Evaluation of Bicycle Traffic Control Devices and Street Design Elements in Minneapolis

The purpose of this report 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 and the Minnesota Department of Transportation's approval of Design Exceptions for State Projects 141-091-020 and 141-091-022.

March 13, 2017

Minneapolis
City of Lakes

Executive Summary

This report documents the evaluation of 16 bicycle treatments and street design elements installed by Minneapolis Public Works in 2011 and 2013. The purpose of the report is to fulfill the final evaluation reporting requirements of the Federal Highway Administration's (FHWA) approval of six experiments under Experiment 9(09)-6(E), and the Minnesota Department of Transportation's (MnDOT) approval of eight design exceptions under State Projects 141-091-020 and 141-091-022. Two additional local evaluations are included in this report for bicycle-related projects installed in Minneapolis at the same time. Projects underwent a thorough evaluation process including monitoring safety, operations, and user behavior, and also soliciting user feedback. This report documents how the individual treatments and street design elements functioned in the context of each project location. Key findings of each evaluation are summarized below.

Experiments

<u>Colored Conflict Zone: Various Locations</u>

This project included colored conflict zones installed at eight locations where motorists merge or turn across a bicycle lane. A colored bicycle lane conflict zone modifies the conventional dotted bicycle lane marking to include a green colored background. The green color is intended to reinforce the message of the dotted bicycle lane line. Approval of this experiment came prior to FHWA's Interim Approval for the Optional Use of Green Colored Pavement for Bicycle Lanes.

- No new operational or safety issues emerged as a result of the installation of colored conflict zones. However, the effectiveness of reducing conflicts between bicyclists and motorists is unclear.
- Evaluation of user behavior was limited to one of the eight project locations. Bicyclist behavior did not change substantially before-and-after installation, and contrary to the intended motorist behavior, the share of motorists yielding to bicyclists decreased after installation of the colored conflict zone.
- The positive results of the other colored conflict zone locations and peer city evaluations have given staff confidence to maintain these locations and pursue this treatment at other locations.

<u>Colored Crosswalks: Various Locations</u>

This project included colored crosswalks installed at two intersections along the Loring Bikeway trail parallel to Hennepin/Lyndale Avenue South. A colored crosswalk marking modifies the conventional crosswalk marking to include solid green color in between the two white transverse lines. The green color is intended to reinforce the message of a marked crosswalk.

- No new operational or safety issues emerged as a result of the installation of colored crosswalks. However, the project locations were each installed at one leg of complex intersections and it is unclear what effect the treatment had on safety relative to the other existing conditions at these locations.
- Evaluation of user behavior was limited to one location. For motorists, there was no significant change in westbound motorist stopping location or compliance with the no turn on red condition. No significant changes were observed for bicyclist-motorist interactions or pedestrian-motorist interactions.
- User feedback was generally positive for the specific treatment, although bicyclists and pedestrians stated that the colored crosswalk did little to improve the overall perceived safety of the intersections. After the project was installed, bicyclists and pedestrians stated that many motorists still failed to yield the right-of-way when turning.

Enhanced Shared Lane Markings: LaSalle Avenue South

This project included enhanced shared lane markings installed on a 0.3-mile segment of LaSalle Avenue South, which operates as a one-way street with two travel lanes. An enhanced shared lane marking modifies the standard marking to include a dotted white longitudinal line on both sides of the bicycle symbol and chevron module. The dotted white lines are intended to reinforce the purpose of conventional shared lane markings.

- No new operational or safety issues emerged as a result of the installation of enhanced shared lane markings and the street operated as intended. However, due to the evaluation design, it is not possible to know the effectiveness of enhanced shared lane markings over conventional shared lane markings or no markings in the same context.
- Evaluation of user behavior was limited to after the project was installed. Nearly all southbound bicyclists rode over the shared lane markings, although due to high parking demand, riding to the right of the shared lane marking or in the parking lane was rarely feasible. Most motorists operated as intended, driving over the shared lane when a bicyclist was not present, but merging to the left when a bicyclist was present. No unsafe passing of bicyclists by motorists was observed.
- User feedback was mixed. Most bicyclists believed the markings provided more awareness of bicycle traffic to motorists. However, many bicyclists stated that a dedicated bicycle lane would be preferred on a street with an uphill grade and high volumes of motor vehicle traffic. Many motorists stated that they did not prefer to be sharing a lane with bicycle traffic.

Intermittent Colored Background for Shared Lane Markings: Bryant Avenue South

This project included shared lane markings with intermittent colored background installed on 1.3-mile segment of Bryant Avenue South. Intermittent colored background for shared lane markings modifies the conventional shared lane marking to include a green colored background. The green color is intended to reinforce the purpose of conventional shared lane markings. To further evaluate the effectiveness of the treatment, two configurations were installed. In one direction, the shared lane markings were centered 12.5 feet from the face of curb, and in the other direction the markings were centered 14 feet from the face of curb.

- No new operational or safety issues emerged as a result of the installation of intermittent shared lane markings. However, due to the evaluation design, it is not possible to know the effectiveness of enhanced shared lane markings over conventional shared lane markings or no markings in the same context.
- Evaluation of user behavior was limited to after installation. Most motorists used the street as intended. Over half of bicyclists did not use the treatment as intended and chose to ride between the green area and parked vehicles or curb. This behavior was more prevalent in the direction where shared lane markings were offset 14 feet from the face of curb than in the direction where the markings were offset 12.5 feet from the face of curb. When no parked vehicles were present, more bicyclists were observed riding closer to the curb.
- User feedback was mixed. Most bicyclists believed the markings provided more awareness of bicycle traffic to motorists. However, many bicyclists stated that a dedicated bicycle lane would be preferred on a street with frequent bus service and high volumes of motor vehicle traffic. Motorists expressed confusion about how to drive on Bryant Avenue South, although this confusion was not reflected in the user behavior or in reported crashes. Many motorists stated that they did not prefer to be sharing a lane with bicycle traffic.

Advisory Bicycle Lanes: Grant Street East/14th Street East

This project included the installation of advisory bicycle lanes on a 0.5-mile segment of Grant Street East and 14th Street East. An advisory bicycle lane replaces the inside solid line defining the bicycle lane to a modified dashed line pattern, and is often used 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.

- After the installation of the advisory bicycle lanes and removal of the center line, the street operated as intended and no new operational or safety issues emerged.
- 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. Except for one instance of a bicyclist riding against traffic, no unsafe maneuvers were observed as motorists negotiated with bicyclists and oncoming traffic.
- Of the limited user feedback, bicyclists tended to believe the purpose of the treatment was similar to a conventional bicycle lane. Motorists stated that the lack of a center line was confusing and it was 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.

Bicycle Signal Indications: 5th Street Northeast at Broadway Street Northeast

The project included the installation of a new traffic signal with bicycle signal indications at the three-legged intersection of 5th Street Northeast and Broadway Street Northeast. To establish a continuous north-south bicycle boulevard along 5th Street Northeast, an existing concrete diverter at the intersection was opened to allow for bicycle passage and crossing of Broadway Street Northeast. To enhance safety and reduce delay for pedestrians and bicyclists, a traffic signal was proposed at this location with actuated bicycle signal indications for northbound and southbound bicycle traffic. A bicycle signal indication is a variation of a conventional signal indication and consists of an illuminated red, yellow, or green bicycle symbol in lieu of a conventional red, yellow, or green ball. Approval of this experiment came prior to FHWA's interim approval for the Optional Use of Bicycle Signal Indications.

- After the installation of the new signal and bicycle indications, no crashes of any type were observed at the intersection.
- While the new network connection saw increases in bicyclist volumes, only 42 percent of bicyclists were observed actuating either the bicyclist or pedestrian push buttons. No apparent safety issues were observed when bicyclists crossed on red. All motorists were observed using the signal as intended.
- User feedback from bicyclists was generally positive, and comprehension of the bicycle signal indications was high. Nearly all bicyclist survey participants believed the wait for green was reasonable, although about half stated they have disregarded the signal when the wait was long.

Design Exceptions

Travel Lane Width on a Two-Way Street: Bloomington Avenue South

This project included the installation of bicycle lanes on a 0.15-mile segment of Bloomington Avenue South. Bloomington Avenue South is 30 feet wide and operates as a two-way street. The project included a design with two 10-foot travel lanes and two five-foot bicycle lanes in lieu of the Municipal State Aid minimum standard of two 10-foot travel lanes and two six-foot bicycle lanes.

- While the evaluation period and measures of effectiveness were limited, the project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety of users or operations or the street.
- User behavior was not formally observed, although Public Works was not notified of any operational issues during the two-year installation period.
- The project was removed after two years, but only for the purposes of constructing an off-street trail parallel to the roadway.

Travel Lane Width and Parking Lane Width on a Two-Way Street: 24th Street East

This project included the installation of bicycle lanes on a 0.2-mile segment of 24th Street East. Twenty-Fourth Street East is 37 feet wide and operates as a two-way street. The project included a design with two 10-foot travel lanes, two five-foot bicycle lanes, and one seven-foot parking lane in lieu of the Municipal State Aid minimum standard of two 10-foot travel lanes, two six-foot bicycle lanes, and an eight-foot parking lane.

- The evaluation found that the street generally operated as intended. The project installed a dedicated bicycle lane treatment in a constrained corridor without having a negative impact on the safety or operations of the street.
- After the installation of the bicycle lanes, the predictability of where bicyclists rode improved. Before installation, about half of bicyclists shared the travel lane with motorists, a quarter rode in the parking lane, and a quarter rode on the sidewalk. After installation, most bicyclists operated in the bicycle lane, and the share of bicyclists riding on the sidewalk decreased.
- After installation, 90 percent of motorists operated completely in their respective travel lanes. Nine percent of all motor vehicles and 34 percent of all large motor vehicles encroached into the bicycle lane area. However, the encroachment was not observed to create safety or operational issues and did not coincide with the immediate presence of a bicyclist in the bicycle lane.

Travel Lane Width and Parking Lane Width on a Two-Way Street: Como Avenue Southeast

This project included the installation of bicycle lanes on a 0.25-mile segment of Como Avenue Southeast. Como Avenue Southeast is 45 feet wide and operates as a two-way street. The project included a design with two 10.5-foot travel lanes, two five-foot bicycle lanes, and two seven-foot parking lanes in lieu of the Municipal State Aid minimum standard of two 10-foot travel lanes, two six-foot bicycle lanes, and two eight-foot parking lanes.

- The project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety of users or operations of the street. Motor vehicle crashes did increase after installation, although the relationship to the street design elements is not strong.

- After the installation of the bicycle lanes, 86 percent of bicyclists operated in the bicycle lane, and 97 percent of motorists operated completely in their respective travel lane. Less than three percent of motor vehicles encroached into other lanes. However, the encroachment was not observed to create safety or operational issues and did not coincide with the immediate presence of a bicyclist in the bicycle lane.
- While there is no regular transit service on this street, staged bus observations were performed to better understand bus and bicycle interactions within a constrained corridor. Lane deviation was observed, and operators noticed that the lanes were narrower than typical. However, the observations demonstrate that large vehicles operated by professional drivers on low-speed urban streets, can safely negotiate with other traffic in constrained environments.

<u>Travel Lane Width and Parking Lane Width on a Two-Way Street: 15th Street West</u>

This project included the installation of bicycle lanes on a 0.4-mile segment of 15th Street West. Fifteenth Street West is 45 feet wide and operates as a two-way street. The project included a design with 10.5-to-11-foot travel lanes, five-to-5.5-foot bicycle lanes, and two seven-foot parking lanes in lieu of the Municipal State Aid minimum standard of two 10-foot travel lanes, two six-foot bicycle lanes, and two eight-foot parking lanes.

- The project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety of users or operations of the street.
- After the installation of the project and installation of the bicycle lanes, the street generally operated as intended. Ninety-two percent of bicyclists operated in the bicycle lane, and 94 percent motorists stayed in their respective travel lane. Encroachment of motor vehicles into the adjacent bicycle lane was observed, but was not observed to create safety or operational issues.

<u>Curb Reaction Width, Travel Lane Width, and Parking Lane Width on a Two-Way Street: 1st Avenue South</u>

This project included the installation of a one-way bicycle lane on a 0.7-mile segment of 1st Avenue South. First Avenue South is 35 to 36 feet wide and operates as a two-way street. The project included a design with 1.5-foot curb reaction distance and a seven-foot parking lane in lieu of the Municipal State Aid minimum standard of two-foot curb reaction distance and an eight-foot parking lane. The design also included two 11-foot travel lanes and one five-to-5.5-foot bicycle lane, which are consistent with the Municipal State Aid standards.

- The project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety of users or operations of the street.
- One "dooring" crash appears to have occurred along the project after installation. While a trend of "dooring" crashes was not observed, Public Works will continue to monitor the bicycle lane adjacent to the seven-foot parking lane.
- After the bicycle lane was installed, 96 percent of northbound bicyclists rode in the northbound bicycle lane. Under the new configuration, 99 percent of the motorists operated in their respective travel lane.

Number of Travel Lanes Required on a One-Way Street: Fremont Avenue North

This project included the installation of a one-way buffered bicycle lane on a 1.5-mile segment of Fremont Avenue North. Fremont Avenue North is 32 feet wide and operates as a one-way street. The project included one 12-foot travel lane, one seven-foot bicycle lane, four foot buffer, and one nine-foot parking lane in lieu of the Municipal State Aid minimum standard of two general purpose travel lanes on a one-way street.

- The project installed a preferential bicycle lane treatment in a constrained corridor and modified the capacity of the roadway without having a negative impact on the safety or operations of the street.
- After the bicycle lane was installed, most bicyclists rode in the lane as intended, and fewer bicyclists were observed riding on the sidewalk. Under the new configuration, 97 percent motor vehicles operated in the single travel lane. Encroachment of buses and large vehicles into the buffer area was observed after the project was installed, but was not observed to create safety or operational issues.

Number of Travel Lanes Required on a One-Way Street: 1st Avenue South

This project included the installation of a one-way buffered bicycle lane on a 0.5-mile segment of 1st Avenue South. First Avenue South is 29 to 32 feet wide and operates as a one-way street. The project included a weekday and weekend configuration. The weekday configuration included one 11-foot travel lane, one seven-foot bicycle lane, one four-to-five-foot buffer, and one seven-to-eight-foot parking lane in lieu of the Municipal State Aid minimum standard of two general purpose travel lanes on a one-way street. The weekend configuration permitted parking within the seven-foot bicycle lane area.

- The project installed a preferential bicycle lane treatment in a constrained corridor and modified the capacity of the roadway without having a negative impact on the safety or operations of the street. The safety of the corridor did not vary between the weekend and weekday operation, although Public Works has received continued negative feedback from bicyclists about the weekend configuration.
- After the installation of the bicycle lanes, most bicyclists were riding in the bicycle lane on weekdays as intended. No safety issues were observed under the weekend configuration, although a shared lane configuration is not desired and the four-foot buffer does not provide adequate space for bicyclists to overtake parked cars.
- After installation, most motorists operated in the single travel lane at slower speeds. Encroachment of motor vehicles into the buffer area and bicycle lane was observed after the project was installed, but was not observed to create safety or operational issues.

Local Evaluations

Colored Conflict Zone: Various Locations

This project included colored conflict zones installed at three locations along 15th Avenue Southeast where motorists were merging or turning across a bicycle lane on. A colored bicycle lane conflict zone modifies the conventional dotted bicycle lane marking to include a green colored background. The green color is intended to reinforce the message of the dotted bicycle lane line. This project was installed after FHWA's Interim Approval for the Optional Use of Green Colored Pavement for Bicycle Lanes.

- The colored conflict zones had positive effects on the safety and operations of the street.
- After installation, significantly more motorists yielded to bicyclists. However, about half of the motorists merged after the bicycle lane merge area which is not consistent with Minnesota State Statute. While there are positive trends in behavior, Public Works is evaluating ways to encourage motorists to merge at the appropriate location, including the use of dotted green markings instead of solid green markings.
- Feedback from bicyclists was positive. Most bicyclists believed that motorists were more aware of bicyclist traffic since the colored conflict zones were installed. However, some bicyclists stated that not all motorists yield the right-of-way and that the street can be stressful to ride on due to bus traffic.

25 MPH Posted Speed Limit: 15th Avenue Southeast

The project reduced the posted speed limit from 30 mph to 25 mph on a 0.6-mile segment of 15th Avenue Southeast. At the time of original installation only the posted speed limit was changed, although subsequent striping changes were made to establish wider bicycle lanes and narrower travel lanes. Speed limits on streets in Minnesota are prescribed by Minnesota Statute 169.14, and in urban districts, the statutory speed limit is 30 mph. On streets with bicycle lanes, State Statute permits a posted speed limit of 25 mph without an engineering or traffic investigation.

- There was no substantial effect on motor vehicle speeds after the posted speed limit was reduced from 30 mph to 25 mph, or after the subsequent striping changes were made.
- The 85th-percentile speeds before the project was installed ranged between 23 mph and 32 mph. After the project was installed, 85th-percentile speeds ranged between 23 mph and 33 mph. Only a one-block segment between University Avenue Southeast and 4th Street Southeast had 85th-percentile speeds below the 25 mph posted speed limit; although 85th-percentile speeds were below 25 mph prior to project installation on that block.
- Before-and-after speed distribution varied by block segment. This suggests that other factors such as signal spacing, pedestrian and bicycle volumes, and adjacent land uses may have a greater influence on motor vehicle speeds than the in place signing and striping installed along this corridor.

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Chapter 1

Introduction

Background

In the 2005 federal transportation funding bill, *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users*, Congress established the Non-Motorized Transportation Pilot Program (NTPP). The purpose of NTPP was to demonstrate how walking and bicycling infrastructure and programs can increase rates of walking and bicycling. Four pilot communities, including Minneapolis, were each awarded $25 million in funding to implement infrastructure and programs and study the impact of these investments on traffic congestion, energy use, health, and the environment. To understand the effectiveness of investments, project-level evaluation methods were encouraged including: the use of count data, surveys, safety data, and modeling.

The Twin Cities non-profit Transit for Livable Communities was designated to administer the pilot program to Minneapolis and the surrounding communities through an initiative called Bike Walk Twin Cities. Under NTPP, over 35 miles of new or improved bikeways were implemented in Minneapolis. NTPP infrastructure projects funded through Bike Walk Twin Cities aimed to incorporate innovative treatments to help address safety, and operational and network issues.

The innovative treatments fell into two categories:

- Traffic control devices including signs, signals, and pavement markings not included in the 2009 edition of the Minnesota Manual on Uniform Traffic Control Devices (MMUTCD). To be installed, these treatments required an approved Request to Experiment from the Federal Highway Administration (FHWA).
- Street design elements including lane width, curb reaction width, and lane configurations not included in the current Minnesota State Aid Standards. To be installed, these design elements required an approved design exception through the Minnesota Department of Transportation (MnDOT) State Aid for Local Transportation Division.

During the time of NTPP, Minneapolis received approval for seven experiments and nine design exceptions. Project approval was contingent on monitoring and regular reporting of safety and operational issues. Six of the seven experiments and eight of the nine design exceptions are included in this report. An experiment on Hennepin Avenue was evaluated separately from this report due to coordination with a broader corridor evaluation. Another project on Fremont Avenue North was canceled due to the installation a bicycle facility on a parallel route.

Purpose of this Report

The purpose of this report is to fulfill the final evaluation reporting requirements of both FHWA's approval to experiment 9(09)-6(E) – Bicycle Markings and Signals – Minneapolis, MN and MnDOT's approved design exceptions under State Projects 141-091-020 and 141-091-022. Concurrently, Minneapolis installed two other bicycle-related projects that utilized new types of treatments. The projects did not require a request to experiment or a design exception, but are included in this report due to similar installation schedules, similar evaluation methods, and local interest in the effectiveness of the treatments. In total, 16 projects were installed in 2011 and 2013 and are documented in this report: six experiments, eight design exceptions, and two local evaluations.

Each chapter follows a similar structure and is devoted to one experiment, design exception, or local evaluation. Projects underwent a thorough evaluation process including monitoring safety, operations, user behavior, and soliciting user feedback. Full documentation of the evaluation plan and methods can be found in Chapter 2. While cross sectional analysis can be conducted across multiple treatment types, that is not the primary intent of this report. This report documents how the individual treatments and street design elements functioned in the context of the project locations.

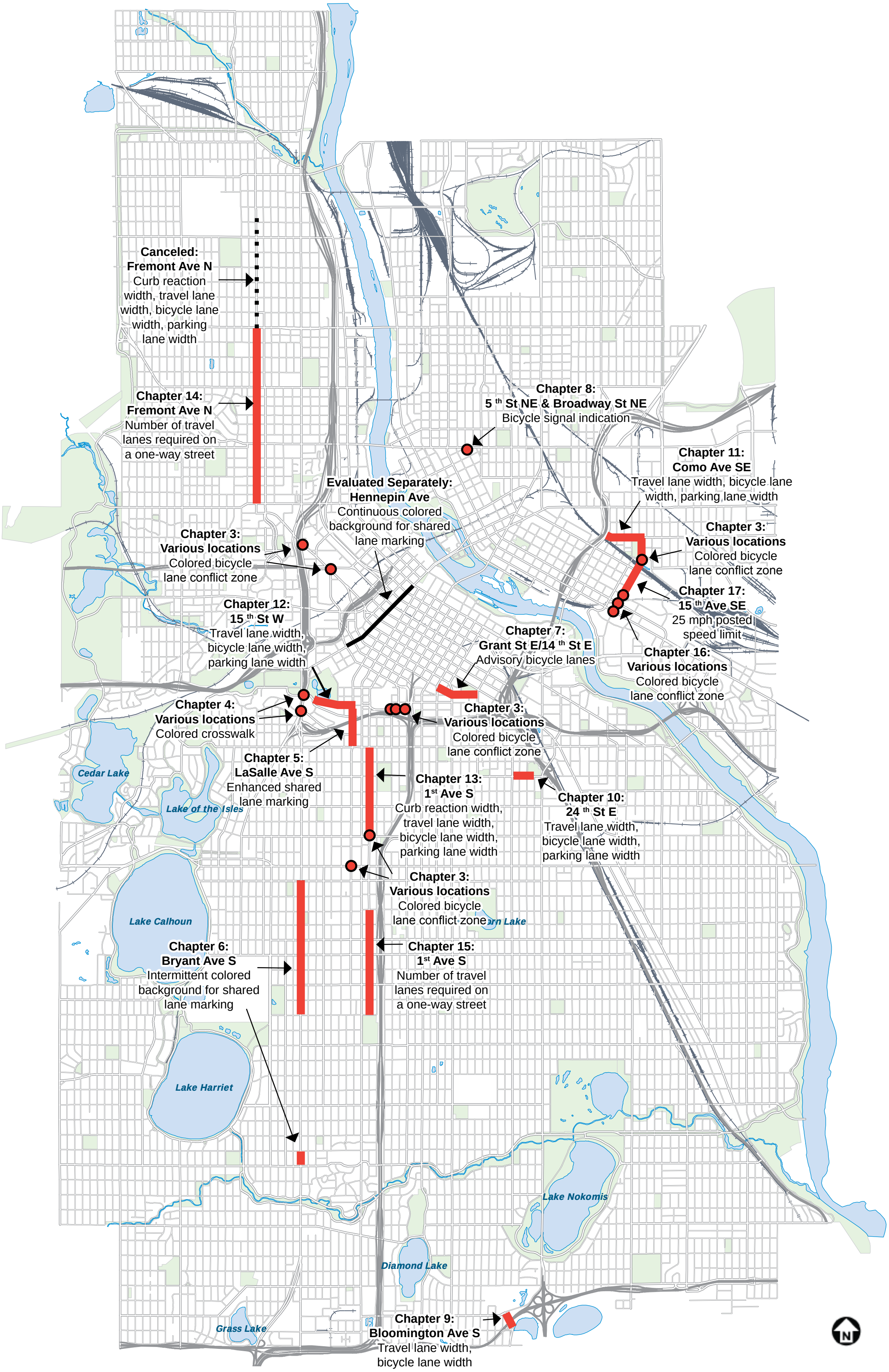
In addition to fulfilling the formal evaluation reporting requirements of FHWA and MnDOT, Public Works intends for this report to be used by staff and peer agencies as they design, plan, and evaluate bicycle traffic control devices and street design elements.

Projects

Table 1-1: List of approved experiments, approved design exceptions, and local evaluations

Chapter	Treatment	Location(s)	Details
Approved Experiments by FHWA Experimentation 9(09)-6(E) – Bicycle Markings and Signals – Minneapolis, MN			
3	Colored bicycle lane conflict zone	Multiple intersections	Installed prior to FHWA interim approval for optional use of green colored pavement for bicycle lanes (IA-14)
4	Colored crosswalk	Multiple intersections	-
6	Enhanced shared lane marking	LaSalle Avenue South	-
5	Intermittent colored background for shared lane marking	Bryant Avenue South	-
7	Advisory bicycle lanes	14th Street East, Grant Street East	-
8	Bicycle signal indications	5th Street Northeast at Broadway Street Northeast	Installed prior to FHWA interim approval for optional use of bicycle signal faces (IA-16)
-	Continuous colored background for shared lane marking	Hennepin Avenue	Treatment evaluated in separate report: *Hennepin Avenue Green Shared Lane Study*
Approved Design Exceptions by Minnesota Department of Transportation State Projects 141-091-020 and 141-091-022			
9	Travel lane width, bicycle lane width	Bloomington Avenue South	Two-way street with no parking
10	Travel lane width, bicycle lane width, parking lane width	24th Street East	Two-way street with parking on one side, bicycle lanes in both directions
11	Travel lane width, bicycle lane, width, parking lane width	Como Avenue Southeast	Two-way street with parking on both sides, bicycle lanes in both directions
12	Travel lane width, bicycle lane width, parking lane width	15th Street West	Two-way street with parking on both sides, bicycle lanes in both directions
13	Curb reaction width, travel lane width, bicycle lane width, parking lane width	1st Avenue South	Two-way street with parking on one side, bicycle lane in one direction
14	Number of travel lanes required on a one-way street	Fremont Avenue North	Buffered bicycle lane in lieu of second travel lane
15	Number of travel lanes required on a one-way street	1st Avenue South	Buffered bicycle lane in lieu of second travel lane (weekdays only)
	Number of travel lanes required on a one-way street	1st Avenue South	One travel lane and buffer lane in lieu of second travel lane (weekends only)
-	Curb reaction width, travel lane width, bicycle lane width, parking lane width	Fremont Avenue North	Project canceled due to the installation of a bicycle facility on a parallel route
Local Evaluations			
16	Colored bicycle lane conflict zone	Multiple intersections	Installed after FHWA interim approval for optional use of green colored pavement for bicycle lanes (IA-14)
17	25 mph posted speed limit	15th Avenue Southeast	-

Figure 1-1: Map of project locations



Chapter 2

Evaluation Plan and Methods

The purpose of this chapter is to document the evaluation plan and general methods for all projects in this report. Unique measures or circumstances for each project are discussed in the respective project chapters.

Overview

For the experiments and design exceptions, FHWA and MnDOT approval was contingent on the City of Minneapolis committing to monitoring and regular reporting of safety and operational issues. This chapter documents the evaluation guidance used, the initial evaluation plan outlined in the original requests to experiment and original design exception requests, and finally the modified evaluation plan.

Evaluation Guidance

FHWA Guidance

The FHWA report, *Pedestrian and Bicyclist Traffic Control Device Evaluation Methods* (Publication No. FHWA-HRT-11-035, May 2011) describes methods that practitioners can use to conduct reliable evaluations of pedestrian and bicyclist traffic control devices. The FHWA report was published after the submission of the requests to experiment and the design exception requests, although Public Works did reference this guidance when refining the evaluation plan after project approvals.

FHWA provides recommended steps to plan an evaluation of traffic control devices. The process begins with the problem identification, answering the question: "What is the safety or traffic operations issue?" "The process continues with the development of a research question, the identification of measures of effectiveness, and the determination of the evaluation design and evaluation methods." The final step in the process is to select components of the evaluation plan. This step aims to answer the question: "How can time, budget, and practicality be balanced to execute the plan?"

Table 2-1: FHWA recommended steps to plan an evaluation of traffic control devices

Step	Name of Step	Question Answered
1	Problem identification	What is the safety or traffic operations issue?
2	Research question	What is the research question?
3	Measures of effectiveness	How will performance be assessed?
4	Evaluation designs	What is the study approach?
5	Evaluation methods	How will users, traffic operations, or crashes be measured?
6	Selecting components to the evaluation plan	How can time, budget, and practicality be balanced to execute the plan?

Literature Review

In addition to the FHWA guidance, Public Works performed a literature review of similar evaluation reports. The literature review included:

- Brady, John et. al. *Effects of Colored Lane Markings on Bicyclist and Motorist Behavior at Conflict Areas.* Center for Transportation Research the University of Texas at Austin. August 2, 2010.
- City of Davis, California. *The Use of Bicycle Signal Heads at Signalized Interactions*. July 1, 1996.
- City of Portland. *Portland's Blue Bike Lanes: Improved Safety through Enhanced Visibility*. July 1, 1999.
- Florida Department of Transportation. *Operation and Safety Impacts of Restriping Inside Lanes of Urban Multilane Curbed Roadways to 11 Feet or Less to Create Wider Outside Curb Lanes for Bicyclists*. BDK82 977-01. September 2011.
- Furth, Peter G. et. al. *More Than Sharrows: Lane-Within-A-Lane Bicycle Priority Treatments in Three U.S. Cities*. Presented at the 2011 Annual Meeting of the Transportation Research Board. January 31, 2011.
- Hunter, William W. et. al. *Evaluation of Shared Lane Markings in Miami Beach, Florida*. University of North Carolina Highway Safety Research Center. March 2012.
- Hunter, William W. et. al. *Evaluation of a Green Bike Lane Weaving Area in St. Petersburg, Florida*. University of North Carolina Highway Safety Research Center. September 2008.
- Jensen, Soren Underlien. *Safety Effects of Blue Cycle Crossings: A Before-After Study*. Accident Analysis and Prevention 40 (2008) 742-750.

- Monsere, Christopher et. al. *Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track and SW Stark/Oak Street Buffered Bike Lanes*. January 14, 2011
- San Francisco Department of Parking and Traffic and Alta Planning + Design. S*an Francisco's Shared Lane Markings: Improving Bicycle Safety*. February 2004.
- Wolfe, Michael et. al. B*ike Scramble Signal at N Interstate & Oregon*. Portland State University CED 454 Urban Transportation Systems. Fall 2006.

Evaluation Plan

Original Request

In the original request to experiment and design exception requests, different measures of effectiveness, or variables were listed. Below is the original evaluation plan provided to FHWA and MnDOT in 2010 and 2012.

<u>Request to Experiment 9(09)-6(E) – Bicycle Markings and Signals Evaluation Plan (2010)</u>

"Bicyclist and motorist behavior and interaction will be observed by staff and volunteers along the subject streets after the application of the test devices. Variables to be studied and recorded in the field will be:

- Direction of bicyclist travel (with or against traffic)
- Before-and-after bicycle volumes
- Before-and-after crash rates
- Bicyclist surveys to determine recognition, comprehension, and effectiveness
- Driver surveys to determine recognition, comprehension, and effectiveness
- Driver and bicyclist surveys to identify any parking/bicycle conflicts
- Driver and bicyclist surveys to gauge value
- Effectiveness of signal timing relative to safety and operation efficiency
- Motorist and bicycle behavior (compliance with device)

If resources permit the following variables may be considered in this study:

- Distance between bicyclists and parked vehicles.
- Number and frequency of conflicts between bicyclists and motorists in the same lane.

In addition to videotaped data, surveys will be given to cyclists, residents, and motorists traveling along the streets of the experiment. The survey will be conducted along the corridor by stopping bicyclists and motorists. Willing participants will fill out a short survey about the installed treatment. Residents will be mailed their surveys. This survey will include questions regarding the visibility of the pavement marking, the person's interpretation of the pavement marking's meaning, and what, if any, changes were made to one's driving or riding behavior after the pavement marking was applied to the street."

<u>SP 141-091-020 Design Exception Request Evaluation Plan (2010)</u>

"As a condition of allowing design exceptions the City of Minneapolis will conduct data collection, site reviews and prepare reports regularly to monitor safety and gain understanding of the impacts of the proposed designs. Reporting of data obtained will occur approximately once per year with the assumption that the projects will be constructed in summer and fall of 2010 and the first report will be submitted in January 2012 and annually thereafter for a reporting period of five years. Review will be on-going with formal data collection activities occurring in May and September of 2011 during the first full season of operation and then in September for years 2 through 5 as outlined below.

Data Collection/Reviews:

1. Crashes before-and-after by type. Review details and reports as needed.
2. Bicyclist volume data collection before-and-after."

SP 141-091-022 Design Exception Request Evaluation Plan (2012)

"As a condition of allowing design exceptions the City of Minneapolis will conduct data collection, site reviews and prepare reports regularly to monitor safety and gain understanding of the impacts of the proposed designs. Reporting of data obtained will occur approximately once per year with the assumption that the projects will be constructed in the fall of 2013 and the first report will be submitted in January 2014 and annually thereafter for a reporting period of five years. Review will be on-going with formal data collection activities occurring in the summer of 2014 during the first full season of operation. Continued monitoring will occur through 2018.

Data Collection/Reviews:

1. Metro Transit will be invited to test drive and provide feedback on the segment.
2. Observations of parked vehicles, motorist and bicyclist locations in lanes.
3. Crashes before-and-after by type. Review details and reports as needed.
4. Speed data collection before-and-after.
5. Bicycle volume data collection before-and-after."

Modified Evaluation Plan

Following approval of the projects, the evaluation plan was refined based on new evaluation planning guidance, the unique circumstances of each project, and available resources. The intent of the original evaluation plan was retained. The modified evaluation plan included six steps:

1. Problem Identification

At a city-wide level there are observed and anticipated conflicts between bicyclists and motorists. These conflicts may exist at a specific location or along a corridor. Supporting the policy goals of the City of Minneapolis, Public Works aims to reduce observed and anticipated conflicts between bicyclists and motorists. Project-level problems are identified in each chapter of this report.

2. Research Question

All the traffic control devices and street design elements aim to reduce bicyclist-motorist conflicts. The research question is: "What effect, if any, do these traffic control devices and street design elements have on the safety of users, the operations of the street, and the experience of users?"

3. Measures of Effectiveness

The measures of effectiveness include traffic volumes, motor vehicle speeds, reported crashes, parking compliance, user behavior, and user feedback. These measures of effectiveness span areas of safety, operations, and user feedback.

4. Evaluation Design

To understand the effectiveness of projects, a before-and-after evaluation design was desired for all measures of effectiveness. This evaluation design was achieved in most instances; however, time, budget, and practicality did not allow this to be fully realized for all projects and all measures effectiveness. Some projects also included a cross-sectional design such as the intermittent colored background for shared lane markings on Bryant Avenue South.

5. Evaluation Methods

Public Works utilized several methods that are already part of its routine data collection efforts. These included the monitoring of traffic volumes, motor vehicle speeds, and reported crashes. Additional methods were developed for this evaluation, such as parking compliance observations, monitoring user behavior, and the solicitation of user feedback. Descriptions of individual evaluation methods are discussed later in this chapter.

6. Selecting Components to the Evaluation Plan

Complete before-and-after measures of effectiveness were desired for all projects. This was achieved for some measures, although parking compliance and user feedback was only collected after project installation. Statistically significant samples of user behavior and user feedback were also desired. However, statistical analysis was only completed for some changes in user behavior. Efforts to collect user feedback were resource intensive and did not yield adequate sample sizes to perform analysis. These results are still reported for information purposes. A summary of the modified evaluation plan is shown in Figure 2-2.

Table 2-2: Modified evaluation plan

Chapter	Treatment	Traffic Volumes	Motor Vehicle Speeds	Reported Crashes	Parking Compliance	User Behavior	User Feedback
3	Colored bicycle lane conflict zone	*B/A	-	B/A	-	B/A[1]	*A
4	Colored crosswalk	*B/A	-	B/A	-	B/A[1]	*A
5	Enhanced shared lane marking	B/A	-	B/A	-	B/A[1]	A
6	Intermittent colored background for shared lane marking	B/A	-	B/A	-	B/A[1]	A
7	Advisory bicycle lanes	B/A	B/A	B/A	A	B/A[1]	*A
8	Bicycle signal indications	B/A	-	B/A	-	B/A[1]	A
9	Travel lane width, bicycle lane	*B/A	-	B/A	-	-	-
10	Travel lane width, bicycle lane width, parking lane width	B	-	B/A	A	B/A[2]	-
11	Travel lane width, bicycle lane, width, parking lane width	*B/A	B/A	B/A	A	A[3]	-
12	Travel lane width, bicycle lane width, parking lane width	B/A	B/A	B/A	A	A[1]	-
13	Curb reaction width, travel lane width, bicycle lane width, parking lane width	*B/A	-	-	A	A[1]	-
14	Number of travel lanes required on a one-way street	*B/A	B/A	B/A	-	B/A[1]	-
15	Number of travel lanes required on a one-way street	B/A	B/A	B/A	-	A[2]	-
16	Colored bicycle lane conflict zone	B/A	B/A	B/A	-	B/A[1]	A
17	25 mph posted speed limit	B/A	B/A	B/A	-	-	-

B = measure collected before installation
A = measure collected after installation
B/A = measure collected before-and-after installation

*Incomplete or limited data for some locations or users

[1]Tabulation by University of Minnesota Traffic Observatory
[2]Tabulation by University of Minnesota Humphrey School
[3]Tabulation by Minneapolis Public Works

Seasonal Considerations

Most measures of effectiveness were measured in the summer or fall. The only year-round measure was reported crashes. Although Minneapolis typically observes snow between November and April, substantial accumulation and cold temperatures are concentrated between December and February. Other than reported crashes, this evaluation did not monitor other measures during winter months. Snow can limit the visibility of roadway markings and can alter the operation of the roadway as snow windrows accumulate on the side of the roadway. It is important to note that visibility of roadway markings and windrow accumulation is a general traffic operations issue in Minnesota and is not exclusively a bicycle-related issue. This may be an area to monitor in future evaluation efforts.

Figure 2-1: Snow limits the visibility of a colored crosswalk on Hennepin Avenue South at Groveland Avenue South

Figure 2-2: A large windrow forces parked vehicles to encroach into the bicycle lane on 1st Avenue South

Evaluation Methods

This section provides details on the evaluation methods for each measure of effectiveness. Unique measures or circumstances for each project are discussed in the respective project chapters.

Traffic Volumes

Bicycle and motor vehicle traffic volumes were collected for all projects. Pedestrian traffic volumes were collected for select projects based on available resources. All volumes were collected as part of Public Works' routine traffic count program.

Non-Motorized Traffic

Public Works conducts non-motorized traffic counts during the second full week of September, and make-up counts are conducted in the third or fourth week of September. This observation period captures warm-weather traffic in addition to trips generated by school activities. The count days also align with dates selected by the National Bicycle and Pedestrian Documentation Project, a nationwide effort to collect non-motorized traffic data using a consistent methodology.

Non-motorized counts are typically conducted on Tuesday, Wednesday, or Thursday to capture routine weekday traffic. Counts are conducted from 4:00-6:00 p.m., and a simple extrapolation factor is used to estimate traffic over a 24-hour period, referred to as estimated daily traffic (EDT). Continuous, automated counts are also used to validate the model.

To conduct counts, Public Works uses in-field observations in which trained volunteers manually tabulate the number of bicyclists and pedestrians at an assigned location. At each count location, an imaginary screen line is drawn across a street and includes any sidewalks or paths. All bicyclists and pedestrians crossing that line are counted. It is important to note that changes in EDT presented in this report may be attributed to daily or seasonal variation.

Figure 2-3: A trained volunteer counts a bicyclist as part of Public Works' non-motorized traffic count program

Figure 2-4: Pneumatic tubes installed on the roadway collect motor vehicle counts, class, and speeds as part of Public Work's motorized traffic count program

Motor Vehicle Traffic

Public Works conducts motorized traffic counts from May through October. Counts are conducted on Tuesday, Wednesday, or Thursday to capture routine weekday traffic. Counts are collected over a 48-hour period. The raw counts are averaged and then extrapolated to annual average daily traffic (AADT) using factors provided by MnDOT. To conduct counts, Public Works installs pneumatic tubes across the roadway that detect motor vehicles as they pass.

For some projects, measures of effectiveness were monitored for large motor vehicles. For the purposes of this report, "large motor vehicles" are defined as FHWA Class IV or larger. Class IV and above includes buses, school buses, and all types of trucks. To collect counts of vehicle class, Public Works installs pneumatic tubes that detect motor vehicles as they pass. The tubes are installed in a way that can measure the vehicle wheel base and thus determine motor vehicle class. Motor vehicle class was also documented during the monitoring of user behavior. During user behavior observations, staff manually categorized and tabulated vehicle class according to the FHWA vehicle classification.

For three projects, motor vehicle turning movement counts were conducted. Turning movements are collected by recording video at an intersection and tabulating the movements of motor vehicles. The counts included in this report were collected in either 2011 or 2013 from April through November. Even with applying MnDOT factoring, it is important to note that changes in AADT presented in this report may be attributed to daily or seasonal variation.

Motor Vehicle Speeds

Public Works has the ability to conduct speed studies as part of its routine motor vehicle traffic count program. To collect motor vehicle speeds, Public Works installs pneumatic tubes that detect motor vehicles as they pass. The tubes are installed in a way that can measure the vehicle wheel base and determine motor vehicle speeds. Counts are conducted over a 48-hour period and then averaged.

Reported Crashes

Information about crashes is collected through reported crash records from the Minnesota Department of Public Safety (DPS). The Minneapolis Public Works Department receives copies of DPS accident reports from the Minneapolis Police Department and the Minneapolis Park Police. Public Works records select crash attributes from DPS accident reports in a crash database. Select attributes available for each crash are:

- Date and time
- Intersection and distance from intersection
- Weather and road surface
- Injury severity
- Pedestrian, bicyclist, and motorist contributing factor(s)
- Pedestrian, bicyclist, and motorist pre-crash maneuver(s)

For most projects, crash data is presented as a summary of three-year before-and-after crashes. For the experiments, FHWA requires crash monitoring for three years after installation and for design exceptions, State Aid requires continued monitoring for five years. To fulfill the requirements of State Aid, Public Works will continue to monitor crashes for the full five-year period (through 2016 for SP 141-091-020 and through 2018 for SP 141-091-022).

In this report, the number of crashes by crash type are included for each project location. Further analysis of police reports was conducted to gain a better understanding of the crash circumstances and their relationship to the traffic control device or street design element. For example, a bicycle facility may be installed on a street, but a crash may have occurred 100 feet away on a cross street.

Another consideration for using crash data pertains to the low number of bicycle and pedestrian crashes. Due to the low number of these crash types at a single intersection or along a short project corridor, it is difficult to draw conclusions about changes in safety after a project is installed. For example, if there were three bicycle-related crashes in the three years before installation and two bicycle-related crashes in the three years after installation, it is difficult to conclude that bicycle safety improved based only on a small sample of crash data. For this reason, other measures of effectiveness are important when evaluating bicycle and pedestrian safety at the project locations.

Motor Vehicle Parking Compliance

Motor vehicle parking compliance was evaluated for several projects. Parking lanes on Minneapolis streets without bicycle lanes are typically eight feet wide, but are often wider. Several projects installed parking lanes that were seven feet wide. Public Works was interested in how users operated under this narrower configuration and whether there was encroachment by motor vehicles into the adjacent bicycle lane.

A total of 2,136 parked vehicle observations were conducted across five corridors. Four to five observations were conducted along each corridor by Public Works staff. Most observations were typically conducted during evening hours to capture peak usage. Staff tabulated parked vehicles into three categories: “compliant,” “minor encroachment,” or “major encroachment.” “Compliant” vehicles were parked fully to the right of the inside bicycle lane edge line. Vehicles with “minor encroachment” were parked with at least one tire on the inside bicycle lane edge line. Vehicles encroaching further into the bicycle lane were recorded as “major encroachment.”

Figure 2-5: Example of compliantly parked vehicles

Figure 2-6: Example of partially compliant parked vehicle

Figure 2-7: Example of non-compliant parked vehicle

User Behavior Monitored

User behavior was monitored for most project installations using multiple methods. Monitoring user behavior allowed staff to understand how users operate at the project location and how they interact with other users. Behaviors tabulated depended on the type of project and the available time and resources needed to tabulate the specific behavior.

<u>Observations</u>

User behavior was monitored before-and-after installation for nine projects and after installation for five projects. User behavior was not monitored before or after installation for the Bloomington Avenue South project (Chapter 9) and 15th Avenue Southeast project (Chapter 17). Most behavior was monitored by recording events with video cameras. The cameras were installed at the project location using a contractor or by Public Works staff. For the 1st Avenue South project (Chapter 15), in-field observations were conducted by Public Works staff.

<u>Processing and Tabulation</u>

Video for each project was processed and tabulated in one of three ways:

- For 10 of the projects, Public Works worked with the Minnesota Traffic Observatory (MTO) at the University of Minnesota Civil Engineering Department. The work was conducted and supervised by Dr. John Hourdos. Video processing and tabulation was conducted by MTO student staff and periodically cross checked by Dr. Hourdos or an MTO manager.
- For the Como Ave SE project (Chapter 11), Public Works worked with Dr. Greg Lindsey at the Humphrey School of Public Affairs at the University of Minnesota. The video processing and tabulation was performed by Dr. Lindsey's students as part of course work under 4290/5290 *Practicum in Non-Motorized Transportation* in the Summer of 2011 and 2012. The 2011 class tabulated before behavior and the 2012 class tabulated after behavior. Due to minor discrepancies in tabulation between the two efforts only the after results are published in this report.
- For the 24th Street East project (Chapter 10), video processing and tabulation was performed by Public Works staff.

Figure 2-8: A contractor setting up a camera at the colored crosswalk markings

Figure 2-9: A screen capture of recorded video on Bryant Avenue South

Figure 2-10: A screen capture of recorded video on 24th Street East

Figure 2-11: Staff at the Minnesota Traffic Observatory reviewing video from 5th Street Northeast and Broadway Street Northeast

Statistical Analysis

Statistical analysis of the user behavior observations was conducted for most projects. The analysis was performed by Dr. Alireza Ermagun, with the McCormick School of Engineering and Applied Science at Northwestern University. To determine whether the difference between two observations are statistically significant, the analysis calculated a two-proportion z-test and chi-squared test. The two tests aimed to understand whether the traffic control devices and street design elements have an effect on user behavior.

The two-proportion z-test provides an indication of how the bicycle traffic control devices and street design elements effect each user behavior separately. However, it does not necessarily capture behaviors that are interdependent. To alleviate this concern to the extent possible, a chi-squared test was also used to understand if there is a statistically significant relationship between the projects and the general behavior of users. Unlike the two-proportion z-test, the chi-squared test examines the effects of the bicycle traffic control devices on user behaviors, while considering all user behaviors together.

User Feedback

To gain an understanding of user experience and comprehension of the projects, user feedback was solicited through intercept surveys or Minneapolis 311 signs.

Minneapolis 311 Signs

At three project locations, signs were installed in September and October of 2012 encouraging users to provide feedback about the projects. The signs encouraged users to call Minneapolis 311 to provide feedback. Minneapolis 311 operators recorded customer feedback and provided them to Public Works staff.

Figure 2-12: An intercept survey sign on 15th Avenue Southeast placed in advance of a survey card distribution location

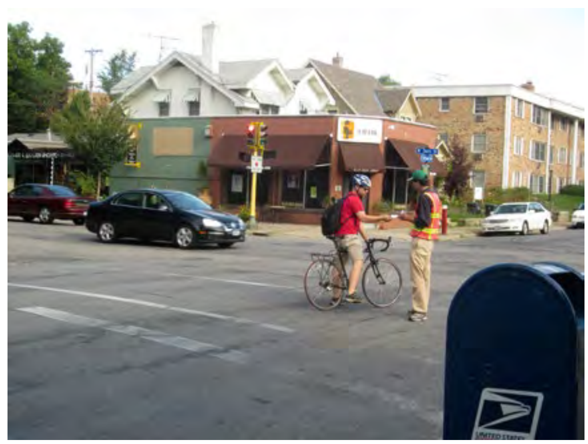


Figure 2-13: Public Works staff hand a survey card to a bicyclist on Bryant Avenue South at 36th Street West

Figure 2-14: A survey card placed on a parked vehicle along 14th Street East

Figure 2-15: A sign installed at 5th Street Northeast and Broadway Street Northeast encouraging users to provide feedback

Intercept Surveys

Intercept surveys were conducted in August of 2012, approximately one year after the projects were installed. Public Works recruited people to take the bicyclist and pedestrian surveys in the field. Public Works staff handed out survey cards to users at project locations. For the motorist survey, staff placed survey cards on the windshield of parked vehicles along project corridors. The cards contained a link to an online survey. Printed versions of the bicyclist and pedestrian surveys and pre-addressed and paid postage return envelopes were available upon request. Due to the nature of survey distribution, printed surveys were not available for the motorist survey. As an incentive to take the survey, participants could enter to win one of three 50 dollar gift cards to a local grocery store. This incentive was prominently printed on the survey cards. All survey materials were in English, although the contact information was included in Hmong, Somali, and Spanish for participants wishing to take the survey in a non-English language.

For the bicyclist and pedestrian survey, most distribution took place on weekdays, although some locations included weekend distribution. Staff were stationed at signalized intersections at or near each project where many users were likely to stop. An attempt was made to distribute a survey card to any bicyclist or pedestrian that came to a complete stop and did not pose a safety issue to the user or the staff person distributing cards. At most distribution locations advanced signs were temporarily installed, alerting approaching users that a bicyclist and/or pedestrian survey was being conducted. As a user approached, staff would typically say, "Hi, I'm from the City. Would you like to take an online survey about this new project along [Street A]? You could enter to win a 50 dollar gift card to [Store A]." If someone refused the card, a second attempt was made by offering a paper version with a pre-addressed envelope. If the user refused a second time, a third attempt was not made. Over 60 hours was spent distributing 649 survey cards and paper surveys.

For the motorist survey, most distribution occurred on weeknights when parking demand was highest. For the motorist survey, staff placed survey cards on the windshield of parked vehicles along project corridors. A total of 1,325 survey cards were distributed over five days.

Valid responses across all survey types ranged from four to 112, with an average of 35 responses. FHWA guidance recommends a minimum of 100 survey responses for user surveys, although that depends on the context of the project and other statistical factors. Based on this guidance, no survey responses for an individual project met the minimum recommended sample sizes for FHWA except the Bryant Avenue South motorist survey. The results are still reported for informational purposes.

Table 2-3: Survey response rates by project

Chapter	Project	Survey	Survey Cards Distributed	Paper Surveys Distributed	Valid Responses	Response Rate
3	Colored conflict zones (7th S N)	Bicyclist	32	0	4	13%
4	Colored crosswalks (Oak Grove St W)	Bicyclist	67	1	19	28%
		Pedestrian	65	0	9	14%
5	Enhanced shared lane markings (LaSalle Ave S)	Bicyclist	110	2	34	30%
		Motorist	359	-	44	12%
6	Intermittent colored background for shared lane markings (Bryant Ave S)	Bicyclist	92	1	37	40%
		Motorist	685	-	112	16%
7	Advisory bicycle lanes (Grant St E/14th St E)	Bicyclist	41	0	22	54%
		Motorist	281	-	12	4%
8	Bicycle Signal (5th St NE at Broadway St NE)	Bicyclist	70	1	27	38%
16	Colored conflict zones (15th Ave SE)	Bicyclist	166	1	65	39%
	Total	-	1,968	6	385	20%

The online surveys contained 14 to 26 questions and were intended to take approximately 10 minutes to complete. Each survey opened with a set of questions about the trip purpose and trip frequency along the project location. Some surveys included photos of specific project elements, such as colored conflict markings, and asked respondents to state the purpose(s) of the marking. In order to not influence responses, the question was open-ended, and participants typed or wrote into a blank field. Each survey included an open-ended question asking for general feedback. For each project, the "intended purpose" question and the "general feedback" question provided the most insight into user feedback, perceived safety, and comprehension of the facility. The survey concluded with a short set of optional demographic questions asking the participant to self-report their sex and age. Race, ethnicity, or household income was not collected.

For the pedestrian, bicyclist, and motorist surveys, approximately half the participants were male and half were female. This share was generally close to the Minneapolis male/female population share, as captured by the American Community Survey 2012 Five-year estimate.

Table 2-4: Survey participant self-reported sex for all surveys

Sex	Pedestrian		Bicyclist		Motorist		Total		Minneapolis	
	Count	%	Count	%	Count	%	Count	%	Count	%
Male	4	44%	77	46%	107	51%	188	49%	193,360	50%
Female	5	56%	79	47%	95	46%	179	46%	191,663	50%
Other	0	0%	1	1%	3	1%	4	1%	-	-
Declined	0	0%	11	7%	3	1%	14	4%	-	-
Total	9	100%	168	100%	208	100%	385	100%	385,023	100%

Participants self-reported their age. For all the pedestrian, bicyclist, and motorist surveys, the most frequent cohort was age 25-34. When compared to the Minneapolis population data from American Community Survey 2012 Five-Year Estimate, the 25-34 age cohort was substantially overrepresented and the 0-17 age cohort was substantially underrepresented. The lack of participants younger than 18 is excepted for the motorist survey since the legal driving age in Minnesota is 16.

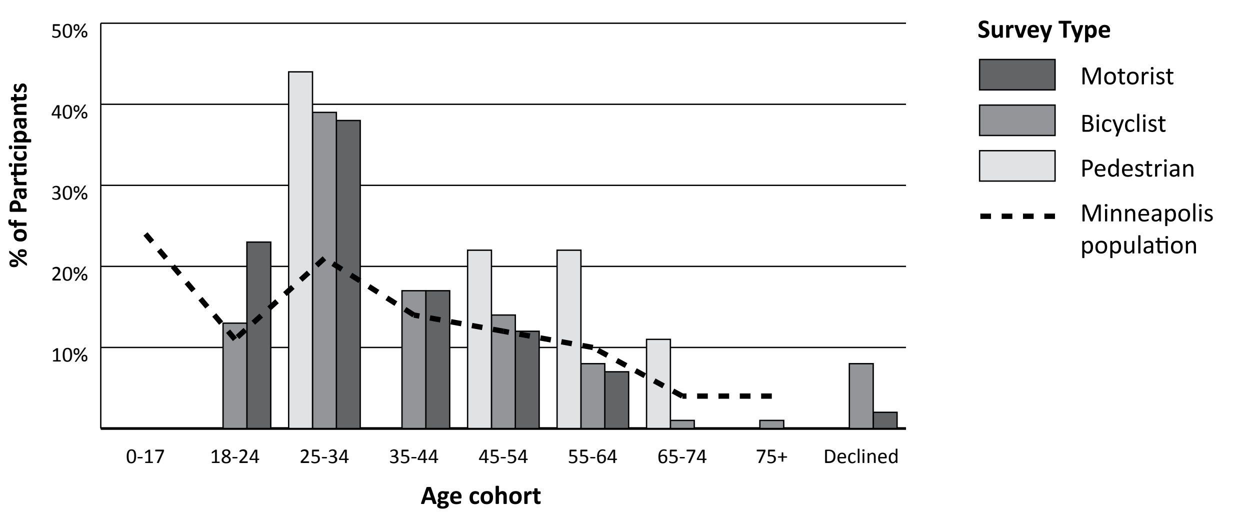


Figure 2-16: Survey participant self-reported age for all surveys

Participants self-reported their home address zip code. In total, 91 percent of participants were Minneapolis residents and the remainder lived outside of Minneapolis. The home address zip code for each participant aligned closely with the location of each project, although some projects and user surveys had wider geographical distribution than other projects and user surveys.

Legend

Percentage of survey participants

- 0-5%
- 5-10%
- 10-25%
- 25% or more
- Project location (corridor)
- Project location (intersection)
- Zip code boundary

Note: Map of colored conflict zone bicyclist survey (7th Street N) and advisory bicycle lane motorist survey not shown due to low response rate

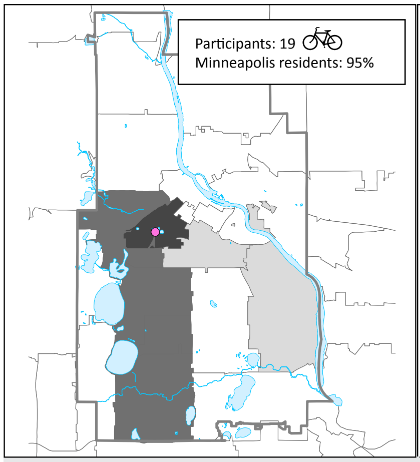


Figure 2-17: Colored crosswalk bicyclist survey participants

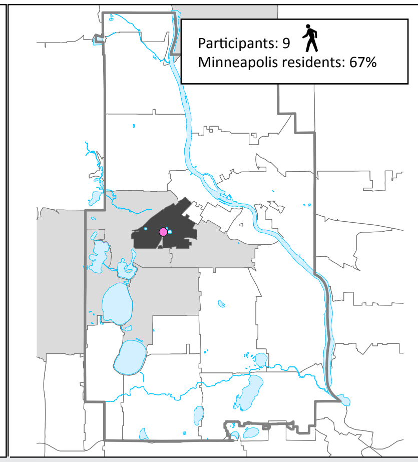


Figure 2-18: Colored crosswalk pedestrian survey participants

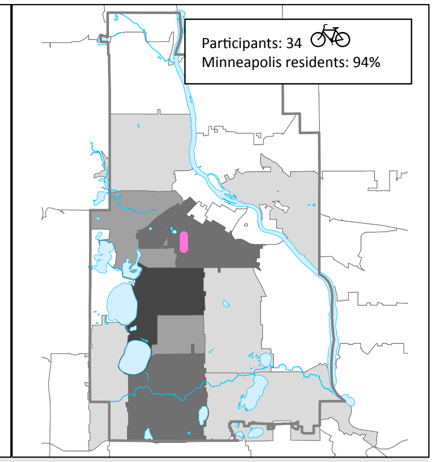


Figure 2-19: Enhanced shared lane markings bicyclist survey participants

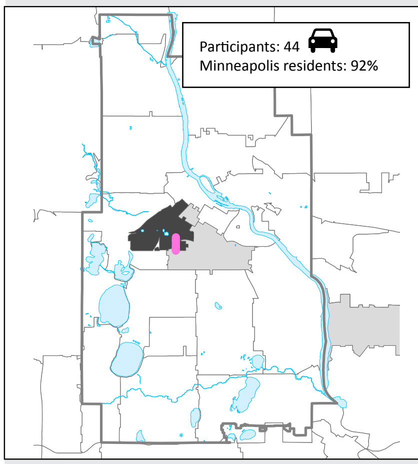


Figure 2-20: Enhanced shared lane markings motorist survey participants

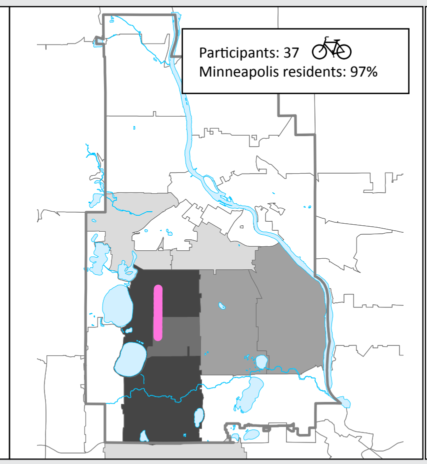


Figure 2-21: Intermittent colored background for shared lane markings bicyclist survey participants

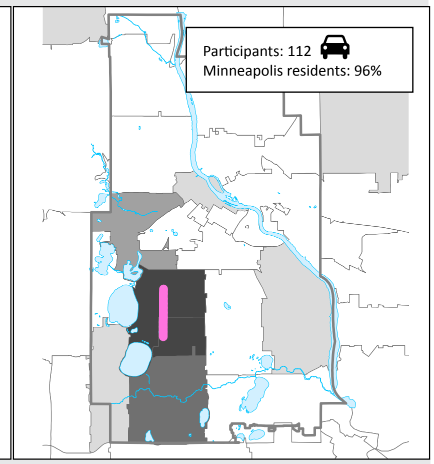


Figure 2-22: Intermittent colored background for shared lane markings motorist survey participants

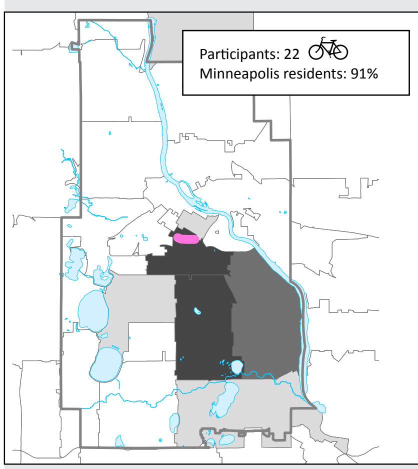


Figure 2-23: Advisory bicycle lane bicyclist survey participants

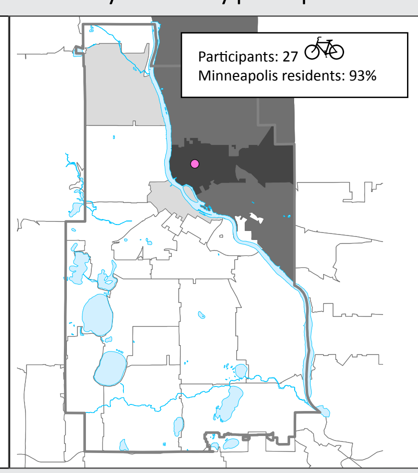


Figure 2-24: Bicycle signal indication bicyclist survey participants

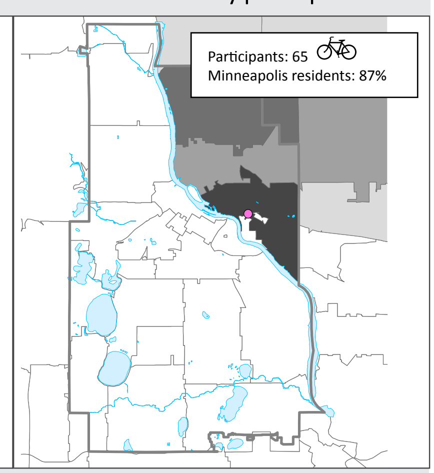


Figure 2-25: Colored conflict zone (15th Avenue) bicyclist survey participants

For the bicyclist survey, participants were asked “Which statement best describes your comfort level when bicycling on city streets?” This question aimed to understand the respondent’s confidence riding a bicycle in an urban context. The majority of participants stated that they were comfortable riding in traffic, although they prefer streets with bicycle facilities such as bicycle lanes. Fewer participants were confident riding in traffic without a bicycle facility or they were only confident riding on quiet streets or on separated bicycle facilities. Due to the nature of an intercept survey, it is important to note that the survey only solicited feedback from existing users of the Minneapolis bicycle network. The survey was not designed or intended for participants who do not currently use the bicycle network.

Table 2-5: Survey participant self-reported bicycle riding comfort level

Which statement best describes your comfort level when bicycling on city streets?	Valid Responses	Response Rate
I am confident riding in traffic regardless if there is a bicycle facility such as a bike lane	23	11%
I am comfortable riding in traffic, although I prefer streets with bicycle facilities such as bike lanes	144	69%
I am only comfortable riding on streets with bicycle facilities such as bike lanes	19	9%
I am comfortable riding on bicycle paths or on quiet streets, but avoid riding on busier streets	17	8%
Other	3	1%
Declined	2	1%
Total	208	100%

Chapter 3

Colored Bicycle Lane Conflict Zone

Project Locations:

7th Street North at 6th Avenue North
7th Street North at East Lyndale Avenue North
15th Avenue Southeast at Rollins Avenue Southeast
16th Street East at 3rd Avenue South (eastbound)
16th Street East at 3rd Avenue South (westbound)
16th Street East at I-94 Westbound On-Ramp
1st Avenue South at 28th Street East
Blaisdell Avenue South at Lake Street West

This chapter pertains to the eight colored conflict zones approved by FHWA for experimentation in 2010. The City of Minneapolis installed colored conflict zones at three additional locations following the 2011 Interim Approval for the Optional Use of Green Colored Pavement for Bicycle Lanes (IA-14). That project evaluation is documented in Chapter 16.

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

A colored bicycle lane conflict zone is a variation of a conventional bicycle lane marking. Conventional bicycle lanes are typically defined by solid longitudinal lines. At bus stop locations, turn lanes, and intersection approaches, the bicycle lane longitudinal markings are typically dotted to allow motor vehicle traffic to maneuver across the bicycle lane to access the curb or prepare for a turn. Longitudinal markings can be extended through intersections to provide guidance and raise additional awareness to road users.

The 2009 edition of the MMUTCD states that "a dotted line provides guidance or warning of a downstream change in lane function." This message is consistent with Minnesota State Statute 169.429, which states that motorists are required to yield to approaching bicycle traffic before merging across a bicycle lane. For bicycle lane markings, the MMUTCD states that "dotted edge line extensions may be placed through intersections or major driveways." Dotted lines are intended to raise awareness for bicyclists and motorists to potential conflict areas, reinforce that through bicyclists have priority over turning vehicles or vehicles entering the roadway, and provide guidance to bicyclists through the intersection in a straight and direct path.

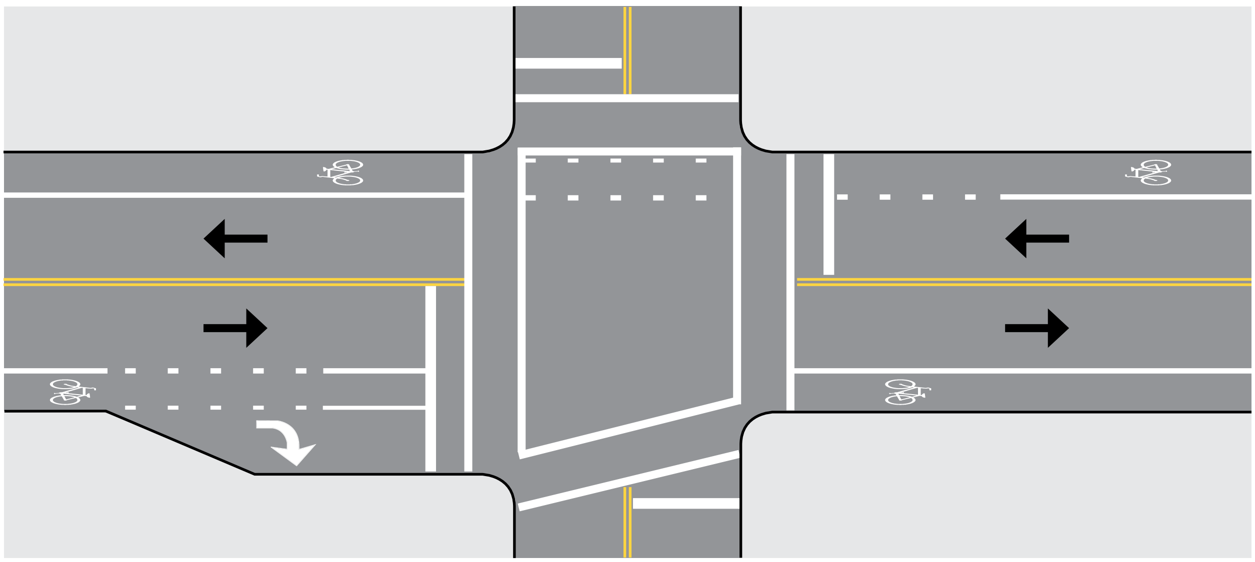


Figure 3-1: Conventional bicycle lane markings at an intersection and dedicated turn lane

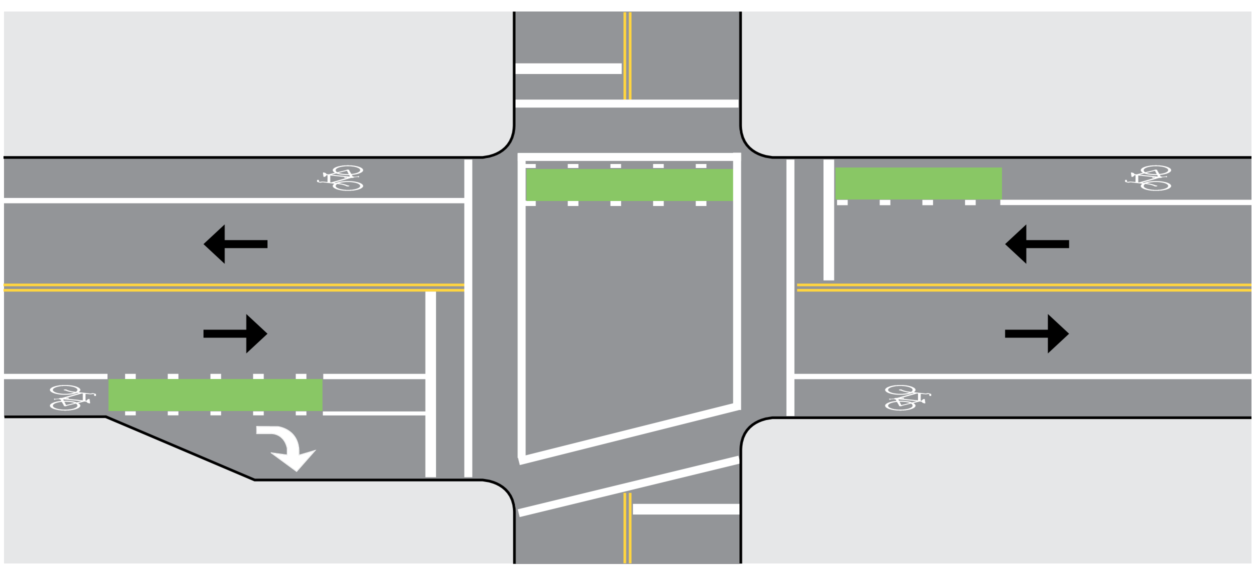


Figure 3-2: Colored bicycle lane conflict zones at an intersection and dedicated turn lane

A colored bicycle lane conflict zone modifies the conventional dotted bicycle lane marking to include a green colored background. The green color is intended to reinforce the message of the dotted line and the fact that motorists are required to yield to bicyclists riding in the bicycle lane. The green color is also intended to increase awareness to both bicyclists and motorists that this portion of roadway requires a higher degree of care due to the nature of interactions and merging.

At the time of planning and project approvals, colored bicycle lane conflict zones were considered by FHWA to be experimental. In April 2011, FHWA issued Interim Approval for the Optional Use of Green Colored Pavement for Bicycle Lanes (IA-14). The applications of the installed projects are consistent with the interim approval. To date, colored bicycle lane conflict zones and colored bicycle lane applications are used extensively in many U.S. cities.

Project Location

Eight project locations were installed throughout the city and were open for use in October, 2011.

The green color was installed by applying latex paint with no glass beads to the roadway surface. With the original installation, the City of Minneapolis selected a dark green color. The green was repainted in 2012 with a brighter color. The colored background has not been repainted since 2012.

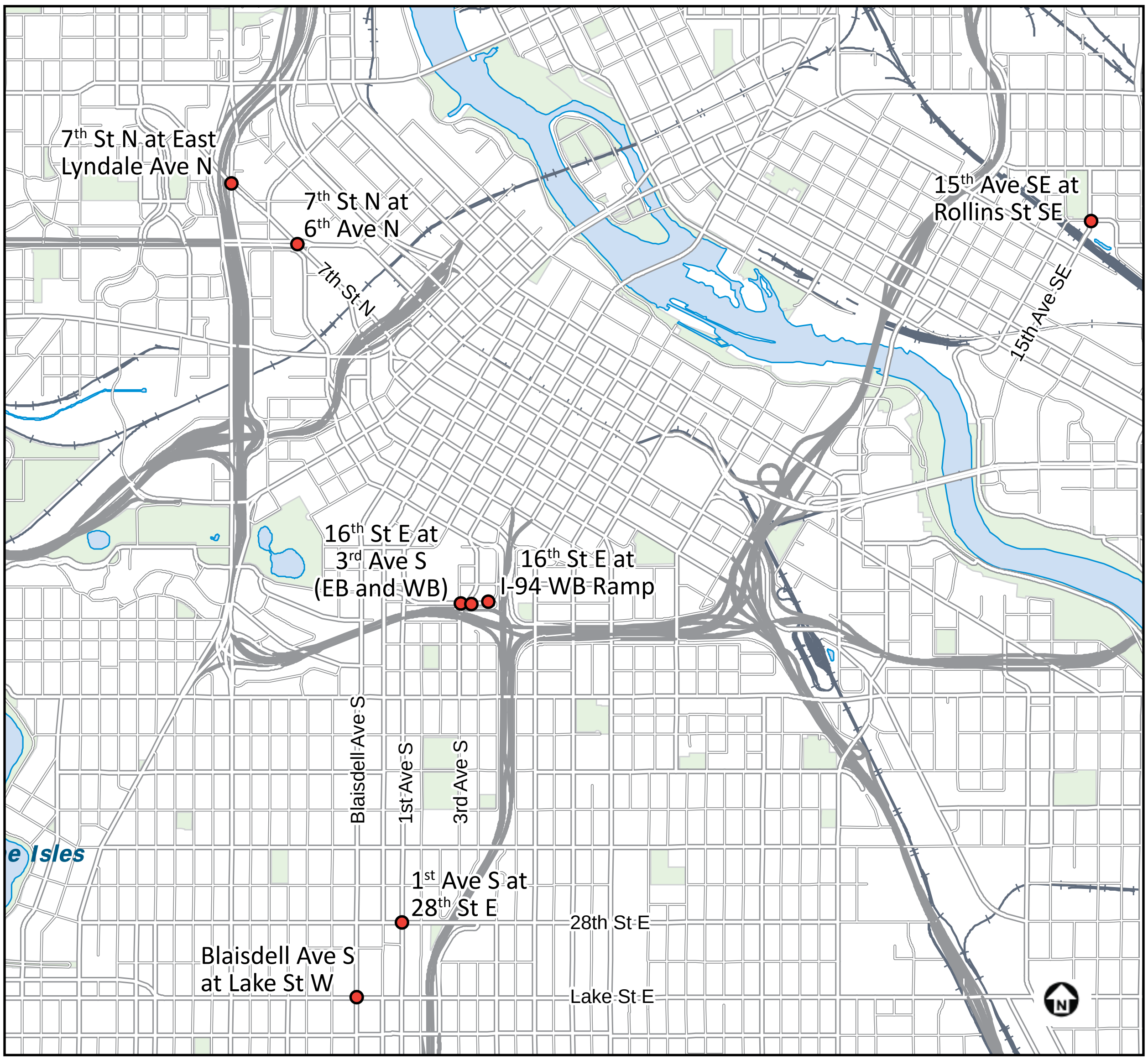


Figure 3-3: Project locations

7th Street North at East Lyndale Avenue North

This location is at a dedicated right turn lane northwest of downtown Minneapolis. The right turn develops in advance of a signalized intersection and provides access to East Lyndale Avenue North and westbound I-94. The westbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into and cross the bicycle lane. Seventh Street North is typically a four lane divided roadway with an AADT of 10,200. Peak hour turns across the bicycle are 102 in the AM and 282 in the PM. Daily bicycle traffic prior to installation ranged between 70 and 100. There is a moderate uphill grade in the direction of travel. The bicycle lane was striped two months prior to the green being installed.

Figure 3-4: 7th Street North at East Lyndale Avenue North facing northwest after installation

7th Street North at 6th Avenue North

This location is at a free right turn lane northwest of downtown Minneapolis. The turn lane is in advance of a signalized intersection and provides access to eastbound 6th Avenue North. The westbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into and cross the bicycle lane. Seventh Street North is typically a four lane divided roadway with an AADT of 10,200. Peak hour turns across the bicycle lane are 41 in the AM and 48 in the PM. Daily bicycle traffic prior to installation ranged between 70 and 100. The bicycle lane was striped two months prior to the green being installed.

Figure 3-5: 7th Street North at 6th Avenue North facing southeast after installation

15th Avenue Southeast at Rollins Avenue Southeast

This treatment is located at a dedicated right turn lane in the Como neighborhood near the University of Minnesota. The right turn lane develops in advance of a signalized intersection and provides access to eastbound Rollins Avenue Southeast. The northbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into and cross the bicycle lane. 15th Avenue Southeast is a two-lane roadway with an AADT of 10,300. Peak hour turns across the bicycle lane are 223 in the AM and 335 in the PM. Daily bicycle traffic prior to installation was 3,580. There is a moderate uphill grade in the direction of travel. The bicycle lane on 15th Avenue Southeast has been in place since 1975, although it terminated just south of Rollins Avenue Southeast.

Figure 3-6: 15th Avenue Southeast at Rollins Avenue Southeast facing north after installation

16th Street East at 3rd Avenue South (eastbound)

This location is at a free right turn south of downtown Minneapolis. The turn lane is in advance of a signalized intersection and provides access to southbound 3rd Avenue South. The eastbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into and cross the bicycle lane. Sixteenth Street East is a two-lane roadway with AADTs ranging from 4,600 to 4,900. Peak hour turns across the bicycle lane are 34 in the AM and 36 in the PM. Daily bicycle traffic prior to installation was 470. The bicycle lane was striped two months prior to the green being installed.

Figure 3-7: 16th Street East at 3rd Avenue South (eastbound) facing east after installation

16th Street East at 3rd Avenue South (westbound)

This treatment is located at a free right turn south of downtown Minneapolis. The turn lane is in advance of a signalized intersection and provides access to northbound 3rd Avenue South. The eastbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into and cross the bicycle lane. Sixteenth Street East is a two-lane roadway with AADTs ranging from 4,600 to 4,900. Peak hour turns across the bicycle lane are 23 in the AM and 20 in the PM. Daily bicycle traffic prior to installation was 470. The bicycle lane was striped two months prior to the green being installed.

Figure 3-8: 16th Street East at 3rd Avenue South (westbound) facing west after installation

16th Street East at I-94 Westbound On-Ramp

This treatment is located at a dedicated right turn lane south of downtown Minneapolis. The right turn lane develops in advance of a signalized intersection and provides access to the I-94 westbound on-ramp. The eastbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into the right turn lane. Sixteenth Street East is a two-lane roadway with AADTs ranging from 4,600 to 4,900. Peak hour turns across the bicycle lane are 128 in the AM and 399 in the PM. Daily bicycle traffic prior to installation was 470. The bicycle lane was striped two months prior to the green being installed.

Figure 3-9: 16th Street East at I-94 westbound on-ramp facing east after installation

1st Avenue South at 28th Street East

This location is at a dedicated right turn lane in south Minneapolis. The right turn lane develops in advance of a signalized intersection and provides access to eastbound 28th Street East. The northbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into the right turn lane. First Avenue South is a one-way, two-lane roadway with an AADT of 7,800. Peak hour turns across the bicycle lane are 114 in the AM and 122 in the PM. Daily bicycle traffic prior to installation was 180. North of 28th Street East, 1st Avenue South becomes a two-way street. The bicycle lane was striped two months prior to the green being installed.

Figure 3-10: 1st Avenue South at 28th Street East facing north after installation

Blaisdell Avenue South at Lake Street West

This location is at a dedicated right turn lane in south Minneapolis. The right turn lane develops in advance of a signalized intersection and provides access to Lake Street West. The southbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into the right turn lane. Blaisdell Avenue South is a one-way, two-lane roadway with an AADT of 7,000. Peak hour turns across the bicycle lane are 31 in the AM and 234 in the PM. Daily bicycle traffic prior to installation was 320. The bicycle lane was striped two months prior to the green being installed.

Figure 3-11: Blaisdell Avenue South at Lake Street West facing south after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of the colored conflict zone locations, the measures of effectiveness are traffic volumes, reported crashes, user behavior, and user feedback. All measures include before-and-after monitoring, although before-and-after traffic volumes are not available for all locations.

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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Results

Traffic Volumes

Bicycle and motor vehicle traffic varied across each location before-and-after project installation. Bicycle traffic volumes generally increased, although before-and-after motor vehicle data was not available for all locations.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 3-1: Daily traffic volumes

Type	Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	7th St N at E Lyndale Ave N	70	100	90	130	170	140
	7th St N at 6th Ave N	70	100	90	130	170	140
	15th Ave SE at Rollins Ave SE	3,580	-	-	3,860	-	-
	16th St E at 3rd Ave S (EB)	470	-	-	-	590	-
	16th St E at 3rd Ave S (WB)	470	-	-	-	590	-
	16th St E at I-94 WB On-ramp	470	-	-	-	590	-
	1st Ave S at 28th St E	180	-	-	-	430	-
	Blaisdell Ave S at Lake St W	-	-	320	-	-	330
Motor Vehicle (AADT)	7th St N at E Lyndale Ave B	10,200	-	-	-	-	-
	7th St N at 6th Ave N	-	12,900	9,100	-	-	-
	15th Ave SE at Rollins Ave SE	10,300	-	-	-	9,400	-
	16th St E at 3rd Ave S (EB)	-	4,900	4,600	-	5,540	5,500
	16th St E at 3rd Ave S (WB)	-	4,900	4,600	-	5,540	5,500
	16th St E at I-94 WB On-ramp	-	4,900	4,600	-	5,540	5,500
	1st Ave S at 28th St E	-	-	7,800	-	-	-
	Blaisdell Ave S at Lake St W	-	-	7,000	-	-	-

Total motor vehicle traffic volumes (AADT) provide context for the roadway. Peak hour motor vehicle turning movement counts provide further detail for the level of traffic crossing the bicycle lane and potentially interacting with bicyclists. All turning movement counts were collected in 2011 or 2013.

Table 3-2: Peak hour turning movement volumes across bicycle lane

Type	Location	Movement	Peak Hour Turning Volumes Across Bicycle Lane	
			AM	PM
Motor Vehicle (Turning Movements)	7th St N at E Lyndale Ave N	NB Right Turn	102	282
	7th St N at 6th Ave N	NB Right Turn	41	48
	15th Ave SE at Rollins Ave SE	NB Right Turn	223	335
	16th St E at 3rd Ave S (EB)	EB Right Turn	34	36
	16th St E at 3rd Ave S (WB)	WB Right Turn	23	20
	16th St E at I-94 WB On-ramp	EB Right Turn	128	399
	1st Ave S at 28th St E	NB Right Turn	114	122
	Blaisdell Ave S at Lake St W	SB Right Turn	31	234

Reported Crashes

Changes in crashes varied across each project location. During the three years before installation, there were 110 reported crashes across all eight locations (seven intersections), including 99 motor vehicle crashes, five bicycle crashes, and six pedestrian crashes. During the three years after installation, there were 112 reported crashes, including 100 motor vehicle crashes, three bicycle crashes, and nine pedestrian crashes.

Table 3-3: Reported crashes

Location	Crash Type	Before	After	Change
7th St N at E Lyndale Avenue N	Motor Vehicle	12	15	3
	Bicycle	0	1	1
	Pedestrian	0	0	0
	Total	12	16	4
7th St N at 6th Avenue N	Motor Vehicle	16	13	-3
	Bicycle	1	0	-1
	Pedestrian	1	0	-1
	Total	18	13	-5
15th Avenue SE at Rollins Avenue SE	Motor Vehicle	4	4	0
	Bicycle	0	0	0
	Pedestrian	0	0	0
	Total	4	4	0
16th St E at 3rd Avenue S (EB & WB)	Motor Vehicle	5	12	7
	Bicycle	0	0	0
	Pedestrian	1	2	1
	Total	6	14	8
16th St E at I-94 WB On-ramp	Motor Vehicle	2	3	1
	Bicycle	0	0	0
	Pedestrian	0	0	0
	Total	2	3	1
1st Avenue S at 28th St E	Motor Vehicle	29	22	-7
	Bicycle	0	0	0
	Pedestrian	1	0	-1
	Total	30	22	-8
Blaisdell Avenue S at Lake St W	Motor Vehicle	31	31	0
	Bicycle	4	2	-2
	Pedestrian	3	7	4
	Total	38	40	2
All locations	Motor Vehicle	99	100	1
	Bicycle	5	3	-2
	Pedestrian	6	9	3
	Total	110	112	2

After the projects were installed, there were three bicycle crashes across the eight locations. One occurred at the intersection of 7th Street North and East Lyndale Avenue North. The crash occurred on East Lyndale Avenue North and involved a northbound through motorist and northbound bicyclist making a left turn. The bicyclist was cited for “improper turning”. The two other crashes occurred at the Blaisdell Avenue South and Lake Street West location. One involved a southbound motorist on Blaisdell Avenue South and Eastbound bicyclist on Lake Street West. The bicyclist was cited for “disregarding a traffic control device." The other crash also involved a southbound motorist on Blaisdell Avenue South and Eastbound bicyclist on Lake Street West. The motorist was cited for being "inattentive or distracted."

User Behavior Monitored

User behavior was evaluated before-and-after installation by recording video at the 7th Street North at East Lyndale Avenue North location and tabulating events. The video was recorded with a NW facing camera located on 7th Street North between 10th Avenue North and East Lyndale Avenue North. Events tabulated include bicyclists riding location, motorist merging location, and bicyclist-motorist interactions. User behavior was not monitored at other colored conflict zone locations included this chapter.

Before video was collected in July of 2011 and after video was collected in August of 2012. For bicyclist behavior, 75 hours of before video was processed over five days (6:00 a.m. to 10:00 p.m.) and 30 hours of after video was processed over two days (6:00 a.m. to 10:00 p.m.). The motor vehicle observations were collected over those same periods, but observations were only processed and tabulated for one day.

Figure 3-12: Screen capture of before video of 7th Street North between 10th Avenue North and East Lyndale Avenue North

Figure 3-13: Screen capture of after video of 7th Street North between 10th Avenue North and East Lyndale Avenue North

<u>Bicyclist Behavior</u>

Changes in bicyclist's riding location were observed after the project was installed. Before installation, one percent of bicyclists rode in the travel lane, 42 percent rode in the bicycle lane, 10 percent rode in the right turn lane, 30 percent rode on the sidewalk, and 18 percent rode against traffic in the street. After installation, two percent of bicyclists rode in the travel lane, 48 percent rode in the bicycle lane, nine percent rode in the right turn lane, 25 percent rode on the sidewalk, and 16 percent rode against traffic in the street.

The results of the two-proportion z-test show the colored bicycle lane conflict zone only had a significant effect on the location of bicyclists riding in the bicycle lane at the 90% confidence interval. However, the chi-squared test shows there is not a significant relationship between the colored bicycle lane conflict zone and bicyclist riding location.

Table 3-4: Bicyclist location

Location of Bicyclists	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Travel lane	5	1%	4	2%	0.486	-0.6966
Bicycle Lane	220	42%	127	48%	0.108	-1.6077
Right turn lane	51	10%	25	9%	0.9	0.126
Sidewalk	157	30%	67	25%	0.174	1.3595
Riding against traffic in street	94	18%	43	16%	0.557	0.5878
Total	527	100%	266	100%	-	-

Chi-Square = 3.56, P-value = 0.46881405

Motorist Behavior

Right turning motorist merging location was tabulated and the presence of a bicyclist was noted.

When a bicyclist was present, no significant change in merge location was observed after the project was installed. Before installation, one percent of motorists merged before the conflict area, 46 percent merged over the conflict area, and 53 percent merged after the conflict area. After installation, no motorists were observed merging before the conflict area, 48 percent merged over the conflict area, and 52 percent merged after the conflict area.

Table 3-5: Motorist merge location when bicyclist is present

Motorist Merge Location	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Before conflict area	1	1%	0	0%	0.413	0.8192
Over conflict area	41	46%	29	48%	0.738	-0.3341
After conflict area	48	53%	31	52%	0.841	0.2003
Total	90	100%	60	100%	-	-

Chi-Square = 0.745, P-value = 0.68901

When no bicyclist was present, a significant change in merge location was observed after the project was installed. Before installation, 22 percent of motorists merged before the conflict area, 54 percent merged over the conflict area, and 25 percent merged after the conflict area. After installation, nine percent merged before the conflict area, 66 percent merged over the conflict area, and 26 percent merged after the conflict area.

The results of the two-proportion z-test show the colored bicycle lane conflict zone had a significant effect on the motorist merge location before conflict area and over conflict area. However, there was not a significant change in the motorist merge location after conflict area. The results of the chi-squared test show there is a significant relationship between the colored bicycle lane conflict zone and the motorist merge location at the 99% confidence interval.

Table 3-6: Motorist merge location when no bicyclist is present

Motorist Merge Location	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Before conflict area	510	22%	234	9%	0	12.6693
Over conflict area	1,271	54%	1,737	66%	0	-8.5202
After conflict area	580	25%	675	26%	0.441	-0.7697
Total	2,361	100%	2,646	100%	-	-

Chi-Square = 166.087, P-value < 0.00001

Bicyclist-Motorist Interactions

Bicyclist-motorist interactions changed significantly after the project was installed. Before the project was installed, 39 percent on interactions involved a motorist yielding, none involved a bicyclist yielding, 45 percent were categorized as safe passes, where the motorist provided at least three feet when overtaking the bicyclist, and 16 percent were categorized as a near miss, where one user had to perform an evasive maneuver. After installation, 31 percent of interactions involved a motorist yielding, seven percent involved a bicyclist yielding, 40 percent were categorized as a safe pass, and 21 percent were categorized as a near miss.

The results of the two-proportion z-test show the colored bicycle lane conflict zone only had a significant, although unintended, effect on motorist yielding behavior. However, the results of the chi-squared test show there is a significant relationship between the colored bicycle lane conflict zone and bicyclist-motorist interactions at the 95% confidence interval.

Table 3-7: Bicyclist-motorist interactions

Type of Interaction	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Motorist yield	41	39%	21	31%	0.274	1.0939
Bicyclist yield	0	0%	5	7%	0.005	-2.8196
Safe pass	47	45%	27	40%	0.511	0.6565
Near miss	17	16%	14	21%	0.461	-0.7367
Other	0	0%	1	1%	0.213	-1.2462
Total	105	100%	68	100%	-	-

Chi-Square = 10.725, P-value: 0.02983483

User Feedback

User feedback was solicited through an intercept survey for bicyclists.

Public Works recruited people to take the bicyclist survey in the field. Staff handed out survey cards to bicyclists waiting at a red semaphore at the intersection of 7th St N and 10th Avenue N. A total of 34 survey cards were distributed over an eight-hour period, resulting in only four valid survey responses. The online survey was 15 questions, was intended to take 10 minutes or less to complete, and was available in an online or printed format. See Chapter 2 for additional information about the survey methods.

Table 3-8: Survey response rates

Survey Type	Distributed	Valid Responses	Response Rate
Bicyclist	34	4	13%

Due to the low number of responses, it is difficult to draw conclusions about user feedback. The following responses are provided for informational purposes only.

Survey participants were shown a photo of the colored bicycle lane conflict zone on 7th St N at E Lyndale Avenue N and asked to state the intended purpose of the roadway marking. All four participants provided a relevant response. To not influence responses, the question was opened ended and participants wrote or typed into a blank field.

Table 3-9: Stated purpose of colored bicycle lane conflict zone

Stated Purpose
“To specify a bike lane and alert motorists.”
“Alert motorists of the bicycle lane as they merge into the turn lane and alert cyclists that motorists may be merging across the cycle lane into the turn lane.”
“Clearly shows motorists merging into the off/on ramp that there is a cycle lane there, and serves as a very obvious reminder to check the right blind spot.”
“I honestly have no idea, it's a shade I haven't seen on roads before, either. Maybe a bright reminder of the bike lanes for motorists?”

Survey participants were also asked if they had any general feedback about the recent changes to 7th St North. One of the four participants provided comments relevant to the colored bicycle lane conflict zone.

Table 3-10: Select feedback from bicyclist survey

Select feedback from Bicyclist Survey
“I love that there’s finally more effort to make this a safer St! If I remember correctly, there are a few places with parking along the St; I’d love to see the lanes buffered by that parking. Perhaps instead/also, if there’s room in the [right-of-way] to add a small striped buffer between traffic and the bike lane? Traffic still feels and comes too close.”

Conclusions

The evaluation of colored conflict zones at the eight project locations had inconclusive results. No new operational or safety issues emerged as a result of the installation of colored conflict zones. However, the effectiveness of reducing conflicts between bicyclists and motorists is unclear.

During the three years before installation, there were 110 reported crashes across all eight locations, including 99 motor vehicle crashes, five bicycle crashes, and six pedestrian crashes. During the three years after installation, there were 112 reported crashes, including 100 motor vehicle crashes, three bicycle crashes, and nine pedestrian crashes. According to police reports, none of the reported bicycle crashes that occurred after installation occurred within close proximity to the treatment area. All the crashes occurred under circumstances that do not appear to be a factor of the project design.

Evaluation of user behavior was limited to one of the eight locations. Bicyclist behavior did not change substantially before-and-after installation and changes in motorist behavior were mixed. When a bicyclist was present, there was no change in where motorists merged across the bicycle lane. When no bicyclist was present, there was a significant decrease in motorists merging prior to the marked conflict area. Significant changes were observed with bicyclist-motorist interactions. However, contrary to the intended behavior, the percentage of motorist yielding decreased after installation of the colored conflict zone.

Efforts to solicit user feedback did not result in a high response rate. Of the very limited sample of bicyclist survey participants, most users believed the purpose of the green was to highlight the bicycle lane to motorists and increase awareness of bicycle traffic to motorists.

While the specific value to bicyclists at these particular locations is not clear, Public Works intends to maintain this facility. The positive results of the other colored conflict zone locations (Chapter 16) and peer cities have given staff confidence to maintain these locations and pursue this treatment at other locations. Public Works is installing many more green locations in the City using durable thermoplastic. As of 2016, green colored conflict zones have been installed at over 100 intersections in Minneapolis.

Since this original installation, Public Works has modified the design of the colored conflict zones based on additional observations at the Blaisdell Avenue South and Lake Street west and at the 15th Avenue SE and Rollins Avenue Southeast locations. At these intersections, a large share of drivers were avoiding the solid green and merging after the green. This was also observed to some extent at the 7th Street North and East Lyndale Avenue N location. As a result of these observations, Public Works has modified the solid marking to be a dotted green marking to encourage drivers to merge at the intended location.

Figure 3-14: Example of modified dotted green conflict zone through an intersection

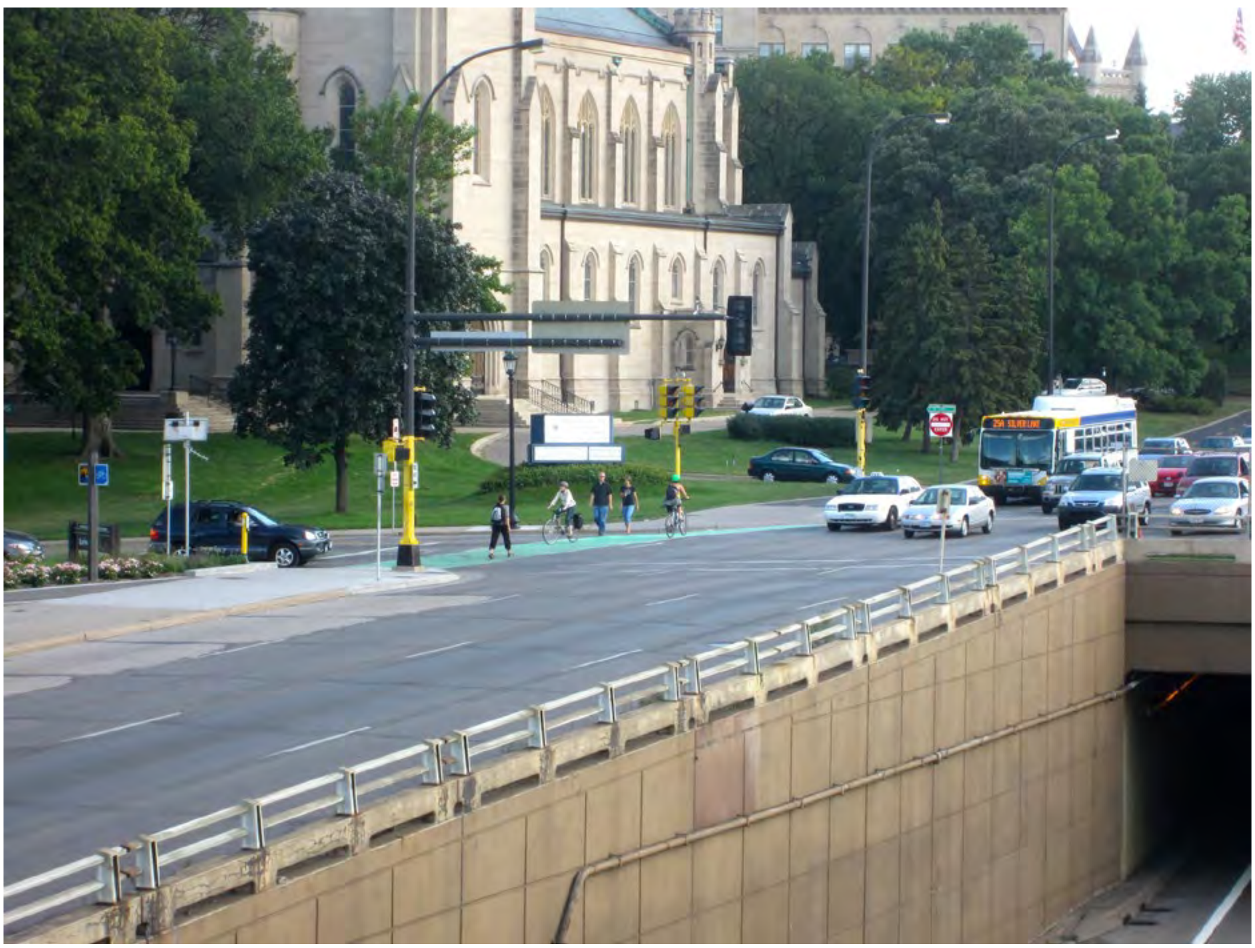
Figure 3-15: Example of modified dotted green conflict zone at a developing right turn lane

Chapter 4

Colored Crosswalk

Project Locations:
Hennepin/Lyndale Avenue South at Groveland Avenue South
Hennepin/Lyndale Avenue South at Oak Grove Street West

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

A marked crosswalk provides guidance for pedestrians who are crossing roadways by defining and delineating paths on approaches to and within signalized intersections, and on approaches to other intersections where traffic stops. A marked crosswalk is also intended to highlight legal crossings to motorists and raise awareness of pedestrians waiting to cross or traveling within the crossing. Per Minnesota State Statute 169.21, motorists are required to stop to yield the right-of-way to pedestrians at marked and unmarked crosswalks.

The 2009 edition of the MMUTCD provides multiple examples of allowable crosswalk marking styles, including standard traverse lines, diagonal, and longitudinal (e.g. continental or zebra). At the time of project implementation, the standard crosswalk design in Minneapolis included transverse lines consisting of two parallel six-inch white lines spaced 10 to 15 feet apart. A 12-inch stop bar was installed five feet upstream. Crosswalks are typically marked at signalized intersection crossings and controlled school patrolled crossings. In Minnesota, at marked and unmarked crosswalks, motorists are required to stop to yield the right-of-way to pedestrians.

A colored crosswalk marking modifies the conventional marking to include solid green color in between the two white transverse lines. The green color is intended to reinforce the message of a marked crosswalk outlined above.

At the time of implementation and the writing of this report, colored crosswalks are allowable per the MMUTCD with certain restrictions. Section 3G.01 of the 2009 MMUTCD states:

> "Colored pavement located between crosswalk lines should not use colors or patterns that degrade the contrast of white crosswalk lines, or that might be mistaken by road users as a traffic control application."

Colored or decorative crosswalks are prevalent in many U.S. cities and the treatment and style is wide ranging. As such, FHWA issued Interpretation Letter 3(09)-24(I) – Application of Colored Pavement to clarify the use of colored markings for traffic control devices.

> "The FHWA's position has always been, and continues to be that subdued-colored aesthetic treatments between the legally marked transverse crosswalk lines are permissible provided that they are devoid of retroreflective properties and that they do not diminish the effectiveness of the legally required white transverse pavement markings used to establish the crosswalk. Examples of acceptable treatments include brick lattice patterns, paving bricks, paving stones, sets, cobbles, or other resources designed to simulate such paving. Acceptable colors for these materials would be red, rust, brown, burgundy, clay, tan or similar earth tone equivalents."

Because the green color of the crosswalk did not necessarily align with the earth tones, the City of Minneapolis determined it was prudent to request to experiment with green.

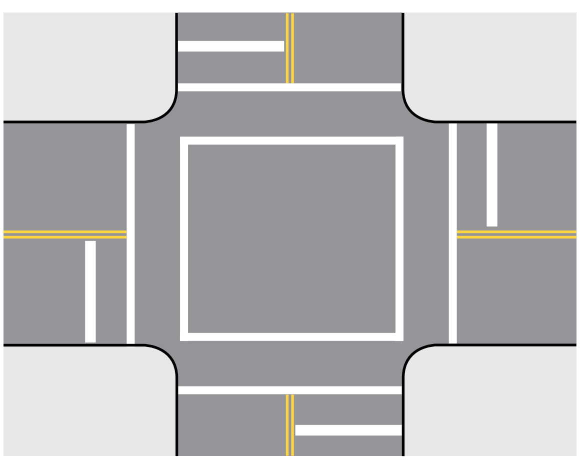


Figure 4-1: Conventional longitudinal crosswalk markings

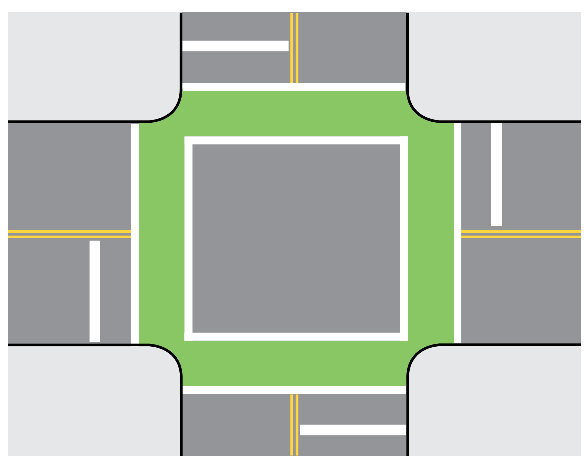


Figure 4-2: Colored longitudinal crosswalks with green markings

Project Location

The project location is located at two intersections along Hennepin Avenue South and Lyndale Avenue South: Oak Grove Street West and Groveland Avenue South. The project is located southwest of downtown where Hennepin Avenue South and Lyndale Avenue South converge for a quarter-mile segment, providing access to downtown, south Minneapolis, and I-94. Surrounding land uses and destinations include high-density residential, churches, regional parks, and the Walker Art Center.

At the project location, Hennepin/Lyndale Avenue South is an eight-lane divided highway. AADTs range between 29,600 and 30,400 vehicles per day. The intersections of Oak Grove Street West and Groveland Ave S are both signalized. On the east side of the roadway is the Loring Bikeway, which provides bicycle and pedestrian connections to downtown and south Minneapolis. The Loring Bikeway consists of a two-way bicycle path with a parallel sidewalk. Due to constrained right-of-way, the Loring Bikeway and sidewalk merge between Oak Grove Street West and Groveland Avenue South to be a shared-use path. Several high frequency transit routes use this segment of Hennepin/Lyndale Avenue South. Metro Transit bus route 25 bus operates on Oak Grove Street West with limited service during peak hour weekdays. No regular transit routes operate on Groveland Avenue South.

The goal of the project was to highlight the existing trail crossings at Oak Grove Street West and Groveland Avenue South. Prior to implementation, standard longitudinal crosswalks were installed at both crossings. Public Works had observed conflicts between pedestrians and bicyclists and motor vehicles. Conflicts involved motorists failing to yield the right-of-way to trail users when turning across the crosswalk. To reduce the documented conflict, an enhanced crosswalk treatment was explored. Due to the high volumes of bicycle traffic at this location, Public Works considered a green treatment to be consistent with other new colored markings in the city. The recommended design treatment was a green colored crosswalk.

The green color was installed by applying latex paint with no glass beads to the roadway surface. With the original installation, the City of Minneapolis selected a green color that was dark and muted in tone. The green was repainted in 2012 with a brighter color. The colored background has not been repainted since 2012.

The project was open for use in October, 2011.

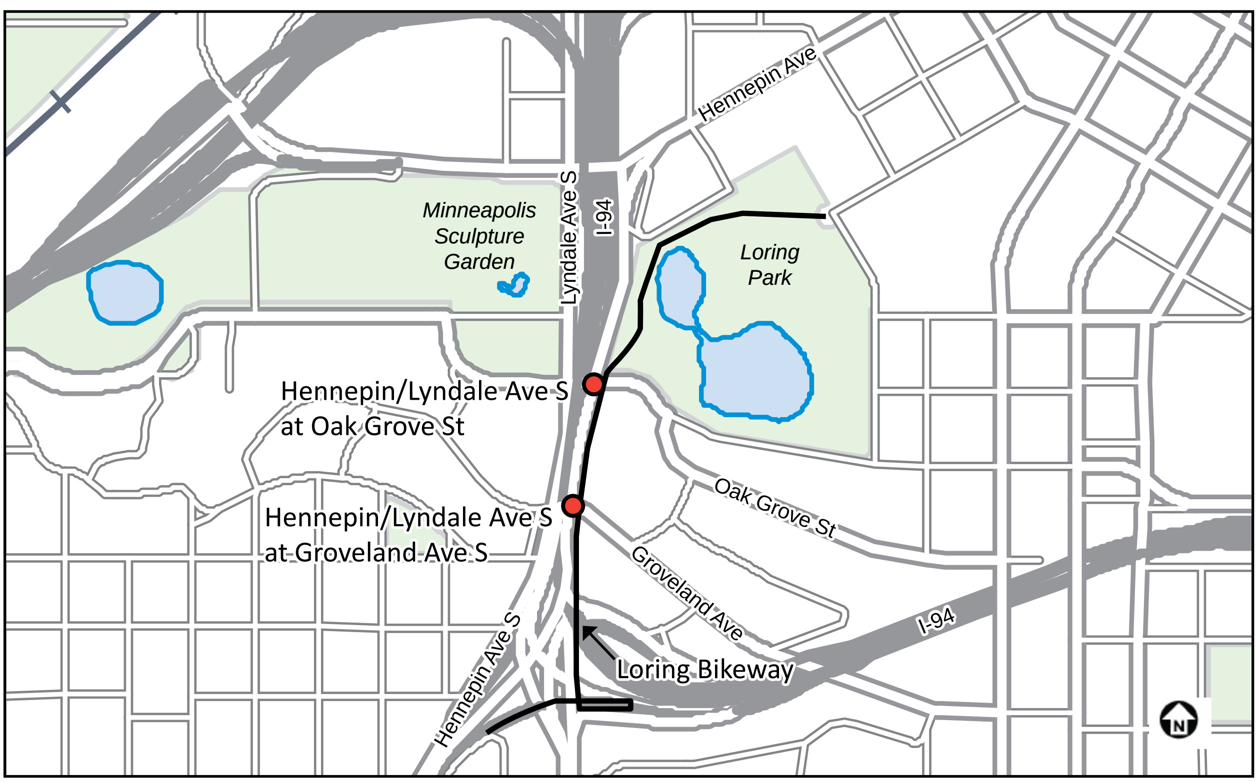


Figure 4-3: Project locations

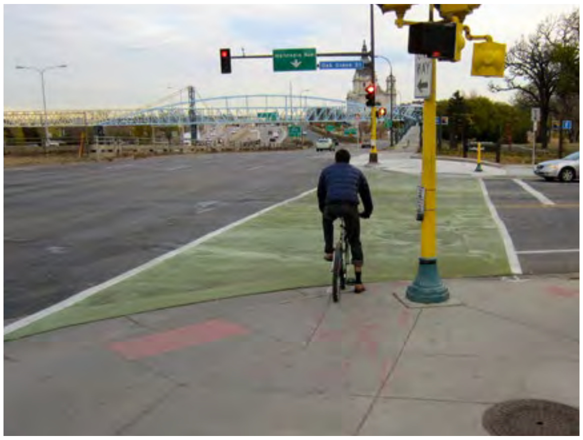


Figure 4-4: Oak Grove Street West intersection after installation with original colored crosswalk

Figure 4-5: Groveland Avenue South intersection after installation with original colored crosswalk

Figure 4-6: Oak Grove Street West intersection after installation with updated colored crosswalk

Figure 4-7: Groveland Avenue South intersection after installation with updated colored crosswalk

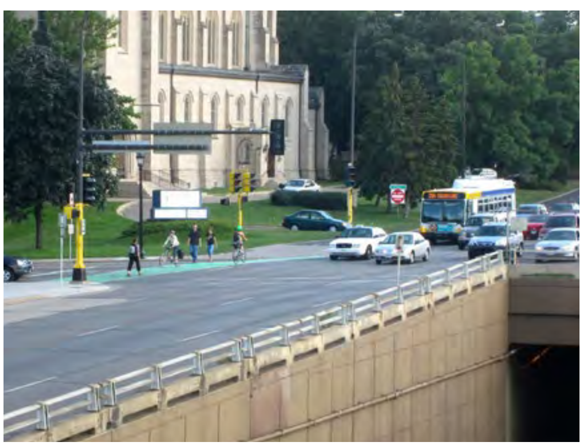


Figure 4-8: Bicyclists and pedestrians cross at Oak Grove Street West after installation

Figure 4-9: A pedestrian and dog cross at Groveland Avenue South after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of the colored crosswalk locations, the measures of effectiveness are traffic volumes, reported crashes, user behavior, and user feedback. All measures, except user feedback and some traffic volume data, 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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Results

Traffic Volumes

Bicycle traffic increased slightly after the project was installed. Before the project was installed, traffic volumes ranged between 1,150 and 1,300 bicyclists per day. After the project was installed, traffic volumes ranged between 1,170 and 1,670 bicyclists per day.

Pedestrian traffic decreased slightly after the project was installed. Before the project was installed, traffic volumes ranged between 550 and 570 pedestrians per day. After the project was installed, traffic volumes ranged between 390 and 510 pedestrians per day.

At Oak Grove Street West, the AADT before the project was: 29,600 and at Groveland Avenue, the AADT was 30,400. No data was available after the project was installed, although Public Works does not believe there were substantial changes in motor vehicle traffic after installation.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 4-1: Daily traffic volumes

Type	Location	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	Hennepin/Lyndale Ave S at Oak Grove St W	1,300	1,150	1,280	1,290	1,670	1,170
	Hennepin/Lyndale Ave S at Groveland Ave S	1,300	1,150	1,280	1,290	1,670	1,170
Pedestrian (EDT)	Hennepin/Lyndale Ave S at Oak Grove St W	550	570	550	510	390	400
	Hennepin/Lyndale Ave S at Groveland Ave S	550	570	550	510	390	400
Motor Vehicle (AADT)	Hennepin/Lyndale Ave S at Oak Grove St W	-	-	29,600	-	-	-
	Hennepin/Lyndale Ave S at Groveland Ave S	-	-	30,400	-	-	-

Total motor vehicle traffic volumes (AADT) provide context for the roadway. Peak hour motor vehicle turning movements provide further detail for the level of traffic crossing the crosswalk and potentially interacting with bicyclists and pedestrians. All turning movement counts were collected in 2011.

Table 4-2: Peak hour turning movements across crosswalk

Type	Location	Movement	Type of Movement	Peak Hour Turning Volume Across Crosswalk	
				AM	PM
Motor Vehicle (Turning Movements)	Hennepin/Lyndale Ave S South at Oak Grove St W	NB right turn	Permissive	183	34
		WB right turn	No Turn on Red	242	509
	Hennepin/Lyndale Ave S at Groveland Ave S	NB right turn	Permissive	33	45
		WB right turn	Permissive	91	145

Reported Crashes

During the three years before installation, there were 92 reported crashes, including 83 motor vehicle crashes, eight bicycle crashes, and one pedestrian crash. During the three years after installation, there were 106 reported crashes, including 99 motor vehicle crashes, six bicycle crashes, and one pedestrian crash.

Table 4-3: Reported crashes

Location	Crash Type	Before	After	Change
Hennepin/Lyndale Avenue South at Oak Grove Street West	Motor Vehicle	56	54	-2
	Bicycle	5	1	-4
	Pedestrian	0	1	1
	Total	61	56	-5
Hennepin/Lyndale Avenue South at Groveland Avenue South	Motor Vehicle	27	45	18
	Bicycle	3	5	2
	Pedestrian	1	0	-1
	Total	31	50	19
All locations	Motor Vehicle	83	99	16
	Bicycle	8	6	-2
	Pedestrian	1	1	0
	Total	92	106	14

At Oak Grove Street West there was one bicycle and one pedestrian crash following installation. The bicycle crash involved a northbound bicyclist and westbound motorist. The bicyclist was cited for "disregarding a traffic control device"; and the crash report stated that the bicyclist "had been drinking." The pedestrian crash involved a northbound pedestrian and westbound motorist. The impact area, however, was 190 feet west of the Oak Grove Street West intersection, suggesting it was a mid-block crash.

At Groveland Avenue South there were five bicycle crashes following installation. Three of the bicycle crashes involved turning vehicles failing to yield the right-of-way, one involved a bicycle disregarding a traffic control device, and one crash report cited "weather" as the contributing factor.

User Behavior Monitored

User behavior was evaluated before-and-after installation by recording video at the Oak Grove Street West location and tabulating events. The video was recorded with a north facing camera located on Hennepin/Lyndale Avenue South just south of the Oak Grove Street West intersection. Events tabulated include westbound motorists turning right on red compliance, westbound motorist stopping locations, bicyclist-motorist interactions, and pedestrian-motorist interactions.

Figure 4-10: Screen capture of before video of Hennepin/Lyndale Avenue South at Oak Grove Street West

Figure 4-11: Screen capture of after video of Hennepin/Lyndale Avenue South at Oak Grove Street West

Before video was collected in July of 2011 and after video was collected in August of 2012. Eight hours of video was processed during the morning (6:00 a.m. to 9:00 a.m.), midday (11:00 a.m. to 1:00 p.m.), and afternoon periods (3:00 p.m. to 6:00 p.m.) for both the before-and-after periods.

Motorist Behavior

There is a signed "No Turn on Red" condition for westbound motorists on Oak Grove Street West at Hennepin/Lyndale Avenue South. Before installation, 93 percent of westbound right-turning motorists complied with the condition. After installation, 95 percent complied with this condition. The results of the two-proportion z-test and chi-squared test show the colored crosswalk treatment did not have any statistically significant effects on westbound motorist right turn on red compliance.

Table 4-4: Westbound motorist right turn on red compliance

Type	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Stopped on red	576	93%	581	95%	0.205	-1.2672
Turned right on red	43	7%	32	5%	0.205	1.2672
Total	619	100%	613	100%	-	-

Chi-Square = 1.6058, P-value = 0.205089

After the project was installed, fewer motorists stopped before the marked stop bar.

Before installation, of westbound motorists complying with the no turn on red condition, 85 percent stopped before the marked stop bar, 13 percent stopped between the marked stop bar and crosswalk, and two percent encroached into the crosswalk. After installation, 80 percent stopped before the marked stop bar, 17 percent stopped between the marked stop bar and crosswalk, and three percent encroached into the crosswalk.

The results of the two-proportion z-test show there was a significant change in stopping before the stop bar and stopping between the stop bar and the crosswalk at the 95% confidence interval. However, the colored crosswalk treatment did not have a significant effect on motorists encroaching into the crosswalk. The results of the chi-squared test show the colored crosswalk treatment does not have a significant relationship to motorist stopping location at the 95% confidence interval.

Table 4-5: Westbound motorist stopping location, stopped on red

Type	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Before stop bar	491	85%	465	80%	0.019	2.3381
Between stop bar and crosswalk	73	13%	99	17%	0.037	-2.0872
Encroached into crosswalk	12	2%	17	3%	0.359	-0.9168
Total	576	100%	581	100%	-	-

Chi-Square = 5.4779, P-value = 0.064638

Bicyclist-Motorist Interactions

Before the project was installed, 38 percent of motorists fully yielded to crossing bicyclists, allowing the bicyclists to clear all lanes in the direction of travel before turning. This is considered a legal yield per Minnesota Statute 169.21 Subd. 2. Fifty-one percent of motorists partially yielded to a crossing bicyclist, allowing the bicyclist to clear just the nearest lane in the direction of travel. This behavior is not considered a legal yield per Minnesota Statute 169.21. One collision was observed during the before period involving a northbound bicyclist and northbound right turning motorist. The bicyclist was struck by the right turning motorist while in the crosswalk.

After installation, 40 percent of motorists fully yielded to crossing bicyclists, allowing the bicyclists to clear all lanes in the direction of travel before turning. Forty-seven percent of motorists partially yielded to crossing bicyclists, allowing the bicyclist to clear just the nearest lane in the direction of travel before turning.

The results of the two-proportion z-test and chi-square test show the colored crosswalk treatment did not have a significant effect on bicyclist-motorist interactions.

Table 4-6: Bicyclist-motorist interactions

Type of Interaction	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Motorist yield (full)	232	38%	160	40%	0.565	-0.5759
Motorist yield (partial)	309	51%	187	47%	0.202	1.277
Bicyclist yield	18	3%	19	5%	0.14	-1.4754
Motorist failed to yield (no negotiation required)	43	7%	21	5%	0.244	1.1641
Near miss	3	0%	3	1%	0.605	-0.517
Collision	1	0%	1	0%	0.766	-0.2979
Other	3	0%	10	2%	0.006	-2.7606
Total	609	100%	401	100%	-	-

Chi-Square = 12.276, P-value = 0.05608733

<u>Pedestrian-Motorist Interactions</u>

Pedestrian-motorist interactions did not change significantly after the project was installed. Before the project was installed, 41 percent of motorists fully yielded to crossing pedestrians, allowing pedestrians to clear all lanes in the direction of travel before turning. Fifty percent of motorists partially yield to crossing pedestrians, allowing the pedestrian to clear just the nearest lane in the direction of travel before turning.

After installation, 38 percent of motorists fully yielded to crossing pedestrians, allowing pedestrians to clear all lanes in the direction of travel before turning. Fifty-two percent of motorists partially yielded to crossing pedestrians, allowing the pedestrian to clear just the nearest lane in the direction of travel before turning.

The results of the two-proportion z-test and chi-square test show the colored crosswalk treatment did not have a significant effect on pedestrian-motorist interactions.

Table 4-7: Pedestrian-motorist interactions

Type of Interaction	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Motorist yield (full)	164	41%	99	38%	0.535	0.62
Motorist yield (partial)	200	50%	135	52%	0.519	-0.65
Bicyclist yield	1	0%	0	0%	0.423	0.8
Motorist failed to yield (no negotiation required)	32	8%	16	6%	0.396	0.85
Near miss	2	0%	0	0%	0.257	1.13
Collision	0	0%	0	0%	-	-
Other	3	1%	7	3%	0.044	-2.02
Multiple interactions	0	0%	1	0%	0.212	-1.25
Total	402	100%	258	100%	-	-

Chi-Square = 8.601, P-value = 0.28258538

User Feedback

User feedback was solicited through intercept surveys for bicyclists and pedestrians and also signs encouraging users to call Minneapolis 311 to comment.

Survey

Public Works recruited people to take the bicyclist and pedestrian survey in the field. Staff handed out cards to bicyclists and pedestrians waiting at a red semaphore at the intersection of Hennepin/Lyndale Avenue South and Oak Grove Street West. A total of 132 survey cards were distributed over four hours resulting in 28 valid responses. The bicycle survey was 15 questions and the pedestrian survey was 13 questions. Both surveys were intended to take 10 minutes or less to complete and were available in an online or printed format. See Chapter 2 for additional information about the survey methods.

Table 4-8: Survey response rates by user group

Survey Type	Distributed	Valid Responses	Response Rate
Bicyclist	67	19	28%
Pedestrian	65	9	14%

In both surveys, participants were shown a photo of the colored crosswalk at the intersection of Hennepin/Lyndale Avenue South and Oak Grove Street West and asked to state the intended purpose of the roadway marking. To not influence responses, the question was opened ended and participants wrote or typed into a blank field. Staff categorized responses based on content or common themes. Many participants provided responses that included multiple purposes.

Bicyclist survey and pedestrian survey participants most frequently stated that the purpose was to increase the visibility of the crosswalk, to mark the bicycle and pedestrian path, and to increase awareness of bicycle and pedestrian traffic.

Table 4-9: Stated purpose of markings

Stated Purpose (Staff Tabulated Category)	Frequency		
	Bicyclist Survey	Pedestrian Survey	Total
Increase visibility of crosswalk	9	8	17
Mark the bicycle and pedestrian path	11	2	13
Increase awareness of bicycle & pedestrian traffic	9	2	11
Motorists should wait behind crosswalk or stop bar	2	0	2
Don't know or confused	1	1	2
Total	32	13	45

Survey participants were also asked if they had any general feedback about the recent changes to the two intersections along Hennepin/Lyndale Avenue South.

The general feedback from bicyclists was that the markings provide some awareness to motorists about trail users. However, many said the intersection is very busy and many motorists do not always yield the right-of-way, especially westbound motorists at the Groveland Avenue South intersection.

Table 4-10: Select feedback from bicyclist survey

Select feedback from bicyclist survey
"Can be a little crowded and difficult to navigate during peak hours. Cars turning right onto Oak Grove seem to (anecdotally) be the largest threat to bikes and peds."
"I feel like painting the crosswalk green at this location may have slightly improved motorist alertness about bicycle and pedestrian traffic. However, I'm not sure that the results are drastic enough to justify doing this at all intersections."
"I have repeatedly seen motorists cut in front of bicyclists while making turns, such as the right hand turn off of Lyndale on to Oak Grove St.; the colored strip alerts motorists to look to see if a bicyclist is about to cross the green strip, and to notice any pedestrians who may be about to enter the intersection. I am extremely grateful that it is there, I believe it is much safer to have the strip, and hope more such paint is used in the city."

The general feedback from pedestrians was that the markings provide some awareness to motorists about crossing pedestrians. However, due to the size and complexity of the intersections, many participants stated that the two green crosswalks are only a marginal improvement.

Table 4-11: Select feedback from pedestrian survey

Select feedback from pedestrian survey
"I love the idea of clearly marked crosswalks more prominently but the green looks a little sloppy. I would have done bold white slashes with a bicycle icon and walking pedestrian icon to make it bolder/clearer. And maybe added a State Law/Pedestrians have the right-of-way sign?"
"I'm glad that someone noticed that this is a difficult intersection, but I wish there were more changes to crossing Hennepin/Lyndale rather than crossing Oak Grove Street West."
"I use a scooter. Cars don't see it, particularly when turning right. Cars also roll into the crosswalk making it dangerous for me. I see fewer cars rolling into the green crosswalk and that's safer for me."

Minneapolis 311 Feedback

Minneapolis 311 signs were installed August-September of 2012. A total of 11 comments were received by emails to Minneapolis 311 or phone calls to Minneapolis 311 operators. A mix of self-identified pedestrians, bicyclists, and motorists who travel through the intersection provided comments. Some users stated there was noticeable change, some users expressed confusion, and one user wondered about the slickness of the green paint in wet conditions.

Table 4-12: Select feedback from Minneapolis

Select feedback from Minneapolis 311
"I love the green markings that have started to appear on dedicated cycle lanes and this is a prime location that is crying out for the same treatment. I use the crossings as a pedestrian and cyclist regularly, and often have my children (infant and toddler) with me either in their stroller or being towed behind my bike when I convert the stroller."
"I think it's confusing. Over the past few years, there seem to be a lot of different types of markings on the street related to bikers. Seems like there needs to be some public education about what the markings mean. Then to have a pedestrian crosswalk painted the same color as some of the bike lanes?"
"While I like the visibility, it made me wonder if the paint make it slippery for rubber tires, especially in wet conditions."

Conclusions

The evaluation of colored crosswalks at the two project locations found varied results across different users and different types of user interactions. No new operational or safety issues emerged as a result of the installation of colored crosswalks. However, the treatment locations were installed at one leg of two complex intersections and it is unclear what effect the treatment had on safety relative to the other existing conditions at these locations.

During the three years before installation, there were 92 reported crashes, including 83 motor vehicle crashes, eight bicycle crashes, and one pedestrian crash. During the three years after installation, there were 106 reported crashes, including 99 motor vehicle crashes, six bicycle crashes, and one pedestrian crash. After installation, some of the of the bicycle crashes at Groveland Avenue South involved north-south bicyclists and turning motorists. The one pedestrian crash that occurred after installation occurred far from the treatment location and does not appear to be a factor of the project design.

Evaluation of user behavior was limited to one location. For motorists, there was no significant increase in westbound motorists stopping and waiting on red, although compliance was already high before installation. After installation, there was also no significant change in westbound motorist stopping location. No significant changes were observed for bicyclist-motorist interactions or pedestrian-motorist interactions.

User feedback was generally positive for the specific treatment, although bicyclists and pedestrians stated that the colored crosswalk did little to improve the overall perceived safety of the intersections. After the project was installed, bicyclists and pedestrians stated that many motorists still failed to yield the right-of-way when turning.

While the specific value to bicyclists and pedestrians may be limited, Public Works intends to maintain this facility. The positive results of other colored intersection treatments (Chapter 16) have given staff confidence to maintain these locations and pursue this treatment at other locations. Public Works is installing many more green locations in the City using durable thermoplastic. As of 2016, green colored conflict zones have been installed at over 100 intersections in Minneapolis.

Since this original installation, Public Works has modified design of the colored crosswalks to a dotted green marking. The modified design is consistent with the modified bicycle colored conflict zones and compatible with the new Minneapolis standard of zebra crosswalk markings. Public Works is reconstructing this segment in Hennepin/Lyndale Avenue South in 2016-2017. The Loring Bikeway will be reconfigured to have fully separate bicycle and pedestrian lanes. The intersection geometry is being modified and the bicycle colored conflict zones and crosswalk markings will be installed with the modified pattern.

Figure 4-12: Example of modified dotted green conflict zone installed parallel to a crosswalk

Figure 4-13: Example of modified dotted green conflict zone installed parallel to a crosswalk

Chapter 5

Enhanced Shared Lane Markings

Project Location:

LaSalle Avenue South between 15th Street West and Franklin Avenue West

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 enhanced shared lane marking is a variation of a conventional shared lane marking, often referred to as a "sharrow." A shared lane marking is a pavement marking consisting of a conventional bicycle symbol with a double chevron. The marking is typically placed within a travel lane on a roadway that is too narrow to accommodate conventional bicycle lanes. A conventional shared lane marking does not include any longitudinal markings.

The 2009 edition of the MMUTCD states the purpose of a shared lane marking is to:

- Assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to reduce the chance of a bicyclist's impacting the open door of a parked vehicle,
- Assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane,
- Alert road users of the lateral location bicyclists are likely to occupy within the traveled way,
- Encourage safe passing of bicyclists by motorists, and
- Reduce the incidence of wrong-way bicycling

An enhanced shared lane marking modifies the standard marking to include a dotted white longitudinal line on both sides of the bicycle symbol and chevron module. The dotted white lines are intended to reinforce the purpose of the shared lane marking as outlined above. Similar to standard shared lane markings, enhanced shared lane markings do not establish a preferential lane or area for bicyclists. Rather, the markings are intended to encourage safe behavior of bicyclists and motorists.

At the time of implementation and writing of this report, enhanced shared lane markings are considered by FHWA to be experimental. Conventional shared lane markings are an approved treatment and are used extensively in many U.S. cities. Enhanced shared lane markings are less common.

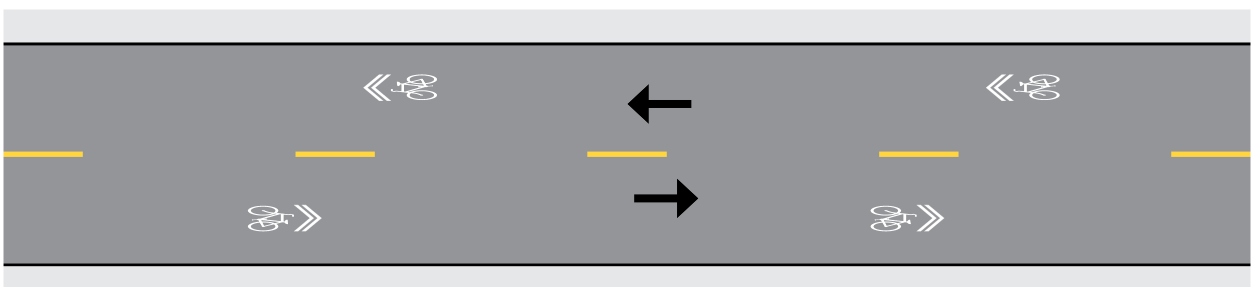


Figure 5-1: Conventional shared lane markings on a two-way street

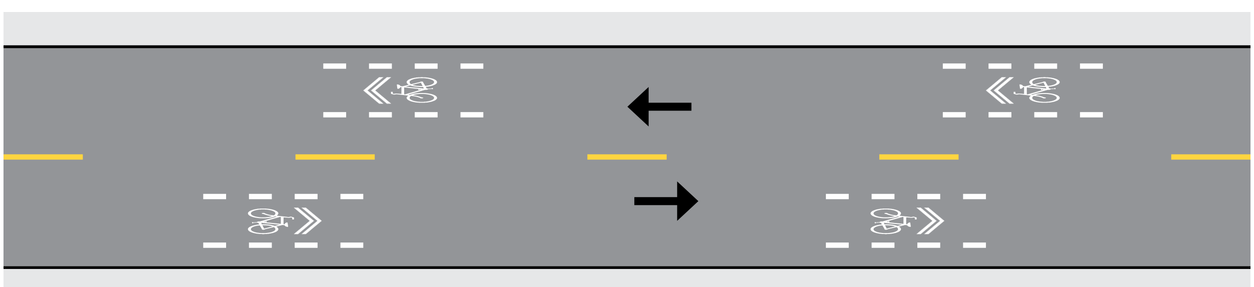


Figure 5-2: Enhanced shared lane markings on a two-way street

Project Location

The project location is on LaSalle Avenue South between 15th Street West and Franklin Avenue West. The project is approximately 0.3 miles or four city blocks long. This segment of LaSalle Avenue South operates as a one-way pair with 1st Avenue South. LaSalle Avenue South operates southbound, serving outbound traffic from downtown Minneapolis. There is a notable change in elevation in the direction of travel, requiring bicyclists to negotiate a steep grade. Surrounding land uses are primarily high-density residential. The project limits include a one-block bridge over I-94.

LaSalle Avenue South is typically 40 feet wide. Prior to installation, the cross section included parking on both sides of the street and two southbound travel lanes. AADTs ranged from 6,500 to 7,900 vehicles per day. There are high concentrations of traffic in the afternoon peak hour due to the outbound nature of the street. The posted speed limit is 30 mph. No regular transit route uses this segment of LaSalle Avenue South.

The goal of the bicycle project was to provide a southbound bicycle connection from 15th Street West to existing bicycle lanes on Blaisdell Avenue South south of Franklin Avenue West. Bicyclists tend to travel at low speeds while negotiating the steep grade. Due to the large difference in speeds between bicycles and motor vehicles, a preferential bicycle lane was desired. However, to establish a preferential bicycle lane, one parking lane or one travel lane would need to be removed. 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. Removal of one travel lane was evaluated, but that alternative was eliminated due to the anticipated negative impacts to motor vehicle traffic flow. The recommended design treatment was a series of enhanced shared lane markings, installed in the right-hand travel lane. Two enhanced shared lane marking modules were installed per block. Parking is prohibited on the bridge over I-94, so a dedicated bicycle lane was installed for the length of the bridge deck.

The project was open for use in October, 2011.

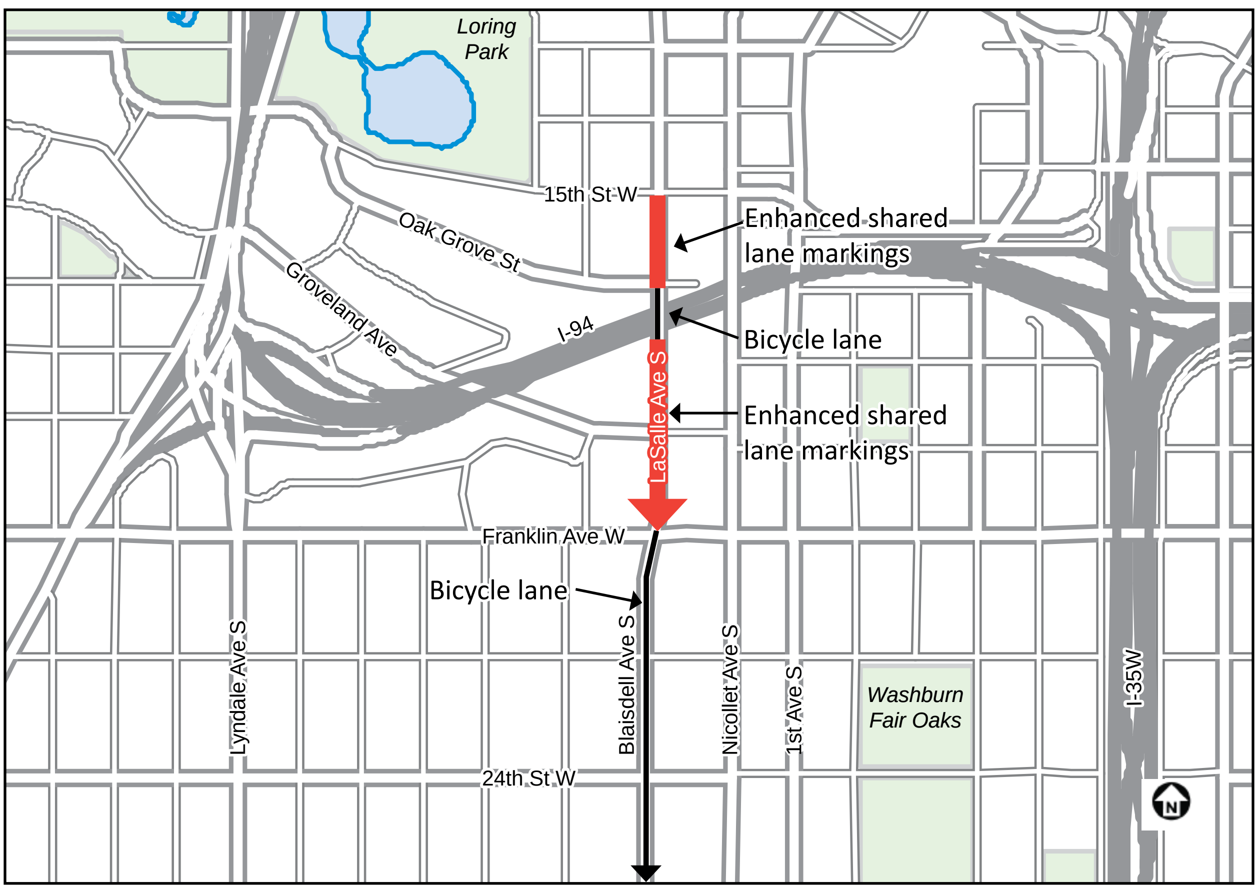


Figure 5-3: Project location

Typical: 15th Street West to Oak Grove Street West, I-94 to Franklin Avenue West (40')

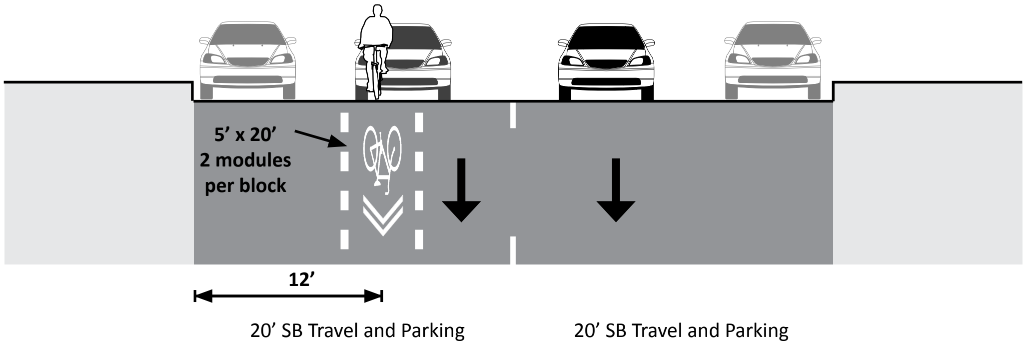


Figure 5-4: Typical cross section

Figure 5-5: A southbound bicyclist on LaSalle Avenue South at 15th Street West after installation

Figure 5-6: A southbound bicyclist on LaSalle Avenue South at Groveland Avenue South after installation

Figure 5-7: A southbound bicyclist on LaSalle Avenue South approaching Franklin Avenue West after installation

Figure 5-8: Traffic on LaSalle Avenue South at Groveland Avenue South after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the LaSalle Avenue South evaluation, the measures of effectiveness are traffic volumes, reported crashes, user behavior, and user feedback. Except for user behavior 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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Results

Traffic Volumes

Bicycle traffic volumes increased slightly from 340 to 380 bicyclists per day. Motor vehicle traffic volumes decreased from 6,500 to 5,000 vehicles per day. No motor vehicle data was collected during the three years after installation, so a 2015 count was used to represent after conditions.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 5-1: Daily traffic volumes

Type	Location (between)	Before			After			
		2009	2010	2011	2012	2013	2014	2015
Bicycle (EDT)	15th St W and Oak Grove St	-	-	340	-	-	380	-
Motor Vehicle (AADT)	Groveland Ave and Franklin Ave W	-	6,500	-	-	-	-	5,000

Reported Crashes

During the three years before installation, there were 47 reported crashes, including 45 motor vehicle crashes, no bicycle crashes, and two pedestrian crashes. During the three years after installation, there were 46 reported crashes, including 39 motor vehicle crashes, three bicycle crashes, and four pedestrian crashes.

Table 5-2: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	45	39	-6
Bicycle	0	3	3
Pedestrian	2	4	2
Total	47	46	-1

The three bicycle crashes that occurred after the project was installed involved various circumstances and do not appear to be a factor of the project design. One involved an eastbound bicyclist on 15th Street West and a southbound motorist on LaSalle Avenue South. The bicyclist was cited for "disregarding a traffic control device." Another crash involved an eastbound bicyclist and westbound motorist turning left at Groveland Avenue South. The motorist was cited for "failing to yield the right-of-way." The third crash involved a northbound bicyclist riding against traffic on LaSalle Avenue South and an eastbound motorist making a right turn at Oak Grove Street The bicyclist was cited as "disregarding a traffic control device."

User Behavior Monitored

User behavior was evaluated after installation by recording video on LaSalle Avenue South. The video was recorded with a north facing camera located on LaSalle Avenue South between 15th Street West and Oak Grove Street West. Events tabulated include bicyclist location, motorist location, and bicyclist-motorist interactions. After video was collected in May 2012. Forty-eight hours of video were processed.

Figure 5-9: Screen capture of after video of LaSalle Avenue South between 15th Street West and Oak Grove Street West

Bicyclist Location

A total of 984 bicyclists were observed. This included 846 bicyclists riding southbound and 138 riding northbound, or against traffic.

After the enhanced shared lane markings were installed, three percent of southbound bicyclists rode to the left of the shared lane marking, 88 percent rode over the shared lane markings, one percent rode to the right of the shared lane markings, six percent rode on the sidewalk, and two percent rode in multiple locations within the video frame. No bicyclists were observed riding in the parking lane due to the continuous presence of parked vehicles. Seventy-six percent of northbound bicyclists rode on the sidewalk.

Table 5-3: Bicyclist location

Bicyclist Location	Southbound		Northbound (against traffic)		Total	
	Count	%	Count	%	Count	%
Left of shared lane marking	29	3%	14	10%	43	4%
Over shared lane marking	741	88%	13	9%	754	77%
Right of shared lane marking	10	1%	0	0%	10	1%
Parking Lane	0	0%	0	0%	0	0%
Sidewalk	47	6%	105	76%	152	15%
Multiple	19	2%	6	4%	25	3%
Total	846	100%	138	100%	984	100%

Motorist Location

After the enhanced shared lane markings were installed, motorists used the street as intended. When a bicyclist was not present, 46 percent of motorists drove in the left travel lane, one percent straddled the left and right travel lanes, and 53 percent drove in the right travel lane, which contained the enhanced shared lane markings.

When a bicyclist was present, 53 percent of motorists drove in the left travel lane, 27 percent straddled the left and right travel lanes, and 20 percent drove in the right travel lane. The 27 percent that straddled the left and right lanes is probably reflective of motorists overtaking bicyclists. The 20 percent of motorists that operated completed in right lane were not observed overtaking the bicyclist within the video frame or involved a bicyclist riding on the sidewalk.

Both the two-proportion z-test and the chi-squared test show the motorist location was significantly related to the presence of a bicyclist.

Table 5-4: Motor vehicle location

Motorist Location	No Bicyclist Present		Bicyclist Present		Significance	
	Count	%	Count	%	P-value	Z-score
Left travel lane	6,603	46%	411	53%	0	-4.1487
Straddled left/right travel lane	81	1%	209	27%	0	-52.5562
Right travel lane (shared lane marking)	7,796	53%	152	20%	0	18.5074
Total	14,480	100%	722	100%	-	-

Chi-Square = 2,882.9603, P-value < 0.00001

Bicyclist-Motorist Interactions

After the enhanced shared lane markings were installed, 421 events were observed involving bicyclist-motorist interactions. Of these, no "unsafe passing events" were observed.

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 of clearance when overtaking a bicyclist. This definition is generally 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." It should be noted that due to the camera angle and clarity of the video, measurements were estimated based on tick marks in the roadway and were measured from the outside edge of the bicyclist (person on a bicycle) to the outside edge of the motor vehicle tire. The estimated distance did not account for the width of vehicle mirrors.

User Feedback

User feedback was solicited through an intercept survey for bicyclists and motorists.

Public Works recruited people to take the bicyclist survey in the field. Staff handed out survey cards to bicyclists waiting at a red semaphore at the intersection of LaSalle Avenue South and Franklin Avenue West. A total of 110 survey cards and two printed surveys were distributed over a 10-hour period, resulting in 34 valid responses.

For the motorist survey, staff placed survey cards on the windshield of parked vehicles along LaSalle Avenue South and one block in either direction. Survey distribution occurred during two weeknights. A total of 359 cards were distributed, resulting in 44 valid survey responses.

The surveys were each 20 questions. The bicyclist survey was available in an online or printed format, and the motorist survey was only available in an online format. See Chapter 2 for additional information about the survey methods.

Table 5-5: Survey response rates by user group

Survey Type	Distributed	Valid Responses	Response Rate
Bicyclist	112	34	30%
Motorist	359	44	12%

In both surveys, participants were shown a photo of the enhanced shared lane markings on LaSalle Avenue South and asked to state the intended purpose of the roadway marking. To not influence responses, the question was opened ended and participants wrote or typed into a blank field. Staff categorized responses based on content or common themes. Many people provided responses that included multiple purposes.

Both the bicyclist and motorist survey participants provided responses that generally align with the purpose stated in the MMUTCD. Stated purposes included: to indicate the recommended riding area for bicycle traffic, to increase awareness of bicycle traffic, and to indicate a shared lane for bicycle and motor vehicle traffic. Some bicyclists and motorists identified the purpose was to mark a bicycle lane. It is not known whether this is intended to mean a dedicated bicycle lane or shared lane.

Table 5-6: Stated purpose of markings

Stated Purpose (Staff Tabulated Category)	Frequency		
	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 LaSalle Avenue South.

The general feedback from bicyclists was that the markings increase awareness of bicycle traffic on LaSalle Avenue South. However, many bicyclists stated that the markings have done little to affect the speeds or behavior of motorists. Many stated that they would prefer a dedicated bicycle lane rather than a shared lane.

Table 5-7: Select feedback from bicyclist survey

Select feedback from bicyclist survey
"I do feel safer with the markings than without. I'm not sure if motorists behave any differently but it does provide a sense of security."
"Cars still drive too close at times and don't slow down, but it seems that the markings have legitimized bicycles on this stretch, which is great!"
"Cars go real fast and there doesn't yet seem to be an awareness for bicycles. An independent bicycle only lane would be preferred."

The general feedback from motorists was that the markings are confusing. Many motorists expressed confusion about how to behave or operate around the markings either when a bicyclist was or was not present. There was a general theme that motorists did not prefer to be sharing a lane with bicycle traffic.

Table 5-8: Select feedback from motorist survey

Select feedback from motorist survey
"I find them to be slightly confusing. I'm not sure if I should always avoid driving in the bicycle lane, or stay behind a cyclist."
"It isn't very clear what the bicycle markings actually mean."
"Busy streets where bicyclists often ride should be significantly wider for everyone's safety."

Conclusions

The evaluation of enhanced shared lane markings on LaSalle Avenue South found that the street operated as intended. No new operational or safety issues emerged as a result of the installation of enhanced shared lane markings. However, both bicyclists and motorists stated that they do not prefer to be sharing a lane. Due to the evaluation design, it is not possible to know the effectiveness of enhanced shared lane markings over conventional shared lane markings or no markings in the same context.

During the three years before installation, there were 47 reported crashes, including 45 motor vehicle crashes, no bicycle crashes, and two pedestrian crashes. During the three years after installation, there were 46 reported crashes, including 39 motor vehicle crashes, three bicycle crashes, and four pedestrian crashes. According to police reports, the three bicycle crashes occurred under circumstances that do not appear to be a factor of the project design.

Evaluation of user behavior was limited to after the project was installed. Observations found that the street was used as intended. Nearly all southbound bicyclists rode over the shared lane markings, although due to high parking demand, riding to the right of the shared lane marking or in the parking lane was rarely feasible. About 14 percent of bicyclists rode against traffic, although most of these bicyclists were riding on the sidewalk. The wrong-way riding is likely a factor of bicycle network access on a one-way street, rather than any effect of the markings. Most motorists operated as intended, driving over the shared lane when a bicyclist was not present, but merging to the left when a bicyclist was present. No unsafe passing of bicyclists by motorists was observed.

User feedback was mixed. Most bicyclist survey participants believed the markings provided more awareness of bicycle traffic to motorists. However, they believe markings have had little effect on motorist behavior and perceived speeds. Many bicyclists stated that a dedicated bicycle lane would be preferred on a street with a steep uphill grade and high volumes of motor vehicle traffic. Motorist survey participants expressed confusion about how to drive on LaSalle Avenue South with the markings and around bicyclists, although this confusion was not reflected in the user behavior or reported crashes. Many motorists stated that they did not prefer to be sharing a lane with bicycle traffic.

While the specific value to bicyclists may be limited, Public Works intends to maintain this facility as no operational or safety issues have been observed. Public Works recognizes the high volume of motorists and the uphill grade do not provide a comfortable environment for bicyclists using the street. In the 2015 update to the Minneapolis Bicycle Master Plan, LaSalle Avenue South has been identified as a future protected bikeway. A protected bikeway would consist of a design that would physically separate bicycle traffic from motor vehicle traffic.

Chapter 6

Intermittent Colored Background for Shared Lane Markings

Project Location:

Bryant Avenue South between Lake Street West and 40th Street West, 49th Street West and 50th Street West

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

Intermittent colored background for shared lane markings is a variation of a conventional shared lane marking, often referred to as a "sharrow." A shared lane marking is a pavement marking consisting of a conventional bicycle symbol with a double chevron. The marking is typically placed within a travel lane on a roadway that is too narrow to accommodate conventional bicycle lanes. A conventional shared lane marking does not include any longitudinal markings or colored background.

The 2009 edition of the MMUTCD states the purpose of a shared lane marking is to:

- Assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to reduce the chance of a bicyclist's impacting the open door of a parked vehicle,
- Assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane,
- Alert road users of the lateral location bicyclists are likely to occupy within the traveled way,
- Encourage safe passing of bicyclists by motorists, and
- Reduce the incidence of wrong-way bicycling.

Intermittent colored background for shared lane markings modifies the conventional shared lane marking to include a green colored background. The green color is intended to reinforce the purpose of the shared lane marking as outlined above. Similar to conventional shared lane markings, shared lane markings with intermittent colored background do not establish a preferential lane or area for bicyclists. Rather, the markings encourage safe behavior of bicyclists and motorists.

At the time of implementation and writing of this report, intermittent colored background for shared lane markings are considered by FHWA to be experimental. Green color for bicycle lane lanes was granted interim approval by FHWA in 2011. However, the interim approval does not permit color in conjunction with shared lane markings; only conventional bicycle lanes. Conventional shared lane markings are an approved treatment and are used extensively in many U.S. cities. Shared lane markings with intermittent colored background are less common.

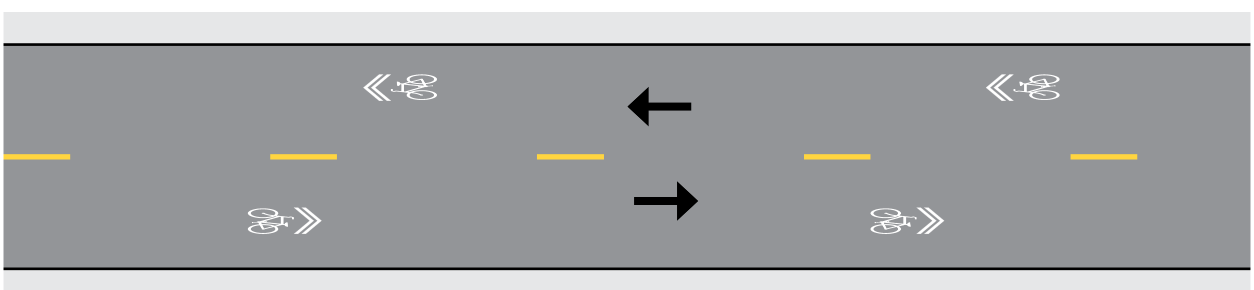


Figure 6-1: Conventional shared lane markings on a two-way street

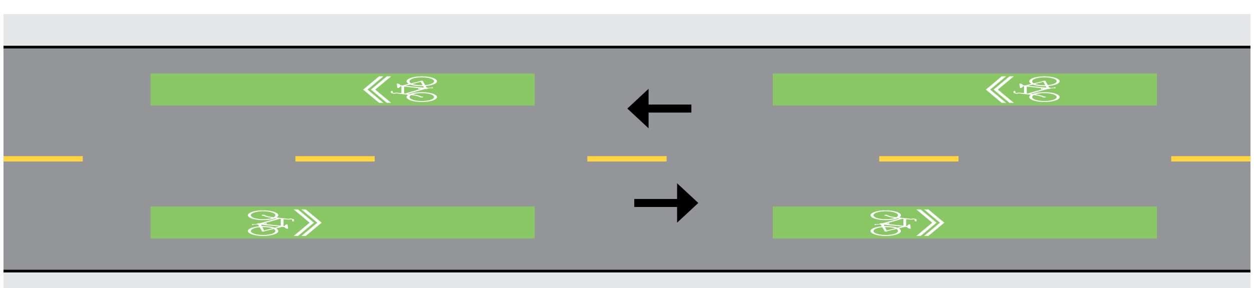


Figure 6-2: Shared lane markings with intermittent colored background on a two-way street

Project Location

The project location is on Bryant Avenue South between Lake Street West and 40th Street West and between 49th Street West and 50th Street West. The project is approximately 1.3 miles or 11 city blocks long. Surrounding land uses and destinations include single-family homes, multi-family apartments, neighborhood parks, and three neighborhood commercial nodes.

Bryant Avenue South is 40 feet wide and operates as a two-way street. Prior to installation, 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. Between Lake Street West and 36th Street West standard shared lane markings were installed in 2008, although the markings had faded and were not visible at the time this project was installed. Prior to implementation, the street had AADTs ranging from 1,800 to 3,100 vehicles per day with a posted speed limit of 30 mph. Two bus routes operate on segments of the project corridor. Metro Transit bus route 4 operates from 31st Street West to 40th Street West and 49th Street West to 50th Street West with an average headway of 10 minutes. Metro Transit bus route 23 operates from 36th Street West to 38th Street West with an average headway of 30 minutes.

The goal of the bicycle project was to provide a north-south connection along Bryant Avenue South. Based on motor vehicle traffic volumes and the frequency of buses, a preferential bicycle lane was desired. However, to establish a dedicated bicycle lane, one parking lane would need to be removed. 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.

The recommended design treatment was shared lane markings with intermittent green background. The green background was four feet wide and 100 feet long. Conventional shared lane markings were installed at the beginning of each module. Three modules were installed per block with a one hundred-foot gap between each module.

To further evaluate the effectiveness of the treatment and observe possible differences in lateral positioning of bicycle and motor vehicle traffic, two configurations were installed. In the southbound direction, the modules were centered 12.5 feet from the face of curb. In the northbound direction, the modules were centered 14 feet from the face of curb.

The treatment was installed as part of a longer 4.7-mile project. The goal of the bicycle project was to provide a north-south connection between downtown Minneapolis and 58th Street West. The project corridor includes several bicycle facilities including a trail, bicycle and pedestrian bridges, a bicycle boulevard, conventional shared lane markings, and shared lane markings with intermittent colored background.

No intermittent colored background was applied between 40th Street West and 49th Street West due to a limited project budget. Intermittent colored background was applied between 49th Street West and 50th Street because it is a transitional block from a bicycle boulevard to a shared lane marking. Also, there is a steep grade in the northbound direction, so project staff believed intermittent colored background would provide value at that location.

The project was open for use in October, 2011.

The shared lane symbols were installed using ground-in poly preform tape. The green color was installed by applying latex paint with no glass beads to the roadway surface. With the original installation, the City of Minneapolis selected a dark green color. The green was repainted in 2012 with a brighter color. The colored background has not been repainted since 2012.

Typical: Lake Street West to 40th Street West, 49th Street West to 50th Street West (40')

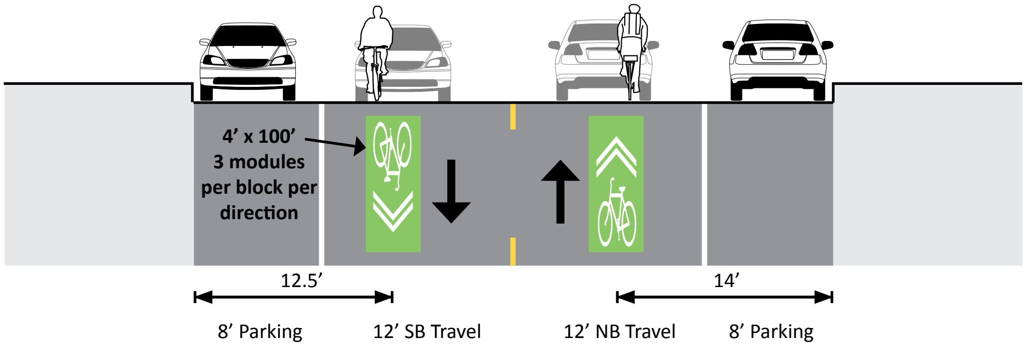


Figure 6-3: Typical cross section

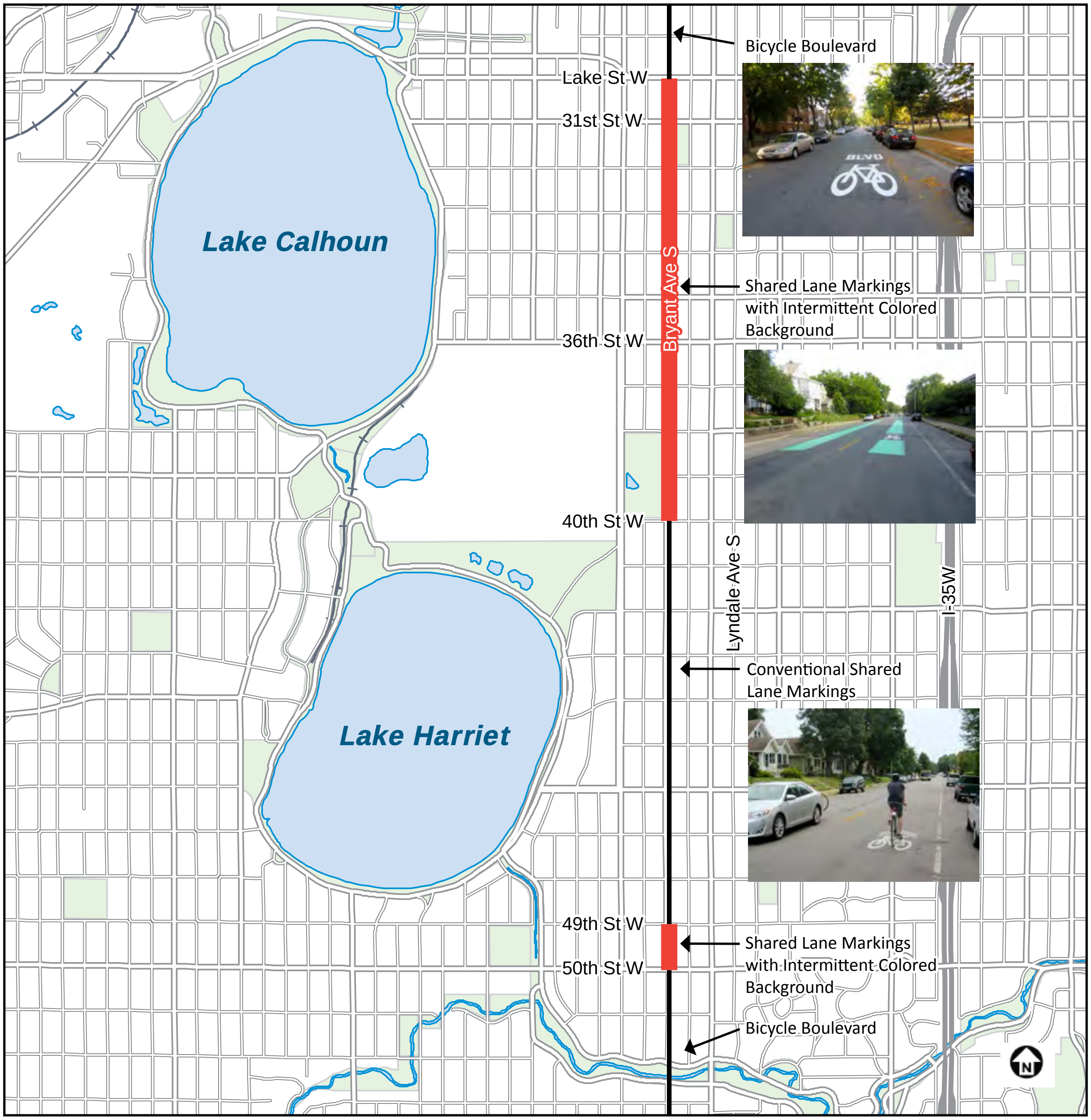


Figure 6-4: Project location

Figure 6-5: Bryant Avenue South facing north at 40th Street West in 2011 after installation with original intermittent colored background for shared lane markings

Figure 6-6: Bryant Avenue South facing north at 35th Street West after installation with updated intermittent colored background for shared lane markings

Figure 6-7: Traffic on Bryant Avenue South looking north at 39th Street West after installation

Figure 6-8: Bicyclist riding south on Bryant Avenue South at 38th Street West after installation

Figure 6-9: Motor vehicle traveling south on Bryant Avenue South at 35th Street West after installation

Figure 6-10: Metro Transit route 4 bus traveling south on Bryant Avenue South at 39th Street West after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the Bryant Avenue South evaluation, the measures of effectiveness are traffic volumes, reported crashes, user behavior, and user feedback. Except for user behavior 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 on the northern part of the corridor did not change substantially, while bicycle traffic on the southern part of the corridor did increase. At Lake Street West, bicycle traffic volumes were 1,190 bicyclists per day before the project was installed. After the project was installed traffic volumes ranged between 930 and 1,260 bicyclists per day. At 40th Street West bicycle traffic volumes were 210 before the project and increased to 390 after the project was installed.

Motor vehicle traffic volume remained flat. At 31st Street West, traffic volume was 3,100 vehicles per day before the project was installed and 3,000 after the project was installed. At 41st Street West, traffic volumes ranged between 1,800 and 3,000 vehicles per day. After installation the traffic volume was 1,800 vehicles per day. No motor vehicle data was collected during the three years after installation, so a 2015 count was used to represent after conditions.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 6-1: Daily traffic volumes

Type	Location (between)	Before			After			
		2009	2010	2011	2012	2013	2014	2015
Bicycle (EDT)	29th St W and Lake St W	1,190	-	-	1,160	1,260	930	-
	35th St W and 36th St W	-	-	-	-	-	730	670
	39th St W and 40th St W	210	-	-	390	-	-	-
	49th St W and 50th St W	-	-	-	160	-	-	-
Motor Vehicle (AADT)	31st St W and 32nd St W	3,100	-	3,100	-	-	-	3,000
	41st St W and 42nd St W	3,000	-	1,800	-	-	-	1,800
	48th St W and 49th St W	-	-	2,000	-	-	-	1,800

Crashes

During the three years before installation, there were 56 reported crashes, including 52 motor vehicle crashes, four bicycle crashes, and no pedestrian crashes. During the three years after installation, there were 44 reported crashes including 33 motor vehicle crashes, seven bicycle crashes, and four pedestrian crashes.

Table 6-2: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	52	33	-19
Bicycle	4	7	3
Pedestrian	0	4	4
Total	56	44	-12

The reason for the increase in bicycle and pedestrian crashes is not clear. Most crashes before-and-after the project was installed occurred at the intersection of Bryant Avenue South and Lake Street West which has the highest entering volumes of all intersections along the project corridor.

Before the project was installed, two of the four crashes occurred at the intersection of Bryant Avenue South and Lake Street West, one at 35th Street West, and one at 36th Street West. For two of the crashes, the bicyclist was cited for “failing to yield the right-of-way.” And in the other two crashes, the motorists were cited for “failing to yield the right-of-way.” There were no reported pedestrian crashes before the project was installed.

After the project was installed, there were seven bicycle crashes. Five of the crashes occurred at the intersection of Lake Street West, one at 35th Street West, and one at 39th Street West. Of the five crashes at Lake Street West, one involved a “dooring” crash of a bicyclist traveling east on Lake Street West. The other four crashes on Lake Street West involved various circumstances, all with impact areas in the center of the intersection. The crash at 35th Street West involved a motorist running a red light, and the crash at 39th Street West involved a motorist failing to yield the right-of-way at a stop sign.

After the project was installed, there were four pedestrian crashes. Three of the four crashes occurred at the intersection of Lake Street West and one at 36th Street West. All crashes involved motorists failing to yield the right-of-way to pedestrians while turning, and do not appear to be a factor of the project design.

User Behavior Monitored

User behavior was evaluated after installation by recording video on Bryant Avenue South. The video was recorded with a north facing camera located on Bryant Avenue South between 32nd Street West and 33rd Street West. Events tabulated include bicyclist location, motorist location, and bicyclist-motorist interactions.

After video was collected in August 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. Follow up field observations were conducted by City staff in July of 2013.

Figure 6-11: Screen capture of after video of Bryant Avenue South between 32nd Street West and 33rd Street West

Bicyclist Location

A total of 2,248 bicyclists were observed. Bicyclist location varied by direction of travel. More bicyclists rode over the shared lane marking that was offset 12.5 feet (southbound) from the face of curb than the shared lane marking that was offset 14 feet (northbound).

In northbound direction, one percent of bicyclists rode to the left of the shared lane marking, 24 percent rode over the shared lane marking, 75 percent rode to the right of the shared lane marking, and the remainder rode in the parking lane or on the sidewalk. In the southbound direction, two percent of bicyclists rode to the left of the shared lane marking, 51 percent rode over the shared lane marking, 46 percent rode to the right of the shared lane marking, and the remainder rode in the parking lane or on the sidewalk.

Both the two-proportion z-test and the chi-squared test show the bicyclist riding location is significantly related to shared lane marking offset.

Table 6-3: Bicyclist location August of 2012

Bicyclist Location (August of 2012)	Northbound (SLM offset 14')		Southbound (SLM offset 12.5')		Significance	
	Count	%	Count	%	P-value	Z-score
Left of shared lane marking	7	1%	19	2%	0.006	-2.7439
Over shared lane marking	286	24%	527	51%	0	-13.1851
Right of shared lane marking	898	75%	475	46%	0	14.0543
Parking Lane	4	<1%	0	0%	0.063	1.8624
Sidewalk	10	1%	22	2%	0.011	-2.5538
Total	1,205	100%	1,043	100%	-	-

Chi-Square = 205.1898, P-value < 0.00001

To understand the consistency of bicyclist behavior, follow up observations were collected. Field observations were conducted by Public Works staff positioned on Bryant Avenue South between 32nd Street West and 33rd Street West. Observations were conducted in July of 2013 and included one 12-hour weekday (6:30 a.m. to 6:30 p.m.). Only bicyclist behavior was recorded. No information about motorist behavior or bicyclist-motorist interactions were tabulated.

A total of 688 bicyclists were observed. Similar to the 2012 observations, bicyclist location varied by direction of travel. More bicyclists rode over the shared lane marking that was offset 12.5 feet (southbound) from the face of curb than the shared lane marking that was offset 14 feet (northbound). In the northbound direction, two percent of bicyclists rode to the left of the shared lane marking, 30 percent rode over the shared lane marking, 65 percent rode to the right of the shared lane marking, and the remainder rode in the parking lane or on the sidewalk. In the southbound direction, one percent of bicyclists rode to the left of the shared lane marking, 48 percent rode over the shared lane marking, 51 percent rode to the right of the shared lane marking, and the remainder rode in the parking lane or on the sidewalk.

Similar to the 2012 observations, the two-proportion z-test and the chi-squared test show the bicyclist riding location is significantly related to shared lane marking offset.

Table 6-4: Bicyclist location July of 2013

Bicyclist Location (July of 2013)	Northbound (SLM offset 14')		Southbound (SLM offset 12.5')		Significance	
	Count	%	Count	%	P-value	Z-score
Left of shared lane marking	7	2%	2	1%	0.156	1.4173
Over shared lane marking	120	30%	139	48%	0.001	-3.3967
Right of shared lane marking	260	65%	145	50%	0.016	2.4059
Parking Lane	8	2%	0	0%	0.009	2.6052
Sidewalk	4	1%	3	1%	0.884	0.1456
Total	399	100%	289	100%	-	-

Chi-Square = 18.1105, P-value = 0.001174

In August of 2012, the number of parked motor vehicles in the adjacent parking lane was tabulated in coordination with the bicyclist location observations. As parking demand (volume/capacity) in the adjacent parking lane increased, more bicyclists rode over the shared lane markings. When the parking demand was lower than 50 percent, more bicyclists rode to the right of the shared lane marking or in the parking lane.

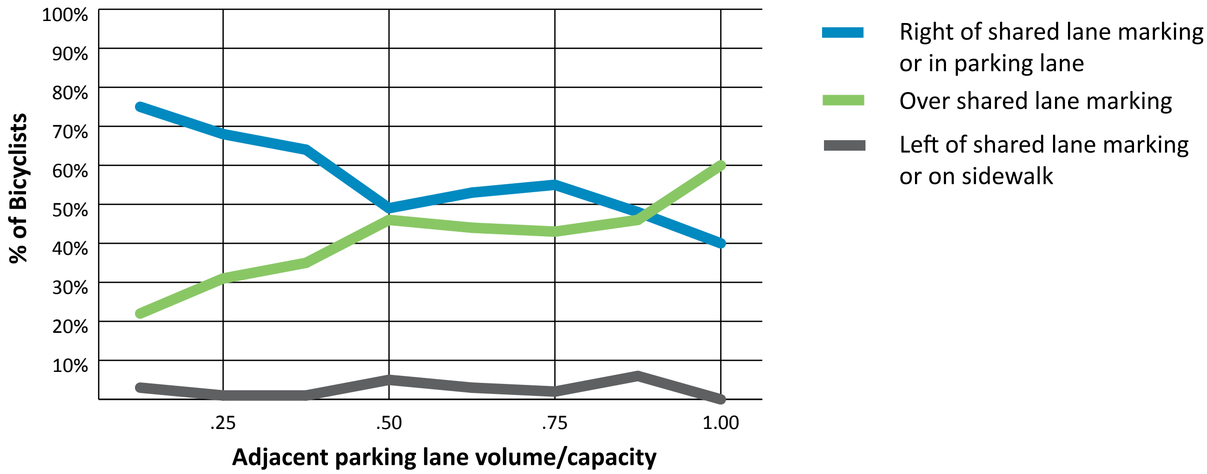


Figure 6-12: Bicyclist riding location and parking lane volume/capacity

Motorist Location

A total of 2,740 motorists were observed. When no oncoming vehicles were present, 92 percent of motorists drove within their respective travel lane and eight percent encroached in the oncoming lane. Most of the vehicles encroaching into the oncoming lane were overtaking a bicyclist traveling in the same direction. When an oncoming vehicle was present, all observed motorists drove within the travel lane and none were observed encroaching into the oncoming lane.

Both the two-proportion z-test and chi-squared test show the presence of oncoming vehicles had a significant relationship to motorist location at the 99% confidence interval.

Table 6-5: Motor vehicle location

Motorist Locations	Absence of Oncoming Vehicles		Presence of Oncoming Vehicles		Significance	
	Count	%	Count	%	P-value	Z-score
Travel lane	2,059	92%	512	100%	0	-6.4335
Encroached into oncoming lane	169	8%	0	0%	0	6.4335
Total	2,228	100%	512	100%	-	-

Chi-Square = 41.3895, P-value < 0.00001

Bicyclist-Motorist Interactions

After the enhanced shared lane markings were installed, 235 events were observed involving bicyclist-motorist interactions. In the absence of oncoming vehicles, 97 percent of vehicles passed bicyclists “safely” and three percent did not pass “safely.” In the presence of oncoming vehicles, 93 percent of motorists passed bicyclists “safely,” and seven percent did not pass “safely.”

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 clearance when overtaking a bicyclist. This definition is generally 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 of clearance, when passing the bicycle or individual.” It should be noted that due to camera angle and clarity of the video, measurements were estimated based on tick marks in the roadway and were measured from the outside edge of the bicyclist (person on a bicycle) to the outside edge of the motor vehicle tire. The estimated distance did not account for the width of vehicle mirrors.

Both the two-proportion z-test and chi-squared test show the presence of oncoming vehicles does not have a significant relationship to bicyclist-motorist interactions.

Table 6-6: Bicyclist-motorist interactions

Passing Interactions	Absence of Oncoming Vehicles		Presence of Oncoming Vehicles		Significance	
	Count	%	Count	%	P-value	Z-score
Safe Pass	159	97%	66	93%	0.164	1.3927
Unsafe Pass	5	3%	5	7%	0.164	-1.3927
Total	164	100%	71	100%	-	-

Chi-Square = 1.9395, P-value = 0.163723

User Feedback

User feedback was solicited through an intercept survey for bicyclists and motorists.

Public Works recruited people to take the bicyclist survey in the field. Staff handed out survey cards to bicyclists waiting at a red semaphore at the intersection of Bryant Avenue South and Lake Street West and the intersection of Bryant Avenue South and 36th Street West. A total of 92 survey cards and one printed survey were distributed over a 10-hour period, resulting in 37 valid responses.

For the motorist survey, staff placed survey cards on the windshield of parked vehicles along Bryant Avenue South between 26th Street West and Minnehaha Parkway. Survey distribution occurred over a weeknight. A total of 685 cards were distributed, resulting in 112 valid survey responses.

The 21-question surveys were intended to take 10 minutes or less to complete. The bicyclist survey was available in an online or printed format while the motorist survey was only available in an online format. See Chapter 2 for additional information about the survey methods.

Table 6-7: Survey response rates by user group

Survey Type	Distributed	Valid Responses	Response Rate
Bicyclist	93	37	40%
Motorist	685	112	16%

In both surveys, participants were shown a photo of the shared lane markings with intermittent colored background on Bryant Avenue South and asked to state the intended purpose of the roadway marking. To not influence responses, the question was opened ended, and participants wrote or typed into a blank field. Staff categorized responses based on content or common themes. Many participants provided responses that included multiple purposes.

Both the bicyclist survey and motorist participants provided responses that generally align with the purpose stated in the MMUTCD. Stated purposes include: to recommend a riding area of bicycle traffic, to increase awareness of bicycle traffic, and identify a bicycle route. Some bicyclists and motorists identified the purpose was to mark a bicycle lane. It is not known whether this is intended to mean a dedicated bicycle lane or shared lane.

Table 6-8: Stated purpose of markings

Stated Purpose (Staff Tabulated Category)	Frequency of stated purpose		
	Bicyclist Survey	Motorist Survey	Total
Increase awareness of bicycle traffic	14	41	55
Indicate lane for bicycle traffic	9	17	26
Indicate recommended riding area for bicycle traffic	8	8	16
Identify a bicycle route	4	18	22
Communicate that motorists should yield to bicycle traffic	4	15	19
Don't know/confused	0	13	13
Other	17	36	53
Total	56	148	204

Survey participants were also asked if they had any general feedback about the recent changes to Bryant Avenue South. Some participants indicated that they both ride a bicycle and drive on Bryant Avenue South.

The general feedback from bicyclists was that the markings provide awareness to motorists about bicycle traffic on Bryant Avenue South. However, many participants stated the markings have done little to affect motorists speeds or behavior. Given the high volumes of traffic and buses, many bicyclists stated that they would prefer a dedicated bicycle lane.

Table 6-9: Select feedback from bicyclist survey

Select feedback from bicyclist survey
"I did not know that the different symbols [bicycle boulevard, shared lane markings, and green shared lane markings] meant something specific. I assumed they were only to increase motorist awareness."
"I like the attention the green markings make to motorists and bicyclers stating clearly it's a designated bicycle route. With this everyone should still pay attention and be courteous and share the road."
"The new brighter color is much better. It will always concern me though that I have to share that road with commuters and buses. I wish more could be done to make car traffic choose a different route."

The general feedback from motorists was that the markings are confusing. Many motorists expressed confusion about how to drive around the shared lane markings with and without the presence of a bicyclists. There was a general theme that motorists did not prefer to be sharing a lane with bicycle traffic.

Table 6-10: Select feedback from motorist survey

Select feedback from motorist survey
"I'm honestly unsure of exactly what the green markings mean. It seems most bicyclers ride on the far right making it easy to pass--if they are supposed to ride in the green lane, I would be unsure how or if I could go around them as a motorist."
"Bryant Ave South is a HEAVY bus traffic street with buses going way too fast for a residential area. In front of our house buses can be going both up and down the hill at twice the speed limit. Adding bicycles now has made it even more stressful to drive and live on. Highly suggest that bus traffic is moved to Lyndale and leave the bicyclist's on Bryant--this residential street should not have both."
"I'm both a bicycler and a motorist and in both instances prefer bicycle lanes that allow cars to pass by safely without having to go around bicyclers. In other words, both bicycles and cars should have their own lanes."

Conclusions

The evaluation of intermittent colored background for shared lane markings had mixed results. The project installed a modified shared lane treatment that raised awareness of bicycle traffic on Bryant Avenue South, although the treatment did not appear to influence the lateral positioning of bicyclists. Most bicyclists did not prefer a shared lane bicycle treatment and many motorists also expressed a desire to not share a lane with bicycle traffic. Due to the evaluation design it is not possible to know the effectiveness of intermittent colored background for shared lane markings over conventional shared lane markings or no markings in the same context.

During the three years before installation, there were 56 reported crashes, including 52 motor vehicle crashes, four bicycle crashes, and no pedestrian crashes. During the three years after installation, there were 44 reported crashes including 33 motor vehicle crashes, seven bicycle crashes, and four pedestrian crashes. According to police reports, the bicycle and pedestrian crashes occurred under circumstances that do not appear to be a factor of the project design.

Evaluation of user behavior was limited to after installation. Most motorists used the road as intended, although the effect of the enhanced shared lane markings is not known since only after behavior was observed. Over half of bicyclists did not use the treatment as intended and chose to ride between the green area and parked vehicles or curb. This behavior was more prevalent in the northbound direction (shared lane marking offset 14 feet from the face of curb) than the southbound direction (shared lane marking offset 12.5 feet from the face of curb). When no parked vehicles were present, more bicyclists were observed riding closer to the curb.

User feedback was mixed. Most bicyclist survey participants believed the markings provided more awareness of bicycle traffic to motorists. However, they believe markings have little effect on motorist behavior and perceived speeds. Many bicyclists stated that a dedicated bicycle lane would be preferred on a street with frequent bus service and high volumes of motor vehicle traffic. Motorists expressed confusion about how to drive on Bryant Avenue South with the markings as well as how to drive around bicyclists, although this confusion was not reflected in the user behavior or in reported crashes. Many motorists stated that they did not prefer to be sharing a lane with bicycle traffic.

Based on this evaluation, Public Works believes shared lane markings – even markings enhanced with color – installed on long segments with transit and higher volumes of motor vehicles do not provide an optimal experience for people bicycling or people driving. Future applications may be considered to provide guidance or increase awareness on short, constrained segments. However, there should not be the expectation that a shared lane marking will be used as intended or serve as a substitute for the experience of a dedicated bicycle facility.

While the Bryant Avenue South project may provide added awareness of bicycle traffic, Public Works has not repainted the green since 2012. At the time of the writing of this report in 2016, the green along the corridor is nearly all faded. Maintenance of the green was time intensive taking over two full weeks of staff time in 2011 and again in 2012. More durable markings have been evaluated but have not been determined to be cost effective at the corridor level. The conventional shared lane markings remain in place and are still visible. This segment of Bryant Avenue South is programmed for a full reconstruction in the City's Five-Year Capital Improvement Program in 2020. Alternative bikeway designs may be explored as part of that project.

Figure 6-13: Bicyclists ride on Bryant Avenue South in fall of 2014

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.

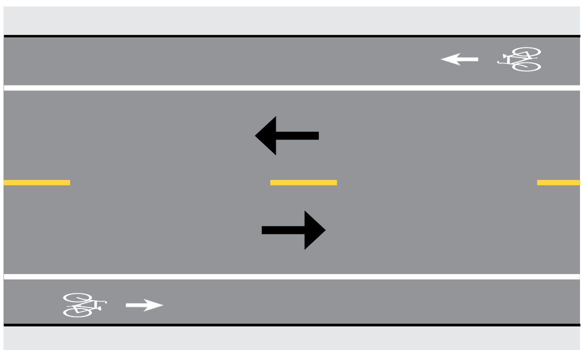


Figure 7-1: Conventional bicycle lanes on a two-way street with a marked center line

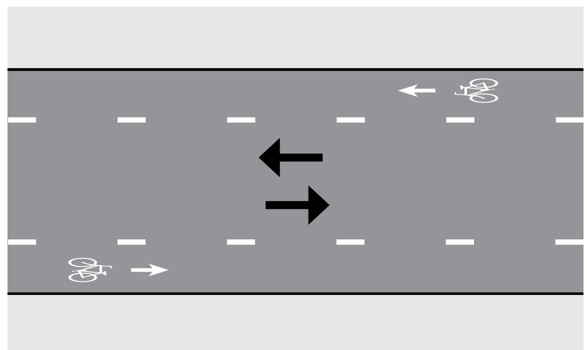


Figure 7-2: Advisory bicycle lanes on a two-way street with no marked center line

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

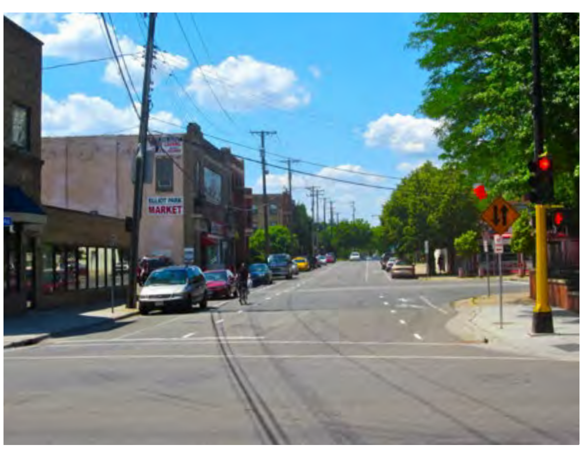


Figure 7-7: 14th Street East facing west at Chicago Avenue South after installation with a 14-foot two-way travel lane

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

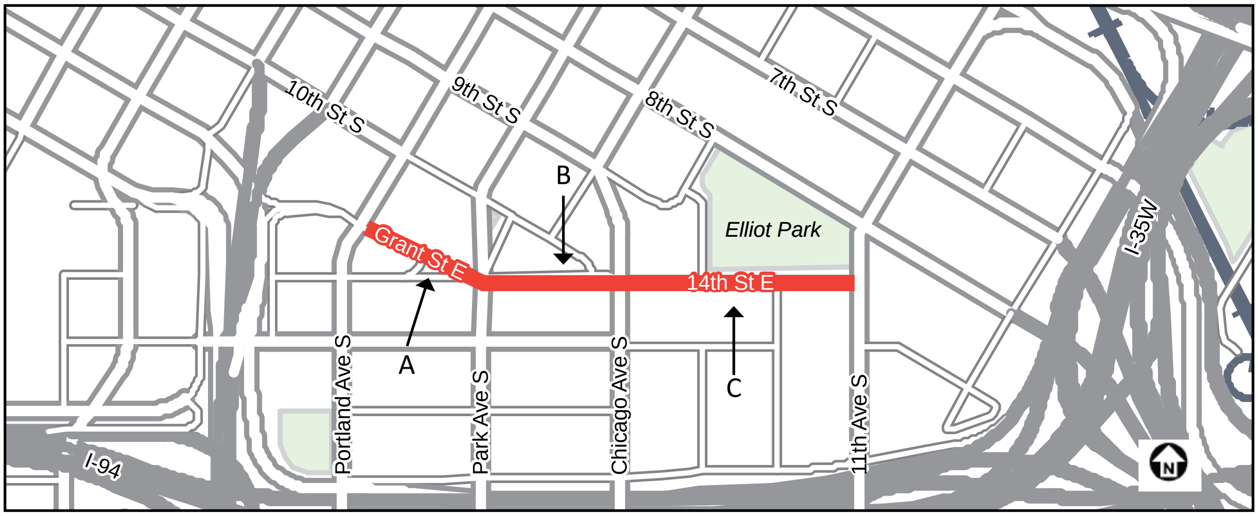
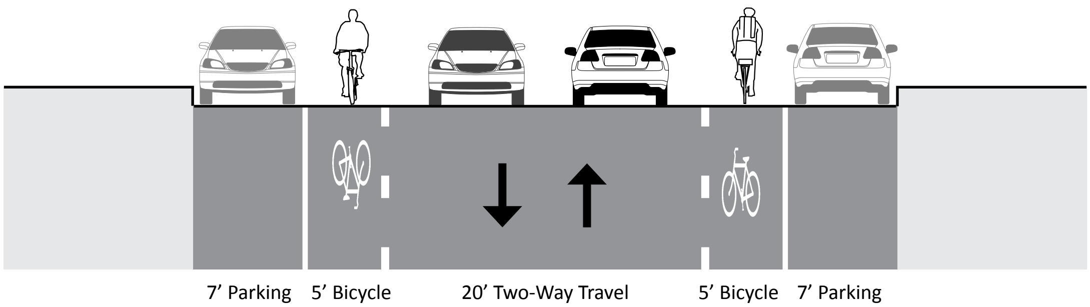
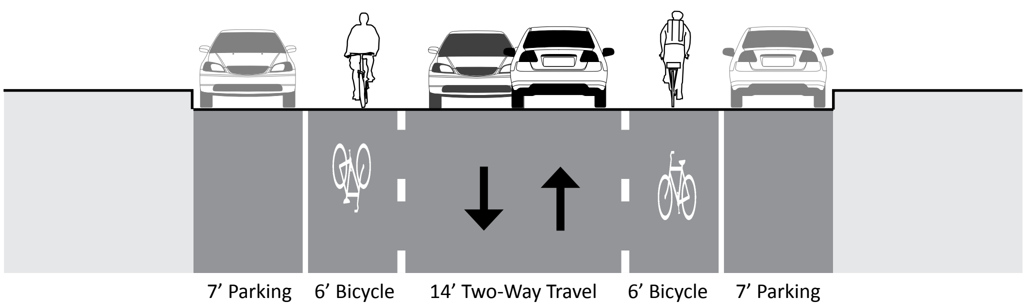


Figure 7-15: Project location

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')

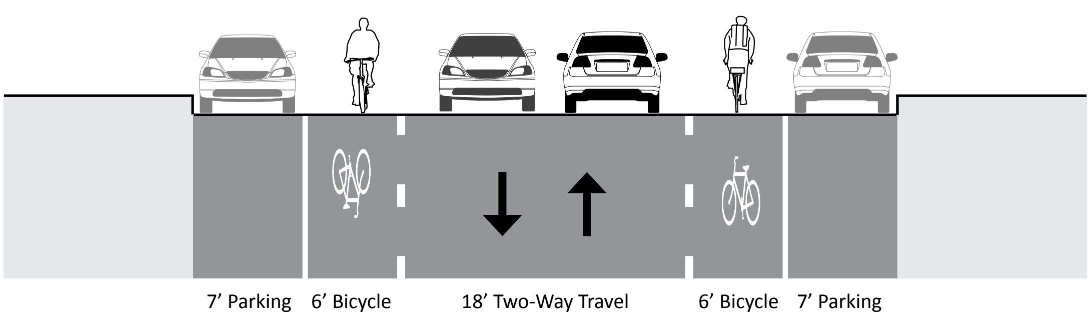


Figure 7-16: Typical cross sections

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

<u>Bicyclist Location</u>

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 14^{th} 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 14^{th} 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 14^{th} Street East at Chicago Avenue South

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

Chapter 8

Bicycle Signal Indications

Project Location:
5th Street Northeast at Broadway Street Northeast

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

A bicycle signal indication is a variation of a conventional signal indication or semaphore. A bicycle signal indication consists of an illuminated red, yellow, or green bicycle symbol in lieu of a conventional red, yellow, or green ball signal indication. Bicycle signal indications are operated as part of a phased semaphore system, facilitating safe and non-conflicting movements of different legs of an intersection of roadways.

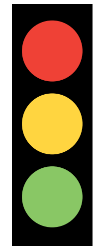


Figure 8-1: Conventional red, yellow, green ball signal indications and signal head

A bicycle signal indication recognizes that bicycle traffic may have different travel speeds, need to access different areas of the roadway, or need different movements through an intersection. A bicycle signal indication may be warranted if a conventional red, yellow, or green ball indication or a pedestrian indication does not meet the needs of bicycle traffic or create potential conflicts between modes that can be mitigated through separate signal phasing.

Figure 8-2: Red, yellow, green bicycle signal indications and signal head

At the time of implementation, bicycle signal indications were considered by FHWA to be experimental. In December of 2013, FHWA issued an interim approval for the Optional Use of Bicycle Signal Indications (IA-14). Due to concurrent southbound bicycle and motor vehicle phases, this experiment (approved by FHWA in 2010) is not fully consistent with the optional use of a bicycle signal indications. The use of compliant and experimental bicycle signal indications is currently used in many U.S. cities.

Project Location

The project location is at the intersection of 5th Street Northeast and Broadway Street Northeast. The installation is northeast of downtown Minneapolis along the intersection of the orthogonal street grid and the historic angled street grid. Surrounding land uses include single-family houses.

Prior to implementation, 5th Street Northeast and Broadway Street Northeast was a three-leg “T-intersection” with a concrete diverter disconnecting the south leg of the intersection. To establish a continuous north-south bicycle boulevard along 5th Street Northeast, the existing concrete diverter was opened to allow for bicycle passage and crossing of Broadway Street Northeast. Fifth Street Northeast north of Broadway Street Northeast had an estimated AADT of 500 vehicles per day and Broadway Street Northeast had an AADT of 16,000. No regular transit routes operate on these streets.

The goal of the bicycle project was to install a bicycle boulevard on 5th Street Northeast and provide a safe crossing at Broadway Street Northeast. An important consideration for bicycle boulevards is to provide bicyclists with safe and convenient crossings of major arterials. Broadway Street Northeast is four lanes wide with an AADT of 16,000. At the time of project development, the four lanes were determined to be warranted, and a four lane to three lane conversion was not recommended. Existing traffic signals were located two blocks to the east at Washington Street Northeast and two blocks west at University Avenue Northeast. Detouring the bicycle boulevard two blocks was not seen as a convenient option for bicyclists. To establish a safe and convenient crossing, a new traffic signal was explored at 5th Street Northeast.

An intersection evaluation was conducted to document the existing number of traffic gaps available for safe bicycle and pedestrian crossings. The study found the average delay for pedestrians to be between three and 10 minutes and the average delay for bicyclists to be greater than one minute. To enhance safety and reduce delay for pedestrians and bicyclists, a traffic signal was proposed at this location. Because of the difference in time required to cross the full street width between a pedestrian and a bicyclist, it was undesirable and inefficient to require the bicyclist to cross on a pedestrian interval. In addition, the northbound roadway approach would only facilitate bicycle traffic because the concrete diverter would only be open to bicycle traffic. It was desired to locate the bicycle curb cut with the alignment of the bicycle facility on 5th Street Northeast and separate the bicycle and pedestrian movements.

The original signal operation was as follows:

- Semi-actuated control (southbound motor vehicle approach and bicycle phase actuated).
- Interconnected and coordinated operation with Broadway Street Northeast/Washington Avenue Northeast Broadway Street Northeast/University Avenue Northeast (next adjacent signal systems two blocks to the east and west, respectively).
- Exclusive bicycle phase, activated by a push button. Push buttons, placed adjacent to the curb, were readily accessible to bicyclists in the street. Clearance time was increased from the typical five seconds to seven seconds.
- Southbound bicyclists operate on both the exclusive bicycle phase and concurrent with southbound motor vehicle phase. A 12-inch bicycle signal head was mounted next to the pedestrian head.
- Pedestrian crossing intervals with countdown timers were provided for crossing the east, west and north legs of the intersection.

The project was open for use in November, 2011.

Initial feedback from bicyclists and pedestrians crossing at the signal was negative due to the long delay. The average delay was measured by staff to be between 45 and 60 seconds. The delay was a factor of the coordinated operation with the intersection of Broadway Street Northeast and Washington Avenue Northeast and the intersection of Broadway Street Northeast and University Avenue Northeast. Upon further evaluation and testing, it was decided to operate the 5th Street Northeast and Broadway Street Northeast signal free from coordination, so that when the northbound and southbound signal is actuated by any mode, the eastbound and westbound phase immediately counts down the minimum pedestrian clearance phase. If a northbound or southbound user actuates the signal, the delay is approximately 10 seconds. This operation has been in place since June 28, 2012.

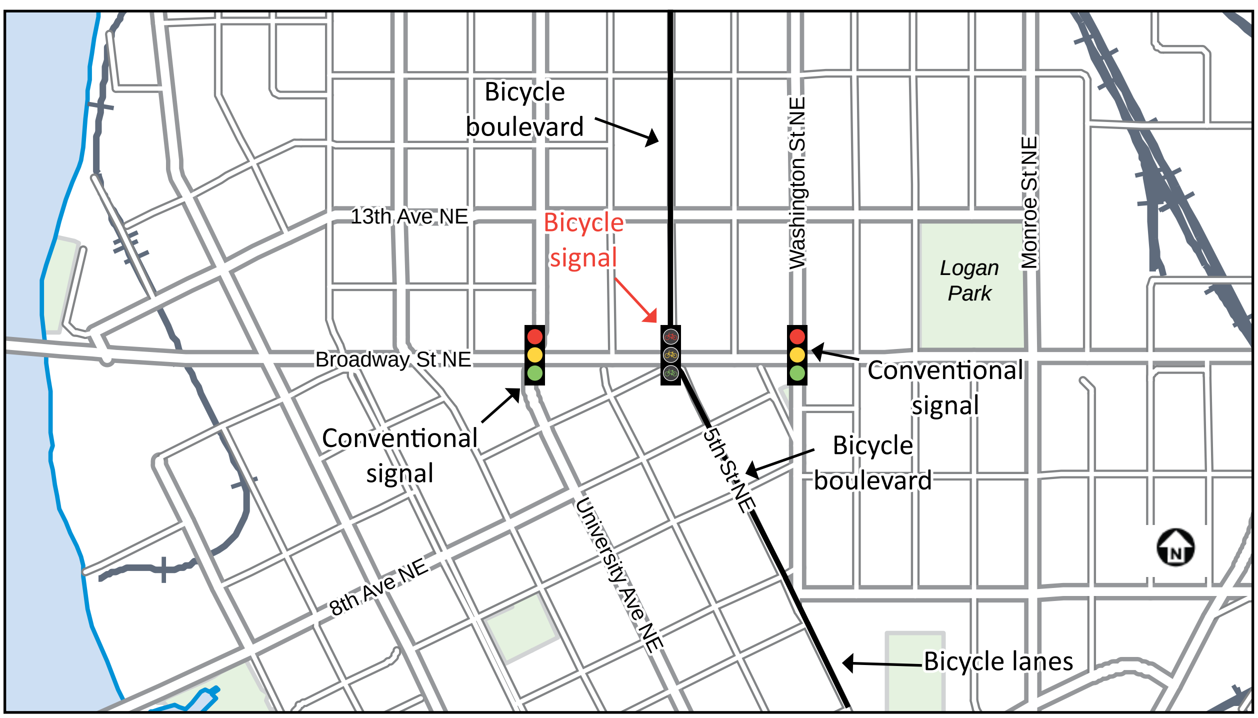


Figure 8-3: Project location

Figure 8-4: 5th Street Northeast approaching Broadway Street Northeast from the north after installation

Figure 8-5: 5th Street Northeast approaching Broadway Street Northeast from the south after installation*

Figure 8-6: Southbound bicyclist and passenger actuating the bicycle phase to cross Broadway Street Northeast after installation

Figure 8-7: Two northbound bicyclists waiting for the green bicycle phase to cross Broadway Street Northeast after installation

Figure 8-8: 12-inch signal heads and "Bicycle Signal" signing on southbound 5th Street Northeast approach at Broadway Street Northeast after installation

Figure 8-9: 12-inch signal heads and "Bicycle Signal" signing on northbound 5th Street Northeast approach at Broadway Street Northeast after installation

*5th Street Northeast between 8th Avenue Northeast and 9th Avenue Northeast is a one-way street southbound for motor vehicle traffic. Bicycle traffic is permitted to travel northbound on 5th Street Northeast between 8th Avenue Northeast and 9th Avenue Northeast in order to access the crossing at Broadway Street Northeast. This unique operation is signed on either ends of the 800 block of 5th Street Northeast.

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the 5th Street Northeast and Broadway Street Northeast evaluation, the measures of effectiveness are traffic volumes, reported crashes, user behavior, and user feedback. Except for user behavior and user feedback, all measures include before and after monitoring.

The before period includes November 1, 2008 through October 31, 2011. The after period includes November 1, 2011 to October 31, 2014. For simplicity of presentation, before conditions are listed from 2009 to 2011 and after conditions from 2012 to 2014. It should be noted the bicyclist cut through was accessible and open to bicycle traffic in October of 2011, although the signal was not operational until early December of 2011.

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

Results

Traffic Volumes

Initially, bicycle traffic increased slightly after the project was installed from 100 to 110 bicyclists per day. However, the initial after count in 2012 was conducted in inclement weather. An additional 2015 count conducted in fair weather observed 290 bicyclists per day.

Motor vehicle traffic increased after the project was installed from 14,000 to 19,300 vehicles per day. The increase is likely attributed to the closure of Plymouth Avenue Bridge during the 2013 count, which is approximately a half mile south of Broadway Street Northeast.

Table 8-1: Daily traffic volumes

Type	Location (Between)	Before			After			
		2009	2010	2011	2012	2013	2014	2015
Bicycle (EDT)	5th St NE north of Broadway St NE	100	-	-	110	-	-	290
Motor Vehicle (AADT)	Broadway St NE east of 5th St NE	14,000	-	-	-	19,300	-	-

Reported Crashes

During the three years before installation, there were five reported crashes, including four motor vehicle crashes, one bicycle crash, and no pedestrian crashes. During the three years after installation, there were no reported crashes.

The bicycle crash before the project was installed involved a bicyclist and motorist both traveling westbound on Broadway Street Northeast. The four motor vehicle crashes involved vehicles traveling eastbound or westbound on Broadway Street Northeast.

Table 8-2: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	4	0	-4
Bicycle	1	0	-1
Pedestrian	0	0	0
Total	5	0	-5

User Behavior Monitored

User behavior was evaluated after installation by recording video at the intersection of 5th Street Northeast and Broadway Street Northeast. The video was recorded with a north-facing camera located at 5th Street Northeast south of Broadway Street Northeast. Events tabulated included bicyclist crossing behavior, pedestrian crossing behavior, bicyclist delay, pedestrian delay, and motorist behavior.

After video was collected in August, 2012 after the signal was removed from coordination. A total of 72 hours of video were processed over three weekdays.

Figure 8-10: Cropped screen capture of after video at the intersection of 5th Street Northeast at Broadway Street Northeast

<u>Bicyclist Behavior</u>

A total of 568 bicyclists were observed crossing Broadway Street Northeast. Fifty-eight percent of bicyclists crossed without actuating the button, 38 percent actuated the bicycle push button, and four percent actuated the pedestrian push button. Most bicyclists who did not actuate either of the push buttons crossed Broadway Street Northeast on a red indication. Others crossed on a green indication or walk indication due to prior actuation from a motorist, pedestrian, or other bicyclist. Most bicyclists actuating the bicyclist push button were observed approaching from the street, while most bicyclists actuating the pedestrian push button approached from a sidewalk location.

Table 8-3: Bicyclist behavior

	No Actuation		Actuated Bicyclist Push Button		Actuated Pedestrian Push Button		Total	
Approached on green/walk	40	7%	1	<1%	0	0%	41	7%
Cross on red	265	47%	14	2%	1	0%	280	49%
Wait for green	19	3%	156	27%	19	3%	194	34%
Quick start	5	1%	45	8%	3	1%	53	9%
Total	329	58%	216	38%	23	4%	568	100%

<u>Pedestrian Behavior</u>

A total of 161 pedestrians were observed crossing Broadway Street Northeast. Forty-three percent of pedestrians crossed without actuating the button, seven percent actuated the bicycle push button, and 50 percent actuated the pedestrian push button. Most pedestrians who did not actuate either of the push buttons crossed Broadway Street Northeast on a red indication. Others crossed on green or walk due to prior actuation from a motorist, bicyclist, or other pedestrian.

Table 8-4: Pedestrian behavior

	No Actuation		Actuate Bicyclist Button		Actuate Pedestrian Button		Total	
Approached on green/walk	6	4%	0	0%	0	0%	6	4%
Cross on red	59	37%	0	0%	7	4%	66	41%
Wait for green	2	1%	10	6%	62	39%	74	46%
Quick start	2	1%	1	1%	12	7%	15	9%
Total	69	43%	11	7%	81	50%	161	100%

Bicyclist and Pedestrian Delay

Delay was measured for bicyclists and pedestrians crossing Broadway Street Northeast. The average delay for bicyclists was just under 11 seconds. The majority of bicyclists exhibited either no delay or a delay of approximately 10 seconds, consistent with the required time for the permissive green to be given to 5th Street Northeast. Instances of no delay are generally attributed to either arriving to the intersection while 5th Street Northeast has a permissive green, or crossing over a non-permissive (red indication) phase to take advantage of a gap in traffic on Broadway Street Northeast. The maximum observed delay was 33 seconds. This level of delay coincided with a crossing bicyclist arriving when the bicycle signal turned yellow, requiring the cyclist to wait through the minimum green time of Broadway Street Northeast before receiving a green bicycle indication.

Table 8-5: Bicyclist and pedestrian delay

User	Before (Signal Study Warrant)	After	
	Average Delay (sec)	Number of Crossings	Average Delay (sec)
Bicyclists	180	568	10.9
Pedestrians	600	189	9.0
All	-	757	10.5

Bicyclist-Motorist Interactions and Motorist Compliance

No improper use of the bicycle signal by motorists was observed. Four events were observed where a bicyclist interacted with a southbound left turning motorist were recorded. During each event, the motorist yielded to the crossing bicyclist before turning.

User Feedback

User feedback was solicited through an intercept survey for bicyclists and also through signs encouraging users to call Minneapolis 311 to comment.

Survey

Public Works recruited people to take the bicyclist survey in the field. Staff handed out survey cards to bicyclists waiting at a red semaphore at the intersection of 5th Street Northeast and Broadway Street Northeast. A total of 71 cards were distributed over a 10 hour-period, resulting in 27 valid responses. The survey was 24 questions, intended to take 10 minutes or less to complete, and available in an online or printed format. See Chapter 2 for additional information about the survey methods.

Table 8-6: Survey response rates

User Group	Distributed	Valid Responses	Response Rate
Bicyclist survey	71	27	38%

In the survey, participants were shown separate photos of red, yellow, and green ball indications and asked the message of each indication. Nearly all participants correctly identified the symbols, although there was some mix of responses for yellow indications. Participants were also shown separate photos of red, yellow, and green bicycle indications and asked the message of each indication. Nearly all participants correctly identified the symbols, although similar to the conventional ball indications, there was some mix of responses for the yellow indications.

Survey participants were also asked a series of questions about the signal timing. Nearly all participants thought the time to cross Broadway Street Northeast is reasonable, although approximately half stated that the wait was sometimes long enough to cause them to disregard the signal and cross Broadway Street Northeast while the bicycle signal was still red. Over half of participants noted that the wait time to cross Broadway Street Northeast recently decreased.

Table 8-7: Perceived wait time to cross Broadway Street Northeast

If you press the push button for the bicycle signal, how long is the wait before the green bicycle signal comes up?	Count	%
The wait is too long	0	0%
The green signal comes up too quickly	0	0%
The wait is reasonable	25	93%
Don't know	2	7%
Total	27	100%

Table 8-8: Perceived wait time to cross Broadway Street Northeast and compliance

Has the wait ever been long enough to cause you to disregard the signal and cross Broadway Street Northeast while the bicycle signal was still red?	Count	%
Yes	13	48%
No	11	41%
Don't know	3	11%
Total	27	100%

Table 8-9: Perceived changes to wait time to cross Broadway Street Northeast and compliance

Have you noticed any difference in the wait time at the signal?	Count	%
Yes, the wait time for bicycles has increased recently.	1	4%
Yes, the wait time for bicycles has decreased recently.	15	56%
No, I have not noticed a difference.	8	30%
Don't know	3	11%
Total	27	100%

Table 8-10: Select feedback from bicyclist survey

Select feedback from bicyclist survey
"It's great! It's nice to be able to cross Broadway in a timely fashion, and to have the curb cuts on the south side of the street to proceed through smoothly."
"At first the bicycle button didn't seem to work well. It sometimes would trigger the signal to change, but then wouldn't fully change. Other times it was unresponsive. Now, however, it works great!"
"I had stopped using this intersection because the signal wasn't working. I just re-used it yesterday and was able to see the adjustments that have been made. The signal worked quickly when I pushed the button. I will start using this intersection on a regular basis again. Thank you for the improvements to my neighborhood."

Minneapolis 311 Feedback

Minneapolis 311 signs were installed August-September of 2012. A total of 11 comments were received by emails to Minneapolis 311 or phone calls to Minneapolis 311 operators. Six comments were negative indicating additional delay or observed bicyclists violations. Four positive comments were received indicating a safer crossing or route and one neutral comment was received.

Table 8-11: Select feedback from Minneapolis 311

Select feedback from Minneapolis, the customer says:
"The new traffic light is creating more traffic problems than ever. It is routing commercial vehicles through residential streets, causing congestion and forcing motorists to make risky moves to get through back-ups."
"[The customer] does not like the new signal. There are many signals within close proximity. Now has to leave for work 2 minutes earlier."
"Great Idea! As a motorist and a biker it's a great idea to get the bikes off the busy streets."

Conclusions

The evaluation of bicycle signal indications on 5th Street Northeast at Broadway Street Northeast found positive effects on the safety and operations of the street. The bicycle boulevard, cut through, and new traffic signal facilitated a new crossing of a multilane, high volume roadway. The use of bicycle signal indications was found to be appropriate in this context, and no new operational or safety issues emerged as a result of the installation. However, due to the nature of the installation and the evaluation design, it is not possible to know the full effectiveness of bicycle signal over conventional signal indications in the same context.

The nature of the intersection 5th Street Northeast and Broadway Street Northeast changed substantially from a three-legged unsignalized intersection to a four-legged signalized intersection. After the installation of the project and bicycle indications, no crashes of any type were observed at the intersection.

Evaluation of user behavior was limited to after installation. While the new network connection saw increases in bicyclist volumes, only 42 percent of bicyclists were observed actuating either the bicyclist or pedestrian push buttons. Over half of bicyclists crossed Broadway Street Northeast without actuating either the bicyclist or pedestrian push button. No apparent safety issues were observed when bicyclists crossed on red. All motorists were observed using the signal as intended.

User feedback from bicyclists was generally positive, and comprehension of the bicycle signal indications was high. Nearly all bicyclist survey participants believed the wait for green was reasonable, although about half stated they have disregarded the signal when the wait was long. About half of bicyclist survey participants noticed a recent improvement in the signal timing.

Public Works plans to maintain the signal as it is providing value to bicyclists and pedestrians traveling on the 5th Street Northeast, and no related safety or operational issues have been observed. It may be valuable to conduct follow up observations to understand the circumstances under which some users choose not to actuate the push button.

As of 2016, Public Works has seven other bicycle signal indication installations in Minneapolis. Some required additional experimentation approvals, while some are compliant with the interim approval. Public Works is monitoring all locations to understand the effectiveness in different contexts.

Chapter 9

Travel Lane Width on a Two-Way Street

Project Location:
Bloomington Avenue South between 60th Street East and City of Minneapolis limits

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-022

Design Element Involved

Design Standard the Exception is from:

Minnesota State Statute 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects, Subpart 1. Two-way streets

Design Element(s) Involved:

Travel lane width, bicycle lane width

Required Standard:

Minnesota State Aid design standard 8820.9951 states: "When creating a multimodal design with a combination of vehicle lane, parking lane, and bikeway lane widths, if a vehicle lane width of less than 11 feet is used, the parking and bikeway lanes shall be at least one foot wider than the minimum widths."

"In Lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes along Bloomington Avenue South, two 10-foot travel lanes and two five-foot bicycle lanes were proposed in lieu of two 10-foot travel lanes and two six-foot bicycle lanes.

Bloomington Avenue South is a two-way, two-lane collector street with AADT<10,000 vehicles per day and a design speed of 30 mph. Under the required standard, travel lanes less than 11 feet on Bloomington Avenue South would require minimum bicycle lane widths of six feet. To achieve a design consistent with MSA standards, the roadway would need to be 32 feet wide, or two feet wider than the existing 30 feet.

Upon application, an exception was granted for this configuration

Table 9-1: Required standard and "in lieu of" design

Design Element	Southbound		Northbound		Total
	Bicycle	Travel	Travel	Bicycle	
Required Standard	6'	10'	10'	6'	32'
"In Lieu of" Design	5'	10'	10'	5'	30'

Project Location

The project location is on Bloomington Avenue South between 60th Street East and the Minneapolis-Richfield city border. This project is approximately 0.15 miles, or one long block. Surrounding land uses and destinations include single-family homes and a neighborhood park. Part of the project includes a bridge over MN-62.

Bloomington Avenue South is 30 feet wide and operates as a two-way street. Prior to installation, the cross section included a travel lane in each direction. A double yellow center line extended the length of the corridor. The street had an AADT of 4,000 with a posted speed limit of 30 mph. Metro Transit bus route 14 operates on this segment of Bloomington Avenue South with an average headway of 15-30 minutes. Bloomington Avenue South is on the MSA system in Minneapolis.

The goal of the bicycle project was to provide a north-south connection along Bloomington Avenue South to connect Minneapolis with the neighboring city of Richfield. Due to the motor vehicle traffic volumes, a preferential bicycle lane was desired. However, to establish a dedicated bicycle lane and meet MSA design standards, the bridge deck would need to be widened. This was determined not to be feasible within the scope of the signing and striping project. The recommended design was two five-foot bicycle lanes and two 10-foot travel lanes. The project connects on the north to a bicycle boulevard on 12th Avenue South and on the south to bicycle lanes in Richfield.

The project was open for use in October, 2012, but was removed in July, 2015. The reason for the removal was to construct a shared-use path along Bloomington Avenue South as part of the Lake Nokomis-Minnesota River Trail. The project narrowed the width of the roadway to less than 30 feet and widened the sidewalk area to create a shared-use path.

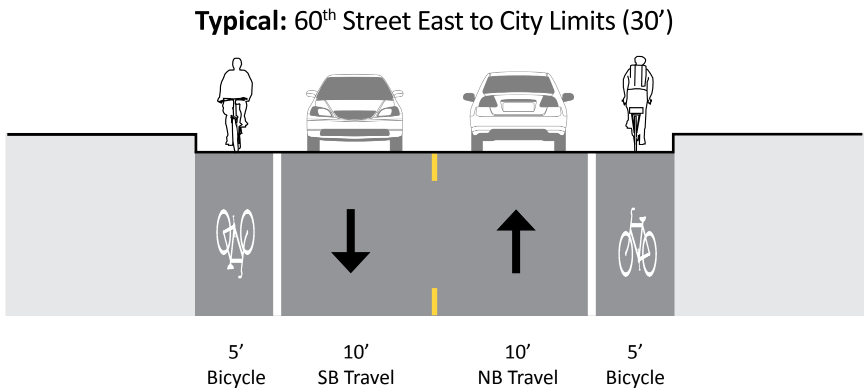


Figure 9-1: Typical cross section

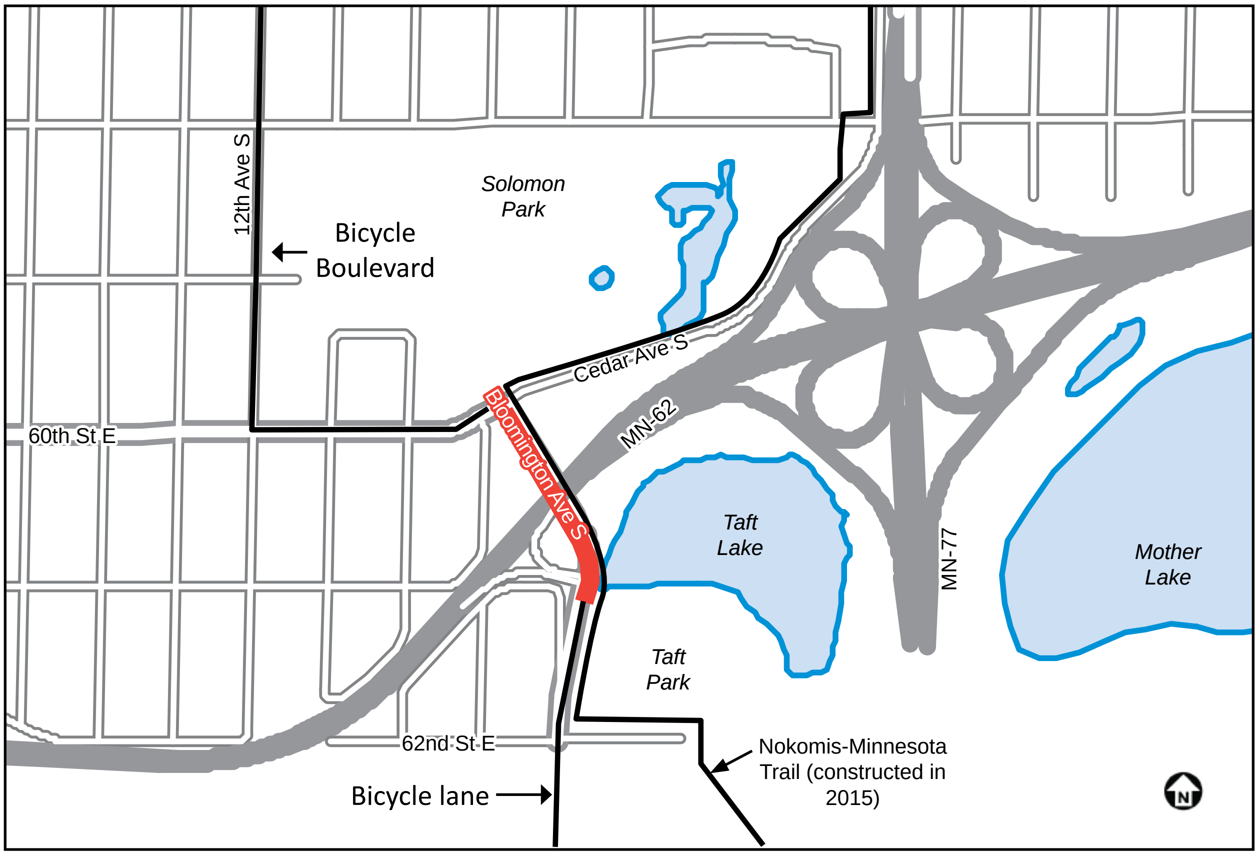


Figure 9-2: Project location

Figure 9-3: Bloomington Avenue South over MN-62 just prior to installation of the bicycle lanes (no photos are available after the bicycle lanes were installed)

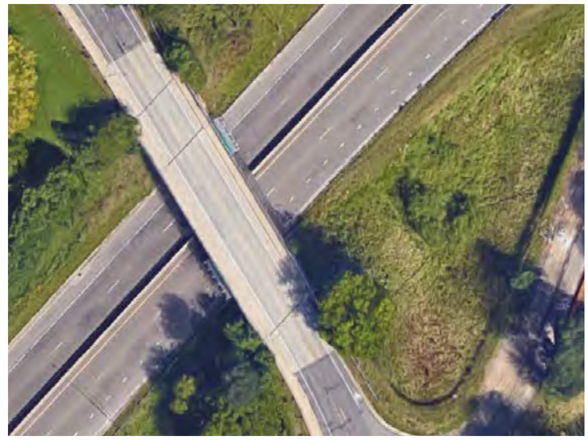


Figure 9-4: Aerial image of Bloomington Avenue South over MN-62 after installation of the bicycle lanes (Source: Google Maps)

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report, although the reporting period differs. For the Bloomington Avenue South evaluation, the specific measures of effectiveness are traffic volumes (after) and reported crashes (before and after).

The project was installed in 2013, two years after most other projects in this report. To align with the reporting of the other projects, a 24-month before observation period and 21-month after period were used in lieu of the standard three years. The before period includes October 1, 2011 through September 30, 2013. The after period includes October 1, 2013 to June 30, 2015. For simplicity of presentation, before conditions are listed from 2012 to 2013 and after conditions from 2014 to 2015.

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

Results

Traffic Volumes

Bicycle traffic before the project was installed ranged between 100 and 290 bicyclists per day. After the project was installed traffic volumes were 280 bicyclists per day. After the bicycle lanes were removed and the shared-use path was installed, traffic volumes were 380 per day with 82% of bicyclists riding on the trail and 18% riding in the street. Motor vehicle traffic before the project was 4,000 vehicles per day. No data is available after the project was installed.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 9-2: Daily traffic volumes

Type	Count Location	Before		After	
		2012	2013	2014	2015
Bicycle (EDT)	Over MN-62	100	290	280	380*
Motor Vehicle (AADT)	Over MN-62	4,000	-	-	-

*Count conducted after shared-use path was installed

Reported Crashes

During the two years before installation, there were two reported crashes, including two motor vehicle crashes, no bicycle crashes, and no pedestrian crashes. During the 21 months after installation, there was one reported motor vehicle crash, no bicycle crashes, and no pedestrian crashes. The one motor vehicle crash that occurred after installation involved an impaired motorist traveling eastbound on Cedar Avenue South, 900 feet east of the intersection of Bloomington Avenue South and 60th Street East.

Table 9-3: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	2	1	-1
Bicycle	0	0	0
Pedestrian	0	0	0
Total	2	1	-1

Conclusions

The evaluation of bicycle and travel lanes on Bloomington Avenue South found the street operated as intended. While the evaluation period and measures of effectiveness were limited, the project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety of users or operations or the street.

User behavior was not formally observed, although Public Works was not notified of any operational issues during the short installation from any users, including Metro Transit. The project was removed after two years, but only for the purposes of constructing an off-street trail.

Figure 9-5: Nokomis-Minnesota Trail after installation in 2015

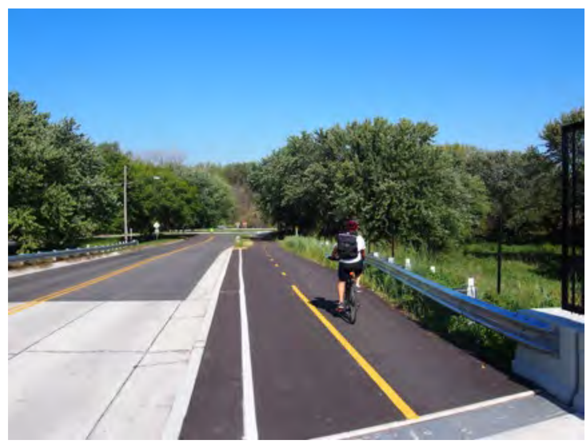


Figure 9-6: A bicyclist rides on the Nokomis-Minnesota Trail in 2016 after the shared-use path was installed and the bicycle lanes were removed

Chapter 10

Travel Lane Width and Parking Lane Width on a Two-Way Street

Project Location:

24th Street East between Bloomington Avenue South and 18th Avenue South

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-022

Design Element Involved

Design Standard the Exception is from:

Minnesota State Statute 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects, Subpart 1. Two-way streets

Design Element(s) Involved:

Travel lane width, bicycle lane width, parking lane width

Required Standard:

Minnesota State Aid design standard 8820.9951 states: "When creating a multimodal design with a combination of vehicle lane, parking lane, and bikeway lane widths, if a vehicle lane width of less than 11 feet is used, the parking and bikeway lanes shall be at least one foot wider than the minimum widths."

"In Lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes along 24th Street East and maintain on-street parking, two 10-foot travel lanes, two five-foot bicycle lanes, and one seven-foot parking lane are proposed in lieu of two 10-foot travel lanes, two six-foot bicycle lanes, and an eight-foot parking lane.

Twenty-fourth Street East is a two-way, two-lane collector street with an AADT<10,000 vehicles per day and a design speed of 30 mph. Under the required standard, travel lanes less than 11 feet on 24th Street East would require minimum bicycle lane widths of six feet and a minimum parking lane width of eight feet. To achieve a design consistent with MSA standards, the roadway would need to be 40 feet, or three feet wider than the existing 37 feet.

Upon application, an exception was granted for this configuration

Table 10-1: Required standard and "in lieu of" design

Design Element	Eastbound			Westbound		Total
	Parking	Bicycle	Travel	Travel	Bicycle	
Required Standard	8'	6'	10'	10'	6'	40'
"In Lieu of" Design	7'	5'	10'	10'	5'	37'

Project Location

The project location is on 24th Street East between Bloomington Avenue South and 18th Avenue South. This project is approximately 0.2 miles, or three blocks long. Surrounding land uses and destinations include single-family homes, multi-family apartments, a church, and a neighborhood park.

Twenty-fourth Street East is 37 feet wide and operates as a two-way street. Prior to installation, the cross section included a travel lane in each direction and parking on both sides of the street. A yellow center line extended the length of the corridor. The street had AADT of 6,600 vehicles per day with a posted speed limit of 30 mph. No regular transit route uses this segment of 24th Street East. Twenty-fourth Street East is on the MSA system in Minneapolis.

The goal of the bicycle project was to provide an east-west connection along 24th Street East. Due to the motor vehicle traffic volumes, a preferential bicycle lane was desired. However, to establish a dedicated bicycle lane and meet MSA design standards, the roadway would need to be widened. This was determined to not be feasible within the scope of the signing and striping project. The recommended design was two five-foot bicycle lanes, two 10-foot travel lanes, and one seven-foot parking lane. The project connects to bicycle lanes on 24th Street East to the west, bicycle boulevard on 17th Avenue South to the south, and bicycle lanes, a pedestrian bridge, and the Hiawatha LRT Trail to the east.

The project was open for use in October, 2013.

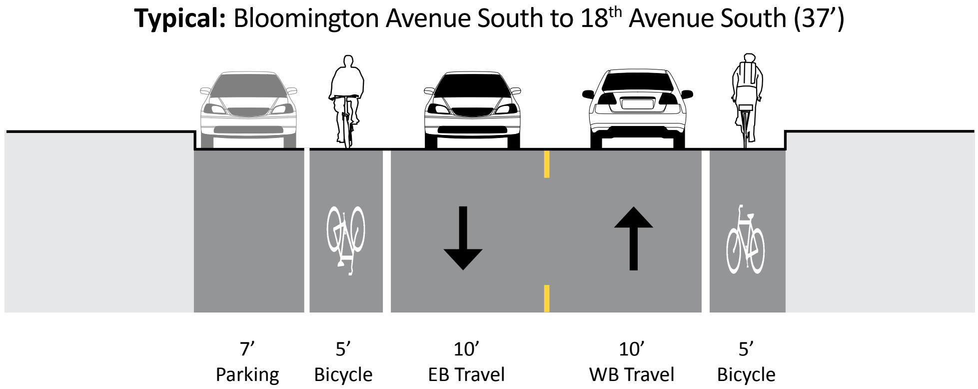


Figure 10-1: Typical cross section

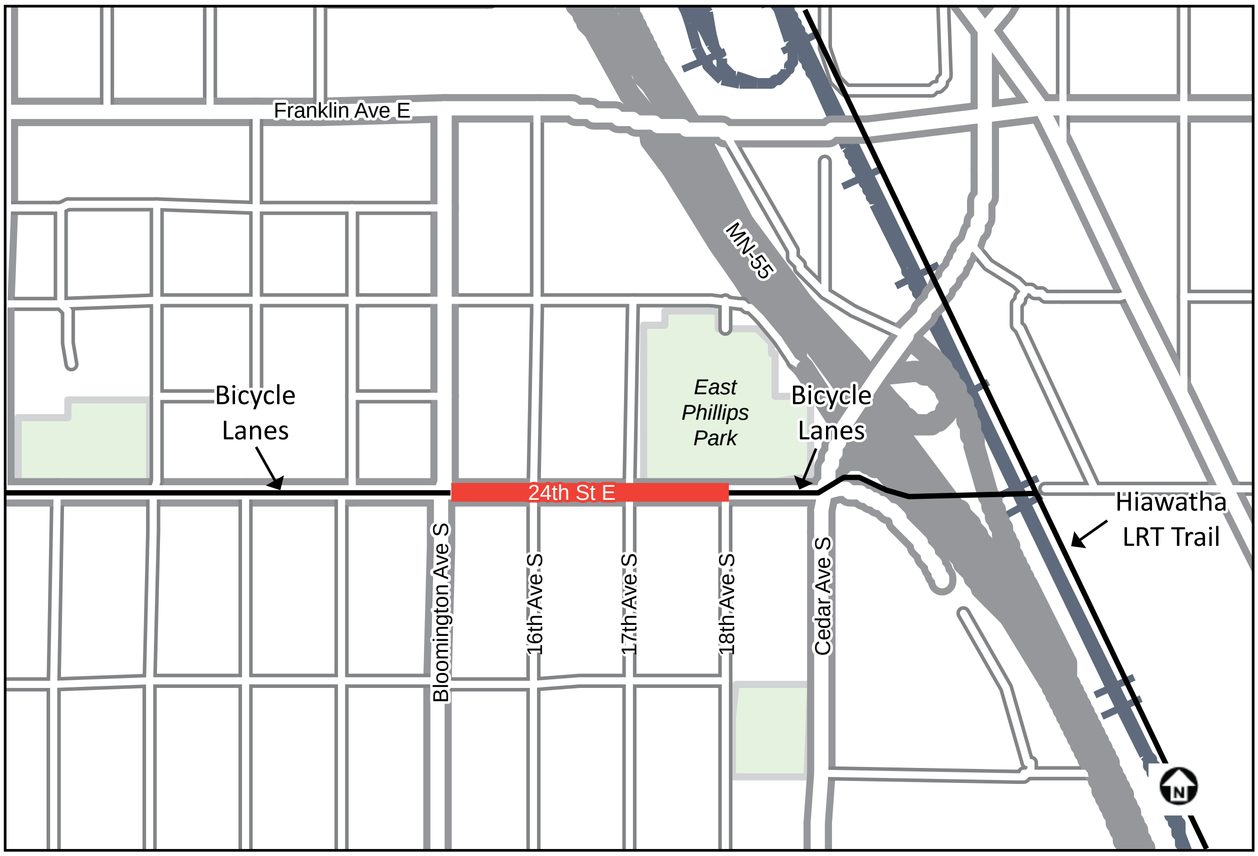


Figure 10-2: Project location

Figure 10-3: 24th Street East facing west at 16th Avenue South after installation

Figure 10-4: 24th Street East facing east at 16th Avenue South after installation

Figure 10-5: 24th Street East facing west at 17th Avenue South after installation

Figure 10-6: 24th Street East facing east at 16th Avenue South after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report, although the reporting period differs. For the 24th Street East evaluation, the specific measures of effectiveness are traffic volumes, reported crashes, and user behavior. Except for traffic volumes and parking compliance, all measures include before-and-after monitoring.

The project was installed in 2013, two years after most other projects in this report. To align with the reporting of the other projects, a two-year before-and-after observation period was used in lieu of the standard three years. The before period includes October 1, 2011 through September 30, 2013. The after period includes October 1, 2013 to September 30, 2015. Parking observations and after user behavior were collected later in May of 2016. For simplicity of presentation, before conditions are listed from 2012 to 2013 and after conditions from 2014 to 2015.

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

Results

Traffic Volumes

Before the project was installed, bicycle traffic volumes were 390 bicyclists per day and motor vehicle traffic before the project was 6,600 per day. Daily traffic volumes were not available after the project was installed. Public Works does not believe there were substantial changes in motor vehicle traffic after installation, although bicycle traffic volumes may have increased slightly following the installation of bicycle lanes.

Table 10-2: Daily traffic volumes

Type	Count Location (between)	Before		After	
		2012	2013	2014	2015
Bicycle (EDT)	16th Ave S and 17th Ave S	390	-	-	-
Motor Vehicle (AADT)	17th Ave S and 18th Ave S	6,600	-	-	-

Reported Crashes

During the two years before installation, there were 35 reported crashes, including 35 motor vehicle crashes, no bicycle crashes, and no pedestrian crashes. During the two years after installation, there were 27 reported crashes, including 23 reported motor vehicle crashes, one bicycle crash, and three pedestrian crashes.

The one bicycle crash involved a northbound motorist and a westbound bicyclist. The motorist was cited for "failing to yield the right-of-way" and the bicyclist was described as "riding against traffic."

The three pedestrian crashes all had varying circumstances. One occurred mid-block on 16th Avenue South between 24th Street East and 25th Street East. Another crash involved a left turning vehicle "failing to yield the right-of-way" for a pedestrian crossing at the intersection of 24th Street East and Bloomington Avenue South. The third pedestrian crash occurred at the intersection of 24th Street East and 18th Avenue South involving unclear circumstances.

Table 10-3: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	35	23	-12
Bicycle	0	1	1
Pedestrian	0	3	3
Total	35	27	-8

Motor Vehicle Parking Compliance

After installation, most motor vehicles parked compliantly in the seven-foot parking lane on 24th Street East. In June of 2016, 47 parked vehicle observations were conducted over five periods. Overall, 97 percent of vehicles were parked compliantly, two percent were parked with a least one tire on the inside bicycle lane edge line (minor encroachment), and none were fully encroaching in the bicycle lane area (major encroachment).

Table 10-4: Parked vehicle location

Parked Vehicle Location	Count	Percentage
Compliant	46	98%
Minor encroachment	1	2%
Major encroachment	0	0%
Total	47	100%

User Behavior Monitored

User behavior was evaluated by recording before-and-after video on 24th Street East. The video was recorded with an east-facing camera located on 24th Street East between 16th Avenue South and 17th Avenue South. Tabulated events included bicyclist location and motorist location.

Before video was collected in July of 2011 and after video was collected in May of 2016. Sixteen hours of video were processed (6:00 a.m. to 10:00 p.m.) in both the before-and-after periods, although approximately two hours of before video was not tabulated due to a crash observed at 5:48 p.m. The crash involved a northbound vehicle on 17th Avenue South that apparently disregarded the northbound stop sign, striking a vehicle traveling westbound on 24th Street East. The crash occurred in the center of the intersection and blocked the roadway, requiring temporary traffic control by police officers. The crash was cleared by 7:27 p.m., and normal operations resumed. Due to this event, observations were not tabulated in the before video between 5:48 p.m. to 7:30 p.m. Also, it is important to note that the before video did not fully capture the sidewalk on the south side of the street resulting in incomplete data for bicyclist behavior.

Figure 10-7: Screen capture of before video on 24th Street East between 16th Avenue South and 17th Avenue South

Figure 10-8: Screen capture of after video on 24th Street East between 16th Avenue South and 17th Avenue South

Bicyclist Behavior

Bicyclist location changed after the project was installed. Before installation, 46 percent of bicyclists rode in the travel lanes, 26 percent rode in the parking lane, 24 percent rode on the sidewalk, and four percent rode in multiple locations. Four bicyclists were observed riding against traffic in the street.

After installation, 78 percent of bicyclists rode in the appropriate bicycle lane, 19 percent rode on the sidewalk, two percent rode in the parking lane, one percent rode in the travel lane, and less than one percent rode in multiple locations. No bicyclists were observed riding against traffic in the street.

Both the two-proportion z-test and chi-squared test show the project had a significant effect on bicyclist location. However, it is important to consider that this may be due to incomplete sidewalk data.

Table 10-5: Bicyclist location

Bicyclist Location	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Bicycle lane	-	-	179	78%	-	-
Travel lane	113	46%	3	1%	0	11.3909
Parking lane	64	26%	4	2%	0	7.602
Sidewalk (incomplete “Before” data)	58	24%	42	19%	0.142	1.4694
Multiple	9	4%	2	<1%	0.042	2.0373
Total	244	100%	230	100%	-	-

Chi-Square = 66.4336, P-value < 0.00001

Motorist Behavior

After the project was installed, most motorists were observed driving in the appropriate travel lane, although increases in lane deviation were observed.

Before installation, most motorists were observed using the street as intended and drove in the appropriate travel lane. Ninety-eight percent drove in the appropriate travel lane and the remainder encroached in the oncoming travel lane or parking lane. After installation, 90 percent of motorists drove within the travel lane, nine percent encroached into the bicycle lane, and the remainder encroached into the oncoming travel lane or parking lane. Occurrences of encroachment into the bicycle lane were not observed when a bicyclist was simultaneously in the bicycle lane.

Both the two-proportion z-test and chi-squared test show the project had a significant effect on motor vehicle location.

Table 10-6: Motor vehicle location

Motorist Location	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Encroachment into oncoming travel lane	26	<1%	57	1%	0.004	-2.8706
Travel lane	6,789	98%	6,980	90%	0	21.8624
Encroachment into bicycle lane	-	-	731	9%	-	-
Encroachment into parking lane	70	1%	4	<1%	0	8.2228
Total	6,894	100%	7,772	100%	-	-

Chi-Square = 753.1723, P-value: < 0.00001

Before-and-after installation, large motor vehicles accounted for approximately three percent of motor vehicle traffic. School buses comprised most of the observed large vehicles. Due to the wider vehicle width, large vehicles tended to exhibit different behavior than typical single occupant vehicles.

Before installation, most large vehicles were observed driving in the appropriate travel lane. Ninety-seven percent drove in the appropriate travel lane, and three percent encroached in the oncoming travel lane. After installation, 63 percent of large vehicles drove within the travel lane, 34 percent encroached into the bicycle, and three percent encroached into the oncoming travel lane.

The change in the location of the large motor vehicles in travel lane was significant at the 95% confidence interval. The chi-squared test shows the project had a significant effect on large motor vehicle location.

Table 10-7: Large motor vehicle location

Large Motor Vehicle Location	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Encroachment into oncoming travel lane	8	3%	7	3%	0.694	0.3937
Travel lane	224	97%	157	63%	0	8.9958
Encroachment into bicycle lane	-	-	84	34%	-	-
Encroachment into parking lane	0	0%	0	0%	-	-
Total	232	100%	248	100%	-	-

Chi-Square = 95.4215, P-value: < 0.00001

Conclusions

The evaluation of the street design elements on 24th Street East found that the street generally operated as intended. The project installed a dedicated bicycle lane treatment in a constrained corridor without having a negative impact on the safety or operations of the street.

During the two years before installation, there were 35 reported crashes, including 35 motor vehicle crashes, no bicycle crashes, and no pedestrian crashes. During the two years after installation, there were 27 reported crashes, including 23 reported motor vehicle crashes, one bicycle crash, and three pedestrian crashes. According to police reports, the circumstances of the bicycle and pedestrian crashes do not appear to be related to the street design elements.

After the installation of the project and installation of the bicycle lanes, the street generally operated as intended and created a more organized street environment. The predictability of where bicyclists rode improved. Before installation, about half of bicyclists shared the travel lane with motorists, a quarter rode in the parking lane, and a quarter rode on the sidewalk. After installation, most bicyclists operated in the bicycle lane, and the share of bicyclists riding on the sidewalk decreased.

After installation, 90 percent of motorists operated completely in their respective travel lanes. Nine percent encroached into the bicycle lane area. It is important to note that encroachment into the oncoming lane is allowable when overtaking vehicles, including bicycles, since 24th Street East has a broken yellow center line. Encroachment after installation was higher among large vehicles. However, the encroachment was not observed to create safety or operational issues and did not coincide with the immediate presence of a bicyclist in the bicycle lane.

Public Works intends to keep the project in place as the project is providing value to bicyclists, and no related safety or operational issues have been observed.

Chapter 11

Travel Lane Width and Parking Lane Width on a Two-Way Street

Project Location:
Como Avenue Southeast between 10th Avenue Southeast and 15th Avenue Southeast

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-020

Design Element Involved

Design Standard the Exception is from:

Minnesota State Statute 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects, Subpart 1. Two-way streets

Design Element(s) Involved:

Travel lane width, bicycle lane width, parking lane width

Required Standard:

Minnesota State Aid design standard 8820.9951 states: "When creating a multimodal design with a combination of vehicle lane, parking lane, and bikeway lane widths, if a vehicle lane width of less than 11 feet is used, the parking and bikeway lanes shall be at least one foot wider than the minimum widths."

"In Lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes on Como Avenue Southeast and maintain on-street parking, two 10.5-foot travel lanes, two five-foot bicycle lanes, and two seven-foot parking lanes are proposed in lieu of two 10-foot travel lanes, two six-foot bicycle lanes, and two eight-foot parking lanes.

Como Avenue Southeast is a two-way, two-lane collector street with AADT<10,000 vehicles per day and a design speed of 30 mph. Under the required standard, 10-foot vehicle lanes on Como Avenue Southeast would require minimum bicycle lane widths of six feet and a minimum parking lane width of eight feet. To achieve a design consistent with MSA standards, the roadway would need to be 48 feet, or three feet wider than the existing 45 feet.

Upon application, an exception was granted for this configuration

Table 11-1: Required standard and "in lieu of" design

Design Element	Eastbound			Westbound			Total
	Parking	Bicycle	Travel	Travel	Bicycle	Parking	
Required Standard	8'	6'	10'	10'	6'	8'	48'
"In Lieu of" Design	7'	5'	10.5'	10.5'	5'	7'	45'

Project Location

The project location is on Como Avenue Southeast between 10th Avenue Southeast and 15th Avenue Southeast. This project is approximately 0.25 miles, or four city blocks long. Surrounding land uses and destinations include single-family homes, multi-family apartments, a neighborhood park, and a commercial node.

Como Avenue Southeast is 45 feet wide and operates as a two-way street. Prior to installation, 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 AADTs ranging from 4,100 to 4,800 vehicles per day with a posted speed limit of 30 mph. No regular transit route uses this segment of Como Avenue Southeast. Como Avenue Southeast is on the MSA system in Minneapolis.

The goal of the bicycle project was to provide an east-west connection along Como Avenue Southeast. Due to the motor vehicle traffic volumes, a preferential bicycle lane was desired. However, to establish a dedicated bicycle lane and meet MSA design standards, one parking lane would need to be removed. Due to high parking demand, there was the desire from the community to maintain parking on at least one side of the street for the length of the corridor. The recommended design was two seven-foot parking lanes, two five-foot bicycle lanes, and two 10.5-foot travel lanes. The project connects to bicycle lanes on 10th Avenue Southeast on the west, bicycle lanes on 15th Avenue Southeast to the south, and bicycle lanes and shared lane markings on Como Avenue Southeast to the east.

The project was open for use in October, 2011.

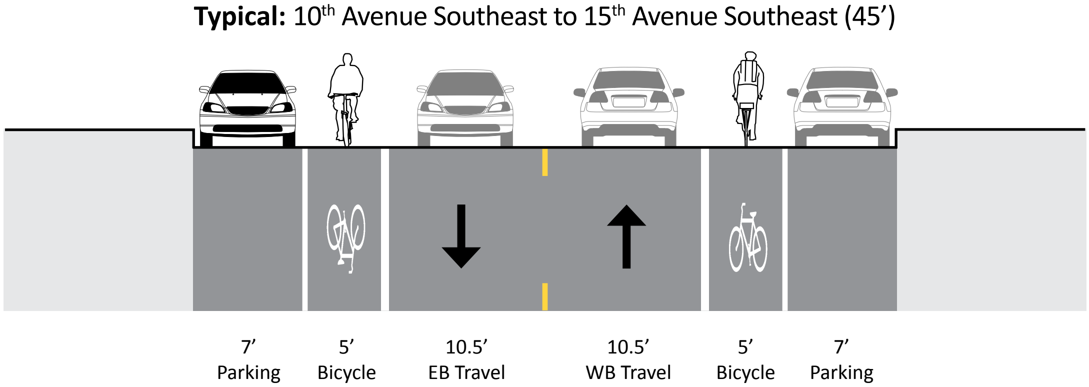


Figure 11-1: Typical cross section

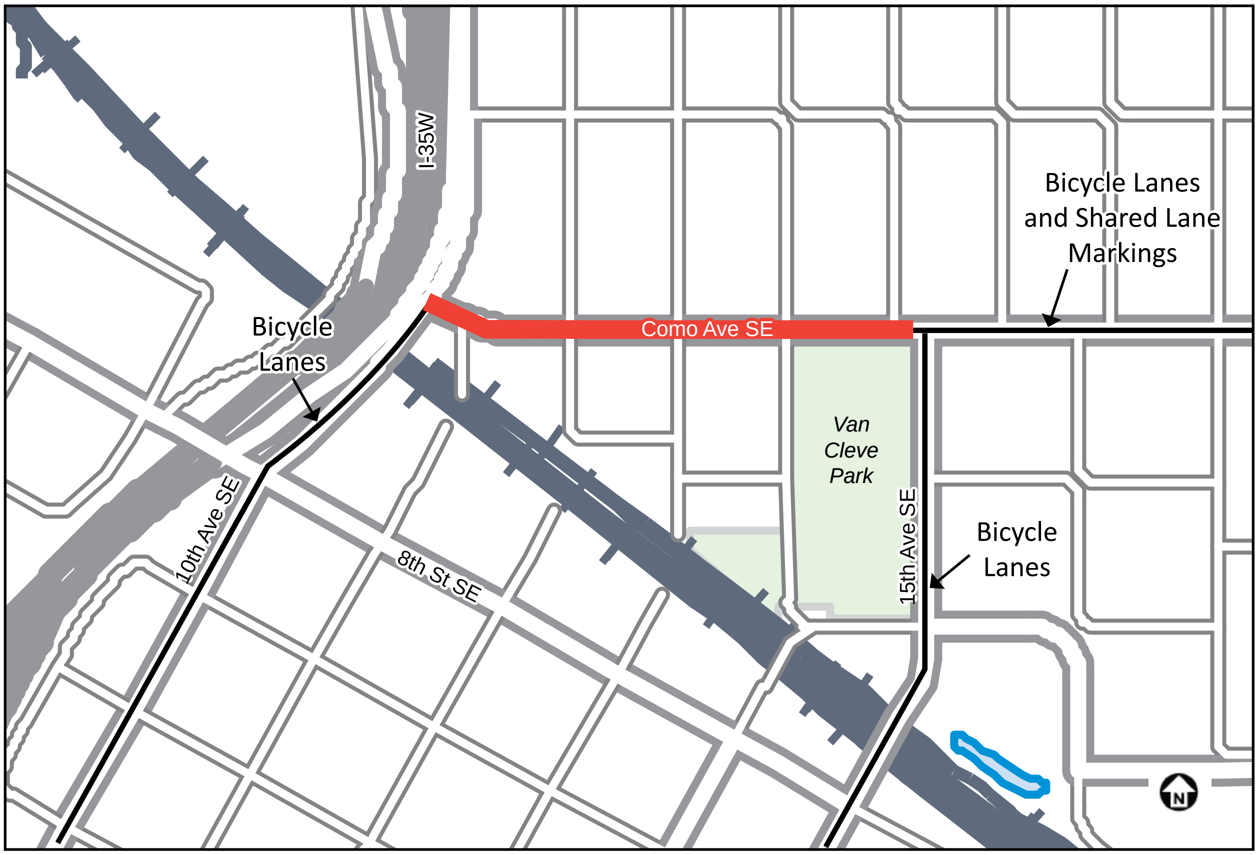


Figure 11-2: Project location

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the Como Avenue Southeast evaluation, the specific measures of effectiveness are traffic volumes, motor vehicle speeds, reported crashes, user behavior, and staged bus-bicycle observations. All measures include before-and-after monitoring except bicycle traffic volumes, user behavior, and staged bus-bicycle observations.

The before period includes October 1, 2008 through September 30, 2011. The after period includes October 1, 2011 to September 30, 2014. Parking compliance observations were conducted later in May of 2016. For simplicity of presentation, before conditions are listed from 2009 to 2011 and after conditions from 2012 to 2014.

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

Figure 11-3: Como Avenue Southeast facing west at 15th Avenue Southeast after installation

Figure 11-4: Como Avenue Southeast facing east at 13th Avenue Southeast after installation

Figure 11-5: Traffic on Como Avenue Southeast at 14th Avenue Southeast after installation

Figure 11-6: Bicyclist riding westbound on Como Avenue Southeast after installation

Results

Traffic Volumes

Bicycle traffic after the project was installed was 350 bicyclists per day. No data was available before the project was installed, although Public Works believes bicycle traffic volumes were comparable before and after installation of the bicycle lanes.

Motor vehicle traffic increased after the project was installed. Between 11th Avenue Southeast and 12th Avenue Southeast, the AADT increased from 4,800 to 5,200 vehicles per day. Between 12th Avenue Southeast and 13th Avenue Southeast, the AADT increased from 4,100 to 4,800.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 11-2: Daily traffic volumes

Type	Count Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	10th Ave SE and 12th Ave SE	-	-	-	350	-	-
Motor Vehicle (AADT)	11th Ave SE and 12th Ave SE	4,800	-	-	-	5,200	-
	12th Ave SE and 13th Ave SE	-	-	4,100	4,800	-	-
	13th Ave SE and 14th Ave SE	-	-	-	4,900	4,700	-

Motor Vehicle Speeds

Motor vehicle speeds along the corridor did not change substantially after the project was installed. The 85th-percentile speeds before the project was installed ranged between 33 and 34 mph. After the project was installed, the 85th-percentile the speed was 33 mph. Both the before-and-after 85th-percentile speeds are above the 30 mph posted speed limit.

Table 11-3: 85th-percentile speeds

Between	Before (mph)			After (mph)		
	2009	2010	2011	2012	2013	2014
12th Ave SE and 13th Ave SE	-	33	-	-	-	-
13th Ave SE and 14th Ave SE	-	-	34	33	-	-

Reported Crashes

During the three years before installation, there were 11 reported crashes, including 10 motor vehicle crashes, one bicycle crash, and no pedestrian crashes. During the three years after installation, there were 16 reported crashes, including 15 motor vehicle crashes, no bicycle crashes, and one pedestrian crash.

Table 11-4: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	10	15	5
Bicycle	1	0	-1
Pedestrian	0	1	1
Total	11	16	5

The one pedestrian crash occurred on 15th Avenue Southeast approximately 50 feet south of Como Avenue Southeast. It involved a southbound motorist and eastbound pedestrian crossing mid-block.

There were 15 motor vehicle crashes after installation. Of the crashes that occurred, six occurred on Como Avenue Southeast. Five of those six were rear end or fixed object crashes. Three occurred during winter with pre-crash maneuvers described as "skidding." One crash involved a westbound vehicle making a left turn at 15th Avenue Southeast.

Motor Vehicle Parking Compliance

After installation, most motor vehicles parked compliantly in the seven foot parking lane on Como Avenue Southeast. Four observation periods in July, 2016 tallied 137 parked vehicles. Overall, 92 percent of vehicles were parked compliantly, seven percent were parked with a 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 11-5: Parked vehicle location

Parked Vehicle Location	Count	Percentage
Compliant	126	92%
Minor encroachment	10	7%
Major encroachment	1	1%
Total	137	100%

User Behavior Monitored

User behavior was evaluated by recording before-and-after video on Como Avenue Southeast. The video was recorded with an east-facing camera located on Como Avenue Southeast between 13th Avenue Southeast and 14th Avenue Southeast. Before video was collected in July, 2011 and after video was collected in July and November, 2012. For the before period, 10 hours of video over five periods (4:00 to 6:00 p.m.) was processed. For the before period, 22.5 hours of video over six periods (8:00 to 9:00 a.m. and 4:00 to 6:30 p.m.) was processed. The before-and-after tabulation was completed by two groups of University of Minnesota students. Both groups used sound tabulation and analysis techniques, but the focus of the research and course was related to general lane deviations, rather than the specific location tabulation presented for other projects in this report. Due to this difference in tabulation, it is difficult to analyze and present the before-and-after results. Due to this discrepancy, only after video tabulation from 2012 is presented in this report.

Figure 11-7: Screen capture of before video on Como Avenue Southeast between 13th Avenue Southeast and 14th Avenue Southeast (Video processed, but not used in final analysis)

Figure 11-8: Screen capture of after video on Como Avenue Southeast between 13th Avenue Southeast and 14th Avenue Southeast

Bicyclist Location

After the bicycle lanes were installed, 86 percent of bicyclists rode in the appropriate bicycle lane, two percent rode in a travel lane, five percent rode in the parking lane, five percent rode on the sidewalk, and one percent rode in multiple locations. Two percent of all bicyclists were observed riding in the street against traffic. It was noted that the eastbound parking lane had less overall demand than the westbound parking lane.

Table 11-6: Bicyclist location

Bicyclist Location	Eastbound		Westbound		Total	
	Count	%	Count	%	Count	%
Bicycle lane	233	85%	253	92%	486	86%
Travel lane	10	4%	2	1%	12	2%
Parking lane	27	10%	4	1%	31	5%
Sidewalk	15	5%	14	5%	29	5%
Multiple	4	1%	2	1%	6	1%
Total	**289**	**100%**	**275**	**100%**	**564**	**100%**

Motor Vehicle Location

After the bicycle lane was installed, 97 percent of motorists drove in their respective travel lanes, two percent encroached into the bicycle lane, and less than one percent of motorists encroached into the oncoming travel lane or in the parking lane.

Table 11-7: Motor vehicle location

Motorist Location	Eastbound		Westbound		Total	
	Count	%	Count	%	Count	%
Travel lane	1,698	97%	2,655	98%	4,353	97%
Encroachment into bicycle lane	37	2%	54	2%	91	2%
Encroachment into parking lane	9	1%	2	<1%	11	<1%
Encroaching into oncoming travel lane	3	<1%	9	<1%	12	<1%
Total	1,747	100%	2,720	100%	4,467	100%

Bus-Bicycle Observations

No regular transit route uses this segment of Como Avenue Southeast. However, staged bus-bicycle observations were conducted for research purposes in anticipation of requesting a similar design exception on Bloomington Avenue South (documented in Chapter 9). Bloomington Avenue South, which has a regular transit route, was proposed to have a configuration with 10-foot travel lanes and five-foot bicycle lanes. The Como Avenue Southeast project had been recently installed with 10.5-foot travel lanes, five-foot bicycle lanes, and seven-foot parking. Due to a similar constrained corridor with travel lanes less than 11 feet, Public Works coordinated with Metro Transit to conduct staged observations to better understand how buses, bicycles, and other traffic operate under this type of configuration.

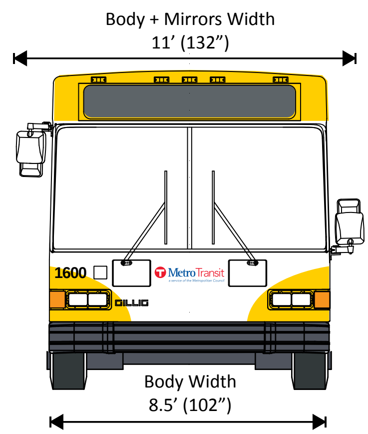


Figure 11-9: Metro Transit 40-foot low-floor bus width (Fleet specs as of 2013)

The staged observations were conducted on Thursday, September 12, 2013 between 1:00-2:00 p.m. The study area was on Como Avenue Southeast between 13th Avenue Southeast and 14th Avenue Southeast. Four Metro Transit staff and two Public Works staff participated in the study. Metro Transit staff consisted of two bus operators and two street operations supervisors. One Public Works staff rode a bicycle, and the other coordinated the study with the transit supervisors and took photos. Two, 40-foot low-floor buses from Metro Transit's fleet were used for this study. The bus body width is 8.5 feet (102 inches) and the effective width including mirrors is 11 feet (132 inches).

The staged observations consisted of seven different runs. Each run involved different combinations of a westbound bus, an eastbound bus, a westbound bicycle, and/or an eastbound bicycle traveling on Como Avenue Southeast. During runs involving multiple vehicles, the goal was for the vehicles to converge on the block between 13th Avenue Southeast and 14th Avenue Southeast. After each run, the participants made a loop and returned to their respective eastbound or westbound starting point. It should be noted that parking demand was low on the south side of the street (eastbound direction) and was at nearly full capacity along the north side of the street (westbound direction). It is also important to note that the road was not closed to regular traffic. Other bicyclists, pedestrians, motorists operated on the street during the observations.

The Public Works bicyclist was encouraged to stay within the bicycle lane, although they could deviate from that location if needed. The two bus operators were encouraged to operate their vehicles as they normally would. They were told that they were participating in a study looking at bus-bicycle operations, but they were not provided information about the lane widths or other details.

Results

Staff observations

The seven runs were completed successfully without interruption. Staff observations and photos documented when and where lane deviations occurred and how the participants interacted with each other.

No lane deviations occurred when the buses operated independently (Runs 2 and 3). When the buses operated concurrently without a bicyclist present, the westbound bus deviated slightly onto the bicycle lane edge line (Run 4).

When the westbound bus and westbound bicycle operated concurrently (Run 5), the bus slowed for a gap in oncoming traffic and merged approximately two feet into the eastbound travel lane. This allowed the bus body and mirrors to clear the bicyclist by more than three feet. When the eastbound bus and eastbound bicycle operated concurrently (Run 6), the bus slowed but did not deviate from the travel lane. This allowed the bus body to clear the bicyclist by more than three feet, although it appears the bus mirror encroached in the three-foot envelope. The final run (Run 7) involved all three participants. The westbound bus and westbound bicycle did not deviate, although the eastbound bus deviated slightly onto the bicycle lane edge line. This maneuver appeared to be purposeful to give more maneuvering room to the westbound bus operator who also had to negotiate the westbound bicycle.

Table 11-8: Motor vehicle location

Run	Westbound		Eastbound		Observations
	Bicycle	Bus	Bus	Bicycle	
1	-	-	-	-	• Unstructured practice run
2	-	X	-	-	• No lane deviation observed
3	-	-	X	-	• No lane deviation observed
4	-	X	X	-	• WB bus encroached on WB bike lane edge line • EB bus remained in EB travel lane
5	X	X	-	-	• WB bicyclist remained in WB bicycle lane • WB bus slowed for a gap in oncoming traffic and merged about 2’ into EB travel lane to overtake bicyclist; provided >3’ clearance between edge of bus mirror and bicyclist
6	-	-	X	X	• EB bicyclist remained in EB bicycle lane • EB bus remained in EB travel lane when overtaking bicyclist- appeared to leave 3’ clearance between edge of bus body and bicyclist, but <3’ between edge of bus mirror and bicyclist
7	X	X	X	-	• WB bicyclist remained in WB bicycle lane • WB bus encroached on WB bike lane line • EB bus encroached on EB bike lane line

Figure 11-10: Run 4 – Westbound bus and eastbound bus together

Figure 11-11: Run 5 – Westbound bus with westbound bicycle

Figure 11-12: Run 6 – Eastbound bus with eastbound bicycle

Figure 11-13: Run 7 – Eastbound bus with westbound bus and westbound bicycle

<u>Operator Feedback</u>

Both Metro Transit operators were interviewed independently by Public Works staff after the study. The eastbound operator had six years of experience with Metro Transit and the westbound operator had 25 years experience.

Both operators stated that driving alone during runs 2 and 3 was the easiest. They stated that the most difficult run involved the oncoming bus and bicycle (Run 7).

Figure 11-14: Metro Transit bus operator and street operations supervisor

The westbound operator thought it was difficult to stay in the travel lane during runs 4, 5, and 7. They thought it was difficult to maintain a four-foot clearance between the bus and bicycle without crossing the center line. While Minnesota State Statute requires three feet, Metro Transit trains operators to provide four feet clearance. When the oncoming bus was present, the operator felt like he had to merge into the bicycle lane slightly.

The eastbound operator mentioned that the travel lane appeared to be narrower than a typical street, although once they centered the bus in the lane, they believed they could maintain a consistent position. Generally, the eastbound motorist said the most difficult part about sharing the road with bicycles is at intersections when some bicyclists merge into the travel lane to avoid right turning vehicles.

Conclusions

The evaluation of the street design elements on Como Avenue Southeast showed that 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 of users or operations of the street. Motor vehicle crashes did increase after installation, although the relationship to the street design elements is not strong.

During the three years before installation, there were 11 reported crashes, including 10 motor vehicle crashes, one bicycle crash, and no pedestrian crashes. During the three years after installation, there were 16 reported crashes, including 15 motor vehicle crashes, no bicycle crashes, and one pedestrian crash. The motor vehicle crashes do not appear to be a factor of the project design.

After the installation of the project and installation of the bicycle lanes, the street generally operated as intended. Eighty-six percent of bicyclists operated in the bicycle lane, and 97 percent of motorists operated completely in their respective travel lane. Less than three percent of motor vehicles encroached into other lanes. However, the encroachment was not observed to create safety or operational issues and did not coincide with the immediate presence of a bicyclist in the bicycle lane.

While there is no regular transit service on this street, the bus observations were valuable in understanding general bus and bicycle interactions within a constrained corridor. Lane deviation was observed, and operators noticed that the lanes were narrower than typical. However, the observations demonstrate that large vehicles operated by professional drivers on low-speed urban streets, can safely negotiate with other traffic in constrained environments.

Public Works intends to maintain the project as it is providing value to bicyclists and no related safety or operational issues have been observed. The current configuration provides better accommodation for all users, including bicycle traffic, and represents the best and highest use of the public resource, despite the slight increase in non-significant motor vehicle crashes.

Chapter 12

Travel Lane Width and Parking Lane Width on a Two-Way Street

Project Location:

15th Street West between Oak Grove Street West and Nicollet Avenue South

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-020

Design Element Involved

Design Standard the Exception is from:

Minnesota State Statute 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects, Subpart 1. Two-way streets

Design Element(s) Involved:

Travel lane width, bicycle lane width, parking lane width

Required Standard:

Minnesota State Aid design standard 8820.9951 states: "When creating a multimodal design with a combination of vehicle lane, parking lane, and bikeway lane widths, if a vehicle lane width of less than 11 feet is used, the parking and bikeway lanes shall be at least one foot wider than the minimum widths."

"In Lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes along 15th Street West and maintain on-street parking, 10.5 foot travel lanes and seven to 7.5-foot parking lanes are proposed in lieu of 11-foot travel lanes and eight-foot parking lanes.

Fifteenth Street West is a two-way, two-lane collector street with AADT<10,000 vehicles per day and a design speed of 30 mph. Under the required standard, travel lanes less than 11 feet on 15th Street West would require minimum bicycle lane widths of five feet and a minimum parking lane width of eight feet. To achieve a design consistent with MSA standards, the roadway would need to be 48 feet, or two feet wider than the existing 46 feet.*

Upon application, an exception was granted for this configuration

Table 12-1: Required standard and "in lieu of" design

Design Element	Eastbound			Westbound			Total
	Parking	Bicycle	Travel	Travel	Bicycle	Parking	
Required Standard	8'	6'	10'	10'	6'	8'	48'
"In Lieu of" Design	7-7.5'	5'	10.5-11'	10.5'	5'	7'	46'

Project Location

The project location is 15th Street West between Oak Grove Street West and Nicollet Avenue South. This project is approximately 0.4 miles, or four city blocks long. Surrounding land uses include, multi-family apartments and a large neighborhood park. The project is located immediately southwest of downtown Minneapolis.

Fifteenth Street West is 46 feet wide and operates as a two-way street. Prior to installation, 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 AADTs ranging from 7,300 to 10,800 vehicles per day with a posted speed limit of 30 mph. Metro Transit bus route 25 operates between Oak Grove Street West and Willow Street with limited service during peak hour weekdays. Fifteenth Street is on the MSA system in Minneapolis.

The goal of the bicycle project was to provide an east-west connection along 15th Street West. Due to the motor vehicle traffic volumes, a preferential bicycle lane was desired. However, to establish a dedicated bicycle lane and meet MSA design standards, one parking lane would need to be removed. 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. The recommended design was two 7 to 7.5-foot parking lanes, 5 to 5.5-foot bicycle lanes, and 10.5 to 11-foot travel lanes. The project connects to bicycle lanes on Vineland Place and also bicycle lanes on 16th Street East. The project was open for use in October, 2011.

*After this design exception was approved, it was determined by Public Works and later confirmed by State Aid engineering staff that if 11-foot travel lanes are used, a multi-modal design on a 46-foot roadway is feasible without an approved design exception or variance. The design would consist of two 11-foot travel lanes, two five-foot bicycle lanes, and two seven-foot parking lanes.

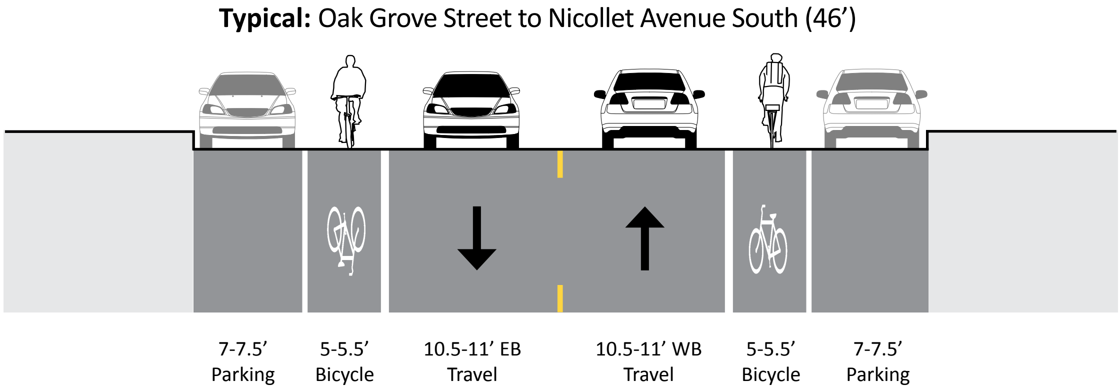


Figure 12-1: Typical cross section

Figure 12-2: Project location

Figure 12-3: 15th Street West facing east at Willow Street after installation

Figure 12-4: 15th Street West facing west at Oak Grove Street West after installation

Figure 12-5: An eastbound bicyclist riding on 15th Street West after installation

Figure 12-6: Traffic on 15th Street West between Oak Grove Street West and Willow Street after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of 15th Street West the specific measures of effectiveness are traffic volumes, motor vehicle speeds, parked vehicle compliance, reported crashes, and user behavior. Except for parked vehicle compliance and user behavior, 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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Results

Traffic Volumes

Bicycle traffic before the project was installed ranged from 250 and 830 bicyclist per day. After the project was installed, daily traffic ranged from 360 to 600 bicyclists per day.

Motor vehicle traffic decreased after the project was installed. Before installation, AADTs ranged from 7,300 to 10,800 vehicles per day. After the project was installed, AADTs ranged from 6,500 and 9,200.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 12-2: Daily traffic volumes

Type	Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	LaSalle Ave S and Nicollet Ave S	-	-	830	-	-	660
	Hennepin Ave S and Oak Grove St	250	-	-	360	-	-
Motor Vehicle (AADT)	Spruce Pl and LaSalle Ave S	-	7,300	-	-	-	6,500
	Oak Grove St W and Willow St S	9,900	10,800	-	9,200	-	9,200

Motor Vehicle Speeds

Motor vehicle speeds along the corridor did not change substantially after the project was installed. The 85^{th}-percentile speed before the project was installed was 31 mph. After the project was installed, the 85^{th}-percentile speed was 30 mph.

Table 12-3: 85^{th}-percentile speeds

Location (between)	Before (mph)			After (mph)		
	2009	2010	2011	2012	2013	2014
Oak Grove St W and Willow St S	31	31	-	30	-	-

Reported Crashes

Crashes along the corridor decreased by 18 percent after the project was installed. During the three years before installation, there were 66 reported crashes, including 63 motor vehicle crashes, no bicycle crashes, and three pedestrian crashes. During the three years after installation, there were 54 reported crashes, including 47 motor vehicle crashes, six bicycle crashes, and one pedestrian crash.

Table 12-4: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	63	47	-16
Bicycle	0	6	6
Pedestrian	3	1	-2
Total	66	54	-12

Six bicycle crashes occurred after installation. Three occurred at the intersection of Nicollet Avenue South, all involving unclear circumstances. Crash information on police reports included “vehicle parked illegally”, “motorist inattentive or distracted,” “vision obstructed by other factors,” or “other factors.” One crash, occurring at LaSalle Avenue South, involved an eastbound bicyclist on 15^{th} Street West and a southbound motorist on LaSalle Avenue South. The bicyclist was cited for “disregarding a traffic control device.” One crash occurred at Willow Street; it involved a southbound bicyclist a southbound bicyclist on Willow Street and an eastbound motorist making a left turn on 15^{th} Street West. The bicyclist was cited as “inattentive or distracted.” One crash occurred at Oak Grove Street, involving an eastbound bicyclist and eastbound motorist. The circumstances of the crash are unclear.

One pedestrian crash occurred after installation at the intersection of LaSalle Avenue South. The crash occurred east of the intersection and involved an eastbound motorist and northbound pedestrian “emerging from behind a parked vehicle.”

Motor Vehicle Parking Compliance

After installation, most motor vehicles parked compliantly in the seven-foot parking lane on 15^{th} Street West. Five observation periods in September and October, 2016 tallied 507 parked vehicles. Overall, 91 percent of vehicles were parked compliantly, six percent were parked with a least one tire on the inside bicycle lane edge line (minor encroachment), and three percent were fully encroaching in the bicycle lane area (major encroachment). Most vehicles with major encroachment were westbound vehicles parked on the curve between Willow Street and Oak Grove Street West.

Table 12-5: Parked vehicle location

Parked Vehicle Location	Count	Percentage
Compliant	459	91%
Minor encroachment	33	6%
Major encroachment	15	3%
Total	507	100%

User Behavior Monitored

User behavior was evaluated after installation by recording video on 15th Street West. The video was recorded with an east-facing camera located on 15th Street West between Willow Street and Oak Grove Street West. Events tabulated included bicyclist location and motorist location. Motorist encroachment into the adjacent bicycle lane were tabulated, although motorist encroachment into the oncoming travel lane was not tabulated.

After video was collected in October, 2012. Sixteen hours of video over one period (6:00 a.m. to 10:00 p.m.) was processed.

Figure 12-7: Screen capture of after video at 15th Street West between Willow Street and Oak Grove Street West

Bicyclist Location

After installation, two percent of bicyclists rode in the travel lane, 92 percent rode in the appropriate bicycle lane, six percent rode on the sidewalk, and two percent rode in the travel lane. No bicyclists were observed riding in the parking lane or in multiple locations.

Table 12-6: Bicyclist location

Bicyclist Location	Eastbound		Westbound		Total	
	Count	%	Count	%	Count	%
Travel lane	2	2%	3	3%	5	2%
Bicycle lane	93	94%	89	90%	182	92%
Parking lane	0	0%	0	0%	0	0%
Sidewalk	4	4%	7	7%	11	6%
Multiple	0	0%	0	0%	0	0%
Total	99	100%	99	100%	198	100%

Motor Vehicle Location

After installation, 94 percent of motorists drove in the appropriate travel lanes and six percent encroached in the bicycle lane. Encroachment into the oncoming travel lane was not tabulated.

Table 12-7: Motor vehicle location

Motorist Location	Eastbound		Westbound		Total	
	Count	%	Count	%	Count	%
Travel lane	4,526	93%	5,249	95%	9,775	94%
Encroaching into oncoming travel lane	*Not tabulated*					
Encroachment into bicycle lane	327	7%	257	5%	584	6%
Total	4,853	100%	5,506	100%	10,359	100%

Conclusions

The evaluation of the street design elements on 15th Street West found that 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 of users or operations of the street.

During the three years before installation, there were 66 reported crashes, including 63 motor vehicle crashes, no bicycle crashes, and three pedestrian crashes. During the three years after installation, there were 54 reported crashes, including 47 motor vehicle crashes, six bicycle crashes, and one pedestrian crash. According to police reports, the circumstances of the bicycle crashes do not appear to be a factor of the project design.

After the installation of the project and installation of the bicycle lanes, the street generally operated as intended. Ninety-two percent of bicyclists operated in the bicycle lane, and 94 percent motorists stayed in their respective travel lane. Encroachment of motor vehicles into the adjacent bicycle lane was observed, but was not observed to create safety or operational issues.

Public Works intends to maintain the project as it is providing value to bicyclists and no related safety or operational issues have been observed.

Chapter 13

Curb Reaction Width, Travel Lane Width, and Parking Lane Width on a Two-Way Street

Project Location:

1st Avenue South between Franklin Avenue East and 28th Street East

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-020

Design Element Involved

Design Standard the Exception is from:

Minnesota State Statute 8820.9946 Minimum Design Standards, Urban; Reconditioning Projects, Subpart 1. Two-way streets

Design Element(s) Involved:

Curb reaction width, travel lane width, and parking lane width

Required Standard:

Minnesota State Aid design standard 8820.9951 states: "When creating a multimodal design with a combination of vehicle lane, parking lane, and bikeway lane widths, if a vehicle lane width of less than 11 feet is used, the parking and bikeway lanes shall be at least one foot wider than the minimum widths."

"In lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes and maintain on-street parking, 1.5-foot curb reaction distance and a seven-foot parking lane are proposed in lieu of two-foot curb reaction distance and an eight-foot parking lane.

First Avenue South is a two-way, two-lane collector street with AADT<10,000 vehicles per day and a design speed of 30 mph. Under the required standard, travel lanes less than 11 feet would require minimum bicycle lane widths of six feet and a minimum parking lane width of eight feet. Two feet of curb reaction distance are also required for the southbound travel lane. To achieve a design consistent with MSA standards, the roadway would need to be 37 feet, or one to two feet wider than the existing width.

Upon application, an exception was granted for this configuration

Table 13-1: Required standard and "in lieu of" design

Design Element	Southbound		Northbound			Total
	Curb Reaction	Travel	Travel	Bicycle	Parking	
Required Standard	2'	11'	11'	5'	8'	37
"In Lieu of" Design	1.5'	10.5-11'	11'	5-5.5'	7'	35-36'

Project Location

The project location is on 1st Avenue South between Franklin Avenue East and 28th Street East. This project is approximately 0.25 miles, or six city blocks long. Surrounding land uses include, multi-family apartments and a parallel commercial corridor. First Avenue South is located about 0.5 miles south of downtown Minneapolis.

First Avenue South is 35 to 36 feet wide and operates as a two-way street between Franklin Avenue East and 28th Street East. North of Franklin Avenue East and south of 28th Street East, 1st Avenue South operates as a one-way street for northbound traffic. Prior to installation, the cross section included parking on one side of the street and a travel lane in each direction. A broken yellow center line extended the length of the corridor. The street had AADTs of 4,400 vehicles per day with a posted speed limit of 30 mph. No regular transit route uses this segment of 1st Avenue South. First Avenue South is on the MSA system in Minneapolis.

The goal of the bicycle project was to provide a northbound bicycle connection on 1st Avenue South. While 1st Avenue South operates as a two-way street for the project segment, only a northbound bicycle connection was desired to achieve consistency with the corridor north and south of the project limits. A southbound bicycle facility was provided two blocks west on Blaisdell Avenue South. Due to the motor vehicle traffic volumes, a preferential bicycle lane was desired on 1st Avenue South. However, to establish a dedicated bicycle lane and meet MSA design standards, the existing parking lane would need to be removed. Due to high parking demand there was the desire from the community to maintain parking along the street for the length of the corridor. The recommended design was a seven-foot northbound parking lane, a five to 5.5-foot northbound bicycle lane, an 11-foot northbound travel lane, and a 10.5 to 11-foot southbound travel with a curb reaction width of 1.5-foot. The project connects to bicycle lanes on 1st Avenue South to the north and south.

The project was open for use in October, 2011.

Typical: Franklin Avenue East to 28th Street East (35-56')

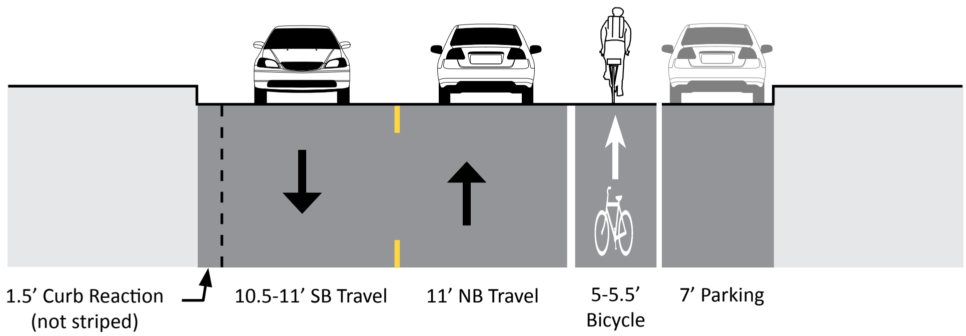


Figure 13-1: Typical cross section

Figure 13-2: Project location

Figure 13-3: 1st Avenue South at 27th Street East after installation

Figure 13-4: Traffic on 1st Avenue South at 25th Street East after installation

Figure 13-5: Bicyclist riding on 1st Avenue South at 25th Street East after installation

Figure 13-6: Bicyclist riding on 1st Avenue South at 22nd Street East after installation

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of 1st Avenue South, the specific measures of effectiveness are traffic volumes, parked vehicle compliance, reported crashes, and user behavior. Except for parked vehicle observations and user behavior, 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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Results

Traffic Volumes

Bicycle traffic before the project was installed was not available. Bicyclist traffic after installation was 120 bicyclists per day. Motor vehicle traffic increased slightly after the project was installed. Before the project was installed, the AADT was 4,400 vehicles per day. After installation, the AADT was 4,900. No motor vehicle data was collected during the three years after installation, so a 2015 count was used to represent after conditions.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 13-2: Daily traffic volumes

Type	Location (between)	Before			After			
		2009	2010	2011	2012	2013	2014	2015
Bicycle (EDT)	27th St E and 28th St E	-	-	-	120	-	-	-
Motor Vehicle (AADT)	22nd St E and 24th St E	-	-	4,400	-	-	-	4,900

Reported Crashes

During the three years before installation, there were 135 reported crashes, including 127 motor vehicle crashes, four bicycle crashes, and four pedestrian crashes. During the three years after installation, there were 112 reported crashes including 108 motor vehicle crashes, three bicycle crashes, and one pedestrian crash.

Table 13-3: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	127	108	-19
Bicycle	4	3	-1
Pedestrian	4	1	-3
Total	135	112	-23

Three bicycle crashes occurred after installation. One crash occurred on 1st Avenue South, 100 feet south of the intersection of 27th Street East. The crash involved a northbound bicyclist and a northbound vehicle parked legally. The motorist was cited for "other human factors." Based on these circumstances, this may be a "dooring" crash. Two cashes occurred at the intersection of Franklin Avenue East and involved either eastbound or westbound bicyclists and motorists. The one pedestrian crash after installation involved a pedestrian crossing mid-block on Franklin Avenue East east of 1st Avenue South.

Motor Vehicle Parking Compliance

After installation, most motor vehicles parked compliantly in the seven-foot parking lane on 1st Avenue South. Five observation periods in September and October, 2012 tallied 504 parked vehicles. Overall, 90 percent of vehicles were parked compliantly, eight percent were parked with a least one tire on the inside bicycle lane edge line (minor encroachment), and two percent were fully encroaching in the bicycle lane area (major encroachment).

Table 13-4: Parked vehicle location

Parked Vehicle Location	Count	Percentage
Compliant	454	90%
Minor encroachment	39	8%
Major encroachment	11	2%
Total	504	100%

User Behavior Monitored

User behavior was evaluated after installation by recording video on 1st Avenue South. The video was recorded with a north-facing camera located on 1st Avenue South between 25th Street East and 26th Street East. Tabulated events included bicyclist location and motorist location, although motorist encroachment into the oncoming travel lane was not tabulated.

Before video was collected in May, 2012. Thirty-two hours of video were processed over two periods (6:00 a.m. to 10:00 p.m.). Due to the camera angle, visibility was limited, and behavior was only clearly visible for a segment approximately 100 feet north of 26th Street East.

Figure 13-7: Screen capture of after video on 1st Avenue South between 25th Street East and 26th Street East

<u>Bicyclist Behavior</u>

After the northbound bicycle lane was installed, 96 percent of northbound bicyclists rode in the bicycle lane, four percent rode on the sidewalk, and the remainder road in other locations. Seventy-five percent of southbound bicyclists were observed riding in the southbound travel lane, 21 percent rode on the sidewalk, and four percent were observed riding against traffic in the northbound bicycle lane.

Table 13-5: Bicyclist location

Bicyclist Location	Northbound		Southbound	
	Count	%	Count	%
Southbound travel lane	1	<1%	54	75%
Northbound travel lane	2	<1%	0	0%
Northbound bicycle lane	611	96%	3	4%
Parking lane	0	0%	0	0%
Sidewalk	25	4%	15	21%
Multiple	0	0%	0	0%
Total	639	100%	72	100%

<u>Motorist Behavior</u>

After installation, 99 percent of northbound motorists drove within the northbound travel lane, and one percent encroached into the northbound bicycle lane. All southbound motorists were observed driving in the southbound travel lane. Encroachment into the oncoming travel lane was not tabulated.

Table 13-6: Motor vehicle location

Motorist Location	Northbound		Southbound	
	Count	%	Count	%
Travel lane	7,175	99%	1,169	100%
Encroachment into oncoming travel lane	*Not tabulated*			
Encroachment into bicycle lane	58	1%	0	0%
Encroachment into parking lane	0	0%	0	0%
Total	7,233	100%	1,169	100%

Conclusions

The evaluation of the street design elements on 1st Avenue South showed that the street generally operated as intended and that there was an improvement in safety for many users. The project installed a preferential bicycle lane treatment in a constrained corridor without having a negative impact on the safety of users or operations of the street.

During the three years before installation, there were 135 reported crashes, including 127 motor vehicle crashes, four bicycle crashes, and four pedestrian crashes. During the three years after installation, there were 112 reported crashes including 108 motor vehicle crashes, three bicycle crashes, and one pedestrian crash. According to police reports, the circumstances of two of the bicycle crashes do not appear to be related to the street design elements. One “dooring” crash appears to have occurred along 1st Avenue South. While a trend of “dooring” crashes was not observed after installation, Public Works will continue to monitor the bicycle lane adjacent to the seven-foot parking lane.

After the installation of the project, the street generally operated as intended. After the bicycle lane was installed, 96 percent of northbound bicyclists rode in the northbound bicycle lane. Under the new configuration, 99 percent of the motorists operated in their respective travel lane.

Public Works intends to maintain the project as it is providing value to bicyclists and no related safety or operational issues have been observed.

Chapter 14

Number of Travel Lanes Required on a One-Way Street

Project Location:
Fremont Avenue North between Lowry Avenue North and Plymouth Avenue North

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-020

Design Element Involved

Design Standard the Exception is from:

8820.9936 Design Standards, Urban; New or Reconstruction Projects, Subpart 2. One-way streets

Design Element(s) Involved:

Number of travel lanes required on a one-way street

Required Standard:

One-way streets must have at least two through traffic lanes.

"In lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes along Fremont Avenue North, a seven-foot bicycle lane is proposed as one of two travel lanes on the 1.5 mile one-way southbound segment between Plymouth Avenue North and Lowry North Avenue in lieu of two general purpose travel lanes. To achieve a design consistent with MSA standards, the roadway would need to be 35 feet, or three feet wider than the existing width. This would allow for a bicycle lane. A wider street width would be needed to establish a buffered bicycle lane.

Upon application, an exception was granted for this configuration

Figure 14-1: Required standard and "in lieu of" design

Design Element	Southbound					Total
	Parking	Travel	Travel	Buffer	Bicycle	
Required Standard	8'	11'	11'	-	5'	35'
"In Lieu of" Design	9'	12'	-	4'	7'	31'

Project Location

The project location is on Fremont Avenue North between Lowry Avenue North and Plymouth Avenue North. The project is approximately 1.5 miles, or sixteen city blocks long. This segment of Fremont Avenue North operates as a one-way pair with Emerson Avenue North. Fremont Avenue North operates southbound, primarily serving inbound traffic into downtown Minneapolis. Surrounding land uses include single family residential, a high school, business node, and neighborhood park.

Fremont Avenue North is 32 feet wide. Prior to installation, the cross section included parking on one side of the street and two southbound travel lanes. The street had AADTs ranging from 3,400 to 4,300 vehicles per day with a posted speed limit of 30 mph. The high-frequency Metro Transit bus route 5 operates on this segment of Fremont Avenue North with an average headway of 10 minutes or less. Fremont Avenue North is on the MSA system in Minneapolis.

The goal of the bicycle project was to provide a north-south connection between Lowry Avenue North and Plymouth Avenue North with connections to the north and south. Due to high parking demand between Lowry Avenue North and Plymouth Avenue North, there was the desire from the community to maintain parking on one side of the street for the length of the corridor. The preferred design included: a nine-foot southbound parking lane, a 12-foot southbound travel lane, a four-foot buffer, and a seven-foot southbound bicycle lane. The project connects to bicycle lanes on Fremont Avenue to the north and bicycle lanes on Plymouth Avenue North to the south.

The project was open for use in October, 2011.

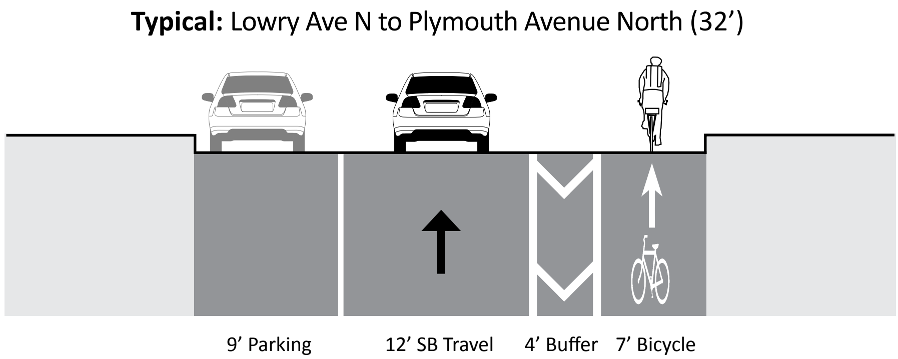


Figure 14-2: Typical cross section

Figure 14-3: Project location

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of Fremont Avenue North, the specific measures of effectiveness are traffic volumes, motor vehicle speeds, reported crashes, and user behavior. 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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Figure 14-4: Fremont Avenue North approaching West Broadway Avenue North after installation

Figure 14-5: Traffic on Fremont Avenue North at 26th Avenue North after installation

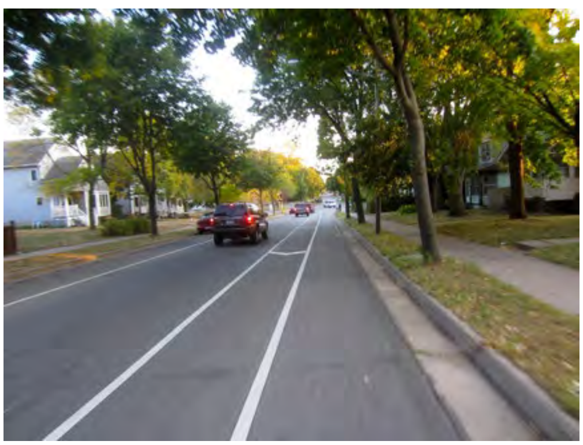


Figure 14-6: Traffic on Fremont Avenue North approaching 26th Avenue North after installation

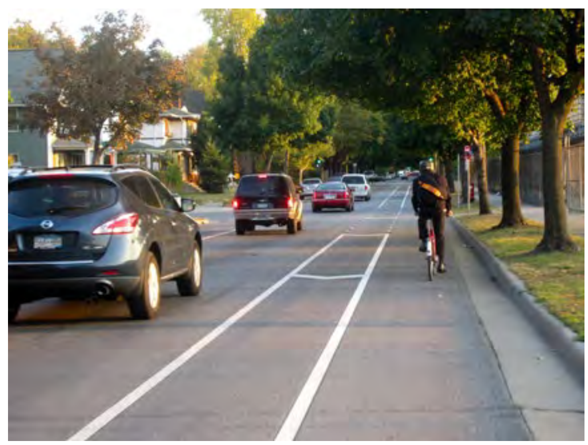


Figure 14-7: A bicyclist riding on Fremont Avenue North at 18th Avenue North after installation

Results

Traffic Volumes

Before installation of the project, bicycle traffic was 110 bicyclist per day. Bicyclist data after installation was not available, although Public Works believes that bicycle traffic volumes may have increased slightly following the installation of bicycle lanes.

Motor vehicle traffic increased slightly after the project was installed. Before the project was installed, AADTs ranged between 3,400 and 4,300 vehicles per day. After the project was installed, AADTs ranged from 3,400 and 4,600.

It is important to note that changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 14-2: Daily traffic volumes

Type	Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	Lowry Ave N and 30th Ave N	-	-	110	-	-	-
Motor Vehicle (AADT)	29th Ave N and 30th Ave N	-	3,400	-	3,400	-	-
	25th Ave N and 26th Ave N	4,300	-	-		4,600	-
	17th Ave N and 18th Ave N	-	3,700		3,700	-	-
	Plymouth Ave N and 14th Ave N	3,400	-	-	-	3,800	-

Motor Vehicle Speeds

Motor vehicle speeds along the corridor did not change substantially after the project was installed. The 85th-percentile speeds before the project was installed ranged from 34 to 35 mph. After the project was installed, 85th-percentile speeds ranged from 33 to 34 mph. Both the before-and-after 85th-percentile speeds are above the 30 mph posted speed limit.

Table 14-3: 85th-percentile speeds

Location (between)	Before (mph)			After (mph)		
	2009	2010	2011	2012	2013	2014
29th Ave N and 30th Ave N	-	35	-	33	-	-
17th Ave N and 18th Ave N	-	34	-	34	-	-

Reported Crashes

During the three years before installation, there were 115 reported crashes, including 103 motor vehicle crashes, six bicycle crashes, and six pedestrian crashes. During the three years after installation, there were 109 reported crashes including 100 motor vehicle crashes, six bicycle related-crashes, and three pedestrian crashes.

Table 14-4: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	103	100	-3
Bicycle	6	6	0
Pedestrian	6	3	-3
Total	115	109	-6

Six bicycle crashes occurred after installation. Four occurred on Fremont Avenue North, three of which occurred at West Broadway Avenue North. Two of the crashes involved bicyclists “riding against traffic”; and the third crash involved a bicyclist cited for “improper lane use”while the motorist was cited for “failing to yield the right-of-way.” One crash occurred at 30th Avenue North involving a southbound bicyclist and southbound motorist. The circumstances are unclear, but the motorist was cited for “improper lane use.”

User Behavior Monitored

User behavior was evaluated with before-and-after observations by recording video on Fremont Avenue North. The video was recorded with a south-facing camera located on Fremont Avenue North between 21st Avenue North and 22nd Avenue North. Events tabulated include northbound bicyclist location, motorist location, and the location of large motor vehicles.

Before video was collected in July, 2011 and after video was collected in May, 2016. Sixteen hours of video were processed (6:00 a.m. to 10:00 p.m.) in both the before-and-after periods.

Figure 14-8: Screen capture of before video on Fremont Avenue North between 21st Avenue North and 22nd Avenue North

Figure 14-9: Screen capture of after video on Fremont Avenue North between 21st Avenue North and 22nd Avenue North

Bicyclist Behavior

Bicyclist location changed after the project was installed. Before installation, 33 percent of bicyclists rode in the left travel lane, 22 percent rode in the right travel lane, 43 percent rode on the sidewalk, and one percent rode in multiple locations. After installation, five percent of bicyclists rode in the single travel lane, five percent rode in the buffer area, 65 percent rode in the bicycle lane, 16 percent rode on the sidewalk, and nine percent rode in multiple locations.

Table 14-5: Bicyclist location

Bicyclist Location	Before		After	
	Count	%	Count	%
Travel lane (left)	24	33%	4	5%
Travel lane (right)	16	22%		
Parking lane	0	0%	0	0%
Buffer area	-	-	4	5%
Bicycle lane	-	-	49	65%
Sidewalk	31	43%	12	16%
Multiple	1	1%	7	9%
Total	72	100%	76	100%

Motorist Behavior

Before the project was installed, all motorists were observed driving in one of the two travel lanes. Before installation, 58 percent of motorists drove in the left travel lane, and 42 percent drove in the right travel lane.

After the project was installed, most motorists were observed using the street as intended by driving in the single travel lane. After installation, 97% of motorists drove in the single travel lane, three percent encroached into the buffer area, and less than one percent encroached into the bicycle lane or drove in multiple locations.

Table 14-6: Motor vehicle location

Motorist Location	Before		After	
	Count	%	Count	%
Travel lane (left)	2,819	58%	4,886	97%
Travel lane (right)	2,032	42%		
Encroached into parking lane	0	0%	0	0%
Encroached into buffer area	-	-	125	3%
Encroached into bicycle lane	-	-	15	<1%
Multiple	0	0%	4	<1%
Total	4,851	100%	5,030	100%

Before installation, large vehicles accounted for three percent of motor vehicle traffic. After installation, large vehicles accounted for six percent of motor vehicles. Most large vehicles included Metro Transit buses and school buses. Due to the wider vehicle width, large vehicles tended to exhibit different behavior than typical single occupant vehicles.

Before installation, 17 percent of large vehicles drove in the left travel lane and 83 percent drove in the right travel lane. The Metro Transit bus stops are located on the right side of the roadway, and most Metro Transit vehicles stayed within the right travel lane, presumably to more easily access the bus stop locations.

After installation, 87 percent of large vehicles drove in the single travel lane, eight percent encroached into the buffer area, and five percent encroached into the bicycle lane.

Table 14-7: Large motor vehicle location

Large Motor Vehicle Location	Before		After	
	Count	%	Count	%
Travel lane (left)	26	17%	253	87%
Travel lane (right)	127	83%		
Encroached into parking lane	0	0%	0	0%
Encroached into buffer area	-	-	24	8%
Encroached into bicycle lane	-	-	14	5%
Multiple	0	0%	0	0%
Total	153	100%	291	100%

Conclusions

The evaluation of the street design elements on Fremont Avenue North found that the street generally operated as intended and that there was an improvement in safety for many users. The project installed a preferential bicycle lane treatment in a constrained corridor and modified the capacity of the roadway without having a negative impact on the safety or operations of the street.

During the three years before installation, there were 115 reported crashes, including 103 motor vehicle crashes, six bicycle crashes, and six pedestrian crashes. During the three years after installation, there were 109 reported crashes including 100 motor vehicle crashes, six bicycle related-crashes, and three pedestrian crashes. According to police reports, the circumstances of the bicycle crashes after installation do not appear to be a factor of the project design.

After the installation of the project and installation of the bicycle lanes, the street generally operated as intended and created a more organized street environment. After the bicycle lane was installed, most bicyclists were riding in the lane as intended, and fewer bicyclists were observed riding on the sidewalk. Under the new configuration, 97 percent motor vehicles operated in the single travel lane. Encroachment of buses and large vehicles into other lanes and the buffer area was observed after the project was installed, but was not observed to create safety or operational issues.

Public Works intends to maintain the project as it is providing value to bicyclists and no related safety or operational issues have been observed. In the 2015 update to the Minneapolis Bicycle Master Plan, Fremont Avenue and Emerson Avenue North are identified as a future protected bikeways. A protected bikeway on Fremont Avenue North would preserve the one lane configuration, but may relocate the bicycle lane to the left side of the street and parking lane to the right side of the street. It would also consist of a design that would physically separate bicycle traffic from motor vehicle traffic and mitigate encroachment of motor vehicles into the buffer and bicycle lane areas.

Chapter 15

Number of Travel Lanes Required on a One-Way Street

Project Location:

1st Avenue South between 33rd Street East and 40th Street East

The purpose of this chapter is to fulfill the final evaluation reporting requirements of the Minnesota Department of Transportation's approval of Design Exceptions for State Project 141-091-020

Design Element Involved

Design Standard the Exception is from:

8820.9936 Design Standards, Urban; New or Reconstruction Projects, Subpart 2. One-way streets

Design Element(s) Involved:

Number of travel lanes required on a one-way street

Required Standard:

One-way streets must have at least two through traffic lanes.

"In lieu of" Design:

As part of the reconditioning project to modify pavement markings and signing to include on-street bicycle lanes along 1st Avenue South,

- A seven-foot bicycle lane with a four-to-five-foot buffer is proposed as one of two travel lanes in lieu of two general purpose travel lanes. To achieve a design consistent with MSA standards, the roadway would need to be 35 feet wide, or three to six feet wider than the existing width. This would allow for a bicycle lane. A wider street width would be needed to establish a buffered bicycle lane.
- It is further proposed to allow the existing weekend parking to occur on the east side of the street in the seven-foot marked bicycle lane/weekend parking lane, while maintaining the existing full time parking along the west side of the street, and to provide a bicycle lane buffer of four to five-feet wide adjacent to the bicycle lane/weekend parking lane. To achieve a design consistent with MSA standards, the roadway would need to be 38 feet wide, or six to nine feet wider than the existing width.

A design exception was successfully received for both weekday and weekend configurations.

Table 15-1: Required standard and "in lieu of" design (Monday-Friday)

Direction	Northbound					Total
Design Element	Parking	Travel	Travel	Buffer	Bicycle	
Required Standard	8'	11'	11'	-	5'	35'
"In Lieu of" Design	7-9'	11'	-	4-5'	7'	29-32'

Table 15-2: Required standard and "in lieu of" design (Saturday-Sunday)

Direction	Northbound					Total
Design Element	Parking	Travel	Travel	Buffer	Parking	
Required Standard	8'	11'	11'	-	8'	38'
"In Lieu of" Design	7-9'	11'	-	4-5'	7'	29-32'

Project Location

The project location is on 1st Avenue South between 33rd Street East and 40th Street East. The project is approximately 0.5 miles or seven city blocks long. This segment of 1st Avenue South operates as a one-way pair with Blaisdell Avenue South. First Avenue South operates northbound, primarily serving inbound traffic into downtown Minneapolis. Surrounding land uses include single family residential and a neighborhood park.

First Avenue South varies in width from 29 feet to 32 feet. On weekdays, the existing cross section included parking on one side of the street and two northbound travel lanes. On weekends, parking was permitted on both sides of the street with one northbound travel lane. The street had AADTs ranging from 700 to 3,500 vehicles per day with a posted speed limit of 30 mph. No regular transit route uses this segment of 1st Avenue South.

The goal of the bicycle project was to provide a north-south connection between 33rd Street East and 40th Street East with connections to the north and south. Due to high parking demand between 33rd Street East and 40th Street East it was the desire of the community to maintain parking on both sides of the street for the length of the corridor, especially during the weekends when parking demand was observed to be higher. The preferred design included a dynamic design with a weekday and weekend configuration:

- Weekdays: A seven to nine-foot northbound parking lane, a 11-foot northbound travel lane, a four to five-foot buffer, and a seven-foot northbound bicycle lane
- Weekends: A seven to nine-foot northbound parking lane, a 11-foot northbound travel lane, a four to five-foot buffer, and a seven-foot northbound parking lane; the weekend configuration did not include a preferential bicycle lane

The project was open for use in October, 2011.

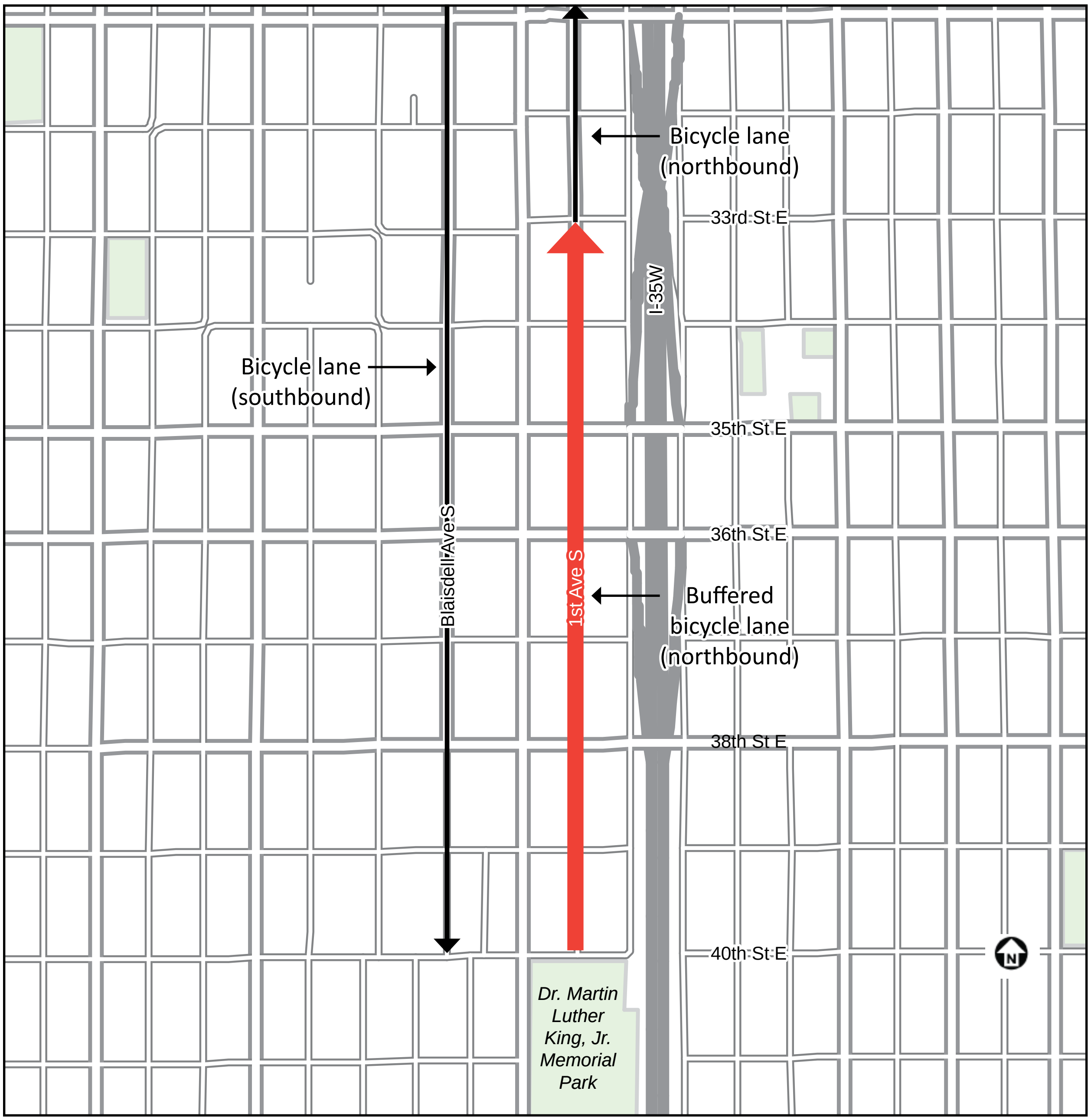


Figure 15-1: Project location

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of 1st Avenue South the specific measures of effectiveness are traffic volumes, motor vehicle speeds, reported crashes, and user behavior. All measures include before-and-after monitoring except for user behavior.

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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

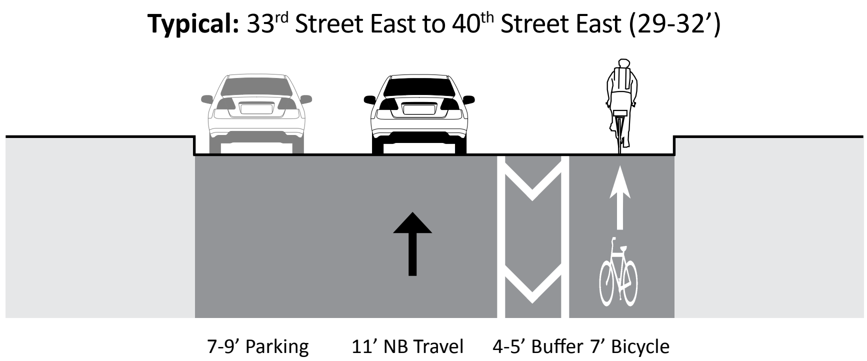


Figure 15-2: Typical cross section Monday-Friday

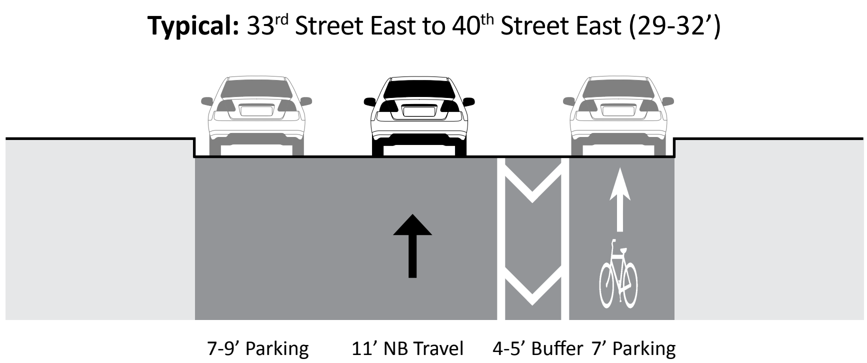


Figure 15-3: Typical cross section Saturday-Sunday

Figure 15-4: 1st Avenue South at 39th Street East after installation on a weekday

Figure 15-5: Traffic on 1st Avenue South approaching 35th Street East after installation on a weekday

Figure 15-6: Bicyclist riding on 1st Avenue South at 35th Street East after installation on a weekday

Figure 15-7: Parked vehicles on both sides of 1st Avenue South at 40th Street East after installation on a weekend

Figure 15-8: Traffic on 1st Avenue South at 40th Street East after installation on a weekend

Figure 15-9: Bicyclists riding on 1st Avenue South at 40th Street East after installation on a weekend

Results

Traffic Volumes

Bicycle traffic volumes before the project was installed was 150 bicyclist per day. Bicycle traffic volumes after the project was installed decreased to 110 bicyclists per day.

Motor vehicle traffic varied after the project was installed. Before the project was installed, the AADT ranged between 600 and 3,200 vehicles per day. After installation, the AADT was 2,300.

It is important to note that all counts were conducted on weekdays and changes in EDT and AADT may be attributed to daily or seasonal variation.

Table 15-3: Daily traffic volumes

Type	Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicycle (EDT)	39th St E and 40th St E	-	-	150	110	-	-
Motor Vehicle (AADT)	33rd St E and 34th St E	-	-	3,200	-	-	-
	34th St E and 35th St E	-	-	3,400	-	-	-
	36th St E and 37th St E	-	-	1,600	2,300	-	-
	39th St E and 40th St E	-	-	600	-	-	-

Motor Vehicle Speeds

Motor vehicle speeds along the corridor decreased after the project was installed. The 85th-percentile speed speeds before the project was installed ranged from 34 to 35 mph. After the project was installed, the 85th-percentile speed was 30 mph. The 85th-percentile speeds before installation were above the 30 mph posted speed limit. The 85th-percentile speed after installation was equal to the 30 mph posted speed limit.

Table 15-4: 85th-percentile speeds

Location (between)	Before (mph)			After (mph)		
	2009	2010	2011	2012	2013	2014
33rd St E and 34th St E	-	-	34	-	-	-
36th St E and 37th St E	-	-	33	30	-	-

Reported Crashes

During the three years before installation, there were 89 reported crashes, including 89 motor vehicle crashes, zero bicycle crashes, and zero pedestrian crashes. During the three years after installation, there were 70 reported crashes, including 69 motor vehicle crashes, one bicycle crash, and zero pedestrian crashes. The number of crashes occurring on weekdays versus weekends was nearly proportional to the days they represent: weekdays represent 71 percent of days, weekends represent 29 percent of days. However, the daily traffic likely varies between weekdays and weekends, so the exposure may not represent the same share.

Table 15-5: Reported crashes - Total

Crash Type Total	Before	After	Change
Motor Vehicle	89	69	-20
Bicycle	0	1	1
Pedestrian	0	0	0
Total	89	70	-19

Table 15-6: Reported crashes on weekdays

Crash Type Weekday	Before	After	Change
Motor Vehicle	65	46	-18
Bicycle	0	1	0
Pedestrian	0	0	0
Total	65	47	-18

Table 15-7: Reported crashes on weekends

Crash Type Weekend	Before	After	Change
Motor Vehicle	24	23	-1
Bicycle	0	0	0
Pedestrian	0	0	0
Total	24	23	-1

One bicycle crash occurred after installation. It occurred on a weekday at the intersection of 36th Street East. The crash involved an eastbound bicyclist and northbound motorist. The motorist was cited for "disregarding traffic control device."

User Behavior Monitored

User behavior was monitored after installation by field observations on 1st Avenue South. These field observations were conducted by Public Works staff on 1st Avenue South between 35th Street East and 36th Street East and between 39th Street East and 40th Street East. Tabulated events included bicyclist location and motorist location.

Field observations were collected in September, 2012. Four hours of observations were conducted at each location on weekends between 7:00 a.m. and 9:00 a.m. and also between 4:00 p.m. and 6:00 p.m. Two hours of observations were conducted at each location on weekends between 11:00 a.m. and 1:00 p.m.

Bicyclist Behavior

In the 3500 block on weekdays, 88 percent of bicyclists rode in the bicycle lane, one percent rode in the buffer area, and nine percent rode on the sidewalk. In the 3900 block on weekdays, 79 percent of bicyclists rode in the bicycle lane, 12 percent rode in the buffer area, and 10 percent rode on the sidewalk.

Table 15-8: Bicyclist location on weekdays

Bicyclist Location (Weekday)	3500 Block		3900 Block	
	Count	%	Count	%
Parking lane (west side)	0	0%	0	0%
Travel lane	1	1%	0	0%
Buffer area	1	1%	5	12%
Bicycle lane	61	88%	33	79%
Sidewalk	6	9%	4	10%
Multiple	0	0%	0	0%
Total	69	100%	42	100%

In the 3500 block on weekends, 46 percent of bicyclists rode in the bicycle lane, 54 percent rode in the buffer area, and no bicyclists were observed riding on the sidewalk. Parking demand was at about 50 percent capacity in the parking lane on the east side of the street.

In the 3900 block on weekdays, no bicyclists rode in the bicycle lane, 33 percent rode in the buffer area, 25 percent rode in the travel lane, and 42 percent rode on the sidewalk. Parking demand was at nearly 100 percent capacity in the parking lane on the east side of the street.

Table 15-9: Bicyclist location on weekdays

Bicyclist Location (Weekend)	3500 Block		3900 Block	
	Count	%	Count	%
Parking lane (west side)	0	0%	0	0%
Travel lane	0	0%	3	25%
Buffer area	7	54%	4	33%
Parking lane (east side)	6	46%	0	0%
Sidewalk	0	0%	5	42%
Multiple	0	0%	0	0%
Total	13	100%	12	100%

<u>Motorist Behavior</u>

On weekdays, after the bicycle lane was installed, 37-72 percent of motorists drove in the single travel lane, 25-54 percent encroached into the buffer area, and the remainder encroached into the bicycle lane or drove in multiple locations.

Table 15-10: Motorist location on weekdays

Motorist Location	3500 Block		3900 Block	
	Count	%	Count	%
Parking lane (west side)	0	0%	0	0%
Travel lane	505	72%	90	37%
Buffer area	176	25%	129	54%
Bicycle lane	16	2%	11	5%
Multiple	0	0%	11	5%
Total	697	100%	241	100%

On weekends, after the bicycle lane was installed, 63-76 percent of motorists drove in the single travel lane, 24-36 percent encroached into the buffer area, and the remainder encroached into the parking lane on the east side of the street.

Table 15-11: Motorist location on weekends

Motorist Location	3500 Block		3900 Block	
	Count	%	Count	%
Parking lane (west side)	0	0%	0	0%
Travel lane	145	76%	44	63%
Buffer area	45	24%	25	36%
Parking lane (east side)	1	1%	0	0%
Multiple	0	0%	0	0%
Total	191	100%	70	100%

Conclusions

The evaluation of the street design elements on 1st Avenue South showed that the street generally operated as intended and that there was an improvement in safety for many users. The project installed a preferential bicycle lane treatment in a constrained corridor and modified the capacity of the roadway without having a negative impact on the safety or operations of the street. The safety of the corridor did not vary between the weekend and weekday operation, although Public Works has received continued negative feedback from bicyclists about the weekend configuration.

During the three years before installation, there were 89 reported crashes, including 89 motor vehicle crashes, zero bicycle crashes, and zero pedestrian crashes. During the three years after installation, there were 70 reported crashes, including 69 motor vehicle crashes, one bicycle crash, and zero pedestrian crashes. Crashes do not appear more or less prevalent on weekdays compared to weekends. According to the police report, the one bicycle crash involved a vehicle on a cross street and did not appear to be related to the street design elements.

After the installation of the project and installation of the bicycle lanes, the street generally operated as intended. Most bicyclists were riding in the lane as intended. No safety issues were observed under the weekend configuration, although a shared lane configuration is not desired and the four-foot buffer does not provide adequate space for bicyclists to overtake parked cars. While not formally collected as part of this evaluation, Public Works has received negative feedback from bicyclists about the weekend configuration.

After installation, most motor vehicles operated in the single travel lane at slower speeds. Encroachment of vehicles into the buffer area and bicycle lane was observed after the project was installed, but was not observed to create safety or operational issues. The travel lane is effectively 11 feet, although motorists may be encroaching in the buffer area in order to provide adequate clearance from parked vehicles. Striping an edge line between the travel lane and parking could provide additional guidance both of parked vehicles and motorists operating in the travel lane.

Public Works intends to keep the project in place as the project is providing value to bicyclists. Except for feedback related to the weekend configuration, no related safety or operational issues have been raised. In the 2015 update to the Minneapolis Bicycle Master Plan, 1st Avenue South and Blaisdell Avenue South have been identified as a future protected bikeways. A protected bikeway on 1st Avenue South would preserve the one-lane configuration, but would eliminate the weekend parking in the bicycle lane area. It would also consist of a design that would physically separate bicycle traffic from motor vehicle traffic and mitigate encroachment of motor vehicles into the buffer and bicycle lane areas.

Chapter 16

Colored Bicycle Lane Conflict Zone

Project Location:
15th Avenue Southeast at University Avenue Southeast
15th Avenue Southeast at 4th Street Southeast
15th Avenue Southeast at 5th Street Southeast

Local Evaluation - Installed after the Federal Highway Administration's interim approval for optional use of green colored pavement for bicycle lanes (IA-14)

Treatment Description

A colored bicycle lane conflict zone is a variation of a conventional bicycle lane marking. Conventional bicycle lanes are typically defined by solid longitudinal lines. At bus stop locations, turn lanes, and intersection approaches, the bicycle lane longitudinal markings are typically dotted to allow motor vehicle traffic to maneuver across the bicycle lane to access the curb or prepare for a turn. Longitudinal markings can be extended through intersections to provide guidance and raise additional awareness to road users.

The 2009 edition of the MMUTCD states that "a dotted line provides guidance or warning of a downstream change in lane function." This message is consistent with Minnesota State Statute 169.429, which states that motorists are required to yield to approaching bicycle traffic before merging across a bicycle lane. For bicycle lane markings, the MMUTCD states that "dotted edge line extensions may be placed through intersections or major driveways." Dotted lines are intended to raise awareness for bicyclists and motorists to potential conflict areas, reinforce that through bicyclists have priority over turning vehicles or vehicles entering the roadway, and provide guidance to bicyclists through the intersection in a straight and direct path.

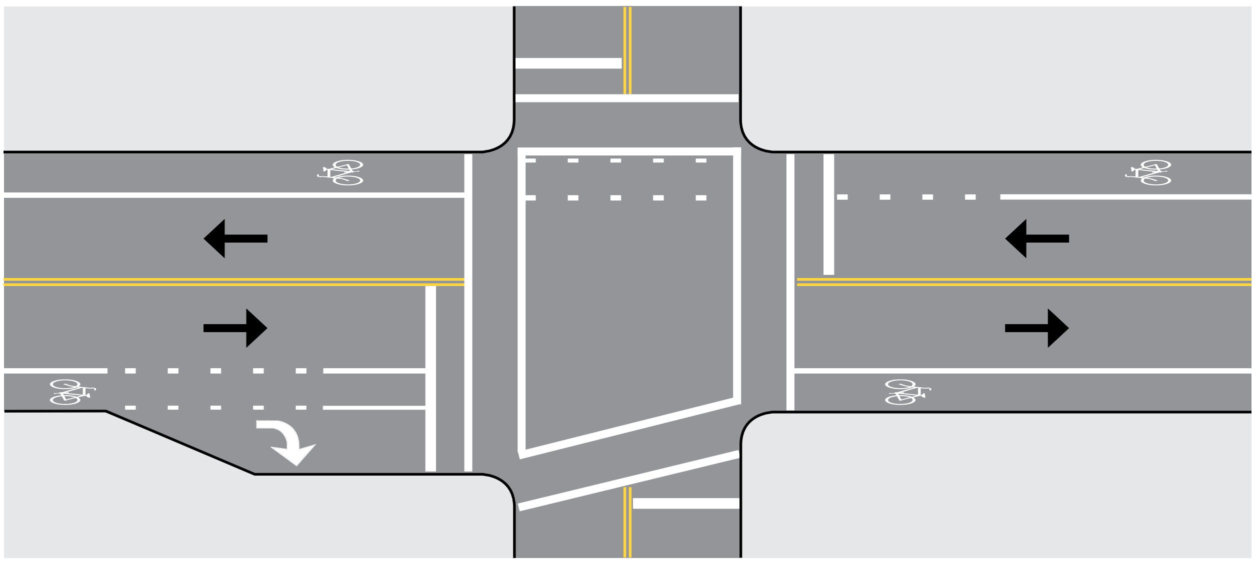


Figure 16-1: Conventional bicycle lane markings at an intersection and dedicated turn lane

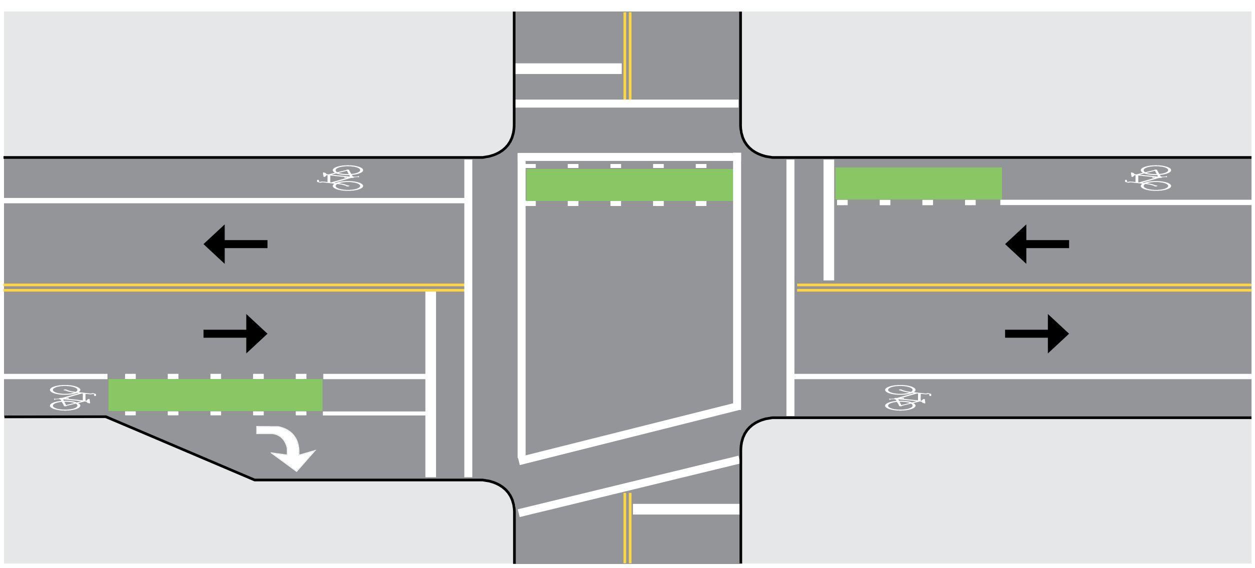


Figure 16-2: Colored bicycle lane conflict zones at an intersection and dedicated turn lane

A colored bicycle lane conflict zone modifies the conventional dotted bicycle lane marking to include a green colored background. The green color is intended to reinforce the message of the dotted line and the fact that motorists are required to yield to bicyclists riding in the bicycle lane. The green color is also intended to increase awareness to both bicyclists and motorists that this portion of roadway requires a higher degree of care due to the nature of interactions and merging.

At the time of project planning, colored bicycle lane conflict zones were considered by FHWA to be experimental. In April 2011, FHWA issued Interim Approval for the Optional Use of Green Colored Pavement for Bicycle Lanes (IA-14). The applications of the installed projects are consistent with the interim approval. To date, colored bicycle lane conflict zones and colored bicycle lane applications are used extensively in many U.S. cities.

Project Location

Three project locations were installed along 15th Avenue Southeast at three intersections: University Avenue Southeast, 4th Street Southeast, and 5th Street Southeast. Surrounding land uses and destinations include the University of Minnesota and athletic facilities, two commercial nodes, multi-family apartments, and a neighborhood park. Fifteenth Avenue Southeast is a primary corridor connecting the University of Minnesota to the Marcy-Holmes, Dinkytown, Southeast Como, and Northeast neighborhoods of Minneapolis. The neighborhoods are home to many university students who use 15th Avenue Southeast to walk, bicycle, take transit, or drive to the campus.

Prior to implementation, the street had AADTs ranging from 7,700 to 12,500 vehicles per day. In coordination with this project, the posted speed was reduced from 30 mph to 25 mph. The evaluation of the posted speed limit is documented in Chapter 17 of this report. The high-frequency Metro Transit bus route 3 operates on this segment of 15th Avenue Southeast with an average headway of 10 minutes or less. 15th Avenue Southeast is also one of the busiest on-street locations for bicycle traffic in the city, carrying 2,930 to 3,940 bicyclists per day.

The projects were open for use in September, 2011.

Figure 16-3: Project locations

15th Avenue Southeast at University Avenue Southeast

This treatment is located on 15th Avenue Southeast at University Avenue Southeast. To access University Avenue Southeast, which is one-way eastbound, southbound vehicles on 15th Avenue Southeast must cross the northbound bicycle lane. Northbound vehicles, accessing University Avenue Southeast, merge into a right turn lane in advance of the intersection on 15th Avenue Southeast, which is on the University of Minnesota campus. The northbound bicycle lane is colored green through the University Avenue Southeast intersection. Peak hour turns across the bicycle are 141 in the AM and 161 in the PM. These counts include northbound 15th Avenue Southeast right turns and southbound left turns.

Figure 16-4: Bicyclist riding northbound on 15th Avenue Southeast at University Avenue Southeast after installation

15th Avenue Southeast at 4th Street Southeast

This treatment is located on 15th Avenue Southeast at 4th Street Southeast. To access 4th Street Southeast, which is one-way westbound, vehicles on 15th Avenue Southeast must cross the southbound bicycle lane. The southbound bicycle lane is colored green at two points: at the point where right turning vehicles intend to merge into and cross the bicycle lane, and through the length of the 4th Street Southeast intersection to the receiving southbound bicycle lane. Peak hour turns across the bicycle are 186 in the AM and 362 in the PM. These counts include southbound 15th Avenue Southeast right turns and northbound left turns. There is a moderate uphill grade in the direction of travel.

Figure 16-5: Bicyclists riding southbound on 15th Avenue Southeast at 4th Street Southeast after installation

15th Avenue Southeast at 5th Street Southeast

This treatment is located at a free right turn on 15th Avenue Southeast at 5th Street Southeast. The right turn lane is in advance of a signalized intersection and provides access to eastbound 5th Street Southeast. The northbound bicycle lane is colored green at the point where right turning vehicles are intended to merge into and cross the bicycle lane. Peak hour turns across the bicycle are 80 in the AM and 19 in the PM. There is a moderate downhill grade in the direction of travel.

Figure 16-6: Bicyclist riding northbound on 15th Avenue Southeast at 5th Street Southeast after installation

Materials

Other green colored treatments in this report were installed by applying latex paint with no glass beads to the roadway surface. On 15th Avenue Southeast, the green color was installed by applying preformed thermoplastic panels to the roadway surface. Prior to installation, the roadway was milled so that the markings would be slightly recessed relative to the roadway surface.

Figure 16-7: Preformed thermoplastic material panels prior to installation

Figure 16-8: A contractor installing preformed thermoplastic on 15th Avenue Southeast at 4th Street Southeast

Figure 16-9: Preformed thermoplastic material shortly after installation on 15th Avenue Southeast at 4th Street Southeast

Figure 16-10: Preformed thermoplastic material shortly after installation on 15th Avenue Southeast at University Avenue Southeast

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report. For the evaluation of 15th Avenue Southeast, the specific measures of effectiveness are traffic volumes, motor vehicle speeds, reported crashes, user behavior, and user feedback. All measures include before-and-after monitoring, except user feedback.

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 from 2009 to 2011 and after conditions from 2012 to 2014.

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

Results

Traffic Volumes

Bicycle traffic increased after the project was installed. Before the project was installed, traffic volumes ranged between 3,170 and 3,940 bicyclists per day. After the project was installed, traffic volumes ranged between 3,620 and 4,330 bicyclists per day.

Motor vehicle traffic varied before-and-after the project was installed. Before the project was installed, AADTs ranged between 7,700 and 12,500 vehicles per day. After the project was installed, AADTs ranged between 6,500 and 11,400.

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

Table 16-1: Daily traffic volumes

Type	Location (between)	Before			After		
		2009	2010	2011	2012	2013	2014
Bicyclist	University Ave SE and 4th St SE	3,170	2,930	3,940	4,020	4,330	3,620
AADT	University Ave SE and 4th St SE	-	-	7,700	6,500	-	-
	4th St SE and 5th St SE	-	-	9,300	9,300	-	-

Total motor vehicle traffic volumes (AADT) provide context for the roadway. Peak hour motor vehicle turning movement counts provide further detail for the level of traffic crossing the bicycle lane and potentially interacting with bicyclists. All turning movement counts were collected in 2011 or 2013.

Table 16-2: Peak hour turning movement volumes across bicycle lane

Type	Location	Movement	Peak Hour Turning Volumes Across Bicycle Lane	
			AM	PM
Motor Vehicle (Turning Movements)	15th Ave SE at University Ave SE	SB Left Turns + NB Right Turns	141	161
	15th Ave SE at 4th St SE	SB Right Turns + NB Left Turns	186	362
	15th Ave SE at 5th St SE	NB Right Turns	80	19

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 23 and 32 mph. After the project was installed, 85th-percentile speeds ranged between 27 and 32.5 mph. Both the before-and-after 85th-percentile speeds are below the 25 mph posted speed limit except for the data collected between 5th Street Southeast and 6th Street Southeast.

Table 16-3: 85th-percentile speeds

Location (between)	Before (mph)			After (mph)		
	2009	2010	2011	2012	2013	2014
University Ave SE to 4th St SE	-	-	23	23	-	-
4th St SE to 5th St SE	-	-	26	26.5	-	-
5th St SE to 6th St SE	-	-	-	32.5	32	-

Reported Crashes

During the three years before installation, there were 22 reported crashes across the three locations, including 15 motor vehicle crashes, four bicycle crashes, and three pedestrian crashes. During the three years after installation, there were 23 reported crashes, including 17 motor vehicle crashes, five bicycle crashes, and one pedestrian crash.

Table 16-4: Reported crashes

Location	Crash Type	Before	After	Change
15th Ave SE at University Ave SE	Motor Vehicle	2	2	0
	Bicycle	0	1	1
	Pedestrian	0	0	0
	Total	2	3	1
15th Ave SE at 4th St SE	Motor Vehicle	8	8	0
	Bicycle	2	0	-2
	Pedestrian	3	1	-2
	Total	13	9	-4
15th Ave SE at 5th St SE	Motor Vehicle	5	7	2
	Bicycle	2	4	2
	Pedestrian	0	0	0
	Total	7	11	4
All locations	Motor Vehicle	15	17	2
	Bicycle	4	5	1
	Pedestrian	3	1	-2
	Total	22	23	1

Five bicycle crashes occurred after installation. Four crashes occurred at the intersection of 5th Street Southeast.

One involved a northbound bicyclist and northbound motorist on 15th Avenue Southeast approaching 5th Street Southeast, although the circumstances are unclear. Another crash involved a bicyclist "riding against traffic" on 15th Avenue Southeast. The other two crashes involved northbound bicyclists and southbound motorists making left turns onto eastbound 5th Street Southeast.

One crash occurred at University Avenue Southeast involving a northbound bicyclist riding on 15th Avenue Southeast and a northbound motorist making a right turn. The motorist was cited for "failing to yield the right-of-way."

User Behavior Monitored

User behavior was evaluated before-and-after installation by recording video at the 15th Avenue Southeast and 4th Street Southeast location and tabulating events. The video was recorded with a northeast facing camera located on the southwest quadrant of the intersection. Events tabulated include bicyclist riding location, motorist merging location, and bicyclist-motorist interactions.

Before video was collected in August of 2011 and after video was collected in May of 2012. For bicyclist and motorist behavior, 22 hours of before video was processed over two days (6:00 a.m. to 10:00 p.m.) and 16 hours of after video was processed over two days (6:00 a.m. to 10:00 p.m.).

Figure 16-11: Screen capture of before video on 15th Avenue Southeast at 4th Street Southeast.

Figure 16-12: Screen capture of after video on 15th Avenue Southeast at 4th Street Southeast.

<u>Bicyclist Behavior</u>

Bicyclist behavior changed significantly after installation. Before installation, eight percent rode in the travel lane, 62 percent rode in the bicycle lane approaching/through the intersection, six percent rode between the bicycle lane and parallel crosswalk, and 24 percent rode on the sidewalk or in the crosswalk. After installation six percent of bicyclists rode in the travel lane, 69 percent rode in the bicycle lane, eight percent rode between the bicycle lane and parallel crosswalk, and 17 percent rode on the sidewalk or in the crosswalk.

The results of the two-proportion z-test show the colored bicycle lane conflict zone had a significant effect on the proportion of bicyclists riding in the bicycle lane and on the sidewalk at the 95% confidence interval. The chi-squared test shows that the relationship between the colored bicycle lane conflict zone and bicyclist location is significant at the 99% confidence interval.

Table 16-5: Bicyclist location

Location of Bicyclists	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Travel lane	67	8%	30	6%	0.286	1.0663
Bicycle Lane	535	62%	333	69%	0.012	-2.5046
Between Bicycle Lane and Crosswalk	50	6%	40	8%	0.081	-1.7424
Sidewalk/Crosswalk	211	24%	81	17%	0.001	3.2967
Multiple Locations	0	0%	0	0%	-	-
Total	863	100%	484	100%	-	-

Chi-Square = 14.631, P-value = 0.002

Motorist Behavior

When a bicyclist was present, the southbound motorist merge location changed significantly after installation. Before installation, 46 percent of motorists merged before the approaching stop bar and 54 percent merged after the stop bar. After installation, 25 percent of southbound motorists merged before the stop bar and 75 percent merged after the stop bar.

The results of the two-proportion z-test and the chi-squared test show the colored bicycle lane conflict zone did not have a significant effect on motorist merge location when a bicyclist is present.

Table 16-6: Southbound motorist merge location when bicyclist is present

Location of	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Merge before stop bar	45	34%	77	37%	0.561	-0.5812
Merge after stop bar	87	66%	130	63%	0.561	0.5812
Total	132	100%	207	100%	-	-

Chi-Square = 0.3378, P-value = 0.561

When a bicyclist was not present, the southbound motorist merge location changed significantly after installation. However, the change was not as significant as when a bicyclist was present and had an inverse relationship. Before installation 45 percent of motorists merged before the approaching stop bar and 55 percent merged after the stop bar. After installation, 51 percent of motorists merged before the stop bar and 49 percent merged after the stop bar.

The results of the two-proportion z-test and the chi-squared test show the colored bicycle lane conflict zone did not have a significant effect on motorist merge location when no bicyclist is present.

Table 16-7: Motorist merge location when no bicyclist is present

Location of	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Merge before stop bar	484	45%	787	48%	0.101	-1.6421
Merge after stop bar	603	55%	862	52%	0.101	1.6421
Total	1,087	100%	1,649	100%	-	-

Chi-Square = 2.6965, P-value = 0.100

Bicyclist-Motorist Interactions

Some types of bicyclist-motorist interactions changed significantly after installation. Before installation, motorists yielded during 56 percent of interactions, a bicyclist yielded during 19 percent of interactions, a motorist turned right on red in front of a queued bicyclist during 19 percent of interactions, and a motorist turned on green in front of moving bicyclist during five percent of interactions. After installation, motorists yielded during 77 percent of interactions, bicyclists yielded during 11 percent of interactions, motorists turned right on red in front of a queued bicyclist during 10 percent of interactions, and motorists turned on green in front of moving bicyclist during two percent of interactions.

The results of the two-proportion z-test are mixed. While adding the colored bicycle lane conflict zone had a significant effect on motorist and bicyclist yielding, there is not a statistically significant effect on the proportion of motorists turning in front of bicyclists. The chi-squared test show there is a significant relationship between the bicyclist-motorist interactions and adding the colored bicycle lane conflict zone at the 99 percent confidence interval.

Table 16-8: Bicyclist-motorist interactions

Type of Interaction with Vehicles	Before		After		Significance	
	Count	%	Count	%	P-value	Z-score
Motorist yields	105	56%	124	77%	0	-3.94
Bicyclist yields	36	19%	18	11%	0.161	1.4
Motorist turns on red in front of queued bicyclist	36	19%	16	10%	0.079	1.76
Motorist turns on green in front of moving bicyclist	10	5%	4	2%	0.287	1.06
Other	0	0%	0	2%	-	-
Total	187	100%	162	100%	-	-

Chi-Square = 19.406, P-value = 0.000654

User Feedback

User feedback was solicited through an intercept survey for bicyclists, and signs encouraged users to call Minneapolis 311 to provide feedback.

Survey

Public Works recruited people to take the bicyclist survey in the field. Staff handed out survey cards to bicyclists waiting at a red semaphore at the intersections of 15th Avenue Southeast and University Avenue Southeast and 15th Avenue Southeast and 4th Street Southeast. A total of 166 survey cards and one printed survey were distributed over a six-hour period, resulting in 65 valid responses. The online survey, containing 13 questions, was intended to take 10 minutes or less to complete, and was available in an online or printed format. See Chapter 2 for additional information about the survey methods.

Figure 16-9: Survey response rates by user group

Survey Type	Distributed	Valid Responses	Response Rate
Bicyclist	167	65	39%

In both surveys, participants were shown a photo of the green conflict zone at the intersection of 15th Avenue Southeast and 4th Street Southeast and asked to state the intended purpose of the roadway marking. To not influence responses, the question was opened ended and participants wrote or typed into a blank field. Staff categorized responses based on content or common themes. Many participants provided responses that included multiple purposes.

Both the bicyclist survey and pedestrian survey participants provided responses that generally align with the intended purpose. Survey participants most frequently stated that the purpose was to indicate a lane for bicycle traffic and communicate that motorists should yield to bicycle traffic.

Table 16-10: Stated purpose of markings

Stated Purpose (Staff Tabulated Category)	Frequency
	Bicyclist Survey
Indicate lane for bicycle traffic	57
Communicate that motorists should yield to bicycle traffic	32
Provide guidance for bicyclists	17
Provide guidance for motorists	11
Other	5
Total	122

Survey participants were also asked if they had any general feedback about the recent changes to the three intersections along 15th Avenue Southeast.

The general feedback from bicyclists was that the markings have provided increased awareness to motorists about bicycle traffic on 15th Avenue Southeast. However, the intersection is very busy, and many motorists and buses are still not consistently yielding the right-of-way.

Table 16-11: Select feedback from bicyclist survey

Select feedback from bicyclist survey
"Making the bike lanes as obvious as possible makes motorists more aware. Motorists seem more cautious in the 15 Ave SE area than in other areas around campus, and it seems to me that more cyclists stay in the appropriate designated lanes and stopping areas, and observe traffic signals, than in other areas as well."
"The green material is particularly useful at the intersection of University and 15th: it makes motorists more likely to yield/allow space for cyclists in the intersection. I have nearly gotten hit by careless motorists in that exact spot multiple times. It hasn't happened in the last month or so. Hopefully that continues. Thanks for your attention to this road, it's a busy one."
"I think these features help, but probably not enough to make the intersection completely safe. Motorists still take unnecessary risks to make a right turn at 4th Street because pedestrians don't follow the Do Not Walk signs, which makes it difficult for motorists to make a turn at this intersection in the allotted time."

<u>Minneapolis 311 Feedback</u>

Minneapolis 311 signs were installed August-September of 2012. A total of two comments were received by emails to Minneapolis 311 or phone calls to Minneapolis 311 operators. The two comments were related to bicycle traffic in Minneapolis, but not relevant to the treatment on 15th Avenue Southeast.

Conclusions

The evaluation of colored conflict zones at the three project locations found there were positive effects on the safety and operations of the street after the project was implemented. The colored conflict zones were able to significantly improve the predictability of bicyclists traveling through the intersection and significantly increase yielding behavior of motorists merging across the bicycle lane.

During the three years before installation, there were 22 reported crashes across the three locations, including 15 motor vehicle crashes, four bicycle crashes, and three pedestrian crashes. During the three years after installation, there were 23 reported crashes, including 17 motor vehicle crashes, five bicycle crashes, and one pedestrian crash. Four of the five crashes that happened after installation occurred at the 5th Street Southeast intersection. According to police reports, the impact area occurred in the center of the intersection, not at the free right turn lane. Installing additional green markings through the intersection may mitigate these observed conflicts.

The installation had positive effects on bicyclist-motorist interactions. After installation, significantly more motorists yielded to bicyclists. However, about half of the motorists were still merging after the bicycle lane merge area which is not consistent with Minnesota State Statute. While there are positive trends in behavior, Public Works staff are evaluating ways to encourage motorists to merge at the appropriate location, including the use of dotted green markings.

Feedback from bicyclists was positive. Most bicyclist survey participants stated that the green was intended to increase awareness of the bicycle lane or encourage motorists to yield to bicyclists in the bicycle lane. Most participants believed that motorists were more aware of bicyclist traffic since the colored conflict zones were installed. However, some bicyclists stated that not all motorists yield the right-of-way and that the street can be stressful to ride on due to bus traffic.

Public Works intends to keep the project in place as the project is providing value to bicyclists, and no related safety or operational issues have been observed. As discussed in Chapter 3, Public Works is installing many more green locations in the City using durable thermoplastic. As of 2016, green colored conflict zones have been installed at over 100 intersections in Minneapolis.

Since this original installation, Public Works has modified the design of the colored conflict zones based on additional observations at the Blaisdell Avenue South and Lake Street West and 15th Avenue Southeast and Rollins Avenue Southeast locations (Chapter 3). At these locations, a large share of drivers were avoiding the solid green and merging after the green. This was also observed to some extent at the 7th Street North and East Lyndale Avenue North location and 15th Avenue Southeast and 4th Street Southeast location. As a result of these observations, Public Works has modified the solid marking to be a dotted green marking to encourage drivers to merge at the intended location.

Figure 16-13: Example of modified dotted green conflict zone through an intersection

Figure 16-14: Example of modified dotted green conflict zone at a developing right turn lane

Chapter 17

25 MPH Posted Speed Limit

Project Location:

15th Avenue Southeast between University Avenue Southeast and Como Avenue Southeast

Local Evaluation

Treatment Description

Speed limits on streets in Minnesota are prescribed by Minnesota Statute 169.14. In urban districts, the statutory speed limit is 30 mph. In Minneapolis, the local speed limit is consistent with the statutory speed limit of 30 mph. There are some streets with other speed limits. On parkways in the city, the posted speed limit is 25 mph. And there are some industrial streets, County State Aid Highways, and State Trunk Highways in Minneapolis with posted speed limits of 35 mph or higher.

Motor vehicle speed is an important factor for bicyclist safety and comfort. The large differentials in speeds between bicyclists and adjacent motorists contribute to the stress of riding a bicycle. Speed is also a documented factor of injury severity in bicyclist-motorist crashes. A posted speed limit is not a guarantee for controlling actual vehicle speeds. However, it is a measure to regulate appropriate operation of a vehicle, and it allows for related enforcement.

Should a local agency want to change the posted speed limit on a street under its jurisdiction, the process is outlined in Minnesota Statute, section 169.14, subd. 5:

> When local authorities believe that the existing speed limit upon any street or highway, or part thereof, within their respective jurisdictions and not a part of the trunk highway system is greater or less than is reasonable or safe under existing condition, they may request the commissioner (of transportation) to authorize, upon the basis of an engineering and traffic investigation, the erection of appropriate signs designating a reasonable and safe speed limit thereat, which speed limit shall be effective when such signs are erected.

There is an exception to this process for streets with bicycle lanes. Minnesota Statute 160.263, subd. 4. states that:

> Speed on street with bicycle lane. Notwithstanding section 169.14, subdivision 5, the governing body of any political subdivision, by resolution or ordinance and without an engineering or traffic investigation, may designate a safe speed for any street or highway under its authority upon which it has established a bicycle lane; provided that such safe speed shall not be lower than 25 miles per hour. The ordinance or resolution designating a safe speed is effective when appropriate signs designating the speed are erected along the street or highway, as provided by the governing body.

At the time of implementation and subsequent writing of this report, the 25 mph posted speed limit installed on a street with a bicycle lane is allowable per Minnesota Statute 160.263 Subd. 4 without utilizing the process outlined by Minnesota Statute 169.14.

Project Location

The project location is on 15th Avenue Southeast between University Avenue Southeast and Como Avenue Southeast. This project is approximately 0.6 miles, or eight city blocks long. Surrounding land uses and destinations include the University of Minnesota campus and athletic facilities, two commercial nodes, multi-family apartments, and a neighborhood park. Fifteenth Avenue Southeast is a primary corridor connecting the University of Minnesota to the Marcy-Holmes, Dinkytown, Southeast Como, and Northeast neighborhoods of Minneapolis. The neighborhoods are home to many university students who use 15th Avenue Southeast to walk, bicycle, take transit, or drive to the campus.

Fifteenth Avenue Southeast ranges from 38 to 52 feet wide and operates as a two-way street. Prior to installation, the corridor had conventional bicycle lanes in both directions ranging in width from five to 6.5 feet and travel lanes ranging in width from 11 to 14 feet in both directions. Between University Avenue Southeast and 5th Street Southeast, a center left turn lane was present; and between Rollins Avenue Southeast and Como Avenue Southeast, there was a 10-foot parking lane on the west side of the street. The intersections of University Avenue Southeast, 4th Street Southeast, 5th Street Southeast, Rollins Avenue Southeast, and Como Avenue Southeast are signalized.

Prior to implementation, the street had AADTs ranging from 7,700 to 12,500 vehicles per day with a posted speed limit of 30 mph. The high-frequency Metro Transit bus route 3 operates on this segment of 15th Avenue Southeast with an average headway of 10 minutes or less.

The goal of the bicycle project was to reduce motor vehicle speeds along 15th Avenue Southeast. Since the bicycle lanes existed on 15th Avenue Southeast, Minnesota Statute 160.263, subd. 4 allowed for the posted speed limit to be reduced to 25 mph. The recommended design was to install 25 mph speed limit signs along the length of the project corridor. At the time of implementation, no other changes to signing or striping were made, except for the addition of colored conflict markings at University Avenue Southeast, 4th Street Southeast, and 5th Street Southeast. The colored conflict marking project is documented in Chapter 16 of this report. The original project was open for use in October, 2011.

In 2015, striping changes were made to establish a wider bicycle lane space and buffer area on some segments of 15th Avenue Southeast.

- Segment A: Between University Avenue Southeast and 5th Street Southeast, the bicycle lane was increased in width from 6.5 feet to seven feet and a three-foot painted buffer was added between the bicycle lane and travel lane. The travel lanes were reduced in width from 14 feet to 11 feet, and the left turn lane was reduced in width from 11 feet to 10 feet.
- Segment B: Between 5th Street Southeast and Rollins Avenue Southeast, the bicycle lane was increased in width from five feet to six feet, and a two-foot painted buffer was added between the bicycle lane and travel lane. The travel lanes were reduced in width from 14 feet to 11 feet.
- Segment C: Between Rollins Avenue Southeast and Como Avenue Southeast, the bicycle lane was increased from six feet to seven feet. The parking lane was reduced in width from 10 feet to eight feet.

The 25 mph speed limit signs remained installed after the striping changes were installed. The goal of these changes were to understand if the wider bicycle lane, painted buffer, and narrower travel lanes had an affect on motor vehicle speeds along 15th Avenue Southeast. The modified project was open for use in October, 2015.

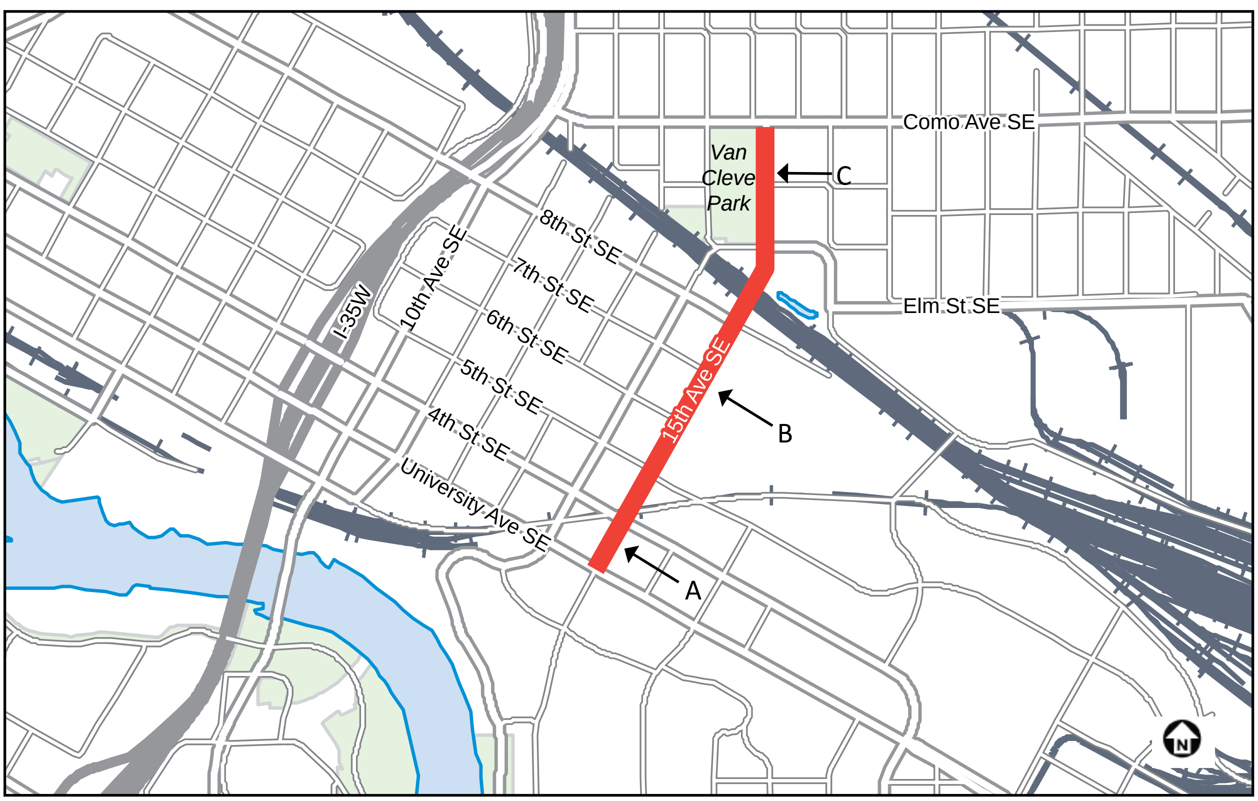
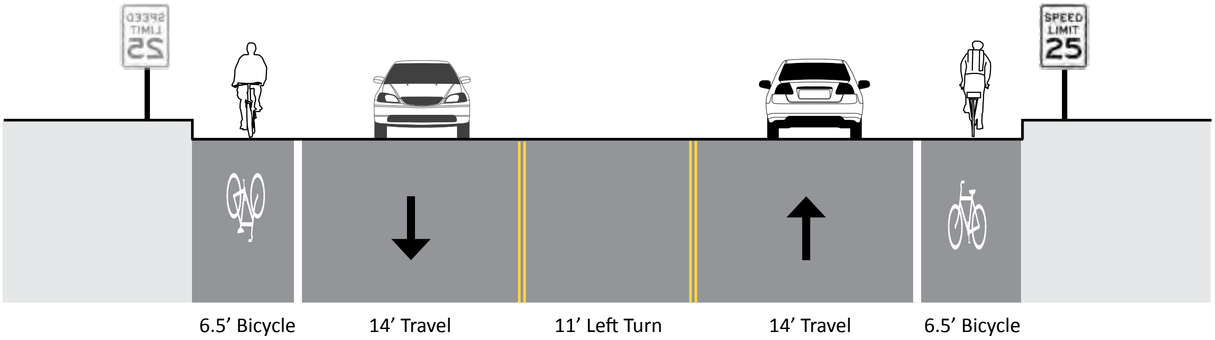
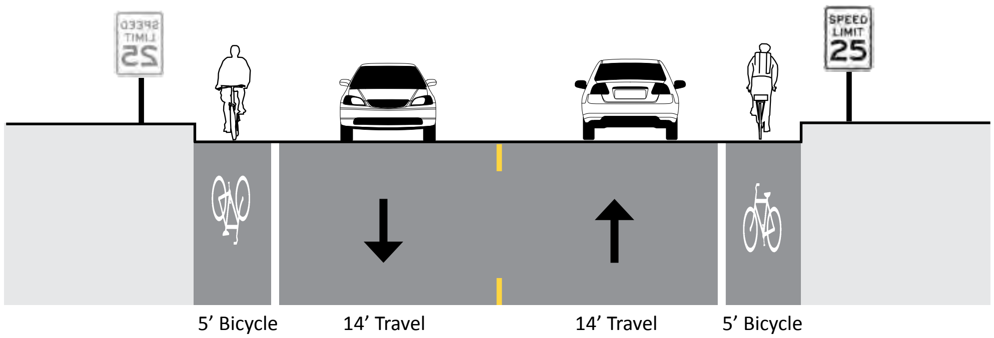


Figure 17-1: Project location

Typical A: 15th Avenue Southeast between University Avenue Southeast and 5th Street Southeast (52’)



Typical B: 15th Avenue Southeast between 5th Street Southeast and Rollins Avenue Southeast (38’)



Typical C: 15th Avenue Southeast between Rollins Avenue Southeast and Como Avenue Southeast (44’)

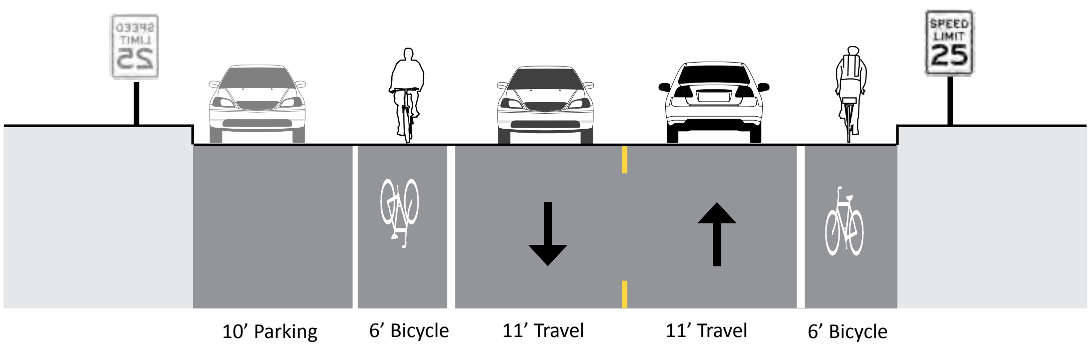
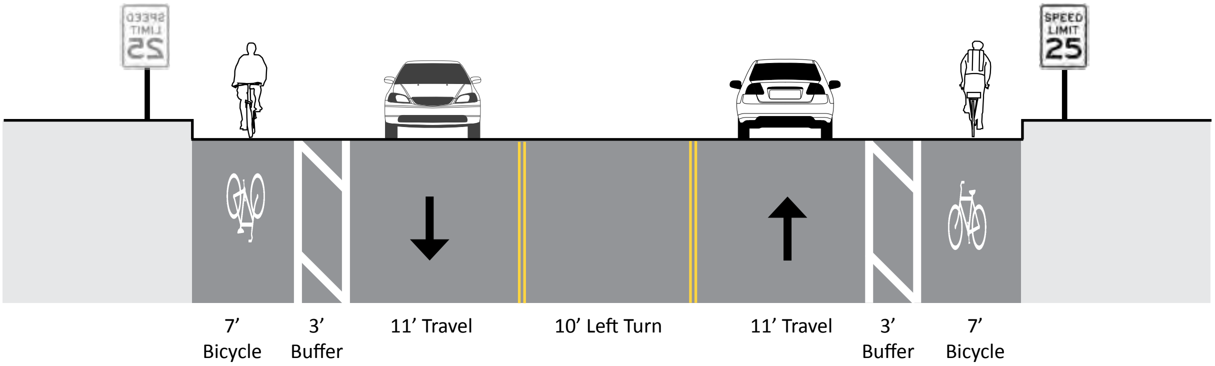


Figure 17-2: Typical cross sections reflecting 2011-2015 conditions

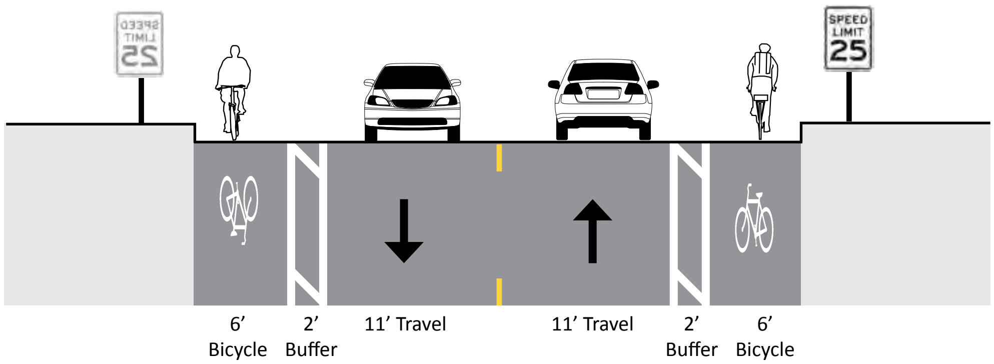
Figure 17-3: 25 mph speed limit sign posted on 15th Avenue Southeast at 4th Street Southeast in 2011

Figure 17-4: 25 mph speed limit sign posted on 15th Avenue Southeast at 5th Street Southeast in 2011

Typical A: 15th Avenue Southeast between University Avenue Southeast and 5th Street Southeast (52’)



Typical B: 15th Avenue Southeast between 5th Street Southeast and Rollins Avenue Southeast (38’)



Typical C: 15th Avenue Southeast between Rollins Avenue Southeast and Como Avenue Southeast (44’)

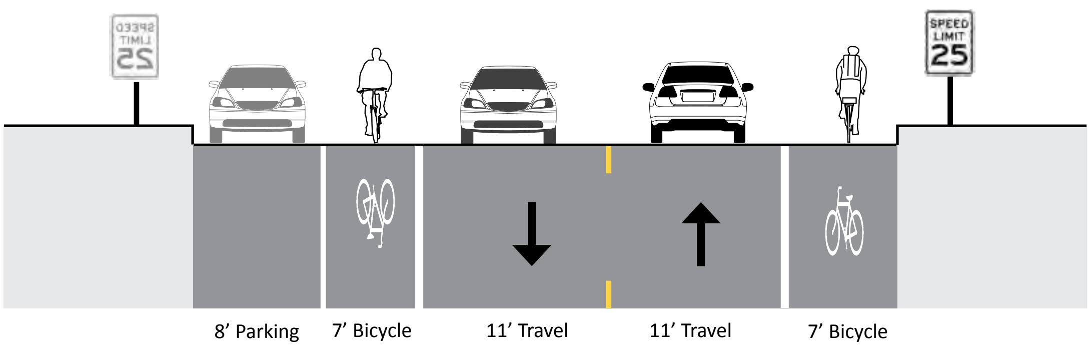


Figure 17-5: Typical cross sections reflecting 2015-2016 conditions

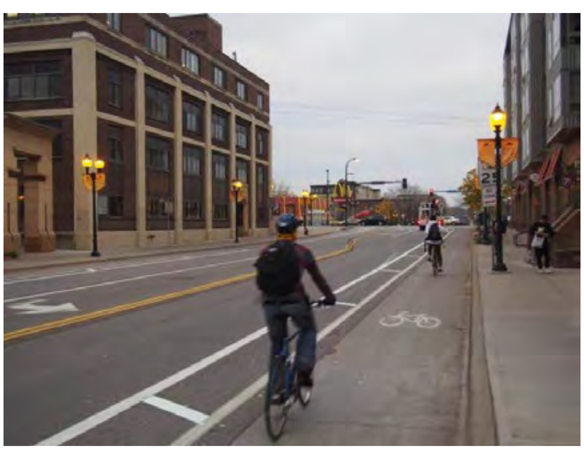


Figure 17-6: Buffered bicycle lane between University Avenue Southeast and 4th Street Southeast in 2015

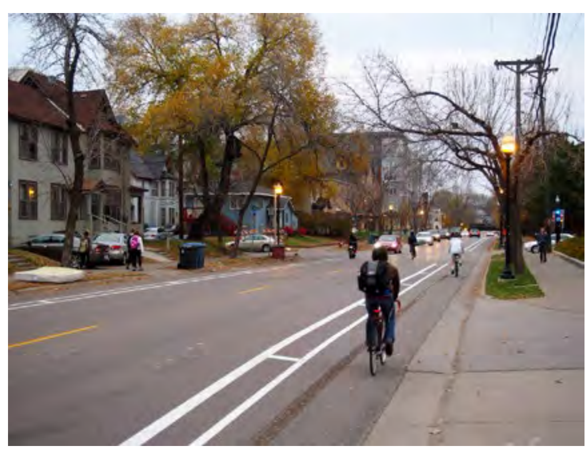


Figure 17-7: Buffered bicycle lane between 5th Street Southeast and 6th Street Southeast in 2015

Evaluation Plan and Methods

The evaluation plan and methods are consistent with the other projects in this report, although the reporting period includes an extended after period. For the evaluation of 15th Avenue Southeast, the specific measures of effectiveness are traffic volumes, motor vehicle speeds, and reported crashes. All measures include before-and-after monitoring, although only travel volumes and motor vehicle speeds were collected in the extended after period.

The before period includes October 1, 2008 through September 30, 2011. The initial after period includes October 1, 2011 to September 30, 2014. The extend after period includes additional traffic volumes and speed observations in 2015 and 2016. For simplicity of presentation, before conditions are listed from 2009 to 2011 and after conditions from 2012 to 2016.

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

Results

Traffic Volumes

Bicycle traffic increased after the project was installed. Before the project was installed, traffic volumes ranged between 3,170 and 3,940 bicyclists per day. After the project was installed, traffic volumes ranged between 3,620 and 4,330 bicyclists per day. In 2015 and 2016, traffic volumes were 3,840 and 3,590, respectively.

Motor vehicle traffic varied before and after the project was installed. Before the project was installed, AADTs ranged between 7,700 and 12,500 vehicles per day. After the project was installed, AADTs ranged between 6,500 and 11,400. In 2016, the AADT between 6th Street Southeast and 7th Street Southeast was 10,600.

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 the University of Minnesota.

Table 1: Daily traffic volumes

Type	Location (between)	Before			After				
		2009	2010	2011	2012	2013	2014	2015	2016
Bicyclist	University Ave SE and 4th St SE	3,170	2,930	3,940	4,020	4,330	3,620	3,840	3,590
AADT	University Ave SE and 4th St SE	-	-	7,700	6,500	-	-	-	-
	4th St SE and 5th St SE	-	-	9,300	9,300	-	-	-	-
	5th St SE and 6th St SE	12,500	-	12,000	9,800	11,400	-	-	-
	6th St SE and 7th St SE	-	-	9,810	-	-	-	-	10,600

Motor Vehicle Speeds

Motor vehicle speeds along the corridor did not change substantially after the posted speed limit was changed in 2011, or after the striping changes were made in 2015. The 85th-percentile speeds before the project was installed ranged between 23 mph and 32 mph. After the project was installed, 85th-percentile speeds ranged between 23 mph and 33 mph. After the project was installed, only the segment between University Avenue Southeast and 4th Street Southeast had 85th-percentile speeds below the 25 mph posted speed limit — although 85th-percentile speeds were below 25 mph prior to project installation.

Table 17-2: 85th-percentile speeds

Location (between)	Before (mph)			After (mph)				
	2009	2010	2011	2012	2013	2014	2015	2016
University Ave SE to 4th St SE	-	-	23	23	-	-	-	-
4th St SE to 5th St SE	-	-	26	26.5	-	-	-	-
5th St SE to 6th St SE	-	-	-	32.5	32	-	-	-
6th St SE to 7th St SE	-	-	32	-	-	-	-	33

While motor vehicle speeds did not change substantially after the project was installed, the speed distribution varied by block segment. Before-and-after, motor vehicle speeds between University Avenue Southeast and 5th Street Southeast were relatively low, but more widely distributed. Before-and-after, motor vehicle speeds north of 5th Street Southeast were higher, but more concentrated.

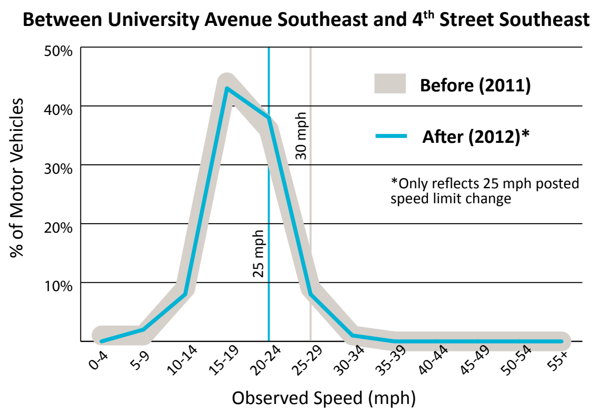


Figure 17-8: Observed motor vehicle speed distribution between University Avenue Southeast and 4th Street Southeast

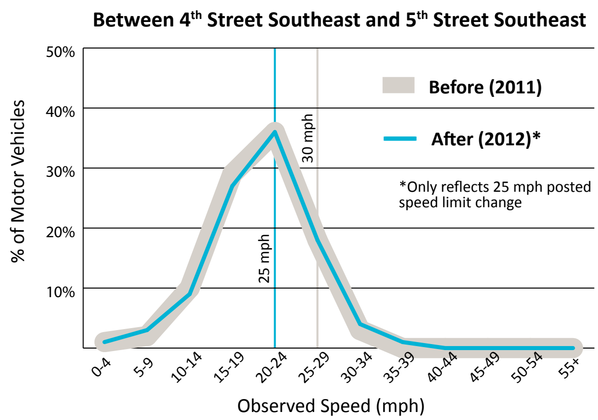


Figure 17-9: Observed motor vehicle speed distribution between 4th Street Southeast and 5th Street Southeast

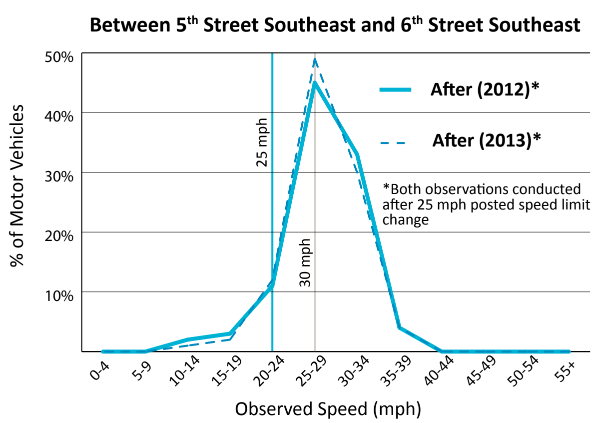


Figure 17-10: Observed motor vehicle speed distribution between 5th Street Southeast and 6th Street Southeast

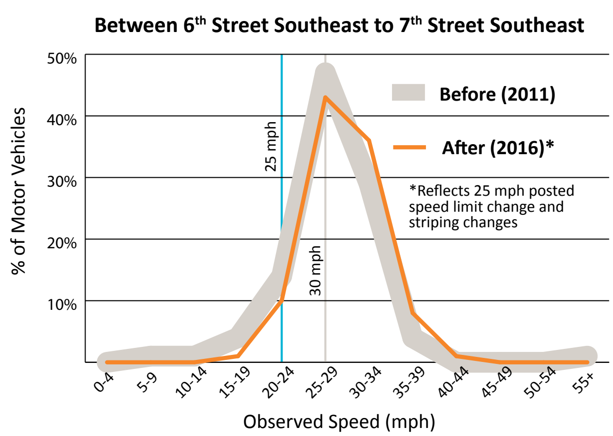


Figure 17-11: Observed motor vehicle speed distribution between 6th Street Southeast and 7th Street Southeast

Reported Crashes

During the three years before installation, there were 49 reported crashes, including 39 motor vehicle crashes, seven bicycle crashes, and three pedestrian crashes. During the three years after installation, there were 54 reported crashes, including 43 motor vehicle crashes, eight bicycle crashes, and three pedestrian crashes. The after period only reflects the period between 2012-2014. At the time of the writing of this report, crash data was not available for the period between 2015-2016.

Table 17-3: Reported crashes

Crash Type	Before	After	Change
Motor Vehicle	39	43	4
Bicycle	7	8	1
Pedestrian	3	3	0
Total	49	54	5

Eight bicycle crashes occurred after installation.

Four crashes occurred at the intersection of 5th Street Southeast. One involved a northbound bicyclist and northbound motorist on 15th Avenue Southeast approaching 5th Street Southeast, but the circumstances are unclear. Another crash involved a bicyclist "riding against traffic" on 15th Avenue Southeast. The other two crashes involved northbound bicyclists and southbound motorists, who were making left turns onto eastbound 5th Street Southeast.

One crash occurred at University Avenue Southeast involving a northbound bicyclist riding on 15th Avenue Southeast and a northbound motorist making a left turn. The motorist was cited for "failing to yield the right-of-way."

Another crash occurred at 6th Street Southeast involving a northbound bicyclist and northbound motorist. The bicyclist was cited for "disregarding a traffic control device."

At 7th Street Southeast, a crash involved a southbound bicyclist and northbound motorist. The motorist was cited for "failing to yield the right-of-way."

There were two motor vehicle crashes involving "illegal speeding" before installation. One occurred on 15th Avenue Southeast, and one occurred on 8th Street Southeast west of 15th Avenue Southeast. There were no crashes involving "illegal speeding" after installation.

Conclusions

The evaluation of the 25 mph posted speed limit on 15th Avenue Southeast found there was no substantial effect on motor vehicle speeds after the posted speed limit was changed from 30 mph to 25 mph, or after the striping changes were made.

During the three years before installation, there were 49 reported crashes across the three locations, including 39 motor vehicle crashes, seven bicycle crashes, and three pedestrian crashes. During the three years after installation, there were 54 reported crashes, including 43 motor vehicle crashes, eight bicycle crashes, and three pedestrian crashes. The crashes do not appear to be a factor of the project design elements, and there were no crashes involving "illegal speeding" after installation.

The signing and striping installations had a minimal effect on motor vehicle speeds on the corridor. The 85th-percentile speeds before the project was installed ranged between 23 mph and 32 mph. After the project was installed, 85th-percentile speeds ranged between 23 mph and 33 mph. Only the segment between University Avenue Southeast and 4th Street Southeast had 85th-percentile speeds below the 25 mph posted speed limit; although 85th-percentile speeds were below 25 mph prior to project installation.

Before-and-after speed distribution varied by block segment. Before-and-after motor vehicle speeds on the southern end of the corridor were lower than the speeds further north, suggesting further comparison between those two street segments is warranted. The segment between University Avenue Southeast and 5th Street Southeast has closer signal spacing (every block), higher pedestrian and bicycle volumes, and a denser built environment. At University Avenue Southeast, 15th Avenue Southeast transitions to Pleasant Street Southeast on the University of Minnesota campus, which has a landscaped boulevard with a more pedestrian-oriented street design. The segment north of 5th Street Southeast has less frequent signal spacing, lower pedestrian and bicycle volumes, and further set back buildings. Street trees and sidewalks exist for the length of the project.

Public Works intends to keep the project in place, as no related safety or operational issues have been observed. This segment of 15th Avenue Southeast is programmed in the City's Five-Year Capital Improvement Program to include a protected bikeway in 2019. A protected bikeway on 15th Avenue Southeast would preserve most of the lane configurations installed in 2015. The design would also include physical separation between bicycle traffic from motor vehicle traffic, which may influence user behavior along the corridor. Public Works intends to continue monitoring the corridor to understand if future changes have an effect on motor vehicle speeds.