PHOTO RADAR SPEED ENFORCEMENT IN STATE HIGHWAY WORK ZONES

DEMONSTRATION PROJECTS ON YEON AVENUE AND ON POWELL BOULEVARD IN PORTLAND, OREGON

Final Report

SR 500-390

PHOTO RADAR SPEED ENFORCEMENT IN A STATE HIGHWAY WORK ZONE:

DEMONSTRATION PROJECT YEON AVENUE

SR 500-390

by

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16. Abstract

The 2007 Oregon legislative assembly passed House Bill 2466, allowing the Oregon Department of Transportation to use photo radar in ODOT work zones on non-interstate state highways and required ODOT to report back to them on the safety impacts of this enforcement action. This research project examined the impact of photo radar speed enforcement on traffic speed through an active highway work zone. The project also examined the speed data in an attempt to find speed impacts that persisted following the photo radar enforcement periods. During photo radar enforcement periods, speeding was reduced by an average 23.7% at the traffic sensor site within the work zone. The observed speeding reduction was temporary and did not persist beyond the departure of the photo radar enforcement van.

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APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
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yd^3	cubic yards	0.765	meters cubed	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit	(F-32)/1.8	Celsius	°C

NOTE: Volumes greater than 1000 L shall be shown in m^3.

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
m^2	meters squared	1.196	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

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PHOTO RADAR SPEED ENFORCEMENT IN A STATE HIGHWAY WORK ZONE: DEMONSTRATION PROJECT YEON AVENUE

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1.0 INTRODUCTION

1.1 OVERVIEW

In June 2007 the State of Oregon amended ORS 810.438 and 810.439 authorizing the use of photo radar in work zones on Oregon highways. The Oregon Department of Transportation (ODOT) conducted an evaluation of an initial photo radar installation in a highway work zone and will report back to the legislature as part of the reporting requirements of the bill. Radar use on highways is restricted to state work zones and is valid until December 31, 2014.

Oregon has averaged more than 20.5 billion annual vehicle miles traveled (VMT) between 1998 and 2007. In 2007 there were 44,162 vehicle crashes on Oregon roads and highways resulting in 455 fatalities; 591 of these crashes took place in work zones, resulting in 11 fatalities.

Every day the State of Oregon operates within over 500 work zones across the state. These sites may be operational day or night with approximatly 80% of these sites seeing only day work (anytime between 7:00 a.m. and 7:00 p.m.) and 20% seeing only night work (anytime between 8:00 p.m. and 4:00 a.m.) (*Keller 2008*). In ODOT Region One, where the evaluation site was located, construction projects nearly all occur at night with most maintenance operations conducted during the day.

1.2 RESEARCH PROBLEM STATEMENT

The 2007 Oregon legislative assembly passed House Bill (HB) 2466, allowing the Oregon Department of Transportation to use photo radar in ODOT work zones on non-interstate state highways. The objective of this research was to evaluate the impact of photo radar on safety in a work zone and provide a quantitative answer to the question of whether photo radar speed enforcement causes speed reduction in work zones. It looked to determine if there was a measurable impact on the safety of the work zone as ev aluated by traffic speed, as well as create a benchmark for the biennial evaluations of photo radar in work zones required by HB 2466.

Given strict timeline and budget restrictions, the study focused on traffic speed as an indicator of general safety conditions. Evaluation of direct measures would require multiple work zone sites and extended observation periods. Therefore, the research recorded traffic speed impacts within a specific work zone.

The selected work zone was associated with the Yeon preservation project on US 30 – Lower Columbia River Highway in northeast Portland, Oregon. The project work zone stretched two miles through an industrial area. Traffic is heavy (Average Annual Daily Traffic: 27,900 vehicles in 4 lanes) with a large number of trucks. The roadway is four lanes plus a continuous left turn lane. The preservation project included curb work and a grind/relay of the traffic lanes. Work began in March of 2009 and continued into mid-September of the same year.

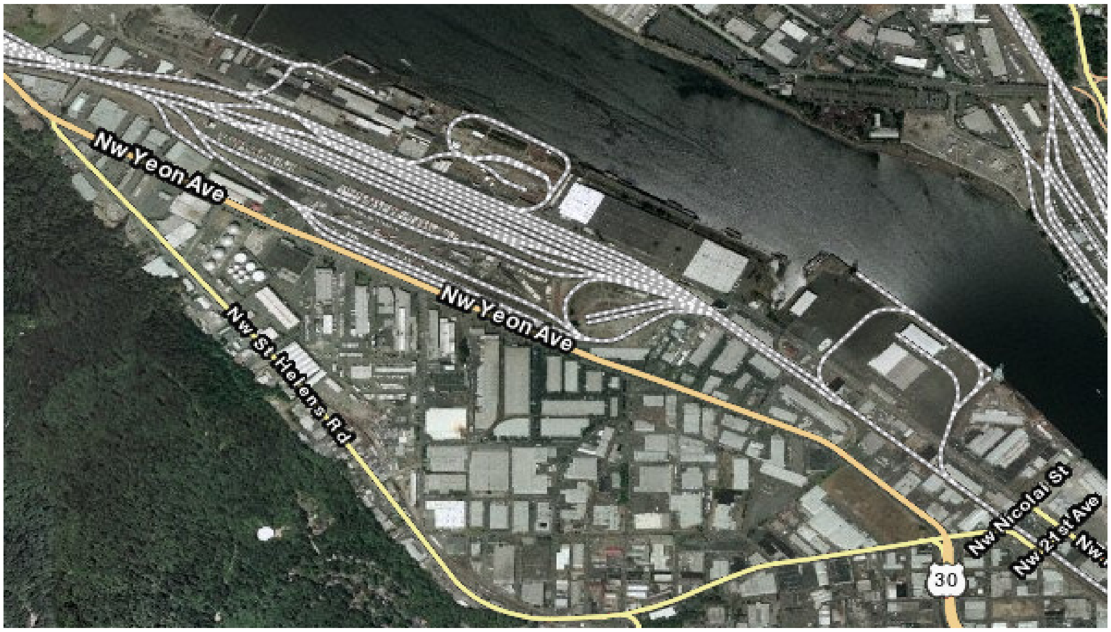

Figure 1.1: Aerial view of work zone site in northeast Portland, Oregon.

2.0 LITERATURE REVIEW

Highway work zones may feature complex and transitory traffic patterns that can increase the level of risk for both passing motorists and work zone crews. This condition is made more hazardous on highways with a greater traffic speed. Voluntary compliance with reduced work zone speed limits is often low and automated enforcement may be especially helpful in reducing speeds due to its high visibility.

In a 1992 study by the Virginia Transportation Research Council, increasing difficulties in enforcing posted speed limits on the Capital Beltway around Washington, D.C. led local officials to propose that experiments be conducted with photo-radar to determine if it could help reduce the average speed and speed variance in drivers. The study concluded that is was operationally feasible to use photo-radar technology to detect and photograph speed violators on high-speed, high-volume roads (*Lynn et al. 1992*).

In a 1998 review, *Managing Speed: Review of Current Practices for Setting and Enforcing Speed Limits,* William Glauz examined the effects of handing the control of speed limits back to the states by the federal government. The review touches on aspects of what enforcement programs states have started to curb speed-related crashes, including the affects of photo-radar enforcement. Glauz concludes that automated enforcement has consistently shown to be an effective means of reducing crashes on sections of road where it is utilized consistently.

In a 1998 article by Steven A. Bloch entitled, *Comparative Study of Speed Reduction Effects of Photo-Radar and Speed Display Boards,* Bloch examined two forms of automated motor-vehicle speed control, speed display boards and photo-radar by attempting to answer three issues:

(a) which of these devices is more effective in lowering speeds;

(b) whether supplementing display boards with police enforcement makes them more effective; and

(c) which device is more cost-effective.

Bloch concludes that both speed display boards and photo radar can be effective traffic safety tools for reducing vehicle speeds. Both devices were found to reduce vehicle speeds while deployed, lowering speeds 7 to 8 km/h where the baseline speed averages 55 to 56 km/h. The devices appeared particularly effective at reducing the number of vehicles traveling 16 km/h (10 mph) or more over the speed limit. Cost-effectiveness estimates demonstrated consistently that the un-enforced speed display board was the most cost-effective, the enforced display board was second, and photo-radar was third. Results of the cost per deployment analysis showed that: (a) Un-enforced speed display boards cost just one-ninth as much as enforced display boards, and (b) enforced display boards cost 40 percent less than photo-radar assuming that police use an outside vendor, and 60 percent less assuming that police purchase the equipment.

The National Highway Traffic Safety Administration released guidelines for automated speed enforcement (*NHTSA 2008*). These guidelines cover many aspects of program planning and operations, including the following:

- site selection;
- system procurement;
- resource and personnel management;
- revenue management;
- planning for program evaluation;
- marketing and media relations; and
- program rollout.

The NHTSA guidelines also feature an extensive reference section.

The only prior study of photo radar specifically in work zones was based on analysis of short (one-hour) video records of work zones on interstate highways in Illinois during off-peak hours. That study showed a speed reduction between 3.4 to 7.9 MPH during photo radar operation, with dramatic reductions in vehicles exceeding the speed limit. The study was unable to verify a consistent 'halo effect' wherein the speed reduction might have persisted beyond the removal of the photo radar equipment. (*Benekohal et al. 2009*)

The Yeon Avenue work zone study reported upon in herein built upon the Illinois study by gathering speed data over a much longer time period and examining a large number of transitions between periods of enforcement and non-enforcement. This study also compared photo radar enforcement periods to equivalent time of day periods without enforcement to assure fair comparison.

3.0 METHODOLOGY

Studying safety and speed enforcement within a short section of highway during the relatively short duration of a construction or maintenance project offers a number of challenges. Data must be collected without interfering with the work being done on the project, and be collected in a manner which is not compromised by the ongoing work. There must be flexible data collection coverage for periods when local law enforcement is able to provide speed enforcement and coverage for comparable periods speed enforcement is not present.

3.1 SPEED AS A PROXY FOR SAFETY

Measuring a safety impact in a short length of highway over a short time period presents a research obstacle. Crashes can be considered random and rare events that would be expected to yield a low number of instances (possibly zero) over the length of any specific work zone project. Evaluating the statistical magnitude of a change in safety may be effectively impossible if crashes are the selected measurement.

There is, however, a clear and broadly recognized correlation between speeding and safety which allows the use of speeding as a proxy for crash safety. Given the constraints of evaluating safety within a short-lived work zone, the use of speeding as a measure of safety was a reasonable approach.

The posted speed limit throughout the project work zone was 40 miles per hour (MPH). Preliminary traffic monitoring revealed a mean vehicle speed very close to 45 MPH. Impacts on speed of work zone signage and photo radar enforcement were evaluated on the basis of the percentage of vehicles traveling faster than the mean speed of 45 MPH. Consideration was given to evaluating ‘speeding’ based on vehicles traveling faster than the 85th percentile speed (50 MPH in this case), but the mean speed was selected based on greater statistical sensitivity around the mean and on the assumption that all drivers traveling faster than the mean speed would be impacted by the tested speed reduction measures.

3.2 DATA ACQUISITION TECHNOLOGY

There are a number of techniques available to collect traffic speed data, but the specific conditions of the selected work zone environment eliminated many of these options.

- Rubber ‘road tubes’ are often used for short-term traffic count and speed collection, but the high traffic volume, high heavy truck proportion, and multi-month length of the project are all contra-indicators for this technology.

- Embedding ‘inductive loop’ sensors into the pavement would solve the high traffic volume and heavy truck problems, but installation of the loops would have been expensive and the preservation project included grinding away the roadway and laying a new surface which would destroy the inductive loops at some point during the project.

A newer data collection technology in the form of radar traffic sensors eliminates the issues of wear and inclusion into the roadway surface. The radar unit selected for this study was the Wavetronix SmartSensor HD which can measure traffic volume and classification, average speed, individual vehicle speed, lane occupancy, and presence for up to ten lanes of traffic. The unit is small, inconspicuous, and mounts to an available lighting or utility pole along the roadway. It operates on a radio band which does not interfere with law enforcement radar.

3.3 PHOTO RADAR ENFORCEMENT

The Yeon preservation project lies within the jurisdiction of the Portland Police Bureau. The Traffic Division of the Portland Police Bureau has operated photo radar enforcement vans since 1996 and was willing to support this research with their equipment and officers. The contractor and police coordinated their schedules to best utilize police manpower and equipment availability. The Yeon preservation project work zone could only be enforced as a work zone with increased fines if at least one worker was present and actually performing work, and the great majority of the work was performed during evening hours.

The Portland Police Bureau provided a total 207 hours of photo radar enforcement. During that time they recorded 2069 speed violations and issued 1014 citations.

3.4 DATA COLLECTION

The radar traffic sensor was installed and data collection of average speed and traffic volume in 10-minute ‘bins’ was begun in November, 2008. This was done several months before the start of work on the preservation project in order to gather baseline data and to assure that the traffic sensor was a suitable tool for the job. The traffic sensor remained in continuous operation for weeks beyond the end of the preservation project and was removed in October, 2009. Key time periods for data collection were:

- prior to implementation of the work zone or photo radar enforcement (November, 2008 to March, 2009);
- with implementation of work zone signage but without photo radar enforcement (March, 2009 to September, 2009);
- with implementation of work zone signage and during periods of photo radar enforcement (March, 2009 to mid-September, 2009); and
- with the work zone and photo radar signs/equipment removed completely (late-September, 2009).

Comparison of these key periods isolated the effects of work zone signage, photo radar enforcement, and the extent to which photo radar enforcement impacts might carry over to periods of no enforcement.

3.5 DATA CLEANING

Initial data screening identified statistical differences in vehicle speeds during weekends and holidays compared to weekdays. The weekends had speeds averaging approximately two MPH higher than weekdays. Since all photo radar enforcement was being done during active weekday evening work periods, the weekend and holiday speed data was removed from the baseline comparison data.

Also removed from the baseline data were sections where construction activities or lane closures were taking place in the immediate vicinity of the data collection radar sensor, or where traffic at the sensor was otherwise identified as not 'free flowing'.

Data from November and December 2008 were not used. November was a partial month of data and December had a severe snow/ice period that severely impeded traffic patterns and flow. March data was also excluded from the analysis as the project had a phased start in that month that had various features of the work zone (signage, equipment positioning, cones and barricades) implemented at differing times during the month.

4.0 RESULTS

4.1 PRE-WORK ZONE

The posted speed throughout the project work zone on Yeon Avenue is 40 miles per hour. Mean vehicle speed and the number of speeding drivers varied throughout the day. Peak numbers of speeding vehicles in the early morning with a smaller peak in the early evening as shown in Figure 4.1 proved to be a standard pattern over the duration of the project. Mean speed was 44.3 MPH with an 85th percentile speed of 49.2 MPH. The weighted percentage of vehicles traveling at more than 45 MPH was 46.0%.

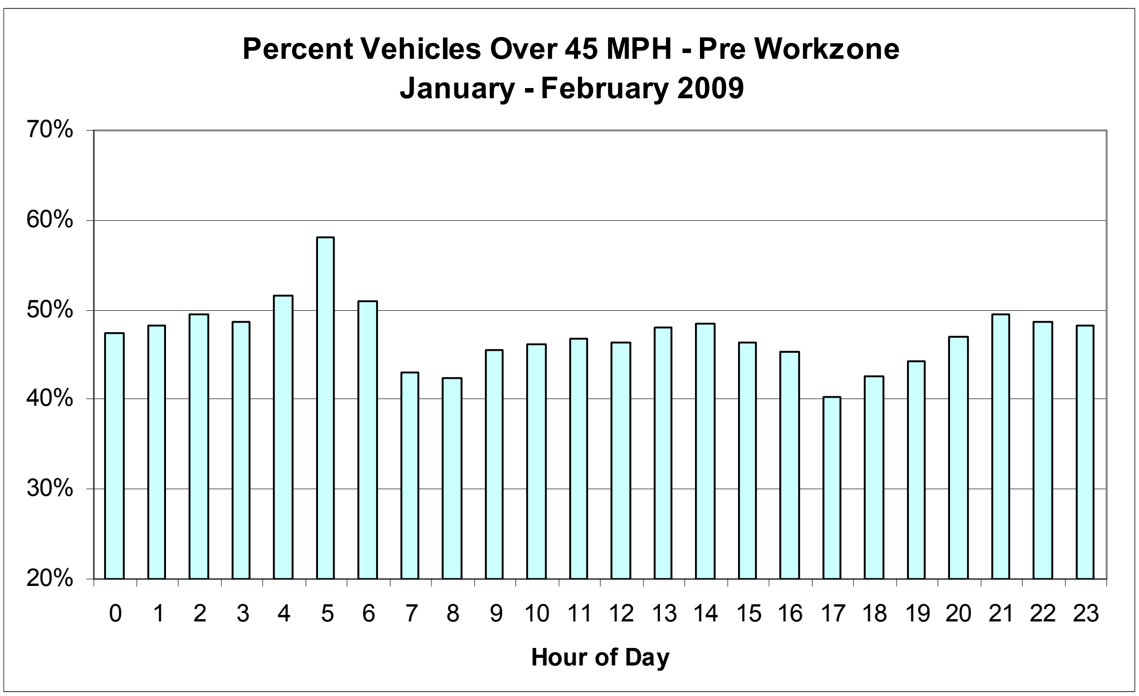

Figure 4.1: Speeding vehicles by hour of the day in the two months prior to start of work in the project work zone

4.2 DURING PROJECT

The early morning and early evening speeding peaks observed in pre-project speed monitoring continued and were more pronounced during the period in which the work zone was identified by signage and work was ongoing. Some of this change in speeding pattern may have been due to changes in weather and sunrise/sunset times as the calendar moved from winter into spring and summer. Liu and Chen (*2009*) reported such seasonal and weather related factors in their analysis of speed related crashes. Mean speed during non-enforcement was 44.2 MPH with an 85th percentile speed of 49.5 MPH. The weighted percentage of vehicles traveling faster than 45 MPH during periods of non-enforcement was 48.7%.

The impact of photo radar enforcement on speeding is substantial (Figure 4.2). The average reduction in vehicles traveling faster than 45 MPH in same-hour comparison is 23.7%. These reductions were seen in same-hour comparisons in each of the individual months as well as in the aggregate. It should be noted that this pronounced speeding reduction is based on speed at the traffic monitoring radar where drivers approaching from one direction had not yet passed by the enforcement site and would have no visual warning of active radar enforcement. It may be assumed that the entire reduction in speeders at the traffic sensor came from one direction.

Persistence of speeding reduction following active photo radar enforcement was not evident. The hour following removal of the enforcement equipment showed no reduction in speeders compared to the same hour not following radar enforcement during the same month. Examining the hours during which photo radar enforcement was present on the next comparable day (non-weekend, non-holiday) also showed no detectable reduction in speeding vehicles.

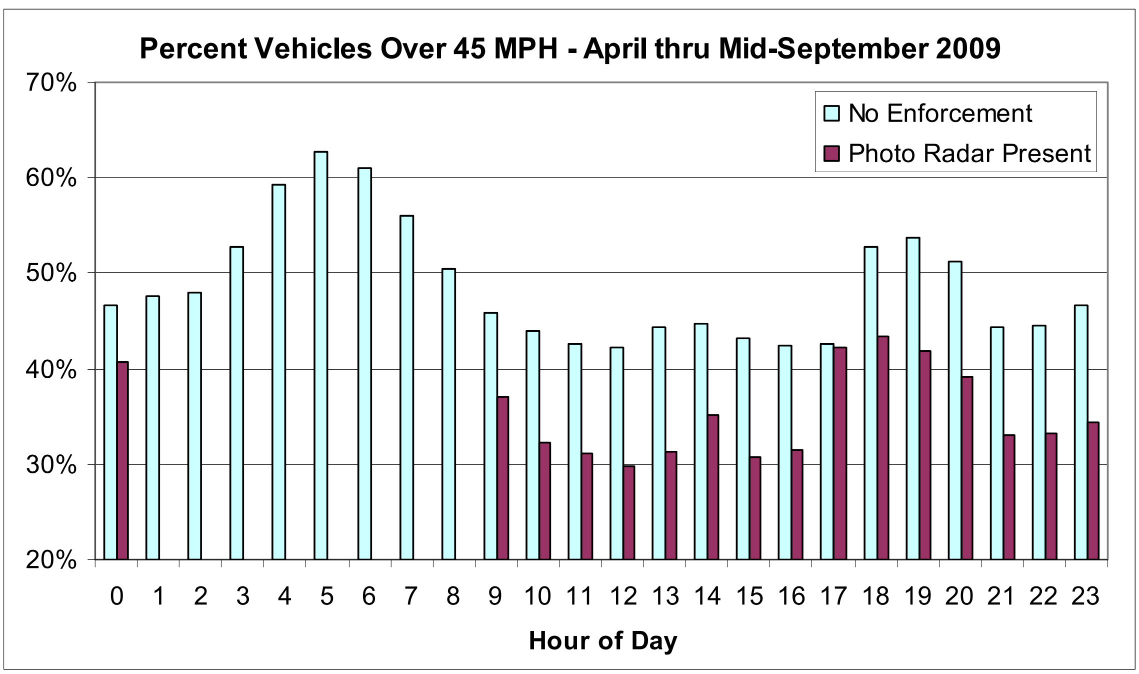

Figure 4.2: Speeding vehicles by hour of the day during the active life of the work zone showing the effect of photo radar enforcement.

4.3 POST-WORK ZONE

The pattern of early morning and early evening speeding peaks continued following the end of the project and the removal of all work zone signage. Mean speed during the last half of September was 44.8 MPH with an 85th percentile speed of 49.9 MPH. The weighted percentage of vehicles traveling at more than 45 MPH was 52.0%. These speeds are comparable to the speeds in the project area prior to the start of work. Improved pavement smoothness may have contributed to the overall increase in speeding seen in Figure 4.3 as compared to the period before the project start.

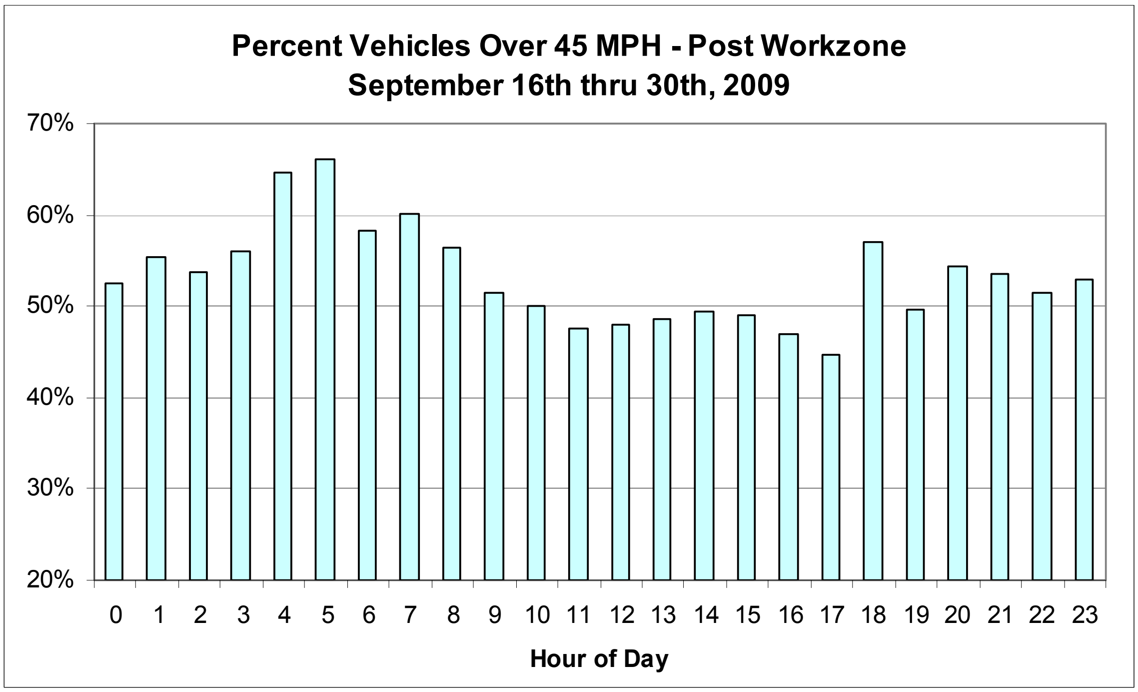

Figure 4.3: Speeding vehicles by hour of the day in the fifteen days following completion of project work and closure of the work zone.

5.0 CONCLUSIONS

Photo radar enforcement, as conducted by the Portland Police Bureau, has a substantial impact on reducing the number of speeding vehicles in a construction work zone. During photo radar enforcement periods, speeding was reduced by an average of 23.7% at the traffic sensor site within the work zone. This large reduction in speeding was observed even though vehicles passing the traffic sensor from one direction had not yet seen the enforcement activity. A greater reduction in speeding would be expected if photo radar enforcement covered both directions of travel. Overall mean and 85th percentile speeds during periods of non-enforcement remained quite stable throughout the study period, which emphasizes the impact of photo radar speed enforcement as a tool to reduce speeding in a work zone environment.

The observed speeding reduction was temporary and did not persist beyond the departure of the photo radar van. Other activities such as work zone signage and the presence of active work in the work zone did not produce an observable effect on speeding when compared to the pre-construction zone monitoring period.

6.0 ERRATA

The Abstract and Conclusions sections of an earlier version of this report incorrectly reported the speed reduction during photo radar enforcement at 27.3% due to a transposition error. The correct figure is a reduction by 23.7%, as originally given in the Results section. The text of this report was corrected in January, 2013.

7.0 REFERENCES

Benekohal et al. Speed Photo-Radar Enforcement and Its Effects on Speed in Work Zones. In *Transportation Research Record: Journal of the Transportation Research Board*, No, 2096, Transportation Research Board of the National Academies, Washington D.C., 2009: pp. 89-97.

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Addendum - Powell Boulevard

ODOT Research conducted a second photo-radar enforcement study from July 15th thru August 15th of 2013. The study took place on the site of an extensive paving and signals project on SE Powell Blvd (US26, Mt. Hood Highway) in Portland, Oregon. The project stretched from SE 111th Ave to SE 176th Ave – a distance of 3.3 miles.

The character of the Powell Boulevard work zone differs from the Yeon Avenue work zone used in the previous study. The Powell work zone had fewer traffic lanes, much lower traffic volume, and a more residential influence.

	SE Powell Boulevard Work Zone	Yeon Avenue Work Zone
Length	3.3 miles	2.0 miles
Traffic Lanes	Two	Four
Center Turn Lane	One section between 157th avenue and 164th avenue	Continuous
Traffic Volume	~18,000 AADT	~169,000 AADT
Posted Speed	35 MPH west of 136th Avenue 40 MPH east of 136th Avenue	40 MPH
Adjacent Land Usage	Residential / Commercial	Industrial / Commercial
Arterial Crossings	Six	None

Table A-1: Comparison of the Powell and Yeon work zones

The most important difference between the two sites may be the introduction of new traffic components at six arterial signalized intersections along the Powell work zone. These intersections allow drivers to enter or leave the study area before or after exposure to the photo radar enforcement site.

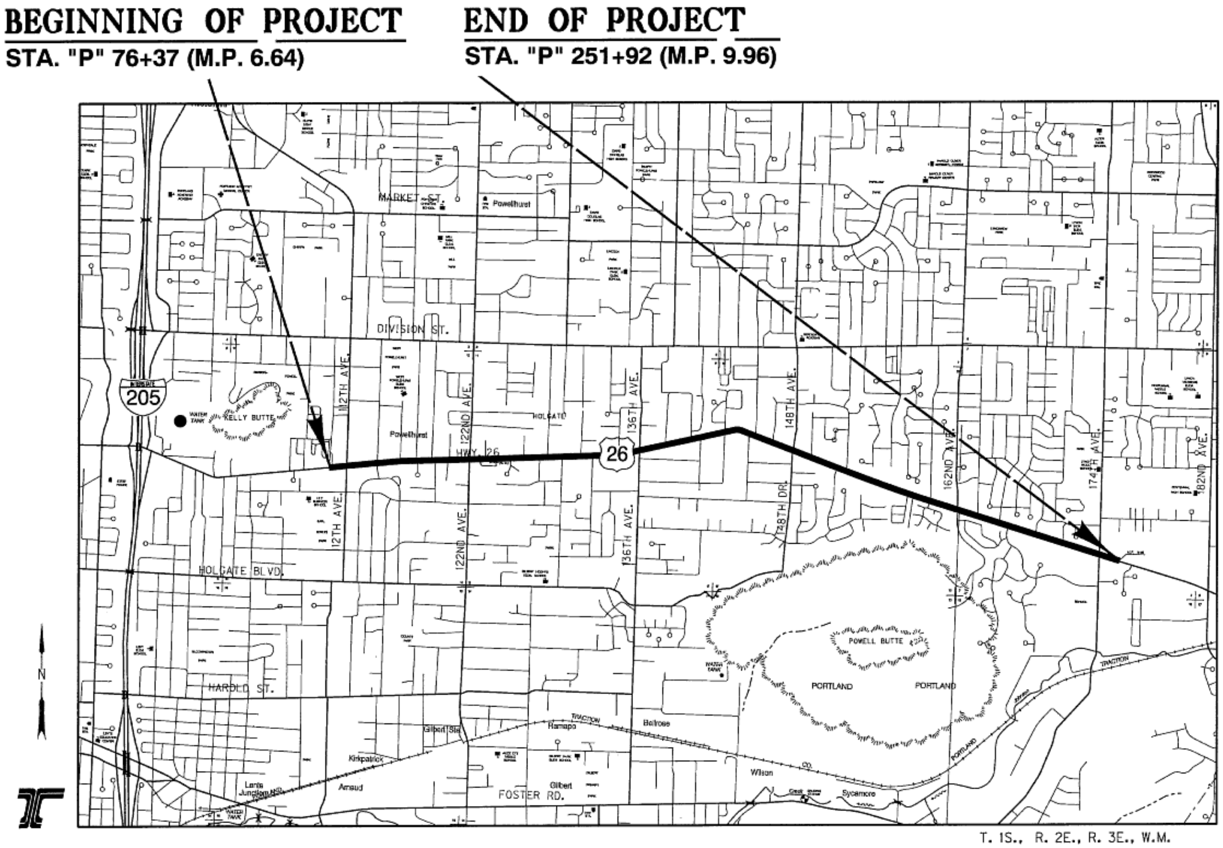

Figure A-1: US 26 – Powell Boulevard Work Zone

During the study, the Portland Police Traffic Division conducted a total of 116 hours of photo-radar enforcement in four-hour shifts during both daylight and nighttime hours. Enforcement avoided the congested morning and evening commute hours, concentrating on mid-day (10:30 am to 2:30 pm – 13 shifts) and evening (8:30 pm to 12:30 am – 16 shifts) on weekdays. Shifts were randomized; some days had both mid-day and evening enforcement, some had only one shift, and others had no enforcement. The only speed enforcement present in the work zone during the study was the photo-radar enforcement.

The data collection and analysis process was identical to the Yeon Avenue study. The Wavetronics speed recorder was installed on a utility pole at 16735 SE Powell -- a site selected for free-flowing traffic and clear access for installation and data downloads. The posted speed limit at the data collection site is 40 MPH. The speed recorder obtained a record of vehicle counts and 5 mph bin speeds in 10-minute intervals for the entire study period. The data was sorted by periods of enforcement and non-enforcement to determine the impact of photo-radar enforcement on speeding, just as was done for the Yeon study.

Results of the Powell Boulevard work zone study were much different from the Yeon Road study. Weighted for traffic volume, the percentage of vehicles travelling more than 5 MPH over the posted speed in the Powell work zone was 1.8% greater when the photo radar speed enforcement was in place (30.3% vs. 28.5%).

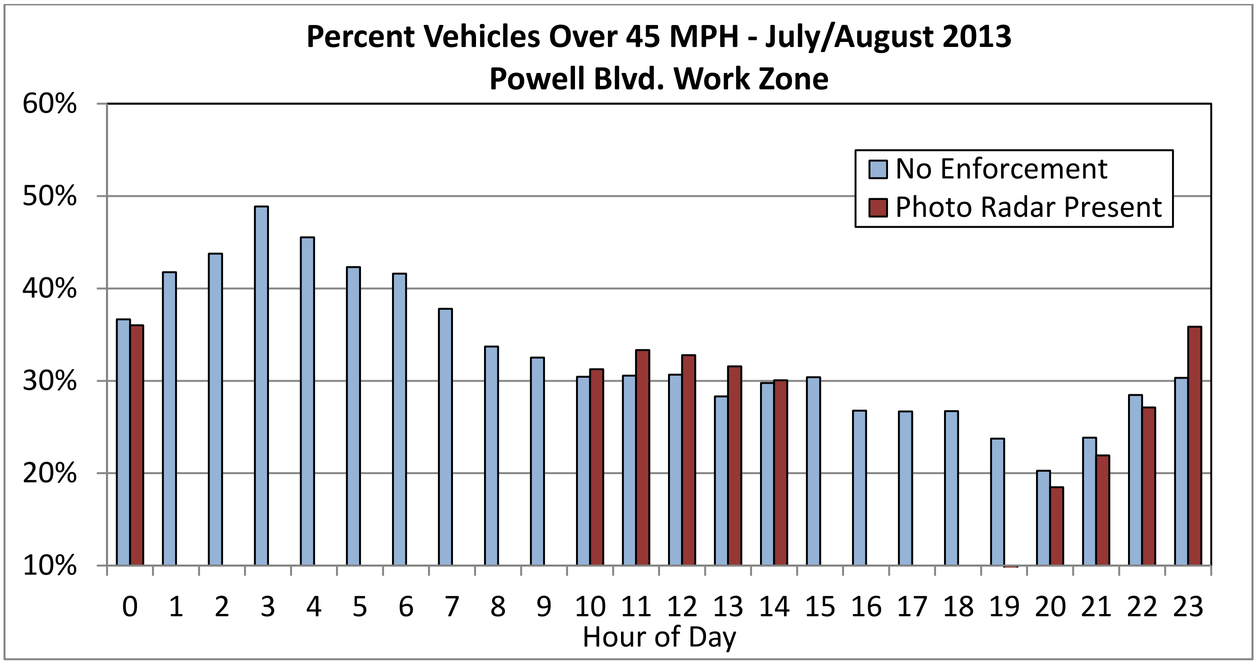

Figure A-2: Speeding Vehicle Frequency by Hour of Day – Powell Work Zone.

Restricting the analysis to only the lane of traffic that passed the photo radar van prior to passing the Wavetronics speed collection device also showed an increase in speeding of 2.5% (33.8% to 31.3%).

The specific causes of the very different effectiveness of photo radar enforcement between the Yeon and Powell work zones are not clear, but they may include:

- Significant differences in the roadway geometry of the test sites: two lanes vs. four lanes, presence of a continuous center turn lane, variation in lane widths, curbing and sidewalks, etc.
- The residential nature of much of the Powell work zone (trees, reduced setback…) compared to the more open industrial environment of Yeon;
- Much greater traffic volume on Yeon compared to Powell;
- The high percentage of commercial vehicles on Yeon compared to Powell.

- The previously mentioned arterial roads crossing SE Powell, which may dilute the percentage of vehicles on the highway which have actually driven by the photo radar enforcement prior to traffic passing the speed collection equipment;

The conclusion of the follow-on study is that while photo-radar was shown to be effective at reducing speeding in one specific Oregon state highway work zone, no positive effect was found in a second Oregon state highway work zone. Until the variables which influence the effectiveness of photo radar enforcement in Oregon state highway work zones can be identified and modeled, the effectiveness of photo radar enforcement in any specific Oregon state highway work zone is uncertain.