



FINAL REPORT | December 31, 2014

FHWA Request to Experiment 2014 Final Evaluation Report



Prepared for
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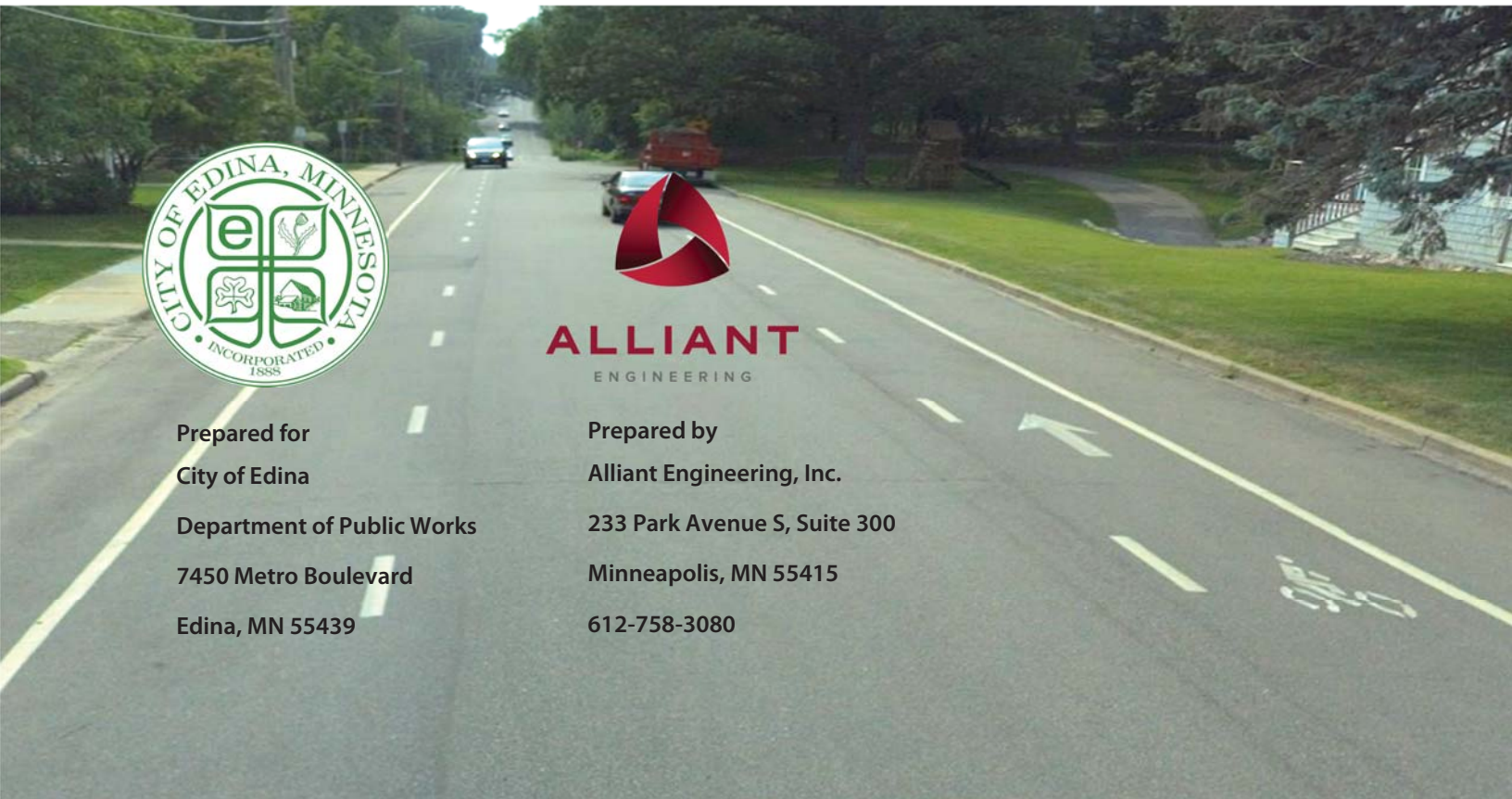


Table of Contents

Table of Contents	i
List of Figures	i
List of Tables	ii
1.0 Introduction	1
2.0 Data Collection	1
3.0 Experiment Evaluation	4
3.1 Advisory Bicycle Lanes – West 54 th Street near Halifax Avenue.....	4
3.2 Designated Bicycle Lane / Shared Lane Markings – 55 th Street and Wooddale Avenue.....	7
3.3 Shared Lane Markings – 60 th Street and Wooddale Avenue.....	11
3.4 Continuous Colored Shared Lane Marking – Valley View Road.....	15
4.0 Motor Vehicle Speed Study	18
4.1 Advisory Bicycle Lane – West 54 th Street.....	18
4.2 Designated Bicycle Lane / Shared Lane Markings – Wooddale Avenue at 55 th Street.....	19
4.3 Shared Lane Markings – Wooddale Avenue at 60 th Street.....	20
4.4 Continuous Colored Shared Lane - Valley View Road.....	22
5.0 Crash Analysis	23
6.0 General Conclusions	24

List of Figures

Figure 1. Experimental Pavement Markings and Study Locations.....	3
Figure 2. West 54th Street near Halifax Avenue Camera View	4
Figure 3. West 54th Street 24-Hour Volumes	4
Figure 4. West 54th Street Bicycle Lane Positioning	5
Figure 5. West 54th Street Single Vehicle Behavior	5
Figure 6. West 54th Street Vehicle Meeting Oncoming Vehicle Behavior.....	6
Figure 7. West 54th Street Vehicle Meeting Bicycle (in Same Direction).....	6
Figure 8. Wooddale Avenue at West 55th Street Camera View.....	7
Figure 9. Wooddale Avenue at 55th Street 24-Hour Volumes.....	7
Figure 10. Wooddale Avenue at 55th Street Bicycle Lane Positioning	8
Figure 11. Wooddale Ave at 55th Street Single Vehicle Behavior	9
Figure 12. Wooddale Avenue at 55th Street Vehicle Meeting Oncoming Vehicle Behavior.....	10

Figure 13. Wooddale Avenue at 55th Street Vehicle Meeting Bicycle (in Same Direction) 10

Figure 14. Wooddale Avenue at West 60th Street Camera View..... 11

Figure 15. Wooddale Avenue at 60th Street Volumes 11

Figure 16. Wooddale Avenue at 60th Street Bicycle Lane Positioning 12

Figure 17. 60th and Wooddale Single Vehicle Behavior 13

Figure 18. Wooddale Avenue at 60th Street Vehicle Meeting another Oncoming Vehicle Behavior 14

Figure 19. Wooddale Avenue at 60th Street Vehicle Meeting Bicycle (in Same Direction) 14

Figure 20. Valley View Road Camera View 15

Figure 21. Valley View Road Volumes..... 15

Figure 22. Valley View Rd and Kellogg Bicycle Lane Positioning..... 16

Figure 23. Valley View Road Single Vehicle Behavior 17

Figure 24. Valley View Road Vehicles Reacting to Left Turning Vehicles 17

Figure 25. Valley View Road Vehicle Meeting a Bicyclist (in Same Direction)..... 18

List of Tables

Table 1. West 54th Street Speed Study Summary 19

Table 2. Wooddale Avenue at 55th Street Speed Study Summary..... 20

Table 3. Wooddale Avenue at 60th Street Speed Study Summary..... 21

Table 4. Valley View Road Speed Study Summary 22

Table 5. Crash Analysis Summary..... 23

1.0 Introduction

This document serves as the final report for the evaluation of experimental pavement markings put into effect by the City of Edina in October 2012. The City of Edina evaluated the following experimental treatments:

- Advisory Bike Lanes – 54th Street (Minnehaha Avenue to France Avenue)
- Shared Lane Markings (advisory bicycle lanes were approved as part of the Edina’s original request to experiment but were removed in June 2013) – Wooddale Avenue (Valley View Road to 50th Street)
- Continuous Colored Shared Lane Markings – Valley View Road (Wooddale Avenue to Kellogg Avenue)

The need for experimentation stems from space restrictions due to insufficient curb-to-curb street widths to accommodate all desired street uses (vehicle lanes, on-street parking and bicycle lanes). Key factors in the evaluation include: bicycle and vehicle behaviors, (both when traveling alone and in reaction to meeting other vehicles), vehicle and bicycle volumes, vehicle speeds, and crash history.

The following document summarizes the results of the 2 year evaluation period for each of the experimentation segments. It should be noted that the City of Edina removed the advisory bicycle lane pavement markings from Wooddale Avenue in June 2013 and installed shared lane markings in its place. The pavement markings now in place on Wooddale Avenue are in compliance with the Manual on Uniform Traffic Control Devices (MUTCD) and are no longer required to be evaluated under the request to experiment. However, data was collected at two locations along Wooddale Avenue, and the results of the data evaluation summarized herein will provide a useful vehicle/bicycle behavior comparison between three separate treatments (shared lane markings alone, continuous colored shared lane markings, and advisory bicycle lanes).

2.0 Data Collection

To evaluate and compare the experimental treatments, vehicle and bicycle data was collected at four locations. The four study locations and their respective street typical sections are illustrated in Figure 1. The data analysis included the following:

- **Motorist and Bicyclist Positioning and Behavior.** 24-hour video was collected at each location which was then viewed and analyzed. The data analysis summarized the pedestrian, bicycle, and vehicle volumes by direction as well as the bicycle and vehicle positions in relation to the given pavement marking treatment in each study area. In addition, the bicycle and vehicle positions were tabulated for cases where the cyclist or motorist reacted to oncoming or passing vehicles. It should be noted that the day the Fall 2014 study was recorded was relatively cooler than the rest of the studies. This may be reflected by a lower volume of pedestrians and bicyclists.

- **Vehicle Speed Study.** 48-hour speed studies were conducted at each of the four study locations. The data was analyzed and, where available, compared to previous “before” condition speed studies.
- **Crash Analysis.** A crash analysis was conducted using data from the MnDOT Crash Mapping Analysis Tool. Crashes were pulled from the system and then filtered to reflect only crashes that occurred during the experimentation period (after October 2012). The crashes were analyzed over the entire stretches of West 54th Street, Wooddale Avenue, and Valley View Road, where the experimentation pavement markings were put into place.

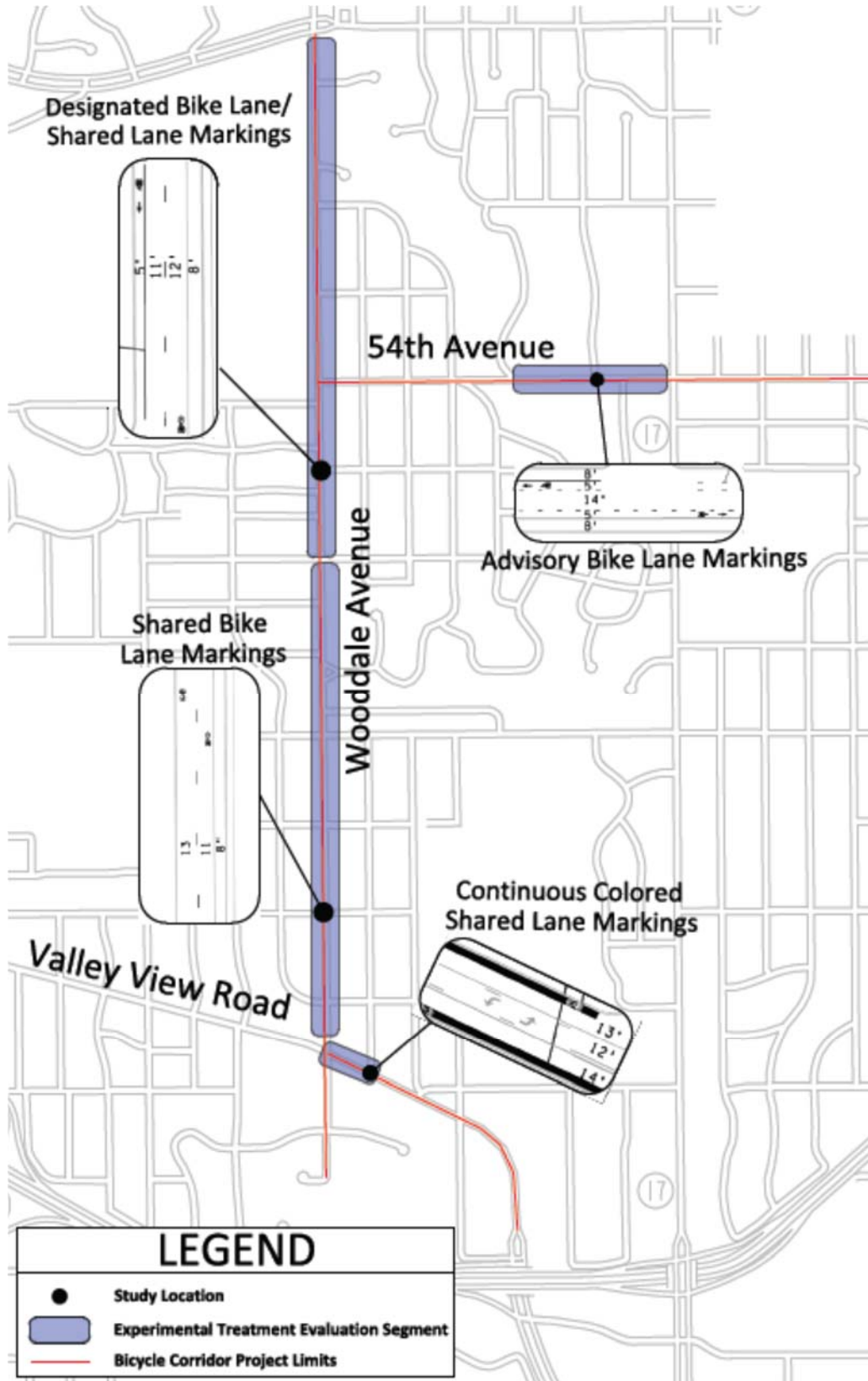


Figure 1. Experimental Pavement Markings and Study Locations

3.0 Experiment Evaluation

The following summarizes the motor vehicle, bicycle and pedestrian volumes, lane positioning and behavior analysis for each of the study locations.

3.1 Advisory Bicycle Lanes – West 54th Street near Halifax Avenue

West 54th Street has symmetric lane geometry, consisting of an 8 foot parking lane with a solid white stripe and a 5 foot wide bike lane. The bike lane has a bicycle symbol with arrow message and a dashed white stripe on the left side of the lane. The two-way traffic center space is 14 feet wide and does not have a centerline.



Figure 2. West 54th Street near Halifax Avenue Camera View

Figure 3 shows the 24-hour vehicle, pedestrian and bicycle volumes collected on West 54th Street for each of the evaluation periods.

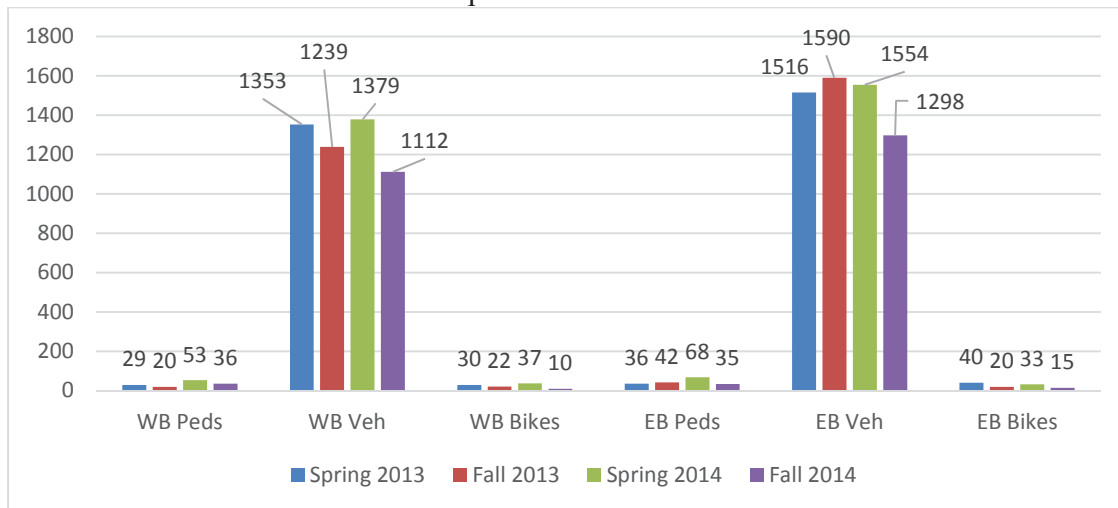


Figure 3. West 54th Street 24-Hour Volumes

Figure 4 summarizes the observed bicyclist lane positioning. The study found that the majority of bicyclists used the bike lane, however a large percentage still traveled in the parking lane as long as there was no vehicle present. This is acceptable as the extra space allows for a greater perceived safety by the bicyclists. The study also shows that a very small number of bicyclists travel on the sidewalk or travel in the wrong direction.

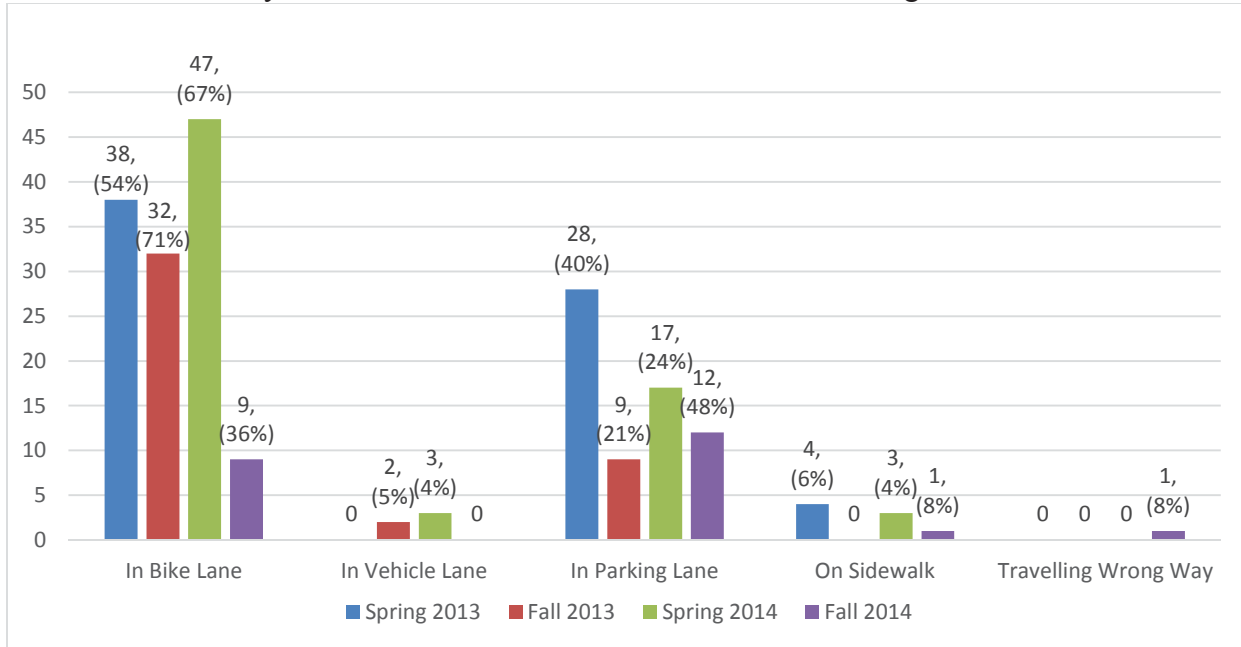


Figure 4. West 54th Street Bicycle Lane Positioning

Figure 5 summarizes the motor vehicle lane positioning when only one vehicle is present (no conflict). The data shows that over time, vehicles that lie completely to the left of the bike dash reduce, while the number of vehicles that straddle the bike dash increases. This change represents a growing comfortability with the design that complies with the intended operation (vehicles can use advisory lanes, so long as no bicycles are present). This occurrence may have an indirect correlation with more bicyclists riding in the parking lane.

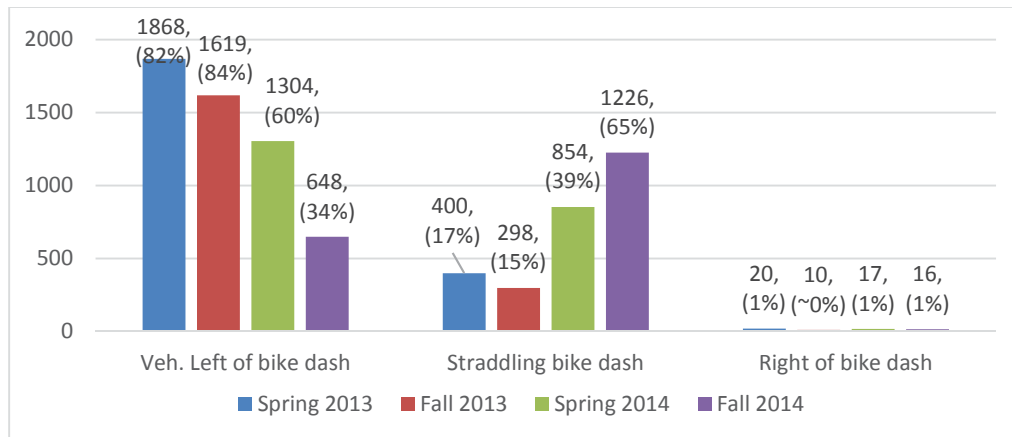


Figure 5. West 54th Street Single Vehicle Behavior

Figure 6 summarizes the motorist’s behavior when approaching an oncoming vehicle. The data does not show a consistent trend; however, for the most part the motorist moves to the right when meeting an oncoming vehicle. This complies with the intended and expected operation, so long as no bicycles are present in the advisory lane.

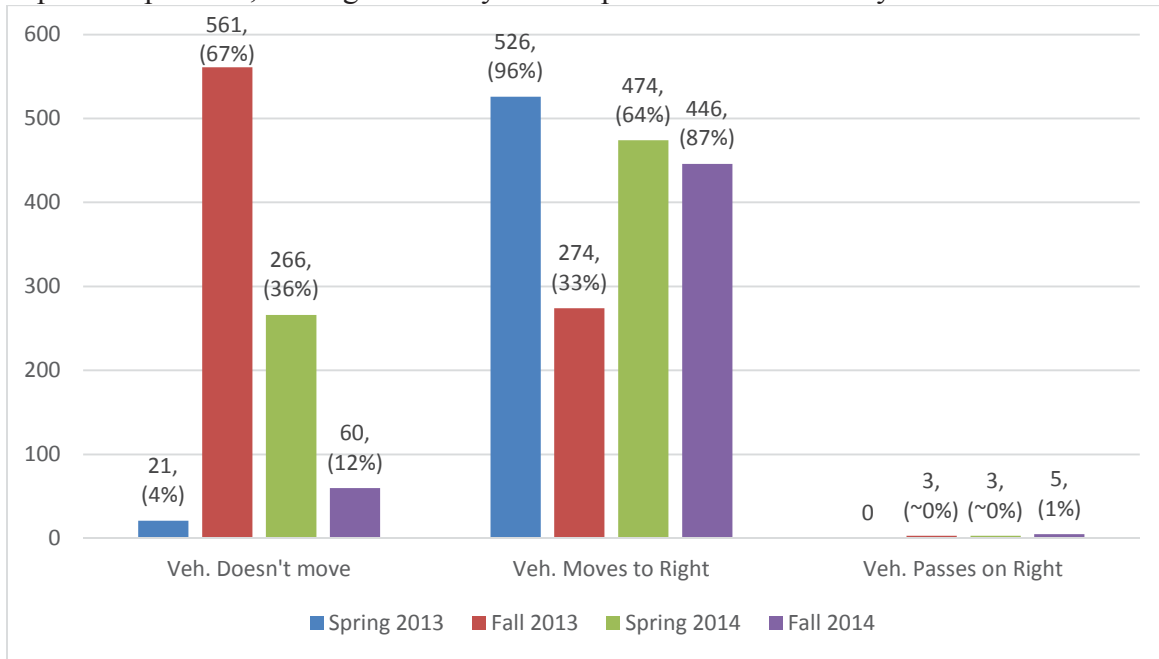


Figure 6. West 54th Street Vehicle Meeting Oncoming Vehicle Behavior

Figure 7 summarizes the vehicle behavior when a bicycle is present. The data shows an excellent compliance with the intended operation, with only one vehicle observed passing within 3 feet of the bicyclist.

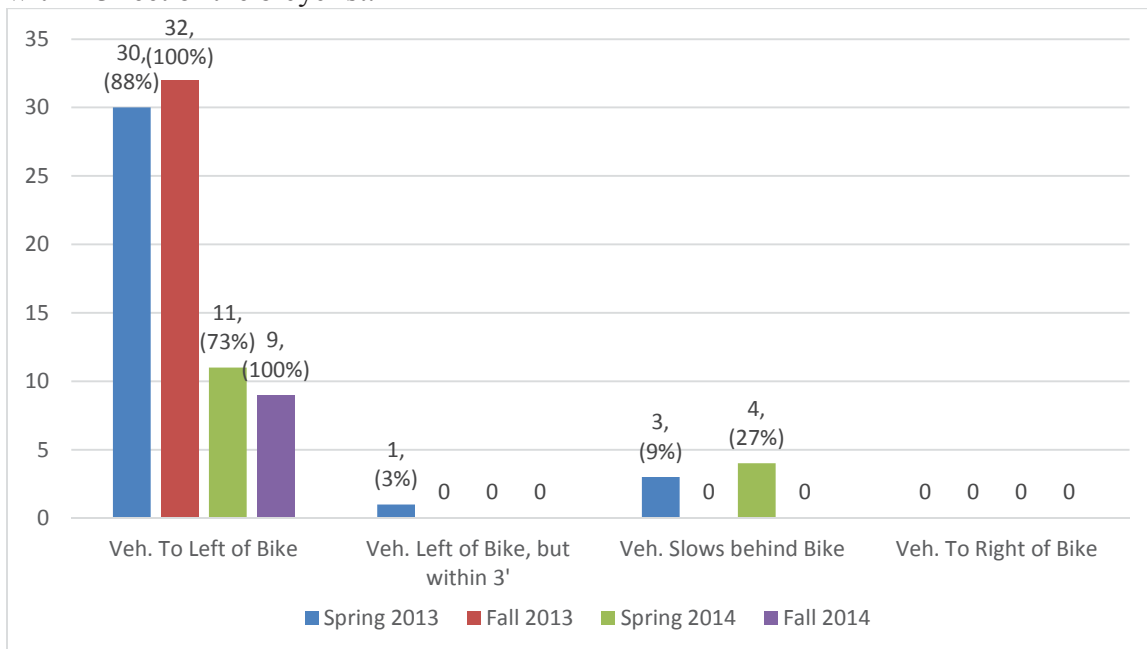


Figure 7. West 54th Street Vehicle Meeting Bicycle (in Same Direction)

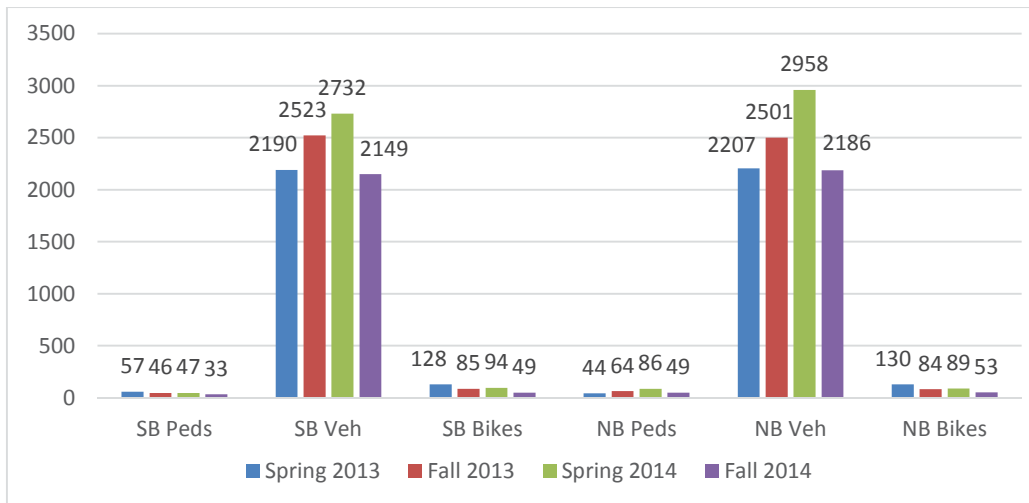
3.2 Designated Bicycle Lane / Shared Lane Markings – 55th Street and Wooddale Avenue

Wooddale Avenue was evaluated under two separate design scenarios – advisory bike lanes and shared lane markings. The Spring 2013 evaluation period consisted of an advisory bike lane design, with the parking on the northbound side of the road only. The section evaluated under the Fall 2013-Fall 2014 period consisted of an asymmetric geometry, with the northbound direction containing an 8 foot vehicle parking lane with a solid white line to designate the end width, and a shared lane marking within the 12 foot travel lane. The southbound direction has a 5 foot designated bicycle lane (with white bicycle symbol and arrow), and an 11 foot vehicle travel lane. A dashed yellow centerline is present.



Figure 8. Wooddale Avenue at West 55th Street Camera View

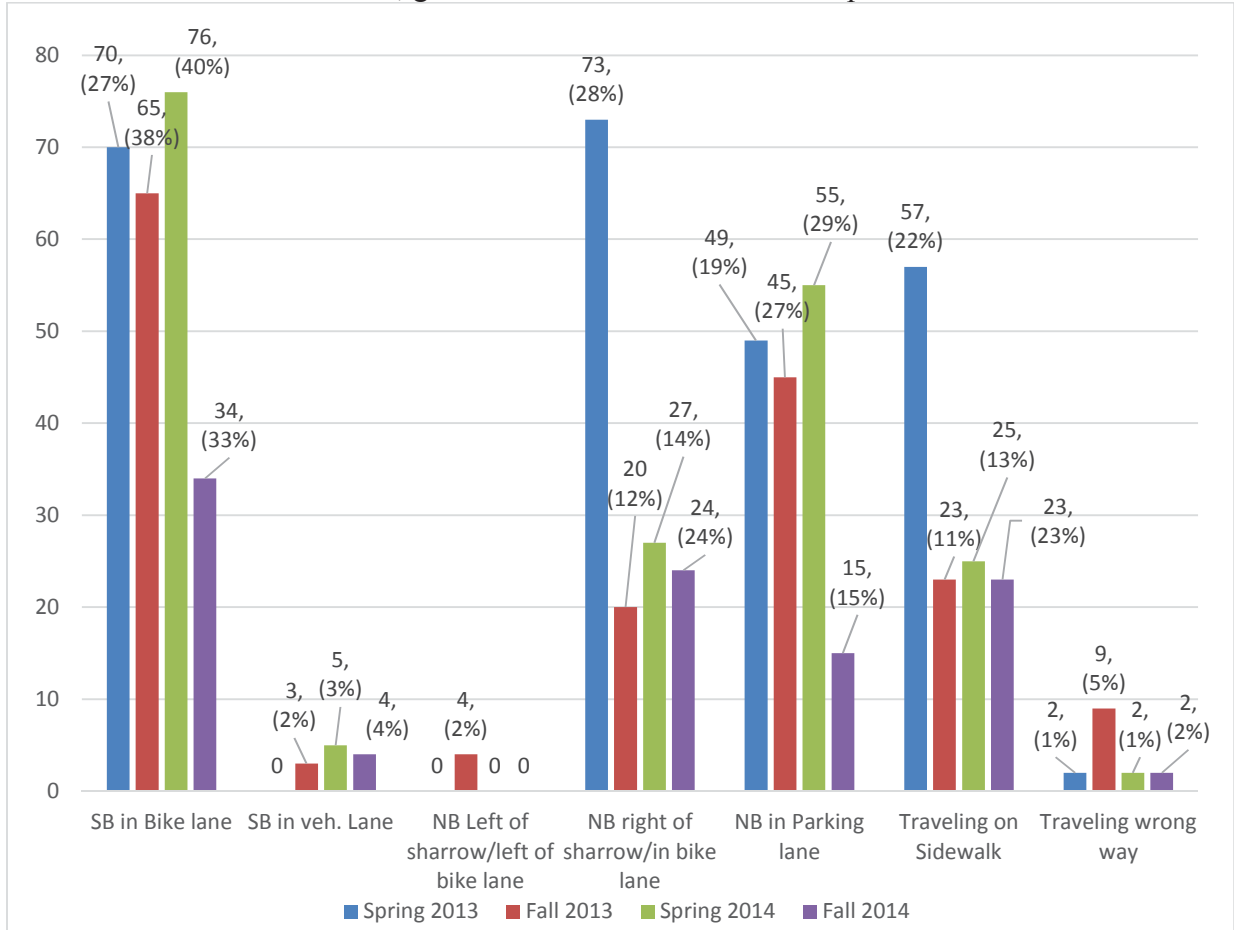
Note: Advisory bike lanes were in place during the Spring 2013 evaluation period. Figure 9 shows the 24-hour vehicle, pedestrian and bicycle volumes collected on Wooddale Avenue.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period.

Figure 9. Wooddale Avenue at 55th Street 24-Hour Volumes

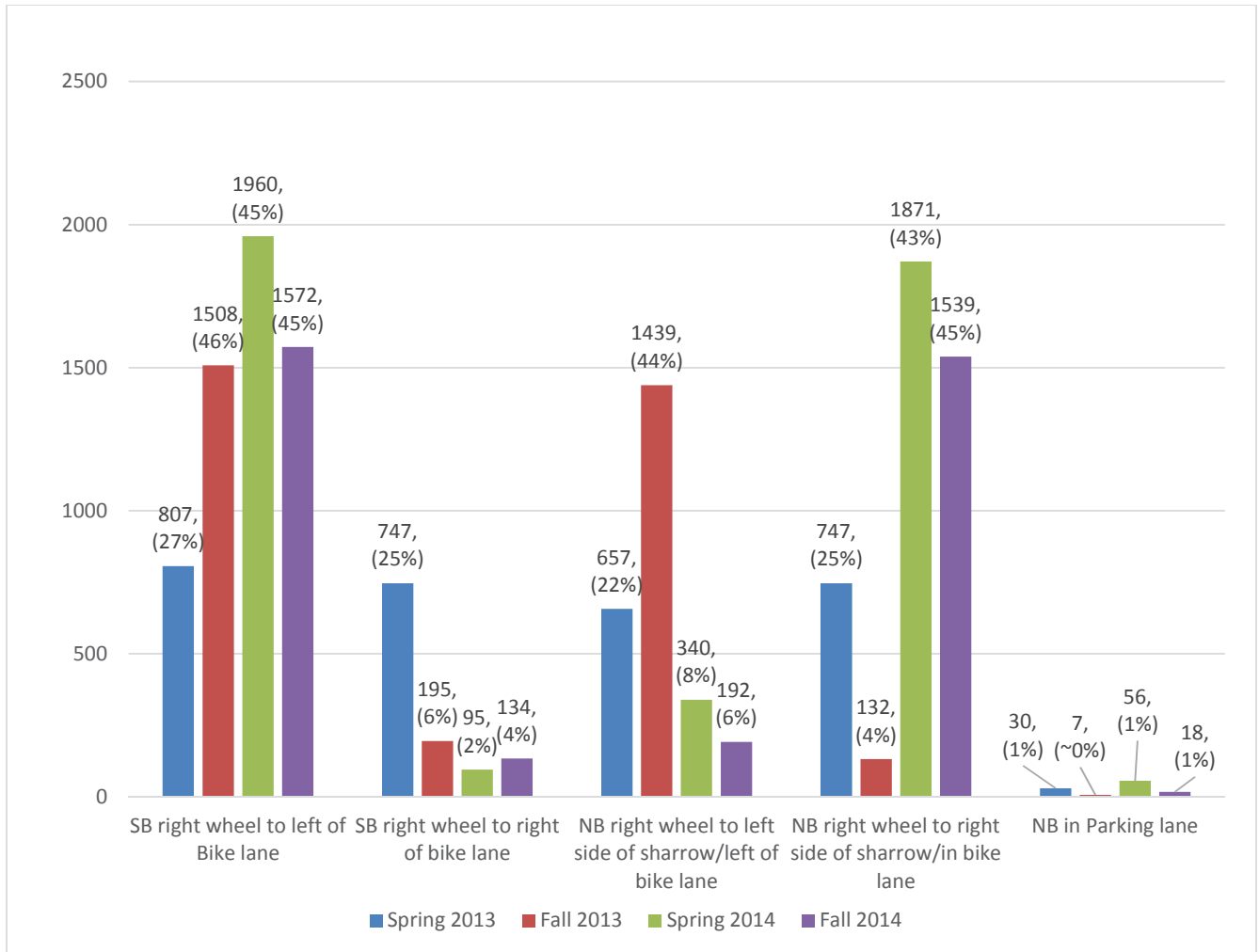
Figure 10 summarizes the observed bicyclist lane position by direction. The data shows excellent compliance by bicycles in the southbound direction, with the strong majority of southbound bicyclists using the bike lane. In the northbound direction, the data shows a large number of bicyclists using the parking lane when no vehicles were parked, with a much higher percentage occurring under the shared lane markings design. This seems to be caused by an increase in the perceived safety of the bicyclists by offering additional buffer clearance from vehicles, given a dedicated bike lane is not provided.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period.

Figure 10. Wooddale Avenue at 55th Street Bicycle Lane Positioning

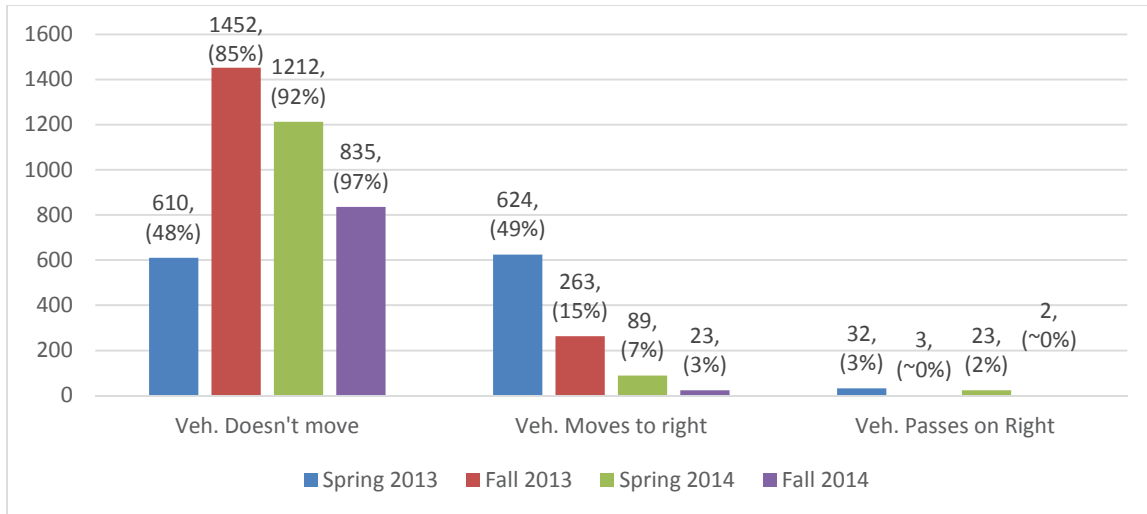
Figure 11 summarizes the motorist behavior when no other vehicles or bicyclists were present. In the southbound direction, compliance with the intended operation (vehicles traveling in the center of the travel lane) increases over time as vehicles become more comfortable with the design. The same was observed in the northbound direction. At the time of the shared lane marking implementation (Fall 2013), most northbound vehicles drove to the left of the shared lane marking, but over time the motorist position shifted rightward (i.e. traveling in the center of the drive lane as long as no bicyclists were present).



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period.

Figure 11. Wooddale Ave at 55th Street Single Vehicle Behavior

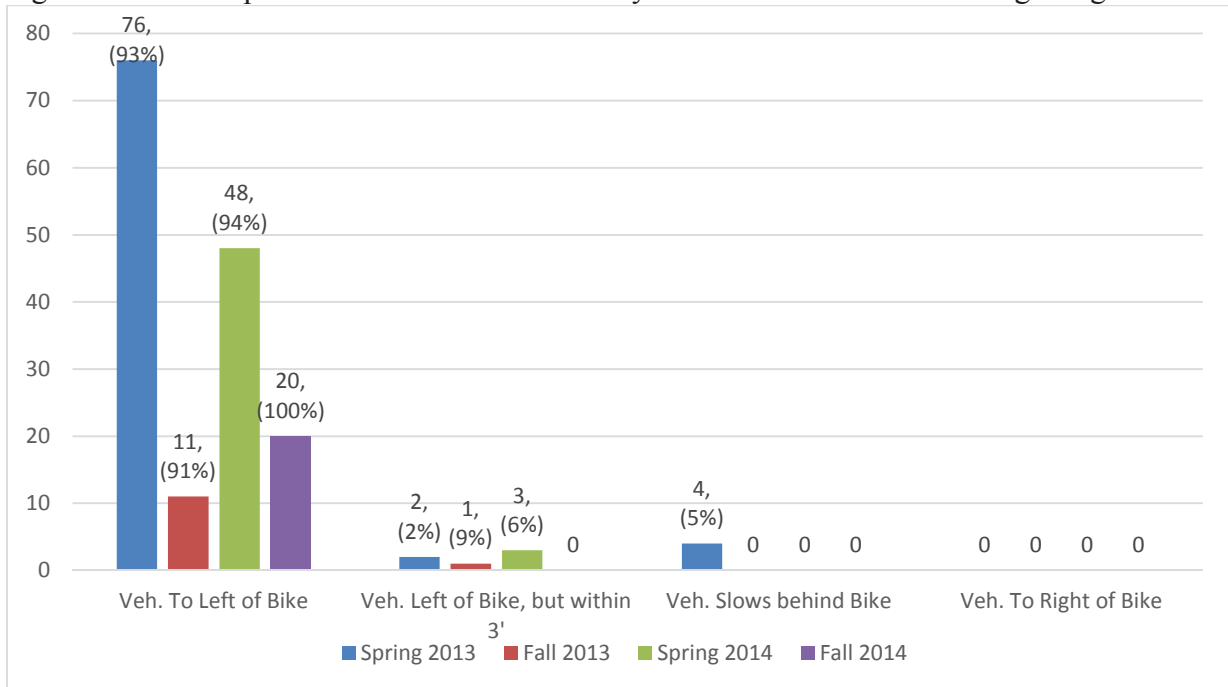
Figure 12 summarizes how the motorists reacted to another oncoming vehicle. A broken yellow centerline was in place during the Fall 2013 – Fall 2014 evaluation periods. As a result, the data shows motorists experienced a much improved sense of comfort in the travel lane, though still less than 100 percent. The data shows that over time, fewer vehicles move to the right when an oncoming vehicle approaches, suggesting the drivers have become more comfortable with the space provided.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period.

Figure 12. Wooddale Avenue at 55th Street Vehicle Meeting Oncoming Vehicle Behavior

Figure 13 summarizes the occurrences of vehicles reacting to bicyclists. The data shows high levels of compliance under both the advisory lane and shared lane marking designs.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period.

Figure 13. Wooddale Avenue at 55th Street Vehicle Meeting Bicycle (in Same Direction)

3.3 Shared Lane Markings – 60th Street and Wooddale Avenue

Wooddale Avenue was evaluated under two separate design scenarios – advisory bike lanes and shared lane markings. The Spring 2013 evaluation period consisted of an advisory bike lane design, with the parking on the northbound side of the road only. The section evaluated under the Fall 2013-Fall 2014 period consisted of an asymmetric geometry with both the northbound and southbound vehicle travel lanes containing a shared lane marking. An 8 foot parking lane is provided in the northbound direction. Parking does not exist in the southbound direction, so the shared lane marking is located approximately 4 feet from the face of curb. A dashed yellow centerline is present.



Figure 14. Wooddale Avenue at West 60th Street Camera View

Figure 15 shows the 24-hour vehicle, pedestrian and bicycle volumes collected on Wooddale Avenue.

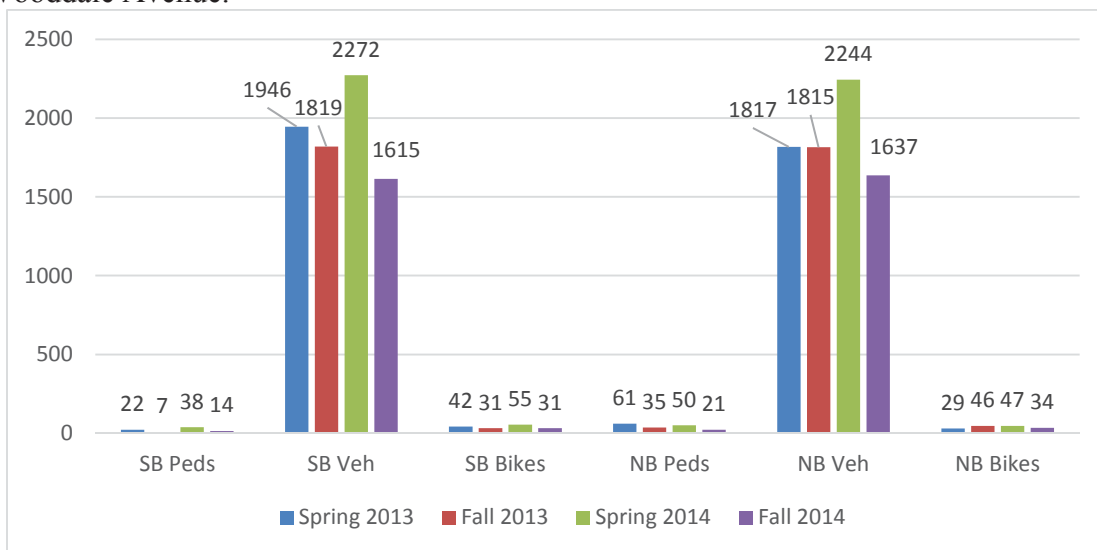
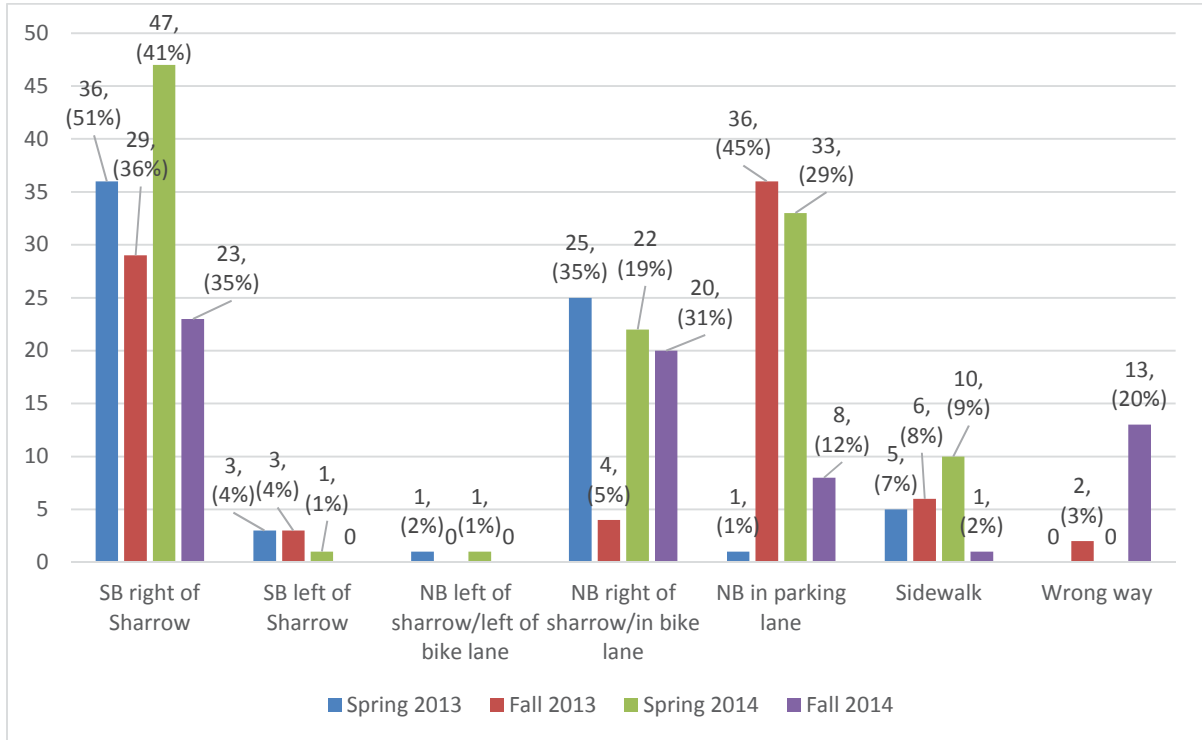


Figure 15. Wooddale Avenue at 60th Street Volumes

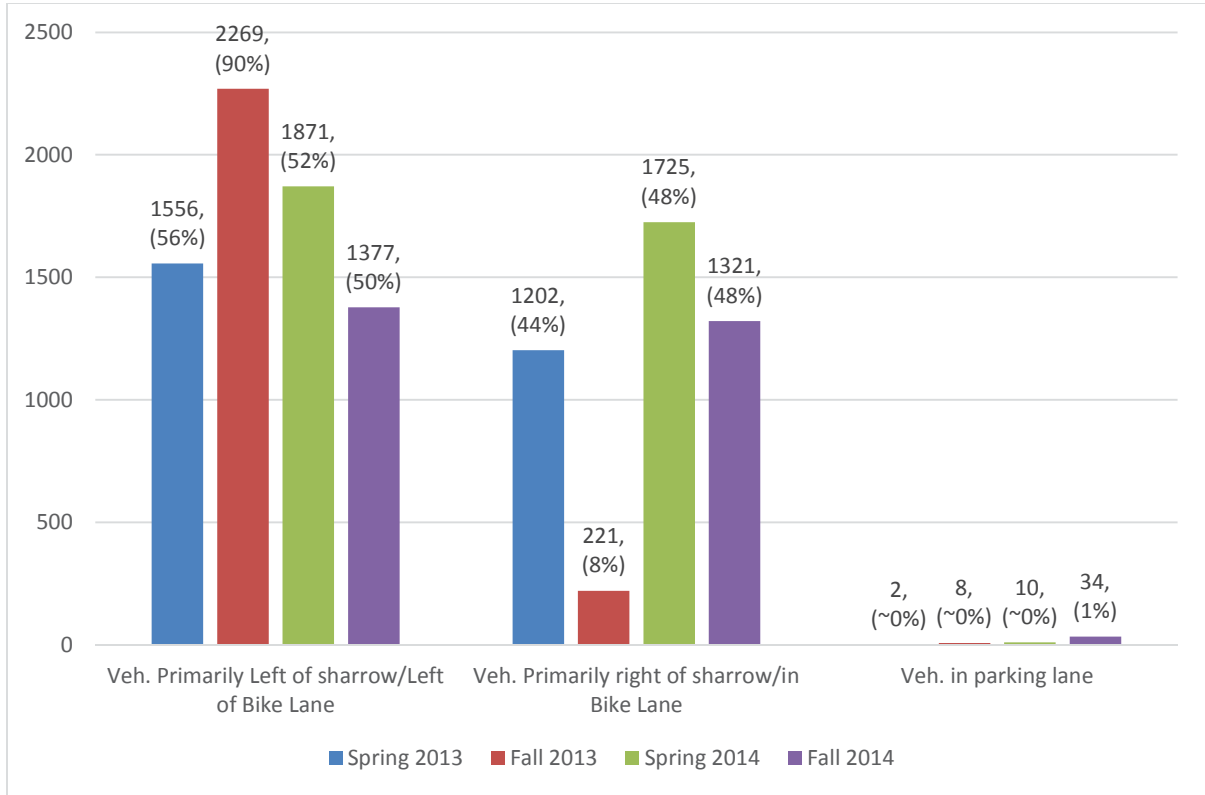
Figure 16 summarizes the observed bicyclist lane positions by direction. The data shows that the bicyclists were best positioned under the advisory lane design. At the time of the switch to the shared lane markings, it can be suggested that bicycle position improved over time, as shown by the decreasing number of bicyclists riding in the parking lane; however, bicyclists appear to be less comfortable riding in the shared travel lane.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period

Figure 16. Wooddale Avenue at 60th Street Bicycle Lane Positioning

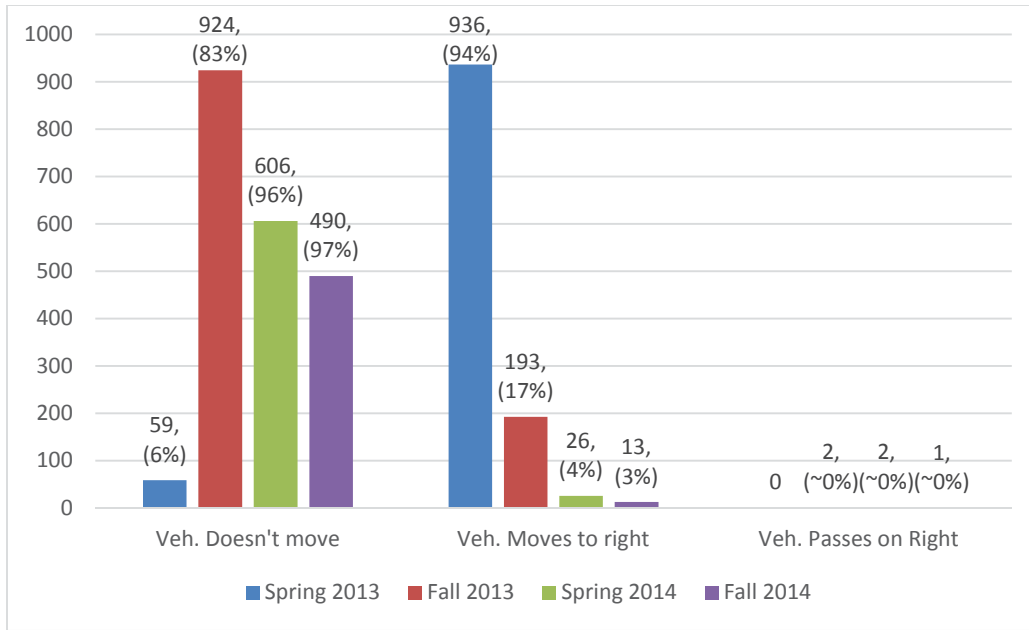
Figure 17 summarizes the motorist’s behavior when no other vehicles or bicyclists are present. In the southbound direction, the motorists tended to navigate rightward in the lane over time. The Fall 2014 evaluation period found the motorists traveling in similar position on the roadway between the advisory lane and shared lane marking conditions. The same observation was found for the northbound direction.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period

Figure 17. 60th and Wooddale Single Vehicle Behavior

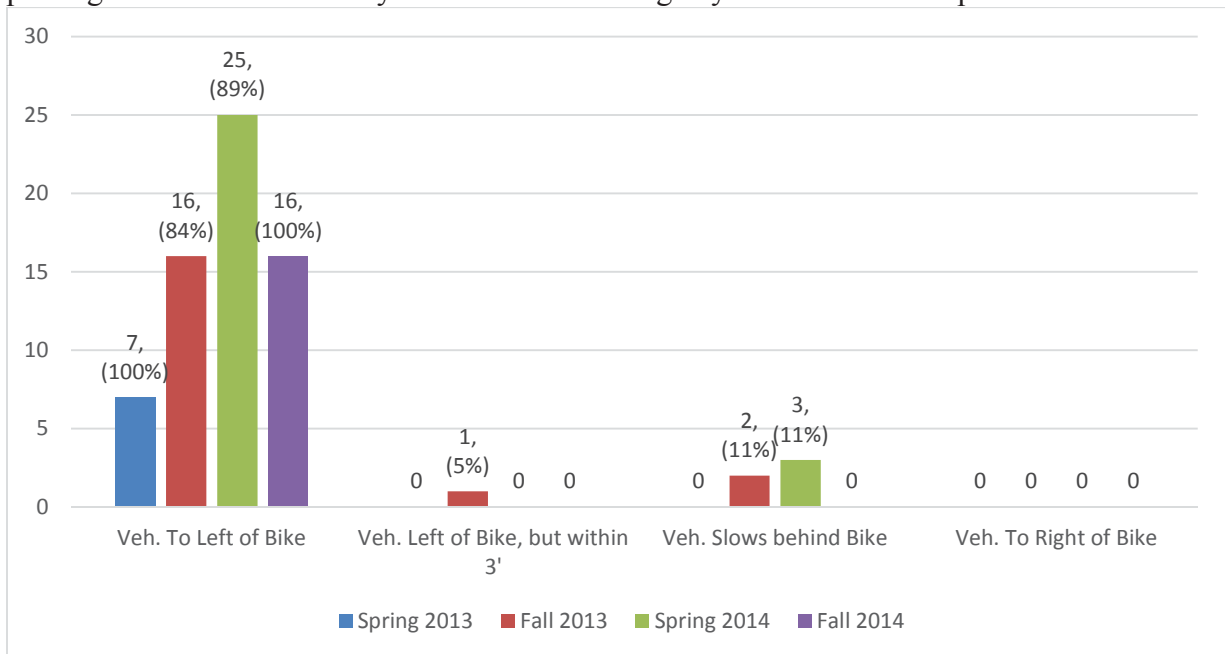
Figure 18 summarizes the behavior of motorists that approached oncoming vehicles. Although the overall travel way space is the same, it can be seen from the percentages that the presence of a yellow centerline has a dramatic influence on the perceived comfort of the motorist. Under the shared lane marking design, the motorists tended to not adjust their lane position, whereas the majority of motorists on the advisory lane tended to drift rightward.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period

Figure 18. Wooddale Avenue at 60th Street Vehicle Meeting another Oncoming Vehicle Behavior

Figure 19 summarizes the occurrences of when a motorist approached a bicycle and how they reacted. The data shows excellent compliance under both the advisory lane and the shared lane marking designs. It is also noted that only one observation of a motorist passing within 3 feet of a bicyclist was made during any of the evaluation periods.



Note: Advisory bike lanes were in place during the Spring 2013 evaluation period

Figure 19. Wooddale Avenue at 60th Street Vehicle Meeting Bicycle (in Same Direction)

3.4 Continuous Colored Shared Lane Marking – Valley View Road

The segment of Valley View Road between Wooddale Avenue and Kellogg Boulevard consists of a three lane cross-section (two way center left turn lane) and a four foot wide green colored continuous shared bicycle lane located within the 14 foot wide eastbound and westbound travel lanes.



Figure 20. Valley View Road Camera View

Figure 21 shows the 24-hour vehicle, pedestrian and bicycle volumes collected on Valley View Road.

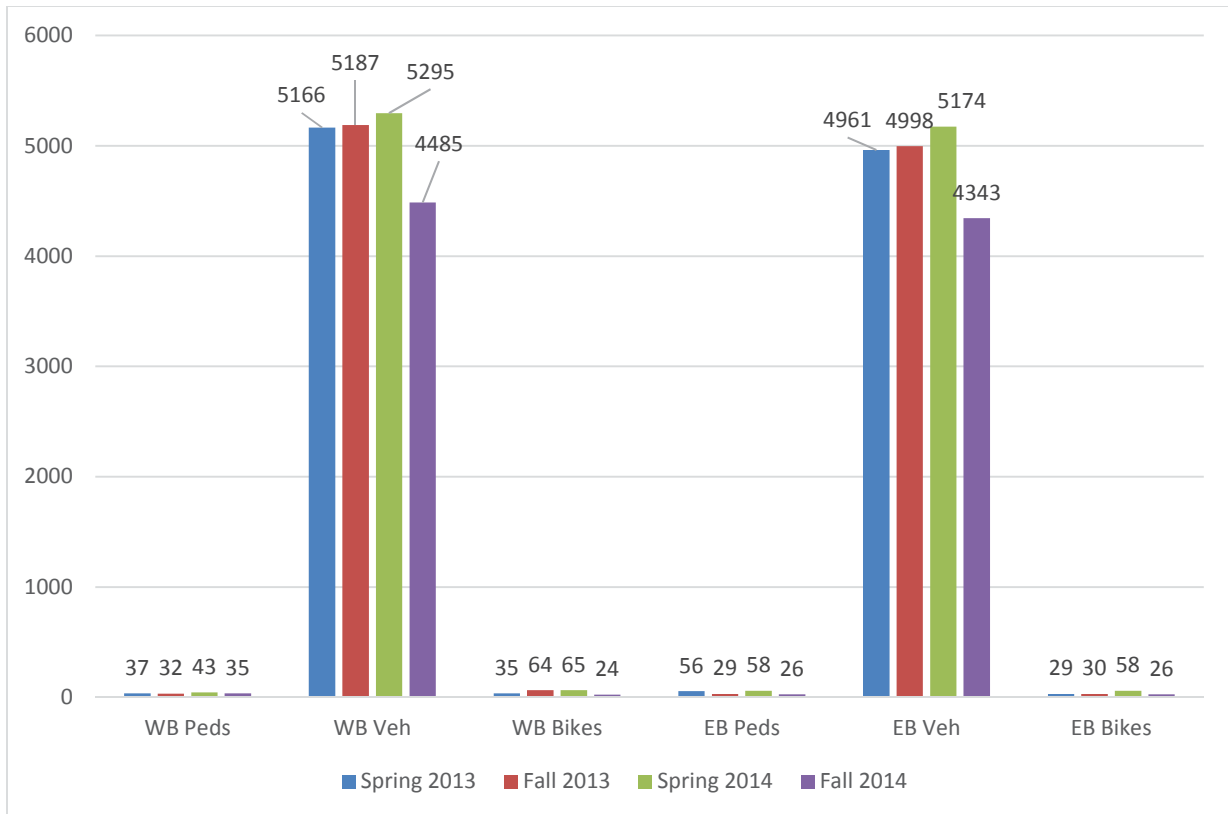


Figure 21. Valley View Road Volumes

Figure 22 summarizes the observed bicyclist lane positions, which was found to be relatively consistent over the evaluation periods.

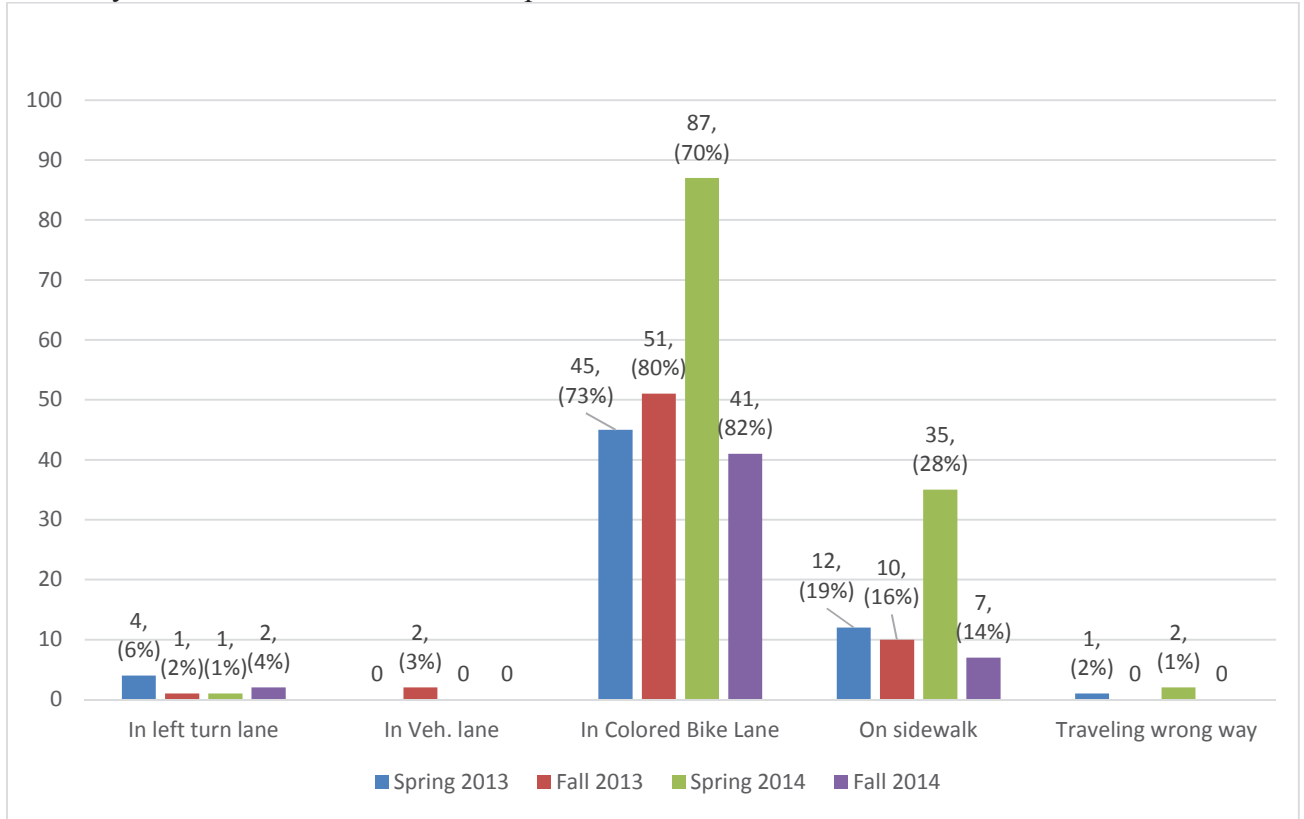


Figure 22. Valley View Rd and Kellogg Bicycle Lane Positioning

Figure 23 summarizes the behavior of single vehicle motorists along Valley View Road. As shown by the data, the motorist travels predominately to the left of the colored shared bike lane markings. Comparing this observation with observations of shared lane markings on Wooddale Avenue, the colored shared lane exhibits much improved vehicle lane position. However, this observation may be skewed due to the presence of an adjacent two way center left turn lane as opposed to an opposing through lane.

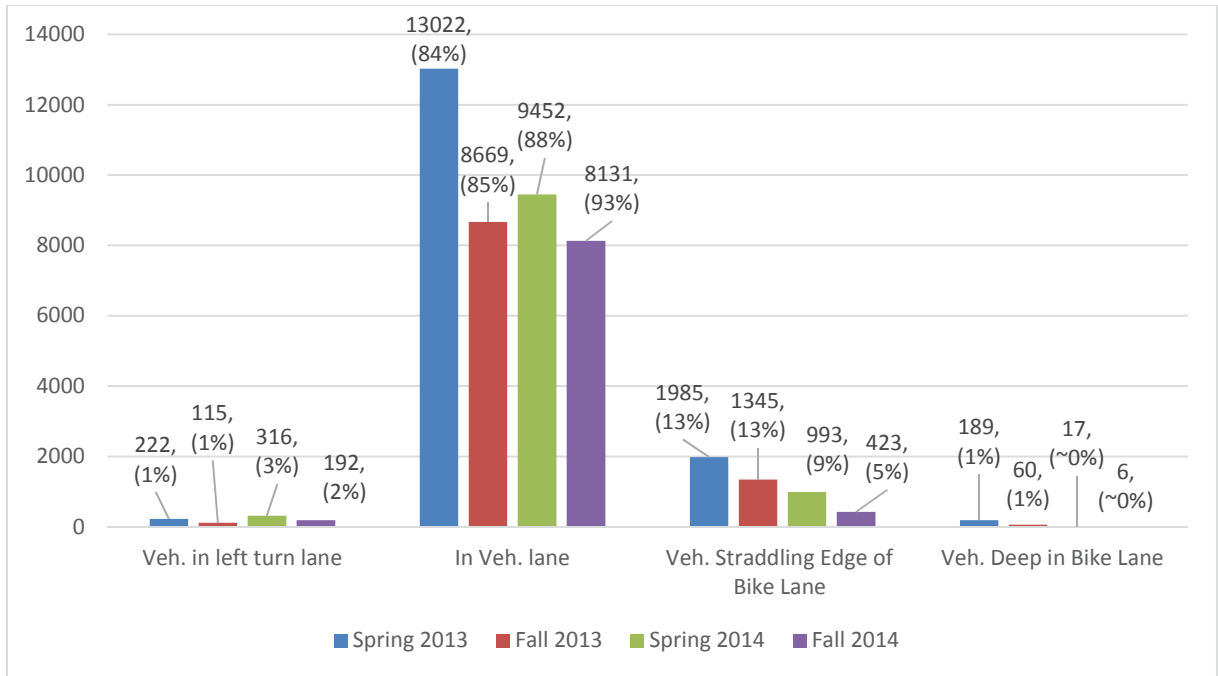


Figure 23. Valley View Road Single Vehicle Behavior

Figure 24 summarizes the reactions of motorists to oncoming vehicles using the center left turn lane.

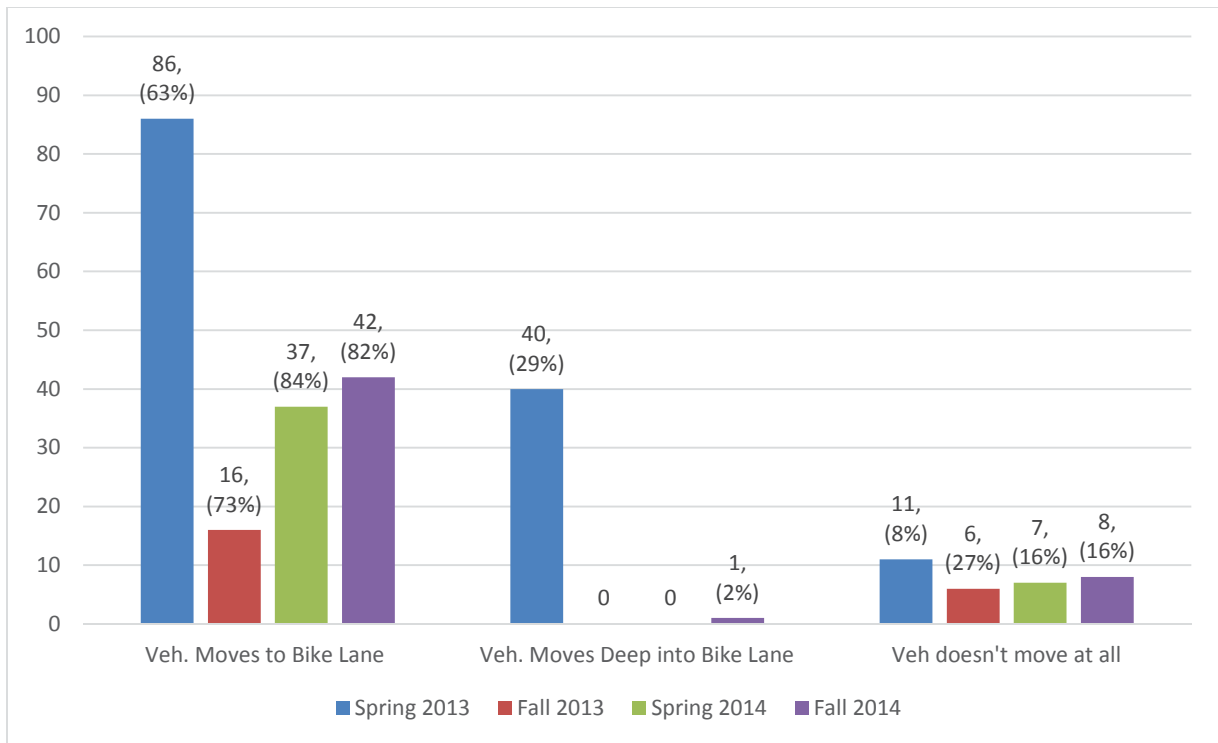


Figure 24. Valley View Road Vehicles Reacting to Left Turning Vehicles

Figure 25 summarizes the behavior of motorists when approaching a bicyclist. As shown by the percentages, motorists are observed safely passing bicyclists. Only 1 observation of a motorist passing a bicyclist within 3 feet was made over the two year evaluation period.

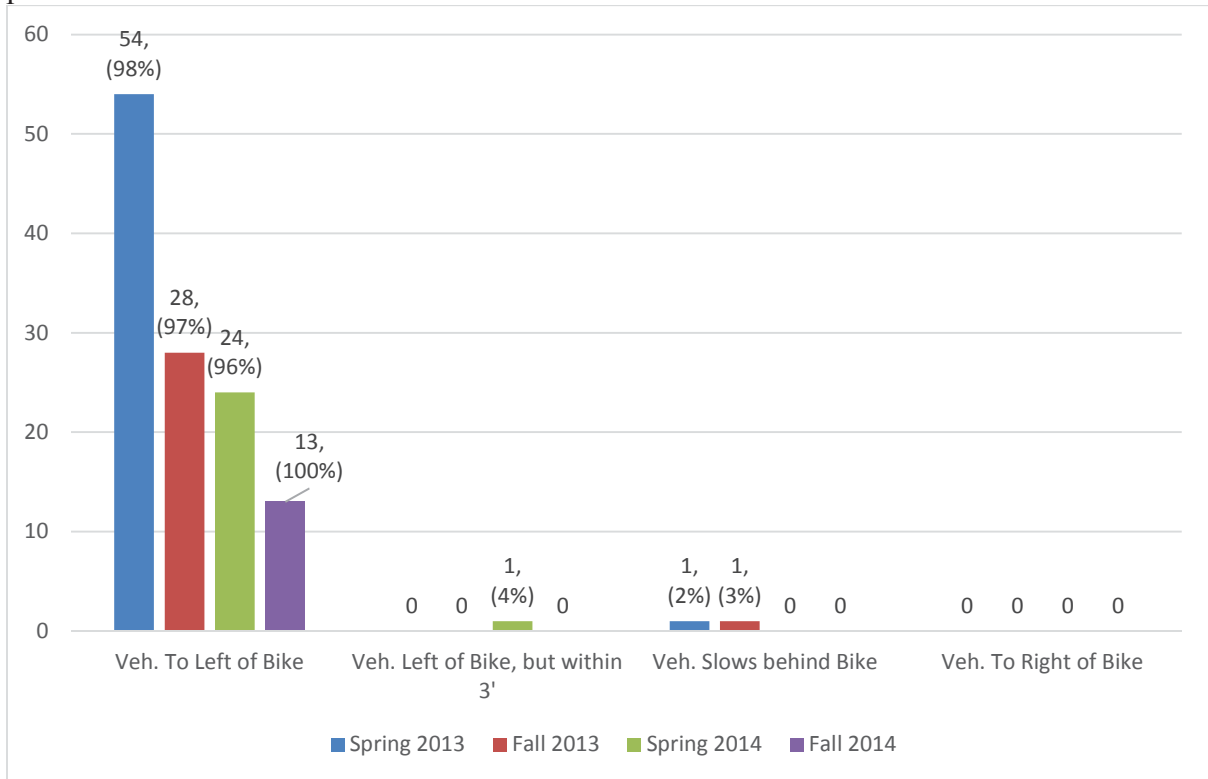


Figure 25. Valley View Road Vehicle Meeting a Bicyclist (in Same Direction)

4.0 Motor Vehicle Speed Study

A 48-hour motor vehicle speed study was conducted at each of the four study locations. Key measurements include the 85th percentile, 50th percentile, mean speeds and percentage categories for motorists exceeding the posted speed limit.

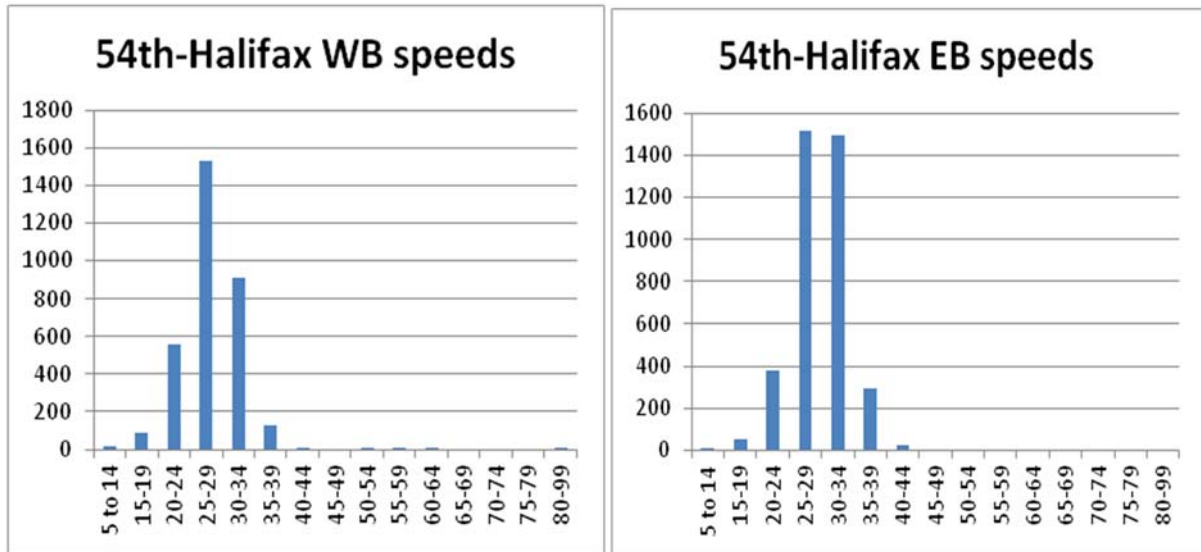
4.1 Advisory Bicycle Lane – West 54th Street

West 54th Street has a 30 mph posted speed limit. Table 1 summarizes the results of the speed study.

Table 1. West 54th Street Speed Study Summary

Speeds (mph)	Westbound	Eastbound
85th percentile mph	33.1	34.2
50th percentile mph	28.1	29.8
Mean speed	27.6	29.2
% volume <30mph	68%	52%
% volume 30-35 mph	28%	39%
% volume 35-40 mph	4%	8%
% volume 40+ mph	0%	1%

Note: Speed Study conducted in November 2013 (Advisory Bicycle Lane Present)



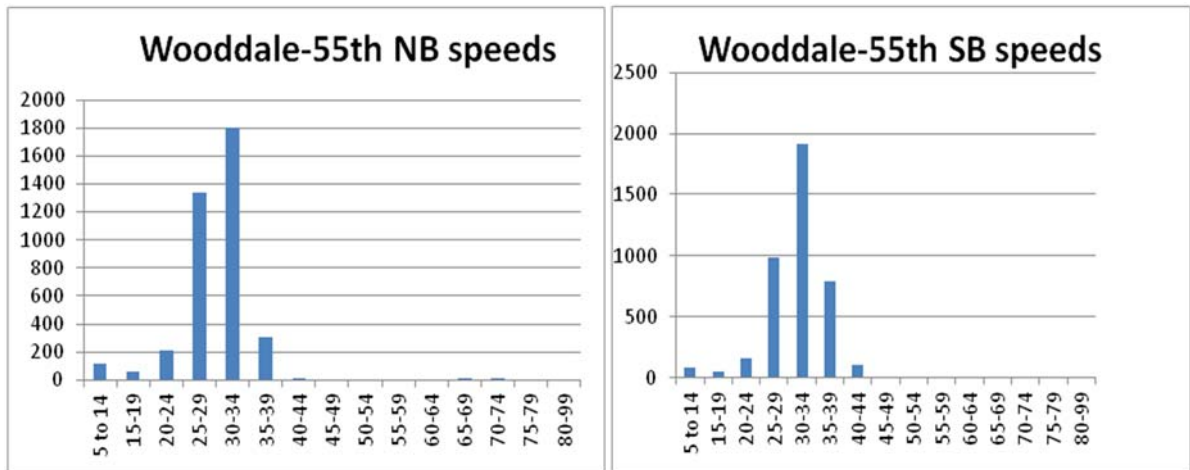
4.2 Designated Bicycle Lane / Shared Lane Markings – Wooddale Avenue at 55th Street

Table 2 summarizes the speed study conducted for the Wooddale Avenue at 55th Street location. Wooddale Avenue has a 30 mph posted speed limit. Table 2 also compares the Fall 2013 speed study results to the previous years’ pavement marking and lane assignment scenarios. The before data (2012 and 2011) was collected by the City of Edina.

Table 2. Wooddale Avenue at 55th Street Speed Study Summary

Before-After Comparison	2013		2012		2011	
Scenario	Shared Lanes		Advisory Bike Lane		Existing Conditions	
Speeds (mph)	NB	SB	NB	SB	NB	SB
85th percentile speed	34.3	36.9	32.9	33.4	NA	NA
50th percentile speed	30.5	32	NA	NA	NA	NA
Mean speed	29	31	NA	NA	NA	NA
% of volume <30mph	45%	31%	NA	NA	NA	NA
% of volume 30-35 mph	47%	47%	19% over 30 mph	25% over 30 mph	NA	NA
% of volume 35-40mph	8%	19%			NA	NA
% of volume 40+	0%	3%			NA	NA

Note: 2013 data collected in November 2013 (Bicycle Lane / Shared Lane Markings present). The 2012 data was collected in October 2012 immediately following the Advisory Bicycle Lane installation. The 2011 data representing the original pavement marking condition (two travel lanes separated by centerline and one on-street parking lane delineated with a solid white edge line) was not available.



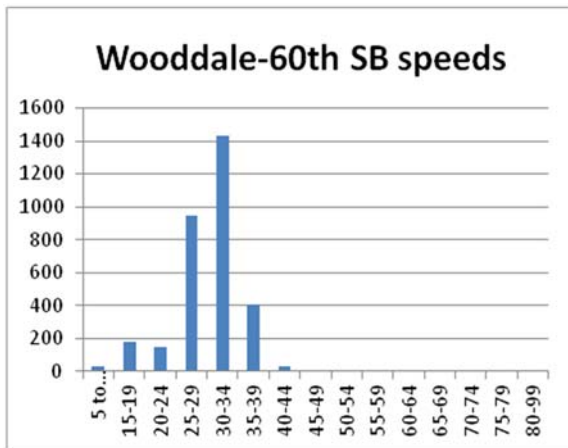
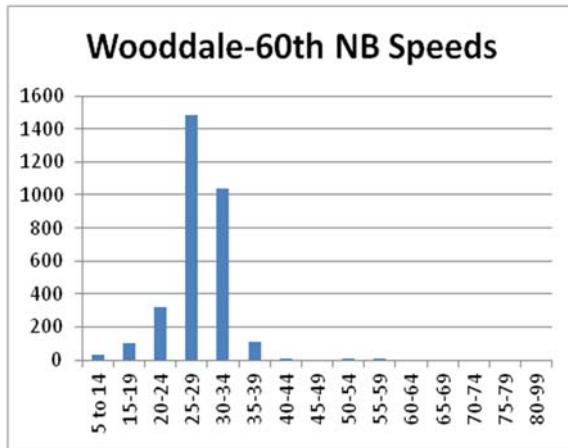
4.3 Shared Lane Markings – Wooddale Avenue at 60th Street

The speed data for the 60th Street and Wooddale Avenue location is shown in Table 3. Just as with the Wooddale Avenue and 55th Street location, a before and after comparison was performed using past speed data obtained by the City of Edina. The posted speed limit is 30 mph.

Table 3. Wooddale Avenue at 60th Street Speed Study Summary

Before-After Comparison	2013		2012		2011	
Scenario	Shared Lanes		Advisory Bike Lane		Existing Conditions	
Speeds (mph)	NB	SB	NB	SB	NB	SB
85th percentile speed	33.3	34.9	33.7	33.4	33.7	34.2
50th percentile speed	28.7	31	NA	NA	NA	NA
Mean speed	28	29.7	NA	NA	NA	NA
% of volume <30mph	63%	41%	NA	NA	NA	NA
% of volume 30-35 mph	34%	45%	20% over 30 mph	29% over 30 mph	25% over 30 mph	28% over 30 mph
% of volume 35-40mph	3%	13%				
% of volume 40+	0%	1%				

Note: 2013 data collected in November 2013 (Bicycle Lane / Shared Lane Markings present). The 2012 data was collected in October 2012 immediately following the Advisory Bicycle Lane installation. The 2011 data represents the original pavement marking condition (two travel lanes separated by centerline and one on-street parking lane delineated with a solid white edge line).



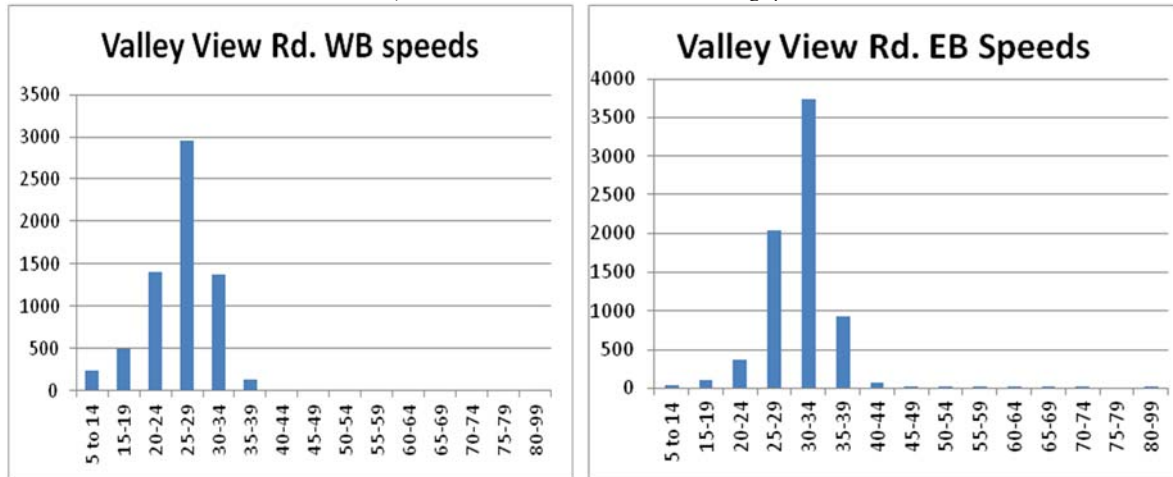
4.4 Continuous Colored Shared Lane - Valley View Road

The speed data for Valley View Road, near Kellogg Boulevard, is summarized in Table 4. The posted speed limit is 30 mph.

Table 4. Valley View Road Speed Study Summary

Speeds (mph)	Westbound	Eastbound
85th percentile speed	32	34.9
50th percentile speed	27	31.5
Mean speed	25.9	30.5
% volume <30 mph	77%	35%
% volume 30-35 mph	21%	51%
% volume 35-40 mph	2%	13%
% volume 40+ mph	0%	1%

Note: 2013 data collected in November 2013 (Continuous Colored Shared Lane markings present. 2012 and 2011 data not available.



5.0 Crash Analysis

Using the MnDOT Crash Mapping Analysis Tool (CMAT), crash analyses were conducted for Wooddale Avenue (from Valley View Road to 50th Street), 54th Street (Wooddale Avenue to France Avenue), and Valley View Road (Wooddale Avenue to Kellogg Boulevard). Crashes were filtered by the dates, crash type, direction of travel, and contributing factors. The before period extends from August 2010 to August 2012, and the after period from October 2012 to October 2014 (experimental treatments installed in September 2012). The Wooddale crashes were evaluated further by splitting the after period into with and without the advisory bike lanes. Valley View and 54th after periods range from October 2012 to October 2014. All crashes that occurred within the length of each experimental treatment were reviewed. Only crashes relevant to the pavement markings or traffic operation were further evaluated. The crash analysis results are shown in Table 5.

Table 5. Crash Analysis Summary

Collection Area	Before		Advisory Lanes		Shared Lanes		Colored Shared Lanes	
	Crashes	Relevant Crashes	Crashes	Relevant Crashes	Crashes	Relevant Crashes	Crashes	Relevant Crashes
Wooddale	10	2	4	3	2	1	NA	NA
Valley View	2	1	NA	NA	NA	NA	0	0
54th	0	0	1	1	NA	NA	NA	NA

Note: Advisory bike lanes on Wooddale were in place October 2012 to June 2013.

Among the relevant before crashes on Wooddale, one crash was of a vehicle sideswiping a parked snow plow (no injuries) and one non-injury rear-end type crash. The four relevant after crashes experienced on Wooddale Avenue consisted of 3 non-injury rear end type crashes and a right angle crash between two vehicles caused by a speeding vehicle reacting to a slowing bicycle during the advisory lane period.

The evaluation found two before reported crashes on Valley View Road and none in the after period (colored shared lane markings). The relevant before crash on Valley View Road was of a vehicle sideswiping a parked snow plow (no injuries).

The evaluation only found one crash on 54th in the after period, between a left turning vehicle and a left turning bicycle. The crash was deemed relevant and reported as the fault of the motorist for failing to yield.

After analyzing the before and after crash data, it appears the advisory lane, shared lane markings or colored shared lane markings have not resulted in any adverse safety conditions.

6.0 General Conclusions

Based on a review of the motor vehicle and bicycle data over the course of two years, the following general conclusions are made:

- Motorist/bicyclist interactions are as intended, with only a small number of violations taking place, and continue to improve over time.
- When bicyclists have a designated lane/shared lane and a parking lane together (54th/Wooddale), bicyclists tend to use the parking lane if no parked vehicles are present. This is probably due to the increased perceived safety of the extra space being provided by the parking lane and discomfort in riding within a shared space with motor vehicles. With the advisory lane present on Wooddale Avenue, the observations found a considerably higher percentage of bicyclists positioned within the bike lane.
- When bicyclists have their own lane without a parking lane present (southbound 55th and Wooddale), bicycles tend to comply by riding in their own designated lane. This was consistent with the observations made for the previous advisory lane markings on Wooddale Avenue. This finding is expected as the bike lane is adjacent to the curb in both design scenarios.
- The study found the continuous colored shared lane on Valley View Road is resulting in very effective results, with bicyclists using the colored shared lane more and the sidewalks less. Single vehicles were observed to travel predominately to the left of the colored shared bike lane. Comparing this observation with observations of shared lane markings on Wooddale Avenue, the colored shared lane exhibits much improved vehicle lane position. However, this observation may be skewed due to the presence of an adjacent two way center left turn lane as opposed to an opposing through lane. Also, motorists were observed to respond well to left turning vehicles by moving only slightly into the colored shared lane instead of moving deep into the colored shared lane.
- Over time, vehicles tend to become comfortable with advisory bike lane markings on 54th Street. Motorist would travel with the right wheel to the right of the dashed pavement marking as long as no bicyclists are present and would pass on the left with sufficient space or they would slow behind the bicyclist.
- Motorist behavior, perception and operation along an advisory bike lane street is greatly improved with a symmetrical cross-section. An asymmetrical cross-section (e.g., parking on only one side of the street) places the motorists in a perceived uncomfortable position in the roadway (feels too far left). As a result motorist behavior and lane positioning is inconsistent.
- The speed studies found that the advisory bike lanes tended to achieve an additional 1-3 mph 85th percentile speed reduction over traditional shared lane markings or no bike lane markings.

Overall the study data results, and video observations, find the traffic operations to be performing as intended or as expected and there were no present safety issues or hazards observed.