

Benefit-Cost Analysis Narrative

Executive Summary

North Carolina Department of Transportation (NCDOT) is submitting a Benefit-Cost Analysis (BCA) for the construction phase of the Wake County Bridge 371 Flood Mitigation and Resilience Project (Project) as part of its application for the PROTECT grant program from the U.S. Department of Transportation (USDOT). The BCA was conducted using USDOT's BCA Spreadsheet Template, and the project will generate substantial benefits across multiple categories, resulting in a robust benefit-cost ratio of 5.13.

Key benefits of the Bridge replacement include:

1. **Vulnerability and Risk:** The current structure's structural integrity has started to decline as referenced in recent inspection reports (Attachment F; Attachment G). Elements such as the wingwalls and spans were designated priority level 2 to be replaced and addressed in the 2024 inspection report. The substructure has also been rated as poor condition in the 2025 inspection report. The current bridge is about 5-ft lower than the creek, making overtopping a constant challenge and risk for travelers relying on this route. For example, multiple events of fire department rescues for impacted bridge users were logged between 2020 and 2024. The project will convert the existing structure into a single span concrete girder, elevating the bridge surface much higher than the creek surface, completely mitigating normally expected flooding events.
2. **Criticality to American Families and Communities:** The project will maintain a substantially shorter route for vehicles to travel across White Oak Creek, thereby significantly reducing the travel time due to closures of the bridge. Infrastructure improvements such as sidewalks and bike lanes will also generate new pedestrian and biking opportunities and volumes.
3. **Design Elements:** The analysis shows the existing bridge has become structurally deficient and prone to constant weather-related closures in the past decade. The consistent flooding events have also degraded the integrity of the bridge. The new bridge will provide much-needed rehabilitation and resilience and ensure the critical link between the jurisdiction of Holly Springs and SR 149 (Friendship Rd) remains uninterrupted and secure.
4. **Resilience:** Replacing the existing bridge will avoid lengthy closures and repairs associated with prolonged wear and tear on a nearly 70-year-old structure.

The BCA leverages detailed collision records, historical bridge condition data, and local mode share information to quantify the project's benefits and costs over a 30-year analysis period. With a Benefit-Cost Ratio (BCR) of 5.13 and total discounted benefits of \$52,532,848 and a net present value of \$42,175,447, the Wake County Bridge 371 replacement offers a compelling investment opportunity aligned with USDOT and Federal Policy Priorities

addressing vulnerability and risk, criticality to surrounding communities, and resilience through innovative design and infrastructure elements.

Benefit-Cost Analysis

This narrative summarizes the strategies, assumptions, and outstanding data needs that will be utilized in the calculation of the Benefit-Cost Ratio for the Project as part of an application for funding to the federal PROTECT grant program.

This analysis was performed in accordance with the “Benefit-Cost Analysis Guidance for Discretionary Grant Programs” published by USDOT in December 2025. Additionally, the process will heavily utilize the Department’s BCA Spreadsheet Template, last updated on December 23, 2025. These resources include numerous economic benefit reference values that have been vetted by USDOT, but analysts are also permitted to use values found elsewhere if cited and sourced from a reputable organization.

Table 1: Summary of Project Benefits Build Scenario

Benefit Category	No-Build Condition	Build Condition	Benefit Captured
Safety	Substantial additional crashes are expected to occur on detour routes due to the addition of bridge’s existing volumes.	Current crash rates of existing bridge route is much lower than detour route crash rates; the lower crash rate will be applied to the bridge’s volumes	Avoided crash costs.
Travel Time	Users remain on longer detour routes.	Users return to the direct bridge route.	Avoided vehicle-hours of delay.
Vehicle Operating Costs	Vehicles travel excess detour miles.	Trips use a shorter direct connection.	Avoided vehicle operating costs.
Emissions	Longer detours increase VMT.	Reduced VMT lowers emissions.	Avoided emissions costs.
Road Congestion and Noise Costs	Longer detours increase costs associated with congestion and road noise.	Trips use a shorter direct connection.	Avoided congestion and noise costs.
Bicycle and pedestrian access	No direct bike access before or during bridge closure.	Barrier-separated multiuse path providing pedestrian and bicycle access	Increases mobility and connectivity. Increased health benefits due to physical activity

Existing Bridge Condition

According to National Bridge Inventory (NBI) records obtained for the year 2024, Wake 371 received a condition score of 4 (Poor Condition) for the substructure. The substructure, at its lowest point, reached a rating of 3 in 2022. While the deck and superstructure average a 7 and 6 rating, respectively, the substructure low ratings raise significant concerns, as the creek’s frequent flooding events will quickly reduce the substructure’s integrity even further. Historical data taken from the USDOT InfoBridge website showing condition scores of the bridge over time can be seen below in **Table 2**. **Table 3** also shows the projected conditions for the substructure, with a projection of 3 by 2038 (upper bound projection).

Table 2: Historical Condition Ratings of Wake County Bridge 371

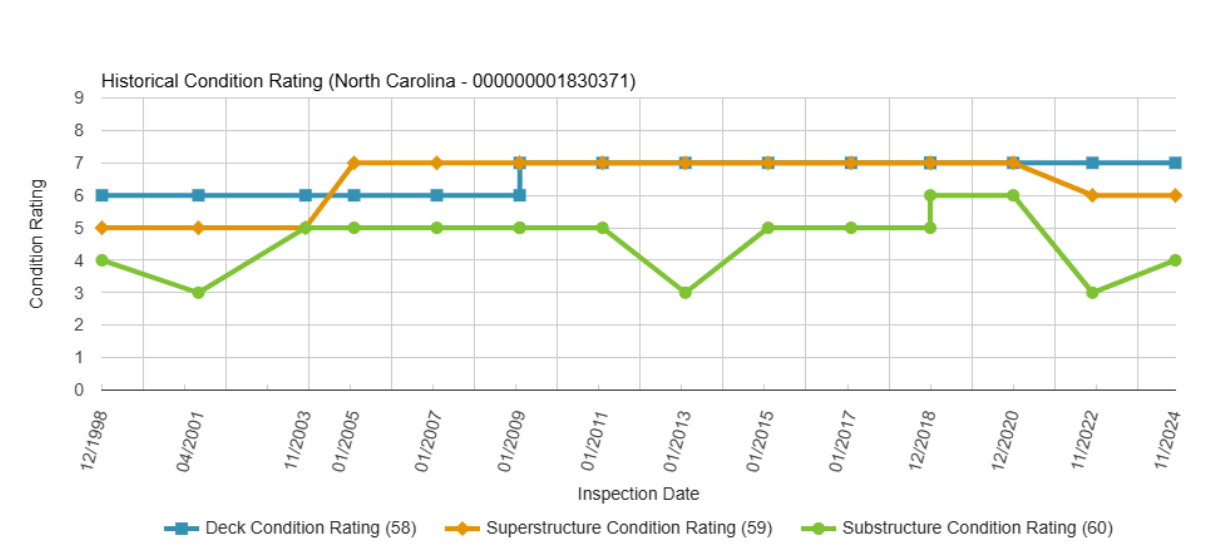
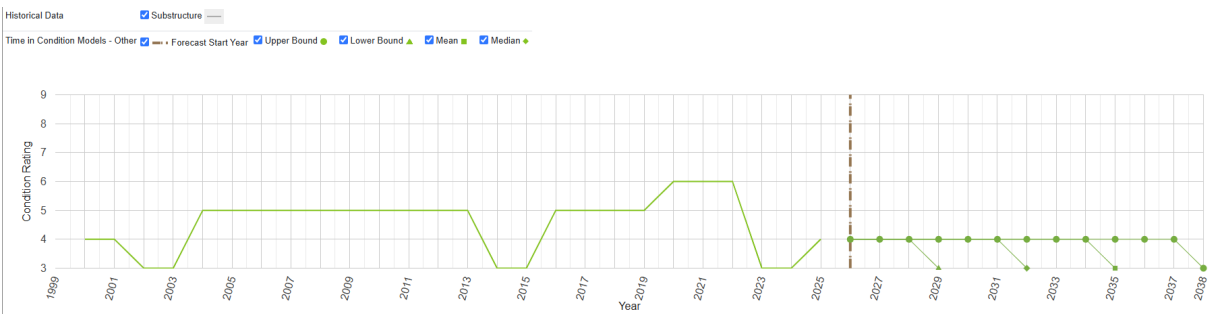


Table 3: Future Substructure Condition Rating



Build vs. No-Build Conditions

Benefit-Cost Analysis requires a clear and consistent distinction between a Build and a No-Build scenario. For the Project, the Build scenario is presumed to be one in which:

- The existing bridge (61'x25.4') is replaced with a single span concrete girder bridge (125'x49')
- Temporary detour route built just south of the existing alignment to facilitate throughput during Build scenario construction years, to be removed at the end of construction

A No-Build scenario is one in which:

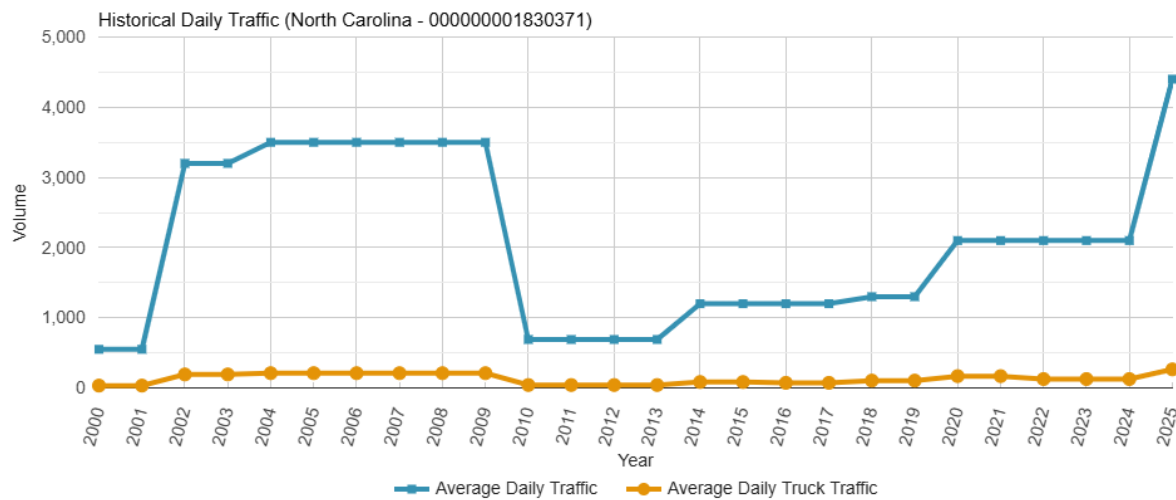
- The existing bridge continues to function with maintenance and operations continuing until the bridge's substructure conditions reach a rating of a 3, projected to occur in 2038. According to NBI, this is the **upper bound** projection year of when the bridge will be considered in too poor of a condition to be open, meaning that there is a high probability that the substructure rating may drop to 3 at an earlier date.
- Closure and demolition of existing bridge in 2038.

The term “cost” is often used in varying contexts. All costs are expressed in a dollar amount but could vary from being a direct expenditure (such as a project’s construction cost), an estimated gradual expenditure imposed or avoided on another person (such as the cost imposed by the use of their personal vehicle), or a value converted from a non-monetary value, such as a person’s travel time, health, or injury (or lack thereof). Only direct project construction is considered part of the “Cost” side of a Benefit-Cost Ratio. For all other costs, the difference between Build and No-Build cost is calculated, with the net difference considered a “Benefit” in the context of Benefit-Cost Ratio. Therefore, avoided non-construction costs are “Benefits,” and imposed non-construction costs are “Negative Benefits.”

Vehicle Volumes

To ensure a consistent and defensible benefit calculation, vehicle volumes must be projected for the 30-year benefit window; these assumptions are used consistently in all subsequent calculations, including detour and safety assumptions. NBI’s data set identified Wake County Bridge 371 to carry an estimated volume of traffic of 7,900 vehicles per day as reported in the National Bridge Inventory (as described in [Table 4](#) below).

Table 3 NBI Historical Daily Traffic



Ambient Growth Rate

NBI also forecasts an expected volume of 8,800 vehicles per day by 2040, a 100% increase within 15 years. This equates to a 4.7% annual growth rate for vehicle volumes. While the immediate vicinity of Wake 371 is largely a rural area, its proximity to Holly Springs and its identity as one of the only crossings across White Oak Creek necessitate carrying additional volumes generated by Holly Springs' nearby community developments. Multiple planned and ongoing developments, including seven major developments identified in project documentation.

Pedestrian and Bike Volumes

Currently, no pedestrian and bike volumes are identified along the bridge as no pedestrian or bike infrastructure exists on the current route. However, the future concrete bridge will include sidewalks and bike infrastructure in its design. Thus, a 2% percent factor of each year's vehicle volumes is applied to estimate future pedestrian and bike volumes.

Truck Volumes

This Project also includes some benefits for truck traffic as NBI tracks 6% of existing volumes as truck volumes. While the original bridge enforces an axle weight limit of 6.5 tons, trucks still utilize this connection due to the lack of alternative routes between US-1 and Holly Springs. As such, truck volumes are also projected to increase within the 30-year period as Holly Springs continues to develop.

Project Construction and Capital Costs

Construction costs and timelines are based on assumptions outlined in [Table 4](#) below. A more comprehensive outline of these costs can be found in the budget narrative.

Table 4: Timeline of Construction Costs

Year	Total Anticipated Cost
2031	\$10,098,821.09
2032	\$4,600,396.64
2033	\$4,613,391.14
2034	\$3,190,891.14

It should be noted that although the Project's scheduled opening year is 2034, the USDOT calculation spreadsheet template used for this application does not accept capital costs for the opening year. To account for all capital and construction costs, the opening year was assumed to be 2035 in the spreadsheet.

Operations and Maintenance

This BCA assumes a No-Build demolition cost of \$54,229 once the bridge is closed due to poor structural inspection ratings. Before then, an annual average maintenance cost of \$3,555 was assumed. This average was calculated by dividing NCDOT's total maintenance spending on bridges (\$ 73,885,117 over 19 years) by the total number of bridges under its jurisdiction (1094). An additional \$10,000 was estimated to cover repairs incurred due to crashes and other extreme weather events, as logged by NCDOT in 2011 and 2021 (see the screenshot in the O&M Tab of the BCA Calculations Workbook).

As mentioned earlier, the bridge also experiences frequent closures due to flooding and weather events. The No Build scenario costs associated with detours during bridge closures are calculated in the Time Savings Tab in the BCA Calculations Workbook. An average of three full-day closures were estimated on an annual basis and are logged as operations costs for the No Build scenario before permanent closure in 2038.

The Build scenario also includes closures thought at a much lower frequency compared to the No Build scenario. These closure costs are calculated in the same way and reflect a full-day closure

that occurs once every five years due to crashes or outlying circumstances. Annual flood closures are expected to be completely mitigated in the Build scenario due to the new bridge's higher elevation, eliminating the possibility of future overtopping. Aside from closures, expected 10-year, 20-year, and 30-year cycle maintenance costs were also included; the source of these numbers are identified in the O&M tab in the BCA Calculations Workbook.

External Environmental Event Costs

Often a BCA will consider the reduction in costs associated with extreme environmental events, such as damage and closures caused by extreme flooding, that is observable when comparing the Build scenario to the No-Build scenario.

While an unlikely event, the Build Scenario incorporates maintenance costs to prepare for the effects of a 500-year flood that may strike White Oak Creek. This is to reflect the resiliency of the bridge in the face of an extreme weather hazard. With general FEMA assumptions and guidance, annual probabilities of 0.2% are assumed/calculated for the likelihood of a 500-year flood occurring during the BCA analysis period. These probabilities were then utilized in developing annual potential repair costs associated with each event, as well as costs associated with closing the improved bridge to through traffic for one day while repairs occur. These costs are respectively included in the Operations and Maintenance tab located in the BCA calculation worksheet.

Vehicle Detouring

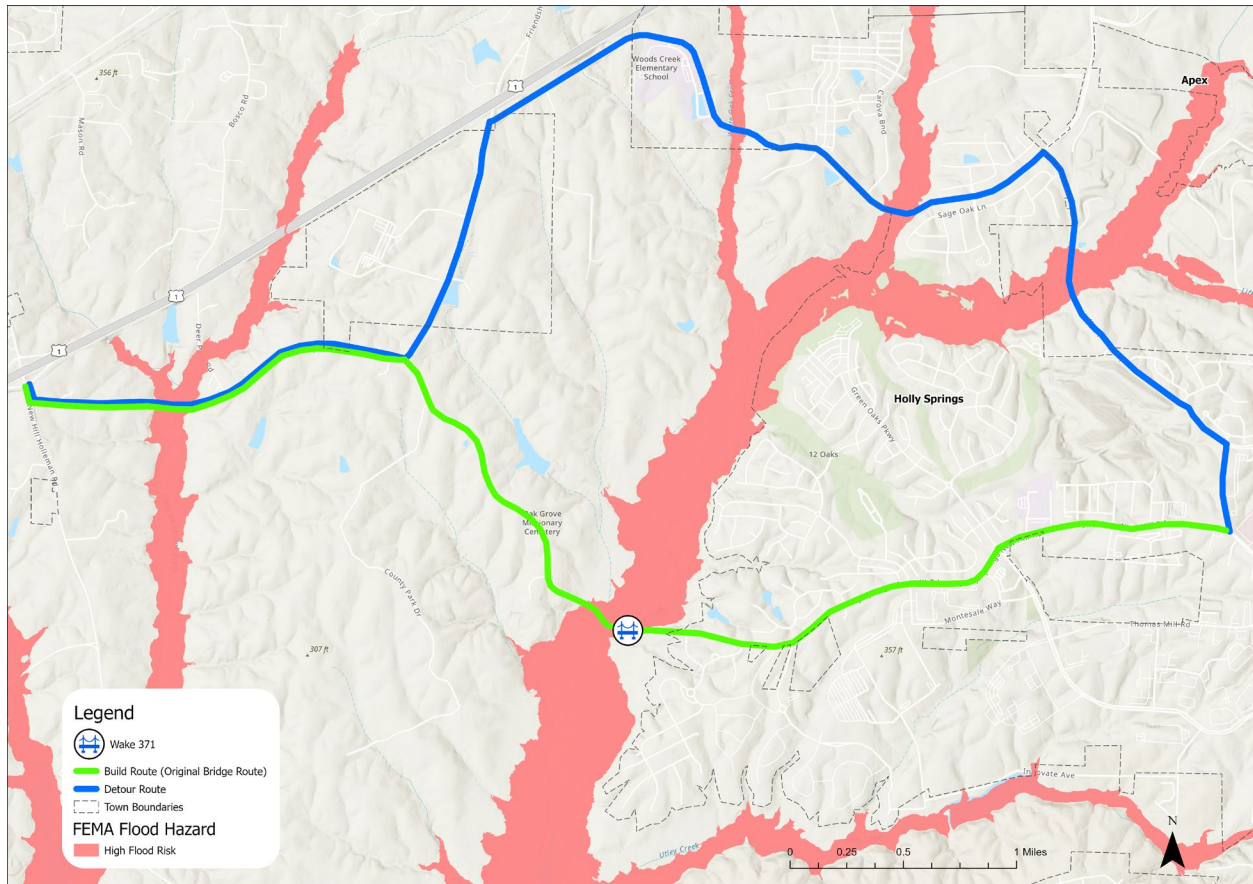
The project Build scenario is expected to substantially shorten vehicle trips when compared to the No-Build scenario, particularly due to the No-Build scenario containing the complete decommissioning of the bridge by 2038. According to NCDOT’s alternative routes analysis, one major detour route was identified, shown in [Table 5](#):

Table 5: Summary of Bridge Detours

Detour	Assumed Share	Added Distance	Added Travel Time	Source/Justification
SR 149 (Friendship Road)	100%	1.4 miles (WB) 1.4 miles (EB)	3 minutes (WB) 3 minutes (EB)	Detour route identified by NCDOT

These assumptions may be adjusted if information becomes available to suggest alternate values. While other, more convoluted detour routes most certainly exist, the volumes on these routes are likely within single digits and not applicable in the context of this analysis. A map displaying each of these detour routes can be found on the following page in [Figure 1](#).

Figure 1: Primary Detour During Wake County Bridge 371 Closure



Note that the original bridge route is around 5.1 miles while the detour route is around 6.5 miles, resulting in an additional distance of 1.4 miles and estimated 3 extra minutes of travel time for both directions.

Safety Benefits

Traffic safety analysis is an important element in driving forward project benefits. The following values are recommended by USDOT:

- No Injury: \$5,500
- Possible Injury: \$122,400
- Non-incapacitating: \$256,300
- Incapacitating: \$1,302,300
- Fatal: \$13,700,000

Other crash classifications and values also include:

- PDO Crash: \$9,700
- Injury Crash: \$342,400
- Fatal Crash: \$15,366,900

These costs are representative of costs to the users, those affiliated with them, and to society as a whole.

Calculation of the cost difference was calculated by first identifying the number of collisions that occurred on each detour route over a five-year period (2020-2024). Collisions occurring on a “Build scenario” route where the bridge was open were also determined over a five-year period.

Collection of Collision Data

For this analysis, collision records were obtained on October 2nd 2026, from the NCDOT crash data portal. Intersection and segment crashes are identified in separate maps in the portal, with intersections being between 2020 - 2024, and segments being between 2021 - 2025. While slightly different year frames, these crashes were utilized as they originated from an authoritative source; both data sets were combined to reflect crashes on the original bridge route and the detour route. The links to each of these map portals can be found in Safety Tab of the BCA Calculations Workbook.

Calculation of Five-Year VMT Along Detour Routes

The singular detour identified above consisted of 4 segments of existing roadways, with the segments coded as such:

A	Friendship Rd, between New Hill Holleman Rd & Holly Springs New Hill Rd
B	Friendship Rd, between Holly Springs New Hill Rd & Woods Creek Rd
C	Woods Creek Rd, between Friendship Rd & Old Holly Springs Apex Rd
D	Old Holly Springs Rd, between Woods Creek Rd & Holly Springs New Hill Rd

For each segment, the overall objective is to determine the total five-year VMT (which is calculated by multiplying vehicle volumes by segment length). Thus, the total five-year VMT for each detour route is calculated by summing the five-year VMT of its segments. Detailed traffic count data were obtained through NCDOT’s AADT web map. Links to the AADT web map may also be found in the Safety Tab of the BCA Calculations Workbook.

Finally, these volumes were multiplied by the segment length, then adjusted to reflect five-year VMT rather than daily VMT, providing a singular number that represents the detour VMT over the five years for the purposes of BCA calculations. The VMT was then incorporated into the collision rate calculation.

Calculation of Collision Rates

Collision rates per million vehicle-miles (MVMT) were subsequently calculated for each collision type/severity level along each detour route and the “Build scenario” route for each of the five study years. These rates are displayed in the series of tables below, along with the number of collisions recorded on each detour route and the Build scenario route, organized by year and severity level.

Table 7 presents the crash rates per MVMT for both the detour and original bridge route.

Table 7: Collision Rates per MVMT for Detour Route and Open Bridge Route

Detour Route Crash Rates		Original Bridge Route (AKA Build Scenario Route)	
K	0	K	0
A	0	A	0
B	0.03197122	B	0
C	0.07992806	C	0.067983276
O	0.23978418	O	0.339916381
PDO	1.03906476	PDO	0.730820218
Injury	0.17584173	Injury	0.305924743
Fatal	0.01598561	Fatal	0.016995819

Calculation of the collision rates was performed by first determining the five-year million vehicle miles traveled for the detour route and the “Build scenario” route. This was found by extrapolating each route’s estimated daily vehicle miles traveled over five years and dividing by 1,000,000. The resulting number was then used in the following equation to generate rates for each collision type.

These collision rates were multiplied by each detour route’s share of projected trips for each of the future years 2035 to 2064 to determine each year’s projected annual collisions, as organized by collision type (the total number of projected trips was used to calculate projected collisions for the “Build scenario”). Note that the Build scenario route is the same as the original bridge

route, as the new bridge is to replace the existing one at the same location, with no substantial road realignment.

Estimation of Future Collisions

After collision rates along each route are calculated, these rates are used to estimate future collisions under the No-Build versus Build scenario. The detour route volumes, whose calculation method is described in “Vehicle Detouring” above, are then multiplied by these collision rates. The presumption is that the historic collision rates will be maintained, absent clear evidence to the contrary, such as design improvements, and thus any additional trips sent to these routes will experience collisions at the same frequency as any other vehicle along this route. Using the aforementioned monetary values recommended for each collision by USDOT, the total collision cost incurred by the project in future years was determined for the No-Build scenario (sum of collision values for the detour route) and the Build scenario (sum of collision values for the route containing the open bridge, modified by design improvements associated with the Project).

Cost of Future Collisions

The total projected collision-related cost of the detour route combined over the 29-year analysis period is \$390,215,457, whereas the total projected collision-related cost of the improved open bridge route over the same period is \$441,773,635. This represents that the Build route configuration has an additional expected crash cost of \$51,558,178, compared to detour crash costs.

Note, however, that the crash costs of the current bridge route (which is the same as the Build scenario) reflect the dangers and the need for the existing bridge’s replacement. The frequent overtopping, debris, and heavy rains often make driving conditions along the current Wake 371 extremely arduous and dangerous. The year 2024 alone saw 6 incident reports along bridge logged by the fire department ([Attachment I](#)). The newly designed Wake 371 will be significantly more resilient to these weather conditions, thereby dramatically reducing the crash rate of the Build scenario bridge route. There unfortunately is no countermeasure that encapsulates the construction and resiliency of the new bridge in USDOT’s clearinghouse database, so no crash reduction factor could be built into the Build scenario.

Vehicle Travel Time Benefits

Vehicle-based Travel Time Benefits are based primarily on projected detours. The detour route has an estimated eastbound and westbound travel time. The projected traffic on each detour is multiplied by the estimated travel time to determine how many additional vehicle-hours would take place in a No-Build scenario compared to a Build scenario. The total excess vehicle-hours are multiplied by \$21.80 per hour, the all-purpose travel time value recommended by USDOT. Note that a travel time factor of 1.18 was applied to truck volumes.

In the No-Build scenario, expected travel time costs are around \$44,621,132; with the reconstructed bridge, travel time costs are reduced to around \$31,040,787, a decrease of about \$13,580,345, or about 30%.

The substantial detour further creates a scenario where drivers may choose to take the risk of crossing the current Wake 371, even during highly risky weather events that reduce the safety of the bridge route. So, while the crash rate of the detour route is relatively lower, drivers may nevertheless take the risk utilizing the bridge route to reduce the amount of travel time. This, in turn, creates a cycle of highly-risky travel behaviors which contributes to the original bridge route's higher crash rates. Thus, unless Wake 371 permanently closes or is refurbished to be resilient to these weather events, the existing detour will not be an adequate nor cost-effective alternative to the safety and resiliency of residents utilizing this route.

Vehicle Operating Cost Savings

Like Vehicle Travel Time Benefits, the Vehicle Operating Cost Savings are based on the projected detours that result from the bridge closure. The projected traffic on each detour is multiplied by the distance of each detour route to determine how many additional vehicle-miles would take place in a No-Build scenario compared to a Build scenario. The total excess vehicle-miles are multiplied by a rate of \$0.56 per mile for light-duty vehicles (such as personal vehicles) and \$1.27 per mile for commercial trucks.

Similarly, longer detours equate to higher degradation of equipment due to longer usage and travel times. In a No-Build scenario, vehicle operating costs are estimated to be around \$42,825,476 by 2064. With the direct route to the port provided by the bridge, operating costs are brought down to about \$32,687,307 which is a \$10,138,168 decrease (a 24% decrease in costs). While not calculated in this BCA, the detours caused by the No-Build scenario will also accelerate the wear-and-tear costs on the roadway infrastructure along detour routes.

Emissions Benefits

Emission-related costs are based on recommended USDOT per-mile values that correspond to specific vehicle types. A general recommended value of \$0.016 per mile (attributable to all vehicles) was utilized to estimate the future emission costs for the No-Build scenario (assuming vehicles travel along the detour route) and the Build scenario (vehicles travel via the bridge). A total emission-related cost of \$14,472,701 was calculated for the Build scenario, while \$18,176,731 was calculated for the No-Build scenario. This represents savings of \$3,704,030.

Other Highway Externalities

As noted previously, the No-Build scenario generates a detour route that ultimately increases travel time costs, vehicle operation costs, and emissions costs. Other highway externalities that result from increased volumes on these detour routes were also considered, specifically through noise, congestion, and safety costs. The increased distances of each detour were multiplied by the

expected user volumes and by the costs per VMT provided by USDOT. By the bridge opening in 2035, eliminating bridge detours would save about \$705,741 on average. This number will more than triple by 2062, saving about \$2,695,636.