MID-CURRITUCK BRIDGE STUDY

2040
PREFERRED ALTERNATIVE
TRAFFIC REPORT

FINAL

STATE PROJECT NO. 6.049002T
TIP NO. R-2576
CURRITUCK COUNTY
DARE COUNTY

prepared by
WSP USA
434 Fayetteville Street, Suite 1500
Raleigh, North Carolina 27601

for the
NORTH CAROLINA
Turnpike Authority
Raleigh, North Carolina

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Table of Contents

List of Tables

List of Figures

Appendices

1.0 Introduction

This report is the *2040 Preferred Alternative Traffic Report* supports the Mid-Currituck Bridge Final Environmental Impact Statement (EIS) reevaluation being conducted by the North Carolina Turnpike Authority (NCTA). The study is examining a new seven-mile bridge connecting US 158 near Aydlett to NC 12 south of Corolla on the Currituck County portion of the Outer Banks.

The project study area for the environmental study includes US 158 between Barco and Southern Shores and follows NC 12 north from Southern Shores to Corolla. For the 2040 Traffic Design Analysis Report, a smaller study area was examined, focused on the roadway and intersection improvements required as part of Preferred Alternative.

The Preferred Alternative includes construction of a Mid-Currituck Bridge, as well as limited improvements to existing NC 12 and US 158. The Preferred Alternative identifies the extent to which network congestion and travel time could be improved, as well as other associated benefits, if only a Mid-Currituck Bridge were built. Limited existing road improvements were added to ensure that southbound traffic on NC 12 from the bridge would not queue back onto the bridge on summer weekend. The basic features of this alternative are:

- Constructing a 5.3-mile-long, two-lane toll bridge across Currituck Sound, with approach roads, in Currituck County. The mainland approach road to the bridge over Currituck Sound would include a bridge over Maple Swamp.
- Improvement to NC 12 in the bridge terminus area, including a roundabout at the bridge's connection to NC 12.
- US 158 improvements would include an interchange at the connection of US 158 and the proposed bridge. Toll plazas would be just east of the interchange. Drivers traveling between US 158 and Aydlett would continue to use Aydlett Road.
- For hurricane evacuation improvement, traffic will use the existing center turn lane on US 158 from the interchange to the intersection of US 158 and NC 168 as a third outbound evacuation lane. One inbound lane on the Knapp (Intracoastal Waterway) Bridge would be used as a third outbound evacuation lane. In addition, adding approximately 1,600 feet of new third outbound lane to the west of the NC 12/US 158 intersection in Dare County to provide additional hurricane evacuation capacity.

The Preferred Alternative is shown below in Figure 1. The components shown reflect the revised Preferred Alternative design prepared to take into consideration the 2040 traffic forecasts prepared in 2016.

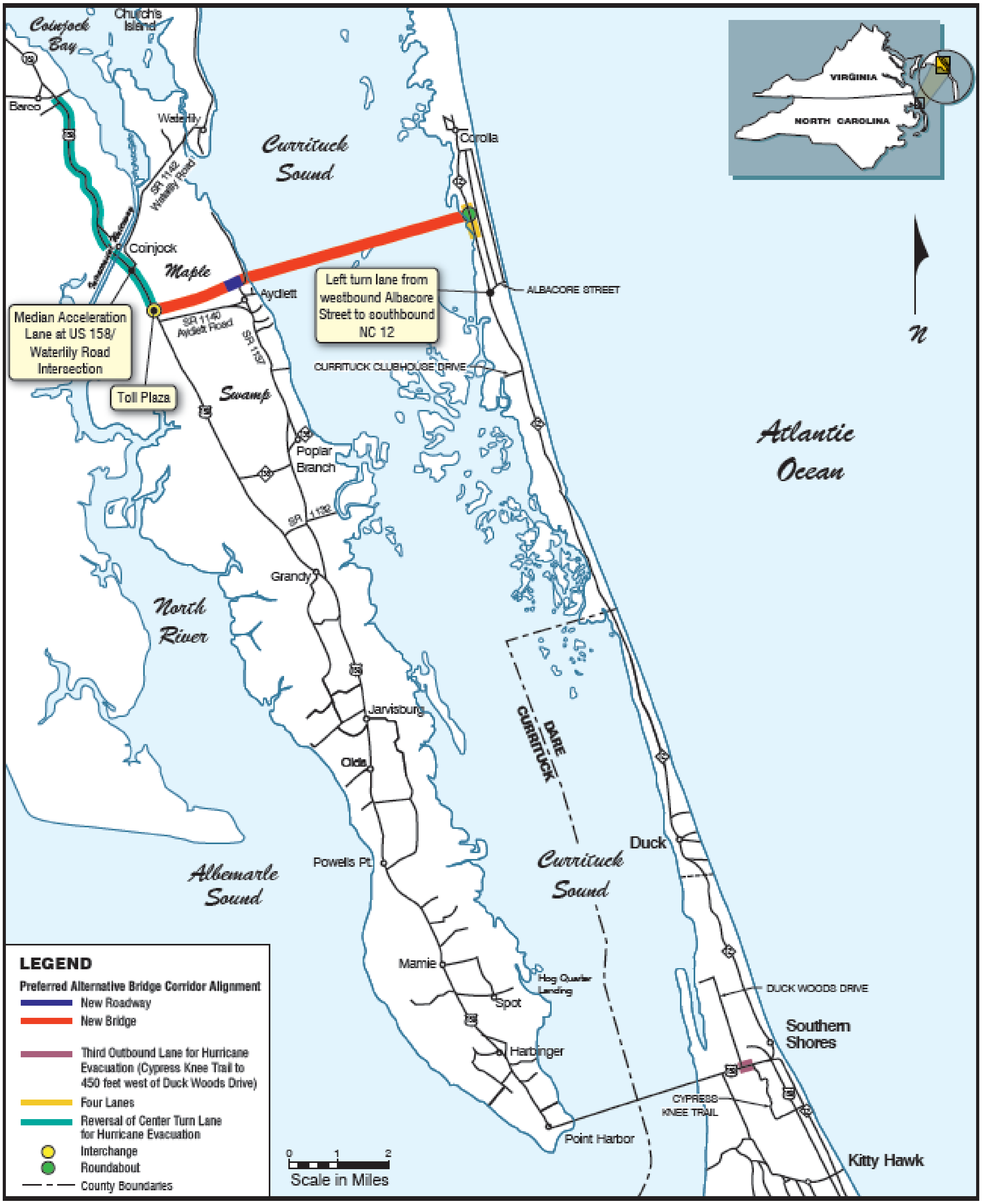


Figure 1. Preferred Alternative

1.1 Project Background

The Mid-Currituck Bridge project, State Transportation Improvement Program (STIP) project number R-2576, has been under study for several years dating back to before 1995. The most recent traffic analysis was prepared and summarized in the 2035 Traffic Alternatives Report dated April 2008 and revised March 2009. The 2035 Traffic Alternatives Report was utilized in the project development process and development of the EIS to evaluate congestion measures and design requirements for the proposed project. In 2012, a draft Record of Decision (ROD) was prepared based on the 2035 Report. Prior to final signature of the ROD, the NC General Assembly rescinded state funding for the project. At that time, a decision was made that the ROD would not be signed since there was inadequate funding to construct the project. In 2015, the Mid-Currituck Bridge project was included in North Carolina Department of Transportation's (NCDOT) 2016-2025 STIP for construction funding starting in 2017. In 2017, the Mid-Currituck Bridge project was included in NCDOT's 2018-2027 STIP for construction funding starting in 2018.

1.2 Chronology of Traffic Studies

The *2040 Preferred Alternative Traffic Report* is the latest step in a series of traffic studies conducted since 2002. The process has been an iterative process with revised alternatives, forecasts, measures of effectiveness, and issues that have been raised during the project development process. The most recent developments have been lower forecast traffic and changes in capacity assumptions, based on the updated Highway Capacity Manual, for a 2040 analysis of the project.

A chronology of various stages of traffic studies for the project is outlined below:

- *Traffic Needs Report (July 2002):* The initial traffic analysis for this phase of the EIS was completed and submitted to NCDOT as the Traffic Needs Analysis in July 2002. The report documented the methodology, assumptions, and findings for existing (2001) traffic conditions, future (2025) No-Build traffic conditions, and hurricane evacuation clearance times. The 2025 No-Build traffic conditions included analysis of thirteen roadway links and two intersections.
- *2025 Traffic Alternatives Report (May 2007):* Building upon the No-Build analysis, follow-up analysis was developed to look at 2025 traffic forecasts and traffic capacity under potential alternatives including widening and Build Bridge scenarios. This analysis step included traffic information for a new link, the Mid-Currituck Bridge. In addition, non-highway alternatives were investigated, including a sketch-level examination of reversible lanes. The findings were initially presented in a draft report in March 2004 to NCDOT, but were finalized and incorporated into the 2025 Traffic Alternatives Report (May 2007) submitted to NCTA, which is currently a division of NCDOT.

- *Revised 2025 Traffic Alternatives Report (December 2005):* Additional 2025 alternatives analysis was conducted to address issues identified in the first stage of the alternatives analysis. The first issue was to determine the year that traffic flow is expected to reach Level of Service (LOS) E and LOS F under different roadway typical sections for the peak summer traffic seasons. The second issue was to examine the operational feasibility of a reversible third lane on NC 12 for use on summer weekends when tourists are arriving and departing beach houses as well as during a hurricane evacuation. The findings were initially presented in a draft report to NCDOT in December 2005, but were finalized and incorporated into the 2025 Traffic Alternatives Report.
- *2035 Traffic Alternatives Report (April 2008):* The 2035 Traffic Alternatives Report, developed in April 2008 and revised in March 2009, was an update of the 2025 Traffic Alternatives Report and utilizing year 2035 traffic volumes. In addition, the updated analysis examined the impact of expected toll diversion on traffic volumes. As with previous analyses, this analysis was built upon all previous alternatives analysis and draft reports. Although new assumptions were utilized in some cases, most of the analysis assumed that the previous traffic studies were applicable. The additional analysis focused on new information related to traffic operations.
- *2035 NC 12 Minimum Design Traffic Report (December 2010):* The 2035 NC 12 Minimum Design Traffic Report summarizes the anticipated 2035 traffic operations with the refined NC 12 Minimal Design features including the provision of two roundabouts and reducing the proposed typical cross-section from four lanes to two lanes in multiple locations.
- *2040 Traffic Alternatives Report (September 2017):* The 2040 Traffic Alternatives Report, was an update of the 2035 Traffic Alternatives Report and utilizing year 2040 traffic volumes. As with previous analyses, this analysis was built upon all previous alternatives analysis and draft reports but did include a new traffic forecast developed (completed June 2016) from 2015 traffic counts. Although new assumptions were utilized in some cases, most of the analysis assumed that the previous traffic studies were applicable.
- *Potential Traffic Constraints Report (June 2018):* The Potential Traffic Constraints Report was developed in June 2018 to outline the comparison between alternatives with constraints. This was based on current and future land use and how much more development could be handled by each alternative. This was a follow up to the 2040 Traffic Alternatives Report.

1.3 Purpose of Preferred Alternative Traffic Report

As noted previously, this report is entitled the *2040 Preferred Alternative Traffic Report*. Instead of focusing on the 40-mile roadway network, it focuses on the actual roadway improvements that would be required for constructing the preferred alternative in order to support the preliminary design process associated with this alternative. Both the project and design study areas are shown in Figure 1.

As shown, the design study area includes the proposed Mid-Currituck Bridge (including a toll plaza), an interchange at the western bridge terminus on US 158, and a multilane roundabout at eastern bridge terminus on NC 12. The design traffic analysis focuses on 2040 operations for both the Summer Weekday and Summer Weekend time periods.

As part of the design process, NCDOT indicated that Summer Weekday volumes were appropriate for the design of the existing roadway network including US 158 and NC 12. For operation of the Mid-Currituck Bridge, however, NCTA determined that the bridge should operate without extensive queuing even during the 2040 Summer Weekend conditions. Consequently, Summer Weekend traffic volumes were utilized for determining operations at locations that could affect traffic operations on the bridge, including the western terminus at US 158 and the eastern terminus at NC 12.

The traffic analysis utilized Synchro software to evaluate intersection operations as per NCDOT (Congestion Management Section) requirements for preliminary design. SIDRA software was used to analyze the proposed roundabout at the eastern terminus of the proposed Mid-Currituck Bridge at NC 12. PTV VISSIM simulation modeling software was used to model the traffic operations at the proposed interchange and toll plaza operations at the western terminus of the proposed Mid-Currituck Bridge at US 158. The capacity analysis results are provided in Appendix A for Synchro analysis outputs and in Appendix B for SIDRA roundabout analysis outputs.

1.4 Need for Updated Analysis

In 2017, the Mid-Currituck Bridge project was included in NCDOT's 2018-2027 STIP for construction funding starting in 2018. To proceed with the project, multiple elements are being reevaluated. As part of this reevaluation process, it was determined that the traffic analysis needed to be updated, primarily to account for a general slowdown in development activity in Currituck and Dare Counties and reflected in the updated project level traffic forecast dated June 2016.

2.0 Roadway Characteristics

The design study area includes two existing facilities and the proposed Mid-Currituck Bridge. Specific characteristics of these facilities are described below.

2.1 US 158

US 158 is currently a five-lane roadway in Currituck County where the new bridge is proposed to connect onto the mainland. Through the design study area, there are no existing signals and the five-lane cross section operates at LOS D or better for both Summer Weekday and Summer Weekend conditions.

If the bridge is constructed, 2040 traffic analysis indicates this section will operate at LOS B during the Summer Weekday and LOS D on the Summer Weekend north of the new bridge. South of the proposed bridge, traffic volumes will decrease resulting in LOS A during the Summer Weekday and LOS C during the Summer Weekend. (See Section 4.3 for a discussion of the roadway LOS.)

Approximately one mile north of the proposed connection with the new Mid-Currituck Bridge, US 158 crosses the Intracoastal Waterway at the Knapp Bridge. For the bridge crossing, US 158 has a four-lane section divided by a jersey barrier median section.

With the preferred alternative, no widening is proposed on US 158. An interchange is proposed at the connection between the Mid-Currituck Bridge and US 158. Through the interchange, US 158 is proposed as a four-lane facility with right of way and structure clearance reserved to allow for a future widening of US 158 to six lanes as part of a future NCDOT project.

It should be noted that at the Knapp Bridge crossing the Intracoastal Waterway, no widening is proposed. Instead, a reversible lane system is to be developed for emergency applications only.

2.2 NC 12

On the Outer Banks side of the proposed Mid Currituck Bridge, the primary roadway in Currituck County is NC 12. NC 12 is a two-lane facility in Currituck County with a variable speed limit (35 miles per hour [mph] in the summer, 45 mph in the non-summer).

In Currituck County in the vicinity of the bridge, two typical roadway types are observed. For the majority of the roadway, the road has access limited to cross roads serving typically residential developments. The access points vary from 800 feet to 1200 feet or more. In these sections, there are no driveways with access to NC 12. In the half-mile section between Albacore Road and Monteray Shores/Dolphin Drive, the roadway passes through a retail area with multiple driveways and access points to development on both sides of the road.

With the existing roadway network, traffic volumes are lower on NC 12 in Currituck County than in Dare County as a result of the "dead end" traffic pattern in which NC 12 is the only access to US 158. Construction of a new bridge is forecast to increase traffic on NC 12 in Currituck County as traffic will be oriented towards the new bridge as a new route to/from the Currituck Outer Banks.

The Currituck County section of NC 12 also has fewer traffic signals than in Dare County. In the design study area, there are two existing signals on NC 12: at Albacore Street and a new signal at Currituck Clubhouse Drive. The Final EIS Mid-Currituck Bridge design also included a proposed traffic signal at the intersection of NC 12 with the new bridge. The current design in the preferred alternative replaces the signalized intersection at the proposed bridge and NC 12 intersection with a multilane roundabout.

Previous analysis has also concluded that this intersection would require a four lane NC 12 feeding onto the new bridge (which would be tapered back to two lanes on the bridge structure). To accommodate the four-lane section the widening of NC 12 would extend just beyond N. Harbor View to the south and up to Herring St. to the north.

2.3 Mid-Currituck Bridge

The Mid-Currituck Bridge is being proposed as a two-lane bridge of approximately seven miles in length. Previous analysis has shown that the bridge would operate at LOS D during Summer Weekday and LOS E during Summer Weekend with design year traffic volumes.

In concluding that a two-lane bridge section would be adequate, the operational impacts of LOS E during the Summer Weekend were evaluated for a two-lane section. In general, LOS E congestion on a two-lane road reflects that mainline traffic typically is unable to pass and, therefore, traffic speeds are controlled by the slowest driver. In addition, the total volume of cars reduces overall speed.

On most two-lane roadways, LOS E is also reflective of conditions where vehicles on the side roads find it difficult to find adequate gaps for turning onto mainline traffic. In addition, mainline traffic wanting to take a left can be forced to wait for a gap, effectively blocking the through movement. On the bridge section, however, there are no side roads so these types of operational deficiencies would not occur. Therefore, LOS E on the proposed bridge will have a reduced speed, but will not be subjected to friction from side roads and turning traffic.

The western terminus or western side of the bridge, an interchange is planned with US 158. Incorporated into the interchange will be toll plazas for both directions of traffic flow. As part of a separate analysis, the toll plaza has been sized for Summer Weekend flow because inadequate capacity at a toll plaza can rapidly queue, possibly impacting both flow on US 158 and/or the new bridge. On the western side of the bridge, the multiple lanes through the toll plaza will be transitioned down to a single lane in both directions. It is anticipated that the transition lanes would need to be built on structure. US 158 would remain four lanes through the interchange area, but a median barrier would be constructed and adequate offsets be provided for future widening to six lanes

The eastern terminus or eastern side of the bridge, capacity is controlled by the traffic operations at the NC 12/ New Bridge intersection with a roundabout. In order to provide four lanes through the intersection, the new bridge will be transitioned from two lanes to four lanes at the eastern end through the intersection and continue onto NC 12 then transition back to two lanes. The bridge transition would need to be built on structure. Details on the assumed bridge transition are examined in **Section 5.2.1.**

3.0 Traffic Forecasts

Traffic Forecast were developed for STIP R-2576, Mid-Currituck Bridge, for base year (2015) and future year (2040) in June 2016 and are documented in the 2040 Project Level Traffic Fore Report. The forecasting analysis assumes that tolls will be in place on the proposed Mid-Currituck Bridge with the 2040 Build scenario.

Because of the unique nature of beach holiday travel pattern in the study area, the design period for this project is the Summer Weekday instead of the typical annual average daily traffic (AADT). Additional analysis is also needed for the Summer Weekend, which has the peak daily trip volumes.

Detailed traffic forecasts (intersection level) were developed for Summer Weekday and Summer Weekend as per NCDOT Traffic Forecasting guidelines. Link traffic forecasts (corridor level) were developed for AADT, Non-Summer Weekday, Non-Summer Weekend, Summer Weekday and Summer Weekend for the four scenarios.

Most of the analysis in this report is based on link forecasts, except for travel time analysis (**Section** Error! Reference source not found.), which utilizes peak hour volumes developed from detailed forecasts.

3.1 Daily Traffic Forecast

The traffic forecast prepared for the *2040 Traffic Forecasting Report* included 2040 daily traffic forecasts for multiple alternatives on 16 (+1) critical links along a 40-plus mile roadway network. The forecast took into account the impacts of tolls and congestion. Separate traffic forecasts were developed for AADT, non-Summer Weekdays, non-Summer Weekends, Summer Weekday, and Summer Weekends.

In addition, the *2040 Traffic Forecasting Report* developed a more refined traffic forecast to support the design traffic analysis. This forecast included the development of balanced daily traffic counts per NCDOT standards to support preliminary design analysis. Although more fully documented in the *2040 Traffic Forecasting Report,* the primary forecasting assumptions for the design traffic forecast include:

- A smaller study area was examined focusing on the proposed bridge design area in Currituck County. The design study area includes five of the 16 (+1) links for which daily forecasts were developed. These daily volumes were utilized as the initial input into developing balanced traffic forecasts including daily turning movements at intersections.
- The Base Year No-Build forecast was developed primarily based upon traffic counts taken for the forecast.
- Traffic forecast were developed for the 2040 Summer Weekday and 2040 Summer Weekend. In general, the Summer Weekday is the design period for the bridge. The

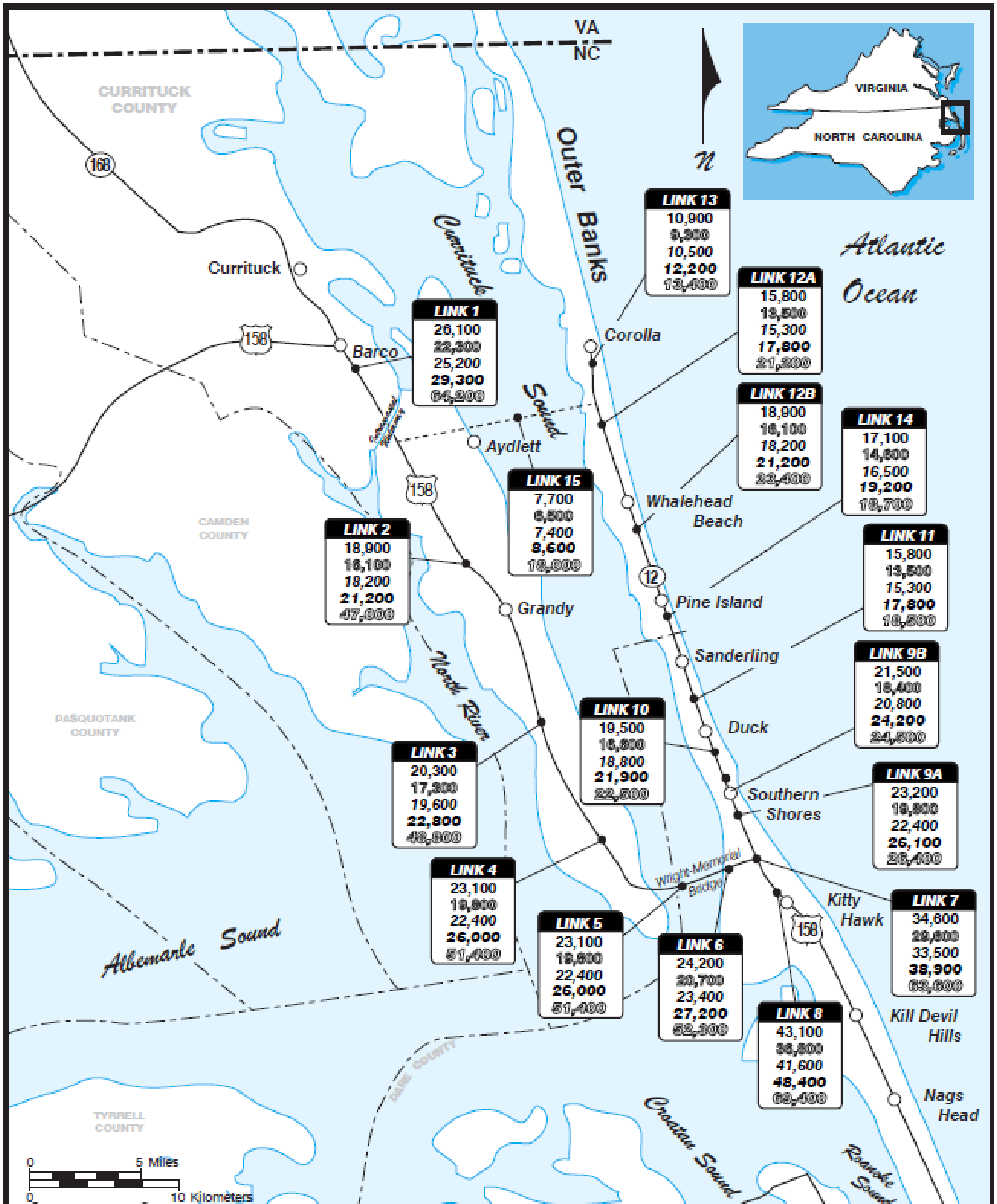
Summer Weekend was analyzed to identify additional improvements that may be required to avoid queuing that could impact the new bridge in order to prevent bottleneck failures spilling into larger system failures.

- The preferred alternative for the design capacity analysis it is assumed that a new Mid-Currituck Bridge is constructed, an interchange is constructed at US 158 on the western terminus of the bridge, and a multilane roundabout is constructed at NC 12 on the eastern terminus of the bridge. Also, NC 12 is widened for a limited distance with a cross-section that transitions between two- and four -lane cross-section.
- The future year forecasts assume construction of projects listed within the STIP with ROW or construction funding allocated. According to the 2016 STIP for the years 2016-2025, two projects were identified that included ROW funding within the project area. The two projects are:
    - R-3419: US 158 Widening from the Wright Memorial Bridge past the NC 12 intersection to the south.
    - R-4457: Improvements at the US 158/NC 12 intersection.

NOTE: These two projects are now included under one project (R-3419) in the 2018-2027 STIP: Access Improvements from Wright Memorial Bridge to US 64

- The tables below provide a summary of the daily traffic volumes developed in the design traffic forecast for the five-primary links for this study. The link-based forecasts for the Existing (2015) condition are shown in **Table 1**. The link-based forecasts for the 2040 No-Build condition are shown in

- **Table** 2. The link-based forecasts for the 2040 Build Preferred Alternative with Tolls are shown in **Table 3**.



LEGEND
38,100 - Annual Average Daily Traffic
33,400 - Non-Summer Weekday Traffic
21,900 - Non-Summer Weekend Traffic
54,800 - Summer Weekday Traffic
59,800 - Summer Weekend Traffic

Future Year (2040) Daily Traffic Volumes for Build Bridge with Tolls Scenario

Figure 7

Figure 2 provides a graphic illustration of the 2040 Build forecast.

Table 1. Existing (2015) Daily Traffic Volumes

Link #	Roadway Link	2015 Existing	
		Summer Weekday	Summer Weekend
1	US 158 Between Barco & MCB	19,600	43,600
2	US 158 Between MCB & Grandy	18,400	43,000
12A	NC 12 Between Albacore St. & MCB	11,800	14,300
13	NC 12 North of MCB	10,700	12,700
15	Mid-Currituck Bridge	Not Applicable – Proposed Bridge	

Table 2. Future 2040 No-Build Daily Traffic Volumes

Link #	Roadway Link	2040 No-Build Scenario with No Mid-Currituck Bridge	
		Summer Weekday	Summer Weekend
1	US 158 Between Barco & MCB	29,300	64,200
2	US 158 Between MCB & Grandy	27,800	63,200
12A	NC 12 Between Albacore St. & MCB	15,200	16,000
13	NC 12 North of MCB	12,200	13,400
15	Mid-Currituck Bridge	Not Applicable – Proposed Bridge	

Table 3. Future 2040 Build w/Bridge Daily Traffic Volumes

Link #	Roadway Link	2040 Build with the Mid-Currituck Bridge (With Tolls)	
		Summer Weekday	Summer Weekend
1	US 158 Between Barco & MCB	29,300	64,200
2	US 158 Between MCB & Grandy	21,200	47,000
12A	NC 12 Between Albacore St. & MCB	17,800	21,200
13	NC 12 North of MCB	12,200	13,400
15	Mid-Currituck Bridge	8,600	18,000

Note: Build Bridge scenario assumes tolls are in place on the Mid-Currituck Bridge.

3.2 Hourly Traffic Volumes

The critical link forecasts were further refined as described in the Traffic Forecast Report to develop a balanced traffic forecast for the design analysis. The daily forecasts provided were developed for 16 (+1) links in the study area. To provide capacity analysis for the roadway links, peaking characteristics and other traffic flow characteristics were identified in the 2040 Traffic Forecast Report. The details impacting the capacity analysis are summarized in this section.

3.2.1 Traffic Characteristics of Roadway Network

The traffic analyses for this project utilized traffic diurnal profiles derived from traffic counts collected in summer of 2015. Count data and diurnal profile from NCDOT's Automatic Traffic Recorder station A2703 on the Wright Memorial Bridge was also utilized in addition to the project-level traffic counts.

The temporal distribution of traffic counts along NC 12 and US 158 were analyzed and general findings include:

- During Summer Weekday conditions, traffic volumes along NC 12 have a traditional AM and PM peak although traffic volumes throughout the day are only slightly less than the peak hour flows.

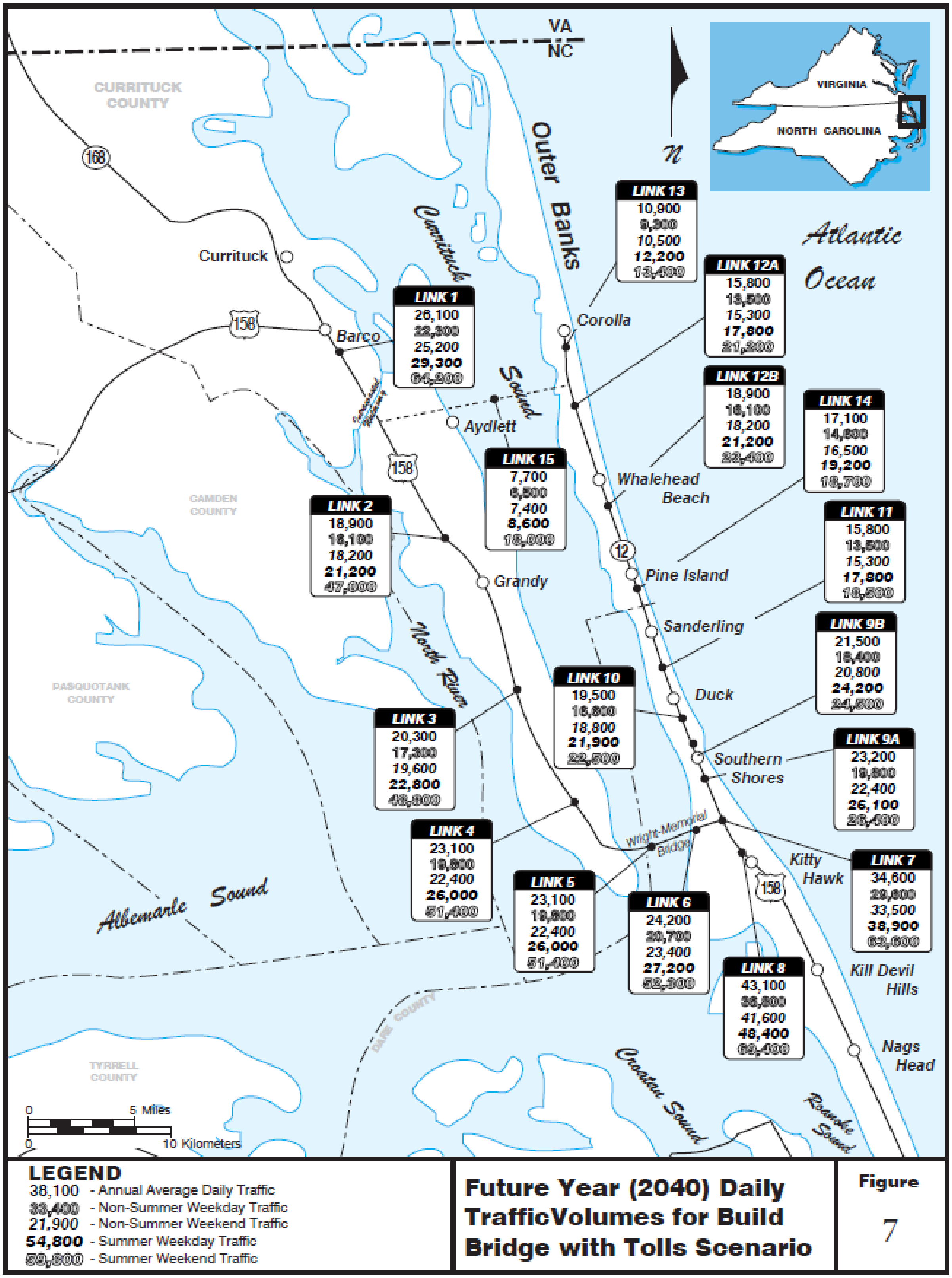


Figure 2. 2040 Build Preferred Alternative Forecast

- On summer Saturdays, traffic volumes along NC 12 are higher than on weekdays and peak period traffic volumes exceed weekday peak period volumes for a longer timeframe, from 8 AM to 8 PM.
- On summer Sundays, NC 12 traffic volumes are less than Saturdays, but still exceed peak weekday levels from 10 AM to 5 PM.

4.0 Roadway Level of Service

As part of the *2040 Traffic Alternatives Report*, traffic capacity was analyzed for 2015 and 2040, both on the Summer Weekday and Summer Weekend for the 16 (+1) roadway links on the 40-mile roadway network. Traffic operations were assessed utilizing LOS, a qualitative measure that characterizes the operational conditions within a traffic stream and the perception of traffic service by motorists and passengers as explained in Section 5.1. Using a volume to capacity ratio approach, the LOS was estimated for each link under multiple time periods for overall roadway operations.

The assumptions and methodology for this analysis are summarized in the *2040 Traffic Alternatives Report*. A summary of the roadway traffic capacity is shown in **Table 4** for the Summer Weekday and in **Table 5** for the Summer Weekend. The analysis is provided for 2015 Existing, 2040 No-Build, and 2040 Build with Bridge.

With a Mid-Currituck Bridge, the Summer Weekday and Summer Weekend traffic flow would improve overall because of traffic re-routing to the bridge from US 158. The effect of operations on US 158, NC 12, and the new Mid-Currituck Bridge is examined in the following sections.

4.1 US 158

As shown in **Table 4** and **Table 5**, operational issues on US 158 include:

- North of the new bridge (Link 1), traffic volumes and operations on US 158 remain the same as the No-Build condition with LOS D congestion on the Summer Weekend. This indicates potential long-term improvement needs on US 158 to the north of the Mid-Currituck Bridge and the project study area, regardless of the presence of a Mid-Currituck Bridge. Regardless, the section operates at an acceptable LOS B for the Summer Weekday design period.
- The section of US 158 south of the proposed bridge termini to the Wright Memorial Bridge (Link 2) operates at LOS D during the 2040 Summer Weekend with no Mid-Currituck Bridge. The construction of the new bridge would improve traffic operations in this section to LOS C during the 2040 Summer Weekend due to trips diverted from US 158 to the new bridge. On the Summer Weekday, this roadway section operates at LOS B without and LOS A with the new bridge.

Table 4. Future (2040) Traffic Capacity – LOS and V/C Ratio (Summer Weekday)

Link #	Roadway Link	2015 Existing		2040 No-Build		2040 Build w/ Bridge	
		LOS	V/C	LOS	V/C	LOS	V/C
Proposed Bridge		**No bridge**		**No bridge**		**2-Lane bridge**	
15	Mid-Currituck Bridge	N/A - Proposed Bridge		N/A - Proposed Bridge		D	0.24
US 158 Barco to Wright Memorial Bridge		**Existing 5 lanes**		**Existing 5 lanes**		**Existing 5 lanes**	
1	US 158 south of Barco	A	0.22	B	0.34	B	0.34
2	US 158 near Bertha	A	0.21	B	032	A	0.24
NC 12 in Currituck County		**Existing 2 lanes**		**Existing 2 lanes**		**Existing 2 lanes**	
12A	NC 12 at Corolla south of MCB	C	0.37	D	0.48	D	0.56
13	NC 12 at Corolla north of MCB	C	0.34	C	0.39	C	0.39

Table 5. Future (2040) Traffic Capacity – LOS and V/C Ratio (Summer Weekend)

Link #	Roadway Link	2015 Existing		2040 No-Build		2040 Build w/ Bridge	
		LOS	V/C	LOS	V/C	LOS	V/C
Proposed Bridge		**No bridge**		**No bridge**		**2-Lane bridge**	
15	Mid-Currituck Bridge	N/A - Proposed Bridge		N/A - Proposed Bridge		E	0.50
US 158 Barco to Wright Memorial Bridge		**Existing 5 lanes**		**Existing 5 lanes**		**Existing 5 lanes**	
1	US 158 south of Barco	C	0.58	D	0.86	D	0.86
2	US 158 near Bertha	C	0.58	D	0.85	C	0.63
NC 12 in Currituck County		**Existing 2 lanes**		**Existing 2 lanes**		**Existing 2 lanes**	
12A	NC 12 at Corolla south of MCB	D	0.41	D	0.45	D	0.60
13	NC 12 at Corolla north of MCB	C	0.36	C	0.38	C	0.38

4.2 NC 12

As shown in **Table 4** and **Table 5**, operational issues on NC 12 include:

- On NC 12 north of the new bridge (Link 13), the proposed bridge is not forecast to increase traffic volumes. In this section, future operations are expected to reach LOS C in the Summer Weekday and Summer Weekend. No widening is proposed except as necessary to align and improve the approaches at the intersection of NC 12 with the new bridge.

- With a Mid-Currituck Bridge and no other improvements, traffic volumes are increased in northern Currituck County south of the new bridge (Link 12). As a direct result, congestion on NC 12 in Currituck County would slightly worsen (as compared with the No-Build), reaching LOS E on the Summer Weekday and LOS F on the Summer Weekend if NC 12 is not widened. Therefore, this section will be widened to four lanes as part of the Mid-Currituck Bridge project improving operations to LOS C or better throughout the year.

4.3 Mid-Currituck Bridge

As shown in **Table 4** and **Table 5**, the proposed Mid-Currituck Bridge would operate at LOS D during non-summer and the Summer Weekday conditions, but would operate at LOS E during Summer Weekend conditions with the proposed two-lane bridge.

4.3.1 Potential Future Need for Four Lane Bridge

The two-lane bridge recommendation is based upon the 2040 Build Bridge forecast assuming that a toll is required for crossing the bridge. The previously conducted 2025 no toll forecast had higher bridge volumes than the 2035 with tolls scenario since no toll diversion was included. As a result, if the toll were to be removed from the bridge in the future or if diversions were to be less than anticipated, it is likely that a two-lane bridge would have more severe congestion than identified for 2035.

The potential congestion issues related to the toll policies and future growth may require the consideration of a four-lane bridge improvement in the future. Although additional study would be required at a future date when the bridge is in operation, it was discussed in the *2035 Traffic Alternatives Report* that thresholds for widening of the proposed bridge should provide for LOS D operation on the Summer Weekday and LOS E on the Summer Weekend.

4.3.2 Bridge Approach Issues

Traffic volumes also require that additional capacity provisions be provided at the western termini with US 158 and the eastern termini with NC 12. Some of these provisions include:

- At the western termini with US 158, an interchange is required to adequately serve traffic on US 158 and the new bridge. In addition, the provision of a toll collection plaza at the west would require some widening of the bridge at the western approach to transition from a two-lane bridge to the toll plaza. This transition would likely require additional structure width. Note that on the Summer Weekend, the toll plaza would be a potential bottleneck, so it is recommended that this component be designed to serve Summer Weekend traffic.

- On the eastern termini of the bridge, capacity is controlled by the traffic operations at the intersection with NC 12. The preferred alternative recommends a multilane roundabout over a traffic signal as recommended in the Draft EIS. Due to high volumes, this intersection will require multi-lane approaches to accommodate the dual turning movements to and from NC 12 and the Mid-Currituck Bridge. Since this intersection is located less than 1000 feet from the Sound, the transition from a two-lane bridge to a multilane roundabout will require widening of the basic bridge section to allow for appropriate transition lengths and laneage requirements.

5.0 Intersection Level of Service

Intersection analysis using the balanced turn movement forecasts and Synchro software was performed for the multiple scenarios. The analysis included three intersections on US 158 and a roundabout at the MCB and NC 12, one signalized intersection at NC 12 and Albacore Street, and 14 unsignalized intersections on NC 12.

5.1 Level of Service Concept

LOS is a qualitative measure that characterizes the operational conditions within a traffic stream and the perception of traffic service by motorists and passengers. The LOS performance measure used in this project is based on definitions outlined in the *Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis (HCM 6E) (Transportation Research Board, 2016).* The Transportation Research Board's *2000 Highway Capacity Manual (2000 HCM)* generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience.

Table 6 and **Table 7** provide a general description of the various LOS categories and delay ranges for signalized intersections and unsignalized intersections, respectively. Six levels are used, ranging from A to F. For roadways, LOS A indicates no congestion. LOS F represents traffic demand exceeding roadway capacity resulting in extreme delays. The engineering profession generally accepts LOS D as a minimally acceptable operating condition with LOS C desired in rural areas.

Table 6. Signalized Intersection LOS Criteria

LOS	Description	Average Control Delay (seconds/vehicle)
A	Little or no delay	<= 10 sec.
B	Short traffic delay	10-20 sec.
C	Average traffic delay	20-35 sec.
D	Long traffic delay	35-55 sec.
E	Very long traffic delay	55-80 sec.
F	Unacceptable delay	> 80 sec.

Source: *2016 HCM*

Table 7. Unsignalized Intersection LOS Criteria

LOS	Description	Control Delay for Critical Approach (seconds/vehicle)
A	Little or no delay	<= 10 sec.
B	Short traffic delay	10-15 sec.
C	Average traffic delay	15-25 sec.
D	Long traffic delay	25-35 sec.
E	Very long traffic delay	35-50 sec.
F	Unacceptable delay	> 50 sec.

Source: *2016 HCM*

LOS for signalized and unsignalized intersections is measured and evaluated differently. Although the LOS for both is based on the average control delay/vehicle, traffic signals utilize the average delay for all vehicles entering into an intersection. In contrast, unsignalized LOS is estimated by examining only the delay for the most congested approach. This method is utilized because only those approaches with a stop sign or other form of intersection control are forced to stop at an intersection. No delays are typically observed for the major movements at an unsignalized intersection.

Since LOS at an unsignalized intersection reflects operations on the critical approach only (instead of delays to all traffic), LOS E or even F are often observed at unsignalized intersection on major corridors. The presence of LOS E or F operations alone is not adequate reason for adding a signal. Instead a more thorough traffic warrants study including an analysis of traffic volumes and field conditions would be required before signalization would be recommended.

5.2 NC 12 Roundabout Analysis

The tie-in point of the eastern bridge termini with NC 12 was deemed a critical location because of the potential for negative traffic flow impacts on the proposed bridge. Consequently, multiple roundabout alternatives were tested at this location including variations in each of the approaches, realignment of NC 12 directly into the proposed bridge, and the use of bypass lanes. Signalized and Unsignalized Intersection Design and Research Aid (SIDRA) roundabout analysis software was utilized to estimate the future LOS and queuing at the roundabout.

It should be mentioned that roundabout capacity analysis approach is different than the signalized intersection analysis approach. Consequently, V/C ratios reported in the roundabout analysis cannot be compared to V/C ratios reported for signalized intersections. The differences are a result of how capacity is defined for each approach. In a roundabout configuration, approach capacity is dependent on available gaps within the circulating flow volume in front of the entry point. Therefore, two approaches with the same geometry can operate with two different capacities because of the presence of different circulating flows. Circulating flow volumes are determined based on the turning movement pattern.

5.2.1 Proposed Roundabout Layout

The proposed roundabout layout is shown in **Figure 3**. The primary features are:

- The preferred layout maintains NC 12 as the primary north-south route with the proposed bridge coming in at a 90-degree angle from the west.
- The eastbound approach from the proposed bridge requires two lanes – a shared left-right-turn lane and an exclusive right-turn lane. The two right-turn lanes feed directly to the two NC 12 southbound lanes. Note that this treatment will require widening of the eastern end of the Mid-Currituck Bridge to transition from two lanes to four lanes.
- The eastbound approach from the Mid-Currituck Bridge will need to transition higher speed bridge traffic into a lower speed roundabout. Recognizing that some vehicles may be crossing the bridge at speeds exceeding 55 mph and that the vehicles are traveling on a long, straight approach, safety enhancements should be strongly considered to warn the drivers of the lower speed movement. Potential enhancement tools could include warning signs, flashing lights, electronic message boards, rumble strips, or other strategies as determined in final design.
- The northbound approach requires two lanes – an exclusive left-turn lane and a shared left-through lane. The two left-turn lanes feed directly to the proposed bridge.
- The southbound approach also requires two lanes – an exclusive through lane and an exclusive right-turn lane. The exclusive right-turn lane feeds directly onto the proposed bridge and the through lane feeds directly to the NC 12 southbound lanes.

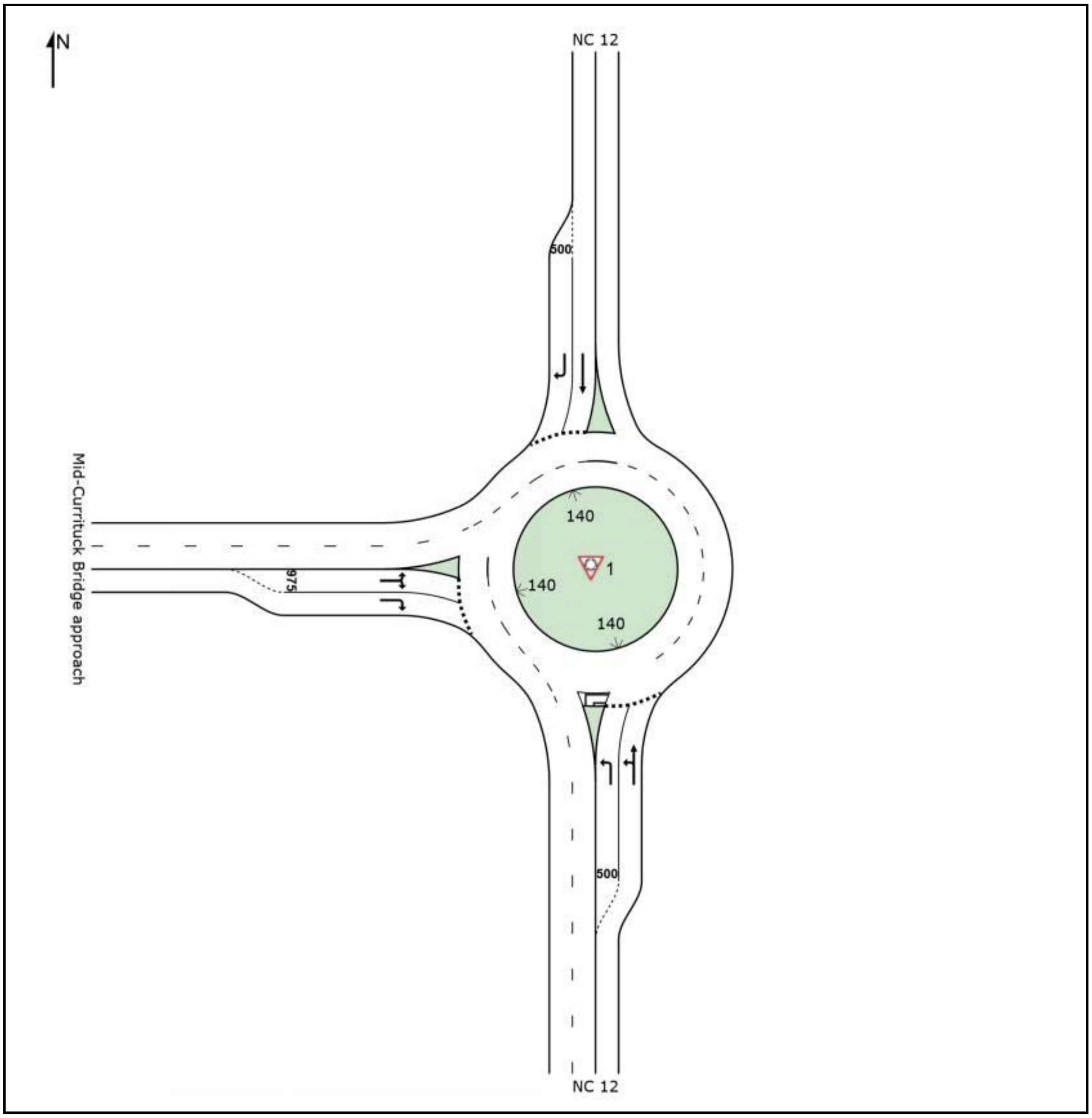


Figure 3. Proposed Roundabout at Mid-Currituck Bridge / NC 12 Intersection

5.2.2 Roundabout Capacity Analysis

A summary of the SIDRA analysis is provided in

Table 8 through **Table 11**. Primary findings of the SIDRA analysis are summarized below:

- The proposed multi-lane roundabout operates with an overall LOS A during both AM and PM peak hours on a Summer Weekday. All approaches operate at LOS B or better with the maximum queue reaching only 69 feet.

Table 8. NC 12 at Mid-Currituck Bridge Roundabout: 2040 Summer Weekday AM

Movement	Total Flow	Total Capacity	Degree of Saturation	Average Delay	LOS	95th Percentile Queue (vehicles)	95th Percentile Queue (feet)
Eastbound from Currituck Bridge							
Left	142	--	0.331	8.4	A	1.1	28
Right	388	--	0.331	8.3	A	1.1	28
Northbound from NC 12							
Left	249	--	0.260	6.4	A	1.1	28
Thru	467	--	0.487	9.7	A	2.7	69
Southbound from NC 12							
Thru	440	--	0.474	9.7	A	1.8	47
Right	87	--	0.095	4.8	A	0.3	6.5
All Vehicles							
	1,772		0.487	8.6	A	2.7	69

Table 9. NC 12 at Mid-Currituck Bridge Roundabout: 2040 Summer Weekday PM

Movement	Total Flow	Total Capacity	Degree of Saturation	Average Delay	LOS	95th Percentile Queue (vehicles)	95th Percentile Queue (feet)
Eastbound from Currituck Bridge							
Left	87	--	0.214	7.0	A	0.6	16
Right	249	--	0.214	6.9	A	0.6	16
Northbound from NC 12							
Left	388	--	0.382	7.6	A	1.9	49
Thru	440	--	0.434	8.4	A	2.3	59
Southbound from NC 12							
Thru	467	--	0.556	12.3	B	2.6	65
Right	142	--	0.173	6.1	A	0.5	13
All Vehicles							
	1,772		0.556	8.8	A	2.6	65

Table 10. NC 12 at Mid-Currituck Bridge Roundabout: 2040 Summer Weekend AM

Movement	Total Flow	Total Capacity	Degree of Saturation	Average Delay	LOS	95th Percentile Queue (vehicles)	95th Percentile Queue (feet)
Eastbound from Currituck Bridge							
Left	173	--	0.411	9.1	A	1.5	39
Right	539	--	0.411	9.1	A	1.5	39
Northbound from NC 12							
Left	779	--	.0563	11.6	B	3.4	87
Thru	267	--	0.563	11.6	B	3.4	87
Southbound from NC 12							
Thru	333	--	0.525	14.4	B	2.1	53
Right	313	--	0.513	14.5	B	2.1	53
All Vehicles							
	2,404		0.563	11.6	B	3.4	87

- During AM peak hours, the critical approaches for queuing are northbound and southbound NC 12. During the PM peak hours, the eastbound movement from the bridge is critical for queuing.
- In comparison, the proposed traffic signal with the Draft EIS alternatives operated at LOS B during Summer Weekday AM and PM peak hours and at LOS C or better during Summer Weekend AM and PM peak hours (from the *2035 Traffic Design Report*, March 2009 final revision).
- Although the proposed roundabout operates better than LOS C, it is not recommended that a fourth leg be added to the roundabout si*nce this could potentially* compromise future traffic flows on the bridge and would require land use restrictions on the fourth leg.

Table 11. NC 12 at Mid-Currituck Bridge Roundabout: 2040 Summer Weekend PM

Movement	Total Flow	Total Capacity	Degree of Saturation	Average Delay	LOS	95th Percentile Queue (veh)	95th Percentile Queue (feet)
Eastbound from Currituck Bridge							
Left	313	--	0.600	12.8	B	3.3	84
Right	779	--	0.600	12.7	B	3.3	84
Northbound from NC 12							
Left	539	--	0.542	12.3	B	3.2	82
Thru	333	--	0.542	12.3	B	3.2	82
Southbound from NC 12							
Thru	267	--	0.354	9.1	A	1.1	29
Right	173	--	0.236	7.6	A	0.7	18
All Vehicles							
	2,404		0.600	11.8	B	3.3	84

5.3 US 158 Intersection & Interchange Analysis

On the western limit of the Mid-Currituck Bridge, an interchange is proposed at the connection with US 158. The need for an interchange was evaluated taking into multiple considerations including both traffic operations along US 158 as well as toll plaza operations located approximately 1000 feet from US 158. The following section examines intersection operations along US 158 as well as the proposed interchange operations.

5.3.1 US 158 Intersection Analysis

US 158 in the vicinity of the proposed connection with the Mid-Currituck Bridge is a five-lane rural section with two unsignalized at-grade crossings. By 2040, the US 158 capacity analysis (Section 4.3) indicates that north of the proposed interchange the US 158 mainline will operate at LOS D on the Summer Weekday, but LOS F on the Summer Weekend with only four lanes. With the construction of a new bridge, operations south of the new bridge on the US 158 mainline will improve to LOS C on the Summer Weekday and to LOS E on the Summer Weekend. The improvement results from a diversion of traffic to the new bridge and away from the Wright Memorial Bridge. For this analysis it is assumed that US 158 is not widened.

Table 12 and **Table 13** summarize intersection operations at two unsignalized intersections on US 158. In addition, the tables examine traffic operations if a traffic signal were installed at US 158 (instead of an interchange). Note that on the west end of the bridge there is only one tie-in point and one set of analysis.

Table 12. 2040 Summer Weekday Intersection Operations on US 158

Int. #	Unsignalized Intersection	Movement	Summer Weekday 2040 AM		Summer Weekday 2040 PM		Comments
			Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	
US 158 (north to south)							
16	Waterlilly Rd & US 158	WB Total	80.5	F	81.3	F	Right in-right out provided based upon safety and LOS F capacity with conventional intersection.
14	**Mid-Currituck Bridge & US 158**	**Signalized**	**25.1**	**C**	**24.8**	**C**	**Interchange to be provided. Signal analysis provided for information only.**
15	Aydlett Rd & US 158	WB LT	38.9	E	47.9	E	US 158 through volumes restrict gaps.
		WB RT	11.9	B	12.9	B	
		SBL	9.8	A	11.0	B	

Notes: Signalized intersections are highlighted for emphasis.

Table 13. 2040 Summer Weekend Intersection Operations on US 158

Int. #	Unsignalized Intersection	Movement	Summer Weekend 2040 AM		Summer Weekend 2040 PM		Comments
			Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	
US 158 (north to south)							
16	Waterlilly Rd & US 158	WB Total	Err	F	Err	F	Right in-right out provided based upon safety and LOS F capacity with conventional intersection.
14	**Mid-Currituck Bridge & US 158**	**Signalized**	**35.9**	**D**	**100.6**	**F**	**Interchange to be provided to avoid LOS F at 2035 Summer Weekend.**
15	Aydlett Rd & US 158	WB LT	Err	F	Err	F	US 158 through volumes restrict gaps.
		WB RT	46.6	E	25.8	D	
		SBL	34.8	D	24.7	C	

Notes: Signalized intersections are highlighted for emphasis. "Err" indicates that the volume on specific movement greatly exceeds capacity and Synchro can't compute delay or queue length based on HCM methodology.

The primary findings include:

- Initial analysis indicated that both unsignalized intersections (Waterlilly Road and Aydlett Road) operate at LOS F in 2040 in both the Summer Weekday and Summer Weekend. For both intersections, the high level of delays occurs on the minor road approach to US 158. Note that the side road volumes are not particularly high (60 to 120 vehicles per hour). The primary issue is high volumes on US 158 resulting in too few gaps for vehicles to turn onto US 158.
- Based upon the initial capacity analysis and discussions with NCDOT, the Waterlilly Road intersection was modified to only provide right in-right out access. In addition to relieving congestion delays on Waterlilly Road, this treatment improves safety for the merging of traffic between US 158 northbound and the northbound ramp from the proposed Mid-Currituck Bridge interchange. Note that this adjustment will require traffic from Waterlilly Road to take a right, cross the Knapp Bridge, and U-turn back to go south on US 158. This action causes a diversion of over two miles.
- Based upon the initial capacity analysis and discussion with NCDOT, the Aydlett Road intersection was examined in greater detail including Synchro and SimTraffic analysis. Based upon this analysis, it is recommended that a separate left and right turn lane be provided on the Aydlett Road approach to US 158. Even with this improvement, the southbound left from US 158 is expected to operate at LOS F during the summer weekend although queuing would be less than 200 feet. In addition, widening the westbound approach still leaves westbound lefts at LOS F although westbound rights improve to LOS D or better on the summer weekday. On the summer weekend, both Aydlett Road approaches operate at LOS F.

5.3.2 US 158 Interchange Merge & Diverge Analysis

An interchange was provided at the junction of US 158 with the proposed Mid-Currituck Bridge. As part of the Alternatives analysis process, three interchange schemes were evaluated. Of these, one alternative (a traditional trumpet interchange) functioned well from a traffic perspective, but impacted wetlands with both interchange ramps and the toll plaza. A second alternative considered providing a half interchange with a signal on US 158, but this proposal had capacity issues with traffic operations on US 158.

The alternative decided upon was a modified Y-interchange providing continuous flow and merges for all movements between US 158 and the Mid Currituck Bridge. In addition, it allowed for a split toll collection plaza that would minimize wetland impacts. A sketch of the proposed interchange is provided in **Figure 4**.

For this interchange concept, HCS ramp junction analyses were performed for the on and off ramps associated with the interchange of US 158 at the Mid-Currituck Bridge. Although the US 158 mainline acts as the multilane highway due to the presence of at-grade intersections, it is considered to function as freeway in the vicinity of the interchange.

The LOS for ramp junctions is determined by the density of the segment and is measured on a scale of A through E. If the capacity of downstream freeway segment cannot accommodate the flow from the upstream merging area, LOS F is applied. **Table 14** provides the LOS criteria for merging and diverging areas.

Table 14. Ramp Merge and Diverge LOS Criteria and Results

LOS*	Density (veh/mi/ln)*
A	<=10
B	10 - 20
C	20 - 28
D	28 - 35
E	> 35
F	Demands exceeds Capacity

	AM Weekday		PM Weekday		AM Weekend		PM Weekend	
	Density (pc/mi/ln)	LOS	Density (pc/mi/ln)	LOS	Density (pc/mi/ln)	LOS	Density (pc/mi/ln)	LOS
US 158 NB Diverge	10.4	B	11.8	B	23.4	C	21.8	C
US 158 NB Merge	6.2	A	8.6	A	22.5	C	17.1	B
US 158 SB Diverge	7.9	A	5.2	A	17.2	B	23.3	C
US 158 SB Merge	10.2	B	9	A	19.3	B	22.3	C

*2016 HCM

5.4 Preferred Alternative Toll Plaza Analysis

The purpose of the analysis was to investigate future year toll plaza operations, for the year 2040 (Design Year) Summer Weekend and Weekday, AM and PM peak hour operations. Analysis looked at the traffic operations with the preferred alternative design of the toll plaza as well the interchange of US 158 and the Mid-Currituck Toll Bridge (henceforth referred to as the Toll Bridge) shown in **Figure 4**.

For this analysis, traffic operations through the interchange were simulated using the PTV VISSIM simulation modeling software (version 9.00-09). In addition to the interchange, the VISSIM models also included one intersection each on US 158 north and south of the interchange. The primary purpose of the simulation task was to determine the queue lengths that could be expected at the toll facility during the peak hour conditions in the year 2040 (design year).

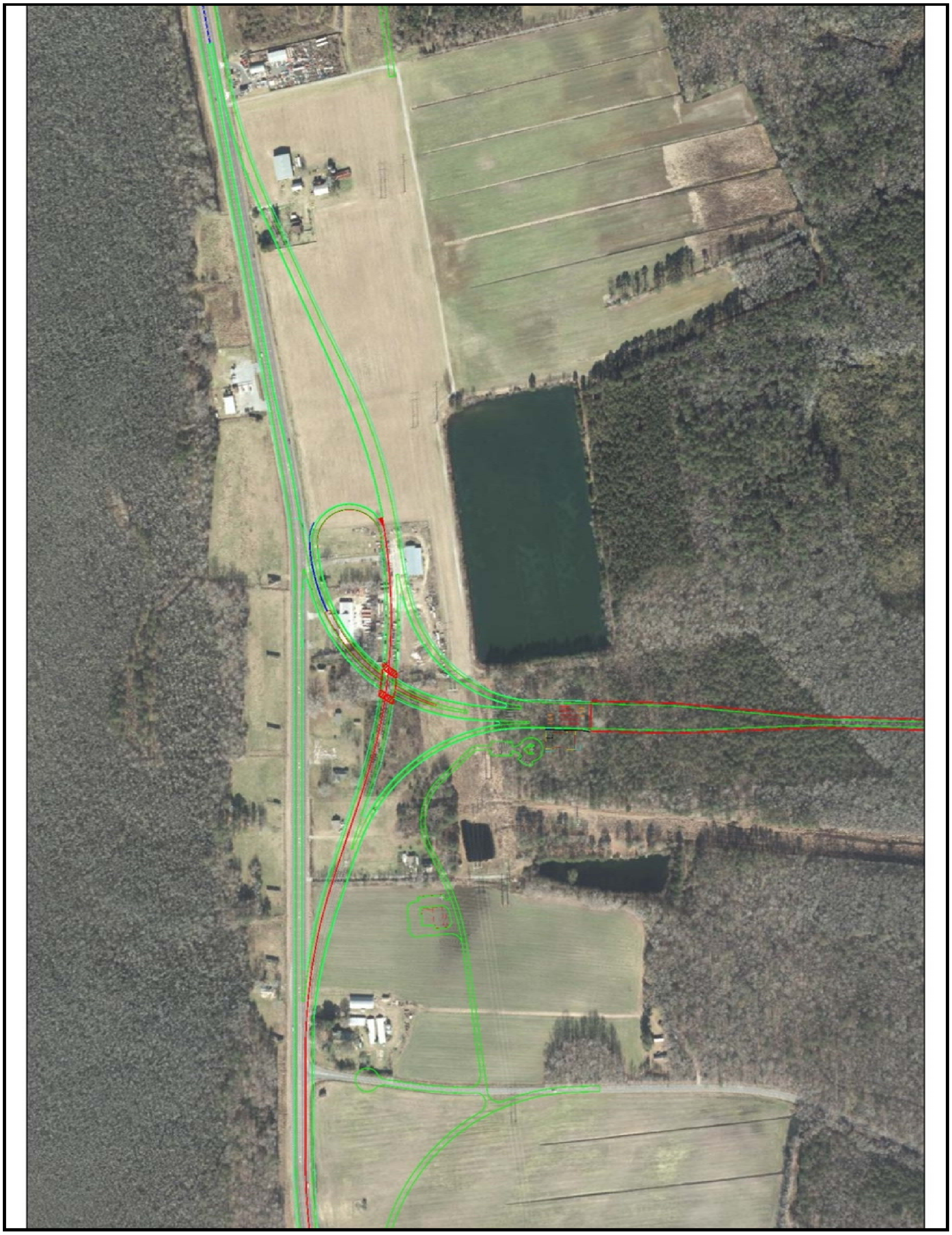


Figure 4. US 158 & Mid-Currituck Toll Bridge Interchange – VISSIM Screenshot

5.4.1 Traffic Demand Scenarios

Traffic demand was the key factor in determining the operation of the toll lanes along with the interchange design as laid out in the preferred alternative. The simulation models looked at multiple traffic volume scenarios for the design year – 2040 Summer Weekday and 2040 Summer Weekend. In each scenario, the AM and PM peak hour volumes were modeled. These volumes are shown below in **Figures 5** and **6**.

Summer weekend traffic is expected to be heavier than the summer weekday traffic demand. This is due to the fact that the Toll Bridge will provide access to the Outer Banks area and tourists typically have weekly rentals that begin and end on a weekend. Weekly rentals typically require tourists to vacate/check-out of the rentals in the mornings, i.e., AM peak sees heavier traffic existing the Outer Banks along the westbound Toll Bridge. Similarly, rental check-in typically begin in the afternoon period, i.e., PM peak sees heavier traffic flows in eastbound direction heading towards the Outer Banks.

As seen in **Figures 5** and **6**, there is also another pattern where the heavier traffic demand to and from the Toll Bridge is towards the north. A higher percentage of the eastbound Toll Bridge traffic flows come from southbound US 158 than northbound US 158. Similarly, a higher percentage of the westbound Toll Bridge traffic heads to northbound US 158 than to southbound US 158.

5.4.2 Toll Facility Operational Assumptions

The preferred alternative toll design (shown in **Figure 1**) includes six toll lanes, three toll lanes each in the eastbound and westbound directions. Of the three toll lanes in each direction, one is assumed to be designed for Electronic Toll Collection (ETC) and the remaining two will be for manual toll collection. The ETC lane is for use by vehicles equipped with special transponders that pay the toll electronically without the need to stop at a toll both. At the two manual lanes, vehicles will stop at the toll booth and pay a toll prior to proceeding.

In each direction, of the three toll lanes, the center lane is designated for ETC and two outer lanes (the ones nearest to the curb and the median) are designed for manual toll collection.

Of the total traffic demand to and from the Toll Bridge, 60 percent of the traffic is assumed to use a transponder in the year 2040. Accordingly, the peak hour traffic volumes were further divided among each of the three toll lanes.

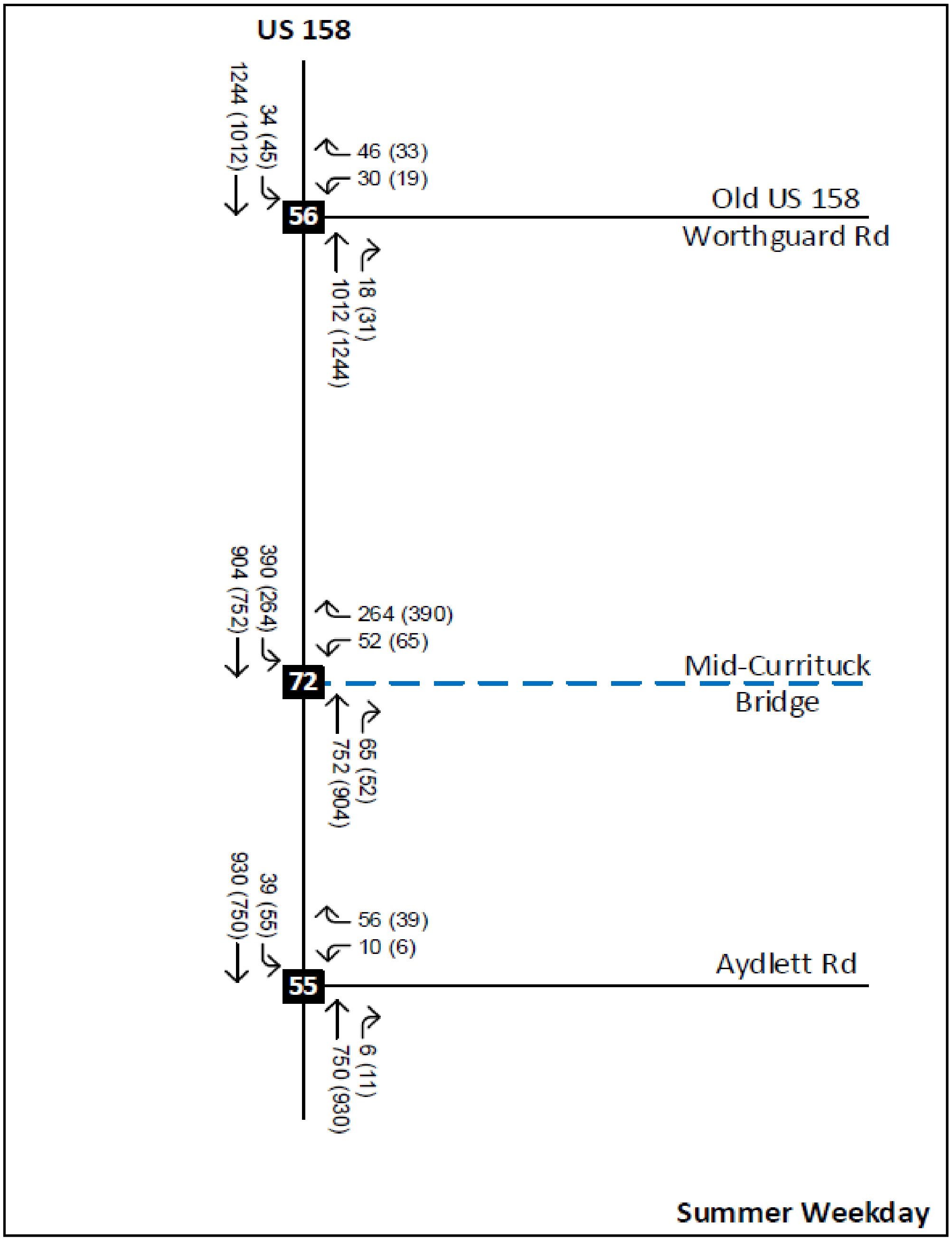


Figure 5: 2040 Summer Weekday AM (PM) Peak Hour Volumes

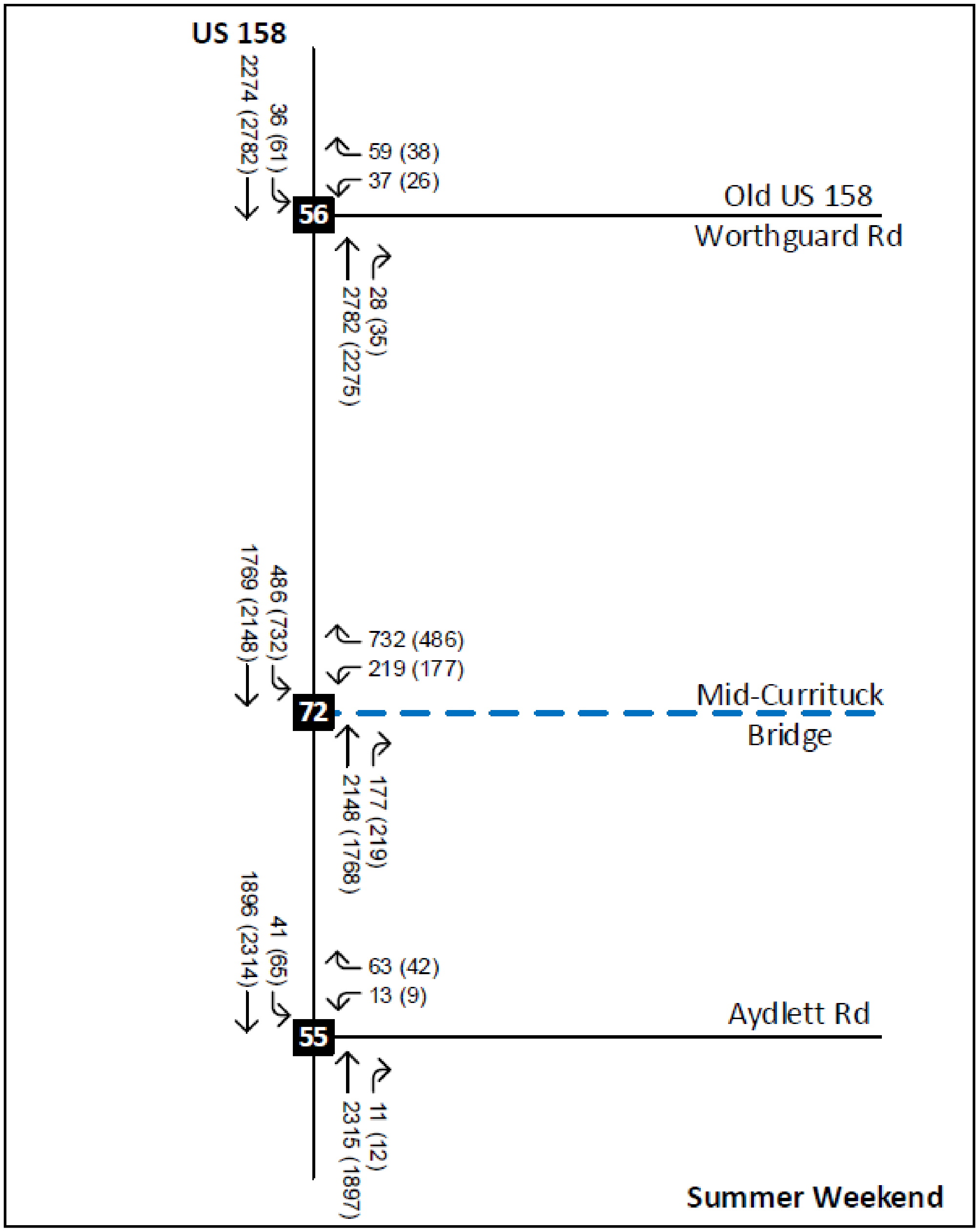


Figure 6: 2040 Summer Weekend AM (PM) Peak Hour Volumes

5.4.3 Simulation Analysis Results

Two different types of evaluations were looked at from VISSIM simulation model runs – queue length summaries and travel times.

For the queue length analysis, a queue counter was coded at each of the toll lanes, approximately at the STOP bar of the toll booth. Queues were continuously measured upstream of the queue counter location for average queues (average of queue lengths during each time interval of the simulation). A vehicle is considered part of a queue and counted in the queue length when it is traveling between 3.1 mph and 6.2 mph, as per VISSIM default definition.

The center ETC lane does not experience any queues as vehicles with electronic toll tags do not stop to pay tolls.

As shown in **Table 15**, during the weekday peak hours, queueing is minimal with no more than 4 vehicles in an average queue. The maximum queue during the weekday peak hour's simulation was seen in the AM peak hour with a maximum queue length of 314 feet (or 12 vehicles, at approximately 25 feet per queued vehicle) in the EB manual toll lane for the traffic from US 158 SB direction.

Table 15 VISSIM Queue Length Evaluation – 2040 Weekday Peak hour

No.	Toll Bridge - Direction & Type	2040 Build Weekday AM Peak Hour		2040 Build Weekday PM Peak Hour	
		Avg Queue (ft)	Max Queue (ft)	Avg Queue (ft)	Max Queue (ft)
1	EB Manual Lane 1 (from US 158 NB)	3.1	40.1	3.0	43.0
2	EB ETC	0.0	0.0	0.0	0.0
3	EB Manual Lane 2 (from US 158 SB)	81.5	314.2	20.0	83.7
4	WB Manual Lane 1 (to US 158 NB)	19.8	123.9	54.4	243.2
5	WB ETC	0.0	0.0	0.0	0.0
6	WB Manual Lane 2 (to US 158 SB)	2.4	60.6	3.1	57.3

Table 16 shows the results of the vehicle queuing analysis at the toll lanes in the Weekend peak hours. During the Weekend, the heaviest queuing in the eastbound direction is experienced in the PM peak hour while the heaviest queues in the westbound direction was seen in the AM peak hour, which is the reverse of the trend seen in the weekday peak hours. The larger queues at the toll-booths are also a reflection of the higher traffic flow direction in each peak hour. The longest queue under the 2040 Weekend conditions was 1,657 feet (approximately 66 vehicles) but the average queue did not exceed 28 vehicles.

Table 16 VISSIM Queue Length Evaluation – 2040 Weekend Peak hour

No.	Toll Bridge - Direction & Type	2040 Build Weekend AM Peak Hour		2040 Build Weekend PM Peak Hour	
		Avg Queue (ft)	Max Queue (ft)	Avg Queue (ft)	Max Queue (ft)
1	EB Manual Lane 1 (from US 158 NB)	41.7	182.7	713.5	1,657.2
2	EB ETC	0.0	0.0	0.0	0.0
3	EB Manual Lane 2 (from US 158 SB)	85.2	262.4	714.0	1,657.0
4	WB Manual Lane 1 (to US 158 NB)	586.9	1,657.2	281.0	776.9
5	WB ETC	0.0	0.0	0.0	0.0
6	WB Manual Lane 2 (to US 158 SB)	488.4	1,657.2	11.6	99.5

5.4.4 Toll Facility Operational Assumptions

VISSIM simulations of both the 2040 AM and PM worst case summer weekday and weekend scenarios were performed for the six-lane toll operation. This simulation included the latest geometric design of the preferred alternative interchange at the junction of US 158 and the Mid-Currituck Bridge. The purpose of the simulation was to determine operations and queuing at primarily the toll booth.

Key Assumptions of the analysis:

- By 2040, 60 percent of the drivers going through the toll booth will have transponders to use ETC.
- There will be a total of six (6) lanes in operation at all times with no reversible lanes. The simulation shows the middle lane in each direction as the ETC lane with the outside lanes being used as all-purpose lanes.
- If the vehicle did not have a transponder, it would approach the closest lane to the entrance of the toll facility.

Key findings from the simulation included:

- Preliminary analysis focused on identifying the design requirements for the proposed toll plaza. Based on the preliminary results, the decision was made by NCTA and Currituck Development Group to pursue a six-lane non-reversible toll plaza.
- The summer weekend period is critical for toll operations with the highest flows being in the westbound direction (away from the beach area) in the AM peak and in the eastbound direction in the mid-afternoon/PM peak (to the beach area).

Key Conclusions:

- The analyses were using the extremely conservative number of 60 percent of the users having transponders by 2040. With technology increase, that number will most likely be near 100 percent by 2040. All lanes will transition to ETC lanes over time.
- Drivers will have access to the toll operations building, from Aydlett Road, to purchase electronic tolling devices.
- There will be direct emergency access from the toll operations building to the roadway/bridge.
- Bicycles will not be allowed to cross through the toll booth. Other provisions will be made for bicycle access closer to the bridge.
- There may be a possible weave of vehicles before the toll booth eastbound, as drivers want to avoid the queue in the left all-purpose lane. Since the traffic from US 158 north-bound will be significantly less than traffic from US 158 south-bound, a stop condition (from US 158 north-bound to Mid-Currituck Bridge east-bound) will help the weave problem. This will also balance the vehicles using the two (2) all-purpose lanes and reduce queuing.
- The ETC lanes may be best suited to be placed in the leftmost lane eastbound and the rightmost lane westbound as those lanes will most likely have the heaviest flow of traffic.

6.0 Conclusions

The purpose of the *2040 Preferred Alternative Traffic Report* is to examine intersection operations to support the preliminary design process. The design forecast utilized the 2040 forecast as a basis for the peak hour analysis. The primary findings of the analysis are summarized in the following sections.

6.1 NC 12 Operations

- A dual-lane roundabout is proposed at the intersection of the Mid-Currituck Bridge and NC 12. Based upon simulation analysis of the Summer Weekend flows on NC 12, a four lane NC 12 will be constructed just south of the roundabout to contain queues.
- Along NC 12, the current roadways have multiple minor side roads with unsignalized intersections. Over half of these intersections operate at LOS F on the Summer Weekend. While traffic volumes are lower on the Summer Weekday, some intersections still operate at LOS F during this period also. The primary reason for poor operations is inadequate gaps in the NC 12 traffic stream, not excessively high side street volumes. The provision of right in-right out restrictions could be considered in the future.

6.2 US 158 Operations

- An interchange is proposed at the connection between US 158 and the Mid-Currituck Bridge. It is a trumpet interchange with direct movements to/from US 158 to minimize environmental effects. Merge/diverge are acceptable on the 2040 Summer Weekday and Weekend.
- The toll booth analyses were done using VISSIM with as assumption that cash collection will still be needed. This developed queues in both directions into the interchange eastbound and onto the bridge westbound. Here are the other conclusions associated with the tool booth operations:
    - The analyses were using the extremely conservative number of 60 percent of the users having transponders by 2040. With technology increase, that number will most likely be near 100 percent by 2040. All lanes will transition to ETC lanes over time.
    - Drivers will have access to the toll operations building, from Aydlett Road, to purchase electronic tolling devices.
    - There will be direct emergency access from the toll operations building to the roadway/bridge.
    - Bicycles will not be allowed to cross through the toll booth. Other provisions will be made for bicycle access closer to the bridge.
    - There may be a possible weave of vehicles before the toll booth eastbound, as drivers want to avoid the queue in the left all-purpose lane. Since the traffic from US 158 north-bound will be significantly less than traffic from US 158 south-bound, a stop condition (from US 158 north-bound to Mid-Currituck Bridge east-bound) will help the weave problem. This will also balance the vehicles using the two all-purpose lanes and reduce queuing.
    - The ETC lanes may be best suited to be placed in the leftmost lane eastbound and the rightmost lane westbound as those lanes will most likely have the heaviest flow of traffic.
- Approximately 1,000 feet north and south of the proposed interchange are existing unsignalized intersections. Due to high volumes on US 158, these unsignalized intersections are forecast to operate at LOS F by 2040. Due to high volumes on US 158 north of the bridge, the Waterlilly Road intersection will be converted to right in-right out operations. The Aydlett Road intersection is proposed to be shifted south from its current intersection to increase storage for southbound lefts. Note that with the 2040 volumes on US 158, it is likely that most unsignalized intersections on US 158 will operate at or near LOS F during the peak periods.

6.3 Mid-Currituck Bridge Operations

- The proposed bridge section will be a two-lane bridge. This section will provide LOS C on the 2040 Summer Weekday and LOS E operations on the 2040 Summer Weekend. The primary implication of LOS E is a reduced speed on the Summer Weekend. The bridge will be widened for transitions into the toll plaza and NC 12 at the west and east termini, respectively.
- A toll plaza will be located on the US 158 side of the proposed bridge to serve traffic in both directions. This was evaluated and here are the conclusions:
    - The analyses were using the extremely conservative number of 60 percent of the users having transponders by 2040. With technology increase, that number will most likely be near 100 percent by 2040. All lanes will transition to ETC lanes over time.
    - Drivers will have access to the toll operations building, from Aydlett Road, to purchase electronic tolling devices.
    - There will be direct emergency access from the toll operations building to the roadway/bridge.
    - Bicycles will not be allowed to cross through the toll booth. Other provisions will be made for bicycle access closer to the bridge.
    - There may be a possible weave of vehicles before the toll booth eastbound, as drivers want to avoid the queue in the left all-purpose lane. Since the traffic from US 158 north-bound will be significantly less than traffic from US 158 south-bound, a stop condition (from US 158 north-bound to Mid-Currituck Bridge east-bound) will help the weave problem. This will also balance the vehicles using the two all-purpose lanes and reduce queuing.
    - The ETC lanes may be best suited to be placed in the leftmost lane eastbound and the rightmost lane westbound as those lanes will most likely have the heaviest flow of traffic.

APPENDIX

Appendix A Volume Development

Appendix B Sidra Printouts – 2040 Design Year

- Appendix B1: 2040 Design Year Sidra Printout Weekday
- Appendix B2: 2040 Design Year Sidra Printout Weekend

Appendix C HCS Printouts – 2040 Design Year

- Appendix C1: 2040 Design Year HCS Weekday AM
- Appendix C2: 2040 Design Year HCS Weekday PM
- Appendix C3: 2040 Design Year HCS Weekend AM
- Appendix C4: 2040 Design Year HCS Weekend PM

APPENDIX A

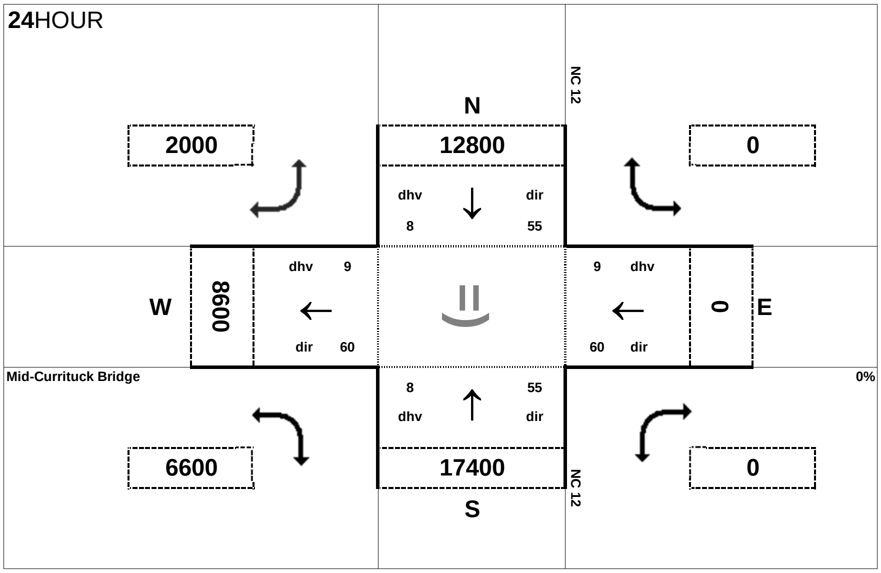
Volume Development

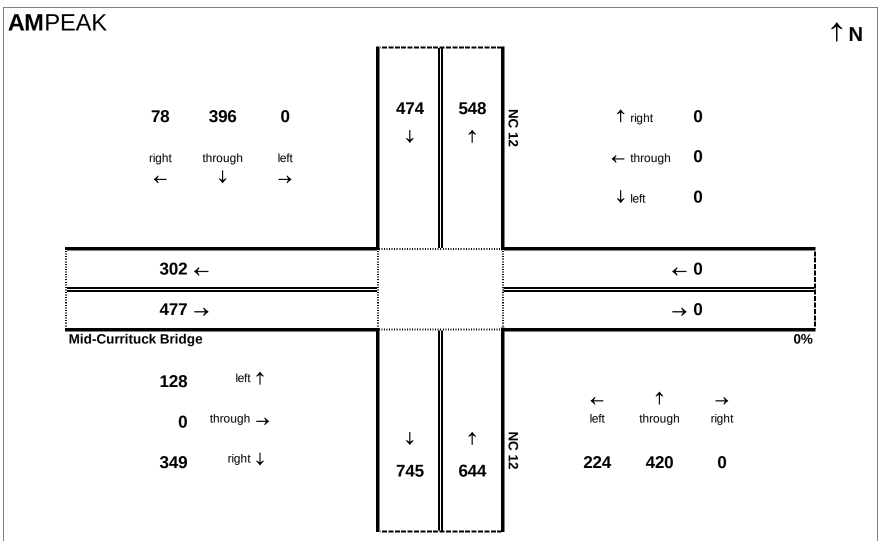
Peak Hour Volume Breakouts Report:
NC 12 and Mid-Currituck Bridge

Traffic Forecast Release Date:
June-16

Traffic Data Year:
7/1/2040

Project:
2040 Build Summer Weekday





AM peak hour inflow is 1595 vehicles. AM peak hour outflow is 1594 vehicles.

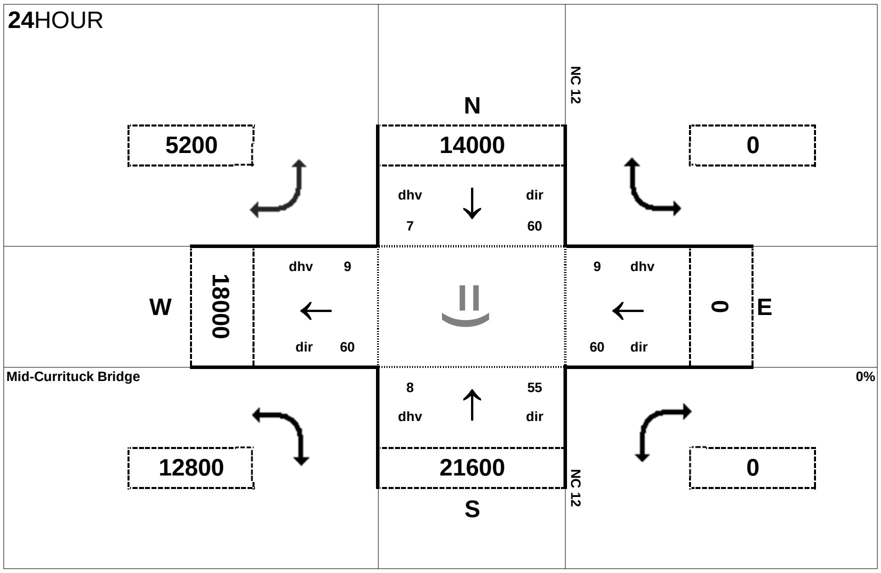
PM peak hour inflow is 1594 vehicles. PM peak hour outflow is 1595 vehicles.

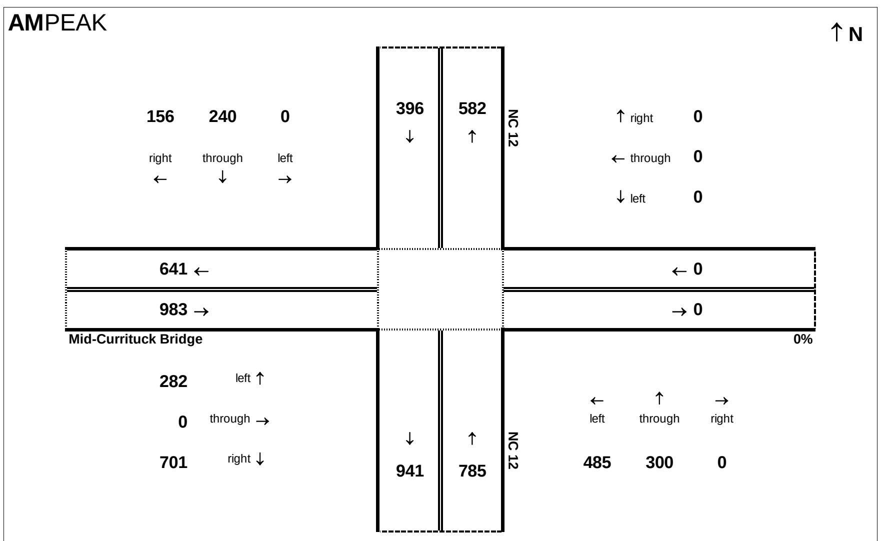
Peak Hour Volume Breakouts Report:
NC 12 and Mid-Currituck Bridge

Traffic Forecast Release Date:
June-16

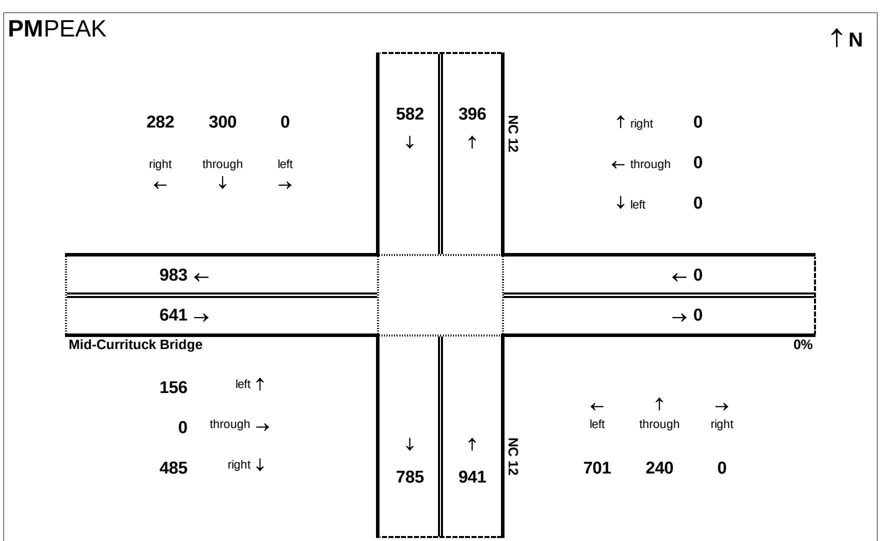
Traffic Data Year:
7/1/2040

Project:
2040 Build Summer Weekend





AM peak hour inflow is 2164 vehicles. AM peak hour outflow is 2164 vehicles.



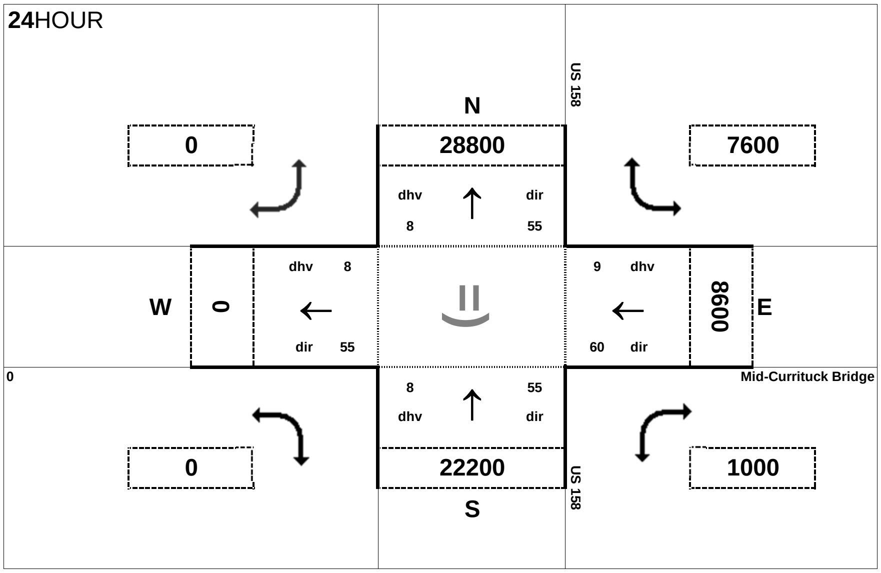
PM peak hour inflow is 2164 vehicles. PM peak hour outflow is 2164 vehicles.

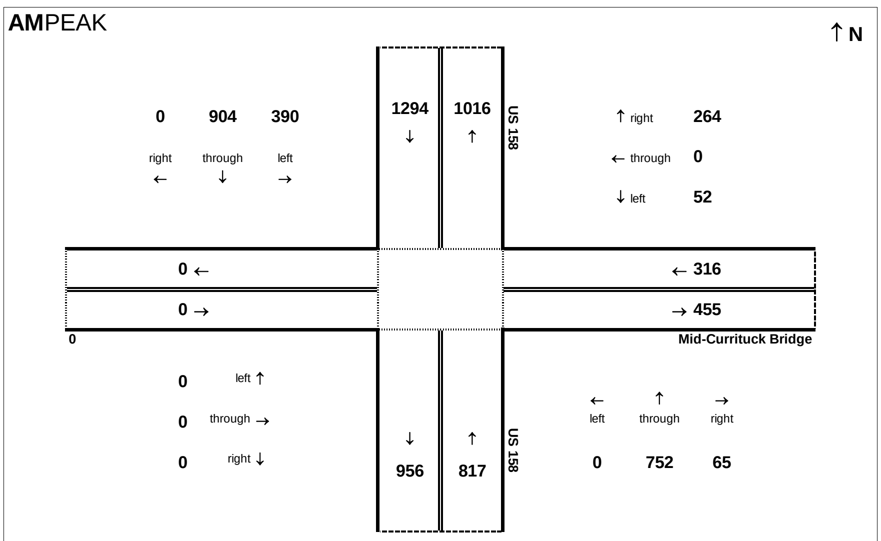
Peak Hour Volume Breakouts Report:
US 158 and Mid-Currituck Bridge

Traffic Forecast Release Date:
June-16

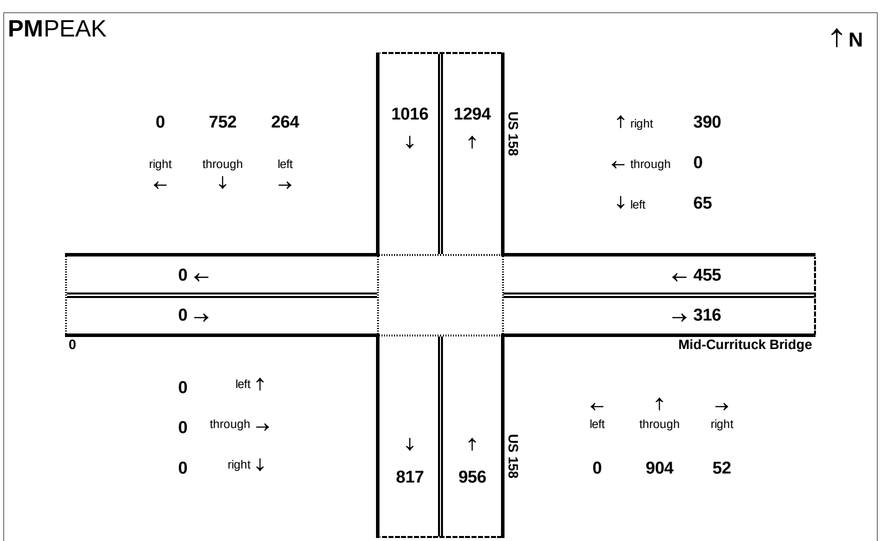
Traffic Data Year:
7/1/2040

Project:
2040 Build Summer Weekday





AM peak hour inflow is 2426 vehicles. AM peak hour outflow is 2427 vehicles.



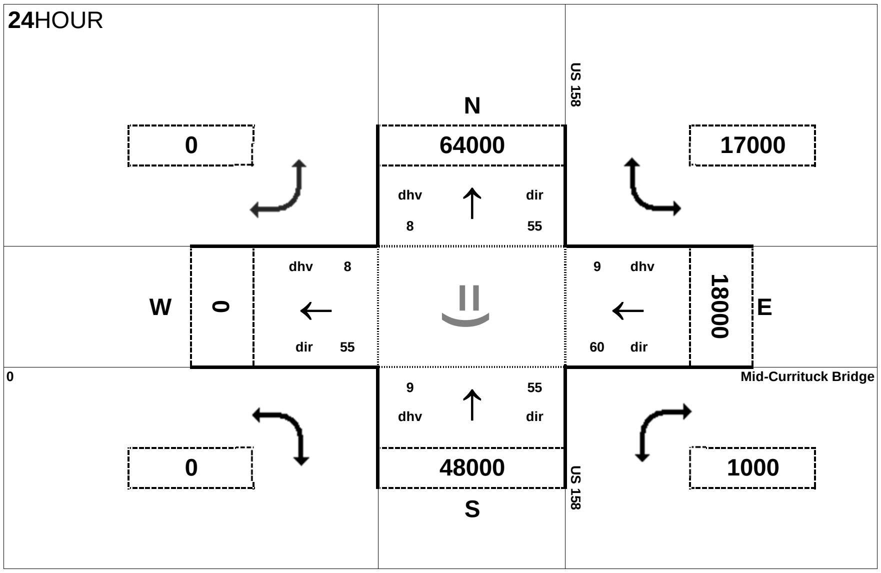
PM peak hour inflow is 2428 vehicles. PM peak hour outflow is 2426 vehicles.

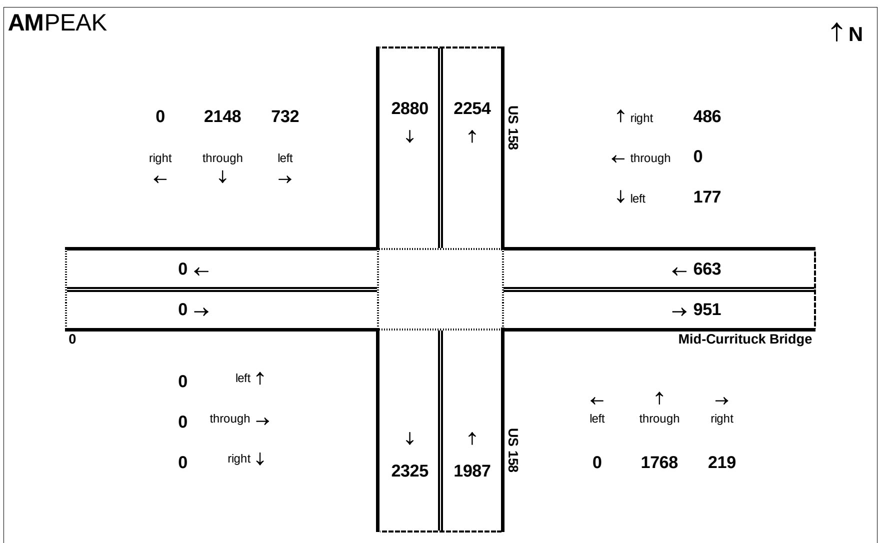
Peak Hour Volume Breakouts Report:
US 158 and Mid-Currituck Bridge

Traffic Forecast Release Date:
June-16

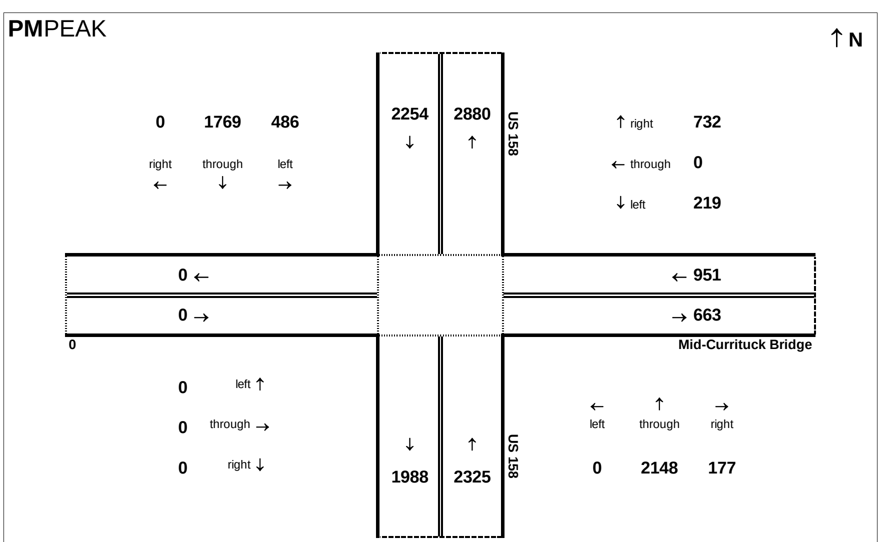
Traffic Data Year:
7/1/2040

Project:
2040 Build Summer Weekend





AM peak hour inflow is 5531 vehicles. AM peak hour outflow is 5530 vehicles.



PM peak hour inflow is 5530 vehicles. PM peak hour outflow is 5531 vehicles.

APPENDIX B

Sidra Printouts – 2040 Design Year

- Appendix B1: 2040 Design Year Sidra Printout Weekday
- Appendix B2: 2040 Design Year Sidra Printout Weekend

- Appendix B1: 2040 Design Year Sidra Printout Weekday

LANE LEVEL OF SERVICE

Lane Level of Service

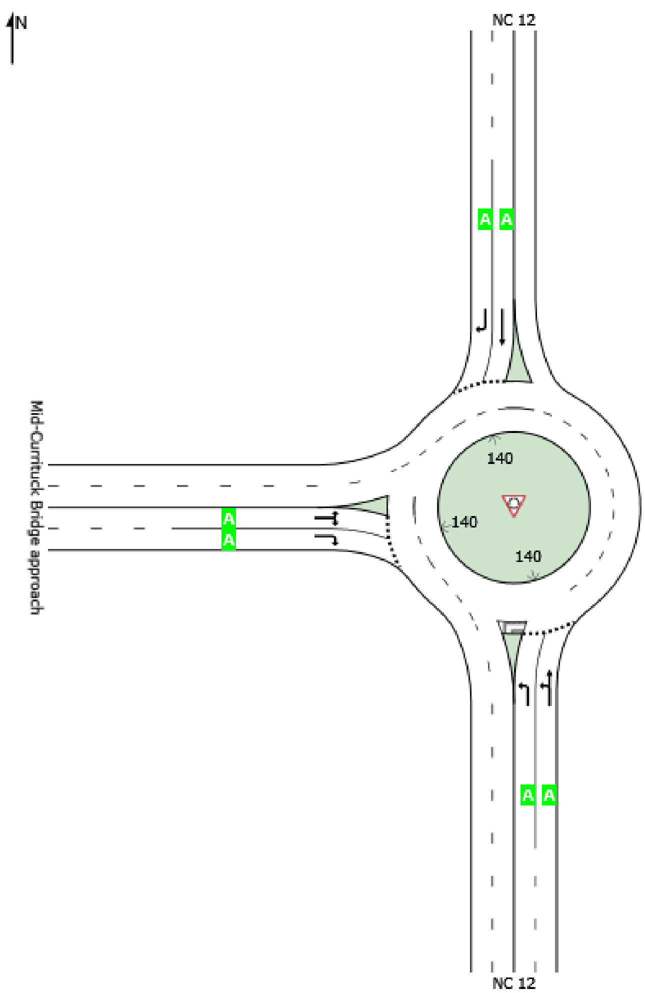
Site: 1 [NC 12 and MCB]

AM

NC 12 and Mid-Currituck Bridge
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	A	A	A	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

MOVEMENT SUMMARY

Site: 1 [NC 12 and MCB]

AM

NC 12 and Mid-Currituck Bridge
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NC 12											
3	L2	249	2.0	0.260	6.4	LOS A	1.1	27.7	0.31	0.20	30.4
8	T1	467	2.0	0.487	9.7	LOS A	2.7	69.0	0.42	0.29	31.1
Approach		716	2.0	0.487	8.5	LOS A	2.7	69.0	0.38	0.26	30.8
North: NC 12											
4	T1	440	2.0	0.474	9.7	LOS A	1.8	46.7	0.39	0.33	31.1
14	R2	87	2.0	0.095	4.8	LOS A	0.3	6.5	0.28	0.20	31.7
Approach		527	2.0	0.474	8.9	LOS A	1.8	46.7	0.38	0.31	31.2
West: Mid-Currituck Bridge approach											
5	L2	142	2.0	0.331	8.4	LOS A	1.1	27.6	0.45	0.45	30.6
12	R2	388	2.0	0.331	8.3	LOS A	1.1	27.6	0.44	0.43	29.8
Approach		530	2.0	0.331	8.4	LOS A	1.1	27.6	0.44	0.44	30.0
All Vehicles		1772	2.0	0.487	8.6	LOS A	2.7	69.0	0.40	0.33	30.7

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

LANE LEVEL OF SERVICE

Lane Level of Service

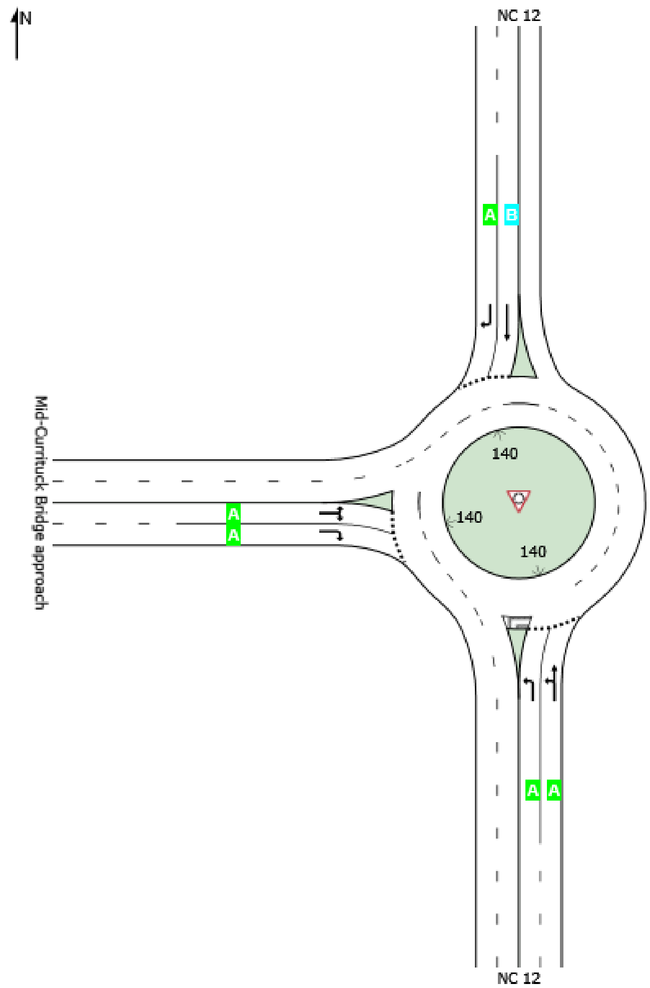
Site: 1 [NC 12 and MCB]

PM

NC 12 and Mid-Currituck Bridge
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	A	B	A	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

MOVEMENT SUMMARY

Site: 1 [NC 12 and MCB]

PM

NC 12 and Mid-Currituck Bridge
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NC 12											
3	L2	388	2.0	0.382	7.6	LOS A	1.9	48.6	0.28	0.16	29.9
8	T1	440	2.0	0.434	8.4	LOS A	2.3	59.3	0.30	0.17	31.6
Approach		828	2.0	0.434	8.1	LOS A	2.3	59.3	0.29	0.16	30.8
North: NC 12											
4	T1	467	2.0	0.556	12.3	LOS B	2.6	65.3	0.52	0.55	30.0
14	R2	142	2.0	0.173	6.1	LOS A	0.5	12.6	0.37	0.33	31.1
Approach		609	2.0	0.556	10.9	LOS B	2.6	65.3	0.49	0.50	30.3
West: Mid-Currituck Bridge approach											
5	L2	87	2.0	0.214	7.0	LOS A	0.6	16.1	0.42	0.40	31.2
12	R2	249	2.0	0.214	6.9	LOS A	0.6	16.1	0.40	0.39	30.4
Approach		336	2.0	0.214	6.9	LOS A	0.6	16.1	0.41	0.39	30.6
All Vehicles		1772	2.0	0.556	8.8	LOS A	2.6	65.3	0.38	0.32	30.6

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

- Appendix B2: 2040 Design Year Sidra Printout Weekend

LANE LEVEL OF SERVICE

Lane Level of Service

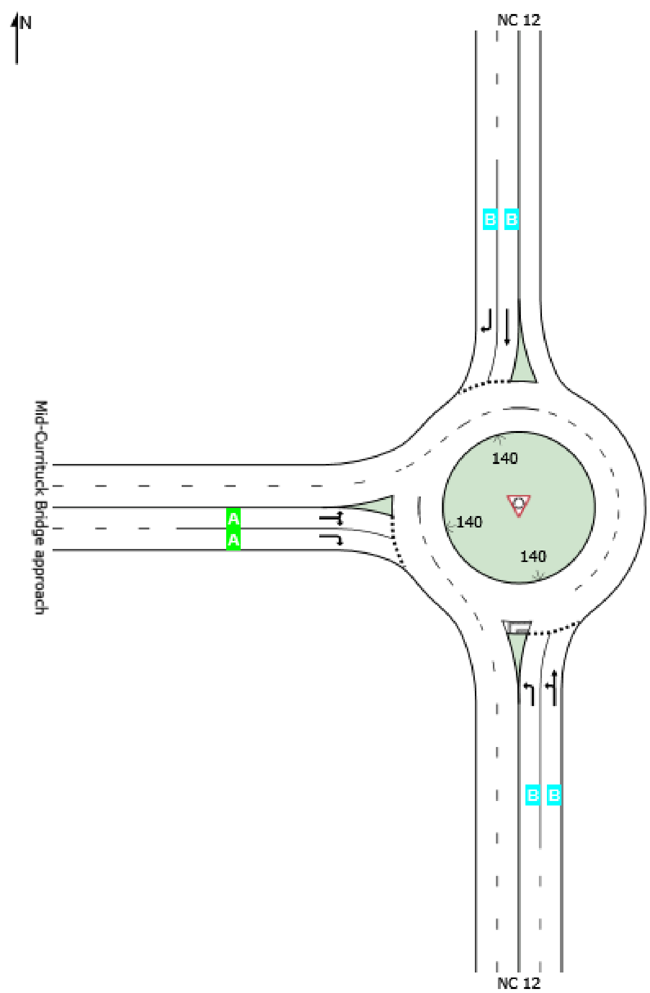
Site: 1 [NC 12 and MCB]

AM

NC 12 and Mid-Currituck Bridge
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	B	B	A	B



Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

MOVEMENT SUMMARY

Site: 1 [NC 12 and MCB]

AM

NC 12 and Mid-Currituck Bridge
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NC 12											
3	L2	779	2.0	0.563	11.6	LOS B	3.4	86.9	0.51	0.38	28.9
8	T1	267	2.0	0.563	11.6	LOS B	3.4	86.9	0.51	0.38	29.2
Approach		1046	2.0	0.563	11.6	LOS B	3.4	86.9	0.51	0.38	28.9
North: NC 12											
4	T1	333	2.0	0.525	14.4	LOS B	2.1	52.9	0.61	0.67	29.2
14	R2	313	2.0	0.513	14.5	LOS B	2.1	52.9	0.63	0.69	27.8
Approach		647	2.0	0.525	14.4	LOS B	2.1	52.9	0.62	0.68	28.6
West: Mid-Currituck Bridge approach											
5	L2	173	2.0	0.411	9.1	LOS A	1.5	38.5	0.44	0.40	30.4
12	R2	539	2.0	0.411	9.1	LOS A	1.5	38.5	0.42	0.39	29.5
Approach		712	2.0	0.411	9.1	LOS A	1.5	38.5	0.43	0.39	29.7
All Vehicles		2404	2.0	0.563	11.6	LOS B	3.4	86.9	0.51	0.46	29.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

LANE LEVEL OF SERVICE

Lane Level of Service

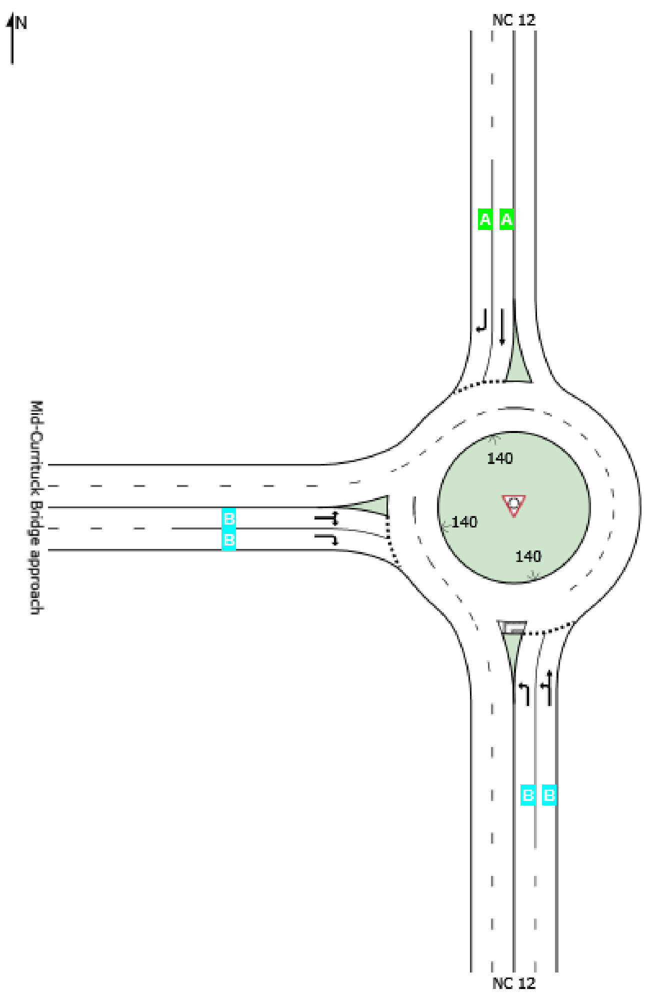
Site: 1 [NC 12 and MCB]

PM

NC 12 and Mid-Currituck Bridge
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	B	A	B	B



Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

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Project: \\USRAG100CIFS01\Jobs\Traffic\PROJECTS\20367 Currituck\TO 22 (2016 Cong Mgmt)\4. ANALYSIS\E. Sidra\2040 Build (MCB4)\New

MOVEMENT SUMMARY

Site: 1 [NC 12 and MCB]

PM

NC 12 and Mid-Currituck Bridge
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NC 12											
3	L2	539	2.0	0.542	12.3	LOS B	3.2	81.6	0.61	0.59	28.6
8	T1	333	2.0	0.542	12.3	LOS B	3.2	81.6	0.61	0.59	29.5
Approach		872	2.0	0.542	12.3	LOS B	3.2	81.6	0.61	0.59	28.9
North: NC 12											
4	T1	267	2.0	0.354	9.1	LOS A	1.1	28.9	0.47	0.48	31.3
14	R2	173	2.0	0.236	7.6	LOS A	0.7	17.9	0.45	0.45	30.5
Approach		440	2.0	0.354	8.5	LOS A	1.1	28.9	0.47	0.47	31.0
West: Mid-Currituck Bridge approach											
5	L2	313	2.0	0.600	12.8	LOS B	3.3	83.5	0.51	0.48	28.8
12	R2	779	2.0	0.600	12.7	LOS B	3.3	83.5	0.49	0.46	28.2
Approach		1092	2.0	0.600	12.7	LOS B	3.3	83.5	0.50	0.47	28.4
All Vehicles		2404	2.0	0.600	11.8	LOS B	3.3	83.5	0.53	0.51	29.0

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

APPENDIX C

HCS Printouts – 2040 Design Year

- Appendix C1: 2040 Design Year HCS Weekday AM
- Appendix C2: 2040 Design Year HCS Weekday PM
- Appendix C3: 2040 Design Year HCS Weekend AM
- Appendix C4: 2040 Design Year HCS Weekend PM

- Appendix C1: 2040 Design Year HCS Weekday AM

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday AM
Project Description	MCB PA - US 158 NB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	200
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	817	65
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	2.00	2.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.980	0.980
Flow Rate (v_i), pc/h	926	74
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.21	0.04

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	10.4
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.305
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	5000	Off-Ramp Influence Area Speed (S_R), mi/h	51.0
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	926	Ramp Junction Speed (S), mi/h	51.0
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	9.1
Level of Service (LOS)	B		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday AM
Project Description	MCB PA - US 158 NB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	1300
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	752	264
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	869	305
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.26	0.15

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	6.4
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.217
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	52.2
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	869	Ramp Junction Speed (S), mi/h	52.2
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	1174	Average Density (D), pc/mi/ln	11.2
Level of Service (LOS)	A		

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday AM
Project Description	MCB PA - US 158 SB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	2
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	1000
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	1294	390
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	1495	450
Capacity (c), pc/h	4500	4200
Volume-to-Capacity Ratio (v/c)	0.33	0.11

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	8.1
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.338
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	50.6
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	1495	Ramp Junction Speed (S), mi/h	50.6
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	14.8
Level of Service (LOS)	A		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday AM
Project Description	MCB PA - US 158 SB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	600
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	904	52
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	1044	60
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.25	0.03

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	10.4
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.279
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	51.4
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	1044	Ramp Junction Speed (S), mi/h	51.4
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	1104	Average Density (D), pc/mi/ln	10.7
Level of Service (LOS)	B		

- Appendix C2: 2040 Design Year HCS Weekday PM

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday PM
Project Description	MCB PA - US 158 NB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	200
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	956	52
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	1104	60
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.25	0.03

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	11.9
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.303
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	51.1
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	1104	Ramp Junction Speed (S), mi/h	51.1
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	10.8
Level of Service (LOS)	B		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday PM
Project Description	MCB PA - US 158 NB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	1300
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	904	390
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	1044	450
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.33	0.21

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	8.8
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.221
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	52.1
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	1044	Ramp Junction Speed (S), mi/h	52.1
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	1494	Average Density (D), pc/mi/ln	14.3
Level of Service (LOS)	A		

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday PM
Project Description	MCB PA - US 158 SB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	2
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	1000
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	1016	264
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	1173	305
Capacity (c), pc/h	4500	4200
Volume-to-Capacity Ratio (v/c)	0.26	0.07

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	5.3
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.325
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	50.8
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	1173	Ramp Junction Speed (S), mi/h	50.8
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	11.5
Level of Service (LOS)	A		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekday PM
Project Description	MCB PA - US 158 SB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	600
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	752	65
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	869	75
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.21	0.04

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	9.1
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.277
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	51.4
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	869	Ramp Junction Speed (S), mi/h	51.4
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	944	Average Density (D), pc/mi/ln	9.2
Level of Service (LOS)	A		

- Appendix C3: 2040 Design Year HCS Weekend AM

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend AM
Project Description	MCB PA - US 158 NB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	200
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	2148	177
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2481	204
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.55	0.10

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	23.8
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.316
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	50.9
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2481	Ramp Junction Speed (S), mi/h	50.9
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	24.4
Level of Service (LOS)	C		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend AM
Project Description	MCB PA - US 158 NB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	1300
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	2148	732
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2481	845
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.74	0.40

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	23.0
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.313
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	50.9
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2481	Ramp Junction Speed (S), mi/h	50.9
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	3326	Average Density (D), pc/mi/ln	32.7
Level of Service (LOS)	C		

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend AM
Project Description	MCB PA - US 158 SB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	2
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	1000
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	2254	486
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2603	561
Capacity (c), pc/h	4500	4200
Volume-to-Capacity Ratio (v/c)	0.58	0.13

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	17.6
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.348
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	50.5
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2603	Ramp Junction Speed (S), mi/h	50.5
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	25.8
Level of Service (LOS)	B		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend AM
Project Description	MCB PA - US 158 SB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	600
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	1769	219
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2043	253
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.51	0.12

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	19.6
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.306
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	51.0
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2043	Ramp Junction Speed (S), mi/h	51.0
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	2296	Average Density (D), pc/mi/ln	22.5
Level of Service (LOS)	B		

- Appendix C4: 2040 Design Year HCS Weekend PM

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend PM
Project Description	MCB PA - US 158 NB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	200
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	1987	219
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2295	253
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.51	0.12

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	22.2
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.321
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	50.8
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2295	Ramp Junction Speed (S), mi/h	50.8
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	22.6
Level of Service (LOS)	C		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend PM
Project Description	MCB PA - US 158 NB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	1300
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	1768	486
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2042	561
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.58	0.27

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	17.4
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.257
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	51.7
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2042	Ramp Junction Speed (S), mi/h	51.7
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	2603	Average Density (D), pc/mi/ln	25.2
Level of Service (LOS)	B		

HCS7 Freeway Diverge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend PM
Project Description	MCB PA - US 158 SB Diverge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	2
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Deceleration Length (L_D), ft	1500	1000
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	2880	732
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	3326	845
Capacity (c), pc/h	4500	4200
Volume-to-Capacity Ratio (v/c)	0.74	0.20

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	23.9
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (D_S)	0.374
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	Off-Ramp Influence Area Speed (S_R), mi/h	50.1
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FD})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	3326	Ramp Junction Speed (S), mi/h	50.1
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	-	Average Density (D), pc/mi/ln	33.2
Level of Service (LOS)	C		

HCS7 Freeway Merge Report

Project Information

Analyst		Date	
Agency		Analysis Year	2040
Jurisdiction		Time Period Analyzed	Summer Weekend PM
Project Description	MCB PA - US 158 SB Merge		

Geometric Data

	Freeway	Ramp
Number of Lanes (N)	2	1
Free-Flow Speed (FFS), mi/h	55.0	45.0
Segment Length (L) / Acceleration Length (L_A), ft	1500	600
Terrain Type	Level	Level
Percent Grade, %	-	-
Segment Type / Ramp Side	Freeway	Right

Adjustment Factors

Driver Population	All Familiar	All Familiar
Weather Type	Non-Severe Weather	Non-Severe Weather
Incident Type	No Incident	-
Final Speed Adjustment Factor (SAF)	1.000	1.000
Final Capacity Adjustment Factor (CAF)	1.000	1.000
Demand Adjustment Factor (DAF)	1.000	1.000

Demand and Capacity

Demand Volume (V_i), veh/h	2148	177
Peak Hour Factor (PHF)	0.90	0.90
Total Trucks, %	4.00	4.00
Single-Unit Trucks (SUT), %	-	-
Tractor-Trailers (TT), %	-	-
Heavy Vehicle Adjustment Factor (f_{HV})	0.962	0.962
Flow Rate (v_i), pc/h	2481	204
Capacity (c), pc/h	4500	2100
Volume-to-Capacity Ratio (v/c)	0.60	0.10

Speed and Density

Upstream Equilibrium Distance (L_{EQ}), ft	-	Density in Ramp Influence Area (D_R), pc/mi/ln	22.6
Distance to Upstream Ramp (L_{UP}), ft	-	Speed Index (M_S)	0.324
Downstream Equilibrium Distance (L_{EQ}), ft	-	Flow Outer Lanes (v_{OA}), pc/h/ln	-
Distance to Downstream Ramp (L_{DOWN}), ft	-	On-Ramp Influence Area Speed (S_R), mi/h	50.8
Prop. Freeway Vehicles in Lane 1 and 2 (P_{FM})	1.000	Outer Lanes Freeway Speed (S_O), mi/h	-
Flow in Lanes 1 and 2 (v_{12}), pc/h	2481	Ramp Junction Speed (S), mi/h	50.8
Flow Entering Ramp-Infl. Area (v_{R12}), pc/h	2685	Average Density (D), pc/mi/ln	26.4
Level of Service (LOS)	C		