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SPEED PHOTO-RADAR ENFORCEMENT EVALUATION IN ILLINOIS WORK ZONES

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Speed Photo-Enforcement in Illinois Work Zones

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16. Abstract The effects of an automated Speed Photo-radar Enforcement (SPE) system on the speed of vehicles in highway work zones were evaluated in this study. The SPE effects were also compared to other speed management treatments, including speed display trailers, police presence (with the patrol emergency lights on and off), and the combination of speed display trailer and police presence. Three datasets were collected in two work zones and the effects were studied at the location of the treatment and also at a location about 1.5 miles downstream in the work zone (spatial effects). The halo effects (temporal effects) of police presence and SPE, after they left the work zone, were also analyzed. Results are presented separately for cars and trucks in free-flow and in the general traffic stream in the median and shoulder lanes. SPE reduced the average speed of free flowing cars in the median lane by 6.3-7.9 mph and in the shoulder lane by 4.1-7.7 mph. The reductions brought down the average speeds near or below the posted speed limit of 55 mph. In addition, the SPE reduced the speeding by 40-51% in the median and by 7-57% in the shoulder lane for free flowing cars. Similarly, for free flowing trucks SPE reduced the average speed in the median lane by 3.4-6.9 mph and in the shoulder lane by 4.0-6.1 mph, to speeds below the posted speed limit of 55 mph. SPE also reduced the speeding free flow trucks by 10-53% in the median lane and by 0-56% in the shoulder lane. For the general traffic stream, SPE reduced average speeds by 5.1-8.0 mph in the median lane and by 4.3-7.7 mph in the shoulder lane. Likewise, trucks in the general traffic stream traveled 3.7-5.7 mph slower in the median and 3.9-6.4 mph slower in the shoulder lane. SPE lowered the average speed of the general traffic stream below the speed limit in all cases. SPE was as effective as the police patrol presence with the emergency lights off. In two of the three datasets, SPE had 2.0-3.8 mph spatial effects on free flowing cars and 1.1-1.9 mph on cars in the general traffic stream. However, on all three datasets SPE had 0.8-5.3 mph spatial effects on free flowing trucks and 0.9-3.2 mph on trucks in the general traffic stream. The reduction in the percentage of downstream speeding drivers varied from 0%-44%. Finally, halo effects were very limited and only observed for SPE on free-flowing heavy vehicles in one work zone and free flowing cars in the second work zone. Police presence did not have halo effects.					
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EXECUTIVE SUMMARY

The effects of an automated Speed Photo-radar Enforcement (SPE) system on the mean speed and the degree of speeding in interstate work zones were compared to other speed management methods, including speed display trailers, police presence (with the patrol emergency lights on and off), and the combination of speed display trailer and police presence. Three datasets were collected in two work zones, and the effects were studied at the location of the SPE system and at another location about 1.5 miles downstream in the work zone (spatial effects). The halo effects of police presence and SPE when drivers left the work zone (temporal effects) were also evaluated. When the SPE was present, cars traveled 5.1-8.0 mph slower in the median lane and 4.3-7.7 mph slower in the shoulder lane. Likewise, trucks traveled 3.7-5.7 mph slower in the median lane and 3.9-6.4 mph in the shoulder lane. The SPE lowered the average speed of the general traffic stream below the speed limit in all cases. In general, SPE was as effective as the police patrol with the emergency lights off. In two of the datasets, SPE had 2.0-3.8 mph spatial effects on free flowing cars and 1.1-1.9 mph on cars in the general traffic stream. However, on all three datasets, SPE had 0.8-5.3 mph spatial effects on free flowing trucks, and 0.9-3.2 mph on trucks in the general traffic stream. The reduction in the percentage of downstream speeding drivers varied from 0% to 44%. Finally, halo effects were very limited and only observed for SPE on free-flowing heavy vehicles in one work zone and on free flowing cars in the second work zone. Police presence did not have halo effects.

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CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The U.S. Department of Transportation (USDOT) and the American Association of State Highway and Transportation Officials (AASHTO) have developed strategic highway safety plans to improve traffic safety and to reduce traffic fatalities. In 2006, there were 42,642 traffic fatalities (NHTSA, NCSA, Overview, 2006) in the U.S.; speeding was a contributing factor in 31% of all fatal crashes, and 13,543 people lost their lives in speeding-related crashes (NHTSA, NCSA, Speeding, 2006). The National Highway Traffic Safety Administration estimates that the economic cost of speeding-related crashes is \$40.4 billion annually (NHTSA, NCSA, Speeding, 2006). The number of fatalities within the work zones in the U.S. increased from less than 800 in 1995 to more than 1,050 in 2005 (NHTSA, FARS, 2005). The large number of crashes and fatalities due to speeding, and especially speeding in work zones, calls for practical and reliable techniques to reduce the speed in the work zones. Some of these techniques are: using a speed feedback sign, police presence in work zones, and automated Speed Photo-radar Enforcement (SPE) systems.

Traffic law enforcement by police officers is not feasible at all locations and all times. In addition, enforcing traffic laws by police officers requires identifying a violator, pulling him/her over, checking the driving record of the violator, and issuing a citation to him/her. Although this one-on-one (one police officer working on one violator) approach works when police are present, its scope is limited due to the extensive manpower requirements, potential risks for the police officers working under live traffic conditions, and roadway/shoulder width constraints to temporarily park the vehicles at certain locations and to safely pull over the violator. On the other hand, the SPE can overcome these limitations and has potential to offer a more powerful tool for traffic law enforcement. Recognizing this potential, in 2004, Illinois enacted the Automated Traffic Control Systems in Highway Construction or Maintenance Zones Act. This act authorized the use of the SPE van in the work zones for the first time in the U.S.

Automated speed enforcement systems have been used extensively in Europe, and their use in the U.S. is increasing. For example, in the United Kingdom, almost half of all speeding tickets come from automated enforcement (Status Report, published by IIHS). In the U.S., automated speed enforcement has been used in nearly 30 communities (IIHS's web site). Illinois is the only state that has employed this system in work zones statewide.

In this study, the effects of the SPE on mean speed and degree of speeding are compared to the conditions without police presence (base and speed display trailer) and conditions with some variations of police presence in the work zone. Two Illinois work zones were chosen to collect the data. The first work zone was located on Interstate 64 in Illinois close to the St. Louis area. Two datasets were collected in this work zone, one representing a.m. and the other p.m. traffic. Dataset 1 was collected in the off-peak morning hours, and Dataset 2 was collected in the off-peak afternoon hours. The second work zone was on Interstate 55 near Naperville, a suburb of Chicago. Dataset 3 was collected during afternoon off-peak hours in this work zone.

The variations of the police presence in the work zone are sometimes referred to as the traditional law enforcement method, and the SPE is sometimes referred to as the automated law enforcement method.

The mean speed and the degree of speeding in each treatment (SPE, police presence, and the speed display trailer are all considered treatments) were determined and compared to those in the base case, and to each other. The mean speeds were compared using appropriate statistical methods. The degree of speeding was divided into four levels. The first level corresponds to the percentage of drivers who exceeded the work zone speed limit (55 mph for both sites). The second level shows the proportion of drivers who exceeded the speed limit by up to 5 mph. The third degree corresponds to speeding by 5-10 mph, and the fourth level shows the proportion of drivers who exceeded the speed limit by more than 10 mph.

In addition, the spatial and temporal (halo) effects of some of the treatments were investigated. For the spatial effects, the speed of vehicles at a location about 1.5 miles downstream from the treatment location was measured. To study the temporal effects (halo effects), the speed of vehicles after the treatment was removed from the work zone was compared to the speed when the treatment was in place.

The effects of different treatments were studied on cars and trucks separately. Moreover, the vehicles were divided into free flowing and general traffic stream vehicles. Since free flowing vehicles have freedom to choose their desired speed, the effect of treatments may be different for the free flowing and general traffic stream vehicles. Furthermore, the effects were studied separately on the median (passing lane) and the shoulder lane (driving lane).

This report is organized into eight chapters and two appendices: introduction, study objectives, and literature review are in Chapter One. Chapter Two contains detailed information regarding data collection and data reduction as well as a brief description for each dataset. Methodology of data analysis and description of different treatments are presented in Chapter Three. Chapters Four, Five, and Six describe the treatment effects, spatial effects, and halo effects of each treatment. The last chapter includes the conclusions and recommendations. Appendix I contains additional detailed information about the treatment effects on cars and truck in the general traffic stream. Appendix II has additional detailed information about the spatial effects of different treatments.

1.2 OBJECTIVES

The main objective of this research is to evaluate the effects of the SPE on speed and degree of speeding in work zones and compare them to the results from other methods that included law enforcement presence in work zones.

1.3 LITERATURE REVIEW

Numerous studies have been conducted to evaluate the effectiveness of different methods of increasing the speed limit compliance in work zones. Some of the common techniques are: regulatory or advisory speed limit signs, reduced lane width, flaggers, drone radar, speed feedback sign, police enforcement, rumble strips, etc. Because this research considers the effects of the speed feedback sign, police presence in work zone, and the SPE in work zone, only some of the previous research related to these techniques is presented here. The literature review is divided into three sub-sections. First, the effects of automated speed photo enforcement on speed reduction in work zones and highways are presented followed by the effects of traditional law enforcement techniques on speed reduction in work zones. Finally, the effects of speed display signs and other treatments on speed reduction in work zones are discussed.

1.3.1 Effects of Automated Speed Photo Enforcement

Goldenbeld and Van Schagen (2005) studied the effects of speed enforcement with mobile radar on speeds and accidents on rural roads in the Dutch province Friesland. The evaluation covered a 5-year period of enforcement. Their studies showed a significant reduction in mean speed and percentage exceeding the posted speed limit. They estimated 21% decrease in the number of injury accidents and the number of serious casualties.

Fontain et al. (2002) studied the feasibility of real-time remote speed enforcement in the work zone (WZ). They summarized the initial testing of the concept of remote speed enforcement. They found the system successful in taking picture of vehicles exceeding the threshold.

Chen et al. (2002) evaluated the influence of the photo radar program on speeds of vehicles and collisions at the location of the photo radars and also at interleaving locations. They found that using photo radar reduced average speed and its standard deviation by 2.8 km/h (1.74 mph) and 0.5 km/h (0.31 mph), respectively. In addition, they observed 14% \pm 11% reduction in expected collisions at photo radar locations and 16% \pm 7% reduction along the study area.

Bloch (1998) studied the speed reduction effects of photo-radar and a speed display board on three streets in Riverside, California. The results showed that both devices significantly reduced vehicles' speeds by 7 to 8 km/h and reduced the number of vehicles exceeding the speed limit by 16%. The study showed that only the speed display board had carryover effects. He concluded that the enforced display sign had a substantial short-term carryover effect while the unenforced display board had a "longer-term" carryover effect.

Oei (1998) looked at previous studies in Europe, Australia, and North America on speed enforcement, its effects on traffic safety, and potential halo effects of the treatments. He found a significant speed reduction at the enforcement location. However, the evidence for safety effect were not reliable. In addition, for the halo effect, further research was needed.

Rogersson et al. (1994) evaluated the effects of speed cameras on casualty crash frequency in Melbourne. Their methodology did not include any speed measurements. They compared the number of crashes on days when the speed camera influence was assumed to be present to the number of crashes on days when the speed camera influence was assumed to be absent. They found a statistically significant reduction in casualty crashes within 1 km of the speed camera site. This reduction was due to the receipt of traffic infringement notice. This effect was confined to the high alcohol hour of the week. They defined the low alcohol hour as: Monday to Thursday 6am to 6pm, Friday 6am to 4pm, Saturday 8am to 2pm, and Sunday 10am to 4pm. The high alcohol hours are defined as hours not included in the low alcohol hours of the week. They observed the effect of traffic infringement notice for up to two weeks in the vicinity of the speed camera site. Newstead et al. (1995) continued this research and found out that the speed cameras did not have a significant effect on casualty crashes on Victorian rural town roadways within 1 km of a camera site. However, when they studied casualty crashes within a 15 km radius of the speed camera site on Victorian rural highways they observed a statistically significant reduction.

1.3.2 Effects of Traditional Law Enforcements

Kentucky Transportation Center (2006) conducted a study in which the effects of typical signs, double fine sign only, double fine sign with police, and double fine sign with

radar box and police were evaluated. They found that the highest mean speed reductions occurred when the police were present at the work zone.

Zech et al. (2005) evaluated the effectiveness of rumble stripes and police presence in the WZ in combination with rumble stripes. They found that the presence of the police resulted in more speed reduction compared to rumble stripes, which resulted in speed reductions from 3 to 6 mph.

The Minnesota DOT (1999) assessed the effectiveness of police presence in work zones. They observed 8-9 mph reduction in the 85th percentile speeds. This study was conducted in three different work zones with 40, 50, and 55 mph posted speed limits.

Benekohal et al. (1992) studied the effects of a circulating marked police car in a work zone. They found that while the police cars were present in the work zone, the mean speeds of cars and trucks were reduced 4 and 5 mph, respectively. In addition, they observed 14% and 32% reduction in the percentage of cars and trucks exceeding the speed limit, respectively.

Richards et al. (1985) evaluated different speed control techniques within the work zone. The techniques they studied were flagging, law enforcement, changeable message sign, lane width reduction, rumble strips, and conventional regulatory and advisory speed signing. They found that flagging and law enforcement were the most effective methods to reduce the speed of vehicles in the work zone.

1.3.3. Effects of Speed Display Sign and Other Treatments

Brewer et al. (2006) conducted a study to evaluate the effectiveness of three different methods to improve compliance with the speed limit within the work zone. These three methods were speed display trailer, changeable message sign with radar, and orange-border speed limit signs. They observed a considerable potential for reducing speeds when showing the speed of drivers to them. They mentioned that orange-border speed display signs improved the visibility of the speed limit signs. In addition, they found that with lack of active speed enforcement, drivers traveled as fast as they like.

1.3.4 Summary of Literature Review

The study of literature showed that automated speed enforcement has significantly reduced the mean speed and percent exceeding the speed limit in the locations it has been used. In addition, the traditional law enforcement methods were capable of reducing the mean speed and percent exceeding the speed limit in the work zone. However, no one has evaluated the effects of automated speed enforcement on the mean speed and percent exceeding the speed limit in work zones. In addition, the differences and similarities of traditional law enforcement methods and the SPE have not been studied. Thus, this research evaluates and compares the effects of the SPE and traditional law enforcement methods on speed of vehicles in the work zone.

CHAPTER 2 DATA COLLECTION / REDUCTION

Three data sets were collected in two work zones on Interstate Highways. Dataset1 and Dataset2 contain the data collected on I-64 in Illinois near St Louis. Dataset1 is for off-peak a.m. traffic and Dataset2 is for off-peak p.m. traffic. Dataset3 was collected on I-55 near Chicago, Illinois during off-peak hours in the afternoon. In both work zones, the posted speed limit was 55 mph, and two lanes were open to through traffic. The construction zone on I-64 was for adding a third lane in the median. Concrete barriers separated the work area from the traveled lanes. In the I-55 construction zone, bridge deck repair was taking place at the time of data collection. In both sites at the locations where data was collected, there were two traveled lanes open, and a normal-width-right-hand-side shoulder was available.

In both work zones, data was collected at two locations. These locations were about 1.5 miles apart. The first location was several hundred feet downstream of where the treatment (i.e. the SPE) was located. This distance provided additional room for the drivers to react to the treatments, but the treatments were visible before the drivers reached this point. The effects of different treatments were studied at the first location. To study the spatial effects of each treatment (if there is any), data was collected at another location 1.5 miles downstream of the first location.

In addition, to study the temporal effect (halo effects) of the SPE and traditional law enforcement methods, data collection continued for some time (40-60 minutes) after SPE or police left the work zone. Data was collected using camcorders and two markers that were about 200 feet apart as shown in Figure 2-1. All of the data collection equipments were placed outside of the shoulder with no interference with the traffic stream.

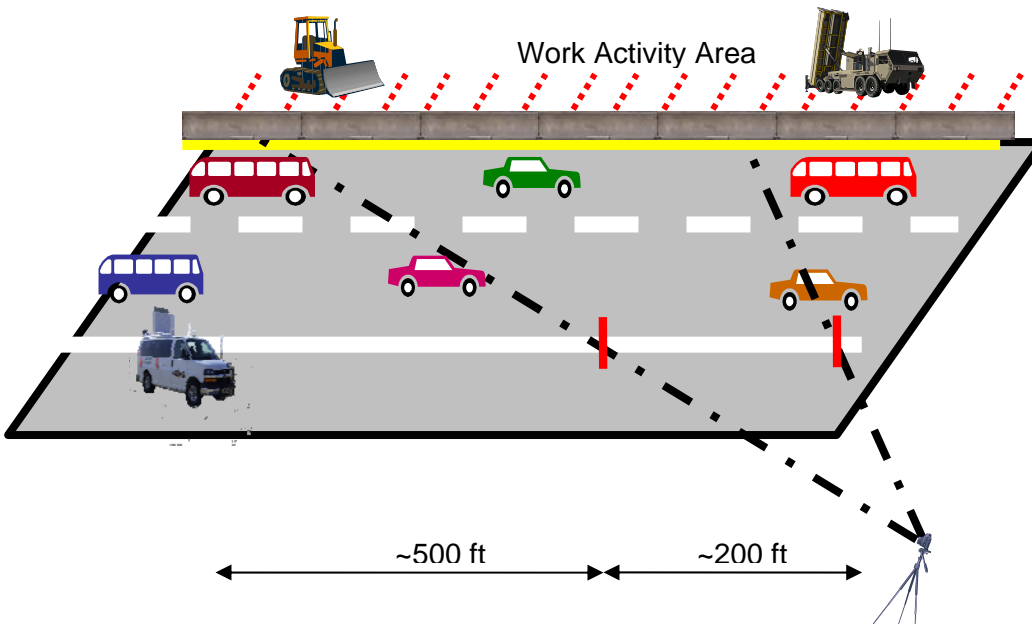


Figure 2-1. Schematic Diagram of the Data Collection Setup

For data reduction, all recorded tapes were time stamped with frame numbers allowing the accuracy in time measurements to be 0.033 second (one frame). This level of accuracy in reading travel time between two markers resulted in speed measurement error less than 1 mph. The following information was recorded for all vehicles:

- Time at the first marker (time when the left edge of the front bumper reaches the marker)
- Time at the second marker (time when the left edge of the front bumper reaches the marker)
- Vehicle type (passenger car or heavy vehicle)
- Vehicle lane (shoulder (driving) lane or median (passing) lane)
- Whether the vehicle is free flowing or in-platoon

The speed of vehicles was calculated using the distance vehicles traveled between the markers and time at each marker.

Free flowing vehicles were those with the freedom to travel at their desired speed in the work zones, and they were not closely following another vehicle. To distinguish free flowing vehicles from in-platoon vehicles a four-second criterion was used. This means that if the headway between a vehicle and the vehicle in front was more than or equal to four seconds, the following vehicles was considered a free flowing vehicle. To obtain the information for the general traffic stream, a systematic approach was employed. The information of all fifth vehicles in the traffic stream was recorded regardless of the lane the vehicle was traveling. The effect of treatments on these vehicles may be different from the effects on the general traffic stream. Thus, the effect of each treatment on free flowing and general traffic stream vehicles was studied separately.

The work zone on I-64 was around 7 miles long. The starting milepost was 9 and the treatments were placed around milepost 14. The second location was placed 1.5 miles downstream of the first location between mileposts 15 and 16. The end of work zone was after post 16. Figure 2-2 shows an aerial view of the I-64 work zone.

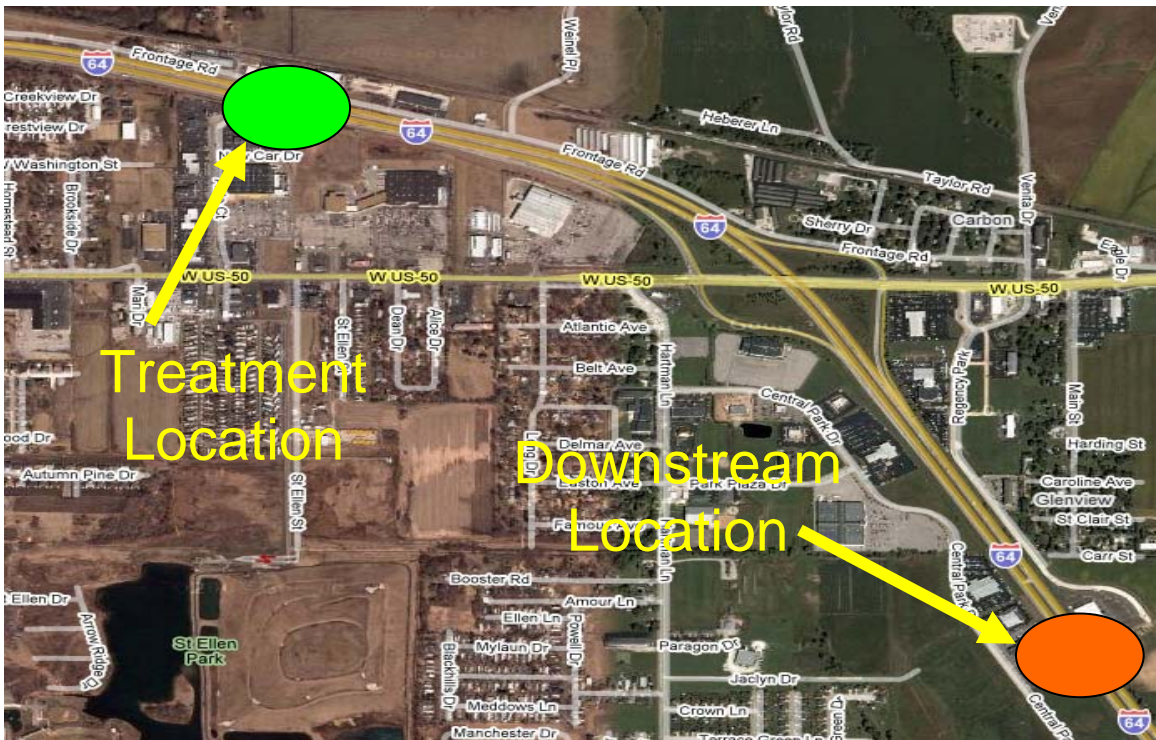
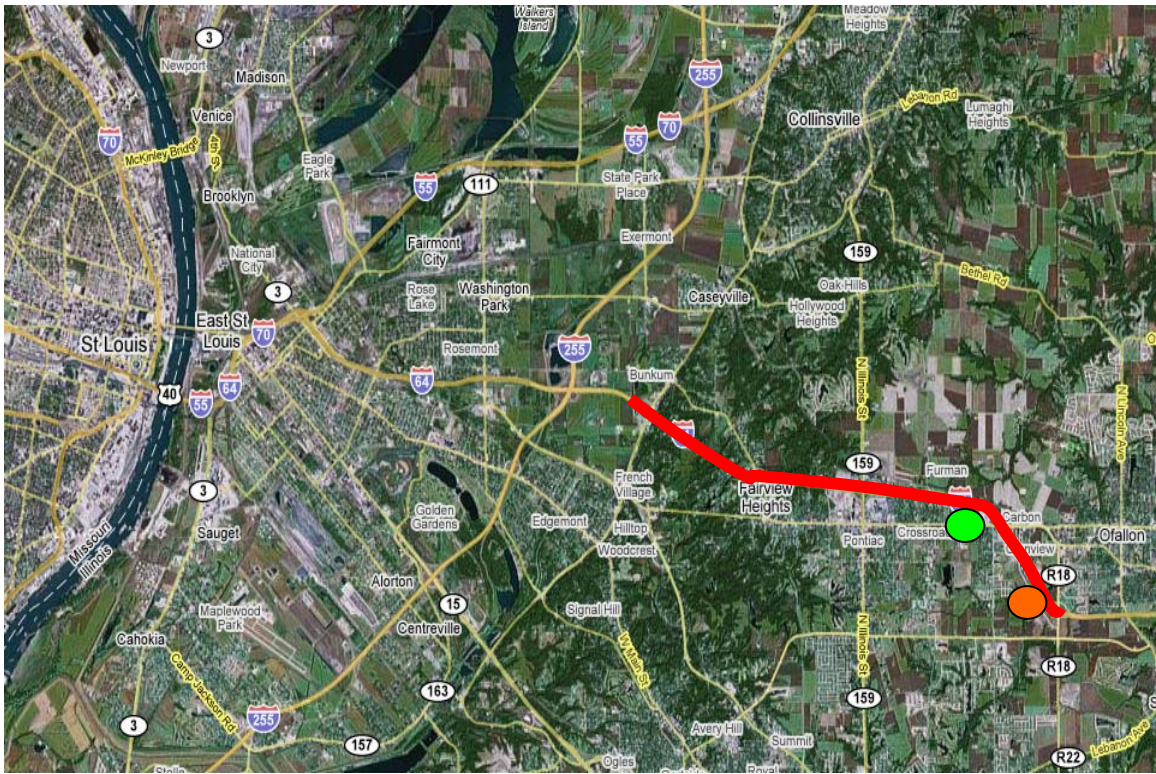


Figure 2-2. Treatment and Downstream locations on I-64 Work Zone

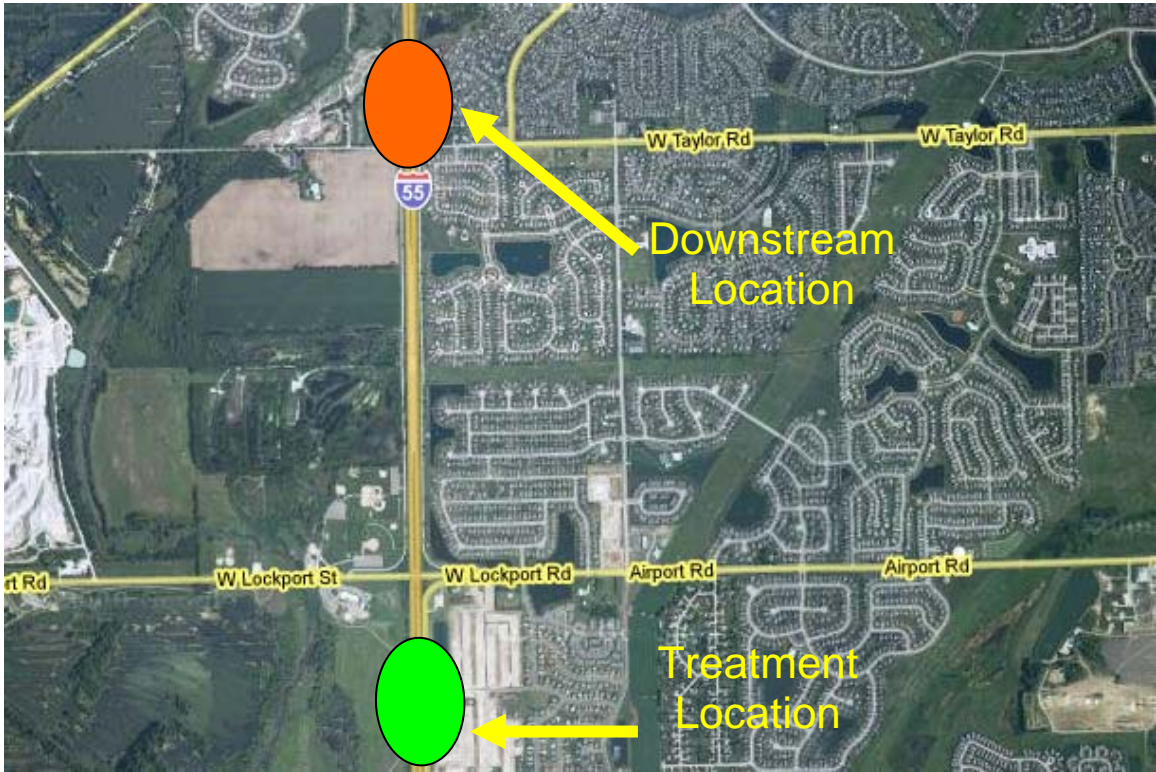
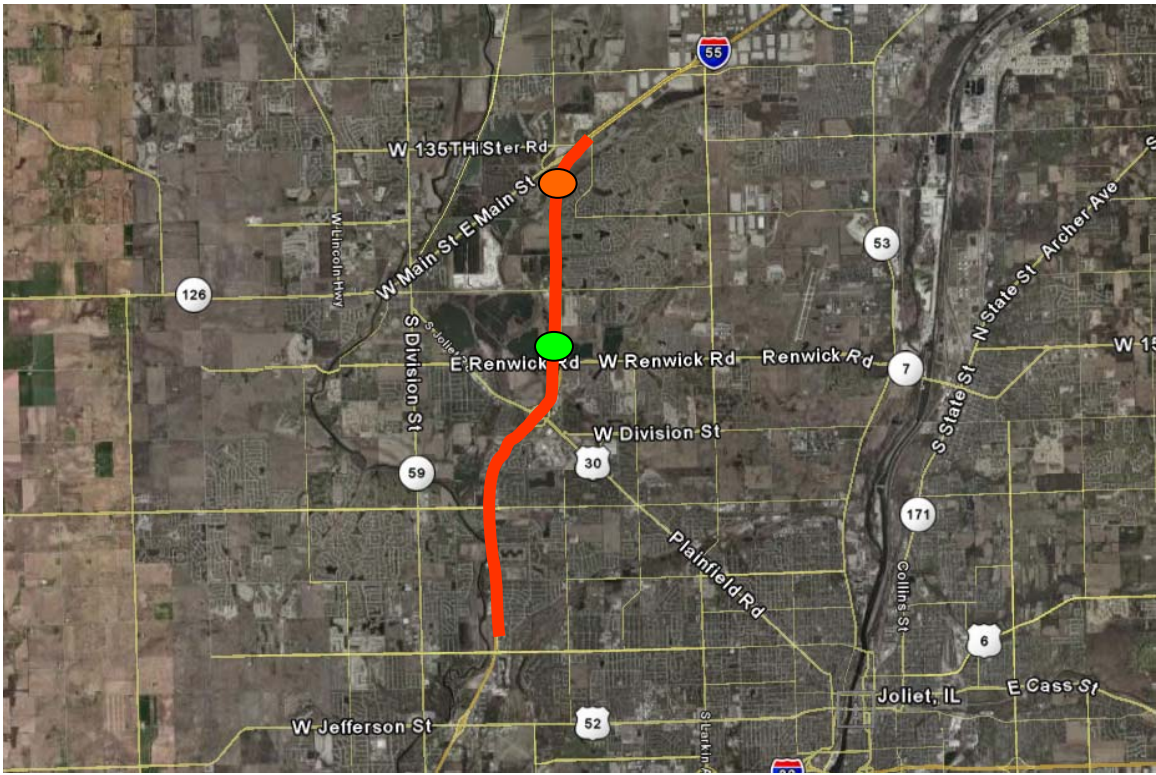


Figure 2-3. Treatment and downstream locations on I-55 work zone.

The work zone in I-55 highway started around milepost 255 and was about 7 miles long. The treatment and downstream locations were placed around mileposts 259 and 260 respectively. The aerial photos of this work zone are presented in Figure 2-3. This chapter includes a brief description of each dataset below.

2.1 BRIEF DESCRIPTION OF DATASET 1

Dataset 1 was collected on the eastbound of I-64 during off peak hours on weekdays in June 2006. For Dataset 1, data collection started at 8:30 a.m. and finished at 12:00 noon. The portions of the data used in analysis are as follows:

- | | | |
|---------------------------------------|--------------------------|--------------------|
| 1. Base case | Wednesday, June 28, 2006 | 09:30 – 10:30 a.m. |
| 2. Trailer case | Thursday, June 29, 2006 | 08:30 – 09:30 a.m. |
| 3. Police-with-Lights-on | Thursday, June 22, 2006 | 10:30 – 11:30 a.m. |
| 4. Police-without-Lights on | Thursday, June 22, 2006 | 08:50 – 10:30 a.m. |
| 5. Trailer + Police-with-Lights-on | Friday, June 30, 2006 | 10:40 – 12:00 a.m. |
| 6. Trailer + Police-without-Lights on | Friday, June 30, 2006 | 09:40 – 10:40 a.m. |
| 7. Speed Photo Enforcement | Wednesday, June 28, 2006 | 10:40 – 11:40 a.m. |

At the downstream location, the median lane was temporarily closed on June 22, and June 29, 2006, in the morning. This caused a long queue on the shoulder lane and so the data collected during these two days at the downstream location was not used for further analysis. A brief description of Dataset 1 is provided separately for the treatment and downstream locations as follows below.

2.1.1 Dataset 1 – Treatment Location

Table 2.1 presents the volume, percent heavy vehicle, and percent of vehicles in each lane.

Table 2-1. Volume Data for Dataset 1 at Treatment Location

Treatment	Volume	Percent Heavy Vehicle	Percent in the Shoulder Lane	Percent in the Median Lane
Base	1510	19%	46%	54%
Trailer	1540	17%	68%	32%
Police w/ Lights on	1430	12%	48%	52%
Police w/o Lights on	1300	13%	71%	29%
Trailer + Police w/ Lights on	1770	12%	53%	47%
Trailer + Police w/o Lights on	1500	17%	53%	47%
SPE Van	1510	18%	71%	29%

As it is presented in Table 2-1 for most of the cases the volume is in the range of 1500 vehicles per hour. The lowest and highest observed volumes were 1300 and 1770 vehicles per hour. It should be noted that the volumes are for two lanes. The percentage of heavy vehicles was in range of 12% to 19%. The lowest percentage of vehicles on the shoulder lane was 46% while at most 71% of vehicles were traveling on the shoulder lane.

Tables 2-2 and 2-3 present the minimum speed, 15% speed, average speed, and speed reduction as well as the 85% speed, maximum speed, speed variance, the sample size in each treatment for cars and heavy vehicles separately based on the lane they are traveling on, and if they are free flowing or just are a sample from the general traffic stream.

Table 2-2. Brief Findings for Free Flowing Vehicles at the Treatment Location in Dataset 1

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	FFS Cars	Base	43.9	52.9	57.0	0.0	61.3	70.3	21.1	119
		Trailer	48.2	52.1	55.9	1.1	60.2	71.3	16.8	136
		Police w/ Lights on	41.3	47.1	50.3	6.6	53.7	62.4	13.7	108
		Police w/o Lights On	41.3	47.1	50.9	6.1	53.7	68.9	17.1	155
		Trailer + Police w/ Lights on	38.1	46.3	50.3	6.7	54.5	61.3	19.9	124
		Trailer + Police w/o Lights on	40.4	45.1	48.6	8.4	52.1	65.9	14.2	113
		SPE Van	33.4	46.5	50.6	6.4	55.4	63.5	22.0	146
	FFS Trucks	Base	45.1	50.2	53.7	0.0	56.9	60.7	13.2	40
		Trailer	46.9	49.4	52.0	1.7	55.0	57.5	6.6	43
		Police w/ Lights on	35.0	44.5	47.9	5.8	52.5	55.9	17.2	41
		Police w/o Lights On	43.9	45.8	49.4	4.2	51.7	55.9	8.9	42
		Trailer + Police w/ Lights on	42.2	45.6	48.6	5.1	51.7	54.1	10.2	36
		Trailer + Police w/o Lights on	39.8	44.1	48.0	5.7	51.7	56.6	14.5	39
		SPE Van	43.8	46.9	50.3	3.4	54.1	56.8	12.3	41
Shoulder	FFS Cars	Base	38.2	47.6	51.2	0.0	54.8	64.3	18.9	135
		Trailer	41.6	46.8	50.9	0.3	53.6	73.3	17.7	211
		Police w/ Lights on	30.3	40.7	45.5	5.7	50.8	53.9	18.5	130
		Police w/o Lights On	35.1	42.8	46.7	4.5	50.0	54.8	14.0	186
		Trailer + Police w/ Lights on	33.5	41.6	45.9	5.3	50.7	53.9	18.0	116
		Trailer + Police w/o Lights on	36.8	41.6	45.9	5.3	50.3	56.6	14.9	125
		SPE Van	33.9	42.8	47.0	4.2	50.8	62.6	17.1	191
	FFS Trucks	Base	41.7	47.9	50.3	0.0	53.2	58.3	9.9	41
		Trailer	40.3	45.8	49.5	0.7	52.4	58.1	11.7	71
		Police w/ Lights on	34.6	41.9	45.1	5.2	48.7	51.3	14.7	52
		Police w/o Lights On	39.1	42.5	46.3	3.9	49.6	51.3	10.0	56
		Trailer + Police w/ Lights on	36.4	42.0	45.0	5.2	48.2	53.0	13.1	40
		Trailer + Police w/o Lights on	38.5	43.1	45.7	4.6	48.7	52.5	9.0	49
		SPE Van	36.6	42.0	46.1	4.1	49.7	54.1	15.2	54

Table 2-3. Brief Findings for Sampled Vehicles at the Treatment Location in Dataset 1

Lane	Category	Treatment	min	15% eductic	Mean	Reduction	85% eductic	Max	Variance	Sample Size		
Median	Sampled Cars	Base	43.9	50.5	0.0	54.9	0.0	59.6	0.0	65.0	17.7	85
		Trailer	43.6	48.7	1.9	53.3	1.6	58.2	1.4	62.7	19.9	98
		PWL	38.1	45.7	4.9	49.4	5.5	53.6	6.0	60.2	16.8	95
		PWOL	42.9	45.7	4.8	49.4	5.5	52.8	6.8	68.5	16.6	90
		TPWL	34.9	44.0	6.5	47.9	7.1	52.1	7.5	61.3	20.5	103
		TPWOL	39.0	43.4	7.1	47.2	7.7	50.5	9.0	65.9	15.2	93
		SPEVan	33.4	44.8	5.7	49.8	5.1	54.9	4.7	63.5	25.1	97
	Sampled Trucks	Base	46.1	49.4	0.0	53.0	0.0	55.9	0.0	60.0	11.7	36
		Trailer	45.1	47.3	2.1	50.6	2.4	53.3	2.6	55.6	8.0	41
		PWL	42.2	45.1	4.3	48.4	4.6	51.0	4.9	55.0	8.9	35
		PWOL	43.9	46.8	2.6	49.9	3.0	52.8	3.0	55.9	8.8	37
		TPWL	36.9	44.6	4.8	47.8	5.1	51.6	4.2	54.1	13.8	37
		TPWOL	39.8	45.1	4.3	48.0	4.9	50.6	5.3	55.9	9.4	37
		SPEVan	41.7	45.6	3.7	49.3	3.7	52.6	3.2	56.8	13.1	40
Shoulder	Sampled Cars	Base	38.9	46.1	0.0	49.8	0.0	53.6	0.0	58.9	13.7	81
		Trailer	39.2	45.4	0.7	49.3	0.4	52.6	0.9	66.8	14.1	151
		PWL	29.8	40.3	5.8	44.0	5.8	47.6	6.0	52.6	17.0	95
		PWOL	35.1	41.4	4.7	45.6	4.1	50.0	3.6	53.6	13.9	139
		TPWL	35.6	40.9	5.2	44.5	5.2	48.3	5.2	53.6	15.0	98
		TPWOL	36.4	39.2	6.9	44.0	5.7	48.3	5.2	52.6	16.5	85
		SPEVan	33.1	40.5	5.6	45.5	4.3	50.0	3.6	55.6	19.4	155
	Sampled Trucks	Base	40.2	45.3	0.0	48.2	0.0	51.3	0.0	53.2	9.0	44
		Trailer	43.0	47.3	-2.0	49.4	-1.2	51.3	-0.1	55.1	5.5	40
		PWL	31.0	39.6	5.7	43.5	4.6	47.0	4.3	51.2	17.9	33
		PWOL	37.3	42.3	3.0	45.1	3.0	48.2	3.0	51.3	10.1	39
		TPWL	33.8	39.7	5.6	43.8	4.3	47.3	4.0	50.5	14.3	38
		TPWOL	36.3	38.8	6.5	44.0	4.1	47.3	4.0	52.5	17.2	37
		SPEVan	33.4	40.7	4.6	45.3	2.9	50.5	0.8	51.3	18.6	38

2.1.2 Dataset 1 – Downstream Location

Table 2-4 presents the volume, percent heavy vehicle, and percent of vehicles in each lane.

Table 2-4. Volume Data for Dataset 1 at Downstream Location

Treatment	Volume	Percent Heavy Vehicle	Percent in the Shoulder Lane	Percent in the Median Lane
Base	1230	22%	50%	50%
Trailer	1380	n1	n2	n3
Police w/ Lights on	510	n4	n5	n6
Police w/o Lights on	490	n7	n8	n9
Trailer + Police w/ Lights on	1560	28%	68%	32%
Trailer + Police w/o Lights on	1380	17%	56%	44%
SPE Van	1260	21%	67%	33%
Footnotes				

n1: Median Lane Was Closed. 33% Heavy Vehicles

n2: Median Lane was Closed. 42% in Shoulder

n3: Median Lane was Closed. 58% in Median

n4: Median Lane was Closed. 24% Heavy Vehicles

n5: Median Lane was Closed. 94% in Shoulder

n6: Median Lane was Closed. 6% in Median

n7: Median Lane Was Closed. 29% Heavy Vehicles

n8: Median Lane was Closed. 92% in Shoulder

n9: Median Lane was Closed. 8% in Median

As it is presented in Table 2-4, for three cases (trailer, police-with-lights-on, and police-without-lights-on), the median lane was closed and as a result, the collected data was not reliable. For most of the cases, the volume was in the range of 1300 vehicles per hour. The lowest and highest observed volumes were 490 (due to lane closure) and 1560 vehicles per hour. It should be mentioned that the volumes are for two lanes together. The percent of heavy vehicles was in range of 17% to 33%. The lowest percent of vehicles on the shoulder lane was 42% while at most 67% of them were traveling on the shoulder lane.

Tables 2-5 and 2-6 present the minimum speed, 15% speed, average speed, and speed reduction as well as the 85% speed, maximum speed, speed variance, and the sample size in each treatment for cars and heavy vehicles separately based on the lane they are traveling on, and if they are free flowing or just are a sample from the general traffic stream.

Table 2-5. Brief Findings for Free Flowing Vehicles at the Downstream Location in Dataset 1

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	FFS Cars	Base	45.3	57.1	61.8	0.0	66.5	74.3	25.5	98
		Trailer	n1	n1	n1	n1	n1	n1	n1	n1
		Police w/ Lights on	n2	n2	n2	n2	n2	n2	n2	n2
		Police w/o Lights on	n3	n3	n3	n3	n3	n3	n3	n3
		Trailer + Police w/ Lights on	48.7	57.2	61.9	-0.2	66.5	78.7	24.3	212
		Trailer + Police w/o Lights on	52.8	57.8	61.7	0.1	66.5	73.6	19.0	121
		SPE Van	48.3	57.2	61.6	0.2	65.9	77.3	22.5	126
	FFS Trucks	Base	53.6	55.7	59.4	0.0	62.5	68.6	11.2	43
		Trailer	n4	n4	n4	n4	n4	n4	n4	n4
		Police w/ Lights on	n5	n5	n5	n5	n5	n5	n5	n5
		Police w/o Lights on	n6	n6	n6	n6	n6	n6	n6	n6
		Trailer + Police w/ Lights on	51.5	56.9	60.7	-1.3	66.7	71.4	22.7	30
		Trailer + Police w/o Lights on	52.0	55.8	59.4	0.0	62.2	70.6	14.5	30
		SPE Van	48.1	53.9	56.8	2.5	59.6	64.3	9.3	52
Shoulder	FFS Cars	Base	48.2	55.3	58.6	0.0	62.0	72.7	13.9	188
		Trailer	n7	n7	n7	n7	n7	n7	n7	n7
		Police w/ Lights on	n8	n8	n8	n8	n8	n8	n8	n8
		Police w/o Lights on	n9	n9	n9	n9	n9	n9	n9	n9
		Trailer + Police w/ Lights on	45.2	54.1	58.3	0.3	62.0	75.1	16.4	336
		Trailer + Police w/o Lights on	49.8	54.5	58.6	0.0	62.0	73.9	15.4	174
		SPE Van	43.3	53.8	57.9	0.6	61.7	78.9	20.8	209
	FFS Trucks	Base	50.0	53.4	57.3	0.0	61.6	63.5	12.5	57
		Trailer	n10	n10	n10	n10	n10	n10	n10	n10
		Police w/ Lights on	n11	n11	n11	n11	n11	n11	n11	n11
		Police w/o Lights on	n12	n12	n12	n12	n12	n12	n12	n12
		Trailer + Police w/ Lights on	48.2	54.3	56.9	0.4	59.5	68.1	9.7	85
		Trailer + Police w/o Lights on	47.2	53.5	56.4	0.9	59.3	62.1	8.1	56
		SPE Van	47.7	53.4	56.4	0.9	59.5	64.3	9.1	73

Footnotes

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size	
n1: Median Lane was closed	Median	FFS Cars	Trailer	47.5	55.0	59.5	2.2	65.0	83.3	24.9	156
n2: Median Lane was closed			Police w/ Lights on	55.9	59.4	63.3	-1.6	67.3	71.5	13.7	41
n3: Median Lane was closed			Police w/o Lights on	52.3	56.9	62.6	-0.9	68.9	75.5	26.9	99
n4: Median Lane was closed			Trailer	46.4	54.2	57.5	1.9	61.1	68.0	20.2	52
n5: Median Lane was closed	Median	FFS Trucks	Police w/ Lights on	53.4	56.3	58.2	1.2	59.7	63.6	10.6	6
n6: Median Lane was closed			Police w/o Lights on	52.0	54.8	59.9	-0.6	64.8	65.0	20.6	11
n7: Median Lane was closed			Trailer	44.9	53.2	59.1	-0.5	64.6	76.3	29.8	172
n8: Median Lane was closed	Shoulder	FFS Cars	Police w/ Lights on	48.7	53.8	58.1	0.5	63.1	68.4	18.2	78
n9: Median Lane was closed			Police w/o Lights on	48.7	53.8	57.9	0.7	61.7	76.3	19.4	276
n10: Median Lane was closed			Trailer	47.8	52.1	56.3	1.0	59.9	62.6	12.7	31
n11: Median Lane was closed			Police w/ Lights on	47.3	50.9	55.6	1.7	58.7	62.6	14.9	26
n12: Median Lane was closed			Police w/o Lights on	47.7	52.8	55.7	1.6	58.2	63.7	7.8	94

Table 2-6. Brief Findings for Free Flowing Vehicles at the Downstream Location in Dataset 1

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	Sampled Cars	Base	45.3	55.4	60.1	0.0	65.0	69.7	23.3	78
		Trailer	n1	n1	n1	n1	n1	n1	n1	n1
		Police w/ Lights on	n2	n2	n2	n2	n2	n2	n2	n2
		Police w/o Lights on	n3	n3	n3	n3	n3	n3	n3	n3
		Trailer + Police w/ Lights on	51.4	56.9	61.4	-1.3	66.1	75.5	22.9	91
		Trailer + Police w/o Lights on	47.1	56.6	61.2	-1.1	66.5	72.7	22.1	102
		SPE Van	43.5	54.4	59.3	0.8	64.2	77.3	29.4	94
	Sampled Trucks	Base	53.6	55.0	58.6	0.0	62.0	63.6	9.0	38
		Trailer	n4	n4	n4	n4	n4	n4	n4	n4
		Police w/ Lights on	n5	n5	n5	n5	n5	n5	n5	n5
		Police w/o Lights on	n6	n6	n6	n6	n6	n6	n6	n6
		Trailer + Police w/ Lights on	51.5	57.0	60.7	-2.1	65.4	71.4	21.2	32
		Trailer + Police w/o Lights on	52.0	55.5	58.9	-0.3	62.2	70.6	13.9	35
		SPE Van	46.5	53.6	56.7	1.9	59.0	65.0	14.4	43
Shoulder	Sampled Cars	Base	46.3	54.1	57.2	0.0	60.4	66.1	14.4	82
		Trailer	n7	n7	n7	n7	n7	n7	n7	n7
		Police w/ Lights on	n8	n8	n8	n8	n8	n8	n8	n8
		Police w/o Lights on	n9	n9	n9	n9	n9	n9	n9	n9
		Trailer + Police w/ Lights on	48.2	53.2	57.3	-0.1	61.0	75.1	18.9	109
		Trailer + Police w/o Lights on	49.2	53.2	57.5	-0.3	61.8	69.4	19.6	92
		SPE Van	45.8	53.8	57.1	0.1	60.9	68.4	15.8	128
	Sampled Trucks	Base	48.9	53.1	57.0	0.0	60.8	65.5	12.7	43
		Trailer	n10	n10	n10	n10	n10	n10	n10	n10
		Police w/ Lights on	n11	n11	n11	n11	n11	n11	n11	n11
		Police w/o Lights on	n12	n12	n12	n12	n12	n12	n12	n12
		Trailer + Police w/ Lights on	47.4	52.4	55.9	1.1	60.2	63.7	17.5	27
		Trailer + Police w/o Lights on	52.5	54.0	56.9	0.1	59.6	62.6	7.4	31
		SPE Van	48.9	52.8	55.3	1.7	57.6	61.0	7.4	42

Footnotes

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
n1: Median Lane was closed	Sampled Cars	Trailer	37.9	50.5	56.5	3.7	63.4	70.6	37.5	102
n2: Median Lane was closed		Police w/ Lights On	58.3	59.1	64.1	-4.0	68.7	69.7	25.5	5
n3: Median Lane was closed		Police w/o Lights On	53.8	56.5	63.3	-3.1	69.8	71.5	37.6	14
n4: Median Lane was closed	Sampled Trucks	Trailer	38.3	51.3	55.7	2.9	59.6	68.0	24.8	66
n5: Median Lane was closed		Police w/ Lights On								0
n6: Median Lane was closed		Police w/o Lights On	60.0	60.1	61.1	-2.5	62.1	62.9	2.5	3
n7: Median Lane was closed	Sampled Cars	Trailer	48.2	53.0	58.1	-0.9	63.0	76.3	30.0	92
n8: Median Lane was closed		Police w/ Lights On	44.1	51.4	54.5	2.7	59.7	62.8	18.5	43
n9: Median Lane was closed		Police w/o Lights On	39.8	51.7	55.6	1.6	60.1	69.4	21.2	124
n10: Median Lane was closed	Sampled Trucks	Trailer	47.8	52.0	56.0	1.0	59.6	62.6	12.7	35
n11: Median Lane was closed		Police w/ Lights On	43.5	49.6	54.2	2.8	58.4	59.5	25.9	15
n12: Median Lane was closed		Police w/o Lights On	40.5	50.1	53.7	3.3	57.1	61.2	14.5	36

2.2 BRIEF DESCRIPTION OF DATASET 2

Dataset 2 corresponds to the data recorded on Interstate Highway 64 in off peak hours the afternoon. Data collection was scheduled as follows:

1. Base case: Monday, June 19, 2006 02:40 – 03:40 PM.
2. Trailer case: Wednesday, Jun 28, 2006 02:00 – 03:00 PM
3. Trailer + Police-without-Lights-on: Thursday, June 29, 2006 02:00 – 03:00 PM
4. Speed Photo Enforcement: Friday, June 23, 2006 01:50 – 02:50 PM

A brief description of Dataset 2 is provided separately for the treatment and downstream locations as follows:

2.2.1 Dataset 2 - Treatment Location

Table 2-7 presents the volume, percent heavy vehicle, and percent of vehicles in each lane.

Table 2-7. Volume Data for Dataset 2 at Treatment Location

Treatment	Volume	Percent Heavy Vehicle	Percent in the Shoulder Lane	Percent in the Median Lane
Base	2190	12%	66%	34%
Trailer	1830	22%	67%	33%
Trailer + Police w/o Lights on	1710	20%	45%	55%
SPE Van	1830	15%	55%	45%

As it is presented in Table 2-7, the volume ranged from 1710 to 2190 vehicles per hour. It should be mentioned that the volumes are for two lanes together. The percent of heavy vehicles was in range of 12% to 22%. The lowest percent of vehicles on the shoulder lane was 45% while at most 67% of them were traveling on the shoulder lane.

Tables 2-8 and 2-9 present the minimum speed, 15% speed, average speed, and speed reduction as well as the 85% speed, maximum speed, speed variance, and the sample size in each treatment for cars and heavy vehicles separately based on the lane they are traveling on, and if they are free flowing or just are a sample from the general traffic stream.

Table 2-8. Findings for Free Flowing Vehicles at the Treatment Location in Dataset 2

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	FFS Cars	Base	44.5	52.1	55.4	0.0	59.2	70.3	15.6	181
		Trailer	41.8	49.8	54.5	0.9	60.2	65.9	25.1	107
		Trailer + Police w/o Lights on	38.1	45.0	48.7	6.7	52.1	57.2	14.0	93
		SPE Van	36.9	45.7	49.1	6.3	52.1	61.3	15.7	95
	FFS Trucks	Base	46.3	50.3	53.2	0.0	55.0	65.6	12.1	40
		Trailer	35.7	49.5	51.8	1.5	54.8	58.7	12.9	41
		Trailer + Police w/o Lights on	33.7	42.2	46.3	6.9	49.5	66.5	23.6	41
		SPE Van	39.2	43.8	46.3	7.0	49.4	56.6	12.1	41
Shoulder	FFS Cars	Base	41.6	46.8	50.2	0.0	52.9	64.3	11.9	141
		Trailer	40.5	46.1	49.9	0.4	53.6	64.3	17.6	125
		Trailer + Police w/o Lights on	30.4	41.7	45.8	4.4	49.7	54.5	15.1	90
		SPE Van	36.8	40.9	44.8	5.5	49.1	50.8	13.4	71
	FFS Trucks	Base	41.8	45.9	48.8	0.0	52.1	54.1	8.4	42
		Trailer	41.7	44.5	48.4	0.4	51.3	58.3	11.5	43
		Trailer + Police w/o Lights on	1.6	42.3	44.0	4.8	47.9	51.3	47.3	47
		SPE Van	33.7	41.6	44.8	4.0	48.2	52.5	15.8	40

Table 2-9. Findings for Sampled Vehicles at the Treatment Location in Dataset 2

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	Sampled Cars	Base	39.0	50.5	53.9	0.0	57.2	64.7	17.7	160
		Trailer	39.0	46.8	51.5	2.4	55.4	65.9	23.1	103
		Trailer + Police w/o Lights on	34.7	42.9	46.9	6.9	51.1	57.2	20.1	92
		SPE Van	36.5	43.0	46.8	7.1	50.5	61.3	18.9	103
	Sampled Trucks	Base	42.2	46.7	50.5	0.0	54.1	54.7	11.1	41
		Trailer	35.7	46.8	50.0	0.5	53.3	55.0	14.4	48
		Trailer + Police w/o Lights on	15.0	39.3	44.0	6.6	49.4	52.1	43.8	42
		SPE Van	21.1	42.0	45.4	5.1	49.5	53.3	25.4	43
Shoulder	Sampled Cars	Base	33.1	45.4	48.7	0.0	52.6	58.9	14.7	226
		Trailer	35.1	44.1	47.9	0.8	51.7	58.1	14.4	148
		Trailer + Police w/o Lights on	32.4	38.9	42.8	6.0	46.8	51.7	16.9	89
		SPE Van	31.7	37.9	42.4	6.3	46.1	50.0	16.8	96
	Sampled Trucks	Base	41.4	45.7	48.1	0.0	51.0	54.4	7.8	44
		Trailer	38.5	43.6	47.2	0.9	51.3	54.1	13.9	53
		Trailer + Police w/o Lights on	33.1	37.6	43.3	4.8	47.9	51.3	20.4	49
		SPE Van	35.7	40.2	44.2	3.9	48.7	53.2	17.1	49

2.2.2. Dataset 2 - Downstream Location

Table 2-10 presents the volume, percent heavy vehicle, and percent of vehicles in each lane.

Table 2-10. Volume Data for Dataset 2 at Downstream Location

Treatment	Volume	Percent Heavy Vehicle	Percent in the Shoulder Lane	Percent in the Median Lane
Base	1820	15%	73%	27%
Trailer	1630	23%	64%	36%
Trailer + Police w/o Lights on	1650	13%	51%	49%
SPE Van	1970	14%	65%	35%

As presented in Table 2-10, the volume ranged from 1630 to 1970 vehicles per hour. It should be mentioned that the volume is not per lane, but it shows the volume of the two lanes together. The percent of heavy vehicles was in range of 13% to 23%. The lowest percent of vehicles on the shoulder lane was 51% while at most 73% of them were traveling on the shoulder lane.

Tables 2-11 and 2-12 present the minimum speed, 15% speed, average speed, and speed reduction as well as the 85% speed, maximum speed, speed variance, and the sample size in each treatment for cars and heavy vehicles separately based on the lane they are traveling on, and if they are free flowing or just are a sample from the general traffic stream.

Table 2-11. Findings for Free Flowing Vehicles at the Downstream Location in Dataset 2

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	FFS Cars	Base	55.5	58.9	63.5	0.0	68.9	77.3	20.0	158
		Trailer	51.5	56.6	61.4	2.1	66.8	75.2	23.0	127
		Trailer + Police w/o Lights on	50.9	56.4	59.4	4.1	63.5	73.3	13.1	101
		SPE Van	51.0	54.8	59.7	3.8	65.1	75.5	27.0	107
	FFS Trucks	Base	51.1	55.6	59.5	0.0	63.6	66.5	14.0	33
		Trailer	48.1	56.0	58.3	1.1	61.3	65.8	11.7	48
		Trailer + Police w/o Lights on	48.5	55.1	58.5	1.0	62.2	69.1	16.4	43
		SPE Van	46.4	49.4	54.2	5.2	58.4	62.6	19.4	32
Shoulder	FFS Cars	Base	45.8	54.3	58.6	0.0	62.7	73.9	21.1	165
		Trailer	45.7	54.5	58.4	0.2	62.6	71.6	20.3	167
		Trailer + Police w/o Lights on	48.2	53.2	56.6	2.0	59.6	68.1	12.4	119
		SPE Van	43.3	51.5	55.6	3.0	59.4	68.1	18.1	125
	FFS Trucks	Base	51.1	54.9	57.8	0.0	60.2	68.1	8.7	57
		Trailer	47.9	54.4	56.8	0.9	59.5	63.7	8.6	51
		Trailer + Police w/o Lights on	49.4	51.8	55.6	2.2	58.7	62.6	10.2	56
		SPE Van	47.0	48.9	53.0	4.8	55.9	58.0	10.2	39

Table 2-12. Findings for Sampled Vehicles at the Downstream Location in Dataset 2

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	Sampled Cars	Base	52.9	57.8	61.4	0.0	66.5	70.6	15.7	106
		Trailer	50.6	55.1	60.0	1.3	64.6	76.3	21.9	104
		Trailer + Police w/o Lights on	48.7	55.5	58.7	2.6	63.2	70.6	13.1	91
		SPE Van	42.9	54.3	58.5	2.9	63.4	71.8	24.0	96
	Sampled Tru	Base	52.6	55.4	59.5	0.0	62.9	66.5	11.9	34
		Trailer	51.5	54.1	57.9	1.6	62.0	65.8	12.7	43
		Trailer + Police w/o Lights on	50.2	54.9	57.8	1.7	60.9	69.1	13.0	61
		SPE Van	43.9	50.8	56.2	3.3	62.2	68.0	28.5	34
Shoulder	Sampled Cars	Base	44.9	52.6	56.5	0.0	59.4	71.2	21.5	134
		Trailer	46.6	52.0	56.7	-0.2	60.9	67.4	18.1	187
		Trailer + Police w/o Lights on	46.6	52.0	55.0	1.5	58.6	68.1	13.8	96
		SPE Van	43.9	50.3	54.0	2.5	57.4	66.4	14.8	166
	Sampled Tru	Base	49.7	53.7	56.0	0.0	58.2	60.2	5.8	34
		Trailer	47.5	51.9	55.4	0.6	58.9	61.2	10.4	48
		Trailer + Police w/o Lights on	26.4	51.1	54.8	1.2	58.9	66.2	29.4	62
		SPE Van	46.1	49.5	52.8	3.2	55.9	58.2	8.9	35

2.3 BRIEF DESCRIPTION OF DATASET 3

Dataset 3 corresponds to the work zone on I-55 near Chicago, IL. Data was collected on the northbound lanes on weekdays during off peak hours in June and July 2007. Data collection was started at 1 p.m. and finished at 4:00 p.m. This dataset contains five different cases:

1. Base case: Wednesday, June 20, 2007, 14:00 – 15:00 PM
2. Trailer case: Thursday, June 21, 2007, 14:00 – 15:00 PM
3. Police-without-Lights-on: Tuesday, July 10, 2007, 14:00 – 15:00 PM
4. Trailer + Police-without-Lights-on: Thursday, July 12, 2007, 14:00 – 15:00 PM
5. Speed Photo Enforcement: Wednesday, July 11, 2007, 14:00 – 15:00 PM

A brief description of Dataset 3 is provided separately for the treatment and downstream locations as follows.

2.3.1 Dataset 3 – Treatment Location

Table 2.13 presents the volume, percent heavy vehicle, and percent of vehicles in each lane.

Table 2-13. Volume Data for Dataset 3 at Treatment Location

Treatment	Volume	Percent Heavy Vehicle	Percent in the Shoulder Lane	Percent in the Median Lane
Base	2240	28%	53%	47%
Trailer	2274	24%	58%	42%
Police w/o Lights on	2145	21%	59%	41%
Trailer + Police w/o Lights on	2405	20%	58%	42%
SPE Van	2005	22%	58%	42%

As it is presented in Table 2-13, the volume ranged from 2005 to 2274 vehicles per hour. It should be mentioned that the volume is for two lanes together. The percent of heavy vehicles was in range of 20% to 28%. The lowest percent of vehicles on the shoulder lane was 53% while at most 59% of them were traveling on the shoulder lane.

Table 2-14. Brief Findings for Free Flowing Vehicles at the Treatment Location in Dataset 3

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	FFS Cars	Base	50.7	57.7	63.9	0.0	69.8	80.7	31.6	106
		Trailer	49.2	56.5	61.7	2.2	66.9	77.1	29.2	103
		Police w/o Lights on	48.9	52.2	55.9	8.0	59.4	64.3	11.5	100
		Trailer + Police w/o Lights	47.6	53.0	56.4	7.4	60.5	68.5	17.3	81
		SPE Van	40.7	51.4	56.0	7.9	60.5	75.9	29.0	101
	FFS Trucks	Base	40.9	52.7	56.2	0.0	59.8	65.8	14.0	120
		Trailer	48.6	54.3	57.0	-0.7	59.4	64.6	8.5	91
		Police w/o Lights on	45.6	51.7	54.1	2.1	56.5	60.3	7.1	95
		Trailer + Police w/o Lights	42.2	50.2	52.9	3.3	55.6	63.7	10.0	98
		SPE Van	43.3	48.6	52.2	4.0	55.0	63.8	12.0	100
Shoulder	FFS Cars	Base	49.8	56.0	61.4	0.0	67.1	78.4	26.7	204
		Trailer	48.2	55.5	59.7	1.8	64.3	72.5	21.5	163
		Police w/o Lights on	45.5	51.1	54.7	6.7	58.1	68.1	12.8	208
		Trailer + Police w/o Lights	43.6	50.3	53.7	7.7	57.0	65.0	11.6	181
		SPE Van	41.3	49.6	53.7	7.8	57.8	67.1	17.6	218
	FFS Trucks	Base	51.6	53.4	57.4	0.0	61.0	67.3	14.7	39
		Trailer	44.2	51.8	56.2	1.2	60.7	65.1	20.9	38
		Police w/o Lights on	46.0	48.3	52.6	4.9	55.6	59.6	12.0	31
		Trailer + Police w/o Lights	44.1	48.0	51.8	5.6	56.0	58.8	14.2	30
		SPE Van	43.4	47.4	51.3	6.1	54.7	62.8	15.8	44

Tables 2.14 and 2.15 present the minimum speed, 15% speed, average speed, and speed reduction as well as the 85% speed, maximum speed, speed variance, and the sample size in each treatment for cars and heavy vehicles separately based on the lane they are traveling on, and if they are free flowing or just are a sample from the general traffic stream.

Table 2-15. Brief Findings for Sampled Vehicles at the Treatment Location in Dataset 3

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	Sampled Cars	Base	44.6	55.9	60.6	0.0	65.9	77.7	30.0	152
		Trailer	46.2	54.7	59.2	1.4	63.5	74.8	24.8	116
		Police w/o Lights on	38.5	49.9	53.8	6.8	57.7	62.9	18.3	114
		Trailer + Police w/o Lights	42.4	49.3	53.0	7.5	56.5	64.7	14.8	163
		SPE Van	42.0	47.8	52.6	8.0	57.1	67.2	22.6	140
	Sampled Trucks	Base	38.8	51.6	56.1	0.0	60.7	63.8	17.9	97
		Trailer	41.6	53.1	55.8	0.3	59.0	61.5	12.6	51
		Police w/o Lights on	46.0	51.2	53.8	2.3	56.0	59.3	6.2	62
		Trailer + Police w/o Lights	41.6	48.2	51.7	4.4	55.6	58.1	12.0	95
		SPE Van	37.9	46.4	50.5	5.7	54.0	63.8	23.7	64
Shoulder	Sampled Cars	Base	45.3	54.8	59.3	0.0	63.8	72.9	20.8	223
		Trailer	47.7	54.4	58.1	1.1	61.9	72.5	16.7	187
		Police w/o Lights on	42.5	49.8	53.3	6.0	57.0	63.1	13.8	226
		Trailer + Police w/o Lights	43.2	49.3	52.7	6.6	56.0	65.7	11.0	310
		SPE Van	39.5	46.6	51.6	7.6	56.4	63.2	20.6	227
	Sampled Trucks	Base	48.6	53.1	56.1	0.0	58.8	63.5	12.0	44
		Trailer	49.3	52.2	56.5	-0.5	60.3	71.7	18.8	43
		Police w/o Lights on	46.9	49.5	53.1	2.9	56.5	58.1	9.8	31
		Trailer + Police w/o Lights	45.6	48.2	52.5	3.5	55.3	58.8	11.7	29
		SPE Van	37.8	45.3	49.7	6.3	54.0	59.8	19.4	46

2.3.2 Dataset 3 – Downstream Location

Table 2-16 presents the volume, percent heavy vehicle, and percent of vehicles in each lane.

Table 2-16. Volume Data for Dataset 3 at Downstream Location

Treatment	Volume	Percent Heavy Vehicle	Percent in the Shoulder Lane	Percent in the Median Lane
Base	2115	27%	62%	38%
Trailer	2340	22%	66%	34%
Police w/o Lights on	2226	25%	57%	43%
Trailer + Police w/o Lights on	2365	29%	52%	48%
SPE Van	2305	29%	54%	46%

As presented in Table 2-16, the volume ranged from 2115 to 2365 vehicles per hour. It should be mentioned that the volume is for two lanes together. The percent of heavy vehicles was in range of 22% to 29%. The lowest percent of vehicles on the shoulder lane was 54% while at most 62% of them were traveling on the shoulder lane.

Table 2-17. Findings for Free Flowing Vehicles at the Downstream Location in Dataset 3

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	FFS Cars	Base	51.1	57.8	62.5	0.0	68.2	79.7	29.1	102
		Trailer	52.6	58.6	63.4	-0.8	68.4	75.2	23.7	103
		Police w/o Lights on	53.0	56.6	62.2	0.3	66.8	78.8	21.9	123
		Trailer + Police w/o Lights	49.7	56.6	61.3	1.3	65.5	75.2	23.2	107
		SPE Van	51.6	55.4	60.5	2.0	65.6	74.2	23.1	102
	FFS Trucks	Base	45.2	52.8	56.2	0.0	59.4	66.9	12.8	134
		Trailer	50.3	54.0	56.8	-0.7	60.1	64.3	8.5	107
		Police w/o Lights on	50.5	54.3	57.3	-1.1	60.8	68.0	9.9	148
		Trailer + Police w/o Lights	47.7	53.0	56.0	0.2	59.4	69.5	10.1	128
		SPE Van	48.2	53.2	55.4	0.7	58.1	62.2	6.4	107
Shoulder	FFS Cars	Base	50.2	54.8	59.8	0.0	65.0	76.4	25.4	207
		Trailer	45.6	55.1	59.8	0.1	64.8	74.1	23.8	213
		Police w/o Lights on	50.2	55.1	59.5	0.3	64.1	77.9	22.8	281
		Trailer + Police w/o Lights	46.1	54.4	58.6	1.2	62.6	74.7	21.4	248
		SPE Van	42.4	53.8	57.2	2.6	61.4	71.9	14.6	226
	FFS Trucks	Base	50.0	52.3	56.5	0.0	59.7	70.2	19.1	40
		Trailer	50.2	53.9	57.4	-0.9	60.3	65.9	13.0	48
		Police w/o Lights on	50.8	53.9	57.7	-1.2	62.2	69.7	17.8	31
		Trailer + Police w/o Lights	51.3	53.5	56.1	0.4	58.8	63.6	9.3	34
		SPE Van	49.1	51.9	55.6	0.9	58.8	64.4	10.5	35

Table 2-18. Findings for Sampled Vehicles at the Downstream Location in Dataset 3

Lane	Category	Treatment	min	15%	Mean	Reduction	85%	Max	Variance	Sample Size
Median	Sampled Cars	Base	48.2	55.4	59.9	0.0	65.6	75.2	23.0	143
		Trailer	50.7	56.6	61.1	-1.2	65.6	72.1	20.4	125
		Police w/o Lights on	51.0	56.0	60.5	-0.6	64.8	73.9	20.2	133
		Trailer + Police w/o Lights	49.7	55.2	59.8	0.1	64.1	74.2	19.6	175
		SPE Van	46.1	54.2	58.4	1.6	62.5	69.1	18.4	140
	Sampled Trucks	Base	45.2	52.1	56.4	0.0	60.3	66.3	17.5	71
		Trailer	50.5	54.4	57.5	-1.1	61.3	65.5	10.6	76
		Police w/o Lights on	50.9	54.6	57.4	-1.0	59.6	66.3	7.9	88
		Trailer + Police w/o Lights	48.4	53.5	56.5	0.0	60.1	67.4	10.6	108
		SPE Van	46.1	53.5	55.5	1.0	58.1	60.8	6.0	83
Shoulder	Sampled Cars	Base	49.7	54.4	58.4	0.0	61.8	71.9	16.0	264
		Trailer	50.0	55.1	59.3	-0.9	64.0	77.7	20.1	326
		Police w/o Lights on	51.3	54.7	58.5	-0.1	61.9	72.9	13.0	244
		Trailer + Police w/o Lights	46.1	54.4	58.3	0.1	61.8	74.7	16.6	245
		SPE Van	46.5	53.2	57.3	1.0	61.4	69.8	16.3	210
	Sampled Trucks	Base	45.0	54.1	57.3	0.0	60.7	66.1	12.4	67
		Trailer	51.0	53.1	57.1	0.2	60.3	63.5	9.6	57
		Police w/o Lights on	50.8	53.6	57.4	-0.1	60.8	64.0	10.7	39
		Trailer + Police w/o Lights	48.2	53.8	56.4	0.9	59.0	64.2	9.8	56
		SPE Van	42.9	51.9	55.5	1.8	59.5	64.4	14.8	56

Tables 2-17 and 2-18 present the minimum speed, 15% speed, average speed, and speed reduction as well as the 85% speed, maximum speed, speed variance, and the sample size in each treatment for cars and heavy vehicles separately based on the lane they are traveling on, and if they are free flowing or just are a sample from the general traffic stream.

CHAPTER 3 METHODOLOGY AND DESCRIPTIONS

3.1 METHODOLOGY

To evaluate the effectiveness of each treatment, two indicators were used:

1. Mean Speed
2. Degree of Speeding

The mean speed for different treatments and the base condition were determined (presented in Chapter Two in Tables: 2-2, 3, 5, 6, 8, 9, 11, 12, 14, 15, 17, 18) and compared to each other using Least Significant Difference (LSD) tests. This test shows if two treatments have similar or significantly different mean speeds at an assumed confidence level (90% used in this research). If the mean speed of a treatment is significantly less than the mean speed of the base condition, it is concluded that the treatment has significantly reduced the mean speed compared to the base condition. The same conclusion could be made for two different treatments. However, if the test shows that the mean speed of a treatment is not significantly different than the mean speed of the base condition, it is concluded that the treatment did not have any significant speed reduction compared to the base case.

In addition to assessing the effects on mean speeds, the effects of treatments on the degree of speeding are studied. The degree of speeding is studied at four levels. The first level corresponds to the percentage of drivers exceeding the speed limit. The proportion of drivers exceeding the speed limit by up to 5 mph is called the second level of speeding. The third level corresponds to speeding by 5-10 mph and the fourth level of speeding shows the proportion of drivers exceeding the speed limit by more than 10 mph.

Both point and spatial effects of each treatment are studied using the two indicators introduced above. The point effects correspond to the effects of each treatment that is observed immediately at the location where the treatment was implemented. Thus, they show the changes in the mean speeds and degree of speeding at a location very close to the treatments. The spatial effects correspond to the effects of each treatment on the mean speeds and degree of speeding about 1.5 miles downstream of the location of the treatment.

In addition to point and spatial effects, the temporal effects of each treatment are studied as well. The temporal effects (halo effects) indicate if the effects of a treatment are sustainable over time after the treatment is removed from the work zone. To study the temporal effects, the speed of vehicles were measured for some time (40-60 minutes) after the treatment was entirely removed from the work zone.

The mean speed of free flowing vehicles in each treatment was compared to the mean speed of the general traffic stream using t-test. In all datasets at the treatment location, the mean speed of free flowing vehicles was significantly different than the mean speed of the traffic stream at 90% confidence level (for all treatments). The same trend was observed at the 1.5 miles downstream of the treatment location for dataset 2. For dataset 1, the mean speed of free flowing vehicles was not significantly different than the mean speed of traffic stream for two treatments: Trailer + Police-without-Lights-on and Trailer + Police-with-Lights-on. In this dataset for all other treatments, the mean speeds were significantly different. For dataset 3, the mean speed of free flowing vehicles was significantly different from the mean speed of traffic stream for the Base and Police-without-Lights-on cases. For the remaining three cases, these means speeds

were not significantly different. Since for all three datasets at the treatment location, and for most of the cases at the downstream location, the mean speed of free flowing vehicles was significantly different than the mean speed of general traffic stream, we decided to study the effects of different treatments on speed reduction of free flowing vehicles and general traffic stream separately.

Similarly, the mean speeds of cars were compared to the mean speeds of trucks in each treatment for all three datasets. Again, the t-test with 90% significance level was used. In dataset 1 at the treatment location, the mean speed of cars was not significantly different than the mean speed of trucks for the following three treatments: Police-without-Lights-on, Trailer + Police-without-Lights-on, and the SPE. For the other four cases, the mean speeds were significantly different. In dataset 2 at the treatment location only for the SPE case the mean speed of cars was similar to the mean speed of trucks. In the three remaining cases, the mean speeds were significantly different among cars and trucks. In dataset 3 at the same location, for all the cases the mean speed of cars was significantly different than the mean speed of trucks. At the downstream location (1.5 m downstream of the treatment) for all the cases, the mean speed of cars was significantly different than the mean speed of trucks. As a result, we decided to study the effects of different treatments on reducing the speeds of cars and trucks separately.

Finally, the mean speeds of vehicles traveling on the shoulder lane were compared to the mean speeds of vehicles traveling on the median lane for all three datasets. A t-test was used with 90% significance level. At the treatment location in datasets 1 and 2, the mean speed of vehicles on shoulder lane was significantly different than the mean speed of vehicles on the median lane. In dataset 3 for the base and trailer cases, these mean speeds were not significantly different at the treatment location. However, for the rest of treatments the mean speeds were significantly different. At the downstream location (1.5 m downstream of the treatment location) for datasets 1 and 2, the mean speed of vehicles on the shoulder lane was significantly different from the mean speed of vehicles on the median lane. This was not the case for dataset 3 for the Base and Trailer + Police-without-Lights-on cases. Since for most of the cases at both locations in all datasets the mean speed of vehicles on the shoulder lane was different than the mean speed of vehicles on the median lane, we decided to study the effects of different treatments on speed reduction of vehicles on shoulder and median lane separately.

These three points lead us to conduct the analyses in the following way: the free flowing vehicles were separated from the sampled vehicles. For each group, the analyses were done separately on shoulder lane and median lane with respect to the vehicle type. As a result, analyses were done for the eight groups listed in Section 3.2.

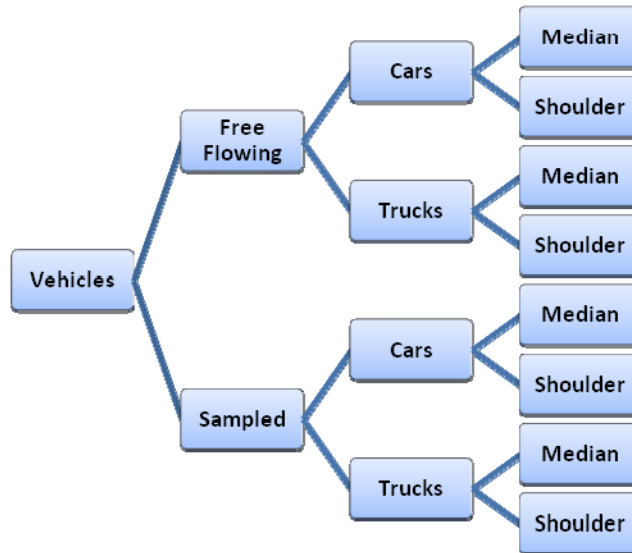


Figure 3-1. Different groups for analysis.

3.2 DESCRIPTIONS OF DIFFERENT TREATMENTS

3.2.1 Base Case

In the base case, there is no treatment present at the work zone. As a result, drivers travel at their desired speed without being influenced by police or other kind of speed reduction treatments.

3.2.2 Speed Photo Enforcement Van

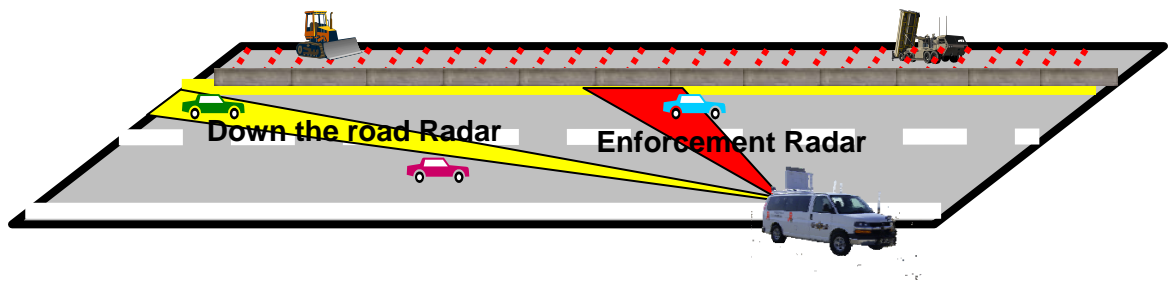
In 2003, the fatalities in work zones in Illinois increased to 44 (including five workers) from 31 in 2002 and 36 in 2001. Higher work zone fines were introduced and the Automated Traffic Control Systems in Highway Construction or Maintenance Zones Act was passed by Illinois. The Act authorized the use of cameras by the state police to enforce speed limits in the construction zones. Currently, the Act requires that construction workers be present when the SPE is used and allows it to be used in day or nighttime and whether or not the workers are behind temporary concrete barriers. The law also requires that special signs (such as the one shown in Figure 3-2-a) be posted to inform the motorists of speed photo enforcement in the work zones. The deployment of SPE vans started in the summer of 2006.



a) Special signs to be posted in work zones when SPE is deployed.



b) Photo enforcement vehicle.



c) Operation of the photo enforcement.

Figure 3-2. Speed photo enforcement van in the work zone.

The self-contained SPE van (shown in Figure 3-2-b) was provided by a private vendor (ACS State and Local Solutions). The principle behind the SPE is that, radars monitor the speeds of the vehicles approaching the SPE van. As shown in Figure 3-2-b, the SPE van is equipped with two radars. One is called the down-the-road radar and the other is called across-the-road radar. The speed obtained using the down-the-road radar is displayed on the LED display on top of the SPE van. This gives one last chance for the speeding drivers to reduce their speeds and comply with the speed limit. The range of the down-the-road radar is similar to typical radar used in work zones (about one fourth to one half mile). The across-the-road radar measures the speed of the vehicles when they are about 150 ft upstream of the van. The across-the-road radar operates at a specified angle to the path of vehicles and accounts for the angle effect. The operation of the SPE van is shown in Figure 3-2-c. If the speed of the vehicle (as measured by the across-the-road radar) is greater than a specified value, the radar activates the two on-board cameras to take pictures of the vehicle. The camera at the rear of the van (shown in Figure 3-3-a) captures the face of the driver and the front license plate if one is present. It also shows the speed of the violator, date, location and time of the violation. The front camera (shown in Figure 3-3-b) captures the rear license plate of the violating vehicle. The vans are staffed by Illinois State Police officers trained to use the SPE vans. The officers at the deployment station (shown in Figure 3-3-c) can see the speeding vehicle on the computer monitor in addition to the audible sound that alerts the officer about the speeding vehicle. The SPE van can also be operated at night and is equipped with two 140 W bulbs at the rear (shown in Figure 3-3-d) to act as a flash unit and provide light to take a clear picture of the car and the driver. The light at the front of the vehicle provides enough light to identify the license plate of the vehicle. The officer can activate a warning system (if installed) to warn the workers in the work area of an arriving speeding vehicle.

The officer in the van can issue a citation for speeding vehicles, if he/she decides it is a clear case of excessive speeding. Currently, the violation is tied to the driver of the vehicle. From the license plate of the speeding vehicles, the vehicle's owner is identified. The picture of the speeding driver is compared to the owner's picture in the driver's license database. Currently, if the picture of the driver at the time of the violation matches the picture of the registered owner of the vehicle, the ticket is approved by the police. A sample citation is shown in Figure 3-4. The vendor processes the approved citation and mails it to the registered owner of the vehicle within 14 business days as required by law. When the registered owner is not the speeding driver, changes are proposed so that the ticket can be issued. Currently, rental and trucking companies are required to provide the violator's name and information. This is done through an Affidavit of Non-Liability. They are required to provide this information within 30 days.



(a, b) Rear and front cameras




(c) Deployment station.



(d) Flash unit at the rear of the SPE van.

NOTE: USE SEPARATE CITATION FOR EACH VIOLATION

 * 4 4 3 5 6 5 0 *		4435650 ILLINOIS STATE POLICE CITATION AND COMPLAINT
COMPLAINANT	CASE NO. _____ ISP DIST. OCCURRENCE 03 ISP DIST. ASSIGNMENT 03 POLICE RECORD _____	
	COUNTY OF Cook TOWNSHIP OF EX-33 <input type="checkbox"/> TWP. RD.	
DEFENDANT	<input checked="" type="checkbox"/> PEOPLE STATE OF ILLINOIS VS. <input type="checkbox"/> CITY/VILLAGE OF _____ MUNICIPAL CORPORATION PLAINTIFF VS.	
	NAME _____ SID# _____ (Last) (First) (M.I.)	
	ADDRESS _____ (Street) (Apt.)	
	CITY STATE ZIP _____ EYES BRN <input checked="" type="checkbox"/> Female <input type="checkbox"/> Male HAIR BRN HEIGHT 65" WEIGHT 135	
VEHICLE	DR. LIC. _____ IL STATE _____ EXPIR. DATE _____ DATE OF BIRTH _____ <input type="checkbox"/> CDL	
	The Undersigned states that on _____ at _____ A.M. P.M. Defendant did unlawfully operate:	
VIOLATION	REGISTR. NO. _____ STATE IL YEAR 2010 US DOT # _____ MAKE _____ YEAR _____ COLOR DRK	
	0. <input type="checkbox"/> PEDESTRIAN 1. <input type="checkbox"/> PASSENGER CAR 2. <input type="checkbox"/> REC VEHCL OR TRUCK 3. <input type="checkbox"/> BUS 4. <input type="checkbox"/> TRUCK TRACTOR 5. <input type="checkbox"/> TRAIL OR SEMI TRAIL 6. <input type="checkbox"/> MOTORCYCLE OR BICYCLE 7. <input checked="" type="checkbox"/> OTHER 8. <input type="checkbox"/> COM MOTOR VEHCL 9. <input type="checkbox"/> PLACARDED HAZ. MAT.	
INCIDENT	Upon a Public Highway, or other Location, Specifically 194 S/B 135TH	
	Located in the County and State Aforesaid and Did Then and There Commit the Following Offense	
	I.V.C. 625 ILCS 5/ : <input type="checkbox"/> 3-797 OPERATING UNINSURED VEHICLE <input type="checkbox"/> 11-502 () ILLEGAL TRANSPORTATION ALCOHOL <input type="checkbox"/> 6-101 NO VALID DRIVER'S LICENSE <input type="checkbox"/> 11-601(a) FAILURE TO REDUCE SPEED/ACCIDENT <input type="checkbox"/> 6-303 () DRIVING WHILE LICENSE SUSPENDED/REVOKED <input type="checkbox"/> 11-601(b) SPEEDING _____ MPH IN A _____ MPH ZONE <input type="checkbox"/> 11-305 DISOBEYING TRAFFIC CONTROL DEVICE <input type="checkbox"/> 11-709 () IMPROPER LANE USAGE <input type="checkbox"/> 11-501(a) () DRIVING UNDER INFLUENCE <input type="checkbox"/> 12-603.1 FAILURE TO WEAR SEAT BELT () DI () P <input checked="" type="checkbox"/> ILCS <input type="checkbox"/> LOCAL ORDINANCE CH. 625 ACT 5/11 /SEC. 605.1 NATURE OF OFFENSE SPEEDING - 55 MPH IN 45 MPH PHOTO ENFORCED CONSTRUCTION WORK ZONE	
BOND	ACCIDENT TYPE: <input type="checkbox"/> DRIVER INJURY ONLY <input type="checkbox"/> PROPERTY DAMAGE <input type="checkbox"/> PERSONAL INJURY <input type="checkbox"/> FATAL REP. NO. _____ ROAD CONDITIONS: <input type="checkbox"/> WET <input checked="" type="checkbox"/> DRY <input type="checkbox"/> SNOW <input type="checkbox"/> ICE VISIBILITY: <input type="checkbox"/> DAY <input checked="" type="checkbox"/> NIGHT <input type="checkbox"/> RAIN <input type="checkbox"/> SNOW <input type="checkbox"/> FOG <input type="checkbox"/> CLEAR METHOD: 0. <input type="checkbox"/> H.H. RADAR 1. <input type="checkbox"/> PL. CAR 2. <input checked="" type="checkbox"/> RADAR 3. <input type="checkbox"/> A. CRAFT 4. <input type="checkbox"/> MARKED 5. <input type="checkbox"/> VASCAR 6. <input type="checkbox"/> C. SIGNED 7. <input type="checkbox"/> ASSIST 8. <input type="checkbox"/> ACCIDENT 9. <input checked="" type="checkbox"/> OTHER NOTATIONS: PHOTO ENFORCEMENT VAN IN WORK ZONE WHILE WORKERS PRESENT	
	(See middle portion, back side of Gold copy) BOND INFORMATION <input type="checkbox"/> 1. CASH \$ _____ <input type="checkbox"/> FULL AMOUNT <input type="checkbox"/> 10% <input type="checkbox"/> 2. IL DRIVER'S LICENSE <input type="checkbox"/> 3. BOND CARD NO. _____ ISSUED BY _____ <input type="checkbox"/> 4. BOND POSTED ON TICKET NO. _____ <input type="checkbox"/> 5. NO BOND-CONFINED AT _____ <input checked="" type="checkbox"/> 6. NOTICE TO APPEAR <input type="checkbox"/> 7. PROMISE TO COMPLY <input type="checkbox"/> 8. INDIVIDUAL BOND (FULL) AMOUNT \$ _____ WITHOUT ADMITTING GUILT, I promise to comply with the terms of this Ticket and Release. SIGNATURE X _____	
COURT PLACE/DATE	CIRCUIT COURT LOCATION AND DATE ADDRESS/ COURTHOUSE 10220 S. 76th Ave - Rm. #210	
	CITY Bridgeview ZIP 60455 IL ON 11/06/2009 AT 2:30 <input checked="" type="checkbox"/> P.M. <input type="checkbox"/> A.M. <input checked="" type="checkbox"/> COURT APPEARANCE REQUIRED <input type="checkbox"/> NO COURT APPEARANCE REQUIRED See instructions on top portion, back side of Gold copy.	

Under penalties as provided by law for false certification pursuant to Section 1-109 of the Code of Civil Procedure and perjury pursuant to Section 32-2 of the Criminal Code of 1961, the undersigned certifies that the statements set forth in this instrument are true and correct.

09 / 15 / 09 _____ (Secured signature) _____
 MONTH DAY YEAR OFFICER'S SIGNATURE I.D. NO.

NOTE: USE SEPARATE CITATION FOR EACH VIOLATION

IL 493-0815 **ISP5-052 (PR-06)**

Figure 3-4. Sample citation.

For the SPE, the standard work zone speeding fines apply. For the first violation, the ticket is for \$375 (\$125 goes to pay off-duty state troopers to provide additional enforcement in work zones) and the fine for the second violation is \$1000 (\$250 for trooper hire-back) and a 90-day suspension of the license. The court appearance is mandatory for each violation. The vans are part of the service provided under a contract by the vendor at a cost of \$2,950 per month per van (including the van, equipment, maintenance, upgrades, and training) plus a processing fee of \$15 per citation mailed.

In this study, the SPE van was parked outside of the right shoulder of the highway. It was parked at the treatment location about 500 ft upstream of the first marker.

3.2.3 Speed Display Sign

The speed display signs or speed display trailers use RADAR technology to determine the speed of approaching vehicles and display speed of vehicles to drivers using a LED board. As a result, each driver knows his or her speed while approaching the speed display sign.

In this study, a speed display trailer was placed outside of the right shoulder of the highway showing the speed of vehicles. It was parked at the treatment location several hundred ft upstream of the first marker. Figure 3-5 shows the speed display trailer. A speed display trailer was used in all datasets alone and in combination with police car presence.



Figure 3-5. Speed display trailer.

3.2.4 Traditional Law Enforcement

Four different variations of traditional law enforcement methods were used in this study. These variations are:

1. Police car with lights on (Police-with-Lights-on)
2. Police car with lights off (Police-without-Lights-on)
3. Speed Trailer plus Police car with lights on (Trailer + Police-with-Lights-on)
4. Speed Trailer plus Police car with lights off(Trailer + Police-without-Lights-on)

Each treatment was placed about several hundred ft upstream of the first speed measurement marker. For the last two treatments, drivers who drive along the highway first see the speed display trailer and then immediately the police car with or without lights on. Only dataset 1 includes all four variations of police presence in the work zone. Dataset 2 contains Trailer + Police-without-Lights-on treatment. Dataset 3 has two variations which are Police-without-Lights-on and Trailer + Police-without-Lights-on treatments.



Figure 3-6. Traditional law enforcement.

In the traditional law enforcement, the marked police car was parked outside of the right side shoulder of the highway. The location was several hundred ft upstream of the first marker. A police car is shown in Figure 3-6.

CHAPTER 4 EFFECTS AT TREATMENT LOCATION

In this chapters, the effects of each treatment on speed and speeding at the location the treatment was implemented are discussed. First, the effects on the free flowing vehicles are presented in detail. Then a summary of the effects on the general traffic stream is given. The effects on the cars and trucks were studied separately on median and shoulder lanes.

4.1. FREE FLOWING CARS IN MEDIAN LANE

4.1.1 Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test was used to determine whether the mean speeds in different treatments were similar. Table 4-1 shows the results of LSD test for free flowing cars in median lane. In column one of the table, each treatment is marked with a letter. For the treatments marked with the same letter, mean speeds are not significantly different with 90% confidence level. If treatments are marked with different letters, it indicates that the mean speeds are significantly different.

Table 4-1. LSD Result for Free Flowing Cars in Median Lane

	Mean Speed	Treatment
A	57.0	Base
B	55.9	Trailer
C	50.9	Police w/o Lights on
C	50.6	SPE Van
C	50.3	Police w/ Lights on
C	50.3	Trailer + Police w/ Lights on
D	48.6	Trailer + Police w/o Lights on

The mean speed in the base case (57 mph) was significantly higher than the mean speed of all treatments (ranged from 48.6 to 55.9 mph). This indicates that all of the treatments significantly reduced the mean speed of free flowing cars in the median lane. The presence of the speed display trailer in the work zone reduced the mean speed only by 1.1 mph to 55.9 mph. However, the mean speeds for the Police-without-Lights-on, SPE, Police-with-Lights-on, and Trailer + Police-with-Lights-on treatments were significantly less than the mean speed for the base and the trailer cases. The reductions in mean speed for the above-mentioned four cases were similar and ranged from 6.1 to 6.7 mph, reducing the mean speed to 50.3 to 50.9 mph. The mean speed in the Trailer + Police-without-Lights-on treatment (48.6 mph) was significantly lower than that of all other treatments. This indicated that for this data set, the presence of the police car in the work zone with lights off and with the speed display sign resulted in the most speed reduction. In the other word, the Trailer + Police-without-Lights-on treatment had the most reduction in mean speed among the free flowing cars in the median lane, for this data set. This treatment resulted in 8.4 mph speed reduction while the SPE van resulted in 6.4 mph speed reduction for the free flowing cars in median lane. This may be due to the threat level that the drivers perceived with the police car compared to the SPE.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for the free

flowing cars in the median lane are shown Figure 4-1. The cumulative speed distributions for all treatments were shifted towards left compared to the base case. This shift was more pronounced for the Police-without-Lights-on, SPE, Police-with-Lights-on, and Trailer + Police-with-Lights-on cases compared to the Trailer case. The Trailer + Police-without-Lights-on case resulted in the highest shift towards the left. Two statistical tests, Chi Squared and Kolmogorov-Smirnov, were conducted to determine whether these distributions were significantly different. The results of these tests supported the results of the LSD test at the same confidence level.

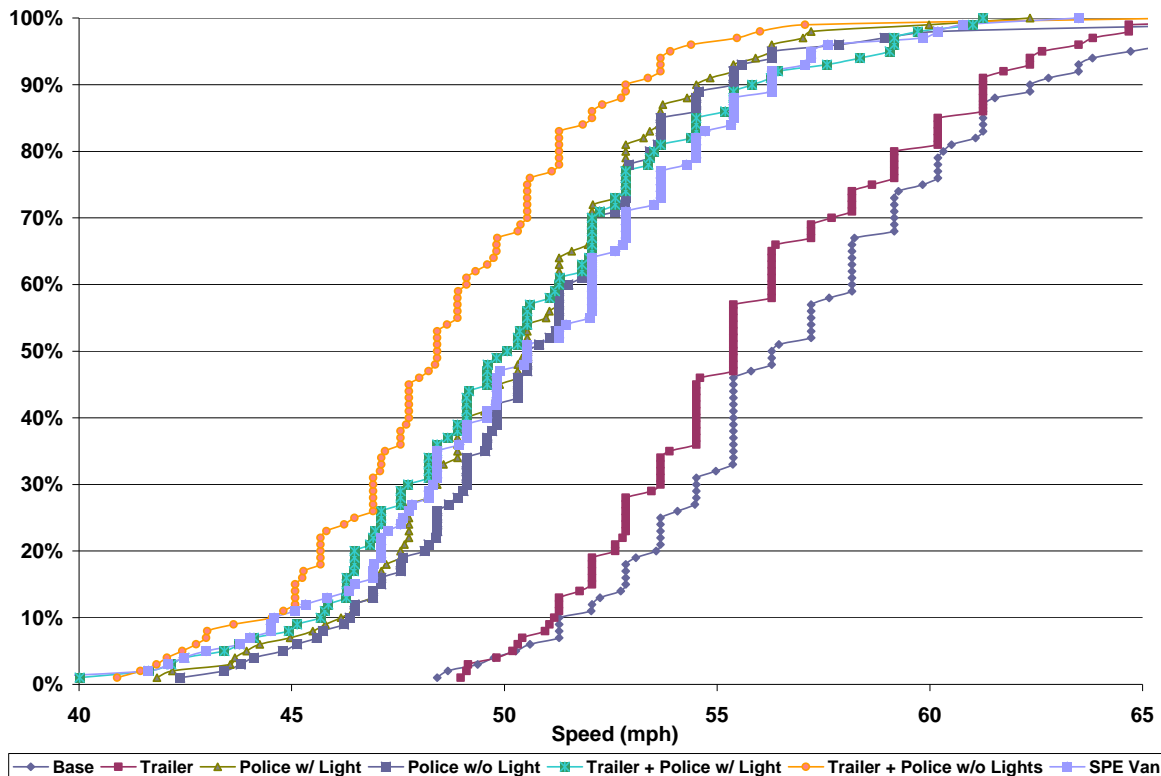


Figure 4-1. Cumulative speed distribution for the free flowing cars in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-2. The first level indicates traveling at a speed higher than the posted speed limit (55 mph for this site). In the base case 68.1% and in the trailer case 53.7% exceeded the speed limit. For the treatments that included law enforcement, less than 18% of drivers exceeded the speed limit. The highest speed limit compliance, 96.5%, occurred in the trailer + Police-without-Lights-on treatment. In the SPE case 82.9% of drivers complied with the speed limit. This finding supports the results of the mean speed reductions.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 42.9% of vehicles exceeded the speed limit by 5 mph. This percentage reduced to 33.8% when the trailer was present in the work zone. The law enforcement methods reduced the percentage to less than 14%. The presence of Police-without-Lights-on plus trailer reduced this percentage to 2.6% while SPE van reduced it to 13.7%. This finding is in line with the results of mean speed reduction.

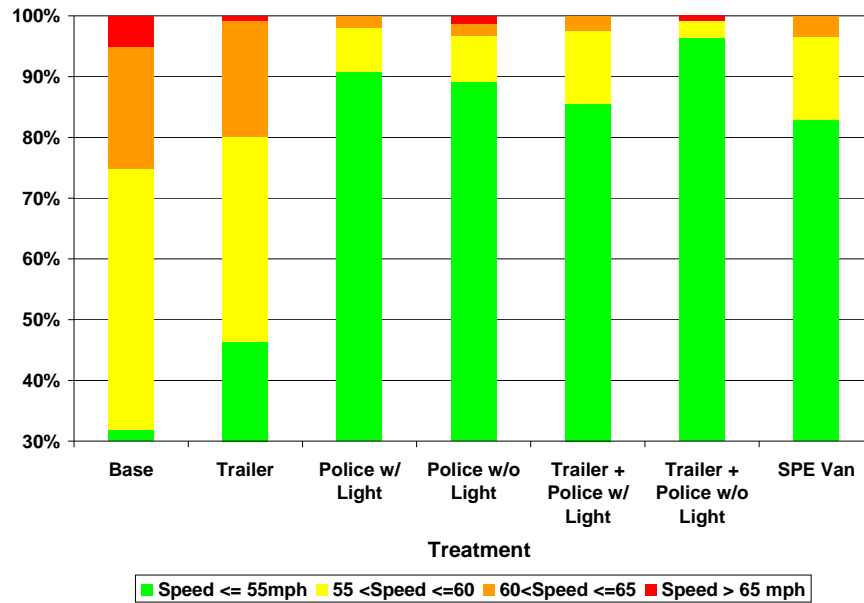


Figure 4-2. The degree of speeding for free flowing cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 5-10 mph were 20.2% and 19.1%, respectively. For all other treatments, the percentages were less than 4%. The Trailer + Police-without-Lights-on treatment reduced this percentage to zero while the SPE van reduced it to 3.4%. The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base case, 5%, and in all other treatments around 1% of drivers exceed the speed limit by more than 10 mph.

4.1.2 Dataset 2

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table 4-2 shows the results of LSD test for free flowing cars in median lane for Dataset 2.

Table 4-2. LSD Result for Free Flowing Cars in Median Lane

	Mean Speed	Treatment
A	55.4	Base
A	54.5	Trailer
B	49.1	SPE Van
B	48.7	Trailer + Police w/o Lights on

The mean speed in the base case (55.4 mph) was significantly higher than the mean speed of all law enforcement methods (ranged from 48.7 to 49.1 mph) but, similar to the mean speed in the trailer case. This indicates that all of the law enforcement methods significantly reduced the mean speed of free flowing cars in the median lane. The presence of the speed display trailer in the work zone did not significantly reduce the mean speed compared to the base case. However, the mean speeds for the SPE, and Trailer + Police-without-Lights-on treatments were significantly lower than the mean

speed for the base and the trailer cases. The reductions in mean speed for the above-mentioned two cases were similar and ranged from 6.3 to 6.7 mph, reducing the mean speed to 48.7 to 49.1 mph. As a result, automated and traditional law enforcement methods significantly reduced the mean speeds of the free flowing cars in the median lane for this dataset.

The cumulative speed distribution curves for the free flowing cars in the median lane are shown Figure 4-3. The cumulative speed distributions for the law enforcement methods are shifted towards left compared to the base and trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

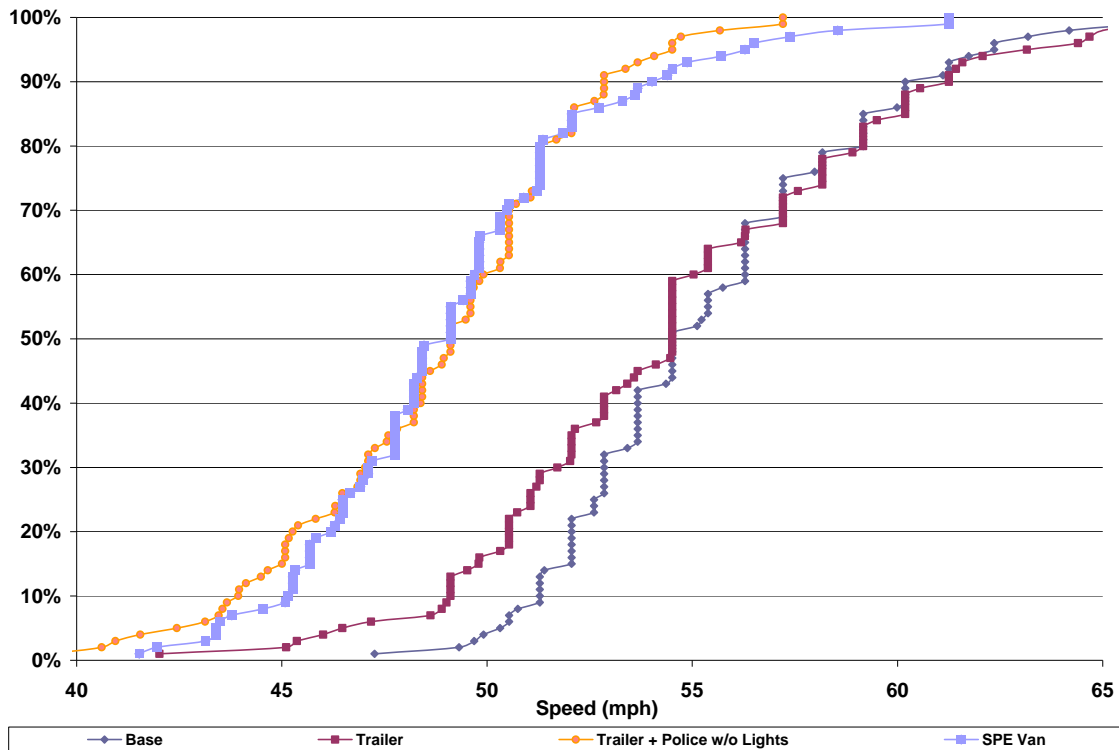


Figure 4-3. Cumulative speed distribution for the free flowing cars in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-4. In the base case 48.6%, and in the Trailer case 40.2% exceeded the speed limit of 55 mph. However, when the SPE van was present in the work zone less than 7.4% of the drivers exceeded the speed limit. For the case of trailer plus Police-without-Lights-on, only 3.2% of drivers exceed the speed limit.

The percentages of vehicles exceeding the speed limit by 5 mph or less were 34.2% for the base case and 24.3% when the trailer was present in the work zone. The presence of Police-without-Lights-on plus Trailer reduced this percentage to 3.2% while SPE van reduced it to 5.3%.



Figure 4-4. The degree of speeding for free flowing cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 5-10 mph were 12.7% and 13.1%, respectively. The presence of police with lights off plus trailer reduced this percentage to zero while the SPE van reduced it to 2.1%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base case 1.7%, and in the Trailer case 2.8% of drivers exceeded the speed limit. In the other treatments, no one exceeded the speed limit by more than 10 mph.

4.1.3 Dataset 3

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table 4-3 shows the results of LSD test for free flowing cars in median lane for Dataset 3.

Table 4-3. LSD Result for Free Flowing Cars in Median Lane

	Mean Speed	Treatment
A	63.9	Base
B	61.7	Trailer
C	56.4	Trailer + Police w/o Lights on
C	56.0	SPE Van
C	55.9	Police w/o Lights on

The mean speed in the base case (63.9 mph) was significantly higher than the mean speed of any of the treatments (ranged from 55.9 to 61.7 mph). This indicates that all of the treatments significantly reduced the mean speed of free flowing cars in the median lane. The presence of the speed display trailer in the work zone reduced the mean speed by 2.2 mph to 61.7 mph. The mean speeds for the Trailer + Police-without-

Lights-on, Police-without-Lights-on, and the SPE treatments were significantly less than the mean speed for the base and the trailer cases. The reductions in mean speed for the three law enforcement cases were similar and ranged from 7.5 to 8.0 mph, resulting in mean speed from 55.9 to 56.4 mph. This clearly shows that all law enforcement methods reduced the average speed and the SPE and traditional law enforcement methods had a similar speed reduction effects on free flowing cars in median lane.

The cumulative speed distribution curves for the free flowing cars in the median lane are shown Figure 4-5. The cumulative speed distributions for all treatments are shifted towards left compared to the base case. This shift was more pronounced for the Trailer + Police-without-Lights-on, Police-without-Lights-on, and SPE cases compared to the Trailer case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

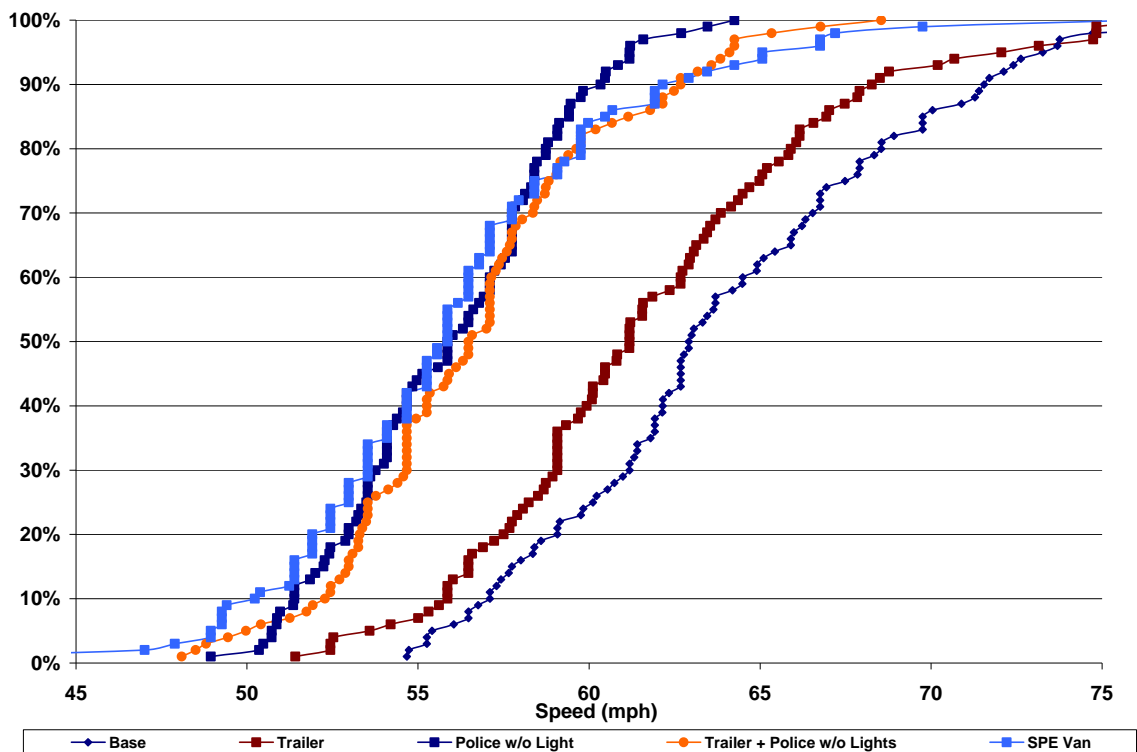


Figure 4-5. Cumulative speed distribution for the free flowing cars in the median lane.

Degree of Speeding

The degree of speeding for different treatments is presented in Figure 4-6. In the base case 97.0%, and in the Trailer case 92.2% of travelers exceeded the speed limit of 55 mph. For the treatments that included law enforcement officer, the speed limit compliance ranged from 41.7% to 45.0%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 23.0% for the base case and increased to 33.0% when the trailer was present in the work zone. For the law enforcement methods, the percentages increased to 41.6%-44%. The increase at the low-level speeding was because of the reduction in high-level speeding, as discussed later.

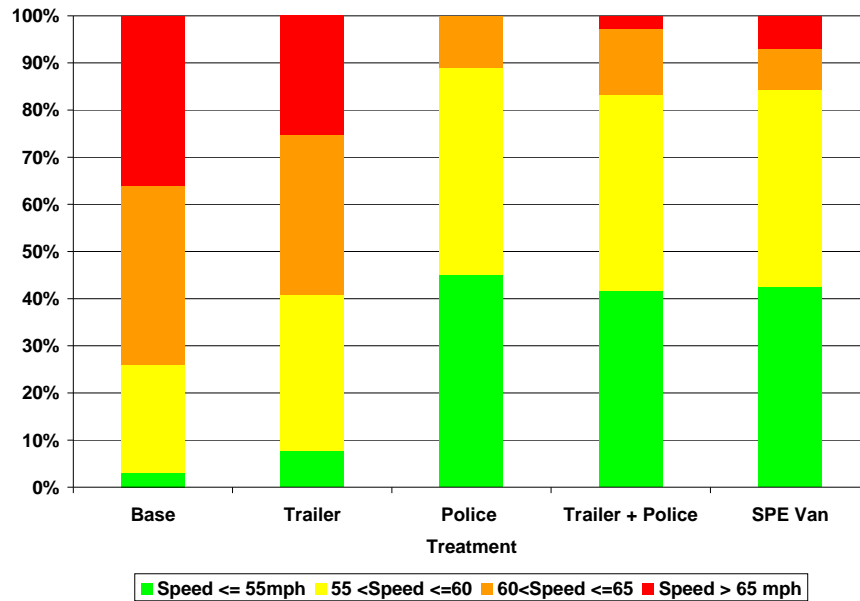


Figure 4-6. The degree of speeding for free flowing cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 5-10 mph were 38.0% and 34.0%, respectively. For the traditional law enforcement treatments, the percentage dropped to less than 13.9% and for the SPE it was reduced to 8.9%. The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base and trailer cases, 36.0% and 25.2% of drivers exceeded the speed limit by more than 10 mph. The SPE reduced this percentage to 6.9%. Trailer + Police-without-Lights-on reduced it even more to 2.8% and finally the Police-without-Lights-on treatment eliminated it.

4.1.4 Summary of Effects of SPE on Free Flowing Cars on Median Lane

The three data sets showed that SPE was effective in reducing the average speed of free flowing cars on median lane to 49.1-56.0 mph. Speeding was more prevalent on I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 6.3-7.9 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE reduced the percentage of speeding cars by 39.6%-50.9%; thus, it increased the compliance with work zone speed limit to 42.6% to 92.6%.

4.2 FREE FLOWING CARS IN SHOULDER LANE

4.2.1 Dataset 1

Mean Speeds and Speed Reductions

Table 4-4 shows the results of LSD test with 90% confidence level for free flowing cars in shoulder lane.

Table 4-4. LSD Result for Free Flowing Cars in Shoulder Lane

	Mean Speed	Treatment
A	51.2	Base
A	50.9	Trailer
B	47.0	SPE Van
B	46.7	Police w/o Lights on
C	45.9	Trailer + Police w/o Lights on
C	45.9	Trailer + Police w/ Lights on
C	45.6	Police w/ Lights on

The mean speeds in the base case (51.2 mph) and the trailer case (50.9 mph) were significantly higher than the mean speed of all law enforcement treatments (ranged from 45.6 to 47.0 mph). This indicates that all law enforcement treatments resulted in significantly lower mean speeds for the free flowing cars in the shoulder lane. The presence of the speed display trailer did result in significantly lower mean speed compared to the base case. However, the mean speeds for the SPE van and the Police-without-Lights-on treatments were significantly lower than the mean speed for the base and the trailer cases. The reductions in mean speed for the above-mentioned two cases were similar and ranged from 4.2 to 4.5 mph, reducing the mean speed to 46.7 to 47.0 mph. The mean speeds in the Trailer + Police-without-Lights-on, Trailer + Police-with-Lights-on, and Police-without-Lights-on treatments were significantly lower than all of the other treatments and ranged from 45.6 to 45.9 mph. These treatments resulted in similar speed reductions that ranged from 5.3 to 5.6 mph. The SPE van resulted in smaller speed reduction than Police-with-Lights-on due to the threat level that the drivers may have perceived with the police car in the work zone.

The cumulative speed distribution curves for the free flowing vehicles in the shoulder lane are shown Figure 4-7. The cumulative speed distributions for all law enforcement treatments are shifted towards the left compared to the base and trailer cases. This shift was a little bit more for Trailer + Police-without-Lights-on, Trailer + Police-with-Lights-on, and Police-without-Lights-on cases compared to the SPE van and the Police-without-Lights-on. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

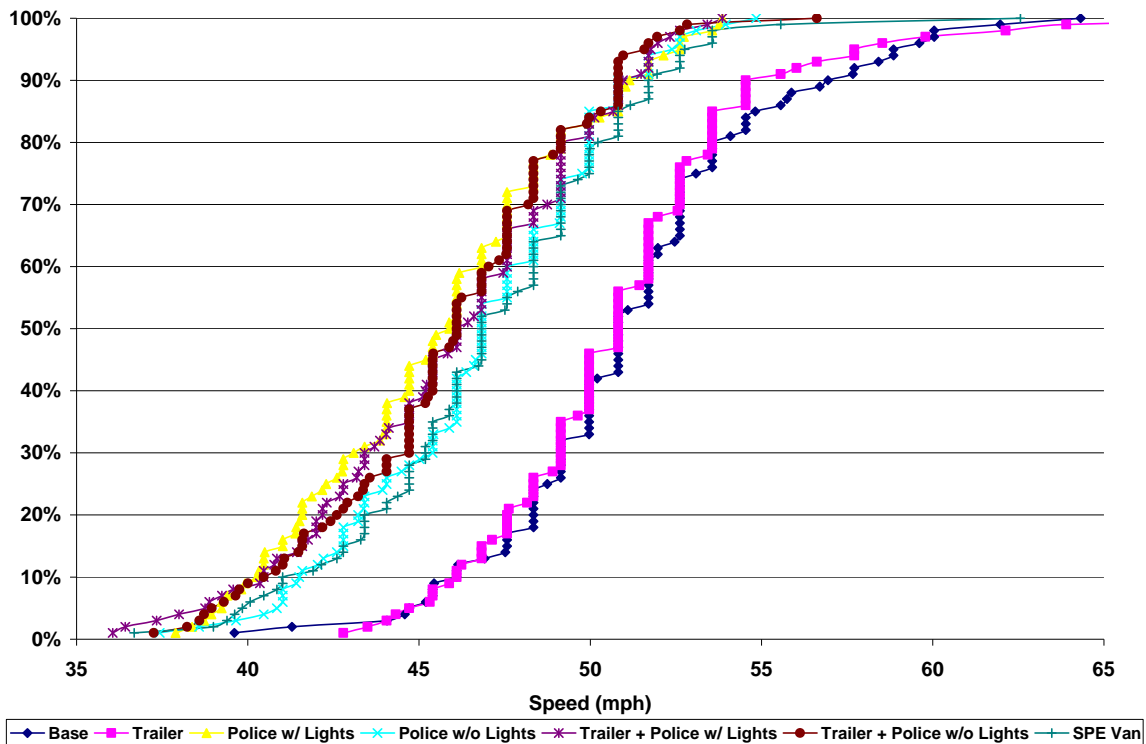


Figure 4-7. Cumulative speed distribution for the free flowing cars in the shoulder lane.

Degree of Speeding

In the base case 14.8%, and in the trailer case 9.5% exceeded the speed limit of 55 mph. For the treatments that included law enforcement, less than 1.6% of drivers exceeded the speed limit. The highest speed limit compliance occurred in the traditional law enforcement methods. In the SPE case, 1.6 % of drivers exceeded the speed limit the speed limit.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 10.4% of vehicles exceeded the speed limit by 5 mph. This percentage reduced to 6.2% when the trailer was present in the work zone. All the traditional law enforcement methods except Trailer + Police-without-Lights-on reduced this percentage to 0.0% while SPE van reduced it to 1.1%.

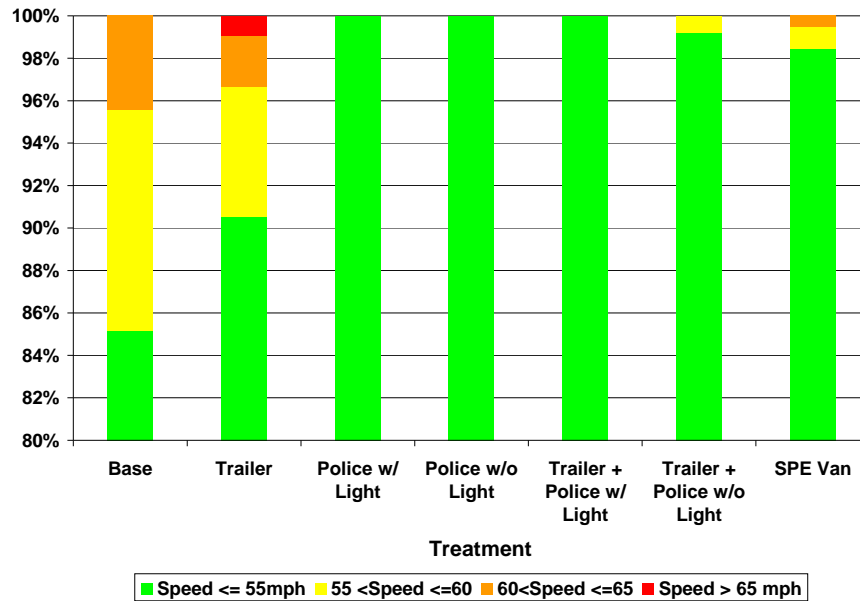


Figure 4-8. The degree of speeding for free flowing cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 10 mph were 4.4% and 2.4%, respectively. For all traditional law enforcement methods, this percentage reduced to 0% while the SPE van reduced it to 0.5%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the trailer case 1.0%, and in all other cases 0.0% of drivers exceeded the speed limit by more than 10 mph.

4.2.2 Dataset 2

Mean Speeds and Speed Reductions

Table 4-5 shows the results of LSD test with 90 percent confidence level for free flowing cars in shoulder lane for Dataset 2.

Table 4-5. LSD result for Free Flowing Cars in shoulder Lane

	Mean Speed	Treatment
A	50.2	Base
A	49.9	Trailer
B	48.8	Trailer + Police w/o Lights on
C	44.8	SPE Van

The mean speed in the base case (50.2 mph) was significantly higher than the mean speed of all law enforcement methods (ranged from 44.8 to 48.8 mph) but, similar to the mean speed in the trailer case. This indicates that all of the law enforcement methods significantly reduced the mean speed of free flowing cars in the shoulder lane. The presence of the speed display trailer in the work zone did not reduce the mean speed significantly. However, the mean speeds for the Trailer + Police-without-Lights-on, and the SPE treatments were significantly lower than the mean speed for the base and

the trailer cases. Trailer + Police-without-Lights-on treatment reduced the mean speed by 1.4 mph to 48.8 mph. The mean speed reduction by SPE was more pronounced than the traditional law enforcement method. SPE reduced the mean speed by 5.4 mph to 44.8 mph. As a result, automated enforcement reduced the mean speed by far more than the traditional enforcement for the free flowing cars in the shoulder lane for this data set.

The cumulative speed distribution curves for the free flowing cars in the shoulder lane are shown in Figure 4-9. The cumulative speed distributions for the law enforcement methods were shifted towards left compared to the base and trailer cases. This shift was more pronounced for the SPE. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

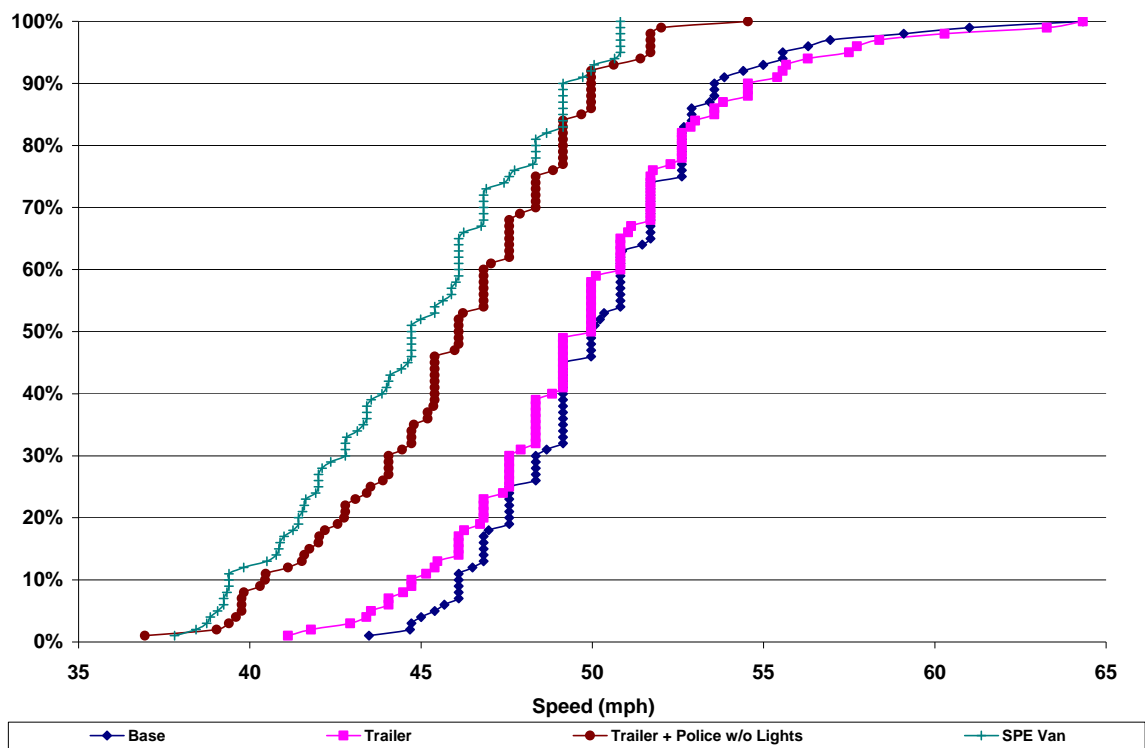


Figure 4-9. Cumulative speed distribution for the free flowing cars in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-10. In the base case 7.1%, and in the Trailer case 9.6% exceeded the speed limit, but in case of law enforcement this percentage was reduced to zero.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 5.0% of vehicles exceeded the speed limit by 5 mph. This percentage was 7.2% when the trailer was present in the work zone. None of the free flowing cars in the shoulder lane exceeded the speed limit when the law was enforced and as a result, no vehicle belongs to the second, third, and fourth levels of speeding.



Figure 4-10. The degree of speeding for free flowing cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 10 mph were 2.1% and 2.4%, respectively. For other treatments, the percentage was zero again. This finding supports the results of the mean speed reduction. None of the free flowing cars in the shoulder lane exceeded the speed limit by more than 10 mph in all the cases.

4.2.3 Dataset 3

Mean Speeds and Speed Reductions

Table 4-6 shows the results of LSD test at 90 percent confidence level for the free flowing cars in shoulder lane for dataset 3.

Table 4-6. LSD result for Free Flowing Cars in Shoulder Lane

	Mean Speed	Treatment
A	61.4	Base
B	59.7	Trailer
C	54.7	Police w/o Lights on
D	53.7	Trailer + Police w/o Lights on
D	53.7	SPE Van

The mean speed in the base case (61.5 mph) was significantly higher than the mean speed of all treatments (ranged from 53.7 to 59.7 mph) indicating that all of the treatments significantly reduced the mean speed of free flowing cars in the shoulder lane. The presence of the speed display trailer in the work zone reduced the mean speed by 1.7 mph to 59.7 mph. Police-without-Lights-on reduced the mean speed by 6.7 mph to 54.7 mph. The Trailer + Police-without-Lights-on, and the SPE treatments resulted in significantly lower mean speeds compared to the other treatments. The

reductions in mean speed for the above-mentioned two cases were 7.7 and 7.7 mph, reducing the mean speed to 53.7 mph. This shows that the SPE and traditional law enforcement methods reduced the speed of free flowing cars in shoulder lane similarly.

The cumulative speed distribution curves for the free flowing cars in the shoulder lane are shown Figure 4-11. The cumulative speed distributions for all law enforcement treatments are shifted towards left compared to the base case. This shift was more pronounced for the Trailer + Police-without-Lights-on, and SPE cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

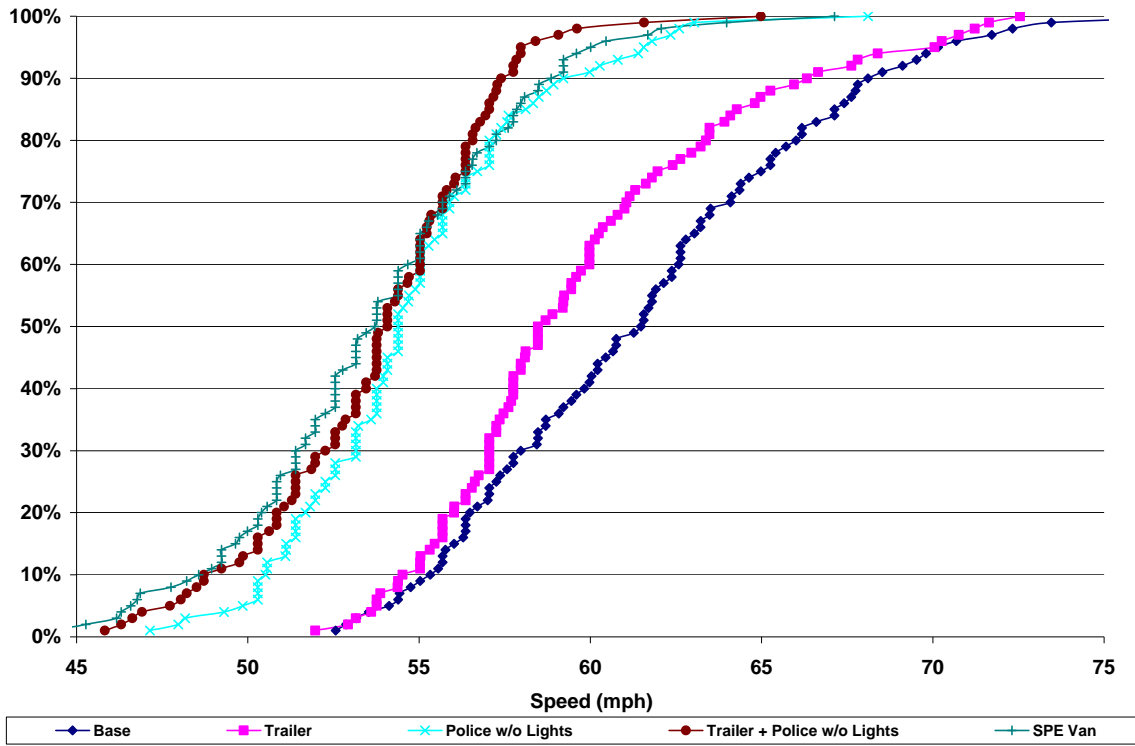


Figure 4-11. Cumulative speed distribution for the free flowing cars in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-12. In the base case 90.7%, and in the Trailer case 89.6% exceeded the speed limit. For the treatments that included law enforcement the speed limit compliance ranged from 39.9% to 43.7%.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 35.0% of vehicles exceeded the speed limit by 5 mph. This percentage increased to 53.4% when the trailer was present in the work zone. The law enforcement methods reduced this percentage to 34.9% to 38.7%.

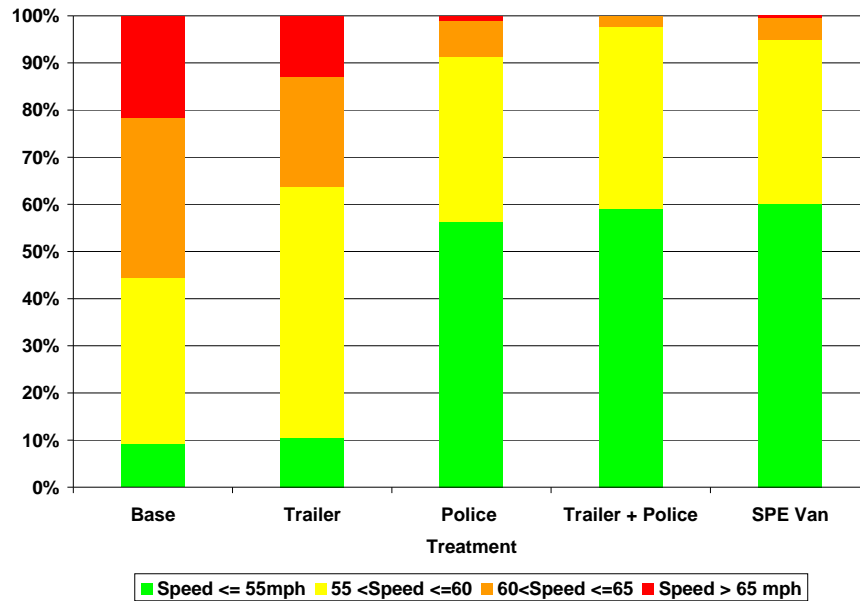


Figure 4-12. The degree of speeding for free flowing cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 5-10 mph were 34.0% and 23.3%, respectively. For the law enforcement treatments, this percentage dropped to less than 7.7%. The SPE van reduced it to 4.6% and Trailer + Police-without-Lights-on reduced it to 2.3%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base and trailer cases, 21.7% and 12.9% of drivers exceeded the speed limit by more than 10 mph. The law enforcement methods reduced this percentage to less than 1.0% and Trailer + Police-without-Lights-on eliminated this percentage.

4.2.4 Summary of Effects of SPE on Free Flowing Cars on Shoulder Lane

The three data sets showed that SPE was effective in reducing average speed of free flowing cars on shoulder lane to 44.8-53.7 mph. Speeding was more prevalent on I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 4.1-7.7 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE was decreased the percentage of speeding cars by 7.1-50.8%; thus, it increased the work zone speed limit compliance level to 60.1-100%.

4.3 FREE FLOWING TRUCKS IN MEDIAN LANE

4.3.1 Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test was used to determine whether the mean speeds in different treatments were similar. Table 4-7 shows the results of LSD

test for free flowing trucks in the median lane. Each treatment is marked with a letter. Mean speeds are not significantly different (90% confidence level) for the treatments marked with the same letter, but if treatments are marked with different letters, this indicates that the mean speeds are significantly different.

Table 4-7. LSD Result for Free Flowing Trucks in Median Lane

		Mean Speed	Treatment
A		53.7	Base
B		52.0	Trailer
C		50.3	SPE Van
D	C	49.4	Police w/o Lights on
D	E	48.6	Trailer + Police w/ Lights on
E		48.0	Trailer + Police w/o Lights on
E		47.9	Police w/ Lights on

The mean speed in the base case (53.7 mph) was significantly higher than the mean speed of all treatments (ranged from 47.9 to 52.0 mph). This indicates that all of the treatments significantly reduced the mean speed of free flowing trucks in the median lane. The presence of the speed display trailer in the work zone reduced the mean speed by 1.7 mph to 52.0 mph. The mean speed in this treatment was significantly higher from the mean speeds in the other treatments. The speed reductions due to the SPE van and Police-without-Lights-on were similar and ranged from 3.4 mph to 4.3 mph. The mean speed in Trailer + Police-with-Lights-on case was similar to that in presence of Police-without-Lights-on (5.1 mph reduction) but it was significantly different from the mean speed in the SPE van case. Finally, the mean speeds in Trailer + Police-without-Lights-on, and Police-with-Lights-on were similar to that in Trailer + Police-with-Lights-on case. These mean speeds (48.0 and 47.9 mph respectively) were significantly lower than the mean speeds in the other cases. These cases resulted in speed reductions that ranged from 5.7 mph to 5.8 mph.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for the free flowing trucks in the median lane are shown Figure 4-13. The cumulative speed distributions for all treatments were shifted towards left compared to the base case. This shift was more pronounced for all law enforcement methods compared to the trailer case. Two statistical tests, Chi Squared and Kolmogorov-Smirnov, were conducted to determine whether these distributions were significantly different. The results of these tests supported the results of the LSD test at the same confidence level.

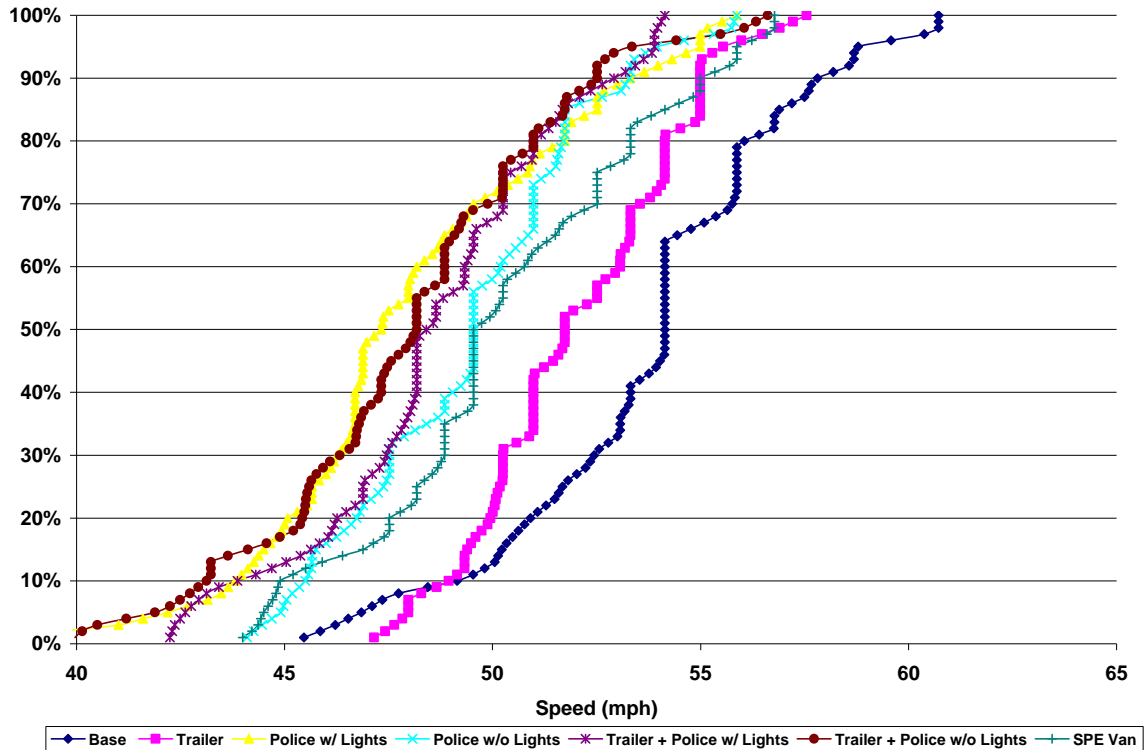


Figure 4-13. Cumulative speed distribution for the free flowing trucks in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-14. The first level indicates traveling at a speed higher than the posted speed limit (55 mph for this site). In the base case 32.5%, and in the trailer case 7.0% exceeded the speed limit. For the treatments that included law enforcement, less than 10% of drivers exceeded the speed limit. The highest speed limit compliance, 100.0%, occurred when the police car with lights on plus a trailer were present in the work zone. In the SPE case, 90.2% of drivers complied with the speed limit.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 27.5% of vehicles exceeded the speed limit by 5 mph. This percentage reduced to 7.0% when the trailer was present in the work zone. This means that all the free flowing trucks in the median lane that exceed the speed limit in the trailer case, exceed it by 5 mph. The law enforcement methods did not reduce this percentage significantly excluding Trailer + Police-with-Lights-on case.

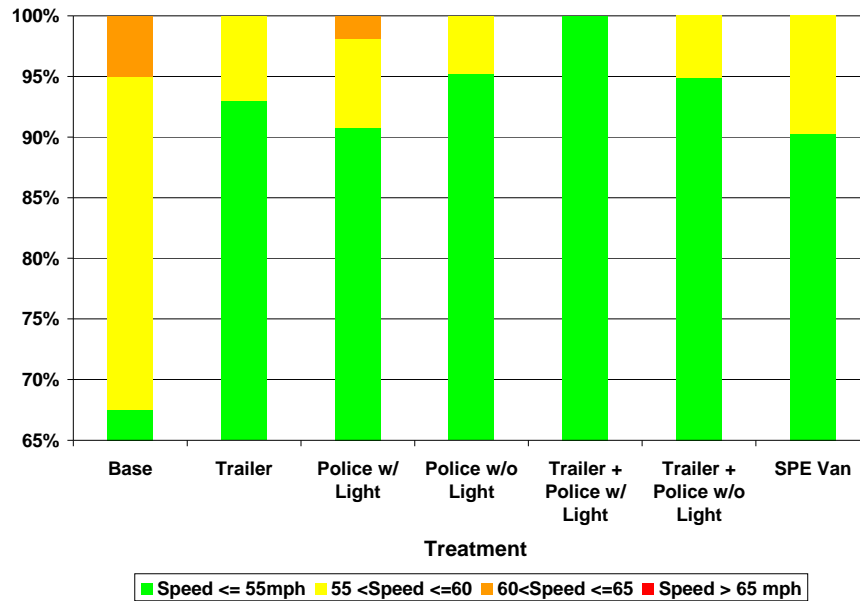


Figure 4-14. The degree of speeding for free flowing trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 10 mph (more than 5 mph and less than or equal to 10 mph). In the base and Police-with-Lights-on cases, the percentages speeding by 10 mph were 5.0% and 1.8%, respectively. For all other treatments, the percentage reduced to zero. The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. None of the vehicles in this case exceeded the speed limit by more than 10 mph.

4.3.2 Dataset 2

Mean Speeds and Speed Reductions

The LSD test results are shown in Table 4-8 for free flowing trucks in the median lane.

Table 4-8. LSD Result for Free Flowing Trucks in Median Lane

	Mean Speed	Treatment
A	53.2	Base
B	51.7	Trailer
C	46.3	Trailer + Police w/o Lights on
C	46.3	SPE Van

The mean speed in the base case (53.2 mph) was significantly higher than the mean speed of all other treatments (ranged from 46.3 to 51.7 mph). The presence of the speed display trailer in the work zone reduced the mean speed by 1.5 mph to 51.7 mph. The law enforcement treatments reduced the means speeds more than the trailer. Both of these treatments reduced the means speed by 6.9 mph to 46.3 mph similarly. This indicates that law enforcement methods similarly and significantly reduced the mean speed of free flowing trucks in the median lane for this data set.

The cumulative speed distribution curves for the free flowing trucks in the median lane are shown Figure 4-15. The cumulative speed distributions for the law enforcement methods are shifted towards the left compared to the base and trailer cases. The results

of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

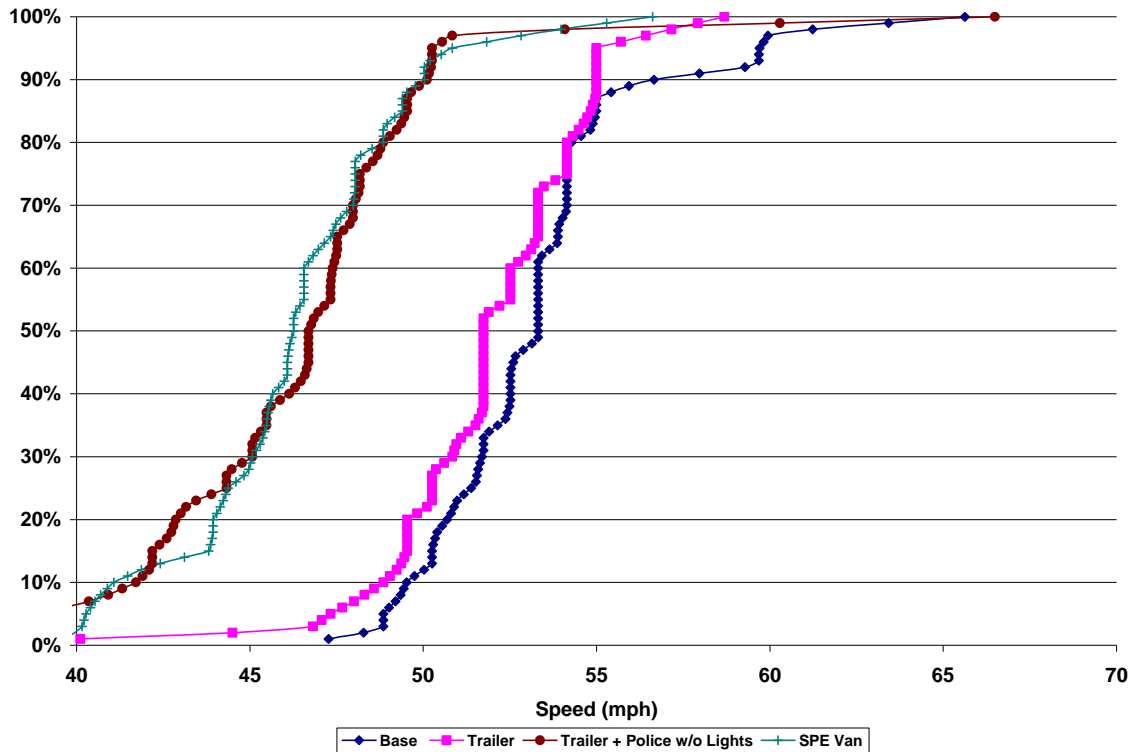


Figure 4-15. Cumulative speed distribution for the free flowing trucks in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-16. In the base case, 12.5% and in the trailer case 4.9% exceeded the speed limit. However, in case of law enforcement, these percentages reduced to 2.4% for both cases (SPE and Trailer + Police-without-Lights-on).

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 10.0% of vehicles exceeded the speed limit by 5 mph. This percentage reduced to 4.9% when the trailer was present in the work zone. The SPE reduced this percentage to 2.4% while the presence of Police-without-Lights-on plus trailer reduced this percentage to 0.0%.

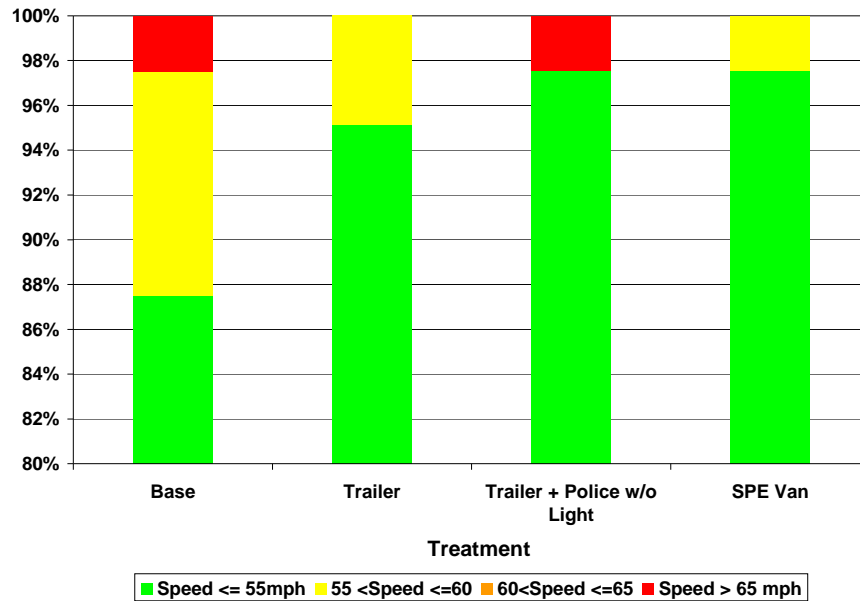


Figure 4-16. The degree of speeding for free flowing trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). None of the free flowing trucks in the median lane exceeded the speed limit by 5-10 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base case 2.5%, and in the trailer + Police-without-Lights-on case 2.4% of drivers exceeded the speed limit. For the other treatments, no one exceeded the speed limit by more than 10 mph.

4.3.3 Dataset 3

Mean Speeds and Speed Reductions

The LSD test results are shown in Table 4-9 for free flowing trucks in the median lane.

Table 4-9. LSD Result for Free Flowing Trucks in Median Lane

	Mean Speed	Treatment
A	57.0	Trailer
A	56.2	Base
B	54.1	Police w/o Lights on
C	52.9	Trailer + Police w/o Lights on
C	52.2	SPE Van

The mean speed in the base case (56.2 mph) was not significantly different than the mean speed in the Trailer case (57.0 mph). However, it was significantly higher than the mean speed of all law enforcement treatments (ranged from 54.1 to 52.2 mph). This indicates that all of the law enforcement treatments significantly reduced the mean speed of free flowing trucks in the median lane. The presence of the speed display trailer in the work zone did not reduce the mean speed. Police-without-Lights-on resulted in significantly lower mean speed compared to the base case. It reduced the mean speed by 2.1 mph to 54.1 mph. The Trailer + Police-without-Lights-on, and SPE treatments

resulted in significantly lower mean speeds compared to the other treatments. The reductions in mean speeds for the above-mentioned two cases were similar and ranged from 3.3 to 4.0 mph, bringing the mean speed to 52.2 to 52.9 mph. This shows that the SPE and traditional law enforcement methods reduce the speed of free flowing trucks in median lane similarly.

The cumulative speed distribution curves for the free flowing trucks in the median lane are shown Figure 4-17. The cumulative speed distributions for all law enforcement treatments were shifted towards left compared to the Base and Trailer cases. This shift was more pronounced for the Trailer + Police-without-Lights-on, and SPE cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

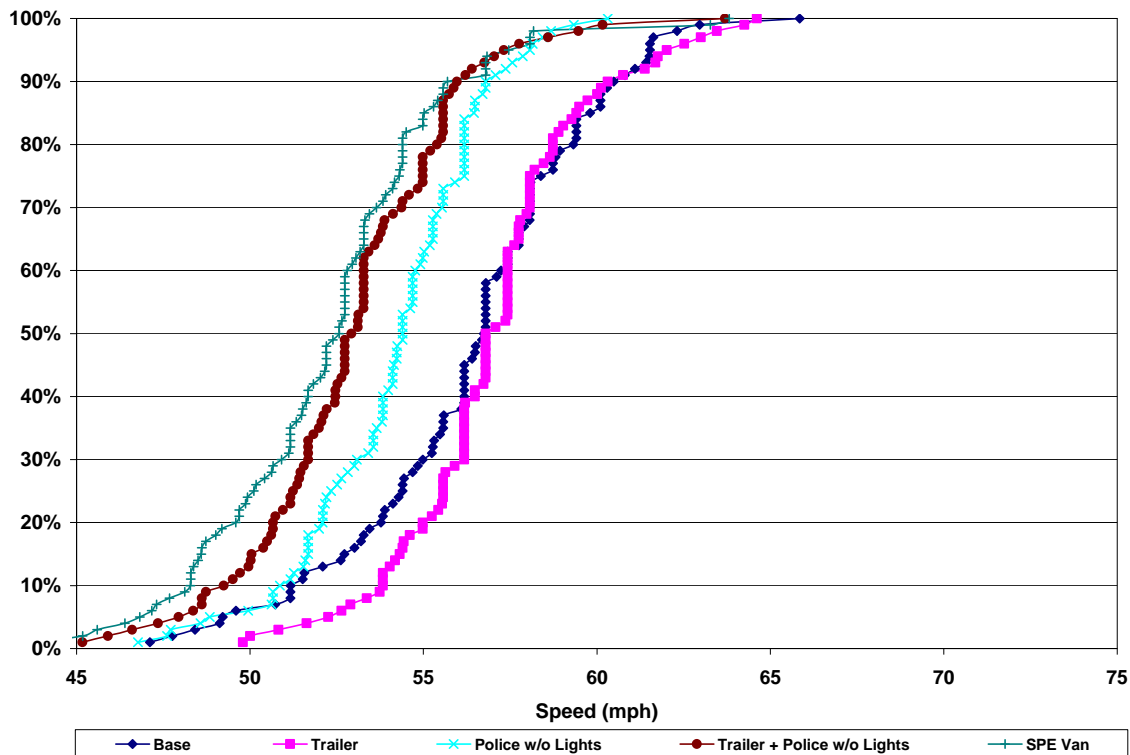


Figure 4-17. Cumulative speed distribution for the free flowing trucks in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-18. In the base case 68.4%, and in the trailer case 79.1% exceeded the speed limit. Police-without-Lights-on treatment reduced this percentage to 36.8%. The other two remaining treatments, Trailer + Police without Lights and SPE, reduced these percentages even more to 21.2% and 15.0% respectively.

In the base case, 53.9% of vehicles exceeded the speed limit by 5 mph. This percentage increased to 67.0% when the trailer was present in the work zone. Police-without-Lights-on treatment reduced this percentage to 35.8%. Trailer + Police-without-Lights-on and SPE treatments were more effective in reducing the percentage of free flowing trucks in the median lane exceeding the speed limit by 5 mph. They reduced this percentage to 20.2% and 13.0% respectively.

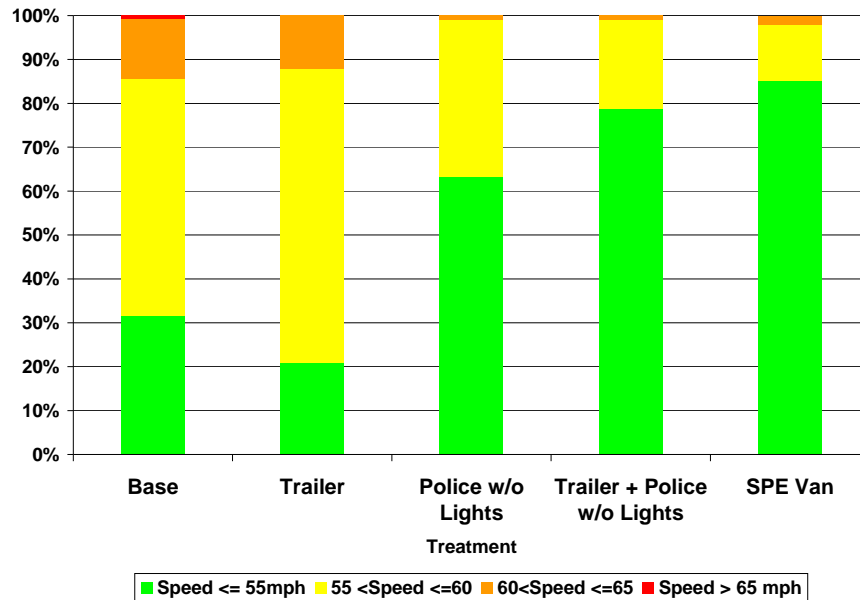


Figure 4-18. The degree of speeding for free flowing trucks in the median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 5-10 mph were 13.7% and 12.1%, respectively. The SPE van reduced it to 2.0% and both other two treatments reduced it to 1.0%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base case, 0.9% of drivers exceeded the speed limit by more than 10 mph. For all other cases, none of the drivers exceeded the speed limit by more than 10 mph.

4.3.4 Summary of Effects of SPE on Free Flowing Trucks on Median Lane

The three data sets showed that SPE was effective in reducing average speed of free flowing trucks on the median lane to 46.3 - 52.2 mph. Speeding was more prevalent in the I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 3.4 - 6.9 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE decreased the percentage of speeding trucks by 10.1% - 53.4 %; thus, it increased the work zone speed limit compliance level to 85.0% - 97.6%.

4.4 FREE FLOWING TRUCKS IN SHOULDER LANE

4.4.1 Dataset 1

Mean Speeds and Speed Reductions

The LSD test was used to compare the mean speeds of free flowing trucks in shoulder lane for different treatments, see Table 4-10.

Table 4-10. LSD Result for Free Flowing Trucks in Shoulder Lane

		Mean Speed	Treatment
	A	50.3	Base
	A	49.5	Trailer
	B	46.3	Police w/o Lights on
C	B	46.1	SPE Van
C	B	45.7	Trailer + Police w/o Lights on
C		45.1	Police w/ Lights on
C		45.0	Trailer + Police w/ Lights on

The mean speeds in the base (50.3 mph) and trailer (49.5) cases were significantly higher than the mean speeds of all law enforcement treatments (ranged from 45.0 to 46.3 mph). This indicates that all of the law enforcement treatments significantly reduced the mean speed of free flowing trucks in the shoulder lane. The mean speeds in Police-without-Lights-on, SPE van, and Trailer + Police-without-Lights-on cases were similar and ranged from 45.7 mph to 46.3 mph. These treatments resulted in similar speed reductions that ranged from 4.0 mph to 4.6 mph. The mean speeds in Police-with-Lights-on and Trailer + Police-with-Lights-on cases (45.1 mph and 45.0 mph respectively) were similar to that in SPE and Trailer + Police-without-Lights-on cases. These treatments resulted in speed reductions that ranged from 5.2 mph to 5.3 mph. The mean speeds in these two treatments were significantly lower than the mean speed in the base, trailer, and Police-without-Lights-on cases.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for the free flowing trucks in the shoulder lane are shown Figure 4-19. The cumulative speed distributions for all law enforcement treatments were shifted towards left compared to the base and trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

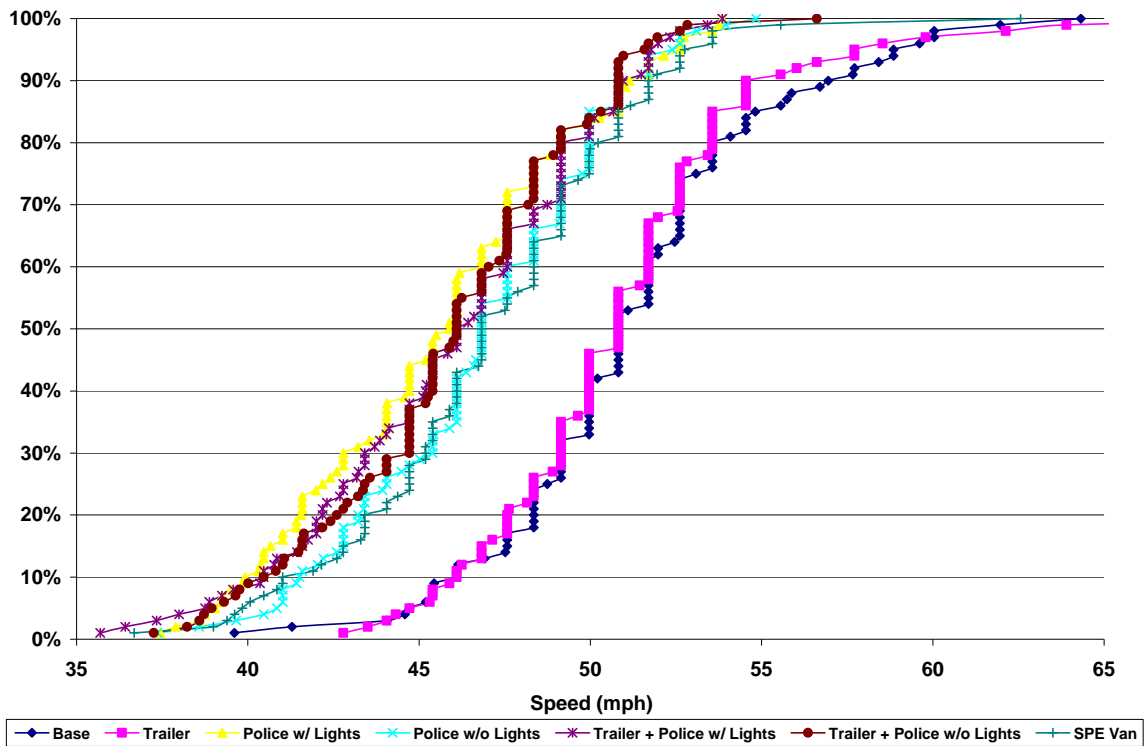


Figure 4-19. Cumulative Speed Distribution for the Free Flowing Trucks in the shoulder lane

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-20. In the base case 2.4%, and in the trailer case 5.6% exceeded the speed limit. For the other treatments, none of the free flowing trucks in the shoulder lane exceeded the speed limit. In addition, none of them exceeded the speed limit more than 5 mph even in the base and trailer cases.

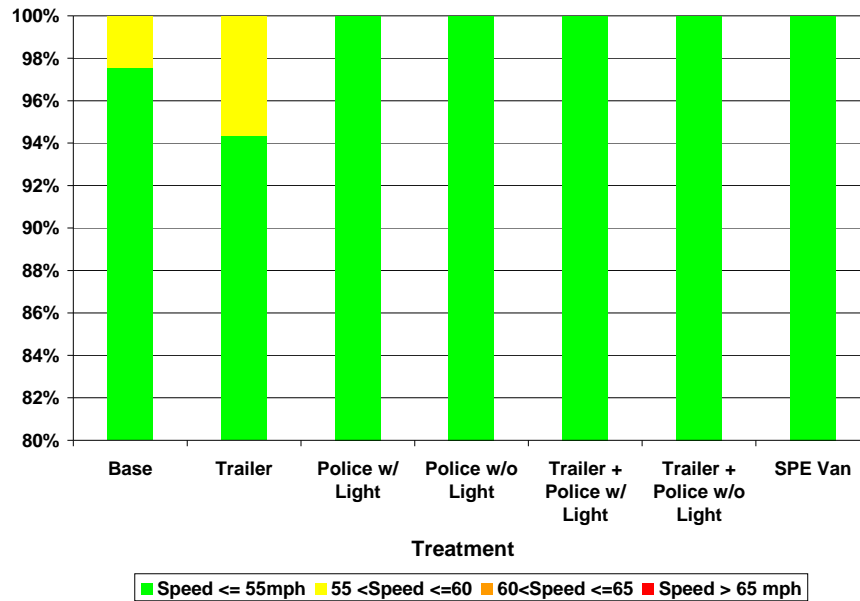


Figure 4-20. The degree of speeding for free flowing trucks in shoulder lane.

4.4.2 Dataset 2

Mean Speeds and Speed Reductions

Table 4-11 shows the results of LSD test at 90 percent significance level for free flowing trucks in shoulder lane.

Table 4-11. LSD Result for Free Flowing Trucks in Shoulder Lane

	Mean Speed	Treatment
A	48.8	Base
A	48.3	Trailer
B	44.8	SPE Van
B	44.0	Trailer + Police w/o Lights on

The mean speed in the base case (48.8 mph) was significantly higher than the mean speed of all law enforcement methods (ranged from 44.0 to 44.8 mph) but, similar to the mean speed in the trailer case. This indicates that all of the law enforcement methods significantly reduced the mean speed of free flowing trucks in the shoulder lane. The mean speeds for the SPE, and Trailer + Police-without-Lights-on treatments were significantly less than the mean speed for the base and the trailer cases. The reductions in mean speeds for the above-mentioned two cases were similar and ranged from 4.0 to 4.4 mph, reducing the mean speed to 44.0 to 44.8 mph. Thus, the SPE and traditional law enforcement methods significantly reduced the mean speeds of the free flowing trucks in the shoulder lane for this dataset.

The cumulative speed distribution curves for the free flowing trucks in the shoulder lane are shown Figure 4-21. The cumulative speed distributions for the law enforcement methods are shifted towards left compared to the base and trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

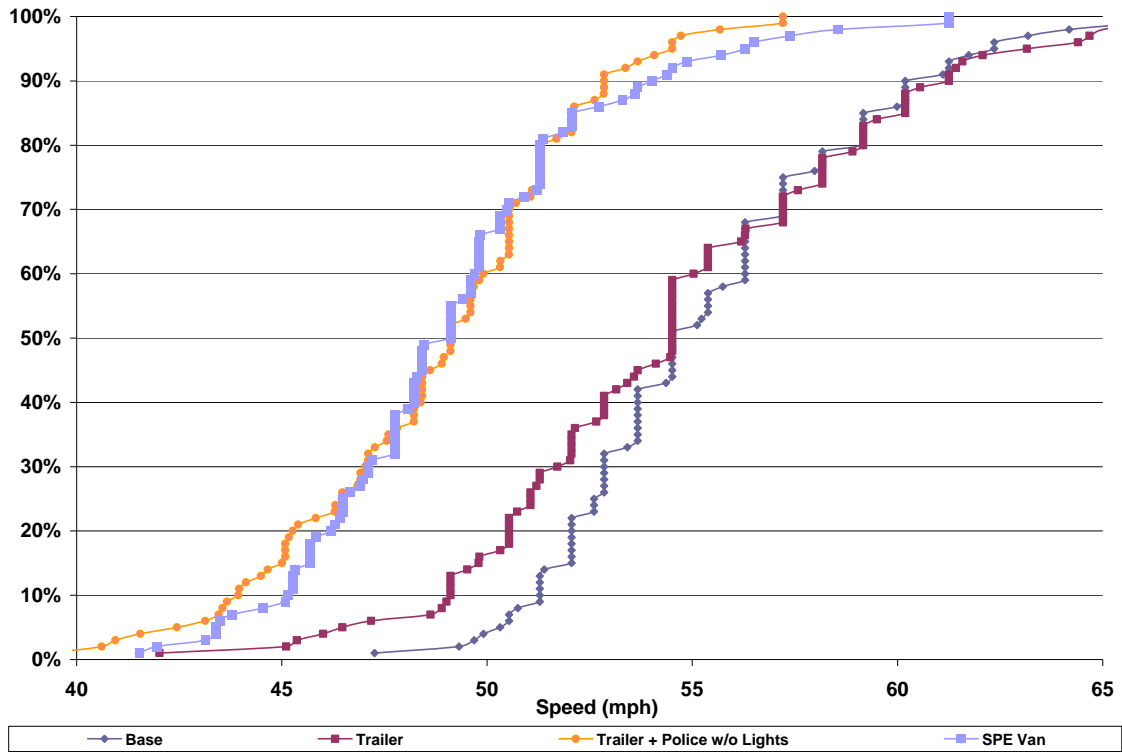


Figure 4-21. Cumulative speed distribution for the free flowing trucks in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-22. Only in the trailer case, 2.3% of the free flowing trucks traveling in the shoulder lane exceeded the speed limit. In all of the other cases, none of the trucks exceeded the speed limit.



Figure 4-22. The degree of speeding for free flowing trucks in shoulder lane.

4.4.3 Dataset 3

Mean Speeds and Speed Reductions

Table 4-12 shows the results of LSD test at 90 percent confidence level for free flowing trucks in shoulder lane.

Table 4-12. LSD Result for Free Flowing Trucks in Shoulder Lane

	Mean Speed	Treatment
A	57.4	Base
B	56.2	Trailer
C	52.6	Police w/o Lights on
C	51.8	Trailer + Police w/o Lights on
C	51.3	SPE Van

The mean speed in the base case (57.4 mph) was significantly higher than the mean speed of all treatments (ranged from 51.3 to 56.2 mph). This indicates that all of the treatments, significantly reduced the mean speed of free flowing trucks in the shoulder lane. The mean speeds for the Police-without-Lights-on, Trailer + Police-without-Lights-on, and SPE treatments were significantly less than the mean speeds for the base case and the trailer. The reductions in mean speeds for the above-mentioned three cases were similar and ranged from 4.8 to 6.1 mph, reducing the mean speeds to 51.3 to 52.6 mph. This shows that the SPE and traditional law enforcement methods reduced the speed of free flowing trucks in shoulder lane similarly.

The cumulative speed distribution curves for the free flowing trucks in the shoulder lane are shown Figure 4-23. The cumulative speed distributions for all law enforcement treatments are shifted towards left compared to the base and trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

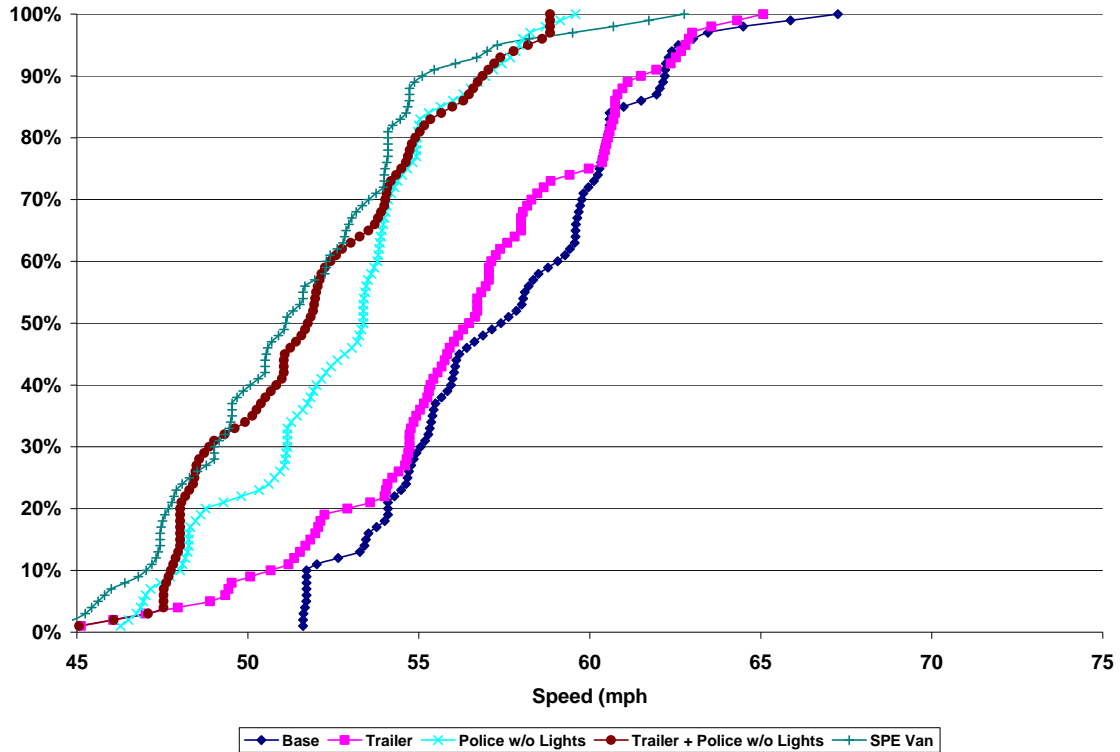


Figure 4-23. Cumulative speed distribution for the free flowing trucks in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure 4-24. In the base case 67.6% and in the trailer case 63.2% exceeded the speed limit. The traditional law enforcement methods reduced it to 17.9% to 19.4% while the SPE reduced it to 11.4%.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the base case, 40.5% of vehicles exceeded the speed limit by 5 mph. This percentage reduced to 36.8% when the trailer was present in the work zone. The traditional law enforcement methods reduced this percentage to 17.9% to 19.4% while the SPE reduced it to 7.0 %.

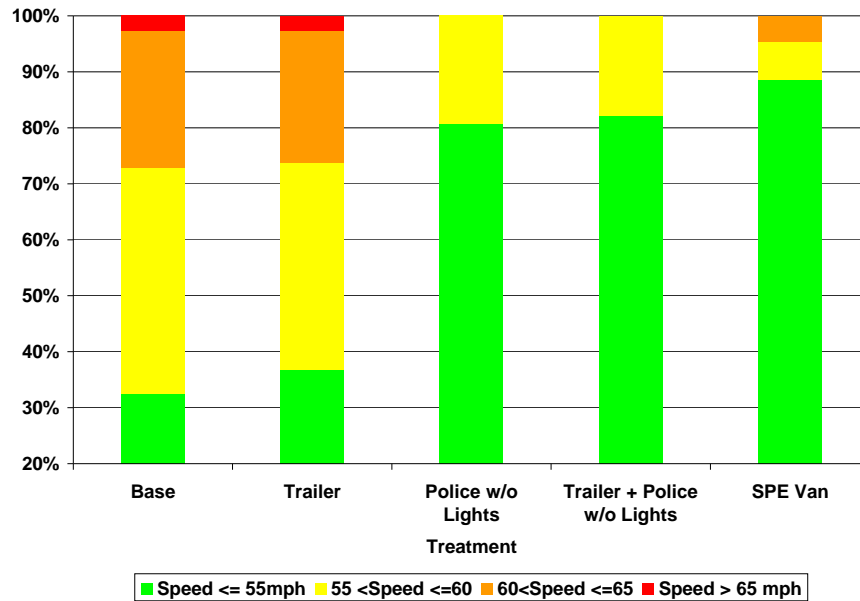


Figure 4-24. The degree of speeding for free flowing trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the base and trailer cases, the percentages speeding by 5-10 mph were 24.3% and 23.7% respectively. The traditional law enforcement treatments reduced this percentage to zero while the SPE had 4.5% of free flowing trucks in the shoulder lane exceeded the speed limit by 5-10 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the base case 2.7%, and in the trailer case, 2.6% of trucks exceeded the speed limit by more than 10 mph and in all the other cases, no one exceeded the speed limit at this extent.

4.4.4 Summary of Effects of SPE on Free Flowing Trucks on Shoulder Lane

The three data sets showed that SPE was effective in reducing average speed of free flowing trucks on the shoulder lane to 44.8 - 51.3 mph. Speeding was more prevalent in the I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 4.0-6.1 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE was very effective in decreasing the percentage of speeding trucks by 0.0% - 56.2% (since no vehicle exceeded the speed limit even in the base case); thus, it increased the work zone speed limit compliance level to 88.6% - 100.0%.

4.5 GENERAL TRAFFIC STREAM

In addition to evaluating the effects of SPE and other speed reduction treatments on the free flowing vehicles, their effects on general traffic stream were studied. The detailed analyses discussions are given in Appendix I, and a brief summary of the findings are presented here, especially for the SPE case.

The speed of general stream traffic is determined by systematically sampling every fifth vehicle regardless of their travel lane. The findings for the general traffic stream supports the finding for the free flowing vehicles but, the speed reductions are slightly lower compared to the free flowing case. This is expected because the free flowing vehicles travel faster than the general stream traffic.

4.5.1 Effects of the SPE on Cars in General Traffic Stream on Median Lane

The three datasets showed that the SPE was effective in reducing the average speed of cars in the general traffic stream (sampled cars) on median lane to 46.8 - 52.6 mph. Similarly, the traditional law enforcement methods were effective and reduced the mean speeds to 46.9 – 53.8 mph. Speeding was more prevalent on I-55 work zone than the I-64 work zone and the SPE reduced the average speeds on I-55 more than on I-64. The speed reductions ranged from 5.1 to 8.0 mph. The speed reductions due to the SPE were similar to the speed reductions due to traditional speed enforcement methods. In all three sites, the SPE was as effective as having a police car with flashing lights off present in the work zone. Furthermore, the SPE reduced the percentage of speeding cars by 31.6-58.4%; thus, it increased the compliance with work zone speed limit to 70.0% - 98.1%.

4.5.2 Effects of the SPE on Cars in General Traffic Stream on Shoulder Lane

The three datasets showed that the SPE reduced the average speed of cars in general traffic stream (sampled cars) on shoulder lane to 42.4 – 51.6 mph. Similarly, the traditional speed enforcement methods reduced the average speeds to 42.8 – 53.3 mph. The speed reductions due to the SPE ranged from 4.3 to 7.7 mph. The speed reductions due to the SPE were similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, the SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE reduced the percentage of speeding cars by 5.7-54.2%; thus, it increased the compliance with work zone speed limit to 70.4% - 100%

4.5.3 Effects of SPE on Trucks in General Traffic Stream on Median Lane

The three datasets showed that the SPE reduced the average speeds of trucks in general traffic stream (sampled trucks) on median lane to 45.4 - 50.4 mph. The traditional law enforcement methods were also effective in reducing the mean speeds as they reduced the mean speeds to 44.0 – 53.8 mph. The SPE reduced the average speed by 3.7-5.7 mph. The speed reductions due to the SPE are similar to the speed reductions due to traditional law enforcement efforts. In all three sites, the SPE was as effective as having a police car with flashing lights off present in the work zone. Furthermore, the SPE reduced the percentage of speeding trucks by 0.0% - 58.5% (since no vehicle exceeded the speed limit); thus, it increased the compliance with work zone speed limit to 92.2% - 100.0%

4.5.4. Effects of SPE on Trucks in General Traffic Stream on Shoulder Lane

The three datasets showed that the SPE was effective in reducing the average speeds of trucks in general traffic stream (sampled trucks) on shoulder lane to 44.2 - 49.7 mph. The traditional law enforcement methods reduced the mean speeds to 43.3 – 53.1 mph. The SPE reduced the mean speeds by 3.9-6.4 mph. The speed reductions due to the SPE are similar to the speed reductions due to traditional law enforcement methods. In all three sites, the SPE was as effective as having a police car with flashing lights off present in the work zone. Furthermore, the SPE reduced the percentage of speeding trucks by 0.0% - 56.1% (since no vehicle exceeded the speed limit); thus, it increased the compliance with work zone speed limit to 95.7% - 100.0%.

4.5.5 Summary

SPE reduced the average speed of cars and trucks in the general traffic stream on median lanes by 5.1-8.0 and by 3.7-5.7 mph, respectively. The reductions for the shoulder lanes were 4.3 - 7.7 mph for cars, and 3.9 - 6.4 mph for trucks. The speed reduction effects of the SPE and traditional law enforcement methods on the general traffic stream are very similar to their effects on the free flowing vehicles. The reductions in the mean speeds and degrees of speeding were slightly lower compared to the free flowing vehicles because the speed of free flowing vehicles was slightly higher than the speed of general traffic stream vehicles.

CHAPTER 5 SPATIAL EFFECTS

The effects of law enforcement presence in work zones were measured at a location still inside the work zone about 1.5 miles downstream (Location C) the treatment location (Location B). The mean speed of free flow and general stream vehicles by lane (median and shoulder) and type of vehicle (cars and trucks) was measured at the downstream location. Also, percentage of drivers exceeding the speed limit by less than 5 mph, 5 to 10 mph, and over 10 mph were obtained and included in the analysis. Differences of speeds and speed limit compliance under normal conditions (without any treatment) and when traditional treatments and SPE were used at the upstream location (Location B) would indicate the presence of spatial effects.

The analysis on the spatial effects at Location C is based on three data sets from the same two work zones where the effects of treatments at Location B were analyzed. General findings, by lane and type of vehicle, are briefly described in this section. The detailed results and analysis are included in Appendix II.

5.1 SPATIAL EFFECTS OF SPE ON FREE FLOWING VEHICLES

5.1.1. Cars on Median Lane

The SPE had spatial effects on two of the three data sets, as it kept the speeds lower at the downstream location by 3.8 mph in dataset 2 and by 2.0 mph in dataset 3. The spatial effect in the SPE was similar to trailer plus Police-without-Lights-on treatment. In addition, the SPE decreased the percentage of speeding drivers by 20.6% in Dataset 2 and 7.1% in dataset 3, bringing the percent speeding to 79.4% and 86.3%, respectively. The SPE also reduced the percentage of excessive speeders (over 10 mph) by 14.2% and 13.3% in datasets 2 and 3, bringing the percent speeding to 18.4% and 14.9%, respectively.

5.1.2 Cars on Shoulder Lane

The SPE had spatial effects on datasets 2 and 3 and reduced the average speed of free flowing cars on the shoulder lane by 3.0 mph and 2.6 mph, respectively. In these two datasets, the spatial effect of SPE was greater than with the traditional speed enforcement methods. The SPE decreased the percentage of speeding drivers by 23.4% in dataset 2 and by 21.3% in dataset 3, bringing the percent speeding to 56% and 72.1%, respectively. Also, the reduction of excessive speeders (over 10 mph) with the SPE was 4.5% in dataset 2 and 15.2% in dataset 3, bringing the percent speeding to 4% and 3.1%, respectively.

5.1.3 Trucks on Median Lane

The SPE had spatial effects on free flowing trucks on the median lane, as their mean speed decreased by 2.6 mph in dataset 1, and by 5.3 mph in dataset 2, bringing mean speed down to 56.8 mph and 54.2 mph, respectively. A smaller decrease of 0.8 mph was also observed in the mean speed in dataset 3. Effects of SPE in the mean speed were greater than those from traditional speed enforcement methods. In addition, the SPE reduced the percentage of speeding drivers by 15.7% in dataset 1, by 41% in dataset 2, and by 7.9% in dataset 3. The percentage of drivers exceeding the speed limit

by more than 10 mph was eliminated by the SPE in the three datasets, from 9.3%, 12.1%, and 1% in the base case.

5.1.4 Trucks on Shoulder Lane

The SPE had spatial effects on free flowing trucks on the shoulder lane, as their mean speed was reduced by 0.9 mph and 4.8 mph in datasets 1 and 2, to 56.4 mph and 53 mph, respectively. It reduced the mean speed by 0.9 mph in dataset 3 on the shoulder lane, and the resulting speed was 55.6 mph. The speed reductions due to SPE were greater than the speed reductions due to traditional speed enforcement methods. The percentage of speeding drivers was reduced in the SPE by 4.2% in dataset 1 and by 48.3% in dataset 2, down to 28.8% and 35.9%, respectively.

5.2 SPATIAL EFFECTS OF SPE ON THE GENERAL TRAFFIC STREAM

5.2.1 Cars on Median Lane

The average speed of cars in the general traffic stream on the median lane had 2.9 mph and 1.6 mph spatial effects on datasets 2 and 3, bringing the mean speeds to 59.3 mph and 58.3 mph, respectively. Speed reductions in the SPE case were greater than those from traditional speed enforcement methods. The percentage of speeding drivers was reduced in the SPE case by 2.9% in dataset 1, by 22.2% in dataset 2, and by 10.3% in dataset 3, down to 83%, 75%, and 77.9%, respectively. The percentage of drivers speeding by more than 10 mph was also reduced in the SPE case by 8.5% in dataset 2, and by 10.4% in dataset 3, down to 10.4% and 9.3%.

5.2.2 Cars on Shoulder Lane

The SPE had 2.7 mph and 1.1 mph spatial effects in datasets 2 and 3, where the average speed of cars in general traffic stream on shoulder lane was reduced to 54 mph and 57.3 mph, respectively. The speed reductions in the SPE case were greater than traditional speed enforcement methods. The SPE increased the speed limit compliance, as it decreased the percentage of speeding drivers by 4.3% in dataset 1, 28.6% in dataset 2, and 9.6% in dataset 3, down to 75.0%, 38.6%, and 73.8%, respectively.

5.2.3 Trucks on Median Lane

For the three datasets, the SPE had some spatial effect on the average speed of the trucks in general traffic stream on median lane. Reductions in average speed were 1.9 mph in dataset 1, 3.3 mph in dataset 2, and 0.9 mph in dataset 3, with mean speeds of 56.7 mph, 56.2 mph, and 55.5 mph, respectively. The SPE also decreased the percentage of speeding drivers by 7.5% in dataset 1, by 23.5% in dataset 2, and by 10.4% in dataset 3, down to 76.7%, 61.8%, and 57.8%, respectively.

5.2.4 Trucks on Shoulder Lane

For the three datasets, SPE had spatial effects as it decreased the mean speed of the trucks in the general traffic stream on shoulder by 1.7 mph in dataset 1, by 3.2 mph in Dataset 2, and by 1.8 mph in dataset 3, down to 55.3 mph, 52.8 mph, and 55.5

mph, respectively. The speed reductions in the SPE case were greater than traditional speed enforcement methods. The percentage of speeding drivers also decreased in the three datasets, with reductions of 7.8% in dataset 1, 36.1% in dataset 2, and 16.1 % in dataset 3, down to 64.3%, 28.6%, and 55.4%, respectively.

CHAPTER 6 HALO EFFECTS

Previous research (Benekohal, et al. 1992) reported that police presence had a lasting effect on speeds of heavy vehicles even after the police departure from the work zone (halo effect). In this study, the possibility of halo effect due to police presence or SPE was investigated using two sets of data from two work zones. The data sets were collected in the p.m. off-peak hours on I-64 and I-55 work zones. However, the I-64 a.m. dataset did not provide enough time to study the halo effects because SPE van and police presence treatments lasted till 11:30 a.m., and that left very little time before the lunch hour traffic. Therefore, the a.m. dataset was not utilized to evaluate the halo effect.

To determine if any halo effects existed, nearly an hour of data was collected after the departure of the police patrol vehicle or the SPE van from the work zones. First, the temporal variation of speeds is presented. The speed data was grouped into five-minute intervals, and average speeds of cars and heavy vehicles for each interval were computed. Then, the results of statistical comparisons (LSD tests) of speeds when the police or SPE was present to the speeds after their departures as well as to the speeds in the base case are discussed. It should be noted that this analysis was done for the treatment location.

The drivers who were free to choose their speeds (free flowing) are considered in this analysis. If there is no halo effect on free flowing vehicles, there should not be halo effects on the general stream traffic. Therefore, the speeds of free flowing vehicles were examined first. If there is a halo effect on free flowing vehicles, then the speed of the general traffic stream is examined to determine the halo effects on the latter group.

6.1 SPE HALO EFFECT ON I-55

Figure 6-1 shows the variation of the average speeds of cars and heavy vehicles (5 minute averages) when SPE was present and after its departure from the I-55 work zone. It clearly shows a significant increase in the speeds of both cars and heavy vehicles immediately after the departure of the SPE van from the work zone. It can be observed that the average speed of cars increased from around 55 mph while the SPE van was present to over 60 mph after its departure. Similarly, the average speed of heavy vehicles increased from lower 50s to upper 50s after the departure of SPE van.

It should be noted that the mere speed increase after the SPE is gone does not mean that there is no halo effect. In fact, it is expected that the speed will increase when drivers do not see the SPE van, but the question is by how much. If it increased to the level it was in the base condition then there is no halo effect. On the other hand, if the speed is increased but is significantly less than the base case, then there is a halo effect. The statistical comparison of average speed after SPE left to the average speed of the base data is carried out to determine the halo effects.

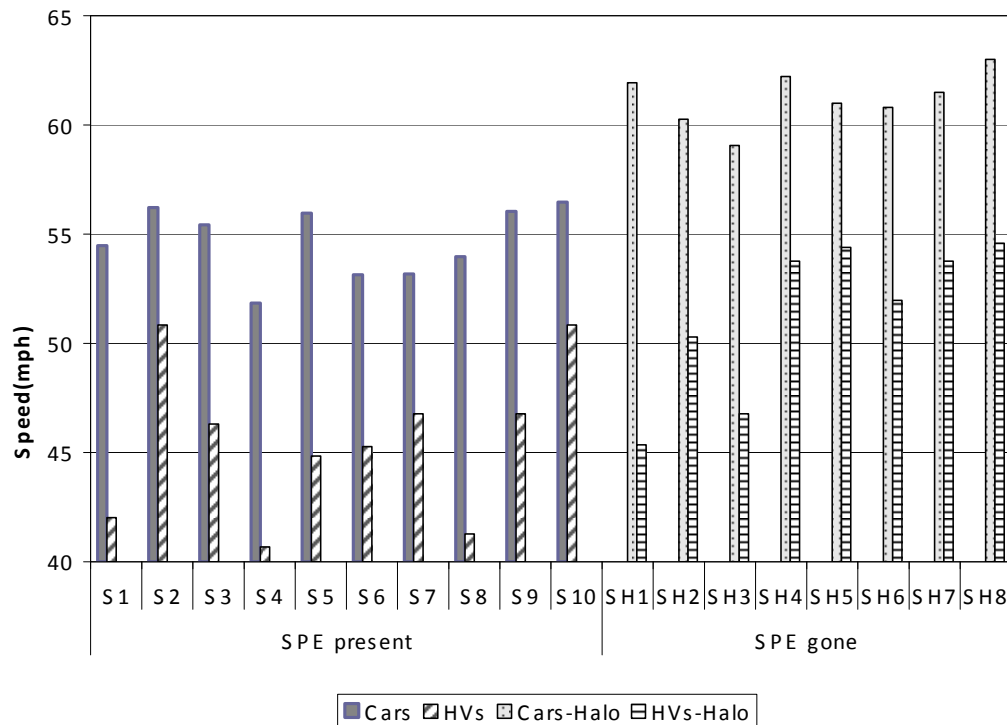


Figure 6-1. Effects of SPE on temporal variation of speed in I-55 work zone.

In addition to visual display of the average speeds for five-minute intervals, LSD tests were performed to compare the average speeds for the entire time periods before and after the departure of SPE to the average speeds of base case. A separate LSD test was performed for cars and heavy vehicles, and for median and shoulder lanes. The LSD results with 90% confidence level are listed in Table 6-1. For free flowing cars, the average speed on the median lane is not significantly lower after the police vehicle was gone, but it is lower by 1.2 mph on the shoulder lane compared to the average speed in the base case. For heavy vehicles, the differences are not statistically significant on median or shoulder lanes. The results indicate that SPE had small amount of halo effects on cars traveling on shoulder lane. The amount was 1.3 mph that may be considered practically insignificant, though statically significant. However, no halo effect exists for cars traveling on the median lane or heavy vehicles traveling on either lane of the I-55 work zone.

Table 6-1. LSD Results for Comparison of Speeds With and Without SPE (I-55 work zone)

Grouping	Median			Treatment	Grouping	Shoulder		
	Mean	N				Mean	N	Treatment
Cars								
A	63.7	106		Base case	A	61.5	204	Base case
A	63.5	76		SPE Gone	B	60.2	156	SPE Gone
B	56.5	80		SPE Present	C	53.7	174	SPE Present
Heavy Vehicles								
A	57.4	60		SPE Gone	A	57.7	22	SPE Gone
A	56.2	119		Base case	A	57.0	40	Base case
B	52.5	80		SPE Present	B	50.7	23	SPE Present

6.2 SPE HALO ON I-64

The average speeds for each five-minute intervals are shown in Figure 6-2. It can be seen that the speeds increased after the departure of the SPE van from the work zone.

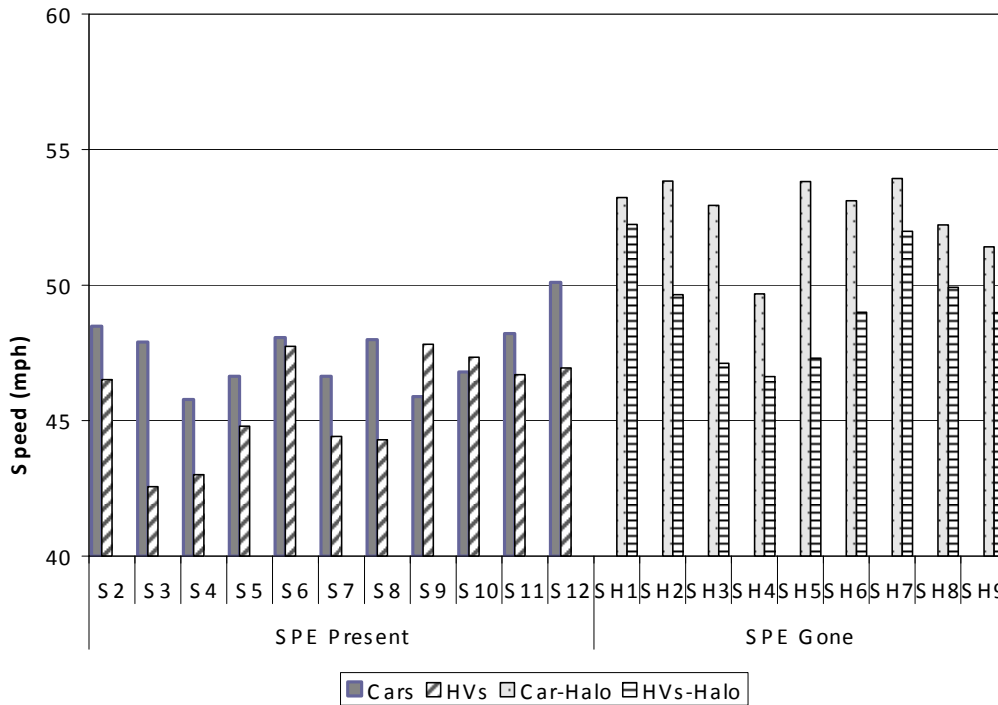


Figure 6-2. Effects of SPE on temporal variation of speed in I-64 work zone.

Table 6-2 presents the LSD test results for the comparison of average speeds for the entire time periods before and after the SPE was gone to the average speed in Base case, with 90% confidence level. It is obvious that the average speeds went up after the SPE was gone for cars on either median lane or shoulder lane. For heavy vehicle, the average speed also went up after the SPE was gone. However, the average speeds are still significantly lower than the average speed of the Base case. It indicates that there was a halo effect on heavy vehicles traveling either median or shoulder lanes on I-64 work zone. The halo effect on trucks was 1.8 mph on shoulder lane and 2.7 mph on the median lane.

Table 6-2. LSD Results for comparison of speeds with and without SPE (I-64 work zone)

Grouping	Median			Shoulder			
	Mean	N	Treat	Grouping	Mean	N	Treat
Cars							
A	55.5	133	Base case	A	50.5	87	SPE Gone
A	54.8	106	SPE Gone	A	50.4	102	Base case
B	49.0	126	SPE Present	B	44.9	94	SPE Present
Heavy Vehicles							
A	53.6	20	Base case	A	49.1	32	Base case
B	50.9	22	SPE Gone	B	47.3	30	SPE Gone
C	47.2	16	SPE Present	C	44.7	34	SPE Present

6.3 POLICE HALO ON I-55

For the I-55 site, there was only 20 minutes data available to determine the halo effects of police because another police car that was not assigned to this work zone had stopped a vehicle in the work zone

Figure 6-3 and Figure 6-4 show the effect of Police presence on the temporal variation of speeds for I-55 and I-64 work zones, respectively. It can be observed from Figures 3 and 4 that the average speeds of cars and heavy vehicles increased significantly soon after the departure of the police from the work zone. In I-55 dataset, the average speed of cars increased from around 55 mph to over 60 mph and that of heavy vehicles increased from lower 50s to mostly upper 50s. This indicates that the speeds went up after the Police presence was gone.

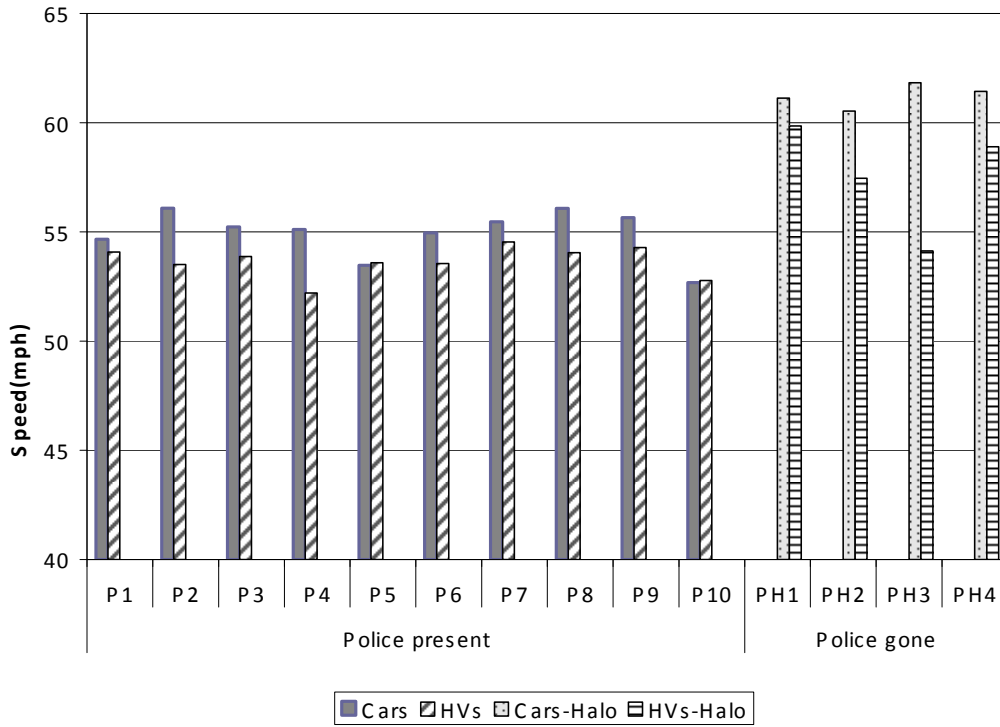


Figure 6-3. Effects of police on temporal variation of speed in I-55 work zone.

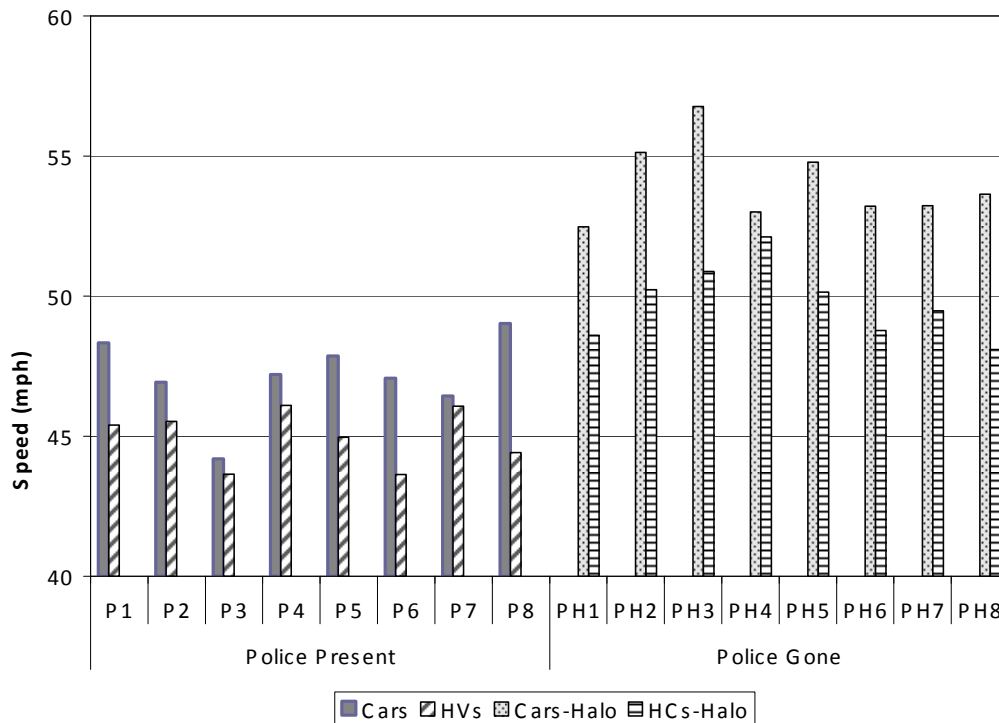


Figure 6-4. Effects of Police on Temporal Variation of Speed in I-64 work zone.

Table 6-3 and Table 6-4 present the LSD test results for the comparison of average speed for the entire time periods before and after the police was gone to the average speeds in the Base case. It is obvious that average speed went up to the same level it was in the Base case after the police was gone for either cars or heavy vehicles on both median and shoulder lanes. This indicates that there is no halo effect of police presence on either cars or heavy vehicles in both I-55PM and I-64PM Data Sets.

Table 6-3. LSD Results for Comparison of Speeds with and Without Police (I-55 work zone)

Grouping	Median			Grouping	Shoulder		
	Mean	N	Treatment		Mean	N	Treatment
Cars							
A	63.7	106	Base case	A	61.5	204	Base case
A	62.6	30	Police Gone	A	60.6	59	Police Gone
B	55.7	81	Police present	B	54.7	175	Police present
Heavy Vehicles							
A	57.7	22	Police Gone	A	58.8	12	Police Gone
B	56.2	119	Base case	A	57.0	40	Base case
C	54.0	82	Police present	B	52.3	21	Police present

Table 6-4. LSD Results for Comparison of Speeds With and Without Police (I-64 work zone)

Grouping	Median			Grouping	Shoulder		
	Mean	N	Treatment		Mean	N	Treatment
Cars							
A	56.2	124	Police Gone	A	51.2	95	Police Gone
A	55.5	133	Base case	A	50.4	102	Base case
B	48.7	93	Police Presence	B	45.8	90	Police Presence
Heavy Vehicles							
A	53.6	20	Base case	A	49.6	34	Police Gone
A	51.6	10	Police Gone	A	49.1	32	Base case
B	45.5	25	Police Presence	B	44.7	34	Police Presence

The LSD test results indicate that police presence had no halo effects on cars or heavy vehicles on I-64 or I-55 work zones.

6.4 SUMMARY OF HALO EFFECTS

Police presence had no halo effect on free flowing vehicles (This was true for free flowing cars and heavy vehicles on both work zones). On the other hand, SPE had 1.8-2.7 mph halo effects on free flowing heavy vehicles on I-64 work zone. SPE had no halo effects on free flowing heavy vehicles on I-55 work zone. SPE had no halo effects on free flowing cars on either work zones, except on free flowing cars on shoulder on I-55 work zone, which was 1.3 mph.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The effects of the SPE on mean speed and degree of speeding were compared to the effects of other speed management methods with and without police presence in work zones. Three datasets were collected in two Interstate highway work zones. The effects were studied at the location the treatment was implemented and at another location about 1.5 miles downstream in the work zone (spatial effects). In addition, the halo effects of police presence and SPE after leaving the work zone (temporal effects) were evaluated.

7.1.1 Effects at Treatment Location

The main findings at the location the treatments were implemented are presented below for cars and trucks in free flow condition and in the general traffic stream.

Free Flowing Cars

The SPE significantly reduced the speed of free flowing cars at the treatment location in all three datasets. It reduced the average speed of free flowing cars in the median lane by 6.3 mph - 7.9 mph and brought the speeds down to 49.1 mph - 56.0 mph. For the shoulder lane, the reductions were 4.1 mph - 7.7 mph, and the mean speeds were lowered to 44.8 mph - 53.7 mph. In addition, the SPE reduced speeding drivers in the median lane by 40% - 51% so that only 7% - 57% were still speeding. In the shoulder lane, the SPE reduced speeding drivers by 7% - 51%, so that only 0.0% - 40% were still speeding. The SPE was as effective in reducing speed as having a police car with its flashing lights off present in the work zone.

Free Flowing Trucks

The SPE significantly reduced the speed of free flowing trucks at the treatment location in all three datasets. It reduced the average speed of free flowing trucks in the median lane by 3.4 mph - 6.9 mph and brought the speeds down to 46.3 mph - 52.2 mph. For the shoulder lane, the reductions were 4.0 mph - 6.1 mph, and the mean speeds were lowered to 44.8 mph - 51.3 mph. In addition, the SPE reduced speeding drivers by 10% - 53% in the median lane so that only 2% - 15% were still speeding. In the shoulder lane, speeding drivers were reduced by 0% - 56% so that only 0.0% - 11% were still speeding. The SPE was as effective in reducing speed as having a police car with its flashing lights off present in the work zone.

Cars in General Traffic Stream

The SPE significantly reduced the speed of cars in the general traffic stream at the treatment location in all three datasets. It reduced the average speed of cars in the general traffic stream on the median lane by 5.1 mph - 8.0 mph and brought the speeds down to 46.8 mph - 52.6 mph. For the shoulder lane, the reductions were 4.3 mph - 7.7 mph, and the mean speeds were lowered to 42.4 mph - 51.6 mph. In addition, the SPE reduced speeding drivers by 32% - 58% so that only 2% - 30% were still speeding in the median lane. In the shoulder lane, the SPE reduced speeding drivers by 6% - 54% so

that only 0% - 30% were still speeding. The SPE was as effective in reducing speed as having a police car with its flashing lights off present in the work zone.

Trucks in General Traffic Stream

The SPE significantly reduced the speed of trucks in the general traffic stream at the treatment location in all three datasets. It reduced the average speed of trucks in the general traffic stream on the median lane by 3.7 mph - 5.7 mph and brought the speeds down to 45.4 mph - 50.4 mph. For the shoulder lane, the reductions were 3.9 mph - 6.4 mph and the mean speeds were lowered to 44.2 mph - 49.4 mph. In addition, the SPE reduced speeding drivers by 0% - 58% so that only 0% - 8% were still speeding in the median lane. On the shoulder lane, the SPE reduced speeding drivers by 0% - 56% so that only 0% - 4% were still speeding. The SPE was as effective in reducing speed as having a police car with flashing lights off present in the work zone for Datasets 1 and 2.

7.1.2 Spatial Effects

Similar to the previous section the conclusions are presented first for the free flowing vehicles followed by the general traffic stream.

Free Flowing Cars

The SPE had spatial effects on free flowing cars in the median lane, as it reduced the mean speeds by 3.8 mph in Dataset 2, and by 2.0 mph in Dataset 3, resulting in mean speeds of 59.7 mph and 60.5 mph, respectively. On the shoulder lane, it reduced the speed by 3.0 mph for Dataset 2 and by 2.6 mph for Dataset 3, resulting in mean speeds of 55.6 mph and 57.2 mph, respectively. In addition, the SPE decreased speeding drivers in the median lane by 21% in Dataset 2 and 7% in Dataset 3 so that 79% and 86% were still speeding, respectively. In the shoulder lane, the SPE reduced speeding drivers by 23% for Dataset 2 and 21% for Dataset 3, so that 56% and 72% were still speeding, respectively. SPE had no significant spatial effect on free flowing cars in Dataset 1.

Free Flowing Trucks

The SPE had spatial effects on free flowing trucks on median lane, as it reduced the mean speed by 2.6 mph in Dataset 1, and by 5.3 mph in Dataset 2, resulting in speeds of 56.8 mph and 54.2 mph, respectively. A smaller decrease of 0.8 mph in the mean speed was observed for Dataset 3 on the median lane, and the resulting speed was 55.4 mph. On the shoulder lane, it reduced the mean speeds by 0.9 and 4.8 for Dataset 1 and Dataset 2, respectively, and brought the speeds down to 56.4 mph and 53 mph. The SPE reduced the mean speed by 0.9 mph in Dataset 3 on the shoulder lane, and the resulting speed was 55.6 mph. In addition, the SPE reduced speeding drivers in the median lane by 16% in Dataset 1, by 41% in Dataset 2, and by 8% in Dataset 3 so that 75%, 47%, and 54% were still speeding, respectively. On the shoulder lane, the SPE reduced the speeding drivers by 4% for Dataset 1 and by 44% for Dataset 2 so that 71% and 36%, respectively, were still speeding.

Cars in General Traffic Stream

The SPE had spatial effects on cars in the general traffic stream in two of the three datasets. It reduced the average speeds of cars on the median lane by 2.9 mph and 1.6 mph in Datasets 2 and 3 and brought the mean speeds down to 59.3 mph and 58.3 mph, respectively. In the shoulder lane, the SPE reduced the mean speeds by 2.7 mph and 1.1 mph in Datasets 2 and 3, respectively, and brought down the speeds to 54

mph and 57.3 mph. In addition, the SPE reduced the speeding drivers in the median lane by 22% in Dataset 2 and by 10% in Dataset 3 so that 75% and 77.9%, respectively, were still speeding. In the shoulder lane, the SPE reduced the speeding drivers by 29% in Dataset 2 and 10% in Dataset 3 so that 39% and 74%, respectively, were still speeding.

Trucks in General Traffic Stream

In all three datasets, the SPE had spatial effects on speed of trucks in the general traffic stream in median and shoulder lanes. It reduced the speed by 1.9 mph in Dataset 1, 3.3 mph in Dataset 2, and 0.9 mph in Dataset 3, and that brought down the mean speeds to 56.7 mph, 56.2 mph, and 55.5 mph, respectively. In the shoulder lane, it reduced the speeds by 1.7 mph in Dataset 1, by 3.2 mph in Dataset 2, and by 1.8 mph in Dataset 3, and that brought down the speeds to 55.3 mph, 52.8 mph, and 55.5 mph, respectively. The SPE also decreased the speeding drivers in the median lane by 8% in Dataset 1, by 24% in Dataset 2, and by 10% in Dataset 3 so that 77%, 62%, and 58%, respectively, were still speeding. On the shoulder lane, the SPE reduced speeding drivers by 8% in Dataset 1, by 36% in Dataset 2, and by 16% in Dataset 3 so that only 64%, 29%, and 55%, respectively, were still speeding.

7.1.3 Halo Effects of Police Presence and SPE

Police presence had no halo effect on free flowing vehicles. (This was true for free flowing cars and heavy vehicles in both work zones.) On the other hand, SPE had 1.8 - 2.7 mph halo effects on free flowing heavy vehicles in the I-64 work zone and no halo effects on free flowing heavy vehicles in the I-55 work zone. SPE had no halo effects on free flowing cars in either work zone, except on free flowing cars in the shoulder lane in the I-55 work zone, which was a 1.3 mph reduction in the average speed.

7.2 RECOMMENDATIONS FOR FUTURE RESEARCH

The SPE van is several times more expensive than a similar van without the photo enforcement equipment, and it may not be feasible to put a SPE van in all work zones. Therefore, to increase compliance with the speed limit, it is recommended to study the effectiveness of swapping regular vans with the SPE vans to cover a larger number of work zones.

The spatial effects of SPE may be improved by using another law enforcement officer in a work zone in conjunction with the SPE. It is recommended to conduct a study to determine the most effective strategy that combines SPE and traditional law enforcement methods.

The effects of the SPE on individual vehicles as they travel through the work zone would reveal how different drivers react to the SPE. A study to determine the effects on each vehicle by matching their speeds at several locations is recommended.

Effects of the SPE on the traffic flow characteristic in the work zone is not known. The SPE may have some effects on the platooning and headway characteristics of vehicles. Conducting research to study these effects is recommended.

It is important to reduce the speed of vehicles close to the workers. A study should be conducted to identify the optimal location where SPE should be placed to achieve the desired speed reduction where it is most needed.

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**APPENDIX I: EFFECTS AT TREATMENT LOCATION FOR
GENERAL TRAFFIC STREAM**

GENERAL STREAM

I.1. CARS

I.1.1. Median Lane

I.1.1.a. Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test was used to determine whether the mean speeds in different treatments were similar. Table I-1 shows the results of the LSD test for cars in the traffic stream (sampled cars) in the median lane. In column one of the table, each treatment is marked with a letter. For the treatments marked with the same letter, mean speeds are not significantly different with 90% confidence level. If treatments are marked with different letters, the mean speeds are significantly different.

Table I-1. LSD result for Sampled Cars in Median Lane

	Mean Speed	Treatment
A	54.9	Base
B	53.3	Trailer
C	49.8	SPE Van
C	49.4	Police w/o Lights on
C	49.4	Police w/ Lights on
D	47.9	Trailer + Police w/ Lights on
D	47.2	Trailer + Police w/o Lights on

The mean speed in the base case (54.9 mph) was significantly higher than the mean speed of all treatments (ranged from 47.2 to 53.3 mph). This indicates that all of the treatments significantly reduced the mean speed of the cars in the traffic stream traveling in the median lane. The presence of the speed display trailer in the work zone reduced the mean speed by 1.6 mph to 53.3 mph. However, the mean speeds for the SPE van, Police-without-Lights-on, and Police-with-Lights-on treatments were significantly less than the mean speed for the Base and the Trailer cases. The reductions in mean speed for the above-mentioned three cases were similar and ranged from 5.1 to 5.5 mph, reducing the mean speed to 49.4 to 49.8 mph. The mean speeds in the Trailer + Police with and without Lights on treatments (47.9 mph and 47.2 mph respectively) were significantly lower than all of the other treatments. This indicated that the presence of the police car in the work zone with the speed display sign resulted in the lowest mean speed. In the other word, the Trailer + Police treatment had the most reduction in mean speed among the cars in the traffic stream traveling in the median lane, for this data set. These treatments resulted in reduction ranged from 7 mph to 7.7 mph while the SPE van resulted in 5.1 mph speed reduction for the cars in general traffic stream (sampled cars) in median lane. This may be due to the threat level that the drivers perceived with the police car compared to the SPE.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for the cars in traffic stream traveling in the median lane are shown in Figure I-1. The cumulative speed distributions for all treatments were shifted towards the left compared to the base case. This shift was more pronounced for the SPE, Police-without-Lights-on, and Police-with-Lights-on cases compared to the Trailer case. The Trailer + Police-with-Lights-on and Trailer + Police-without-Lights-on cases resulted in the highest shift towards the left. Two statistical tests, Chi Squared and Kolmogorov-Smirnov, were

conducted to determine whether these distributions were significantly different. The results of these tests supported the results of the LSD test at the same confidence level.

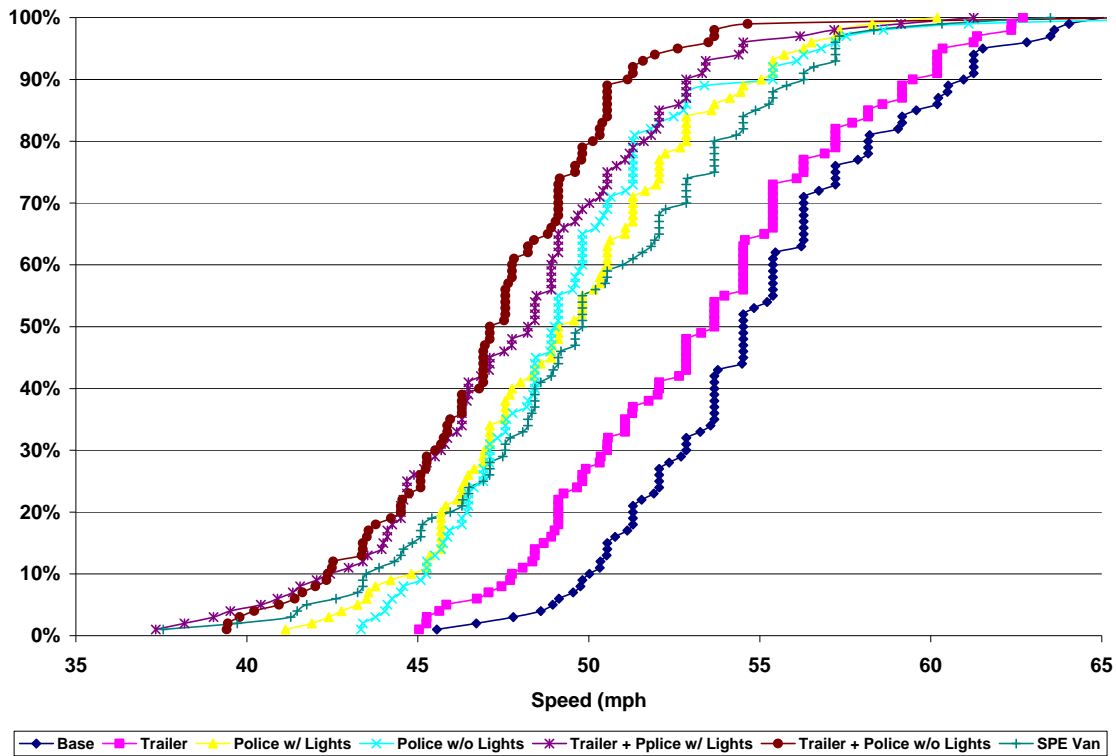


Figure I- 1. Cumulative speed distribution for the sampled cars in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-2. The first level indicates traveling at a speed higher than the posted speed limit (55 mph for this site). In the Base case 47.1% and in the Trailer case 35.7% exceeded the speed limit. For the treatments that included law enforcement, less than 16% of drivers exceeded the speed limit. The highest speed limit compliance, 98.2%, occurred in the Trailer + Police-without-Lights-on treatment. In the SPE case 84.5% of drivers complied with the speed limit. This finding supports the results of the mean speed reductions.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the Base case, 31.8% of vehicles exceeded the speed limit by 5 mph. This percentage was 25.5% when the Trailer was present in the work zone. The law enforcement methods reduced the percentage to less than 14%. The presence of Police-without-Lights-on plus Trailer reduced this percentage to 0.0% while SPE van reduced it to 13.4%. This finding is in line with the results of mean speed reduction.

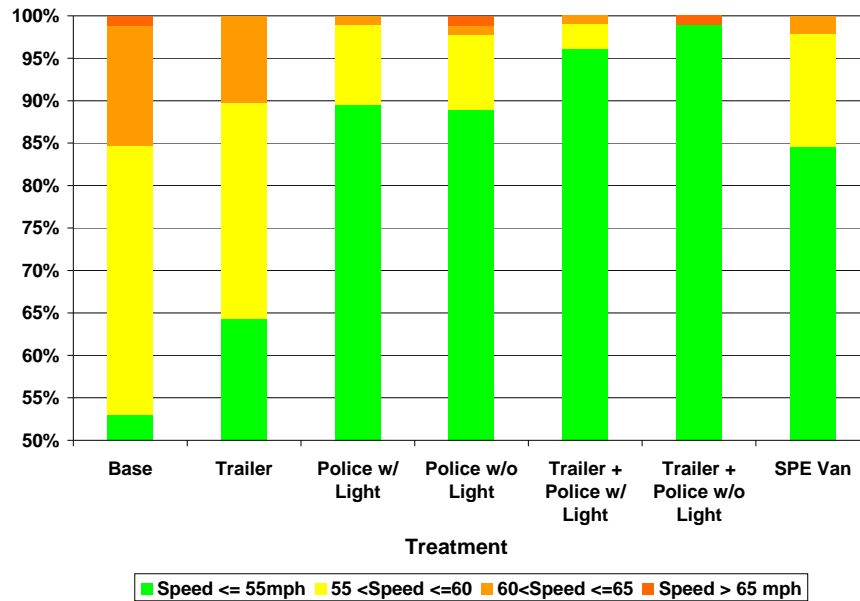


Figure I-2. The degree of speeding for sampled cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Base and Trailer cases, the percentages speeding by 5-10 mph were 14.1% and 10.2%, respectively. For all other treatments, this percentage reduced to less than 2.1%. The Trailer + Police-without-Lights-on treatment reduced this percentage to zero while the SPE van reduced it to 2.1%. The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer + Police-without-Lights-on cases, 1.2% and 1.1% of drivers exceed the speed limit by more than 10 mph respectively. For all other cases none of the Cars in general traffic stream (Sampled cars) in the median lane exceeded the speed limit by more than 10 mph for this data set.

I.1.1.b Dataset 2

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-2 shows the results of LSD test for cars in the traffic stream in median lane for Dataset 2.

Table I- 2. LSD Result for Sampled Cars in Median Lane

	Mean Speed	Treatment
A	53.9	Base
B	51.5	Trailer
C	46.9	Trailer + Police w/o Lights on
C	46.8	SPE Van

The mean speed in the Base case (53.9 mph) was significantly higher than the mean speed of any of the treatments (ranged from 46.8 to 51.5 mph). This indicates that all of the treatments significantly reduced the mean speed of cars in general traffic stream (sampled cars) in the median lane. The presence of the speed display Trailer in the work zone reduced the mean speed by 2.4 mph to 51.5 mph. This mean speed was significantly less than the mean speed in the Base case. The mean speeds for the

Trailer + Police-without-Lights-on, and SPE treatments were significantly less than the mean speed for the Base and the Trailer cases. The reductions in mean speeds for the law enforcement cases were similar and ranged from 6.0 to 6.1 mph, reducing the mean speed to 46.8 to 46.9 mph. As a result, the SPE and traditional law enforcement methods similarly and significantly reduced the mean speeds of the cars in the traffic stream traveling in the median lane.

The cumulative speed distribution curves for cars in general traffic stream (sampled cars) in the median lane are shown Figure I-3. The cumulative speed distribution for the Trailer case was shifted towards left compared to the base case. This shift was more pronounced for the law enforcement methods. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

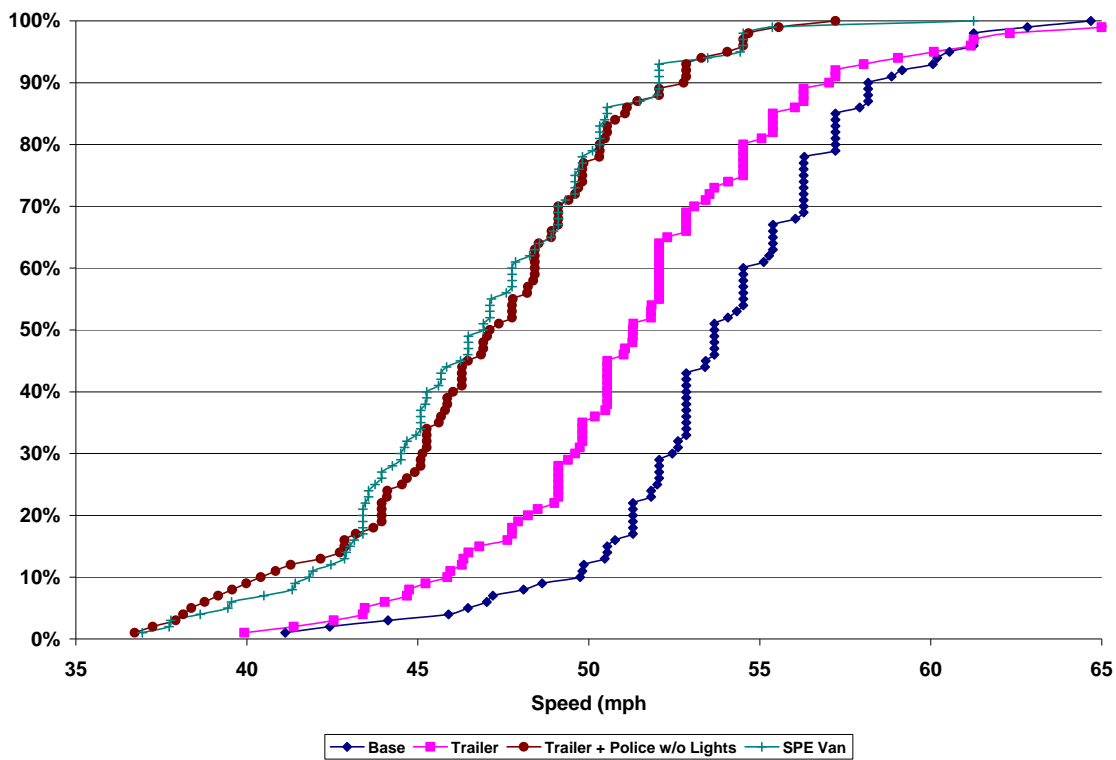


Figure I- 3. Cumulative speed distribution for the sampled cars in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-4. In the Base case 39.4% and in the Trailer case 19.4% exceeded the speed limit of 55 mph. But, in case of law enforcement, this percentage reduced to less than 2.2%. When Trailer plus Police car without Lights on was present in the work zone, less than 2.2% of the drivers exceeded the speed limit. The presence of the SPE van reduced this percentage to 1.9%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 31.9% for the Base case reduced to 13.6% when the Trailer was present in the work zone. The law enforcement methods reduced the percentage to less than 2.2%. The

presence of Police-without-Lights-on plus trailer reduced this percentage to 2.2% while SPE van reduced it even more to 1.0%.



Figure I-4. The degree of speeding for sampled cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Base and Trailer cases, the percentages speeding by 5-10 mph were 7.5% and 3.9%, respectively. The SPE reduced this percentage to less than 1% while Trailer + Police-without-Lights-on case eliminated speeding by 5-10 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. Only when the Trailer was present in the work zone 1.9% of the cars in general traffic stream (sampled cars) in the median lane exceeded the speed limit by more than 10 mph.

I.1.1.c. Dataset 3

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-3 shows the results of LSD test for the cars in the traffic stream (sampled cars) in median lane for Dataset 3.

Table I-3. LSD Result for Sampled Cars in Median Lane

		Mean Speed	Treatment
	A	60.6	Base
	B	59.2	Trailer
	C	53.8	Police w/o Lights on
D	C	53.0	Trailer + Police w/o Lights on
D		52.6	SPE Van

The mean speed in the Base case (60.6 mph) was significantly higher than the mean speed of all treatments (ranged from 52.6 to 59.2 mph). This indicates that all of the treatments significantly reduced the mean speed of the cars in general traffic stream

(sampled cars) in the median lane. The presence of the speed display Trailer in the work zone reduced the mean speed by 1.4 mph to 59.2 mph. Police-without-Lights-on and Trailer + Police-without-Lights-on resulted in significantly lower mean speeds compared to the Base and Trailer cases. They reduced the mean speed by 6.8 mph and 7.6 mph to 53.8 mph and 53.0 mph respectively.

The SPE van resulted in lower mean speed compared to Police-without-Lights-on treatment but similar to the Trailer + Police-without-Lights-on treatment. SPE reduced the mean speed by 8.0 mph to 52.6 mph.

The cumulative speed distribution curves for the cars in general traffic stream (sampled cars) in the median lane are shown in Figure I-5. The cumulative speed distributions for all treatments were shifted towards left compared to the Base case. Police-without-Lights-on resulted in a bigger shift compare to the Trailer case. This shift was more pronounced for the Trailer + Police-without-Lights-on, and SPE cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

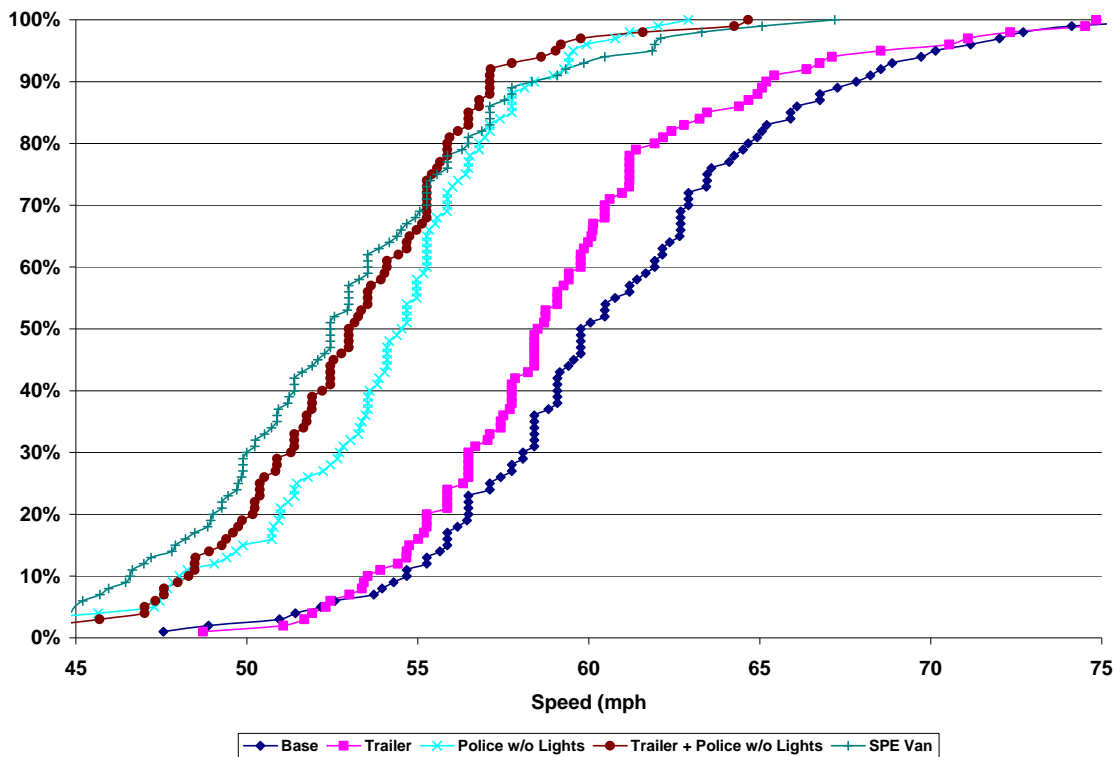


Figure I-5. Cumulative speed distribution for the sampled cars in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-6. In the Base case 88.4% and in the Trailer case 83.6% exceeded the speed limit of 55 mph. Police-without-Lights-on improved the speed limit compliance to 58.8%. Trailer + Police-without-Lights-on was more successful in improving the speed limit compliance and improved it to 66.9%. Finally, SPE increased it even more to 70.0%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 42.5% for the Base case and 48.3% when the Trailer was present in the work zone. The

presence of the Police-without-Lights-on in the work zone reduced this percentage to 36.8%. Trailer + Police-without-Lights-on reduced it even more to 30.7% and finally SPE reduced it to 23.6%.

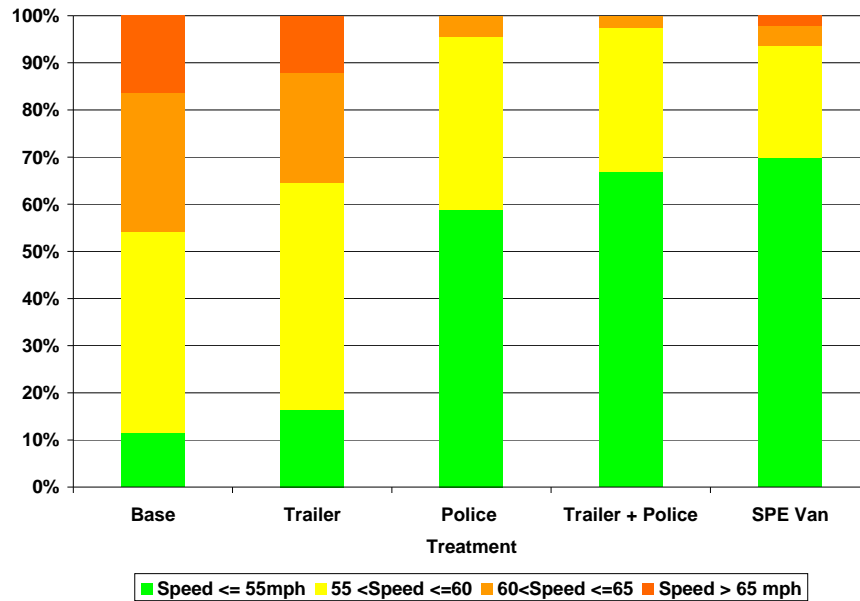


Figure I-6. The Degree of Speeding for Sampled Cars in Median Lane

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Base and Trailer cases, the percentages speeding by 5-10 mph were 29.4% and 23.3%, respectively. For the law enforcement treatments, this percentage dropped to less than 4.4%. The SPE van reduced it to 4.3% and Trailer + Police-without-Lights-on reduced it to 2.4%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases, 16.4% and 12.1% of drivers exceeded the speed limit by more than 10 mph. The traditional law enforcement methods reduced this percentage to zero but in the SPE, 2.1% of cars in general traffic stream (Sampled cars) in the median lane still exceed the speed limit by more than 10 mph.

I.1.1.d. Summary of Effects of SPE on Cars in General Traffic Stream on Median Lane

The three data sets showed that SPE was effective in reducing average speed of cars in the general traffic stream (sampled cars) on median lane to 46.8 - 52.6 mph. Speeding was more prevalent on I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 5.1-8.0 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with its flashing lights off to be present in the work zone. Furthermore, the SPE reduced the percentage of speeding cars by 31.6-58.4%; thus, it increased the compliance with work zone speed limit to 70.0% - 98.1%.

I.1.2. Shoulder lane

I.1.2.a. Dataset 1

Table I-4 shows the results of LSD test with 90% confidence level for the cars in the traffic stream (sampled cars) traveling in the shoulder lane.

Table I-4. LSD Result for Sampled Cars in Shoulder Lane

	Mean Speed	Treatment
A	49.8	Base
A	49.3	Trailer
B	45.6	Police w/o Lights on
B	45.5	SPE Van
C	44.5	Trailer + Police w/ Lights on
C	44.0	Trailer + Police w/o Lights on
C	44.0	Police w/ Lights on

The mean speed in the Base case (49.8 mph) was significantly higher than the mean speed of any of the law enforcement methods (ranged from 44.0 to 45.6 mph). This indicates that all of the law enforcement treatments significantly reduced the mean speed of the cars in general traffic stream (sampled cars) in the shoulder lane. The presence of the speed display trailer in the work zone did not significantly reduce the mean speed (0.5 mph reduction to 49.3 mph). However, the mean speeds for Police-without-Lights-on, and the SPE van treatments were significantly less than the mean speed for the Base and the Trailer cases. The reductions in mean speed for the above-mentioned two cases were similar and ranged from 4.2 to 4.3 mph, reducing the mean speed to 45.6 to 45.5 mph. The mean speeds in the other traditional law enforcement method, Trailer + Police-with-Lights-on, Trailer + Police-without-Lights-on, and Police-with-Lights-on treatments were significantly lower than all of the other treatments (44.5 mph, 44.0 mph, and 44.0 mph respectively). This indicated that the presence of the police car with lights on in the work zone with or without speed display trailer resulted in the most speed reductions. In the other word, the Trailer + Police and Police-with-Lights-on treatments had the most reduction in mean speed among the cars in general traffic stream (sampled cars) in the shoulder lane for this data set. These treatments resulted in reductions that ranged from 5.3 mph to 5.8 mph while the SPE van resulted in a 4.3 mph mean speed reduction. This may be due to the threat level that the drivers perceived with the police car compared to SPE.

The cumulative speed distribution curves for the cars in the general traffic stream (sampled cars) on the shoulder lane are shown Figure I-7. The cumulative speed distributions for all law enforcement treatments were shifted towards left compared to the Base and Trailer cases. The Results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

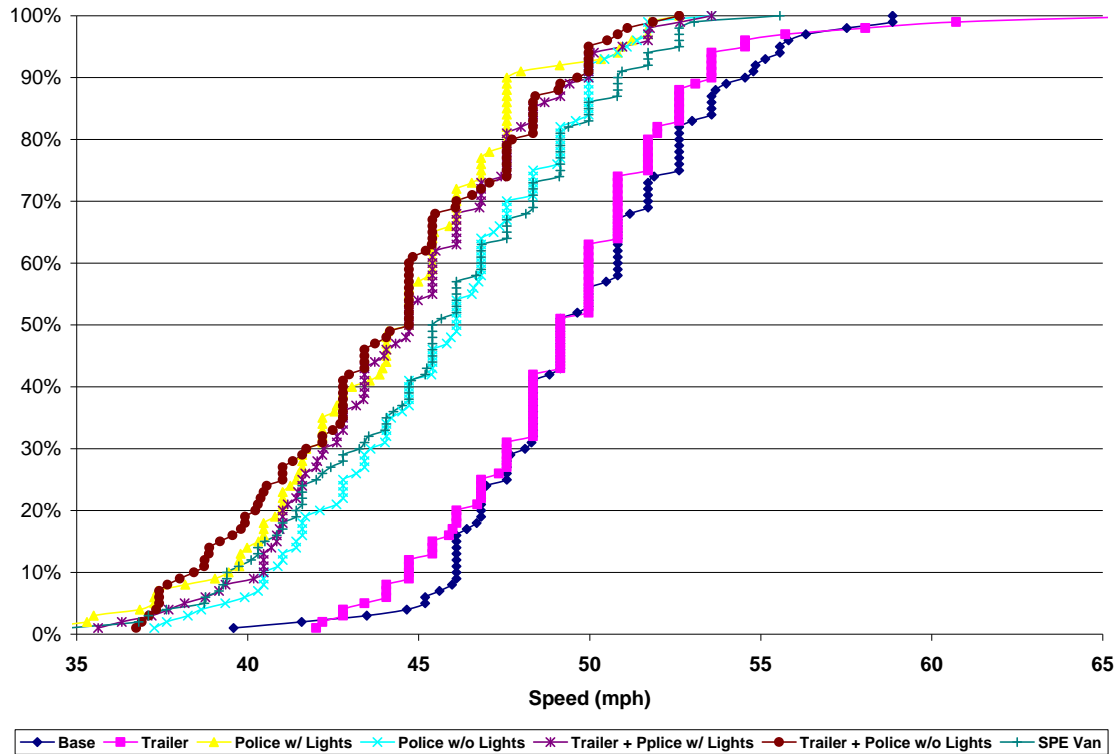


Figure I-7. Cumulative speed distribution for the sampled cars in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-8. In the Base case 7.4% and in the Trailer case 4.0% exceeded the speed limit of 55 mph. For the traditional law enforcement methods, no one exceeded the speed limit. In the SPE case, only 0.6% percent of the drivers exceeded the speed limit.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 7.4% for the Base and reduced to 2.6% when the Trailer was present in the work zone. The traditional law enforcement methods reduced the percentage to 0.0% while in the SPE case this percentage was 0.6%.

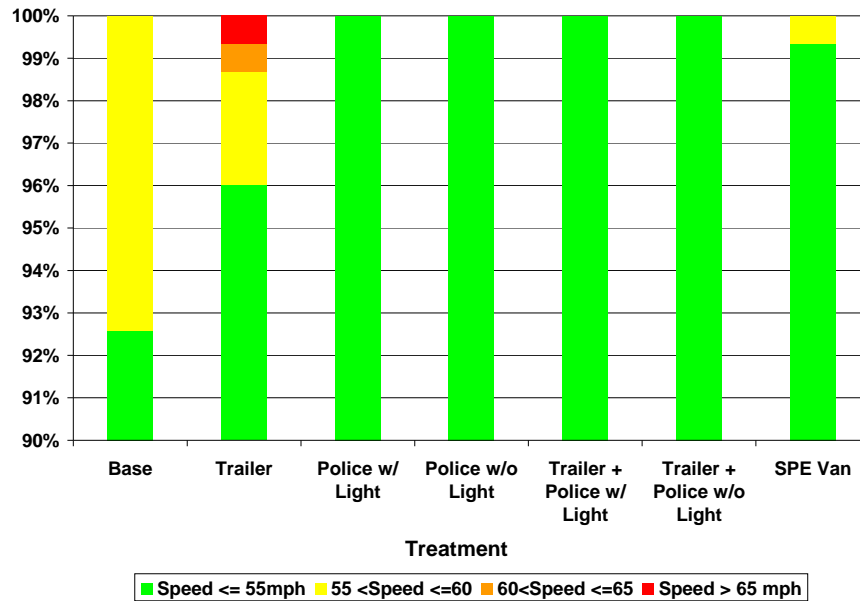


Figure I-8. The degree of speeding for sampled cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Trailer case, the percentages speeding by 10 mph were 0.7%. For all other cases, no one exceeded the speed limit by 5-10 mph. The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Trailer case 0.7% of drivers exceed the speed limit by more than 10 mph while for all other cases none of the cars in general traffic stream (sampled cars) in the shoulder lane exceeded the speed limit by more than 10 mph for this data set.

I.1.2.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-5 shows the results of LSD test for the cars in general traffic stream (sampled cars) traveling in the shoulder lane for Dataset 2.

Table I-5. LSD Result for Sampled Cars in Shoulder Lane

	Mean Speed	Treatment
A	48.7	Base
B	47.9	Trailer
C	42.8	Trailer + Police w/o Lights on
C	42.4	SPE Van

The mean speed in the Base case (48.7 mph) was significantly higher than the mean speed of any of the treatments (ranged from 42.4 to 47.9 mph). This indicates that all of the treatments significantly reduced the mean speed of the cars in general traffic stream (sampled cars) in the shoulder lane. The presence of the speed display trailer in the work zone reduced the mean speed by 0.8 mph to 47.9 mph. This mean speed was significantly less than the mean speed in the Base case. The mean speeds for the Trailer + Police-without-Lights-on, and SPE treatments were significantly less than the mean speed for the Base and the Trailer cases. The reductions in mean speed for the

above-mentioned two cases were similar and ranged from 5.9 to 6.3 mph, reducing the mean speeds to 42.4 to 42.8 mph. As a result, the SPE and traditional law enforcement methods similarly and significantly reduced the mean speeds of the cars in general traffic stream (sampled cars) in the shoulder lane.

The cumulative speed distribution curves for the cars in general traffic stream (sampled cars) in the shoulder lane are shown in Figure I-9. The cumulative speed distribution for the Trailer case was shifted towards left compared to the base case. This shift was more pronounced for the law enforcement methods. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

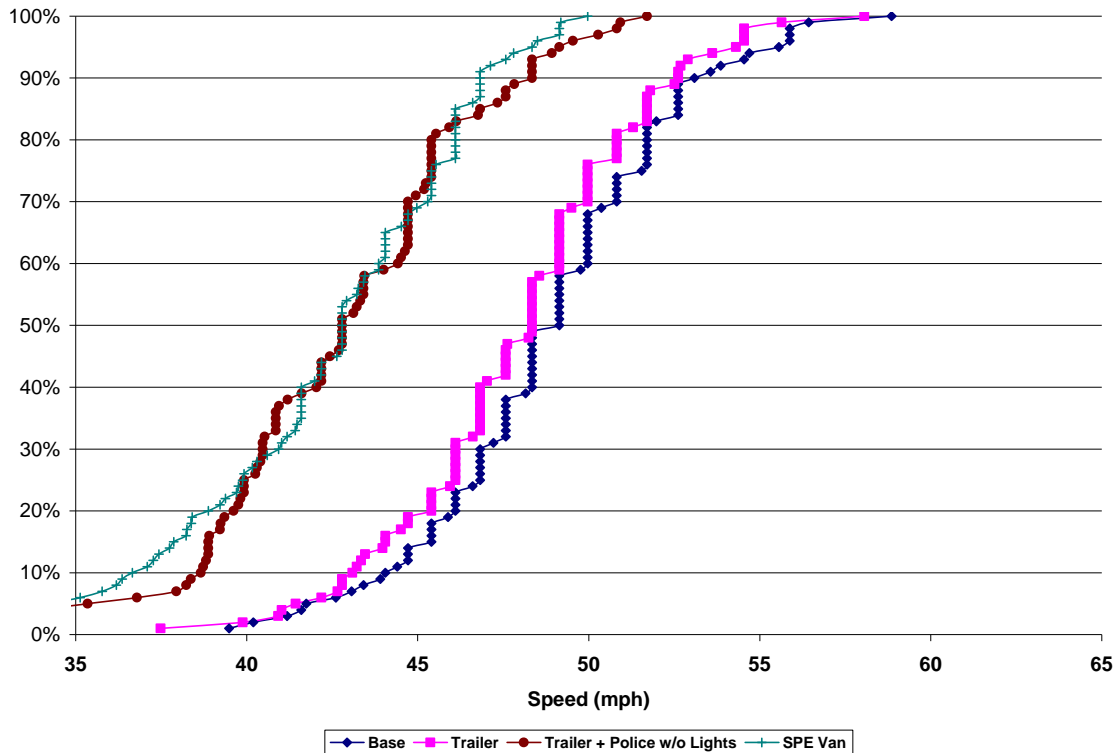


Figure I-9. Cumulative speed distribution for the sampled cars in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-10. In the Base case only 5.7% and in the Trailer case only 1.3% exceeded the speed limit of 55 mph. Law enforcement methods eliminated speeding for the cars in general traffic stream (sampled cars) in the shoulder lane.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 5.7% for the Base case and reduced to 1.3% when the Trailer was present in the work zone. None of the cars in general traffic stream (sampled cars) in the shoulder lane exceeded the speed limit by more than 5 mph in this dataset.



Figure I-10. The degree of speeding for sampled cars in shoulder lane.

I.1.2.c. Dataset 3

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-6 shows the results of LSD test for the cars in the traffic stream (Sampled cars) traveling in the shoulder lane for Dataset 3.

Table I- 6: LSD Result for Sampled Cars in Shoulder Lane

	Mean Speed	Treatment
A	59.3	Base
B	58.1	Trailer
C	53.3	Police w/o Lights on
D	52.7	Trailer + Police w/o Lights on
E	51.6	SPE Van

The mean speed in the Base case (59.3 mph) was significantly higher than the mean speed of any of the treatments (ranged from 51.6 to 58.1 mph). This indicates that all of the treatments significantly reduced the mean speed of the cars in general traffic stream (Sampled cars) in the shoulder lane. The presence of the speed display Trailer in the work zone reduced the mean speed by 1.2 mph to 58.1 mph. Police-without-Lights-on resulted in significantly lower mean speed compared to the Trailer case. It reduced the mean speed by 6.0 mph to 53.3 mph. The Trailer + Police-without-Lights-on resulted in significantly lower mean speed compared to the Police-without-Lights-on case. It reduced the mean speed by 6.6 mph to 52.7 mph (compare to the Base case). Finally, the SPE resulted in the lowest mean speed compared to all of the other treatments. It reduced the mean speed by 7.7 mph to 51.6 mph. This shows that in this dataset for the cars in general traffic stream (Sampled cars) in the shoulder lane, the SPE reduced the mean speed more than the traditional law enforcement methods.

The cumulative speed distribution curves for the cars in general traffic stream (Sampled cars) in the shoulder lane are shown in Figure I-11. The cumulative speed distributions for all treatments were shifted towards left compared to the Base case.

Police-without-Lights-on resulted in a bigger shift compare to the Trailer case. This shift was more pronounced for the Trailer + Police-without-Lights-on, and SPE cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

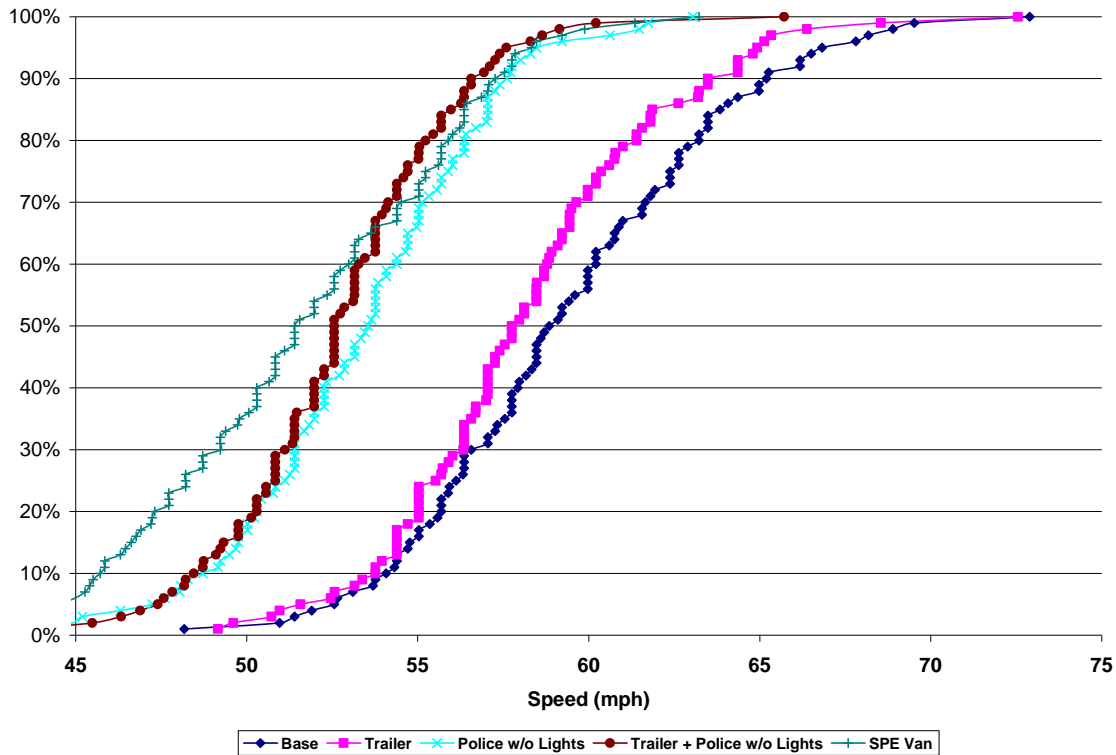


Figure I-11. Cumulative speed distribution for the sampled cars in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-12. In the Base case 84.2% and in the Trailer case 81.3% exceeded the speed limit of 55 mph. Police-without-Lights-on improved the speed limit compliance to 65.9%, Trailer + Police-without-Lights-on 77.3%, and SPE to 70.0%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 44.3% for the Base case and increased to 53.5% when the Trailer was present in the work zone. The presence of the police car without lights on in the work zone reduced this percentage to 30.5%. Trailer + Police-without-Lights-on reduced it to 21.0% and the SPE reduced to 27.7%.

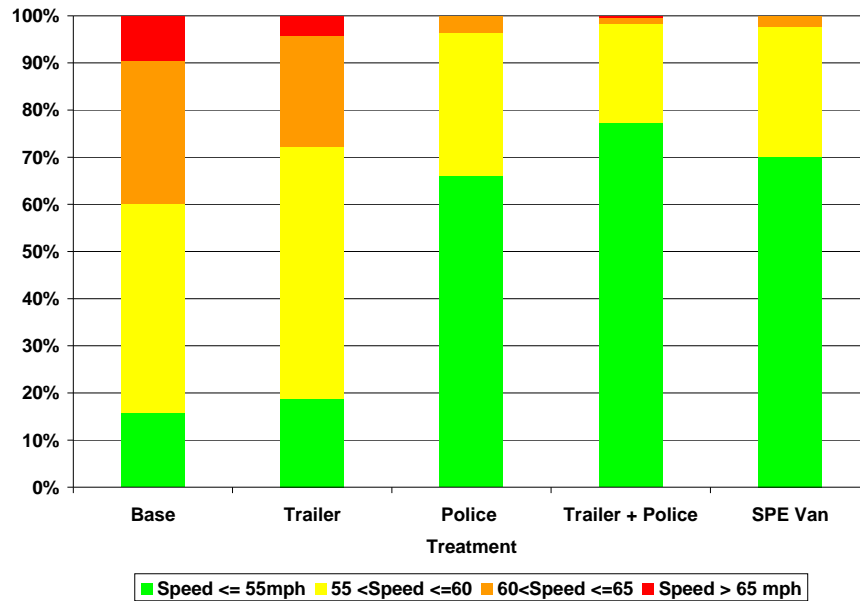


Figure I-12. The degree of speeding for sampled cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Base and Trailer cases, the percentages speeding by 5-10 mph were 30.3% and 23.5%, respectively. For the law enforcement treatments, this percentage dropped to less than 3.5%. The SPE van reduced it to 2.2% and Trailer + Police-without-Lights-on reduced it to 1.3%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases 9.5% and 4.3% of drivers exceeded the speed limit by more than 10 mph. Police-without-Lights-on and SPE entirely eliminated this much speeding among the Cars in general traffic stream (sampled cars) in the shoulder lane but in the Trailer + Police-without-Lights-on case still 0.3% of drivers violating the speed limit to this extent.

I.1.2.d. Summary of Effects of SPE on Cars in General Traffic Stream on Shoulder Lane

The three data sets showed that SPE was effective in reducing average speed of cars in general traffic stream (sampled cars) on shoulder lane to 42.4 – 51.6 mph. Speeding was more prevalent on I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 4.3-7.7 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE reduced the percentage of speeding cars by 31.6-54.2%; thus, it increased the compliance with work zone speed limit to 70.4% - 100%

I.2.Trucks

I.2.1.Median lane

I.2.1.a.Dataset 1

Mean Speeds and Speed Reductions

Table I-7 shows the results of LSD test with 90% confidence level for the trucks in the traffic stream (Sampled trucks) traveling in the median lane.

Table I-7. LSD Result for Sampled Trucks in Median Lane

		Mean Speed	Treatment
	A	53.0	Base
	B	50.6	Trailer
C	B	49.9	Police w/o Lights on
C	D	49.3	SPE Van
E	D	48.4	Police w/ Lights on
E	D	48.0	Trailer + Police w/o Lights on
E		47.8	Trailer + Police w/ Lights on

The mean speed in the Base case (53.0 mph) was significantly higher than the mean speed of any of the treatments (ranged from 47.8 to 50.6 mph). This indicates that all of the treatments significantly reduced the mean speed of the trucks in general traffic stream (Sampled trucks) in the median lane. The trailer and Police-without-Lights-on cases reduced the mean speed by 2.4 mph to 50.6 mph and by 3.1 mph to 49.9 mph respectively. The mean speeds in these two cases were similar but, significantly lower than the mean speed in the Base case. The SPE reduced the mean speed by 3.7 mph to 49.3 mph. This mean speed was significantly lower than the mean speed in the Trailer and Base cases, but not significantly different from the Police-without-Lights-on case.

Police-with-Lights-on and trailer + Police-without-Lights-on cases resulted in mean speeds significantly lower than the Police-without-Lights-on case but similar to the SPE. These two cases reduced the mean speed by 4.6 mph and 5.0 mph to 48.4 mph and 48.0 mph respectively.

The mean speed for the Trailer + Police w/ Lights on case was significantly lower than the mean speed for SPE van case but, it was similar to the mean speeds for Police-with-Lights-on and Trailer + Police-without-Lights-on cases. This treatment reduced the mean speed by 5.2 mph to 47.8 mph.

The cumulative speed distribution curves for the trucks in general traffic stream (sampled trucks) in the median lane are shown in Figure I-13. The cumulative speed distributions for all treatments were shifted towards left compared to the base case. This shift was more pronounced for all law enforcement methods compared to the Trailer case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

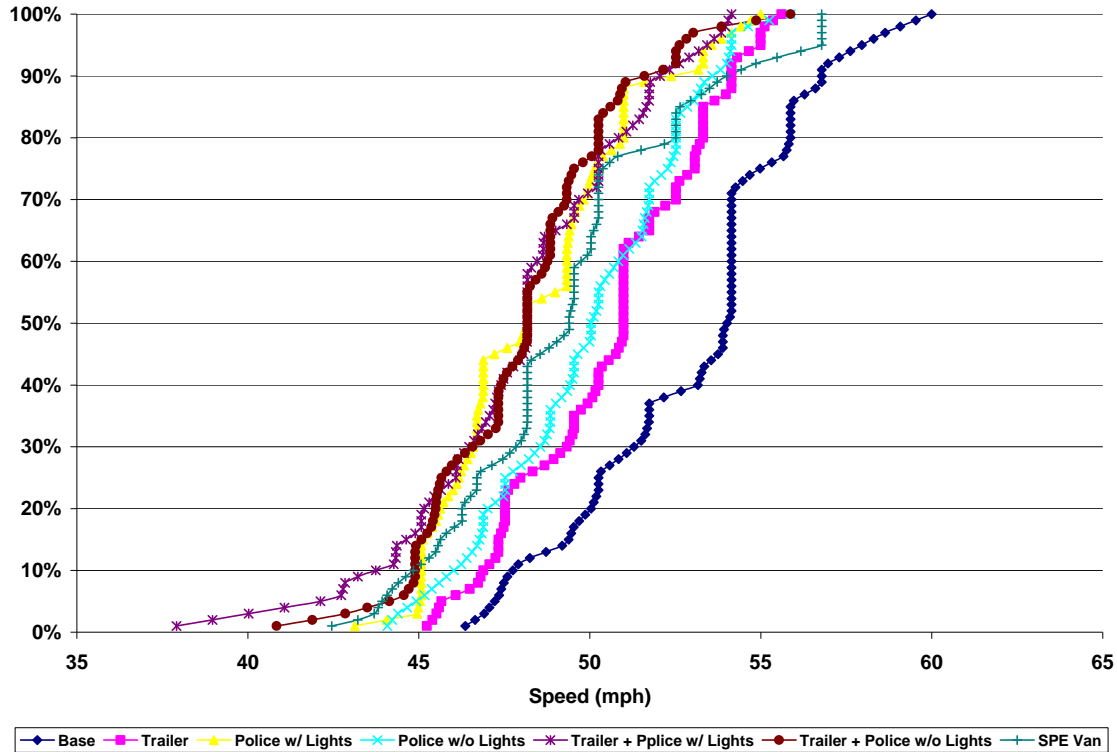


Figure I-13. Cumulative speed distribution for the sampled trucks in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-14. In the Base case 25.0% and in the Trailer case 2.4% exceeded the speed limit of 55 mph. For the treatments that included law enforcement, less than 10% of drivers exceeded the speed limit. The highest speed limit compliance, 100.0%, occurred in the trailer + Police-with-Lights-on treatment. In the SPE case 92.5% of drivers complied with the speed limit. This finding supports the results of the mean speed reductions.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 25.0% for the Base case and reduced to 2.4% when the Trailer was present in the work zone. This means that all the trucks in general traffic stream (sampled trucks) in the median lane that exceed the speed limit in Trailer case, exceed it by 5 mph. The law enforcement methods did not reduce this percentage that much.

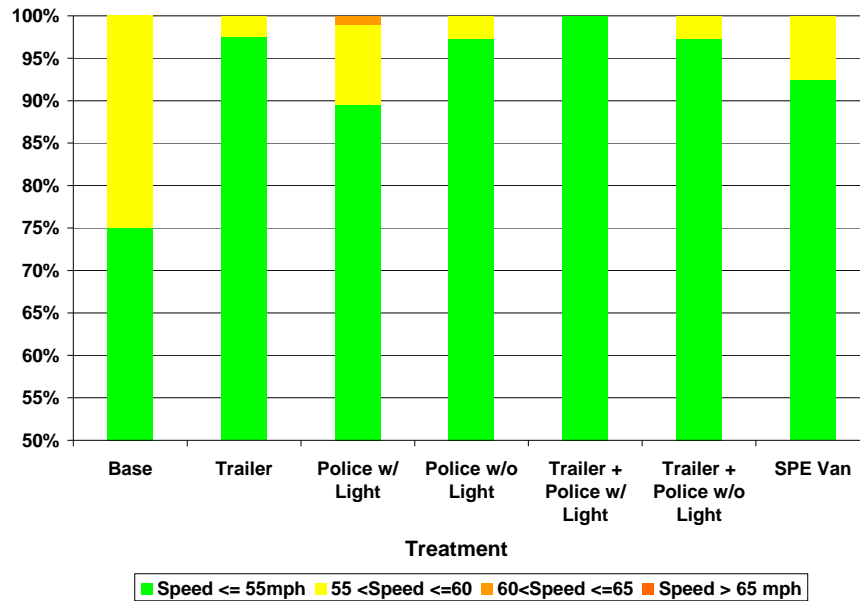


Figure I-14. The degree of speeding for sampled trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In Police-with-Lights-on case, the percentages speeding by 10 mph was 1.0%. For all other treatments, the percentage reduced to zero. None of the trucks in general traffic stream (Sampled trucks) in the median lane exceeded the speed limit by more than 10 mph.

I.2.1.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table 4-8 shows the results of LSD test for the trucks in the traffic stream (Sampled trucks) traveling in the median lane for Dataset 2.

Table I-8. LSD Result for Sampled Trucks in Median Lane

	Mean Speed	Treatment
A	50.5	Base
A	49.9	Trailer
B	45.4	SPE Van
B	44.0	Trailer + Police w/o Lights on

The mean speed in the Base case (50.5 mph) was significantly higher than the mean speed of all law enforcement methods (ranged from 44.0 to 45.4 mph) but, similar to the mean speed in the Trailer case (49.9 mph). This indicates that all of the law enforcement methods significantly reduced the mean speed of trucks in general traffic stream (sampled trucks) in the median lane. The presence of the speed display trailer in the work zone did not significantly reduce the mean speed. However, the mean speeds for the SPE, and Trailer + Police-without-Lights-on treatments were significantly less than the mean speed for the Base and the Trailer cases. The reductions in mean speed for the above-mentioned two cases were similar and ranged from 5.1 to 6.5 mph, reducing the mean speed to 44.0 to 45.4 mph. Thus, the SPE and traditional law

enforcement methods similarly and significantly reduced the mean speeds of the Trucks in general traffic stream (sampled trucks) traveling in the median lane.

The cumulative speed distribution curves for the trucks in general traffic stream (sampled trucks) in the median lane are shown in Figure I-15. The cumulative speed distributions for all law enforcement methods were shifted towards left compared to the Base and Trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

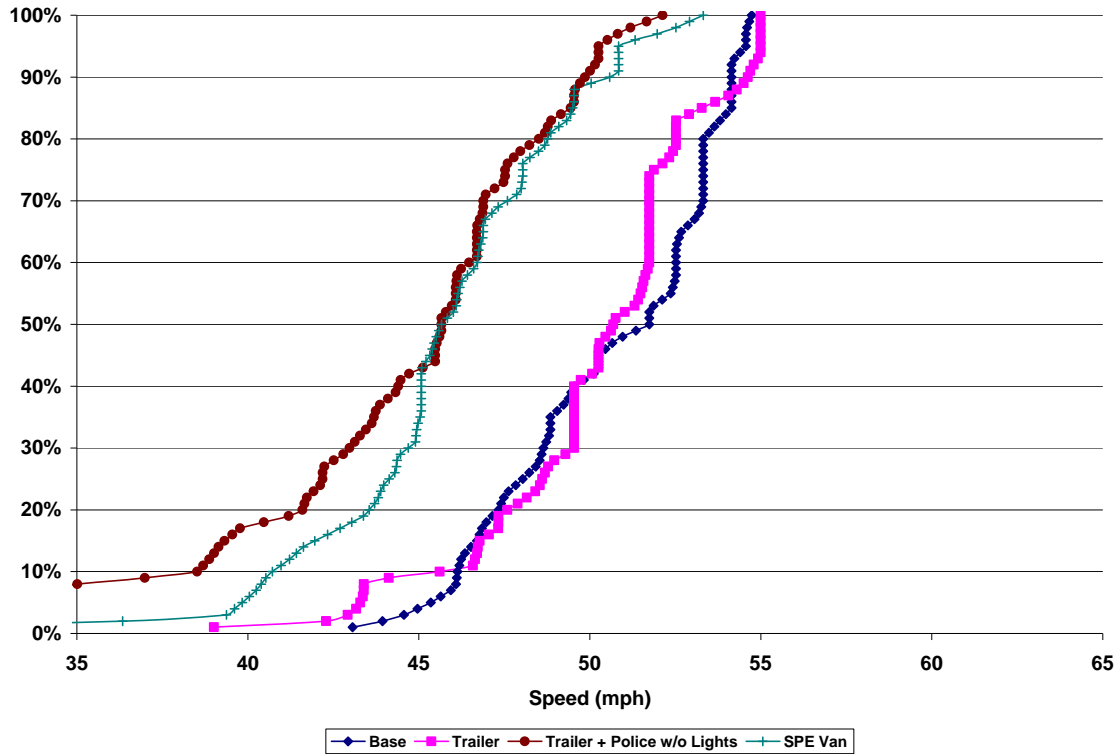


Figure I-15. Cumulative speed distribution for the sampled trucks in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-16. None of the trucks in the general traffic stream (sampled trucks) in the median lane exceeded the speed limit of 55 mph for this data set.

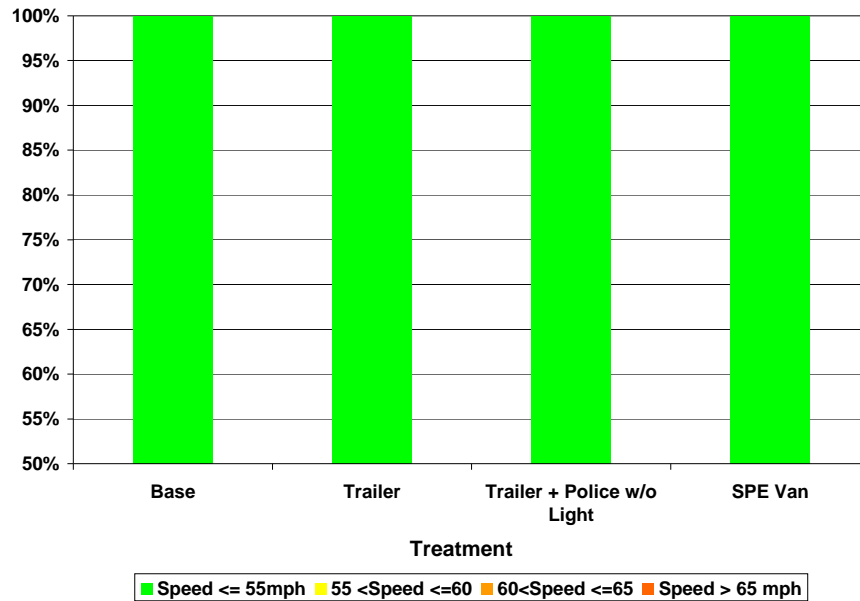


Figure I-16. The degree of speeding for sampled cars in median lane.

I.2.1.c. Dataset 3

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-9 shows the results of LSD test for the trucks in the traffic stream (sampled trucks) traveling in median lane for Dataset 3.

Table I- 9. LSD Result for Sampled Trucks in Median Lane

	Mean Speed	Treatment
A	56.1	Base
A	55.8	Trailer
B	53.8	Police w/o Lights on
C	51.7	Trailer + Police w/o Lights on
D	50.4	SPE Van

The mean speed in the Base case (56.1 mph) was significantly higher than the mean speed of any of the law enforcement treatments (ranged from 50.6 to 53.8 mph) but similar to the mean speed of the Trailer case. This indicates that all of the law enforcement treatments significantly reduced the mean speed of the trucks in general traffic stream (sampled trucks) in the median lane. The presence of the speed display trailer in the work zone did not significantly lower the mean speed. Police-without-Lights-on resulted in significantly lower mean speed compared to the Base and Trailer cases. It reduced the mean speed by 2.3 mph to 53.8 mph. The Trailer + Police-without-Lights-on case resulted in significantly lower mean speed compared to the Police-without-Lights-on case. It reduced the mean speed by 4.4 mph to 51.7 mph. Finally, the SPE resulted in the lowest mean speed compared to all other treatments. It reduced the mean speed by 5.7 mph to 50.4 mph. This shows that for the trucks in general traffic stream (Sampled trucks) in the median lane, the SPE reduced mean speed more than the traditional law enforcement methods.

The cumulative speed distribution curves for the Trucks in general traffic stream (sampled trucks) in the median lane are shown in Figure I-17. The cumulative speed

distributions for all law enforcement treatments were shifted towards left compared to the Base and Trailer cases. This shift was more pronounced for the Trailer + Police-without-Lights-on case, and still more for SPE case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

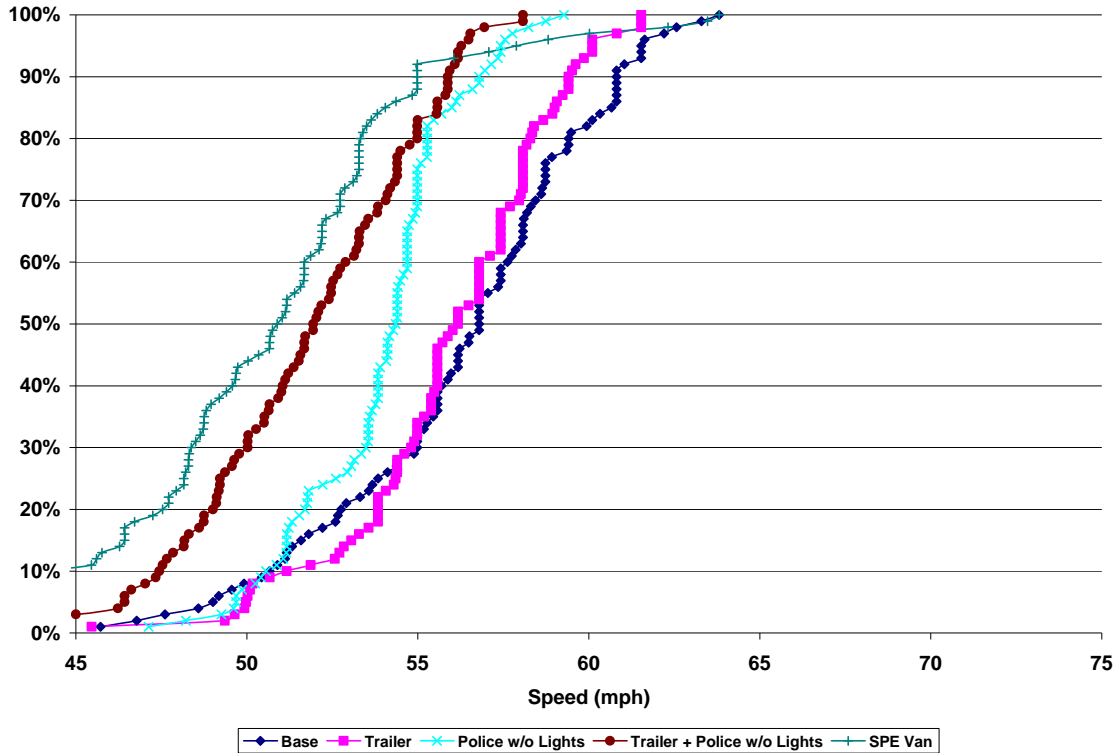


Figure I-17. Cumulative speed distribution for the sampled trucks in the median lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-18. In the Base case 66.3% and in the Trailer case 64.7% exceeded the speed limit of 55 mph. Police-without-Lights-on improved the speed limit compliance to 75.8%, Trailer + Police-without-Lights-on to 83.0%, and the SPE increased it to 92.2%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 47.4% for the Base case and 56.9% when the Trailer was present in the work zone. The presence of the police car without lights on in the work zone reduced this percentage to 24.2%. Trailer + Police-without-Lights-on reduced it to 17.0% and finally the SPE reduced it to 4.7%.

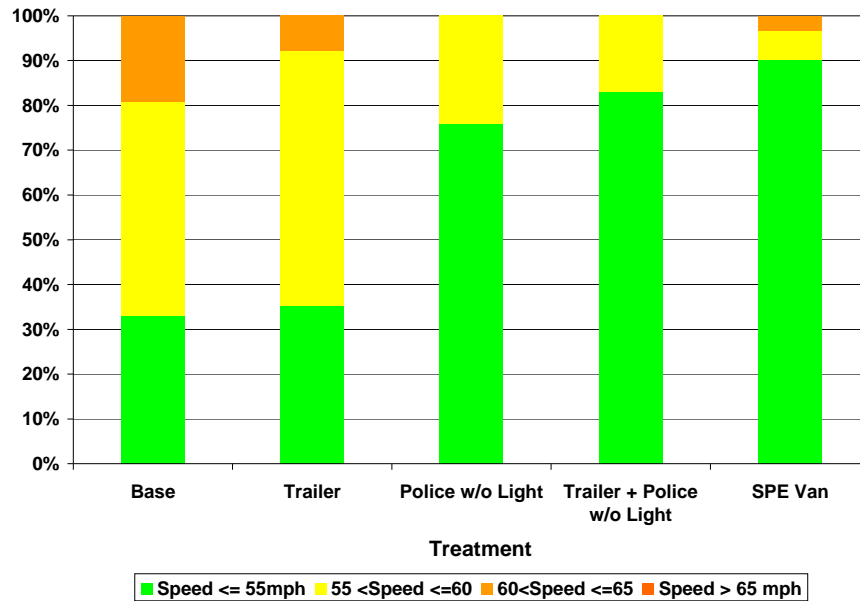


Figure I-18. The degree of speeding for sampled trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Base and Trailer cases, the percentages speeding by 5-10 mph were 19.0% and 7.8%, respectively. All traditional law enforcement treatments entirely eliminated speeding at this extent but, when the SPE van was present in the work zone still 3.1% of trucks in general traffic stream (sampled trucks) in the median lane exceeded the speed limit by 5-10 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In any of the cases, no driver exceeded the speed limit by more than 10 mph.

I.2.2.d. Summary of Effects of SPE on Trucks in General Traffic Stream on Median Lane

The three data sets showed that SPE was effective in reducing average speed of trucks in general traffic stream (sampled trucks) on median lane to 45.4 - 50.4 mph. Speeding was more prevalent on I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 3.7-5.7 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with its flashing lights off to be present in the work zone. Furthermore, the SPE reduced the percentage of speeding trucks by 0.0% - 58.5% (since even in the Base case no vehicle exceeded the speed limit); thus, it increased the compliance with work zone speed limit to 92.2% - 100.0%

I.2.2. Shoulder lane

I.2.2.a. Dataset 1

Mean Speeds and Speed Reductions

Table I-10 shows the results of LSD test with 90% confidence level for the trucks in the traffic stream (Sampled trucks) traveling in the shoulder lane.

Table I-10. LSD Result for Sampled Trucks in Shoulder Lane

			Mean Speed	Treatment
	A		49.4	Base
	A		48.2	Trailer
	B		45.3	SPE Van
C	B		45.1	Police w/o Lights on
C	B	D	44.0	Trailer + Police w/o Lights on
C		D	43.8	Trailer + Police w/ Lights on
		D	43.5	Police w/ Lights on

The mean speeds in the Base (49.4 mph) and Trailer (48.2) cases were significantly higher than the mean speeds of any of the law enforcement treatments (ranged from 43.5 to 45.3 mph) indicating that all of the law enforcement treatments significantly reduced the mean speeds of the trucks in general traffic stream (sampled trucks) in the shoulder lane. As it is presented in Table 4-22, the mean speeds for SPE, Police-without-Lights-on, and Trailer + Police-with-Lights-on cases were similar and ranged from 44.0 mph to 45.3 mph. These treatments resulted in significantly lower mean speeds compared to the Base and Trailer cases. The speed reductions ranged from 4.1 mph to 5.4 mph.

The mean speeds for the Police-without-Lights-on, Trailer + Police-without-Lights-on and trailer + Police-with-Lights-on were similar and ranged from 43.8 mph to 45.1 mph but, the mean speed for the SPE case was significantly higher than that of the Trailer + Police-with-Lights-on case. The above-mentioned three treatments resulted in speed reductions ranged from 4.3 mph to 5.6 mph.

The mean speeds for the Trailer + Police-without-Lights-on, Trailer + Police-with-Lights-on, and Police-with-Lights-on cases were similar and ranged from 43.5 mph to 44.0 mph but the mean speed for Police-with-Lights-on case was significantly lower than that for Police-without-Lights-on case. The mean speed reductions for the three above-mentioned treatments ranged from 5.4 mph to 5.9 mph.

The cumulative speed distribution curves for the trucks in traffic stream traveling in the shoulder lane are shown Figure I-19. The cumulative speed distributions for all law enforcement treatments were shifted towards left compared to the Base and Trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

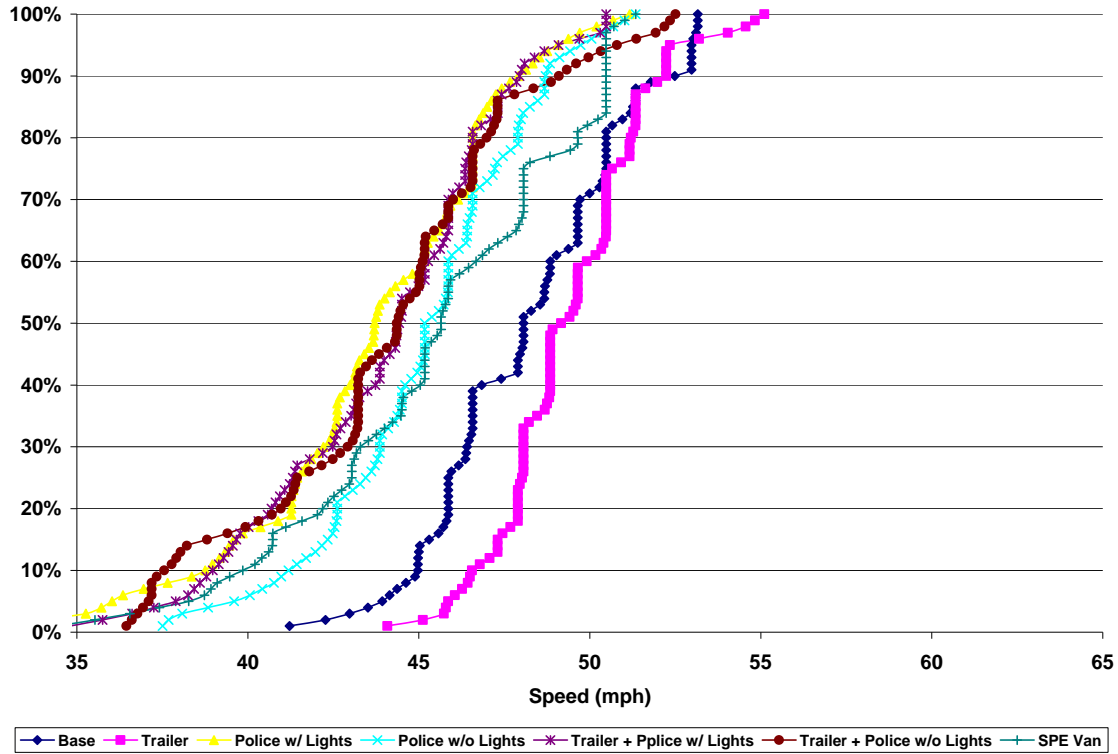


Figure I-19. Cumulative speed distribution for the sampled trucks in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-20. In the Trailer case, 2.5% exceeded the speed limit of 55 mph. For the other treatments, none of the Trucks in general traffic stream (sampled trucks) in the shoulder lane exceeded the speed limit. In addition, none of them exceeded the speed limit more than 5 mph even in the Base and Trailer cases.

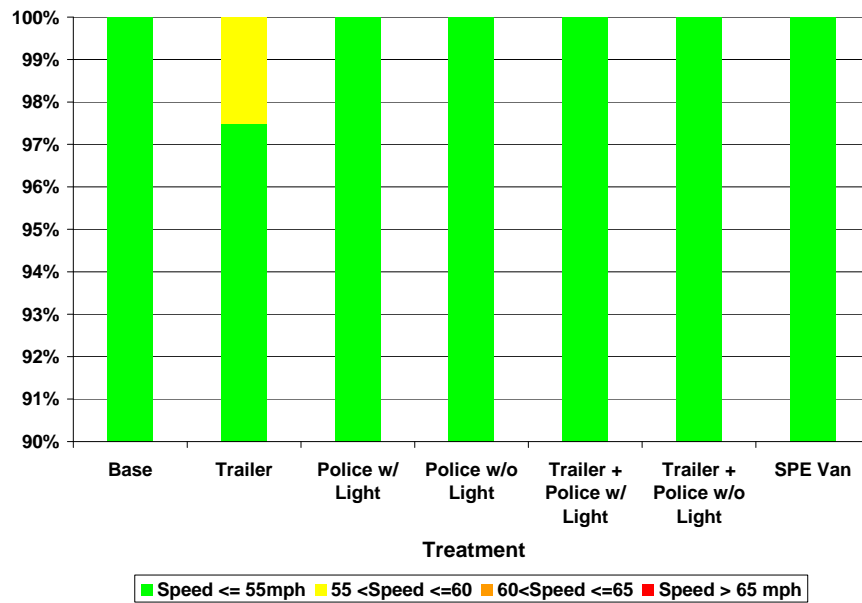


Figure I- 20. The degree of speeding for sampled trucks in shoulder lane.

I.2.2.b Dataset 2

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-11 shows the results of LSD test for the trucks in the traffic stream (Sampled trucks) traveling in the shoulder lane for Dataset 2.

Table I- 11. LSD result for Sampled Trucks in Shoulder Lane

	Mean Speed	Treatment
A	48.1	Base
A	47.2	Trailer
B	44.2	SPE Van
B	43.3	Trailer + Police w/o Lights on

The mean speed in the Base case (48.1 mph) was significantly higher than the mean speed of any of the law enforcement methods (ranged from 43.3 to 44.2 mph), but it was similar to the mean speed in the Trailer case. This indicates that all of the law enforcement methods significantly reduced the mean speed of the trucks in general traffic stream (sampled trucks) in the shoulder lane. The presence of the speed display trailer in the work zone did not significantly reduce the mean speed. However, the mean speeds in the SPE, and Trailer + Police-without-Lights-on treatments were significantly lower than the mean speed in the Base and the Trailer cases. The reductions in mean speed for the law enforcement cases were similar and ranged from 3.9 to 4.8 mph, reducing the mean speed to 43.3 to 44.2 mph. Thus, the SPE and traditional law enforcement methods significantly reduced the mean speeds of the trucks in general traffic stream (Sampled trucks) in the shoulder lane.

The cumulative speed distribution curves for the Trucks in general traffic stream (sampled trucks) in the shoulder lane are shown in Figure I-21. The cumulative speed distributions for the law enforcement methods were shifted towards left compared to the Base and Trailer cases. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

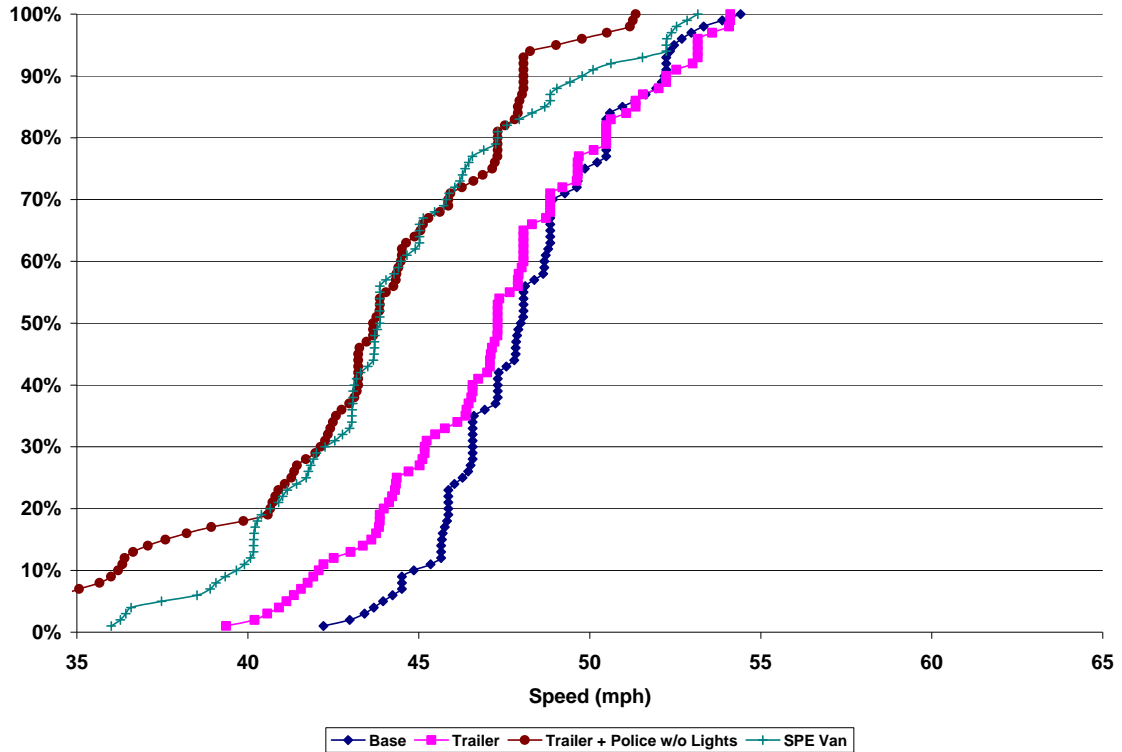


Figure I-21. Cumulative speed distribution for the sampled trucks in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-22. None of the trucks in general traffic stream (sampled trucks) in the shoulder lane exceeded the speed limit of 55 mph for this data set.



Figure I-22. The degree of speeding for sampled trucks in shoulder lane.

I.2.2.c. Dataset 3

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table I-12 shows the results of LSD test for the trucks in the traffic stream (sampled trucks) traveling in the shoulder lane for Dataset 3.

Table I-12. LSD result for Sampled Trucks in Shoulder Lane

	Mean Speed	Treatment
A	56.1	Base
A	56.1	Trailer
B	53.1	Police w/o Lights on
B	52.5	Trailer + Police w/o Lights on
C	49.7	SPE Van

The mean speed in the Base case (56.1 mph) was significantly higher than the mean speed of any of the law enforcement treatments (ranged from 49.7 to 53.1 mph) but similar to the means speed of the Trailer case. This indicates that all of the law enforcement treatments significantly reduced the mean speed of the trucks in general traffic stream (sampled trucks) in the shoulder lane. The presence of the speed display trailer in the work zone did not significantly reduce the mean speed. However, the mean speeds for the traditional law enforcement methods (Police-without-Lights-on, and Trailer + Police-without-Lights-on) were significantly less than the mean speed for the Base and the Trailer cases. The reductions in mean speed for the above-mentioned two cases were similar and ranged from 3.0 to 3.6 mph, reducing the mean speed to 52.5 to 53.1 mph. The SPE resulted in significantly lower means speed compared to the other cases. The SPE reduced the mean speed by 6.4 mph to 49.7 mph. This shows that the SPE reduced the speed of the trucks in general traffic stream (sampled trucks) in the shoulder lane more than other treatments.

The cumulative speed distribution curves for the Trucks in general traffic stream (sampled trucks) in the shoulder lane are shown in Figure I-23. The cumulative speed distributions for traditional law enforcement treatments were shifted towards left compared to the Base and Trailer cases. The SPE resulted in a biggest shift towards the left in this data set. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

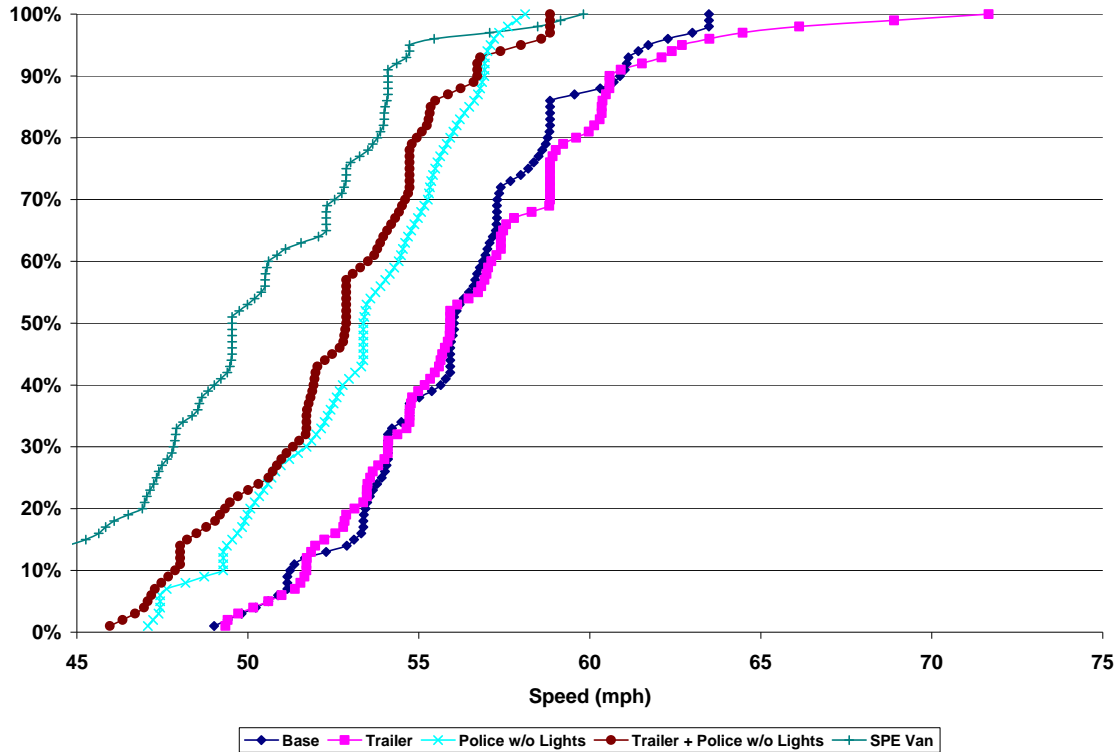


Figure I-23. Cumulative speed distribution for the sampled trucks in the shoulder lane.

Degree of Speeding

The degree of speeding for different treatments at four levels is presented in Figure I-24. In both the Base and Trailer cases 60.5% exceeded the speed limit of the 55 mph. The Police-without-Lights-on and Trailer + Police-without-Lights-on treatments reduced it to 32.3% and 21.4% while the SPE reduced it to 4.3%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 46.5% for the Base case and reduced to 41.9% when the Trailer was present in the work zone. The Police-without-Lights-on and Trailer + Police-without-Lights-on treatments reduced it to 32.3% and 21.4% respectively while the SPE reduced it to 4.3%.

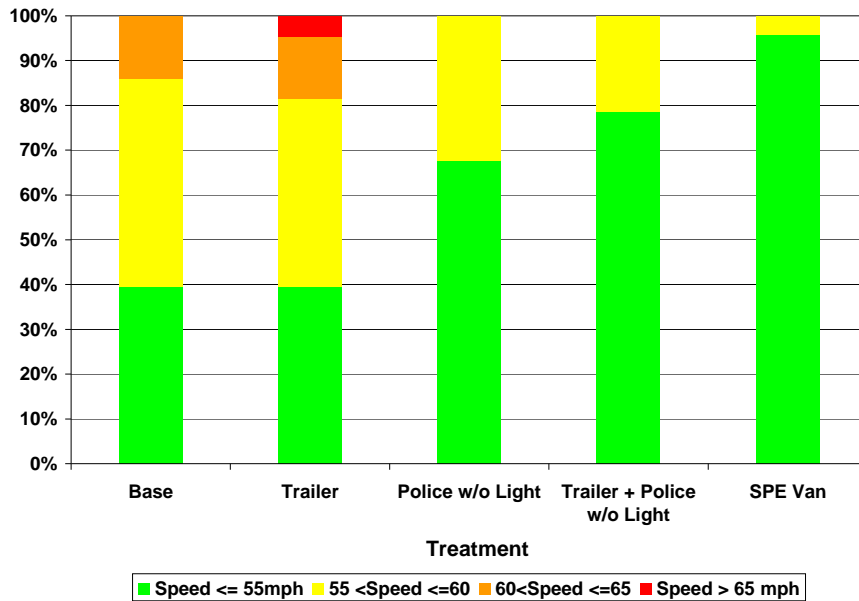


Figure I-24. The degree of speeding for sampled trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In both Base and Trailer cases the percentages speeding by 5-10 mph were similarly 13.9%. The law enforcement treatments eliminated this percentage.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. Only in the Trailer case, 4.6% of trucks exceeded the speed limit by more than 10 mph and in all the other cases, no one exceeded the speed limit at this extent.

I.2.2.d. Summary of Effects of SPE on Trucks in General Traffic Stream on Shoulder Lane

The three data sets showed that SPE was effective in reducing the average speed of trucks in the general traffic stream (sampled cars) on shoulder lane to 44.2 - 49.7 mph. Speeding was more prevalent on I-55 work zone near Chicago than the I-64 work zone near St Louis, and SPE reduced the average speed by 3.9-6.4 mph. The speed reductions due to SPE are similar to the speed reductions due to traditional speed enforcement efforts. In all three sites, SPE was as effective as having a police car with flashing lights off to be present in the work zone. Furthermore, the SPE reduced the percentage of speeding trucks by 0.0% - 56.1% (since even in the Base case no vehicle exceeded the speed limit); thus, it increased the compliance with work zone speed limit to 95.7% - 100.0%.

APPENDIX II: SPATIAL EFFECTS

SPATIAL EFFECTS

The presence of a law enforcement officer in a work zone may reduce the speed not only at the location of the police vehicle, but also some distance downstream from that location. This is called spatial effect. To determine if there was any spatial effect due to police presence or SPE, data was collected at a location about 1.5 miles downstream (Location C), but still inside the work zone. The data for Location C is analyzed in a manner similar to the procedure used for data analysis at the treatment location (Location B). Then, the results are used to ascertain if there were any spatial effects.

II.1. Free flowing

II.1.1. Cars

II.1.1.1. Median lane

II.1.1.1.a. Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test results for free flowing cars in median lane at the downstream location are given in Table II-1. It should be mentioned that three treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was unexpectedly closed during the data collection period for these three treatments.

Table II- 1. LSD Result for Free Flowing Cars in Median Lane

	Mean Speed	Treatment
A	61.9	Trailer + Police w Lights on
A	61.8	Base
A	61.7	Trailer + Police w/o Lights on
A	61.6	SPE Van

As Table II-1 shows, the mean speeds for the three law enforcement treatments were not significantly different than the mean speed in the Base case. This means that none of the law enforcement methods had any spatial effect on mean speed of free flowing cars in the median lane, even though all three significantly reduced the speed at the treatment location.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for the free flowing cars in the median lane are shown Figure II-1. No shift was observed in cumulative speed distributions of any of the treatments compared to the Base case. Two statistical tests, Chi Squared and Kolmogorov-Smirnov, were conducted to determine whether these distributions were significantly different. The results of these tests supported the results of the LSD test at the same confidence level.

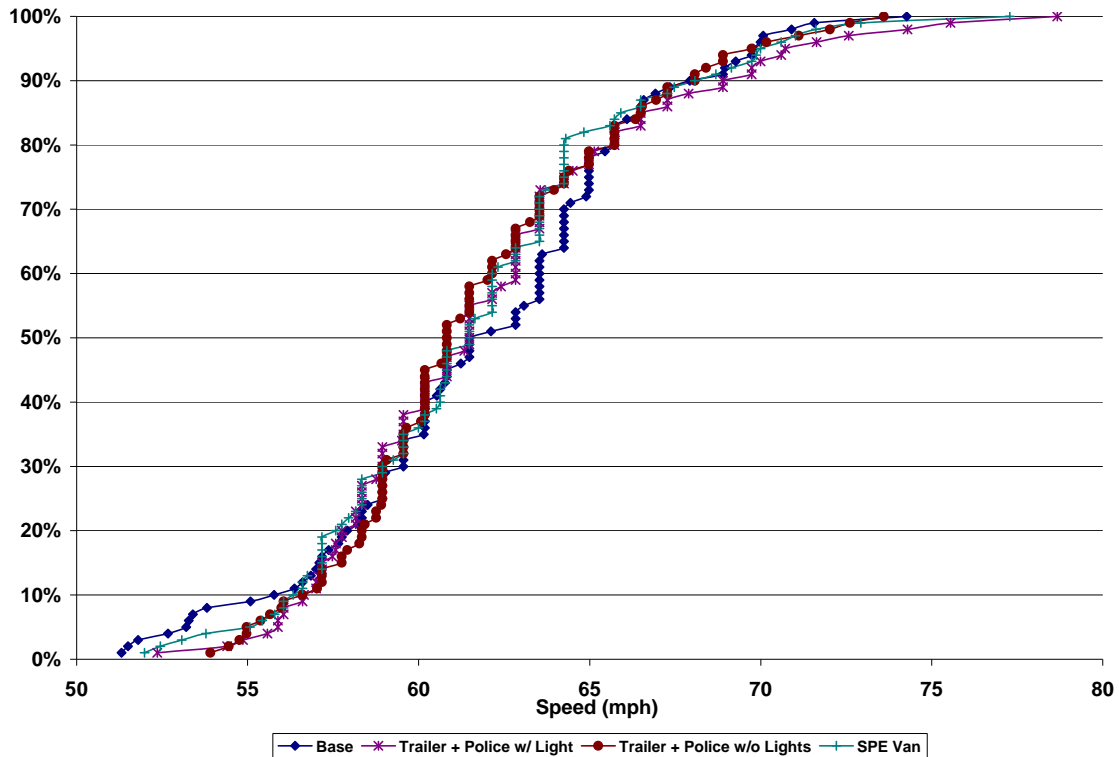


Figure II-1. Cumulative speed distribution for the free flowing cars in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-2. In the Base case 90.8% vehicles exceeded the speed limit of 55mph. The law enforcement methods did not reduce this percentage.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the Base case, 25.5% of vehicles exceeded the speed limit by 5 mph. When the law was being enforced in the work zone, this percentage ranged from 31.0% to 34.9%, indicating no reductions in speeding.

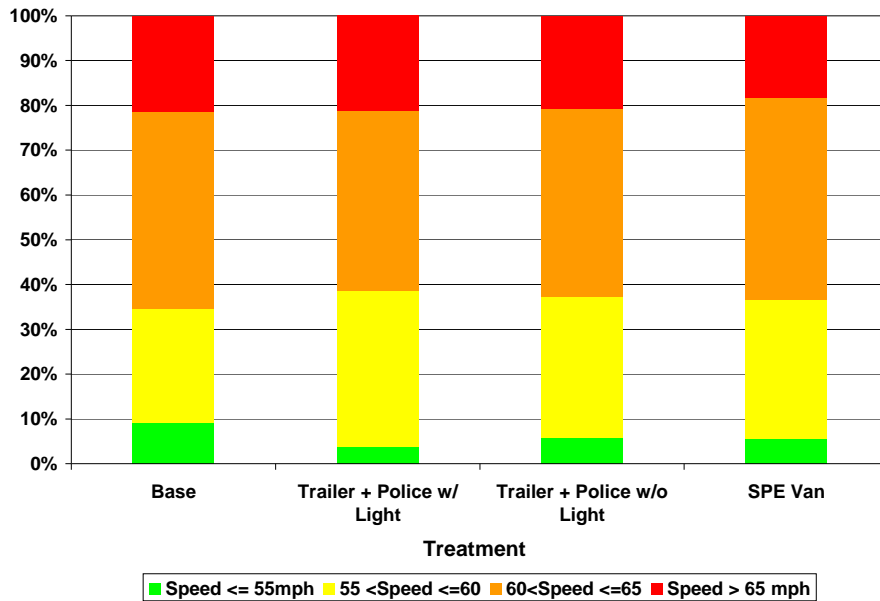


Figure II- 2. The degree of speeding for free flowing cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph (more than 5 mph and less than or equal to 10 mph). In the Base case, the percentage speeding by 5-10 mph was 43.9%. For all law enforcement treatments, the percentages ranged from 40.1% to 45.2%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 21.4% of vehicles exceeded the speed limit by more than 10 mph. These percentages ranged from 18.3% to 21.2% when the law was being enforced in the work zone. The findings for the third and fourth degrees of speeding showed that none of the law enforcement methods had any spatial effect on reducing the percentage of speeders.

II.1.1.1.b Dataset 2

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-2 shows the results of LSD test for free flowing cars in median lane for Dataset 2.

Table II-2. LSD Result for Free Flowing Cars in Median Lane

	Mean Speed	Treatment
A	63.5	Base
B	61.4	Trailer
C	59.7	SPE Van
C	59.4	Trailer + Police w/o Lights on

The mean speed in the Base case (63.5 mph) was significantly higher than the mean speed of all treatments, which ranged from 59.4 to 61.4 mph, and indicates that the treatments had some spatial effects on the free flowing cars in the median lane. The presence of the speed display Trailer in the work zone reduced the mean speed by 2.1 mph, to 61.4 mph. The SPE and Trailer + Police-without-Lights-on treatments reduced

by 3.8 to 4.1 mph, and brought the mean speed to 59.4 and 59.7 mph. As a result, the SPE had 3.8 mph and the traditional law enforcement method had 4.1 mph spatial effects on the mean speed of the free flowing cars in the median lane.

The cumulative speed distribution curves for the free flowing cars in the median lane are shown Figure II-3. The cumulative speed distribution for the Trailer case was shifted towards the left compared to the Base case. This shift was more pronounced for the law enforcement methods. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

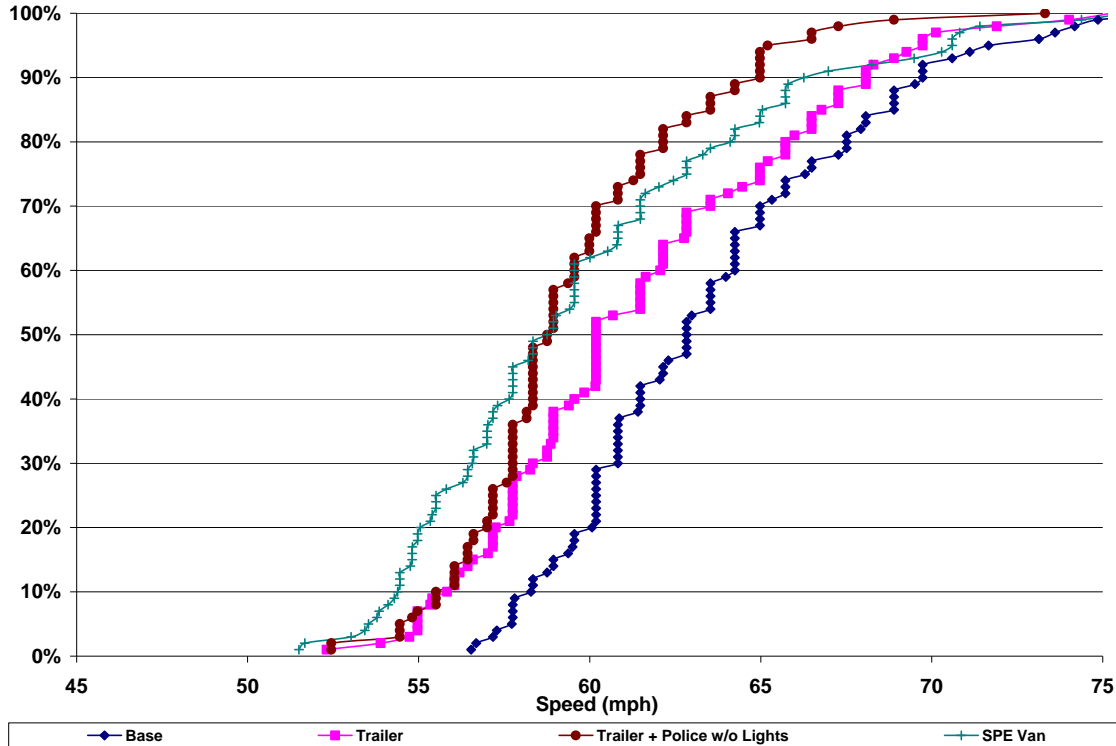


Figure II-3. Cumulative speed distribution for the free flowing cars in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-4. In the Base case none of the free flowing cars in the median lane complied with the speed limit of 55 mph at the downstream location. In the Trailer and Trailer plus Police-without-Lights-on cases, 92.1% vehicles exceeded the speed limit, and this percentage was reduced to 79.4% in the SPE case.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 20.2% for the Base case and 33.93% when the Trailer was present in the work zone. For the traditional and automated law enforcement methods, these percentages were 57.4% and 41.1%, respectively.



Figure II-4. The degree of speeding for free flowing cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 10 mph were 50.6% and 34.7%, respectively. Traditional and the SPE methods reduced these percentages to 28.7% and 23.4%, respectively.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case 29.1% and in the Trailer case 23.6% of drivers exceeded the speed limit by more than 10 mph. The SPE reduced this percentage to 14.9%, and traditional law enforcement method reduced it to 5.9%.

II.1.1.1.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-3 shows the results of LSD test for free flowing cars in median lane for Dataset 3.

Table II- 3: LSD Result for Free Flowing Cars in Median Lane

		Mean Speed	Treatment
	A	63.4	Trailer
B	A	62.5	Base
B	C	62.2	Police w/o Lights on
D	C	61.3	Trailer + Police w/o Lights on
D		60.5	SPE Van

The mean speed in the Base case (62.5 mph) was similar to the mean speed in the Trailer (63.4 mph) and Police-without-Lights-on (62.2 mph) cases. However, Trailer + Police without Lights and the SPE reduced the mean speeds by 1.2 and 2.0 mph, to 61.3 mph and 60.5 mph, respectively. Therefore, the Trailer plus Police-without-Lights-on had 1.2 mph and the SPE had 2.0 mph spatial effects on the mean speed of free flowing cars in the median lane.

The cumulative speed distribution curves for the free flowing cars in the median lane are shown in Figure II-5. The cumulative speed distributions for Trailer + Police-

without-Lights-on and the SPE cases were shifted towards left compared to the Base case but no shift towards left was observed in the other distributions. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

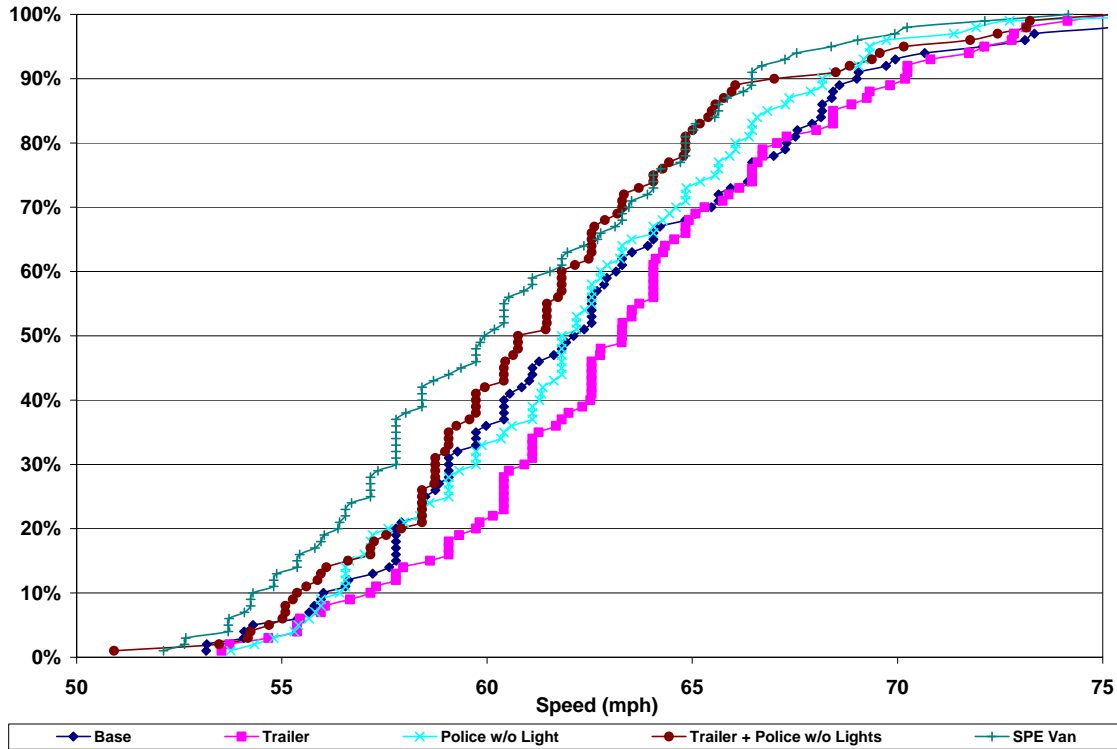


Figure II-5. Cumulative speed distribution for the free flowing cars in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-6. In the Base case 93.4% and in the Trailer case 96.1% exceeded the speed limit of 55 mph. For the traditional law enforcement methods, these percentages ranged from 94.4% to 95.9%, while for the SPE it was reduced to 86.3%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 30.8% and 29.3% for the Base and Police-without-Lights-on cases, respectively. This percentage reduced to 18.4% when the Trailer was present in the work zone. In the Trailer + Police-without-Lights-on and the SPE cases these percentages were 38.3% and 37.2%, respectively.

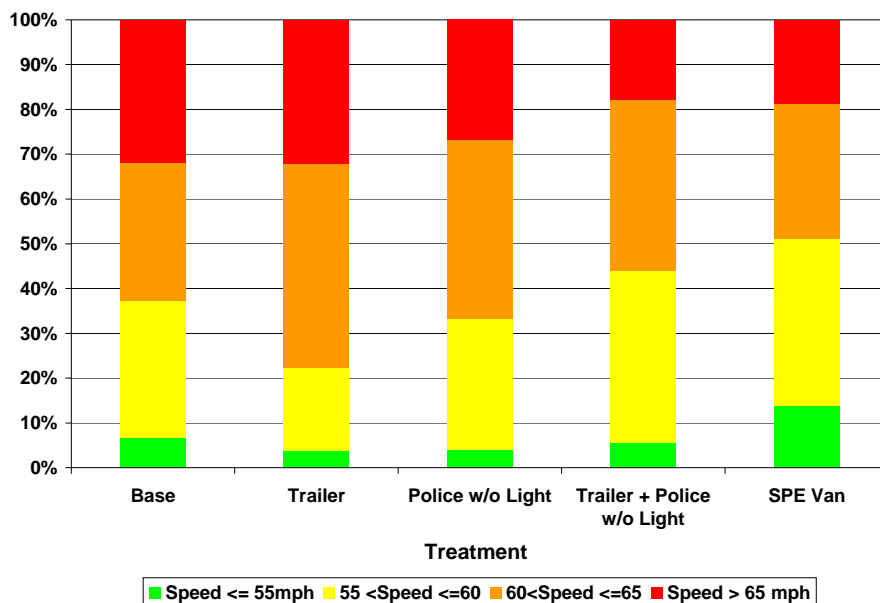


Figure II-6. The degree of speeding for free flowing cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and the SPE cases, the percentages speeding by 5-10 mph were 30.8% and 30.4%, respectively. For the other treatments, these percentages ranged from 38.3% to 45.6%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases 31.9% and 32.0% of drivers exceeded the speed limit by more than 10 mph. Police-without-Lights-on reduced this percentage to 26.8%, and the Trailer + Police-without-Lights-on and the SPE resulted in smaller percentages and reduced them to 17.8% and 18.6% respectively.

II.1.1.1.d. Summary of Spatial Effects of SPE on Free Flowing Cars on Median Lane

The SPE had spatial effects on two of the three data sets, as it kept the speeds lower at the downstream location by 3.8 mph in Dataset 2 and by 2.0 mph in Dataset 3. The spatial effect in the SPE was similar to trailer plus Police-without-Lights-on treatment. In addition, the SPE decreased the percentage of speeding drivers by 20.6% in Dataset 2 and 7.1% in Dataset 3, bringing the percent speeding to 79.4% and 86.3%, respectively. The SPE also reduced the percentage of excessive speeders (over 10 mph) by 14.2% and 13.3% in Datasets 2 and 3, bringing the percent speeding to 18.4% and 14.9%, respectively.

II.1.1.2. Shoulder lane

II.1.1.2.a. Dataset 1

Mean Speeds and Speed Reductions

The LSD test results for free flowing cars in the shoulder lane at the downstream location are given in Table II-4. It should be mentioned that three treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was closed during the data collection period for these three treatments, and that could influence traffic flow on the shoulder lane.

Table II-4. LSD Result for Free Flowing Cars in Shoulder Lane

	Mean Speed	Treatment
A	58.6	Trailer + Police w/o Lights on
A	58.6	Base
A	58.3	Trailer + Police w/ Lights on
A	57.9	SPE Van

As Table II-4 shows, the mean speeds for all three law enforcement treatments were not significantly different than the mean speed for the Base case. This means that none of the law enforcement methods had any spatial effect on the mean speed of free flowing cars on the shoulder lane.

The cumulative speed distribution curves for the free flowing vehicles in the shoulder lane are shown Figure II-7. No shift was observed in the cumulative speed distributions of any of the treatments compared to the Base case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

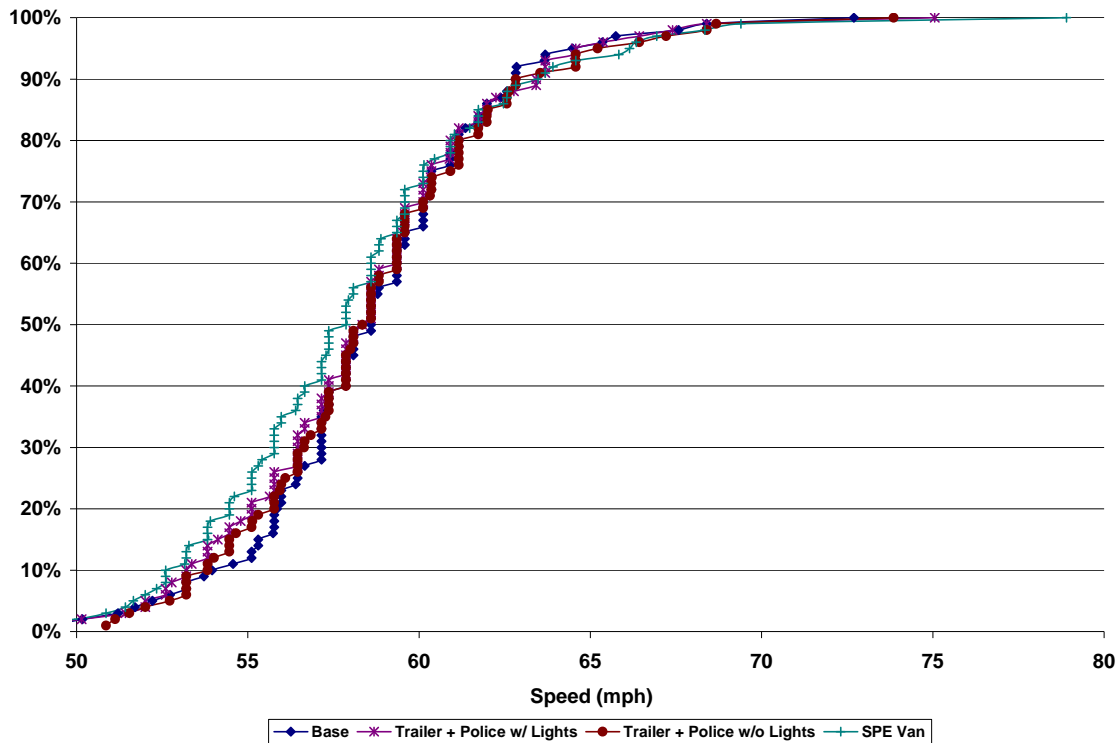


Figure II-7. Cumulative speed distribution for the free flowing cars in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-8. In the Base case, 88.3% exceeded the speed limit of 55 mph. The law enforcement methods slightly reduced this percentage when they were present in the work zone.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 53.7% for the Base case, and it ranged from 49.6% to 51.7% when the law enforcement was present in the work zone. This indicates that this level of speeding remained the same for all treatments.

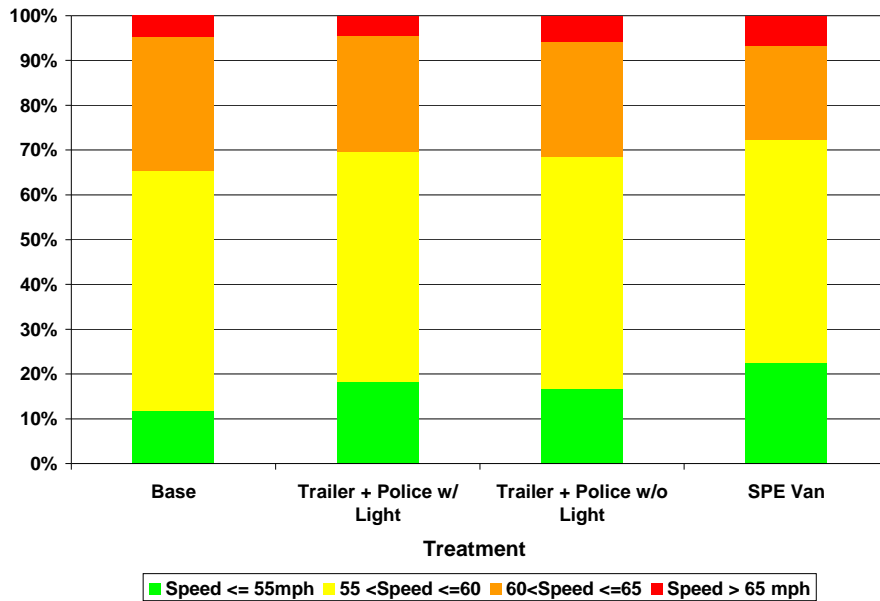


Figure II-8. The degree of speeding for free flowing cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, the percentage speeding by 5-10 mph was 29.8%, and for the law enforcement treatments the percentages ranged from 21.1% to 25.9%. This shows a small reduction in the percentage of free flowing cars in the shoulder lane exceeding the speed limit by 5-10 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 4.8% of the drivers exceed the speed limit by more than 10 mph. These percentages ranged from 4.5% to 6.7% when the law was being enforced in the work zone. The findings for the fourth degree of speeding showed that none of the law enforcement methods had an effect on reducing the percentage of high speeders.

II.1.1.2.b Dataset 2

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-5 shows the results of LSD test for free flowing cars traveling in the shoulder lane for Dataset 3.

Table II-5. LSD Result for Free Flowing Cars in Shoulder Lane

	Mean Speed	Treatment
A	58.6	Base
A	58.4	Trailer
B	56.6	Trailer + Police w/o Lights on
C	55.6	SPE Van

The mean speed in the Base case (58.6 mph) was similar to the mean speed in the Trailer case (58.4 mph), but significantly higher than the mean speed of all law enforcement methods (which ranged from 55.6 to 56.6 mph). On the other hand, the SPE and Trailer + Police-without-Lights-on treatments reduced the mean speed by 3.0 mph and 2.0 mph, to 55.6 mph and 56.6 respectively. As a result, the SPE and traditional law enforcement methods had significant spatial effects on the mean speed of free flowing cars in the shoulder lane

The cumulative speed distribution curves for the free flowing cars in the shoulder lane are shown in Figure II-9. The cumulative speed distributions for the law enforcement methods were shifted towards the left compared to the Base and Trailer cases. This shift was more pronounced for the SPE case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

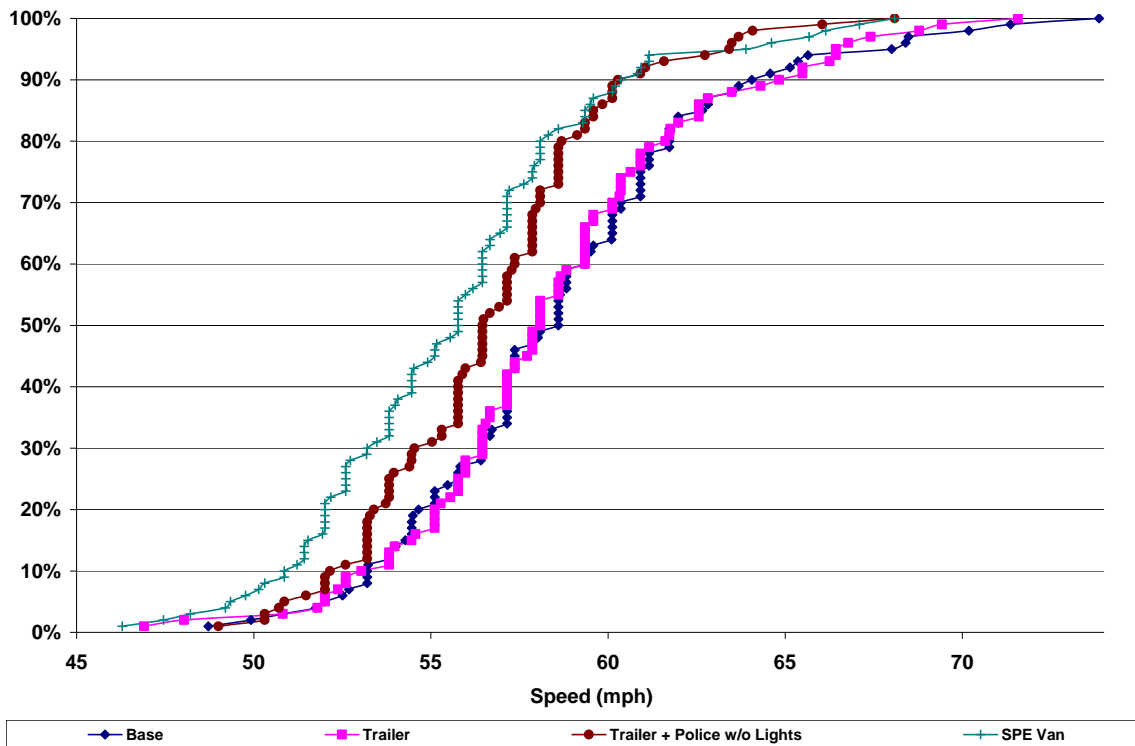


Figure II-9. Cumulative speed distribution for the free flowing cars in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-10. The percentage of drivers exceeding the speed limit of 55mph in the Base case was 79.4% and in the Trailer case was 83.2%. Traditional and automated law enforcement methods reduced these percentages to 68.9% and 56.0%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 43.0% for the Base case and 43.2% for the SPE case. In Trailer and Trailer + Police-without-Lights-on cases, the percentage increased to 51.5% and 54.6%, respectively.

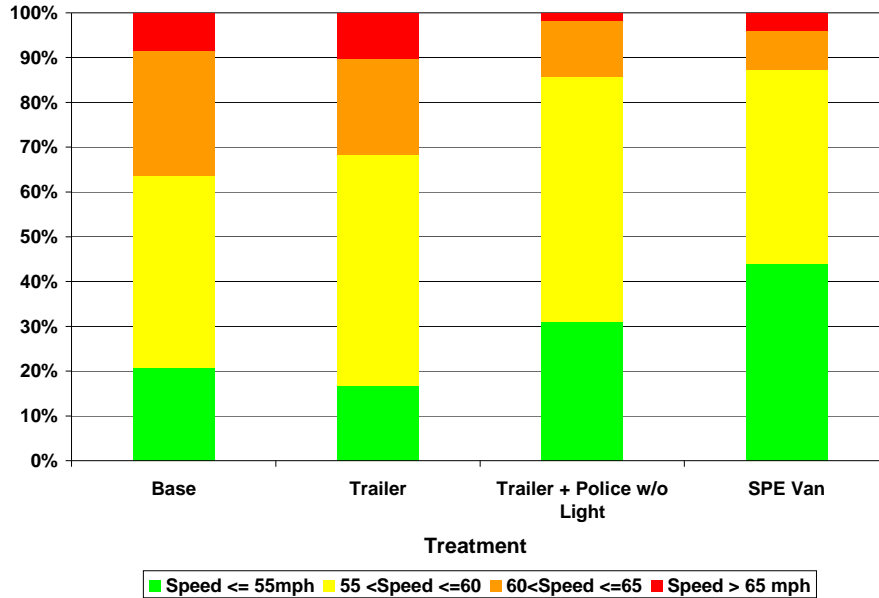


Figure II-10. The degree of speeding for free flowing cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 5-10 mph were 27.9% and 21.6%, respectively. The traditional law enforcement and the SPE methods reduced the third level speeding substantially to 12.6% and 8.8%, respectively.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases, the percentages speeding by more than 10 mph were 8.5% and 10.2%, respectively. The traditional law enforcement reduced this percentage to 1.7% while the SPE reduced it to 4.0%. Like in the third level of speeding, the reductions in the fourth level of speeding are also substantial.

II.1.1.2.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-6 shows the results of LSD test for free flowing cars in median lane for Dataset 3.

Table II-6. LSD Result for Free Flowing Cars in Shoulder Lane

	Mean Speed	Treatment
A	59.8	Base
A	59.8	Trailer
A	59.5	Police w/o Lights on
B	58.6	Trailer + Police w/o Lights on
C	57.2	SPE Van

The mean speed in the Base case (59.8 mph) was similar to the mean speed in the Trailer (59.8 mph) and Police-without-Lights-on (59.5 mph) cases. However, Trailer + Police-without-Lights-on and the SPE reduced the mean speed by 1.2 and 2.6 mph, to 58.6 and 57.2 mph. Thus, Trailer + Police-without-Lights-on and the SPE had spatial effects on mean speed reduction for free flowing cars in the shoulder lane.

The cumulative speed distribution curves for the free flowing cars in the shoulder lane are shown in Figure II-11. The cumulative speed distributions for Trailer + Police-

without-Lights-on and the SPE cases were shifted towards the left compared to the Base case, being the shift from the SPE curve more pronounced. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

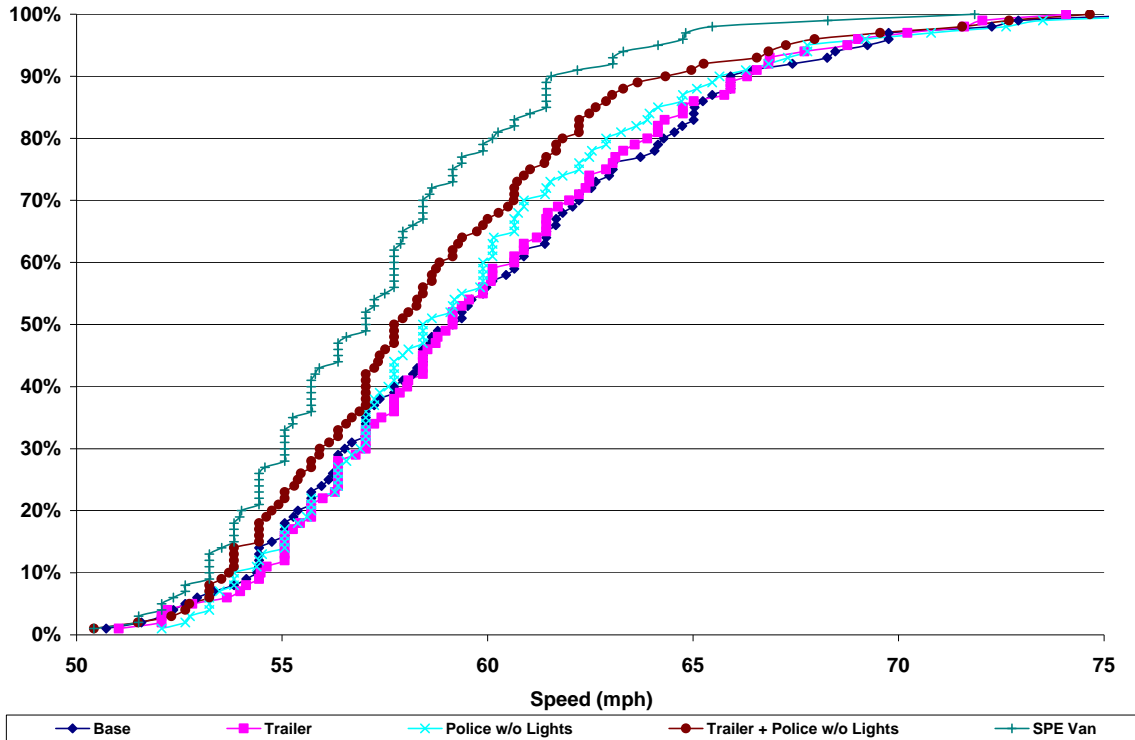


Figure II-11. Cumulative speed distribution for the free flowing cars in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-12. In the Base case 93.4% and in the Trailer case 88.2% exceeded the speed limit of 55 mph. For the traditional law enforcement methods, this percentage ranged from 78.6% to 86.2%, and for the SPE it was 72.1%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 39.8% in the Base case. This percentage ranged from 45.1% to 51.3% for other treatments. The increases in second level speeding are due to the decreases in third and fourth-level speeding, thus the shift from high speeding to low speeding is still beneficial, though speeding itself is not desirable.

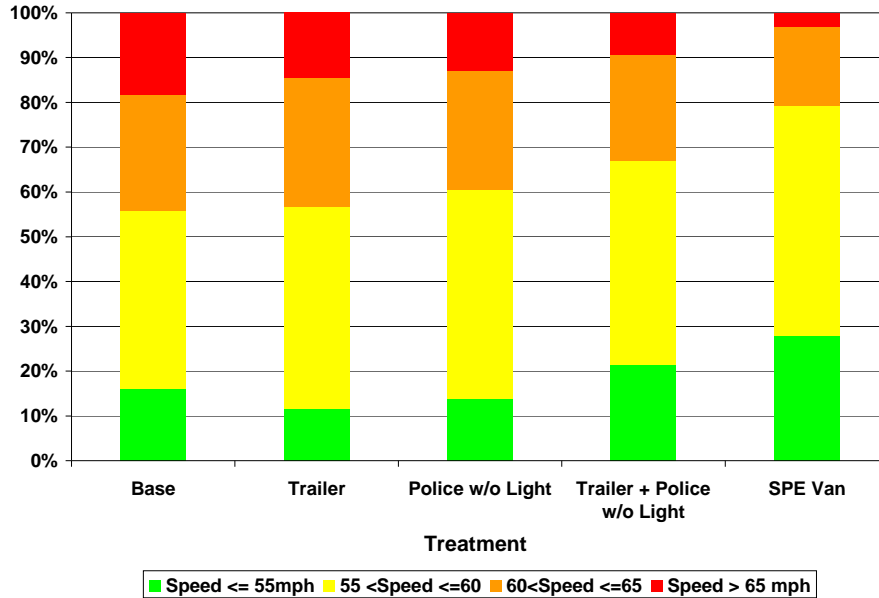


Figure II-12. The degree of speeding for free flowing cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 5-10 mph were 25.8% and 28.6%, respectively. The traditional law enforcement methods resulted in percentages that ranged from 23.8% to 26.7%, while the SPE reduced it to 17.7% mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases 18.3% and 14.5% of drivers exceeded the speed limit by more than 10 mph. Police-without-Lights-on reduced this percentage to 12.8%, Trailer + Police-without-Lights-on to 9.3%, and the SPE reduced it to 3.1%. Thus, SPE had some spatial effects in reducing the percentages of level 3 and level 4 speeding.

II.1.1.2.d. Summary of Spatial Effects of SPE on Free Flowing Cars on Shoulder Lane

The SPE had spatial effects on Datasets 2 and 3 and reduced the average speed of free flowing cars on the shoulder lane by 3.0 mph and 2.6 mph, respectively. In these two datasets, the spatial effect of SPE was greater than with the traditional speed enforcement methods. The SPE decreased the percentage of speeding drivers by 23.4% in Dataset 2 and by 21.3% in Dataset 3, bringing the percent speeding to 56% and 72.1%, respectively. Also, the reduction of excessive speeders (over 10 mph) with the SPE was 4.5% in Dataset 2 and 15.2% in Dataset 3, bringing the percent speeding to 4% and 3.1%, respectively.

II.1.2.Trucks

II.1.2.1.Median lane

II.1.2.1.a.Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test results for free flowing trucks on the median lane are shown in Table II-7. Three different treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was unexpectedly closed during the data collection periods for these treatments.

Table II-7. LSD Result for Free Flowing Trucks in Median Lane

	Mean Speed	Treatment
A	60.7	Trailer + Police w Lights on
A	59.4	Trailer + Police w/o Lights on
A	59.4	Base
B	56.8	SPE Van

As Table II-7 shows, the mean speeds for the traditional law enforcement methods were not significantly different than the mean speed in the Base case, but the SPE significantly decreased the mean speed by 2.6 mph, to 56.8 mph. Thus, the SPE had a significant spatial effect for free flowing trucks in the median lane.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for the free flowing trucks in the median lane are shown in Figure II-13. Neither of the traditional law enforcement methods resulted in a shift in the cumulative speed distribution. However, the SPE resulted in a significant shift towards the left in the distribution. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

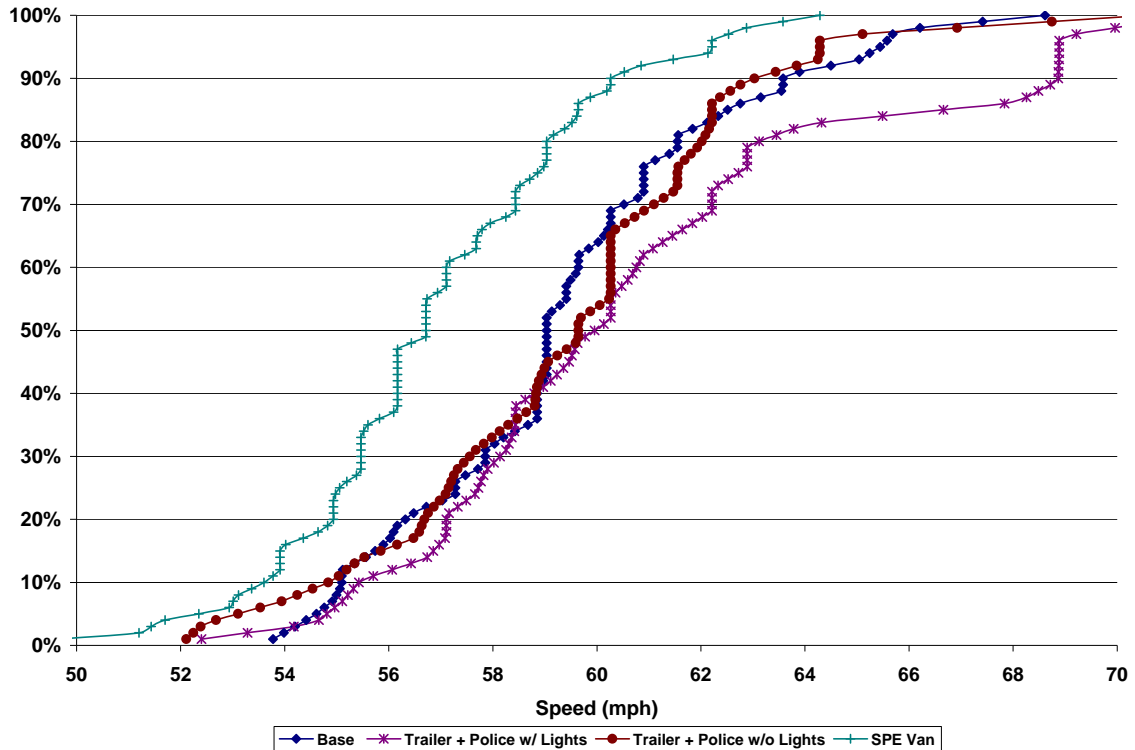


Figure II-13. Cumulative speed distribution for the free flowing trucks in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-14. In the Base case, 90.7% exceeded the speed limit of 55mph and the traditional law enforcement methods did not change it substantially however, the SPE reduced it to 75.0%.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the Base case, 53.5% of vehicles exceeded the speed limit by 5 mph. The traditional law enforcement in the work zone reduced this percentage to a range of 40.0% to 43.3% while for the SPE it increased to 61.5%. The increase in the second level of speeding is due to the reduction in the third and fourth levels of speeding.

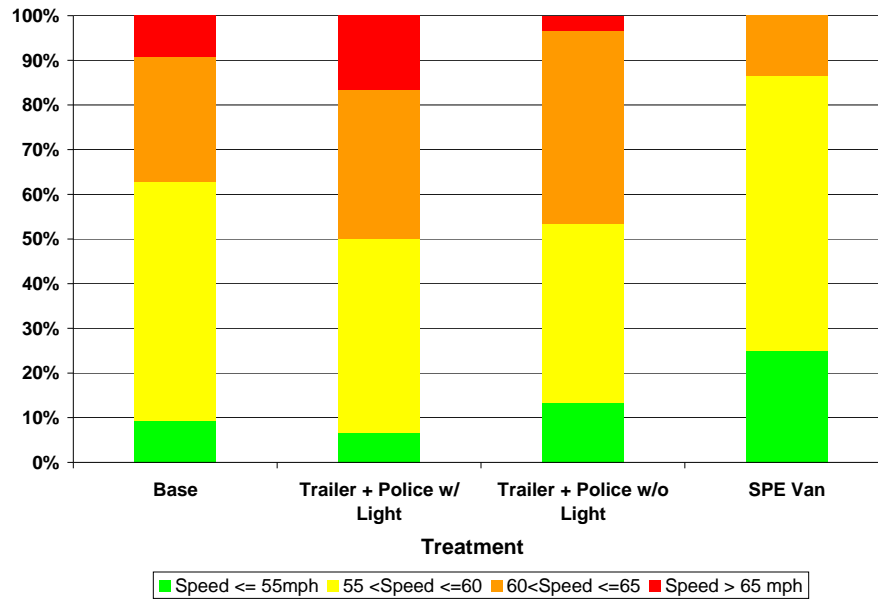


Figure II-14. The degree of speeding for free flowing trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, the percentage speeding by 5-10 mph was 27.9%. For traditional law enforcement methods the percentage ranged from 33.3% to 43.3%; however, the SPE reduced it to 13.5%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 9.3% of drivers exceeded the speed limit by more than 10 mph. This percentage increased to 16.7% for Trailer + Police-with-Lights-on case. It should be noted that Trailer + Police-without-Lights-on reduced this percentage to 3.3% and the SPE eliminated it. The increases in the third and fourth levels speeding in not desirable and indicates that the degree of speeding increased when the perceived threat (police with lights on) was passed.

II.1.2.1.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-8 shows the results of LSD test for free flowing trucks in median lane for Dataset 2.

Table II-8. LSD Result for Free Flowing Trucks in Median Lane

	Mean Speed	Treatment
A	59.5	Base
A	58.5	Trailer + Police w/o Lights on
A	58.3	Trailer
B	54.2	SPE Van

The mean speed in the Base case (59.5 mph) was similar to the mean speed of Trailer + Police-without-Lights-on (58.5 mph) and Trailer cases (58.3 mph). The SPE reduced the mean speed by 5.3 mph, to 54.2 mph, indicating some spatial effect in the mean speed of free flowing trucks in the median lane.

The cumulative speed distribution curves for the free flowing trucks in the median lane are shown in Figure II-15. The cumulative speed distributions showed a distinct shift

of the SPE curve towards the left. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

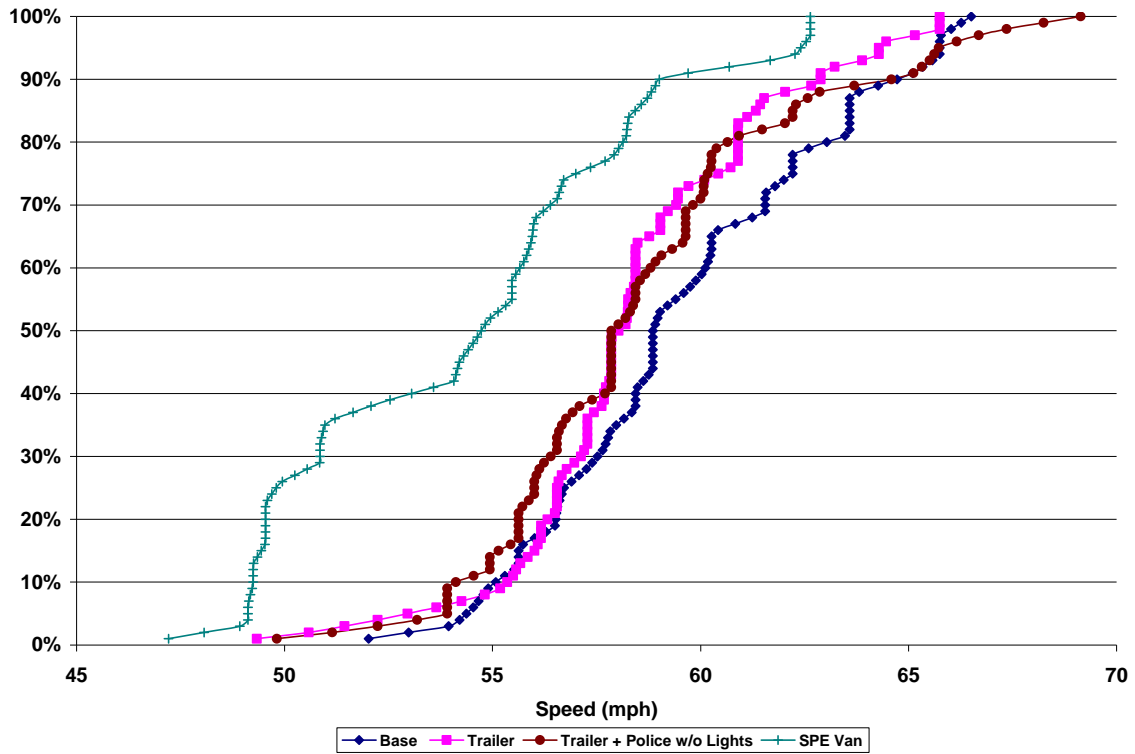


Figure II-15. Cumulative speed distribution for the free flowing trucks in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-16. In the Base case 87.9% and in the Trailer case 91.7% exceeded the speed limit of 55 mph. The traditional law enforcement method and SPE reduced these percentages to 83.7% and 46.9%, respectively.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 45.4% for the Base case and for the other treatments ranged from 37.5% (SPE) to 65.6%, indicating SPE slightly reduced the percentage of drivers exceeded the speed limit by 5 mph at the downstream location, but other two treatments increased it.

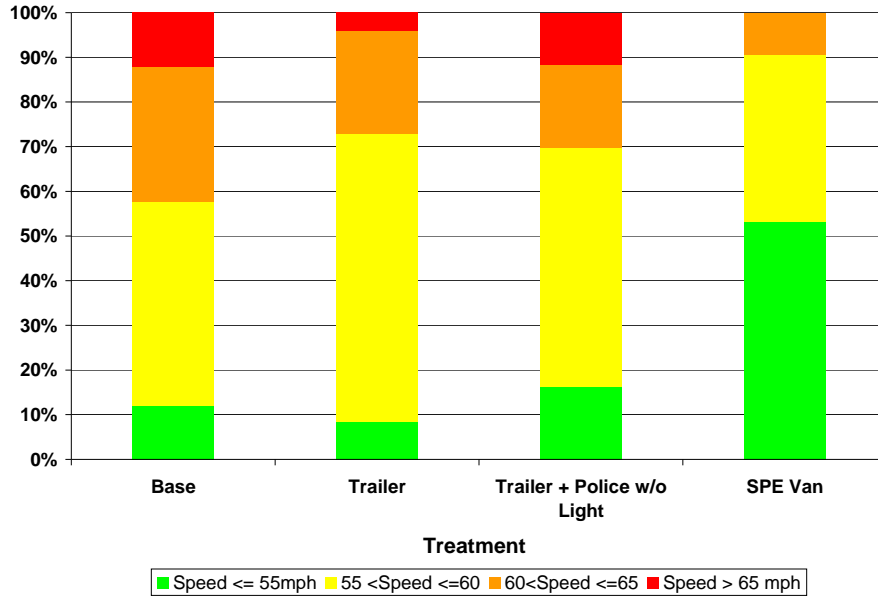


Figure II-16. The degree of speeding for free flowing trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, 30.3% of vehicles exceeded the speed limit by 5-10 mph, while these percentages decreased for all treatments, ranging from 9.4% (the SPE) to 22.9%. These reductions are desirable.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 12.1% of drivers exceeded the speed limit by more than 10 mph. For the law enforcement methods these percentages ranged from 0% (the SPE) to 11.6% (traditional law enforcement methods), indicating that the SPE was effective in reducing the excessive speeding.

II.1.2.1.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-9 shows the results of LSD test for free flowing trucks in median lane for Dataset 3.

Table II-9. LSD Result for Free Flowing Trucks in Median Lane

	Mean Speed	Treatment
A	57.3	Police w/o Lights on
A	56.8	Trailer
B	56.2	Base
C	56.0	Trailer + Police w/o Lights on
C	55.4	SPE Van

The mean speed in the Base case (56.2 mph) was similar to the mean speed in the Trailer + Police-without-Lights-on (56.0 mph) but significantly less than the mean speed in the Police-without-Lights-on (57.3 mph) and the Trailer (56.8 mph) cases. The SPE reduced the mean speed only by 0.8 mph to 55.4 mph.

The cumulative speed distribution curves for the free flowing trucks in the median lane are shown in Figure II-17. All the cumulative speed distributions were close to each

other, but SPE was slightly shifted to the left and the Trailer and Trail plus Police-without-Lights-on were shifted slightly to the right of the Base case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

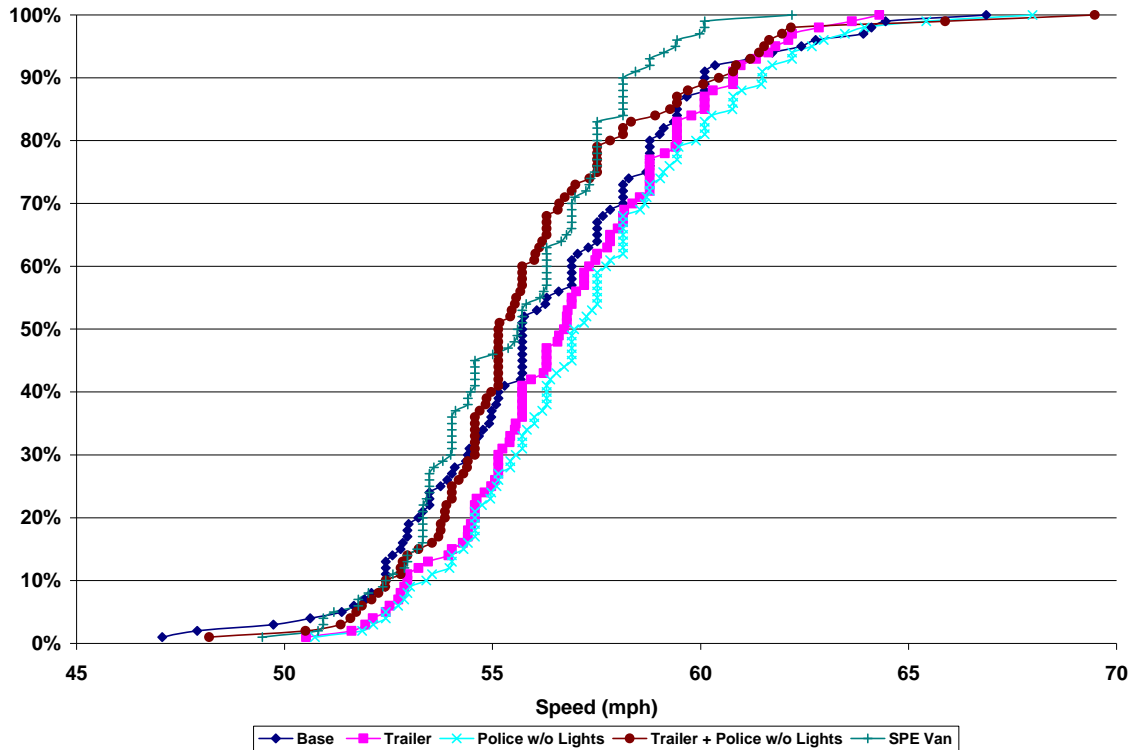


Figure II-17. Cumulative speed distribution for the free flowing trucks in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-18. In the Base case 62.1% and in the Trailer + Police-without-Lights-on case 60.1% exceeded the speed limit of 55 mph. For the Trailer and Police-without-Lights-on cases, these percentages were 70.2% and 75.4% respectively. For the SPE this percentage was 54.2%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 49.2% for the Base case and 55.3% for the Trailer case. For the law enforcement methods, these percentages ranged from 48.3% to 56.0%.

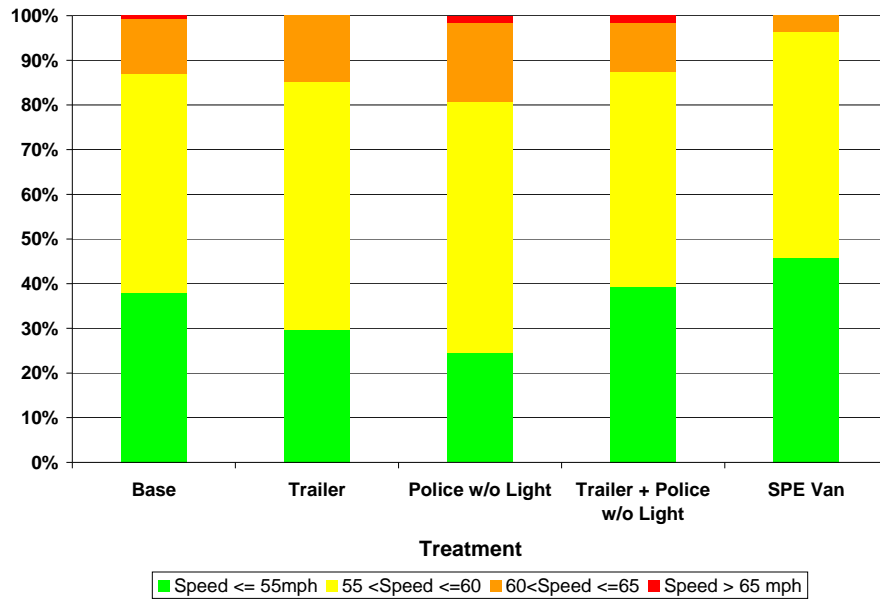


Figure II-18. The degree of speeding for free flowing trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 10 mph were 12.1% and 14.9%, respectively. For the traditional law enforcement methods, these percentages ranged from 10.8% to 17.9%, and the SPE reduced this percentage to 3.7%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases 1.0% and 0% of drivers exceeded the speed limit by more than 10 mph. Traditional law enforcement methods resulted in percentages that ranged from 1.3% to 2.0%, while SPE reduced it to 0%.

II.1.2.1.d. Summary of Spatial Effects of SPE on Free Flowing Trucks on Median Lane

The SPE had spatial effects on free flowing trucks on median lane, as their mean speed decreased by 2.6 mph in Dataset 1, and by 5.3 mph in Dataset 2, bringing mean speed down to 56.8 mph and 54.2 mph, respectively. A smaller decrease of 0.8 mph was also observed in the mean speed in Dataset 3. Effects of SPE in the mean speed were greater than those from traditional speed enforcement methods. In addition, the SPE reduced the percentage of speeding drivers by 15.7% in Dataset 1, by 41% in Dataset 2, and by 7.9% in Dataset 3. The percentage of drivers exceeding the speed limit by more than 10 mph was eliminated by the SPE in the three datasets, from 9.3%, 12.1%, and 1% in the Base case.

II.1.2.2. Shoulder lane

II.1.2.2.a. Dataset 1

Mean Speeds and Speed Reductions

Table II-10 shows the results of LSD test for free flowing Trucks in shoulder lane. It should be mentioned that three treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was closed during the data collection period for these treatments.

Table II-10. LSD Result for Free Flowing Trucks in Shoulder Lane

Mean Speed		Treatment
A	57.3	Base
A	B	Trailer + Police w/ Lights on
	B	Trailer + Police w/o Lights on
	B	SPE Van

The mean speed in the Base case (57.3 mph) was similar to the mean speed in the Trailer + Police-with-Lights-on (56.9 mph), but significantly higher (by 0.9 mph) than the mean speed of Trailer + Police-without-Lights-on (56.4 mph) and the SPE (56.4 mph). Although the mean speed during Trailer + Police-without-Lights-on and SPE was statistically significant, a difference of only 0.9 mph may not be considered significant in practice.

The cumulative speed distribution curves for the free flowing trucks in the shoulder lane are shown Figure II-19. No shift was observed in cumulative speed distributions from any treatment compared to the Base case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

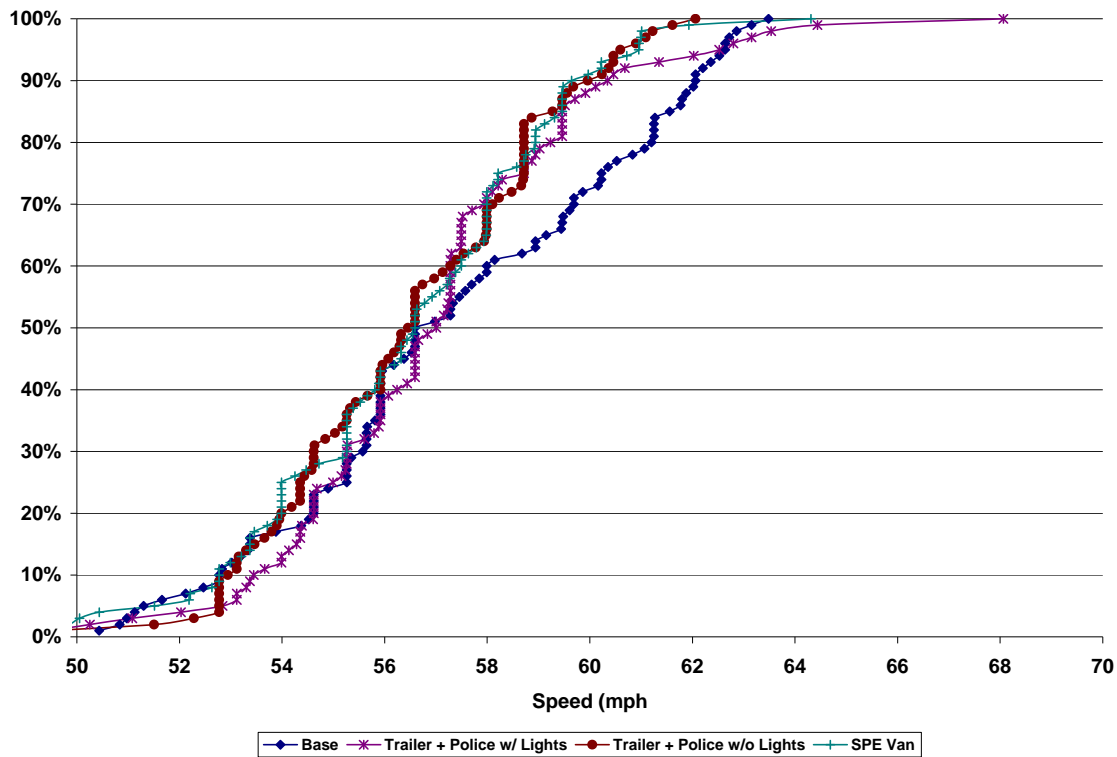


Figure II-19. Cumulative speed distribution for the free flowing trucks in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-20. In the Base case, 75.4% exceeded the speed limit of 55 mph. For the Law enforcement methods, this percentage ranged from 66.1% to 74.1%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 47.4% for the Base case and ranged from 49.8% to 62.3% when the law was being enforced in the work zone.

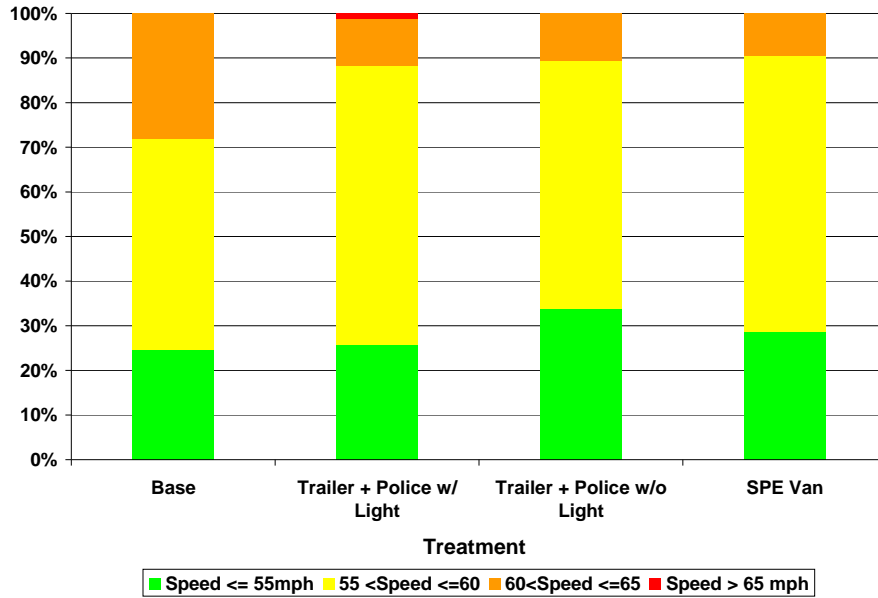


Figure II-20. The degree of speeding for free flowing trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, the percentage speeding by 5-10 mph was 28.1%. Law enforcement methods reduced this percentage to a range between 9.6% and 10.7%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, none of the drivers exceeded the speed limit by more than 10 mph. This percentage ranged from 0% to 1.2% for the law enforcement methods.

II.1.2.2.b Dataset 2

Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-11 shows the results of LSD test for free flowing trucks in shoulder lane for Dataset 2.

Table II-11. LSD Result for Free Flowing Trucks in Shoulder Lane

	Mean Speed	Treatment
A	57.8	Base
A	56.8	Trailer
B	55.6	Trailer + Police w/o Lights on
C	53.0	SPE Van

The mean speed in the Base case (57.8 mph) was similar to the mean speed in the trailer case (56.8 mph), but significantly higher than the mean speed of any of the law enforcement methods, which ranged from 53.0 to 55.6 mph. This indicates that the traditional law enforcement had 2.2 mph and SPE had 4.8 mph spatial effects.

The cumulative speed distribution curves for the free flowing trucks in the shoulder lane are shown in Figure II-21. The cumulative speed distributions for the law enforcement methods were shifted towards the left compared to the Base and Trailer cases, and this shift was more pronounced for the SPE. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

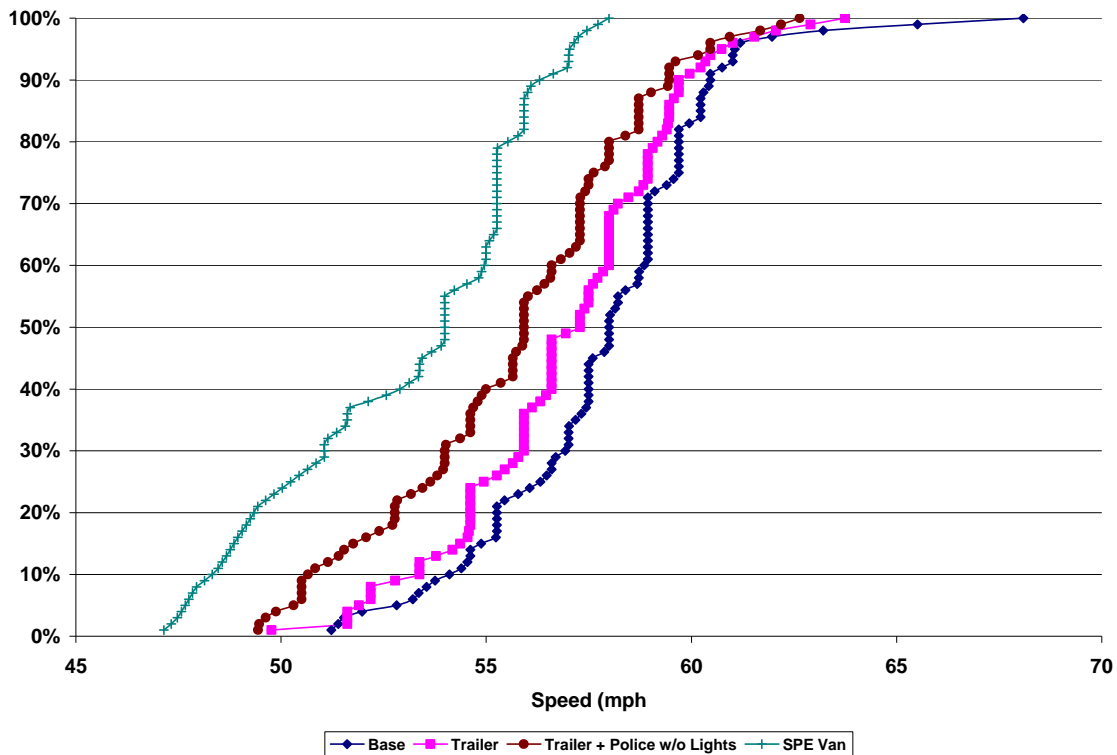


Figure II-21. Cumulative speed distribution for the free flowing trucks in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-22. In the Base case 84.2% and in the Trailer case 74.5% exceeded the speed limit of 55 mph. Traditional and automated law enforcement methods reduced these percentages to 58.9% and 35.9% respectively.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 66.7% and 64.7% in the Base and Trailer cases, respectively. Traditional law enforcement reduced this percentage to 51.8% and the SPE reduced it to 35.9%. This indicates that for the SPE none of the drivers exceeded the speed limit by more than 5 mph.

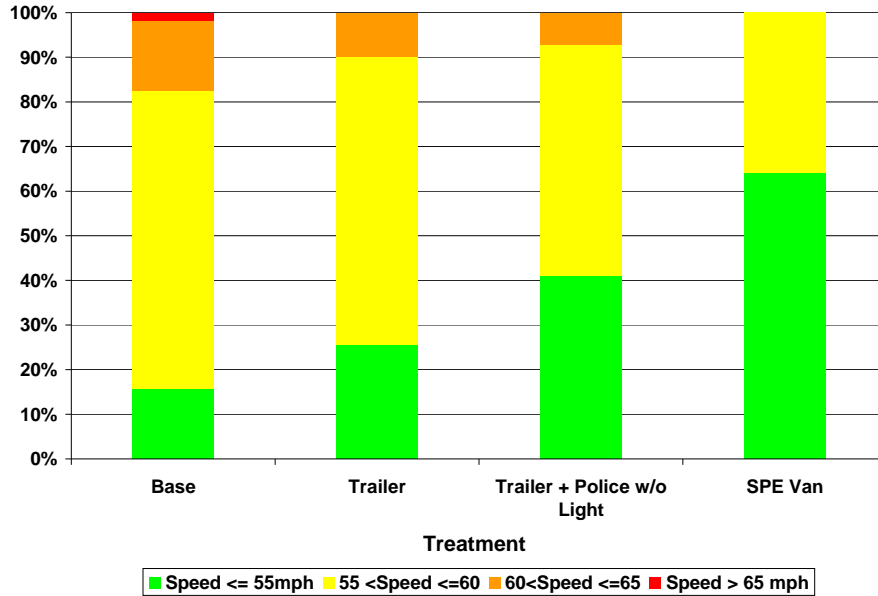


Figure II-22. The degree of speeding for free flowing trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, 15.8% of vehicles exceeded the speed limit by 5-10 mph. This percentage ranged from 7.2% to 0% (the SPE) for all of treatments, indicating a reduction at this speeding degree.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 1.7% of drivers fell into this speeding category. All treatments reduced this percentage to zero.

II.1.2.2.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-12 shows the results of LSD test for free flowing trucks in shoulder lane for Dataset 3.

Table II-12. LSD Result for Free Flowing Trucks in Shoulder Lane

			Mean Speed	Treatment
	A		57.7	Police w/o Lights on
B	A		57.3	Trailer
B	A	C	56.5	Base
B		C	56.1	Trailer + Police w/o Lights on
		C	55.6	SPE Van

The mean speed in the Base case (56.5 mph) was similar to the mean speed in all other cases. Thus, none of treatments was effective in reducing the mean speed of free flowing trucks in the shoulder lane at the downstream location for this Dataset.

The cumulative speed distribution curves for the free flowing trucks in the shoulder lane are shown in Figure II-23. None of the treatments resulted in a clear shift towards the left in the cumulative speed distribution. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

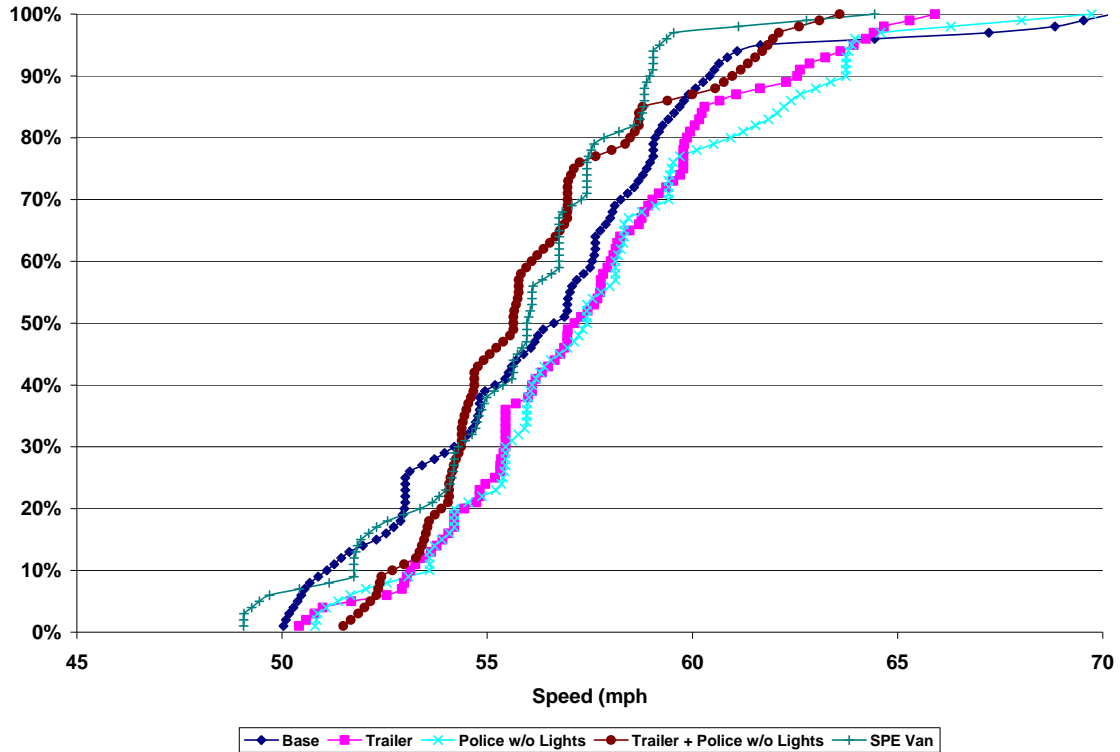


Figure II-23. Cumulative speed distribution for the free flowing trucks in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-24. In the Base case 60.0% and in the Trailer case 73.3% exceeded the speed limit of 55 mph. Police-without-Lights-on and the SPE changed this percentage to 79.3% and 62.9% respectively, and for Trailer + Police-without-Lights-on treatment this percentage was 62.5%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 52.0% for the Base case. Trailer + Police-without-Lights-on reduced this percentage to 41.67% but for the other cases these percentages ranged from 55.6% to 60.0%.

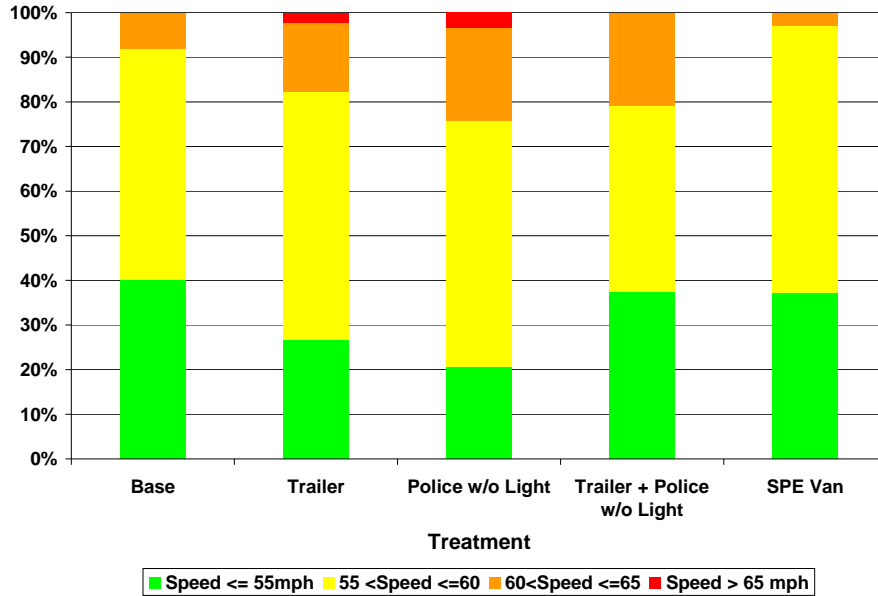


Figure II-24. The degree of speeding for free flowing trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, 8.0% of the drivers exceeded the speed limit by 10 mph. The SPE was the only treatment that reduced this percentage (to 2.9%).

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. None of the vehicles in the Base case exceeded the speed limit by more than 10 mph. For all of the treatments the percentage of drivers speeding by more than 10 mph ranged from 0.0% (the SPE and Trailer + Police-without-Lights-on) to 3.4%.

II.1.2.2.d. Summary of Spatial Effects of SPE on Free Flowing Trucks on Shoulder Lane

The SPE had spatial effects on free flowing trucks on shoulder lane, as their mean speed was reduced by 0.9 mph and 4.8 mph in Datasets 1 and 2, to 56.4 mph and 53 mph, respectively. It reduced the mean speed by 0.9 mph in Dataset 3, and the resulting speed was 55.6 mph. The speed reductions due to SPE were greater than the speed reductions due to traditional speed enforcement methods. The percentage of speeding drivers was reduced in the SPE by 4.2% in Dataset 1 and by 48.3% in Dataset 2, down to 71.2% and 35.9%, respectively.

II.2. General Stream

II.2.1.Cars

II.2.1.1.Median lane

II.2.1.1.a.Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test results for cars in general traffic stream in median lane are given in Table II-13. It should be mentioned that three different treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was unexpectedly closed during the data collection.

Table II-13. LSD Result for Sampled Cars in Median Lane

		Mean Speed	Treatment
	A	61.4	Trailer + Police w/ Lights on
B	A	61.1	Trailer + Police w/o Lights on
B	C	60.1	Base
	C	59.3	SPE Van

As Table II-13 shows, the mean speed for Trailer + Police w/ Lights on (61.4 mph) was significantly higher than the mean speed in the Base case (60.1 mph). The mean speed in the Base case was similar to the mean speed in the Trailer + Police w/o Lights on (61.1 mph) and the SPE (59.3 mph). As a result, none of the law enforcement methods had a spatial effect in the mean speed of general traffic stream in the median lane at the downstream location.

In addition to assessing the effects on mean speeds, the effects of treatments on the speed distribution were studied. The cumulative speed distribution curves for cars in general traffic stream in the median lane are shown in Figure II-25. No distinct shift was observed in cumulative speed distributions, except for the SPE case, which is slightly shifted towards left compared to the Base case. Two statistical tests, Chi Squared and Kolmogorov-Smirnov, were conducted to determine whether these distributions were significantly different. The results of these tests supported the results of the LSD test at the same confidence level.

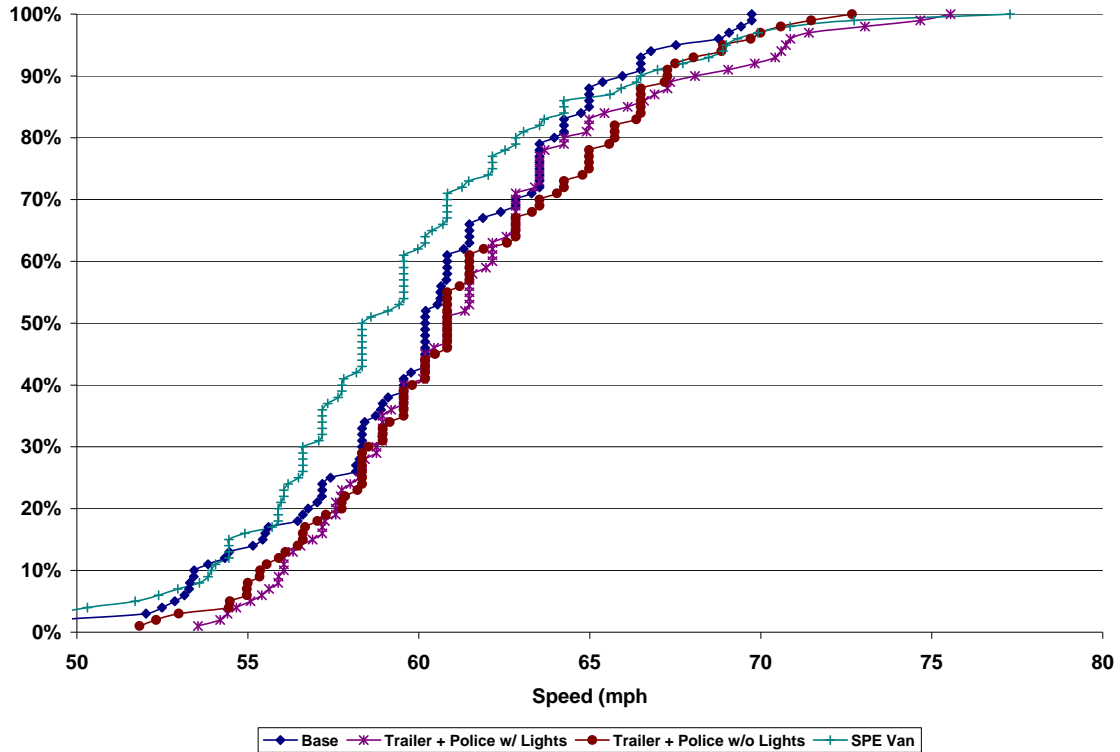


Figure II-25. Cumulative speed distribution for the sampled cars in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-26. In the Base case, 85.9% exceeded the speed limit of 55 mph. The traditional law enforcement methods did not reduce this percentage, which ranged from 91.2% to 94.5%, but the SPE slightly reduced it to 83%.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the Base case, 28.1% of vehicles exceeded the speed limit by 5 mph. When the law was being enforced in the work zone, these percentages ranged from 31.4% to 44.7%.

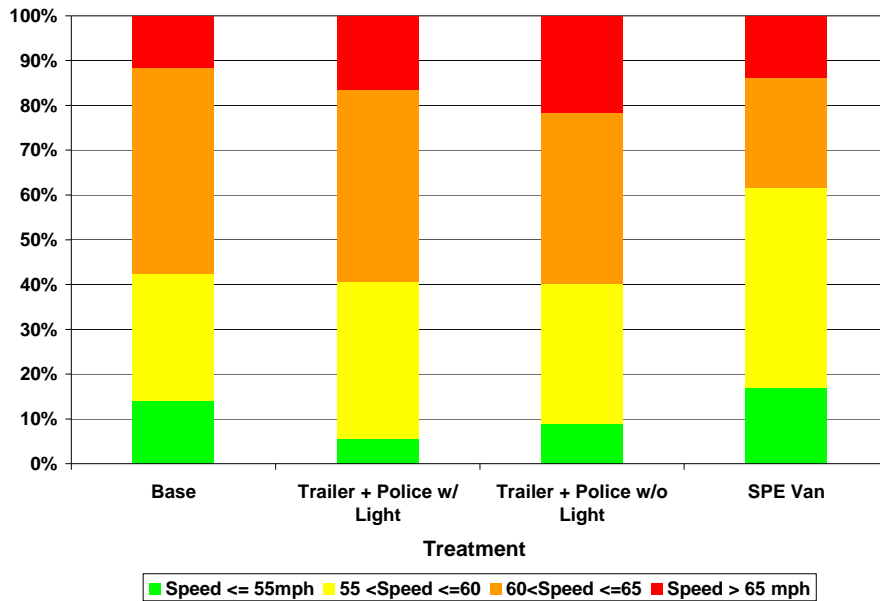


Figure II-26. The degree of speeding for sampled cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph, and in the Base case 46.2% of drivers did that. When traditional law enforcement method was used, this percentage ranged from 38.3% to 42.9%. However, SPE reduced it to 24.5%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph and in the Base case 11.5% of drivers did it. The percentages ranged from 13.8% to 21.6% when the law enforcement was present upstream in the work zone. The increases are not desirable and indicate that excessive speeding was prevalent in the downstream location and there was no spatial effect.

II.2.1.1.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-14 shows the results of LSD test for the cars in general traffic stream on median lane for Dataset 3.

Table II-14. LSD Result for Sampled Cars in Median Lane

	Mean Speed	Treatment
A	61.4	Base
B	60.0	Trailer
C	58.7	Trailer + Police w/o Lights on
C	58.5	SPE Van

The mean speed in the Base case (61.4 mph) was significantly higher than the mean speed of any of the treatments, which ranged from 58.5 to 60.0 mph. The presence of the speed display trailer in the work zone reduced the mean speed by 1.4 mph, to 60.0 mph, while the reductions with Trailer + Police-without-Lights-on and SPE were 2.7 and 2.9 mph, respectively. Thus, the SPE had 2.9 mph and traditional law enforcement methods had 2.7 mph spatial effect on the mean speed of cars in the general traffic stream in the median lane.

The cumulative speed distribution curves for the cars in general traffic stream in the median lane are shown Figure II-27. The cumulative speed distribution for Trailer was shifted towards the left compared to the Base case, and this shift was more pronounced for the law enforcement methods. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

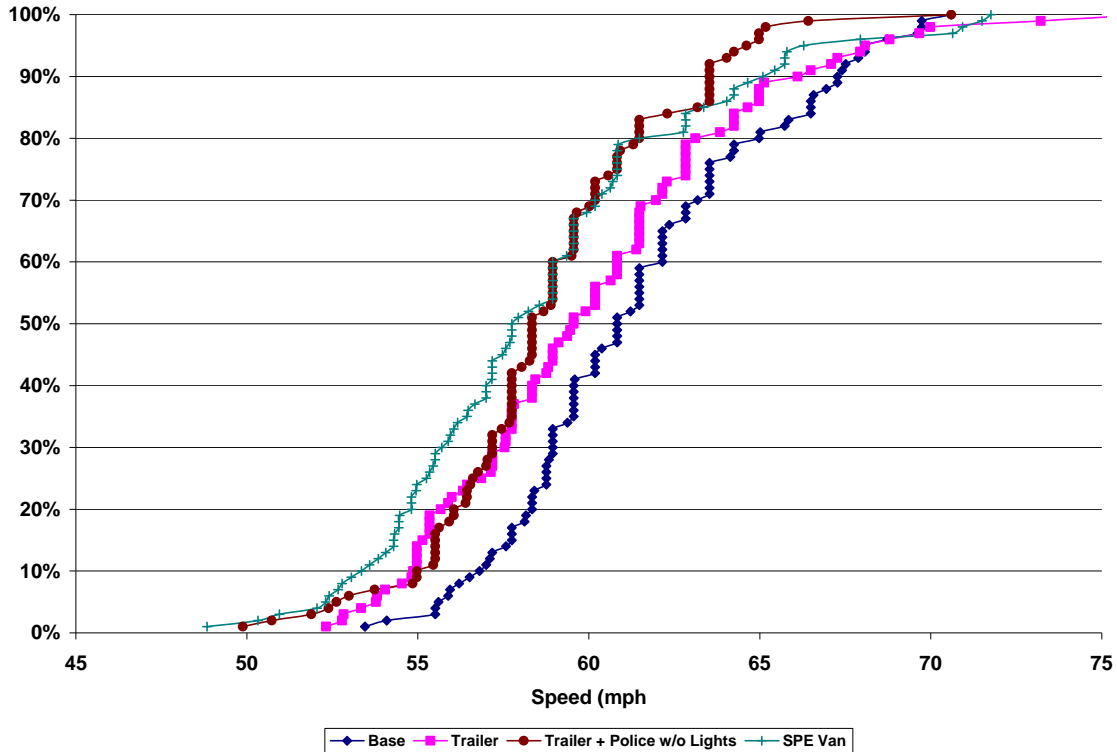


Figure II-27. Cumulative speed distribution for the sampled cars in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-28. In the Base case, 97.2% of the drivers exceeded the speed limit of 55 mph. In the Trailer and Trailer + Police-without-Lights-on cases 84.6% and 89.0% exceeded the speed limit, while with the SPE this percentage was reduced to 75.0%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 38.7% and 36.5% for the Base and SPE cases, respectively. For the traditional and automated law enforcement methods, these percentages were 58.2% and 42.7%, respectively.

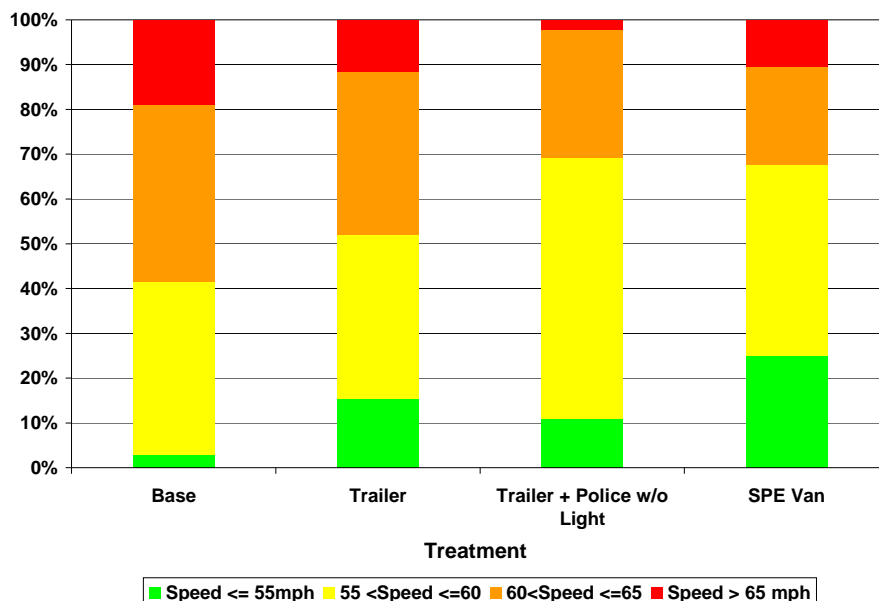


Figure II-28. The degree of speeding for sampled cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 5-10 mph were 39.6% and 36.5%, respectively. The traditional law enforcement method reduced it to 28.6% and SPE to 21.9%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 18.9% of drivers exceeded the speed limit by more than 10 mph. Trailer and the SPE reduced these percentages to 11.5% and 10.4%, while it was 2.2% in the Trailer + Police-without-Lights-on case.

II.2.1.1.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-15 shows the results of LSD test for the cars in general traffic stream traveling on the median lane for Dataset 3.

Table II-15. LSD Result for Sampled Cars in Median Lane

	Mean Speed	Treatment
A	61.1	Trailer
B	60.5	Police w/o Lights on
B	59.9	Base
B	59.8	Trailer + Police w/o Lights on
C	58.3	SPE Van

The mean speed in the Base case (59.9 mph) was lower than in the Trailer case (61.1mph) and similar to the mean speed in the Police-without-Lights-on (60.5 mph) and Trailer + Police-without-Lights-on (59.8 mph) cases. However, the SPE reduced the mean speed by 1.6 mph, to 58.3 mph. SPE was the only treatment that had the spatial effect.

The cumulative speed distribution curves for the cars in general traffic stream in the median lane are shown in Figure II-29. The curve for the SPE case is shifted towards

the left compared to the Base case, but no clear shift in the same direction was observed in other distributions. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

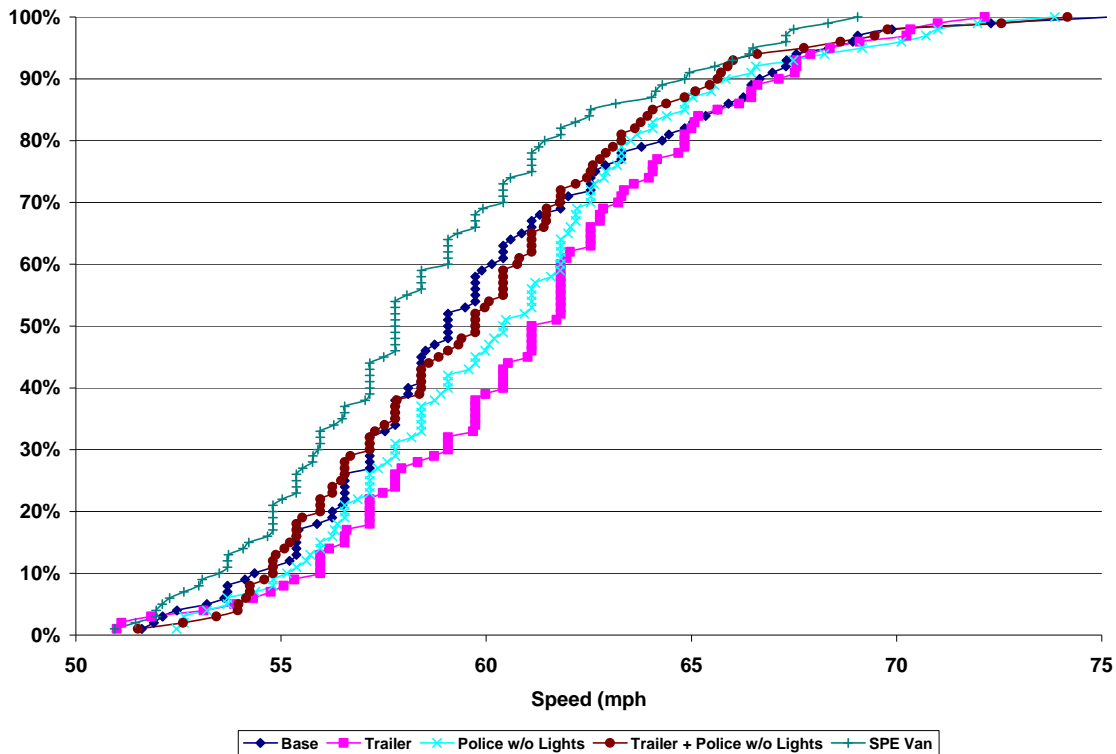


Figure II-29. Cumulative speed distribution for the sampled cars in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-30. In the Base case 88.2% and in the Trailer case 92.0% exceeded the speed limit of 55 mph. For the traditional law enforcement methods, these percentages ranged from 86.3% to 90.2% while in the SPE it was reduced to 77.9%.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 50.0% for the Base case and 31.2% for the Trailer case. Traditional law enforcement methods reduced these percentages to 36.0% - 39.4%, and SPE slightly increased it to 47.1%.

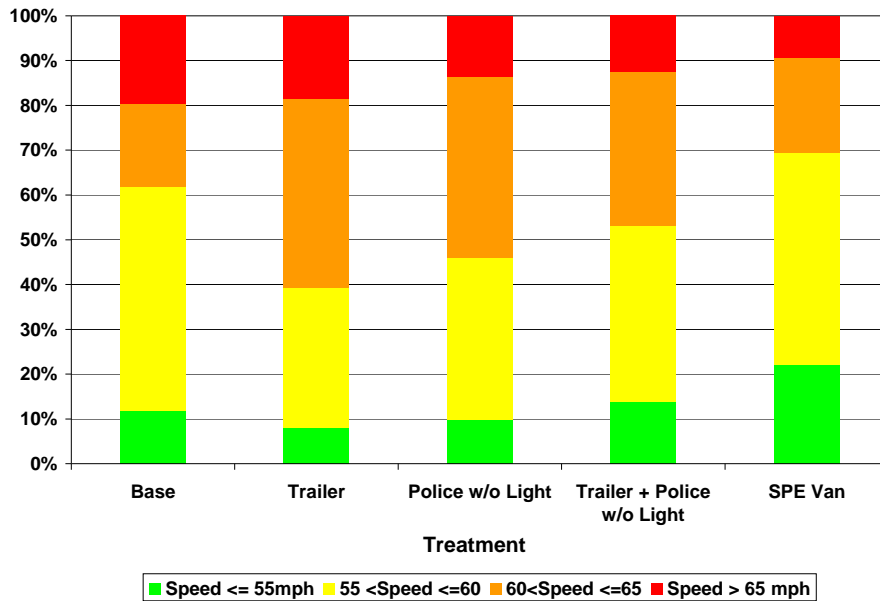


Figure II-30. The degree of speeding for sampled cars in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and the SPE cases, the percentages speeding by 5-10 mph were 18.4% and 21.4%, respectively. For the other treatments, these percentages ranged from 34.3% to 42.4%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases, 19.7% and 18.4% of drivers exceeded the speed limit by more than 10 mph. For the traditional law enforcement methods, these percentages ranged from 12.6% to 13.5%, and SPE reduced it to 9.3%. Thus, SPE reduce the third and fourth level speeding.

II.2.1.1.d. Summary of Spatial Effects of SPE on Cars in General Traffic Stream on Median Lane

The SPE reduced the average speed of cars in the general traffic stream on the median lane at the downstream location by 2.9 mph and by 1.6 mph on Datasets 2 and 3, bringing the mean speeds to 59.3 mph and 58.3 mph, respectively. Speed reductions in the SPE case were greater than those from traditional speed enforcement methods. The SPE increased the speed limit compliance as it decreased the percentage of speeding drivers by 2.9% in Dataset 1, by 22.2% in Dataset 2, and by 10.3% in Dataset 3, down to 83%, 75%, and 77.9%, respectively.

II.2.1.2. Shoulder lane

II.2.1.2.a. Dataset 1

Mean Speeds and Speed Reductions

Table II-16 shows the results of LSD test results for cars in general stream on the shoulder lane. It should be mentioned that three different treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was closed during the data collection.

Table II-16. LSD result for Sampled Cars in Shoulder Lane

	Mean Speed	Treatment
A	57.5	Trailer + Police w/o Lights on
A	57.3	Trailer + Police w/ Lights on
A	57.2	Base
A	57.1	SPE Van

As shown in Table II-16, the mean speeds for the three law enforcement treatments were not significantly different than the mean speed in the Base case, indicating no spatial effect on cars in general stream on the shoulder lane.

The cumulative speed distribution curves for the cars in general stream on the shoulder lane are shown Figure II-31. No shift was observed in the cumulative speed distributions of any treatment compared to the Base case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

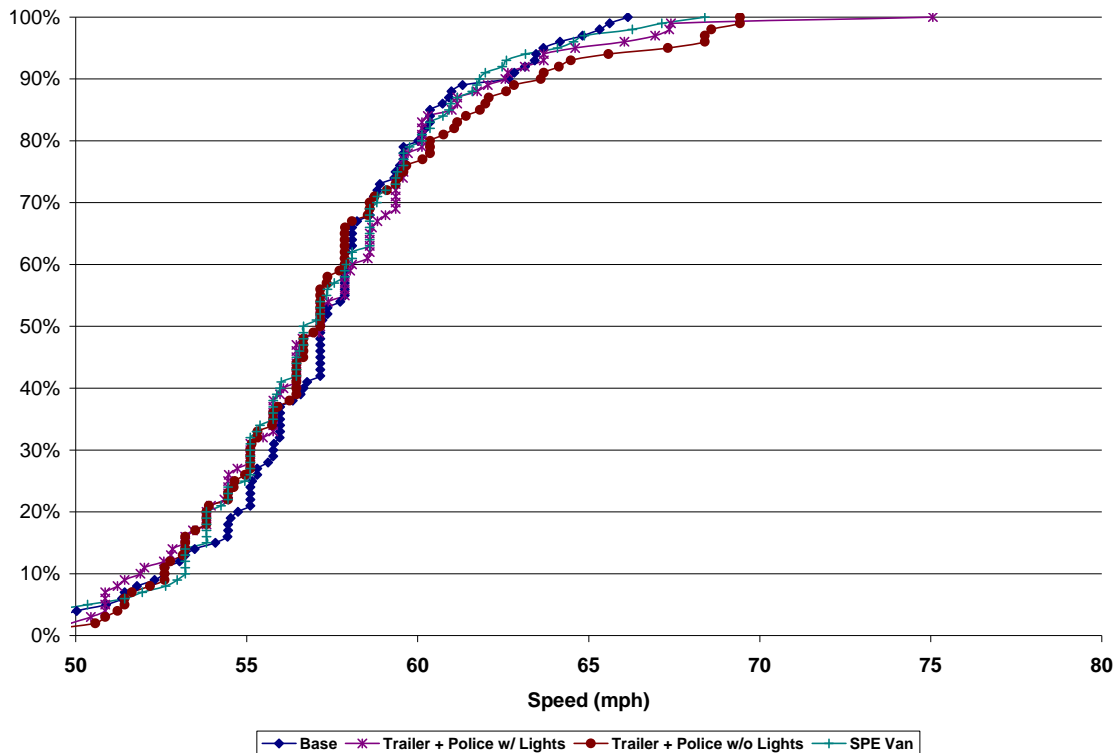


Figure II-31. Cumulative speed distribution for the sampled cars in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-32. In the Base case, 79.2% exceeded the speed limit of 55 mph. The law enforcement methods slightly reduced this percentage, with drivers exceeding the speed limit ranging from 72.4% to 75.0% (the SPE).

The proportion of drivers who exceeded the speed limit by 5 mph or less was 58.5% for the Base case. When the law was being enforced in the work zone these

percentages ranged from 50.0% to 53.9%, indicating some effect in decreasing the percentage of drivers exceeding the speed limit by 5 mph.

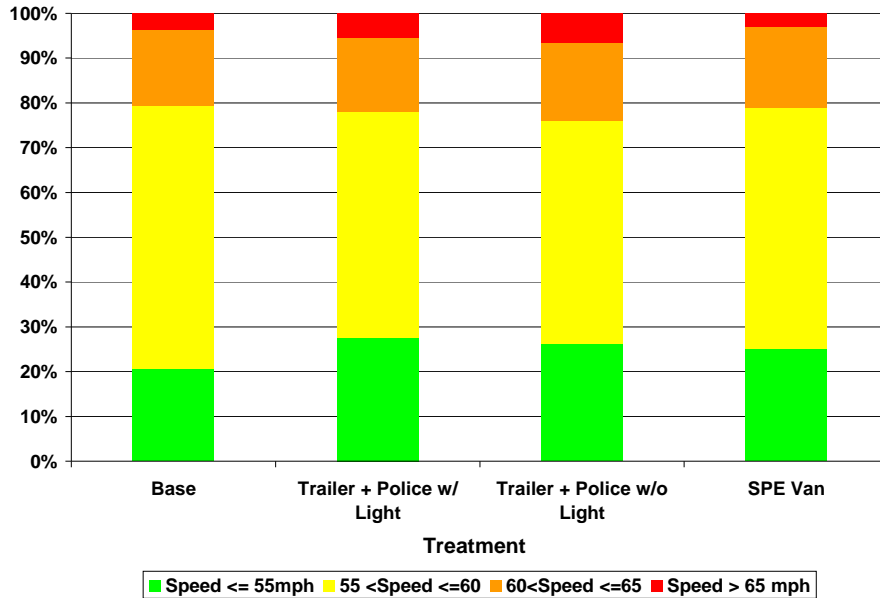


Figure II-32. The degree of speeding for sampled cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, the percentage speeding by 5-10 mph was 17.1%. For all law enforcement treatments, the percentage ranged from 16.5% to 18.0%, indicating no change in the proportion of drivers that exceeded the speed limit by 5-10 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 3.7% of drivers exceeded the speed limit by more than 10 mph. These percentages ranged from 3.1% to 6.5% when the law enforcement was present in the work zone.

II.2.1.2.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-17 shows the results of LSD test for the cars in general traffic stream traveling on the shoulder lane for Dataset 2.

Table II-17. LSD Result for Sampled Cars in Shoulder Lane

	Mean Speed	Treatment
A	56.7	Base
A	56.5	Trailer
B	55.0	Trailer + Police w/o Lights on
C	54.0	SPE Van

The mean speed in the Base case (56.7 mph) was similar to the mean speed in the Trailer case and significantly higher than the mean speed of all law enforcement methods (ranged from 54.0 to 55.0 mph). This shows spatial effect of 2.7 mph for SPE and 1.7 mph for the traditional law enforcement methods.

The cumulative speed distribution curves for the cars in general traffic stream in the shoulder lane are shown in Figure II-33. The curves for the law enforcement methods were shifted towards the left compared to the Base and Trailer cases. This shift was more pronounced for the SPE. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

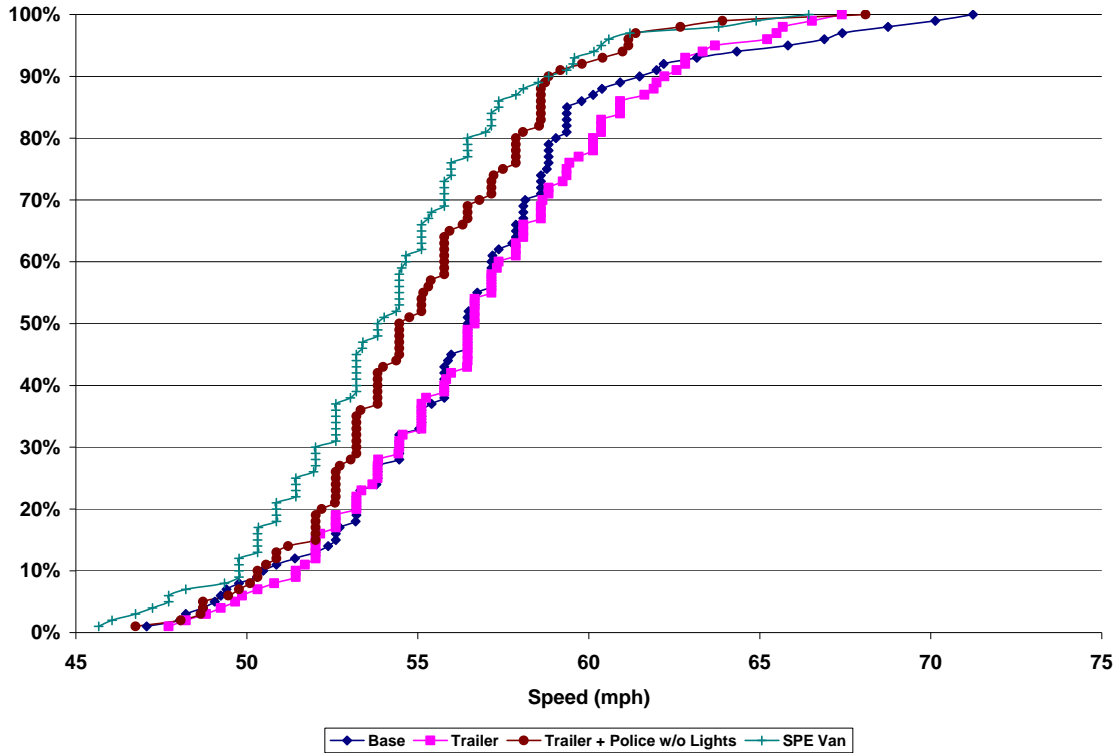


Figure II-33. Cumulative speed distribution for the sampled cars in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-34. In the Base case 67.2% and in the Trailer case 67.4% exceeded the speed limit of 55 mph. The traditional law enforcement methods reduced it to 49.0% and SPE to 38.6%.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 53.0% for the Base case. In Trailer and Trailer + Police-without-Lights-on cases, this percentage was reduced to 44.4% and 40.6%, respectively. A greater reduction was observed in the SPE case with 31.9%.



Figure II-34. The degree of speeding for sampled cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 5-10 mph were 8.2% and 18.2%. The traditional and automated law enforcement methods reduced these percentages to 7.3% and 5.4%, respectively.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and Trailer cases, the percentages speeding by more than 10 mph were 5.6% and 4.8%. The traditional and automated law enforcement methods reduced these percentages to 1.0% and 1.2%, respectively.

II.2.1.2.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-18 shows the results of LSD test for the cars in general traffic stream traveling on the shoulder lane for Dataset 3.

Table II-18. LSD Result for Sampled Cars in Shoulder Lane

	Mean Speed	Treatment
A	59.3	Trailer
B	58.5	Police w/o Lights on
B	58.4	Base
B	58.3	Trailer + Police w/o Lights on
C	57.3	SPE Van

The mean speed in the Base case (58.4 mph) was lower than in the Trailer case (59.3 mph), but similar to the mean speed in Police-without-Lights-on (58.5 mph) and Trailer + Police-without-Lights-on (58.3 mph) cases. It was higher than in the SPE case (57.3 mph) by 1.1 mph. This indicates that SPE had 1.1 mph spatial effect on mean speed reduction for cars in general traffic stream in the shoulder lane for this Dataset.

The cumulative speed distribution curves for the cars in general traffic stream in the shoulder lane are shown in Figure II-35. The cumulative speed distributions for the SPE case was shifted towards the left compared to the Base case. No shift in the same direction was observed in any other distribution. The results of Chi Squared and

Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

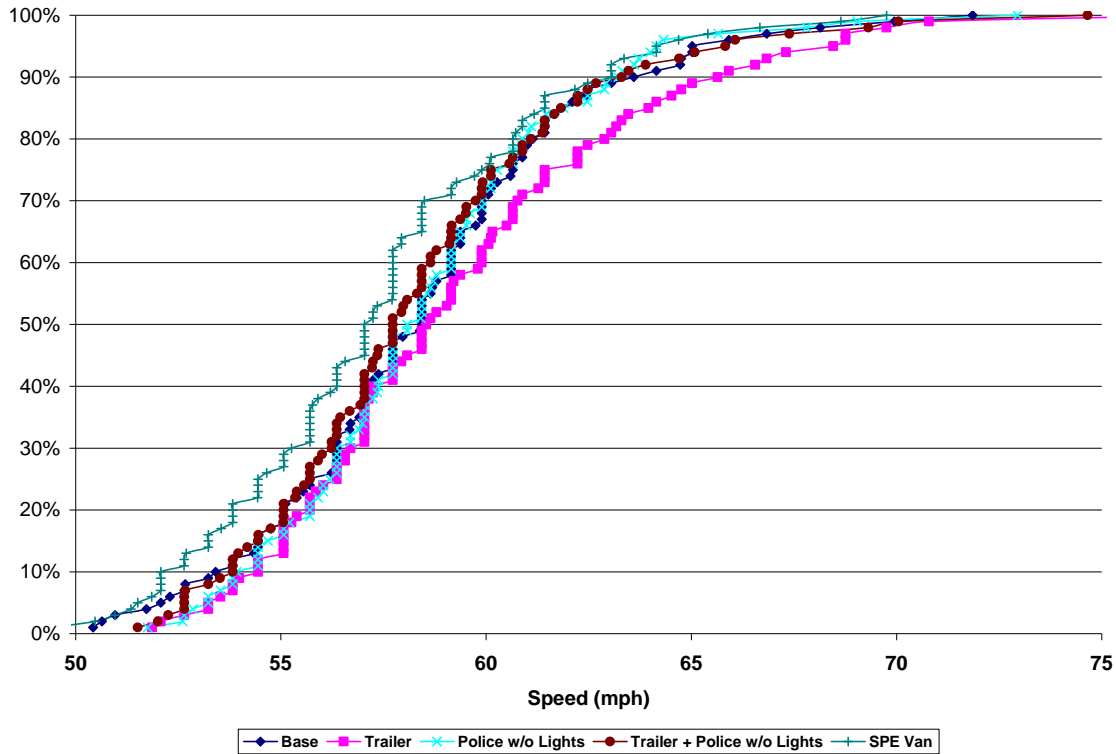


Figure II-35. Cumulative speed distribution for the sampled cars in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-36. In the Base case 83.4% and in the Trailer case 87.4% exceeded the speed limit of 55 mph. For the traditional law enforcement methods, these percentages ranged from 82.0% to 84.4%. For the SPE it was 73.8%, showing a reduction in the speeders downstream the treatment location.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 55.4% for the Base case, and these percentages ranged from 49.5% to 56.1% for other treatments.

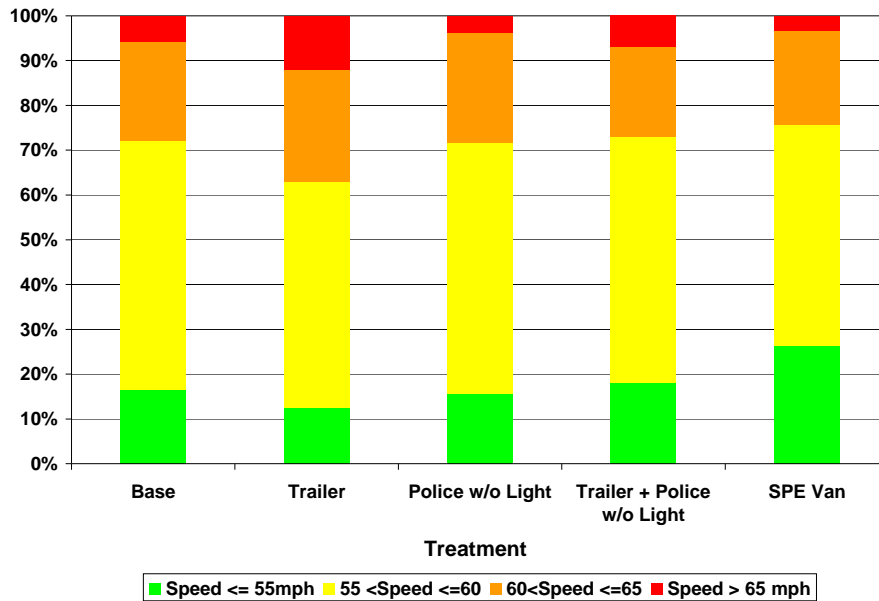


Figure II-36. The degree of speeding for sampled cars in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 5-10 mph were 22.3% and 25.1%, respectively. The law enforcement methods resulted in percentages that ranged from 20.0% to 24.6%.

In the Base and Trailer cases, 5.7% and 12.0% of drivers exceeded the speed limit by more than 10 mph, while law enforcement methods resulted in percentages that ranged from 3.3% to 6.9%.

II.2.1.2.d. Summary of Spatial Effects of SPE on Cars in General Traffic Stream on Shoulder Lane

The SPE had 2.7 mph and 1.1 mph spatial effects in Datasets 2 and 3, where the average speed of cars in the general traffic stream on shoulder lane was reduced to 54 mph and 57.3 mph, respectively. The speed reductions in the SPE case were greater than traditional speed enforcement methods. The SPE increased the speed limit compliance, as it decreased the percentage of speeding drivers by 4.3% in Dataset 1, 28.6% in Dataset 2, and 9.6% in Dataset 3, down to 75.0%, 38.6%, and 73.8%, respectively.

II.2.2.Trucks

II.2.2.1.Median lane

II.2.2.1.a.Dataset 1

Mean Speeds and Speed Reductions

The Least Significance Difference (LSD) test results for trucks in general traffic stream in median lane are given in Table II-19. It should be mentioned that three different treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was closed during the data collection.

Table II-19. LSD Result for Sampled Trucks in Median Lane

	Mean Speed	Treatment
A	60.7	Trailer + Police w/ Lights on
B	58.9	Trailer + Police w/o Lights on
B	58.6	Base
C	56.7	SPE Van

As shown in Table II-19, the mean speed in the Trailer + Police-with-Lights-on case (60.7 mph) was significantly higher than the mean speed of the Base case (58.6 mph). The mean speed in the Base case was similar to Trailer + Police-without-Lights-on (58.9mph), but higher than the speed for the SPE case (56.7 mph) by 1.9 mph. Therefore, SPE had 1.9 mph spatial effect on the mean speed of trucks in general traffic stream in the median lane for Dataset 1.

The cumulative speed distribution curves for the trucks in general traffic stream in the median lane are shown Figure II-37. Only the SPE resulted in a significant shift towards the left respect to the Base case. Two statistical tests, Chi Squared and Kolmogorov-Smirinov, were conducted to determine whether these distributions were significantly different. The results of these tests supported the results of the LSD test at the same confidence level.

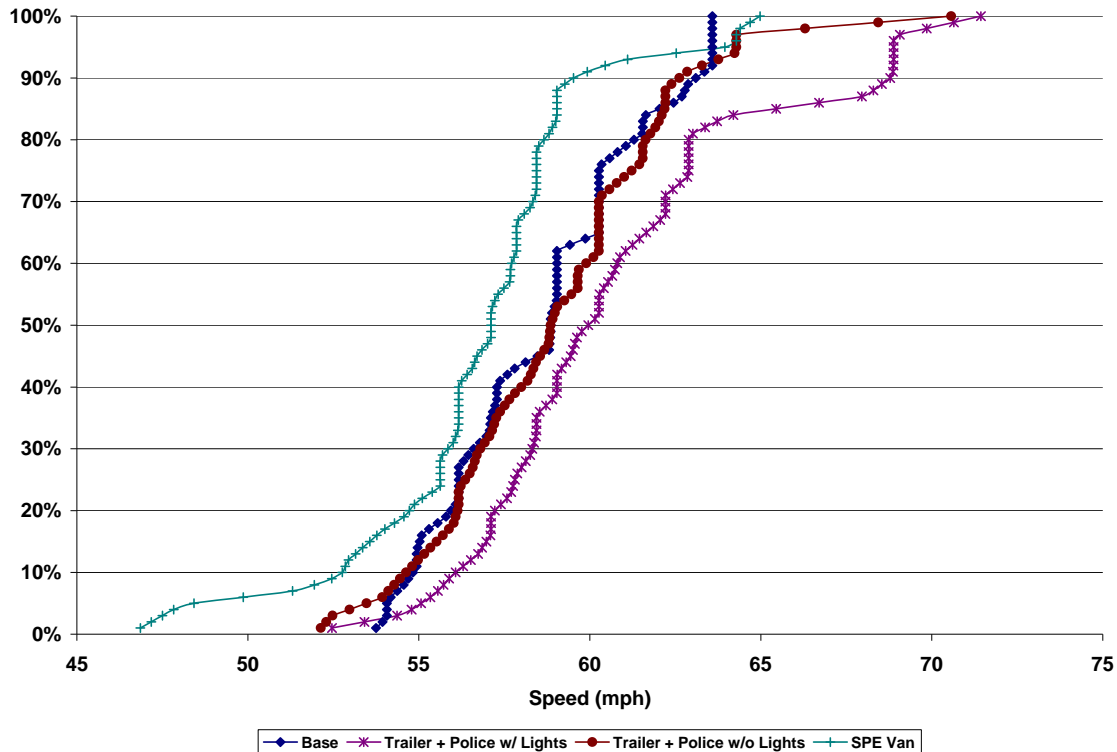


Figure II-37. Cumulative speed distribution for the sampled trucks in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-38. In the Base case, 84.2% exceeded the speed limit of 55mph. The traditional law enforcement methods did not reduce this percentage, which ranged from 85.7% to 93.7%; however, the SPE slightly reduced it to 76.7%.

The second level of speeding corresponds to exceeding the speed limit by 5 mph or less. In the Base case, 47.4% of vehicles exceeded the speed limit by 5 mph. The Trailer + Police-with-Lights-on and Trailer + Police-without-Lights-on treatments slightly reduced this percentage to 43.8% and 45.7% respectively. However, for the SPE this percentage increased to 67.4%. The increase in the second level of speeding was because of the substantial decrease in the third level of speeding.



Figure II-38. The degree of speeding for sampled trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, the percentage speeding by 5-10 mph was 36.8%. The traditional law enforcement reduced these percentages to a range of 34.4% to 37.1%, while the SPE brought it down to 9.3%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base and the SPE cases, none of the drivers exceeded the speed limit by more than 10 mph. This percentage increased to 3.3% for Trailer + Police-without-Lights-on, and to 15.6% for Trailer + Police-with-Lights-on case.

II.2.2.1.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-20 shows the results of the LSD test for the trucks in the general traffic stream traveling on the median lane for Dataset 2.

Table II-20. LSD Result for Sampled Trucks in Median Lane

	Mean Speed	Treatment
A	59.5	Base
B	57.9	Trailer
B	57.8	Trailer + Police w/o Lights on
C	56.2	SPE Van

The mean speed in the Base case (59.5 mph) was significantly higher than the mean speed for Trailer case (57.9 mph) and the traditional speed enforcement method (57.8 mph). The greatest reduction was of 3.3 mph, observed in the SPE case (56.2 mph). Thus, all of the treatments had some spatial effect in the mean speed of trucks in the general traffic stream in median lane and SPE was on top by 3.3 mph reduction.

The cumulative speed distribution curves for the trucks in the general traffic stream in the median lane are shown Figure II-39. The cumulative speed distributions for the SPE, Trailer, and Trailer + Police-without-Lights-on were shifted towards the left compared to the Base case, and this shift was more pronounced for the SPE. The

results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

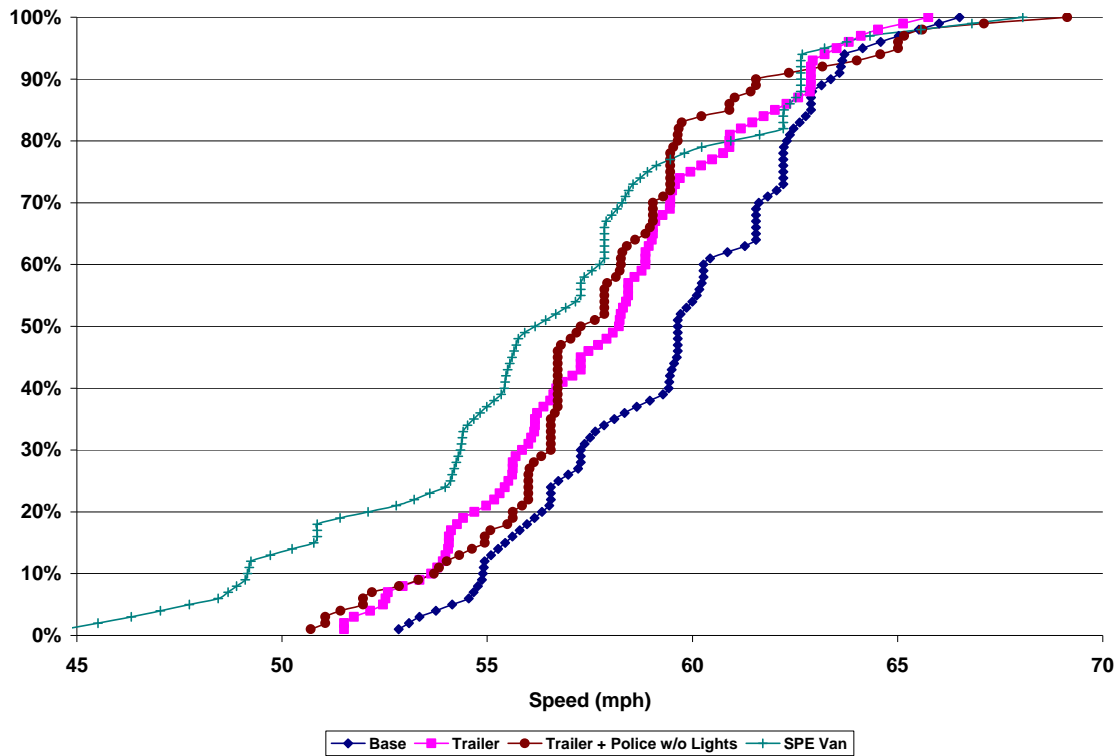


Figure II-39. Cumulative speed distribution for the sampled trucks in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-40. In the Base case, 85.3% of drivers exceeded the speed limit of 55 mph. This percentage was reduced to 61.8% for the SPE and to about 80% for others.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 38.2% for the Base case and 53.5% for the Trailer case. For the traditional and automated law enforcement methods, these percentages were 65.6% and 38.2%, respectively.

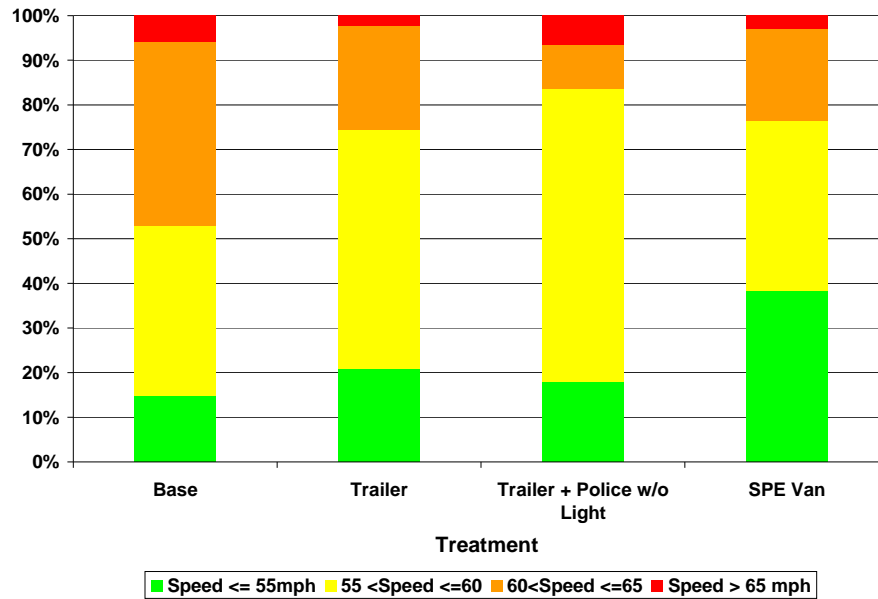


Figure II-40. The degree of speeding for sampled trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, 41.2% of drivers exceeded the speed limit. Trailer and the SPE reduced these percentages to 23.3% and 20.6% respectively, while Trailer + Police-without-Lights-on resulted in 9.8%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 5.9% of drivers exceeded the speed limit by more than 10 mph. Trailer and the SPE reduced this percentage to 2.3% and 2.9% respectively, whereas it was 6.6% in the Trailer + Police-without-Lights-on case.

II.2.2.1.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-21 shows the results of LSD test for the trucks in general traffic stream traveling on the median lane for Dataset 3.

Table II-21. LSD Result for Sampled Trucks in Median Lane

	Mean Speed	Treatment
A	57.5	Trailer
A	57.4	Police w/o Lights on
B	56.5	Trailer + Police w/o Lights on
B	56.4	Base
C	55.5	SPE Van

The mean speed in the Base case (56.4 mph) was lower than the mean speed in the Trailer (57.5 mph) and Police-without-Lights-on (57.4 mph). However, mean speed in the SPE case was reduced by 0.9 mph, to 55.5 mph. Therefore, SPE had 0.9 mph spatial effect on the mean speed of trucks in general traffic stream in the median lane at the downstream location.

The cumulative speed distribution curves for the trucks in general traffic stream in the median lane are shown in Figure II-41. The cumulative speed distributions for the

SPE case was slightly shifted towards the left compared to the Base case. No distinct shift towards the same direction was observed in the other distributions. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

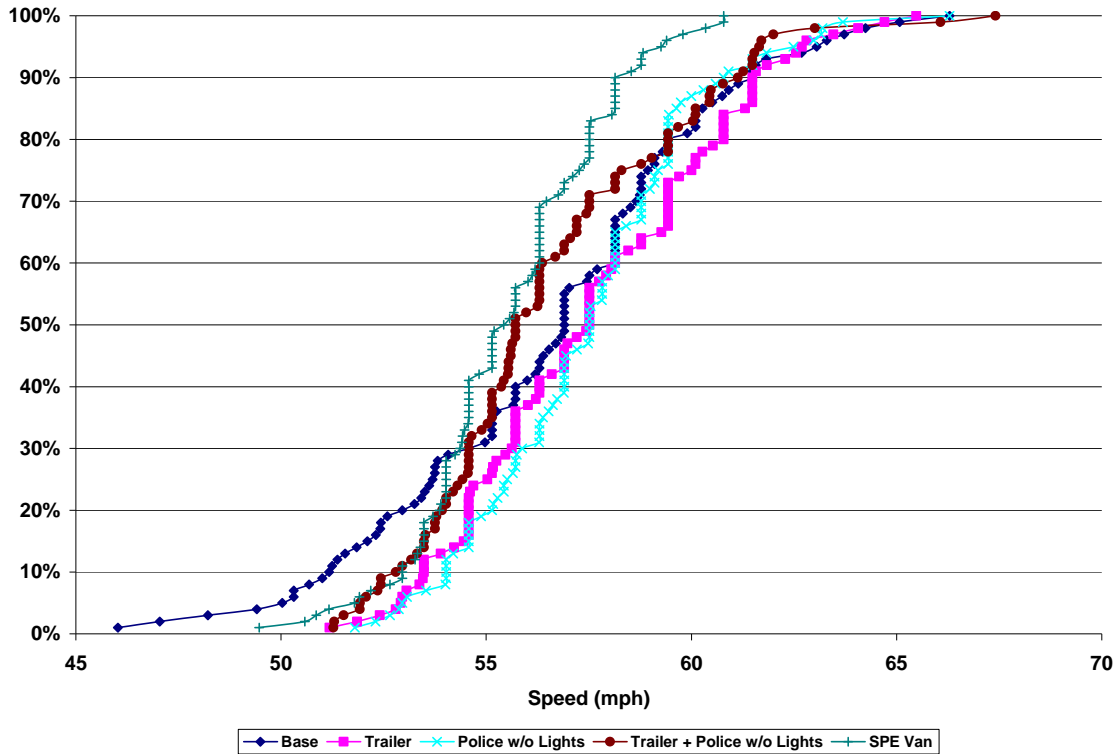


Figure II-41. Cumulative speed distribution for the sampled trucks in the median lane.

Degree of Speeding

The degree of speeding is presented in Figure II-42. In the Base case 68.2% and in the Trailer case 75.3% exceeded the speed limit of 55 mph. For the Police-without-Lights-on case this percentage was 81.8%, while in the Trailer + Police-without-Lights-on and the SPE cases, the percentages were 65.3% and 57.8%, respectively.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 47.6% for the Base case and 50.7% for the Trailer case. For the Police-without-Lights-on case, this percentage was 76.53%. In the Trailer + Police-without-Lights-on and the SPE cases 46.5% and 54.2% of drivers exceeded the speed limit by 5 mph.

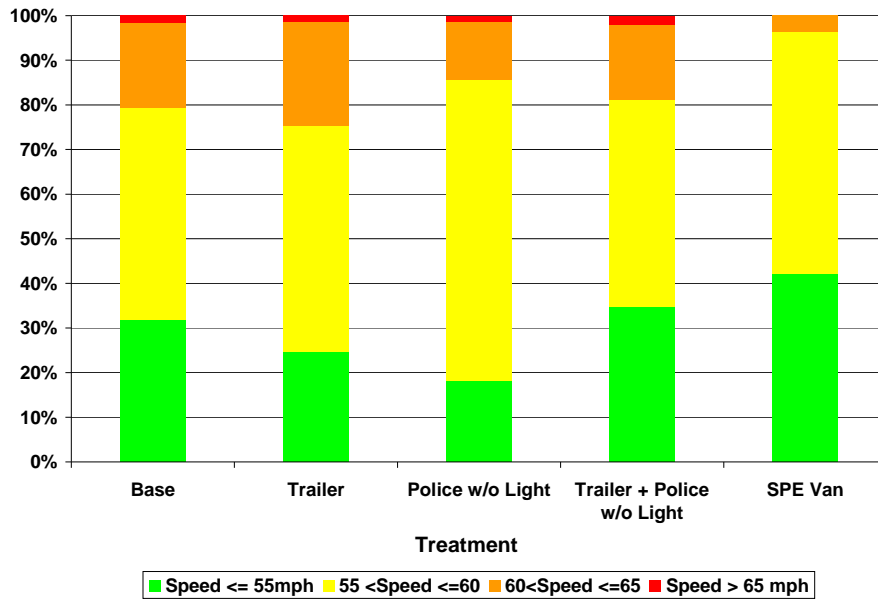


Figure II-42. The degree of speeding for sampled trucks in median lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and the Trailer cases, the percentages speeding by 10 mph were 19.1% and 23.3%, respectively. In case of traditional law enforcement these percentages ranged from 13.0% to 16.8%. The SPE reduced this percentage to 3.6%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the SPE case, none of the drivers exceeded the speed limit by more than 10 mph, while for the Base and all other treatments it ranged from 1.3% to 2.0%.

II.2.2.1.d. Summary of Spatial Effects of SPE on Trucks in General Traffic Stream on Median Lane

For the three datasets, the SPE had some spatial effect on the average speed of the trucks in general traffic stream on median lane. Reductions in average speed were 1.9 mph in Dataset 1, 3.3 mph in Dataset 2, and 0.9 mph in Dataset 3, with mean speeds of 56.7 mph, 56.2 mph, and 55.5 mph, respectively. The SPE also decreased the percentage of speeding drivers by 7.5% in Dataset 1, by 23.5% in Dataset 2, and by 10.4% in Dataset 3, down to 76.7%, 61.8%, and 57.8%, respectively.

II.2.2.2. Shoulder lane

II.2.2.2.a. Dataset 1

Mean Speeds and Speed Reductions

Table II-22 shows the results of LSD test for the trucks in the general stream on the shoulder lane. It should be mentioned that three different treatments (Trailer, Police-with-Lights-on, and Police-without-Lights-on) were not considered for further analysis because the median lane was closed during the data collection period for these treatments.

Table II-22. LSD Result for Sampled Trucks in Shoulder Lane

		Mean Speed	Treatment
	A	57.0	Base
	A	56.9	Trailer + Police w/o Lights on
B	A	55.9	Trailer + Police w/ Lights on
B	B	55.3	SPE Van

As Table II-22 shows, the mean speed in the Base case (57.0 mph) was similar to the mean speed in the traditional law enforcement methods (55.9 mph to 56.9 mph), and significantly higher than the mean speed in the SPE case (55.3 mph). Thus, for the trucks in general traffic stream in the shoulder lane the SPE had 1.7 mph spatial effect on the mean speeds.

The cumulative speed distribution curves for trucks in general traffic stream in the shoulder lane are shown Figure II-43. No shift was found in the cumulative speed distributions of traditional law enforcements compared to the Base case, but for the SPE a small shift towards the left was observed. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

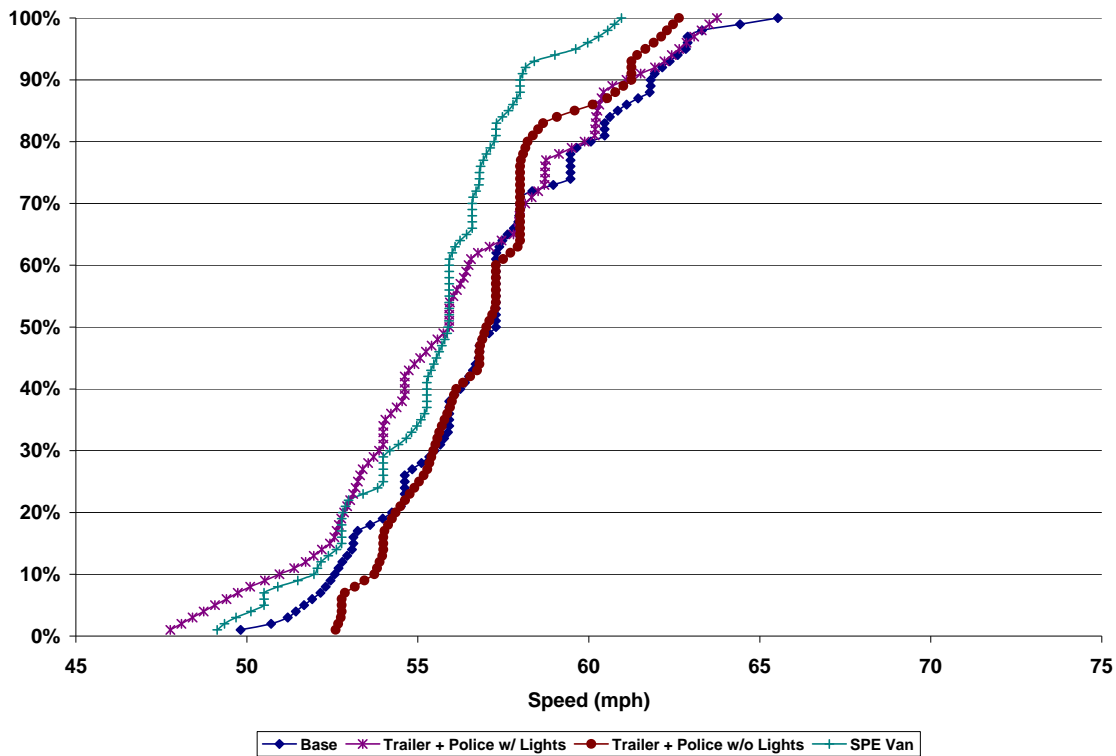


Figure II-43. Cumulative speed distribution for the sampled trucks in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-44. In the Base case 72.1% exceeded the speed limit of 55 mph. Trailer + Police-without-Lights-on had 74.2% exceeding the speed limit, while in the Trailer + Police-with-Lights-on and the SPE the percentages were 55.6% and 64.3% respectively.

The proportion of drivers who exceeded the speed limit by 5 mph or less was 51.2% for the Base case. Trailer + Police-without-Lights-on and the SPE resulted in 58.1% and 59.5% speeding by 5 mph respectively, and in Trailer + Police-with-Lights-on reduced it was 33.3%.

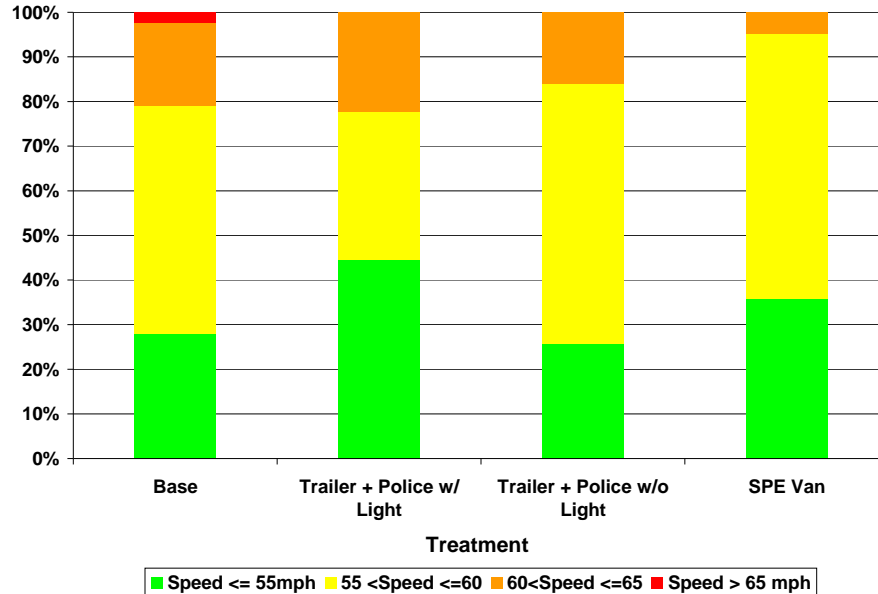


Figure II-44. The degree of speeding for sampled trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case the percentage speeding by 5-10 mph was 18.6%, while in all law enforcement methods this percentage ranged from 4.8% (for SPE case) to 22.2%.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 2.3% of drivers exceeded the speed limit by more than 10 mph. All law enforcement methods resulted in no speeding by more than 10 mph.

II.2.2.2.b Dataset 2 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-23 shows the results of LSD test for the trucks in general traffic stream on shoulder lane for Dataset 2.

Table II-23. LSD Result for Sampled Trucks in Shoulder Lane

	Mean Speed	Treatment
A	56.0	Base
A	55.4	Trailer
A	54.8	Trailer + Police w/o Lights on
B	52.8	SPE Van

The mean speed in the Base case (56.0 mph) was similar to the mean speed of Trailer and Trailer + Police-without-Lights-on cases (55.4 and 54.8 mph, respectively). However, the SPE resulted in a mean speed reduction of 3.2 mph, to 52.8 mph. Thus, the SPE had 3.2 mph spatial effect on the mean speed of trucks in general traffic stream in the shoulder lane at the downstream location.

The cumulative speed distribution curves for trucks in general traffic stream in the shoulder lane are shown Figure II-45. The cumulative speed distributions for the Trailer and Trailer + Police-without-Lights-on cases were not shifted, but the SPE resulted in a distinct shift towards the left compared to the Base case. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

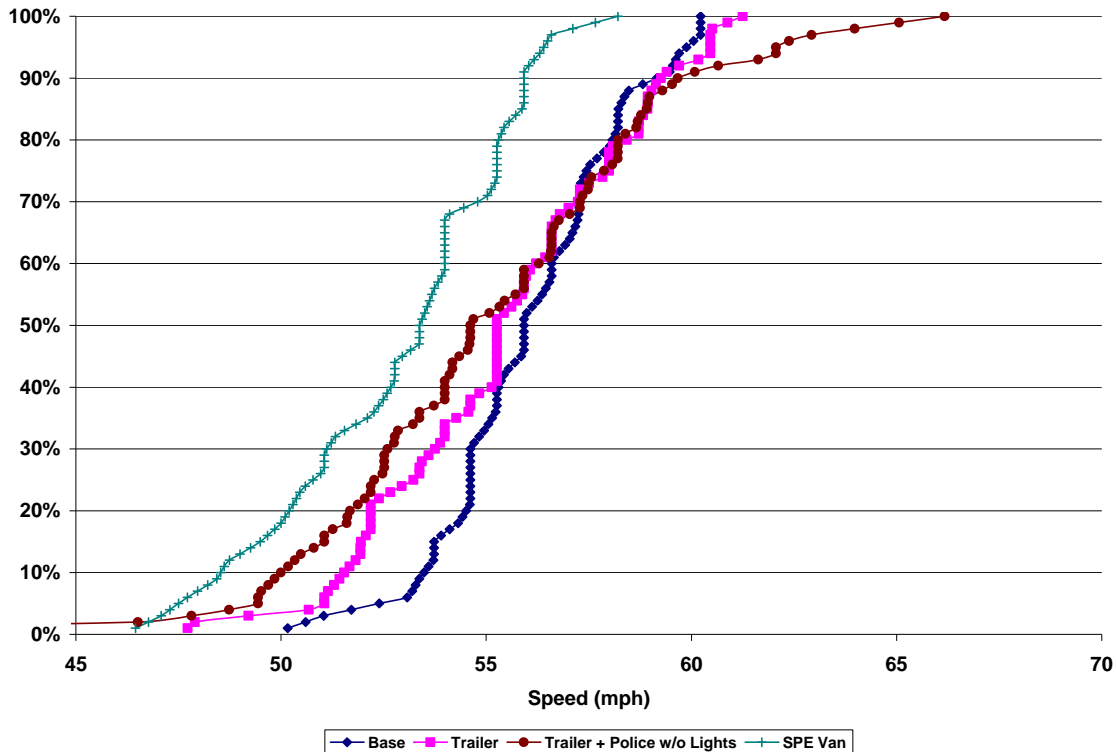


Figure II-45. Cumulative speed distribution for sampled trucks in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-46. In the Base case 64.7% and in the Trailer case 60.2% exceeded the speed limit of 55 mph. The traditional and automated law enforcement methods reduced these percentages to 48.4% and 28.6%, respectively.

The proportion of drivers who exceeded the speed limit by 5 mph or less were 58.8% for the Base case and 52.1% for the Trailer case. On the other hand, traditional and automated law enforcement methods reduced these percentages to 38.7% and 28.6%, respectively.



Figure II-46. The degree of speeding for sampled trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base case, 5.8% of vehicles exceeded the speed limit by 5-10 mph. The SPE reduced it to zero, while they ranged from 8.1% to 8.3% for other treatments. This means that for the SPE case none of the drivers exceeded the speed limit by more than 5 mph.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base, Trailer and the SPE cases none of the drivers exceeded the speed limit by more than 10 mph, while for traditional law enforcement, this percentage was 1.6%.

II.2.2.2.c. Dataset 3 Mean Speeds and Speed Reductions

Similar to Dataset 1, Table II-24 shows the results of LSD test for the trucks in general traffic stream traveling on the shoulder lane for Dataset 3.

Table II-24. LSD Result for Sampled Trucks in Shoulder Lane

Mean Speed		Treatment
A	57.4	Police w/o Lights on
A	57.3	Base
A	57.1	Trailer
B	56.4	Trailer + Police w/o Lights on
B	55.5	SPE Van

The mean speed in the Base case (57.3 mph) was similar to the mean in all of the cases except the SPE, which resulted in a reduction of 1.8 mph, to 55.5 mph. Thus, the SPE had 1.8 mph spatial effect in the mean speed of trucks in general traffic stream in the shoulder lane at the downstream location.

The cumulative speed distribution curves for the trucks in general traffic stream in the shoulder lane are shown in Figure II-47. The cumulative speed distributions for the SPE case was shifted towards the left compared to the Base case. In addition, a very

small shift in the same direction was observed for the Trailer + Police-without-Lights-on curve. The results of Chi Squared and Kolmogorov-Smirnov tests supported the results of the LSD test at the same confidence level.

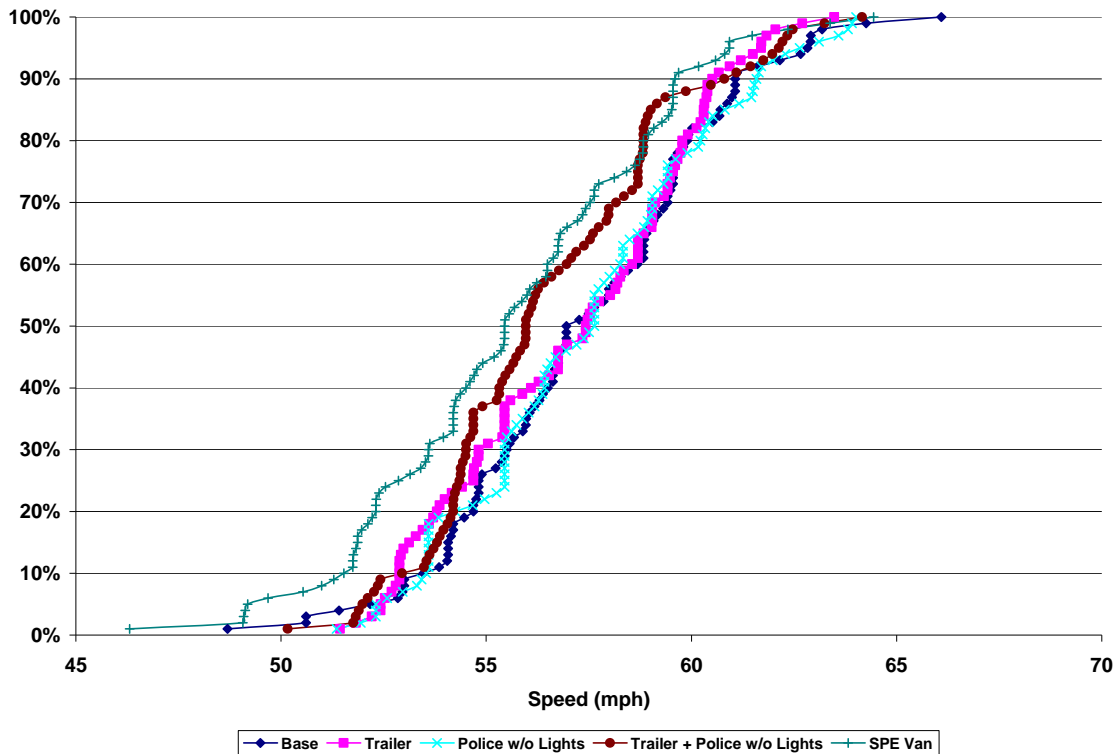


Figure II-47. Cumulative speed distribution for the sampled trucks in the shoulder lane.

Degree of Speeding

The degree of speeding is presented in Figure II-48. In the Base case 71.4% and in the Trailer case 68.9% exceeded the speed limit of 55 mph. In the Police-without-Lights-on case, this percentage was 82.4%, in the Trailer + Police-without-Lights-on it was 62.0%. The SPE resulted in 55.4% exceeding the speed limit.

The proportion of drivers who exceeded the speed limit by 5 mph or less ranged from 46.4% to 55.9% for all cases. In the Base case 54.0% and in the SPE case 46.4% of vehicles exceeded the speed limit by 5 mph.

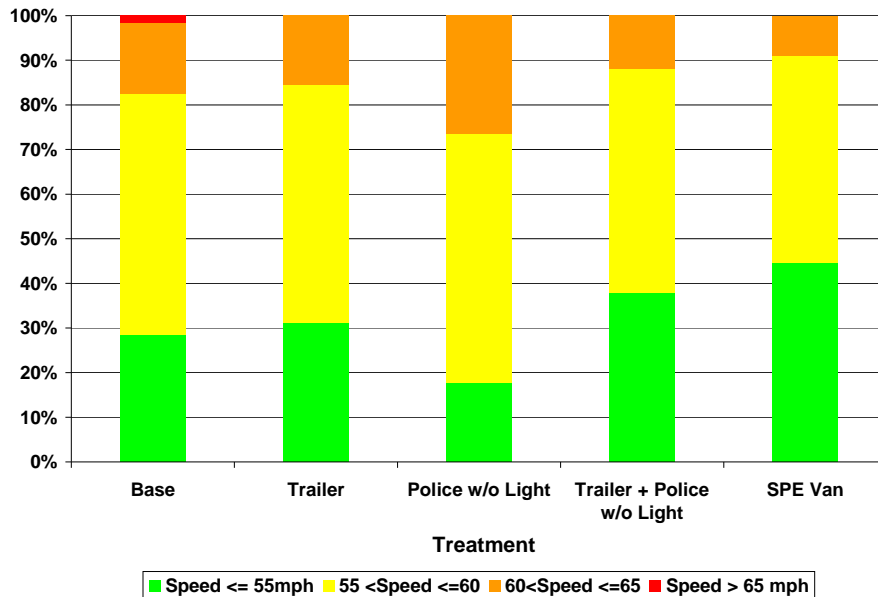


Figure II-48. The degree of speeding for sampled trucks in shoulder lane.

The third level of speeding corresponds to exceeding the speed limit by 5-10 mph. In the Base and Trailer cases, the percentages speeding by 5-10 mph were 15.9% and 15.6%, respectively. In the Police-without-Lights-on case this percentage was 26.5% while in the Trailer + Police-without-Lights-on and the SPE cases they were 12.0% and 8.9%, respectively.

The fourth level of speeding corresponds to exceeding the speed limit by more than 10 mph. In the Base case, 1.6% of drivers exceeded the speed limit by more than 10 mph. No speeding trucks over 10 mph were found in any of the treatments for the general traffic stream in the shoulder lane.

II.2.2.2.d. Summary of Spatial Effects of SPE on Trucks in General Traffic Stream on Shoulder Lane

For the three datasets, SPE had spatial effects as it decreased the mean speed of the trucks in the general traffic stream on shoulder by 1.7 mph in Dataset 1, by 3.2 mph in Dataset 2, and by 1.8 mph in Dataset 3, down to 55.3 mph, 52.8 mph, and 55.5 mph, respectively. The speed reductions in the SPE case were greater than traditional speed enforcement methods. The percentage of speeding drivers also decreased in the three datasets, with reductions of 7.8% in Dataset 1, 36.1% in Dataset 2, and 16.1% in Dataset 3, down to 64.3%, 28.6%, and 55.4%, respectively.

