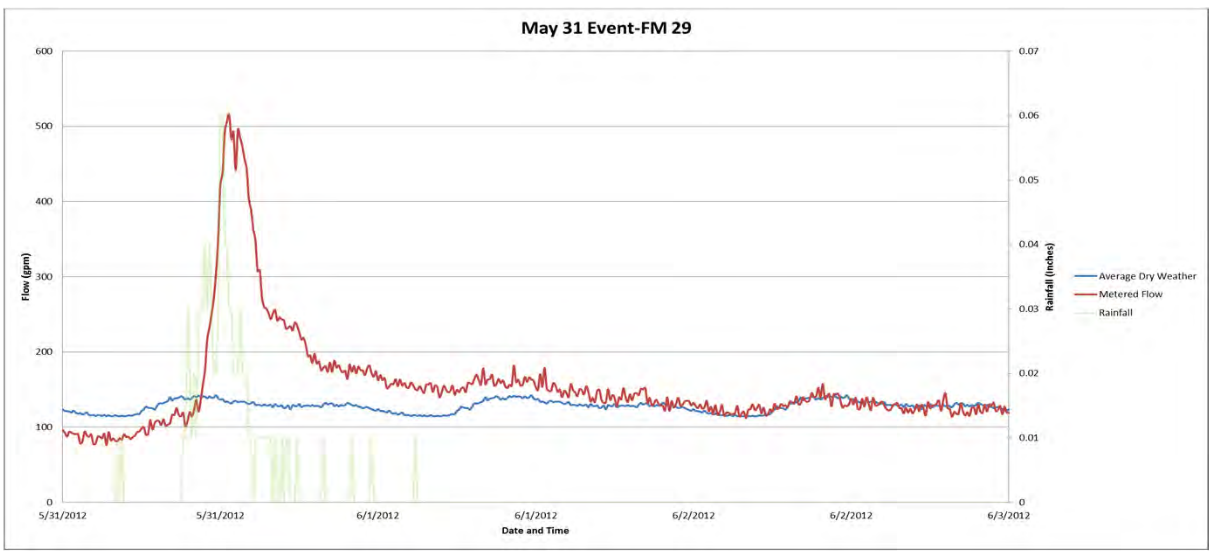

April 15 Event-FM 28
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
300
250
200
150
100
50
0
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012

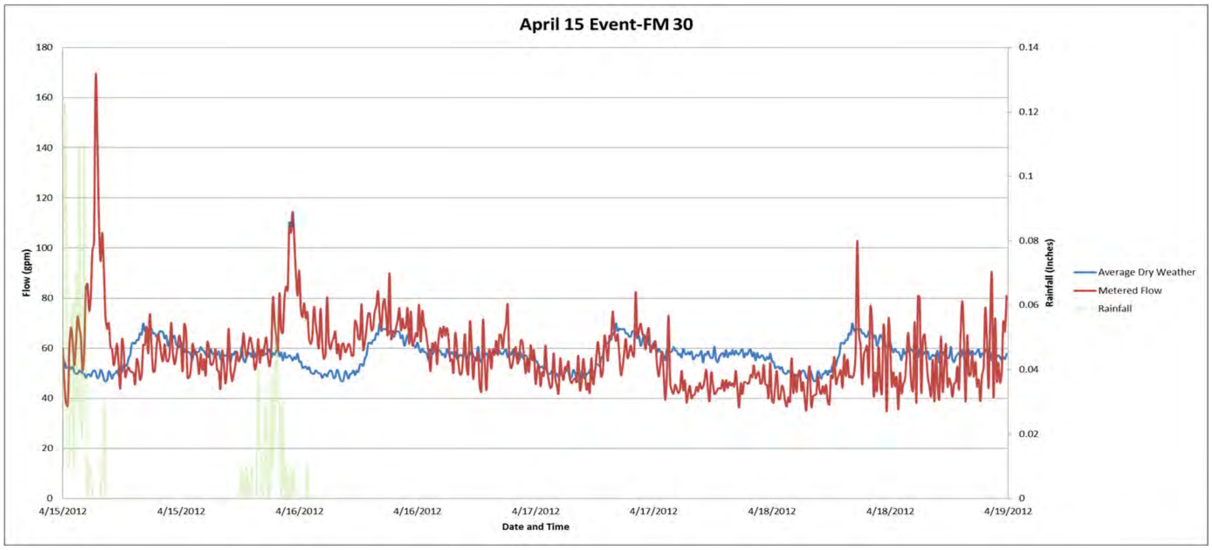

May 26 Event-FM 28
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
300
250
200
150
100
50
0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012

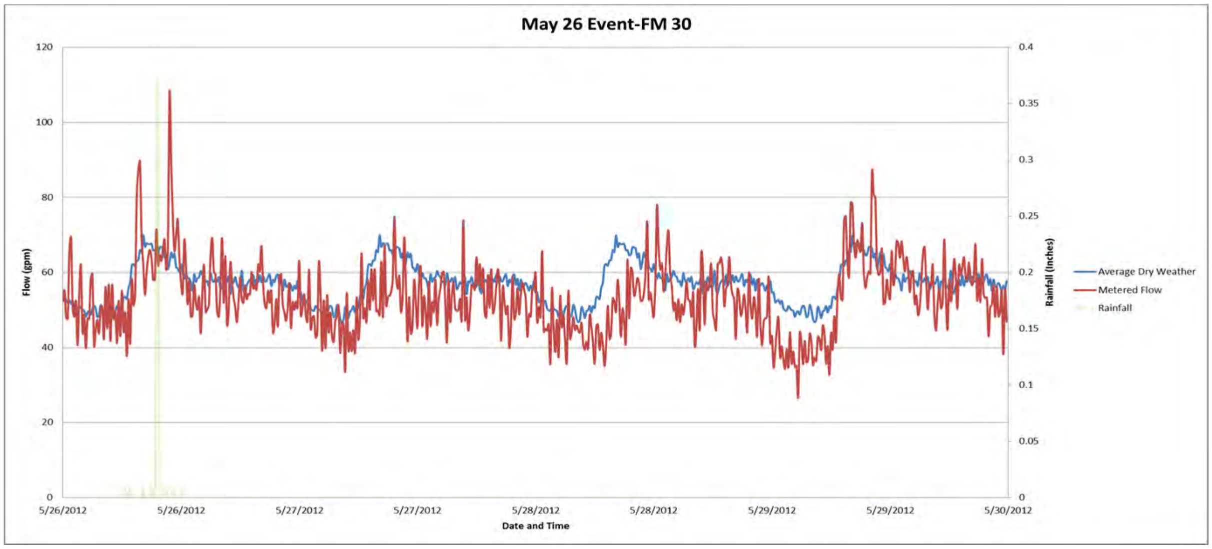

May 31 Event-FM 28
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
450
400
350
300
250
200
150
100
50
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012

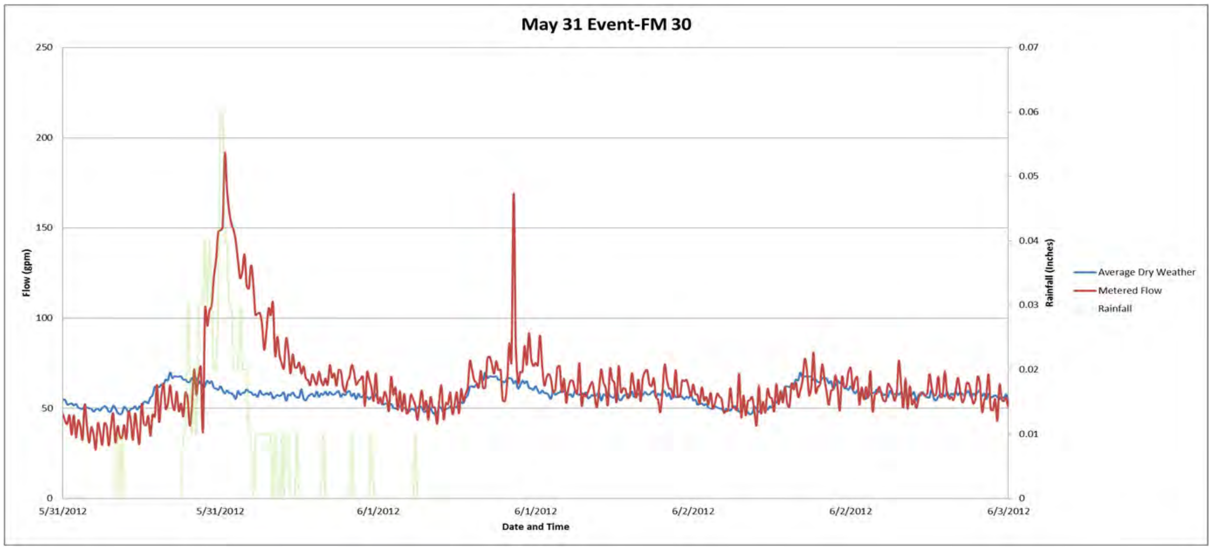

April 15 Event-FM 29
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
600
500
400
300
200
100
0
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
4/15/2012
4/15/2012
4/16/2012
4/16/2012
4/17/2012
4/17/2012
4/18/2012
4/18/2012
4/19/2012


May 26 Event-FM 29
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
350
300
250
200
150
100
50
0
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5/26/2012
5/26/2012
5/27/2012
5/27/2012
5/28/2012
5/28/2012
5/29/2012
5/29/2012
5/30/2012


May 31 Event-FM 29
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall
600
500
400
300
200
100
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
5/31/2012
5/31/2012
6/1/2012
6/1/2012
6/2/2012
6/2/2012
6/3/2012


April 15 Event-FM 30
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall


May 26 Event-FM 30
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall


May 31 Event-FM 30
Flow (gpm)
Rainfall (inches)
Date and Time
Average Dry Weather
Metered Flow
Rainfall