NORTH CAROLINA
Department of Transportation

NCDOT LIDAR Applications in Transportation

Matt Lauffer, PE

State Hydraulics Engineer

2024_03_26 – USGS 3DEP

Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina

NCDOT LIDAR Applications in Transportation

- Background
- Overview of Applications
- LIDAR in Resilient Planning
- Hydraulic Modeling and Design
- Flood Warning Tools
- Research

NCDOT

NCDOT

AVIATION

72 PUBLICLY OWNED AIRPORTS

nearly **487** other airports, heliports and other landing areas

DMV

125+ LICENSE PLATE AGENCIES

110+ DRIVER LICENSE OFFICES

HIGHWAY

MORE THAN **81,000** MILES OF ROAD

MORE THAN **13,600** BRIDGES

FERRY

2nd largest state-operated ferry system in the nation

22 FERRIES

8 ROUTES

RAIL

MORE THAN **3,600** CORRIDOR MILES OF RAILROAD TRACK

8 daily trains and growing serving NC

TURNPIKE

65+ MILES OF TOLL ROADS

PORTS

4M+ TONS OF GENERAL CARGO ANNUALLY

98 TRANSIT SYSTEMS

Serving residents in **all 100 counties**

INTEGRATED MOBILITY

MORE THAN **3,000** MILES OF STATE AND REGIONAL BICYCLE ROUTES

GLOBAL TRANSPARK

2,500 ACRE MULTIMODAL, INDUSTRIAL & BUSINESS PARK

MISSION

Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina.

Overview of LIDAR Applications

NCDOT LIDAR Applications

- Bridges:
  - Structural health monitoring
  - Geometry and clearance measurements
  - Restoration
- Construction
  - Earthwork quantity estimation
  - As-built Modeling
- Geotechnical Engineering
  - Rock mass characterization
  - Rockfall characterization
  - Landslide mapping
  - Slope stability
- Highway Design and Corridor Mapping:
  - Design Improvement
  - Elevation and cross-section
  - Topographic Survey
- Hydraulics and Hydrology
  - Digital Elevation Model
  - Coastal Change
  - Flood inundation mapping
  - Flood Warning Tools
- Pavement
  - Grade estimation
  - Cross-slope
  - Resurface assessment
  - Crack detection

LIDAR in Resilient Planning

2018: Hurricane Florence

2024: Hurricane Helene

Transportation

$9.8 billion

Estimated cost of damages, strengthening, and mitigation

> ***It's almost impossible to believe that water and wind alone could have torn apart rock and asphalt and the literal ground near where we're standing.***
>
> —Pete Buttigieg, U.S. Secretary of Transportation (*Raleigh News & Observer*)

6K

Miles of road damaged

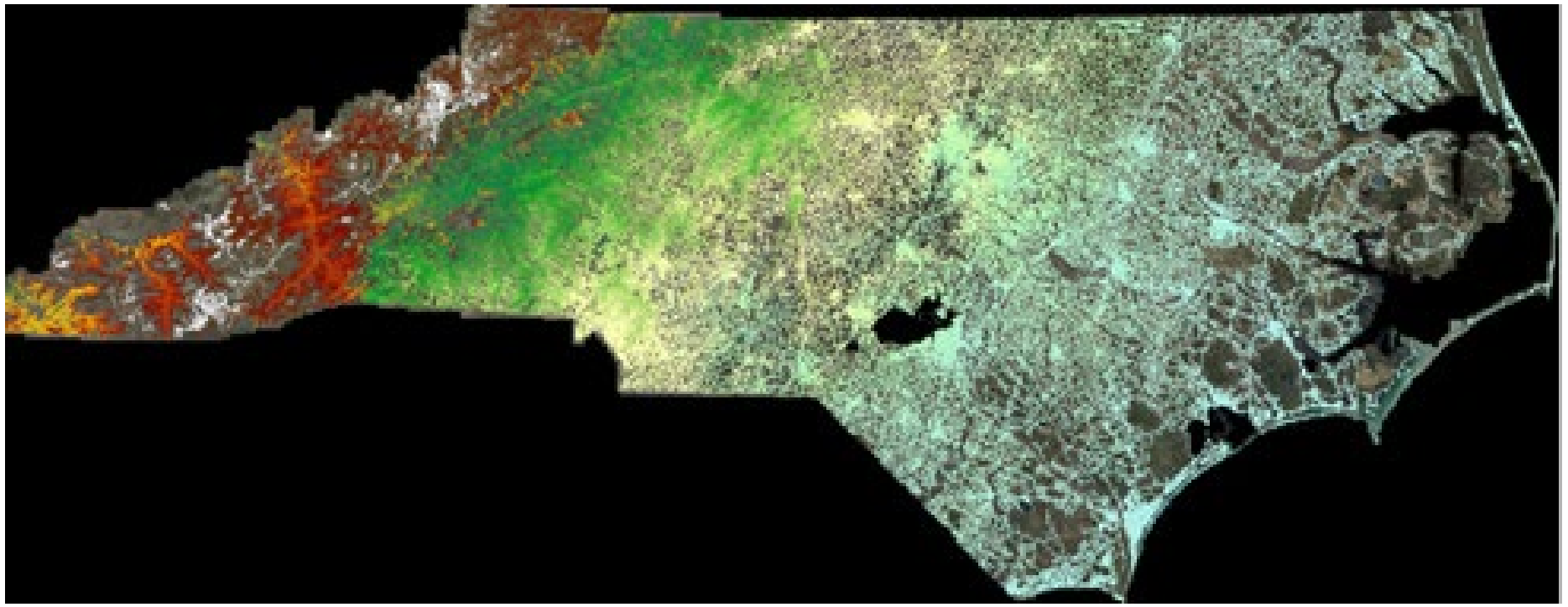
1K+

Bridges and culverts damaged

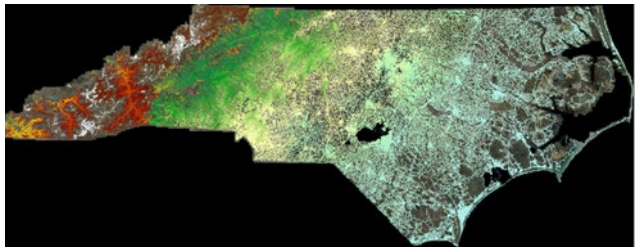
Photo credit: NCDOT – I-40 in Black Mountain Township (top), Mount Paradise Campground (bottom)

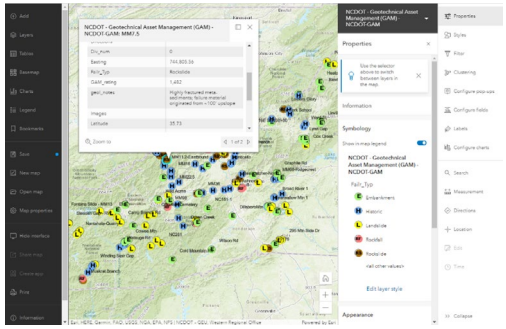
Partnership

Statewide Road Elevation Model

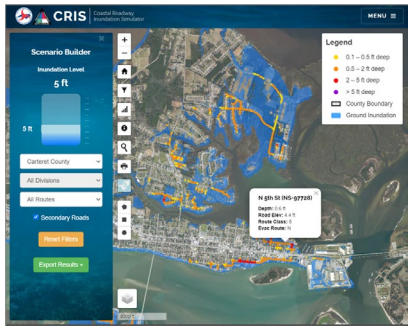


Planning and Project Delivery Resilience Tools

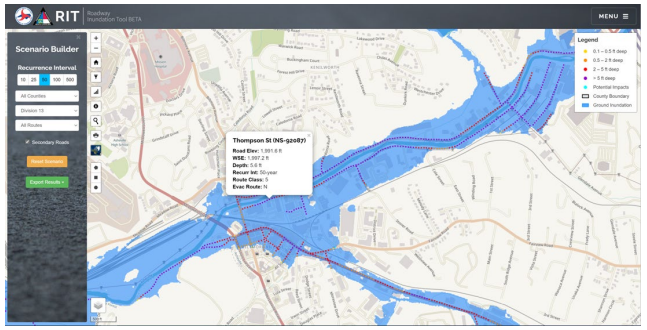




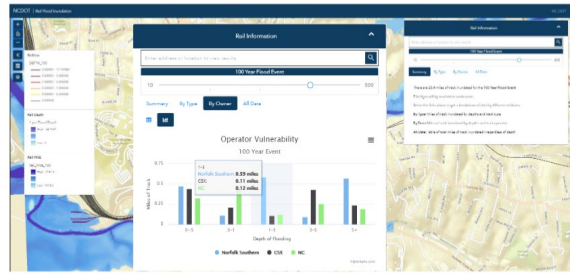
Landslide Risk



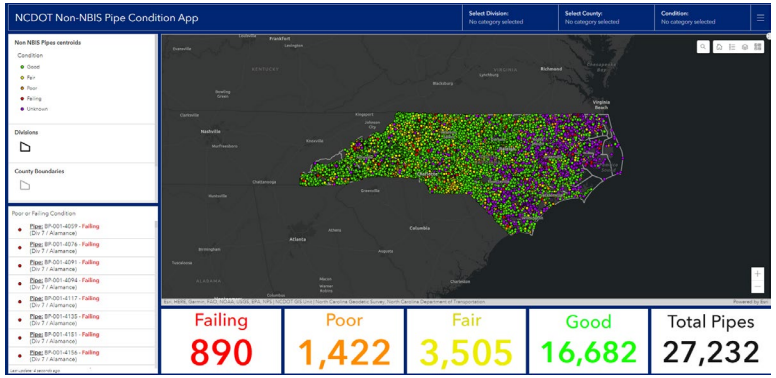
Coastal Road Flood Risk - SLR



Inland Road Flood Risk



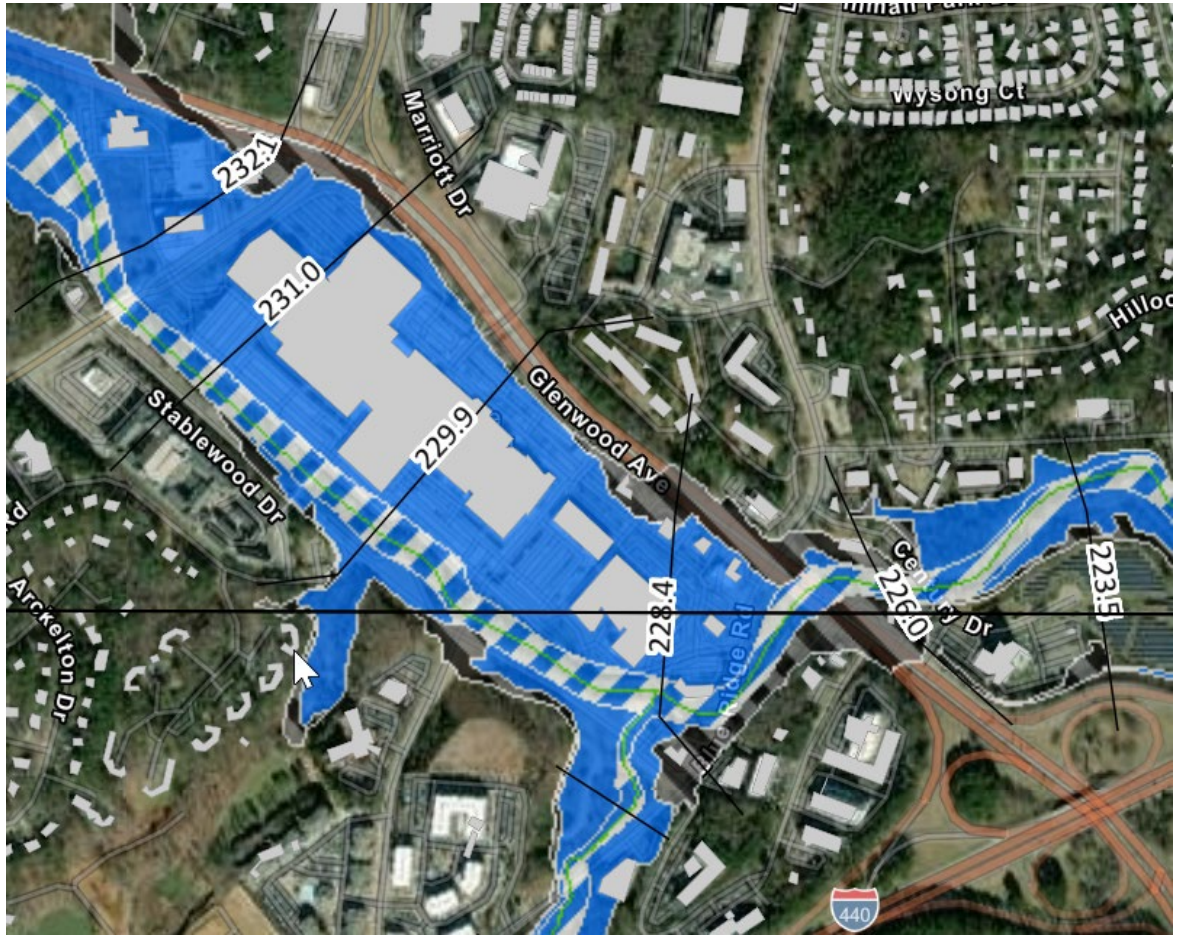
Rail Flood Risk

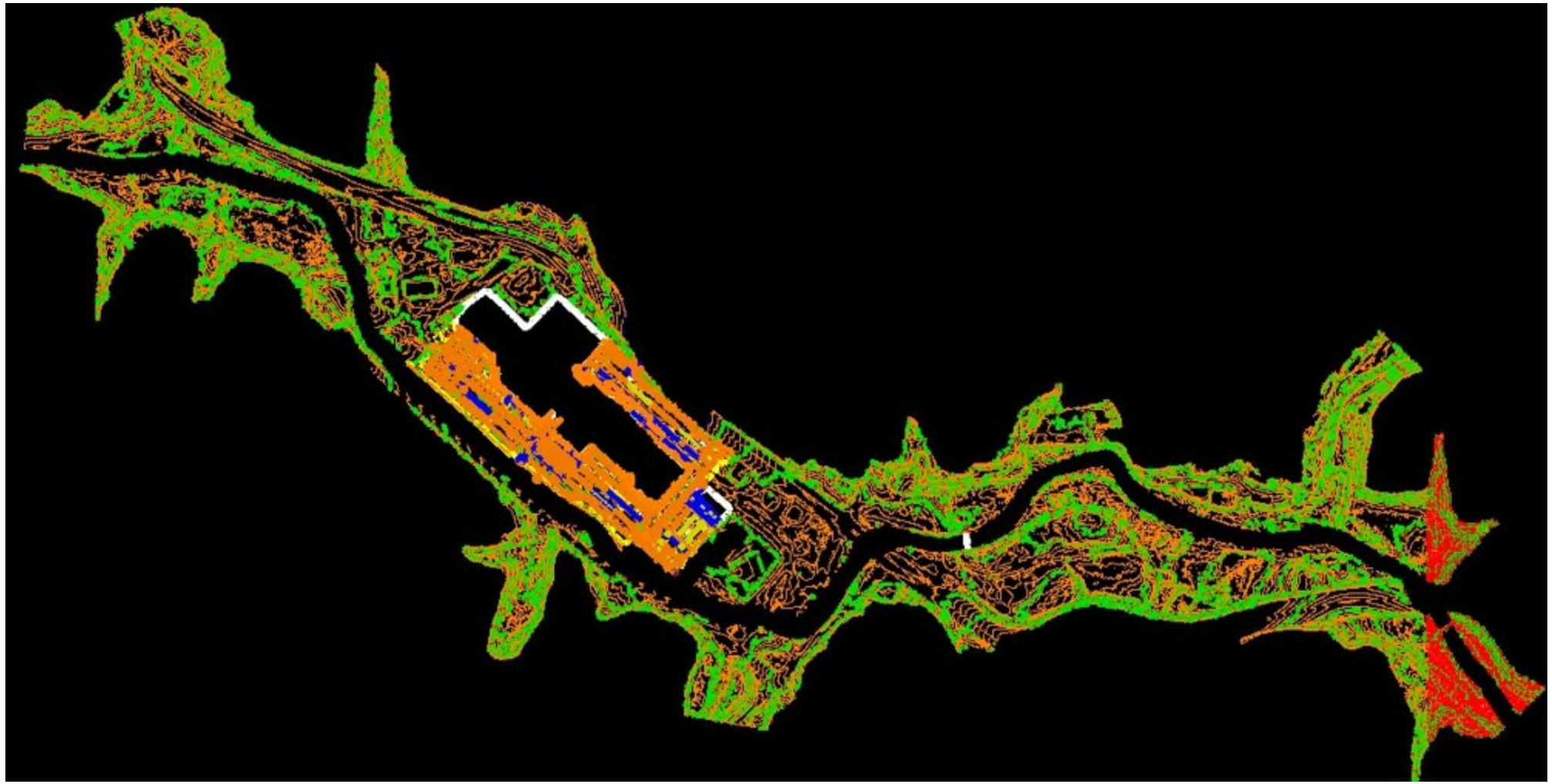


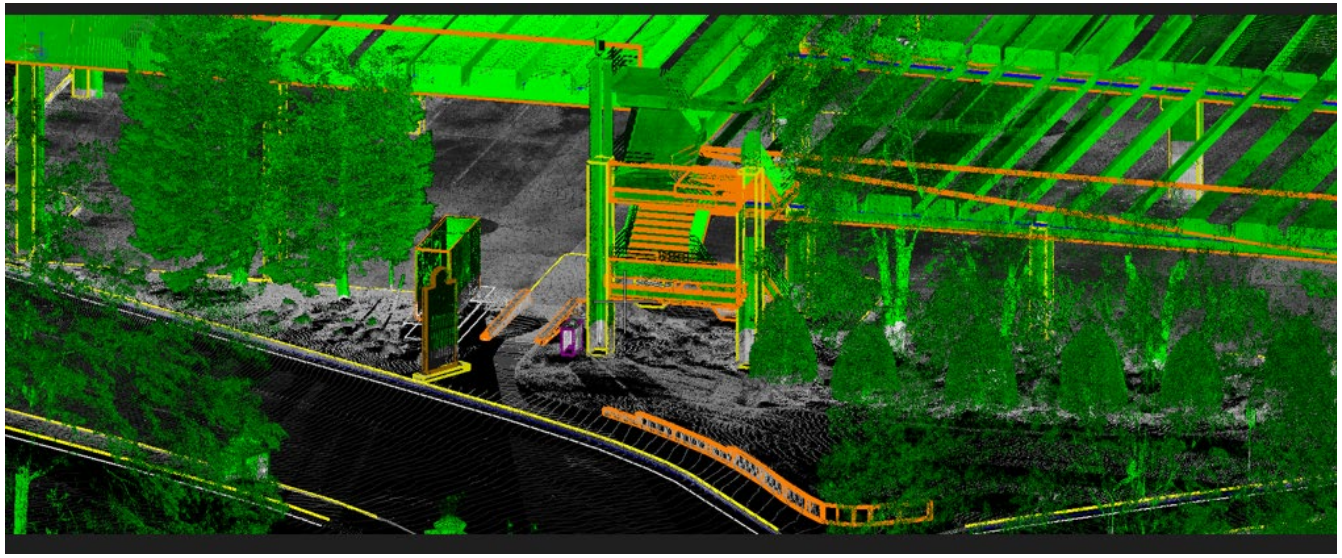
Asset Management

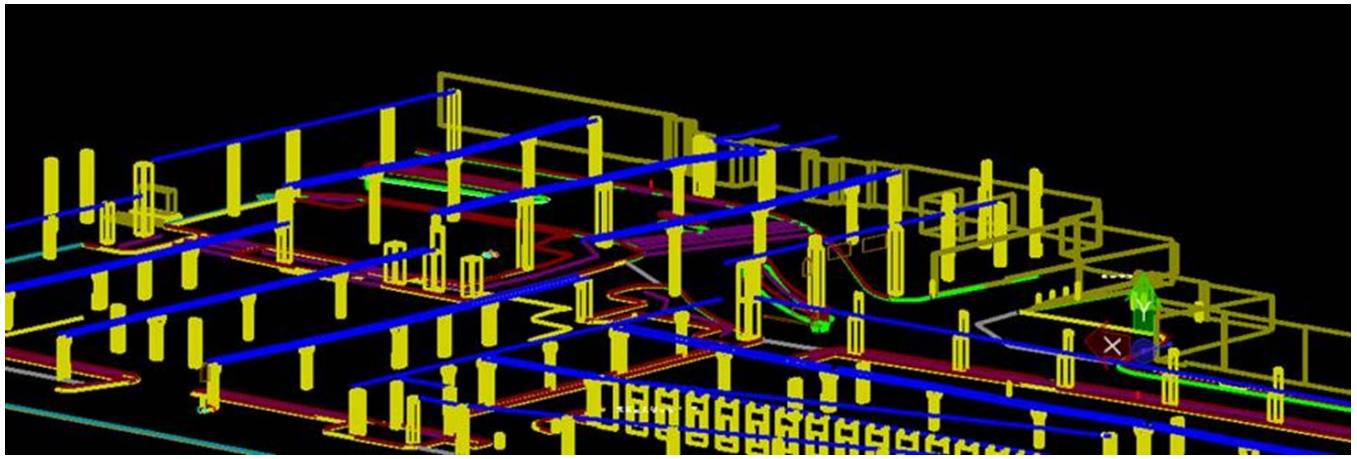
LIDAR in Hydraulic Modeling and Design

I-5870 – Raleigh Outer Beltline



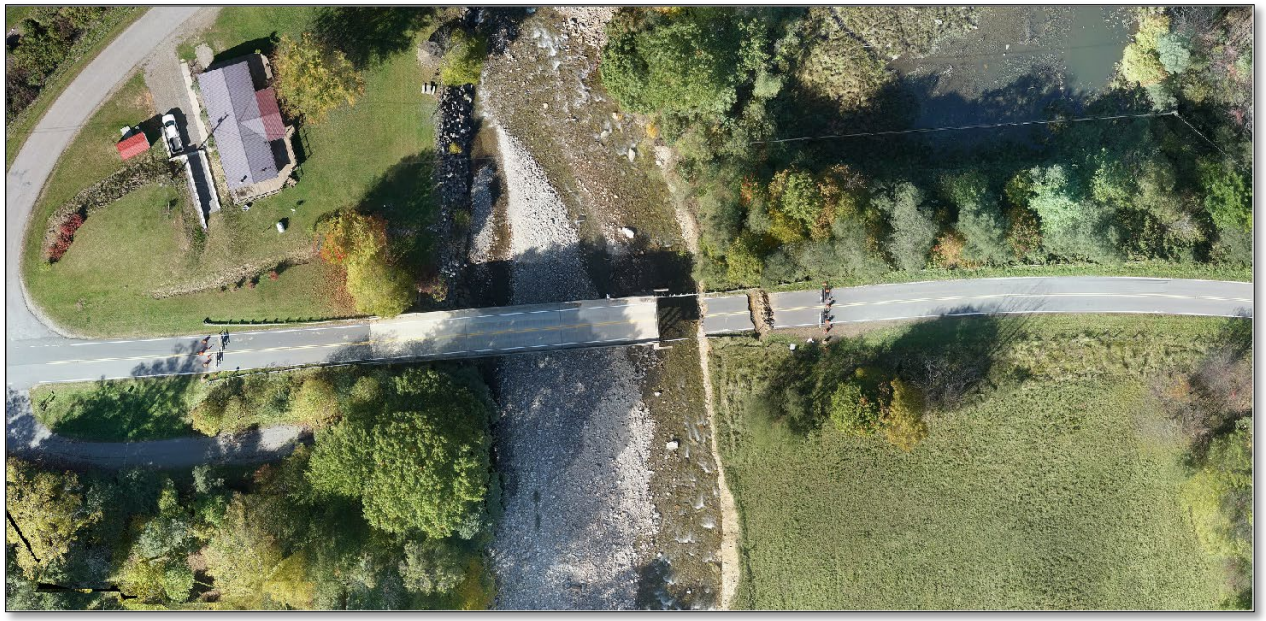






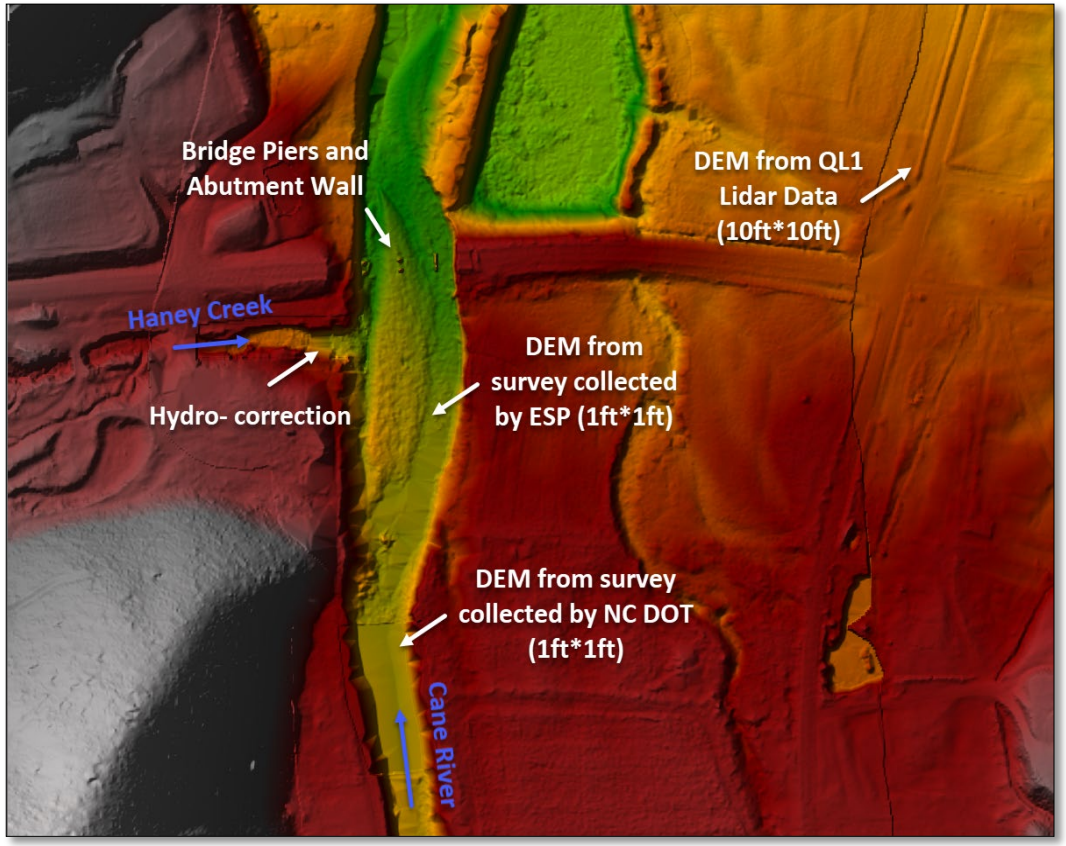
YANCEY-040 HYDRAULIC MODELING

- Tropical Storm Fred caused significant damage to Yancey-040 bridge at NC-197 in Yancey County.
- It is estimated that almost 6000 Cu.Yd. of soil material was carried downstream from the right bank.
- NCDOT proposed a bank stabilization design for the right bank.
- Proposed design section is analyzed and supported with two different hydraulic models, HEC-RAS 2D and SRH-2D.



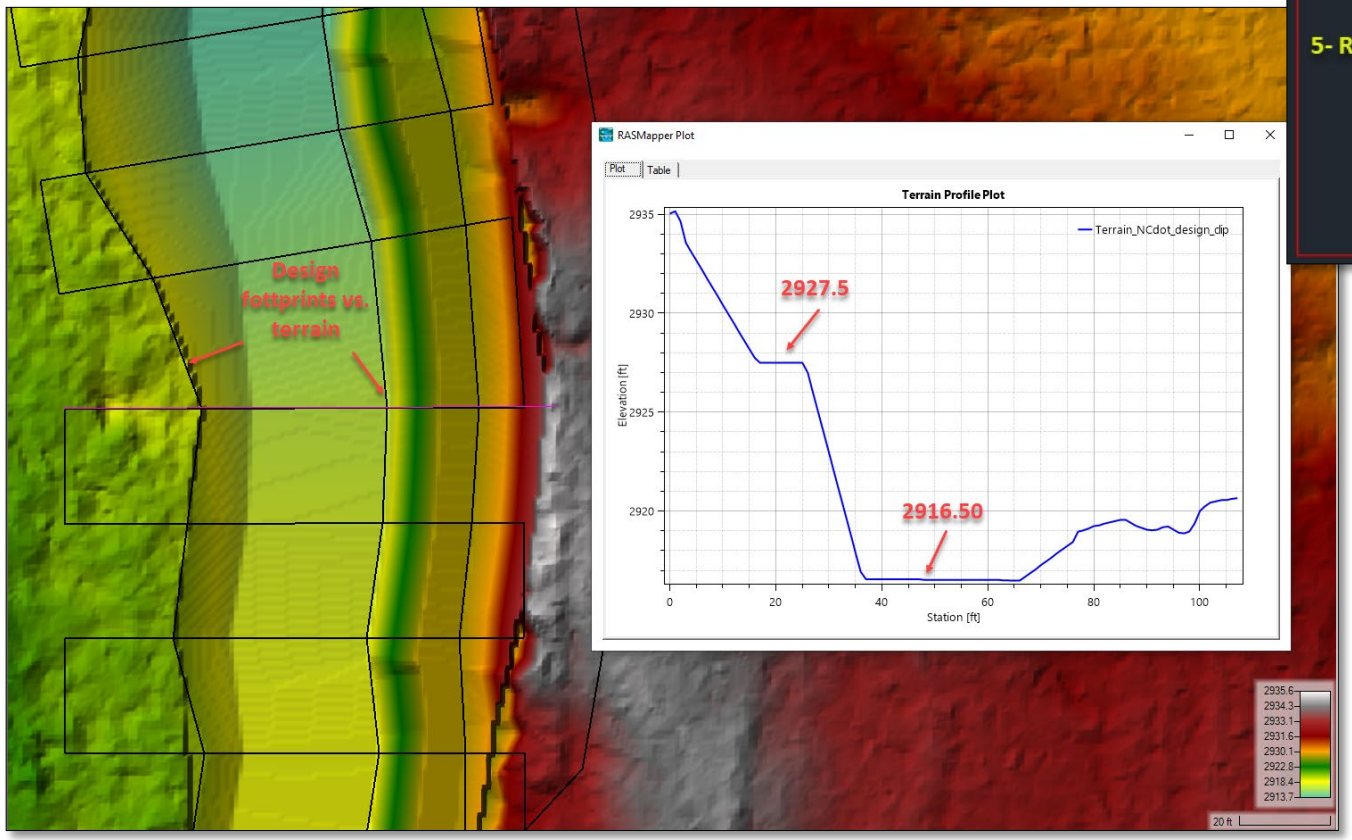
2D Hydraulic Modeling – Terrain Development

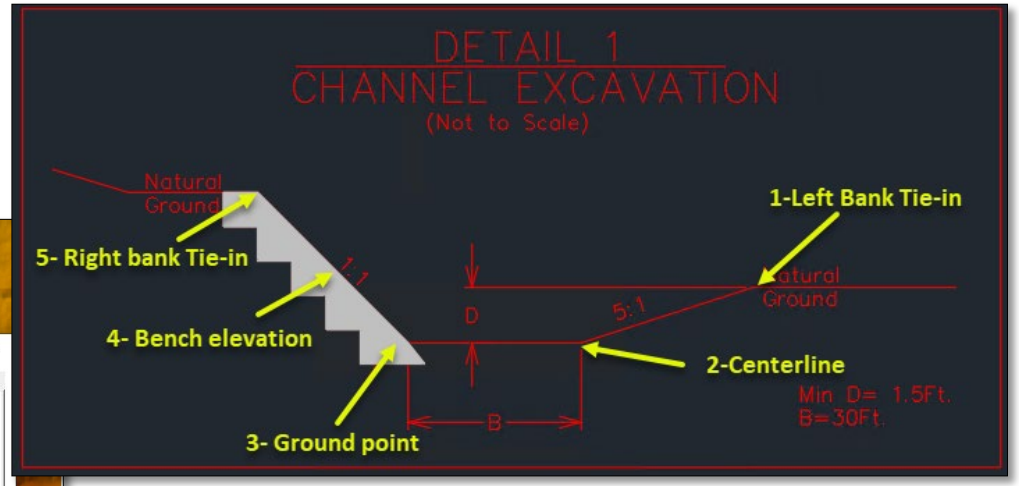
- Post-Fred (Existing Terrain) was developed by combining different data sources:
    - Lidar survey collected by ESP
    - Survey collected by NCDOT
    - QL1 Lidar collected by NCEM
    - Yancey-040 standing bridge piers and abutment wall
    - Hydro-correction to maintain connectivity on Haney Creek



2D Hydraulic Modeling – Terrain Development

- Proposed Terrain Development NCDOT bank stabilization design is incorporated in the existing terrain and verified.





Final Product – Monitor with LIDAR

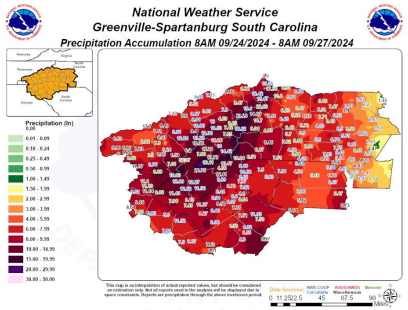
Helene Recovery 2D Modeling

Rainfall Totals

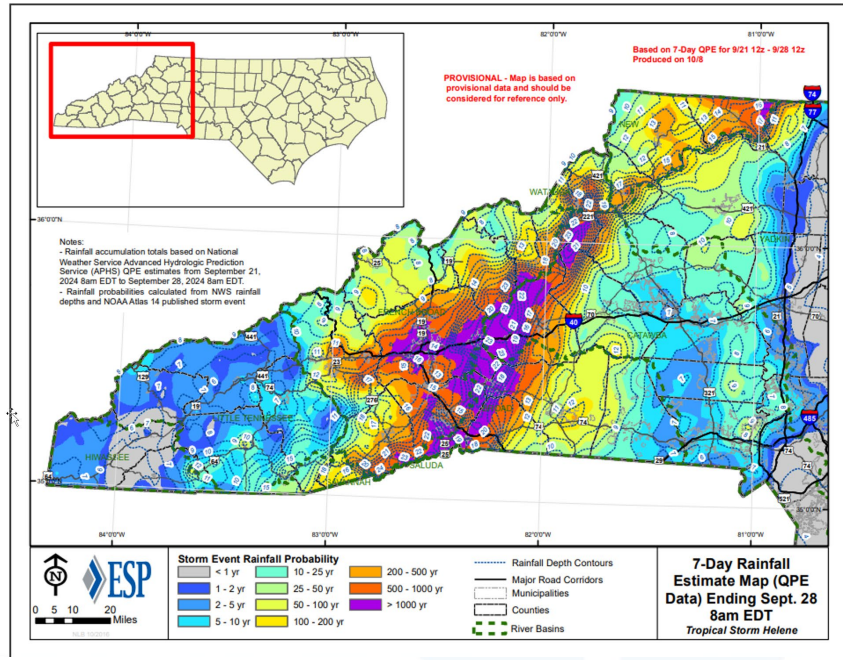
Rainfall Totals Across NC

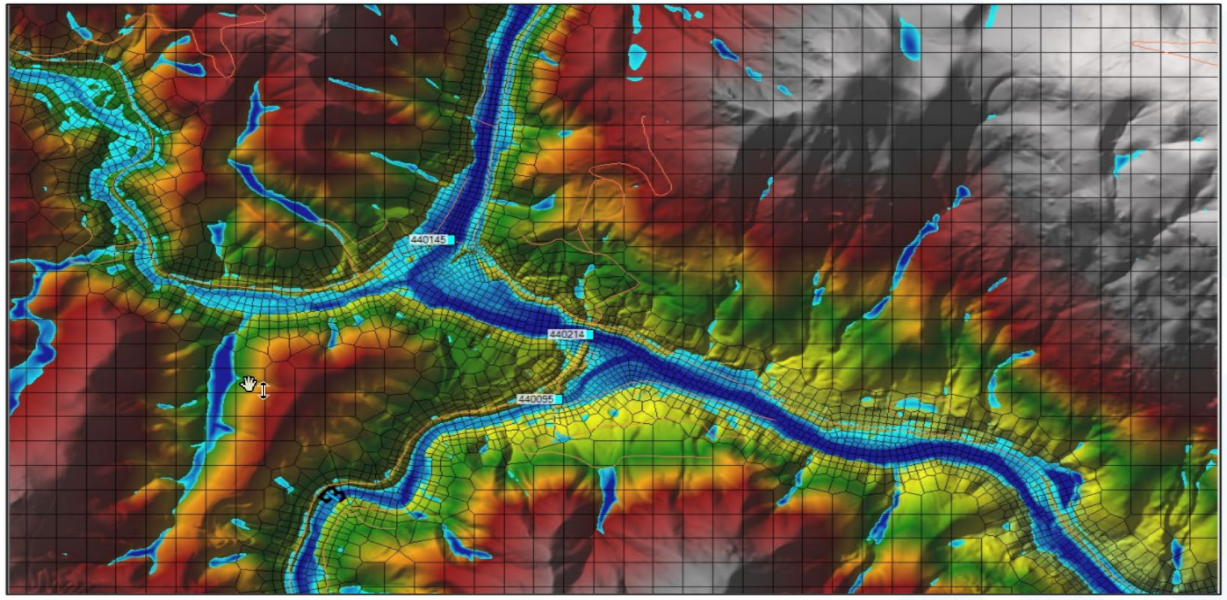
- Busick (Yancey Co) → 30.78 in
- Mt Mitchell State Park (Yancey Co) → 24.2 in
- Spruce Pine (Mitchell Co) → 18.23 in
- Davidson River (Transylvania Co) → 17.7 in
- Asheville (Buncombe Co.) → 17.3 in

Predecessor Rain Event



Courtesy NWS GSP: https://x.com/NWSGSP/status/1839701767552147752

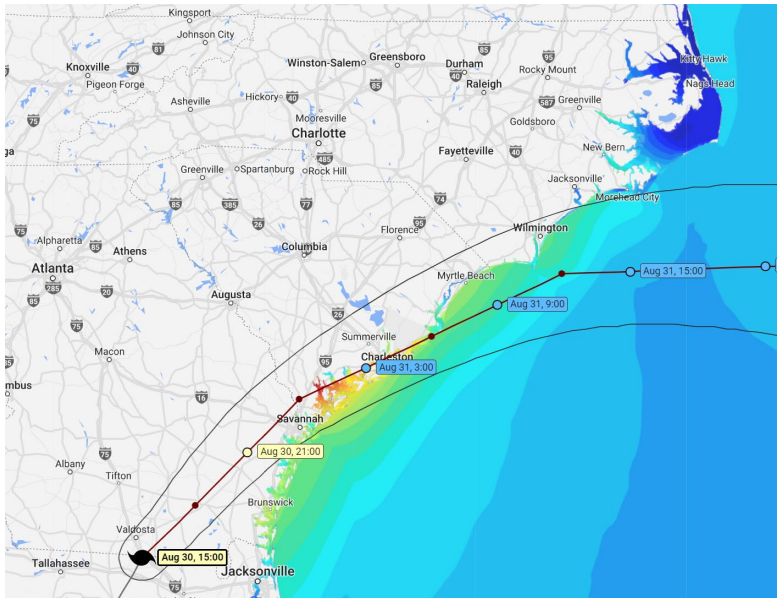




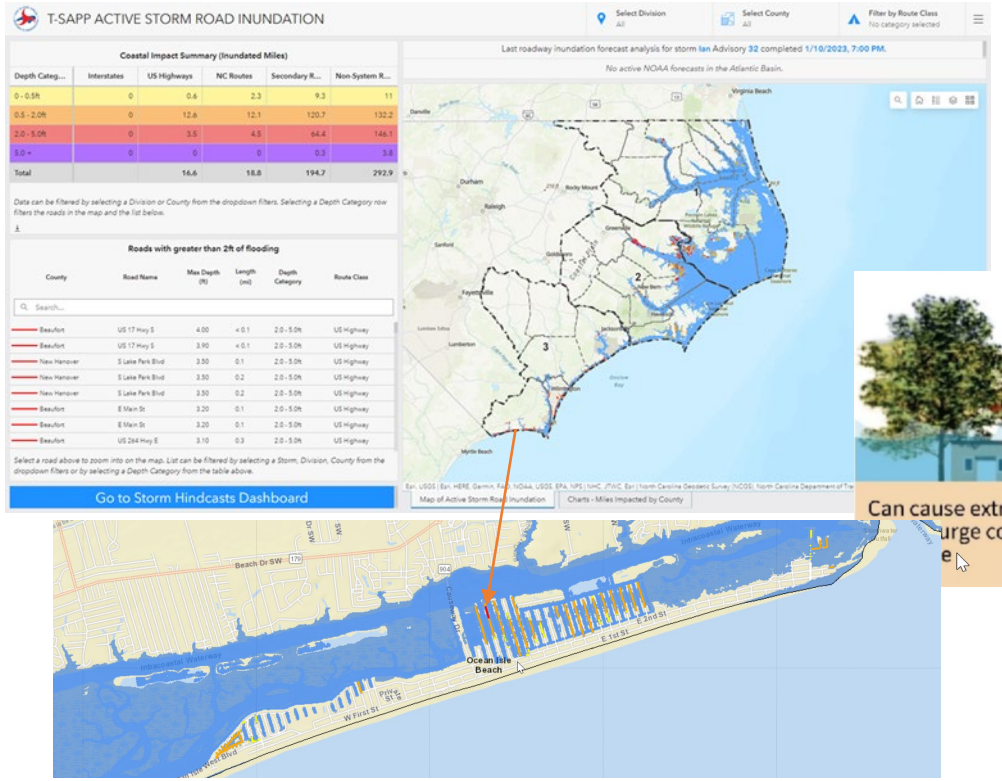
Flood Warning Tools

T-SAPP – Before the Storm

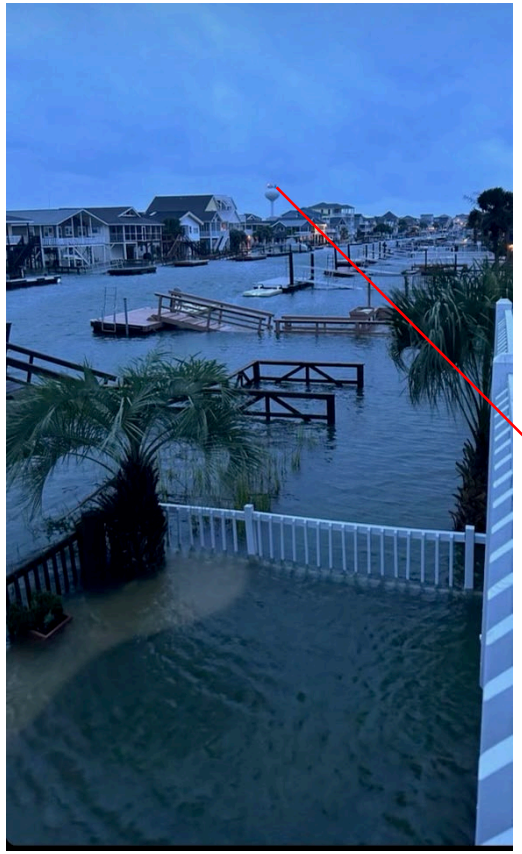
- **T-SAPP**: Transportation Surge Analysis Prediction Program
  - **Predictive tool based on ADCIRC modeling provided by UNC-RENCI Center capable or providing advance awareness of potential coastal roadway flood impacts for entire NC coast specific to individual storms**



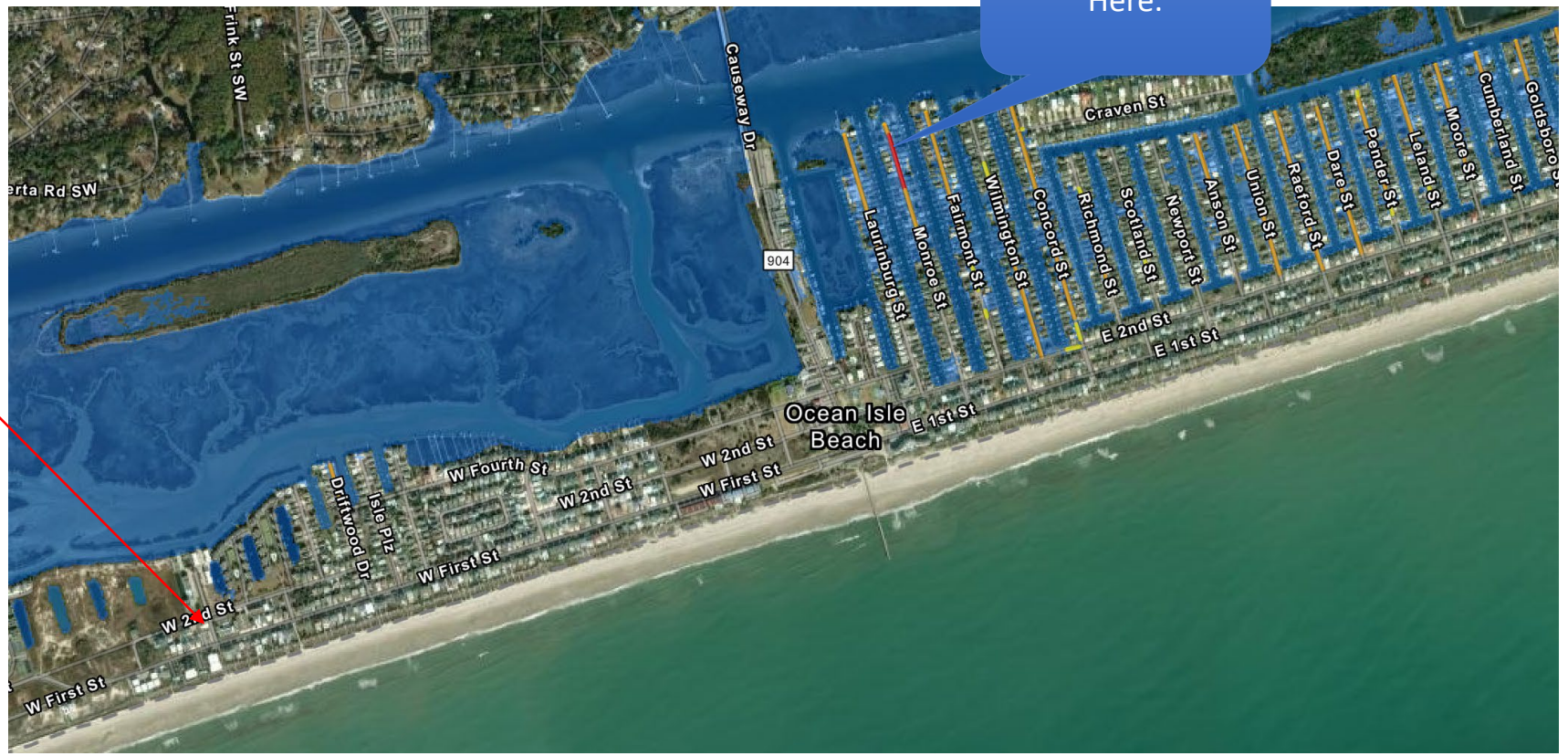
August 30, 3:00pm



Predicted Coastal Surge Impacts (T-SAPP)



August 31st, – 8:10pm

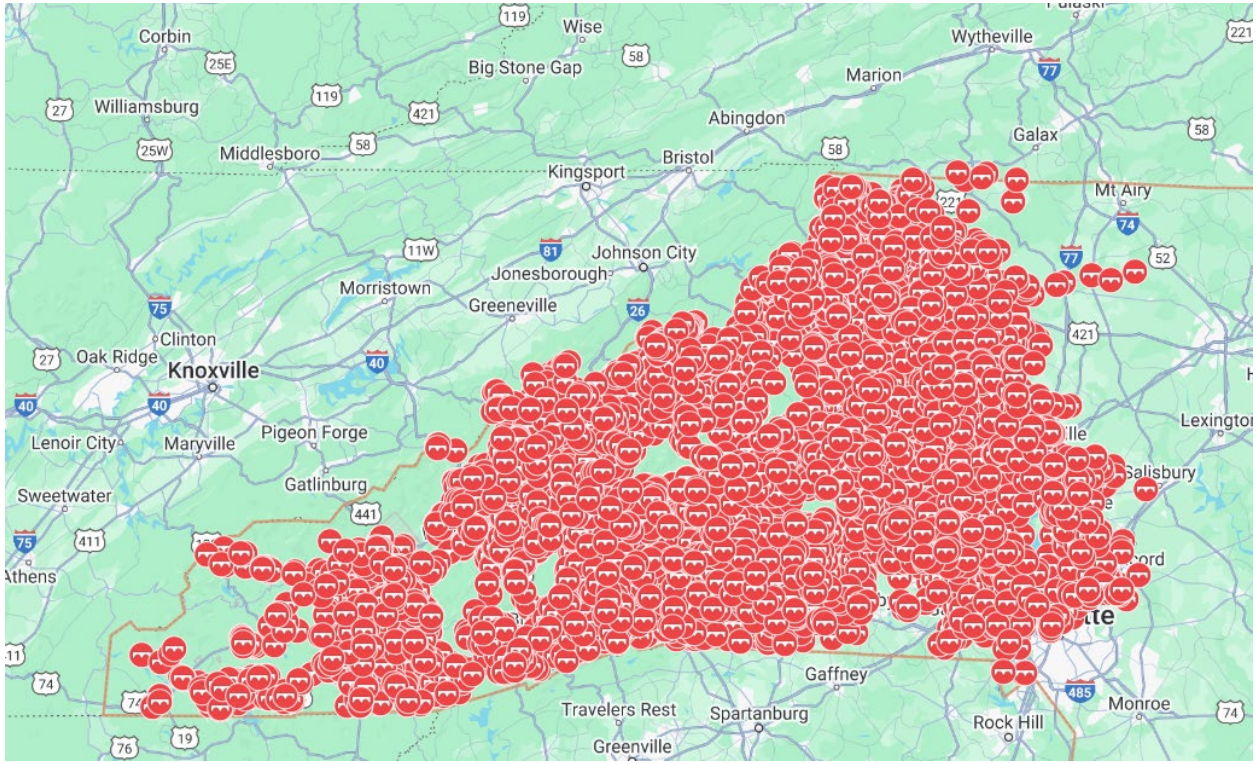


August 30, 3:00pm

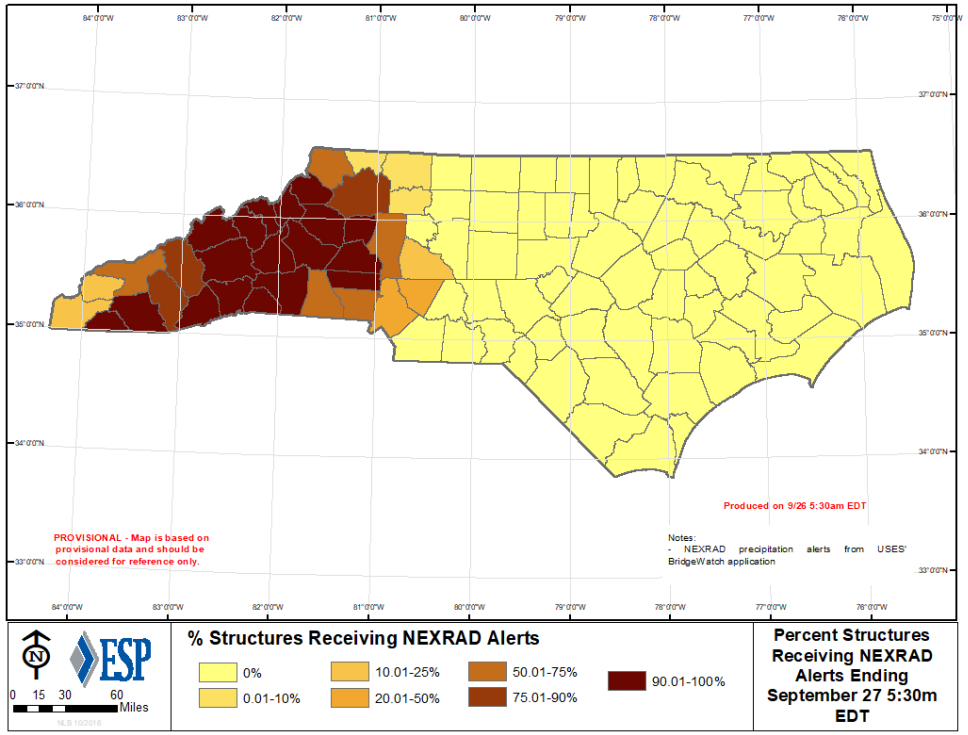
BridgeWatch Alert Data

Alert Source	Total Alerts	>=500-Year Alerts
QPE	5,963	2,397
NEXRAD	9,818	6,044
NCEM Gage	104	N/A
USGS	71	N/A

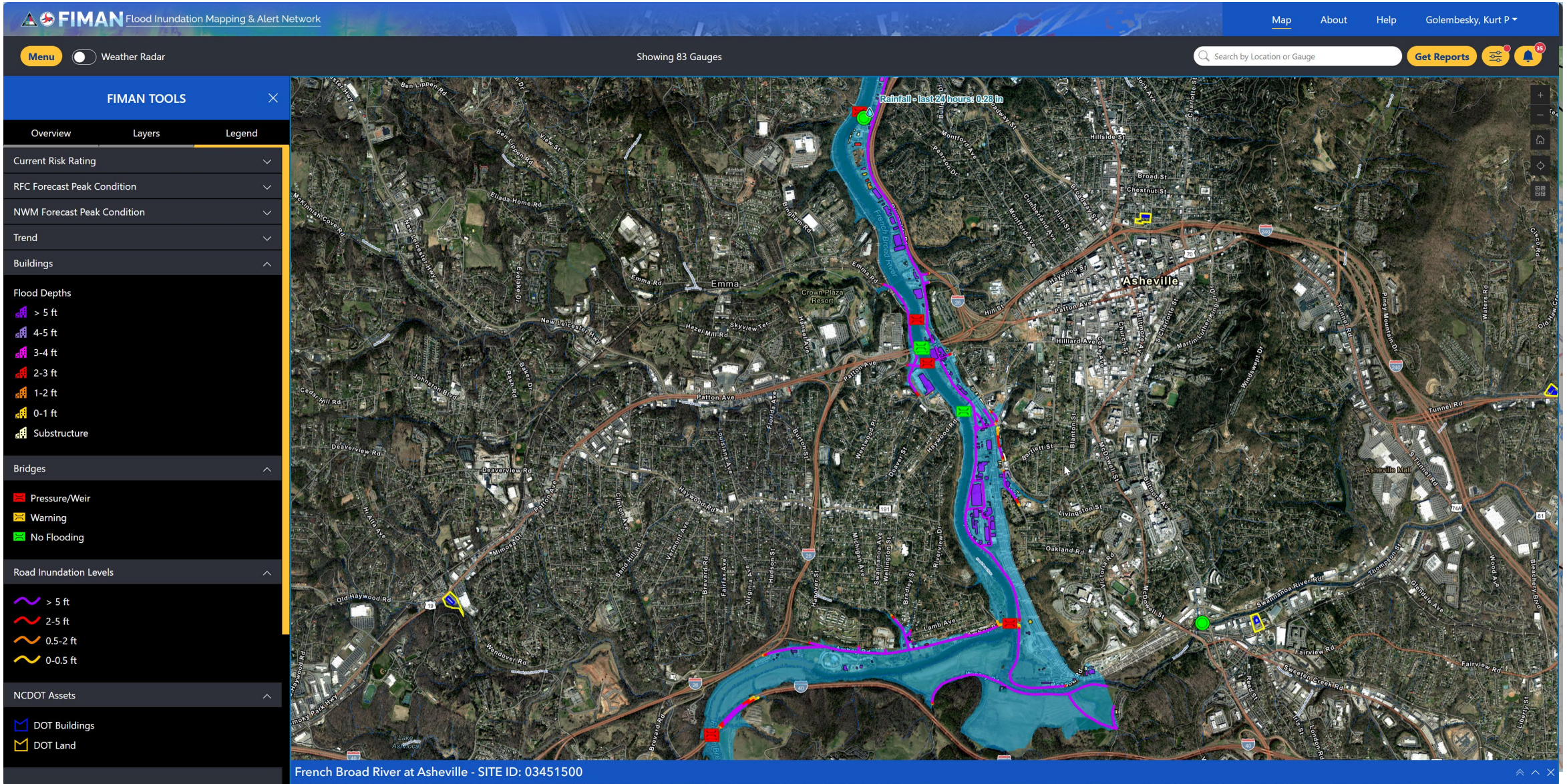
Alert Map at 7am EDT on 9/27/24



% of Structures Receiving NEXRAD Alerts at 5:30am EDT on 9/27/24



The Tools during Hurricane Helene-RIT and FIMAN



Hurricane Helene I-40 at French Broad River: Proactive Response

- IMAP Crew was dispatched to I-40 to monitor potential flooding at the French Broad River crossing.
- IMAP and SHP observed water rising along road and initiated a control closure and rerouting prior to water impacting the travel lanes.

NORTH CAROLINA

NCDOT knew I-40 would flood in Asheville 2 days before Helene hit. Here's how

By **Richard Stradling**
Updated November 19, 2024 6:29 PM | 2

Biltmore Village and the River Arts District in Asheville received extensive damage from flooding of the Swannanoa River after Helene caused torrential rainfall in western North Carolina over the weekend. Satellite imagery provided by Planet Labs PBC shows the river overwhelming parts of the city. By Kevin Keister

Only have a minute? Listen instead
Powered by **Trinity Audio**
1.0x
00:00 04:30

As it flows north into Asheville, the French Broad River passes under Interstate 40 and takes a hard right, paralleling the highway for about a mile before turning again toward the city's River Arts District.

As the N.C. Department of Transportation braced for Hurricane Helene, this stretch of I-40 was not a place engineers expected to worry about, despite its proximity to the river. That changed when the department's two-year-old flood warning system began predicting the French Broad would put as much as two feet of water onto the highway.

"I was shocked when they told me that," said Chad Franklin, NCDOT's intelligent transportation systems engineer for the region that includes Asheville. "It had never flooded before."

The initial prediction from the flood-warning system came on Wednesday, Sept. 25, a day before Helene had even come ashore in Florida. As the storm moved inland and the rainfall predictions grew more dire, so did the predicted flooding.

LIDAR Research

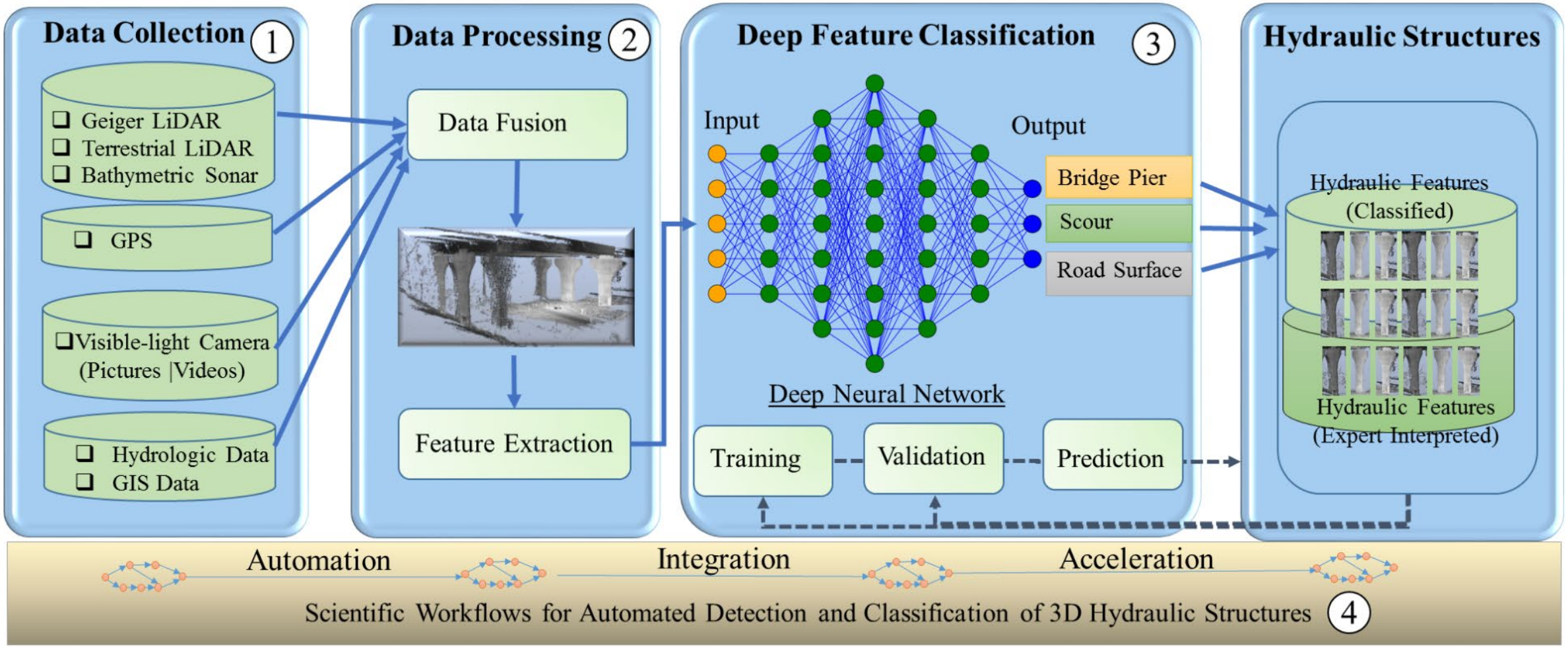
RESEARCH & DEVELOPMENT

DeepHyd: A Deep Learning-based Artificial Intelligence Approach for the Automated Classification of Hydraulic Structures from LiDAR and Sonar Data

Wenwu Tang, Ph.D.
Shen-En Chen, Ph.D.
John Diemer, Ph.D.
Craig Allan, Ph.D.
Tianyang Chen, Graduate Research Assistant
Zachery Slocum, Graduate Research Assistant
Tarini Shukla, Graduate Research Assistant
Vidya Shubhash Chavan, Ph.D., Former Graduate Research Assistant
Navanit Sri Shanmugam, Graduate Research Assistant

Center for Applied Geographic Information Science
Department of Geography and Earth Sciences
Department of Civil and Environmental Engineering
School of Data Science
University of North Carolina at Charlotte

A deep learning-based 3D modeling framework for the automated classification of hydraulic structures from LiDAR and sonar data.



Thank you!

Matt Lauffer
mslauffer@ncdot.gov
919-621-0443