ASDSO 2017

Enhanced Real-Time Rainfall and Flood Forecasting

Understanding the Storm and Implications for Dam Safety

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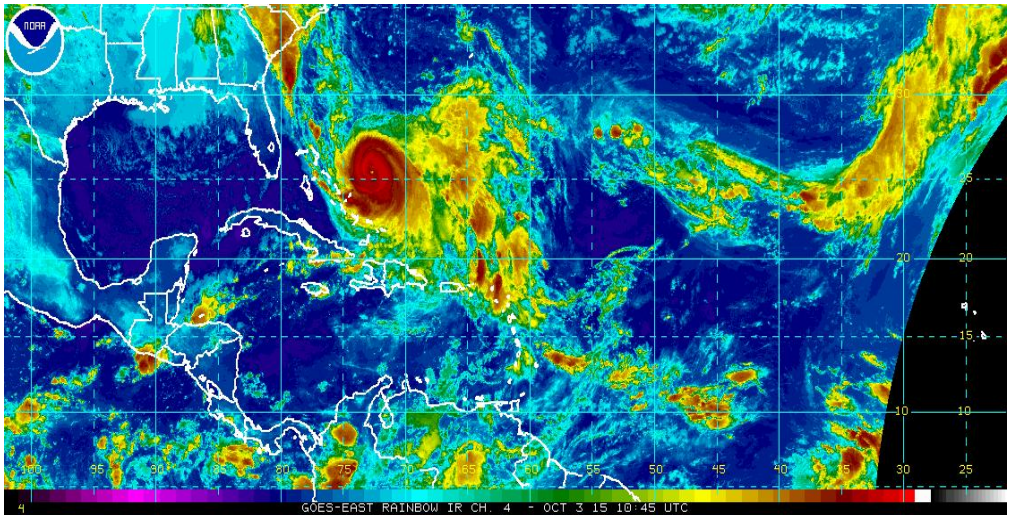
Presentation Outline

- Storm Background and Analysis
- Hydrologic Model
  - HEC-HMS (Lumped Unit Hydrograph)
  - 2D (Fully Distributed)
- Rainfall and Flood Forecasting
  - Rainfall – QPF vs Actual
  - Flood Prediction – QPF vs Actual
- Enhanced Approach to Real-Time Rainfall and Flood Forecasting

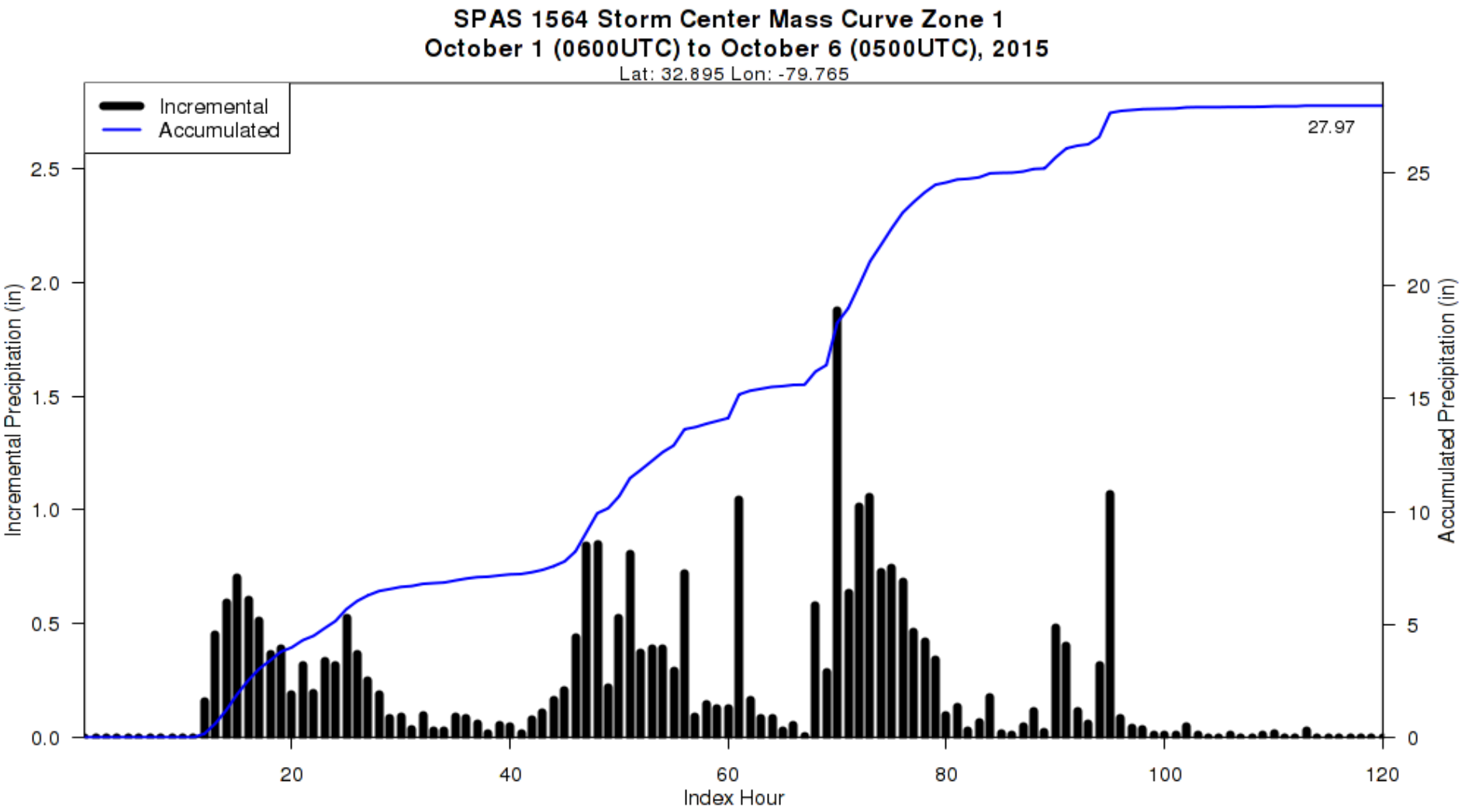
➢ Acknowledge additional contributions JBA Consulting (JBA)

Storm Background and Analysis

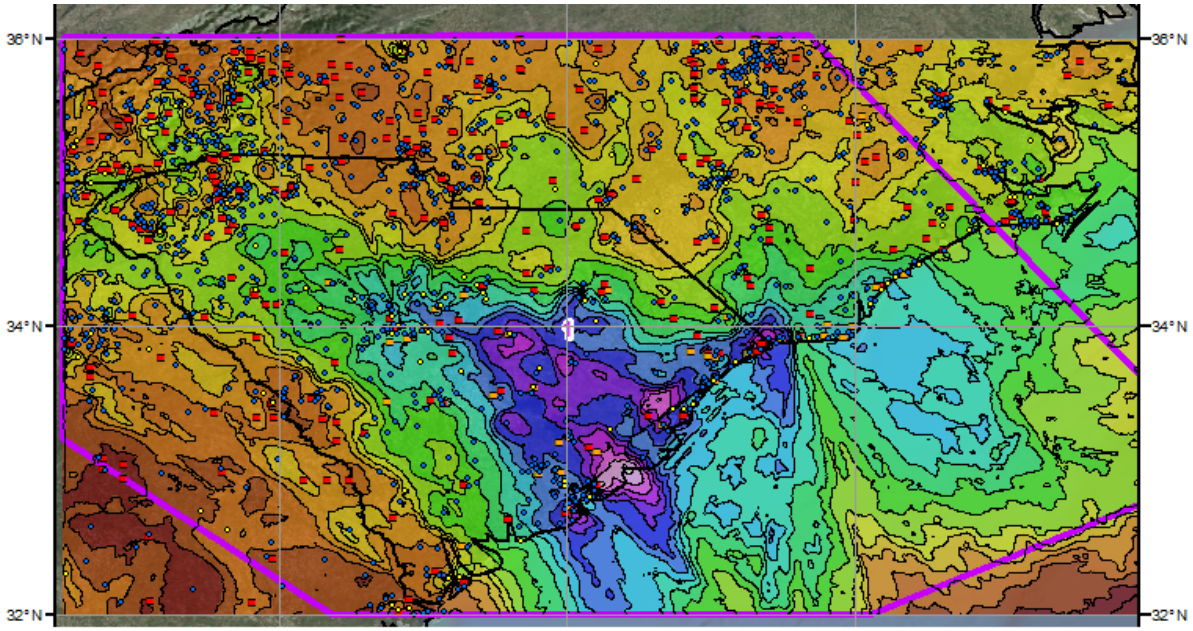
- Heavy rainfall associated with Hurricane Joaquin
- October 1-5, 2015
- Concentrated over Piedmont and coast of South Carolina
- High moisture/stalled front over same area for several days
- Widespread region with more than 20 inches
- Several areas less than 1/1,000-yr AEP



AWA SPAS Analysis of Rainfall



AWA SPAS Analysis of Rainfall



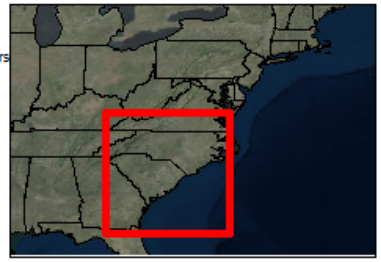
Total Storm (120-hours) Precipitation (mm)
10/1/2015 0600 UTC - 10/6/2015 0500
SPAS-NEXRAD #1564

Gauges
- Daily
- Hourly
- Hourly Pseudo
- Supplemental

Miles: 0, 45, 90, 180
Kilometers: 0, 85, 170, 340

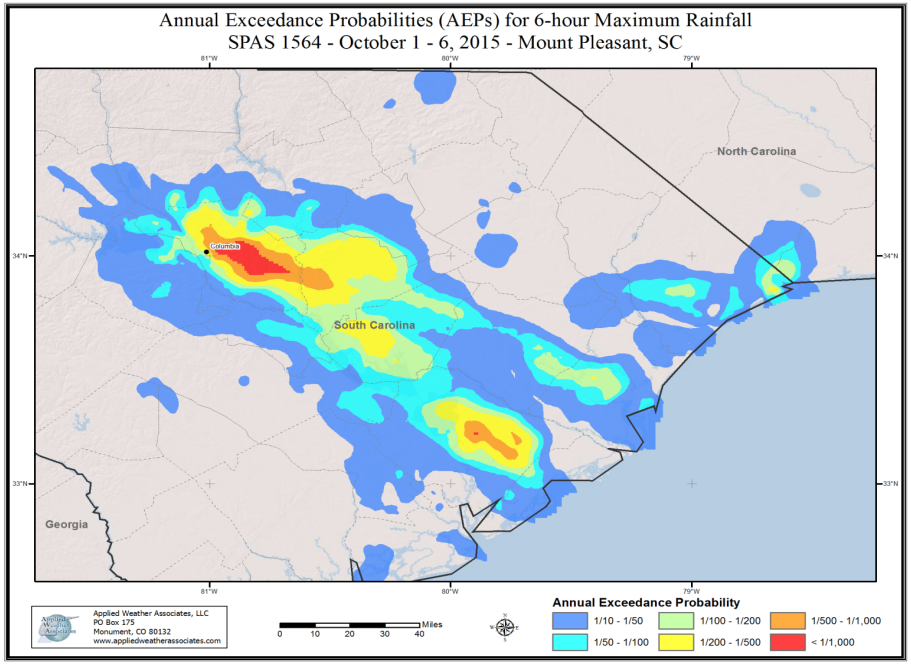
Precipitation (mm)

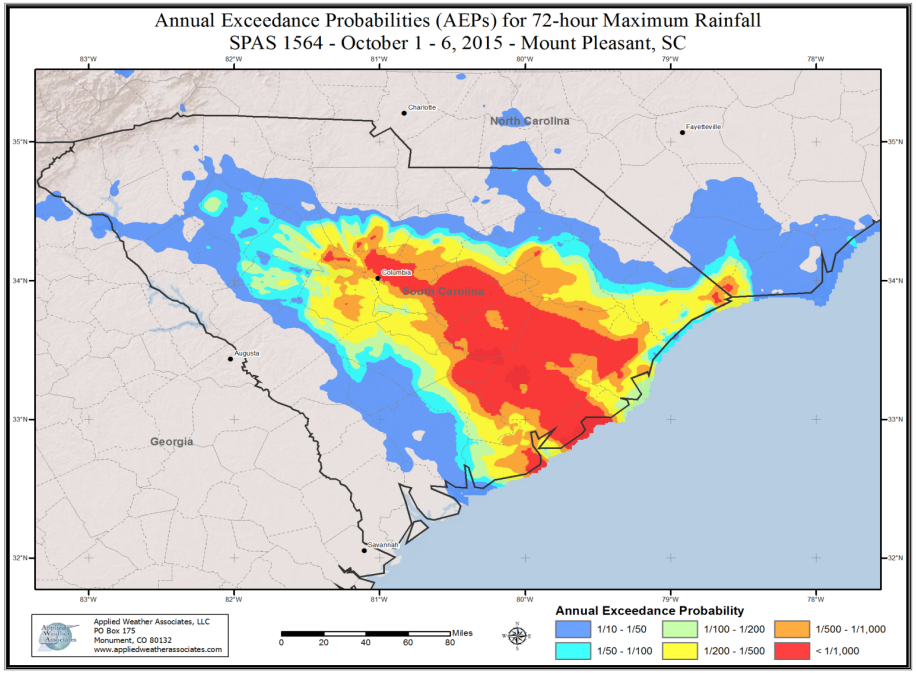
0 - 25	101 - 125	251 - 300	451 - 500	651 - 700
26 - 50	126 - 150	301 - 350	501 - 550	701 - 750
51 - 75	151 - 200	351 - 400	551 - 600	
76 - 100	201 - 250	401 - 450	601 - 650	



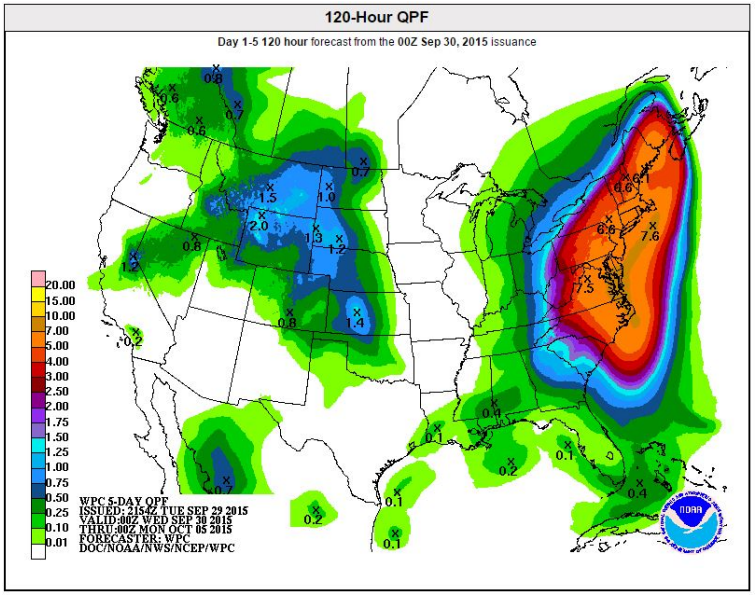
3/21/2016

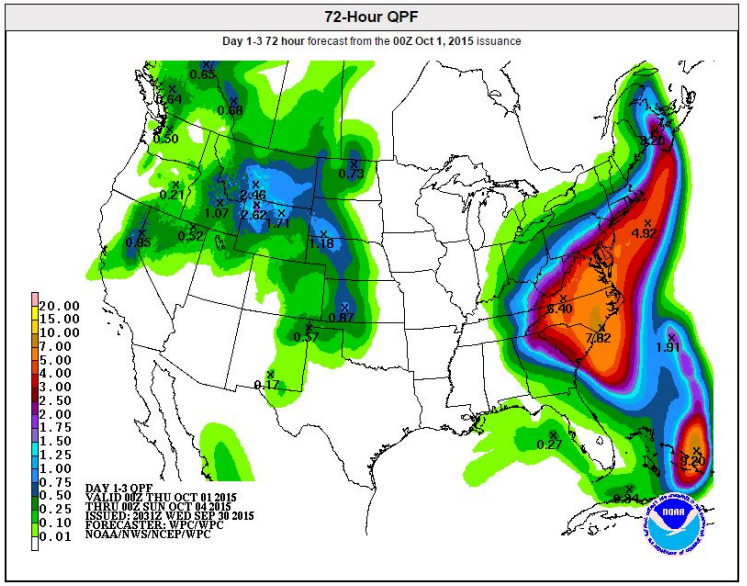
AWA Annual Exceedance Probability (AEP)

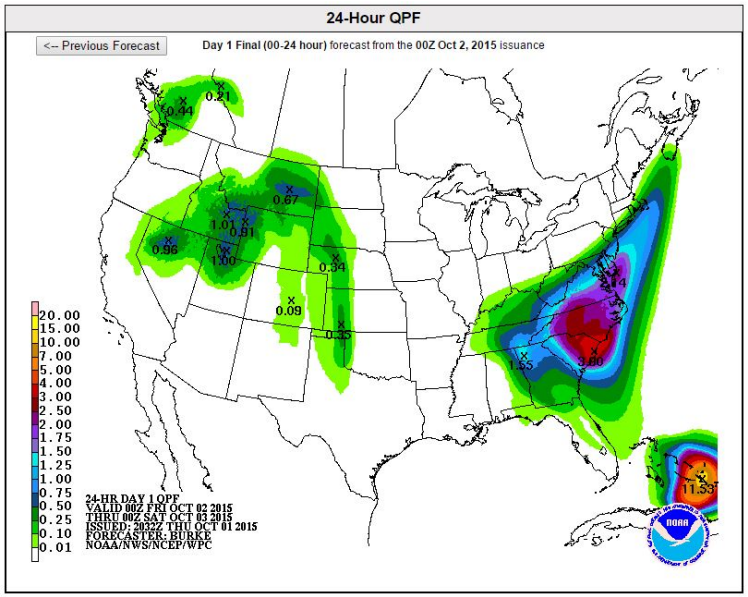


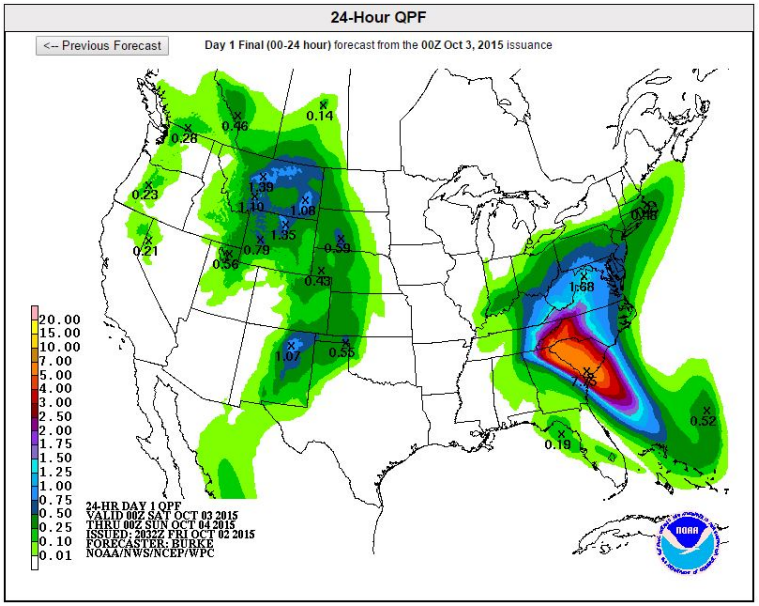


NOAA Quantitative Precipitation Forecasts (QPF)

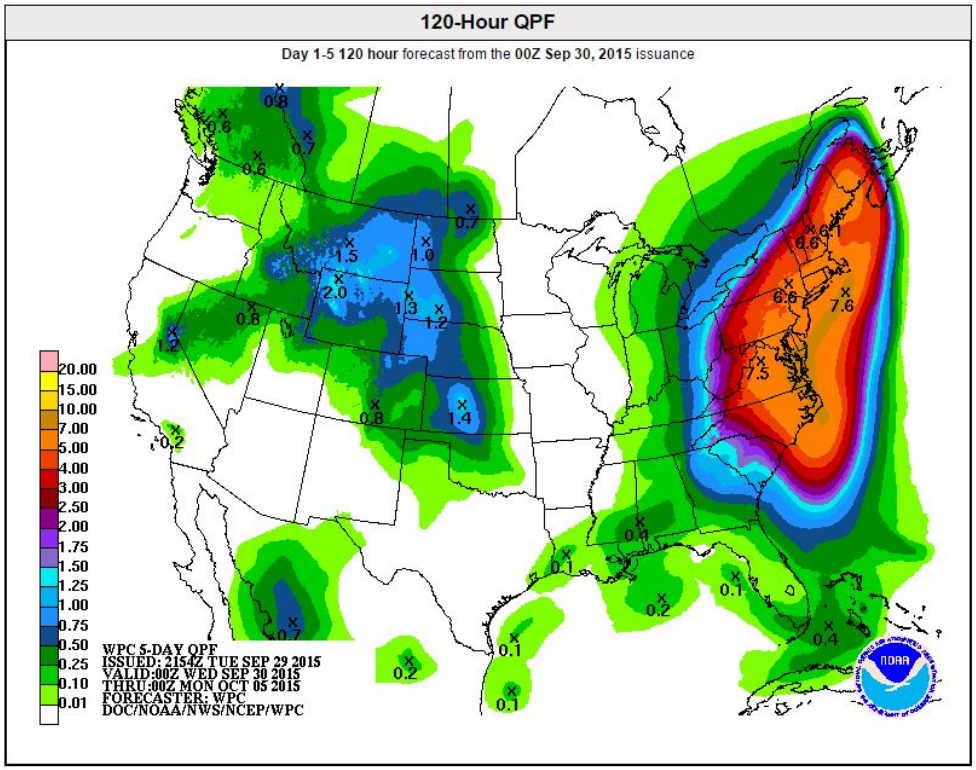


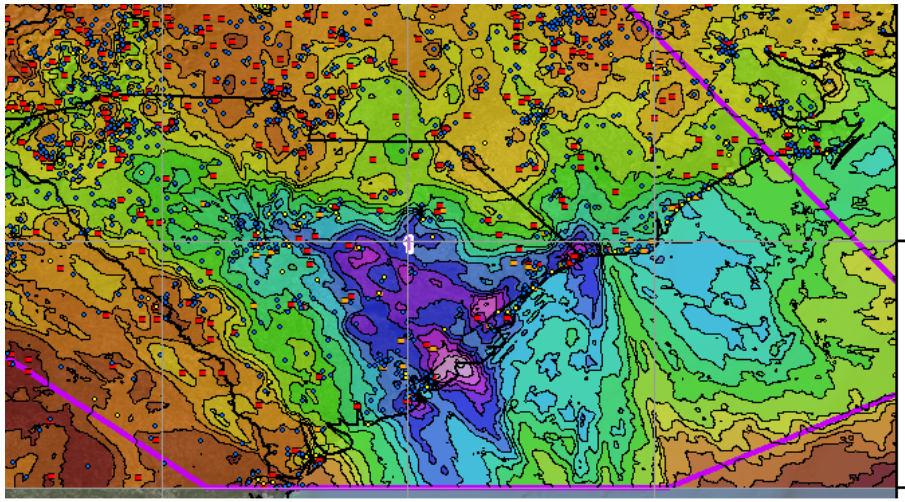


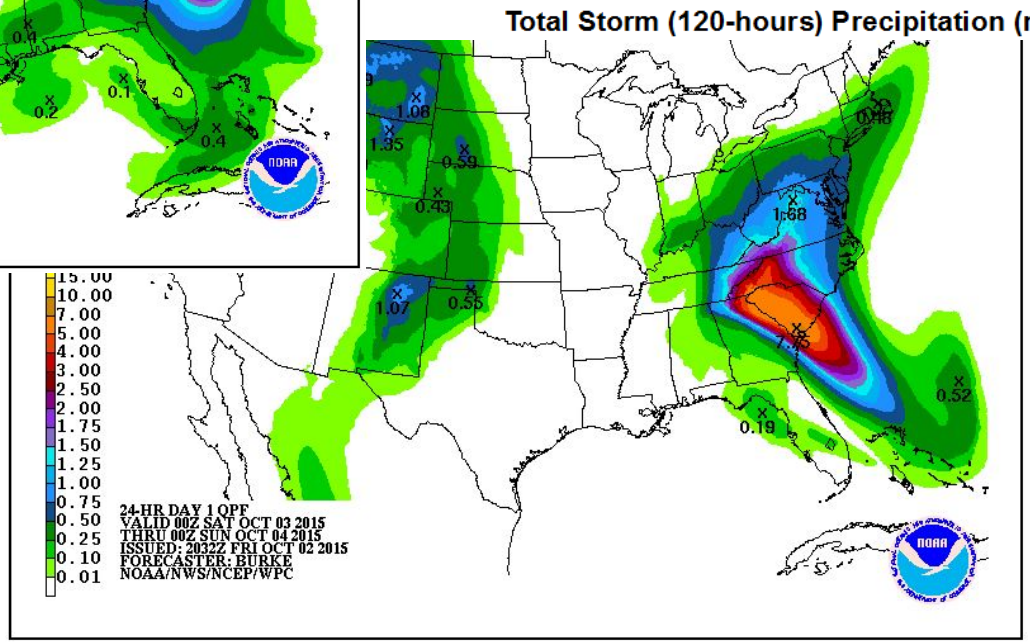




Storm Background and Analysis
NOAA QPF – 1 Day (10/3 – 10/4)

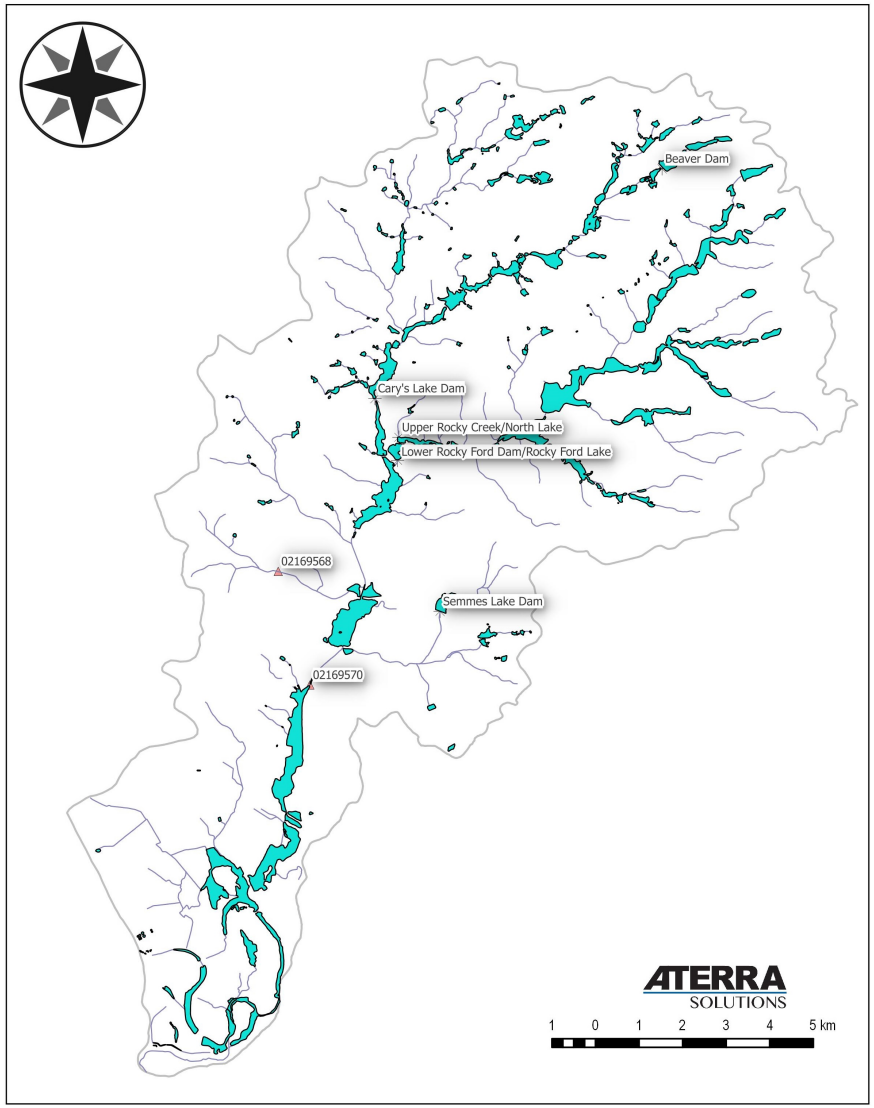




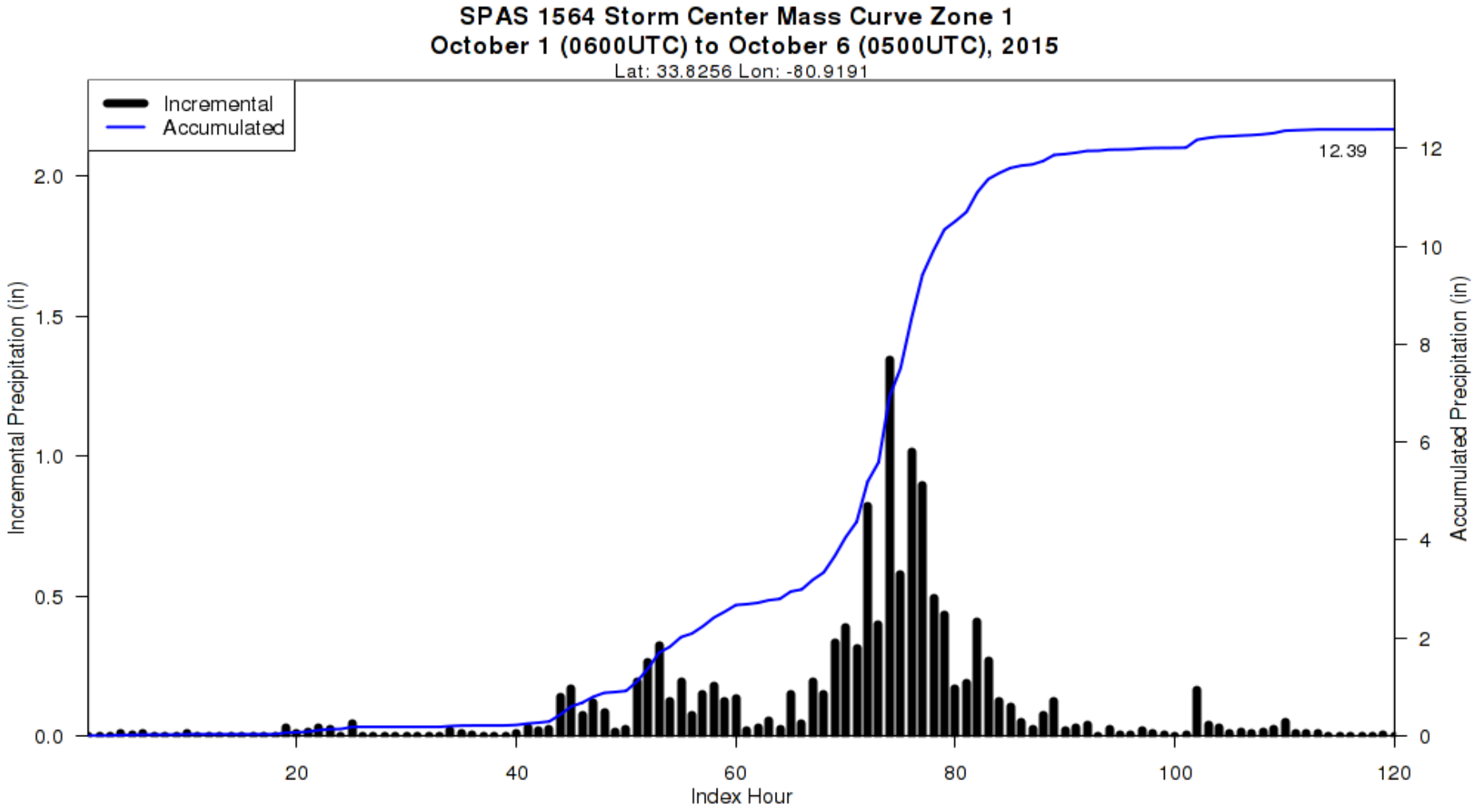


Hydrologic Model

- Hydrologic analysis conducted for selected watershed to compare watershed's response to predicted (QPF) and SPAS-estimated actual
- Gills Creek (75 sq mi) selected as the subject watershed due to severity of flooding and dam failure events
- 23 regulated and several unregulated dams



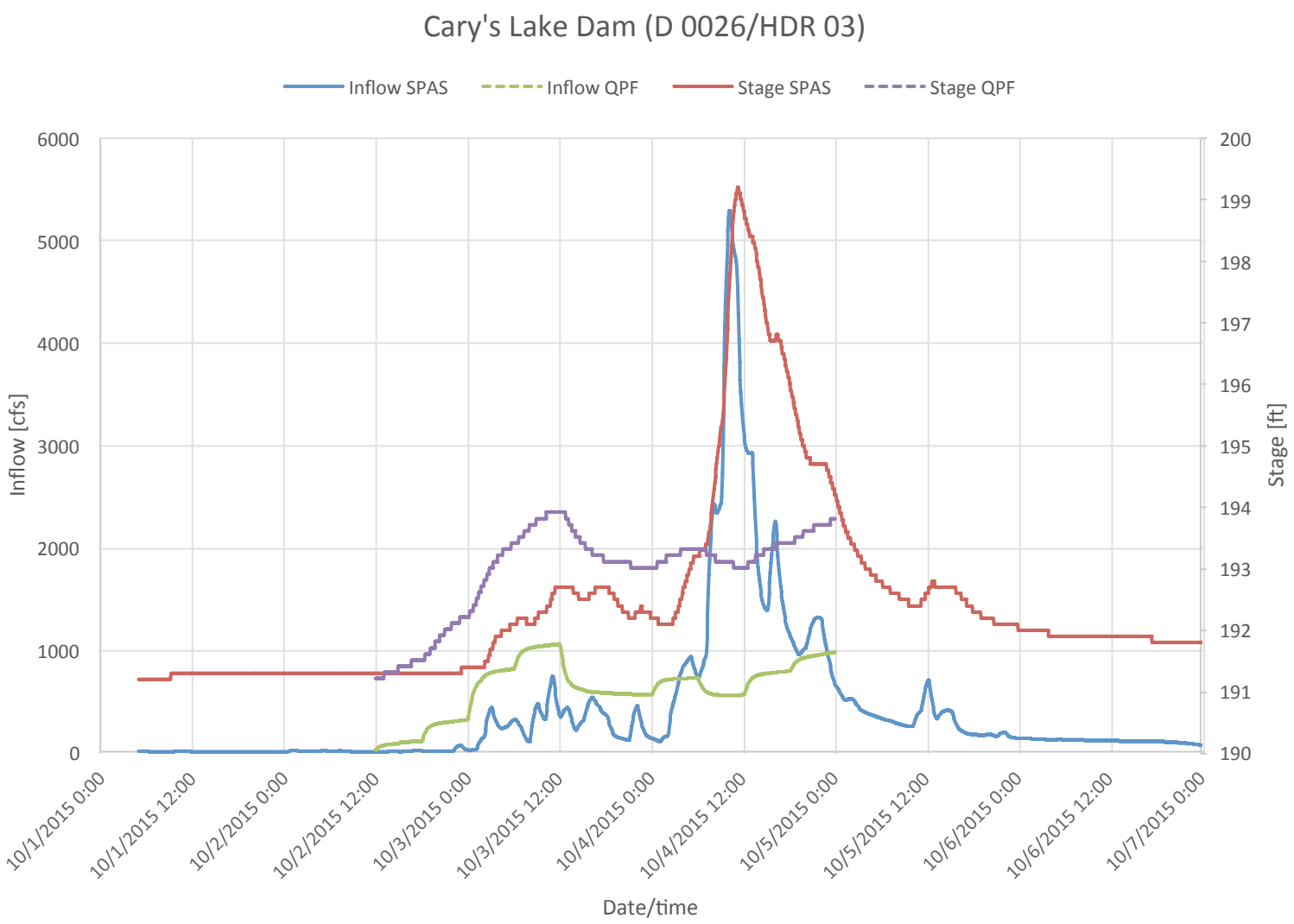
Hydrologic Model



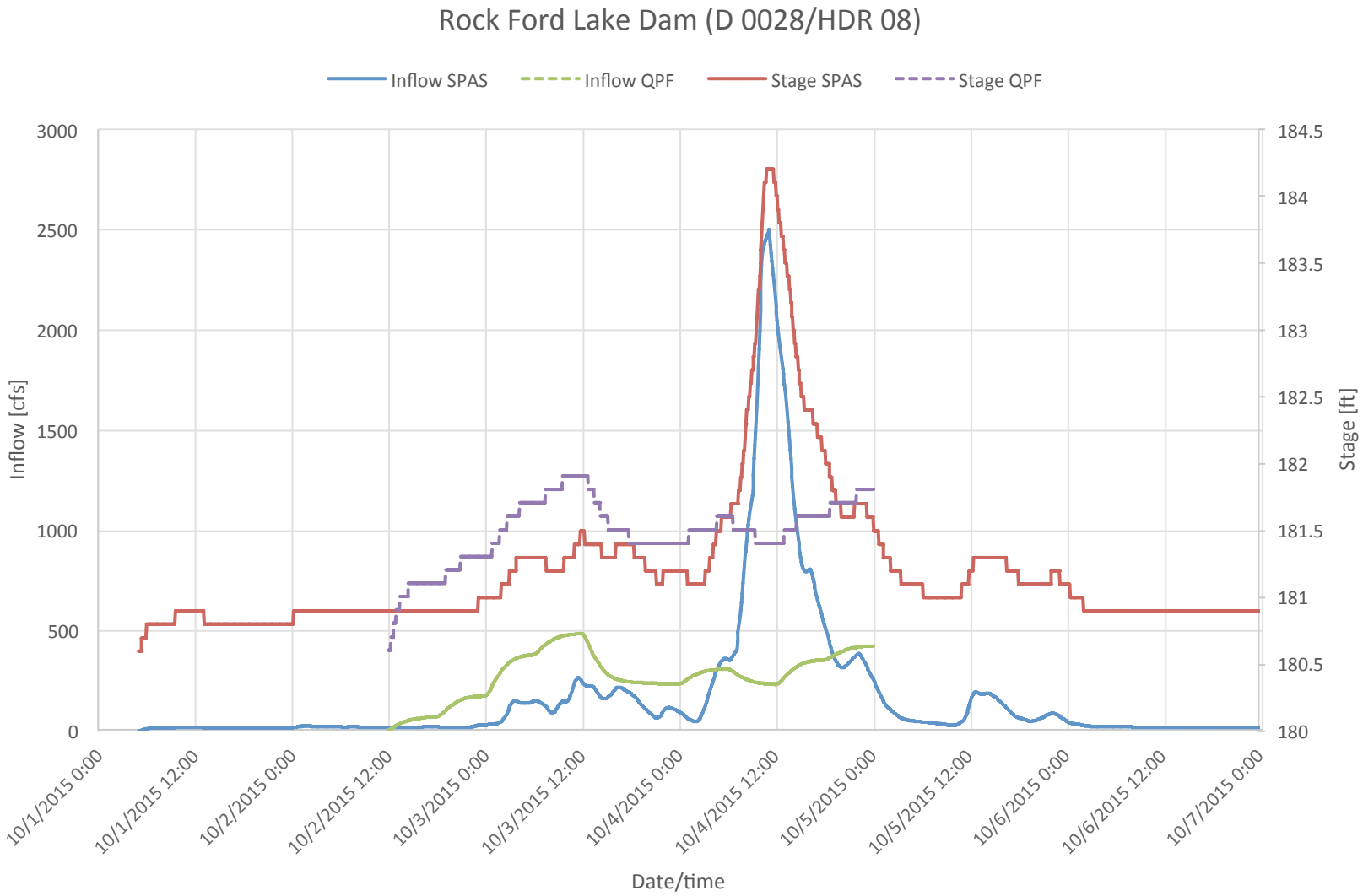
Hydrologic Model

- Two hydrologic scenarios were developed:
  - Post-event 1-hour gridded data developed by AWA
  - NOAA 3-Day Quantitative Precipitation Forecast (QPF) (6-hour QPFs for 72 hours)

Hydrologic Model
HEC-HMS



Hydrologic Model
HEC-HMS



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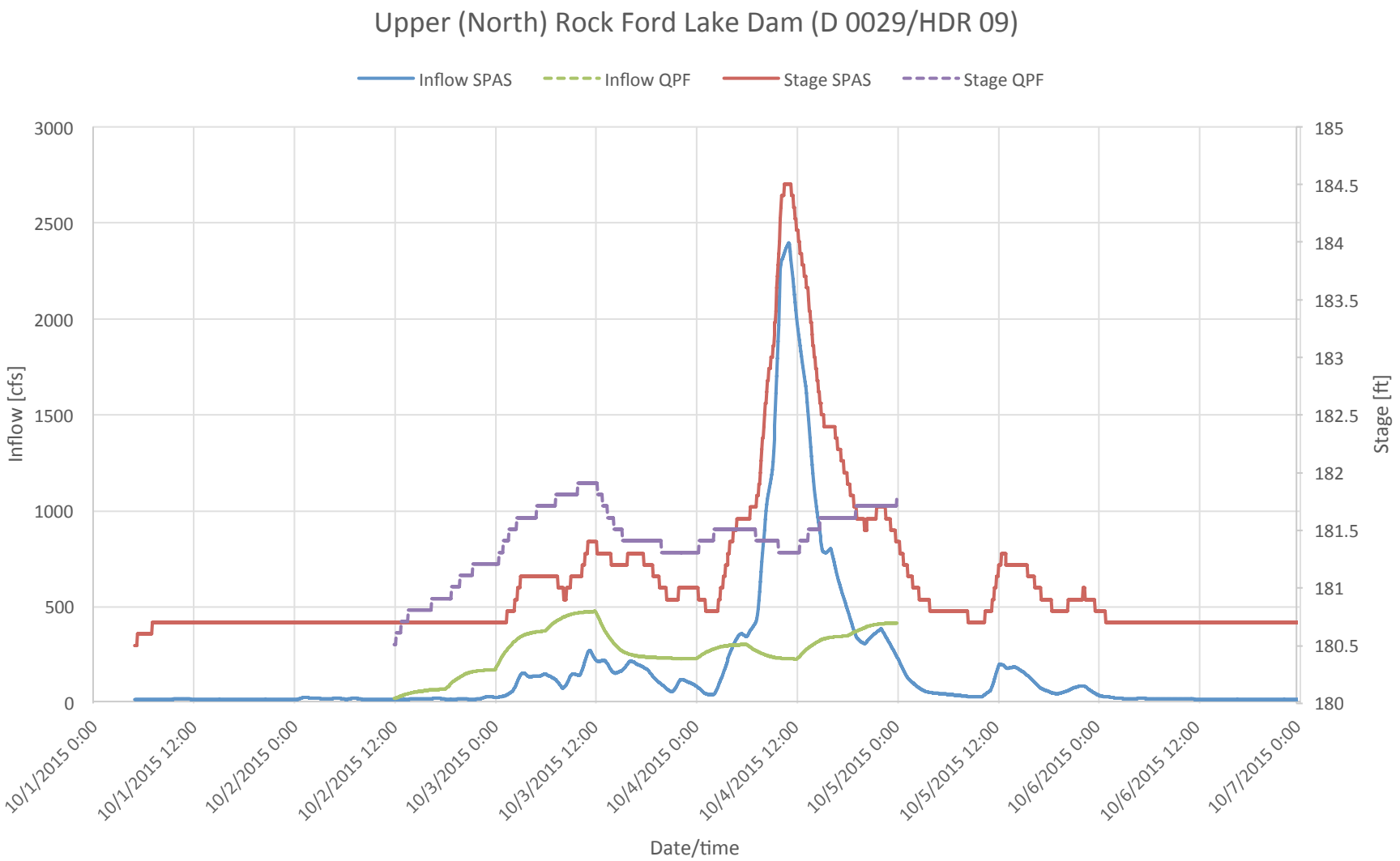
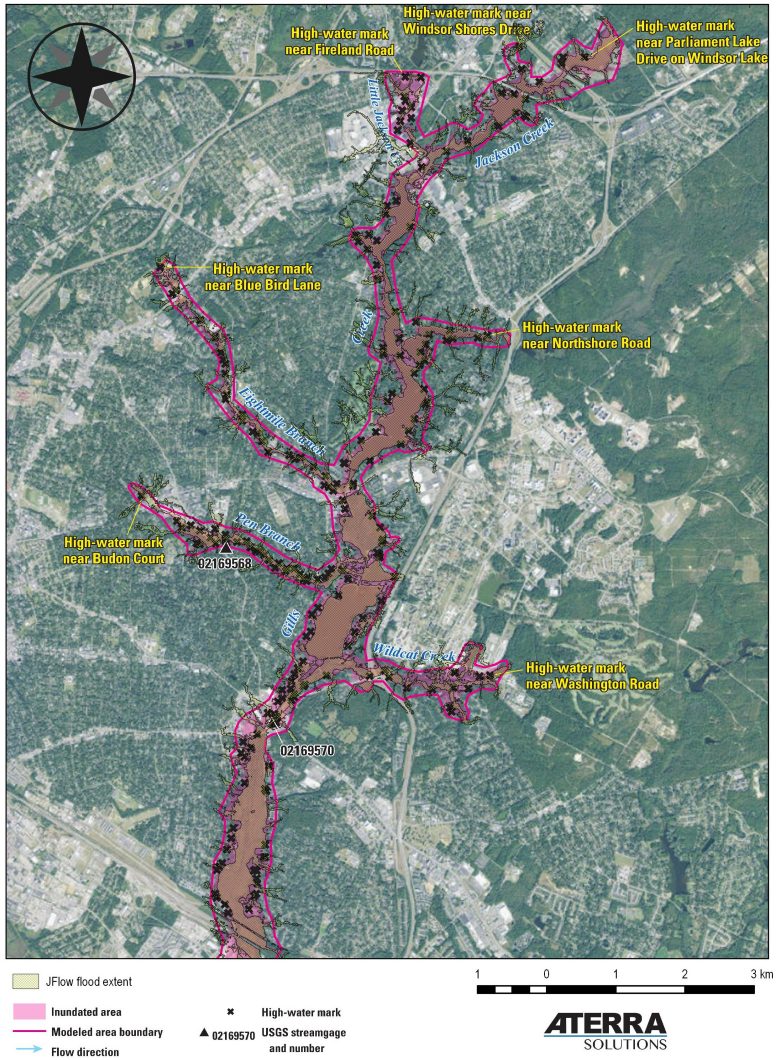
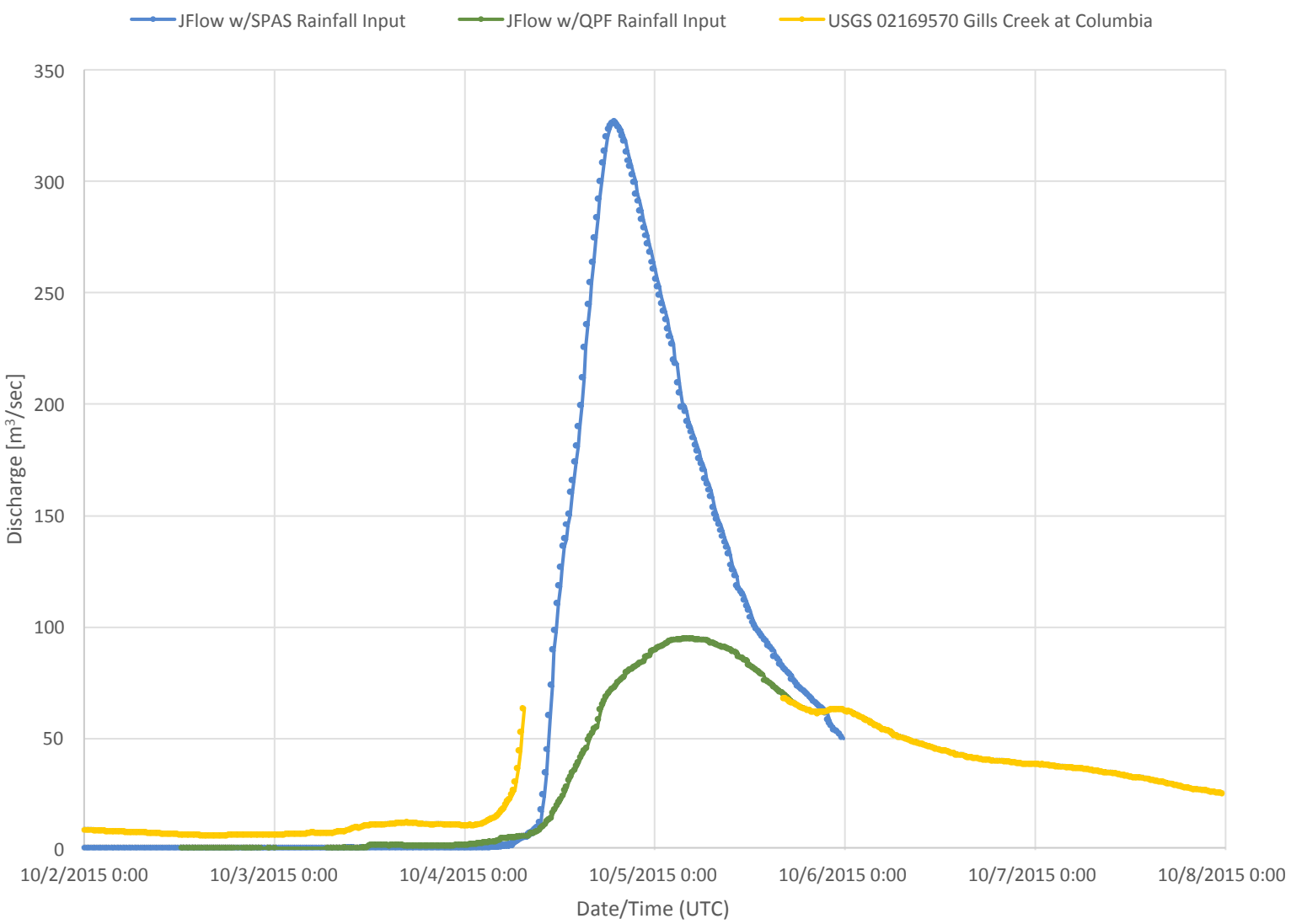


Hydrologic Model
Fully Distributed 2D

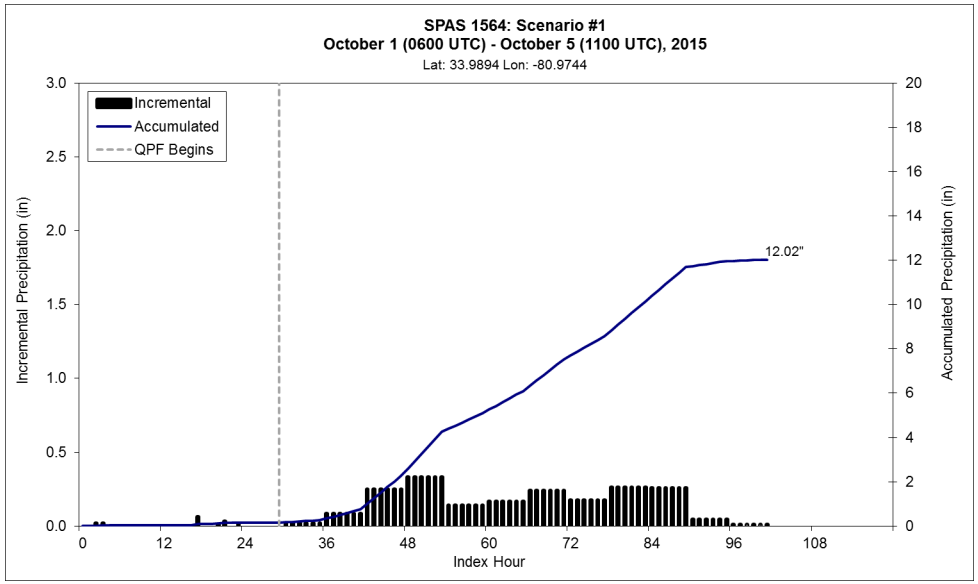
- JFlow modeling software (JBA Consulting) was adapted for use as a fully-distributed 2D hydrologic model to evaluate the Gills Creek Watershed response during the October 2015 event.
- A fully-distributed 2D hydrologic modeling approach has advantages over conventional lumped and semi-distributed hydrologic models (e.g. HEC-HMS), particularly for transforming real-time rainfall to flood flow/ stage forecasting.
  - The fully distributed approach is physically-based, making it flexible in modeling hydrologic responses to rainfall events of various magnitudes, intensities, spatial distributions, and temporal distributions.

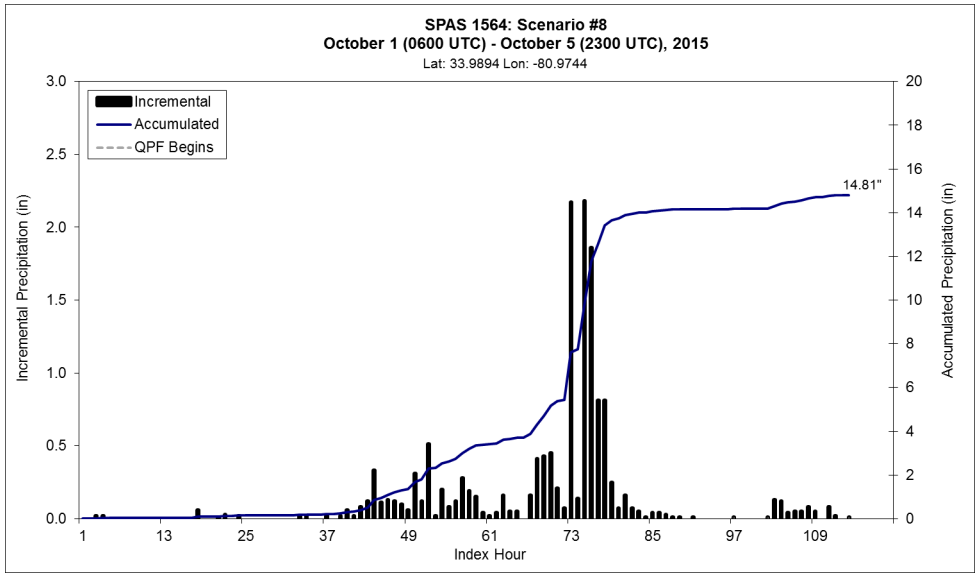


Hydrologic Model
Fully Distributed 2D



QPF vs Actual



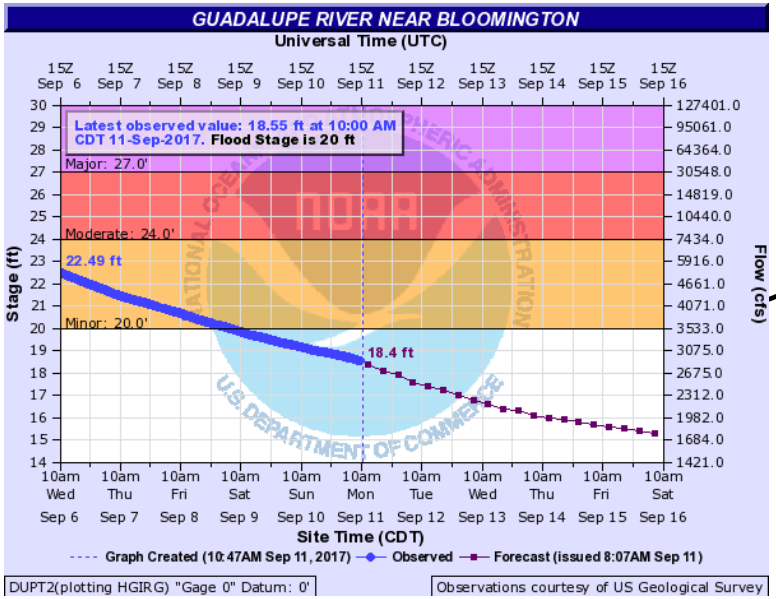


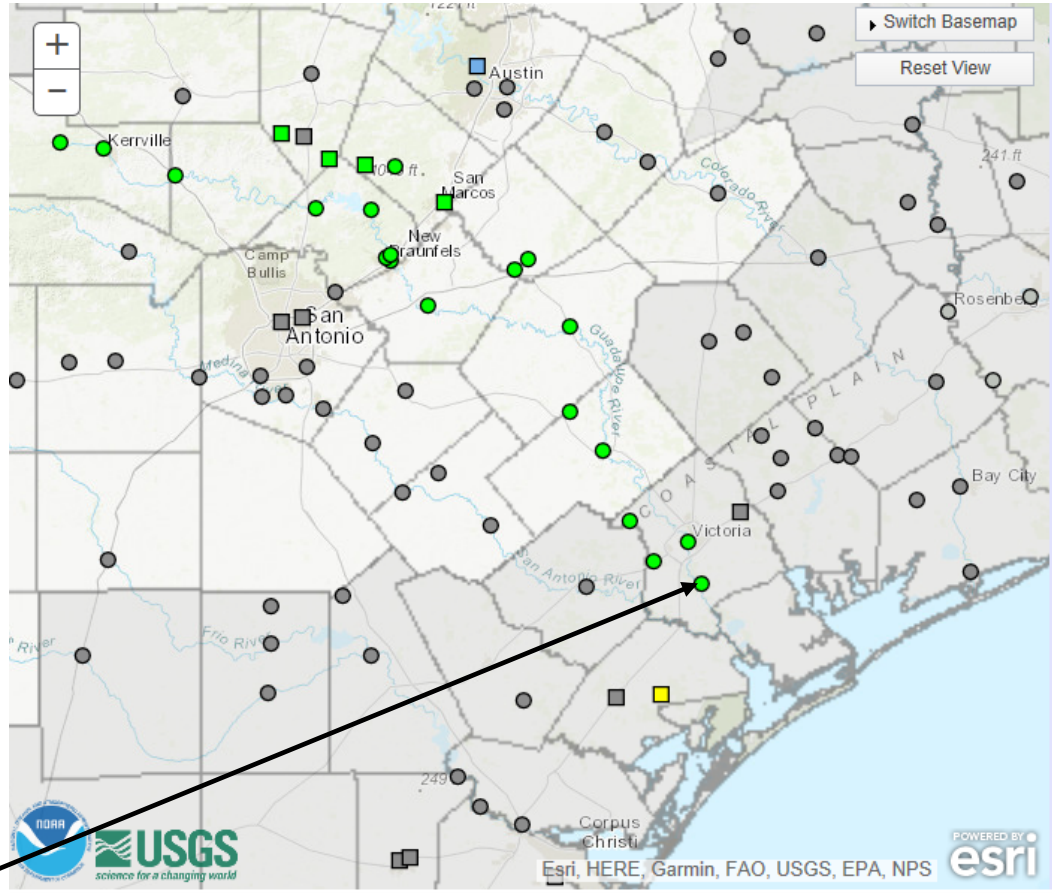
Real-Time Rainfall & Flood Forecasting Challenges

- Using QPF forecasts alone may lead to misleading information, particularly for small and medium size watersheds (not covered by the 6-hour duration)
- Limitations in QPF resolution and accuracy, especially more than 3-days in advance, for shorter durations, and extreme events.
- Conventional hydrologic models use “lumped” processes for transforming rainfall to runoff. Limited use for flood forecasting – only reliable for similar size, intensity, and distribution of calibration storms and at specific calibration points in the watersheds.

Enhanced Approach to Real-Time Rainfall & Flood Forecasting

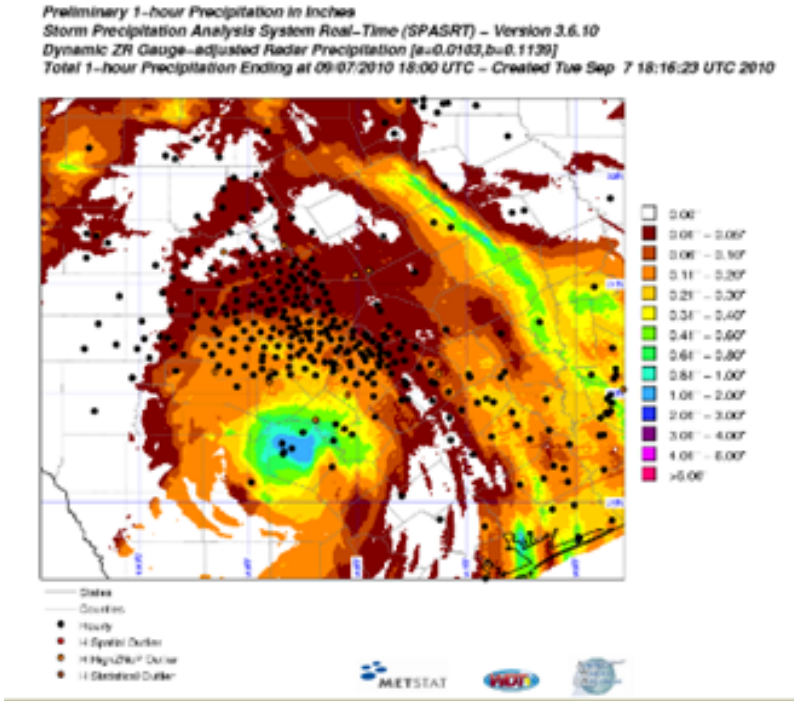
- NOAA/NWS River Forecasts are provided at scattered locations and typically for larger watersheds.





Enhanced Approach to Real-Time Rainfall & Flood Forecasting

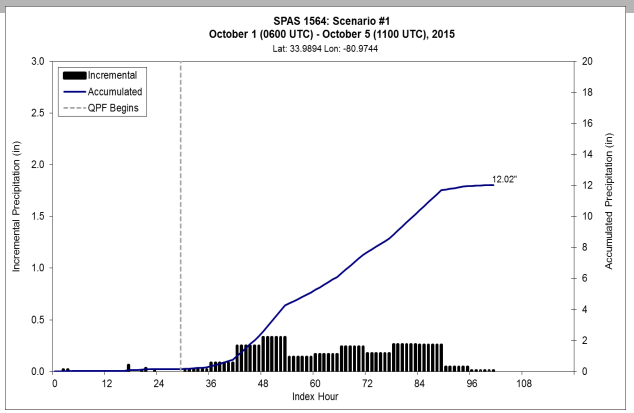
- Flood Forecasting system under development:
  - Optimize forecasted rainfall, using real-time gage and NEXRAD data, through SPAS
  - Use of PQPF, ingested through SPAS, to run "what-if" scenarios as storm approaches
  - SPAS can produce gridded (1 sq. km.) rainfall forecasts every 5 minutes based on QPF forecasts

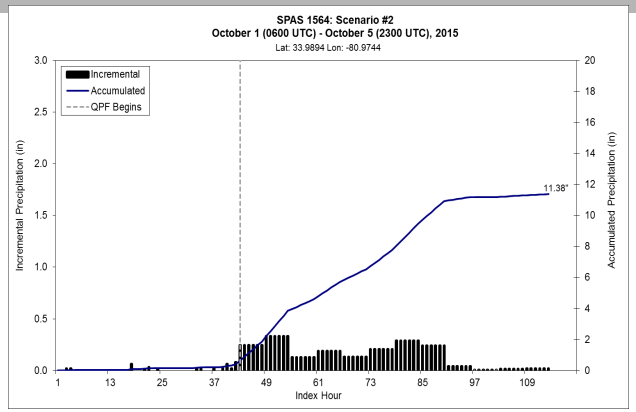


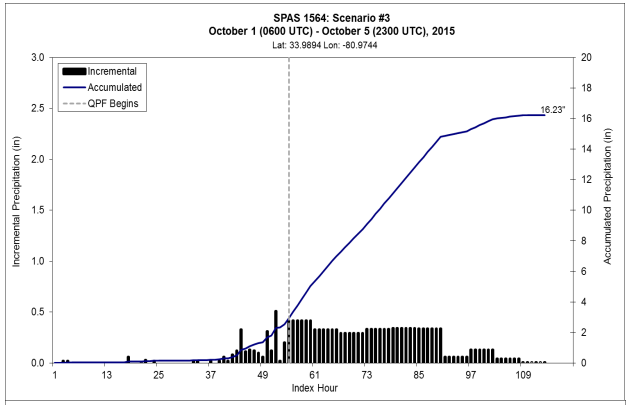
Enhanced Approach to Real-Time Rainfall & Flood Forecasting

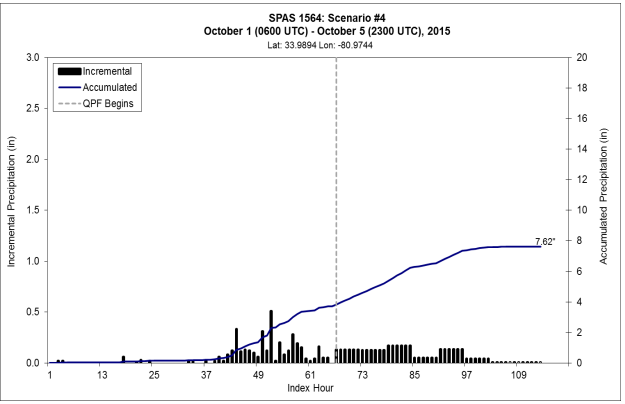
- Diverse and flexible for transforming rainfall to runoff in near real-time, using higher resolution rainfall forecasts, for a:
  - Variety of sizes, intensities, and distributions of rainfall, and
  - Various flooding points of interest throughout the watershed
- Particularly useful for small and medium sized watersheds
- Enhance ability of emergency management and dam operator officials to make more informed and reliable flooding response and dam safety decisions.

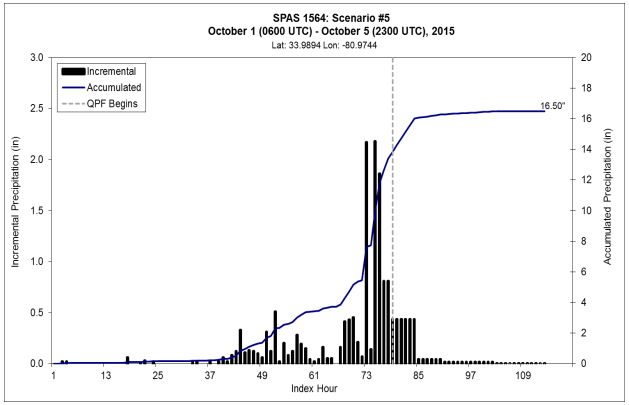
Enhanced Approach to Real-Time Rainfall & Flood Forecasting

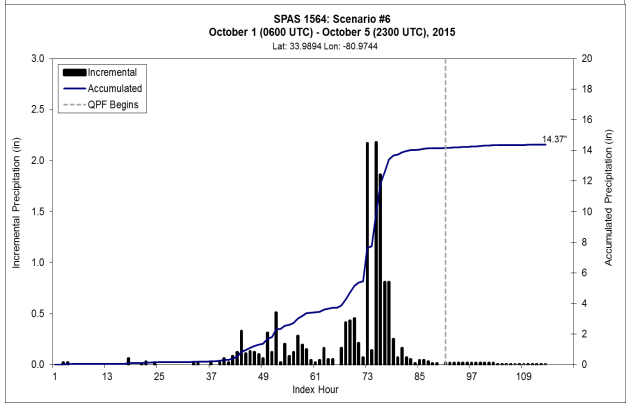


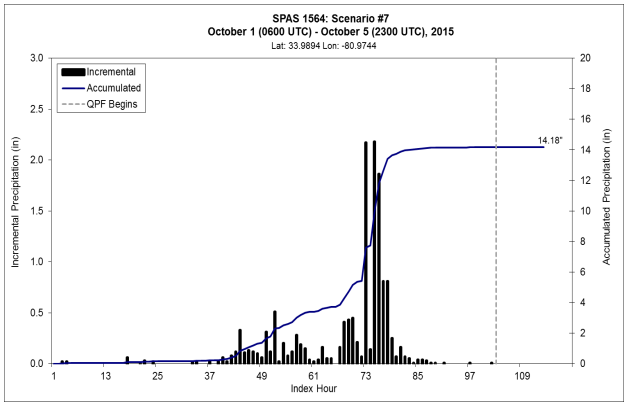


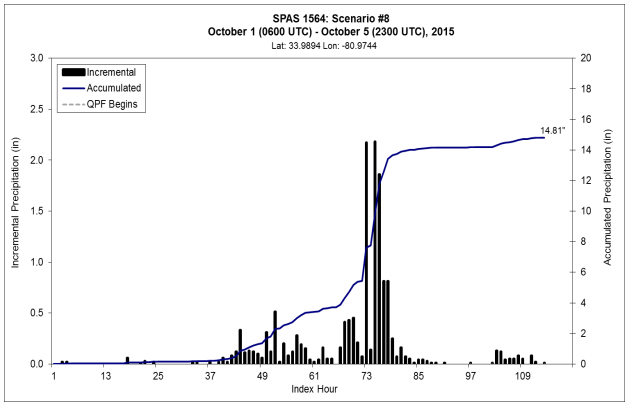


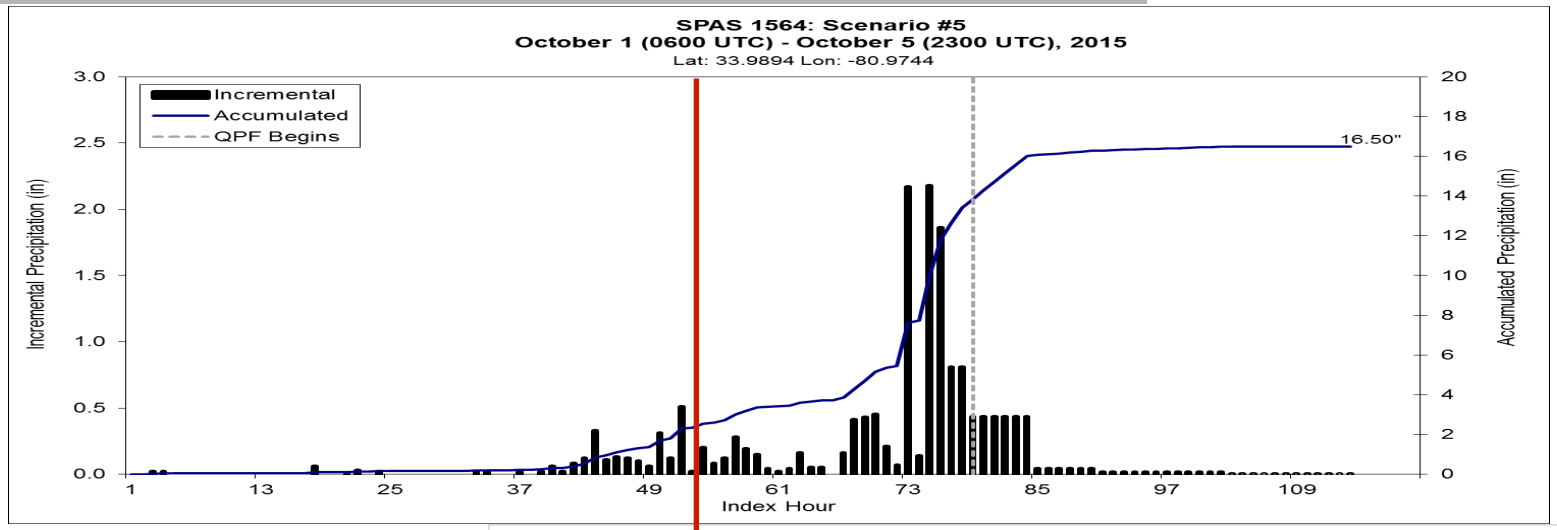


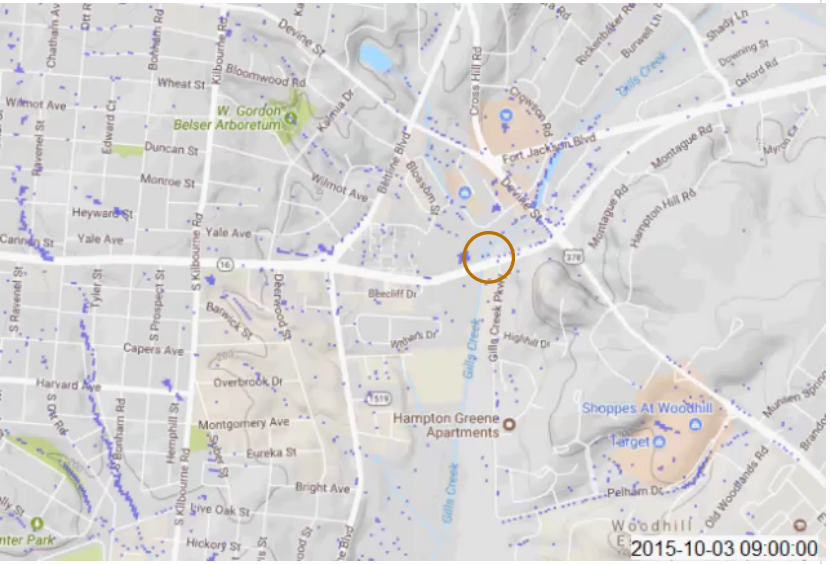


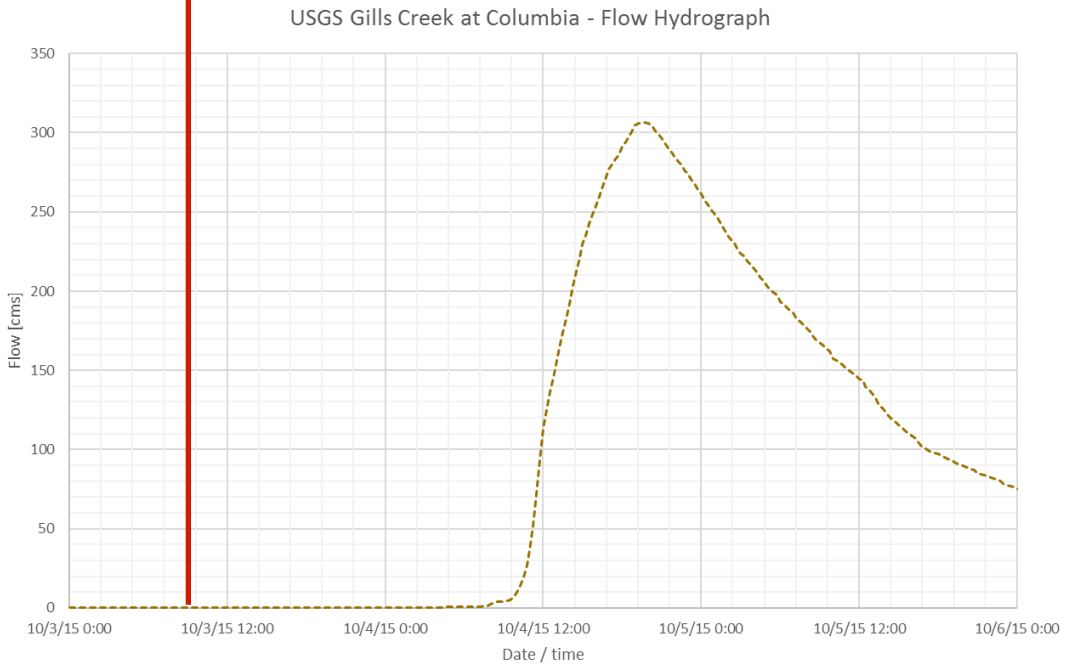







SPAS 1564: Scenario #5
October 1 (0600 UTC) - October 5 (2300 UTC), 2015
Lat: 33.9894 Lon: -80.9744
Incremental
Accumulated
QPF Begins
16.50"
Incremental Precipitation (in)
Accumulated Precipitation (in)
Index Hour
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
18
16
14
12
10
8
6
4
2
0
1
13
25
37
49
61
73
85
97
109


2015-10-03 09:00:00
Hampton Greene Apartments
Shoppes At Woodhill
Target
W. Gordon Belser Arboretum
Woodhill


USGS Gills Creek at Columbia - Flow Hydrograph
Flow [cms]
Date / time
350
300
250
200
150
100
50
0
10/3/15 0:00
10/3/15 12:00
10/4/15 0:00
10/4/15 12:00
10/5/15 0:00
10/5/15 12:00
10/6/15 0:00

Open Discussion and Questions

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