# Evaluating Alternatives to Improve Resilience to Riverine Flooding in Eastern North Carolina

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### Purpose:

Help Small Towns with Big Problems

### Approach:

Understand why it floods Determine if there is anything we can do about it





SRH-2DRiver HydraulicsSpatialBureau of ReclamationM

**ArcGIS** Spatial Data Processing, Model Setup



HEC-HMS Watershed Hydrology Extreme Event Discharges



HEC-RAS River Hydraulics Water Surface Elevations



SWAT Landuse Change *Water Balance* 

# **Neuse Basin Flood Mitigation Study**

### **Stakeholder Workshops**

- Purpose: Gather relevant information about flooding and flood-related impacts
- Three Workshops in 2018
  - Kinston April 17
  - Smithfield April 23
  - Goldsboro April 23

### **Invited Attendees**

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



# **DOT Scope of Work**

- 1. Develop early-warning for road closures
- 2. Identify locations for new stream gages
- 3. Model river crossings suspected of exacerbating flooding
- 4. Prioritize upgrade of downtown crossings subject to flash flooding
- Model future upstream development and extreme weather
- 6. Review local floodplain ordinances



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# **Bridges Evaluated**

Identified at stakeholder meetings

### Smithfield

- o US 301 (Brightleaf Blvd)
- o Railroad bridge
- o **I-95**

### Goldsboro

o Arrington Bridge Rd

### Kinston

OUS 70 (New Bern Ave)
King St. (NC 11)
Queen St. (US 258)
Railroad

Craven County

NC 43 – Neuse River
NC 43 – Swift Creek



# **Example Bridge Evaluations**

**Roadway Constructed – Embankment Added** 



**Cross section (looking downstream)** 

# **Kinston Bridge Evaluations**

### **Proposed Scenario to Increase Floodplain Conveyance**



**Cross section (looking downstream)** 





Bridge	Existing Span Width (feet)	Modified Span Width (feet)	Change in Water Surface Elevation (feet)
US 70	700	2000	0.3
King St	670	3470	0.7
Queen St	600	2050	0.2
RR Bridge		removed	0.0
Combined (US 70, King & Queen)	-	-	1.2

## **Bridge Evaluation Summary**

Community	Single Bridge	Multiple Bridges
Smithfield	0.0 ft	1.0 - <mark>1.4 ft</mark>
Goldsboro	0.0 ft	-
Kinston	0.2 – 0.7 ft	0.9 - 1.2 ft
Craven County	0.0 - 0.3 ft	0.0 - 0.9 ft

- Relatively large modifications were modeled to determine maximum potential drop in Water Surface Elevation (WSE)
- Modifying the bridges resulted in minimal impact on upstream WSE
  - Particularly if evaluated individually
  - Minimal impact on flooding extent
  - Low hydraulic gradient, backwater

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Tributaries identified during stakeholder meetings:

#### Smithfield

Spring Branch Buffalo Creek **Goldsboro** Big Ditch Billy Bud Creek Stoney Creek **Kinston** Adkin's Branch Jericho Run Taylor's Branch



NC 11 south of Kinston (WITN)

# **Tributary Crossing Prioritization Process**

- 1. Inventory crossings
- 2. Evaluate capacity & condition
- 3. Obtain existing hydraulic models (NC EM Effective Model)
- 4. Prioritize transportation importance
- 5. Develop alternatives for under-sized crossings
- 6. Develop a decision matrix for prioritizing replacement or improvement



### Adkin Branch, Kinston



### **Tributary Crossings – Flood Frequency**



Goldsboro – 45 Crossings Total along three tributaries

- 26 crossings overtopped by the 10year storm
- 6 crossings overtopped by the 25-year storm

# **Tributary Crossings – Condition**



### **Tributary Crossings – Critical Transportation Importance**



### **Tributary Crossings – MCDA**

MCDA Variables- Replacement Cost, Roadway LOS, Condition, Critical Transportation, Flooding Risk

MCDA Scores								
Multi-Criteria Decision Analysis		Replacement Cost	Roadway Use Designation	Condition	Critical Transportation Importance	Flooding Risk		
<b>Objective Weighting Factor (0-4)</b>		2	3	1	4	4	MCDA Score	MCDA Rank
<b>Big Ditch</b>	E. Ash St.	1	4	1	3	5	47	1
Stoney Creek	E. Elm St.	1	4	2	2	5	44	2
Stoney Creek	Royal Ave.	1	3	1	3	5	44	2
<b>Big Ditch</b>	S. George St.	1	4	2	2	5	44	2
Stoney Creek	Wayne Memorial Dr.	2	4	2	4	2	42	5

### **Tributary Crossings – Develop Alternatives**



# Tributary Crossings Planning Maps



### **Resilient "Safe" Routes**



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# **Future Scenario**

- Buildout in Southern Wake County
  - Swift, Middle, and Black Creeks
  - Increase in CN due to develop forested land
- Climate Change effect on Storms
  - Total accumulation

### **Climate Change – Impact on Extreme Storms**



### **Climate Modeling**

Jared Bowden, NCSU, Southeast Climate Adaptation Science Center Anna Jalowska, NCSU, EPA

# Rainfall Distribution for Hurricane Matthew and Future Storms (Year 2100) for Kinston



**CESM 4.5** – Some carbon reduction efforts made

**CESM 8.5** – No carbon reduction efforts made (Business as usual)





## Natural Infrastructure (Nature-based solutions)

**Research Question:** How can natural Infrastructure mitigate flooding during extreme rainfall events? And what are the cost and benefits (environmental & damage reduction?



Reforestation



Wetland restoration



Stream restoration



Water Farming

### Approach:

- 1. Identify Opportunity
- 2. Model watershed hydrology to determine flow reduction
- 3. Model river hydraulics to estimate the associated flood reduction
- 4. Model water quality benefit
- 5. Estimate costs and benefits



# http://go.ncsu.edu/flooding



### N.C. Coastal Rivers Flood Mitigation

On this page:

Major Floods Transportation Impacts Future Risks Improving Resilience Forecasting and Planning References

The content below was prepared by J. Jack Kurki-Fox and edited by Barbara Doll, Julie Leibach, and Jonathan Page.

Major storms have exposed glaring vulnerabilities to riverine flooding in many N.C. Coastal Plain communities.

Riverine flooding imperils life, health and livelihoods. It also threatens transportation infrastructure. Road closures and flooding can severely affect the movement of vital goods and services, with crippling effects on local economies and emergency response.