DE 2 Before-and-After Travel Time and Emissions Analyses

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From: Rybinski Engineering

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Purpose

This in-depth look into operations on DE 2 makes use of Bluetooth travel time and system loop volume data to demonstrate how continuous operations data can be used to evaluate changes in traffic patterns, motorist behavior, and emissions before and after corridor signal retimings.

Background and Approach

Rybinski Engineering (RE) has studied the impacts of recent signal retiming projects using Synchro's SimTraffic microsimulation software. This allowed RE to observe the impact of signal retimings along corridors in a controlled environment; however, it did not provide insight into how the retimings actually impacted measured traffic flow and travel times along the corridors.

The impact of retimings can also be measured by calculating changes in emissions due to delay. In September 2017, RE submitted a memo to WILMAPCO evaluating methods to calculate changes in emissions based on operations data. RE recommended applying emissions rates published by Maryland State Highway Administration's (MDSHA) Coordinate Highway and Arterial Response Team (CHART) to the travel times collected by Bluetooth sensors. These emissions rates are shown in **Table 1**.

Table 1. Delay-Based Emissions Rates

Pollutant	Grams Emitted / Hour of Delay
CO	146.831
HC	13.073
NO	6.261

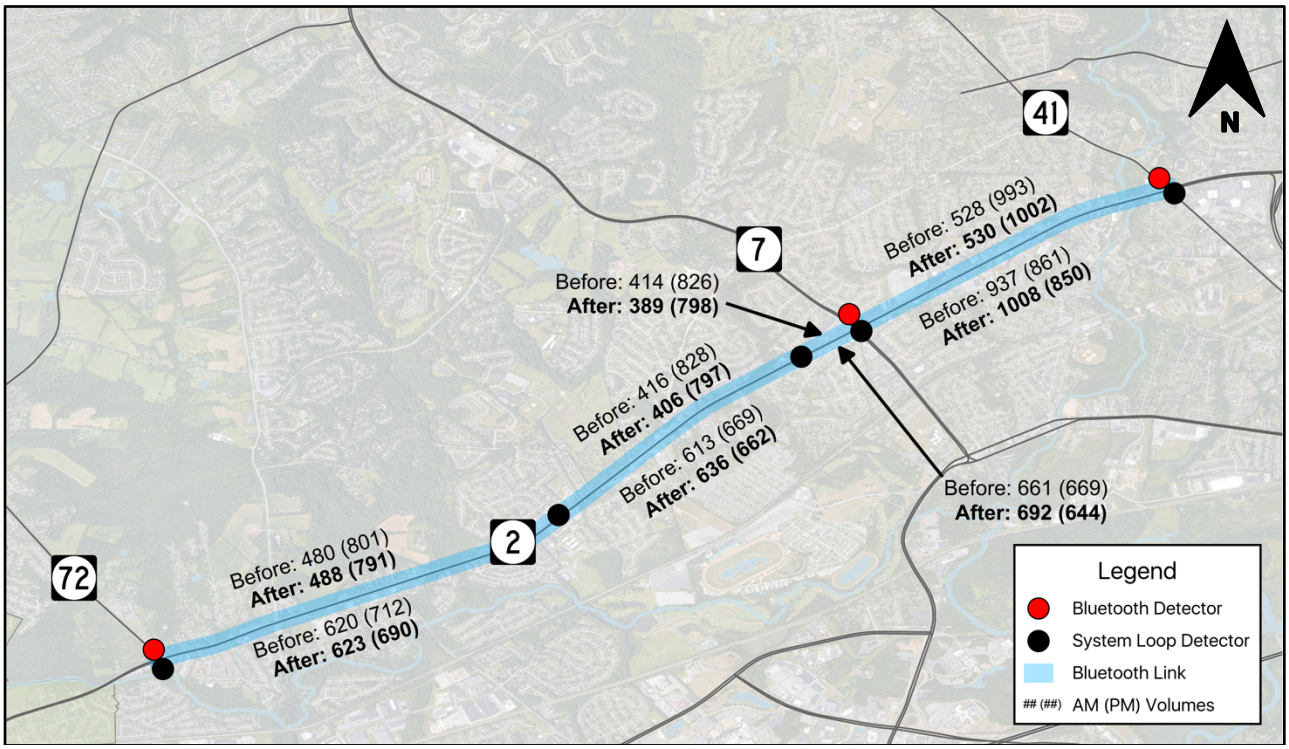
It was recommended that traffic volumes from system loops be incorporated into this and future Bluetooth analyses. While Bluetooth provides measured travel time data, it does not take volume into account, and after signal retimings it is reasonable to assume that the throughput may increase during the peak hour due to improved travel times.

As part of the DE 2 signal retiming analysis, RE built upon previous work by incorporating traffic volumes collected by system loop detectors maintained and operated by the Delaware Department of Transportation's (DelDOT's) Transportation Management Center (TMC).

Data Collection

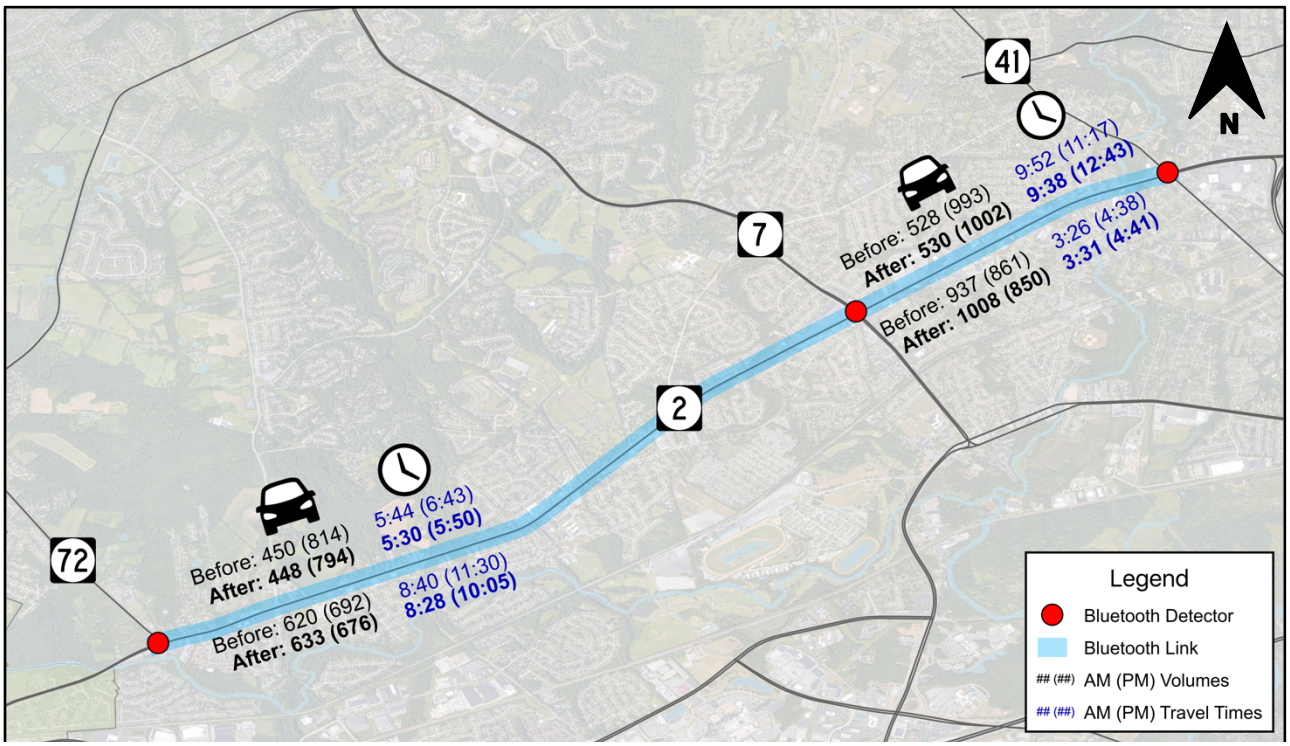
Following the completion of the DE 2 signal retiming project, RE acquired three weeks of Bluetooth travel time and system loop volume data from the DelDOT TMC from both before the project began (May 2017) and after its completion (May 2018). RE calculated average hourly travel times and volumes for weekday (Tuesday through Thursday) AM peaks (7:00-9:00 AM) and PM peaks (4:00-6:00 PM). **Figure 1** shows the location of the Bluetooth sensors and system loop detectors used.

Figure 1. DE 2 Average Peak Hour Volumes



The volumes shown in **Figure 1** were then used to calculate the average volumes along each Bluetooth link. These volumes, and the travel times associated with each Bluetooth link, are shown in **Figure 2**.

Figure 2. DE 2 Average Bluetooth Link Travel Times and Volumes



Average delay was calculated by subtracting the travel time at the posted speed limit from the average measured travel time in **Figure 2**. Calculated values for delay were then applied to the CHART delay-based emissions rates.

Operations Data Analysis Findings

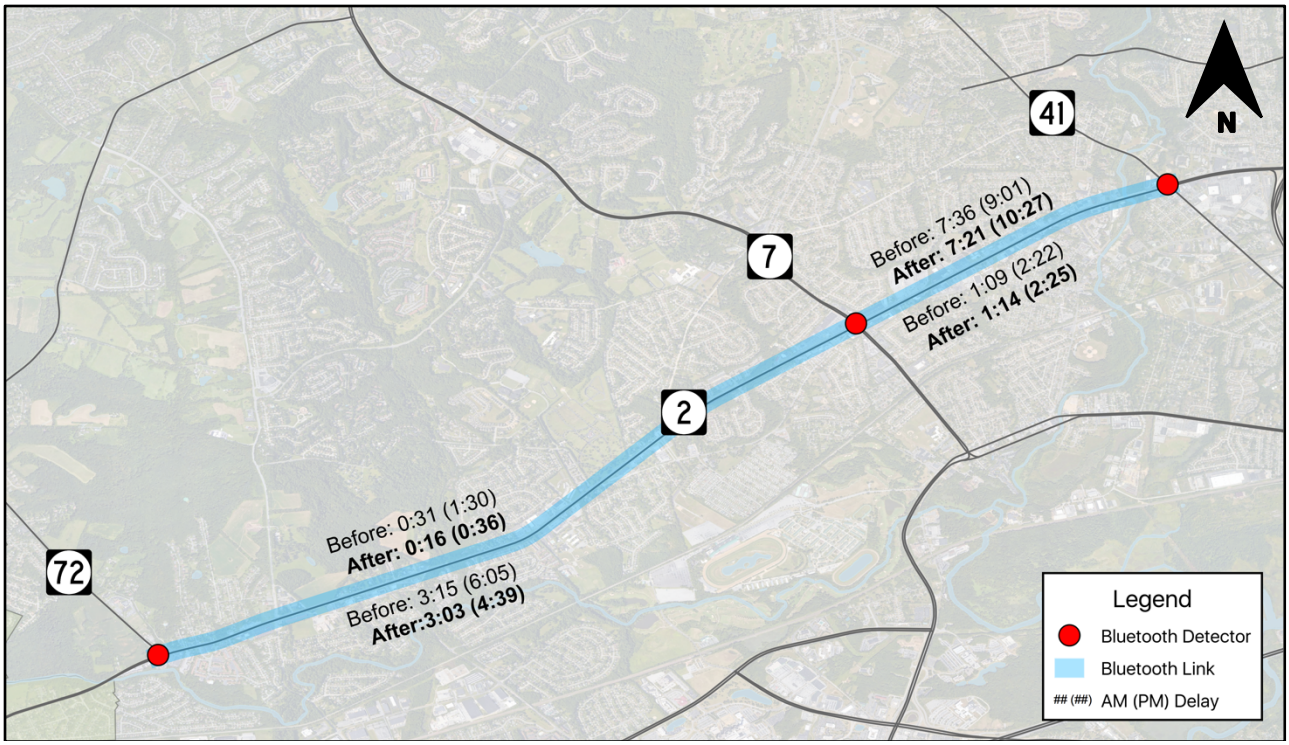
Travel Time and Emissions Analysis

A review of travel time data reveals an overall improvement in travel times along DE 2 from DE 72 to DE 41 during both peak hours in the eastbound direction and during the AM peak hour in the westbound direction, showing retimings had a positive impact on the ability of motorists to proceed along the corridor. **Table 2** and **Figure 3** break down the details of these findings.

Table 2. Changes to Average Travel Times

Segment	Direction	Peak	Before (min)	After (min)	Percent Change
DE 72 to DE 7	EB	AM	8.67	8.47	-2%
		PM	11.50	10.08	-12%
	WB	AM	5.74	5.50	-4%
		PM	6.72	5.83	-13%
DE 7 to DE 41	EB	AM	3.43	3.51	2%
		PM	4.59	4.69	2%
	WB	AM	9.68	9.63	-1%
		PM	11.28	12.72	13%
Full Corridor (DE 72 to DE 41)	EB	AM	12.10	11.98	-1%
		PM	16.12	14.77	-8%
	WB	AM	15.60	15.13	-3%
		PM	18.01	18.56	3%

Figure 3. Average Delay Per Trip



As shown in **Table 3**, while retimings along DE 2 reduced travel times and delay for motorists traveling the full length of the corridor and from DE 72 to DE 7, results were different between DE 7 and DE 41. Motorists traveling eastbound along DE 2 between DE 7 and DE 41 can expect similar travel times as prior to the retimings. For those traveling

westbound along the same segment of DE 2, travel times and delay increased during the PM peak hour.

These changes in travel times also had a visible impact on pollutants emitted as a result of idling-caused delay. Emissions calculated from measured delay and traffic volumes are shown in **Table 3**.

Table 3. Emissions Analysis (based on CHART delay-based emissions rates)

Segment	Peak	Pollutant	Before (kg)	After (kg)	Percent Change
DE 72 to DE 7	AM	CO	5.49	5.03	-8%
		NO	0.23	0.21	-8%
		HC	0.49	0.45	-8%
	PM	CO	13.26	8.88	-33%
		NO	0.57	0.38	-33%
		HC	1.18	0.79	-33%
DE 7 to DE 41	AM	CO	12.47	12.60	1%
		NO	0.53	0.54	1%
		HC	1.11	1.12	1%
	PM	CO	26.87	30.67	14%
		NO	1.15	1.31	14%
		HC	2.39	2.73	14%
Full Corridor (DE 72 to DE 41)	AM	CO	17.96	17.63	-2%
		NO	0.77	0.75	-2%
		HC	1.60	1.57	-2%
	PM	CO	40.13	39.55	-1%
		NO	1.71	1.69	-1%
		HC	3.57	3.52	-1%

Peak Hour Volume Analysis

In order to evaluate whether or not the signal retimings impacted the intensity or duration of the AM and PM peaks along DE 2, average 15-minute volumes were calculated for each Bluetooth link—DE 72 to DE 7 and DE 7 to DE 41—and the full corridor before and after the signal retimings. The volumes showed only minor changes to peak hour volumes before and after retimings. These volumes are shown in **Appendix A**.

Summary and Recommendations

The signal retimings on DE 2 resulted in improvements to both observed travel times and total vehicle emissions based on operations data.

On average, corridor travel times decreased by 2% in the AM peak hour and 2.5% in the PM peak hour. Of the 4 analysis time periods and directions for the full corridor outlined in **Table 2**, only one saw an increase, DE 2 westbound during the PM peak. The signal retimings were followed by net decrease in emissions along the full corridors during all peak periods despite slightly overall higher volumes, with decreases of 2% in the AM peak hour and 1% in the PM peak hour.

These emissions decreases are noticeably lower than those calculated by Synchro which showed decreases of approximately 4% in the AM peak hour and 23% in the PM peak hour. The two methodologies report different pollutants (aside from CO), have slightly different geographic bounds, and are based on different inputs, yielding different results. As DelDOT continues to expand their Bluetooth network, RE recommends analyzing the impact of signal retimings using the CHART method as it considers real-time travel time measurements.

Appendix A: Peak Hour Analysis

DE 2 Traffic Volumes Between DE 72 and DE 7

Figure A1. Average Eastbound AM Peak – 15 Minute Intervals

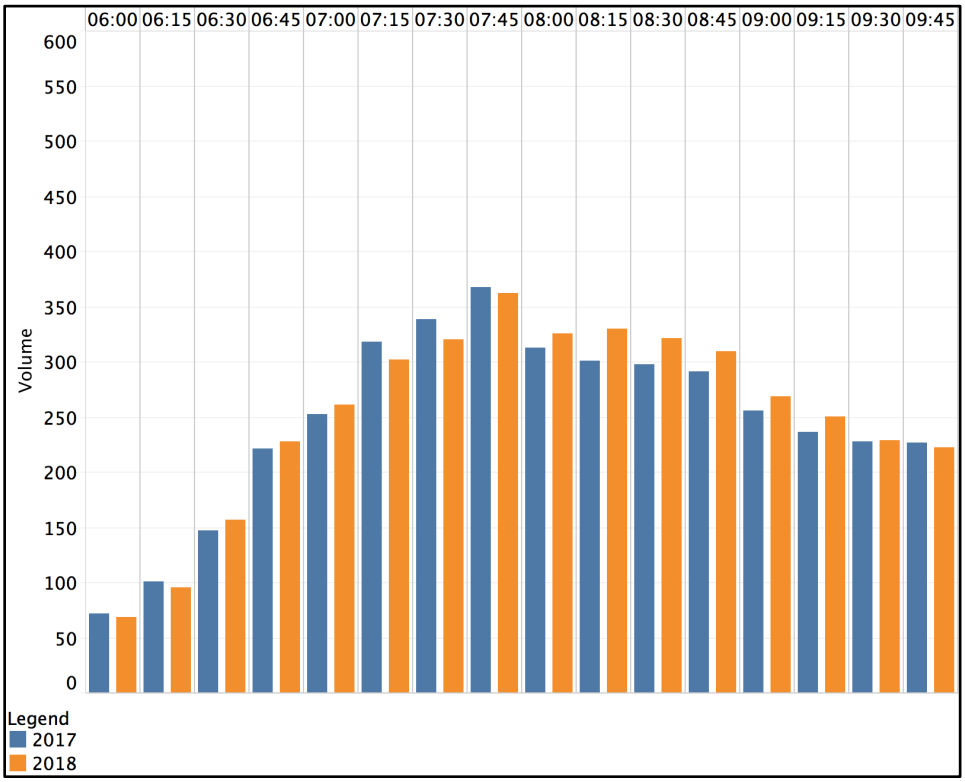
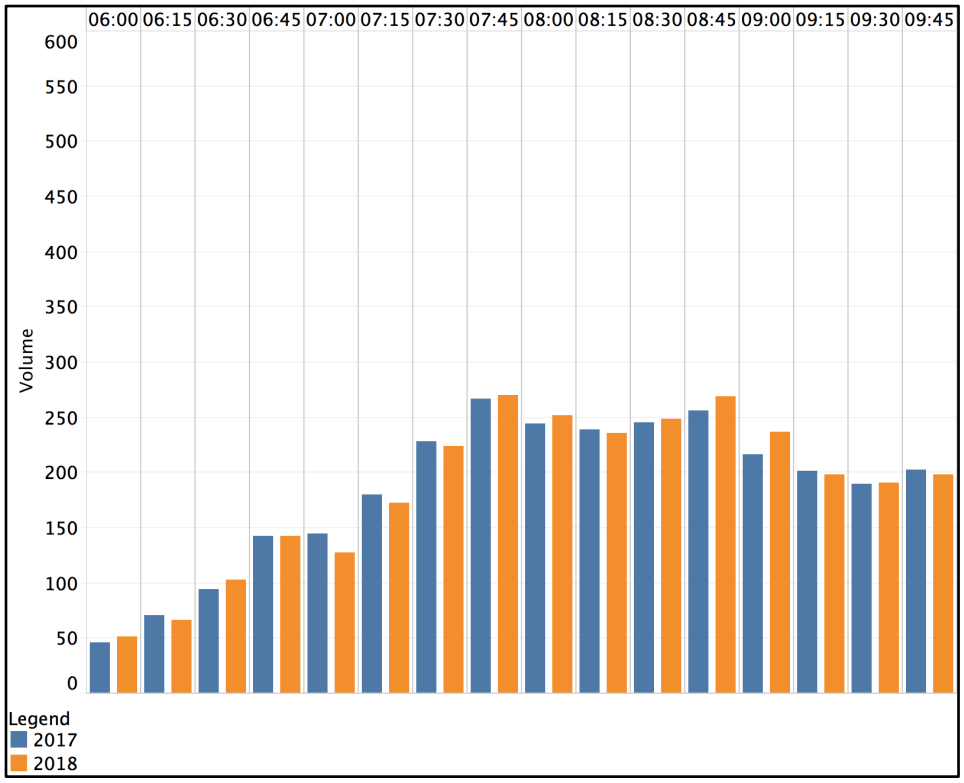


Figure A2. Average Westbound AM Peak – 15 Minute Intervals



DE 2 Traffic Volumes Between DE 72 and DE 7

Figure A3. Average Eastbound PM Peak – 15 Minute Intervals

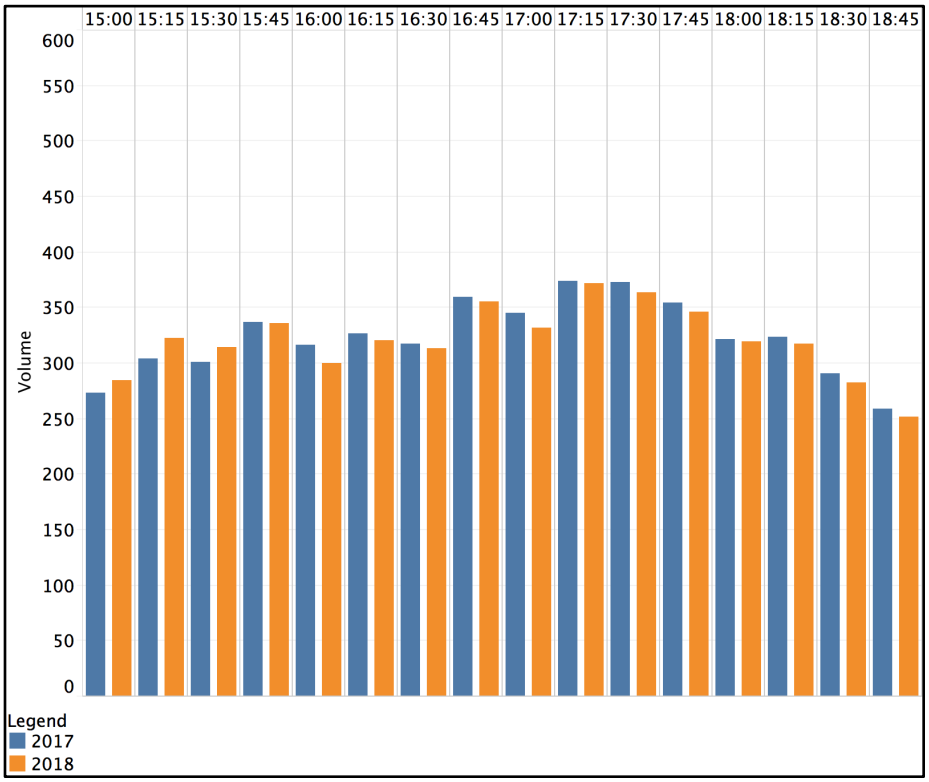
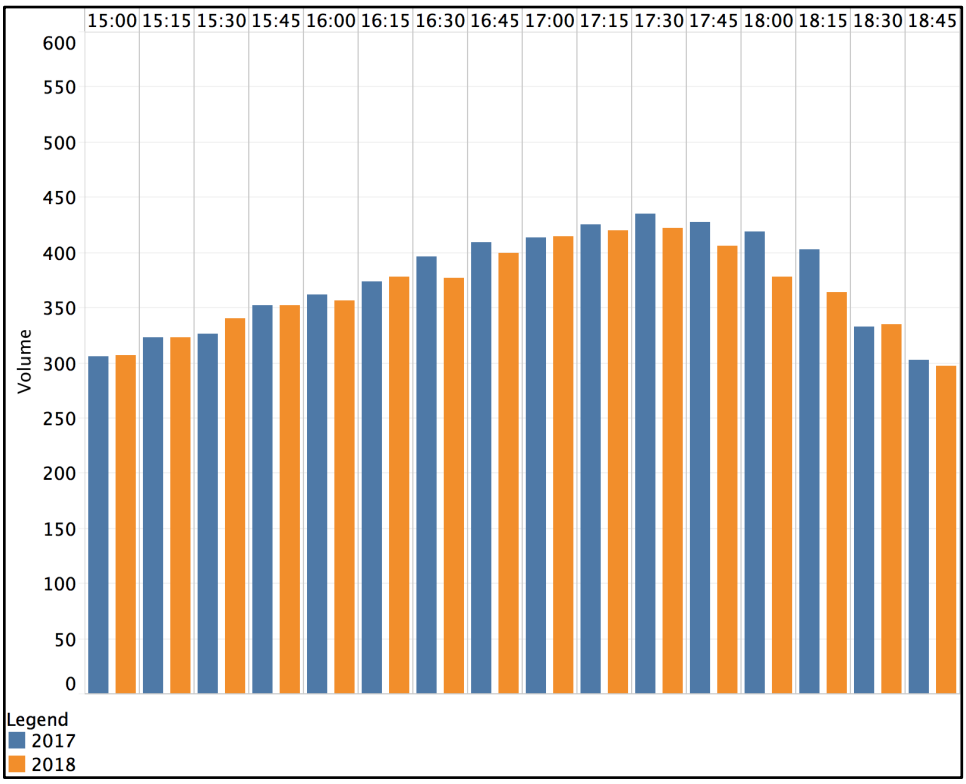


Figure A4. Average Westbound PM Peak – 15 Minute Intervals



DE 2 Traffic Volumes Between DE 7 and DE 41

Figure A5. Average Eastbound AM Peak – 15 Minute Intervals

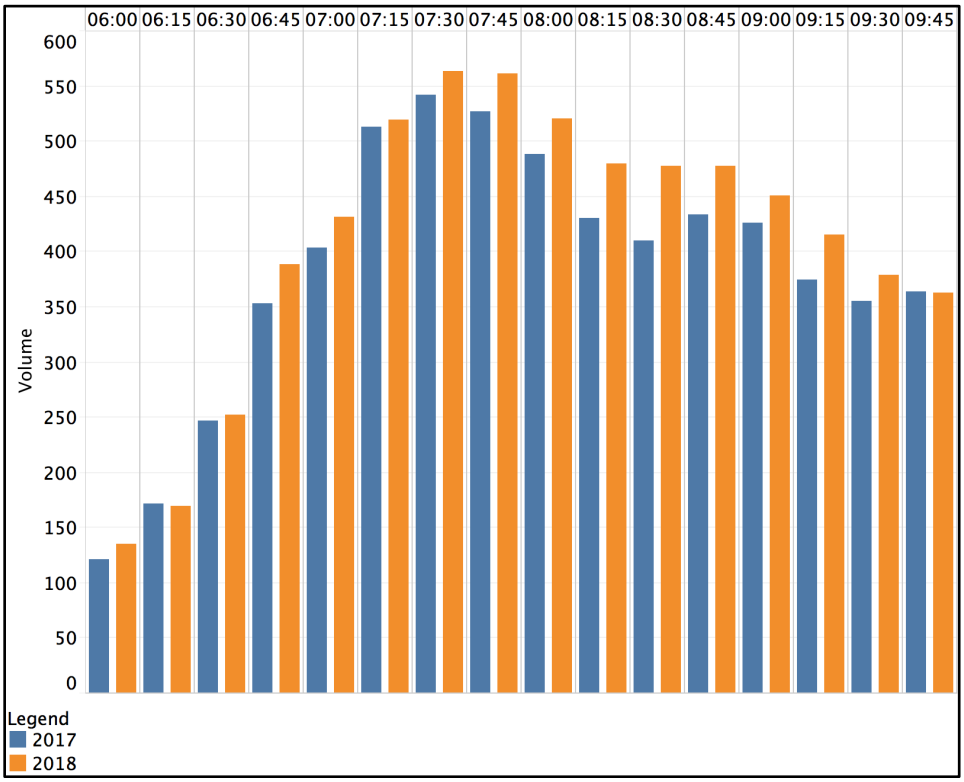
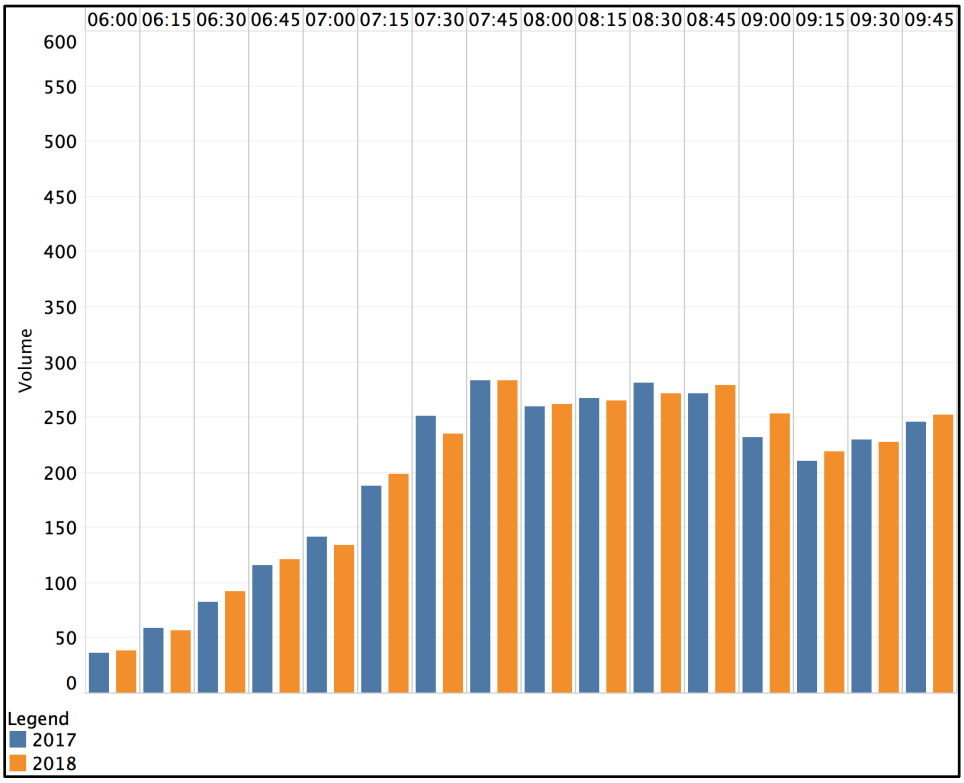


Figure A6. Average Westbound AM Peak – 15 Minute Intervals



DE 2 Traffic Volumes Between DE 7 and DE 41

Figure A7. Average Eastbound PM Peak – 15 Minute Intervals

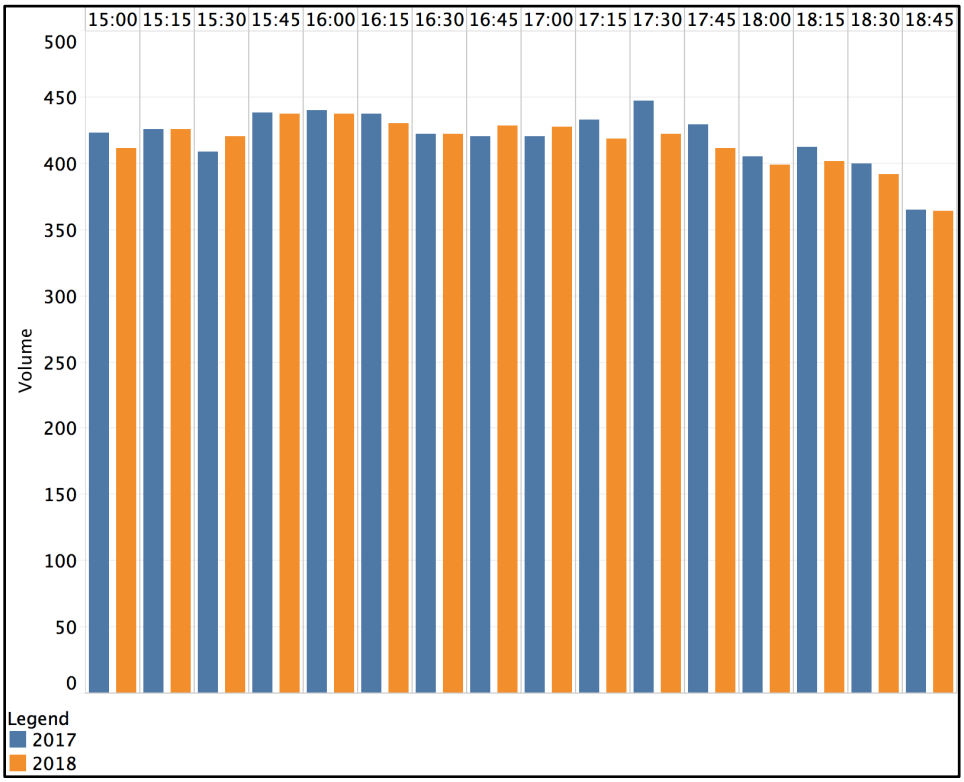
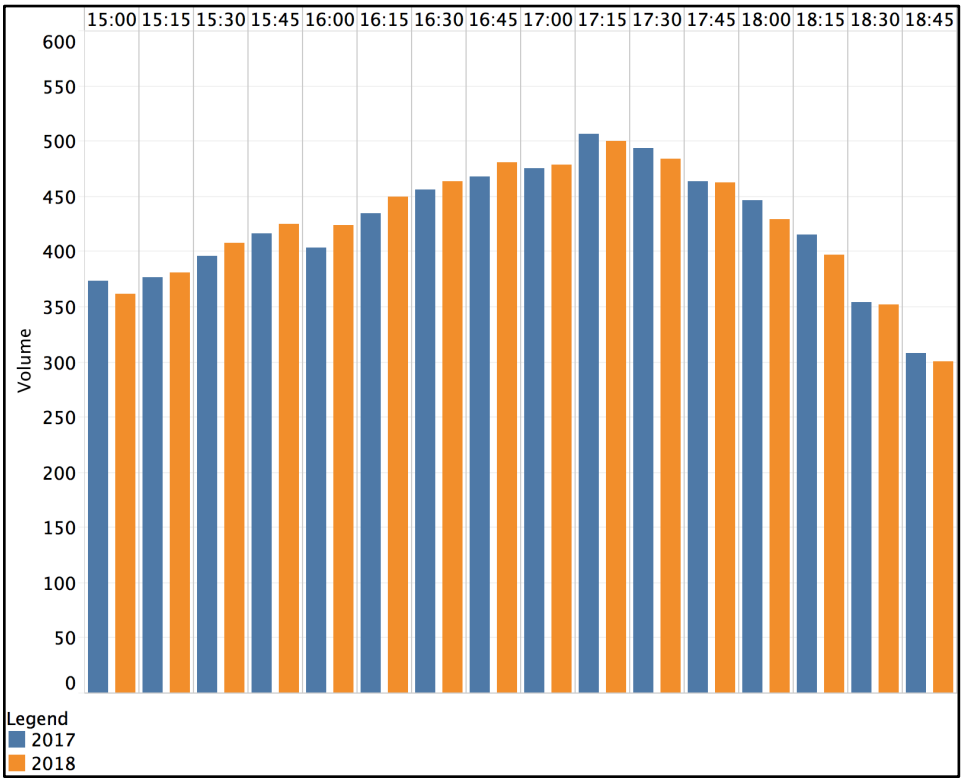


Figure A8. Average Westbound PM Peak – 15 Minute Intervals



DE 2 Traffic Volumes Between DE 72 and DE 41—Full Corridor

Figure A9. Average Eastbound AM Peak – 15 Minute Intervals

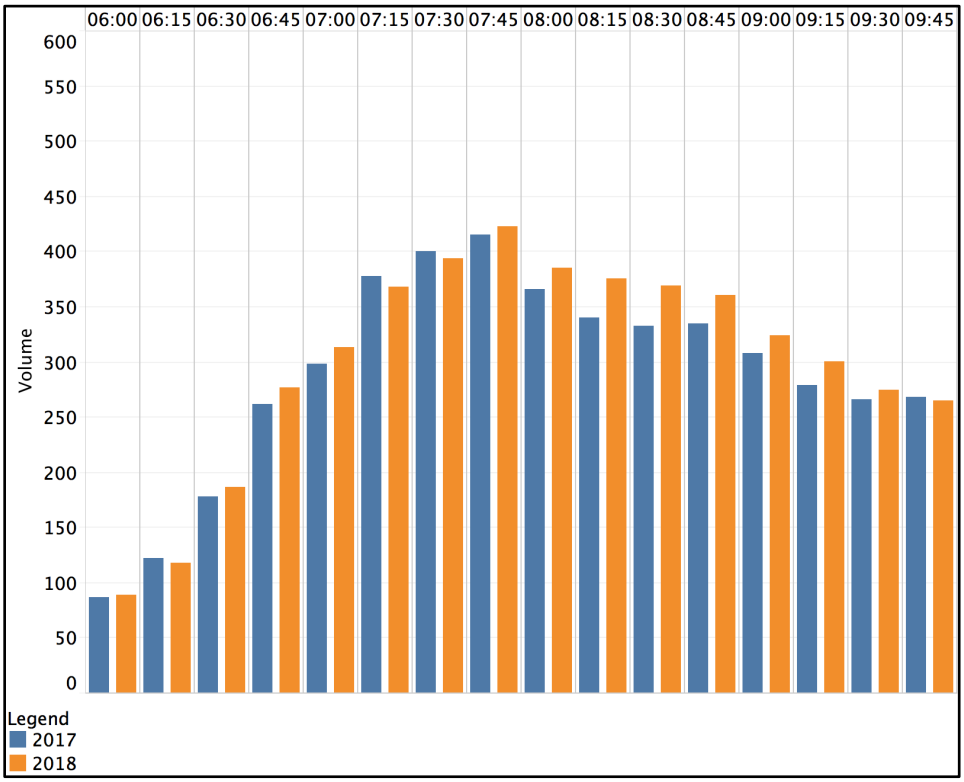
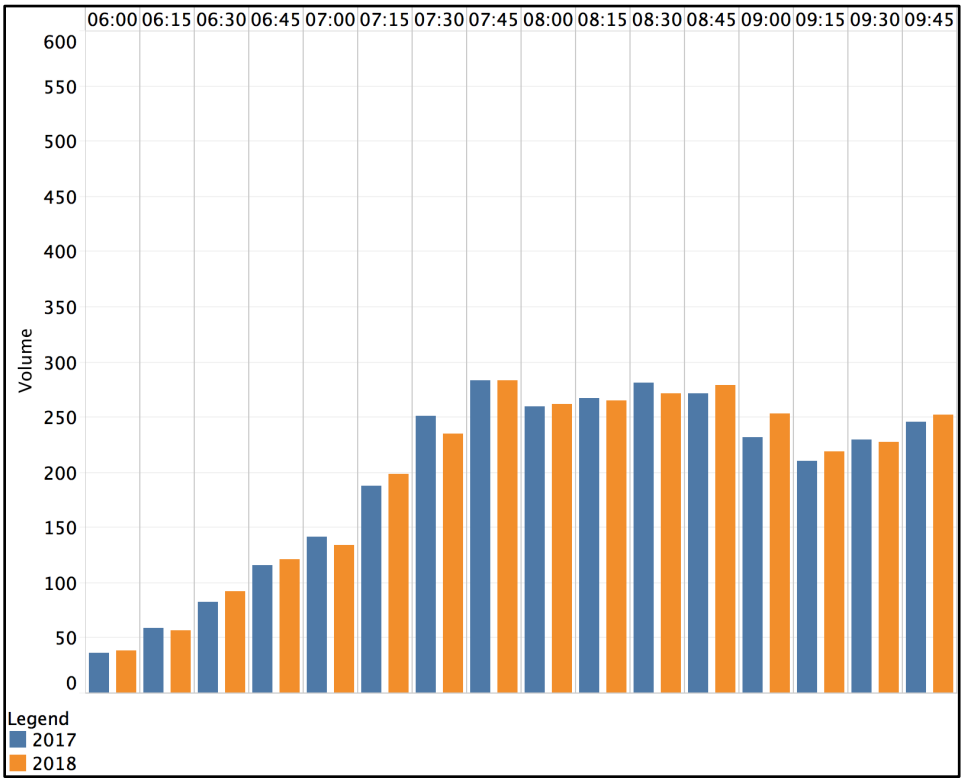


Figure A10. Average Westbound AM Peak – 15 Minute Intervals



DE 2 Traffic Volumes Between DE 72 and DE 41—Full Corridor

Figure A11. Average Eastbound PM Peak – 15 Minute Intervals

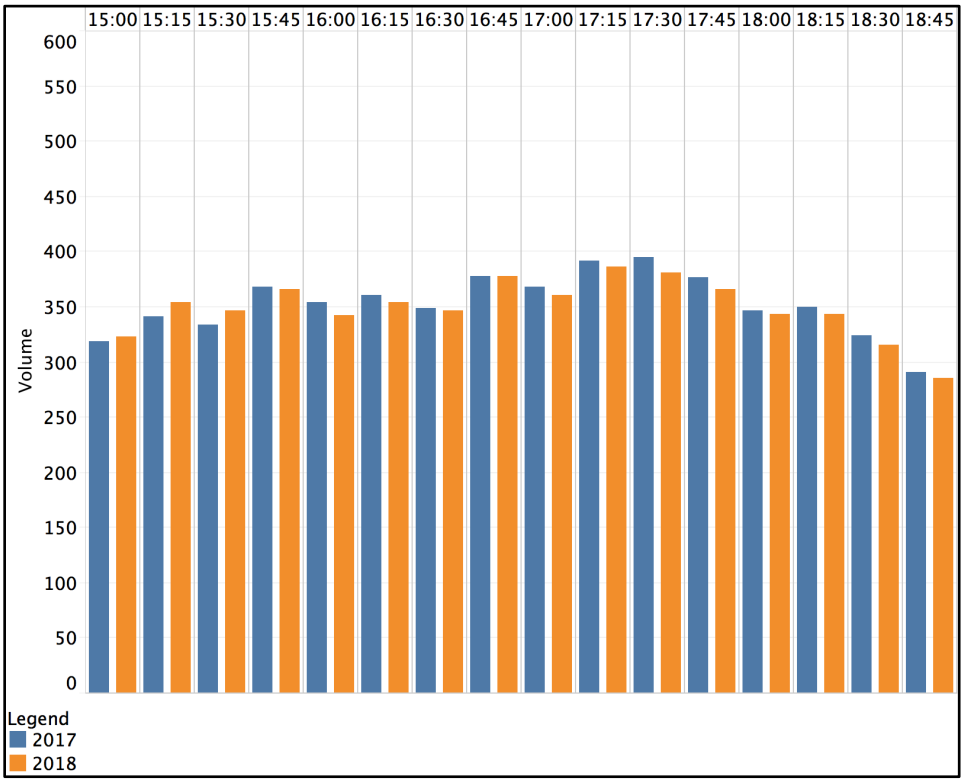


Figure A12. Average Westbound PM Peak – 15 Minute Intervals