Amendment No. 2
for
2010 Sewer Evaluation & Capacity Assurance Plan (SECAP) Update
April 2019

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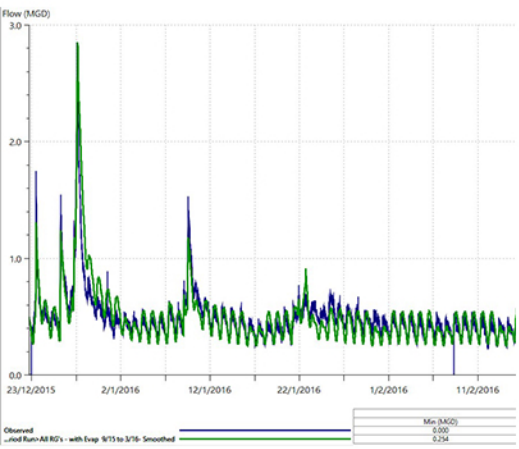

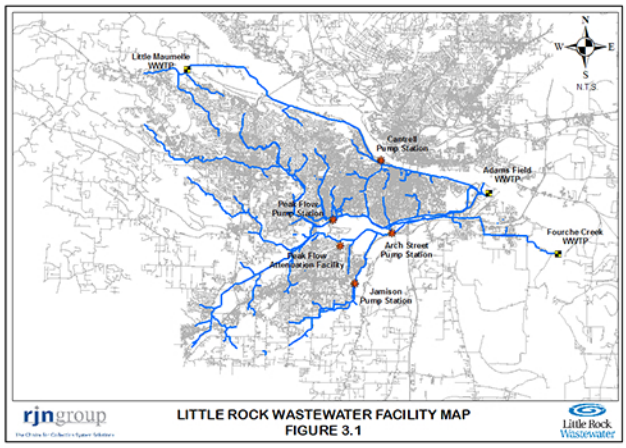

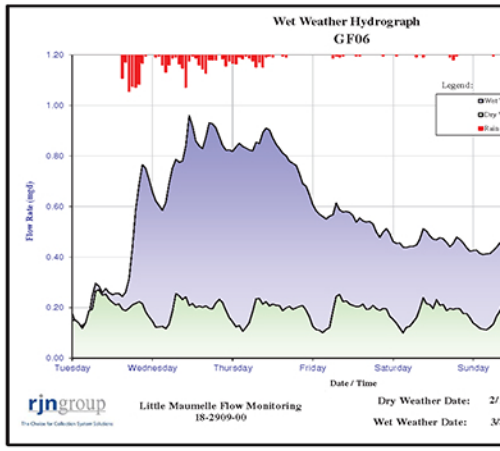

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SECAP UPDATE

2010 SEWER EVALUATION & CAPACITY ASSURANCE PLAN (SECAP)UPDATE AMENDMENT NO. 2- LRWRA

INTRODUCTION
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FIND IT / FIX IT PROGRAM
PROPOSED RAINFALL ANALYSIS – SYSTEM COMPLIANCE FRAMEWORK

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INTRODUCTION

This technical memo has been prepared to document Little Rock Water Reclamation Authority's (LRWRA) proposed updates to the 2010 SECAP Update. These proposed updates will mitigate the impact of Sanitary Sewer Overflows (SSO) in the collection system and enable compliance by 2023 for the Agreement with the Sierra Club and the Arkansas Department of Environmental Quality (ADEQ).

The key changes to the 2010 SECAP Update that will be described in this amendment are:

- In place of constructing large underground wet weather storage facilities at Rock Creek Basin / Markham Area and in the Upper Cantrell Basin, LRWRA is undertaking a Find It / Fix It Program, which is an efficient and comprehensive inflow/infiltration (I/I) reduction strategy to reduce wet weather flows and negate the need for these facilities. The Find It / Fix It Program strategy complements LRWRA's Project Renew program by continued asset renewal within the collection system.
- The 2010 SECAP Update program was developed to contain all flows from an observed storm on November 23-24, 2000, which equals approximately a 2-year, 48-hour design storm. This observed storm event has been applied to all subsequent updates and amendments to the SECAP. The September 2001 agreement with the Sierra Club had the intent that SECAP improvements would contain flows from the design storm event. As the program and compliance mechanisms have evolved, the current agreement doesn't consider the impact of ground saturation at the start of any storm or the impact of rainfall events with different durations along with the significance of back to back storm events. The revised compliance framework that incorporates the "2-year return period precipitation data" table outlined in the Sierra Club Settlement Agreement along with a 10-day look back, is proposed to provide LRWRA and ADEQ with a simple and unambiguous compliance mechanism that covers the impact of extended periods of rainfall. Additionally, as outlined within this amendment a dashboard has been created by LRWRA that allows easy access online to view rainfall totals within a 2-year 10 day curve and compliance within that curve.

BACKGROUND

The following timeline provides some historical background to the current 2010 SECAP Update:

2010 SECAP Update Program:

- Systemwide flow monitoring and rainfall data collection program.

- Using the November 2000 design storm, development of a comprehensive updated SECAP that comprised extensive system improvements/upgrades as well as the construction of four (4) major wet weather storage facilitates to contain peak flows in excess of the system capacity.

- Wet weather storage facilitates were proposed at:

    - Rock Creek Basin / Markham Area – 7 MG wet weather storage proposed to capture peak flows downstream of Rock Creek and Grassy Flat basins.

    - Upper Cantrell Basin – 4 MG wet weather storage proposed to provide surcharge relief for the Cantrell Road Pump Station (PS) which receives all flows from the Rose Creek and Rebsamen Park basins.

    - Scott Hamilton existing storage expanded with an additional 51 MG of storage

    - Adams Field WRF existing storage expanded with an additional 14 MG of storage

2010 to 2016 – SECAP Update Implementation, Concept Design and Engineering:

During the period from 2010 to 2016 LRWRA undertook a range of activities to implement the 2010 SECAP Update:

- Many projects were designed, constructed and commissioned to remove identified hydraulic throttles from the system. The remaining required projects are on schedule to be completed by 2023.

- Design consultants were engaged to commence preliminary design activities for the Rock Creek Basin / Markham Area and Upper Cantrell Basin wet weather storage facilities.

- Through SECAP Update Amendment No. 1, that was adopted by Little Rock Water Reclamation Commission (LRWRC) in April 2016, the Adams Field WRF storage needs were modified due to regulation changes in allowable wet weather discharge flows. Through detailed modeling analysis with the revised regulations in place it was determined that the additional wet weather storage at Adams Field WRF was no longer required and that the additional storage required at Scott Hamilton was reduced to 31 MG from the 51 MG determined in the 2010 SECAP Update. Due to the proposed location for the Rock Creek Basin / Markham Area and Upper Cantrell Basin wet weather storage facilities, the changes at Adams Field WRF had negligible impact on the required volume of storage at these sites.

- The preliminary design improvements undertaken for the Rock Creek Basin / Markham Area and Upper Cantrell Basin wet weather storage facilities, identified a range of challenges to the design and construction of these proposed wet weather storage

facilities including jurisdictional issues with other agencies, land availability, and utility conflicts, resulting in cost escalations and public relations.

- Given these challenges, in 2015, LRWRA commissioned a detailed flow monitoring and rain gauging program with detailed model update and recalibration in the basin's tributary to these two proposed storage facilities. The objective of these investigations and analysis was to determine the viability and extent of improvements that would be required to eliminate the need for these storage facilities through Project Renew, using the Find It / Fix It Program which addresses I/I reduction in key tributary areas.

The following section details the tasks, analysis, results and outcomes from these activities.

FIND IT / FIX IT PROGRAM

Overview

LRWRA commissioned a major Find It / Fix It Program for the:

- Rose Creek / Rebsamen Park drainage areas tributary to the Cantrell Road PS and proposed Upper Cantrell Basin Storage Facility.
- Rock Creek / Grassy Flat drainage areas tributary to the Rock Creek Main Sewer and Rock Creek Basin / Markham Area Flow Storage Facility.

The objective of these programs was to locate and quantify the sources of I/I entering these systems and develop targeted I/I removal programs sufficient to negate the need for these storage facilities.

The major tasks of the Find It / Fix It Program consisted of:

- Flow/Rainfall Monitoring:
    - Rose Creek / Rebsamen Park Area - 28 temporary flow meters, six (6) additional temporary meters for model calibration, and five (5) temporary rain gauges for a 90-day period.
    - Rock Creek / Grassy Flat Area - 31 temporary flow meters, three (3) additional temporary meters for model calibration, and five (5) temporary rain gauges for 90-day period.
- Comprehensive update, refinement and recalibration of the hydraulic model to 2016 geometry and flow conditions.
- Simulate the November 2000 design storm on the updated model.

- Determine I/I reductions achieved to date by comparing the updated model against 2009 flow conditions and rainfall events.
- Quantify the I/I response in each of the monitored sub basins.
- Through an iterative modelling analysis determine the monitored sub-basins to target and the level of I/I that would be required to eliminate the previously recommended storage facilities.
- Assess the performance of the remaining SECAP Update improvement projects against 2016 flow conditions.

Flow Monitoring and Rain Gauging

Flow monitoring was conducted for a 90-day survey period from December 23, 2015 to March 23, 2016 to collect sufficient dry and wet weather flows to recalibrate the updated model and undertake detailed I/I analysis.

Between 15.8" and 19.6" of rainfall was recorded at the ten (10) temporary rain gauges over the survey period including the following significant storm events:

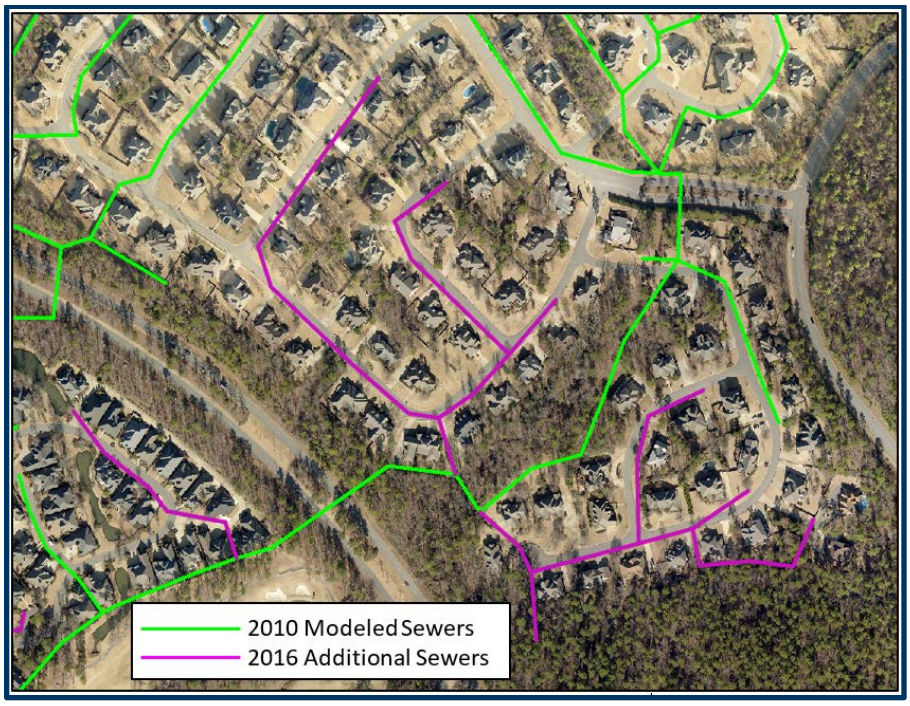
- December 25-28, 2015 – 4.3" to 6.3"
- January 7-9, 2016 – 1.5" to 1.9"
- February 23-24, 2016 – 1.4" to 1.8"
- March 8-13, 2016 – 4.7" to 5.2"

In addition to capturing data from a good range of storms to facilitate wet weather calibration, an extended dry period from mid-January to late-February provided a solid set of dry weather flow data that enabled differentiation between sanitary flows and permanent infiltration from delayed rainfall induced infiltration.

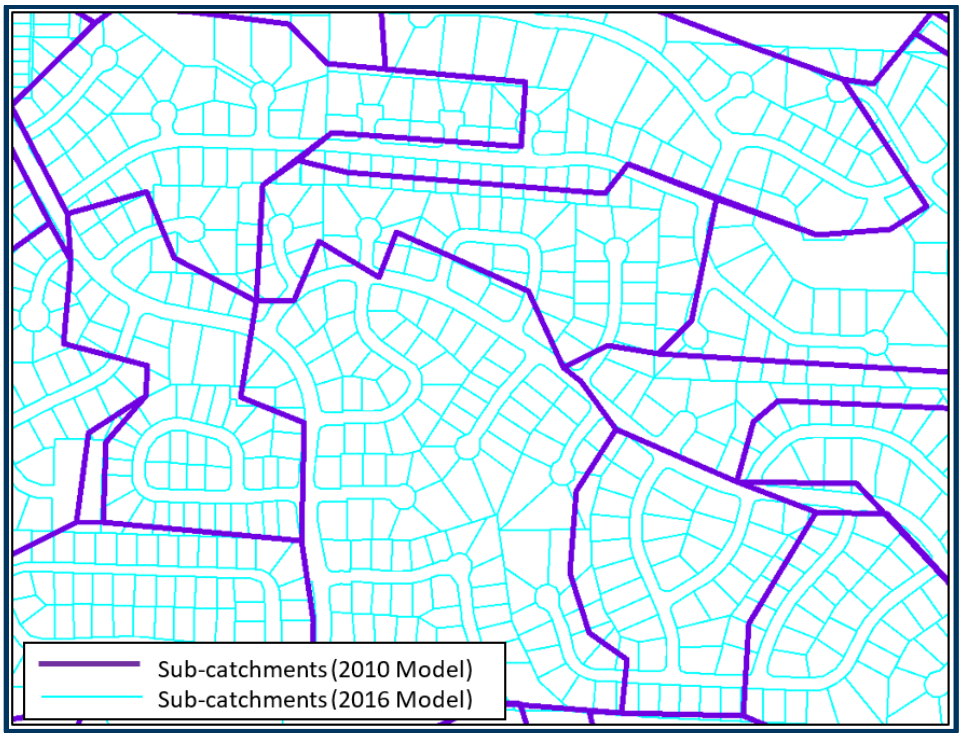
Model Update to 2016 Condition

Using the 2010 hydraulic model as a starting point, a comprehensive update was made to the 2016 Infoworks ICM hydraulic model of the complete sewerage network. The following model update tasks were completed as part of this study:

- LRWRA's GIS had been significantly refined and expanded between 2010 and 2016. The model update included all sanitary sewers from LRWRA's GIS, including those that had not previously been included in the model. The additional pipework enabled the model to better reflect attenuation of flows in the system as well as the surcharge storage that is mobilized during significant wet weather events as illustrated in the following figure.



- As-built plans were used to include all recently constructed sanitary sewer infrastructure.
- All sewer relining/relaying projects completed since 2010 were updated into the model.
- The model was updated with pipe and MH data from "Record" drawings obtained from LRWRA's online mapping system where issues and conflicts were identified.
- All new development post-2010 was incorporated into the model.
- Non-residential dry weather flows updated using 2015-2016 water billing data provided by Central Arkansas Water to LRWRA.
- Residential dry weather flows were updated using customer address point data provided by LRWRA and 2010 census data.
- Due to the unavailability of detailed property parcel data in 2010, the modeled subcatchments were manually digitized with an average area of approximately 20 acres. A GIS layer provided by LRWRA containing detailed property parcels was made available in 2016. The previous subcatchments were deleted from the model and substituted with the individual property parcels. Loading the model with flows from individual parcels provides a better distribution of dry and wet weather flows into the sewer network, eliminates the need for time of concentration assumptions and provides a robust platform for future redevelopment assessment. The following figure compares the difference in level of detail between the 2010 and 2016 sub catchments.



Model Calibration

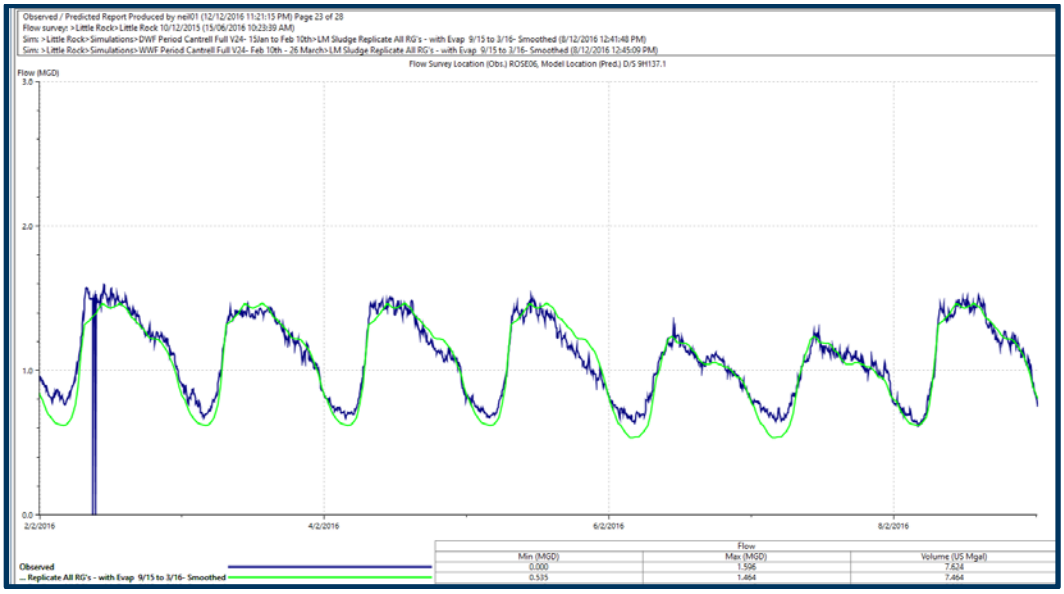
Model calibration is the process through which model variables and coefficients are adjusted through multiple iterations until model predicted flow, depth, and velocity matches within a reasonable accuracy to the observed flow meter recorded data. The model was calibrated to replicate the sewerage system performance in both dry-weather and wet-weather conditions.

The 7-day period selected for dry weather calibration ran from February 2, 2016 thru February 8, 2016. Using data collected from flow meters downstream of primarily residential areas, residential weekday and weekend dimensionless diurnal profiles were developed through a process of groundwater subtraction and normalization to modulate the residential flows into the model initially applying a per capita flow rate of 80 gpd/person. The volume of non-residential flows into the model was initially estimated based on a 90% return to sewer of billed water consumption, with flows modulated with an assigned a standard commercial/industrial profile representative of the land use activity.

Through an iterative process, adjustments were made to residential per capita flow rates, diurnal profiles, non-residential return to sewer ratios and diurnal profiles as well as permanent infiltration rates until a satisfactory level of calibration was achieved across the network.

The following figure illustrates an example of the comparison between recorded dry weather flows (DWF), in blue and model predicted flow, in green, for the selected DWF period which ran from Tuesday morning through to Monday evening. Note the reduced flows over the weekend

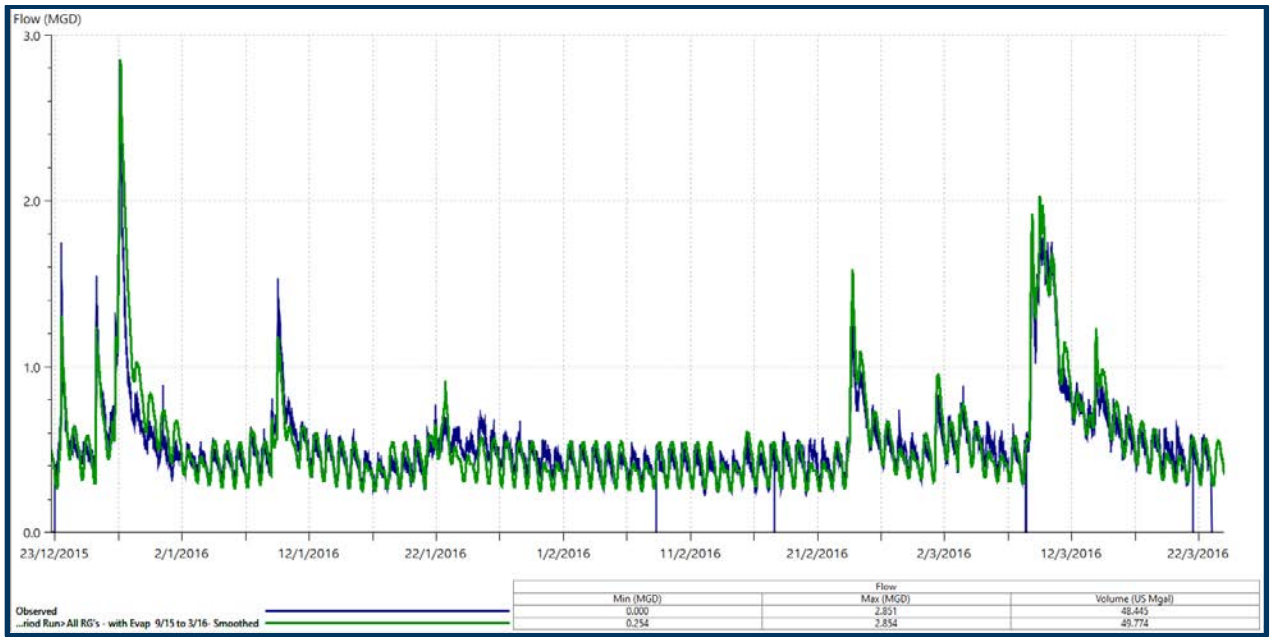
captured by this monitor located downstream from a portion of the Little Rock Central Business District.



Wet weather flows (WWF) are generated within the model by assigning the recorded time series of rainfall from a nearby rain gauge to each model sub-catchment and combining with hydrological parameters to reflect the system response to rainfall. To achieve a suitable level of calibration it was necessary to iteratively adjust the hydrological parameters and compare with the recorded flows and surcharge depths at each meter site.

Following each significant rainfall event, it took several days at some sites for flows to recede to the normal dry weather pattern. In many cases the flows were still elevated when the wet weather response to a subsequent storm came through. To ensure that the full hydrological cycle was accurately simulated the wet weather calibration was achieved by running the model over the full observed survey period. Overall the calibrated model provided a good representation of the 2016 dry and wet weather flows and system hydraulics.

The following figure illustrates a comparison between the recorded flows in blue, and the model predicted flows, in green, over the full survey period.



Capacity Analysis

The calibrated model was simulated with the November 2000 design storm and the analysis indicated a high level of correlation with the documented SSO locations, providing confidence in its use as a platform to determine the extent of I/I reduction necessary to negate the need for the Peak Flow Storage Facilities in Rock Creek Basin/Markham Area and Upper Cantrell Basin.

A copy of the calibrated model was modified to include all outstanding capital improvements from the 2010 SECAP Update other than the two proposed wet weather storage facilitates. Through an iterative process, I/I parameters were modified to reflect various levels of I/I reduction in the basins with the highest levels of I/I and simulated on the model with the design storm until all SSOs were mitigated and the need for the Peak Flow Storage Facilities eliminated.

Revised SECAP Update– Rose Creek & Rebsamen Park Drainage Areas (Cantrell Road)

The sewers in the Rose Creek and Rebsamen Park areas are some of the oldest in Little Rock and most of the monitored sub-basins indicated a reasonably high level of I/I. The analyses determined that an average I/I reduction in the entire tributary area of 35% will achieve the goals of eliminating the recommended Storage Facility and mitigate the SSOs to the design storm threshold.

Following construction of the rehabilitation improvements, further flow and rainfall monitoring surveys will be undertaken, the model recalibrated to reflect the reduced flows, and modelling analysis undertaken to confirm effectiveness of Find It / Fix It Program.

Revised SECAP Update– Rock Creek & Grassy Flat Drainage Areas (Rock Creek)

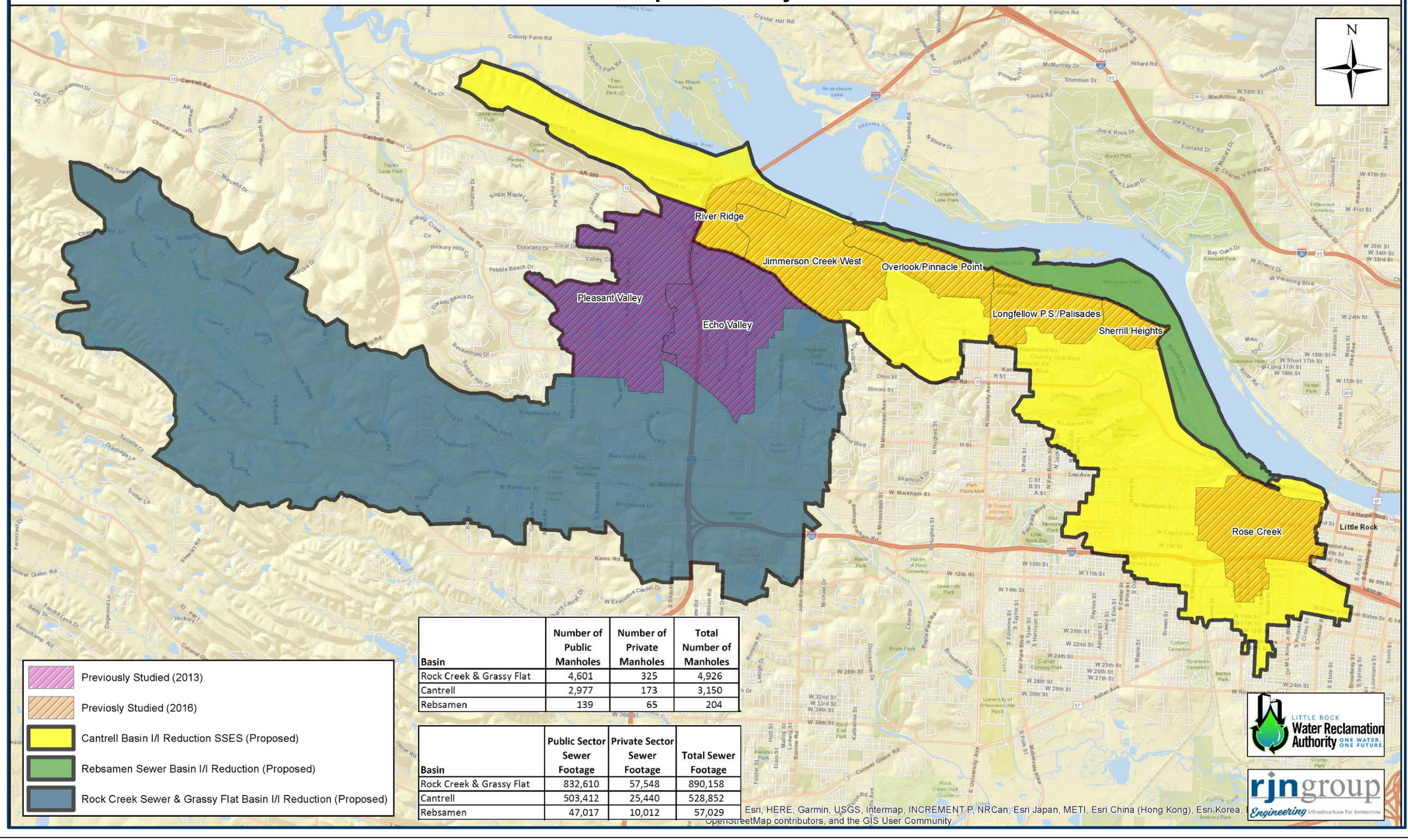
The sewers in the Rock Creek and Grassy Flat areas are generally newer than those in the Cantrell Road area and calibration results illustrated a wide range of I/I rates. By targeting those monitored basins with the highest I/I rates for I/I reduction the analyses determined that an average I/I reduction of 35% was required in the following ten sub-basins to prevent SSOs and negate the need for the Rock Creek Storage Facility. Those sub-basins where the Find It/Fix It program will target in Rock Creek & Grassy Flat are the following:

- ROCK05
- ROCK17
- GF12
- ROCK18
- GF09
- GF07
- GF11
- ROCK03
- GF10
- GF06 basins.

Following construction of the rehabilitation improvements, further flow and rainfall monitoring surveys will be undertaken, the model recalibrated to the reflect the reduced flows and modelling analysis undertaken to confirm effectiveness of Find It / Fix It program.

The following figure illustrates the proposed Find It / Fix It program's study areas to eliminate the wet weather storage facilities.

LRWRA
Proposed Study



Basin	Number of Public Manholes	Number of Private Manholes	Total Number of Manholes
Rock Creek & Grassy Flat	4,601	325	4,926
Cantrell	2,977	173	3,150
Rebsamen	139	65	204

Basin	Public Sector Sewer Footage	Private Sector Sewer Footage	Total Sewer Footage
Rock Creek & Grassy Flat	832,610	57,548	890,158
Cantrell	503,412	25,440	528,852
Rebsamen	47,017	10,012	57,029

PROPOSED RAINFALL ANALYSIS – SYSTEM COMPLIANCE FRAMEWORK

Background

The September 12, 2001 agreement between the Sierra Club and the Little Rock Sanitary Sewer Committee, predecessor to the current LRWRC, defined that the long-term goal of the program was to "eliminate Capacity-Related SSOs, except for Capacity – Related SSOs caused by a storm event greater than the Design Storm Event".

The "Design Storm Event" was defined in the following 2-year return period precipitation data table published by the U.S Department at the time of the Agreement listed below.

2-Year Return Period Precipitation Data		
Storm Duration (Hours)	2-Year Intensity (Inches/Hour)	Given Duration Rainfall Total Required for 2-Year Event (Inches)
0.5	2.80	1.4
1	1.85	1.9
2	1.15	2.3
5	0.60	3.0
12	0.30	3.6
24	0.175	4.2
36	0.125	4.5
48	0.100	4.8
72	0.074	5.3
96	0.057	5.5
120	0.048	5.8

During the development of the 2001 SECAP, the Consultant and LRWRA selected an observed storm from November 2000, with characteristics closely resembling a 2-year, 48-hour event, as the "design storm" to be used to assess and compare augmentation options.

To maintain consistency, all subsequent SECAP updates and amendments have been developed using the same November 2000 design storm.

Design Storm Rainfall Analysis

LRWRA commissioned a study to analyze recent historic rainfall data and system performance and assess different mechanisms with the objective of developing:

"*A simple and unambiguous framework that provides LRWRA and ADEQ with a reasonable but enforceable mechanism for determining compliance in all climatic conditions*".

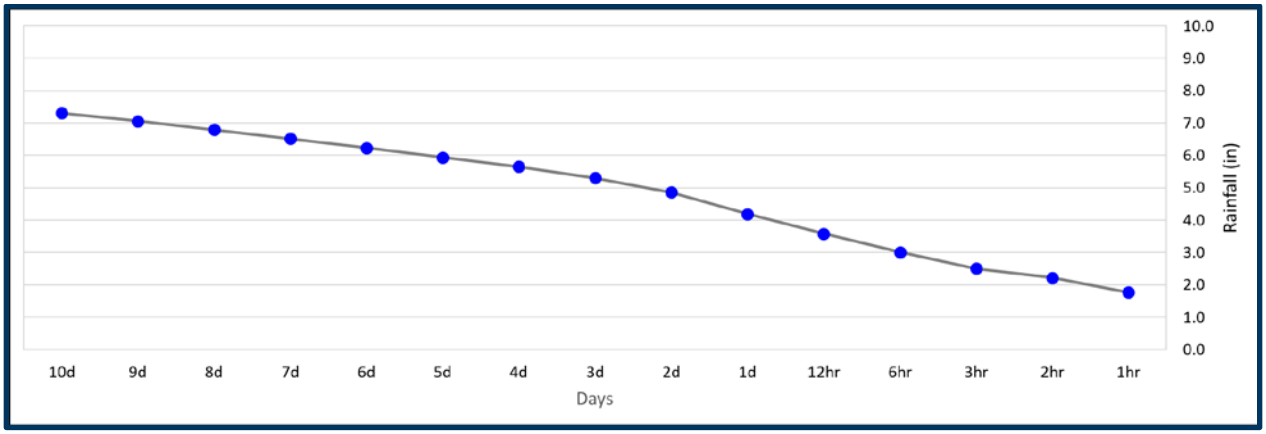
The following details the key steps taken during the analysis.

- The National Oceanic and Atmospheric Administration (NOAA) is now the defined agency under the Department of Commerce with the responsibility to "understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others". NOAA has recently published updated rainfall depth duration frequency data which was accessed for the Adams Field gauging location.

- The following NOAA table defines the rainfall depths for 2-year ARI (Average Return Interval) storm events of durations from 1-hour to 10-days. These revised rainfall depths are similar to those in the original Sierra Club Settlement Agreement. NOAA updated their rainfall intensities based on duration in 2017.

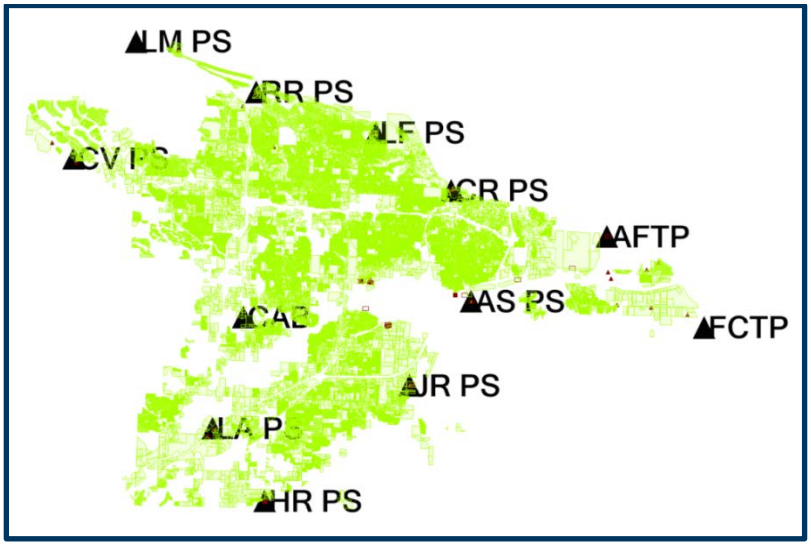
ARI	10-day	9-day	8-day	7-day	6-day	5-day	4-day	3-day	2-day	1-day	12-hr	6-hr	3-hr	2-hr	1-hr
1 Yr	6.41	6.19	5.96	5.72	5.46	5.21	4.96	4.65	4.26	3.68	3.14	2.67	2.220	1.970	1.560
2 Yr	7.31	7.06	6.79	6.52	6.23	5.94	5.65	5.30	4.86	4.19	3.58	3.01	2.50	2.220	1.770
5 Yr	8.62	8.35	8.07	7.78	7.44	7.14	6.82	6.42	5.92	5.12	4.32	3.59	2.96	2.630	2.500

- When plotted on a graph with time on the horizontal axis and cumulative rainfall depth on the vertical axis, the following "2-year, 10-day compliance curve" can be created.



- If the cumulative rainfall from any rain gauge readings does not exceed the curve for all durations and an SSO occurs, LRWRA would be out of compliance. If the cumulative rainfall readings at any rain gauge exceeds the curve and an SSO occurs, the storm event exceeds a 2-year design storm then LRWRA would be in compliance with the Consent Administrative Order (CAO).

- Historic rainfall data was sourced from the 12 permanent LRWRA rain gauge network illustrated below for the 3-year period from 2015 through 2017.



- The 5-minute rainfall data from each gauge was processed to calculate the cumulative rainfall at each gauge site for durations from 1-hour to 10-days. The greatest rainfall depth at any of the gauge sites was then determined for each duration and assessment made of occasions when the maximum recorded rainfall was "above the curve", i.e. greater than a 2-year design storm curve, as defined in the Sierra Club Settlement Agreement.

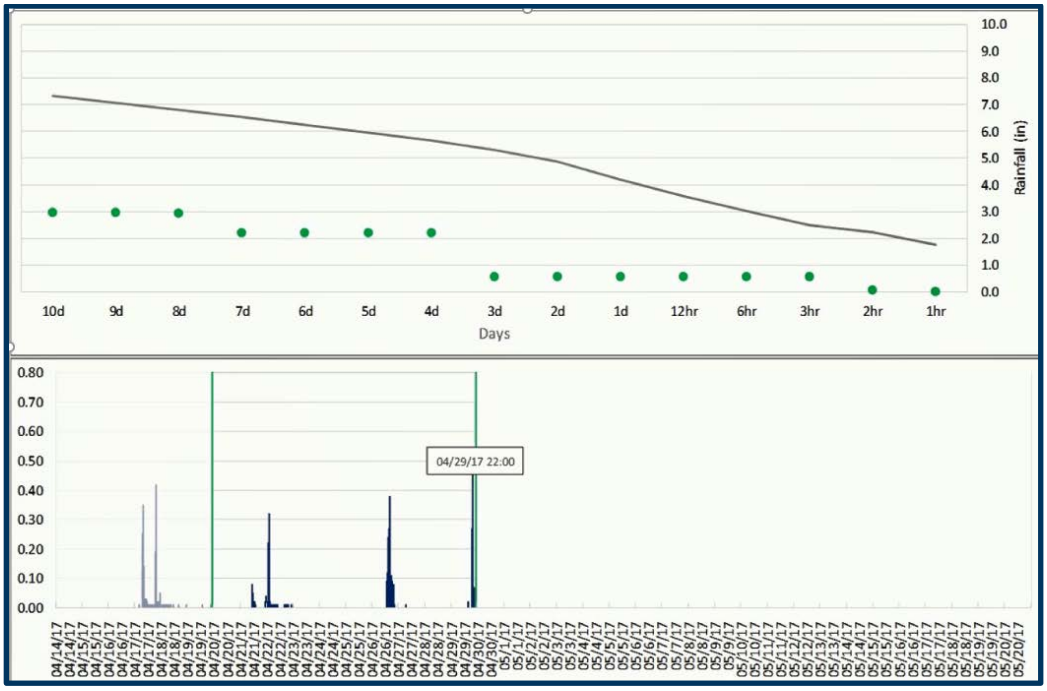
- An analysis was then undertaken of the actual system compliance over the period 2015 through 2017. During this period LRWRA reported 25 occasions when non-exempt SSOs occurred from storms less than 4.1" in a 24-hour time period. Using the revised rainfall analysis extending to 10-days demonstrated that on six (6) of these "non-exempt" occasions LRWRA were in compliance with the CAO.

Rainfall Analysis – Compliance Tool

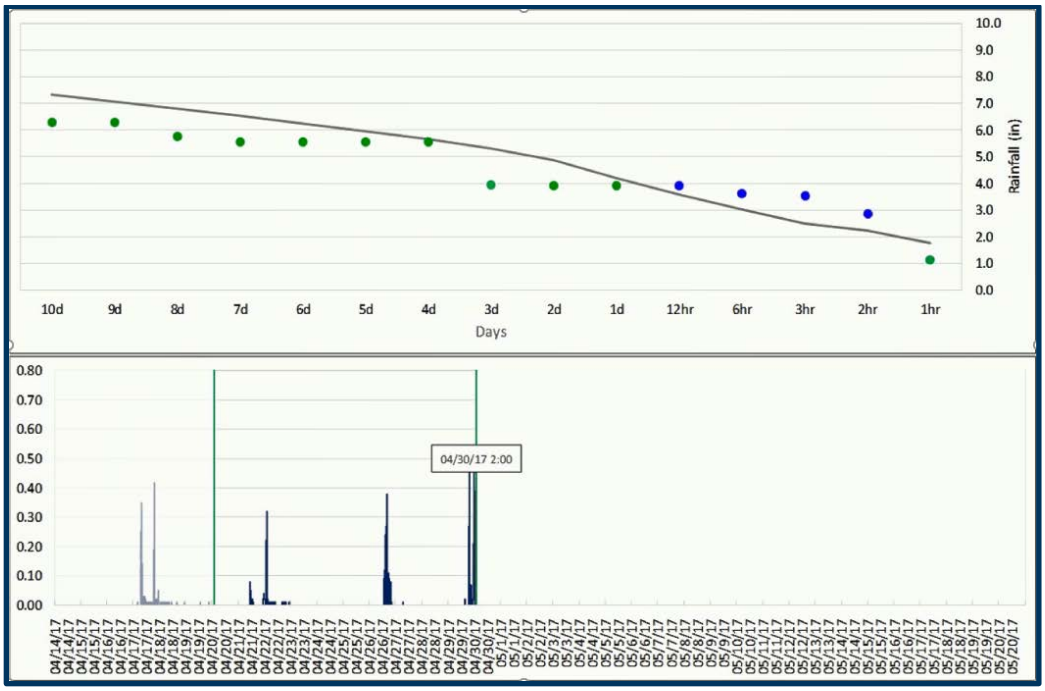
Based upon the positive outcomes from the initial analysis, LRWRA has been iteratively refining an analysis tool that could both provide LRWRA operators and ADEQ with an online "dashboard" that clearly reflects and updates the return period classification of the rainfall that has fallen over the past 10-days at any point in time.

The following graphic demonstrates a snapshot of how the tool may work in the future using historic rainfall data from April to May 2017. The upper section demonstrates the highest level of cumulative rainfall at any of the rain gauges for durations from 1-hour to 10-days (green dots) and plots these points against the 2-year 10-day curve (grey). The lower panel provides a 10-day window of the preceding rainfall.

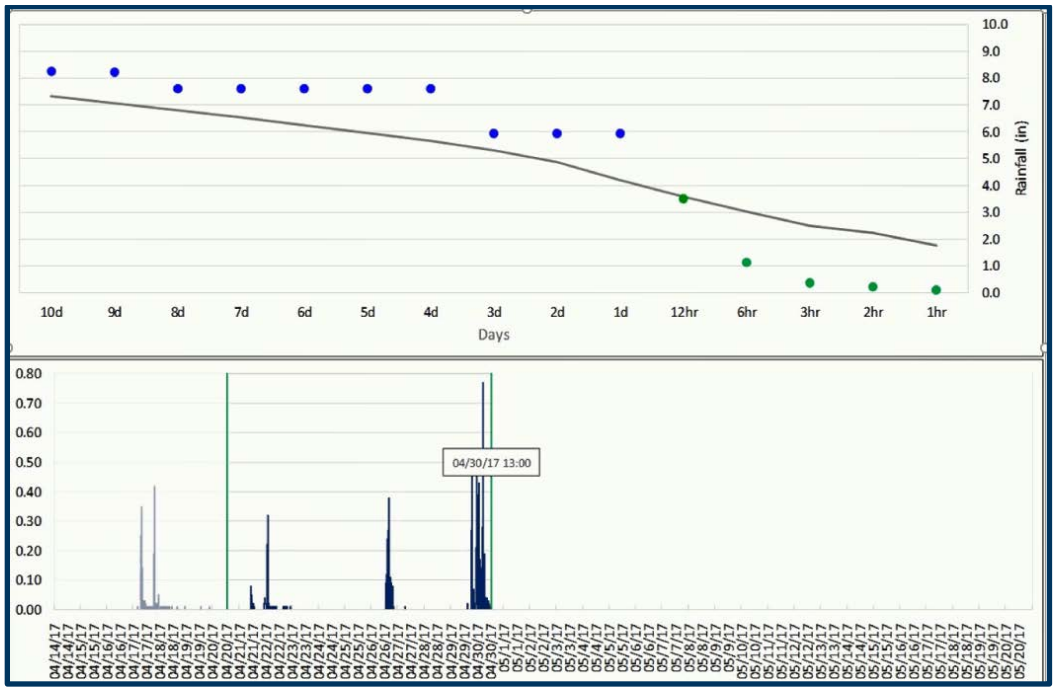
The first figure illustrates the status at 22:00 on April 29, 2017. The earlier storm from April 21, 2017 recorded approximately 0.9" of rain, the storm from April 26, 2017 recorded approximately 1.3" of rain and approximately 0.8" of rain had fallen in the previous three (3) hours.



The following figure shows the status four (4) hours later at 02:00 on April 30, 2017. The cumulative rainfall between 2-hour and 12-hour is now above the 2-year curve as illustrated by the blue dots and hence is classified as an exempt storm event.

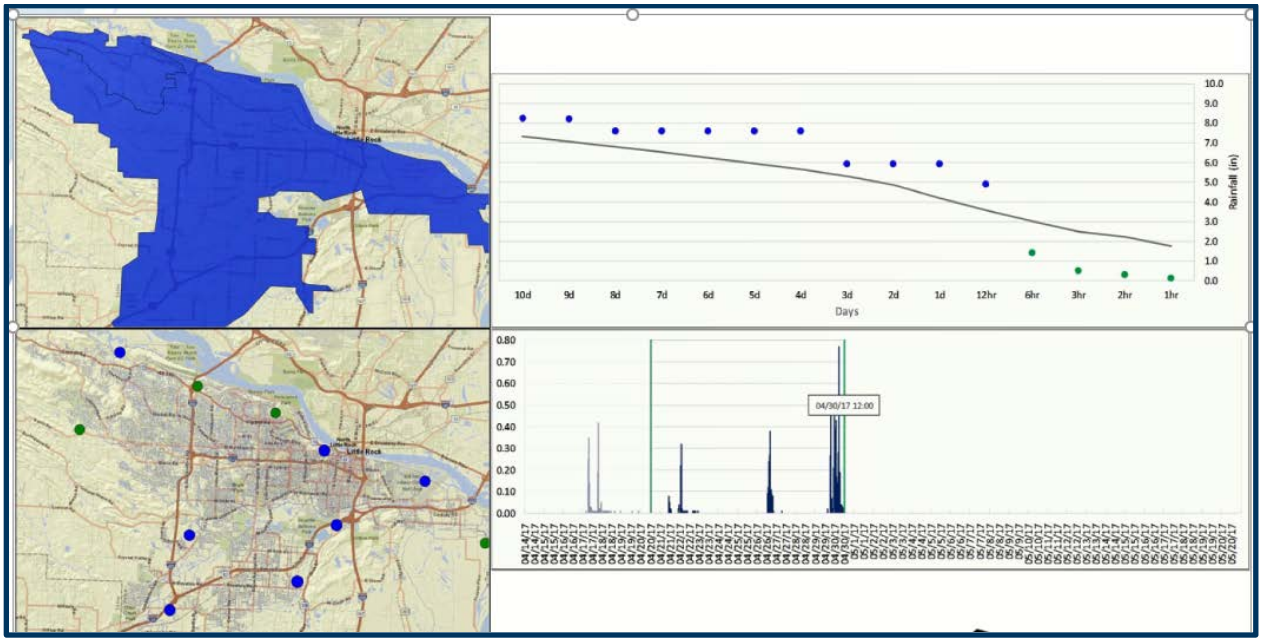


The following figure shows the status 11 hours later at 13:00 on 4/30/17, nearly 2-hours since the rain ceased. While the cumulative rainfall between 1-hour and 12-hour is now below the 2-year curve, for all durations from 1 to 10-days the blue dots are above the curve and hence any SSOs in this period are still classified as being exempt.



Dashboard

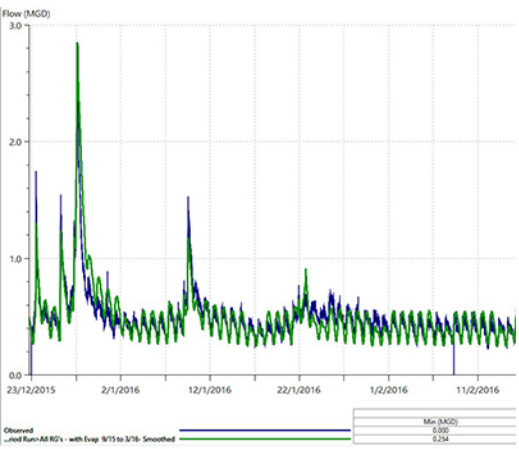
In addition to developing the underlying rainfall analysis methodology, LRWRA has concluded that a dashboard, outlined in the following figure, would incorporate regional maps as well as displaying current and past rainfall status at each and every rain gauge be accessible on LRWRA's website.

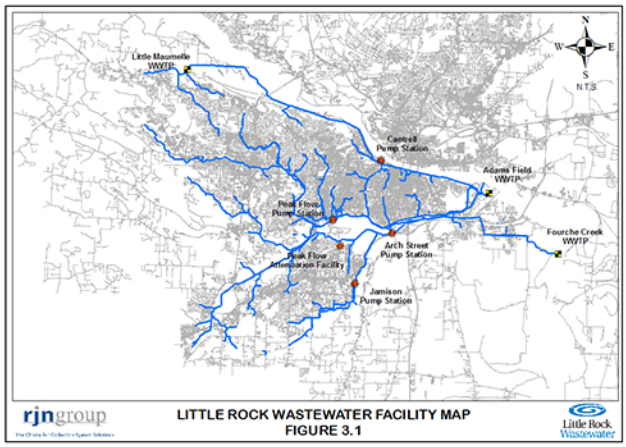


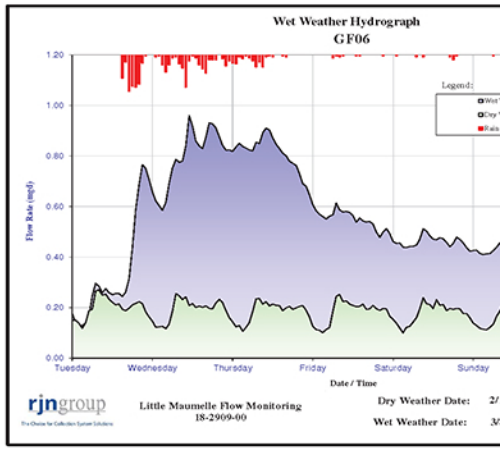
Conclusions

- Implementing the Find It / Fix It program with objectives geared towards removing I/I from the Rock Creek Basin / Markham Area and Upper Cantrell Basin will eliminate the need for storage facilities to contain wet weather flows during storm events. Additionally, by undergoing this program LRWRA will be renewing assets within the collection system and improving the system overall.

- The Sierra Club Settlement Agreement outlines the "2-year return period precipitation data" to evaluate compliance for LRWRA and occurring SSOs. This SECAP Update Amendment #2 has reflected a mechanism to evaluate a 2-year, 10-day curve to evaluate compliance within. This curve provides considerations for back to back storm events and differing rainfall intensities over periods of time.







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