MBNEP

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Bayou La Batre Watershed Study

June 2020

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1. Executive Summary

The study on the Bayou La Batre watershed was performed to gain an understanding of the watershed's response during rain events. It was also performed to generate a baseline hydrologic model that can be used for determining discharges for the design of future restoration projects and their impact on the watershed. The model can also be utilized for future storm water planning and management. The method of analysis used for the study employed the use of the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model. This two-dimensional overland flow model was calibrated to available rain events from September 2018 to June 2020.

During the evaluation period, the Bayou La Batre watershed experienced many small rain events with the largest being classified as a 2-year 12-hour event that occurred on June 7-8, 2020 due to Tropical Storm Cristobal. The next largest event was classified as a 2-year 6-hour rainfall event that occurred on August 26, 2019. The other rainfall events used for calibration of the hydrologic model were deemed to be no greater than a 1-year event. These other events used for the analysis occurred on September 4, 2018, July 13, 2019, and October 30, 2019. Results of the findings for the Bayou La Batre watershed indicate that storm events less than or equal to a 2-year recurrence interval produce discharges equal to its determined recurrence interval for a rural basin.

For rain events (2-year or less), the currently calibrated GSSHA model can be used as a management tool for determining bank forming discharges throughout the watershed. Future restoration projects may be able to utilize these discharges for bankfull analysis. For larger flood events, recalibration will most likely be necessary to account for possible changes in timing, infiltration variables, and storage capacity within the watershed.

2. Introduction

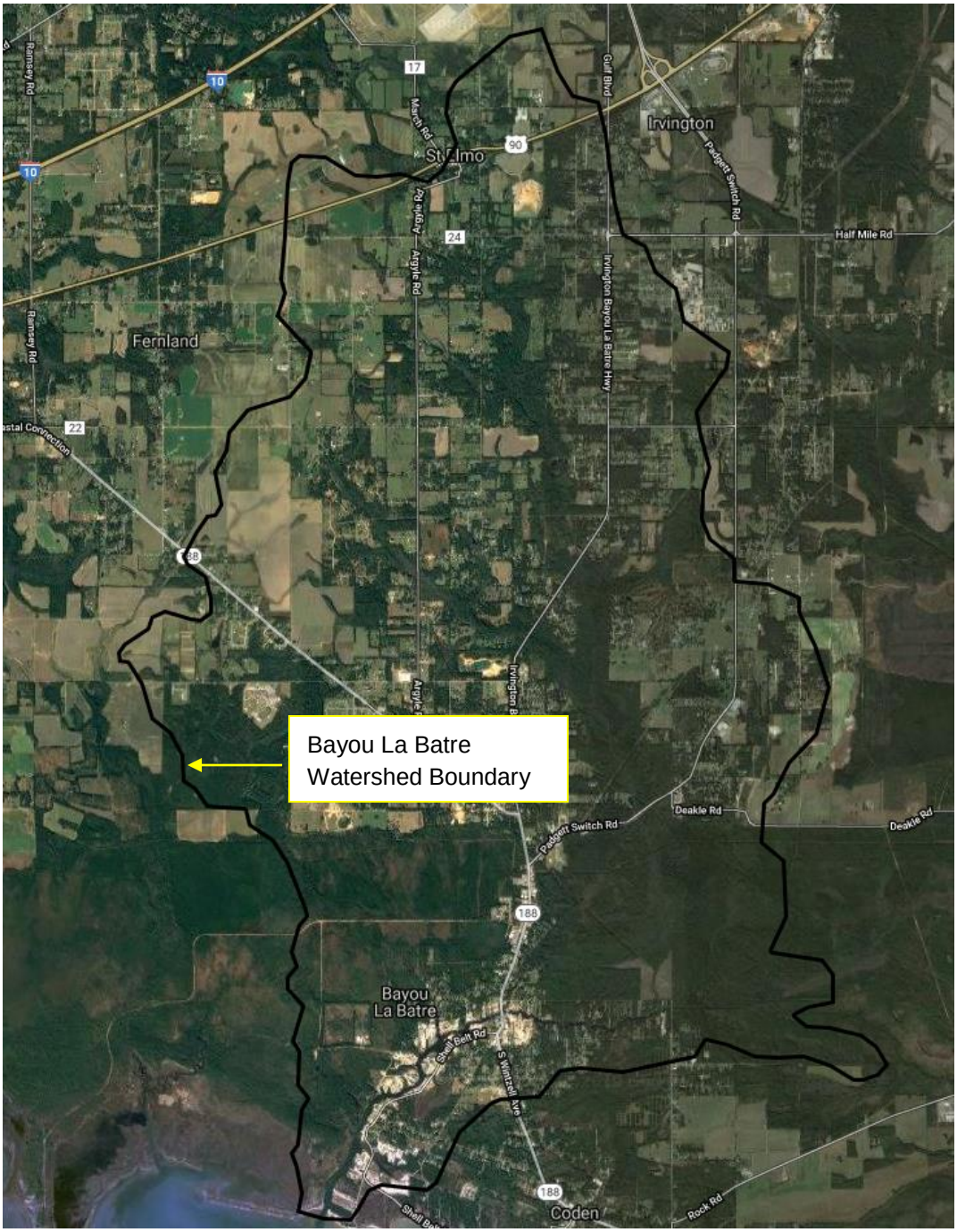
2.1. Description

According to the Bayou La Batre Watershed Management Plan (WMP) by Dewberry (2018), “The Bayou La Batre Watershed (Figure 2-1) is located in the Escatawpa River Basin and forms in southern Mobile County. The watershed is defined by the U.S. Geological Survey (USGS) 12-digit hydrologic unit code (HUC) as HUC 031700090102 and receives drainage from several named tributaries: Hammer Creek, Bishop Manor Creek, and Carls Creek; and multiple unnamed tributaries, which all flow south into the Bayou. The total drainage area of the Watershed is approximately 19,562 acres (30.6 square miles) and includes the 5.46 mile length of Bayou La Batre, a tidally influenced waterbody, with a water use classification of Fish & Wildlife (ADEM 2009).”

2.2. Climate

The 2018 Bayou La Batre WMP states, “The Watershed is located in a humid, subtropical climate region and is characterized by temperate winters and long, hot summers with rainfall that is fairly evenly distributed throughout the year. Annual temperatures range from below freezing to over 100 degrees Fahrenheit, with a normal mean annual temperature of 68 degrees Fahrenheit along the coast (USACE 2014). Average annual precipitation is 68.1 inches (Summersell 2008). Summer temperatures are generally warm, being moderated by sea breezes, and are influenced to a considerable extent by the mild water temperatures of the Gulf of Mexico. Prevailing southerly winds provide moisture for high humidity from May through September. Winter temperatures are relatively mild, and are greatly influenced by seasonal cold fronts. The area averages 15-20 cold fronts per year, occurring from October through March.”

Figure 2-1
Location Map and Watershed Boundary



2.3. Physiography

The Bayou La Batre WMP also states, “The Bayou La Batre area is classified as primarily coastal lowlands, with upper areas of the Watershed lying within the Southern Pine Hills physiographic district. Elevations range from sea level to about 40 feet in elevation.” The Southern Pine Hills is an upland area while the Coastal Lowlands is a flat to very gently undulating area that is locally swampy. Many streams are tidally influenced. The landward edge of the Coastal Lowlands, the boundary with the Southern Pine Hills, is defined by the Pamlico marine scarp at an elevation of approximately 25-30 feet (Sapp and Emplaincourt, 1975).

According to the 2018 WMP, there are six major soil associations present in the Bayou La Batre watershed. They are the Bayou Escambia (15.8%), Saucier sandy loam (14.4%), Notcher sandy loam (13.8%), Heidel sandy loam (11.3%), Troup sandy loam (11.3%) and Johnston-Pamlico association (10.9%).[1] Bayou Escambia association and the Johnston Pamlico association are generally poorly drained soils. The upper portion of the watershed contains a broader mix of soil association whereas the bottom portion of the watershed primarily consists of the Bayou Escambia association and the Johnston Pamlico association. Soil types are described in detail in the Soil Survey of Mobile County, Alabama publication (USDA, 1980).

2.4. Land Use

The majority of the Bayou La Batre watershed is described mostly as undeveloped areas with about 14% of the watershed consisting of urban development. According to Cook (2016), the majority of the development in the northern portion of the watershed consists of residential development with the southern development being associated with the town of Bayou La Batre.

The upland herbaceous and upland forest classifications make up about 36% and 20% of the land use coverage, respectively. The upland herbaceous areas consist of grassland/herbaceous areas, pasture/hay, and cultivated crops. Another large component of the watershed is woody wetlands which make up about 26% of the land use coverage. The remainder of the watershed consists of open water, barren areas, and non-woody wetlands.

3. Hydrologic Model

3.1. General

The hydrologic model used to evaluate the Bayou La Batre watershed is the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model. GSSHA is developed and maintained by the US Army Engineer Research and Development Center (ERDC) Hydrologic Modeling Branch, in the Coastal and Hydraulics Laboratory. GSSHA is a physically-based, distributed parameter hydrologic model with sediment and constituent fate and transport capabilities. Features include two dimensional (2-D) overland flow, 1-D stream flow, 1-D infiltration, 2-D groundwater, and full coupling between the groundwater, shallow soils, streams, and overland flow. Sediment and constituent fate and transport are simulated in the shallow soils, overland flow plane, and in streams and channels. GSSHA can be used as an episodic or continuous model where soil surface moisture, groundwater levels, stream interactions, and constituent fate are continuously simulated. Parameters used to generate a GSSHA simulation include rainfall data, digital terrain data, land use data, and soils data. The interface for building the GSSHA model is the Watershed Modeling System (WMS) developed by Aquaveo.

3.2. Rainfall Data

One of the strengths of the GSSHA model is the ability to perform long-term simulations utilizing rainfall distributions longer than just a 24-hour storm. A key element in forecasting discharges for future storm occurrences depends upon good rainfall data. For the rainfall component used in the simulations, Hydro-Engineering Solutions (Hydro) obtained storm data from three different monitoring sources.

The first source for gathering rainfall data was from weather stations that Hydro deployed throughout the watershed (Figure 3-1). On December 13, 2018, three weather stations were installed. The first weather station (MBNEP 132) was installed at Alma Bryant High School in the western part of the watershed. The second weather station (MBNEP 133) was installed at Dixon Elementary School in the middle part of the watershed. The third station (MBNEP 134) was installed at St. Elmo Elementary School in the upper part of the watershed.

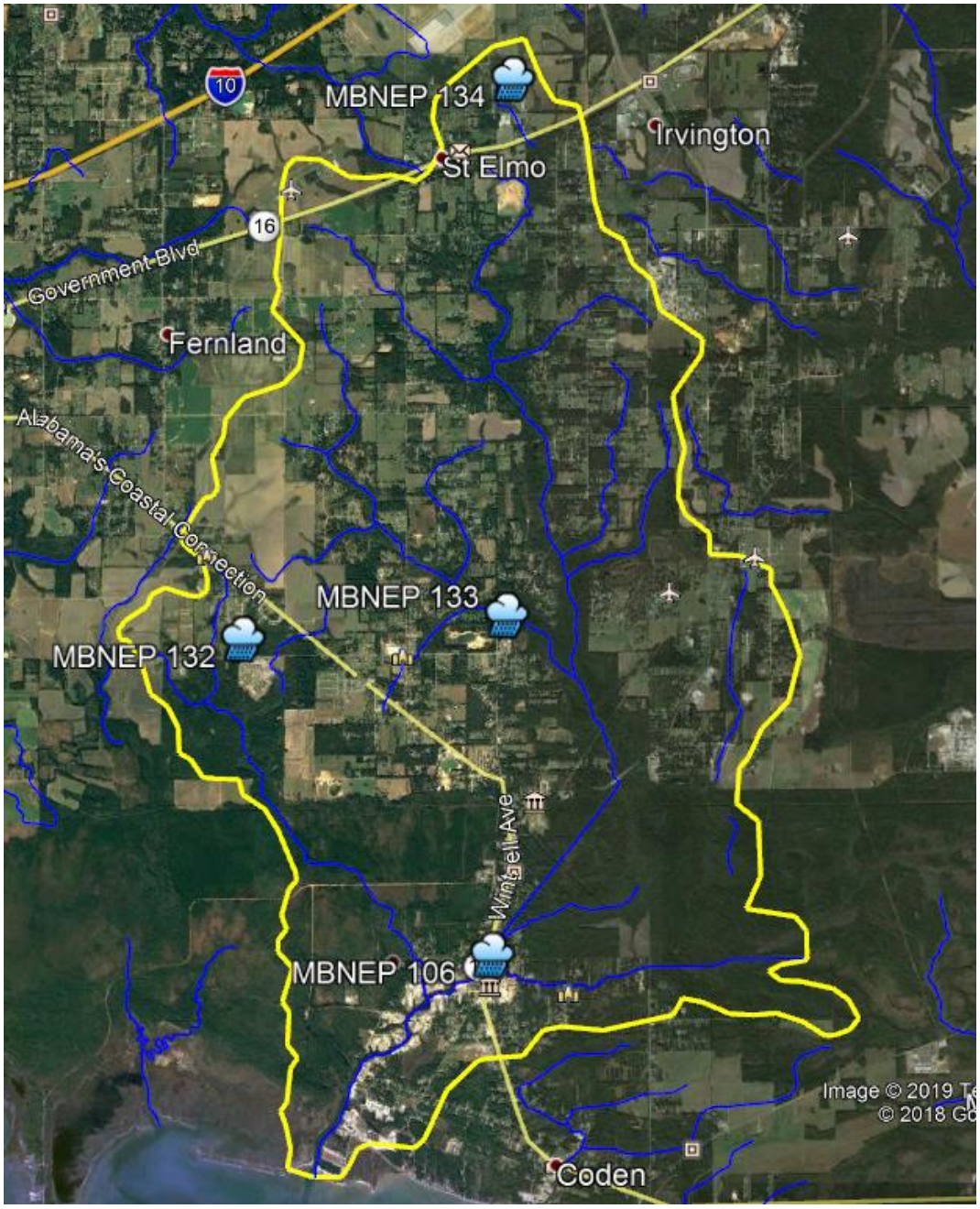
After coordinating with other entities and getting the required permission, one more weather station was installed within the watershed (Figure 3-1). On April 16, 2019, MBNEP 106 was installed at the Bayou La Batre Fire Station in the lower part of the watershed.

The Davis Instruments, Corp.'s Vantage Pro 2 Precision Weather Station was used for data collection. Information collected from this weather station include: rainfall, temperature, humidity, wind speed, and barometric pressure. The data is sent to Weatherlink.com, which is Davis' global weather network. Data can be transferred using a wireless console connected to a nearby computer with internet or via Davis' Vantage Connect®. According to the website, Vantage Connect® is a "cellular-based, solar-powered unit that sends remote weather station data to the internet." Weatherlink software was used for data retrieval for each station. After a storm event, data would be retrieved and then processed for use in the GSSHA model.

The second source of data was obtained from Gridded Binary (GRIB2) rainfall data provided by the National Weather Service. GRIB2 is the second version of the World Meteorological Organization's (WMO) standard for distributing gridded data. The major advantages of the GRIB files are that they are typically 1/2 to 1/3 the size of normal binary files (floats), the fields are self-describing, and GRIB is an open, international standard. A decoder is required to view or use the information. Once decoded, the GRIB2 data is in 2-minute increments which provide a good rainfall distribution for calibrating the timing aspect of the model. When there is a lack of information between the installed Hydro weather stations or any Wundermap gauges, GRIB2 data was utilized to get storm distributions. Oftentimes the total rainfall accumulation is low and needs to have a correction factor applied to it. Rainfall totals from other sources (e.g. Hydro Weather Stations, Weather Underground, NWS maps, etc) are used to correct the rainfall amounts when necessary.

The third source of rainfall data was obtained from Weather Underground. Weather Underground is a weather service that provides real-time weather information over the internet. According to their website, "Our brand mission is to make quality weather information available to every person on this planet." The service makes use of "the generous and passionate community of weather enthusiasts that share weather data and content..." The information is obtained from the members who send real-time data from their personal weather stations. The weather stations available are plotted on a map (Wundermap) based on the parameter selected. The parameters available in which to sort the gauges are temperature/wind, temperature, dew point/humidity, and precipitation.

Figure 3-1
Bayou La Batre Watershed with Rainfall Gauge Locations



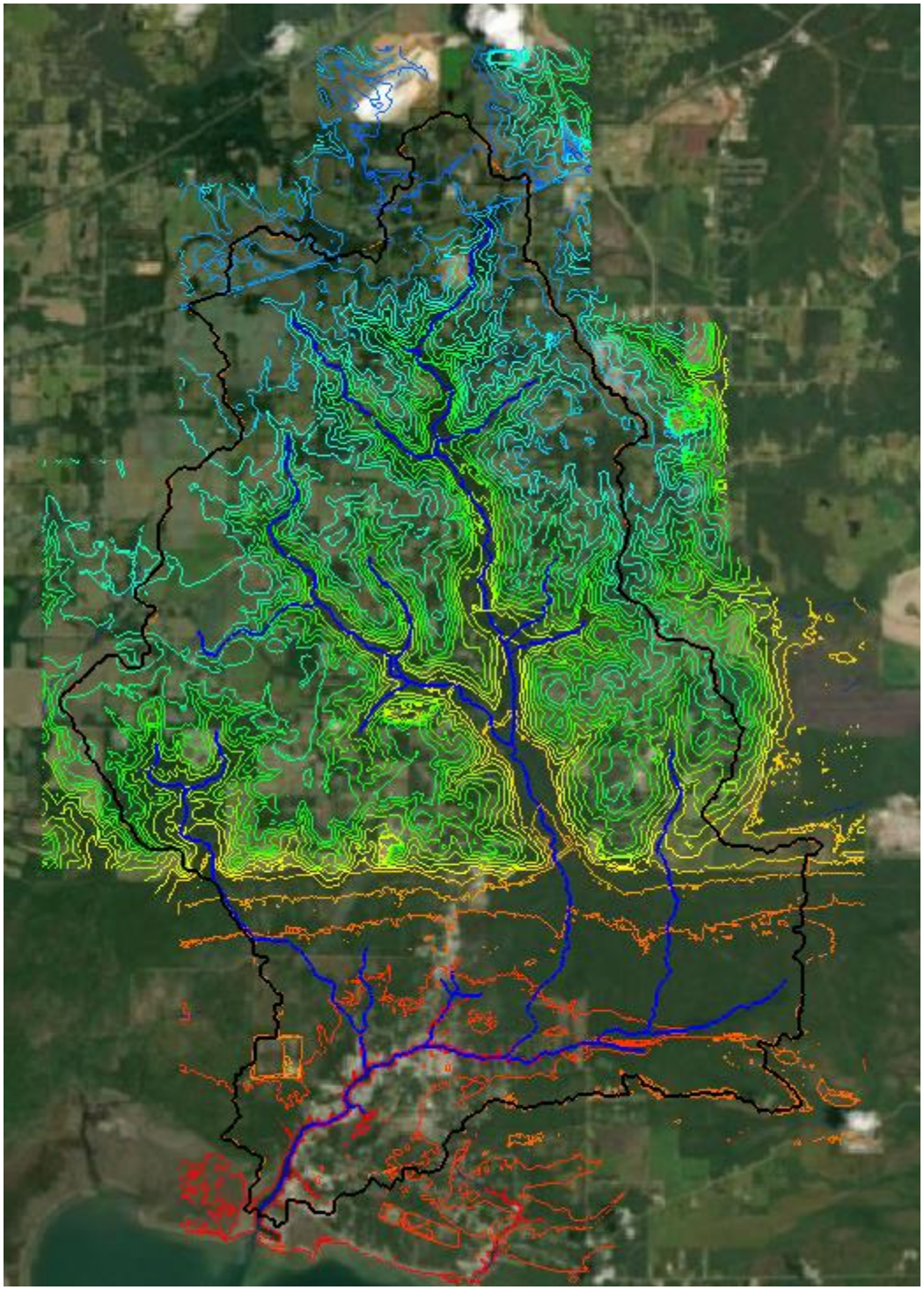
3.3. Digital Terrain Data

The GSSHA model uses digital terrain data to incorporate topography into the hydrologic model. For the model, Light Detection and Ranging (LiDAR) data was obtained from the 2014 Mobile County Lidar DEM (AL) dataset. This information is warehoused by the Office of Coastal Management of the National Oceanic and Atmospheric Administration (NOAA). The raster data is saved as a .tif file, with each file encompassing approximately 1.29 square miles (6000' x 6000'). The coordinate system for the raster data is State Plane AL-W and the units are in feet. The information can be found at the following web address: https://coast.noaa.gov/htdata/raster2/elevation/Mobile_DEM_2014_5169/.

In order to get digital elevation data for basin delineation, each .tif was converted individually to a DEM. Each conversion utilized 40-foot point spacing. For easier data manipulation, the individual DEM was converted to a .dwg. Once all of the individual DEM files were converted to a .dwg, they were merged into one file using Microstation. The complete basin .dwg was then imported back into WMS for a conversion back to a single DEM.

The GSSHA model requires all units to be in the International System of Units. It was therefore necessary to convert the State Plane AL-W data to UTM Zone 16 data. The units were also converted from feet to meters. After proper conversion, the DEM data can be used for automatic delineation of the basin, as well as, for generating cell elevations for the gridded model. Figure 3-2 indicates the topographic data that was utilized for the hydrologic model.

Figure 3-2
Bayou La Batre Watershed with Topographic Data



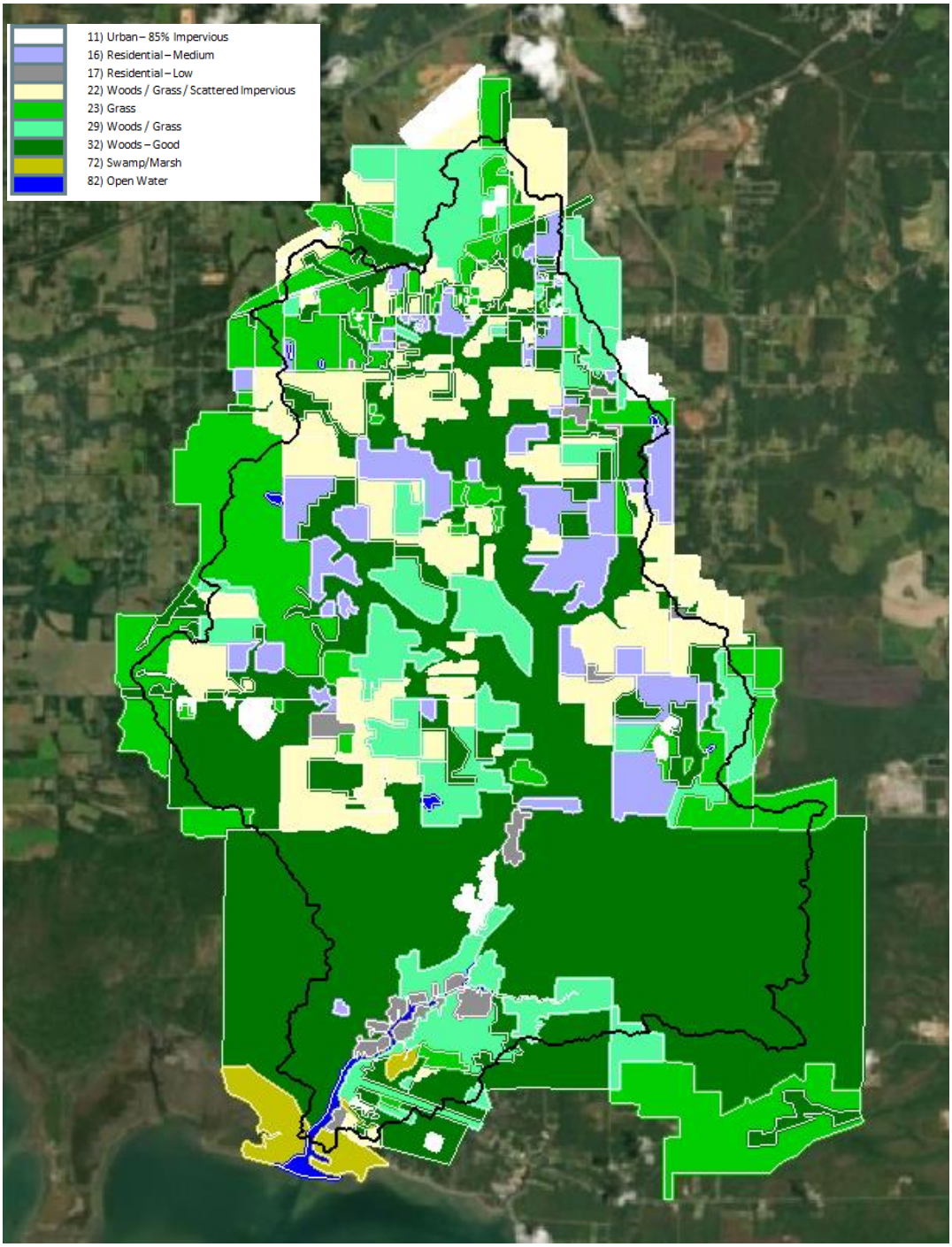
3.4. Land Use

The land use component of the model is necessary to define the various overland flow types throughout the basin. Land use was delineated using geo-referenced aerial imagery. WMS was used to automatically import the latest version of Esri's World Imagery map. (more information can be found at http://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer) The GSSHA model utilizes the land use coverage by assigning a value to describe the overland roughness. The roughness of each land use type is described by an overland Manning's 'n' value. Table 3-1 lists the land use types and the respective 'n' values assigned to them. Figure 3-3 indicates the land use assignments.

Table 3-1
Land Use and Manning's 'n' Values

GSSHA ID	Land Use	Manning's 'n'
11	Urban – 85% Impervious	0.011
16	Residential - Medium	0.030
17	Residential - Low	0.040
22	Woods / Grass / Scattered Impervious	0.150
23	Grass	0.170
29	Woods / Grass	0.190
32	Woods – Good	0.200
72	Swamp/Marsh	0.250
82	Open Water	0.011

Figure 3-3
Bayou La Batre Watershed with Digitized Land Use



3.5. Soils

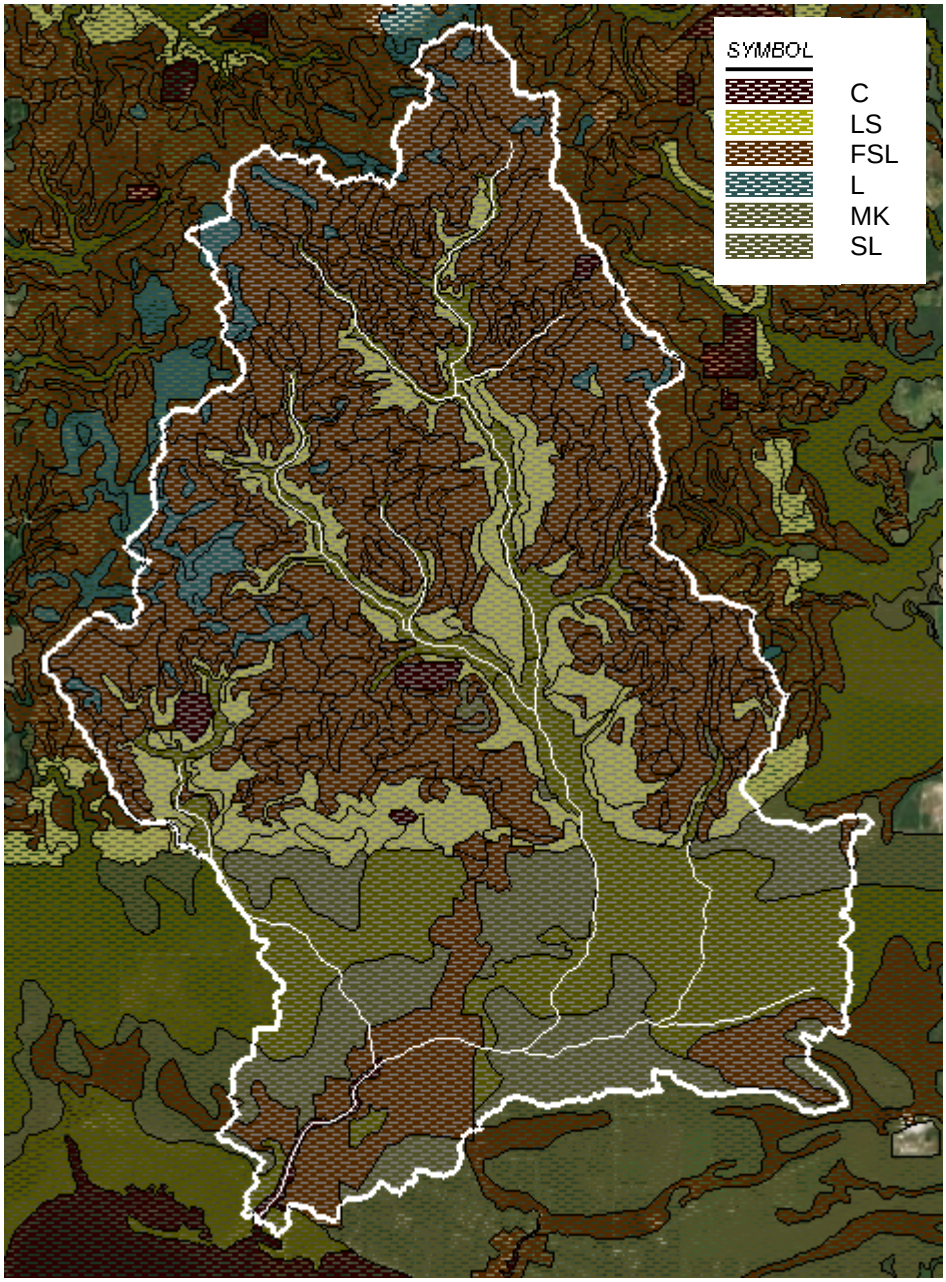
Similarly to the land use, the GSSHA model has the capability to incorporate specific characteristics of the soils located within a drainage basin. The soils coverage can be used for defining infiltration into the soil or setting the initial soil moisture. Green and Ampt (G&A) with soil moisture redistribution was used for determining the infiltration of rainfall throughout the basin. Soil parameters used by the G&A method include hydraulic conductivity, porosity, capillary head, pore distribution index, residual saturation, and field capacity. These infiltration values allow the GSSHA model to evaluate the soil's ability to infiltrate stormwater for calculating peak discharge and volume of storm events.

Soils data shapefiles were provided by the Mobile Bay National Estuary Program (MBNEP). According to the metadata provided with the shapefiles, this soil survey is an update to the 1980 soil survey of Mobile County. According to the metadata, "The Soil Survey information was updated using the latest advanced geospatial software ArcGIS 10.3 ArcInfo…. The U.S. Department of Agriculture, Natural Resources Conservation Service, should be acknowledged as the data source in products derived from these data." Figure 3-4 indicates the soil data that has been incorporated into the GSSHA model. Infiltration can be defined through the soils coverage alone or through a combined land use/soils data coverage.

3.6. Combined Coverage

A combined land use / soils coverage layer can be generated in order to incorporate a more detailed way to specify infiltration. Instead of defining the infiltration parameters with just soils, it can be defined based on a soil type and specific land use. For example, a sandy loam may have woods described as the land use in one part of the watershed and a parking lot in another. Instead of applying the infiltration values for just a sandy loam, a combined coverage can utilize an infiltration value for the woods and a separate one for the parking lot. This can help better replicate the timing and infiltration related to the ground cover and soil type.

Figure 3-4
Bayou La Batre Watershed with Digitized Soil Type



3.7. Gridded Model

Once all of the variables mentioned above were incorporated into the model it was necessary to divide the model into individual grid cells. For the Bayou La Batre model a 60 meter x 60 meter (197 feet x 197 feet) grid size was utilized (Figure 3-5). As mentioned previously, the settings for GSSHA require the units to be in the International System of Units (SI). The total drainage area, determined from the LiDAR data, to the mouth of the river at the Gulf of Mexico is approximately 31.7 square miles. Over the entire watershed this generates approximately 22,800 grid cells. Figures 3-5 to 3-8 indicate the gridded elevation data, gridded land use, gridded soils data, and gridded combined layer.

Figure 3-5
Bayou La Batre Watershed with Gridded Elevation Data

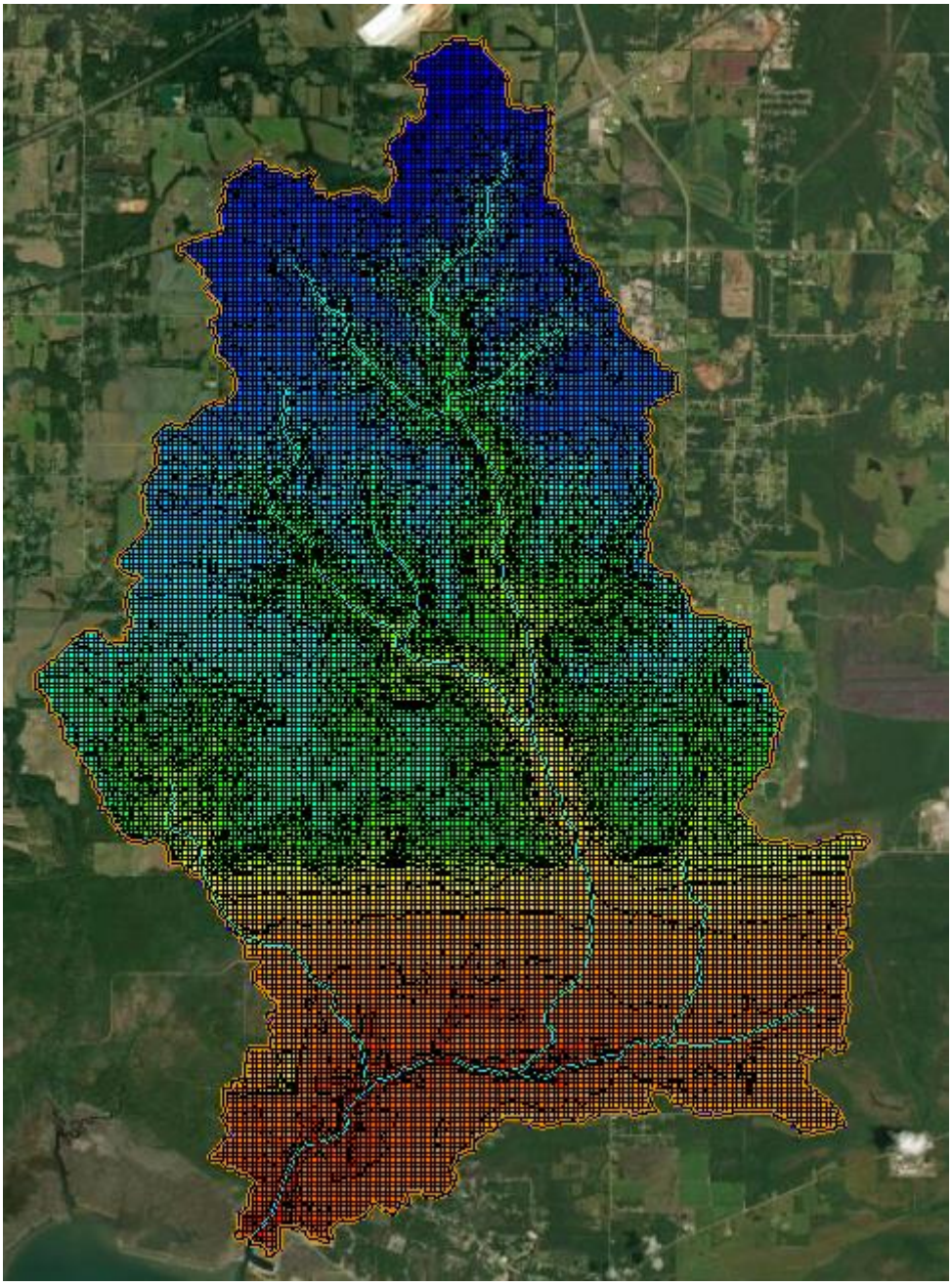


Figure 3-6
Bayou La Batre Watershed with Gridded Land Use Data

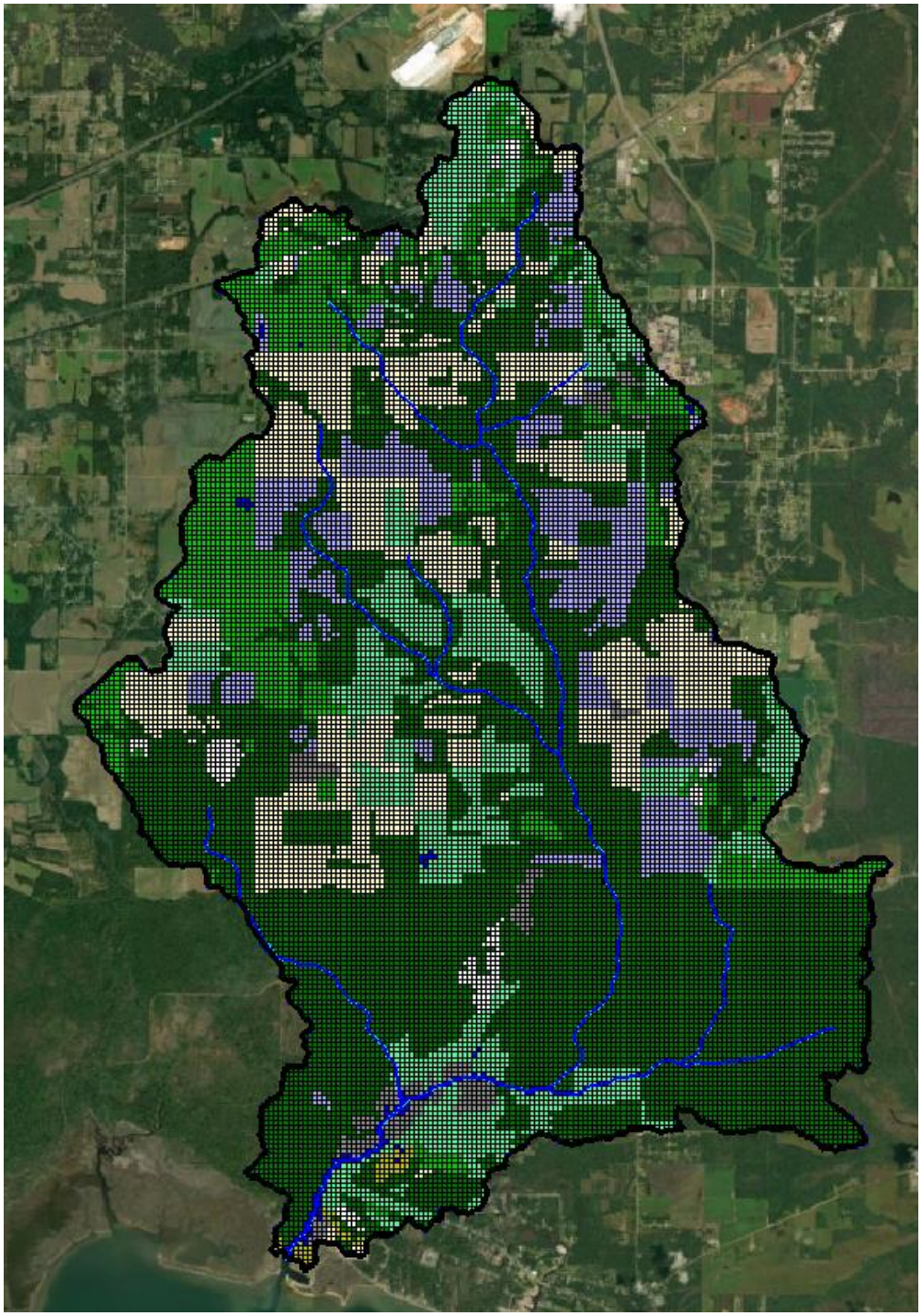


Figure 3-7
Bayou La Batre Watershed with Gridded Soils Data

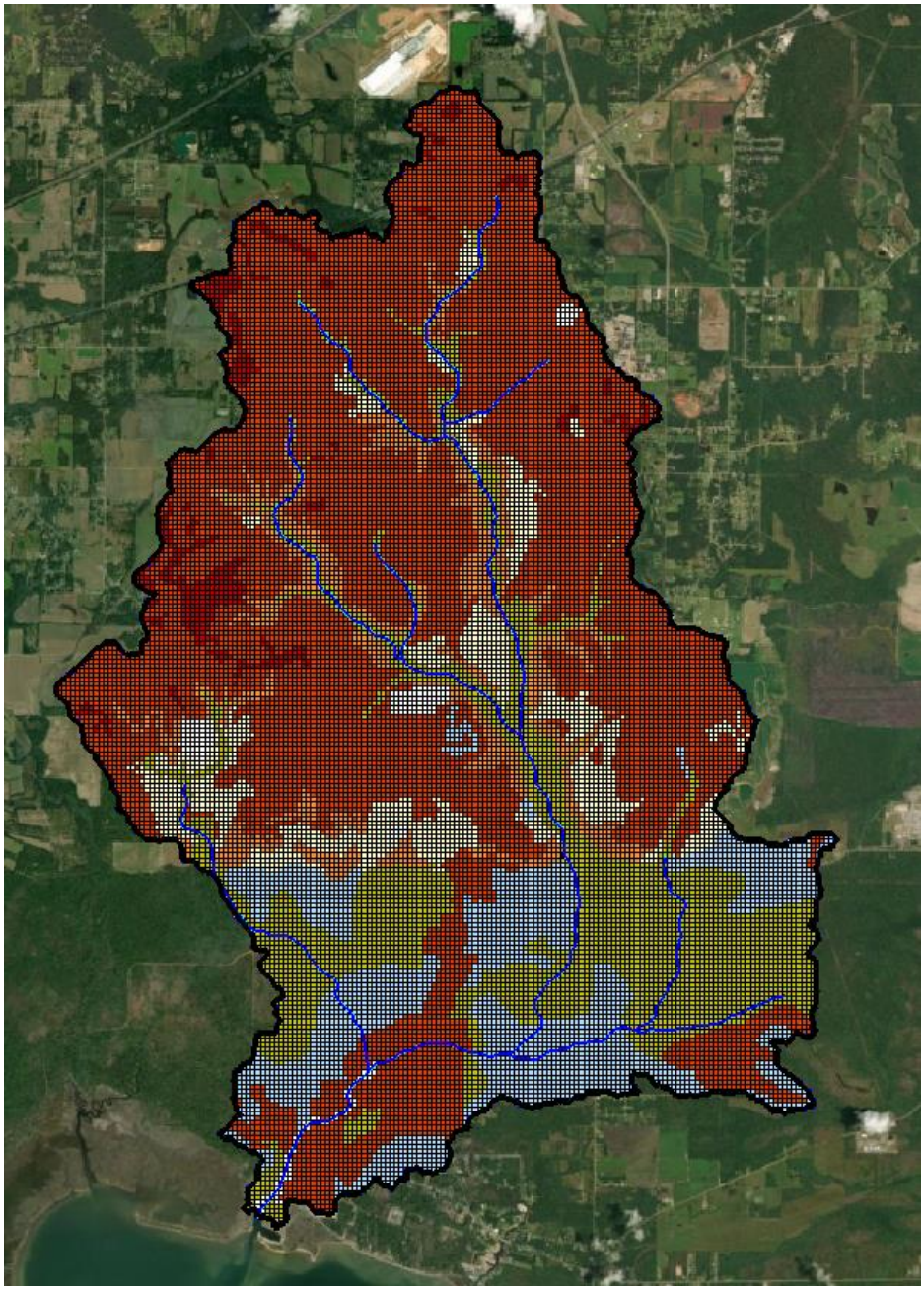
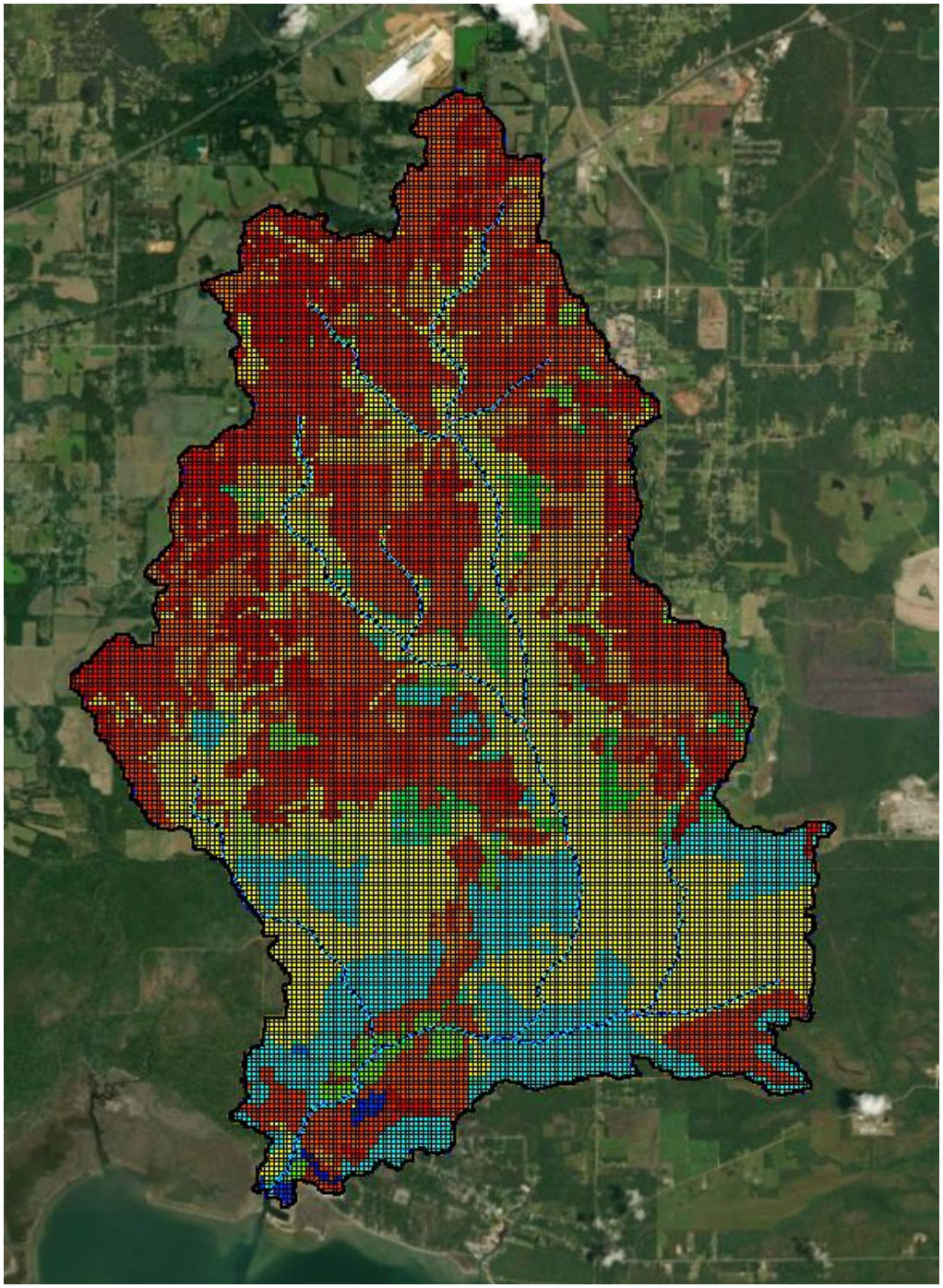


Figure 3-8
Bayou La Batre Watershed with Gridded Combined Data



4. Calibration

4.1. Bayou La Batre Calibration

For a model to be used for forecasting it is best to calibrate to real world storm events. Calibration requires both historic rainfall data distribution and river water surface elevations or discharge measurements during the rain event. With the rainfall distribution being obtained from the installed weather stations, it was necessary to find or install gauges in the watershed to determine stream stages. Telog RU-33 gauges with level logger sensors were used for measuring stream data. These gauges contain a Recording Telemetry Unit (RTU) which forwards data wirelessly to a host computer which can be accessed through the internet. After a rain event, level data can easily be downloaded from the Telog Enterprise website.

A site visit was performed in order to determine the best location for installing the monitoring gauges. In addition to the RU-33 gauges, crest stage gages were also installed either upstream or downstream in order to record another highwater mark. These simple gages were constructed with PVC pipe, a wooden rod, and some crushed cork. During a flooding event, the cork would rise with the water level and then be deposited on the wooden rod. A measurement of the cork marking can be used to determine maximum stage height during the storm. These cork gage marks were used in conjunction with the RU-33 highwater readings in order to obtain the water surface slope during the flood event.

There were three locations within the watershed that were deemed useful for monitoring (Figure 4-1). These locations were located near existing drainage structures to help with ease of access. Variables that come into consideration for a gauge location are dependent on location in the watershed, backwater effects, and the possibility of the gauge being vandalized. The three gauges were installed and started recording data on June 12, 2018. A list of gauges and locations can be found in Table 4-1.

Figure 4-1
Bayou La Batre Watershed with Stream Gauge Locations

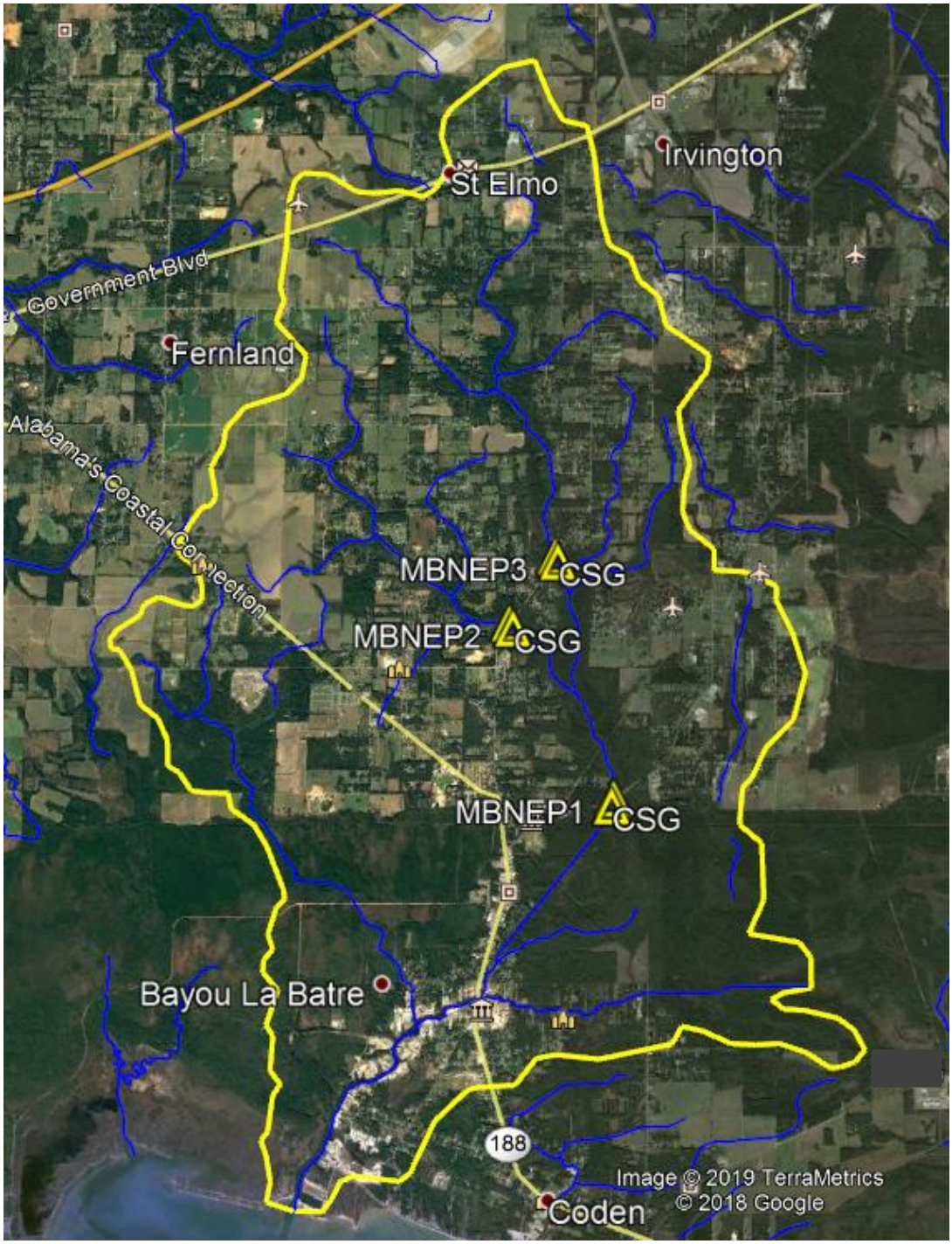


Table 4-1
Stream Gauges and Locations

Gauge Name	Stream	Location
MBNEP 1	Carls Creek	85' d.s. of Padgett Switch Rd CL
Cork Gauge 1	Carls Creek	330' d.s. of MBNEP 1
MBNEP 2	Bishop Manor Creek	60' d.s. of Bayou La Batre-Irvington Hwy CL
Cork Gauge 2	Bishop Manor Creek	270' d.s. of MBNEP 2
MBNEP 3	Hammer Creek	65' d.s. of Bayou La Batre-Irvington Hwy CL
Cork Gauge 3	Hammer Creek	440' d.s. of MBNEP 3

During the June 2018 to June 2020 time period there were a couple of storm events that were possible candidates for calibration and validation. From the Telog RU-33 stream gauge data (Figures 4-2 to 4-4), it was determined that a fairly adequate rainfall event occurred on September 4-5, 2018 due to Tropical Storm Gordon. This event produced just over 2" of rain in 3 hours. While this is less than a 1-year storm event, it was used to get an initial understanding of timing throughout the basin.

The second rainfall event that was analyzed was the July 13, 2019 event (Figures 4-2 to 4-4). This event produced approximately 5" to 6" of rain throughout the watershed in approximately 16 hours. Interpolating from NOAA Atlas 14 (Figure 4-5) for this rain depth and time period, it was determined that this rain event is equivalent to a 2-year storm. The next rainfall event that was analyzed was the August 26, 2019 event. This event produced approximately 3" of rain throughout the watershed in approximately 3 hours. Using NOAA Atlas 14 (Figure 4-5) for this rain depth and time period, it was determined that this rain event is equivalent to a 1-year storm.

The next storm event occurred on October 30, 2019 when the watershed experienced between 2.5” and 3” of rain in 12 hours. Using Figure 4-5, it can be determined that this is below a 1-year rain event. The final storm event used for calibration occurred on June 7, 2020. During this event approximately 5.2” of rain fell in a 12 hour period. The rainfall depth for this time period equates to a 2-year recurrence interval.

In order to compare discharges from the hydrologic model to the discharges in the field, it was necessary to build a hydraulic model of the stream in the location of the stream gauge. Information required for the hydraulic model includes a field surveyed cross-section at the location of the RU-33 gauge, Manning’s ‘n’ values for the channel and floodplain, discharges, and a stream slope. The stream slope was determined from the difference in elevation of the peak stage at the RU-33 gauge and at the crest stage gage divided by the distance between them. A range of discharges were entered into the hydraulic model along with the stream slope in order to develop a rating curve. This curve was plotted in Excel against the discharge output from the hydrologic model. If any additional model cross-sections were necessary for enhancing the hydraulic model, they were cut using the LiDAR data obtained from NOAA.

Calibration of the model requires adjustment of the key parameters that affect infiltration, overland flow, and channel routing. The three main variables that are usually examined and adjusted include hydraulic conductivity, overland roughness, and channel roughness. These values were adjusted until the model output best fit the observed data. Other factors that can be considered are interception and retention.

Figure 4-2
MBNEP 1 Gauge Height Readings – June 2018-June 2020

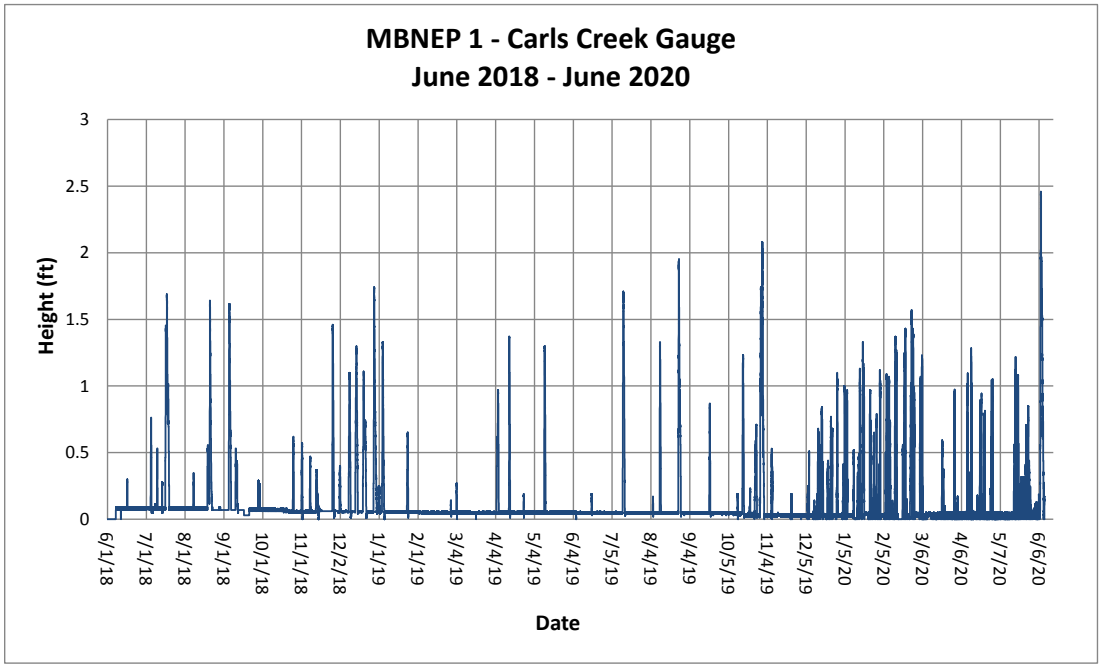


Figure 4-3
MBNEP 2 Gauge Height Readings – June 2018-June 2020

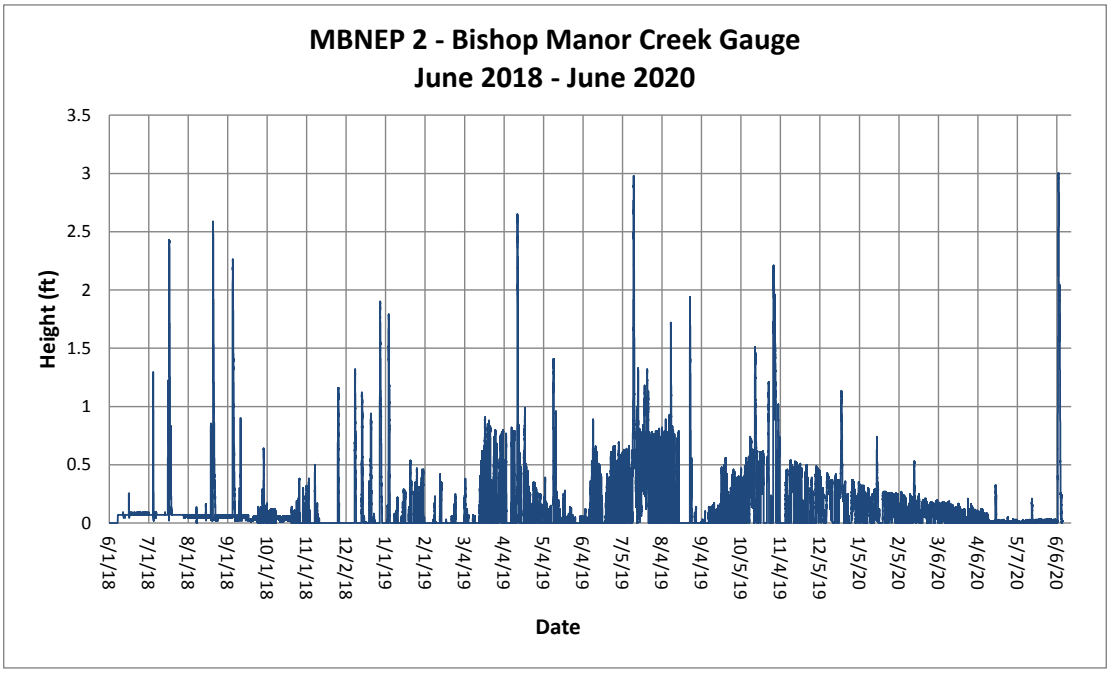


Figure 4-4
MBNEP 3 Gauge Height Readings – June 2018-June 2020

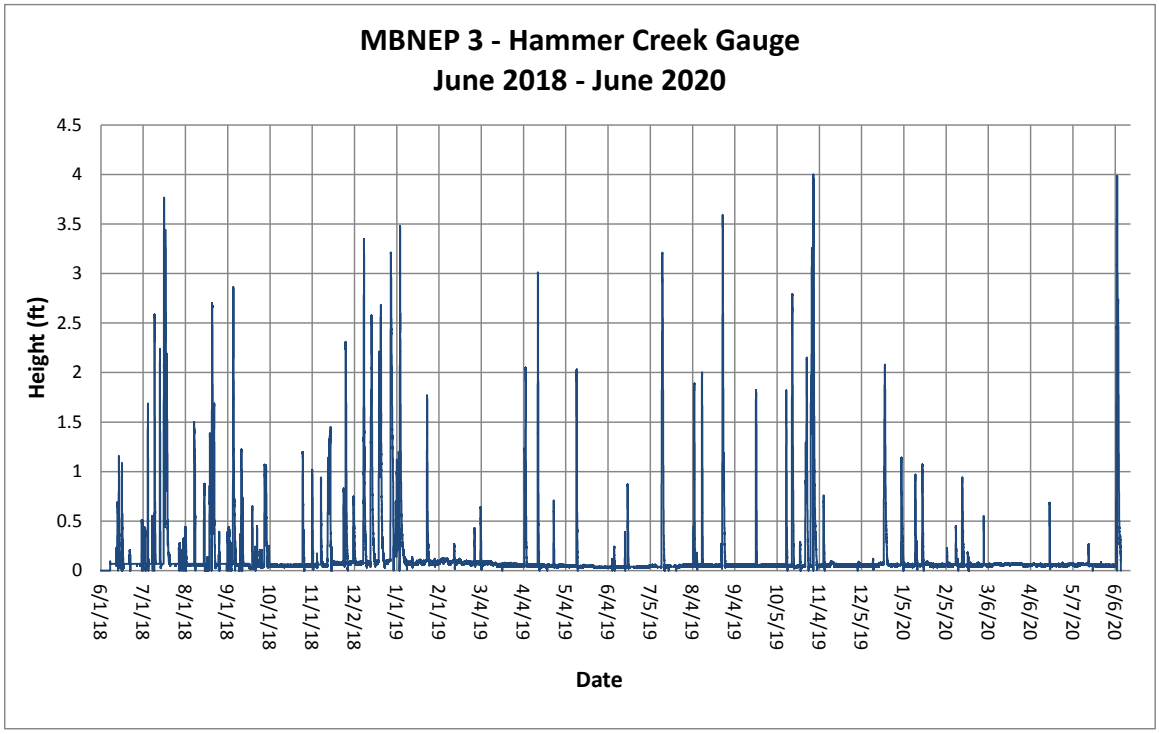


Figure 4-5
Point Precipitation Frequency Estimates

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 9, Version 2

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

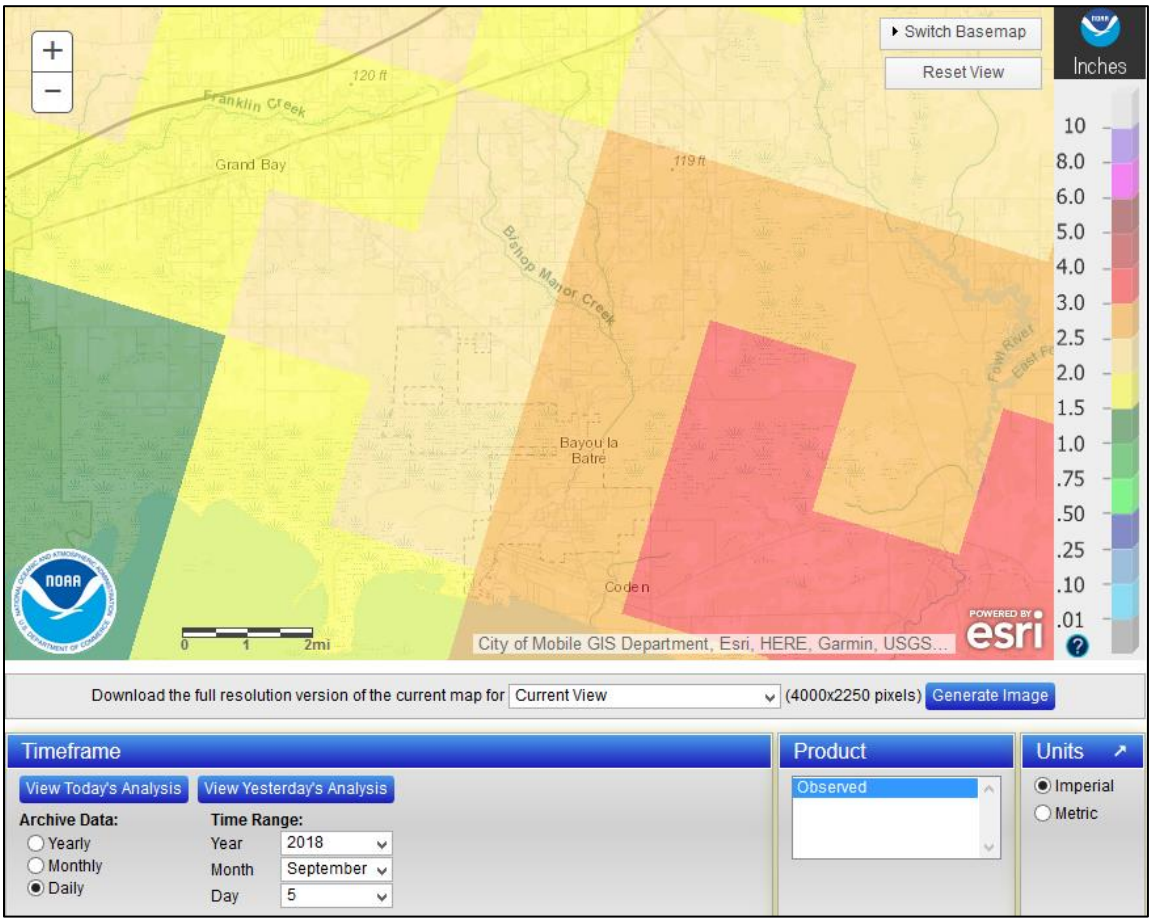
Duration	Average recurrence interval (years)								
	1	2	5	10	25	50	100	200	500
5-min	0.613 (0.497-0.758)	0.698 (0.566-0.863)	0.837 (0.676-1.04)	0.952 (0.765-1.18)	1.11 (0.864-1.41)	1.24 (0.938-1.59)	1.36 (0.998-1.78)	1.49 (1.05-1.98)	1.65 (1.12-2.25)
10-min	0.897 (0.728-1.11)	1.02 (0.828-1.26)	1.23 (0.990-1.52)	1.39 (1.12-1.73)	1.63 (1.26-2.07)	1.81 (1.37-2.32)	1.99 (1.46-2.60)	2.17 (1.53-2.90)	2.42 (1.64-3.30)
15-min	1.09 (0.888-1.35)	1.25 (1.01-1.54)	1.49 (1.21-1.85)	1.70 (1.37-2.11)	1.99 (1.54-2.52)	2.21 (1.68-2.83)	2.43 (1.78-3.17)	2.65 (1.87-3.54)	2.95 (2.00-4.02)
30-min	1.60 (1.30-1.97)	1.83 (1.48-2.26)	2.21 (1.78-2.73)	2.52 (2.02-3.13)	2.95 (2.29-3.75)	3.28 (2.49-4.21)	3.61 (2.65-4.72)	3.95 (2.78-5.27)	4.39 (2.98-5.98)
60-min	2.15 (1.75-2.66)	2.45 (1.98-3.03)	2.95 (2.38-3.65)	3.37 (2.71-4.19)	3.98 (3.10-5.08)	4.47 (3.40-5.75)	4.96 (3.65-6.51)	5.48 (3.87-7.34)	6.19 (4.20-8.46)
2-hr	2.70 (2.21-3.32)	3.07 (2.50-3.77)	3.68 (2.99-4.54)	4.22 (3.41-5.22)	5.01 (3.93-6.37)	5.65 (4.33-7.25)	6.31 (4.68-8.25)	7.02 (4.99-9.35)	7.99 (5.47-10.9)
3-hr	3.07 (2.51-3.76)	3.47 (2.84-4.25)	4.18 (3.41-5.13)	4.82 (3.90-5.93)	5.77 (4.55-7.34)	6.55 (5.05-8.40)	7.39 (5.50-9.64)	8.29 (5.92-11.0)	9.55 (6.57-13.0)
6-hr	3.69 (3.03-4.49)	4.22 (3.46-5.13)	5.17 (4.23-6.30)	6.04 (4.91-7.38)	7.36 (5.85-9.34)	8.47 (6.57-10.8)	9.66 (7.24-12.6)	11.0 (7.89-14.5)	12.8 (8.87-17.3)
12-hr	4.30 (3.55-5.18)	5.02 (4.14-6.07)	6.33 (5.21-7.66)	7.52 (6.15-9.13)	9.32 (7.46-11.8)	10.8 (8.45-13.8)	12.5 (9.40-16.1)	14.2 (10.3-18.7)	16.7 (11.7-22.5)
24-hr	4.97 (4.12-5.95)	5.87 (4.87-7.04)	7.50 (6.20-9.01)	8.99 (7.39-10.8)	11.2 (9.06-14.1)	13.2 (10.3-16.6)	15.2 (11.5-19.5)	17.4 (12.7-22.8)	20.6 (14.5-27.5)
2-day	5.76 (4.81-6.86)	6.75 (5.63-8.05)	8.56 (7.11-10.2)	10.2 (8.46-12.3)	12.8 (10.4-16.0)	15.0 (11.9-18.9)	17.4 (13.3-22.2)	20.0 (14.7-26.0)	23.7 (16.8-31.5)
3-day	6.27 (5.24-7.43)	7.32 (6.12-8.69)	9.24 (7.70-11.0)	11.0 (9.13-13.1)	13.7 (11.2-17.1)	16.0 (12.7-20.1)	18.5 (14.2-23.6)	21.3 (15.7-27.6)	25.1 (17.8-33.2)
4-day	6.69 (5.61-7.91)	7.78 (6.52-9.21)	9.76 (8.15-11.6)	11.6 (9.62-13.8)	14.4 (11.7-17.8)	16.7 (13.3-20.8)	19.2 (14.8-24.4)	22.0 (16.2-28.4)	25.9 (18.4-34.2)
7-day	7.82 (6.58-9.20)	8.92 (7.50-10.5)	10.9 (9.15-12.9)	12.7 (10.6-15.1)	15.5 (12.7-19.1)	17.9 (14.3-22.1)	20.4 (15.8-25.7)	23.2 (17.2-29.8)	27.2 (19.4-35.6)

* This chart was generated from the lat/long point of 30.4511, -88.2443

Source: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=al

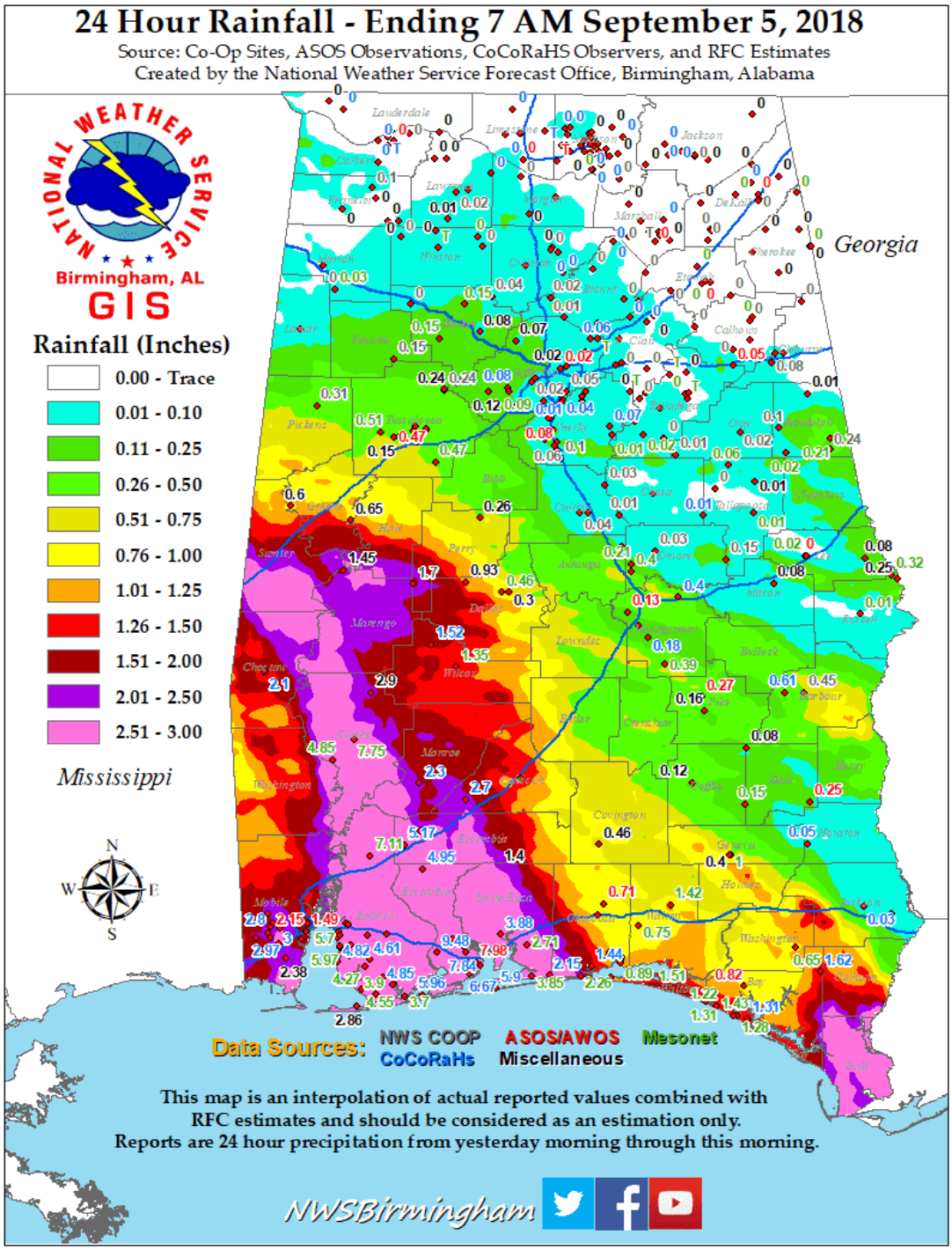
Figures 4-6 and 4-7 indicate the total rainfall maps for the September 4, 2018 rain event generated by the NWS Advanced Hydrologic Prediction Service and the Birmingham NWS Forecast Office. Figures 4-8, 4-9, 4-10, and 4-11 indicate total rainfall distribution and the calibrated model output.

Figure 4-6
Sept 4-5, 2018 – AHPS Total Rainfall Map



Source: https://water.weather.gov/precip/

Figure 4-7
Sept 4-5, 2018 – Total Rainfall Map



Source: https://www.weather.gov/bmx/rainfallplots

Figure 4-8
Sept 4-5, 2018 – Total Rainfall Distribution

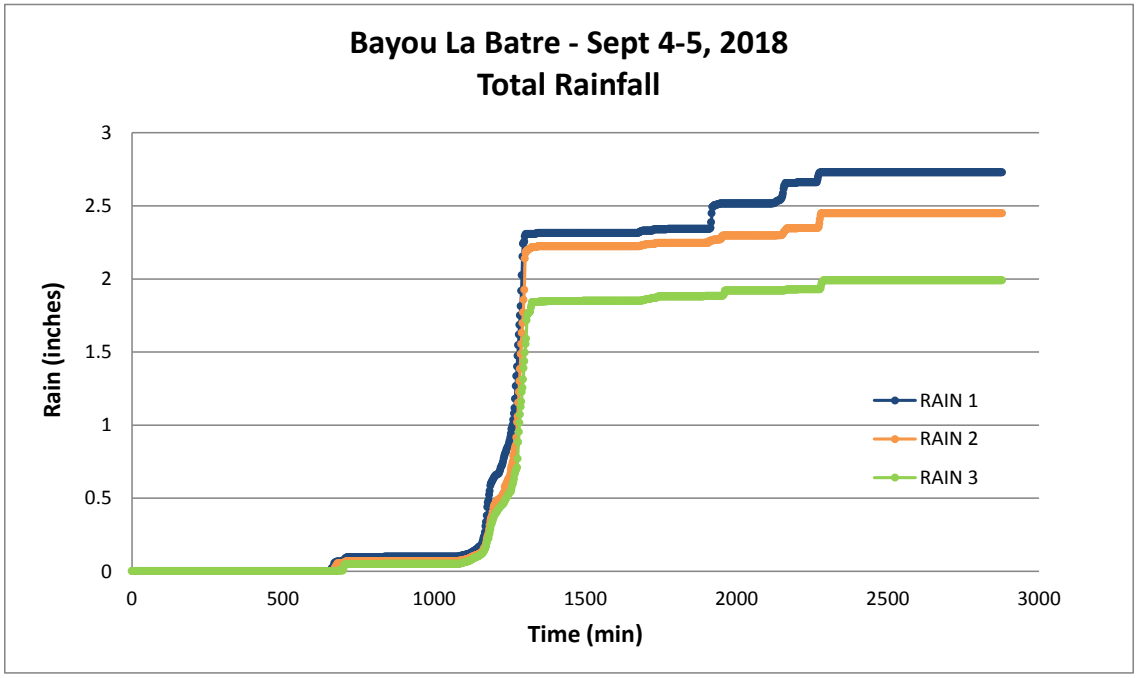


Figure 4-9
Sept 4-6, 2018 – Carls Creek Calibration

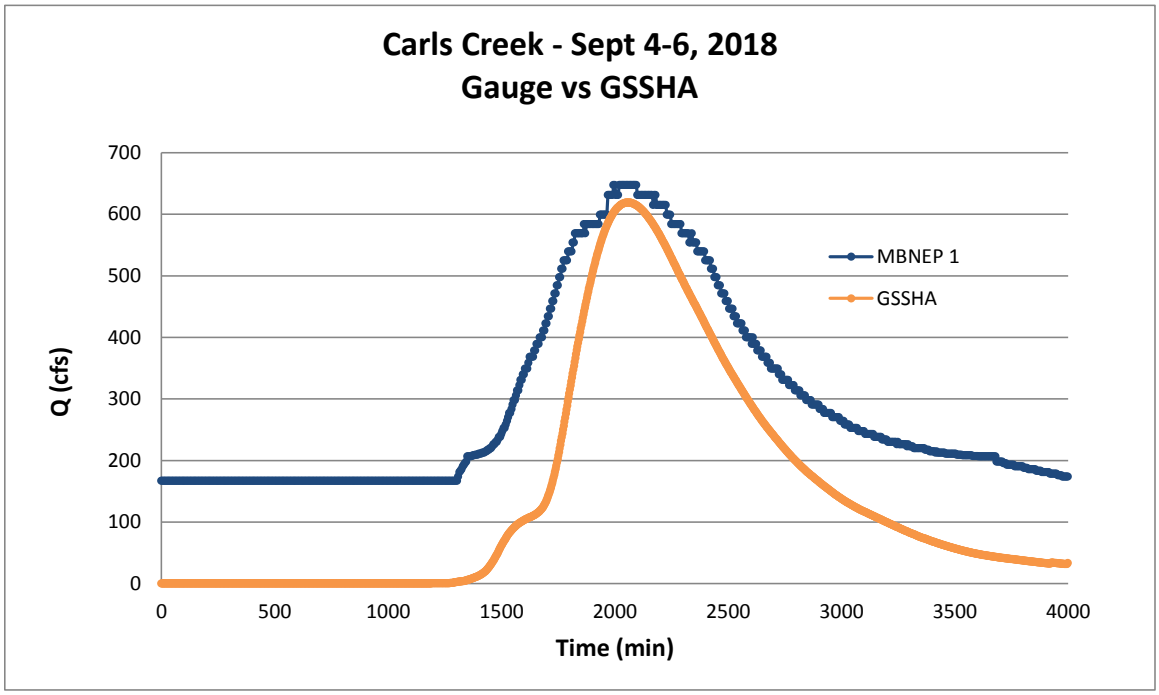


Figure 4-10
Sept 4-5, 2018 – Bishop Manor Creek Calibration

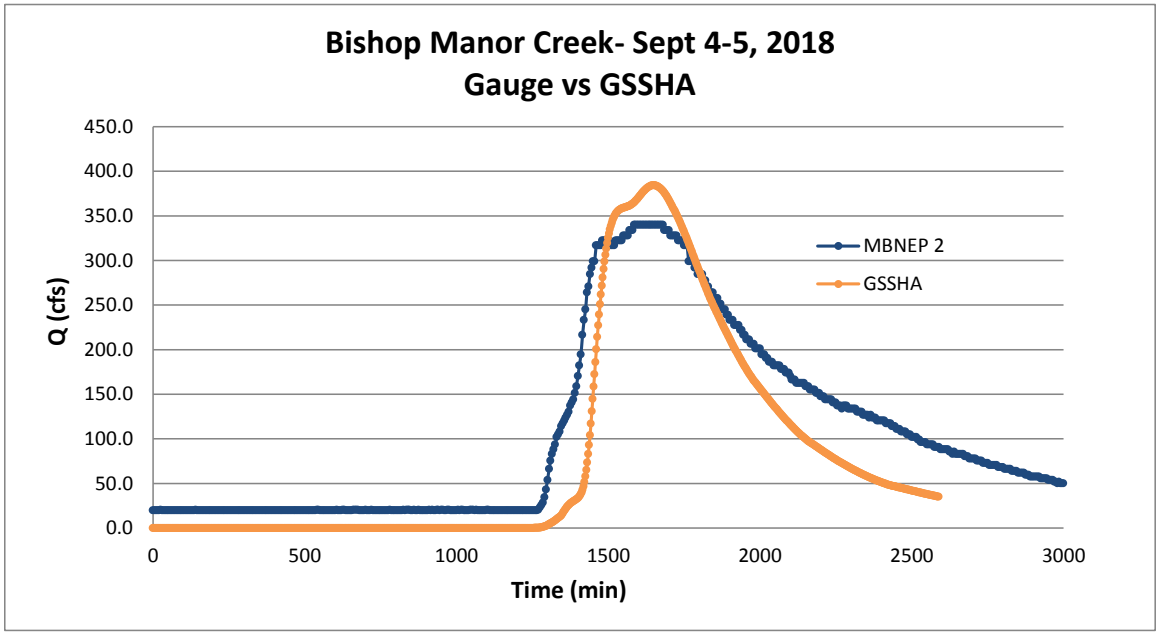
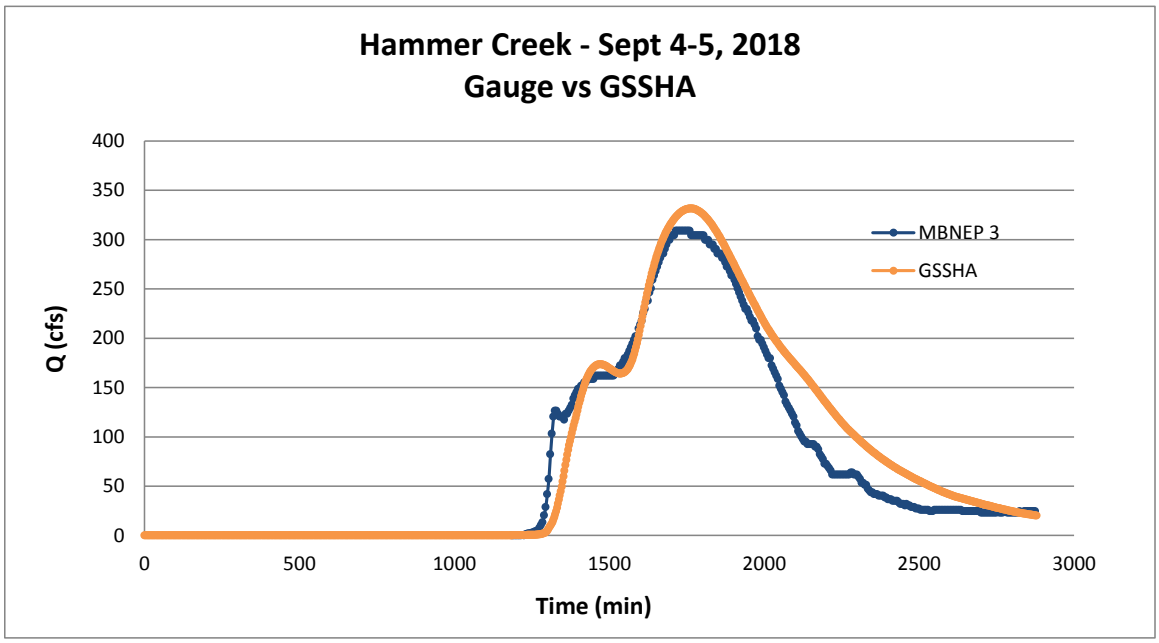


Figure 4-11
Sept 4-5, 2018 – Hammer Creek Calibration



Figures 4-12 and 4-13 indicate the total rainfall maps for the July 13, 2019 rain event generated by the NWS Advanced Hydrologic Prediction Service and the Birmingham NWS Forecast Office. Figures 4-14, 4-15, 4-16, and 4-17 indicate total rainfall distribution and the calibrated model output.

Figure 4-12
July 13-14, 2019 – AHPS Total Rainfall Map

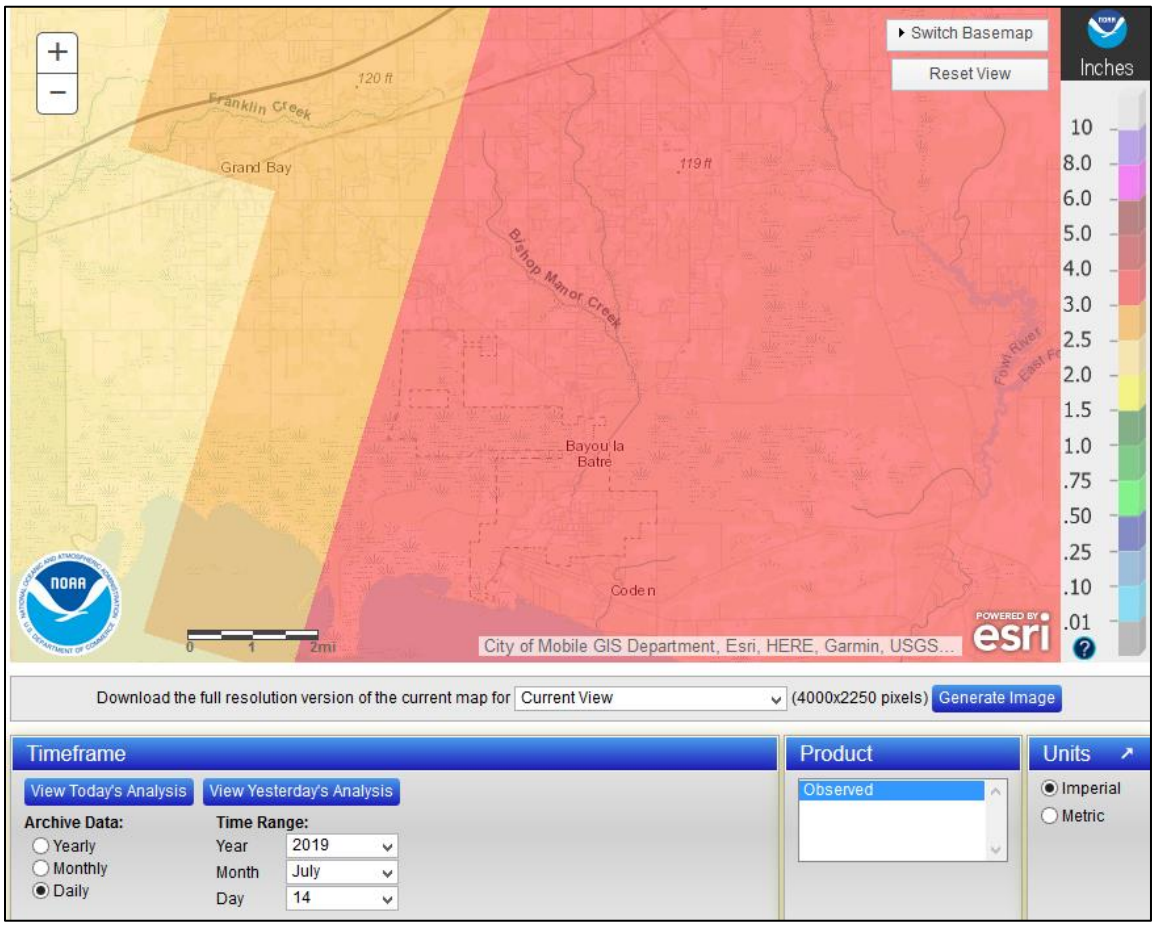


Figure 4-13
July 13-14, 2019 – Total Rainfall Map

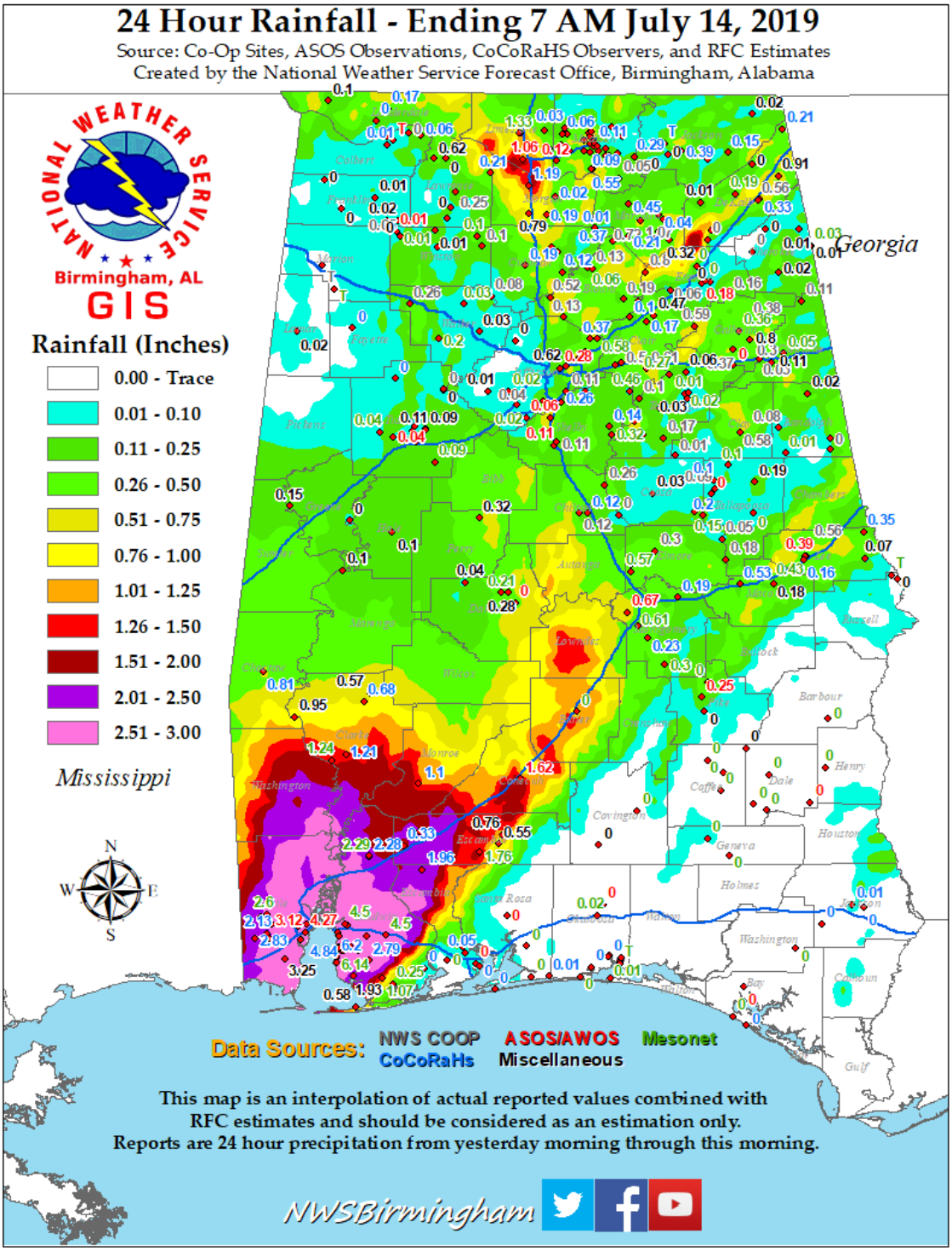


Figure 4-14
July 13, 2019 – Total Rainfall Distribution

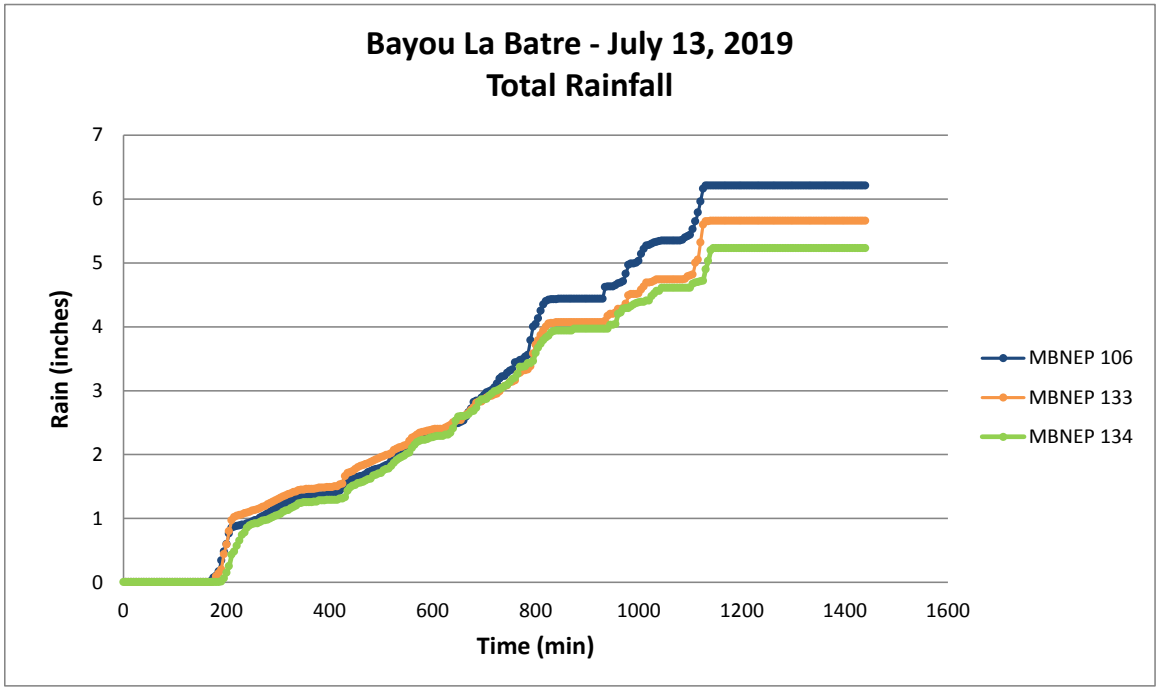


Figure 4-15
July 13-14, 2019 – Carls Creek Calibration

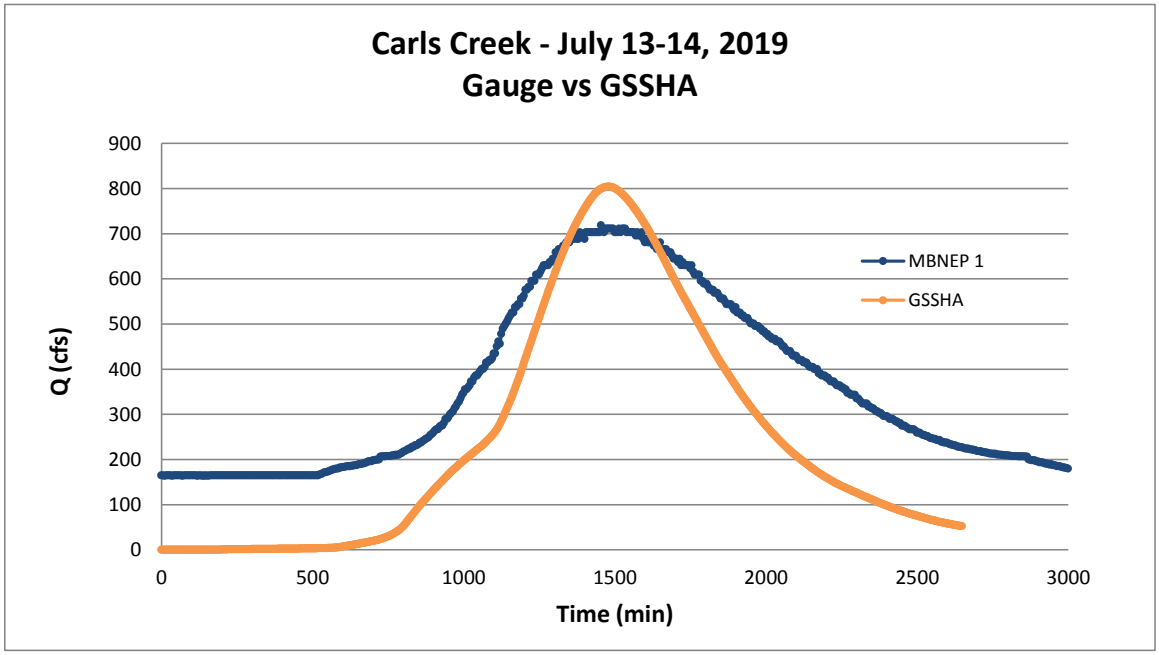


Figure 4-16
July 13-14, 2019 – Bishop Manor Creek Calibration

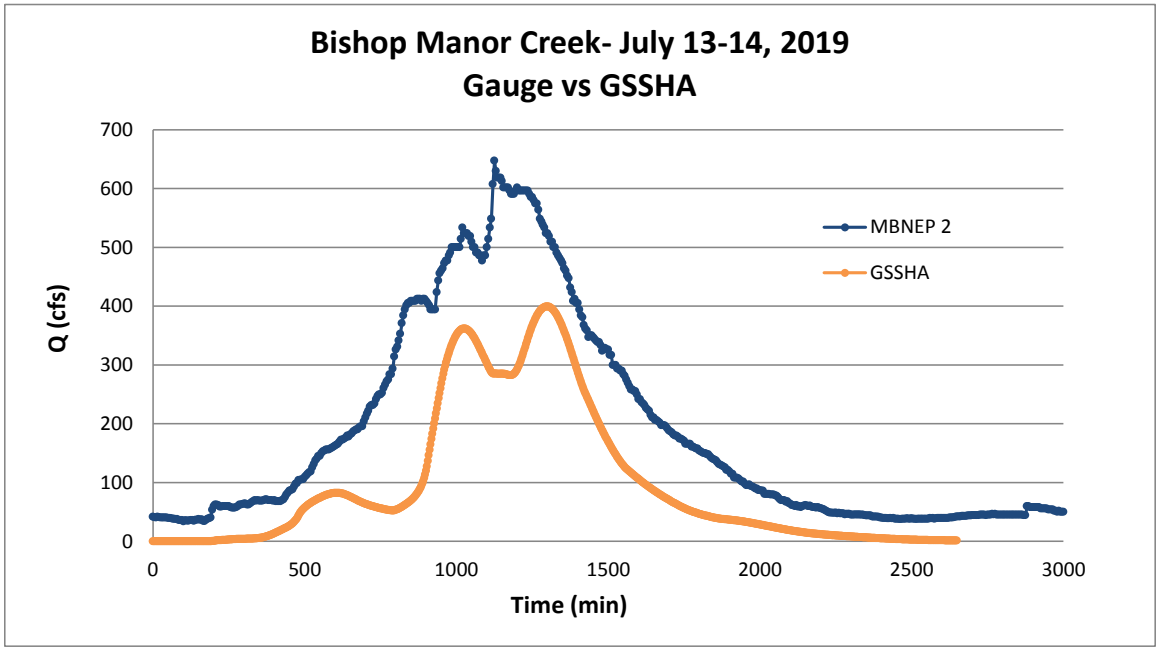
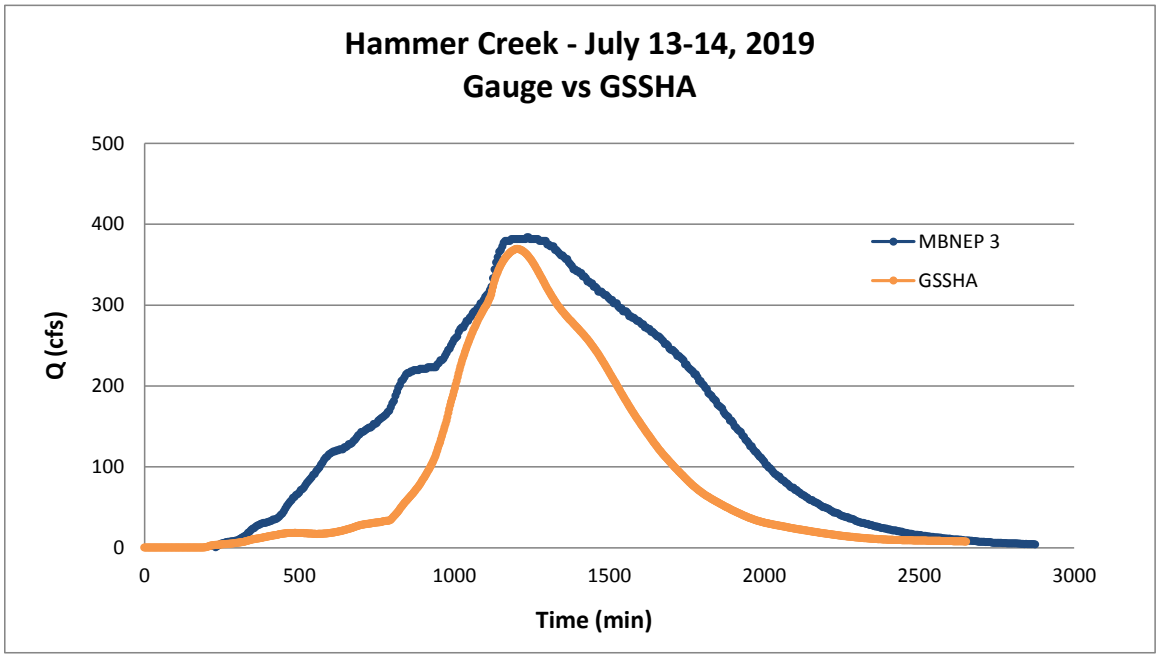


Figure 4-17
July 13-14, 2019 – Hammer Creek Calibration



Figures 4-18 and 4-19 indicate the total rainfall maps for the August 26, 2019 rain event generated by the NWS Advanced Hydrologic Prediction Service and the Birmingham NWS Forecast Office. Figures 4-20, 4-21, 4-22, and 4-23 indicate total rainfall distribution and the calibrated model output.

Figure 4-18
August 26-27, 2019 – AHPS Total Rainfall Map

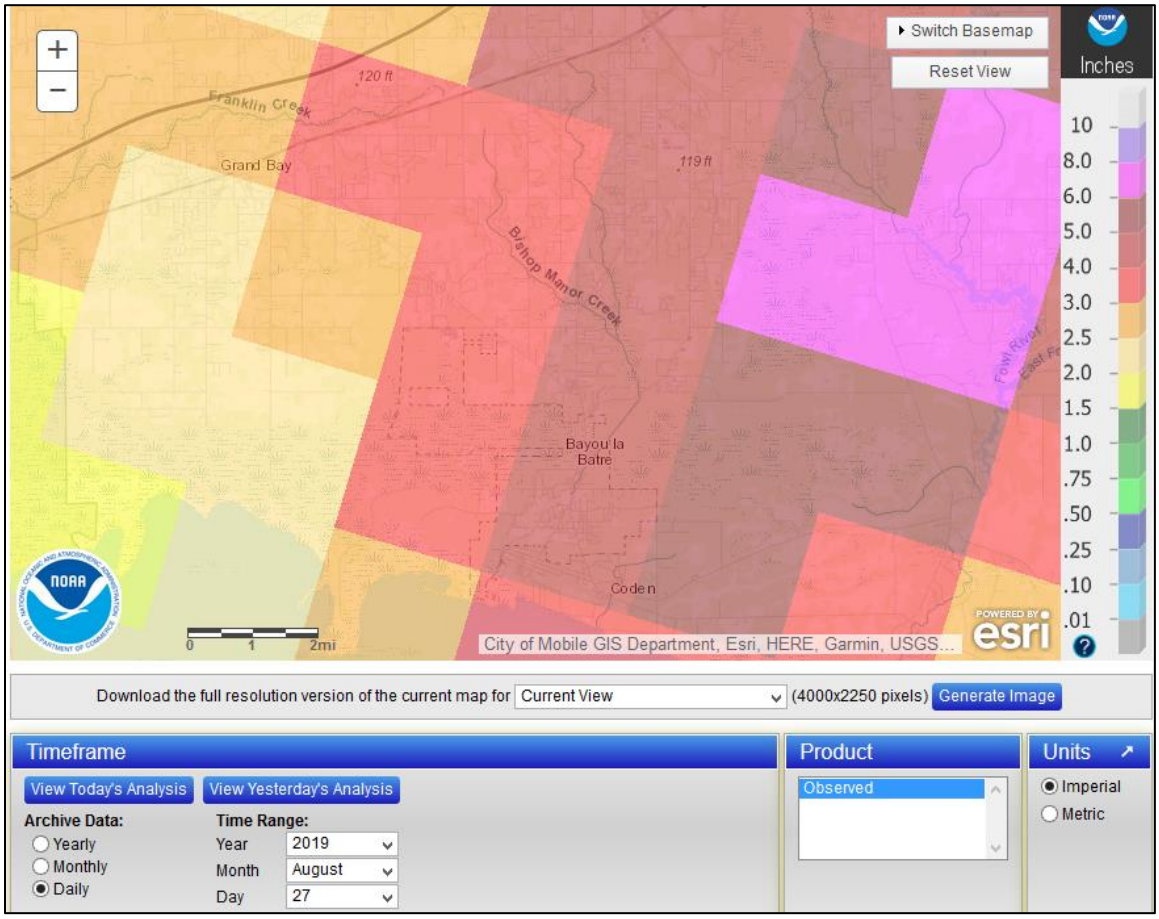


Figure 4-19
August 26-27, 2019 – Total Rainfall Map

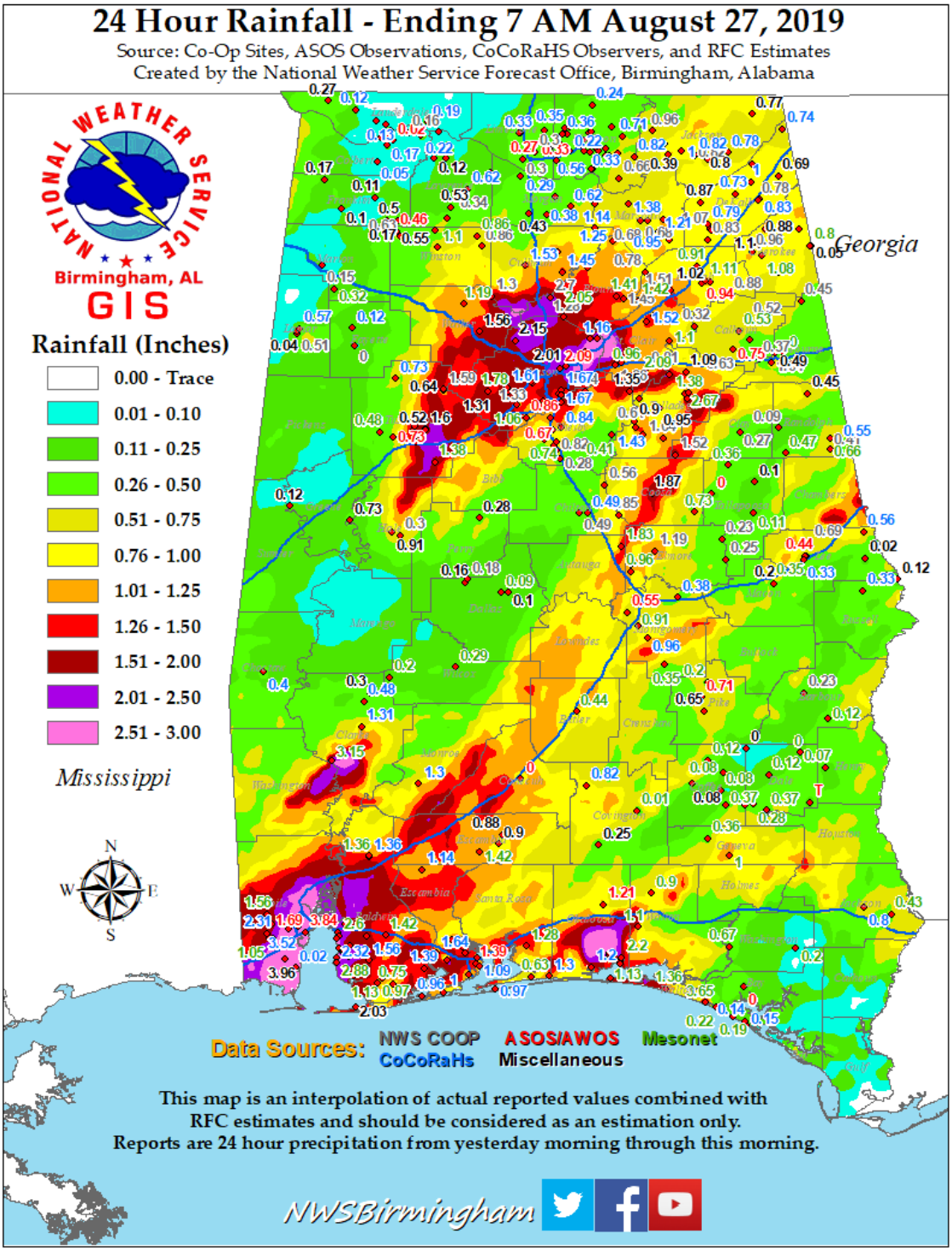


Figure 4-20
August 25-26, 2019 – Total Rainfall Distribution

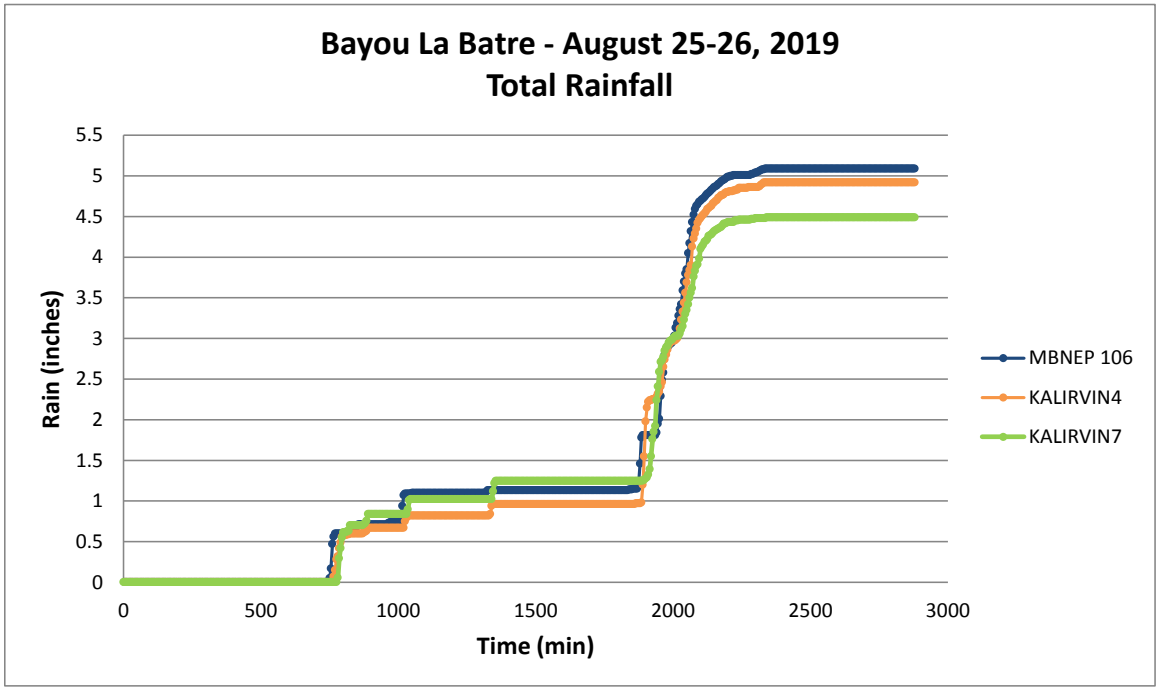


Figure 4-21
August 25-27, 2019 – Carls Creek Calibration

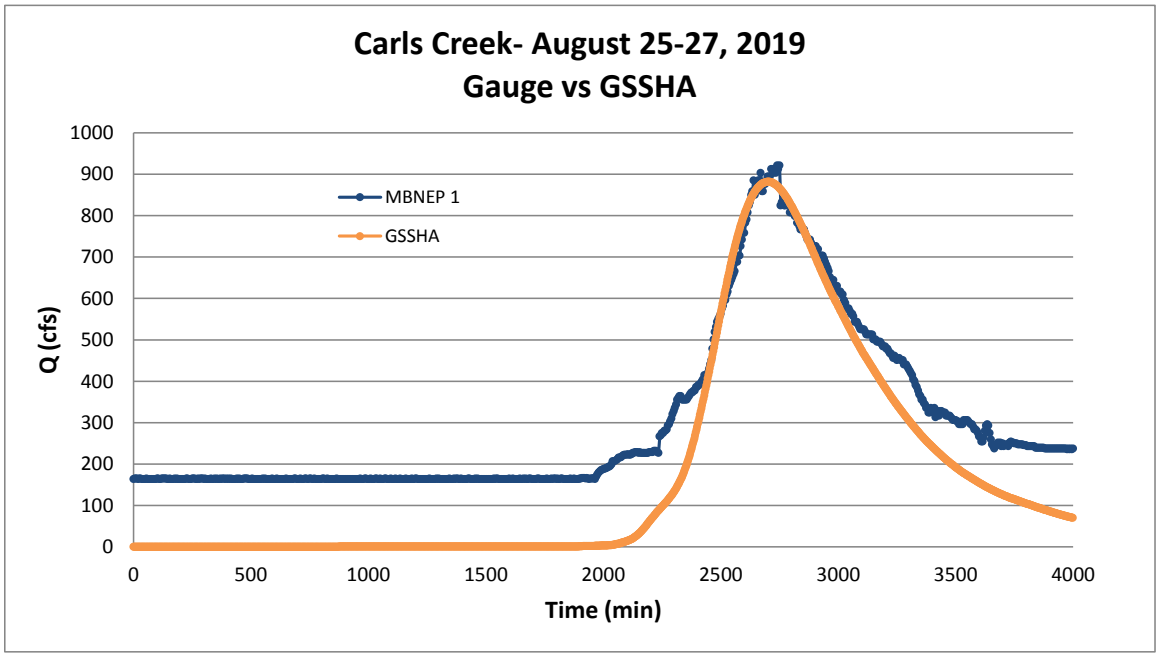


Figure 4-22
August 25-27, 2019 – Bishop Manor Creek Calibration

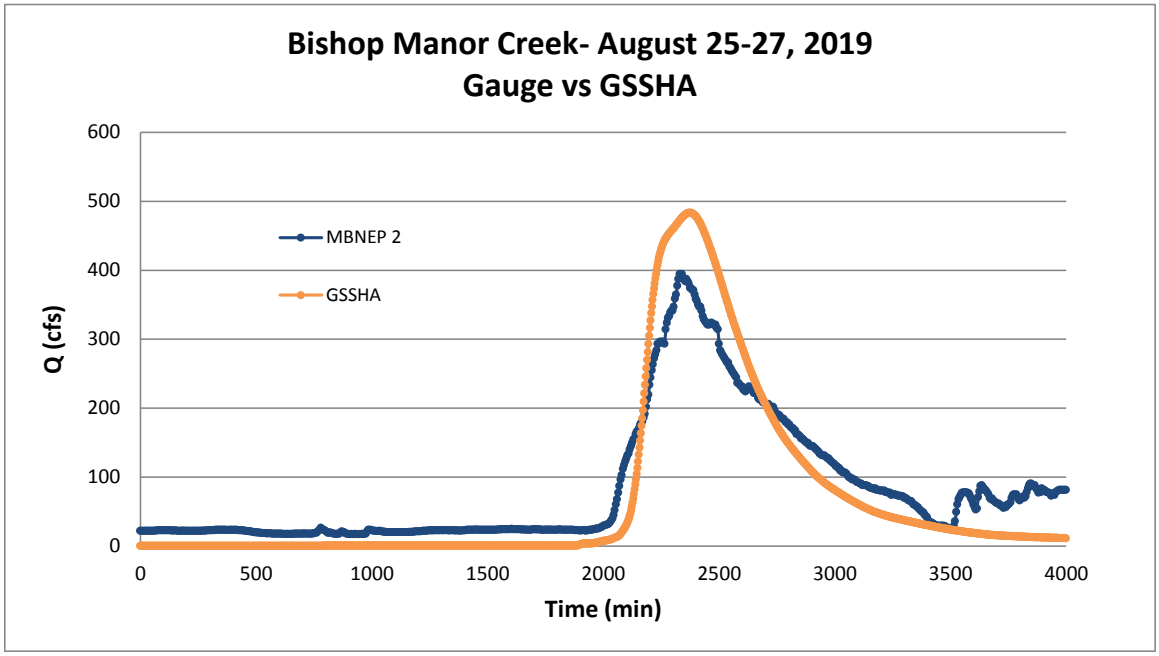
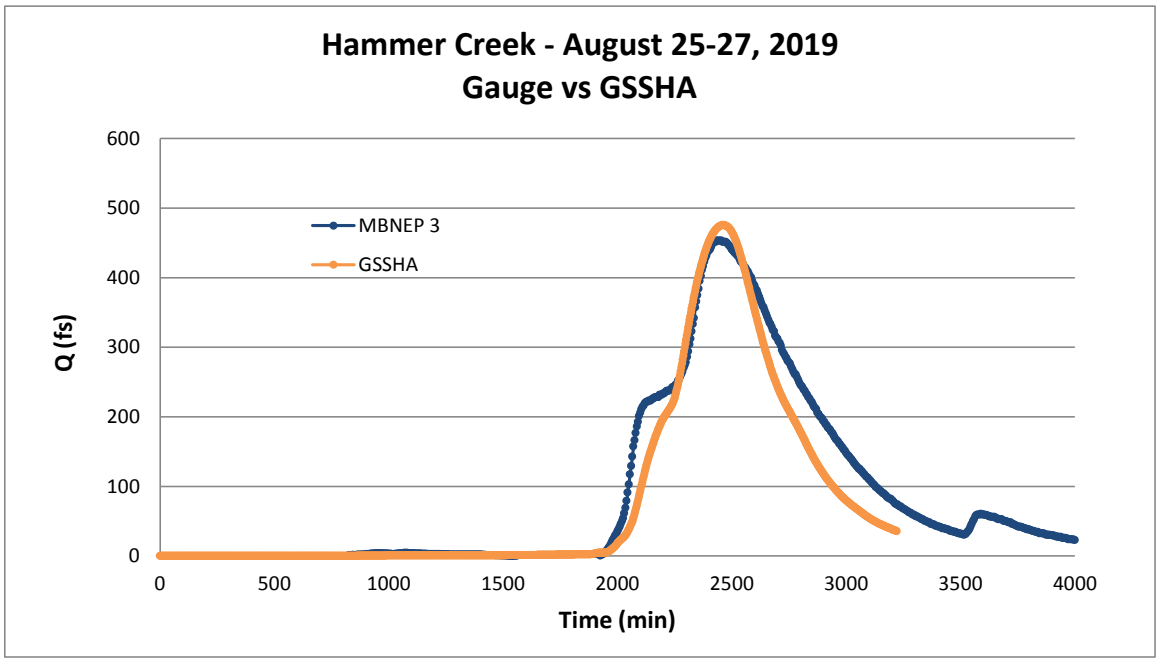


Figure 4-23
August 25-27, 2019 – Hammer Creek Calibration



Figures 4-24 and 4-25 indicate the total rainfall maps for the October 30, 2019 rain event generated by the NWS Advanced Hydrologic Prediction Service and the Birmingham NWS Forecast Office. Figures 4-26, 4-27, 4-28, and 4-29 indicate total rainfall distribution and the calibrated model output.

Figure 4-24
October 30, 2019 – AHPS Total Rainfall Map

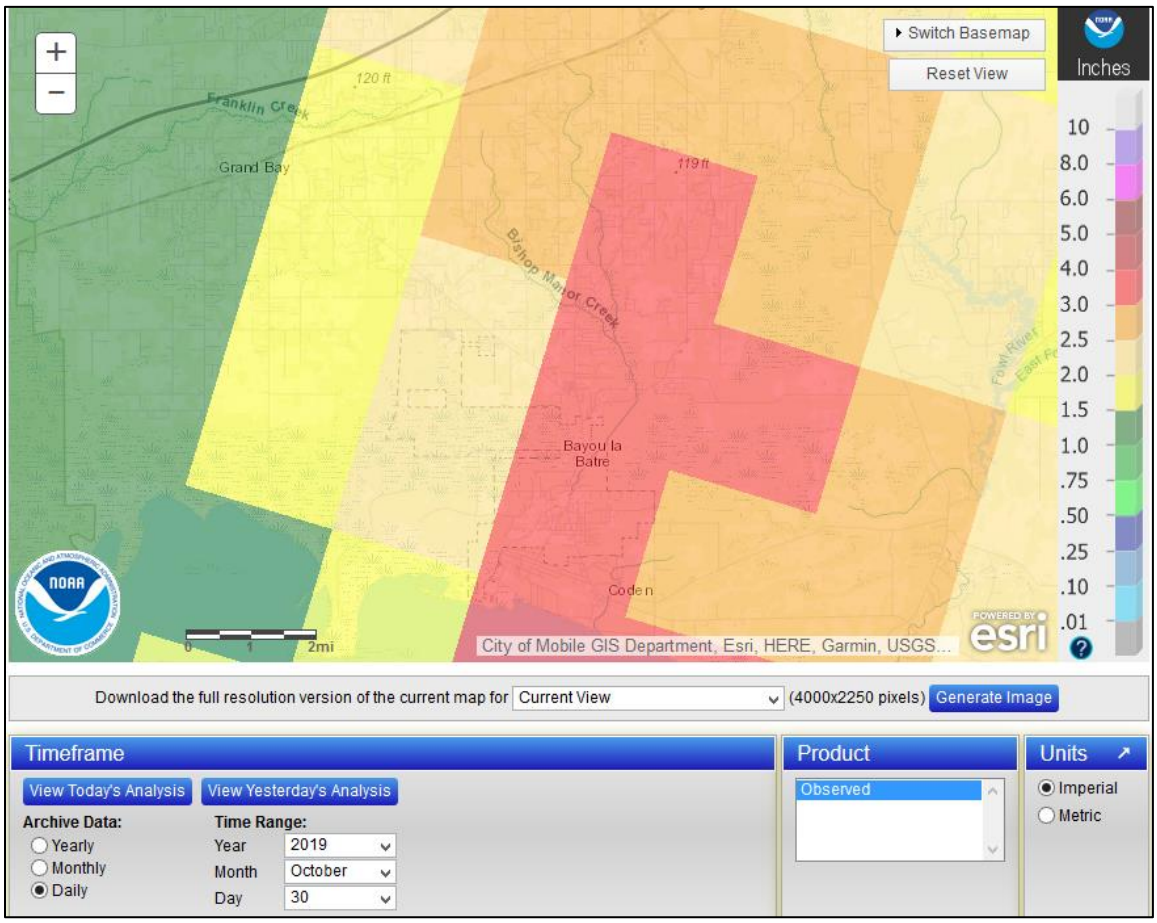


Figure 4-25
October 30, 2019 – Total Rainfall Map

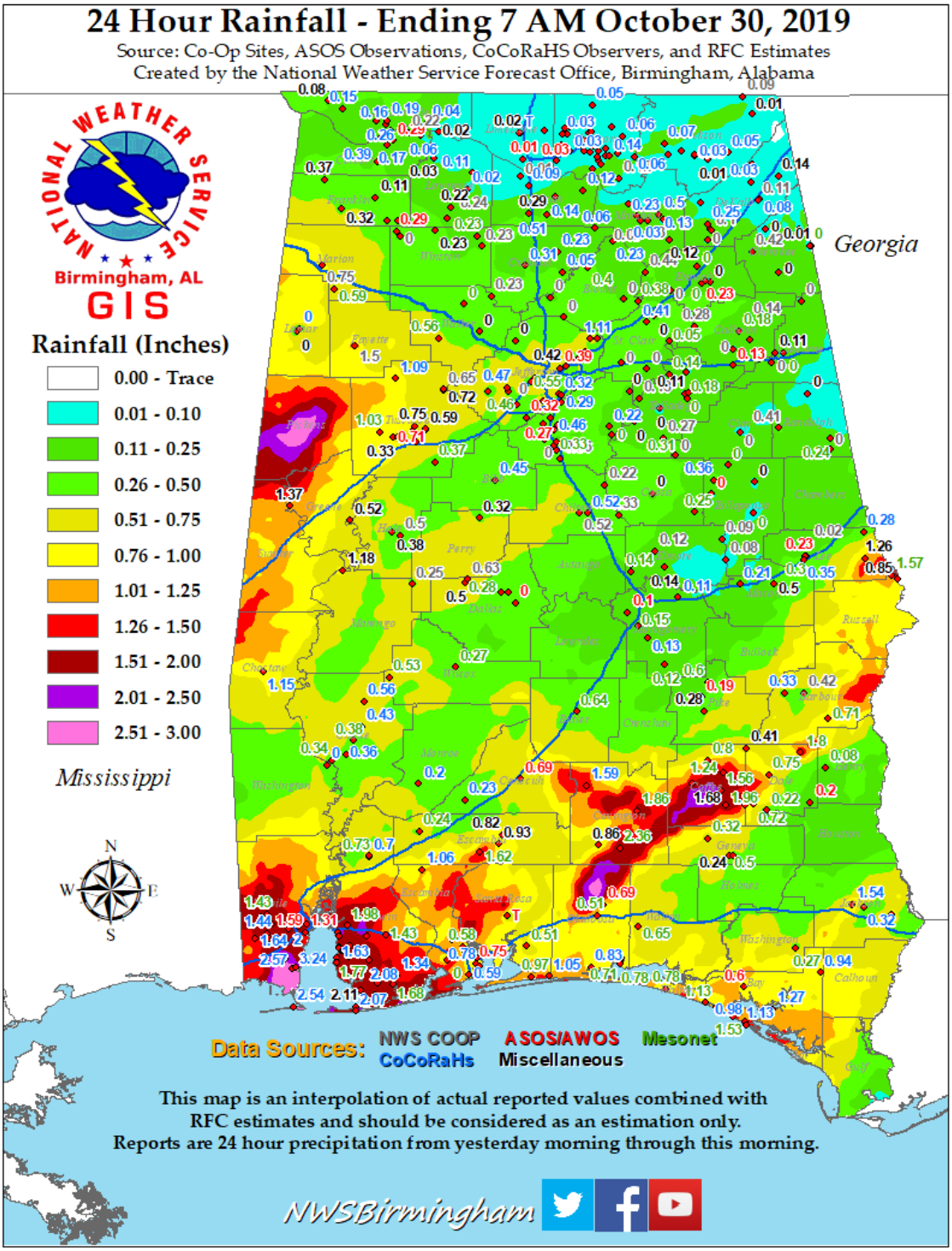


Figure 4-26
October 30, 2019 – Total Rainfall Distribution

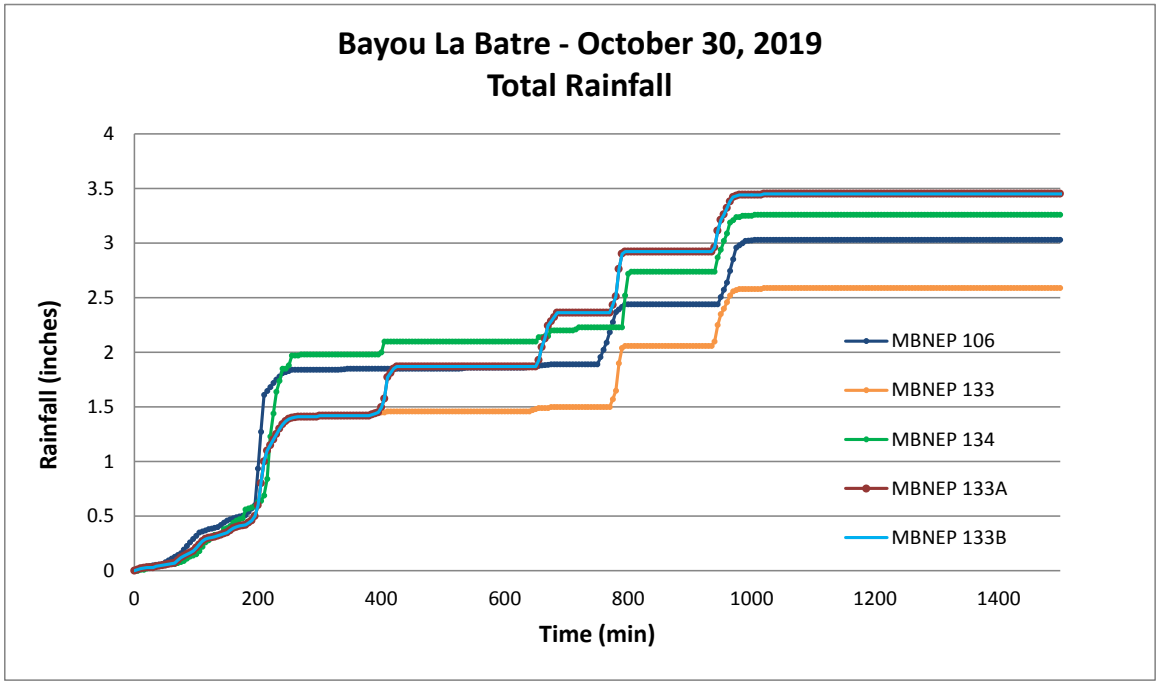


Figure 4-27
October 30-31, 2019 – Carls Creek Calibration

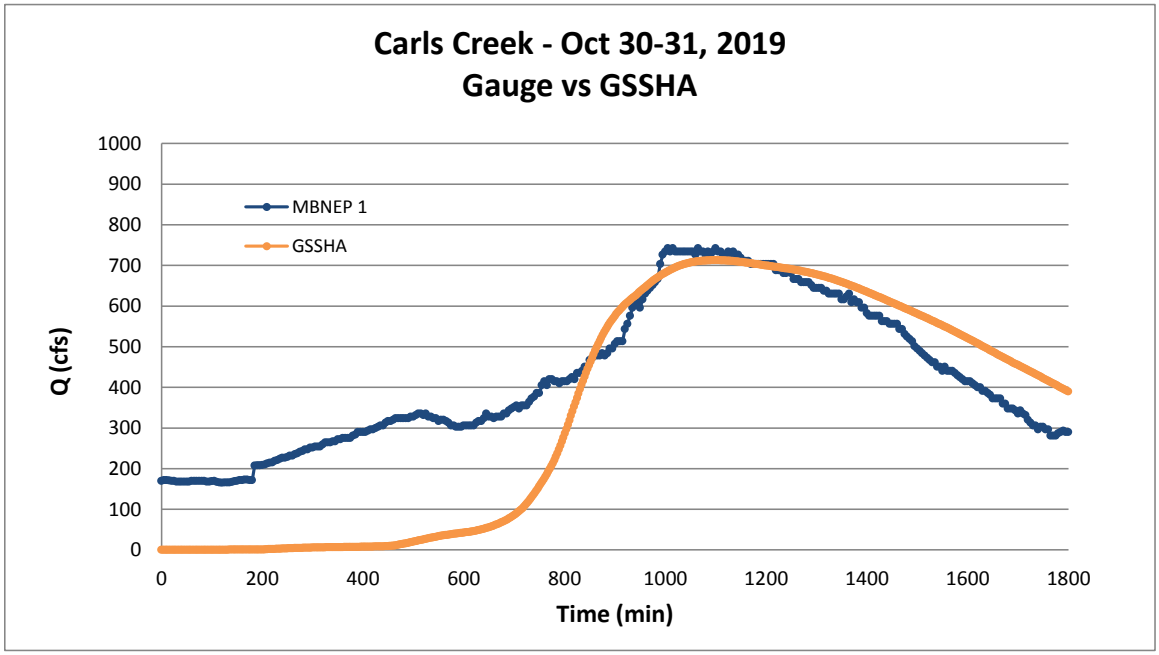


Figure 4-28
October 30-31, 2019 – Bishop Manor Creek Calibration

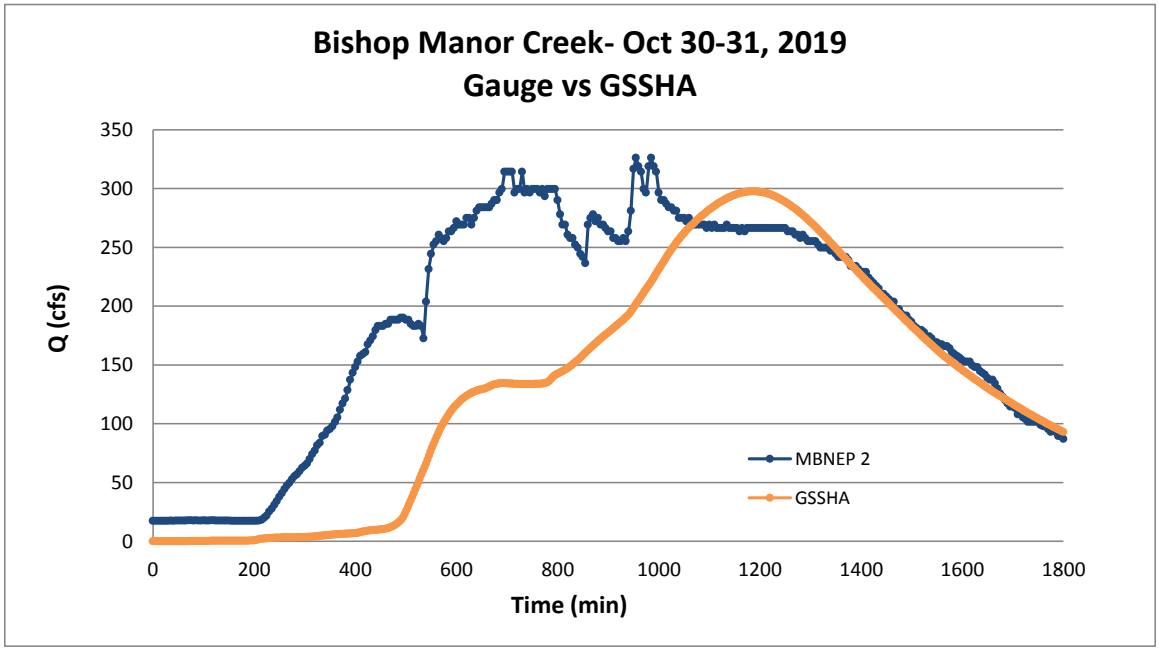
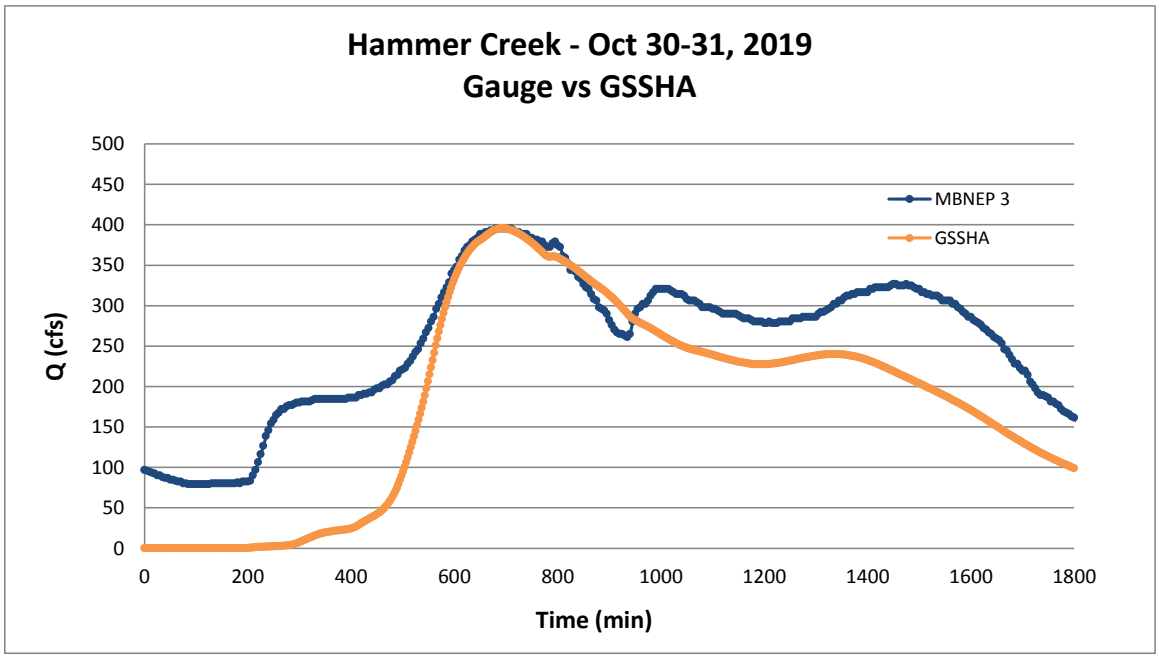


Figure 4-29
October 30-31, 2019 – Hammer Creek Calibration



Figures 4-30 and 4-31 indicate the total rainfall maps for the June 7, 2020 rain event generated by the NWS Advanced Hydrologic Prediction Service and the Birmingham NWS Forecast Office. Figures 4-32, 4-33, 4-34, and 4-35 indicate total rainfall distribution and the calibrated model output.

Figure 4-30
June 7-8, 2020 – AHPS Total Rainfall Map

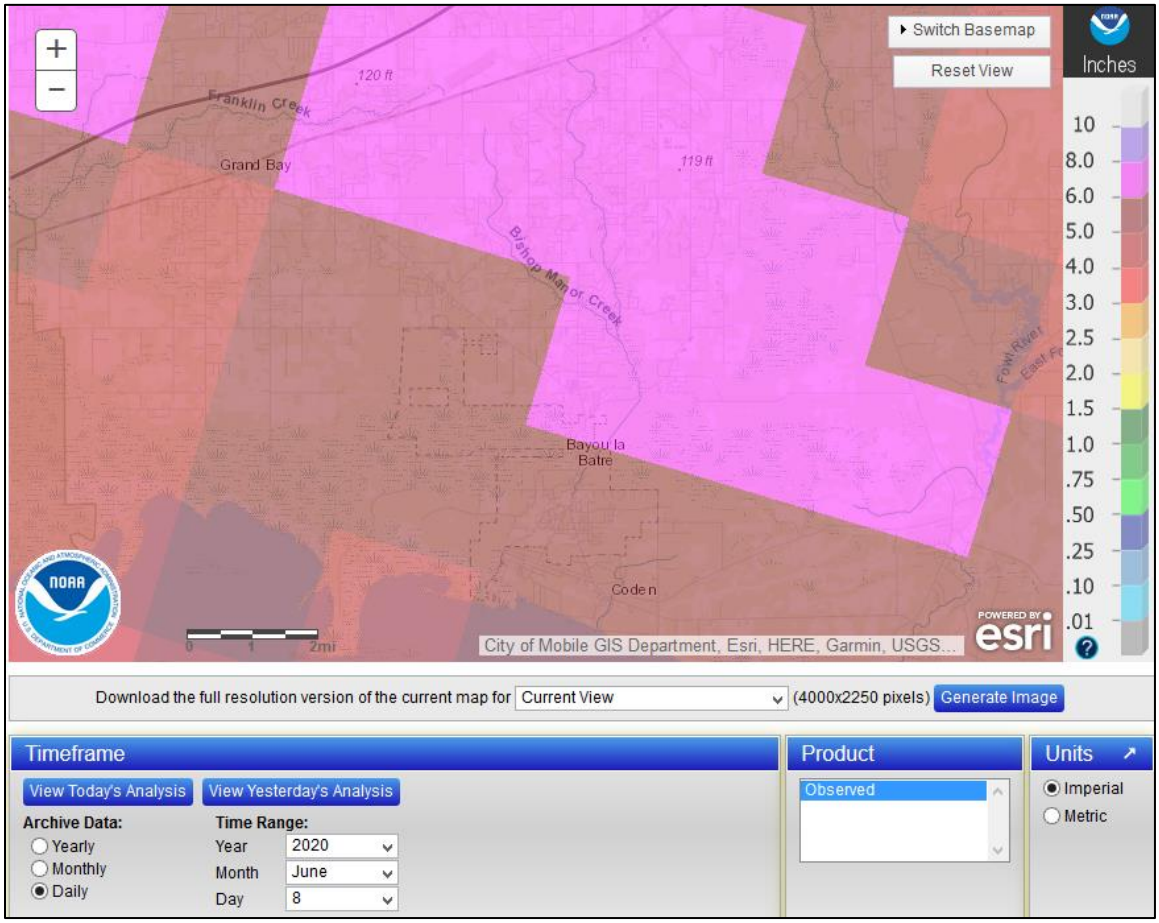


Figure 4-31
June 7-8, 2020 – Total Rainfall Map

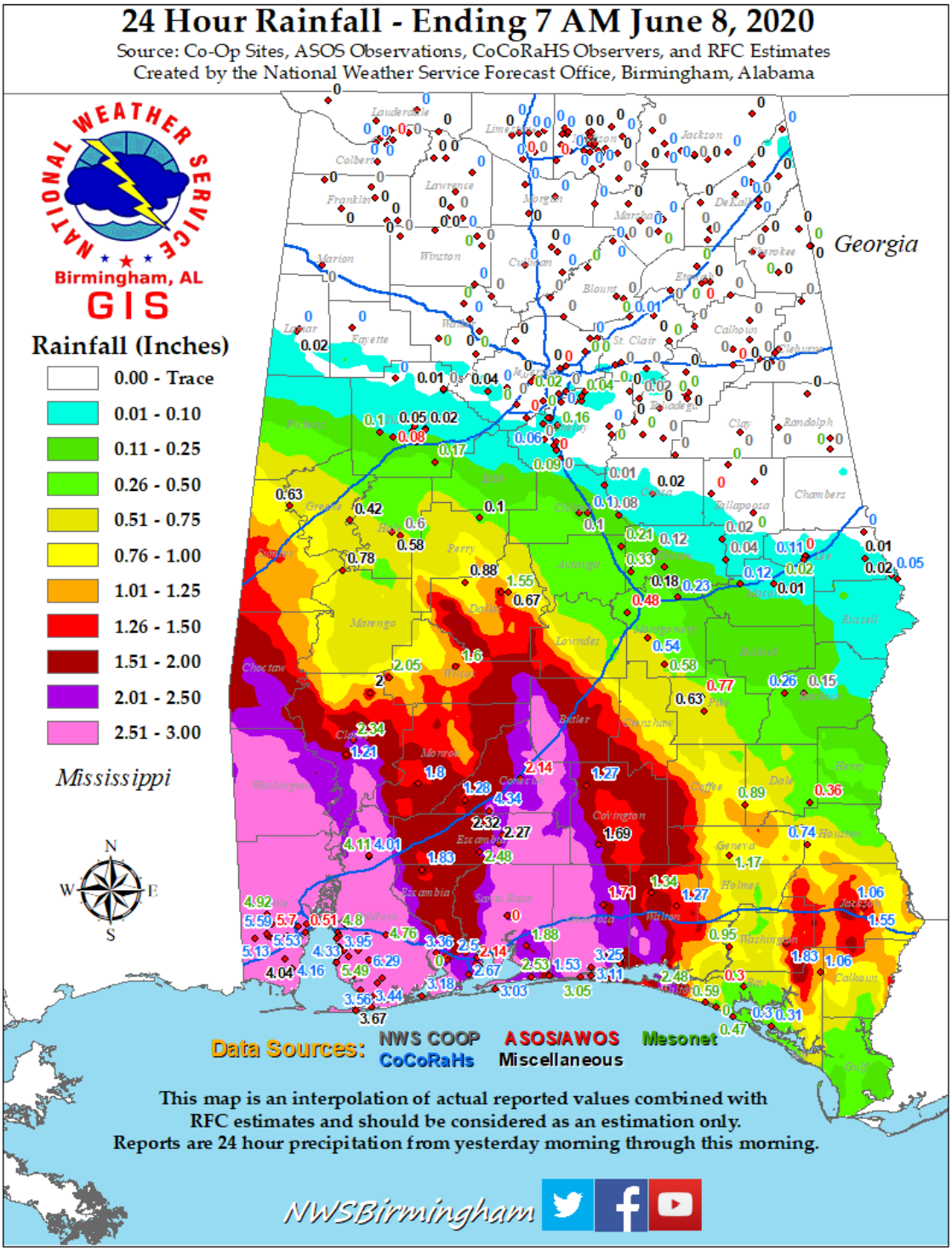


Figure 4-32
June 7-8, 2020 – Total Rainfall Distribution

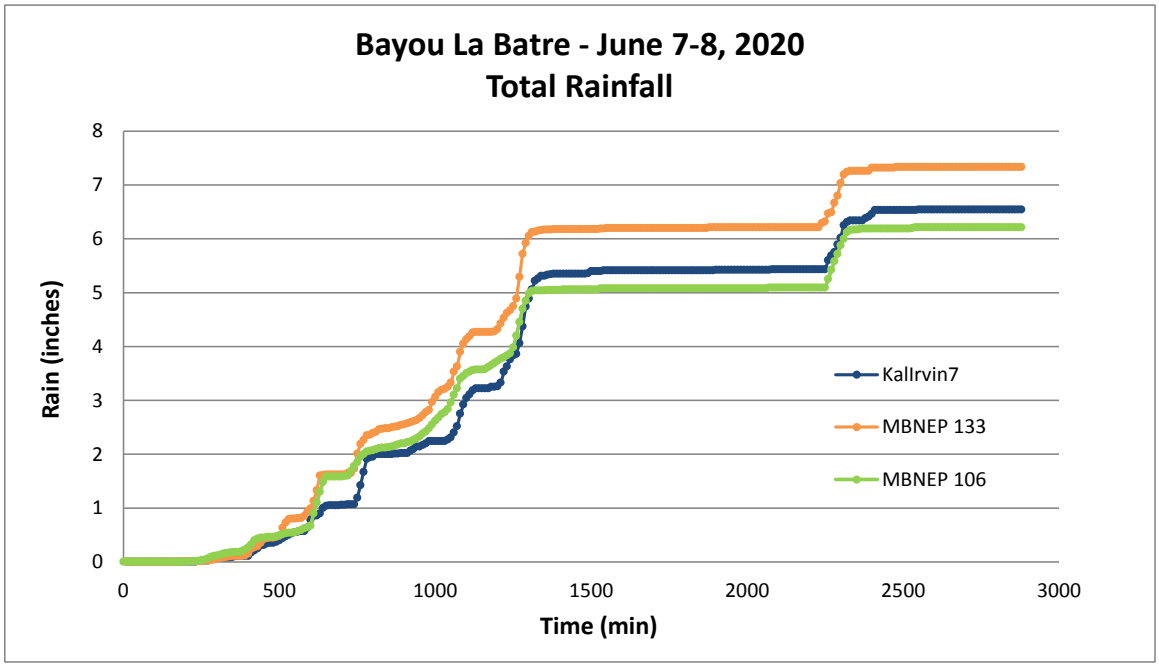


Figure 4-33
June 7-8, 2020 – Carls Creek Calibration

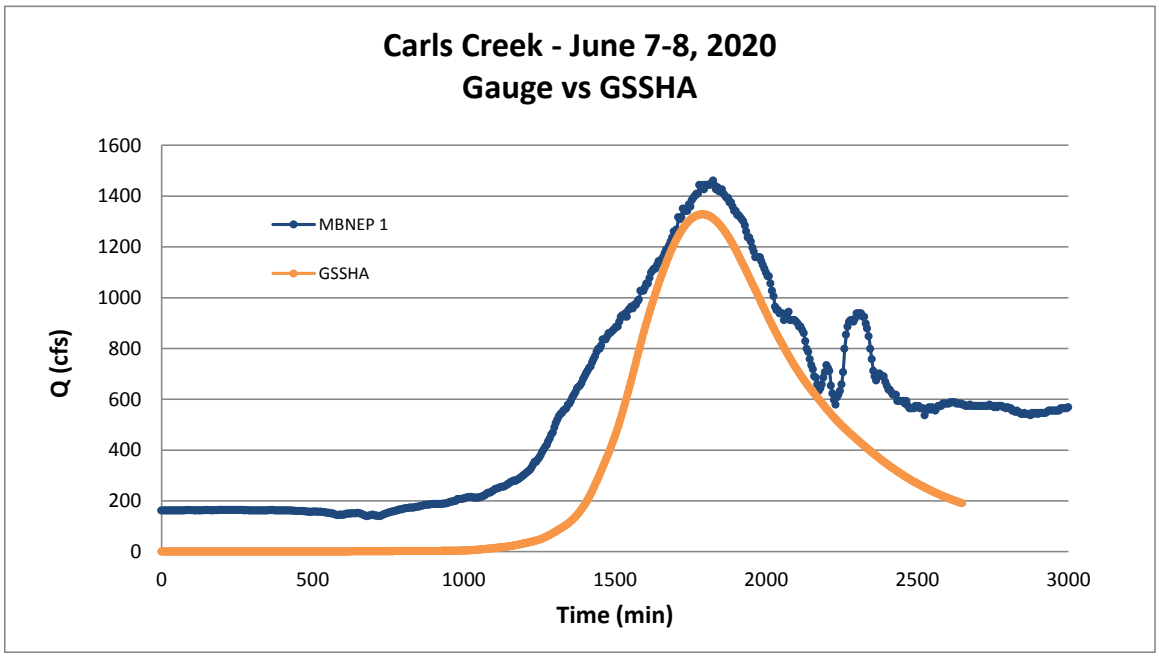


Figure 4-34
June 7-8, 2020 – Bishop Manor Creek Calibration

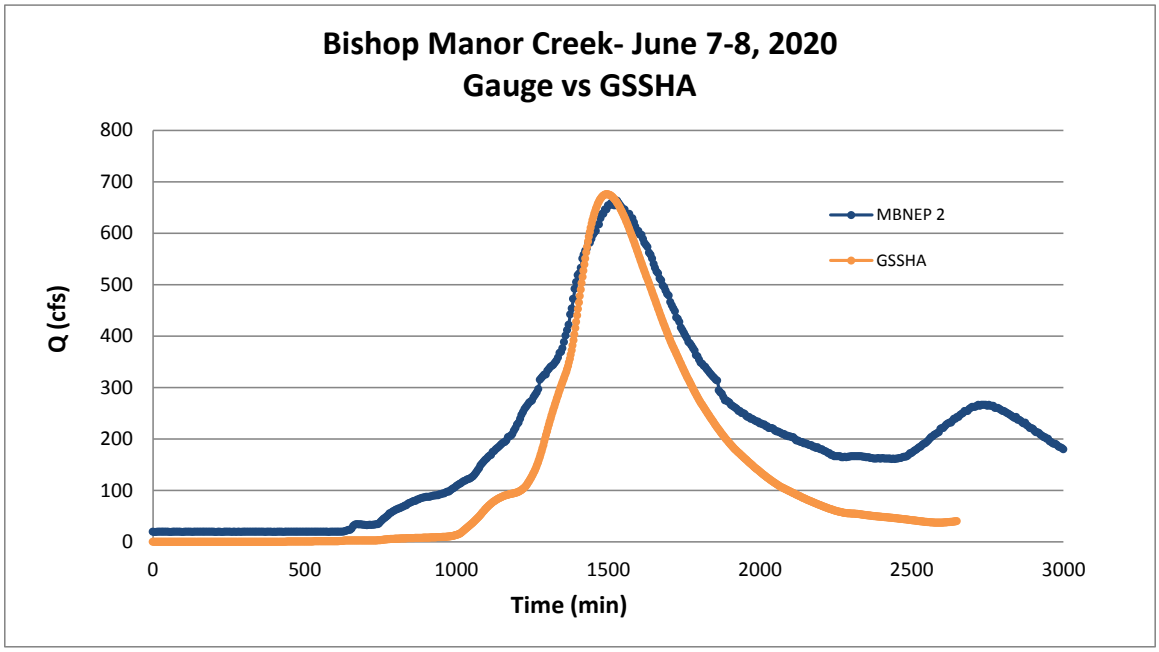
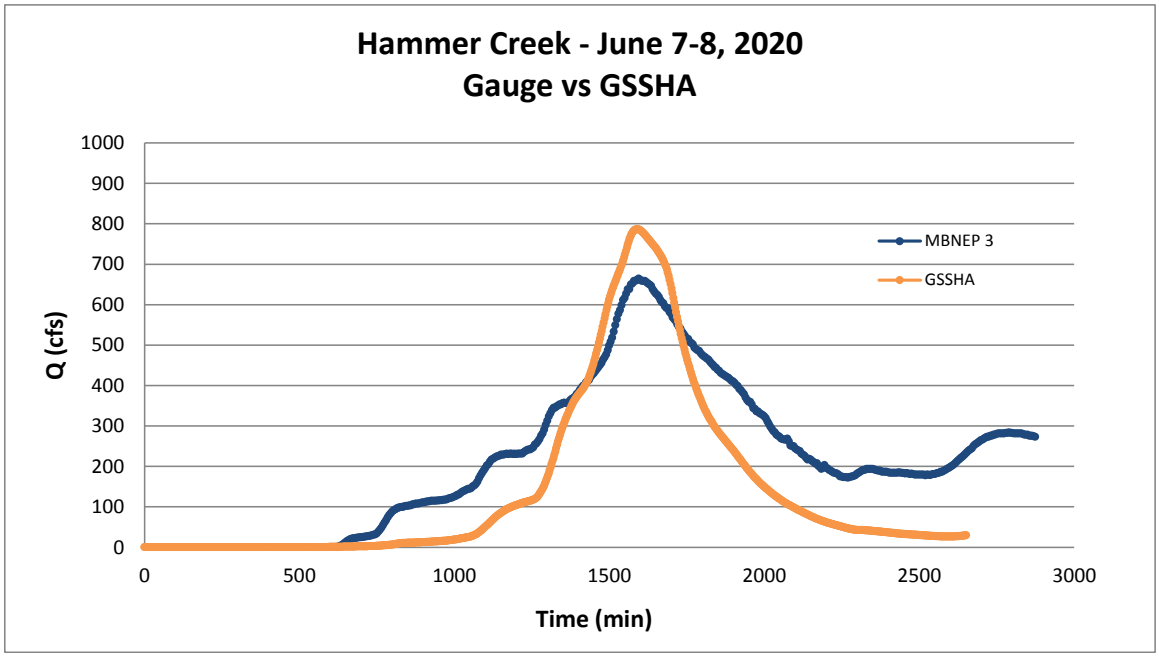


Figure 4-35
June 7-8, 2020 – Hammer Creek Calibration



5. Results and Conclusions

5.1. Results

During the evaluation period between the middle of June 2018 and June 2020 the Bayou La Batre watershed experienced multiple small rain storms. These rain storms typically produced less than 2 or 3 inches of rain per event. Using the stream gauge plots found in Figures 4-2, 4-3, and 4-4, the largest events were chosen for model calibration. During this study, the largest event occurred on June 7-8, 2020 when the watershed experienced 5” of rain in 12 hours. Using Figure 4-5, it can be determined that this is equal to a 2-year rain recurrence interval. The modeled discharges are in line with the rural regression equations for the same recurrence interval.

The first event used for the study occurred on September 4, 2018 from Tropical Storm Gordon. During this event, the watershed experienced approximately 2.2” in 3 hours. This event was considered to be less than a 1-year recurrence interval for the amount of rain in this period of time. On July 13, 2019 the watershed experienced approximately 4.4” in 12 hours. This equates to a storm event just above a 1-year recurrence interval. The modeled discharges are in line with a rural basin experiencing just over a 1-year storm event.

On August 26, 2019 the watershed experienced approximately 3.9” in 6 hours. This equates to a storm event just below a 2-year recurrence interval. The modeled discharges are in line with the rural regression equations for the same recurrence interval (just under a 2-year rural discharge). On October 30, 2019 the watershed experienced between 2.5” and 3” of rain in 12 hours. Using Figure 4-5, it can be determined that this is below a 1-year rain event. Comparing the calibrated discharges to the discharges determined from the small stream rural regression equations, it can be seen that the even though the watershed experienced a rain event less than a 1-year, the discharges are more in line with those just over a 1-year storm. This is due to the antecedent moisture conditions from rainfall occurring over the previous 5 days.

5.2. Conclusions

After analysis of the discharges and rainfall events that occurred between June 2018 and June 2020, it has been determined that a 1-year or 2-year rainfall event produces discharges equivalent to their recurrence interval for a rural basin. The top two thirds of the watershed contain a variety of woody wetlands, pastureland, grasslands, and residential development. The small increase in discharge from the residential development in the northern part of the watershed is offset by the percentage of forest, pasture, and wetlands still remaining.

There are opportunities for increased storage in the bottom third of the watershed due to the very flat topography and presence of evergreen forest and woody wetlands. These undisturbed natural areas contribute to interception and retention of the rainfall. While this is the case for the smaller rainfall events, it is uncertain what the extent of the storage routing will be during larger flooding events.

For smaller rain events (<= 2-year), the currently calibrated GSSHA model can be used as a management tool for determining bank forming discharges throughout the watershed. Future restoration projects may be able to utilize these discharges for bankfull analysis. For larger discharge events, the model will need to be reevaluated to determine if further calibration is required. This is due to the uncertainty of the amount of impact the storage within the watershed will have on timing and peak discharges.

6. References

1. Cook, M, Inc., Pre-Restoration Analysis of Discharge, Sediment Transport Rates, Water Quality, and Land-Use Impacts in the Bayou La Batre Watershed, Mobile County, Alabama. Mobile Bay National Estuary Program (www.mobilebaynep.com), August 2016.

2. Dewberry, Bayou La Batre Watershed Management Plan. Mobile Bay National Estuary Program (www.mobilebaynep.com), August 10, 2018.

3. Hedgecock, T.S., and Feaster, T.D., 2007, Magnitude and frequency of floods in Alabama, 2003: U.S. Geological Survey Scientific Investigations Report 2007-5204.

4. Hedgecock, T.S., 2004, Magnitude and frequency of floods on small rural streams in Alabama: U.S. Geological Survey Scientific Investigations Report 2004-5135, 10p.

5. NOAA Atlas 14 Point Precipitation Frequency Estimates: AL, NOAA's National Weather Service, Hydrometeorological Design Studies Center, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=al_. Accessed September 2018.

6. NWS Advanced Hydrologic Prediction Service: NOAA's National Weather Service, https://water.weather.gov/precip/, Accessed January 2020.

7. NWS Alabama Rainfall Plots: NOAA's National Weather Service, https://www.weather.gov/bmx/rainfallplots, Accessed January 2020.