

# Cape Fear Crossing Corridor Alternatives Hurricane Evacuation Analysis

Technical Memorandum

August 2016

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**Raleigh, North Carolina 27607**

And for the

**North Carolina Department  
of Transportation**



# **Cape Fear Crossing Corridor Alternatives**

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# Cape Fear Crossing Corridor Alternatives

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### I. BACKGROUND

The North Carolina Department of Transportation (NCDOT) proposes to construct a new location project in Brunswick and New Hanover Counties (Figure 1). The project is included in the 2016-2025 State Transportation Improvement Program (STIP) as Cape Fear Crossing (STIP Project U-4738). The project would be a fully controlled access facility extending from the vicinity of US 17 Bypass and I-140 in Brunswick County to US 421 in New Hanover County, including a crossing of the Cape Fear River.

NCDOT has selected 12 alternatives for detailed study in addition to the No-Build Alternative. These detailed study alternatives (DSAs) include two alternatives that will upgrade existing US 17, four alternatives on new location, and six “hybrid” alternatives that incorporate components of new location and upgrades to the existing roadway. Individual descriptions of the 12 alternatives are included below and are shown on Figure 1.

- Upgrade Existing Alternatives:
  - **Alternative F/P:** These two alternatives include upgrading US 17 from the I-140/US 17 interchange, to US 421 in the City of Wilmington. These alternatives will also include upgrading US 421 south to terminate at Shipyard Boulevard. The alternatives will be designed as a freeway (Alternative F) and as a standard widening (Alternative P).
- New Location Alternatives:
  - **Alternative B:** This alternative begins at I-140 and crosses US 17, travels between the Brunswick Forest and Mallory Creek developments, and crosses the Cape Fear River to terminate at Shipyard Boulevard and US 421.
  - **Alternative C:** This alternative begins at I-140 and crosses US 17, travels parallel to Wire Road, and crosses the Cape Fear River to Independence Boulevard. This alternative will also include upgrading US 421 north to terminate at Shipyard Boulevard.
  - **Alternatives M Avoidance and N Avoidance:** These alternatives begin at the I-140/US 17 interchange, avoid the Snee Farm/Stoney Creek subdivisions, travel south of Brunswick Forest, and cross the Cape Fear River to terminate at either Independence Boulevard (Alternative M Avoidance) or Shipyard Boulevard (Alternative N Avoidance). Alternative M Avoidance will also include upgrading US 421 north to terminate at Shipyard Boulevard.
- “Hybrid” Alternatives:
  - **Alternative G/Q:** These two alternatives begin at the I-140/US 17 interchange, upgrade existing US 17 for approximately two miles, then continue on new

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location between the Brunswick Forest and Mallory Creek developments, and cross the Cape Fear River to Independence Boulevard. These alternatives will also include upgrading US 421 north to terminate at Shipyard Boulevard.

Alternative G and Alternative Q follow the same alignment, but Alternative G will be designed as a freeway for its entire length, while Alternative Q will be designed as a standard widening along US 17 and a freeway on its new location portion.

- **Alternative J/T:** These two alternatives begin at the I-140/US 17 interchange, upgrade existing US 17 for approximately two miles, then continue on new location parallel to Wire Road, and cross the Cape Fear River to terminate at Shipyard Boulevard. Alternative J and Alternative T follow the same alignment, but Alternative J will be designed as a freeway for its entire length, while Alternative T will be designed as a standard widening along US 17 and a freeway on its new location portion.
- **Alternative V (freeway and standard widening option):** This alternative will include upgrading US 17 to the US 17/US 421 interchange, then travel south along Eagle Island on new location, and cross the Cape Fear River to US 421 just north of the Port of Wilmington. This alternative will also include upgrading US 421 south to terminate at Shipyard Boulevard. This alternative will have two options: it will be designed as a freeway with service roads and interchanges, and as a standard widening with access remaining similar to its current function.

Approximately ten years ago, NCDOT contracted with Atkins (formerly PBS&J), the foremost technical authority in the country in regards to hurricane evacuation transportation analysis, to assist in guiding the state in establishing standard evacuation clearance goals for the coastal region. The work resulted in the State Assembly passing North Carolina General Statute 136-10.7 which sets forth an 18 hour evacuation goal. This work established the role, issues, and appropriate time thresholds related to hurricane evacuation that could potentially be considered as part of the purpose and need for various pending roadway projects throughout the state. A number of corridor specific hurricane evacuation analyses have been performed since then to define the clearance time benefits/disbenefits of various roadway improvement alternatives in the North Carolina coastal region.

Concurrent with NCDOT's efforts in the hurricane evacuation analysis arena, the U.S. Army Corps of Engineers (USACE), Wilmington District on behalf of Federal Emergency Management Agency (FEMA) Region IV led several major hurricane evacuation studies (HESs) covering the entire North Carolina coast. Beginning with a mid-1980s initial study, an update was

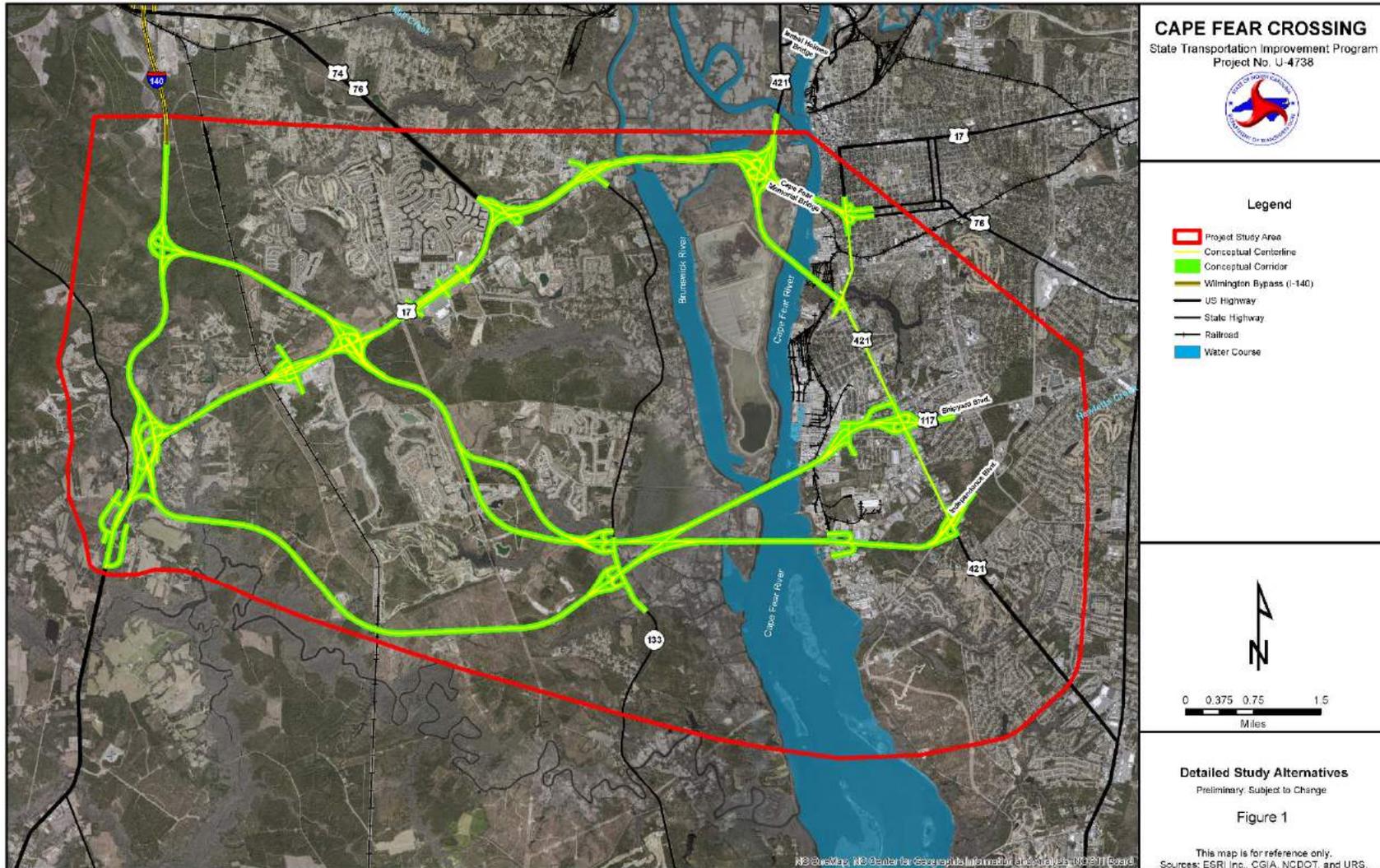
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accomplished in the late 1990s/year 2000 timeframe. Currently, based on new storm surge modeling (and associated evacuation areas), new socioeconomic data, new behavioral assumptions and the inclusion of several roadway improvements, Atkins has been retained by the USACE to update the state's hurricane evacuation clearance times for a 2015 base year. The project will be completed in August 2016. The products and times will be used for evacuation decision making by the state and counties during an actual threat.

Other HES efforts that should be recognized include a number of post storm evacuation assessments that FEMA and the USACE have led after actual hurricane events to document lessons learned. These efforts (after benchmark storms like Bertha, Fran, and Floyd) have also looked at evacuation traffic flows and made favorable comparisons of Atkins generated pre-event clearance times to actual experienced clearance times based on interviews with law enforcement and analysis of real time traffic counts.

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**Figure 1: Detailed Study Alternatives**

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## II. STUDY TASKS

AECOM (formerly URS Corporation) contracted Atkins in the fall of 2015 to study the hurricane evacuation impacts of potential Cape Fear Crossing alternatives within both New Hanover County and Brunswick County. Atkins was charged with using the ongoing USACE HES transportation modeling work as a base to analyze a Year 2040 no build condition and then to analyze various alternatives specified in previous phases of the Cape Fear Crossing project. Consistency with assumptions and concepts (behavioral and hazards) already “endorsed” by federal, state, and local emergency management, NCDOT, and law enforcement staff in ongoing North Carolina HES study work was deemed to be of the highest priority in this analysis. In addition, the analysis focuses on a worst probable scenario of a Category 3 hurricane with three quarters of tourist units assumed to be occupied at the start of an evacuation. This scenario is consistent with the scenario that the state has previously deemed appropriate for analyzing evacuation benefits/disbenefits.

Hurricane evacuation analysis tasks included the following:

- 1) Enhance latest FEMA/USACE NC HES transportation model to incorporate a 2040 future year and each Cape Fear Crossing improvement alternative.
- 2) Incorporate best available future population projections as well as zone by zone vehicle ownership, social, and behavioral characteristics.
- 3) Establish existing evacuation clearance time impacts for the Cape Fear Crossing corridor under a variety of no build, existing network improvements, and new alignment alternatives.
- 4) Interact with AECOM, NCDOT and agency representatives to provide the best technical guidance possible regarding the project and hurricane evacuation issues.



### III. MODEL ENHANCEMENTS FOR THE CAPE FEAR CROSSING ALTERNATIVES STUDY

A number of important elements were incorporated in the North Carolina HES model so that future analysis could be performed and study tasks accomplished. These included:

- 1) Roadway segmentation updated with future expected directional number of lanes for each of the 12 Cape Fear Crossing study alternatives and with the I-140 corridor in place. Based on guidance from AECOM, directional number of lanes was input for the no build, improve existing (Alternatives F, P, V (freeway), and V (arterial widening)), northern alternatives (Alternatives B, C, G, Q, J, and T), and southern alternatives (Alternatives M Avoidance and N Avoidance) for each model run. Alternatives were grouped together based on having common evacuation characteristics.
- 2) Based on new sea, lake, and overland surges from Hurricanes (SLOSH) model storm surge inundation mapping and ongoing FEMA/USACE HES local meetings, the latest intended primary evacuation areas were incorporated for New Hanover, Brunswick, and Pender Counties.
- 3) Existing and future projected population and dwelling unit data were incorporated per the 2010 US Census Estimates, 2014 American Community Survey, and NC State Data Center long range projections. Various environmental documents prepared by AECOM/URS were also reviewed to ensure consistency.

	<u>Existing Perm. Pop.</u>	<u>Year 2040 Perm. Pop.</u>
New Hanover	216,900 people	300,469 (plus seasonal pop)
Brunswick	118,800	199,100 (plus seasonal pop)
Pender	56,250	85,000

- 4) People and vehicles per occupied unit were stratified by evacuation zone to reflect various neighborhood and auto ownership characteristics (rather than the usage of a countywide figure).
- 5) Special social factors by zone were developed to influence evacuation behavioral parameters. These include average household income, percent of households with no vehicle, and percent of population over 75 years old.
- 6) Recognition of ambient background traffic early in an evacuation in addition to



evacuation vehicles on the road network.

- 7) Hourly flow rates for evacuations based on Atkins' extensive experience reviewing real time evacuation flow rates on specific facility types with a specific number of directional travel lanes.
- 8) Inclusion of latest NCDOT 2016-2025 STIP widening projects for area assumed to be implemented by Year 2040.
- 9) Clearance time defined as the time it takes for all vehicles to clear the network. Clearance time starts when the first vehicle enters the road network and ends when the last vehicle leaving reaches I-95 (at I-40).
- 10) Traffic metered through bottlenecks reflecting varying flow rates and rapid loading of evacuees with background traffic diminishing at an inverse rate.
- 11) Out of county evacuation movements reflect a 65 percent northbound and 35 percent westbound intended destination stratification per FEMA/USACE evacuation behavioral research for the area.
- 12) Analysis allows specific assignment of zonal traffic to alternatives based on geographic and network proximity as well as unique zonal evacuation behavioral parameters.

#### IV. EXISTING HURRICANE EVACUATION CLEARANCE TIMES

For the New Hanover, Brunswick, and Pender County region of the state, existing times range from 10 to 40 hours depending on category of hurricane and tourist occupancy. The evacuation issues associated with a weak Category 1 hurricane with low tourist occupancy are miniscule compared to those evacuation issues associated with a worst case Category 5 hurricane with high tourist occupancy. For the Category 3 hurricane, three quarters percent tourist occupancy scenario, times are approximately 29 hours and the controlling bottlenecks include I-40 northbound and US 74/76 westbound as well as a number of in county local bottlenecks. Considerable queuing at the Cape Fear Memorial Bridge, College Road (all sections), and US 421 are likely if the public responds as expected for this level of strong threat.

#### V. FUTURE CLEARANCE TIMES—NO BUILD ALTERNATIVE

While the hurricane evacuation issue is considered a potential secondary benefit in establishing purpose and need for the Cape Fear Crossing project, it is an important issue to recognize. In evaluating the Cape Fear Crossing improvement alternatives, the model developed for the region for the year 2040 was run for the storm/tourist occupancy scenario assuming no Cape

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Fear Crossing improvements are made. With the expected large regional population growth over the next 25 years, times escalate by some 11 hours depending on category of hurricane and tourist occupancy. ***For the Category 3 hurricane, 75% tourist occupancy scenario in the Year 2040, times will be 40 hours with the last vehicle through the corridor assumed to reach I-95 (at I-40) as an inland cut off point. (Please note that this is NOT the time it will take for an individual vehicle to make its evacuation movement but is the theoretical time to accommodate all vehicles wishing to exit the multicounty region).*** In reality, this time requirement is unworkable because it will be very hard to convince citizens to leave this far in advance of an approaching storm especially given forecast uncertainty. I-40 northbound and US 74/76 roadway segments out of the region are the worst congested segments. In-county roadway segments such as the Cape Fear Memorial Bridge, US 74/76 from the bridge to I-140, and US 17 in Brunswick County from I-140 to NC 133 will also experience difficult levels of evacuation traffic greatly contributing to the lengthy times.

While reverse laning of I-40 northbound out of Wilmington was attempted late in the Hurricane Floyd event, the state of North Carolina as a matter of current policy does not intend to reverse lane I-40 northbound out of New Hanover County or US 74/76 westbound out of Brunswick County. By the Year 2040, the number of lanes on I-40 and US 74/76 (out of the study area) is not expected to change and reverse laning may need to be considered for major hurricane evacuations at that point.



## VI. ANALYSIS OF IMPROVEMENT ALTERNATIVES

Tables 1 through 3 show the impact on evacuation congestion and associated clearance time requirements for each evacuation bottleneck and improvement alternative in the Year 2040. The effect on worst evacuation bottleneck congestion is the most important issue to consider in weighing evacuation impacts. In the table, the worst bottlenecks are identified and include:

- 1) College Road northbound south of I-40
- 2) Cape Fear Memorial Bridge westbound
- 3) US 74/76 causeway westbound from Cape Fear Memorial Bridge to US 17 split
- 4) US 74/76 from US 17 split to I-140
- 5) US 74/76 westbound out of Brunswick County
- 6) US 421 between Shipyard Boulevard and Wilmington Central Business District
- 7) US 17 in Brunswick County between I-140 and Cape Fear Crossing improvement alternatives

Improvement alternatives are grouped by upgrade existing (Table 1), northern (Table 2), and southern alternatives (Table 3) corresponding to the Cape Fear Crossing's 12 detailed study alternatives. Each improvement alternative is then graded as to its positive, neutral, or negative impact at each of those evacuation bottlenecks. A qualitative measure of major positive, positive, neutral, negative, major negative is assigned to each roadway segment/improvement alternative pairing based on the reduction or addition to evacuation congestion at that spot. Descriptors reflect the following impacts for a Category 3 Hurricane, 75% tourist occupancy:

- 1) MAJOR POSITIVE: Greater than 25% reduction in segment clearance time
- 2) POSITIVE: 5 to 25% reduction in segment clearance time
- 3) NEUTRAL: No substantial reduction or increase in segment clearance time
- 4) NEGATIVE: 5 to 25% increase in segment clearance time
- 5) MAJOR NEGATIVE: Greater than 25% increase in segment clearance time

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**Table 1: Corridor Alternatives Impact on Hurricane Evacuation Congestion Associated with Critical Roadway Segments – Upgrade Existing**

Critical Roadway Segments	No Build Clearance Times	FUTURE YEAR 2040 – CLEARANCE TIME IMPACTS			
		UPGRADE EXISTING			
		F	P	V freeway	V arterial widening
College Road northbound south of I-40	40.6	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
Cape Fear Memorial Bridge westbound	21.2	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 causeway westbound from Cape Fear Memorial Bridge to US 17 split	13.6	MAJOR POSITIVE	POSITIVE	POSITIVE	POSITIVE
US 74/76 from US 17 split to I-140	20.0	POSITIVE	NEUTRAL	NEUTRAL	NEUTRAL
US 74/76 westbound out of Brunswick County	34.1	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
US 421 between Shipyard Boulevard and Wilmington Central Business District	8.2	POSITIVE	POSITIVE	POSITIVE	POSITIVE
US 17 in Brunswick between I-140 and CFX improvement alternatives	1.8	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL

For a Category 3 Hurricane, 75% tourist occupancy:

- 6) MAJOR POSITIVE: Greater than 25% reduction in segment clearance time
- 7) POSITIVE: 5 to 25% reduction in segment clearance time
- 8) NEUTRAL: No substantial reduction or increase in segment clearance time
- 9) NEGATIVE: 5 to 25% increase in segment clearance time
- 10) MAJOR NEGATIVE: Greater than 25% increase in segment clearance time

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**Table 2: Corridor Alternatives Impact on Hurricane Evacuation Congestion Associated with Critical Roadway Segments – Northern Alternatives**

Critical Roadway Segments	No Build Clearance Times	FUTURE YEAR 2040 – CLEARANCE TIME IMPACTS					
		NORTHERN ALTERNATIVES					
		B	C	G	Q	J	T
College Road northbound south of I-40	40.6	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
Cape Fear Memorial Bridge westbound	21.2	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 causeway westbound from Cape Fear Memorial Bridge to US 17 split	13.6	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 from US 17 split to I-140	20.0	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 westbound out of Brunswick County	34.1	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
US 421 between Shipyard Boulevard and Wilmington Central Business District	8.2	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE	MAJOR POSITIVE
US 17 in Brunswick between I-140 and CFX improvement alternatives	1.8	NEUTRAL	NEUTRAL	NEGATIVE	MAJOR NEGATIVE	NEGATIVE	MAJOR NEGATIVE

For a Category 3 Hurricane, 75% tourist occupancy:

- 1) MAJOR POSITIVE: Greater than 25% reduction in segment clearance time
- 2) POSITIVE: 5 to 25% reduction in segment clearance time
- 3) NEUTRAL: No substantial reduction or increase in segment clearance time
- 4) NEGATIVE: 5 to 25% increase in segment clearance time
- 5) MAJOR NEGATIVE: Greater than 25% increase in segment clearance time

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**Table 3: Corridor Alternatives Impact on Hurricane Evacuation Congestion Associated with Critical Roadway Segments – Southern Alternatives**

Critical Roadway Segments	No Build Clearance Times	FUTURE YEAR 2040 – CLEARANCE TIME IMPACTS	
		SOUTHERN ALTERNATIVES	
		M avoidance	N avoidance
College Road northbound south of I-40	40.6	NEUTRAL	NEUTRAL
Cape Fear Memorial Bridge westbound	21.2	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 causeway westbound from Cape Fear Memorial Bridge to US 17 split	13.6	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 from US 17 split to I-140	20.0	MAJOR POSITIVE	MAJOR POSITIVE
US 74/76 westbound out of Brunswick County	34.1	NEUTRAL	NEUTRAL
US 421 between Shipyard Boulevard and Wilmington Central Business District	8.2	MAJOR POSITIVE	MAJOR POSITIVE
US 17 in Brunswick between I-140 and CFX improvement alternatives	1.8	NEUTRAL	NEUTRAL

For a Category 3 Hurricane, 75% tourist occupancy:

- 1) MAJOR POSITIVE: Greater than 25% reduction in segment clearance time
- 2) POSITIVE: 5 to 25% reduction in segment clearance time
- 3) NEUTRAL: No substantial reduction or increase in segment clearance time
- 4) NEGATIVE: 5 to 25% increase in segment clearance time
- 5) MAJOR NEGATIVE: Greater than 25% increase in segment clearance time

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All improvement alternatives will have major positive benefits to evacuation congestion and associated clearance time requirements for the Cape Fear Memorial Bridge. Major positive impacts are achieved by substantial capacity improvements and/or reduction in number of evacuation vehicles to be processed. The northern and southern alternatives substantially reduce evacuation vehicle volumes on the bridge. “Improve Existing” F and P alternatives greatly improve capacity thereby achieving great relief to evacuation congestion. Alternative F provides the greatest reduction in segment clearance time as multiple westbound lanes are added and the segment functions as a freeway.

US 74/76 from the Cape Fear Memorial Bridge to I-140 will experience major positive evacuation impacts for all of the northern and southern improvement alternatives as evacuation vehicles are attracted to the new Cape Fear Crossing segments away from this critical evacuation congestion area. The upgrade existing alternatives provide positive relief to the US 74/76 segment between the Cape Fear Memorial Bridge and US 17 split but little impact to the US 74/76 segment between the US 17 split and I-140. That is because the “improve existing” alternatives upgrade westbound evacuation service volume on the one segment but not the other.

US 421 between Shipyard Boulevard and downtown Wilmington will experience major positive evacuation impacts for all of the northern and southern improvement alternatives as evacuation traffic is shifted from the arterial approaches to the Cape Fear Memorial Bridge to the new potential crossings of the Cape Fear River. The upgrade existing alternatives will have lesser positive impacts but will relieve some evacuation congestion through capacity improvements on US 421 and approaches to the Cape Fear Memorial Bridge.

US 17 in Brunswick County east of I-140, will experience major negative evacuation congestion impacts from alternatives Q and T, and negative but lesser negative impacts from alternatives G and J. This is because these Cape Fear Crossing new alignments end at US 17 rather than continue to I-140. Evacuation traffic would exit the Cape Fear Crossing onto US 17 and have to travel southbound to the southern terminus of I-140. This section of US 17 even with capacity improvements will experience substantial levels of background traffic and evacuation congestion making for a less than ideal improvement situation.

While the Cape Fear Crossing improvement alternatives help evacuation congestion levels on local bottlenecks, they do not solve the area’s worst regional bottleneck evacuation congestion locations associated with US 74/76 westbound out of Brunswick County or I-40 northbound out of New Hanover and Pender Counties. The table reflects this neutral impact for all improvement alternatives at these two locations. The real utility/benefit of the improvement

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alternatives would be experienced in conjunction with enhanced evacuation flow on these out of region segments. Whether this happens as a result of future reverse lane plans, use of shoulders for evacuation, or some other creative traffic management technique is an issue that could be studied and addressed at a future time.

While the hurricane evacuation impact analysis provides useful findings for the environmental process, the differences in specific northern and southern alignments all within several miles of one another are somewhat indistinguishable in terms of evacuation movements. Evacuation travel patterns for major hurricane events (unlike daily traffic patterns which are based on everyday driver experiences) are based on situations that may happen once every 15 years. Drivers will tend to overuse major access controlled facilities and underutilize minor arterials. Those evacuees who strongly desire to travel westbound and who live south of Market Street will be greatly attracted to a new Cape Fear River Crossing if it seamlessly connects them to I-140 and US 74/76 out of Brunswick County regardless of alignment. Likewise, those evacuees who strongly desire to travel northbound, will use I-40. The area has not had a substantial evacuation take place since Hurricane Floyd in 1999 and with the tremendous population growth that has taken place (and will take place between now and 2040), only an educated guess can be made about evacuation behavior 25 years from now. While certain improvement alternatives may have more positive evacuation impacts than others, those alternatives must be weighed for their other community and environmental impacts and ability to meet the purpose and need before a preferred alternative is selected.

## VII. REFERENCES

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