UPDATE TO METHODOLOGY FOR SETTING SPEED LIMITS IN URBAN AREAS

Selection of Key Performance Measures and Identification of Study Locations

SPR 827

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June 2019

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
UPDATE TO METHODOLOGY FOR SETTING SPEED LIMITS IN URBAN AREAS: Selection of Key Performance Measures and Identification of Study Locations	-month- -year-
	6. Performing Organization Code
7. Author(s) Miguel Figliozzi, Avinash Unnikrishnan, Jaclyn Schaefer	8. Performing Organization Report No.
9. Performing Organization Name and Address Oregon Department of Transportation Research Section 555 13th Street NE, Suite 1 Salem, OR 97301	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Oregon Dept. of Transportation Research Section and Federal Highway Admin. 555 13th Street NE, Suite 1 1200 New Jersey Avenue SE Salem, OR 97301 Washington, DC 20590	13. Type of Report and Period Covered _______ Report 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract
Many cities in Oregon are requesting a comprehensive review of speed zoning guidelines and existing procedures for streets with high volumes of active travelers. Cities are proposing alternative speed zoning guidelines that are starkly different from existing guidelines based on the 85th percentile speed distribution. The alternative guidelines and criteria for setting speed zones have not been thoroughly studied or evaluated yet. The main goal of this research is to develop recommendations for alternate criteria for setting speed zones on roadways with a high percentage of active travelers. This report analyzes performance measures and discusses potential variables to collect as well as their source or collection method. A list of proposed, preliminary study locations considering road and traffic characteristics is given. A preliminary analysis of two sites along Southeast Lincoln St. is presented including traffic composition, speed percentiles, and speed limit compliance.

17. Key Words	18. Distribution Statement
Speed limit, speed zoning, speed compliance, active traveler, bicycle, pedestrian, operating speed, urban roads.	Copies available from NTIS, and online at http://www.oregon.gov/ODOT/TD/TP_RES/

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	XXX	

Technical Report Form DOT F 1700.7 (8-72) Reproduction of completed page authorized Printed on recycled paper

SI* (MODERN METRIC) CONVERSION FACTORS

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
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in 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

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

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The current speed setting methodology is heavily weighted towards motor vehicles and does not balance multimodal needs. A more balanced approach may result in improved safety and an enhanced environment for all road users. This research will help fill a gap left by previous research studies and guidelines on setting speed limits by focusing on the impact of variables related to active travelers and an environment consisting of urban roads that experience a high volume of such travelers.

This memo fulfills the requirements of Tasks 3 and 4. The goal of Task 3 is to analyze and select key performance measures that will guide data collection and analysis. Potential variables and data sources are also discussed. The goal of Task 4 is to identify study locations and start a pilot data collection/analysis.

Section 2 discusses compliance measures and performance criteria found. Data collection methods are also noted. A list of proposed performance measures is included. Section 3 discusses the data collection needs and methods. A list of potential variables and data sources is also given.

Section 4 outlines the considerations used to select potential corridors where speeds will be analyzed. Considerations of road and traffic characteristics for potential study locations are discussed. Site characteristics are described, and street view photos are included.

Section 5 gives a summary overview of a preliminary analysis of data obtained for two sites along Southeast Lincoln Street including traffic composition, 50th and 85th percentile speeds, and speed limit compliance. Section 6 ends with a list of proposed discussion points for TAC meeting #2.

2.0 SELECTION OF PERFORMANCE MEASURES

This section discusses the safety and speed compliance performance measures that were used in previous studies. This section also recommends a list of key performance measures that can be utilized in this project.

2.1 DEFINITION OF SPEEDING

One of the key questions to answer when it comes to speed studies is to define speed limit compliance: what constitutes speeding? how can speeding be measured? and what amount of speeding is considered excessive?

Speeding can be defined as exceeding the speed limit or as driving too fast for the given conditions *(National Highway Traffic Safety Administration [NHTSA], 2014)*. In this report, the term "speeding" will be defined as operating at a speed above the posted speed limit.

The definition of excessive speeding is not as clear. The *Global Road Safety Partnership (2008)* defines "low-level speeding" as driving a few km/h over the speed limit. On the other hand, "Excessive speeding" or "high-range speeding" have been used to describe speeds typically in excess of 40 km/h (25 mph) over the posted speed limit (*Gargoum, 2015)*.

Police enforcement of speed limits has been cited to have an important role in managing speed limit compliance *(Shrestha & Shrestha, 2016)*. However, not all agencies are equipped to handle the large burden traffic enforcement places upon them. Oregon ranks 48th out of 49 states when comparing the number of state troopers per capita, according to Captain Tim Fox of the Oregon State Police *(Adams, 2018)*. The Portland Police Bureau is also experiencing a shortage of traffic division officers. In 2011, there were 66 officers employed in the traffic division, but there were only 34 officers in the 2018 budget *(Shepherd, 2018)*. These gaps in resources require that speed limits be highly credible to lessen the burden of enforcement.

2.2 MEASURES OF SPEED COMPLIANCE

Ponnaluri & Groce (2005) evaluated the effectiveness of 12-foot speed humps to calm traffic on a two-lane residential road in central Florida with a 25 mph speed limit by calculating mean, median, and 85th percentile speeds before and after the speed humps were installed. Additional before and after speed parameters measured were the 10 mph pace (defined as the 10 mph window in which the highest number of vehicles travel), the percent of vehicles within the pace, and the percent of vehicles exceeding the posted speed limit.

Islam et al. (2014) used mean free-flow speed, the 85th percentile speed, the standard deviation of speed, speed percentile plots, and the percentage of vehicles exceeding 50 km/h and 65 km/h

in their research regarding a reduction in the posted speed limit from 50 km/h to 40 km/h in six urban residential neighborhoods with local and collector roads in Edmonton, Canada.

Gargoum et al. (2016) collected speed data from urban arterial and collector roads in Edmonton, Canada with posted speed limits ranging from 30 km/h to 80 km/h. Compliance with the speed limits was calculated as the difference between the speed limit and the vehicle's recorded speed and was divided into five categories for analysis within the study to further assess the various margins of speeding. The categories were:

- Fully compliant
- Exceeding the speed limit by no more than 5 km/h
- Exceeding the speed limit by more than 5 km/h but no more than 10 km/h
- Exceeding the speed limit by more than 10 km/h but no more than 20 km/h
- Exceeding the speed limit by 20 km/h or more.

A before and after evaluation of the effectiveness of an automated speed enforcement program on residential streets with speed limits of 25 to 35 mph in Montgomery County, Maryland used mean speed and the percentage of vehicles exceeding the speed limit by 10 mph or more as performance metrics *(Hu & McCartt, 2016)*.

A study by *Hu & Cicchino (2018)* investigated changes in vehicle speeds on relatively flat, straight segments that included arterial, collector, and local roads following a default speed limit reduction from 30 mph to 25 mph in Boston, Massachusetts. The raw percentages as well as estimated odds (accounting for trends at unchanged comparison site) of vehicles exceeding 25, 30, and 35 mph and mean speed were used as speed performance measures.

The *NHTSA (2008)* cites multiple studies regarding the effects of automated speed enforcement (ASE) programs. One study found that the percentage of vehicles traveling 10 mph or more over the speed limit during a four-month period post camera installation at five problematic sites in Beaverton and Portland, Oregon declined from 18% to 13% and the proportion of vehicles traveling 5 mph or more over the speed limit decreased from 19% to 13% in Beaverton as compared to pre-camera installation. Meanwhile, the proportions of vehicles exceeding the speed limit by 5 or 10 mph increased slightly at control sites *(Cities of Beaverton and Portland, 1997, as cited in NHTSA, 2008)*. An evaluation of the ASE program in Washington DC in 2003 found an 82% decrease in the proportion of vehicles traveling more than 10 mph over the speed limit and a 14% decrease in mean speed during enforcement hours compared to control sites *(Retting & Farmer, 2003, as cited in NHTSA, 2008)*. Lastly, the percentage of vehicles exceeding the speed limit by more than 10 mph was reduced on average by 55% at ASE treatment sites in Charlotte, North Carolina compared to control sites. Median and 85^{th} percentile speeds decreased by 0.88 mph and 0.99 mph, respectively, compared to the control sites *(Cunningham et al., 2005, as cited in NHTSA, 2008)*.

The Manual on Uniform Traffic Control Devices, MUTCD (Federal Highway Administration [FHWA], 2009) as well as several state *(California Department of Transportation, 2018; Massachusetts Department of Transportation, 2017; New York Department of Transportation, 2017; and Oregon Department of Transportation, 2014)* and other guidelines *(Forbes et al., 2012)* suggest using the 85th percentile speed as a basis for setting speed limits based on the idea that most drivers select appropriate speeds for the given conditions. By changing the direction of its application, the 85th percentile operating speed (and its difference from the speed limit) can be used to gage the level of speed limit compliance.

2.3 CRASH HISTORY

In addition to speed limit compliance, crash history may be another indicator of the safety performance of a roadway. The MUTCD *(FHWA, 2009)*, the Oregon Department of Transportation *(ODOT, 2014)*, and several other state DOT representatives *(Shrestha & Shrestha, 2016)* agree that crash history may be taken into account when setting speed limits in speed zones.

Typical exposure variables include vehicle miles traveled (VMT), vehicle hours traveled (VHT), length of roadway network, and population. The choice of exposure variable is an important consideration when communicating crash rate as using different exposure measures can produce varying results. For example, *Pei et al. (2012)* found that crash involvement appeared to decrease as speed increased when using distance-based exposure metrics, but when using time-based exposure metrics, the crash involvement appeared to increase with increased speeds. The importance of incorporating exposure metrics is also apparent from the results of *Figliozzi et al. (2018)*. The authors demonstrated that crash frequency increased as AADT increased up to a certain threshold while controlling for the length of the highway network, and a similar trend was seen when controlling for the number of VMT.

2.4 PROPOSED PERFORMANCE MEASURES

Based on the reviews of speed studies and performance measures, the following list of performance measures are proposed for speed distributions, compliance, and by vehicle type.

(a) Based on the speed distribution
- The pace
- The mean speed
- The standard deviation of speed
- The speed percentiles of 5, 15, 30, 50, 70, 85, and 95
- The range of the speed distribution from the 5th to the 95th percentile

(b) In relation to the posted speed limit

- The total percentage of vehicles exceeding the posted speed limit
- The percentage of vehicles exceeding the posted speed limit by 5, 10, 15, and 20 mph (and/or km/h) categories
- Pace, mean, and standard deviation of vehicles exceeding the posted speed limit

(c) In relation vehicle type

- The previous measures, listed in (a) and (b), can be calculated for motorized vehicles only, non-motorized vehicles only, and/or all types of vehicles.
- Within motorized vehicles, the focus can be on passenger vehicles or the vehicles that show higher speeds.

A before and after evaluation of performance measures may be conducted where speed limits have been changed and data is available.

Additionally, it is proposed that crash history also be included as a performance measure.

There may be tradeoffs regarding the number of performance measures to be analyzed and the number of data collection sites and variables that can be collected within the allowable time and resources. Speed data collection and site selection may be subject to limitations of the data collection equipment.

3.0 POTENTIAL VARIABLES

A high number of qualitative and quantitative attributes or variables that may affect operating speed have been identified. This section discusses these attributes or variables. Those that were found to be significant in the literature review are highlighted. Recommendations regarding data collection needs for use with this project are given and summarized in Table 3-1 at the end of this section.

3.1 TRAFFIC SURVEY DATA

3.1.1 Posted Speed Limit

Many of the studies reviewed included the posted speed limit as an independent variable. The studies and significance are noted below.

Fitzpatrick et al. (2001) found that when including the posted speed limit in the model for tangent road sections in Texas, it was the only significant variable. When it was included in the model for horizontal curved sections, it was found to be significant along with deflection angle and access density.

Himes et al. (2013) found the posted speed limit to be significant while evaluating operating speed models on urban and rural two-lane highways in Pennsylvania and Virginia, explaining 82% of the variation in operating speed.

Gargoum et al. (2016) studied factors affecting compliance on urban arterial and collector roads in Edmonton, Canada. The posted speed limit was considered as an independent variable and results indicated it was significant in affecting compliance levels.

Thiessen et al. (2017) also found the posted speed limit significant while exploring relationships between road features and operating speeds on urban tangential road segments in Edmonton, Canada.

Models estimated for speed distribution profiles of urban local and arterial roads in Montreal, Canada indicated the posted speed limit was a significant variable in the model for arterial roads *(Eluru et al., 2013)*.

Bassani et al. (2014) considered the posted speed limit as a variable for modeling speed dispersion on urban arterial and collector roads in northern Italy. Results did not show it as a significant variable.

In researching the effects of lighting conditions on driving speed in Turin, Italy, *Bassani et al. (2016)* found the posted speed limit to be a significant variable for all models of mean speed and speed deviation.

The posted speed limit had a significant relationship to operating speeds in the analysis by *Gargoum & El-Basyouny (2016)* which sought to explore the association between speed and crash frequency in Edmonton, Canada.

3.1.2 Vehicle Classification

Vehicle classification was studied as an independent variable in a few studies which are discussed next.

Vehicle class was labeled as "light" or "heavy" and each category was evaluated separately with respect to speed limit compliance in urban residential neighborhoods in Edmonton, Canada following a speed limit reduction from 50 km/h to 40 km/h *(Islam et al., 2014)* as heavy vehicles are expected to operate and respond differently to a change in speed limit.

Gargoum & El-Basyouny (2016) considered average vehicle length as a proxy for traffic composition as an independent variable to model both average speed and collision frequency, which was found significant for the model of average speed.

Thiessen et al. (2017) also used average vehicle length per location as a proxy for traffic composition to relate road and roadside characteristics to operating speeds on urban, tangential arterial and collector roads in Edmonton, Canada, which was found to be a significant variable in the model for arterial roads.

Gargoum et al. (2016) included vehicle class categories in the analysis of speed compliance on urban arterial and collector roads in Edmonton, Canada. In general, the results showed that single-unit trucks seemed to record higher instances of speed violations than passenger cars, combination trucks, or multi-trailer trucks.

3.1.3 Traffic Volume

Traffic volume was collected as an exposure or control variable in several studies noted in the literature review which are mentioned next.

The average traffic flow per hour was used as a surrogate for AADT by *Gargoum & El-Basyouny (2016)* and was found to have significant effects on both average speed and crash frequency.

Gargoum et al. (2016) included traffic volume as an exposure measure when assessing speed limit compliance.

AADT was also used as a control variable by *Islam & El-Basyouny (2015)* to evaluate the safety effects of reducing the posted speed limit from 50 km/h to 40 km/h in eight urban residential neighborhoods in Edmonton, Canada.

Hourly traffic volume was included as an independent variable by *Himes et al. (2013)* in modeling vehicle operating speeds and was indicated as a significant variable in the models of speed dispersion.

3.1.4 Temporal Factors

The time of day, day of the week, or season have been included as variables in a few of the studies summarized in the literature review.

The time period of the day, categorized as nighttime (12am-6am), rush hour (6am-10am and 3pm-7pm), evening time (7pm-12am), and midday (10am-3pm) was tested by *Eluru et al. (2013)*. Additionally, weekday indicator variable and a monthly component to denote season were tested in the models for vehicle speed on local and arterial roads. The nighttime variable was the only significant temporal variable in the local model. In the arterial model, the results showed all periods of the day were significant when midday was used as the reference period and that the weekday and summer month (June-August) indicators were significant.

Gargoum et al. (2016) included temporal factors such as day of the week and if the record occurred during peak hours (7:30am-9am and 4pm-5:30pm) or non-peak hours. A seasonal factor was included with three categories corresponding to the typical weather patterns of Edmonton, Canada (December-April, May-August, and September-November). Whether or not the day of the week was a shoulder day (Monday or Friday) was also considered. The researchers found that drivers were more likely to comply with speed limits during peak hours on arterials but the opposite was observed on collectors. Seasonal effects were found to be significant in both models and the shoulder day indicator had marginal effects with arterials experiencing a slight drop in compliance on those days and collectors experiencing the opposite effect.

Islam et al. (2014) analyzed the effects of lowered residential speed limits in Edmonton, Canada on vehicle speed behavior separately for weekdays versus weekends and daytime versus nighttime. The results indicated the greatest speed reduction was observed in the new communities (compared to grid style and older style communities) during the nighttime hours.

3.2 FIELD DATA

Field data to be considered for collection is discussed within this section.

3.2.1 General Road Features

3.2.1.1 Segment Length

A measure of segment length, defined in various ways, is often seen throughout the literature reviewed in Task 1. Several of these studies and their definitions of segment length are described in the following paragraphs.

Fitzpatrick et al. (2001) tested the effects of multiple definitions of segment length on operating speeds for suburban arterials in Texas. The distances between both the downstream and upstream traffic control devices and the traffic speed collection location were measured. The signal spacing, given in signals per kilometer, was also measured. None of the distance variables were significant in the horizontal curve analysis. For the analysis of the straight sections, the distance to the downstream control device was the only significant variable from the alignment category, however, it was not significant when significant variables from all categories were combined.

Dinh & Kubota (2013) included the length of the study street section in their analysis of operating speeds on urban residential streets in Japan with 30 km/h speed limits. Sections were defined as a segment between two intersections with a specified direction. The length was measured from the stop line of the entering approach of the entering intersection to the stop line at the exiting intersection. Results suggested that the length of the street section was significantly positively correlated with both the mean and 85^{th} percentile operating speeds.

Two variables related to segment length were examined by *Eluru et al. (2013)* in the model of operating speed for local roads, the distance to the next exit and the distance from the last exit. The final results indicated neither distance variable to be significant.

Himes et al. (2013) measured tangent length for use in models which would determine the validity of including the posted speed limit as an independent variable to predict operating speeds. The final resulting model did not show tangent length to be a significant variable.

Islam & El-Basyouny (2015) considered section length as a parameter to predict the safety effects of reducing the posted speed limit in urban residential areas in Edmonton, Canada from 50 km/h to 40km/h. Section length was determined to be highly significant in both the univariate and multivariate empirical Bayesian models as well as the full Bayesian model.

Segment length was investigated as a potential predictor of average speed and collision frequency by *Gargoum & El-Basyouny (2016)*. The researchers concluded it had significant positively associated effects on both average speed and crash frequency.

Thiessen et al. (2017) included segment length as a variable to model operating speed on tangential urban collector and arterial roads. Segment length was measured as the distance from and to the center of an intersection or at the beginning of a curve at which the segment began or

ended. Each of the three models developed (collector, arterial, and combined) suggested segment length had significant positively correlated effects on operating speed.

3.2.1.2 Segment End Conditions

Along with the distance to the upstream and downstream traffic controls, *Fitzpatrick et al. (2001)* noted the type of traffic control device in their analysis of factors affecting operating speed. The traffic control types given were traffic signal, stop sign, and other. Traffic control type was not found to be a significant factor in the analysis.

The type of entering and exiting intersection was examined as a variable by *Dinh & Kubota (2013)* to model operating speed. The types of entering intersections were given as signalized intersection, 4-leg non-signalized intersection, and 3-leg non-signalized intersection. For exiting intersections, the types were 4-leg non-signalized intersection and 3-leg non-signalized intersection. The type of exiting intersection was included as a significant variable in the final model of the mean speed at intersection, although it was not found to significantly affect the models of the mean and 85th percentile tangent speed or the 85th percentile speed at intersection.

Thiessen et al. (2017) considered four types of segment end conditions in the analysis of factors that affect operating speed on urban collector and arterial roads in Edmonton, Canada. The four categories of end conditions were signalized intersection, stop-controlled intersection, curve, or uncontrolled intersection. The combined arterial and collector model indicated the category of end condition had statistically significant effects on operating speed, but the variable was not significant in either of the separate models for arterials or collectors.

3.2.1.3 Number of Traveled Ways

Eluru et al. (2013) included a dummy variable to indicate whether a street carried one-way or two-way traffic in the operating speed model for local streets in Montreal, Canada and found the effect of a one-way street to be negatively correlated with speed.

Bassani et al. (2014) also considered a variable indicating whether a street was one-way or two-way while modeling operating speeds on urban arterial and collector roads. Of the three models estimated, the number of traveled ways significantly affected the central tendency of speed in the fixed effects model and the random effects model as well as the speed dispersion in the random effects model.

A one-way binary indicator variable was included in the analysis by *Thiessen et al. (2017)*. Like *Eluru et al. (2013)*, one-way streets were significantly negatively correlated with operating speed. This finding held true for all three models estimated (arterial, collector, and combined).

3.2.1.4 Number of Lanes

Lee et al. (2017) concluded from a series of judgements on 35 photos depicting a variety of highways around Malaysia that certain characteristics of the road such as the number of lanes affect a driver's choice of an appropriate speed more than features related to the roadside.

Dinh & Kubota (2013) found that the number of lanes was a significant factor in modeling the 85th percentile operating speed on tangent segments, with 3.24% higher speeds expected for two-lane streets compared with one-lane streets.

Eluru et al. (2013) also suggested the number of lanes to be significantly positively associated with operating speed for both local and collector roads.

The number of lanes was not found to be significant for predicting mean operating speeds on urban arterial and collector roads in Italy by *Bassani et al. (2014)* according to their random effects model, but it was a significant factor for predicting speed dispersion.

When examining the effects of lighting conditions on operating speeds on urban roads in Italy, *Bassani et al. (2016)* considered the number of lanes as a factor in their analysis, but it was not found to be significant for any of the lighting conditions tested.

Thiessen et al. (2017) also explored whether the number of lanes affects operating speeds on arterial and collector tangent segments. The results of the three models developed indicated it is not a significant factor.

Gargoum et al. (2016) found that an increase in the number of lanes increased the likelihood of a driver complying with the speed limit for arterial roads but decreased compliance levels for collector roads in Edmonton, Canada.

3.2.1.5 Roadway Classification

Most of the studies on traffic behavior and safety that were reviewed as part of Task 1 incorporated some aspect of road classification within the analysis, either by limiting the study sites to a certain classification or by developing separate models for the different classifications included in the given study.

Fitzpatrick et al. (2001) and *Bassani et al. (2016)* limited their data collection to arterial streets while *Dinh & Kubota (2013)* and *Islam & El-Basyouny (2015)* both limited their studies to residential streets. On the other hand, *Eluru et al. (2013)* developed separate operating speed models for local and arterial roads.

Islam& El Basyouny. (2015) compared speed limit compliance levels after speed limits were reduced from 50 km/h to 40 km/h for local versus collector roads. Overall, the average speed was

higher on collector roads. Both classifications experienced significant speed reductions but mean free-flow speed on local roads was reduced at a higher rate than that of collector roads when adjusted for potential trends.

Gargoum et al. (2016) built two models to study factors that affect speed compliance – one for arterial roads and one for collector roads. Factors that were found to have notable differences between the models include the number of lanes, the presence of parking, and traveling during peak hours, where the direction of effects for the collector model were opposite that of the arterial model.

Several variables differed in the direction of effects on operating speed between the collector and arterial models developed by *Thiessen et al. (2017)*. These variables were median width, road width, object density, object offset, posted speed limit, and the presence of a bus stop. The researchers also found that speed variability decreased as the road classification increased.

3.2.1.6 Access Density

Access density generally refers to the number of driveways or entrances and exits along a given length of road.

Fitzpatrick et al. (2001) counted access density as the number of access points on both sides of the road per km. Access density was found to significantly affect operating speed at the horizontal curved sites but not on the straight sections. For horizontal sections, access density ranged between 5 and 28 points per km and was divided into a categorical variable with 12 or fewer points as “low” and more than 12 as “high.” The researchers found that high access density predicted speeds that were 4.4 km/h slower.

Himes et al. (2013) considered the number of access point per 1000 ft. while exploring operating speeds on two-lane roads in Pennsylvania and Virginia, although the researchers did not find it to have significant effects on mean speed or speed deviation.

Driveway density was included as a variable by *Dinh & Kubota (2013)* to model operating speed although it was not found to be significant in any of the models developed.

The number of access points within a segment, the presence of an access point within a segment, and the access point density of a segment were all considered as independent variables in *Islam & El-Basyouny (2015)* while exploring the safety effects of reduced speed limits. The presence of access points was shown to be positively related to the number of total and property damage only (PDO) crashes in the empirical Bayesian and univariate full Bayesian models.

Bassani et al. (2014) included multiple measures of access density in their study of urban roads in northern Italy. The presence of driveways, the density of driveways, the presence of intersections, and the density of intersections were all considered as separate variables. None of

these variables were found to significantly affect the central tendency of the model that the researchers concluded was the best fit, but all variables did significantly influence speed dispersion.

The same four measures of access density used in *Bassani et al. (2014)* were again studied in *Bassani et al. (2016)*. Driveway density and intersection density were found to be significant factors in all models with one exception – the sunny sub-dataset model did not show intersection density to be significant.

The results of all three models in *Thiessen et al. (2017)* also indicated access density to be a significant factor affecting operating speed for arterial and collector roads. For the chosen segments, access density ranged from zero to 103 points per km. Access density was found to lower operating speed by 0.03 km/h on collector roads, 0.16 km/h on arterial roads, and 0.04 km/h for both collector and arterial roads combined.

3.2.1.7 Horizontal Curves

Several of the papers reviewed in Task 1 considered the effects of the presence or length of a horizontal curve on operating speed or safety.

Fitzpatrick et al. (2001) developed separate models for horizontal curved sites and straight section sites for suburban arterials in Texas. In the horizontal curve analysis, the curve radius and curve length were considered as variables. Neither variable was indicated as significant, however.

Himes et al. (2013) examined the effects of horizontal curve presence and length on mean operating speed and speed deviation. The models for the aggregated dataset indicated the presence of a left-hand curve is a significant factor for both mean speed and speed deviation, but the curve length is not for either. In the disaggregated dataset, both variables were found to be significant for both mean speed and speed deviation.

Curvature of the road, denoted as 1/R where R is the radius of the curve, was shown to be a significant factor for both the central tendency and dispersion of operating speed by *Bassani et al. (2014)*.

Curvature of the road was again tested in *Bassani et al. (2016)* in conjunction with lighting effects but was not indicated as a significant factor.

The presence of a curved alignment as determined by inspection of Google Street View was included in the study performed by *Gargoum et al. (2016)* although it was found to be insignificant for both the collector and arterial models.

While exploring factors that may affect speed limit credibility, *Lee et al. (2017)* concluded that drivers judge an appropriate driving speed to be lower on roads where a horizontal curve is present.

3.2.1.8 Grade %

The percent grade of a road segment was considered as a variable in the operating speed models by *Himes et al. (2013)*. The aggregate model of speed deviation and the disaggregated models for both mean speed and speed deviation found the percent of grade to be a significant factor.

Eluru et al. (2013) considered variables for vertical alignment (greater than 10% or less than 4%) in the analysis of local roads in Montreal, Canada and found a high vertical grade is associated with lower operating speeds.

Gargoum et al. (2016) found that the presence of a vertical alignment affected operating speeds by reducing the odds of compliance to the speed limit, but the direction of association was not determined due to the absence of directional traffic volume data.

3.2.2 On-Road Features

3.2.2.1 Pedestrian Crossings

Since this research is concerned with active travelers, measures related to pedestrian activity are imperative.

Dinh & Kubota (2013) explored whether the presence of a pedestrian crossing strip affected tangent speed or the speed at an intersection on urban residential streets in Japan but did not find it as a significant variable.

Both the presence of a pedestrian crossing and the density of pedestrian crossings were included as potential explanatory variables for operating speed and speed dispersion by *Bassani et al. (2014)*. Both variables were found to significantly reduce speed dispersion in the random effects model.

The presence of a pedestrian crossing was included as a variable by *Gargoum et al. (2016)* when studying operating speeds on arterial and collector roads but did not appear to contribute any significant effects.

Gargoum & El-Basyouny (2016) considered the presence of a pedestrian crossing as a variable in their analysis of average speed and crash frequency but found it had no statistically significant effects on either outcome.

Thiessen et al. (2017) also considered the presence of a pedestrian crossing in modeling operating speeds on arterial and collector roads. The presence of a pedestrian crossing was indicated as a significant variable in the collector only model, contributing to lower operating speeds.

3.2.2.2 Bus Stops

Gargoum & El-Basyouny (2016) included a variable for the presence of a bus stop in their models for operating speed. The presence of a bus stop did not show significant effects in either the collector or arterial model.

In *Thiessen et al. (2017),* the presence of bus stops was indicated as a significant factor affecting operating speeds on both arterial and collector roads, however, the direction of influence for arterials was opposite than of collectors.

Gargoum et al. (2016) concluded that the presence of a bus stop has significant direct effects on average speed and indirect effects on collision frequency.

3.2.2.3 Medians

The presence or width of medians have been studied by multiple researchers included in the literature review of Task 1 and are highlighted below.

Fitzpatrick et al. (2001) originally included variables for the median width and type in their research on operating speed, but later modified the type variable that had three classes to one that had only two classes – the presence or absence of a median. Neither of the variables for medians were significant in either the curved or straight section analyses when the posted speed limit was included as an explanatory variable, but the presence of medians became significant in the curved analysis when the posted speed limit was omitted.

The presence of a median or left-hand turn lane was included as a variable to model operating speed in *Himes et al. (2013)* and was found to be significant in the disaggregated model but not the aggregated model.

The presence and width of a median were included in the analysis of operating speeds on arterial roads by *Eluru et al. (2013)* but neither was shown as a significant variable.

Bassani et al. (2014) considered median width as a variable to help explain operating speeds and found it to be a significant factor affecting speed dispersion in the random effects model that was developed.

When exploring the effects of lighting conditions on operating speed on urban roads in Turin, Italy, *Bassani et al. (2016)* also included median width as a variable in the models developed.

Median width was not a significant variable considering the entire dataset as a whole but was significant in the nighttime subset.

The presence of a median was found to be statistically significant in the arterial model of *Gargoum & El-Basyouny (2016)* but not for the collector model.

Median type and median width were considered in the analysis by *Thiessen et al. (2017)*. Median type was divided into six categories: divided, barrier, raised, painted median, painted line only, and no line. Median width was determined to be a significant factor affecting operating speed for all three models developed but had opposite effects for collector roads than for arterial roads or the combined model.

3.2.2.4 Lane and Road Width

Fitzpatrick et al. (2001) evaluated the effects of lane width on operating speed. Lane width did not appear to be a significant variable for curved sections, but when the posted speed limit was excluded from analysis, a one meter increase in lane width predicted speeds that were 15 km/h higher for straight sections.

Dinh & Kubota (2013) used multiple measures of width to model operating speed. Lane width, carriageway width, and roadway width were tested. Carriageway width was found to be significant for models of both the mean and 85th percentile speeds.

Eluru et al (2013) included the width of lanes, the total width of the street, and the width per lane for the local road model. The average width of lanes and the total width of the street were included in the arterial model. None of these variables were indicated as significant for either model.

Bassani et al. (2014) considered lane width as an explanatory variable for operating speed and found it to be a significant term affecting speed dispersion.

Bassani et al. (2016) also found that lane width affected speed deviation when the effects of lighting conditions are considered.

Thiessen et al. (2017) found that the effects of road width differed on collector roads as compared to arterial roads where a positive correlation was seen with the former and a negative correlation with the latter.

Lee et al. (2017) also concluded that road width significantly affects drivers' perception of appropriate driving speeds, based on a series of photo judgements of various roads around Malaysia.

3.2.2.5 Shoulders

Both the total shoulder width and the unpaved shoulder width were included in the analysis by *Himes et al. (2013)* but neither were shown to be significant terms.

The presence and width of both the right and left shoulders were determined to significantly affect speed dispersion in *Bassani et al. (2014)*.

Bassani et al. (2016) found mixed effects of the presence and width of right and left shoulder variables when various lighting conditions were considered.

Gargoum et al. (2016) found that the presence of a shoulder was a significant factor affecting speed limit compliance on arterial roads, but not for collector roads.

The results from *Dinh & Kubota (2013)* indicate the width of the right shoulder as a significant variable affecting operating speed.

Gargoum & El-Basyouny (2016) also concluded that the presence of a shoulder is associated with increased operating speed and has a statistically significant indirect effect on crash frequency for urban roads in Edmonton, Canada.

3.2.2.6 Parking

Islam & El-Basyouny (2015) explored the effects of the presence of on-street parking in relation to potential safety effects of reduced speed limits. The presence of parking was a significant variable in each of the three models developed.

Bassani et al. (2014) included the presence of a parking lane as a variable to model operating speed and noted it had a small contribution to speed dispersion using the random effects model.

Eluru et al. (2013) considered the number of sides parking was allowed on the street as a variable to model operating speed on local roads and found it to be significant and negatively associated with speed. For arterial roads, the presence of parking was included as a variable but not found as a significant term.

Thiessen et al. (2017) used a categorical variable in their analysis for the number of sides roadside parking was allowed but the results did not indicate it as a significant variable in any of the models developed.

3.2.2.7 Bicycle Facilities

The presence or type of a bicycle facility along a roadway is another imperative measure to collect as it directly relates to active travel.

The presence of a bicycle lane was noted by *Fitzpatrick et al. (2001)* in the list of variables to analyze, but only one site in the curved analysis had a bicycle lane and just two of the straight section sites had bicycle lanes present.

Islam & El-Basyouny (2015) considered the effects of bicycle lanes on crash frequency but results did not show it as a significant factor.

Gargoum et al. (2016) analyzed the presence of bicycle lanes in relation to speed limit compliance on collector roads but determined it was not a significant variable.

Gargoum & El-Basyouny (2016) considered if the presence of bicycle lanes might affect average speed or crash frequency but also found it to have insignificant effects.

Eluru et al. (2013) included a variable indicating the presence of a bicycle route in the operating speed model for local roads and found it to be a significant factor and positively associated with speed.

Thiessen et al. (2017) developed categorical variables for the type of on-road bike markings which included buffered lanes on both sides, a marked lane on one side and buffered on the other side, marked bike lanes on both sides, a marked bike lane on only one side, and no bike lane marking or sharrows. The results of the combined arterial and collector model of operating speed indicated the presence of bike lanes was a significant and positively associated variable.

3.2.2.8 Traffic Calming

Ponnaluri & Groce (2005) studied the effectiveness of 12-foot speed humps that were 3.5 inches high to control speeds and reduce cut-through traffic on a two-lane residential road with a 25 mph speed limit in central Florida. Five speed humps were installed along a 2,600 foot long segment of road at 255 feet, 660 feet, 1,170 feet, 1,670 feet, and 2,305 feet. Mean, median, and 85th percentile speeds as well as the 10 mph pace decreased at all three locations except for the middle section where the mean and median speeds increased by 1 mph, which was attributed to the low values measured in the pre-installation period. The 85th percentile speeds decreased 8-12 mph to within 4 mph of the speed limit and the 10 mph pace decreased 5-10 mph. The percent in pace increased between 9% and 30.7% and the percent of vehicles exceeding the posted speed limit decreased between 43% and 61%.

Bassani et al. (2014) explored the effects of the presence of a traffic-calming device regarding operating speed and speed deviation. In the model that the researchers determined provided the best fit, the presence of traffic calming was a significant factor affecting speed dispersion.

Gitelman et al. (2017) performed a before and after study of the safety effects of converting non-signalized pedestrian crosswalks into raised crosswalks. Vehicle and pedestrian behaviors were examined, including vehicle travel speeds when approaching the crosswalks. Eight sites

comprising 16 crosswalks were chosen where the speed limit was 50 km/h and there were at least 25 pedestrian crossings per hour. The original crosswalks had zebra markings. The raised crosswalks were built as trapezoidal speed humps and circular speed humps were installed 15-20 m upstream from the raised crosswalks. Trapezoidal speed humps were 10-15 cm high and generally 4 m wide. Circular speed humps were 6-10 cm high and typically 3-4 m wide. With the exception of one site which had relatively low travel speeds in the ‘before’ period, mean speeds two months post-installation decreased at all sites by 7-30 km/h with the biggest decreases taking place at locations with higher speed humps.

3.2.2.9 Additional On-Road Features

Dinh & Kubota (2013) considered the presence and type of street marking in their evaluation of operating speed models. Centerline markings, edge line markings, or the absence of markings were considered, but were not found to be significant.

Eluru et al. (2013) included a variable for the presence of good pavement (which was not objectively defined) for the local road model of operating speed and concluded the presence of good pavement encourages faster driving speeds.

3.2.3 Roadside Features

3.2.3.1 Sidewalks

The number of sides a sidewalk was available was considered as a variable to explain operating speed on local roads by *Eluru et al. (2013)* who found it to be a significant factor.

Dinh & Kubota (2013) discovered the presence of a sidewalk had statistically significant effects on the 85th percentile operating speed.

As with the presence of pedestrian crossings, *Bassani et al. (2014)* concluded the presence of a sidewalk reduces speed dispersion.

Bassani et al. (2016) found the presence of a sidewalk to significantly affect operating speed during cloudy or night time lighting conditions.

Thiessen et al. (2017) considered not only the presence of a sidewalk, but the type as well in their study on operating speeds. Categories were given as boulevard walks on both sides, a boulevard walk on one side and a monowalk (monolithic sidewalk) on the other, a monowalk on both sides, and no sidewalk or a boulevard on one side only. The researchers noted the presence of sidewalks had significant effects for the combined model and that the presence of a boulevard walk on both sides was associated with higher operating speeds compared to any other type of sidewalk.

Instead of a dummy or categorical variable related to the presence of sidewalks, *Fitzpatrick et al. (2001)* considered the level of pedestrian activity on a scale of 1 (low) to 5 (high) in their study on operating speed. Pedestrian activity was not shown to be a significant factor.

3.2.3.2 Land Use

Many of the studies reviewed as part of Task 1 considered land use as either a categorical variable or a factor in the study site selection.

Islam et al. (2014) studied residential communities within Edmonton, Canada as a whole, but divided the study sites into three groups according to the age of the community since each possessed different characteristics.

Dinh & Kubota (2013) limited their study to residential streets but categorized the adjacent land use development according to the type of dominant housing or buildings. Types listed were private houses, apartments/tall buildings, mixed development, or near a park/school. Land use was ultimately not seen to be a significant variable.

Fitzpatrick et al. (2001) used roadside development as a variable in both the horizontal curve and straight section analyses. Types were categorized as residential, commercial, or mixed for straight sections. Park and school types were substituted for the mixed type in the curved analysis. Roadside development was significant for the curved sections when the posted speed limit was excluded from the model.

Himes et al. (2013) considered two land use variables in their study of operating speed – whether or not the adjacent land was residential in nature or not and whether it was wooded. Both indicator variables were shown to have significant effects.

Gargoum et al. (2016) included four land use types in the arterial model and two land use types in the collector model. The odds of speed limit compliance on collectors appeared to be lower in industrial areas compared to residential areas and the odds of compliance was reduced on arterial roads in commercial and agricultural areas compared to direct control areas.

Roadside treatment was used as a proxy for land use in *Thiessen et al. (2017)*. Four categories were given including downtown commercial, mixed high to medium density, mixed low density, and open urban. Both mixed density categories seemed to have significant effects on collector roads compared to the open urban category.

3.2.3.3 Roadside Objects

Roadside object density was defined by *Dinh & Kubota (2013)* as the number of rigid objects within 0.5 m of the roadway edge per 100 m of segment length. Roadside object density was shown to have significant effects for both the mean speed and 85th percentile speed.

Fitzpatrick et al. (2001) defined roadside environment as a combination of the frequency of rigid objects and their distance from the road, however this variable was not significant for either the curved sections or the straight sections.

Pole and tree density as well as their average offset from the roadway were included for evaluation of urban arterial and collector roads in Edmonton, Canada by *Thiessen et al. (2017)*. The combined model and the arterial model showed speeds decreasing as the object density increased and the distance from the road decreased.

3.2.4 Active Traffic Generators

Generators such as schools, supermarkets and commercial facilities, or any other activity that attracts or generates a high number of active trips can be noted and from the analysis of online maps.

3.2.5 Other Site Specific Data

Additional site-specific data that may be collected include driver behavior or other characteristics that may only be noted during a site visit.

Table 3-1: Summary of data collection needs and methods.

DATA CATEGORY	VARIABLE
Traffic Survey Data	Posted Speed Limit
	Vehicle Classification
	Traffic Volume
	Period of the Day
	Day of the Week
	Season
General Road Features	Segment Length
	Distance to Traffic Control
	Distance to Traffic Calming
	Number of Traveled Ways
	Number of Lanes
	Road Classification
	Grade %
	Curve Presence
	Access Density
On-Road Features	Pedestrian Crossing Presence
	Bus Stop Presence
	Median Presence
	Median Width
	Lane Width
	Road Width
	Shoulder Presence
	Shoulder Width
	Parking Type
	Bicycle Facilities
	Traffic Calming Presence
	Traffic Calming Type
	Pavement Condition
Roadside/Area Features	Sidewalk Presence
	Boulevard Width
	Land Use
	Roadside Object Density
	Average Object Offset
	Signage
	Nearby School Presence
	Nearby Active Travel Generator
Other	Driver Behavior
	Crash Occurrence

3.3 DATA SOURCES

A number of data sources have been identified to address potential data needs identified in Table 3-1. These sources are listed below:

- PBOT traffic survey data files will provide traffic volume information, including bicycle volumes as well as individual vehicle speeds
- Satellite imagery or GIS data, for example to estimate distances including segment length and signal spacing, or the distance to pedestrian crossings and traffic calming devices.
- Google Maps and Google Street View can be used to obtain many attributes related to road geometry and bicycle/pedestrian facilities.
- The grade or presence of vertical alignment can be estimated from maps provided by the USGS.
- Transit activity and stop locations can be obtained from TriMet data.
- Segment boundary conditions can be observed by the use of Google Street View or by conducting a site visit.
- Posted speed limits can be obtained from PBOT or the PBOT traffic count website
- On-site traffic survey and data collection, for example to measure lane and road widths or other attributes that cannot be obtained from previously listed data sources.
- Crash data can be sourced from the PBOT Vision Zero crash map.

4.0 SITE SELECTION

This section describes the selection criteria to be used in identifying potential study locations with and without a significant number of active travelers. Additionally, a list of proposed locations selected according to the given criteria is presented.

4.1 SIGNIFICANT NUMBER OF ACTIVE TRAVELERS

This project focuses on roadways with a significant number of active travelers. Feedback provided by the TAC helped define the concept of significant number of active travelers.

When counts are available, the presence of a significant number of active travelers can be defined by a threshold or a percentage. Both thresholds and percentages can be useful to provide guidelines based on facility type and size of the urban area. Given the high seasonality of active trips and the lastingness of posted speed limits, it may be more appropriate to utilize data for months with high bicycle and/or pedestrian activity.

When active user counts are not available, it is necessary to utilize proxy measures for bicycle or pedestrian activity. Street functional classification and characteristics, bike/pedestrian network connectivity, transit activity, and land use (densities) can be utilized to identify streets or corridor segments that are likely to have a high percentage of active users.

4.2 SITE CRITERIA

In order to gather a representative sample of sites, several considerations were taken into account. These considerations included road geometry, current speed limits, traffic composition, traffic characteristics, and the level of expected active traveler presence.

Topological maps were referenced to choose segments such that significant grades are not present. The segments chosen are straight or relatively straight in alignment. Selected segments have current speed limits that range between 20 mph and 30 mph *(City of Portland, 2019b)*. Where available, bicycle counts obtained from PBOT *(City of Portland, 2019a)* were used. The type of bicycling facility available and its designation or lack thereof as a recommended route *(Metro, 2014)* were used in conjunction with the bicycle counts to estimate expected bicycle volume. TriMet regular and frequent service bus line routes were noted *(TriMet, 2019)* and the most recently available data for passenger boardings and alightings were used to estimate areas with high pedestrian activity.

Potential locations that can be included in future steps and data analysis are shown in the next subsection. Final selection will be based on the evaluation of all potential locations, TAC recommendations, and time/resource availability.

4.3 POTENTIAL LOCATIONS

The potential locations are described and pictured in the following sections. Following the location descriptions, Table 4-1 provides a summary of their characteristics.

4.3.1 Southeast Clinton Street

Southeast Clinton Street from Southeast 12th Avenue to Southeast 39th Avenue is an established bikeway and is designated as a neighborhood greenway *(Metro, 2014)*. The current speed limit along this corridor is 20 mph. From 2016 through 2018, the average daily bicycle volume through the corridor was approximately 3,000 bicycles per day and appears to be one of the more heavily used bikeways in Portland according to PBOT daily bike estimates *(City of Portland, 2019a)*. Figures 4-1 shows a street view of this street.

Figure 4-1: SE Clinton St. looking west toward SE 21st Ave. *(Google, 2019)*

4.3.2 Southeast Division Street

SE Division Street from SE 21st Avenue to SE 39th Avenue is served by TriMet bus route 002 which is a frequent service route *(TriMet, 2019)*. Stops in the area serve a high number of passengers daily with many of them being within the top 20% of stops when ranked according to yearly totals of boardings and alightings. The speed limit is currently 25 mph. No bicycle volume data were available for reference. Figures 4-2 and 4-3 show street views along SE Division St.

Figure 4-2: SE Division St. at SE 31st Ave. looking east. *(Google, 2019)*

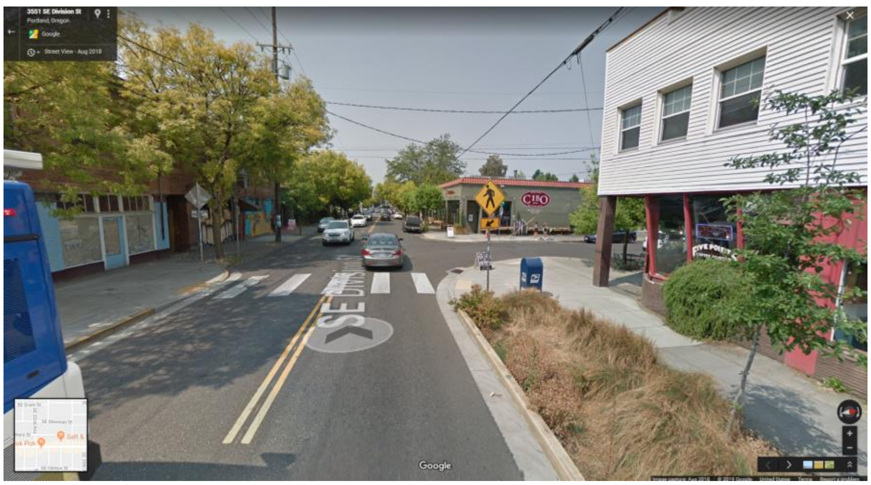

Figure 4-3: SE Division St. looking west toward SE 35th Ave. *(Google, 2019)*

4.3.3 East Burnside Street

East Burnside Street between SE 6th Avenue and SE 20th Avenue has a bicycle lane until SE 13th Avenue, after which no facilities exist until SE 28th Avenue where they resume *(Metro, 2014)*. Bicycle counts at SE 6th Avenue and SE 12th Avenue averaged approximately 2,000 and 1,100 bicycles per day between 2016 and 2018, respectively *(City of Portland, 2019a)*. East Burnside Street is served by TriMet route 020, and although it is not a frequent service route *(TriMet, 2019)*, many of the stops in this area are also within the top 20% of stops ranked by yearly total passenger boarding and alighting data. The speed limit along the corridor ranges from 25 mph to 30 mph *(2019b)*. Figures 4-4 and 4-5 show street views along E Burnside St.

Figure 4-4: E Burnside St. at SE 7th Ave. looking east. *(Google, 2019)*

Figure 4-5: E Burnside St. at SE 13th Ave. looking west. *(Google, 2019)*

4.3.4 Southeast 17th Avenue

SE 17th Avenue from SE Holgate Boulevard to SE Boise Street has a speed limit of 30 mph *(City of Portland, 2019b)*. PBOT bicycle counts estimate about 750 bicycles travel through the intersection of SE 17th Avenue and SE Holgate Boulevard, daily *(City of Portland, 2019a)* based on counts performed between 2016 and 2018. Buffered bike lanes are present along SE 17th Avenue in this area. TriMet route 017 services this area and stops along this section handle a relatively large number of passengers, ranking within the top 40% of stops by volume. In addition, the MAX Orange line runs adjacent to SE 17th Avenue and a boarding station is present near SE Holgate Boulevard *(TriMet, 2019)*. Figures 4-6 and 4-7 provide street views of SE 17th Avenue near SE Holgate Boulevard and SE Boise St.

Figure 4-6: SE 17th Ave at SE Holgate Blvd. looking north. *(Google, 2019)*

Figure 4-7: SE 17th Ave. near SE Boise St. looking south. *(Google, 2019)*

4.3.5 Northeast Sacramento Street

NE Sacramento Street between NE 62nd Avenue and NE 74th Avenue is designated as a neighborhood greenway. Although it is not listed as a recommended bike route, it is labeled as bike friendly *(Metro, 2014)*. Bicycle counts for the area were not available and no bus line services this street although routes 012 and 071 operate within several blocks of the area *(TriMet, 2019)*. According to the *City of Portland (2019b)*, the speed limit is 20 mph. Figures 4-8 and 4-9 provide street views along NE Sacramento St.

Figure 4-8: NE Sacramento St. at NE 74th Ave. looking west. *(Google, 2019)*

Figure 4-9: NE Sacramento at NE 62nd Ave. looking east. *(Google, 2019)*

4.3.6 Southeast Hawthorne Boulevard

SE Hawthorne Boulevard between SE Grand Avenue and SE 50th Avenue is served by TriMet frequent service route 014 *(TriMet, 2019)*. As with the E Burnside Street and SE Division Street corridors mentioned previously, these bus stops serve a high number of passengers based on yearly totals of boarding and alighting passengers, placing most of the stops in the top 20%. The speed limit on SE Hawthorne Boulevard is 25 mph from SE Grand Avenue until SE 30th Avenue where it reduces to 20 mph *(City of Portland, 2019b)*. According to *Metro (2014)*, the majority of this section of SE Hawthorne Street is labeled "bike with caution." Bicycle volume counts were unavailable for this area. SE Hawthorne Boulevard is a one-way street in the eastbound direction until SE 12th Avenue where it becomes a two-way street. Figures 4-10 to 4-12 provide street views along SE Hawthorne Boulevard. Note the significant changes in road geometry and configuration.

Figure 4-10: SE Hawthorne Ave. at SE 7th Ave. looking east. *(Google, 2019)*

Figure 4-11: SE Hawthorne Blvd. at SE 37th Ave. looking east. *(Google, 2019)*

Figure 4-12: SE Hawthorne Blvd. at SE 48th Ave. looking west. *(Google, 2019)*

4.3.7 Southeast Lincoln Street

SE Lincoln Street between SE 30th Avenue and SE 60th Avenue is identified as a neighborhood greenway with a current speed limit of 20 mph *(City of Portland, 2019b; Metro, 2014)*. Recent bicycle counts at SE 52nd Avenue and SE 41st Avenue suggest 1,300 to 1,950 bicycles travel through the area per day *(City of Portland, 2019a)*. Although the corridor as a whole is not served by bus, TriMet route 071 stops at SE 57th Avenue and at SE 52nd Avenue. Additionally, route 014 serves a stop on SE 50th Avenue near SE Lincoln Street and route 075 serves a stop along SE 39th/Cesar Chavez near SE Lincoln Street, both of which are frequent service routes and handle a moderate amount of passenger activity *(TriMet, 2019)*. Figures 4-13 and 4-14 show street views along SE Lincoln Street.

Figure 4-13: SE Lincoln St. at SE 30th Ave. looking east. *(Google, 2019)*

Figure 4-14: SE Lincoln St. near SE 37th Ave. looking west. *(Google, 2019)*

Table 4-1: Summary of characteristics for the selected locations.

Location	Daily Bike Volume	Bike Facility	Pedestrian Activity	Bus Route	Bus Volume	Speed Limit (mph)
SE Clinton, 12th to 39th	3,000	Neighborhood greenway	high	none	na	20
SE Division, 21st to 39th	na	Separated in-roadway	high	002	high	25
SE Lincoln, 30th to 60th	1,300-1,950	Neighborhood greenway	medium	071	moderate	20
SE Hawthorne, Grand to 50th	na	Bike lane until 12th Ave.*	high	014	high	20-25
E Burnside, 6th to 20th	1,100-2,000	Bike lane until 13th Ave.	medium/high	020	high	25-30
SE 17th, Holgate to Boise	750	Buffered bike lane	low	017	moderate	30
NE Sacramento, 62nd to 74th	na	Neighborhood greenway	medium/low	none	na	20

*According to Google Street View as of August 2018.

5.0 PRELIMINARY SPEED ANALYSIS

A dozen data files including vehicle counts, classification, and speed were obtained from PBOT *(PBOT, 2019)*. Traffic characteristics such as vehicle class composition and speed distribution are shown for two locations. A summary of the preliminary analysis can be viewed in Table 5-1.

5.1 SOUTHEAST LINCOLN STREET AT 59TH AVENUE

A traffic speed study was performed at SE Lincoln Street on the east side of SE 59th Avenue from June 30th to July 5th, 2012. At the time of the study, the speed limit was 25 mph. A total of 8947 records were obtained. After eliminating the faulty readings, 8475 records were analyzed – 4520 in the eastbound direction and 3955 in the westbound direction. The traffic was composed of 3.41% class 1 vehicles (including motorcycles and bicycles) and 79.8% class 2 vehicles (passenger vehicles) in the eastbound direction. The westbound direction was comprised of 3.82% class 1 vehicles and 76.7% class 2 vehicles.

Figures 5-1 and 5-2 show the street views of SE Lincoln Street looking westbound from east of SE 59th Avenue and looking eastbound from west of SE 59th Avenue, respectively

The speed distribution for all vehicle classes can be seen in Figures 5-3 and 5-4 for the eastbound and westbound direction, respectively. The 50th and 85th percentile speeds were calculated and are displayed with the histograms, along with the speed limit for reference.

Separate analyses were performed for class 2 vehicles only and class 1 vehicles only. Histograms for each vehicle class and each direction can be seen in Figures 5-5 through 5-8, as well as their calculated 50th and 85th percentile speeds.

Overall, compliance with the speed limit of 25 mph at the time of the study is approximately 84% and 82% for the eastbound and westbound directions, respectively.

Figure 5-1: SE Lincoln St. east of SE 59th Ave. looking west. *(Google, 2019)*

Figure 5-2: SE Lincoln St. west of SE 59th Ave. looking east. *(Google, 2019)*

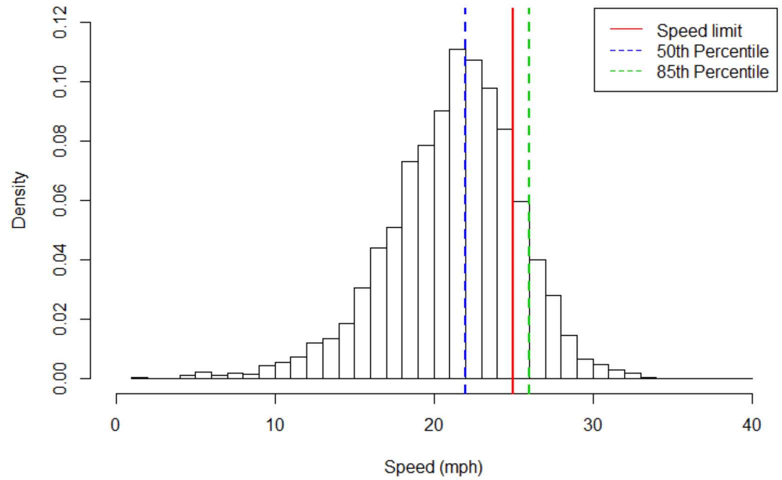

Figure 5-3: Speed distribution for SE Lincoln St. east of SE 59th Ave., all vehicle classes, eastbound direction.

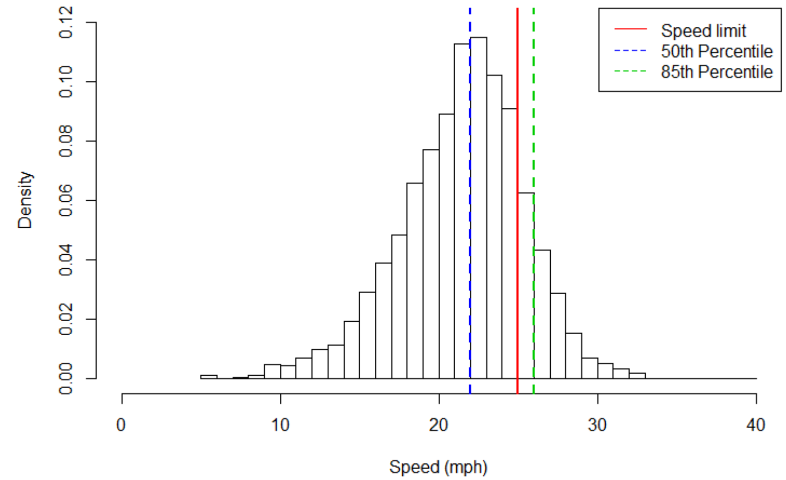

Figure 5-5: Speed distribution for SE Lincoln St. East of SE 59th Ave., class 2 vehicles, eastbound direction.

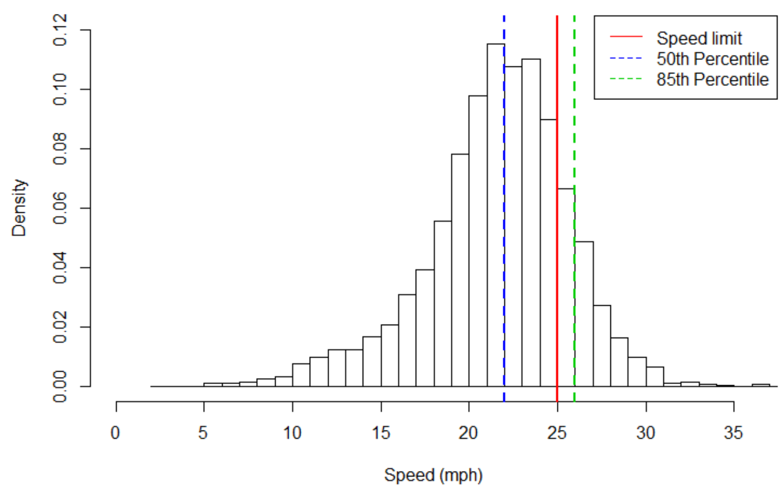

Figure 5-4: Speed distribution for SE Lincoln St. east of SE 59th Ave., all vehicle classes, westbound direction.

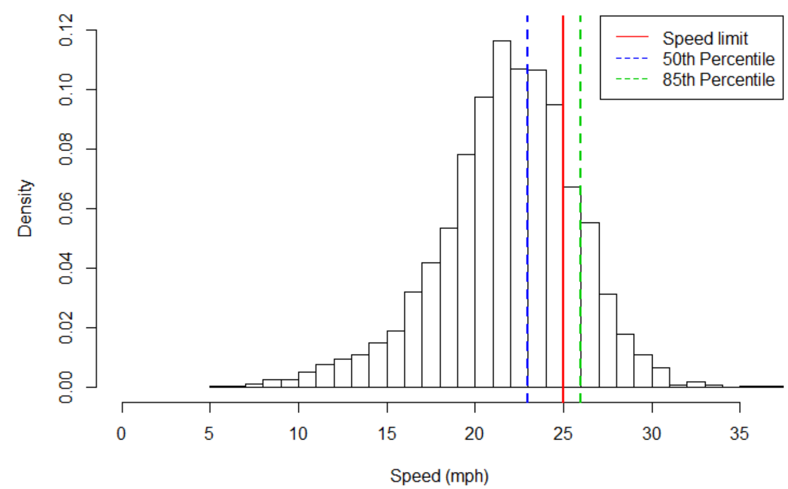

Figure 5-6: Speed distribution for SE Lincoln St. east of SE 59th Ave., class 2 vehicles, westbound direction.

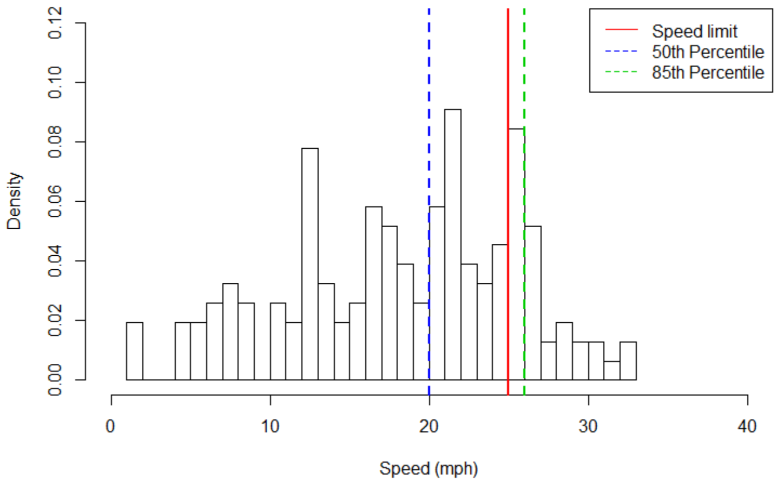

Figure 5-7: Speed distribution for SE Lincoln St. east of SE 59th Ave., class 1 vehicles, eastbound direction.

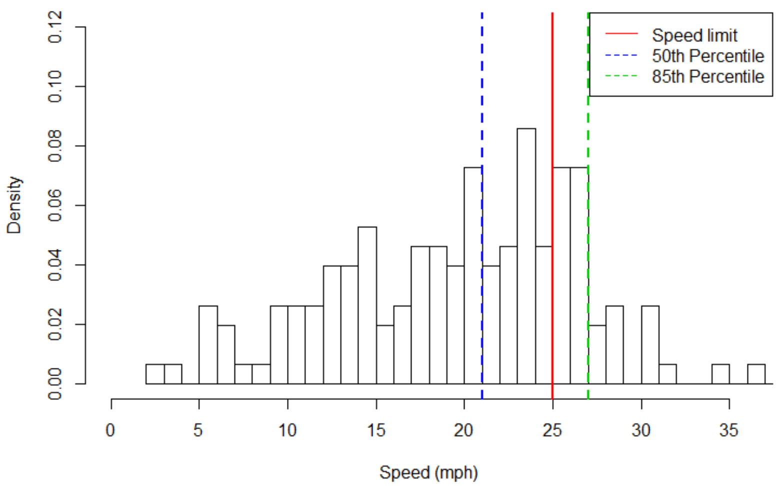

Figure 5-8: Speed distribution for SE Lincoln St. east of SE 59th Ave., class 1 vehicles, westbound direction.

5.2 SOUTHEAST LINCOLN STREET AT 41ST AVENUE

The traffic study performed on SE Lincoln Street west of SE 41st Avenue from January 5th to January 6th, 2017 is the most recent speed data obtained for the corridor. At the time of the study, the speed limit was 20 mph. A total of 1,260 records were obtained with the majority of them for the westbound direction. After faulty records were eliminated, 128 and 1,060 records remained for the eastbound and westbound directions, respectively. The eastbound traffic was primarily comprised of class 1 vehicles with 78.9% of the records and only 12.5% belonging to class 2. Approximately 11.3% of vehicles in the westbound direction were class 1 and 76.2% were class 2 vehicles.

Figures 5-9 and 5-10 provide street views of SE Lincoln Street looking westbound from west of SE 41st Avenue and looking eastbound from west of SE 41st Avenue, respectively.

Figures 5-11 and 5-12 show histograms of the speed distributions and the 50th and 85th percentile speeds for all vehicle classes combined for the eastbound and westbound directions, respectively. Again, the speed limit is also plotted for reference.

Since the eastbound direction had a small sample size which was composed mainly of class 1 vehicles, the class 2 only data for the eastbound direction is not shown. Figure 5-13 shows the speed distribution for the class 2 only vehicles for the westbound direction. Figures 5-14 and 5-15 show the distributions for only the class 1 vehicles in the eastbound and westbound directions, respectively. The 50th and 85th percentile speeds are shown for each distribution.

Compliance to the speed limit is quite high in the eastbound direction as might be expected, owing to the predominance of class 1 vehicles. The analysis found that over 91% of vehicles were compliant. However, the eastbound direction saw nearly 50% of vehicles exceeding the 20 mph speed limit and 11.6% of vehicles were traveling more than 5 mph over the speed limit.

Figure 5-9: SE Lincoln St. west of SE 41st Ave. looking west. *(Google, 2019)*

Figure 5-10: SE Lincoln St. west of SE 41st Ave. looking east. *(Google, 2019)*

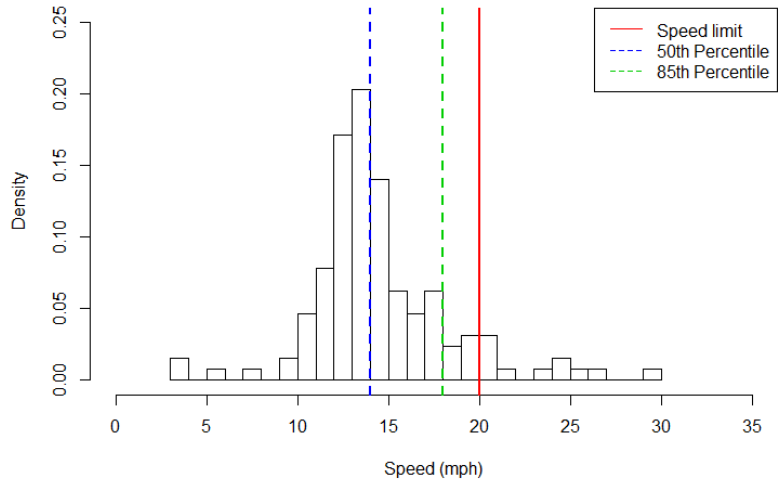

Figure 5-11: Speed distribution for SE Lincoln St. west of SE 41st Ave., all vehicle classes, eastbound direction.

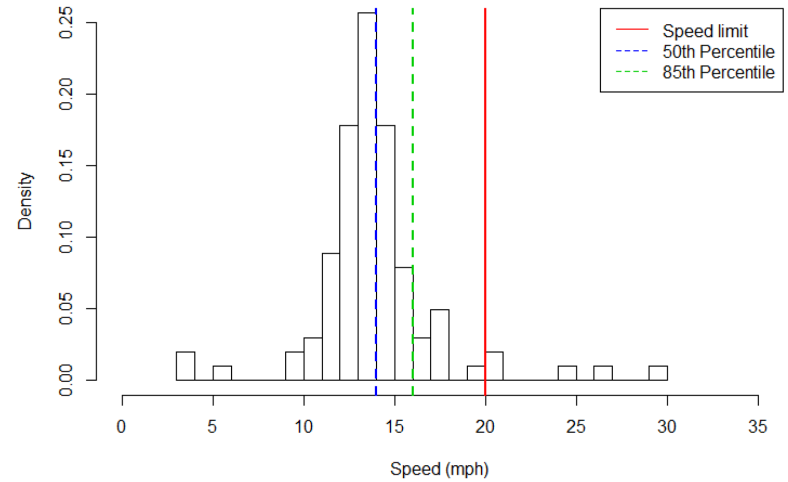

Figure 5-13: Speed distribution for SE Lincoln St. west of SE 41st Ave., class 1 vehicles, eastbound direction.

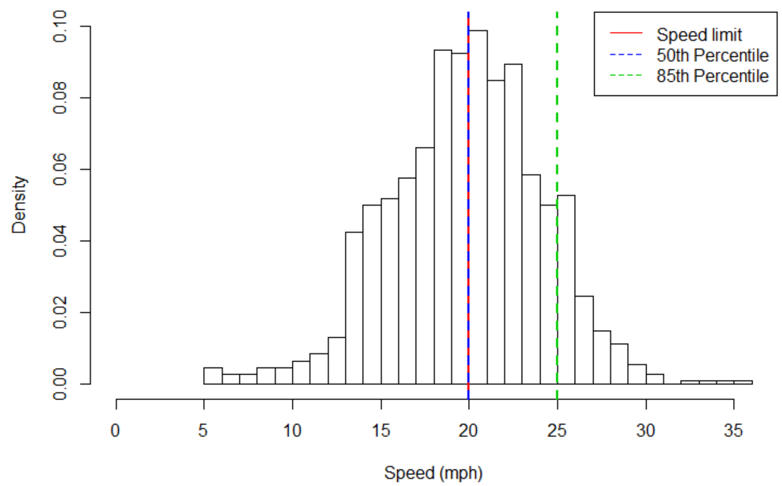

Figure 5-12: Speed distribution for SE Lincoln St. west of SE 41st Ave., all vehicle classes, westbound direction.

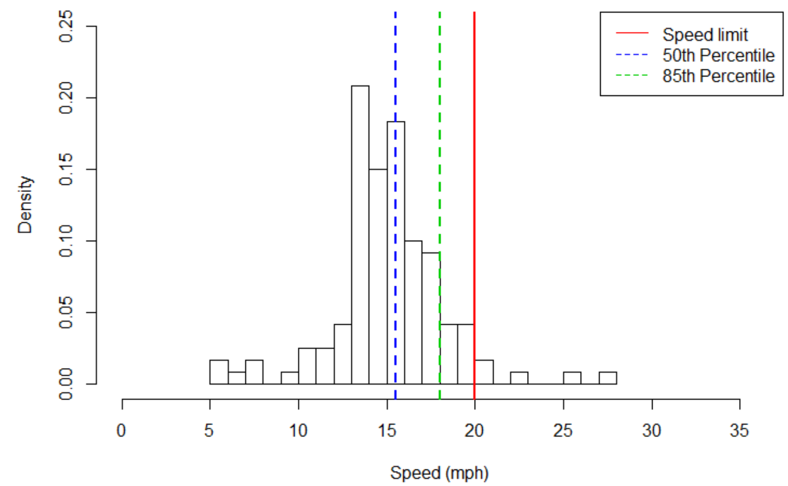

Figure 5-14: Speed distribution for SE Lincoln St. west of SE 41st Ave., class 1 vehicles, westbound direction.

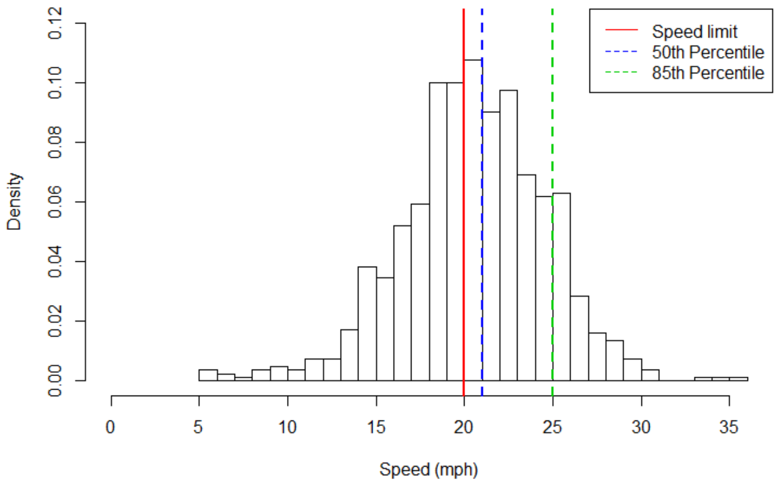

Figure 5-15: Speed distribution for SE Lincoln St. west of SE 41st Ave., class 2 vehicles, westbound direction.

5.3 PRELIMINARY ANALYSIS SUMMARY

Table 5-1 gives a summary of the traffic composition and various speed statistics for the locations mentioned in sections 5.1 and 5.2.

Table 5-1: Summary of the preliminary analysis on SE Lincoln St.

Location	**SE Lincoln E of 59th**		**SE Lincoln W of 41st**	
	EB	WB	EB	WB
Observations	4520	3955	128	1060
50th % Speed (mph)	22	22	14	20
85th % Speed (mph)	26	26	18	25
% Exceeding PSL	16.1	18.2	8.59	49.8
Class 1 %	3.41	3.82	78.9	11.3
Class 2 %	79.8	76.7	12.5	76.2

6.0 NEXT STEPS

This draft document addresses Tasks 3 and 4 and also provides an initial agenda of items to be considered and discussed during TAC meeting #2 (Task 5). Next steps also include Task 6 where data will be collected based on recommendations provided in this document and TAC feedback.

The following discussion points are proposed for TAC meeting #2:

- Future utilization of PBOT data that includes traffic counts, vehicle classification, and vehicle speeds (as shown in Section 5).
- Definition and prioritization of performance measures.
- Discuss and/or expand list of proposed variables that will be considered in future analysis.
- Discuss methodology to select potential data collection streets or corridors.
- Proposed area of analysis includes flat and straight streets or corridors in SE, NE, and/or North Portland with different levels of bicycle and pedestrian activity.

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