Chapter 7

Advisory Bicycle Lanes

Project Location:
Grant Street East/14th Street East between Portland Avenue South and 11th Avenue South

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Federal Highway Administration's approval to experiment 9(09)-6(E) – Bicycle Markings and Signals – Minneapolis, MN.

Treatment Description

An advisory bicycle lane is a variation of a conventional longitudinal marking for a bicycle lane. An advisory bicycle lane replaces the inside solid line defining the bicycle lane to a modified dashed line pattern. The modified dashed line pattern is often used in conjunction with center line removal.

An advisory bicycle lane establishes a preferential lane for bicyclists within a street that is too narrow for the installation of conventional bicycle lanes and standard-width travel lanes for motor vehicles. In conjunction with center line removal, motor vehicle traffic primarily operates within a narrow two-way travel lane. The dashed bicycle lane line permits motorists to merge into the bicycle lane to negotiate oncoming traffic, but only when the adjacent bicycle lane is not occupied by bicycle traffic.

At the time of implementation and writing of this report, advisory bicycle lanes are considered by FHWA to be experimental. The 2009 edition of the MMUTCD permits dotted line patterns for bicycle lane markings and a center line is not required on a roadway with an AADT of 6,000 vehicles per day or less. However, using the markings in the manner of advisory bicycle lanes is still considered experimental.

Advisory bicycle lanes may also be referred to as “dashed bicycle lanes” or “suggestion lanes.” In conjunction with center line removal this treatment has been used extensively in European countries. Prior to installation in Minneapolis, City staff observed successful installations in northern Europe. The 14th Street East installation in Minneapolis is believed to be the first installation in the U.S.

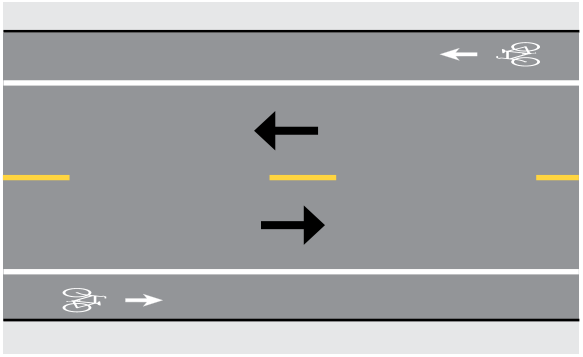


Figure 7-1: Conventional bicycle lanes on a two-way street with a marked center line

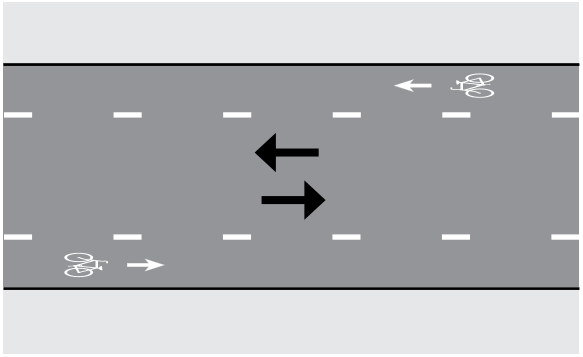


Figure 7-2: Advisory bicycle lanes on a two-way street with no marked center line

Figure 7-3: Example of bicyclists traveling on a street with advisory bicycle lanes in Utrecht, Netherlands

Figure 7-4: Example of two oncoming motorists negotiating on a street with advisory bicycle lanes in Utrecht, Netherlands

Project Location

The project location is on Grant Street East and 14th Street East between Portland Avenue South and 11th Avenue South. Operationally, these segments of Grant Street East and 14th Street are continuous street segments, connecting at Park Avenue South. The project is approximately 0.5 miles or six city blocks long. Surrounding land uses and destinations include high-density residential, North Central University, and a neighborhood park. The installation is southeast of downtown Minneapolis along the intersection of the orthogonal street grid and the downtown historic angled street grid, which consists primarily of a one-way street network. It is relevant to note that two intersections along Grant Street and 14th Street East are offset: Park Avenue South and Chicago Avenue South.

Grant Street East and 14th Street East operate as two-way traffic streets and vary in width from 40 to 44 feet. Prior to implementation, the cross section included parking on both sides of the street and a travel lane in each direction. A broken yellow center line extended the length of the corridor. The street had AADT's ranging from 1,800 to 4,700 vehicles per day with a posted speed limit of 30 mph. No regular transit routes operate on these segments of Grant Street East and 14th Street East.

The goal of the bicycle project was to provide an east-west connection between 11th Avenue South and Portland Avenue South. Due to high parking demand, there was the desire from the community to maintain parking on both sides of the street for the length of the corridor. Shared lane markings were explored, but there was the desire to have a preferential bicycle lane treatment. The recommended design were advisory bicycle lanes ranging in width from five to six feet and a two-way shared travel lane that were 14, 18, or 20 feet wide. The project was open for use in October, 2011.

Figure 7-5: Grant Street East facing east at Portland Avenue South after installation with a 20-foot two-way travel lane

Figure 7-6: Grant Street East facing west at Park Avenue South after installation with a 20-foot two-way travel lane

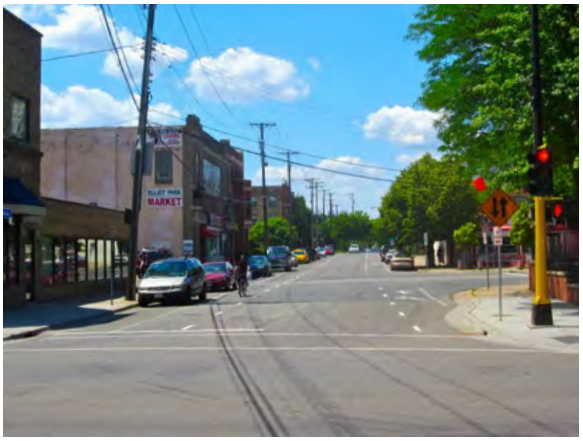


Figure 7-7: 14th Street East facing west at Chicago Avenue South after installation with a 14-foot two-way travel lane

Figure 7-8: 14th Street East facing east at Park Avenue South after installation with a 14-foot two-way travel lane

Figure 7-9: A westbound bicyclist riding on 14th Street East between Park Avenue South and Chicago Avenue South adjacent to a 14-foot two-way travel lane after installation

Figure 7-10: Two oncoming vehicles negotiating on 14th Street East between Park Avenue South and Chicago Avenue South within a 14-foot two-way travel lane after installation

Figure 7-11: 14th Street East facing east at Chicago Avenue South after installation at the transition from a 14-foot to 18-foot two-way travel lane

Figure 7-12: A bicyclist and motorist traveling on 14th Street East facing east towards 11th Avenue South after installation with a 18-foot two-way travel lane after installation

Figure 7-13: Traffic on 14th Street East at 11th Avenue South after installation with a 18-foot two-way travel lane

Figure 7-14: Traffic on 14th Street East between 11th Avenue South and Elliot Avenue South after installation with a 18-foot two-way travel lane

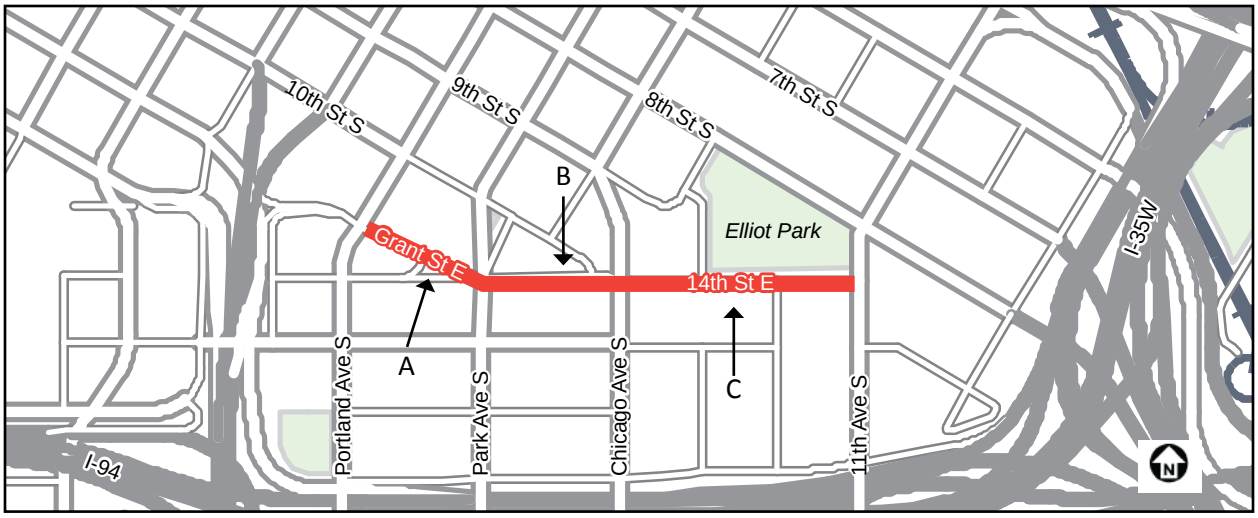
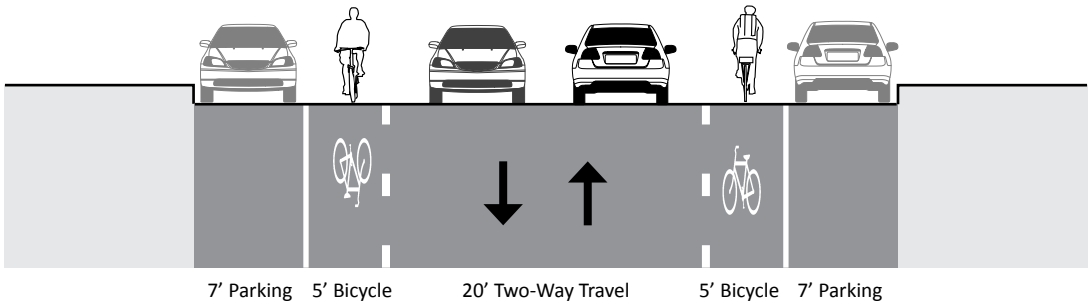
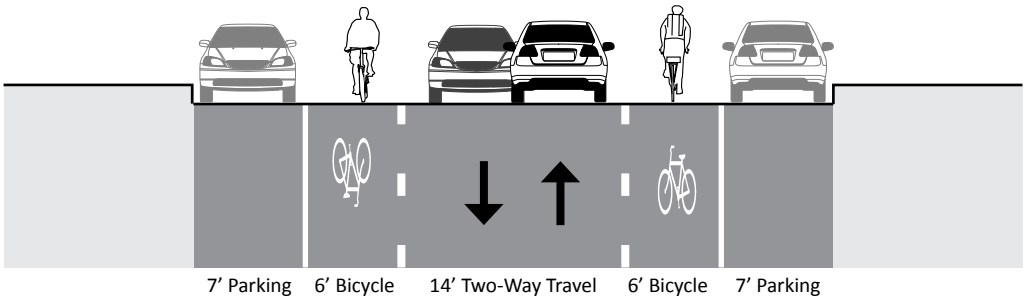


Figure 7-15: Project location

Typical A: Grant Street East between Portland Avenue South and Park Ave S (44')



Typical B: 14th St E between Park Avenue South and Chicago Avenue South (40')



Typical C: 14th Street East between Chicago Avenue South and 11th Avenue South (44')

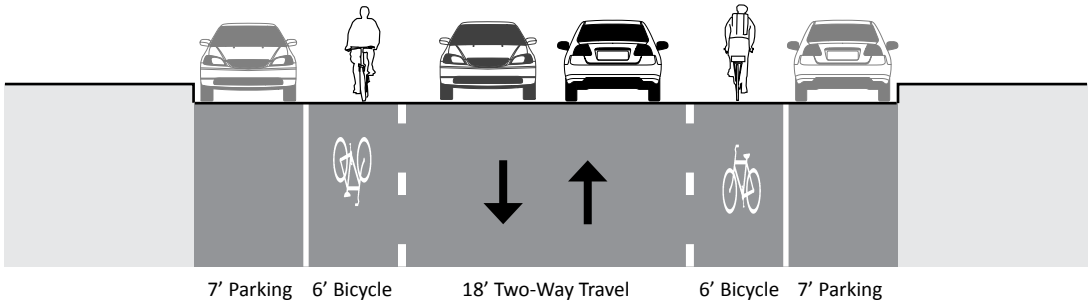


Figure 7-16: Typical cross sections

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the Grant Street East and 14th Street East evaluation, the measures of effectiveness are traffic volumes, motor vehicle speeds, reported crashes, parking compliance, user behavior, and user feedback. Except for parking compliance and user feedback, all measures include before and after monitoring.

The before period includes October 1, 2008 through September 30, 2011. The after period includes October 1, 2011 to September 30, 2014. For simplicity of presentation, before conditions are listed as 2009 to 2011 and after conditions are listed as 2012 to 2014.

Complete documentation of the evaluation plan and methods can be found in Chapter 2.

Results

Traffic Volumes

Bicycle traffic decreased slightly after the project was installed. Before the project was installed, traffic volumes ranged between 240 and 340 bicyclists per day and decreased to 230 bicyclists per day after the project was installed.

Motor vehicle traffic varied before-and-after the project was installed. Between Portland Avenue South and Park Avenue South, the AADT decreased from 4,700 to 2,300 vehicles per day. Between Park Avenue South and Chicago Avenue South, the AADT decreased from 1,900 to 1,800. Between 11th Avenue South and Chicago Avenue South, the AADTs ranged from 1,100 to 1,400 before the project and increased to 2,500 after the project.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation as well as to the academic calendar of North Central University.

Table 7-1: Daily traffic volumes

Type	Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	Chicago Ave S and Elliot Ave S	240	-	340	230	-	-
Motor Vehicle (AADT)	Portland Ave S and Park Ave S	-	4,700	-	-	-	2,300
	Park Ave S and Chicago Ave S	-	-	1,900	1,800	-	-
	Chicago Ave S and Elliot Ave S	-	-	1,400	2,500	-	-
	Elliot Ave S and 10th Ave S	-	-	1,100	-	-	-

Motor Vehicle Speeds

Motor vehicle speeds along the corridor did not change substantially after the project was installed. Eighty-fifth-percentile speeds before the project was installed ranged between 26 mph and 27 mph. After the project was installed, 85th-percentile speeds ranged between 27 mph and 28 mph.

Both the before-and-after 85th-percentile speeds are below the 30 mph posted speed limit. Speeds along this corridor may be a factor of traffic signal timing and stop sign spacing. Parking is in high demand along the corridor, and a large number of circulating vehicles traveling at relatively slow speeds may be represented in the data.

Table 7-2: 85th-percentile speeds

Location (between)	Before (mph)			After (mph)		
	2009	2010	2011	2012	2013	2014
Chicago Ave S and Elliot Ave S	-	-	26	27	-	-
Park Ave S and Chicago Ave S	-	-	27	28	-	-

Reported Crashes

During the three years before installation, there were 59 reported crashes, including 49 motor vehicle crashes, six bicycle crashes, and four pedestrian crashes. During the three years after installation, there were 48 reported crashes, including 45 motor vehicle crashes, two bicycle crashes, and one pedestrian crash. Of the two bicycle crashes after installation, one involved a bicyclist and motor vehicle traveling on 11th Avenue South. The other bicycle crash involved an eastbound bicyclist and a northbound motor vehicle turning onto 14th Street East from an alley.

Table 7-3: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	49	45	-4
Bicycle	6	2	-4
Pedestrian	4	1	-3
Total	59	48	-11

Due to the two-way shared travel lane feature of this treatment, the occurrence of sideswipe and head-on crashes was identified as a specific measure to monitor after the project was installed.

Before installation there were eight sideswipe crashes and one head-on crash. Three of these sideswipe crashes involved eastbound or westbound vehicles on 14th Street East or Grant Street East and the remainder involved northbound or southbound vehicles traveling on a cross street. The head-on crash occurred at the intersection of 14th Street East and Park Avenue South and involved an eastbound vehicle and westbound vehicle. The police report cited “improper lane use” as the primary contributing factor for both vehicles.

After the installation, there were seven sideswipe crashes and two head-on crashes. Three of the sideswipe crashes involved eastbound or westbound vehicles on 14th Street East or Grant Street East. In each case, the two vehicles were traveling in the same direction. The two head-on crashes involved vehicles making left turns onto 14th Street East at Chicago Avenue South and onto Grant Street East at Park Avenue South and hitting an eastbound vehicle slowing for a red semaphore indication. The two police reports cited “improper turning” and “inattentive motorist” as the primary contributing factors. Both of these intersections include offset alignments for Grant Street East and 14th Street East.

Motor Vehicle Parking Compliance

After installation, most motor vehicles parked compliantly in the seven-foot parking lane on Grant Street East and 14th Street East. Five observation periods in September and October, 2012, tallied 494 parked vehicles. Overall, 94 percent of vehicles were parked compliantly, five percent were parked with at least one tire on the inside bicycle lane edge line (minor encroachment), and one percent were fully encroaching in the bicycle lane area (major encroachment).

Table 7-4: Parked vehicle location

Parked Vehicle Location	Count	Percentage
Compliant	466	94%
Minor encroachment	23	5%
Major encroachment	5	1%
Total	494	100%

User Behavior Monitored

User behavior was evaluated before-and-after installation by recording video on 14th Street East and tabulating events. The video was recorded with an east-facing camera located on 14th Street East between Park Avenue South and Chicago Avenue South. Events tabulated include bicyclist location, motorist location, and bicyclist-motorist interactions.

Before video was collected in July of 2011 and after video was collected in May of 2012. Three 16-hour weekdays (6:00 a.m. to 10:00 p.m.) of video were processed in both the before-and-after periods. Temporary tick marks were spray painted on the roadway surface at one-foot intervals. The tick marks provided reference points to estimate the relative location of users and vehicles.

Figure 7-17: Screen capture of before video at 14th Street East between Park Avenue South and Chicago Avenue South

Figure 7-18: Screen capture of after video at 14th Street East between Park Avenue South and Chicago Avenue South

Bicyclist Location

Bicyclist location changed significantly after the advisory bicycle lanes were installed. Before installation, 83 percent of observed bicyclists rode in the travel lanes, 10 percent rode on the sidewalk, and seven percent rode in multiple locations. After installation, 92 percent of bicyclists rode in the appropriate advisory bicycle lane, three percent rode on the sidewalk, and five percent rode in multiple locations.

The results of the two-proportion z-test show the change in sidewalk riding after installation was significant at the 99 percent confidence interval. The shift from the travel lane to the advisory bicycle lane was also significant at the 95 percent confidence interval. The chi-squared test also shows a significant relationship between the existence of the advisory bicycle lane and the bicyclist location at the 99% confidence interval.

Table 7-5: Bicyclist location

Bicyclist Location	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Advisory bicycle lane	-	-	290	92%	0.003	-2.9702
Travel lane	187	83%	1	<1%		
Parking lane	0	0%	0	0%	-	-
Sidewalk	22	10%	10	3%	0.001	3.2377
Multiple	16	7%	16	5%	0.309	1.0177
Total	225	100%	317	100%	-	-

Chi-Square = 475.5884, P-value < 0.00001

Motor Vehicle Location

Before installation, most motorists were observed using the street as intended and drove in the appropriate travel lane. When no oncoming vehicle was present, 93 percent of motorists drove in the appropriate travel lane and seven percent encroached into the oncoming travel lane. When an oncoming vehicle was present, 96 percent of motorists drove in the appropriate travel lane and four percent encroached into the oncoming travel lane.

After installation, most motorists were observed using the street as intended by operating in the two-way shared travel lane and using the advisory bicycle lane to negotiate oncoming vehicles. When no oncoming vehicle was present, 69 percent of motorists drove fully in the two-way shared travel lane, 25 percent drove with minor encroachment in the adjacent bicycle lane, and six percent drove with major encroachment into the adjacent bicycle lane. When an oncoming vehicle was present, 21 percent of motorists drove fully in the two-way shared lane, 34 percent drove with minor encroachment in the bicycle lane, and 45 percent drove with major encroachment into the bicycle lane.

An instance of “minor bicycle lane encroachment” is defined as encroachment up to but not beyond the point of the vehicle’s tire having fully traversed into the advisory bicycle lane. Further encroachment is categorized as “major bicycle lane encroachment.”

Table 7-6: Motor vehicle location

Motorist Location	No Oncoming Vehicle Present				Oncoming Vehicle Present			
	Before		After		Before		After	
	Count	%	Count	%	Count	%	Count	%
One-way travel lane	1,554	93%	-	-	113	96%	-	-
Encroachment into oncoming travel lane	116	7%	-	-	5	4%	-	-
Two-way shared travel lane	-	-	1,058	69%	-	-	49	21%
Minor bicycle lane encroachment	-	-	377	25%	-	-	79	34%
Major bicycle lane encroachment	-	-	96	6%	-	-	102	45%
Total	1,670	100%	1,531	100%	118	100%	230	100%

Bicyclist-Motorist Interactions

Before installation, only 16 events were observed involving bicyclist-motorist interactions. Of these, 12 events involved a motorist safely passing a bicyclist. No “unsafe passing events” were observed. The remainder of events involved a bicyclist and motorist traveling in opposite directions.

After installation, 35 events were observed involving bicyclist-motorist interactions. Of these, 13 events involved a motorist safely passing a bicyclists. No “unsafe passing events” were observed. The one event that did not involve a “safe pass” involved a bicyclist traveling the wrong way in the advisory bicycle lane.

A “safe passing event” involved a motorist leaving a minimum of three feet when overtaking a bicyclist and an “unsafe passing event” involved a motorist leaving less than three feet clearance when overtaking a bicyclist. This definition is consistent with Minnesota State Statute 169.18 which states that “the operator of a motor vehicle overtaking a bicycle or individual proceeding in the same direction on the roadway shall leave a safe distance, but in no case less than three feet clearance, when passing the bicycle or individual.” A “non-passing event” involved a bicyclist and motorist occupying the roadway, but the motorist did not overtake the bicyclist within the video frame.

The results of the two-proportion z-test show that non-passing events increased significantly at the 95% confidence interval. The chi-squared test shows that there is a significant relationship between the adding the advisory bicycle and bicyclist-motorist interactions at the 95% confidence interval.

Table 7-7: Bicyclist-motorist interactions

Passing Interactions	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Non-passing events	4	25%	21	60%	0.051	-1.9536
Safe passing events	12	75%	13	37%	0.012	2.5218
Unsafe passing events	0	0%	1	3%	0.22	-1.2256
Total bicyclist-motorist interactions	16	100%	35	100%	-	-

Chi-Square = 6.6567, P-value = 0.035

There was not a sufficient number of events where a motorist would have been forced to choose between yielding to a bicyclist or improperly occupying the right-of-way. At this location, the only situation in which a motorist would be required to yield to a bicyclist would be when two oncoming vehicles and two oncoming bicyclists simultaneously occupied their designated locations within the roadway. No such situation was observed. Presumably this scenario would occur at an infrequent rate as to not be a notable source of conflict given the traffic volumes of bicyclists and motorists on Grant Street East and 14th Street East.

User Feedback

User feedback was solicited through intercept surveys for bicyclists and motorists.

Public Works recruited people to take the survey in two ways. For the bicyclist survey, staff stood at the intersection of 14th Street East and Chicago Avenue South and handed cards to bicyclists waiting at a red semaphore. A total of 41 cards were distributed over a 12-hour period, resulting in 22 valid responses.

For the motorist survey, staff placed survey cards on the windshield of parked vehicles along Grant Street East and 14th Street East and one block in either direction. Survey distribution occurred during two weekdays and two weeknights. A total of 281 cards were distributed, resulting in only 12 valid survey responses.

The surveys were 19 questions and were intended to take 10 minutes or less to complete. See Chapter 2 for additional information about the survey methods.

Table 7-8: Survey response rates by user group

User Group	Distributed	Valid Responses	Response Rate
Bicyclists	41	22	54%
Motorists	281	12	4%

In both surveys, participants were shown a photo of the advisory bicycle lanes on Grant Street East and 14th Street East and asked to state the intended purpose of the roadway marking. To not influence responses, the question was opened ended where participants typed into a blank field. Staff categorized responses based on content or common themes. Many participants provided responses that included multiple purposes.

Bicyclist and motorist participants stated the purpose was related to bicycle traffic. Survey participants most frequently stated that the purpose was to indicate a recommended riding area for bicycle traffic, increase awareness of bicycle traffic, and to indicate a shared lane for bicycle and motor vehicle traffic.

Table 7-9: Stated purpose of markings

Stated Purpose Category (Staff Tabulated Category)	Frequency of stated purpose		
	Bicyclist Survey	Motorist Survey	Total
Indicate recommended riding area for bicycle traffic	11	11	22
Increase awareness of bicycle traffic	12	8	20
Indicate shared lane for bicycle and motor vehicle traffic	8	10	18
Indicate lane for bicycle traffic	5	11	16
Communicate that motorists should yield to bicycle traffic	4	7	11
Other	5	3	8
Total	45	50	95

Survey participants were also asked if they had any general feedback about the recent changes to 14th Street East. Many bicyclists believe that motorists are confused by the markings since the travel lanes are narrower than typical lanes and not marked with a center line. Some bicyclists expressed confusion about the purpose of the markings, although the confusion appears to be motivated by the survey questions.

Table 7-10: Select feedback from bicyclist survey

Select feedback from bicyclist survey
"I work in a restaurant on [14th St E]. At first motorists and bicyclists expressed confusion, but it was new and now I think most people familiar with Minneapolis get it."
"Since I live in the area, I don't find it confusing. But I have had friends and relatives tell me the markings confuse them. They feel it looks like there is only room for traffic in one direction."
"Motorists are a bit confused - I also am confused as I thought it was a bicycle lane but now I'm not sure."

The general feedback from motorists was that the markings are confusing motorists due to the narrow travel lanes and lack of center line. Some motorists were originally unsure if the street is one-way or two operation.

Table 7-11: Select feedback from motorist survey

Select feedback from motorist survey
"It is definitely stressful to drive on E 14th St when there are bicyclists and cars coming from both directions. Also, it is hard to tell that it is a 2-way street. The only way that I can tell is that the parked cars are facing both ways. I've never noticed the sign before."
"The lack of a yellow line is the confusing part."
"Motorists are somewhat confused since there is no longer a yellow center line which clearly separate east bound traffic from west bound traffic. Some motorist, drives down the middle between the dash lines thinking that it's a one way street."

Conclusions

The evaluation of advisory bicycle lanes on Grant Street East and 14th Street East found the street generally operated as intended. The project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety or operations of the street. While some users expressed confusion about the narrow lane configuration and the lack of a marked center line, this confusion was not reflected in reported crashes or observed user behavior.

During the three years before installation, there were 59 reported crashes, including 49 motor vehicle crashes, six bicycle crashes, and four pedestrian crashes. During the three years after installation, there were 48 reported crashes including, 45 motor vehicle crashes, two bicycle crashes, and one pedestrian

crash. The two bicycle crashes after installation occurred under circumstances that do not appear to be a factor of the project design. After installation, there were three sideswipe and two head on crashes that occurred along Grant Street East and 14th Street. It is important to consider that these crash types occurred prior to installation and may be a factor of the offset intersections at Park Avenue South and at Chicago Avenue South. In the fall of 2015, Public Works installed green bicycle conflict markings on 14th Street East at Chicago Avenue South with the intent to reduce bicyclist-motorist conflicts. Public Works is monitoring the location to understand if the conflict markings provide guidance to bicyclists as well as motorists traveling through the offset intersection.

After the installation of the advisory bicycle lanes and removal of the center line, the street operated as intended. Most bicyclists rode in the advisory bicycle lane, similar to the operation of a conventional bicycle lane. When no oncoming vehicles were present, most motorists utilized the two-way travel lane. When an oncoming vehicle was present, motorists used the advisory bicycle lane area to negotiate oncoming traffic. The operation was comparable to the operation of a typical residential street with no marked center line. Except for one instance of a bicyclist riding against traffic, no unsafe maneuvers were observed as motorists negotiated with bicyclists and oncoming traffic.

Efforts to solicit user feedback did not result in high response rates. Of the limited sample of bicyclist survey participants, users tended to believe the purpose of the treatment was similar to a conventional bicycle lane, although many believed that motorists were confused by the treatment. Of the limited sample of motorist survey participants, users stated that they were confused by the treatment. Most motorists identified the lack of a center line as contributing to confusion and were not clear if the street was one-way or two-way. This confusion was not reflected in reported crashes or observed user behavior, although the design of intersections and transitions to the connecting street network may be an important consideration for future advisory bicycle lane applications. This consideration may be particularly important when planning or evaluating advisory bicycle lane locations that are proximate to one-way street networks, such as downtown areas.

Public Works intends to maintain the project as it is providing value to bicyclists and no related safety or operational issues have been observed. Ongoing monitoring by Public Works continues to support results from this evaluation. Even during peak hours, the street operates as intended. Staff believe the positive experience with advisory bicycle lanes is context sensitive. While AADT's approach 5,000 vehicles per day on some segments, the preexisting operation of the street was complementary to the operation of advisory bicycle lane treatments: motorists traveled at relatively low speeds along the corridor, and anecdotally, many motorists exhibited extra caution, possibly due to maneuvering through the skewed intersections, circulating for on-street parking, or yielding to bicycle and pedestrian traffic generated by North Central University.

Figure 7-19: Green bicycle lane conflict markings installed on 14th Street East at Chicago Avenue South

Figure 7-20: Bicyclist riding eastbound on 14th Street East at 11th Avenue South on a weekday afternoon