MIDWEST SMART WORK ZONE DEPLOYMENT INITIATIVE

MwSWZDI

FHWA POOLED FUND STUDY

Report Title	Report Date: 2000

Safety Warning System

Principle Investigator		Vendor Name and Address
Name	Maze, Tom	MPH Industries
Affiliation	Iowa State Univ	
Address	2901 S. Loop Drive, Suite 3100 Ames, IA 50010	
Phone	515-294-9523	
Fax	515-294-0467	
Email	tmaze@iastate.edu	

Author(s) and Affiliation(s)

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Supplemental Notes

Abstract

SAFETY WARNING SYSTEM

Introduction

The Radio Association Defending Airwave Rights Inc. (RADAR) conceived and developed the concept of the Safety Warning System (SWS). This system consists of a transmitter and receiver (detector). MPH Industries Inc manufactures SWS transmitters (see Figure 2-35). A number of companies, including Bel-Tronics, Sanyo, Uniden, and Whistler, manufacture the SWS detectors.

FIGURE 2-35 SWS Transmitter

The transmitter can be mounted on the outside of a vehicle (e.g., inside the emergency lightbar), or placed in a stationary outdoor location (e.g., on the flashing arrow board trailer at a work zone). The SWS transmitter sends warning messages concerning road hazards to drivers of vehicles equipped with SWS detectors. Any K-band radar detector will sound a basic alarm when the SWS transmitter is sending a warning message, however, the ones capable of reading transmitted SWS messages will specifically display (in some cases state) applicable messages.

A SWS detector is capable of identifying over 60 messages. These messages fall under five categories:

1. highway construction/maintenance
2. highway hazard zone advisory
3. weather related hazards
4. travel information/convenience
5. fast/slow moving vehicles

The following 12 messages are currently stored under the highway construction/maintenance category:

- Work Zone Ahead
- Road Closed Ahead/Follow Detour
- Bridge Closed Ahead/Follow Detour
- Highway Work Crews Ahead
- Utility Work Crews Ahead
- All Traffic Follow Detour Ahead
- Al Trucks Follow Detour Ahead
- All Traffic Exit Ahead
- Right Lane Closed Ahead
- Center Lane Closed Ahead
- Left Lane Closed Ahead
- Stationary Police Vehicle Ahead

It is believed that drivers of vehicles equipped with SWS detectors will respond to these messages by reducing their speed and proceeding more cautiously through the work zone.

The SWS runs off a 12-volt power source. The SWS transmitter features a narrow, bi-directional beam. The bi-directional beam focuses the transmission so it only affects drivers along the roadway where the construction is taking place. Depending on the operating conditions, it can send a signal along the roadway up to two miles.

As a part of the Midwest States Smart Work Zone Deployment Initiative (MwSWZDI), in September 1999, the SWS transmitter was deployed at a work zone on Interstate 35. The purpose of this field test was to evaluate the impact of the Safety Warning System on reducing vehicles' speed in work zones.

Test Operation

The case study work zone consisted of a left lane closure with a crossover leading into two-way traffic. The SWS transmitter was mounted atop a stationary pole located 2,250 feet upstream of the lane closure taper.

Traffic data were collected at 1,500 feet and 500 feet upstream of the taper using two traffic data collection trailers, shown in Figure 2-36. The trailer in Figure 2-36 includes a pneumatic mast to hoist a video camera 30 feet above the pavement's surface, where the camera collects video of traffic operations. Videos are later reduced into traffic flow performance data through the use of image processing technology.

FIGURE 2-36 Traffic data collection trailer.

Traffic Data

Traffic flow performance data (vehicle speed, headways, volume, etc.) were recorded for five hours each day during the two days prior to and two days after the SWS transmitter installation. Using the Autoscope image processing technology, the recorded videotapes were analyzed to determine the types (i.e., passenger cars and non-passenger cars), arrival times, and speeds of approaching vehicles.

During each day of data collection, more than 2,500 data points were recorded. The MwSWZDI technical committee defined the free-flowing vehicles as those with headways greater than or equal to five seconds. Following the committee guidelines, the data points with headways of five seconds or less were eliminated from the database. This resulted in the elimination of more than half of the data points.

We were concerned that eliminating data would result in broad confidence intervals of the estimate of the mean speed before and after the system was implemented. However, reduction in the quantity of data was not found to be a problem. The remaining data were sufficient to test our hypothesis that the SWS would reduce the average speed of traffic in the work zone.

A number of significant parameters were obtained through analysis of the speed data. Some of these parameters were computed directly from the data while others were determined from a graphical representation. The analysis of the speed data included the following evaluation parameters:

- The time mean speed.
- The speed that 85 percent of the vehicles travel (the 85th percentile speed).
- The 10 mph speed interval containing the most observations (the10-mph pace).
- The percentage of observations in the 10-mph pace.
- The standard deviation of the time speed.
- The percentage of observations complying with posted regulatory and advisory speed limits
- The time mean speed of the highest 15 percent of speeds.

Except for mean speeds and standard deviations, the balance of these parameters is determined from graphical analysis.

The speed data initially were grouped into before and after data sets for each data collection site (i.e., 1,500 feet and 500 feet upstream of the taper). The listed speed data parameters were determined for passenger cars, non-passenger cars, and all vehicles for all four data sets (i.e., before and after data at 1,500 feet and 500 feet upstream of the taper) resulting in twelve data sets.

Results

For graphical analysis, each data set was first grouped into intervals of two miles per hour (mph). For example, vehicles traveling from 50 mph to 52 mph were grouped together. Frequencies of vehicles traveling in each two-mph group were then obtained and used to calculate the cumulative percentage of vehicles traveling at each interval. Plots of the cumulative percentages for each of the 12 data sets are shown in Figures 2-37 through 2-48. These figures exhibit the expected S-shaped curves and also shown in each plot are dashed lines for the lower and upper boundary of the 10-mph pace. The values estimated through both graphical and numerical analysis are shown in Tables 2-15 through 2-18.

At the 1,500 feet data collection location, no visible changes were observed in the mean speed when the SWS was deployed (see Tables 2-15 to 2-17). Tables 2-15 through 2-17 also show an increase in the observed 85th percentile speed. Modest decreases in the mean speed and almost no changes in the 85th percentile speed, however, were observed at the 500 feet location where vehicles are about to enter the work zone. The percentage of vehicles complying with the posted 55 mph speed limit is the only observed parameter which indicated up to an eight percent increase for all data sets at both 1,500 and 500 feet locations while the SWS was operational.

In order to determine whether the difference between the mean traffic speed before and after the SWS transmitter installation was statistically significant, t-tests were conducted at the 0.05 level of significance. As shown in Tables 2-19 through 2-26, the differences between the mean speeds recorded before and after the transmitter installation were not found to be statistically significant for all data sets and therefore the hypothesis that the SWS will reduce the mean speed is rejected. The reason for similar mean speed before and after the use of the SWS is probably due to the small number of vehicles equipped with radar detectors able to receive the transmitted SWS signals.

The other measures of effectiveness similarly resulted in no discernable trend. Although in all data sets there was a slight increase in the number of vehicle observing the speed limit when the SWS is implemented.

Conclusions

The SWS holds promise as a means of warning drivers of upcoming hazardous conditions. However, its effectiveness is based directly upon the percentage of vehicles that are equipped with regular or enhanced SWS radar detectors. Therefore, until the number of radar detector users increases, the system is not likely to have a significant impact on the speed reductions at work zones.

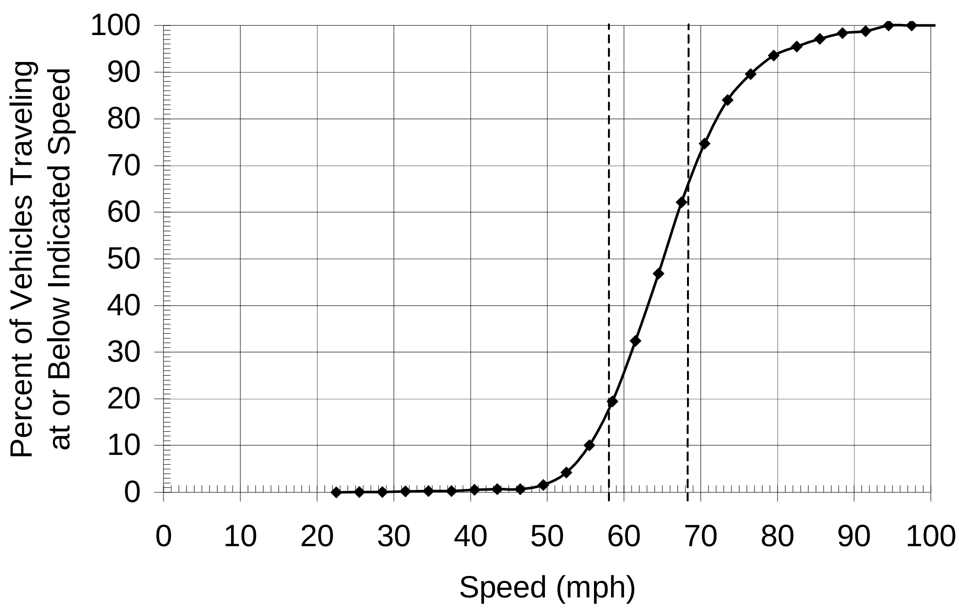

FIGURE 2-37 Before data – passenger cars – 1,500 feet upstream of taper.

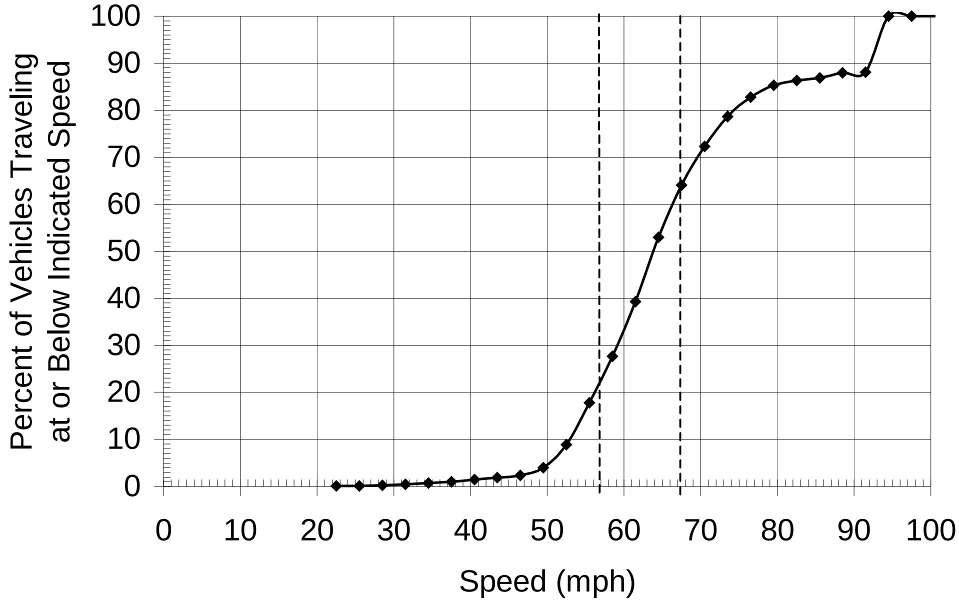

FIGURE 2-38 SWS data – passenger cars – 1,500 feet upstream of taper.

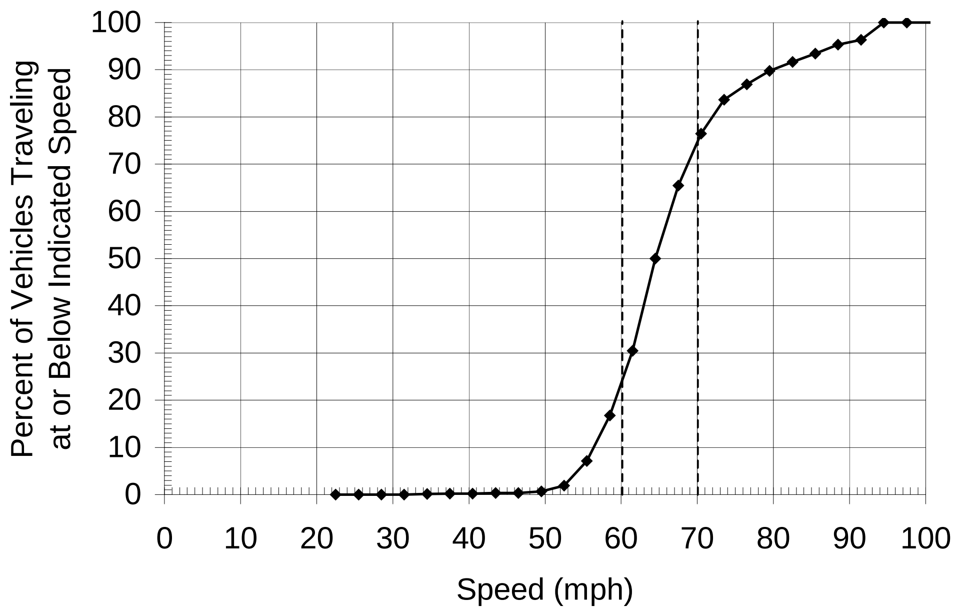

FIGURE 2-39 Before data – non-passenger cars – 1,500 feet upstream of taper.

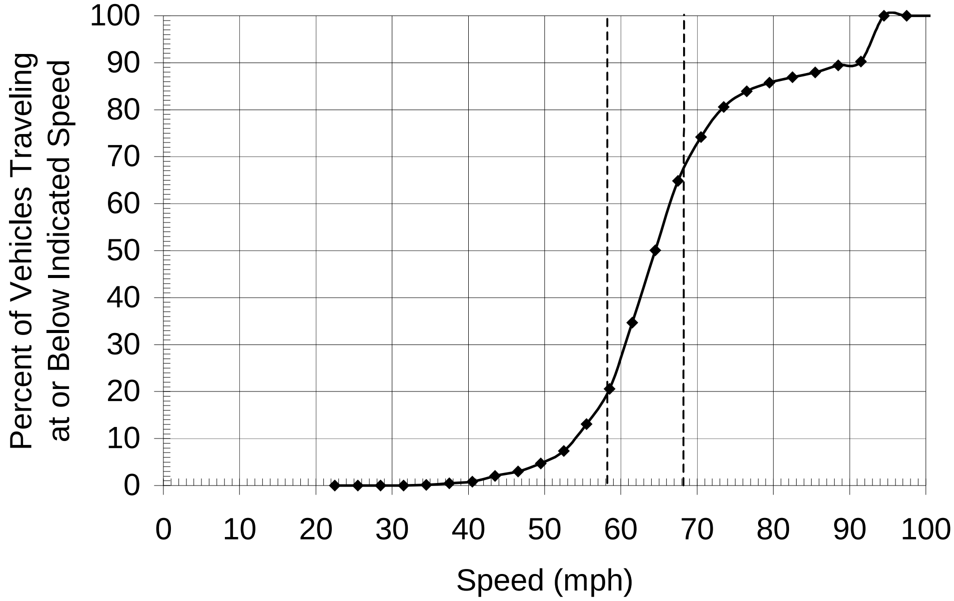

FIGURE 2-40 SWS data – non-passenger cars – 1,500 feet upstream of taper.

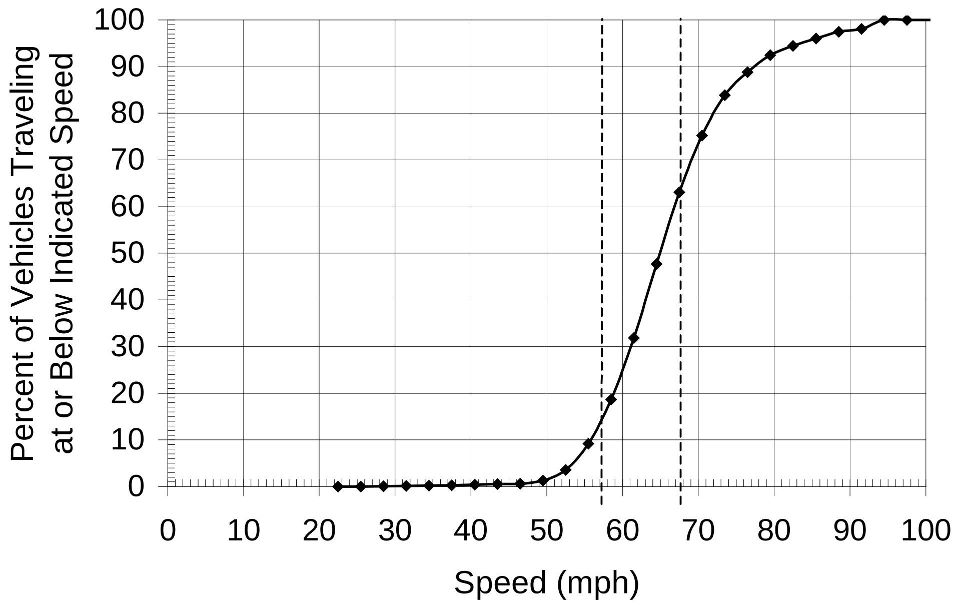

FIGURE 2-41 Before data – all vehicles – 1,500 feet upstream of taper.

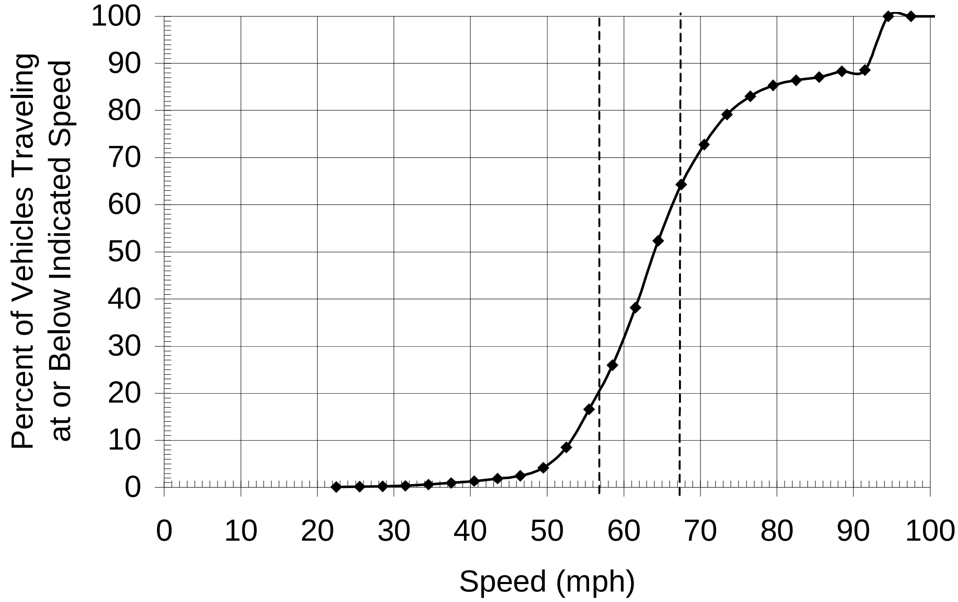

FIGURE 2-42 SWS data - all vehicles – 1,500 feet upstream of taper.

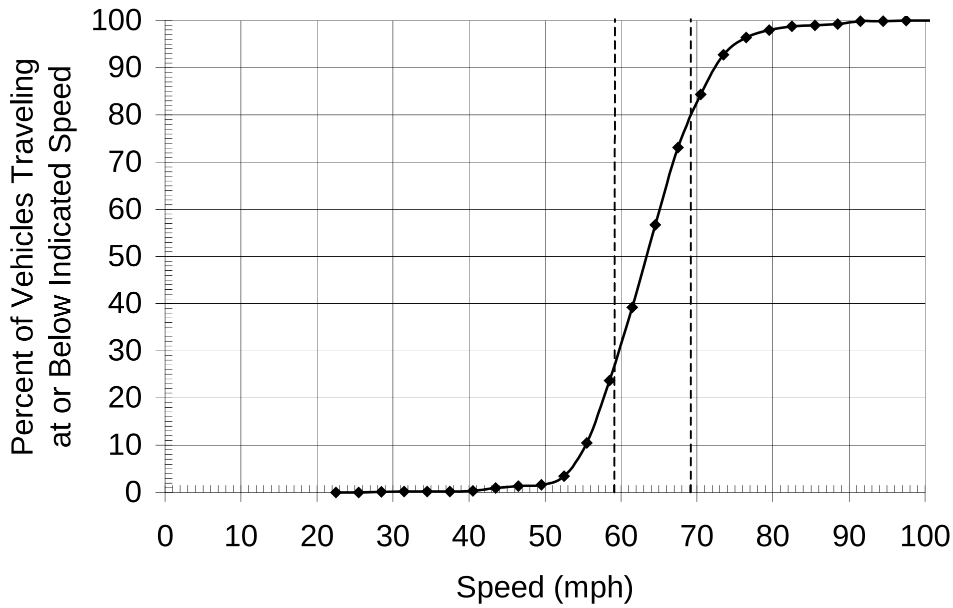

FIGURE 2-43 Before data – passenger cars – 500 feet upstream of taper.

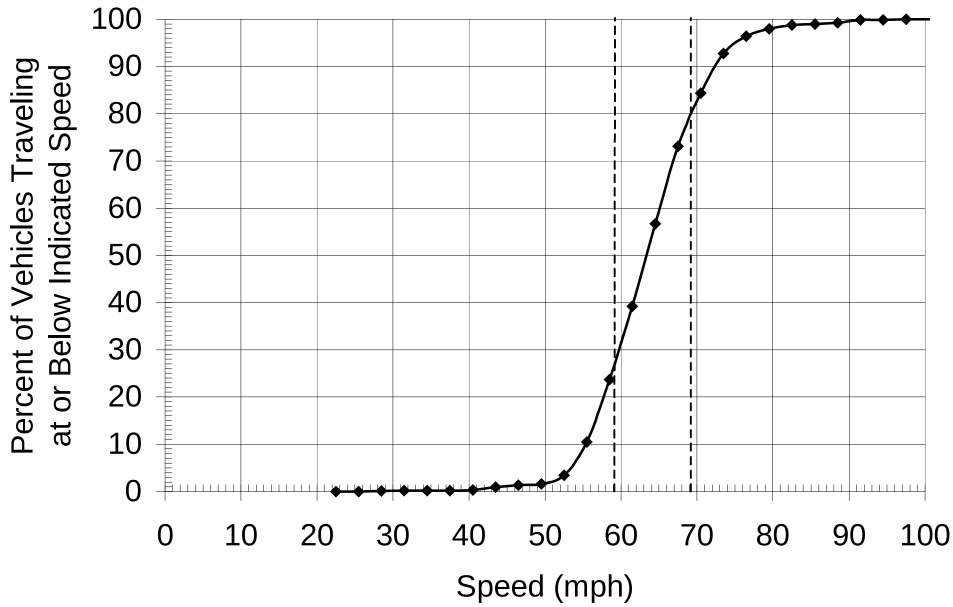

FIGURE 2-44 SWS data – passenger cars – 500 feet upstream of taper.

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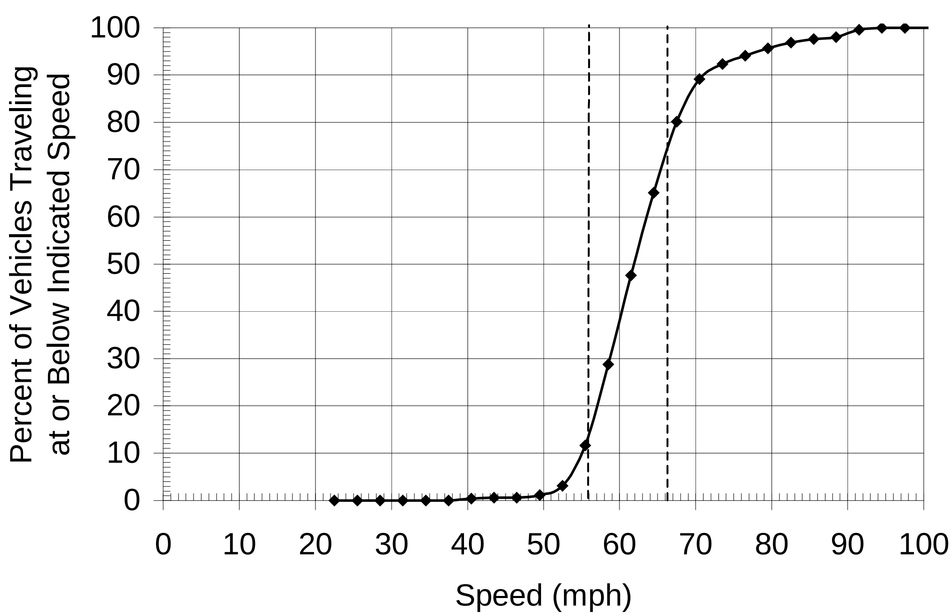

FIGURE 2-45 Before data – non – passenger cars – 500 feet of taper.

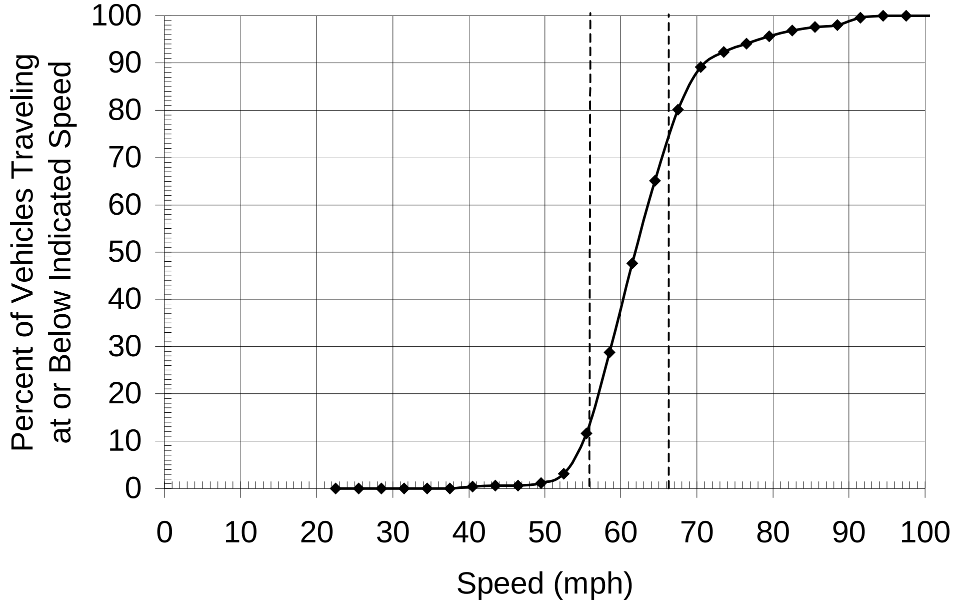

FIGURE 2-46 SWS data – non-passenger cars – 500 feet upstream of taper.

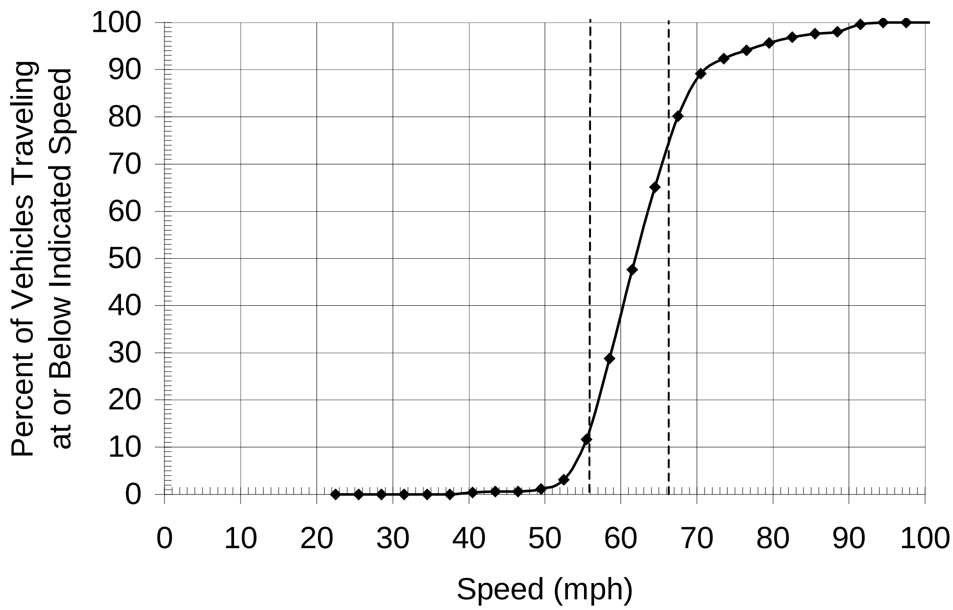

FIGURE 2-47 Before data – all vehicles – 500 feet upstream of taper.

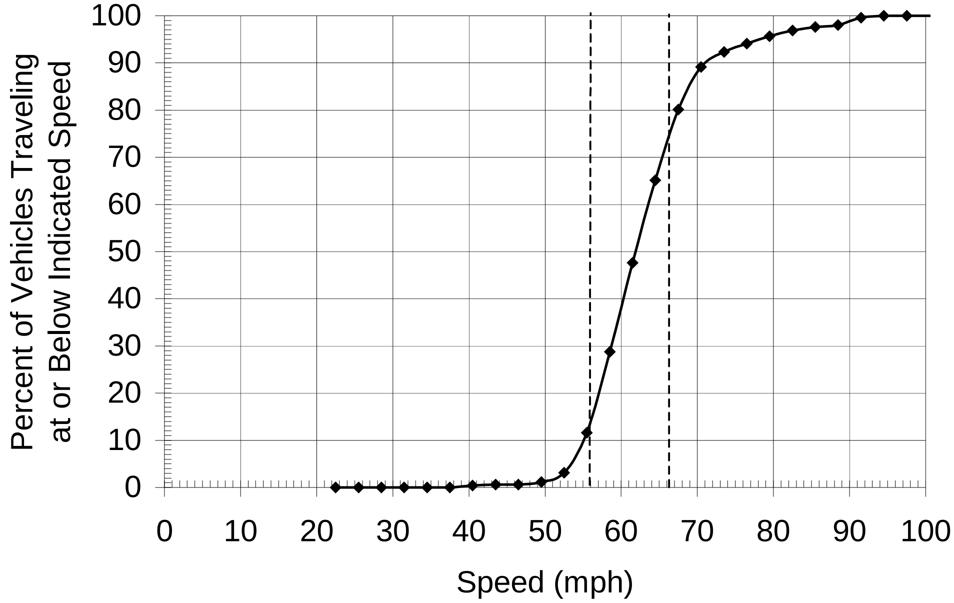

FIGURE 2-48 SWS data – all vehicles – 500 feet upstream of taper.

Table 2-15 Traffic data: passenger cars - 1,500 feet upstream of taper.

SWS	Mean Speed	85th Percentile	10-mph Pace	Percent in Pace	Standard Deviation	% Comply w/SL	Mean of Highest 15%
Before	65.7	74	59-69	43.5	8.8	10	80
After	66.2	79	58-68	36	13	18	91.3

Table 2-16 Traffic data: non- passenger cars - 1,500 feet upstream of taper.

SWS	Mean Speed	85th Percentile	10-mph Pace	Percent in Pace	Standard Deviation	% Comply w/SL	Mean of Highest 15%
Before	66.4	74	60-70	48.7	9.5	7	83.5
After	66.6	78.6	58-68	44	12	13	89.8

Table 2-17 Traffic data: All vehicles - 1,500 feet upstream of taper.

SWS	Mean Speed	85th Percentile	10-mph Pace	Percent in Pace	Standard Deviation	% Comply w/SL	Mean of Highest 15%
Before	65.9	74	59-69	45	9	9.3	81
After	66.3	79	58-68	38.3	12.9	16.7	91

Table 2-18 Traffic data: passenger cars – 500 feet upstream of taper.

SWS	Mean Speed	85th Percentile	10-mph Pace	Percent in Pace	Standard Deviation	% Comply w/SL	Mean of Highest 15%
Before	63.5	71	59-69	50.8	7.5	10.6	63.3
After	62.6	70	56-66	49.2	7.8	14.6	62.6

Table 2-19 Traffic data: non- passenger cars – 500 feet upstream of taper.

SWS	Mean Speed	85th Percentile	10-mph Pace	Percent in Pace	Standard Deviation	% Comply w/SL	Mean of Highest 15%
Before	62.9	69	56-66	58.3	7.7	11.6	77.5
After	62.7	69	56-66	54	7	12.3	75.2

Table 2-20 Traffic data: All vehicles – 500 feet upstream of taper.

SWS	Mean Speed	85th Percentile	10-mph Pace	Percent in Pace	Standard Deviation	% Comply w/SL	Mean of Highest 15%
Before	63.3	70	56-66	53	7.6	10.9	76
After	62.6	70	56-66	50.4	7.7	14	74.3

Table 2-21 Mean speed data: passenger Cars – 1,500 feet upstream of taper.

SWS	Mean Speed	Confidence Intervals	Standard Deviation	Data Points	Statistically Significant?
Before	65.7	0.36	8.8	2,267	No
After	66.2	0.59	13	1,902	No

Table 2-22 Mean speed data: non-passenger Cars – 1,500 feet upstream of taper.

SWS	Mean Speed	Confidence Intervals	Standard Deviation	Data Points	Statistically Significant?
Before	66.4	0.62	9.5	900	No
After	66.6	0.97	12	597	No

Table 2-23 Mean speed data: All Vehicles – 1,500 feet upstream of taper.

SWS	Mean Speed	Confidence Intervals	Standard Deviation	Data Points	Statistically Significant?
Before	65.9	0.31	9	3,167	No
After	66.3	0.51	12.9	2,499	No

Table 2-24 Mean speed data: passenger Cars – 500 feet upstream of taper.

SWS	Mean Speed	Confidence Intervals	Standard Deviation	Data Points	Statistically Significant?
Before	63.5	0.47	7.5	976	No
After	62.6	0.31	7.8	2,341	No

Table 2-25 Mean speed data: non-passenger Cars – 500 feet upstream of taper.

SWS	Mean Speed	Confidence Intervals	Standard Deviation	Data Points	Statistically Significant?
Before	62.9	0.67	7.7	508	No
After	62.7	0.50	7	765	No

Table 2-26 Mean speed data: All Vehicles – 500 feet upstream of taper.

SWS	Mean Speed	Confidence Intervals	Standard Deviation	Data Points	Statistically Significant?
Before	63.3	0.38	7.6	1,484	No
After	62.6	0.27	7.7	3,106	No