Currituck Development Group

Mid-Currituck Bridge

Final Report Traffic and Revenue Forecasts

209783

Final | July 2011

ARUP

Contents

Tables

Figures

Appendices

Appendix E

Technical Memo #5 - Peak Season Traffic Survey Report

Appendix F

Technical Memo #6 - Shoulder-Peak Season Traffic Survey Report

Appendix G

Willingness to Pay Survey Report

Appendix H

Willingness to Pay Survey Independent Review

Appendix I

Demographic and Land Use Survey Report

Appendix J

Technical Memo #8 - Base Year Model Validation Report

Appendix K

Technical Memo #9 - Forecasting Methodology & Growth Models Report

Appendix L

Final Traffic and Revenue Forecasts

Executive Summary

North Carolina Turnpike Authority (NCTA) is authorized to study, plan, develop and undertake preliminary design work on the Mid-Currituck Bridge (MCB), a proposed toll facility in the Outer Banks. The Currituck Development Group (CDG) have entered into a Pre-Development Agreement (PDA) with NCTA to analyze, identify, plan, develop, design, construct, maintain, operate and finance the Mid-Currituck Bridge. Arup was commissioned by the Currituck Development Group (CDG) to develop the traffic and revenue forecast as part of the PDA, which is required to support the financing of the project.

The main findings of the study include:

- The proposed bridge is expected to attract approximately 1 million annual transactions in the opening year of 2015 and generate approximately $13 million revenue for the optimal toll scenario. These figures grow close to 2.5 million transactions and slightly over $30 million revenue by 2030.
- The toll rates estimated in the eastbound direction (towards the Outer Bank) from the toll optimization process are $14 for visitors and $10 for residents during peak season weekday (PM Peak). Toll rates reach the highest level during peak season weekend and are in the range of $9-$28.
- As expected, visitors account for over 73% of revenue annually and 82% during peak season. Over half of the annual revenue is expected to be generated during the three months of peak season.
- The proposed bridge provides significant time and distance savings for travel to Outer Banks. It saves approximately 37 miles for traffic going to the Corolla area and more than 2 hours travel time during peak season.

Project Description

The Mid-Currituck Bridge is located in northeastern North Carolina and would connect the Currituck County mainland to the Outer Banks of Currituck County. The bridge would provide a connection between the NC-12 and the US-158 close to Aydlett on the mainland and just south of Corolla on the Outer Banks, as shown in Figure ES1 below. A toll will be charged to cross the bridge.

The new bridge would have one lane in each direction and be connected to the US-158 on the mainland and the NC-12 on the Outer Banks. At the intersection with the NC-12 a roundabout will be provided. At the intersection of the US-158 and the bridge a free-flow interchange would be provided. The proposed toll plaza would be on the approach to the bridge from the US-158. It is also proposed that the NC-12 would be widened to four lanes along specific sections to the south of the intersection with the bridge (immediately to the south of intersection with the bridge, around the Food Lion and TimBuckII commercial areas and Currituck Clubhouse Drive).

The Outer Banks area currently has very limited road access. US-158 and NC-12 are the only means of north-south travel to the Outer Banks. There are two existing crossings south of the Virginia border; the Wright Memorial Bridge (around 32 miles south of the Virginia border) and the Washington Baum Bridge further south. Both of them are untolled facilities. The two existing crossings and the road access have shaped the current development in the Outer Banks. Most of

residents are located along US 158 south of the Wright Memorial Bridge (WMB). The US 158 in the Outer Banks is two-lanes in each direction and easy to drive, while NC-12 is winding and one lane in each direction for most part with turning lanes at some locations.

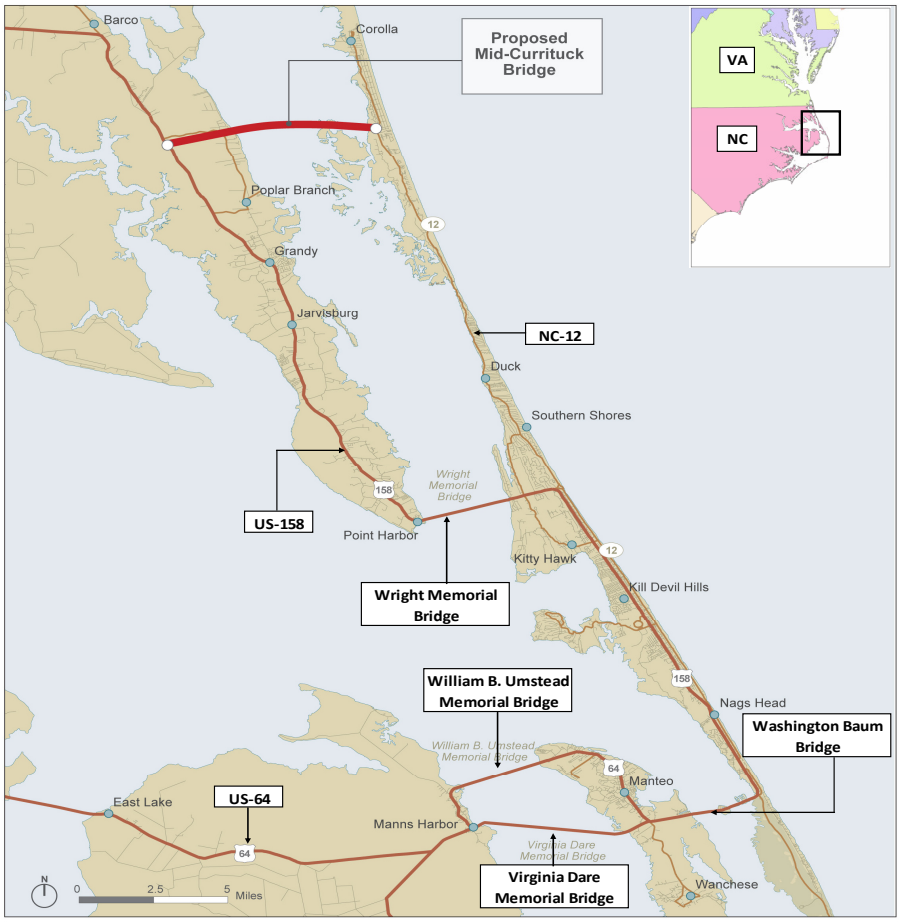


Figure ES1 Study Area of the Mid-Currituck Bridge

The access issue makes the growth and development of the Corolla area and further north very difficult. During summer weekend, heavy demand from Wright Memorial Bridge going to the northern Outer Banks frequently causes traffic back up and blocks the bridge even for traffic going to the south. It takes 1 hour 35 minutes to drive from the Wright Memorial Bridge to the Corolla area in the northern Outer Banks during the peak times on Saturday in the summer peak season and approximately 44 minutes during other uncongested time periods.

The new bridge provides significant distance and time savings for travel to communities on the northern Outer Banks. The bridge will provide a saving of up to 37 miles and over 2 hours time saving in the Peak Season. The proposed bridge offers an alternative to the currently congested route through Wright Memorial Bridge during summer and alleviates the congestion on Wright Memorial Bridge and improves the local residents' trips to the south. The new bridge could greatly facilitate the continued growth within the area, which are consistent with local land use and transportation plans. In the event of emergencies, the proposed bridge will also improve the evacuation time of the Outer Banks.

Study Overview

The study included the development of traffic and revenue forecasts based on a methodology that took into account the unique characteristics of the project area and potential market. A detailed study of these unique characteristics was undertaken as part of an extensive data collection and survey program commissioned by Arup for this project. Several existing sources provided valuable information on certain elements of the traffic profile within the study area, including historical traffic data, hourly, daily, monthly and seasonal traffic profile and local travel patterns derived from the Origin / Destination Mailback /Intercept Survey undertaken by WSA in 2006. In addition, four key primary data collection exercises were undertaken that include:

- Realtors Survey: used to understand existing historical visitor patterns to the Outer Banks, which was important given that visitors on vacations will be a key market segment for the bridge.
- Willingness to Pay Survey: used to develop specific Values of Time of potential bridge users.
- Traffic surveys: used to establish the existing traffic profile within the study area, including classified automatic traffic counts, turning movement manual classification counts (MCC) and journey time surveys; and
- Land-Use / Demographic surveys: used to collect project specific demographic and socio-economic land use data for the study area. This survey was undertaken by Delta Associates.

Three future year models of 2015, 2020 and 2030 were developed for the Mid-Currituck Bridge traffic and revenue forecasts. Future year traffic growth was based on the demographic and socio-economic forecasts produced as part of the demographic survey. The growth in the future year trip tables is shown in Table ES1 below.

The demographic forecasts indicated a 100% increase in the number of rental bedrooms in the Outer Banks in the period 2009 – 2040. This was based on the growth forecasts for the seasonal peak population and the development capacity of the Outer Banks. The seasonal population forecasts were driven by growth in the national economy in the form of GDP growth, on the basis that a better performing economy leads to an increase in the number of vacationers. The base case forecasts for GDP growth were a 1.95% per annum increase in GDP and 2.35% per annum increase in GRP for the period of 2009 – 2040. A 1.9% per annum increase in the employment was also forecast.

Table ES1 Forecast Future Year Growth in Trip Tables

Period	Peak Weekday	Peak Saturday	Peak Sunday	Shoulder Peak Weekday	Shoulder Peak Weekend
2009 – 2015	2.43%	2.44%	2.33%	2.94%	3.0%
2015 – 2020	3.23%	2.97%	2.94%	3.32%	3.2%
2020 - 2030	1.85%	1.85%	1.68%	1.92%	1.83%

Traffic and Revenue Forecast

The traffic and revenue forecast was developed with toll optimization based on the willingness-to-pay analysis and distance and time savings. A preliminary Frequent User Policy scenario was also evaluated.

Optimal Toll Scenario

A toll scenario was developed based on the Optimal Tolls for each user type / time period / direction outputs from the toll optimization process. The maximum toll rate in the Optimal Toll scenario occurred on a Peak Season Saturday in PM Period in the eastbound direction (towards the Outer Banks). This toll rate was applied to visitors making start / end vacation trips, and was $28. The lowest toll rates in this scenario were on a Peak Season Weekday in the PM Period for the residents segment, this was $4. The toll rates for the Optimal Toll Scenario are shown in Table ES2.

Table ES2 Optimal Toll Scenario Toll Rates

Time Period			Toll ($) – Car, 2009 US$			
			Westbound		Eastbound	
			Visitors	Residents	Visitors	Residents
			(Business, Vacation, Other)	(Business, Commute, Other)	(Business, Vacation, Other)	(Business, Commute, Other)
Daytime - Peak	Weekday	AM	12	6	11	7
		MD	15	12	12	4
		PM	11	9	14	10
	Sat	AM	14	9	14	9
		MD	16	14	24	13
		PM	11	10	28	17
	Sun	AM	13	6	13	9
		MD	15	12	18	9
		PM	11	11	14	8
Daytime - Shoulder-Peak	Weekday	AM	11	8	12	14
		MD	13	6	15	8
		PM	10	7	8	7
	Weekend	AM	13	9	9	7
		MD	14	6	16	9
		PM	11	5	13	5

The 2015 forecast models show that inbound to the Outer Banks via the Mid-Currituck Bridge have significant journey time savings in the PM time period on a Saturday in the Peak Season. For example, trips to Corolla save 142 minutes if undertaken via the Mid-Currituck Bridge rather than the Wright Memorial Bridge. This is because the route via the Mid-Currituck Bridge avoids the severe levels of congestion that occur at the Wright Memorial Bridge during this period. There are time savings for trips to all locations on the Outer Banks north of Southern

Shores, even trips to Southern Shores gain a 57 minutes time saving, although the distance saving is only 4 miles. This demonstrates that the Mid-Currituck Bridge will provide significant benefits in terms of journey time to users who want to access the Outer Banks at the weekend during the Peak Season.

The market segmentation of the trips potentially using the Mid-Currituck Bridge indicated that differing levels of capture would occur in terms of trips transferring to the bridge. For example the forecasts indicate that for visitor vacation trips (those at the start and end of a vacation) occurring on a Peak Weekend, there would be a capture rate of 99% for some origin / destination pairings (e.g. between Norfolk and Corolla). This is because for this trip the new bridge provides a very significant journey time saving of 2 hours and 22 minutes (given the very high level of congestion) and a distance saving of 37 miles.

Commuters (e.g. cleaning crew) travelling between Elizabeth City and Sanderling on a Sunday in the AM Peak in the Peak Season the capture rate is only 46%. This is because the time saving is much lower due to lower level of congestion in this period, and also this market segment has a lower value of time compared with the visitor vacation market segment. Annual transactions and revenue for the Mid-Currituck Bridge for the Optimal Toll Scenario are shown below in Tables ES3.

Table ES3 MCB Annual Transaction and Revenue Forecast

Year	Annual Transactions	Annual Revenue (2010 $)
2015	1,023,006	$13,236,264
2020	1,755,735	$22,149,039
2030	2,474,699	$31,121,583

The forecast average Mid-Currituck Bridge daily traffic volumes for the Peak Season are shown below in Table ES4. Traffic volumes are greatest on Peak Saturdays, with traffic volumes 200% higher than Peak Weekdays in 2015. In 2030, Peak Saturday volumes are 158% higher than Peak Weekdays. Strong growth is observed between 2015 and 2020 due to the ramp-up assumptions, although transactions continue to grow at a faster rate than the Wright Memorial Bridge traffic volumes beyond 2020 due to the real growth in values of time, increased congestion and induced traffic.

Table ES4 MCB Peak Season Forecast Daily Transactions

Year	Peak Weekday	Peak Saturday	Peak Sunday
2015	3,671	11,424	6,337
2020	6,413	17,674	9,399
2030	9,361	24,176	14,990
CAGR 2015 – 2020*	11.80%	9.12%	8.20%
CAGR 2020 – 2030	3.85%	3.18%	4.78%

**Note: growth between 2015 and 2020 includes the effect of ramp up*

In 2015 the Mid-Currituck Bridge captures 21% of all trips crossing between the Currituck Peninsula and the Outer Banks on a Saturday in the Peak Season. In terms of trips known as 'in-scope' (those crossing to the northern Outer Banks) the Mid-Currituck Bridge captures 61% of all trips. As Table ES5 below shows

the importance of visitors in terms of revenue and therefore the project presents a unique marketing opportunity to leverage the existing Outer Banks travel/tourism industry with tailored marketing strategies, with 82% of forecast Mid-Currituck Bridge revenues from visitors to the area in the Peak Season, 77% in the Shoulder Peak Season and 58% in the Off Peak Season.

Table ES5 Proportion of MCB Revenue by User Type

2015 – Optimal Toll Scenario	% Revenue from Visitors	% Revenue from Residents	% Revenue from Trucks	Total	% Revenue by Season
Peak	82%	15%	3%	100%	52%
Shoulder Peak	77%	18%	5%	100%	17%
Off Peak	58%	39%	3%	100%	31%

Preliminary Frequent User Policy Scenario

A preliminary Frequent User Policy Scenario was explored at the request of NCTA in this analysis. The NCTA framework for such a policy is to assist regular commuters, particularly those making home to work trips and trip to /from services and supplier business on the Outer Banks, to enjoy travel time savings provided by the Mid-Currituck Bridge at an affordable cost. To participate in such a program a commuter or frequent user would be required to purchase a transponder and open a pre-funded account with the Mid-Currituck Bridge operator.

For the purpose of testing such a policy, the toll rate for commuters is fixed at $3 per crossing trip. A second category was a “frequent user” whose business or personal use of the Mid-Currituck Bridge would, in the normal course, be less than the commuter frequency, but greater than that of infrequent users. Frequent users would pay a reduced toll, but not reduced as much as the toll for commuters. Regardless of frequency of use, all participants would pay posted tolls during peak periods in the peak season. In comparison with the Optimal Toll, total revenue was lower in the Preliminary Frequent User Policy Scenario due to lower level of tolls compared with the Optimal Toll Scenario. This was around -9% in 2014 and -12% in 2030.

Summary

This comprehensive Traffic and Revenue study builds on the extensive data collected in previous studies and also as part of this project that included extensive traffic count, journey time survey, origin-destination travel pattern survey, realtor survey and willingness-to-pay surveys to establish the unique characteristics of the project area and potential market.

These data were incorporated in the state-of-the-art travel forecasting developed for this project, which is well calibrated to represent these unique characteristics of the proposed new bridge and study area.

Detailed socioeconomic analysis of the Outer Banks and the potential visitor markets were performed, to understand the existing historical visitor patterns to the Outer Banks, which was important given that visitors on vacations will be a key market segment for the bridge.

An extensive toll rate optimization was conducted in order to estimate a reasonable toll schedule. This was undertaken to optimize the toll rates for each of the 15 model time periods in order to identify the revenue maximizing toll rate (for each time period, residency type and direction of travel).

The forecast results were thoroughly analyzed and comprehensive QA/QC process was applied to ensure the reasonable and robust traffic and revenue estimate.

In summary, the study has developed traffic and revenue forecasts that represent the unique characteristics of the project area and potential market for the bridge. This provides a solid foundation for the production of the forecasts, which have the ability to support the financing of the Mid-Currituck Bridge project to a level which would be acceptable to the United States Department of Transportation (USDOT) in connection with their approval prior to TIFIA (Transportation Infrastructure Finance and Innovation Act) loans and to bond rating agencies.

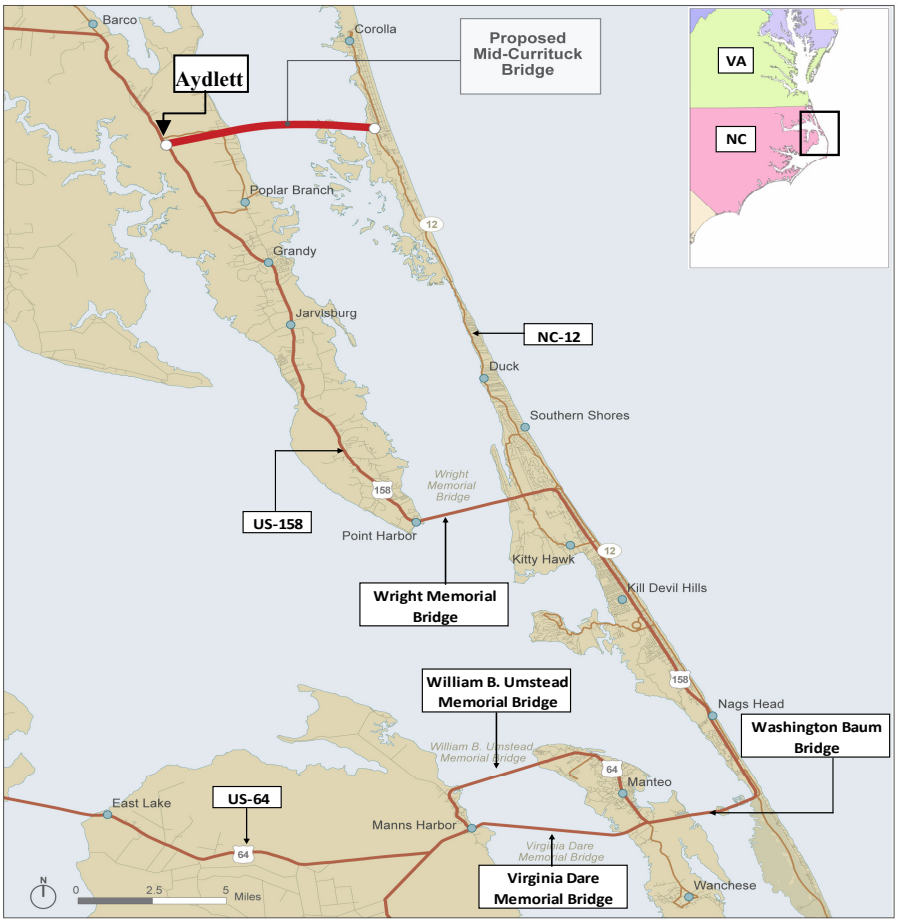
1 Introduction

1.1 Project Description

The North Carolina Turnpike Authority (NCTA) is authorized to study, plan, develop and undertake preliminary design work on the Mid-Currituck Bridge (MCB), a proposed toll facility in the Outer Banks. The Currituck Development Group (CDG) have entered into a Pre-Development Agreement (PDA) with NCTA to analyze, identify, plan, develop, design, construct, maintain, operate and finance the Mid-Currituck Bridge.

The Mid-Currituck Bridge is located in northeastern NC and would connect the Currituck County mainland, to Currituck County on the Outer Banks (see Figure 1). The bridge would provide a connection between the NC-12 and the US-158 close to Aydlett on the mainland and just south of Corolla on the Outer Banks.

Figure 1: Study Area



The Mid-Currituck Bridge would offer one lane in each direction and be connected to the US-158 on the mainland and the NC-12 on the Outer Banks. At the intersection with the NC-12 a roundabout will be provided. At the intersection of the US-158 and the bridge a free-flow interchange would be provided. The proposed toll plaza would be on the approach to the bridge from the US-158. It is also proposed that the NC-12 would be widened to four lanes along specific sections to the south of the intersection with the bridge (immediately to the south

of intersection with the bridge, around the Food Lion and TimBuckII commercial areas and Currituck Clubhouse Drive).

The Outer Banks is a 200-mile (320-km) long string of narrow barrier islands off the coast of North Carolina. They cover approximately half the northern North Carolina coastline, separating the Albemarle Sound and Pamlico Sound from the Atlantic Ocean. The majority of the Outer Banks island communities, from Corolla to Nags Head, are prime summer vacation destinations. There are two existing crossings south of the Virginia border; the Wright Memorial Bridge (around 32 miles south of the Virginia border) and the Washington Baum Bridge further south. Both crossings are untolled facilities.

1.2 Arup's Role

Arup was commissioned by the Currituck Development Group (CDG) to develop traffic and revenue forecasts as part of the PDA between CDG and NCTA. This included traffic and revenue forecasts which would be required to support the financing of the Mid-Currituck Bridge project to a level which would be acceptable to the United States Department of Transportation (USDOT) in connection with their approval prior to TIFIA (Transportation Infrastructure Finance and Innovation Act) loans and to bond rating agencies. This included the development of traffic and revenue forecasts based on a methodology that took into account the unique characteristics of the project area and potential market. A detailed study of these unique characteristics was undertaken as part of a significant data collection and survey program commissioned by Arup for the project. This data collection and survey program included:

- Realtors Survey: used to understand existing and historical visitor patterns to the Outer Banks, which was of key importance given that visitors on vacations will be a key market segment for the bridge;
- Willingness To Pay survey: used to develop specific Values of Time of potential bridge users
- Traffic Surveys: used to establish the existing traffic profile within the study area, including traffic counts and journey time surveys, and
- Land Use and Demographic surveys: used to collect and forecast project specific demographic and socio-economic land use data for the study area.

For each of these surveys a specialist survey contractor was identified by Arup and commissioned to undertake each survey.

Outputs from all the surveys were analyzed and incorporated into the methodology used to develop the traffic and revenue forecasts. The traffic and revenue forecasts were produced for a 50 year horizon for each market segment.

1.3 The Need for the Project

The proposed Mid-Currituck Bridge involves the construction of approximately seven miles of new road from US-158 on mainland Currituck County, to NC-12 on the Outer Banks (Figure 1). A toll would be charged to all users of the new bridge. The bridge will provide one lane in each direction, together with a 10 foot shoulder. This compares with the existing Wright Memorial Bridge Crossing,

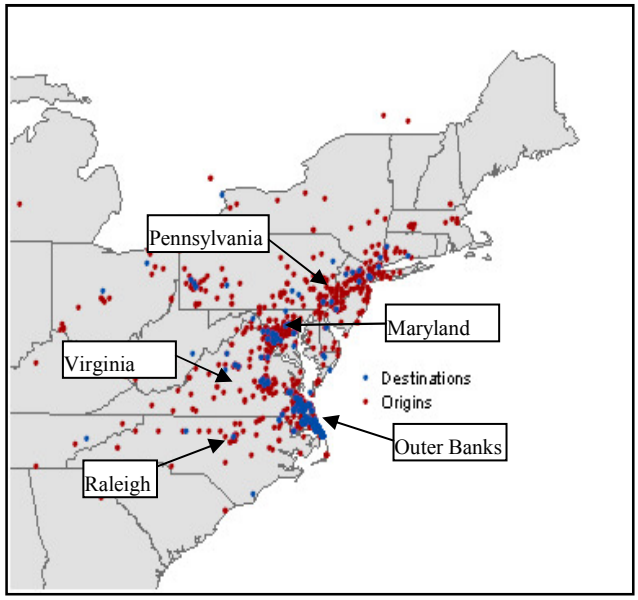
which is two lanes in each direction, but only with a 6 foot shoulder. The design speed of the new bridge will be 60mph. The existing route on the mainland is the US-158, which is a two lane per direction road with a speed limit ranging from 30-55mph. The NC-12 which runs north / south on the Outer Banks is one lane in each direction with a speed limit of between 25 and 45 mph. The route runs through the built up areas of Duck, Sanderling and Corolla. At these locations there is direct access on to the route from residences and local business/commercial establishments. The NC-12 will also be improved in the vicinity of the Mid-Currituck Bridge as part of the project.

The Outer Banks area currently has very limited road access. US-158 and NC-12 are the only means of north-south travel to the Outer Banks. The new bridge will reduce the distance travelled to communities on the Outer Banks by up to 37 miles and in the Peak Season reduce travel time by up to two hours and twenty minutes. It will also improve the evacuation time of the Outer Banks in the event of an emergency.

In the summer, the Outer Banks become heavily congested and the proposed bridge offers an alternative to the currently congested route while facilitating continued growth within the area. The Outer Banks attracts millions of vacationers throughout the year and significant growth has been observed in recent years. Traffic within the area is highly seasonal, with peak weekend flows between June, July and August (Peak Season) about 125% higher on the existing Wright Memorial Bridge and the Outer Banks than traffic observed during Shoulder Peak Season (May and September). Similarly, in the Peak Season, weekend traffic is about 70% higher than weekday traffic, as visitors start / end their vacations mainly on Saturdays (and to a lesser extent on Sundays).

An important feature of the area is that the visitors vacationing in the Outer Banks usually travel significant distances (average distance of 300 miles) by car. Figure 2 below provides an outline of the key origins of vacationers to the Outer Banks. The red dots show origins of trips to the Outer Banks while the blue dots show the destinations. This shows that most of the visitors to the Outer Banks are from the north-eastern states (e.g. Virginia, Maryland, Pennsylvania and New Jersey) and travel a significant distance. This means that there is likely a significant demand from this user group for the bridge, considering the significant distances they have travelled. This group is unlikely to want to spend additional time queuing in congestion once they have arrived at the Outer Banks if an alternative option, such as the Mid-Currituck Bridge is available.

Figure 2: Distribution of Visitors to the Outer Banks



The existing road infrastructure operates at or near capacity on NC-12 between US-158/NC-12 and Corolla during Peak Season weekends. Journey times significantly increase on Saturdays in the Peak Season, due to the significant increase in demand as visitors arrive at the Outer Banks to begin their vacations. Journey times between the mainland (Barco) and Corolla (Outer Banks) increase from around 1 hour 10 minutes in relatively free flowing conditions to over 3.5 hours on an afternoon in the Peak Season (based on the 2010 Peak Season traffic surveys).

The new bridge will substantially improve these traffic flow conditions on NC-12 and US-158 and, at the same time, reduce travel time between the mainland and the Outer Banks as well improve the overall system efficiency with additional linkages. As a result, it could provide opportunities for sustainable additional development of the northern part of the Outer Banks and the mainland. This will improve the attractiveness of one of the key vacation/beach areas on the East Coast of the United States. This project is not about a traditional urban toll facility, rather the provision of infrastructure that will significantly increase the level of access to this key vacation destination.

In this respect, the project presents a unique marketing opportunity to leverage the existing Outer Banks travel/tourism industry with tailored marketing strategies to highlight substantial travel time savings, cost savings, and increased accessibility to this beautiful and unique destination. Not only will the Mid-Currituck Bridge offer benefits to visitors to the Outer Banks, but also to residents of the area as well. Residents will be able to use the bridge to avoid the congestion at the Wright Memorial Bridge to cross between the Currituck Peninsula and the Outer Banks and also save distance traveled (and therefore associated costs such as gas).

1.4 Structure of this Report

The purpose of this report is to present the traffic and revenue forecasts for the Mid-Currituck Bridge project. Chapter 2 outlines the data sources and surveys used in the study, while Chapter 3 details the development of the model used to produce the traffic and revenue forecasts. Chapter 4 outlines the model calibration

and validation, while Chapter 5 summarizes the traffic and revenue forecasting methodology. Chapter 6 provides the traffic and revenue forecasts, and Chapter 7 presents the results of a series of sensitivity tests undertaken.

2 Data Sources and Surveys

2.1 Overview

For the development of the traffic and revenue forecasts a review of existing datasets was undertaken. This review identified two key sources of data which would be essential to the development of the traffic and revenue forecasts. These were;

- Data collected as part of the "Proposed Mid-Currituck Bridge Preliminary Traffic and Revenue Study, January 2007", developed by Wilbur Smith Associates (WSA).
- North Carolina Department of Transportation (NCDOT) permanent traffic count data from site A2703, Wright Memorial Bridge (US-158).

These sources provided valuable information on certain elements of the traffic profile within the study area, including:

- Historical traffic growth
- Hourly, daily, monthly and seasonal traffic profiles
- Local travel patterns. This included information regarding specific origins and destinations of trips which would potentially use the Mid-Currituck Bridge. This information was derived from the Origin / Destination Mailback /Intercept Survey undertaken by WSA in 2006. This survey was undertaken on the NC-12 in Southern Shores on the Outer Banks.

While the review identified some key sources of existing data which would be used, it also established that there was a need to collect additional project specific data in order to develop the traffic and revenue forecasts of sufficient quality for this study.

Arup proposed and commissioned a range of project specific surveys. As outlined in Chapter 1, these included:

- Realtors Survey: used to understand existing historical visitor patterns to the Outer Banks, which was important given that visitors on vacations will be a key market segment for the bridge. This survey was undertaken by Catevo;
- Willingness to Pay Survey: used to develop specific Values of Time of potential bridge users. This survey was undertaken by NuStats;
- Traffic surveys: used to establish the existing traffic profile within the study area, including traffic counts and journey time surveys. These surveys were undertaken by Arcadis and Peggy Malone Associates; and
- Land-Use / Demographic surveys: used to collect project specific demographic and socio-economic land use data for the study area. This survey was undertaken by Delta Associates.

The proposed survey program (together with the existing data) ensured that the study area and its unique characteristics could be modeled in detail for the purpose of developing the traffic and revenue forecasts. A scoping exercise was

undertaken to plan and outline the requirements of the proposed data collection exercise. The scoping report (Technical Memo #1) can be found in Appendix A.

2.2 Realtors Survey

2.2.1 Survey Requirements

Arup commissioned Catevo in May 2009 to undertake a survey of local Realtors to collect detailed information regarding vacationers staying on the Outer Banks. This was undertaken through a series of interviews and data requests with the Realtors, and data was then analyzed and integrated within the traffic and revenue studies. Data from these surveys was used for a number of key aspects of the development of the traffic and revenue forecasts, including development of the traffic model zone system, the demographic forecasts and development of a weighted average value of time.

The Realtors survey comprised of two separate phases. The first phase involved the collection and assessment of information and perspectives from leading realty firms in Currituck and Dare counties. This considered general aspects of the rental market, historic and projected tourism, development and rental trends, issues and experience with owners and renters, as well as opinions on the proposed Mid-Currituck Bridge.

The second phase comprised of a request from the Realtors for historical data, providing information including the city and state of origin of vacationers, the classification of properties, property incomes and occupancy rates.

2.2.2 Phase1 Real Estate Market Assessment

Phase 1 provided key insights into the tourism industry from those who were most knowledgeable. Information was obtained from 12 of the Outer Banks' leading realtors through informal discussions led by Catevo with support from Arup and the Turnpike Authority. While the conclusions drawn from the discussions were not suitable for input into the traffic model directly, the discussions assisted in understanding the core market for the Project, including key growth areas, constraints and local issues regarding the vacation industry, insight into the rental market and local opinions on the Project.

Historically, the rental market has been strong and, despite the economic downturn, the Realtors indicated that peak 2009 occupancy rates were projected to match recent years. The majority of visitors to the area come from the Mid-Atlantic and North Eastern regions of the United States, entering the area via US-158 from the North. These trips, many of which involve journey times of six to eight hours, will be the core market for the new bridge. The average group size was estimated at between 10 and 15 individuals, with some groups of up to 20 to 30 individuals. As such, groups typically arrive in multiple vehicles.

The survey indicated that development is continuing throughout the study area both on the mainland and the Outer Banks, although the pace has slowed with the current economic climate. The potential for residential growth is greatest in the Carova four wheel drive area. The largest time savings for journeys via the Mid-Currituck Bridge compared to the Wright Memorial Bridge were forecasted in this location. However, development of this area will require infrastructure

improvements to allow development to take place (requiring both public utilities and road access). Other redevelopment is taking place throughout the Outer Banks, with many rental properties being replaced by larger structures.

Rental homes that are closer to the Mid-Currituck Bridge will likely be occupied more often given their improved accessibility and 'closeness' to the mainland because of the new bridge.

The majority of realtors indicated that they would be willing to explore opportunities to bundle tolls as part of the rental contracts. Some indicated a willingness to manage distribution of toll materials, potentially including transponders or bar codes, and discussed the potential to offer toll passes as guest incentives. Some realtors indicated that they would not want to be involved in this process at all.

Realtors also indicated a willingness to purchase toll passes at bulk rates for their office employees and housekeeping staff members. These employees commute to the Outer Banks on weekends and traffic congestion is a major concern, many of whom travel up to two hours to and from work. One realtor stated that "*Without the bridge, we will steadily choke.*"

The complete real estate market assessment report (Technical Memo #2) can be found in Appendix B.

2.2.3 Phase 2 Realtors Database

Phase 2 of the project involved the collection and assessment of data regarding the firms' existing rental stock (location, number of units, type of unit, number of bedrooms and parking capacity). A data request was developed collaboratively by Catevo and Arup, and was submitted to seven of the larger Outer Banks realtors. The primary geographic area targeted was the northern region of Bodie Island, including Currituck County and the northern part of Dare County, including the communities of Carova, Corolla, Duck and Southern Shores.

Historical data from 2004 to 2009 was collected and assessed in order to provide supplementary information for the traffic and revenue forecasting study. Data collected included:

- Percentage of rental properties by type, size and location.
- Historic occupancy rates by season on the rental market.
- The number of families/groups in current rental properties annually, if available.
- Seasonal fluctuations in the rental market and rates.
- zip codes of origin for clients during the last five years, if available.

The complete Realtors Database Report (Technical Memo #4) can be found in Appendix D. The key findings included information on the distribution of visitors and occupancy rates. The majority of individuals who signed contracts for rental units in the sample were from Virginia (88%), Maryland (8%) and Pennsylvania (4%). This suggests that a large proportion of the visitors to the Outer Banks travel for more than five hours and are accustomed to paying tolls. Visitor numbers remained consistent, with occupancy rates during the peak of the Peak

Season (mid July to mid August) consistently reaching 100%. For the Peak outside of the peak of the peak (early June to mid July and mid August to the end of August) the rate was 85%. Occupancy rates during the Shoulder Peak Season (May and September) were between 50-70%, and Off Peak occupancy rates were approximately 7-14%.

The data indicated that 65% of all units in the sample had Saturday check in / check outs. This corresponds with the traffic surveys, which highlighted that Saturday volumes were highest. It can be concluded that the peak in traffic volumes are directly related to the arrival of visitors to the Outer Banks with 34% of check in / check outs occurring on Sunday. This facilitated the development of a Peak Sunday traffic model as well. The remaining 1% of check in / outs were observed on Fridays.

The data collected from Phase 2 of the realtors survey was used in three key areas of the development of the traffic and revenue forecasts;

Traffic model zone system

The database is comprised of over 160,000 records and was used to determine the areas with the greatest frequency of contracts with a view to identifying clusters of zip codes defined by metropolitan areas or sub-metropolitan areas. This ensured that the external zones were focused on the origins of Outer Banks visitors which are clustered in certain areas and not distributed widely throughout a state. This approach enabled the zone system to be tailored to the unique characteristics of the Outer Banks catchment area and ensured that the demographic survey produced detailed demographic information at a suitable level of disaggregation for the purposes of the study.

Demographic forecasts

The findings of the realtor's survey were provided to Delta Associates to assist them in targeting appropriate town and regional bodies for interview. These findings were directly integrated within the demographic forecasts which were utilized in the Mid-Currituck Traffic Model. Key local agencies on the Outer Banks were interviewed, in order to ensure that the demographic forecasts were based on a solid foundation in terms of both understanding the key issues and unique characteristics associated with the Outer Banks area. Furthermore, realtors with interests in specific aspects of the Outer Banks (e.g. the four wheeled drive area north of Corolla) were interviewed, along with key public officials. As a result, the forecasts integrate many of the findings highlighted within the realtors survey.

Value of Time (VOT)

There is a strong relationship between VOT and personal or household income. The willingness to pay survey provided VOTs for each market segment, specific to the unique characteristics of the study and also by four different income bands. The traffic model required a single value of time that accurately represents the income distributions of visitors in the northern Outer Banks area. Weighted average values of time were produced using the zonal household income data from Delta Associates, and the realtors' survey contract database. The proportion of contracts associated with each external zone in the contracts database was calculated, and this was cross-referenced with the household income data calculated within the demographic forecasts. Based on the number of trips

associated with each value of time income band, a weighted average value of time was developed.

2.3 Willingness to Pay Survey

2.3.1 Introduction

Arup commissioned NuStats in July 2009 to undertake Willingness To Pay analysis conducted through a Stated Preference (SP) survey. This was used to derive local value of time to be used in the traffic and revenue forecasting.

For a large proportion of trips within the study area, the Mid-Currituck Bridge will offer a significant reduction in travel times. In order to produce traffic and revenue forecasts, it was necessary to estimate the value which travelers were willing to place on their time when deciding on their route choice. The value of time (VOT), expressed in dollars per hour, is typically used to compare the value of time saved using a toll road with the toll cost incurred and, in this context, is more correctly a measure of the value of travel time savings. VOT is an individual preference for spending money to save time and this information was used to build toll diversion models for use within the traffic and revenue model. It is critical to the traffic and revenue forecasts for the Project.

SP surveys are a form of attitudinal survey and are strongly recommended when a substantially new infrastructure option is being introduced and there is little historical evidence of how people might respond to this alternative.

2.3.2 Method

The SP survey was undertaken using a number of different data collection methods. Face to face intercept interviews were used as the primary means of the data collection for visitors to the Outer Banks while a web based survey was used as the primary means of data collection for local residents. One overall database was used to develop the VOT and willingness to pay analysis.

The survey instrument was designed collaboratively between all members of the project team and included four stages consisting of screening questions, reference trip questions, stated preference trade off questions and demographic questions. A team of trained interviewers visited several popular visitor locations in the Outer Banks between August 13th and September 2nd, 2009. A total of 1383 visitor questionnaires were completed. A total of 750 web based residents interviews were completed.

2.3.3 Key Findings

Key market segments were identified based on the findings of the survey. These were:

- Visitors Vacation (trips at the beginning / end of a vacation to and from the Outer Banks);
- Visitor Other (trips made by visitors while staying on the Outer Banks); and

- Resident Commute (trips made by residents of the Outer Banks to / from their place of work).

The values of time developed and used in the traffic and revenue forecasts are shown in Table 1.

Table 1: Base Year Weighted Average Value of Time

Trip Purpose	**VOT ($/Hour)**
Resident Business	$10.69
Resident Commute	$10.02
Resident Other	$11.59
Visitor Business	$11.04
Visitor Other	$11.97
Visitor Vacation	$14.25

The willingness to pay survey report can be found in Appendix G.

2.3.4 Independent Review of Willingness to Pay Survey

An independent review of the stated preference survey, the experimental design, administration methods, and the survey data was undertaken by Resource Systems Group (RSG).

RSG concluded that the survey structure and data collected provided a satisfactory basis on which to base the estimation of value of time for the purposes of this study. It was also confirmed that the approach used was commonly employed in developing VOT for use in this context. RSG concluded that the method and design used was successful in collecting uncorrelated variations in travel time savings and toll costs in terms of the responses to the stated preference questions, as required in developing estimates of value of time.

In addition to the review of the survey structure, survey design, and collected data, RSG also performed an independent estimation model and found the results were similar to those developed as part of the main willingness to pay survey. The report summarizing the independent review can be found in Appendix H.

2.4 Traffic Survey

2.4.1 Existing Traffic Data

Arup obtained historical traffic data for the permanent count site on US-158, (east of Wright Memorial Bridge) the data included hourly traffic flows by direction and day. This data was utilized in assessing historical traffic growth within the study area, and in the definition of the base year models.

Existing data collected as part of the preliminary forecasting work undertaken by Wilbur Smith Associates (WSA) was made available to Arup, including:

- Detailed Origin / Destination Mail-back Intercept survey data (conducted during summer 2006).

- Traffic and journey time surveys (conducted during 2006).
- Existing model zone system.
- Base year trip tables (2006), and
- Forecast year trip tables (2010, 2015, 2020 and 2025).

Arup reviewed the information and concluded that the data formed a sound basis to build upon which could be supplemented with additional project specific surveys.

The detailed origin / destination mail-back intercept survey was undertaken over four days in August and September 2006 (August 24 and 26, September 28 and 30). The survey station was located in Southern Shores just north of the intersection of the NC-12 and the US158 at Chicahauk Trail. This location was chosen as it was expected to intercept the largest numbers of potential Mid-Currituck Bridge users. The survey was undertaken in both the northbound and southbound direction. In conjunction with the intercept survey, 7-day traffic counts were also performed in order to expand the survey sample to reflect average weekday and weekend day traffic levels during each period.

A mail-back handout survey was distributed to drivers passing the site during the hours of 7:00AM to 7:00PM on each surveyed day. The survey questionnaire was used to obtain information about travel patterns of potential users of the new bridge. Information including trip origin and destination, residency status within the Outer Banks (whether a resident or a visitor), trip purpose, trip frequency and vehicle occupancy was collected.

Outlined below are some of the key results obtained from the survey data;

Residency Status

It was important to determine the residency status of each respondent in order to estimate the number of potential users of the bridge. The majority of trips during the weekend in both the Peak and Shoulder Peak Season were made by visitors (78% in the Peak Season and 60% in the Shoulder Peak Season). During the weekday residents made the most trips, with 58% in the Peak Season and 68% in the Shoulder Peak Season.

Trip Purpose

The survey results indicated variation in the patterns of trip purposes between the different survey periods and between the different residency statuses. For example, trips to/from work accounted for 36% of trips made by residents during the Shoulder Peak weekday and 43% during the Peak Season, with 32% and 44% at the weekend (Shoulder Peak / Peak Season). For visitors, the main trip purpose during the weekend in both the Shoulder Peak and Peak Season was to begin or end a vacation, with 75% of trips in the Shoulder Peak and 89% in the Peak Season. These were to be expected given that the majority of changeover days for rental units are at the weekend.

Trip Frequency

The survey results indicated that residents made more trips per week than visitors, which can be explained by the number of trips to/from work residents would make, which would not be undertaken by visitors. Visitors would make most of

their trips at the weekend, at the beginning / end of their vacation, and few trips during the week.

Vehicle Occupancy

The majority of residents traveled alone or with one passenger during all periods. Whereas, visitors traveled with a higher number of passengers (71% of trips with 3 or more passengers on a Peak Season weekend day), especially during the Peak Season, as family groups accessed the Outer Banks to undertake their vacations.

Trip Origins / Destinations

Analysis of the trip origins / destinations show that during the Peak Weekend over 38% of all trips (both resident and visitor) started or ended outside of the Outer Banks. In the Peak weekday period this reduces to just 16%, which is due to the number of trips being undertaken at the weekend by visitors beginning or ending their vacation. During the Shoulder Peak Season the proportion of trips starting or ending outside of Outer Banks decreases to 28%.

Summary

This data provided key information upon which the trip tables for the traffic model were developed. As outlined above the data was reviewed and it was concluded that the data formed a sound basis to develop the trip tables.

2.4.2 Historical Traffic Trend

The data shown in Table 2 provides the historic trend in Annual Average Daily Traffic (AADT) across the Wright Memorial Bridge for the period 1998-2009. This shows that since 1998 there has been growth in bridge traffic that up to 2007 was on average 2% per annum. Since the economic downturn this has reduced to just under 1% per annum. However, in 2010 growth increased to above pre economic downturn levels with a 3.9% increase in traffic.

Table 2 Wright Memorial Bridge; Historical Traffic, 1998-2009, Annual Average Daily Traffic (AADT)

Year	AADT	Annual Growth Rate	Average Annual Growth Rate from 1998
1998	17,350		
1999	18,095	4.3%	4.3%
2000	17,519	-3.2%	0.5%
2001	18,325	4.6%	1.8%
2002	18,962	3.5%	2.2%
2003	20,420	7.7%	3.3%
2004	20,953	2.6%	3.2%
2005	20,718	-1.1%	2.6%
2006	20,530	-0.9%	2.1%
2007	20,806	1.3%	2.0%
2008	19,353	-7.0%	1.1%
2009	18,989	-1.9%	0.8%
2010	19,724	3.9%	1.1%

*Source, NCDOT Long Term Count Data; Site A2703

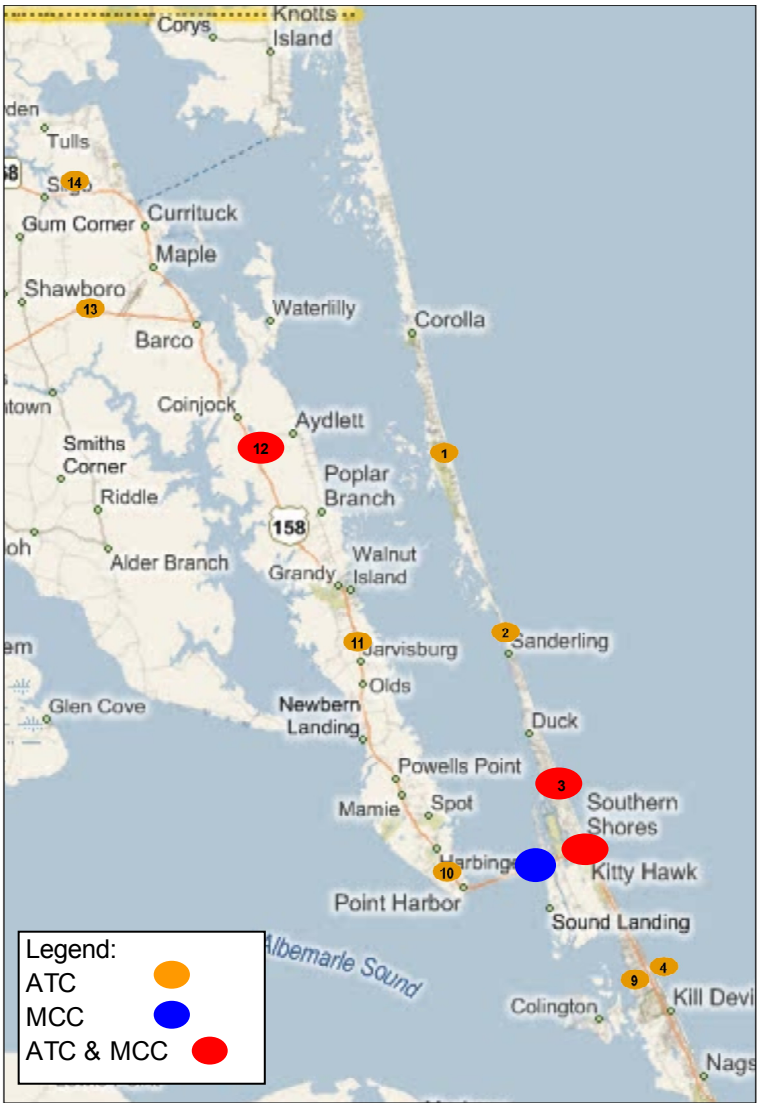
2.4.3 Project Specific Traffic Surveys

To validate and supplement the existing data, Arup commissioned a specialist traffic survey company to undertake a series of traffic surveys, conducted during the Peak and Shoulder Peak Season in 2009, and in the Peak Season in 2010. The Peak Season surveys were repeated in 2010 as a check on the 2009 surveys, as it was suspected these were impacted by the weather in 2009. In the Outer Banks the Peak Season is June, July and August, and the Shoulder Peak Season is May and September.

The following types of surveys were undertaken and their locations are shown in Figure 3:

- Classified automatic traffic counts (ATC),
- Turning movement manual classification counts (MCC), and
- Journey time surveys.

Figure 3: Traffic Survey Locations



2.4.4 Automatic Traffic Counts

The ATC counts provided information regarding hourly, daily and seasonal traffic variations, while the MCC counts were used to categorize the traffic flows down by vehicle type, and also provide information on the key intersection of US-158 and NC-12.

Figure 4 provides an outline of the seasonal profile of traffic flow on the Wright Memorial Bridge (based on information provided by NCDOT in 2010). This clearly shows that the Peak Season in terms of traffic flow is in June, July and August, while the months of May and September are higher than the rest of the year.

Figure 4: Seasonal Traffic Flows 2010, Wright Memorial Bridge

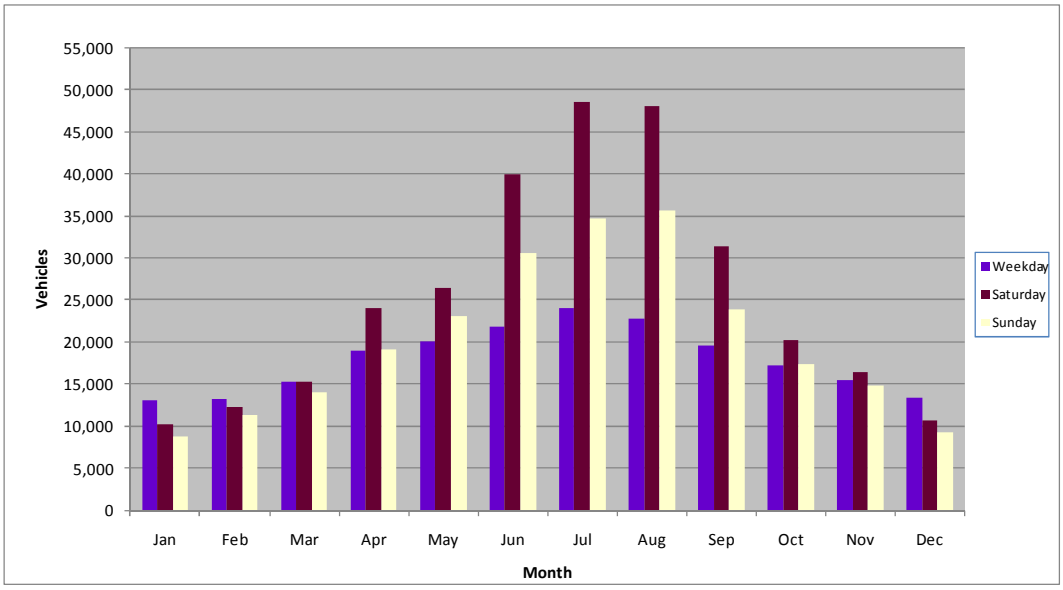


Figure 5 shows the 2010 Peak Season ADT (Average Daily Traffic) traffic flows that were collected. This shows the variation in traffic flow by locations and also by day of the week. Saturday volumes are highest of any day of week, which is associated with the arrival of visitors to the Outer Banks (Saturdays is the main changeover day). The highest flows are along the US-158 and across the Wright Memorial Bridge, with traffic accessing both the northern (towards Duck / Corolla) and southern (towards Kill Devil Hills and Nags Head) Outer Banks.

Figure 5: Peak Season AADT Traffic Flows, 2010

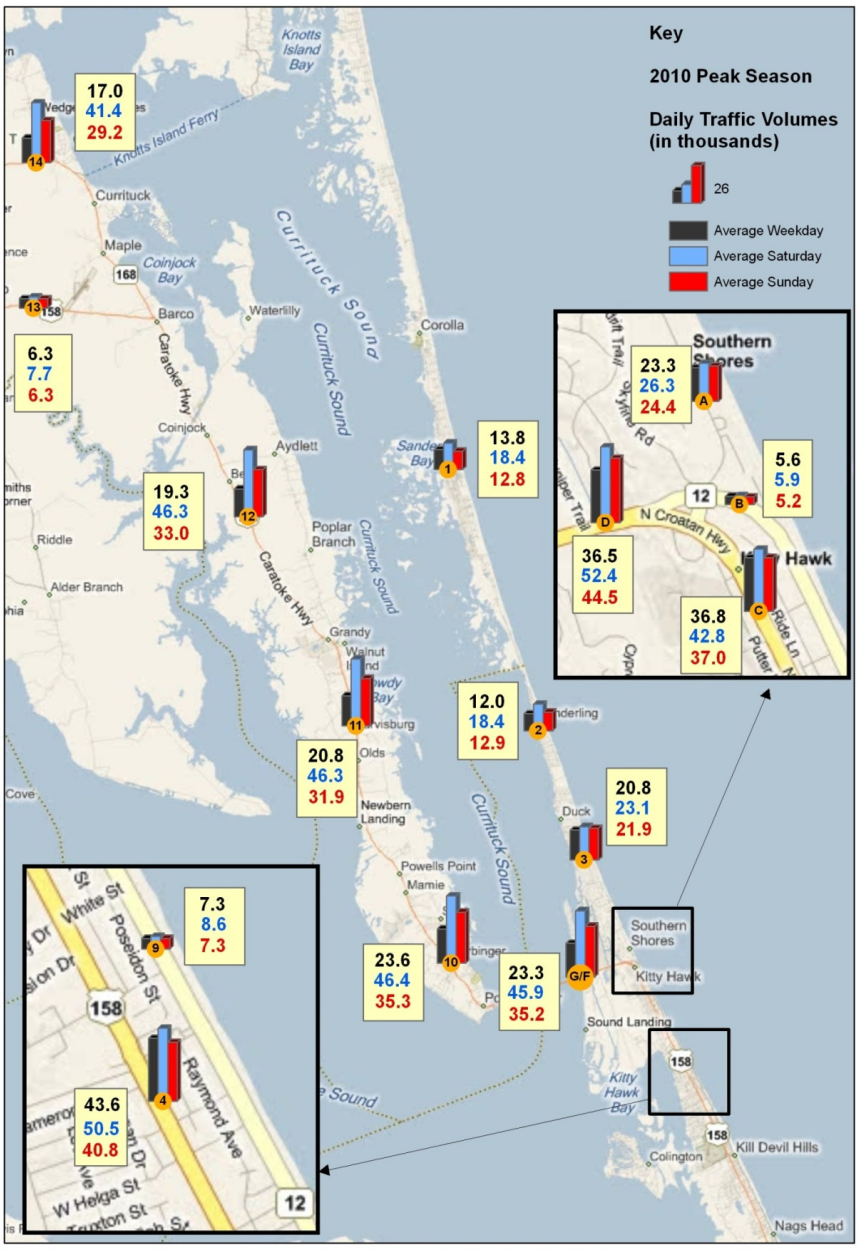
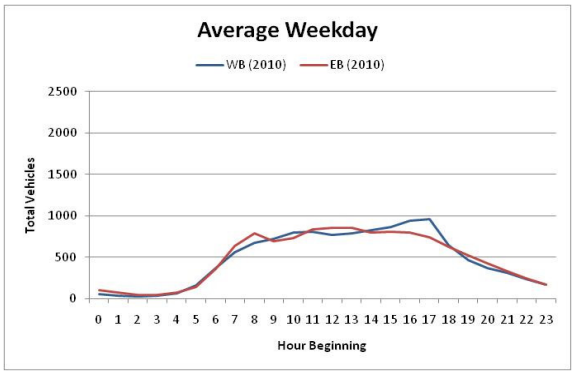
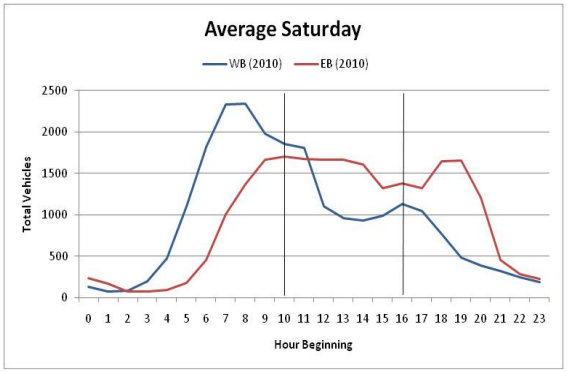


Figure 6 shows the Peak Season daily profiles in 2010 at the Wright Memorial Bridge. This shows that the peak hour varies by day of the week. In general the PM peak period is the busiest weekday period, while the AM and Midday (MD) periods have the highest levels of traffic during Saturday and Sunday respectively. Saturday traffic volumes are the highest of any day, which is directly associated with the check-in and check-out of (changeover day) for vacation accommodation on the Outer Banks. Sunday volumes are lower than on Saturday, with the busiest period around mid-morning.

Figure 6: Peak Season Daily Profiles 2010 – Wright Memorial Bridge





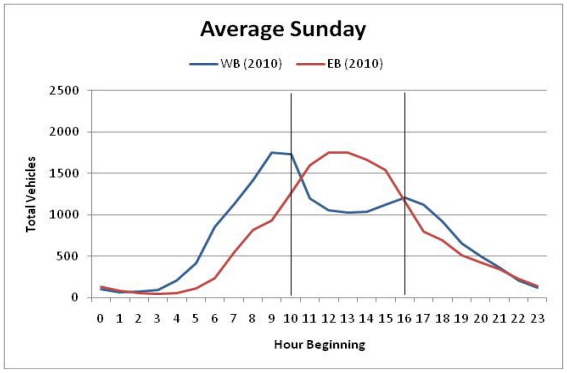


Table 3 below compares the Shoulder Peak and Peak Season traffic at two sites, one on the NC-12 in Southern Shores (Site 3) and one on the US-158 south of Grandy, Site 11). This indicates that traffic is significantly higher on the US-158 and NC-12 in the Peak Season compared with the Shoulder Peak Season. On Saturdays, traffic is 60% higher in Peak Season at Site 3 and 84% higher at Site 11.

Table 3: NC-12 and US-158 (Average Daily Traffic)

Location	Day	Shoulder Peak	Peak Season	Difference
NC-12 Southern Shores (Site 3)	Weekday	11,500	20,800	+81%
	Saturday	14,400	23,100	+60%
	Sunday	12,400	21,900	+77%
US-158 South of Grandy (Site 11)	Weekday	16,200	20,800	+28%
	Saturday	25,100	46,300	+84%
	Sunday	18,600	31,900	+72%

2.4.5 Turning Counts

Classified turning movement counts were undertaken at the following locations;

i. Intersection of US-158 (North Croatan Highway), NC-12 southbound (Virginia Dare Trail) and NC-12 northbound (Ocean Boulevard),

ii. Intersection of US-158 and Walmart/Marketplace @ Southern Shores

These surveys were used to provide information regarding the volumes of passenger vehicles and trucks, making each turning movement. This survey was conducted using video recording equipment. Turning movement (i) was conducted in the Peak and Shoulder Peak Season (2009 and 2010), while count (ii) was only undertaken in the Peak Season (2010).

Analysis of the turning movement counts is focused on the US 158 / NC 12 intersection, as this provided a good estimate of the origins of traffic heading north on NC 12 in the peak season Figure 7, Figure 8 and Figure 9 show graphically the turning movement counts for the average Weekday, Saturday and Sunday, respectively. A summary of key movements at this intersection is shown in Table 4.

Figure 7 Summary of 2010 Peak Season Average Weekday Turning Movement Counts at US 158/NC 12

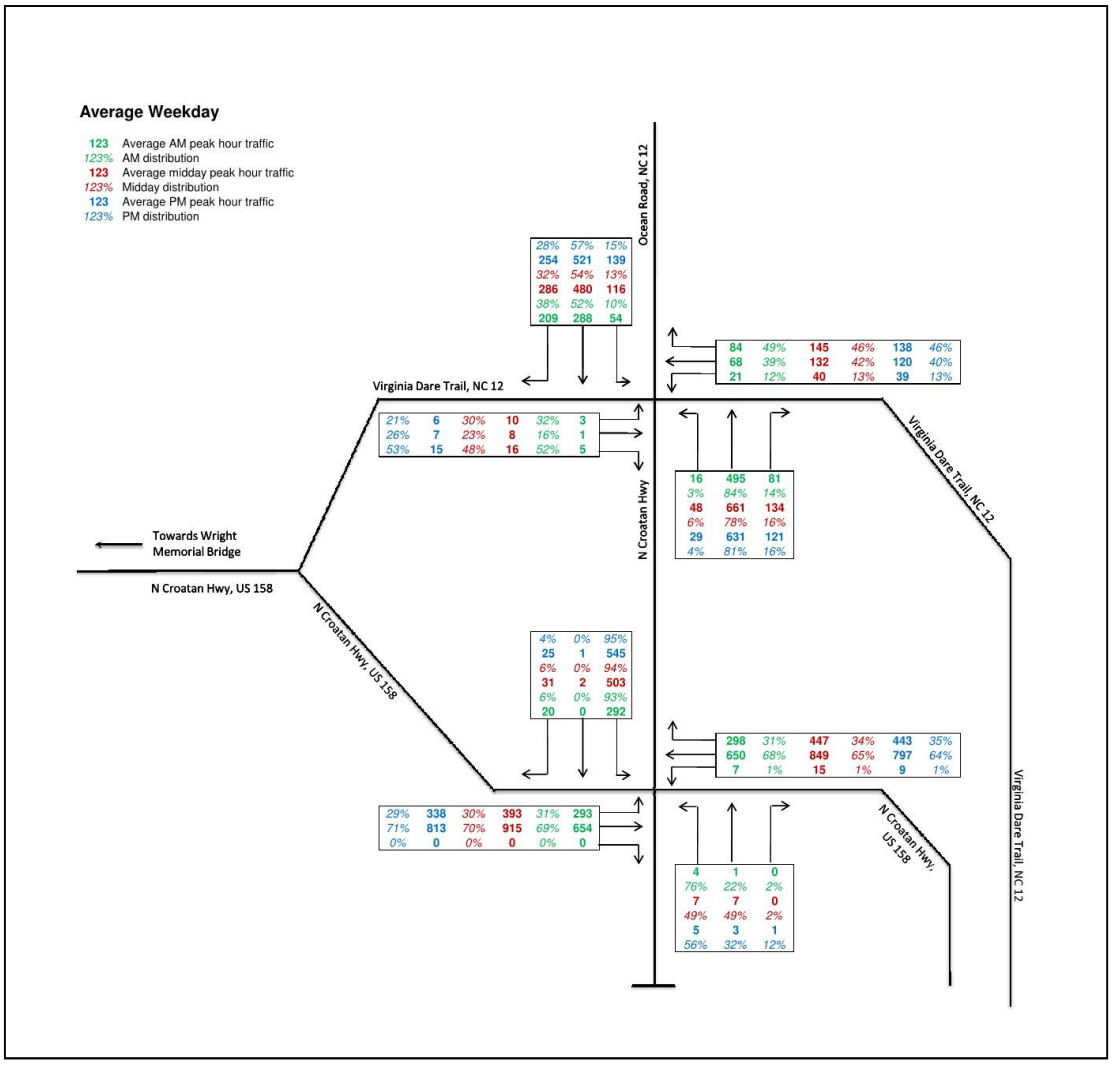


Figure 8 Summary of 2010 Peak Season Average Saturday Turning Movement Counts at US 158/NC 12

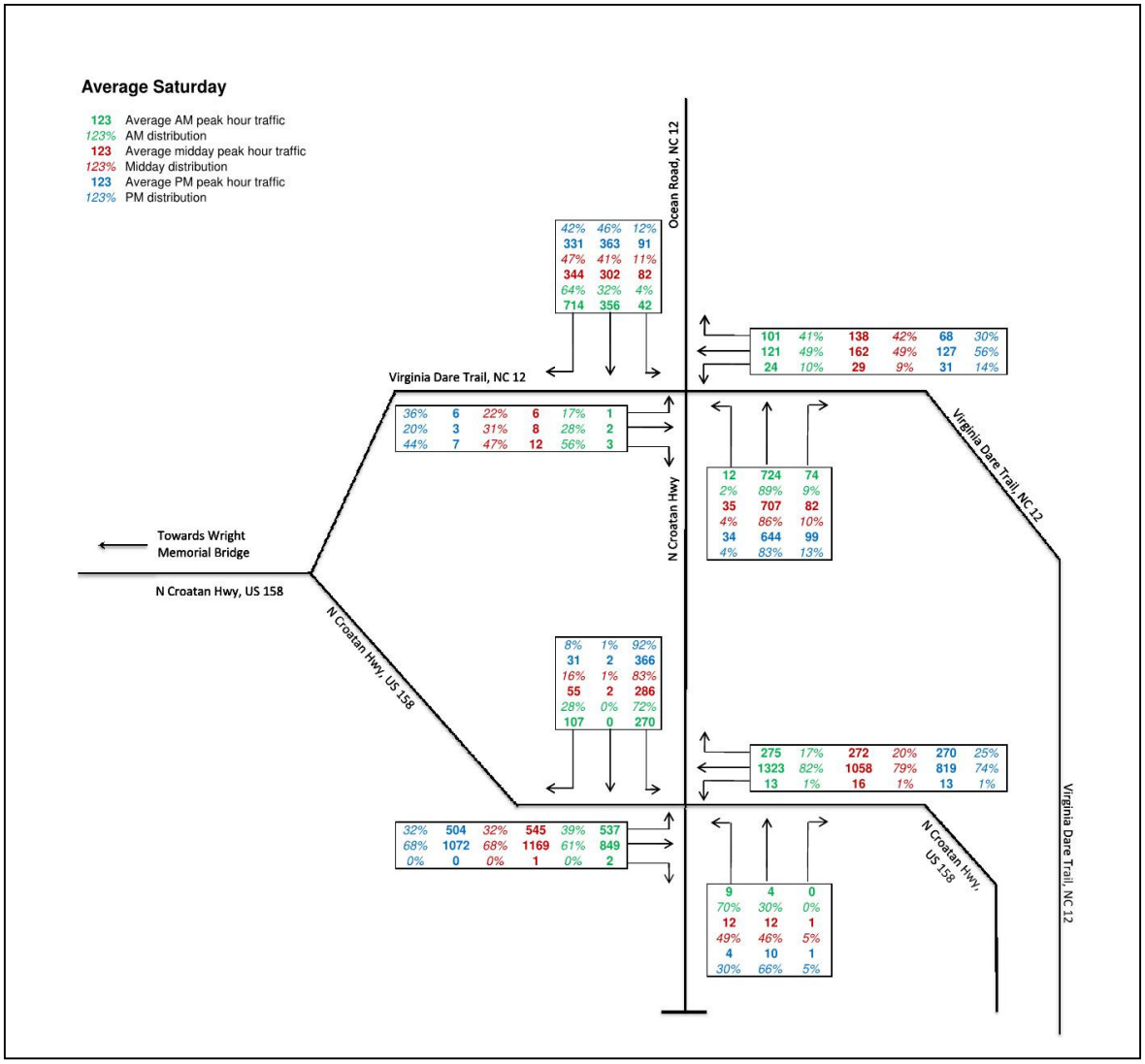


Figure 9 Summary of 2010 Peak Season Average Sunday Turning Movement Counts at US 158/NC 12

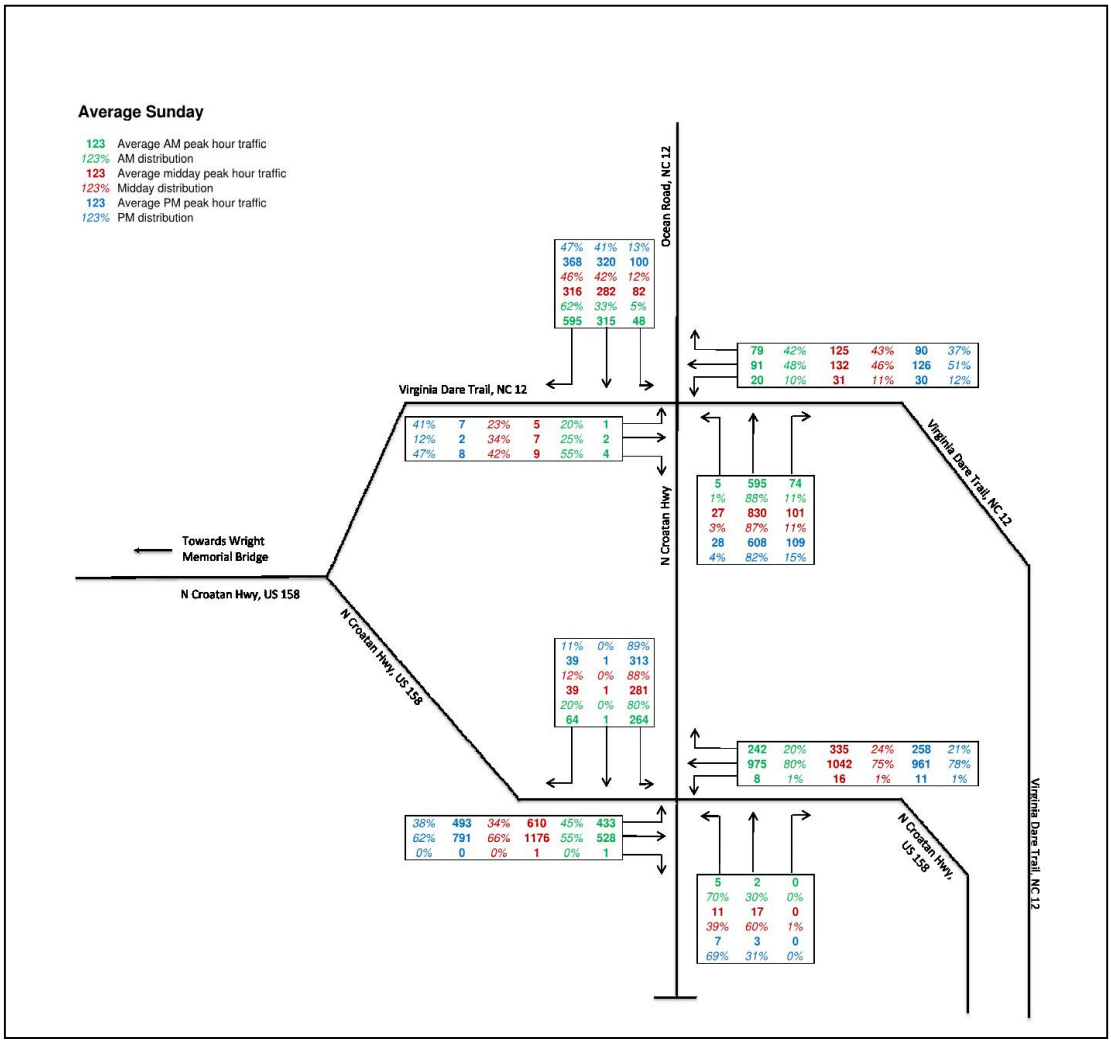


Table 4 2010 Peak Season Turning Movement Summary, US158 / NC12 Intersection

AM Peak Average Hour	To NC 12 Northbound					
From	Average Weekday		Saturday		Sunday	
US-158 / WMB (EB)	293	49.6%	537	66.1%	433	64.2%
US-158 / N. Croatan Hwy (NB)	298	50.4%	275	33.9%	242	35.8%
Total	**591**	**100%**	**812**	**100%**	**675**	**100%**
Midday Average Hour	To NC 12 Northbound					
From	Average Weekday		Saturday		Sunday	
US-158 / WMB (EB)	393	46.8%	545	66.7%	610	64.6%
US-158 / N. Croatan Hwy (NB)	447	53.2%	272	33.3%	335	35.4%
Total	**840**	**100%**	**817**	**100%**	**945**	**100%**
PM Peak Average Hour	To NC 12 Northbound					
From	Average Weekday		Saturday		Sunday	
US-158 / WMB (EB)	338	43.3%	504	65.1%	493	65.7%
US-158 / N. Croatan Hwy (NB)	443	56.7%	270	34.9%	258	38.2%
Total	**781**	**100%**	**774**	**100%**	**751**	**104%**

In addition, two further classified counts were conducted in the Peak Season on US-158 and NC-12 at locations close to the ATC count surveys to verify these outputs as robust.

The following conclusions were drawn from the classified turning count surveys;

- Northbound flows onto NC 12 during the AM and PM peak periods are highest on Saturdays. In the Midday Peak they are highest on Sundays.
- Flows approaching from the Wright Memorial Bridge (North Croatan Highway 158) are highest at the weekends in all time periods.
- During Saturdays and Sundays, approximately 65% of traffic heading north on NC 12 originates from destinations from the Wright Memorial Bridge. During the average weekday this changes to around 50%, reflecting the increased level of demand originating from the Wright Memorial Bridge (arriving visitor traffic) at weekends.
- During the average weekday, the split of trips from the Wright Memorial Bridge and to the south (Kitty Hawk) differs, between 50% and 56%. On a weekend this reduces to 30%-40%, showing more traffic is turning north on a weekend.
- The proportion of trucks crossing the Wright Memorial Bridge and heading north on NC 12 varies by the day of the week. 3.0% were trucks on an average weekday compared to 0.7% and 0.4% on Saturday and Sunday respectively

2.4.6 Journey Time Surveys

The following journey time surveys were undertaken in the 2009 Peak and Shoulder Peak Season in 2009.

- Route 1 – US-158/NC-168 to US-158/NC-12 (Southern Shores)
- Route 2 – Manns Harbor to US-158/NC-12 (Southern Shores) via Virginia Dare Memorial Bridge and Virginia Dare Trail
- Route 3 – Manns Harbor to Corolla via William B. Umstead Bridge and Croatan Highway

A further journey time survey was undertaken in the 2010 Peak Season, in order to provide further data to that collected in 2009. The route of this survey is shown in Figure 12. This was undertaken between Barco (intersection of US-158/NC-168) and Corolla (Carova Beach Access), a distance of 51 miles. This is the primary route for which the Mid-Currituck Bridge will provide an alternative and therefore benefit the most from.

Surveys were conducted in each direction (four runs in each direction) for the following time periods (covering both weekday and weekend day):

- AM peak - between 07:00 and 10:00;
- Inter-peak – between 10:00 and 16:00; and
- PM peak – between 16:00 and 19:00

The results of the 2010 Peak Season journey time survey are shown in Table 5

Table 5: 2010 Peak Season Journey Times (average time hh:mm:ss)

Direction	Time Period	Weekday	Saturday	Sunday
Barco to Corolla (inbound towards the Outer Banks)	AM Peak	01:11:57	01:12:49	01:12:11
	Midday Peak	01:14:18	02:00:02	01:23:00
	PM Peak	01:13:18	03:31:56	01:11:27
Corolla to Barco (outbound away from the Outer Banks)	AM Peak	01:10:29	01:23:20	01:13:46
	Midday Peak	01:17:21	01:24:00	01:11:40
	PM Peak	01:15:41	01:32:45	01:11:19

Figure 10 shows the results of the 2010 Peak Season journey time survey, between Barco and Corolla (towards the Outer Banks) for each of the individual time periods. These are presented showing the accumulated journey time along the surveyed route. Therefore as the gradient of each line in the graph increases, this represents the delay along the journey time route. The results show the variation in recorded journey time across each of the time periods. It can be seen that journey times are consistent across most time periods, other than the Peak Season weekend in the midday period (10.00AM - 4.00PM) and PM Peak (4.00PM – 7.00PM) period. These two time periods show significantly longer journey times for the journey between Barco and Corolla. This is due to the levels of congestion occurring along the US-158 and the NC-12 in these periods and more specifically on the approaches to the Wright Memorial Bridge.

Figure 10 2010 Peak Season Average Journey Time Survey (Barco to Corolla)

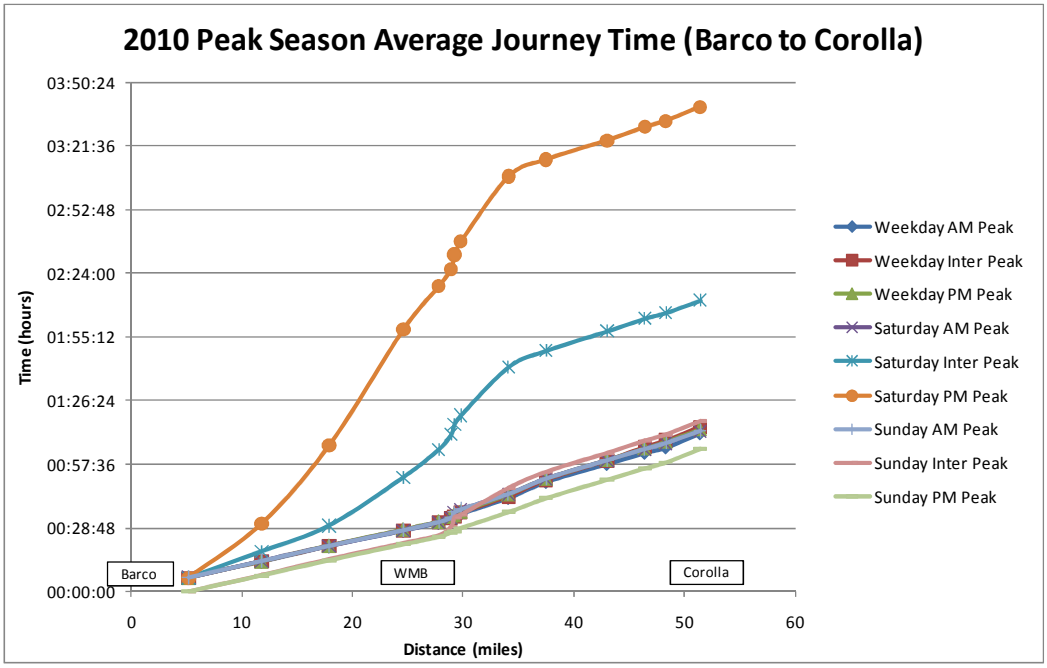


Figure 11 2010 Peak Season Average Journey Time Survey (Corolla to Barco)

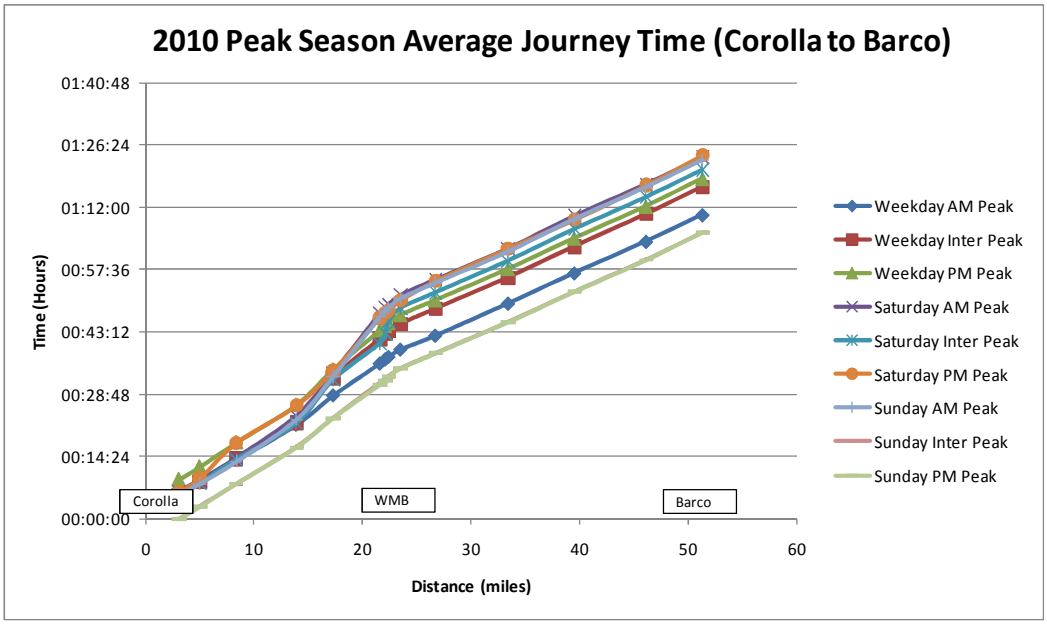


Figure 11 shows the results of the 2010 Peak Season journey time surveys in the Corolla to Barco (away from the Outer Banks) direction for each of the surveyed time periods. This shows that there is less variation in the journey times in this direction, with a lower level of congestion occurring in the Peak weekend than that observed in the opposite (towards the Outer Banks) direction.

The key findings from the journey time surveys were:

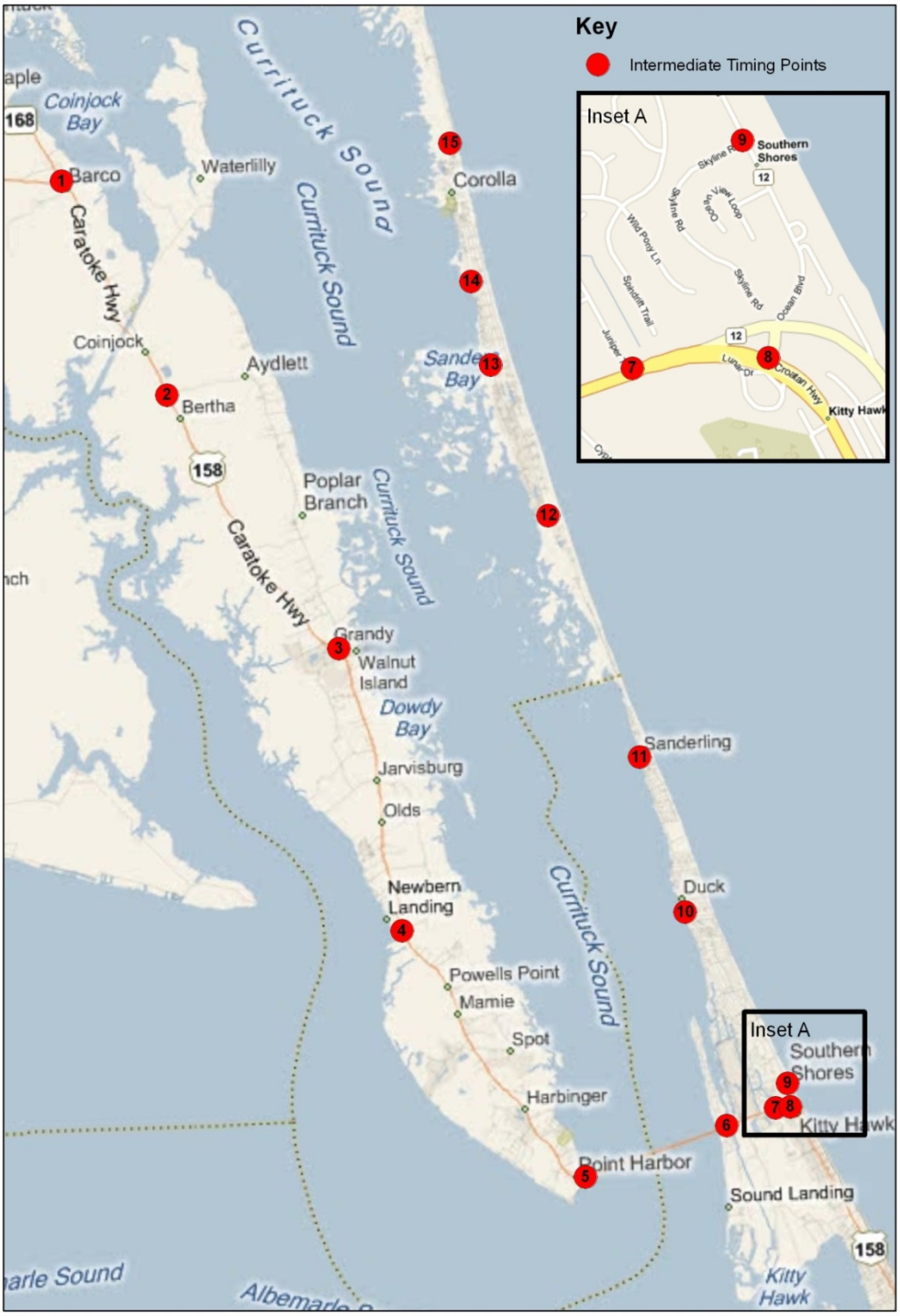
- Significant delays were observed during the Midday and PM peak on Saturdays when traveling from Barco to Corolla (towards the Outer

Banks). Queuing was observed in the PM Peak period in the inbound direction beginning near Grandy on the US-158. This was due to the significant increases in demand associated with the arrival of visitors starting their vacations on Saturdays (Saturday is the main changeover day for rentals in the Outer Banks). Given the distances travelled by visitors, as highlighted in Chapter 1.3, most visitors arrive at the Outer Banks between Midday and 5.00PM.

- The Sunday journey time surveys show significantly less delay than those observed on Saturdays.
- There was only a small amount of variation in the weekday and Sunday journey times throughout all time periods.
- Near free-flow conditions were maintained throughout the weekday journey time runs in both directions

The results of the traffic surveys were presented in Technical Memos #5 and #6.which can be found in Appendix E and Appendix F.

Figure 12: 2010 Peak Season Journey Time Survey Route



2.5 Demographic & Land Use Survey

The demographic, land use and long-term development potential for the Outer Banks is of key importance to the traffic and revenue forecasts. Arup

commissioned Delta Associates in association with Dr James Kleckley, Director of the Bureau of Business Research at East Carolina University, to undertake a demographic and land use survey of the Outer Bank. Dr Kleckley was the primary contributor to the socio-economic forecasts, as well as the GDP and GRP forecasts

A wide range of data was publicly available, but due to the unique nature of the Outer Banks system and the current economic downturn, it was deemed necessary to obtain up-to-date information. In addition, the surveys incorporated localized trends regarding the outlook for future rent increases, increasing maintenance and service costs, and financing availability, all of which may impact willingness to acquire residential property in the wider project area. The development of the Outer Banks will have a marked impact on the potential use of the Mid-Currituck Bridge, and the land use survey was required to highlight historical trends, and to produce both land use and socioeconomic projections for use within the forecasting process. As part of the demographic survey, US GDP and study area GRP forecasts (Currituck and Dare counties) were also developed.

This survey was conducted in two stages. Stage 1 involved the collection of existing data, reports, planning documents from government and public organizations. Interviews were undertaken with realtors, developers and land owner to establish the location, type, scale and timing of potential development in the Outer Banks. Discussions were also organized with key public officials in local, state and federal government agencies relating to long term growth, planning and land use regulation in the Outer Banks.

Stage 2 incorporated the development of land use and socio-economic forecasts through to 2040, including the general development of the Outer Banks and mainland Currituck and Dare counties. A base case forecast and two alternative scenarios with high and low growth assumptions were developed, including population, household income, vehicle ownership, Gross Domestic Product for the United States and Gross Regional Product (GRP) for the study area.

The primary focus of the socioeconomic and land use work was to develop forecasts for use within the trip generation stage of the traffic model. A base scenario and two variations around the base were developed, in five year intervals from 2009 to 2040.

Prior to forecasting, the traffic analysis zone system was defined in an iterative effort between Arup and Delta Associates. No revisions were required to the zone system over the forecast period as there were no major developments which would justify additional detail.

To define the external zones, Delta analyzed a database assembled by Catevo of about 160,000 rental contracts for vacation homes in Currituck and Dare Counties. The clusters of zip codes in metropolitan areas that generated the most contracts were identified, which led to the definition of 23 Metropolitan Statistical Areas (MSAs) that accounted for 75% of the contracts within the realtors database. After these 23 top MSAs, no single MSA accounted for more than 0.5% of the contracts. 12 external zones that represented the remaining areas of each state (other than North Carolina) were also defined as sending zones (i.e. the portions of the states that are not in the MSA sending zones).

For internal zones (24 in total) forecasts were prepared for twelve variables, including seasonality considerations for population, employment, rental housing

occupancy and hotel occupancy. Five variables were analyzed for the remaining 46 external zones, with no consideration to seasonality.

The principal sources of information for the demographic components included Woods & Poole Economics (population, households, employment and income), tax parcel records, data from the Outer Banks Visitors Bureau and the Currituck County Travel and Tourism Department. Socioeconomic and vehicle ownership information from the US Census and the Catevo Phase 2 Realtors Database formed the principal data sources for the analysis of the external zones. The methodologies used to derive each variable differed, and different approaches were adopted for internal and external zones – complete details can be found in Appendix I.

The GDP and GRP forecasts were derived from data developed by Woods & Poole. In order to account for the impact of future economic cycles, all US economic cycles since 1945 were analyzed. It was found that, on average, a 5-year expansion period was followed by a downturn in year 6. Based on the observed pattern, cyclical changes in US GDP and GRP were developed for the base case and two variations.

The high and low variations around the base were defined primarily through the use of the high and low variation GDP / GRP forecasts, as GDP and GRP were utilized in the calculation of a number of variables. In addition, a number of findings from the interview process were incorporated in the variations. For example, Currituck County officials anticipated that the bridge will attract commercial development on the mainland, and this was supported by the realtor interviews. As such, an amusement park or similar recreational amenity was assumed in Crawford Township close to the mainland terminus of the bridge, along with 100,000 square feet of retail space and a 100-room hotel. The high scenario also assumed improved vehicular access to Carova and an easing of the land-use policies to allow large scale development.

In 2009 the population and employment figures for the Outer Banks and Currituck Peninsula were as follows:

- Permanent Population: 51,822,
- Seasonal Population (average of Peak Season): 70,998,
- Average Annual Employment (jobs): 29,975, and
- Seasonal Employment (average of Peak Season): 35,440.

The forecasts are shown in more detail in Table 6.

Table 6 Base Case Demographic Forecasts, 2009 - 2040

Demographic Variable		2009	2040	% Change
Population	Permanent Population	51,822	84,044	62%
	Average Daily Peak Season	70,998	107,062	51%
	Average Daily Peak of Peak Season	85,451	128,858	51%
	Average Daily Spring / Fall Shoulder Peak Season	21,268	32,072	51%
Employment	Annual Average	29,975	53,794	79%
	Average Peak Season	35,440	63,573	79%
	Average Peak of Peak Season	35,734	64,143	80%
	Average Daily Spring / Fall Shoulder Peak Season	31,894	57,238	79%
Households	Number of Households	21,659	37,088	71%
	Number of 2nd Homes	2,120	3,286	55%
Rental Units	Number of Units	16,417	22,118	35%
	Number of Bedrooms	63,233	103,732	64%
Hotels	Number of Rooms	3,108	4,408	42%

Outlined below is a summary of the demographic forecasts;

- Permanent Population increases by 32,222 persons from 51,822 currently.
- Average Daily Peak Visitor Population increases by 36,065 from 70,998 currently.
- Average Daily Peak of Peak Visitor Population increases by 43,407 from 85,451 now. (Note: the Peak and Peak of Peak figures rise by 51% in the Study Area, compared to 68% in zones 4-9, indicating that the Mid-Currituck Bridge will serve the area of the fastest relative growth.)
- Average Employment increases by 23,819 jobs from 29,975 currently. (Note: The largest share of new jobs will be in Mainland Currituck in the northern end of the county where it adjoins the City of Chesapeake, which could translate into business for the bridge.)
- Permanent Households increase from 21,659 to 37,088, a gain of 15,428. Again, the growth is primarily in Mainland Currituck.

- Retail Space grows by 50%, from 3.8 to 5.7 million square feet.
- Seasonal Rental Units increase by 5,701, from 16,417 today to 22,118 in 2040, with virtually all of the new development taking place on the Outer Banks.
- Rental Unit Bedrooms grow by 40,499 to 103,732.
- Hotel Rooms will grow by 1,300 rooms from an existing stock of 3,108 rooms. No major hotels are anticipated due to zoning and utility constraints, along with severe seasonality of demand.

Resident population and household forecasts through 2040 were calculated using ratios of population to employment and of households to population, respectively. The county-level data are distributed among zones based on the distribution of primary residences in the county property records database. In some zones (e.g., Zone 4) projected household growth (i.e., new permanent residences) is limited by land availability at some point during the forecast period. In Zone 9, projected growth is based in part on past development activity – an average of only 23.5 units per year since 1998. In addition, we assumed that current barriers to growth in Zone 9, including county land use policies, the lack of road access, lack of public utilities, etc., will remain during the low case and base case forecast periods. Note that flood zones, wetlands, poor soils, etc. were excluded from the vacant land area used to determine the development capacity of each Traffic Analysis Zone (TAZ).

Seasonal unit growth forecasts were estimated in proportion to seasonal population forecasts and the development capacity of each TAZ. As noted above, flood zones, wetlands, poor soils, etc. were excluded from the vacant land area used to determine the development capacity of each TAZ. The ratio of second homes to rental homes was held constant during the forecast period. In zones with limited development capacity, permanent home growth was given priority over seasonal unit growth, and the number of units is capped when a zone's estimated capacity was reached. In addition, no seasonal rental development is projected in Zone 17 (Wanchese) and Zones 19, 21, 25, 26, and 27 (Currituck mainland) because they are not considered to be feasible locations for seasonal rentals.

The key outcomes in terms of the growth forecasts are shown below for the Base Case, High Case and Low Case.

Table 7 Summary of Demographic Forecasts

Variable	Base Case	High Case	Low Case
Change in Rental Bedrooms* (2009 – 2040)	+100%	+170%	+67%
Change in Rental Units* (2009 – 2040)	+65%	+129%	+45%
Change in Employment in the Outer Banks (per annum)	+1.9%	+3%	+1.35%
GDP Growth (per annum)	+1.95%	+2.92%	+1.46%
GRP Growth (per annum)	+2.35%	+3.36%	+1.91%

*north of Sanderling

The results in Table 7 show that there was forecast to be:

- An increase of 100% in rental bedrooms in the Outer Banks (north of Sanderling) between 2009 and 2040, from 16,301 to 32,243, as a result of

new construction and redevelopment of existing properties. This was based on the growth forecasts for the seasonal peak population forecasts and the development capacity of the Outer Banks. The seasonal population forecasts were driven by growth in the national economy in the form of GDP growth, on the basis of that a better performing economy leads to an increase in the number of vacationers. The base case forecasts for GDP growth and GRP are shown below.

- A increase in the number of rental units of 65% in the Base (2009-2040), 129% in the High Case and 45% in the Low Case.
- A 1.9% per annum increase in employment in the study area (2009 – 2040).
- GDP growth forecast of 1.95% increase per annum 2009 – 2040;
- GRP growth forecast of 2.35% increase per annum 2009 – 2040;

It is all worth noting that based on Delta's field interviews and data collected on recent residential construction activity, new rental units have substantially more bedrooms (typically in the range of 6 -12) then the older rental inventory (typically 4- 6). This trend is projected to continue in response to observed rental market demand. It will apply both to new construction and to redevelopment of the existing rental stock as the latter occurs slowly over time. As a result, the average number of bedrooms per rental unit will increase from 4.8 in 2009 to 5.7 in 2040, assuming the average new unit contains 7 bedrooms

The outcomes of this survey fed into all stages of the modeling process. The above projections were included in the forecasting of traffic and revenue for the Project.

The demographic survey final report (Technical Memos #6) can be found in Appendix I

3 Model Development

3.1 Introduction

Due to the characteristics of the traffic flows within the study area, the Mid-Currituck Traffic Model (MCTM) was developed to include the following features in order to robustly represent current and future traffic conditions taking into account the application of a toll at the Mid-Currituck Bridge:

- The ability to model the variation of traffic flows within a given time period, with the model sub-divided into separate time periods, each with its own distinct travel characteristics and trip matrices.
- The ability to model different trip purposes to reflect their different distribution, toll sensitivity and growth patterns.
- Realistic representation of special features of the road networks, including one-way systems and banned turns.
- An assignment algorithm that recognizes the inter-relationship between traffic flows, capacities and delays (speeds).
- Toll Optimization and diversion analysis.

A summary of the model development process is outlined below. Full details of the model development can be found in Technical Memo #8, included within Appendix J.

3.2 Model Structure

The MCTM included the following stages:

i. Trip generation – the study area was sub-divided into zones and the number of trips that begin and end in each zone was identified based on the 2006 mail-back survey.

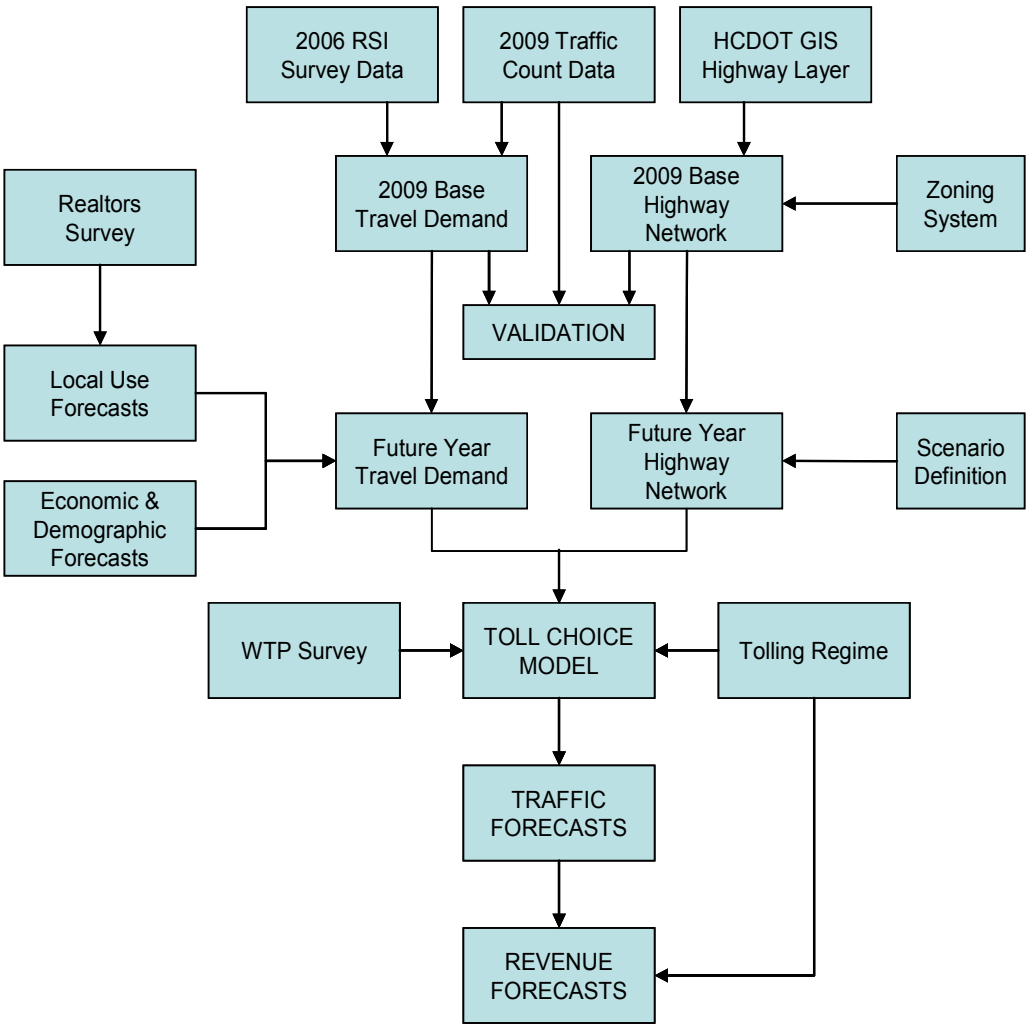
ii. Trip distribution – the number of trips between each pair of zones within the study area was estimated.

iii. Trip assignment –the trips between each pair of zones was allocated using the appropriate route.

iv. Toll choice model – determines the proportion of trips between each pair of zones that would utilize the toll road, and those who would not.

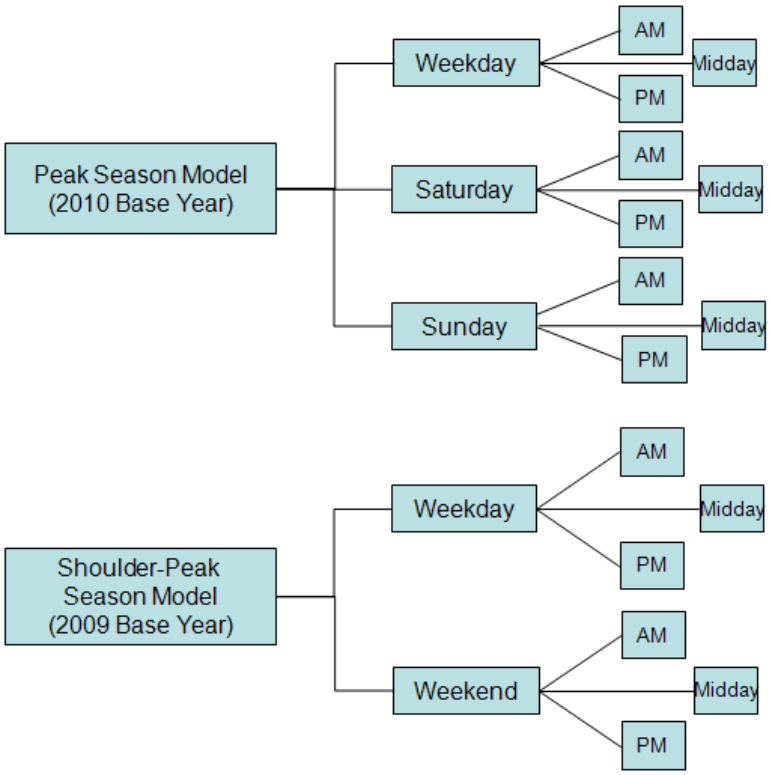
The structure of the traffic model is shown below in Figure 13.

Figure 13 Structure of the Mid-Currituck Traffic Model



A total of fifteen base year models were developed, as outlined below in Figure 14. The Peak Season models were validated to Peak 2010 traffic volumes (July), while the Shoulder-Peak models were validated to Shoulder-Peak 2009 volumes (September / October 2009). A 2010 Peak Season was modeled using the traffic data collected in the 2010 Peak Season.

Figure 14: Base Year Models



Significantly higher traffic volumes and delays were observed on Saturdays during the Peak Season associated with vacationer traffic heading to and from the Outer Banks. Sunday traffic volumes and journey times, in comparison, were considerably lower. The Realtors Survey also highlighted that the majority of rental property check-ins/outs were on Saturday. As a result in order to reflect the difference between Saturday and Sunday during the Peak Season, two sets of models were developed for peak weekends – Saturday models and Sunday models.

3.3 Market Segments

Based on analysis of the 2006 Mail-Back / Intercept survey data, four trip purposes were modeled in detail:

- To or from work (commute)
- Company business
- Other (personal business, school, shopping, social/ recreational)
- Begin or end vacation stay

In addition, these four purposes were split into local residents and visitors and were modeled independently in order to incorporate a variety of behavioral responses to the toll facility. Residents were defined as those who live in Pasquotank, Camden, Currituck and Dare Counties, while visitors were all other people who are not residents of the above named counties.

Overall, a very detailed segmentation was applied. The level of detail ensured that each modeled time period and its dominant journey purpose (vacation trips in the

weekend models and other trips in the weekday models) was replicated, and the unique characteristics that accompany each journey purpose within the study area were represented in the fifteen base year models.

3.4 Model Time Periods

As illustrated in Figure 14, fifteen base year models were developed. Each model represents an average hour during the AM peak (07:00 to 10:00), the midday inter-peak (10:00 to 16:00), and the PM peak period (16:00 to 19:00).

Overnight traffic was estimated using factors applied to the daytime (07.00 to 19.00) modeled traffic on the basis of the long term traffic count data collected in the study area.

3.5 Vehicle Types

Analysis of the 2006 Mail-Back / Intercept survey data and the 2009 and 2010 turning movement counts highlighted that the only significant vehicle category in the study area were cars/pickup vans, with the majority of count sites showing in excess of 95%.

In the absence of any detailed origin-destination survey data regarding heavy vehicles, only cars/pickup vans were modeled. Potential truck traffic utilizing the tolled facility and associated revenue was assessed outside of the traffic model using the data collected as part of the 2009 and 2010 classified turning movement survey conducted at the intersection of NC-12 and US-158 in Southern Shores.

3.6 Zone System

The zoning system is an important part of the traffic model, since it provides the basis for defining the origins and destinations of trips. The Mid-Currituck Traffic model area was subdivided into 24 internal zones, which cover the immediate study area, and 46 external zones, which cover the area of influence.

The size of traffic zones is a critical factor in determining the realism and accuracy of the traffic model. If zones are too large, the model will be unable to estimate traffic flows to the required level of precision, even if the quality of the trip table data is very good. On the other hand, if the zones are too small, the sample sizes in the cells of the trip table will be small also, affecting the accuracy of the trip and flow estimates.

Each zone contains a relatively homogenous geographical unit, with common characteristics including:

- Land-use.
- Development constraints
- Environmental constraints
- Specific growth forecasts

3.6.1 External Zones

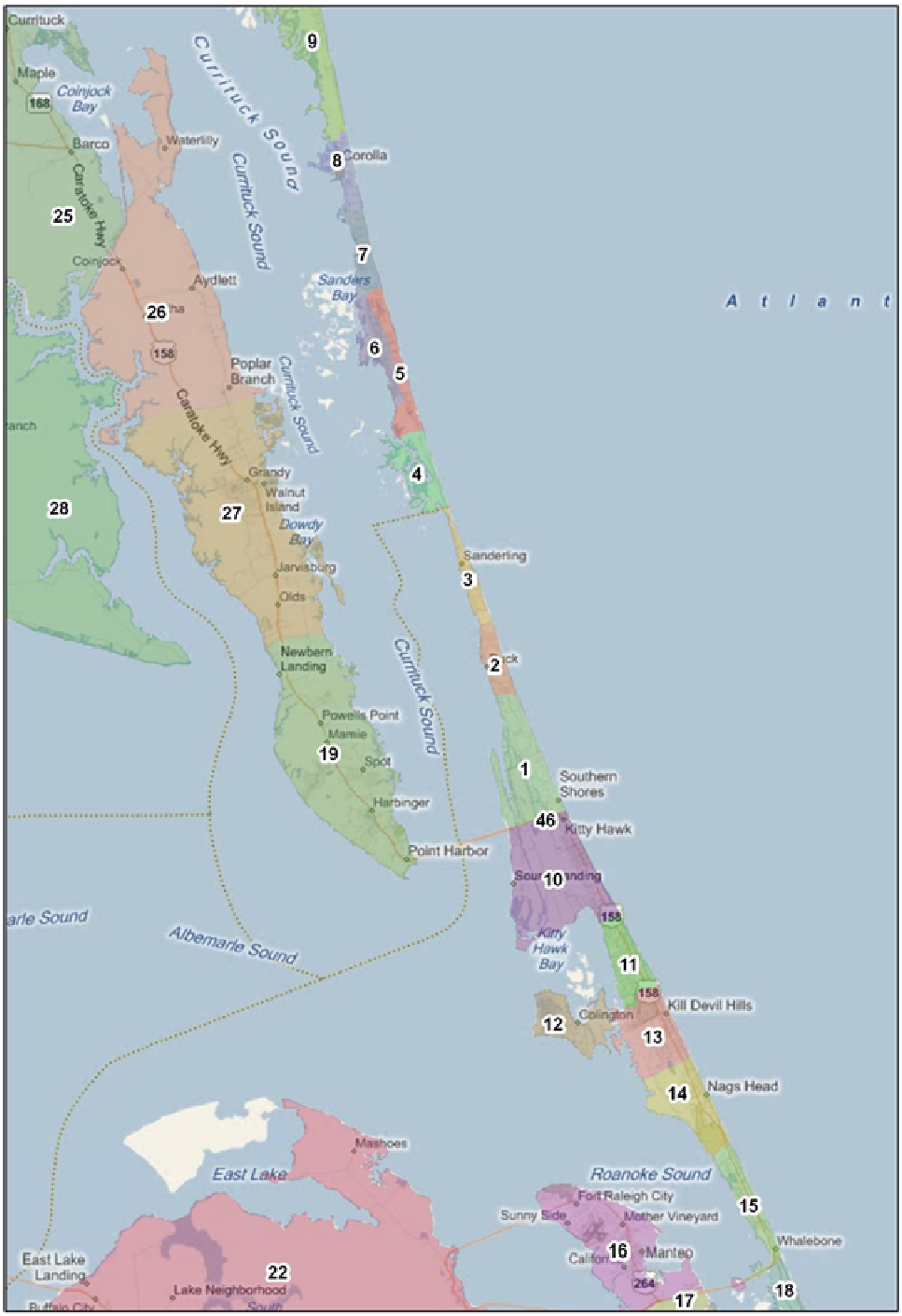
The 46 external zones were defined based on survey data collected as part of the Realtors Survey. A database of home zip codes based on signed rental contracts, comprising of approximately 160,000 records (rental contracts), was organized by zip code to determine the areas with the greatest frequency of rental contracts. The goal of this process was to identify clusters of zip codes defined by metropolitan areas or sub-metropolitan areas that have a high frequency of rental contracts. The most prolific 'sending areas' were defined as external zones within the MCTM.

3.6.2 Internal Zones

The 24 internal zones shown in Figure 15 were based on an analysis of the survey data taken from the Mail-Back / Intercept survey. Based on analysis of the 2006 zone system, the original zone system was deemed appropriate to be used as a base for the MCTM. It included sufficient detail on the Outer Banks for the study, with at least one zone associated with each major settlement.

A series of enhancements were made to the internal zone system where deemed appropriate. It was necessary to introduce a finer zoning system on the mainland to differentiate between local counties and external zones. These were previously grouped together based upon the road used to access the local study area.

Figure 15: Internal Traffic Model Zone System



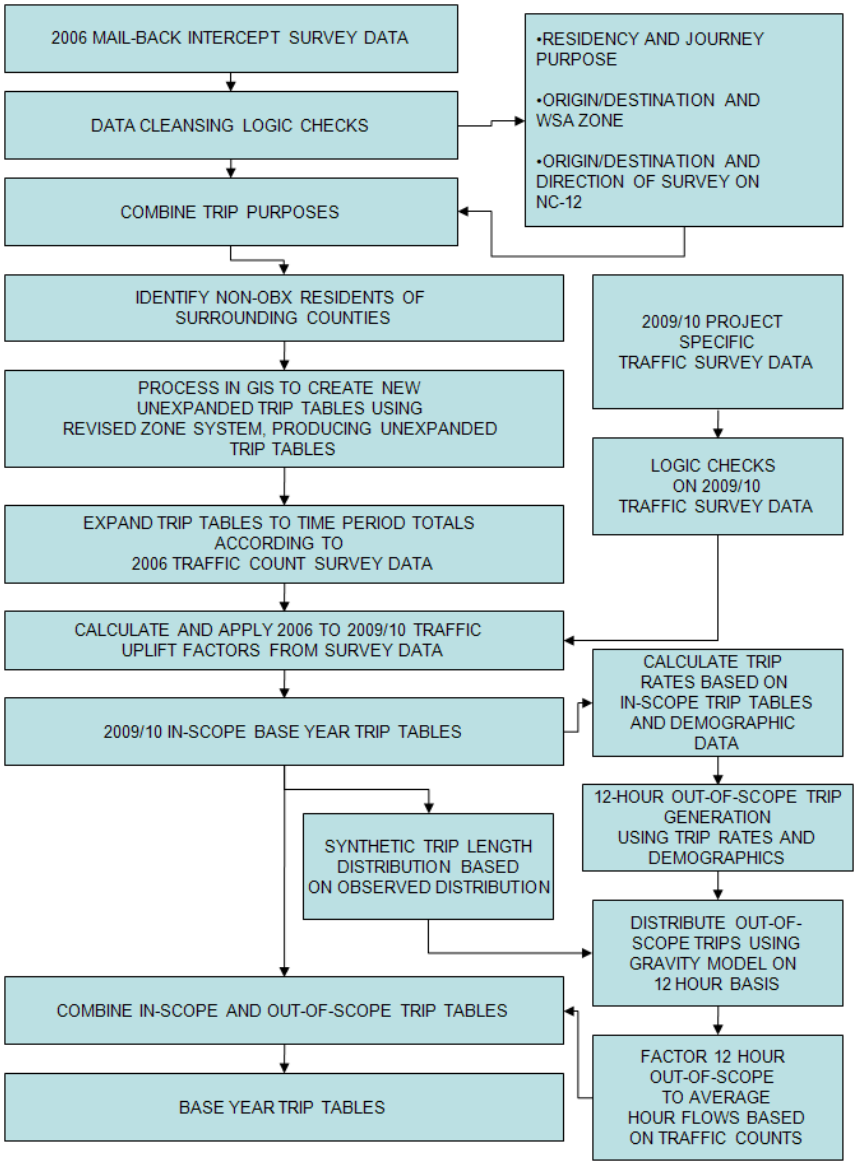
3.7 Trip Tables

3.7.1 Introduction

The overall process followed to develop the 2009/10 base year trip matrices is outlined below in Figure 16. Full details of the trip table development can be found in Technical Memo #8, included within Appendix J.

The trip tables comprise of two elements, one defined as 'In-Scope' and one defined as 'Out-of Scope'. The 'In-Scope' trip tables included those trips that were 'in-scope' to the Mid-Currituck Bridge (i.e those trips that could transfer to the Mid-Currituck Bridge). These were observed as part of the 2006 Mailback / Intercept survey and were trips that crossed the Wright Memorial Bridge on the US-158 with either origins or destinations to the north of the US-158 / NC-12 intersection. Out-of-scope trip tables included trips that were not observed as part of the 2006 Mailback / Intercept survey. These were generated using the demographic datasets and locally derived trip rates. Out-of-scope traffic was distributed at a 12 hour level using a gravity model before being disaggregated to the average hour model. It was necessary to include 'Out-of-Scope' traffic to ensure the correct amount of traffic was modeled on the US-158 and NC-12 so that observed levels congestion were reproduced within the traffic model. This is important, as a key element of developing the traffic and revenue forecasts is to incorporate the correct response to the overall level of congestion in the traffic model.

Figure 16: Trip Table Development (Average Weekday, Peak Saturday and Shoulder-Peak Weekend)



3.7.2 In-Scope Trip Tables

3.7.2.1 Mail-Back Survey Data Cleansing and Logic Checking

The mail-back intercept data was first logic checked to ensure that the dataset is robust. A series of cross-checks were conducted to ensure that the residency status and journey purposes corresponded, the origin and destination locations were correctly attributed to the previous zone system, and that the origin and destination locations matched the direction of survey on NC-12. A series of multiple regressions were also conducted, comparing the number of observed trips in the 2006 mail-back survey against a wide variety of demographic variables. This process was conducted within each season and weekday / weekend on a trip-purpose basis to ensure that the number of trips was logical compared with zonal population, employment, quantities of rental units and retail. Strong regressions

were observed for all key journey purposes and time periods. For example, visitor vacation trips were compared to available hotel and rental unit bedrooms. R-squared statistics between 0.70 and 0.92 were observed across all models. T-statistics highlighted all coefficients were statistically significant at the 95% confidence interval.

3.7.2.2 Trip Purpose Reclassification

A number of trip purposes were combined from the mail-back survey data. This gave a maximum of eight segments (four trip purposes, and two residency types). The Personal business, school, social/recreational and shopping purposes were combined to form the 'other' category.

3.7.2.3 2006 Trip Table Expansion

Traffic count data was collected at the same time and location as the mail-back intercept surveys. As the mail-back intercept survey collected only a sample of all drivers passing the survey site, the traffic count data was used to expand the survey interview records to match the total traffic volumes for each time period in each direction in 3 time bands for expansion (AM Peak – 07:00-10:00, Inter Peak-10:00-16:00, PM Peak – 16:00-19:00).

These expansion factors were appended directly to the survey records, ensuring that the detail in each survey record was retained for future data manipulation. This ensured that the journey purpose mix was retained and a variety of behavioral responses to tolling could be modeled.

3.7.2.4 2006 – 2009 / 2010 Trip Table Uplifting

In addition to the expansion of the survey sample to 2006 total traffic volumes, it was necessary to apply a further set of factors to account for traffic growth between 2006, when the surveys were undertaken, and the model base year. These were calculated based on a comparison of observed data from traffic counts undertaken in 2006, and the project specific counts collected in 2009 and 2010 for counts conducted between Southern Shores and Duck on NC-12. From this comparison, a series of growth factors were derived.

These factors were applied by season, day of week, time of day and directional basis, and were applied to the 2006 traffic volumes. A similar process was adopted to that outlined in Section 3.7.2.3, whereby the expansion factor was appended to the raw survey data. The impact of this was that all journey purpose data was retained, enabling the modeling of each journey purpose individually.

It is important to recognize that the counts were conducted during different times of the year and for different lengths of time. The purpose of this process was to ensure that the observed traffic from the intercept survey data replicates the base year traffic counts. It was not to compare the 2006 and 2009 / 2010 counts as these are not directly comparable as they were conducted at different times of the year and for different durations.

3.7.2.5 Observed Traffic Trip Tables

A total of 90 trip tables (15 time periods x 6 trip purposes) were produced for the base year models using the observed trip pattern data collected as part of the 2006 Mailback/ Intercept survey data. Resident vacation trips and visitor commute trips were not modeled as there were an insignificant number of observed trips in the 2006 Mailback/ Intercept survey. All other segments were assigned to the network individually.

3.7.3 Out-of-Scope Traffic

The 2006 Mailback/ Intercept survey includes those movements passing through the single survey site at Southern Shores on NC-12. It also included in detail all movements in scope for potential use of the Mid-Currituck Bridge. Traffic between the mainland and the southern part of the Outer Banks and short distance traffic on the Outer Banks that do not pass through the survey site was not included in the mail-back survey. It was important to include estimates of this traffic as this contributes to congestion on US-158 on the mainland, on the Wright Memorial Bridge, and on the northern part of the Outer Banks.

This chapter outlines the trip generation and distribution process for those trips considered as 'out-of-scope'. To clarify, the term 'out-of-scope' means those trips that cross the existing Wright Memorial and have origins/destination to the south (i.e. in Kitty Hawk, Kill Devil Hills, Nags Head and beyond). Consequently, these trips were not observed in the 2006 Mailback/ Intercept survey used to develop the trip table for 'in-scope' trips.

Table 8 summarizes those trips that are in/out-of-scope in terms of this process (based on whether they were fully, partially, or not observed in the WSA intercept survey), identifying those trips that were synthesized as part of this process.

Table 8: Definition of In-Scope and Out-of-Scope Trips

Origins / Destinations	**Northern Outer Banks**	**Southern Outer Banks**	**Mainland**
Northern Outer Banks	'In-Scope' Partially observed	'In-Scope'; Fully observed	'In-Scope ' Fully observed'
Southern Outer Banks	'In-Scope ' Fully observed'	'Out-of-Scope' Not observed	'Out-of-Scope' Not observed
Mainland	'In-Scope ' Fully observed'	'Out-of-Scope' Not observed	'Out-of-Scope' Not observed

While out-of-scope traffic is important in terms of modeling the correct level of congestion on the Wright Memorial Bridge, the 'out-of-scope' trips are not likely to use the new Mid-Currituck Bridge given that the bridge would not provide significant time savings due to their origins / destination being in the southern section of the Outer Banks. Therefore, the important issue including out of scope traffic was to ensure journey times and congestion experienced by in-scope trips was accurately reflected.

Two inputs were incorporated into the out-of-scope trip table generation and distribution as follow:

- Observed trip movement data, from which the trip length distribution (TLD) was extracted and against which the synthetic trip tables were validated. The WSA survey data was used to this effect; and
- Zonal planning data (as developed by Delta Associates) from which trip ends were estimated.

Total trip ends were calculated on a 12-hour basis for each journey purpose, model season and day of the week utilizing the demographic data and locally derived trip rates. The trips rates were calculated using the following approach:

- The number of in-scope trips was calculated for each zone in each model and combined to represent a 12-hour total.
- Regressions were run for the number of trip origins and destinations in each zone against each demographic variable, highlighting relationships between each journey purpose and the demographic characteristics of the area.

The resulting coefficients represented the number of trips generated per unit of each demographic variable (i.e. the trip rates). These trip rates were applied to all zones within the model to generate 12 hour totals for trip generation and attraction. These 12 hour zonal trip totals were imported into the gravity models.

A Tanner function of the form shown below was fitted to the observed trip length distributions for each journey purpose, season and day of week

Equation 1: Tanner Function

$$f(c_{ij}) = c_{ij}^{\alpha}.\exp(-\beta c_{ij})$$

where,

$f(c_{ij})$ = generalized function of travel costs

α and β = parameters for calibration

The model was calibrated using observed average trip lengths taken from the 2006 Mailback/ Intercept survey and the Realtors survey database, and the 12-hour out-of-scope trip tables were generated for each season and day of the week. Logic checking was undertaken to ensure that the gravity model produced a sensible representation of the observed trip length distribution. The output 12-hour trip tables were then factored to represent each average hourly model (AM, Midday and PM Peak) using factors output from analyses of the available traffic survey data.

3.8 Peak Sunday Model Development

In the absence of data collected on a peak Sunday (from the 2006 Mailback / Intercept Survey), the peak Sunday models were developed using observed trip data from both the weekday and Saturday survey data. This approach was adopted as the Sunday model was expected to share characteristics with both the weekday and Saturday traffic, with some long-distance visitor vacation traffic still arriving/departing the study area (in line with the Saturday observations), but also a greater proportion of local traffic (in line with the weekday observations).

Therefore synthetic models were developed for the peak Sunday period. These were developed using matrix estimation. Full details are included within Appendix J.

3.9 Network Development

The highway network was represented in the model by links, each of which has a variety of attributes associated with it. Link attributes in the MCTM include:

- the reference numbers at the ends of the link (i.e. 'nodes');
- the link length;
- the base year travel speed on the link (during the time period being modeled);
- the speed-flow relationship appropriate for the link;
- the link capacity;
- whether the link operates in both directions or in one direction only; and
- any restrictions to particular vehicle types using the link.

The network was developed based on GIS information available from NCDOT. The available GIS layer included link distance and the number of lanes. Additional information regarding other road characteristics was appended to the network for use within the assignment process including link classification, the number of lanes, free flow travel times and volume delay functions.

A range of logic checks were conducted on the network before zonal information was appended to the network. This process is outlined below:

- Logic checking of existing link-based information (speed, number of lanes, classification etc.).
- The coding of the zone system, including the coding of both internal and external centroid connectors.
- Logic checking of centroid locations and centroid connector characteristics (network connection locations).

Finally, capacities and speeds were appended to the network based on the Highway Capacity Manual (2000) and observations made during site visits to the Outer Banks. The base year model consisted entirely of buffer networks with no detailed junction simulation. This was deemed appropriate given the strategic nature of the model.

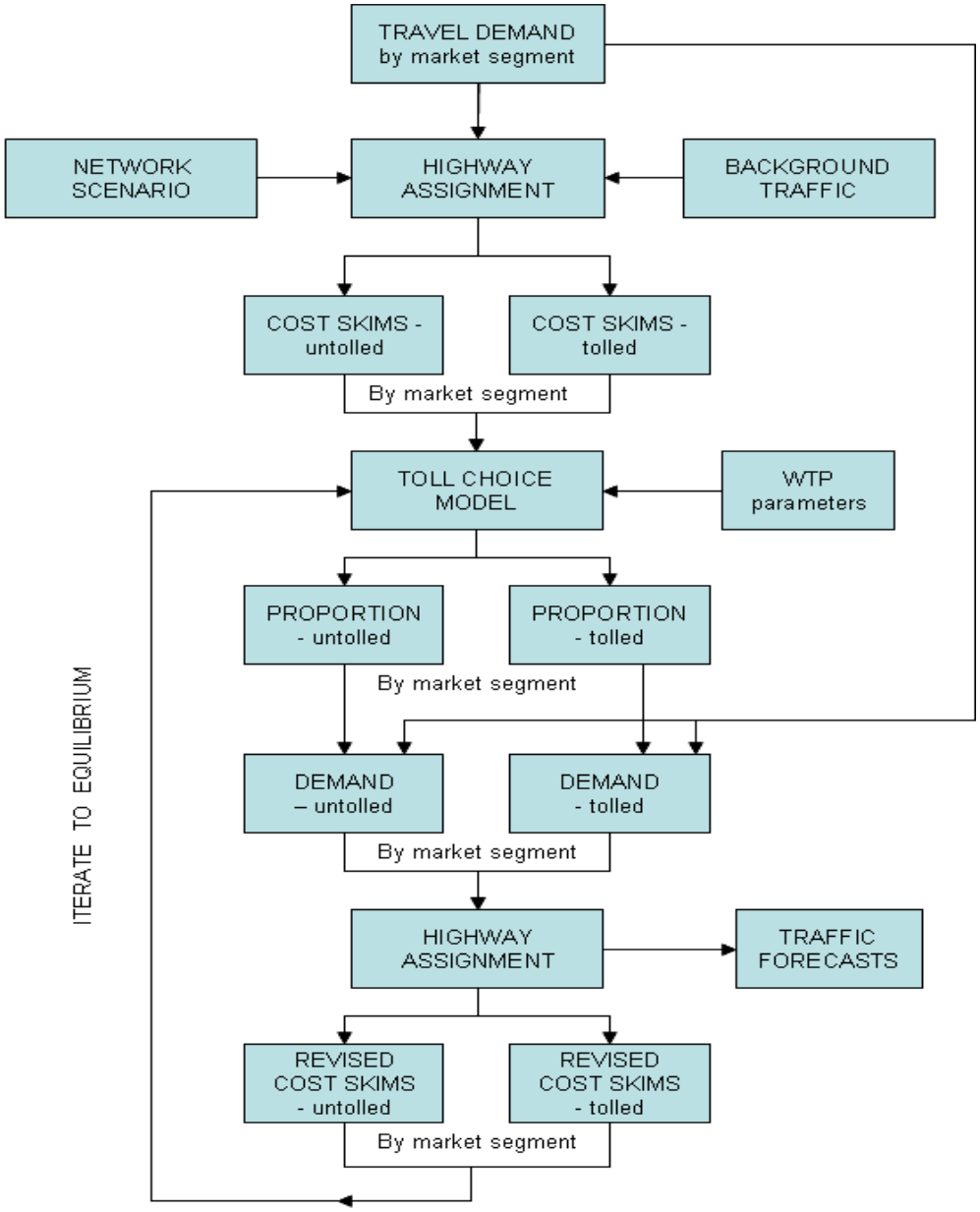
A detailed review of NCDOT's State Transportation Improvement Program (STIP, June 2008) indicated that there are currently no committed improvements within the study area in addition to the ones identified as the Preferred Alternative for the Project. The Preferred Alternative includes several improvements to be constructed as part of the construction scope of the Project. These improvements were deemed to have a very minor impact on forecast traffic and revenue. As such, the future year networks were identical to the base year network with the exception of the Mid-Currituck Bridge.

3.10 Assignment and Toll-Choice Model

The assignment process is outlined below in Figure 17. While there are no toll facilities within the MCTM base year model, the base year demand will be utilized in a series of toll optimization runs to aid in establishing optimal toll rates for different toll products. The assignment algorithm transfers the congested network highway travel times from the highway assignment models into the toll-choice model. This process compares tolled and untolled generalized costs, allowing the proportions of traffic which use the tolled and free facilities to be calculated. All out-of-scope traffic will be restricted from using the tolled facility.

The subsequent proportions were then applied to the input matrices and the model re-runs the assignment based on the revised tolled and untolled input matrices. This is an iterative procedure which continues until equilibrium is established.

Figure 17 Assignment Model and Toll Choice Model Structure



4 Base Year Model Calibration and Validation

4.1 Introduction

Model validation is a check which ensures the model reflects observed trip patterns and journey times on the main routes in the study area. The data utilized in the validation process is independent of the data used in the model development. This data was not utilized within the model development. Model validation serves several purposes:

- To provide a level of comfort to decision makers that the model reproduces observed data.
- To provide evidence that the model results are accurate enough to be used for the desired analysis.
- To account for the errors in observed data used for comparisons.

The following was undertaken as part of the approach to the model validation:

- Validation of modeled traffic volumes;
- Validation of modeled turning movements at the NC-158/NC-12 intersection; and
- Validation of modeled journey times between Barco and the end of NC-12, north of Corolla.

Full details of the model validation can be found in Technical Memo #8, included within Appendix J.

4.2 Validation Criteria

No specific model validation criteria exist in North Carolina, as with many south-eastern states. However, criteria have been developed for Florida (FSUTMS – Florida State Urban Transportation Model Structure) based on national research. Acceptability criteria for each validation criteria were developed as part of this. A summary of the relevant FSUTMS standards and acceptability criteria are outlined in Table 9 below. These were used as the basis for the validation criteria for the MCTM and represent a rigorous set of criteria against which the model was validated

Table 9: Model Validation Acceptability Criteria

Model Statistic to Evaluate	**Road Type / Typical Volume**	**Accuracy Standard**
Volume over Count	Freeway	+/-7%
	Divided / Principal Arterial	+/-10%
	Minor / Undivided	+/-15%
	Collector	+/-20%
	Frontage Road	+/-25%
Root Mean Squared Error (RMSE)	< 5k ADT	+/-45% to +/- 100%
	5k to 10k ADT	+/-35% to +/- 45%
	10k to 15k ADT	+/-27% to +/- 35%
	15k to 20k ADT	+/-25% to +/- 30%
	20k to 30k ADT	+/-15% to +/- 27%
	30k to 50k ADT	+/-15% to +/- 25%
	50k to 60k ADT	+/-10% to +/- 20%
	> 60k ADT	+/-10% to +/- 19%
	Areawide	+/-30% to +/- 50%
Percentage Error	<10k Volume	+/-25% to +/- 50%
	10k to 30k Volume	+/-20% to +/- 30%
	30k to 50k Volume	+/-15% to +/- 25%
	50k to 65k Volume	+/-10% to +/- 20%
	65k to 75k Volume	+/-5% to +/- 15%

The GEH (Geoffrey E. Hayes' goodness of fit) statistic was also included. A GEH value below 5 indicates that the model at that location is a very good representation of observed conditions. A GEH statistic between 5 and 10 is acceptable, while a value greater than 10 indicates that a specific location within the model needs additional attention. GEH statistics are reported for each count site in each direction. The GEH statistic takes into account the magnitude of the traffic volume in question in its calculation. Therefore, the higher the traffic volume, the lower the accepted tolerance.

The GEH Statistic is defined as;

$$GEH = \sqrt{\frac{(V_2 - V_1)^2}{(V_1 + V_2)/2}}$$

4.3 Validation Results

The detailed validation results are presented in Appendix J. This shows the detailed validation of link flows, turning movements and journey times. Table 10 summarizes the validation results against the acceptability criteria for each measure, as outlined above. The detailed link flow validation for the Peak Saturday PM Peak period is shown in Figure 18 and the Peak Saturday Journey Time validation results are shown in Figure 19.

The following is a brief commentary on the results

Root Mean Square Error between Modeled and Observed Traffic Flows (RMSE):

- All models are within the acceptability criteria (of 30%) for RMSE on an individual modeled hour basis with the exception of the Peak Weekday PM model (31%) only marginal.
- When aggregating the model results to represent average daily traffic within each season and grouping sites based on average daily traffic, all models and groups meet the required criteria.
- Area wide RMSE varies between 5% and 26%, within the acceptable standard of +/-30%.

Percentage Error:

- 100% of sites meet these criteria (shown in Table 9) within the Peak Sunday model.
- Over 86% of all sites are within the compliant standards in terms of percentage error

GEH Statistic:

- Between 68% and 93% of count locations meet the preferred GEH criteria (less than 5) across the 15 models. The strongest validation in terms of GEH is found in the Sunday model.
- Over 91% of count locations meet the acceptable GEH standard (less than 10).

Turning Movements:

- The key movements (Wright Memorial Bridge to NC-12 northbound and vice versa) are acceptable (GEH less than 10) in all models. Most models showed a GEH less than 5 for these movements.
- The turning movement validation highlighted that the models were representative of the observed data, with 14 out of 15 models showing 50% or more movements with a GEH less than 5.

Journey Time Validation:

- 93% of journey time routes (30 in total) were within the +/- 15% acceptability criteria.
- The shoulder-peak weekday Midday model was the only model not to fully achieve the criteria, with a variance just outside the tolerance of 16% and 20% from the observed journey times.

Given the strategic important of the Wright Memorial Bridge in the existing road network the specific modeled and observed speeds on the bridge were compared for each base year model. The results of this comparison are shown in Table 10. These results show that the modeled speeds were accurately reflected in each time period.

Based on the above criteria a high level of validation was achieved, and the model provides a sound basis for developing the traffic and revenue forecast.

Table 10: Base Year Validation Summary

Model Statistic to Evaluate	Road Type / Typical Volume	Criteria	PK WD AM	PK WD MD	PK WD PM	PK SA AM	PK SA MD	PK SA PM	PK SU AM	PK SU MD	PK SU PM	SPK WD AM	SPK WD MD	SPK WD PM	SPK WE AM	SPK WE MD	SPK WE PM
Root Mean Squared Error (RMSE) (Time Period)	Average Hour	+/-30%	23%	27%	31%	12%	15%	22%	13%	11%	12%	19%	18%	17%	17%	17%	17%
Root Mean Squared Error (RMSE) (Average Daily Traffic)	< 5k ADT	+/-45% to +/-100%	12%			71%						26%			40%		
	5k to 10k ADT	+/-35% to +/-45%	10%			11%						20%					
	10k to 15k ADT	+/-27% to +/-35%	15%												10%		
	15k to 20k ADT	+/-25% to +/-30%							6%								
	20k to 30k ADT	+/-15% to +/-27%				8%											
	30k to 50k ADT	+/-15% to +/-25%															
	50k to 60k ADT	+/-10% to +/-20%															
	> 60k ADT	+/-10% to +/-19%															
	Areawide	+/-30% to +/-50%	26%			12%			5%			16%			11%		
Percentage Error (Average Daily Traffic)	All	Compliant %	86%			91%			100%			86%			86%		
Volume over Count (Time Period)	All Links	Compliant %	55%	68%	64%	73%	77%	73%	77%	95%	77%	50%	55%	73%	55%	82%	64%
GEH (Time Period)	All Links	<5 (Preferred)	77%	82%	68%	82%	73%	82%	86%	93%	93%	86%	86%	86%	77%	82%	77%
GEH (Time Period)	All Links	<10 (Acceptable)	95%	91%	91%	95%	100%	91%	100%	100%	100%	100%	100%	100%	100%	95%	100%
Journey Time - Inbound		+/-15%	-7%	9%	2%	2%	4%	1%	-9%	15%	3%	8%	20%	11%	7%	15%	-11%
Journey Time - Outbound		+/-15%	-7%	12%	7%	9%	2%	-11%	4%	12%	2%	10%	16%	11%	3%	14%	8%
Turning Movements (GEH) (Time Period)		<5	67%	50%	50%	50%	67%	50%	83%	100%	67%	50%	100%	67%	67%	83%	83%
Turning Movements (GEH) (Time Period)		<10	100%	100%	100%	83%	83%	67%	100%	100%	83%	100%	100%	100%	67%	100%	100%

Key; PK; Peak, SPK, Shoulder Peak, WD; Weekday, SA, Saturday, SU, Sunday, AM (Morning), MD; Midday, PM (Afternoon).

Figure 18 Base Year 2010 Peak Saturday PM Peak Link Flow Validation

Direction	Count Site	Observed Flow (Veh/hr)	Modeled Flow (Veh/hr)	Difference	GEH	% Difference
NB/WB	1	637	541	-96	3.9	-15%
	2	597	610	13	0.5	2%
	3	512	512	0	0.0	0%
	4	1306	982	-324	9.6	-25%
	9	260	312	52	3.1	20%
	10	971	1028	57	1.8	6%
	11	933	936	3	0.1	0%
	12	929	941	12	0.4	1%
	13	381	182	-199	11.8	-52%
	14	661	775	114	4.2	17%
	F/G	962	1028	66	2.1	7%
SB/EB	1	556	447	-109	4.9	-20%
	2	474	583	109	4.7	23%
	3	713	713	0	0.0	0%
	4	1736	1055	-681	18.2	-39%
	9	321	281	-40	2.3	-12%
	10	1450	1425	-25	0.6	-2%
	11	1405	1484	79	2.1	6%
	12	1079	958	-121	3.8	-11%
	13	162	210	48	3.5	30%
	14	1021	1230	209	6.2	20%
	F/G	1552	1425	-127	3.3	-8%

Figure 19 Base Year 2010 Peak Saturday Journey Time Validation

Route	Modeled (min)		Observed (min)		% Difference	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Peak Saturday AM	74	90	72	82	2%	9%
Peak Saturday MD	137	86	132	84	4%	2%
Peak Saturday PM	222	74	219	84	1%	-11%

Table 11: Comparison of Modeled and Observed (Peak Season 2010) Wright Memorial Bridge Speeds (mph)

Time of Day	**Direction**	**Peak Weekday**		**Peak Saturday**		**Peak Sunday**	
		Modeled	**Observed**	**Modeled**	**Observed**	**Modeled**	**Observed**
AM	Eastbound	52	45	48	45	51	46
	Westbound	51	52	36	44	45	49
MD	Eastbound	51	45	18	13	42	33
	Westbound	49	49	44	38	45	48
PM	Eastbound	50	44	12	9	49	46
	Westbound	49	48	48	37	46	46

5 Future Year Model Development

5.1 Introduction

Three future year models, each comprising of fifteen sub-models representing the individual peaks, days and average hours, were developed for the Mid-Currituck Bridge traffic and revenue forecasts. These cover:

- 2015 (opening year)
- 2020
- 2030

The study area and zone system used in the base year model were retained in the forecasting models. The demographic and socioeconomic study (conducted by Delta Associates) confirmed that there was no need to change the zoning system as it contained sufficient detail for the accurate representation of future year development. The MCTM coverage includes the area of influence surrounding the Mid-Currituck Bridge as defined by the realtor's survey rental contract database, and contains a total of 70 zones. Full details of the forecasting model development can be found in Technical Memo #9, included within Appendix K.

5.2 Traffic Growth

5.2.1 Weekday & Saturday Models

Regression analysis was used to develop trip generation rates specific to the Outer Banks for each trip purpose contained within the model. These trip rates were then used to derive future trip generation based on the demographic and socio-economic forecasts. This was undertaken for each journey purpose on a zone-by-zone basis. These relationships were utilized in developing the future year trip tables. The trips rates were derived based on the regression analysis using the current demographic and socio-economic data collected during the Demographic survey and the trip data taken from the 2006 Mailback / Intercept survey. Full details regarding the demographic forecasts, their development and all associated assumptions can be found in the Demographic Survey Final Report by Delta Associates (Appendix I).

The relationships were utilized in forecasting growth in traffic by journey purpose for the peak weekday and Saturday models, and the shoulder-peak weekday and weekend models. The growth in each demographic variable, shown in Figure 20, was input to the relevant equations to calculate the increase in observed traffic for each zone during each day (i.e. peak weekday, shoulder peak weekday etc.).

These daily trips were then distributed between the three models (AM, MD and PM) according to the observed temporal distribution from the 2006 Mailback / Intercept survey, before being distributed spatially in line with the base year distribution.

Where trips were not observed in particular zones in the base year model due to sampling in the 2006 Mailback / Intercept survey but growth was forecast, a

distribution was seeded for that particular zone. This seeded distribution (based on either an average distribution from across all zones within the Northern Outer Banks or an entirely synthetic distribution) was then factored so that the row and column totals associated with those zones were equal to the forecast number of trips that were calculated in the trip generation stage.

Figure 20: Demographic Forecasts – Compound Annual Growth Rates (CAGR)

CAGR			Peak Weekday							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	1.96%	2.92%	1.97%	2.62%	0.36%	0.39%	2.43%	-
2015	2020	2.70%	1.89%	3.65%	2.46%	2.44%	0.21%	0.25%	3.23%	11.30%
2020	2030	1.99%	1.19%	1.94%	1.54%	1.38%	0.06%	0.16%	1.85%	3.54%
CAGR			**Peak Saturday**							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	1.96%	2.92%	1.97%	2.56%	0.36%	0.39%	2.44%	-
2015	2020	2.70%	1.89%	3.65%	2.46%	2.44%	0.21%	0.25%	2.97%	9.02%
2020	2030	1.99%	1.19%	1.94%	1.54%	1.38%	0.06%	0.16%	1.68%	3.15%
CAGR			**Peak Sunday***							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	N/A	N/A	N/A	N/A	N/A	N/A	2.33%	-
2015	2020	2.70%	N/A	N/A	N/A	N/A	N/A	N/A	2.94%	8.05%
2020	2030	1.99%	N/A	N/A	N/A	N/A	N/A	N/A	1.70%	4.56%
CAGR			**Shoulder-Peak Weekday**							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	1.96%	2.92%	1.97%	2.56%	0.36%	0.39%	2.94%	-
2015	2020	2.70%	1.89%	3.65%	2.46%	2.44%	0.21%	0.25%	3.32%	10.28%
2020	2030	1.99%	1.19%	1.94%	1.54%	1.38%	0.06%	0.16%	1.92%	3.11%
CAGR			**Shoulder-Peak Weekend**							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	1.96%	2.92%	1.97%	2.56%	0.36%	0.39%	3.00%	-
2015	2020	2.70%	1.89%	3.65%	2.46%	2.44%	0.21%	0.25%	3.20%	8.36%
2020	2030	1.99%	1.19%	1.94%	1.54%	1.38%	0.06%	0.16%	1.83%	3.02%
CAGR			**Off-Peak Weekday**							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	N/A	N/A	1.97%	2.56%	0.36%	0.39%	N/A	-
2015	2020	2.70%	N/A	N/A	2.46%	2.44%	0.21%	0.25%	N/A	13.33%
2020	2030	1.99%	N/A	N/A	1.54%	1.38%	0.06%	0.16%	N/A	3.11%
CAGR			**Off-Peak Weekend**							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	N/A	N/A	1.97%	2.56%	0.36%	0.39%	N/A	-
2015	2020	2.70%	N/A	N/A	2.46%	2.44%	0.21%	0.25%	N/A	12.96%
2020	2030	1.99%	N/A	N/A	1.54%	1.38%	0.06%	0.16%	N/A	3.02%
CAGR			**Annual Average Day**							
Period		GDP	Seasonal Population	Seasonal Employment	Permanent Population	Rental Bedrooms	Visitor Car Ownership	Resident Car Ownership	Trip Table Growth (Pre-Induced)	MCB Traffic Growth
2009	2015	1.81%	N/A	N/A	1.97%	2.56%	0.36%	0.39%	N/A	-
2015	2020	2.70%	N/A	N/A	2.46%	2.44%	0.21%	0.25%	N/A	11.17%
2020	2030	1.99%	N/A	N/A	1.54%	1.38%	0.06%	0.16%	N/A	3.31%

Forecast trip table growth is shown in Table 12below.

Table 12: Forecast Trip Table Growth - by Day Type (annual growth rates)

Period	Peak Weekday	Peak Saturday	Peak Sunday	Shoulder Peak Weekday	Shoulder Peak Weekend
2009 – 2015	2.43%	2.44%	2.33%	2.94%	3.0%
2015 – 2020	3.23%	2.97%	2.94%	3.32%	3.2%
2020 - 2030	1.85%	1.85%	1.68%	1.92%	1.83%

5.2.2 Long Term Growth Rates

The long term growth rates (beyond 2030) applied to the traffic and revenue forecasts for the period 2030 – 2065 are shown in Table 13. The long term growth rates are based on the extrapolation of forecasted growth rates exhibited between 2020 and 2030. A reducing level of growth was assumed beyond 2030 as the level of capture by the bridge and the level of growth relating to future development on the Outer Banks stabilizes.

Table 13: Mid-Currituck Bridge Long Term Growth Rates

Period	% Annual Growth
2030 - 2035	2.00%
2035 - 2040	1.50%
2040 - 2045	1.00%
2045 - 2050	0.75%
2050 Onwards	0.50%

5.2.3 Peak Sunday Models

As the origin / destination data collected during the 2006 Mailback / Intercept survey undertaken by WSA in 2006 was only collected on a Saturday, synthetic models were required for the peak Sunday models. As a result, the growth forecasting methodology detailed above was not appropriate for the peak Sunday model. Growth in the peak Sunday model was forecast and applied using the following methodology:

i. growth by origin-destination pair in the Peak Saturday model was calculated by dividing the forecast year trip table (prior to induced traffic) by the base year trip table to calculate a table of growth factors by origin-destination pair and journey purpose.

ii. the peak Sunday base year trip table was multiplied by the table of growth factors by origin-destination pair for each journey purpose to calculate a peak Sunday trip table for each forecast year.

5.2.4 Induced Traffic

The impact of induced traffic was forecast as a proxy for a number of behavioral responses, including the generation of new trips, trip frequency and trip

redistribution responses relating to the implementation of the Mid-Currituck Bridge.

An elasticity-based induced traffic module was integrated into the Mid-Currituck traffic model. The elasticity-based approach used the generalized costs (including vehicle operating costs as a function of distance) for each movement within the model. These were extracted for both a 'no-build' scenario and the standard forecasting scenarios (including the new tolled facility). The change in the generalized cost between the no-build and 'build' scenario was then calculated.

Where a generalized cost change was observed, an elasticity factor was applied to the cost difference in order to calculate the absolute number of induced trips in each sector-to-sector movement. The elasticity applied was based on U.S. research and Federal guidance. The U.S. DOT Highway Economic Requirements System (HERS) investment analysis model uses a travel demand elasticity factor of –0.8 for the short term and –1.0 for the long term (Federal Highway Administration, 2000)

5.2.5 Growth in Car Ownership

The forecasts also included an increase in the level of car ownership. Differential growth rates were applied to the visitor and resident trip rates utilized in the future year trip table development, based on the Delta Associates car ownership forecasts. The growth rates forecast in internal zones were applied to resident journey purposes, while the rates forecast in external zones will be applied to visitor journey purposes. The car ownership growth forecast assumptions are shown in Table 14

Table 14: Car Ownership Forecasts (Delta Demographic Forecasts)

	Internal Zones	**Growth (from 2009)**	**External Zones**	**Growth (from 2009)**
2009	0.961		0.638	
2015	0.984	2.39%	0.651	2.15%
2020	0.997	3.70%	0.658	3.22%
2025	1.006	4.67%	0.662	3.76%
2030	1.013	5.37%	0.662	3.83%

5.3 Values of Time

There is a strong relationship between VOT and personal or household income and with trip purpose. The willingness to pay survey provided VOTs for each market segment, specific to the unique characteristics of the study area, and the typical patrons of the proposed bridge. These were provided for four different income bands.

Weighted average values of time (shown in Table 15) were produced using the zonal household income data from Delta Associates, who developed the income distribution dataset, the 2006 Mailback / Intercept survey trip distribution, and the realtors' survey contract database. This process was required to ensure that the values of time represented the income distributions observed within the study area rather than those observed in the WTP sample.

Table 15: Base Year Values of Time Per Hour (2009 $)

Market Segment	VOT (2009 $US)	Comments
Resident – Business	$10.69	Weighted according to the Realtors Contracts Database (visitor trip purposes) and the observed trip distribution (resident trip purposes)
Resident – Commute	$10.02	
Resident – Other	$11.59	
Visitor – Vacation	$14.25	
Visitor – Business	$11.04	
Visitor - Other	$11.97	

5.3.1 Multiple Occupancy

The values of time for resident commuter trips were adjusted to allow for multiple occupancy trips which include more than one financial contributor to the toll. This was based on an analysis of vehicle occupancy by journey purpose taken from the 2006 Mailback / Intercept survey.

The weighted average occupancy of resident commute trips based on analysis of the WSA intercept survey data was found to be 1.3, indicating that carpooling is present and many of these vehicles are occupied by multiple economically active occupants. It would be expected that the toll would be shared by all occupants and, as such, it is proposed to apply this factor to the value of time detailed in Table 15 within the forecasting models.

Adjustments were not applied to other journey purposes. Visitor vacation trips showed the greatest levels of multiple passenger occupancy. However, these did not exceed 6 occupants within a vehicle. While it was possible that these occupants may include more than one financial contributor to the toll, it was not possible to ascertain the proportion of these. It was assumed that these were predominantly large families rather than multiple families carpooling. As such, the approach assumed no adjustments would be made to these journey purposes. Multiple passenger occupancy was considerably lower for 'resident other' trips and no adjustment was justified based on the data

5.3.2 Value of Time Escalation

It is generally accepted that the VOT exhibits real growth over time. One of the most important considerations in assessing the change in value of time is the disposable income available to potential users. Growth in GDP / GRP per capita was used as a proxy in terms of assessing growth in disposable income. Our previous experience and available research highlights the relationship between real income level growth and toll road patronage. For example, guidance recommends the use of the GDP per capita as a measure of income and also as a driver of the value of time growth. As part of the demographic survey, US GDP and study area GRP forecasts (Currituck and Dare counties) were developed. These datasets were used to escalate the VOT. These are shown below in Table 17.

5.4 Optimization Methodology

An extensive toll optimization program was undertaken using the base year model and future year network. The base year model was used to optimize the toll rates given that it had been validated against current traffic flows and travel times within the study area. The network used was the network assumed to be in place in the year of opening of the bridge. The only modification to the network was the inclusion of the Mid-Currituck Bridge, excluding all other network modifications. A wide range of tolls were applied to each of the 15 base year models in order to identify the revenue maximizing toll rates. This process was conducted based on time period, residency status, and direction of travel (to or from the Outer Banks).

The revenue maximizing toll rates from this process were utilized in defining the frequent user toll policy which forms one of two forecasting scenarios which were developed.

5.5 Non-Modeled Periods

The tolls for the overnight and off peak periods were estimated based on optimizations performed using the midday models, which were taken from the appropriate model with trip demand reduced to an average overnight / off-peak hour, as well as using factors derived from the NCDOT permanent count site. The midday models were chosen as they did not include the significant imbalance in directional flows observed during the weekend AM and PM periods.

5.6 Vehicle Operating Costs

Perceived vehicle operating costs were incorporated in the model in the assignment and toll choice procedures. Perceived vehicle operating costs include ‘out of pocket’ costs for a particular journey, and therefore costs associated with fuel, oil maintenance and tire wear. Other costs, including insurance, vehicle ownership costs, financing and depreciation, have been excluded as they are not considered as an element of perceived costs in route choice decision making. An average value of $0.154 per mile was included. Full details are included within Appendix K

5.7 Congestion Factor

An adjustment for the time spent in congested conditions was applied to the generalized cost calculation. Research indicates that time spent in congested conditions is valued more highly and therefore an adjustment was made to the cost of travel in the MCTM to allow for this

Analysis of the WTP survey data undertaken by RSG indicated that the time spent in congested conditions was in fact valued more highly and therefore an adjustment was made to the cost of travel in the traffic model to allow for this. A weight of 1.2 was calculated using the locally collected WTP survey data. Therefore, in the model, the proportion travel time spent in excess of free flow conditions had an additional weight of 1.2 applied in the overall cost of that specific journey.

5.8 Annualization

Annualization factors were produced based on the NCDOT Wright Memorial Bridge permanent count side data. These are shown in Table 17 below. Full details are included within Appendix K. These factors were used to convert the following;

- Peak of Peak Season 12 Hour to Average Peak Season 24 Hour (Weekday, Saturday and Sunday).
- Shoulder Peak Season 12 Hour to Shoulder Peak Season 24 Hour (Weekday and Weekend Day).
- Shoulder Peak Season to Off Peak Season (Weekend and Weekday).

The traffic forecasts were then annualized based on the number of days assumed within each season, which is also shown in Table 17.

5.9 Ramp-Up

A longer ramp-up period was assumed for residents as the willingness to pay survey highlighted some resistance to using the new bridge. It is expected that this reluctance to use the new facility will diminish once potential users see the benefits of the new crossing. A shorter ramp-up period has been assumed for visitors, relating to the role of the Realtors in marketing the bridge and its benefits. This is because it is intended that the realtors will distribute material regarding the bridge as part of the package of information sent to visitors to the Outer Banks in advance of their vacations. Therefore, visitors will have a good understanding of the benefits of using the bridge before planning their journeys.

The ramp up assumptions are shown in Table 16

Table 16: Ramp-Up Factors

Year	Residents	Visitors
2015	70%	90%
2016	80%	95%
2017	90%	100%
2018 onwards	100%	100%

5.10 Toll Choice Methodology

The likelihood of paying tolls was forecasted outside the assignment model using a logit choice model. This model compared the generalized costs via the tolled route and by avoiding the tolls, subsequently estimating the proportion of trips that will use the motorway. The toll choice model was a binary (toll/non-toll) pre-route choice model, undertaken for all six market segments. The binary choice structure was preferred over an assignment based approach using generalized costs that included tolls in the route choice procedure, since it was likely to give more stable and realistic results, and avoid simplistic 'all or nothing' responses.

Traffic splits between the tolled motorway and the existing road network were based on forecast probabilities, calculated from the cost differences between the alternatives. This avoided the potential instability of an assignment based

approach, in which a small change in costs on one route could trigger all forecasted traffic to switch from one alternative to the other.

The logit model determined the probability of selecting the toll bridge based on the time and cost savings. The model had the following structure:

$$P_{toll} = exp(-\lambda * C_{toll}) / [exp(-\lambda * C_{toll}) + exp(-\lambda * C_{notoll})]$$

Where Ptoll is the proportion of trips that will pay the toll, Ctoll is the cost via the tolled route and Cnotoll is the cost via the non tolled route.

Toll choice coefficients were developed for each trip purpose. These toll model parameters were determined by the stated preference survey conducted by NuStats.

5.11 Forecasting Assumptions

A summary of all forecasting assumptions used in the model is shown in Table 17.

Table 17: Forecasting Assumptions

Category	Variable	Forecasting Assumption	Comments
Concession Period	Opening Year	2015	In accordance with design specifications
	End of Concession	2061	50 year concession
	Modeled Years	2015, 2020, 2030	As previously agreed with CDG
Network Assumptions	Mid-Currituck Bridge Alignment	C1	In accordance with design specifications
	Mid-Currituck Bridge Capacity (vehicles per hour per lane)	1800	In accordance with design specifications and HCM recommendations
	Toll Bridge Distance (Miles)	6.87	In accordance with design specifications
	Speed	60 miles per hour	In accordance with design specifications and posted speed assumptions communicated by CDG
	Wright Memorial Bridge Capacity (vehicles per hour per lane)	1200	Based on Arup's experience of similar projects
	Other Study Area Future Year Network Improvements	None	In accordance with NC State Transport Improvement Plan (June 2008)
Demographic & Economic Forecasts	Demographic & Economic Forecasts	Delta Associates Forecasts	Only used to 2030, Long Term growth factors shown below used beyond 2030.
Annualization Factors	Peak of Peak to Peak Season Weekday: 12 Hour to 24 Hour Factor	1.20	Based on 2009/10 NCDOT WMB Permanent Count Data
	Peak Season: Number of Weekdays	66	
	Peak of Peak to Peak Season Saturday: 12 Hour to 24 Hour Factor	1.23	
	Peak Season: Number of Sunday Days	13	

	Peak of Peak to Peak Season Sunday: 12 Hour to 24 Hour Factor	1.17	
	Peak Season: Number of Sunday Days	13	
	Shoulder Peak Season Weekday: 12 Hour to 24 Hour Factor	1.25	
	Shoulder Peak Season: Number of Weekdays	44	
	Shoulder Peak Season Weekend: 12 Hour to 24 Hour Factor	1.10	
	Shoulder Peak Season: Number of Weekend Days	18	
	Off Peak Season Weekday: Shoulder Peak 12 Hour to Off Peak 24 Hour Factor	0.96	
	Off Peak Season: Number of Weekdays	151	
	Off Peak Season Weekend: Shoulder Peak 12 Hour to Off Peak 24 Hour Factor	0.60	
	Off Peak Season: Number of Weekend Days	60	
Heavy Vehicles	Heavy Vehicle Percentage Peak Season Weekday	3.00%	Based on turning movement count at US-158 / NC-12 intersection
	Heavy Vehicle Percentage Peak Season Saturday	0.70%	
	Heavy Vehicle Percentage Peak Season Sunday	0.40%	

	Heavy Vehicle Percentage Shoulder Peak Season Weekday	2.70%	
	Heavy Vehicle Percentage Shoulder Peak Season Weekend	2.20%	
	Heavy Vehicle Percentage Peak Season Weekday - Night	3.00%	
	Heavy Vehicle Percentage Peak Season Saturday - Night	0.70%	
	Heavy Vehicle Percentage Peak Season Sunday - Night	0.40%	
	Heavy Vehicle Percentage Shoulder Peak Season Weekday - Night	2.70%	
	Heavy Vehicle Percentage Shoulder Peak Season Weekend - Night	2.20%	
	Heavy Vehicle Percentage Off-Peak Peak Season Weekday	2.70%	
	Heavy Vehicle Percentage Off-Peak Peak Season Weekend	2.20%	
Values of Time ($ per Hour)	Resident Business	$10.69	Based on NuStats 2009 WTP survey. Resident Commute VOTs include a multiple occupancy factor of 1.3
	Resident Commute	$13.03	
	Resident Other	$11.59	
	Visitor Business	$11.04	
	Visitor Vacation	$14.25	
	Visitor Other	$11.97	

VOT Escalation (CAGR – Compound Annual Growth Rate)	Visitor Business Trips	In line with GDP per Capita based on Delta Associates GDP Forecast	GDP and GRP per Capita based on Delta Associates Forecasts.
	2009 - 2015 CAGR	1.06%	
	2015 - 2020 CAGR	1.73%	
	2020 - 2030 CAGR	1.08%	
	Visitor Non-Business Trips	In line with GDP per Capita based on Delta Associates GDP Forecast with elasticity of 0.8	
	2009 - 2015 CAGR	0.85%	
	2015 - 2020 CAGR	1.38%	
	2020 - 2030 CAGR	0.86%	
	Resident Business Trips	In line with GRP per Capita based on Delta Associates GRP Forecast	
	2009 - 2015 CAGR	0.79%	
	2015 - 2020 CAGR	1.49%	
	2020 - 2030 CAGR	0.86%	
	Resident Non-Business Trips	In line with GRP per Capita based on Delta Associates GDP Forecast with elasticity of 0.8	
	2009 - 2015 CAGR	0.64%	
	2015 - 2020 CAGR	1.19%	
	2020 - 2030 CAGR	0.69%	
Other Revenue Parameters	Resident Traffic Ramp-Up - Year 1	70%	

	Resident Traffic Ramp-Up - Year 2	80%	
	Resident Traffic Ramp-Up - Year 3	90%	
	Resident Traffic Ramp-Up - Year 4	100%	
	Visitor Traffic Ramp-Up - Year 1	90%	
	Visitor Traffic Ramp-Up - Year 2	95%	
	Visitor Traffic Ramp-Up - Year 3	100%	
	Visitor Traffic Ramp-Up - Year 4	100%	
	Heavy Vehicle Traffic Ramp-Up - Year 1	90%	
	Heavy Vehicle Traffic Ramp-Up - Year 2	95%	
	Heavy Vehicle Traffic Ramp-Up - Year 3	100%	
	Heavy Vehicle Traffic Ramp-Up - Year 4	100%	
	Leakage	0.0%	Incorporated within the financial model
MCB Long Term Growth	2030 to 2035	2.00%	
	2035 to 2040	1.50%	
	2040 - 2045	1.00%	
	2045 - 2050	0.75%	
	2050 Onwards	0.50%	

6 Traffic and Revenue Forecasts

6.1 Introduction

The base year model, validated to 2010 for the Peak season and 2009 for the Shoulder Peak Season, was used to develop traffic and revenue forecasts using the approach outlined in Chapter 5.

A key assumption is that the forecasts assume that electronic keys will be available at all rental properties, or Realtors will provide facilities throughout the Northern Outer Banks to ensure vehicles can travel directly to their ultimate destination via the new bridge. This is an important assumption as under this scenario all visitors would travel directly to their rental accommodation rather than stopping at a Realtors office first to pick up their keys (which could impact upon the choice of route to access the Outer Banks).

All revenues are presented in 2010 US dollars unless stated otherwise. Inflation from 2009 to 2010 prices was assumed at 2% within the forecasts based on (BEA (US Bureau of Economic Analysis) data (accessed 21st November, 2010).

Two toll scenarios were developed, an Optimal Toll Scenario (using the optimized tolls outputs from the toll optimization process) and the Preliminary Frequent User Policy Scenario. This scenario was explored at the request of NCTA in this analysis. The NCTA framework for such a policy is to assist regular commuters, particularly those making home to work trips and trip to/from services and supplier business on the Outer Banks, to enjoy travel time savings provided by the Mid-Currituck Bridge at an affordable cost.

6.2 Optimal Toll Scenario

6.2.1 Introduction

Outlined below is a summary of the results from the Optimal Toll Scenario. This scenario was based on the outputs from the optimization process detailed in Chapter 4. Presented below are the toll rates, some of the key benefits of the scheme (why trips will be attracted to the bridge in this scenario), the forecast transactions, and the forecast revenue.

6.2.2 Toll Rates

The forecast toll rates for the Optimal Toll Scenarios are shown below in Table 18. No real growth in the toll rates was assumed throughout the concession period.

The maximum toll rate is $28. This is for an eastbound trip (towards the Outer Banks) on a Peak Season Saturday in the PM Peak Period for a visitor. This is the period with the most congestion, where journey times to the Outer Banks can take up to 2.5 times non-congested periods. Therefore, this would be the period when it would be expected travelers would pay the most to use the Mid-Currituck Bridge to avoid the congestion on the existing route. Since visitors have a higher value of

time than residents, they would therefore be willing to pay a higher toll. The highest toll for residents is also in this period at $17.

The optimum toll rates for visitors range from $8 (Shoulder Peak Season, Weekday, PM Peak Period, eastbound) to $28 (Peak Season Weekend, Weekend, PM Peak Period, eastbound).

The optimum toll rates for residents range from $4 (Peak Season Weekday, Midday Period, eastbound) to $17 (Peak Season Weekend, Weekend, PM Peak Period, eastbound).Figure 21,Figure 22 and Figure 23 show some example optimization curves taken from the toll optimization process. These curves show the point at which revenue and transactions are maximized in each user / time period / direction combination. These outputs were used to calculate the optimal toll in each of the user type / time period / direction combinations as shown in Table 18.

Table 18: Optimal Toll Scenario; Toll Rates

Time Period			Toll ($) – Car, 2009 US$			
			Westbound		Eastbound	
			Visitors	Residents	Visitors	Residents
			(Business, Vacation, Other)	(Business, Commute, Other)	(Business, Vacation, Other)	(Business, Commute, Other)
Daytime - Peak	Weekday	AM	12	6	11	7
		MD	15	12	12	4
		PM	11	9	14	10
	Sat	AM	14	9	14	9
		MD	16	14	24	13
		PM	11	10	28	17
	Sun	AM	13	6	13	9
		MD	15	12	18	9
		PM	11	11	14	8
Daytime - Shoulder-Peak	Weekday	AM	11	8	12	14
		MD	13	6	15	8
		PM	10	7	8	7
	Weekend	AM	13	9	9	7
		MD	14	6	16	9
		PM	11	5	13	5
Overnight (12hr) - Peak	Weekday		10			
	Sat		14			
	Sun		13			
Overnight (12hr) - Shoulder-Peak	Weekday		10			
	Weekend		12			
Off-Peak (24hr)	Weekday		10			
	Weekend		12			

Figure 21 Toll Optimization Graph; Peak Season Saturday PM Peak Period, Visitor, Eastbound

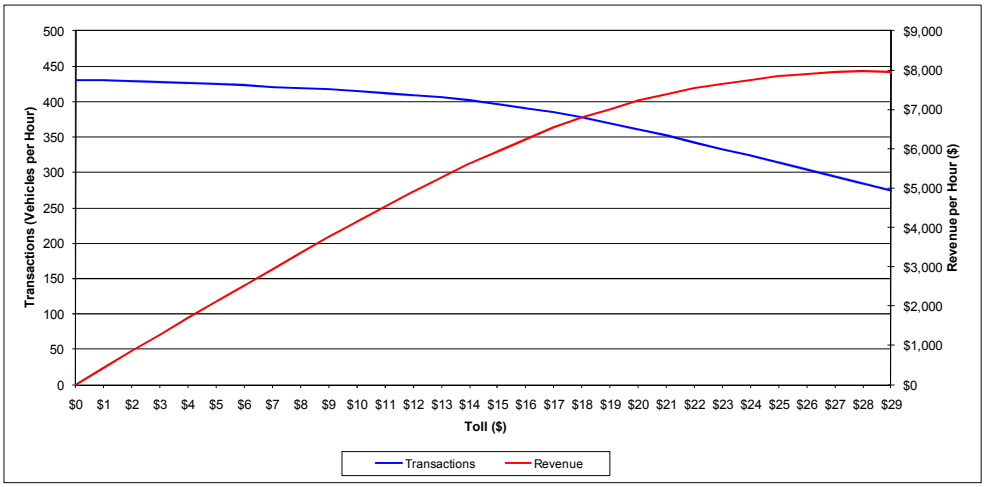


Figure 22 Toll Optimization Graph; Peak Season Saturday PM Peak Period, Visitor, Westbound

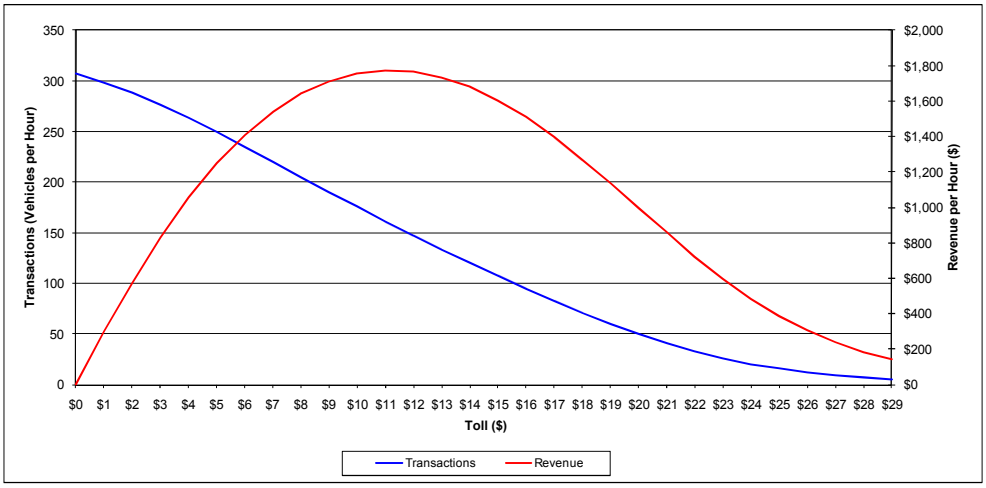
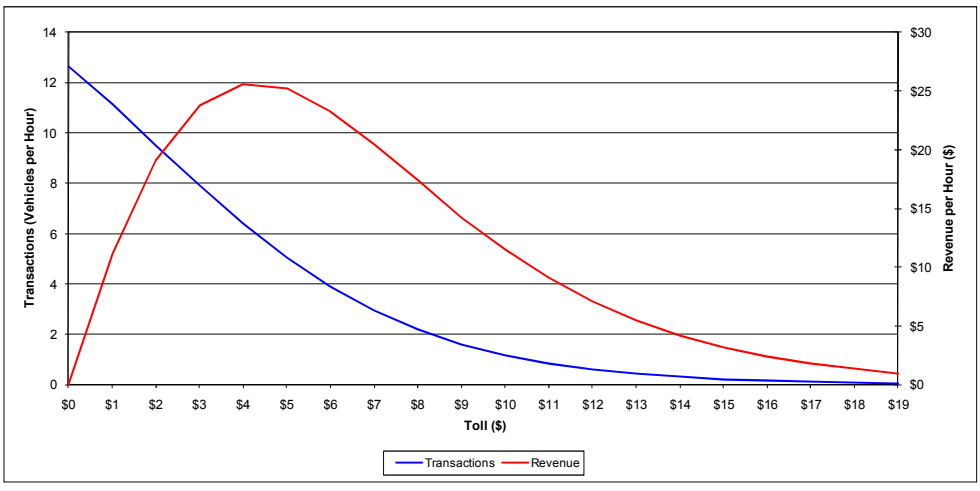


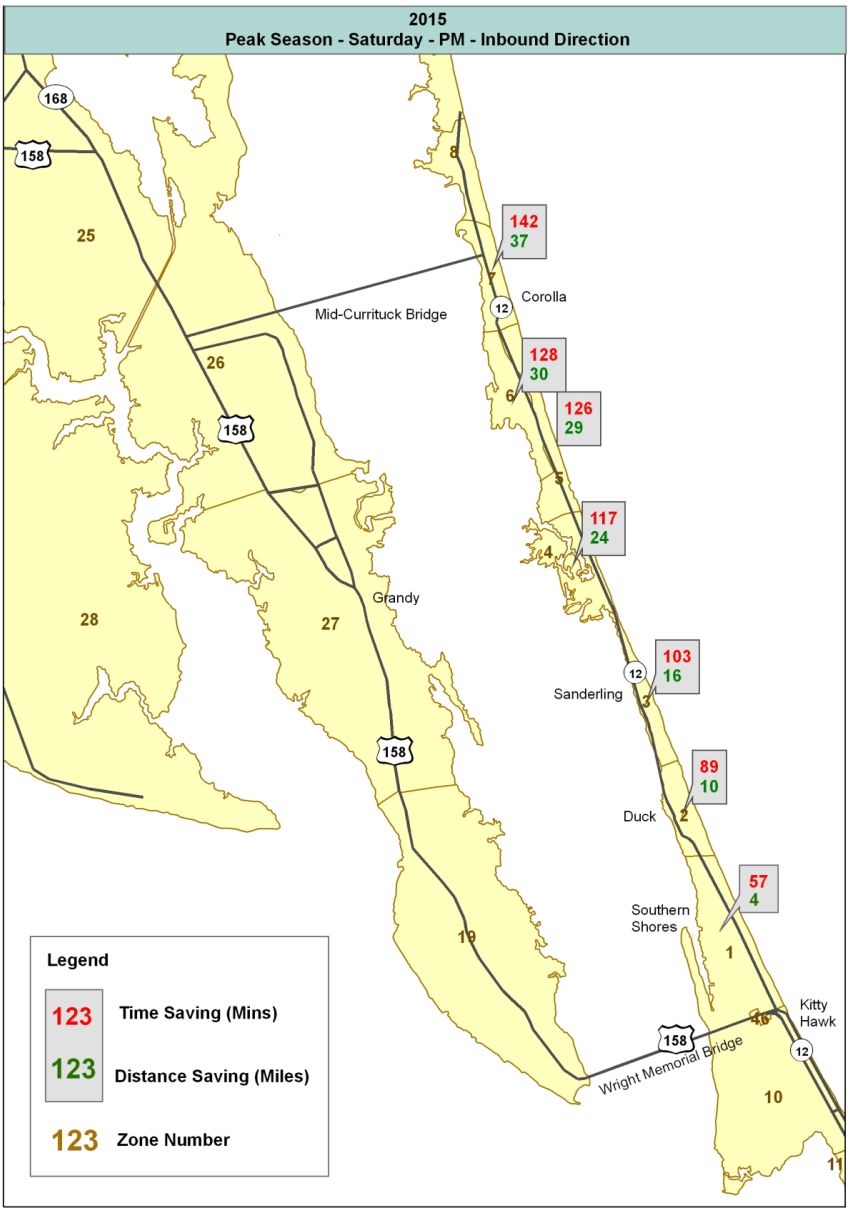
Figure 23 Toll Optimization Graph; Peak Season Weekday Midday Peak Period, Resident, Eastbound



6.2.3 Benefits of the Mid-Currituck Bridge

Figure 24 below illustrates the forecast journey time savings resulting from the construction of the Mid-Currituck Bridge. These are shown for the Saturday PM Peak model in the Peak Season in the inbound (towards Corolla) direction (shown for the Optimal Toll Scenario). This is shown for a trip between the intersection of the Mid-Currituck Bridge link and the US-158 and each of the locations identified on the plan (e.g. to Southern Shores, Duck, Sanderling etc).

Figure 24: Journey Time Savings – Mid-Currituck Bridge



The results show that trips via the Mid-Currituck Bridge have significant journey time savings in the PM Peak time period on a Saturday in the Peak Season. For example, trips to Corolla save 142 minutes if undertaken via the Mid-Currituck Bridge rather than the Wright Memorial Bridge. This is because the route via the Mid-Currituck Bridge avoids the severe level congestion that occurs at the Wright Memorial Bridge during this period. There are time savings for trips to all

locations on the Outer Banks north of Southern Shores, even trips to Southern Shores gain a 57 minutes time saving, even though the distance savings is only 4 miles. This shows that the Mid-Currituck Bridge will provide significant benefits in terms of journey time to users who want to access the Outer Banks at the weekend during the Peak Season.

6.2.3.2 Examples of benefits associated with specific trip types.

Table 19 Example Trip Benefits and Capture Rates of the Mid-Currituck Bridge

Origin	Destination	Residency Status / Purpose	Time Period	Route	Toll	Journey Time	Distance (miles)	Capture Rate
Norfolk, VA	Corolla	Visitor – start / end of vacation	Peak Season, Saturday, PM Peak	WMB	-	3hr 18min	79	99%
				MCB	$28	55mins	41	
Elizabeth City	Sanderling	Commuting, Cleaning Crew	Peak Season, Sunday, AM Peak	WMB	-	1hr 13 min	57	46%
				MCB	$9	52mins	43	
Washington DC	Duck	Visitor – start / end of vacation	Shoulder Peak Season, Weekday, Midday Period	WMB	-	5hrs 4mins	274	9%
				MCB	$15	4hrs 59mins	265	

Table 19 provides a summary of the benefits of using the Mid-Currituck Bridge compared with the existing Wright Memorial Bridge, and how this differs for different time periods and user types. These are outlined in more detail below.

The following are examples of different types of trips that will use the Mid-Currituck Bridge.

Example 1: Visitor from Norfolk, VA headed to Corolla, 2015 Peak Saturday PM Period (Zone 52 to Zone 8)

1. Travel via the Wright Memorial Bridge

   Journey takes 3 hours 18 minutes

   Distance is 79 miles

   No toll cost

2. Travel via the Mid-Currituck Bridge

   Journey takes 55 minutes –saving of 2 hours 23 minutes

   Distance is 41 miles – saving of 38 miles

   Typical toll cost of $28 (visitor toll, eastbound)

   Mid-Currituck Bridge capture rate for this trip: 99%

The first example (outlined above) is a visitor vacation trip from Norfolk, Virginia to Corolla on a Peak Season Saturday in the PM period (2015). The journey time, distance, and toll costs are compared together with the forecast capture rate for

this type of trip. This shows that travelling via the new bridge provides a very significant journey time saving of 2 hours and 23 minutes and a distance saving of 38 miles. Although, there is an additional cost of $28 for the toll charged to cross the Mid-Currituck Bridge. Given the significant time saving and the high value of time for this type of trip, the forecast level of capture is very high at 99%. This means that 99% of the trips between Norfolk and Corolla on Peak Season Saturdays in the PM time period that have a trip purpose that is visitor vacation will use the tolled Mid-Currituck Bridge rather than the toll free Wright Memorial Bridge.

Example 2: Cleaning Crew (commuting trip) from Elizabeth City, NC headed to Sanderling (South), 2015 Peak Sunday AM Period (Zone 20 to Zone 3)

1. Travel via the Wright Memorial Bridge

   Journey takes 1 hour 13 minutes

   Distance is 57 miles

   No toll cost

2. Travel via the Mid-Currituck Bridge

   Journey takes 52 minutes – saving of 21 minutes

   Distance is 43 miles – distance saving of 14 miles

   Typical toll cost of $9 (resident toll, eastbound)

   Mid-Currituck Bridge B capture rate for this trip: 46%

The second example shown is of a cleaning crew (a commute trip) undertaking a trip between Elizabeth City and Sanderling on a Sunday in the Peak Season (AM time period). The results show that for this trip the Mid-Currituck Bridge offers a 21 minute saving, and a distance saving of 14 miles. The time saving is much lower than that in the first example because of the level of congestion at the Wright Memorial Bridge is much lower on Sunday in the Peak Season than a Saturday. The toll for this type of trip would be $9. Given the lower time saving and also lower value of time for this type of trip, the capture rate at 46% is lower when compared to the previous example.

Example 3: Visitor from Washington, DC headed to Duck, 2015 Shoulder-Peak Weekday MD Period (Zone 47 to Zone 2))

1. Travel via the Wright Memorial Bridge

   Journey takes 5 hours 4 minutes

   Distance is 274 miles

   No toll cost

2. Travel via the Mid-Currituck Bridge

   Journey takes 4 hours 59 minutes – saving of 5 minutes

   Distance is 265 miles – saving of 9 miles

   Typical toll cost of $15 (visitors eastbound)

Mid-Currituck Bridge capture rate for this trip: 5%

The third example is for a visitor vacation trip between Washington DC and Duck on a Weekday during the middle of the day (Midday time period) in the Shoulder Peak Season. The analysis shows that during this time period the time saving is 5 minutes and the distance saving 9 miles. The lower time saving is due to the lower level of congestion that occurs on the Wright Memorial Bridge during this period. There is little if, any congestion during the week in the Shoulder Peak season on the Wright Memorial Bridge. Therefore, given the toll rate of $15 the capture rate is only 5%.

6.2.4 Transactions

Table 20 shows the potential market size of the bridge, defined as the number of transactions assuming no tolls are charged. This is forecasted to be approximately 1.67 million annual transactions in the opening year (2015). This corresponds to an annual average of 4,570 transactions per day, growing to 13,560 transactions per day during peak weekends. The potential market increases to 3.1 million transactions in 2030 – a compound growth rate of 4% per year.

Table 20: Total Mid-Currituck Bridge Market Size

Year	Potential Market Size (Forecast Toll Free Transactions)		
	Peak Weekend (Sum of Peak Saturday and Sunday)	Annual Total	Peak Weekend (% of Total)
2015	352,565	1,669,749	21%
2020	389,203	2,530,032	15%
2030	427,972	3,133,080	14%

The forecast growth in annual transactions is shown for the entire concession period (to 2065) in Table 21 and Figure 25 for the Optimal Toll Scenario. Total forecast transactions for the entire concession period can be found in Appendix L.

Figure 25: Forecast Annual Transactions – Optimal Toll Scenario

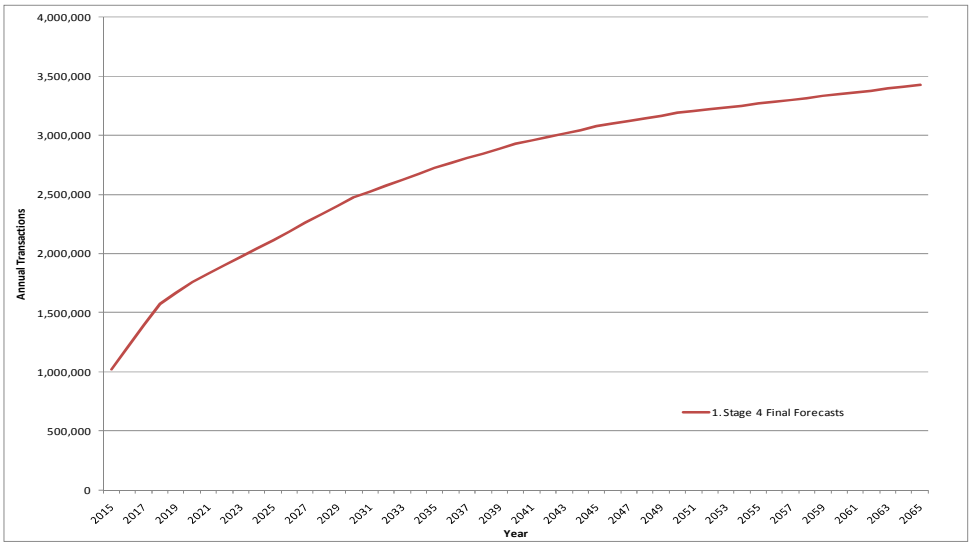
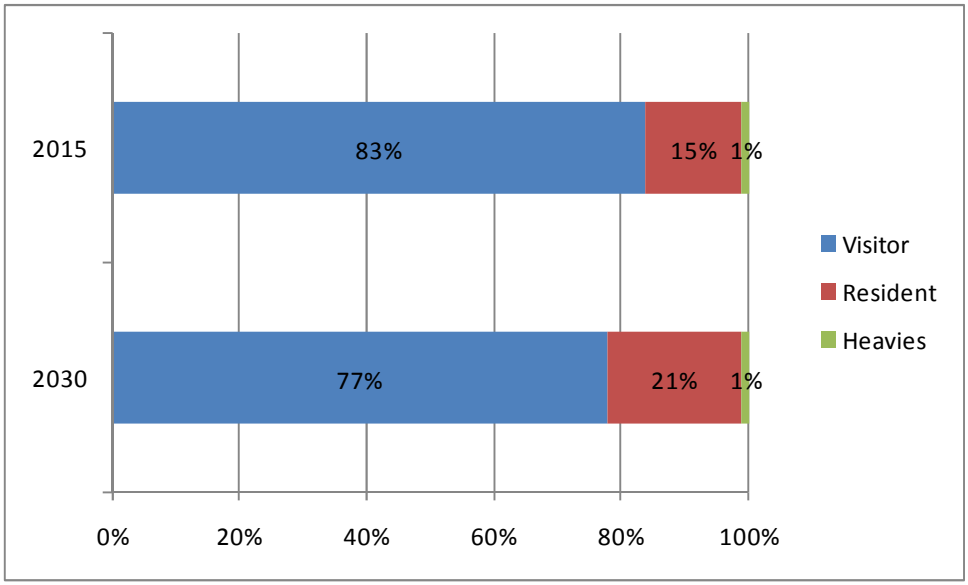


Table 21: Optimal Toll Scenario; Annual Transactions

Year	Annual Transactions	Year	Annual Transactions
2015	1,023,006	2041	2,959,214
2016	1,202,201	2042	2,987,924
2017	1,397,555	2043	3,016,920
2018	1,571,188	2044	3,046,207
2019	1,663,462	2045	3,075,786
2020	1,755,735	2046	3,098,193
2021	1,827,632	2047	3,120,767
2022	1,899,528	2048	3,143,511
2023	1,971,425	2049	3,166,426
2024	2,043,321	2050	3,189,512
2025	2,115,217	2051	3,205,018
2026	2,187,114	2052	3,220,602
2027	2,259,010	2053	3,236,264
2028	2,330,907	2054	3,252,004
2029	2,402,803	2055	3,267,823
2030	2,474,699	2056	3,283,720
2031	2,524,193	2057	3,299,698
2032	2,574,677	2058	3,315,755
2033	2,624,406	2059	3,331,892
2034	2,675,129	2060	3,348,111
2035	2,726,866	2061	3,364,410
2036	2,766,445	2062	3,380,791
2037	2,806,618	2063	3,397,253
2038	2,847,394	2064	3,413,798
2039	2,888,781	2065	3,430,426
2040	2,930,789	-	-

The proportion of transactions by residency type is shown in Figure 26. This indicates that 83% of transactions were attributable to visitors in 2015, reducing to 77% in 2030. Approximately 1% of transactions were associated with heavy vehicles in both scenarios and all forecast years.

Figure 26: Proportion of Transactions by Residency Type and Vehicle Type (Optimal Toll Scenario)



The forecasted average Mid-Currituck Bridge daily traffic volumes by season, day and scenario are shown in Table 22 to Table 24. It can be seen that:

- Growth in transactions is forecasted to be greatest on Peak Weekdays between 2015 and 2020, with a compound annual growth rate of over 11%.
- Traffic volumes are greatest on Peak Saturdays, with traffic volumes 200% higher than Peak Weekdays in 2015. In 2030, Peak Saturday volumes are 158% higher than Peak Weekdays.
- Visitor trips are the most significant market for the Mid-Currituck Bridge during Peak Weekends, and show considerable forecast growth throughout the forecast period.
- Strong growth is observed between 2015 and 2020 due to the ramp-up assumptions, although transactions continue to grow at a faster rate than the Wright Memorial Bridge traffic volumes beyond 2020 due to the real growth in values of time, increased congestion and induced traffic.

Table 22: Mid-Currituck Bridge Peak Season Average Daily Traffic by Day (Optimal Toll Scenario)

Year	Peak Weekday ADT	Peak Saturday ADT	Peak Sunday ADT
2015	3,671	11,424	6,337
2020	6,413	17,674	9,399
2030	9,361	24,176	14,990
CAGR 2015 – 2020	11.80%	9.12%	8.20%
CAGR 2020 – 2030	3.85%	3.18%	4.78%

2015-2020; include ramp up.

Table 23: Mid-Currituck Bridge Shoulder Peak Season Average Daily Traffic by Day

Year	Shoulder-Peak Weekday ADT	Shoulder-Peak Weekend ADT
2015	2,553	4,085
2020	4,190	6,111
2030	5,794	8,289
CAGR 2015 - 2020	10.42%	8.39%
CAGR 2020 - 2030	3.29%	3.10%

Table 24: Mid-Currituck Bridge Off Peak Season Average Daily Traffic by Day (Optimal Toll Scenario)

Year	Off-Peak Weekday ADT	Off-Peak Weekend ADT
2015	1,696	1,797
2020	3,220	3,331
2030	4,453	4,519
CAGR 2015 - 2020	13.68%	13.13%
CAGR 2020 - 2030	3.29%	3.10%

6.2.4.1 Capture Rate Analysis

Table 25 shows the average daily traffic flows on the Wright Memorial Bridge and Mid-Currituck Bridge in the Optimal Toll Scenario. These results show that the percentage capture of traffic crossing both bridges on an annual average daily traffic business is 12% in 2015, rising to 19% in 2030.

Mid-Currituck traffic was forecasted to grow faster than the overall trip table growth rate. Strong growth is observed between 2015 and 2020 due to the ramp-up assumptions, although transactions continue to grow at a faster rate than the overall trip table size beyond 2020 due to the real growth in values of time, increased congestion, and induced traffic.

Table 25: Average Annual Daily Traffic Forecasts – Optimal Toll Scenario

Year	**AADT**			
	Wright Memorial Bridge	**Mid-Currituck Bridge**	**Total**	**% Capture**
2015	21,271	2,803	24,074	12%
2020	24,397	4,810	29,208	16%
2030	29,820	6,780	36,600	19%
CAGR 2015 - 2020*	2.78%	11.41%	3.94%	-
CAGR 2020 - 2030	2.03%	3.49%	2.28%	-

*Growth includes ramp-up assumptions on Mid-Currituck Bridge

Table 26 provides a summary of the forecast capture rates for the Mid-Currituck Bridge for the Optimal Tolls. This shows a comparison of the forecast volumes of traffic crossing both the Wright Memorial Bridge and the Mid-Currituck Bridge, as well as a comparison of the 'in-scope' traffic, which is a subset of the Wright Memorial traffic (i.e. those trips crossing the Wright Memorial Bridge and turning towards / coming from the northern Outer Banks).

It can be seen that:

- Mid-Currituck Bridge capture rates increase throughout the forecasts, peaking at 77% of all in-scope traffic in the 2030 Peak Saturday Model.
- Weekend capture rates are generally greater than weekday capture rates as expected.

Table 26: Mid-Currituck Bridge Capture Rates – Optimal Toll Scenario

Peak Weekday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	3671	25458	3059	13%	55%
2020	6413	30220	3072	18%	68%
2030	9361	38726	2946	19%	76%
Peak Saturday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	11424	43332	7288	21%	61%
2020	17674	47446	7046	27%	71%
2030	24176	54941	7178	31%	77%
Peak Sunday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	6337	37525	6034	14%	51%
2020	9399	41761	6354	18%	60%
2030	14990	45845	4897	25%	75%
Shoulder-Peak Weekday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	2553	22726	2281	10%	53%
2020	4190	26174	2565	14%	62%
2030	5794	32440	2936	15%	66%
Shoulder-Peak Weekend - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	4085	27513	3189	13%	56%
2020	6111	30795	3113	17%	66%
2030	8289	36009	2997	19%	73%

Table 27 shows the forecast traffic growth rates for the Mid-Currituck and Wright Memorial Bridge for the period 2015 to 2030. This shows that for all day types the growth rate on the Mid-Currituck Bridge is higher than the Wright Memorial Bridge. The growth rate is much higher in the initial period (2015-2020) due to the ramp up period that would occur once the new facility opens. In the period 2020 – 2030 the growth rates are more comparable, although the Mid-Currituck Bridge is consistently higher.

Table 27: Mid-Currituck Bridge and Wright Memorial Bridge Growth Rates – Optimal Toll Scenario

Peak Weekday - Average Daily Traffic - Annual Average Growth				
Year	**MCB**	**WMB (All Traffic)**	**MCB**	**WMB (All Traffic)**
2015	3671	25458	-	-
2020	6413	30220	11.8%	3.5%
2030	9361	38726	3.9%	2.5%
Peak Saturday - Average Daily Traffic - Annual Average Growth				
Year	**MCB**	**WMB (All Traffic)**	**MCB**	**WMB (All Traffic)**
2015	11424	43332	-	-
2020	17674	47446	9.1%	1.8%
2030	24176	54941	3.2%	1.5%
Peak Sunday - Average Daily Traffic - Annual Average Growth				
Year	**MCB**	**WMB (All Traffic)**	**MCB**	**WMB (All Traffic)**
2015	6337	37525	-	-
2020	9399	41761	8.2%	2.2%
2030	14990	45845	4.8%	0.9%
Shoulder-Peak Weekday - Average Daily Traffic - Annual Average Growth				
Year	**MCB**	**WMB (All Traffic)**	**MCB**	**WMB (All Traffic)**
2015	2553	22726	-	-
2020	4190	26174	10.4%	2.9%
2030	5794	32440	3.3%	2.2%
Shoulder-Peak Weekend - Average Daily Traffic - - Annual Average Growth				
Year	**MCB**	**WMB (All Traffic)**	**MCB**	**WMB (All Traffic)**
2015	4085	27513	-	-
2020	6111	30795	8.4%	2.3%
2030	8289	36009	3.1%	1.6%

6.2.5 Revenue Forecasts

The forecast growth in annual revenue throughout the period 2015 – 2065 for the Optimal Toll scenario is shown in Figure 27 and Table 28. Total forecast revenue for the entire concession period can be found in Appendix L.

Figure 27: Forecast Annual Revenue – Optimal Toll Scenario

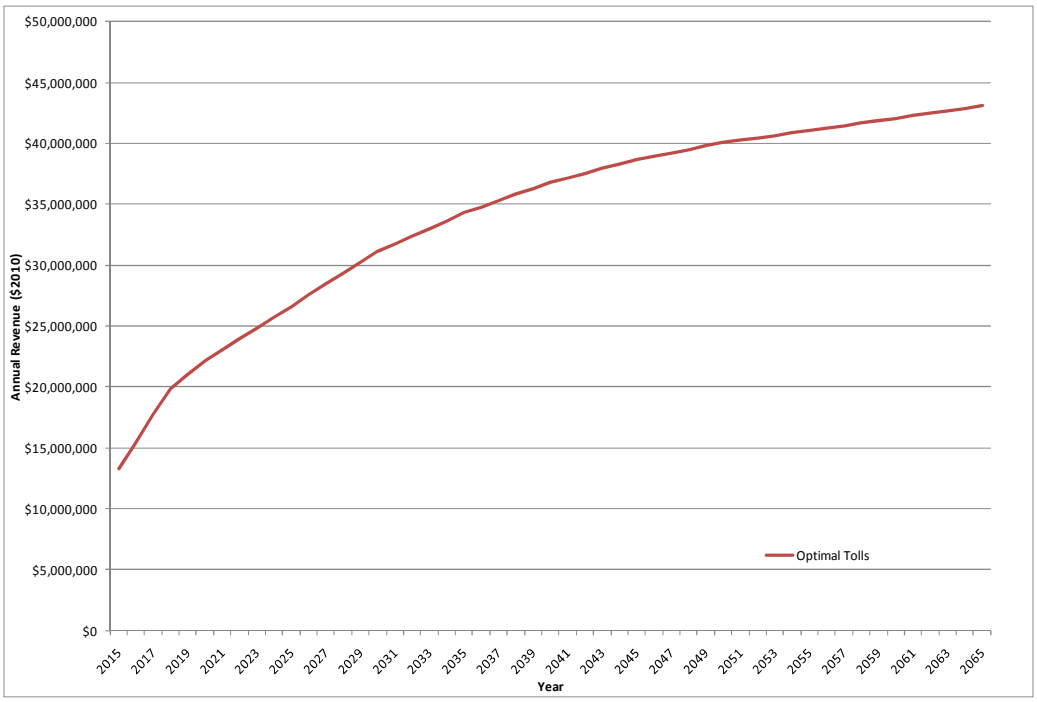


Table 28: Annual Revenue, Optimal Toll Scenario

Year	Annual Revenue	Year	Annual Revenue
2015	$13,236,264	2041	$37,190,893
2016	$15,420,629	2042	$37,550,158
2017	$17,823,260	2043	$37,913,015
2018	$19,835,615	2044	$38,279,501
2019	$20,992,327	2045	$38,649,652
2020	$22,149,039	2046	$38,930,041
2021	$23,046,293	2047	$39,212,534
2022	$23,943,548	2048	$39,497,144
2023	$24,840,802	2049	$39,783,890
2024	$25,738,056	2050	$40,072,786
2025	$26,635,311	2051	$40,266,828
2026	$27,532,565	2052	$40,461,840
2027	$28,429,820	2053	$40,657,827
2028	$29,327,074	2054	$40,854,794
2029	$30,224,329	2055	$41,052,746
2030	$31,121,583	2056	$41,251,688
2031	$31,744,015	2057	$41,451,624
2032	$32,378,895	2058	$41,652,560
2033	$33,001,184	2059	$41,854,501
2034	$33,635,920	2060	$42,057,451
2035	$34,283,350	2061	$42,261,416
2036	$34,778,634	2062	$42,466,401
2037	$35,281,347	2063	$42,672,411
2038	$35,791,601	2064	$42,879,451
2039	$36,309,509	2065	$43,087,526
2040	$36,835,185	-	-

Figure 28 below details the percentage of annual revenue in 2015 associated with each individual season and day for the Optimal Toll Scenario. This indicates that;

- 21% of annual revenue is associated with Peak Saturdays, which accounts for just 13 days of the year. This highlights the significance of the visitor market during the peak season.
- Peak Sundays, in comparison, account for just 9% of annual revenue. This reflects the dominant check-in and check-out times as reflected in the Realtors Survey.

- The shoulder-peak weekday and weekend models accounted for a combined 16% of total revenue, while the Off-Peak models constituted the remaining 31% of revenue.
- The differences between the optimal and frequent user policy scenarios were minimal in terms of the revenue attributable to each modeled season and day.

Figure 28: Revenue by Season and Day – Optimal Toll Scenario

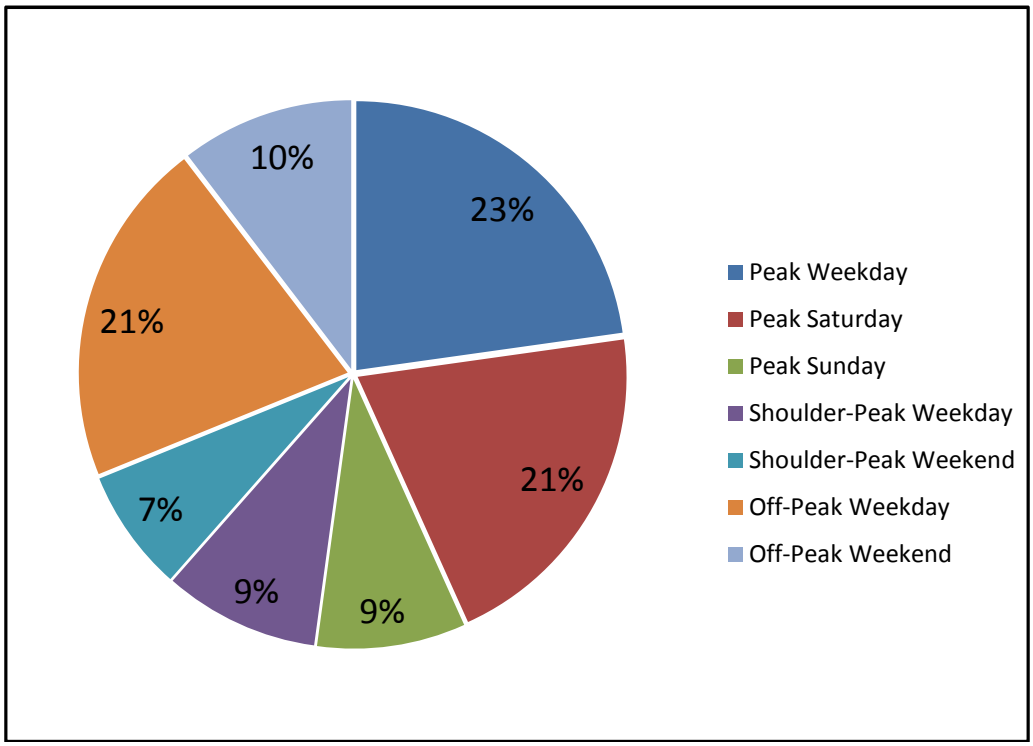


Table 29 shows the importance of visitors in terms of revenue and therefore the project presents a unique marketing opportunity to leverage the existing Outer Banks travel/tourism industry with tailored marketing strategies, with 82% of forecast Mid-Currituck Bridge revenues from visitors to the area in the Peak Season, 77% in the Shoulder Peak Season and 58% in the Off Peak Season.

Table 29: Split in Revenue by Residency Status (2015) - Optimal Toll Scenario

2015	Visitors	Residents	Trucks	Total
Peak	82%	15%	3%	100%
Shoulder Peak	77%	18%	5%	100%
Off Peak	58%	39%	3%	100%

6.3 Preliminary Frequent User Policy Scenario

6.3.1 Introduction

A preliminary Frequent User Policy Scenario was explored at the request of NCTA in this analysis. The NCTA framework for such a policy is to assist regular

commuters, particularly those making home to work trips and trip to /from services and supplier business on the Outer Banks, to enjoy travel time savings provided by the Mid-Currituck Bridge at an affordable cost. To participate in such a program a commuter or frequent user would be required to purchase a transponder and open a pre-funded account with the Mid-Currituck Bridge operator.

For the purpose of testing such a policy, "affordable" was defined as a one way toll for commuters that was recovered in real time by fuel savings associated fewer miles travelled assuming gasoline were priced at $3.00 gallon and that the average trip distance was 15 or so miles.

A second category was a "frequent user" whose business or personal use of MCB would, in the normal course, be less then commuter frequency, but greater than that of infrequent users. Frequent users would pay a reduced toll, but not reduced as much as the toll for commuters. Regardless of frequency of use, all participants would pay posted tolls during peak periods in the peak season.

6.3.2 Toll Rates

The optimized tolls output from the optimization process (by time period, residency status and by direction of travel) were adjusted using trip frequency information available from the 2006 Mailback / Intercept survey data to calculate weighted average tolls for use in the scenario. The toll rates applied in this scenario are shown in Table 30. As shown in the table, resident commuter tolls are fixed at $3 per trip except for the peak season Saturday midday, when market rates are charged.

Table 30: Preliminary Frequent User Policy Toll Rates

Time Period			Toll ($) – Car, 2009 US$					
			Westbound			Eastbound		
			Visitors (Business, Vacation, Other)	Residents (Business, Other)	Residents Commute	Visitors (Business, Vacation, Other)	Residents (Business, Other)	Residents Commute
Daytime - Peak	Weekday	AM	12	8	3	11	8	3
		MD	15	8	3	12	7	3
		PM	11	7	3	14	8	3
	Sat	AM	14	13	3	14	13	3
		MD	16	16	16	24	24	24
		PM	11	9	3	27	13	3
	Sun	AM	13	12	3	13	12	3
		MD	15	12	3	17	13	3
		PM	11	8	3	14	10	3
Daytime - Shoulder-Peak	Weekday	AM	11	5	3	12	6	3
		MD	13	6	3	14	6	3
		PM	10	5	3	8	5	3
	Weekend	AM	13	7	3	9	6	3
		MD	14	7	3	16	7	3
		PM	11	6	3	13	7	3
Overnight (12hr) - Peak	Weekday		8					
	Sat		11					
	Sun		10					
Overnight (12hr) - Shoulder-Peak	Weekday		8					
	Weekend		11					
Off-Peak (24hr)	Weekday		8					
	Weekend		11					

6.3.3 Transactions

The forecast growth in annual transactions for preliminary Frequent User Policy Scenario is shown in

Figure 29 and Table 31 show the transactions for the period 2015 – 2065 for the Frequent User Policy Scenario.

Figure 29: Forecast Annual Transactions – Preliminary Frequent User Policy Scenario

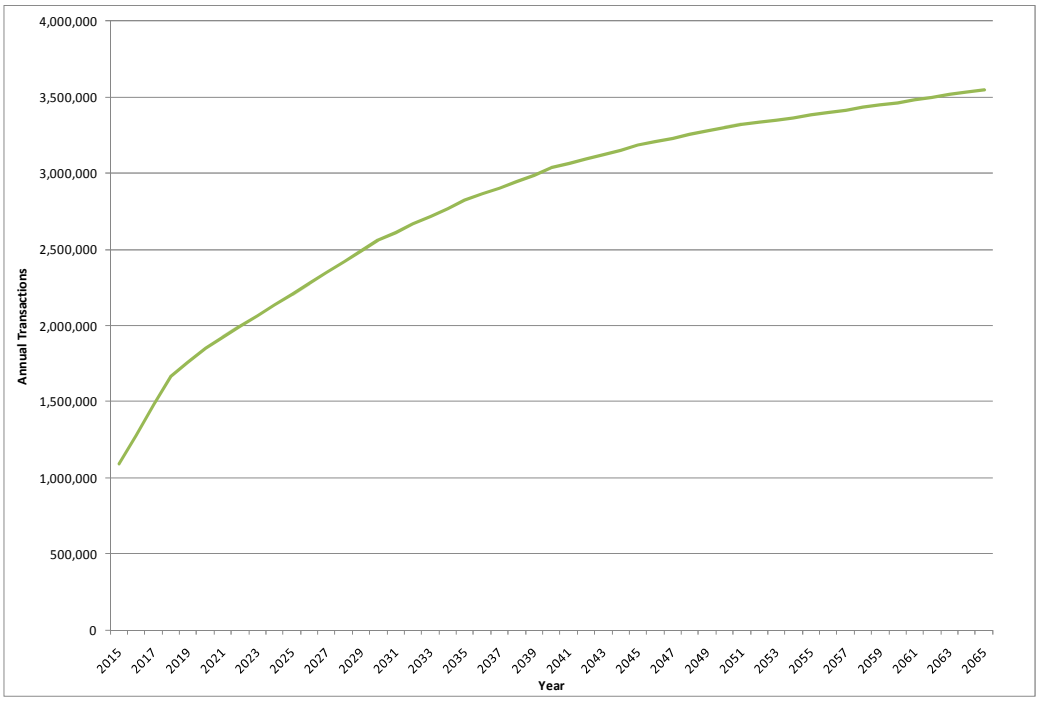
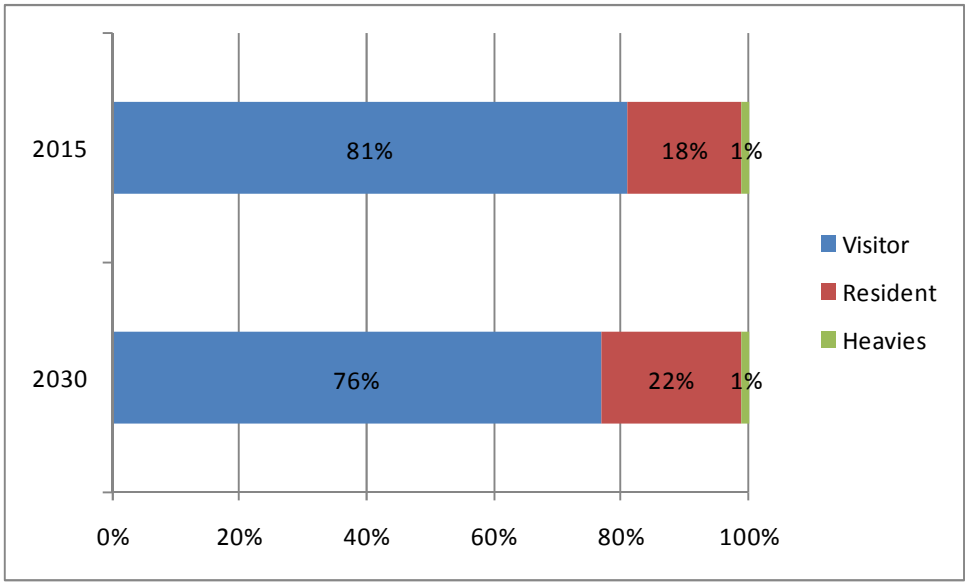


Table 31 Annual Transactions; Preliminary Frequent User Policy Scenario

Year	Annual Transactions	Year	Annual Transactions
2015	1,089,730	2041	3,062,661
2016	1,277,989	2042	3,092,420
2017	1,482,602	2043	3,122,477
2018	1,665,148	2044	3,152,834
2019	1,757,714	2045	3,183,494
2020	1,850,280	2046	3,206,720
2021	1,921,481	2047	3,230,119
2022	1,992,682	2048	3,253,694
2023	2,063,883	2049	3,277,446
2024	2,135,084	2050	3,301,376
2025	2,206,285	2051	3,317,449
2026	2,277,486	2052	3,333,603
2027	2,348,687	2053	3,349,837
2028	2,419,888	2054	3,366,152
2029	2,491,089	2055	3,382,549
2030	2,562,290	2056	3,399,028
2031	2,613,535	2057	3,415,589
2032	2,664,071	2058	3,432,233
2033	2,715,617	2059	3,448,961
2034	2,768,193	2060	3,465,772
2035	2,821,822	2061	3,482,667
2036	2,862,847	2062	3,499,646
2037	2,904,489	2063	3,516,710
2038	2,946,754	2064	3,533,860
2039	2,989,654	2065	3,551,096
2040	3,033,197	-	-

The proportion of transactions by residency type is shown in Figure 30. These results indicate that between 81% of transactions were attributable to visitors in 2015, reducing to 76% in 2030. Approximately 1% of transactions were associated with heavy vehicles in both scenarios and all forecast years.

Figure 30: Proportion of Transactions by Residency Type and Vehicle - Preliminary Frequent User Policy Scenario



The forecast average Mid-Currituck Bridge daily traffic volumes by season, day and scenario are shown in Table 31 to Table 34. It can be seen that:

- Growth in transactions is forecast to be greatest on Peak Weekdays between 2015 and 2020, with a compound annual growth rate of over 11%.
- Traffic volumes are greatest on Peak Saturdays, with traffic volumes 200% higher than Peak Weekdays in 2015. In 2030, Peak Saturday volumes are 152% higher than Peak Weekdays.
- Visitor trips are the most significant market for the Mid-Currituck Bridge during Peak Weekends, and show considerable forecast growth throughout the forecast period.
- Strong growth is observed between 2015 and 2020 due to the ramp-up assumptions, although transactions continue to grow at a faster rate than the Wright Memorial Bridge traffic volumes beyond 2020 due to the real growth in values of time, increased congestion and induced traffic.

Table 32: Mid-Currituck Bridge Peak Season Average Daily Traffic by Day – Preliminary Frequent User Policy Scenario

Year	Peak Weekday ADT	Peak Saturday ADT	Peak Sunday ADT
2015	3,964	11,510	6,662
2020	6,771	17,724	9,813
2030	9,586	24,172	15,323
CAGR 2015 – 2020	11.30%	9.02%	8.05%
CAGR 2020 – 2030	3.54%	3.15%	4.56%

2015-2020; include ramp up.

Table 33: Mid-Currituck Bridge Shoulder Peak Season Average Daily Traffic by Day – Preliminary Frequent User Policy Scenario

Year	Shoulder-Peak Weekday ADT	Shoulder-Peak Weekend ADT
2015	2,777	4,231
2020	4,529	6,322
2030	6,152	8,510
CAGR 2015 - 2020	10.28%	8.36%
CAGR 2020 - 2030	3.11%	3.02%

Table 34: Mid-Currituck Bridge Off Peak Season Average Daily Traffic by Day - Preliminary Frequent User Policy Scenario

Year	Off-Peak Weekday ADT	Off-Peak Weekend ADT
2015	1,862	1,874
2020	3,481	3,446
2030	4,728	4,639
CAGR 2015 - 2020	13.33%	12.96%
CAGR 2020 - 2030	3.11%	3.02%

6.3.3.1 Capture Rates

Table 35 outlines the average daily traffic flows on the Wright Memorial Bridge and the Mid-Currituck Bridge in the Preliminary Frequent User Policy Scenario. These results show that the % capture of traffic crossing both bridges on an annual average daily traffic business is 13% on 2015, rising to 19% in 2030.

Mid-Currituck traffic was forecast to grow faster than the overall trip table growth rate. Strong growth is observed between 2015 and 2020 due to the ramp-up assumptions, although transactions continue to grow at a faster rate than the overall trip table size beyond 2020, which is due to the real growth in values of time, increased congestion, and induced traffic.

Table 35: Average Annual Daily Traffic Forecasts – Preliminary Frequent User Policy Scenario

Year	**AADT**			
	Wright Memorial Bridge	**Mid-Currituck Bridge**	**Total**	**% Capture**
2015	20,875	2,986	23,860	13%
2020	23,903	5,069	28,972	17%
2030	29,097	7,020	36,117	19%
CAGR 2015 - 2020*	2.75%	11.17%	3.96%	-
CAGR 2020 - 2030	1.99%	3.31%	2.23%	-

*Growth includes ramp-up assumptions on Mid-Currituck Bridge

Table 36 provides a summary of the forecast capture rates for the Mid-Currituck Bridge for the Preliminary Frequent User Policy Scenarios. This shows a comparison of the forecast volumes of traffic crossing both the Wright Memorial Bridge and the Mid-Currituck Bridge, as well as a comparison of the 'in-scope' traffic, which is a subset of the Wright Memorial traffic (i.e. those trips crossing the Wright Memorial Bridge and turning towards / coming from the northern Outer Banks).

It can be seen that:

- Mid-Currituck Bridge capture rates increase throughout the forecasts, peaking at 78% of all in-scope traffic in the 2030 Peak Saturday Model.
- Weekend capture rates are generally greater than weekday capture rates as expected.

Table 36: Mid-Currituck Bridge Capture Rates – Preliminary Frequent User Policy Scenario

Peak Weekday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	3964	24966	2701	14%	59%
2020	6771	29534	2735	19%	71%
2030	9586	37718	2724	20%	78%
Peak Saturday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	11510	41867	7008	22%	62%
2020	17724	45283	6781	28%	72%
2030	24172	51097	7124	32%	77%
Peak Sunday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	6662	36695	5555	15%	55%
2020	9813	40721	5879	19%	63%
2030	15323	43831	4525	26%	77%
Shoulder-Peak Weekday - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	2777	22324	1995	11%	58%
2020	4529	25744	2240	15%	67%
2030	6152	31868	2580	16%	70%
Shoulder-Peak Weekend - Average Daily Traffic					
Year	**MCB**	**WMB (All Traffic)**	**WMB (In-Scope Traffic)**	**% Capture , Total Traffic**	**% Capture - In-Scope Traffic**
2015	4231	27157	3054	13%	58%
2020	6322	30308	2973	17%	68%
2030	8510	35429	2843	19%	75%

6.3.4 Revenue Forecasts

The forecast annual revenue throughout the period 2015 – 2065 for the Preliminary Frequent User Policy Scenario is shown in Figure 31 and Table 37. Total forecast revenue for the entire concession period can be found in Appendix L.

Figure 31: Forecast Annual Revenue – Preliminary Frequent User Policy Scenario

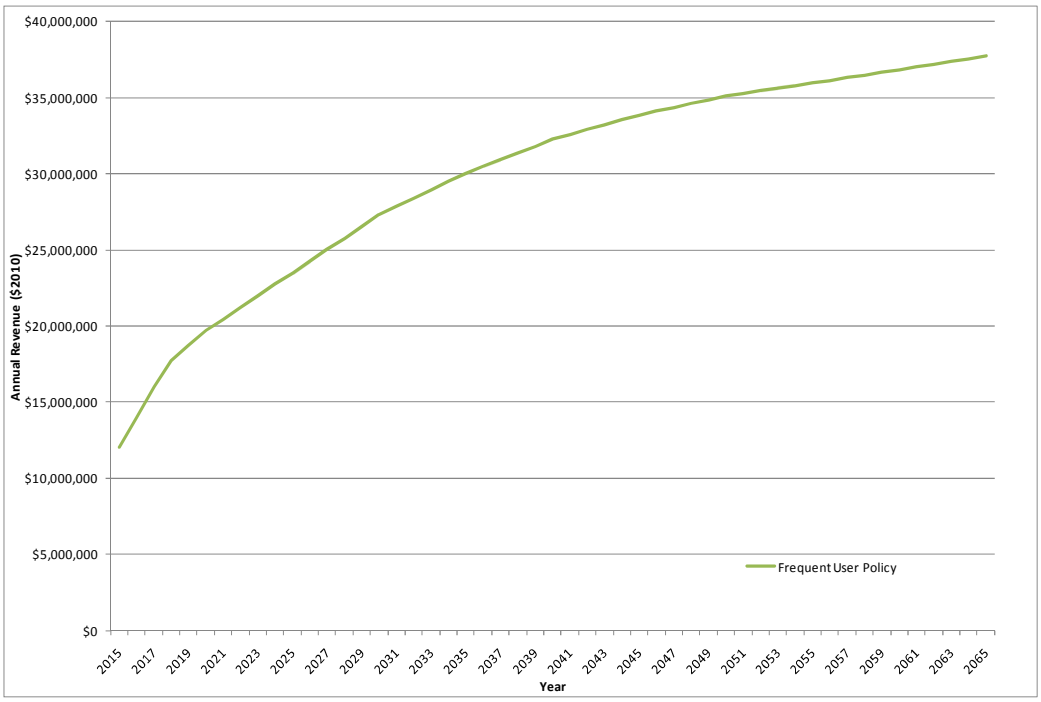


Table 37: Annual Revenue, Preliminary Frequent User Policy Scenario

Year	Annual Revenue	Year	Annual Revenue
2015	$12,044,363	2041	$32,585,227
2016	$13,947,753	2042	$32,899,194
2017	$16,032,146	2043	$33,216,301
2018	$17,722,336	2044	$33,536,579
2019	$18,709,292	2045	$33,860,059
2020	$19,696,247	2046	$34,105,096
2021	$20,456,699	2047	$34,351,970
2022	$21,217,151	2048	$34,600,696
2023	$21,977,603	2049	$34,851,288
2024	$22,738,055	2050	$35,103,759
2025	$23,498,506	2051	$35,273,335
2026	$24,258,958	2052	$35,443,759
2027	$25,019,410	2053	$35,615,035
2028	$25,779,862	2054	$35,787,168
2029	$26,540,314	2055	$35,960,161
2030	$27,300,766	2056	$36,134,019
2031	$27,846,781	2057	$36,308,747
2032	$28,379,946	2058	$36,484,348
2033	$28,923,775	2059	$36,660,827
2034	$29,478,480	2060	$36,838,189
2035	$30,044,279	2061	$37,016,437
2036	$30,477,116	2062	$37,195,577
2037	$30,916,445	2063	$37,375,612
2038	$31,362,364	2064	$37,556,547
2039	$31,814,972	2065	$37,738,388
2040	$32,274,368	-	-

As Table 38 shows the importance of visitors in terms of revenue and therefore the project presents a unique marketing opportunity to leverage the existing Outer Banks travel/tourism industry with tailored marketing strategies, with 82% of forecast Mid-Currituck Bridge revenues from visitors to the area in the Peak Season, 77% in the Shoulder Peak Season and 58% in the Off Peak Season.

Table 38: Split in Revenue by Residency Status (2015) - Preliminary Frequent User Policy Scenario

2015	Visitors	Residents	Trucks	Total
Peak	82%	15%	3%	100%
Shoulder Peak	77%	18%	5%	100%
Off Peak	58%	39%	3%	100%

6.3.5 Comparison With the Optimal Toll Scenario

Outlined below is a brief comparison of the transactions and revenue between the Preliminary Frequent User Policy Scenario and the Optimal Toll Scenario;

- The differences in average daily traffic volumes between the two scenarios were minimal.
- The level of capture is marginally higher in the Preliminary Frequent User Policy Scenario given the lower level of tolls charged
- Total revenue is lower in the Preliminary Frequent User Policy Scenario due to lower level of tolls compared with the Optimal Toll Scenario. This is around -9% in 2015 and -12% in 2030.

The Preliminary Frequent User Policy Scenario, as tested, is preliminary and the frequency of use parameters and toll rates were set to achieve the highest level of participation among prospective users. Therefore, as tested, Preliminary Frequent User Policy has the largest negative impact on Optimal Revenue. Therefore, Preliminary Frequent User Policy will be further refined as the project moves toward completion. This process will, in turn change transaction and revenue impacts.

7 Sensitivity Tests

7.1 Introduction

A series of sensitivity tests were conducted on key inputs to the model as outlined below. The purpose of the sensitivity tests was to assess the impact of key variables on the traffic and revenue forecasts. Tests were run on the Optimal Toll Scenario.

7.2 Key Model Inputs

7.2.1 Sensitivity Test 1 – Toll Rates

Sensitivity tests assuming toll rates 20% higher and lower than the assumed parameters were conducted. The impact on traffic and revenue are outlined below in Table 39 and Table 40

Table 39: Sensitivity Test 1 - +/-20% Toll Rate, Transactions

Year	Optimal Toll Scenario	+20% Toll	Difference from Optimal Toll Scenario	-20% Toll	Difference from Optimal Toll Scenario
2015	1,023,006	864,495	-15%	1,174,013	15%
2020	1,755,735	1,560,321	-11%	1,938,630	10%
2030	2,474,699	2,303,944	-7%	2,634,273	6%

Table 40: Sensitivity Test 1 - +/-20% Toll Rate, Revenue

Year	Optimal Toll Scenario	+20% Toll	Difference from Optimal Toll Scenario	-20% Toll	Difference from Optimal Toll Scenario
2015	13,236,264	13,451,513	2%	12,120,335	-8%
2020	22,149,039	23,697,815	7%	19,508,481	-12%
2030	31,121,583	34,856,798	12%	26,448,732	-15%

It can be concluded that:

- The implied toll elasticity of demand is -0.75, as a +/-20% revision to the tolls resulted in a +/-15% change in transactions in 2015.
- Increasing the tolls by 20% results in an increase in revenue compared to the optimal toll scenario, with 2% more revenue in 2015 and 12% more revenue in 2030.This is due to the fact that the optimization was conducted using the base year matrices and future year networks. VOT and congestion throughout the Outer Banks continue to escalate throughout the construction period to 2015 while the tolls stay constant.

- Reducing the tolls by 20% results in the tolls being further sub-optimal than the original scenarios. As such, a further reduction in revenue was observed.

7.2.2 Sensitivity Test 2 – High / Low Socioeconomic Forecasts

Sensitivity tests results showing the impact of the high and low socio-economic growth forecasts which were developed as part of the demographic survey developed by Delta Associates are presented below.

Table 41: Sensitivity Test 2 – High / Low Socioeconomic Forecasts, Transactions

Year	Optimal Toll Scenario	High Growth Forecasts	Difference from Optimal Toll Scenario	Low Growth Forecasts	Difference from Optimal Toll Scenario
2015	1,023,006	1,182,540	16%	936,871	-8%
2020	1,755,735	2,219,920	26%	1,483,696	-15%
2030	2,474,699	3,461,079	40%	1,932,500	-22%

Table 42: Sensitivity Test 2 - High / Low Socioeconomic Forecasts, Revenue

Year	Optimal Toll Scenario	High Growth Forecasts	Difference from Optimal Toll Scenario	Low Growth Forecasts	Difference from Optimal Toll Scenario
2015	13,236,264	15,274,817	15%	12,096,049	-9%
2020	22,149,039	27,924,180	26%	18,694,871	-16%
2030	31,121,583	43,124,423	39%	24,355,332	-22%

It can be concluded that:

- The high growth scenario resulted in 40% more transactions and 39% more revenue in 2030 compared to the central case scenario. The high growth scenario assumed the relaxation of environmental, infrastructure and utility restrictions which resulted in additional trips being made throughout the Outer Banks. In addition, more optimistic GDP and GRP forecasts were incorporated, increasing the escalation of all values of time. As a result, the tolls were more acceptable and increased capture rates were observed.
- The low growth scenario resulted in 22% less transactions and revenue as a result of slower development of the Outer Banks, and reduced escalation rates for value of time.

7.2.3 Sensitivity Test 3 – Value of Time

Sensitivity tests assuming values of time 20% higher and lower than the assumed parameters were conducted. The impact on traffic and revenue are outlined below in Table 43 and Table 44

Table 43: Sensitivity Test 3 - +/-20% Value of Time, Transactions

Year	Optimal Toll Scenario	+20% VOT	Difference from Optimal Toll Scenario	-20% VOT	Difference from Optimal Toll Scenario
2015	1,023,006	1,122,758	10%	880,360	-14%
2020	1,755,735	1,879,090	7%	1,575,937	-10%
2030	2,474,699	2,586,830	5%	2,308,380	-7%

Table 44: Sensitivity Test 3 - +/-20% Value of Time, Revenue

Year	Optimal Toll Scenario	+20% VOT	Difference from Optimal Toll Scenario	-20% VOT	Difference from Optimal Toll Scenario
2015	13,236,264	14,511,573	10%	11,395,938	-14%
2020	22,149,039	23,674,016	7%	19,920,801	-10%
2030	31,121,583	32,499,387	4%	29,079,449	-7%

It can be concluded that:

- The model is sensitive to the WTP assumptions, with a 14% reduction in transactions and revenue in 2015 compared to the optimal toll scenario when VOT is reduced by 20%.
- Increasing VOT by 20% led to a 10% increase in traffic and revenue in 2015 compared to the optimal toll scenario.
- The impact of the VOT change reduces throughout the concession, with a 7% reduction / 4% increase in revenue in 2030 depending on the VOT adjustment. The absolute impact on transactions and revenues is consistent throughout the forecast period.

Disclaimer

The traffic and revenue report has been prepared for the Currituck Development Group and North Carolina Turnpike Authority. Current accepted professional practices and procedures were used in the development of these traffic and revenue forecasts. However, as with any forecasts, it should be understood there may be differences between forecasted and actual results caused by events and circumstances beyond the control of the forecasters. In formulating the forecasts Arup has reasonably relied upon the accuracy and completeness of information provided by North Carolina Turnpike Authority and other local and states agencies. Arup has also relied upon the reasonable assurances of some independent parties and are not aware of any facts that would make such information misleading. In preparing its assessment, Arup has relied on data collected and analyzed by third parties for which Arup does not assume responsibility

Certain forward-looking statements are based upon interpretations or assessments of best available information at the time of writing. Actual events may differ from those assumed, and events are subject to change. Findings are time-sensitive and relevant only to current conditions at the time of writing. Factors influencing the accuracy and completeness of the forward-looking statements may exist that are outside of the purview of the consulting firm. Arup makes or provides no warranty, whether implied or otherwise, as to the accuracy of the information presented, nor does it take any responsibility or bear any liability whatsoever as to the actions taken by others, including third parties, based upon the statements made in the Report. Arup's Report is thus to be viewed as an assessment that is time-relevant, specifically referring to conditions at the time of review

These estimates and projections may not be indicative of actual or future values, and are therefore subject to substantial uncertainty. Future developments cannot be predicted with certainty, and may affect the traffic and revenue forecasts expressed within this report, such that Arup does not specifically guarantee or warrant any estimate or projection within this report.

While Arup believes that the projections or other forward looking statements contained within the report are based on reasonable assumptions as of the date in the report, such forward looking statements involve risks and uncertainties that may cause actual results to differ materially from the results predicted. Therefore, following the date of this report Arup will take no responsibility or assume any obligation to advise of changes that may affect its assumptions contained within the report, as they pertain to; socio-economic and demographic forecasts, proposed residential or commercial land use development projects and/or potential improvements to the regional transport network.