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Subtask 3.9, 3.10, & 3.14: Recommendations: Standardized Statewide Datasets

North Carolina Flood Resiliency Blueprint

Prepared for the North Carolina Department of Environmental Quality by AECOM and ESP Associates

June 2024

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Definitions

A comprehensive list of definitions applicable to multiple Flood Resiliency Blueprint documents is provided in a separate document.

- https://ncfloodblueprint.com/documents/DraftBlueprint_DefinitionsGlossary.pdf (PDF)

Acronyms

2D 2-Dimensional

AOI Area of Interest

CGIA Center for Geographic Information and Analysis

GIS Geographic Information System

LiDAR Light Detection and Ranging

NAVD North American Vertical Datum

NC North Carolina

GICC Geographic Information Coordinating Council

NCDOT NC Department of Transportation

NCEM NC Emergency Management

RARR Risk Assessment and Risk Reduction

SMAC Statewide Mapping Advisory Committee

1 Introduction

This report supports the development of the North Carolina (NC) Flood Resiliency Blueprint (Blueprint) and includes dataset recommendations based on Stakeholder Engagement (Task 1) and the Gap Analysis (Task 2).

The purpose of this document is to summarize the following Phase 1 recommendations.

- ***3.9**: Recommendations for standardizing datasets and models that can be implemented statewide and are useful at the community and watershed scales to help close the resource gap among communities, along with the effort and estimated costs required to maintain the usefulness of datasets and models.*
- ***3.10**: Identify efforts, datasets, model efforts, etc., that can immediately be developed statewide instead of waiting for additional pilot efforts.*
- ***3.14**: Recommendations on strategies to maintain the Blueprint, including update frequencies and strategy.*

There are many datasets required for the determination of flood risk and the evaluation of mitigation alternatives. These datasets have been identified and documented as part of the Task 2 deliverables. The datasets have various scales and degrees of accuracy, and many are managed at the local or watershed level. This document will cover priority datasets and modeling efforts deemed necessary to be developed, updated, or maintained statewide for economies and scale. The following report is organized to clarify and summarize the Statewide Datasets Recommendations. Recommendations for statewide modeling efforts are covered in Subtask 3.5.

It should be noted that this document makes recommendations concerning datasets that should be developed or enhanced at a Statewide level for North Carolina. Task 2 of the Blueprint Phase 1 documents datasets necessary for modeling and flood mitigation alternative analysis. While the Blueprint process will utilize these datasets, the datasets are currently developed, maintained, and distributed by other agencies and federal partners (for example, the National Land Cover Dataset, maintained by the United States Geological Survey).

2 Statewide Dataset Recommendations

Below is a summary of recommended statewide geospatial (GIS) datasets that can be used by the Blueprint Decision Support tool and by communities that may lack the resources to develop and maintain these datasets. Collecting and curating these statewide datasets and providing a "data warehouse" will allow communities to leverage the Blueprint Decision Support Tool and use these datasets for additional analysis, communication, and outreach.

2.1 Dataset 1: Topographic Data

2.1.1 Dataset Summary

Topographic data is a primary "building block" dataset necessary to construct, enhance, or provide essential context to other flood risk-related data. Ground topography is one of the most important foundational layers specific to flood risk. Topographic data captures the elevation of the land surface and landform features such as hills, lakes, rivers, valleys, road embankments, and others. The primary source of topographic data collection is LiDAR (Light Detection and Ranging). The State of North Carolina has used LiDAR for large-scale topographic data collection since 2001. The NC Department of Emergency Management oversees data collection, processing, quality control, and distribution collected through the statewide LiDAR program and maintains this vital dataset. The LiDAR data and derivatives are available to the public and industry via the States Spatial Data Download website (https://sdd.nc.gov/).

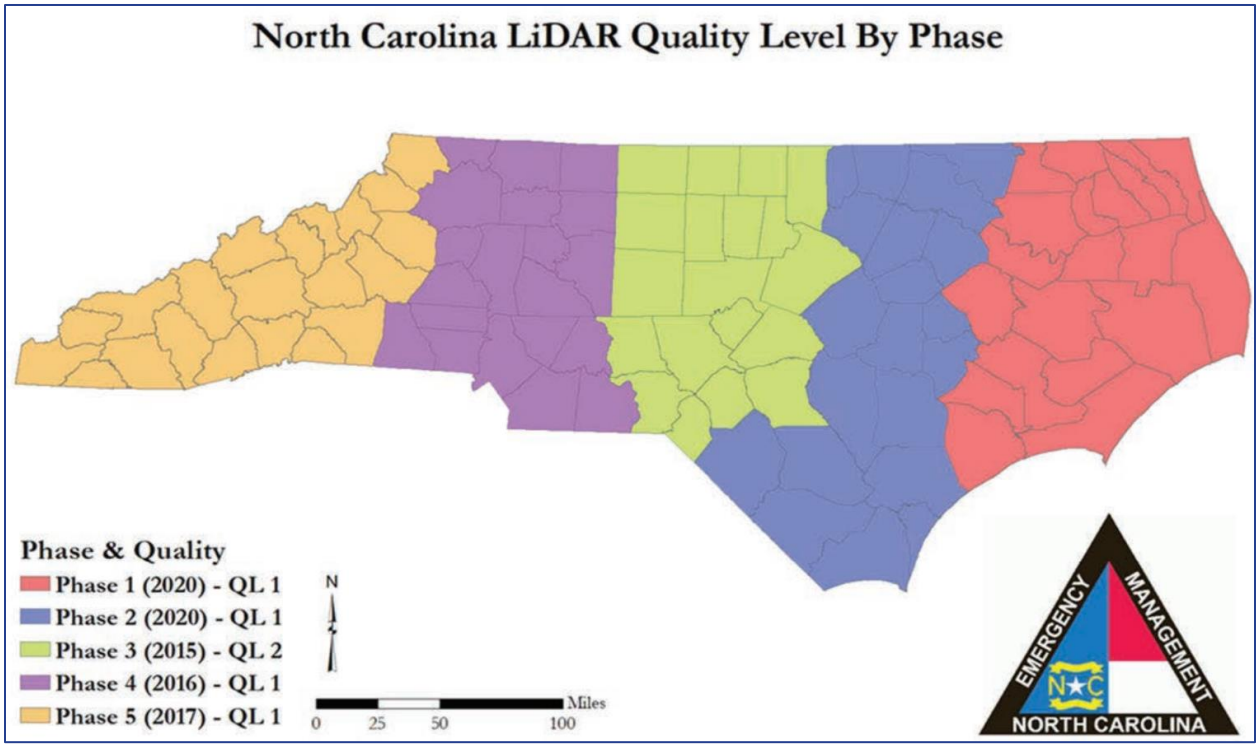

Figure 2-1: NC LiDAR Quality and Collection Year by Phase (Source: NCEM)

North Carolina is currently experiencing rapid population and development growth. This vital dataset requires frequent updates and maintenance as terrain data and river alignment change, and technology improves the accuracy of various LiDAR/remote sensing products.

2.1.2 Blueprint Recommendations

With respect to statewide topographic data, this report provides the following recommendations:

- North Carolina should continue to provide annual updates to the LiDAR datasets by Phase, as shown above in Figure 2-1. This will ensure that no areas of the state have topographic datasets older than five years. Updates currently occur as funding is available.
- North Carolina should continue enhancing LiDAR/remote sensing products, including classified building outlines, roadways, and bridges. This will allow for semi-automated extraction of building polygons and 3-dimensional road elevation datasets for risk assessment and disaster response. LiDAR classification should match existing NC collections for ease of extraction.
- North Carolina should continue to distribute these topographic datasets publicly via the Spatial Data Download tool and website. These tools and websites should be maintained and updated to allow additional functionality and enhancements.
- Remote-sensing LiDAR data should be leveraged to develop or enhance statewide land use/land cover and impervious surface coverage datasets. These datasets should be maintained at a frequency synchronized with the LiDAR phases. Opportunities for developing high-resolution Coastal Change Analysis Program datasets could also be considered.
- North Carolina should consider using technology such as change detection algorithms to detect

newly constructed buildings that may be in either a Regulatory (Federal Emergency Management Agency) floodplain, Advisory (NC Floodplain Mapping Program), or additional modeling program developed by future phases of the Blueprint. These newly constructed buildings should be included in additional community outreach and mitigation alternatives where practical. It should be noted that address data could be used to identify new developments. Statewide address datasets are updated monthly and would likely indicate a new structure.

2.1.3 Collection/Maintenance Costs

Data maintenance is vital for accurate and reliable topographic data, which drives future hydrologic and hydraulic modeling, mitigation alternative analysis, and preliminary designs. Maintenance of these datasets should be an annually appropriated task, similar to state and/or federal appropriations allocated in previous years of collection phases based on the availability of funding (Figure 2-1). Table 2-1 shows planning level estimates for the collection and maintenance costs for LiDAR:

Table 2-1: Planning level estimates for the collection and maintenance costs for LiDAR

Item	Unit Cost	Estimated Annual Units	Annual Cost
LiDAR Acquisition and Processing	$325 – $450/Square Mile[1]	10,000 square miles	**$3.25M - $4.5M**
Distribution Website Maintenance	1	Annual	**$50,000**
Operations and Management	1	Annual	**$250,000**
		Total	**$3.55M – $4.8M**
1 – Varies based on relief (coastal – mountains)			

It should be noted that the NC Emergency Management (NCEM) is currently collecting QL1 LiDAR data for Phase 3 (See Table 2-1). This LiDAR will be collected according to the QL-1 data standard in the winter flying season 2024. The bare earth classified datasets and LiDAR-derived datasets will be available by the Fall of 2024.

2.2 Dataset 2: Topobathymetric LiDAR

2.2.1 Dataset Summary

Detailed knowledge of nearshore topography and bathymetry is necessary for many geospatial data applications in coastal areas. One vital dataset for modeling and risk assessment is the development of seamless, topobathymetric digital elevation models. These digital elevation models integrate multi-sensor, topographic, and bathymetric datasets to provide a base layer for coastal analysis applications such as storm surge and wave height modeling, flood hazard determination, wetland

mapping and monitoring, sea-level-rise assessment, benthic habitat mapping, erosion monitoring, and storm-impact assessments.

Applications of topobathymetry include:

- ***Coastal Modeling:*** Topobathymetry is necessary for advanced storm surge and wave height analysis, including inundation mapping.
- ***Shoreline and Coastal Mapping:*** Topobathymetric LiDAR can significantly increase the geospatial mapping and understanding of the foreshore zone of coastal waters, increasing the accuracy of shoreline delineation, debris mapping, resource mapping, inundation modeling, nautical charting, and benthic habitat mapping.
- ***Fisheries and Habitat Assessment:*** Providing geospatial details on floodplain geomorphology and vegetation of streams, rivers, and watersheds, topobathymetric LiDAR provides valuable insight on depth, fish habitat, substrate, pool-riffle sequence, sinuosity, connectivity, aspect, slope, flow dynamics, woody debris, etc.
- ***Infrastructure Planning and Engineering:*** Topobathymetric LiDAR provides critical data to support engineering infrastructure planning, design, and construction.

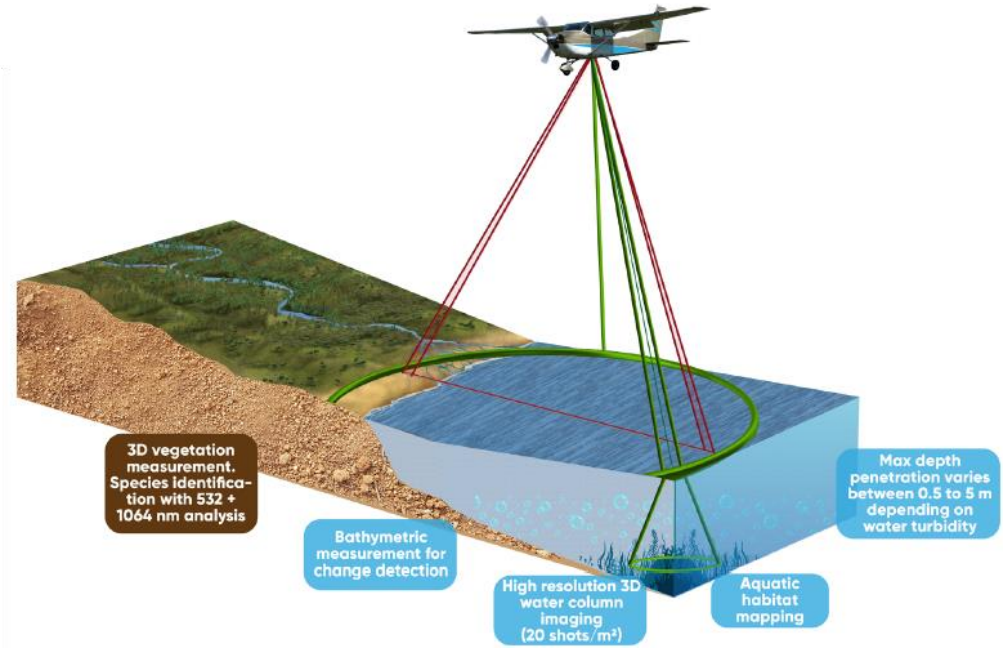

Figure 2-2 Topobathymetric Lidar (Source NV5)

2.2.2 Blueprint Recommendation

With respect to statewide topobathymetric LiDAR data, this report provides the following recommendations:

- The NC Department of Environmental Quality should analyze the status and quality review of the existing bathymetric data statewide. This analysis should be followed by developing a plan to collect and complete any existing data voids in coordination with federal agencies that may also

be responsible for these data.

2.2.3 Collection and Maintenance Costs

Data collection and maintenance costs will vary based on the flight plan and flooding source needed. Area of interest candidates for the aerial topobathy method may need to be supplemented with a vessel or traditional survey. Cost differences exist between aerial topobathy, vessel-based bathy, and traditional bathy surveys. Conditions/caveats can impact actual project costs, such as:

- Water quality
- Water body floor
- Waves and chop
- Size of the Area of Interest (AOI)
- Configuration of the AOI
- Collection season
- Atmospheric conditions (clouds, moisture, wind)

Collection costs can range from $2,500 to $7,500 per sq mile, depending on the methodology used to acquire the data and the unique AOI conditions/caveats.

2.3 Dataset 3: Building Data

2.3.1 Dataset Summary

Building footprint data and the associated building level attributes are a critical geospatial dataset used for flood mitigation planning. This dataset is a valuable tool in developing hydrologic and hydraulic models (especially 2-dimensional (2D) modeling), a powerful tool in performing flood risk assessments and risk scoring and determining the benefits and effectiveness of various structural and nonstructural flood mitigation alternatives. Beginning in 2010, the State of North Carolina became one of the only states in the nation to invest in developing a Statewide building footprint database with building-level attributes to support flood risk communication and risk assessment.

While the current building dataset is valuable, the footprint data resources were derived between 2010 and 2014, leaving many areas missing new building footprints and with out-of-date attributions from the dataset. It is important to keep this dataset up to date with all new developments and modifications so when new hazard-based studies are performed, their associated impact analyses are up to date and as accurate as possible.

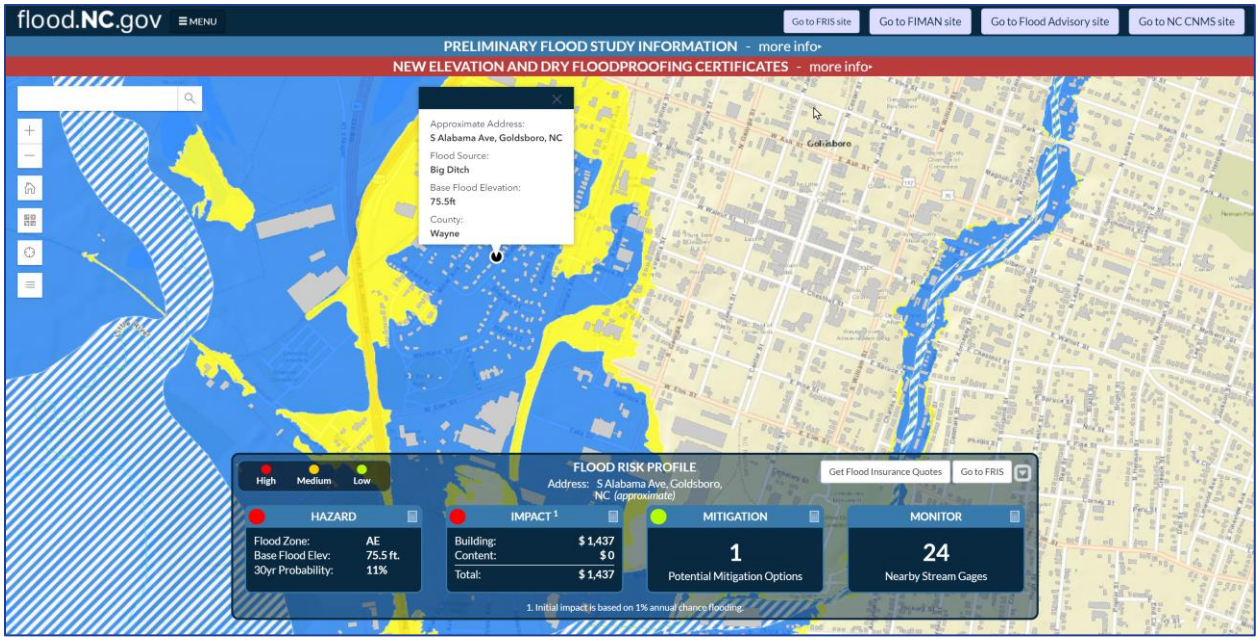

Figure 2-3: Example of Building Footprints used in the Decision Support Tool on Flood.NC.Gov

2.3.2 Blueprint Recommendation

The NC Flood Resiliency Blueprint makes the following recommendations concerning statewide Building Data:

- North Carolina should continue to update and conduct regular maintenance of the statewide building footprint database in close coordination with the NC Geographic Information Coordinating Council (GICC), NC Center for Geographic Information and Analysis (CGIA), and NCEM.
- North Carolina should, where feasible and available, update and enhance the building footprint dataset to include the following *minimum* attributes for each building contained in proximity to a Special Flood Hazard Area or NC Advisory Flood Hazard Area:
    - First Floor Elevation measurements
    - Lowest Adjacent Grade elevation from LiDAR
    - Highest Adjacent Grade elevation from LiDAR
    - Occupancy Type
    - Building Type
    - Number of Stories
    - Foundation Type
- First-Floor Elevations were collected for approximately 135,000 buildings within the special flood hazard areas in North Carolina between 2011 and 2013. This data should be updated where new buildings have been constructed in proximity to a Special Flood Hazard Area or NC Advisory flood hazard area or have otherwise had significant modifications.
- Blueprint decision support tools should leverage this data through web services to avoid data duplication while sharing this data with other State of NC web-based applications.

- Footprint data should be publicly available via the State's Spatial Data Download portal hosted by NCEM.

2.3.3 Collection and Maintenance Costs

NCEM, NC CGIA, and NC GICC have ongoing collection and maintenance programs to collect and maintain building footprint data. The blueprint recommends close coordination with CGIA and NCEM for all building datasets.

2.4 Dataset 4: Critical Infrastructure/Key Resources

2.4.1 Dataset Summary

Critical infrastructure includes those assets, systems, networks, and functions—physical or virtual—that are vital to the State of North Carolina, such that their incapacitation or destruction would have a debilitating impact on security, economic security, public health or safety, or any combination of those matters. Key resources are publicly or privately controlled resources essential to the minimal operation of the economy and the government. Critical infrastructure and key resource GIS products can be used to identify, communicate, and quantify vulnerabilities to specific features/areas from flooding and to assess the beneficial impacts of mitigation projects. Critical infrastructure at risk for flooding impacts will be weighed into evaluating and prioritizing possible blueprint mitigation projects.

Figure 2-4: Critical Infrastructure Sectors (source Department of Homeland Security)

2.4.2 Blueprint Recommendation

The NC Flood Resiliency Blueprint makes the following recommendations concerning statewide Critical Infrastructure Data:

- North Carolina should conduct a detailed gap analysis of existing Critical Infrastructure and Key Resources datasets available statewide and countywide. The results of this gap analysis will be a recommendation for dataset enhancements. Coordination with the Statewide Mapping Advisory Committee (SMAC), NCEM, and/or the NC Department of Transportation (NCDOT) should also be considered.
- The Blueprint team should work with NCEM and manage through the SMAC to develop a statewide database schema for Critical Infrastructure and Key Resources.
- North Carolina should develop the geospatial data layer for Critical Infrastructure and Key Resources statewide.

2.4.3 Collection and Maintenance Costs

Collecting and updating a Statewide Critical Infrastructure/Key resources data layer will require close coordination with various state agencies. The details of this coordination are not included in this report. However, Table 2-2 summarizes the estimated planning level of effort required to update the Critical Infrastructure/Key Resources geospatial datasets for each of North Carolina's 100 counties. It should be noted that these planning-level estimates cannot fully account for the costs of qualitative and localized input needed to supplement quantitative data for critical assets found in each county.

Table 2-2 Estimated planning level of effort required to update the Critical Infrastructure/Key Resources

Item	Unit Cost[1]	Estimated Units	One Time/Annual Cost
Critical Infrastructure/Key Resources Data Set Updates	$25,000/County	100 Counties Statewide	**$2.0M**
Annual Updates	1	Annual	**$100,000**

[1] *Based on an estimated average labor cost for an update of 200 hours of labor per county.*

2.5 Dataset 5: Statewide Risk "Scores" for Buildings and Transportation Assets

2.5.1 Dataset Summary

One of the Decision Support Tools identified and discussed as part of Task 2 is Mecklenburg County's Risk Assessment and Risk Reduction (RARR) tool. Mecklenburg County is the most populated county in North Carolina and one of the fastest-growing metropolitan areas in the country. Over 370 miles of mapped streams and an estimated 2,800 houses and buildings are in mapped floodplain areas. As part of the county's overall flood mitigation strategy, a RARR plan was developed to help assess flood risks and prioritize and guide mitigation strategies. The RARR plan includes a data-driven framework

and associated tools that allow the county to dynamically assess, evaluate, and prioritize mitigation strategies for flood prone buildings and properties[1]. Various vital datasets and geoprocessing tools support the RARR decision support tool(s), summarized by category in Table 2-3. Despite identifying various building-level mitigation options, upstream practices are notably excluded as mitigation options in the RARR tool(s). This could be a promising future addition, depending on the outcomes of additional modeling.

Table 2-3: Various vital RARR decision support tool(s) datasets

RARR Tool Category	Category Component	Summary
Flood Risk	Risk Score Components (17 tools)	• Calculates flood risk score based on spatial and attributed data at the building level. • Batch tool allows for all components to be assessed at once
Mitigation Technique Evaluation	Mitigation Techniques (19 tools)	• Evaluate mitigation techniques at the building level. • Batch tool allows for all mitigation techniques to be evaluated in one step
Mitigation Scoring	Mitigation Score Components (13 tools)	• Calculates a mitigation score for each technique deemed "Effective" or "Highly Effective" at the building level and the maximum mitigation score. • Batch tool calculates all mitigation scoring components
Losses Avoided Tools	Numerous logic structures	• Various tools used to determine losses avoided at previously mitigated structures

The backbone of the county's system is a unique flood risk score, calculated for each building in and near the flood hazard areas. This flood risk score consists of probabilistic components- and location-based. Advanced, multi-frequency modeling and floodplain mapping, coupled with building data, compute the scores. The Mecklenburg County flood risk score is developed using the following components:

Probabilistic-Based Score Components

- First Floor Elevation flooding
- Lowest Mechanical Elevation flooding
- Lowest Adjacent Grade flooding
- Property surrounded probability
- Building surrounded probability
- Critical facility surrounded probability
- Potential structural damage

[1] https://www.charlottenc.gov/files/sharedassets/city/v/1/services/stormwater/documents/flooding/flood_rarr_plan.pdf

- Vehicle flooding
- Yard flooding

Location-Based Score Components

- Medium/high flood velocity zones
- Drainage overflow zones
- Community non-encroachment/regulatory floodway zone

For each of the components above, building data and flood hazard inundation maps are used to compute a component score, and the sum of the component scores is the Flood Risk Score.

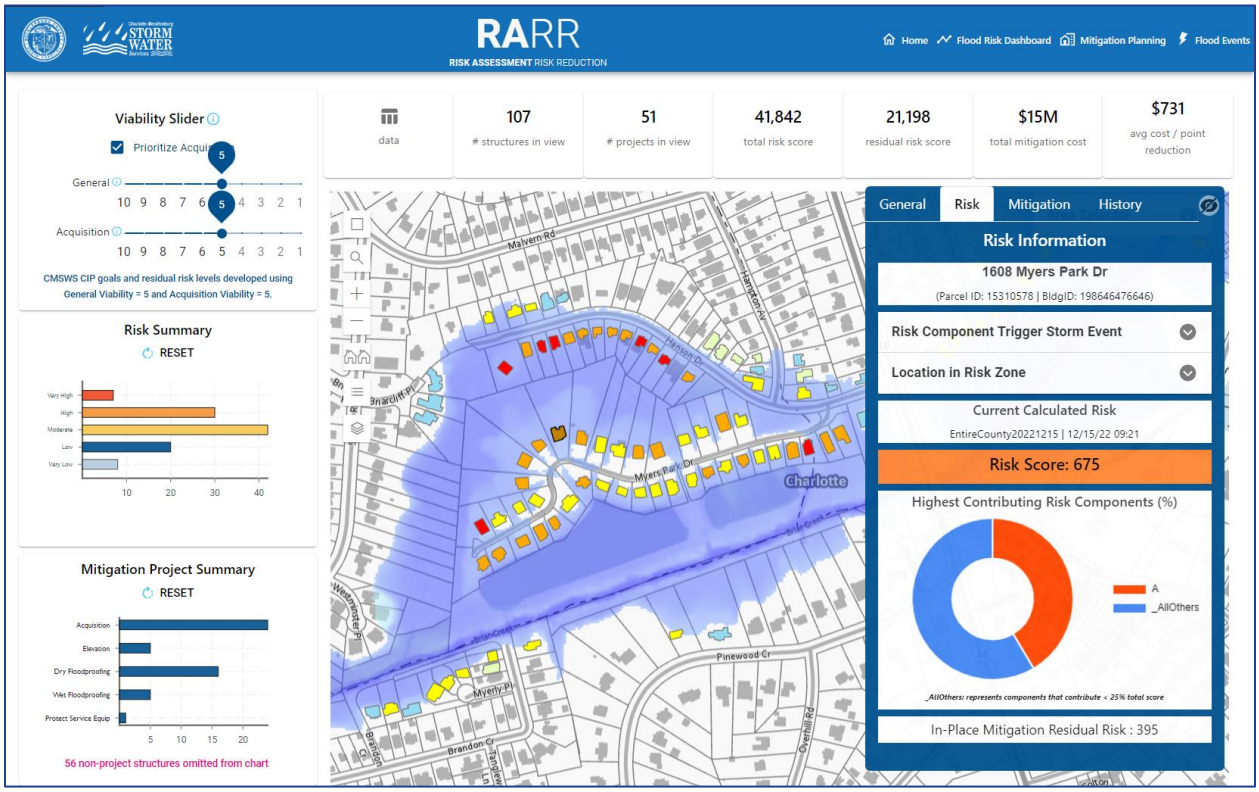

Figure 2-5: Example building flood risk score (Risk Score = 675) - Mecklenburg County RARR System

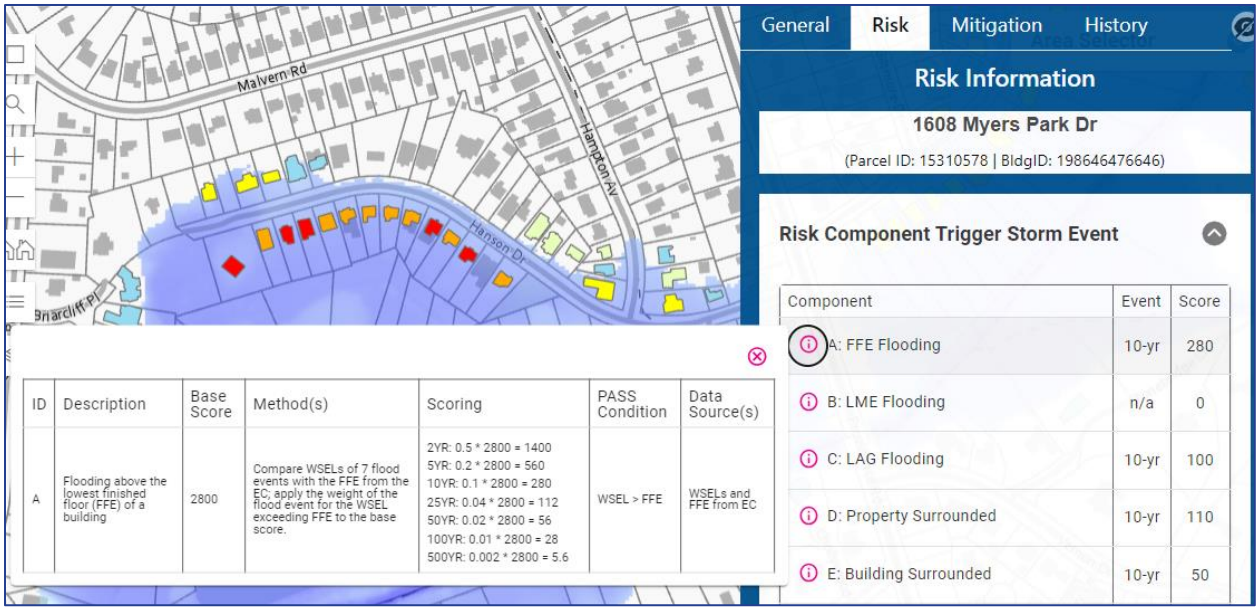

Figure 2-6: Example flood risk score Component A (First Floor Elevation Flooding) calculation - Mecklenburg County RARR System

2.5.2 Blueprint Recommendation

Building Flood Risk Scores

The NC Flood Resiliency Blueprint recommends establishing a similar flood risk score for every building within the pilot Neuse River Basin and, eventually, all river basins statewide. A building-specific flood risk score would be possible to determine through the updated building statewide dataset discussed previously in this document and the statewide fluvial and pluvial modeling recommended by the NC Flood Resiliency Blueprint. These flood risk scores would provide an objective metric of flood risk for each building. Risk assessment and mitigation alternative analysis could be aggregated for sub-basins, counties, municipal limits, critical infrastructure, etc. The aggregated flood risk scores would serve as a baseline for flood resilience progress tracking and metric-based goals for communities, river basins, and the state.

The concept of the multi-variable flood risk score differs from the assessed risk in Flood.NC.Gov in the following ways:

- Flood.NC.Gov limits the flood risk to a 1% annual chance of regulatory flood event.
- The multi-variable flood risk score will consider a full suite of annual exceedance probability events, future conditions, flood velocities, social vulnerability, and other factors.

It is recommended that the statewide flood risk scores include a subset of the components used in the Mecklenburg County example, as a statewide collection of several of the datasets required for components would be cost-prohibitive. Examples of some of these cost-prohibitive components include Lowest Mechanical Elevation, vehicular flooding, etc.

In addition, these flood risk scores and associated data will provide additional benefits for flood resiliency, including:

- Incorporate updated Federal Emergency Management Agency Benefit-Cost Analysis Methodology
- Incorporate enhanced mitigation benefits
- Incorporate partnerships into mitigation benefits
- Track residual risk
- Estimate future benefits
- Perform optimization of funding allocations
- Incorporate historical tracking of risk scores
- Provide enhanced dashboard/reporting features
- Incorporate mitigation actions in final risk scores
- Provide interactive scenarios to assess the impacts of mitigation on the score
- Compute the highest contributing factor/component to scores
- Include freeboard mapping or analysis (Policy changes)

Transportation Flood Risk Scores

Transportation assets could be scored based on roadway classification, flooding probability, and depth. These Transportation Flood Risk Scores could be applied to at-risk segments of the road. Flood mitigation alternatives can be evaluated based on any benefits from reductions in flooding along at-risk transportation corridors. Scores can be cumulated or aggregated in a way that is similar to the building-level flood risk scores for baseline conditions and flood resilience progress tracking. Aligning the development of transportation flood risk scores with NCDOT findings may be beneficial since it is actively working on similar methodologies based on resilience and vulnerability studies.

2.5.3 Collection and Maintenance Costs

The development and quality control of a statewide flood risk score for each at-risk building and at-risk transportation segment assumes that the Blueprint tool's process develops the required updated building data and modeling data to allow these calculations.

Table 2-4 summarizes the estimated planning-level effort required to produce these recommended statewide flood risk scores for buildings, critical infrastructure, and transportation assets. The Blueprint tool will use these scores for risk assessment, communication, and mitigation alternative analyses.

Table 2-4: Estimated planning level effort required to produce statewide flood risk score for buildings, critical infrastructure, and transportation assets

Item	Unit Cost	Estimated Units	One Time/Annual Cost
Pilot Basin (Neuse): Building Risk Scores	$35/building	35,000	**$1,225,000**
Pilot Basin (Neuse): Transportation Risk Scores	$20,000/County	15	**$300,000**
Statewide: Building Risk Scores	$20/building	280,000	**$5,600,000**
Statewide: Transportation Risk Scores	$20,000/County	85	**$1,700,000**
Annual maintenance	1	Annual	**$200,000**

2.6 Dataset 6: Statewide Transportation Hydraulic Crossing Dataset

2.6.1 Dataset Summary

One of the gaps identified and discussed as part of Task 2 is current and comprehensive, multi-return period modeling, including future conditions. Phase 2 of the NC Flood Resiliency Blueprint may consider updates to the modeling for the Neuse River Basin (and other river basins). This modeling will take advantage of advances in two-dimensional modeling (2D modeling), which can produce cost-effective, hydrologic and hydraulic modeling for pluvial and fluvial flooding sources in a watershed or river basin. 2D modeling has numerous advantages over traditional 1-dimensional modeling. However, one limitation of 2D modeling is that representing all hydraulic crossings (bridges, culverts, etc.) in the model mesh (input geometry) requires significant data collection, processing, and labor. This data collection, processing, and labor are typically efforts repeated by the industry for all modeling, creating inefficiencies, redundancies, and data duplications. In many cases, the hydraulic structure geometry in the model does not accurately represent the hydraulic opening. It can cause unintended errors in the model results or flood elevations and boundaries.

The NC Department of Transportation data shows approximately 15,500 hydraulic structures (bridges, culverts, etc.) statewide.

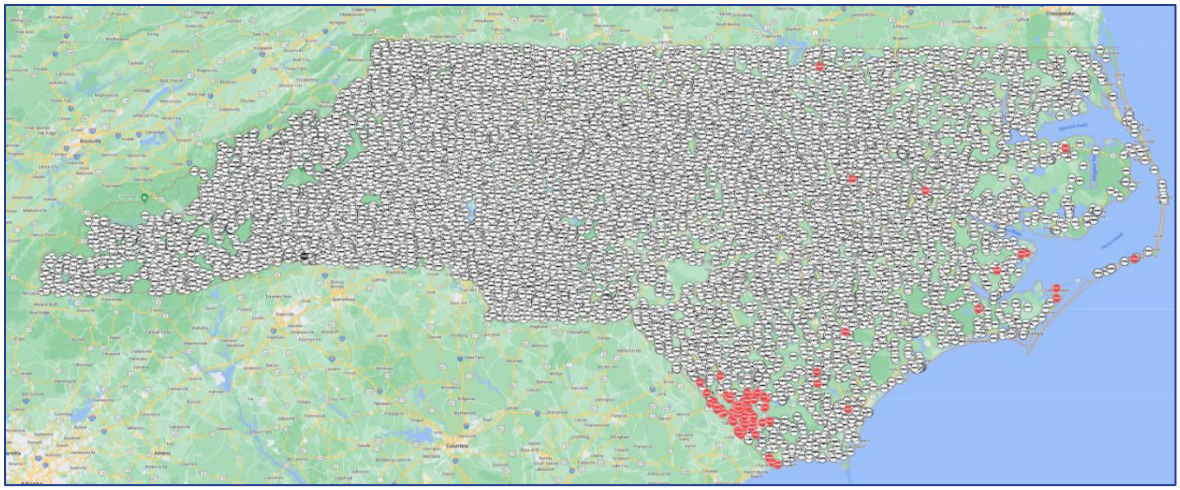

Figure 2-7: Representation of the approximately 15,500 hydraulic structures (bridges and culverts) statewide. (Source: NCDOT)

2.6.2 Blueprint Recommendation

The NC Flood Resiliency Blueprint makes the following recommendations concerning statewide roadway hydraulic structures data:

- Consider developing a pilot program to enhance the existing NCDOT hydraulic structure inventory for the Neuse River Basin. This dataset would be enhanced with data from the best available sources and/or field-collected data as needed in coordination with NCDOT. The following key information will be added to enhance the dataset:
    - Culverts
        - Culvert barrel size, shape, length, material, etc., for hydraulic modeling
        - Culvert invert elevation (North American Vertical Datum (NAVD) 88)
        - Metadata and data maintenance fields
        - Photo
    - Bridges
        - Bridge low chord elevation(s) (NAVD 88)
        - Bridge geometry/hydraulic opening area (NAVD 88)
        - Pier number, shape, width
        - Metadata and data maintenance fields
        - Photo
- The pilot data will be developed into a standardized geospatial dataset that will aid in refining 2D hydraulic modeling. Coordination with NCEM (e.g., FLOOD geodatabase schema) and NCDOT (e.g., digital as-built requirements) may benefit this effort.
- After completing the Pilot collection for the Neuse River Basin, a sensitivity analysis should be performed on 2D modeling containing the enhanced structures and 2D modeling using traditional methods. The results of this pilot sensitivity analysis will dictate if there is a benefit to applicable basin action plan projects and/or statewide implementation.

2.6.3 Collection and Maintenance Costs

The statewide hydraulic structure dataset collection will require close coordination with the NC Department of Transportation to determine key starting points. Table 2-5 summarizes the estimated planning level of effort required to collect the data needed to complete the pilot program of hydraulic structures data and run a sensitivity analysis.

Table 2-5: Estimated planning level of effort to complete the pilot program of hydraulic structures data

Item	Unit Cost	Estimated Units	One Time/Annual Cost
Pilot Collection: Neuse River Basin	$500/Structure	1,650 (estimated) in the Neuse River Basin	**$825,000**
Sensitivity Analyses	$75,000	3	**$225,000**
Statewide Collection	$500/Structure	13,850	**$6,925,000**
Ongoing Maintenance	1	Annual	**$150,000**

GIS data development recommendations should include the GICC/SMAC to every extent necessary. In many instances (i.e., the case of the building footprints), there is already a plan endorsed by the GICC and a work in progress. Sometimes, a working group may have developed a schema or identified data providers. Avoiding duplication of efforts is critical and can be addressed by collaborating with these statewide committees and ensuring that data developed by one agency can also be used by other organizations that need it.