Automated Traffic Recorder Data in Traffic Safety: System Diagnostics and Program Assessment

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ABSTRACT

Speed is one of many factors that increase the risk of serious or fatal injury in traffic crashes. Understanding driver and road manager decisions regarding travel speeds is fundamental to improving traffic safety. The objective of this study was to test existing equipment and technology assets in monitoring driver decisions with regard to posted speed limits. Driver behaviors with regard to systematic and special traffic speed programs were considered. In cooperation with the state transportation agency, data were collected from a group of automatic traffic recorder sites (ATRs) for this effort. Analysis focused on speed metrics to quantify differentials relative to posted limit observed traffic speeds, and high-risk driver prevalence.

Systematic measures showed that some ATR sites had consistently higher shares of drivers operating beyond the expected range. This suggests that these roads may need re-evaluation with regard to posted speeds or additional enforcement and education efforts. Significant differences were found among sites with regard to high-risk driver pervasiveness. In regard to driver response to heightened enforcement and public information campaigns, limited data in a quasi-experimental design analysis showed positive, but not statistically significant, reductions in traffic speeds. The project did serve a valuable purpose in establishing the framework and processes for future speed program evaluations through the use of existing traffic monitoring devices.

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1. INTRODUCTION

The relationship between travel speed and safety is perplexing. While traffic speed is a factor in economic mobility, managing road speeds to optimize traveler safety is a priority (U.S. DOT 2000). Higher travel speeds may reduce congestion and commuter travel times, but studies are convincing in showing that as travel velocity increases so does crash severity. Higher speeds are also associated with greater crash risk which may be related to less time for operator reaction to hazards and the physical relationship of mass and speed to energy (U.S. DOT 1998). However, it is difficult to distinguish speed as a factor given the multitude of simultaneous roadway, driver, vehicle, and environmental elements.

Travel speeds are often discussed in terms of absolute and variance. Most often, studies focus on the variance – or deviation from the mean operating speed – as the problem when speed is a crash factor. The operating speed is a measure of driver behavior in free flow traffic. Drivers traveling at speeds above and below the surrounding traffic speeds are at higher crash risk (Solomon 1964, Cirollo 1968, West and Dunn 1971, Harkey 1990). Posted speeds are also considered in the speed studies. Posted speed limits are generally set through statute for road classes or by roadway managers for road segments. Selecting an appropriate posted speed is essential in maintaining safe, efficient travel flows because they are primary means of advising drivers on safe roadway speeds.

Understanding road manager and driver decisions regarding travel speed is fundamental to road safety. The design speed recommended based on engineering specifications and road environment, sets an initial data point for establishing a posted speed limit. Roadway managers are advised that posted speeds should be within 5-miles-per hour of the 85th percentile speed of free flowing traffic. Other factors commonly considered in establishing or assessing a posted speed are road development, crash history, mode speed, roadway geometrics, test run speed, and special user traffic (Parker 1985).

Primary Posted Speed Factors

- 85th Percentile Speed
- Roadside Development
- Crash History
- 10 mph Pace
- Roadway Geometrics
- Average Test Run Speed
- Pedestrian Traffic

Source: Parker 1985

Federal, state and local agencies dedicate resources to reduce speed violations related to posted speeds and driving too fast for conditions on an ongoing basis. These agencies use a variety of interventions, ranging from passive signage to increased enforcement to technology-driven choices such as automatic traffic recorder locations coupled with high speed cameras. The goal of interventions is encourage drivers to make a safe choice by following posted speed limits and adjusting speeds in response to driving conditions. Studies have shown interventions differ in terms of deterrence with driver groups and in enduring effects, sometimes referred to as “halo” effects and measured in terms of either time or distance (Vaa 1997, Goldenbend 2005, Lawpoolsri et. al 2007).

Increased enforcement or high visibility enforcement (HVE) has been used effectively for a variety of traffic-related issues. The Click It or Ticket model is a highly successful HVE used to increase seatbelt use across the nation through a coordinated enforcement and education program. HVE models have also been applied in various situations to decrease speeding. One example is the Heed the Speed campaign. These models look to affect the targeted issue by changing driver behavior over the long run by implying that enforcement is always present and you will be ticketed for a violation. The success of enforcement programs varies, with programs that couple sustained enforcement with public education campaigns generally having wider and more enduring results. Public benefits from the resources committed to these programs are reflected in serious crash reduction. Christensen (1981), Ward (1994), and others have demonstrated that reductions in average or median driving speed of 4 to 8 miles per hour (mph) can result in up to a 30% reduction in injury and fatal crashes. Holland and Conner (1996) suggest that this reduction results from a reduction in speed by many drivers who break the speed limit by a small amount, as opposed to reductions by the smaller group of drivers who break the legal speed limit by 15 mph or more.

In an effort to expand metrics for traffic safety resource allocations in the state, a pilot project was designed to better understand driver speed decisions. Several highways in North Dakota have technology built into sites on the highway that allow public agents to collect speed data from vehicles passing over the site. Other characteristics such as axle spacing and weight can also be collected. Here, researchers worked with the NDDOT to create a sample of vehicle records in the state that provide details on vehicle speeds. Automatic traffic recorder (ATR) devices, which are placed periodically throughout the state highways system, were used in the effort. The ATRs are used primarily to monitor traffic counts used in systems planning and management. An option to collect speed, available with many of ATRs, was used for this pilot. Speed data was collected during the summer driving season to monitor typical speed patterns for sites in the pilot, as well as the effects of HVE at specific sites and traffic safety messaging around holiday weekends for all pilot sites.

The following section provides an overview of the ATR system in the state and explains the approach used in the speed analysis. Results, presented in section three, discuss travel patterns across sites and time – in terms of vehicle speeds. Attempts are also made to estimate the effects of enforcement and education during HVE and holiday traffic safety campaigns. The final section offers conclusions and suggestions for future work.

2. METHODOLOGY

ATR data was collected in cooperation with the state transportation department to better understand driver decisions with regard to speed at sites along selected travel corridors in the state. These sites are all on higher speed traffic roads – with posted speeds of 55 mph and faster – where studies have shown speed to be a determining factor in traffic safety. This pilot project was designed to test the communication and operational processes required to actively utilize ATR speed data in system diagnostics and program assessment. The study focused primarily on the state's northwest region. This offered an opportunity to study an area where traffic safety discussions have been on the forefront in many communities. The region has recently experienced large traffic volume increases because of rapid expansion in the energy sector. It had also been identified by state patrol as a potential area for HVE activity. Statistical analysis was used to model systematic speed factors and assess interventions related to traffic safety.

2.1 Data

The NDDOT maintains a network of 48 ATRs equipped to monitor traffic patterns on state roadways. The ATRs record traffic data 24 hours a day, seven days a week. The recorder output includes site-identifying information and traffic descriptors. The site information specifies location and number of road lanes. Traffic data is captured in aggregated vehicle counts, which are stratified by hour and vehicle type among 5-mph speed increments from 40.1 to 89.99 miles per hour (Table 2.1). Speeds above and below that range complete the mileage categories. The direction of travel may also be distinguished. Thus, each hour and direction is represented by 180 values: 15 vehicle types for each of 12 speed categories.

Table 2.1 Vehicle Speed Categories

Category Description	Category
40.0 mph and under	1
40.1 to 45.0	2
45.1 to 50.0	3
50.1 to 55.0	4
55.1 to 60.0	5
60.1 to 65.0	6
65.1 to 70.0	7
70.1 to 75.0	8
75.1 to 80.0	9
80.1 to 84.99	10
85.0 to 89.99	11
Greater than 89.99	12

Table2.2 Federal Highway Administration Vehicle Types

FHWA Vehicle Class	Class	Definition
Motorcycles	1	All two or three-wheeled motorized vehicles. Typical vehicles in this category have saddle-type seats and are steered by handlebars rather than steering wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles.
Passenger Cars	2	All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.
Other Two-Axle, Four-Tire Single Unit Vehicles	3	All two-axle, four-tire vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single-unit vehicles pulling recreational or other light trailers are included in this classification. *Because automatic vehicle classifiers have difficulty distinguishing class 3 from class 2, these two classes may be combined into class 2.*
Buses	4	All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be a truck and should be appropriately classified.
Two-Axle, Six-Tire, Single-Unit Trucks	5	All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with two axles and dual rear wheels.
Three-Axle Single-Unit Trucks	6	All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with three axles.
Four or More Axle Single-Unit Trucks	7	All trucks on a single frame with four or more axles.
Four or Fewer Axle Single-Trailer Trucks	8	All vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit.
Five-Axle Single-Trailer Trucks	9	All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.
Six or More Axle Single-Trailer Trucks	10	All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.
Five or fewer Axle Multi-Trailer Trucks	11	All vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power unit.
Six-Axle Multi-Trailer Trucks	12	All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.
Seven or More Axle Multi-Trailer Trucks	13	All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.
Optional	14, 15	Optional, definition to be provided when utilized (not available).

Vehicle type is assigned by an automatic vehicle classifier using an algorithm to interpret axle spacing information collected by the ATR based on vehicle types described in Table 2.2. The first three vehicles groups – comprising of motorcycles, cars, and light trucks – were of primary interest in this analysis. Large truck data was collapsed into a single class with exploration limited to systematic assessment related to 85th percentile discussion. The large truck information may also be useful to law enforcement and in campaigns designed to target commercial operators.

This treatment of large trucks mitigated several factors. Truck traffic patterns are inherently different than passenger traffic and are affected by enforcement differently. In addition, HVE campaigns focus mainly on passenger vehicle traffic because the commercial vehicle traffic has a separate enforcement unit. In addition, commercial truck speeds may be governed by company policy rather than driver risk perceptions and posted speeds.

Initially, 14 ATRs were identified as preferred as candidates for the pilot study. Due to limitations in technology and accessibility of some sites, data from 11 ATRs, primarily in the northwest region of the state were collected (Figure 2.1). The group forms a pilot for testing systematic analysis and includes the potential intervention group for program analysis. Nine sites were located in the northwest region. In addition, data at two eastern region sites were captured for potential use in control group for the intervention analysis. The sites are distributed across rural principle arterial and rural minor arterial functional classes in the state's rural road system.

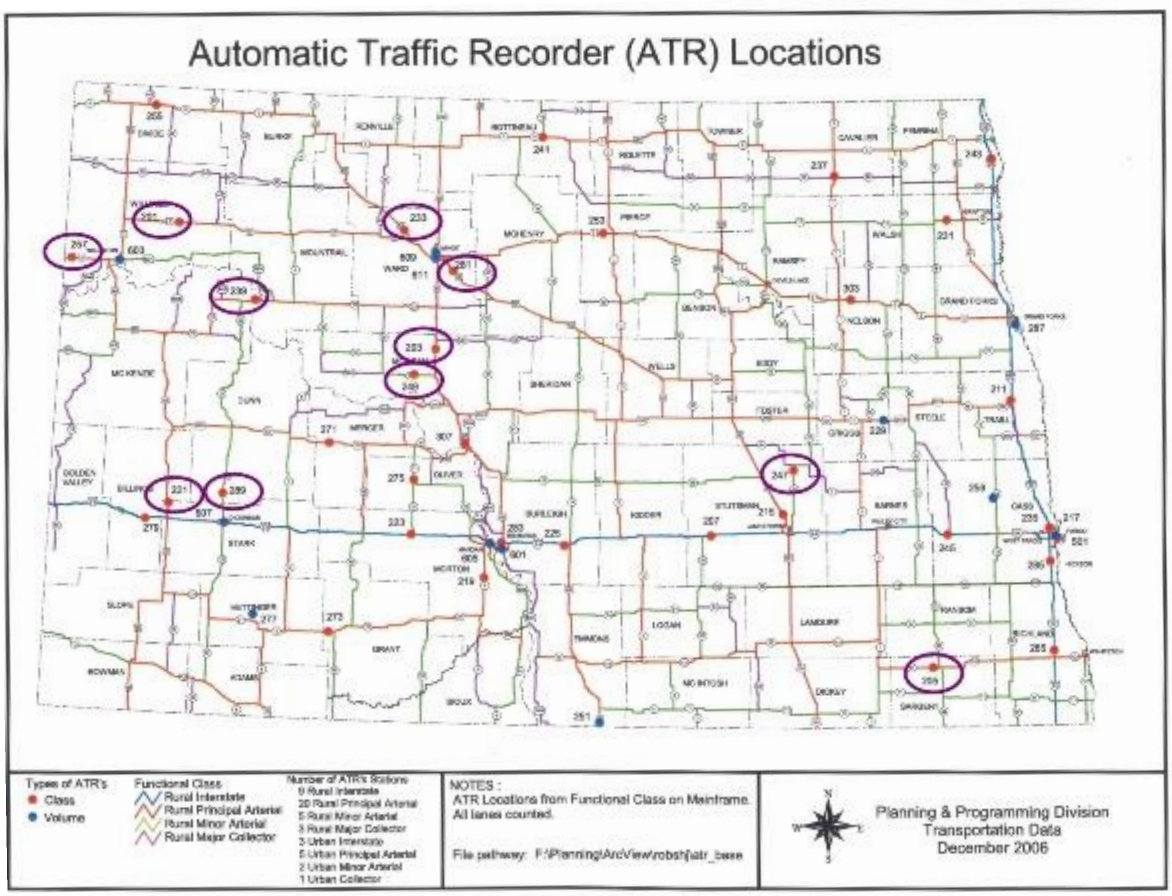

Figure 2.1 Location of ATR Sites Included in Analysis

Over 10,000 ATR station hours of data were collected in the pilot database. Table provides detail about the geographic location and descriptors attached to the sites. For various reasons, data was not received for all 11 sites for every hour and day of the two time periods. Data was parsed to compile information that offered the most complete set for dates and times used in assessing speed patterns in the system and the event analyses.

Table 2.3 ATR Sites Included in Analysis

Station Number	Location	Highway	Functional Class*	Speed Limit	Hours Collected	HVE Intervention
201	Ray	2	RPA	70	1,546	Control
203	Max	83	RPA	70	1,229	Control
205	Gwinner	13	RPA	65	1,387	No
221	Fairfield	85	RPA	65	409	Control
233	Foxholm	52	RPA	65	1,238	No
239	New Town	23	RPA	55	323	Intervention
247	Courtenay	20	RMA	65	308	No
249	Garrison	37	RMA	65	323	No
257	Williston	2	RPA	65	1,435	No
281	Sawyer	52	RPA	65	1,242	No
289	Manning	22	RMA	65	887	Control

*RPA: Rural Principle Arterial; RMA: Rural Minor Arterial

2.2 Scope and Method

Driver speed decisions are affected by a range of influences. Interest here was in capturing systemic summer speed patterns as well as the effects of traffic safety enforcement and education events on high-risk speed behaviors. A baseline collection of speed data for all sites was conducted in weeks prior to the Memorial Day holiday weekend. Speed data was captured from these ATRs during two collection periods: May 13, 2010, to May 31, 2010, and July 22, 2010, to September 6, 2010. The entire speed dataset is used for the systemic component in the analysis. The event analysis focused on holiday intervals and HVE campaigns. Two holidays were captured – Memorial Day and Labor Day weekends. One known HVE episode was captured in the data collection. On August 26 and 27 of 2010, the state patrol targeted several highways with an HVE campaign to reduce speeding. The campaign was conducted on state highways 8, 22, 23, and 73 in northwest North Dakota.

The law designates that any driver driving more than the posted speed limit is speeding. However, in practice both law enforcement and drivers presume a five mile-per-hour allowance to account for factors such as error in radar readings, speedometers, and cruise control setting. Therefore, for purposes of this study, speeding is defined as any vehicle traveling more than five miles-per-hour over the posted speed limit. Because the speed categories from the ATR sites are broken down in five-mile-per-hour increments, this is the smallest allowance that can be made, but it has the added benefit of reflecting the presumed allowance.

The goal of both routine traffic enforcement and HVE campaigns is to increase road safety, discourage drivers from operating at speeds above the posted limits, and encourage a more uniform speed distribution among vehicles. Although average traffic speed would be a preferred performance metric, vehicle speed is not available as continuous variable in the ATR data. Therefore, metrics are formed from the traffic speed range data. Percent of vehicles traveling within the posted speed range and the 85^{th} percentile for traffic speed range create primary metrics. These percentages are superior to the average speed metric to the degree the average would be skewed by extreme values. In addition, solely using the average speed for the analysis could lead to a case where average speed decreases but the percentage of vehicles speeding actually increases. Two additional metrics are the shares of drivers traveling 15 miles-per-hour above and below the posted speed limit. Vehicles traveling at extreme speeds form the high-risk groups which are given a particular focus due to the dangerous effects created in speed differentials. These metrics will closely reflect the main objective of enforcement and can be utilized to for 85th percentile consideration in more systematic decisions.

For the systematic analysis, a range approach for the 85th percentile traffic speed criteria is calculated. With regard to additional insight for traffic speed patterns, systematic univariate analysis will be conducted on the hour of day and day of week. Disaggregate insight is offered in testing individual ATR site locations for effects on speeding. The tests for HVE effects will be conducted in a quasi-experimental setup to control for other factors. A definition of high-risk speeding, defined as 15 mph over the actual speed limit, was also investigated. Several parts of the analysis focused only on passenger vehicles, because these vehicles represent roughly 75% of the vehicles crossing the cohort of ATR sites collected. They represent a very homogenous population of vehicles in comparison to a total population that introduces commercial vehicles such as trucks and buses into population. Hence, changes in behavior should be more easily identified and discussed.

3. RESULTS

The initial set of analyses provides an aggregate view of speed for traffic on corridors where the 11 pilot ATR sites are located. Speed patterns among the sites are also studied in looking at disaggregated variations. Influence of enforcement and education on driver decisions about speeding are estimated based on summer holiday weekends and a single HVE campaign.

As discussed, many factors influence speed decisions of drivers. Trip purpose, traffic density, other drivers, and travel environment are just a few examples of why travel speed may vary across time and space. Aggregate traffic counts for the collection periods during the ATR pilot show differences in the traffic volumes, traffic mix, and speed patterns relative to total traffic levels and traffic flow across sites. The NDDOT provides an annual summary of traffic at the ATR sites (Appendix A). The ATR sites in the pilot group included roads in the rural principal arterial (RPA) and rural minor arterial (RMA) classes (Figure 3.1). Across the state system, these rural classes averaged 2,113 and 1,549 vehicles per day, respectively. Counts for the most recent three years show Max with the highest level of traffic among pilot study stations with daily traffic of 4,217 vehicles. Sawyer and Ray have the next highest traffic counts, at 4,186 and 3,336 vehicles per day. The lowest traffic counts were attributed to the control ATR sites at Gwinner and Courtney.

Total vehicle counts at each site are different, with the higher counts mainly concentrated in the oilfield areas. In terms of the pilot ATR sites, Courtenay accounted for the lowest total of 2% (n=7,579), while the site at Sawyer accounted for 17% (n=72,213). The average daily counts for the 13-day period were 583 and 5,555 at Courtenay and Sawyer, respectively. These counts closely identify the situation for both of these roads. The Sawyer site sees high commuter traffic between Velva and Minot, as well as being a major route between the southeast part of the state and the northwest. The site at Courtenay is a small two-lane road that sees mainly local traffic. Low truck traffic suggests local hauls which are likely agriculture related.

Although not included in the enforcement and education analysis, truck traffic is listed for systematic context and possible influence on passenger speed patterns. Increased interaction between passenger vehicles and trucks is associated with higher crash severity risk for the passenger vehicle. For two-vehicle crashes involving large trucks, crash records show that 98% of the fatalities occur to people in passenger vehicles (Insurance Institute for Highway Safety 2010). Longer stopping distances for trucks and differences in mass of the vehicle types are factors in this increased risk (Agent and Pigman 2002, Golob and Regan 2003). Truck traffic, in terms of percentage and actual vehicle counts, is highest in the western part of the state around the oilfields (Table B.4, Appendix B). With the exception of the Williston ATR site, all of the sites located in oil production areas have a breakdown that is roughly two-thirds passenger traffic and one-third truck traffic. Overall, the percentage of truck traffic ranges from a low of 6.3% at the Gwinner site to a high of 37.2% at the Ray site. Conversely, the passenger traffic ranges from 62.8% at Ray to 93.6% at Gwinner.

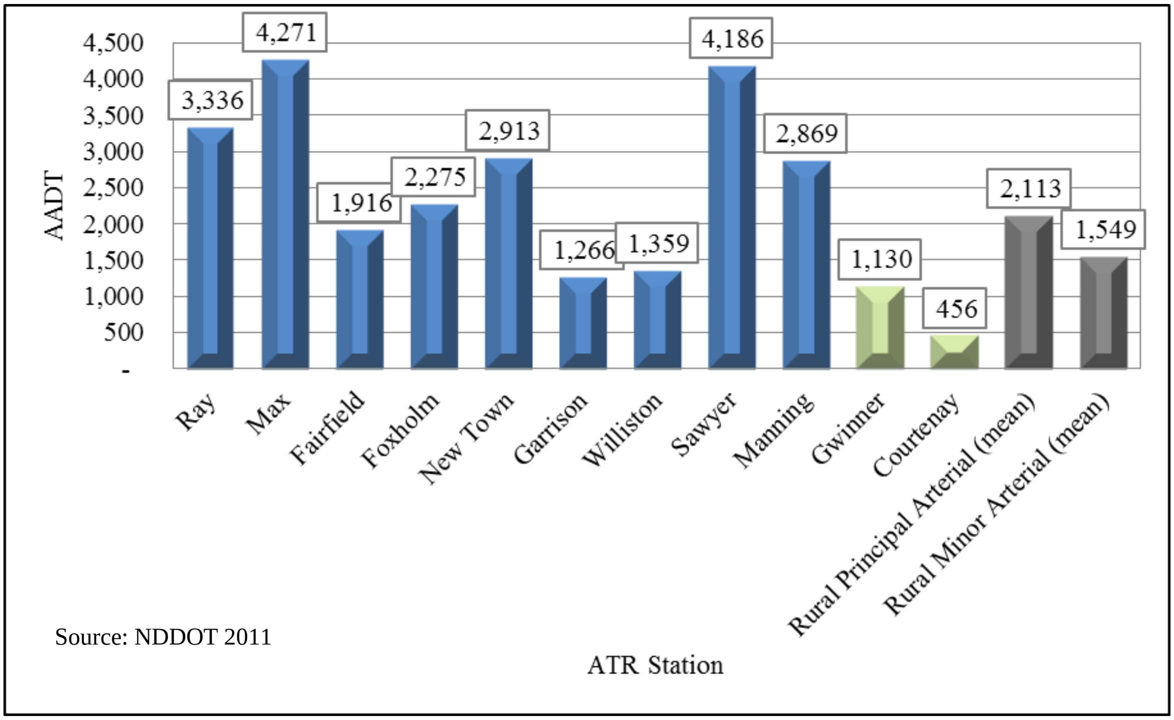

Figure 3.1 AADT 2008-2010

Representation of the stations within the traffic sample collected is acceptable based on a comparison of shares in the NDDOT daily traffic and the pilot study total traffic (Figure 3.2). With the exception of Max, pilot traffic share attributed to sites was within 3% of the of the actual traffic share as represented by the NDDOT AADT in 2010. The reasonable distribution of traffic among roads, in the pilot collection data, provides a means for validating the overall traffic figures and the distribution of traffic among vehicle types and speeds in the analysis.

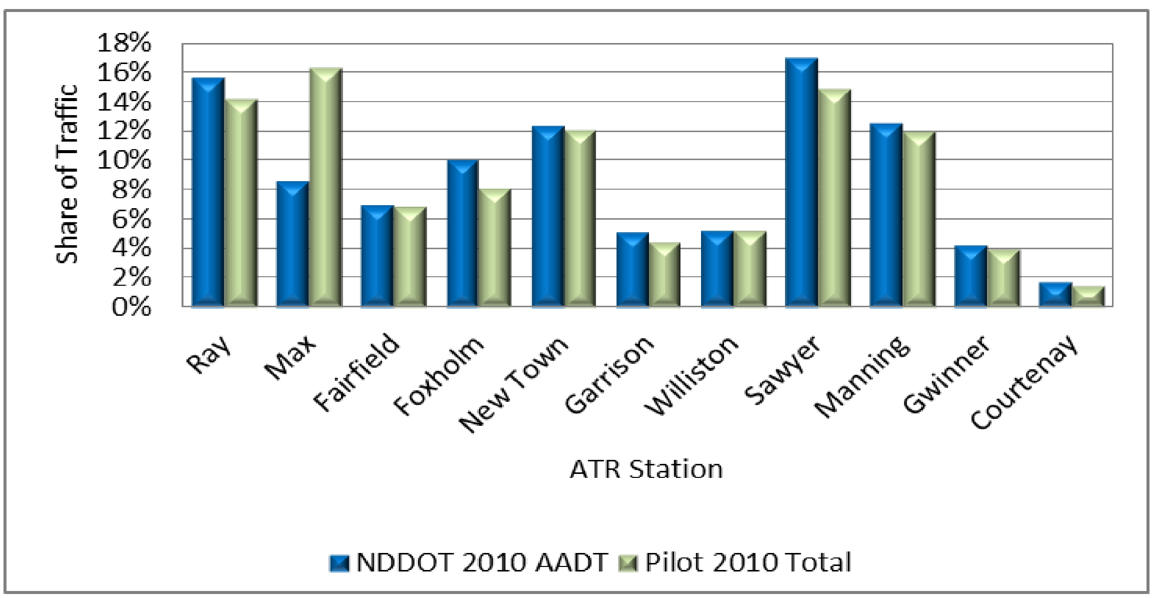

Figure 3.2 Traffic Distribution across ATR Sites

Speed data was collected for more than 400,000 vehicles during the pilot study. Overall, trucks account for 27% of the vehicles speeds collected. Passenger vehicles accounted for 73%. Motorcycles represented less than 1% of the vehicle count. In the north and west regions of study the truck share ranges from a highs of 37% and 35% at Ray and Foxholm, to a low of 7% at Garrison. The two control sites in the south and east are near this low for truck share in the traffic mix.

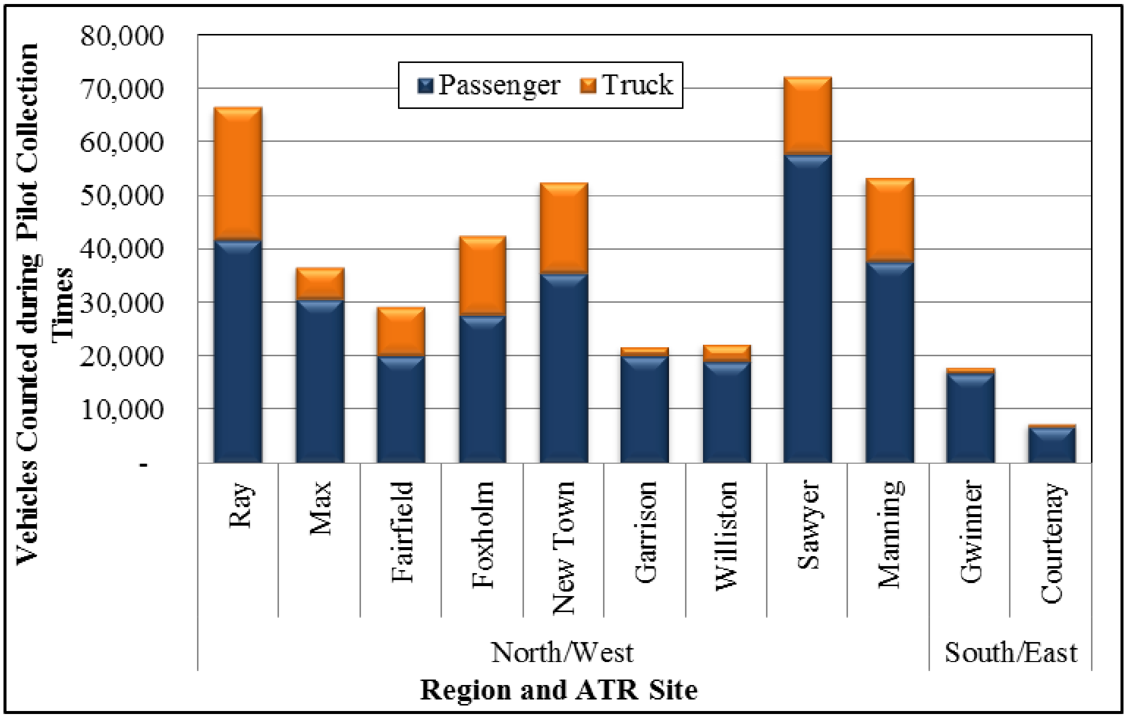

Figure 3.3 Passenger and Truck Traffic during ATR Pilot

3.1 Univariate Analysis

Trending the data by hour indicates there are variations in speeding throughout the day (Figure 3.4). The graph indicates that the five hours from 2:00 a.m. to 7:00 a.m. have the highest percentage of speeders with each hour seeing more than 22% of the vehicles speeding. The morning and afternoon hours are consistent in regard to the percent of vehicles speeding, with a high of 20.0% and a low of 17.0%. The evening hours are more sporadic, with a low of 14.6% and a high of 22.2%.

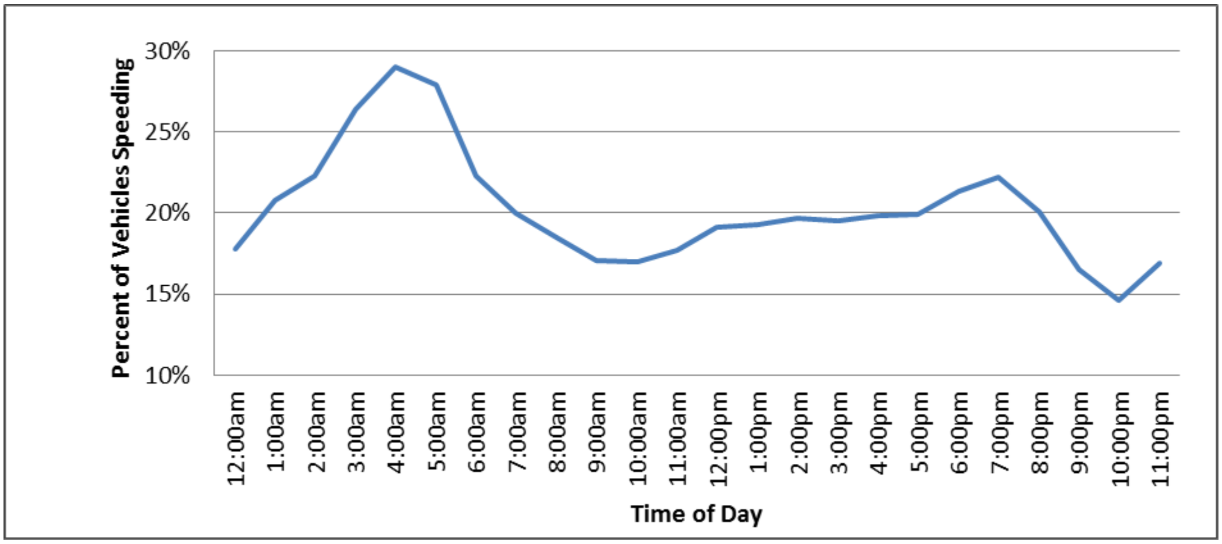

Figure 3.4 Percentage of Passenger Vehicles Speeding by Time of Day

Based on these hourly rates, dividing the day into three time periods is reasonable and will simplify the analysis. The time frames of midnight to 7:59 a.m., 8:00 a.m. to 3:59 p.m., and 4:00 p.m. to 11:59 p.m., have corresponding rates for vehicles speeding of 22.6%, 18.5%, and 19.7%, respectively. The differences in percent of vehicles speeding between these time periods is statistically significantly (χ^2=1132.77, n=765,538, $p<0.0001$).

Figure 3.5 represents the percentage of passenger vehicles speeding when the data is broken down by day of the week. The data shows that the weekdays vary by less than 1.0% total (19.3% to 20.2%). Saturday and Sunday represent the high of 21.0% and low of 18.4% respectively. The uniformity of the weekdays may be due to more consistency in driver pool. These are more heavily work commuter days, with drivers who exhibit the same travel habits each day. This contrasts to Saturday, which may consist of more vehicles traveling for leisure, more school-aged drivers behind the wheel, and less business travel. Sunday may be more representative of family-oriented travel with drivers in less of a hurry to reach destinations. Although the range of rates between the days is not large in absolute terms, it is statistically significant (χ^2=240.58, n=765,538, $p<0.0001$).

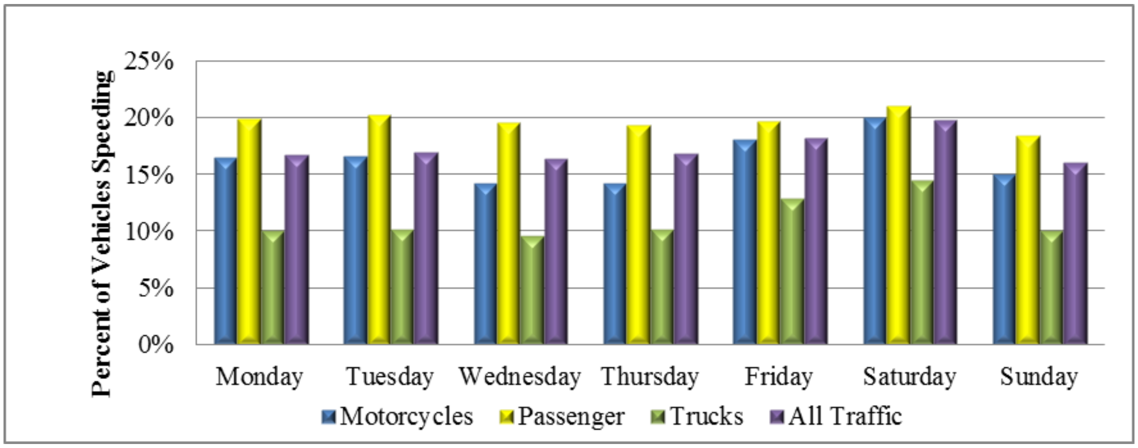

Figure 3.5 Percentage of Vehicles Speeding by Type of Vehicle and Day of Week

The individual sites also display a statistically significant difference in the percentage of vehicles speeding (χ^2=13176.38, n=315,197, p<0.0001). With the exception of the site at Garrison, the percent of speeders decreases as the speed limit increases as indicated in Figure 3.6. As shown in Table 2.3, the posted speed limit on Highway 23 is the lowest of any of the 11 sites – 55 mph – reflecting a speed limit reduction from 65 mph by the North Dakota Department of Transportation and the North Dakota Highway Patrol. It has the highest percentage of vehicles speeding at 38.4%. This compares to the sites at Ray and Max where the speed limit is 70 mph, but the percentage of vehicles speeding are 14.8% and 10.8%, respectively. These represent the second and third lowest rates observed at the 11 sites. The remaining sites all have a speed limit of 65 mph and all but two of the sites have speeding vehicle rates between 20% and 30%.

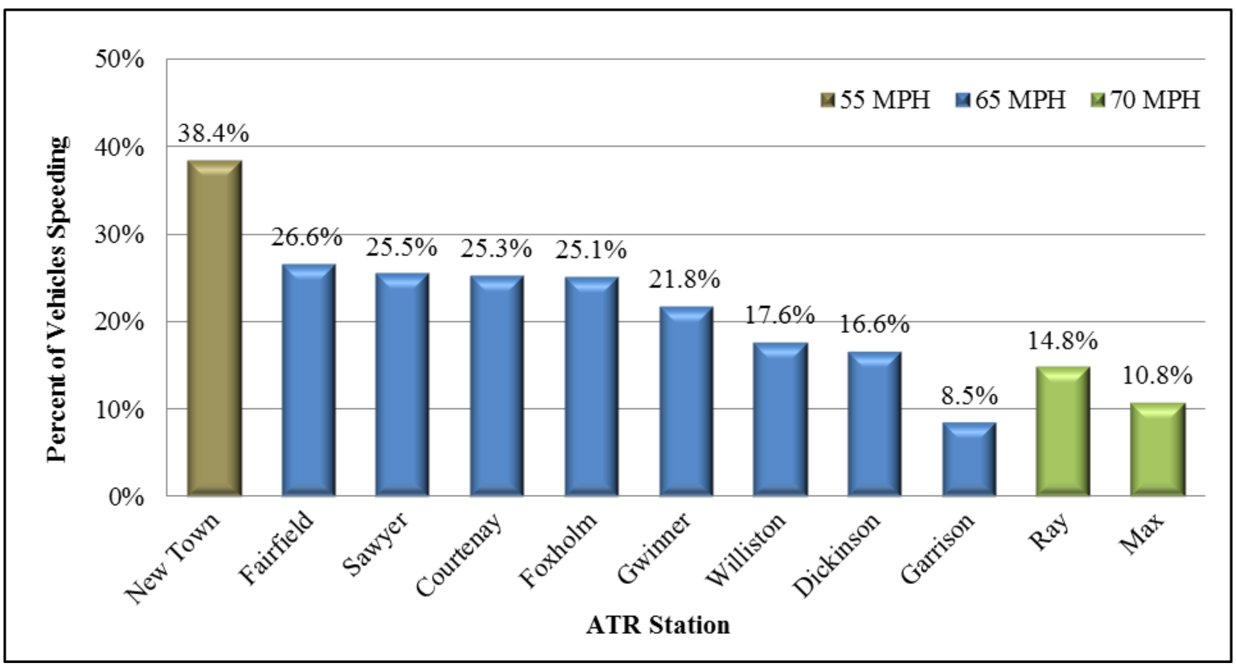

Figure 3.6 Percentage of Passenger Vehicles Speeding by Site from 5/19/10 to 5/31/10

Figre 3.7, Figure 3.8, Figure 3.9, and Figure 3.10 show the relationship between site, day of the week, and time of the day for each of the sites from May 19, 2010, to May 31, 2010. This time span includes a two-week baseline and the Memorial Day holiday weekend. These graphs show some of the same relationship established from the univariate analysis, which must be accounted for in the analysis of the HVE and the holiday weekends. Multivariate analysis will control for the variation in these variables and allow for a direct examination of whether the enhanced enforcement is effective.

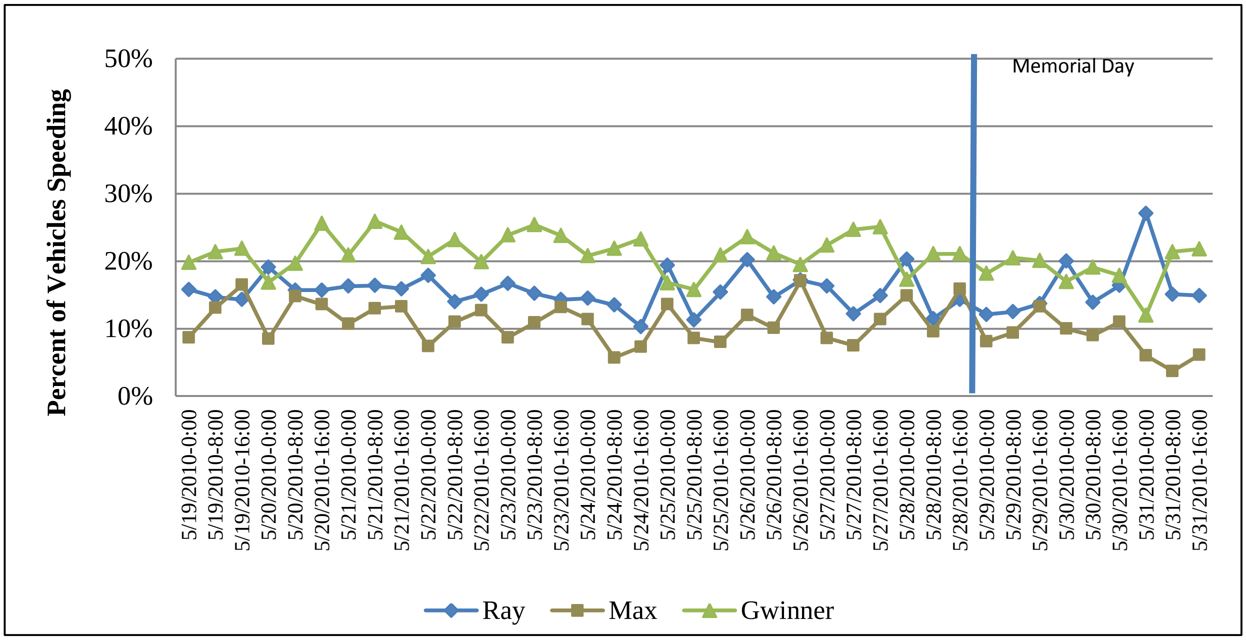

Figure 3.7 Percentage of Passenger Vehicles Speeding by Site and Time of Day

Figure 3.8 Percentage of Passenger Vehicles Speeding by Site and Time of Day

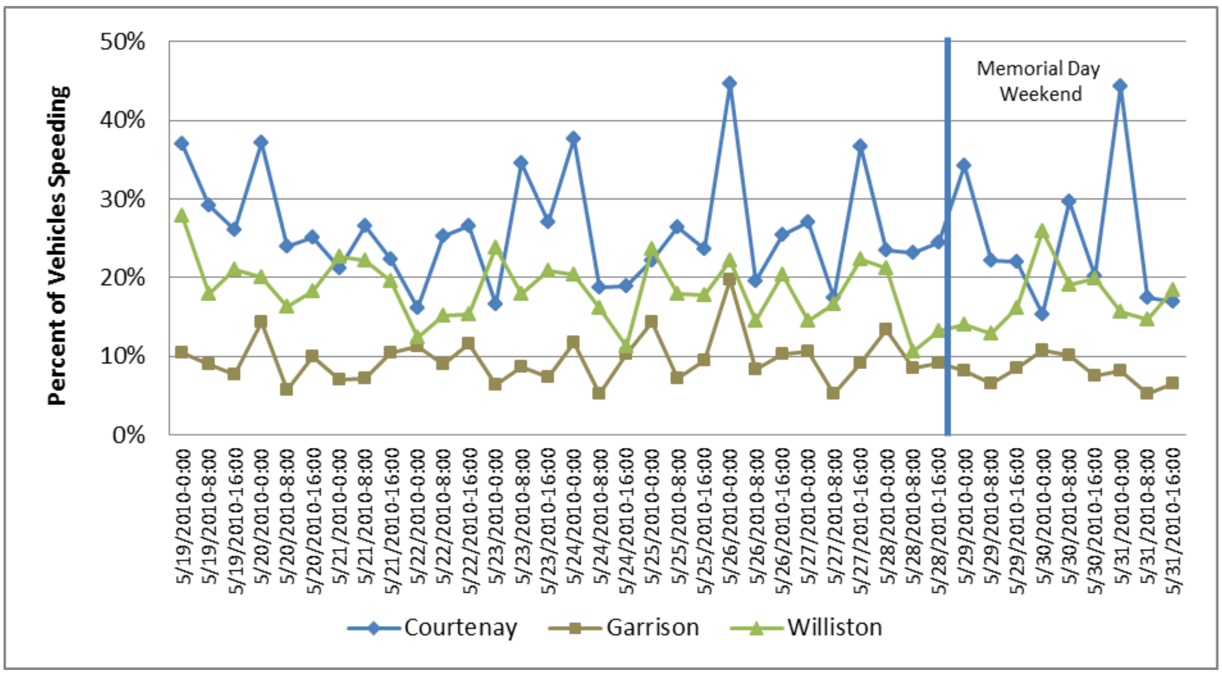

Figure 3.9 Percentage of Passenger Vehicles Speeding by Site and Time of Day

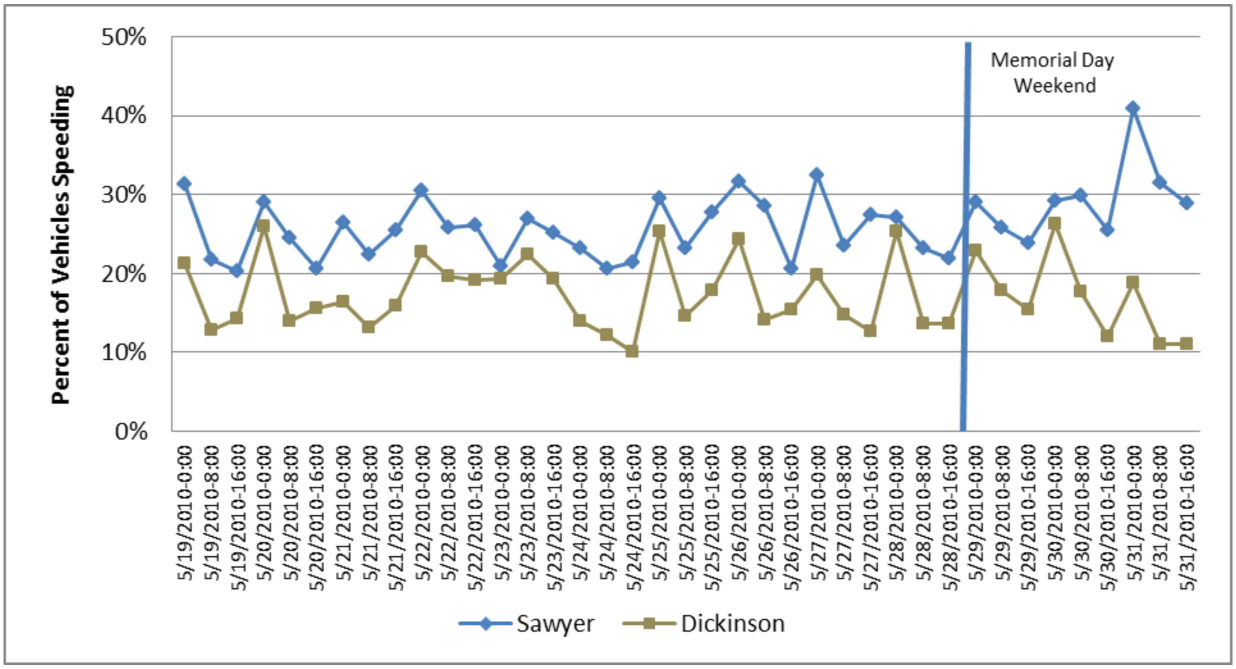

Figure 3.10 Percentage of Passenger Vehicles Speeding by Site and Time of Day

3.2 Systematic Travel Speed Examination and Metrics

Traffic flow is considered to be optimized if driver decisions for travel patterns show 85% of vehicles are moving within posted speed limit range – this includes all vehicles moving at speeds under or at the posted limit plus five miles-per-hour. Deviations from the 85th percentile may provide a prompt for road managers, law enforcement, and traffic safety offices to conduct additional analysis to determine an appropriate intervention or devise a multifaceted strategy. Figure 3.11 displays the percentage of passenger vehicles that were driving within the posted speed limit range or slower. A cursory review of these traffic speed patterns show New Town and Garrison have the largest deviations. At the New Town ATR site, 66.6% of vehicles were traveling within the 85th percentile compared to 91.7% at the Garrison site.

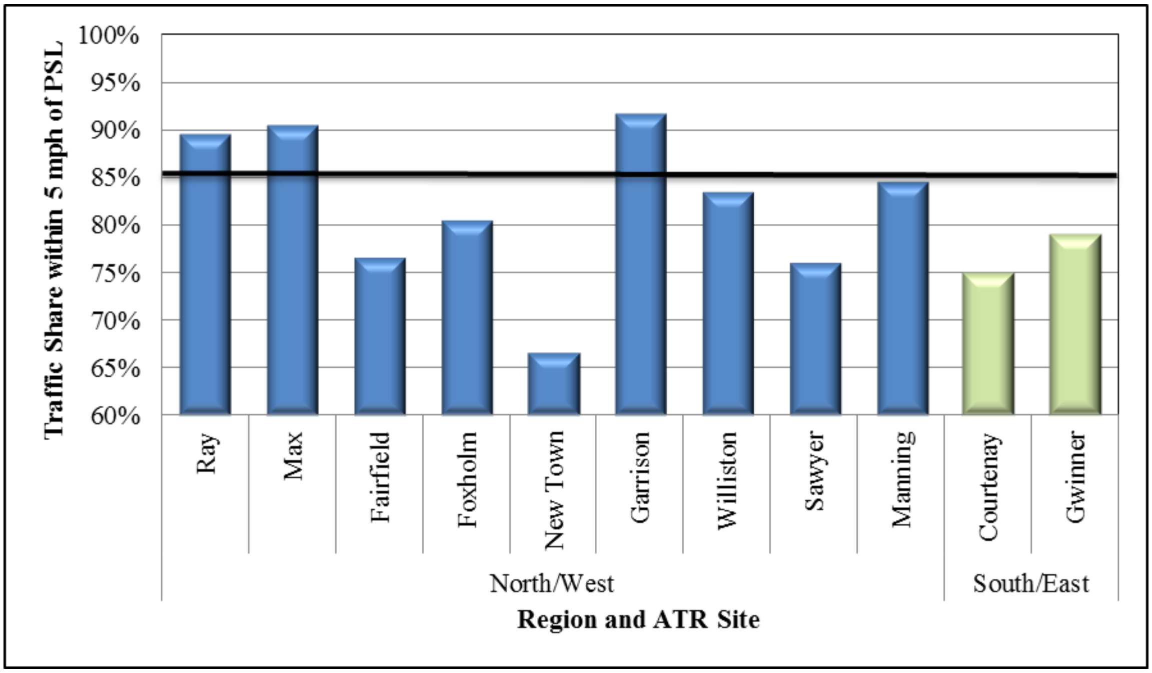

Figure 3.11 Traffic Speed in Relation to 85th Percentile Guideline for Posted Speed Limit

A more detailed summary of traffic speed analysis for individual ATR sties is shown in Table 3.1. The share of traffic operating within each of the 12 speed ranges is specified. These figures are based on all data collected during the pilot. The bottom four rows in the table show the effective traffic speed – estimated by the observed 85th percentile range. Only the Ray, Max, and Garrison observed speeds were within the guideline rule. For these sites, 85% of the traffic falls within speed ranges with the maximum at the 5 mile-per-hour allowance for the posted speed limits (PSLs) range. Systematic review for higher-risk traffic was estimated in the speed differentials. The shares of traffic operating 15 miles-per-hour above and below the PSL are the speed differential metrics. Calculating the standard deviation for the metric among the pilot sites shows the share at the higher-speed differentials more than one standard deviation above the mean for New Town and Courtney. The standard deviations for the lower-speed differentials show that Garrison and Williston are beyond one standard deviation. The high-speed risk at New Town may be related to the lack of driver awareness of the recent reduction in the speed limit or that it has a low speed limit, relative to other sites, such as those in this analysis. Drivers either may not realize the speed limit is that low or may decide the posted speed is too slow. The Garrison and Williston low-speed risk may be related to traffic density or the road environment.

Table 3.1 Traffic Speeds, All Vehicles

	North/West									South/East	
Site	Ray	Max	Fairfield	Fox-holm	New Town	Garrison	Williston	Sawyer	Man-ning	Court-enay	Gwinner
PSL (mph)	*70*	*70*	*65*	*65*	*55*	*65*	*65*	*65*	*65*	*65*	*65*
< =40.0	0.5%	0.1%	0.5%	0.2%	0.7%	2.1%	4.2%	0.4%	0.6%	1.9%	1.1%
40.1 - 45.0	0.1%	0.1%	0.2%	0.2%	0.7%	1.9%	2.4%	0.2%	0.1%	0.8%	0.7%
45.1 - 50.0	0.3%	0.4%	0.6%	0.5%	3.6%	3.6%	2.7%	0.6%	0.4%	0.9%	2.0%
50.1 - 55.0	1.0%	1.2%	2.0%	2.6%	22.8%	10.7%	3.9%	2.4%	1.3%	2.8%	4.8%
55.1 - 60.0	2.9%	3.9%	6.5%	9.9%	38.8%	21.5%	9.6%	6.7%	6.4%	8.0%	12.5%
60.1 - 65.0	9.7%	12.9%	24.6%	36.0%	19.5%	27.9%	23.9%	24.3%	28.7%	20.6%	26.7%
65.1 - 70.0	34.7%	35.5%	42.2%	31.0%	8.1%	24.0%	36.8%	41.5%	46.9%	40.0%	31.1%
70.1 - 75.0	40.3%	36.3%	15.6%	14.3%	3.3%	6.3%	11.2%	17.6%	10.9%	14.3%	15.2%
75.1 - 80.0	8.9%	7.4%	5.5%	3.9%	1.5%	1.4%	3.8%	3.7%	3.3%	6.8%	4.4%
80.1 - 84.9	1.2%	1.7%	1.4%	0.8%	0.5%	0.4%	1.1%	1.6%	0.8%	2.0%	0.8%
85.0 - 89.9	0.3%	0.3%	0.6%	0.3%	0.3%	0.1%	0.3%	0.7%	0.4%	1.0%	0.4%
> 89.99	0.2%	0.2%	0.3%	0.2%	0.3%	0.1%	0.1%	0.4%	0.2%	0.8%	0.2%
Total Vehicle Count	66,462	36,651	29,574	42,740	52,568	21,812	22,415	72,213	53,433	7,579	18,121
Observed 85th Percentile Range	70-75	70-75	70-75	70-75	60-65	65-70	70-75	70-75	70-75	70-75	70-75
PSL (+5 mph)= 85th Percentile Goal	89.5%	90.4%	76.6%	80.5%	66.6%	91.7%	83.4%	76.1%	84.5%	75.1%	79.0%
15 mph or more under PSL	1.8%	1.8%	1.3%	0.9%	1.4%	7.6%	9.3%	1.1%	1.2%	3.6%	3.8%
15 mph or more over PSL	0.5%	0.5%	2.3%	1.3%	5.9%	0.6%	1.5%	2.7%	1.4%	3.8%	1.4%

Further detail for the traffic speeds by vehicle group, including the observed 85th percentile and the high-risk traffic, are provided in Table 3.2 and Table 3.3. This information may be useful to law enforcement and other with interest in traffic safety as they assess needs across the road geography and among user groups. Distinguishing the risk metrics by vehicle group does provide additional insight for high-speed travel. For passenger vehicles, only the New Town site falls beyond one standard deviation from the mean share. The truck calculations show that Courtney and Sawyer have a disproportionately large share of large trucks traveling at high speeds. The low-speed metric results are consistent with those found for all traffic – Garrison and Williston are both outside the range defined by one standard deviation for both passenger and large truck vehicle types with relatively large shares of slow moving vehicles.

Table 3.2 Traffic Speeds, Passenger Vehicles

	North/West									South/East	
Site	Ray	Max	Fairfield	Fox-holm	New Town	Garrison	Williston	Sawyer	Man-ning	Court-enay	Gwinner
PSL (mph)	*70*	*70*	*65*	*65*	*55*	*65*	*65*	*65*	*65*	*65*	*65*
< =40.0	0.4%	0.1%	0.3%	0.2%	0.7%	1.5%	3.0%	0.4%	0.7%	1.2%	0.8%
40.1 - 45.0	0.1%	0.1%	0.2%	0.2%	0.6%	1.7%	2.4%	0.2%	0.1%	0.8%	0.6%
45.1 - 50.0	0.2%	0.3%	0.6%	0.6%	3.3%	3.4%	2.4%	0.6%	0.4%	0.9%	1.6%
50.1 - 55.0	0.8%	0.9%	1.7%	2.8%	20.1%	10.3%	3.4%	2.5%	1.3%	2.6%	4.4%
55.1 - 60.0	2.2%	3.0%	5.7%	9.3%	36.9%	21.7%	8.2%	6.6%	6.4%	8.0%	12.1%
60.1 - 65.0	6.2%	9.3%	22.8%	27.2%	20.8%	28.4%	24.0%	22.6%	27.4%	20.7%	26.9%
65.1 - 70.0	26.3%	35.0%	42.1%	34.7%	9.8%	24.6%	39.1%	41.6%	47.1%	40.6%	31.8%
70.1 - 75.0	49.1%	40.6%	17.5%	18.5%	4.2%	6.4%	11.9%	19.5%	11.6%	14.7%	15.8%
75.1 - 80.0	12.4%	8.4%	6.4%	5.1%	2.0%	1.5%	4.2%	3.8%	3.5%	6.9%	4.6%
80.1 - 84.9	1.7%	1.8%	1.7%	1.0%	0.7%	0.4%	1.1%	1.5%	0.9%	2.1%	0.8%
85.0 - 89.9	0.4%	0.4%	0.8%	0.4%	0.4%	0.2%	0.3%	0.5%	0.4%	0.9%	0.4%
> 89.99	0.3%	0.2%	0.3%	0.2%	0.5%	0.6%	0.1%	0.3%	0.3%	0.8%	0.3%
Total Passenger Count	41,715	30,709	20,201	27,863	35,694	20,258	19,239	57,772	37,695	7,085	16,966
Observed 85th Percentile Range	70-75	70-75	70-75	70-75	65-70	65-70	70-75	70-75	70-75	70-75	70-75
PSL (+5 mph)= 85th Percentile Goal	85.3%	89.2%	73.4%	74.9%	61.6%	91.5%	82.4%	74.5%	83.4%	74.7%	78.2%
15 mph or more under PSL	1.5%	1.3%	1.1%	1.0%	1.3%	6.5%	7.8%	1.2%	1.2%	2.8%	3.1%
15 mph or more over PSL	0.7%	0.6%	2.7%	1.5%	7.8%	1.2%	1.6%	2.2%	1.5%	3.7%	1.5%

Table 3.3 Traffic Speeds, Truck Vehicles											
	North/West									South/East	
Site	Ray	Max	Fairfield	Fox-holm	New Town	Garrison	Williston	Sawyer	Man-ning	Court-enay	Gwinner
PSL (mph)	*70*	*70*	*65*	*65*	*55*	*65*	*65*	*65*	*65*	*65*	*65*
< =40.0	0.6%	0.4%	0.9%	0.1%	0.7%	10.4%	12.0%	0.2%	0.5%	11.9%	5.3%
40.1 - 45.0	0.2%	0.4%	0.3%	0.2%	0.9%	3.7%	2.2%	0.1%	0.2%	0.8%	2.5%
45.1 - 50.0	0.4%	0.8%	0.6%	0.4%	4.2%	7.1%	4.0%	0.6%	0.5%	1.2%	7.3%
50.1 - 55.0	1.2%	2.7%	2.4%	2.4%	28.5%	16.6%	7.0%	2.2%	1.5%	5.7%	11.3%
55.1 - 60.0	4.1%	8.5%	8.2%	11.1%	42.8%	19.2%	18.0%	6.9%	6.3%	8.7%	17.8%
60.1 - 65.0	15.7%	31.8%	28.5%	52.7%	16.8%	21.7%	23.5%	31.1%	31.6%	20.5%	25.0%
65.1 - 70.0	49.0%	38.2%	42.4%	24.1%	4.3%	15.1%	22.8%	41.2%	46.6%	32.0%	22.0%
70.1 - 75.0	25.5%	13.7%	11.7%	6.4%	1.2%	4.5%	7.1%	10.0%	9.0%	8.7%	7.0%
75.1 - 80.0	2.9%	2.5%	3.6%	1.7%	0.4%	0.8%	1.9%	3.2%	2.7%	6.1%	1.3%
80.1 - 84.9	0.4%	0.8%	0.9%	0.5%	0.1%	0.5%	1.0%	2.4%	0.7%	1.4%	0.4%
85.0 - 89.9	0.1%	0.1%	0.4%	0.2%	0.0%	0.1%	0.4%	1.2%	0.2%	2.8%	0.1%
> 89.99	0.0%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.9%	0.2%	0.2%	0.1%
Total Passenger Count	24,747	5,942	9,373	14,877	16,874	1,554	3,176	14,441	15,738	494	1,155
Observed 85th Percentile Range	70-75	70-75	70-75	70-75	60-65	65-70	65-70	70-75	70-75	70-75	70-75
PSL (+5 mph)= 85th Percentile Goal	96.7%	96.5%	83.4%	91.0%	77.0%	93.9%	89.5%	82.4%	87.2%	80.8%	91.2%
15 mph or more under PSL	2.4%	4.3%	1.8%	0.7%	1.6%	21.3%	18.2%	0.9%	1.2%	14.0%	15.1%
15 mph or more over PSL	0.1%	0.2%	1.4%	0.8%	1.9%	0.7%	1.5%	4.5%	1.0%	4.5%	0.5%

3.3 Analysis of Media Campaigns and High Visibility Enforcement

Although there were no specific HVE campaigns conducted on either Memorial Day weekend or Labor Day weekend, there was heightened awareness through additional media attention and increased patrol by law enforcement. The high-profile holiday travel periods may also benefit from previous HVE campaigns on this type of weekend. Because data was not received consistently for all ATRs, only selected ATRs are included in the analysis for each of the weekends.

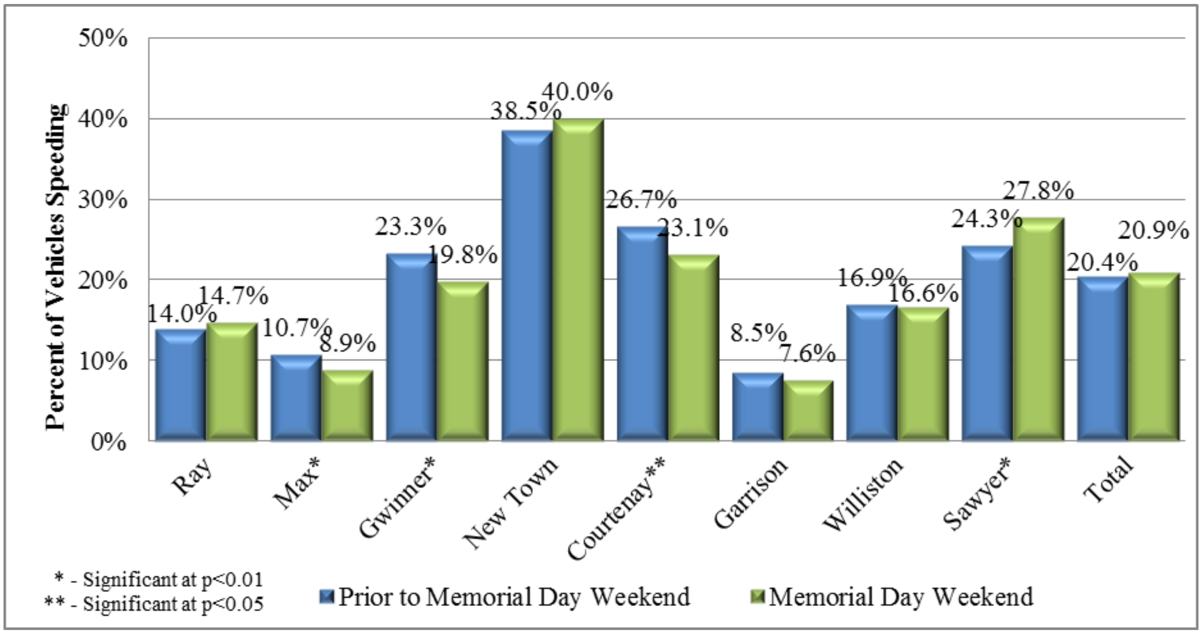

Figure 3.12 Percentage of Passenger Vehicles Speeding Prior to and on Memorial Day Weekend

The ATRs included in the Memorial Day analysis are listed in Figure 3.12. The analysis compares Memorial Day weekend (May 29, 30, and 31) traffic to traffic from the previous weekend (May 22, 23, and 24), again using the same sites and days of the week for each period. Of the eight sites included in the analysis, five saw a decrease in the percentage of vehicles speeding with three of the decreases being statistically significant. Of the three increases, only the increase at the Sawyer site was statistically significant. Overall, there was a slight increase in the rate of vehicles speeding at these eight sites, from 20.4% to 20.9%, (χ^2=2.90, n=89,565, p=0.0888).

Looking at the high-risk speeders overall (Figure 3.13), shows a slight decrease during Memorial Day weekend when compared to the previous weekend. This decrease is not significant (χ^2=1.61, n=89,565, p=0.2051). Two sites, Gwinner and Sawyer, showed small increases, 1.57% to 1.88% and 2.20% to 2.21%, respectively. None of the site differences were significant.

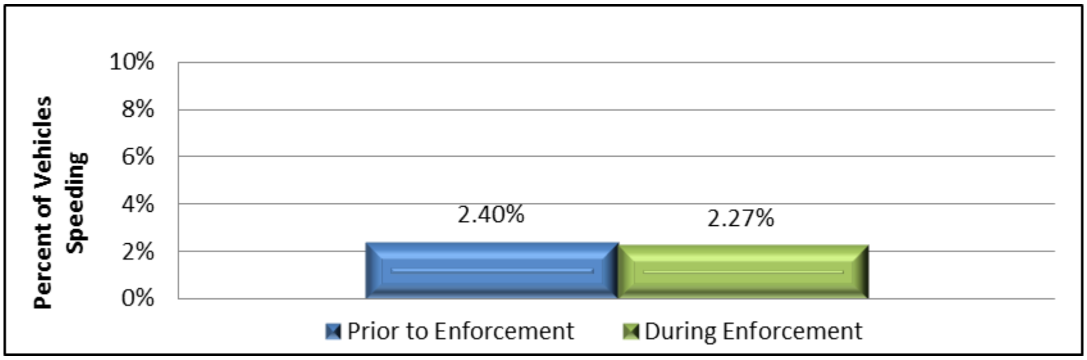

Figure 3.13 Percentage of Passenger Vehicles High Risk Speeding Prior to and on Memorial Day Weekend

Sites included in the Labor Day weekend analysis are Ray, New Town, and Manning (Figure 3.14). Each of these sites saw increases from August 28, 29, and 30 compared to September 4, 5, and 6. These increases are statistically significant. The overall percentage for the three sites also increased and is significant (χ^2=39.61, n=29,330, p<0.0001).

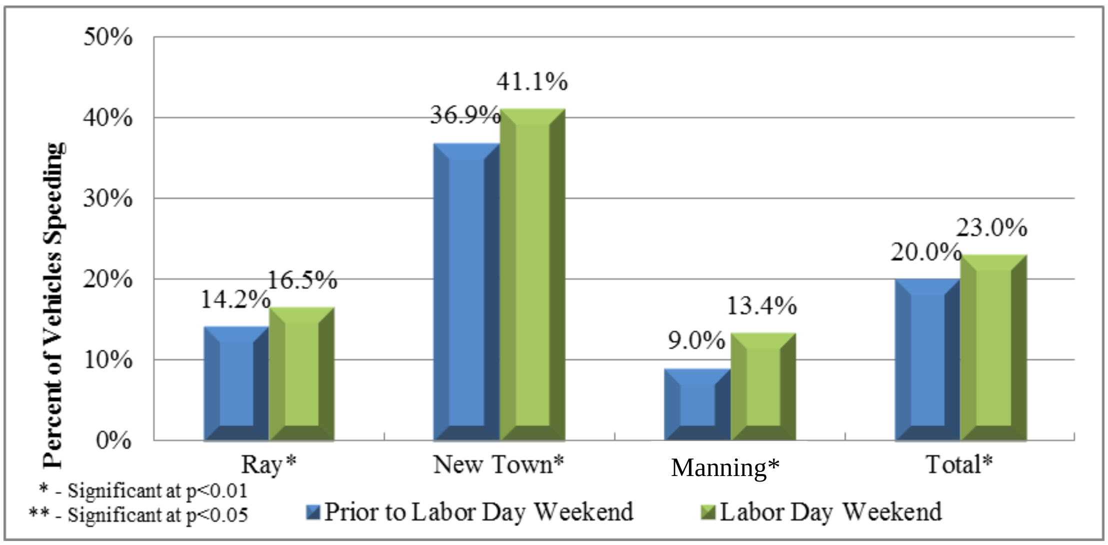

Figure 3.14 Percentage of Passenger Vehicles Speeding Prior to and on Labor Day Weekend

Figure 3.15 shows the percentage of drivers driving more than 15 miles-per-hour over the speed limit increased on Labor Day weekend when compared to the previous weekend. Each of the three individual sites also saw increases in high-speed risk prevalence during Labor Day weekend. Neither the individual nor the overall changes were statistically significant.

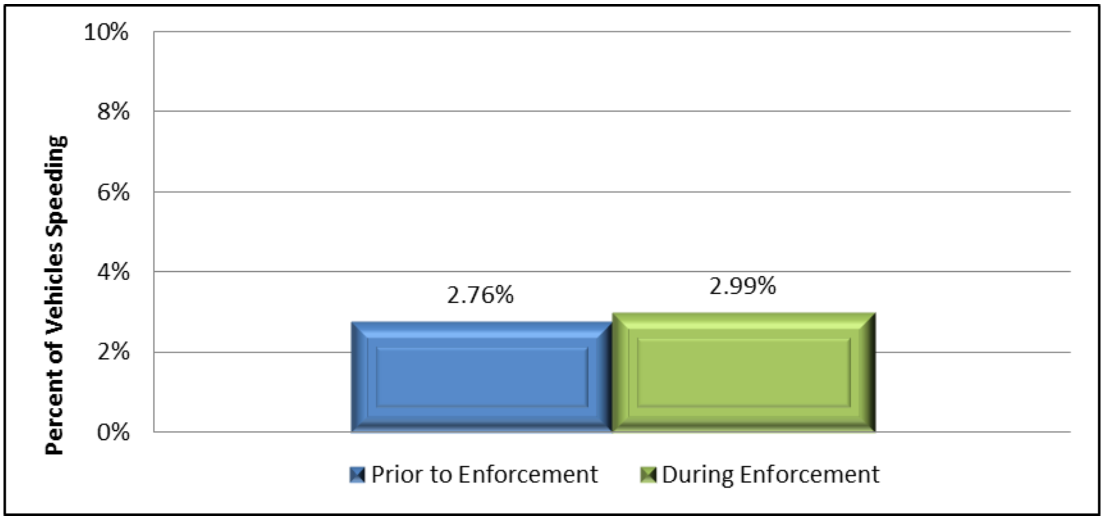

Figure 3.15 Percentage of Passenger Vehicles High Risk Speeding Prior to and on Labor Day Weekend

Increased speeding on both holiday weekends is somewhat surprising given previous campaigns targeted at these weekends. There may, however, be an underlying driver behavior which dictates increased speed on those weekends and the increased rates would be even higher without the previous campaigns. Christensen (1981), Ward (1994), and others suggest that enhanced enforcement on those weekends would be a good investment of resources.

High visibility enforcement couples media and manpower in an effort to modify a behavior – in this case to reduce speeding. On August 26 and 27, 2010, the North Dakota Highway Patrol conducted an HVE campaign concentrated on Highways 8, 22, 23, and 73 in northwestern North Dakota. This campaign corresponds to one ATR site – New Town. Data from four additional ATR sites were analyzed as a control to the New Town site in the HVE analysis. These sites are Ray, Max, Fairfield, and Manning. All five sites had data available for August 26 and 27, as well as the two previous Thursdays and Fridays, August 12, 13, 19, and 20. The same days of the week at the same sites were chosen to help control for the variation that was identified in the univariate analysis. During the HVE campaign, vehicles speeding at the New Town site decreased, although not significantly, from 40.3% to 39.5%, (χ^2=0.80, n=11,420, p=0.3714). Share of vehicles speeding at the other four sites increased significantly, increasing from 12.4% to 14.4%, (χ^2=33.13, n=47,491, p<0.0001). These results are displayed in Figure 3.16.

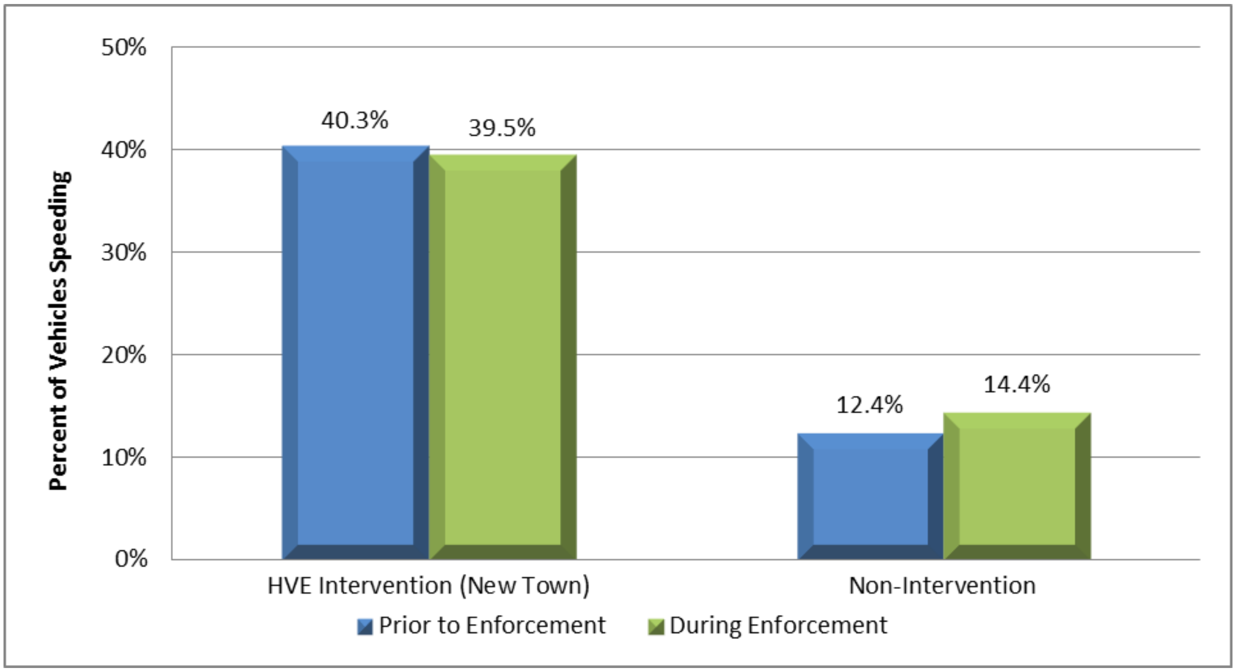

Figure 3.16 Percentage of Passenger Vehicles Speeding Prior to and During HVE Enforcement

However, looking at average speeds shows both groups increasing. The site at New Town saw an average increase in speed of 0.3 mph. The sites not involved in the campaign saw an average increase of 0.6 mph. The average speed was found by assigning the mid-point of the speed range recorded by the ATR for each vehicle and calculating the mean of those values. This is a common estimation method when the distribution within the ranges is unknown but suspected to be normal or symmetric.

The idea behind the HVE is to reduce speeding through targeted enforcement, media coverage, and increased law enforcement visibility. As shown above, the HVE campaign conducted on August 26 and 27 did not significantly reduce the percentage of vehicles speeding. There are a couple issues that may explain why. First, the HVE campaign was conducted in a large area on the four highways but the ATR site at New Town was used as a single point to measure the success of the intervention. Many of the vehicles traveling (even those on Highway 23) do not need to cross the New Town ATR. Second, it looks like there was an increase in speeding at the other sites on these two days when compared to the two previous Thursdays and Fridays. If this increase in propensity to speed was also present in the driver population for the New Town site during August 26 and 27, then the size of the effect of the HVE was larger than the 0.8% observed. Both of these factors would confound the analysis.

When comparing the high-risk speeding percentages during the HVE campaign (Figure 3.17), the results are similar to the results for speeding. The vehicles traveling more than 15 mph over the speed limit at the New Town site increased, although not significantly, from 6.98% to 7.19% (χ^2=0.17, n=11,420, p=0.6777), while vehicles speeding at the other four sites increased significantly from 1.02% to 1.26%, (χ^2=5.76, n=47,491, p=0.0164).

The percentage of high-risk speeders at New Town is roughly seven times more than the other non-HVE sites. The New Town site also has roughly three times as many speeders as the other sites. The lower speed limits at this site may partially explain the higher percentage of speeding and high-risk speeding at this site. However, it suggests that even though the HVE did not significantly reduce the percentage of speeders and high-risk speeders at the New Town site, it may have prevented a statistically significant increase considering the drivers at the New Town site are more likely to engage in speeding and high-risk speeding.

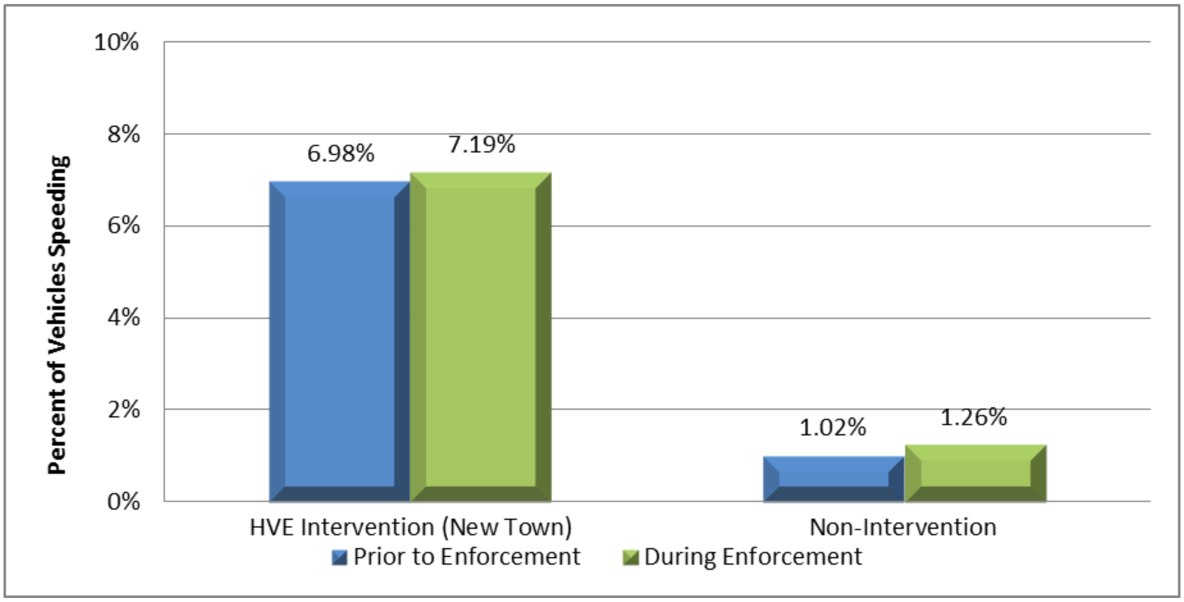

Figure 3.17 Percentage of Passenger Vehicles High Risk Speeding Prior to and During HVE Enforcement

4. CONCLUSION

High speed travel increases risk for crash severity. This work established metrics for assessing speed as a factor in traffic safety through systematic and programmatic analysis. The pilot project used existing assets and technological infrastructure to highlight travel speed in the northwest region of the state. This region has recently experienced exponential growth in traffic volumes due to oil industry development. Analysis of data from 11 ATR sites measured differences in driver behavior with regard to posted speed adherence. In addition, analysis highlighted high-risk driver groups who operate at the extreme ends of the speed scale. Speed differential has been shown to be an important factor in crash risk. Systematic results did show variation across time and geography with regard to driver decision to drive at speeds beyond the expected 85th percentile range. In addition, the prevalence of high-risk drivers was highlighted, and provides information for education and enforcement resource allocations.

The ability to test programs and campaigns targeted at speeding drivers was possible in the pilot. Limited data was used in quasi-experimental design to analyze an HVE campaign using data from a single ATR site. It showed that the percent of vehicles speeding declined for the intervention group, but that the decrease was not statistically significant. In contrast, speeding significantly increased at the non-intervention quasi-control sites. With regard to annual efforts to encourage safe travel during holiday travel times, similar results were observed for a more robust dataset. In both analyses, impacts were most noticeable for highest-risk drivers. In the future, specifically including outcomes measurements as part of the design of the HVE would ensure multiple ATR data sites are included in the intervention group. It also would allow law enforcement to specifically target areas adjacent to the ATR sites rather than the wider road geography where an ATR may or may not be measuring vehicle speeds affected by the HVE.

As traffic density increases, especially on western two-lane highways, crash risk also increases. Proactive plans to address and assess crash risk from traffic speed on rural highways are valuable in overarching goals to improve road safety. The pilot provided a valuable opportunity to test assets and cooperative arrangements around metrics that may be used in this effort.

APPENDIX A. NDDOT AATD TRAFFIC COUNTS

Average Annual Daily Traffic Count, Pilot Stations															
Group	Station Number	Location	1990	1992	1994	1996	1998	2000	2002	2004	2006	2007	2008	2009	2010
RPA	201	Ray	1454	1524	1586	1534	1570	1618	1678	1660	1873	2115	2678	2963	4367
RPA	203	Max	2642	2808	2814	3108	3130	3366	3532	3600	3612	3653	3702	4107	5003
RPA	221	Fairfield	1584	1458	1338	1406	1356	1370	1408	1436	1649	1754	1808	1820	2120
RPA	233	Foxholm	1820	2012	1994	1952	1926	1832	1894	1870	1899	2100	2177	2158	2491
RPA	239	New Town	1038	1072	1406	1374	1382	1520	1606	1682	1599	1726	2357	2680	3703
RMA	249	Garrison	934	956	1022		1142	1166	1208	1178	1164	1177	1184	1254	1359
RPA	257	Williston	928	1052	1068	1156	1236		1208	1186	1229	1265	1251	1206	1620
RPA	281	Sawyer						3646	3724	3878	3902	4004	3883	4112	4563
RMA	289	Manning							1592	1610	1718	1901	2341	2591	3675
RPA	205	Gwinner	920	936	960	994	1026	1146	1118	1266	1255	1200	1109	1066	1216
RMA	247	Courtenay	434	466	518	468		486	518	490	460	456	442	463	464
RPA	Group Mean	Rural Principal Arterial (mean)	1640	1697	1742	1985	2004	1901	1777	1796	1799	1875	1939	2054	2346
RMA	Group Mean	Rural Minor Arterial (mean)	1033	1069	1089	1095	1346	1210	1308	1319	1268	1307	1418	1490	1739
Source: NDDOT 2011															

APPENDIX B.
ATR PILOT SITE SPEED SUMMARY, VEHICLE COUNTS

Table B.1 Traffic Counts for Passenger, Truck, and All Traffic by Speed for Ray, Max, and Gwinner

Site	Ray			Max			Gwinner		
Spd (mph)	**Passenger**	**Trucks**	**Total**	**Passenger**	**Trucks**	**Total**	**Passenger**	**Trucks**	**Total**
< =40.0	144 (0.35%)	154 (0.62%)	298 (0.45%)	27 (0.09%)	24 (0.40%)	51 (0.14%)	142 (0.84%)	61 (5.28%)	203 (1.12%)
40.1 - 45.0	40 (0.10%)	46 (0.19%)	86 (0.13%)	19 (0.06%)	21 (0.35%)	40 (0.11%)	106 (0.62%)	29 (2.51%)	135 (0.74%)
45.1 - 50.0	94 (0.23%)	87 (0.35%)	181 (0.27%)	85 (0.28%)	49 (0.82%)	134 (0.37%)	269 (1.59%)	84 (7.27%)	353 (1.95%)
50.1 - 55.0	338 (0.81%)	307 (1.24%)	645 (0.97%)	273 (0.89%)	162 (2.73%)	435 (1.19%)	743 (4.38%)	131 (11.34%)	874 (4.82%)
55.1 - 60.0	902 (2.16%)	1,021 (4.13%)	1,923 (2.89%)	928 (3.02%)	506 (8.52%)	1,434 (3.91%)	2,060 (12.14%)	205 (17.75%)	2,265 (12.50%)
60.1 - 65.0	2,588 (6.20%)	3,880 (15.68%)	6,468 (9.73%)	2,848 (9.27%)	1,888 (31.77%)	4,736 (12.92%)	4,556 (26.85%)	289 (25.02%)	4,845 (26.74%)
65.1 - 70.0	10,957 (26.27%)	12,119 (48.97%)	23,076 (34.72%)	10,733 (34.95%)	2,269 (38.19%)	13,002 (35.48%)	5,386 (31.75%)	254 (21.99%)	5,640 (31.12%)
70.1 - 75.0	20,494 (49.13%)	6,305 (25.48%)	26,799 (40.32%)	12,478 (40.63%)	814 (13.70%)	13,292 (36.27%)	2,677 (15.78%)	81 (7.01%)	2,758 (15.22%)
75.1 - 80.0	5,180 (12.42%)	705 (2.85%)	5,885 (8.85%)	2,576 (8.39%)	147 (2.47%)	2,723 (7.43%)	775 (4.57%)	15 (1.30%)	790 (4.36%)
80.1 - 84.99	707 (1.69%)	88 (0.36%)	795 (1.20%)	563 (1.83%)	48 (0.81%)	611 (1.67%)	140 (0.83%)	4 (0.35%)	144 (0.79%)
85.0 - 89.99	155 (0.37%)	24 (0.10%)	179 (0.27%)	113 (0.37%)	8 (0.13%)	121 (0.33%)	69 (0.41%)	1 (0.09%)	70 (0.39%)
> 89.99	116 (0.28%)	11 (0.04%)	127 (0.19%)	66 (0.21%)	6 (0.10%)	72 (0.20%)	43 (0.25%)	1 (0.09%)	44 (0.24%)
>5 mph over limit	6,158 (14.76%)	828 (3.35%)	6,986 (10.51%)	3,318 (10.80%)	209 (3.52%)	3,527 (9.62%)	3,704 (21.83%)	102 (8.83%)	3,806 (21.00%)
Total	41,715 (62.77%)	24,747 (37.23%)	66,462 (15.69%)	30,709 (83.79%)	5,942 (16.21%)	36,651 (8.65%)	16,966 (93.63%)	1,155 (6.27%)	18,121 (4.28%)

Shaded areas represent more than 5 mph over the speed limit.

Table B.2 Traffic Counts for Passenger, Truck, and All Traffic by Speed for Fairfield, Foxholm, and New Town

Site	Fairfield			Foxholm			New Town		
Spd	Passenger	Trucks	Total	Passenger	Trucks	Total	Passenger	Trucks	Total
< =40.0	65 (0.32%)	87 (0.93%)	152 (0.51%)	57 (0.20%)	14 (0.09%)	71 (0.17%)	243 (0.68%)	115 (0.68%)	358 (0.68%)
40.1 - 45.0	41 (0.20%)	28 (0.30%)	69 (0.23%)	50 (0.18%)	30 (0.20%)	80 (0.19%)	222 (0.62%)	146 (0.87%)	368 (0.70%)
45.1 - 50.0	112 (0.55%)	53 (0.57%)	165 (0.56%)	165 (0.59%)	57 (0.38%)	222 (0.52%)	1,174 (3.29%)	703 (4.17%)	1,877 (3.57%)
50.1 - 55.0	349 (1.73%)	229 (2.44%)	578 (1.95%)	765 (2.75%)	360 (2.42%)	1,125 (2.63%)	7,178 (20.11%)	4,811 (28.51%)	11,989 (22.81%)
55.1 - 60.0	1,159 (5.74%)	767 (8.18%)	1,926 (6.51%)	2,587 (9.28%)	1,652 (11.10%)	4,239 (9.92%)	13,180 (36.92%)	7,223 (42.81%)	20,403 (38.81%)
60.1 - 65.0	4,606 (22.80%)	2,674 (28.53%)	7,280 (24.62%)	7,565 (27.15%)	7,832 (52.65%)	15,397 (36.02%)	7,411 (20.76%)	2,828 (16.76%)	10,239 (19.48%)
65.1 - 70.0	8,498 (42.07%)	3,974 (42.40%)	12,472 (42.17%)	9,674 (34.72%)	3,591 (24.14%)	13,265 (31.04%)	3,502 (9.81%)	732 (4.34%)	4,234 (8.05%)
70.1 - 75.0	3,527 (17.46%)	1,097 (11.70%)	4,624 (15.64%)	5,148 (18.48%)	958 (6.44%)	6,106 (14.29%)	1,507 (4.22%)	209 (1.24%)	1,716 (3.26%)
75.1 - 80.0	1,292 (6.40%)	333 (3.55%)	1,625 (5.49%)	1,425 (5.11%)	259 (1.74%)	1,684 (3.94%)	716 (2.01%)	71 (0.42%)	787 (1.50%)
80.1 - 84.99	334 (1.65%)	83 (0.89%)	417 (1.41%)	277 (0.99%)	68 (0.46%)	345 (0.81%)	254 (0.71%)	21 (0.12%)	275 (0.52%)
85.0 - 89.99	153 (0.76%)	35 (0.37%)	188 (0.64%)	102 (0.37%)	28 (0.19%)	130 (0.30%)	147 (0.41%)	5 (0.03%)	152 (0.29%)
> 89.99	65 (0.32%)	13 (0.14%)	78 (0.26%)	48 (0.17%)	28 (0.19%)	76 (0.18%)	160 (0.45%)	10 (0.06%)	170 (0.32%)
>5 mph over limit	5,371 (26.59%)	1,561 (16.65%)	6,932 (23.44%)	7,000 (25.12%)	1,341 (9.01%)	8,341 (19.52%)	13,697 (38.37%)	3,876 (22.97%)	17,573 (33.43%)
Total	20,201 (68.31%)	9,373 (31.69%)	29,574 (6.98%)	27,863 (65.19%)	14,877 (34.81%)	42,740 (10.09%)	35,694 (67.90%)	16,874 (32.10%)	52,568 (12.41%)

Shaded areas represent more than 5 mph over the speed limit.

Table B.3 Traffic Counts for Passenger, Truck, and All Traffic by Speed for Courtenay, Garrison, and Williston

Site	Courtenay			Garrison			Williston		
Spd	Passenger	Trucks	Total	Passenger	Trucks	Total	Passenger	Trucks	Total
< =40.0	84 (1.19%)	59 (11.94%)	143 (1.89%)	294 (1.45%)	162 (10.42%)	456 (2.09%)	569 (2.96%)	380 (11.96%)	949 (4.23%)
40.1 - 45.0	53 (0.75%)	4 (0.81%)	57 (0.75%)	347 (1.71%)	58 (3.73%)	405 (1.86%)	458 (2.38%)	70 (2.20%)	528 (2.36%)
45.1 - 50.0	63 (0.89%)	6 (1.21%)	69 (0.91%)	680 (3.36%)	111 (7.14%)	791 (3.63%)	469 (2.44%)	127 (4.00%)	596 (2.66%)
50.1 - 55.0	186 (2.63%)	28 (5.67%)	214 (2.82%)	2,077 (10.25%)	258 (16.60%)	2,335 (10.71%)	654 (3.40%)	223 (7.02%)	877 (3.91%)
55.1 - 60.0	565 (7.97%)	43 (8.70%)	608 (8.02%)	4,393 (21.69%)	299 (19.24%)	4,692 (21.51%)	1,573 (8.18%)	573 (18.04%)	2,146 (9.57%)
60.1 - 65.0	1,463 (20.65%)	101 (20.45%)	1,564 (20.64%)	5,756 (28.41%)	337 (21.69%)	6,093 (27.93%)	4,614 (23.98%)	745 (23.46%)	5,359 (23.91%)
65.1 - 70.0	2,877 (40.61%)	158 (31.98%)	3,035 (40.04%)	4,990 (24.63%)	235 (15.12%)	5,225 (23.95%)	7,522 (39.10%)	724 (22.80%)	8,246 (36.79%)
70.1 - 75.0	1,043 (14.72%)	43 (8.70%)	1,086 (14.33%)	1,295 (6.39%)	70 (4.50%)	1,365 (6.26%)	2,282 (11.86%)	226 (7.12%)	2,508 (11.19%)
75.1 - 80.0	488 (6.89%)	30 (6.07%)	518 (6.83%)	299 (1.48%)	13 (0.84%)	312 (1.43%)	800 (4.16%)	60 (1.89%)	860 (3.84%)
80.1 - 84.99	145 (2.05%)	7 (1.42%)	152 (2.01%)	84 (0.41%)	8 (0.51%)	92 (0.42%)	214 (1.11%)	32 (1.01%)	246 (1.10%)
85.0 - 89.99	62 (0.88%)	14 (2.83%)	76 (1.00%)	30 (0.15%)	1 (0.06%)	31 (0.14%)	57 (0.30%)	13 (0.41%)	70 (0.31%)
> 89.99	56 (0.79%)	1 (0.20%)	57 (0.75%)	13 (0.6%)	2 (0.13%)	15 (0.07%)	27 (0.14%)	3 (0.09%)	30 (0.13%)
>5 mph over limit	1,794 (25.32%)	95 (19.23%)	1,889 (24.92%)	1,721 (8.50%)	94 (6.05%)	1,815 (8.32%)	3,380 (17.57%)	334 (10.52%)	3,714 (16.57%)
Total	7,085 (93.48%)	494 (6.52%)	7,579 (1.79%)	20,258 (92.88%)	1,554 (7.12%)	21,812 (5.15%)	19,239 (85.83%)	3,176 (14.17%)	22,415 (5.29%)

Shaded areas represent more than 5 mph over the speed limit.

Table B.4 Traffic Counts for Passenger, Truck, and All Traffic by Speed for Sawyer, Manning, and All Sites

Site	Sawyer			Manning			All Sites		
Spd	**Passenger**	**Trucks**	**Total**	**Passenger**	**Trucks**	**Total**	**Passenger**	**Trucks**	**Total**
< =40.0	245 (0.42%)	32 (0.22%)	277 (0.38%)	261 (0.69%)	77 (0.49%)	338 (0.63%)	2,131 (0.68%)	1,165 (1.08%)	3,296 (0.78%)
40.1 - 45.0	121 (0.21%)	19 (0.13%)	140 (0.19%)	49 (0.13%)	28 (0.18%)	77 (0.14%)	1,506 (0.48%)	479 (0.44%)	1,985 (0.47%)
45.1 - 50.0	316 (0.55%)	80 (0.55%)	396 (0.55%)	131 (0.35%)	75 (0.48%)	206 (0.39%)	3,558 (1.13%)	1,432 (1.32%)	4,990 (1.18%)
50.1 - 55.0	1,415 (2.45%)	316 (2.19%)	1,731 (2.40%)	485 (1.29%)	232 (1.47%)	717 (1.34%)	14,463 (4.59%)	7,057 (6.51%)	21,520 (5.08%)
55.1 - 60.0	3,830 (6.63%)	996 (6.90%)	4,826 (6.68%)	2,417 (6.41%)	994 (6.32%)	3,411 (6.38%)	33,594 (10.66%)	14,279 (13.18%)	47,873 (11.30%)
60.1 - 65.0	13,076 (22.63%)	4,496 (31.13%)	17,572 (24.33%)	10,336 (27.42%)	4,976 (31.62%)	15,312 (28.66%)	64,819 (20.56%)	30,046 (27.73%)	94,865 (22.40%)
65.1 - 70.0	24,038 (41.61%)	5,954 (41.23%)	29,992 (41.53%)	17,745 (47.08%)	7,338 (46.63%)	25,083 (46.94%)	105,922 (33.61%)	37,348 (34.46%)	143,270 (33.82%)
70.1 - 75.0	11,262 (19.49%)	1,438 (9.96%)	12,700 (17.59%)	4,373 (11.60%)	1,423 (9.04%)	5,796 (10.85%)	66,086 (20.97%)	12,664 (11.69%)	78,750 (18.59%)
75.1 - 80.0	2,190 (3.79%)	461 (3.19%)	2,651 (3.67%)	1,322 (3.51%)	432 (2.74%)	1,754 (3.28%)	17,063 (5.41%)	2,526 (2.33%)	19,589 (4.62%)
80.1 - 84.99	839 (1.45%)	343 (2.38%)	1,182 (1.64%)	320 (0.85%)	106 (0.67%)	426 (0.80%)	3,877 (1.23%)	808 (0.75%)	4,685 (1.11%)
85.0 - 89.99	291 (0.50%)	178 (1.23%)	469 (0.65%)	151 (0.40%)	34 (0.22%)	185 (0.35%)	1,330 (0.42%)	341 (0.31%)	1,671 (0.39%)
> 89.99	149 (0.26%)	128 (0.89%)	277 (0.38%)	105 (0.28%)	23 (0.15%)	128 (0.24%)	848 (0.27%)	226 (0.21%)	1,074 (0.25%)
>5 mph over limit	14,731 (25.50%)	2,548 (17.64%)	17,279 (23.93%)	6,271 (16.64%)	2,018 (12.82%)	8,289 (15.51%)	67,145 (21.30%)	13,006 (12.00%)	80,151 (18.92%)
Total	57,772 (80.00%)	14,441 (20.00%)	72,213 (17.05%)	37,695 (70.55%)	15,738 (29.45%)	53,433 (12.61%)	315,197 (74.41%)	108,371 (25.59%)	423,568 (100.0%)

Shaded areas represent more than 5 mph over the speed limit.

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