CHESAPEAKE BAY BRIDGE CROSSING TRANSPORTATION STUDY

Prepared for

Queen Anne's Conservation Association

Prepared by

AKRF, Inc.

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Executive Summary

Queen Anne's Conservation Association ("QACA") has engaged AKRF, Inc. ("AKRF"), a regionally respected environmental planning and engineering services firm (whose nearest office is in Hanover, MD) to conduct an independent study to determine whether there is a current need for replacement of the Chesapeake Bay Bridge Crossing from a traffic operations perspective. This study reviews and evaluates the methods, results, and conclusions stated in the Purpose and Need Assessment document dated February 2019, which was prepared by the Maryland Transportation Authority (MDTA). This study presents independent results in two broad categories—traffic growth forecasting, and relevant transportation trends and improvements.

The traffic growth forecasting method used by MDTA is a regional travel demand model, which has complicated inputs for population, demographics, origin-destination patterns, and other unknown factors. AKRF does not have access to this model or the assumptions used to forecast traffic at the existing bridge crossing, so our estimates rely on historic growth trends over more than 15 years for summer weekend traffic and the last five years for weekday traffic to present an independent traffic growth forecast.

The MDTA model starts with existing traffic count data from 2017 that leads to biased findings because it only captures one day of weekend traffic from August, which was much higher than an average summer weekend day according to AKRF's research. The Purpose and Need Assessment bases several conclusions on the 2040 forecasted summer weekend conditions which show a high number of hours of traffic congestion and many miles of traffic queues in that document. It is typically not acceptable to rely on one day of traffic counts when there could be a daily fluctuation in traffic that is above or below average. It is customary to use multiple days of traffic count data to present average conditions as has been done in the AKRF study. Furthermore, AKRF has only presented average daily weekend traffic for a particular year if historic counts were available for at least one full weekend in the average summer month of July. For weekday conditions, MDTA used multiple days of counts in 2017, while AKRF used the Maryland Department of Transportation's (MDOT's) reported annual average weekday daily traffic for the bridge, which is already smoothed out using seasonal adjustment factors according to an accepted methodology to eliminate daily traffic fluctuations.

Next, the assumptions in the MDTA model do not indicate whether important trends or other factors such as increased telecommuting or economic recessions were taken into account, nor whether planned or available improvements such as cashless toll collection, improved management of the reversible lane, or variable tolling to reduce congestion were included. It can only be assumed that these trends and improvements were not considered in the model, which then presents future traffic and congestion levels that are higher than may actually materialize. In particular, telecommuting is likely to permanently change from the previous share of five percent of the workforce to a much higher number since a large number of employers and employees have adjusted to a new paradigm in 2020.

The long-term influence of the COVID-19 pandemic on traffic and travel patterns is not yet understood. However, there are discussions of COVID-19 in this study, and an alternate set of traffic forecasts reflecting potential economic downturns is included. The Purpose and Need Assessment does not mention economic recessions or the traffic growth-stagnating effects typically following them. Should two modest economic downturns occur between 2019 and 2040 as is assumed in the alternate traffic forecasts, these may result in the Purpose and Need Assessment's traffic projections being an even larger overestimate of what actual traffic will be.

According to the independent conclusions of AKRF in this study, the levels of traffic and congestion shown to demonstrate the need for a replacement bridge using 2040 projections may not be reached until late this century or beyond. Additionally, according to the 2015 Life Cycle Cost Analysis Study by MDTA, the bridge can be safely maintained through 2065 with currently programmed and anticipated rehabilitation and maintenance work. That study states that beyond 2065, the bridge may require major rehabilitation but would not be structurally deficient or functionally obsolete. Therefore, based on the conclusions of AKRF's study of traffic congestion and operations on the bridge, and MDTA's Life Cycle Study of the bridge's structural integrity, there will not likely be a need for a replacement bridge by 2040 for either traffic or structural purposes.

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Introduction

This report presents an independent study to determine whether there is a current need for replacement of the Chesapeake Bay Bridge Crossing from a traffic operations perspective. The study reviews and evaluates the methods, results, and conclusions stated in the Purpose and Need Assessment document dated February 2019, prepared by the MDTA. This report also considers and relies on results of comprehensive research efforts identifying strategies used at comparable facilities in the region, and available traffic data from MDOT on the Bay Bridge from 2003 to 2018. These findings are then also compared to traffic projections in the 2004 Transportation Needs Report and 2015 Life Cycle Cost Analysis Study. The above three studies and 2019 Open House materials that were provided on the "baycrossingstudy.com" website at the time of preparation of this report are included as the Maryland government agency reports.

For each of the improvements and/or trends that are considered, this report presents up to three types of traffic metrics for comparison, all of which are used by the Purpose and Need Assessment to justify a bridge replacement:

- **Traffic Volumes:** Anticipated growth of typical weekday and/or summer weekend traffic, shown in the units of "vehicles per hour" or "vehicles per day," as applicable;
- **Queue Length:** The line of cars spilling back from the toll plaza in the eastbound direction, shown in the units of miles; and
- **Traffic Congestion:** Hours of the day where the bridge traffic demand would exceed the traffic capacity in either direction of the crossing.

Traffic Volume Growth Forecasting

The AKRF volume projections utilize a 2018 base year calculated from recent traffic data available from MDOT and consider historic traffic trends from 2003 to 2018. In contrast, the Purpose and Need Assessment utilizes 2017 base year traffic counts and the Baltimore Metropolitan Council InSITE travel demand model to develop future volumes. However, the input for the base year in the model used for the Purpose and Need Assessment was based on very limited data and resulted in an overestimate of traffic for summer weekends. By applying more realistic traffic growth to the bridge based on historic trends, the AKRF projection indicates that the average weekend daily traffic could be approximately 31,000 vehicles per day lower, and typical weekday daily traffic could be approximately 3,000 vehicles per day lower by 2040 when compared to the Purpose and Need Assessment (see **Table 1**).

Table 1
Comparison of Chesapeake Bay Bridge Daily Traffic Volume Projections

	Actual Traffic Volumes	AKRF Traffic Volume Projection^		Bay Crossing Study Purpose and Need Assessment (2019)			Life Cycle Cost Analysis (2015)			Bay Bridge Transportation Needs Projection (2004)		
	2018	2040	%Growth	2017	2040	%Growth	2013	2040	%Growth	2001	2025	%Growth
Weekday	75,750	81,487	8%	68,598†	84,276	23%	86,200*	113,100*	31%*	61,000	86,000	41%
Weekend	100,286*	104,219*	4%*	118,597*†	135,280*	14%*	90,200*	118,400*	31%*	95,000*	135,000*	41%

NOTES:

^ Developed by AKRF, based on 2009-2018 annual average daily traffic data and 2003-2019 Automatic Traffic Recorder data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

* Traffic volume for summer day

† 2017 Purpose and Need Assessment traffic volumes are based on multiple day count data for weekdays, not annual average daily traffic, and single-day count data collected in August for weekends

Since actual daily weekday and weekend data were available for 2018, those data were used to establish the 2018 baseline for comparison to 2040 conditions. As shown in Table 1, each subsequent MDTA study from the earliest one in 2004 to the most recent one in 2019 has lowered the expected percentage growth of traffic for its study horizon, as evidenced by the increasingly flatter slope of each line with the release of each subsequent MDTA study. The AKRF projections appear to be even more realistic. These projections and growth rates are illustrated in Figure 1 and explained in greater detail below.

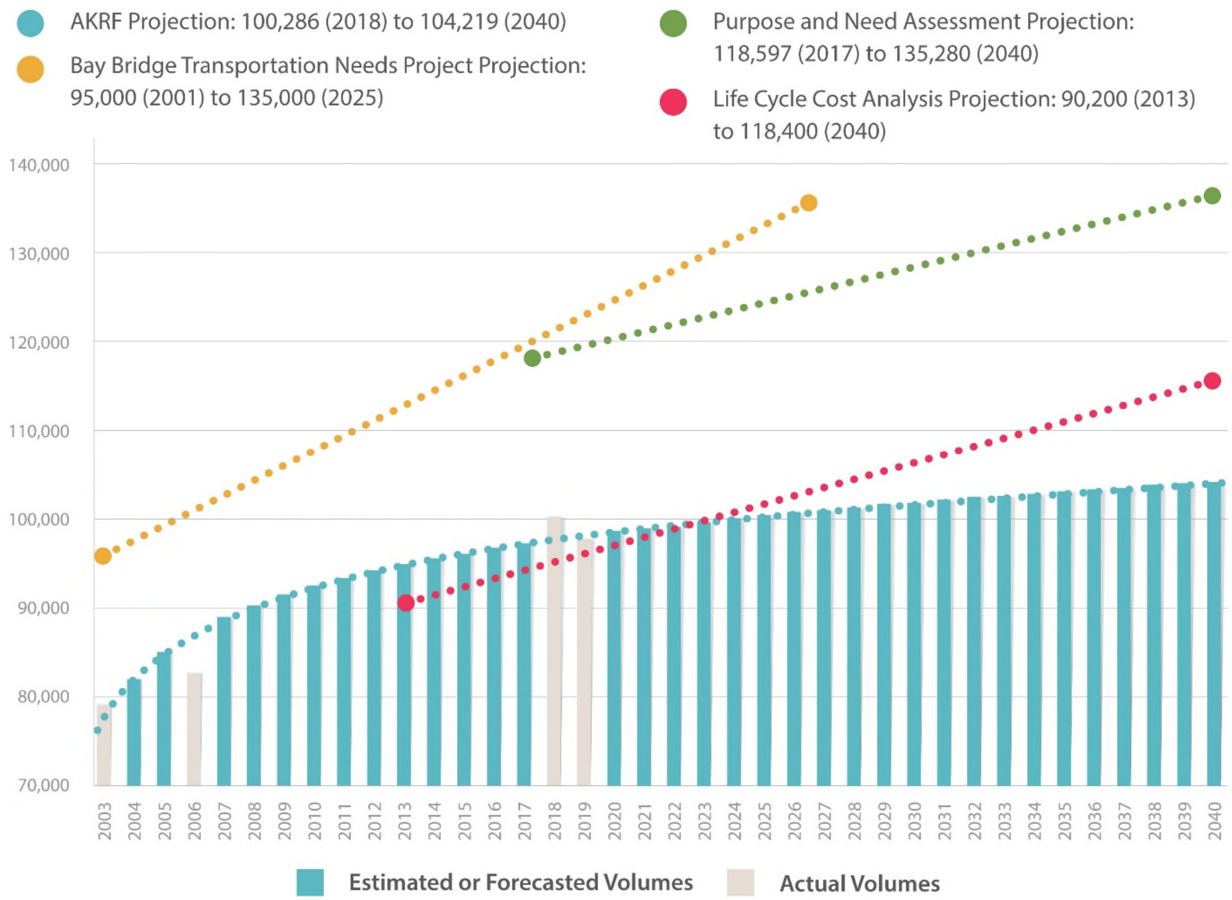


Figure 1. Comparison Graph of AKRF Realistic Traffic Projections to Previous MDTA Studies, Summer Weekend Daily Traffic in Vehicles Per Day

For the purposes of projecting realistic traffic volumes to 2040, a conservative assumption that the pattern of traffic growth observed using summer weekend daily traffic from 2003, 2006, 2018, and 2019 (years for which adequate data were available to present average summer weekend daily conditions) would continue to 2040 was applied. The best fit for these data was not a linear slope, but a logarithmic curve that smooths out as time goes on. The same curve was also used to estimate summer weekend daily traffic for the interim years between 2003 and 2018 for which data were not available. With a logarithmic curve, certain years of actual data can fall below the curve (such as 2006) or above the curve (such as 2018), but the overall correlation of the fitted curve with the data was found to be strong enough for it to be applied for the traffic volume projections[1]. As shown in **Figure 1**, the Purpose and Need Assessment begins with a much higher baseline data point for summer weekend daily traffic (118,600 vehicles a day). This is because the Purpose and Need Assessment used only a one-day sample of data in August of 2017 to report average summer weekday 2017 existing traffic volumes which

[1] The R-squared value, which is a measure of the variation of actual summer weekend traffic volume data to the logarithmic trendline, was determined to be 0.90. This reflects a strong correlation with the actual data, since the R-squared value ranges from 0 to 1, and values closer to 1 reflect greater correlation between fitted trendlines and observed data.

resulted in a much higher traffic volume than for an average 2017 summer weekend day. The difference in these starting points translates to much higher 2040 traffic projections in the Purpose and Need Assessment than would reasonably be expected, which is used to support the need for a bridge replacement. None of the projections shown in **Table 1** and **Figure 1** (including AKRF's) consider the effect on traffic volume associated with the current COVID-19 pandemic, or another recession or two that could occur between 2019 and 2040. The 2007-2008 financial crisis resulted in a decrease in average annual daily traffic (AADT) by 5.4 percent in 2008 according to data from the Purpose and Need Assessment, shown in **Figure 2**.

Figure 2. 2005-2015 Annual Average Daily Traffic, Weekdays and Weekends Combined

Additional recession events would result in reducing the traffic volumes even further. In a scenario where there would be two hypothetical economic downturns between 2019 and 2040, traffic volumes are anticipated to stagnate for several years similar to the pattern shown in **Figure 2** following the 2007-08 financial crisis. **Figures 3 and 4** show the weekday and weekend projected daily traffic volumes, respectively, after factoring in two economic downturns. The first economic downturn was assumed to occur in 2020-2022 due to the 2020 coronavirus pandemic. Traffic volumes would decline in 2020 due to the pandemic and then it was assumed for the purposes of the projection that they would sharply recover but remain stagnant from 2021-2022, though it should be noted that as of September, 2020 there remains significant uncertainty over how quickly the economy, and traffic volumes in general, is expected to recover. The second economic downturn was assumed to occur in 2030-2032, and traffic volumes would also stagnate over this period. Assuming that the same pattern of traffic volume growth would occur during interim years, this would result in a slightly lower projected 2040 traffic volumes and growth rates, as shown in **Table 2**.

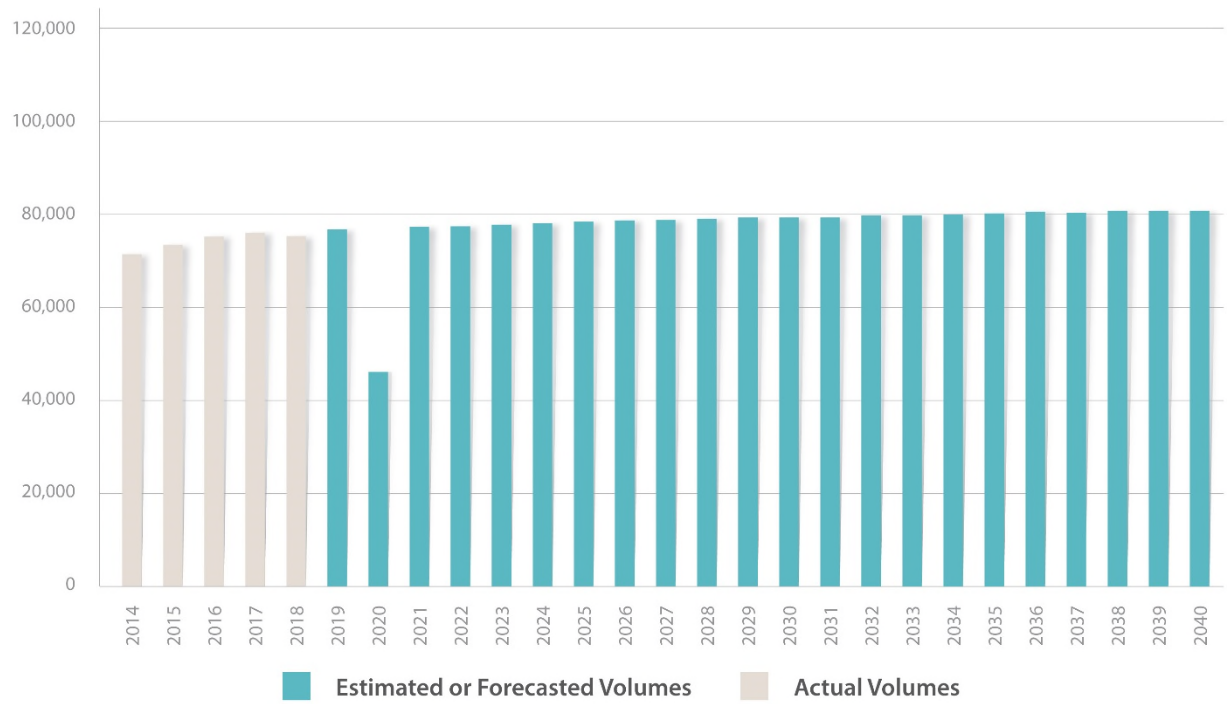


Figure 3. Weekday Annual Average Daily Traffic projections assuming two hypothetical recessions

- 2020-2022: COVID-19 induced recession resulting in 40 percent decline in 2020 traffic volume and stagnation in recovery of traffic volumes in 2021-22
- 2030-2032: Hypothetical recession resulting in a two-year stagnation of traffic volumes

Figure 4. Summer Weekend Annual Average Daily Traffic projections assuming two hypothetical recessions

- 2020-2022: COVID-19 induced recession resulting in 40 percent decline in 2020 traffic volume and stagnation in recovery of traffic volumes in 2021-22
- 2030-2032: Hypothetical recession resulting in a two-year stagnation of traffic volumes

Table 2
Comparison of Chesapeake Bay Bridge Daily Traffic Volume Projections (with economic downturns assumed)

	Actual Traffic Volumes	AKRF Traffic Volume Projection, With Economic Downturns Assumed		Bay Crossing Study Purpose and Need Assessment (2019)			Life Cycle Cost Analysis (2015)			Bay Bridge Transportation Needs Projection (2004)		
	2018	2040	%Growth	2017	2040	%Growth	2013	2040	%Growth	2001	2025	%Growth
Weekday	75,750	81,137	7%	68,598†	84,276	23%	86,200*	113,100*	31%*	61,000	86,000	41%
Weekend	100,286*	103,596*	3%*	118,597*†	135,280*	14%*	90,200*	118,400*	31%*	95,000*	135,000*	41%

NOTES:

^ Developed by AKRF, based on 2009-2018 average annual daily traffic data and 2003-2019 Automatic Traffic Recorder data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge. Assumes a COVID-19 recession from 2020-2022 resulting in temporary decline in traffic volume and subsequent two-year recovery, and a hypothetical recession in 2030-2032 resulting in a flattening of traffic volume over two-year period.

* Traffic volume for summer day

† 2017 Purpose and Need Assessment traffic volumes are based on multiple day count data for weekdays, not average annual daily traffic and single-day count data collected in August for weekends

According to the MDOT data, during an average summer weekend day in 2018, hourly traffic volumes were below the traffic capacity under ideal traffic conditions on the Chesapeake Bay Bridge during 22 hours (92 percent) of the day, as indicated in **Figure 5**. This does not suggest that there were not bridge delays during more than two hours on specific high traffic days in the summer of 2018. Under conditions where this average delay was exceeded, it was because of the constraints of the toll plaza, certain days where the average summer weekend daily traffic was exceeded, and/or the presence of non-recurring delays such as traffic incidents and emergencies which temporarily reduced the capacity of the bridge or nearby highway connections. However, the figure illustrates that when presenting average summer weekend daily traffic in 2018, only two hours of the day exceeded the bridge capacity that year. Replacing the Chesapeake Bay Bridge should not be based on unique traffic conditions that occur only over a relatively small percentage of the time, but must consider entire seasonal averages over many years of historic data, in addition to transportation trends and improvements, as discussed in this report.

2018 Summer Weekend Day—Chesapeake Bay Bridge Capacity

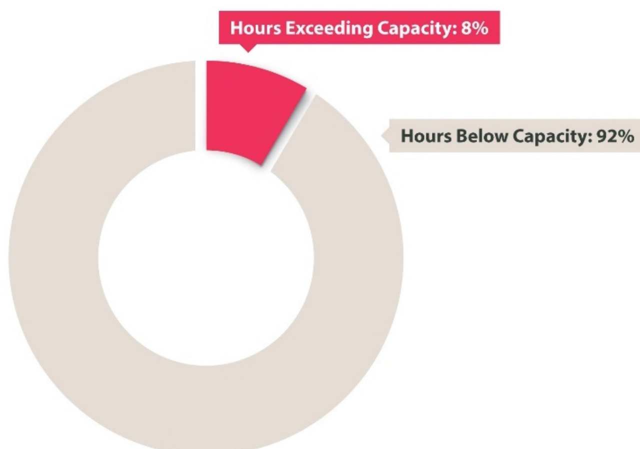


Figure 5. Actual 2018 Volumes

If more realistic growth forecasting is applied to the expected number of hours in a day that the bridge would exceed its traffic capacity, the AKRF volume projection estimates indicate that capacity on the Chesapeake Bay Bridge could be exceeded for only 12 percent of a typical summer day in 2040, compared to 58 percent of a summer day according to the Purpose and Need Assessment traffic volume projections, shown in **Figures 6** and **7**.

2040 Summer Weekend Day—Chesapeake Bay Bridge Capacity

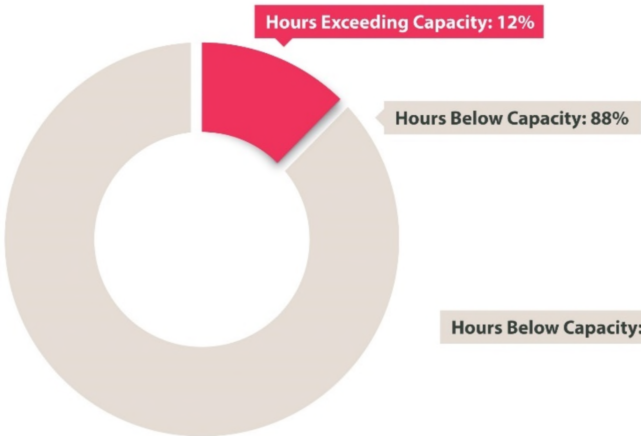


Figure 6. 2040 AKRF Volume Projections

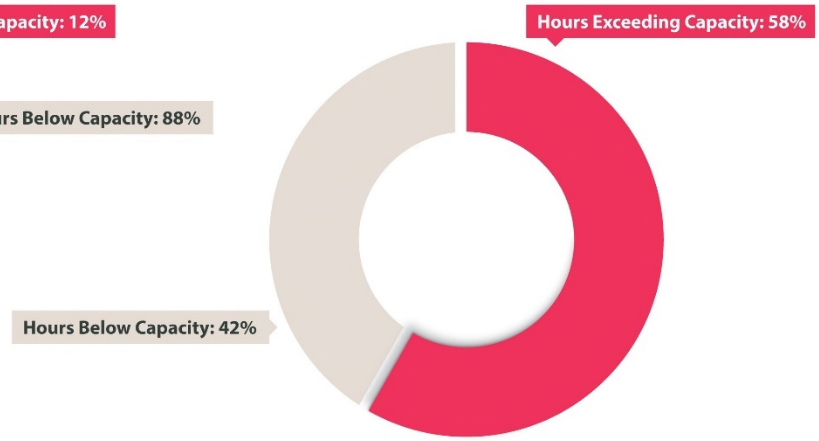


Figure 7. 2040 Purpose and Need Assessment Volume Projections

Although under the AKRF projection, bridge capacity would be exceeded for 12 percent of a typical summer day in 2040, it is AKRF's opinion that this projected capacity exceedance, which is of modest proportions, would likely be even lower than 12 percent considering the operational improvements and mobility trends discussed in the next section of this study..

Trends and Improvements

In addition to traffic growth comparisons, this report presents several traffic operational improvements and mobility trends that could be considered to prolong the life of the bridge. The additional improvements and/or trends analyzed in this report which presumably were not included in the traffic projections in the Purpose and Need Assessment but should be considered in the DEIS are:

- **Telecommuting**, which gained traction among all regional workers between 2000 and 2016 (the most recent year for which census commuting data is available) in the Washington D.C. and Baltimore Metropolitan areas, Queen Anne's County, and Anne Arundel County;

- **Cashless Tolling**, or converting the eastbound Bay Bridge toll plaza to all electronic toll collection which occurred in May 2020;

- **Congestion Pricing**, which uses variable tolls by time of day/year to manage peak period congestion and induce some motorists with flexibility in their travel plans to shift their trip to off-peak times; and

- **Managed Lanes**, a dynamic management tool using real-time data to allow MDTA to better decide when the reversible lane should be used, or if the reversible lane or other lanes should have higher tolls, or require high occupancy vehicles to use it during peak conditions to reduce overall traffic congestion on the Bay Bridge.

These improvements and/or trends are not new to the D.C./Baltimore Metro area, and each are available tools with a proven record for reducing peak period traffic congestion, which could extend the life of the bridge. If implemented in combination, there would be even greater benefits. The results of individual studies for each of the potential improvements and their effects on different metrics for traffic operations are presented below, with supporting materials provided in the appendices.

Telecommuting

If the percent of the region's workforce that chooses to telecommute increased from five percent today to 10 percent in 2040 as a reasonable assumption for more aggressive adoption of telecommuting **(See Appendix 2**), typical weekday daily traffic volumes on the Chesapeake Bay Bridge according to AKRF projections would increase by only four percent from 2018 to 2040, compared to eight percent if the share of the workforce that telecommutes were to continue to grow at the steady rate of three percent per year as for the past decade. These volumes and growth rates are compared to the Purpose and Need Assessment forecasted traffic volume growth rate of 23 percent from 2017 to 2040, as shown in **Table 3.**

Table 3

Comparison of Chesapeake Bay Bridge Daily Traffic Volume Projections

	Actual Traffic Volumes	Current AKRF Traffic Volume Projection*		AKRF Traffic Volume Projection with Accelerated Growth in Telecommuting**			Bay Crossing Study Purpose and Need Assessment (2019)[†]		
	2018	2040	%Growth	2018	2040	%Growth	2017	2040	%Growth
Weekday	75,750	81,487	8%	75,454	78,339	4%	68,598	84,276	23%

NOTES:

* Developed by AKRF, based on 2009-2018 annual average daily traffic data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge, 2018 base year.

** Developed by AKRF, based on 2009-2018 annual average daily traffic data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge and Reverse Journey-to-Work (RJTW) census data from the 2006-10 and 2012-16 American Community Survey for the Baltimore and Washington D.C. Metropolitan Statistical Areas, 2018 base year.

† Purpose and Need Assessment traffic volumes are based on multiple day count data for weekdays in 2017, not annual average daily traffic, and single-day count data collected in August of 2017 for weekends.

The effects of telecommuting cannot readily be applied to summer weekend days since they are outside normal working hours. However, there may be latent positive effects on Friday evening and Sunday afternoon summer weekend traffic since, with greater freedom and encouragement by employers to allow employees to telecommute as has happened during the COVID-19 pandemic, a short weekend vacation could be extended to a four-day weekend or longer vacation through telecommuting. These “long weekends” would have the effect of lowering the peak traffic demand on summer weekend days.

Cashless Tolling

In 2014, MDTA published its *All Electronic Tolling Conversion and Prioritization Study* which studied the potential conversion of various tolled facilities under its jurisdiction, including the Chesapeake Bay Bridge. In 2019 when the Purpose and Need Assessment was presented, it did not include the benefits of all electronic toll collection, also known as “cashless tolling,” which resulted in a greatly overestimated queue length in the Purpose and Need Assessment. In 2020, MDTA implemented cashless tolling on the Bay Bridge. The Purpose and Need Assessment states that the vehicle queues are projected to increase from four miles in 2017 to 13 miles in 2040 for a summer weekend and from one mile to five miles for an average weekday evening, in the eastbound direction. Applying the estimated peak queue length reductions reported for the Chesapeake Bay Bridge from the *All Electronic Tolling Conversion and Prioritization Study* for a summer Friday and an average weekday evening, the 2040 vehicle queues could be reduced to 2.6 miles during a summer weekend peak period and 1.5 miles during an average weekday evening, shown in **Table 4**.

Table 4
Chesapeake Bay Bridge Eastbound Projected Queues – All Electronic Tolling

Scenario	Weekday Queue (miles)	Summer Weekend Queue* (miles)
Existing[1]	1	4
Future 2040[1]	5	13
Future 2040 with All Electronic Tolling	1.5	2.6

NOTES: *Weekend also includes Friday

SOURCES: [1]Chesapeake Bay Crossing Study Purpose and Need Assessment

As shown in **Table 4**, when applying MDTA's Chesapeake Bay Bridge traffic queue projection for cashless tolling, the summer weekend queues in 2040 would be shorter than they were reported to be in the existing condition according to the Purpose and Need Assessment. The MDTA-projected 1.5-mile weekday queue and 2.6-mile summer weekend day queue with cashless tolling would likely be even lower in 2040 if the results would have been modeled by MDTA considering AKRF's more realistic traffic growth projections. Although there could be queues of traffic approaching the bridge even with cashless tolling in 2040, it is AKRF's opinion that this measure, taken together with the other measures described in this section, will reduce peak period traffic congestion and likely substantially prolong the life of the bridge.

Congestion Pricing

"Congestion pricing" is varying the cost of a toll based on real-time traffic demand to manage traffic congestion. Several variable tolling case studies researched for this report show that peak hour traffic operational improvements in travel times and reduction in traffic volumes can be expected after the implementation of a variable tolling system. For example, based on a variable tolling plan for all bridge and tunnel crossings between New York and New Jersey, a post-implementation study by the New Jersey Department of Transportation showed traffic could potentially be reduced by up to 6.78 percent during a weekday peak period or 2.50 percent during a weekend peak period. If variable tolling is implemented on the Chesapeake Bay Bridge, benefits may be experienced in periods where traffic demand exceeds traffic capacity, including the weekday AM and PM peak hours and the summer weekend peak period. The potential effects of these traffic reductions using the New Jersey Department of Transportation findings are shown in **Table 5**.

Table 5
Variable Tolling Volume Projection

Time Period	AKRF Hourly Traffic Volume Projection (vehicles per hour)				
	Without Variable Tolling[1]			With Variable Tolling	
	2018	2040	%Growth	2040	%Growth
Weekday – Westbound AM	3,305	3,555	7.6	3,314	0.3
Weekday – Eastbound AM	1,468	1,580	7.6	1,473	0.3
Summer Weekend – Eastbound	3,362	3,584	6.6	3,494	3.9
Summer Weekend – Westbound	4,098	4,368	6.6	4,259	3.9

SOURCES:

[1] Based on traffic growth rates developed by AKRF, based on 2001-2019 Automatic Traffic Recorder counts and 2009-2018 annual average daily traffic data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

Since there are few alternative mode choices for the Chesapeake Bay Bridge other than taking owned, rented, or for-hire private passenger vehicles, it is conservatively assumed that variable tolling would not noticeably reduce overall annual growth as a congestion management measure by itself, since the same number of vehicular trips would make the journey with variable tolls in place, but at different times of day or days of the same week. However, there could be modest benefits associated with variable tolling to induce ride sharing which could slightly reduce overall average daily traffic volumes.

Although there could be certain times of the day where the bridge capacity is exceeded even with variable tolling in 2040, it is AKRF's opinion that this measure, properly implemented and taken together with the other measures described in this section, will reduce peak period traffic congestion and likely substantially prolong the life of the bridge.

Managed Lanes

Managed lanes are a congestion management strategy that involves the application of lane use restrictions or lane tolls to increase the efficiency of a highway facility. A managed lane employs the use of pricing, vehicle eligibility, and/or access control. Examples of managed lanes include high-occupancy vehicle (HOV) lanes, high-occupancy toll (HOT) lanes, express lanes, reversible lanes, and bus- or truck-exclusive lanes. The Chesapeake Bay Bridge currently uses a reversible lane as a managed lane strategy to redistribute roadway capacity from the westbound direction to the eastbound direction during peak periods. However, the lane is reversed using a fixed schedule and is not actively managed using real-time data.

Using regionally comparable results of a managed lane study of I-66 in Virginia, the application of managed lanes at the Chesapeake Bay Bridge could result in a reduction of 2.7 percent of vehicles during summer weekends during peak hours. On the Chesapeake Bay Bridge, depending on the managed lane strategies implemented (e.g., a high-occupancy vehicle or high-occupancy toll lane at certain times), motorists during summer weekend peak times could be incentivized to change their behavior to take fewer single-occupant vehicle trips, or change their behavior to shift their trip to an off-peak time when there are no managed lane restrictions, resulting in a reduction in traffic during summer weekends during peak hours. The potential reduction in summer weekend traffic is expressed in **Table 6** as vehicles per hour compared to bridge capacity.

Table 6

Summer Weekend Managed Lanes Volume Projection

Hour	AKRF Summer Weekend Hourly Traffic Volume Projection (vehicles per hour)^					
	Without Actively Managed Lanes				With Actively Managed Lanes	
	2018		2040		2040	
	EB	WB	EB	WB	EB	WB
12-1 PM	2,727	4,098	2,906	4,368	2,828	4,250
1-2 PM	2,888	3,942	3,078	4,201	2,995	4,088
2-3 PM	2,885	3,663	3,075	3,904	2,992	3,799
3-4 PM	3,295	3,423	3,512	3,648	3,417	3,550

NOTES:
EB = Eastbound
WB = Westbound
Volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)
^Developed by AKRF, based on 2009-2018 annual average daily traffic and Automatic Traffic Recorder data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

The benefit of managed lanes is shown in **Table 7** as volume-to-capacity (V/C) ratios; a V/C ratio greater than 1.0 indicates that the capacity of the bridge would be exceeded by traffic demand, resulting in traffic congestion.

Table 7

Summer Weekend Managed Lanes Volume-to-Capacity Projection

Hour	AKRF Summer Weekend Hourly Volume-to-Capacity Projection					
	Without Actively Managed Lanes				With Actively Managed Lanes	
	2018		2040		2040	
	EB	WB	EB	WB	EB	WB
12-1 PM	0.72	1.08	0.76	1.15	0.74	1.12
1-2 PM	0.76	1.04	0.81	1.11	0.79	1.08
2-3 PM	0.76	0.96	0.81	1.03	0.79	1.00
3-4 PM	0.87	0.90	0.92	0.96	0.90	0.93

NOTES:
EB = Eastbound
WB = Westbound
V/C ratio exceeds 1.00, indicating that the projected volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)

As shown in **Table 6** and **Table 7**, the application of managed lanes along the Chesapeake Bay Bridge could result in reduced 2040 projected peak hour traffic volumes in the eastbound direction during summer weekends, and could potentially reduce the number of hours when 2040 projected weekday volumes exceed capacity. Although there could be certain times of the day where the bridge capacity is exceeded even with managed lanes in 2040, it is AKRF's opinion that this measure, properly implemented and taken together with the other measures described in this section, will reduce peak period traffic congestion and likely substantially prolong the life of the bridge.

Cumulative Effects and Conclusion

The effects of each individual improvement and/or trend on traffic volume forecasts, toll plaza queues, and traffic congestion show that by applying more realistic assumptions such as realistic growth, telecommuting, or cashless tolling, and implementing appropriate congestion mitigation strategies such as congestion pricing or managed lanes, the projected traffic conditions in the Purpose and Need Assessment would not be reached in 2040. Two cumulative effects analyses are presented:

(1) a typical weekday traffic volume projection showing the number of years it would take to reach the projected 2040 daily volumes presented in the Purpose and Need Assessment of 84,276 vehicles per day (shown in **Table 1**) if more realistic growth and continued natural growth in telecommuting were assumed; and

(2) a summer weekend peak hour volume-to-capacity comparison showing the number of years it would take to reach the projected 2040 daily congested hours exceeding bridge capacity shown in **Figure 6** according to the Purpose and Need Assessment if the benefits of congestion pricing and managed lanes benefits were assumed.

The results of these studies show that by assuming more realistic traffic growth trends, when combined with commonly-used, implementable traffic congestion-reducing tools, the Chesapeake Bay Bridge would not reach the metrics presented in the Purpose and Need Assessment until late this century or beyond.

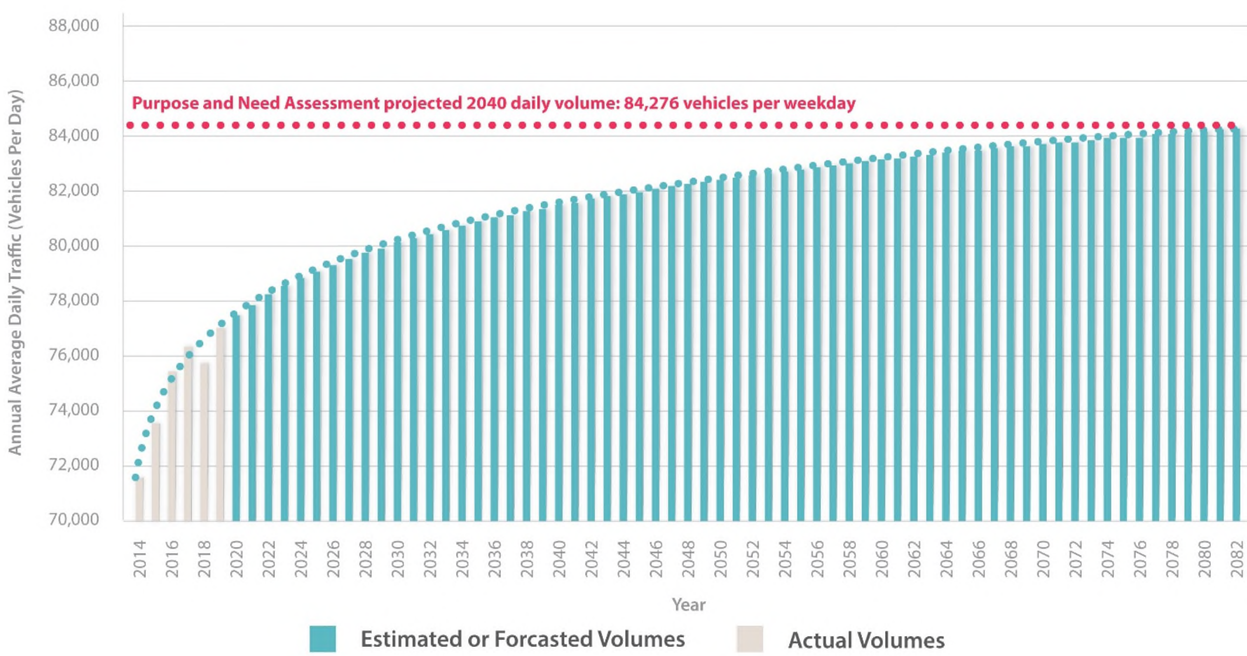


Figure 8. Estimated Number of Years to Reach Purpose and Need Weekday Daily Projected Traffic Volumes per AKRF Realistic Traffic Growth Forecasts and Continued Telecommuting Trends

As shown in **Figure 8**, based on the more realistic traffic volume growth rates, the projected weekday daily traffic volume of approximately 84,276 vehicles in 2040 would not be attained until the year 2082. The estimates presented in **Figure 8** assume a continuous, steady growth in telecommuting; if the growth rate in telecommuting were to accelerate even more rapidly when compared to the rate of growth in recent years, then it could potentially take even longer to attain the projected weekday daily traffic volume from the Purpose and Need Assessment's forecasts for 2040. Furthermore, these projections did not include potential reductions in traffic volume growth that will occur as a result of the COVID-19 pandemic and any future recessions likely to occur and last a year or more between 2019 and 2040.

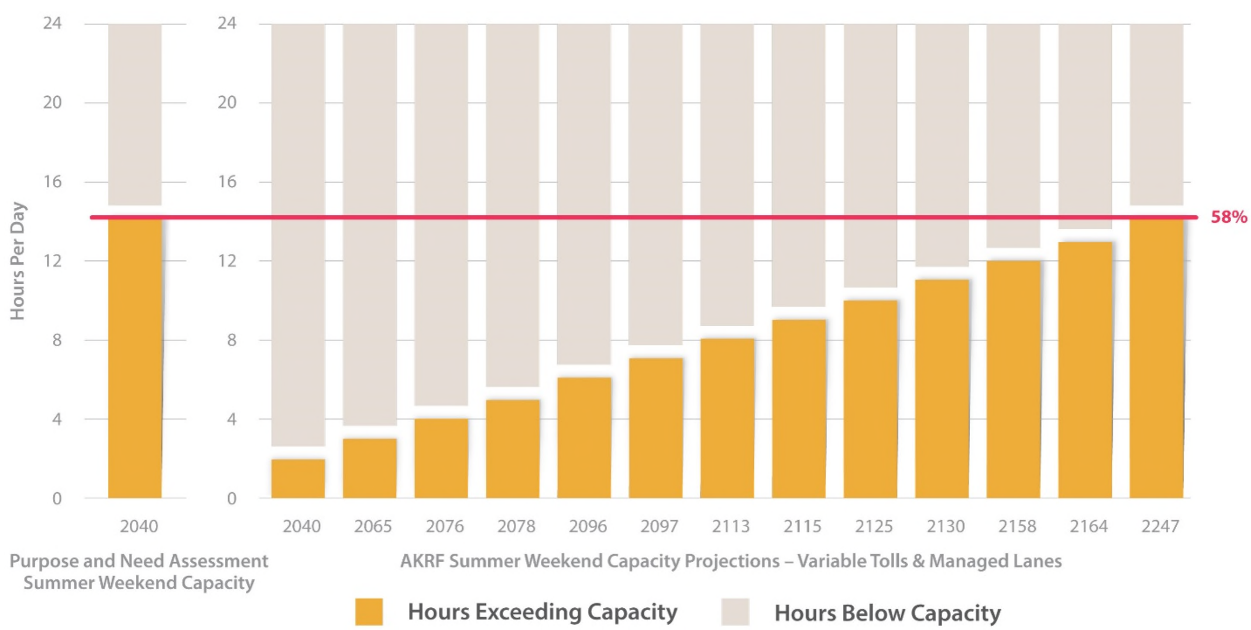


Figure 9. Estimated Years to Reach Purpose and Need Summer Weekend Daily Projected Traffic Congestion per AKRF Realistic Traffic Growth Forecasts with Variable Tolls and Managed Lanes Implemented

As shown in **Figure 9**, the Purpose and Need Assessment projects that in 2040, the bridge's traffic demand would exceed its capacity 58 percent of the time during a typical summer weekend day. However, using AKRF's realistic traffic growth and including the beneficial traffic congestion-reducing effects of variable tolls and managed lanes, in 2040 it would exceed its capacity only eight percent of the time. Furthermore, it would take until the year 2247 to reach the 2040 projections of the Purpose and Need Assessment. Much of this is owed to the higher than average counts that were collected and used as typical summer weekend daily traffic in the Purpose and Need Assessment. Even without actively managed lanes and variables tolls, the bridge would still only exceed its capacity 12 percent of the time in 2040 on summer weekends.

As previously stated, according to the 2015 Life Cycle Cost Analysis Study by MDTA, the bridge can be safely maintained through 2065 with currently programmed and anticipated rehabilitation and maintenance work, and beyond 2065, the bridge may require major rehabilitation but would not be structurally deficient or functionally obsolete. Therefore, based on the conclusions of AKRF's study of traffic congestion and operations on the bridge, and MDTA's Life Cycle Study of the bridge's structural integrity, there will not likely be a need for a replacement bridge by 2040 for either traffic or structural purposes.

APPENDIX 1

REALISTIC TRAFFIC GROWTH FORECASTING

REALISTIC TRAFFIC VOLUME GROWTH FORECASTING

Using publicly available data on annual average daily traffic (AADT) and automatic traffic recorder (ATR) counts from the Maryland Department of Transportation (MDOT), traffic projections were developed in comparison with those from the Purpose and Need Assessment. These projections are referred to as "AKRF Traffic Volume Projections." The available data[1] provides AADT and weekday AADT for roadway segments across the state of Maryland, including the Chesapeake Bay Bridge in both directions, from 2009 to 2018, and weekday and summer weekend ATR counts along the Chesapeake Bay Bridge from 2001 to 2019. The ATR count and weekday AADT data were then used to develop an estimate of the weekday and summer weekend AADT for the Chesapeake Bay Bridge in both directions.

In contrast, the Purpose and Need Assessment used a sample of one day of data in August 2017 to report 2017 existing weekend traffic volumes which resulted in a much higher than average summer weekend day. The AKRF estimates for 2018 reported daily summer weekend traffic of approximately 100,300 vehicles per day on average, and the Purpose and Need Assessment reported 2017 daily summer weekend traffic of approximately 118,600 vehicles per day. Similarly, the Purpose and Need Assessment did not use the MDOT data for weekdays even though weekday AADT is available for the bridge. Rather than use AADT and/or several days or weeks of ATR counts to normalize the traffic data, those volumes are based on single-day ATR counts in May and August 2017. As shown in **Figure 1**, summer weekends averaged annually for the month of July have only surpassed 100,000 vehicles per day one year, in 2018.

[1] https://data.imap.maryland.gov/datasets/3f4b959826c34480be3e4740e4ee025f_1, http://maps.roads.maryland.gov/itms_public/

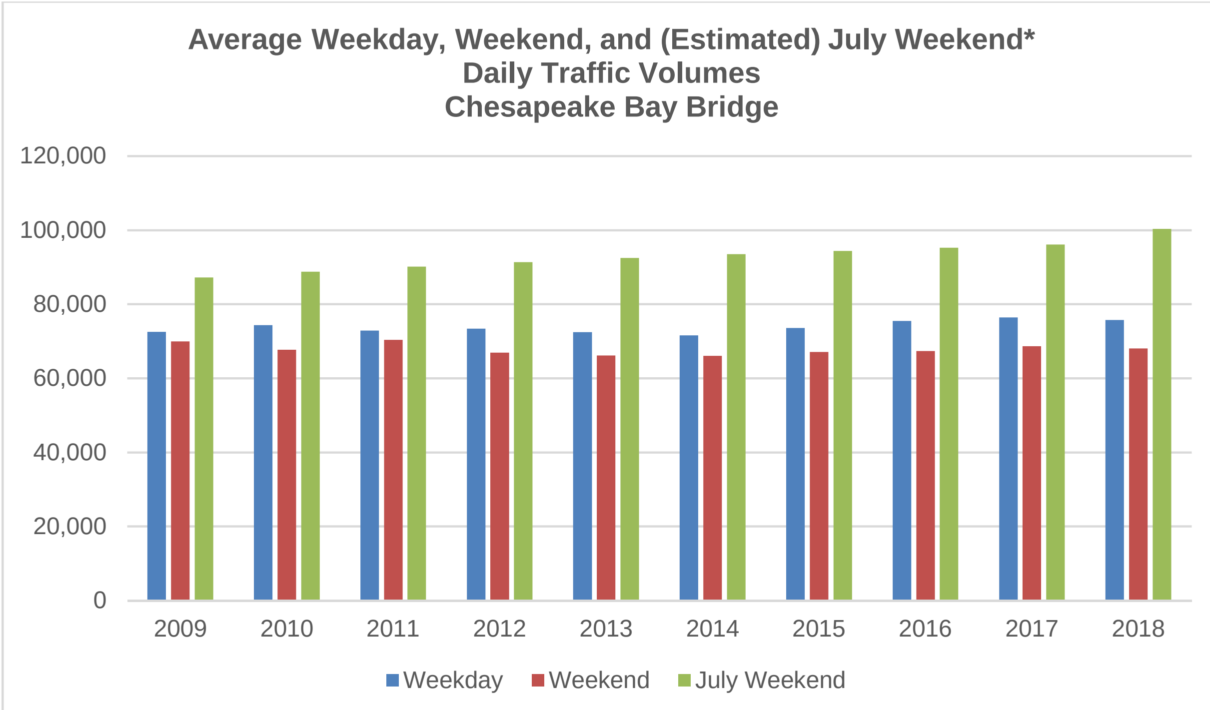


Figure 1. Chesapeake Bay Bridge annual average daily traffic volumes – weekday and weekend day. Source: Maryland Department of Transportation.
*July weekend traffic volumes for years between 2009 and 2018 were estimated, based on ATRcounts on the Chesapeake Bay Bridge on July weekends in 2003, 2006, 2018, and 2019.

For the purposes of projecting traffic volumes to 2040, a conservative assumption that the pattern of traffic growth observed from 2014 to 2018 would continue to 2040 was applied for weekday traffic volumes. The 2040 traffic volumes were projected using a logarithmic trendline that follows the pattern of traffic volume growth observed from 2014 to 2018, as shown in **Figure 2** for weekday traffic volumes. For weekend traffic volumes, the logarithmic trendline based on available July weekend traffic counts in 2003, 2006, 2018, and 2019 was applied to project traffic volumes to 2040, and to estimate traffic volumes for interim years between 2003 and 2019. The 2040 traffic volume projections are shown in **Figure 3** for weekend daily traffic volumes.

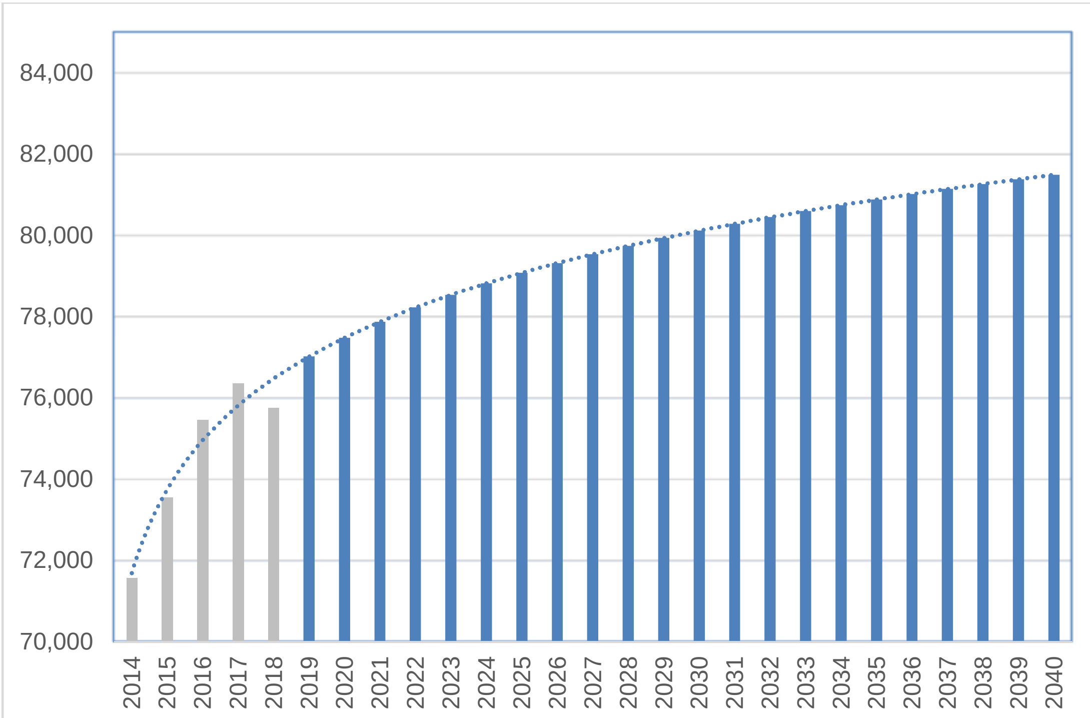


Figure 2. Chesapeake Bay Bridge average weekday daily traffic volumes projections using a logarithmic trendline from 2018 to 2040. The 2014 to 2018 weekday daily traffic volume data are based on data from the Maryland Department of Transportation. Gray bars are for actual data, and blue bars are for estimated daily traffic.

With a logarithmic curve, certain years of actual data can fall below the curve (such as 2006) or above the curve (such as 2018), but the overall correlation of the fitted curve with the data was found to be strong enough for it to be applied for the traffic volume projections. The R-squared value, which is a measure of the variation of actual summer weekend traffic volume data to the logarithmic trendline, was determined to be 0.90. This reflects a strong correlation with the actual data, since the R-squared value ranges from 0 to 1, and values closer to 1 reflect greater correlation between fitted trendlines and observed data.

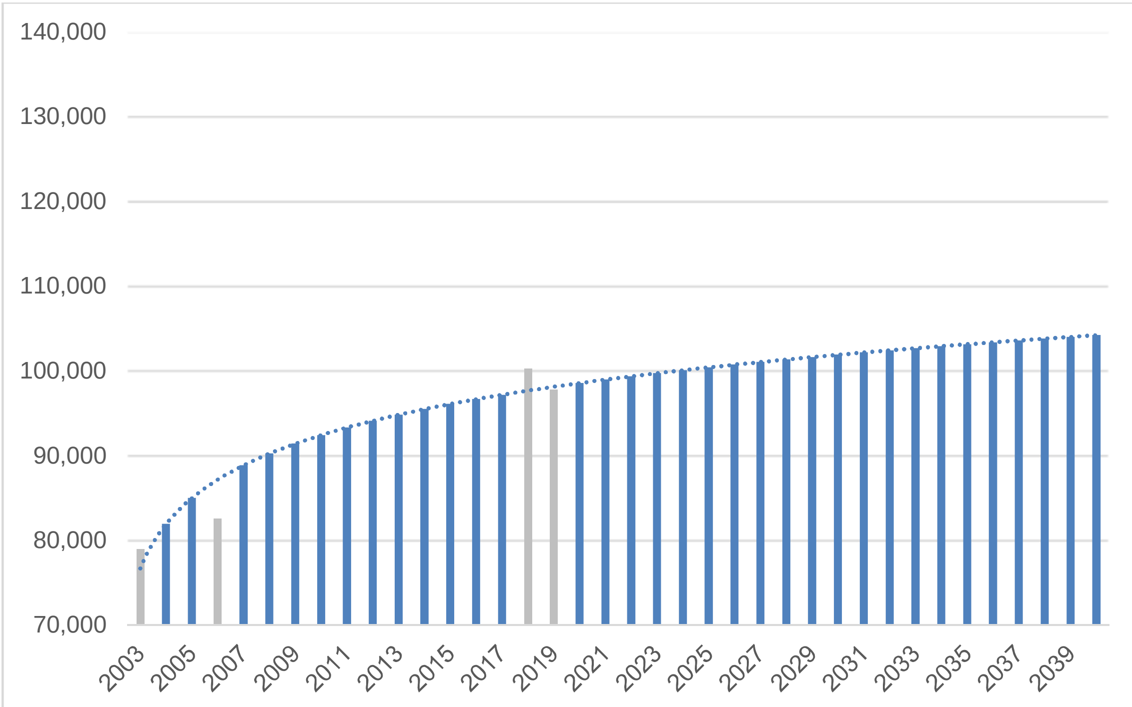


Figure 3. Chesapeake Bay Bridge average summer weekend daily traffic volumes projections using a logarithmic trendline from 2018 to 2040. The 2003, 2006, 2018, and 2019 summer weekend daily traffic volume data was determined using July weekend traffic count data from the Maryland Department of Transportation, the only years for which July weekend traffic count data were available. NOTE: Data for interim years without available data between 2003 and 2018 were also estimated based the logarithmic trendline. Gray bars are for actual data, and blue bars are for estimated daily traffic.

Similarly, the population of Queen Anne's County has grown only modestly over the past decade, as shown in **Figure 4**; population over the past 20 years in the county grew primarily during the 2000s, but has remained relatively flat during the 2010s. Overall, traffic volumes on the Chesapeake Bay Bridge, particularly on weekdays, have been well-correlated with the population of Queen Anne's County, and based on population trends over the past 20 years, it is unlikely that traffic volumes would increase on a linear or exponential pattern, but rather continue at a logarithmic pattern of growth, which would eventually be limited by the capacity of the bridge during certain times of the day/year.

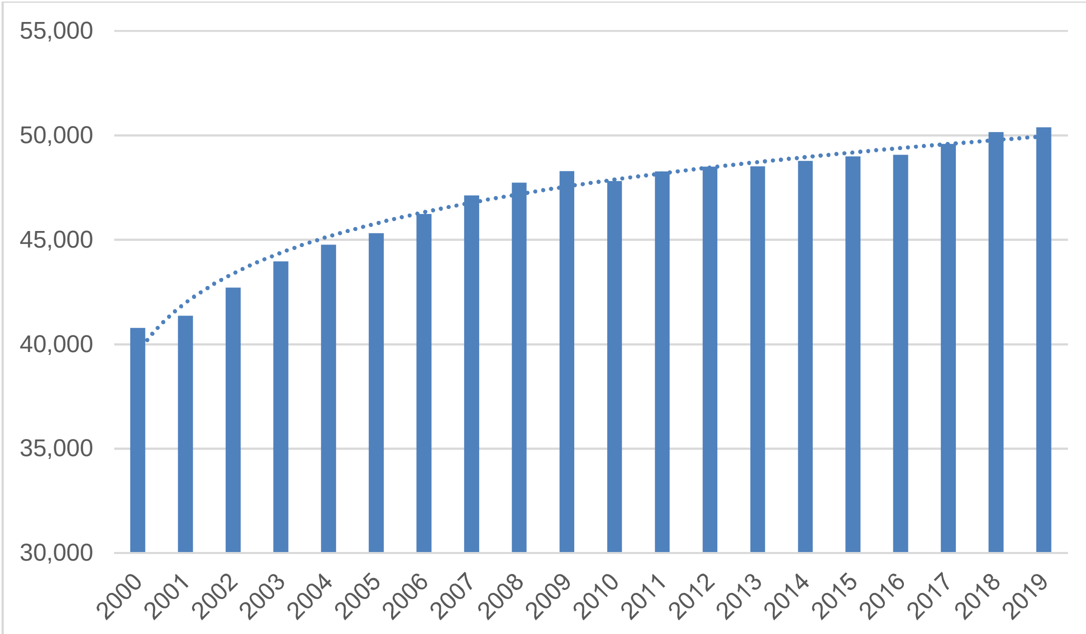


Figure 4. Population of Queen Anne's County, 2000 to 2019. Source: U.S. Census Bureau

According to AKRF projections, the growth rate from 2018 to 2040 for typical weekday traffic would be approximately 8 percent, compared to the 23 percent forecasted in the Purpose and Need Assessment. The AKRF projected 2040 summer weekend daily traffic volumes are forecasted to increase by approximately 4 percent from 2018 to 2040, compared with 14 percent (and starting at a much higher daily traffic baseline) in the Purpose and Need Assessment. The AKRF projections are based on historic traffic and show relatively more modest growth compared to those presented in the Purpose and Need Assessment, and much more modest growth when compared to previous studies.

Table 1 below compares these traffic growth rates with those presented in the Purpose and Need Assessment as well as previous studies. These projections indicate that even if one were to assume that the traffic volume growth in recent years on the Chesapeake Bay Bridge would be sustained from 2017 to 2040, it would be anticipated to grow at a more modest rate than the rate projected in the Purpose and Need Assessment.

Table 1
Comparison of Chesapeake Bay Bridge Traffic Volume Projections

	AKRF Traffic Volume Projection^			Bay Crossing Study Purpose and Need Assessment (2019)			Life Cycle Cost Analysis (2015)			Bay Bridge Transportation Needs Projection (2004)		
	2018 Actual	**2040**	**%Growth**	**2017**	**2040**	**%Growth**	**2013**	**2040**	**%Growth**	**2001**	**2025**	**%Growth**
Weekday	75,750	81,487	8%	68,598†	84,276	23%	86,200*	113,100*	31%*	61,000	86,000	41%
Weekend	100,286*	104,219*	4%*	118,597*†	135,280*	14%*	90,200*	118,400*	31%*	95,000*	135,000*	41%

NOTES:
^Developed by AKRF, based on 2009-2018 AADT data and 2003-2019 ATR data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.
*Traffic volume for summer day
†2017 Purpose and Need Assessment traffic volumes are based on single-day count data collected in May and August, not AADT

Since actual daily weekday and weekend data were available for 2018, those data were used to establish the 2018 baseline for comparison to 2040 conditions. The trends shown in **Table 1** indicate that the Maryland Transportation Authority volume projections have overestimated traffic growth in its past studies. Although the previous bridge studies have lowered the projected growth rate of traffic in each subsequent study, historic trends indicate that realistic growth projections will be even lower, even without accounting for the traffic growth-stalling effects of an economic recession or two between 2018 and 2040.

TRAFFIC VOLUME PROJECTIONS WITH POTENTIAL ECONOMIC DOWNTURNS

As shown in the table from the Purpose and Need Assessment in **Figure 5**, the economic downturn of 2007 to 2009 resulted in a 5.2percent reduction in traffic in 2008, and subsequent stagnation of traffic volumes on the Chesapeake Bay Bridge from 2009 to 2014. The traffic volume projections presented in **Figures 2 and 3** do not account for the potential for cyclical fluctuations in traffic volumes due to economic recessions, and assumes a continuous growth in a logarithmic pattern. The effect of economic recessions could further result in an even more stagnant trend in the growth in traffic volumes by 2040. The potential effects of hypothetical economic recessions were then factored into the projections, as described and summarized below:

The traffic volume projections in **Figures 2 and 3** were adjusted to account for two potential recessions:

- 2020-2022 economic recession, caused by the 2020 coronavirus pandemic
  - This recession would result in an approximately 40 percent decline in average weekday and weekend daily traffic volumes in 2020, consistent with the Institute of Transportation Engineers' studies in other major American metropolitan areas during the pandemic.[1]
  - Although there is significant uncertainty over how quickly the economy will recover from the coronavirus pandemic, it was assumed that traffic volumes would return to baseline levels by 2021, but would stagnate for a two-year period due to the effects of the economic downturn.
- A hypothetical 2030-2032 economic recession, resulting in a two-year period of stagnation in traffic volumes due to the effects of the economic downturn.

The traffic volume forecasts for the interim years would continue to follow the same logarithmic growth pattern used to develop those presented in **Figures 2 and 3**. The traffic volume projections with potential economic downturns are presented in **Figures 6 and 7. Table 2** compares the traffic volume projection with economic downturns assumed with comparable projections from the Purpose and Need Assessment and other recent studies, and shows that if there were to be several economic downturns in the future with a stagnation effect on traffic volumes, weekday daily traffic volumes are expected to continue to grow by 7 percent by 2040. Summer weekend daily traffic volumes are forecast grow by 3, compared to 4 percent by 2040.

[1] "COVID-19 Traffic Volume Trends." https://www.ite.org/about-ite/covid-19-resources/covid-19-traffic-volume-trends/

CHESAPEAKE
BAY CROSSING STUDY
TIER 1 NEPA

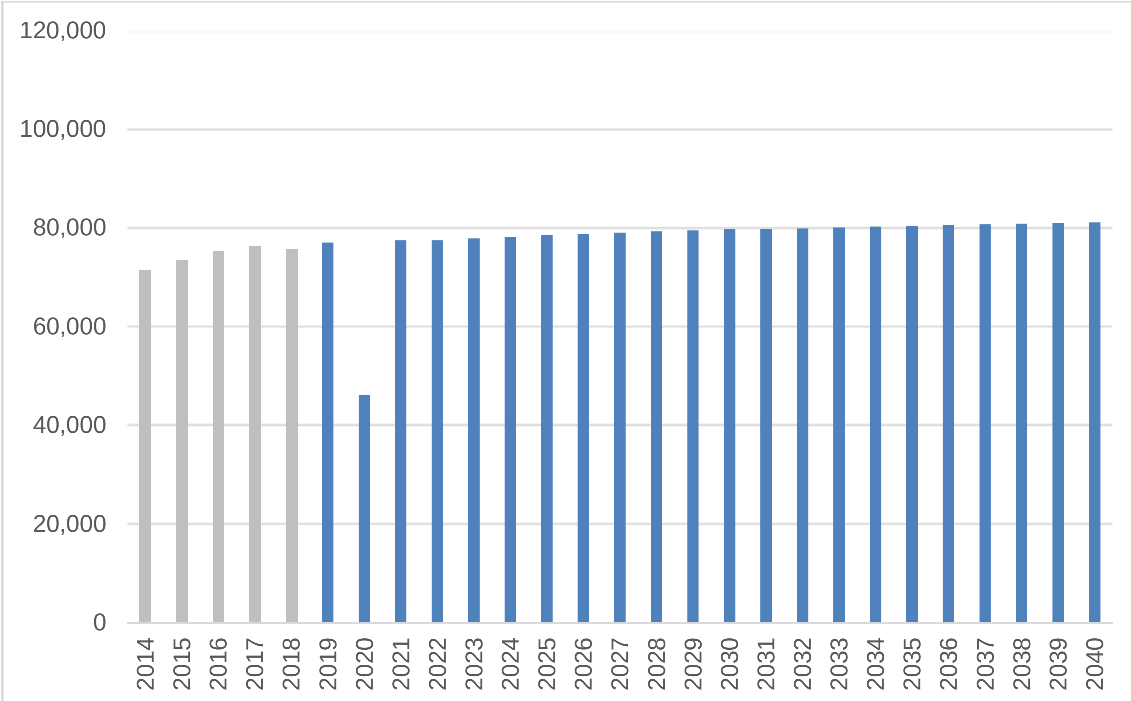
MDTA
Maryland Transportation Authority

Table 1. Annual Number of Vehicle Trips across the Bay Bridge[1]

Year	Number of Vehicles	Annual Growth (%)
1953[2]	2,100,000	-
1974[3]	7,500,000	+6.2
1980[4]	10,323,300	+5.5
1985	13,686,400	+5.8
1990	16,078,600	+3.3
1995	20,410,800	+4.9
2000	23,867,600	+3.2
2005	26,066,100	+1.8
2006	26,855,600	+2.9
2007	27,140,600	+1.1
2008	25,740,950	-5.2
2009	26,184,950	+1.7
2010	26,449,700	+1.0
2011	26,344,950	-0.4
2012	26,193,150	-0.6
2013	25,788,700	-1.5
2014	25,544,900	-0.9
2015	26,173,400	+2.5
2016	26,696,100	+2.0

[1] Number of vehicles obtained by doubling the annual vehicle counts in the EB direction
[2] 1953 is the year after the first Bay Bridge span opened to traffic.
[3] 1974 is the year after the second Bay Bridge span opened to traffic.
[4] Five year increments are shown between 1980 to 2005 due to steady annual growth during this period of time (see Graph 1 below). Annual growth shown reflects the annual growth between each of these entries, not the 5-year growth.

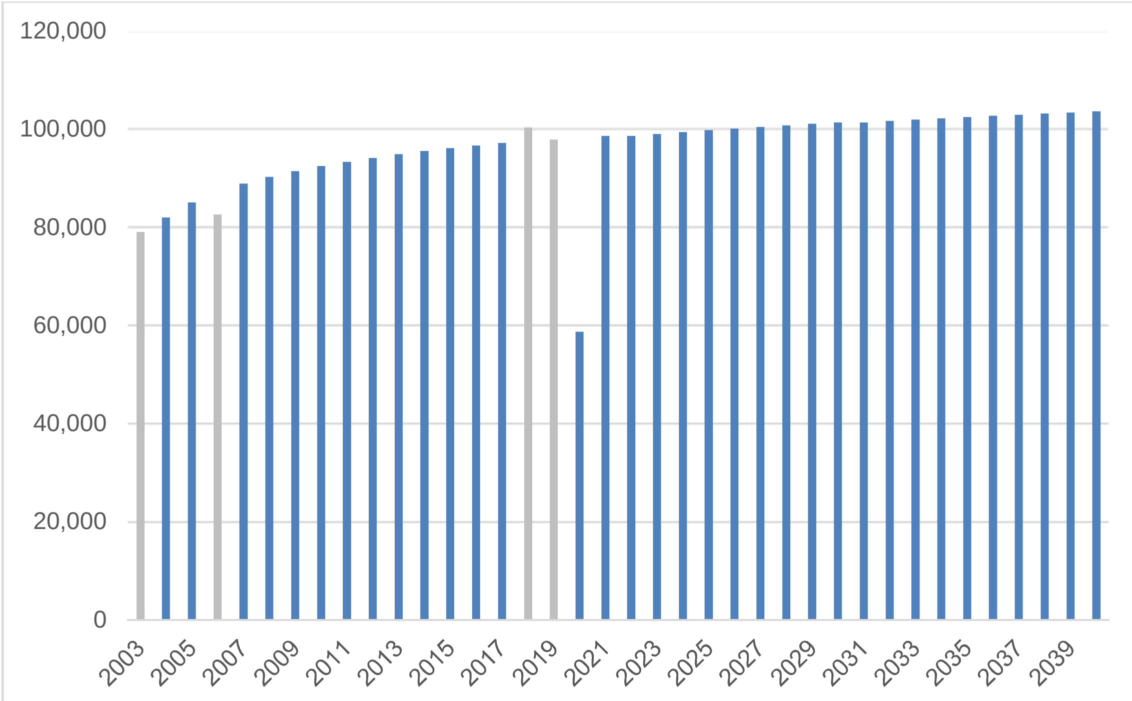
Figure 5. Screenshot of Table 1 from the Purpose and Need Assessment showing annual vehicle trips on the Chesapeake Bay Bridge by year.



Gray bars are for actual data, and blue bars are for estimated daily traffic.

Figure 6. Weekday AADT projections assuming two hypothetical recessions:

- 2020-2022: COVID-19 induced recession resulting in 40 percent decline in 2020 traffic volume (based on ITE COVID-19 traffic volume studies during pandemic) and stagnation in recovery of traffic volumes in 2021-22
- 2030-2032: Hypothetical recession resulting in a two-year stagnation of traffic volumes



Gray bars are for actual data, and blue bars are for estimated daily traffic.

Figure 7. Summer Weekend AADT projections assuming two hypothetical recessions:

- 2020-2022: COVID-19 induced recession resulting in 40 percent decline in 2020 traffic volume (based on ITE COVID-19 traffic volume studies during pandemic) and stagnation in recovery of traffic volumes in 2021-22
- 2030-2032: Hypothetical recession resulting in a two-year stagnation of traffic volumes

Table 2
Comparison of Chesapeake Bay Bridge Traffic Volume Projections (with economic downturns assumed)

	AKRF Traffic Volume Projection, With Economic Downturns Assumed^			Bay Crossing Study Purpose and Need Assessment (2019)			Life Cycle Cost Analysis (2015)			Bay Bridge Transportation Needs Projection (2004)		
	2018 Actual	**2040**	**%Growth**	**2017**	**2040**	**%Growth**	**2013**	**2040**	**%Growth**	**2001**	**2025**	**%Growth**
Weekday	75,750	81,137	7%	68,598†	84,276	23%	86,200*	113,100*	31%*	61,000	86,000	41%
Weekend	100,286*	103,596*	3%*	118,597*†	135,280*	14%*	90,200*	118,400*	31%*	95,000*	135,000*	41%

NOTES:
^Developed by AKRF, based on 2009-2018 AADT data and 2003-2019 ATR data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge. Assumes a COVID-19 recession from 2020-2022 resulting in temporary decline in traffic volume and subsequent two-year recovery, and a hypothetical recession in 2030-2032 resulting in a flattening of traffic volume over two-year period.
*Traffic volume for summer day
†2017 Purpose and Need Assessment traffic volumes are based on multiple day count data for weekdays, not weekday AADT, and single-day count data collected in August for weekends

APPLICATION OF REALISTIC TRAFFIC GROWTH

According to the 2015 *US 50/301 William Preston Lane Jr. Memorial (Bay) Bridge Life Cycle Cost Analysis* report, the maximum vehicular flow to achieve an acceptable Level of Service (LOS) D is 3,800 vehicles per hour (vph) in the eastbound direction and 3,900 vph in the westbound direction. These are daily average values factoring in the contraflow lane, which yields slightly different characteristics by direction according to the Maryland Transportation Authority report.

The AKRF hourly projected volumes for the 2017/2018 and 2040 conditions were calculated based on the weekday and summer weekend hourly volume distribution from historical ATR data from MDOT. Using the maximum vehicular flow as the theoretical capacity of the bridge, **Table 3** shows the projected hourly volumes and highlights the hours that capacity is exceeded, and **Table 4** shows the same highlighted cells but expressed as a volume-to-capacity (V/C) ratio. When the V/C ratio exceeds 1.0, the capacity of the facility is exceeded and delays and queues of traffic form approaching the bridge.

Based on the traffic volume projections developed for the Purpose and Need Assessment, traffic volumes would exceed bridge capacity for two hours (4 PM to 6 PM) on an average weekday in 2040, and for an average summer weekend day for 13 hours (8 AM to 10 AM, 11 AM to 10 PM) in 2017 and 14 hours (8 AM to 10 PM) in 2040. Under AKRF projections, traffic volumes are expected to exceed bridge capacity for two hours (4 PM to 6 PM) on an average weekday in 2040, and for an average summer weekend day for two hours (12 PM to 2 PM) in 2018 and three hours (12 PM to 3 PM) in 2040.

Table 3
Hourly Traffic Volume Projections and Capacity Projections

Time	AKRF Traffic Volume Projection (vph)^								Bay Crossing Study Purpose and Need Assessment (2019) (vph)							
	Weekday				Summer Weekend				Weekday				Summer Weekend			
	2018 Actual		2040		2018 Actual		2040		2017		2040		2017		2040	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
12 AM	271	172	292	186	550	652	587	695	246	156	302	192	651	771	743	879
1 AM	209	149	225	161	401	474	427	505	189	135	233	166	474	560	541	639
2 AM	169	155	181	167	230	298	245	318	153	141	188	173	272	353	310	402
3 AM	180	261	194	281	251	250	268	267	163	236	201	290	297	296	339	337
4 AM	267	715	287	769	311	314	331	334	242	647	297	795	367	371	419	423
5 AM	490	1,875	527	2,017	634	522	675	556	444	1,698	545	2,086	749	617	855	704
6 AM	994	2,883	1,069	3,102	1,349	809	1,438	862	900	2,611	1,106	3,208	1,595	956	1,820	1,091
7 AM	1,468	3,305	1,580	3,555	2,627	1,201	2,800	1,281	1,330	2,993	1,634	3,677	3,107	1,421	3,544	1,621
8 AM	1,629	2,823	1,752	3,037	3,260	1,892	3,475	2,017	1,475	2,556	1,812	3,140	3,854	2,238	4,397	2,553
9 AM	1,702	2,352	1,831	2,531	3,248	2,680	3,462	2,856	1,542	2,130	1,894	2,617	3,840	3,168	4,381	3,615
10 AM	2,002	2,066	2,154	2,222	3,012	3,209	3,210	3,420	1,813	1,871	2,227	2,298	3,561	3,794	4,063	4,328
11 AM	2,212	2,022	2,379	2,175	3,173	3,601	3,382	3,839	2,003	1,831	2,461	2,249	3,751	4,258	4,280	4,858
12 PM	2,216	2,047	2,383	2,202	2,727	4,098	2,906	4,368	2,006	1,854	2,465	2,277	3,224	4,846	3,678	5,528
1 PM	2,274	2,075	2,446	2,232	2,888	3,942	3,078	4,201	2,059	1,879	2,530	2,308	3,414	4,660	3,895	5,317
2 PM	2,506	2,129	2,696	2,290	2,885	3,663	3,075	3,904	2,270	1,928	2,788	2,369	3,411	4,331	3,891	4,941
3 PM	3,254	2,113	3,500	2,274	3,295	3,423	3,512	3,648	2,946	1,914	3,620	2,351	3,896	4,047	4,444	4,617
4 PM	3,736	2,072	4,019	2,228	3,362	3,348	3,584	3,569	3,383	1,876	4,157	2,305	3,976	3,959	4,536	4,516
5 PM	3,582	1,986	3,854	2,137	2,808	3,458	2,993	3,686	3,244	1,799	3,986	2,210	3,320	4,088	3,788	4,664
6 PM	3,040	1,654	3,271	1,779	2,393	3,589	2,550	3,825	2,753	1,498	3,383	1,840	2,829	4,244	3,227	4,841
7 PM	2,066	1,279	2,222	1,375	1,987	3,409	2,118	3,634	1,871	1,158	2,298	1,423	2,349	4,031	2,680	4,599
8 PM	1,725	1,023	1,855	1,100	1,596	3,515	1,701	3,747	1,562	926	1,919	1,138	1,887	4,156	2,153	4,742
9 PM	1,295	826	1,394	889	1,291	3,330	1,376	3,549	1,173	748	1,441	919	1,526	3,937	1,741	4,491
10 PM	947	545	1,019	586	1,010	1,579	1,076	1,683	858	494	1,053	606	1,194	1,867	1,362	2,130
11 PM	675	313	726	337	932	816	993	870	611	284	751	349	1,102	965	1,257	1,101
Total	38,909	36,840	41,856	39,632	46,220	54,072	49,262	57,634	35,236	33,363	43,291	40,986	54,646	63,934	62,344	72,937

NOTES:
EB = Eastbound
WB = Westbound
vph = vehicles per hour
Volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)
^Developed by AKRF, based on 2009-2018 AADT and ATR data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

Table 4

Hourly Traffic Volume-to-Capacity Ratio Projections

	AKRF Traffic Volume Projection V/C								Bay Crossing Study Purpose and Need Assessment (2019) V/C							
	Weekday				Summer Weekend				Weekday				Summer Weekend			
	2018 Actual		2040		2018 Actual		2040		2017		2040		2017		2040	
Time	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**
12 AM	0.07	0.04	0.08	0.05	0.14	0.17	0.15	0.18	0.06	0.04	0.08	0.05	0.17	0.20	0.20	0.23
1 AM	0.06	0.04	0.06	0.04	0.11	0.12	0.11	0.13	0.05	0.03	0.06	0.04	0.12	0.14	0.14	0.16
2 AM	0.04	0.04	0.05	0.04	0.06	0.08	0.06	0.08	0.04	0.04	0.05	0.04	0.07	0.09	0.08	0.10
3 AM	0.05	0.07	0.05	0.07	0.07	0.06	0.07	0.07	0.04	0.06	0.05	0.07	0.08	0.08	0.09	0.09
4 AM	0.07	0.18	0.08	0.20	0.08	0.08	0.09	0.09	0.06	0.17	0.08	0.20	0.10	0.10	0.11	0.11
5 AM	0.13	0.48	0.14	0.52	0.17	0.13	0.18	0.14	0.12	0.44	0.14	0.53	0.20	0.16	0.23	0.18
6 AM	0.26	0.74	0.28	0.80	0.36	0.21	0.38	0.22	0.24	0.67	0.29	0.82	0.42	0.25	0.48	0.28
7 AM	0.39	0.85	0.42	0.91	0.69	0.31	0.74	0.33	0.35	0.77	0.43	0.94	0.82	0.36	0.93	0.42
8 AM	0.43	0.72	0.46	0.78	0.86	0.49	0.91	0.52	0.39	0.66	0.48	0.81	1.01	0.57	1.16	0.65
9 AM	0.45	0.60	0.48	0.65	0.85	0.69	0.91	0.73	0.41	0.55	0.50	0.67	1.01	0.81	1.15	0.93
10 AM	0.53	0.53	0.57	0.57	0.79	0.82	0.84	0.88	0.48	0.48	0.59	0.59	0.94	0.97	1.07	1.11
11 AM	0.58	0.52	0.63	0.56	0.84	0.92	0.89	0.98	0.53	0.47	0.65	0.58	0.99	1.09	1.13	1.25
12 PM	0.58	0.52	0.63	0.56	0.72	1.05	0.76	1.12	0.53	0.48	0.65	0.58	0.85	1.24	0.97	1.42
1 PM	0.60	0.53	0.64	0.57	0.76	1.01	0.81	1.08	0.54	0.48	0.67	0.59	0.90	1.19	1.03	1.36
2 PM	0.66	0.55	0.71	0.59	0.76	0.94	0.81	1.00	0.60	0.49	0.73	0.61	0.90	1.11	1.02	1.27
3 PM	0.86	0.54	0.92	0.58	0.87	0.88	0.92	0.94	0.78	0.49	0.95	0.60	1.03	1.04	1.17	1.18
4 PM	0.98	0.53	1.06	0.57	0.88	0.86	0.94	0.92	0.89	0.48	1.09	0.59	1.05	1.02	1.19	1.16
5 PM	0.94	0.51	1.01	0.55	0.74	0.89	0.79	0.95	0.85	0.46	1.05	0.57	0.87	1.05	1.00	1.20
6 PM	0.80	0.42	0.86	0.46	0.63	0.92	0.67	0.98	0.72	0.38	0.89	0.47	0.74	1.09	0.85	1.24
7 PM	0.54	0.33	0.58	0.35	0.52	0.87	0.56	0.93	0.49	0.30	0.60	0.36	0.62	1.03	0.71	1.18
8 PM	0.45	0.26	0.49	0.28	0.42	0.90	0.45	0.96	0.41	0.24	0.51	0.29	0.50	1.07	0.57	1.22
9 PM	0.34	0.21	0.37	0.23	0.34	0.85	0.36	0.91	0.31	0.19	0.38	0.24	0.40	1.01	0.46	1.15
10 PM	0.25	0.14	0.27	0.15	0.27	0.40	0.28	0.43	0.23	0.13	0.28	0.16	0.31	0.48	0.36	0.55
11 PM	0.18	0.08	0.19	0.09	0.25	0.21	0.26	0.22	0.16	0.07	0.20	0.09	0.29	0.25	0.33	0.28

NOTES:
EB = Eastbound
WB = Westbound
V/C = Volume to Capacity Ratio
(yellow) V/C ratio exceeds 1.00, indicating that the projected volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)

Subsequently, for the 2040 summer weekend volume projections, the AKRF estimates indicate that capacity on the Chesapeake Bay Bridge would be exceeded for 12 percent of the day, compared to 58 percent of the day according to the Purpose and Need Assessment traffic volume projections, shown in **Figure 8** and **Figure 9**.

Figure 8
AKRF Volume Projections – 2040 Summer Weekend– Chesapeake Bay Bridge Capacity

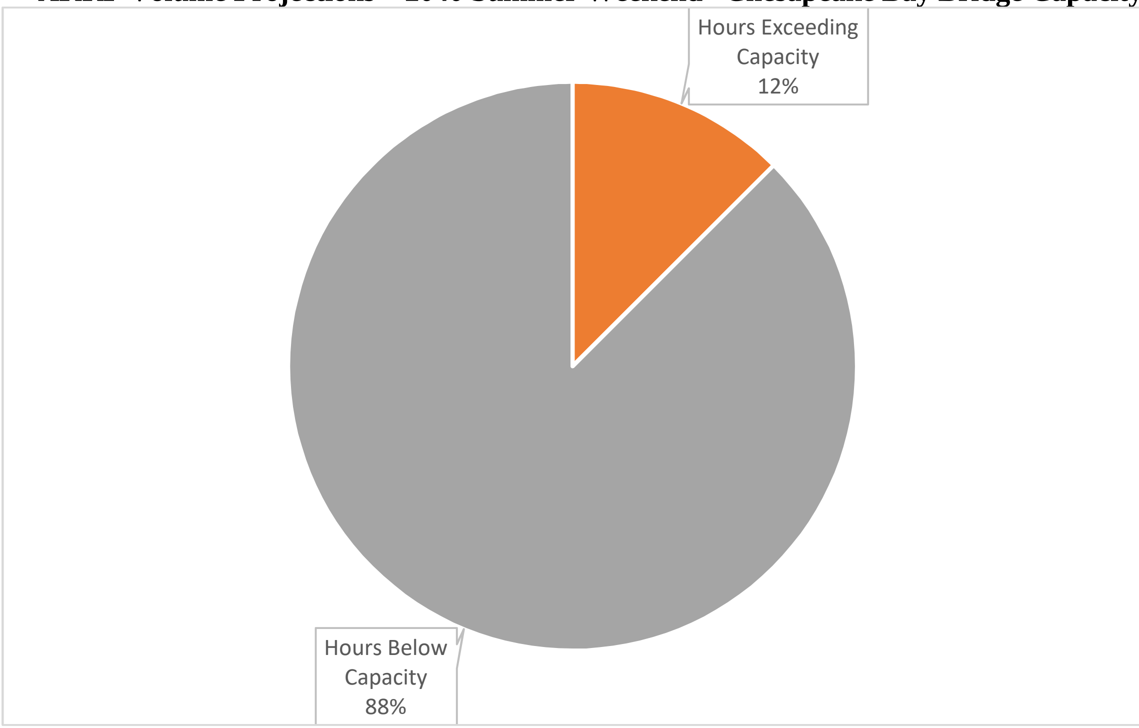
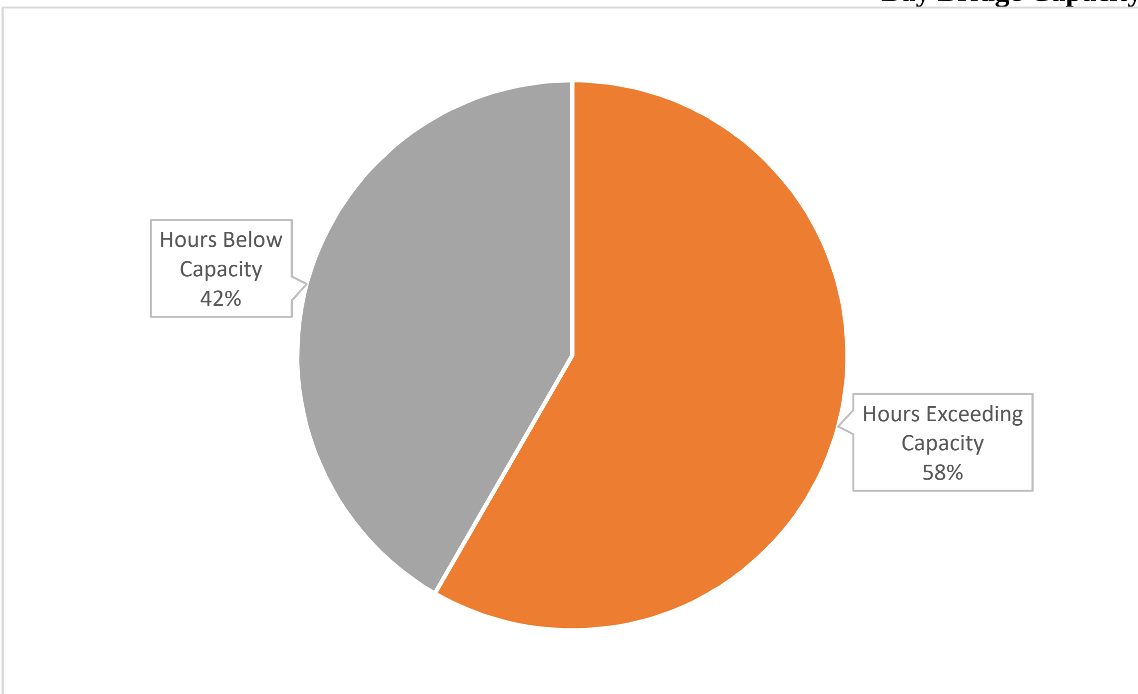


Figure 9
Purpose and Need Assessment Volume Projections – 2040 Summer Weekend– Chesapeake Bay Bridge Capacity



APPENDIX 2
TELECOMMUTING

TELECOMMUTING AND WORKING FROM HOME

According to Figure 3 in the Purpose and Need Assessment, approximately 49 percent of non-summer weekday westbound Chesapeake Bay Bridge traffic originates in Queen Anne's County, while 41 percent is destined for Anne Arundel County; approximately 44 percent of non-summer weekday eastbound bridge traffic originates in Anne Arundel County, while 47 percent is destined for Queen Anne's County. This is an indication that on a typical non-summer weekday, a significant portion of bridge traffic is "local" and likely made up of work-related trips. Many types of work-related trips have the potential to be replaced by telecommuting, as is being proven during the COVID-19 pandemic. Below, research on telecommuting worker population statistics as reported by Census data are presented.

Even if the population of Queen Anne's County, Anne Arundel County, and the surrounding region was assumed to grow at a faster rate than it did over the past 20 years, the corresponding effect on traffic volumes could be partially offset by a substantial rise in telecommuting. The ability for workers, particularly those employed in professional services industries, to tele-commute has already had a modest effect in limiting the growth in commuting by car in Queen Anne's County, Anne Arundel County, and the surrounding region. From 2000 to 2016, the workforce of Queen Anne's County and Anne Arundel County increased by 20 percent and 15 percent, respectively. The workforce of the Washington D.C. and Baltimore metropolitan regions increased by 24 percent and 12 percent, respectively. In comparison, the growth in the number of commuters traveling by car to work over this period was more modest, as shown in **Table 2**.

Table 2
Comparison of Growth in Telecommuting and Car Commuting in Region

	2000	2010	2016	Percent Growth 2000-2016
Workers Telecommuting				
Queen Anne's County	1,150	1,580	1,800	57%
Anne Arundel County	8,765	10,593	14,500	65%
Washington DC Metropolitan Area	93,460	127,540	163,855	75%
Baltimore Metropolitan Area	38,590	48,605	60,060	56%
Workers Commuting By Car				
Queen Anne's County	18,950	21,095	22,135	17%
Anne Arundel County	232,780	242,510	257,315	11%
Washington DC Metropolitan Area	2.18 million	2.36 million	2.52 million	15%
Baltimore Metropolitan Area	1.06 million	1.13 million	1.17 million	10%
Total Workforce				
Queen Anne's County	20,850	23,590	25,060	20%
Anne Arundel County	255,860	270,361	293,520	15%
Washington DC Metropolitan Area	2.67 million	3.04 million	3.32 million	24%
Baltimore Metropolitan Area	1.22 million	1.32 million	1.38 million	12%
Source: U.S. Census Bureau - 2000 Census, 2006-10 and 2012-16 American Community Survey				

As shown in the above table, the greater increase in telecommuter workforce from 2000 to 2016 (57 percent) in Queen Anne's County compared to total workforce growth over the same period (20 percent) means that telecommuting worker growth is outpacing total workforce growth at a rate of almost 3 to 1. The increasing percentage of telecommuters to total workforce (7 percent in 2016 compared to 5 percent in 2000) also shows that telecommuting is on the rise. In Anne Arundel County, the telecommuter workforce grew at an even faster rate from 2000 to 2016 (65 percent), compared to total workforce growth over the same period (15 percent). The telecommuter worker growth in Anne Arundel County outpaced total workforce growth at a rate of 5 to 1. Similar trends of substantial growth in telecommuting relative to growth in commuting by car and growth in the total workforce were also pertinent to the wider region, in both the Baltimore and Washington D.C. metropolitan areas, indicating that this trend was not exclusive to the counties on either end of the Chesapeake Bay Bridge.

The COVID-19 pandemic has permanently changed employers' and employees' attitudes about telecommuting, as evidenced by polls. A poll conducted by Gallup found that in April 2020, a maximum of 63 percent of the surveyed American workforce worked from home due to the pandemic. Due to the COVID-19 pandemic, a growing number of the workforce, particularly those employed in professional services industries, are becoming increasingly accustomed to working from home, and may choose to continue to do so going forward, instead of commuting to work. The Gallup poll also found that approximately 49 percent of respondents would prefer to continue to work from home, and 59 percent of respondents would prefer to work remotely as much as possible rather than return to work at the office. Additionally, research has shown that the implementation of travel demand programs, such as incentivizing workers to telecommute, has had a statistically significant effect on reducing the likelihood that the worker commutes by driving alone.

As shown in the trends from 2000 to 2016, while this potential sustained growth in telecommuting may not necessarily mean that traffic volumes would remain steady over the long term in Queen Anne's County, Anne Arundel County, and the surrounding region, it could help offset the effects of population growth in the region on traffic volumes, as it would reduce the share of the workforce that drives to work.

APPLICATION OF TELECOMMUTING

Based on the telecommuting trends in the surrounding region described above, AKRF traffic volume projections were developed for the year 2040, in a scenario where telecommuters in the Baltimore-Washington region would consist of approximately 10 percent of the workforce by 2040, compared to 5 percent in 2016. This scenario assumes that due to advances in technology and changes in workplace policies and individual preferences, telecommuting will continue to grow to a level where it would be adopted by a growing share of the workforce. While the COVID-19 pandemic in 2020 may have accelerated this trend, with potentially more than 10 percent of the workforce choosing or being required to telecommute, this scenario conservatively assumes that trend to be short-term and temporary in nature due to an external shock, and would eventually return closer to the pre-pandemic telecommuting rate. The doubling of the share of the workforce choosing to telecommute in the Baltimore-Washington region from 2016 to 2040 is assumed to be influenced more by longer term external forces such as improved access to high-speed internet and broadband infrastructure and other technological advances that allow on-site work to be conducted remotely, and changing societal norms and workplace policies that are more receptive toward remote work. The methodology for applying this scenario to the traffic volume projections is described in detail below.

METHODOLOGY

- As shown in **Table 3** below, the share of telecommuters in the Baltimore-Washington D.C. region grew by about 3 percent per year from 2010 to 2016. In comparison, the share of workers commuting by car in the region declined by about 0.3 percent per year from 2010 to 2016.
- Two-way weekday traffic volumes on the Chesapeake Bay Bridge over the same period from 2010 to 2016 were compared to this growth in telecommuting in the region. Based on weekday annual average daily traffic (AADT) data from the Maryland Department of Transportation, two-way traffic volumes on the Chesapeake Bay Bridge totaled 74,362 in 2010. In 2016, two-way traffic volumes totaled 75,454. From 2010 to 2016, the weekday daily traffic volumes on the bridge increased by approximately 180 vehicles per year.
- From 2016 to 2040, the traffic volume projections developed in **Table 1** already account for continuous growth in telecommuters among the workforce, albeit at a similar rate (3 percent) as what was observed from 2010 to 2016.
- As mentioned previously, the growth in telecommuting in the workforce is not assumed to be inversely proportional to the actual traffic volume on the Chesapeake Bay Bridge. While the COVID-19 pandemic resulted in declines in traffic volume due to a widespread adoption of remote work, this is not considered to be reflective of typical patterns and long-term trends, and is treated as a temporary condition due to an external shock. Under steady-state conditions, traffic volumes are expected to grow, even with the increase in telecommuting, as the population of the region increases. As shown in **Table 2**, although the number of telecommuters in the region increased substantially from 2000 to 2016, the number of car commuters also increased in raw numbers. However, as shown in **Table 3**, a greater share of the workforce chose to telecommute, while a smaller share of the workforce chose to commute by car.
- Therefore, for the purposes of applying the 10 percent telecommuting share scenario to the traffic volume projections, the growth in telecommuting was assumed to be inversely proportional to the growth in the traffic volume on the Chesapeake Bay Bridge, rather than the traffic volume itself.
- Assuming that the number of telecommuters in the Baltimore-Washington D.C. region would increase from 5 percent of the workforce in 2016 to 10 percent of the workforce in 2040, that would translate to an annual growth rate in the telecommuting share of 4.5 percent per year, which would be compared to the growth rate of 3 percent per year from 2010 to 2016. Therefore, this scenario assumes that due to technological advances and changing societal norms, the rate of growth in telecommuting in the region would accelerate from 2016 to 2040.
- Assuming that the annual rate of growth in the share of telecommuters in the workforce is inversely proportional to the annual growth in traffic volumes on the Chesapeake Bay Bridge, the annual increase of 180 vehicles per weekday on the Chesapeake Bay Bridge from 2010 to 2016 was multiplied by the ratio in the telecommuting growth rate to arrive at an annual increase of 120 vehicles per weekday from 2016 to 2040, as shown in the calculation below:

(Increase of **180** vehicles per weekday on bridge from 2010 to 2016)

x

[(**3 percent** annual growth rate in telecommuting from 2010 to 2016)
/
(projected **4.5 percent** annual growth rate in telecommuting from 2016 to 2040)]

=

(Increase of **120** vehicles per weekday on bridge from 2016 to 2040)

Table 3
Share of Workforce in Telecommuting and Car Commuting in Region

	2010	2016	Annual Growth 2010-2016
Workers Telecommuting (% of Total Workforce)			
Baltimore and Washington DC Metropolitan Areas (combined)	4.0%	4.8%	3.0%
Queen Anne's County	6.7%	7.2%	1.2%
Anne Arundel County	3.9%	4.9%	4.3%
Washington DC-Arlington-Alexandria Metropolitan Statistical Area	4.2%	4.9%	2.8%
Baltimore-Columbia-Towson Metropolitan Statistical Area	3.7%	4.4%	3.2%
Workers Commuting By Car (% of Total Workforce)			
Baltimore and Washington DC Metropolitan Areas (combined)	80.1%	78.6%	-0.3%
Queen Anne's County	89.4%	88.3%	-0.2%
Anne Arundel County	89.7%	87.7%	-0.4%
Washington DC-Arlington-Alexandria Metropolitan Statistical Area	77.5%	76.0%	-0.3%
Baltimore-Columbia-Towson Metropolitan Statistical Area	85.9%	85.0%	-0.2%
Source: U.S. Census Bureau - 2000 Census, 2006-10 and 2012-16 American Community Survey			

2040 TRAFFIC VOLUME PROJECTION

After applying the annual increase of 120 vehicles per weekday from 2016 to 2040 to the 2016 traffic volume of 75,454 and the 24 year-period from 2016 to 2040, the estimated 2040 traffic volume would be approximately 78,300. Therefore, if the percent of the region’s workforce that choose to telecommute increases from 5 percent today to 10 percent in 2040, weekday traffic volumes on the Chesapeake Bay Bridge according to AKRF projections would increase by approximately 4 percent from 2016 to 2040. If the share of the workforce that telecommutes were to grow at a steady rate (similar to that of the past decade) from 2016 to 2040, and not at the forecasted accelerated rate in the AKRF scenario, the 2040 projected traffic volume would be approximately 81,500, and a 2016 to 2040 traffic volume increase of 8 percent. Both these forecasted traffic volume growth rates are well below the Purpose and Need Assessment forecasted traffic volume growth rate of 23 percent from 2017 to 2040, as shown in **Table 4.**

Table 4
Comparison of Chesapeake Bay Bridge Traffic Volume Projections

	AKRF Traffic Volume Projection with Accelerated Growth in Telecommuting**			AKRF Traffic Volume Projection*			Bay Crossing Study Purpose and Need Assessment (2019)		
	2018	**2040**	**%Growth**	**2018 Actual**	**2040**	**%Growth**	**2017**	**2040**	**%Growth**
Weekday	75,454	78,339	4%	75,750	81,487	8%	68,598	84,276	23%

NOTES:
*Developed by AKRF, based on 2009-2018 AADT data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.
**Developed by AKRF, based on 2009-2018 AADT data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge and Reverse Journey-to-Work (RJTW) census data from the 2006-10 and 2012-16 American Community Survey for the Baltimore and Washington D.C. Metropolitan Statistical Areas.

APPENDIX 3

CASHLESS TOLLING

ALL ELECTRONIC TOLLING, AKA "CASHLESS TOLLING"

The Chesapeake Bay Crossing Study Purpose and Need Assessment conducted transportation analyses for travel time, level of service, and planning time index using an existing condition representing an eastbound 11-lane toll plaza with a combination of manual and electronic toll lanes. The analyzed conditions do not represent the current condition of the Chesapeake Bay Bridge with All electronic toll (AET), resulting in a potential overestimation of the future transportation conditions and the need for additional capacity on the Chesapeake Bay Bridge. AET collection was fully implemented at the Chesapeake Bay Bridge (US 50/301) corridor in early May 2020, during the COVID-19 pandemic and ahead of scheduled implementation in summer 2020. The former 11-lane toll plaza was demolished to install the transponder and video identification system. The system implemented on the Chesapeake Bay Bridge uses toll transponders to charge drivers when possible and video technology to identify and bill vehicles without toll transponders; this form of tolling is also known as cashless or open-road tolling.

AET CAPACITY AND BENEFITS

Prior to the implementation of AET, a combination of manual and electronic toll collection lanes were utilized for toll collection at the bridge. According to the Tri-State Transportation Campaign May 2004 report on open-road tolling, *The Open Road*, mixed manual and electronic collection lanes will process approximately 700 vehicles per hour (vph), electronic tolling lanes in a traditional toll plaza will process approximately 1,200 vph, and open-road rolling processes 1,800 vehicles per hour. The conversion of the Chesapeake Bay Bridge to AET would reduce the toll plaza bottleneck and increase roadway capacity, resulting in improved travel speeds and times at the bridge. Because the stop-and-go traffic at the toll plaza and weaving movements between toll lanes would be all but eliminated, the potential for crashes would also be greatly reduced, according to *Toll Collection Technology and Best Practices* by the Center for Transportation Research at The University of Texas at Austin, January 2007.

In fall 2016, the Massachusetts Department of Transportation implemented all electronic tolling on the Massachusetts Turnpike (I-90), which connects western Massachusetts and the western Boston suburbs with downtown Boston. The *All Electronic Tolling 6-Month Progress Report* published in May 2017 indicated that a comparison of January 2016 pre-AET and January 2017 post-AET resulted in up to 11 minutes of travel time savings per vehicle during the morning rush hour. Similar findings were also determined for February 2016 and February 2017. The Massachusetts Department of Transportation observed reduced congestion and increased safety as a result of AET implementation.

APPLICATION OF ALL ELECTRONIC TOLLING

The January 2014 *AET Conversion and Prioritization Study* for the Maryland Transportation Authority studied the potential conversion of various tolled facilities under the jurisdiction of the Maryland Transportation Authority. The report stated that with the implementation of AET, average peak travel times at the Chesapeake Bay Bridge would decrease by 70 percent, average peak queue lengths would decrease by 80 percent, and maximum peak queue lengths would decrease by 72 percent on a summer Friday, according to VISSIM microsimulation model results. Other Maryland Transportation Authority facilities were projected to see a reduction of 10 to 29 percent in weekday average peak travel times and a reduction of 8 to 83 percent in weekday average peak delays.

The Chesapeake Bay Crossing Purpose and Need Assessment states that the vehicle queues are projected to increase from four miles in 2017 to 13 miles in 2040 for a summer weekend and from one mile to five miles for an average weekday evening, in the eastbound direction.

Applying the peak queue lengths reductions for a summer Friday and an average weekday evening presented in the *AET Conversion and Prioritization Study*, the 2040 vehicle queues could be reduced to 2.6 miles during a summer weekend peak period and 1.5 miles during an average weekday evening, shown in **Table 1**.

Table 1
Bay Bridge Eastbound Projected Queues – All Electronic Tolling

Scenario	Weekday Queue (miles)	Summer Weekend Queue* (miles)
Existing[1]	1	4
Future 2040[1]	5	13
Future 2040 with AET	1.5	2.6

NOTES: *Weekend also includes Friday
SOURCES: [1]Chesapeake Bay Crossing Study Purpose and Need Assessment

APPENDIX 4
CONGESTION PRICING

VARIABLE TOLLS AKA "CONGESTION PRICING"

Variable tolling, a form of congestion pricing, is a congestion management strategy intended to reduce peak hour travel by encouraging drivers to use alternative modes of transportation or travel during off-peak periods, reducing roadway demand during critical peak periods. Variable tolling is an appropriate countermeasure to reduce congestion on bridge crossings such as the Chesapeake Bay Bridge, since the bridge currently experiences peak directional traffic flows, a portion of which are discretionary and can be made at other times than the extreme peak periods. Variable tolling has incentivized a portion of motorists to travel during off-peak times, making variable tolling an effective tool in managing congestion during peak times.

CASE STUDIES

Port Authority of New York and New Jersey Crossings

The Port Authority of New York and New Jersey (PANYNJ) has a variable tolling plan for all bridge and tunnel crossings between New York and New Jersey, with discounted tolls during off-peak hours. Variable tolling at PANYNJ facilities has been in place since March 2001, and was studied by the New Jersey Department of Transportation (NJDOT) in connection with Rensselaer Polytechnic Institute, Rutgers University, and FHWA. The 2005 study found the implementation of variable tolling resulted in a reduction of weekday peak period traffic by between 0.06 and 6.78 percent at various PANYNJ crossings. This supporting the findings of a separate study by Mark Muriello, et al. in the Transportation Research Record that peak period traffic declined by 5.7 percent at PANYNJ crossings. A reduction of 0.28 to 2.50 percent in weekend peak period traffic was also observed at PANYNJ crossings. Overall, the study found that variable tolling led to a decrease in peak period traffic during weekdays and weekends.

New Jersey Turnpike (I-95)

Similar to the PANYNJ, the New Jersey Turnpike Authority has a variable tolling plan along the New Jersey Turnpike (I-95) by time of day with discounted off-peak tolls, which was introduced in September 2000. A study was conducted by the NJDOT in connection with Rensselaer Polytechnic Institute, Rutgers University, New Jersey Turnpike Authority, and FHWA that evaluated the impacts of variable tolling along the New Jersey Turnpike. The study compared the traffic conditions of October 1998 to June 2001 for an evaluation of the first phase of variable tolling. During the first phase, traffic volumes increased along the New Jersey Turnpike by an overall 4.81 percent increase in traffic demand. The percent share of morning and evening peak hour traffic decreased by 1.7 percent and 3.7 percent, respectively, whereas the percent share of off-peak traffic increased by 1.1 percent. Traffic volumes increased at a lower rate during the peak period at 6.27 percent during the morning peak period and 4.17 percent during the evening peak period, compared to an increase of 9.4 percent during the off-peak period.

Highway 407, Ontario, Canada

The Ontario Ministry of Transportation Highway 407 Express Toll Route utilizes variable tolling by time of day and by season. A study conducted by the Canadian Centre for Economic Analysis found that traffic speeds along Highway 407 consistently exceed that of alternate routes, with 85 percent of vehicles traveling at or over 100 kilometers per hour during peak hours at free-flow conditions. This results in a travel time savings of 52 percent during morning peak hours and 65 percent during evening peak hours, resulting in a cumulative time savings of 30.4 million hours per year.

APPLICATION OF VARIABLE TOLLING

The variable tolling case studies show that peak hour traffic operational improvements in travel times and reduction in traffic volumes can be expected after the implementation of a variable tolling system. Based on the PANYNJ study by NJDOT, traffic could potentially be reduced by up to 6.78 percent during a weekday peak period or 2.50 percent during a weekend peak period on the Chesapeake Bay Bridge if variable tolling is implemented, shown in **Table 1**.

Table 1
Variable Tolling Volume Projection

Time Period	Hourly Traffic Volume Projection (vehicles per hour)				
	Without Variable Tolling[1]			With Variable Tolling	
	2018 Actual	2040	%Growth	2040	%Growth
Weekday – Westbound AM	3,305	3,555	7.6	3,314	0.3
Weekday – Eastbound AM	1,468	1,580	7.6	1,473	0.3
Summer Weekend – Eastbound	3,362	3,584	6.6	3,494	3.9
Summer Weekend – Westbound	4,098	4,368	6.6	4,259	3.9

SOURCES:
[1] Based on traffic growth rates developed by AKRF, based on 2001-2019 ATR counts and 2009-2018 AADT data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

Since there are few alternative mode choices for the Chesapeake Bay Bridge other than taking owned, rented, or for-hire private passenger vehicles, it is conservatively assumed that variable tolling would not noticeably reduce overall annual growth if used as a congestion management measure by itself, since the same number of vehicular trips would make the journey with variable tolls in place, but at different times of day or days of the same week.

APPENDIX 5
MANAGED LANES

MANAGED LANES

Managed lanes are a congestion management strategy that involves the application of lane use restrictions or lane tolls to increase the efficiency of a highway facility. A managed lane employs the use of pricing, vehicle eligibility, and/or access control to limit highway ingress and egress. Examples of managed lanes include high-occupancy vehicle (HOV) lanes, high-occupancy toll (HOT) lanes, express lanes, reversible lanes, and bus- or truck-exclusive lanes. The Chesapeake Bay Bridge currently uses a reversible lane as a managed lane strategy to redistribute roadway capacity from the westbound direction to the eastbound direction during peak periods. However, the lane is reversed using a fixed schedule and is not actively managed using real-time data.

CASE STUDIES

SR-91 Express Lanes, California

According to the Federal Highway Administration (FHWA) *Congestion Pricing: A Primer*, the benefits of managed lanes include improvement in transit service and ridership, increase in carpooling, and increased travel speeds to free-flow conditions. California's SR-91 tolled express lanes, which has variable tolling based on time-of-day and roadway congestion with no or discounted tolls for carpooled vehicles, a 40 percent increase in carpool was observed within three months of opening in 1995. Furthermore, peak period travel speeds in the express lanes remained close to free-flow at 60 to 65 miles per hour while speeds in the free lanes were less than 20 miles per hour.

State of California Department of Transportation District 7 (Los Angeles and Ventura Counties)

The State of California Department of Transportation (Caltrans) District 7 has 557 miles of managed lane facilities (as of 2016), including SR-91. The *2016 Managed Lane Annual Report* prepared by Caltrans District 7 shows that since 1992, the managed lane system has resulted in an increase of 86 percent of carpools on managed lanes from 1992 to 2016. Conversely, carpools on highways without managed lanes has decreased by 44 percent during the same time period. During a peak hour, an average Caltrans District 7 managed lane facility carries approximately 33 percent of the entire highway's traffic while utilizing 20 percent of the roadway space.

Atlanta Regional Managed Lane System

The Georgia Department of Transportation highway network includes 55 miles of express lanes and 74 miles of HOV lanes, for a total of 129 managed lanes as of 2017. The I-85 Express Lanes, which are dynamically priced HOT lanes, opened in 2011. Travel speeds in peak hour directions on the Express Lanes generally exceeded the general travel lanes by 8 to 15 miles per hour throughout all of 2016. The Atlanta Regional Managed Lane System Plan analyzed the impact of the proposed expansion of the managed lane system, and showed an 83 percent reduction in delay for future scenarios for managed lane users and an 8 percent system-wide reduction in vehicle delay for all highway users.

I-66 Express Lanes, Virginia

The 2019 I-66 Inside the Beltway Corridor Performance Report provides an initial evaluation of the impacts of managed lanes along the I-66 corridor, comparing 2015 and 2019 performance metrics. After implementation of express lane variable tolling, I-66 in Virginia experienced an increase of 1.2 percent in the number of people in morning rush hour traffic with a decrease of 2.7 percent in the associated number of vehicles, indicating a decrease in vehicle usage and increase in transit and HOV usage. Single-occupancy vehicle usage decreased by 1.7 percent, resulting in an increase in HOV usage by 1.2 percent and increase in transit usage by 0.4 percent.

APPLICATION OF MANAGED LANES

Although these case studies of managed lanes have achieved varied operational results, they have shown at least moderate success in improving rush hour traffic conditions or by encouraging carpooling. The case studies showed that managed lanes, in particular HOV and HOT lanes, are successful in increasing the percentage of carpooled road users, by 40 percent on SR-91 in California within the first three months of implementation, by 86 percent over 14 years throughout Caltrans District 7, and by 1.2 percent in Virginia over 4 years. Travel speed on managed lanes, particularly on express lanes, exceed general travel lanes by up to 40 miles per hour in the case of SR-71 and by 8 to 15 miles per hour in the Atlanta Regional Managed Lane System.

Using the conservative and regionally comparable results of a managed lane study of I-66 in Virginia, the application of managed lanes at the Chesapeake Bay Bridge could result in a reduction of 2.7 percent of vehicles during weekdays or summer weekends during peak hours. On the Chesapeake Bay Bridge, depending on the managed lane strategies implemented, motorists during peak times could be incentivized to change their behavior to take fewer single-occupant vehicle trips, or change their behavior to shift their trip to an off-peak time when there are no managed lane restrictions, resulting in a 2.7 percent reduction in traffic, as shown in **Table 1**. Traffic volumes are presented in vehicles per hour (vph).

Table 1
Weekday Managed Lanes Volume Projection

	AKRF Weekday Hourly Traffic Volume Projection (vph)^					
	Without Actively Managed Lanes				With Actively Managed Lanes	
	2018 Actual		2040		2040	
Hour	EB	WB	EB	WB	EB	WB
7-8 AM	1,468	3,305	1,580	3,555	1,537	3,459
8-9 AM	1,629	2,823	1,752	3,037	1,705	2,955
4-5 PM	3,736	2,072	4,019	2,228	3,910	2,168
5-6 PM	3,582	1,986	3,854	2,137	3,750	2,079

NOTES:
EB = Eastbound
WB = Westbound
vph = vehicles per hour
(highlighted) Volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)
^Developed by AKRF, based on 2009-2018 AADT and ATR data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

Using the same assumptions, **Table 2** shows the effects on volume-to-capacity by direction for key peak hour periods.

Table 2
Weekday Managed Lanes Volume-to-Capacity Projection

Hour	AKRF Weekday Hourly V/C Projection					
	Without Actively Managed Lanes				With Actively Managed Lanes	
	2018 Actual		2040		2040	
	EB	WB	EB	WB	EB	WB
7-8 AM	0.39	0.85	0.42	0.91	0.40	0.91
8-9 AM	0.43	0.72	0.46	0.78	0.45	0.78
4-5 PM	0.98	0.53	1.06	0.57	1.03	0.57
5-6 PM	0.94	0.51	1.01	0.55	0.99	0.55

NOTES:
EB = Eastbound
WB = Westbound
V/C = Volume to Capacity Ratio
(yellow) V/C ratio exceeds 1.00, indicating that the projected volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)

As shown in **Table 1** and **Table 2**, the application of managed lanes along the Chesapeake Bay Bridge could result in weekday peak hour traffic volume reductions, and potentially reducing the number of hours when 2040 projected weekday volumes exceed capacity (from two hours to one hour).

Table 3 and **Table 4** show the volume reduction and capacity improvements that may be incurred by applying the 2.7 percent peak hour traffic reduction to the summer weekday peak periods.

Table 3
Summer Weekend Managed Lanes Volume Projection

Hour	AKRF Summer Weekend Hourly Traffic Volume Projection (vph)^					
	Without Actively Managed Lanes				With Actively Managed Lanes	
	2018 Actual		2040		2040	
	EB	WB	EB	WB	EB	WB
12-1 PM	2,727	4,098	2,906	4,368	2,828	4,250
1-2 PM	2,888	3,942	3,078	4,201	2,995	4,088
2-3 PM	2,885	3,663	3,075	3,904	2,992	3,799
3-4 PM	3,295	3,423	3,512	3,648	3,417	3,550

NOTES:
EB = Eastbound
WB = Westbound
vph = vehicles per hour
(yellow) Volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)
^Developed by AKRF, based on 2009-2018 AADT and ATR data available from the Maryland Department of Transportation for the Chesapeake Bay Bridge.

Table 4
Summer Weekend Managed Lanes Volume-to-Capacity Projection

Hour	AKRF Summer Weekend Hourly V/C Projection					
	Without Actively Managed Lanes				With Actively Managed Lanes	
	2018 Actual		2040		2040	
	EB	WB	EB	WB	EB	WB
12-1 PM	0.72	1.08	0.76	1.15	0.74	1.12
1-2 PM	0.76	1.04	0.81	1.11	0.79	1.08
2-3 PM	0.76	0.96	0.81	1.03	0.79	1.00
3-4 PM	0.87	0.90	0.92	0.96	0.90	0.93

NOTES:
EB = Eastbound
WB = Westbound
V/C = Volume to Capacity Ratio
[yellow] V/C ratio exceeds 1.00, indicating that the projected volume exceeds capacity (EB capacity: 3,800 vph, WB capacity: 3,900 vph)

As shown in **Table 3** and **Table 4**, the application of managed lanes along the Chesapeake Bay Bridge may also result in summer weekend peak hour traffic volume reductions, potentially reducing the number of hours when 2040 projected summer weekend volumes exceed capacity (from three hours to two hours).