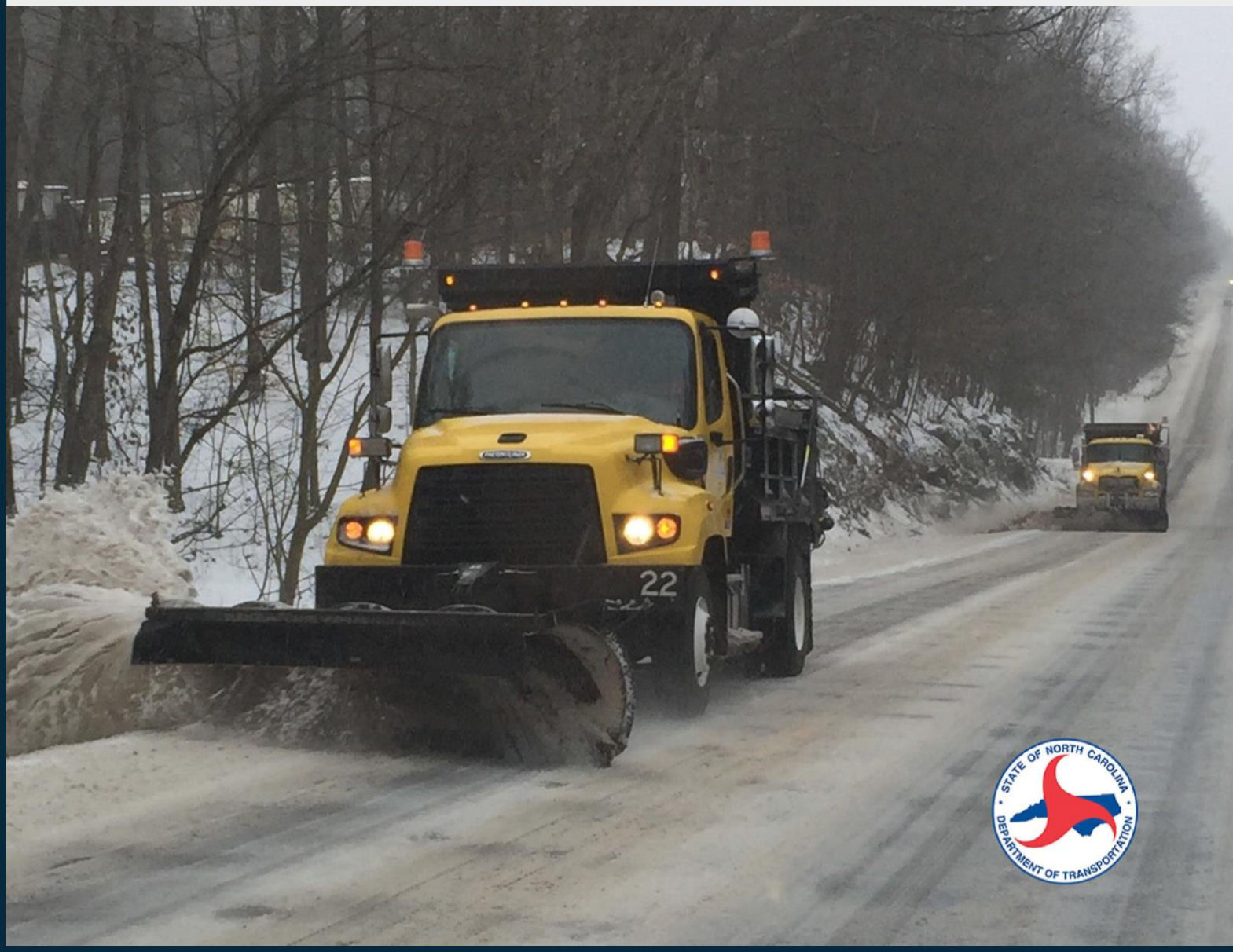
2024 Maintenance Operations and Performance Analysis Report (MOPAR)



Required by G.S. 136-44.3

Section I – Statewide Summary

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1 INTRODUCTION

1.1 EXECUTIVE SUMMARY

Intentional and proactive maintenance of North Carolina's highway system is a critical component of the North Carolina Department of Transportation's mission of connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina. To enable the department's goal of delivering and maintaining our infrastructure efficiently and effectively, **$2.86B is our estimated need for maintenance activities in the coming fiscal year** – an increase of 32 percent from FY25 appropriations that is a necessary result of inflationary pressures, high growth, and aging infrastructure.

The North Carolina Department of Transportation is responsible for the maintenance of 81,000 centerline miles of roads, the 2nd highest of any state. This is in addition to over 13,700 bridges and over 2 million roadside assets (e.g. lft. guardrails, lft. pipes/culverts, words/symbols, etc.). By leveraging traditional data sources alongside new AI-driven analytics, including precise data on the count, location, and AI-assessed condition of each asset as verified by field personnel, the funding request presented here provides a comprehensive, data-driven view of the department's maintenance funding needs.

These needs are driven by three wide-ranging trends:

- North Carolina, along with the rest of the country, has experienced **inflation in prices for construction materials, equipment, and labor** higher than in prior decades. Inflation for maintenance and construction activities is projected at 5%, a planning assumption for the coming years. Without an increase in funding, the real value of current funding levels will decline over time, reducing the amount of work that can be accomplished as costs continue to rise.
- Our state is **experiencing record growth**, experiencing the third-highest numeric population growth of any state in 2022 – over 100,000 new North Carolinians in a single year with no sign that this trend will slow. This will increase not only the overall demand on our transportation network, but also the pressures placed on our secondary system given the widespread nature of this growth.
- North Carolina is also facing a challenge in the form of **aging infrastructure**: over 500 lane miles of North Carolina's interstates are 60+ years old based on original construction date, and over 1,100 of North Carolina's 13,700+ bridges are in poor condition. These assets will require intentional, consistent funding over the long term.

To keep North Carolina competitive and support the growing demands on our roads, steady and intentional investment in transportation maintenance is required. This will help us manage current challenges and make the most of the economic opportunities created by our rapid growth. This MOPAR lays out these needs as well as the return that North Carolina can expect from their investment in highway maintenance.

1.1.1 Context: Critical maintenance resources supporting Helene recovery

The need for consistent and sufficient investment in the maintenance of North Carolina's highway system is made all the more urgent as we work to rebuild from the impacts of Hurricane Helene. This event has exacerbated the key trends laid out above – the demand for labor, materials, and equipment will steepen in the face of recovery efforts, the increased freight traffic necessitated by the reconstruction effort will increase the projected demand on our system, and the Hurricane itself has only increased the natural wear placed on our infrastructure.

The historic impacts of Hurricane Helene, which began to be felt on September 27, 2024, have included over 8,000 identified damage sites, damage to over 800 bridges of which at least 150 will require replacement, and damage to over 800 pipes. Approximately 2,100 NCDOT employees have been actively engaged in the response and recovery efforts, along with 140 contractors and over 90 consultants. This effort has allowed the department to re-open over 1,000 roads that were initially closed due to the event, but based on field assessments the department estimates that it will take about $5B to fully restore the impacted roads, bridges, and other transportation infrastructure. NCDOT is collaborating with FEMA and FHWA regarding fiscal recovery efforts.

Given this level of impact, much of the labor, equipment, and materials that would typically go toward routine maintenance have been supporting recovery efforts. As a result, routine maintenance is being deferred as resources continue to support recovery efforts.

The data used in the development of this report was collected in advance of Hurricane Helene and does not factor in the additional needs incurred by its damages. The analyses conducted here, and the funding recommendations that we are requesting, reflect the steady state operations of the department. The investment necessitated by Hurricane Helene should be considered additive to the requests laid out here.

1.2 ABOUT MOPAR

The state MOPAR integrates the maintenance, rehabilitation and operation of the state highway system into a single management plan that implements state and federal asset management requirements, including primary assets such as those from Session Law 2017-57 Highway Maintenance Improvement Program (HMIP). This document also serves to measure the department's performance against its plans for pavements, bridges and routine maintenance demonstrating the realized return on the state's investment and laying out how past and future investments contribute to the department's overall transportation strategy.

The MOPAR reflects the core principles of asset management, using objective analysis to focus investments on measured condition and performance goals. NCDOT continues to refine and expand the asset management framework, introducing new performance objectives to maintain and expand the network prioritizing key fundamentals – maintaining a customer focused approach, making data-driven decisions, adopting a performance and risk based approach and builds off practices mandated by the US Department of Transportation (USDOT) and Federal Highway Administration (FHWA) requirements, with additional guidance provided by the American Association of State Highway and Transportation Officials (AASHTO) and other industry best practices.

> *"Asset management is considered an integrated set of processes to minimize the lifecycle costs of infrastructure assets, at an acceptable level of risk, while continuously delivering established levels of service. Asset management is a holistic approach that balances costs, opportunities, and risks against the desired performance of assets"*

Definition of asset management from 2019 MDOT SHA Strategic Asset Management Plan

1.2.1 Federal, State & Department Requirements

Federal Requirements – Moving Ahead for Progress in the 21st Century (MAP-21) Act and Fixing America's Surface Transportation Act (FAST Act) outlines federal asset management requirements addressed in the MOPAR. MAP-21 requires states to adopt national asset management performance measures to establish nationwide consistency for pavement and bridge condition reporting. These performance measures use a condition scale (good, fair, and poor) to quantify pavement lane miles or bridge deck area condition. The Automated Pavement Condition Survey (APCS), bridge Element Level Inspection (ELI), Highway Performance Monitoring System (HMPS), and new AI-driven data and analytics are incorporated into NCDOT's practice.

State Requirements – The HMIP is required by law under NCGS 136-44.3A which is a five-year program of projects that collectively improves the condition, operation, and sustainability of the network. In addition, NCGS 136-44.3A requires a HMIP Needs Assessment. The need and schedule of projects is interactively mapped which has many

benefits including the ability to optimize maintenance decisions in the vicinity of planned projects. The HMIP initially only reported on pavement assets but was expanded by S.L. 2017-57 to an integrated management plan to include bridge and general maintenance, beginning in the year 2020.

1.2.2 Department Requirements

Improving the data and analytics behind these needs assessments is an ongoing effort. The Department continues to explore new approaches and technologies to better inform decision-making, accomplish its goals, and be an effective steward of state resources. The HMIP reflects the highway division asset management strategy, it organizes key activity areas or objectives into categories that align with strategic goals. This structure provides clarity on the strategic goals the Department is working to accomplish, including making transportation safer/Vision Zero, improving the reliability and connectivity of the transportation system, delivering and maintaining our infrastructure effectively and efficiently, and providing great customer service, along with transparency of the level of needs and investments in each of the strategic areas.

1.3 Program Overview

1.3.1 Highway Asset Portfolio

NCDOT is responsible for a wide variety of physical assets that increase each year through road additions, road widenings, and new location capital projects. Highway infrastructure assets, within state highway boundaries, include 81,000 centerline miles of pavement, over 13,700 bridges, over 390,000 pipes, and thousands of other assets such as those shown in **Figure 1**. The most significant assets on the state system, in terms of their cost and extent, are pavement and bridges. However, many other assets are needed to support mobility and safety. In many cases, replacement or rehabilitation of roads and bridges includes replacement or upgrades to underlying structural and functional assets. For instance, reconstructing or replacing a bridge includes the cost of guardrail; and pavement projects often include upgrades to associated drainage, traffic, and safety assets.

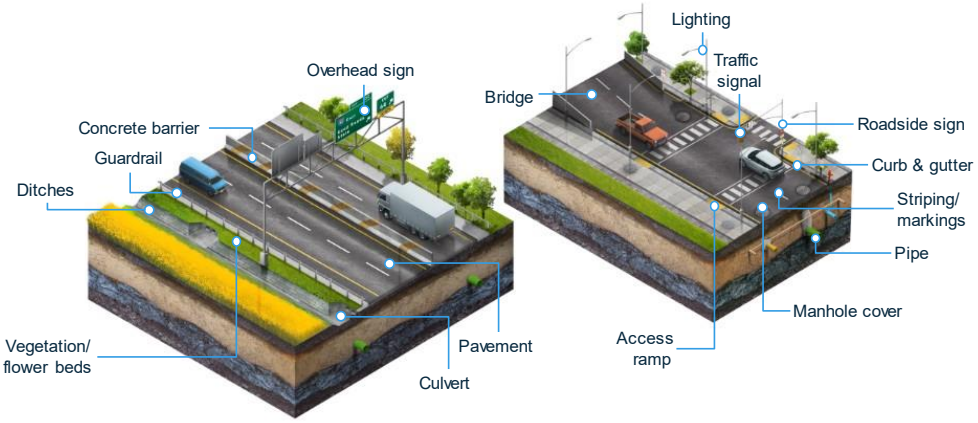


Figure 1: Roadways comprise of numerous assets

Additional support facilities, such as weigh stations, maintenance facilities, equipment shops, rest areas / welcome centers, and transportation materials laboratories / testing facilities, are also included as state assets. Many system components, built in the 1950s, 1960s, and early 1970s, have either reached or are reaching the end of their service life. Highway Asset Portfolio deterioration is accelerating at a faster rate than in previous decades, because of age and increased demand, often requiring extensive rehabilitation and even full reconstruction.

1.3.2 Asset Management Strategy & Framework

The Department strives to preserve the condition of the system at the right cost for the most benefit through carefully planned preservation strategies (i.e., preventive maintenance, corrective maintenance, and minor rehabilitation) and rehabilitation or replacement. The Department maintains system conditions by applying the right treatment at the right time, equipping Highway Divisions to use maintenance strategies that best address the specific needs of their local areas. These strategies are then evaluated against production and expenditure targets, which are essential to achieving Department goals of providing safe, growth-enabling, efficient, effective, and resilient infrastructure.

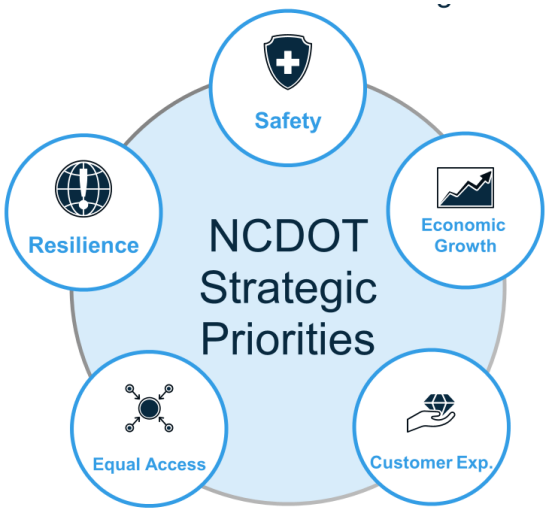


Figure 2: Key outcomes for NCDOT

The Department uses information on stakeholder needs, asset conditions, and performance to project asset performance, anticipate deterioration, and prioritize critical assets. This

approach helps balance needs across our asset portfolio. The Department has been actively improving asset management methods, tools, and data which underpins analyses for performance review and projections and investment strategy in this document.

In addition to planned maintenance activities, crews must be able to respond to unpredictable events such as weather events which can cause significant damage to the Department's infrastructure. Major events such as hurricanes and other tropical storms, localized heavy rain events, as well as significant winter storms, can have lasting impacts. These impacts can cause accelerated deterioration of assets, necessitating early replacement of drainage systems, emergency bridge repairs and replacement, and significant repairs to pavements. Responding to each of these scenarios, combined with an expanding asset base strains maintenance resources and limits the Department's ability to perform planned maintenance activities.

Transportation assets are interdependent, and their effective maintenance requires a holistic, corridor based, approach. Poor drainage on roadways can lead to extensive damage and create significant safety hazards. When water is not properly diverted from the road, it can accumulate, causing erosion around the pavement edges, rutting, and other forms of pavement deterioration. This, in turn, weakens the road structure and leads to issues like potholes and shoulder damage, requiring more frequent and costly repairs to keep roads safe and functional. In addition, standing water on road surfaces can lead to dangerous conditions by increasing the risk of hydroplaning or of drivers swerving to avoid the water and risking roadside accidents or crashes.

1.4 Context and Challenges

Managing transportation assets involves understanding the demands on the system from changes in the population, economy, travel patterns, mobility choices, technology, and potential disruptions and extreme events, like storms. To proactively plan for the maintenance needs of North Carolina's highway system, we need to account for the impacts of three major trends impacting our state. Maintenance funding must account for the price inflation for labor, materials and equipment; the historically high rate of population growth that our state is experiencing, and the growing volume of aging infrastructure that will necessitate both more intensive maintenance and potentially reconstruction in the coming years.

1.4.1 Trend: Inflation

The nation has been facing higher rates of inflation for construction materials, equipment, and labor than were seen in the past several decades. This means that even if we intend to provide the same condition to the same number of people, consistent levels of funding will yield lower and lower returns. And even given cooling rates in recent months, there is no indication that rates will return to pre-COVID lows in the near future.

To account for this, the maintenance funding request presented here, as developed via the Total Cost of Ownership model described in section 1.5, separates cost drivers whenever possible and factors in the different inflation rates currently seen for materials, equipment, and labor. Specifically, we use the findings of the 2023 Q4 Engineering News-Record Cost

Report (which includes data and analyses from the Bureau of Labor Statistics and IHS Global Insight) to project annual inflation rates of 5%, 8%, and 3% for these respective cost drivers. Averaging these together, we apply a blended rate of 5% annually to cost items where a breakdown is not available – this rate matches the one used in the latest State Transportation Improvement Plan (STIP).

1.4.2 Trend: Population Growth

Understanding and accounting for long-term growth and demand forecasts is critical to planning and prioritizing our investment needs. In this respect, North Carolina has seen the 3rd highest numeric population increase in the nation and the 5th highest rate of growth from 2022-2023[1]. **Figure 3** shows the projected rise in road use on North Carolina's highways over the next 30 years due to population growth—an increase that will accelerate road deterioration, requiring more resources to maintain even the current condition and to support the additional infrastructure needed.

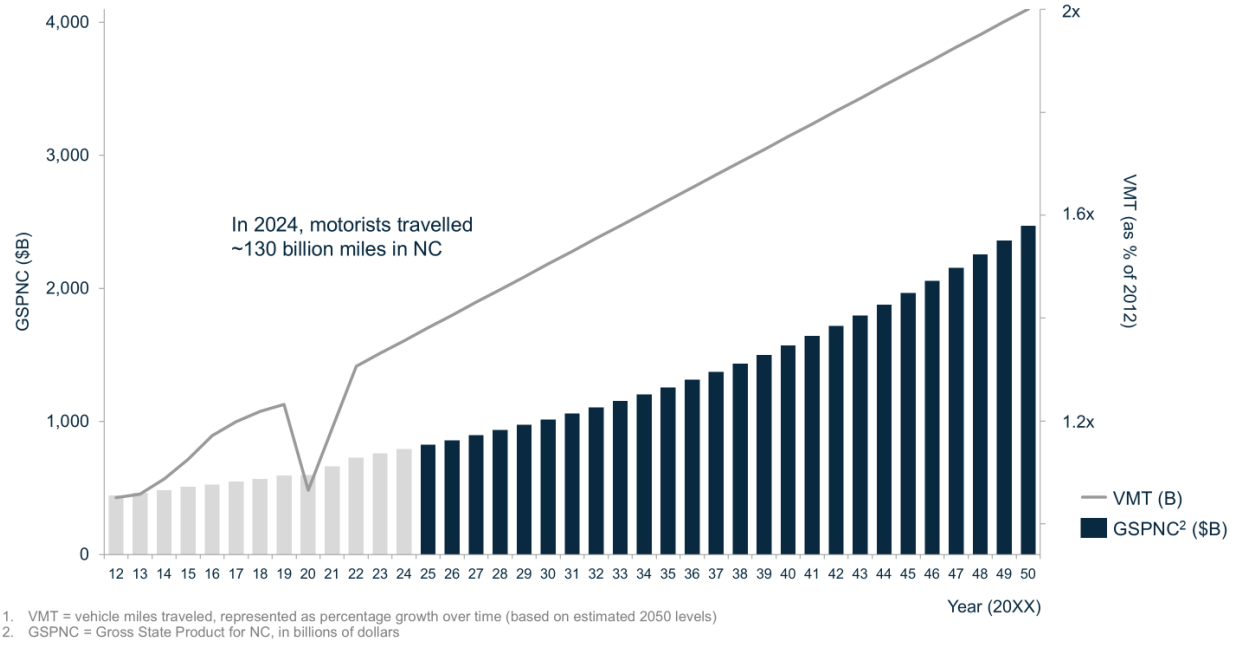


Figure 3: Growth in Gross State Product (GSPNC) and forecasted VMT in North Carolina

In the maintenance funding request presented here, this increase is accounted for by assuming that the rate at which North Carolina's highway system has grown from 2021-2023 will continue, increasing by ~100 centerline miles and ~300 lane miles every year. It also accounts for the increased usage of the system. For context, the bridge inventory increased by ~70 per year during this time period in addition to replacements.

[1] Stradling, R. (2023, Dec 21). New census numbers confirm what we all feel about NC's population growth. *The News & Observer.* https://www.newsobserver.com/news/state/north-carolina/article283184263.html

1.4.3 Trend: Aging Infrastructure

North Carolina has a decades-long track record of successfully delivering transportation infrastructure projects across the entire state since the inception of the DOT over 110 years ago. And while this has had countless benefits to the state's economy and overall well-being, another impact is that we are now facing a growing volume of infrastructure facilities that are nearing or past their original design life. This includes:

- Over 500 lane miles of interstate that are 60+ years old based on original construction date
- An additional 500 miles of interstate that are 50-60 years old (see above)
- Over 1,100 bridges are in poor condition, with average ages of 62 (Overall), 61 (Interstate), 67 (Primary), and 61 (Secondary) years

This MOPAR accounts for aging infrastructure in two ways. The first is by requesting additional funding for bridge maintenance and replacement. The second is by providing a sight picture of the highest priority highway reconstruction/rehabilitation projects that divisions are currently facing. While we are not yet requesting funding to act on these highway reconstruction / rehabilitation projects, it is imperative that we begin to map out the funding mechanisms by which these projects can be supported (see section 4.3).

1.5 Introducing ArTEMIS and Total Cost of Ownership Model

In addition to previous data sources, the 2024 MOPAR report is the first to comprehensively use artificial intelligence and machine learning (AI/ML), alongside the DOT's Total Cost of Ownership (TCO) model, to help detail and forecast investment needs. This data-driven approach combines 1) expanded asset condition data, 2) activity-based cost information for various maintenance treatments, and 3) existing NCDOT data on asset deterioration and treatment frequencies with AI/ML analytics.

In 2020, NCDOT launched an innovative initiative titled Advancing our Transportation Ecosystem through Maintenance Intelligence Solutions (ArTEMIS). The intent was to reinforce planned maintenance with tracking 30+ discrete functions, linked together by a comprehensive data platform.

The ArTEMIS data platform, one of the many data collection and analysis initiatives in NCDOT's modeling toolkit, leverages artificial intelligence and machine learning to identify assets and their conditions across North Carolina's entire state-managed road network. It presents a picture that is complementary to the many well-established and well-validated data sources that North Carolina has developed to date (such as the Pavement Condition Survey, Asset Inventory Collection, and bridge inspections), and that incorporates the invaluable experiences and insights of the field forces. Having multiple such datasets in hand allows the Department to increase confidence levels of analyses and projections. As is the case with whether prediction, having multiple models that point in the same general direction gives us confirmation of their accuracy.

The inventory and condition data used by ArTEMIS was collected across the state from January to September of 2023, representing a point-in-time inventory/assessment for each route and for the state as a whole. During and after collection, this data underwent a wide range of validation and testing. This validation includes route walkthroughs and field

inspections with crews. The data underwent quality reviews involving algorithmic detection of anomalies, comparisons with existing NCDOT datasets and alignment with defect definitions from NCDOT manuals. This resulted in a comprehensive dataset of over 2 million geo-located roadside assets, tagged by route segments, along with square-foot-level data on pavement defects (see section 3.1).

ArTEMIS summarizes this data into a single, comprehensive "Route Score" capturing the overall condition of each route. These scores, which can be aggregated at the county, division, route class, and state level, not only show the condition provided by North Carolina's roads but also is also used to project and quantify the impact of future investment.

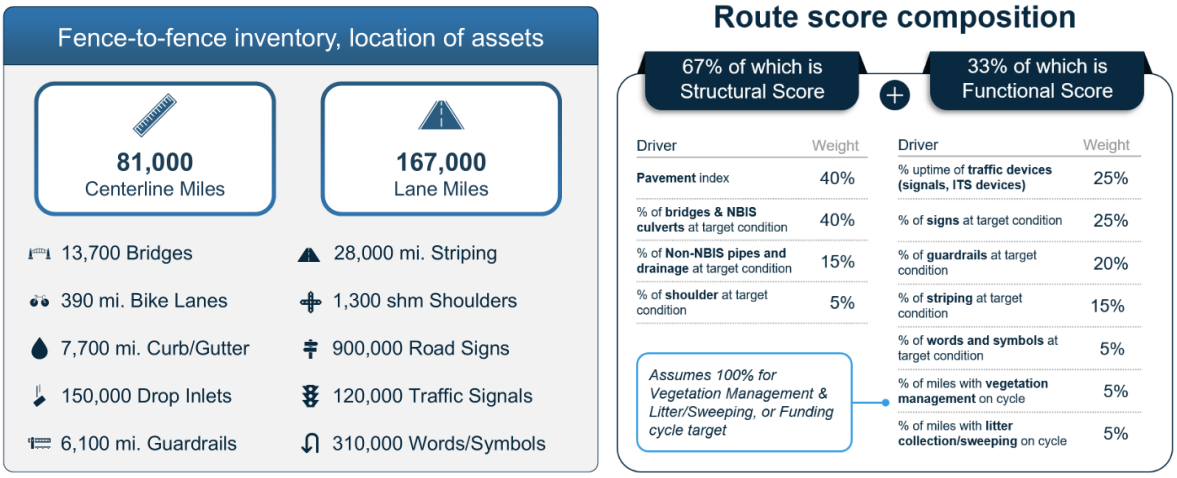


Figure 4: Composition of Route Score

Should-cost data was then gathered through an activity-based costing effort in coordination with Divisions. The goal was to estimate the cost of typical maintenance activities, broken down into their key components: labor, equipment, and materials needed to perform key activities.

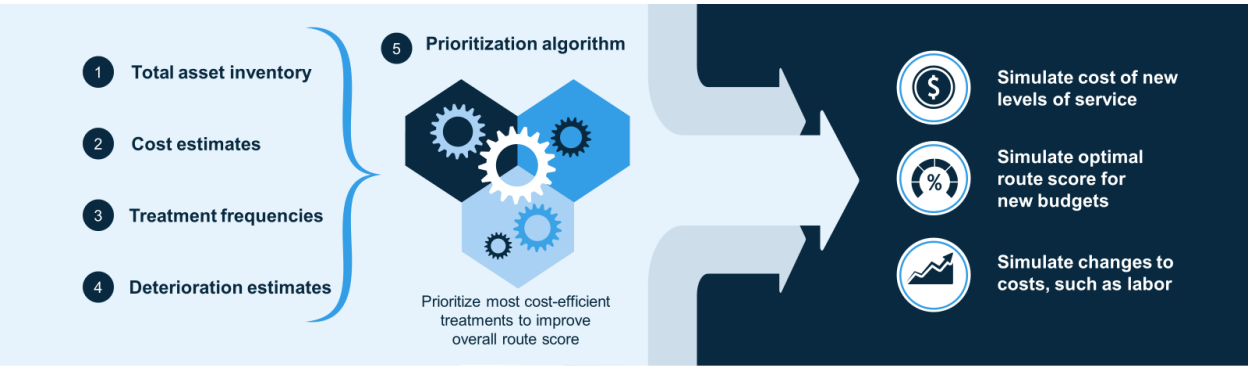


Figure 5: Overview of Total Cost of Ownership model

Validated with multiple rounds of inter- and intra-Division review, these needs capture how much it should cost to perform maintenance activities, representing true need regardless of budget or labor constraints.

Integrating this data with fence-to-fence asset condition enables the TCO model to project the investment required to maintain routes at a given condition level into the future, and inversely the condition that can be expected given a particular level of investment. Various investment scenarios and their outcomes can be evaluated by adjusting a number of variables such as costs, budgets, inflation, condition targets, asset/route prioritization, and other factors.

2 INVESTMENT RECOMMENDATION

The success of the Department's five-year maintenance plans, and of the asset management program more broadly, depends on long-term, consistent, and sufficient funding targeting assets and outcomes or Return on Investment (ROI).

Importantly, this funding should be informed not only by the real conditions on the ground in the state, including the current conditions of NCDOT's managed assets, the costs faced by divisions in maintaining and reconstructing these assets, and the anticipated inflationary pressures that will face the state in the coming years, but also by the condition that system users expect from our state's highway network. To enable targeted investment in maintaining our state's roads, these variables are used to drive TCO scenarios and modelling.

2.1 MAINTENANCE FUNDING RECOMMENDATION

The TCO model is used to quantify the investment need associated with a given scenario – a combination of route score targets, prioritization (e.g. interstate, primary and secondary roads) and economic conditions (e.g. inflation). This data driven method uses specific asset information on each route and "should cost" estimates to optimize investment needed to maintain or achieve a specific condition level over the next ten years, assuming expected inflation and asset deterioration.

In this report, we estimate maintenance needs by maximizing impact of expenditure ("bang for buck") - prioritizing efficiency and cost-effective maintenance activities in terms of their impact on overall state route score, regardless of ongoing projects. We assume rates of inflation for labor, material, and equipment costs of 3%, 5%, and 8% respectively, per the 2023Q4 Engineering News-Record Cost Report. Costs for non-maintenance activities are assumed to increase at annual rate of 5%, in line with the rate used in the latest State Transportation Improvement Program (STIP). We also assume that North Carolina's road network will continue to grow at the rate seen over 2021-2023 (100 new centerline and 450 new lane miles per year, along with ~70 new bridges per year), and account for that increased maintenance need in these estimates.

Our resulting investment recommendation as it relates to each major maintenance group is in **Table 1**:

Fund	FY22 Estimated Need ($M)	FY24 Appropriation ($M)	FY25 Appropriation ($M)	Activity	FY26 Estimated Need ($M)	FY27 Estimated Need ($M)
Pavement Preservation	192	86	86	Preservation	128	147
Contract Resurfacing	805	600	630	Resurfacing	840	966
Bridge Program	330	330	330	Bridge Replacement	585	673
Bridge Preservation	80	85	85	Bridge Preservation	85	98
General Maintenance Reserve (GMR)	902	674	916	GMR Total	1,083	1,246
				• Routine Maintenance Activities	731	841
				• Bridge Maintenance	165	190
				• Snow and Ice/Non-Declared Emergencies	99	114
				• Statewide Programs	88	101
Roadside Environmental	140	119	119	Roadside Activities	140	161
Total	**2,449**	**1,894**	**2,166**	**All Activities**	**2,861**	**3,291**

Table 1: Appropriations and investment needs / recommendations[2]

[2] FY22 Estimated Need sourced from 2022 MOPAR; FY24 and FY25 Appropriations sourced from Certified Budget (Budget Bill) and does not include non-reoccurring revenue which is FY24 $50M and FY25 $100M. FY26 Estimated Need: pavement preservation and contract resurfacing needs estimated via PMS analysis, bridge program, preservation, and maintenance estimated by Structures team, routine maintenance activities need estimated via TCO model, snow and ice/non-declared emergencies, statewide programs, and roadside environmental estimated by FY25 appropriations plus 5% inflation and 0.3% annual system expansion. Roadside activities based on continuation of cycle-based activity needs. FY27 Estimated Need applies 5% inflation and 10% economic risk factor to FY26 baseline.

As described above, this increase in investment is necessitated by North Carolina's high rate of population growth, inflation, and aging infrastructure, as seen in **Figure 6**:

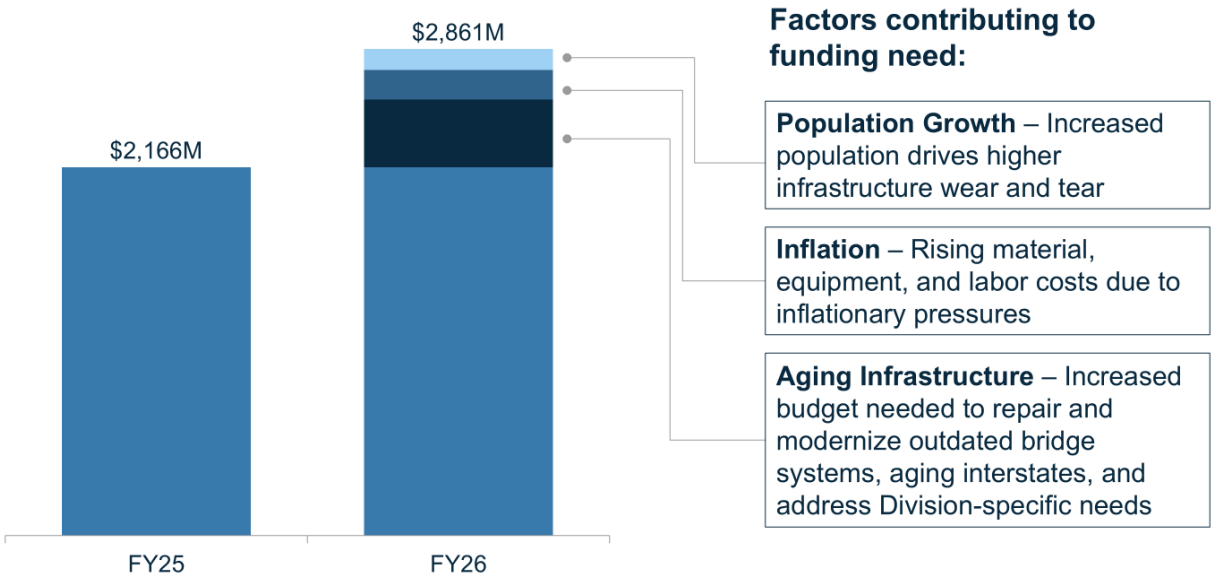


Figure 6: Factors contributing to investment needs

Over the coming decade, we anticipate that each of these pressures will continue to drive growth in the relative funding required to adequately maintain our highway system.

2.2 Investment Scenarios Considered

Table 2 lays out three potential investment scenarios that were considered in the generation of this report, to highlight not only the impact of our proposed level of funding but also the impact that stagnant funding levels would have on our highway network and the level of investment that would be required to bring all of our highway assets up to their maximum possible condition, regardless of their relative use and the capacity of engaging the required labor and material resources.

To ensure alignment with similar long term planning processes, all scenarios assume a 10-year time horizon and start with the network's current condition (as evaluated by ArTEMIS) at a baseline of 83. These scenarios represent a point in time analysis – the intent is to demonstrate the clear, data-driven link between investment in maintenance and outcomes.

	Scenario	Description
A	**Maximize condition**	Raise all routes to highest feasible condition by 2034, funding all outstanding maintenance need
B	**Steady growth**	Gradually raise condition system-wide; condition score from 83 to 85 by 2034 in every Division
C	**Maintain budget**	Funding level remains the same in real dollars; condition declines due to inflation, wear and tear

Table 2: Potential investment scenarios considered

Scenarios A and B involve improving the condition of North Carolina's highway network. Under the first, "maximize condition", we examine what level of investment is required to improve all state routes to their highest feasible condition – bringing all roadside assets to a theoretical "perfect score" condition and addressing every square inch of pavement that falls below any of the existing state maintenance thresholds and treating all road types the same (interstate, primary and secondary roads).

Scenario B, the requested option, involves gradually raising the statewide route score from its current level (83) to an improved 85 over the coming decade. This would represent a steady, sustainable, and actionable target considering both the budgetary/inflationary climate as well as the availability of labor, material, and equipment.

Scenario C is included to demonstrate the impact that static funding levels for highway maintenance would have on the condition of North Carolina's road network. Under this scenario, condition would deteriorate significantly over the coming decade.

Each of these scenarios has wide-ranging implications for the condition of North Carolina's roads and of the individual assets that comprise them. **Figure 7** shows the expected year-over-year changes in route score that would result from these investment scenarios, as well as the level of funding required each year.

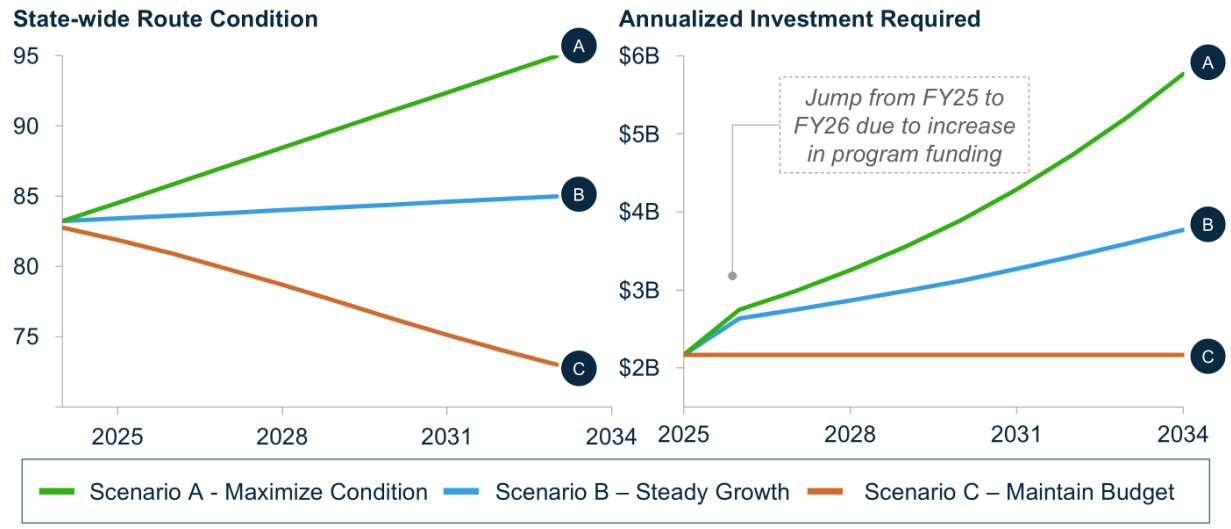


Figure 7: Route condition under maintenance investment scenarios and annualized investment required to achieve targets

There are three important takeaways from these scenarios:

- To address all outstanding maintenance needs in North Carolina's highway network, we would need to be investing upwards of $3B annually by the end of 2030.
- To achieve steady and measured gains in condition based on current priorities, annual investment will need to increase by over 159% by 2030 as a result of inflation, population growth, and our aging infrastructure.
- Due to inflation and regular wear-and-tear, stagnant funding levels will lead to significant and immediate declines in the condition of North Carolina's roads.

2.3 RETURN ON INVESTMENT

Our investment in the maintenance of North Carolina's highway system has clear implications not only for the condition of our road network but also for how well this network performs in terms of its safety, growth-enablement, reliability, accessibility, and resilience.

2.3.1 ROI: Condition

Our maintenance investment decisions will be most immediately apparent in the condition of the structural and functional assets comprising North Carolina's roads. **Table 3** shows how asset conditions are projected to change over the coming decade under each of the described investment scenarios as evaluated via ArTEMIS, demonstrating the clear impact of targeted support.

			Projected Condition in FY34		
Category	Sub-Category	Current	Maintain Budget	Steady Growth	Maximize Condition
Route Score	NC system	83	75	85	96
Pavement Condition (avg. Index)	Interstate	89	87	89	92
	Primary	83	78	89	93
	Secondary	82	61	82	90
Bridges (% Poor)	Interstate	2.7%	4%	2%	1%
	Primary	6.0%	8%	5%	4%
	Secondary	10.0%	14%	9%	9%
Asset Condition (% Defective)	Bike Lanes	21.9%	24.5%	21.9%	0.0%
	Cablerail	1.9%	2.5%	1.9%	0.0%
	Guardrails	2.0%	3.0%	2.0%	0.0%
	Pavement Striping	18.1%	17.6%	11.1%	0.0%
	Road signs	6.2%	9.5%	6.2%	0.0%
	Sharrows	15.7%	20.6%	15.7%	0.0%
	Shoulders	1.9%	4.7%	1.9%	0.0%

Table 3: Projected impact of maintenance investment on asset condition

In addition to demonstrating how improved investment could have real impacts on fence-to-fence assets, these projections also show the negative impacts of insufficient investment, even when this investment is fully optimized for the best possible outcomes. If funding is not

adjusted to keep pace with anticipated inflationary pressures, the secondary system in particular will see drastic decreases in pavement condition as funds are diverted to support increasingly costly treatments for interstate and primary routes.

The return on investment in highway maintenance can also be seen in Pavement Management System (PMS) analyses. These analyses, shown in **Figure 8,** demonstrate how if funding levels are kept constant over the coming decade (based on FY 2025 Contract Resurfacing and Pavement Preservation allocations) then the proportion of Good roads (roads with an NCDOT rating of >=80) will drop statewide, while the proportion of Poor roads (roads with an NCDOT rating of <60) increases significantly. Given that maintenance on the Primary system would be prioritized under this scenario, even more stark declines would be seen on the Secondary system.

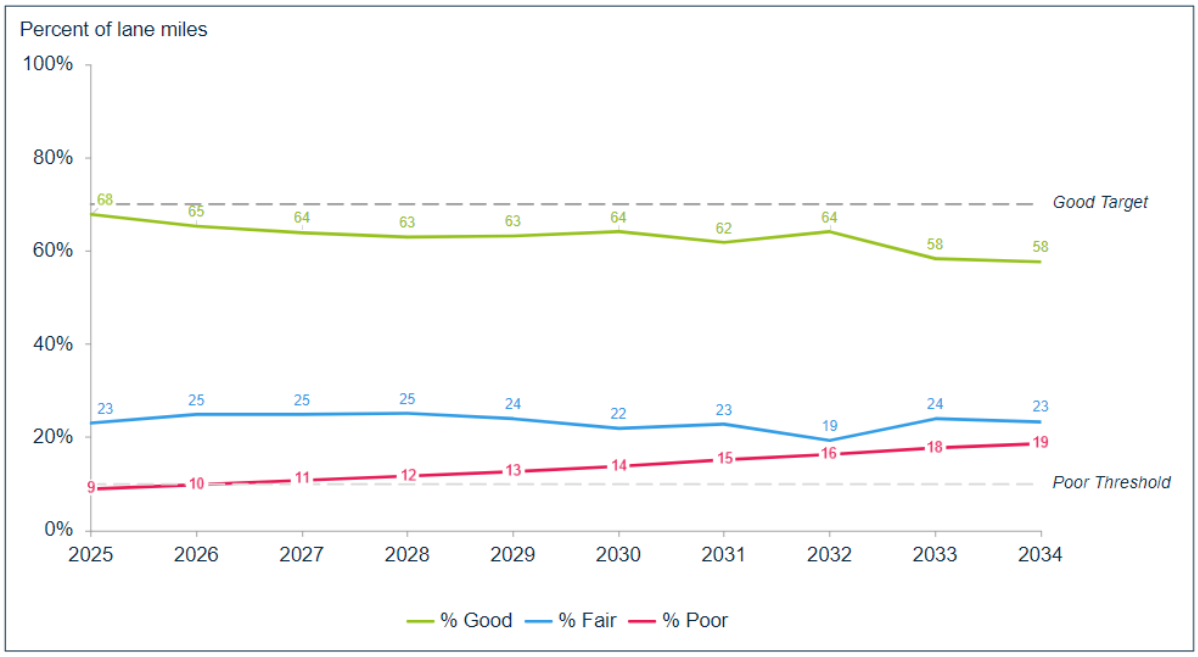
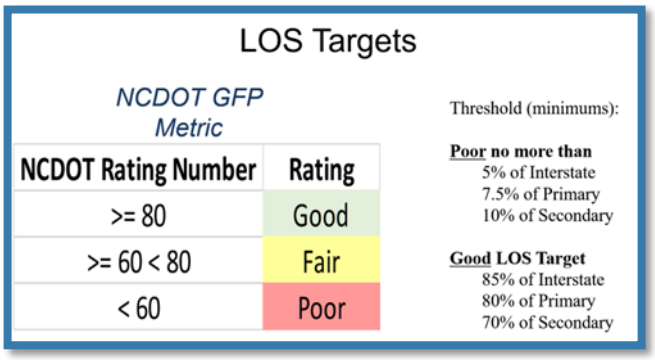


Figure 8: Projected impact of constant funding levels per PMS analysis

PMS analysis also demonstrates the extent to which significant increases in funding for pavement preservation and resurfacing will be required if the department intends to hit and maintain its targets for the proportion of Good and Fair roads. As seen in **Figure 9**, PMS analysis projects that funding levels consistent with the above-stated needs will be required to ensure that the primary and secondary system will be able to maintain level of service (LOS) targets into the coming decade.



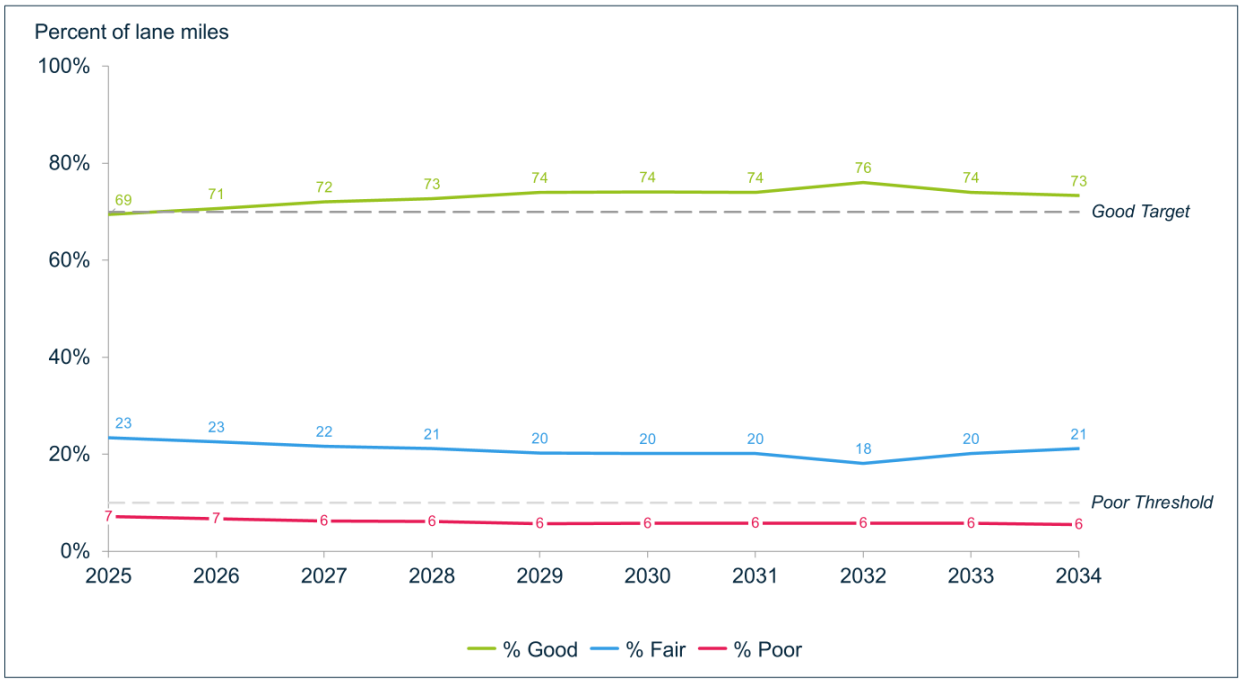


Figure 9: Projected impact of need-based funding levels per PMS analysis

2.3.2 ROI: Performance

The return on our investment in maintaining North Carolina's highways will also be seen in the degree to which we support the critical outcomes associated with our transportation network. Investment supports these outcomes in many ways, including (*data per NC FIRST Commission Report*):

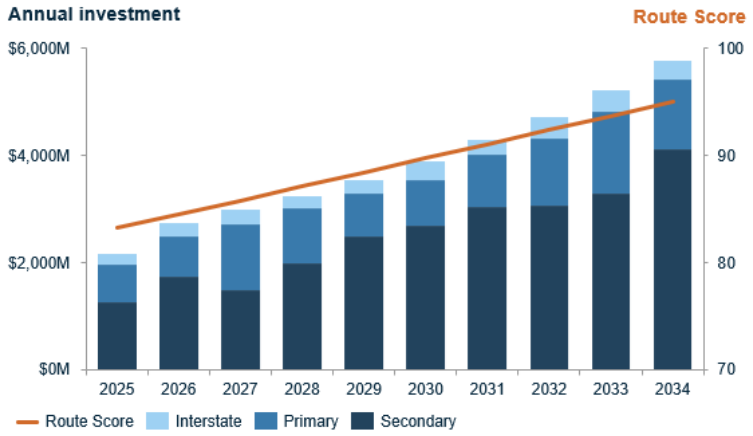
- **Safety:** North Carolina ranks 49th in rural fatality rate, which could be improved through greater investment in rural roads.
- **Economic growth:** State investments in transportation would yield 10x returns in wages and GDP.
- **Customer experience:** Inadequate road safety features contribute to crashes costing North Carolina drivers $3.3B / year.
- **Equal access:** Poor road quality can exacerbate geographic isolation for outlying rural communities.
- **Resilience:** Robust infrastructure is critical for North Carolina's resilience to natural disasters, with preventative maintenance reducing need for expensive replacements.

Delivering targeted investment in maintaining North Carolina's highway system will yield clear returns across these categories, as described in the following scenario details.

2.4 Scenario Details

The following sections highlight the specific investment needs associated with the potential scenarios and provide greater insight into the targets driving them and anticipated impacts.

2.4.1 Scenario A: Maximize Condition



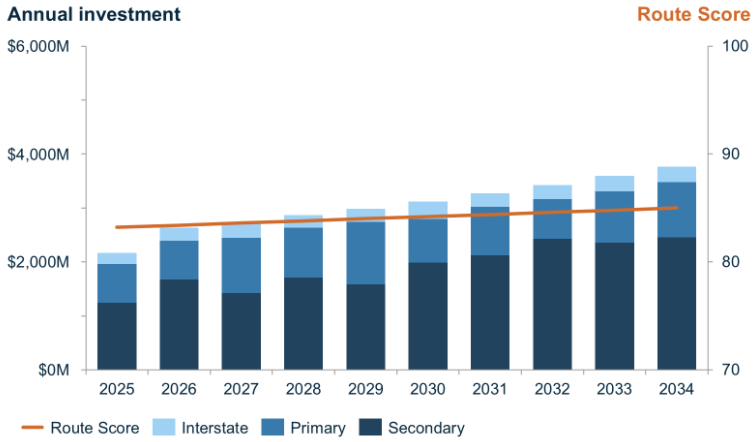
Approach: Improve condition significantly by raising all routes to highest feasible condition by 2034, funding all outstanding/emerging maintenance needs.

Impact on condition: Highest possible condition achieved across system by improving route score greater than 10 points over ten years. Pavement index of 90 or higher across Divisions, all roads having been resurfaced at least once. All defective roadside assets completely cleared fence-to-fence.

Impact on performance:

- **Safety**: Reduce accidents originating from defective assets—e.g., signs, striping, etc.
- **Economic growth**: Improve routes with heavy truck traffic and increase free flow.
- **Customer experience**: Improve ride quality through smoother roads via resurfacing.

2.4.2 Scenario B: Steady Growth



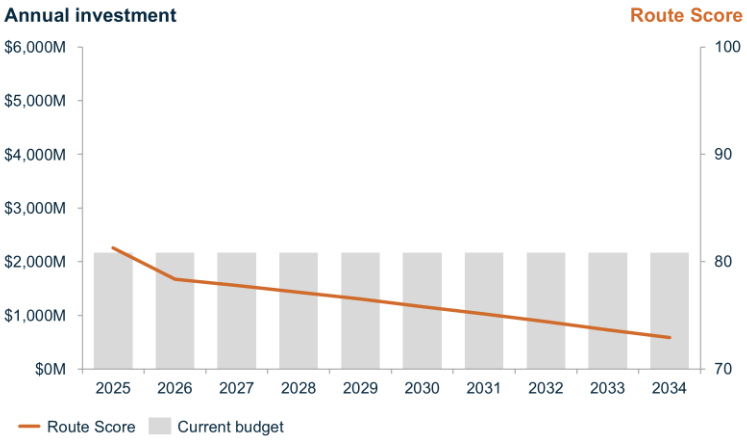
Approach: Improve condition via +2 point increase in route score for every Division, normalized by route class.

Impact on condition: Improvement to overall system's condition via ~2 point increase in route score over 10 years. Maintain current conditions and assets over 10 years for roadside assets currently exceeding target score. Improve pavement index to 85 or higher across all Divisions by year 10.

Impact on Performance:

- **Economic growth:** Increase freight free flow via better road condition
- **Customer experience:** Improve ride quality through smoother roads from resurfacing activities

2.4.3 Scenario C: Maintain Budget



Approach: Maintain current budget allocations and optimize for highest route score despite inflation rates.

Impact on condition: Condition worsens over time, with a future route score of 75.2. Pavement condition sees greatest drop in quality; projected greater than 20-point reduction in secondary system pavement index. Asset conditions drop; most cost-effective treatments may be prioritized more heavily.

Impact on performance:

- **Safety:** Accidents more likely to happen as conditions drop for key assets.
- **Customer experience:** Reduction in ride quality across system, esp. secondary.
- **Economic growth:** Worse conditions may lead to congestion, decreasing freight flow.

3. System Performance

What has been North Carolina's return on its historic investment in maintenance in terms of the condition provided by its road network?

3.1 Current System Condition

The ArTEMIS data allows us to first examine this in terms of not only the overall route score achieved by the state's highway system, but also in terms of individual assets' condition. See section 1.5 for details on the ArTEMIS data.

3.1.1 Route Score

Pulling together data from all state-managed routes, with greater weight given to the Interstate and Primary system, North Carolina has a **state-wide route score of 83.2**, broken down as follows across route classes:

- **Interstate routes: 89**
- **Primary routes: 83**
- **Secondary routes: 82**

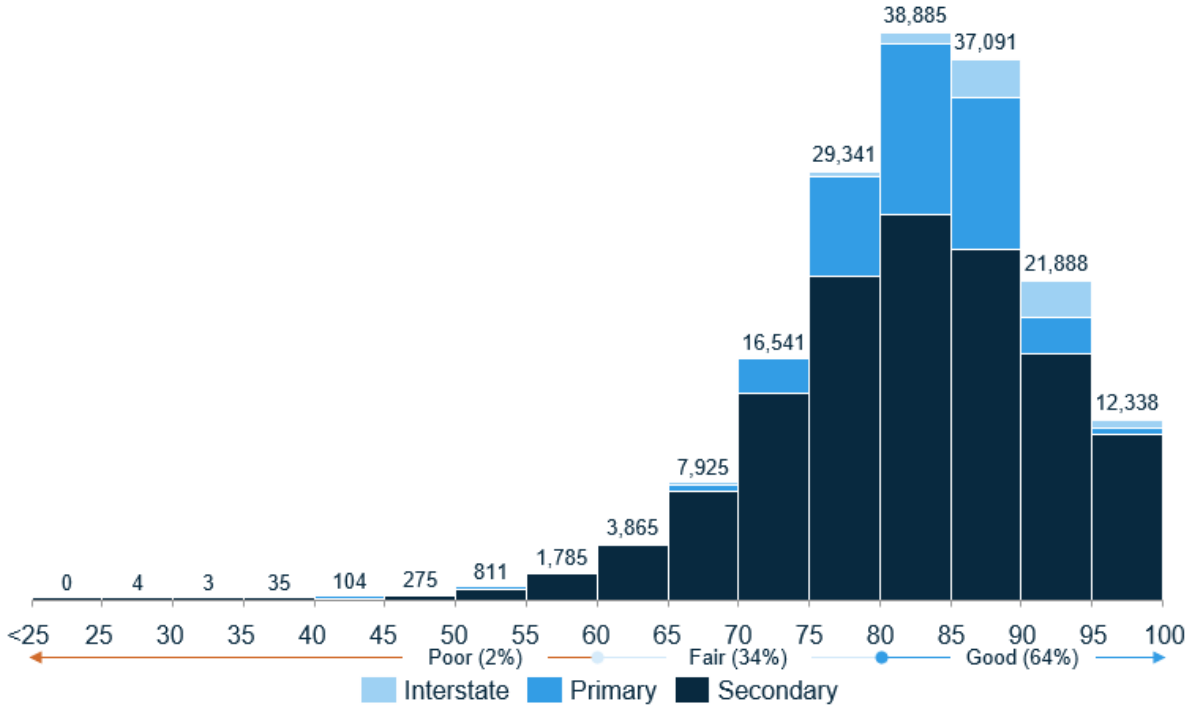


Figure 10: Route score distributed by lane miles

The distribution of these scores across the state's routes can be seen in **Figure 10**, with their geographic distribution displayed via **Figure 11** on the following page. As can be seen, most lane miles in the state (82%) have scores exceeding 75; this includes 78% of Secondary route miles, 92% of Primary route miles, and >99% of Interstate route miles.

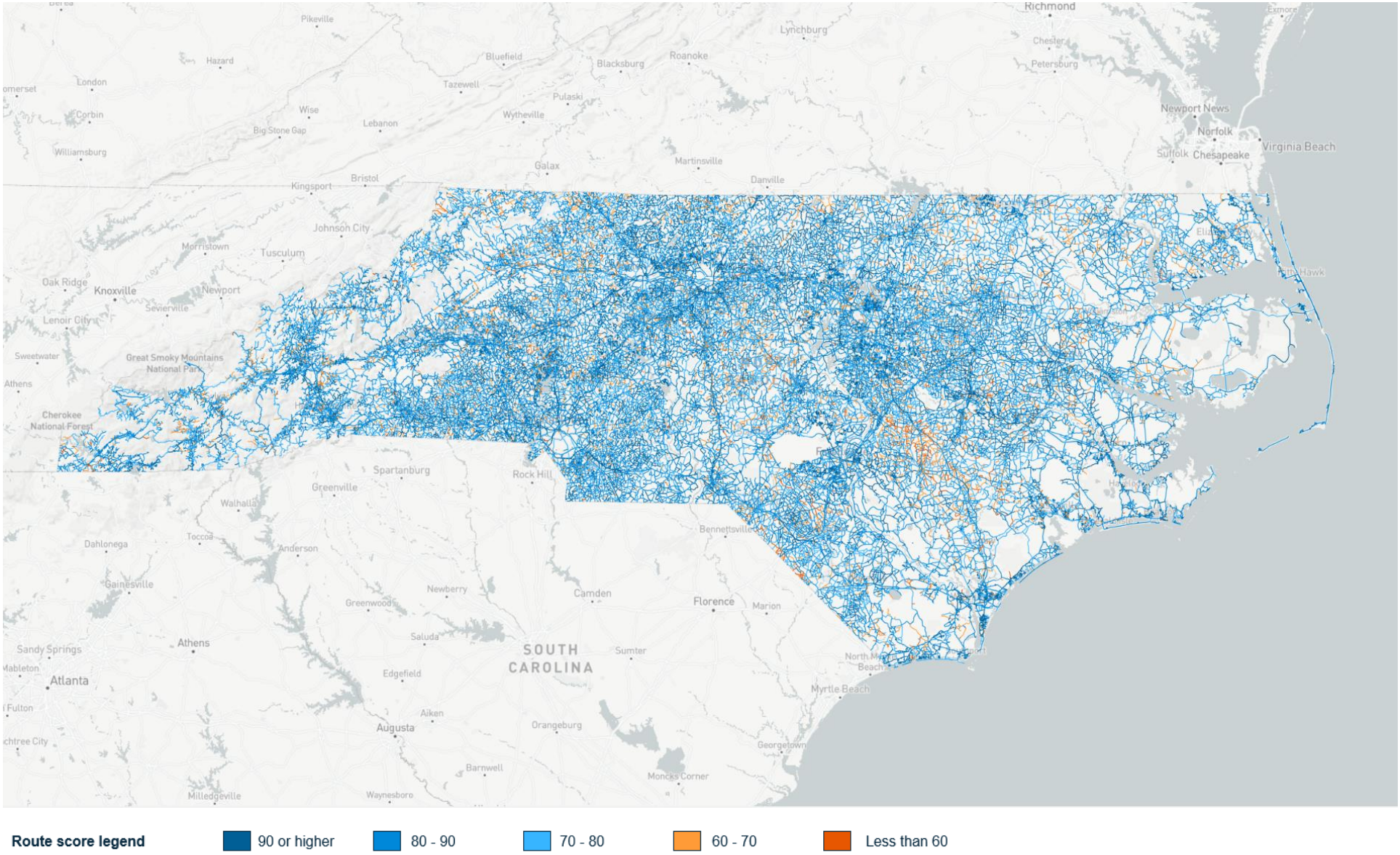


Figure 11: Spatial distribution of route scores

3.1.2 Pavement Condition

The pavement section of the HMIP focuses on maintaining pavements of the state's primary and secondary roadway system. To develop and implement a successful work plan, the specific roadway characteristics, treatment type and timing of treatment must be carefully considered. The Department has a large roadway system, requiring a substantial financial investment to maintain. While the Department continues to provide significant financial investment into pavements, the improvements to pavement conditions will be gradual. Furthermore, while overall system conditions may change slowly from year-to-year, individual roadway conditions can vary seasonally, dependent upon rainfall, freeze-thaw cycles, and traffic loads. As such, the ability to easily respond to rapid condition changes by shifting resources and modifying previously identified treatments is critical.

With the funding level for resurfacing and pavement preservation programs over the past two years, the Department has been able to make some improvements in the number of miles treated and cycle time for which the Department treats pavements. Cycle time (the interval between each treatment activity) helps to identify the number of miles needed to reach targets. The pavement industry recommends contract resurfacing to be completed every 12-15 years, while pavement preservation every 4-7 years. This section provides a summary of plans and accomplishments for each treatment type – contract resurfacing and pavement preservation.

While not included within the Department's HMIP planning process, it should be noted that maintenance of the pavement and bridge assets along the interstate system also require a significant annual financial investment to ensure condition targets are maintained. Although the amount of road miles and bridges contained within the interstate system is far less than that of the primary and secondary systems, the highest volumes of traffic across the state use these routes every day. Interstate routes are critical to the movement of freight and other goods in and through the state and must be maintained at a higher condition level. Interstate maintenance (IM) projects are funded with federal aid funds, and as such are programmed within the 10-year State Transportation Improvement Program (STIP) and not within the 5-year HMIP. In the current STIP, interstate maintenance investment levels average about $150 million/year for the 10-year period. The projects are initialized with treatment types, limits, and cost estimates. Each Highway Division reviews projects in their area and submits recommendations based on local knowledge and engineering judgment. These recommendations can include changes to the treatment types, limits, and estimated cost. Senior management reviews the Division recommendations and selects projects from a statewide perspective within fiscal constraints.

3.1.2.1 Cycle Times – Contract Resurfacing & Pavement Preservation

As shown in **Table 4**, average cycle time for contract resurfacing is 40 years – **roughly three times the industry recommendations, and cycle time for preservation is 46 years – over six times the industry recommendations**. Reaching the recommended cycle times is essential to meeting an expected condition – when roads are not properly preserved, they need to be resurfaced sooner and will cost more due to increased pavement patching needs.

Budget Group		Plan Cycle Time (years)								Completed Cycle Time (years)						
		'18	'19	'20	'21	'22	'23	'24	'25	'18	'19	'20	'21	'22	'23	'24**
Preservation	Overall	31	29	29	31	34	38	54	45	22	31	107	58	54	46	103
	Primary	110	145	98	63	51	93	294	289	33	78	679	82	206	145	210
	Secondary	26	23	24	27	31	32	44	36	20	26	87	54	44	38	90
Resurfacing	Overall	29	25	27	34	25	32	38	32	26	25	51	34	31	40	98
	Primary	16	14	17	23	14	24	32	24	15	16	33	20	20	29	70
	Secondary	38	32	32	40	31	35	40	36	32	30	60	42	36	44	110

Table 4: Cycle times for planned and accomplished work
*****Partial Paving Season***

3.1.2.2 Lane Miles – Contract Resurfacing & Pavement Preservation

The volume of lane miles on which contract resurfacing and pavement preservation activities are conducted is seen in **Table 5**.

Budget Group	Planned Lane Miles (Baseline by Plan Year)								Completed Lane Miles (Dynamic by Paving Season)						
	'18	'19	'20	'21	'22	'23	'24	'25	'18	'19	'20	'21	'22	'23	'24**
Preservation															
Primary	320	244	361	563	687	371	120	122	1,055	454	52	428	171	244	168
Ramp	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
Secondary	4,876	5,303	5,190	4,563	3,989	3,865	2,845	3,467	6,205	4,717	1,439	2,321	2,809	3,262	1,384
Resurfacing															
Primary	2,154	2,457	2,083	1,499	2,453	1,473	1,090	1,483	2,293	2,255	1,089	1,719	1,718	1,228	497
Ramp	16	7	5	19	8	8	0	3	5	13	9	28	20	10	4
Secondary	3,302	3,871	3,828	3,139	3,944	3,507	3,075	3,452	3,876	4,117	2,063	2,947	3,462	2,799	1,129

Table 5: Lane miles of planned and accomplished work
*****Partial Paving Season***

3.1.2.3 Pavement Condition Survey Assessment

Figure 12, **Figure 13**, and **Figure 14** show pavement condition as assessed via the Pavement Condition Survey for interstate, primary and secondary routes. They illustrate funding limitations and trade-offs: while the proportion of secondary routes in good condition has increased, so has the share of primary routes in fair or poor condition. Across systems, improvements in interstate and secondary routes have come at the expense of maintaining the same condition levels on primary routes.

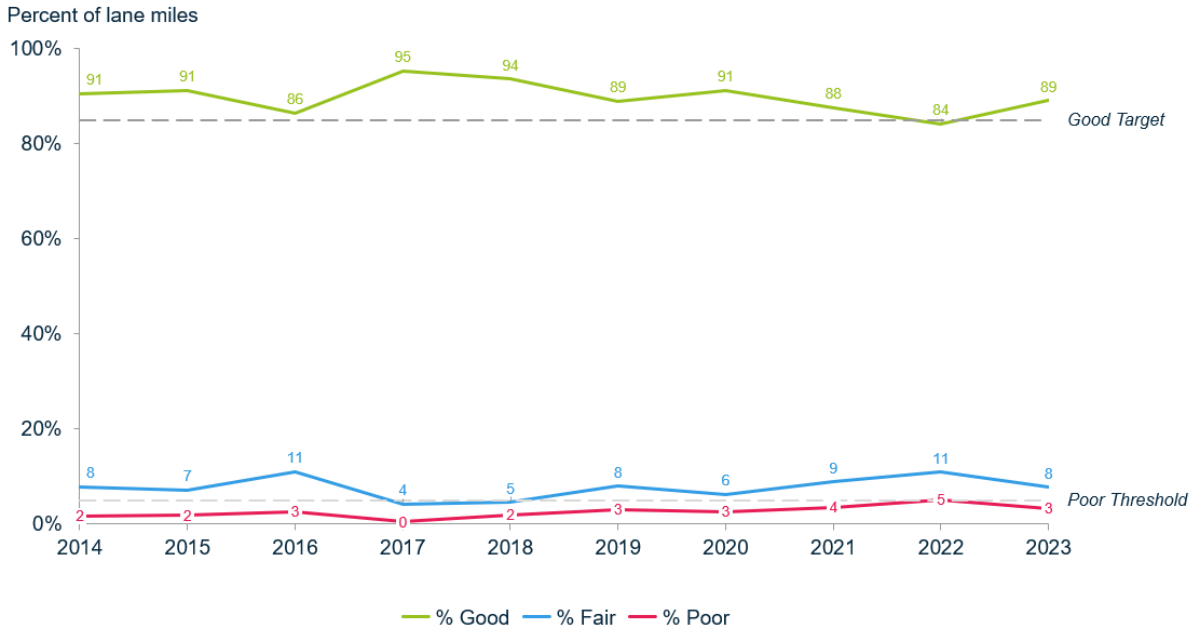


Figure 12: Interstate pavement condition, 2014-2023

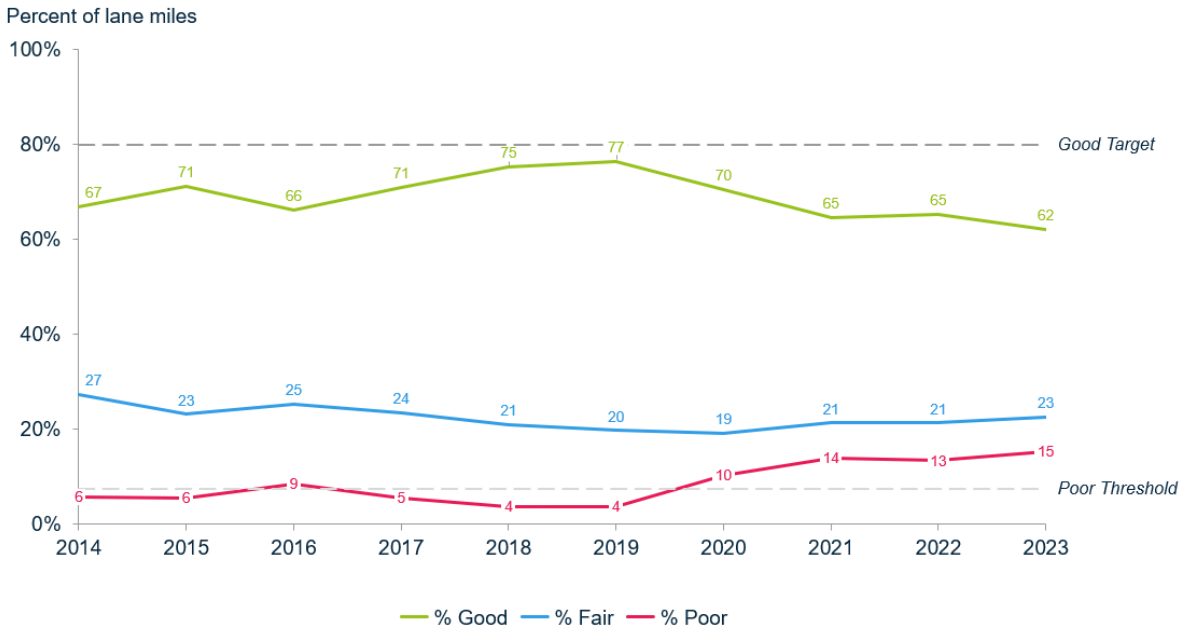


Figure 13: Primary network pavement condition, 2014-2023

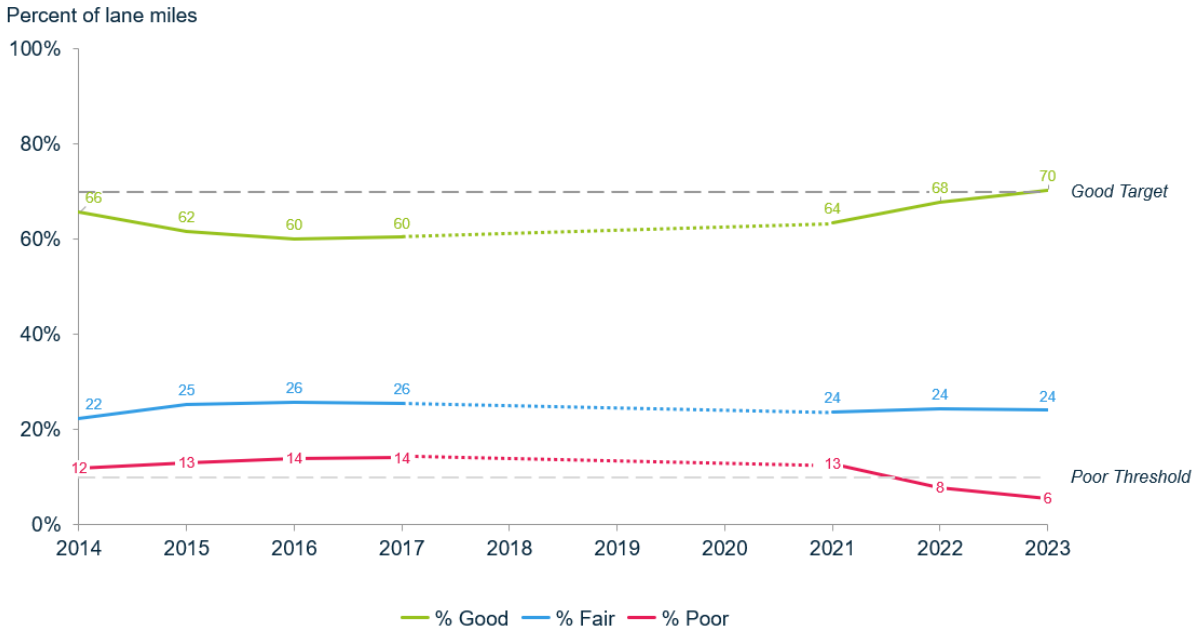


Figure 14: Secondary network pavement condition, 2014-2023[3]

[3] Pavement condition survey results omitted in 2018 due to challenges in automation. No survey conducted in 2019, 2020.

National Highway System Pavements – Federal Performance Measures

There are 5,638 miles of road on the National Highway System (NHS) in North Carolina– which comprises Interstate highways, interstate business, US, NC and selected secondary routes and ramps connecting to an NHS route. Conditions and progress towards targets are reported to the Federal Highway Administration (FHWA) in the Transportation Asset Management Plan (TAMP). Through MAP-21, national performance goals have been established for pavements and bridges to maintain the condition of these assets in a state of good repair. Performance ratings of good, fair, and poor condition for pavements have been established by FHWA based on a combination of several metrics collected by every state DOT in accordance with HPMS (Highway Performance Monitoring System). FHWA uses these metrics to quantify the condition of pavements in terms of roughness (International Roughness Index - IRI), percent cracking, rutting (asphalt) and faulting (concrete). As shown in **Figure 15** and **Figure 16**, the percentage of Poor NHS pavements has remained flat, and the percentage of good NHS pavements has increased slightly in the last half decade.

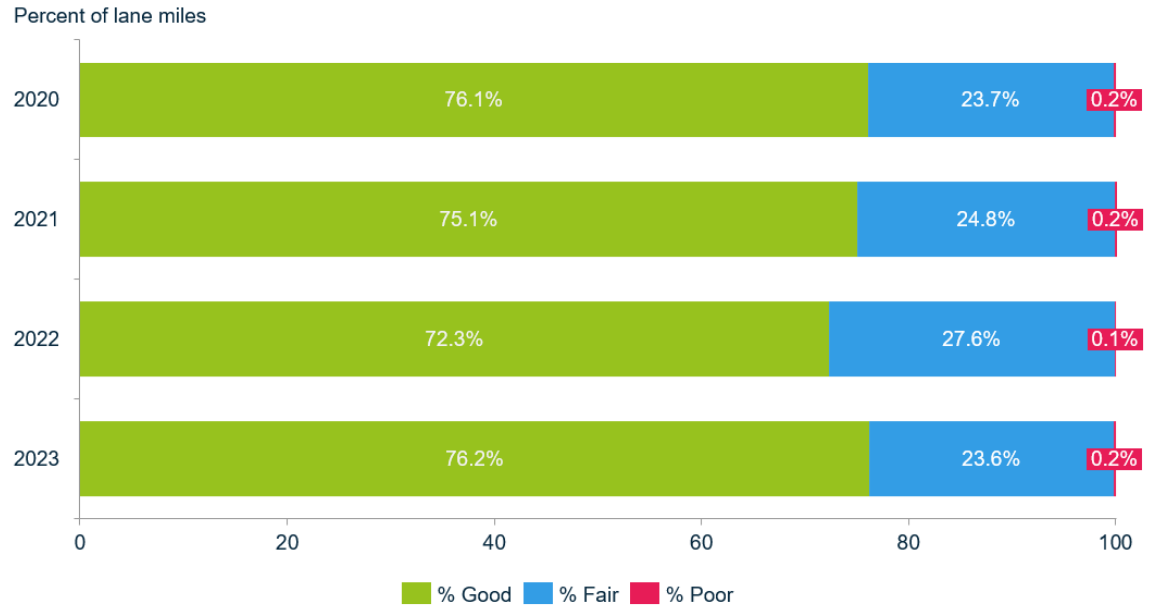


Figure 15: NHS Interstate system pavement conditions

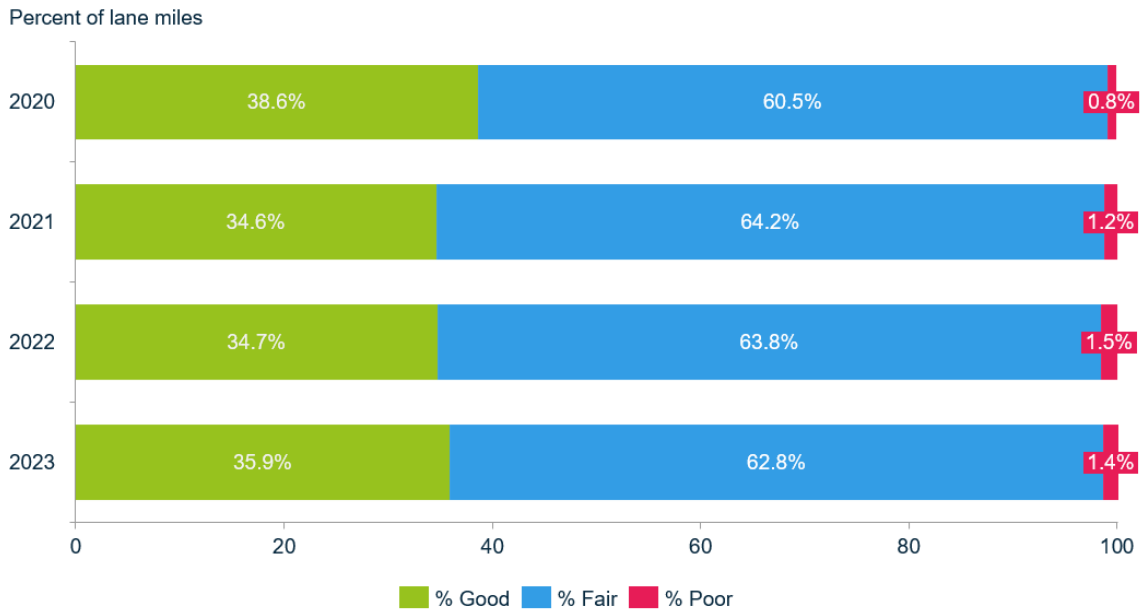


Figure 16: NHS Non-Interstate system pavement conditions

3.1.2.4 Pavement Condition Index Assessment

The ArTEMIS data provides a parallel assessment of pavement condition to the PCS at a statewide level via its Pavement Index, again with the ability to break down across the different route classes (as well as by division, county, route, etc).

ArTEMIS is consistent with and complementary to the existing Pavement Condition Survey data. The ArTEMIS Pavement Index uses the same defect criteria and scoring system as the Pavement Condition Survey, the only difference being the use of the ArTEMIS AI/ML engine to detect and locate pavement defects. These pavement scoring approaches both show Interstates as having a higher pavement condition than Primaries which in turn achieve better scores than Secondaries.

This similarity also carries over to projections of associated maintenance costs as well as to the individual defect assessments comprising the scores.

Figure 17 shows how ArTEMIS' Pavement Index categorizes North Carolina's routes by class, showing a similar picture of high-quality pavement on Interstate routes with comparably worse conditions on Primary and Secondary system routes.

This picture is affirmed by examining the lane-mile-weighted average Pavement Index for each class. Here we see an overall state score of **83**, with Interstate routes scoring an average of **94**, Primary routes an average of **84**, and Secondary routes an average of **81**.

Geographic distribution of these scores by county can be seen in **Figure 18** on the following page, as well as in the Division-level reports in **Section II.** Counties in lighter shades have higher scores, while those in darker shades have lower scores.

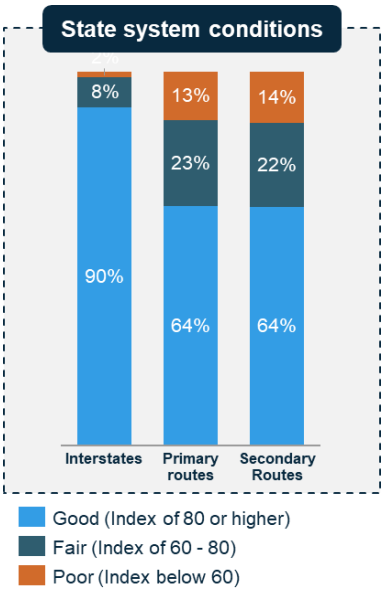


Figure 17: Pavement Index at state level

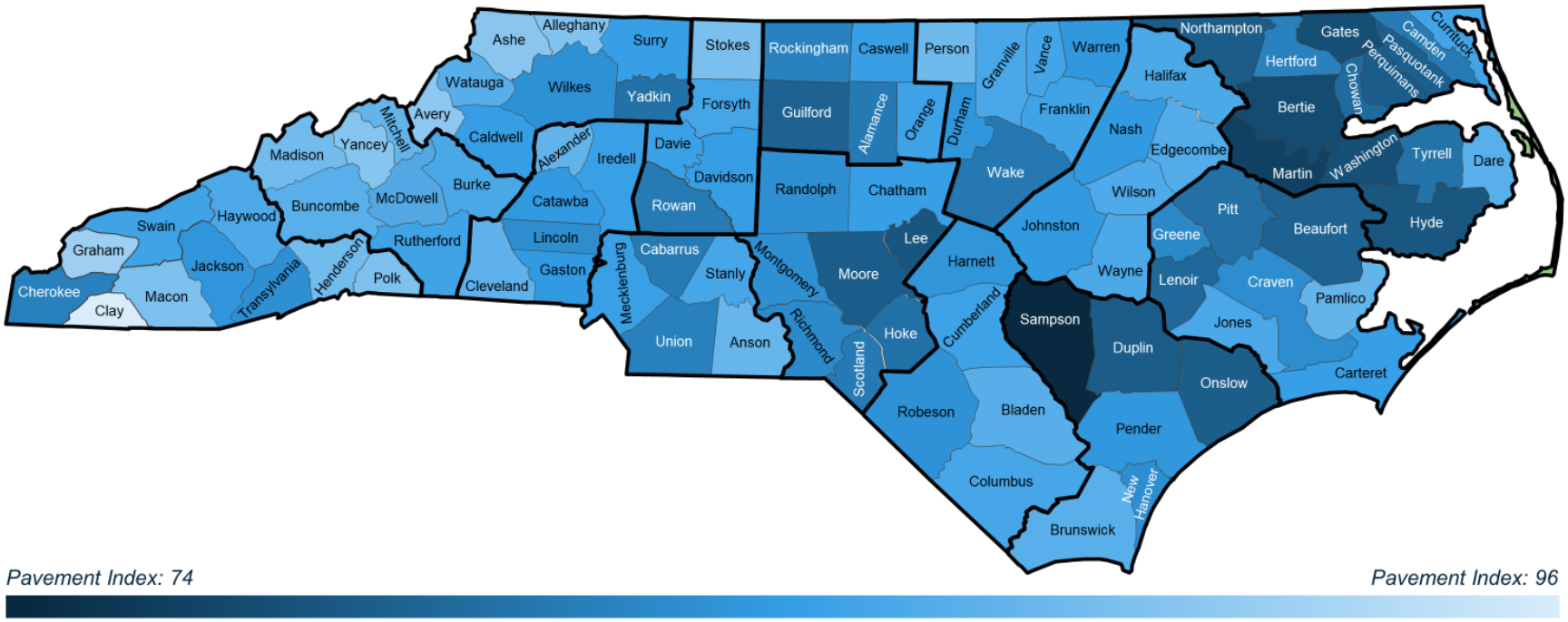


Figure 18: Pavement index by county (weighted average by lane mile)

3.1.3 Bridge Condition

All bridges experience natural deterioration and aging, but each one ages differently. Regular inspections allow the Department to assess the specific condition of each bridge, ensuring maintenance, repairs, and replacements are tailored to its unique needs. The Department follows National Bridge Inspection Standards (NBIS). These structures are inspected on a 24-month cycle but may be inspected more frequently if warranted by poor condition ratings or other factors. Underwater inspections are performed on a 48-month cycle when underwater components cannot be assessed during an above-water inspection. NCDOT collects and stores bridge inspection data and reports for all state and locally owned bridges in North Carolina within the Bridge Management System. Bridge inspection data for all state and locally owned bridges is collected in accordance with the requirements of NBIS. NCDOT collects data on all bridges regardless of owner.

Condition ratings for bridges were established based on a nine-point rating on each of three components: deck, superstructure, and substructure. Culverts are similarly rated on overall condition. The overall condition of a bridge is considered “good” only if all three components are “good” (condition score of 7-9). It is considered “poor” if any one of the three components are “poor” (condition score of 0-4). The bridge is otherwise considered “fair”. Culverts rated solely on their overall condition.

To fully address the issues on a bridge in poor condition, extensive rehabilitation or replacement is typically required. Since 2015, State funds have been the primary and necessary funding source for bridge replacements. As shown in **Table 6**, state funds for the replacement of bridges in poor condition has increased since fiscal year 2017. Beginning in fiscal year 2018, additional bridge preservation dollars were provided to fund cost effective solutions to maximize bridge life and lower lifetime costs.

Program	2017	2018	2019	2020	2021	2022	2023	2024	2025
Bridge Program	$242M	$280M	$272M	$201M	$273M	$274M	$275M	$330M	$330M
Bridge Preservation	-	$80M	$82M	$76M	$60M	$70M	$70M	$85M	$85M

Table 6: Bridge program and preservation allocations

North Carolina’s bridge portfolio consists of over 13,700 bridges statewide, of which 8.4% are in poor condition. As shown in **Table 7**, the percentage of bridges in poor condition has significantly decreased since 2015. This decrease has continued as funds focused on bridge preservation and replacement have increased. As a result of progress in reducing the percentage of poor condition bridges, the Department proactively updated its 2030 Goals in Fall 2023 to better reflect the

1 in 12
Bridges in "poor" condition

bridge asset conditions that are necessary to support NCDOT's mission. The revised goals are: fewer than 1% bridges in "poor" condition on the interstate system, fewer than 4% on the primary system, and fewer than 9% on the secondary system. The updated goals provide an overall statewide goal of 7% which equates to a "B" grade by national infrastructure publication standards. Prior to this MOPAR the goals for percentage of poor condition bridges were 10% statewide including 2%, 6%, and 15% for the interstate, primary, and secondary systems. A 10% goal aligned with a "C-" grade.

System	FY2015	Current	Impact / Change	2030 Goal
Interstate	4%	2.7%	-1.3%	1%
Primary	9%	6.0%	-3.0%	4%
Secondary	17%	10.0%	-7.0%	9%
Statewide (weighted average)	**14%**	**8.4%**	**-5.6%**	**7%**

Table 7: Percentage of bridges in poor condition, FY2015 vs. current

While bridges being built today are designed for a 75-year life or longer, most of the bridges on the state system were designed for a useful life between 50-60 years. However, not all bridges that exceed this age are inherently in poor condition. By contrast, there are several bridges that have deteriorated into poor condition well in advance of the 50-60-year average age expectation. This can be due to a variety of factors including harsh environments, higher than anticipated traffic volumes and local/regional development.

As is evidenced in the funding request, the Department anticipates that increased funding will be required for the Bridge Program to be able to overcome the impacts of inflation, system growth, and its own aging/deteriorating infrastructure to continue recent condition improvements and achieve statewide goals by, or before, year 2030. **Figure 19** indicates the historical performance of the Department's bridge inventory across the interstate, primary and secondary road network—bridge preservation and replacement have driven consistent progress towards the department's goals.

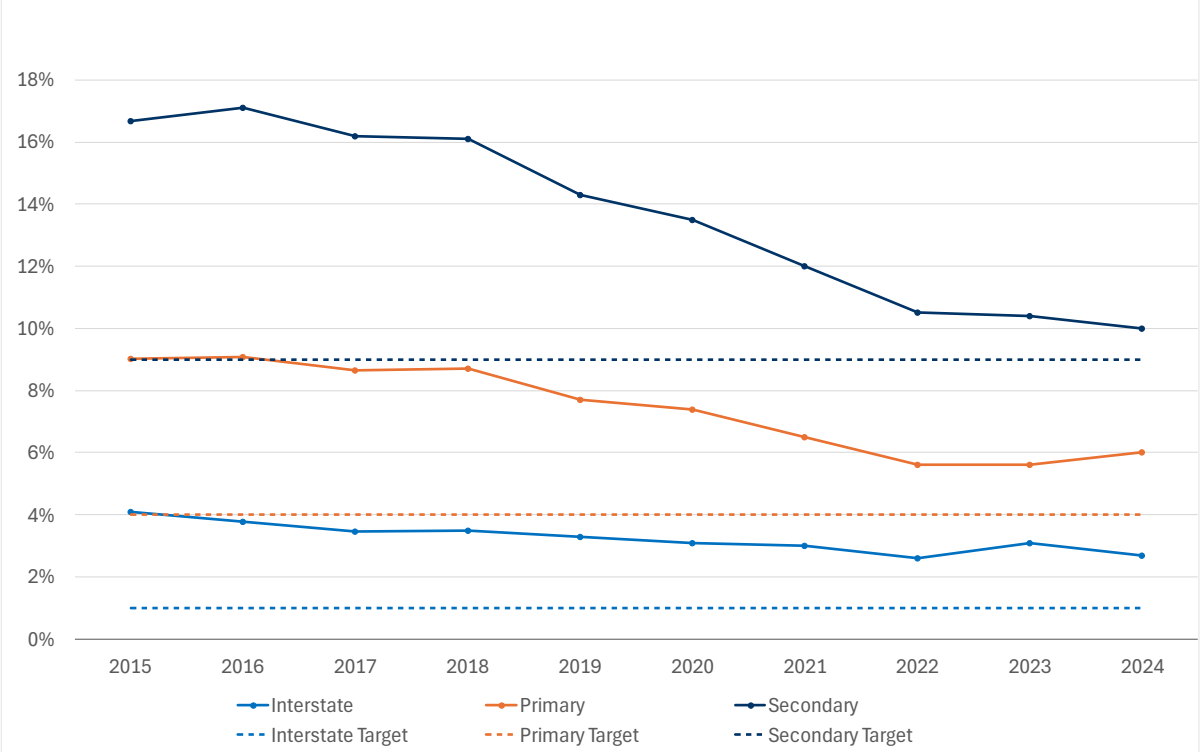


Figure 19: Historical fraction of "poor" bridges

3.1.3.1 Bridge Program - Preservation

While the Department is confident that the requested increase in funding for bridges is sufficient to reach performance goals, risks have been identified that may delay goal achievement. Two such risks are bridges that have disproportionately high replacement costs and interstate/primary system bridges. If the Department's "high value bridges", those that cost more than $20 million to replace, are allowed to deteriorate, then progress toward goals may slow as a large portion of available funds would be required to replace a small number of costly structures. While high value bridges only account for 2.5% of the inventory by bridge count, their combined replacement cost accounts for 40% of the total bridge system value. Preservation funds should also be used on interstate/primary system bridges in good condition to prevent them from becoming fair condition prematurely. Additionally, interstate/primary bridges only account for 35% of the inventory by bridge count, but their combined deck area accounts for 65% of the inventory and 80% of the average daily traffic (ADT) in North Carolina. If long term goals are to be met, it is imperative that these bridges are maintained in the best possible condition through systematic preservation.

In FY2018, the Bridge Preservation Program was established and initially funded at $80 million and is funded at $85 million in FY 2025. This program was sub-allocated into two programs. The first is a program that focuses on preserving the Department's high replacement cost bridges. The remaining funds provided by the Bridge Preservation Program are allocated to Divisions to enable systematic preservation of interstate/primary system bridges.

3.1.3.2 Bridge Program – Maintenance

Bridge maintenance is funded through the General Maintenance Reserve (GMR) appropriation. Bridge maintenance funds are used for both planned and unplanned work activities. These funds are used to assist state bridge maintenance crews in prolonging the life of bridges by funding timely repairs and maintaining bridge components critical to reducing long term maintenance costs.

Planned maintenance work activities are those that are performed on a recurring basis and can be planned to in advance of the work taking place. However, as is typical with all work activities, there are unexpected events that will require forces to be reactive in their maintenance efforts. Therefore, not every expenditure associated with a planned maintenance work activity can be anticipated in advance, resulting in both planned and reactive costs.

Planned Routine Maintenance activities are based on condition targets. Examples include bridge joint repairs and painting steel girders, among others. In addition to the planned work activities/work functions, Divisions conduct significant amounts of reactionary maintenance work on several additional work activities. These are activities that cannot be planned and typically require an immediate response. Examples of these activities include steel beam repairs and substructure repairs.

3.1.3.3 ArTEMIS Bridge Scores

To factor bridge condition into the ArTEMIS route score logic, existing bridge scores were converted into a single 100-point scale, with the superstructure and substructure's scores weighted more heavily than the deck scores. Specifically, this scale takes the average of the superstructure and substructure scores and weights this at 90%, versus 10% for the deck score – a method designed to ensure that overall scores for bridges reflect any significant structural impairment and cleanly reflect the overall quality of each bridge.

The resulting scores at the state and system levels can be seen in **Figure 20** and demonstrate both generally high scores across the board as well as slightly better condition on the Interstate system.

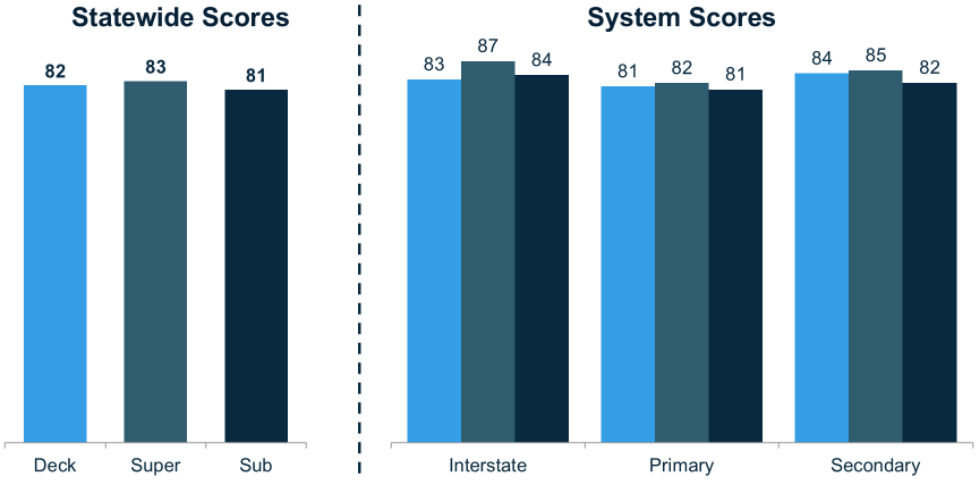


Figure 20: ArTEMIS Bridge Index by sub-score, system

Figure 21 displays all bridges in poor condition (index below 60) or at-risk of becoming poor (index of 60 – 69). They are mostly on the secondary system. Each circle maps one bridge by latitude and longitude; size indicates deck area, with at-risk bridges sized uniformly.

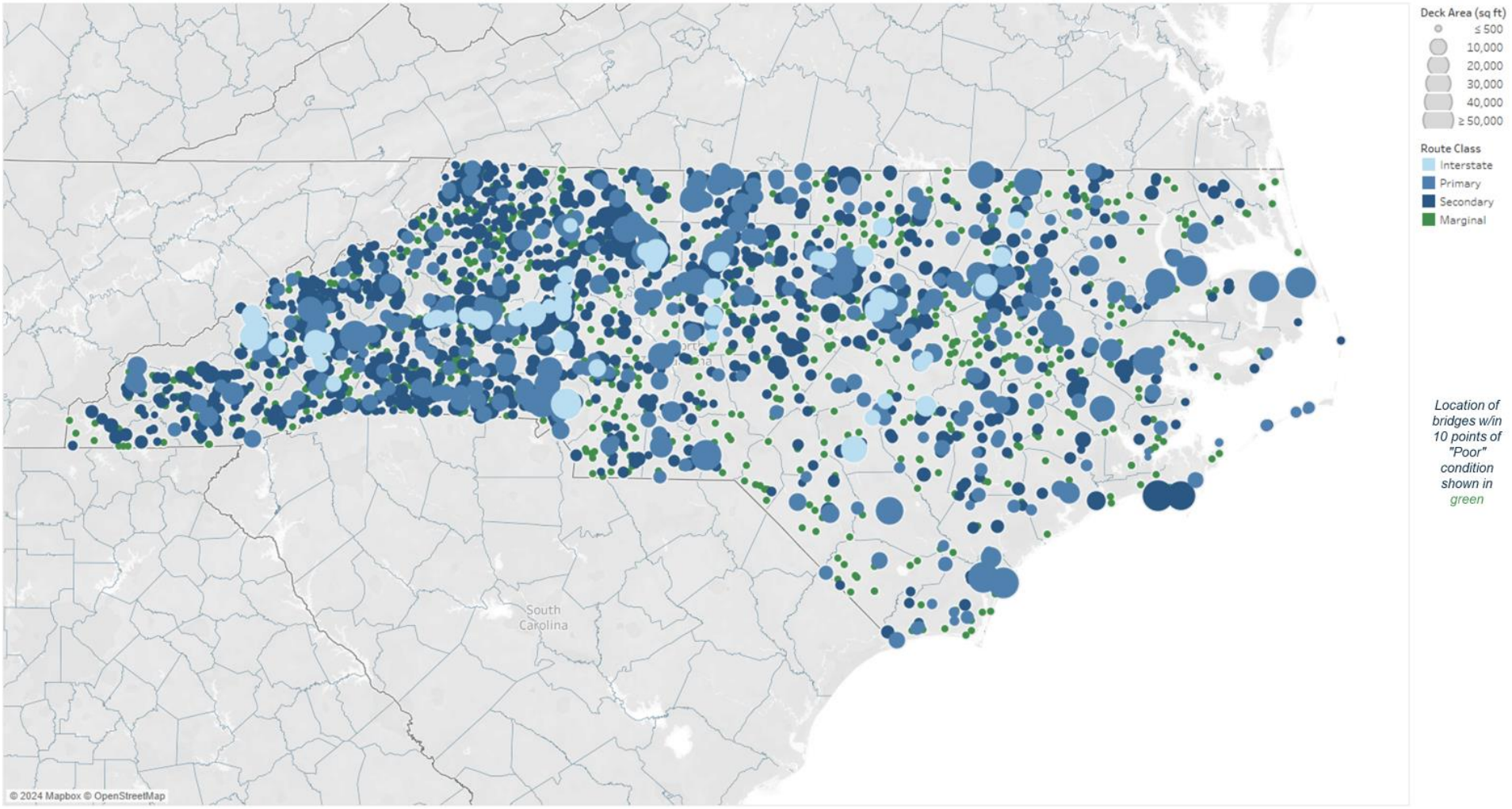


Figure 21: Spatial distribution of poor and at-risk bridges

3.1.4 Roadside Asset Conditions

The ArTEMIS project has allowed NCDOT to assemble a clear *point-in-time* inventory of state assets, displayed in **Table 8**:

Asset	Unit	Interstate	Primary	Secondary	Overall
Bike Lanes	MI	0	123	266	**389**
Cablerail	MI	843	929	51	**1,823**
Concrete Barrier	MI	752	165	98	**1,015**
Crosswalk	EA	0	4,114	6,009	**10,123**
Curb and Gutter	MI	72	3,511	4,110	**7,693**
Drop Inlets	EA	5,078	52,354	89,738	**147,170**
Guardrail	MI	1,439	2,945	1,704	**6,088**
Impact Attenuator	EA	459	667	178	**1,304**
Induction Loop	EA	262	19,714	20,564	**40,540**
Mile marker	EA	4,182	2,996	431	**7,609**
Noise Wall*	LFT	190,978	52,962	49,949	**293,889**
Pavement Striping (defective only)	MI	779	6,170	21,400	**28,349**
Pipes**	LFT	248,231	4,565,850	3,430,763	**8,244,844**
Retaining Wall*	LFT	17,721	194,700	389,229	**601,720**
Road Sign	EA	19,301	261,043	621,574	**901,918**
Rumble Strips*	MI	4,412	5,390	849	**10,652**
Sharrows	EA	0	1,218	2,350	**3,568**
Shoulder (defective only)	MI	43	500	2,039	**2,582**
Traffic Signal	EA	404	61,015	58,368	**119,787**
Variable Message Sign	EA	240	423	448	**1,111**
Word and Symbols	EA	6,290	117,387	123,683	**247,360**

Table 8: Selection of roadside asset inventory; asterisk indicates no significance to route score
***** Includes maintenance pipes as of 2023 inventory***

These assets will be maintained through both planned and unplanned maintenance, with both approaches accounted for in the TCO model projections. With regards to planned maintenance, the work activities/work functions are those that are performed on a recurring

basis and can be planned to the route, system, or asset level in advance of the work taking place, the TCO model uses NCDOT experience and industry data to map out anticipated lifecycles for every roadside asset, estimating the overall rate at which a route's signage, pavement markings, etc. will deteriorate over time. It takes as a baseline the conditions of North Carolina's roadside assets as evaluated in the ArTEMIS data-gathering effort in 2023, seen here in **Table 9**.

Asset	% Non-defective
Pavement Striping	89%
Bike Lanes	78%
Words & Symbols	74%
Shoulder	98%

Asset	% Non-defective
Signs	94%
Drop Inlets	89%
Curb & Gutter	96%
Guardrails	98%

Table 9: Statewide asset non-defectivity rates

A deeper dive into specific rates of asset defectivity at the division and county level, along with how these rates compare across geographic units, can be seen in the Division Insight Reports in **Section II**.

As is typical with all work activities, there are also unexpected events that will require forces to be reactive in their maintenance efforts. Therefore, not every maintenance expenditure can be precisely anticipated in advance, resulting in both planned and reactive costs. Planned Routine Maintenance activities are based on condition and cycle-time targets. Examples include shoulders and ditch maintenance, crossline pipe replacements, pavement striping, bridge joint repairs, mowing, and painting steel girders, among others. In addition to the planned work activities/work functions, Divisions conduct significant amounts of reactionary maintenance work on several additional work functions. These are activities that cannot be planned and typically require an immediate response. Examples of these activities include pothole repair, removal of hazards or guardrail repair. To account for this need, every funding scenario described in the prior section factors in the calculated investment required for unplanned but critical maintenance.

4. Strategic Opportunity: Interstate Rehabilitation and Replacement

Interstates
I-140
I-240
I-26
I-277
I-285
I-295
I-40
I-42
I-440
I-485
I-540
I-587
I-73
I-74
I-77
I-785
I-795
I-840
I-85
I-87
I-885
I-95

A strategic necessity for NCDOT over the coming years will be maintaining the condition of its interstates and other critical routes. They play a critical role in providing mobility options for both people and freight, and while their condition generally exceeds that of Primary and Secondary routes, this advantage is the deliberate result of prioritized maintenance. Of particular note is that not only will these routes require increased funding for maintenance over the coming years as a result of the inflationary pressures and the increased wear and tear caused by a growing population, but the advanced age of some interstates means that full reconstruction is looming for hundreds of lane miles – work that far exceeds the price tag of current maintenance and will require a higher degree of planning.

This section brings insights from the TCO model as well as from a direct survey of division engineers to lay out the costs associated with maintaining the current condition of North Carolina's interstates over the coming decade, and to highlight the coming need for reconstruction/ rehabilitation of these interstates and other critical pieces of infrastructure.

Table 10 lists out the specific interstates feeding into this analysis. A visualization of these routes can be seen in **Figure 22**.

Table 10: Interstates analyzed

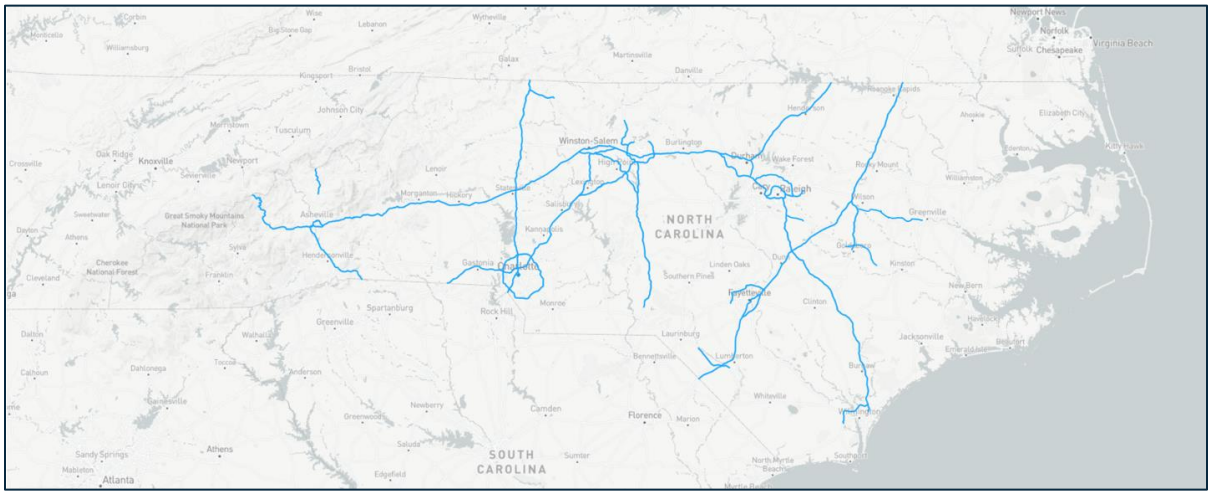


Figure 22: Interstate routes visualized

4.1 INTERSTATE MAINTENANCE NEEDS

As is the case with all of North Carolina's routes, Interstates will require steady funding increases over the coming decade. The TCO model enables us to project the specific maintenance needs associated with each of these routes, taking the current condition of specific assets on each route and modeling their anticipated deterioration over the next ten years. These needs are independent of any larger rehabilitation needs.

The year-over-year maintenance funding needs for each of these routes can be seen in the **Figure 23**. The funding curves represent smoothed spend over time; the specific needs associated with each route will fluctuate from year to year based on deterioration cycles, but for the purposes of budgeting these figures represent the overall maintenance need. The embedded table also notes the Annual Average Daily Traffic (AADT) weighted across all the individual segments for each route. This means that busier sections, like I-40 in Wake County, are averaged together by lane mile with potentially less traveled sections (e.g. I-40 in Haywood County)

These funding needs can be anticipated to increase as additional routes are brought into the Interstate system, adding to the lane mileage that NCDOT is responsible for maintaining. The last two years alone have seen the addition of one more interstate (I-42), as well as the expansion of I-885 and I-26.

A few key takeaways:

- North Carolina's major interstates, including I-40, I-73, I-85, and I-95, will each require over $100 million in maintenance over the next ten years just to preserve their current condition (i.e. route score). These investment need estimates do not account for reconstruction, reclamation, or major rehabilitation.
- These investment need estimates do not account for capacity increases or other expansion projects – solely maintenance.

Overall need to maintain Interstates

	Lane Miles	Avg. AADT[2]	Min AADT	Max AADT	10-Year Need
I-40	2,085	71,000	20,500	183,000	$607,000,000
I-85	1,243	79,000	19,500	190,000	$290,000,000
I-95	789	42,000	8,500	66,500	$244,000,000
I-77	439	27,000	9,900	68,000	$197,000,000
I-73	479	83,000	23,500	158,000	$150,000,000
I-485	371	92,000	55,500	140,000	$134,000,000
I-26	275	27,000	15,000	48,000	$101,000,000
I-74	207	49,000	11,000	83,500	$93,000,000
I-240	153	85,000	55,000	105,000	$65,000,000
I-295	81	27,000	12,500	40,500	$53,000,000
I-540	41	67,000	52,000	88,500	$42,000,000
I-840	22	16,000	15,500	15,500	$42,000,000
I-795	103	17,000	12,000	21,000	$37,000,000
I-277	79	91,000	60,000	121,000	$33,000,000
I-885	43	79,500	76,000	83,000	$33,000,000
I-587	159	31,000	24,500	35,000	$31,000,000
I-87	26	103,000	75,000	127,000	$31,000,000
I-440	85	110,000	78,000	148,000	$27,000,000
I-285	93	36,000	25,500	57,000	$23,000,000
I-140	73	17,000	11,500	26,500	$22,000,000
I-42	87	19,000	16,500	21,500	$22,000,000
I-785	28	14,000	3,300	27,500	$13,000,000

YOY investment to maintain Interstates with highest needs

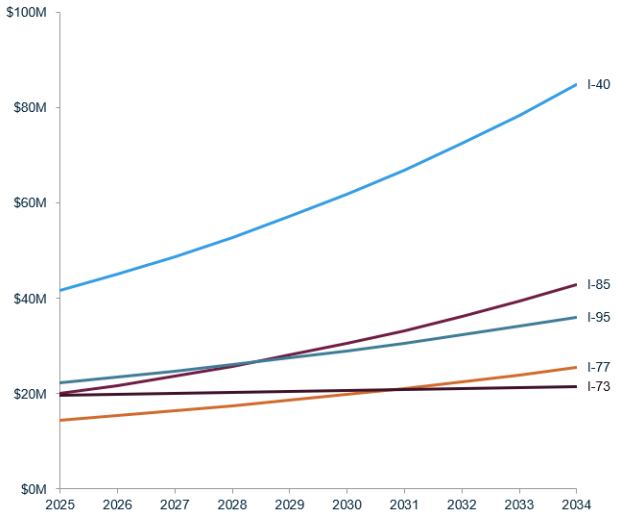


Figure 23: Projected interstate maintenance needs over coming decade

4.2 Interstate Rehabilitation

While consistent maintenance and rehabilitation certainly preserves the condition level provided by each Interstate route in the short and medium term, as time goes on there will be an increasingly pressing need to perform more intensive activities such as reconstruction on the older sections of road.

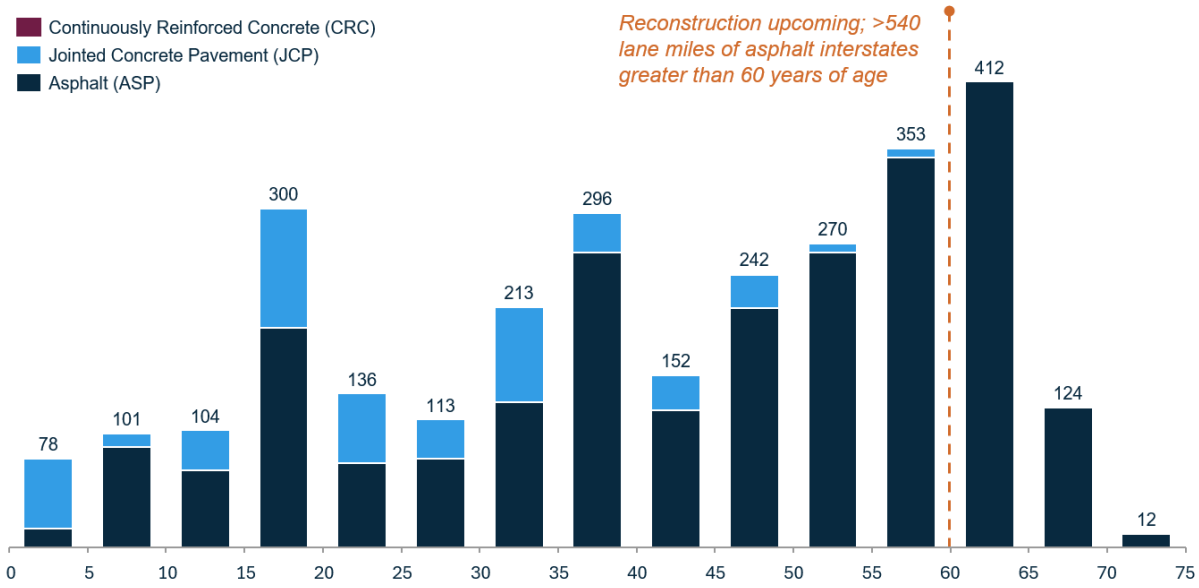


Figure 24: Age of North Carolina interstates by lane mile based on original construction date

The distribution of ages for North Carolina's interstates can be seen in **Figure 24** above. The age depicted here accounts for all past re-construction. As is shown, even factoring in already-completed reconstruction efforts **over 500 lane miles** of North Carolina's interstates are over 60 years old, with another ~500 on track to reach that age in the coming decade.

Given that the current budget of ~$150M per year dedicated to Interstates is already largely consumed by maintenance activities, there will be a growing need to provide targeted funding for Interstate reconstruction in the coming years beyond current allocation.

A detailed breakdown of interstate assets and their condition can be seen in the tables on the following pages.

	Cablerail	Concrete barrier	Curb & gutter	Drop Inlet	Guardrail	Noise Wall	Mile Marker	Pipes	Pavement Striping	Retaining Wall	Road Sign	Variable msg. sign	Word & Symbols
	LFT	LFT	LFT	EA	LFT	LFT	EA	LFT	LFT	LFT	EA	EA	EA
I-140	151,305	3,706	3,198	55	117,924	-	120	19,247	594,346	-	281	6	81
I-240	-	9,156	14,404	3	24,478	-	4	1,950	308,941	-	86	3	4
I-26	18,510	279,347	3,942	273	526,524	-	110	96,397	1,611,172	526	691	1	93
I-277	-	37,122	35,912	75	36,279	1,359	102	-	182,114	521	339	2	133
I-285	147,806	22,516	21,379	32	112,115	-	50	23,834	735,037	-	284	1	51
I-295	123,599	11,964	8,511	27	93,890	17,113	35	34,993	667,046	1,297	243	8	105
I-40	1,402,822	1,594,453	127,474	1,443	2,656,680	23,123	856	538,630	15,641,818	7,277	5,344	70	1,526
I-42	92,462	118,995	335,598	1,112	443,056	-	74	92,462	5,207,361	-	5,422	8	3,238
I-440	-	110,071	11,764	66	65,225	9,227	5	11,671	599,721	-	314	1	161
I-485	319,276	405,959	17,895	405	294,828	36,049	477	48,723	2,650,014	249	895	6	516
I-540	303,513	9,897	4,277	10	182,142	8,808	185	33,469	1,079,793	927	714	11	104
I-587	22,219	137	18,851	55	7,615	-	9	4,886	116,482	-	216	1	187
I-73	450,351	36,618	14,817	323	373,732	7,857	257	181,711	3,375,749	-	1,274	8	553
I-74	528,074	8,799	2,687	38	174,635	2,181	104	83,247	2,127,725	-	668	4	212
I-77	167,378	224,931	24,314	678	605,750	44,490	693	126,849	3,644,616	2,506	1,809	37	581
I-785	-	840	-	45	2,849	-	21	4,093	230,025	167	96	3	18
I-795	170,224	1,141	1,269	55	84,772	-	113	51,699	810,352	-	281	1	70
I-840	-	3,035	-	18	45,947	4,915	8	-	154,075	883	65	2	7
I-85	159,270	652,084	35,416	1,169	1,378,183	34,275	614	265,502	8,711,721	1,669	3,344	46	930
I-87	149,037	32,612	17,919	38	157,607	1,582	46	15,819	555,157	1,598	303	7	85
I-885	124,586	20,161	104,541	127	764,142	-	236	26,068	2,013,144	-	1,409	7	514
I-95	360,815	525,175	33,634	325	666,806	-	382	193,094	6,243,793	102	2,270	23	1,060
Total	4,691,247	4,108,719	837,802	6,372	8,815,179	190,979	4,501	1,854,344	57,260,202	17,722	26,348	256	10,229

Table 11: Asset inventory across interstates

	Centerline miles	Route Score	Structural Score	Functional Score	County where lowest route score is found		County where highest route score is found	
I-140	39	**92**	95	84	Brunswick	92	New Hanover	93
I-240	18	**86**	85	89	Buncombe	86	Buncombe	86
I-26	98	**87**	89	84	Buncombe	84	Madison	91
I-277	9	**85**	83	88	Mecklenburg	85	Mecklenburg	85
I-285	46	**87**	89	83	Forsyth	75	Davidson	90
I-295	45	**95**	95	94	Cumberland	95	Cumberland	95
I-40	878	**89**	88	89	Catawba	81	Davie	93
I-42	32	**87**	89	85	Johnston	75	Johnston	95
I-440	28	**87**	88	84	Wake	87	Wake	87
I-485	131	**91**	93	86	Mecklenburg	91	Mecklenburg	91
I-540	51	**88**	92	81	Durham	79	Wake	89
I-587	37	**86**	84	89	Wilson	79	Greene	99
I-73	200	**90**	91	89	Randolph	82	Rockingham	97
I-74	128	**89**	91	82	Forsyth	86	Randolph	93
I-77	211	**88**	88	90	Yadkin	83	Mecklenburg	93
I-785	15	**96**	95	99	Guilford	96	Guilford	96
I-795	51	**92**	94	86	Wilson	91	Wayne	93
I-840	8	**93**	94	91	Guilford	93	Guilford	93
I-85	407	**91**	91	91	Orange	79	Cabarrus	96
I-87	26	**90**	94	80	Wake	90	Wake	90
I-885	12	**88**	88	87	Durham	88	Durham	88
I-95	394	**85**	87	82	Halifax	81	Northampton	91

Table 12: Current conditions across interstates

4.3 NEXT STEPS — PRIORITY 500 MILES

North Carolina's interstate system is not the only set of highways that will require rehabilitation, and dedicated funding, over the coming years. To understand the scope and scale of the investment required to ensure our state's ability to provide a safe and effective transportation network into the future, the highest priority ~35 miles of reconstruction/ rehabilitation needs were identified for each Division. The result is ~500 miles of highway, equivalent to the width of North Carolina from Murphy to Manteo, that will require targeted investment and funding over the coming decade.

The specific details of rehabilitation and reconstruction needs, detailed in each division's insight report in Part II, indicate a scope of approximately $15-16 billion. This estimate, covering interstates as well as primary and secondary systems, provides a sense of the scale of future needs, which are expected to grow with inflation.

A breakdown of these needs across different road systems is summarized in **Table 13**.

	# Projects	# Miles	Need ($B)
Interstate System	29	157	$6.7
Primary System	82	362	$8.2
Secondary System	11	16	$0.5
Total	**122**	**535**	**$15.4**

Table 13: Summary of Division-Submitted Rehabilitation/Reconstruction Needs

Understanding the scope and scale of these needs is a crucial first step in developing a long-term strategic plan to address these challenges over time. *This analysis is intended to support future planning efforts across the Department and is presented here solely for context, not as an immediate funding request.*

5 DELIVERING THE ASSET MANAGEMENT PROGRAM

5.1 HIGHWAY MAINTENANCE IMPROVEMENT PROGRAM

The Highway Maintenance Improvement Program, or HMIP, is the Department's schedule of projects and their costs across the North Carolina highway system. With focus areas including pavements, bridges and other roadway assets, the current 5-year HMIP covers fiscal years 2025-2029. Each highway division has a schedule by county for each plan year within the 5-year plan. The first year is expected to be "firm," reflecting what will be delivered that year.

The HMIP is submitted annually with modifications to adjust years two through five (which will become years one through four) based on changing conditions such as needs and appropriation levels. For example, an unusually cold and wet winter may cause roads in western North Carolina to deteriorate faster than usual, requiring substantial investment in pavement repairs. Flooding due to a hurricane can also cause deterioration to all assets, requiring unanticipated replacement and stabilization of drainage pipes. Modifications can also be driven by inflation which increases the costs of labor, equipment, and materials. In some cases, the highway division may become aware of local economic development planned along one or more roadways that makes widening and strengthening those roadways a priority. A new year five will be developed as others roll forward.

The process is managed through the Asset Management System (AMS) which is composed of three subsystems: Pavement Management System (PMS); Bridge Management System (BMS); and the Maintenance Management System (MMS). AMS is used to identify potential areas which meet the treatment and funding requirements for inclusion in HMIP. Highway divisions use this data to develop and refine their work plans. Engineers use data from routine condition surveys on all assets to assist in developing their plans.

5.1.1 Pavements

Every year, the Department conducts pavement condition surveys of all its pavement assets on the interstate, primary and secondary systems. These surveys provide a point in time snapshot of the systems' pavement conditions. To develop the maintenance improvement plans, the Operations Program Management Unit uses the PMS's optimization capabilities to develop a five-year roadway section plan using the previous year's needs-based allocation and projected funding. Divisions utilize the pavement condition information, and the recommendations from PMS, to develop contract resurfacing and pavement preservation investment plans to stay within budget over the 5-year period. The approved plans are used by the Divisions to track their work accomplished versus the plan.

5.1.2 Bridges

The Department develops the 5-year bridge investment plan to make progress towards minimizing the proportion of bridges in poor condition. The Structures Management Unit (SMU)

and the Divisions work cooperatively to identify and schedule bridge replacements within the 5-year improvement plan to ensure positive movement toward established goals—fewer than 1% bridges in “poor” condition on the interstate, fewer than 4% on primary roads, and fewer than 9% on secondary roads.

Generally, SMU develops initial recommendations for interstate and primary system bridges and the Divisions develop recommendations for secondary road bridges. On an annual basis bridge condition results are gleaned from the BMS, provided to each Division, and reported to NCDOT senior management. Bridge performance is estimated based on current condition and budgetary amounts. Anticipated results are compared to NCDOT’s long-term state asset targets. Based on the BMS analysis, a list of bridges which meet state funding requirements are prioritized using a Priority Replacement Index (PRI). Division and SMU program managers use this list as they develop the 5-year replacement schedule. Like pavements, interstate bridge maintenance project recommendations are also identified from the BMS and provided to the Divisions for development of bridge rehab and preservation projects for bridge structures along interstate routes. These projects may be stand alone or included within previously described interstate pavement maintenance project limits and are also programmed within the 10-year STIP document and are updated as needed to be responsive to maintenance needs.

5.1.3 Highway Assets

Highway Divisions also create 5-year routine maintenance investment plans for non-pavement and bridge assets based on previous maintenance allocations. This effort includes establishing monetary investment amounts for unplanned activities, as well as anticipated investments and resulting production levels for planned activities. The final three years of the five-year plan are planned at a Division-wide level, based on historical expenditures and long-range maintenance needs.

5.2 Citizen Action Request System

The Citizen Action Request System (CARS) was created to provide a place for both citizens and state personnel to report and track reactive maintenance needs. The Department strives to address each submission in a timely manner; however, meeting CARS responsiveness goals provides limited benefit to highway infrastructure longevity and is typically reactive, pulling staff away from any planned maintenance activities that impact infrastructure health. Across FY 23-24, the Department responded to 37,050 action requests in legislative categories, up 13% from the 32,692 requests across FY 21-22.

Pursuant to the DOT Report Program (G.S. 136-18.05), the Department tracks its responsiveness for a selection of CARS maintenance categories including drainage, guardrail damage, pothole, shoulder repair, signal malfunction, and signing. Excluding potholes which must be repaired within two days of notification, safety-related items must be addressed within 10 days of notification, and non-safety items must be addressed within 15 days of notification. Department performance in these categories for FY 2023-24 is shown in **Table 14**.

Legislative Category	Deadline to Address	Legislative Action Requests	
		Total Reported	Total Addressed On-Time
Pothole	2 days	16,898	13,366
Non-Pothole Safety	10 days	5,799	5,461
Non-Pothole Maintenance	15 days	14,353	10,605
Total		37,050	29,432

Table 14: FY 23-24 completed Citizen Action Requests, legislative categories only

5.3 STAFFING

To examine staffing efficiency, **Table 15** shows the staffing distribution across the 14 Highway Divisions, and the road length, population, and geographic area served by each employee. The table includes the 2022 vacancy rate to demonstrate the consistent vacancy rate across most divisions. Overall staffing trends are consistent with urban/rural and geographical differences such as the Coastal, Sandhills, Piedmont or Mountain regions. For example, Division 1 manages fewer lane miles per employee (26 lane miles per employee) but has a higher area served per employee (13 square miles served per employee). . The data comes from Beacon report B0112 – Positions Vacant-Filled by Count and is for Dec 2024 and Dec 2022 for comparison.

Division	2022 Vacancy Rate	2024 Filled Positions	2024 Vacancy Rate	Lane Mile / Employee	Population Served / Employee	Area Served / Employee (sq. mi.)
1	19.1%	418	18.8%	25	603	19
2	29.5%	359	20.8%	29	1,376	15
3	28.0%	352	24.9%	35	2,232	14
4	22.7%	420	18.6%	33	1,479	10
5	32.1%	458	25.6%	32	3,897	7
6	21.6%	344	14.4%	38	1,816	12
7	25.3%	334	25.6%	36	2,985	6
8	23.6%	373	23.6%	38	1,530	9
9	17.2%	369	14.6%	29	2,182	7
10	26.2%	381	24.3%	30	4,591	6
11	29.1%	367	28.6%	30	995	9
12	29.9%	315	27.1%	41	2,669	7
13	18.8%	432	13.3%	24	1,220	6
14	22.8%	368	25.8%	26	1,041	10
Average	**24.7%**	**378**	**21.9%**	**32**	**2,044**	**10**
Total	**-**	**5,290**	**-**	**-**	**-**	**-**

Table 15: Division staffing, 2024

5.4 Adverse Weather Impacts on Maintenance

Hurricanes, winter storms, heavy rainfall, rockslides, earthquakes, and other weather-related events all affect the highway system and the Department's ability to perform planned maintenance activities. These events may receive emergency declarations and become eligible for federal reimbursement, but those reimbursements typically take three to five years to receive in full. Even then, full reimbursement, from our federal partners – Federal Highway Administration (FHWA) and Federal Emergency Management Agency (FEMA) is typically only 60-70% of the total cost of a declared event. The impact of these events is twofold: the cost of immediate response reduces funds available for routine planned maintenance, and weather-related events accelerate system degradation, creating additional maintenance needs for years to come.

While it can be expected that North Carolina will experience some degree of emergency impacts each year, the severity and scope is unpredictable. For example, as seen in **Figure 25**, the Department incurred an average of $55 million per annum in declared emergency expenses over the past five fiscal years (FY2020-2024). In that same time, expenses ranged from as low as $64 million to as high as $153 million. In general, only a subset of the total amount of emergency expenditures are eligible for federal reimbursement.

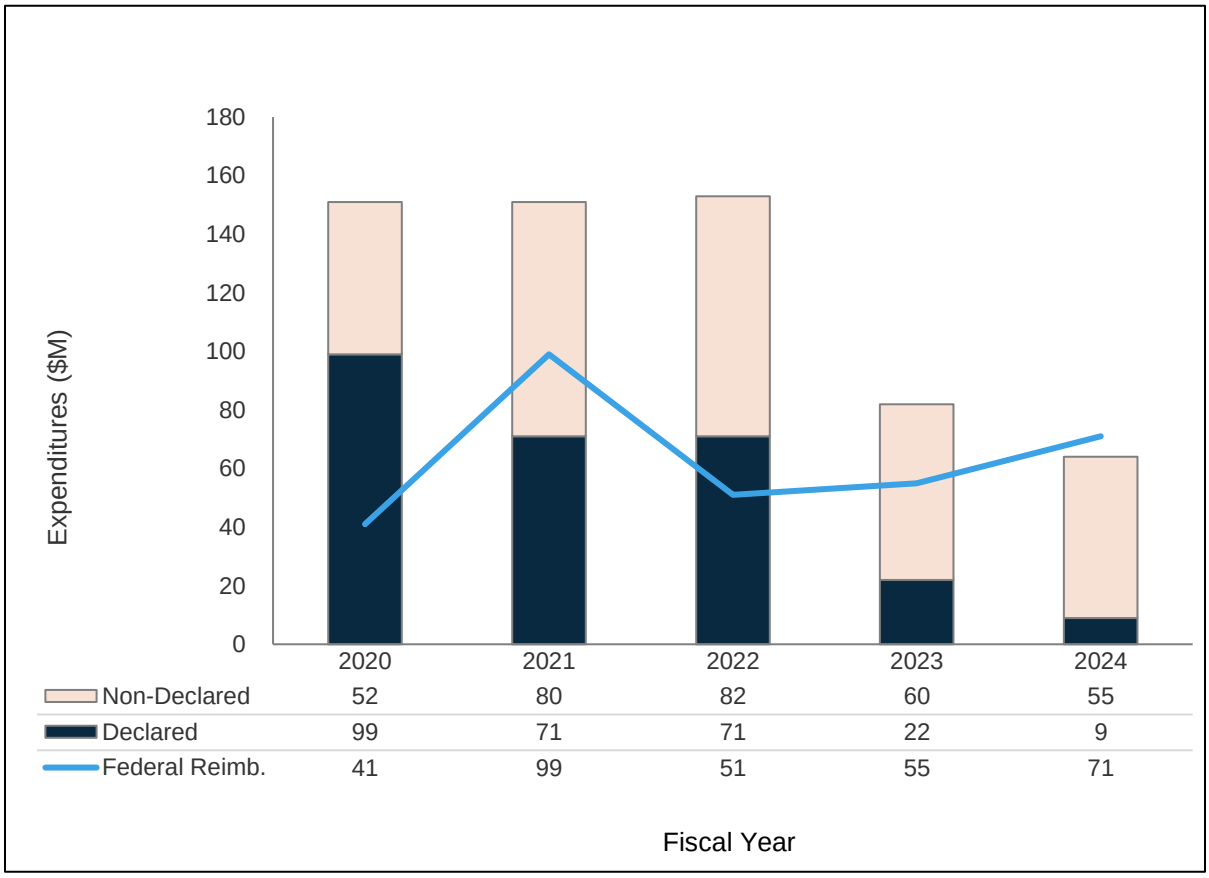


Figure 25: Emergency expenditures and federal reimbursement

The Emergency Reserve, established in Session Law 2019-251, will aid the Department in managing annual fluctuations in declared disaster spending needs. However, since the reserve fund is legislatively mandated to be maintained at $125 million through annual transfers from the Highway Fund, the primary funding source for all highway maintenance activities, significant weather and other disaster events will still directly impact spending on core highway maintenance programs. While non-declared spending has increased from 2020, declared spending and federal reimbursement have shown a slight decrease. The chart also illustrates the lag time in federal reimbursements for declared events.

5.5 CONGESTION

An efficient transportation network means faster and more reliable travel times for both people and goods. For example, with predictable travel times manufacturers can reduce distribution costs and, in turn, pass savings onto consumers. This section uses two measures to evaluate mobility. Each one provides insights into different aspects of congestion and should be viewed together to provide a more complete picture.

- Average Number of Congested Hours – the number of hours that speeds are slow
- Travel Time Reliability – the variability of travel time on a "bad day"

Table 16 shows the average number of hours that speeds drop below 45 miles per hour at the top 10 most congested locations, and **Table 17** shows the day-to-day travel time reliability at these locations via the Level of Travel Time Reliability (LOTTR) index, representing represents how poorly a road performs on a "bad day" – i.e. that day with a crash, weather event or active work zone, compared to an average day. For example, if it takes a motorist 40 minutes to make a given trip on a bad day compared with 20 minutes to make the same trip on an average day, then the LOTTR would be 40/20 = 2.0. The Federal Highway Administration defines an LOTTR higher than 1.5 to mean that the road was considered "unreliable." This means there is a wide variability in travel times from day to day. In addition to the trip taking longer than normal, this variability makes trip planning challenging for motorists.

Rank	Route	Location	Exit #	Direction	Avg Congested Hours/Day
1	I-240	US-19/US-23	3	SB	15
2	I-77	Arrowood Rd	3	NB	13
3	I-77	Remount Rd	8	SB	11
4	I-77	Nations Ford Rd	4	NB	10
5	I-77	I-277/US-74	9	SB	10
6	I-77	Tyvola Rd	5	NB	10
7	I-77	US-521/Woodlawn Rd	6	NB	7
8	I-77	Tyvola Rd	5	SB	6
9	I-77	Clanton Rd	7	NB	5
10	I-77	I-485/J G Martin Fwy	2	NB	5

Table 16: Highest average number of congested hours on heavily travelled interstates

Rank	Route	Cross Street	Exit #	Direction	LOTTR
1	I-40	US-276	20	WB	5.29
2	I-485	Rea Rd	59	EB	3.64
3	I-40	US-276	20	WB	3.55
4	I-485	Arrowood Rd	3	WB	3.47
5	I-485	Arrowood Rd	3	WB	3.32
6	I-485	US-74 / 29 / Wilkinson Blvd	9	EB	3.25
7	I-277	US-74	2	SB	3.11
8	I-277	Davidson St	3	SB	3.05
9	I-77	Arrowood Rd	3	NB	3.01
10	I-485	US-74	51	WB	2.92

Table 17: Highest average LOTTR on heavily travelled interstates

Reducing congestion requires a multi-faceted approach which includes both capital and operational improvements. Operationally, NCDOT has 4 Transportation Management Centers (TMC's) across the state: one in Charlotte, one in Raleigh, one in Greensboro and one in Asheville. We plan to open another TMC in eastern North Carolina in early 2025. Statewide, over 300 dynamic message signs and nearly 1000 traffic cameras help manage congestion caused by crashes, work zones and weather. NCDOT retimes traffic signal systems to maximize throughput on busy corridors. NCDOT manages DriveNC.gov and 511 for traveler information by web and phone. NCDOT coordinates with Google, Apple, Waze, HERE and others to help our citizens who use these services. NCDOT is implementing Advanced Traffic Management Software to optimize traffic management processes across the state. NCDOT is also in the process of upgrading traffic camera images on the DriveNC.gov website to full motion video.

More robust deployment of these operational strategies would improve mobility across North Carolina:

- Additional traffic cameras and dynamic message signs at needed locations
- Additional Intelligent Transportation Systems (ITS) and advanced traffic management solutions
- Expanding Incident Management Assistance Patrol (IMAP) routes and hours
- Additional signal retiming tools and resources

NCDOT continues to drive innovation - advancing mobility, reducing congestion, and enhancing road safety - through a range of impactful programs that have received national recognition. Select programs include:

- **Center of Excellence on Mobility and Congestion**: Initiative focused on developing supervisory capabilities for Autonomous Vehicles (AVs) within regional dispatch centers. By enabling state and local authorities to monitor and communicate with traditional, connected, and autonomous vehicles, the center is pioneering efforts to alleviate congestion and effectively manage both planned and emergent traffic scenarios.
- **National Roadway Safety Award**: In 2023, NCDOT was honored with this prestigious award for its groundbreaking efforts to improve safety at rural intersections. By implementing all-way stops at 350 locations, the department achieved remarkable results: a 55% reduction in total crashes and a 92% decrease in fatal and severe injury crashes as of fall 2022.
- **Integrated Mobility Award** – In 2023, the NCDOT won the AASHTO President's Award for Mobility for its work to advance mobility and multimodal safety programs
- **Traveler Information System Expansion** – In 2023, NCDOT was awarded $1.5 million to develop a system to send alerts to travelers about the need to slow down, stop or change lanes.

These accomplishments underscore NCDOT's commitment to forward-thinking solutions that make transportation systems safer, more efficient, and more inclusive.