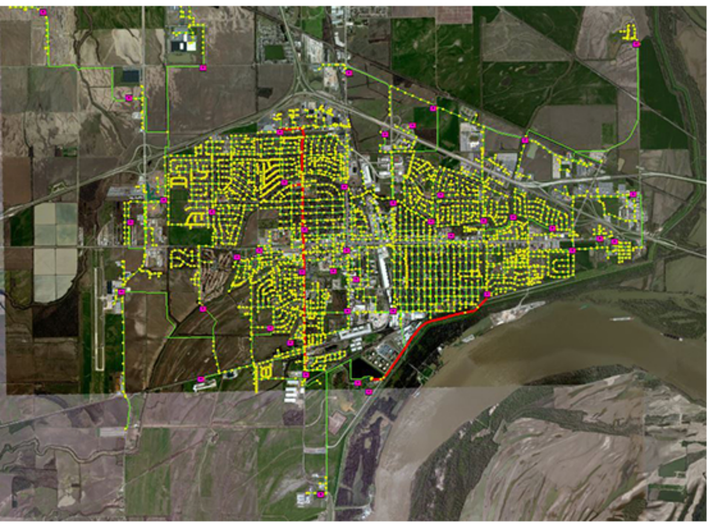
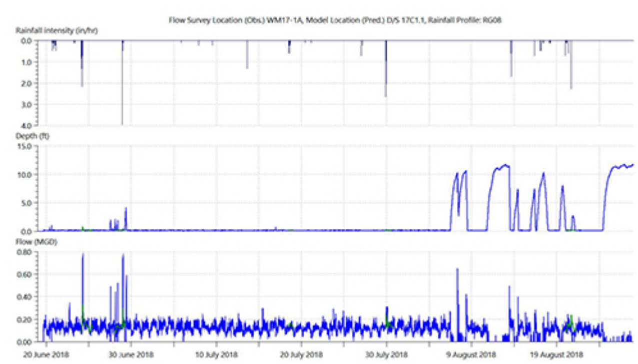
December 2019

West Memphis Wastewater Capacity Analysis and Preliminary Augmentation Options

Final Report

West Memphis Utility





RJN Project No. 18-3352-00

rjn group
Engineering infrastructure for tomorrow

7123 Interstate 30, Suite 9 • Little Rock, AR 72209 • 501.224.2248 • www.rjn.com

December 4, 2019

Todd Peterson
West Memphis Utility Commission
604 East Cooper Ave.
West Memphis, AR 72301

SUBJECT: West Memphis Wastewater Capacity Analysis and Preliminary Augmentation Options
Final Technical Memorandum

Dear Todd:

In accordance with the September 2018 Engineering Agreement, RJN is pleased to present this Final Technical Memorandum for the above referenced project. The activities include flow monitoring, capacity analysis with a calibrated model, and presentation of augmentation options. The following conclusions were based on the results of these activities:

- A manifolded force main along Avalon St. that conveys flows from SPS03, SPS04, SPS05, and SPS06 to SPS09 would reduce flow through SPS07 and SPS08.

- A gravity cross-connection at Washington Ave. would direct flows from the existing 14" main to the 18" main flowing south to SPS09, reducing flows into SPS07.

- A new 16" force main connecting SPS10 to the WWTP will result in significant reduction in surcharging and repumping flows through SPS08. Additionally, an 8" gravity main north-west of SPS10 may need upsizing to a 12" main

If you have any questions regarding this submittal or you require additional information, please do not hesitate to contact us.

Sincerely,
RJN Group, Inc

Mac Compton

Mac Compton, P.E.
Project Manager

MC/3352
Enclosure

TABLE OF CONTENTS

TECHNICAL MEMO

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

LIST OF APPENDICES

TECHNICAL MEMO

INTRODUCTION

This final technical memo has been prepared to provide:

- An overview of the processes undertaken to build and calibrate a model of the existing sanitary sewer system;
- Present results from the system performance analysis undertaken on the calibrated model;
- Present preliminary system augmentation options that have been developed to contain all flows associated with a 2-year/24-hour design rainfall event as well as analysis of the two most significant rainfall events recorded during the flow monitoring survey.

BACKGROUND

The sewerage system serves the City of West Memphis, located within Crittenden County, along the eastern border of Arkansas and directly across the Mississippi River from Memphis, Tennessee.

The system contains over 149 miles of gravity sewer main, 45 lift stations, 21.6 miles of force main and serves a population of approximately 24,000 people. Flow monitoring data collected in the West Memphis catchment from June 7, 2018 to August 31, 2018 was used for both dry and wet weather calibration of the network model. The calibrated model was then simulated with a 2-year/24-hour design storm to highlight system deficiencies. Key areas of deficiency were identified at sewer pumping stations (SPS) SPS03, SPS07 and SPS10.

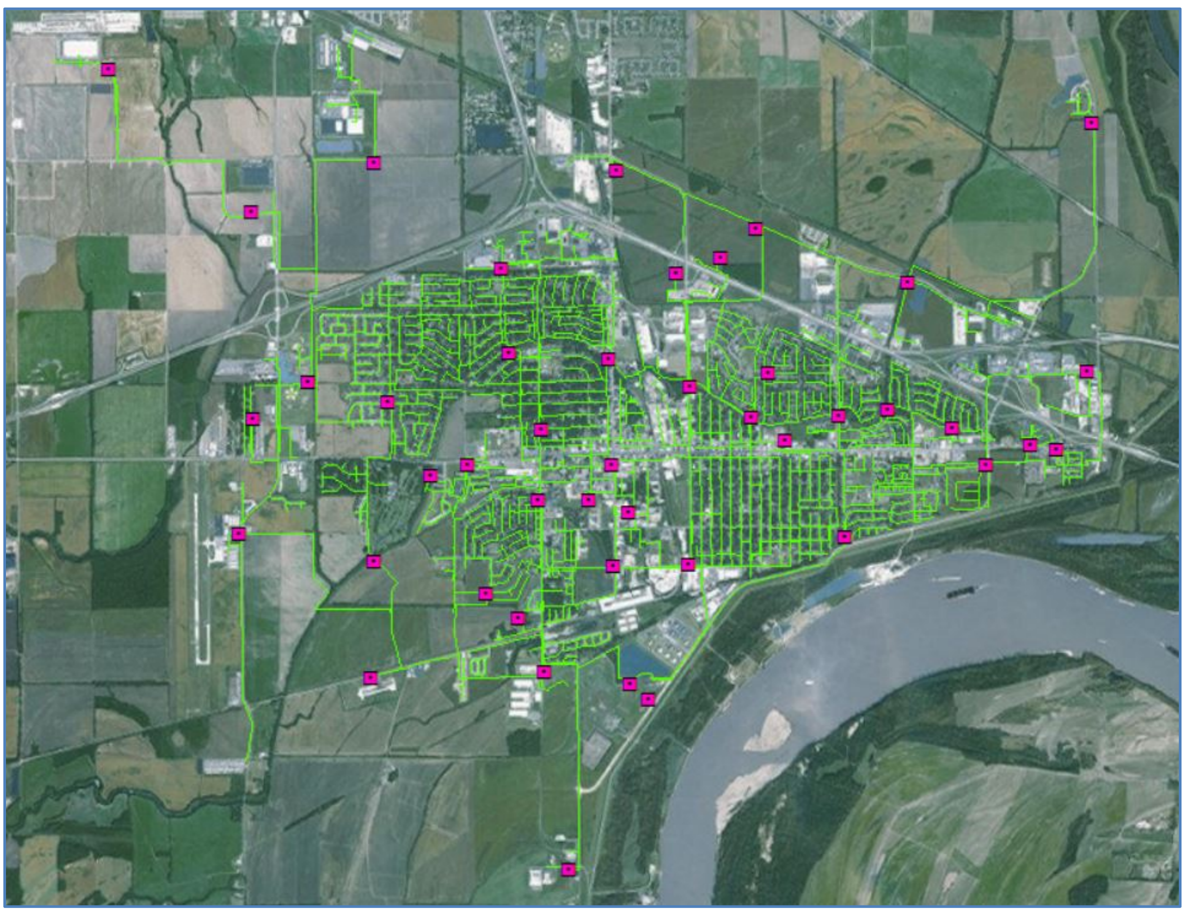
MODEL BUILD

The model was created based on the latest GIS data provided by West Memphis Utility Commission. To improve the accuracy of the model, the GIS data was supplemented with information from “As Built” drawings plus field survey data at selected manholes. Pipe and manhole data from the GIS database were imported into InfoWorks ICM. Subcatchment polygons were created for each property based on available GIS property data. The imported asset data was checked and reviewed for accuracy and completeness. Each asset data attribute was flagged to define its source such as; as-built drawings, survey data, GIS, engineering judgement or inferred data.

Model build tasks included:

- Import of all manholes, pipes, and associated GIS information into InfoWorks ICM.
- Update the model with data from "As Built" drawings (pipe diameters, elevations etc.).
- Update model network based on field surveys undertaken on 377 manholes by others.
- Assign outfall locations and boundary conditions.
- Visually check all pipe vertical profiles and amend as required.
- Import all property parcel information and check for overlapping parcels, duplicates and parcels that are assumed to be unconnected.
- Assign parcels to an appropriate receiving sewer manhole.
- Update the residential and non-residential dry weather flow components of the model based on recent census and parcel data.

Figure 1: West Memphis Sewer Network



RESIDENTIAL AND COMMERCIAL FLOWS

Residential flows were generated based upon population estimates, using the 2010 Census household densities, and an initial sewage discharge estimate of between 50 - 70 gallons/person/day.

The commercial flows were estimated based on the property type/land use and the lot area. Details of the property type and zoning were obtained from the County parcel data and supplemented by Google Maps. Table 1 details the initial sewage discharge estimates used for commercial properties. Where necessary commercial flows were adjusted during calibration.

Table 1: Estimated Sewer Discharge Rates for Commercial Properties

Commercial Property Type	Description	Estimated Sewage Discharge Rate (gallons/acre/day)
High Intensity	Large hotels	2,000
Medium Commercial	Fast Food	2,000
Light Commercial	Gas Stations, Convenience Stores, Small Grocery	400
Industrial	Large scale Manufacturing, Assembly/Processing, Warehouse/Distributions, Bulk storage/utilities	400

FLOW SURVEY

A short-term flow survey was undertaken comprising of 25 flow meters, listed in Table 2, and eight rain gauges for a period of 3 months from June 7, 2018 to August 30, 2018.

Table 2: Flow Monitor Summary

FM Ref	MH Ref	Pipe Diameter (in)
WM03A	3A2	11.4
WM03B	3B2	10.4
WM04	4A2	18.3
WM06	6A12	24.4
WM7A	7A5	24.5
WM8AZ	8BB5	15.3
WM8M	8M1	44.0
WM8S	8M1	13.2
WM09A	9A2	36.3
WM09B	9A1	18.1
WM9B-0	9B10	17.8
WM10A	10A8	17.3
WM10N	10N1	24.5
WM11	11A7	24.3
WM11A	8B4	17.8
WM13A	8C5	18.1
WM13A3	13A2	14.8
WM15A2	15A1	13.0
WM17-1A	17A2	10.1
WM17-1B	17A3	14.6
WM17-2	17B1	14.6
WM17-A	17aA1	7.9
WM20	20C1	10.2
WM21A	21A2	18.2
WM26	26A1	24.3

Figure 2 shows the locations of the flow meters.

Figure 2: Flow Meter Locations

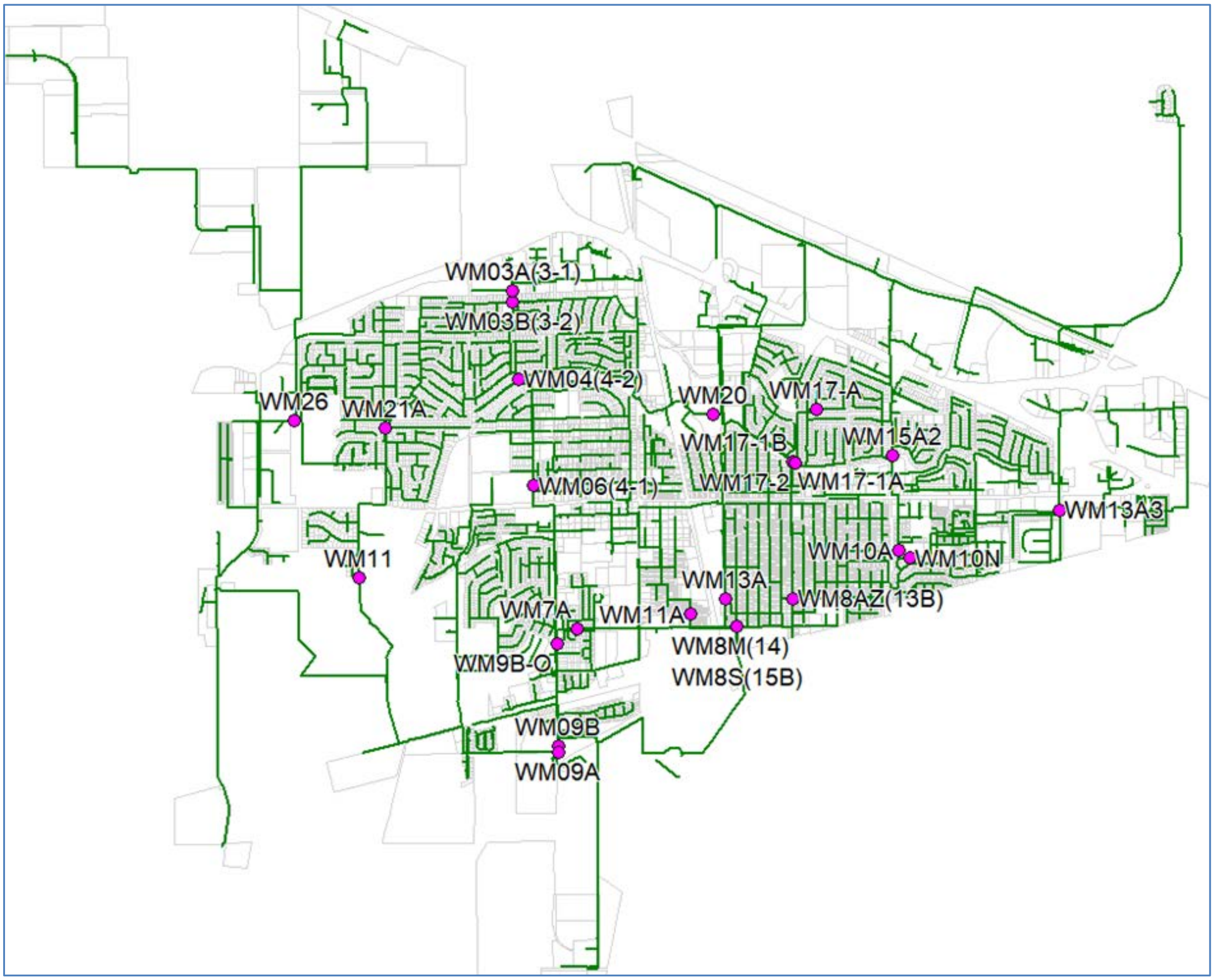
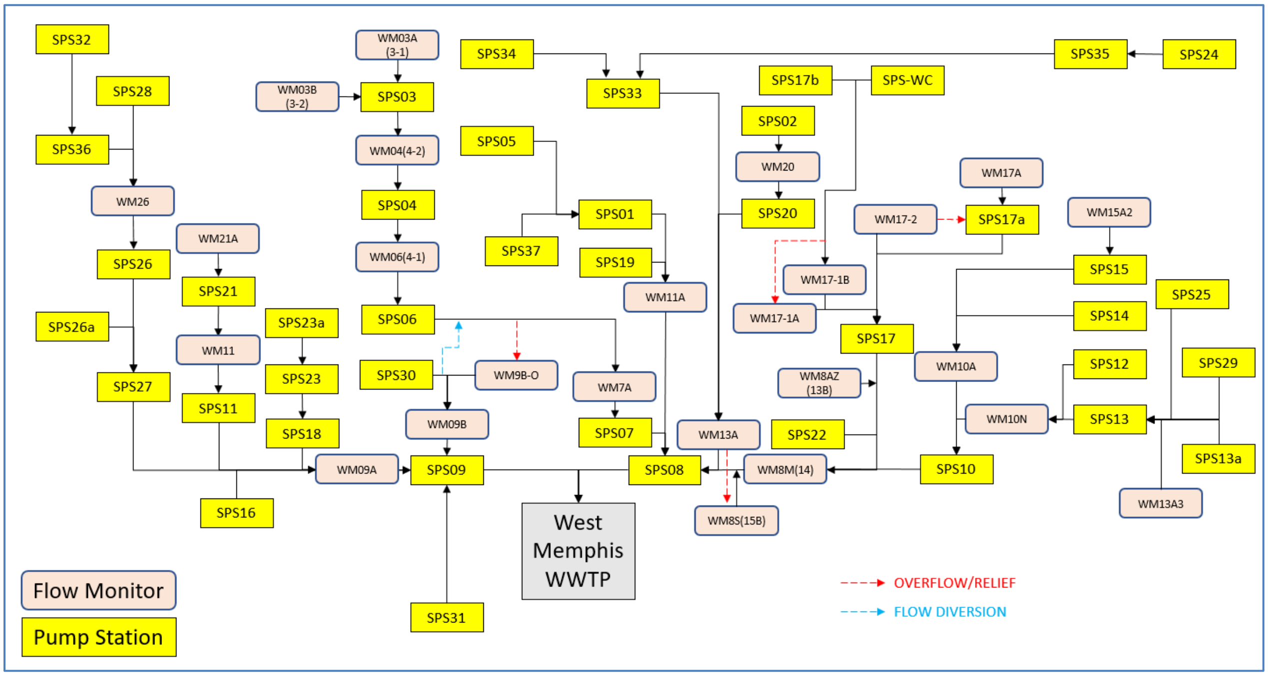


Figure 3 displays a flow survey schematic for the West Memphis sewer network:

Figure 3: West Memphis Flow Survey Schematic



During analysis of the rainfall data, it became apparent that rainfall gauge RG05 was not reading for most of the survey period. As a result, data from rainfall gauges RG04 and RG07 was used to generate an estimation for RG05 between the start of the survey period and August 10, 2018. Following this period, RG05 recorded data. During the flow survey period a total of between 6.3 – 8.0 inches of rainfall was captured with the 5 significant rainfall events summarized in Table 3.

Table 3: Rainfall Events Summary

Event	Date	Rainfall Depth (in)	Peak Intensity (in/hr)	Duration (min)	Estimated ARI*
1	06/24/2018	0.51 – 1.27	0.96 – 2.64	110	<1yr
2	06/28/2018 – 06/29/2018	0.90– 1.71	0.84 – 4.68	60	<1yr
3	07/18/2018	0.15 – 1.13	0.36 – 2.40	85	<1yr
4	07/29/2018 – 07/30/2018	0.72 – 1.48	1.56 – 2.88	160	<1yr
5	08/20/2018	0.15 – 0.64	0.96 – 3.00	45	<1yr

**Estimated ARI based on NOAA PDS-based precipitation frequency estimates with 90% confidence intervals for Latitude: 35.1484° and Longitude: -90.1817°. Website: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ar*

Note: Rain Gauge 5 did not record data during rainfall events 1, 2, 3 and 4.

DRY-WEATHER CALIBRATION

Dry-weather calibration ideally requires at least a 7-day period, including one weekend, unaffected by rainfall induced flows. The recorded flow data was assessed in conjunction with the rainfall data and the period from July 20, 2018 through to July 26, 2018 was selected as a representative dry-weather period.

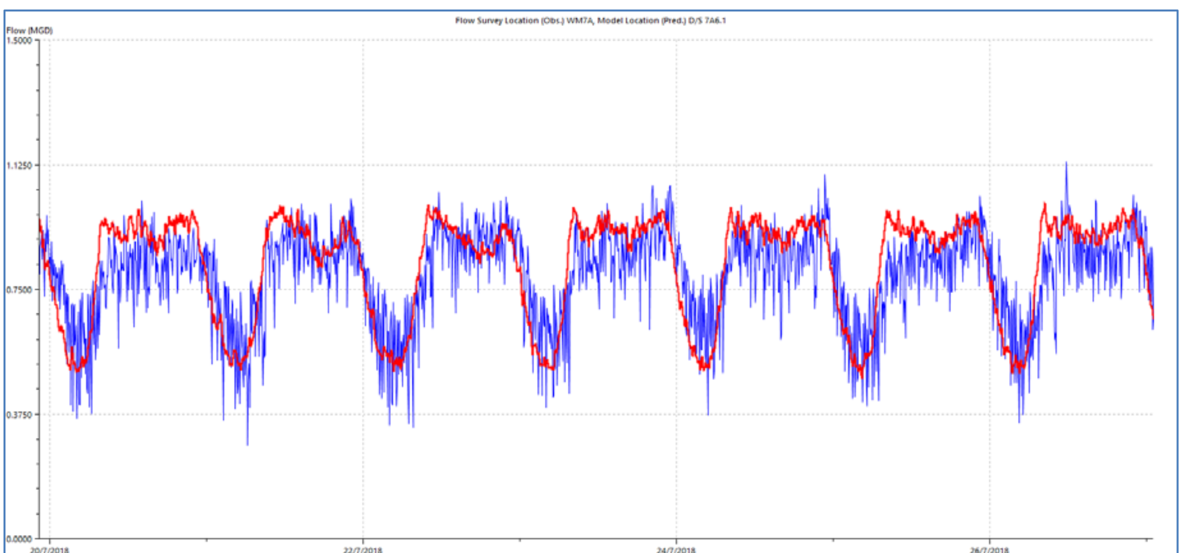
Calibrating the model for dry-weather flow was achieved by modifying the following:

- Residential wastewater profiles
- Per capita flow rates
- Commercial / Industrial flow rates

A good fit was achieved between the modelled and observed flows for most of the flow monitors, however several flow monitors were difficult to calibrate to due to a lack of available information.

Figure 4 to Figure 6 show the dry weather comparisons for the calibration week at flow monitors WM7a, WM8M(14) and WM09. These are the three largest monitored flow sites at the downstream end of the network with observed flows shown in blue and modelled flows in red.

Figure 4: DWF Calibration at WM7a (July 20, 2018 – July 26, 2018)



	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.280	1.133	5.665
WM v148 DWF full duration>DWF #148	0.480	1.009	5.849

Figure 5: DWF Calibration at WM8M(14) (July 20, 2018 – July 26, 2018)

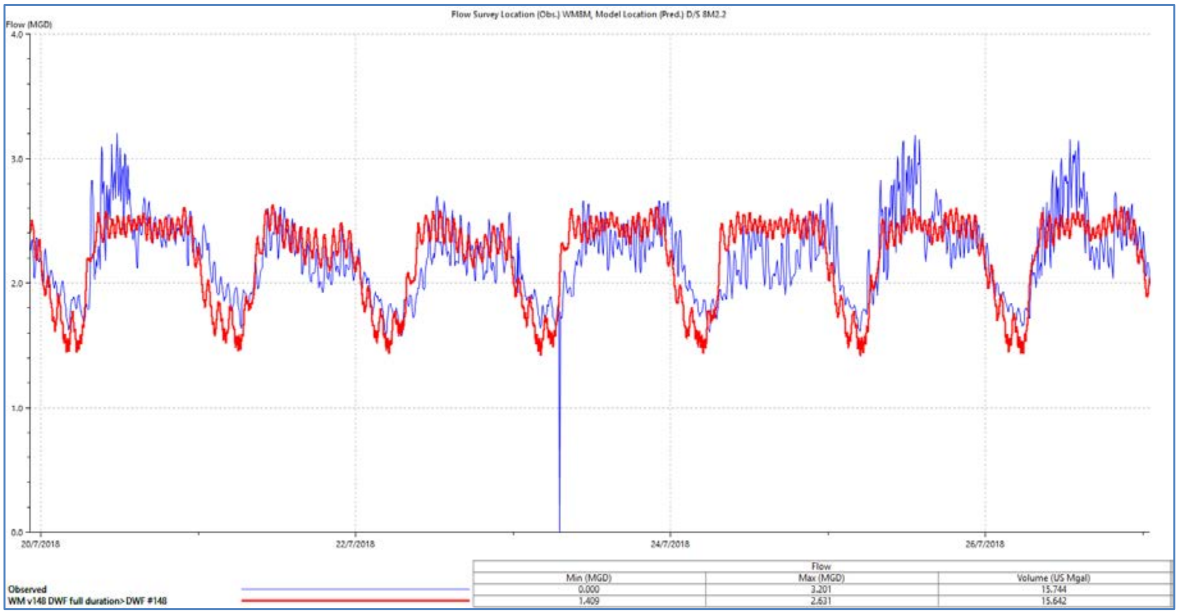
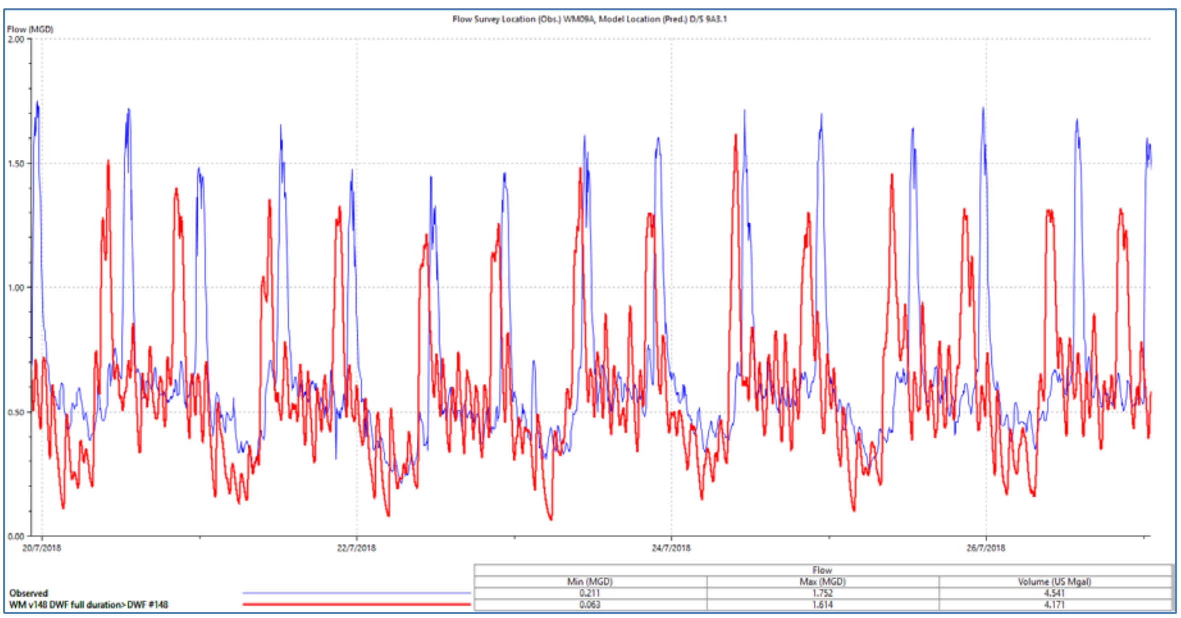


Figure 6: DWF Calibration at WM09A (July 20, 2018 – July 26, 2018)



Flow monitor WM09A recorded periods of high flows that occurred twice each day during the DWF calibration period. The timing of these events varied and were modelled by generating a unique profile which was attributed to the Coca-Cola bottling plant.

Calibration was difficult to achieve for flow monitor WM03A due to the high proportion of commercial properties and it is suspected the flows are influenced by private pumping stations.

Flow data from monitor WM13A showed numerous fluctuations possibly due to changing settings at upstream pump stations.

Conflicting details regarding the wet well area and pump "on" and "off" levels for SPS17 necessitated modifications in the model to achieve a suitable level of calibration at the flow monitors located around this pumping station. Further investigation of the physical attributes of this pumping station and the pump operation levels is recommended prior to any further flow monitoring program.

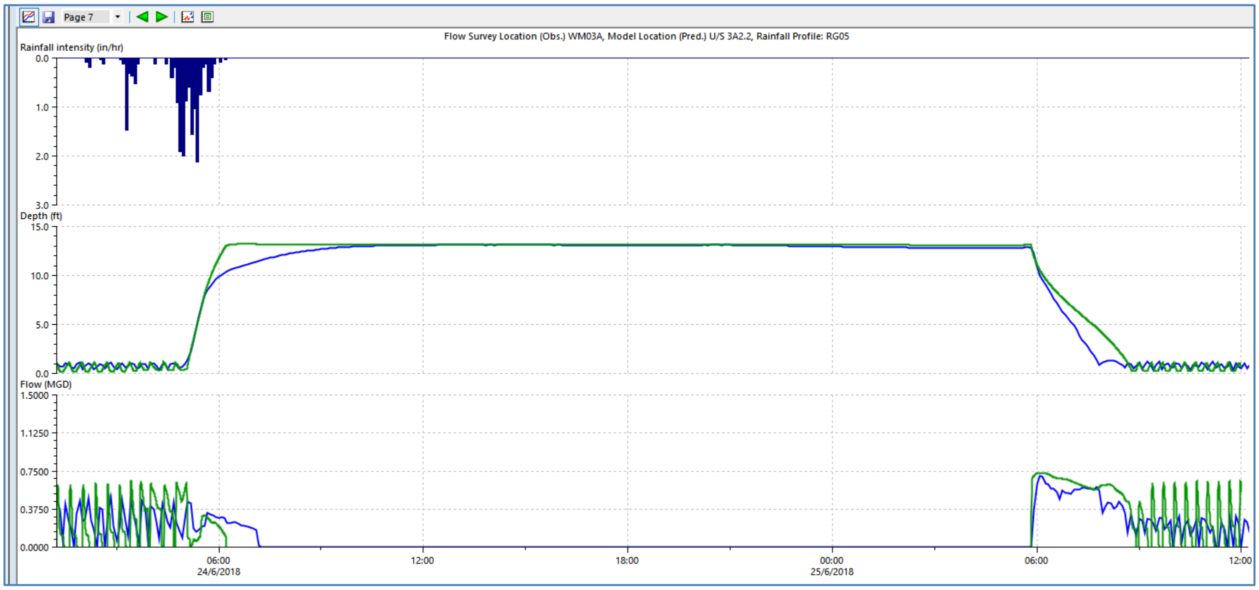
WET-WEATHER CALIBRATION

Wet weather calibration was achieved by comparing model predictions with observed flows and surcharge depths for the five major rainfall events.

It became apparent that there were several pumping stations that failed to operate during some of the major wet weather events. In order to model this behavior, real time controls (RTC) rules were developed to shut down the modeled pumps when the recorded data showed evidence that the pumps had stopped and then to reactivate the pumps when normal operations resumed.

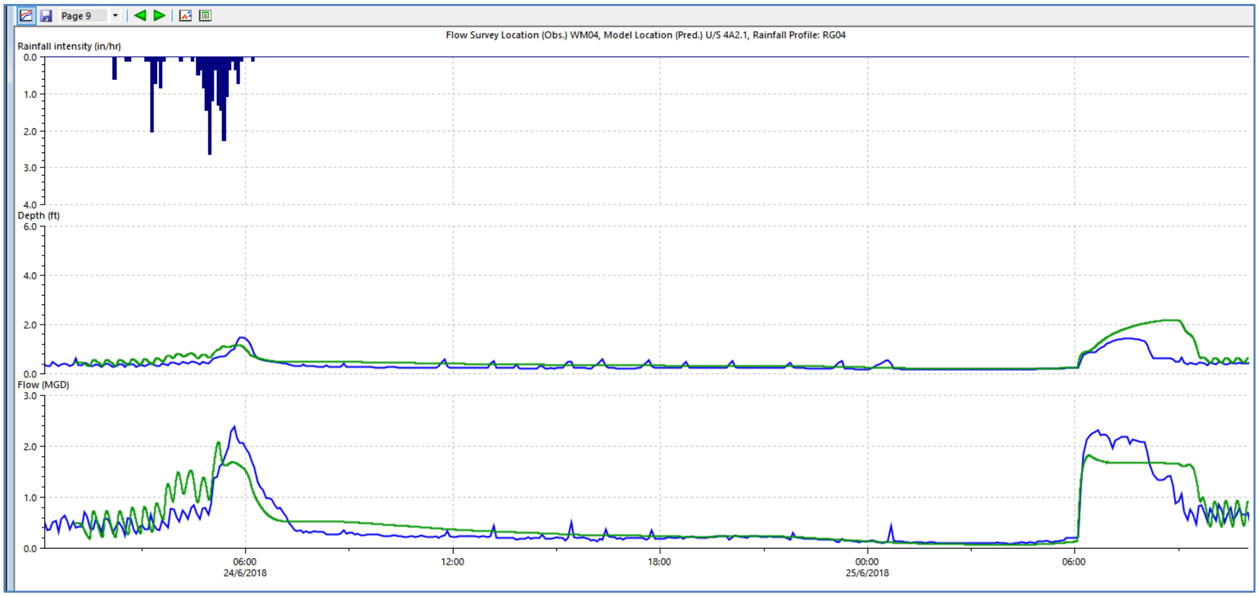
Calibration comparison hydrographs for Event1 at WM03A and downstream flow monitor WM04 are provided in Figure 7 and Figure 8. RTC rules were developed to shut down the pumps at SPS03 at around 5am and this resulted in a rapid increase in the modeled and recorded surcharge depths as demonstrated in Figure 7.

Figure 7: WWF Calibration at WM03A for Event 1 – June 24, 2018



The impact of shutting down the pumps at SPS03 was corroborated by the flows recorded by the downstream flow meter WM04, with comparisons illustrated in Figure 8.

Figure 8: WWF Calibration at WM04 for Event 1 – June 24, 2018



Note how the flows through WM04 fall away significantly by 9am and aren't fully restored until SPS03 is reactivated at 6am the following morning.

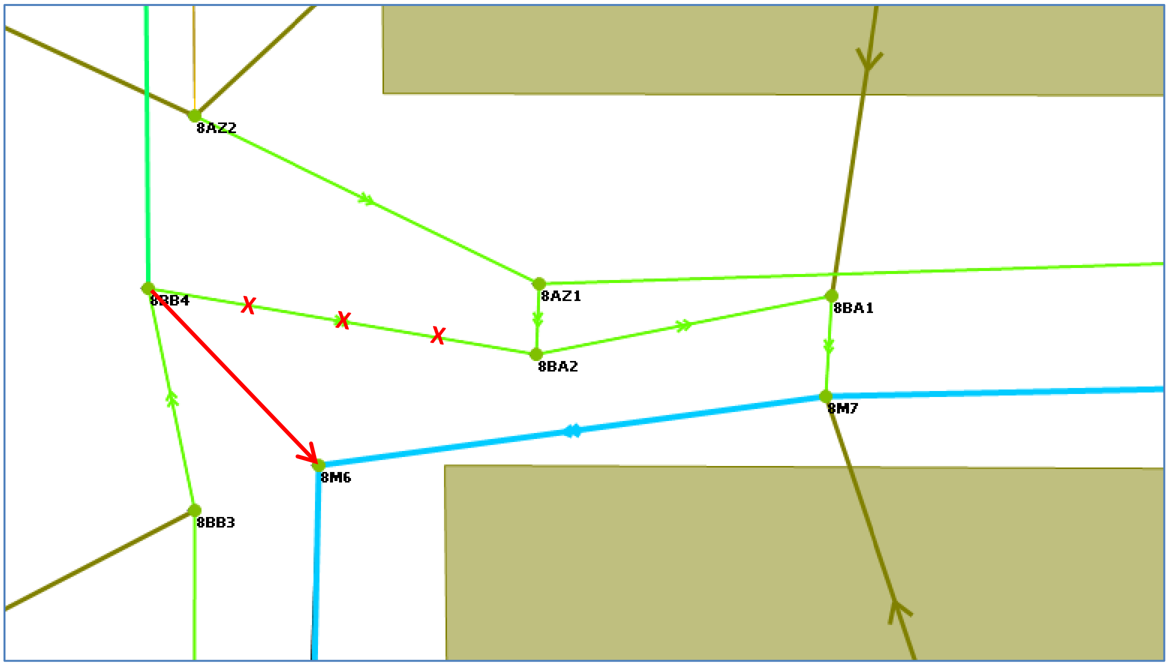
A satisfactory level of calibration was achieved at most of the flow meter sites across all five major events.

CONNECTIVITY

During the model build and calibration there were a few locations where the sewer main connectivity from the GIS was uncertain. Field investigations were carried out to refine most of the connectivity queries and where possible gather ground level and invert data to accurately populate the model.

One location where clarification is still required is in the vicinity of the corner of East Madison Avenue and South 13th Street as illustrated in Figure 9. The assumed connectivity is shown in red however pipe elevations have been estimated in the model and should be updated following a field investigation.

Figure 9: Corner of East Madison Ave and South 13th St



DESIGN STORM

In line with many other cities in Arkansas, a 2yr - 24-hour design storm has been adopted to assess system performance and augmentation requirements. The design storm has a peak intensity of approximately 0.5 inches/hour and a total rainfall depth of 3.87 inches. Figure 10 shows the design storm hyetograph with Figure 11 illustrating the predicted flooding and surcharging locations when the design storm is simulated on the calibrated model.

The two most significant events recorded during the flow monitoring survey have also been simulated on the model to confirm that the proposed augmentation solutions can also contain flows from storms of shorter duration and higher intensity.

Figure 10: 24 Hour-2 Year Design Storm

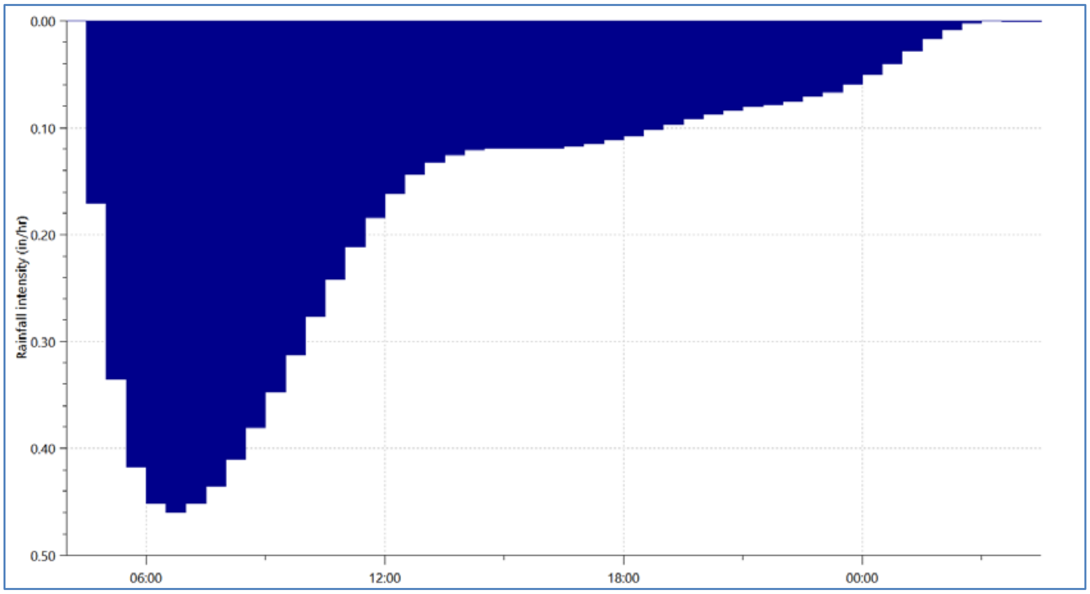
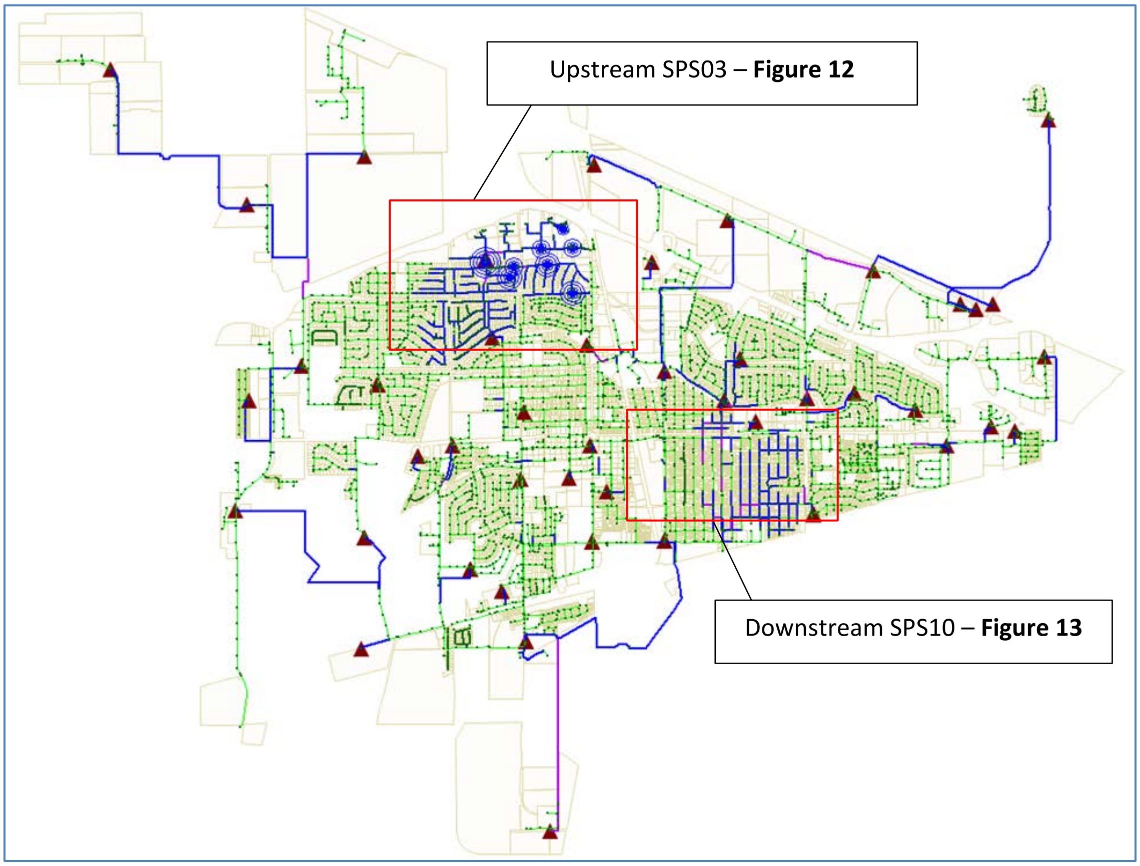


Figure 11: 2 Year-24 Hour Predicted Flooding Locations



3.1 MANHOLE OVERFLOWS UPSTREAM OF SPS03

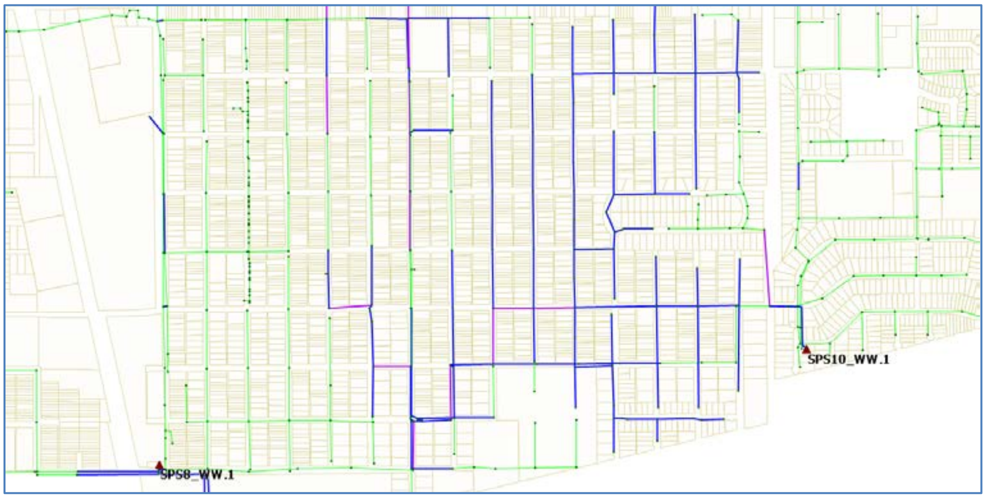
During periods of high flow, SPS03 is overwhelmed by the increased wet weather flow, which results in surcharging and flooding from manholes in the upstream network at several locations as illustrated in Figure 12.

Figure 12: Design Storm Manhole Overflows Upstream of SPS03

3.2 ELEVATED SURCHARGE LEVELS DOWNSTREAM OF SPS10

Following wet weather events with extended periods of pumping from SPS10, the receiving sewers downstream from SPS10 surcharge significantly as illustrated in Figure 13.

Figure 13: Design Storm – Extreme Surcharge Downstream of SPS10



PROPOSED UPGRADE OPTIONS

Conveyance upgrades were found to be the most effective augmentation solution to eliminate the predicted deficiencies identified from the 2-year 24-hour design storm simulations. The following sections detail the required major packages of work.

4.1 SPS 03 UPGRADES

SPS 03 is not currently able to pump the flows associated with a 2-year, 24-hour design storm. Under the current network configuration, upgrading the pumps at SPS03 to convey the required peak flows would in turn result in the need to upgrade significant sections of pipe upstream of SPS04 and SPS06 as well as the pumps at both of these pumping stations.

To minimize these follow-on upgrades, and better manage flows in the network, a new manifolded force main has been proposed that conveys injected flows from SPS03, SPS04, SPS05, and SPS06. The new main will also convey flows directly to SPS09, thus significantly reducing the flows through SPS07 and SPS08. The SPS09 pumps and forcemain has capacity to convey these additional flows without any need for additional upgrades.

A small gravity cross-connection/diversion at Washington Ave. is also proposed that will direct flows from the existing 14” gravity main flowing to the north into the 18” gravity main flowing south to SPS09, thus further reducing flows to SPS07. Figure 14 shows the extent of the required works and is further illustrated in Exhibit A. Figure 15 illustrates the reduction in the extent of the upstream network draining through SPS07 and SPS08 as a result of these works.

Figure 14: Proposed Manifolded Force Main along Avalon St

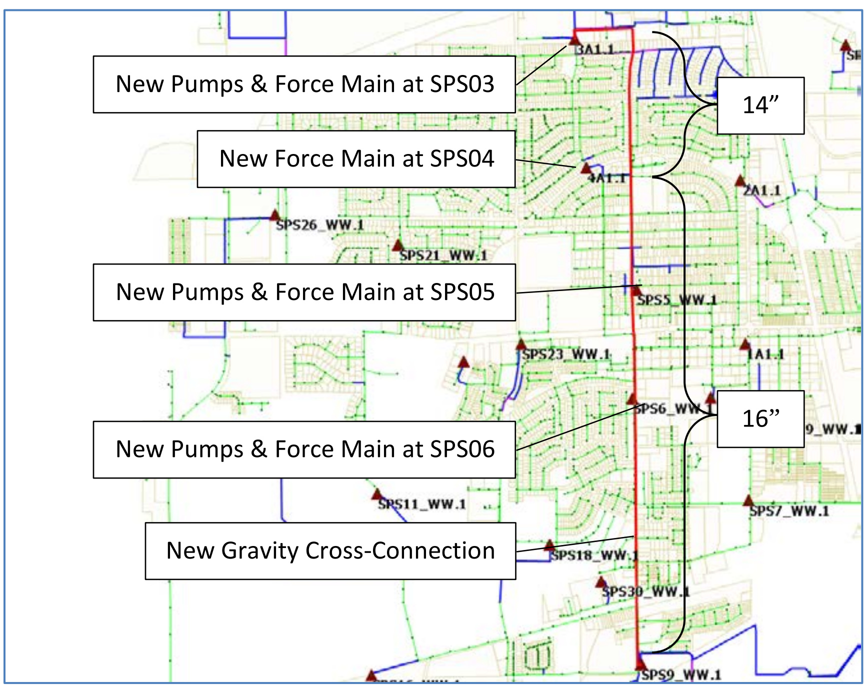
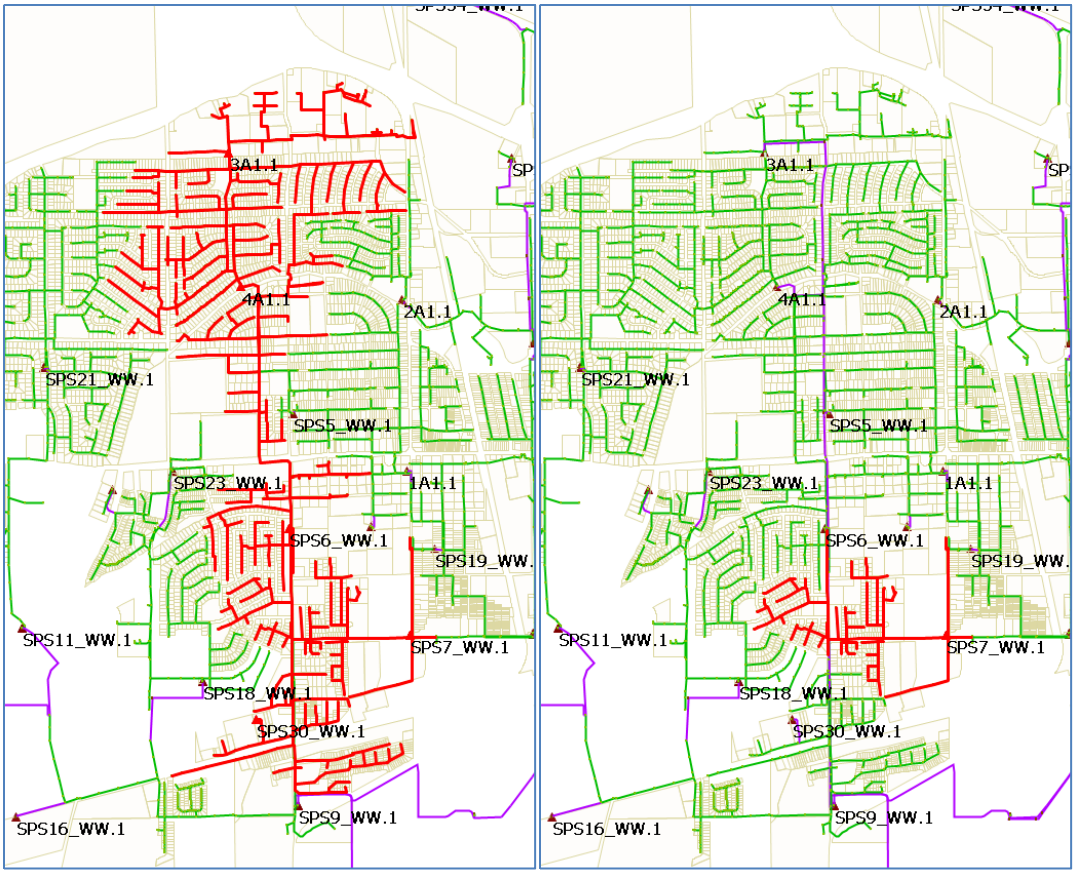


Figure 15: Network Upstream of SPS07 Before and After Proposed Works



Existing **After**

4.2 SPS10 MODIFICATIONS

During the design storm, significant surcharging is predicted downstream at the discharge from SPS10. Redirecting flows from SPS10 directly to the Water Reclamation Facility (WRF) via a new forcemain will result is significant reduction in surcharge and flows being repumped through SPS08.

Figure 16 illustrates the proposed 16” force main proposed to be constructed from SPS10 to the WRF adjacent to the existing roadway and is further illustrated in Exhibit B.

A short section of gravity main is also identified in Figure 16 that may need to be upsized from an 8” gravity main, as designated in the GIS, to a 12” gravity main and a field investigation should be undertaken to confirm the actual diameter.

Figure 16: Extent of Works for SPS10

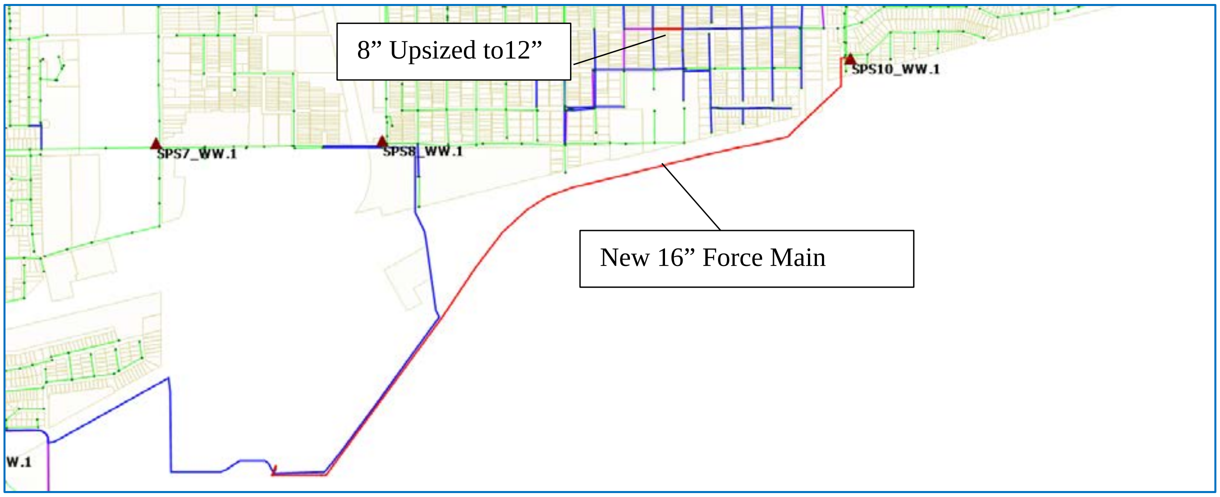


Figure 17 shows the reduction in surcharge downstream of SPS10 and upstream of SPS08.

Figure 17: Extent of Surcharge Before and After Proposed Works

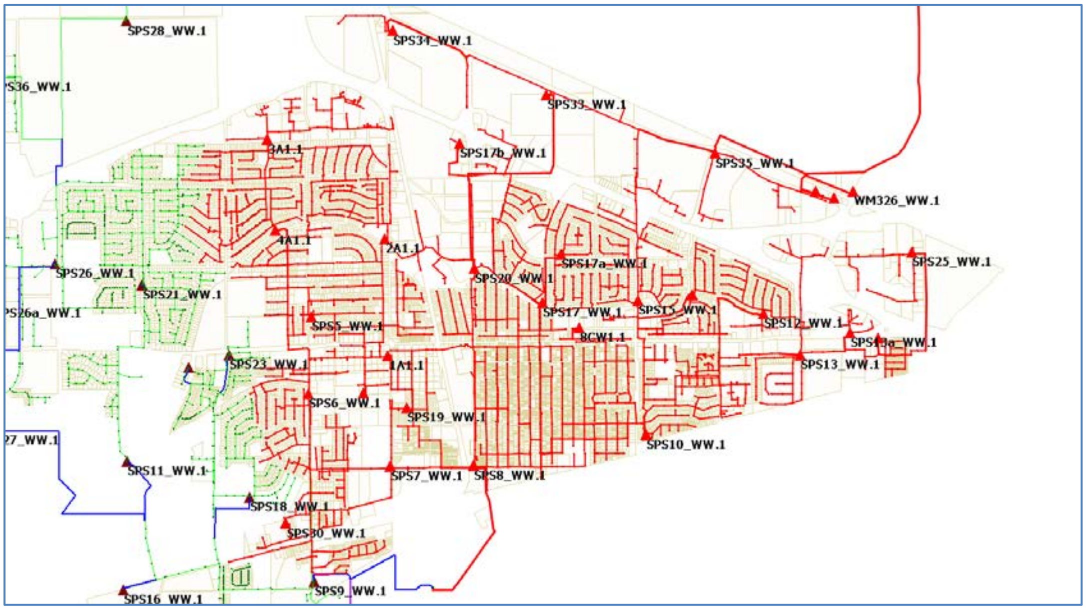
Existing **After**

Figure 18 illustrates the significant reduction in the proportion of the upstream network that will be conveyed through SPS08 when:

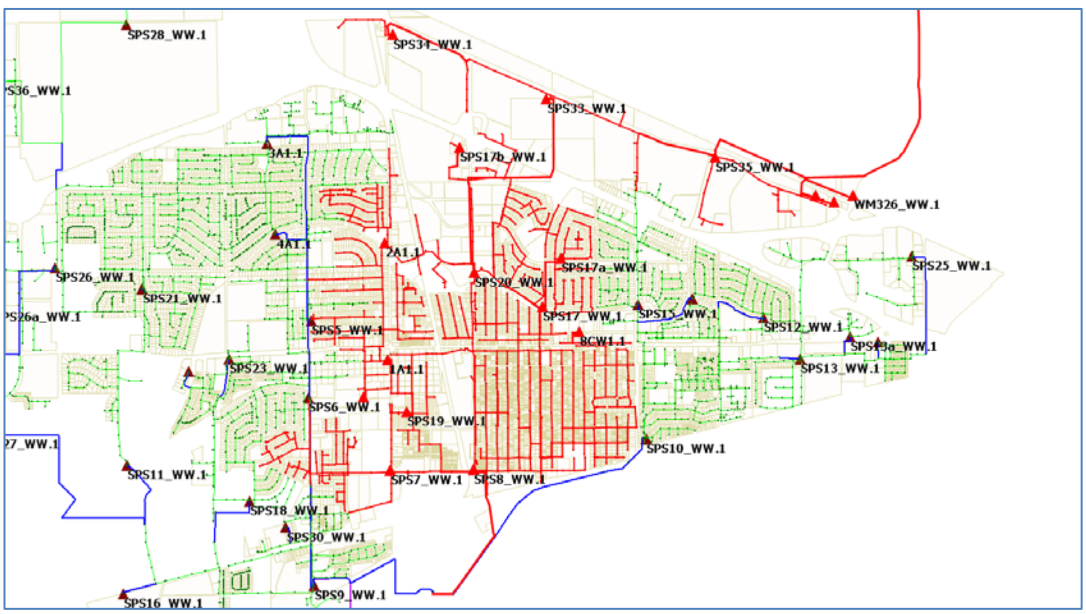
- the force main from SPS10 is constructed and conveys flow directly to the WRF;
- and the manifolded force main for SPS03, SPS04, SPS05, and SPS06 is constructed and diverts flows to SPS09 then directly to the WRF.

In addition to providing augmented conveyance capacity, provided the existing system connections are maintained in the augmentation design, system operators will also have a high degree of flexibility to redirect flows through alternate pathways during emergency operations in the future.

Figure 18: Network Upstream of SPS08 Before and After Proposed Works



Existing

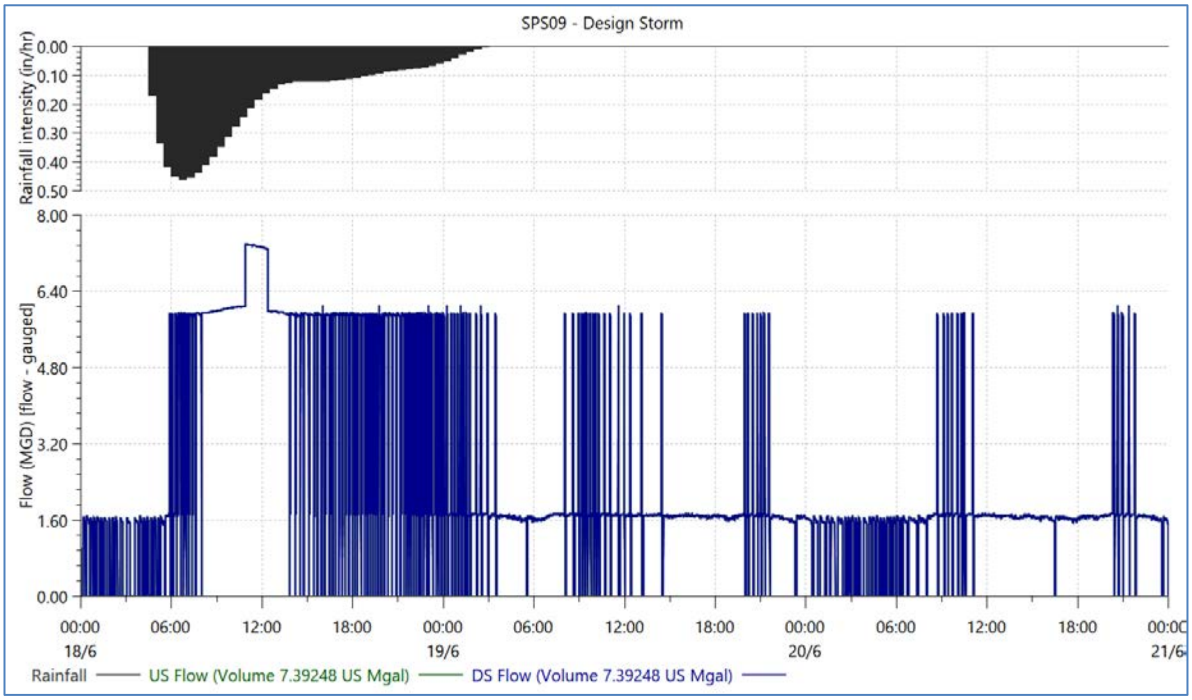


After

SPS09 PROPOSED OPERATION

Under existing conditions, SPS09 has a considerable spare capacity and we have been advised that it now has a fully functional standby pump. The proposed augmentation works assuming that at least two pumps will be installed and available to convey peak flows. The model predicts that a single pump is capable of pumping approximately 6 MGD at full speed and that two pumps at full speed will pump approximately 7.4 MGD to the WRF.

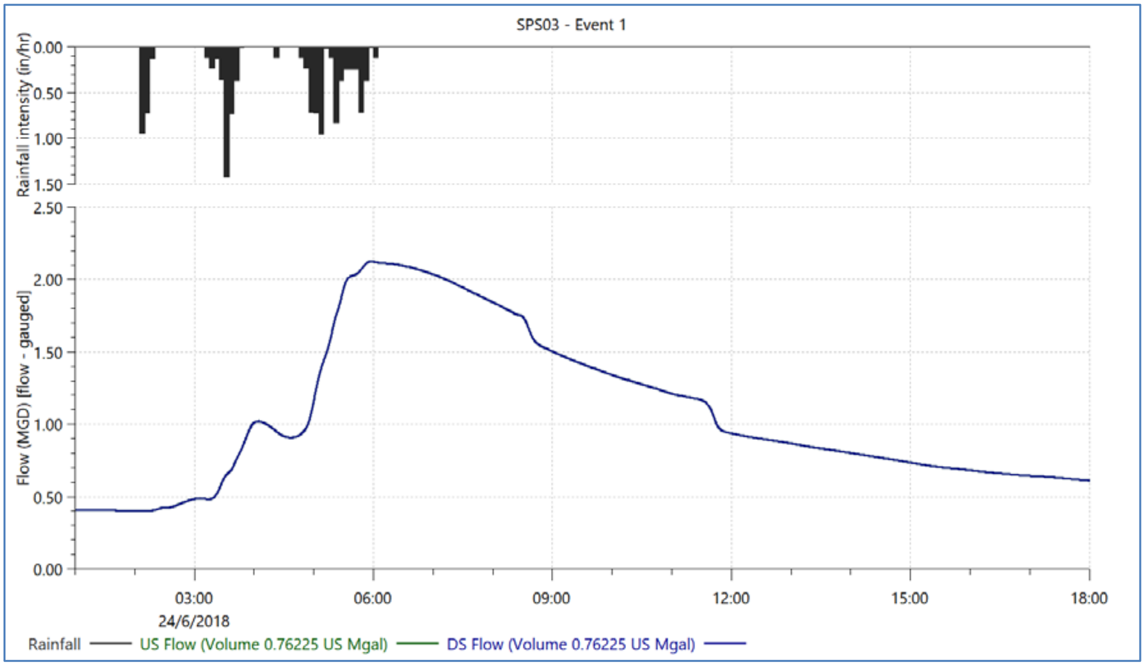
The following hydrograph shows the flows from SPS09 during the design storm with the proposed augmentation works. Note that the in-situ VFD controls at the pumping station will "smooth" out the spikey flows indicated below during the non-peak flow periods.



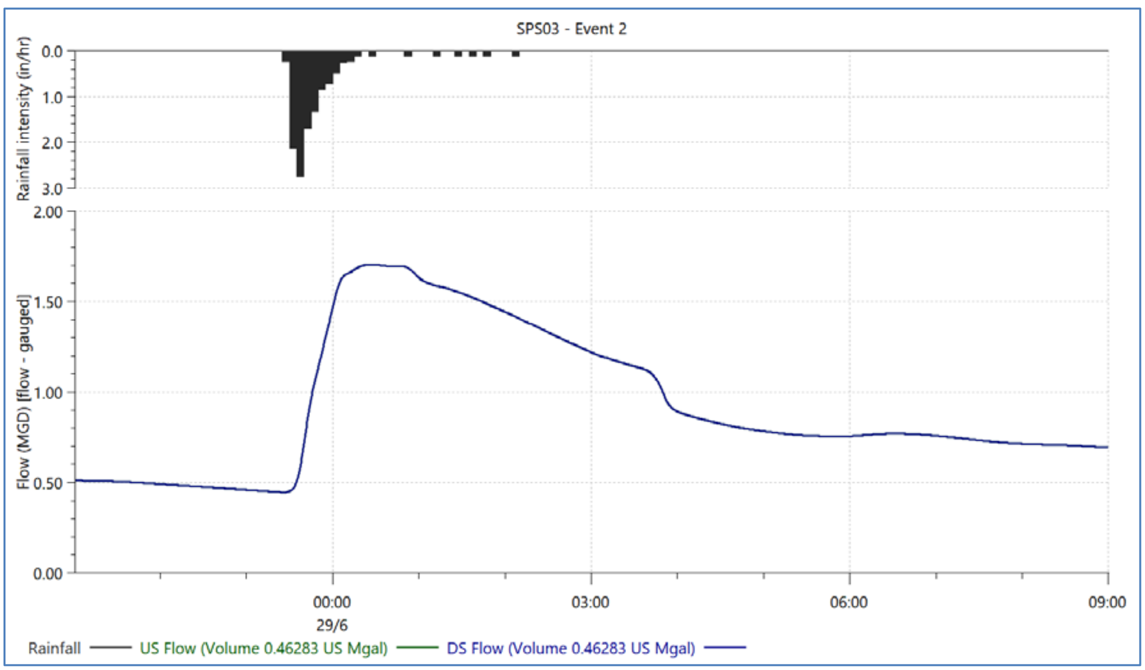
SPS03 PROPOSED OPERATION

Directing the flows from SPS03 through the proposed manifolded force main along Avalon St. will require new pumps to be installed at this station. The following hydrographs show the peak predicted flows into SPS03 from the two major recorded storms as well as from the design storm. The required combined duty for these pumps will be in the order of 2.5 MGD @ 94ft head.

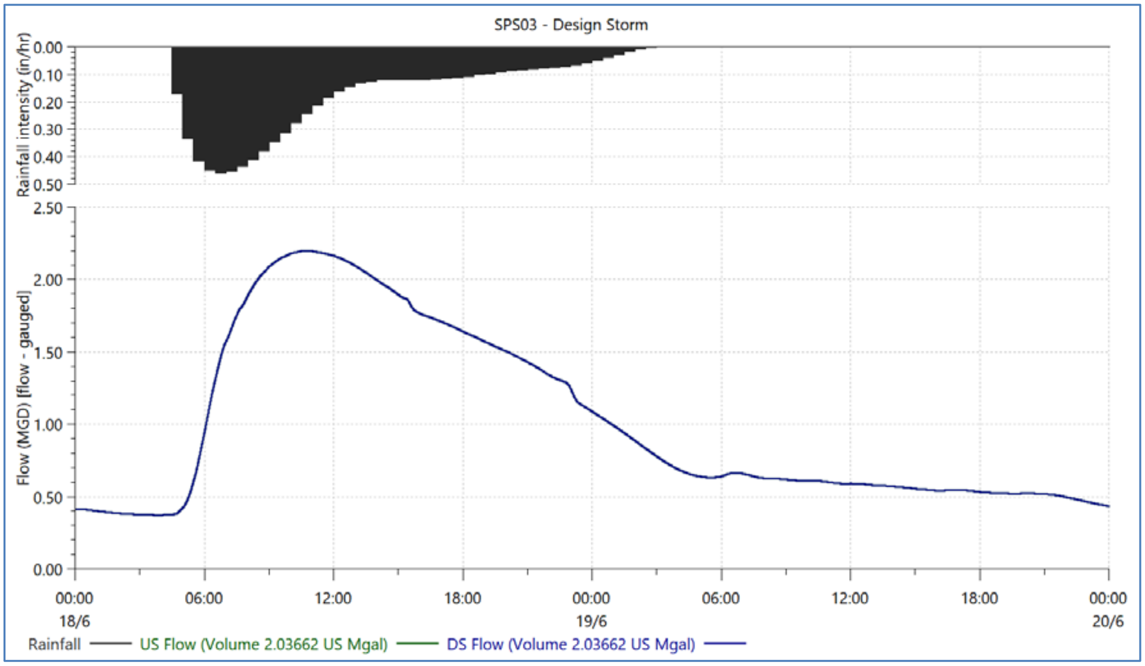
3.1 EVENT 1 – JUNE 24, 2018



3.2 EVENT 2 – JUNE 29, 2018



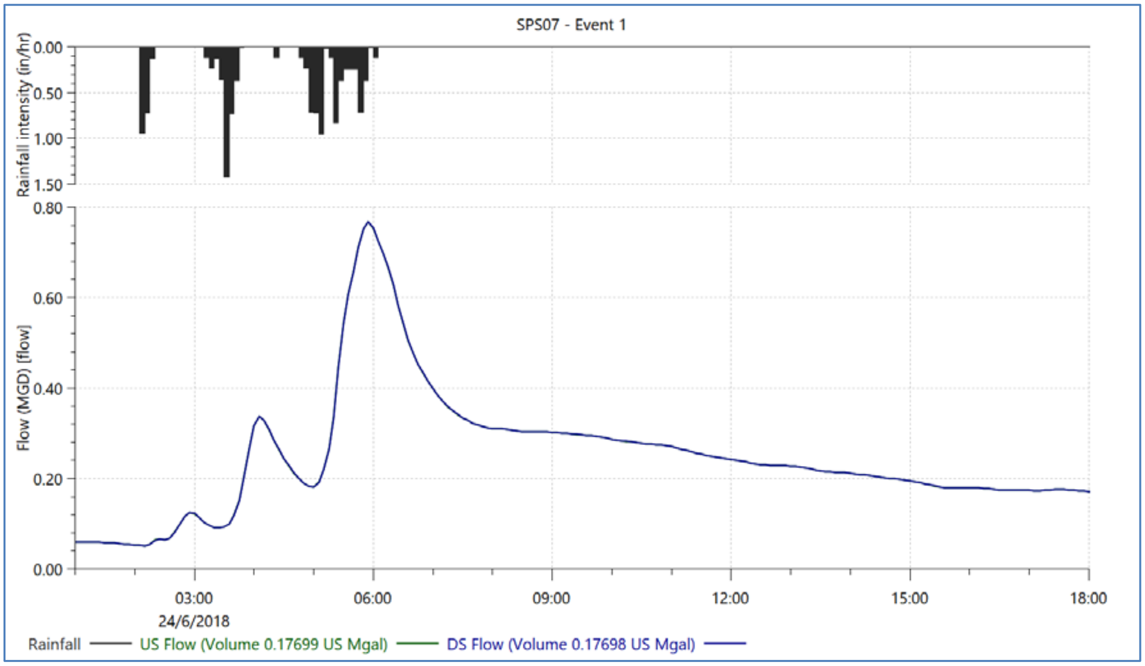
3.3 DESIGN STORM



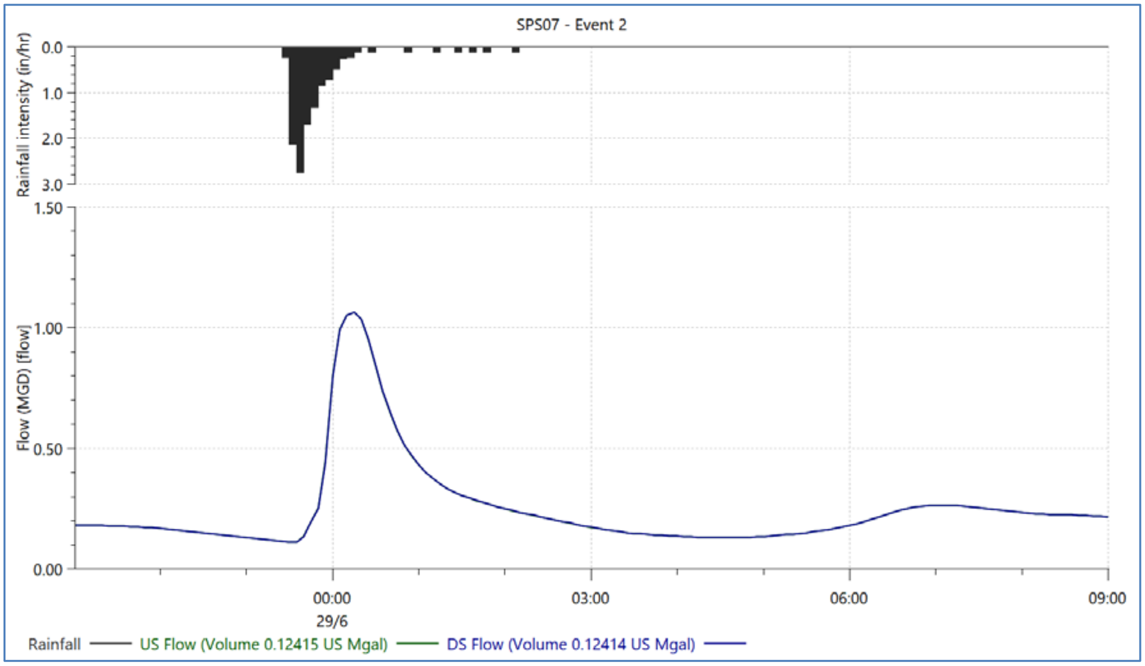
SPS07 PROPOSED OPERATION

The Avalon St. force main and minor gravity diversion works detailed in Sect 4.1 will dramatically reduce the flows to SPS07. The following hydrographs show the peak predicted flows into SPS07 from the two major recorded storms as well as from the design storm. The future required combined duty for these pumps will be in the order of 1 MGD.

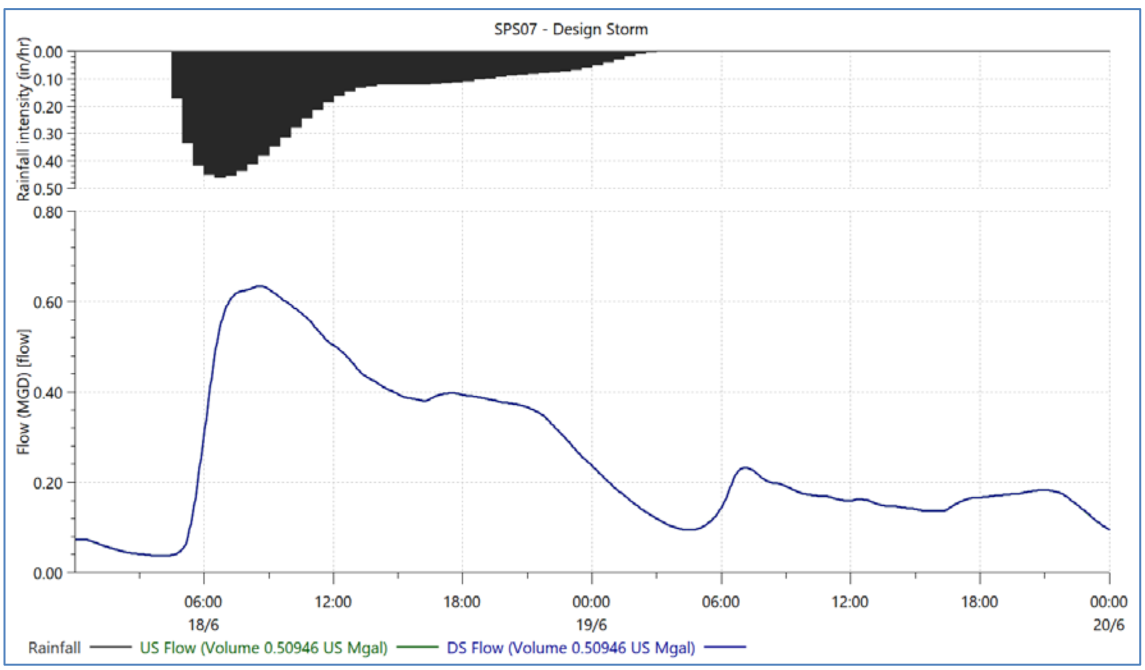
7.1 EVENT 1 – JUNE 24, 2018



7.2 EVENT 2 – JUNE 29, 2018



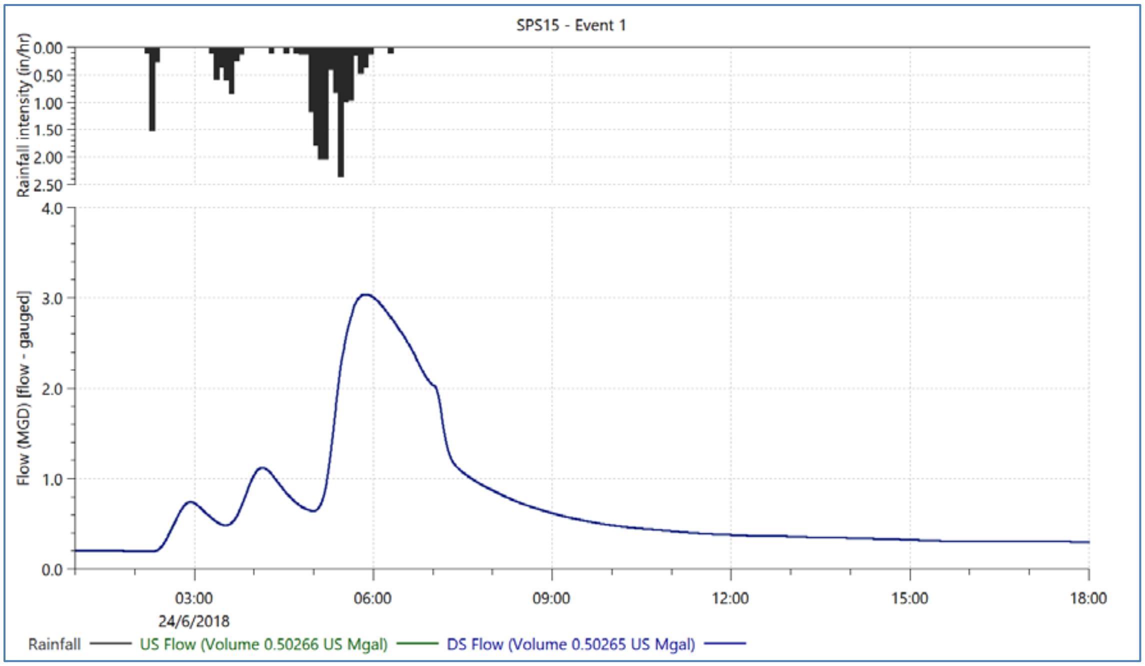
7.3 DESIGN STORM



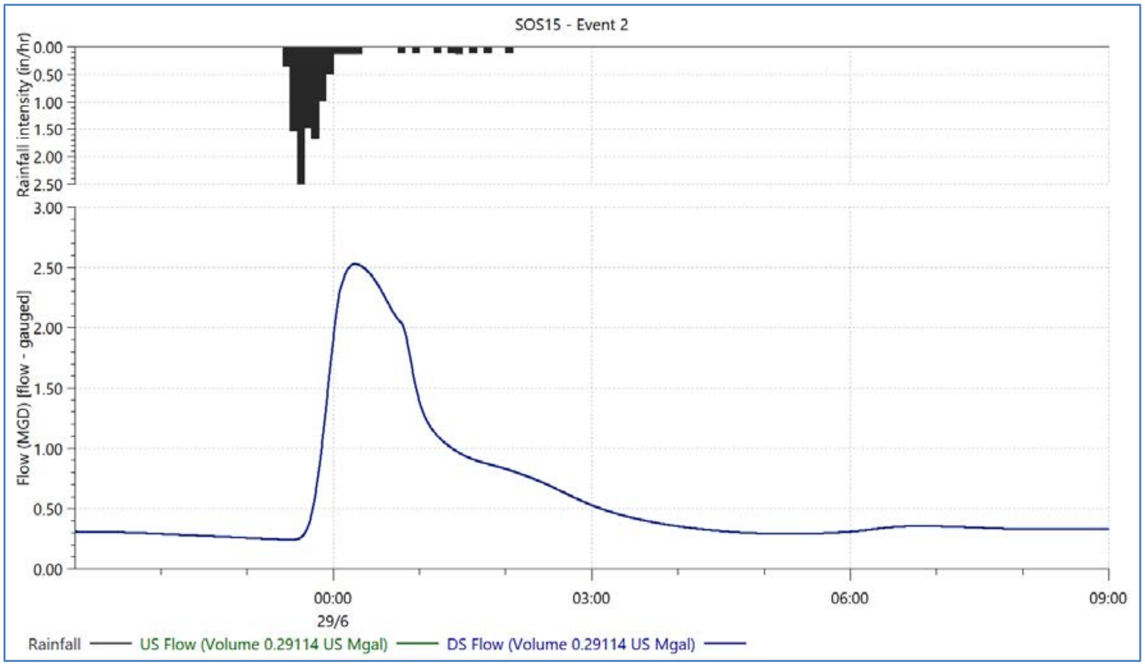
FLOWS TO SPS15

The following hydrographs show the peak predicted flows into SPS15 from the two major recorded storms as well as from the design storm. The model results indicate that if properly functioning, the existing pumps at this station should be adequate to convey peak wet weather flows with some surcharge in the upstream gravity network.

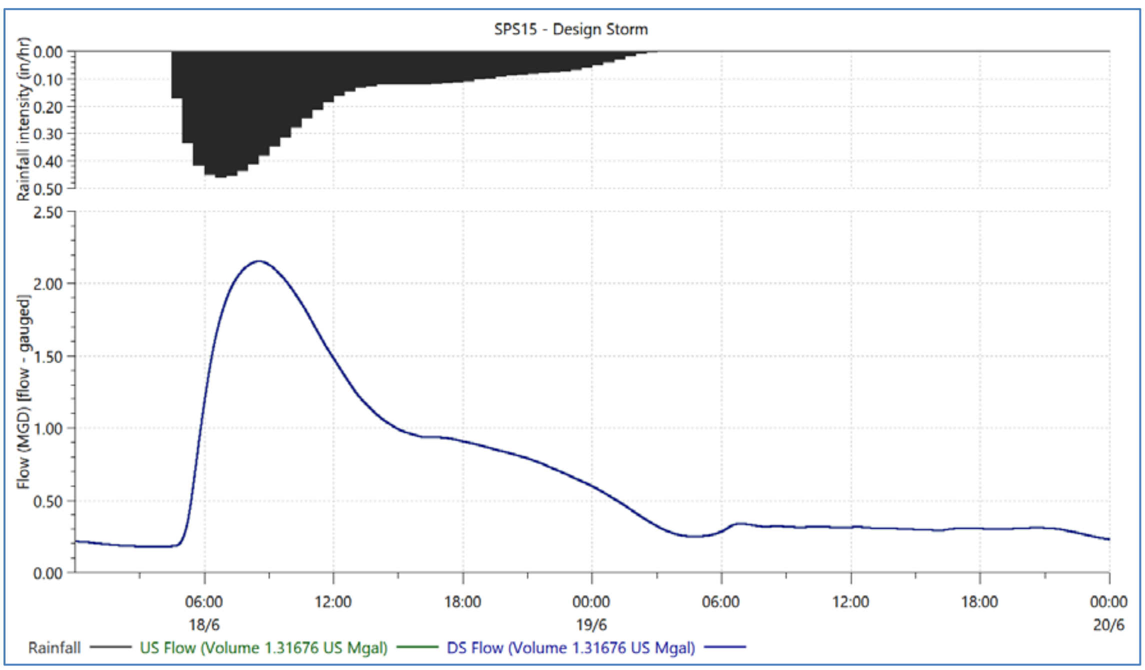
15.1 EVENT 1 - JUNE 24, 2018



15.2 EVENT 2 – JUNE 29, 2018



15.3 DESIGN STORM



FLOWS TO THE WRF

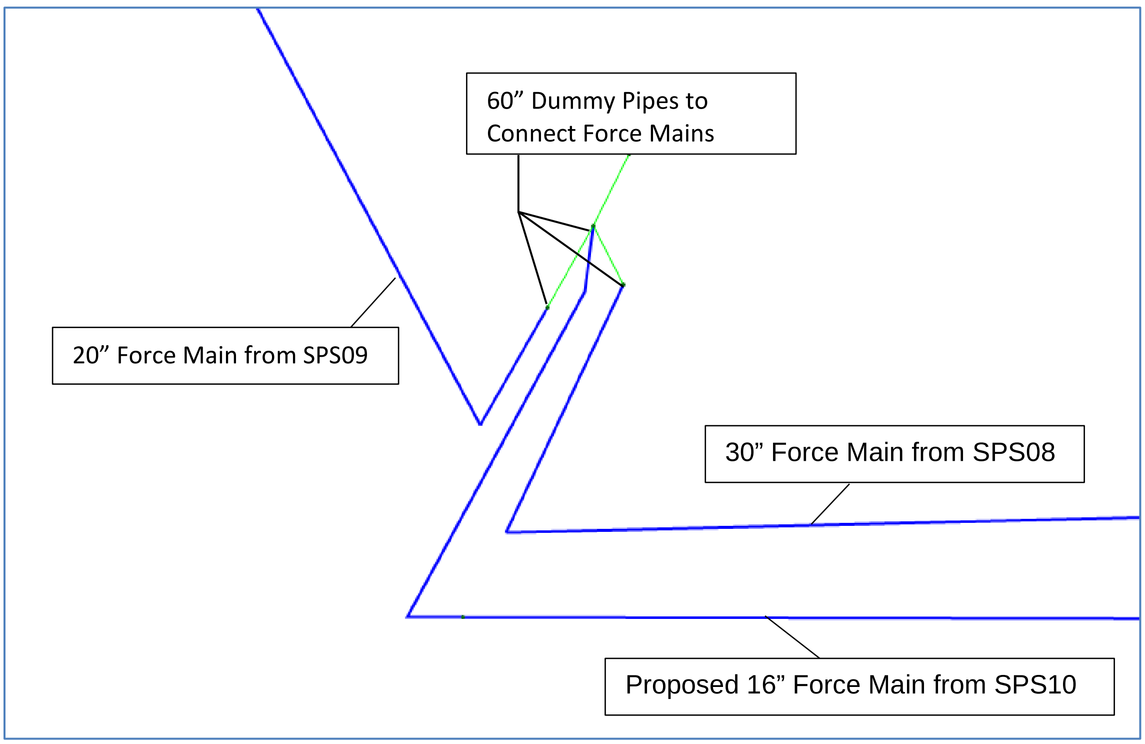
The inlet arrangement at the WRF was modified in the model to allow total flow into the WRF to be reported, as shown in Figure 19. Two dummy sections of 60" pipe connect the force mains from SPS08 and SPS09 to a shared manhole with the proposed force main from SPS10. The combined flow is then directed through a final dummy 60" pipe.

- SPS 10 is assumed to have a combined pumping capacity of 5 MGD @ 132ft
- SPS 09 has a maximum pump rate of 7.4 MGD

Due to the significant reduction in the amount of the network directed through SPS08, the model indicates that the peak pumping rate from this station could be reduced to approximately 8 MGD.

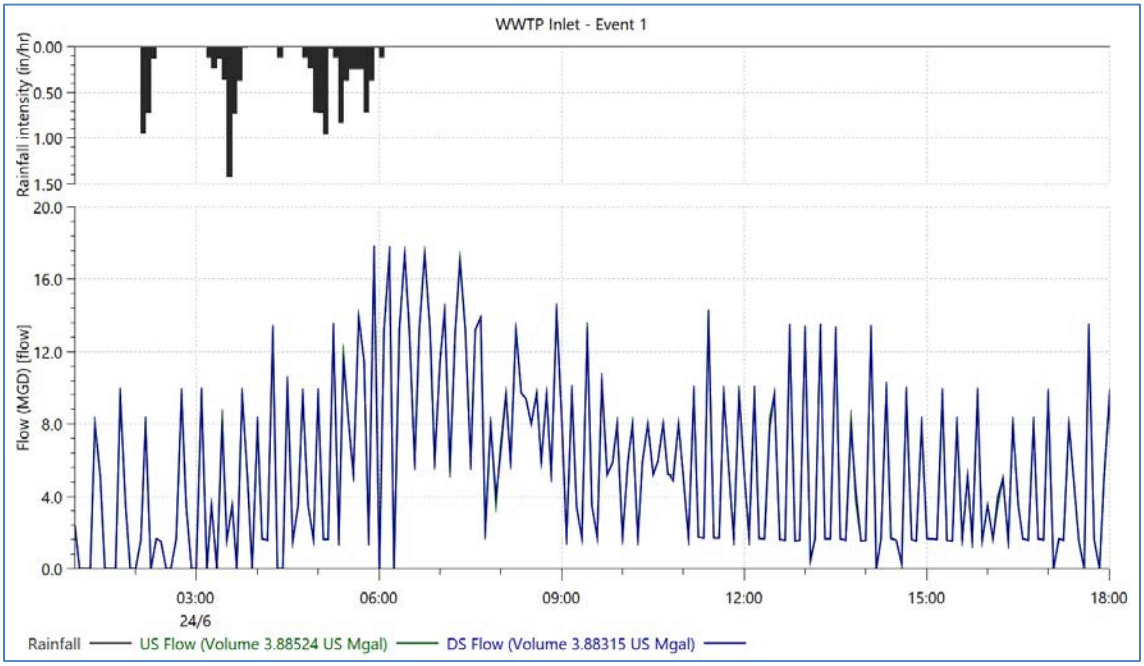
With all stations running at peak capacity, the maximum flow rate into the WRF would be approximately 20 MGD.

Figure 19: WRF Inlet Arrangement

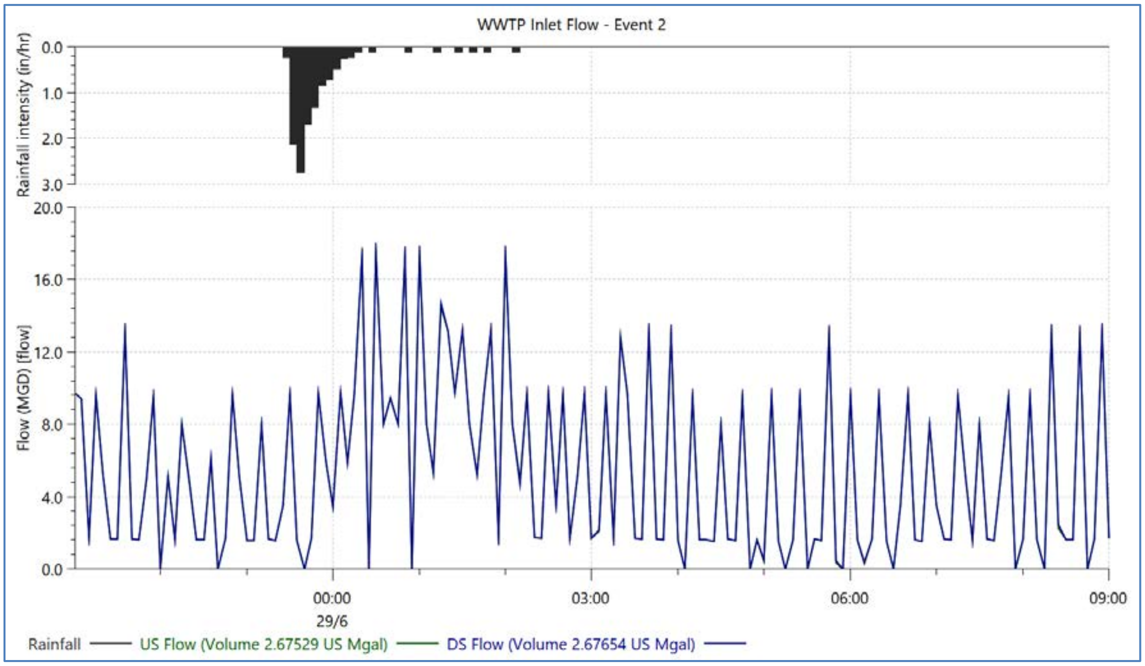


The following hydrographs show the peak predicted flows into WRF from the two major recorded storms as well as from the design storm. Note that the "spikes" indicated in the hydrographs could be smoothed with more refined control rules for the VFD pumps.

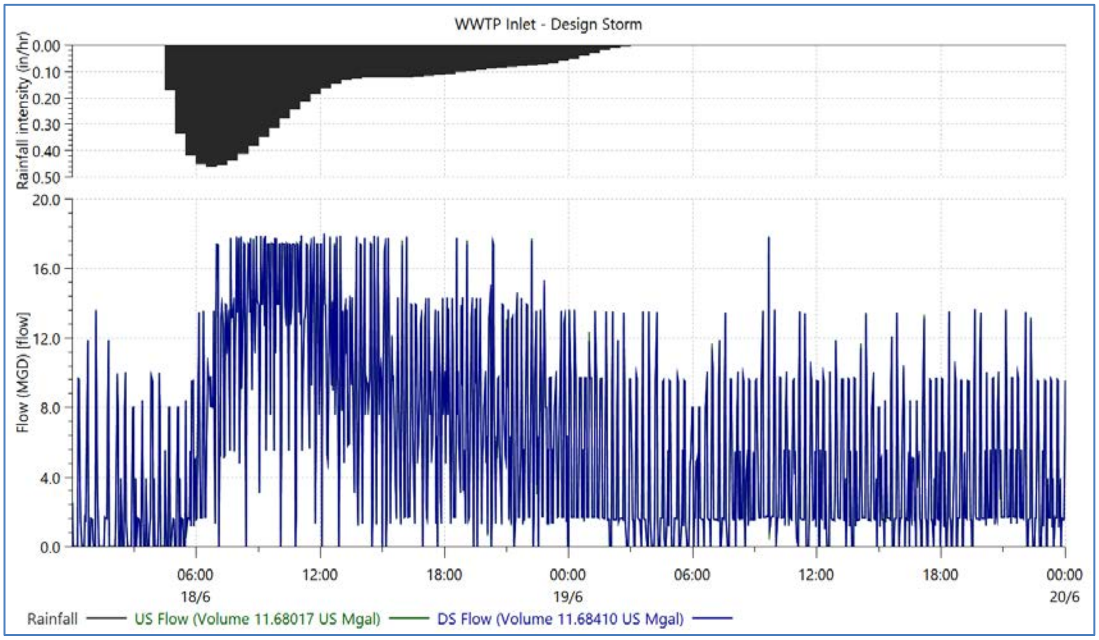
WRF.1 EVENT 1 - JUNE 24, 2018



WRF.2 EVENT 2 – JUNE 29, 2018



WRF.3 DESIGN STORM



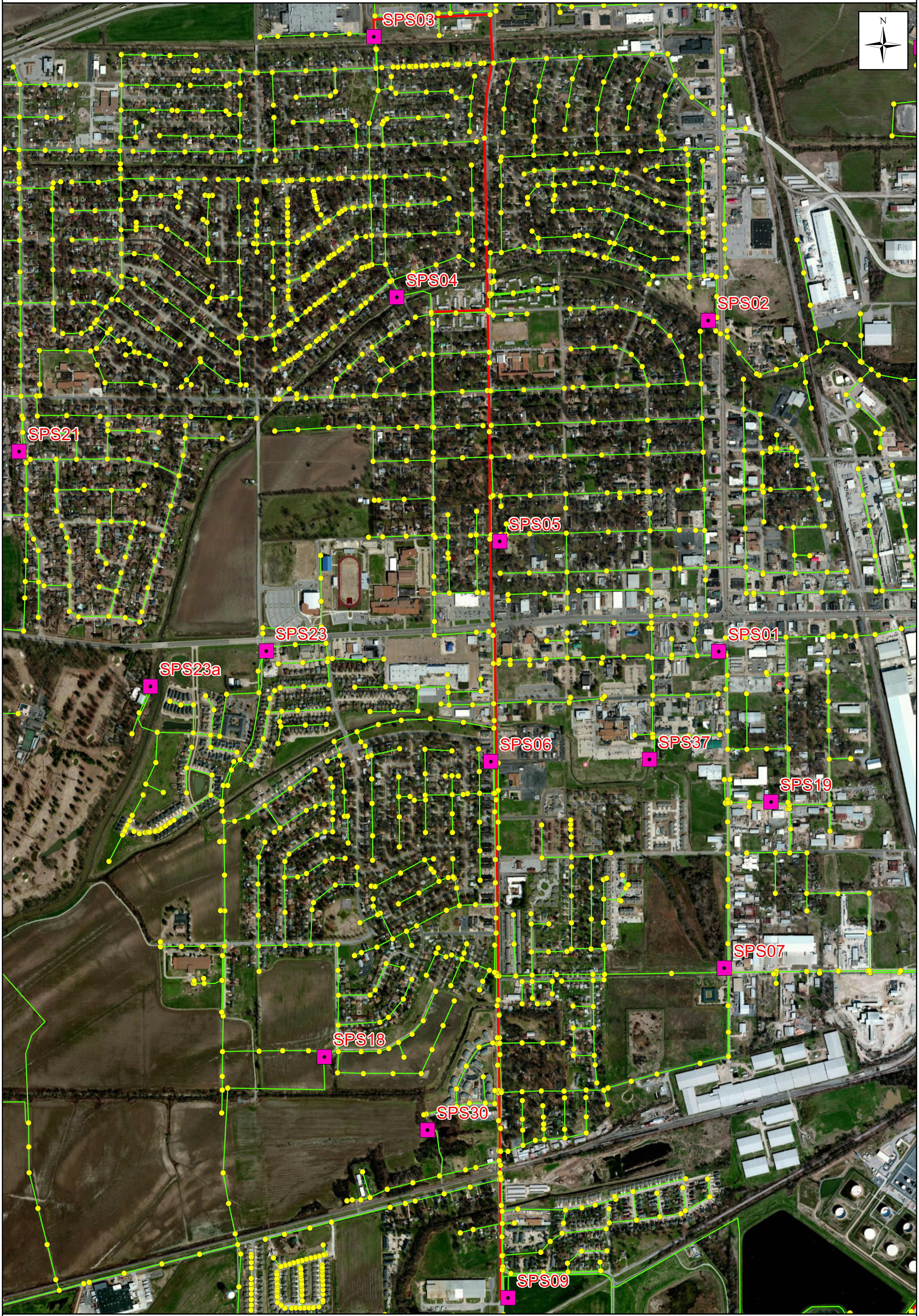
SUMMARY

These preliminary augmentation options have demonstrated that the sewerage system performance can be improved with a few major works packages that fundamentally simplify the way that the system operates, frees up capacity, and reduces repumping of flows multiple times. Proposed pump rates and pressures for the augmented pumps are listed below. We would recommend that selected pumps are tested out on the model to confirm the integrated performance is satisfactory,

Pump	Peak Flow Rate (MGD)	Pressure (ft)
SPS03	2.5	94
SPS04	1.0	70
SPS06	1.0	42
SPS07	1.0	-
SPS08	8.0	45
SPS09	7.4	82
SPS10	5.0	132

It needs to be noted that while these proposed augmentations will free up a lot of capacity in problematic stations and reduce surcharge levels, this can also provide the opportunity for additional I/I to enter the system. Ongoing I/I source detection and remediation programs will need to be part of the future planning.

West Memphis, AR



rjngroup
Engineering Infrastructure for tomorrow

Proposed Force Main
Existing Sewer Main
Manholes
Pump Station

Exhibit A
Proposed Manifolded
Force Main

West Memphis, AR

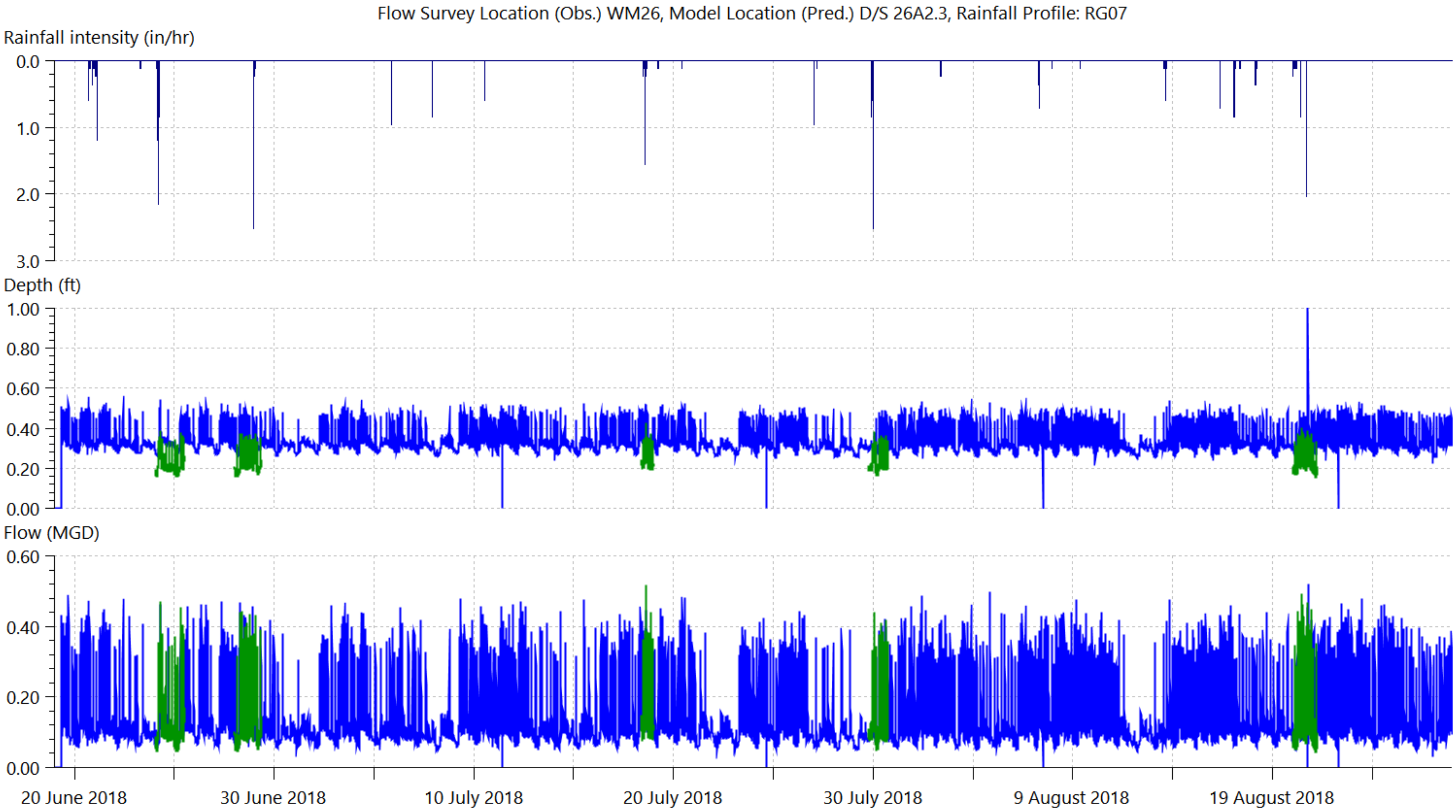
rjngroup Engineering infrastructure for tomorrow

Proposed Force Main	Manholes
Existing Sewer Main	Pump Station

Exhibit B
Proposed Force Main
SPS10 to WWTP

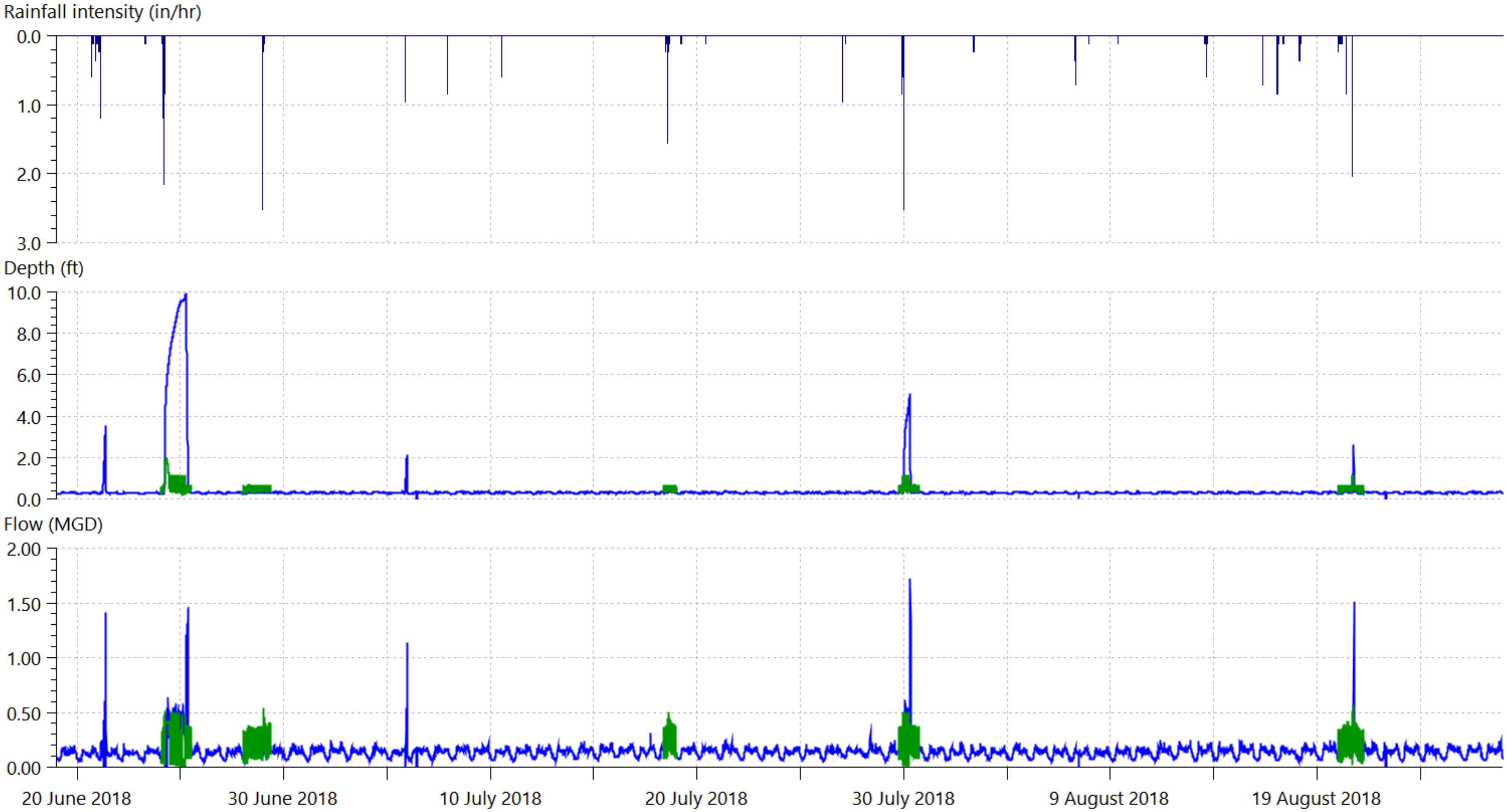
APPENDIX A

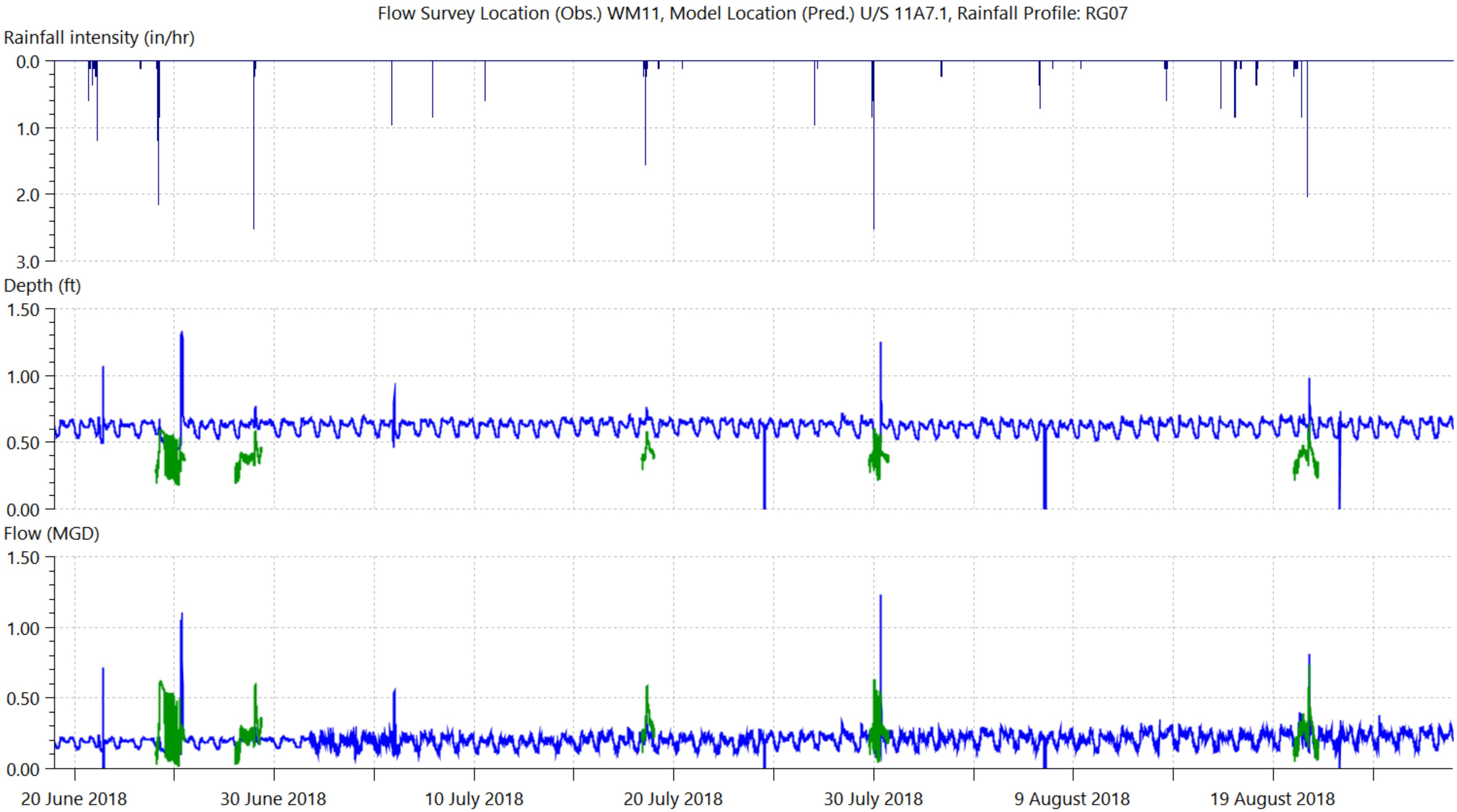
HYETOGRAPHS



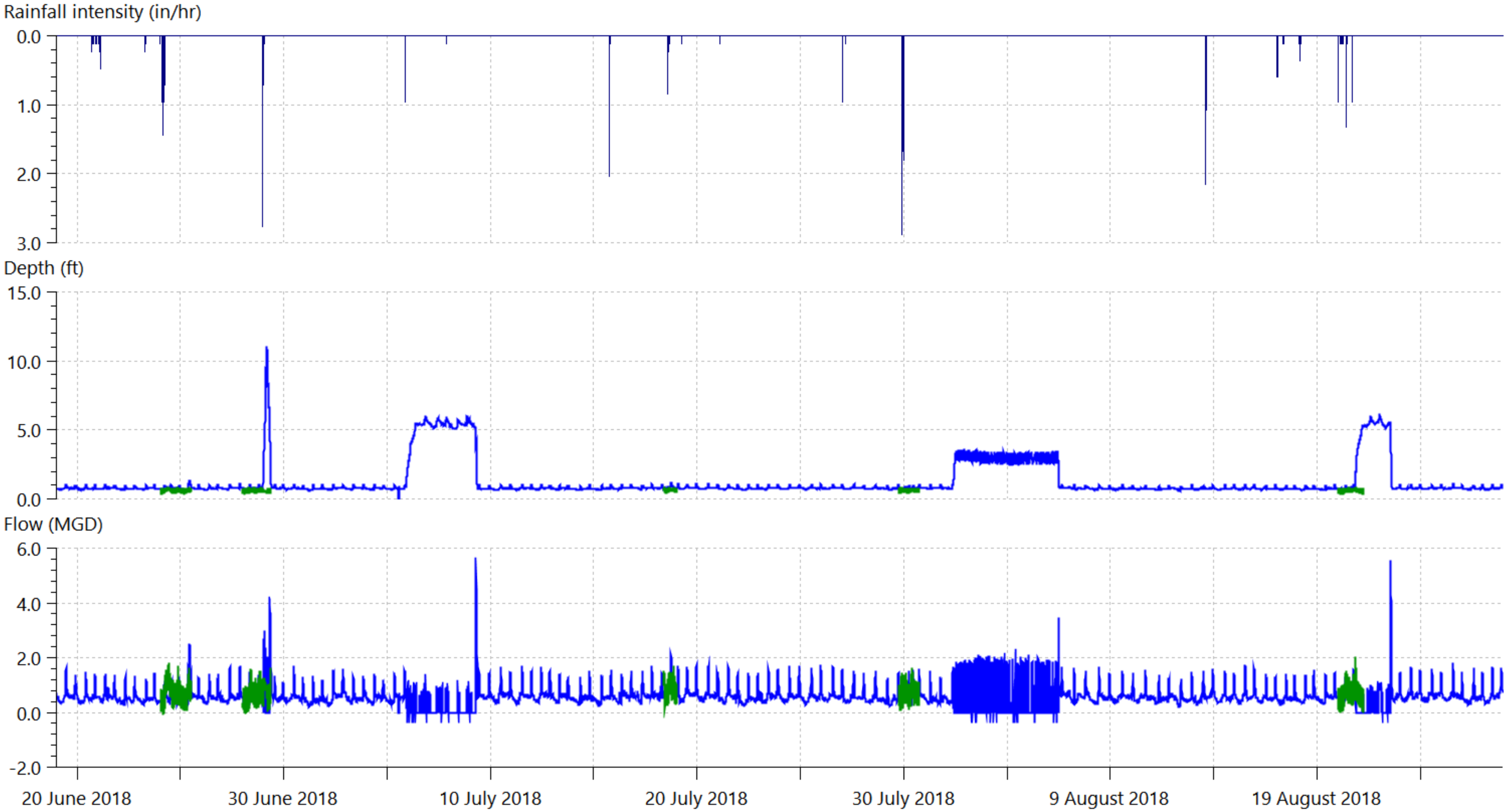
Flow Survey Location (Obs.) WM26, Model Location (Pred.) D/S 26A2.3, Rainfall Profile: RG07
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
1.00
0.80
0.60
0.40
0.20
0.00
Flow (MGD)
0.60
0.40
0.20
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

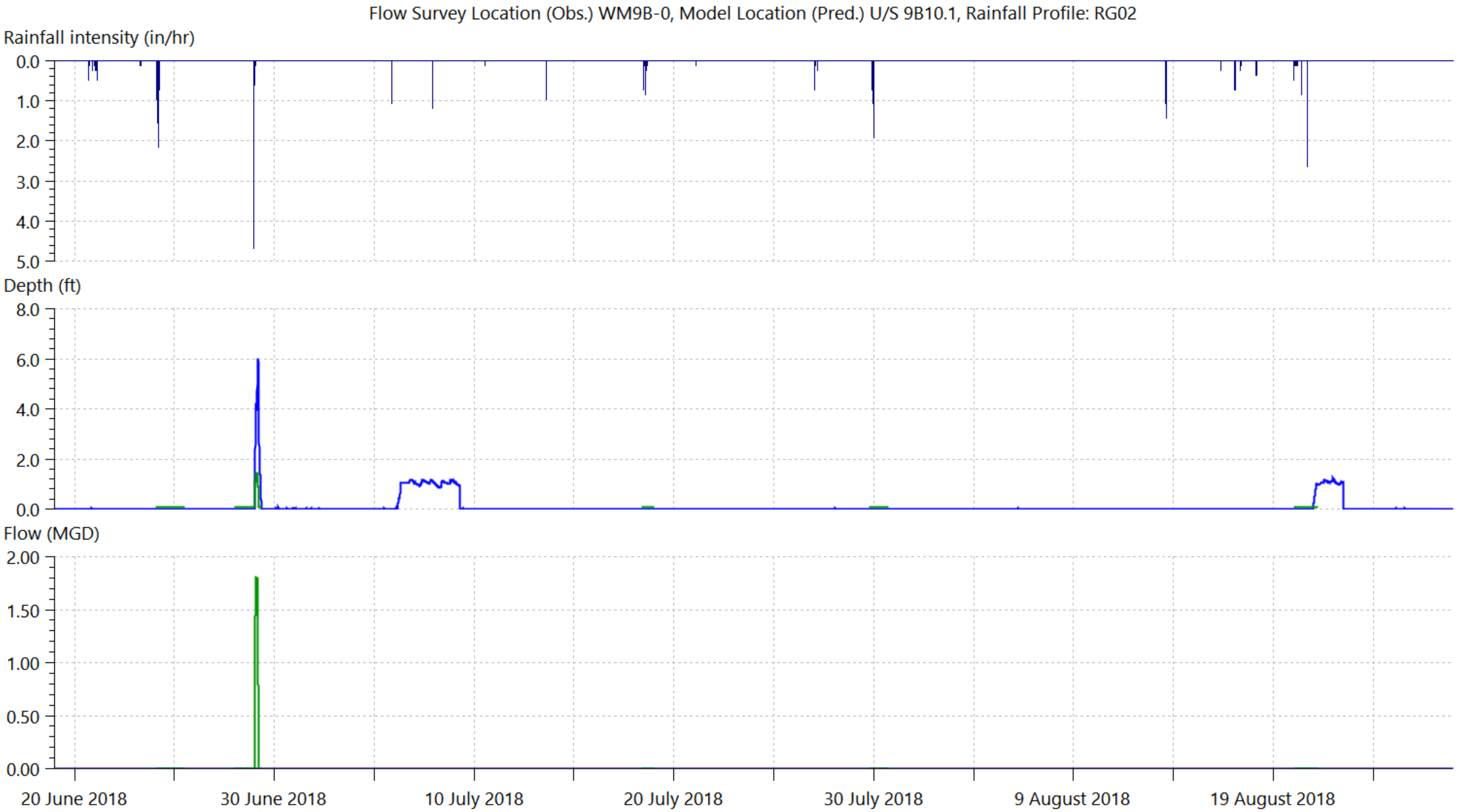
Flow Survey Location (Obs.) WM21A, Model Location (Pred.) D/S 21A3.1, Rainfall Profile: RG07



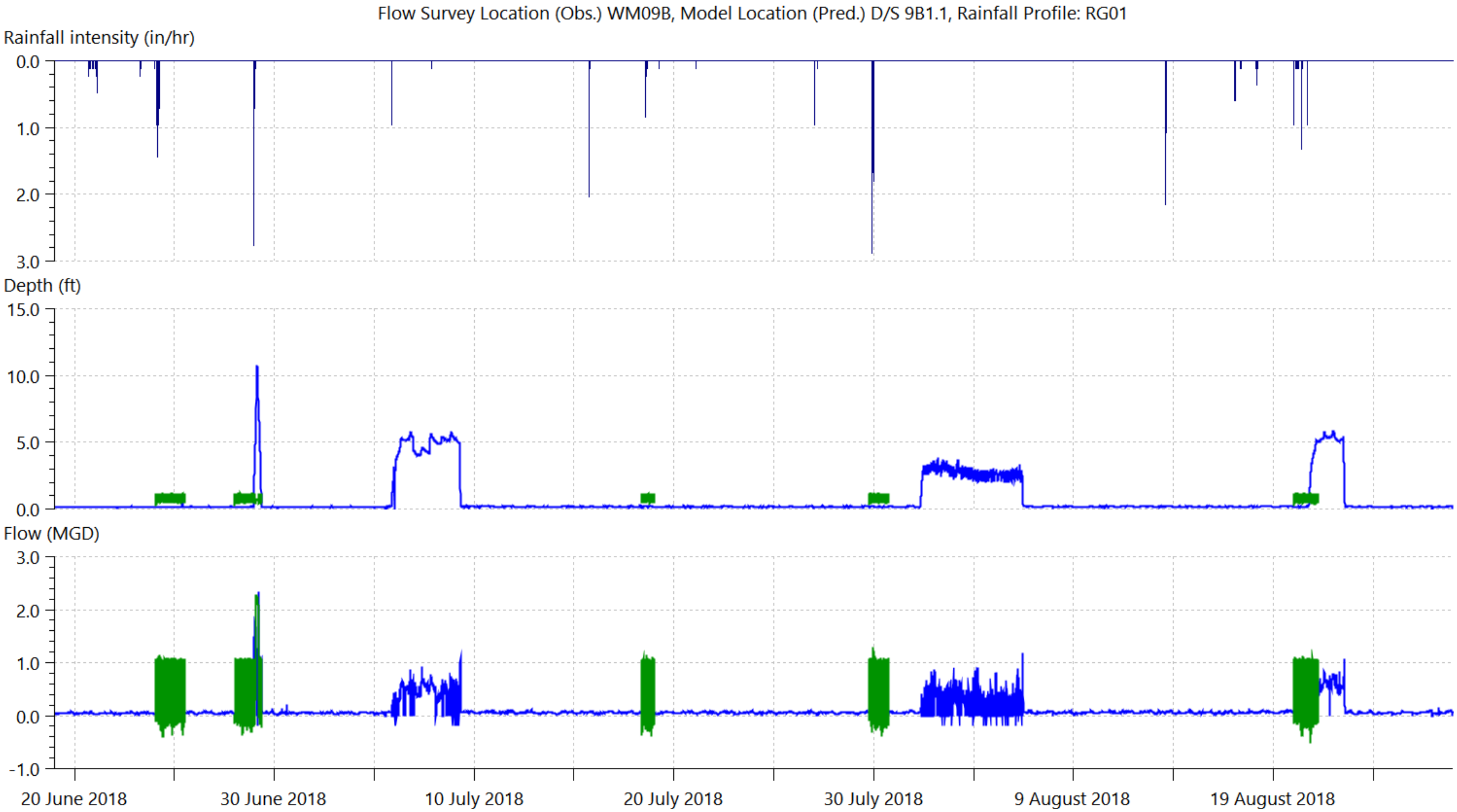

Flow Survey Location (Obs.) WM11, Model Location (Pred.) U/S 11A7.1, Rainfall Profile: RG07
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
1.50
1.00
0.50
0.00
Flow (MGD)
1.50
1.00
0.50
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

Flow Survey Location (Obs.) WM09A, Model Location (Pred.) D/S 9A3.1, Rainfall Profile: RG01

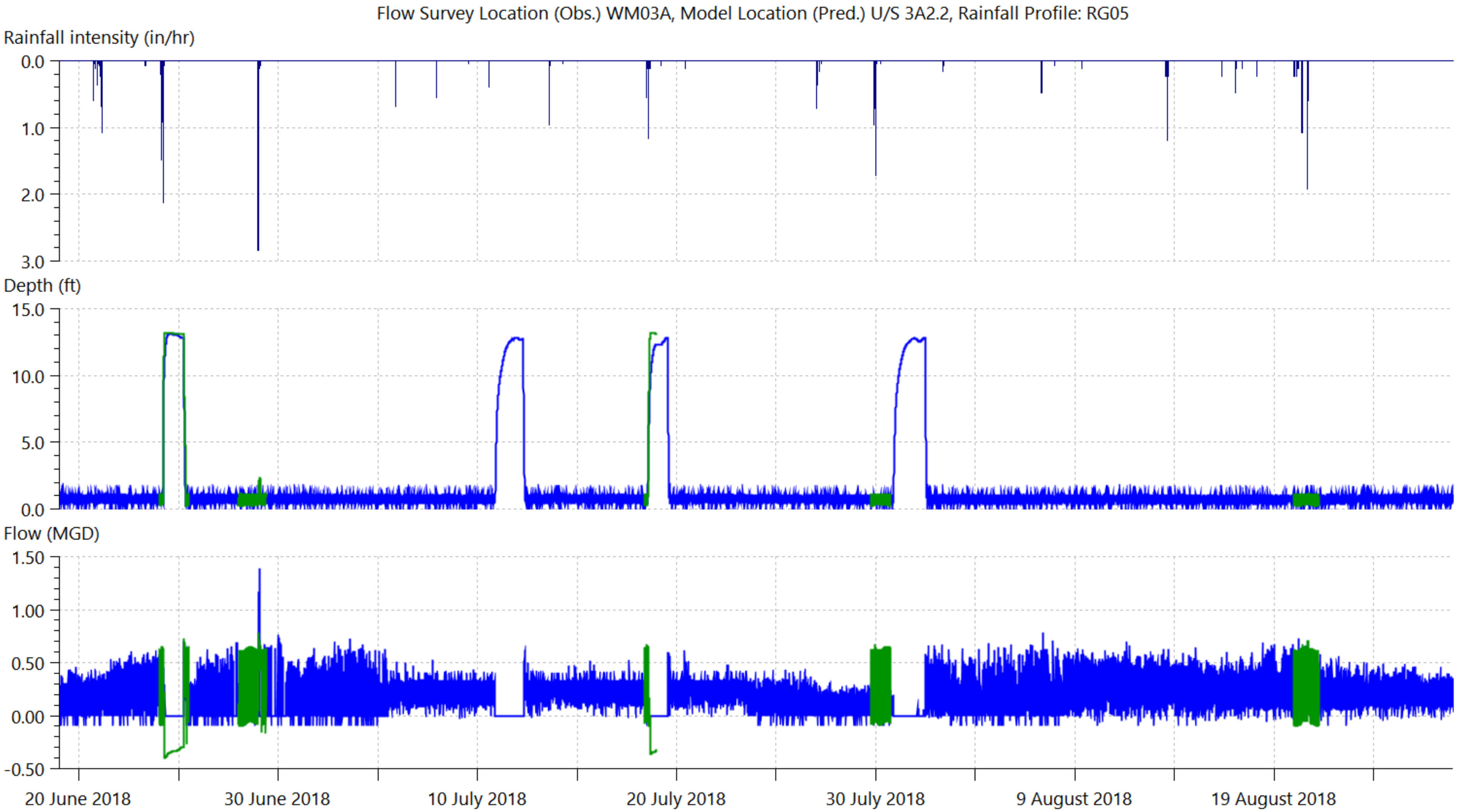




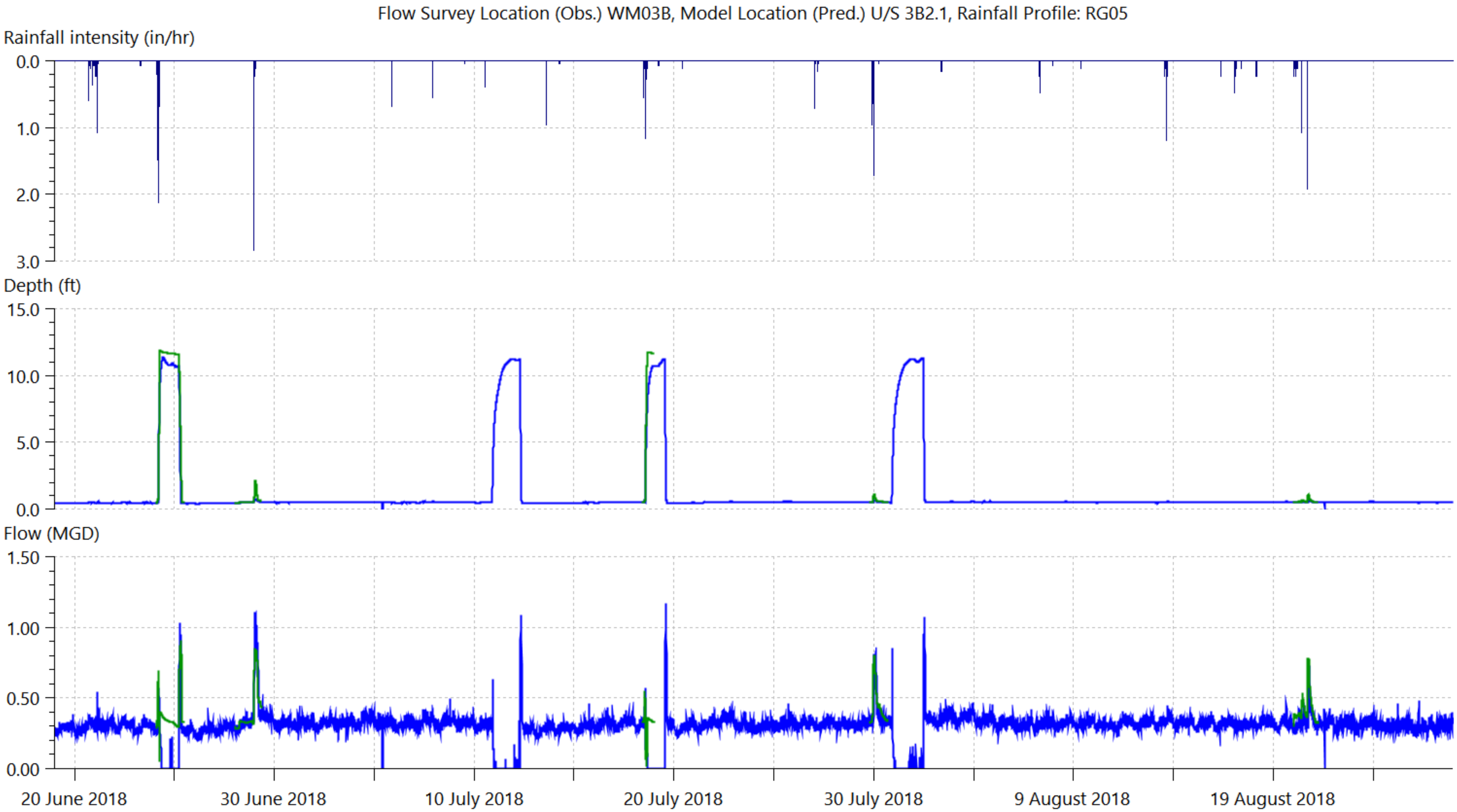
Flow Survey Location (Obs.) WM9B-0, Model Location (Pred.) U/S 9B10.1, Rainfall Profile: RG02
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
4.0
5.0
Depth (ft)
8.0
6.0
4.0
2.0
0.0
Flow (MGD)
2.00
1.50
1.00
0.50
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

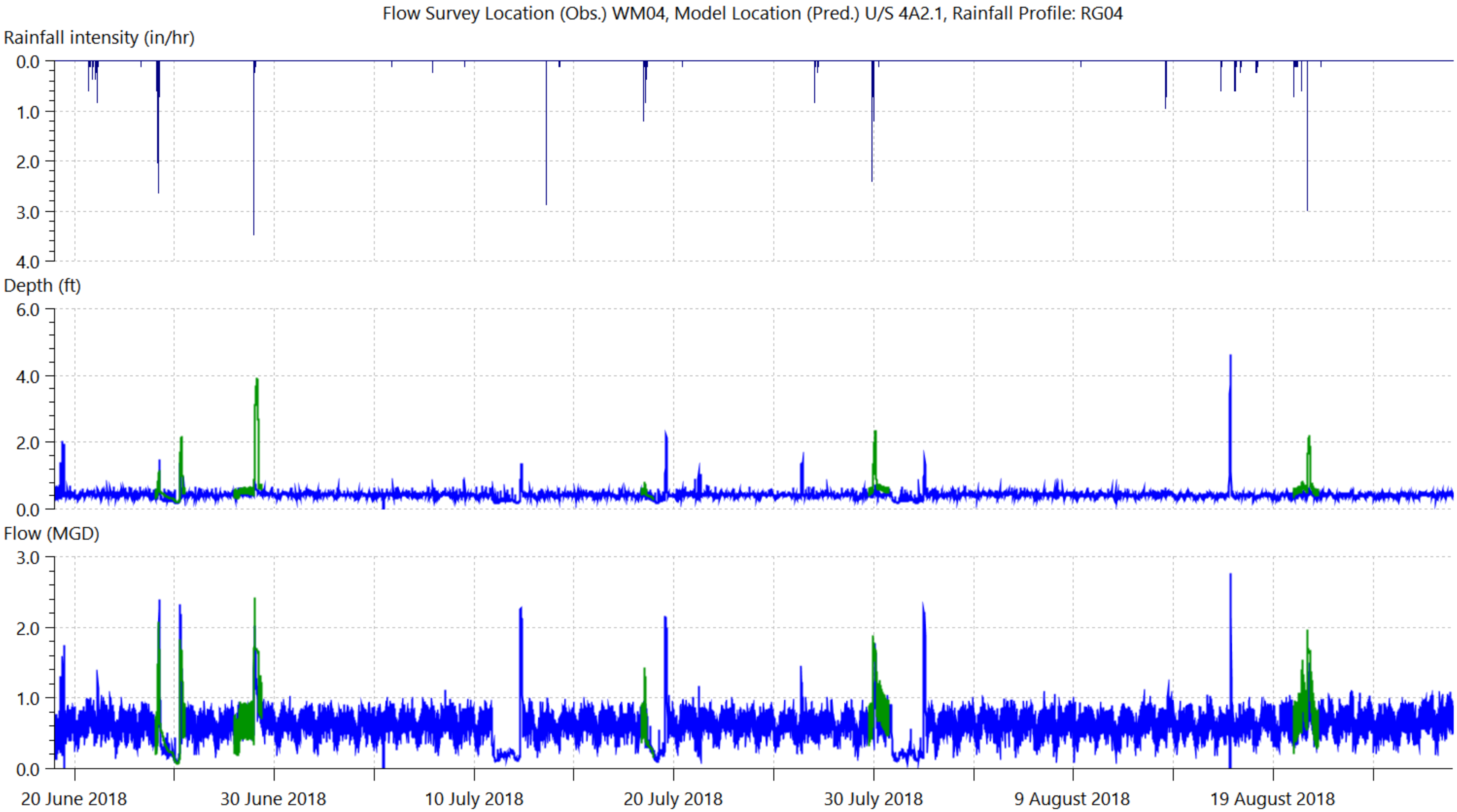


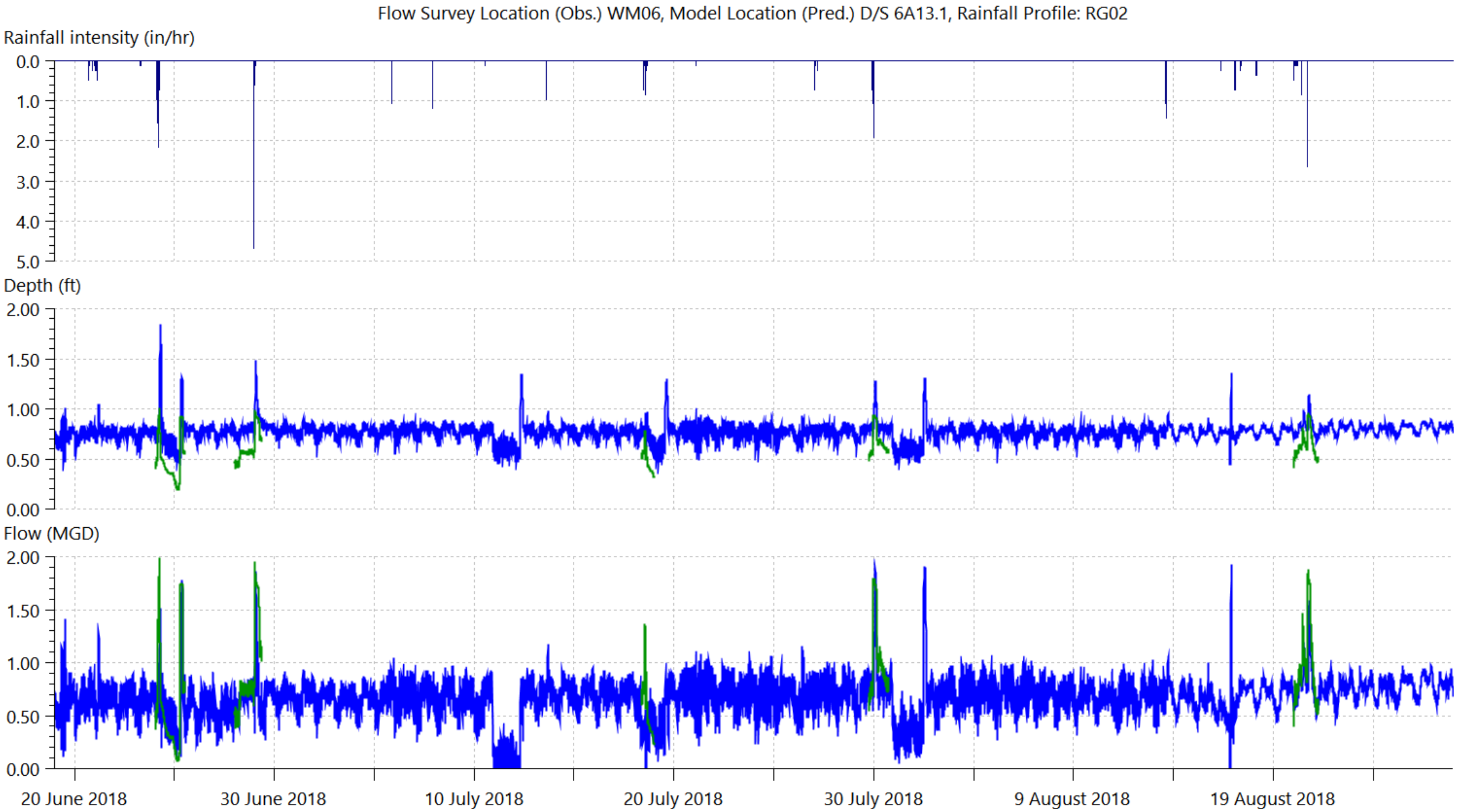
Flow Survey Location (Obs.) WM09B, Model Location (Pred.) D/S 9B1.1, Rainfall Profile: RG01
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
15.0
10.0
5.0
0.0
Flow (MGD)
3.0
2.0
1.0
0.0
-1.0
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018



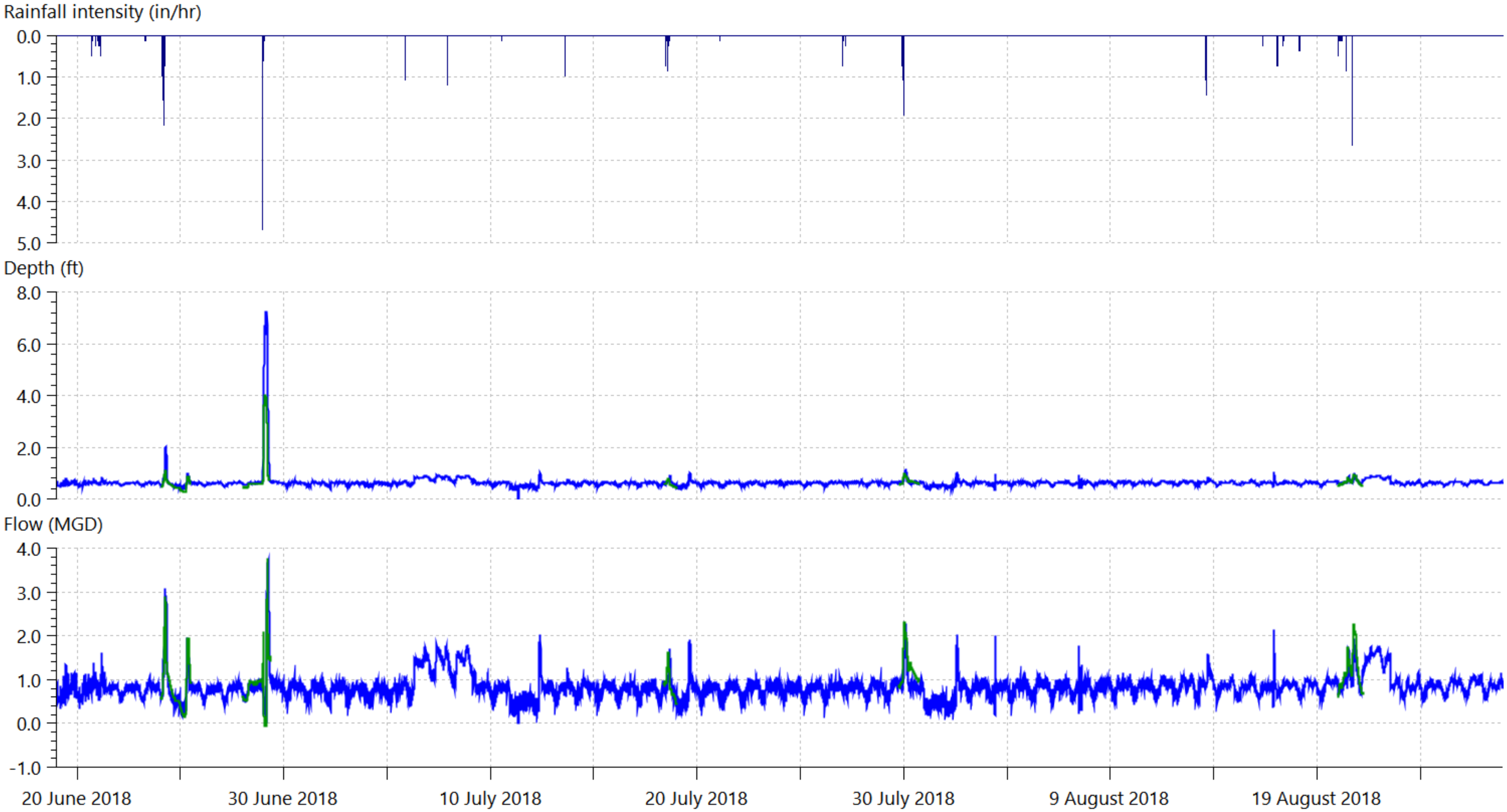
Flow Survey Location (Obs.) WM03A, Model Location (Pred.) U/S 3A2.2, Rainfall Profile: RG05
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
15.0
10.0
5.0
0.0
Flow (MGD)
1.50
1.00
0.50
0.00
-0.50
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

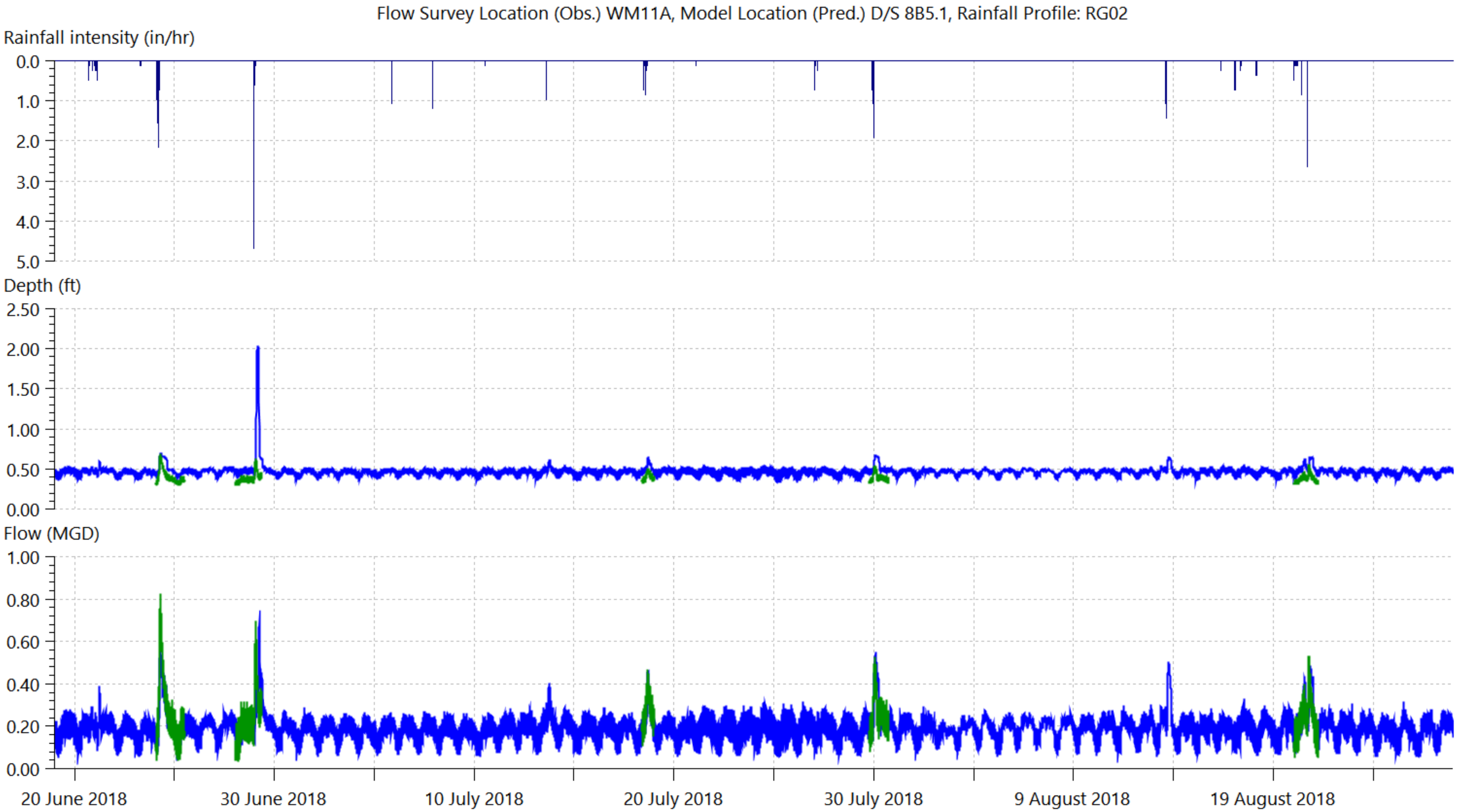

Flow Survey Location (Obs.) WM03B, Model Location (Pred.) U/S 3B2.1, Rainfall Profile: RG05
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
15.0
10.0
5.0
0.0
Flow (MGD)
1.50
1.00
0.50
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018


Flow Survey Location (Obs.) WM04, Model Location (Pred.) U/S 4A2.1, Rainfall Profile: RG04
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
4.0
Depth (ft)
6.0
4.0
2.0
0.0
Flow (MGD)
3.0
2.0
1.0
0.0
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

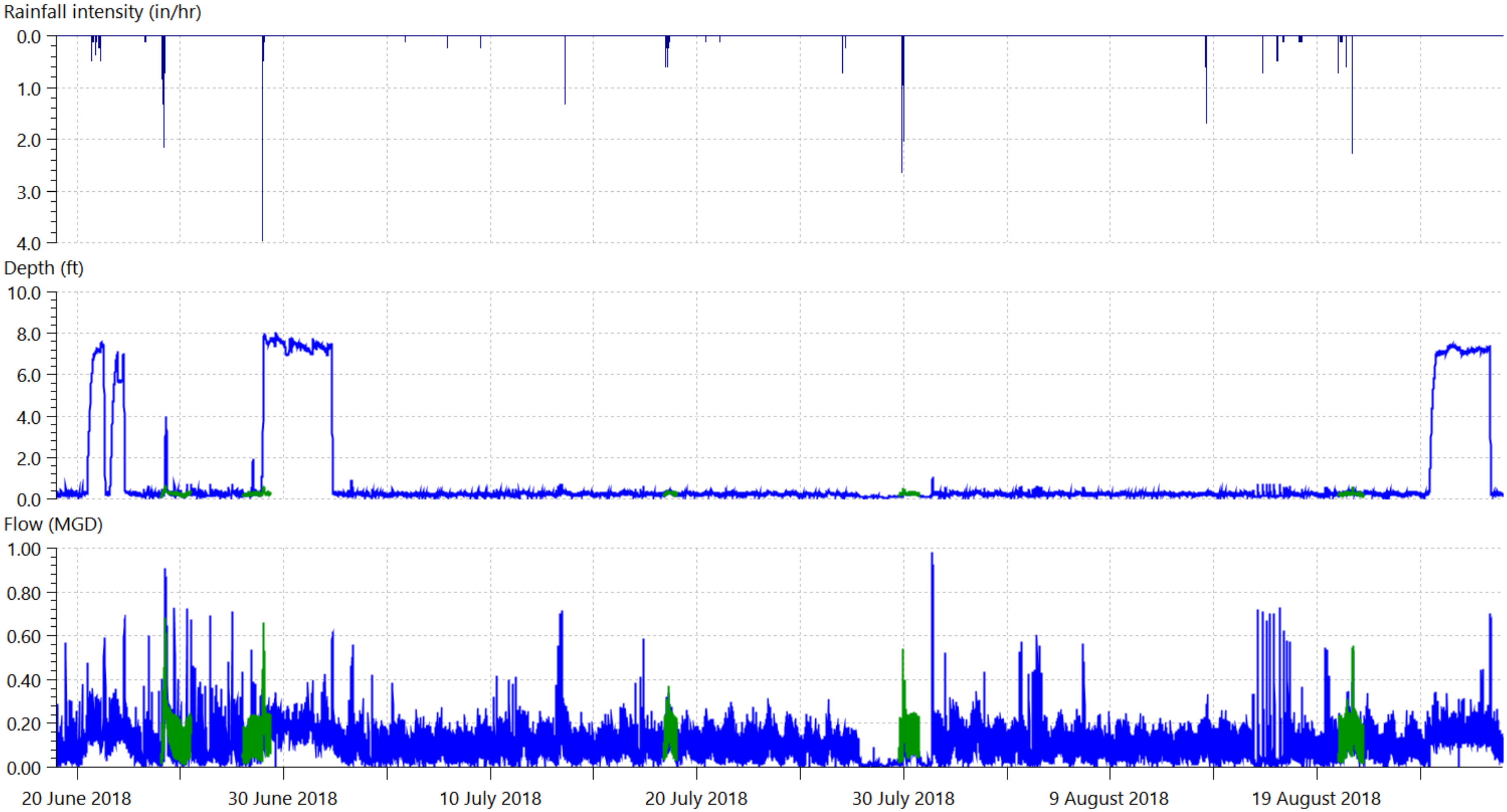

Flow Survey Location (Obs.) WM06, Model Location (Pred.) D/S 6A13.1, Rainfall Profile: RG02
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
4.0
5.0
Depth (ft)
2.00
1.50
1.00
0.50
0.00
Flow (MGD)
2.00
1.50
1.00
0.50
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

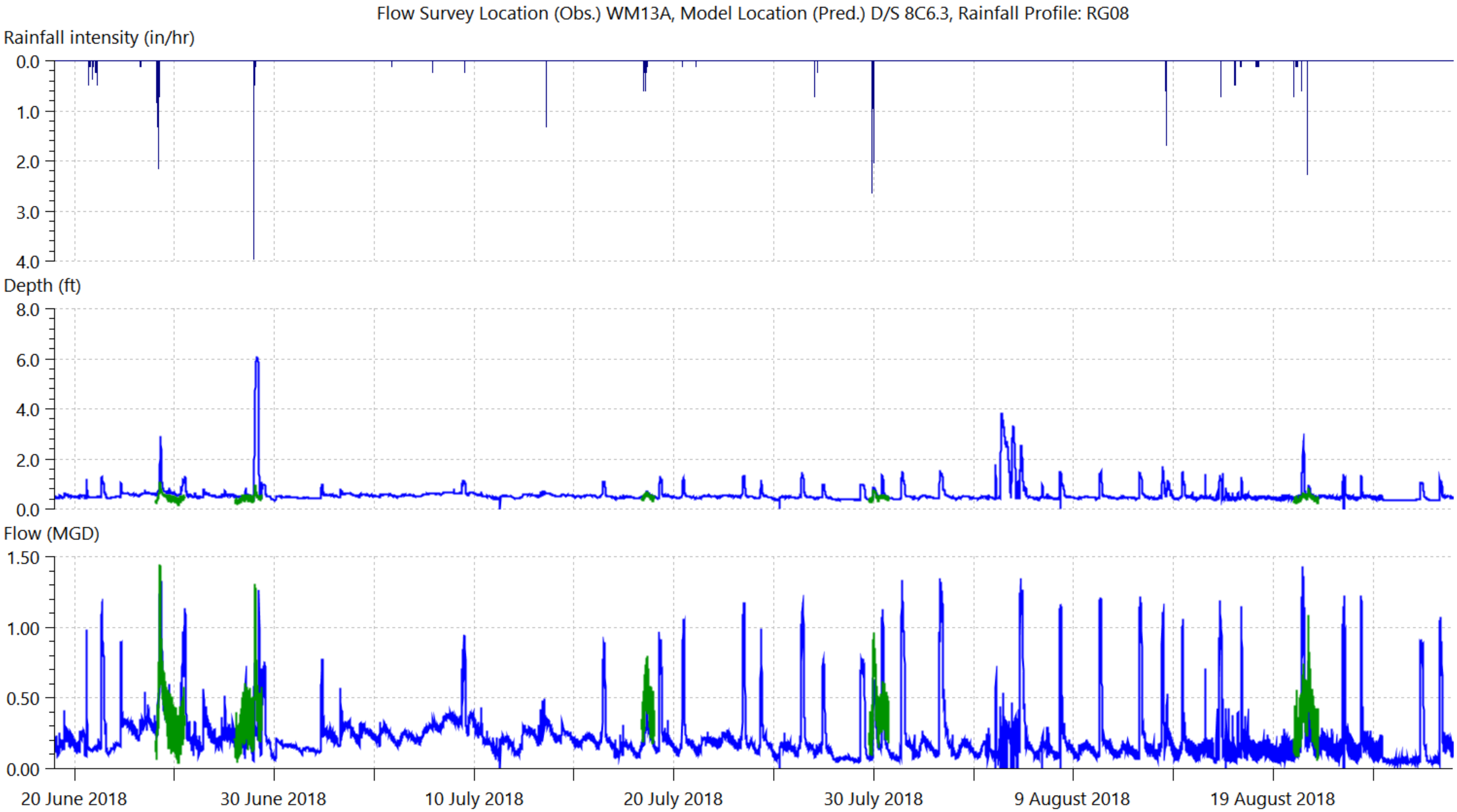
Flow Survey Location (Obs.) WM7A, Model Location (Pred.) D/S 7A6.1, Rainfall Profile: RG02




Flow Survey Location (Obs.) WM11A, Model Location (Pred.) D/S 8B5.1, Rainfall Profile: RG02
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
4.0
5.0
Depth (ft)
2.50
2.00
1.50
1.00
0.50
0.00
Flow (MGD)
1.00
0.80
0.60
0.40
0.20
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

Flow Survey Location (Obs.) WM20, Model Location (Pred.) D/S 20C2.1, Rainfall Profile: RG08

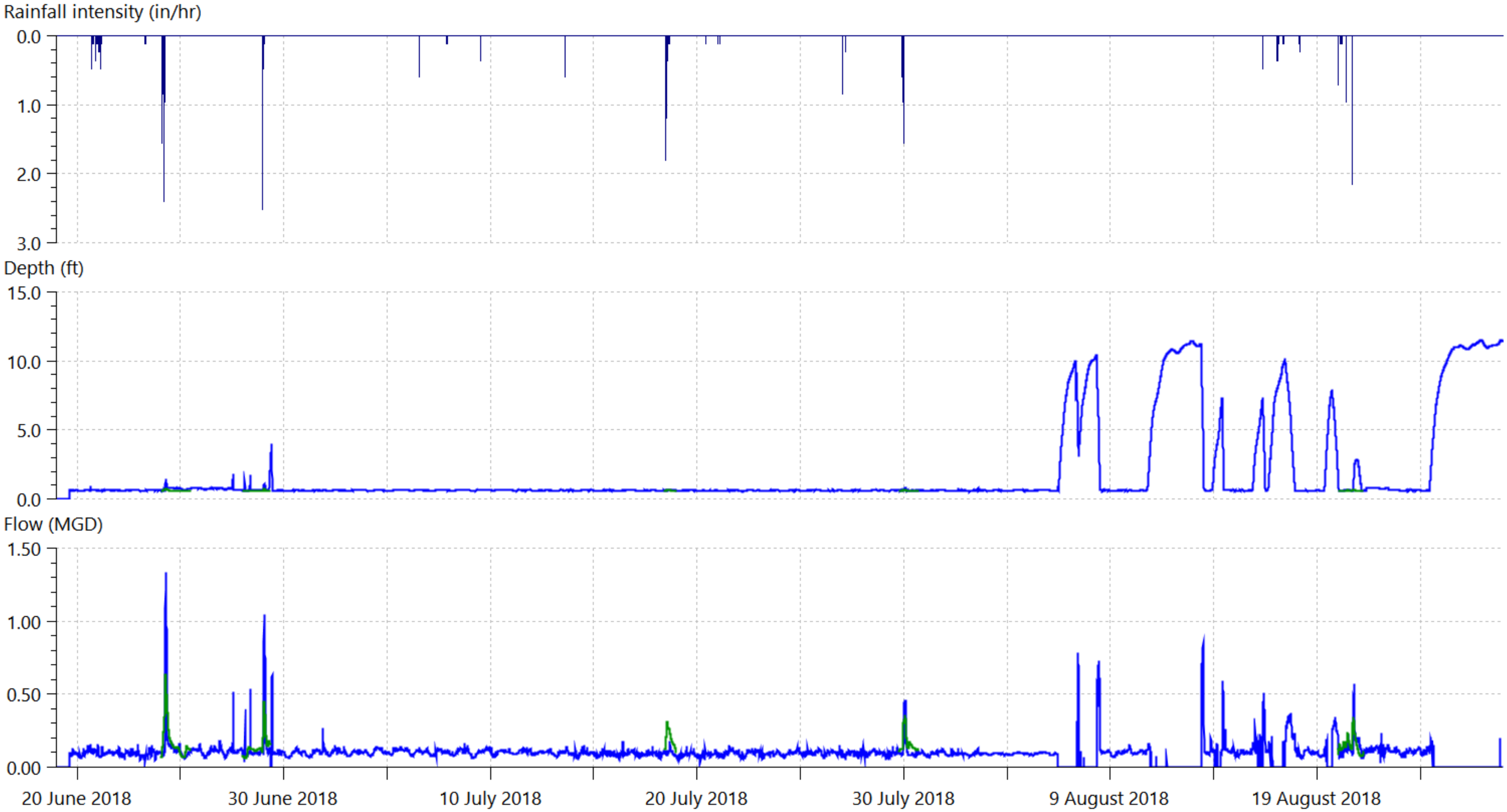




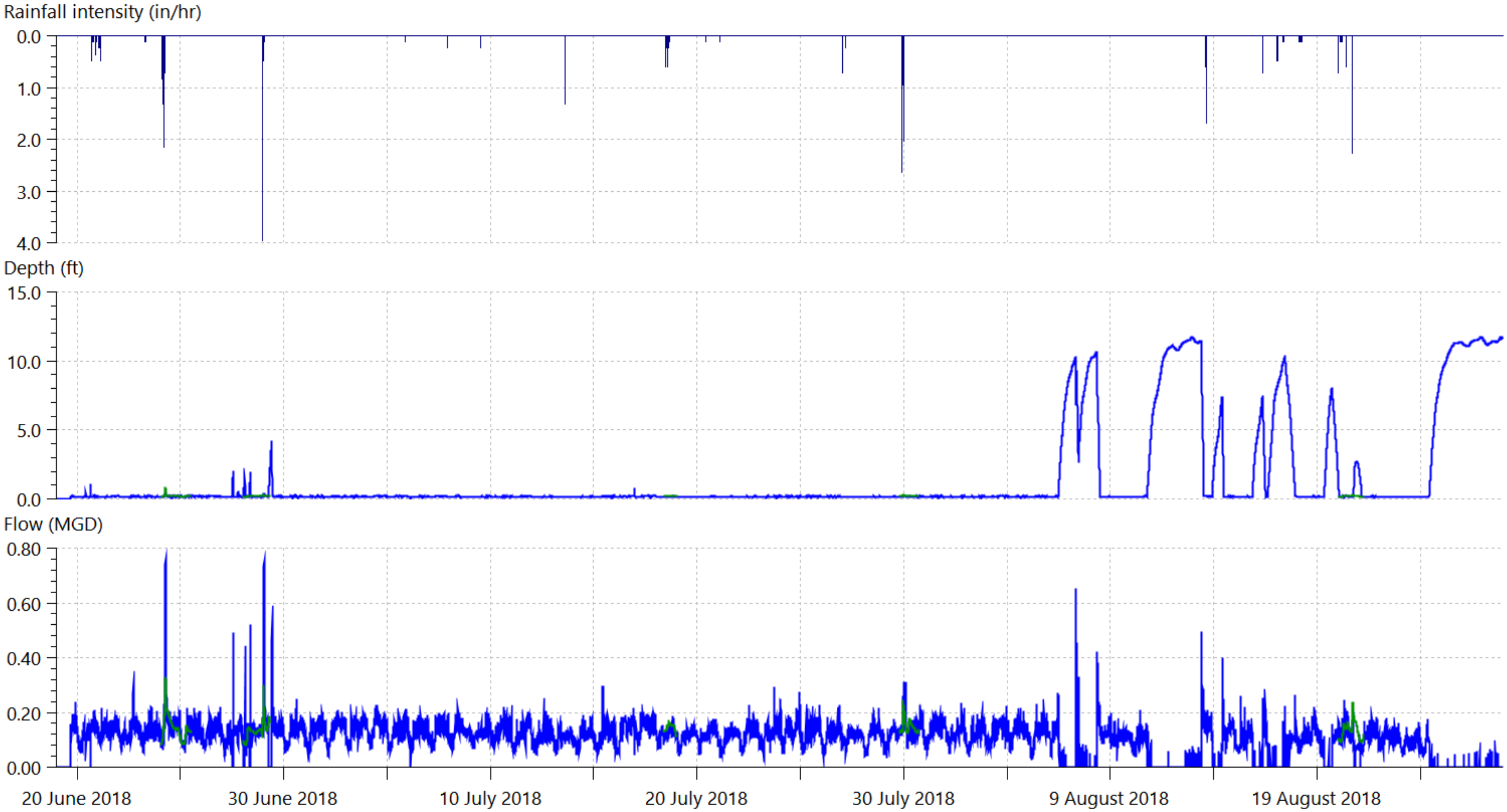
Flow Survey Location (Obs.) WM13A, Model Location (Pred.) D/S 8C6.3, Rainfall Profile: RG08
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
4.0
Depth (ft)
8.0
6.0
4.0
2.0
0.0
Flow (MGD)
1.50
1.00
0.50
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

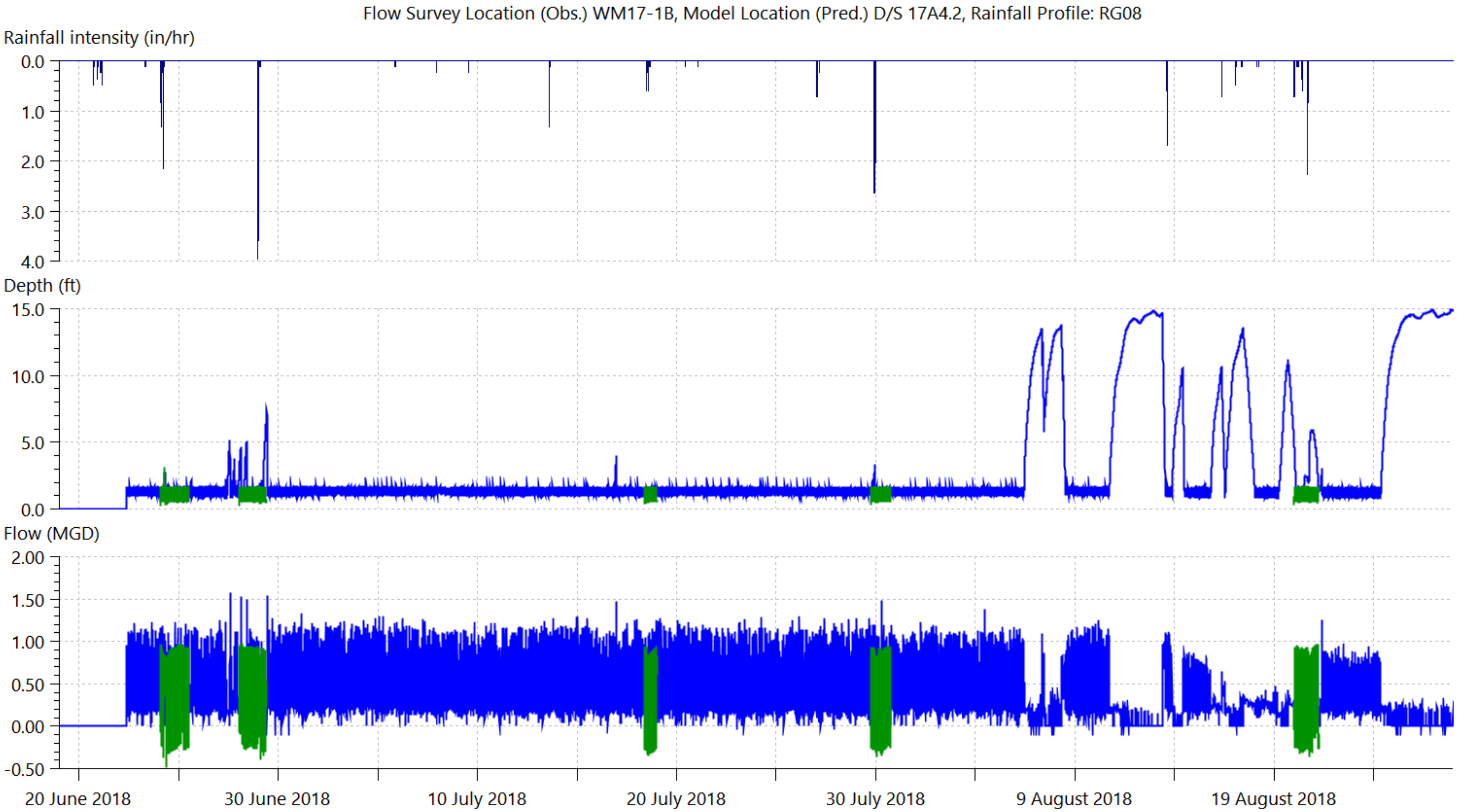
Flow Survey Location (Obs.) WM17-A, Model Location (Pred.) U/S 17aA1.1, Rainfall Profile: RG06

Flow Survey Location (Obs.) WM17-2, Model Location (Pred.) D/S 17B2.2, Rainfall Profile: RG06



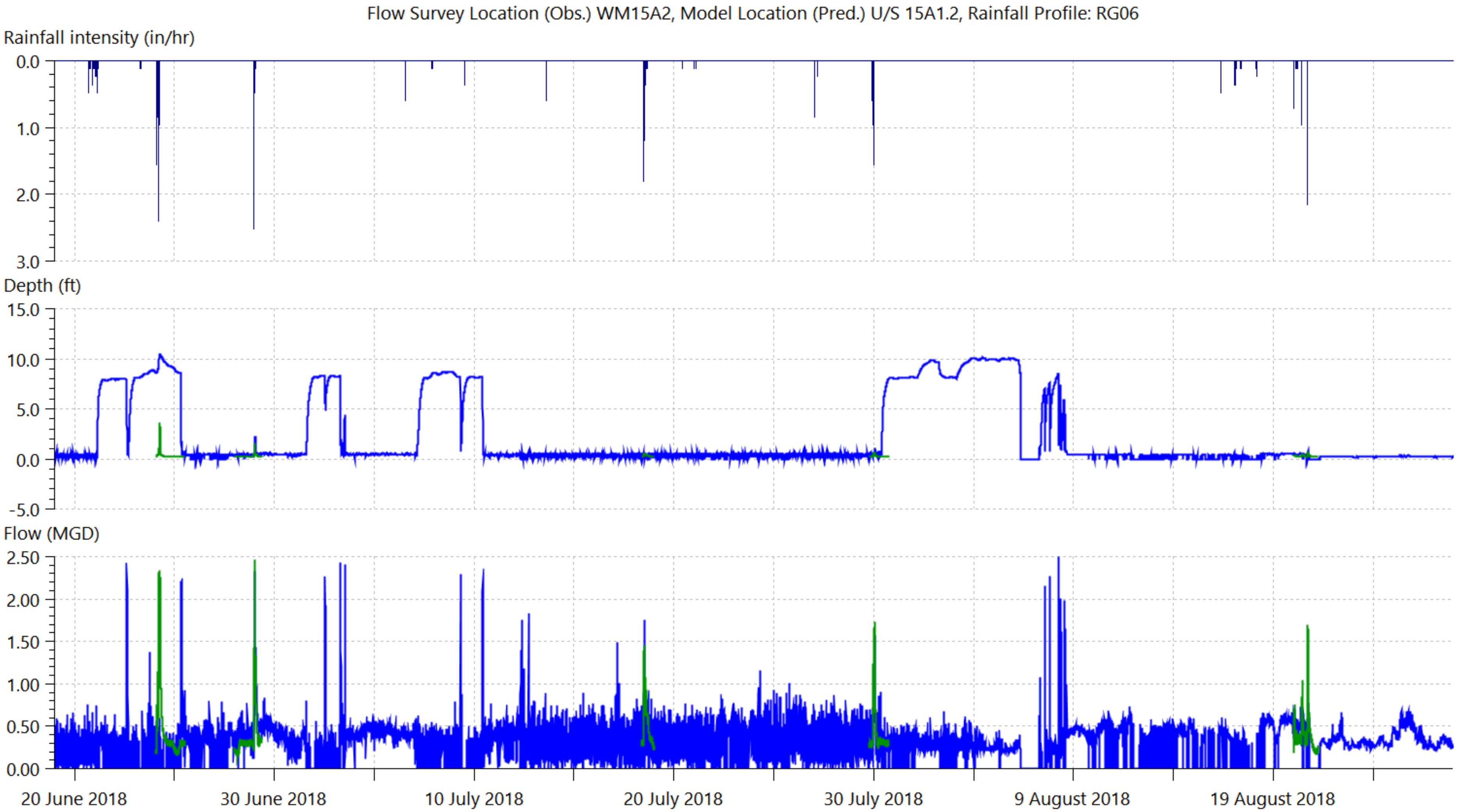
Flow Survey Location (Obs.) WM17-1A, Model Location (Pred.) D/S 17C1.1, Rainfall Profile: RG08



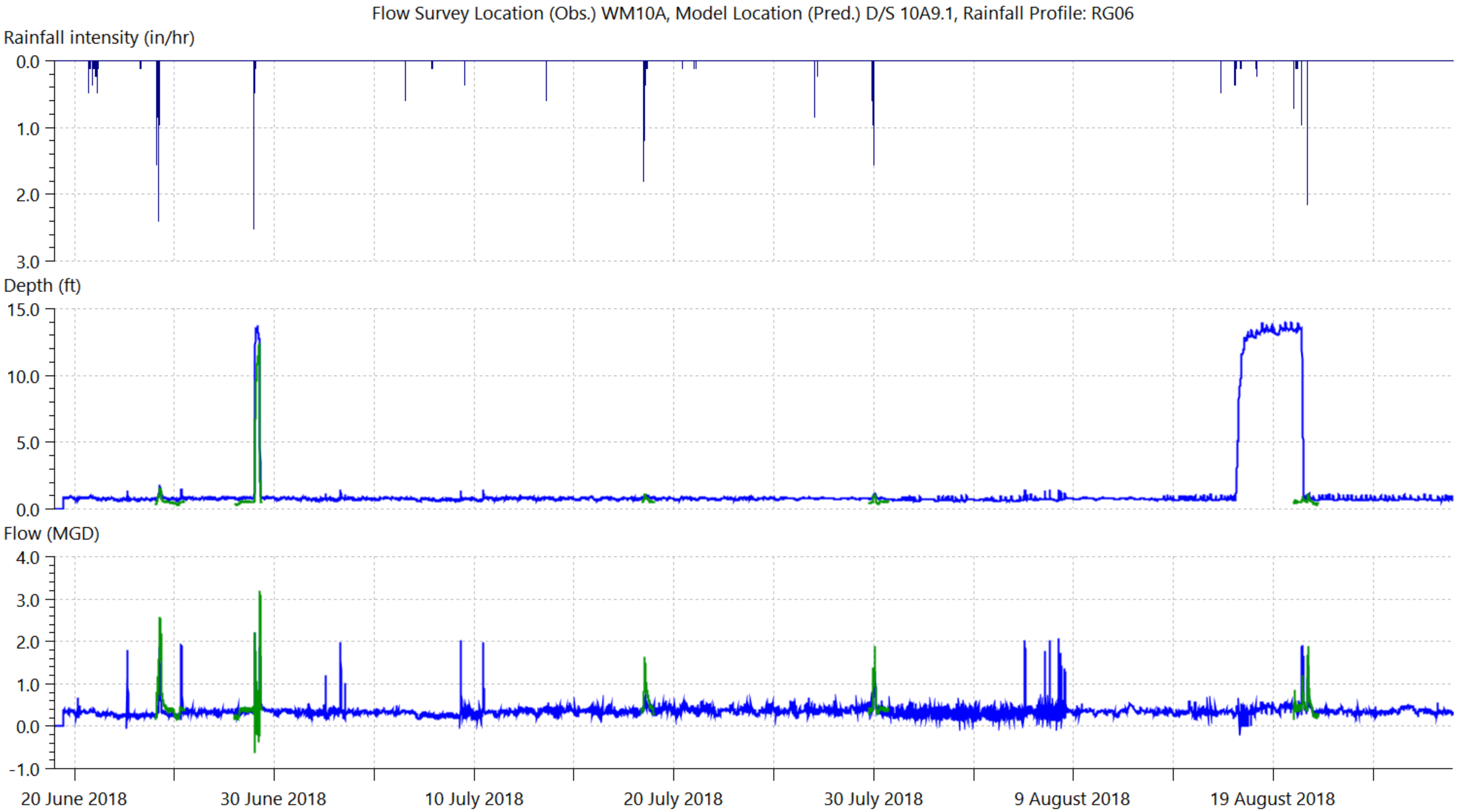


Flow Survey Location (Obs.) WM17-1B, Model Location (Pred.) D/S 17A4.2, Rainfall Profile: RG08
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
4.0
Depth (ft)
15.0
10.0
5.0
0.0
Flow (MGD)
2.00
1.50
1.00
0.50
0.00
-0.50
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

Flow Survey Location (Obs.) WM8AZ, Model Location (Pred.) D/S 8BN10.4, Rainfall Profile: RG01
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
1.50
1.00
0.50
0.00
Flow (MGD)
1.50
1.00
0.50
0.00
-0.50
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018



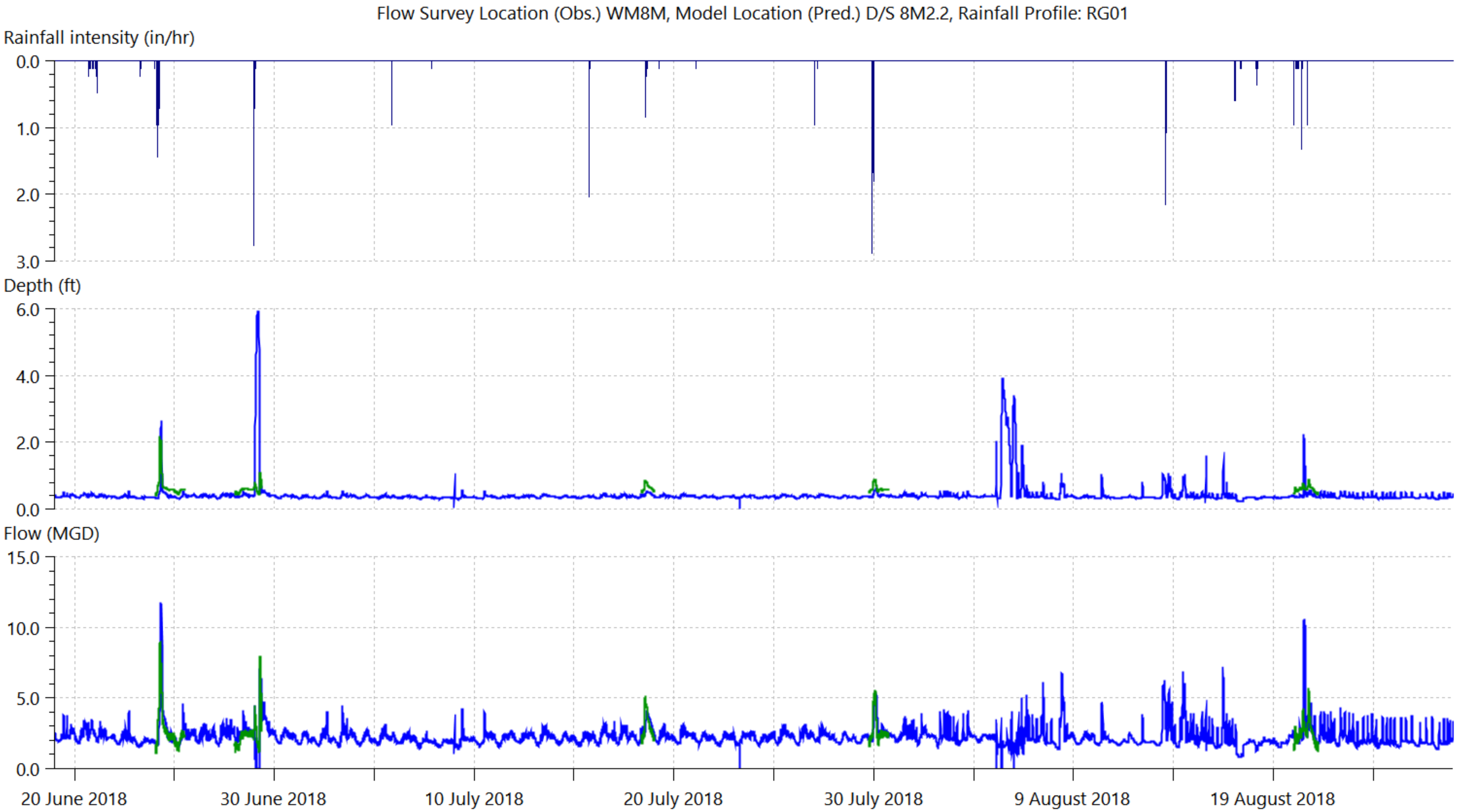
Flow Survey Location (Obs.) WM15A2, Model Location (Pred.) U/S 15A1.2, Rainfall Profile: RG06
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
15.0
10.0
5.0
0.0
-5.0
Flow (MGD)
2.50
2.00
1.50
1.00
0.50
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

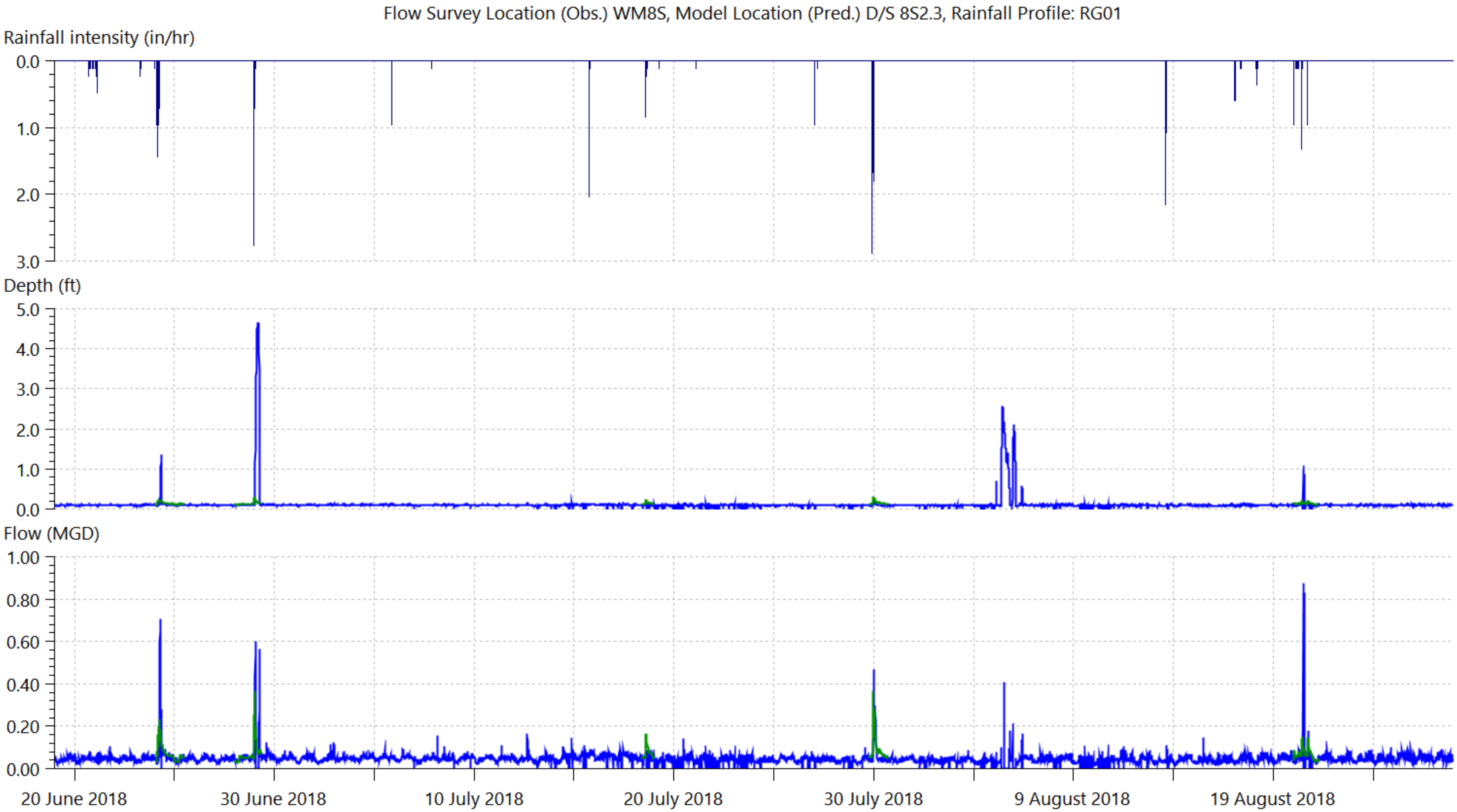


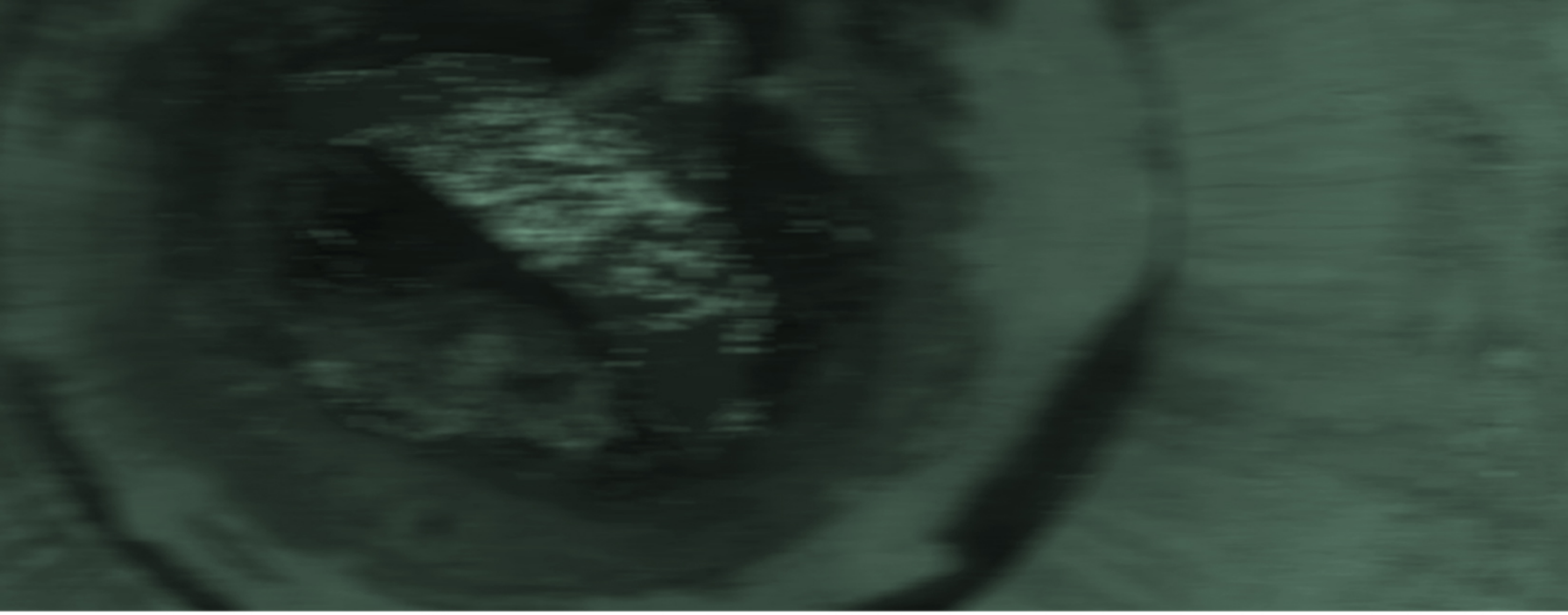
Flow Survey Location (Obs.) WM10A, Model Location (Pred.) D/S 10A9.1, Rainfall Profile: RG06
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
15.0
10.0
5.0
0.0
Flow (MGD)
4.0
3.0
2.0
1.0
0.0
-1.0
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

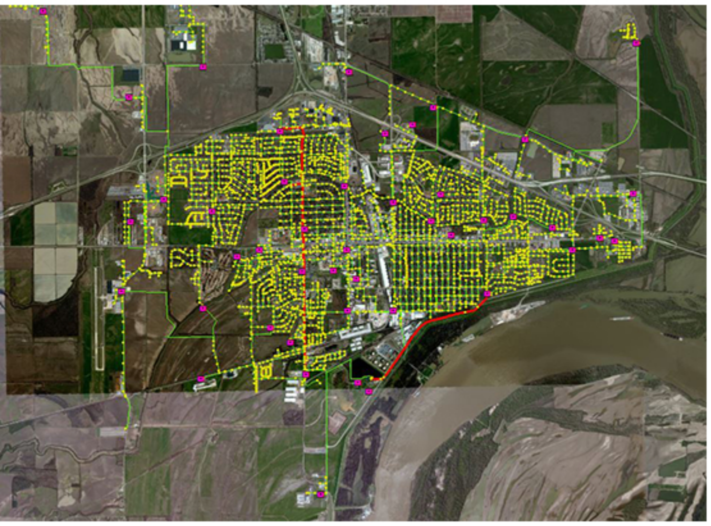
Flow Survey Location (Obs.) WM13A3, Model Location (Pred.) D/S 13A3.2, Rainfall Profile: RG06
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
8.0
6.0
4.0
2.0
0.0
Flow (MGD)
0.80
0.60
0.40
0.20
0.00
-0.20
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018

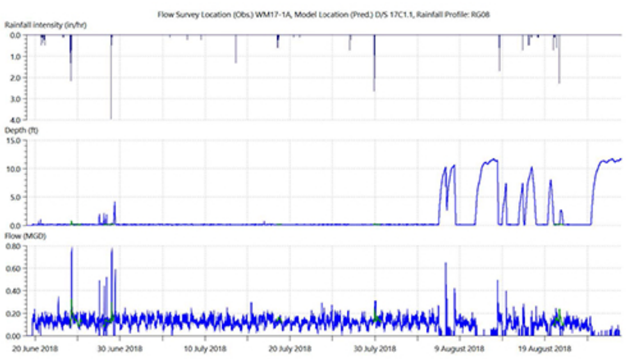
Flow Survey Location (Obs.) WM10N, Model Location (Pred.) D/S 10N2.2, Rainfall Profile: RG06
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
15.0
10.0
5.0
0.0
Flow (MGD)
8.0
6.0
4.0
2.0
0.0
-2.0
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018


Flow Survey Location (Obs.) WM8M, Model Location (Pred.) D/S 8M2.2, Rainfall Profile: RG01
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
6.0
4.0
2.0
0.0
Flow (MGD)
15.0
10.0
5.0
0.0
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018


Flow Survey Location (Obs.) WM8S, Model Location (Pred.) D/S 8S2.3, Rainfall Profile: RG01
Rainfall intensity (in/hr)
0.0
1.0
2.0
3.0
Depth (ft)
5.0
4.0
3.0
2.0
1.0
0.0
Flow (MGD)
1.00
0.80
0.60
0.40
0.20
0.00
20 June 2018
30 June 2018
10 July 2018
20 July 2018
30 July 2018
9 August 2018
19 August 2018







rjngroup

Engineering infrastructure for tomorrow

7123 Interstate 30, Suite 9 • Little Rock, AR 72209 • 501.224.2248 • www.rjn.com