TOWN OF LELAND
RESILIENT ROUTES REPORT

Prepared for Town of Leland | July 2024

Town of Leland
Growing our future. Nourishing our roots.

moffatt & nichol

ESP

Date: July 2024

Subject: Town of Leland Resilient Routes Report

Moffatt & Nichol Job No.: 221621

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1 INTRODUCTION

1.1 PROJECT OVERVIEW AND BACKGROUND

The North Carolina Department of Public Safety, Division of Emergency Management (NCEM) provided a Transportation Infrastructure Resiliency Grant (TIRG) for this Resilient Routes Project. The Resilient Routes Project was initially identified as a priority by the Town during its participation in the NC Division of Coastal Management's Resilient Coastal Communities Program (RCCP) in 2021. The Town of Leland (Town) has assessed critical transportation routes within its municipal boundaries subject to coastal hazards. The Town identified and ranked priority transportation improvement projects to adapt and mitigate potential transportation vulnerabilities vital for emergency services, evacuations, and response in a natural disaster. The Town selected Moffatt & Nichol (M&N) and ESP, subconsultant, to conduct a transportation vulnerability assessment of its roadway network, and to develop five (5) concept level resilient design plans and cost estimates to address assets at risk from future flooding.

The Town of Leland has addressed resilience and climate adaptation in its 2021 Comprehensive Plan, Leland 2045: Planning for Generations that provides policy direction for land use, development, and open space preservation with principles and strategies for building resiliency. The Town participated in the RCCP and produced a Resilience Strategy Report (January 2022) that established the community's vision and goals, reviewed town and regional efforts, included a risk and vulnerability assessment, provided a project portfolio, and conducted community engagement with a community action team that helped guide the assessment. The RCCP Resilience Strategy Report notes that a community survey showed survey participant's top concerns are flooding caused by storm surge and rainfall from intense storm events and protecting critical facilities.

The Resilient Routes Project builds on this previous work and evaluates how future changes in precipitation, SLR, and coastal hazards associated with more intense storms may impact the local transportation network. The Resilient Routes Project also addresses how to sustainably mitigate potential transportation vulnerabilities vital to emergency services, evacuations, and the movement of people and supplies before, during, and after a natural disaster.

The assessment includes 2D modeling of the Town's planning area, calibrated to Hurricane Florence.

Transportation routes were assessed using prioritized criticality indicators of local importance. Five vulnerable segments of the roadway were identified for further study and feasibility studies were conducted for transportation design concepts.

The Resilient Routes Project will be updated in the Town's Capital Improvement Plan and will also be included in other related plans and manuals. The Resilient Routes Project evaluates Town ordinances and provides recommendations for improved resiliency policies and standards and addresses potential funding sources for implementation. The details of the modeling and concept designs of the five resilient transportation projects can be found in the Appendices (see Town of Leland Resilient Routes Report Appendix document).

1.2 DEFINITIONS OF TERMS

The following definitions are derived from U.S. Department of Transportation, Federal Highway Administration's Resilience Definitions. By using consistent definitions, practitioners, designers, engineers, and local and state officials can have a common understanding of technical concepts and strategies that can be applied consistently throughout the transportation project development process.

Adaptive Capacity: The degree to which the system containing the asset (road, bridge, etc.) can adjust or mitigate the potential for damage or service interruption.

Adaptation: The process of adjusting to an actual or expected environmental change and its effects in a way that seeks to moderate harm or exploit beneficial opportunities.

Climate Variable: A characteristic of the climate that affects the transportation system. The climate variables most often analyzed in a transportation vulnerability assessment are temperature, precipitation, sea level, and river discharge.

Climate Stressor: A variation in a climate variable that may lead to a climate impact (e.g. heavy rainfall, cyclical variations in temperature over time).

Criticality: This study established critical factors of local importance that include identified roadways and corridors serving as community connectors and community lifelines.

Exposure: The degree to which a transportation asset (roadway, bridge, etc.) experiences a hazard.

Indicator: An indicator is a representative data element that can be used as a proxy measurement of the overall exposure, sensitivity, or adaptive capacity of a specific asset.

Mitigation: Measures to reduce the amount and rate of future climate change by reducing emissions of heat-trapping gases (primarily carbon dioxide) or removing greenhouse gases from the atmosphere.

Resilience: The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions (NCDOT Resiliency Policy).

Risk: A combination of the likelihood that an asset will experience a particular climate impact, and the severity or consequence of that impact.

Sea Level Rise (SLR): The long-term upward trend in the mean sea level.

Sensitivity: The degree to which an asset is damaged, or service is interrupted by a climatic hazard.

Vulnerability: The extent to which a transportation asset or system is susceptible to sustaining damage from hazards during extreme events. Vulnerability is a function of the extent to which an asset or system is exposed to damaging forces; its sensitivity to those forces; and its adaptive capacity.

TASK	2023												2024						
	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July
1.0 Critical Routes Identification			TM #1																
1.1 Critical Routes List																			
1.2 Geodatabase																			
2.0 Critical Routes Analysis						TM #2						CAT #1							
2.1 Critical Routes Scoring Factors Determination		DRAFT		FINAL															
2.2 Existing Hydraulic Structure Inventory																			
2.3 2D HEC-RAS-Modelling (Existing Conditions)					DRAFT				FINAL										
2.3 2D HEC-RAS-Modelling (Proposed Conditions)													DRAFT					FINAL	
2.4 Prioritization Matrix / Ranking of Routes												DRAFT							
2.5 Report / Technical Memorandum Pre-Design & Post-Design																DRAFT		FINAL	
2.6 ArcGIS Map Package and Supporting GDB																			
2.7 Field Survey																			
3.0 Conceptual Design Plans and Cost Estimates																4/4 Contract Amendment			TOWN COUNCIL PRESENTATION
3.1 Project Site 5 Design, Model, Plan Outputs, Documentation, Estimates, Coordination																			
3.2 Project Site 4 Design, Model, Plan Outputs, Documentation, Estimates, Coordination																			
3.3 Project Site 2 Design, Model, Plan Outputs, Documentation, Estimates, Coordination																			
3.4 Project Site 3 Design, Model, Plan Outputs, Documentation, Estimates, Coordination																4/25 On-Site Meeting			
3.5 Project Site 7 Design, Model, Plan Outputs, Documentation, Estimates, Coordination																		6/28 Final Deliverables	

Figure 1: Project Schedule

1.3 PROJECT GOALS

The Resilient Routes Project goals include assessing the vulnerability and criticality of the Town of Leland's transportation roadway infrastructure and assets. The Project prioritizes five (5) project locations that reduce the vulnerability of those assets to flooding and sea level rise (SLR). The resilient projects include concept level design plans and probable cost estimates for future funding and implementation. The Town intends to promote transportation resiliency through planning, project development, and implementation. This assessment study is intended to help the Town make decisions on how to sustainably reduce future flood risk and prioritize resilient transportation projects.

1.4 PROJECT SCHEDULE

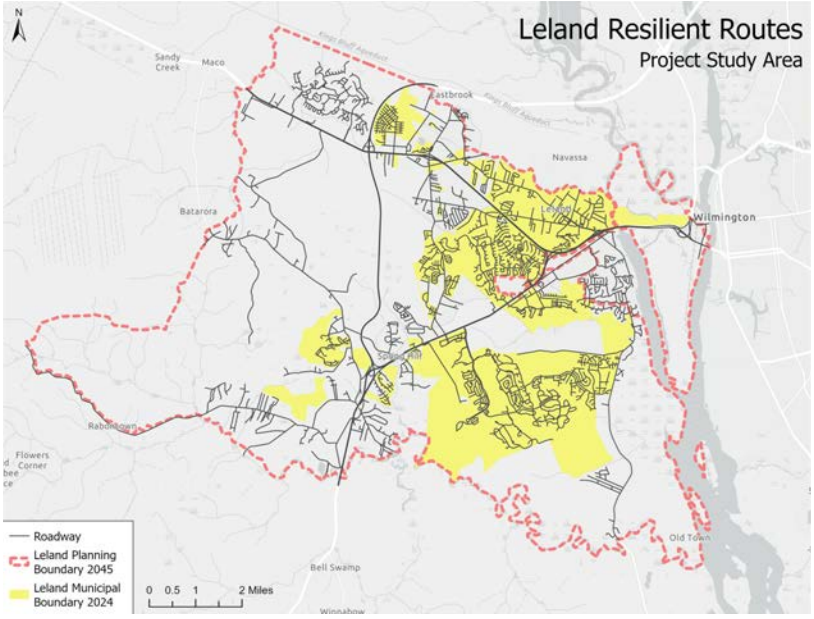
The project schedule, as shown in Figure 1, provides an overview of major project tasks and their duration during the project period beginning January 2023 and ending July 2024, with a presentation to the Town Council in August 2024.

2 RESILIENT ROUTES IDENTIFICATION – TECHNICAL APPROACH

2.1 PROJECT STUDY AREA

The Project's Study Area uses the Town of Leland's 2045 comprehensive land use planning area. The planning area extends along US-74 and NC-87, down to Town Creek, and east to Brunswick River, Cape Fear River, and Eagle Island as shown in Figure 2.

Figure 2: Leland Resilient Routes Project Study Area



2.2 REVIEW AND SELECTION OF STUDY ASSETS

Roadways within the Town's planning area identified using available GIS data were selected for vulnerability analysis. The roadway data was downloaded from the NCDOT maintained database containing route feature geometry and name and functionality attributes. An aerial derived QL1 LiDAR Digital Elevation Model (DEM) was used to process flood inundation depths along the route geometry, therefore any roadways outside of the DEM coverage were not considered in the analysis. The final selection of roadways used in the analysis only included routes with NCDOT designated functional class ratings of Interstate, Highway, NC Route, Secondary, and Local. Roadway geometry was reviewed to ensure positioning of the lines over cells of the DEM that represented roadways, then split into 50-feet segments as shown in Figure 3.

2.3 CLIMATE VARIABLES – PRECIPITATION, STORM SURGE, SLR AND SCENARIO SELECTION

To evaluate the Town's transportation resiliency against coastal hazard impacts, a series of climate variables

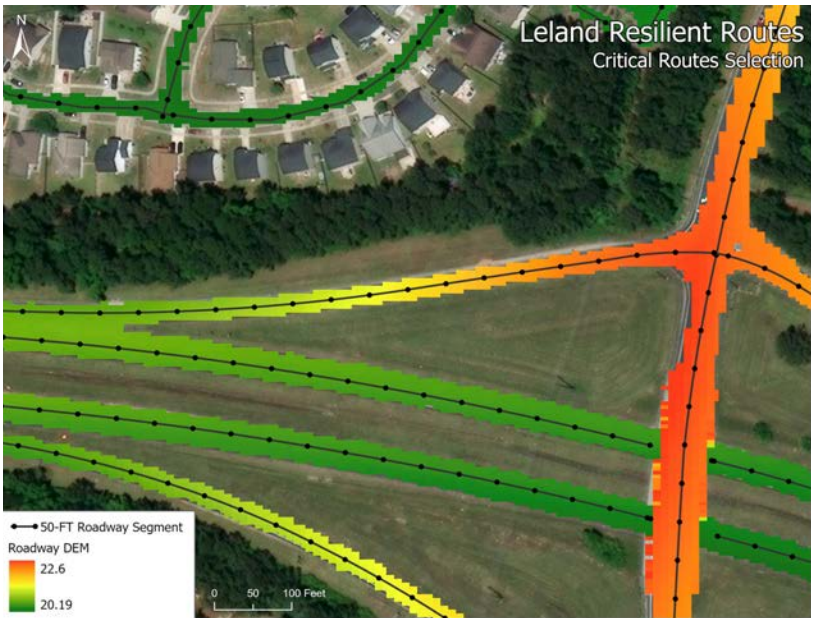


Figure 3: Routes split into 50-FT segments overlying a terrain DEM

directly associated with flood severity were considered. The variables used for this analysis were precipitation, storm surge, and SLR. A summary of each of these variables is provided below along with a description of the scenarios selected for evaluation.

2.3.1 PRECIPITATION

Precipitation is a primary contributor to flooding. When a greater amount of precipitation falls than the ground can infiltrate, runoff occurs. This can happen due to either total volume or intensity of rainfall exceeding the ground's capability to absorb. Precipitation leads to greater amounts of runoff in areas with more development (impervious area). When runoff becomes too excessive, streams, rivers, and other stormwater conveyances that collect it can become overwhelmed leading to flooding outside of the channel, ditch or pipe which can threaten infrastructure including roads and bridges.

The National Oceanographic and Atmospheric Administration (NOAA) has published Atlas 14, Volume 2: Ohio River Basin and Surrounding States includes precipitation frequency estimates covering all of North Carolina. These charts provide rainfall depths for various durations and frequencies of events. The rainfall values for 1-year to 1,000-year average recurrence intervals with durations from 5-minutes to 60-days can be determined allowing evaluation of a broad range of potential storm events that can lead to various degrees of flooding. For example, the 10-year average recurrence interval rainfall for a storm with a 1-hour duration is 3.06-inches, whereas the 200-year average recurrence interval rainfall for a storm with a 72-hour duration is 16.6-inches.

Recent flooding events and associated studies of climate change point to the increasing likelihood of more extreme precipitation events becoming more common. Therefore, to better plan for transportation resiliency against flooding in the future, considerations for future precipitation are considered in this analysis. Many methods for estimating precipitation under future climate conditions exist. More advanced methods use downscaled global climate models with assumptions regarding future greenhouse gas emissions and efforts (or lack thereof) to reduce them. For this analysis, a suite of potential future rainfall values were developed by increasing the 100-year average recurrence interval precipitation from the NOAA Atlas 14 publication by 10 percent, 20 percent, and 30 percent.

Additional details concerning the approach used to incorporate precipitation data into the modeling effort are included in Appendix A.

2.3.2 STORM SURGE

Coastal storms are accompanied by increased wind. As the wind travels across open bodies of water, it generates larger waves capable of pushing water onshore, a phenomenon called storm surge. Storm surge can propagate upstream along streams and rivers occupying storage volume that would otherwise be available for routing stream flow and runoff from upland areas in a normal free-flowing condition. Storm surge can both inundate low-lying coastal areas and exacerbate riverine flooding due to the loss of normal conveyance

Figure 4: >> Submerged vehicle during Hurricane Florence in September 2018 (credit: Town of Leland)

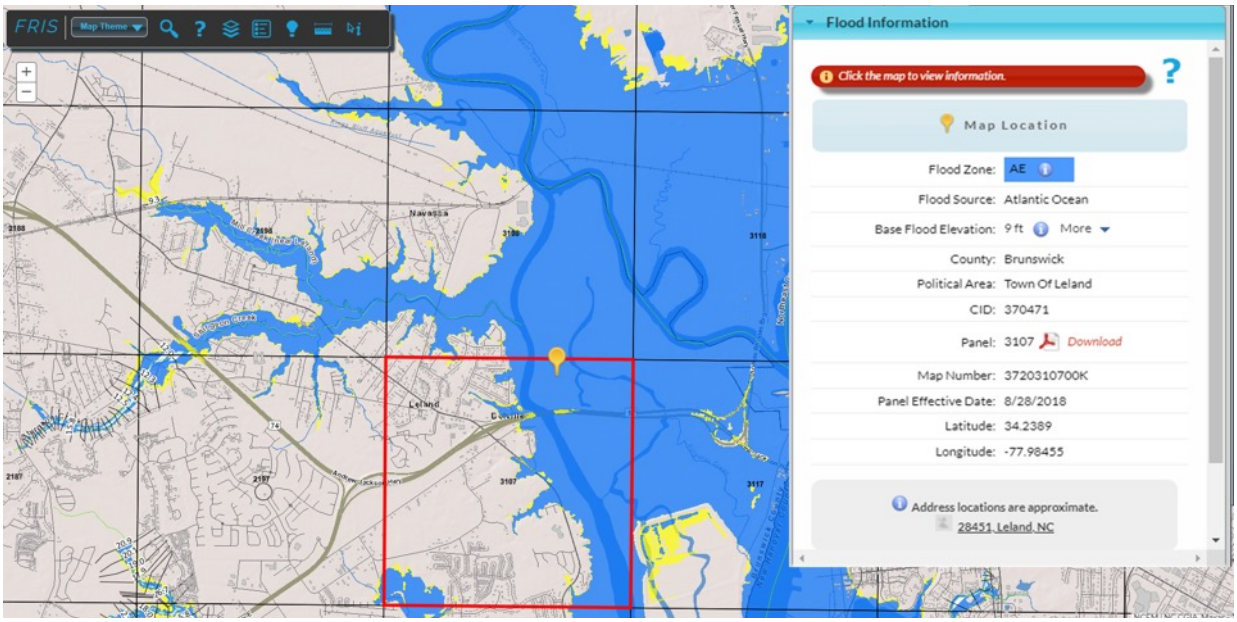


Figure 5: Excerpt from North Carolina FRIS Depicting Coastal Storm Surge Flooding

threatening built infrastructure including roads and bridges.

The mouth of the Cape Fear River, the largest river basin in North Carolina, is downstream of the Town of Leland and the City of Wilmington where the river empties into the Atlantic Ocean. The Town is directly west of the Brunswick River, a major tributary of the Cape Fear River. Figure 5 depicts coastal flood impacts along the river upstream of the Town of Leland. Storm surge is common in the region of the Cape Fear River as evident in the effective FEMA flood studies and as shown in Figure 4.

NOAA operates a monitoring station (ID 8658120) along the Cape Fear River in Wilmington. This site has recorded river levels including those affected by storm surge since 1908 with the all-time highs recorded during Hurricanes Matthew (2016), Florence (2018), and Isaias (2020).

2.3.3 SEA LEVEL RISE (SLR)

For a coastal community like the Town of Leland, future sea level rise can significantly impact the transportation network. Rising sea levels can outright inundate low-lying roads near the coast. In addition, elevated sea levels create a "back-water" effect along streams and rivers such that riverine flows from upper parts of the contributing basins are unable to efficiently drain. This results in streams and rivers overflowing their banks and threatening roads and bridges.

Sea level rise for eastern North Carolina has been studied extensively including in the report, *"Sea Level Rise Planning Pilot Project Wilmington, NC, Probabilistic Sea Level Rise Study,"* dated July 15, 2021, prepared by Moffatt & Nichol for the North Carolina Department of Transportation. This report was used for the analysis and provided a conservative estimate (99 percent chance of non-exceedance) of sea level rise that could occur from 2023 to 2045 as 1.0-foot.

The NC Coastal Resources Commission (CRC) provided an update in April 2024 based on a 2022 Sea Level Rise (SLR) Report that provides future projections for the three tide gauge locations, Duck, Beaufort and Wilmington. The report contains key messages from Sweet et al. (2022); a summary of the regional sea level rise projections for North Carolina, and updated sea level rise projections and assessment of high-tide flooding frequencies for Duck, Beaufort and Wilmington, NC. Regional difference in sea level in all modeled scenarios show higher RSL rise along the east coast as compared to west, and pacific coasts. Historic and projected future SLR in Wilmington, NC for the Intermediate-Low to Intermediate Scenarios from Sweet et al. (2022) range 0.3 meters in 2050 to 0.7 to 1.1 meters in 2100.

2.3.4 SCENARIO SELECTION

To identify and evaluate roadway segments against the climate variables for the Town of Leland's transportation resiliency efforts, a series of 22 scenarios were selected for analysis using a two-dimensional rain-on-grid HEC-RAS model (2D model). These scenarios were selected to provide a wide range of potential flood conditions to evaluate impacts from more frequent-short duration events (such as localized intense thunderstorms) to less frequent-longer duration events (such as tropical systems that last for days).

- Precipitation for average recurrence intervals of 10-,

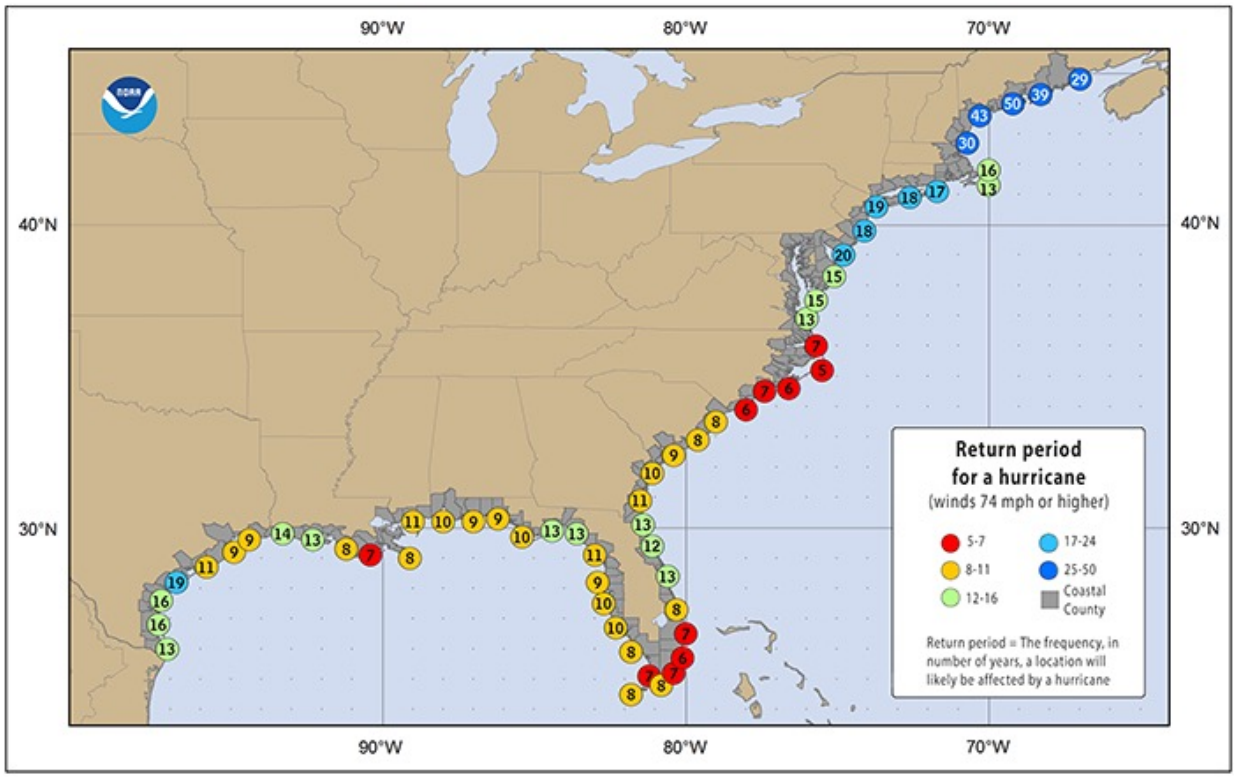


Figure 6: Hurricane return period for any category (NOAA)

50-, 100-, and 200-year as well as 100-year future rainfall based on increases of 10 percent, 20 percent, and 40 percent with durations of 1-hour, 24-hour, and 72-hour for each event (21 total scenarios).

- Downstream boundary conditions for each scenario based on statistical analysis of records from NOAA Gauge 8658120 in Wilmington to account for storm surge.
- Incorporation of 1-foot of sea level rise added to the downstream boundary conditions for the 100-year future rainfall scenarios.

Further discussion of the modeling effort and scenarios is provided in Section 4.1 below and additional details provided in Appendix A.

2.4 INDICATORS FOR VULNERABILITY – EXPOSURE AND SENSITIVITY

2.4.1 FLOOD EXPOSURE

2.4.1.1 INCORPORATION OF REGULATORY AND FUTURE FLOOD DEPTHS

Water surface elevation (WSE) values for regulatory and future flood depths were spatially represented as gridded cell values known as rasters. WSEs were extracted at each 50-feet roadway segment from rasters of the FEMA regulatory effective floodplains (10-, 25-, 50-, 100- and 500-year recurrence intervals where available), as well as from rasters generated from the 2D model (10-, 50-, 100-, and 200-year recurrence intervals) for current and future conditions (discussed in Section 4.1 below). The average water surface elevation value extracted along the road segment was multiplied with the probability of the floodplain recurrence interval (e.g. 50-year flood = .02 or 2 percent). For the 2D model floodplains, the segment score was summarized by rainfall duration period with a weight applied to each summarized score; higher weights applied to longer durations (15 percent for 1 hour, 35 percent for 24 hour, and 50 percent for 72 hour). The score for the FEMA flood risk accounted for 35 percent of the total flood exposure component score, and the 2D modelled flood risk score accounted for 50 percent (30 percent current conditions, 20 percent future conditions).

2.4.1.2 HURRICANE-INDUCED STORM SURGE DEPTHS

The Hurricane-Induced Storm Surge Depths were obtained as GIS data from the National Hurricane Center (NHC) of the NOAA. The storm surge risk maps are developed using high tide scenario SLOSH MOM products and cover the east coast of the US. Storm surge depths are integer values ranging from 1-foot to 21-feet for the entire dataset at a cell resolution of 9 meters. The maximum depths were extracted from the storm surge raster dataset at each 50-feet roadway segment. The values for hurricane and major hurricane probability were identified from maps of return period probability

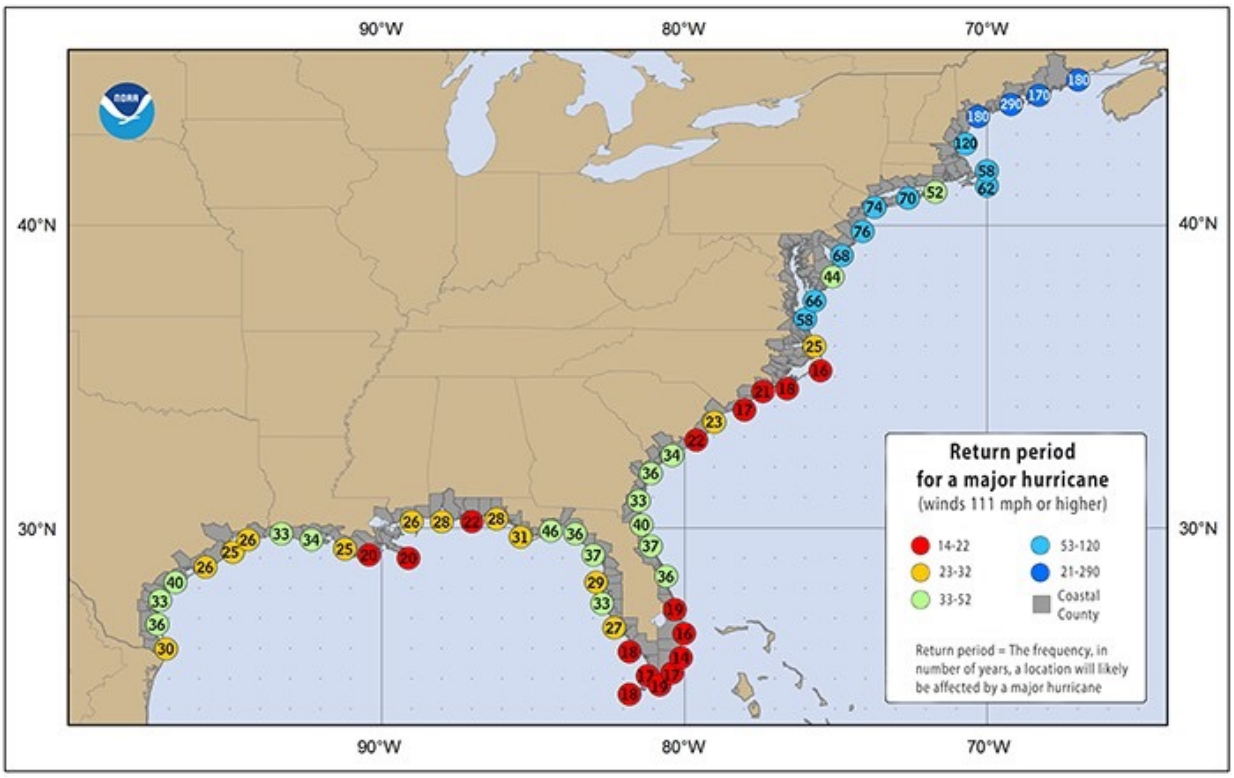


Figure 7: Major (category 3 and above) hurricane return period (NOAA)

produced by NOAA as shown in Figure 6 and Figure 7 below. The probability selection was based on proximity to Leland, NC. An Annual Exceedance Probability (AEP) of 16.7 percent (1/6) was selected for Hurricane Cat 1 and 2 as seen in Figure 6, and 5.9 percent (1/17) AEP for Hurricane Cats 3-5 in Figure 7. The probabilities were applied to the hurricane-induced storm surge depths extracted at roadway segments to produce a storm surge component score. The storm surge component score accounts for 15 percent of the overall flood exposure score.

After score values for FEMA regulatory, 2D model current and future conditions, and the hurricane-induced storm surge were totaled, they were standardized in a maximum-minimum normalization so that the scores are values from 0-1. The standardization rescales values obtained from differing categories so that they can be used together without creating substantial deviations or outliers while still preserving the relationship with the original data.

2.4.2 BRIDGE SENSITIVITY

Bridge sensitivity is an indicator of how susceptible a structure is to damage caused by flooding. The bridge sensitivity scores were calculated using data obtained from the NCDOT's BridgeWatch database. Bridge rating categories were selected from the database using guidance from the National Bridge Inventory (NBI) to determine overall bridge condition. Route segments that overlay structures meeting critical condition ratings for Drift, Substructure, and Channel Condition were assigned an initial score value from 0-4 depending on how many rating condition categories were considered "Poor" or worse by NBI. The scores were standardized in a maximum-minimum normalization.

2.5 CRITICALITY INDICATORS

The following indicators of roadway criticality were used to assess a road's level of operational resilience during a flood hazard event. Indicators include categories of functionality, safety, and socioeconomic importance. The following categories for criticality were developed from FEMA guidelines and input from the Town of Leland.

2.5.1 ROUTE FUNCTIONALITY

Route class, as defined by the North Carolina Department of Transportation (NCDOT), categorizes streets and

Table 1: >> NCDOT Route Classes and corresponding assigned values

Route Class	Value
Interstate	5
US Route	4
NC Route	3
Secondary Route	2
Non-System	1

Table 2: Critical facilities within the Town of Leland

Name	Type
Leland Fire and Rescue	Fire Station/EMS
Winnabow Volunteer Fire Department Incorporated	Fire Station
Leland Fire Station 53	Fire Station
North Brunswick High School	Emergency Shelter
New Hanover Regional Emergency Medical Services Station 2	EMS
Leland Fire Station 52 (HQ)	Fire Station
Proposed Fire Station 54 (Vicinity Of Hwy. 87/Maco Road)	Future Fire Station
Proposed Fires Station 55 (Gateway District)	Future Fire Station

Roadway segments that were within the critical facility service network were assigned a value of 1 for critical facility service score and 0 if outside of the networks.

highways based on the level of service they are designed to deliver. The NCDOT GIS dataset 'NC Routes' contains the route class attributed for each roadway segment included in this assessment. The route classes, listed from highest service level to lowest, included in this analysis are Interstate, US Route, NC Route, Secondary Route, and Non-System. The route classes were assigned values 1-5 as shown below in Table 1. Higher levels of service received a value closer to 5, and then standardized in a maximum-minimum normalization.

2.5.2 CRITICAL FACILITY SERVICE NETWORKS

Critical facilities and infrastructure were identified following FEMA guidance as those facilities that are critical to the health and welfare of the population and that are especially important following hazard events such as flooding. Critical facilities include, but are not limited to shelters, police and fire stations, and hospitals. Roadway networks within 5 miles of a critical facility were identified as service areas that are imperative to remain accessible during a hazard event to maintain response and safety operations.

The following facilities were used to identify critical facility service area routes within the Town boundaries using information from the Town and GIS data from the North Carolina Emergency Management (NCEM) as shown below in Table 2.

Table 3: Land use categories obtained from Leland and Brunswick County GIS data

Group	Name	Rank
Conservation/Natural	Conservation and Protection	0
Conservation/Natural	Conservation District	0
Conservation/Natural	Natural	0
Commercial	Commercial	2
Commercial	County Jurisdiction – Commercial	2
Commercial	County Jurisdiction – Industrial	2
Residential	County Jurisdiction – Multifamily Residential	1
Residential	County Jurisdiction – Residential	1
Residential	Planned Unit Development	1
Residential	Residential	1
Residential	Special District	1
Mixed Use	Flex Code	3
Mixed Use	Innovation District	3
Mixed Use	Civic	3
Mixed Use	General Urban	3
Mixed Use	General Urban Open	3
Mixed Use	Office and Institutional District	3
Mixed Use	Urban Center	3
Mixed Use	Sub-Urban	3

2.5.3 DEVELOPMENT DENSITY

Leland Zoning and Future Land Use Comprehensive Plan GIS data were used as overlays to assign their categories to the 50-feet route segments. Zoning categories were evaluated based on their capacity for development and current level of use with a ranking system. Consequently, each roadway segment was assigned a numerical value reflective of the zoning category it served, ranging from 0 to 3, where 0 indicates less developed and 3 denotes the most developed. The assessment considered the density of development more heavily for current zoning (weighted at 75 percent) compared to future land use (weighted at 25 percent). Roadway segments were assigned a value based on the zone they serviced, then values were standardized in a maximum-minimum normalization as shown below in Table 3.

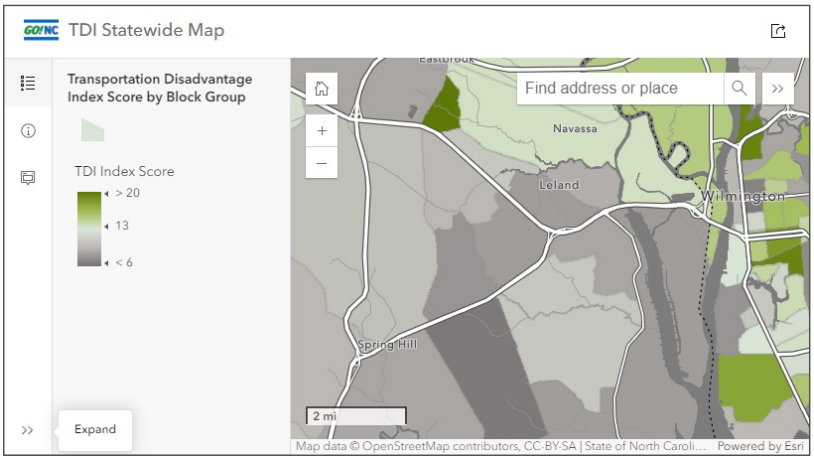
2.5.4 GATEWAYS

Gateways routes were identified as access roads where traffic is typically channeled into an entrance to a defined geographic area. Neighborhoods were considered areas of interest to define gateway routes in this identification. Gateway routes were considered in this analysis due to their importance to remain accessible during a flood hazard event to provide access to neighborhood residents for evacuation or for critical services entry. Route segments were scored as a value of 1 if they were a gateway route, and 0 if they were not considered a gateway route.

2.5.5 DEMOGRAPHICS

NCDOT's Transportation Disadvantage Screening Tool was utilized to obtain the Transportation Index Value (TDI) for each census block group within Leland. TDI was developed to provide insight on disproportionate impacts on disadvantaged communities. This metric was considered in the analysis as it incorporates equity impacts such as low income, ethnic minorities, household vehicle access, and mobility impairments. The TDI GIS layer was used as an overlay to extract the TDI values to the route segments. The extracted TDI values were then standardized in a maximum-minimum normalization as shown below in Figure 8.

Figure 8: NCDOT's online TDI tool



3 METHODOLOGY FOR ASSESSMENT OF RESILIENT ROUTES

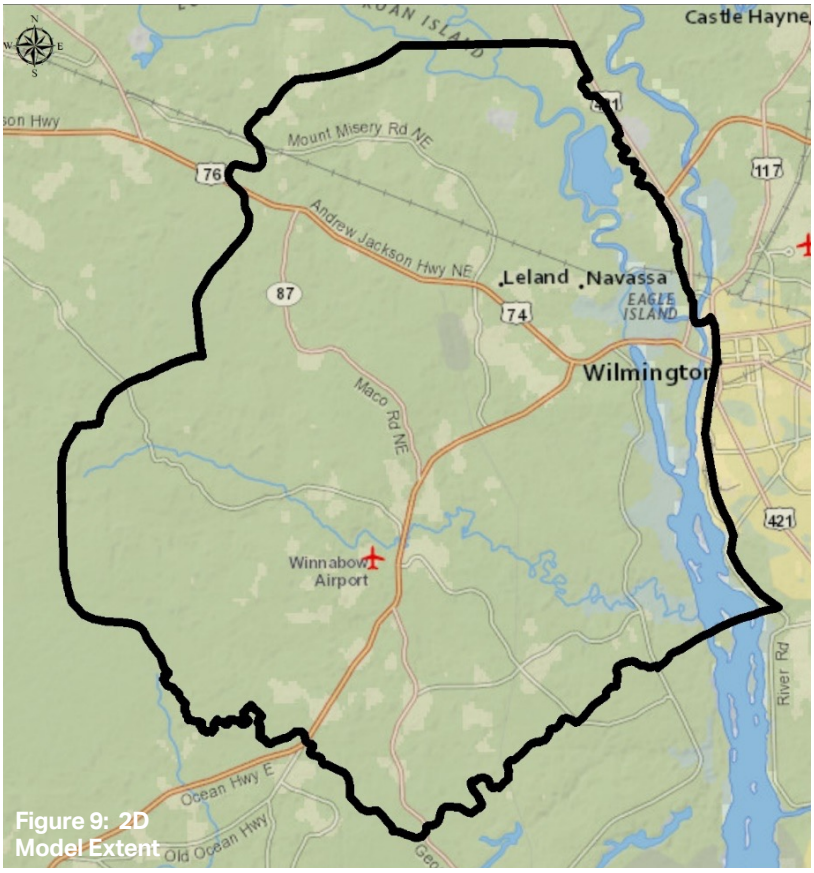


Figure 9: 2D Model Extent

3.1 MODELING AND SCENARIOS

As mentioned previously, a primary component of the flood exposure criteria was development of a rain-on-grid 2D HEC-RAS model. This model was selected based on its ability to incorporate the climate variables previously discussed and identify flood hazards across the entire planning area beyond where existing FEMA studies already exist. Appendix A (Engineering/ Modeling Report) provides a detailed memorandum covering the model development, assumptions, and calibration efforts. The model included all basins draining through the Town's 2045 planning area and covered over 252 square miles, as shown below in Figure 9.

The model incorporates the following data:

- Latest LiDAR topographic data from NCEM
- 2016 NLCD landcover data
- SSURGO Soils data
- Atlas 14 precipitation data
- NOAA Wilmington Gauge 8658120 statistical data
- Sea level rise approximation from "Sea Level Rise Planning Pilot Project Wilmington, NC, Probabilistic Sea Level Rise Study" dated 7/15/2021 prepared by Moffatt & Nichol for NCDOT

Model Scenario	Rainfall (inches)	NOAA Gauge Boundary Condition (feet)	Sea Level Rise Incorporated
10-year, 1-hour	3.06	3.95	No
10-year, 24-hour	7.16	3.22	No
10-year, 72-hour	8.60	3.30	No
50-year, 1-hour	4.04	4.96	No
50-year, 24-hour	10.6	3.43	No
50-year, 72-hour	12.4	3.87	No
100-year, 1-hour	4.50	5.35	No
100-year, 24-hour	12.5	3.48	No
100-year, 72-hour	14.4	4.39	No
200-year, 1-hour	4.98	5.75	No
200-year, 24-hour	14.6	3.61	No
200-year, 72-hour	16.6	4.65	No
100-year +10% Future, 1-hour	4.95	6.35	Yes, 1-foot
100-year +10% Future, 24-hour	13.75	4.48	Yes, 1-foot
100-year +10% Future, 72-hour	15.84	5.39	Yes, 1-foot
100-year +20% Future, 1-hour	5.40	6.35	Yes, 1-foot
100-year +20% Future, 24-hour	15.00	4.48	Yes, 1-foot
100-year +20% Future, 72-hour	17.28	5.39	Yes, 1-foot
100-year +30% Future, 1-hour	5.85	6.35	Yes, 1-foot
100-year +30% Future, 24-hour	16.25	4.48	Yes, 1-foot
100-year +30% Future, 72-hour	18.72	5.39	Yes, 1-foot

Table 4: 2D HEC-RAS Model Scenarios

- Hydraulic structure data along Bishop Branch, Morgan Creek, and Jackeys Creek from effective FEMA models

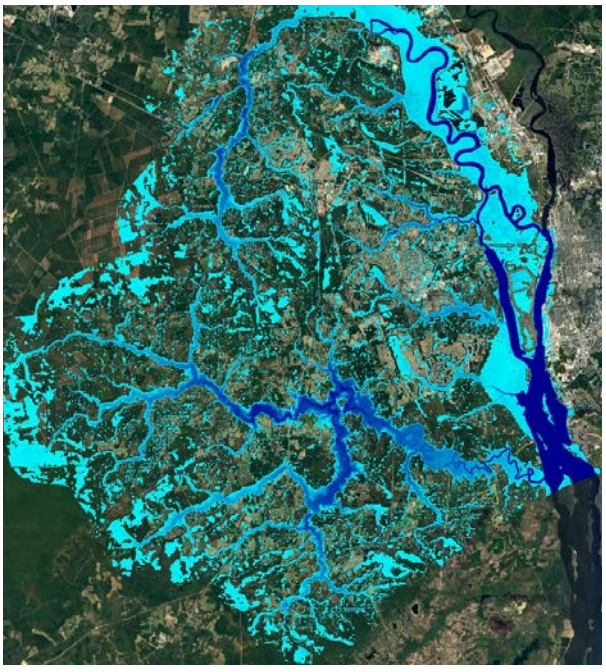


Figure 10: 100-year 24-hour Flood Inundation Model Results

The model was calibrated to Hurricane Florence based on mapping and observations provided by the Town of Leland from that event. The model was used to evaluate a series of theoretical flood events with varying intensities and duration using the various climate variable introduced in Section 3.3 to provide a range of impacts to the Leland transportation network and develop associated flood risk scores for project selection. Modeled scenarios included considerations of climate impacts on both rainfall and sea level rise for theoretical future events. A total of 22 model scenarios were performed as shown in Table 4 and provides a summary of the modeling scenarios outlined in Section 3.3.4.

For each model scenario, the associated inundation mapping was exported from the model in the form of water surface elevation grids. These grids were overlaid with elevations along the road network to develop depths of flooding along all impacted routes within the project area for flood exposure scoring purposes.

The 2D HEC-RAS model developed for this analysis provides valuable awareness of potential flood impacts across the Town of Leland's 2045 Planning Area for the various scenarios outlined above. As shown below, Figure 10 depicts the full extent of the model area with calculated flood extents for the 100-year 24-hour existing conditions model run.

In addition to the water surface elevation results exported into GIS format for the route scoring discussed in Section 4.2 below, the model is capable of providing additional flood hazard information at the street level including depth of flooding, direction and velocity of flow, and other enhanced products such as depth times velocity, arrival time of flood wave, duration of flooding, and sheer stress (among other hydraulic variables) for all model scenarios analyzed.

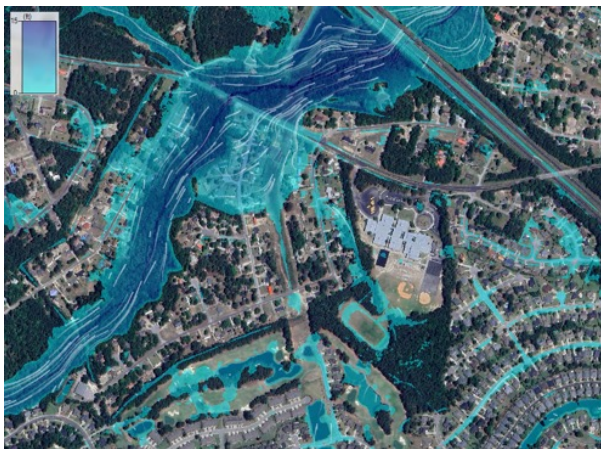
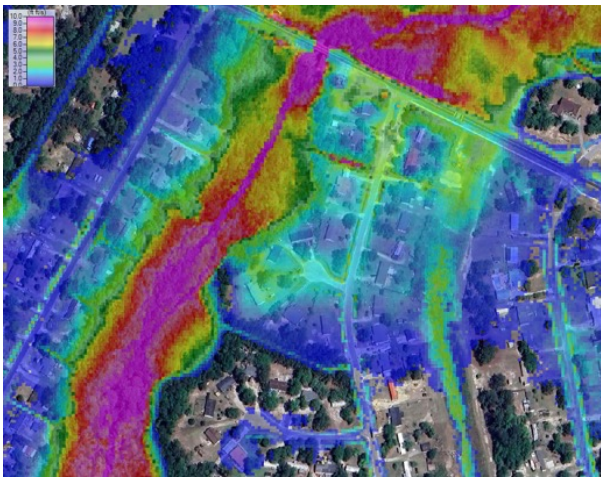


Figure 11: >> Depth of flooding with Particle Tracing

Figure 12: Depth Times Velocity Flood Hazard Layer



As shown, Figure 11 and Figure 12 provide examples of model output available in the RAS Mapper view.

The model results may be used for further analysis of areas impacted by flooding and identification of additional potential project areas as needs are identified and funding made available. Care should be taken with future efforts to evaluate the model for further refinement/improvement in areas of interest. Examples of model improvements may include incorporation of additional field survey data and inclusion of additional hydraulic structures (bridges/culverts) that affect flood conditions.

3.2 SCORING / SURVEY

Prior to the start of the vulnerability analysis, natural hazard factors that influence the flood risk of roadways as well as locational factors that define critical routes within the Town planning limits were identified and sorted into categories (described in the previous section). Categorical weights were assigned values to influence the overall prioritization score of critical routes based on input from the Town stakeholders. After initial risk scores were assigned to the roadways and normalized, the categorical weights were used to generate final scores that allow roadways to be ranked by overall vulnerability.

To appropriately apply multiple categories to a final risk score, an Analytical Hierarchal Process (AHP) was followed. The AHP included a pairwise comparison matrix that used a point system of relative importance values. Input from the Town and the NCDOT Hydraulics unit was used as guidance to assign the relative importance of each category, determining categorical weights that would be applied to the final prioritization score. The weight, represented as a percentage, obtained from the AHP matrix was applied to each normalized categorical score which were then totaled to produce an overall prioritization score for each 50-feet segment as shown in Figure 13 below.

Based on feedback from the Town of Leland and stakeholders, the final evaluation criteria weightings were adjusted based on significance to the Town's

Table 5: >> Final AHP Weightings

Evaluation Criteria	Applied Weighting
Flood Exposure	35%
Road Service	25%
Emergency Response	15%
Bridge Sensitivity	10%
Gateways	5%
Development Density	5%
Demographics	5%

Figure 13: Analytical Hierarchal Process (AHP) matrix used to create categorical weights

Categorical Ranking for Roadway Flood Vulnerability Analysis

Matrix Input Guide

Relative Importance	Description
1	Equally important
3	Slightly more important
5	More important
7	Significantly more important
9	Absolutely more important

2, 4, 6, 8 are used as intermediate determinations if you cannot determine between two categories.

Instructions:
Overwrite the values in the white cells of the matrix, following the Matrix Input Guide to rank the importance of each category in the overall vulnerability score. Results from the matrix update the Weight of Final Score table and pie chart.

Example:
If you were to input '9' in the **Demographics** column on the **Flood Exposure** row, you would be rating the **Flood Exposure** as "Absolutely more important" than the **Demographics** category and therefore the weight percentage of the **Flood Exposure** category will be significantly higher than the weight percentage of the **Demographics** category.

If input values are not trending with each other (i.e. are appearing too random), an error message will appear above the matrix.

Score Matrix for Analysis Categories

Categories	Flood Exposure	Road Service	Bridge Sensitivity	Emergency Response	Gateways	Development Density	Demographics
Flood Exposure	1	7	7	3	7	3	3
Road Service	1/7	1	5	1/3	7	7	9
Bridge Sensitivity	1/7	1/5	1	1/7	3	7	9
Emergency Response	1/3	3	7	1	8	7	9
Gateways	1/7	1/7	1/3	1/8	1	1	9
Development Density	1/3	1/7	1/7	1/7	1	1	7
Demographics	1/3	1/9	1/9	1/9	1/9	1/7	1

Weight of Final Score

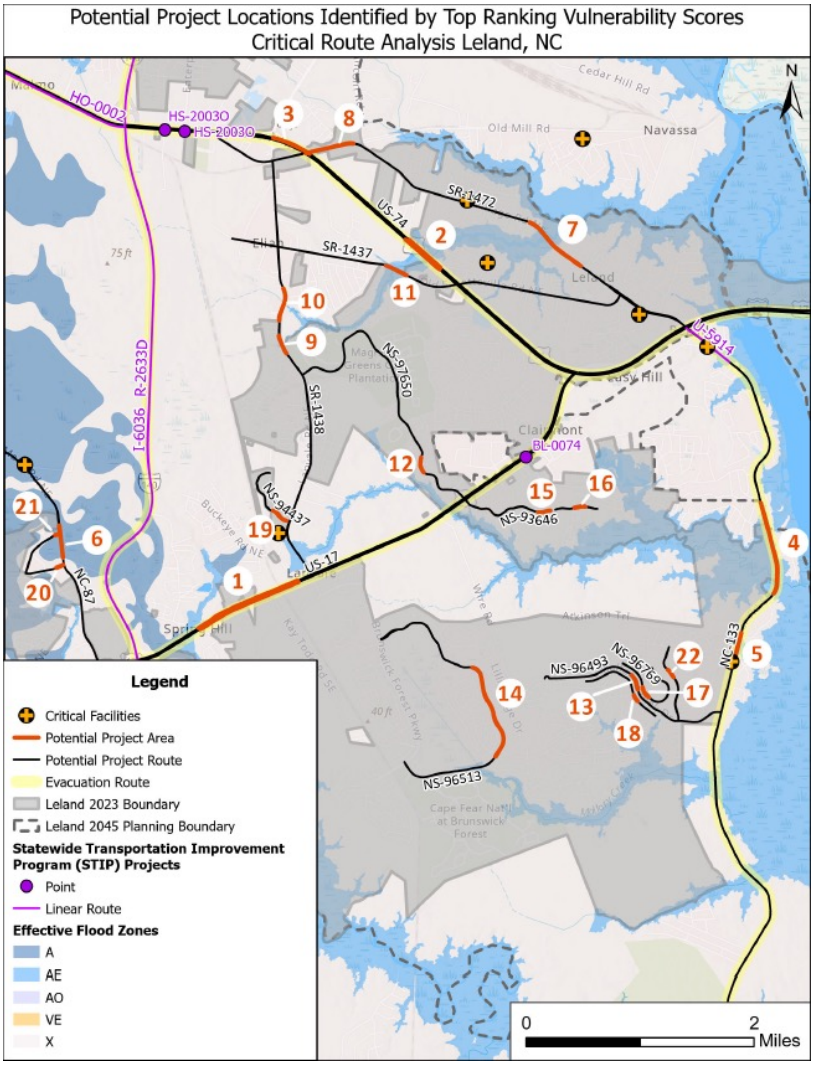
Category	Weight (approx. %)
Flood Exposure	34%
Road Service	17%
Bridge Sensitivity	10%
Emergency Response	24%
Gateways	5%
Development Density	6%
Demographics	3%

priorities. The final evaluation criteria weightings applied from the AHP are shown in Table 5.

3.3 PRIORITIZATION

The prioritization scores for all roadway segments were aggregated by route name for contiguous segments. The summarized scores for each route name were used to rank the roadways by their overall vulnerability and criticality, with the highest values representing the roadways that have highest flood hazard exposure as well as functionality, safety, and socioeconomic importance. Roadways of higher priority indicate the greatest impact potential to the Town if the roadway is compromised during a flood hazard event. A list was created of the top 10 percent high priority scoring roadways which were reviewed to identify potential improvement project areas. The project areas were identified as contiguous segments of high prioritization scores within each route. The 10 percent roadway criticality and vulnerability prioritization list was provided to the Town of Leland and stakeholders to review for suitability as potential improvement project areas as shown below in Figure 14. Appendix B includes a map book depicting the prioritized routes.

Figure 14: Map of identified potential project improvement areas for high priority ranking roadways (not the final project selections)



4 ASSESSMENT OUTCOMES

4.1 STAKEHOLDER / TOWN INPUT AND STIP GAP ANALYSIS

On December 1, 2023, a stakeholder meeting was held with Town Staff, including Engineering, Planning, Public Works, and Emergency Management Departments, the consultant team, and representatives from the North Carolina Office of Recovery and Resiliency, North Carolina Department of Transportation, and the Wilmington Metropolitan Planning Organization (WMPO) to provide opportunities for partner engagement (see Appendix C for stakeholder meeting summary).

The meeting provided an overview of the Resilient Routes Project, project goals, and the methodology for assessing vulnerability of the roadways using a HEC-RAS rain-on-grid two-dimensional (2D) model of the planning area. The model was calibrated to Hurricane Florence and analyzed 21 events, based on 10-, 50-, 100-, and 200-year events at 1 hour, 24 hours, and 72-hour durations and calibration of the model. An overview of mapped model results was provided.

ESP discussed the approach to the assessment study, which segmented all the roads into 50-feet segments that were scored for vulnerability and criticality using an Analytical Hierarchal Process (AHP) to weight seven (7) categories of vulnerability and criticality to develop prioritization. The seven (7) factors include flood exposure, road AADT, bridge sensitivity, emergency response community lifelines, gateways, density, and demographics in a prioritization matrix. Initially, 22 prioritized segments were selected that scored as the most vulnerable roadway segments.

The Town requested that a filter be applied to include projects within the town municipal limits, that resulted in eleven (11) projects identified and considered past flood events and historical data. These eleven (11) projects were ranked for local (non-system or non-NCDOT) routes resulting in ten (10) prioritized projects. These project locations were compared to the present State Transportation Improvement Program (STIP) and no NCDOT projects were planned for the ten (10) selected sites.

The Town identified five (5) priority projects, noting past flooding issues where problems had occurred. Moffatt & Nichol presented potential design criteria for roadway design using aerials and LIDAR for the typical sections of roadway to a 30 percent design. It was noted that potential impacts will be assessed and minimized with structures, including retaining walls. The probable costs

for each project were estimated after the designs were reviewed and finalized.

The Town asked for NCDOT's input and NCDOT Hydraulic Division representative asked about floodplain impact analysis for the five (5) projects, noting that it is easier to fund already programmed projects and add improvements to existing STIP projects for funding, and there may be additional funding available for implementation in the future.

The next steps for the project were discussed and include a review of the 2D model in the project locations looking at any potential needed refinements. The project designers reviewed the top five (5) project sites and confirmed moving forward to concept designs. Supporting the project designs, ESP Associates performed the proposed conditions model runs. As the stakeholder meeting concluded, stakeholders were asked to provide any additional comments or questions to the project PM and the Town. Further details of the stakeholder meeting and the presentation are provided in Appendix C.

4.2 SELECTION OF RESILIENT ROUTES

The Town reviewed the twenty-two (22) sites originally scored from the critical route analysis model using the methodology outlined in Section 3.2. The Town reviewed the original twenty-two sites and indicated that many of the identified sites had no known historical flooding issues and were outside of the municipal limits and were therefore not considered priority sites. The list was then revised to include sites only within the municipal boundaries leaving eleven (11) sites, and the top-scoring local routes were added to the list to give the Town a refined list of twenty-two sites. The Town of Leland also provided a list of five (5) additional sites that they wanted to have investigated due to known flooding issues. Of the revised twenty-two (22) sites, five priority sites were selected along with the five additional sites that had potential flooding issues to form a final list of ten prioritized sites. These ten (10) sites were provided in a ranked format by the Town of Leland and are listed below.

Moffatt & Nichol evaluated the ten (10) sites based on design project feasibility and the benefit of applying resiliency concepts that could improve the critical routes' functionality. Based on engineering recommendations and input from the Town of Leland, five of the sites were selected for conceptual designs. All ten sites that formed the final list of ten prioritized sites are listed below and included in Appendix B. Site #1 at Pine Harvest Drive was removed from preliminary plan development during the design project feasibility and the anticipated resiliency concepts benefits review process. Site #6 was removed from preliminary plan development after it was determined that the site had recently been improved by a NCDOT project and the new, improved crossing met the design standards that were set in the plan development for the sites. The sites that were advanced to preliminary plan development were Sites #2, #3, #4, #5, and #7.

Final List of the Ten (10) priority locations were identified:

- Site # 1 Pine Harvest Drive
- Site # 2 Springstone Drive / Lanvale Road (SR 1438) (Hearthstone)
- Site # 3 Orchard Loop Road and Lanvale Road (SR 1438)
- Site # 4 Low Country Boulevard (Brunswick Forest)
- Site # 5 Old Fayetteville Road (SR 1437) near Scorpion Drive
- Site # 6 Lanvale Road (SR 1438) near Breman Lane
- Site # 7 Old Fayetteville Road (SR 1437) at Division Drive
- Site # 8 Old Fayetteville Road (SR 1437) at Pickett Road
- Site # 9 NC-133 River Road
- Site # 10 Malmo Loop Road

5 DEVELOPMENT OF RESILIENT TRANSPORTATION IMPROVEMENT PROJECTS

Each of the five (5) selected project site descriptions is provided below and contains an environmental screening and project concept design. Appendix D provides each project description, concept plans and Engineer's Opinion of Probable cost for each of the five (5) selected priority project sites. Appendix E provides the survey information collected to inform the conceptual designs.

5.1 PROJECT DESCRIPTIONS AND ENVIRONMENTAL SCREENING

5.1.1 SITE # 5

5.1.1.1 SITE # 5 – PROJECT DESCRIPTION

Old Fayetteville Road near Scorpion Drive, Leland, NC
Replacement of Existing 48-inch Cross Pipe in Brunswick County

The Town's highest ranked priority resilient routes transportation project, proposed for funding through the Disaster Relief and Mitigation Fund, consists of a multi-phase plan to 1) develop final design plans, and 2) implement the replacement of an existing 48-inch reinforced concrete pipe (RCP) that crosses SR 1437 (Old Fayetteville Road) near Scorpion Drive (see below map). Site 5 is on Old Fayetteville Road and serves as a community lifeline route. Site 5 provides access to North Brunswick High School, which operates as a public shelter for the area when extreme weather events occur. Maintaining access to this location is critical for continuity of emergency management functions. Site 5 was prioritized as the highest priority project concept for the Town (see Section 4 Assessment Outcomes).

The project, located in the Sturgeon Creek watershed, a tributary of the Brunswick River, is to replace the existing undersized cross pipe with a larger 2 @ 10-feet x 7-feet Reinforced Concrete Box Culvert (RCBC). The project will maintain the same typical section, 2-12 feet lanes with 2-feet 6-inch curb and gutter on both sides and include the same 10-feet-wide multi-use path on the north side. Currently, the roadway overtops during the ten-year storm event. The proposed RCBC was selected to meet 100-year storm design criteria without overtopping the roadway. Based on available data, it is not anticipated that the new culvert will require a change to the existing roadway profile. The roadway will have to be closed during construction and a detour route will be provided. The construction schedule and road closure will need to be coordinated with North Brunswick High School.

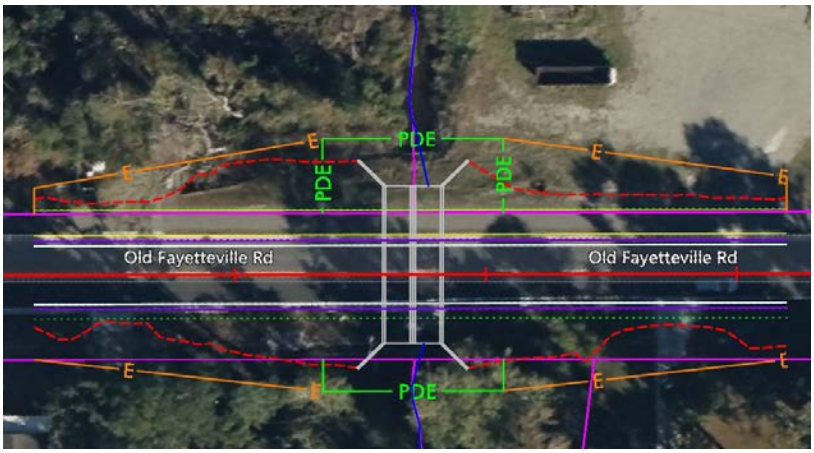


Figure 15: Old Fayetteville Road Proposed Culvert Replacement Project

Estimated High Level of Probable Cost: $1,097,138.

The project's purpose is to provide a resilient solution which will reduce the overtopping frequency of the road and improve access to the nearby emergency shelter. Currently the roadway overtops during the ten-year storm event. Factoring in resilience design concepts the proposed RCBC was selected to meet 100-year storm design criteria without overtopping the roadway and the 100-year peak discharge derived from USGS regression equations was increased by 10 percent. In addition, the tailwater was increased by one feet for sea level rise since the tailwater is coastally influenced. During the development of the final design phase, ecological design concepts can be investigated, including permitting and construction techniques using the FHWA's Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide.

Figure 16: Old Fayetteville Road Proposed Culvert Replacement Project

5.1.1.2 SITE # 5 – ENVIRONMENTAL SCREENING

A GIS desktop analysis was conducted to evaluate the project area and its surrounding environment and natural resources. This environmental screening is helpful to understand regulatory considerations and anticipate likely permitting steps needed in future phases of this project. This screening evaluated federally protected species and jurisdictional waters in the project vicinity. The regulatory requirements associated with each aspect, as well as the methodology used for each, are described in the following sections. However, these results do not preclude the need for an on-site investigation, and this step will still be necessary to conclude permitting needs.

5.1.1.3 NATURAL RESOURCES – PROTECTED SPECIES

As per Section 7 of the Endangered Species Act (ESA), a Section 7 consultation must take place for any project being federally permitted. If this project were to be federally permitted, this consultation must take place to ensure that actions will not jeopardize the continued existence of federally listed species or destroy areas of designated critical habitat. A review was conducted using the U.S. Fish and Wildlife's (USFWS) planning tool, Information for Planning and Consultation (IPaC) to determine which federally listed species are found in the vicinity of the project area. As shown below, Table 6 lists these species and their ESA status. According to IPaC, none of these species are likely to be adversely affected by this project, and no critical habitat exists in the project area.

5.1.1.4 JURISDICTIONAL STREAMS AND WETLANDS

The Clean Water Act (CWA) established federal jurisdiction over "waters of the United States", including streams and wetlands, and Section 404 of the Clean Water Act requires a federal permit for the discharge of dredged or fill material into these waters. If the project area overlaps with a jurisdictional stream or wetland, a federal permit may be required. A GIS desktop analysis was conducted of jurisdictional waters in the area, using the USFWS National Wetland Inventory (NWI) database and the North Carolina Department of Environmental Quality (NCDEQ) surface water classifications, or designated streams. Figure 17 shows the location of these resources near the project.

Table 6: Federally Listed Protected Species With Potential to Occur in The Project Vicinity

Scientific Name	Common Name	ESA Status	Federal Agency with Jurisdiction
Myotis septentrionalis	Northern Long-eared Bat	Endangered	USFWS
Perimyotis subflavus	Tricolored Bat	Proposed Endangered	USFWS
Trichechus manatus	West Indian Manatee	Threatened	USFWS/NOAA NMFS
Picoides borealis	Red-cockaded Woodpecker	Endangered	USFWS
Charadrius melodus	Piping Plover	Threatened	USFWS
Calidris canutus rufa	Rufa Red Knot	Threatened	USFWS
Alligator mississippiensis	American Alligator	Threatened due to similarity of appearance	USFWS
Caretta caretta	Loggerhead Sea Turtle	Threatened	USFWS/NOAA NMFS
Chelonia mydas	Green Sea Turtle	Threatened	USFWS/NOAA NMFS
Lepidochelys kempii	Kemp's Ridley Sea Turtle	Endangered	USFWS/NOAA NMFS
Dermochelys coriacea	Leatherback Sea Turtle	Endangered	USFWS/NOAA NMFS
Planorbella magnifica	Magnificent Ramshorn	Endangered	USWFS
Lyismachia asperulaefolia	Rough-leaved loosestrife	Endangered	USFWS
Thalictrum cooleyi	Cooley's Meadowrue	Endangered	USFWS

5.1.1.5 ANTICIPATED PERMITTING AND NEXT STEPS

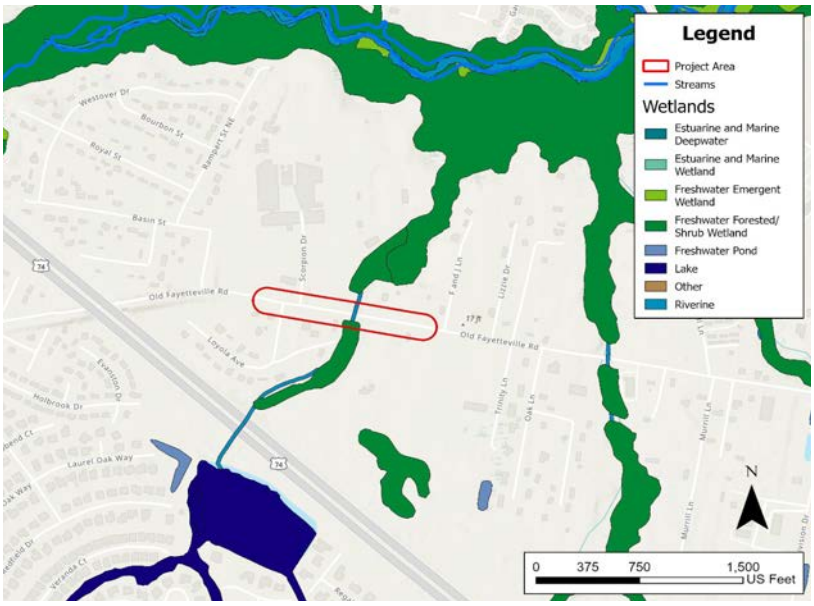
Federal Permits

The project area for this proposed project overlaps with an area classified by the USFWS NWI as wetland area, indicating the likelihood of a jurisdictional wetland, as classified by Section 404 of the Clean Water Act. Additionally, this project area overlaps with a designated stream. Therefore, it is anticipated that this project can be authorized by either a Nationwide Permit or Regional General Permit through the U.S. Army Corps of Engineers. Upon further inspection of the project site, consisting of an in-person investigation of natural resources present and potentially a wetland delineation, if no wetlands or waters of the U.S. (including streams) appear to be impacted, a federal permit may not be required.

State Permits

This project does not appear to involve any impacts to coastal resources, such as an estuarine or marine wetlands or public trust waters, so a North Carolina Coastal Areas Management Act (CAMA) Permit is not expected.

Figure 17: Map of Project Area in Relation to Jurisdictional Streams and Wetlands – Site 5



5.1.2 SITE # 2

5.1.2.1 SITE # 2 – PROJECT DESCRIPTION

Intersections of Lanvale Road./Springstone Road, and Lanvale Road/Old Lanvale Road

The Town's second ranked priority resilient routes transportation project consists of a multi-phase plan to 1) develop final design plans, and 2) alleviate storm drainage concerns and upgrade storm systems in the intersections of Lanvale Road/Springstone Road and Lanvale Road/Old Lanvale Road.

Currently, there is localized flooding at the intersection of Lanvale Road and Springstone Road. This is an entrance into the Hearthstone neighborhood. This flooding is caused because the ditches leading up to the intersection do not have a pipe or structure to capture the runoff before it flows onto Springstone Road. There is also flooding at the intersection of Lanvale Road and Old Lanvale Road. This flooding is caused because the cross

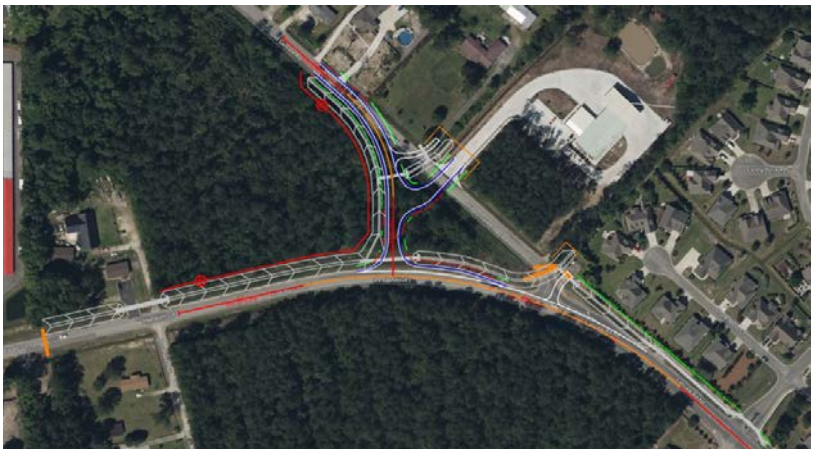


Figure 18: Intersections of Lanvale Road/ Springstone Road and Lanvale Road/ Old Lanvale Road

pipes under the intersection are undersized. Currently there is only a 24-inch RCP and 15-inch RCP conveying all the discharge at this location and the current level of service is only the 10-year storm event.

The project's purpose is to provide a resilient solution which will reduce flooding at the intersections. Proposed upgrades begin near the entrance of Hearthstone neighborhood at Springstone Road and Lanvale Road, where a new drainage system is proposed to alleviate the flooding problem at the intersection. The storm drainage system was proposed instead of ditch clean out to preserve the existing sidewalks. South of the fire station driveway a 36-inch RCP has been proposed to pick up a large drainage area so that all the discharge does not flow to the western side of intersection of Lanvale Road and Old Lanvale Road. The primary upgrade related to improving the emergency services response for the nearby fire station is at the intersection of Lanvale Road and Old Lanvale Road This intersection has been realigned with a proposed 48-inch RCP upgrade.

Both proposed cross-pipes have been designed for the 25-year storm. Factoring in a resilience and sustainability design concept for the roadway facility, the cross pipes have been upsized one nominal pipe size to account for flow increases and future pipe rehabilitation. Additionally, stormwater treatment options will be evaluated in the design phase upstream of the new intersection to utilize the open area created by shifting the intersection.

Estimated High Level of Probable Cost: $1,402,079.

5.1.2.2 SITE # 2 – ENVIRONMENTAL SCREENING

A GIS desktop analysis was conducted to evaluate the project area and its surrounding environment and natural resources. This environmental screening is helpful to understand regulatory considerations and anticipate likely permitting steps needed in future phases of this project. This screening evaluated federally protected species as well as jurisdictional waters in the project vicinity. The regulatory requirements associated with each aspect, as well as the methodology used for each, are described in the following sections. However, these results do not preclude the need for an on-site investigation, and this step will still be necessary to conclude permitting needs.

5.1.2.3 NATURAL RESOURCES – PROTECTED SPECIES

As per Section 7 of the Endangered Species Act (ESA),

Table 7: Federally Listed Protected Species with Potential to Occur in The Project Vicinity

Scientific Name	Common Name	ESA Status	Federal Agency with Jurisdiction
Myotis septentrionalis	Northern Long-eared Bat	Endangered	USFWS
Perimyotis subflavus	Tricolored Bat	Proposed Endangered	USFWS
Trichechus manatus	West Indian Manatee	Threatened	USFWS/NOAA NMFS
Picoides borealis	Red-cockaded Woodpecker	Endangered	USFWS
Charadrius melodus	Piping Plover	Threatened	USFWS
Calidris canutus rufa	Rufa Red Knot	Threatened	USFWS
Alligator mississippiensis	American Alligator	Threatened due to similarity of appearance	USFWS
Caretta caretta	Loggerhead Sea Turtle	Threatened	USFWS/NOAA NMFS
Chelonia mydas	Green Sea Turtle	Threatened	USFWS/NOAA NMFS
Lepidochelys kempii	Kemp's Ridley Sea Turtle	Endangered	USFWS/NOAA NMFS
Dermochelys coriacea	Leatherback Sea Turtle	Endangered	USFWS/NOAA NMFS
Planorbella magnifica	Magnificent Ramshorn	Endangered	USWFS
Lyismachia asperulaefolia	Rough-leaved loosestrife	Endangered	USFWS
Thalictrum cooleyi	Cooley's Meadowrue	Endangered	USFWS

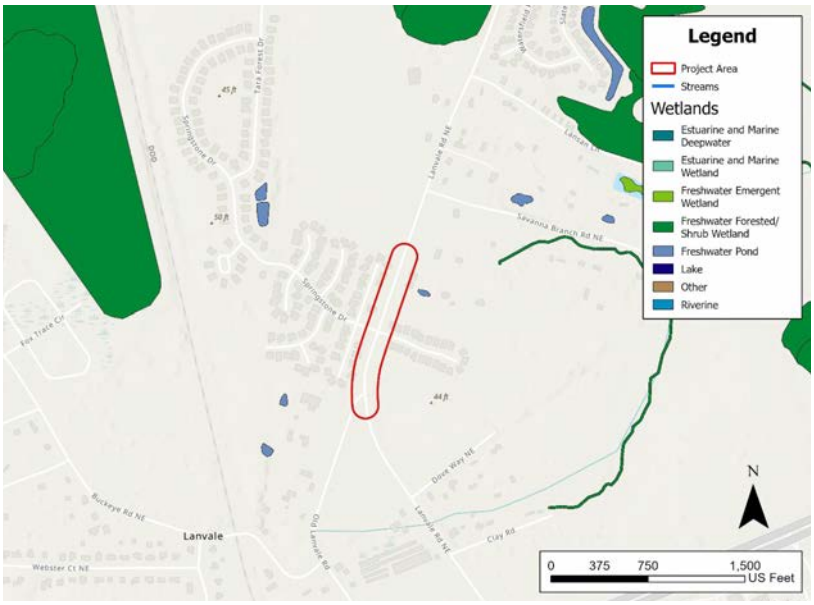


Figure 19: Map of Project Area in Relation to Jurisdictional Streams and Wetlands – Site 2

a Section 7 consultation must take place for any project that is being federally permitted. If this project were to be federally permitted, this consultation must take place to ensure that actions will not jeopardize the continued existence of federally listed species or destroy areas of designated critical habitat. A review was conducted using the U.S. Fish and Wildlife's (USFWS) planning tool, Information for Planning and Consultation (IPaC) to determine which federally listed species are found in the vicinity of the project area. As shown below, Table 7 lists these species and their ESA status. According to IPaC, none of these species are likely to be adversely affected by this project, and no critical habitat exists in the project area.

5.1.2.4 JURISDICTIONAL STREAMS AND WETLANDS

The CWA established federal jurisdiction over "waters of the United States", including streams and wetlands, and Section 404 of the Clean Water Act requires a federal permit for the discharge of dredged or fill material into these waters. If the project area overlaps with a jurisdictional stream or wetland, a federal permit may be required. A desktop analysis was conducted of jurisdictional waters in the area, using the USFWS National Wetland Inventory (NWI) database and the North Carolina Department of Environmental Quality (NCDEQ) surface water classifications, or designated streams. Figure 19 displays the location of these resources in the vicinity of the project.

5.1.2.5 ANTICIPATED PERMITTING AND NEXT STEPS

Federal Permits

The project area for this proposed project does not overlap with any areas classified by the USFWS NWI as wetland areas. Therefore, it is anticipated that this project will not need to be authorized by a Nationwide Permit or Regional General Permit through the U.S. Army Corps of Engineers. Upon further inspection of the project site, consisting of an in-person investigation of natural resources present and potentially a wetland delineation, if no wetlands or waters of the U.S. (including streams) appear to be impacted, a federal permit may not be required.

State Permits

This project does not appear to involve any impacts to coastal resources, such as an estuarine or marine wetlands or public trust waters, so a North Carolina Coastal Areas Management Act (CAMA) Permit is not expected.

5.1.3 SITE # 4

5.1.3.1 SITE # 4 – PROJECT DESCRIPTION

Low Country Boulevard in Brunswick Forest, Improvement of Crossing, Leland, NC

The Town's third ranked priority resilient routes transportation project consists of upgrading two existing 48-inches RCPs carrying Mallory Creek under Low Country Boulevard between Bateau Drive and Leesburg Drive. In the current condition the HEC RAS 1D model analysis shows that the existing crossing overtops during the 10-year storm event. The project's purpose is to provide a resilient solution which will reduce the frequency of the roadway overtopping and ensure it operates at a 100-year level of service.

The recommended concept is to replace the existing 48-inch RCP with a 2 @ 11-feet x 6-feet RCBC. Factoring in resilience design concepts, the crossing was designed for the 100-year storm event and the 100-year peak discharge derived from USGS regression equations was increased by 10 percent. During the development of the final design phase, ecological design concepts can be investigated, including permitting and construction techniques using the FHWA's Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide.

Estimated High Level of Probable Cost: $1,292,210.

5.1.3.2 SITE # 4 – ENVIRONMENTAL SCREENING

A GIS desktop analysis was conducted to evaluate the project area and its surrounding environment and natural resources. This environmental screening is helpful to understand regulatory considerations and anticipate likely permitting steps needed in future phases of this

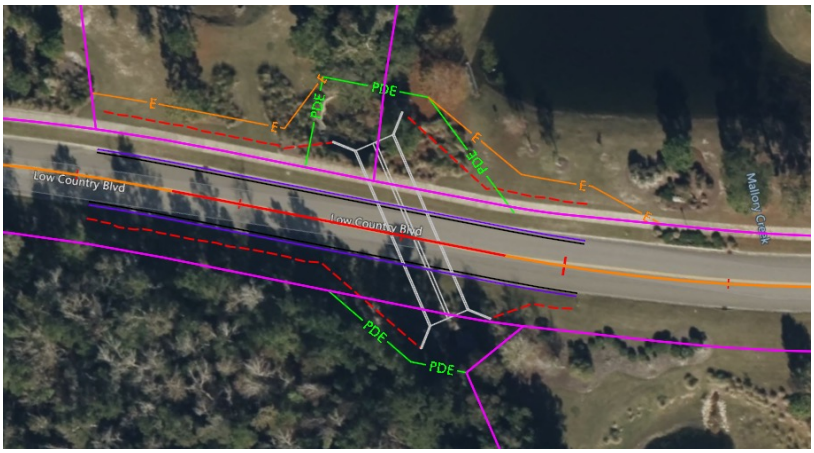


Figure 20: Low Country Boulevard near Brunswick Forest Improvement of Crossing, Leland, NC

project. This screening evaluated federally protected species as well as jurisdictional waters in the project vicinity. The regulatory requirements associated with each aspect, as well as the methodology used for each, are described in the following sections. However, these results do not preclude the need for an on-site investigation, and this step will still be necessary to conclude permitting needs.

5.1.3.3 NATURAL RESOURCES – PROTECTED SPECIES

As per Section 7 of the Endangered Species Act (ESA), a Section 7 consultation must take place for any project being federally permitted. If this project were to be federally permitted, this consultation must take place to ensure that actions will not jeopardize the continued existence of federally listed species or destroy areas of designated critical habitat. A review was conducted using the U.S. Fish and Wildlife's (USFWS) planning tool, Information for Planning and Consultation (IPaC) to determine which federally listed species are found in the vicinity of the project area. As shown below, Table 8 lists these species and their ESA status. According to IPaC, none of these species are likely to be adversely affected by this project, and no critical habitat exists in the project area.

5.1.3.4 JURISDICTIONAL STREAMS AND WETLANDS

The CWA established federal jurisdiction over "waters of the United States", including streams and wetlands, and Section 404 of the Clean Water Act requires a federal permit for the discharge of dredged or fill material into these waters. If the project area overlaps with a jurisdictional stream or wetland, a federal permit may be required. A desktop analysis was conducted of jurisdictional waters in the area, using the USFWS National Wetland Inventory (NWI) database and the North Carolina Department of Environmental Quality (NCDEQ) surface water classifications, or designated streams. Figure 21 displays the location of these resources in the vicinity of the project.

5.1.3.5 ANTICIPATED PERMITTING AND NEXT STEPS

Federal Permits

The project area for this proposed project overlaps with an area classified by the USFWS NWI as wetland area, indicating the likelihood of a jurisdictional wetland, as classified by Section 404 of the Clean Water Act. Additionally, this project area overlaps with a designated

Table 8: Federally Listed Protected Species with Potential to Occur in The Project Vicinity

Scientific Name	Common Name	ESA Status	Federal Agency with Jurisdiction
Myotis septentrionalis	Northern Long-eared Bat	Endangered	USFWS
Perimyotis subflavus	Tricolored Bat	Proposed Endangered	USFWS
Trichechus manatus	West Indian Manatee	Threatened	USFWS/NOAA NMFS
Picoides borealis	Red-cockaded Woodpecker	Endangered	USFWS
Charadrius melodus	Piping Plover	Threatened	USFWS
Calidris canutus rufa	Rufa Red Knot	Threatened	USFWS
Alligator mississippiensis	American Alligator	Threatened due to similarity of appearance	USFWS
Caretta caretta	Loggerhead Sea Turtle	Threatened	USFWS/NOAA NMFS
Chelonia mydas	Green Sea Turtle	Threatened	USFWS/NOAA NMFS
Lepidochelys kempii	Kemp's Ridley Sea Turtle	Endangered	USFWS/NOAA NMFS
Dermochelys coriacea	Leatherback Sea Turtle	Endangered	USFWS/NOAA NMFS
Planorbella magnifica	Magnificent Ramshorn	Endangered	USWFS
Lyismachia asperulaefolia	Rough-leaved loosestrife	Endangered	USFWS
Thalictrum cooleyi	Cooley's Meadowrue	Endangered	USFWS

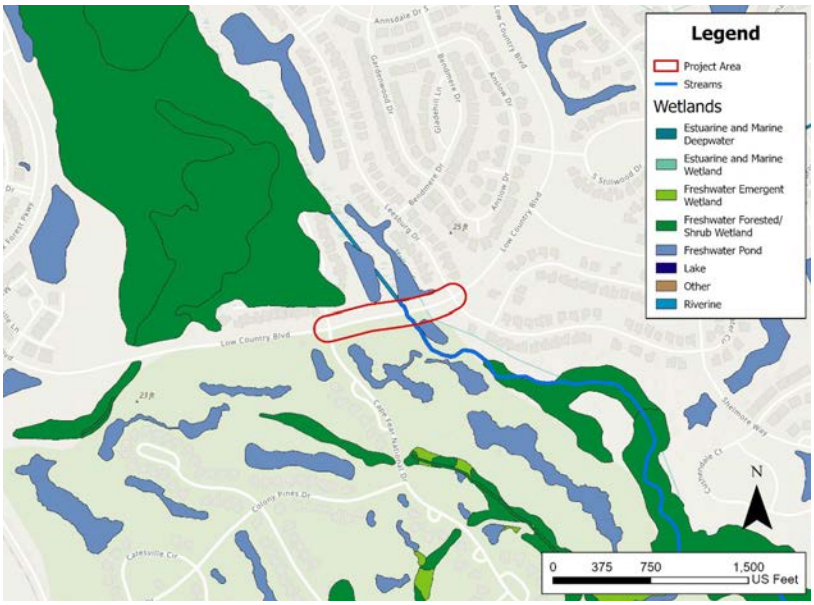


Figure 21: Map of Project Area in Relation to Jurisdictional Streams and Wetlands – Site 4

stream. Therefore, it is anticipated that this project can be authorized by either a Nationwide Permit or Regional General Permit through the U.S. Army Corps of Engineers. Upon further inspection of the project site, consisting of an in-person investigation of natural resources present and potentially a wetland delineation, if no wetlands or waters of the U.S. (including streams) appear to be impacted, a federal permit may not be required.

State Permits

This project does not appear to involve any impacts to coastal resources, such as an estuarine or marine wetlands or public trust waters, therefore a North Carolina Coastal Areas Management Act (CAMA) Permit is not expected to be required.

5.1.4 SITE # 3

5.1.4.1 SITE # 3 – PROJECT DESCRIPTION

Lanvale Road near Orchard Loop Road, Leland, NC

The Town's fourth ranked priority resilient routes transportation project consists of a multi-phase plan to 1) develop final design plans, and 2) alleviate storm drainage concerns and upgrade the outlet drainage near the intersection of Lanvale Road (NCDOT SR 1438) and Orchard Loop Road. The project's purpose is to provide a resilient solution which will reduce flooding at the intersection.

Currently, there is localized flooding at and near the intersection of Lanvale Road and Orchard Loop Road. This is an entrance into the Lanvale Trace neighborhood. There is an alternate entrance into this neighborhood via Lewis Road. The street flooding within the neighborhood is most probably caused by the neighborhood's stormwater pond normal water surface elevation and outlet restrictions to the stormwater pond caused by the roadside ditch and the two existing 42-inch RCPs crossing Lanvale Road approximately ninety feet downstream of the pond outlet.

This concept plan improves the hydraulic conductivity downstream of the neighborhood so that the storm stage elevations of the pond will not cause backwater into the neighborhood streets. Currently downstream of the stormwater pond outlet there are two 42-inch RCPs carrying a 0.20 square mile drainage area across Lanvale Road. The current level of service provided by the existing 42-inch cross pipes is the 10-year storm. The existing crossing does not meet the current NCDOT Drainage Guidelines which would specify a minimum level of service for a 25-year storm event. The pond storm stage elevations also cannot be reduced unless the pipes under Lanvale Road are upgraded to reduce the headwater at the pipe inlets. Upgrading the cross pipes will have the dual purpose of helping with flooding of the neighborhood street but also improving the level of service on a critical emergency response route for the Town of Leland.

Proposed Drainage Improvements

The proposed solution is to upgrade the existing pipe crossing of Lanvale Road to provide a resilient solution. Factoring in resilience design concepts, the crossing was designed for the 100-year storm event and the 100-year peak discharge derived from USGS regression equations was increased by 10 percent. The proposed concept design replaces the existing dual 42-inch pipes with a 2 @ 7-feet (W) x 6-feet (H) RCBC. A headwall is proposed on each end of the culvert. The upstream and downstream channels of the crossing will be regraded to improve hydraulic conductivity with optional stream restoration improvements further downstream.

In addition to the culvert and channel improvements, Lanvale Road will be raised a foot and a half along with a portion of Orchard Loop Road at the entrance to the neighborhood. The project will maintain the same typical section, 2-10 feet lanes with a 10-feet turn lane into the neighborhood. Raising the roadway will help reduce the impacts of roadway flooding caused by the existing neighborhood pond. During the development of the final design phase, ecological design concepts can be investigated, including permitting and construction techniques using the FHWA's Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide.

Estimated High Level of Probable Cost: $1,807,498. Optional stream restoration improvements further downstream will result in an additive bid. Estimated

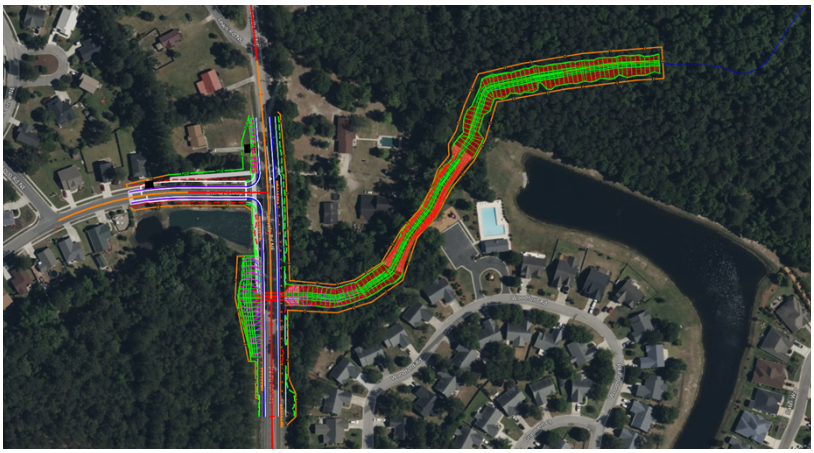


Figure 22: Lanvale Road near Orchard Loop Road, Leland, NC

High Level of Probable Cost for Additive Bid - Stream Restoration: $786,500

Notes: Surveys of existing utilities were not conducted as they were not in the scope of work but will need to be considered in the final design. There is an overhead power line at the crossing that may need to be temporarily relocated during construction. No on-site wetland or stream delineations have been performed for the preliminary design. There is the potential for environmental impacts if the outlet channel is determined to be a jurisdictional stream and/or wetland during the final design process. Any significant impacts to jurisdictional features will require a permit and permit costs are not included in our cost estimate.

5.1.4.2 SITE # 3 – ENVIRONMENTAL SCREENING

A GIS desktop analysis was conducted to evaluate the project area and its surrounding environment and natural resources. This environmental screening is helpful to understand regulatory considerations and anticipate likely permitting steps needed in future phases of this project. This screening evaluated federally protected species as well as jurisdictional waters in the project vicinity. The regulatory requirements associated with each aspect, as well as the methodology used for each, are described in the following sections. However, these results do not preclude the need for an on-site investigation, and this step will still be necessary to conclude permitting needs.

5.1.4.3 NATURAL RESOURCES – PROTECTED SPECIES

As per Section 7 of the Endangered Species Act (ESA), a Section 7 consultation must take place for any project being federally permitted. If this project were to be federally permitted, this consultation must take place to ensure that actions will not jeopardize the continued existence of federally listed species or destroy areas of designated critical habitat. A review was conducted using the U.S. Fish and Wildlife's (USFWS) planning tool, Information for Planning and Consultation (IPaC) to determine which federally listed species are found in the vicinity of the project area. As shown below, Table 9 lists these species and their ESA status. According to IPaC, none of these species are likely to be adversely affected by this project, and no critical habitat exists in the project area.

Table 9: Federally Listed Protected Species with Potential to Occur in The Project Vicinity

Scientific Name	Common Name	ESA Status	Federal Agency with Jurisdiction
Myotis septentrionalis	Northern Long-eared Bat	Endangered	USFWS
Perimyotis subflavus	Tricolored Bat	Proposed Endangered	USFWS
Trichechus manatus	West Indian Manatee	Threatened	USFWS/NOAA NMFS
Picoides borealis	Red-cockaded Woodpecker	Endangered	USFWS
Charadrius melodus	Piping Plover	Threatened	USFWS
Calidris canutus rufa	Rufa Red Knot	Threatened	USFWS
Alligator mississippiensis	American Alligator	Threatened due to similarity of appearance	USFWS
Caretta caretta	Loggerhead Sea Turtle	Threatened	USFWS/NOAA NMFS
Chelonia mydas	Green Sea Turtle	Threatened	USFWS/NOAA NMFS
Lepidochelys kempii	Kemp's Ridley Sea Turtle	Endangered	USFWS/NOAA NMFS
Dermochelys coriacea	Leatherback Sea Turtle	Endangered	USFWS/NOAA NMFS
Planorbella magnifica	Magnificent Ramshorn	Endangered	USWFS
Lyismachia asperulaefolia	Rough-leaved loosestrife	Endangered	USFWS
Thalictrum cooleyi	Cooley's Meadowrue	Endangered	USFWS

Figure 23: Map of Project Area in Relation to Jurisdictional Streams and Wetlands – Site 3

5.1.4.4 JURISDICTIONAL STREAMS AND WETLANDS

The CWA established federal jurisdiction over "waters of the United States", including streams and wetlands, and Section 404 of the Clean Water Act requires a federal permit for the discharge of dredged or fill material into these waters. If the project area overlaps with a jurisdictional stream or wetland, a federal permit may be required. A desktop analysis was conducted of jurisdictional waters in the area, using the USFWS National Wetland Inventory (NWI) database and the North Carolina Department of Environmental Quality (NCDEQ) surface water classifications, or designated streams. Figure 23 shows the location of these resources near the project.

5.1.4.5 ANTICIPATED PERMITTING AND NEXT STEPS

Federal Permits

The project area for this proposed project overlaps with an area classified by the USFWS NWI as wetland area, indicating the likelihood of a jurisdictional wetland, as classified by Section 404 of the Clean Water Act. Additionally, this project area overlaps with a designated stream. Therefore, it is anticipated that this project can be authorized by either a Nationwide Permit or Regional General Permit through the U.S. Army Corps of Engineers. Upon further inspection of the project site, consisting of an in-person investigation of natural resources present and potentially a wetland delineation, if no wetlands or waters of the U.S. (including streams) appear to be impacted, a federal permit may not be required.

State Permits

This project does not appear to involve any impacts to coastal resources, such as an estuarine or marine wetlands or public trust waters, so a North Carolina Coastal Areas Management Act (CAMA) Permit is not expected.

5.1.5 SITE # 7

5.1.5.1 SITE # 7 – PROJECT DESCRIPTION

Intersection of Old Fayetteville Road/Division Drive, Leland, NC

The Town's seventh ranked priority resilient routes transportation project consists of a multi-phase plan to 1) develop final design plans, and 2) alleviate roadway flooding near the intersection of Old Fayetteville Road (NCDOT SR 1437) and Division Drive. Along Old Fayetteville Road, 0.75 miles west of this intersection, is North Brunswick High School, which serves as an emergency shelter. Maintaining access during storm events is critical to the Town.

Currently, there is flooding at the intersection of Old Fayetteville Road and Division Drive. Across Old Fayetteville Road is a turnout that is being connected with Perry Avenue as a part of the Founders Park Renovations. The flooding across Old Fayetteville Road is caused by the undersized 48-inch corrugated metal pipe (CMP) crossing the roadway that also has a lower inlet invert than the outlet invert. The 48-inch CMP has a drainage area flowing to it of 0.35 square miles. The 36-inch CMP under Division Drive is also undersized and likely adds to the flooding problems at the intersection. The 36-inch CMP has a drainage area flowing to it of 0.31 square miles. The current level of service provided for Old Fayetteville Road is less than the 10-year storm event. The existing crossing does not meet the current NCDOT Drainage Guidelines which would specify a minimum level of service for the 25-year storm event.

This concept plan improves the conveyance of the cross pipes under Division Drive and Old Fayetteville Road while providing some additional ponding area and volume in the southwest quadrant. The outlet for the proposed cross pipes under Old Fayetteville Road is also being improved to facilitate better hydraulic conveyance. The purpose of the project is to provide a resilient solution which will reduce the flooding at the intersection and maintain access to the emergency shelter.

Estimated High Level of Probable Cost: $1,017,986.

5.1.5.2 PROPOSED DRAINAGE IMPROVEMENTS

The crossing was designed so the design-year storm event would not overtop the roadway facility. Factoring

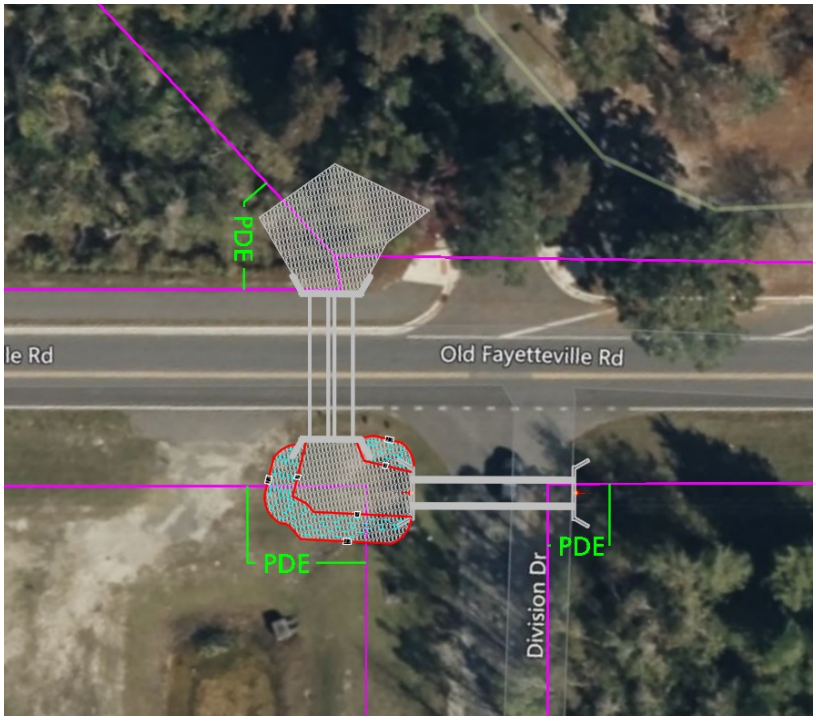


Figure 24: Intersection of Old Fayetteville Road/Division Drive, Leland, NC

resiliency into the design concepts, the old Fayetteville Road crossing was designed for the 100-year storm event and 100-year peak discharge, derived from USGS regression equations, was increased by 10 percent. At the crossing of Old Fayetteville Road, it is proposed to remove the existing 48-inch CMP and replace it with a 2 @ 6-feet X 6-feet RCBC with each barrel buried one foot. At the crossing of Division Drive it is proposed to remove the existing 36-inch CMP and replace it with two 60-inch RCPs buried one foot. An endwall is proposed on each end of the proposed pipes and culvert. The area between the proposed crossings in the southwest quadrant is proposed to be excavated down to the invert of the new proposed pipes to provide additional area for water to pond and to allow the pipes to be installed under both Division Drive and Old Fayetteville Road without needing to regrade the roadways while providing adequate cover. Maintaining the grade of Old Fayetteville Road eliminates potential issues with the construction of the Founders Park Renovations. The downstream impacts from this project are expected to be minimal as the roadway overtops during the existing so the peak discharge is likely to be similar to the existing peak discharge flowing downstream. In addition, using NC Q2LiDAR there does not appear to be any insurable structures that would be impacted by any changes in the discharges downstream or upstream of the proposed improvements.

Notes: Surveys of existing utilities were not conducted as they were not included in the scope of work but will need to be considered in the final design. Existing utilities shown on the plans are referenced from the U-5534D project files provided by the Town of Leland. It indicates that there are gravity sanitary sewer lines in the project area that should not conflict with the proposed improvements as they are located lower than any of the improvements. There are overhead power lines, underground telephone lines, water lines, and potentially three sanitary sewer force mains in the area that could potentially be impacted by the proposed improvements. No on-site wetland or stream delineations have been

Table 10: Federally Listed Protected Species with Potential to Occur in The Project Vicinity

Scientific Name	Common Name	ESA Status	Federal Agency with Jurisdiction
Myotis septentrionalis	Northern Long-eared Bat	Endangered	USFWS
Perimyotis subflavus	Tricolored Bat	Proposed Endangered	USFWS
Trichechus manatus	West Indian Manatee	Threatened	USFWS/NOAA NMFS
Picoides borealis	Red-cockaded Woodpecker	Endangered	USFWS
Charadrius melodus	Piping Plover	Threatened	USFWS
Calidris canutus rufa	Rufa Red Knot	Threatened	USFWS
Alligator mississippiensis	American Alligator	Threatened due to similarity of appearance	USFWS
Caretta caretta	Loggerhead Sea Turtle	Threatened	USFWS/NOAA NMFS
Chelonia mydas	Green Sea Turtle	Threatened	USFWS/NOAA NMFS
Lepidochelys kempii	Kemp's Ridley Sea Turtle	Endangered	USFWS/NOAA NMFS
Dermochelys coriacea	Leatherback Sea Turtle	Endangered	USFWS/NOAA NMFS
Planorbella magnifica	Magnificent Ramshorn	Endangered	USWFS
Lyismachia asperulaefolia	Rough-leaved loosestrife	Endangered	USFWS
Thalictrum cooleyi	Cooley's Meadowrue	Endangered	USFWS

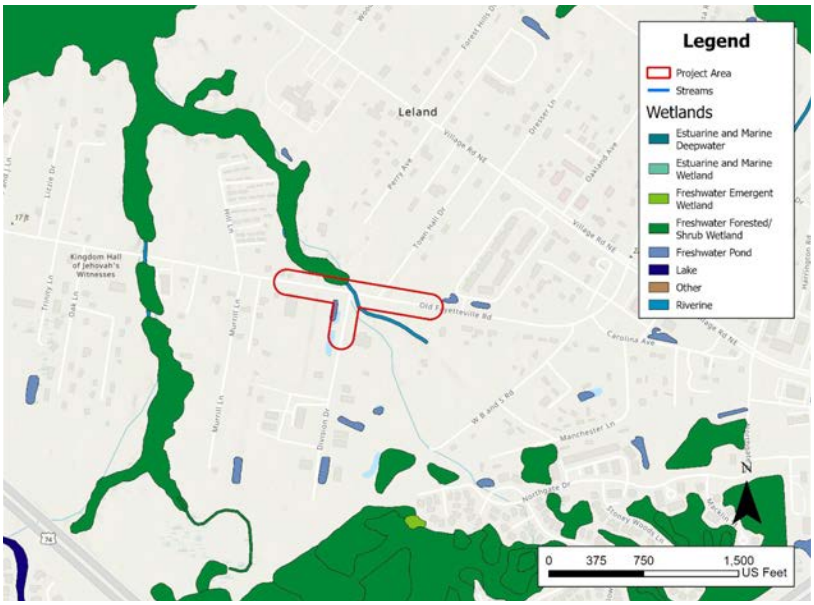


Figure 25: Map of Project Area in Relation to Jurisdictional Streams and Wetlands – Site 7

performed for the preliminary design. The U-5534D_UC Record Drawings provided by the Town of Leland indicate that there are wetlands near the inlet of the existing 36-inch CMP under Division Drive and near the outlet of the 48-inch CMP under Old Fayetteville Road. There are likely to be some wetland impacts from the construction of these proposed improvements if the wetlands are verified to still be present when the project progresses. Any significant impacts to jurisdictional features will require a permit and permit costs are not included in our cost estimate.

5.1.5.3 SITE # 7 – ENVIRONMENTAL SCREENING

A GIS desktop analysis was conducted to evaluate the project area and its surrounding environment and natural resources. This environmental screening is helpful to understand regulatory considerations and anticipate likely permitting steps needed in future phases of this project. This screening evaluated federally protected species as well as jurisdictional waters in the project vicinity. The regulatory requirements associated with each aspect, as well as the methodology used for each, are described in the following sections. However, these results do not preclude the need for an on-site investigation, and this step will still be necessary to conclude permitting needs.

5.1.5.4 NATURAL RESOURCES – PROTECTED SPECIES

As per Section 7 of the Endangered Species Act (ESA), a Section 7 consultation must take place for any project that is being federally permitted. If this project were to be federally permitted, this consultation must take place to ensure that actions will not jeopardize the continued existence of federally listed species or destroy areas of designated critical habitat. A review was conducted using the U.S. Fish and Wildlife's (USFWS) planning tool, Information for Planning and Consultation (IPaC) to determine which federally listed species are found in the vicinity of the project area. As shown below, Table 10 lists these species and their ESA status. According to IPaC, none of these species are likely to be adversely affected by this project, and no critical habitat exists in the project area.

5.1.5.5 JURISDICTIONAL STREAMS AND WETLANDS

The CWA established federal jurisdiction over "waters of the United States", including streams and wetlands, and Section 404 of the Clean Water Act requires a federal permit for the discharge of dredged or fill material into these waters. If the project area overlaps with a jurisdictional stream or wetland, a federal permit may be required. A desktop analysis was conducted of jurisdictional waters in the area, using the USFWS National Wetland Inventory (NWI) database and the North Carolina Department of Environmental Quality (NCDEQ) surface water classifications, or designated streams. Figure 25 displays the location of these resources in the vicinity of the project.

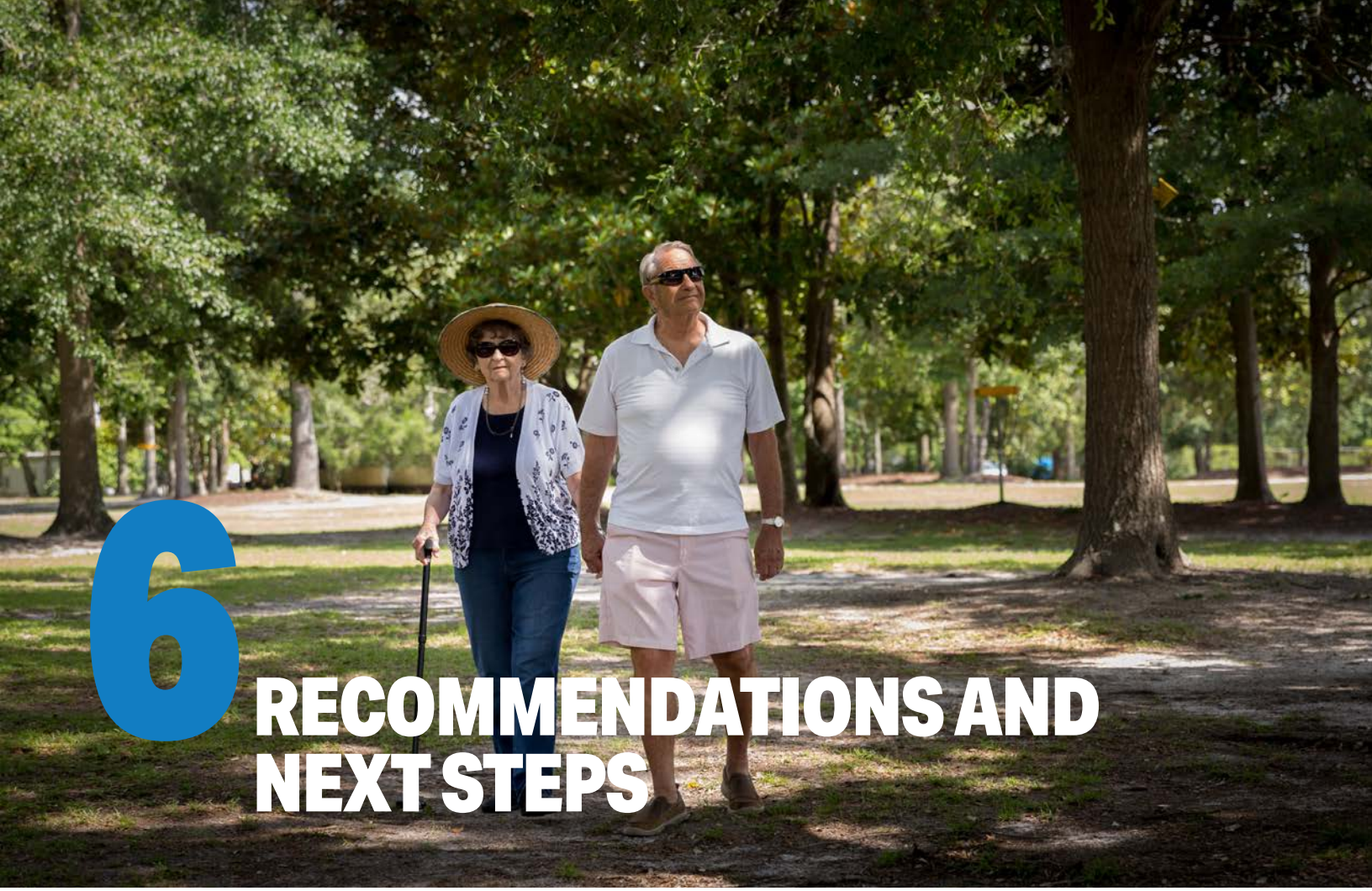
5.1.5.6 ANTICIPATED PERMITS AND NEXT STEPS

Federal Permit

The project area for this proposed project overlaps with an area classified by the USFWS NWI as wetland area, indicating the likelihood of a jurisdictional wetland, as classified by Section 404 of the Clean Water Act. Additionally, this project area overlaps with a designated stream. Therefore, it is anticipated that this project can be authorized by either a Nationwide Permit or Regional General Permit through the U.S. Army Corps of Engineers. Upon further inspection of the project site, consisting of an in-person investigation of natural resources present and potentially a wetland delineation, if no wetlands or waters of the U.S. (including streams) appear to be impacted, a federal permit may not be required.

State Permits

This project does not appear to involve any impacts to coastal resources, such as an estuarine or marine wetlands or public trust waters, therefore a North Carolina Coastal Areas Management Act (CAMA) Permit is not expected to be required.



6 RECOMMENDATIONS AND NEXT STEPS

6.1 RESILIENCY AND POLICY RECOMMENDATIONS

As outlined in Leland 2045, the Town of Leland's vision may be met by "reviewing and updating existing ordinances and regulations to provide clarity, improve organization, and support the vision and goals of the Leland 2045 plan." The Town's policies and zoning standards were reviewed to address infrastructure and community resilience. Taking action to build and plan for resilient infrastructure requires creative solutions that are supported by resilient supportive policies and codes. Land use and transportation strategies can inform and support planning for more resilient infrastructure.

Local governments are in a unique position to promote resiliency through land use planning, ordinances and infrastructure improvements, floodplain management, and more with the appropriate tools and necessary information and understanding of local issues. Moffatt & Nichol reviewed regulatory and policy language from other communities in North Carolina and national resilience projects and used best practices that provide successful land use and transportation

Table 11: Recommended Policy Update

Policy, Code, Ordinance, Existing Condition	Current Policy or Condition	Recommended Changes and Comments
2021 Comprehensive Plan, Leland 2045: Planning for Generations	New Policies, standards and guidance	Integrate and expand resilience concepts into comprehensive plan elements zoning code and define the term "Resilience" recognizing climate change as an overarching issue.
Code, Ordinance, Existing Conditions Overlay Districts	Chapter 46 – Streets, Sidewalks and other Public Spaces New Section	Create a Resilient Transportation Corridor Overlay Zoning District along linear corridors that have one or more vulnerable segments identified in the Resilient Routes project. See "proposed projects" 1-5. This is intended to promote more resilient transportation assets, connectivity, help decision making and prioritization in infrastructure investment, and launch successful resilient projects and funding for the Town of Leland. See information on NCDOT Resilient Policy: https://www.ncdot.gov/initiatives-policies/Transportation/transportation-resilience/Documents/ncdot-resilience-policy.pdf

Policy, Code, Ordinance, Existing Condition	Current Policy or Condition	Recommended Changes and Comments
Stormwater Requirements	Chapter 26 – Environment, Floods, and Stormwater New or Revised development code and stormwater regulations	Address zoning requirements for stormwater and water infrastructure that considers the risks associated with climate change and SLR by incorporating the results of climate projections and modeling into development regulations and infrastructure design. More information regarding opportunities to address improved stormwater and water quality protection can be found at http://www.epa.gov/ smartgrowth/water_scorecard.htm..
Zoning standards for flood mitigation, and development review processes	Chapter 26 – Environment, Floods, and Stormwater and Chapter 66 – Zoning Plan for resilience and adaptation	Adopt higher design standards and thresholds as part of the development review process and incorporate resilience measures into the zoning code, such as those described by LEED or other similar climate-supportive certification systems so all new developments can be designed to attain certification. Create incentive-based programs that promote the creation of development that meets resilience standards. Provide tools that promote resilient development including checklists and applications that can be used by developers and partners.
Address new development in existing designated hazard areas.	Chapter 26 – Environment, Floods, and Stormwater Discourage new development hazard areas utilizing best available data to determine extent of future flood hazard areas due to climate change and new development pressures.	Develop and enforce regulations that prohibit and/or mitigate the development of new projects located in identified hazard zones and assess the use of transfer of development rights and incentives to locate new development to less vulnerable areas. Adopt higher design standards in areas prone to flooding, including seal level rise and rainfall. Proactively expand hazard protection zones and areas to reduce future risk and utilize a layered adaptation approach to apply mitigation and adaptation strategies to promote greater resilience.
Flood Damage Prevention Ordinances	Article 11. Flood Damage Prevention Specifications for development, retaining walls, roads/ watercourse crossings.	Add standards that require hybrid green/nature-based infrastructure and stormwater infiltration, conveyance, and storage improvements be included on all roadway upgrades, new construction, or reconstruction to help mitigate impacts from stormwater and nuisance flooding. This may include larger-diameter grey infrastructure and combinations of hybrid green and gray infrastructure such as vegetative buffers, storm sewers, and culverts. This should follow FHWA's Nature-based Resilience for Coastal Highways guidance.
Dedication of Open Space	Chapter 30 Flexcode Provide New Sections	Reassess open space requirements for subdivisions to include more open space, defined as any portion of any lot proposed for open space, common open space, or recreation area means any space or area characterized by great natural scenic beauty or whose openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding development, or would maintain or enhance the conservation of natural or scenic resources; or any undeveloped or predominately undeveloped land that has value for one or more of the following purposes: (1) Park and recreational uses. (2) Conservation of land and other natural resources and infiltration of rainfall; or (3) Recreational or scenic purposes. Chapter 4 of NCDOT's Complete Streets Planning and Design Guidelines provides specific design guidance and recommendations for greenways, and other facilities.
Promote the use of data for resilience planning	New Section	Utilize the 2D model to continue evaluating Town-Wide effects of flood reduction strategies.

Note: NCDOT Complete Streets Planning and Design Guidelines: http://www.pedbikeinfo.org/pdf/PlanDesign_SamplePlans_CS_NCDOT2012.pdf

integration, alignment with sustainable nature-based planning in response to flooding, and to promote resiliency. The goal is to provide resiliency and policy recommendations, that align with Leland 2045, to enable the Town Council to make informed decisions to adopt and implement policies, objectives, and zoning updates (As shown below, Table 11) help to promote resilient communities and transportation infrastructure. These recommendations may work in tandem with the resilient route projects recommended in Section 5 and Appendix C.

6.2 IMPLEMENTATION AND POTENTIAL FUNDING

The Town plans to update its Capital Improvement Plan (CIP) to include the Resilient Route Projects and seek grant funding to implement the Projects. In February 2024, the Town applied for NCEM Disaster Relief and Mitigation (DRMG) Grant and was awarded in June 2024 $1 million in funds to provide for Site # 5 final design and construction for flood reduction intended to help maintain vital community lifeline functions following flood events. The Town can assess and apply for other

state and federal grant assistance, including Building Resilient Infrastructure in Communities (BRIC), Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant program, the Rural Surface Transportation Grant Program, and the National Culvert Removal, Replacement and Restoration Grants. The Infrastructure Investment and Jobs Act (IIJA) Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) allocates resilience planning, resilience improvement funds, and At-Risk Coastal Infrastructure grant funds over a multiyear basis.

Additional grant opportunities related to resilience and transportation include the Federal STBGP-DA and TASA-DA Funds, the Surface Transportation Block Grant Program Direct Attributable (STBGP-DA), and Transportation Alternative Set Aside Direct Attributable (TASA-DA) distributed by the WMPO. Member jurisdictions of the WMPO are eligible to apply for these funds through a competitive funding process that prioritizes locally administered projects in the region. These projects are funded using a minimum 20 percent local match. https://www.wmpo.org/stp-datap-da/. Carbon Reduction Program (CRP) Funds provide for projects designed to reduce transportation emissions, such as those that shift travel mode from vehicles to walking or bicycling or reduce emissions such as roundabout projects. Projects require a minimum 20 percent local match to the federal funds. For more information: https://www.fhwa.dot. gov/bipartisan-infrastructure-law/crp_fact_ sheet.cfm.

Monitoring and evaluating transportation planning involves a cooperative process that fosters involvement by all users of the transportation network. Monitoring current and future transportation problems and needs, and strategies to address those needs, and fostering relationships with the WMPO and NCDOT will help the Town achieve its vision and goals for a resilient transportation system and community.

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