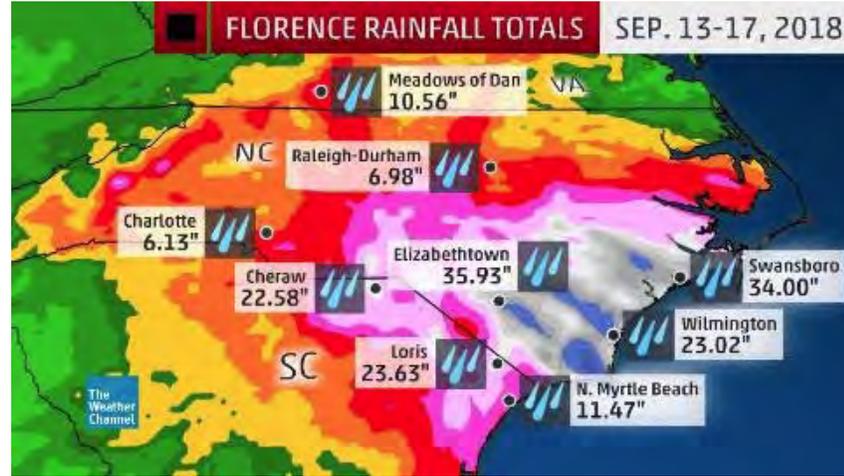
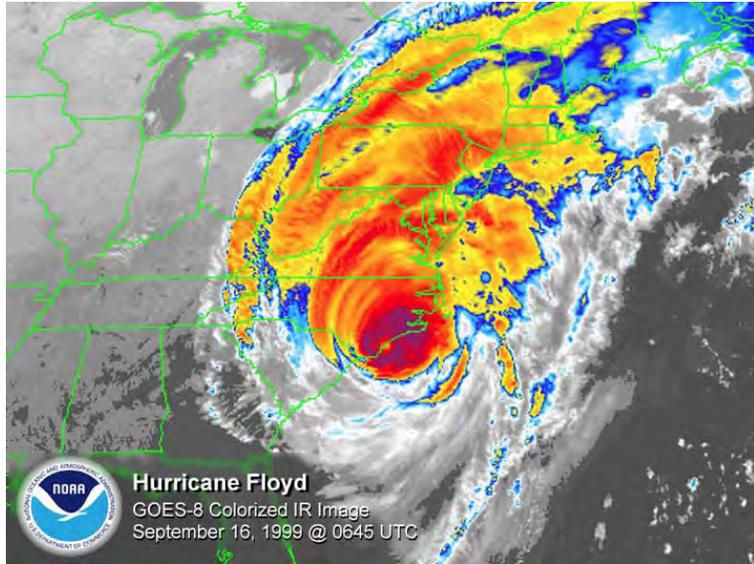


How Do We Improve Our Resilience to Flooding?



Barbara A. Doll, Ph.D., PE

Assistant Extension Professor & Extension Specialist

NC Sea Grant

NC State University, Biological & Agricultural Engineering Dept.

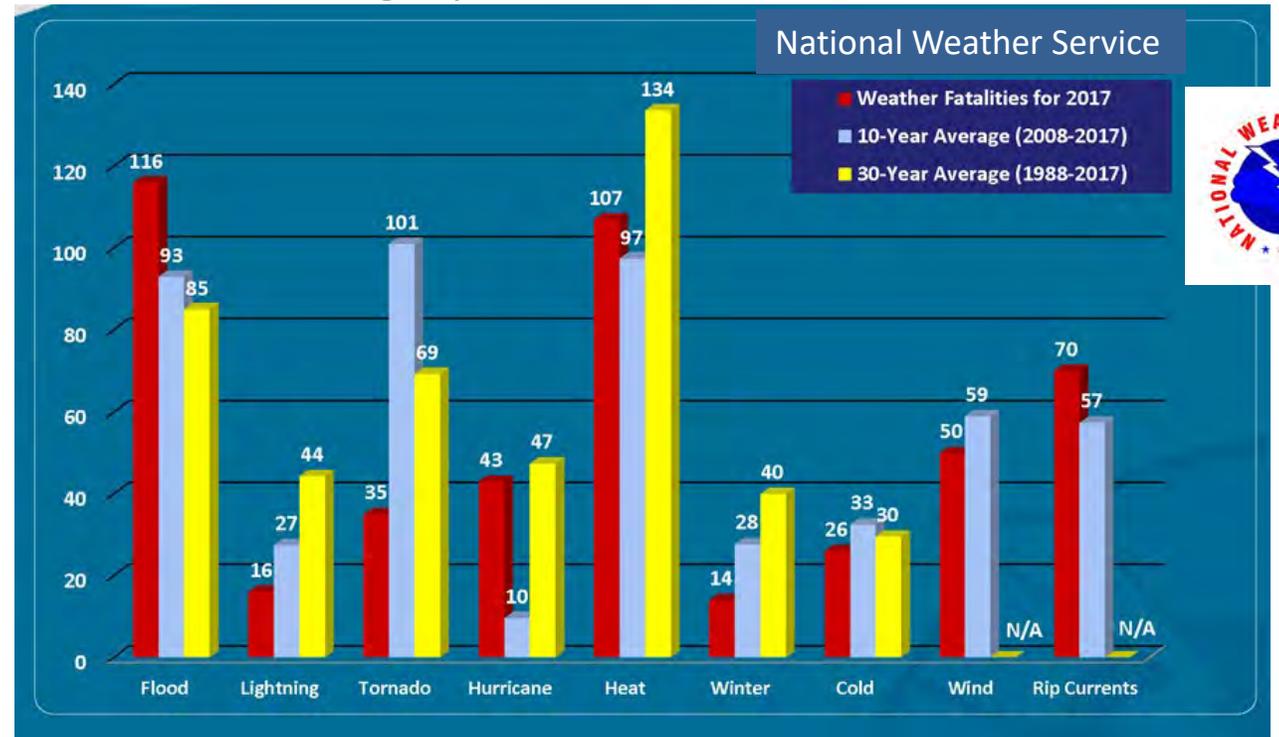
bdoll@ncsu.edu

Cost of Flooding (U.S.)

- 85 deaths per year (30-year average)
- \$59 billion in property damage (2017)
- 90% of all US natural disasters result from flooding. (National Oceanic and Atmospheric Administration, 2005)
- 41 million U.S. residents – about 13 percent of the entire population—are at risk from flooding along rivers. 3 X more than FEMA regulatory flood map (100-year) estimates- *Environmental Research Letters, 2018*



Hurricane Matthew, Hope Mills, N.C., October 2016
Drone Image by Quavas Hart, Source: NPR



Community Technical Flood Assistance

- Small towns lack capacity (funding or staff) to perform engineering analyses
- Unsure how to develop a scope of work for watershed hydrology & hydraulic analyses
- Need modeling, data and cost in order to base future decisions (funding, post- flood response and planning efforts)



Windsor Mayor, Jim Hoggard, following a presentation of the Cashie River study results to the Bertie County Commissioners on July 2, 2018.

Assisting Coastal Communities with Riverine Flooding

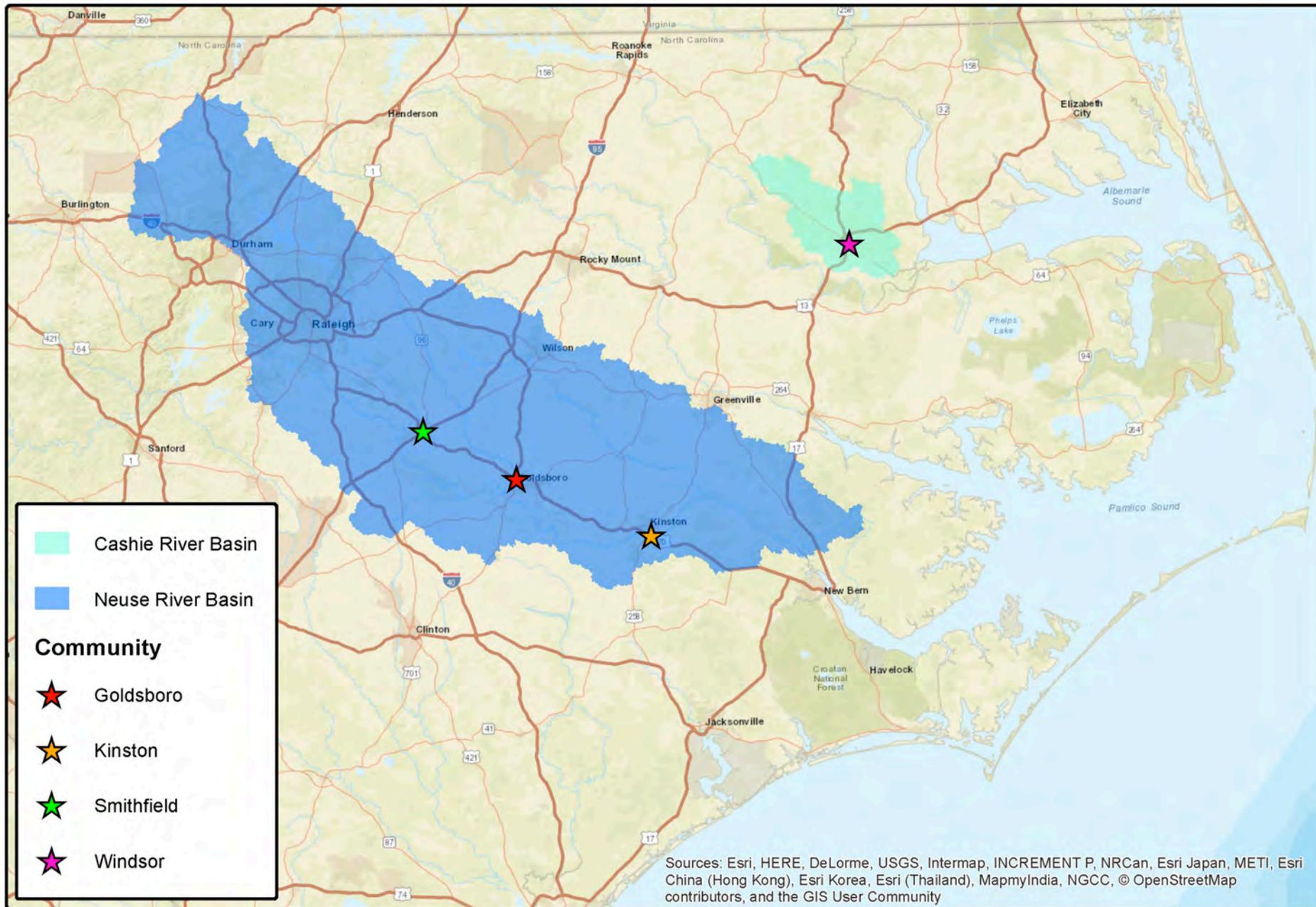


Windsor, Bertie County



Neuse River



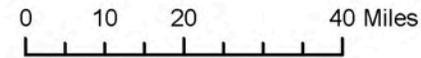


	Cashie River Basin
	Neuse River Basin
Community	
	Goldsboro
	Kinston
	Smithfield
	Windsor

Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community



Coastal River Flood Studies



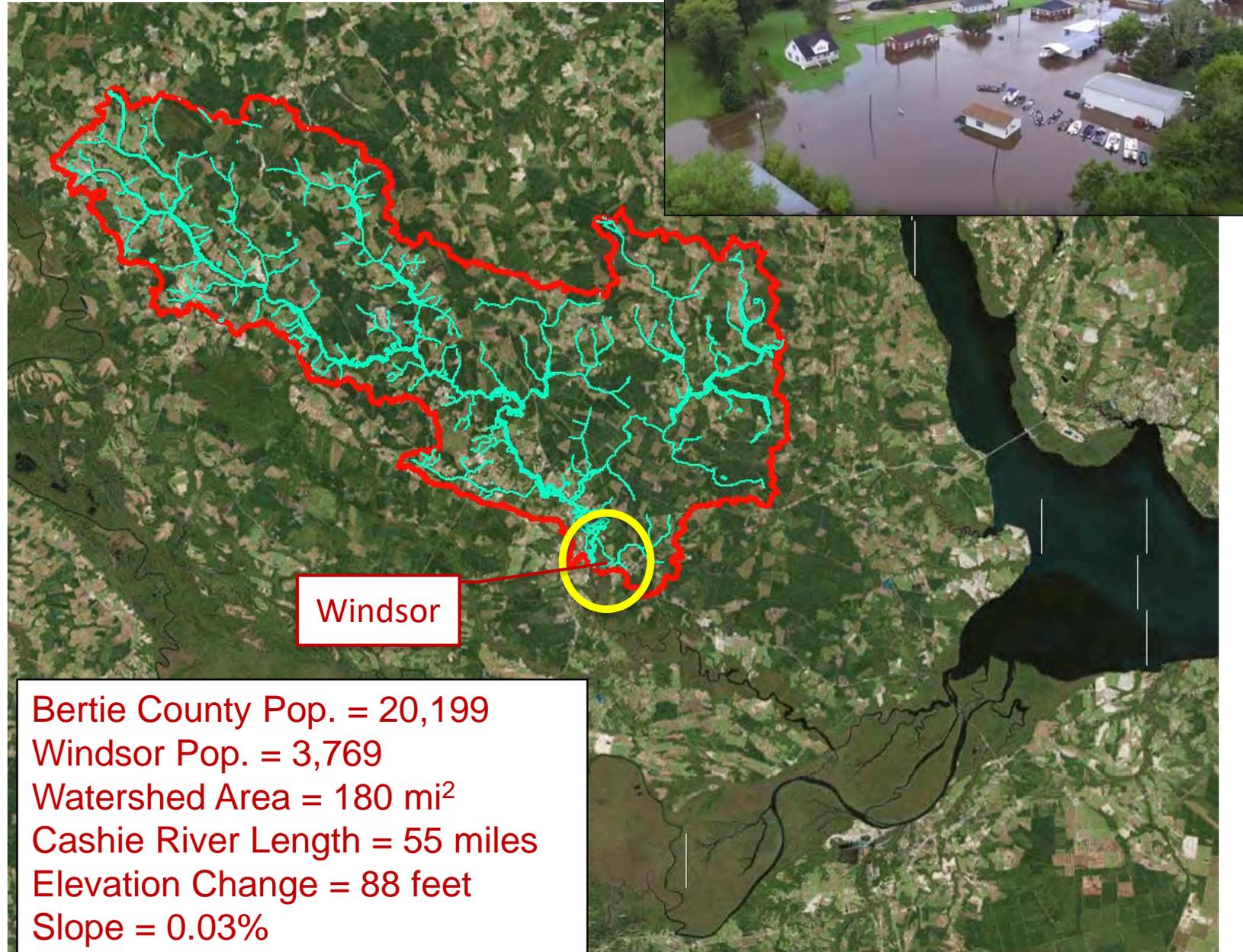
Windsor Flood Mitigation Study

Purpose:

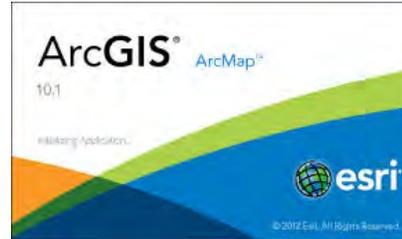
- Why does it flood? And what, if anything, can we do about it?

Project Elements:

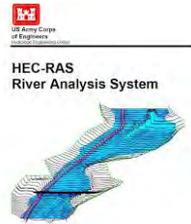
- Evaluated causes of flooding including local “perceptions”
- Identified, investigated, modeled and developed cost estimates for potential mitigation options:
 - Increasing Bridge Spans
 - Controlled Drainage (Ag & Timber)
 - Adding Levees
 - Impoundments



Study Tools and Models



ArcGIS
*Spatial Data Processing,
Model Setup*



HEC-RAS
River Hydraulics
Water Surface Elevations

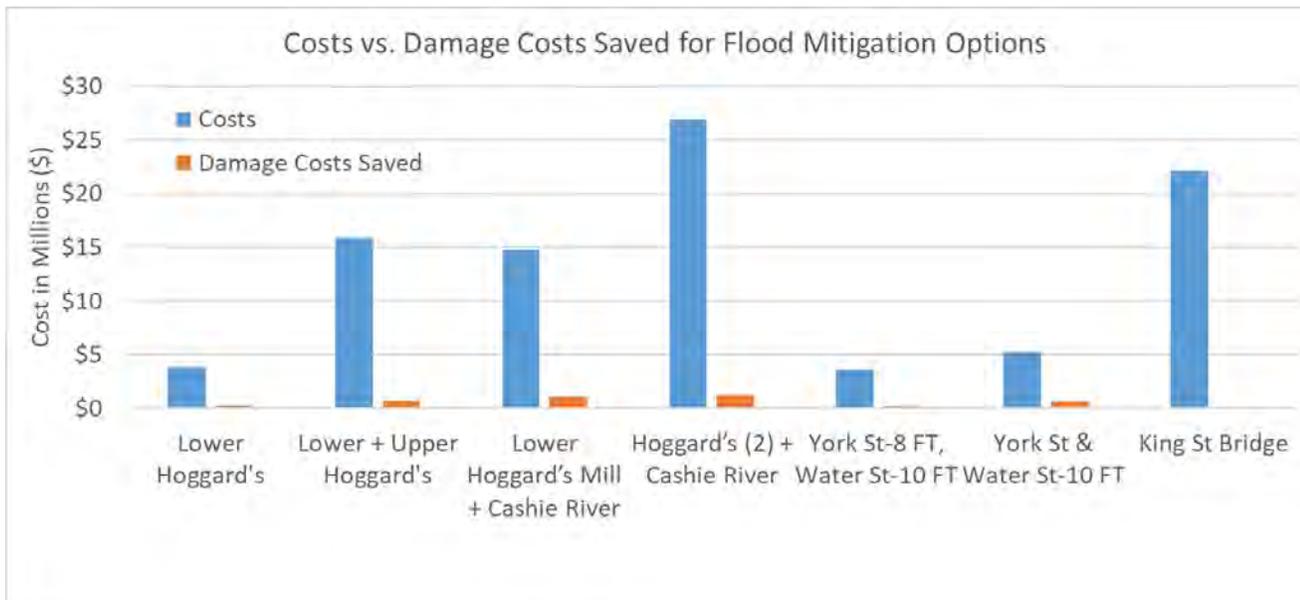
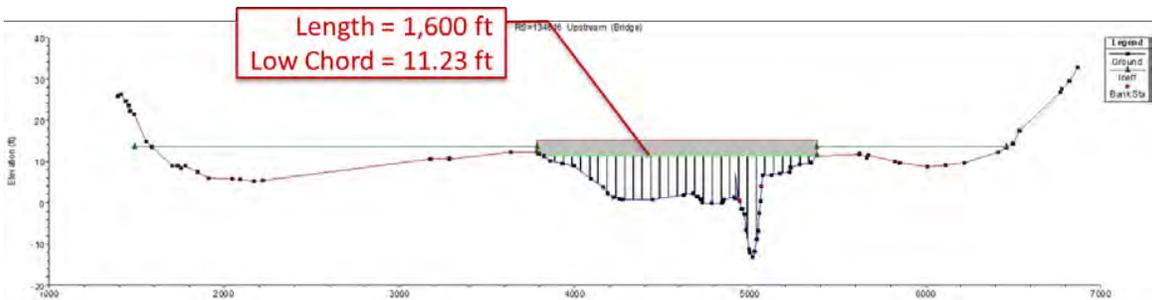
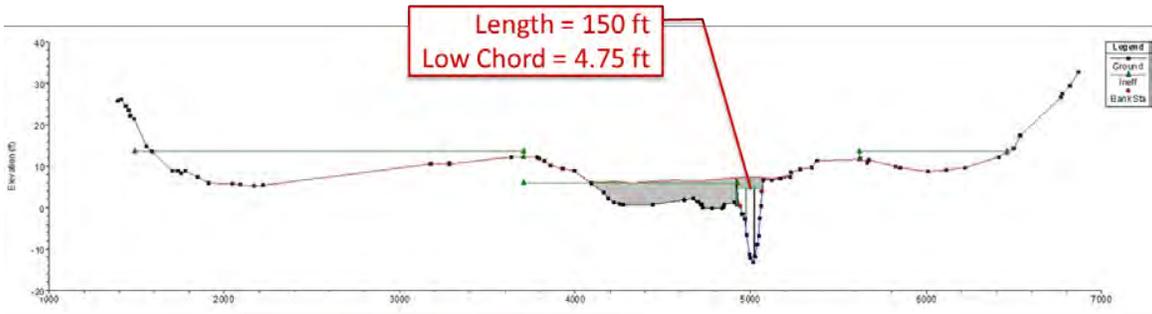
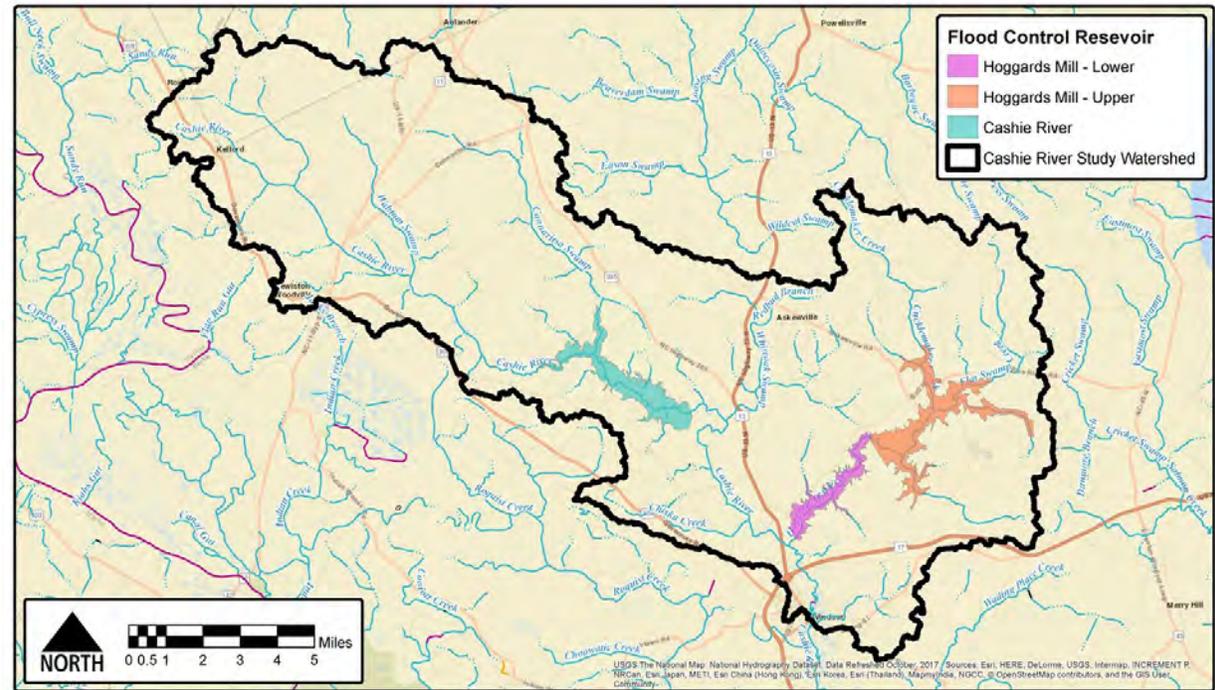
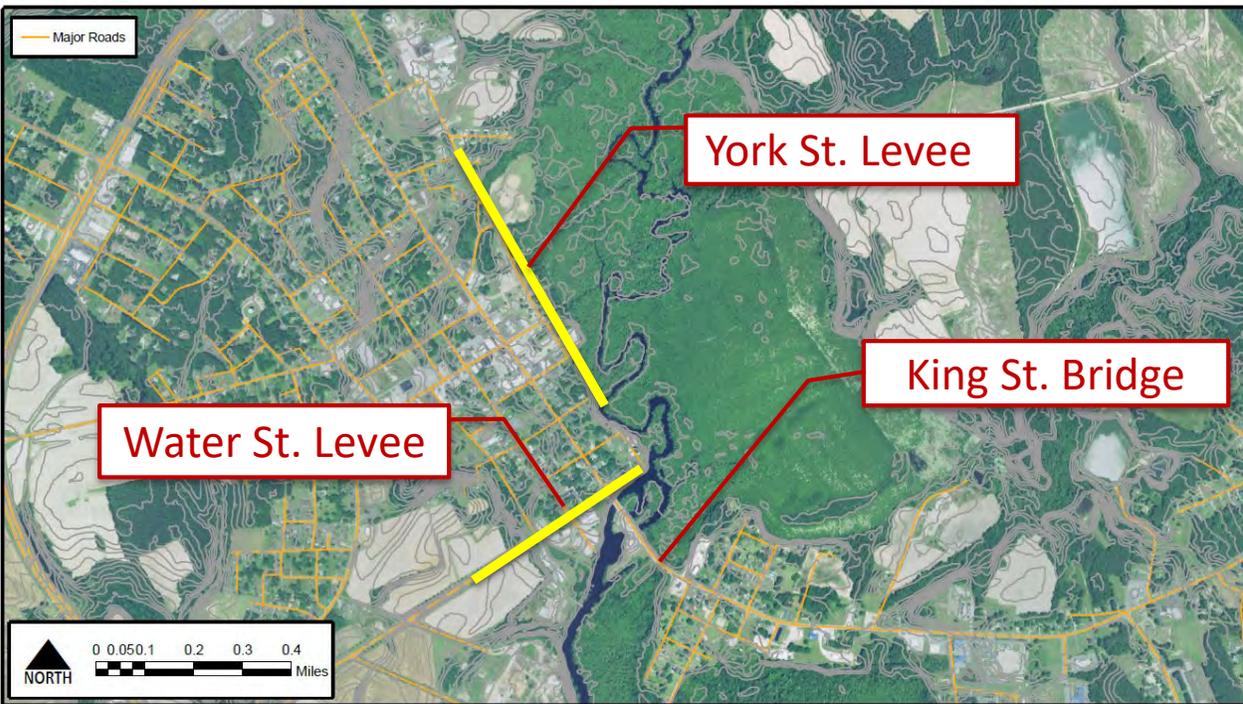


HEC-HMS
Watershed Hydrology
Extreme Event Discharges



SWAT
Landuse Change
Water Balance





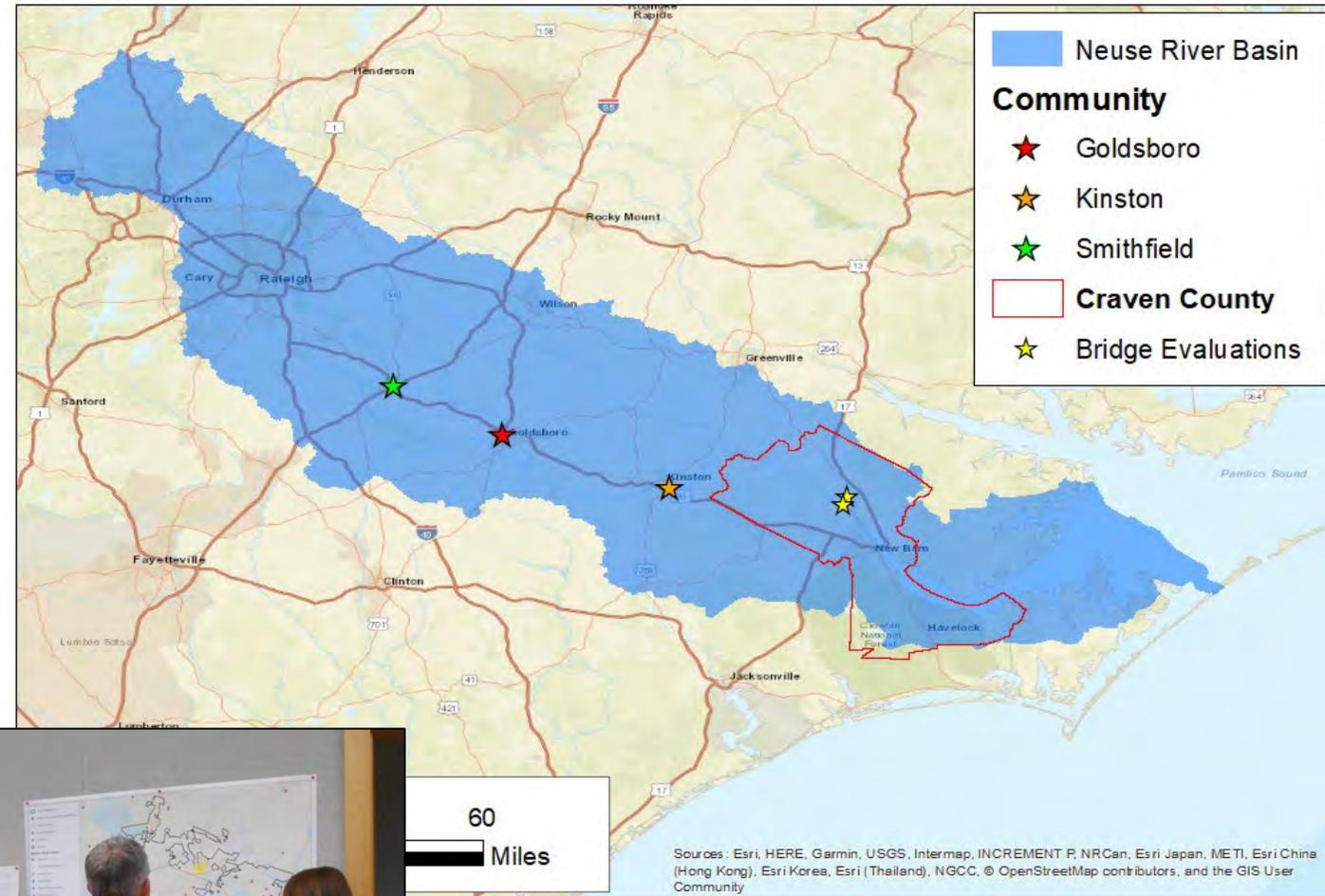
NC DOT Neuse River Flood Mitigation Study

Purpose

- Better understand the source(s) and nature of flooding
- Identify and evaluate potential flood mitigation measures (focus on transportation)
- Smithfield, Goldsboro, Kinston & Carteret County

Stakeholder Workshops

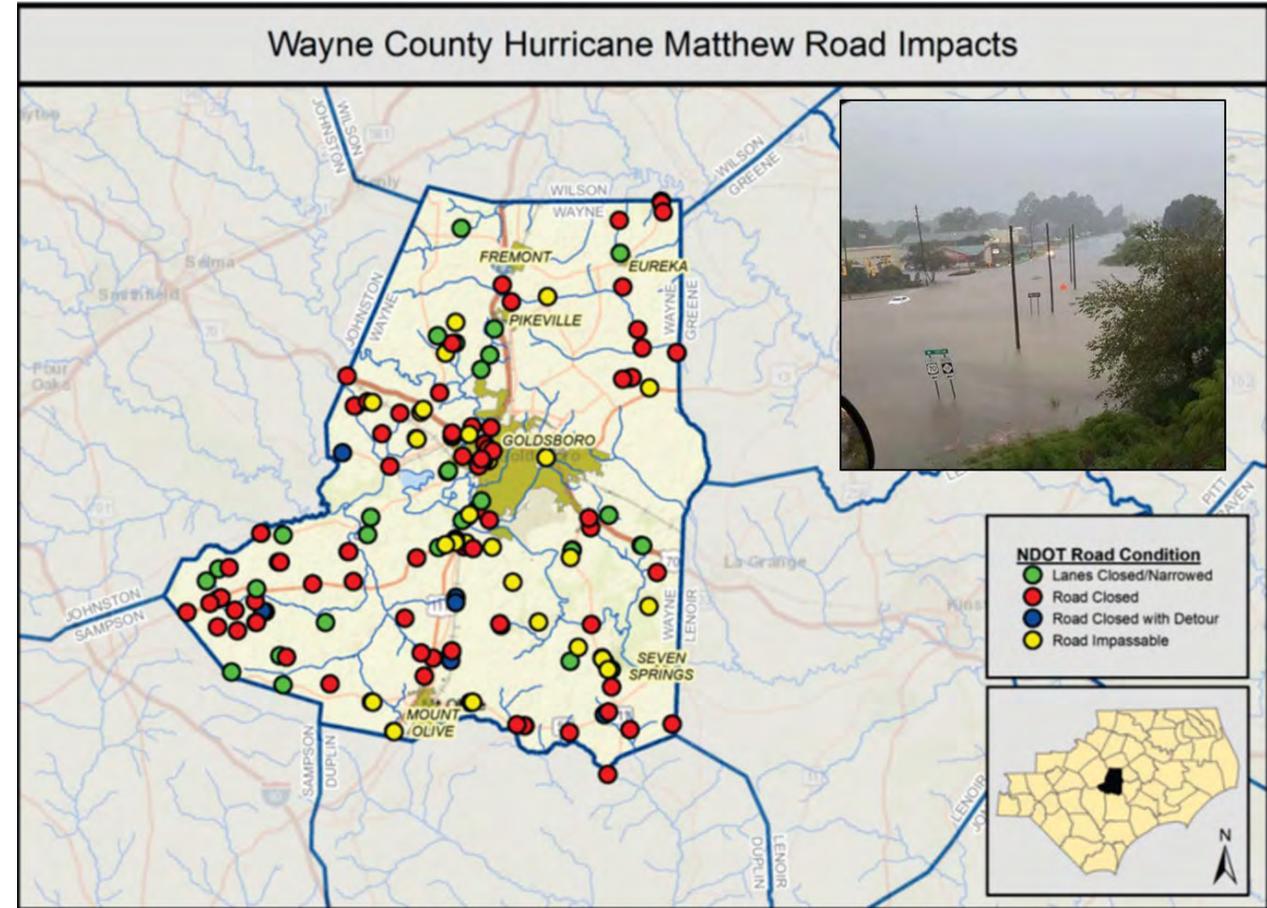
- Emergency responders
- Public works
- Engineering
- Mayor
- City manager
- Planners/land use managers



Workshop Purpose: Gather relevant information about flooding and flood-related impacts

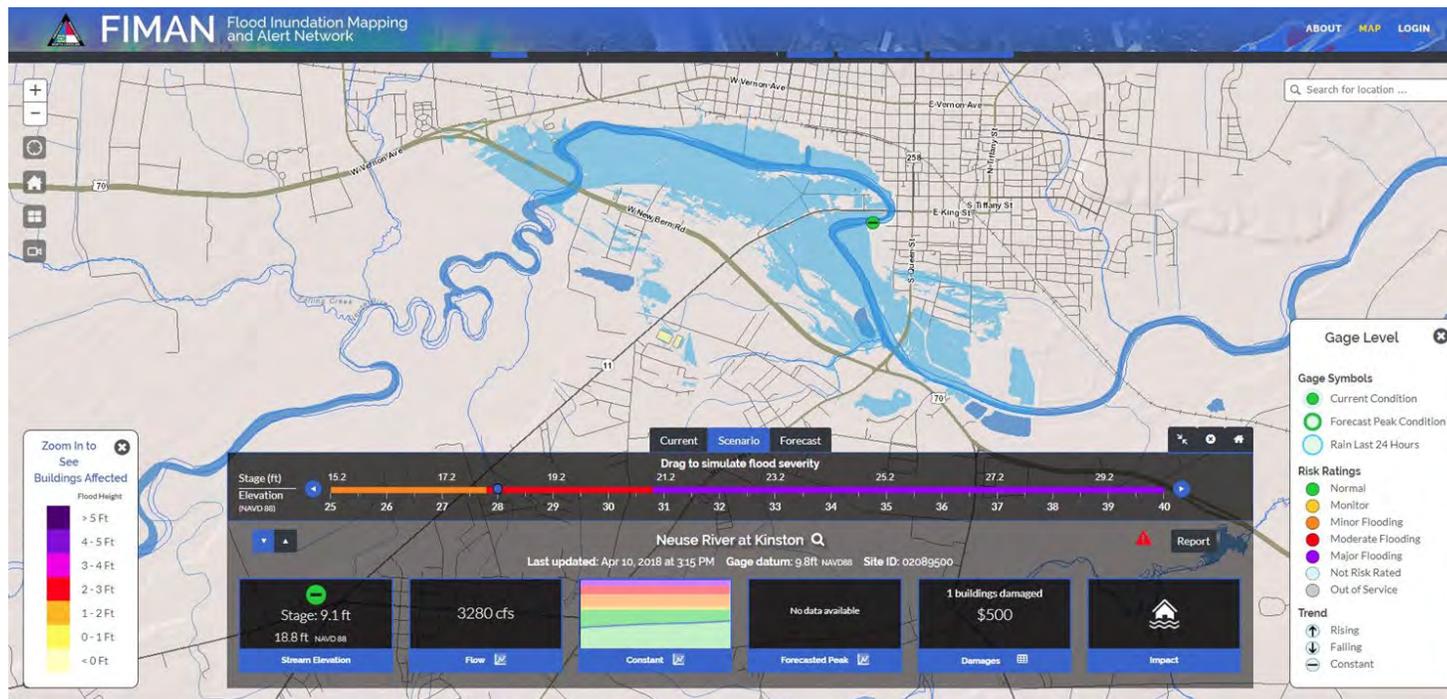
DOT Detailed Scope of Work

- Develop early-warning for road closures
- Model river crossings suspected of exacerbating flooding
- Prioritize downtown crossings subject to flash flooding for upgrade
- Model additional upstream development and future extreme weather events
- Review local floodplain ordinances (Gavin Smith, UNC-Chapel Hill Dept. of City and Regional Planning)



1. Develop early-warning for road closures

Purpose: Provide advanced warning of road closures to Municipal Officials, Emergency Managers and Citizens



Real-time River Stage (Elevation) Data from USGS and NC EM gages



NC EM FIMAN Model which predicts and maps areas flooded based on river elevation



NC DOT Travel Information System (Web-based map and Phone App)

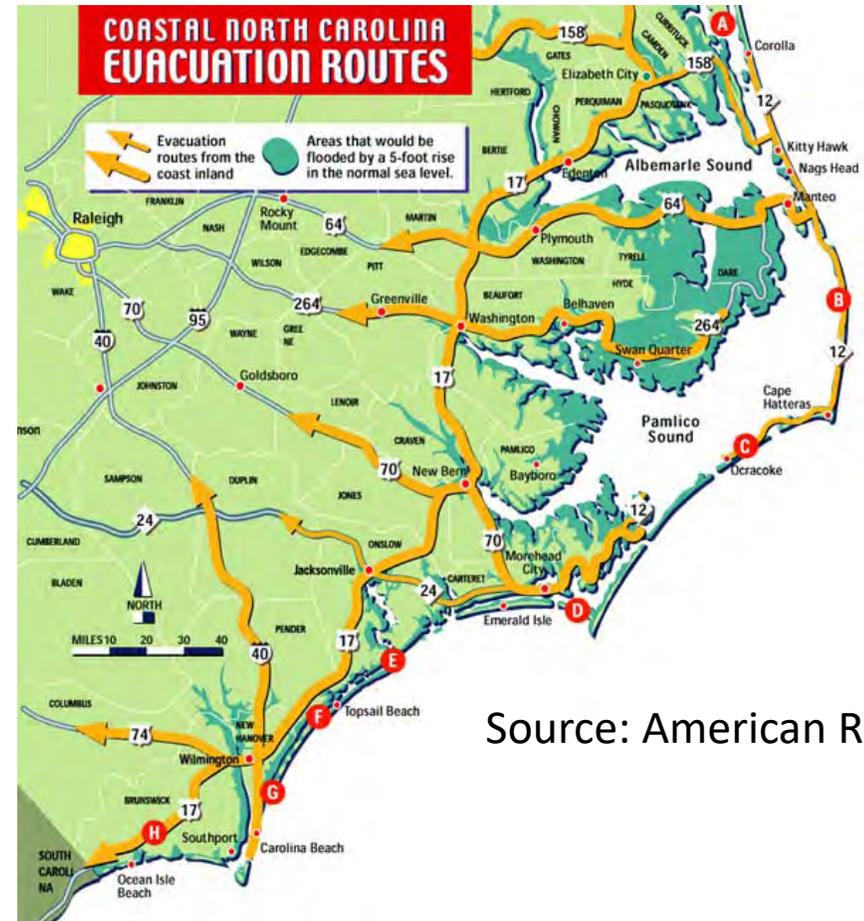
1. Develop early-warning for road closures

Preliminary Roads Identified at Workshops

- Smithfield
 - Hwy 70
 - Hwy 301
 - Interstate 95
- Goldsboro
 - Hwy 117 (multiple locations)
 - Interstate 795 (multiple locations)
 - Arrington Bridge Rd
- Kinston
 - Hwy 70 (multiple locations)
 - Hwy 258/58 (multiple locations)

Storm Evacuation Routes

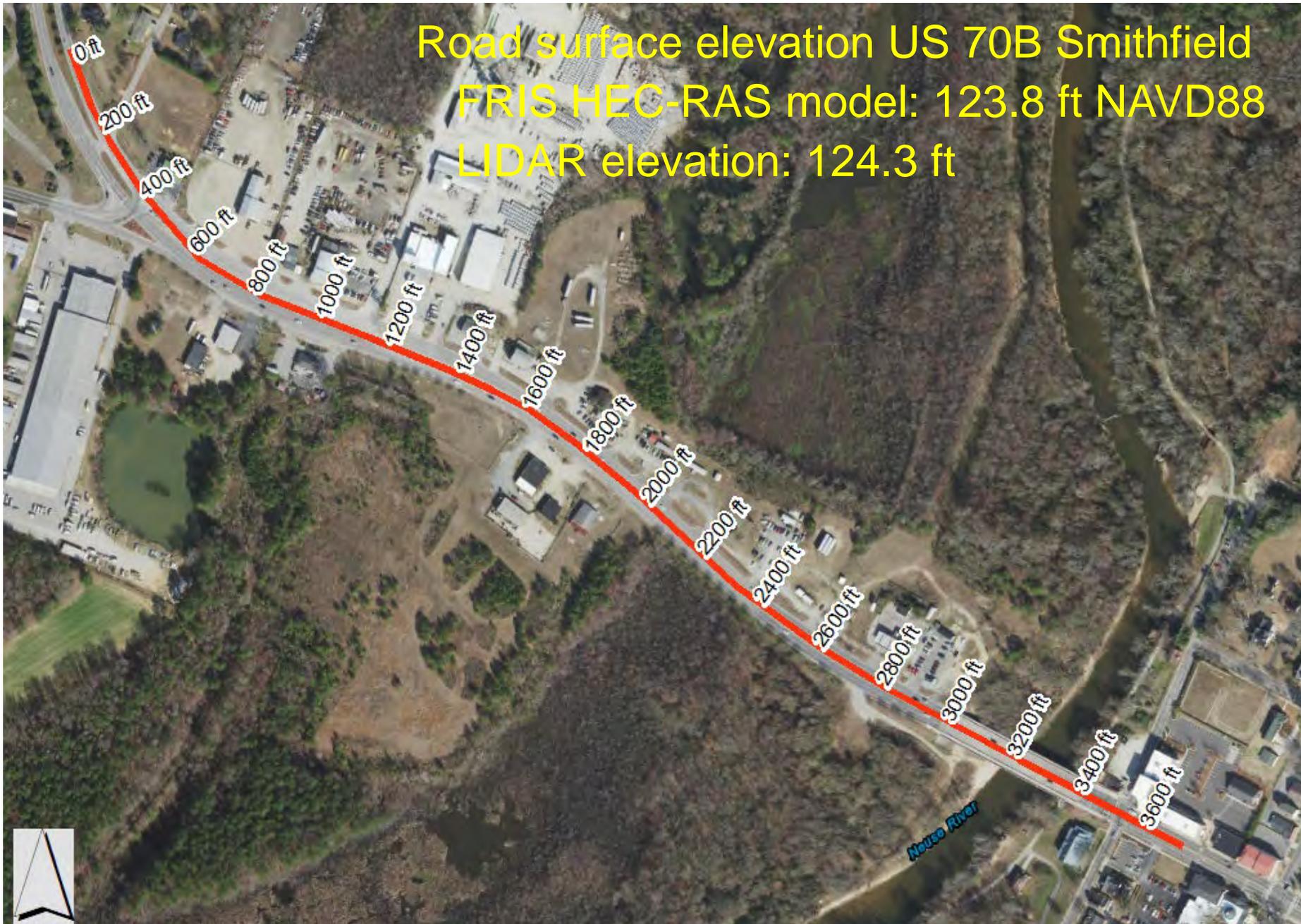
- Primary and Secondary Roads



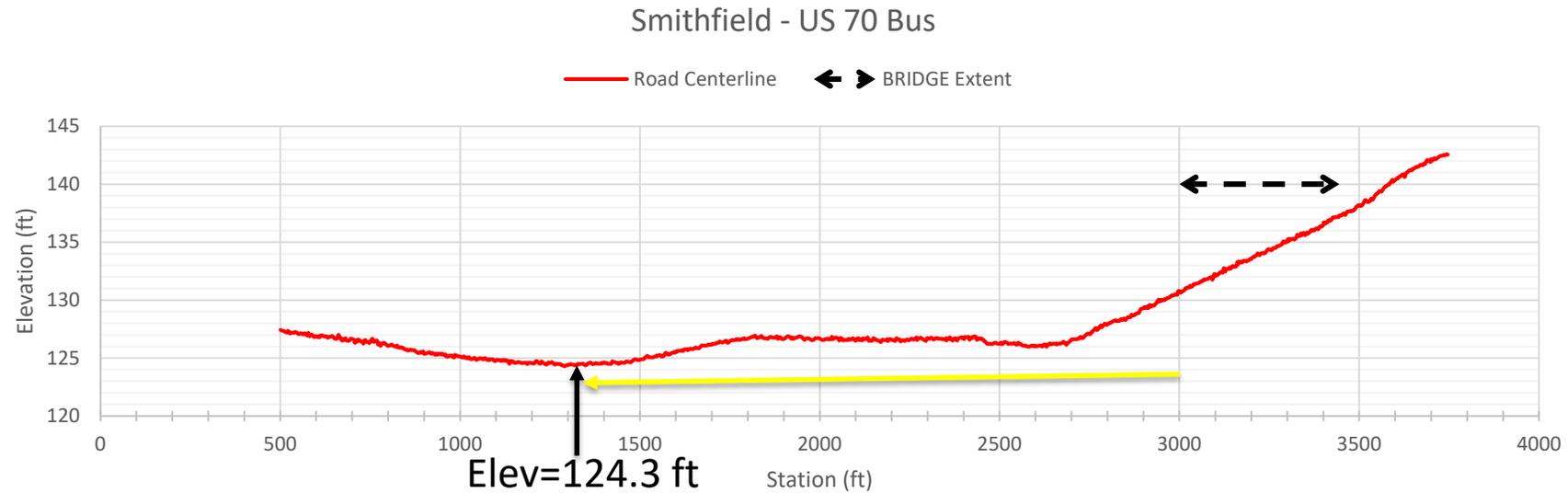
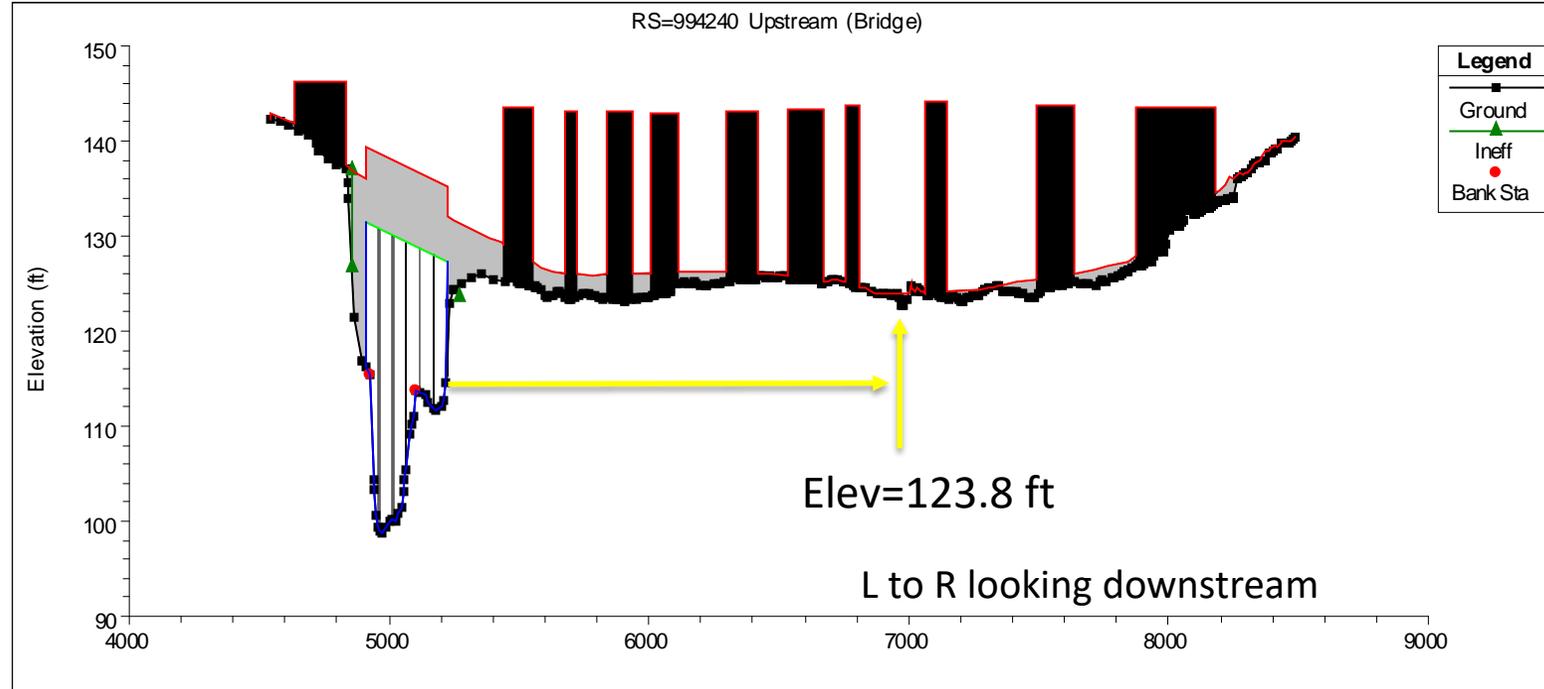
Source: American Red Cross

US 70B Smithfield

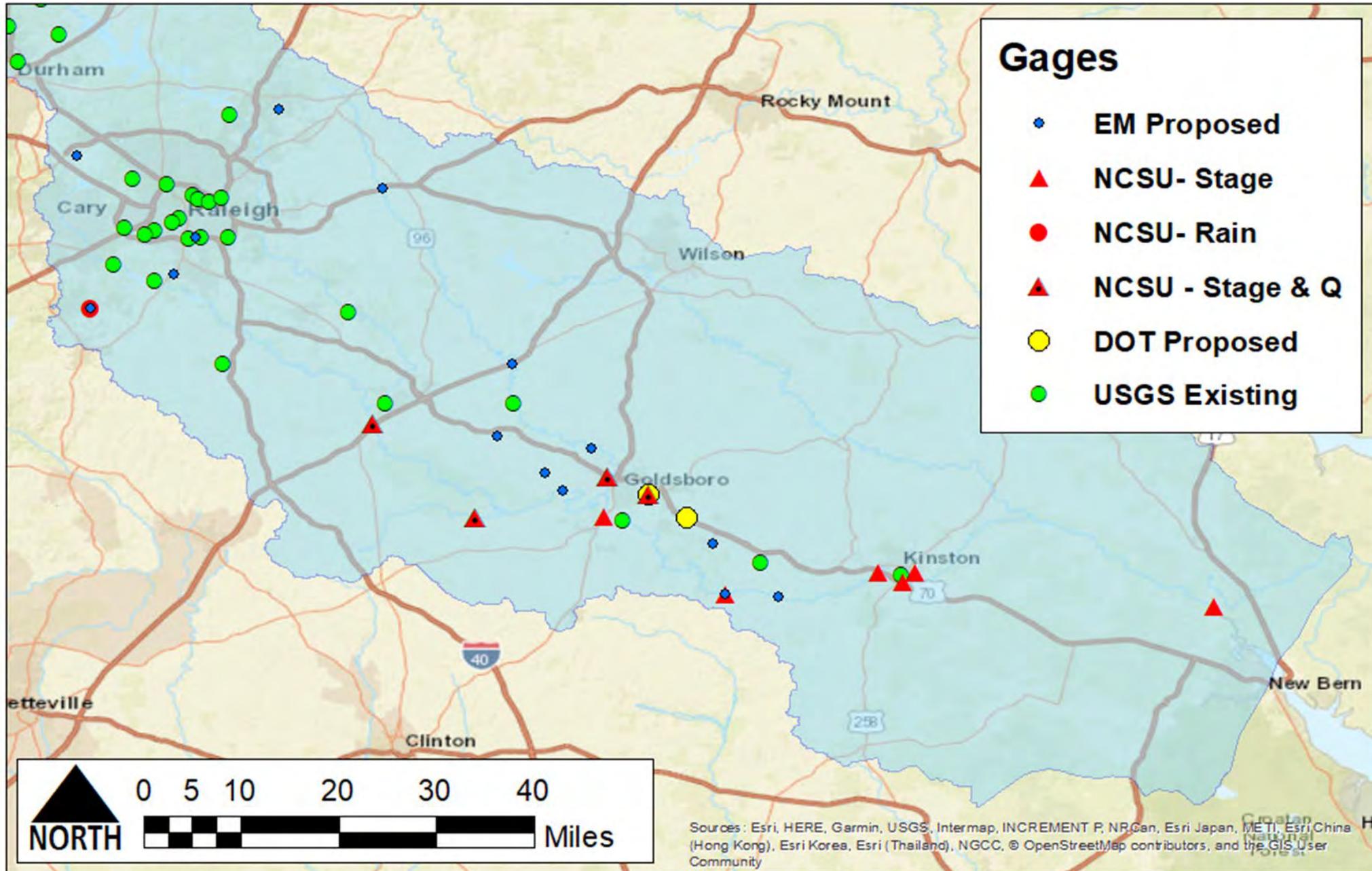
Road surface elevation US 70B Smithfield
FRIS HEC-RAS model: 123.8 ft NAVD88
LIDAR elevation: 124.3 ft



HEC-RAS and LIDAR

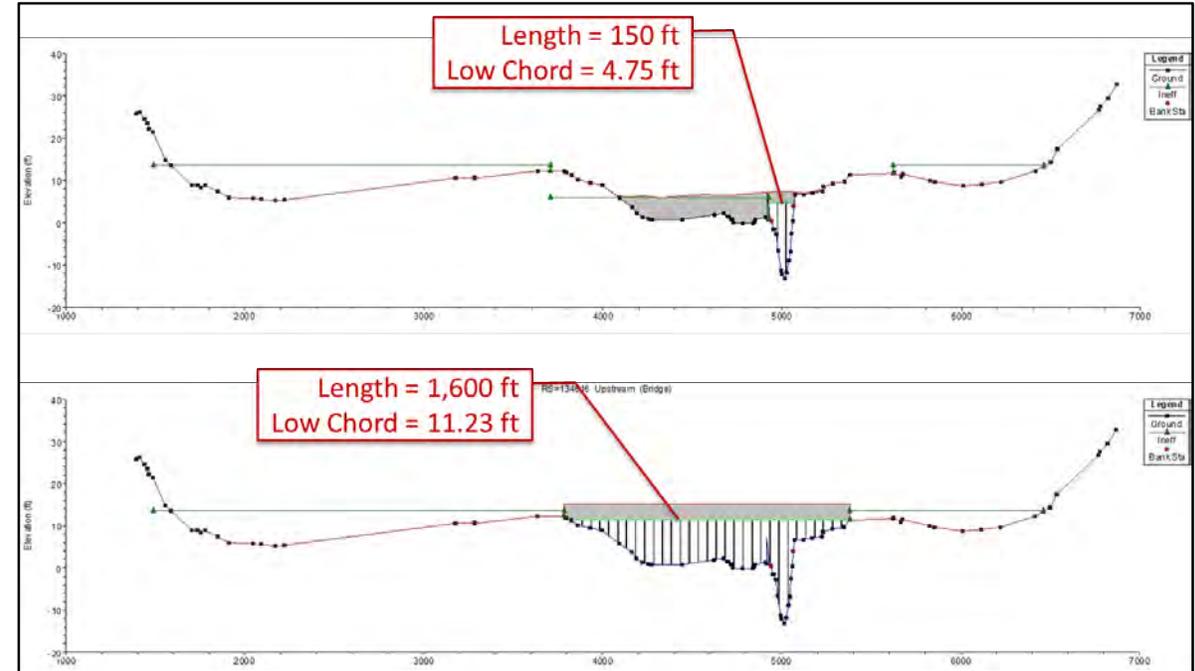


2. Identify locations for new stream gages



3. Model river crossings suspected of exacerbating flooding

- Kinston
 - RR crossing on Neuse River southeast of town
 - Highway 70 and Highway 258 crossing
- Smithfield
 - RR crossing east of Market St. and N. 9th St.
 - Highway 301
- Goldsboro
 - Arrington Bridge Road
- Craven County
 - Highway 43 over the Neuse
 - Highway 43 over Swift Creek



Example of similar modeling conducted on King St. Bridge on Cashie River at Windsor, NC



4. Prioritize upgrade of tributary crossings subject to flash flooding



Source: WRAL - Flash Floods receding in Goldsboro on 9-15-18 prior to Neuse River Stage reaching peak

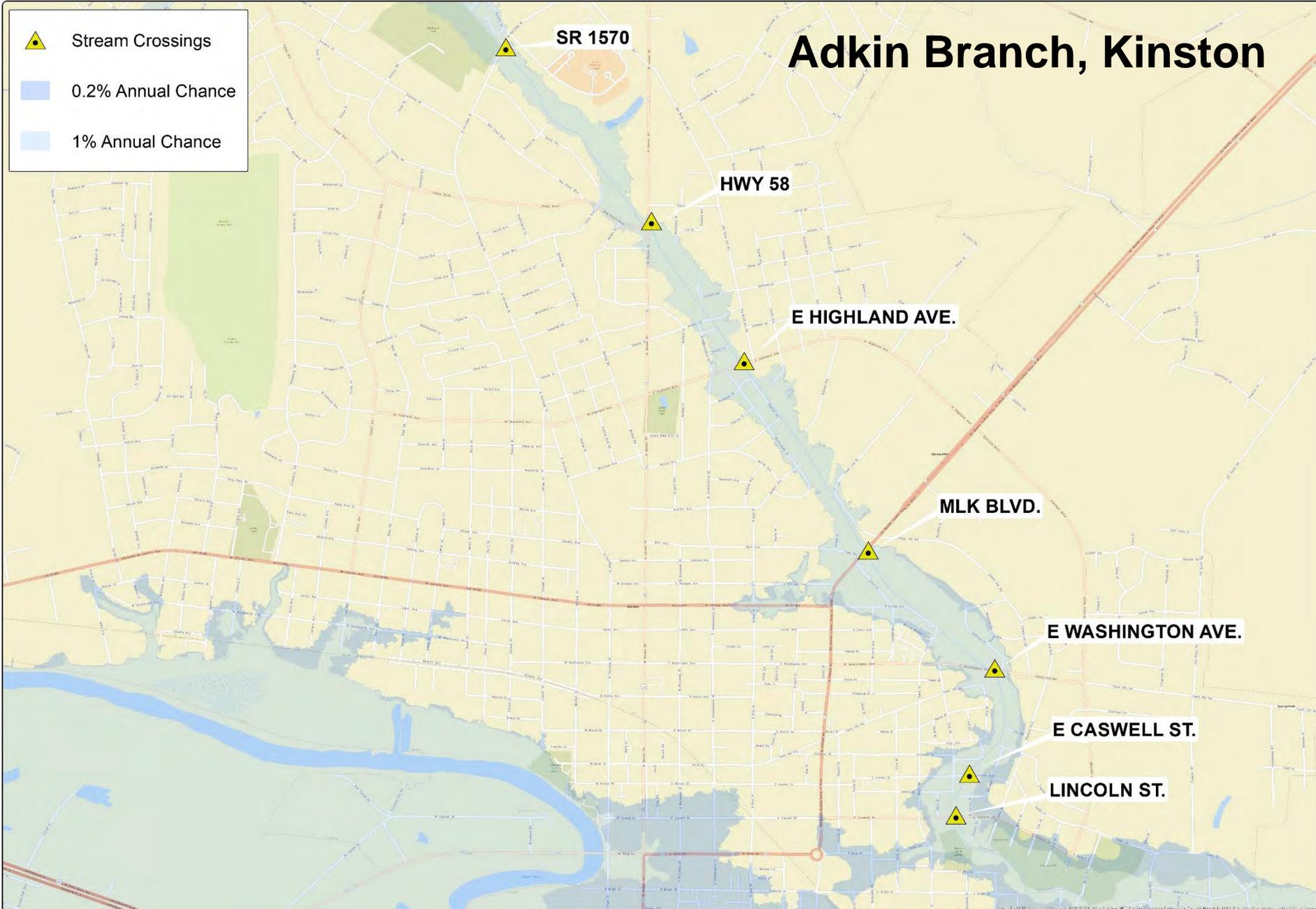
- **Kinston** – Adkin Branch, Jericho Run and Taylor’s Branch
- **Smithfield** – Spring Branch and Buffalo Creek
- **Goldsboro** – Stoney Creek, Big Ditch and Billy Bud Creek

4. Prioritize upgrade of tributary crossings subject to flash flooding

- Inventory crossings
 - location, size & configuration
- Evaluate capacity
- Obtain existing hydraulic models
- Prioritize transportation importance
- Develop alternatives for all under-sized and low elevation crossings
- Develop a decision matrix for prioritizing replacement or improvement
 - hydraulic capacity, condition, maintenance, cost of improvement, transportation importance, emergency access
- Develop planning map for each municipality
 - Photo, key characteristics and crossing improvement priority rank



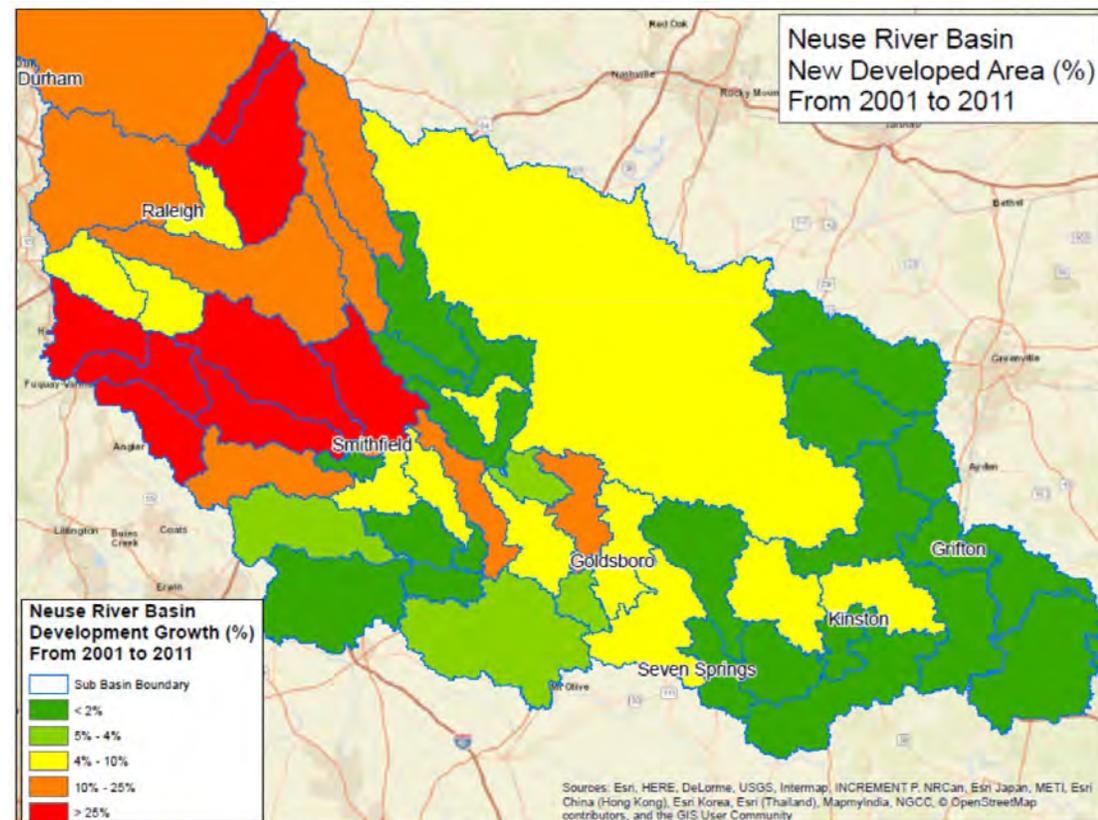
NC 11 south of Kinston (WITN)



5. Model future upstream development and extreme weather



Source: The Weather Channel, NOAA NWS Preliminary Rainfall Totals



Development most significant in the upper drainage basins of the Neuse River watershed

6. Review local floodplain ordinances



MAI THI NGUYEN, PhD

Associate Professor

Dept. of City and Regional Planning

UNC-Chapel Hill

- Review existing floodplain ordinances for Kinston, Goldsboro and Smithfield
- Review ordinances from around the country
- Recommend modifications and develop proposed language



Louisville, Kentucky

1936 Ohio River Flood



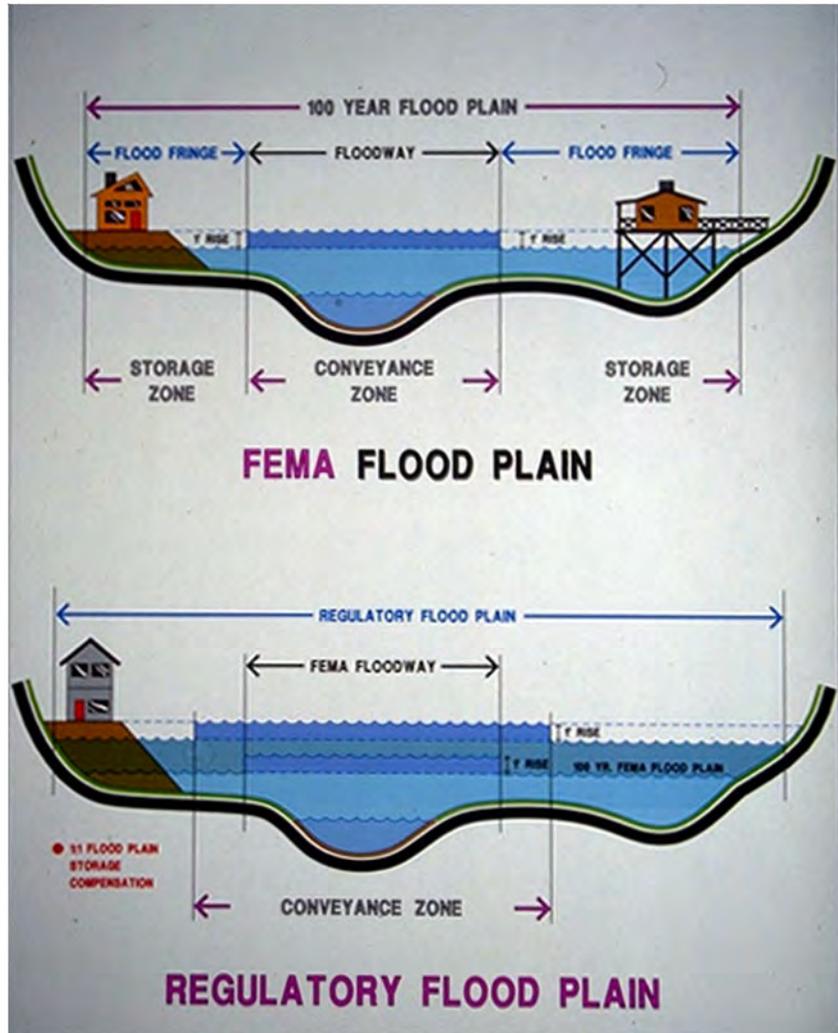
Source: LOJIC MSD

1997 Ohio River Flood -40,000 homes damaged

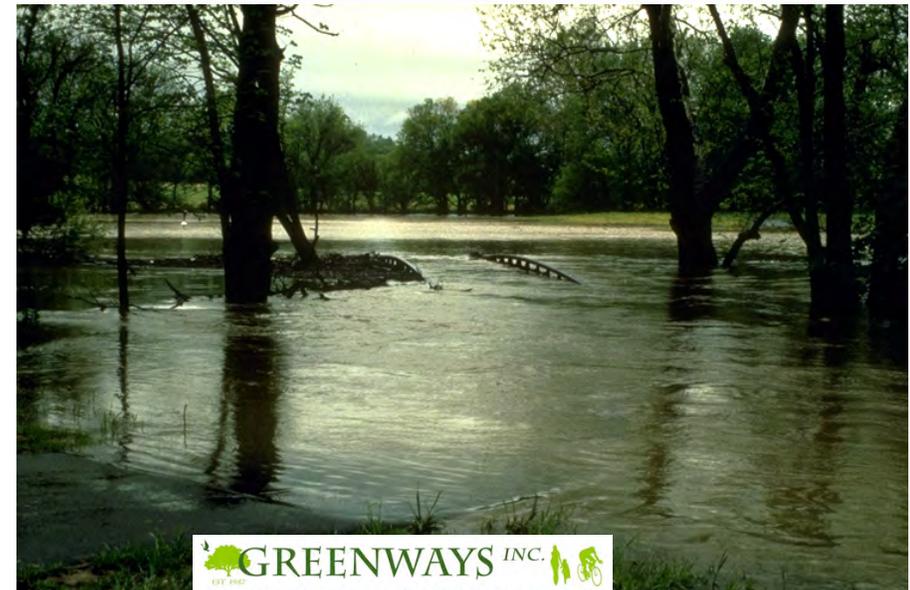


Source: Louisville Courier Journal

Louisville/Jefferson County Metropolitan Sewer District (MSD) Floodplain Ordinance



The highest and best use of floodplain land is for the storage of flood waters



We still don't know how to talk about floods

The Washington Post, September 17, 2017

By Brian Bledsoe September 13, 2017



Floodwaters surround houses and apartment complexes in West Houston on Aug. 30. (Jabin Botsford/The Washington Post)

The author, [Brian Bledsoe](#), is a professor of civil and environmental engineering at the University of Georgia. His research focuses on the interface of hydrology, ecology and urban water sustainability.



Institute for Resilient
Infrastructure Systems
UNIVERSITY OF GEORGIA

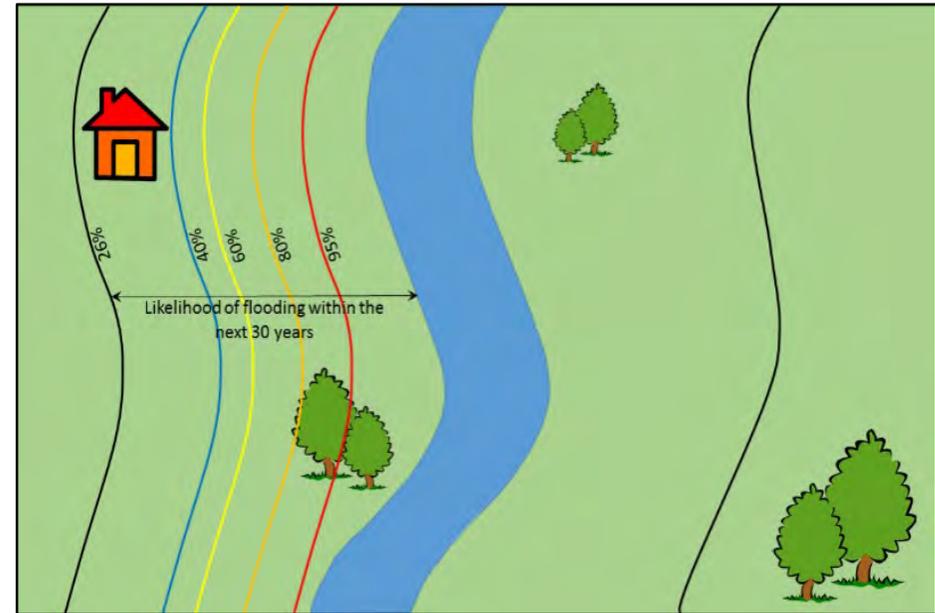
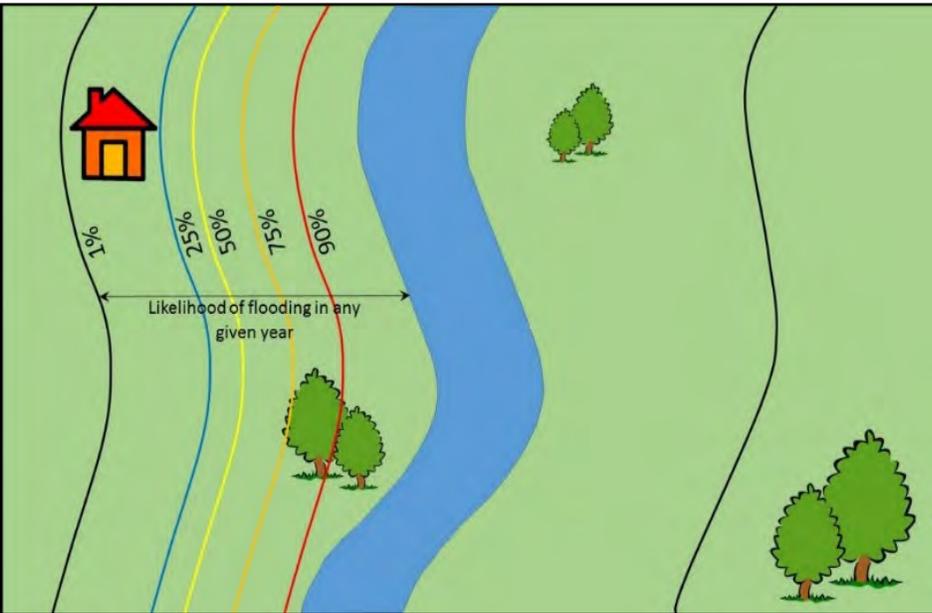
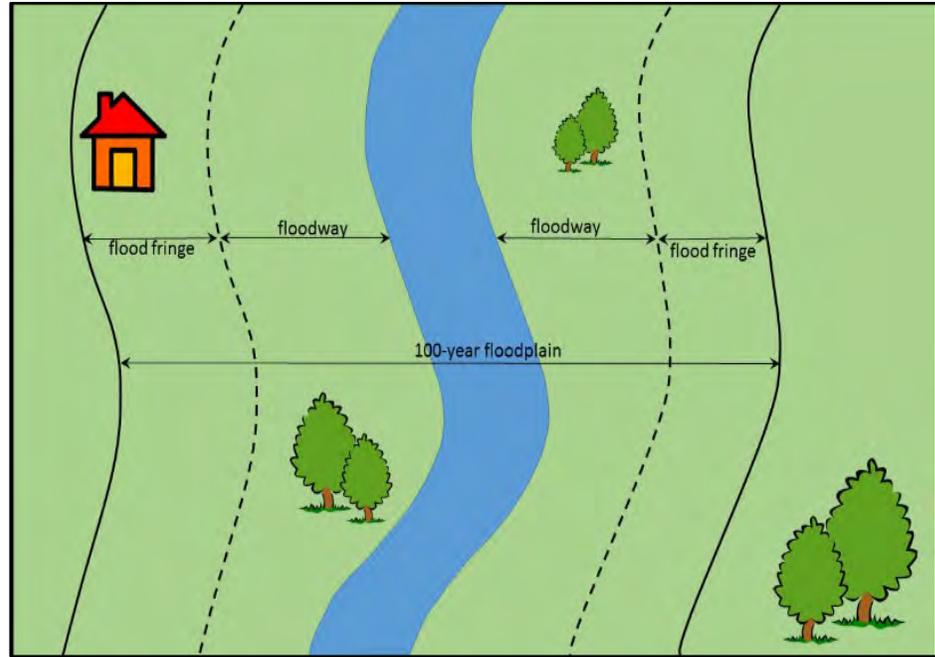
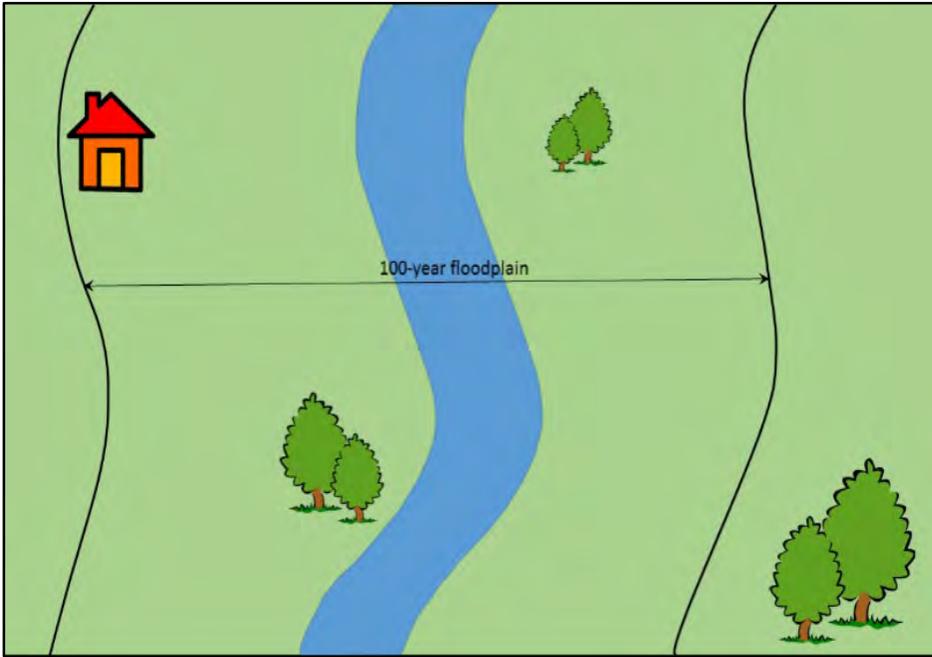


BRIAN BLEDSOE, PH.D., P.E.
Professor

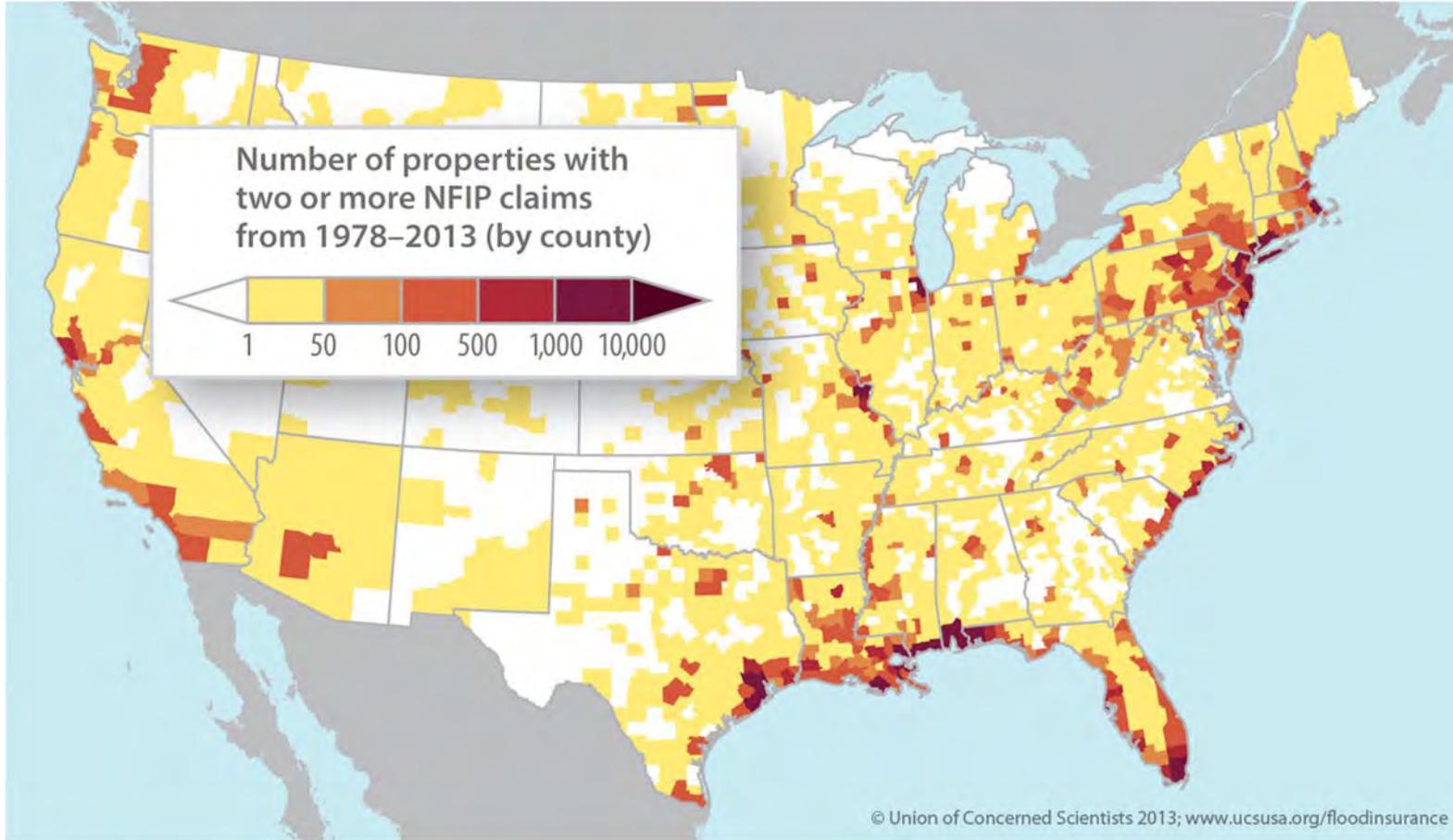
*UGA AA Professor in Resilient
Infrastructure*

Phone: 706-542-7249

Email: bbledsoe@engr.uga.edu



Repetitive-Loss Properties by U.S. County

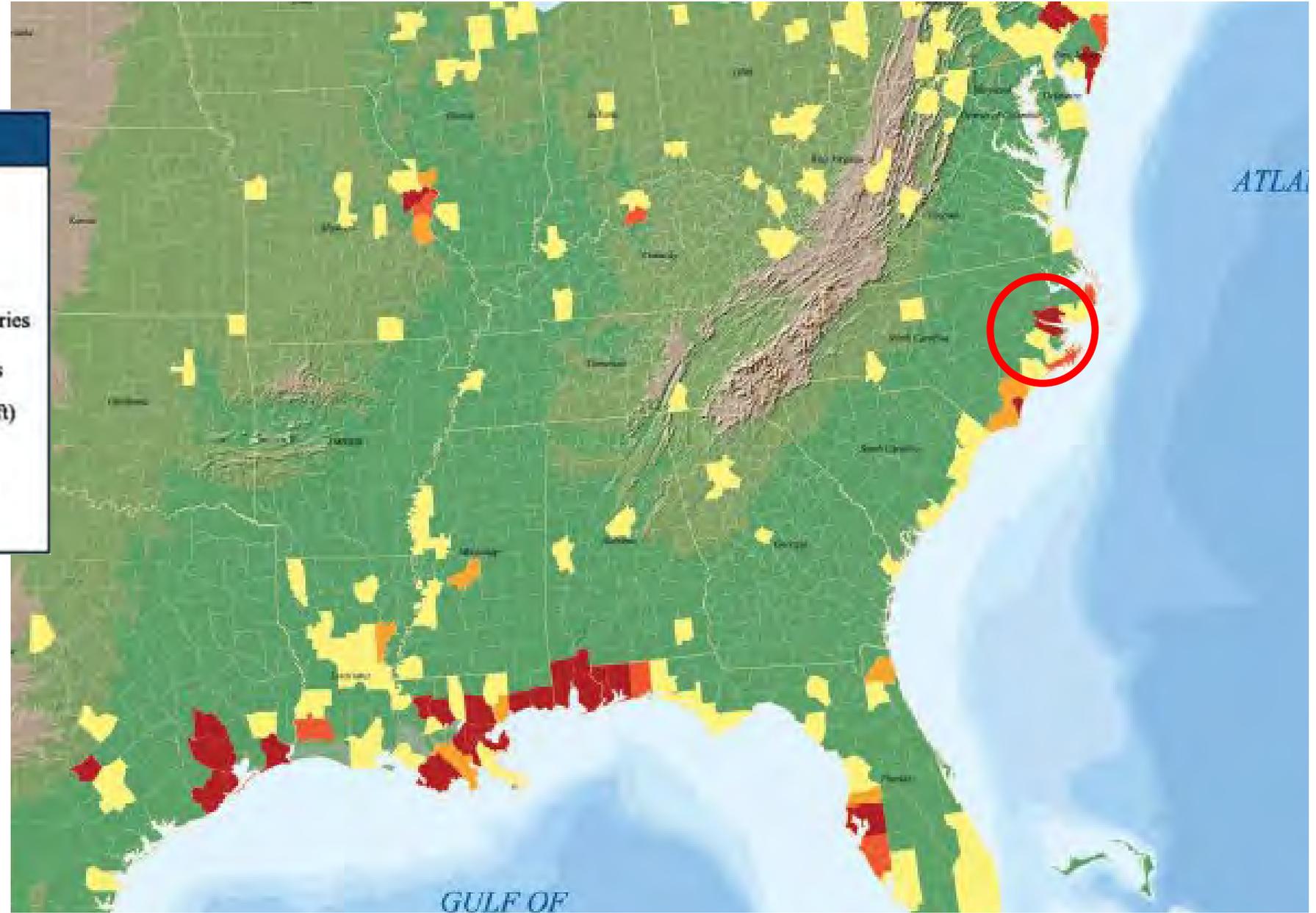
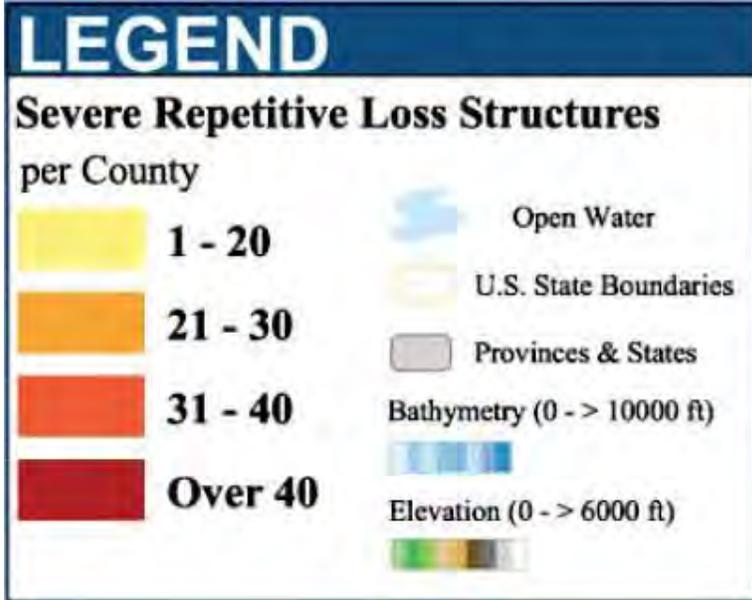


Insurance claims on properties that are repeatedly damaged by flooding, or “repetitive losses,” are of particular concern to the National Flood Insurance Program (NFIP). NFIP has paid out almost \$9 billion in claims to repetitive-loss properties, which amounts to about a quarter of all NFIP payments since 1978. Repetitive-loss properties, shown here, account for just 1.3 percent of all policies but are responsible for fully 25 percent of all NFIP claim payments since 1978. The darker colors show counties particularly prone to repetitive losses. Map based on data from FEMA as of May 2013.

Darker colors indicate counties prone to repetitive loss claims.

- Repetitive Loss Claims:
- Represent 1.3 % of all policies
 - Responsible for 25% of all claims (1978-2013) totaling \$9 billion

FEMA 2016

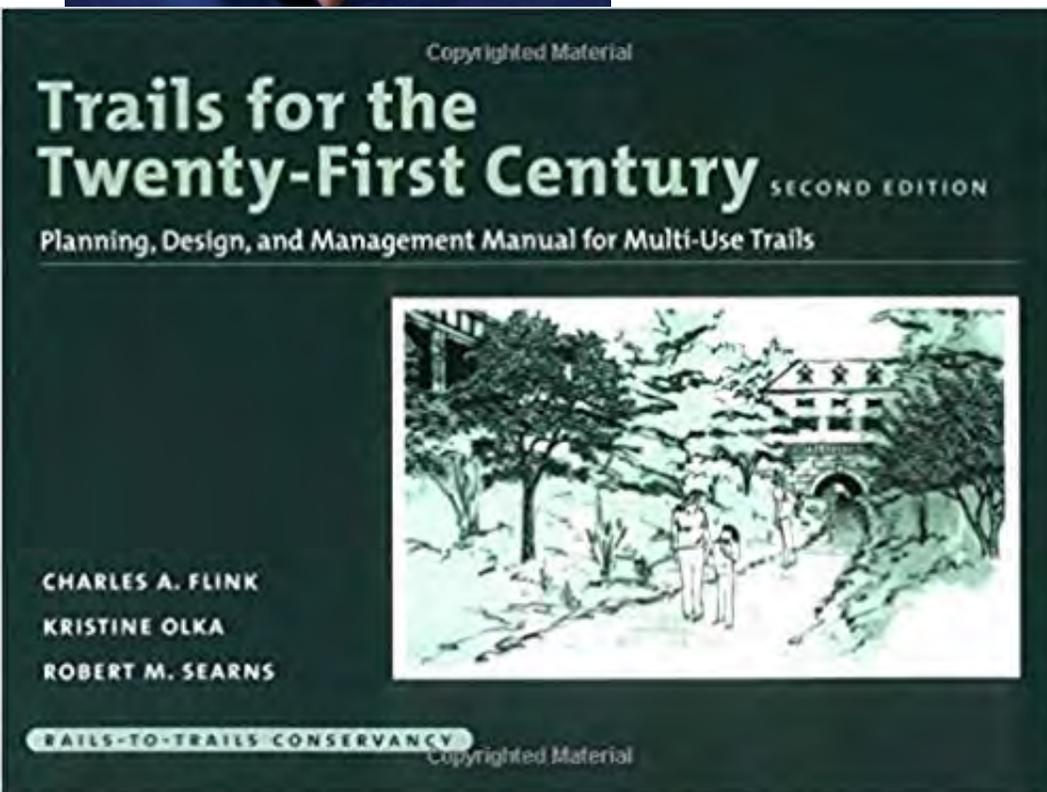




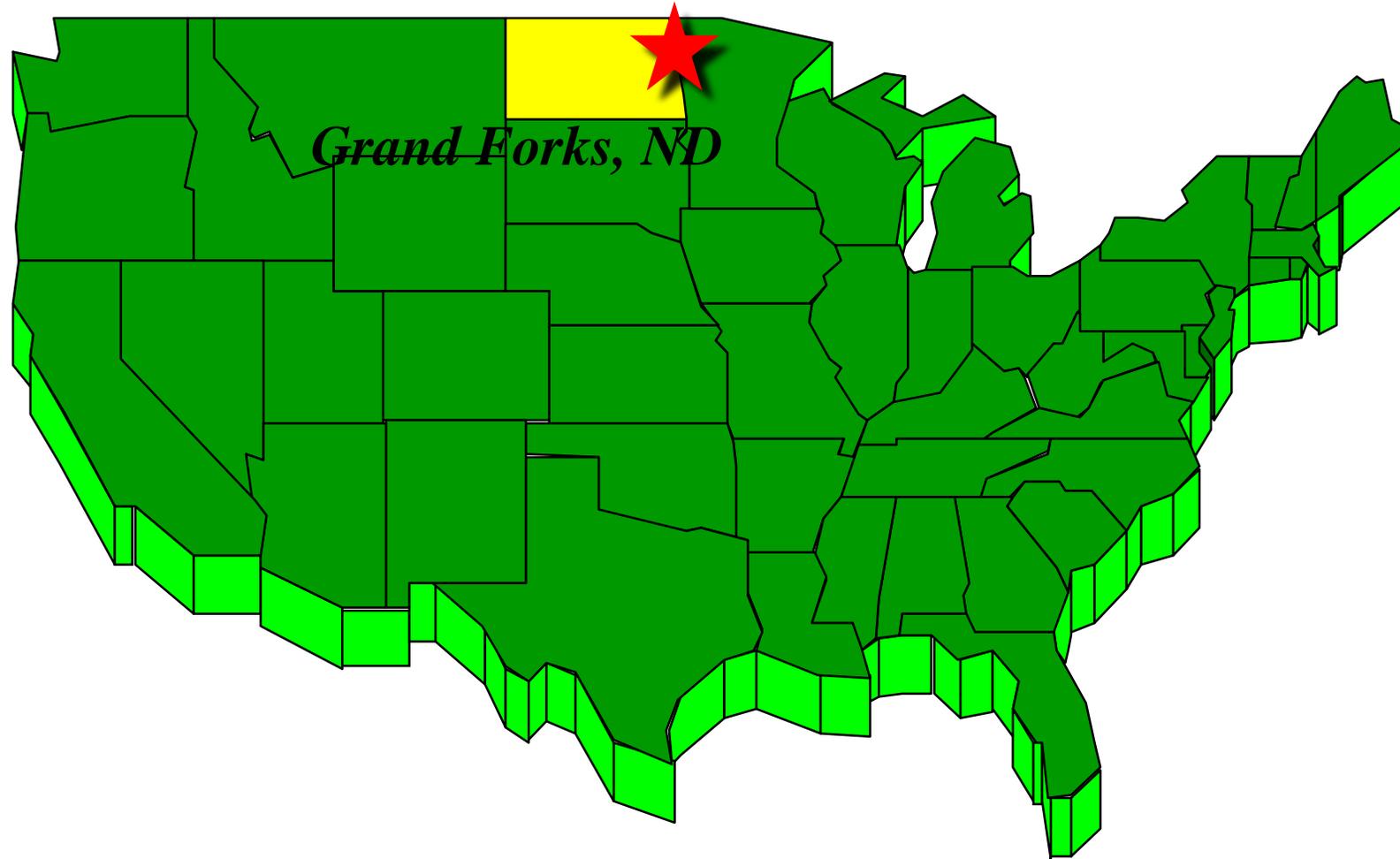
Resilient By Design

Chuck Flink, FASLA, PLA

- Award-winning author, landscape architect and environmental planner.
- Fellow in the American Society of Landscape Architects
- Completed projects in 250 communities within 37 states
- Consults with international clients in Asia, Canada, Europe, and South America
- Co-author of two award winning books **Greenways A Guide to Planning, Design and Development** and **Trails for the Twenty-First Century**.



Case Study: Grand Forks, North Dakota



Red River, Grand Forks, North Dakota (pop. 57,000)



Grand Forks, North Dakota



Source: Grand Forks Herald



- Most severe flood of the river since 1826
- 54 feet flood stage
- 50,000 people evacuated
- 11 buildings on fire & 60 apartment units



Source: Grand Forks Herald

The Recovery – Toward a more resilient Red River community

- **FEMA buyout of repetitive flood loss properties (downtown buildings in East Grand Forks and Grand Forks and an entire neighborhood of 50 residential homes were removed)**
- **Build a protective, flexible floodwall/levee system**
- **Reimagine/rebuild the downtown**
- **Implement a 2,200-acre greenway plan (20 miles of trails) - \$15 million**
- **Program the greenway for activity**

Greater Grand Forks Greenway Master Plan









Cabelas,

East Grand Forks, MN



Grand Forks Greenway Use & Value



50,000 attended first Greenway Day in 2003



FRIENDS
OF THE
GREENWAY
GRAND FORKS/EAST GRAND FORKS



Source: Grand Forks Herald

Grand Forks Greenway





Revenue Projections

Greater Grand Forks Greenway



Annual Revenue Projections for Greenway

	Base Dollars	Total Dollars (multiplier effect)
Direct Revenue	\$28,860	\$50,148
Indirect Revenue	\$600,660	\$1,081,188
Community Revenue	\$8,580,863	\$15,445,553
Total	\$9,209,383	\$16,576,889

Grand Forks Greenway - Press

GRAND FORKS **BEST PLACES** NORTH DAKOTA

River Revival

Grand Forks, N.D. has come back a long way since a disastrous flood in 1997. Could it teach New Orleans a thing or two? **By Christopher Steiner**

WHEN THE ORDER TO EVACUATE GRAND FORKS, N.D. came down, Jon C. Larson and his 20 Sure Foot Corp. employees scrambled to their vehicles and scattered. Hours after the decreed exodus on Apr. 18, 1997 the cantankerous Red River crashed over levees and mauled the town. Two days later Larson and his general sales manager, Wayne Waage, returned to the chaos. "Anything downstairs that wasn't bolted down was floating," Jon says. He recalls turning to Waage to ask, "Is that the compressor going by right there?" It was.



Before and after: The Coast Guard inspects damage in 1997; today's new flood wall along the Red River.



184 FORBES MAY 22, 2006

FORTUNE
SMALL BUSINESS

Does Your Accountant WORK FOR THE IRS? **>> PAGE 22**

2008

BEST PLACES

to LIVE and LAUNCH

100 GREAT TOWNS FOR BUSINESS OWNERS **>> PAGE 66**

#1 Bellevue, Wash.
Earl Overstreet's tech company flourishes near pristine lakes and abundant engineering talent.

MR. CHARLES A. FLINK II
GREENWAYS INC.
5950 FAYETTEVILLE RD.
STE. 2111
DURHAM NC 27713-6289

APRIL 2008



“about the best example we have to date” when it comes to flood protection as a public amenity
Kevin Holden, US Army Corps of Engineers







Grand Forks Greenway



Source: Grand Forks Herald



Source: Grand Forks Herald

6 7:59 AM

Take Home Points

- North Carolina communities need financial and technical assistance with flood mitigation analysis, planning, design and implementation
- Think outside the box! Then, apply the best models to evaluate flooding scenarios and potential abatement measures
- Need to better understand and better communicate the risks and uncertainty of future flood events, especially considering current and future climate conditions
- Relocation of repeat loss structures should be a priority
- The most important use of floodplains is to store floodwater!
- Define a place for water and a place for people – Water always wins!
- Recovery of floodplains can create beneficial opportunities for communities