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# MEMORANDUM

**Date:** October 3, 2019  
**To:** Mark Luszcz, P.E., PTOE, Deputy Director (Design), DeIDOT  
**From:** Owen Hitchcock, RK&K  
 Jim Burnett, RK&K  
 Stephanie Everett, RK&K  
**CC:** Peter Haag, DeIDOT  
**Subject:** **SR 7, SR 41, and SR 48: Dynamic Speed Display Sign Before-After Study**

## **INTRODUCTION**

Senate Resolution Number 10 (SR 10), which was passed by the 149<sup>th</sup> General Assembly of the Delaware State Senate, established a Special Committee to study and make recommendations regarding truck traffic and freight movements along SR 41, SR 48 and SR 7 in New Castle County. Specifically, the Special Committee was directed to study and make recommendations regarding:

1. How to reduce the number of trucks traveling along these roadways; and
2. Any improvements in engineering, infrastructure, education, and enforcement that can improve the quality of life for those that live along these roadways.

The Special Committee completed the study on January 12, 2018 and submitted twenty-four (24) recommendations to the Delaware Department of Transportation (DeIDOT) and the Delaware General Assembly. Recommendation #14 from the Committee was to install permanent “YOUR SPEED XX MPH” signs on SR 7, SR 41, and SR 48 and perform a “before” and “after” study to determine the effectiveness of these signs on arterial roadways over time. DeIDOT requested that RK&K complete a study and make recommendations regarding the effectiveness of these dynamic speed display signs. This technical memorandum presents the methodology, results, and conclusions of the study.

## **SPEED DATA COLLECTION**

Dynamic speed display signs were installed at seven sites along SR 7, SR 41, and SR 48 in New Castle County, Delaware. The sites are shown below in **Table 1** and **Figure 1**.

**Table 1: Study Sites**

Site Number	State Route	Location	Speed Limit (MPH)
1	SB SR 7	Between Milltown Rd and Pickwick Dr	40
2	SB SR 7	Between Stenning Dr and Valley Rd	50
3	SB SR 41	Between Valley Rd and Yorklyn Rd	35
4	NB SR 41	Between Graves Rd and Loveville Rd/McKennans Church Rd	45
5	SB SR 41	Between Faulkland Rd and Milltown Rd	35
6	NB SR 48	Between Centre Rd and Harlech Dr	45
7	SB SR 48	Between Old Wilmington Rd and Hercules Rd	50



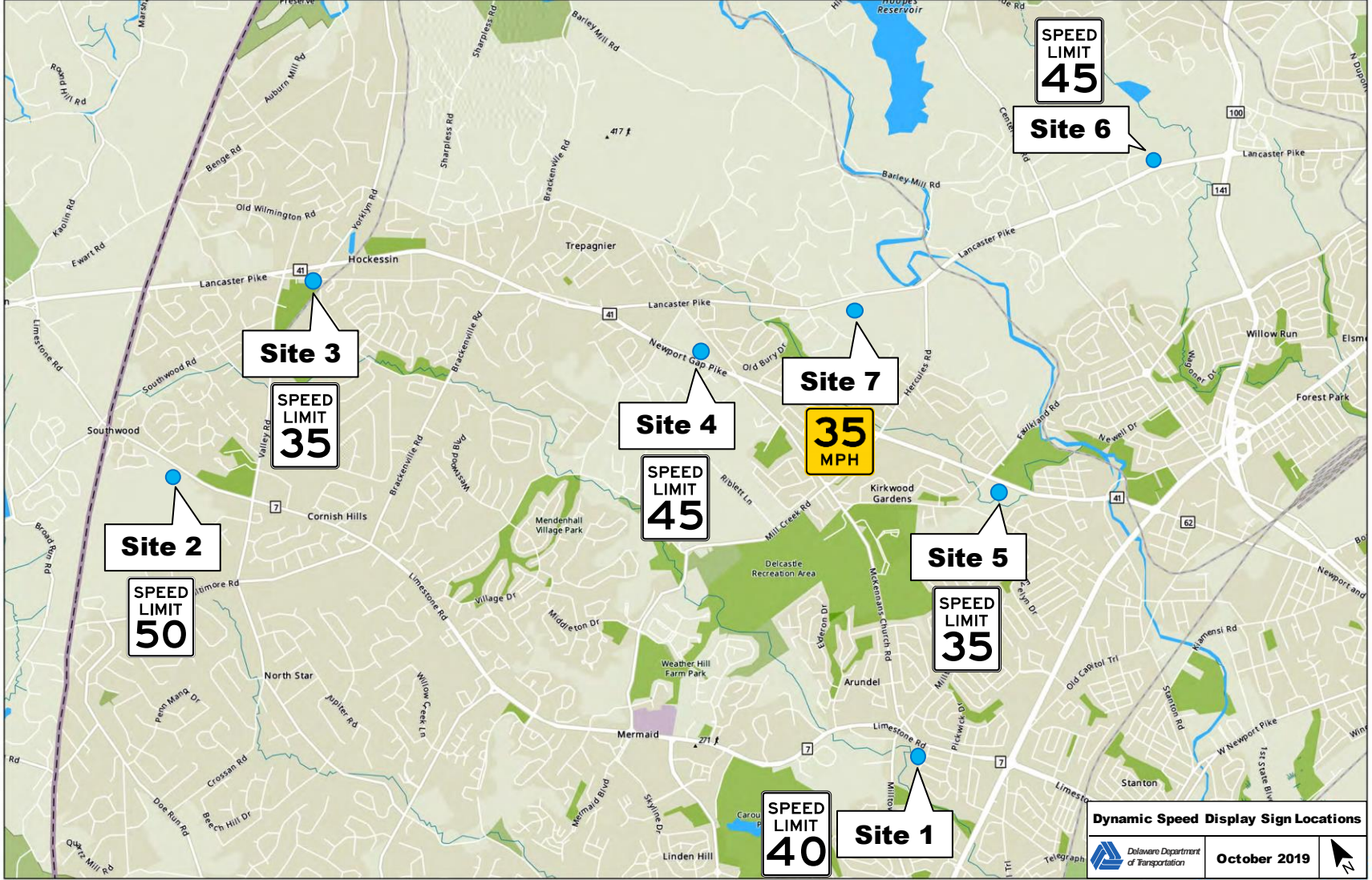


Figure 1: Dynamic Speed Display Sign Locations

At each site, spot speed data were collected using pneumatic road tubes placed at the sign (“Sign” location) and at a location 800 to 1,500 feet downstream of the sign (“Downstream” location). The intent of studying two locations was to determine 1) if vehicles reduced their speeds by the time they reached the sign and 2) to see if they maintained the speed reduction for a moderate distance after the signs. At these two locations, data were collected before sign installation (“Before” period, July 2018) and approximately seven months after sign installation (“After” period, March/April 2019). Data were collected for several days during both the Before and the After periods. Before data were not collected at the sign location for Site 5 because road work blocked access to install speed tubes.

Speed data were recorded using speed bins based on the site’s posted speed limit, as shown in **Table 2** below. The number of vehicles traveling within the speed range of each bin were tallied for each hour. It should be noted that for analysis of binned data, it is assumed that vehicle speeds are uniformly distributed within each bin. Bin 1 and Bin 12 counts were not used for numerical analysis because the uniform distribution is an unrealistic assumption for the lower bound (Bin 1) and there is no upper limit for Bin 12.

**Table 2: Speed Bins (mph)**

Speed Limit	Bin 1	Bin 2	Bin 3	Bin 4	Bin 5	Bin 6	Bin 7	Bin 8	Bin 9	Bin 10	Bin 11	Bin 12
35	0-19	20-24	25-29	30-32	33-35	36-38	39-41	42-44	45-49	50-54	55-59	> 60
40	0-24	25-29	30-34	35-37	38-40	41-43	44-46	47-49	50-54	55-59	60-64	> 65
45	0-29	30-34	35-39	40-42	43-45	46-48	49-51	52-54	55-59	60-64	65-69	> 70
50	0-34	35-39	40-44	45-47	48-50	51-53	54-56	57-59	60-64	65-69	70-74	> 75

#### **ANALYSIS METHODOLOGY**

To analyze the effectiveness of speed display signs on vehicle speeds, effects of other factors that affect vehicle speeds were taken into consideration. Congestion was identified as a significant factor because speeds are often lower during periods of high traffic volume. Before and After speeds were plotted for each hour of the day to determine times when vehicle speeds were highest. Sites with equal speed limits were plotted together to explore any possible relationships between posted speed limit and speed reductions, in addition to determining the times when vehicle speeds were highest. These plots are shown in **Figure 2** on the next page.

As shown in **Figure 2**, speeds were typically the highest on all roads, regardless of the speed limit, between 12AM – 4AM. At these times, vehicle speeds are not affected by other vehicles due to low volumes. However, darkness may be another factor that affects vehicle speeds. During daylight hours, speeds were generally higher between 10AM – 3PM, which typically corresponds with a period of uncongested travel. Compared to overnight hours, vehicle speeds are more likely to be affected by other vehicles between 10AM – 3PM, but not as impacted by heavy congestion that limits motorists’ ability to choose their travel speed. These two time periods, “Overnight” and “Midday Off-Peak”, were chosen to quantitatively examine the effects of the speed display signs. The Overnight analysis period (12AM – 4AM) included data from Monday to Thursday nights. The Midday Off-Peak analysis period (10AM – 3PM) included data from Monday to Friday.

For each analysis time period, the average and 85<sup>th</sup> percentile speeds were calculated for each site at the sign location and downstream of the sign. The standard deviations of average speeds were also calculated to compare Before and After speed uniformity. Due to the data collection methodology, which included speed bins that are not each 5 mph, the 10-mph pace, another measure of speed uniformity, could not be readily calculated. **Table 3** outlines the average speed, 85<sup>th</sup> percentile speed, and standard deviation for each site during the Before and After periods.

The average speeds are shown in **Table 3**, and plotted in **Figure 2**. If the signs were effective, we would expect the blue line (circles) to be above the orange line (squares) and the grey line (diamonds) to be above the yellow line (triangles) in **Figure 2**. However, the data indicate that After speeds were not consistently lower than Before speeds across sites or at any given posted speed limit. For each posted speed limit, After speeds were lower than Before speeds during some time periods, and higher at other times. Visual inspection of Before and After speeds grouped by posted speed limit suggests the speed display signs are not consistently effective at any given posted speed limit. Results of further analysis for each specific site are described in the next section.

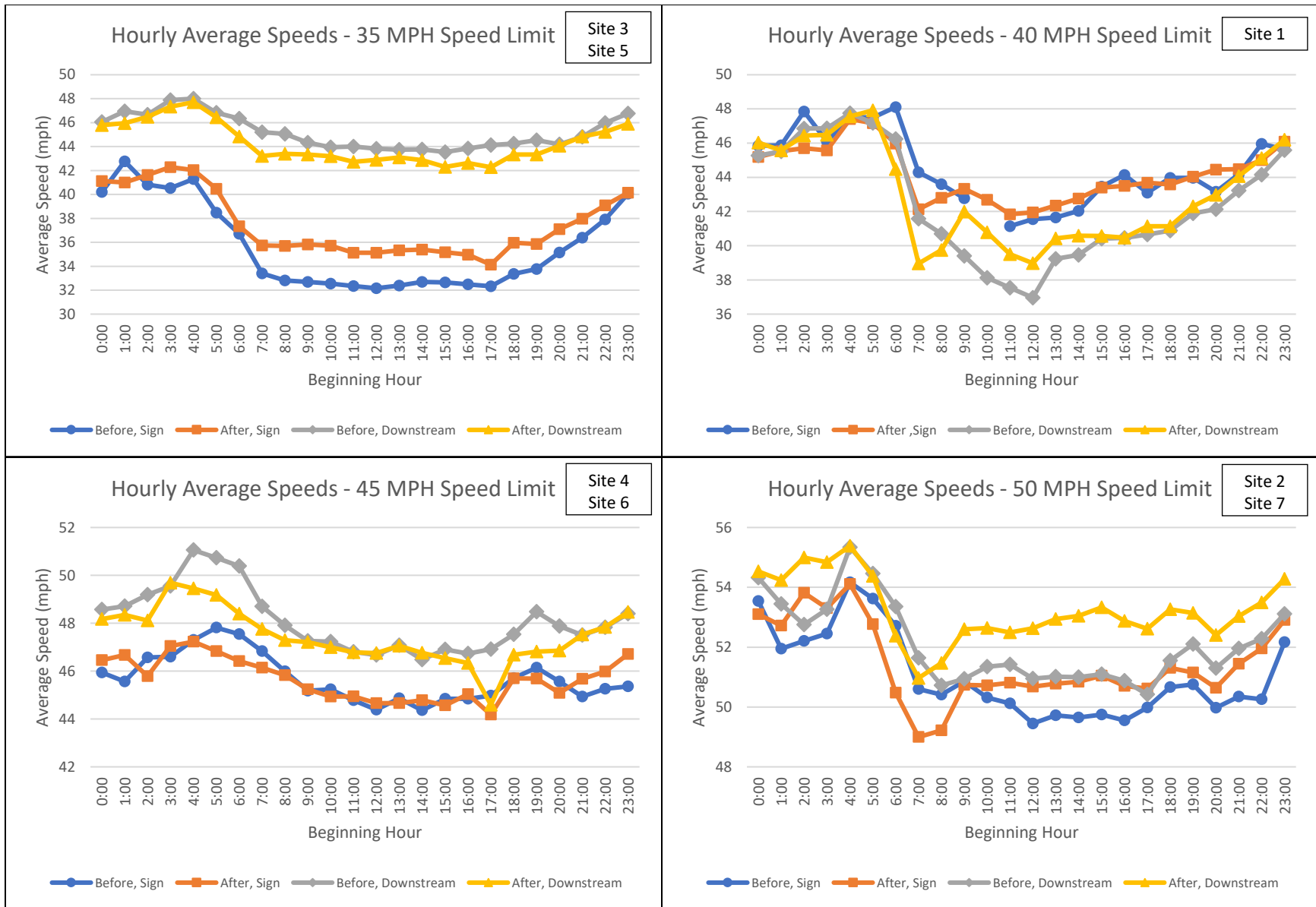


Figure 2: Hourly Average Speeds Grouped by Posted Speed Limit

**Table 3: Before and After Speeds and Standard Deviations**

Site	Posted Speed Limit	Location	Average Speeds				85 <sup>th</sup> Percentile Speeds				Standard Deviation			
			Overnight		Midday Off-Peak		Overnight		Midday Off-Peak		Overnight		Midday Off-Peak	
			Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	40	Sign	46.2	45.6	41.6	42.1	52.9	52.4	45.8	46.4	6.2	6.3	4.4	4.5
		Downstream	46.2	46.5	38.3	40.4	53.0	53.5	44.6	46.1	6.5	6.3	6.5	5.8
2	50	Sign	52.8	51.6	48.2	48.4	58.5	57.3	53.3	53.1	5.8	5.7	4.9	4.6
		Downstream	55.5	54.6	51.1	52.1	61.9	60.4	56.0	56.6	5.4	5.7	4.8	4.6
3	35	Sign	40.8	40.1	31.3	31.3	49.0	47.8	36.4	36.7	8.0	7.1	5.3	5.5
		Downstream	43.6	43.3	40.5	40.2	50.8	50.2	46.4	46.0	6.7	6.5	5.7	5.7
4	45	Sign	44.3	46.0	40.9	41.5	51.7	51.4	46.0	46.3	6.9	6.1	4.9	4.9
		Downstream	44.4	44.1	39.3	39.2	51.6	49.2	44.4	44.2	6.9	6.0	4.6	4.6
5	35	Sign	-	43.0	-	38.9	-	49.4	-	43.8	-	6.1	-	4.8
		Downstream	50.3	49.2	44.9	45.7	56.0	54.9	49.8	50.5	5.0	5.4	5.1	4.8
6	45	Sign	49.2	48.0	48.0	48.0	56.4	54.2	53.7	53.3	7.0	6.4	5.6	5.4
		Downstream	54.4	54.0	54.6	54.6	62.2	60.9	59.9	59.8	6.9	6.5	5.6	5.4
7	50	Sign	53.9	54.4	51.5	52.9	61.0	62.1	56.5	57.8	7.2	6.6	5.0	5.0
		Downstream	53.7	54.4	51.1	53.1	61.5	61.9	56.4	58.1	7.2	6.6	5.2	5.0



## ANALYSIS RESULTS

The changes in average speeds, 85<sup>th</sup> percentile speeds, and standard deviations during Overnight times and Midday Off-Peak times are shown below in **Table 4** and **Table 5**, respectively. For these tables, negative values indicate a reduction in speeds after the signs were installed and positive values indicate that speeds increased after the dynamic speed display signs were installed.

**Table 4: Overnight Speed and Standard Deviation Changes (mph)**

Site	Average Speed Change		85 <sup>th</sup> Percentile Speed Change		Standard Deviation Change	
	Sign	Downstream	Sign	Downstream	Sign	Downstream
1	-0.7	+0.4	-0.5	+0.5	+0.2	-0.2
2	-1.2	-0.9	-1.2	-1.5	-0.1	+0.3
3	-0.7	-0.3	-1.2	-0.7	-0.9	-0.2
4	+1.7	-0.4	-0.3	-2.4	-0.8	-0.9
5	-	-1.0	-	-1.1	-	+0.4
6	-1.2	-0.4	-2.2	-1.3	-0.6	-0.5
7	+0.6	+0.7	+1.1	+0.4	-0.6	-0.6
<b>Average</b>	<b>-0.25</b>	<b>-0.27</b>	<b>-0.72</b>	<b>-0.87</b>	<b>-0.47</b>	<b>-0.24</b>

Note: Before speeds at Site 5 sign location were not collected due to construction work

**Table 5: Midday Off-Peak Speed and Standard Deviation Changes (mph)**

Site	Average Speed Change		85 <sup>th</sup> Percentile Speed Change		Standard Deviation Change	
	Sign	Downstream	Sign	Downstream	Sign	Downstream
1	+0.5	+2.1	+0.6	+1.5	+0.1	-0.6
2	+0.1	+1.0	-0.2	+0.6	-0.2	-0.2
3	-0.0	-0.3	+0.3	-0.4	+0.2	+0.0
4	+0.5	-0.2	+0.3	-0.2	-0.0	-0.0
5	-	+0.9	-	+0.7	-	-0.3
6	-0.0	+0.0	-0.4	-0.1	-0.3	-0.2
7	+1.4	+2.0	+1.4	+1.7	-0.0	-0.3
<b>Average</b>	<b>+0.42</b>	<b>+0.79</b>	<b>+0.33</b>	<b>+0.54</b>	<b>-0.03</b>	<b>-0.23</b>

Note: Before speeds at Site 5 sign location were not collected due to construction work

During both analysis periods, all changes were small in magnitude, with average and 85<sup>th</sup> percentile speeds generally changing by less than 1 mph regardless of site and location (at the sign or a short distance downstream). Some sites experienced increased speeds after sign installation, while others saw decreased speeds. All average and 85<sup>th</sup> percentile speed changes were under 3 mph. The largest average speed change was an increase of 2.1 mph, while the largest change in the 85<sup>th</sup> percentile speed was a decrease of 2.4 mph. No consistent patterns of substantial speed reductions were found at any site or analysis period. These results, generally characterized by small speed reductions and mostly higher After speeds, indicate the dynamic speed display signs are rather ineffective at reducing driver speeds.

Both analysis periods revealed small changes in standard deviation regardless of site and location. A decrease in standard deviation indicates vehicles are traveling at more uniform speeds. Although most standard deviation changes were decreases, their magnitudes were small, typically 0.5 mph or less. Again, these results indicate that the dynamic speed display signs are rather ineffective at substantially improving speed uniformity.

## STATISTICAL ANALYSIS RESULTS

One-tailed, two-sample t-tests were performed to determine if reductions in average speeds at each site were statistically significant at a 95 percent confidence level. It is noted that t-tests with large sample sizes, such as the data obtained for this study, will often result in statistical significance, even if the speed reduction is small. The results of the t-tests are shown below in **Table 6** and **Table 7**.

**Table 6: Overnight Average Speed Change Significance**

Site	Sign Location		Downstream Location	
	Speed Change (mph)	Statistically Significant?	Speed Change (mph)	Statistically Significant?
1	-0.7	No	+0.4	No
2	-1.2	Yes	-0.9	Yes
3	-0.7	No	-0.3	No
4	+1.7	Yes	-0.4	No
5	-	-	-1.0	Yes
6	-1.2	Yes	-0.4	No
7	+0.6	No	+0.7	No

**Table 7: Midday Off-Peak Average Speed Change Significance**

Site	Sign Location		Downstream Location	
	Speed Change (mph)	Statistically Significant?	Speed Change (mph)	Statistically Significant?
1	+0.5	Yes	+2.1	Yes
2	+0.1	No	+1.0	Yes
3	-0.0	No	-0.3	Yes
4	+0.5	Yes	-0.2	No
5	-	-	+0.9	Yes
6	-0.0	No	+0.0	No
7	+1.4	Yes	+2.0	Yes

The statistical analysis of significance revealed varying results. Of all speed changes in the above tables, approximately 20 percent were statistically significant decreases. However, approximately 30 percent were actually statistically significant increases. The remaining half of speed changes were not statistically significant. The analysis did not show the dynamic speed display signs provide consistent statistically significant speed reductions as there were more increases than decreases. Furthermore, the small speed changes (less than 3 mph) are not practically meaningful, regardless of their statistical significance. It should be noted that very large sample sizes are likely contributing to the statistical significance, as their sample sizes were as high as 37,000 vehicles.

## **CONCLUSIONS**

The purpose of this study was to evaluate the impacts of dynamic speed display signs on vehicle speeds along arterial roadways. Dynamic speed display signs were installed at seven sites along SR 7, SR 41, and SR 48 in New Castle County, Delaware. Speed data were collected Before and After the signs were installed, both at the sign location and approximately 800 to 1,500 feet downstream of the sign location.

Analysis of the speed data indicates that dynamic speed display signs are not consistently effective at reducing vehicle speeds. Graphs of average speeds during each hour of the day did not display any trends of consistent speed reductions for a given posted speed limit. Although After speeds were lower than Before speeds for some hours of the day, After speeds were higher at other times. All hourly speed changes were small (less than 3 mph). An analysis of Overnight and Midday Off-Peak average speeds also found small differences (less than 3 mph) in Before and After speeds, with some speeds increasing after sign installation. A statistical analysis found that both decreases and increases in average speeds were statistically significant, with the significance likely due to the large sample sizes. Before and After standard deviation changes were also small (less than 0.5 mph) and sometimes increased, indicating the signs are also ineffective at increasing speed uniformity. There were also small differences (less than 3 mph) between Overnight and Midday Off-Peak Before and After 85<sup>th</sup> percentile speeds, again with some speed increases after sign installation.

Although installation of dynamic speed display signs did not demonstrate consistent effectiveness at reducing speeds along SR 7, SR 41, and SR 48 in New Castle County, there may be other factors at other sites that improve the effectiveness of speed display signs. There is an ongoing effort to evaluate the effectiveness of these signs at other locations around Delaware.