# Mount Vernon Trail Corridor Study

*George Washington Memorial Parkway*

**May 2020**

50 YEARS 1970 – 2020

U.S. Department of Transportation
Volpe Center

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13. ABSTRACT (Maximum 200 words)

This study identifies opportunities to improve the Mount Vernon Trail based on an analysis of trail conditions, safety concerns, users' needs, and resource management considerations. This is the first comprehensive analysis of those data and will help inform park operations and maintenance needs and identify long term capital investments to improve visitor experience. The technical findings are intended to help the park develop projects and identify priorities; inform future National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA) compliance processes; and pursue partnership opportunities with local jurisdictions.

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## ACRONYMS

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ADA | Americans with Disabilities Act |
| ABA | Architectural Barriers Act |
| APBP | Association of Pedestrian and Bicycle Professionals |
| FLH | Federal Lands Highway |
| FMSS | Facility Management Software System |
| FY | Fiscal Year |
| GWMP | George Washington Memorial Parkway |
| MMA | Methyl methacrylate acryline |
| MUTCD | Manual on Uniform Traffic Control Devices |
| MVT | Mount Vernon Trail |
| NACTO | National Association of City Transportation Officials |
| NEPA | National Environmental Policy Act |
| NHPA | National Historic Preservation Act |
| NCA | National Capital Area |
| NCR | National Capital Region |
| NPS | National Park Service |
| TAP | Transportation Alternatives Program |

# 2 EXECUTIVE SUMMARY

## 2.1 STUDY PURPOSE AND SCOPE

### 2.1.1 Background

The George Washington Memorial Parkway (GWMP)—a unit of the National Park Service (NPS)—owns, maintains, and operates the 18-mile Mount Vernon Trail (MVT). This paved, multi-use trail corridor stretches from George Washington's Mount Vernon Estate to Theodore Roosevelt Island, linking Fairfax County and the City of Alexandria, to Arlington County and major Potomac River bridge crossings into the District of Columbia.

The MVT is a popular recreation resource and critical regional transportation connection. The trail hosts over one million pedestrians and bicyclists annually. During peak periods, the MVT north of Alexandria is one of the most heavily used multi-use trails in the country.

***Study Purpose:***
*Identify opportunities to improve the Mount Vernon Trail based on an analysis of trail condition, safety concerns, users' needs, and resource management considerations.*

The National Park Service tasked the U.S. Department of Transportation Volpe National Transportation Systems Center (Volpe Center) to assess the design, condition, usage, and crash history of the Mount Vernon Trail. The analysis is intended to inform park operations and maintenance needs, as well as identify short- and long-term capital projects to improve the visitor experience.

The NPS originally constructed the MVT in the 1970s and 1980s. During this period, there were no commonly held industry engineering standards, guidelines, or best practices for multi-use trails. Instead, the NPS based the design and ultimate alignment of the trail on a series of historical design concepts for bridle trails and footpaths. The trail is relatively narrow by modern standards, and characterized by meandering curves, timber bridges, and in some areas, dense vegetation.

The MVT is beginning to show its age, from deteriorating pavement and bridges, to limited accessibility features, and outdated signage and striping. These attributes, combined with increasing usage and user behavior, contribute to risk exposure and considerable crash history. Public health researchers estimate that there is one ambulance call per week along the corridor.[1]

The NPS has no legal responsibility to bring the MVT up to modern design standards. However, as different parts of the trail come up for recapitalization, GWMP staff have the opportunity to make informed, context-sensitive decisions about trail improvement projects.

This Mount Vernon Trail Corridor Study is the first comprehensive analysis of the design, condition, usage, and crash history of the corridor. The result is a series of wide-ranging recommendations covering safety, signage, trail connections, user counting programs, project cost estimates, internal and external funding opportunities, pavement and bridge maintenance, and vegetation management.

[1] Charles Opalak, "A Study of Crashes and Injuries along a Multiple Use Trail," master's thesis, Drexel University, June 2011.

### 2.1.2 Study Scope

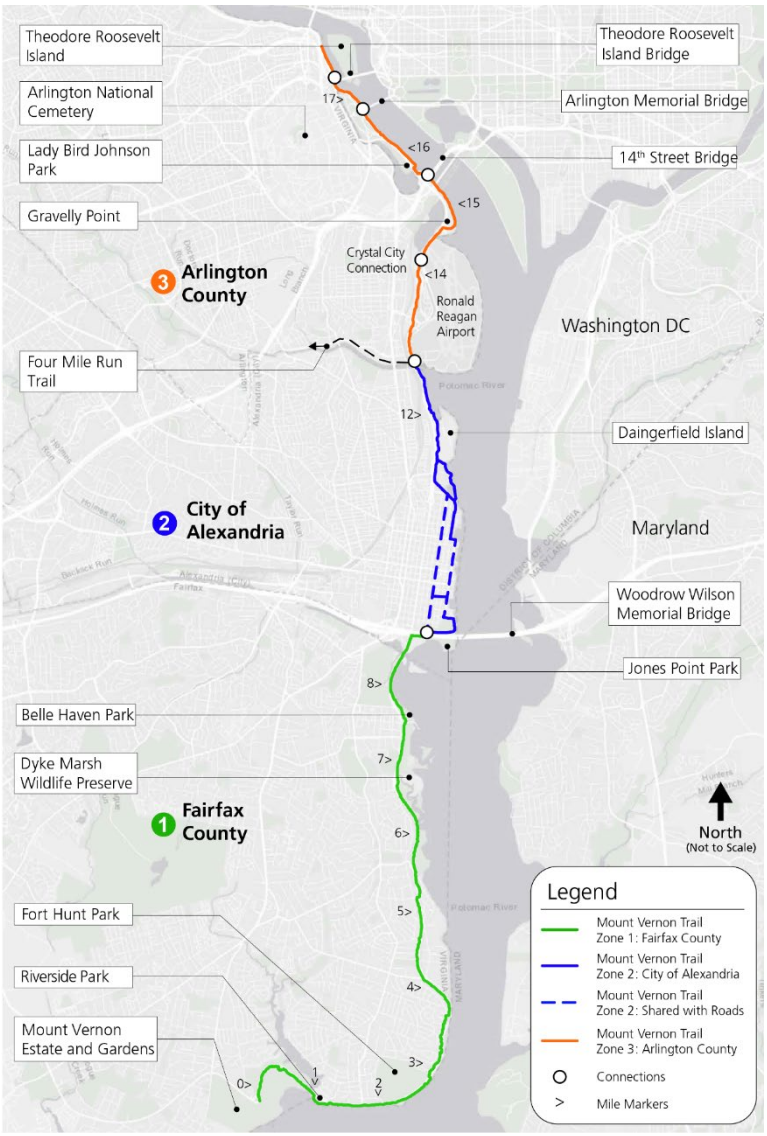
This study is organized into four chapters:

**Background and Context:** Provides an overview of the MVT, key destinations, and a brief history of its development. This section also discusses previous planning efforts, including the 2016 National Capital Region (NCR) Paved Trails Study, the 2014 GWMP Foundation Document, and the 2012 Mount Vernon Trail Transportation Scholar Report.

**Existing Conditions:** Discusses current trail usage, condition, and safety. The study team gathered this information from site visits, count and crash data, discussions with park staff and stakeholders, and condition data gathered by park staff. For purposes of this study, the trail is divided into three management zones: Zone 1 is in Fairfax County, Zone 2 is in the City of Alexandria, and Zone 3 is in Arlington County and the District of Columbia.

**Trail Design Considerations:** Discusses modern trail design standards in light of the existing conditions of the MVT. This section includes design guidelines and best practices for trail pavement, bridges, at-grade crossings, trail intersections, pavement marking and signage, and amenities that improve visitor experience and safety.

**Recommendations:** Outlines steps for GWMP to consider for improving the MVT user experience. Recommendations fall into three broad categories: capital projects, trail enhancements, and operations and maintenance. The recommendations are grouped by short, medium, and long-term timeframes.




## 2.2 Study Findings

The NPS and its partners have collected a significant amount of data regarding MVT usage, conditions, and crash history. The study team developed the following key findings based on an analysis of these data and supplemental field observations:

- **Trail crowding is already acute in the north section of the MVT during peak periods and is projected to increase.** The count analysis identified summer crowding conditions in Zone 3 during peak weekday commute periods and both Zones 2 and 3 during peak weekend recreation periods. Crowding will become more acute over time

given planned trail connections and the increasing number of housing units and jobs projected in this area. Crowding is largely driven by the high number of both commuter and recreational bicyclists in the summer. MVT usage currently either exceeds or nearly exceeds industry thresholds for its width during weekdays, weekends, or both on a seasonal basis.

- **Modal conflict is significant throughout the north section of the MVT during peak periods, particularly near Rosslyn and Crystal City.** Bicycling on the trail peaks during the summer months (June, July, and August), while pedestrian usage plateaus at a high level between April and October. Overall bicyclist counts are highest at the 14th Street Bridge and Ronald Reagan National Airport in the summer months, while pedestrian usage is particularly high at Theodore Roosevelt Island and the Crystal City Connector in the spring through fall. The share of pedestrians on the trail during the summer months exceeds industry thresholds for its width, particularly at the Crystal City Connector, Theodore Roosevelt Island, and the Theodore Roosevelt Bridge.

- **High crash potential entering and exiting the MVT at the 14th Street Bridge and Four Mile Run trail intersections.** Count data suggest that the trail intersections at 14th Street Bridge and Four Mile Run are the most heavily used MVT trail intersections during peak weekday periods. Manual turning movement counts at the 14th Street Bridge and Four Mile Run confirmed that most commuting bicyclists originate from the south. During peak periods, the primary turning movements are the morning northbound left onto the 14th Street Bridge and the evening southbound left onto the Four Mile Run Trail. Both movements are significant conflict points that require bicyclists to cross the mainline of the trail.

- **Infrastructure and behavioral factors contribute to crash rates at key locations.** Crashes along the MVT have a variety of causal factors. While the data are incomplete, the majority of documented crashes on the MVT occur at the following locations: narrow and/or crowded trail segments and trail intersection in Zone 3; surface/grade transitions in Zone 1 and 2; and at-grade roadway crossings. The NPS can leverage engineering standards, guidelines, or best practices for multi-use trails as portions of the MVT are reconstructed to mitigate infrastructure factors. Continued emphasis on enforcement, education, and emergency response is critical to addressing behavioral factors.

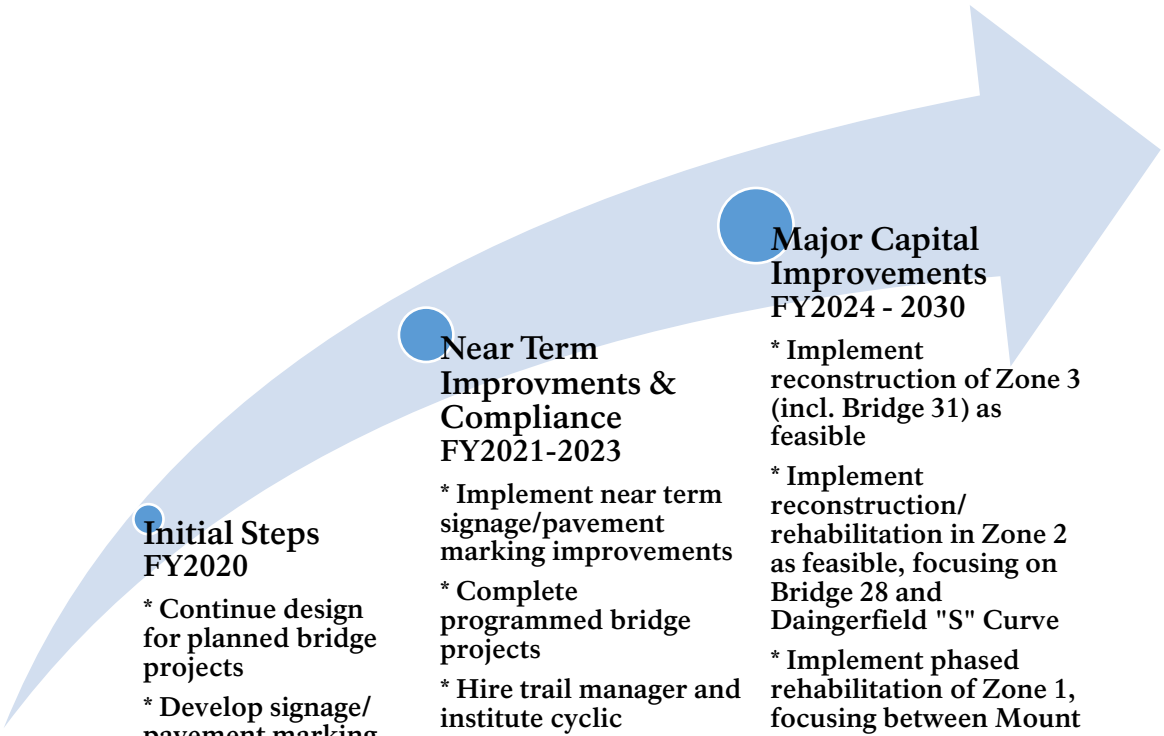
- **The MVT is in fair to good condition, with significant bridge reconstruction and pavement rehabilitation needs on the horizon.** MVT pavement and bridges are in good overall condition in Alexandria and to the north (Zone 2 and 3) and fair condition south of Dyke Marsh (Zone 3). Notwithstanding other design and safety considerations, deterioration of the pavement, including cracking and rutting, indicate that the park will need to plan significant pavement rehabilitation on Columbia Island (Zone 1) and south of Dyke Marsh (Zone 3). The NPS replaced most of the small timber bridges on the MVT in the mid-2000s, leaving six bridges that require reconstruction as of 2020. Four of these bridges are programmed for replacement, including three major bridges at a cost of over $3 million each. Nine bridges do not meet modern railing standards, four of which will be upgraded as part of programmed bridge replacement projects.

- **Maintenance can improve sightlines, increase the usable width of the trail, and prevent pavement deterioration.** The study team observed significant vegetation overgrowth in the wooded section of the trail in Zone 1 and grass encroachment throughout the corridor. Addressing these maintenance issues will improve safety and visitor experience while mitigating root upheaval of the pavement. Industry standards suggest that the trail should have a 3-5 foot graded lateral recovery area, where possible, with a minimum of 2 feet free of vertical obstructions like trees, signposts, and bridge abutments. This helps maintain sightlines, prevent fixed object crashes, and avoid run-off-the-trail crashes. Standards also suggest an 8-10 foot vertical clearance to accommodate adult bicyclists standing upright on pedals and allow maintenance and emergency vehicles to pass.

- **Modern signage and pavement markings can improve visitor experience and safety in the near term.** The type and condition of trail signage and pavement markings vary considerably throughout the corridor. Recently reconstructed sections of the MVT have modern regulatory and entrance/orientation, wayfinding, and emergency signage and center/edge line striping (e.g., Theodore Roosevelt Island and Jones Point Park). These signage and pavement marking approaches are a cost-effective way to improve legacy portions of the trail in the near term, while more costly pavement or bridge projects are planned.

## 2.3 Study Recommendations

Based on an analysis of the MVT's existing conditions and best practices in trail design, the study team recommends a number of capital projects, trail enhancements, and operational/maintenance changes to improve visitor experience and safety. The below graphic summarizes the study recommendations.


Initial Steps
FY2020
* Continue design for planned bridge projects
* Develop signage/ pavement marking plan
* Begin partnership/ funding discussions with adjoining jurisdictions
Near Term Improvments & Compliance
FY2021-2023
* Implement near term signage/pavement marking improvements
* Complete programmed bridge projects
* Hire trail manager and institute cyclic maintenance program
* Refine scope and initiate project development for priority segements across each zone
Major Capital Improvements
FY2024 - 2030
* Implement reconstruction of Zone 3 (incl. Bridge 31) as feasible
* Implement reconstruction/ rehabilitation in Zone 2 as feasible, focusing on Bridge 28 and Daingerfield "S" Curve
* Implement phased rehabilitation of Zone 1, focusing between Mount Vernon Estate to Tulane Dr. and Bridge 1

# 3 INTRODUCTION

The purpose of this Mount Vernon Trail (MVT) Corridor Study is to assess the condition and safety of the 18-mile trail and develop a vision for improving the facility based on transportation industry best practices. The MVT provides connections to nationally and regionally significant destinations; making it one of the most heavily utilized multi-use trails in the country.

Paving of the MVT predates modern engineering guidance, accessibility standards, and best practices. As MVT trail sections and bridges come up for recapitalization, National Park Service (NPS) National Capital Area (NCA) and George Washington Memorial Parkway (GWMP) staff have the opportunity to make informed decisions about trail improvement projects and form strategic partnerships with local governments.

The NPS and its partners have collected a significant amount of data on the condition, usage, and crash history along the MVT. This MVT Corridor Study is the first comprehensive analysis of these data and will help inform park operations and maintenance needs, and identify long term capital investments to improve visitor experience.

This study included internal and external stakeholder engagement; a review of existing conditions, documentation, and data; and an assessment of the trail's design in light of usage (summarized visually in Figure 1). The result is a series of wide-ranging recommendations covering safety, trail signage, trail connections, trail counting programs, project cost estimates, internal and external funding opportunities, pavement and bridge maintenance, and vegetation management.

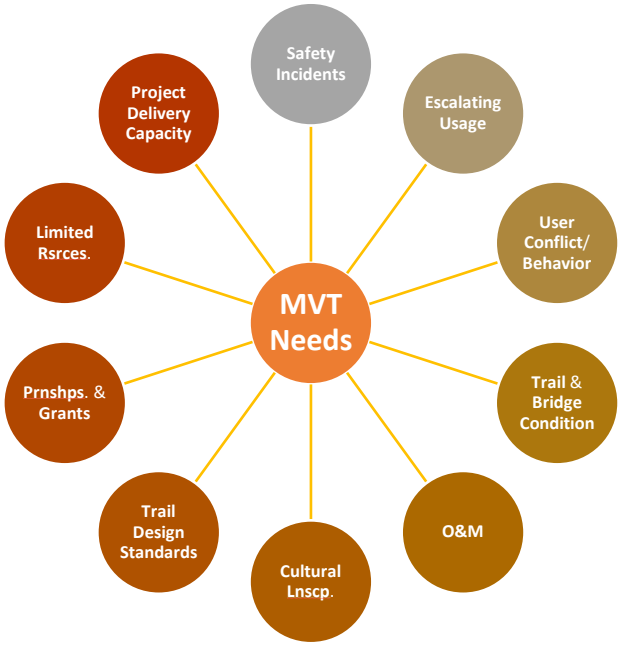



*Figure 1: Graphic visualization of the different components that impact the Mount Vernon Trail*

This is a study, not a decision document or plan. The technical findings are designed to inform National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA) compliance processes that will consider resource management issues in greater depth.

Furthermore, this study is primarily focused on engineering solutions, including capital improvements and maintenance. Park staff, law enforcement, and volunteers can utilize the data analysis, including usage data and crash reports, to inform the other “E’s” of transportation safety: enforcement, education, and emergency response.

# 4 Background and Context

## 4.1 Trail Overview

The MVT has approximately one million users annually and provides recreation and transportation connections to nationally and regionally significant destinations. The 18-mile paved trail stretches from George Washington's Mount Vernon Estate to Theodore Roosevelt Island, linking Fairfax County, the City of Alexandria, and Arlington County to the District of Columbia (see Figure 2 below). It is the only trail connection to the two major Potomac bridge crossings (Arlington Memorial Bridge and 14th Street Bridge), providing a critical link to regional trail connections, particularly Theodore Roosevelt Bridge, Four Mile Run, and Woodrow Wilson Bridge. The MVT is also a designated segment of both the Potomac Heritage National Scenic Trail and the East Coast Greenway.

The GWMP is an administrative unit within the NPS, spanning Virginia, Maryland, and the District of Columbia. The GWMP contains the George Washington Memorial Parkway itself, the Mount Vernon Trail, and over two dozen associated park sites within its 7,300 acres. The MVT provides connections to the following Park sites:

- Belle Haven Park and Marina
- Collingwood Picnic Area
- Daingerfield Island
- Dyke Marsh Wildlife Preserve
- Fort Hunt Park
- Fort Marcy
- Gravelly Point
- Jones Point Park and Lighthouse
- Lady Bird Johnson Park
- Lyndon Baines Johnson Memorial Grove on the Potomac
- Memorial Avenue/Arlington Memorial Bridge
- Navy and Marine Memorial
- Riverside Park
- Roaches Run Waterfowl Sanctuary
- Theodore Roosevelt Island

The MVT was constructed primarily in the 1960s and 1970s, after the construction of the Parkway (which started in the 1930s and continued into the 1970s), and is based on a series of historical design concepts for bridle trails and footpaths. In the mid-1970s, the NPS began paving the trail's stone surface with asphalt. The NPS completed the final segment of the trail from Arlington Memorial Bridge to Theodore Roosevelt Island and Rosslyn in 1987. Therefore, the development of the trail predates modern multi-use trail design standards.

Growing usage of the trail, particularly during commuting periods, contributes to trail crowding, user conflicts, and crashes, which negatively impact the visitor experience. Park staff attribute much of this growth in usage to the growing popularity of bicycle commuting, development activity along the corridor, and new trail connections. Nationally, bicycle commuting grew by 51 percent from 2000 to 2016, while in the Washington, D.C. region, bicycle commuting increased 295 percent over the same period. In 2016, the bicycle commute mode share in Washington,

D.C. was 4.6 percent, which equates to an estimated 16,600 daily bicycle commuters. In Arlington County, the 2016 bicycle commute mode share was 2.4 percent and in the City of Alexandria, it was 0.9 percent. Both of these locations rank highly for bicycle commute mode share in the region.[2]

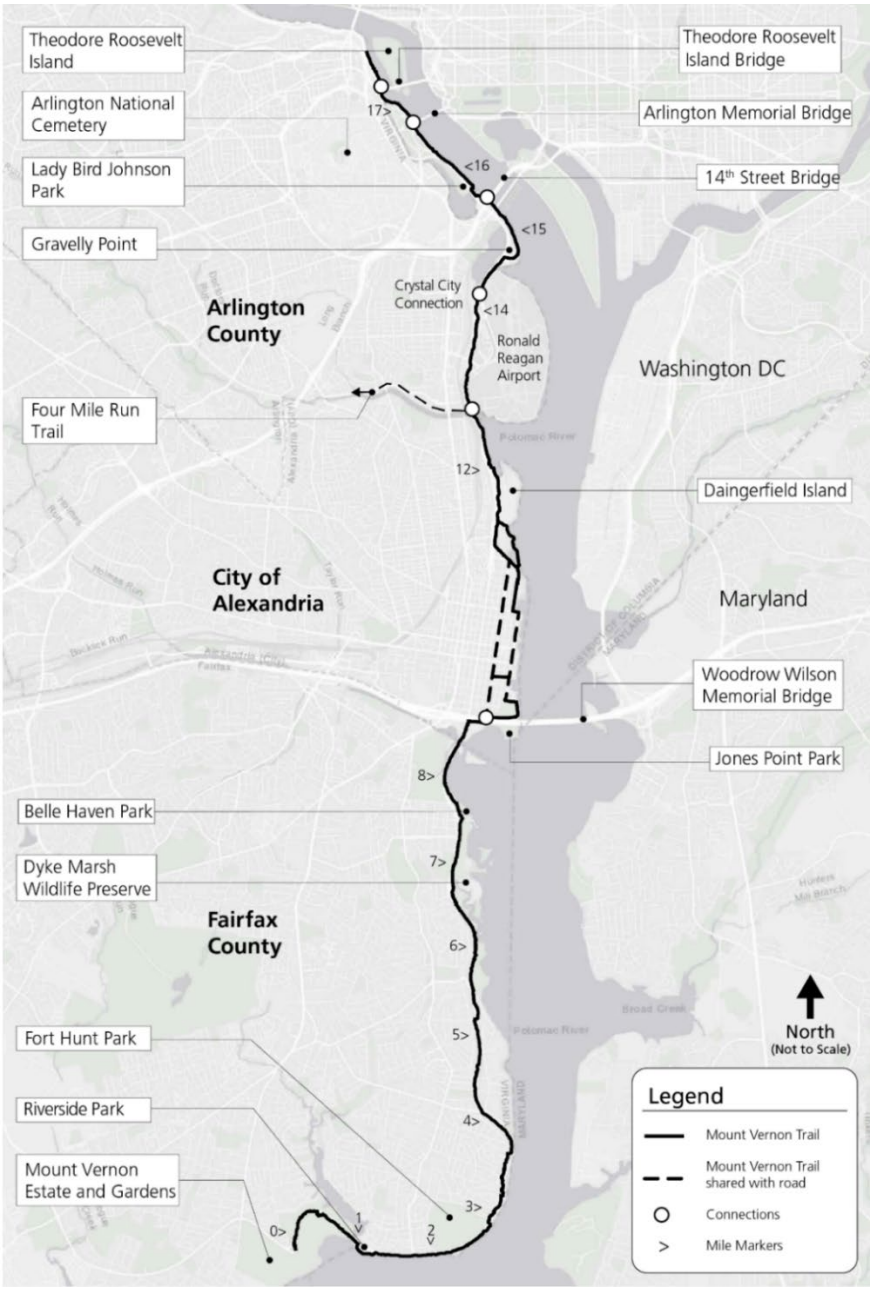



*Figure 2: Context map of the Mount Vernon Trail*

[2] Analysis of Bicycle Commuting in American Cities: Report on 2016 American Community Survey Data. League of American Bicyclists. https://bikeleague.org/sites/default/files/LAB_Where_We_Ride_2016.pdf

## 4.2 Planning Context and Existing Studies

The study team reviewed existing planning studies and analyses related to the MVT to inform background research and understand previous recommendations. Key planning documents include:

- **2016 NPS NCR Paved Trail Plan**. This plan involved a review of the NCA paved trail network and a literature review of relevant regulations and policies. The study also included stakeholder outreach to identify trail priorities, gaps, and areas for partnership and collaboration. This study included the identification of recommendations across all NCA trails, including 26 recommendations for the MVT, ranging from trimming trees to improve sightlines to realigning the trail at certain points. These recommendations are included in Appendix A.
- **2014 NPS GWMP Foundation Document**. The GWMP's Foundation Document provides basic guidance for planning and management decisions by outlining the park's purpose, significance, resources, values, themes, mandates, and administrative commitments. The Mount Vernon Trail aligns with the GWMP's fundamental resource/value of recreational opportunities. The trail provides an urban population with access to biking, walking/jogging, climbing, kayaking, fishing, and other recreational opportunities. The MVT's natural areas, picnic area, boat launches, and marinas are all major assets to the public.
- **2012 MVT Transportation Scholar Report**. Developed between July 2011 and February 2012, this study used trail counts, crash data, and a physical analysis of trail assets to provide recommendations for trail improvements. The scholar report includes a total of 29 recommendations for the trail, ranging from improving signage to realigning curves to improve trail user experience. These recommendations are included in Appendix A.

The recommendations in these studies identify several potential projects to improve the trail, including:

- Either improving the at-grade crossing or moving to a grade-separated crossing of the MVT at Arlington Memorial Bridge. These improvements are being considered as part of an ongoing compliance process for the Memorial Circle.
- Enhancing trail access from major connection points by adding a direct trail connection to the northern side of Arlington Memorial Bridge and the south side of Theodore Roosevelt Bridge.
- Providing traffic calming measures where trail crossings create conflict with vehicles, including at Vernon View Drive, Collingwood Road, Morningside Lane, Belle View Boulevard, and Belle Haven Road.
- Straightening sharp curves along the trail at Bridge 12 and the Daingerfield "S" Curve.
- Developing trailheads at parks along the MVT, including at Fort Hunt Park, Belle Haven Park, Jones Point Park, Long Bridge Park, and Gravelly Point Park.
- Improving signage and wayfinding along the trail, particularly at access and connection points.

The NPS is actively developing or has recently completed planning and NEPA compliance for the following trail enhancements, which will be implemented over approximately the next four years:

- Reconstruction of MVT Bridge 12, 23/24, and 31
- Jones Point Park Area Plan

- Memorial Circle Safety Improvements

NPS partners are pursing the following major trail projects (see Figure 3):

- **Long Bridge Project.** This project includes a 14-foot wide pedestrian bridge across the Potomac River, which would connect Long Bridge Park (Arlington County) and the MVT to the National Mall and Memorial Parks, creating an entirely new connection to the District of Columbia. This facility would be substantially wider and more attractive for bicyclists and pedestrians than the current 14th Street Bridge connection.
- **Humpback Bridge Trail Extension.** The MVT Humpback Bridge spur currently dead-ends at the GWMP park boundary. As part of the Boundary Channel Drive/I-395 Interchange Project, Arlington County intends to extend the trail spur and connect to the Pentagon and Long Bridge Park.
- **Custis Trail Improvements.** Arlington County completed improvements to three intersections near the end of the MVT in Rosslyn, providing better and safer connections between the two trails in October 2018. As of August 2019, construction was underway to upgrade the Lynn Street Esplanade and provide additional improvements to the Custis Trail in the Rosslyn vicinity.[3]
- **Future Amazon Headquarters**. In January 2018, Amazon announced a major corporate expansion in Crystal City. The projected increase of 25,000 jobs over the next decade represent a major economic turnaround for the area, which lost many defense industry jobs over the last decade. The Crystal City Business Improvement District developed a feasibility study for a proposed pedestrian bridge over the GWMP to Reagan National Airport, with potential connections to the MVT. The project is in an early conceptual stage.

[3] "Custis Trail Safety Improvements," Arlington County, accessed August 12, 2019, https://projects.arlingtonva.us/projects/custis-trail-safety-improvements/; "Lynn Street Esplanade & Custis Trail Improvements, Arlington County, accessed August 12, 2019, https://projects.arlingtonva.us/projects/lynn-street-esplanade-custis-trail-improvements/.

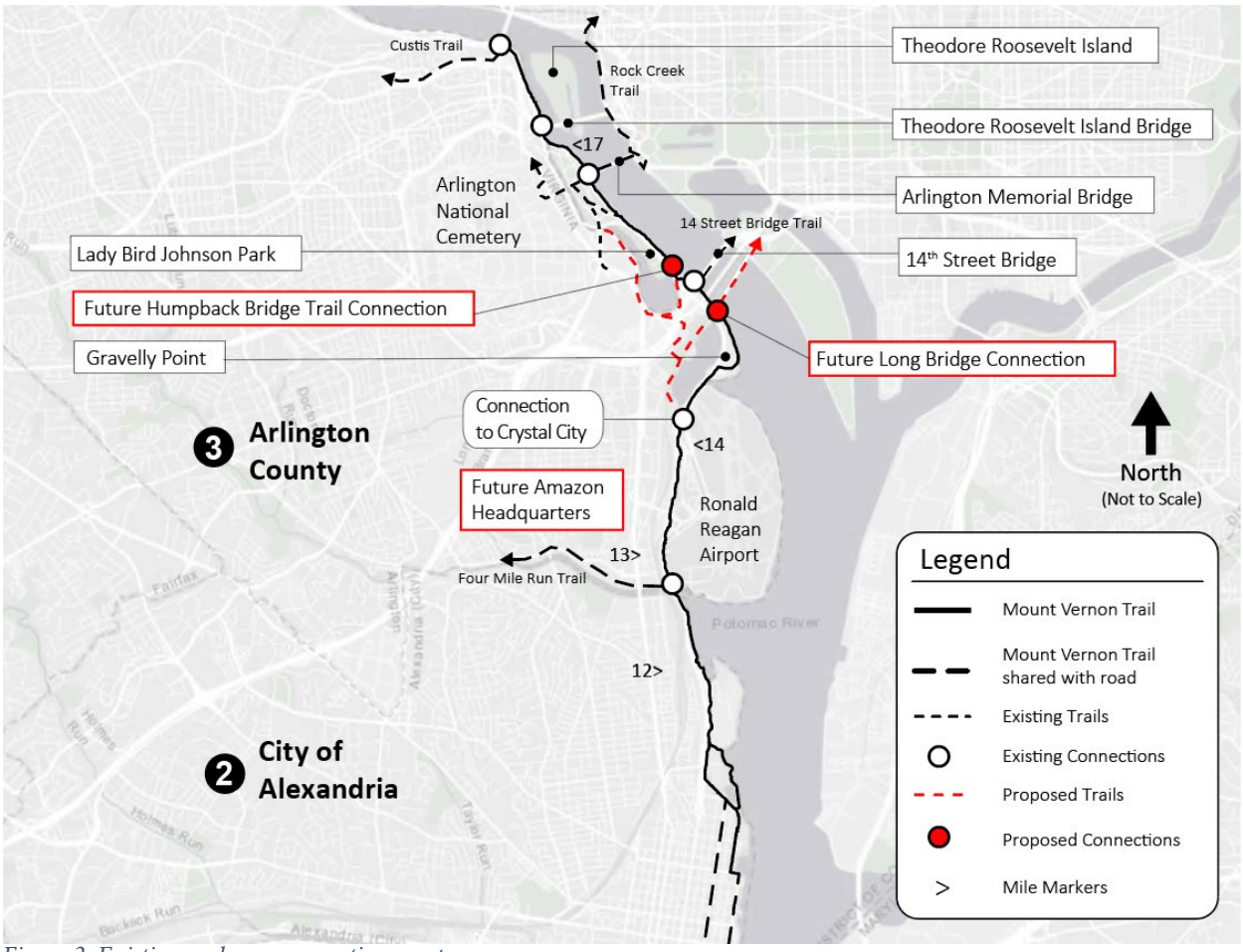



*Figure 3: Existing and new connections map*

Adjoining jurisdictions have developed their own plans recommending improvements to regional multimodal infrastructure. Implementation of these plans is likely to further increase bicycling and walking throughout the region with important implications for the MVT. These plans include:

- The Metropolitan Washington Council of Governments' 2015 Bicycle and Pedestrian Plan
- Arlington County's 2008 Transportation Master Plan and the 2019 Bicycle Element
- The City of Alexandria's 2016 Transportation Master Plan
- Fairfax County's 2014 Bicycle Master Plan
- Washington D.C.'s 2014 moveDC plan, including the Bicycle and Pedestrian Elements

Proposed improvements are summarized fully in Appendix A. Key proposed improvements include:

- Improving signage and wayfinding at trail curves and intersections with other connections, particularly along the Alexandria portion of the MVT (2016 City of Alexandria Transportation Master Plan).

- Adding connections from the MVT to the North Tract Park, the south side of the Roosevelt Bridge, and the downstream side of the Roosevelt Bridge (2016 NPS NCR Paved Trail Plan).

# 5 EXISTING CONDITIONS

Assessing the MVT's existing usage patterns, condition, crash history, and design is critical to understanding the visitor experience on the trail. For the purpose of the study and to describe future management scenarios, the project team divided the 18-mile trail into three zones (see Figure 4). The zones are largely based upon trail geography, but there are also distinct characteristics for each zone in terms of usage patterns, topography, and condition/maintenance issues.

- **Zone 1 in Fairfax County.** Zone 1 is the lower section of the trail extending nine miles from the southern MVT terminus at the Mount Vernon Estate north to mile marker 9 just south of Jones Point Park. This section of trail winds through woodlands, across stream valleys, and over steep grades parallel to low-density neighborhoods. Zone 1 sees a fraction of the usage of Zones 2 and 3, with no clear commute patterns during peak times and recreational usage during evenings and weekends. The dense tree cover at times can contribute to damp, slippery conditions, especially on the timber bridges. The trail is typically 9 feet wide in this zone; however, there are some areas with significant vegetation encroachment that limit the trail to 6-7 feet wide. Pavement condition in this zone is relatively poor. Most of the 24 timber bridges in Zone 1 are in good condition, although some require maintenance and three (including two major bridges) are programmed for replacement. Zone 1 includes the following NPS sites: Fort Hunt Park, the Dyke Marsh Wildlife Preserve, and Belle Haven Park and Marina.
- **Zone 2 in City of Alexandria.** Zone 2 is the middle section of the trail extending four miles from mile marker 9 in Jones Point Park north to mile marker 13 at the Four Mile Run, including a connection to the trail over Woodrow Wilson Bridge. This section of trail traverses a dense, urban area, including a 2-mile segment through the City of Alexandria comprised of city-owned on-road bicycle routes, sidewalks, and multi-use trails. Zone 2 sees significant commuting and recreational usage throughout the year. The MVT is 11 feet wide (including paved shoulders and striped edge lines) through Jones Point Park and approximately 9 feet wide north of Old Town Alexandria. Pavement in Zone 2 in relatively good condition. One major timber bridge requires replacement, while five require maintenance. Furthermore, many users cite lack of wayfinding signage in Old Town Alexandria between NPS-owned portions of the MVT. Zone 2 includes the following NPS sites: Jones Point Park and Daingerfield Island.
- **Zone 3 in Arlington County/District of Columbia.** Zone 3 is the northern section of the trail extending five miles from Four Mile Run Trail north to the northern MVT terminus near Rosslyn. This section of trail is most heavily-used portion, especially during peak commuting times. Zone 3 includes major connections to the Four Mile Run Trail, the Crystal City Connector, and three major river crossings in and out of the District of Columbia (the 14th Street Bridge, the Arlington Memorial Bridge, and the Theodore Roosevelt Bridge). This section of the MVT averages between 8 and 9 feet wide. Pavement in Zone 3 is in overall good condition, although the trail surface through Columbia Island (technically in the District of Columbia) is severely deteriorated. One major timber bridge requires replacement. The remaining seven bridges (which are concrete/steel structures) have no known structural deficiencies. Zone 3 includes the following NPS sites: Gravelly Point, Lady Bird Johnson Park, and Theodore Roosevelt Island.

The study team assessed trail usage and crowding, pavement and bridge condition, safety, and signage by trail zone.

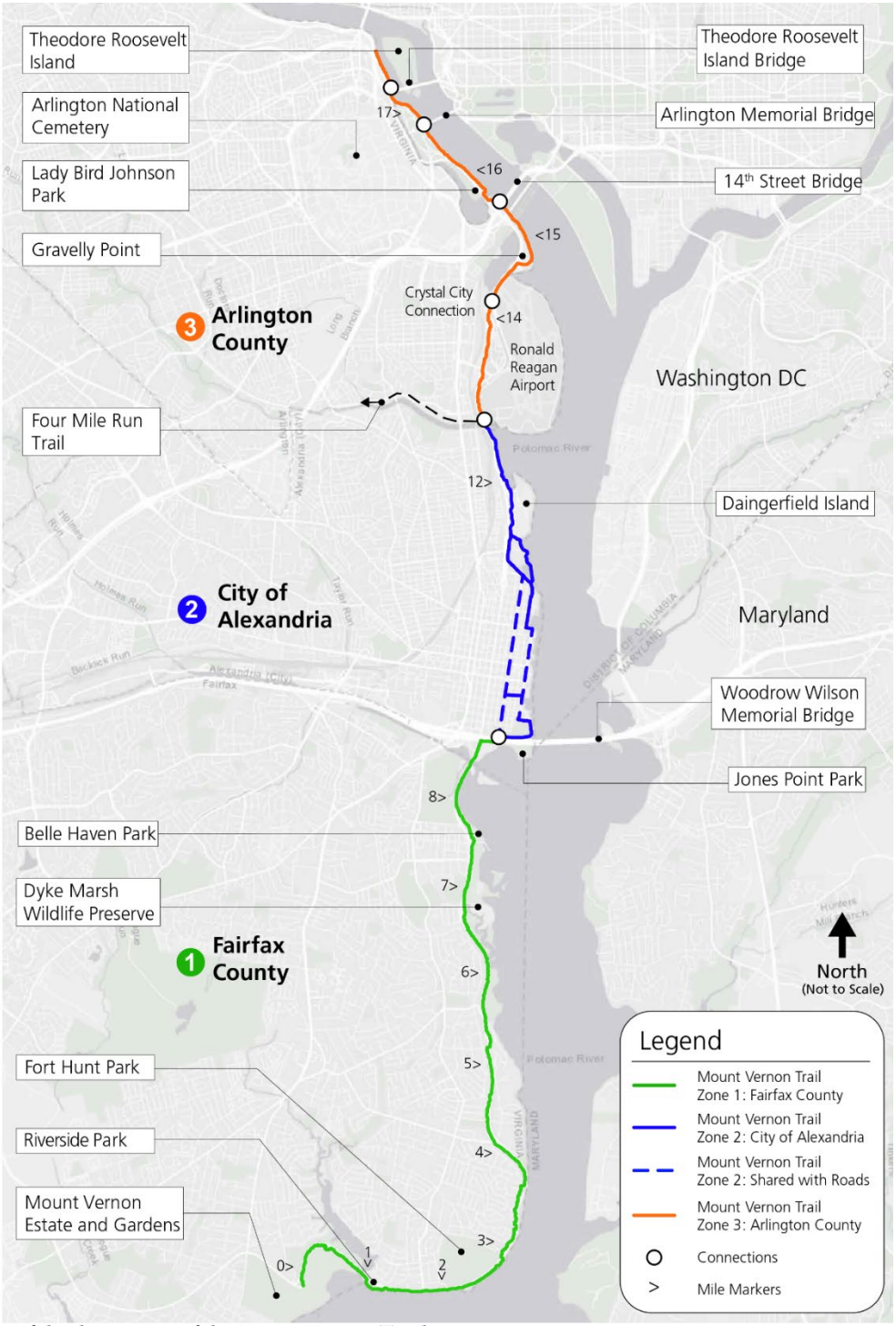



*Figure 4: Map of the three zones of the Mount Vernon Trail*

## 5.1 TRAIL USAGE AND CROWDING

Count data help quantify trail usage and crowding patterns, helping put the MVT's condition, crash history, and design into context. The study team used count data (automated and manual) to evaluate where and when pedestrians and bicyclists use the MVT and analyze relative commuting and recreational use. Count data are also used to estimate crowding levels and user risk exposure.

### Count Data Summary

The study team relied on 2016-2018 automated count data supplemented by manual count and turning movement data collected in 2018. In partnership with the NPS, Arlington County and the City of Alexandria operate and maintain nine bicycle and pedestrian Eco-Counters on or near the MVT. There are currently no functioning counters along the Fairfax County section of the trail. Of the nine Eco-Counters, five are located on the mainline of the MVT while four are located on connecting trails or ramps adjacent to the MVT (see Figure 5).[4] The study team collected manual counts and turn movements at the 14th Street Bridge and Four Mile Run trail connector to validate the automatic counts and to better understand traveler direction. The study team and volunteers completed manual counts at the 14th Street Bridge, Four Mile Run trail connector, and at additional locations on the southern part of the trail where there are no automated trail counters. Appendix B and Appendix C have more information on the count locations and data collected via automated and manual counts.

### Zone 1 Prior Analysis

Though there are currently no functioning counters along the Fairfax County section of the trail (Zone 1), the 2012 MVT Transportation Scholar Report included some count data analysis for this zone from 2010 and 2011. This analysis identified some key findings and trends that likely remain relevant today:

- Zone 1 has the lowest annual counts across the MVT. The heaviest traffic volumes and clearest rush hour peak patterns are in Zone 3.
- Weekday annual average daily trail usage (AADTU) is considerably lower in Zone 1 than in the other zones. Weekday AADTU at Vernon View, for example, is one-third of the weekday AADTU at Gravelly Point.
- Weekend AADTU in Zone 1 is higher than Weekday AADTU, but still significantly lower in Zone 1 than Zone 2 and Zone 3.

### Trail Usage and Crowding Patterns

Generally, the count data show that Zone 3 (between Ronald Reagan Airport and 14th Street Bridge) averages twice as many bicyclists during peak weekday commuting times (4PM-7PM) than Zone 2. During the weekend, bicycle usage is more balanced between Zone 2 and 3, but the overall usage peaks on weekends (9AM-1PM) are at a much lower level across all count locations compared to weekday peaks. There are more pedestrians overall during weekend peaks and they make up a higher proportion of all trail users compared to weekdays.

Figure 5 shows trail usage during the average summer/fall weekday evening peak hours (4:00 PM – 7:00 PM). The counts displayed shows that Zone 3 has significantly higher bicycle commute peaks than Zone 2, particularly between Ronald Reagan Airport and 14th Street Bridge. At these locations, an average of approximately four bicyclists pass through per minute in the summer.

[4] Data limitations by counter are noted in Appendix B.

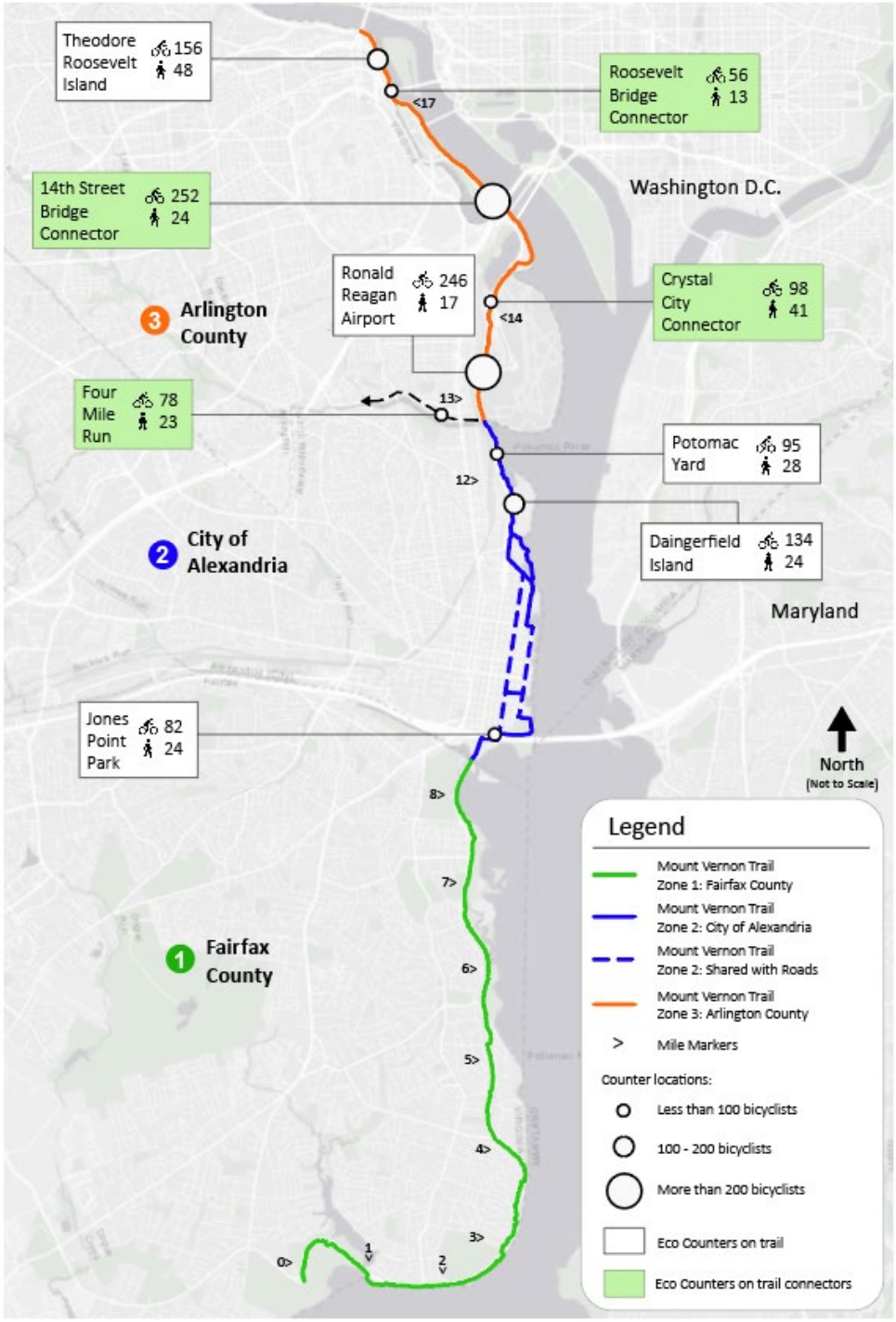



*Figure 5: Summer/fall peak weekday PM peak hourly (4PM-7PM) bicycle and pedestrian volumes, 2016-2018*

Figure 6 shows the average peak hourly counts for summer weekends (9:00 AM – 1:00 PM). Overall trail use on the weekends is lower and Zone 2 and 3 see similar peaking. There are more pedestrians on the MVT during the weekend and they make up a larger share of all trail users compared to weekdays.

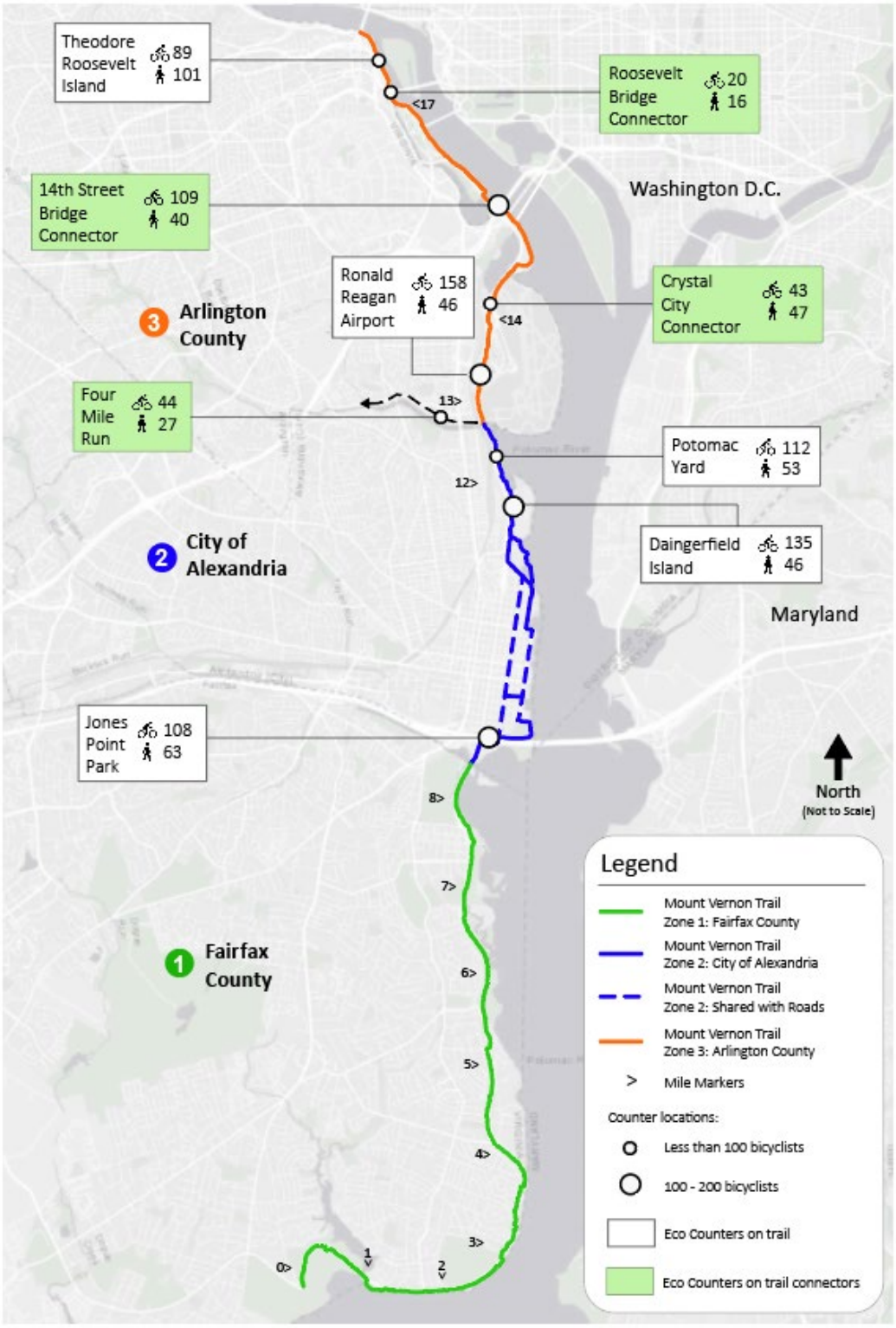



*Figure 6: Summer weekend peak hourly (9AM-1PM) bicycle and pedestrian volumes, 2016-2018*

While these maps above show the peak summer usage, it is also important to consider the seasonal nature of MVT usage. Figure 7 and Figure 8 show the average volumes of bicyclists and

pedestrians on the trail throughout the year. For bicyclists, there is a clear peak in the summer to fall months, while for pedestrians, the counts volumes are more stable throughout the year.

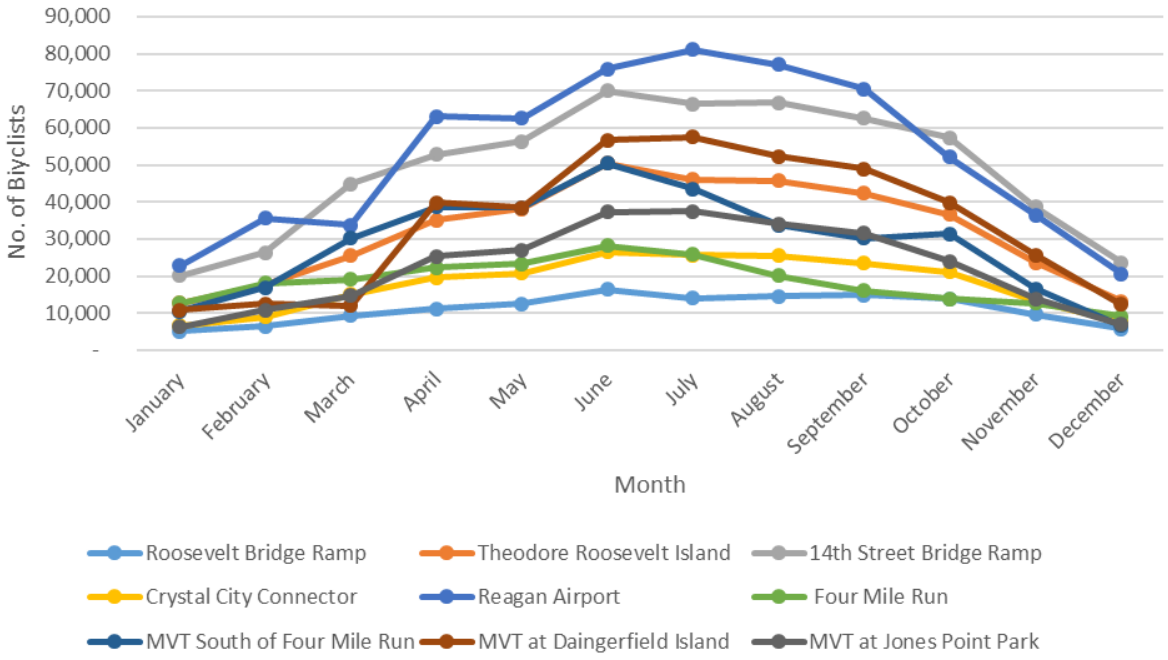



*Figure 7: Average monthly bicyclists by counter location, 2016-2017*

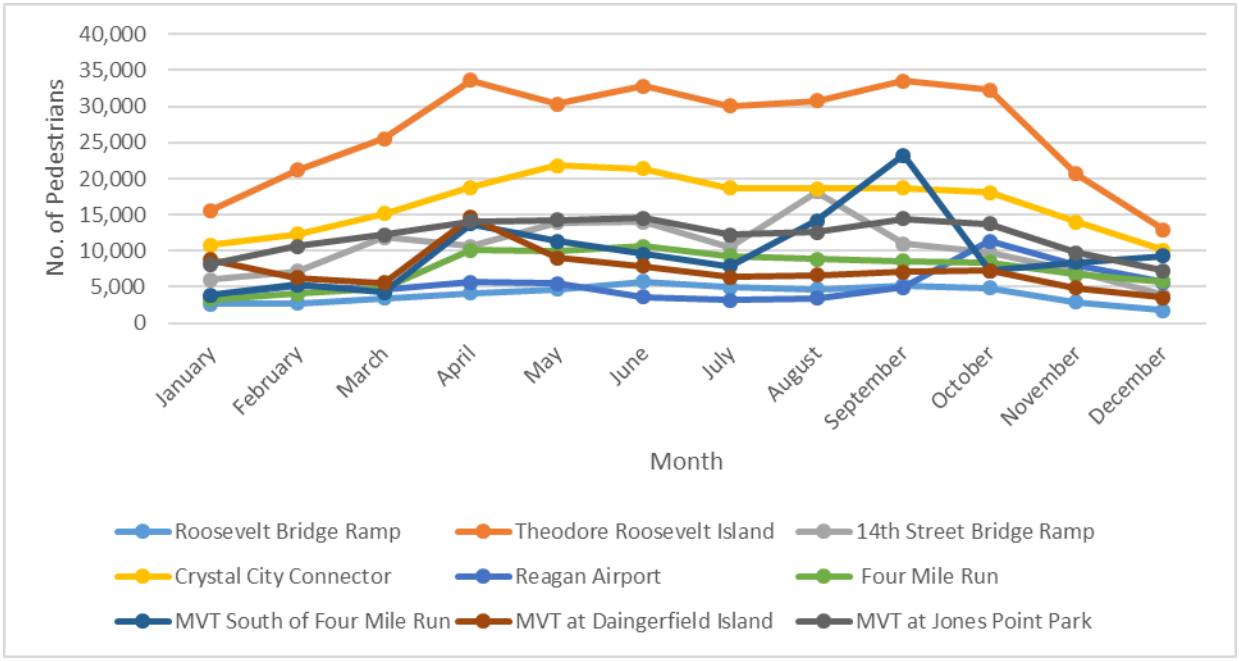



*Figure 8: Average monthly pedestrians by counter location, 2016-2017*

The study team also analyzed bicycle and pedestrian mode share and volume at each counter location. Industry guidelines recommend increased trail widths when 30 percent or more of trail

users are pedestrians or the total number of users exceeds 300 users during the peak hour (these standards are discussed in more depth in the Trail Design Considerations chapter).

Figure 9 shows the percent bicycle and pedestrian mode share by counter location for 2016-2018 and identifies which counter locations exceed the 30 percent pedestrian mode share standard. Almost all locations either exceed or nearly exceed the threshold on weekdays, weekends, or both. Five counter locations—Theodore Roosevelt Island, Crystal City Connector, Four Mile Run, Potomac Yard, and Jones Point Park—exceed the 30 percent pedestrian mode share threshold on weekdays. Six counter locations—Theodore Roosevelt Island, Roosevelt Bridge, Crystal City Connector, Four Mile Run, Potomac Yard, and Jones Point Park—exceed the 30 percent pedestrian mode share threshold on weekends.

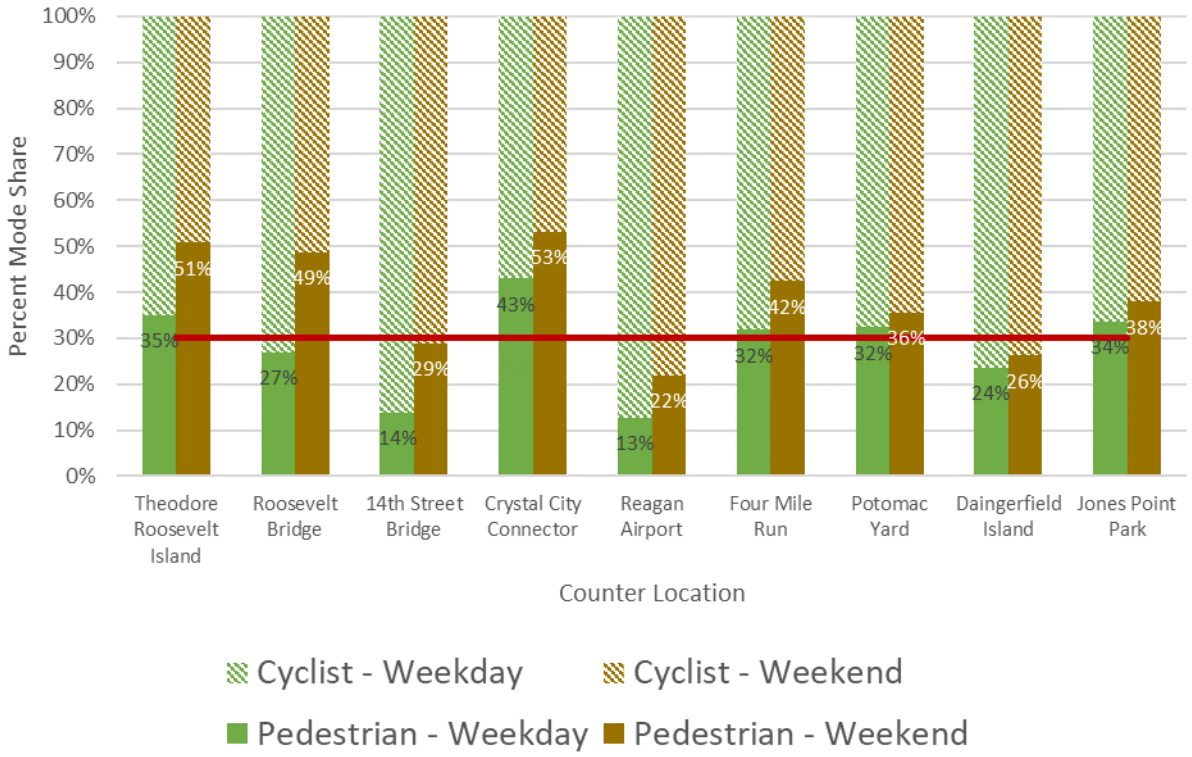



*Figure 9: Bicycle and pedestrian mode share, 2016-2018*

Figure 10 shows the peak hour usage—defined as the 95th percentile peak of the 2016-2018 count data for all modes—by counter location. Three counter locations—Theodore Roosevelt Island, 14th Street Bridge, and Reagan Airport—exceed the 300-user threshold during weekday peak, and five counter locations—Theodore Roosevelt Island, Reagan Airport, Potomac Yard, Daingerfield Island, and Jones Point Park—exceed the 300-user threshold during weekend peak.

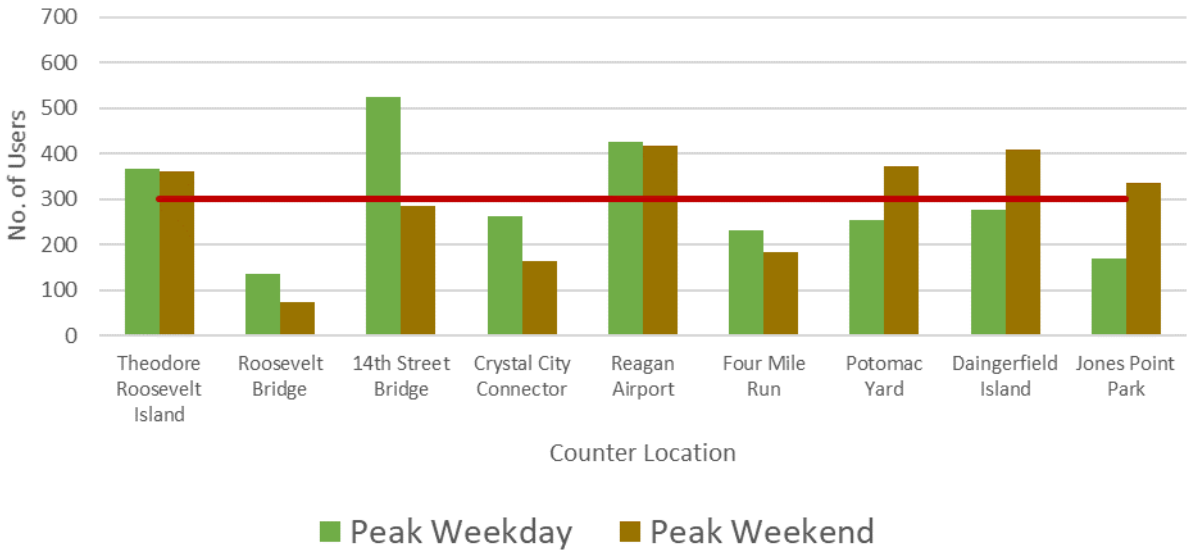



*Figure 10: Peak hour usage, 2016-2018*

Given factors contributing to increasing MVT usage—including an expanding regional trail network, new trail connections and projects (see Figure 4), growing bicycle mode share in the Washington, DC area, and anticipated growth in nearby jobs and housing—the study team also applied two hypothetical growth scenarios to understand potential impacts of increased usage. The study team applied a ten percent and 30 percent growth scenario, which represents a realistic range given the above factors.

In the 10 percent growth scenario (shown in Figure 11), the 14th Street Bridge would exceed the 300-user threshold during the weekday peak and Daingerfield Island would exceed it during the weekend peak compared to existing conditions. The Crystal City Connecter, Four Mile Run, and Potomac Yard would be near the threshold during peak weekdays.

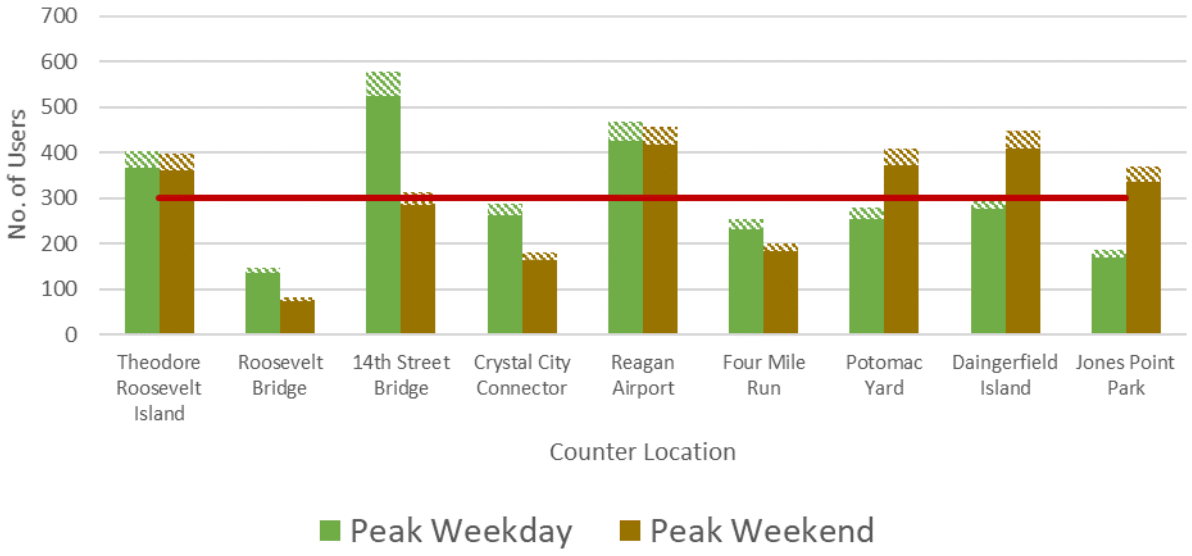



*Figure 11: Peak hour usage, projected 10 percent growth*

In the 30 percent growth scenario (shown in Figure 12), with the exception of Roosevelt Bridge, all of the counter locations would exceed the 300-user threshold during either the weekday and/or weekend peak.

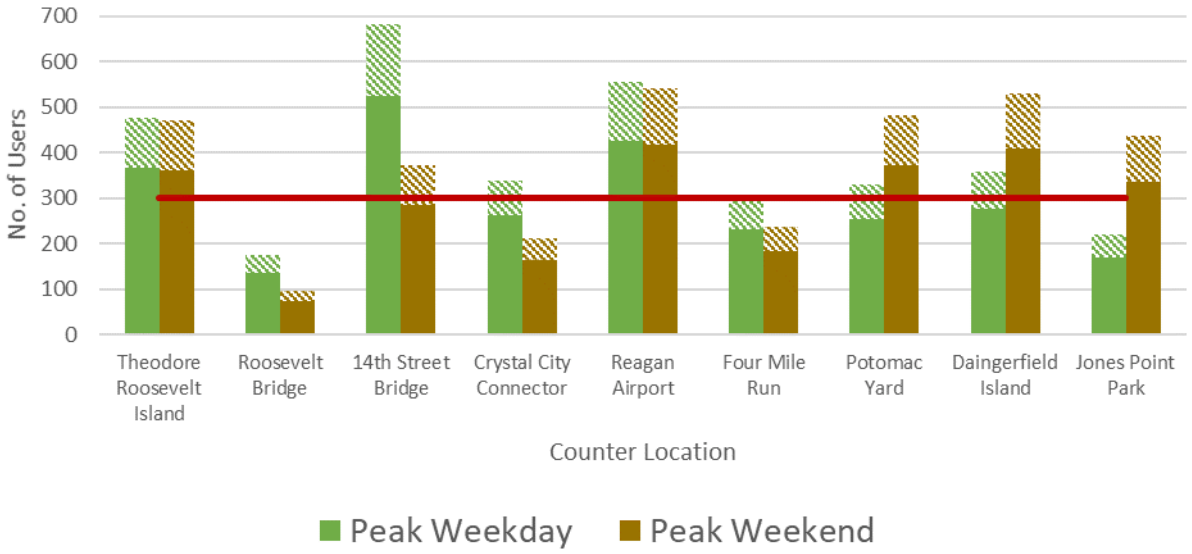



*Figure 12: Peak hour usage, projected 30 percent growth*

**Trail Count Observations**

In addition to the count data analyses, the observations gathered during the manual counts help provide more insight into trail use. The study team conducted pedestrian and bicycle counts at the 14th Street Bridge trail intersection and Four Mile Run trail connector, which are the most heavily used trail intersections on the MVT. The study team counted during weekday morning (7:00 AM to 9:00 AM) and evening rush hour periods (5:00 PM to 7:00 PM) in early August and October, 2018, respectively. Both count locations revealed the evening rush period had about double the amount of trail users than the morning rush period. The majority of trail users were male bicyclists who showed familiarity with the intersections by using hand signals to turn and slowing down for other bicyclists. During the manual counts, the study team observed some trail users with Capital Bikeshare[5] bicycles and electric scooters.[6] The majority of pedestrians were joggers or fast walkers. The automatic counters placed at both of these locations are on the ramp connecting to the trail. Therefore the manual counts provided a more accurate total for the number of users entering and exiting the trail at these points or continuing to travel north or south on the trail.

Figure 13 and Figure 14 show the direction of bicyclist travel in the highest used portion of the MVT during AM and PM weekday peak periods. Approximately 60 percent of AM peak period bicycling commuters on this section of trail are bound for the District of Columbia via the 14th Street Bridge. Approximately 70 percent of these District-bound commuters are coming from points south of the bridge, with the majority originating from the Four Mile Trail. A smaller, but still significant share of bicycle commuters in this section of trail originate from the Crystal City Connector or south of Four Mile Run. During the PM peak, the directionality reverses.

[5] Capital Bikeshare is a multi-jurisdictional bikeshare program in D.C. and surrounding areas designed to provide quick bicycle trips around the D.C. Metro area. There are several bikeshare stations located near the MVT.
[6] Several dockless electric scooter companies provided services in the D.C. area in 2018.

Appendix C includes more detailed diagrams and data from the manual turning movement counts.

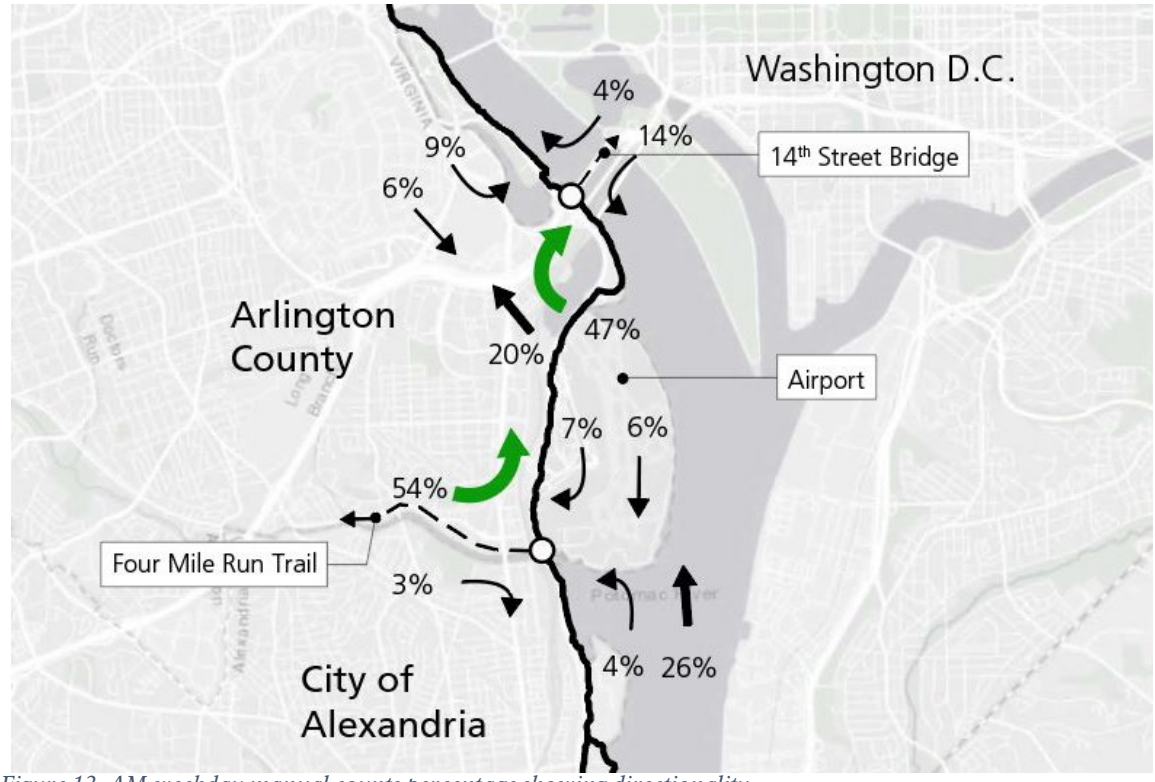



*Figure 13: AM weekday manual counts percentage showing directionality*

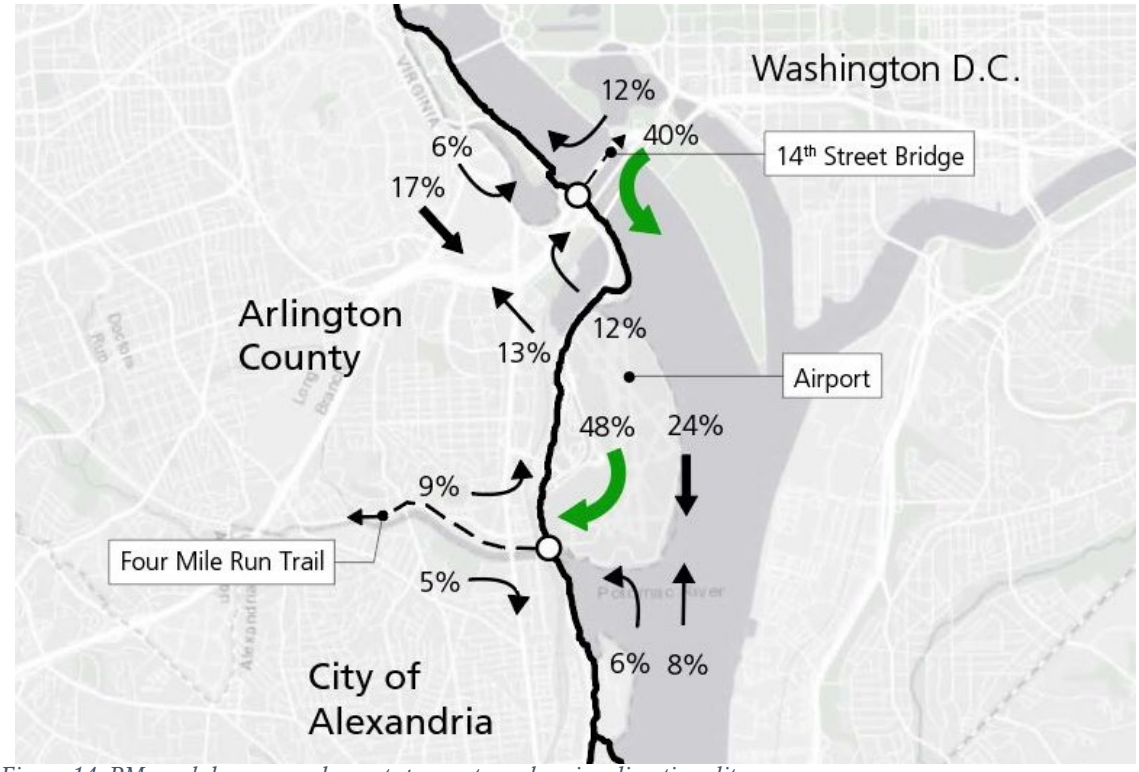



*Figure 14: PM weekday manual counts percentage showing directionality*

The volunteer counts further validated usage trends identified in the counter data. Appendix C includes a table summarizing all of the manual count data collected by trail volunteers. The volunteer counts confirmed the northern part of the trail—particularly those counts taken at Gravelly Point—is more heavily used than the southern section during the AM and PM weekday peak times. A weekend count taken at Jones Point Park also supports the conclusion that weekend usage is higher at MVT locations further south, particularly where the MVT connects to a park.

**Key Findings: Trail Usage and Crowding**

Analysis of trail count data from the nine automated counters on and adjacent to the MVT, along with manual count data collected by trail volunteers and the study team, provides key insights. These data describe how pedestrians and bicyclists use the MVT during different times of year, week, and day. Based on this analysis, the study team identified the following key findings:

- **Trail crowding is acute throughout the north section of the MVT during peak periods, particularly given high bicyclist usage during summer weekdays and weekends.** The count analysis identified summer crowding conditions in Zone 3 during peak weekday commute periods and both Zone 2 and 3 during peak weekend recreation periods. This is largely driven by the high number of both commuting and recreational bicyclists in the summer. Industry guidelines recommend increased trail widths (at least 11 feet wide) when the total number of users exceeds 300 users during the peak hour. Usage on the MVT currently either exceeds or nearly exceeds these thresholds during weekdays, weekends, or both on a seasonal basis. Trail crowding will become more acute

over time given planned trail connections and the increasing number of housing units and jobs projected in this area.

- **Modal conflict is significant throughout the north section of the MVT during peak periods, particularly near Rosslyn and Crystal City.** Bicycling on the trail peaks during the summer months (June, July, and August), while pedestrian usage plateaus at a high level between April and October. Overall bicyclist counts are highest at the 14th Street Bridge and Ronald Reagan National Airport in the summer months, while pedestrian usage is particularly high at Theodore Roosevelt Island and the Crystal City Connector in the spring through fall. Industry guidelines recommend increased trail widths (at least 11 feet wide) if pedestrians comprise at least 30 of all users during peak periods. High weekend pedestrian usage indicates significant modal conflict at virtually all count locations during the summer months, particularly at the Crystal City Connector, Theodore Roosevelt Island, and the Theodore Roosevelt Bridge.

- **High crash potential entering and exiting the MVT at the 14th Street Bridge and Four Mile Run intersections.** Count data suggest that the trail intersections at 14th Street Bridge and Four Mile Run are the most heavily used MVT trail intersections during peak weekday periods. Manual turning movement counts at the 14th Street Bridge and Four Mile Run confirmed that most commuting bicyclists originate from the south. During peak periods, the primary turning movements are the morning northbound left onto the trail to the 14th Street Bridge and the evening southbound left onto the Four Mile Run Trail. Both movements are significant conflict points that require bicyclists to cross the mainline of the trail.

## 5.2 Trail Pavement and Bridge Condition

This section reviews condition data for trail pavement, bridges, and signs to help identify current and upcoming priority capital and maintenance needs along the MVT. Condition data are essential to assessments of an existing transportation asset and are often the primary impetus for capital projects. In general, the pavement on the MVT is in fair to good condition, while there are several trail bridges that require repair or replacement. The deteriorated condition of these assets may contribute to crash risk. Trail sections and bridges requiring replacement often present opportunities to address other deficiencies at the same time, which may contribute to contracting efficiencies and reduce overall trail closure times.

The following observations are based on a review and analysis of condition data collected in 2017, additional data from park staff on maintenance and scheduled improvements, and the study team's site visits in June and October 2018. The condition data collected by GWMP staff were analyzed in GIS. This enabled the study team to identify key focus areas for the site visits.

### Pavement Condition

The study team analyzed the following pavement quality issues and grouped them in ¼-mile segments:

- Ruts
- Cracks
- Edge cracking
- Potholes
- Root heaves

- Uneven surface

There are a total of 784 unique pavement quality issues included in the condition assessment. Based on a spatial analysis of these issues, which was validated through the site visits, the pavement in Zones 2 and 3 are generally in good condition with significantly more pavement quality issues in Zone 1 (see Figure 15). The green sections of the map have nine or fewer pavement issues, while the yellow sections have between nine and 49 issues. Roughly, the green and yellow sections correspond to good and fair pavement quality, respectively. In addition to the pavement quality issues identified in the condition assessment, the study team observed pavement condition worse than indicated in the assessment on site visits to the trail. Specifically, the team observed pavement condition mile marker 4 to 5.5 (Zone 1) and on Columbia Island (Zone 3) is in worse condition than indicated in the assessment. These areas are noted in orange in the pavement condition map. Figure 16, Figure 17, and Figure 18 show examples of the issues listed above.

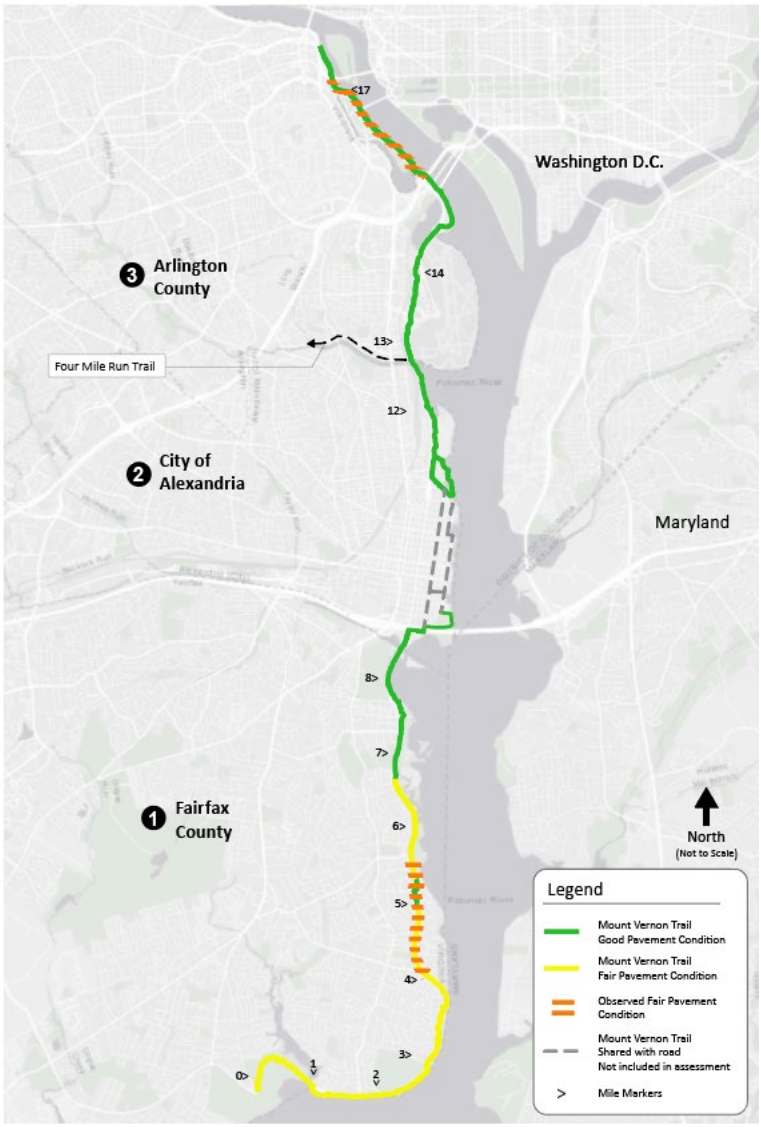



*Figure 15: Pavement condition map*

Additional analysis is needed to rate the pavement quality on a finer scale, but the current analysis corroborated what the study team found when riding the trail: the pavement in Zone 1 has more pavement quality issues that cause rider discomfort compared to the northern sections of the trail. There were no sections on the trail with so many pavement issues that the study team would define its condition as "poor."

*Figure 16: Example of pavement ruts*

The following is a summary of pavement condition issues identified by zone:

***Zone 1***

The lower section of the trail extends from mile marker 0 to 9, between Mount Vernon and Jones Point Park in Alexandria. This zone has lower usage than the other two zones, which are closer to Washington, D.C., and has the most pavement deterioration.

- The majority of pavement deterioration in the lower section of the trail is between mile posts 0 and 4, with significant amounts of cracking. This section of the trail is heavily wooded, with tree roots likely contributing to the deterioration. Significant overhang and raised bumps contribute to blind spots and rider discomfort. Based on the GIS analysis, this section is in fair condition.
- There is a notable amount of weed encroachment concentrated between miles 2 and 4. This encroachment at times narrows the width of the trail.
- Tidal flooding occurs near the mile 2 post adjacent to Fort Hunt Park.
- In general, the pavement condition between miles 4 and 5.5 is fair, and the site visit revealed significant surface deterioration.

*Figure 17: Example of trail cracking and weed encroachment*

***Zone 2***

The middle section of the trail extends 4 miles from mile marker 9 at Jones Point Park to mile marker 13 at the Four Mile Run trail connector. Zone 2 of the trail is heavily used and includes about 1.5 miles of on-street biking on urban streets between miles 9 and 11 in Alexandria.

- The on-street portion of the trail (miles 9 to 11) is under the jurisdiction of the City of Alexandria, and was not assessed by the study team.
- Between miles 11 and 13, the trail is in good condition, with only minor indications of deterioration.

*Figure 18: Example of trail cracking and uneven surface*

***Zone 3***

Zone 3 is the most heavily used, upper section of the trail extending five miles from Four Mile Run at mile 13 in Alexandria to the end of the trail at mile 18 in Arlington. According to the 2017 assessment, Zone 3 is in the best condition of the three zones. While there may be a few spot pavement issues in this section, there are no notable extended pavement

condition issues. Figure 19 shows an example of a stretch of pavement in good condition in Zone 3.

*Figure 19: Example of pavement in good condition in Zone 3*

### *Maintenance and Other Issues*

The condition assessment also includes maintenance and operational issues that may negatively impact trail condition. There are a total of 50 of these "other damages" included in the assessment. These issues may have an influence on trail width, sight lines, safety, and user experience. These issues include:

- Encroachment (dirt, weeds, etc.)
- Overhang (branches, vegetation, etc.)
- Tidal flooding
- Damaged facilities (restrooms, benches, signs, water fountains)

Figure 20 shows an example of grass encroachment on a narrow stretch of trail, and the map in Figure 21 depicts all maintenance issues comprehensively, including maintenance issues observed on a site visit to the trail. These observed maintenance issues include significant overhang and encroachment between miles 5 and 7. These issues likely change more frequently than

*Figure 20: Example of encroachment narrowing trail width in Zone 1*

pavement condition issues given that they are influenced by maintenance activity. Thus, this map gives a picture of common issues along the trail but may not provide the current status of these issues.

The main issues identified are:

- Isolated instances of facility damage, tidal flooding, and tree overhang, with a significant amount of overhang at the southern portion of the trail, most densely concentrated between mile markers 1 and 2.
- Notable amount of weed encroachment concentrated between miles 2 and 4 and miles 5 and 7. This, at times, narrows the width of the trail.
- Less significant weed encroachment and overhang between miles 15 and the northern end of the trail.

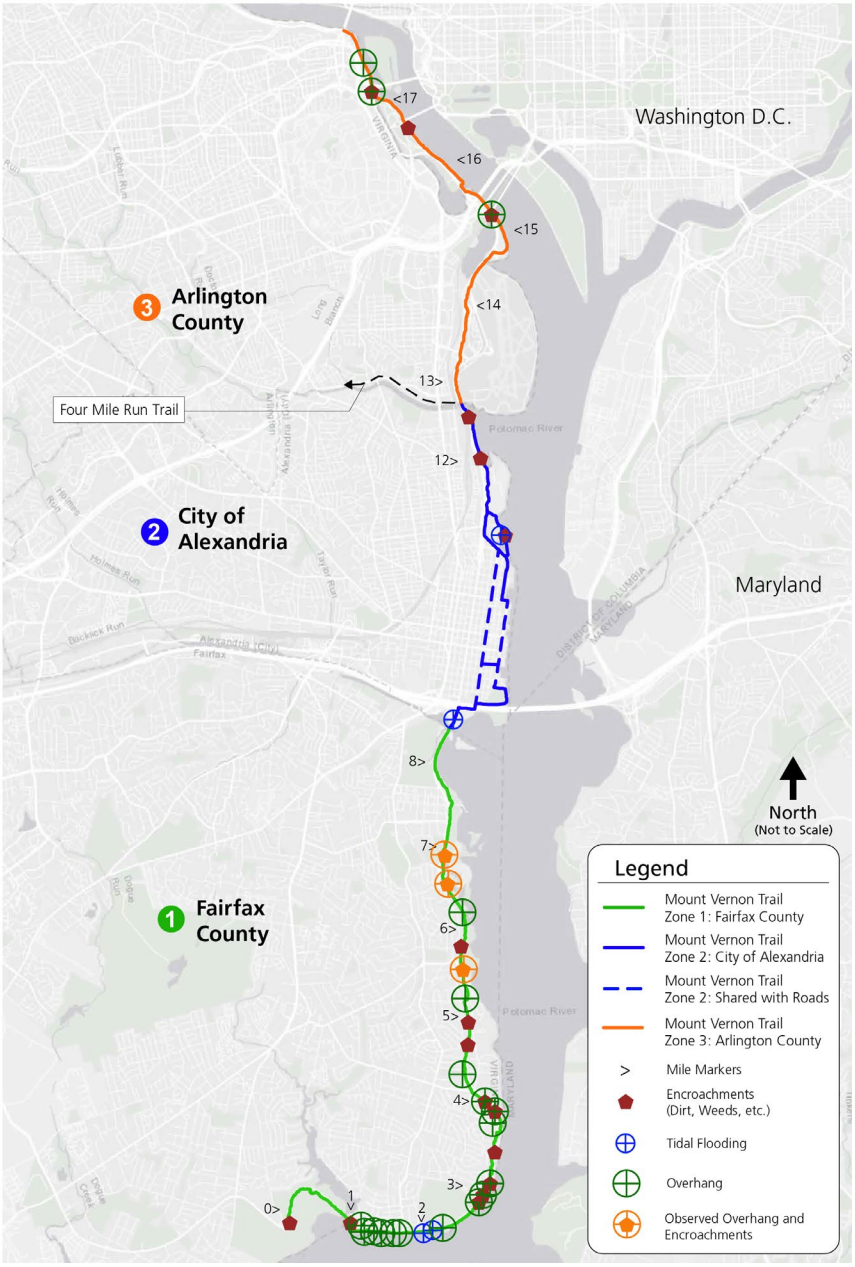



*Figure 21: Trail maintenance issues map*

**Trail Bridge Condition**

There are 38 bridges on the Mount Vernon Trail. The study team analyzed bridge condition data from the following sources:

- 2017 assessment data
- Asset data from park staff
    - Facility Management Software System (FMSS)
    - Recent cost estimates of planned bridge replacements on the MVT
    - Photos taken in 2017
    - Bridge maintenance records
- On-site observations and measurements (October 2018 and June 2019)
- Consultation of park staff concerning trail improvements needs

*Figure 22: An example of a bridge with chain railings*

*Figure 23: An example of a bridge with metal banister railings*

Most of the bridges are in good overall condition, with several needing maintenance, four already programmed for replacement, and two additional bridges requiring replacement (see Figure 24). The analysis indicates that 25 bridges require maintenance follow-up related to deteriorating, uneven, or loose deck boards; overgrown vegetation; and broken railings. The October 2018 site visit confirmed that maintenance needs are minor and isolated, such as uneven boards. Only nine of these bridges have chain railings that do not meet modern standards (see example in Figure 22); updating these to metal banisters is one of the most immediate opportunities for improvement. The project team identified six bridges in need of reconstruction, with four of these bridges already programmed for replacement. A more detailed summary of the bridge data is in Appendix D.

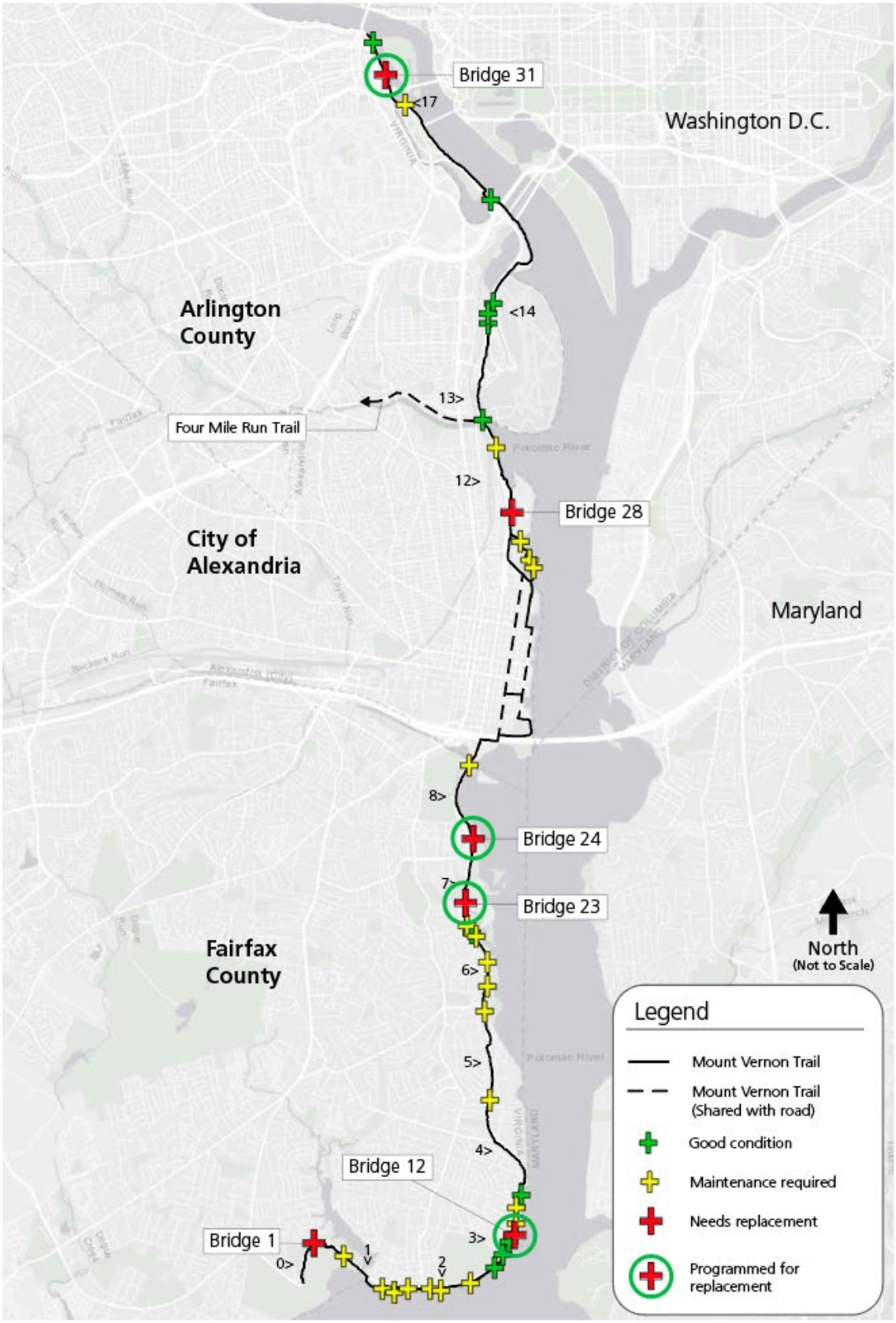



*Figure 24: Bridge condition map*

The study team identified the following general observations related to the MVT bridges:

- *Zone 1: 24 Bridges*
  - Four bridges are in need of replacement given significant deterioration to decking and chain railings not up to modern standards. Three of these, bridges 12, 23, and 24 are already programmed for replacement, including the addition of railings that are compliant with American Association of State Highway and Transportation Officials (AASHTO) guidelines. Bridge 1 is a high priority for future replacement. Figure 25 shows a bridge with deteriorated and irregular deck boards, and Figure 26 shows an example of damaged railings.
  - 15 bridges require maintenance. These bridges are showing their age, including rotting, shaky, or uneven boards, as well as overgrown vegetation or railing damage. Six of these deteriorated bridges are between mile posts 1 and 2.
  - Five bridges are in good condition, and no action is needed.
- *Zone 2*: *Six Bridges*
  - Only bridge 28 has significant enough deterioration to warrant replacement. This bridge is not slated for reconstruction and should be a high priority in the future.
  - The bridges in this section have chain railings, which should be replaced with AASHTO-compliant railings.
- *Zone 3: Eight Bridges*
  - The bridges in this section are typically concrete and steel construction. There are no known structural deficiencies for these bridge (see Figure 27).
  - Only bridge 31 is slated for replacement to be reconstructed and widened. The trail intersection on the bridge will be modified to improve safety.
  - The remaining bridges are in good condition.

*Figure 26: Bridge 2, which needs replacement railings*

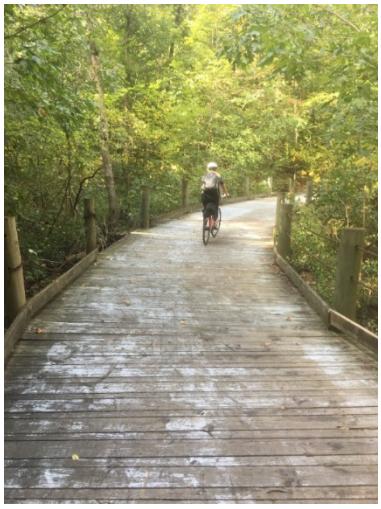


*Figure 25: Example of deteriorated deck boards*

*Figure 27: Bridge 29, an example of a bridge in the northern section of the trail made of concrete*

**Key Findings: Trail Pavement and Bridge Condition**
Based on the observations detailed in this section, the following summary highlights the pavement, bridge, and maintenance issues:

- **Pavement Condition.** The primary concerns with pavement deterioration are between miles 0 and 7, including cracks, ruts, and uneven surfaces. Site visits confirmed that the sections of the trail where these issues cause the greatest rider discomfort and potential safety concerns are between miles 0 and 4.
- **Bridge Condition.** There are several bridges with chain railings that are not up to modern safety standards and others that have shaky or uneven boards. The bridges in the poorest condition have severe railing damage or banisters partially missing. While some of these bridges are slated for replacement, at least two additional bridges require replacement, and several need maintenance.
- **Maintenance Issues.** There are several examples of weed and edge encroachment limiting the width of the trail between miles 2 and 4. Given that this is a curvy, wooded section of the trail, there are also some sightline concerns. Additionally, the Volpe team observed significant encroachment between miles 5 and 7 that limits visibility and creates safety concerns.

## 5.3 Trail Signage

The MVT has a variety of signs posted along the trail, including wayfinding signs, safety and warning signs, and mile markers. The 2017 condition assessment includes information on mile marker and sign deterioration. The assessment indicates that 10 of the 15 mile markers included in the assessment have some level of minor deterioration. The condition assessment also indicates where other deteriorated signs are located along the trail but does not indicate the type of sign.

During the site visits, the study team noticed inconsistencies in the branding of the signage and frequency of the signs throughout the trail. Additionally, lack of wayfinding signage between the transitions to the on-road section of the trail in Alexandria can be confusing to users unfamiliar with the MVT. The adjacent photos show examples of the types of signs located along the MVT.

**Site Entrance/Orientation Maps:** These signs allow visitors to orient themselves to the trail and provide information on nearby destinations. The study team noted these orientation maps at many of the destinations along the trail. Figure 28 shows the orientation map at Jones Point Park and Figure 29 shows an example of a recently updated display in a glass case.

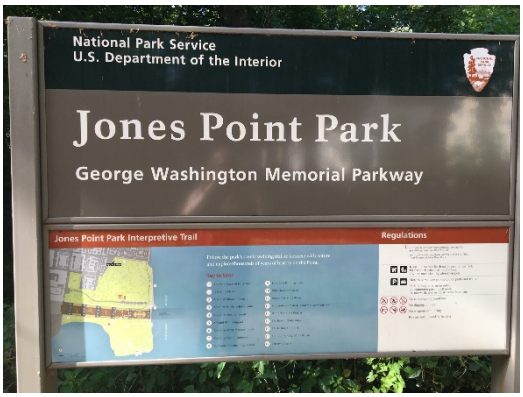



*Figure 28: A site entrance display at Jones Point Park*

**Regulatory/Warning:** Regulatory and warning signs alert trail users to trail crossings and where the topography, grade, or other conditions of the trail require caution or a change of traveling speed. These types of signs are also used to give directions to users on when to limit passing or to use caution on blind curves. While signs convey important messages to trail users, too many signs can create sign clutter, disrupting the trail's natural landscape. Too many signs are also confusing to users (see Figure 30) and the message of a sign is diluted.

On the site visits, the study team noted a few intersections where warning signage may need to be reconsidered (Four Mile Run) or could be reduced or reorganized. On the southern part of the trail, some bridges have sign posts with multiple signs where one or two signs may effectively communicate the intended message.


*Figure 29: A trail information display and orientation map*

**Wayfinding/Directional:** The MVT contains a variety of wayfinding signs added to the trail incrementally over a number of years. While familiar users are able to navigate intersections and connecting trails, new users may have a more difficult time, especially with the transition to the on-road portion of the trail in Alexandra. Figure 31 and Figure 32 below show two examples of wayfinding signs along the trail.


*Figure 30: Warning signs on the Mount Vernon Trail*

*Figure 32: Wayfinding sign at Four Mile Run trail connector*


*Figure 31: Wayfinding sign near Daingerfield Island*

**Emergency:** The study team noted sporadic emergency signs along the MVT while on site visits. Most of these signs appeared severely weathered and it is unclear whether the emergency information they provide is up-to-date. An example of an emergency sign is below in Figure 33.

*Figure 33: An example of an emergency information sign on the Mount Vernon Trail*

**Wayside/Interpretive:** The interpretative waysides provide important information and context to points of interest along the MVT. While some of the waysides appear weathered, the interpretation of cultural resources is not the focus of this study. Figure 34 shows a wayside at Belle Haven Park that overlooks the Potomac River.

*Figure 34: Interpretative wayside at Belle Haven Park*

**Roadway Crossings**: Signage at at-grade intersections of the trail with roadways varies from crossing to crossing. For example, of the 24 at-grade roadway crossings along the MVT, five are signed as pedestrian crossings, four are signed as bicycle crossings, and four have no signage indicating a trail crossing to approaching motorists. At four of these locations, the crossing is signed in one direction but not the other, including at two locations where a roadway intersection occurs immediately before the trail crossing. Appendix F summarizes the different signage conditions for each at-grade crossing.

**Key Findings: Trail Signage**

Based on the observations detailed in this section, the following summary highlights the primary issues for signage:

- Signage is highly variable throughout the trail. Many key sites lack site entrance/orientation signs. The use of regulatory/warning signage also varies considerably and is sometimes excessive. Emergency signs are weathered and may not communicate up-to-date information. Wayfinding/directional signage tends to be weathered, under-sized, and vary widely in terms of style. Signage at at-grade intersections with roadways also varies and is missing completely in some locations. There is a lack of signage for the on-street portion of the trail in Alexandria.

## 5.4 TRAIL SAFETY

Crash data are a key reference point for identifying safety problems on any transportation facility, including multi-use trails. Trail safety issues are caused by a combination of both behavioral and infrastructure factors. There were 225 reported pedestrian and bicycle crash records along the MVT between 2006 and 2010.[7] The MVT's relatively high usage and the mix of commuters, recreational users, routine and episodic users, and pedestrians and bicyclists can lead to user conflicts, particularly along narrow and winding portions of the trail. Trail intersections, at-grade road crossings, and bridge materials and transitions that are frequent problem areas. Conflict points between users, such as when pedestrians cross the trail to access parks and other destinations, also contribute to safety concerns. This section utilizes available crash data and previous studies to assess safety issues along the MVT, combined with input from park staff and observations from the study team's site visits.

### Prior Analysis

A previous 2011 analysis of the 225 crashes found that trail intersections, roadway crossings, surface transitions, and blind curves along the MVT were associated with higher crash and injury rates. This analysis also found that non-bicycle and non-pedestrian users, such as trail users who rollerblade, were at greater risk of injury than other users. The analyst recommended modifying roadway crossing and blind curves and implementing traffic calming at trail intersections, such as traffic circles, to mitigate high crash and injury rates. The crash data from this analysis indicated overarching trends and factors for trail safety:

- On average, the MVT experiences one ambulance call per week related to a bicycle or pedestrian injury.
- Injuries occurred during both low usage and crowded conditions.
- More injuries occurred during warmer temperatures.
- Collisions are more likely to involve male bicyclists (although males are typically overrepresented in the bicycling community).

### Top Crash Locations

The study team consolidated the previously collected crash data into 167 unique pedestrian and bicycle incidents that were not attributed to a health event (e.g., dehydration, heart attack, etc.).[8] Figure 35 identifies the top crash locations down to the ¼-mile.

[7] Charles Opalak, "A Study of Crashes and Injuries along a Multiple Use Trail," master's thesis, Drexel University, June 2011.
[8] 2012 Transportation Scholar Report

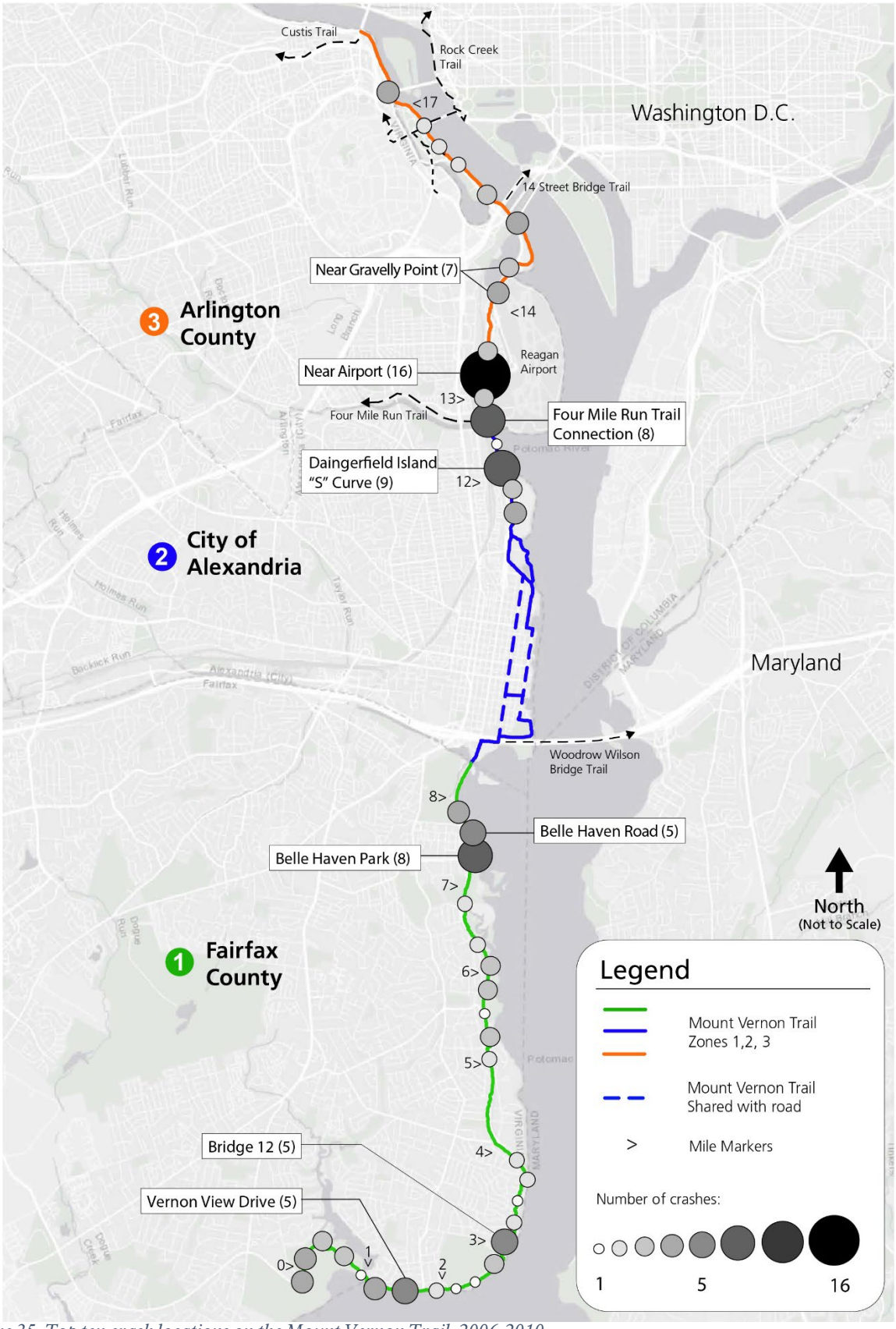



*Figure 35: Top ten crash locations on the Mount Vernon Trail, 2006-2010*

These data is based on crash records collected by five different agencies and volunteers. These data only represent incidents serious enough to report. Unreported and/or minor incidents are not represented. The study team independently assessed the crash data and made the following general observations:

- *Zone 1:* Crashes in this zone are relatively high given the lower overall usage of this section of the MVT. Crashes are spread over a large area and tend to be related to bridge transitions, steep slopes, and at-grade crossings. On the first three miles of the trail, crashes are most commonly related to riders losing control on this steep, narrow, and winding section of the trail. In some cases, bicyclists lost control and hit trees or other users of the trail.
    - In particular, at Vernon View Drive near Fort Hunt, incidents are generally collisions between two bicyclists or a bicyclist and a pedestrian. Some of these crashes may have occurred at at-grade crossings.
    - Several crashes took place on or near trail bridges, including bridges 1, 3, 4, 12, 15, 18, and 24. This includes five reported crashes on bridge 12, and three on bridge 24. Crashes on trail bridges are generally related to wet and slippery conditions, with bicyclists falling and/or colliding with other bicyclists. These incidents are often severe in nature, including flipping over handlebars and falling over the side of the bridge. Injuries included head lacerations requiring an ambulance and bones protruding through the skin.
    - Near Belle Haven Park, trail users fell on the trail, including some instances on bridge 24. Examples include collisions between bicyclists or between a bicyclists and pedestrians while crossing the trail.
- *Zone 2:* Crashes in this zone are concentrated at a few specific locations. Near Daingerfield Island, particularly on the Daingerfield "S" curve, bicyclists lost control of their bikes and fell, hit vegetation, or collided with other trail users. At and near the Four Mile Run Trail intersection, a number of bicyclists hit ruts, railings, or collided with other trail users.
- *Zone 3:* Crashes in this zone occurred mainly in high-use trail segments, intersections, and at-grade crossings, where large numbers of pedestrians and bicyclists (and sometimes vehicles) come together. This includes over a dozen crashes near the airport and mile marker 13.5 where the trail is most crowded during peak times. These data also indicate a number of crashes at the 14th Street Bridge Trail intersection and at-grade trail crossings at Gravelly Point and the trail intersection on Bridge 31.

**Crash Data Analysis**

Figure 36 shows the top three injury types, with fractures as the most common known injury reported along the trail (19 percent), followed by head injury (15 percent), and soft tissue injury (14 percent). "Other" injuries are varied, including loss of consciousness, dislocation, and cardiac arrest following a crash.

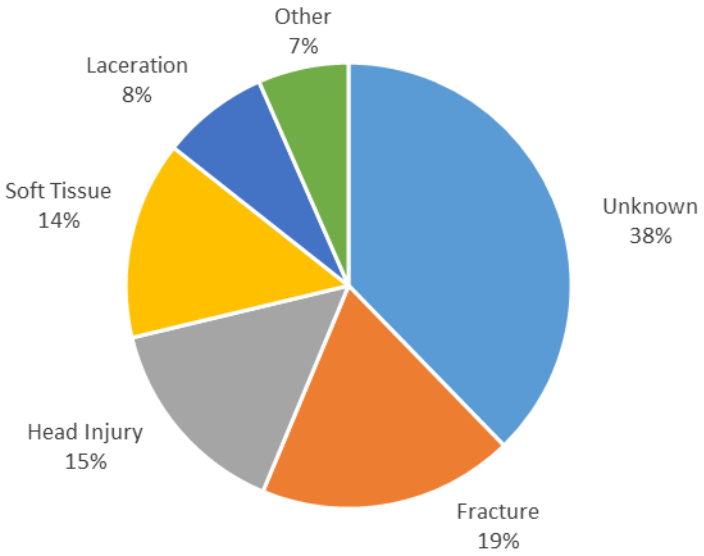



*Figure 36: Top injury types, 2006-2010 (n=167)*

Figure 37 shows the top injuries by trail user type. Crashes involving only one bike was the top reported injury (46 percent), followed by bike-on-bike injuries (10 percent), and bike-on-pedestrian injuries (8 percent).

The bike-only and bike-on-bike injuries are generally due to unsuccessful passing (such as obstacles on or adjacent to the trail), loss of control, trail conditions/geography, dehydration and exhaustion, and weather and other conditions.

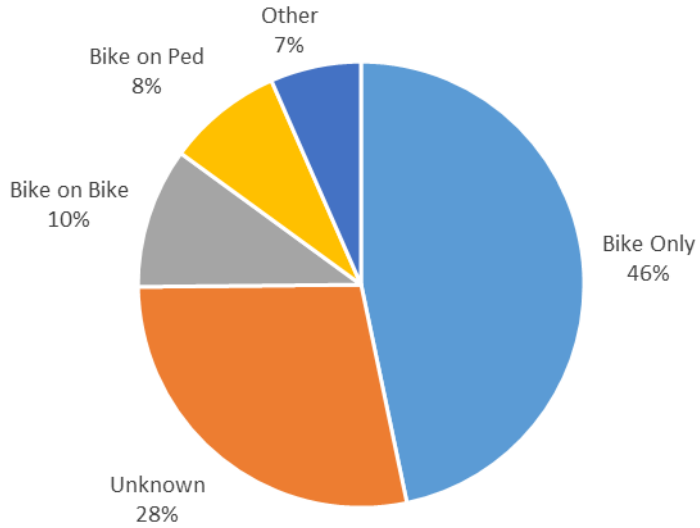



*Figure 37: Injuries by trail user type, 2006-2010 (n=167)*

Based on the above analysis, the main trail conditions identified as safety concerns include:

**Narrow, crowded trail segments.** Narrow trails create safety hazards for passing when there are high volumes of trail users present. Trail crowding, high speeds, poor sightlines, and a mix of trail user types can all increase the likelihood of a crash. Examples of where these conditions exist include:

- Trail sections north of Old Town Alexandria, particularly the in Arlington County and DC section (Zones 3) are the most crowded during peak periods. The trail width in this location averages between 8 and 9 feet, which makes passing difficult and contributes to modal conflict between pedestrians and bicyclists.
- Sections of the trail that pass through popular sites with many pedestrians, including families and children. These include Gravelly Point, Belle Haven Park, and other picnic and parking areas.

**Surface/topography transitions.** The MVT has multiple transitions between asphalt paving and timber bridges, as well as changes in topography with hills and curves on the trail. These transitions may increase chances for crashes when:

- Bicyclists gain speed going downhill toward an intersection, curve, or surface transition and may lose control, especially when other bicyclists or pedestrians are on the trail. The transitions and bridges in Zone 1 and the Daingerfield "S" curve are examples.
- Weather conditions such as rain or ice may make the trail slippery; bicyclists are more likely to lose traction, particularly on timber bridges.

**Trail intersections.** The MVT has multiple connection points to Potomac bridge crossings or other trails. These intersections are a significant conflict point where there may be multiple turning movements per minute during peak times. Poor sightlines, surface transitions, and deficient wayfinding can magnify the crash potential of these locations. Some examples include:

- The Four Mile Run Trail intersection, which has a combination of high usage, unusual geometric design, and limited sightlines.
- The 14th Street Bridge intersection, which has extremely high usage and poor stop sign compliance for bicyclists coming off the spur.
- The Theodore Roosevelt Bridge connection on bridge 31, which is an unusual timber bridge intersection arrangement with unclear turn movement prioritization, poor friction, and high bicyclist travel speed coming down a steep incline.

Figure 38 shows the MVT's trail intersections. Trail intersections that involve high levels of bicycle traffic and high numbers of pedestrians, such as the Four Mile Run trail connector, present conditions for potential safety issues. The design of the intersection at Four Mile Run also contributes to potential safety challenges, as users may not know which approach has priority.

**At-grade roadway crossings.** There is often right-of-way confusion between trail users and motorists at 14 un-signalized, at-grade crossings where the MVT intersects with roadways, parking areas, and access roads. These include:

- Three at-grade crossings in Zone 3 that have both significant trail use and significant vehicle interaction. These include South Smith Boulevard (an on ramp to GWMP from Reagan National Airport), Gravelly Point Parking Lot, and Theodore Roosevelt Island Parking Lot. These crossings lack consistent, modern signage, pavement markings, and accessibility features on both the trail and intersecting roadway.
- 11 at-grade trail crossings in Zones 1 and 2 across low traffic, local streets and the Mount Vernon Estate parking area. While these crossings have relatively fewer trail users and less significant cross-traffic than those listed above, they lack the same basic safety features. In some cases these crossings are located just off of the GWMP or an adjacent low volume intersection in a non-standard location.

Figure 38 shows the at-grade trail intersections along the MVT. At-grade crossings located in Zones 2 and 3 are of most concern, as these crossings include on-ramps to the GWMP and other crossings with high levels of vehicular traffic.

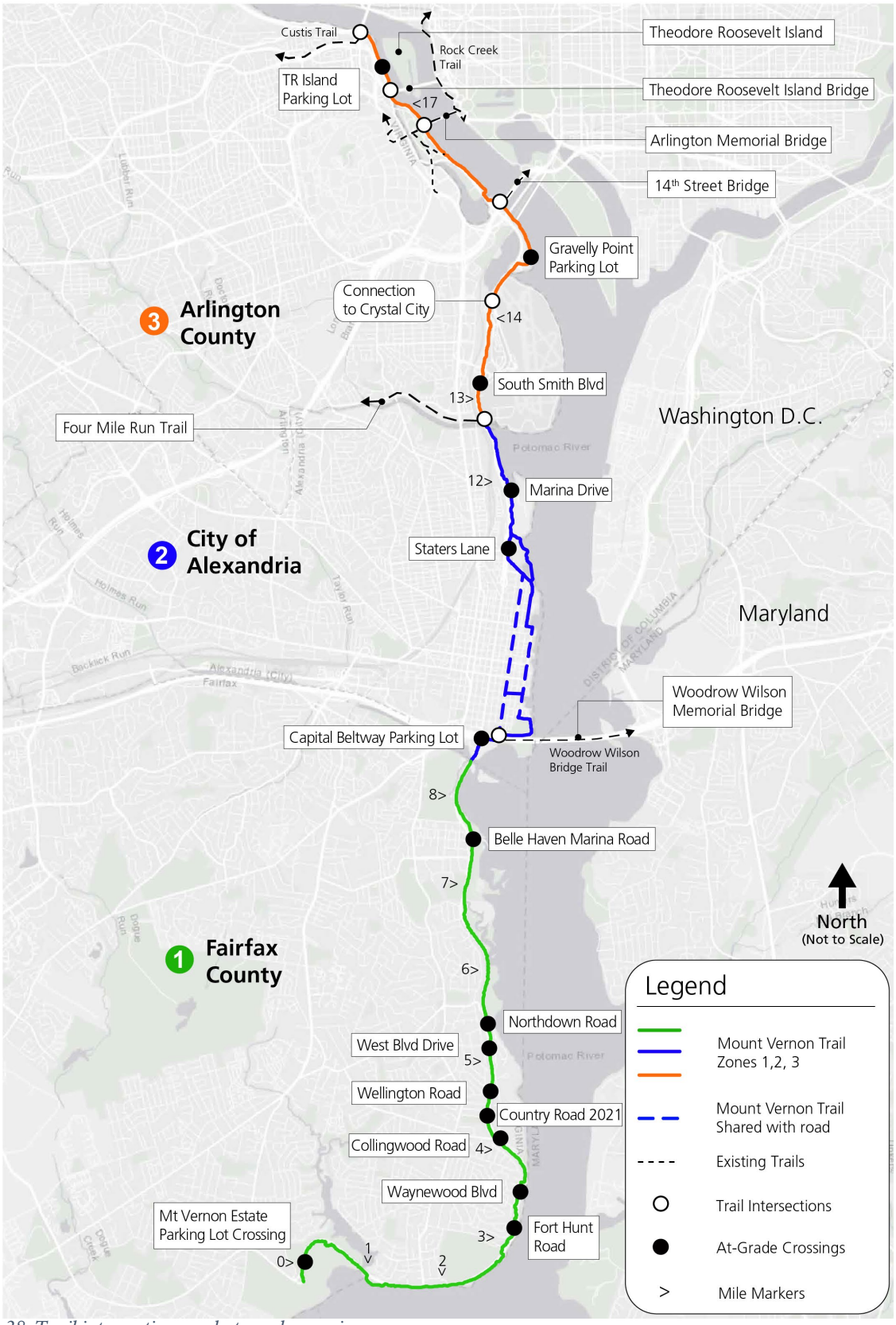



*Figure 38: Trail intersections and at-grade crossings*

While bicycle and pedestrian crash data can provide valuable information on unsafe conditions and behaviors for trail users, they come with significant limitations. First and foremost, serious crashes are relatively infrequent. They may not adequately characterize underlying risks and unsafe conditions throughout the corridor or relative to other trails. Furthermore, many bicycle and pedestrian crashes go unreported, particularly off-road crashes on multi-use trails. Only incidents serious enough to prompt a call to an emergency response unit are reported. Therefore, crashes resulting in minor injuries or property damage typically go unreported.

In addition, the MVT presents unique cross-jurisdictional challenges. GWMP staff and U.S. Park Police do not respond to all emergency incidents in the corridor, leading to wide variability in the quality, consistency, and type of data being collected.

**Key Findings: Trail Safety**
The crash data analysis and observations from staff and the study team indicate several key takeaways to inform planning for improvements to the Mount Vernon Trail. The main factors that impact safety on the trail are:

**Behavioral factors.** The MVT sees a mix of users on the trail (bicyclists, pedestrians, scooters, etc.) who range in experience and familiarity with the trail. Bicyclists who are familiar with the trail may use hand signals when turning at intersections and act courteous to others, or, on the other end of the spectrum, act aggressively by speeding and overtaking trail users. Large groups, families, and users who are less familiar with the trail may stop abruptly, obstructing the trail for bicyclist trying to pass. Additionally, distraction, exhaustion, and dehydration may be factors in trail safety. Education, enforcement, and emergency response are all critical to addressing these behavior factors. For example, the visitor services and trail volunteers implemented a safety culture campaign to raise awareness of these issues. The study team noted the temporary signs installed as part of the safety campaign (see Figure 39).


*Figure 39: Mount Vernon Trail safety campaign signs*

**Infrastructure factors.** While the crash data have limitations, it can be used to help inform and validate the overall safety analysis for the MVT. The top crash locations show that narrow, crowded trail segments, surface/topography transitions, trail intersections, and at-grade roadway crossings have relatively high crash potential. Crash potential can be mitigated in part through the use of engineering standards, guidelines, or best practices for multi-use trails.

# 6 TRAIL DESIGN CONSIDERATIONS

Retrofitting multi-use trails is both an art and a science. The science relies on engineering and accessibility standards, guidelines, technical analysis tools, and best practices, while the art integrates local knowledge, engineering judgement, and resource considerations. When the NPS paved the MVT in the 1970s and 1980s, neither mandatory standards nor voluntary guidelines and best practices existed for multi-use trails. Technically, the NPS is under no legal requirement to make substantial changes to the facility, which with a few exceptions, can be rebuilt in-kind over time.

The above notwithstanding, standards and guidelines are data-driven and carefully crafted by industry professionals based on research to ensure user safety and accessibility. Comparing existing trail infrastructure and current standards highlights where the trail may be deficient and points to opportunities for improvement. This chapter draws from the following resources:

- 2012 AASHTO Guide for the Development of Bicycle Facilities (updated version due in 2019)
- 2013 U.S. Access Board Draft Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way; Shared Use Paths
- 2013 U.S. Access Board Final Accessibility Guidelines for Outdoor Developed Areas
- Manual on Uniform Traffic Control Devices (MUTCD)
- National Association of City Transportation Official (NACTO) Urban Bikeway Design Guide
- 2015 Association of Pedestrian and Bicycle Professionals (APBP) Essentials of Bike Parking

**Accessibility:** NPS Director's Order #42 outlines NPS policies on accessibility, and includes the Architectural Barriers Act (ABA), which applies to federal agencies and facilities built using federal funds. For trails, the ABA standards include guidance on trail surface types, minimum trail width and passing spaces, and accessible trailheads and access points.

The Americans with Disabilities Act (ADA) of 1990 and Section 504 of Rehabilitation Act outlines accessibility policies that recipients of federal aid, such as state and local entities, must comply with. The ADA ensures that pedestrians with disabilities can safely use the transportation system and that pedestrian facilities and roadways reasonably accommodate persons with disabilities.

These resources cover a number of design elements, including multi-use trail width and usage, recovery areas, grades, slopes, trailheads, signs and wayfinding, bicycle parking, trail intersections, and at-grade crossings. For each trail component, these standards and guidelines often offer a range of options given a particular trail's usage and the local geography. Since usage varies along the 18-mile MVT, design options that may be warranted for the high-use northern section of the trail may not be appropriate in the southern part of the trail.

## 6.1 PHYSICAL TRAIL DESIGN

### Trail Width, Recovery Areas, and Vertical Clearance

The MVT ranges in width, with the majority of the trail ranging from 8 to 10 feet wide (average of 9 feet), though some areas are as narrow as 6 to 7 feet, including the area of the trail under Arlington Memorial Bridge. The study team took measurements at every quarter-mile of the trail, listed in Appendix G. Given the mix of users on the trail (pedestrians, bicyclists, skaters,

strollers, etc.), the narrow trail width can contribute to user conflict and create challenges for passing. The 2012 AASHTO Guide for the Development of Bicycle Facilities[9] (AASHTO Guide for Bicycle Facilities) establishes widely-accepted guidance on multi-use trail design, including width recommendations based on the volume and types of users:

- **Basic minimum design width.** Multi-use trails are recommended to be 10 feet wide at a minimum, with at least 11-foot width needed for a bicyclist to pass another user going in the same direction and allow a user coming in the opposite direction to continue traveling safely (see Figure 40). Multi-use trail bridges should be two feet wider on each side than the approaching trail. A reduced trail width as narrow as 8 feet is only recommended for short distances where there is a physical constraint.
- **Design width based on usage.** Multi-use trails are recommended to be 11 to 14 feet wide where pedestrians represent 30 percent or more of users, or if the total multi-use trail volume exceeds 300 users during peak hours.
- **Separation of modes.** The AASHTO Guide for Bicycle Facilities recommends separating bicyclists and pedestrians in areas with very heavy usage, using at least a 5-foot bi-directional pedestrian section and 10-foot section for bicyclists, with separate bicycle travel lanes for each direction. On multi-use trails where there is a view adjacent to the trail on one side (such as a lake, river, or mountain), the pedestrian section should be placed closest to the view.

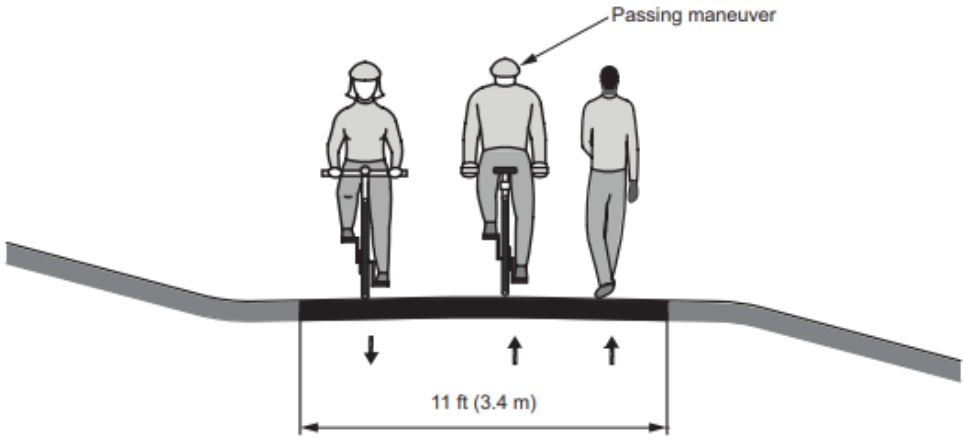



*Figure 40: Minimum width needed to facilitate passing on a multi-use path (2012 AASHTO Guide for Bicycle Facilities)*

Wider paths are also encouraged in the following circumstances:

- **Mix of user types.** Where there is significant use by inline skaters, adult tricycles, children, or other users that need more operating width.
- **Vehicle access for maintenance and emergency services.** To ensure access for routine operations and maintenance activities and emergency incidents.
- **Hilly or curvy topography.** On steep grades to provide additional passing area and/or through curves to provide more operating space.

[9] The 2012 AASHTO Guide for the Development of Bicycle Facilities was being updated at the time this study was developed, and is expected to be released in fall 2019. The standards referenced in this report are not expected to change substantively.

Figure 41 and Figure 42 below show examples of multi-use trails in different contexts. The multi-use trail at Sleeping Bear Dunes National Park is 10 feet wide with 2-foot shoulders. The Sleeping Bear Dunes multi-use trail is used for recreation and does not require separation of modes based on user types.

*Figure 42: A multi-use trail used for recreation at Sleeping Bear Dune National Park in Michigan (Source: NPS)*

*Figure 41: A family walks on a multi-use trail at Sleeping Bear Dunes National Park (Source: NPS)*

The Rock Creek Park Trail was originally constructed in the 1970s and 1980s, with the majority of the trail between 6 feet and 8 feet wide. A recent reconstruction effort resurfaced and widened most of the trail to 10 feet, where possible given environmental and physical constraints.

Figure 43 shows a section of the Anacostia Riverwalk Trail. First developed in 2004, the trail is 12 feet wide in this section and the trail has a yellow centerline striping with an adequate buffer from the road.

*Figure 43: A section of the Anacostia Riverwalk Trail*

The Lakefront Trail in Chicago serves as an example of an extremely high-use trail. This trail is both a transportation and recreation corridor, and pedestrian and bicycling modes are separated along the entire length of the 18-mile trail (see Figure 44).

*Figure 44: A section of the Lakefront Trail in Chicago. The entire length of the trail now has separate sections for pedestrians and bicyclists (Source: Chicago Park District)*

In addition to multi-use trail width, it is also important to consider the recovery area (the space adjacent to the trail on either side), separation between the multi-use trail and nearby roadways, and vertical clearance. All of these elements impact user safety and comfort. Figure 45 shows a multi-use trail at Bryce Canyon National Park with the AASHTO-recommended recovery shoulder, vertical clearance, and separation from the road.

*Figure 45: A section of trail in Bryce Canyon with adequate recovery zones, vertical clearance, and separation from the road*

The following guidelines are recommended in the AASHTO Guide for Bicycle Facilities:

- **Recovery shoulder.** A minimum recovery shoulder of 2 feet is recommended for clearance from lateral obstructions, and a minimum recovery of 3 feet is recommended from vertical obstructions such as trees, poles, walls, and fences. If there is significant change in slope, the AASHTO suggests considering a wider recovery area of 5 feet. If there is a drop off or the multi-use trail is close to a steep embankment, the recommendations is to consider a fence or physical barrier that is at least 42 inches high.
- **Vertical clearance.** The recommended minimal vertical clearance height is 8 feet, with 10 feet required for maintenance and emergency vehicles.
- **Separation between path and road.** The recommended separation between the path and an adjacent roadway is 5 feet, with more space recommended if cars are traveling at speeds of greater than 45 miles per hour (MPH). A barrier may be needed if there is less than 5 feet of space separating the path and roadway.

As described above, the AASHTO Bicycling Facilities Guidelines recommends that trails are 11 to 14 feet wide where pedestrians represent 30 percent or more of users, or where the multi-use trail volume total exceeds 300 users during peak hours. There are currently several counter locations on the MVT that reach or exceed these thresholds (see Existing Conditions chapter for more detail). There are five counter locations that exceed 30 percent pedestrian mode share on weekdays and six counter locations on the weekends.[10] Additionally, there are three counter locations for weekdays and five counter locations for weekends where there are 300 or more users at peak hours (based on 95th percentile peak usage). Taking into consideration potential growth scenarios for the trail (given new trail connections, general growth of bicycling commute mode share, and the development of Amazon HQ2), the study team anticipates that there will be even more times of the day and year when the MVT will meet or exceed usage guidelines for 11- to 14-foot trail width.

In addition to trail width and usage, the frequent bridges along the MVT also impact user safety. The next section discusses best practices in bridge design, and evaluates the current condition of the bridges in light of design guidelines.

**Bridges, Decking, and Railings**

The MVT includes 38 bridges, ranging from small timber boardwalks over wetlands and creeks to large concrete spans across roadways. Since 2004, the GWMP has replaced several deteriorated bridges to meet modern design standards. However, several trail bridges still require replacement or new decking. As trail usage increases and some of these structures are due for replacement, the use of modern design standards helps ensure safety. Furthermore, MVT bridges have different levels of deterioration (warping, rotting, etc.) depending on the bridge's age and materials used for decking and railings. The study team did a preliminary analysis of these conditions to determine whether a bridge replacement or rehabilitation is warranted.

[10] The five counter locations exceeding 30 percent pedestrian mode share on weekdays are Theodore Roosevelt Island, Crystal City Connector, Four Mile Run, Potomac Yard, and Jones Point Park. The six counter locations exceeding 30 percent pedestrian mode share on weekends are Theodore Roosevelt Island, Roosevelt Bridge, Crystal City Connector, Four Mile Run, Potomac Yard, and Jones Point Park.

### *Decking*

One of the main concerns for bridge condition is decking deterioration. Heat, water, and sunlight accelerate the decay of untreated timber. Particularly in the wooded areas along the MVT, humidity and fungal growth make decking slippery, contributing to safety risks, particularly for bicyclists.

*Figure 46: A timber bridge with asphalt patch (Source: Downer EDI)*

For new bridges, treated timber decking helps protect from decay and deterioration. The use of pressure-treated timber can increase the life of timber structures by five times or more, and help prevent fungal growth. Heavier preservatives can also be used to increase stability and reduce susceptibility to moisture. The American Wood Protection Association[11] and the American Institute of Timber Construction[12] provide guidance on the appropriate type of treatment for various wood species and types. Timber decking requires cyclic maintenance, including pressure washing and treatment. With the replacement of many bridges since 2004, park staff changed the decking materials from 2'x6' to 3'x6' lumber. While the 2'x6' lumber had a lifespan of about 10-12 years, the 3'x6' lumber appears to have increased the lifespan of bridge decking, though it is not yet clear by how much.

There are also some opportunities to retrofit existing timber bridges with deck deterioration, and to apply treatments to reduce slipperiness. MVT staff have tried various treatments over the years to improve traction on the bridges, including:

- **Road patches.** Prefabricated sheets with natural rubber bitumen spray seal. Adds skid resistance and waterproofs bridges. Immediately trafficable and easy to install.[13]
- **Decking strips.** Pre-formed fiberglass strips with an abrasive fine frit coating to provide traction.
- **Paint with a grit substance.** Marine-grade paint with grit, which contains sand or aggregates suspended in a paint or residue.[14]

Maintenance crews on the MVT have experimented with decking strips and gritted paint, but these solutions have not lasted more than a few seasons, and require ongoing maintenance. While the new decking appears to be more resilient, other treatments may be useful as these structures age.

In addition to options for construction and rehabilitation, regular bridge maintenance programs can use inspection and periodic in-place treatments to extend the service life of a bridge.

[11] The American Wood Protection Association standards can be found here: http://www.awpa.com/standards/index.asp.
[12] The American Institute of Timber Construction standards can be found here: http://www.aitc-glulam.org/shopcart/index.asp.
[13] The City of Knoxville tested various treatments for slippery wooden decks, and recommends using road patches: https://www.eiseverywhere.com/file_uploads/641f2e0b4baf3c5ec8b35d02f38972a5_15.20SmallBridgesConferenceNov2015-Presentation-ImprovingTimberBridgeDeckSafetyinKnoxCityCouncil.pdf
[14] American Trails recommends using a marine-grade paint with grit to reduce slipperiness on wooden trail bridges: https://www.americantrails.org/resources/faq-slippery-boardwalks-and-bridges

***Railings***

According to the AASHTO Guide for Bicycle Facilities, railings should be a minimum of 42 inches high in locations where bicycles may operate in close proximity to the railing. This standard increases to 48 inches for bridges with high speeds, steep angles, and/or sharp curves, where a bicyclists could make contact with the railing. AASHTO defines a steep angle as 25 degrees or greater. Openings between railings should be small enough that a six-inch sphere cannot pass through the lower 27 inches of the railing. Above 27 inches, openings should be small enough that an eight-inch sphere cannot pass. In some cases, there may be a risk of bicyclists' handlebars coming into contact with the railing. A rub rail can be installed at the typical height of handlebars, between 36 and 44 inches (see Figure 47).

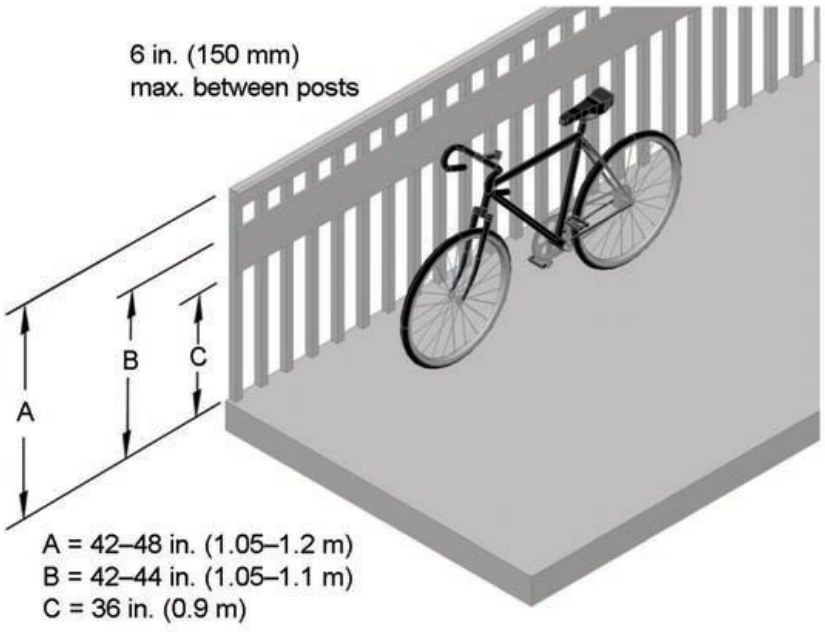



*Figure 47: Recommended railing height for trail bridges, along with a rub railing where bicyclists' handlebars may potentially hit railing (Source: AASHTO Guide for Bicycle Facilities)*

Nine MVT bridges still have chain railings, which are not suitable for bicyclist and pedestrian safety (see Figure 48). Four of these bridges are already scheduled for replacement with two more recommended for replacement. The majority of the railings on the MVT meet the AASHTO Guide for Bicycle Facilities design standards. These adequate MVT railings were installed with bridge replacements since 2004 (see Figure 49). Depending on the expected replacement date for the remaining five bridges, it may be worth replacing or retrofitting the remaining bridges with AASHTO-compliant railings.

*Figure 49: An example of a bridge with chain railings.*

*Figure 48: An example of a bridge with updated metal banister railings*

***Bridge Width***

According to the AASHTO Guide for Bicycle Facilities, the "receiving" ends of the trail bridge should be two feet wider than each side of the approaching trail. This means that the width should equal the width of the path plus a minimum of four feet to avoid fixed-object crashes when bicyclists transition onto bridges. Additional bridge width also allows space stopped pedestrians or bicyclists, especially at scenic overlooks. Furthermore, there should also be adequate width and structural integrity for potential access by emergency, patrol, and maintenance vehicles.

Most MVT bridges are approximately one foot wider than the approaching trail. None meet modern AASHTO guidelines for two additional feet of bridge width on each side. The majority of the MVT is 9 feet wide, with some older sections (i.e., Columbia Island) as narrow as 8 feet and some newly reconstructed sections (i.e., Jones Point Park) are up to 11 feet wide. With some exceptions, almost all of the timber bridges on the MVT are between 9 and 10 feet wide, while the concrete/steel bridges are 12 feet wide (see Appendix G). The four MVT bridges programmed for reconstruction will be widened to 14 feet rail-to-rail.

***Bridge Transitions and Bollards***

The height of the path or trail's surface should match the height of a bridge deck surface to provide a smooth transition. A difference between the height of a pathway and a bridge is known as a bridge deck lip. These lips can cause tire blowouts, bent wheels, and crashes. If a lip has developed, a transitional layer of asphalt can be used to even the surface. Additionally, bollards are sometime used on bridges to slow users before entering the bridge or prevent

unauthorized vehicle access, but this is generally not recommended as users can crash into the bollards and sustain injuries.

## 6.2 Trail At-Grade Crossings and Intersections

The MVT has 18 at-grade road crossings, and 11 trail intersections where the trail connects to other trails or access points (see Appendix E for list of trail crossings). These locations create potential points of conflict among trail users and motor vehicles (or other trail users at trail-trail intersections). Also, high usage locations like the Four Mile Run Trail connector and 14th Street Bridge intersections are areas of concern. The 2012 Transportation Scholar Report identified two specific road crossing locations classified as high-risk for trail users:

- The nine at-grade crossings at Arlington Memorial Bridge (off the main line of the MVT), which involve trail users crossing in areas of high vehicular traffic. These crossings are the subject of a separate, ongoing study and analysis.
- The at-grade trail crossing at National Airport, where vehicles are merging northbound onto the GWMP and trail users are attempting to continue on the MVT across this access ramp.

Based on site visit data, the project team identified the following crossings and intersections where current conditions do not align with modern design and accessibility standards and guidelines:

- **Zone 1 approach signage for trail crossings on Fort Hunt Rd, Waynewood Blvd, Collingwood Rd, Wellington Rd, and W Boulevard Dr**. At these intersections, approach signage warning motorists exiting from the GWMP only warns of pedestrians, not bicyclists. Motorists approaching from adjacent neighborhoods toward the GWMP have no signage to alert them of the trail crossing. Only the curb ramps at Waynewood Blvd. crossing have detectible warnings for trail users with disabilities.
- **Zone 1 on-street trail segments at Fort Hunt Rd and Alexandria Ave**. In these areas, trail users mix with traffic on low volume streets to continue along the trail. Pavement markings and signage alerting motorists to the shared usage of the roadway is limited.
- **The at-grade crossing at National Airport**. This crossing is at an access ramp for motorists exiting the airport northbound onto the GWMP. Trail signage alerts bicyclists to dismount, though the project team did not observe any bicyclists following this signage. While motorists are alerted of the crossing with an advanced warning pedestrian signage, current signage does not instruct motorists to yield to trail users in the crosswalk as state law requires. This crossing does not have detectible warnings for trail users with disabilities.
- **The at-grade crossing with the driveway to Belle Haven Park**. This crossing includes signage for bicyclists to dismount, though based on site visit observations, this area experiences low motorist traffic, and as a driveway, motorists are likely traveling at lower speeds than at other at-grade crossings. Signage alerts motorists of bicyclists only. This crossing does not have detectible warnings for trail users with disabilities.
- **The at-grade crossing with the Gravelly Point parking lot**. This crossing does not include signage for bicyclists to dismount. Signage alerts motorists of bicyclists only. Based on site visit observations, this crossing was busier than other crossings, including higher volumes of pedestrians, bicyclists, and motorists. The current parking lot design introduces high potential for conflict between motorists and non-motorists, and

placement of restroom facilities at Gravelly Point increases the likelihood for conflict between pedestrians and bicyclists. This crossing is signed as a four-way stop, where both motorists and trail users are instructed to stop at the crossing. This crossing does not have detectible warnings for trail users with disabilities.

**At-Grade Trail Crossings**

Design components to reduce the likelihood of roadway conflicts at intersection locations include:

- **Roadway signage to alert motorists of the crossing.** Adequate roadway signage should be provided to motorists to alert them of the trail crossing ahead. Roadways with varying levels of traffic volumes may require different signage, but signs at and approaching the crossing should be retro-reflective and MUTCD-compliant.
- **Visible crosswalks.** Visible crosswalks increase awareness of the crossing and provide an additional level of alertness to motorists. Advanced stop/yield lines and flexible pedestrian signs (where there are multiple lanes) also increase compliance.
- **Safe geometric design.** Trails should intersect roadways at a 90-degree angle whenever possible and crossing distance should be minimized. A maximum 45-degree skew is acceptable. Adequate sight lines should be preserved for both trail users and motorists; specifically, sight triangles should be maintained and kept clear to preserve safety (see Figure 50). Crossings should be flat and conspicuous to all users.
- **Detectible warnings.** Public agencies are required to provide "reasonable accommodation" under Section 504 of the Rehabilitation Act, which includes detectible warnings on roadway curb ramps for visually impaired and blind users. Detectible warnings must be incorporated into at-grade crossings when the trail or intersecting roadway are paved. The NPS could be subject to a complaint filed by the disability community at any point, even where a paving project has not taken place.
- **Increased trail width at intersections.** Wider trails at intersections can reduce user conflicts, particularly in areas where queuing along the trail may occur.
- **Chicanes to help reduce speed.** Chicanes (i.e., horizontal curvature) can reduce trail users' approaching speeds at intersections involving a stop or yield.
- **Accounting for all types of movements from the trail.** At intersections, bicyclists may be entering or exiting the trail. These movements must be considered in evaluating how to design the intersection, in addition to through traffic on the trail.

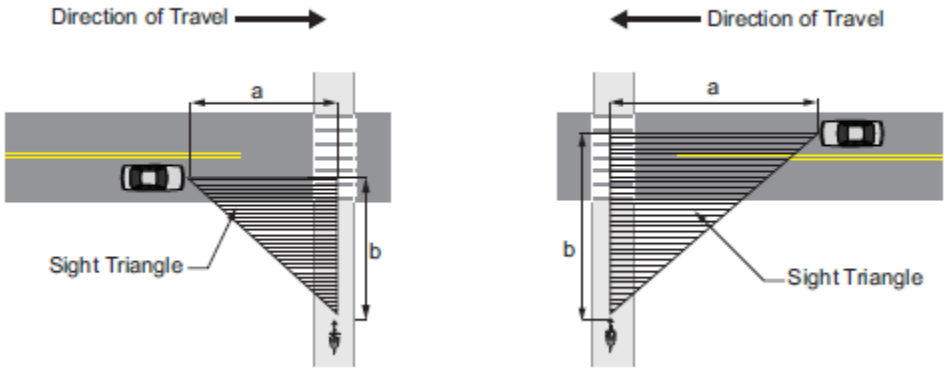



*Figure 50: Adequate sightlines for motorists and trail users help ensure safety at crossings (Source: AASHTO Guide for Bicycle Facilities)*

Similar to bridge approaches, the use of bollards to restrict motor vehicle traffic at at-grade crossings is not recommended. Bollards create barriers for trail users and should only be used if there is a documented history of attempts by motor vehicles to use the trail or other security considerations. Figure 51 shows an example of an option for a trail crossing treatment using landscaping to reduce trail user speed approaching an at-grade crossing. The detectible warning (pictured on the pavement in red) is required for disabled trail users and helps further distinguish that the trail is crossing a roadway.


*Figure 51: Example of a trail is separated into two lanes with landscaping to reduce conflict between users entering and existing crossing (Source: NPS)*

Stop or yield signs should be used in the manner that provides the least amount of restriction to trail users that is effective. Installing unnecessary stop or yield signs for trail users can encourage them to disregard signs at intersections where stop signs are needed for safety reasons. The relative volume of users and average speeds should be assessed to determine whether a stop or yield sign is appropriate for trail users or motorists at each intersection. Where paths cross low-volume roadways and path use is high, priority should be given to the path. It should be clearly marked which corridor has the right-of-way at each crossing. A stop sign, yield sign, or a traffic signal should be installed at at-grade crossings.

Similar to stop or yield signs, rapid flashing beacons are one potential safety countermeasure. Beacons are appropriate for intersections with high user and traffic volumes, but where volumes are not high enough to warrant a full traffic signal. Beacons are only appropriate marked crosswalks. They should also include appropriate signage and pavement markings to warn motorists and control traffic at these locations. Bicycle-sensitive loop detectors or push-buttons that do not require bicyclists to dismount should be installed with these beacons if used.

Trail or roadway pavement markings may also be used to promote safety at intersections. Stop and yield lines can alert trail users to roadway traffic and may be placed across the entire length of the path. MUTCD guidelines should be followed for these types of markings. In areas where roadway users should stop or yield to trail users, supplemental pavement markings may be used. Advance pavement markings may be used in areas where the crossing is unexpected or where

there is a history of incidents or complaints. Where there are multilane roadway crossings, advance stop or yield lines may be used (see Figure 52).

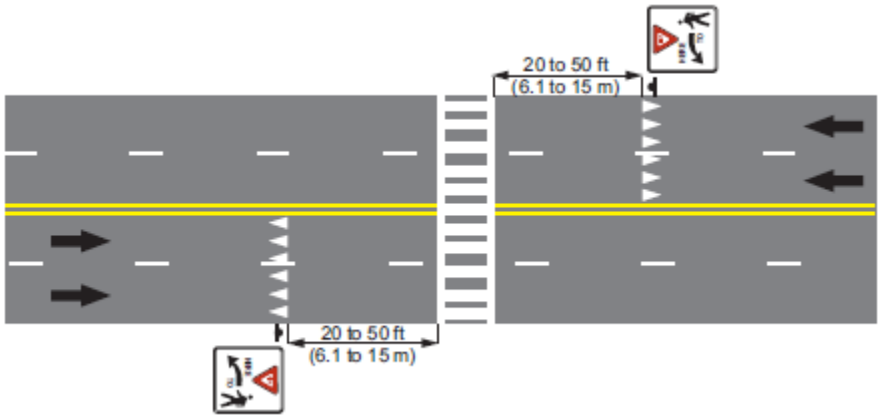



*Figure 52: Signage and advanced pavement markings and signage at a trail crossing appropriate for states with yield to pedestrian laws (Source: AASHTO Guide for Bicycle) Facilities)*

On the MVT, the trail approaches to at-grade crossings are signed with stop signs signaling that trail users should stop and scan for approaching vehicles before crossing. However, there can be considerable confusion at these crossings as to who has the right-of-way, which may be compounded by different laws in the Commonwealth of Virginia and the District of Columbia.

District of Columbia law is somewhat more favorable to pedestrians than Virginia law for marked, un-signalized crosswalks. In the District, motorists are required to "stop and remain stopped to allow pedestrians to cross the roadway within any marked crosswalk..."[15] This includes not only stopping for pedestrians in the same lane, but pedestrians approaching in an adjacent lane to the motorist. In Virginia, motorists are required to yield the right-of-way for any pedestrian who has entered a marked, un-signalized crosswalk, meaning they must "change their course, slow down, or stop if necessary to permit pedestrians to cross."[16] Furthermore, in Virginia, pedestrians are prohibited from entering the crosswalk in "disregard of approaching traffic." The MVT crosses both jurisdictions, however the trail signage is similar throughout. This may make it difficult for motorists and trail users to reliably predict how the other will behave.

In the District of Columbia, other NPS sites including Rock Creek Park, recently changed trail signage to remove stop signs for trail users at crosswalks to minimize confusion about the right-of-way. These stop signs were replaced with signs advising trail users to use caution when crossing.[17] Proper trail and roadway signage and un-signalized crosswalks should be studied in more detail as part of the ongoing GWMP South Parkway Road Safety Audit.

[15] "DC Law Library § 50–2201.28. Right-of-way at crosswalks," District of Columbia, https://code.dccouncil.us/dc/council/code/sections/50-2201.28.html.
[16] "§ 46.2-924. Drivers to stop for pedestrians; installation of certain signs; penalty," Commonwealth of Virginia, https://law.lis.virginia.gov/vacode/title46.2/chapter8/section46.2-924.
[17] "One good question led to an important safety improvement in Rock Creek Park," Greater Greater Washington, last modified October 12, 2018, https://ggwash.org/view/69425/the-curious-case-of-the-mixed-up-rock-creek-trail-signs.

### Trail Intersections

When trails meet, many of the same guidelines for roadway crossings should be applied to design adequate and safe trail crossings. Of particular importance for trail intersections are the following:

- **Sight triangles.** Sight lines should be clear and maintained for users from all directions.
- **90-degree intersections.** Trails should intersect at 90 degrees wherever possible. When a 90-degree intersection is not possible, trails may cross at smaller angles, with the minimum acceptable intersection being 60 degrees (Figure 53).
- **Determine which leg has priority.** Consider the relative volumes of each trail approach and sign and stripe trail stop lines accordingly. A solid yellow centerline on all trail approaches discourages passing.
- **Adopt widest trail segment for intersection.** Where a smaller trail intersects a wider trail, the smaller trail should transition to the width of the wider trail for the intersection.
- **Provide wayfinding signs.** Wayfinding signs identifying the approaching intersection and providing directional guidance to trail users should be provided on all approaches.
- **Apply an enhanced surface.** An enhanced surface is optional; however, using a different surface treatment at an intersection can provide additional safety benefits, as these surfaces warn of potential conflicts and can slow bicyclists and other faster trail users.

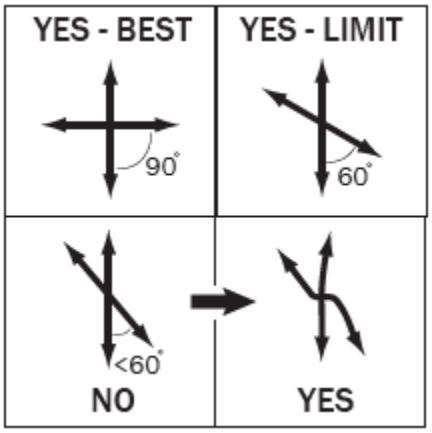



*Figure 53: Appropriate trail intersection design angles (Source: Toronto Multi-use Trail Design Guidelines)*

A less common, but emerging method of designing safe trail-trail intersections is trail roundabouts. In general, roundabouts are best suited for areas where there is potential for high pedestrian-bicyclist conflict or areas where crashes are more likely to occur. Roundabouts require bicyclists to slow their speeds on the approach. Trail roundabouts can be designed in different ways; adding a small planted center island within the existing trail footprint (see Figure 54) can be a simple and effective way at slowing bicyclist traffic and improving safety at intersections, though more extensive design solutions can also be used (see Figure 55).

*Figure 54: A small planted center island serves as a roundabout at the intersection of the Capital City Trail, Southwest Bike Path, and Cannonball Path in Fitchburg, Wisconsin (Source: Jonah Finkelstein, Mike on Traffic)*


*Figure 55: A raised center roundabout at the intersection of the Woodland Trail and Chehalis-Western Trail in Olympia, Washington (Source: Jonah Finkelstein, Mike on Traffic)*

The northern section of the MVT has several major existing and planned trail-trail (or bridge-trail) intersections. These include intersections at the Theodore Roosevelt Bridge, Humpback Bridge (planned), 14th Street Bridge, Long Bridge (planned), Crystal City, Crystal City to Ronald Reagan National Airport (proposed), the Four Mile Run Trail connector, and Woodrow Wilson Bridge. At all trail-trail intersections, users joining the MVT are required to yield to existing trail traffic, though in practice this is not always observed and it can be difficult at some intersections

to discern which leg is the MVT and which is the joining trail. The 2012 Transportation Scholar Report identified the Four Mile Run intersection with the MVT as one of the high risk intersections in need of improvements to reduce safety risks. As trail use increases, it will be important for GWMP staff and its partners to carefully assess and enhance trail intersection conflict points.

## 6.3 Visitor Experience and Safety

Visitor experience and safety is a top priority in designing facilities, including multi-use trails. This section discusses elements beyond the physical footprint of a multi-use trail that ensure bicyclists and pedestrians have a safe and enjoyable experience on a trail, including pavement markings, signs and wayfinding, bicycle parking, and trailheads and amenities.

**Pavement Markings and Trail Conflict Areas**

In addition to providing adequate trail width to allow for safe trail use and passing (as noted above in the Physical Trail Design section), safety can be improved in specific conflict zones by using appropriate pavement markings.

- **Centerline striping.** In areas where bicyclists should not pass other users, a 4- to 6-inch wide, solid yellow centerline may be used. The line should be dotted where there is adequate sight distance for passing and solid where passing is inadvisable. This striping is most useful in areas with heavy user volumes or along curves that have limited sight distance or slow design speeds. Solid centerlines may also be used approaching intersections to discourage passing in these areas.
- **Edgeline striping.** A 4- to 6-inch wide white edgeline may be appropriate in certain circumstances. Trails that are open at dusk or during the night are appropriate locations for white edgelines to improve trail visibility for nighttime cycling. Other appropriate locations include where a change in trail condition occurs or where pedestrians are separated from bicyclists.
- **Approach markings.** If there is an obstruction along a trail, such as a bollard, channelizing lines of the appropriate color (yellow for centerline, white for edgeline) should be used to guide path users around the obstruction.
- **Stop and yield lines.** Where a trail intersects with a roadway and the trail user should stop or yield, a trail stop or yield line may be painted to encourage compliance.
- **Approach warnings.** Where a trail enters an unexpected crossing or in an area with a history of crashes or complaints, advance warning markings may be used. For example, supplemental word pavement markings such as “HWY XING” can be used. All word markings should comply with MUTCD guidelines.

In general, trail pavement markings should be durable, visible, retroreflective, and non-skid. Commonly used materials include paint, thermoplastic, and methyl methacrylate acryline (MMA). Paint is most cost-effective but tends to fade more quickly while thermoplastic lasts longer. MMA is very durable, with a lifespan of five to eight years, but can cost 10 to 15 times as much per mile as paint. Cost, lifespan, geography, weather, and pedestrian and bicycle counts should be considered when choosing pavement marking material. Skid resistance varies with each material; sometimes glass beads, crushed glass, and/or aggregate can be added during placement to increase skid resistance.

The MVT currently has centerline striping along the majority of the trail, but it is faded and in need of updating in certain segments of the trail. Highly used trail-trail intersections, such as 14th

Street Bridge or the Four Mile Run trail intersection, do not prioritize or demarcate turn movements and lack appropriate solid centerline striping, approach warnings, and stop/yield lines. Highly usage areas, like Belle Haven Park, do not have approach warning markings. Furthermore, the trail does not have solid centerline striping in locations with curves or significant topographic changes, such as the Daingerfield Island "S" curve or hilly areas where high speeds may mean bicyclists veer to the opposite side of the trail. Lastly, trail users may benefit from edge line striping in areas where the trail goes under bridges that reduce visibility, or where there is a barrier on the trail's edge.

**Trail Signage and Wayfinding**

Signage and wayfinding are critical components of multi-use trails that let users know where they are and what to expect, aid in navigating to key destinations, and help ensure safety. The NPS Sign Program at the Harpers Ferry Center maintains servicewide NPS sign standards and provides assistance to parks with designing signs. The NPS Sign Program categorizes signs into three different types for guidance: motorist guidance signs, visual information signs, and identity signs. Signs for bicyclists and pedestrians generally fall into the visual information signs category, while signs on roadways related to bicyclists or pedestrians are included in the guidance for motorist signs.

The Harpers Ferry Center guidelines comply with the MUTCD for signs located on roadways. Chapter 9 of the MUTCD provides examples of bicycle wayfinding signs, as does the National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide. The AASHTO Guide for Bicycle Facilities also provides guidance on the usage of signs and strategies for designing effective wayfinding.

A coordinated approach to signage and wayfinding along multi-use trails benefit users, particularly for infrequent or new users to the trail. Signage that is clear and easy to comprehend is critical at trail intersections and at-grade crossings to ensure that all users know the appropriate yielding behaviors. Best practice considerations for signage and wayfinding include:

- **Warning and regulatory signs.** All signs should be retroreflective and conform to the MUTCD if visible from or on a roadway. Generally, regulatory signs are rectangular white signs with black text, and notify trail users of location-specific regulations. Warning signs are diamond shaped and yellow or fluorescent green with black symbols and text (see Figure 56). Warning signs notify users of unexpected conditions that might need a reduction in speed, yielding, or other action. Warning signs should be used sparingly so the message of the sign is not diluted.

*Figure 56: A warning sign indicating the bridge may be slippery on the Anacostia Riverwalk Trail (Source: Volpe Center)*

- **Wayfinding and guide signs.** The goal of wayfinding and guide signs are for users to quickly orient themselves to where they are on the trail and in relation to the greater surrounding area. The MVT has mile marker signs, which are examples of wayfinding signs. Where the trail crosses a road or makes a connection to another trail, a sign should provide information such as the road name or connecting trail, and notify users of connections to key destinations. Wayfinding and directional signage is generally green with a white text on roadways; however, wayfinding sign design can vary on NPS facilities (see and Figure 58 and Figure 57). Wayfinding signs should be consistent in design along the length of a trail.
- **Site entrance/orientation signs.** At major trailheads or trail access points (start and end of trail, parking lots, parks, etc.), site entrance and orientation signs let users know that they are entering an NPS property and provide them with information on the site and overall trail.
- **Wayside/interpretive signs:** Waysides provide key historical and cultural information about a resource. As a NPS trail, waysides are key to helping trail users appreciate and understand the history of the resource they are using.
- **Emergency access signs.** Signs with information about accessing emergency services are useful to place along the trail. Signs should have contact information for emergency services, and the location of where the sign is on the trail to assist with locating a user in need of help.


*Figure 58: Example of a different style of wayfinding signs at Kenilwork Park & Aquatic Garden (Source: Volpe Center)*


*Figure 57. Wayfinding signs at the Anacostia Riverwalk (Source: Volpe Center)*

As discussed in the Existing Conditions chapter, the signage on the MVT is not cohesive or consistent, and the use of regulatory/warning signage is sometimes excessive. The wayfinding/directional signage tends to be weathered, under-sized, and highly variable. Furthermore, the on-street portion of the trail in Alexandria lacks consistent wayfinding signage.

Given the length of the trail, a more detailed inventory of existing signage intended to alert users to changes in trail topography or safety concerns, and to inform wayfinding decisions, may be useful for long-term sign management and maintenance. Balancing the need for wayfinding and safety signage while also limiting sign clutter is an important consideration for the MVT.

**Trailheads and Amenities**

Trailheads are the main access points to a trail and provide amenities and resources based on the volume of trail users, surrounding context, infrastructure, and potential partnerships.

Throughout the MVT, different types of trailheads serve different purposes. The 2016 NCR Paved Trails Study uses a hierarchy of trailhead standards to determine which amenities to provide at different types of trailheads. Table 1 includes recommended amenities based on whether a trailhead is classified as a rest stop, a local trailhead, or a regional trailhead.

Local trailheads or access points typically offer the minimum level of amenities. These may include shelter from weather, seating, lighting, bike racks, parking, or access to transit. Regional trailheads are high-traffic destinations, such as Theodore Roosevelt Island, and provide more amenities to promote connectivity to the overall trail. New trailheads must be accessible and comply with ABA guidelines. Parking areas should include required accessible spaces and van accessible spaces.

*Table 1: Trailhead standards (adapted from NCR Paved Trails Plan)*

| | Local Trailhead | Regional Trailhead |
|---|---|---|
| MVT Locations | Crystal City Entrance<br>Gravelly Point<br>Riverside Park<br>Fort Hunt Park<br>Belle Haven Park<br>Dyke Marsh Wildlife Preserve | Theodore Roosevelt Island<br>Jones Point Park |
| Standard Amenity | Information Kiosk<br>Directional Signs<br>Light(s)<br>Water<br>Trash Receptacle<br>Recycling<br>Seating<br>Bike Racks<br>Picnic Table(s) | Information Kiosk<br>Restrooms<br>Visitor Kiosk<br>Directional Signs<br>Light(s)<br>Water<br>Trash Receptacle<br>Recycling<br>Group/Individual Seating<br>Bike Racks<br>Picnic Tables<br>Bike Repair Station<br>Air Station<br>Transit Access (nearest)<br>Bikeshare |
| Optional Amenity | Restrooms<br>Parking<br>Transit Access<br>Bikeshare<br>Bike Repair Station<br>Air Station<br>Emergency Communications Devices | Staffed Visitor Center<br>Vehicle Parking<br>Shuttle/ Bus Drop-off<br>Bike Storage<br>Showers<br>Emergency Communications Devices |
| Additional Considerations | Frequency should be at primary access points or resources, where space allows. Volumes of adjacent trail(s) should be medium to high. | Select locations where trail(s) volumes are high, number of resources are medium to high and partnership potential is high. Regional trailheads should be seen as destinations themselves. |

As the NPS moves forward with improvements to the MVT, the trailheads could be upgraded as other projects are occurring in the vicinity.

**Water Fountains**

Water fountains are an important amenity to include at trailheads, picnic areas, parks, and other locations throughout the MVT. Currently, water fountains are located at Theodore Roosevelt Island, Daingerfield Island, Jones Point Park, Belle Haven Park, and Fort Hunt Park. There are gaps on the trail where no water fountains are available for five-mile stretches. According to the safety data analysis, dehydration and exhaustion may be a factor in causing some bicycle crashes.

**Bicycle Parking**

Bicycle parking provides trail users with a safe place to store their bicycle when stopping along the trail and help deter users from locking to trees or other objects that may cause resource damage. Bicycle parking also helps prevent theft and creates an orderly and aesthetic appearance. Bike parking facilities along the trail should be located at places where users might want to stop, such as trailheads, parks, picnic areas, and lookout points, and should consider the following guidelines based on the AASHTO Bicycling Facilities Guidelines:

- Easily accessible from the trail and protected from motor vehicles.
- Visible to passersby to promote usage and enhance security.
- Do not impede or interfere with pedestrian traffic or routine maintenance activities.

Although there are no set standards for how much bicycle parking to provide, it is important to consider the demand and projected growth for bicycling on the trail. Outreach to local bicyclist groups can help to determine where and how much bike parking may be needed. In general, bicycle parking planning strategies are categorized into two classes: short-term parking and long-term parking. Short-term parking strategies should focus on proximity to destinations and ease of use. This strategy is most appropriate for areas with typical visits of up to two hours. This type of bicycle parking should be readily visible and easy to use. For most MVT users, short-term strategies are appropriate. Parks, picnic areas, tourist destinations, trailheads, and parking lots are some examples along the MVT that should include short-term bike parking.

For short-term bike parking, the inverted-U and post-and-ring bicycle racks are the recommended design (see Figure 59). These racks support two bikes parked at the same time (one on each side) and can be grouped to provide additional spaces as needed.

*Figure 59: Recommended bike racks located at Sleeping Bear Dunes National Lakeshore (Source: NPS)*

Based on the AASHTO Bicycling Facilities Guidelines, bicycle racks should follow these guidelines:

- Support the bicycle at two points above its center of gravity.
- Accommodate high security U-shaped bike locks.
- Accommodate locks securing the frame and one or both wheels (preferably without removing the front wheel from the bicycle.)
- Provide adequate distance (minimum 36 inches) between spaces so that bicycles do not interfere with each other.

- Do not contain protruding elements or sharp edges.
- Do not bend wheels or damage other bicycle parts.
- Do not make the user lift the bicycle off the ground

Specific guidance on bicycle rack design can be found in the AASHTO Bicycling Facilities Guidelines.

**Public Bike Repair Stands**
Public bike repair stands are standalone stations, free for anyone to use, that provide a bike pump and other tools for general bicycle repairs. They are located throughout many cities in the United States to provide safety support for bicyclists. Arlington and Washington, D.C., have several bicycle "Fixit Stands" located near bicycle parking areas at major transit stations or highly trafficked bicycle routes (see Figure 60). Bike repair stands are another amenity that can be considered for trailheads or connections along a trail. These stands provide bicyclists with the ability to address bike maintenance issues that may otherwise prevent them from continuing to their destination.

*Figure 60: Public bicycle repair station in use (Source: Bike Arlington)*

**Capital Bikeshare**
The Capital Bikeshare system consists of a fleet of specialized bicycles locked into a network of docking stations located region-wide. Bicycles can be unlocked at one station and returned to any other station. The system is ideal for one-way, short trips and people typically use it for commuting, running errands, connecting to transit, and exercising.

There are several docking stations located along the trail or at access points to the trail. Stations are located on the trail adjacent to the entrance to Theodore Roosevelt Island and on Gravelly Point. There are many stations located adjacent to the trail that would enable access in Arlington County and in Alexandria. Capital Bikeshare does not extend to Fairfax County. During observations at 14th Street Bridge and Four Mile Run, the study team noted several users using Capital Bikeshare bicycles.

# 7 RECOMMENDATIONS

Based on an analysis of the MVT's existing conditions and best practices in trail design, the study team recommends that GWMP undertake a number of steps to improve conditions on the MVT and the user experience. These recommendations fall into three broad categories:

- **Capital projects.** Capital expenditures to rehabilitate and reconstruct trail segments, replace bridges, rehabilitate and widen the trail to modern standards (where feasible), enhance at-grade crossings and trail intersections, and realign some segments for safety purposes.
- **Trail enhancements.** Improvements to enhance the user experience including recommendations for wayfinding and signage along the trail, pavement markings to improve safety, and amenities at trailheads and other locations.
- **Operations and maintenance.** Trail operations through organizational changes, enhanced data collection for monitoring trail usage, and increased maintenance activities to improve the user experience and safety.

Figure 61 summarizes the overall recommended implementation steps. Table 2 summarizes recommendations by category and timeframe and provides information on the approximate cost, logical implementing entity/partner, and funding source for each recommendation.

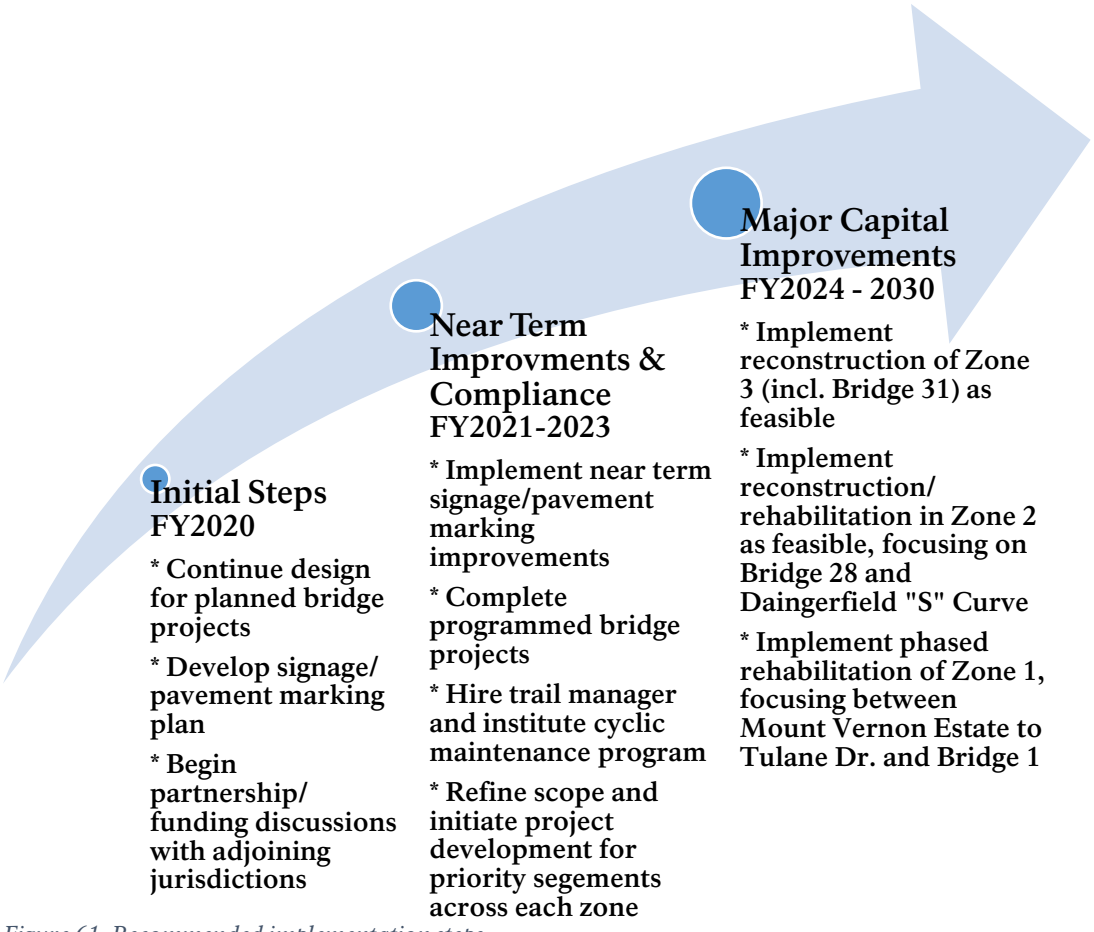



*Figure 61: Recommended implementation steps*

*Table 2: Projected timeframe, estimated costs, potential partners/implementing entity, and probable funding sources*

| Recommendation | | | |
|---|---|---|---|
| Programmed bridge reconstruction (Bridges 12 and 23/24) | $$$$ | NCA/FLH | FLAP/TAP |
| Implement near term signage/ pavement marking improvements, including at-grade trail crossing conspicuity | $$ | GWMP/NCA/DSC | FLTP |
| Hire a trail manager | $ | - | ONPS |
| Bridge and guardrail maintenance and enhancement | $ | - | ONPS |
| Install new trail counters on Arlington Memorial Bridge and in Fairfax County | — | Local Partner(s) | Partner |
| Reconstruct high-use MVT sections in Zone 3, as feasible (incl. Bridge 31) | $$$$$ | NCA/FLH/Local Partner | Partner/ TAP/ FLAP |
| Trailhead enhancements and amenities additions | $$ | NPS | TAP/ Partner |
| Begin in-kind rehabilitation of Zone 1. Focus between the Mount Vernon Estate and Tulane Dr. (incl. Bridge 1) | $$$$ | NCA/FLH/Local Partner | Partner/ TAP/ FLAP/ FLREA |

$ = $50,000 -$200,000
$$ = $200,000 - $1M
$$$ = $1M - 2M
$$$$ = $2M-$5M
$$$$$ = > $5M

The recommendations are described in more detail below. Each is grouped according to timing (short-, medium-, or long-term) and project type (capital projects, trail enhancements, or operations and maintenance). The logical entity responsible for implementation is noted in parentheses after each project name.

## NEAR TERM (1-4 YEARS): FY2021-2023

### Capital Projects

- **Planned bridge reconstruction (NCA/Federal Lands Highway)**. Bridge reconstruction projects are currently funded and in design for bridges 12 and 23/24. Reconstruction of these bridges is expected in FY2020-2022. These projects will address maintenance needs and improve safety through a combination of widening and realignment.
- **Bridge and guardrail maintenance and enhancements (GWMP)**. The decking and railings on bridges 1, 2, 26, 27, and 29 should be repaired or replaced. Permanent guardrails at Roaches Run and along the embankment south of the Fort Hunt Road underpass are also needed.

### Trail Enhancements

- **Trail signage and pavement marking plan (GWMP/NCA/DSC)**. Develop and implement a comprehensive signage/wayfinding and pavement marking plan. The development of this plan presents the opportunity for GWMP to consolidate signs and improve safety and navigation using pavement markings. The plan should include detailed signage and striping specifications. Focus areas for the plan should include:
    - Regulatory signs and pavement markings, including the appropriate sign and marking designs to use, as well as where (and where not) to place signs and pavement markings.
    - At-grade crossings, including what type(s) of signs and pavement marking treatments are appropriate and where they should be placed, for both trail users and motorists.
    - "Slow zones," including the appropriate signage and pavement markings to be used at areas of high conflict among different trail users (e.g., at Arlington Memorial Bridge, Belle Haven Park, Gravelly Point, and other appropriate locations).
    - Wayfinding, including the design of wayfinding signs and guidance on where to place these signs to orient users throughout the trail and at decision points, such as intersections.
    - The signage plan can be completed, but sign replacement should be considered in light of the timeline for the trail reconstruction/repaving recommended below.
- **Alexandria on-street wayfinding improvements (City of Alexandria)**. Coordinate with the City of Alexandria to improve wayfinding throughout the on-street segment of the MVT, in conjunction with the development and implementation of the signage/wayfinding plan.

### Operations and Maintenance

- **Trail manager (GWMP)**. GWMP should hire a dedicated trail manager (1.0 FTE) to ensure a comprehensive approach to trail maintenance and operations, including keeping asset management systems of record up-to-date. The trail manager should also leverage volunteers and seasonal/AmeriCorps crews using count and crash data to evaluate trail needs and develop trail maintenance strategies.
- **Increased routine maintenance (GWMP)**. GWMP should address overgrowth and vegetation encroachment on the MVT. Bridges require more regular repairs and shaded

bridges need annual or biennial power washing to reduce algae growth. To address these challenges, GWMP should increase routine maintenance of the trail.

- **Bridge friction treatments pilot (GWMP)**. Given the MVT's bridge-related challenges and needs, the park is well-positioned to pilot innovative bridge treatments that employ the use of materials designed to reduce slippage. Park staff should pilot these treatments to evaluate effectiveness, durability, and maintenance considerations, using their findings to determine the appropriateness of these treatments throughout the trail's bridges.
- **Installation of new trail counters (Arlington and Fairfax Counties)**. GWMP has a strong partnership with Arlington County and the City of Alexandria to collect count data along the MVT. This program could be furthered by coordinating with Arlington County to install trail counters as part of the Arlington Memorial Bridge Reconstruction and work with Fairfax County to reinstall counters throughout the southern portion of the trail. Currently, no functioning counters are located along the Fairfax portion of the trail, meaning GWMP lacks consistent trail count data for approximately half of the MVT.

## MEDIUM TERM (5-7 YEARS): FY2024-2026

### Capital Projects

- **Zone 3 reconstruction (GWMP/Arlington County/District of Columbia)**. GWMP should prioritize widening high-use areas of the MVT (Zone 3) to meet AASHTO multi-use trail width standards of at least 11 feet, where feasible. As bridges are replaced in this area, they should be at least four feet wider than the approaching trail when feasible. Currently, the trail in Zone 3 is on average 8-9 feet wide, with areas that are narrower due to vegetation encroachment. Widening the trail to meet this standard improves trail safety by providing appropriate width to minimize user conflict in high-traffic areas. Focus areas for widening and modernization include:
    - The portion of the trail located between Four Mile Run and the Theodore Roosevelt Island Bridge, pursuant to NEPA analysis. Some segments of trail in this area face widening constraints, but much of this high-use segment could be widened to better align with best practices and serve trail users.
    - Trail intersection enhancements, such as implementing trail roundabouts, at the 14th Street Bridge and Four Mile Run to better manage these conflict areas by slowing bicycle traffic and reducing conflict points.
    - Consider the use of bicycle-pedestrian separation at areas such as Gravelly Point, which have high levels of user conflict and pedestrian use. This could include a designated pedestrian path or increased separation and access control between the trail and adjacent site. A potential trail redesign in this location could also reduce motorist and trail user conflict at the trail intersection with the Gravelly Point parking lot.
- **Zone 2 reconstruction/rehabilitation (NCA/FLH)**. Bridge 28 is in need of reconstruction to adequately meet safety standards. Similarly, the Daingerfield "S" curve in Zone 2 presents significant safety challenges and does not meet trail standards. This area could be realigned in conjunction with the reconstruction of bridge 28. In addition, given the high usage on this part of the trail, widening may be prudent.
- **Zone 1 rehabilitation of trail in-kind in southern section (Fairfax County).** The southern section of Zone 1 (Mount Vernon Estate to Tulane Drive) is in poor condition.

This section should be rehabilitated and the roots pruned to improve the overall condition and safety of this section of the MVT (including bridge 1).

**Trail Enhancements**

- **At-grade trail crossing improvements in the southern section (GWMP/NCA/Fairfax County).** As part of the rehabilitation of the MVT in Zone 1 from mile 0 to 6.5, at-grade trail crossings should be improved according to the findings of the GWMP South Parkway Road Safety Audit. Traffic calming and safety improvements should be implemented where appropriate for the nine trail crossings in this trail section including at Fort Hunt Rd, Waynewood Blvd, Collingwood Rd, Wellington Rd, and W Boulevard Dr (see Appendix E for a full list of crossings). Design considerations, including signage, striping, and accessibility are provided in the previous chapter.
- **Trailhead enhancements (NCA)**. The 2016 NCR Paved Trail Plan uses a hierarchy of trailhead types and associated amenities, with regional trailheads having the greatest amount of amenities, then local trailheads, and rest areas. As the trail improvement or reconstruction projects are implemented, the MVT trailheads should be improved concurrently. Examples of improvements include adding more bike parking and repair stations where demand is high, additional Capital Bikeshare stations, restrooms and water fountains at parks and destinations, and information kiosks at regional trailheads.
    - Some of the local MVT trailheads can be improved in conjunction with the trail reconstruction and repaving projects outlined above. For the northern Zone 3 trail widening, the following trailheads should be improved with more bicycle parking, repair stations, and additional amenities, as appropriate: Crystal City Entrance and Gravelly Point. Daingerfield Island will be improved as part of the widening project discussed above. The following local trailheads in the Zone 1 southern section of the trail should be addressed in the repaving project from mile 0 to 6.5: Riverside Park, Fort Hunt Park, and Belle Haven Park.

## LONG TERM (8-10 YEARS): FY2027-2030

- **Rehabilitation of remainder of trail in-kind (NPS)**. In the long term, the remainder of the MVT should be repaved to improve the condition of the trail. Roots should also be pruned as appropriate. Focus areas for rehabilitation in the long term include mile marker 6.5 to Jones Point Park.

# APPENDIX A – COMPILED RECOMMENDATIONS FROM PREVIOUS PLANS

*Table 3: MVT recommendations from the 2016 NPS NCR Paved Trails Study*

| Category | Recommendation |
|---|---|
| **Gaps/Connections** | Develop a connection from the Mount Vernon Trail to Theodore Roosevelt Bridge on the south side of the bridge. |
| **Bridges** | Improve access to the Mount Vernon Trail from the Airport Access Road overpass at Ronald Reagan National Airport/Aviation Circle. |
| **Bridges** | Improve safety and access at the intersection of the Mount Vernon Trail and the Custis Trail at Lee Highway/N. Lynn St approach to Key Bridge. Coordinate with NPS regarding access drive to future boathouse. |
| **Crossings** | Explore the potential for a new trail roundabout at Mount Vernon Trail and Four Mile Run Trail and improve safety and sightline at this location |
| **Gaps/Connections** | Realign Mount Vernon Trail at bridge near Little Hunting Creek |
| **Gaps/Connections** | Realign Mount Vernon Trail through Gravelly Point Park to separate through-traffic. |
| **Gaps/Connections** | Conduct alternatives analysis to provide off-road trail connection from the Theodore Roosevelt Bridge to Arlington Ridge Park |
| **Bridges** | Replace existing 300-foot long bridge through wetlands |
| **Trailheads** | Develop a regional trailhead with bike share at Mount Vernon Estate and Gardens |
| **Trailheads** | Enhance existing local/NPS trailhead with improved signage and amenities at Riverside Park |
| **Trailheads** | Develop a local/NPS trailhead at Fort Hunt Park |
| **Trailheads** | Develop a local/NPS trailhead at Belle Haven Park |
| **Trailheads** | Enhance the regional trailhead at Jones Point Park |
| **Trailheads** | Develop a regional trailhead at Long Bridge Park |
| **Trailheads** | Develop a regional trailhead at Gravelly Point Park |
| **Trailheads** | Develop a local/NPS trailhead with bikeshare and viewshed compliancy (adjacent to Arlington National Cemetery) |
| **Trailheads** | Develop a local/NPS trailhead at existing bridge to the Theodore Roosevelt Island |
| **Crossings** | Provide improvements to at-grade highway crossing at Mount Vernon Estate and Gardens |
| **Crossings** | Provide traffic calming measures to facilitate crossing of GWMP at Vernon View Dr. |
| **Crossings** | Provide traffic calming measures to facilitate crossing of GWMP at Collingwood Rd. |
| **Crossings** | Provide traffic calming measures to facilitate crossing of GWMP at Morningside Ln. |
| **Crossings** | Provide traffic calming measures to facilitate crossing of GWMP at Belle View Blvd. |

| | |
|---|---|
| **Crossings** | Provide traffic calming measures to facilitate crossing of GWMP at Belle Haven Rd. |
| **Crossings** | Provide at-grade crossing improvements per ongoing EA recommendations at Memorial Bridge |
| **Crossings** | Provide at-grade crossing improvements per ongoing EA recommendations at Washington Blvd. |
| **Target Areas for Assessment** | Implement edge of pavement striping on trail within close proximity of roadway along Reagan National Airport perimeter |

*Table 4: MVT recommendations from the 2012 Transportation Scholar Report*

| Category | Recommendation |
|---|---|
| **Crossings** | Add a crosswalk warning sign to the southern side of the intersection at Airport Crossing Trail |
| **Crossings** | Upgrade crossing signs to MUTCD W11-15 at Airport Crossing Trail |
| **Crossings** | Trim trees adjacent to Airport Crossing Trail to improve sightlines for both motorists and cyclists |
| **Crossings** | Reduce motorist lane width from 20 ft to reduce motorist speed at Airport Crossing Trail or add rumble strips |
| **Crossings** | Remove stop and dismount signs at Airport Crossing Trail and replace with yield signs |
| **Crossings** | Install bicycle traffic lights, which would remain green unless a vehicle approaches, at Airport Crossing Trail |
| **Bridges** | Relocate Bridge 12 ~170 ft to the west to straight alignment and reduce sharpness of curve |
| **Bridges** | Straight curves at Bridge 12 and reduce grade to maximum of 5 percent (currently 9 percent) |
| **Bridges** | Improve trail surfaces near Bridge 12, including adding 4-6 feet of pavement and/or expanding curve radii |
| **Crossings** | Replace triangular intersection with Four Mile Run Trail with a roundabout |
| **Crossings** | Improve regulatory signage at Four Mile Run Trail -- address ambiguity in who controls right-of-way |
| **Crossings** | Address sightline issues at Four mile Run Trail (and other locations) by trimming trees and vegetation |
| **Gaps/Connections** | Realign MVT at the Daingerfield "S" Curve |
| **Gaps/Connections** | Increase curve radii at Daingerfield "S" Curve |
| **Gaps/Connections** | Use speedbumps or roadcuts to reduce trail user speeds at Daingerfield "S" Curve |
| **Crossings** | Add advanced warning signage at all crossings near Arlington Memorial Bridge, with high retro-reflective signs and pavement markings |
| **Crossings** | Add button or pressure actuated sensors to active crossing warning lights at Arlington Memorial Bridge |
| **Crossings** | Relocate crossings at Arlington Memorial Bridge or restripe roadways to ensure trail users only cross one lane of traffic |
| **Gaps/Connections** | Provide formal access to the MVT from the northern side of Arlington Memorial Bridge |

| | |
|---|---|
| **Crossings** | Provide grade separation at crossings at Arlington Memorial Bridge |
| **Signage** | Enhance visibility of mile markers along the MVT |
| **Signage** | Add half-mile markers along the MVT |
| **Signage** | Investigate each road-trail intersection to determine if a yield sign may be more appropriate than a stop sign |
| **Signage** | Use pavement markings to reinforce messages |
| **Signage** | Add larger wayfinding signs with clearer directional information |
| **Signage** | Locate maps and interpretation displays further from the trail to keep users from stopping on the path |
| **Signage** | Mark pavement with mile markings |
| **Signage** | Improve/correct signage at Four Mile Run Trail |
| **Maintenance** | Conduct a feasibility study for the time and financial costs of plowing the northern half of the trail (north of Alexandria) during winter weather |

*Table 5: MVT improvements identified in local planning documents*

| Recommended Improvement | Source Document |
|---|---|
| Widen trail and add signage in areas where trail turns sharply around Jones Point Park | Alexandria Transportation Master Plan (2016) |
| Improve signage, widen trail on sharp turns and provide wayfinding signage near Royal Street | Alexandria Transportation Master Plan (2016) |
| Install improved crossing and trail signage where the trail intersects Canal Center Plaza | Alexandria Transportation Master Plan (2016) |
| Construct a trail to link the North Tract Park and trail facilities to the trail via an overpass of the GWMP | Arlington County Transportation Master Plan (2008) |
| Extend trail from Theodore Roosevelt Island using existing trails, bike lanes, and proposed bike lanes in Arlington. Construct a short segment of trail between N. Randolph St and the Arlington line, following an existing sanitary sewer easement near Pimmit Run | Arlington County Transportation Master Plan (2008) |
| Widen trail between Roosevelt Island Bridge over GWMP and Four Mile Trail | Arlington County Transportation Master Plan (2008) |
| Construct a trail to link the sidewalk along south side of Roosevelt Bridge directly to the Mount Vernon Trail | Arlington County Transportation Master Plan (2008) |
| Construct a connection between downstream side of Roosevelt Bridge and the Mount Vernon Trail | Arlington County Transportation Master Plan (2008) |
| Upgrade portions of trail including GWMP crossings and Memorial Bridge access | Washington Bicycle Master Plan (2005) |

# APPENDIX B – AUTOMATED TRAIL COUNT DATA

Using available Eco-Counter data, the study team calculated (1) average monthly bicyclists and pedestrian count by location (see Figure x and x) and (2) average summer peak period weekday and weekend bicyclists and pedestrian counts by location (see Appendix A). For analysis purposes, weekday peak periods were defined as 6:00 am to 9:00 am and 4:00 pm to 7:00 pm for both bicyclists and pedestrians. Weekend peak for bicyclists was identified as 11:00 am to 2:00 pm. Weekend peak for pedestrians was identified as 9:00 am to 12:00 pm. The summer season is defined as the months of June, July, and August.

*Table 6: Counter locations, peak bicyclists, peak pedestrians, and data limitations*

| Counter Location | Zone | Peak Bicyclists* | Peak Pedestrians* | Data Limitations |
|---|---|---|---|---|
| **Theodore Roosevelt Island** | 3 | 156 | 48 | Data not available for Feb. 10, 2016; data for Mar. 29-June 30, 2017, only include daily totals and not hourly data |
| **Roosevelt Bridge** | 3 | 56 | 13 | Data not available for July 30, 2018 |
| **14th Street Bridge** | 3 | 252 | 24 | Counter is located on ramp coming off bridge, not actually on the MVT. The counter does not capture trail users continuing through on the trail |
| **Crystal City Connector** | 3 | 98 | 41 | Data not available for Feb. 20, 2018; data for Sept.14-Oct. 16, 2016, and June 30, 2017, only include daily totals and not hourly data |
| **Ronald Reagan Airport** | 3 | 246 | 17 | Data not available for Jan.-June 2016 and July-Sept. 2017 |
| **Four Mile Run** | 3 | 78 | 23 | Data not available for Jan.-Apr. 2016, and Apr. 2018 |
| **Potomac Yard** | 2 | 95 | 28 | Data incomplete for Feb. 2017, Mar. 2017., Nov. 2017, Feb. 2018, Mar. 2018, May 2018 |
| **Daingerfield Island** | 2 | 134 | 24 | Data not available for June 2017-June 2018 |
| **Jones Point Park** | 2 | 82 | 24 | N/A |

* Peak is defined as the average number of bicyclists or pedestrians during evening peak hours of 4:00 PM – 7:00 PM during summer months of June, July, and August, when trail usage is heaviest.

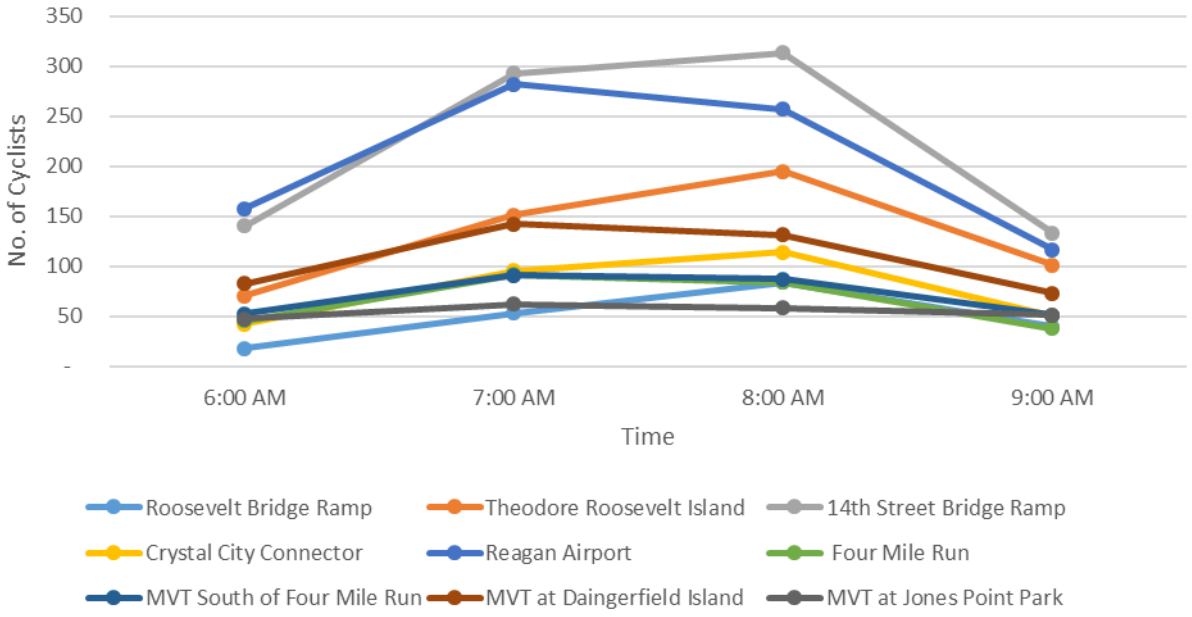



*Figure 62: Average summer weekday morning peak period bicyclist counts by location*

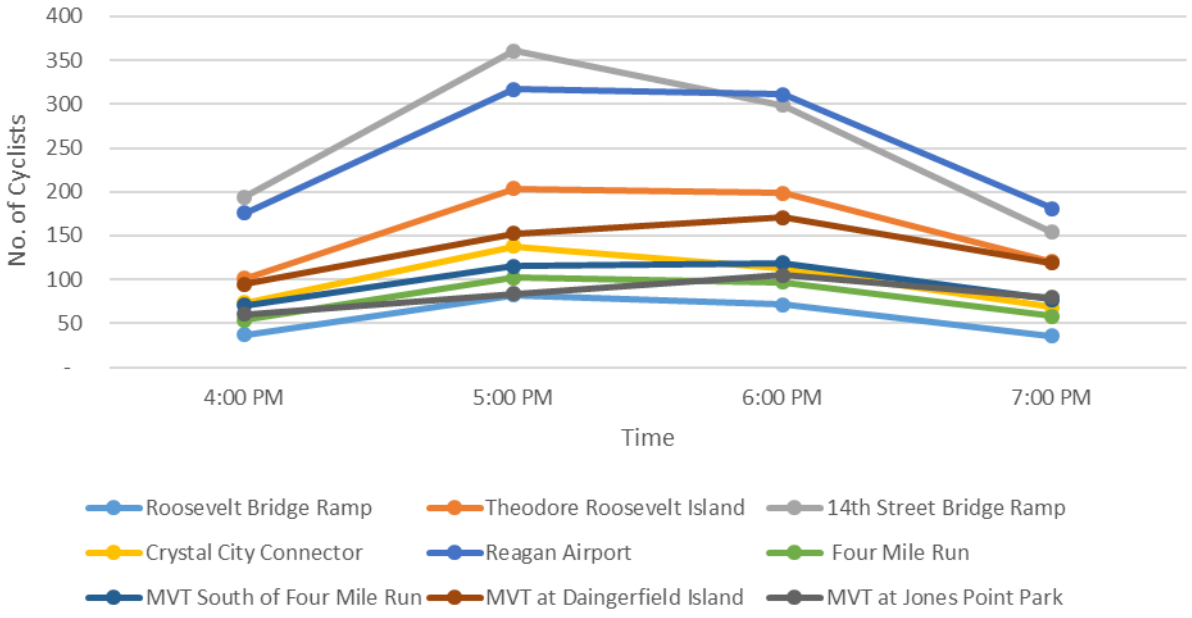



*Figure 63: Average summer weekday evening peak period bicyclist counts by location*

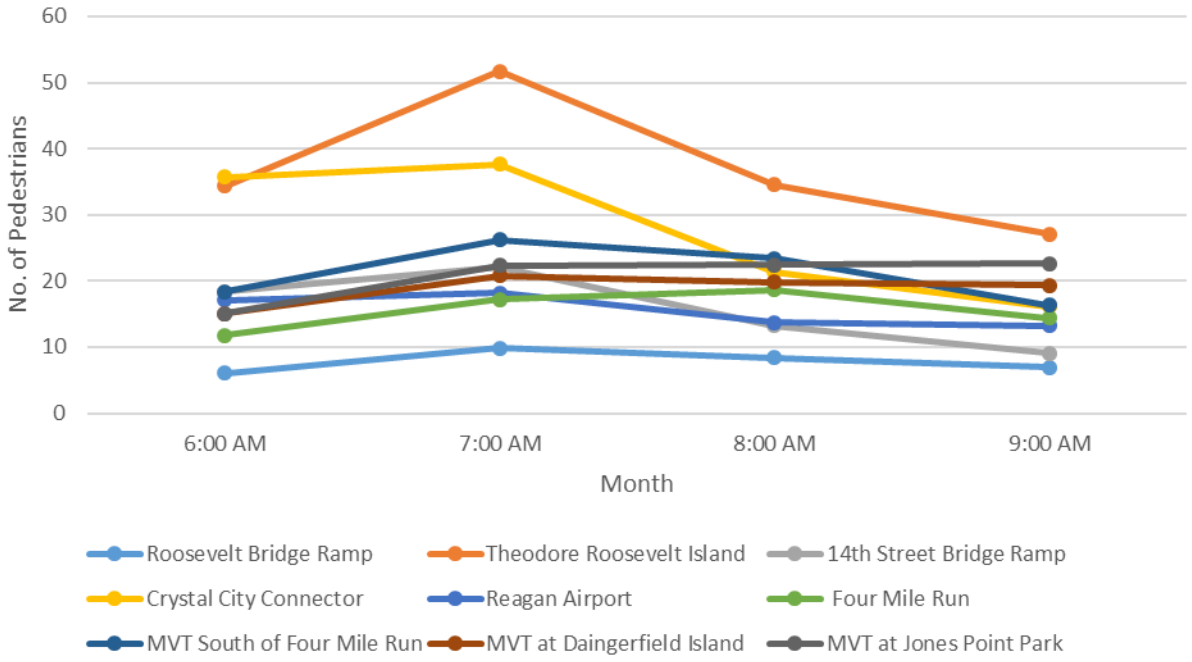



*Figure 64: Average summer weekday morning peak period pedestrian counts by location*

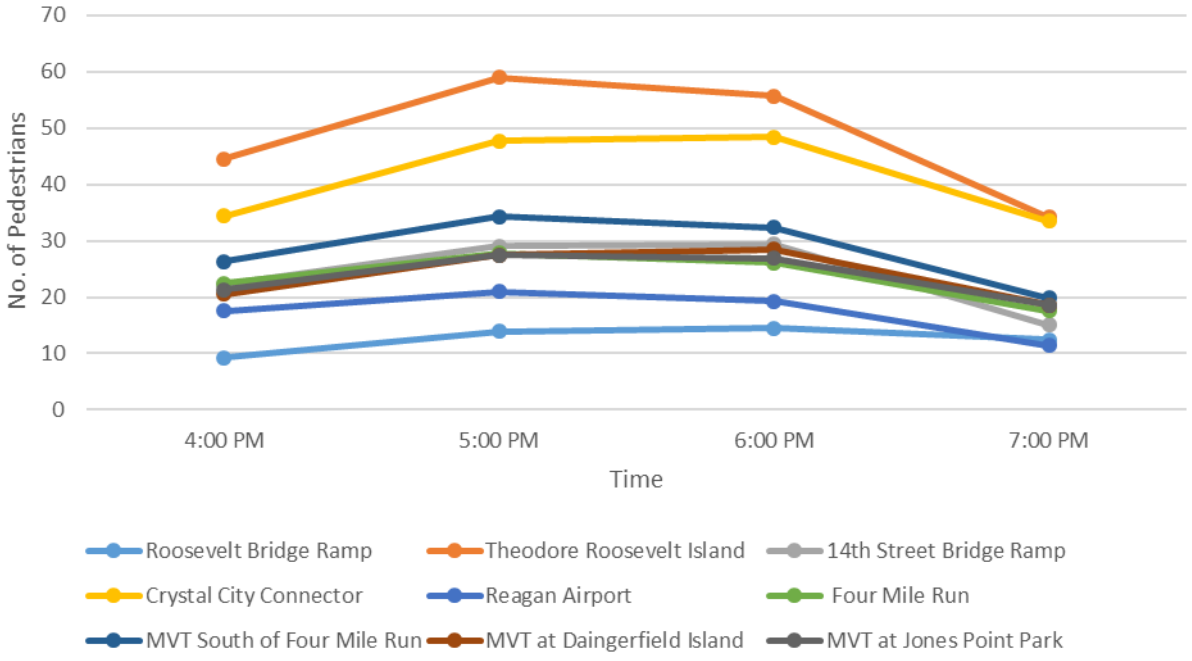



*Figure 65: Average summer weekday evening peak period pedestrian counts by location*

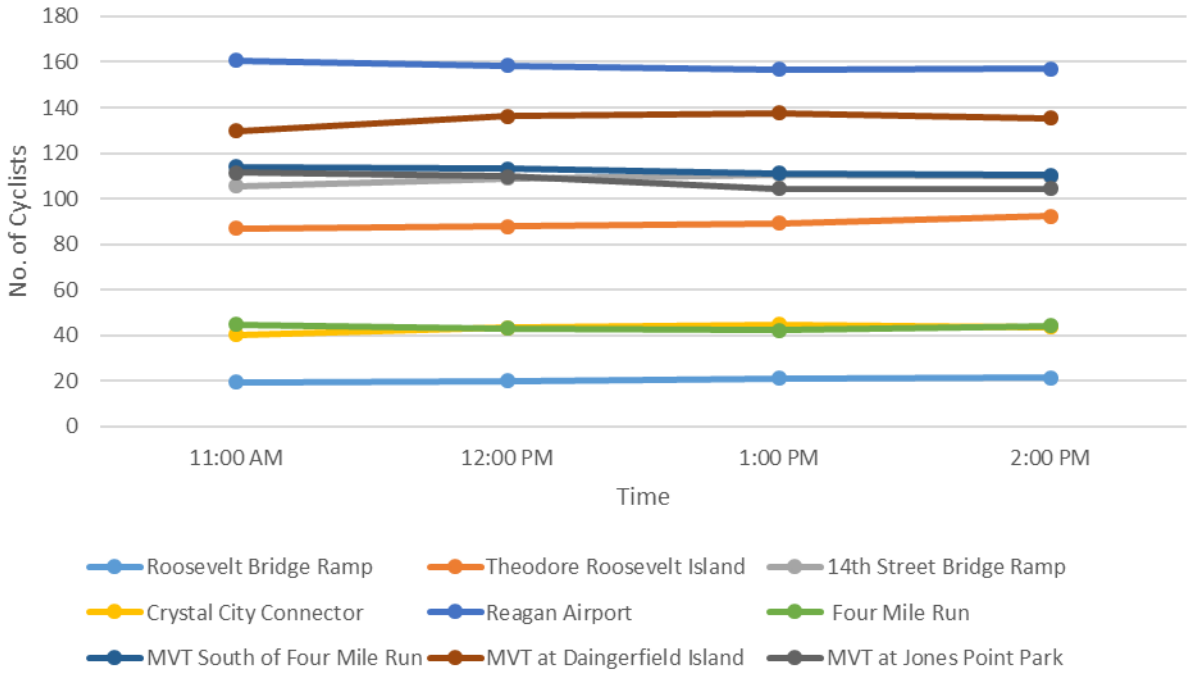



*Figure 66: Average summer weekend peak period bicyclist counts by location*

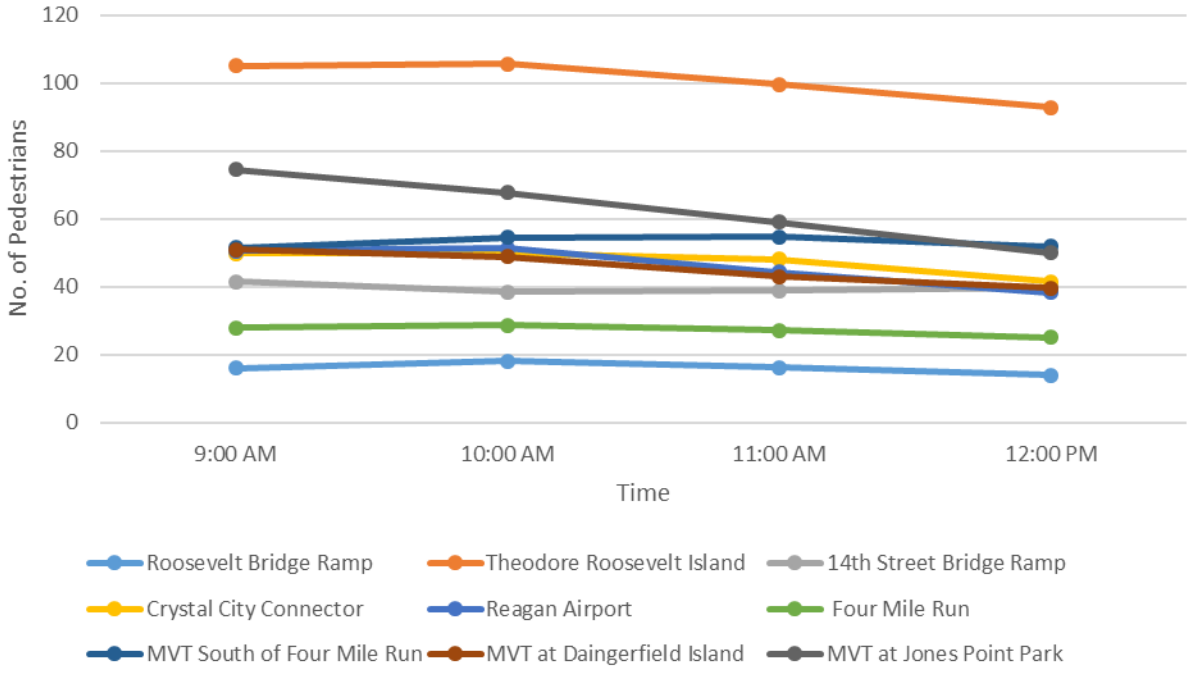



*Figure 67: Average summer weekend peak period pedestrian counts by location*

# APPENDIX C – MANUAL TRAIL COUNTS AND TURN MOVEMENTS

The study team worked with the GWMP volunteer coordinator to complete additional trail counts to validate data from counters, and to provide spot counts for the trail in Fairfax County where there are currently no counters. Trail volunteers completed counts at the following points from September 15 to October 5, 2018:

- Jones Point Park (September 15, 19, 20)
- MVT at Alexandria Avenue, near Dyke Marsh (September 16)
- Belle Haven Park (September 19, 20)
- Gravelly Point (September 26; October 3, 4, 5)
- Daingerfield Island (September 27; October 2)
- Riverside (October 3)
- Fort Hunt (October 4)

*Table 7: Volunteer bicycle counts summary table*

| | Jones Point Park | | | Dyke Marsh | Belle Haven Park | | Gravelly Point | | | | Daingerfield Island | | Riverside | Fort Hunt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9/15 | 9/19 | 9/20 | 9/16 | 9/19 | 9/20 | 9/26 | 10/3 | 10/4 | 10/5 | 9/27 | 10/2 | 10/3 | 10/4 |
| **6:00 AM** | — | 4 | 21 | — | — | — | — | — | — | 214 | — | — | — | — |
| **7:00 AM** | — | 17 | 31 | — | 43 | 3 | 175 | — | — | 238 | 50 | 95 | 13 | 15 |
| **8:00 AM** | — | 25 | 22 | — | 62 | 15 | 253 | — | — | — | 64 | 121 | 14 | 18 |
| **9:00 AM** | 53 | — | — | 51 | — | — | — | — | — | — | — | — | — | — |
| **10:00 AM** | 76 | — | — | 88 | — | — | — | — | — | — | — | — | — | — |
| **11:00 AM** | 125 | — | — | 78 | — | — | — | — | — | — | — | — | — | — |
| **12:00 PM** | 82 | — | — | 93 | — | — | — | — | — | — | — | — | — | — |
| **5:00 PM** | — | — | — | — | 62 | — | — | 496 | 398 | — | — | — | — | — |
| **6:00 PM** | — | — | — | — | 76 | — | — | 388 | 316 | — | — | — | — | — |

*Table 8: Volunteer pedestrian counts summary table*

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6:00 AM** | — | 4 | 14 | — | — | — | — | — | — | 66 | — | — | — | — |
| **8:00 AM** | — | 54 | 34 | — | 46 | 17 | 26 | — | — | — | 31 | 33 | 35 | 18 |
| **10:00 AM** | 90 | — | — | 53 | — | — | — | — | — | — | — | — | — | — |
| **12:00 PM** | 54 | — | — | 23 | — | — | — | — | — | — | — | — | — | — |
| **6:00 PM** | — | — | — | — | 41 | — | — | 168 | 96 | — | — | — | — | — |

The study team also conducted manual counts during both morning and evening peak periods at the 14th Street bridge intersection and Four Mile Run trail connector to collect count data and

make observations. The following diagrams show the directional behavior of the bicyclists and pedestrians during those times.

## MVT AND 14TH STREET BRIDGE INTERSECTION

Manual Pedestrian and Bicycle Counts
Tuesday, August 1, 2018
**PM Peak: 5:00 – 7:00 PM**

*Table 9: Summary of 14th Street Bridge intersection pedestrian and bicycle counts during PM peak*

| Total Counts | Pedestrians | Bicyclists |
|---|---|---|
| Leaving 14th Street Bridge | 19 | 467 |
| Entering 14th Street Bridge | 15 | 165 |
| Remaining on MVT | 71 | 274 |
| Total | 105 | 906 |

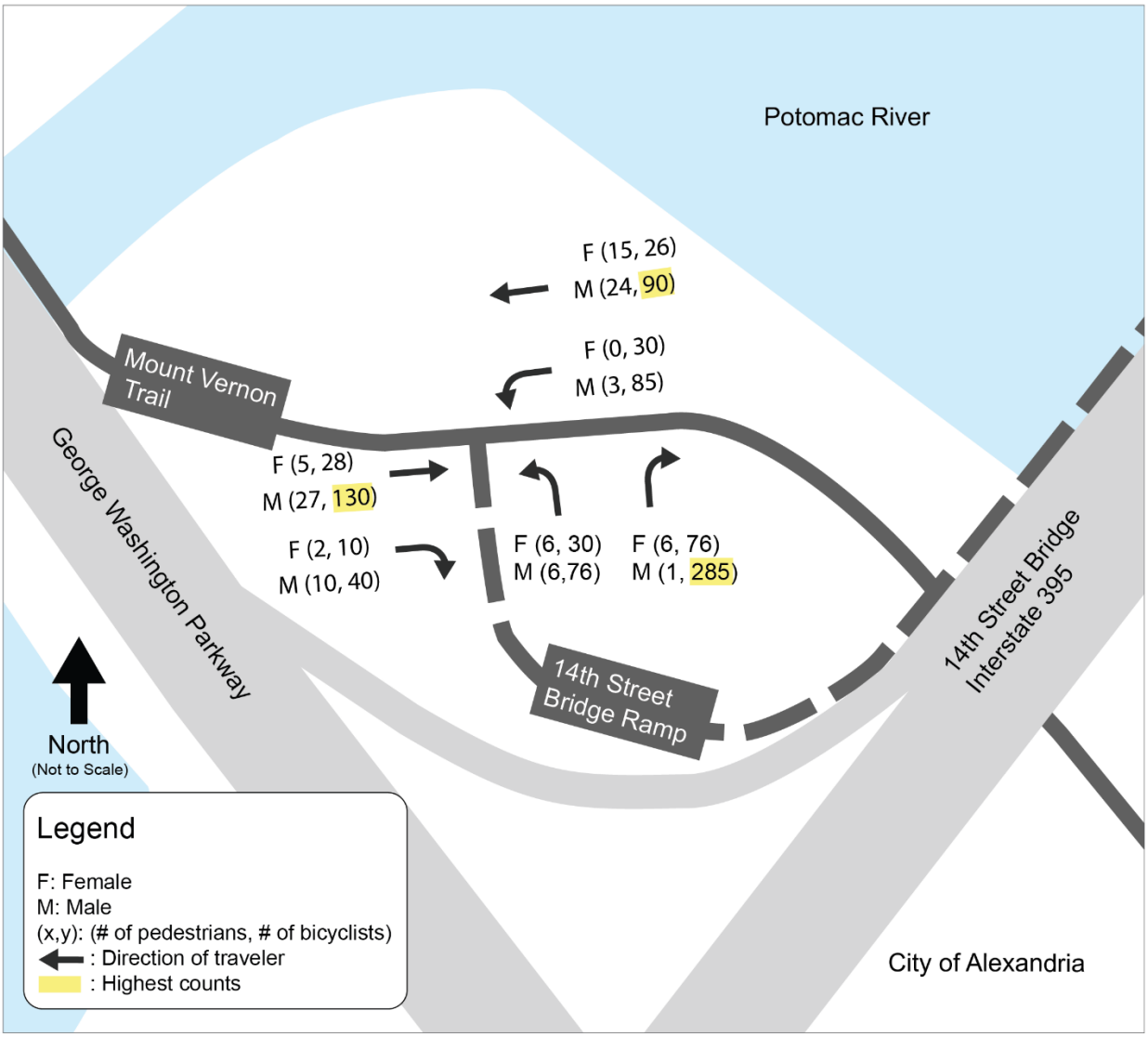



*Figure 68: 14th Street Bridge intersection pedestrian and bicycle PM peak counts diagram*

## MVT AND 14TH STREET BRIDGE INTERSECTION

Manual Pedestrian and Bicycle Counts
Wednesday, August 1, 2018
**AM Peak: 7:00 – 9:00 AM**

*Table 10: Summary of 14th Street Bridge intersection pedestrian and bicycle counts during AM peak*

| Total Counts | Pedestrians | Bicyclists |
|---|---|---|
| Leaving 14th Street Bridge | 9 | 87 |
| Entering 14th Street Bridge | 15 | 263 |
| Remaining on MVT | 28 | 117 |
| Total | 52 | 467 |

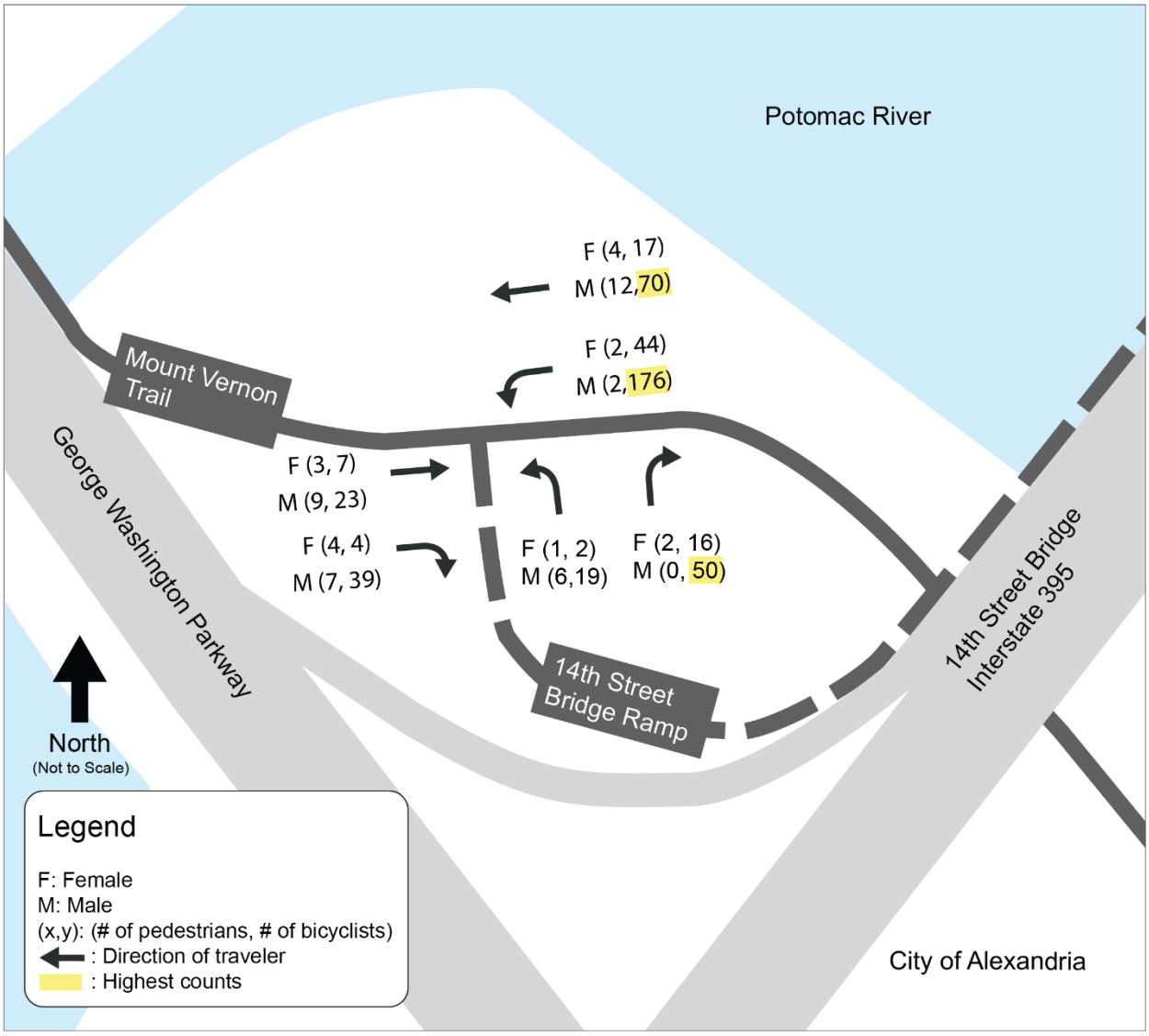



*Figure 69: 14th Street Bridge intersection pedestrian and bicycle AM peak counts diagram*

## MVT AND FOUR MILE RUN CONNECTION

Manual Pedestrian and Bicycle Counts
Tuesday, October 2, 2018
**PM Peak: 5:00 – 7:00 PM**

*Table 11: Summary of Four Mile Run connection pedestrian and bicycle PM peak counts*

| Total Counts | Pedestrians | Bicyclists |
|---|---|---|
| Leaving 4-mile Run | 30 | 107 |
| Entering 4-mile Run | 29 | 403 |
| Remaining on MVT | 41 | 238 |
| Total | 100 | 748 |

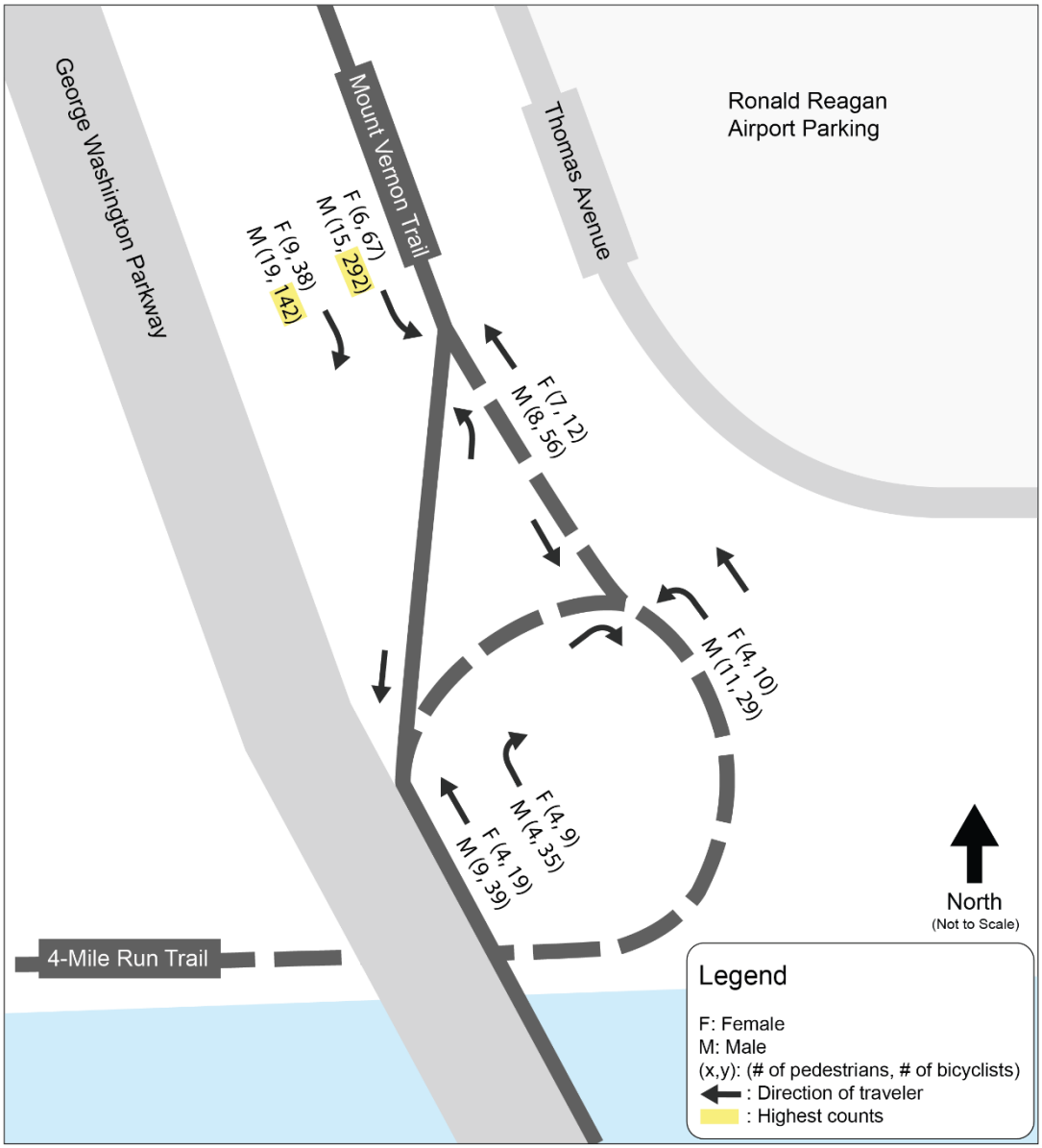



*Figure 70: Four Mile Run connection pedestrian and bicycle PM peak counts diagram*

## MVT AND FOUR MILE RUN CONNECTION

Manual Pedestrian and Bicycle Counts
Wednesday, October 3, 2018
**AM Peak: 7:00 – 9:00 AM**

*Table 12: Summary of Four Mile Run connection pedestrian and bicycle AM peak counts*

| Total Counts | Pedestrians | Bicyclists |
|---|---|---|
| Leaving 4-mile Run | 25 | 301 |
| Entering 4-mile Run | 19 | 63 |
| Remaining on MVT | 37 | 172 |
| Total | 81 | 536 |

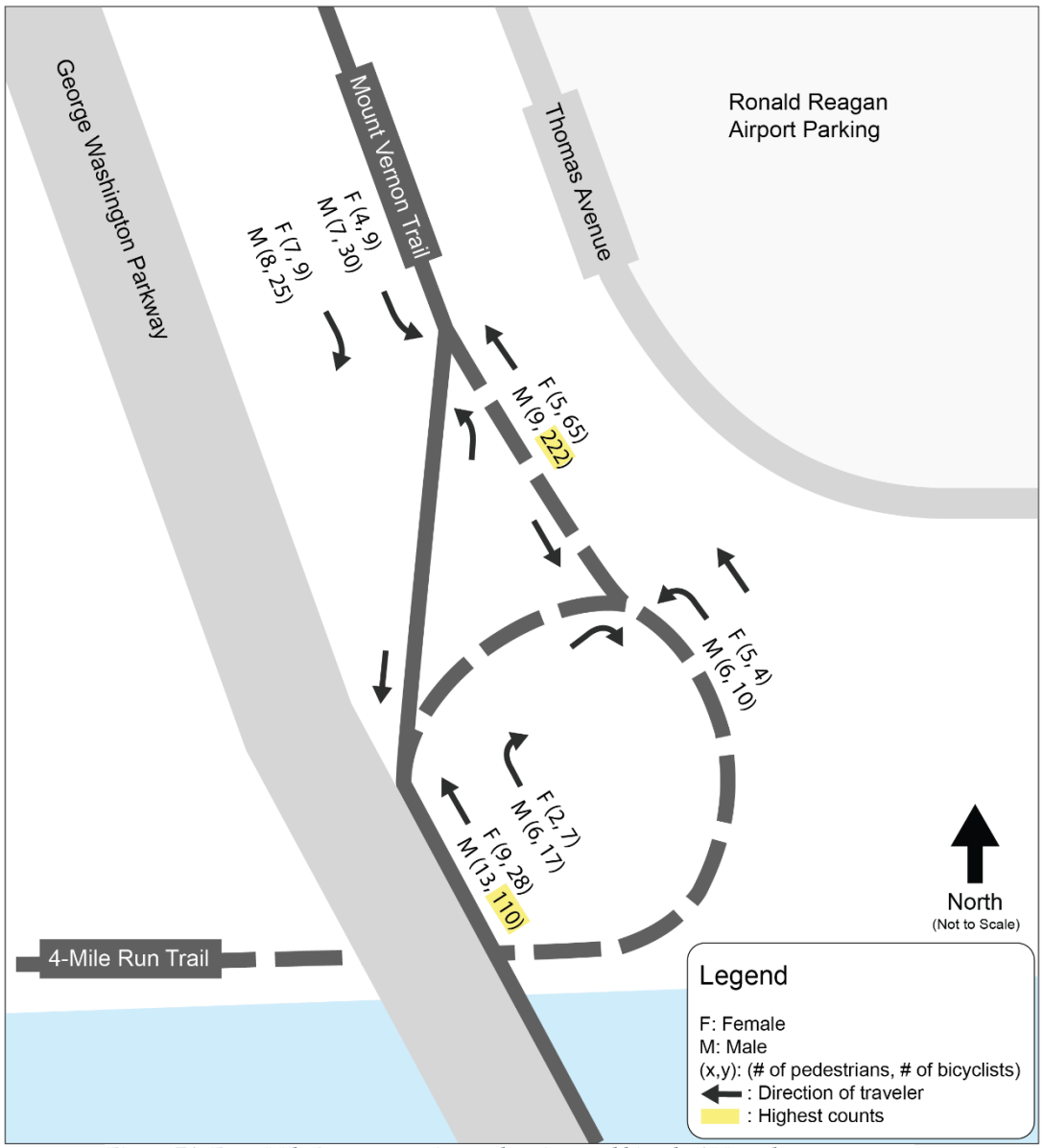



*Figure 71: Four Mile Run connection pedestrian and bicycle AM peak counts diagram*

# APPENDIX D – BRIDGE CONDITION DATA

*Table 13: Bridge size, materials, issues, and planned improvements, based on a synthesis of data and site observations.*

| Bridge | Length (feet) | Riding width (feet) | Surface | Last replaced | Banisters up to AASHTO[18] standards? | Observed Issues |
|---|---|---|---|---|---|---|
| 1 | 120 | 9.5 | Timber | 1997 | No, chain railings | Uneven surface, deck damage, rotting, broken railings |
| 2 | 24 | 9.75 | Timber | 2004 | Yes | |
| 3 | 147 | 9.75 | Timber | 2005 | Yes | Rotting, uneven surface |
| 4 | 50 | 9.75 | Timber | 2005 | Yes | Two cases of uneven boards |
| 5 | 57 | 9.75 | Timber | 2005 | Yes | Three cases of uneven boards |
| 6 | 111 | 10 | Timber | 2005 | Yes | Three cases of uneven boards, one broken board, railings in poor condition with missing bars |
| 7 | 24 | 10 | Timber | 2005 | Yes | Uneven surface, broken railings |
| 8 | 28 | 10 | Timber | 2005 | Yes | Uneven surface |
| 9 | 279 | 10 | Timber | 2005 | Yes | |
| 10 | 188 | 10 | Timber | 2005 | Yes | |
| 11 | 162 | 10 | Timber | 2004 | Yes | |
| 12 | 178 | 8 (14 planned) | Timber | Unknown | No, chain railings | Many boards are shaky, steep hills on both ends, narrow curve |
| 13 | 156 | 10 | Timber | 2005 | Yes | Uneven surface |
| 14 | 137 | 10 | Timber | 2005 | Yes | Uneven surface, uneven transition |
| 15 | 399 | 10 | Timber | 2005 | Yes | |
| 16 | 263 | 10 | Timber | 2005* | Yes | Banister (side) damage, overgrown vegetation, railings in poor condition, uneven transition |

[18] The American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities outlines standards for railings on trail bridges. The chain railings remaining on select MVT bridges do not meet the standards set forth by AASHTO. There is more detail on this topic in the Trail Design Considerations chapter.

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | 62 | 10 | Timber | 2005 | Yes | Banister (side) damage, overgrown vegetation |
| 18 | 13 | 8 | Timber | 2005* | Yes | Two cases of rotting deck boards |
| 19 | 121 | 10 | Timber | 2005 | Yes | Banister (side) damage, overgrown vegetation |
| 20 | 28 | 11 | Timber | 2005* | Yes | |
| 21 | 52 | 10 | Timber | 2005 | Yes | Poor bridge transition |
| 22 | 20 | 10 | Timber | Unknown | Yes | Uneven surface |
| 23 | 1,080 | 10, (14 planned ) | Timber | 1986 | No, chain railings | Two broken boards, rotting boards and banisters, significant bumps causing rider discomfort |
| 24 | 22 | 7.5, (14 planned ) | Timber | Unknown (re-decked 2014) | No, chain railings | Four loose deck boards, significant bumps causing rider discomfort, railings in poor condition |
| 25 | 34 | 10 | Timber | Unknown | No, chain railings | Banisters rotting |
| 26 | 96 | 9.5 | Timber | Unknown | No, chain railings | A few banisters out of place, leaning over, uneven surface |
| 26A (Power Plant) | 152 | 9.5 | Concrete | Unknown | Enclosed metal fence | Rusted fencing, overgrown vegetation |
| 27 (2 parts) | 782 (both parts) | 11.75 | Timber | Approximately 1995* | Timber and metal fencing on waterfront portion; chain railings on northern portion | Loose deck boards, rotting boards and overgrown vegetation |
| 28 | 538 | 9.5 | Timber | Approximately 1995 | No, chain railings | Severe damage from flooding. |
| 29 | 40 | 10 | Timber | Unknown | No, chain railings | Weed encroachment, |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | uneven surface, warped boards |
| 29A | 334 | 8.5 | Concrete | Unknown | Yes | Overgrown vegetation obscuring view leading up to bridge on both sides |
| 29B | 240 | 12 | Concrete | 1999 | Yes | |
| (29-?, unlabeled) | 103 | 12 | Concrete | 1999* | Yes | |
| 29C-north | 308 | 12 | Concrete | 1999 | Yes | |
| Humpback bridge (unlabeled) | 295 | 9.75 | Concrete | 2011 | Yes | |
| 30A | 130 | 10 | Concrete | Unknown | Yes | |
| 31 | 1,192 | 11, (14 planned | Timber | 1987* | No, chain railings | Waste buildup underneath bridge |
| Rosslyn Bridge | 419 | 14) | Concrete | 1988* | Yes | Rusted railing, weed encroachment |

**Estimated from bridges that appear to have been constructed at a similar time*

These data were compiled from the following sources:

- *Length:* MVT Bridge Inspection Book (from John Stefaniak at NPS); FMSS data; on-site and Google Earth measurements to corroborate
- *Width:* On-site measurements
- *Material:* MVT Damage Assessment spreadsheet; on-site observations; photos from NPS
- *Last replaced:* MVT Bridge Inspection Book
- *Banisters:* On-site observations; photos from NPS
- *Observed Issues:* 2017 MVT Assessment (GIS); MVT Bridge Inspection Book; photos from NPS; on-site observations to corroborate

# APPENDIX E – AT-GRADE TRAIL INTERSECTIONS

The study team identified trail crossings along the trail in each zone.

**Zone 1—Fairfax County**

1. *Feeder road to GWMP ramp*—Fort Hunt Road & GWMP underpass
2. *Local street that merges onto GWMP*—9118 Fort Hunt Road
3. *Local street that merges onto* GWMP—Waynewood Boulevard & West Boulevard Drive
4. *Local street that merges onto GWMP*—Collingwood Boulevard & West Boulevard Drive
5. *Local street that merges onto GWMP*—Chadwick Ave & West Boulevard Drive
6. *Local street that merges onto GWMP*—Wellington Road & West Boulevard Drive
7. *Local street that merges onto GWMP*—7385 West Boulevard Drive & GWMP
8. *Local street, overpass of GWMP*—Alexandria Ave & West Boulevard Drive (transition to on-street portion on Northdown Rd)
9. *Local street that merges onto GWMP*—7705 Northdown Road & GWMP (transition to on-street portion on Northdown Rd)
10. *Driveway that merges onto GWMP*—Belle Haven Park Driveway
11. *Local street and driveway*—1200 Thornton Way & GWMP
12. *Local street and driveway*—S. Washington St. &Hunting Point (@ intersection with Capital Beltway)

**Zone 2—Alexandria**

13. *Local street (transition to on-street portion)*—Potomac Street & Jefferson Street
14. *Local street (transition to on-street portion)*—166 Pendleton St (transition to on-street portion)
15. *Local street*—249 Madison Street
16. *Local street*—299 Montgomery Street
17. *Local street*—61 Canal Center Plaza
18. *Local street*—N Royal St & Bashford Lane
19. *Local street, feeder to GWMP*—1477 East Abingdon Drive
20. *Local street, feeder to GWMP*—East Abingdon Drive & Slaters Lane
21. *Drive that merges onto GWMP*—47-1 Marina Drive

**Zone 3—Arlington/District of Columbia**

22. *Feeder road to GWMP ramp*—South Smith Blvd near Thomas Avenue and Abingdon Drive
23. *GWMP ramp*—South Smith Blvd & GWMP
24. *GWMP ramp*—Gravelly Point Boat Ramp & GWMP

# Appendix F – At-Grade Trail Intersection Signage & Markings

The study team documented signage and marking conditions at each at-grade trail intersection crossing. The table below summarizes the signage and markings provided for motorists as they approach the trail crossing from either side of the trail intersection.

| Crossing Location | Crosswalk? | Eastbound Signage | Westbound Signage | Notes |
|---|---|---|---|---|
| Fort Hunt Road & GWMP underpass | N/A | Pedestrian | Pedestrian | On-street portion of trail |
| 9118 Fort Hunt Road | Yes | None | Bicycle | |
| Waynewood Boulevard & West Boulevard Drive | Yes | Pedestrian | Pedestrian | |
| Collingwood Boulevard & West Boulevard Drive | Yes | None | Bicycle | |
| Chadwick Ave & West Boulevard Drive | No | None | None | Unique street – effectively a driveway. Trail is signed as yield |
| Wellington Road & West Boulevard Drive | Yes | None | Pedestrian | Roadway intersection occurs before trail crossing on eastbound approach |
| 7385 West Boulevard Drive & GWMP | Yes | None | Pedestrian | Roadway intersection occurs before trail crossing on eastbound approach |
| Alexandria Avenue & West Boulevard Drive | No | None | None | Trail transitions to on-road portion at this crossing |
| 7705 Northdown Road & GWMP | No | None | None | On-street portion of trail |
| Belle Haven Park Driveway | Yes | Bicycle | Bicycle | |
| 1200 Thornton Way & GWMP | Yes | Stoplight | Stoplight | Crossing is at a driveway; variety of signs for both motorists & trail users |
| S. Washington Street & Hunting Point | Yes | Stoplight | Stoplight | Crossing is at roadway intersection |
| Potomac Street & Jefferson Street | N/A | N/A | N/A | On-street portion of trail |
| 166 Pendleton Street | N/A | N/A | N/A | On-street portion of trail |
| 249 Madison Street | N/A | N/A | N/A | On-street portion of trail |
| 299 Montgomery Street | N/A | N/A | N/A | On-street portion of trail |
| 61 Canal Center Plaza | N/A | N/A | N/A | On-street portion of trail |
| N. Royal Street & Bashford Lane | N/A | N/A | N/A | MVT alternative alignment through Alexandria |
| 1477 East Abingdon Drive | N/A | N/A | N/A | MVT alternative alignment through Alexandria |
| 47-1 Marina Drive | N/A | N/A | N/A | MVT alternative alignment through Alexandria |
| S. Smith Boulevard near Thomas Avenue | Yes | None | None | This ramp is closed to vehicle traffic |

| | | | | |
|---|---|---|---|---|
| **S. Smith Boulevard & GWMP** | Yes | Pedestrian | N/A | Three pedestrian signs on eastbound approach; one-way ramp to GWMP |
| **Gravelly Point Boat Ramp & GWMP** | Yes | Bicycle | Bicycle | Motorists have stop signs on either side of crossing at parking lot |

# APPENDIX G – TRAIL WIDTH

The study team documented the width of the trail at every ¼-mile at a site visit on June 5, 2019. These widths are reported in the table below. Miles 8 through 11 represent the on-street portion of the trail in Alexandria, and therefore were not measured.

| Mile | Trail Width |
|---|---|
| 0 | 9.5 ft |
| 0.25 | 9 ft |
| 0.5 | 9 ft |
| 0.75 | 9 ft |
| 1 | 9 ft |
| 1.25 | 8 ft |
| 1.5 | 10 ft |
| 1.75 | 8.5 ft |
| 2 | 9 ft |
| 2.25 | 9 ft |
| 2.5 | 9 ft |
| 2.75 | 9 ft |
| 3 | 9 ft |
| 3.25 | 9 ft |
| 3.5 | 9 ft |
| 3.75 | 9 ft |
| 4 | 9 ft |
| 4.25 | 9 ft |
| 4.5 | 9 ft |
| 4.75 | 8 ft |
| 5 | 8.5 ft |
| 5.25 | 8 ft |
| 5.5 | 9 ft, 4 in |
| 5.75 | 9 ft |
| 6 | 9 ft |
| 6.25 | 9 ft |
| 6.5 | 9 ft |
| 6.75 | 9 ft |
| 7 | 9 ft |
| 7.25 | 9 ft |
| 7.5 | 9 ft, 8 in |
| 7.75 | 9 ft |
| 8 | — |
| 8.25 | — |
| 8.5 | — |
| 8.75 | — |
| 9 | — |

| Mile | Trail Width |
|---|---|
| 9.25 | — |
| 9.5 | — |
| 9.75 | — |
| 10 | — |
| 10.25 | — |
| 10.5 | — |
| 10.75 | — |
| 11 | 9 ft |
| 11.25 | 9.5 ft |
| 11.5 | 9 ft |
| 11.75 | 9 ft |
| 12 | 9 ft |
| 12.25 | 9 ft |
| 12.5 | 8.25 ft |
| 12.75 | 8.75 ft |
| 13 | 9 ft |
| 13.25 | 11 ft |
| 13.5 | 8.5 ft |
| 13.75 | 9 ft |
| 14 | 9 ft |
| 14.25 | 9.5 ft |
| 14.5 | 7 ft, 7 in |
| 14.75 | 8.75 ft |
| 15 | 9 ft |
| 15.25 | 10.5 ft |
| 15.5 | 10 ft |
| 15.75 | 8 ft |
| 16 | 8.5 ft |
| 16.25 | 8.75 ft |
| 16.5 | 8 ft |
| 16.75 | 8 ft |
| 17 | 8 ft |
| 17.25 | 8.75 ft |
| 17.5 | 9 ft |
| 17.75 | 12.5 ft |
| 18 | — |