The South Carolina Extreme Rainfall Analysis-Understanding the Storm and Implications for Dam Safety

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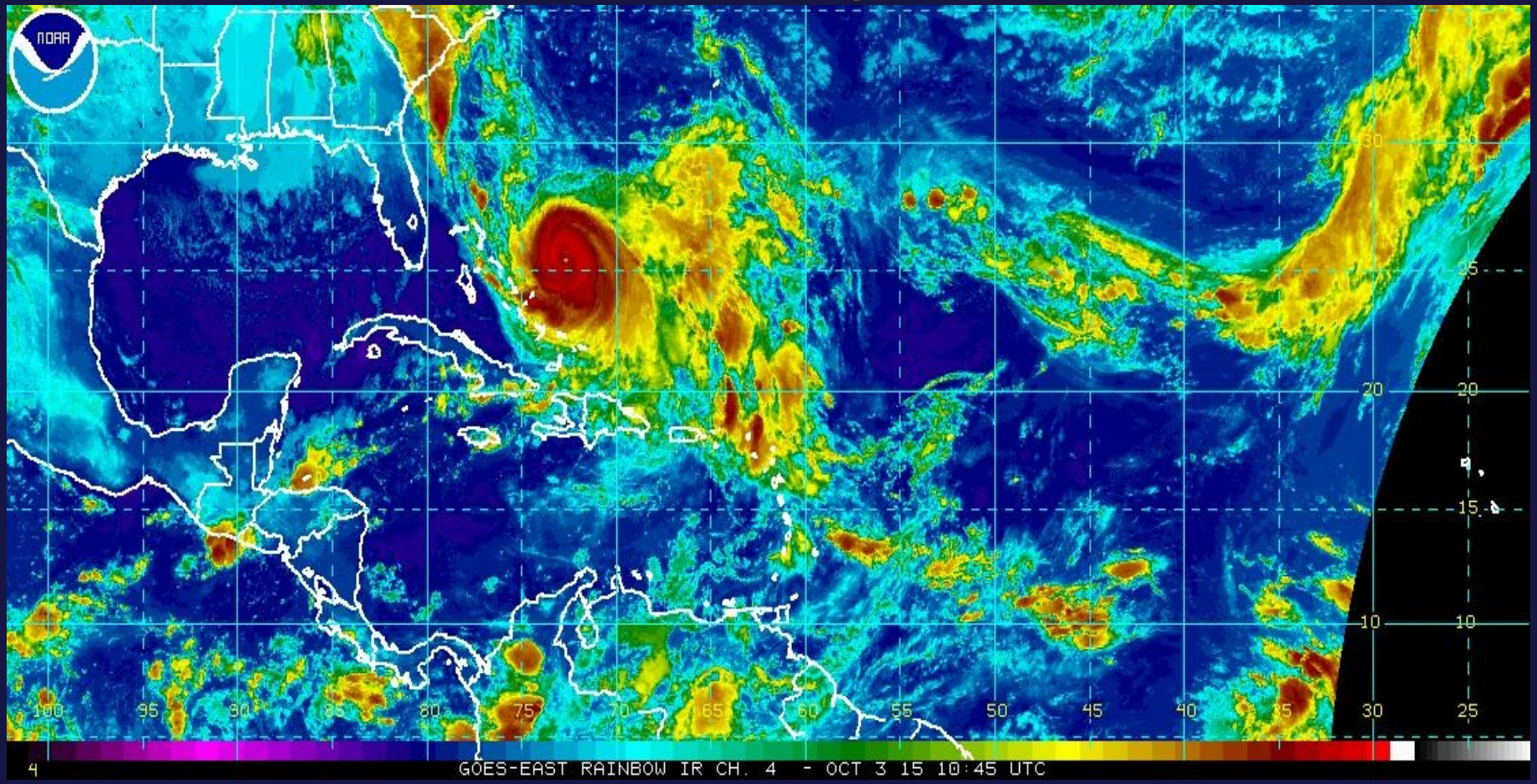
Presentation Outline

- Storm information and background
- Rainfall analysis
- QPF vs reality
- Hydrologic evaluations
- Dam safety implications

Storm Background

- 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

Storm Background



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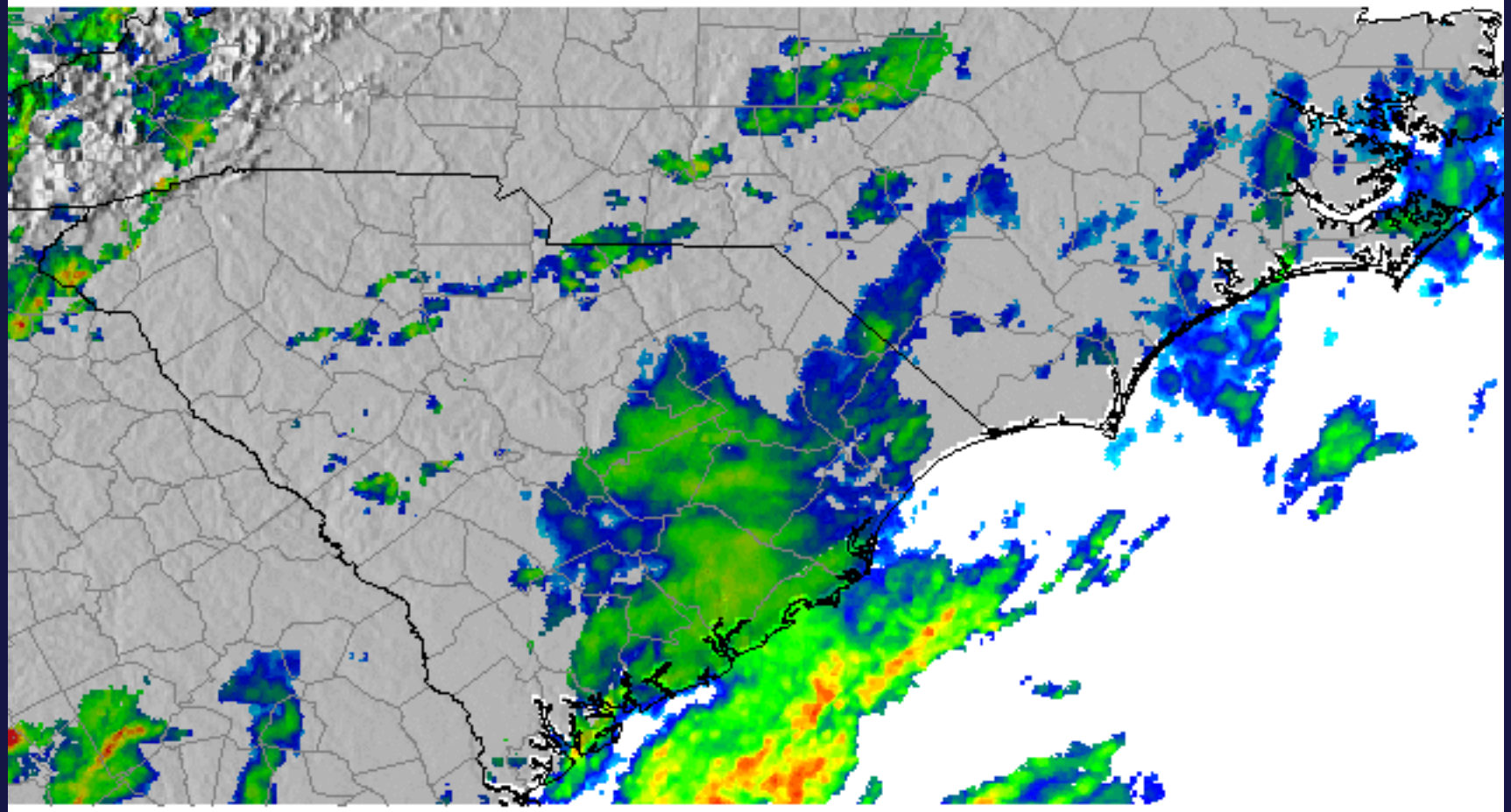
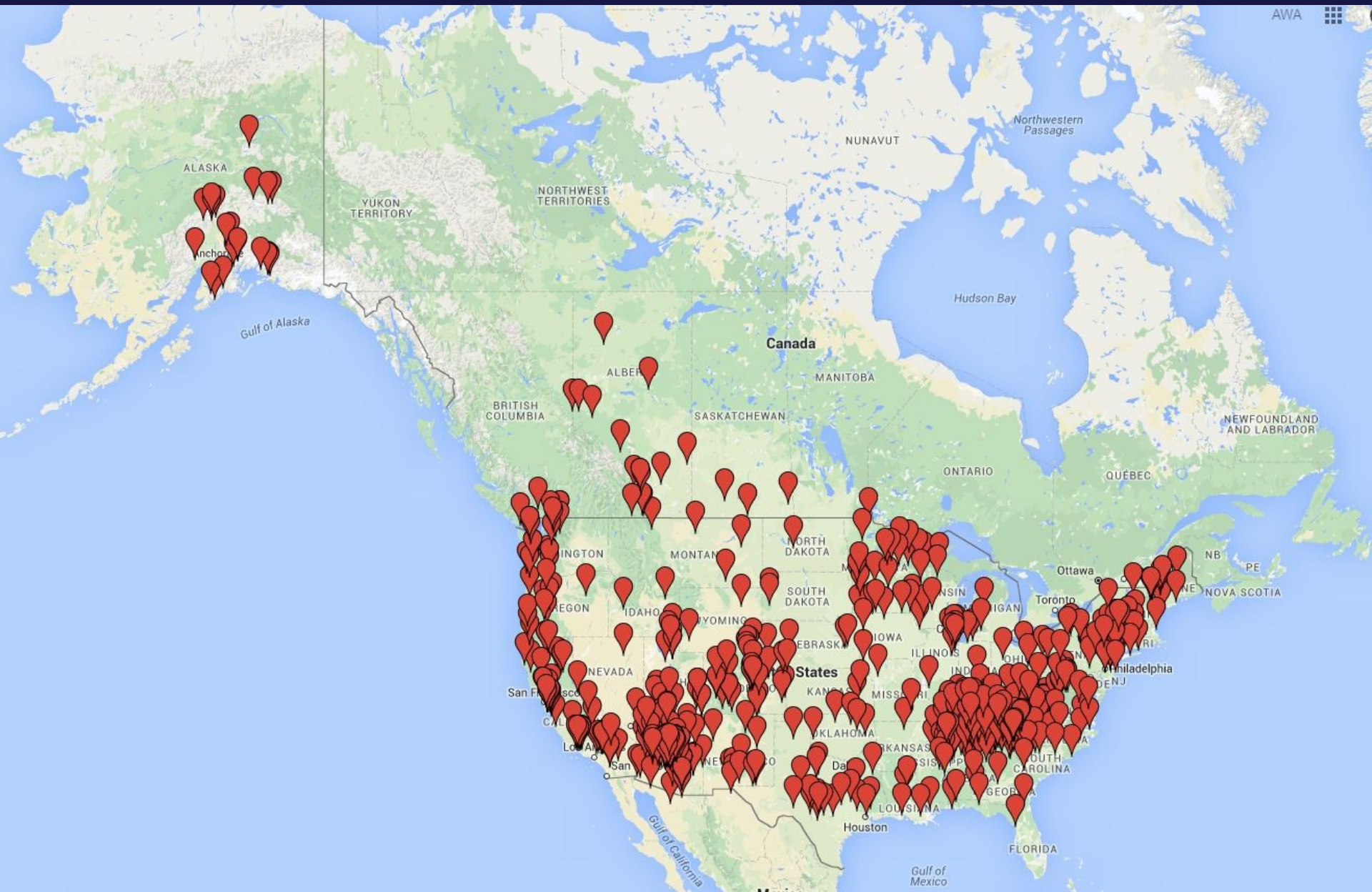


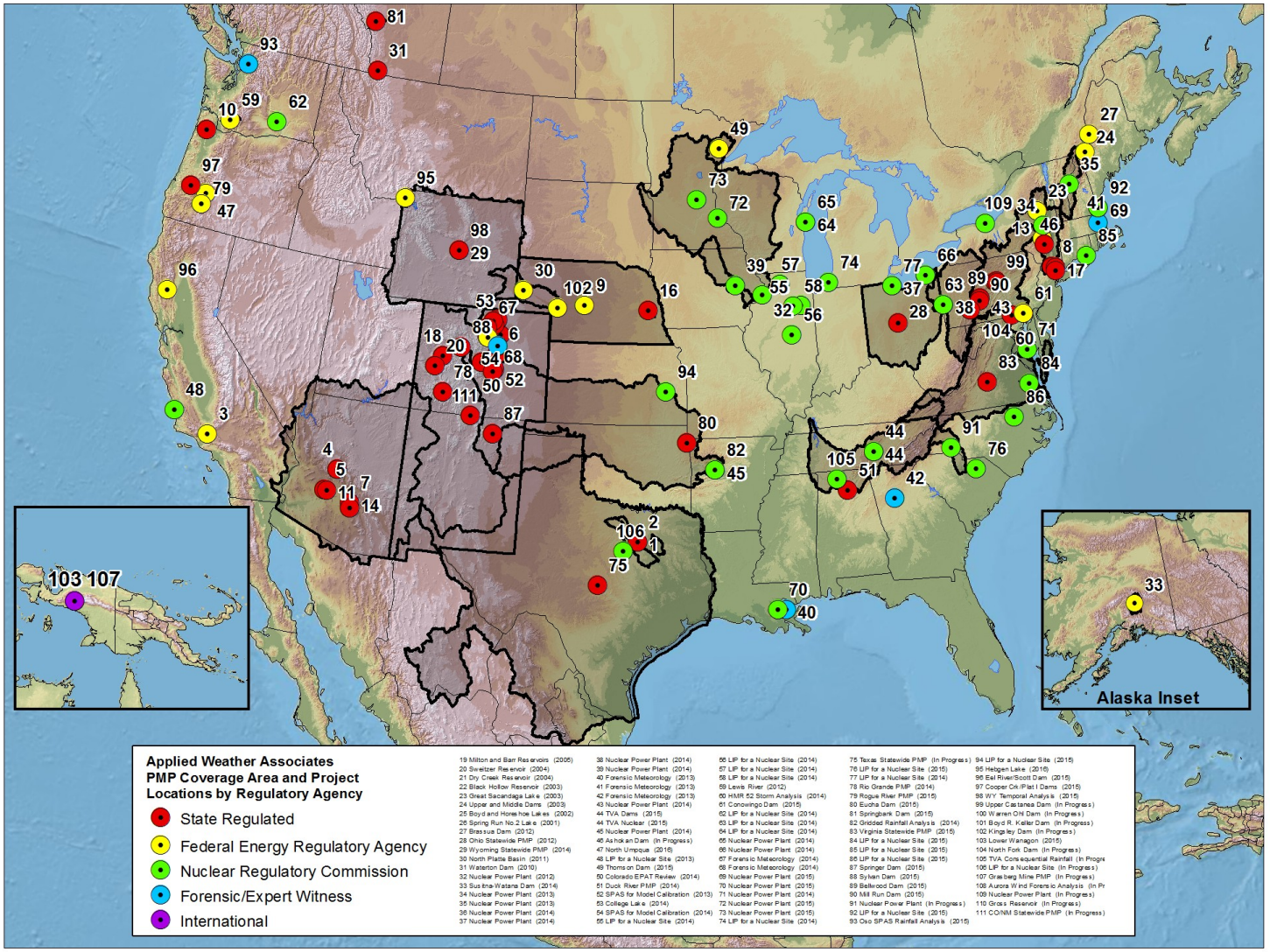
Storm Background

- Widespread region with more than 20”
- Several areas great than 1000-yr AEP
- Storm Precipitation Analysis System (SPAS)
  - Gridded rainfall data
  - Storm isohyetals,
  - DADs, mass curves, etc
- Output used for hydrologic input
- Compared against PMP in region

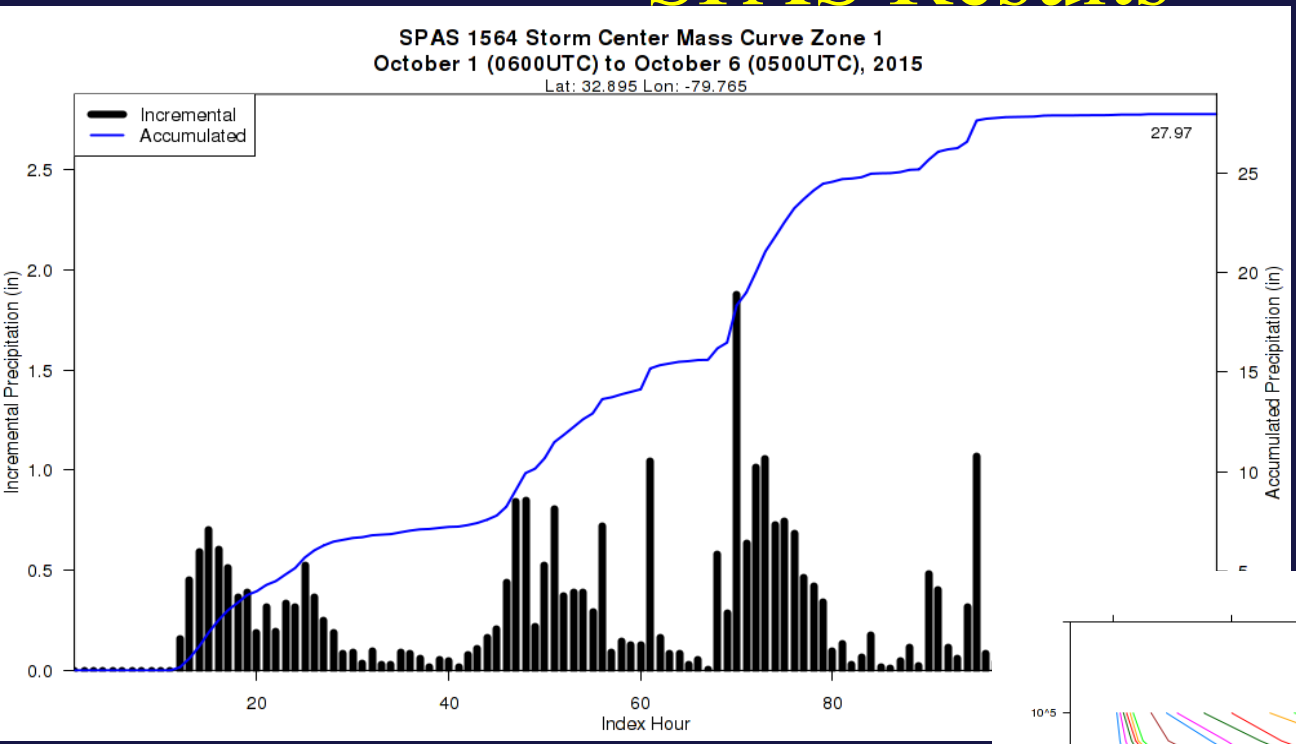
AWA SPAS Storm Locations

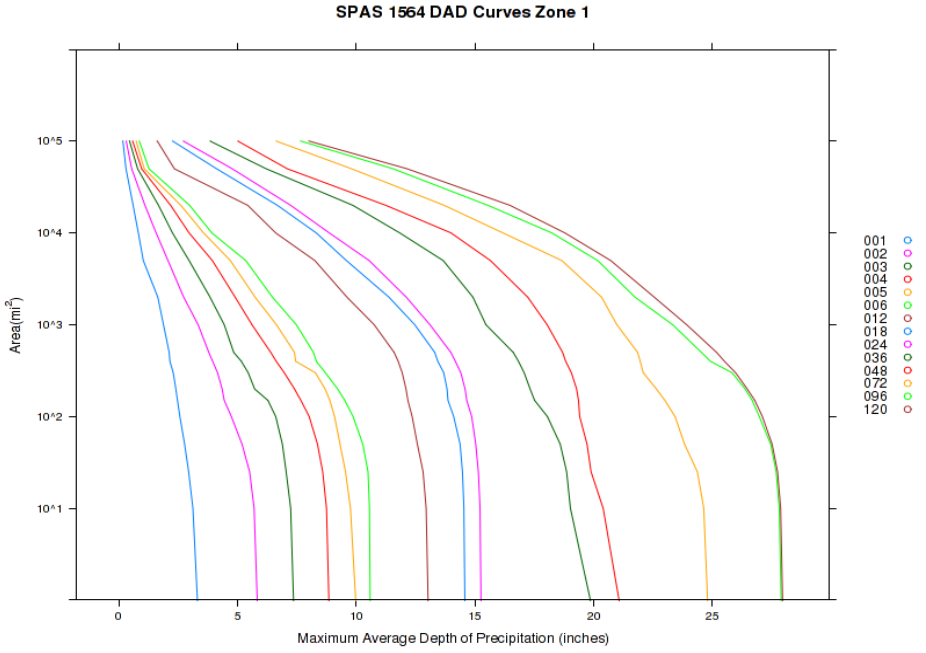


AWA Project Locations



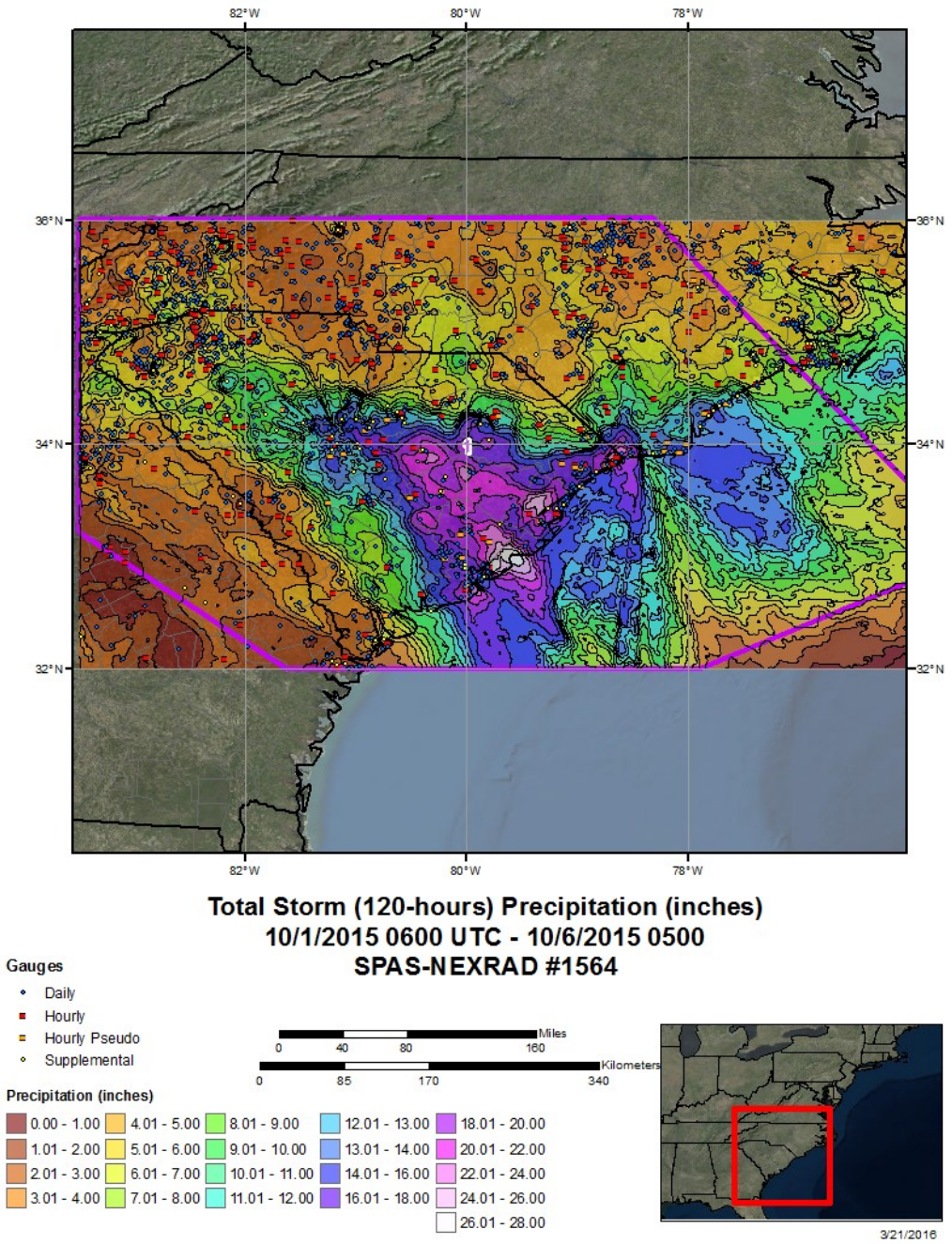
SPAS Results



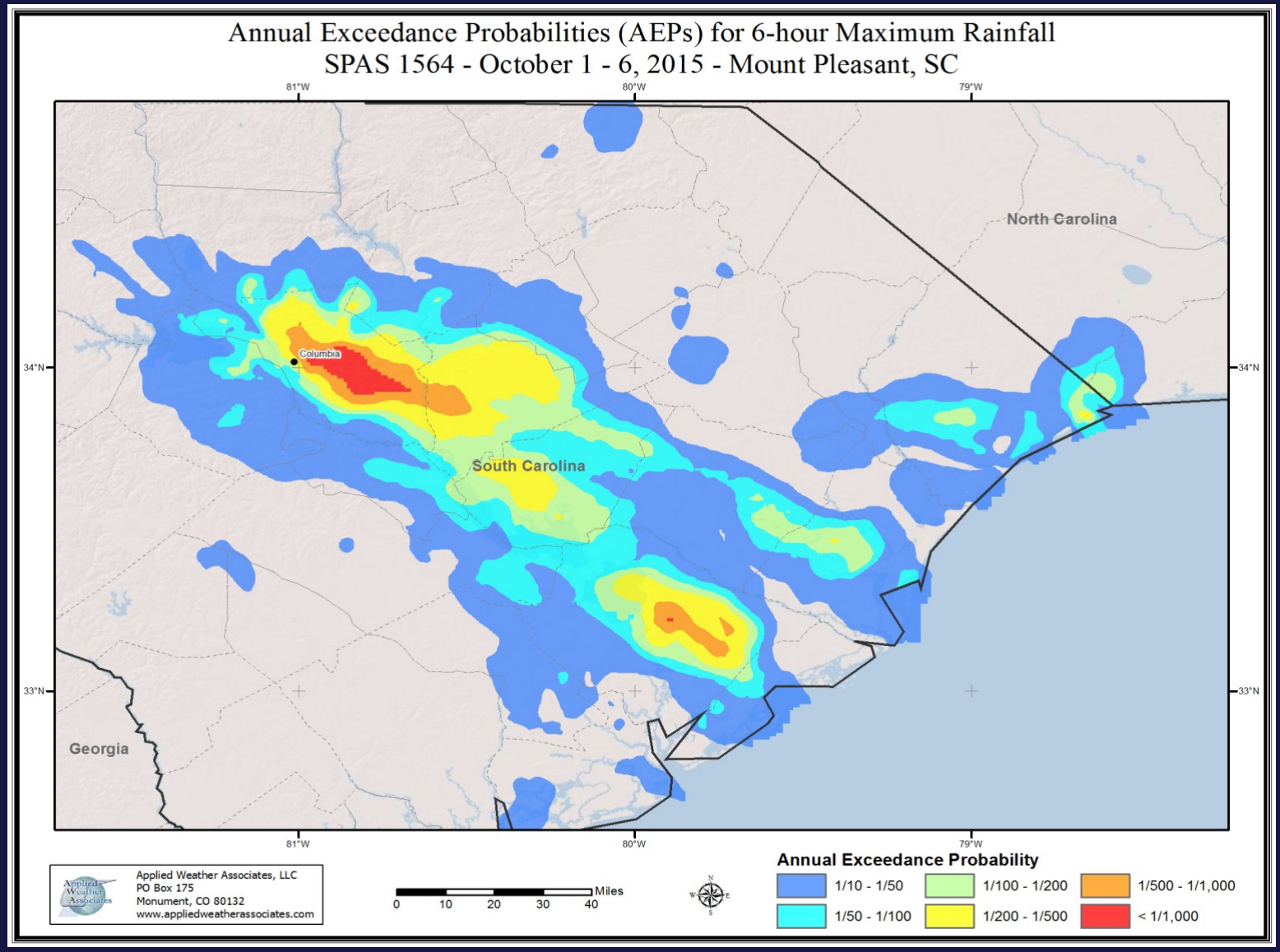


SPAS Results

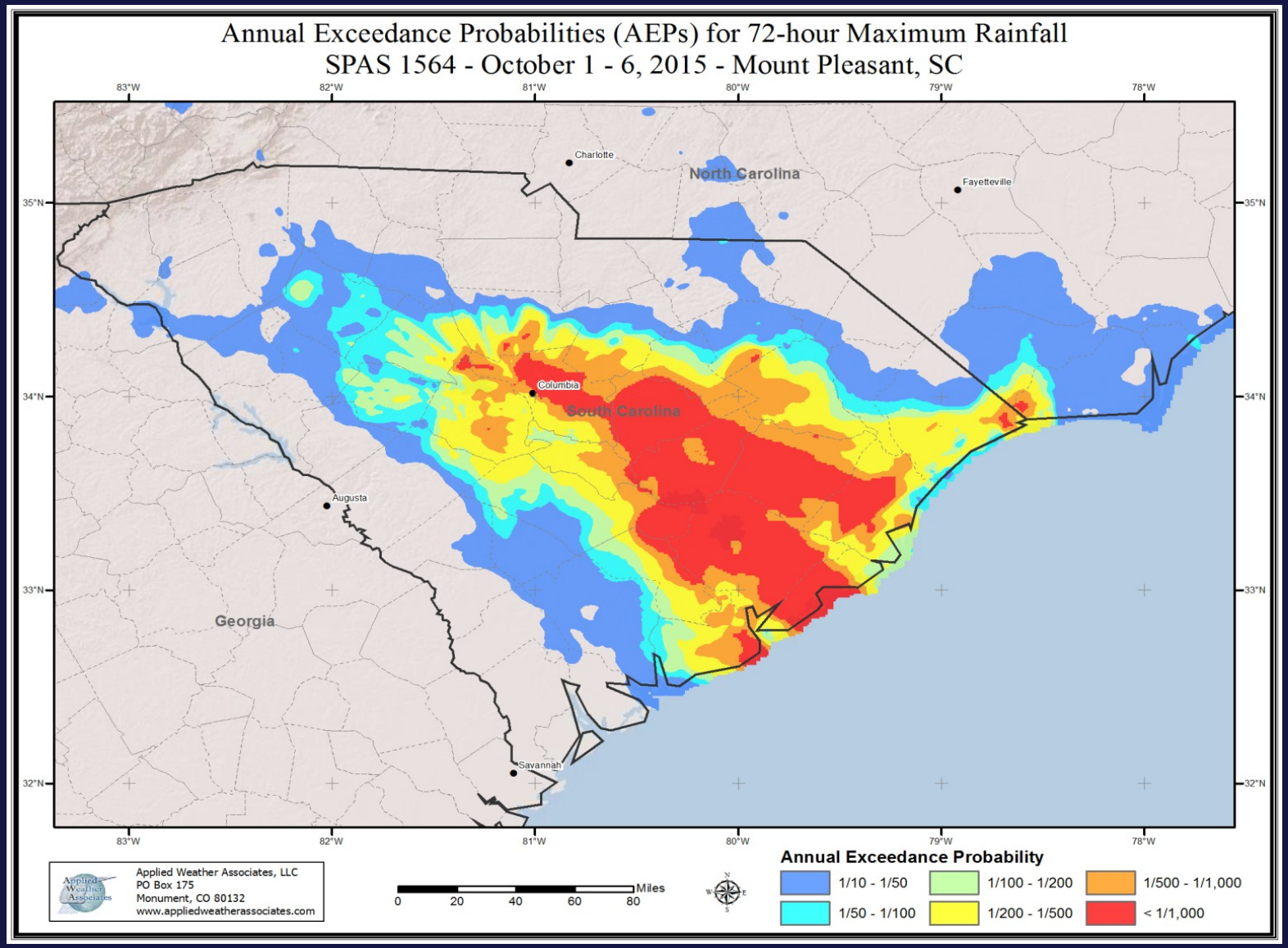
Total Storm Isohyetal



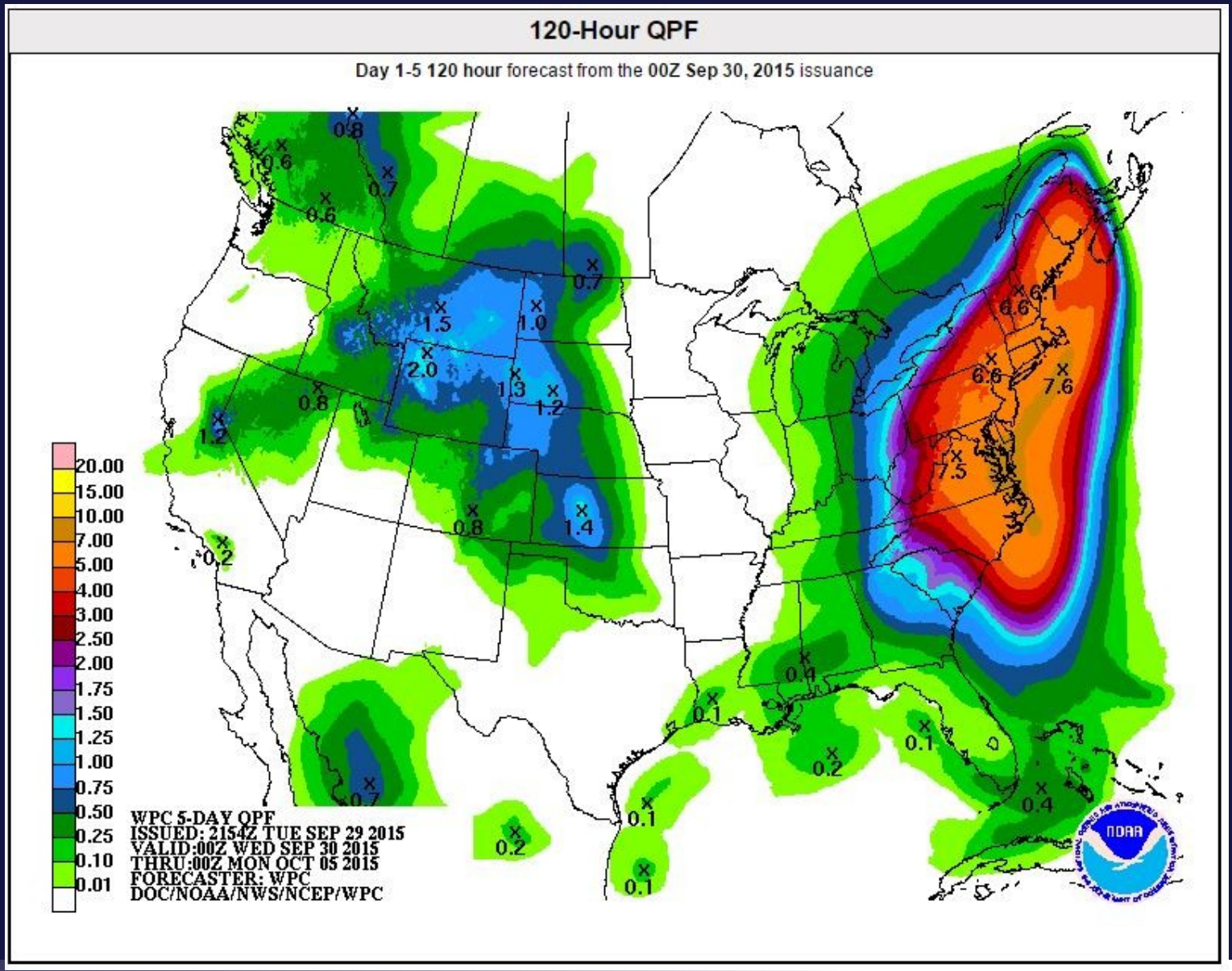
SPAS Results Annual Exceedance Probability



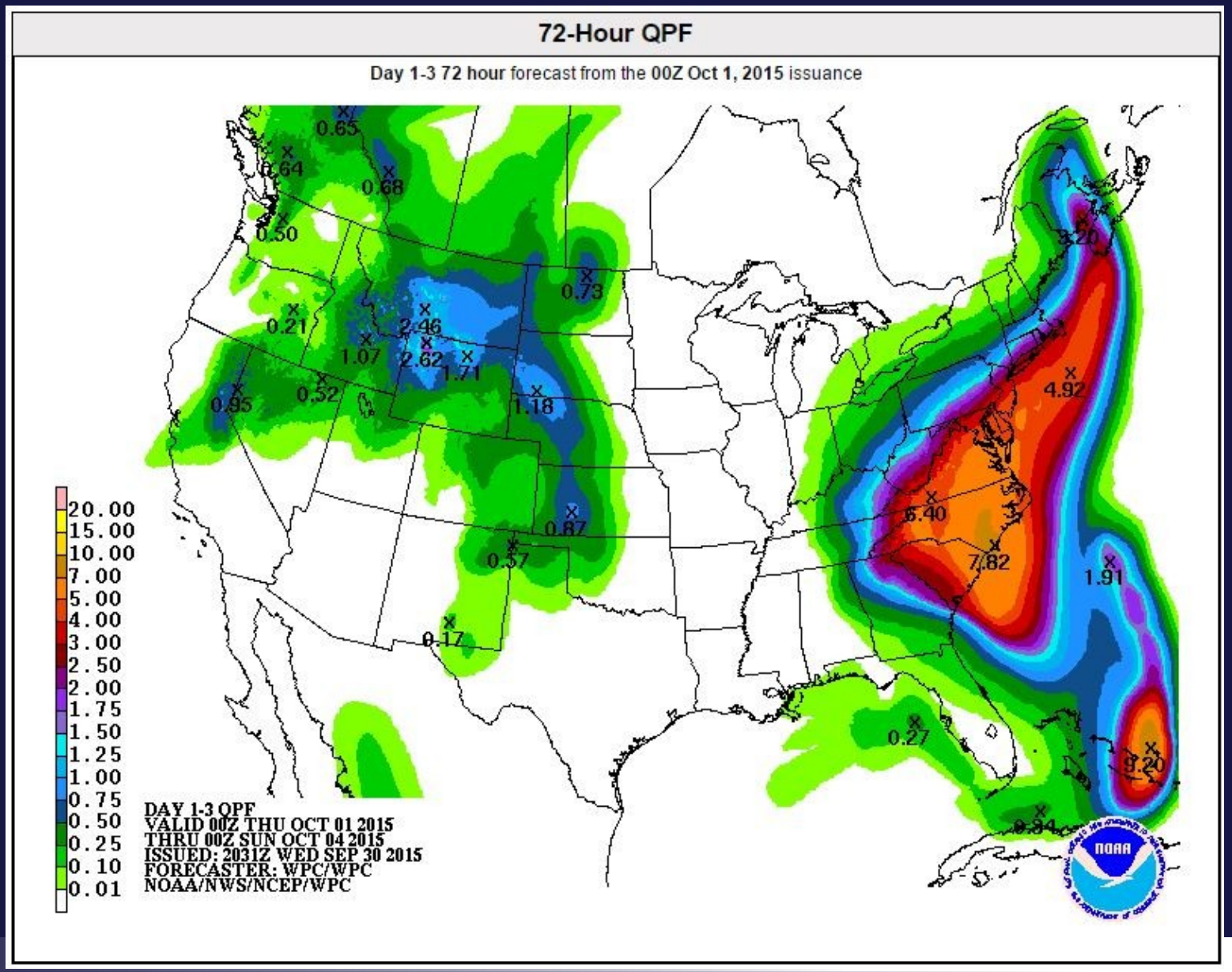
SPAS Results Annual Exceedance Probability



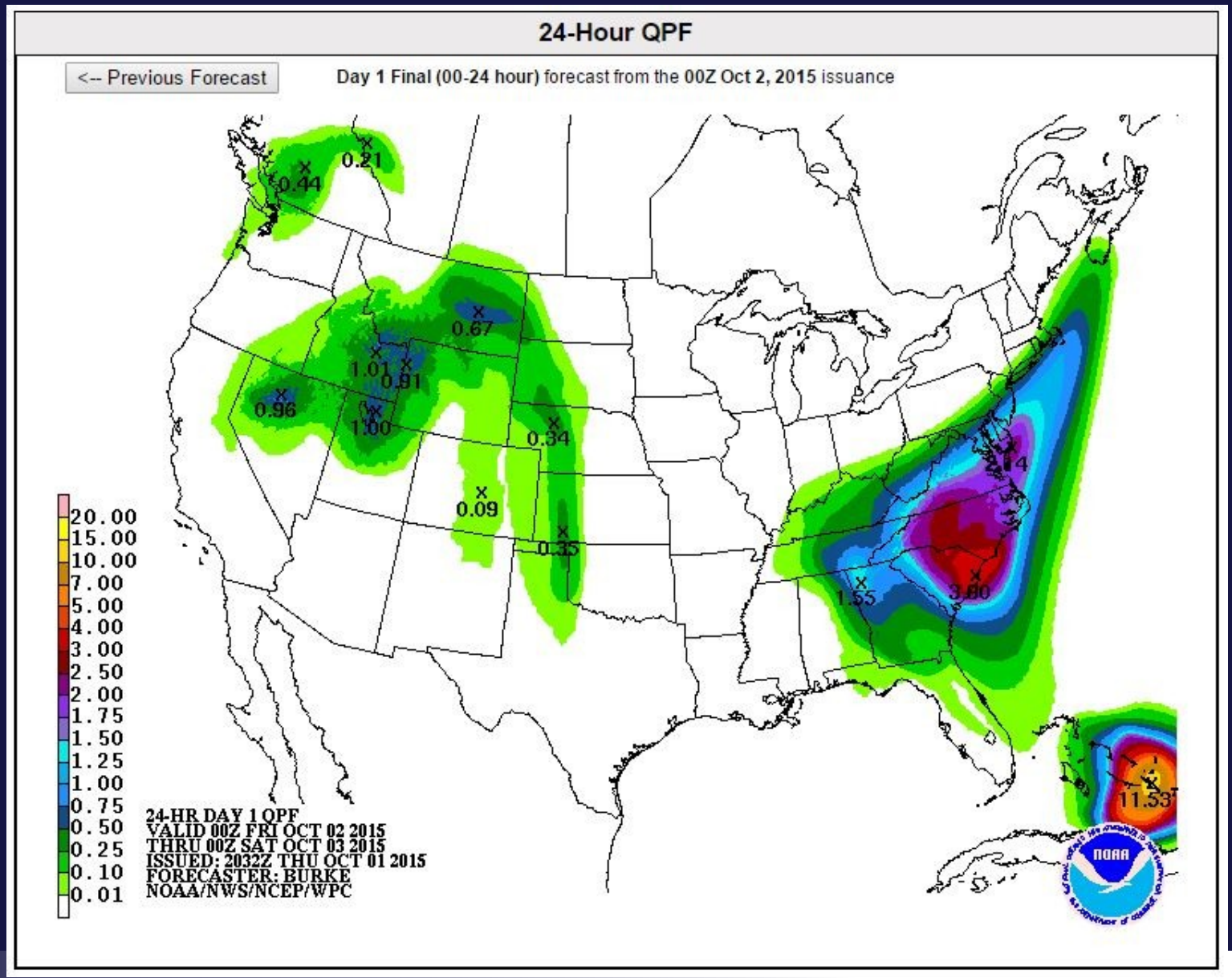
NWS QPF-5 Day


120-Hour QPF
Day 1-5 120 hour forecast from the 00Z Sep 30, 2015 issuance
20.00
15.00
10.00
7.00
5.00
4.00
3.00
2.50
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.10
0.01
WPC 5-DAY QPF
ISSUED: 2154Z TUE SEP 29 2015
VALID:00Z WED SEP 30 2015
THRU:00Z MON OCT 05 2015
FORECASTER: WPC
DOC/NOAA/NWS/NCEP/WPC
NOAA

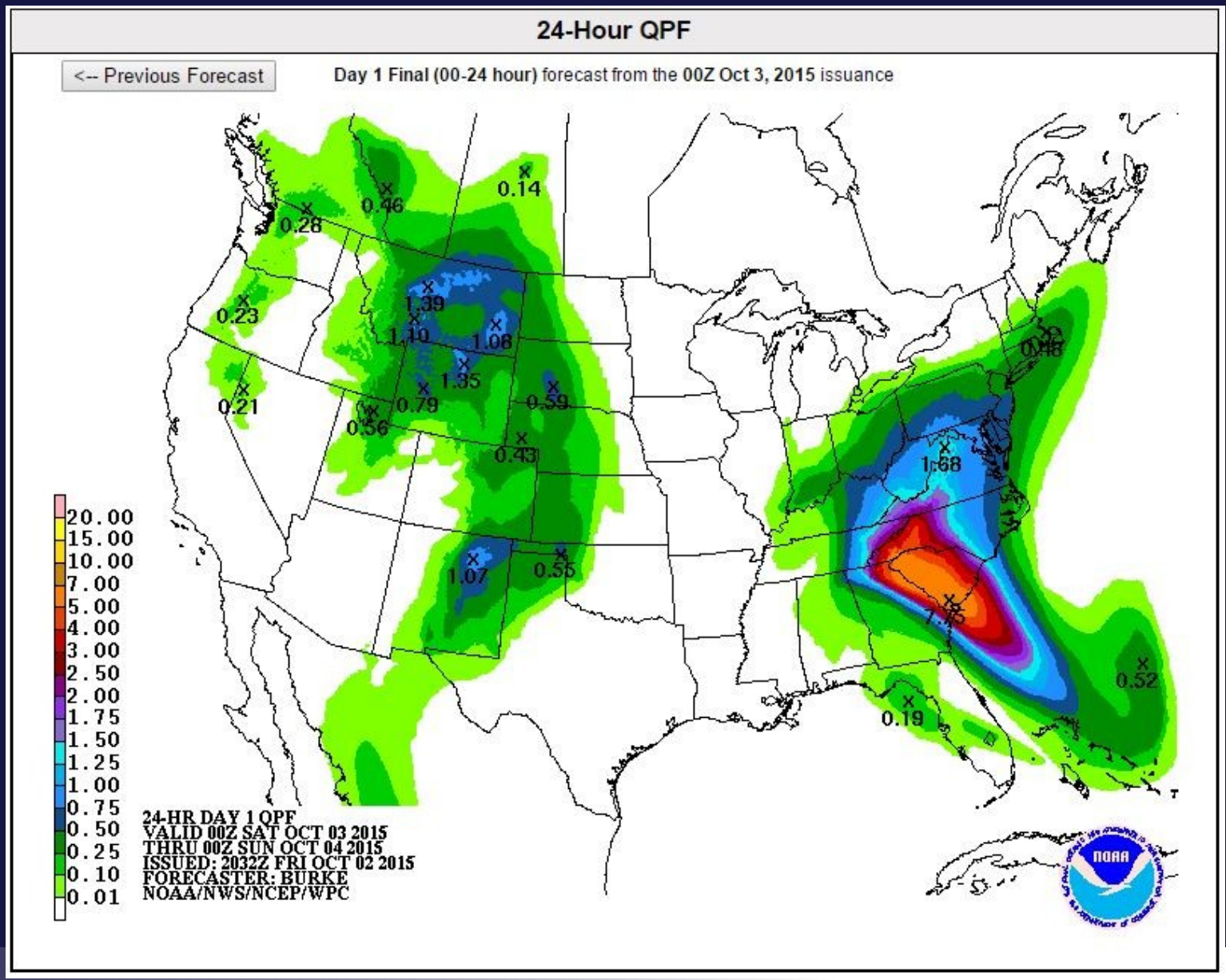
NWS QPF-3 Day


72-Hour QPF
Day 1-3 72 hour forecast from the 00Z Oct 1, 2015 issuance
0.65
0.64
0.68
0.50
0.73
0.21
2.46
1.07
2.62
1.71
0.95
0.52
1.18
4.92
0.87
6.40
0.37
7.82
1.91
0.17
0.27
9.20
0.34
20.00
15.00
10.00
7.00
5.00
4.00
3.00
2.50
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.10
0.01
DAY 1-3 QPF
VALID 00Z THU OCT 01 2015
THRU 00Z SUN OCT 04 2015
ISSUED: 2031Z WED SEP 30 2015
FORECASTER: WPC/WPC
NOAA/NWS/NCEP/WPC
NOAA

NWS QPF-1 Day, 2nd - 3rd



NWS QPF-1 Day, 3rd - 4th

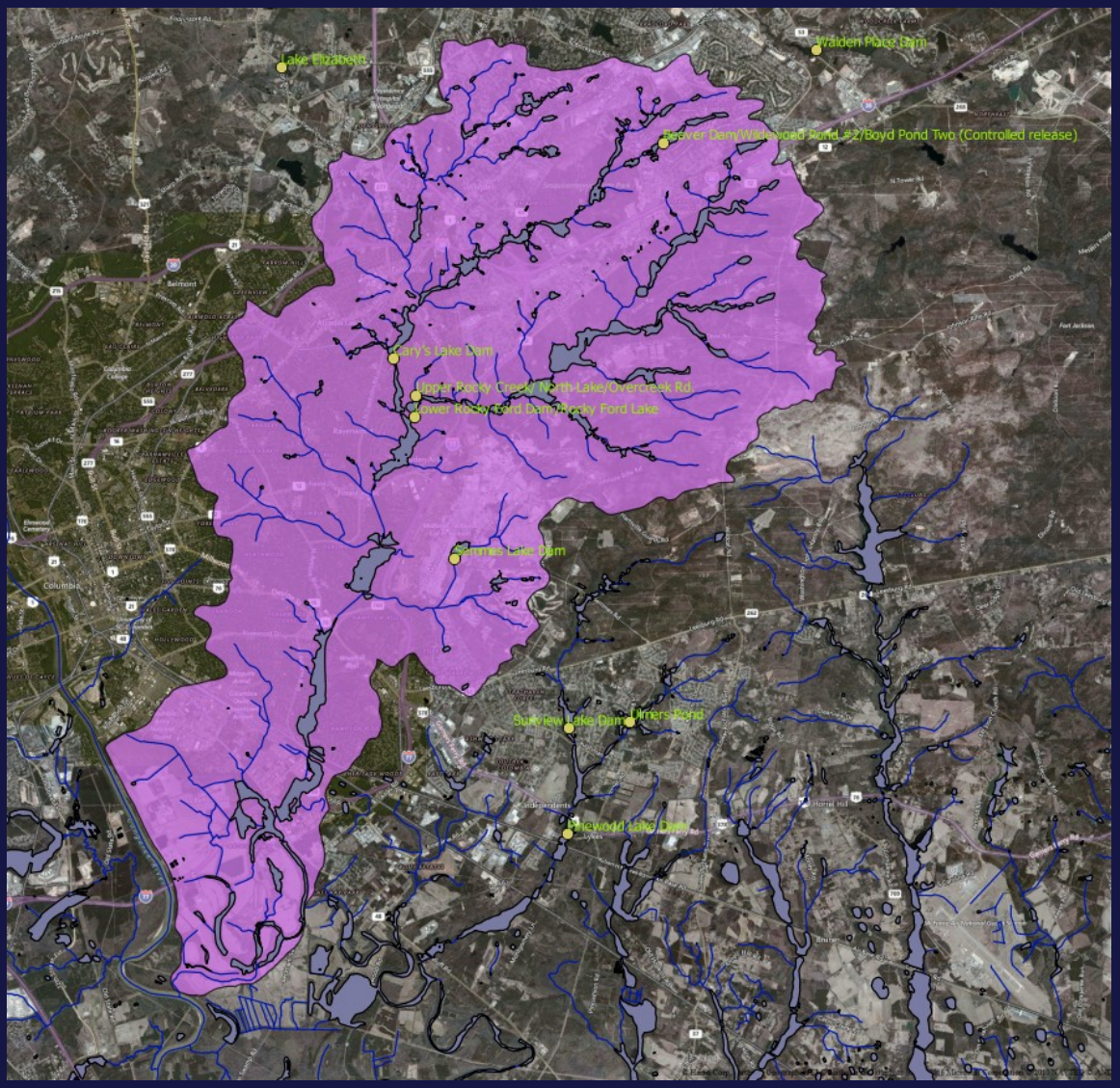


Hydrologic Analysis

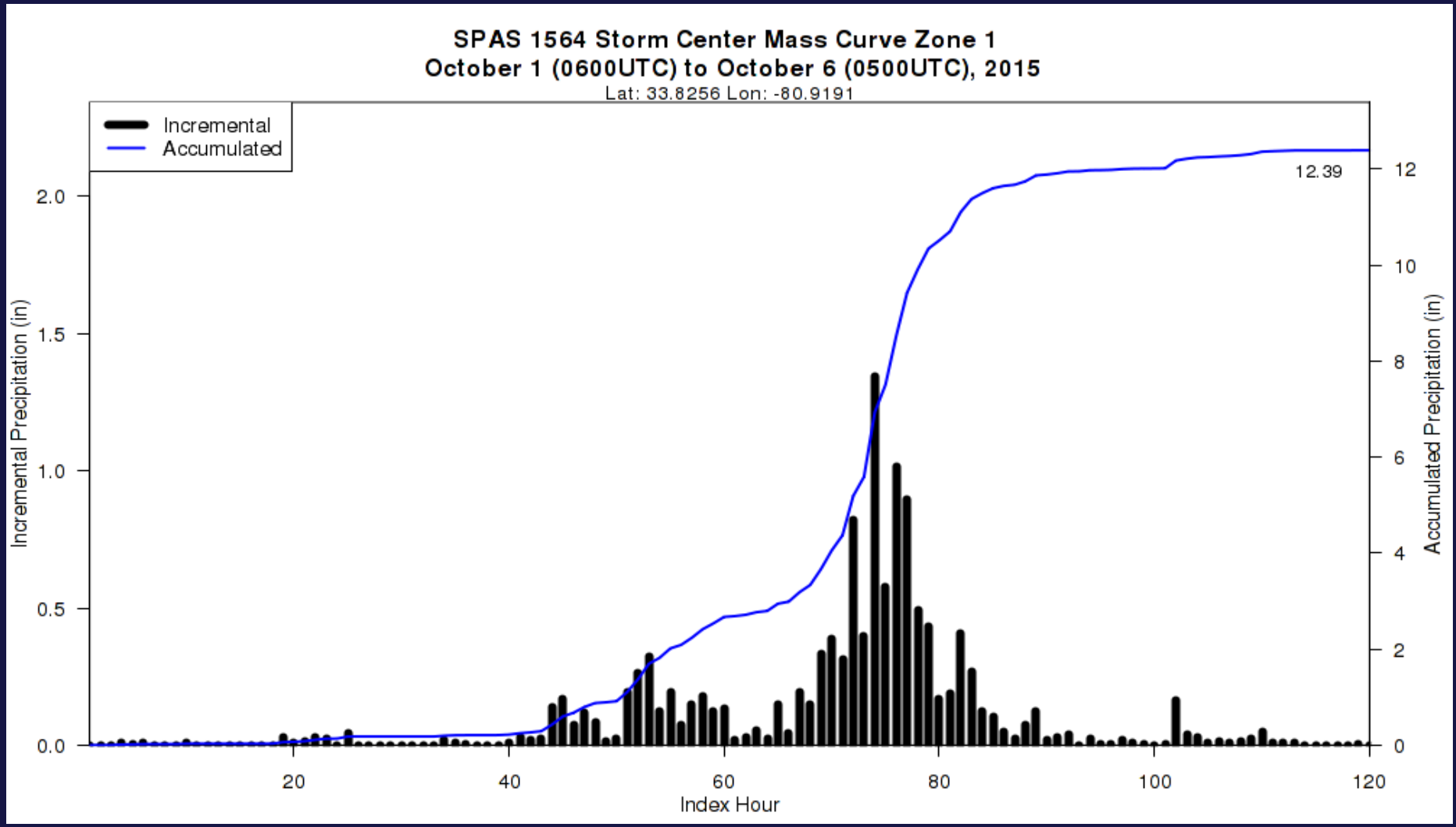
- Hydrologic analysis conducted for selected watershed to compare watershed's response to predicted (QPF) and SPAS-estimated actual
- Gills Creek selected as the subject watershed due to severity of flooding and dam failure events
- 23 regulated and several unregulated dams

Hydrologic Analysis

Gills Creek Watershed
Approximately 75 square miles



Hydrologic Analysis



Mass Curve (from SPAS) for the Gills Creek Watershed Centroid

Hydrologic Analysis

- SCDHEC regulated dams that failed during the event:
  - Carry's Lake Dam (D 0026) – the embankment and the spillways breached due to overtopping. It was noted that the failure of an upstream non-regulated dam may have contributed to the breach of the Carry's Lake Dam.
  - Upper (North) Rocky Ford Lake Dam (D 0029) - the concrete overflow auxiliary spillway breached without the dam being overtopped during the event. It is likely that the failure of the auxiliary spillway contributed to the failure of the Rocky Ford Lake Dam auxiliary spillway.
  - Rocky Ford Lake Dam (D 0028) – the concrete overflow auxiliary spillway breached without the dam being overtopped.

Hydrologic Analysis

- HEC-HMS model previously developed by HDR Inc. (HDR 2016) for the South Carolina Department of Health and Environmental Control (SCDHEC) was used as the basis for the evaluation.
- No additional calibration was performed to enhance the model since the purpose was to make a comparison (predicted versus actual rainfall), not develop absolute values, for insights in enhancing dam safety.

Hydrologic Analysis

- Two hydrologic scenarios were developed:

1. Post-event 1-hour gridded data developed by AWA

2. NWS 5-Day Quantitative Precipitation Forecast (QPF) (archived 6-hour QPFs for 120 hours)

Conclusions and Dam Safety Lessons-Learned

- Using QPF forecasts may result in misleading information, particularly for small and medium size watersheds.

- Until prediction tools improve in granularity and accuracy, understand the limitations of forecasting, especially more than 5-days in advance, for shorter durations, and extreme events.

Conclusions and Dam Safety Lessons-Learned

- Working within these limitations, a warning and preparation time approach can be developed. As an example:
  1. Determine “critical pool level” (level that will likely lead to flood-induced failure)
  2. Determine “consequential rainfall” (depth-area-duration functions that could produce the critical pool level)
  3. Establish monitoring threshold (e.g. use Ralph et al 2010 research for “extreme rainfall” (top 1% of days with rainfall))

Conclusions and Dam Safety Lessons-Learned

- Approach to warning and preparation time (cont'd):
  4. Establish trigger threshold; say ½ consequential rainfall depth in a period equal to 3 times the lag time
  5. Actions are initiated when the Day 1 or 2 (or longer depending on required response time) 95th percentile PQPF projects cumulative rainfall amount greater than the trigger value over the next 24 hrs (if the lag time is 8 hrs)

Conclusions and Dam Safety Lessons-Learned

- Refined approach
  - Automated near-real-time flood model
  - Automate ingestion of QPF into SPAS to develop more accurate near-real-time hourly rainfall data combined with calibrated hydrologic model to predict pool levels for action and flood-warning triggers.

QUESTIONS

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