



DELAWARE AVENUE BIKEWAY

TWO-WAY SEPARATED BIKE LANE FEASIBILITY STUDY





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INTRODUCTION

Background

The State of Delaware has been a national leader in advancing safe, accessible and enjoyable bicycling. In 2014, Delaware was named the 3rd most Bike Friendly State in the U.S., the highest ranked state on the east coast. This ranking is based on successes in a variety of categories including bicycle legislation, enforcement, policies, programs, infrastructure, and education. Delaware Avenue, located in the City of Newark, has been prioritized by the Newark Bike Plan as a desirable location for a separated bike facility. As part of the state’s ongoing plan to improve bicycle infrastructure, the Delaware Department of Transportation has agreed that this location should be investigated as a candidate for the installation of a two-way separated bike facility.

Purpose and Need

Delaware Avenue is located in the City of Newark, along a 15-mile regional bicycle route (Route NC-3). This route provides access to and from two major urban centers in New Castle County and connects to White Clay Creek State Park. The route also provides access to major highways, statewide bicycle routes, regional bicycle routes, and recreational bicycle connectors. The section of Delaware Avenue being examined in this feasibility study plays a central role in the local bicycle network of the City of Newark.

According to the 2010 Census, the City of Newark has a population base of 31,454 people. It is home to the University of Delaware and is comprised of dense mixed-use residential and commercial land uses typical of a “college town”. The city has developed a bicycle transportation network that provides many well-developed connections, making bicycling an attractive transportation alternative for residents. Delaware Avenue serves as a major thoroughfare for University of Delaware students traveling through campus. Although the bicycling volume is significant, Delaware Avenue lacks a dedicated bicycle facility for westbound cyclists. Cyclists are often seen riding on sidewalks or against the one-way traffic (contraflow) in the existing bike lane along Delaware Avenue. This cycling behavior is risky and creates an uncomfortable environment for not only the cyclists but



Photo 1: WB Cyclist in Sidewalk

pedestrians and motorists as well. Main Street, which runs parallel to Delaware Avenue, assists in facilitating westbound bicycle movements through the city utilizing a shared lane with motor vehicles. Travelling in a shared lane can often be uncomfortable and intimidating to novice cyclists and makes this route less desirable than a dedicated bicycle lane.

The purpose of this study is to determine the feasibility of installing a two-way separated bicycle facility along Delaware Avenue that will accommodate both eastbound and westbound bicycle travel. The study is also intended to identify potential solutions to conflict areas within the corridor. The facility recommendations are based on the guidelines provided by National Association of City Transportation Officials (NACTO) and FHWA’s Separated Bike Lane Planning and Design Guide.

The study area includes six signalized intersections, numerous commercial entrances and a major midblock pedestrian crossing, known as “The Green”. The corridor study area is the section of Delaware Avenue that stretches between South Main Street (S.R. 896) and Library Avenue (S.R. 72).

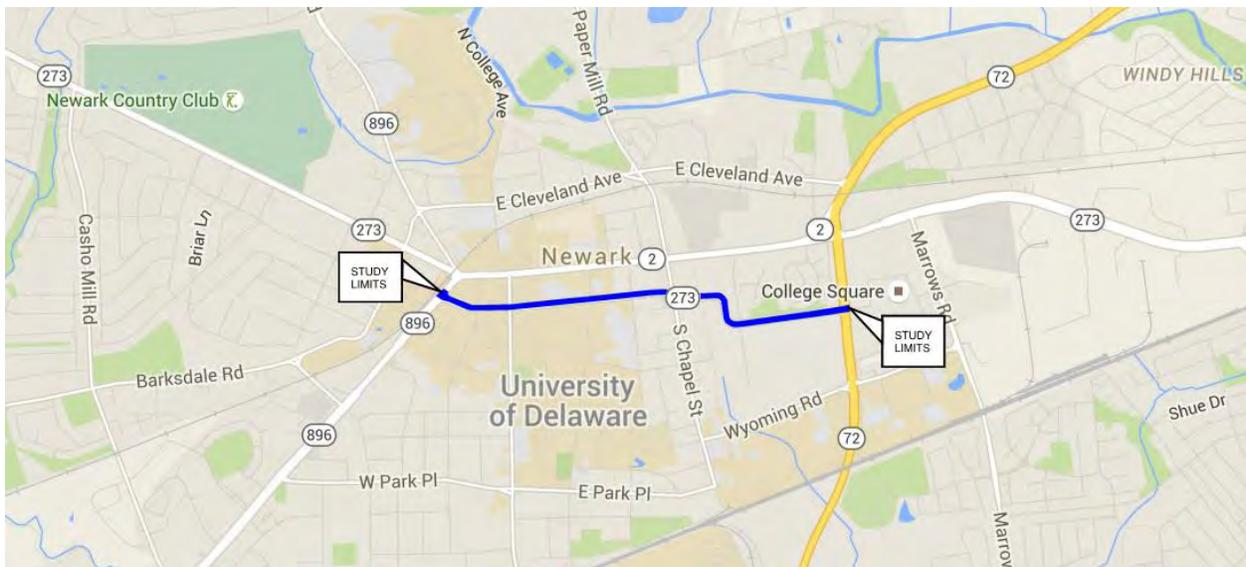


Figure 1: Study Area Map

Map Data ©2015 google

This study evaluates two alternate design scenarios. The “low impact” design alternative is focused on creating a short term solution which has minimal impact to the existing infrastructure. The low impact alternative could conceivably be constructed as part of a pavement resurfacing and rehabilitation project. The second design alternative would be aimed at achieving a fully developed separated bike lane with more desirable widths and buffer areas. This “ideal” alternative would require widening of the roadway typical section which may require the acquisition of right-of-way along with the relocation of utilities.



PLANNING PROCESS

Detailed Planning Method

An initial review of national and international literature on separated bike lanes was conducted by JMT to establish a baseline regarding best practices for on-street separated bicycle facilities. This research informed and guided the planning process to evaluate the feasibility of a separated bicycle facility on Delaware Avenue. The 2015 Federal Highway Association’s (FHWA) *Separated Bike Lane Planning and Design Guide* served as a major resource, providing guidance on the planning and design elements of this study.

The evaluation process included input and review from a steering committee consisting of representatives of the Delaware Department of Transportation (DelDOT), the City of Newark, Bike Delaware, The University of Delaware, Wilmington Area Planning Council (WILMAPCO), and the Newark Bicycle Committee. The planning methodology followed a step-by-step process to ensure that a comprehensive evaluation of key data and design considerations was followed.

The first step of the planning process was to establish an understanding for the surrounding bicycle network as a complete and connected network. This information was used to gain an understanding of the specific role that Delaware Avenue plays within the context of the network. This step included review of existing bicycle plans, pending land development plans, transit information, traffic counts, bicycle counts and crash history along the corridor.

In order to organize the analysis, the corridor was broken into three sections. The three sections are:

- Section 1 – South Main Street to South College Avenue
- Section 2 – South College Avenue to South Chapel Street
- Section 3 – South Chapel Street to Library Avenue

The first decision was to determine which type of separated bike facility would provide the greatest benefit to the operation of the facility. Due to the larger footprint of two protected bike lanes on each side of the road, it was determined that one two-way separated facility was the best solution. The next step in the planning process was to decide if a north (left-side) or a south (right-side) alignment would be preferable for the two-way separated bike lane

segments. This step of the planning process analyzed an assortment of key issues and factors to determine an appropriate recommendation for the alignment of the facility. Intersection design and functionality were also considered a significant factor in deciding the appropriate alignment.

Following the alignment decisions, design recommendations were established for each of the three sections that evaluated the type of separation barriers, facility width, midblock design challenges, and intersection options.

In accordance with the goals of the study, two alternatives were developed (low impact alternative and ideal alternative). The goal of the low impact alternative was to construct a safe and well-designed separated bike lane which could be constructed without modifying the existing curb to curb width. The ideal alternative would alternately involve roadway widening, right-of-way acquisition and utility relocations but would yield a more fully developed separated bike lane facility within the corridor.



DATA COLLECTION

Data Collection

Roadway Description

Delaware Avenue is a 1.2 mile arterial roadway with two eastbound lanes that connect South Main Street to Library Avenue. It is part of a paired one-way road network through downtown Newark with East Main Street serving westbound traffic. A variable width bike lane is striped along the right side of the road to accommodate eastbound bicycle traffic. The road has six signalized intersections, many commercial and residential entrances, a major midblock pedestrian crossing at “The Green”, and seven transit stops along the south side of the road. The speed limit is posted at 25 mph throughout the corridor. Traffic volumes along the roadway vary from 7,500 to 10,000 ADT.

Traffic Volumes

A detailed traffic model and analysis of traffic volumes was not performed for this study. However, WILMAPCO provided turning movement counts for the Delaware Avenue intersections at South College Avenue, Academy Street, South Chapel Street, and Library Avenue. The date of turning movement counts varied by intersection, ranging from 2007-2012. The turning movements demonstrated that the majority of intersections had higher right turning vehicle movements but South Chapel Street had significantly higher left turning vehicle volumes. The turning movement counts are shown in Appendix A. In addition, the 2014 pedestrian counts for the pedestrian crossing at “The Green” were provided and analyzed. It is noted that a traffic signal has been proposed for this area to account for heavy pedestrian “rushes” which primarily occur during class changes. The volumes were used to generally understand traffic patterns along the corridor.

Bicycle Volumes

The Delaware Department of Transportation provided 24 hour bicycle count data that was collected during April and May of 2015 at two locations, Delaware Avenue at Academy Street and Delaware Avenue at South Chapel Street. The data collected accounted for both eastbound and westbound bicycle traffic on Delaware Avenue, within the roadway. Cyclists using the sidewalk were not counted.

Based on the count information, bicycle volume was significantly higher at Academy Street than Chapel Street. Specifically, during a one week period, 1,200 trips were counted at Academy Street. During the same period, 122 trips were counted at the Chapel Street location. Also of note, the split between the directions of travel revealed that 74% of trips were in the eastbound direction while 26% of trips were in the westbound direction. This directional split is most likely the result of westbound cyclists choosing alternate routes (driveways, sidewalks, etc.) to avoid the contraflow movement. The bicycle volume data collected by DeIDOT is shown in Appendix B.

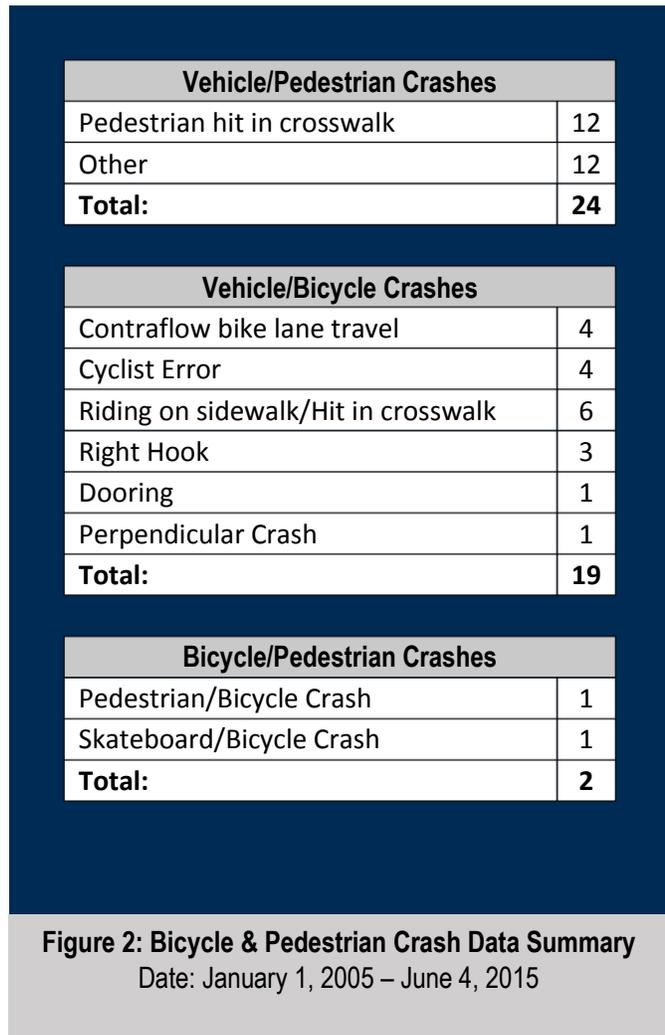
Transit

Several transit systems have stops along Delaware Avenue. They include DART (DeIDOT), UNICITY (City of Newark), UD Shuttle (University of Delaware), and Cecil Transit (Cecil County, MD). There are seven stops along the corridor including the Newark Transit Hub located on Farmers Lane. With the exception of the transit center, all stops are located on the south side of the roadway. Ridership information is shown in Appendix C.

Crash History and Safety Analysis

Data was compiled and analyzed for all bicycle and pedestrian crashes that occurred within the previous ten years. The crash data analysis aimed to identify any crash patterns that could be addressed with the design of the separated bicycle facility. The main contributing factor to bicycle crashes within the study area was bicyclists riding on the sidewalk or contraflow in the existing eastbound bike lane.

There were a total of 45 reported crashes within the project limits that involved either a bicycle or a pedestrian. The crash data indicated there were two crashes involving only pedestrian and bicycle; 19 crashes that involved a bicycle and motor vehicle; and 24 crashes



that involved a pedestrian and motor vehicle. Pedestrian crashes that occurred within a crosswalk accounted for 50% of pedestrian crashes.

The types of crashes vary throughout the corridor. Right-hook crashes, which occur when a right turning vehicle collides with a through cyclist, accounted for three of the crashes. In addition, four crash reports cited cyclist error as the cause of the crash. Failing to yield right of way was a primary contributing factor in 17% of crashes. Factors that may have been a contributor to the crashes involve dark-lighted conditions (33% of crashes) or the time of the week (majority occur on weekends). Further details on the crash data can be found in Appendix D.

The data for the bicycle and pedestrian related crashes along Delaware Avenue did not reveal any significant trends that illustrate any unique safety challenges. As with any street with a dedicated bicycle facility, special design considerations will need to be given at conflict points. Specifically, the signal design, signing and striping at the intersections is a high priority. Furthermore, roadway lighting will need to be analyzed throughout the corridor to ensure that evening and nighttime travel along Delaware Avenue is safe for pedestrians, cyclists and automobiles. While the addition of a dedicated westbound bicycle facility will present some design challenges to accommodate the contraflow movement, it should provide greater protection for cyclists and enhance overall safety.



PUBLIC OUTREACH

Community Involvement

The involvement of interested stakeholders was important to the success of this feasibility study. A steering group was developed early in the planning process that helped guide and develop the planning methodology and design concepts represented in the feasibility study. The steering group included representatives from DelDOT, the City of Newark, the Newark Bike Committee, Bike Delaware, the University of Delaware, and WILMAPCO. Three steering group meetings were held throughout the study period, in which stakeholders were actively engaged and participated in the development of all aspects of the study. Through these meetings, committee members assisted in determining the facility location, buffer type, bike lane widths, intersection controls, and the implementation plan.

In order to assess the level of rider comfort for a two-way separated bike facility within the existing footprint of the road, a “Pop-up Cycle Track” event was coordinated by the City of Newark on July 14, 2015. A temporary two-way bike lane was installed between S. College Avenue and Academy Street and left in place for 2 hours. The temporary installation consisted of an eight (8) foot wide two-way bike facility along the south side of Delaware Avenue. Cones were



Photo 2: Pop-Up Cycle Track Participants

used to delineate the temporary bike lane and motor vehicle lanes. The cones narrowed each of the travel lanes to 10 feet and served as a one (1) foot buffer for the bike lane. People of all ages and abilities were invited to test out the temporary installation and provide input on the facility. A survey was developed and given to each participant to evaluate their experience and judge their comfort with the facility. The survey also provided an opportunity for members of the public to contribute opinions or concerns they may have with a separated two-way bicycling facility along Delaware Avenue. In general, survey respondents were comfortable with the cycle track’s reduced width, but would prefer a wider facility. In addition, several

respondents suggested moving the cycle track to the north side of the road. The full survey report can be found in Appendix E.



ALIGNMENT AND DESIGN CONSIDERATIONS

Low Impact and Ideal Alternatives

The final phase of the feasibility study developed design alternatives for separated bicycle lanes in each section. The alignments needed to ensure compatibility and logical transitions of these facilities throughout the corridor. Two scenarios for the design would be developed: a “low impact” alternative and an “ideal” alternative. The “low impact” design alternative focused on creating a short term solution which will have minimal impact to the existing infrastructure. The ultimate goal of this alternative is to create an effective design without impacting the curb to curb width of Delaware Avenue. In this scenario the project could be fast-tracked by being included in a pavement rehabilitation and maintenance project.

The “ideal” alternative would be aimed at achieving a more fully developed separated bike lane that would have a more desirable width and a more substantial form of separation. This “ideal” alternative would require widening of the roadway and potential right-of-way acquisitions.

Facility Alignment Assessment

Several options were considered for the general design and alignment of the facility including a two-way facility on the right side of Delaware Avenue; a two-way facility on the left side of Delaware Avenue and a separated facility with individual one-way protected bike lanes on each side of the travel lanes. For Section 1 and Section 2 of the study area, the existing roadway width would not accommodate separate protected lanes due to the need to buffer both bike lanes. Therefore through these sections, it was determined that a combined two-way facility was the only feasible low impact alternative.

As part of the analysis to determine which side of the road is optimal for the bike facility, the team performed a vehicle turning analysis for the intersections based on a shift in the travel lanes. Through this effort, it was determined that both a right side and left side alignment will create some isolated impacts. Specifically, intersection radii may need to be adjusted and stop bars may need to be relocated back from the intersection. The turn analysis, however, did not present any fatal flaws on either side of the road that would eliminate the practicality of either the right or left side alignments. The analysis was done for both a single unit (SU) vehicle and a bus (BUS-45). The intersections where adjustments to the intersection radii will be needed were at Haines Street and Academy Street. These locations should be further evaluated during design.

After a thorough review of key issues and deciding factors, it was determined that a left side (north side) alignment would be a more favorable configuration. This was recommended for the following reasons:

- **Safety** – The right-side alignment creates a situation where bicycles would more likely be hidden from view of right-turning vehicles. This situation raises the potential for right hook crashes at intersections. The left side alignment is preferential for the two-way bike lane as it buffers contraflow bicyclists from oncoming motor vehicles. As an added benefit, this configuration places eastbound cyclists immediately adjacent to motor vehicle travel, maximizing visibility. If the bike lane were placed on the right side of the roadway, a vehicle turning right would be less likely to see a bicycle moving eastbound or turning right since there would be a buffer of the westbound bicycle lane in between them. Finally, motorists are more accustomed to looking for and yielding to oncoming traffic when turning left as opposed to making right turns. Positioning the two-way bike lane on the left side of the roadway would be a more intuitive positioning for a person turning a vehicle to look for oncoming bicycle traffic.
- **No Turn on Red** – A right-side two-way bike lane would necessitate a “NO TURN ON RED” requirement at the signalized intersections along Delaware Avenue. The side streets that approach Delaware Avenue from the south would also need to be signed “NO TURN ON RED” to prevent right-turning motorists from interfering with bicyclists queuing ahead of them to make 2-stage left turns. Conversely, a left-side two-way bike lane alignment would not require any of the streets to be signed “NO TURN ON RED” as there will not be any conflicts between bicycles and vehicles turning right.
- **Horizontal Clearance** – By shifting the travel lanes to the north (for a south side bicycle facility), the travel lanes will not have sufficient horizontal clearance from the left travel lane to the utility poles. As such, a design exception would be needed or the poles would need to be relocated.
- **Contra-Flow Buffering** – With a left-side alignment, contraflow bicycle traffic will be buffered from oncoming traffic by the eastbound bicycle lane segment. This separation would provide a more comfortable riding environment for bicycles riding westbound against motor vehicle traffic. A right-side facility configuration would place bicycles immediately adjacent to automobile traffic flowing in the opposite direction which becomes uncomfortable for novice to intermediate bicyclists. Furthermore, the left-side positioning will be better for cyclists during nighttime conditions when headlights are in use.
- **Right-Turning Motor Vehicles** – A review of the general traffic volumes showed more right turns at most of the intersections than left turns. This condition favors the left-side alignment so that bicycles will have less conflicts with turning vehicles. At the South Chapel Street intersection, however, there are significantly higher left turn volumes. This will need to be considered as part of the intersection design at this location.
- **Transit Stop Conflicts** – There are a total of seven transit stops throughout the study limits. The six stops where a bus must stop on Delaware Avenue are all located on the right side of

the roadway. Current ridership of the stops along Delaware Avenue are not very significant but could increase over time. A right-side alignment would require a design that would accommodate the transit busses being able to load passengers across the bike lane. A left-side alignment would eliminate the impact at the existing stops and would eliminate bus stop access conflicts. It is also noted that the busiest transit stop in this corridor, which is actually not on Delaware Avenue, is the transit hub on Farmer’s Lane to the north of Delaware Avenue.

- **Public Input** – Lastly, the public feedback documented through the surveys completed during the “Pop-up Cycle Track” event favored the left side option.

Support for the right-side alignment focused on two areas. First, most student housing and classrooms are located on the south side of Delaware Avenue. The concern was brought up during the steering group meetings that if the facility were placed on the north side students might not use the facility. Another benefit of a right side alignment was to alleviate the conflict at the Main Street Galleria parking lot located on the north side of Delaware Avenue, which has also been considered for a parking garage site. In summary, though, it was determined that the safety issues involved with a right-side alignment were more significant than the benefits of such an alignment, making the left-side alignment the preferred choice.

Intersections

Supplemental Features

The implementation of a two-way separated bicycle facility will require the use of non-conventional traffic control devices, many of which are in various stages of approval from FHWA. Specifically, green paint which would be proposed to be used at conflict points (i.e. driveways and intersections) has Interim Approval from FHWA (issued April 15, 2011).

Similarly, bike signal faces which would be required at the signalized intersections, also have Interim Approval from FHWA (issued December 24, 2013). Bike boxes and turn queues, which are used to manage turns at intersections, are considered experimental by FHWA and would need specific authorization for their use on this project. Installing the two-way turn queue boxes at the



Photo 3: Bicycle Signal Head
(Source: NACTO)

intersections requires the pedestrian crosswalk and stop bar for the side streets to be pushed back at least 6.5 feet from the intersection to make room for cyclists to wait in the turn box for a signal. Signage may also be helpful to define proper positioning and improve the visibility of the turn-queue boxes.

Cautious design should be implemented to maintain adequate sight lines for vehicles to be able to see bicyclists approaching the intersection from both directions along Delaware Avenue.

Signalized Intersections

Accommodating two-way bicycle traffic through the signalized intersections will require the use of a bicycle signal with a separate bicycle phase. It is anticipated that an advanced bicycle only phase will be necessary. While additional research should be performed prior to design, video detection appears to be the most effective way to automatically detect cyclists at intersections. The bike signals would only face the east/west traffic on Delaware Avenue, as cyclists on the side roads or using the turning queues would follow the direction of the primary traffic signal.



Photo 4: Two-Stage Turn Queue Box
(Source: NACTO)

Additional detector feedback signals should also be considered to provide information for bicyclists to receive a green signal. For example, the TO REQUEST GREEN WAIT ON SYMBOL sign (MUTCD R10-22) and the blue light indicator device, which informs cyclists they have been detected by the signal, could both provide beneficial information to cyclists and boost successful green light queuing and signal compliancy. An example of a blue light detector is shown in Photo 5. It is noted, though, that for this project the blue light would be attached to the bike signal.



Photo 5: Blue Light Detector Feedback Device
(Source: FHWA Separated Bike Lane Planning and Design Guide)

Stop controlled intersections

The only intersection that is not signalized within the corridor is at Haines Street. At this

intersection the contraflow traffic turning left will have the option to use the two-stage turn queue box to simplify turning movements.

Conflict Points

Green pavement will be used to identify the separated bicycle facility in conflict areas such as lane transitions and driveways. The purpose of the green pavement is to indicate areas of potential conflict while increasing awareness of bicycles. According to FHWA, the green colored pavement is an additional treatment and *shall not* be used instead of the



Photo 6: Green Paint across Mixing Zone on M Street NW in Washington DC

(Source: FHWA Separated Bike Lane Planning and Design Guide)

dotted lines to extend a bicycle lane across an intersection, driveway, ramp, or at the beginning of a turn bay. Using green colored pavement in a manner that matches the dotted lines; filling in only the areas directly between a pair of dotted line segments has been granted Interim Approval (IA-14) by the MUTCD, as shown in Photo 6.

In addition to using green paint at conflict points, raising the separated bike facility could be considered.

Driveways

Driveways and minor street crossings create unique design challenges for separated bike lanes. For motor vehicles crossing the bike facility, it is important to ensure any street furnishings or other street features accommodate a sight triangle of 20 feet to the facility from any minor street crossing and 10 feet from any driveway crossing. Motor vehicles crossing the separated bike lane should be constrained to make turns at sharp angles so as to reduce travel speed of vehicles before crossing the bike facility. Additionally, yield lines and “Yield to Bikes” signage should be used to identify conflict areas and signify the bike facility as having priority over entering and existing vehicles.

Pedestrian and ADA Impacts

Pedestrian accommodations to ensure ADA compliance will need to be addressed with both the low impact and ideal alternative. Currently the sidewalks along Delaware Avenue are approximately 5’ in width and utilize numerous diagonal curb ramps. Installing any type of separated bicycle facility will require many pedestrian crosswalks, curb ramps, and accessible pedestrian signal poles to be relocated further back on the side streets to

accommodate the bicycle facility crossing and turn-queue boxes. It is important to analyze both pedestrian and bicycle volumes and anticipated needs. Providing sufficient space for each mode will avoid conflicts such as pedestrian overflow into the bike lane.

RECOMMENDED IMPROVEMENTS

Corridor Sections

Due to the varied roadway characteristics throughout the study area, the corridor was broken into three sections for evaluation. These sections were individually analyzed to determine the most appropriate facility type given the varying conditions within each section. The following describes the proposed improvements for both the low impact and ideal alternatives in each section.

Section 1 - South Main Street to South College Avenue

Section 1 of Delaware Avenue has a curb to curb roadway width of 31 feet. In this area, a two-way facility is proposed on the left side of Delaware Avenue. As shown in Figure 3, the facility ends at Orchard Avenue and does not continue on Delaware Avenue to South Main Street. This decision was made due to the complexity of the intersection at South Main Street. This intersection is a T-intersection with a median which is not conducive to accommodating westbound traffic. South Main Street has a northbound travel lane with a bike lane striped on the right side of the road. As shown in Photo 7, the existing bike lane is extremely narrow and easily overtaken by larger turning vehicles. In conjunction with the design of the separated bicycle facility, consideration should be given to removal or restriping of the bike lane in this area.

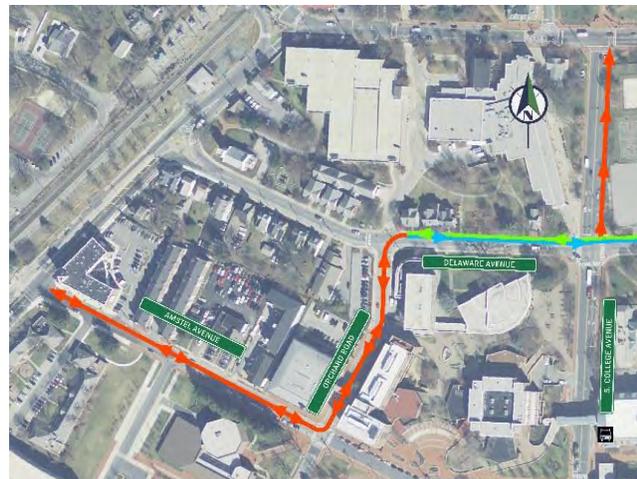


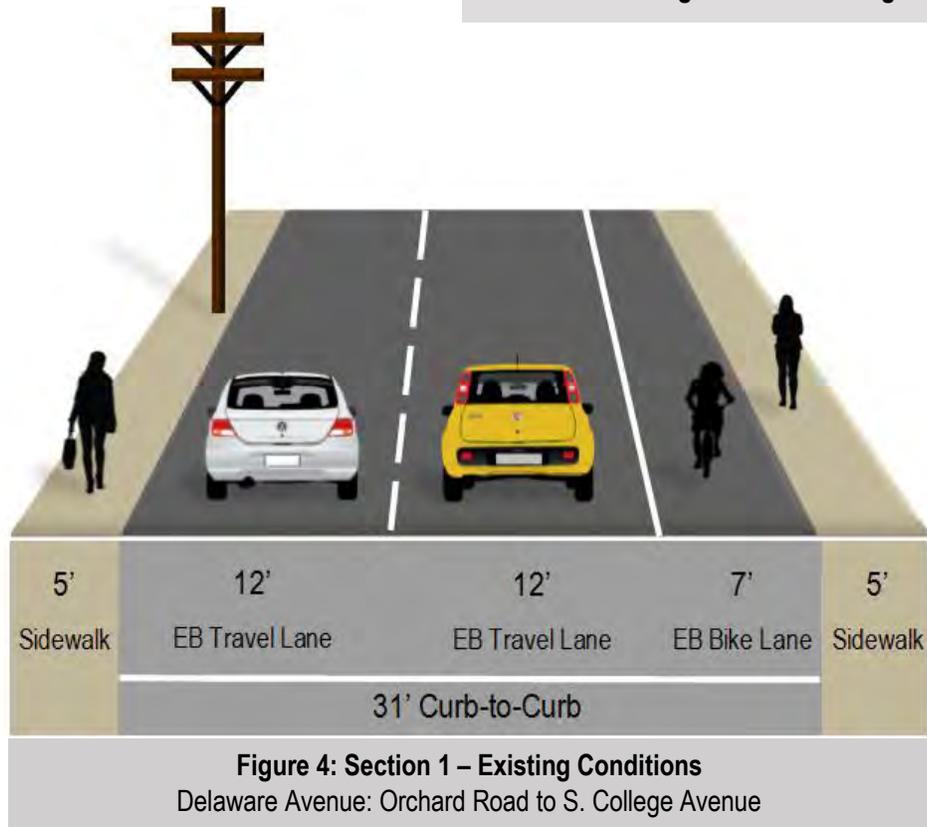
Figure 3: Section 1 Layout Overview

The proposed westbound transition will encourage cyclists destined for north campus to turn north on South College Avenue, while cyclists traveling south will be directed towards Amstel Avenue via Orchard Road utilizing a separate bicycle left turn signal. Conversely, cyclists traveling north on South Main Street will be encouraged to turn right on Amstel Avenue instead of using the Delaware Avenue intersection at South Main Street. Orchard Road is a low volume

2-lane two-way road where on-street parking is prohibited. Amstel Avenue is also a 2-lane two-way road with on-street parking. It is recommended that green-back sharrows be used to highlight the route that connects South Main Street with the separated bike lane on Delaware Avenue. Signage should be evaluated to assist in encouraging cyclists to utilize this connector route.



Photo 7: Turning Truck Overtaking Bike Lane



Low Impact Alternative As shown in Figure 5, the low impact alternative for this section of roadway would consist of a 9 foot wide two-way bike lane with a 2 foot striped buffer with flexible delineator posts and two 10 foot travel lanes. Alternative low impact devices in the buffer area, such as “armadillos” may be considered in lieu of or complementary to the flexible posts. The low impact alternative would be constructed within the existing footprint of the roadway. Due to the shift in the travel lanes, turning radii at each intersection should be evaluated to ensure they can accommodate right turning vehicles. A preliminary review did not indicate the need to adjust the curb line at the intersection radii within this section.

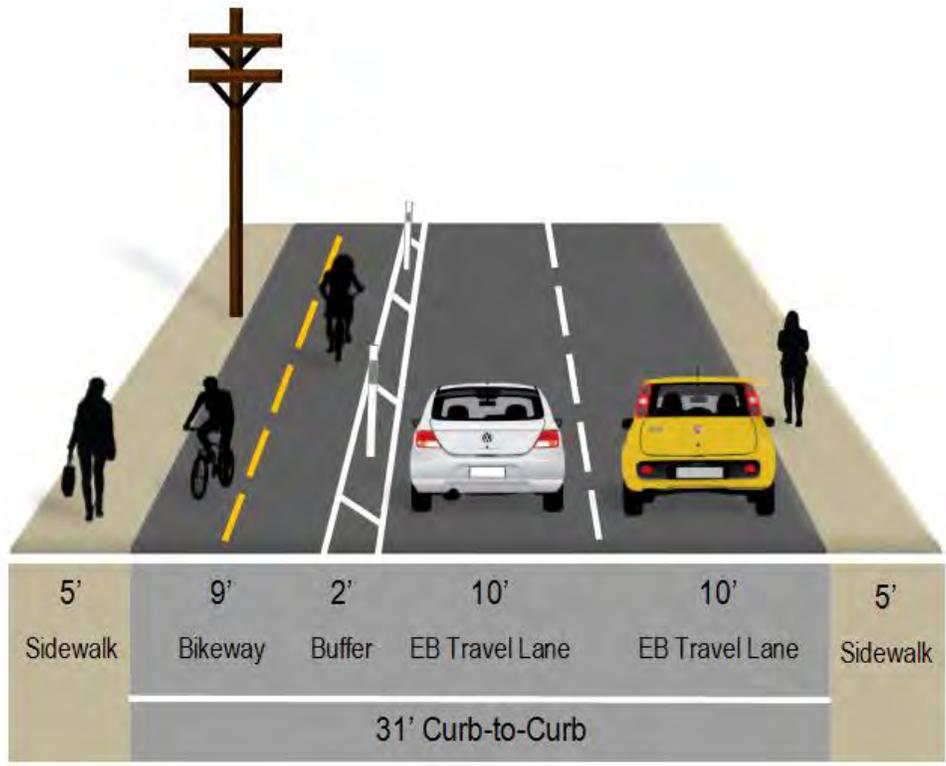


Figure 5: Section 1 – Low Impact Alternative
 Delaware Avenue: Orchard Road to S. College Avenue

Orchard Road

The intersection of Orchard Road and Delaware Avenue would function as the westbound termini for the separated bicycle facility. Westbound cyclists would be directed to Orchard Road to continue to South Main Street or other destinations. In addition to a bicycle signal, the intersection would feature green elephant tracks through the intersection. The westbound bike phase would run concurrent with the northbound right turn movement.

A realignment of the curb west of the signal would serve as a physical queue to cyclists that they are not to continue westbound on Delaware Avenue. The use of green-back sharrows on Orchard Road will reinforce the preferred route for cyclists. The existing bike lane striped on the south side of Delaware Avenue will need to be removed. A bicycle signal face should be placed at this intersection for the westbound bicycles turning left.



Figure 6: Orchard Road Intersection

South College Avenue

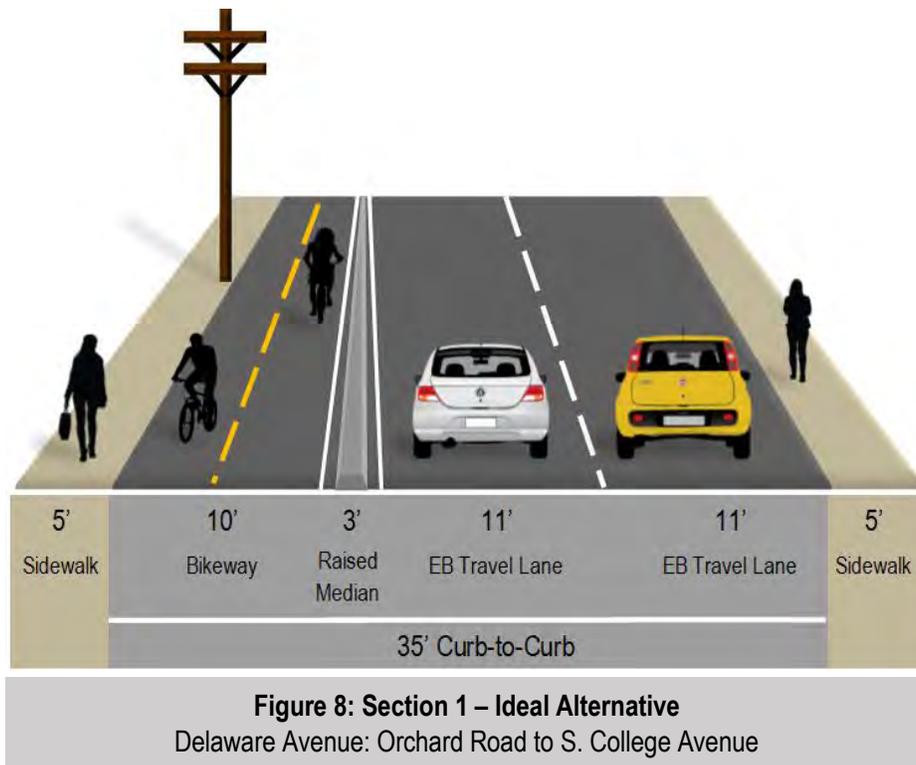
The South College intersection will require the installation of a separate bicycle signal head facing both east and west. An advanced bicycle signal phase is encouraged at this intersection to help facilitate bicyclists through the intersection safely. Green pavement should be incorporated into the intersection design to show the conflict points where the bicycle facility crosses the intersection. The crosswalk on the north side of South College Avenue will need to be moved to accommodate the two-way turn queue box. This will also require the curb ramps and pedestrian signal poles to be relocated to match the pedestrian crossing.



Figure 7: South College Avenue Intersection

Ideal Alternative

As shown in Figure 8, the ideal alternative would consist of two 11 foot travel lanes, a 3 foot buffer with a raised median, and a 10 foot separated bicycle lane. The FHWA Separated Bike Lane Planning and Design Guide recommends a 12 foot width for the bike lanes. The proposed width of 10 feet is intended to reduce the impact of the widening. If, prior to design, it is determined that the usage of the facility creates the need for a wider bike lane, additional width could be claimed by reducing the travel lanes to 10 feet. In this section, the ideal alternative would widen the existing roadway by 4 feet.



Section 2 – South College Avenue to South Chapel Street

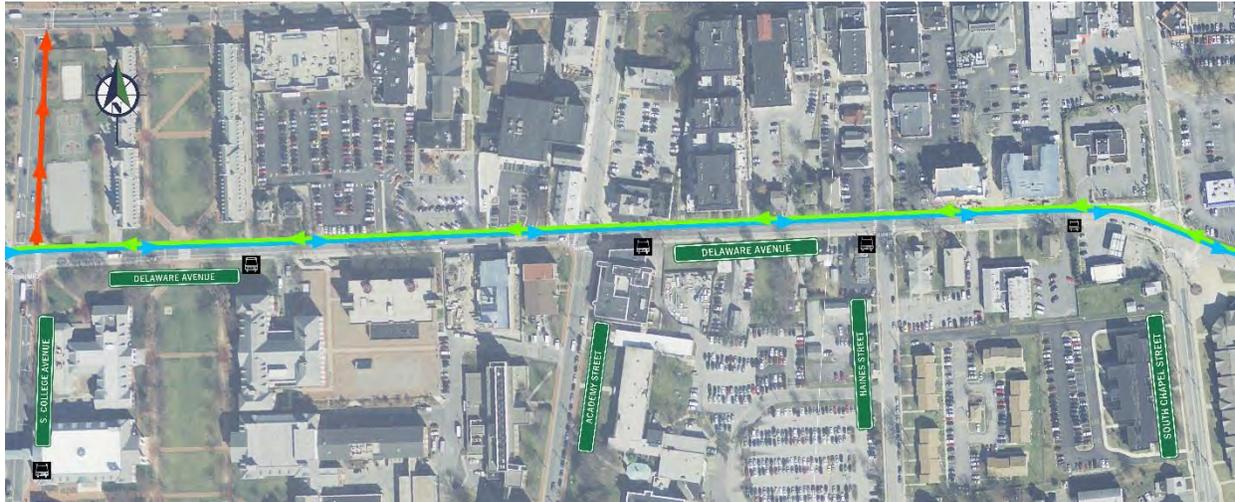


Figure 9: Section 2 Layout Overview

Section 2 of Delaware Avenue has a roadway width of 29 feet. This is the narrowest section of the corridor and serves the greatest number of cyclists. This section is a densely urbanized area with a combination of residential and commercial entrances. There are signalized intersections at Academy Street and South Chapel Street and a planned pedestrian signal to be located at “The Green”.

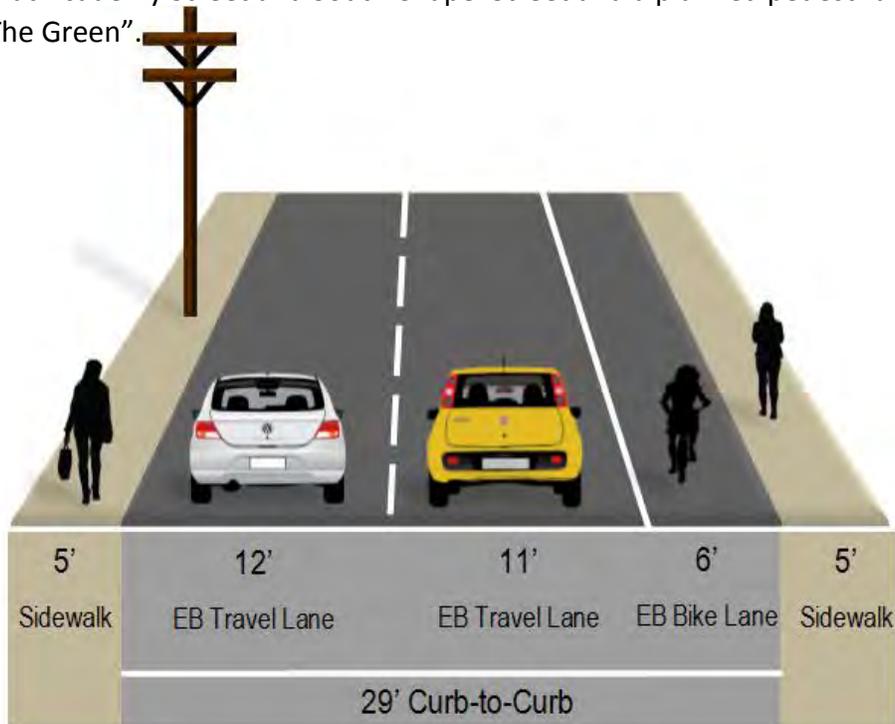


Figure 10: Section 2 – Existing Conditions
Delaware Avenue: S. College Avenue to Chapel Street

Low Impact Alternative As shown in Figure 11, the low impact alternative for this section of roadway would consist of a 7 foot wide two-way bike lane with a 2 foot striped buffer with flexible delineator posts and two 10 foot travel lanes. The effective width of the bike lane would be 8 feet with the consideration of the 1 foot gutter. The low impact alternative would be constructed within the existing curb to curb footprint of the existing roadway. As part of the design, consideration should be given to adjusting, repairing or replacing inlet grates along the bike facility to ensure ride-ability. Due to the shift in the travel lanes, turning radii at each intersection should be checked to ensure they can accommodate right-turning vehicles. A preliminary review of this section indicated the need to adjust the curb line at the intersection radii at the Academy Street and Haines Street to accommodate turning movements for single unit trucks.

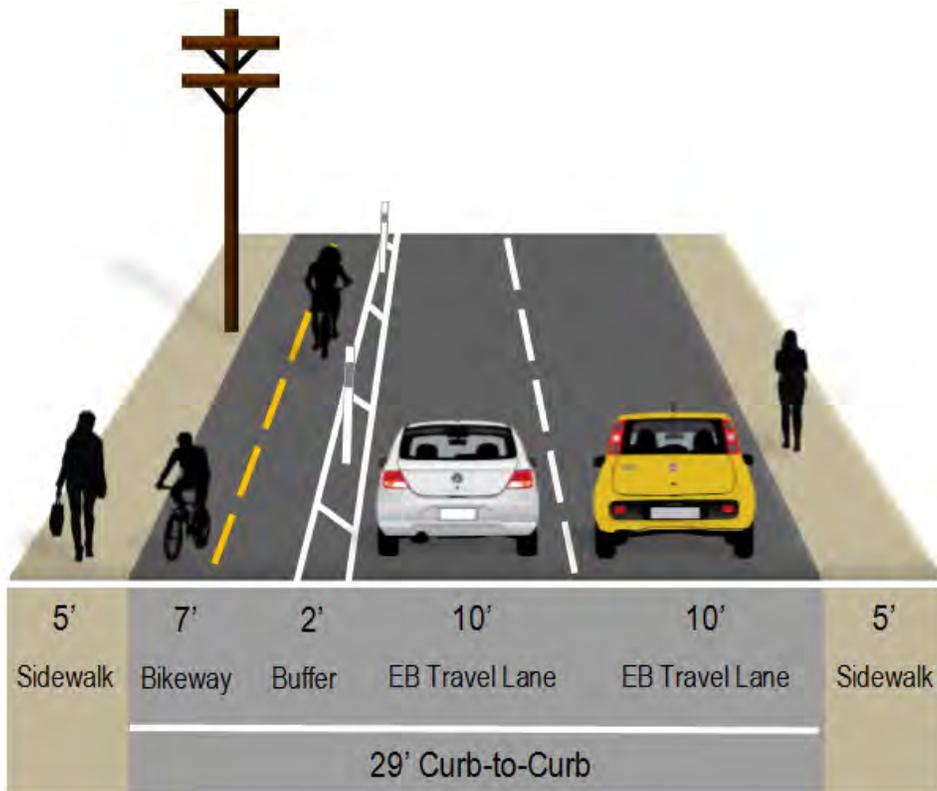


Figure 11: Section 2 – Low Impact Alternative
Delaware Avenue: S. College Avenue to Chapel Street

Main Street Galleria Entrance

One of the larger parking lots with access from Delaware Avenue serves the Main Street Galleria. Due to the volume of traffic entering/exiting the parking lot, it is suggested to modify the bike facility to alert both drivers and cyclists of the conflict. In addition to the pavement markings, it is suggested to consider elevating the bike lane where it crosses the driveway.



Figure 12: Galleria Parking Lot Driveway Entrance

Elevating the bike lane at these approaches will give drivers a physical indicator in addition to the visual queue of green paint to alert the driver of the presence of the bike facility. This could discourage drivers from idling in the bike lane while waiting to turn out onto Delaware Avenue.

Also, the City has considered constructing a parking garage at this location. If the garage project moves forward, the entrance design could accommodate this conflict by realigning the two-way bike lane further north as a bend in at the driveway approach. This design would allow vehicles to pull forward to turn onto Delaware Avenue without blocking the bike lane.

Academy Street

The Academy Street intersection will require the installation of a separate bicycle signal head facing both east and west. It is proposed to provide an advanced phase for cyclists to clear the intersection prior to vehicular and pedestrian phases. Green pavement markings should be incorporated into the intersection design to show the conflict points where the bicycle facility crosses the intersection. The crosswalk on the north side of Academy Street will need to be adjusted to accommodate a two-way turn queue box. This design will also require updates to the pedestrian signals and facilities. A preliminary review showed that intersection radii may need to be adjusted to accommodate right turns from larger vehicles. This should be further evaluated during design.

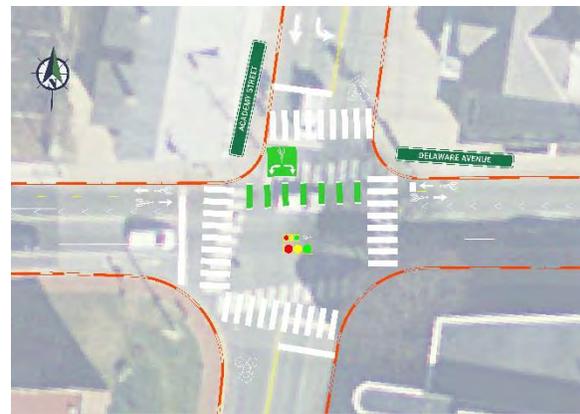


Figure 13: Academy Street Intersection

The Aetna Fire Station, which is located along the northeast corner of Delaware Avenue and Academy Street, will require design consideration to accommodate the size and turning radius of fire-fighting equipment.



Photo 8: Aetna Fire Station

Haines Street

The intersection at Haines Street will function differently from the other intersections throughout the corridor, as it is not a signalized intersection. Green pavement markings should be incorporated into the intersection design to show the conflict points where the bicycle facility crosses the intersection. The crosswalk on the north side of Haines Street will need to be adjusted to accommodate the two-way turn queue box. This will also require updates to the pedestrian facilities at the intersection to match the relocated crosswalk. A preliminary review showed that intersection radii may need to be adjusted to accommodate right turns from larger vehicles. This should be further evaluated during design.

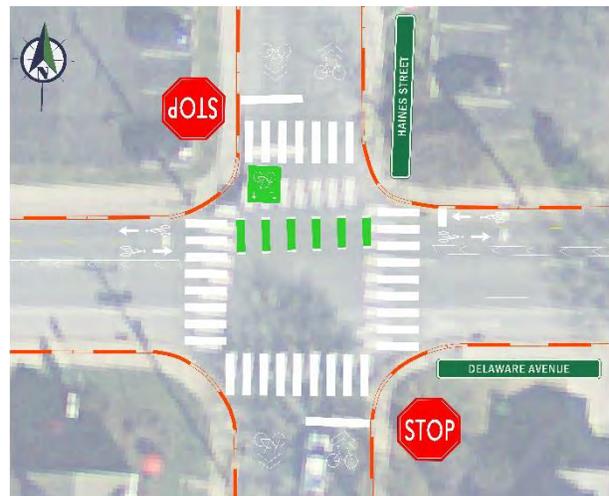


Figure 14: Haines Street Intersection

South Chapel Street

The intersection of South Chapel Street and Delaware Avenue is significantly different from the other intersections within the corridor. The eastbound approach to the intersection is currently configured with a short left turn lane, two travel lanes, and a 2 foot wide bike lane. Unlike the other intersections, the primary turning movement is eastbound left turns. The intersection geometry is skewed which creates a much longer crossing for the bicycle facility.

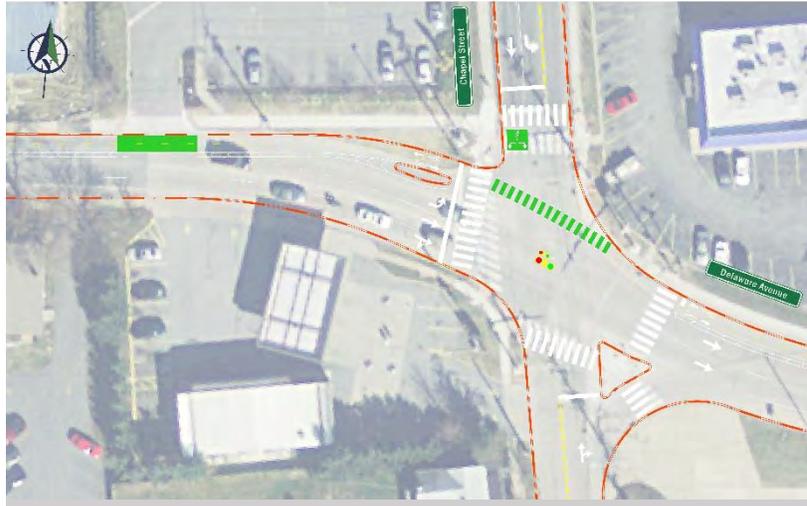


Figure 15: South Chapel Street Buffered Intersection Alternative

As shown in Figure 15, the bike facility would remain on the left side of Delaware Avenue through the intersection. However, in order to accommodate the bicycle lane it is proposed to relocate the curb line at the northwest corner of the intersection and to create an island to help buffer the bicycle traffic. Similar to the other intersection designs, a turn queue is recommended at the southbound through lane to accommodate cyclists heading south on South Chapel Street.

The existing eastbound left turn lane is approximately 50 feet long and provides minimal storage for left turning vehicles. It is suggested that prior to final design, traffic analysis should be performed that would consider the elimination of the lane. This would provide more flexibility for the design.

The South Chapel Street intersection is the beginning of the concrete portion of Delaware Avenue. Coordination with DeIDOT's Pavement Management Section is needed to determine the design approach for the construction and re-stripping of the intersection.

Ideal Alternative

As shown in Figure 16, the ideal alternative would consist of two 11 foot travel lanes, a 3 foot raised buffer, and a 10 foot separated bicycle lane. The FHWA Separated Bike Lane Planning and Design Guide recommends a 12 foot width for the bike lanes. The proposed width of 10 feet is intended to reduce the impact of the widening. If, prior to design, it is determined that the usage of the facility creates the need for a wider bike lane, additional width could be claimed by reducing the travel lanes to 10 feet. In this section, the ideal alternative would widen the existing roadway by 6 feet.

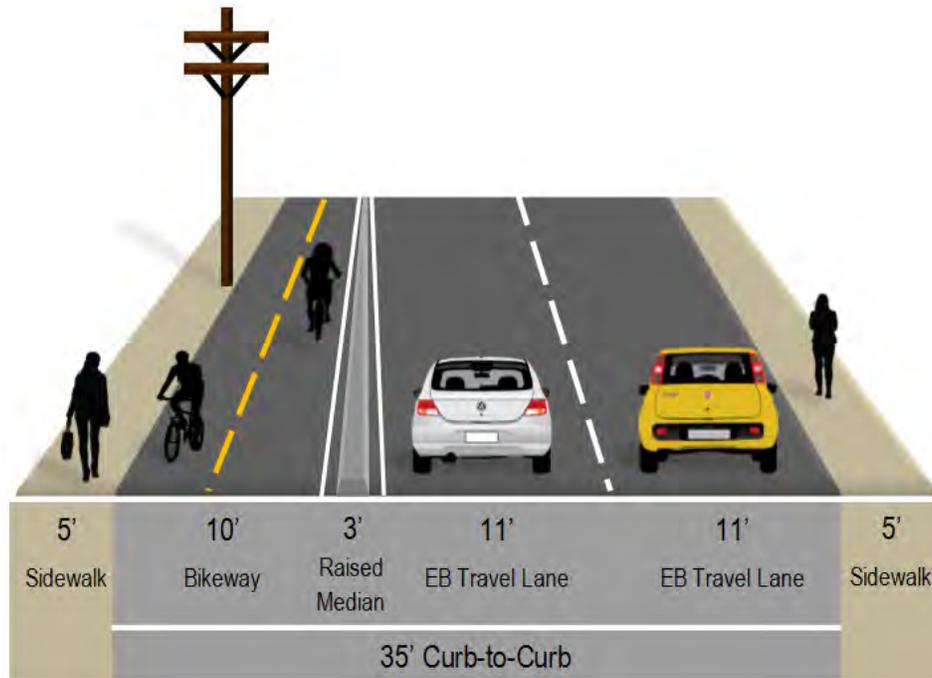


Figure 16: Section 2 – Ideal Alternative
Delaware Avenue: S. College Avenue to S. Chapel Street

Section 3 - South Chapel Street to Library Avenue

Section 3 of the Delaware Avenue study area was broken into two sections: Section 3A, which extends from South Chapel Street to the Pomeroy Trail Crossing. The roadway width in this section is 40 feet.



Figure 17: Section 3 Layout Overview

Section 3B extends from the Pomeroy Trail Crossing to Tyre Avenue and has a width of 48 feet. Additionally, the future phase of the Delaware Avenue Bikeway will extend east of Section 3, as illustrated in figure 17.

Section 3A – South Chapel Street to Pomeroy Trail

As shown in Figure 18, Section 3A contains the roadway from South Chapel Street to the Pomeroy Trail is two 8 foot shoulders with two 12 foot travel lanes. This section contains the Pomeroy Trail crossing which is controlled by a pedestrian activated signal. Pomeroy Trail is a multi-use trail that generally runs north – south through Newark and connects with the White Clay Creek State Park.

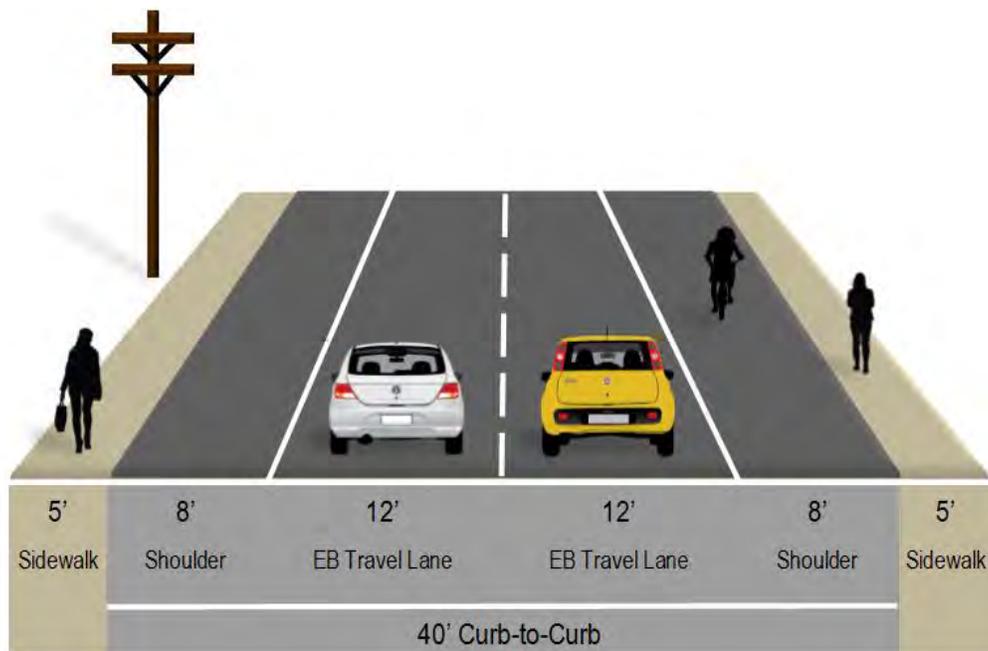


Figure 18: Section 3A – Existing Conditions
Delaware Avenue: S. Chapel Street to Pomeroy Trail

Section 3A - Low Impact and Ideal Alternative

In this section, the low impact and ideal alternatives are the same. As shown on Figure 19, the alternative for the section from South Chapel Street to the Pomeroy Trail features a 10 foot wide bike lane with a 3 foot buffer, two 11 foot travel lanes and a 5 foot shoulder. Flexible posts will be used in the buffer for the low impact alternative.

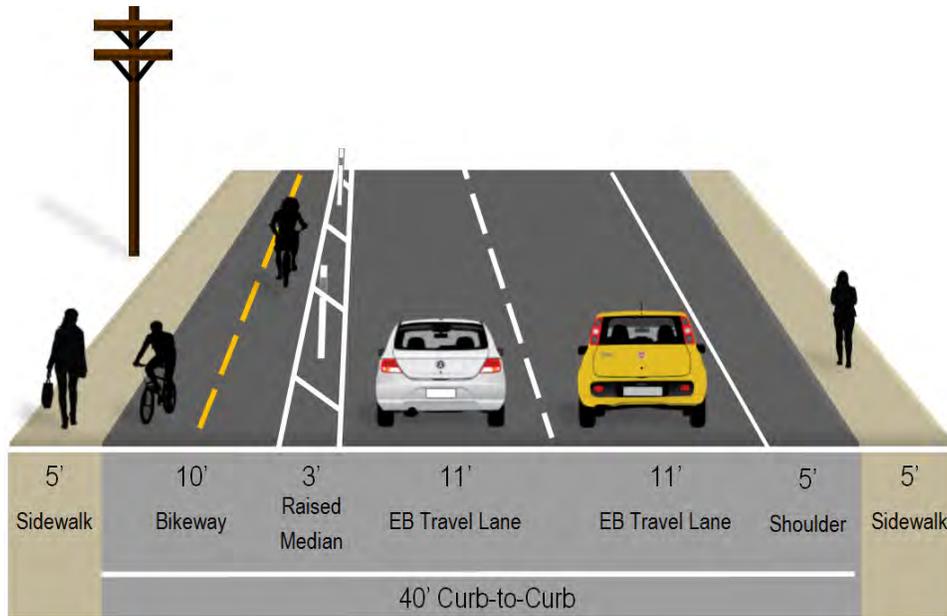


Figure 19: Section 3A – Low Impact and Ideal Alternative
Delaware Avenue: S. Chapel Street to Pomeroy Trail

Section 3B – Pomeroy Trail to Tyre Avenue

Section 3B is the section of roadway between the Pomeroy Trail Crossing and Tyre Avenue. This section has two 12 foot shoulders and two 12 foot travel lanes. A barrier is located along the north side shoulder through the S-curve.

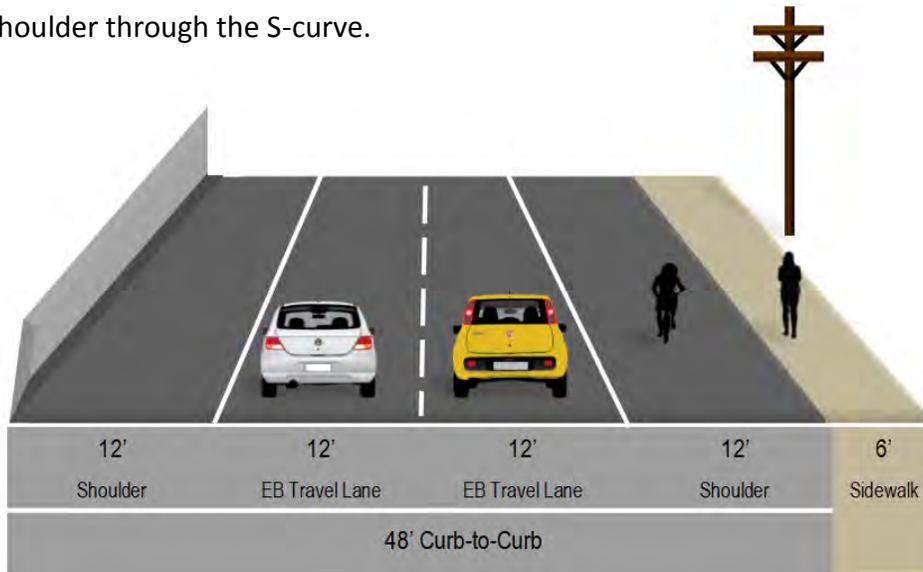


Figure 20: Section 3B – Existing Conditions
Delaware Avenue: Pomeroy Trail to Tyre Avenue

Section 3B - Low Impact and Ideal Alternative

The low impact and ideal alternatives for Section 3B from Pomeroy Trail to Tyre Avenue would include a 5 foot westbound bike lane, a 3 foot buffer, a 5 foot shoulder, two 11 foot travel lanes, a 5 foot shoulder, 3 foot buffer and 5 foot eastbound bike lane. Due to the roadway geometry through the S-curve, consideration should be given to the enhancing the vertical element used in the buffer area on the outside of the curve.

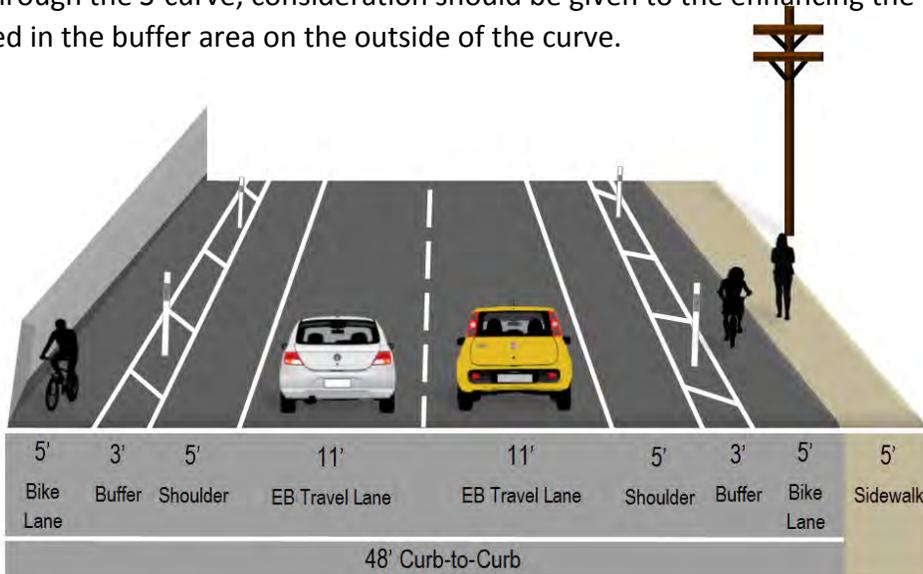


Figure 21: Section 3B – Low Impact and Ideal Alternative
Delaware Avenue: Pomeroy Trail to Tyre Avenue

Through the planning process, it was agreed that there was a benefit to splitting the separated bicycle facility into two individual lanes on each side of the road prior to the transition at the eastern end. The benefit from this approach was twofold. First, the connection with Library Avenue would be improved with the split lane approach. Library Avenue is a four lane highway with right-turn lanes that would create alignment and positioning conflicts with a two-way separated bike lane. Positioning a two-way facility on either side of Delaware Avenue would create significant turning movement conflicts with vehicles turning onto Library Avenue. Second, the facility can fit within the existing footprint, provided the existing on-street parking at the high school is removed. With this in mind, the separation of the lanes is proposed to occur at the Pomeroy Trail intersection.



Photo 9: On-Street Parking near Newark High School

While the continuation of the split lane approach through Tyre Avenue to Library Avenue would be successful, the planning study defers a recommended section until further coordination can occur. Specifically, the second phase would be pursued on a delayed schedule in order to adequately work through the anticipated issues related to the on-street parking adjacent to Newark High School. Also, if the College Square shopping center redevelops, the design of the improvements will become important to potentially continuing the facility east of Library Avenue.

Pomeroy Trail

The Pomeroy Trail is a paved multi-use pathway that runs north-south in Newark. The trail connects to the James F. Hall Trail, which runs east-west in Newark and ultimately connects to a network of trails at White Clay Creek State Park. The trail is used by many Newark residents as a bicycle connection route within the city. The trail currently crosses Delaware Avenue at the intersection west of the transit hub on Farmers Lane. The trail crossing is configured with a pedestrian push button that activates a signal for traffic on Delaware Avenue. It is recommended to design the intersection to direct eastbound bicycles to cross the two travel lanes. A bike signal is recommended for the intersection. Bicycle signage is



Figure 22: Pomeroy Trail Crossing

recommended to inform bicyclists of how to navigate this area as well as to yield to pedestrians.

Tyre Avenue The intersection at Tyre Avenue will be constructed with left turn queue boxes on each side of the side street approach to the intersection. This intersection may also need a dedicated bicycle signal head installed to facilitate bicycles through the intersection. It is recommended to investigate using the advanced bicycle signal phase to give bicycles first access to the intersection.

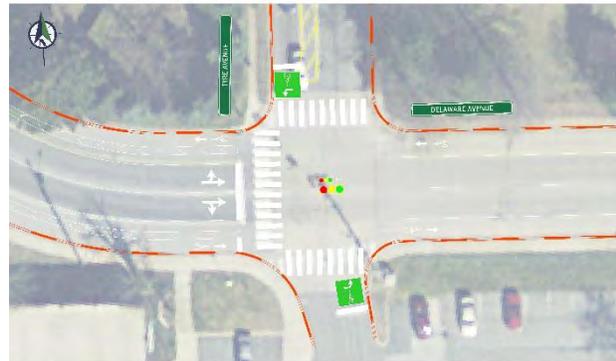


Figure 23: Tyre Avenue Intersection



MOVING FORWARD

Next Steps

Prior to implementation of the low impact alternative, it is recommended that a traffic study be performed to evaluate the operation of the signalized intersections with the advanced bicycle phase. In addition, the study will investigate the need for the dedicated left turn lane at the South Chapel Street intersection.

It is intended to incorporate this project into a pavement rehabilitation project. Coordination with the design team will be needed to adequately convey the concepts required for the separated bicycle facility. In order to complete the project to Library Avenue, outreach should be initiated with Newark High School to discuss the on-street parking.

Several traffic control devices proposed have experimental or interim MUTCD approval from FHWA. If experimental traffic control devices are proposed, a proposal must be prepared and submitted to FHWA describing the device, its purpose, and describing measurements of effectiveness. A before and after evaluation will need to be performed as part of this effort. Independent proposals will need to be done for each experimental feature.

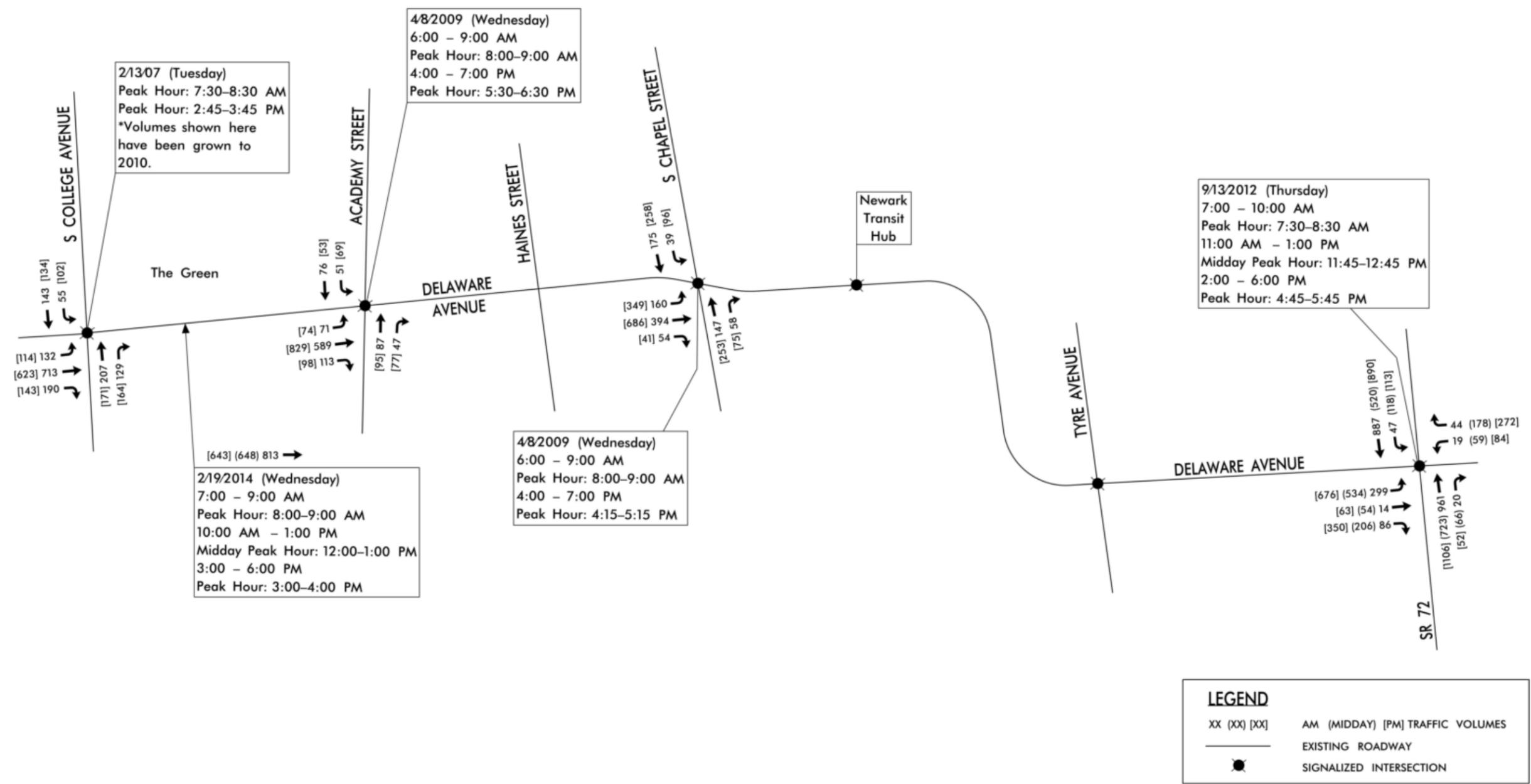
During design and prior to construction, additional public outreach is recommended. This could involve presentations to the City Council, Newark Bike Committee, and the general public.

An educational campaign should be developed to educate users on how the facility functions and how to navigate the new bicycle elements such as turn-queue boxes and bicycle signals. This education component should be incorporated into the University of Delaware's Freshman Orientation as well as any other public outreach opportunities implemented by the university and the City.

Within a year of the construction of the facility, an assessment should be performed to evaluate the operation and performance of the bike lanes. The assessment should consider volumes of all roadway users, crash data, adherence to design intent, intersection operations and user comfort.



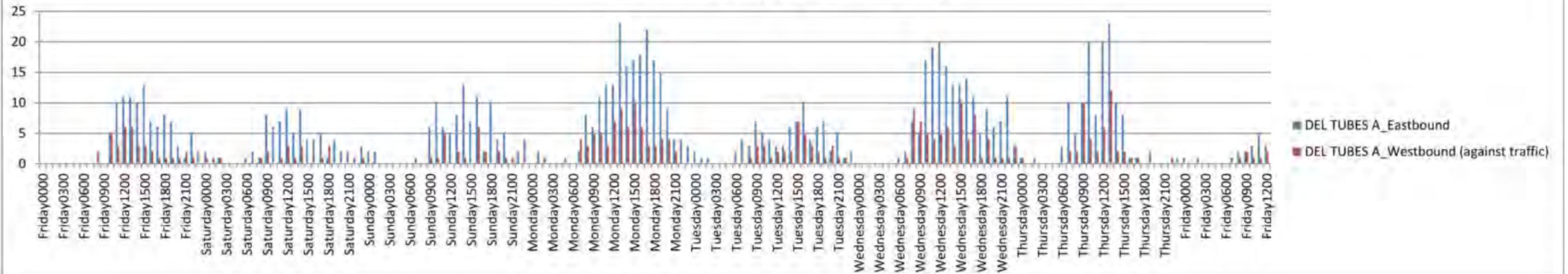
APPENDIX A



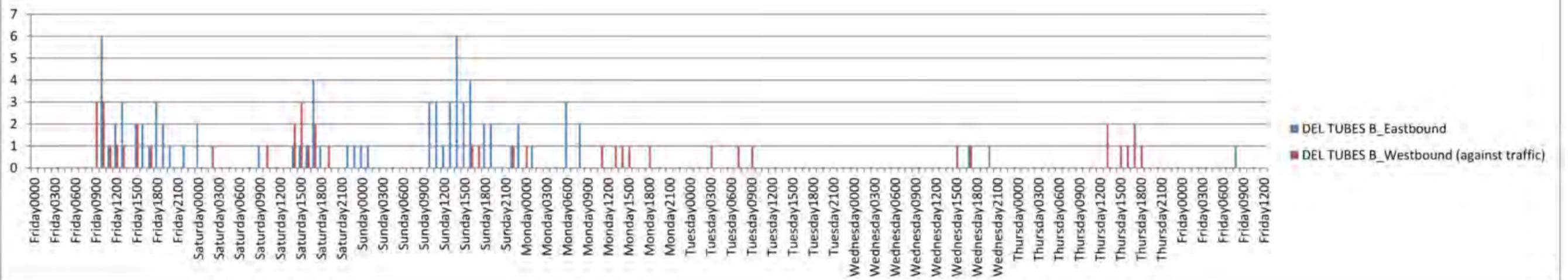


APPENDIX B

Delaware Ave & Academy Rd



Delaware Ave & S Chapel St



APPENDIX C





Delaware Avenue Crashes Involving a Bicycle or Pedestrian

Crash Study Time Period: 01/01/2005 - 6/4/2015

Description: Crash Analysis of crashes that occurred with the proposed cycle track project limits and involved with a bicycle or pedestrian.

Summary: The crash data provided by Delaware Department of Transportation denoted a total of 46 separate crashes that involved either a bicycle or a pedestrian. Of those crashes, 1 bicycle crash was outside of the project limits, it occurred on Wyoming Road. The remaining 45 crashes within the project limits consisted of 2 crashes in which only a pedestrian and bicycle was involved, 20 crashes that involved a bicycle and 24 crashes that involved a pedestrian. Pedestrian crashes that occurred within a crosswalk accounted for 50% of pedestrian crashes.

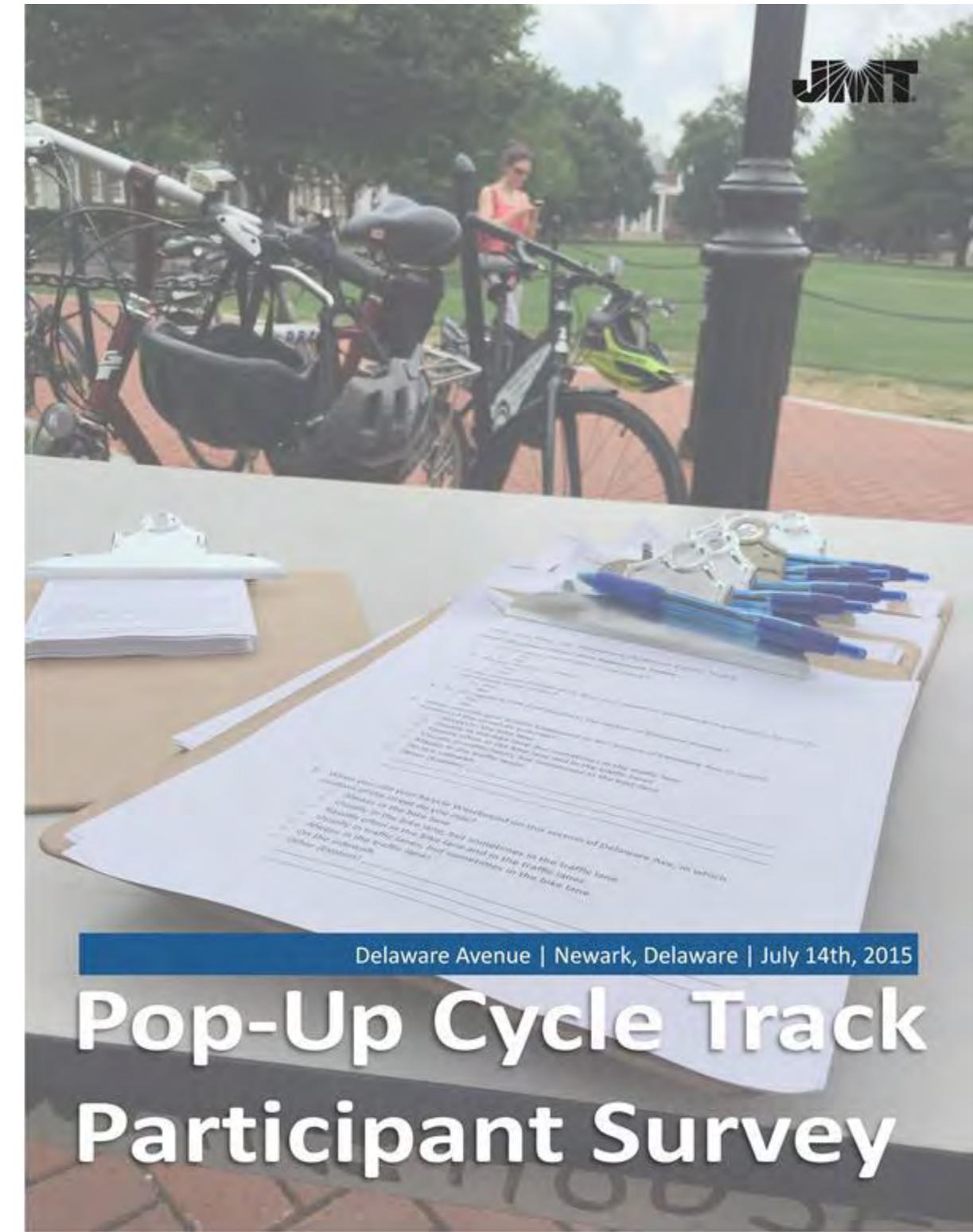
There was a total of 5 alcohol related crashes. 61% of the crashes occurred during daylight in clear conditions. The majority of crashes occurred during the week days with Wednesday having the highest crash rate. Crashes typically occurred at during the day time between 8:00am –7:00pm, and nighttime between 12:00am-3:00 am. Failing to yield right of way was a primary contributing circumstance in 17% of all crashes.

The charts below summarizes the types of pedestrian and bicycle crashes that occurred within the project limits. A variety of the bicycle crashes could be reduced with the installation of a separated bicycle facility.

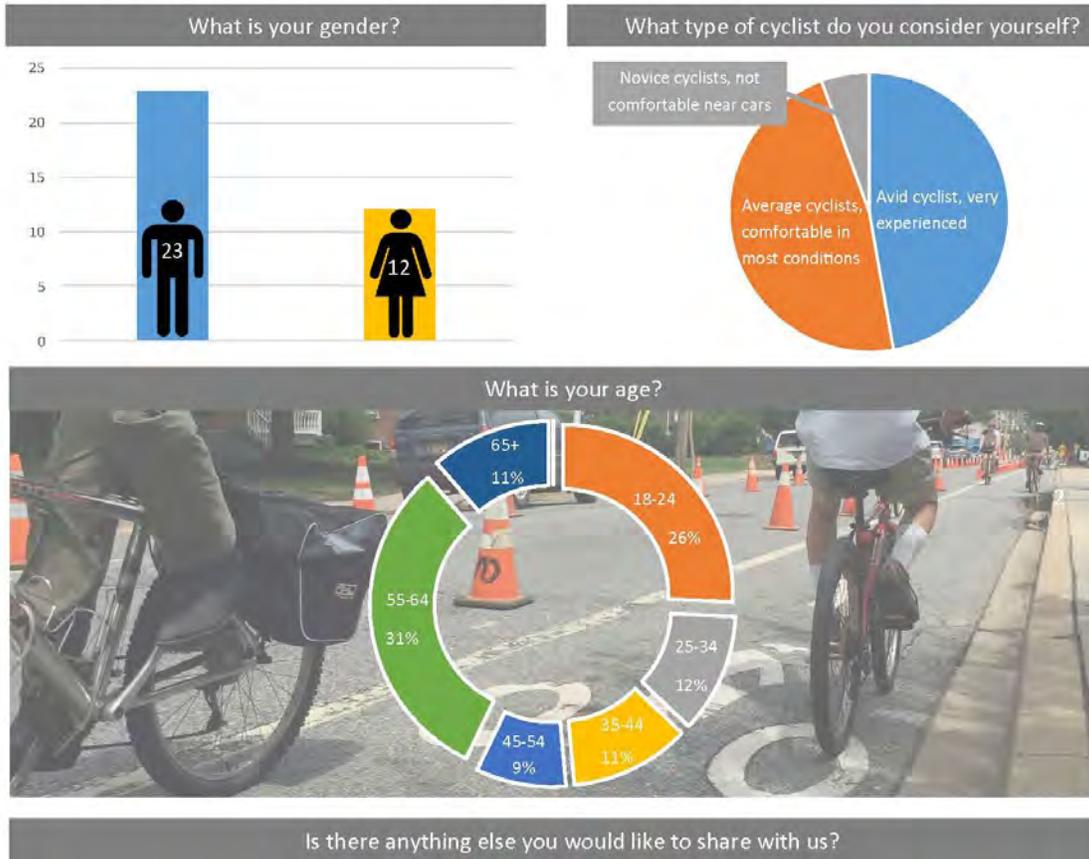
Pedestrian Involved	
Pedestrian hit in crosswalk	12
Other	12
Total	24

Bicycle Involved	
Contraflow bike lane travel	4
Cyclist Error	4
Riding on sidewalk/Hit in crosswalk	6
Right Hook	3
Dooring	1
Perpendicular Crash	1
Outside project limits	1
Total	20

Bicycle/Pedestrian Crash in Bike Lane	
Pedestrian/Bicycle Crash	1
Skateboard/Bicycle Crash	1
Total	2



Survey Participants demographics questions: 36 survey participants.



- All Responses:**
- ◆ Active in Newark Bike Project and bike advocacy. Very excited about Delaware Avenue and other people share the same option.
 - ◆ I live to ride.
 - ◆ Cyclists signs/lights for pedestrian crossings?
 - ◆ Nice mock up. Definitely a possibility for the future.
 - ◆ Let's push DE to #1 most bike friendly state!
 - ◆ Thanks!
 - ◆ This project would make me switch from driving to biking in Newark!
 - ◆ Perfect alternative to what we have now.
 - ◆ Thanks for taking our feedback!
 - ◆ Thanks for doing this work to move the bike path forward.
 - ◆ No, Thank you for this experience.
 - ◆ Just do it. (N - side)
 - ◆ I lived in Holland for 1 year and am hoping Delaware can learn from Holland's transportation network. I also live on East Delaware Ave and use the bike lane almost daily.
 - ◆ Thank you!
 - ◆ Forget the cycle track idea!

Question 1

Do you regularly ride your bicycle in this section of Delaware Avenue?

Yes: 21
No: 15

Question 2

When you ride your bicycle Eastbound on this section of Delaware Ave, in which location of the street do you ride?

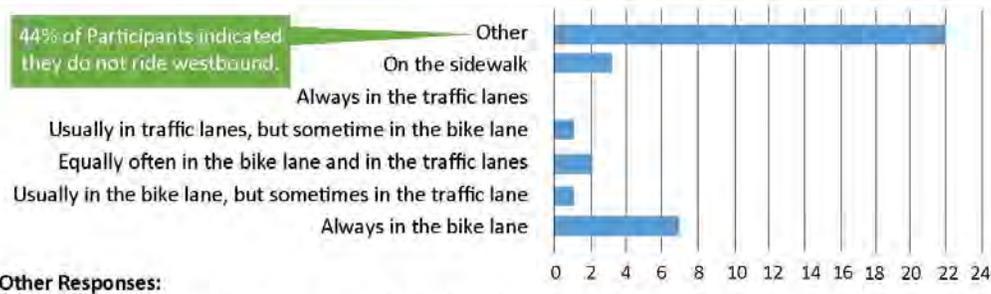


Other Responses:

- ◆ Always in the bike lane except to turn left onto Academy Street.
- ◆ I am as fast as traffic and routinely take the lane to turn.
- ◆ If I need to cross to make a left turn I move to the left side of the road. Usually on Tyre Avenue.
- ◆ Combination of bike lane and sidewalk.
- ◆ Usually in the bike lane and sometimes on the sidewalk.
- ◆ Don't ride, just observing.
- ◆ I haven't ridden my bike on Delaware Avenue because the traffic is so heavy. I would probably use the sidewalk.

Question 3

When you ride your bicycle Westbound on this section of Delaware Ave, in which location of the street do you ride?



Other Responses:

- ◆ 3 respondents stated: They never ride westbound.
- ◆ 3 respondents stated: They use Main Street.
- ◆ 2 respondents stated: They haven't ridden their bike on Delaware Avenue because the traffic is so heavy.
- ◆ Don't ride, just observing.
- ◆ Combination of bike lane and sidewalk.
- ◆ I don't use Delaware Ave Westbound.
- ◆ Never ride the wrong way, it will get you killed.
- ◆ Do not ride westbound
- ◆ 2 respondents stated: They don't bike west on this street; typically take Main or Park.
- ◆ I don't ride westbound, I ride Main Street or the Hall Trail.
- ◆ I don't. I ride on Main Street (not very comfortable, feels unsafe).
- ◆ Don't ride wrong direction, Use the correct street instead.

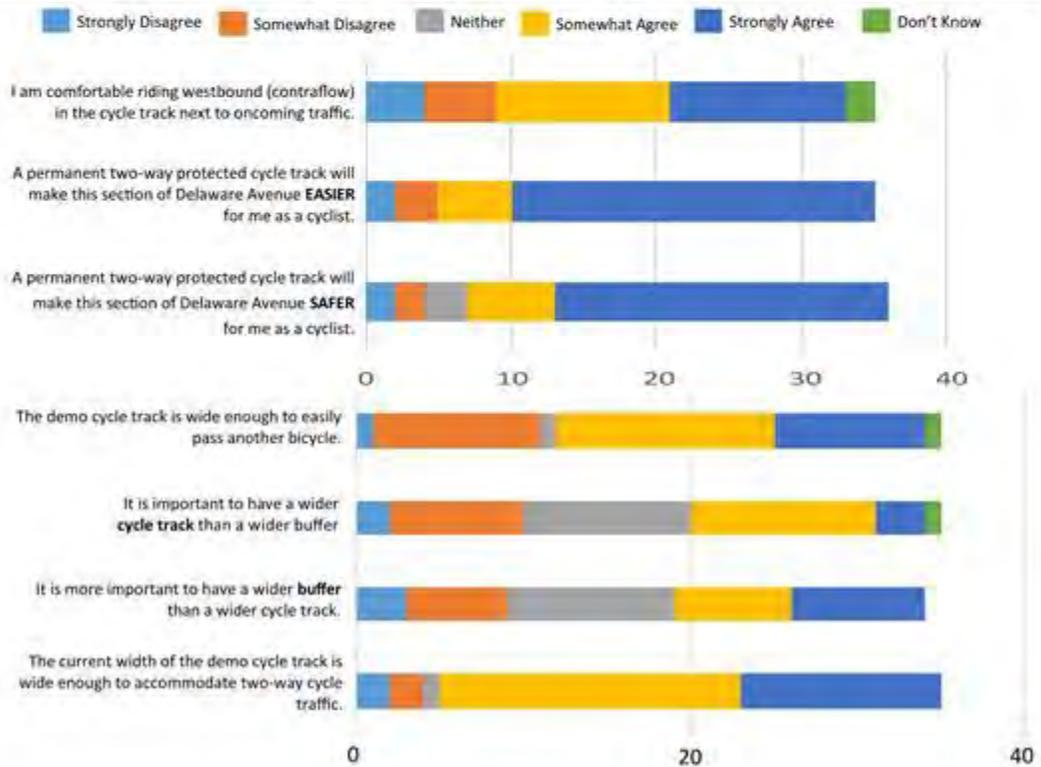
Question 4

When riding in the current bike lane how often do you encounter a pedestrian crossing or standing in the bike lane?



Question 5

Do you agree or disagree with these statements?



Question 6

What would you do to improve the cycle track?

Trends:

- ◆ 4 respondents recommended installing the cycle track on the north side of the road
- ◆ 4 respondents commented on the condition and maintenance needs of the roadway surface.
- ◆ 4 respondents recommended a permanent buffer.
- ◆ 3 respondents recommended using directional arrows to direct bicycle traffic in the cycle track.
- ◆ 3 respondents recommended making the cycle track wider.

All Responses:

- ◆ Like most of Delaware Ave. the condition of road
- ◆ One suggestion provide two way traffic on Delaware Ave. all vehicles follow same rules
- ◆ Paint it a different color; Add cycle logos with arrows for clarity
- ◆ Put it on North side of street
- ◆ Make it about a foot wider in each direction
- ◆ Have all road repairs in the cycle track be permanent, no soft spots
- ◆ Fix the utility lids, some are sunken. Will it be swept of glass/debris more often?
- ◆ Not sure, great start
- ◆ Improve the intersection areas so they are safe for all modes
- ◆ Make it raised (in a perfect world) ensure intersections are well marked. If permanent, physical barrier (i.e. curb) exists, the large buffer zone is not important but if such a barrier exists then a wide buffer is needed
- ◆ Extend the track down further in both directions
- ◆ Turn lanes, no skateboard/non-biker signs
- ◆ Look into a left turn
- ◆ Barrier between traffic and lane. Possibly having lane on left side so it flows with traffic
- ◆ Add a physical barrier between bikes and cars. Add direction markers for cyclists
- ◆ Consider putting it on the other side of the road, may make crossing intersections easier
- ◆ Have a buffer that stops a car
- ◆ Move to North side of street
- ◆ Of course the wider the better
- ◆ Keep it swept, level the utility covers
- ◆ Take it further
- ◆ Should be a two-way
- ◆ Wider
- ◆ More secure barriers
- ◆ Make sure to put warnings near crosswalks and the large curb is definitely a concern
- ◆ Placement of directional arrows
- ◆ Expand the lanes
- ◆ Have signage with bike tips and signage west of Trabant alerting cars of the bike lane
- ◆ Road improvements to eliminate standing water

Question 7

What are the best or worst aspects of the cycle track?

Best Aspects:

- ◆ The best aspect is that it gets westbound bikers off the sidewalk
- ◆ It helps keep bikers out of the traffic lane
- ◆ Width
- ◆ Makes traveling by bike safer if everyone knows which way to go and pedestrians are vigilant
- ◆ You are making it happen
- ◆ Goes in the same direction as traffic
- ◆ It's great
- ◆ Good to see line to buffer/mark it
- ◆ Makes cycling safer
- ◆ Safety, convenience, promotes bike transportation
- ◆ Buffer zone
- ◆ East/West flow of movement, wider lane, etc.
- ◆ Gets bikers off Main Street
- ◆ Comfortable lane widths for cyclists
- ◆ Safety; 2-way traffic (cycling)
- ◆ Accessibility and connectivity
- ◆ Really like the two-way flow and separation from the cars
- ◆ Love the idea of paint and flexi-poles to keep cars away
- ◆ Diminish car dominance while promoting cycling and pedestrian transportation
- ◆ Easier to get around Newark

Worst Aspects:

- ◆ Narrowing due to large puddle
- ◆ Bad part is vehicles coming out of driveways and cross street failing to look right!
- ◆ The puddles on the road may force bikers to swerve into the other bike lane.
- ◆ Creates a tighter space when cyclists are on both sides
- ◆ Proximity to cars
- ◆ Making a turn across 2 lanes of traffic (but not unique to cycle track)
- ◆ Foot traffic
- ◆ Close to traffic
- ◆ Limited width to share with cars
- ◆ Some areas of the curb made it cumbersome with passing bikes
- ◆ Kind of tight two ride two side by side/pass/etc.
- ◆ Hard to left turn, I will need to pass other riders
- ◆ The sidewalk should be angled so if you get pinched, a bike would be able to jump onto the curb if absolutely necessary.
- ◆ No barriers between cars and bikes
- ◆ Gutter pan and water main covers. Wrong side of street
- ◆ The signaling is complex and expensive
- ◆ Narrow for an unexperienced biker



Question 8

Do you have any other thoughts you would like to share about the Delaware Avenue cycle track, intersection design, connections, etc.?

All Responses:

- ◆ If done in the future, better turnarounds
- ◆ Is it possible to have convex mirror at left side of driveways so westbound traffic is reflected and a cue for drivers to look right?
- ◆ Where does it end near lights? This is a major concern
- ◆ Connect to Main Street and Chapel Street
- ◆ I like having it on the right
- ◆ Need actual barriers. Signage/painted streets would help
- ◆ Thanks for the tryout!
- ◆ Strongly support it!
- ◆ Make this happen for all of Delaware Ave
- ◆ Main Street connection?
- ◆ Put it in and let's see what goes down
- ◆ Good to promote bike safety
- ◆ Make up a design for the ends of the path that is safe for riders when approaching cars
- ◆ Run the whole length from South Main to route 72
- ◆ Make sure intersections are well-marked. Intersections should have concrete barrier for protection
- ◆ Great idea! Should be color-coded too
- ◆ Put a big X in the intersection of college and academy so traffic doesn't block it. Then we can do a careful turn to go North onto Academy. Don't block the box!!!
- ◆ Thinking of the study by the U of D student. I believe a permanent track would be better on the left hand side of Delaware Ave.
- ◆ Excellent idea to help solve issue of "students will do what students do"
- ◆ All success comes from a full network of trails. This includes parking spots for bikes, bike lights, maps, distance/time markers, etc.
- ◆ Yes!
- ◆ What will it connect to???