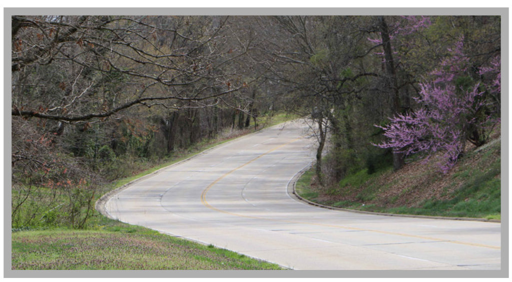
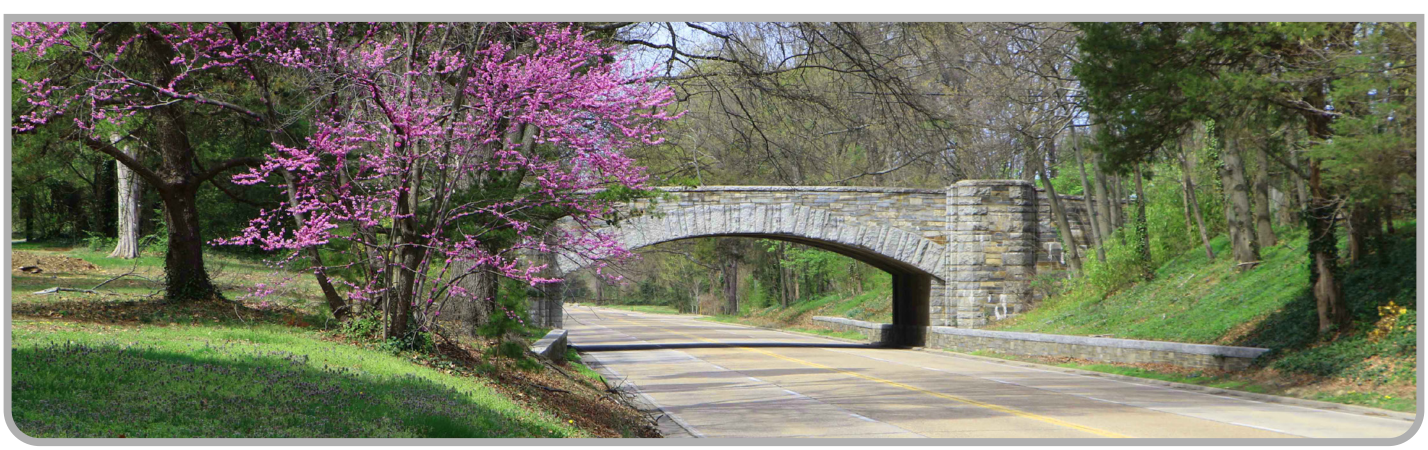
NATIONAL PARK SERVICE • U.S. DEPARTMENT OF THE INTERIOR

George Washington Memorial Parkway

Traffic and Safety Context Sensitive Solutions Assessment

APRIL 2021





This page intentionally blank.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE
- 7/31/2020

2. REPORT TYPE Final Report

3. DATES COVERED *(From - To)*November 2018 - July 2020

4. TITLE AND SUBTITLE

George Washington Memorial Parkway: Traffic and Safety Context Sensitive Solutions Assessment

5a. CONTRACT NUMBER DTFH71-13-D-00002L

5b. GRANT NUMBER: Task Order 693C7319F000010

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Natalie Villwock-Witte, Ph.D., P.E.; Karalyn Clouser; Paul Silberman; Alicia Romo; Brian Laverty; and Casen Keller

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Western Transportation Institute, Montana State University; PO Box 174250, Bozeman, MT 59717-4250; and Mead & Hunt, 7055 Samuel Morse Dr #100, Columbia, MD 21046

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Federal Highway Administration - Eastern Federal Lands Highway Division 21400 Ridgetop Circle Sterling, VA 20166-6511

10. SPONSOR/MONITOR'S ACRONYM(S)
EFLHD

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT: The George Washington Memorial Parkway (GWMP) is a scenic and historic roadway that runs along the south bank of the Potomac River between Mount Vernon and I-495. This study is a traffic and safety assessment, focusing on nine intersections located in the southern segment between the City of Alexandria and Mount Vernon. The purpose is to identify potential concepts for enhancing traffic safety that are also appropriate (context sensitive) for a national park setting. The report presents existing traffic conditions and crash experience for all nine intersections. It also summarizes the the process for identifying and screening concepts, and recommendations for each intersection.

15. SUBJECT TERMS: Traffic safety evaluation, context sensitive solutions, crash analysis

<table>
<tr><td colspan="5">REPORT DOCUMENTATION PAGE</td><td>Form Approved OMB No. 0704-0188</td></tr>
<tr><td colspan="3">16. SECURITY CLASSIFICATION OF:</td><td rowspan="2">17. LIMITATION OF ABSTRACT</td><td rowspan="2">18. NUMBER OF PAGES
252</td><td>19a. NAME OF RESPONSIBLE PERSON</td></tr>
<tr><td>a. REPORT</td><td>b. ABSTRACT</td><td>c. THIS PAGE</td><td>19b. TELEPHONE NUMBER (Include area code)</td></tr>
</table>

CONTENTS

TABLES

FIGURES

This page intentionally blank.

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
DMS	Dynamic message sign
DUI	Driving under the influence
EFL	Eastern Federal Lands
FAT	Fatality
FHWA	Federal Highway Administration
GWMP	George Washington Memorial Parkway
HCM	*Highway Capacity Manual*
H&R	Hit and run
INJ	Injury
LOS	Level of service
MPH	Miles per hour
MVT	Mount Vernon Trail
NHTSA	National Highway Traffic Safety Administration
NPS	National Park Service
NTSB	National Transportation Safety Board
PDO	Property damage only
PEPC	Planning, Environment and Public Comment
ROW	Right-of-way
RRFB	Rectangular Rapid Flash Beacon
USDOT	US Department of Transportation
USPP	US Park Police

This page intentionally blank.

PREFACE

George Washington Memorial Parkway (the Parkway, GWMP) was established by Public Law 71-284 (the Capper-Cramton Act) on May 29, 1930. The Parkway runs along the Potomac River through two states — Virginia and Maryland — as well as the District of Columbia and protects the landscape and natural shoreline of the river while offering magnificent scenic vistas of Washington, DC, and the Great Falls of the Potomac. Along its route, the Parkway also connects several important historic sites, memorials, and scenic and recreation areas in the Washington, DC, metropolitan area.

The Parkway is part of a comprehensive system of parks, parkways, and recreational areas surrounding the nation's capital and a nationally significant scenic transportation corridor linking Mount Vernon with Great Falls on the Potomac. It also preserves invaluable historic, recreational, and natural resources along the Potomac River Valley and has strongly influenced parkway and highway design throughout the United States.

The Parkway helps preserve the Potomac River Gorge and shoreline while serving as a memorial to George Washington, the first president of the United States. The Potomac Gorge is one of the most significant natural areas in the United States and is home to many rare species and communities (Walsh, et al. 2016). The Parkway also houses several unique habitats, including a major river system with numerous tributaries, noteworthy stands of upland forest, seeps and springs harboring rare groundwater fauna, and abundant wetlands (Allen and Flack 2001). Today, the Parkway connects some of the most important historic, natural, and cultural sites from Mount Vernon to Great Falls Park and provides a sanctuary for many rare and unique plant and animal species in the urbanized Washington, DC metropolitan area (NPS 2014). The Parkway comprises a total of 7,146 acres and extends 38.3 miles on both sides of the Potomac River in Virginia and Maryland. Within the Parkway, there are 27 sites associated with George Washington's life and the nation he helped establish. The Parkway is a key transportation artery in northern Virginia, providing access to Washington, DC, Arlington County, Fairfax County, and the City of Alexandria. Many neighboring communities consider the Parkway a commuter route; however, from its inception, the Parkway was established as a recreational and environmental conservation area (NPS 2008). By definition, a parkway is an attenuated (thin) park with a road through it, but a park, nonetheless. The road allows visitors to experience the park, much as a trail is the means to experience the mountains.

The Parkway was built in stages between 1929 and 1970. Construction on the portion originally known as the Mount Vernon Memorial Highway was completed in three years, opening in 1932 for the bicentennial of George Washington's birth (Walsh, et al. 2016). The Mount Vernon Memorial Highway is nationally significant as the first parkway built and maintained by the US government. The intended purpose of the Mount Vernon Memorial Highway was to provide an appropriately designed commemorative pilgrimage route to Mount Vernon as a memorial to George Washington, and this purpose is its most significant historic characteristic. The Parkway's numerous national monuments, historic sites, parks, and other landscaped green spaces visible along the corridor are integral to its character and significance. The Mount Vernon Memorial Highway links Mount Vernon, in Fairfax County, with the Arlington

Memorial Bridge. The original 15.2-mile segment was designed and landscaped to maximize its scenic, aesthetic, and commemorative qualities along its route.

Beyond the project study area, the northern section of the Parkway includes both sides of the Potomac River from Arlington Memorial Bridge to the Capital Beltway/Interstate 495, a distance of 9.7 miles in Virginia, and the 6.6-mile Clara Barton Parkway in Maryland. This portion protects scenic vistas, contains numerous historic architectural and archeological resources, and serves as another quality entryway into Washington, DC.

In 2005, the US Department of Transportation designated the Parkway as an All-American Road in the National Scenic Byways Program. This program recognizes selected roadways throughout the United States based on their archeological, cultural, historic, natural, recreational, and scenic qualities and seeks to protect them (NPS 2005). The Parkway is listed on the National Register of Historic Places through three separate nominations: the Mount Vernon Memorial Highway, the George Washington Memorial Parkway, and the Parkways of the National Capital Region. The Parkway is part of a multiple property listing on the National Register of Historic Places. Its designation is based upon properties that are associated with the lives of persons significant in the nation's past and properties that embody the distinctive characteristics of a type, period, or method of construction in transportation/vehicle-road-related landscape architecture.

Another area of historical significance is the planning efforts related to parkways and roadways in the region that Pierre L'Enfant began in the 18th century and Frederick Law Olmstead, Jr., continued with in the early 20th century. Specific efforts in the early 20th century, which incorporated the Parkway, included in the Park Improvement Commission of the District of Columbia (commonly known as the "McMillan Plan" of 1902). Olmstead was the principal landscape architect for the McMillan Plan. Olmsted pushed for "intensively used" parks and connections between parks, including a road network that would extend parks to the perimeters of the regional city (specifically to Mount Vernon) and along both sides of the Potomac to Great Falls. Charles W. Eliot II, an official of the National Capital Park and Planning Commission instrumental in the development of the Parkway, and Olmsted stated the importance of parks and linkages between them and gave a strong endorsement to the McMillan Commission's findings for a parkway along the Potomac.

Rather than apply a traditional highway design solution, future changes to the Parkway will need to scale appropriately and be ever attentive to context sensitivity. It is within this context that the National Park Service would review, evaluate, and consider changes to the Parkway. The project team excluded potential solutions that are not consistent with Parkway design in this document. Construction, repair, and ground or visual disturbances require the National Park Service to meet requirements of Section 106 of the National Historic Preservation Act as well as any other laws or policies. Chapter 4 describes the importance of context sensitivity when evaluating changes and presents roadway design features that are part of the Parkway character. Road facilities are thought of not for their function alone, but how they lay on the land, are seen by the motorist, framed in the viewshed, affect the tree canopy, impact sensitive archeological sites, and become part of the transportation system. A treatment (e.g., a sign) or change is not only specific to an intersection but also examined for its cumulative effects on the Parkway. As the Parkway implements the various recommendations within the study, adaptations need to be context sensitive. This approach ensures that the Parkway's character and visitor experience remain intact and that the National Park Service has fulfilled its stewardship responsibilities.

This page intentionally blank.

EXECUTIVE SUMMARY

The George Washington Memorial Parkway (the Parkway) was established in 1930 as a scenic roadway running along the Potomac River through two states — Virginia and Maryland — as well as the District of Columbia, protecting the landscape and natural shoreline of the river while offering magnificent scenic vistas of Washington, DC, and the Great Falls of the Potomac. Along its route, the Parkway also connects several important historic sites, memorials, and scenic and recreation areas in the Washington, DC, metropolitan area.

A parkway, by definition, is a narrow park with a road through it, but a park, nonetheless. The road allows visitors to experience the park, much as a trail is the means to experience the mountains. Listed on the National Register of Historic Places, the Parkway is nationally significant due its association with lives of persons significant in the nation's past and for it being the first parkway built and maintained by the US government. It is within this context that the National Park Service would review, evaluate, and consider changes to the Parkway.

The purpose of this traffic and pedestrian safety assessment is to investigate traffic and operational issues and develop context-sensitive solutions to make improvements while maintaining the Parkway's scenic and historic character. The stakeholder team of transportation safety professionals from multiple local, state, and federal agencies reviewed multi-modal traffic data and crash data, performed fieldwork, and developed and screened a menu of potential engineering and enforcement traffic safety treatments. At two key points in the project, the team engaged input from stakeholders, elected officials, and the public.

This traffic and safety assessment focuses on the following nine intersections, shown in Figure 1, that span 6.3 miles along the southern segment between the city of Alexandria and Mount Vernon:

1. Belle Haven Road
2. Belle View Boulevard
3. Tulane Drive
4. Morningside Lane
5. Wellington Road
6. Collingwood Road
7. Waynewood Boulevard
8. Vernon View Drive
9. Stratford Lane

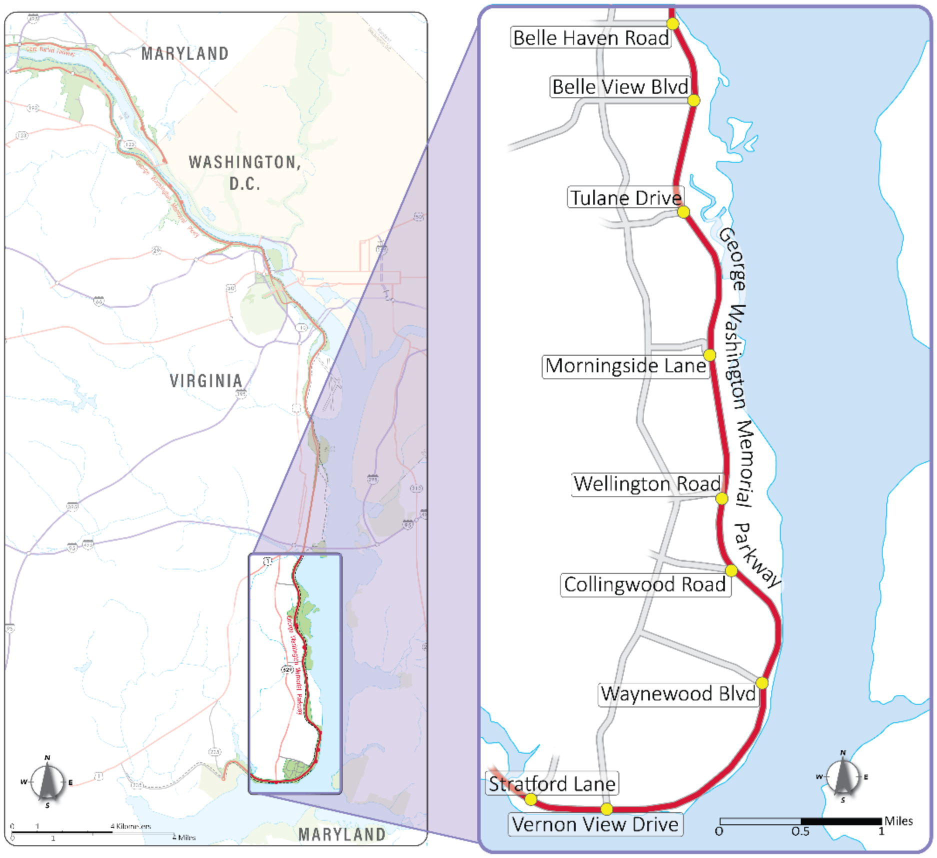


Figure 1. General Location Map

In order to provide data-driven recommendations, it is important to understand existing Parkway conditions. The study team collected data on traffic control at intersections, locations of transit stops in the corridor, locations of pedestrian and bicycle facilities, traffic counts, observed speeds, traffic capacity, queuing (the line of vehicles waiting to turn onto the Parkway), stop delay, and parking lot capacity. There were several key takeaways:

- The speed data collected indicated that the median speed is above the posted speed limits, with the 85th percentile speed ranging from 8–12 mph above the posted speed limits.
- Queuing, a measure of the number of vehicles waiting at a traffic control device to enter a traffic stream, was greatest during the morning peak period for the side streets accessing the Parkway, with the largest queues seen at the northern intersections along the corridor.
- Some intersections have wide medians with trees (e.g., Stratford Lane), whereas other intersections have only a double yellow line separating two lanes of traffic in each direction (e.g., Morningside Lane).
- When the Mount Vernon Trail (MVT) runs along the west side of the Parkway, a vehicle turning from the Parkway onto a side street may not see a crossing pedestrian/bicyclist.

The team analyzed tabular data for 389 crashes (2005–2015 and 2018–2019) across the nine intersections. Overall, while there is some variation across intersections, crashes seem to be overrepresented in April (Morningside Lane, Wellington Road, Collingwood Road, Vernon View Drive, and Stratford Lane) and on Fridays (Belle View Boulevard, Tulane Drive, Morningside Lane, Wellington Road, and Collingwood Road). Therefore, in addition to the proposed geometric and traffic operation modifications that may assist with clarifying rights-of-way (at some intersections) and reducing speeds at other locations, the Parkway, in cooperation with the US Park Police (USPP), could conduct focused traffic enforcement efforts. This, in cooperation with education (e.g., "look for pedestrians" in the month of April), could assist with improving safety in the corridor.

This study identifies 89 potential solutions, including suggestions from the public, stakeholders, and elected officials. These solutions include nine categories: (1) driver behavior, (2) signs and markings, (3) operational changes, (4) multimodal improvements, (5) geometric modifications, (6) roadway departure countermeasures, (7) maintenance, (8) environmental, and (9) Fort Belvoir improvements. The team narrowed down these potential solutions using two filters. The first filter removed potential solutions that were outside of this project's focus (e.g., vehicles hitting the stone arch bridge). The second filter removed potential solutions that were not consistent with the context-sensitivity considerations of the Parkway.

The team then removed remaining potential solutions using the following criteria: (1) traffic safety benefit, (2) law, policy, and regulatory compatibility, (3) implementation timeline, (4) traffic operational benefits, (5) supporting analysis, (6) construction cost, (7) responsible agency for implementation, (8) right-of-way (ROW), and (9) community support. The team categorized the remaining 26 alternatives into engineering, education, and enforcement solutions (following the 3E approach to safety). This study identifies a range of alternatives, as each intersection will likely need a custom solution (or mix of solutions) to address its specific traffic and safety capacity issues.

1. The following list shows the top three results in each category: Engineering (specifically geometric modifications)
    a. Roundabout
    b. Road diet
    c. Longitudinal rumble/mumble strips
2. Education
    a. Speed public awareness campaign
    b. Pedestrian safety public awareness campaign
    c. Distracted driving public awareness campaign
3. Enforcement
    a. Commercial vehicle enforcement/educational campaigns
    b. Increased enforcement of speeding, driving under the influence, and distracted driving
    c. Automated speed enforcement (speed cameras)

The study includes detailed engineering design concepts for the four potential engineering solutions:

1. Access management
2. Road diets
3. Roundabouts
4. Pedestrian/bicycle refuge islands

In addition to these major geometric modifications, this study describes other minor engineering measures, including enhanced signs/pavement markings, lighting, rumble strips/mumble strips, and roadway maintenance such as selective repaving, vegetation trimming, and drainage cleaning.

Several examples of educational campaigns are presented that can provide solutions to some of the crash causes. For example, the study recommends that a speed management plan be developed for the corridor, as the data showed that both the median and 85th percentile speeds are well above the posted speed limits at multiple locations within the corridor.

The following are global recommendations for the study corridor:

1. Develop a program to trim trees and shrubs on a regular basis during the growing season.
2. Initiate education and enforcement measures to reduce excessive speeds, including:
    a. Speed management action plan
    b. Public awareness campaign of the Parkway in a national context
    c. Enforce speeds via manual and automated methods.
3. Reapply the pavement markings for improved conspicuity and develop a plan to reapply markings on a regular basis.
4. Reevaluate crash data collection within the corridor. Detailed crash data provides significant value in understanding crash causes along with demonstrating the impacts of implemented solutions.
5. Install mumble strips to keep vehicles on the roadway.
6. Use dynamic message signs to alert drivers to the presence of wildlife along the corridor from Belle Haven Road to Waynewood Boulevard. The signs are recommended from mid-October through the end of November and between 5:30 p.m. and 9:00 a.m. The signs could remain dark outside of these periods to increase conspicuity.
7. Develop a public awareness educational campaign starting at the end of March to remind motorists about the increasing presence of pedestrians, bicyclists, and motorcyclists who are also using the corridor.

The following are key recommendations that are above and beyond the global recommendations by intersection:

1. Belle Haven Road
    a. Channelize left turns in the median.
    b. Create an acceleration lane at the U-turn location at Belle Haven Marina.
2. Belle View Boulevard
    a. Implement a median U-turn.
3. Tulane Drive
    a. Implement a roundabout while retaining the high-quality access to the Mount Vernon Trail that currently exists (e.g., investigate the possibility of a pedestrian/bicycle roundabout outside of the vehicular roundabout).
4. Morningside Lane, Wellington Road, Collingwood Road, Waynewood Boulevard, and Vernon View Drive
    a. Implement a road diet throughout these intersections to calm vehicle speeds and provide a center turn lane.
    b. For Wellington Road, implement a rectangular rapid flash beacon with a refuge island to address pedestrian/bicyclist crossings.

Based on the recommendations in this study, the National Park Service plans to implement a road diet between four intersections (Morningside Lane, Wellington Road, Waynewood Boulevard, and Vernon View Drive) in 2021. This plan includes signs and striping to calm vehicle speeds and provide a center turn lane. Additionally, the National Park Service will improve signs and striping to five MVT crossings (Belle Haven Marina, Wellington Road, Collingwood Road, Waynewood Boulevard, and Fort Hunt Road).

The findings and recommendations in this report are intended to help the National Park Service make informed decisions when considering traffic and safety mitigation actions and future planning decisions for the Parkway.

Potential solutions must be carefully considered to ensure that they are context sensitive. Furthermore, potential impacts on traffic operations and traffic safety, costs, and maintenance for the National Park Service also must be considered.

This page intentionally blank.

1. STUDY SCOPE AND EXISTING TRAFFIC AND ROADWAY CONDITIONS

The purpose of this traffic and pedestrian safety assessment is to investigate traffic and operational issues and develop context sensitive solutions to make improvements while maintaining the Parkway's scenic and historic character.

This study included a stakeholder team of transportation safety professionals including the National Park Service, Federal Highway Administration (FHWA), Eastern Federal Lands (EFL) Highway Division, US Park Police, Virginia Department of Transportation, the city of Alexandria, and Fairfax County. Input was solicited from elected officials, community groups (e.g., Mount Vernon Council of Citizens' Associations, Inc.), individual members of the public, and advocacy groups such as the Friends of the Mount Vernon Trail.

The study process included numerous tasks to develop a deep understanding of traffic safety and operational conditions along the Parkway, including the following:

- Creating project base maps
- Collecting multi-modal traffic data at study locations, including car, bus, truck, pedestrian and bicycle traffic volumes, transit boardings, and parking use
- Performing a roadway safety field audit of existing roadway design features
- Conducting field measurements of traffic conditions such as speeds, queues, and gaps for entering traffic
- Completing field observations of risky behavior by motorists, pedestrians, and bicyclists
- Assessing existing traffic capacity and creating a traffic model of the corridor
- Obtaining, reviewing, and analyzing tabular crash data
- Developing and screening a menu of potential engineering and enforcement traffic safety treatments, with input from the stakeholders, elected officials, and public
- Conducting two rounds of public engagement
- Evaluating a retained list of engineering, enforcement, and educational traffic safety solutions for context appropriateness, cost, traffic operations, safety performance, and geometric design
- Identifying a final set of recommendations for implementation

This study focused on nine key intersections along the Parkway between the city of Alexandria and Mount Vernon. This report evaluates the following intersections within the Parkway, as well as Parkway segments between them:

1. Belle Haven Road
2. Belle View Boulevard
3. Tulane Drive
4. Morningside Lane
5. Wellington Road
6. Collingwood Road (including Collingwood Road and East and West Boulevard Drive)
7. Waynewood Boulevard
8. Vernon View Drive (VA 629)
9. Stratford Lane

Figure 2 shows the study area map with the traffic control from each approach and posted speed limits identified.

Figure 2. Study Corridor: Traffic Controls and Speed Limits

Commercial vehicle access is prohibited along the roadway without a permit from the National Park Service (Code of Federal Regulations 2012) (Code of Federal Regulations 1997). While there are no sidewalks and bicycles are prohibited on the roadway (NPS 2011), adjacent to the roadway is the Mount Vernon Trail. This trail is an 18-mile paved multiuse trail that stretches from George Washington's Mount Vernon Estate to Theodore Roosevelt Island. The trail connects with regional trails, including the Potomac Heritage, Custis, Rock Creek, Four Mile Run, and Woodrow Wilson Bridge Trails. In addition to vehicular traffic traveling to see the sites along the corridor, the roadway is a heavily used commuter route. The heavy commuter traffic flow can create challenges for vehicular traffic traveling between sites, commuters egressing adjacent neighborhoods onto the Parkway, as well as pedestrians and bicyclists crossing the Parkway to access recreational facilities, bus stops, and the Mount Vernon Trail. Furthermore, the design of the roadway was not intended for the point-to-point travel that many commuters prefer — the roadway includes trees along the corridor, gradual rises and falls, and gentle curvature to allow drivers to see the beauty of the surrounding landscape. The Parkway was also developed at a time when vehicles traveled at slower speeds. There have been previous efforts to recommend safety solutions at specific locations within the southern corridor; however, the frequency and severity of crashes persists (Ocel 2019).

1.1 Roadway Design Elements

At the time of initial construction, the Parkway's roadway design was forward thinking; however, design standards have significantly changed (Harwood, Potts and Prosser 2002) along with vehicle capabilities, such as faster speeds. While right- and left-turn auxiliary lanes and medians are present at several locations in the corridor, some intersections with a large number of crashes do not have median or left-turn lanes. Typical travel lane widths are 10 feet wide and raised and marked median widths vary. A mountable curb bounds the roadway section and has storm drains to collect rainwater. Existing typical roadway sections, labeled A, B, C, and D are shown in Figure 3. Measurements were taken at four select locations, representing where distinct transitions in configurations were found (e.g., from a section with a median to a section without a median); therefore, some variability may be present within the identified typical roadway section (e.g., indications are that pavement widths may be as narrow as 8 feet in select locations).

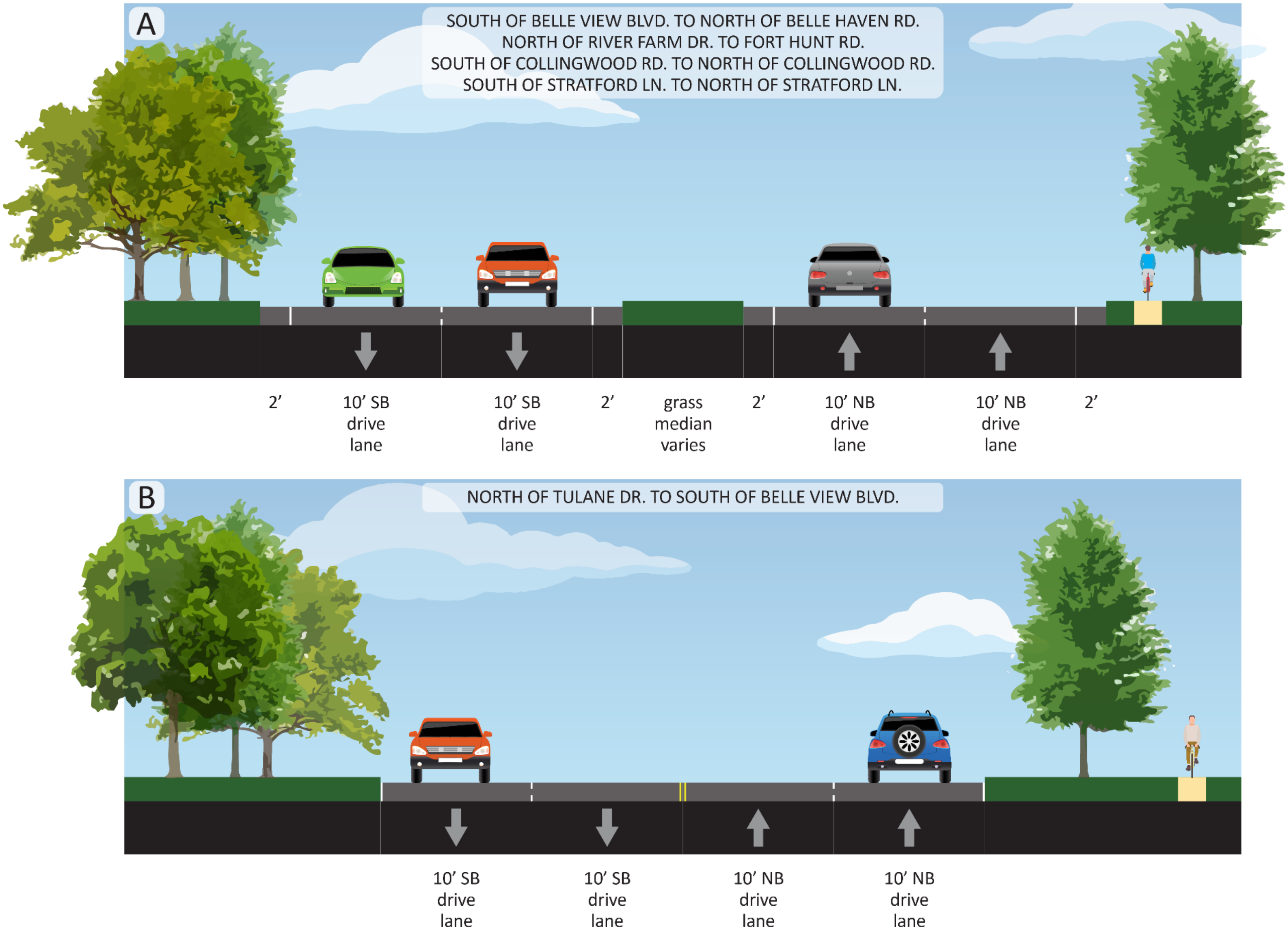
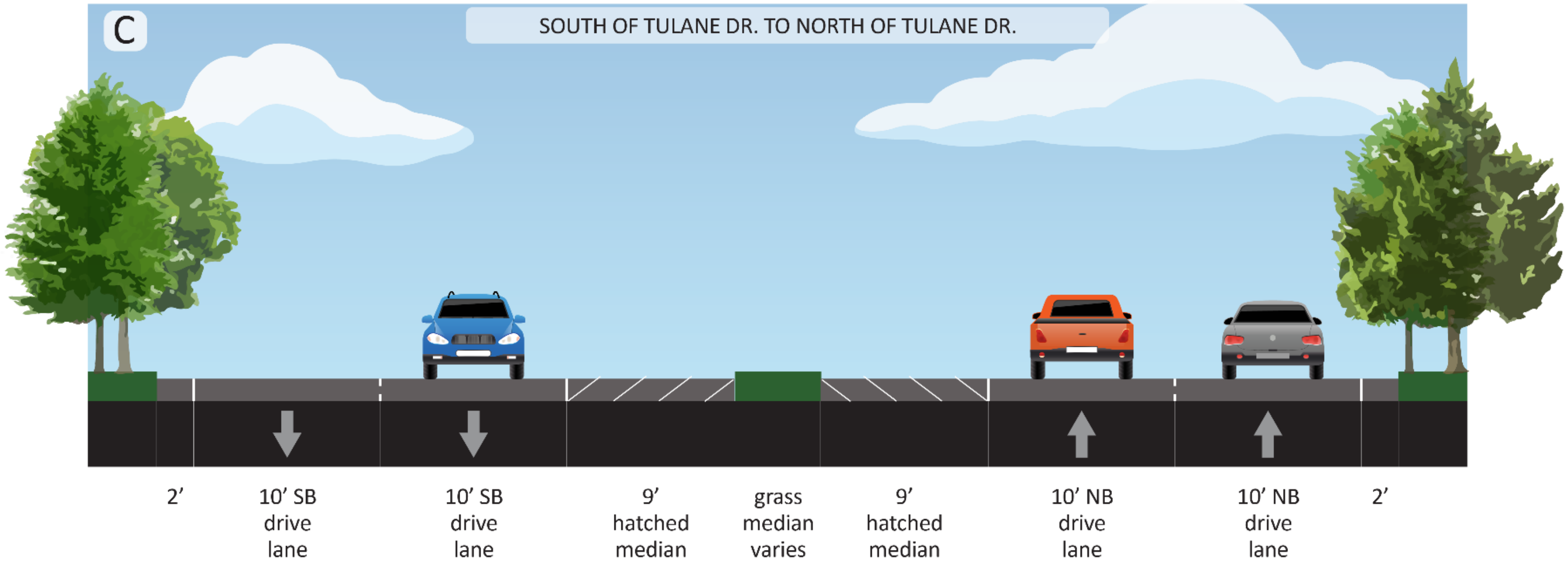


Figure 3. The Parkway’s Existing Typical Roadway Sections **(continues on next page)**



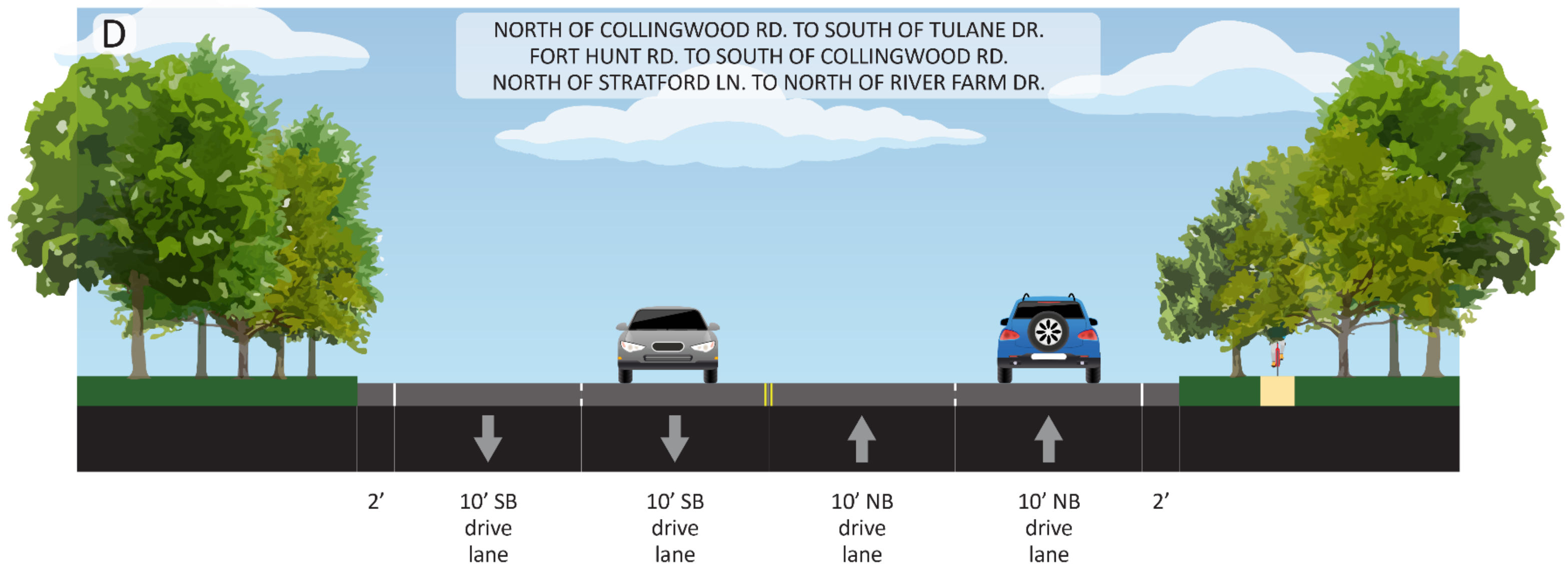


Figure 3. The Parkway's Existing Typical Roadway Sections

The posted speed limit of the southern section of the Parkway varies from 45 miles per hour at the south end near Stratford Lane to 35 miles per hour just before some of the most heavily trafficked intersections (Belle View Boulevard and Belle Haven Road, at the north end of the corridor). For traffic entering from the cross streets, all study intersections are controlled by stop signs. Several horizontal and vertical curves along the roadway within the study segment were part of the original roadway design, incorporated as part of the intended experience of the Parkway. The Mount Vernon Trail parallels the roadway for much of the study segment. Crossings of the Mount Vernon Trail occur along several side streets, within approximately 200 feet of the mainline Parkway. No sidewalks exist along the Parkway; however, many intersecting streets provide sidewalks for pedestrian access. The Metrobus 11Y route serves the Parkway, with six northbound stops and six southbound stops. Many of the bus stops have lay-bys so that the bus can pull out of the travel lane for passenger boarding. All bus stops are marked with flag signs. However, other bus stop infrastructure, such as benches and landing pads, is extremely limited, with the exception of a few rustic bus stop shelters.

Base maps of each study intersection illustrating existing curb lines, pavement marking, signs, and right-of-way information are included in "Appendix A: Intersection Existing Conditions Mapping."

1.2 Parkway Traffic Volumes

Intersection traffic counts were collected in March and June of 2019. The network a.m. and p.m. peak hours for the study intersections occurred between 7:00 a.m. and 8:00 a.m. and from 5:00 p.m. to 6:00 p.m., respectively. Traffic volumes experience directional peaks, with a northbound peak in the morning of approximately 1,700 vehicles per hour at Belle View Boulevard and 2,000 vehicles per hour southbound in the evening at Belle Haven Road. The heaviest side street volume entering the Parkway is from Collingwood Road, with approximately 350 vehicles per hour. The traffic volumes indicate that some of the traffic may be using the Parkway as a bypass to US Route 1, based on the heavy northbound left-turn volumes in the morning at Belle View Boulevard. Additionally, heavier left-turn volumes entering the Parkway in the morning from side streets such as Collingwood Road do not mirror the returning southbound right-turn volumes, which are heaviest at Belle Haven Road and Morningside Lane, indicating that drivers may be traversing the neighborhoods to enter the Parkway further south in order to avoid congested intersections further north. Detailed peak hour traffic volume diagrams for each intersection and traffic count reports are included in "Appendix B: Peak Hour Traffic Volumes" and "Appendix C: Intersection Traffic Counts."

Pneumatic tubes were used to collect multi-day volume, classification, and speed counts for one full week in March 2019 near Morningside Lane and Collingwood Road and in June 2019 near Belle View Boulevard. Traffic averages and the heavy vehicle (buses and trucks) percentages decrease in the southern sections of the corridor. Table 1 summarizes the average daily and average weekday traffic volumes. Full traffic count reports are included in "Appendix D: Average Daily Traffic Counts."

Table 1. Average Daily Traffic on the Parkway

Count Location	Average Daily Traffic (vehicles per day)			Average Weekday Daily Traffic (vehicles per weekday)			Percent Heavy Vehicles
	Northbound	Southbound	Total	Northbound	Southbound	Total	
The Parkway South of Belle View Boulevard	10,895	12,651	23,546	11,943	13,639	25,581	2.4%
The Parkway South of Morningside Lane	8,316	8,458	16,775	9,190	9,181	18,371	1.7%
The Parkway south of Collingwood Road	5,442	5,600	11,042	5,948	6,050	11,998	1.8%

1.3 Pedestrian and Bicycle Traffic

As shown in Table 2, pedestrian and bicycle traffic volumes were higher in the p.m. peak hour than in the morning peak hour. The data collection counted more than 600 combined pedestrians and bicyclists at the locations along the Mount Vernon Trail during the 12-hour study. For further information about trail conditions, safety concerns, and maintenance needs and opportunities, please reference *Mount Vernon Trail Corridor Study: George Washington Memorial Parkway* (Daddio, et al. 2019). Figure 4 illustrates the existing pedestrian and bicycle network including the Mount Vernon Trail, and Figure 5 illustrates the existing transit routes, stops, and daily boardings.

Table 2. Pedestrian and Bicycle Traffic on the Parkway

Mount Vernon Trail Crossing Location	Pedestrians			Bicycles		
	a.m. Peak Hour	p.m. Peak Hour	Total 12 Hours	a.m. Peak Hour	p.m. Peak Hour	Total 12 Hours
Collingwood Road west of the Parkway	7	22	137	0	17	204
Wellington Road west of the Parkway	7	16	134	0	22	212

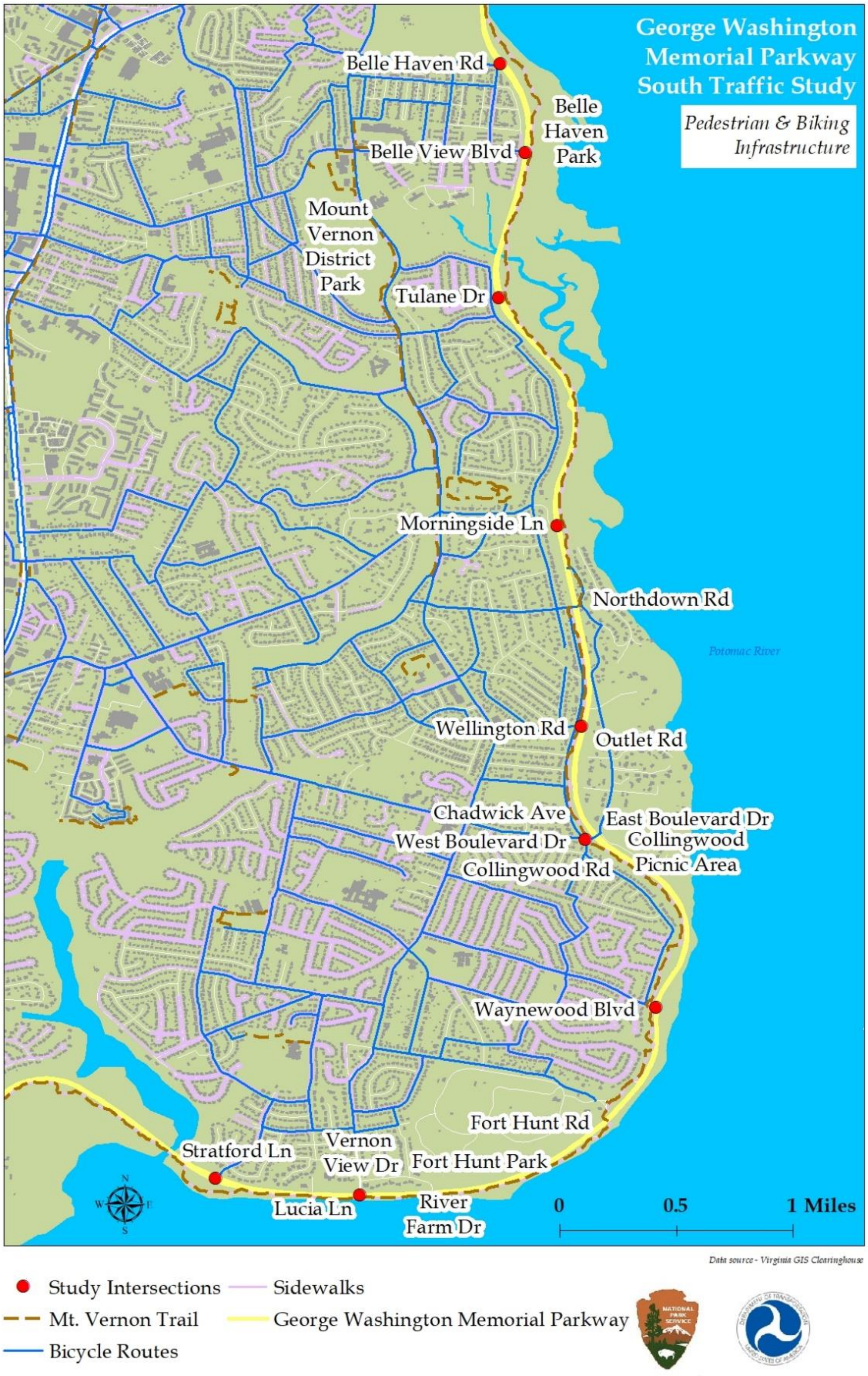


Figure 4. Existing Pedestrian Infrastructure and Bicycle Routes

Figure 5. Existing Transit Routes, Stops, and Daily Boardings

1.3.1 Vehicle Speeds

The results of the speed study indicate that the 85th-percentile speed (the speed at which a majority of drivers travel at or below) at all three sampled locations was 8–12 mph above the posted speed limit. The median speed at these locations was also above the posted speed limit, indicating that a majority of vehicles on the Parkway are traveling above the posted speed limit. Table 3 summarizes vehicle speed profiles (e.g., posted speed, median speed, 85th percentile, 10 mph pace, percent in pace, and percent enforceable) and Figure 6 illustrates speed distributions compared to the posted speed limit.

Table 3. Speed Study

Location and Direction	Posted Speed	Median Speed [1]	85th Percentile Speed [2]	10 mph Pace [3]	Percent in Pace [4]	Percent Enforceable [5]
The Parkway, South of Belle View Boulevard						
Northbound	45 mph	47 mph	53 mph	41-50 mph	64.9%	6.7%
Southbound	45 mph	47 mph	52 mph	41-50 mph	68.3%	4.8%
The Parkway, South of Morningside Lane						
Northbound	45 mph	48 mph	54 mph	46-55 mph	63.7%	12.9%
Southbound	45 mph	49 mph	55 mph	46-55 mph	67.3%	17.1%
The Parkway, South of Collingwood Road						
Northbound	45 mph	47 mph	53 mph	46-55 mph	60.7%	9.2%
Southbound	45 mph	50 mph	57 mph	46-55 mph	63.7%	21.9%

[1] Median speed is the speed at which an equal number of vehicles were traveling above and below.
[2] The 85th percentile speed is the speed at which 85% of the vehicles were traveling at or below when unaffected by other vehicles and is a good indicator of the speed the majority of motorists find safe and reasonable.
[3] The 85th percentile speed is the speed at which 85% of the vehicles were traveling below when unaffected by other vehicles and is a good indicator of the speed the majority of motorists find safe and reasonable.
[4] The percent in the 10 mph pace reflects the percentage of vehicles that were traveling within this pace and is a good indicator of the range of speeds along a particular segment of roadway.
[5] Percent enforceable refers to the percentage of vehicles traveling 10 mph or more above the speed limit.

In Figure 6, the top half of the bar shows green when vehicles are traveling at speeds at or below the speed limit and red where they are traveling above. The bottom half of the bar further breaks down the speeds of the vehicles by the percentage of the total sample according to the following eight categories: 1–35 mph, 36–40 mph, 41–45 mph, 46–50 mph, 51–55 mph, 56–60 mph, 61-65 mph, and greater than 65 mph.

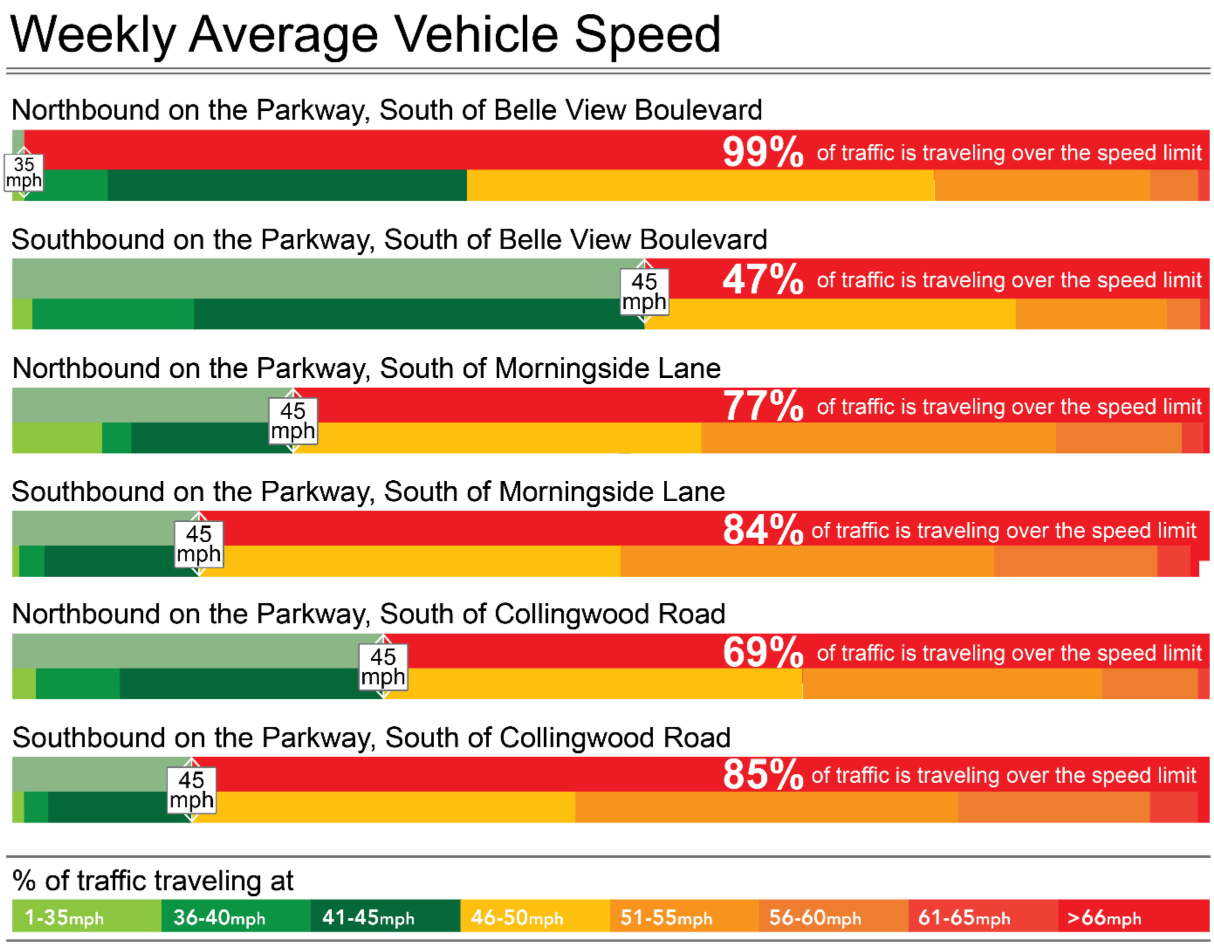


Figure 6. Weekly Average Vehicle Speed on the Parkway: South of Belle View Boulevard, South of Morningside Lane, and South of Collingwood Road

1.4 Traffic Capacity Analysis

All study intersections were coded into a traffic operations model (Synchro) of the study area network to perform capacity analysis. Synchro is a deterministic and macroscopic signal analysis computer software program that models arterial street networks and implements the methodology of the National Academy of Sciences Transportation Research Board's *Highway Capacity Manual* (HCM). The model inputs included geometric data such as number of lanes, lane configuration, storage lengths, tapers, and distances between intersections. The model was calibrated based on adjusting gap acceptance parameters using field-measured data so that queues and delays observed in the field were accurately replicated in the model. A queue is defined as a "line of vehicles, bicycles, or persons waiting to be served by the system in which the flow rate from the front of the queue determines the average speed within the queue" (AASHTO

2010). Intersection capacity analyses were performed using the industry standard HCM methodology for all study intersections. Performance measures of effectiveness include level of service, volume-to-capacity ratio, and average vehicle delay. Key performance measures are defined as follows:

Level of service (LOS) is a qualitative measure describing operational conditions of an intersection or any other transportation facility. Level of service measures the quality of traffic service and may be determined for intersections, roadway segments, or arterial corridors on the basis of delay, congested speed, volume to capacity (v/c) ratio, or vehicle density by functional class. At intersections, LOS is a letter designation that corresponds to a certain range of roadway operating conditions. The levels of service range from “A” to “F,” with “A” indicating the best operating conditions and “F” indicating the worst, or a failing, operating condition.

Volume-to-capacity ratio (v/c ratio) is the ratio of current flow rate to the capacity of the intersection. This ratio is often used to evaluate capacity on a given roadway. Generally, a ratio of 1.0 indicates that the roadway is operating at capacity. A ratio of greater than 1.0 indicates that the facility is operating above capacity, as the number of vehicles exceeds the roadway capacity.

Delay (control delay) is the portion of delay attributed to traffic signal operation for signalized intersections or stop/yield signs for stop or roundabout-controlled intersections. Control delay (overall delay) is categorized into deceleration delay, stopped delay, and acceleration delay. Figure 7 and Figure 8 show the LOS for each movement at each study intersection on a map view for a.m. peak and p.m. peak, respectively. During the a.m. peak (shown in Figure 7. A.M. Peak Level of Service per Lane at Study Intersections), the approach from Belle Haven Road, Belle View Boulevard, and Morningside Lane all experienced a LOS F. Wellington Road and eastbound Collingwood Road experienced a LOS E. The Waynewood Boulevard approach experienced a LOS D. During the p.m. peak (shown in Figure 8), the situation became more congested at Belle Haven Road, with the left turn from the Parkway to Belle Haven Road experiencing an LOS F. The Belle View Boulevard and Morningside Lane approaches remained consistent in the p.m. peak to that in the a.m. peak, with a LOS F. The Wellington Road, eastbound Collingwood Road, and Waynewood Boulevard approaches all improved during the p.m. peak, with an LOS D; LOS A, B, C; and LOS A, B, C, respectively.

The following intersections have an approach that operates with a LOS E or LOS F during at least one peak hour:

- Belle Haven Road — LOS F during a.m. and p.m. peak hour
- Belle View Boulevard — LOS F during a.m. and p.m. peak hour
- Morningside Lane — LOS F during a.m. and p.m. peak hour
- Collingwood Road — LOS E during a.m. peak hour

Figure 7. A.M. Peak Level of Service per Lane at Study Intersections

Many of the intersections in the northern portion of the study corridor have an approach that experiences high vehicle delays. As an example, eastbound Belle View Boulevard experienced 95.4 seconds of Average Delay per Approach Vehicle in the p.m. peak hour (see the red arrow to the right in Figure 8 at the Belle View Boulevard intersection). A delay of 95 seconds for a stop sign-controlled approach is considered excessive based on the *Highway Capacity Manual*, which grades delays of greater than 50 seconds (about half of what drivers approaching the Parkway on Belle View Boulevard experience) as failing LOS for stop signs. Lowering the delay threshold can help reduce the variability in waiting time that motorists currently experience at stop signs when trying to find an adequate gap to safely enter traffic.

Figure 8. P.M. Peak Level of Service per Lane at Study Intersections

Table 4 shows the LOS and the corresponding delay values for the a.m. and p.m. peak hours at all study intersections.

Table 4. Existing Capacity Analysis

Node	Intersection	Approach	Existing Conditions a.m. (p.m.) Delay	Level of Service	Volume-to-Capacity Ratio
1	The Parkway and Belle Haven Road	Control Type	Stop (T Intersection)		
		Eastbound	76.0 (51.5)	F (F)	0.95 (0.80)
		NB Parkway LT	1.7 (15.3)	A (C)	0.50 (0.87)
		SB Parkway	0.0 (0.0)	A (A)	0.20 (0.65)
2	The Parkway and Belle View Boulevard	Control Type	Stop (T Intersection)		
		Eastbound	52.4 (97.6)	F (F)	0.74 (0.95)
		NB Parkway LT	0.2 (1.8)	A (A)	0.54 (0.27)
		SB Parkway	0.0 (0.0)	A (A)	0.21 (0.53)
3	The Parkway and Tulane Drive	Control Type	Stop (2-Way)		
		Eastbound LT	20.5 (19.0)	C (C)	0.53 (0.28)
		Eastbound RT	9.2 (11.2)	A (B)	0.01 (0.03)
		Westbound	13.4 (18.5)	B (C)	0.00 (0.05)
		NB Parkway LT	9.2 (17.8)	A (C)	0.01 (0.07)
		SB Parkway	0.0 (0.0)	A (A)	0.21 (0.52)
4	The Parkway and Morningside Lane	Control Type	Stop (T Intersection)		
		Eastbound	87.8 (32.4)	F (D)	0.89 (0.42)
		NB Parkway LT	0.1 (0.3)	A (A)	0.00 (0.01)
		SB Parkway	0.0 (0.0)	A (A)	0.14 (0.65)
5	The Parkway and Wellington Road	Control Type	Stop (T Intersection)		
		Eastbound	49.5 (22.6)	E (C)	0.68 (0.19)
		NB Parkway LT	0.0 (0.1)	A (A)	0.48 (0.32)
		SB Parkway	0.0 (0.0)	A (A)	0.14 (0.65)
6	E. Boulevard Drive and Collingwood Road	Control Type	Stop (2-Way)		
		Eastbound	7.2 (7.1)	A (A)	0.01 (0.01)

Node	Intersection	Approach	Existing Conditions		
			a.m. (p.m.)		
			Delay	Level of Service	Volume-to-Capacity Ratio
		Northbound	0.0 (7.0)	A (A)	0 (0.01)
		Southbound	6.4 (6.6)	A (A)	0 (0.01)
7	The Parkway and Collingwood Road	Control Type	Stop (2-Way)		
		Eastbound	42.3 (25.9)	E (D)	0.84 (0.36)
		Westbound	17.8 (17.0)	C (C)	0.01 (0.02)
		NB Parkway LT	8.1 (10.3)	A (B)	0.00 (0.02)
		SB Parkway LT	9.9 (8.4)	A (A)	0.00 (0.00)
8	W. Boulevard Drive and Collingwood Road	Control Type	Stop (2-Way)		
		Eastbound	0.6 (0.6)	A (A)	0.01 (0.00)
		Westbound	1.7 (1.6)	A (A)	0.01 (0.03)
		Northbound	11.6 (10.4)	B (B)	0.14 (0.06)
		Southbound	11.7 (11.1)	B (B)	0.01 (0.03)
9	The Parkway and Waynewood Boulevard	Control Type	Stop (T Intersection)		
		Eastbound	28.0 (12.8)	D (B)	0.53 (0.10)
		NB Parkway LT	0.5 (9.6)	A (A)	0.01 (0.02)
		SB Parkway	0.0 (0.0)	A (A)	0.13 (0.50)
10	The Parkway and Vernon View Drive	Control Type	Stop (T Intersection)		
		EB Parkway LT	4.2 (9.9)	A (A)	0.12 (0.16)
		WB Parkway	0.0 (0.0)	A (A)	0.13 (0.44)
		Southbound	10.3 (13.2)	B (B)	0.21 (0.24)
11	The Parkway and Stratford Lane	Control Type	Stop (2-Way)		
		EB Parkway LT	8.8 (9.9)	A (A)	0.04 (0.10)
		WB Parkway LT	9.0 (9.0)	A (A)	0.00 (0.01)
		Northbound	23.1 (14.6)	C (B)	0.03 (0.06)
		Southbound	9.6 (15.2)	A (C)	0.14 (0.18)

1.5 Queues and Stopped Delays

Vehicular queue lengths and stopped delays were measured for each approach roadway during the a.m. and p.m. peak hours for the same periods when the traffic count was recorded. The longest observed queue was at eastbound Belle Haven Road, with a 21-vehicle-long queue in the a.m. peak hour. Average vehicle delays of greater than one minute were observed for Belle Haven Road (a.m. and p.m.), Belle View Boulevard (a.m. and p.m.), Tulane Drive (a.m.) and Morningside Lane (a.m. and p.m.). Table 5 summarizes the field-measured queues and delays; Figure 9 illustrates maximum observed peak hour queues.

Table 5. Queue and Delay Study

The Parkway Approach	Total Delay (vehicle-hours)		Average Delay per Stopped Vehicle (seconds)		Average Delay per Approach Vehicle (seconds)		Maximum Observed Queue (vehicles)	
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
Eastbound Belle Haven Road	5.8	3.3	82.9	58.5	71.7	51.8	21	13
Eastbound Belle View Boulevard	2.7	5.1	65.5	101.3	55.0	95.4	11	13
Eastbound Tulane Drive	4.6	0.8	75.4	33.5	69.9	26.9	10	6
Eastbound Morningside Lane	4.34	2.25	96.4	61.4	90.3	54.4	9	10
Eastbound Wellington Road	2.25	0.27	59.2	28.7	54.8	18.8	7	4
Eastbound Collingwood Road	4.82	0.58	48.8	23.3	44.9	16.7	10	6
Westbound Collingwood Road	0.03	0.05	17.1	24.4	13.3	17.7	1	2
Eastbound Waynewood Boulevard	1.2	0.2	37.2	25.4	27.9	12.7	9	3
Southbound Vernon View Drive	0.5	0.4	20.7	20.0	10.7	11.2	6	5
Northbound Stratford Lane	0.0	0.1	25.0	20.8	21.4	12.3	1	1
Southbound Stratford Lane	0.3	0.2	18.5	20.0	9.5	11.1	4	2

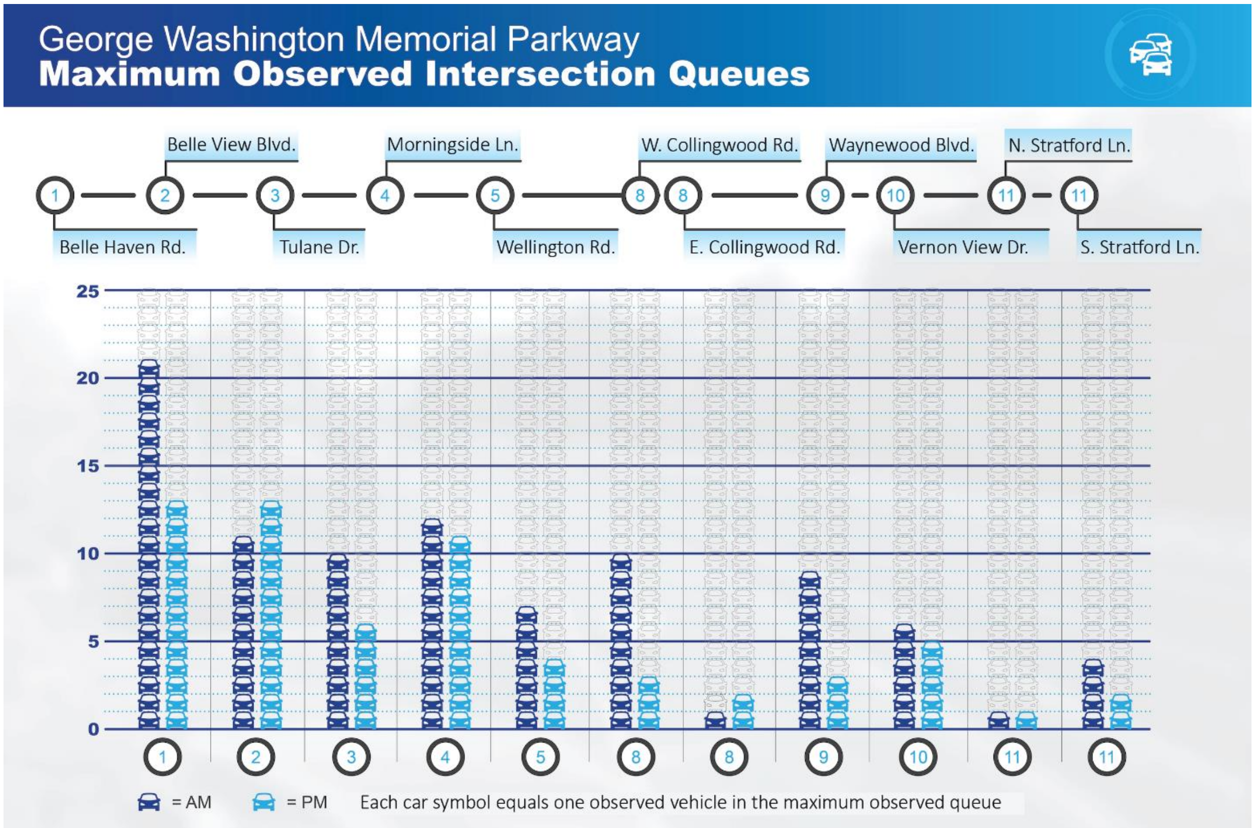


Figure 9. Maximum Observed Peak Hour Queues Approaching the Parkway

1.5.1 Gaps to Enter the Parkway from Cross Streets

A gap study was performed along the Parkway at each study intersection. This study determines the number, length, and frequency of available gaps in each direction of traffic and in the combined traffic of the Parkway to assess the ability of vehicles to enter from a stopped position on each side street. The length (in seconds) of the gaps indicates whether vehicles have enough time to enter the Parkway safely. The study was performed during the same peak hours as the traffic count.

The American Association of State Highway and Transportation Officials (AASHTO) recommend a critical gap of 8.5 seconds (AASHTO 2018) for a left turn from a minor street onto a four-lane major street for passenger cars. The number of simultaneous gaps of 8 seconds or longer for automobiles to cross or enter the Parkway from many cross streets, particularly the more northern study intersections, is very low. Comparing the gaps with the peak hour demand volumes for these movements shows that an insufficient number of gaps are available during the a.m. and p.m. peak hours to accommodate the number of turns. A lack of adequate gaps can cause long queues and delays at an intersection. Tables 6–14 summarize the gap data; Figure 10 illustrates the gap availability.

Table 6. Gap Study at Belle Haven Road

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	311 (160)	91% (83%)	201 (273)	61% (86%)	314 (154)	95% (95%)
6–11	24 (19)	7% (10%)	53 (19)	16% (6%)	12 (7)	4% (4%)
12–17	7 (10)	2% (5%)	34 (11)	10% (3%)	4 (1)	1% (1%)
18–23	1 (15)	0% (8%)	39 (15)	12% (5%)	0 (0)	0% (0%)
24–29	0 (1)	0% (1%)	8 (3)	2% (1%)	0 (0)	0% (0%)
> 29	0 (0)	0% (0%)	15 (2)	5% (1%)	0 (0)	0% (0%)
> 8 [car turns]	32 (32)	9% (17%)	126 (45)	39% (14%)	16 (8)	5% (5%)
Avg. Gap	3–4 (7–8)		8–9 (5–6)		3–4 (3–4)	

Table 7. Gap Study at Belle View Boulevard

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	390 (256)	92% (76%)	251 (313)	66% (83%)	368 (240)	92% (87%)
6–11	23 (53)	5% (16%)	62 (31)	16% (8%)	30 (31)	8% (11%)
12–17	10 (19)	2% (6%)	35 (24)	9% (6%)	1 (5)	0% (2%)
18–23	1 (8)	0% (2%)	32 (8)	8% (2%)	0 (1)	0% (0%)
24–29	0 (3)	0% (1%)	2 (0)	1% (0%)	0 (0)	0% (0%)
> 29	0 (0)	0% (0%)	12 (4)	3% (1%)	0 (0)	0% (0%)
> 8 [car turns]	34 (82)	8% (24%)	129 (63)	34% (17%)	10 (16)	3% (6%)
Avg. Gap	4–5 (5–6)		7–8 (5–6)		3–4 (3–4)	

Table 8. Gap Study at Tulane Drive

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	430 (284)	87% (71%)	244 (371)	66% (85%)	392 (347)	87% (88%)
6–11	51 (59)	10% (15%)	58 (43)	16% (10%)	54 (41)	12% (10%)
12–17	11 (38)	2% (9%)	34 (17)	9% (4%)	4 (8)	1% (2%)
18–23	1 (7)	0% (2%)	34 (7)	9% (2%)	0 (0)	0% (0%)

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
24–29	0 (7)	0% (2%)	5 (0)	1% (0%)	0 (0)	0% (0%)
> 29	0 (2)	0% (0%)	11 (0)	3% (0%)	0 (0)	0% (0%)
> 8 [car turns]	63 (117)	13% (29%)	126 (67)	34% (15%)	27 (27)	6% (7%)
Avg. Gap	4–5 (6–7)		7–8 (4–5)		3–4 (3–4)	

Table 9. Gap Study at Morningside Lane

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	479 (219)	85% (52%)	169 (337)	48% (70%)	480 (404)	91% (82%)
6–11	81 (131)	14% (31%)	102 (111)	29% (23%)	46 (81)	9% (16%)
12–17	5 (48)	1% (11%)	41 (25)	12% (5%)	3 (9)	1% (2%)
18–23	1 (7)	0% (2%)	19 (7)	5% (1%)	0 (1)	0% (0%)
24–29	0 (10)	0% (2%)	7 (0)	2% (0%)	0 (0)	0% (0%)
> 29	0 (1)	0% (0%)	12 (1)	3% (0%)	0 (0)	0% (0%)
> 8 [car turns]	25 (152)	4% (36%)	147 (84)	42% (17%)	11 (36)	2% (7%)
Average Gap	3–4 (7–8)		8–9 (5–6)		3–4 (3–4)	

Table 10. Gap Study at Wellington Road

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	413 (216)	74% (54%)	152 (288)	45% (62%)	479 (451)	85% (81%)
6–11	130 (117)	23% (29%)	100 (124)	29% (27%)	84 (94)	15% (17%)
12–17	12 (45)	2% (11%)	41 (36)	12% (8%)	1 (10)	0% (2%)
18–23	3 (12)	1% (3%)	24 (12)	7% (3%)	1 (0)	0% (0%)
24–29	0 (6)	0% (1%)	13 (3)	4% (1%)	0 (1)	0% (0%)
> 29	0 (3)	0% (1%)	9 (1)	3% (0%)	0 (0)	0% (0%)
> 8 [car turns]	70 (141)	13% (35%)	151 (129)	45% (28%)	35 (61)	6% (11%)
Average Gap	4–5 (7–8)		8–9 (5–6)		3–4 (4–5)	

Table 11. Gap Study at Collingwood Road

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	272 (171)	59% (48%)	108 (234)	37% (56%)	379 (357)	73% (73%)
6–11	137 (100)	30% (28%)	78 (125)	27% (30%)	119 (105)	23% (22%)
12–17	40 (46)	9% (13%)	47 (45)	16% (11%)	16 (20)	3% (4%)
18–23	6 (11)	1% (3%)	37 (11)	13% (3%)	2 (5)	0% (1%)
24–29	3 (8)	1% (2%)	6 (2)	2% (0%)	0 (0)	0% (0%)
> 29	0 (8)	0% (2%)	14 (4)	5% (1%)	0 (0)	0% (0%)
> 8 [car turns]	118 (147)	26% (42%)	150 (127)	52% (30%)	75 (78)	15% (16%)
Average Gap	5–6 (8–9)		10–11 (6–7)		4–5 (4–5)	

Table 12. Gap Study at Waynewood Boulevard

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	260 (212)	66% (61%)	151 (259)	52% (66%)	316 (356)	64% (72%)
6–11	64 (54)	16% (16%)	40 (49)	14% (13%)	137 (103)	28% (21%)
12–17	44 (39)	11% (11%)	39 (58)	14% (15%)	30 (31)	6% (6%)
18–23	25 (26)	6% (8%)	58 (26)	20% (7%)	6 (5)	1% (1%)
24–29	6 (12)	2% (3%)	19 (4)	7% (1%)	1 (0)	0% (0%)
> 29	5 (12)	1% (3%)	12 (5)	4% (1%)	0 (0)	0% (0%)
> 8 [car turns]	133 (133)	34% (39%)	137 (133)	48% (34%)	96 (89)	20% (18%)
Avg. Gap	7–8 (8–9)		10–11 (7–8)		5–6 (5–6)	

Table 13. Gap Study at Vernon View Drive

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	238 (283)	63% (69%)	156 (223)	54% (62%)	331 (388)	68% (75%)
6–11	68 (65)	18% (16%)	44 (57)	15% (16%)	119 (100)	24% (19%)
12–17	52 (35)	14% (8%)	37 (47)	13% (13%)	32 (20)	7% (4%)
18–23	21 (35)	6% (8%)	53 (35)	18% (10%)	4 (5)	1% (1%)
24–29	6 (8)	2% (2%)	12 (6)	4% (2%)	0 (2)	0% (0%)
> 29	4 (8)	1% (2%)	20 (6)	7% (2%)	1 (0)	0% (0%)
> 8 [car turns]	141 (129)	37% (31%)	134 (139)	46% (38%)	101 (75)	21% (15%)
Avg. Gap	7–8 (7–8)		10–11 (8–9)		5–6 (4–5)	

Table 14. Gap Study at Stratford Lane

Gap Size (sec)	Northbound		Southbound		Simultaneous Northbound and Southbound	
	# Gaps	% Gaps	# Gaps	% Gaps	# Gaps	% Gaps
	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)	a.m. (p.m.)
< 5	284 (249)	70% (67%)	201 (278)	58% (68%)	384 (354)	74% (74%)
6–11	60 (62)	15% (17%)	50 (71)	14% (17%)	101 (108)	19% (23%)
12–17	40 (32)	10% (9%)	50 (39)	14% (9%)	31 (14)	6% (3%)
18–23	22 (23)	5% (6%)	46 (23)	13% (6%)	1 (1)	0% (0%)
24–29	4 (10)	1% (3%)	12 (9)	3% (2%)	1 (0)	0% (0%)
> 29	5 (4)	1% (1%)	7 (3)	2% (1%)	0 (0)	0% (0%)
> 8 [car turns]	122 (125)	30% (33%)	146 (133)	42% (32%)	85 (58)	16% (12%)
Avg. Gap	6–7 (7–8)		8–9 (7–8)		4–5 (4–5)	

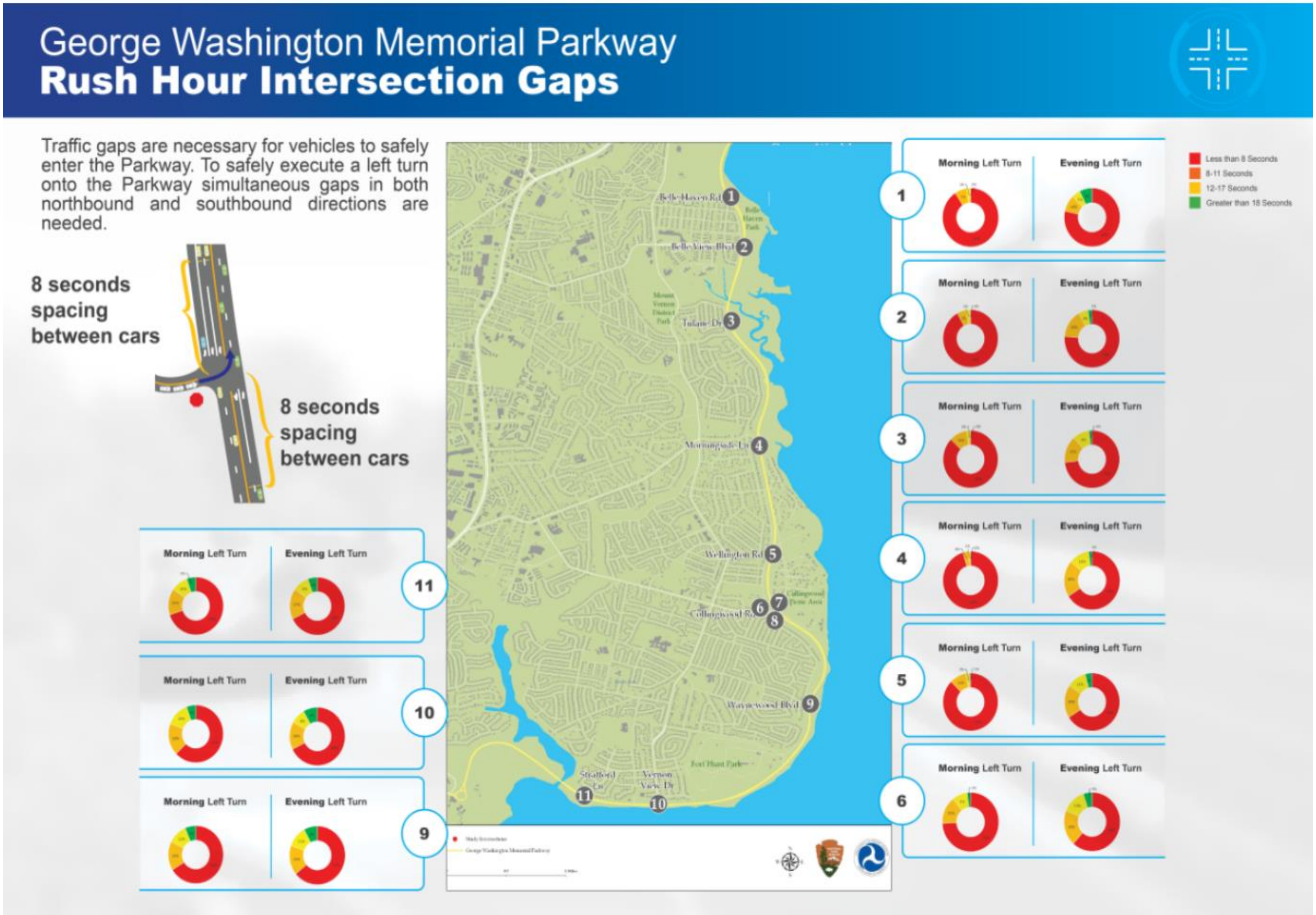


Figure 10. Gap Availability during Peak Hours

1.6 Parking Lot Capacity and Utilization

Parking lots were inventoried and a utilization survey performed in March 2019 to evaluate visitor activity. Table 15 summarizes the parking lot capacity and utilization data. Figure 11 illustrates the parking lot locations. The largest parking lot is located near Belle Haven Road, followed by Stratford Lane. Overall, no parking lot was found to be more than approximately 50% utilized in any weekday period.

Table 15. Parking Lot Capacity and Utilization

Parking Lot Description	Number of Spaces	Number of Spaces Filled		
		a.m. Peak	Midday	p.m. Peak
Belle Haven Road	165	10	57	43
East of the Parkway, American Horticultural Society at River Farm, north of Wellington Road	28	0	21 in lot 5 on road	6 in lot 5 on road
East of the Parkway, Collingwood Picnic Area	16	0	0	5
East side of the Parkway, north of Waynewood Boulevard	14	0	1	0
East side of the Parkway, at Waynewood Boulevard	9	0	0	1
Stratford Lane	58	5	33	20

Figure 11. Existing Parking Lots

2. TRAFFIC SAFETY EVALUATION AND CRASH EXPERIENCE

A traffic and safety assessment analyzed nine intersections on the Parkway and two that are in close proximity to the Parkway and Collingwood Road intersection: Collingwood Road/East Boulevard Drive and Collingwood Road/West Boulevard Drive. As part of this project, the team conducted a crash analysis based on the crash data provided by the Federal Highway Administration, Eastern Federal Lands, and the US Park Police. No data were provided for Collingwood Road/East Boulevard Drive and Collingwood Road/West Boulevard Drive; therefore, these intersections will not be discussed.

Overall, when crashes occur at the intersections in the corridor, they tend to be severe. Even for intersections that have low crash counts, crashes that involve injuries and fatalities seem to be represented to a higher degree than expected. The following sections summarize the specific crash details for each intersection, with the intent of better understanding the underlying crash characteristics using the available tabular data. This report discusses the analysis for each intersection based on the data from both crash databases (one from 2005 to 2015 and the second from April 1, 2018, through October 3, 2019 (referred to as 2018–2019 from this point forward).

A total of 352 crashes were recorded at the following nine intersections for the years 2005–2015 and 2018–2019; the intersections are listed from north to south within the Parkway corridor:

1. Belle Haven Road
2. Belle View Boulevard
3. Tulane Drive
4. Morningside Lane
5. Wellington Road
6. Collingwood Road
7. Waynewood Boulevard
8. Vernon View Drive
9. Stratford Lane

(See "Appendix F: Traffic Safety" for the summary crash tables based on the tabular data that were provided as well as an explanation of similarities and differences between the 2005–2015 and 2018–2019 crash data.) Belle View Boulevard had the greatest number of crashes reported at 90, with Stratford Lane having the fewest at 12 (Table 16). For intersections with a small number of crashes, the difference between peak month, day and time of day could change based on one or two additional crashes. This is an inherent drawback of small datasets and something to keep in mind for those intersections.

Table 16. Summary of Number of Crashes and Rate of Crashes by Period

Intersection with the Parkway	Number of Crashes: 2005–2015	Annual Rate of Crashes: 2005–2015	Number of Crashes: 2018–2019	Annual Rate of Crashes: 2018–2019	Total Number of Crashes
Belle Haven Road	68	4.3	4	2.6	72
Belle View Boulevard	81	5.1	9	6	90
Tulane Drive	29	1.8	3	2	32
Morningside Lane	64	4.0	9	6	73
Wellington Road	21	1.3	2	1.3	23
Collingwood Road	41	2.6	5	3.3	46
Waynewood Boulevard	16	1.0	1	0.7	17
Vernon View Drive	22	1.4	2	1.3	24
Stratford Lane	10	0.6	2	1.3	12
TOTAL	**352**	**22**	**37**	**25**	**389**

Intersections within the study corridor were observed on October 28, 2019, and October 29, 2019. Crash analysis informed observation times for each intersection. Photos illustrating points in the following crash analysis, videos, and general observations of issues potentially contributing to the safety and traffic issues at these intersections were recorded.

The following intersections were observed during specific times on October 28, 2019 (Eastern Time):

- Stratford Lane, 9:12 a.m.–9:32 a.m.
- Collingwood Road, 11:17 a.m.–11:32 a.m.
- Waynewood Boulevard, 12:19 p.m.–12:34 p.m.
- Vernon View Drive, 1:45 p.m.–2:00 p.m.

The following intersections were observed during specific times on October 29, 2019 (Eastern Time):

- Tulane Drive, 8:28 a.m.–8:43 a.m.
- Morningside Lane, 9:00 a.m.–9:15 a.m.
- Belle View Boulevard, 3:33 p.m.–3:48 p.m.
- Belle Haven Road, 4:00 p.m.–4:15 p.m.
- Wellington Road, 4:40 p.m.–4:55 p.m.

License plate data were collected during intervals at several intersections to investigate the states displayed on the vehicles' license plates. The majority of the plates were from Virginia.

The following sections discuss the crash occurrence, sight distance limitations, and recommendations at each of the nine intersections.

2.1 The Parkway and Belle Haven Road

Figure 12 shows the orientation of the Parkway and Belle Haven Road, a three-legged intersection with a median.

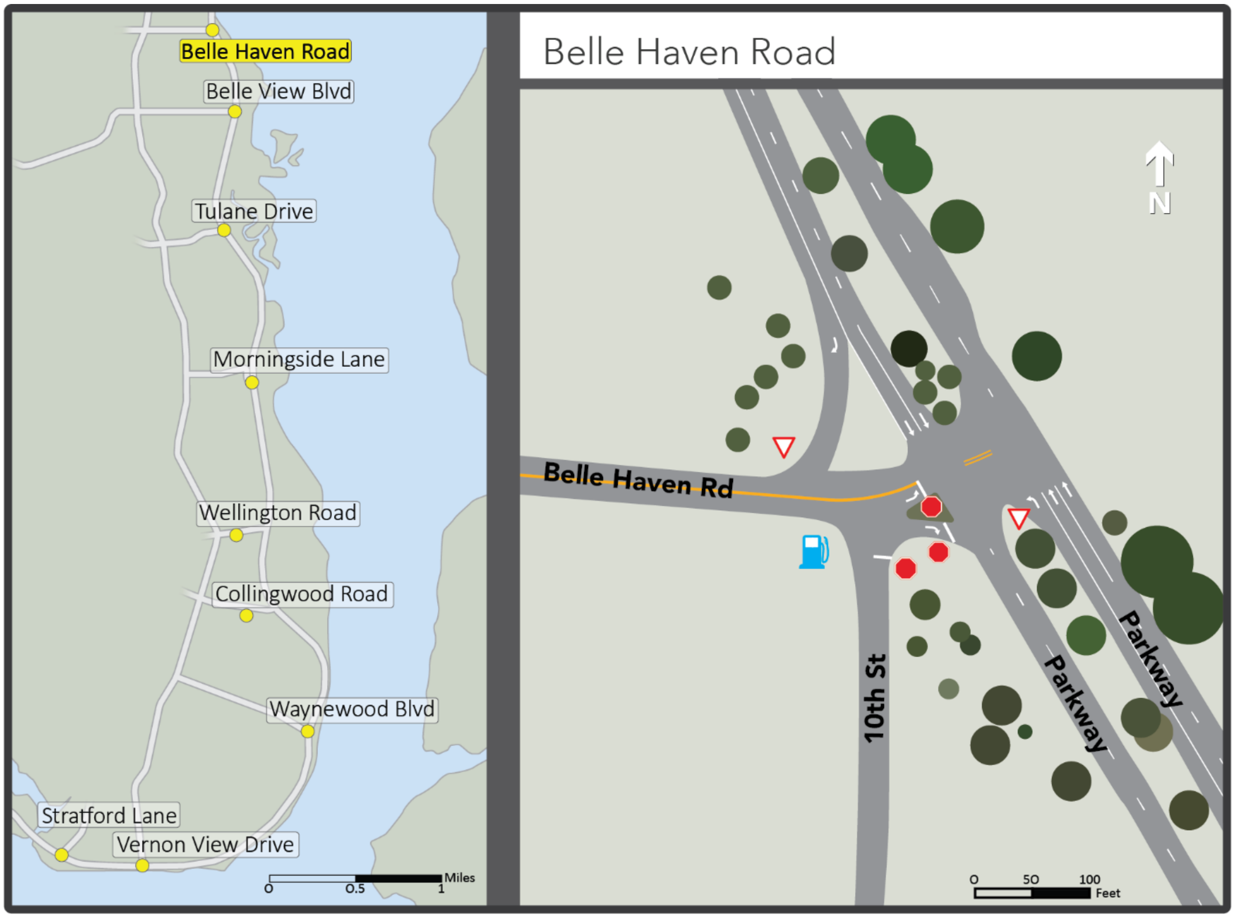


Figure 12. The Parkway and Belle Haven Road

The existing traffic control at the Parkway and Belle Haven Road does not clearly establish right-of-way because there is a suggestion that left-turning northbound traffic should yield to left-turning eastbound traffic (a yield sign faces the former). In theory, drivers yield here before they pull forward past the double yellow line and then cross the southbound direction of the Parkway when there is a gap. This is one of the most challenging movements, as they then have to make sure that southbound Parkway traffic that is turning right yields at the yield sign. Furthermore, unlike the rest of the intersections in the southern section of the Parkway, there is a gas station on the southwest corner of the Belle Haven Road and 10th Street intersection, with access from both streets. Along the east side of the gas station is 10th Street, which provides access to residences along the road and those beyond. These factors make the intersection complex, with numerous diverging and merging movements adding up to 16 conflict points (see "Appendix F: Traffic Safety" for more about conflict points), and rights-of-way not always clearly established.

Between 2005 and 2015, the intersection of Parkway and Belle Haven Road had 68 crashes, and between 2018 and 2019, the intersection had four crashes (for a total of 72 crashes). (*Note:* Crashes were identified in the dataset for the exit from the park to the north of this intersection and at the intersection of the Parkway and Belle Haven Marina to the south of the intersection, but these crashes were removed from the analysis in this report.) Every crash occurrence in this dataset was reviewed for each intersection to ensure that any potential crash associated with the intersection was identified. The annual occurrence of crashes appears random, although 2011 had the greatest number of crashes reported (Figure 13). In 2015, there were no reported crashes at this intersection. Compared to the historical crash count, those recorded for the 2018–2019 period seem underrepresented.

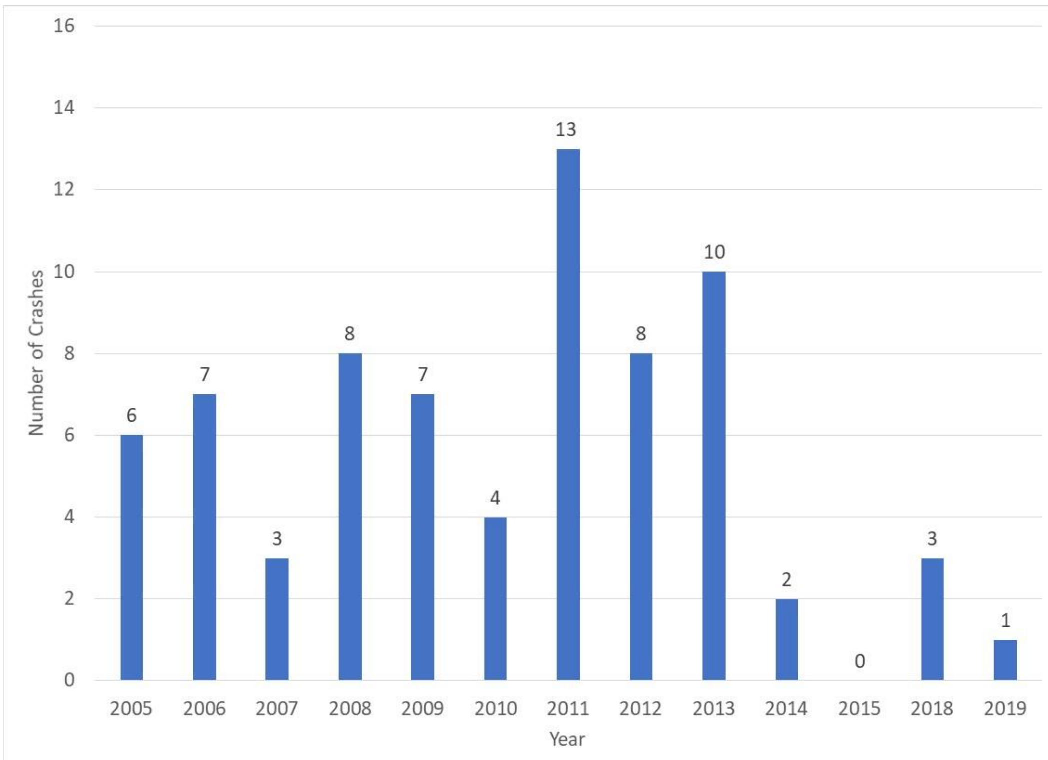


Figure 13. The Parkway and Belle Haven Road, Total Crashes by Year

2.1.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in January (Figure 14).

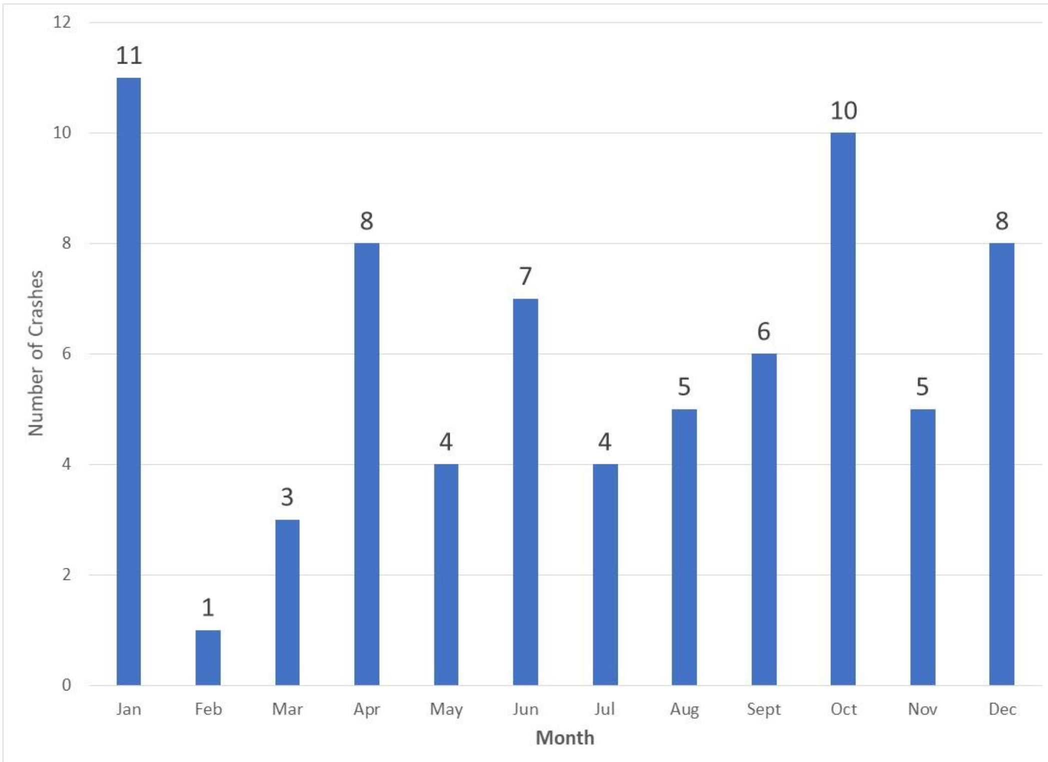


Figure 14. The Parkway and Belle Haven Road, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to determine when crashes occurred more often. The study showed that 32% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 8:00 a.m. and 9:00 a.m. and 2:00 p.m. and 3:00 p.m. (Figure 15).

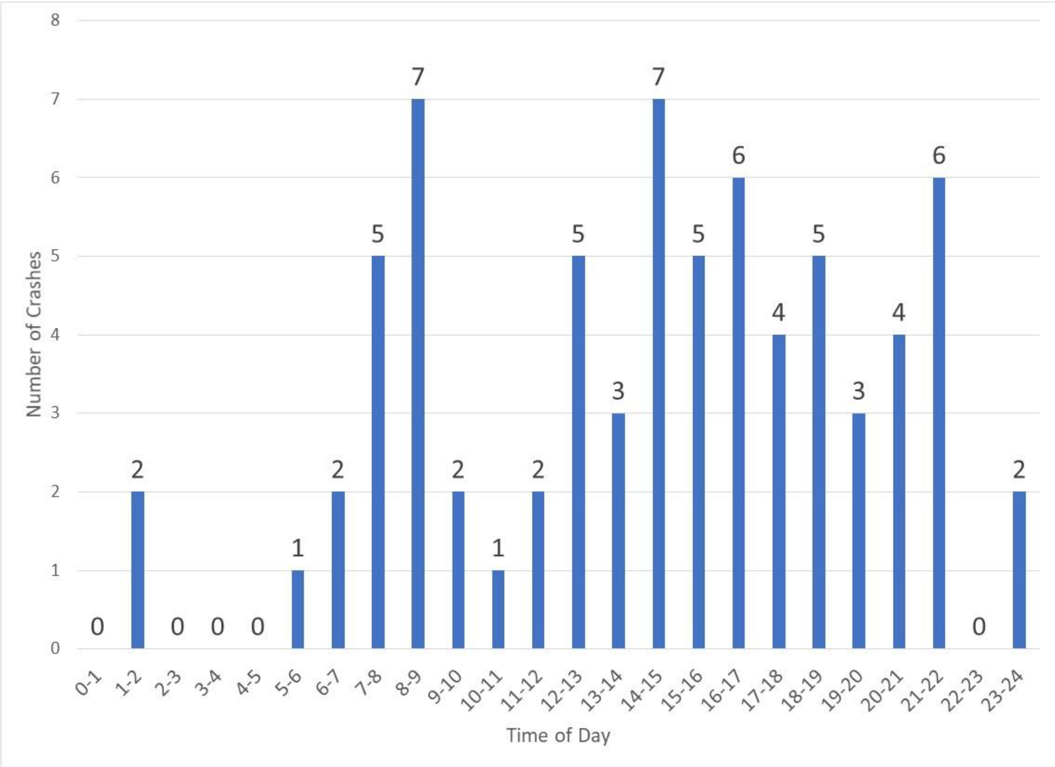


Figure 15. The Parkway and Belle Haven Road, Crashes by Time of Day

Considering the frequency of crashes per hour, the highest rate of crashes occurred during the p.m. peak period (Table 17).

Table 17. The Parkway and Belle Haven Road, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	3	0.5
6:00 a.m.–9:00 a.m.	a.m. Peak	14	4.7
9:00 a.m.–3:00 p.m.	Midday	20	3.3
3:00 p.m.–6:00 p.m.	p.m. Peak	15	5.0
6:00 p.m.–12:00 a.m.	post-p.m. Peak	19	3.3
TOTAL		**72**	–

The crashes at this intersection are almost evenly distributed across the days of the week, with Thursday having the greatest number of crashes (Figure 16).

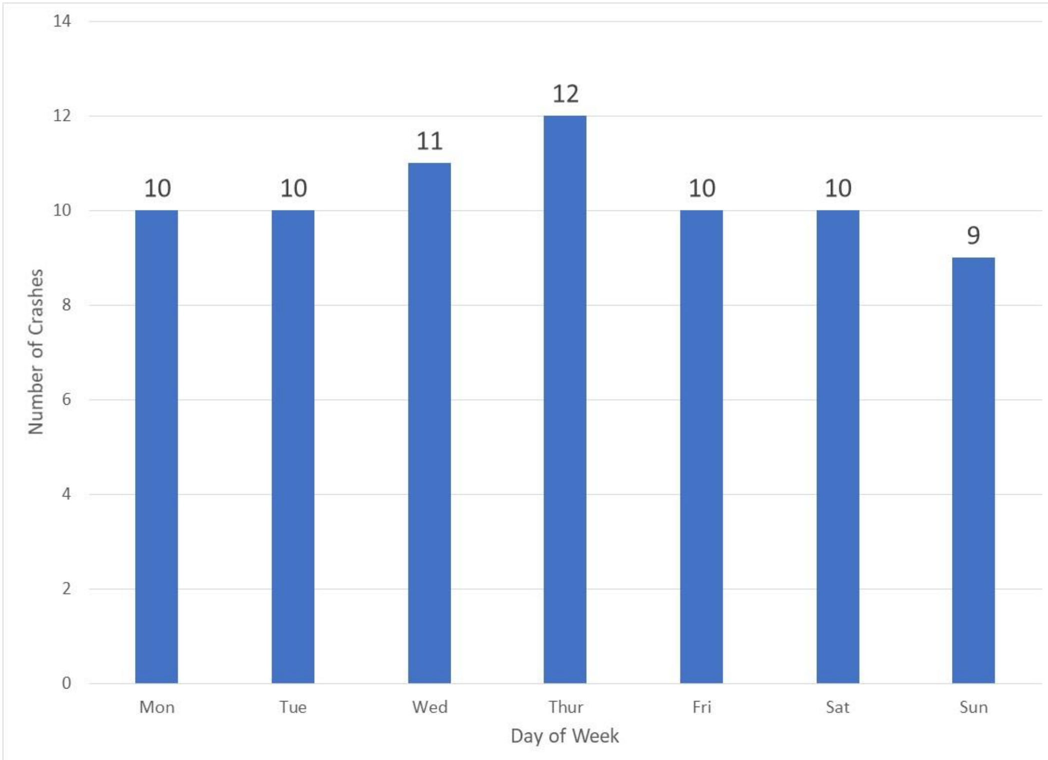


Figure 16. The Parkway and Belle Haven Road, Crashes by Day of the Week

Generally, the counts by day of the week are consistent. However, the results suggest the possibility of contributing factors that are increasing the number of crashes slightly on Thursdays.

2.1.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Figure 17 shows an analysis of lighting conditions during crashes.

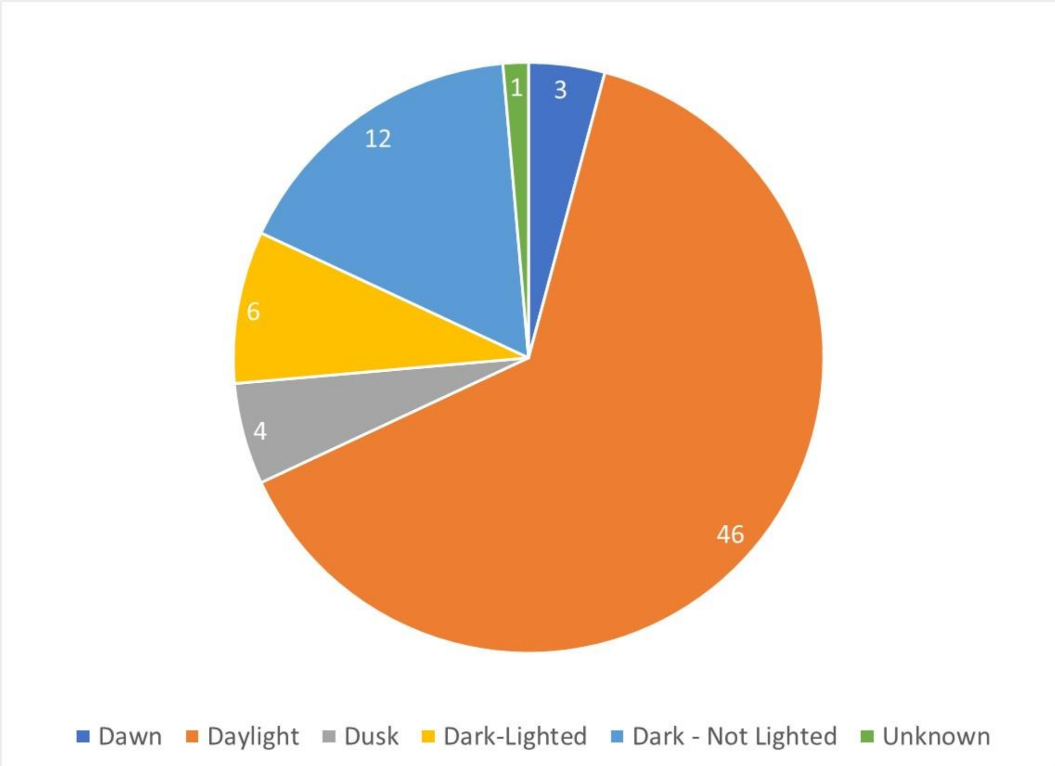


Figure 17. The Parkway and Belle Haven Road, Lighting (Number of Crashes during Each Lighting Condition)

Some of the data were inconsistent, showing that 12 crashes occurred when the intersection was "Dark – Not Lighted" and six when the intersection was "Dark – Lighted." The study section of the Parkway does not have lighting; therefore, "Dark – Lighted" must be an error.

Most crashes (46) were identified as having occurred during "Daylight." Looking at the data in more detail, of the crashes that were identified as occurring during "Daylight," nine of these crashes were during periods when conditions were indicated as "Cloudy" or "Rain." These conditions would suggest that the crashes occurred when there was reduced visibility. The remaining 37 crashes occurred during "Daylight." Therefore, approximately half of the crashes occurred during hours when visibility was good, while the other half occurred during periods when it was not.

The researchers also considered whether the "Daylight" crashes occurred during peak periods. (*Note:* It was anticipated that "Daylight" crashes would be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 18 shows the number of crashes within these groups.

Table 18. The Parkway and Belle Haven Road, "Daylight" Crash Counts and Rates by Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	0	0
6:00 a.m.–9:00 a.m.	a.m. Peak	12	4.0
9:00 a.m.–3:00 p.m.	Midday	19	3.2
3:00 p.m.–6:00 p.m.	p.m. Peak	12	4.0
6:00 p.m.–12:00 a.m.	post-p.m. Peak	3	0.5
TOTAL "Daylight" Crashes		**46**	–

"Daylight" crashes were most likely to occur during the a.m. peak or p.m. peak and least likely to occur from 12:00 a.m. to 6:00 a.m. (pre-a.m. peak).

With regard to weather, the majority of the crashes (58) occurred during "Clear" periods; therefore, *weather does not appear to be a factor contributing to crashes* (Figure 18).

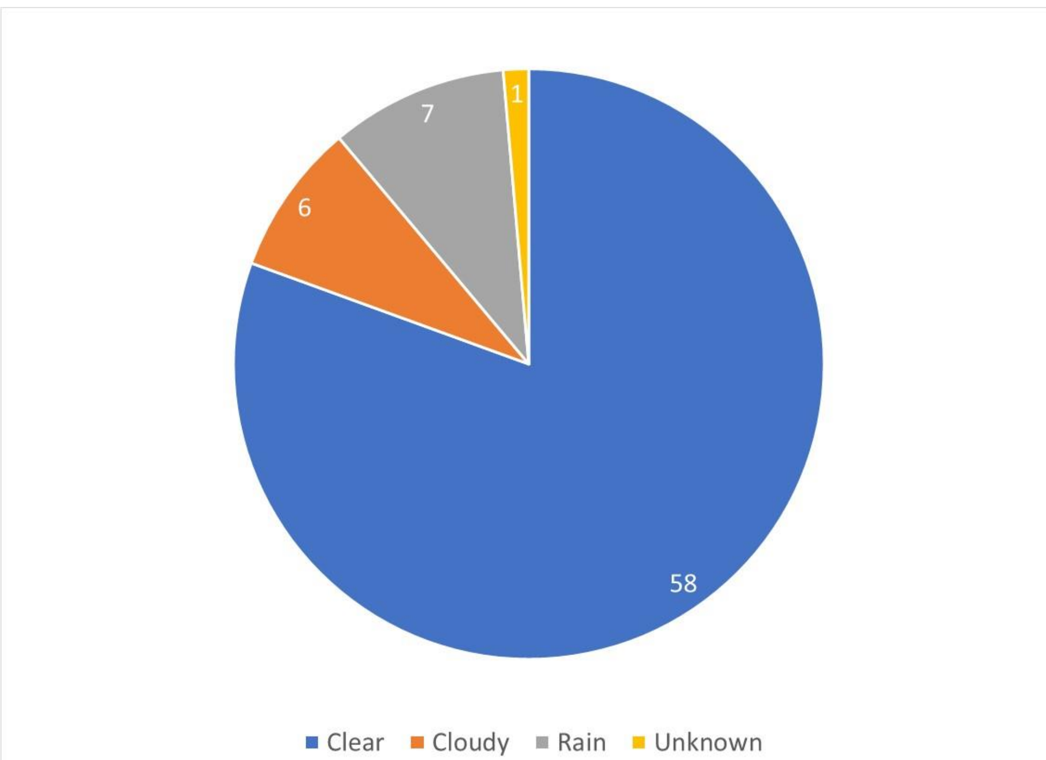


Figure 18. The Parkway and Belle Haven Road, Weather

The majority of crashes (64) occurred when surface conditions were "Dry," which suggests that *surface condition is unlikely to be an issue* (Figure 19).

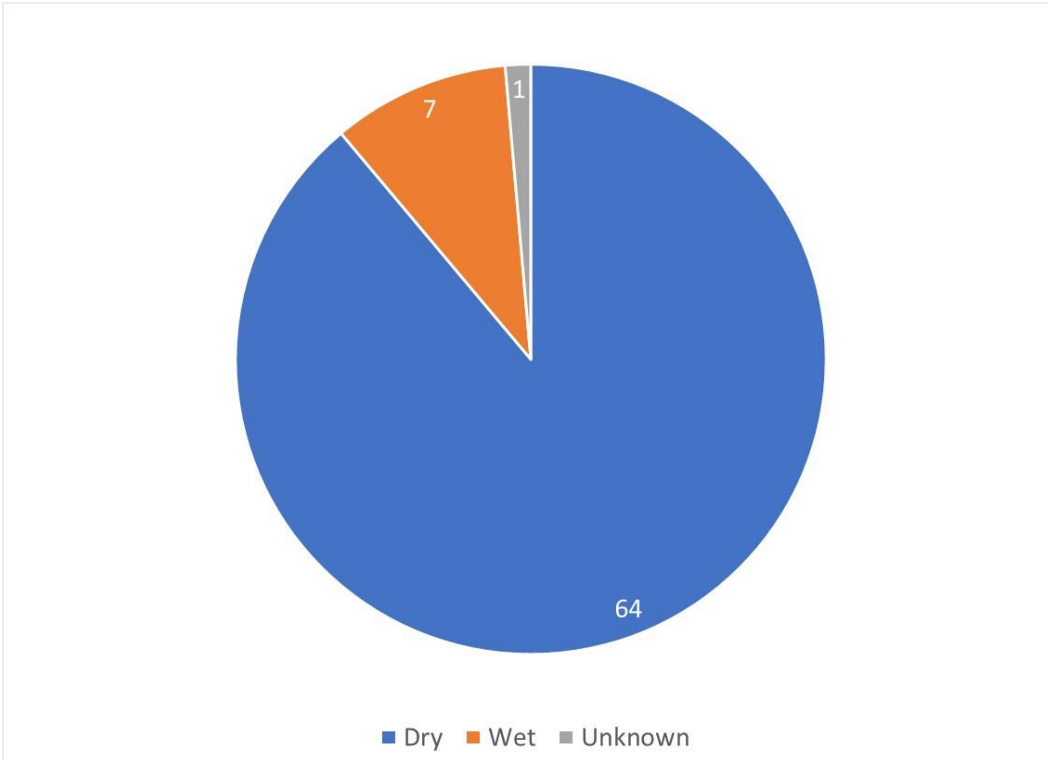


Figure 19. The Parkway and Belle Haven Road, Surface Condition

2.1.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. “Angle” was the most common crash type (30) (Figure 20).

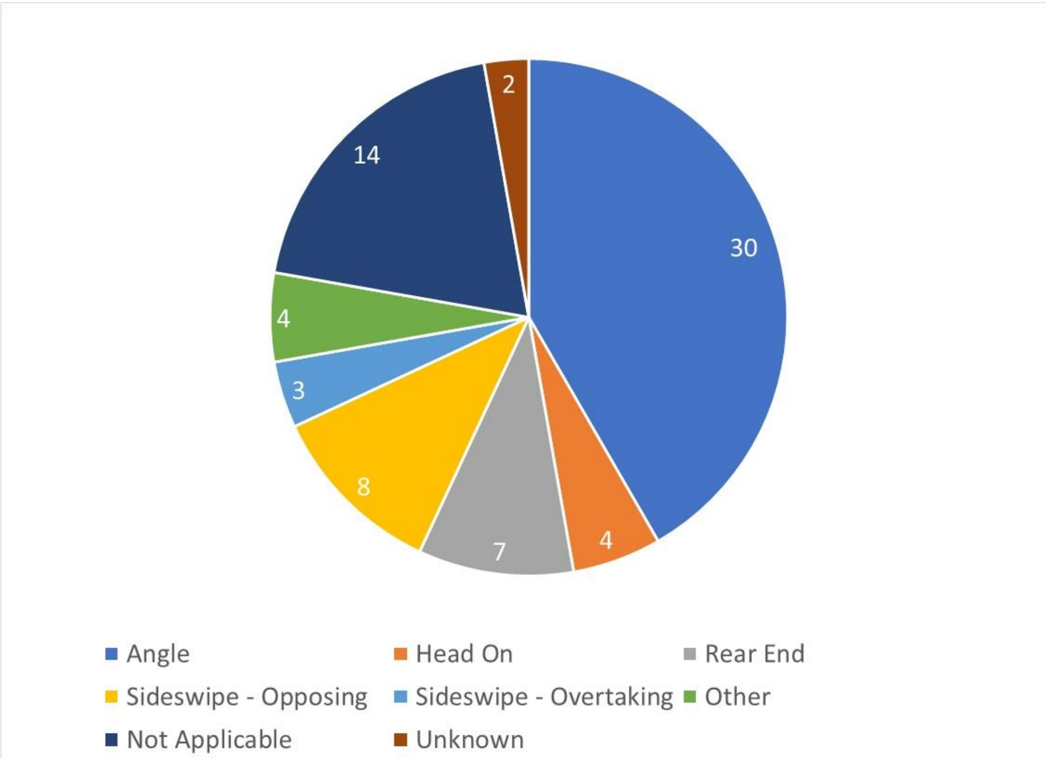


Figure 20. The Parkway and Belle Haven Road, Crash Type

Fourteen crashes were identified as “Not Applicable” and involved a collision with an animal (4), tree/shrub (3), pole (2), boulder (1), other fixed object (1), guardrail/barrier (1), non-collision (1), or a sign (1).

By far, the most frequently reported "Primary Cause" was "Failed to Yield Right-of-Way" (Figure 21), which was reported in 15 of the 68 crashes (22%). (*Note:* Figure 21 only shows 47 of the 72 crashes that occurred at the intersection, as 25 crashes provided no information on the "Primary Cause.")

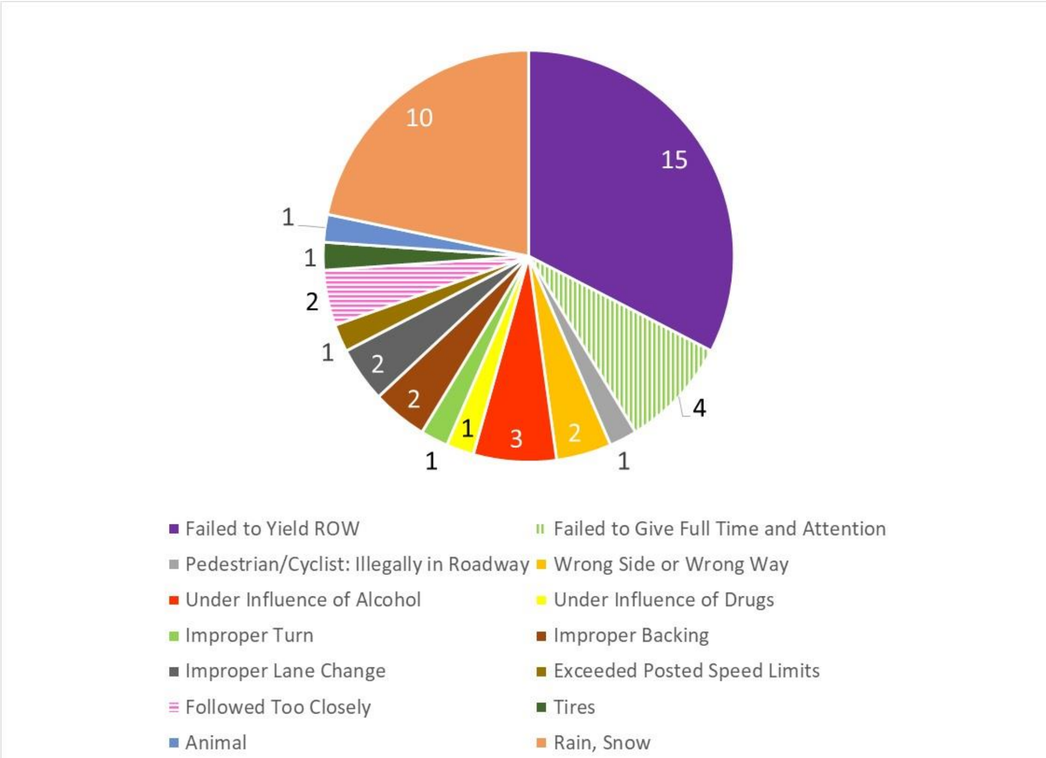


Figure 21. The Parkway and Belle Haven Road, Primary Cause

"Other" was the second most frequently identified "Primary Cause," at 10. "Failed to Give Full Time and Attention" was the third most frequently identified "Primary Cause," at 4.

2.1.4 Driving Under the Influence

As noted in the "Primary Cause" section, of the 72 crashes identified at the intersection during 2005–2015, two crashes, or 2.8% of all crashes at the intersection were identified as involving a driver who was under the influence of alcohol or other substances.

2.1.5 Hit and Run

Five of the 72 crashes, or 6.9%, were identified as hit and run. Therefore, grouping these crashes with the previous category could potentially suggest a greater concern that there are drivers passing through the intersection who are operating a vehicle under the influence.

2.1.6 Crash Severity

This section identifies the number of property damage only (PDO), injury (INJ), and fatal (FAT) crashes. The majority of crashes (54) that occur at the intersection are PDO crashes; no fatal crashes were reported at the intersection (Figure 22).

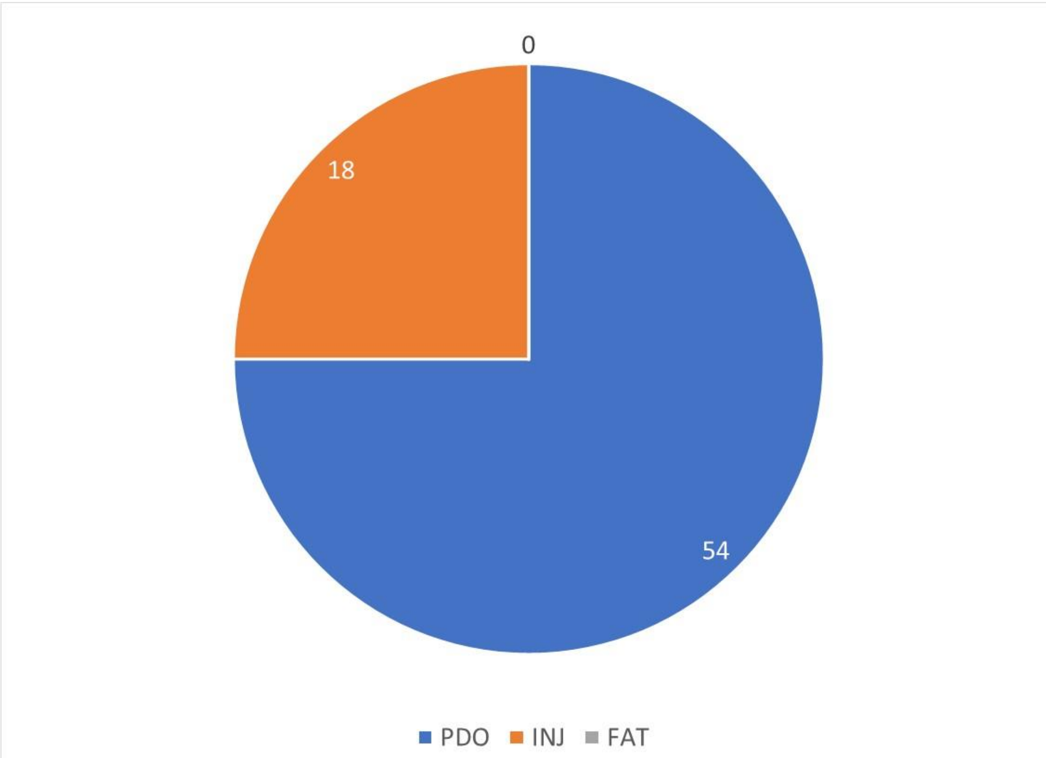


Figure 22. The Parkway and Belle Haven Road, Crash Severity

One-quarter of all of the crashes at the intersection resulted in an injury.

A total of 32 injured people were reported across all 18 of the crashes involving injuries; no fatalities were reported.

The occurrence of the injury crashes by both month and day of the week was investigated (Figure 23 and Figure 24).

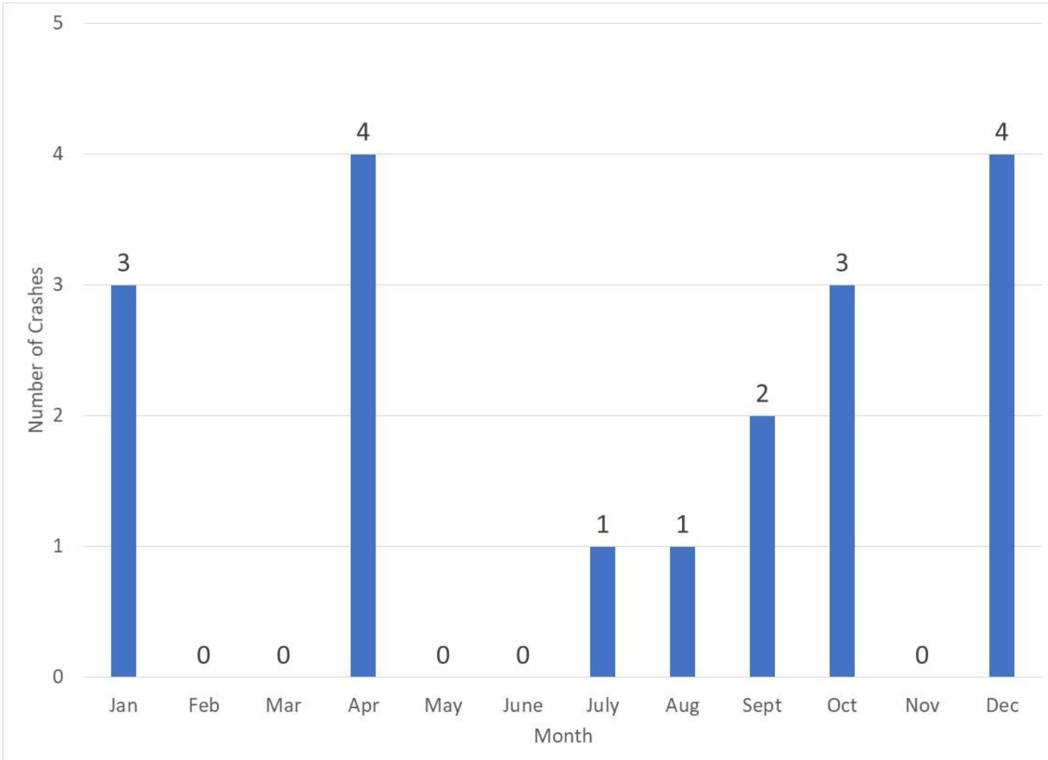


Figure 23. The Parkway and Belle Haven Road, Injury and Fatal Crashes by Month

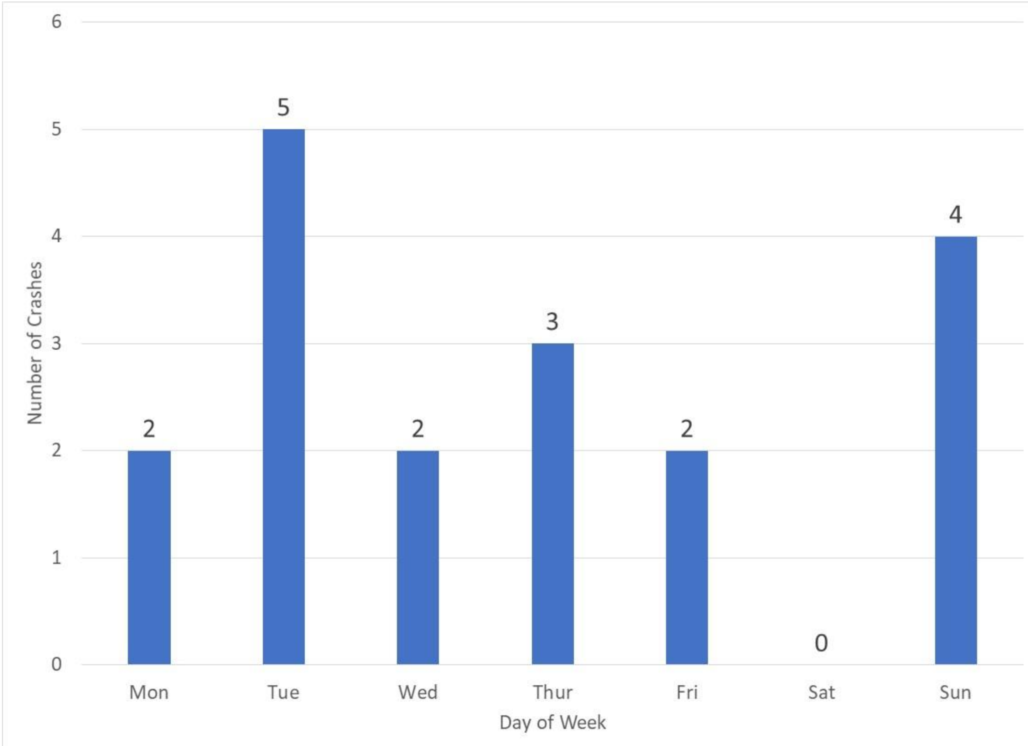


Figure 24. The Parkway and Belle Haven Road, Injury Crashes by Day of the Week

Crashes also seem to be more likely to result in injuries during both the a.m. and p.m. Peak periods (Figure 25).

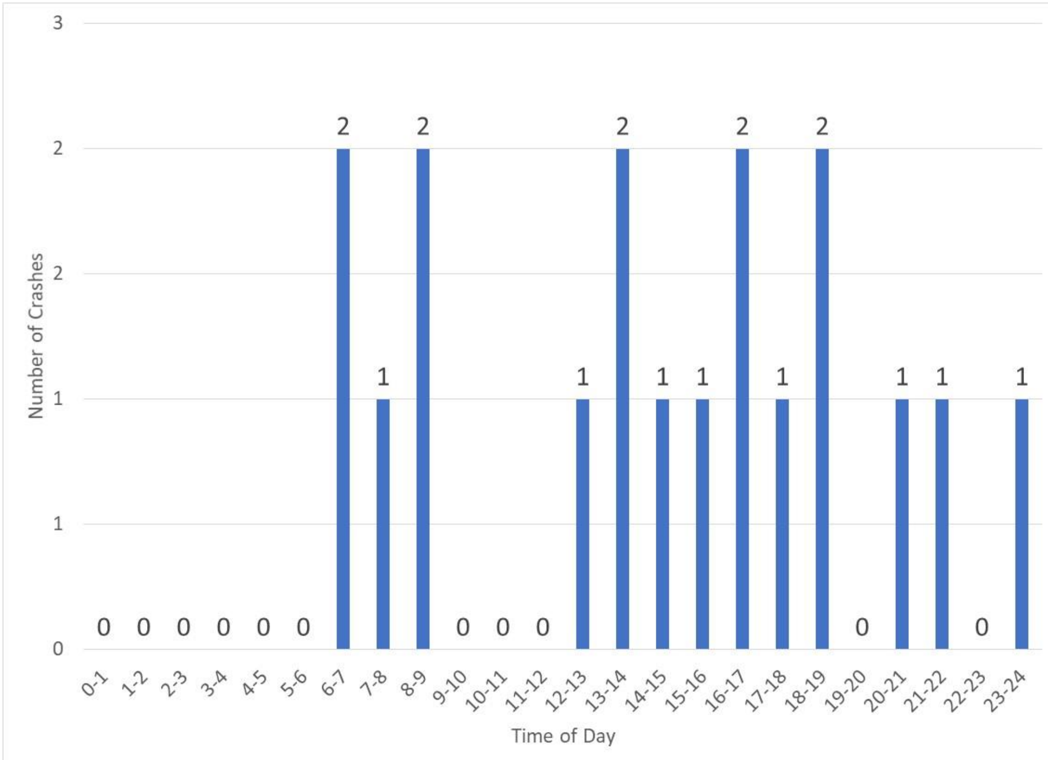


Figure 25. The Parkway and Belle Haven Road, Injury Crashes by Time of Day

2.1.7 Pedestrians and Bicycles

A "sideswipe-overtaking" crash was identified as having occurred between a motor vehicle and bicycle.

2.1.8 Crash Diagram

The following crash diagram (Figure 26) illustrates the location of crashes for this intersection for which location data were available. In some cases, this information was not available; however, further details are provided in the footnotes.

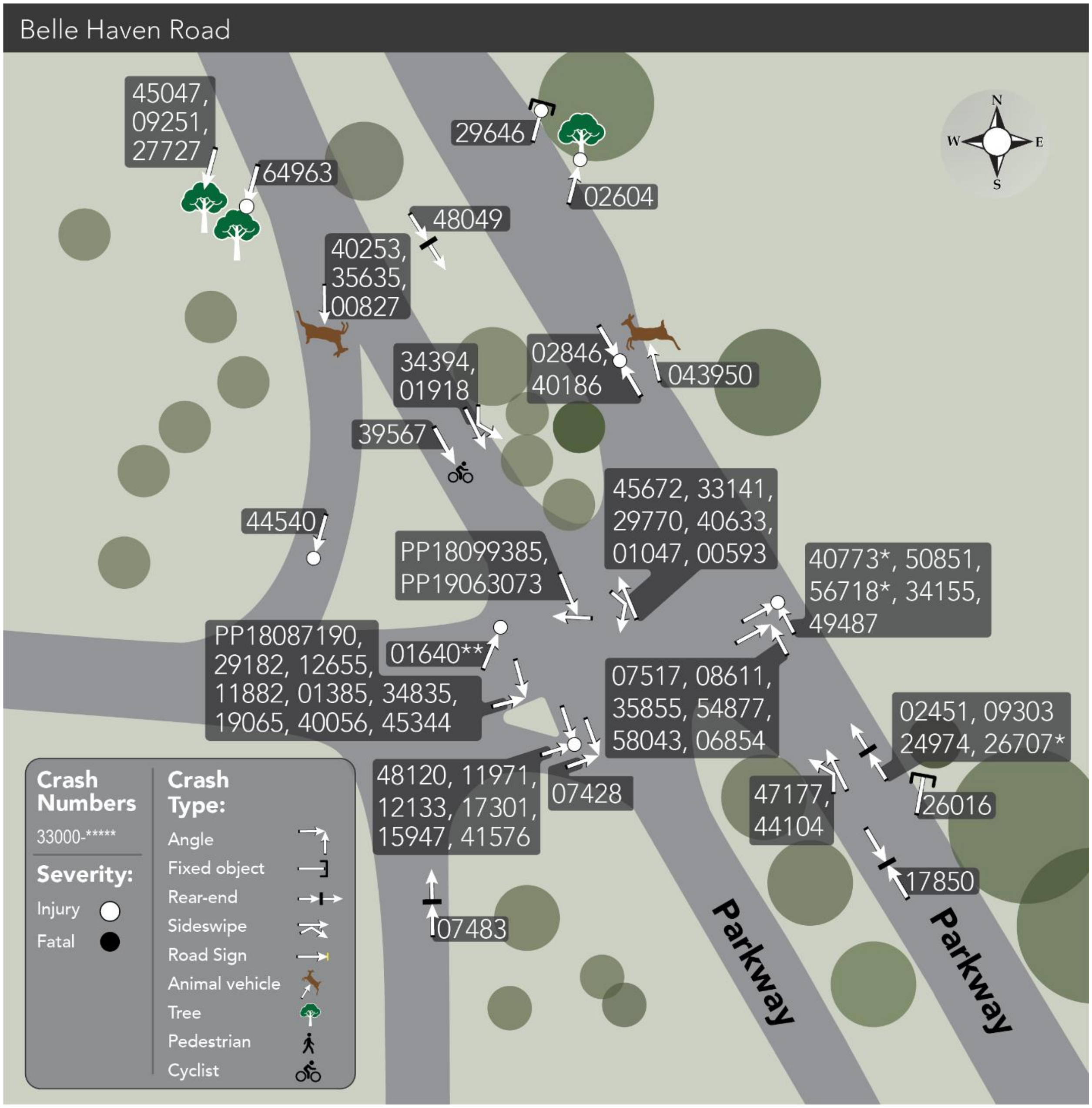


Figure 26. The Parkway and Belle Haven Road, Crash Diagram* ** ‡‡

* The assumption was made in the safety study that a vehicle involved in the crash was traveling northbound, although the tabular data is not explicit.
** The tabular data suggests that the crash occurred west of the intersection, although the data is not explicit.
‡‡ The following are additional crashes that occurred at Belle Haven Road that could not be placed on the crash diagram:
14051607 — no direction or crash type identified; PDO
3300047021 — southbound; no crash type identified; PDO
3300013994 — northbound, no crash type identified; PDO
3300046226 — southbound, no crash type identified; INJ
3300034012 — northbound, crash cause was "tires"; PDO
3300002835 — no direction, crash with a pole; PDO
3300015960 — southbound, says "improper turn," although it is unclear in what direction the turn was made; PDO
PP18053829 — says that both vehicles were traveling southbound; no crash type; PDO

The north leg of the intersection seems to be a crossing for animals, as all four of the crashes with animals occurred on this leg. While the animal crashes are depicted as a deer for the diagram, it is unclear what types of animals were involved. The six opposite-direction sideswipe crashes suggest that the current traffic control does not clearly establish right-of-way.

2.1.9 Summary — Belle Haven Road

Based on crash data (2005–2015, 2018–2019), the largest number of crashes occurred in 2011; in January; most often between 8:00 a.m. and 9:00 a.m. and 2:00 p.m. and 3:00 p.m.; and slightly more often on Thursdays (Table 19). The majority of crashes were reported as occurring when the weather was clear and the road surface was dry. The most frequent crash type was "Angle." Most often, the primary cause was identified as "Failed to Yield ROW," which suggests that there may be a lack of clarity regarding who has the right-of-way.

Table 19. The Parkway and Belle Haven Road, Summary of Key Data Findings

Criteria	Count
Number of Crashes	72
Year (of greatest frequency)	2011
Month (of greatest frequency)	January
Day (of greatest frequency)	Thursday
Percent from 12:00 a.m. to 12:00 p.m.	32%
Most Frequent 1-Hour Block	8:00 a.m.–9:00 a.m.; 2:00 p.m.–3:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	p.m. Peak
Most Typical Crash Type	Angle
Most Typical Reported Cause	Failed to Yield ROW (15 of 72)
Driving Under the Influence	2.8% of Crashes
Hit and Run	6.9% of Crashes
Percent of Injury and Fatal Crashes (measure of severity)	25%

Criteria	Count
Total Number of People Injured in Crashes	32 People
Pedestrian/Bicycle Involved Crashes?	Yes; 1 Crash (1.4%)
Animal Involved Crashes?	Yes; 4 Crashes (5.6%)

2.2 The Parkway and Belle View Boulevard

Figure 27 shows the orientation of the Parkway and Belle View Boulevard, a three-legged intersection with a median.

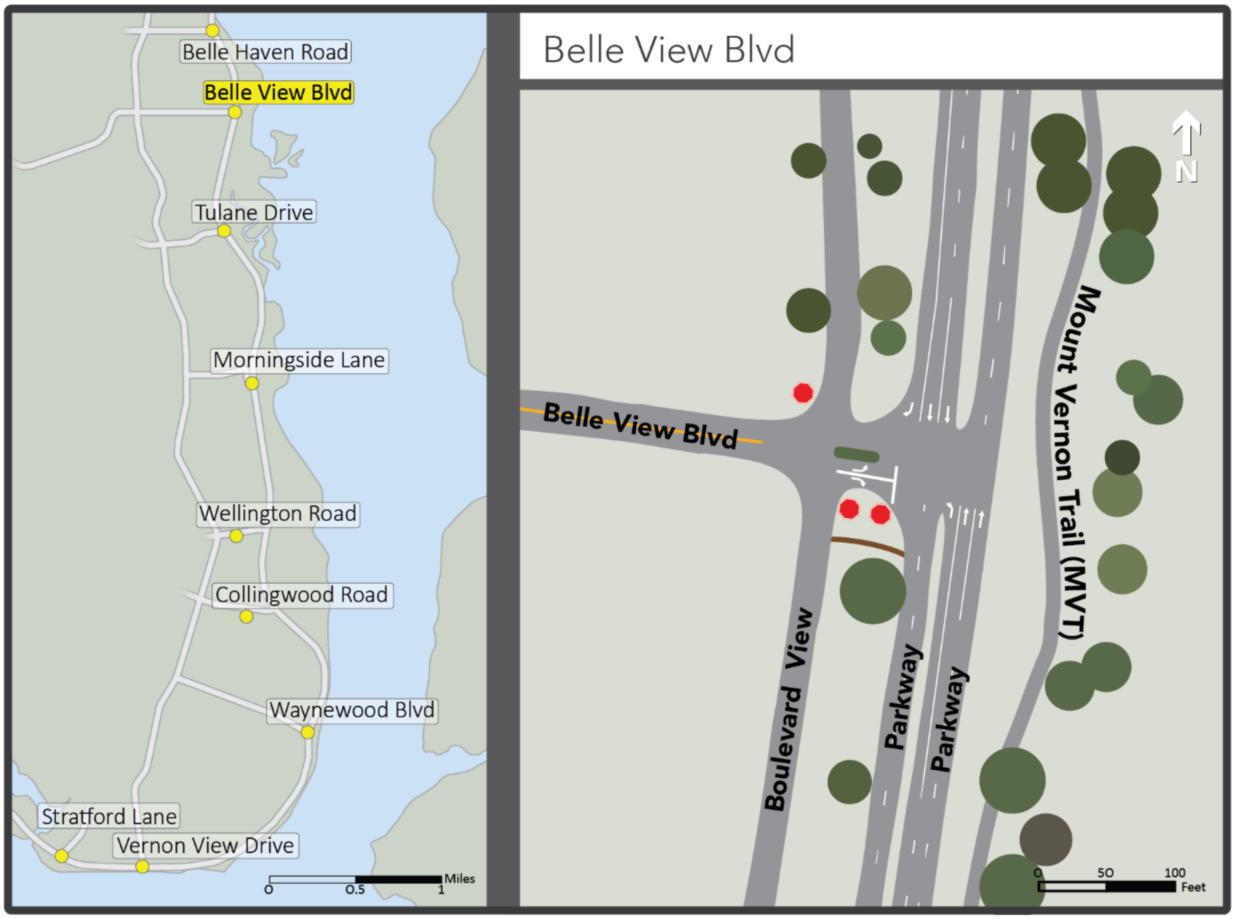


Figure 27. The Parkway and Belle View Boulevard

There are a few interesting geometric considerations at this intersection. First, Boulevard View closely parallels the Parkway; the lack of an offset between two intersections (the Parkway and Belle View Boulevard and Boulevard View and Belle View Boulevard) can be problematic from a safety perspective, as a driver at one intersection may not detect someone who is arriving at the second intersection from the first. Also, on the east side of the intersection, notice the close proximity of the Mount Vernon Trail. While there is not an official pedestrian/bicyclist crossing, there is a dirt impression (i.e., social trail) on the south side between Boulevard View and the Parkway.

Figure 28 shows one of many photos taken of pedestrians/bicyclists at this intersection. Finally, in the southbound direction of the Parkway, there is a right-turn lane. This lane can potentially obstruct a driver's view when looking to turn northbound from eastbound on Belle View Boulevard. In addition, there is the potential for confusion if someone in the right-turn lane does not commit to turning right.

Figure 28. Pedestrian, Bicyclist, and Vehicle at the Parkway and Belle View Boulevard

During 2005–2015 and 2018–2019, 90 crashes occurred at the intersection of the Parkway and Belle View Boulevard. Generally speaking, the annual occurrence of crashes appears to be random, although 2014 had the greatest number of crashes reported (Figure 29). In 2015, there were no crashes at this intersection.

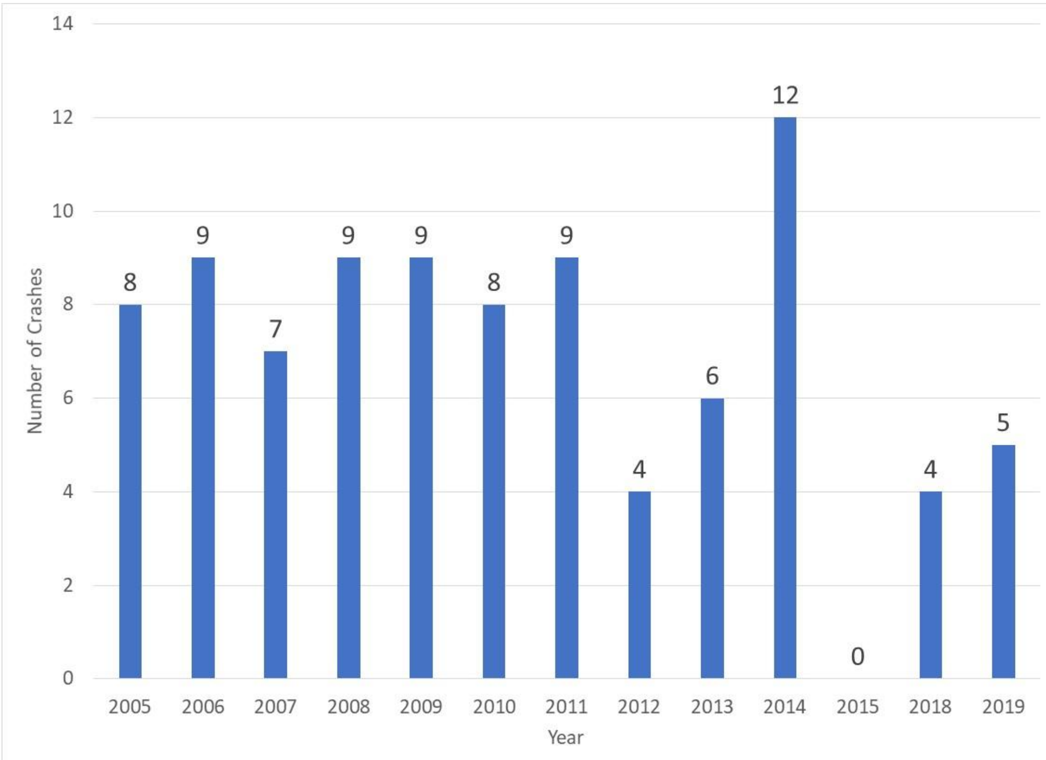


Figure 29. The Parkway and Belle View Boulevard, Total Crashes by Year

Notably, the data indicates a drop in crash occurrence from 2011 to 2012 and a jump in 2014. Identifying if any operational or geometric changes were made in 2011 and 2013 would be worth the effort. The results could also suggest that there are issues with the crash data. However, while a gap exists between the more recent data and past years, some consistency can be seen between the 2012 and 2013 data when compared with the 2018 and 2019 data. However, the 2018 and 2019 data is only partial data for the year.

2.2.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in May (Figure 30).

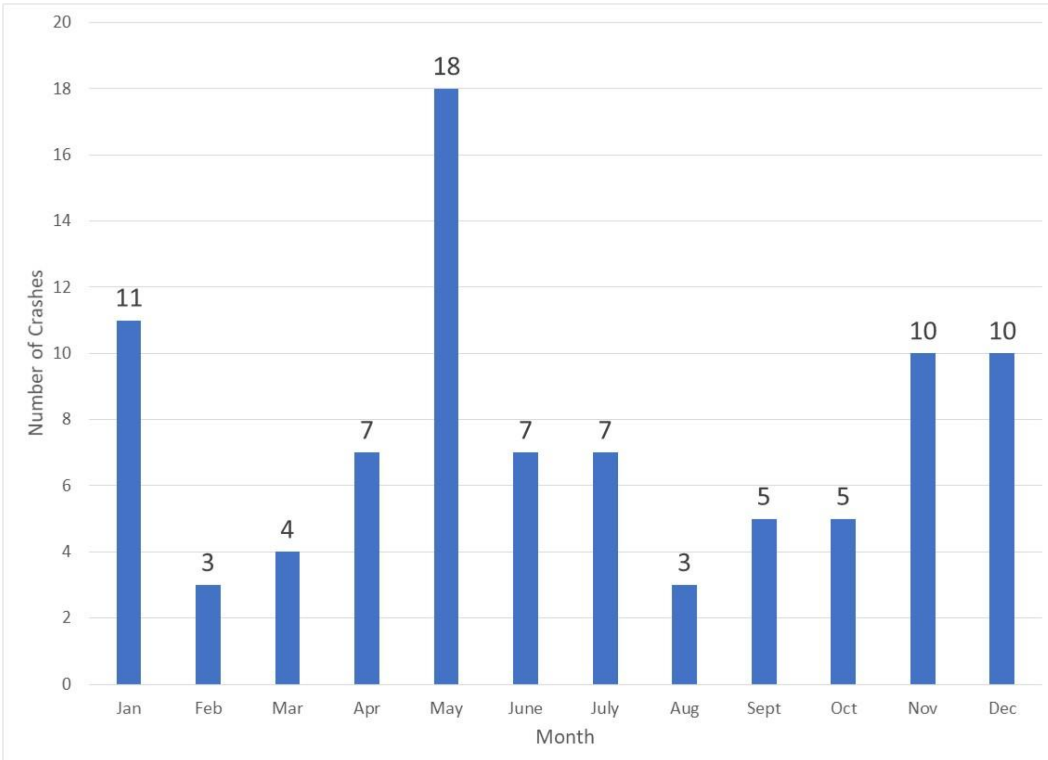


Figure 30. The Parkway and Belle View Boulevard, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate when crashes occurred more often. The data show that 30% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 3:00 p.m. and 4:00 p.m. (Figure 31).

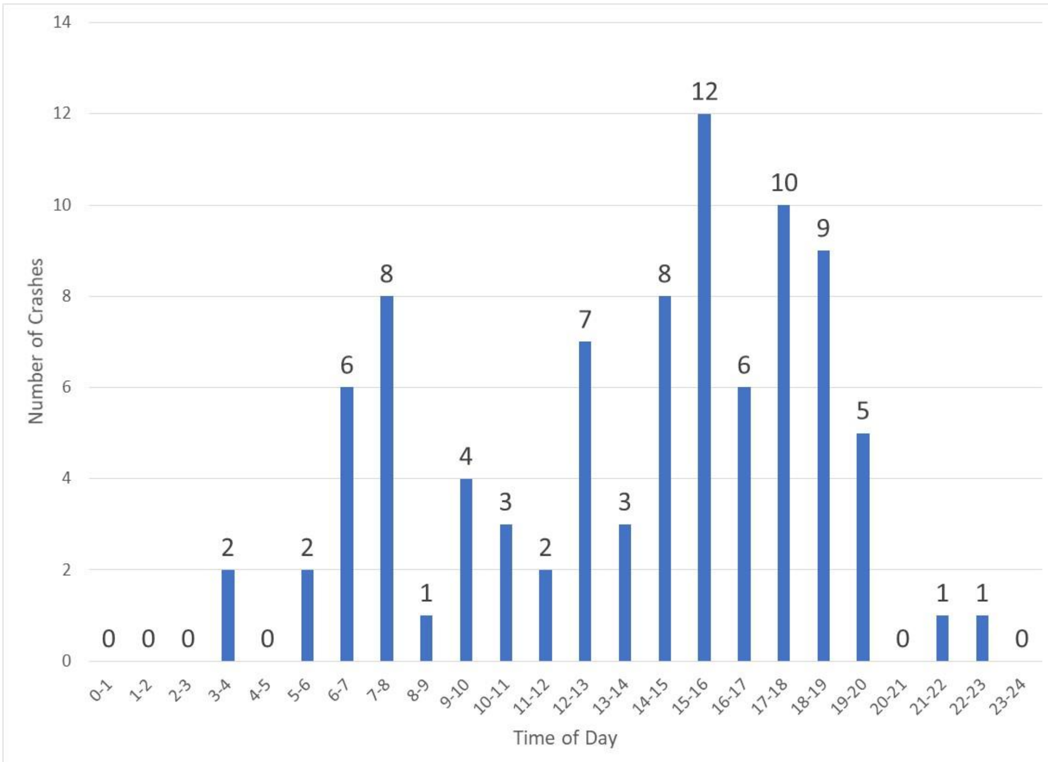


Figure 31. The Parkway and Belle View Boulevard, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the largest number and the highest rate of crashes occurred during the p.m. peak period (Table 20).

Table 20. The Parkway and Belle View Boulevard, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	4	0.7
6:00 a.m.–9:00 a.m.	a.m. Peak	15	5.0
9:00 a.m.–3:00 p.m.	Midday	27	4.5
3:00 p.m.–6:00 p.m.	p.m. Peak	28	9.3
6:00 p.m.–12:00 a.m.	post-p.m. Peak	16	2.7
TOTAL		**90**	–

The day of the week with the greatest number of crashes is Friday (Figure 32).

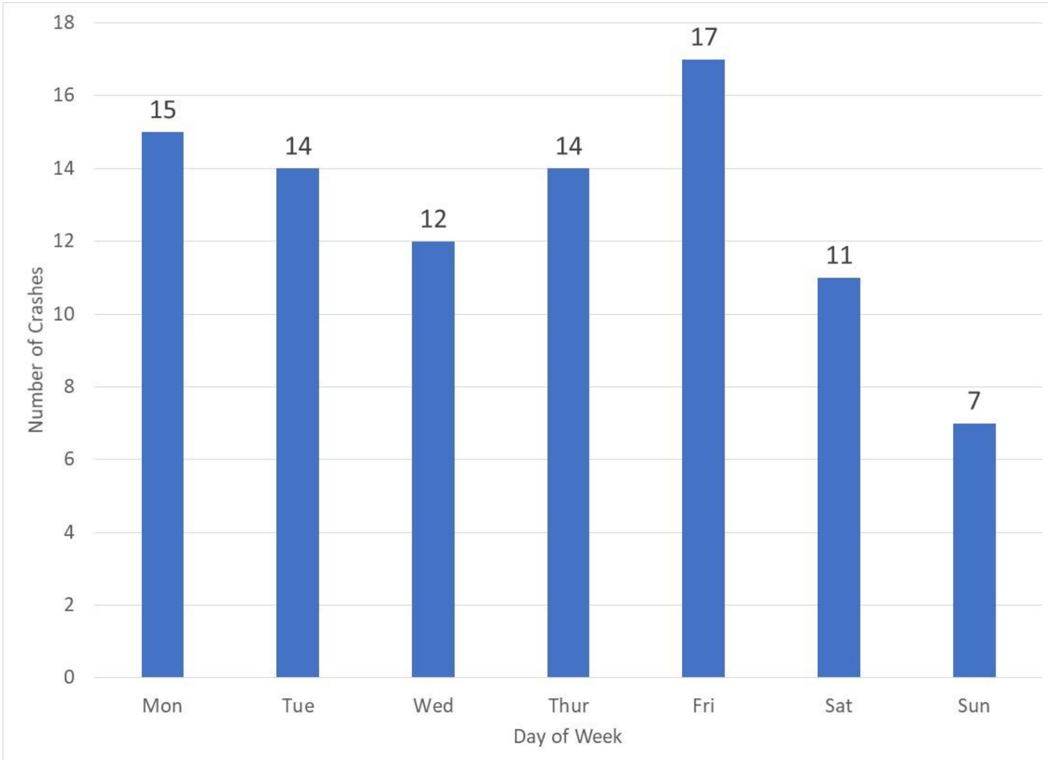


Figure 32. The Parkway and Belle View Boulevard, Crashes by Day of the Week

These results suggest the possibility of contributing factors occurring on Friday that are increasing the number of crashes.

2.2.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence. Figure 33 shows an analysis of lighting conditions during crashes.

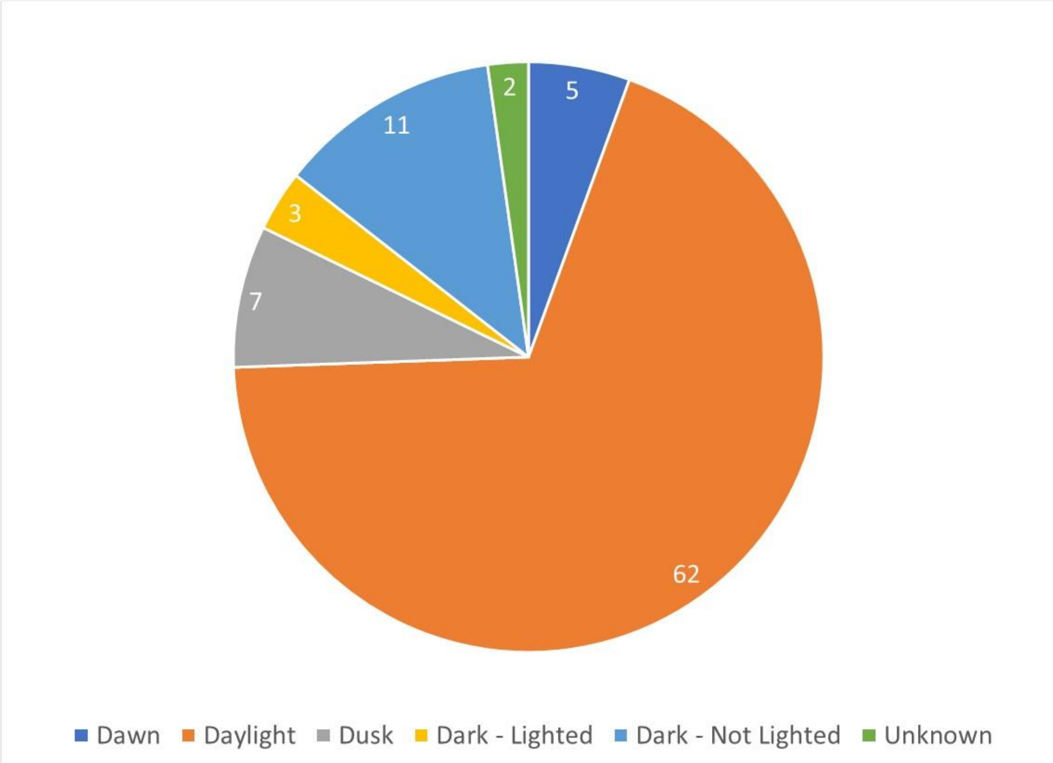


Figure 33. The Parkway and Belle View Boulevard, Lighting (Number of Crashes during Each Lighting Condition)

Some of the data were inconsistent, showing that. Eleven crashes occurred when the intersection was "Dark – Not Lighted," and three when the intersection was "Dark – Lighted." The study section of the Parkway does not have lighting; therefore, "Dark – Lighted" must be an error.

Most crashes (62) were identified as having occurred during "Daylight." Looking at the data in more detail, of the crashes that occurred during "Daylight," 19 of these crashes were during periods when conditions were indicated as "Cloudy," "Rain," or "Sleet, Hail, Freezing Rain." These conditions would suggest that the crashes occurred when there was reduced visibility. The remaining 43 crashes occurred during "Daylight." Therefore, a little more than half of the crashes occurred during hours when visibility was good, while the remaining crashes occurred during periods when it was not.

The researchers also considered whether the "Daylight" crashes occurred during peak periods. (*Note:* It was anticipated that "Daylight" crashes would be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 p.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 21 shows the number of crashes within these groups.

Table 21. The Parkway and Belle View Boulevard, "Daylight" Crashes in Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. peak	2	0.3
6:00 a.m.–9:00 a.m.	a.m. peak	8	2.7
9:00 a.m.–3:00 p.m.	midday	26	4.3
3:00 p.m.–6:00 p.m.	p.m. peak	18	6.0
6:00 p.m.–12:00 a.m.	post-p.m. peak	8	1.3
TOTAL "Daylight" Crashes		**62**	–

"Daylight" crashes were most likely to occur during the p.m. peak and least likely to occur from 12:00 a.m. to 6:00 a.m. (pre-a.m. peak).

With regard to weather, the majority of the crashes (53) occurred during "Clear" periods (Figure 34); however, this was just over half. There is the potential that weather could be impacting the number of crashes; more information is needed regarding the implications of "other."

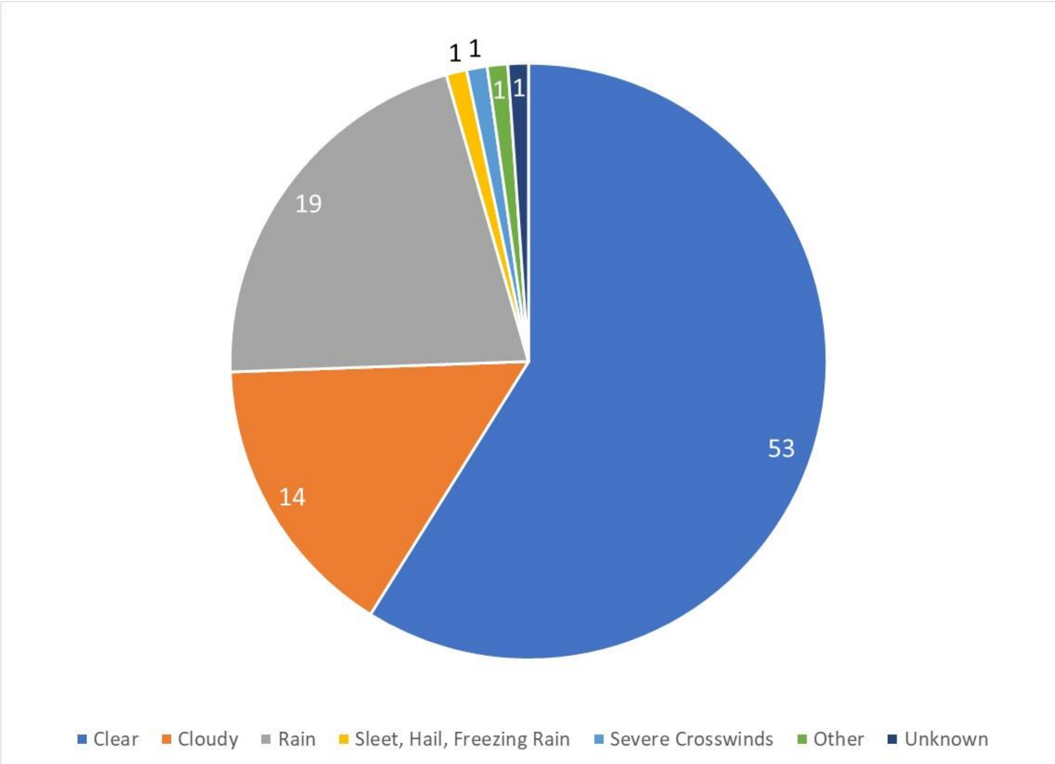


Figure 34. The Parkway and Belle View Boulevard, Weather

The majority of crashes (66) occurred when surface conditions were “Dry”; however, just over a quarter of them occurred when the pavement was reported as being “Wet” (Figure 35).

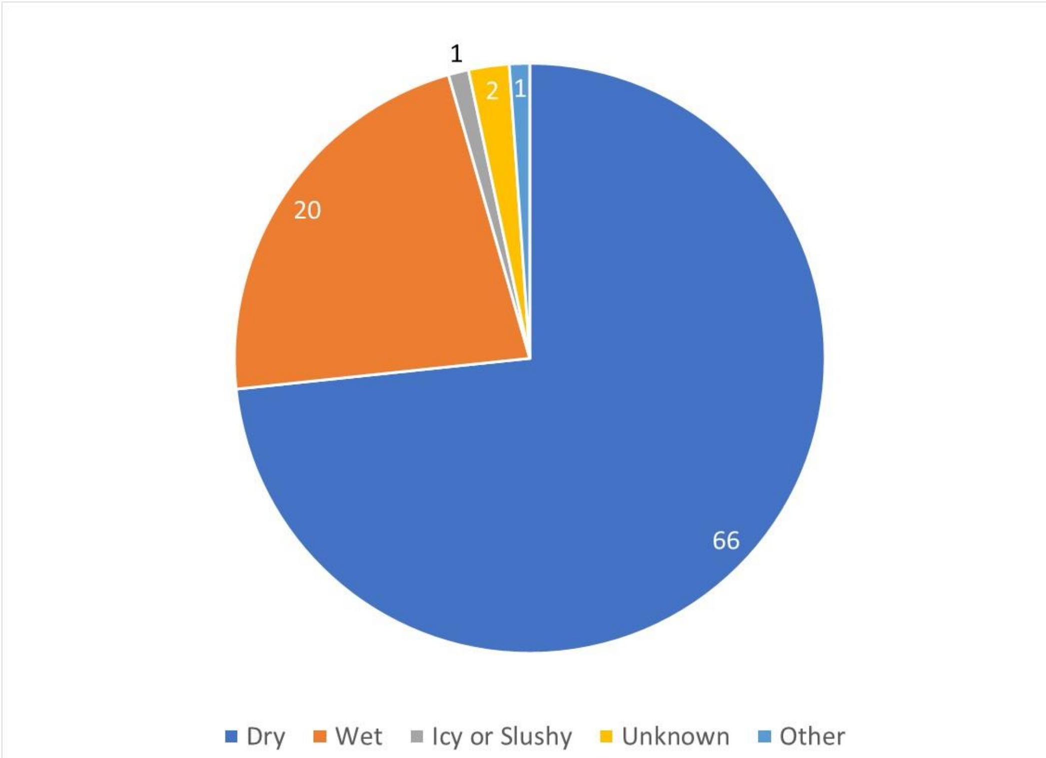


Figure 35. The Parkway and Belle View Boulevard, Surface Condition

2.2.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. "Angle" was the most common crash type (46) (Figure 36).

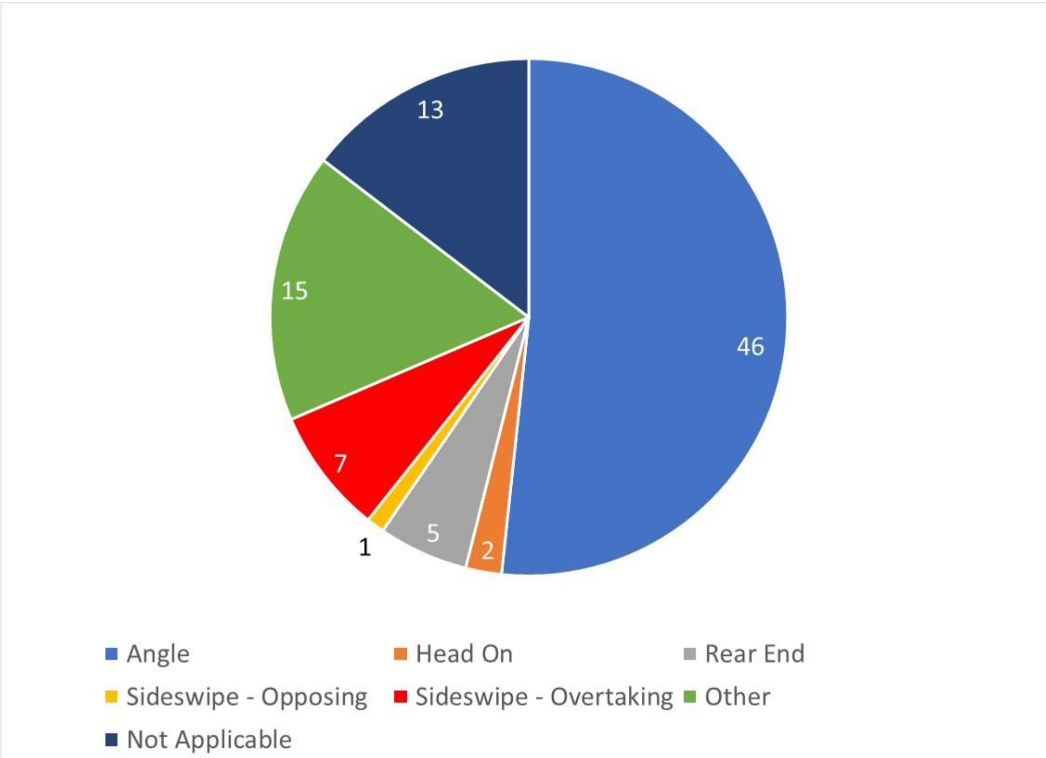


Figure 36. The Parkway and Belle View Boulevard, Crash Type

Thirteen crashes were identified as "Not Applicable" and involved a collision with a tree/shrub (5), animal (3), pedestrian (2), sign (1), other (1), or were identified as a "non-collision" (1). These results suggest that addressing why vehicles are hitting trees/shrubs, animals, and pedestrians would assist with reducing the crash occurrence at the intersection.

By far, the most frequently reported "Primary Cause" was "Failed to Yield ROW" (Figure 37), which was reported in 43 of the 90 crashes (48%). (*Note:* Figure 37 only shows 70 of the 90 crashes that occurred at the intersection, as 20 crashes provided no information on the "Primary Cause.")

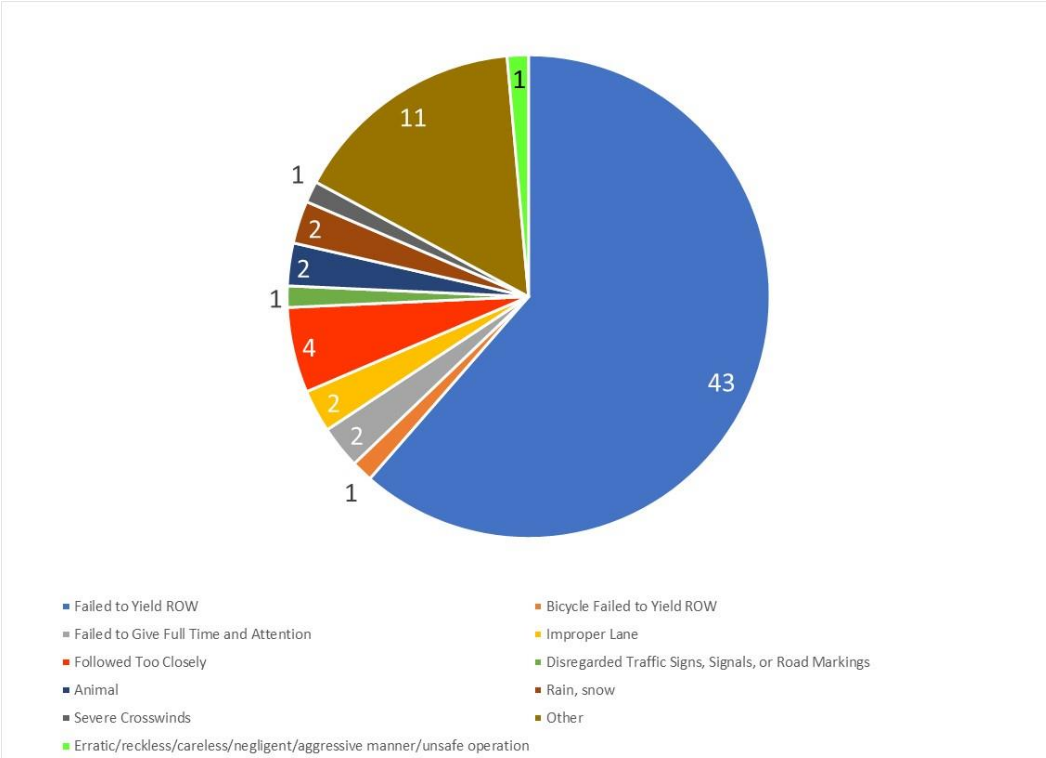


Figure 37. The Parkway and Belle View Boulevard, Primary Cause

"Other" was the second most frequently identified "Primary Cause," at 11. "Followed Too Closely" was the third most frequently identified "Primary Cause," at 4.

2.2.4 Driving Under the Influence

As noted in the "Primary Cause" section, of the 90 crashes identified at the intersection (2005–2015, 2018–2019), no crashes were identified as having a driver who was under the influence of alcohol or other substances.

2.2.5 Hit and Run

Interestingly, 4 of the 90 crashes, or 4.4%, were identified as hit and run (Benson, et al. 2017).

2.2.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. While the majority of crashes (55) that are occurring at the intersection are PDO crashes, the overall severity is high, as shown by the presence of a fatal crash and 38% of all crashes being injury or fatal crashes (Figure 38).

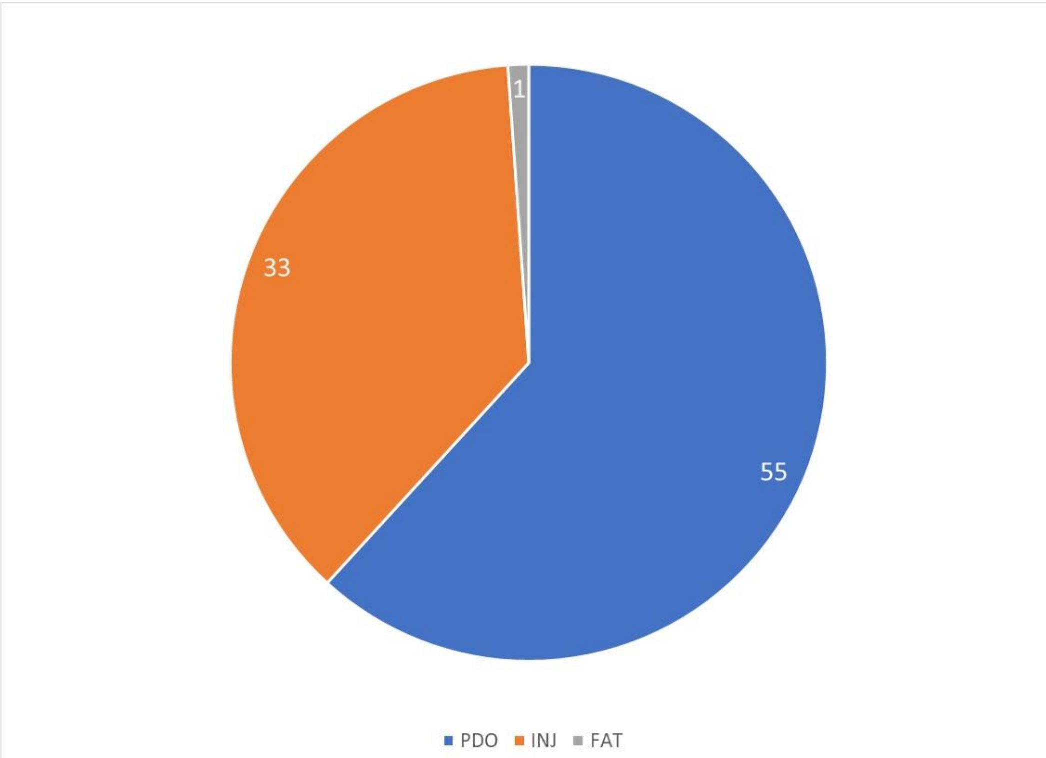


Figure 38. The Parkway and Belle View Boulevard, Crash Severity

Across the injury and fatal crashes, there were a total of 47 injuries and 1 fatality.

The occurrence of the injury and fatal crashes by month, day of week, and time of day was investigated. In Figure 39, Figure 40, and Figure 41, blue represents injury crashes and orange represents the fatal crash. There is clearly some aspect related to crashes in May that is resulting in an increase in severity of the crashes (Figure 39).

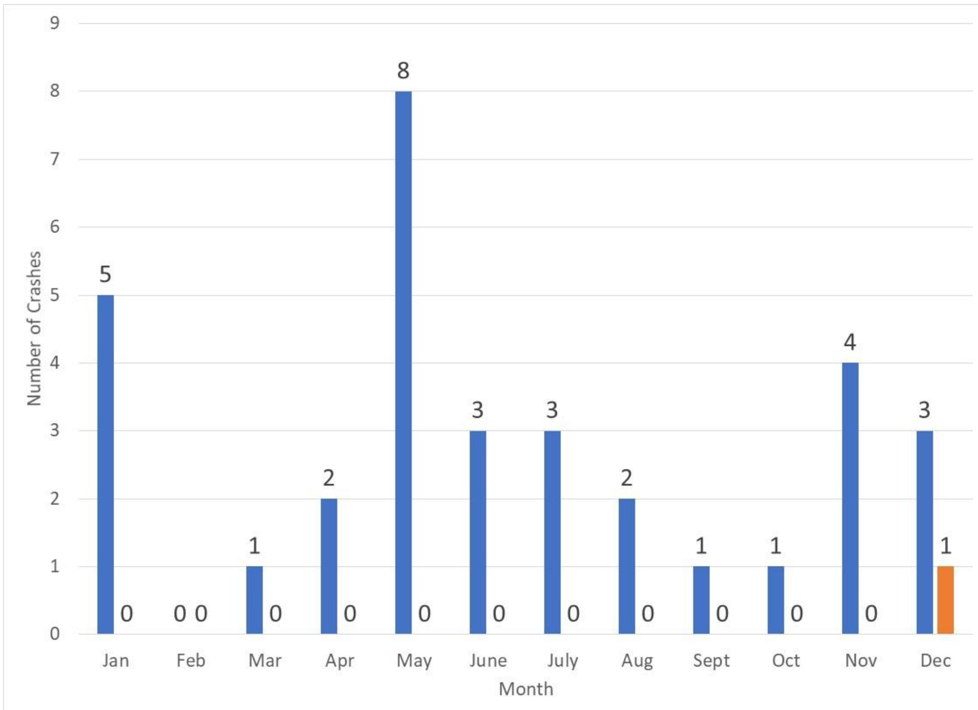


Figure 39. The Parkway and Belle View Boulevard, Injury and Fatal Crashes by Month

Based on this small data set, there seems to be a larger number of crashes on Fridays than on other days of the week, and because of the large number of crashes, seems to have some characteristics that are contributing to crashes.

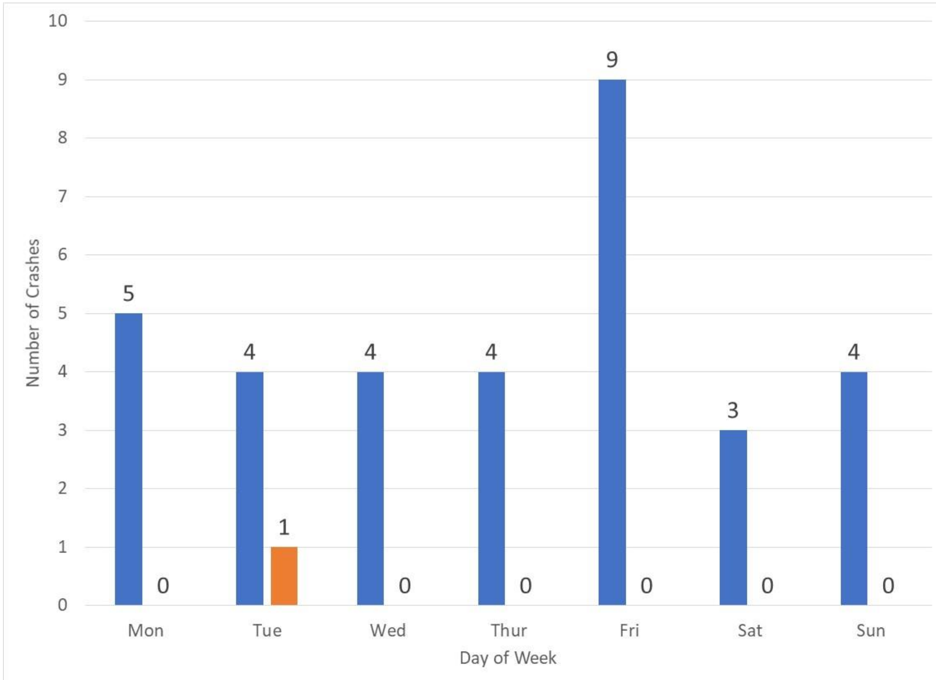


Figure 40. The Parkway and Belle View Boulevard, Injury and Fatal Crashes by Day of Week

Overall, it appears as if the p.m. Peak period has a large concentration of injury and fatal crashes. There is a high likelihood of injury crashes between 3:00 p.m. and 4:00 p.m. as compared with the other times of day.

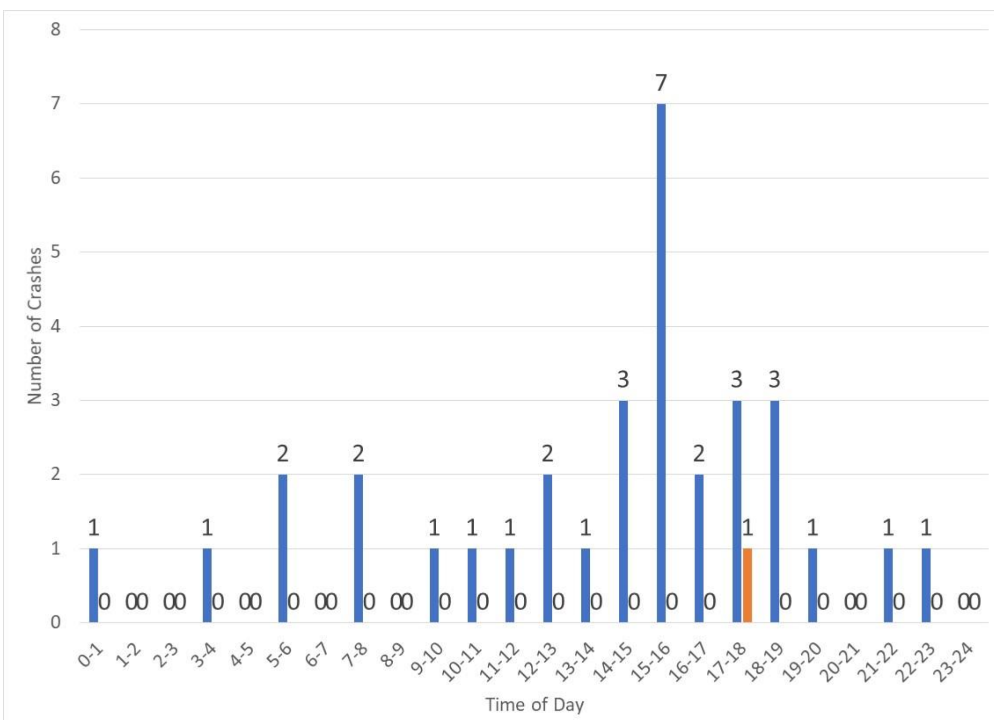


Figure 41. The Parkway and Belle View Boulevard, Injury and Fatal Crashes by Time of Day

2.2.7 Pedestrians and Bicycles

Three crashes (3.3%) involved a bicyclist and pedestrian; two of the three crashes were injury crashes.

2.2.8 Crash Diagram

The following crash diagram (Figure 42) illustrates the location of crashes for this intersection for which location data were available. In some cases, this information was not available; however, further details are provided in the footnotes.

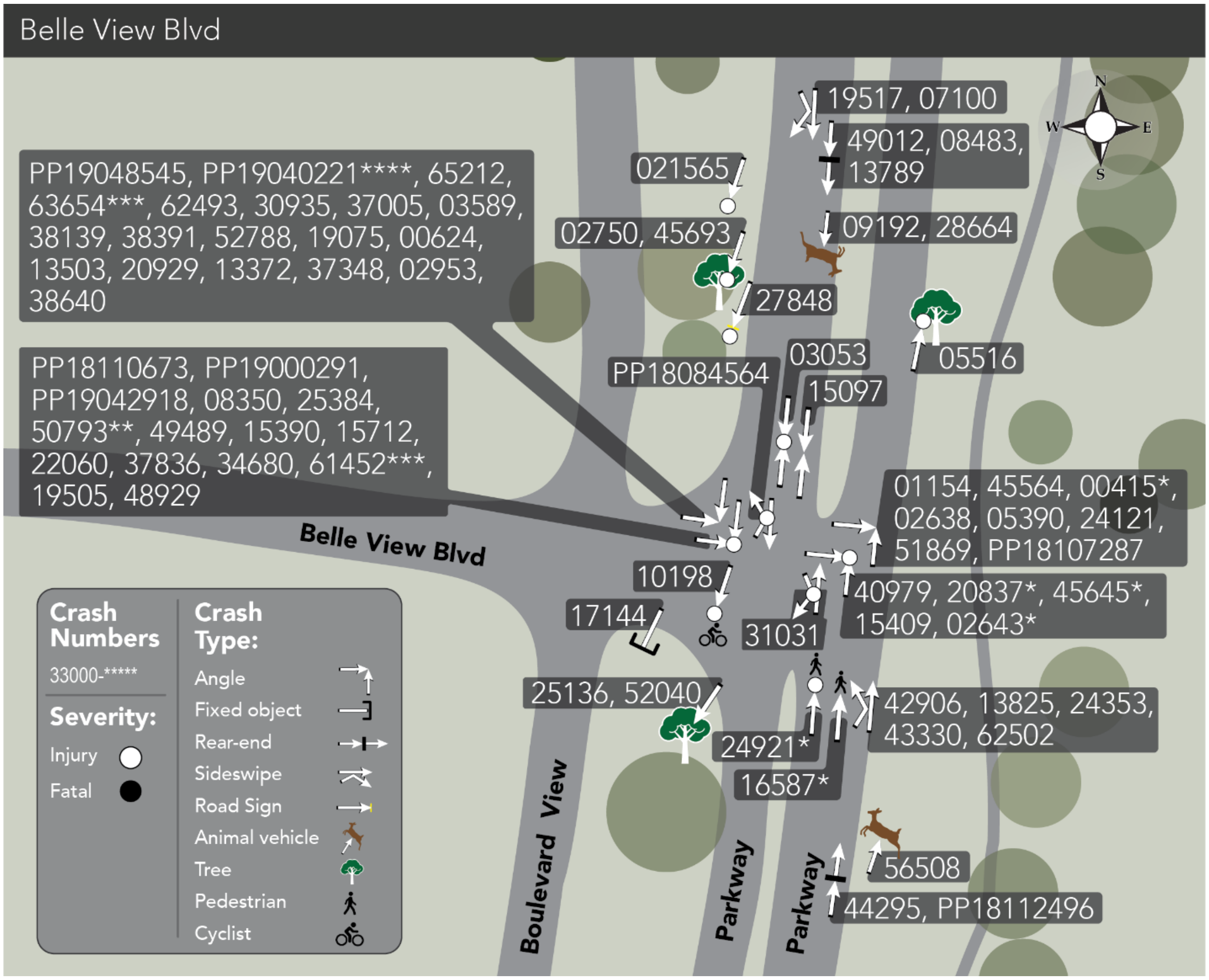


Figure 42. The Parkway and Belle View Boulevard, Crash Diagram *** ** *** **** †††

*** The assumption was made in the safety study that a vehicle involved in the crash was traveling northbound.

** It is implied that a vehicle was traveling eastbound.

*** The assumption was made in the safety study that a vehicle involved in the crash was traveling southbound.

**** The crash says "Other," but the crash was with eastbound and southbound vehicles.

††† The following are additional crashes that occurred at Belle View Boulevard and could not be placed on the diagram:

3300001197 — says "other"; PDO
3300046188 — says "other"; INJ
3300044488 — says "other"; southbound; FAT
330007878 — says "other"; southbound; PDO
3300014040 — says "other"; no direction; PDO
3300011574 — says "non-collision"; northbound; PDO
3300005346 — says "Made Improper Turn"; southbound; PDO
3300015232 — says "other"; southbound; PDO
3300014837 — says "other"; southbound; INJ
3300031614 — says "other"; southbound; INJ
14112997 — says "other"; southbound; PDO
14054019 — says "other"; southbound; PDO
PP19076919 — no information for crash type; one vehicle was identified as going eastbound and the other one southbound; there is no information regarding severity

The majority of the crashes seem to involve those accessing the Parkway from Belle View Boulevard. There are also crashes involving drivers leaving the roadway and hitting trees/shrubs and crashes with animals. While the animal crashes are depicted as deer for the diagram, it is unclear what types of animals were involved.

2.2.9 Summary — Belle View Boulevard

Based on crash data (2005–2015, 2018–2019), the largest number of crashes occurred in 2014; in May; between 3:00 p.m. and 4:00 p.m.; and on Fridays (Table 22). The greatest number of injury crashes also occurred in May, between 3:00 p.m. and 4:00 p.m., and on Fridays. (*Note:* In contrast, with only one fatality occurring, there does not seem to be any correlation between when (month, day, or time of day) this crash occurred and other trends observed, suggesting randomness.)

Regarding pedestrian and bicycle crashes, two of the pedestrian/bicycle crashes occurred in May with the third in April. Both of the May crashes occurred between 4:00 p.m. and 5:00 p.m. (4:24 p.m. and 4:54 p.m.). (*Note:* Two of the three pedestrian/bicycle crashes occurred on Sunday; one on Monday.) At the end of March, a public awareness campaign could be implemented to remind drivers to be aware of pedestrians/bicyclists, as there are likely more people getting out, walking, and bicycling at this time. With two of the crashes with pedestrians/bicycles occurring on Sundays, it should be pointed out that the day and time did not coincide with the peak crash time and day of the week (e.g., Friday and 3:00 p.m.–4:00 p.m.). Therefore, to address these crashes as compared with motor vehicle/to motor vehicle crashes, different techniques could be used. In particular, it is well known that the speed of a vehicle at the time of collision with a pedestrian/bicyclist significantly impacts the outcome regarding whether or not the vulnerable road user (pedestrian/bicyclist) survives, and if so, whether or not the injury is incapacitating or recoverable (see Figure 1 within Literature Review on Vehicle Travel Speeds and Pedestrian Injuries (USDOT, NHTSA 1999)).

Table 22. The Parkway and Belle View Boulevard, Summary of Key Data Findings

Criteria	Count
Number of Crashes	90
Year (of greatest frequency)	2014
Month (of greatest frequency)	May
Day (of greatest frequency)	Friday
Percent from 12:00 a.m.–12:00 p.m.	31%
Most Frequent 1-Hour Block	3:00 p.m.–4:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	p.m. Peak
Most Typical Crash Type	Angle
Most Typical Reported Cause	Failed to Yield ROW (43 of 90)

Criteria	Count
Driving Under the Influence	0 Crashes (0%)
Hit and Run	4 crashes (4.4%)
Percent of Injury and Fatal Crashes (measure of severity)	37%
Total Number of People Injured in Crashes	48 people*
Pedestrian/Bicycle Involved Crashes?	Yes; 3 crashes (3.3%)
Animal Involved Crashes?	Yes; 2 crashes (2.2%)

* 47 injured; 1 died

2.3 The Parkway and Tulane Drive

Figure 43 shows the orientation of the Parkway and Tulane Drive, a three-legged intersection with a median.

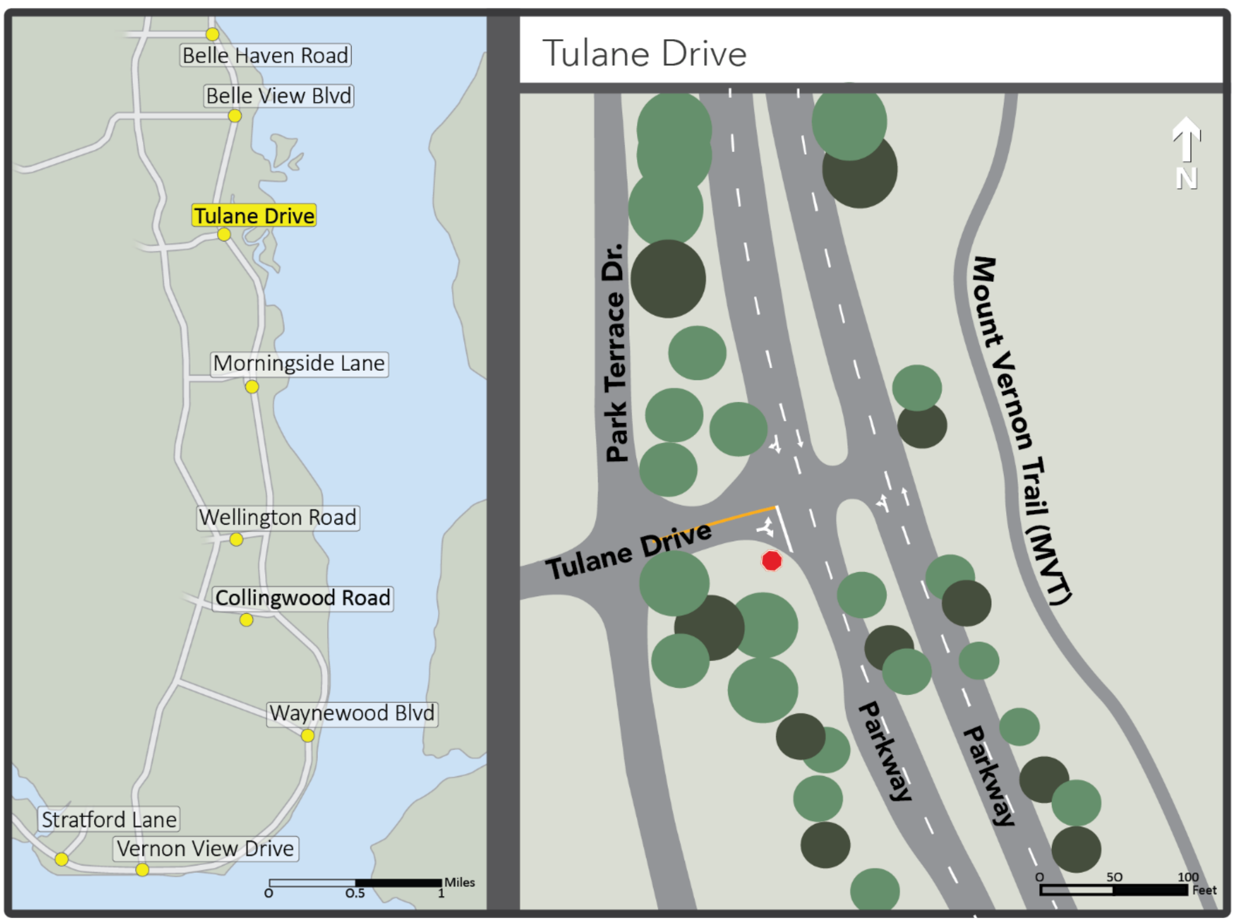


Figure 43: The Parkway and Tulane Drive

There are a few interesting geometric considerations at this intersection. First, Park Terrace Drive closely parallels the Parkway; the lack of an offset between two intersections (the Parkway and Tulane Drive and Tulane Drive and Park Terrace Drive) can be problematic from a safety perspective. Also, on the east side of the intersection, notice the close proximity of the Mount Vernon Trail. While there is not a clearly established pedestrian/bicyclist crossing, the population center to the left of these intersections and the Mount Vernon Trail to the east would make crossing appealing. Finally, the southbound direction includes a right-turn lane. This lane can potentially obstruct a driver's view who is looking to turn northbound from eastbound on Tulane Drive. In addition, there is the potential for confusion if someone in the right-turn lane does not commit to turning right.

During 2005–2015 and 2018–2019, 32 crashes occurred at the intersection of the Parkway and Tulane Drive. The annual occurrence of crashes appears to be random, although 2007 had the greatest number of crashes reported (Figure 44). In 2015, there were no reported crashes at this intersection.

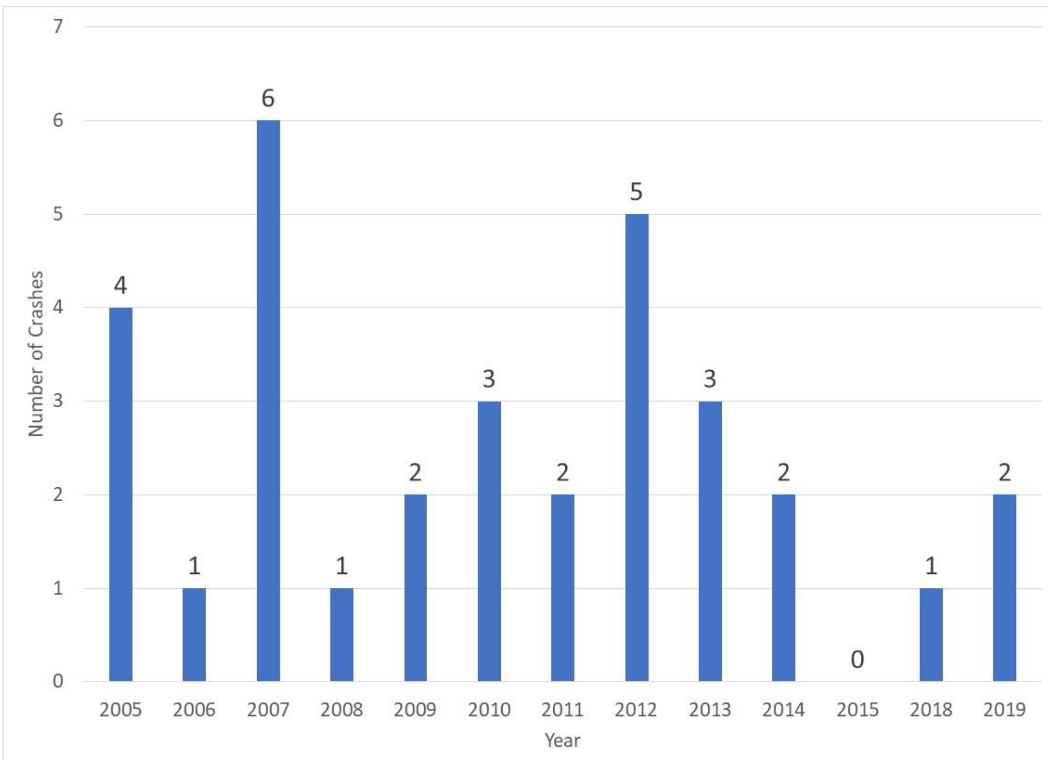


Figure 44. The Parkway and Tulane Drive, Total Crashes by Year

2.3.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015), crashes occurred most frequently in June, September, and October (Figure 45).

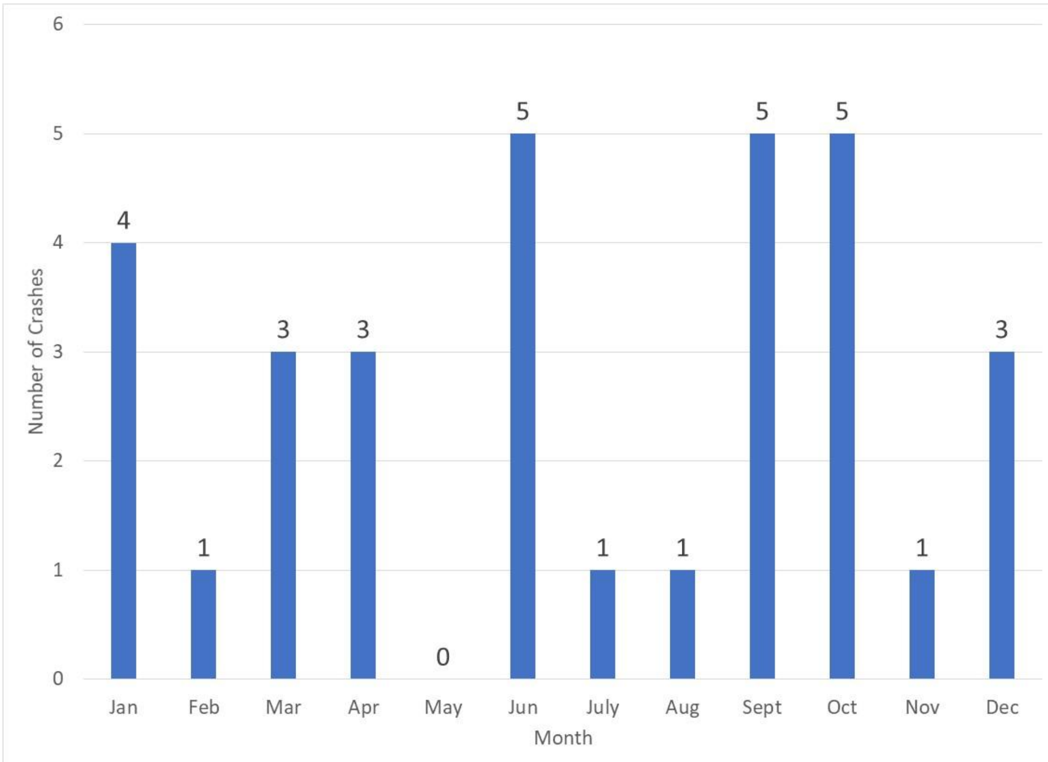


Figure 45. The Parkway and Tulane Drive, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to determine when crashes occurred more often. The data show that 44% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 3:00 p.m. and 4:00 p.m. and 7:00 p.m. and 8:00 p.m. (Figure 46).

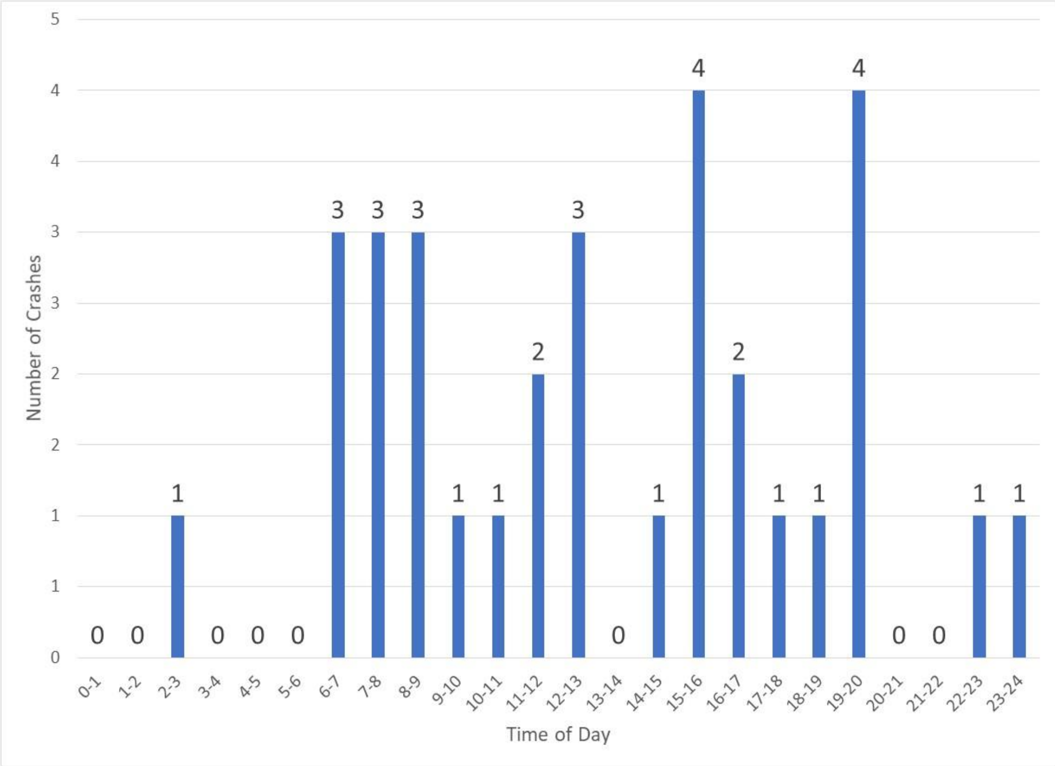


Figure 46. The Parkway and Tulane Drive, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the largest number and highest rate of crashes occurred during the a.m. peak period (Table 23).

Table 23. The Parkway and Tulane Drive, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	1	0.2
6:00 a.m.–9:00 a.m.	a.m. Peak	9	3.0
9:00 a.m.–3:00 p.m.	Midday	8	1.3
3:00 p.m.–6:00 p.m.	p.m. Peak	7	2.3
6:00 p.m.–12:00 a.m.	post-p.m. Peak	7	1.2
TOTAL		**32**	–

The day of the week that is most represented in the crash records is Friday (Figure 47).

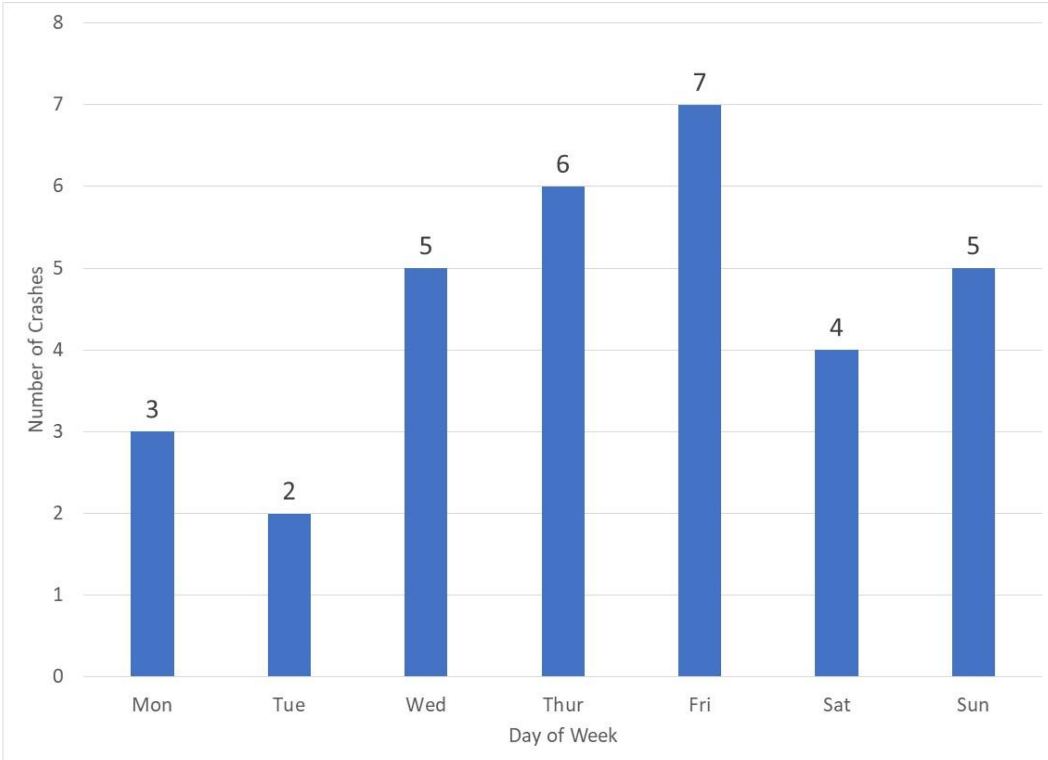


Figure 47. The Parkway and Tulane Drive, Crashes by Day of the Week

The results suggest the possibility of contributing factors that are increasing the number of crashes on Fridays.

2.3.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Figure 48 shows an analysis of lighting conditions during crashes.

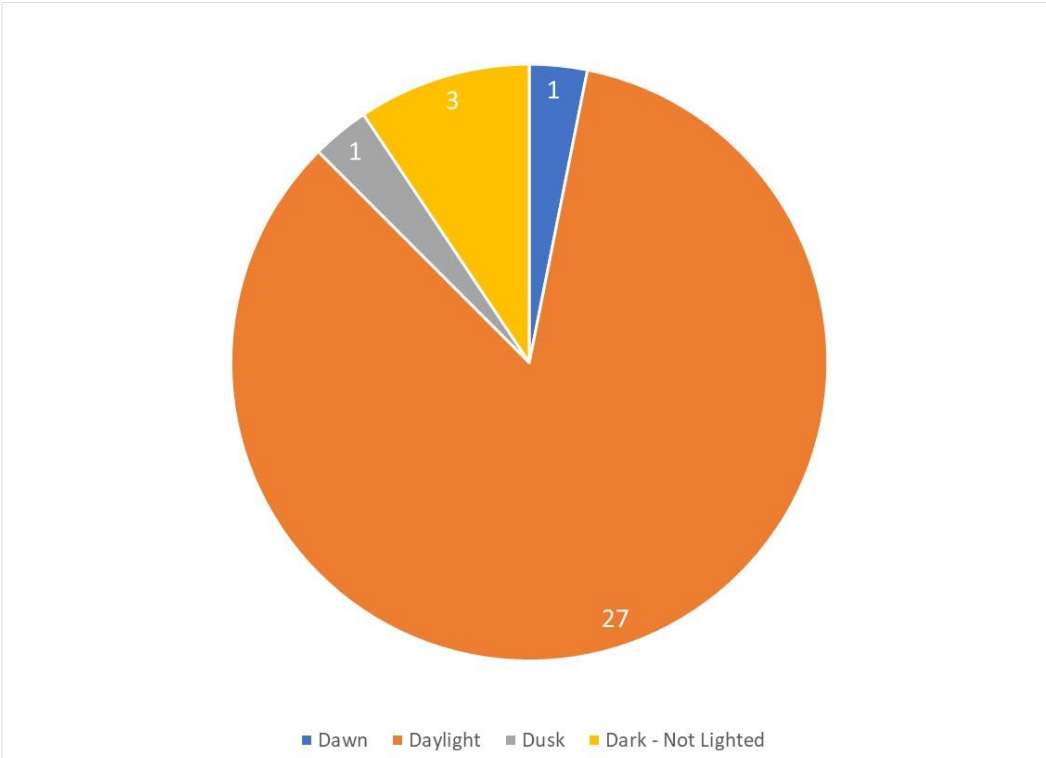


Figure 48. The Parkway and Tulane Drive, Lighting (Number of Crashes during Each Lighting Condition)

The data show that most crashes (27) occurred during "Daylight." Looking at the data in more detail, of the crashes that occurred during "Daylight," five of these crashes were during periods when conditions were indicated as: "Cloudy," "Rain," or "Sleet, Hail, Freezing Rain." These conditions would suggest that the crashes occurred when there was reduced visibility. The remaining 22 crashes occurred during "Daylight."

The researchers also considered whether the “Daylight” crashes occurred during peak periods. (*Note:* The team anticipated that “Daylight” crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 24 shows the number of crashes within these groups.

Table 24. The Parkway and Tulane Drive, “Daylight” Crash Counts and Rates by Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	0	0
6:00 a.m.–9:00 a.m.	a.m. Peak	8	2.7
9:00 a.m.–3:00 p.m.	Midday	8	1.3
3:00 p.m.–6:00 p.m.	p.m. Peak	7	2.3
6:00 p.m.–12:00 a.m.	post-p.m. Peak	4	0.7
TOTAL “Daylight” Crashes		**27**	–

“Daylight” crashes were most likely to occur during the a.m. peak and least likely to occur from 12:00 a.m. to 6:00 a.m. (pre-a.m. peak).

With regard to weather, more than three quarters of the crashes (25) occurred during “Clear” periods (Figure 49).

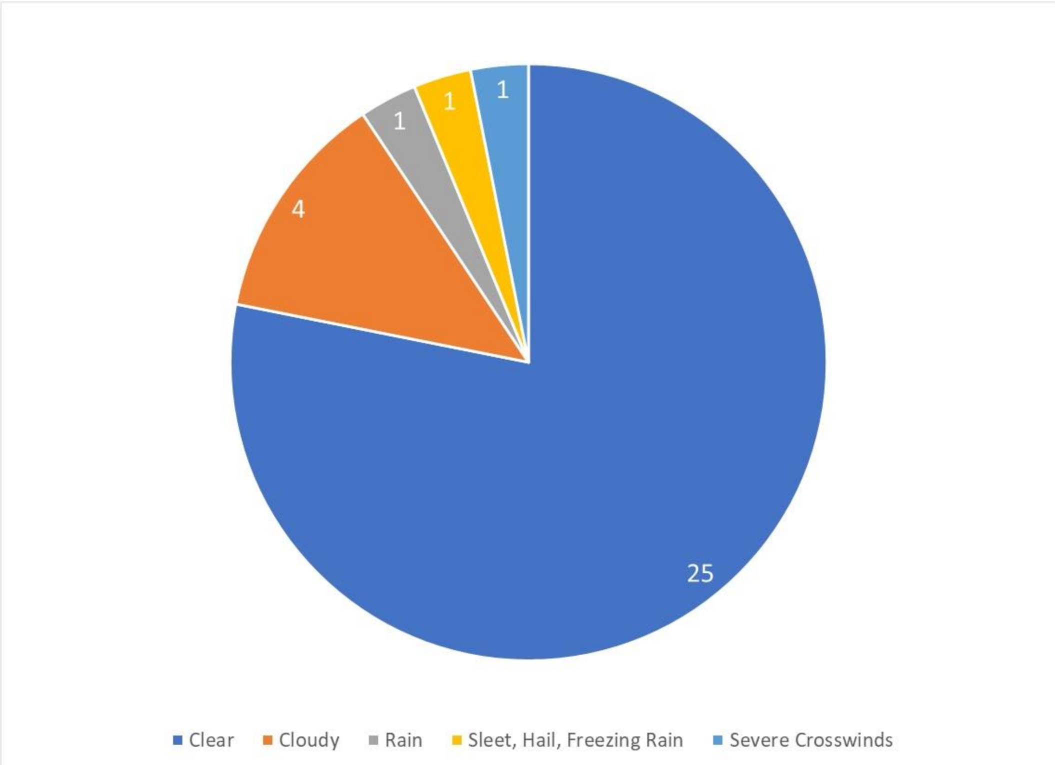


Figure 49. The Parkway and Tulane Drive, Weather

The majority of the crashes (29) occurred when surface conditions were “Dry,” which suggests that *surface condition is unlikely to be an issue* (Figure 50).

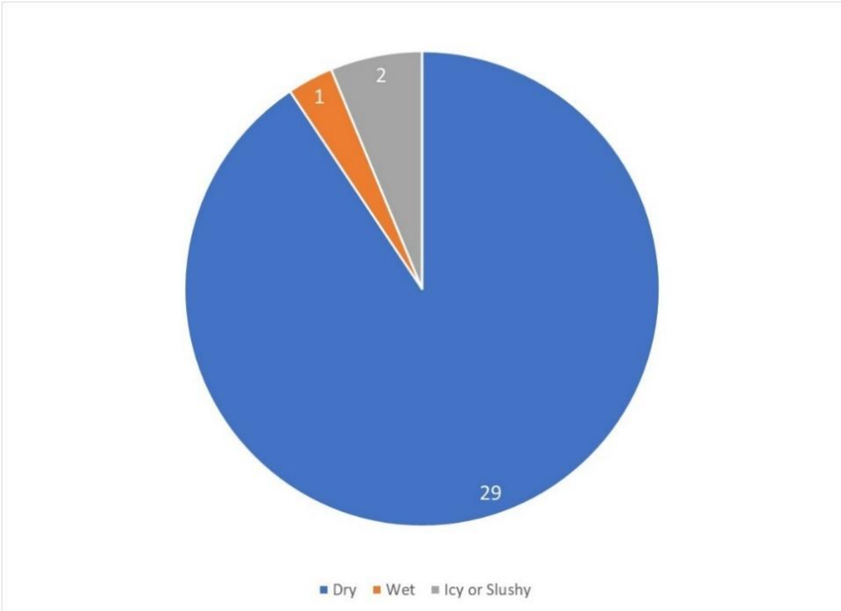


Figure 50. The Parkway and Tulane Drive, Surface Condition

2.3.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the indicated primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. “Not Applicable” was the most common crash type (14) (Figure 51).

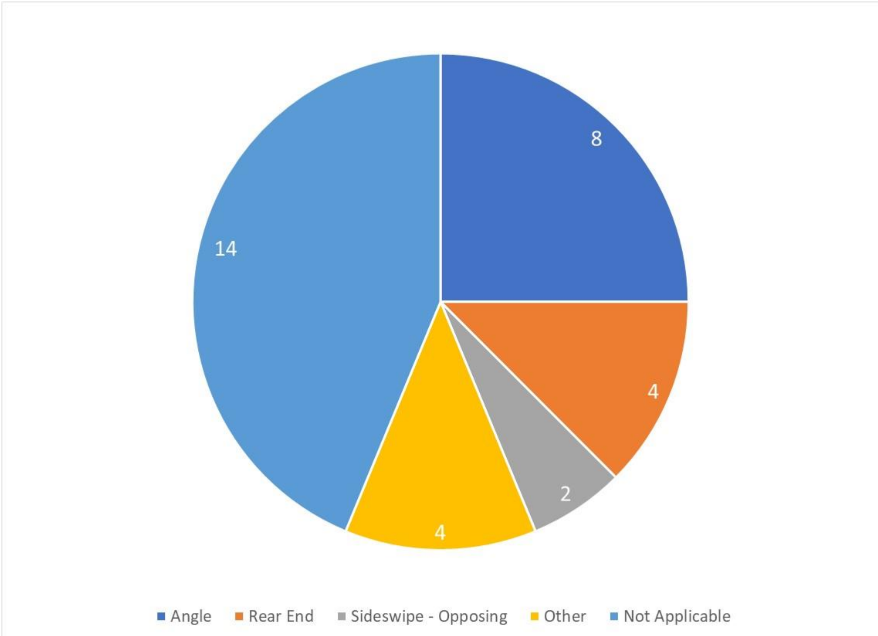


Figure 51. The Parkway and Tulane Drive, Crash Type

The data show that the crashes were involved in collisions with a tree/shrub (5), animal (3), motor vehicle (2), rock/stone wall (2), guardrail/barrier (1), or a barricade (1). It is unclear why the data do not identify a type for a crash in which two motor vehicles may have been involved (e.g., the "Not Applicable" crash was specified as "motor vehicle"). In the 2018–2019 crash data, where additional information was available, there was at least one instance where a vehicle reportedly crashed into a parked maintenance vehicle; this could potentially be a similar situation.

The most frequently reported "Primary Cause" was "Failed to Yield ROW" (Figure 52), which was reported in 7 of the 32 crashes (22%). (*Note:* Figure 52 only shows 23 of the 32 crashes that occurred at the intersection, as 9 crashes provided no information on the "Primary Cause.")

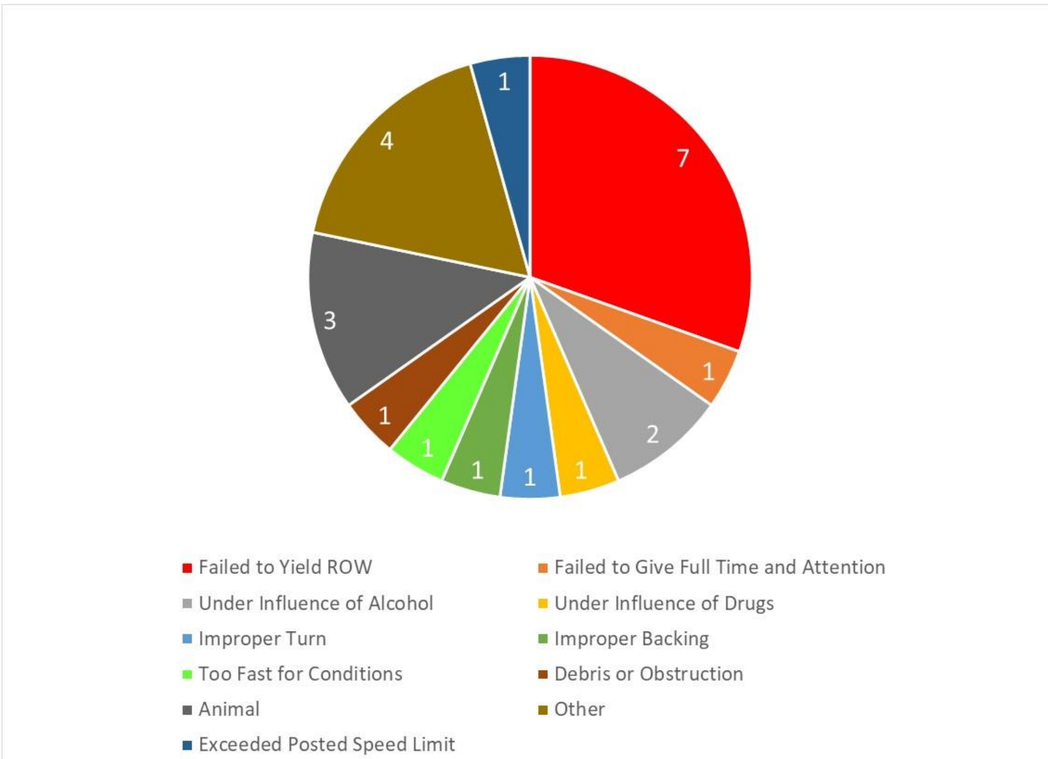


Figure 52. The Parkway and Tulane Drive, Primary Cause

2.3.4 Driving Under the Influence

As noted in the "Primary Cause" section, of the 32 crashes identified at the intersection during 2005–2015 and 2018–2019, 3 crashes, or 9.4% of all crashes at the intersection were identified as having a driver who was under the influence of alcohol or other substances. This seems exceptionally high, and further investigation may shed light on what is causing the high rate of driving under the influence crashes.

2.3.5 Hit and Run

Interestingly, 1 of the 32 crashes (3.1%) was identified as a hit-and-run crash.

2.3.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. Twelve of the crashes at Tulane Drive were INJ crashes (Figure 53).

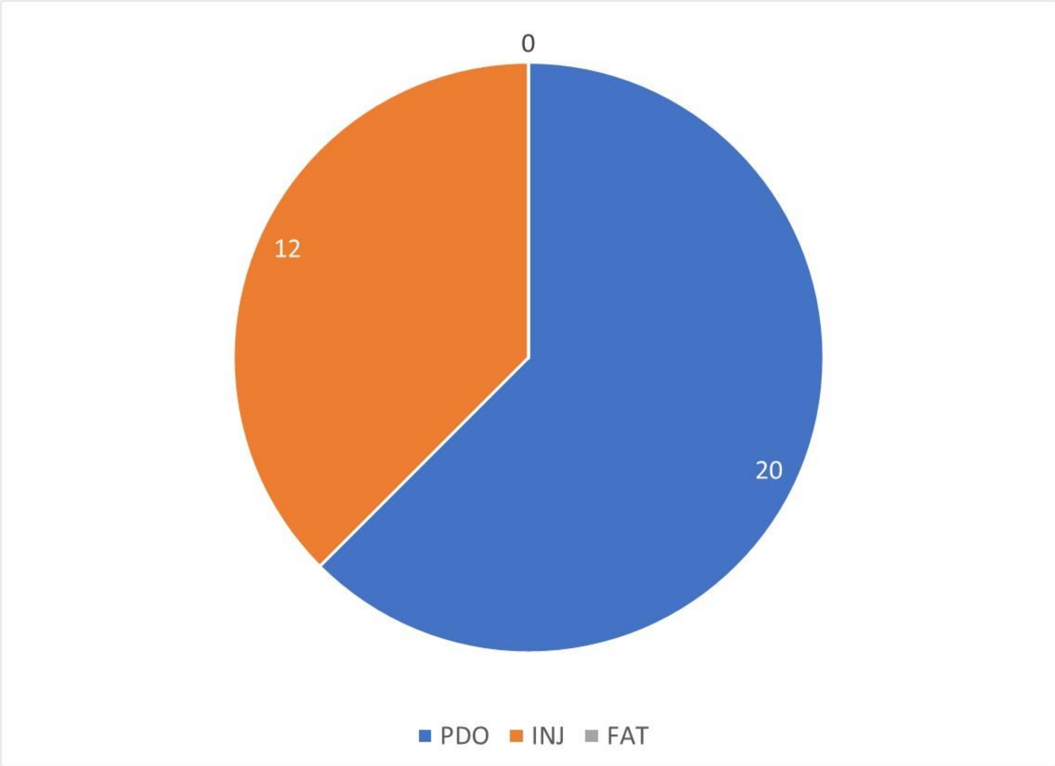


Figure 53. The Parkway and Tulane Drive, Crash Severity

Across the injury crashes, there were 16 injuries. The occurrence of the injury crashes by month, day of week, and time of day was investigated.

There seems to be a higher probability of injury crashes in October; on Fridays and Sundays; and between 3:00 p.m. and 4:00 p.m. However, since the difference between the peak month, day, and time of day is only one when compared with the vast majority of other months, days of week, and times of day, another crash at the intersection could change the month and day on which injury crashes most frequently occur (Figure 54, Figure 55, and Figure 56). Yet, considering that October, Fridays, and the time between 3:00 p.m. and 4:00 p.m. also had the highest crash counts, the month, day of week, and time of day likely have contributing factors that could be investigated, with the understanding that additional crashes could change these recommendations. This is an inherent drawback to datasets with a small number of crashes.

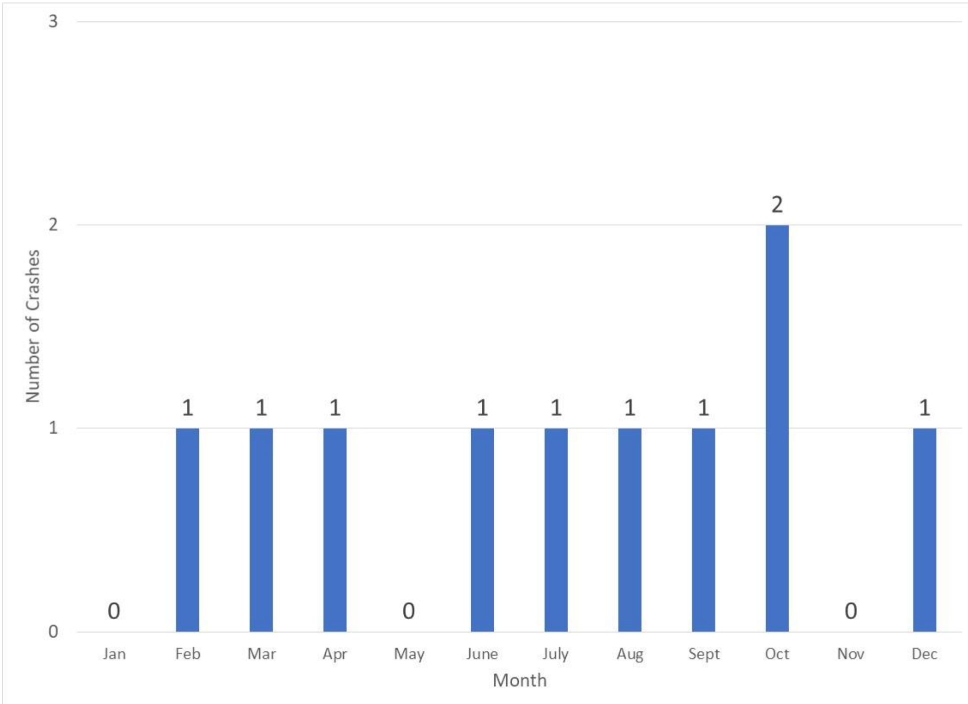


Figure 54. The Parkway and Tulane Drive, Injury and Fatal Crashes by Month

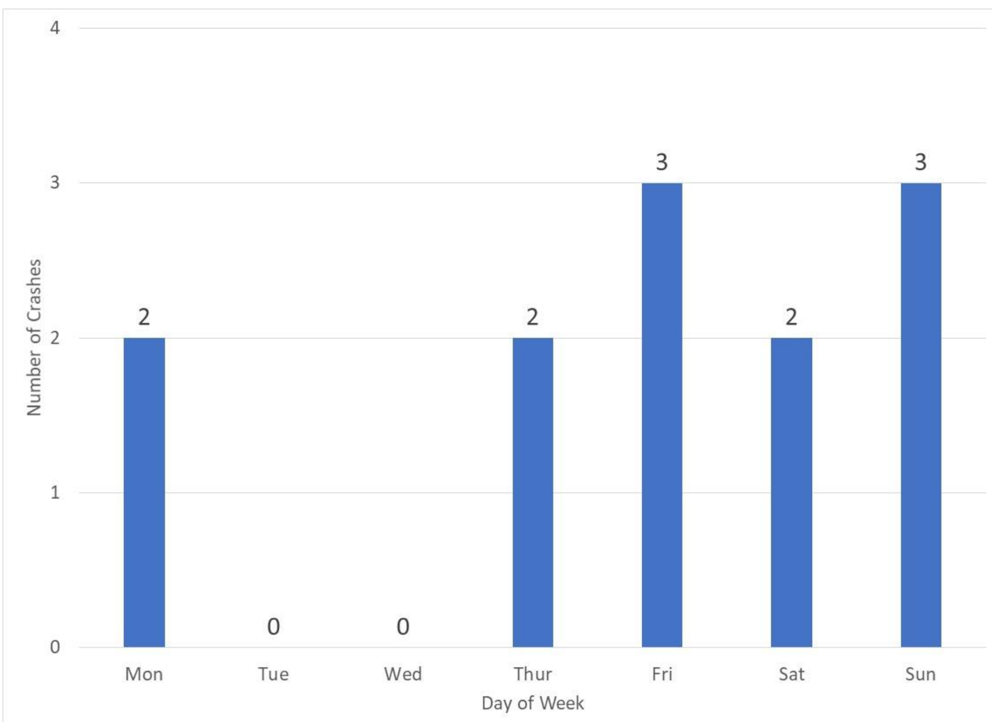


Figure 55. The Parkway and Tulane Drive, Injury Crashes by Day of the Week

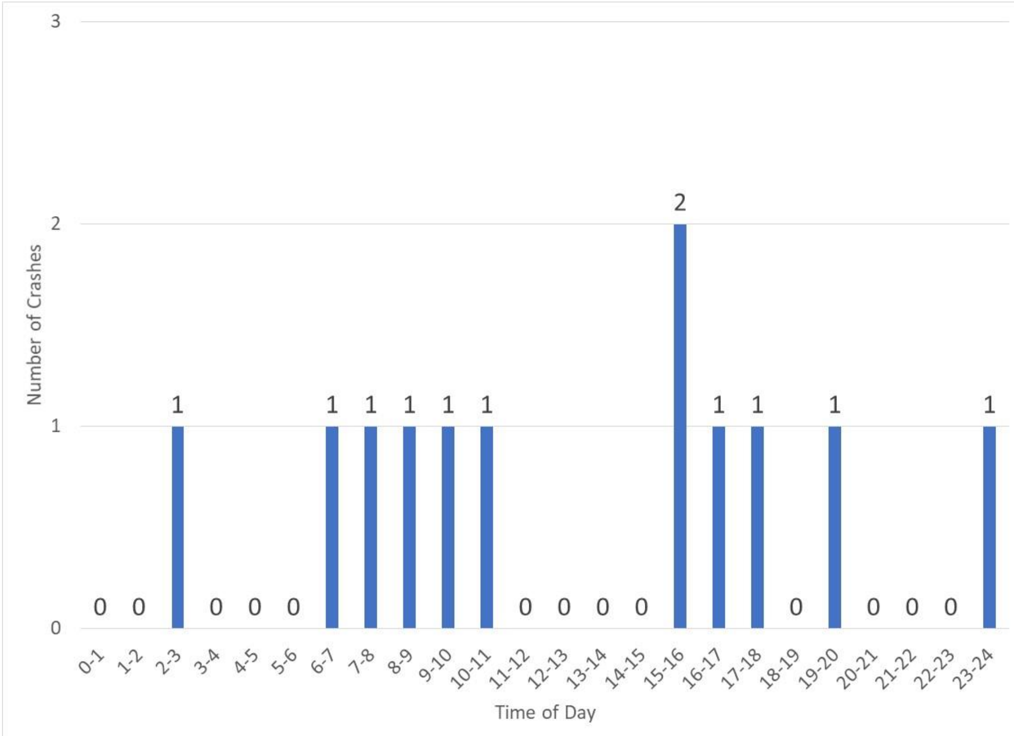


Figure 56. The Parkway and Tulane Drive, Injury Crashes by Time of Day

2.3.7 Pedestrians and Bicycles

No crashes between pedestrians/bicycles and a motor vehicle were reported at this intersection.

2.3.8 Crash Diagram

The following crash diagram (Figure 57) illustrates the location of crashes for this intersection for which location data were available. In some cases, this information was not available; however, further details are provided in the footnotes.

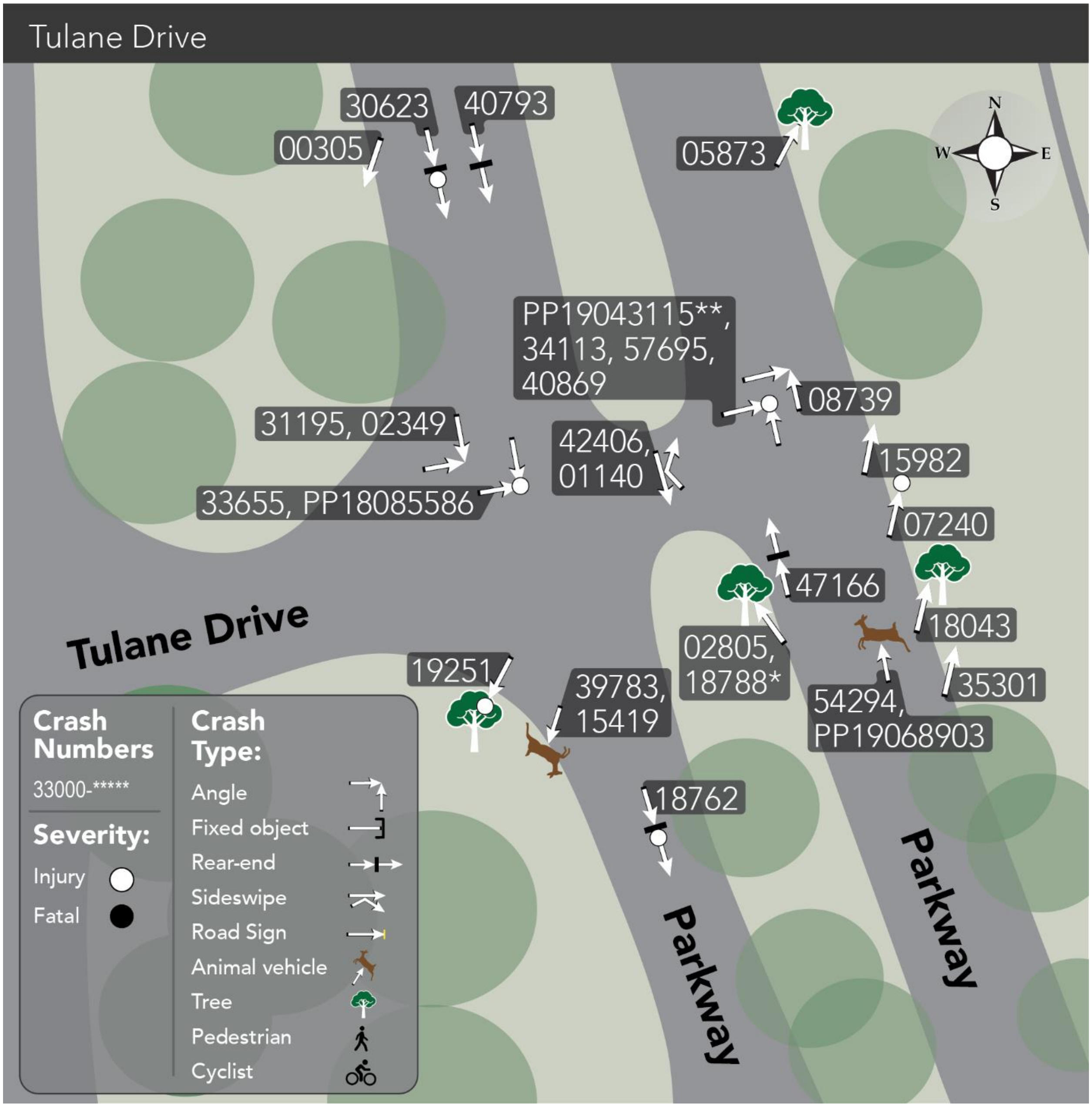


Figure 57. The Parkway and Tulane Drive, Crash Diagram * ** †

---

* Location was not specific; however, the crash indicated that it was with a tree, PDO.

** Information for this crash suggested that it involved a commercial bus and at least three vehicles.

† The following are additional crashes that occurred at Tulane Drive, which could not be placed on the crash diagram:

140101456 – no information, PDO

3300025915 – no information on direction or type of crash, PDO

3300039422 – southbound direction, but no information on crash type, PDO

3300044036 – southbound direction, south of Tulane Drive, but no information on crash type, INJ

Several crashes with animals appear to be occurring on the southern part of the intersection; while more information is needed, measures could be considered that would help with reducing animal/vehicle crashes. While the animal crashes are depicted as a deer for the diagram, it is unclear what types of animals were involved. Keeping vehicles within the roadway may be a problem that is contributing to the number of collisions with a fixed object (e.g., tree/shrub). The data include several rear-end crashes, which may suggest that a vehicle entered from Tulane Drive and did not accelerate fast enough. It may also suggest that a vehicle was slowing down to access Tulane Drive and was rear-ended by someone traveling in close proximity to the leading vehicle and/or that the driver did not anticipate the lead vehicle slowing down.

2.3.9 Summary — Tulane Drive

Based on crash data during 2005–2015 and 2018–2019, the largest number of crashes occurred in 2007; in June, September, and October; between 3:00 p.m. and 4:00 p.m. and 7:00 p.m. and 8:00 p.m.; and on Fridays (

Table 25).

Table 25. The Parkway and Tulane Drive, Summary of Key Data Findings

Criteria	Count
Number of Crashes	32
Year (of greatest frequency)	2007
Month (of greatest frequency)	June, September, and October
Day (of greatest frequency)	Friday
Percent from 12:00 a.m.–12:00 p.m.	44%
Most Frequent 1-Hour Block	3:00 p.m.–4:00 p.m.; 7:00 p.m.–8:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	a.m. Peak
Most Typical Crash Type	Not Applicable
Most Typical Reported Cause	Failed to Yield ROW (7 of 32)
Driving Under the Influence	9.4% of Crashes (3 of 32)
Hit and Run	3.1% of Crashes (1 of 32)
Percent of Injury and Fatal Crashes (measure of severity)	38% (12 of 32)
Total Number of People Injured in Crashes	16 People
Pedestrian/Bicycle Involved Crashes?	No
Animal Involved Crashes?	Yes; 9.4% (3 of 32)

2.4 The Parkway and Morningside Lane

The Parkway and Morningside Lane is a three-legged intersection, with a horizontal and vertical curve along Morningside Lane (Figure 58).

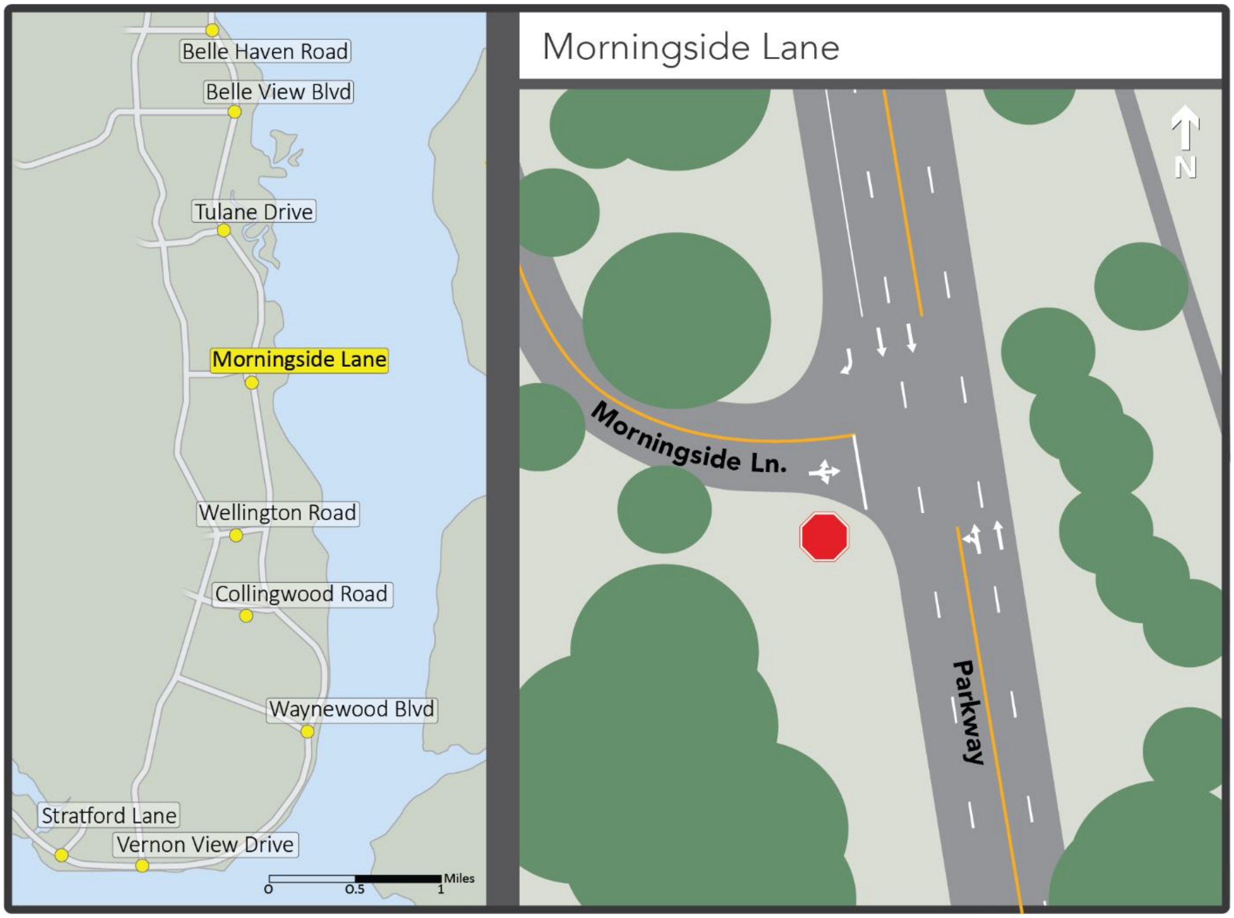


Figure 58. The Parkway and Morningside Lane

Morningside Lane is stop-controlled. Morningside Lane itself seems to be slightly down-sloped (Figure 59); there is a right-turn lane in the southbound direction on the Parkway turning onto Morningside Lane (Figure 60).

Figure 59. The Parkway and Morningside Lane, Looking North

Figure 60. The Parkway and Morningside Lane, Looking South

During 2005–2015 and 2018–2019, 73 crashes occurred at the intersection of the Parkway and Morningside Lane. The annual occurrence of crashes appears to be random, although 2009 had the greatest number of crashes reported (Figure 61). The year 2015 did not have any reported crashes at this intersection.

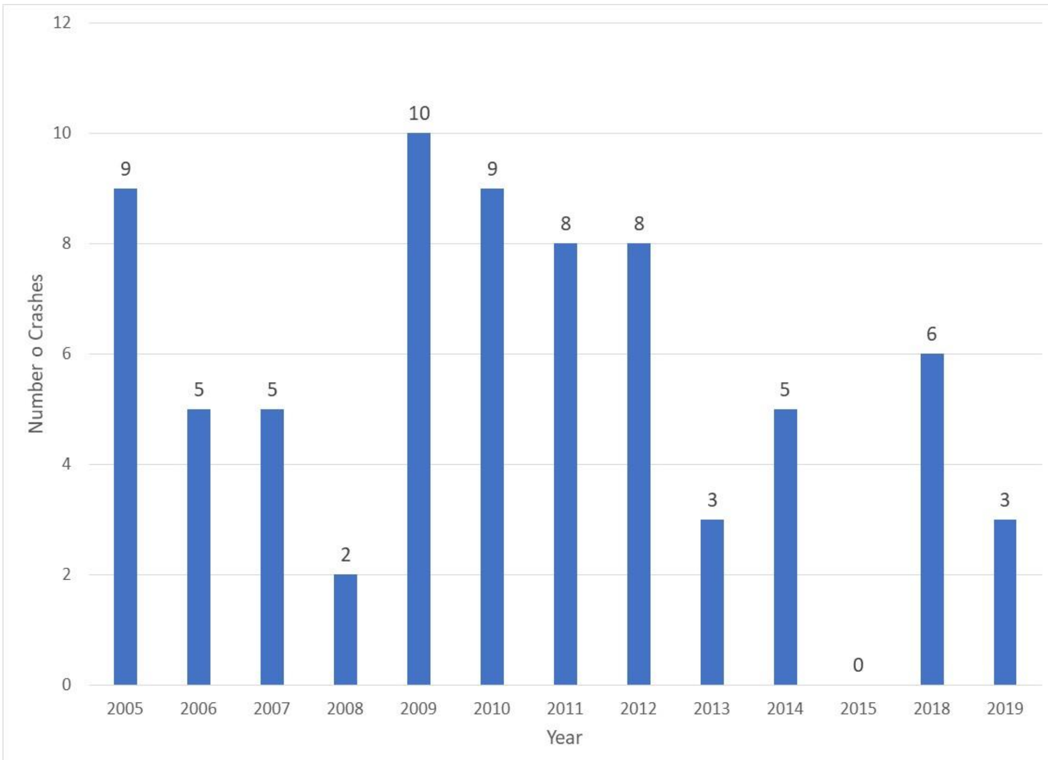


Figure 61. The Parkway and Morningside Lane, Total Crashes by Year

Based on available historical images from the intersection for 2007, 2014, and 2015 (see "Appendix F: Traffic Safety"), it does not appear that any significant geometric changes were made, although it does appear that supplementary signs (e.g., a sign beneath the stop sign) were present in 2014 that are no longer present in 2019. The information on the sign appears to be restricting people from accessing the Parkway during certain periods.

2.4.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in April (Figure 62).

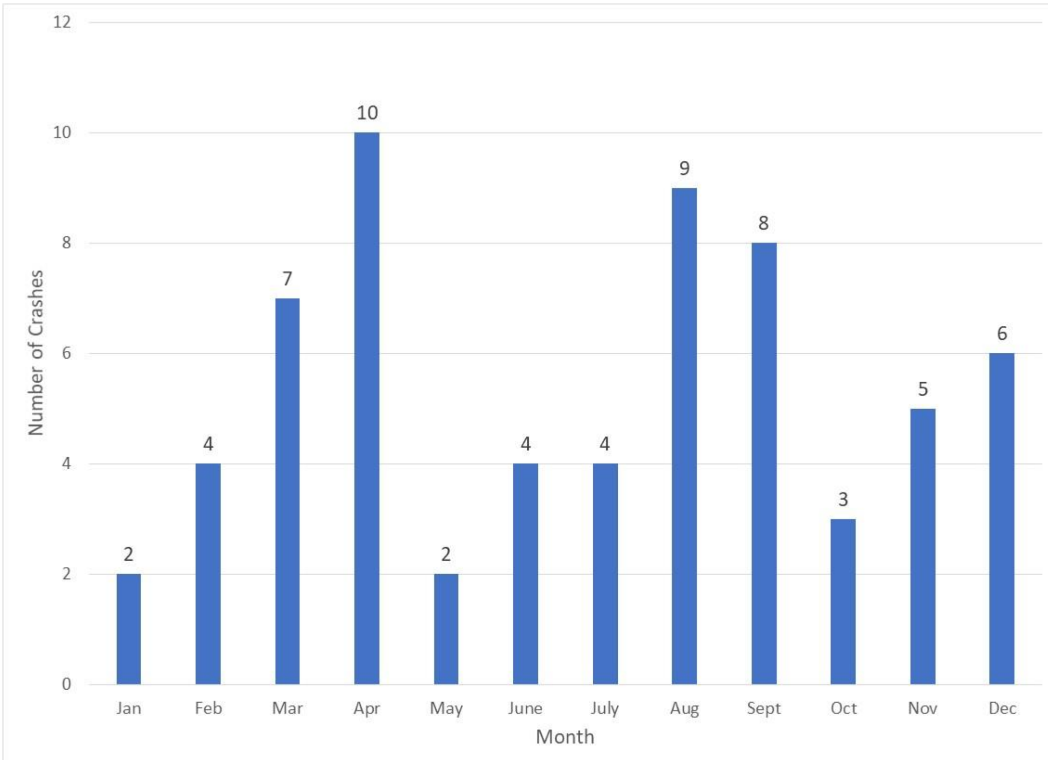


Figure 62. The Parkway and Morningside Lane, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate when crashes occurred more often. The data show that 40% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 8:00 a.m. and 9:00 a.m. (Figure 63).

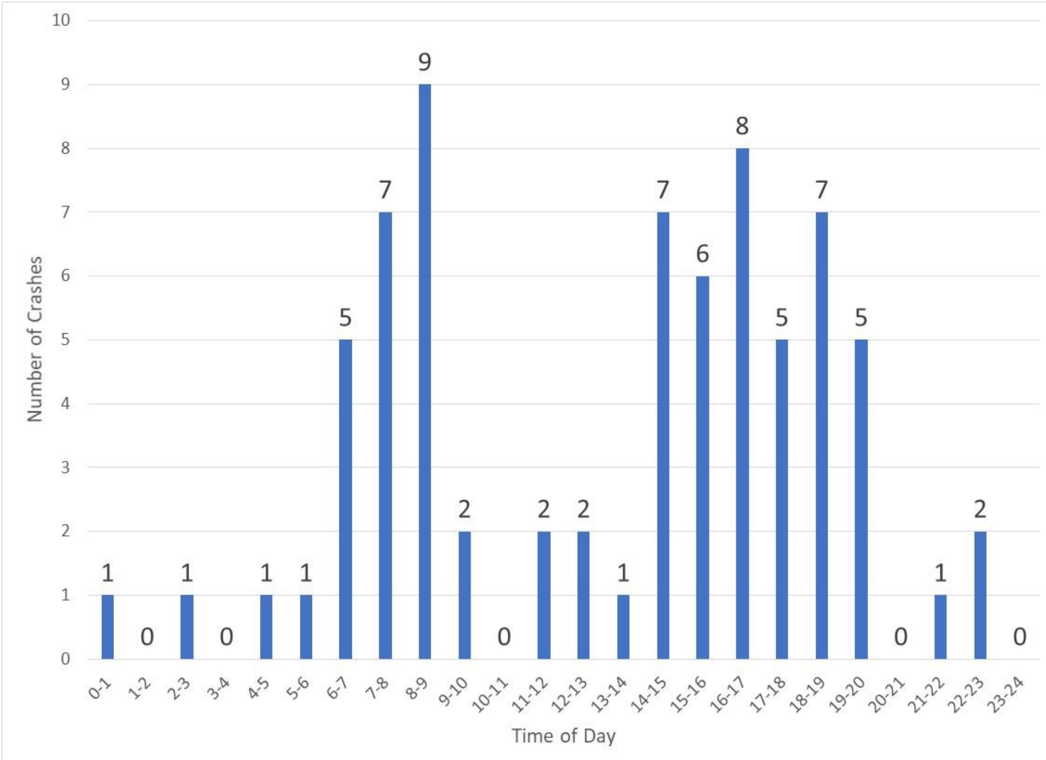


Figure 63. The Parkway and Morningside Lane, Crashes by Time of Day

In addition, there seems to be a peak in the number of crashes between 6:00 a.m. and 9:00 a.m. and 2:00 p.m. and 7:00 p.m., which are roughly equivalent to the a.m. and p.m. peak periods.

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the largest number and highest rate of crashes occurred during the a.m. peak period. Table 26 shows the number of crashes within these groups.

Table 26. The Parkway and Morningside Lane, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	4	0.7
6:00 a.m.–9:00 a.m.	a.m. Peak	21	7.0
9:00 a.m.–3:00 p.m.	Midday	14	2.3
3:00 p.m.–6:00 p.m.	p.m. Peak	19	6.3
6:00 p.m.–12:00 a.m.	post-p.m. Peak	15	2.5
TOTAL		**64**	–

The day of the week most represented in the crash records is Friday (Figure 64).

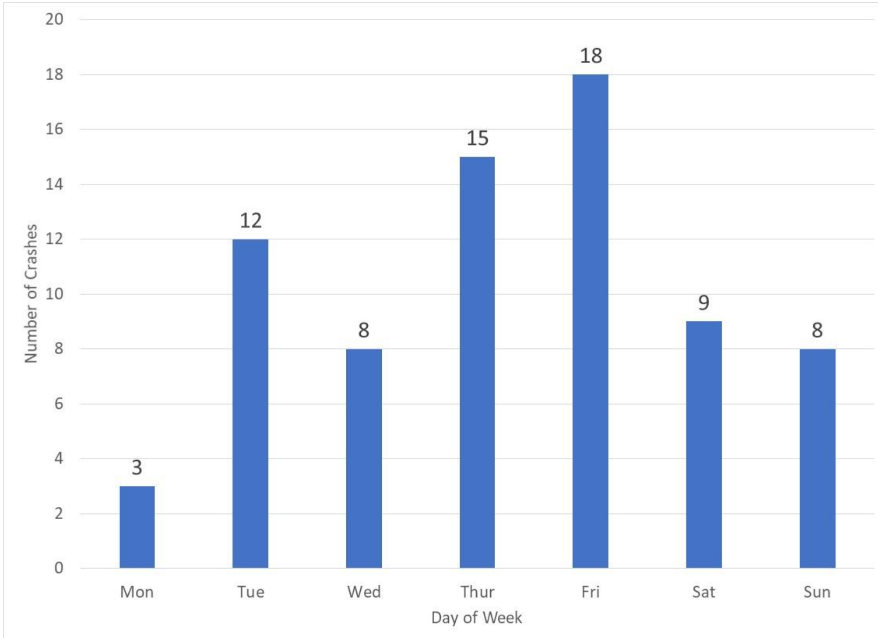


Figure 64. The Parkway and Morningside Lane, Crashes by Day of the Week

The results suggest the possibility of contributing factors that are increasing the number of crashes on Fridays.

2.4.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence. Figure 65 shows an analysis of lighting conditions during crashes.

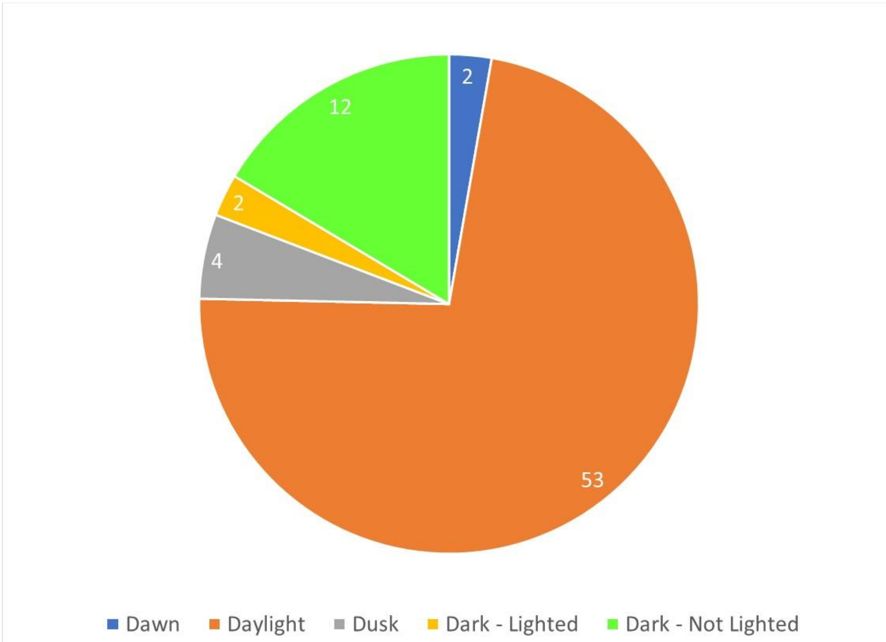


Figure 65. The Parkway and Morningside Lane, Lighting (Number of Crashes during Each Lighting Condition)

Some of the data were inconsistent, showing that 12 crashes occurred when the intersection was "Dark – Not Lighted," and 2 when the intersection was "Dark – Lighted." The Parkway does not have lighting on the roadway in the study section; therefore, "Dark – Lighted" must be an error.

The data show that most crashes (53) occurred during "Daylight." Looking at the data in more detail, of the crashes that occurred during "Daylight," 15 of these crashes were during periods when conditions were indicated as: "Cloudy," "Fog, Smog, Smoke," "Rain," or "Snow." These conditions would suggest that the crashes occurred when there was reduced visibility. The remaining 38 crashes occurred during "Daylight." Therefore, approximately half of the crashes occurred during hours when visibility was good, while the other half occurred during periods when it was not.

The researchers also considered whether the "Daylight" crashes occurred during peak periods. (*Note:* The team anticipated that "Daylight" crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 27 shows the number of crashes within these groups.

Table 27. The Parkway and Morningside Lane, "Daylight" Crash Counts and Rates by Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	0	0
6:00 a.m.–9:00 a.m.	a.m. Peak	16	5.3
9:00 a.m.–3:00 p.m.	Midday	14	2.3
3:00 p.m.–6:00 p.m.	p.m. Peak	18	6.0
6:00 p.m.–12:00 a.m.	post-p.m. Peak	5	0.8
TOTAL "Daylight" Crashes		**53**	–

"Daylight" crashes were most likely to occur during the p.m. peak and least likely to occur from 12:00 a.m. to 6:00 a.m. (pre-a.m. peak).

With regard to weather, the majority of the crashes (52) occurred during "Clear" periods (Figure 66).

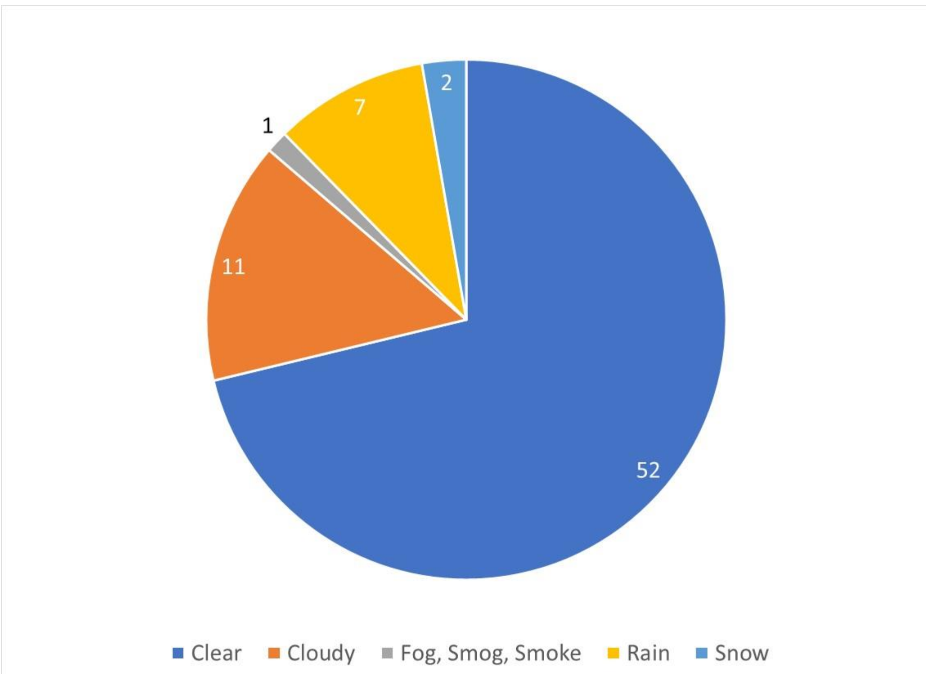


Figure 66. The Parkway and Morningside Lane, Weather

The majority of the crashes (61) occurred when surface conditions were “Dry” (Figure 67).

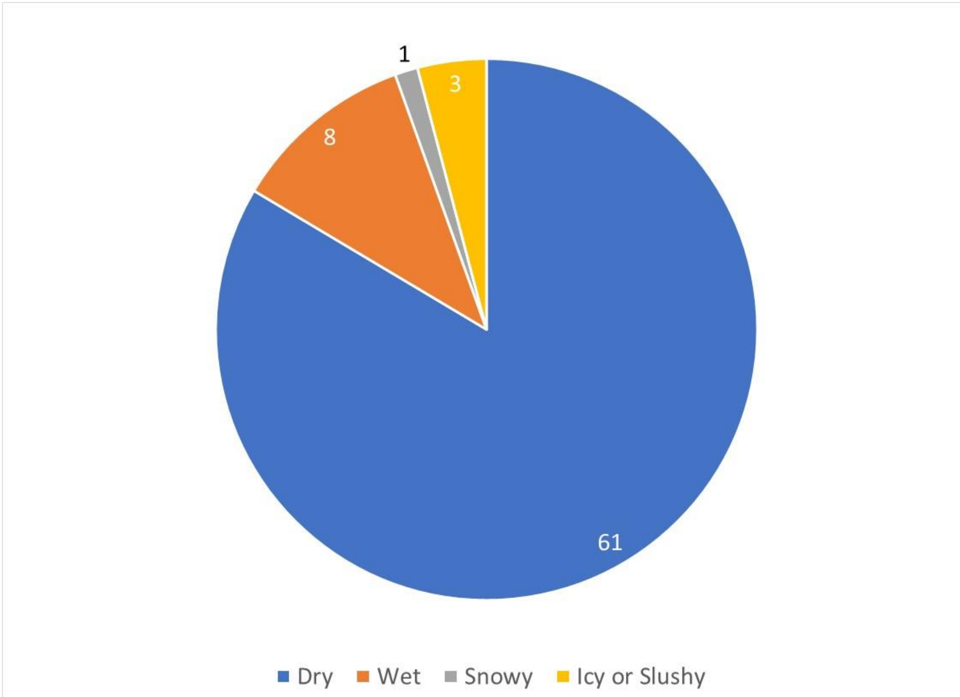


Figure 67. The Parkway and Morningside Lane, Surface Condition

2.4.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. "Angle" was the most common crash type (32) (Figure 68).

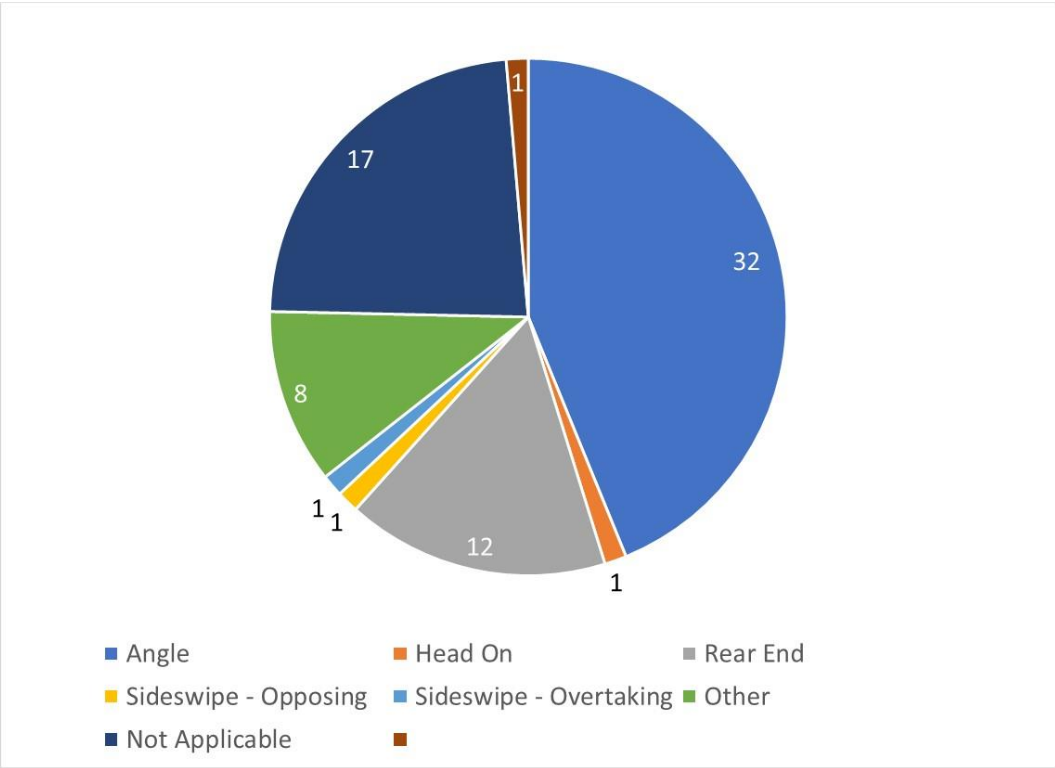


Figure 68. The Parkway and Morningside Lane, Crash Type

Seventeen crashes were identified as "Not Applicable" and involved a collision with a tree/shrub (6), sign (3), ditch (2), drainage structure (1), bridge structure (1), animal (1), motor vehicle (1), other fixed object (1), or were identified as "non-collision" (1). It is unclear why a collision that appears to be between two motor vehicles did not have a crash type identified with it. Similarly, it is unclear what is meant by a "non-collision."

By far, the most frequently reported “Primary Cause” was “Failed to Yield ROW” (Figure 69), which was reported in 21 of the 73 crashes (29%). (*Note:* Figure 69 only shows 55 of the 73 crashes that occurred at the intersection, as 18 crashes provided no information on the “Primary Cause.”)

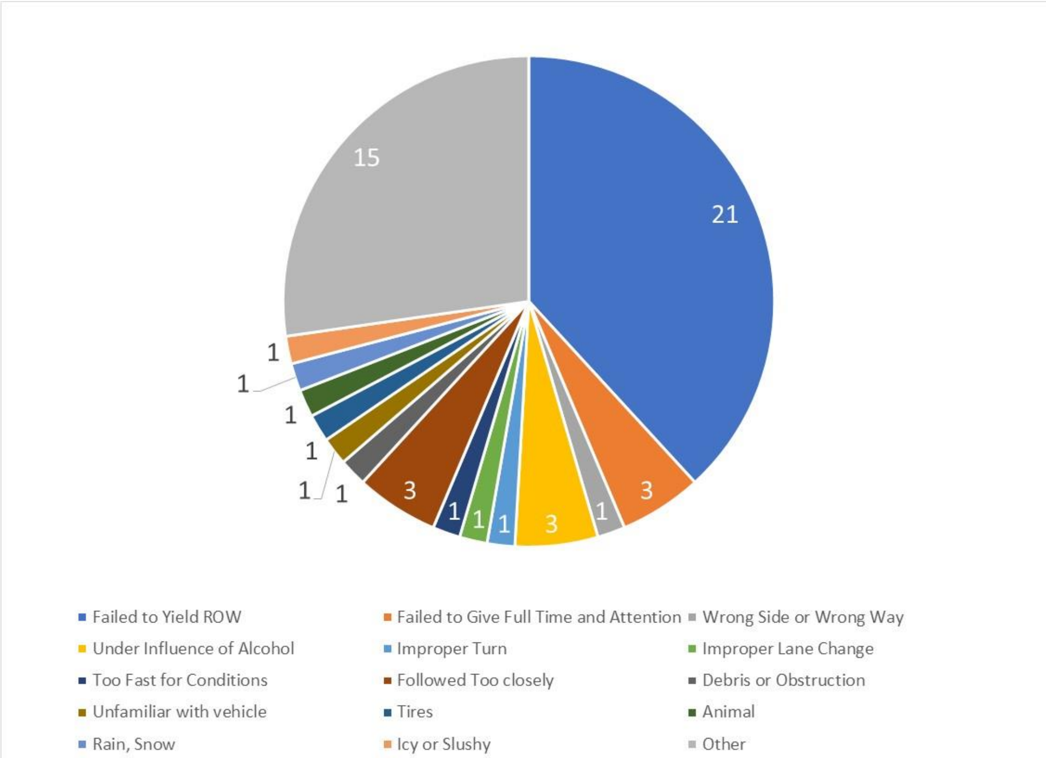


Figure 69. The Parkway and Morningside Lane, Primary Cause

2.4.4 Driving Under the Influence

As noted in the “Primary Cause” section, of the 73 crashes identified at the intersection during 2005–2015, 3 crashes, or 4.1% of all crashes were identified as having a driver who was under the influence of alcohol or other substances.

2.4.5 Hit and Run

Interestingly, 2 of the 73 crashes (2.7%) were identified as hit and run.

2.4.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. The majority of crashes (40) that are occurring at the intersection are PDO crashes (Figure 70). (*Note:* Three of the crashes from 2018–2019 did not provide a severity level.)

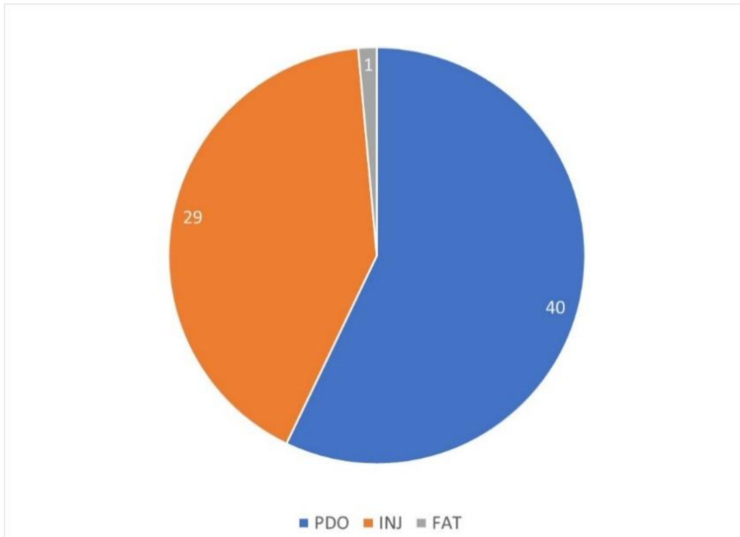


Figure 70. The Parkway and Morningside Lane, Crash Severity

Almost half of the crashes at the intersection resulted in injuries or a fatality.

There were a total of 40 injuries and 1 fatality at the intersection.

In Figure 71, Figure 72, and Figure 73, blue represents injury crashes and orange represents the fatal crash. March, April, August, and September have the largest count of injury crashes, although June, with comparably fewer injury crashes, also has the only fatal crash (Figure 71).

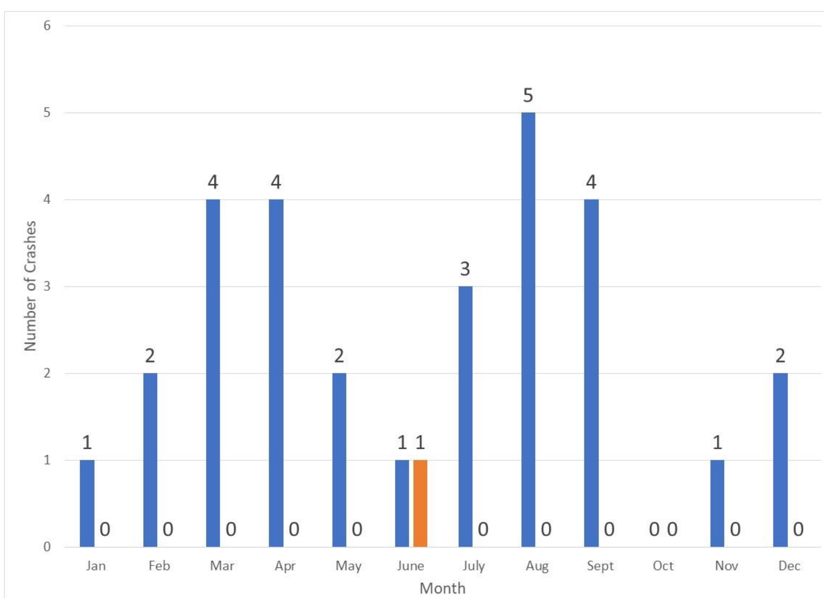


Figure 71. The Parkway and Morningside Lane, Injury and Fatal Crashes by Month

April had the greatest number of crashes and the second greatest number (tied) of injury crashes; August had the largest number of injury crashes.

There was an injury crash every day of the week; however, Tuesday had the largest number of injury crashes. Friday has almost as many injury crashes and also had the only fatal crash (Figure 72).

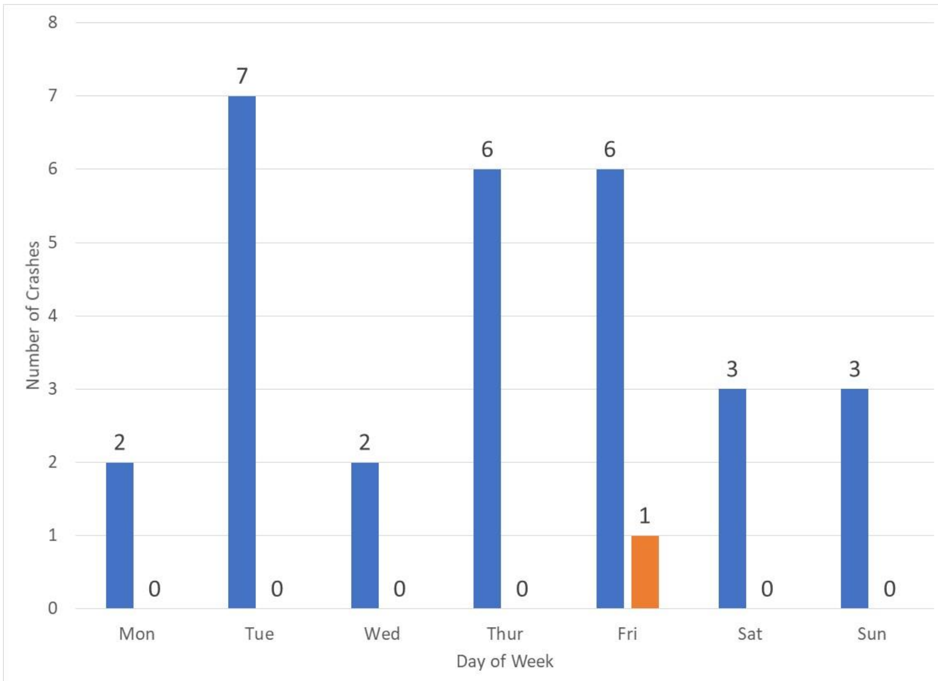


Figure 72. The Parkway and Morningside Lane, Injury and Fatal Crashes by Day of Week

While Friday had the largest number of crashes, it also had the second largest number of injury crashes (tied with Thursday). However, Friday only had one less injury crash than Tuesday, which was the day of the week with the most injury crashes.

Overall, the a.m. and p.m. Peak periods were associated with a greater occurrence of injury and fatal crashes, with 4:00 p.m.–5:00 p.m. having the greatest count (Figure 73).

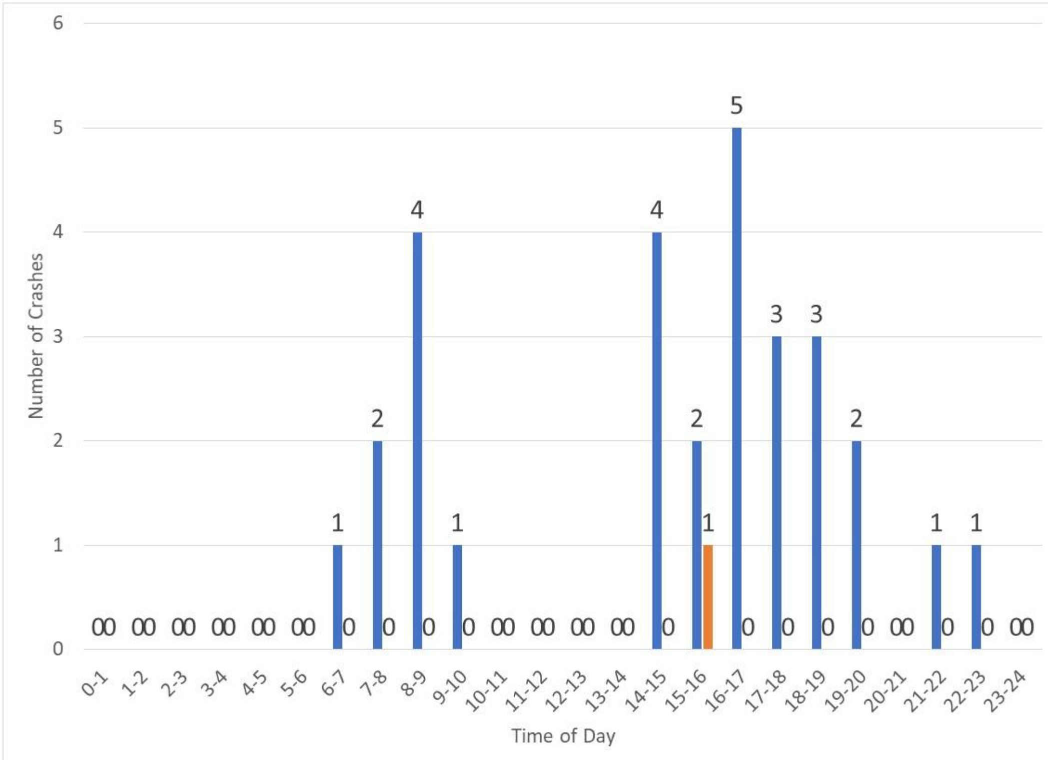


Figure 73. The Parkway and Morningside Lane, Injury and Fatal Crashes by Time of Day

The period of 8:00 a.m.–9:00 a.m. had the largest number of crashes and the second largest number (tied with 2:00 p.m.–3:00 p.m.) of injury crashes.

Overall, there appears to be consistency between the months, days of week, and times of day with the greatest number of crashes and the greatest number of injury crashes.

2.4.7 Pedestrians and Bicycles

No crashes between pedestrians/bicycles and a motor vehicle were reported at this intersection. Therefore, it appears that the crashes were primarily between two motor vehicles or between a motor vehicle and a fixed object. There is no access between this intersection and the Mount Vernon Trail to the east.

2.4.8 Crash Diagram

The following crash diagram (Figure 74) illustrates the location of crashes for this intersection to which data regarding location within the intersection was available. In some cases, this information was not available; however, further details are provided in the footnotes.

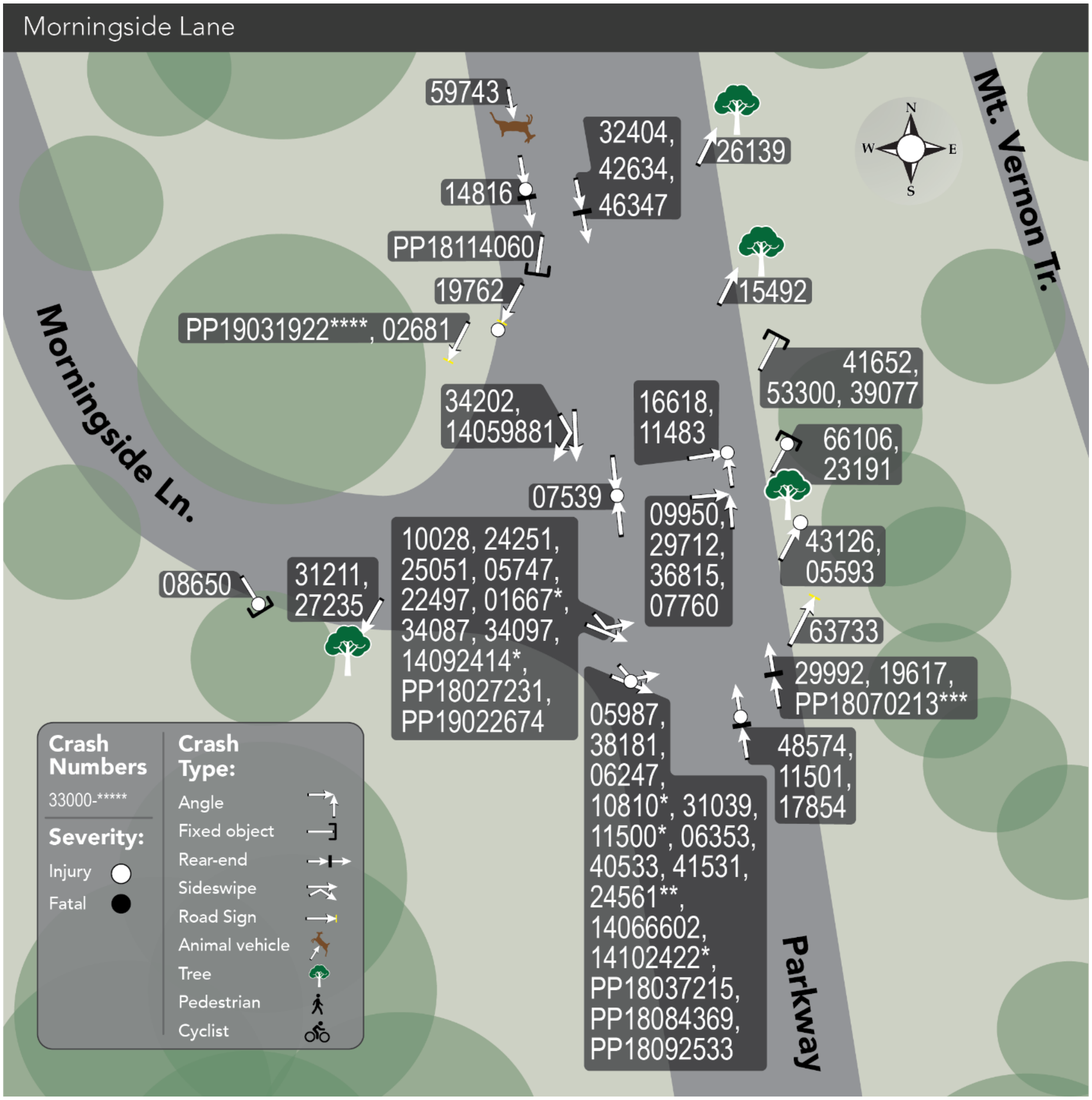


Figure 74. The Parkway and Morningside Lane, Crash Diagram* ** *** **** †

* The assumption was made in the safety study that a vehicle involved in the crash was traveling southbound.

** This crash report says that a crash occurred both with a motor vehicle and tree/shrub. There is the possibility that the vehicles crashed and then the force took one or both vehicles into a tree/shrub.

*** No severity was provided; it was assigned to PDO to show the crash on the diagram.

**** Crash is indicated as single vehicle motorcycle crash in the southbound direction; no information regarding severity was provided.

† The following are additional crashes that occurred at Morningside Lane, which could not be placed on the crash diagram:

14085848 — rear-end crash, injury crash; no direction information
3300030855 — southbound, injury crash, tire failure.
3300042920 — collision with another vehicle, PDO crash; other
3300006413 — collision with another vehicle, injury crash; other
3300035967 — collision with another vehicle, PDO crash; other
3300011633 — collision with another vehicle, PDO crash; other
3300042974 — collision with another vehicle, PDO crash; other
3300014203 — collision with another vehicle, PDO crash; "not applicable"
3300017069 — northbound, says it collided with another vehicle, fatal crash
PP19042029 — southbound, it says it was between two vehicles; no information on severity; crash was identified as being an angle crash

While the animal crashes are depicted as a deer for the diagram, it is unclear what types of animals were involved.

By far, it appears that the most common problem is the interaction between vehicles traveling southbound on the Parkway and vehicles entering the Parkway from Morningside Lane. It could be that the drivers on Morningside Lane erroneously assume that some of the southbound traffic is turning right or that the southbound traffic's speed is faster than drivers entering from Morningside Lane anticipate.

2.4.9 Summary — Morningside Lane

Based on crash data (2005–2015, 2018–2019), the largest number of crashes occurred in 2009; in April; most often between 8:00 a.m. and 9:00 a.m.; and on Friday (Table 28).

In terms of crash types and contributing factors, pedestrians or bicyclists were not associated with crashes at the intersection. It could also be that the drivers on Morningside Lane erroneously assume that some of the southbound traffic is turning right or move into the right turn lane but then back into the through lanes. Furthermore, while driving under the influence crashes only accounted for about 5% of the *reported* crashes, the only fatality at the intersection was associated with a driver operating under the influence, so this factor may warrant further investigation.

Table 28. The Parkway and Morningside Lane, Summary of Key Data Finding

Criteria	Count
Number of Crashes	73
Year (of greatest frequency)	2009
Month (of greatest frequency)	April
Day (of greatest frequency)	Friday
Percent from 12:00 a.m.–12:00 p.m.	40%
Most Frequent 1-Hour Block	8:00 a.m.–9:00 a.m.*
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	a.m. Peak
Most Typical Crash Type	Angle
Most Typical Reported Cause	Failed to Yield ROW (21 of 73)
Driving Under the Influence	4.1% of Crashes (3 of 73)
Hit and Run	2.7% of Crashes (2 of 73)
Percent of Injury and Fatal Crashes (measure of severity)	41% (30 of 73)
Total Number of People Injured in Crashes	41 People**
Pedestrian/Bicycle Involved Crashes?	No
Animal Involved Crashes?	Yes; 1.4% (1 of 73)

* While this is the period with the greatest count, there seems to be a broader trend for a higher crash count during the a.m. peak and p.m. peak periods.
** 40 injured; 1 died

2.5 The Parkway and Wellington Road

Figure 75 shows the orientation of the Parkway and Wellington Road, a three-legged intersection.

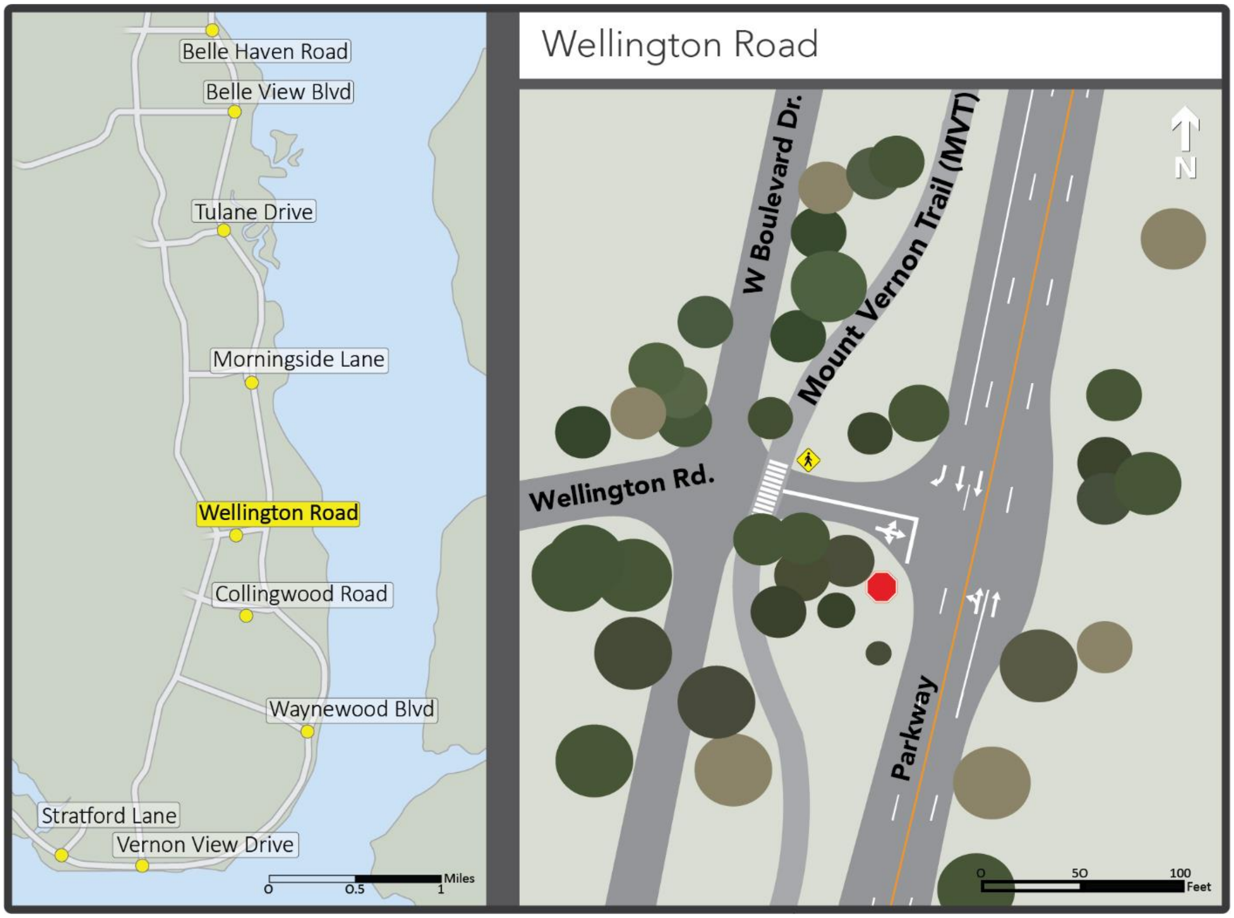


Figure 75. The Parkway and Wellington Road

Notice the close proximity between the Parkway and the parallel roadway (West Boulevard Drive) and to the Mount Vernon Trail. There is no advance warning to motorists traveling southbound and turning right that the trail crossing is present. A pedestrian warning sign (W11-2 from the *Manual on Uniform Traffic Control Devices* (USDOT/FHWA 2017)) is just east of the crossing.

During 2005–2015 and 2018–2019, 23 crashes occurred at the intersection of the Parkway and Wellington Road. Generally, there have been two crashes annually, although 2011 has the greatest number of crashes reported (Figure 76).

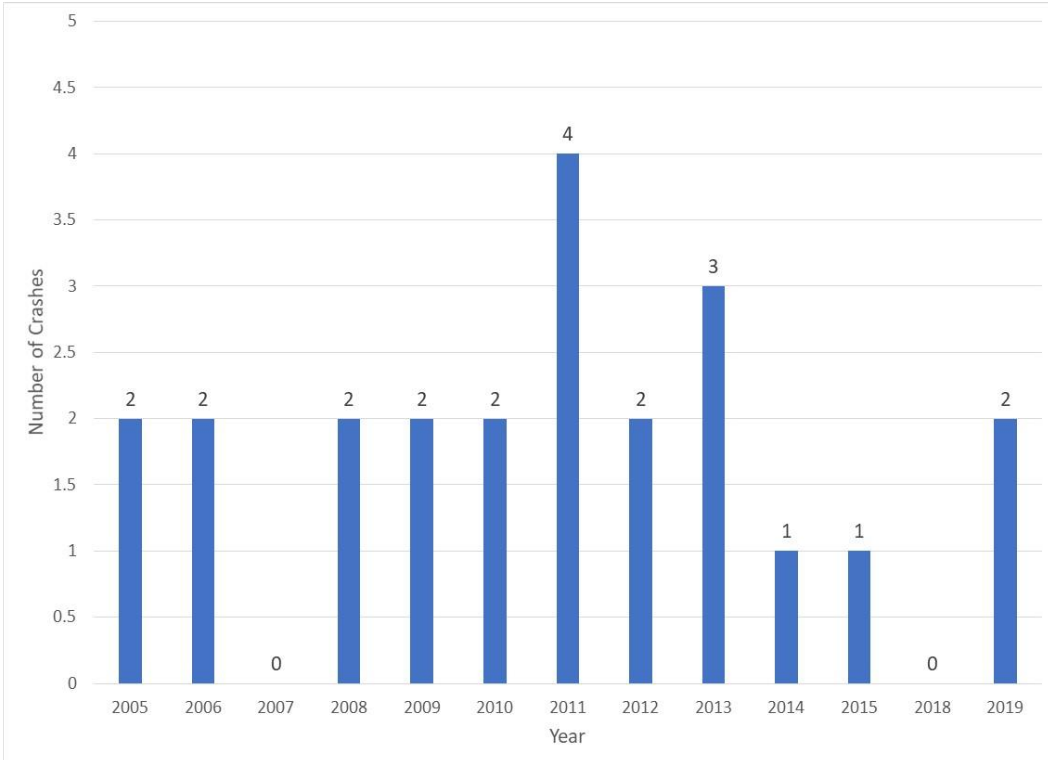


Figure 76. The Parkway and Wellington Road, Total Crashes by Year

2.5.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in April (Figure 77).

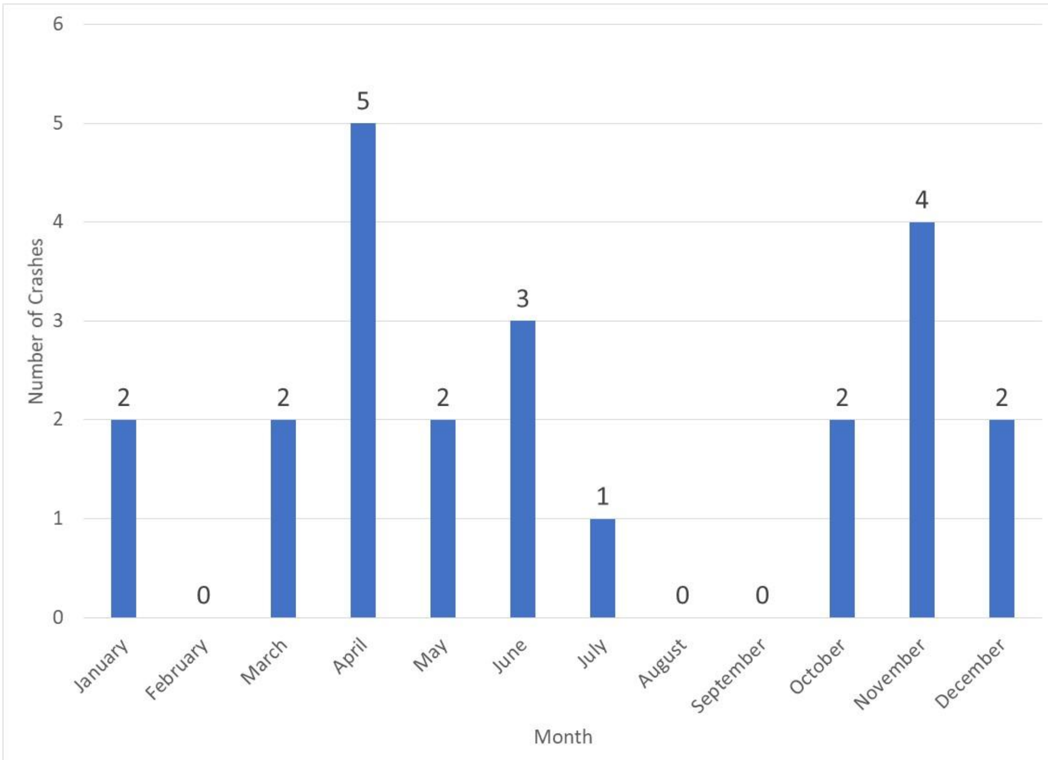


Figure 77. The Parkway and Wellington Road, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate when crashes occurred more often. The data show that 26% of crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 4:00 p.m. and 5:00 p.m. (Figure 78).

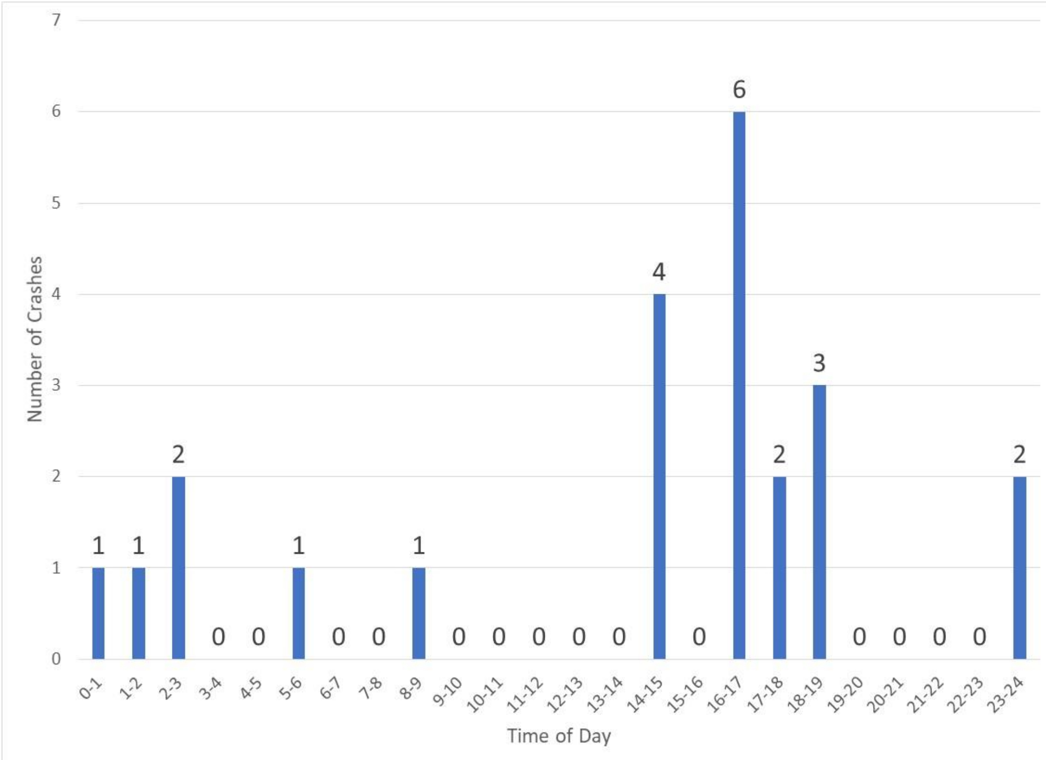


Figure 78. The Parkway and Wellington Road, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the largest number and highest rate of crashes occurred during the p.m. peak period. Table 29 shows the number of crashes within these groups.

Table 29. The Parkway and Wellington Road, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	5	0.8
6:00 a.m.–9:00 a.m.	a.m. Peak	1	0.3
9:00 a.m.–3:00 p.m.	Midday	4	0.7
3:00 p.m.–6:00 p.m.	p.m. Peak	8	2.7
6:00 p.m.–12:00 a.m.	post-p.m. Peak	5	0.8
TOTAL		**23**	–

The day of the week that is most represented in the crash records is Friday (2005–2015) (Figure 79).

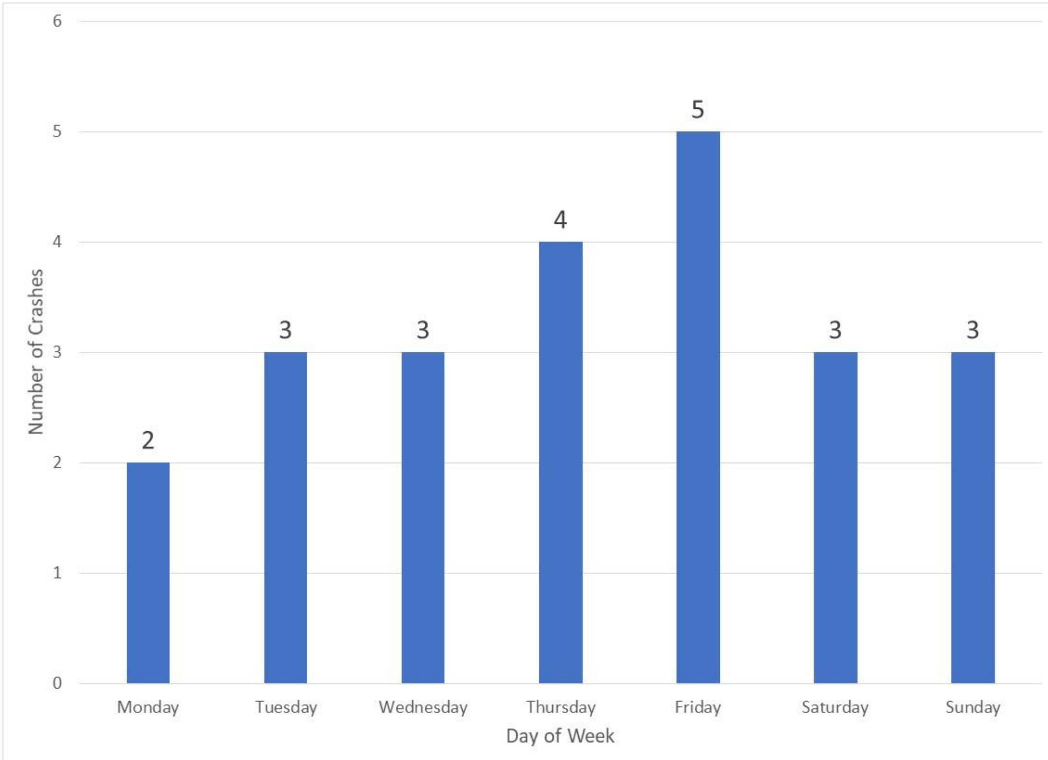


Figure 79. The Parkway and Wellington Road, Crashes by Day of Week

The results suggest the possibility of contributing factors that are increasing the number of crashes on Fridays.

2.5.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Figure 80 shows an analysis of the lighting conditions identified during crashes.

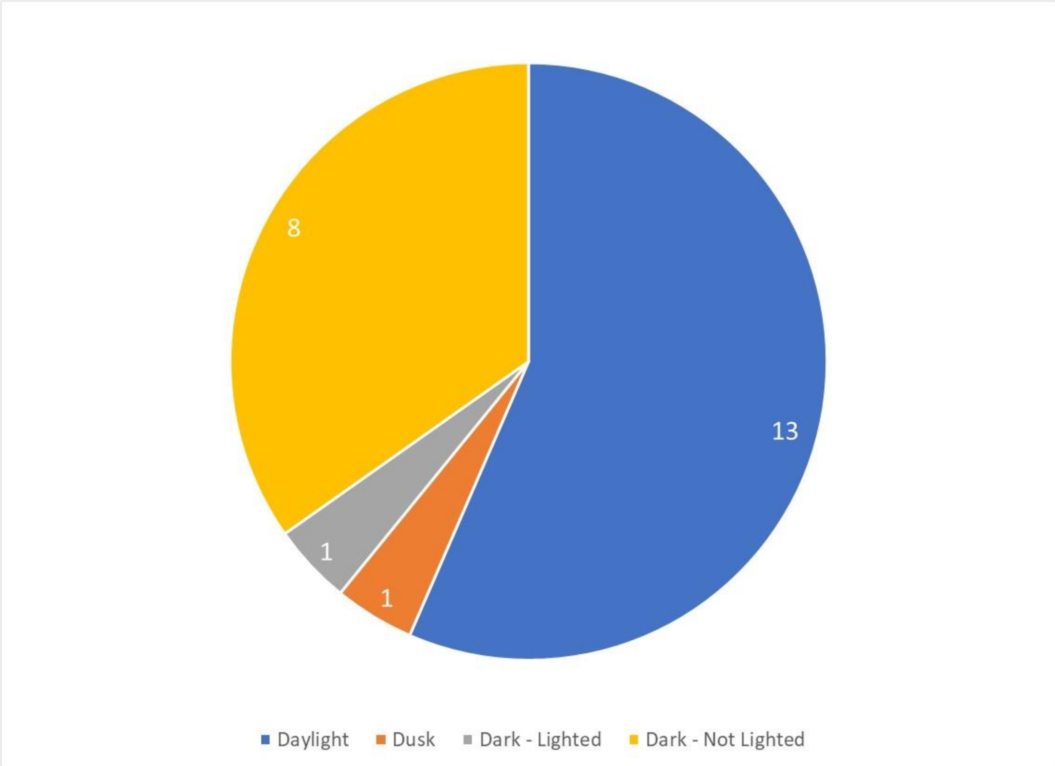


Figure 80. The Parkway and Wellington Road, Lighting (Number of Crashes during Each Lighting Condition)

Most crashes (13) were identified as having occurred during "Daylight." None of the reported "Daylight" crashes had conditions that would have limited visibility (e.g., cloudy, rain, etc.). The "Dark – Lighted" categorization was likely miscoded, as there currently are no lights along the Parkway in the study corridor.

It was considered whether the "Daylight" crashes occurred during peak periods. (*Note:* The team anticipated that "Daylight" crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 30 shows the number of crashes within these groups.

Table 30. The Parkway and Wellington Road, "Daylight" Crash Counts and Rates by Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	2	0.3
6:00 a.m.–9:00 a.m.	a.m. Peak	1	0.3
9:00 a.m.–3:00 p.m.	Midday	4	0.7
3:00 p.m.–6:00 p.m.	p.m. Peak	6	2.0
6:00 p.m.–12:00 a.m.	post-p.m. Peak	0	0
TOTAL "Daylight" Crashes		**13**	–

"Daylight" crashes were most likely to occur during the p.m. peak and least likely to occur from 6:00 p.m. to 12:00 a.m. (post-p.m. peak).

With regard to weather, all but three crashes occurred during "Clear" periods (Figure 81).

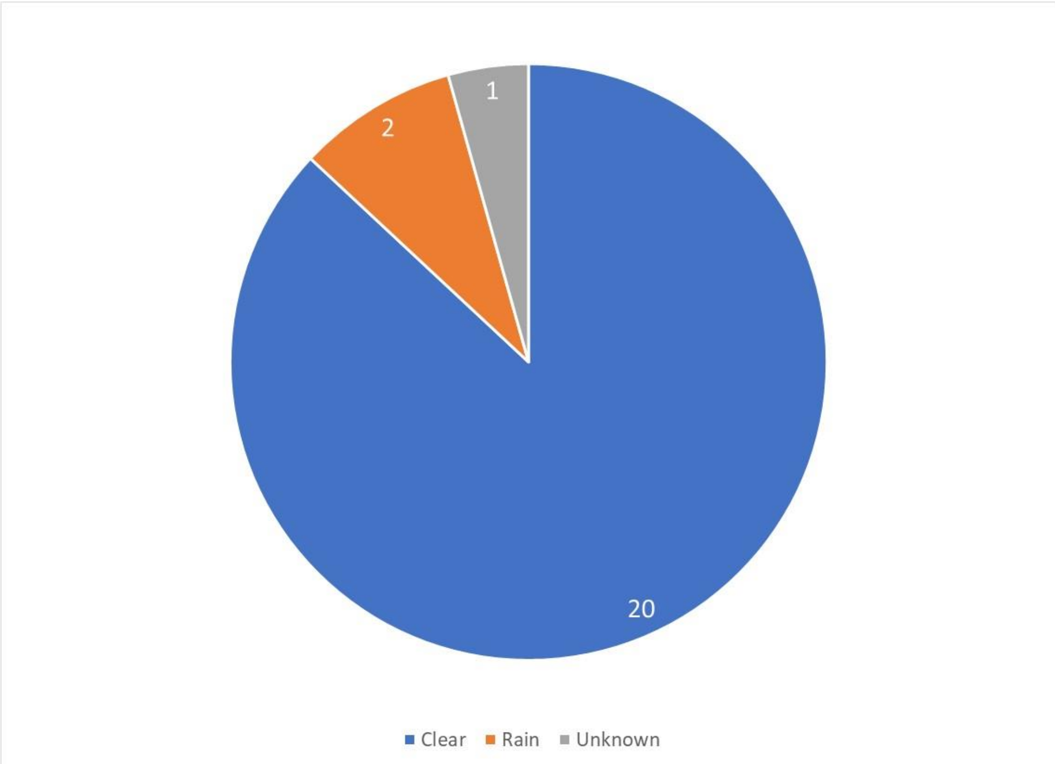


Figure 81. The Parkway and Wellington Road, Weather

Therefore, weather does not seem to be a contributing factor to crash occurrence.

The majority of the crashes (20) occurred when the road conditions were identified as "Dry," (Figure 82).

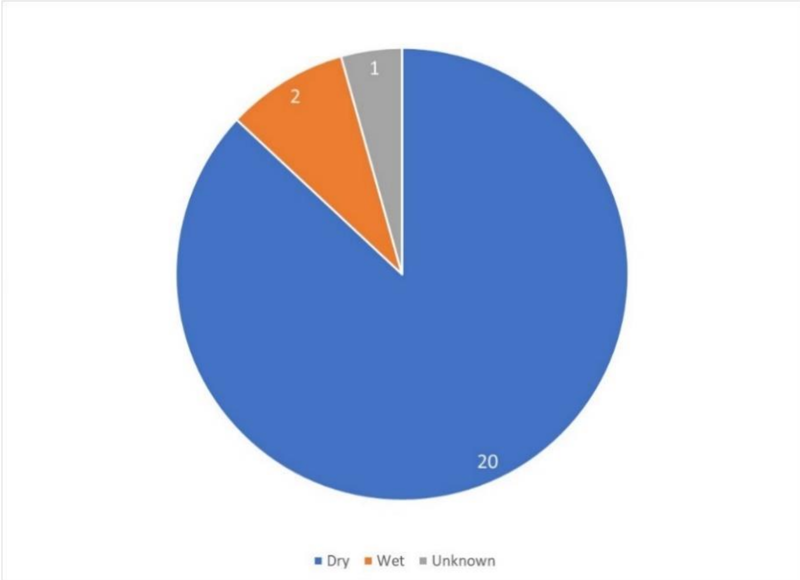


Figure 82. The Parkway and Wellington Road, Surface Condition

2.5.3 Factors Contributing to Crashes

This section discusses the type of crash, the primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. "Rear End" was the most frequently identified crash type (six) (Figure 83).

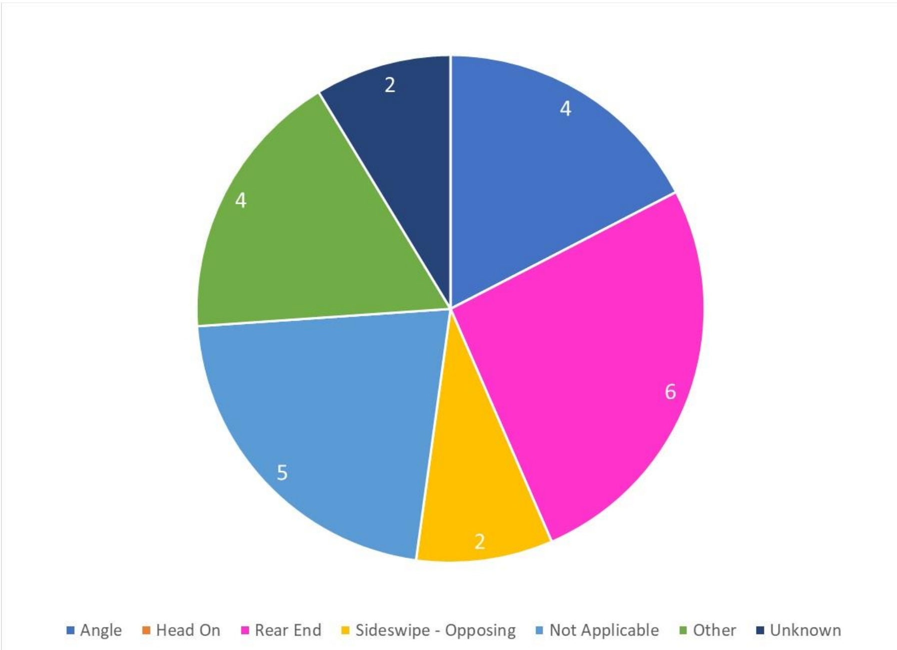


Figure 83. The Parkway and Wellington Road, Crash Type

The second most common crash type was “Not Applicable.” The “Not Applicable” crashes involved a collision with a tree/shrub (3) or an animal (2).

The most frequently reported “Primary Causes” were “Failed to Yield ROW” and “Other” (Figure 84), which was reported in 4 of the 23 (17%) crashes each. (*Note:* Figure 84 only shows 17 of the 23 crashes that occurred at the intersection, as 6 crashes provided no information on the “Primary Cause.”)

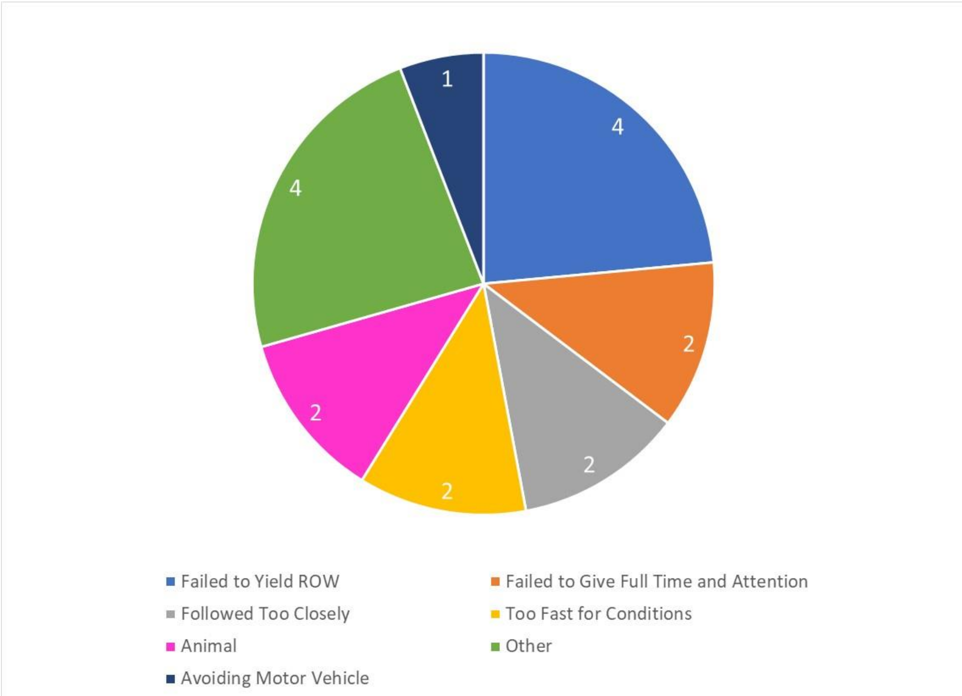


Figure 84. The Parkway and Wellington Road, Primary Cause

2.5.4 Driving Under the Influence

Zero crashes at this intersection were attributed to a driver operating a vehicle under the influence of alcohol or other substances.

2.5.5 Hit and Run

One of the 23 crashes (4.3%) was identified as hit and run.

2.5.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. More than a quarter of the crashes (7) at Wellington Road were INJ/FAT crashes (Figure 85).

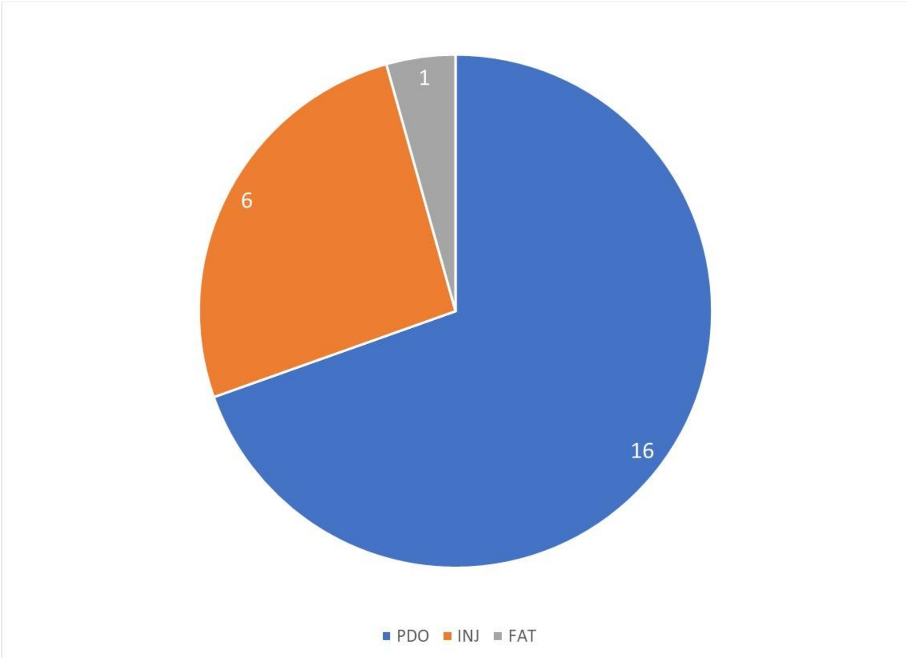


Figure 85. The Parkway and Wellington Road, Crash Severity

Across the injury and fatal crashes, there were a total of 11 injuries and 1 fatality.

The occurrence of the injury and fatal crashes by month, day of week, and time of day was investigated. In Figure 86, Figure 87, and Figure 88, blue represents injury crashes and orange represents the fatal crash.

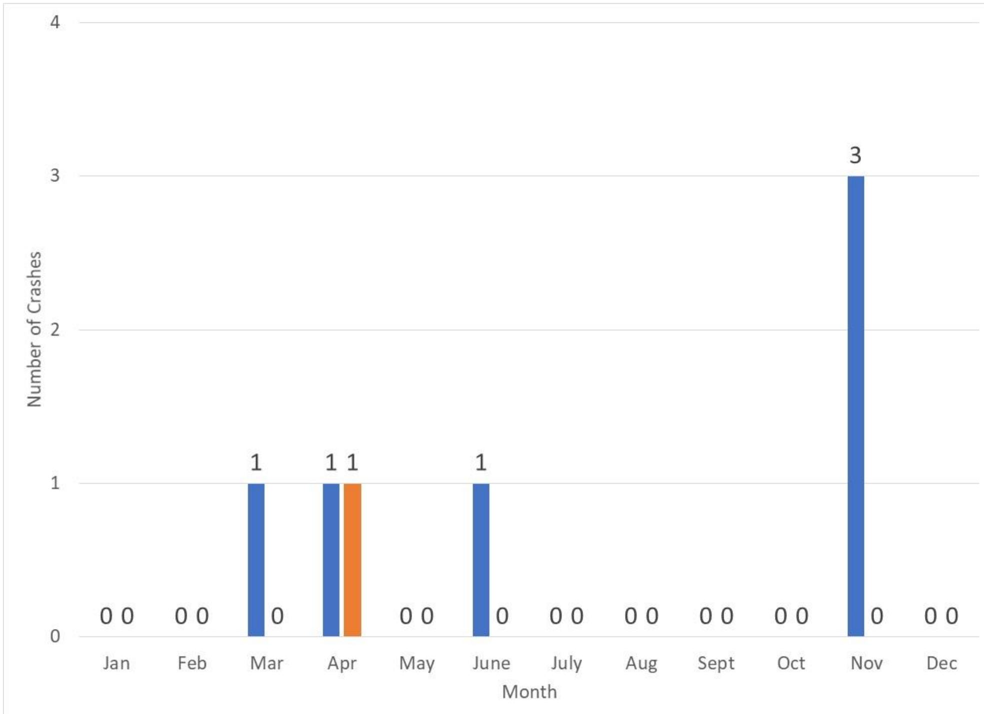


Figure 86. The Parkway and Wellington Road, Injury and Fatal Crashes by Month

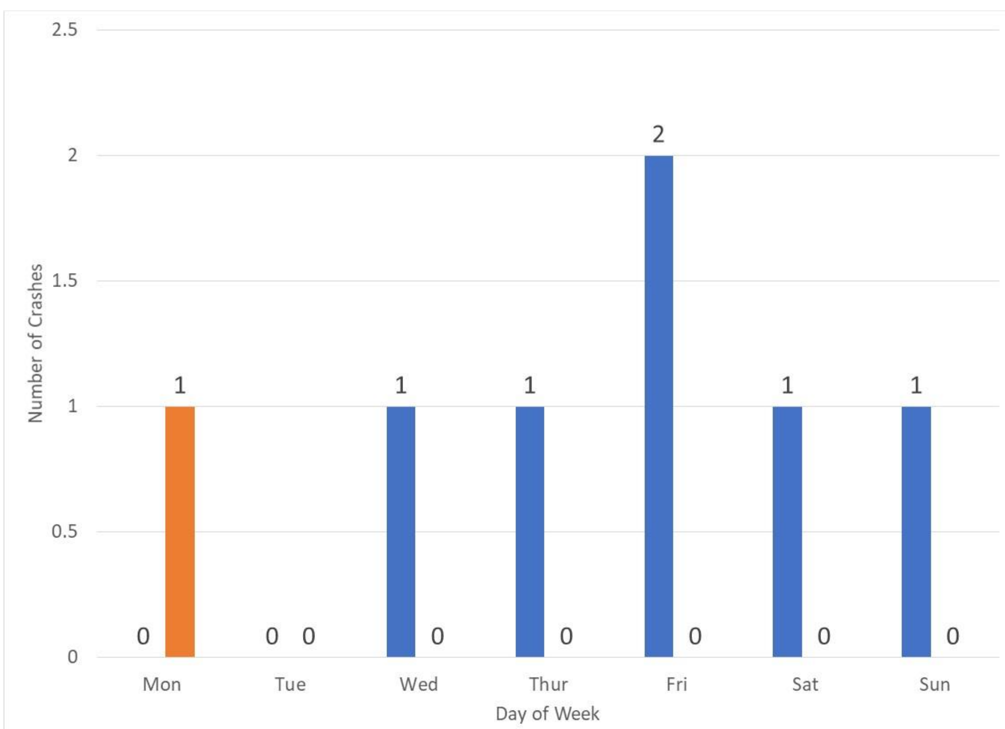


Figure 87. The Parkway and Wellington Road, Injury and Fatal Crashes by Day of the Week

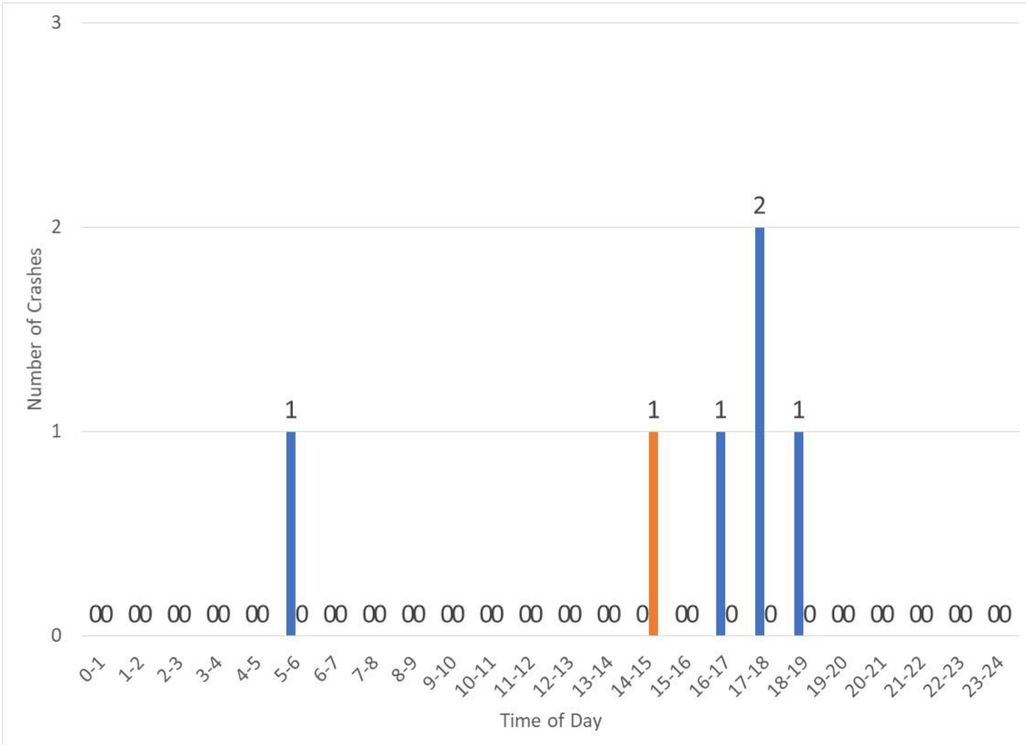


Figure 88. The Parkway and Wellington Road, Injury and Fatal Crashes by Time of Day

While November had the greatest number of injury crashes, April had both an injury crash and fatal crash, making it the second most severe month for Wellington Road (Figure 86). Similarly, while Fridays have the largest number of injury crashes, the only fatal crash occurred on a Monday (and the total count was only one less than Friday) (Figure 87). Finally, while the 5:00 p.m.–6:00 p.m. hour has the greatest number of injury crashes, overall, it seems there is a greater probability of an injury or fatal crash during the period from 2:00 p.m. to 7:00 p.m. (Figure 88).

Considering that the largest crash count was in April, on Friday, and from 4:00 p.m. to 5:00 p.m., it appears, as while it does not perfectly map, the higher crash count month, day of week, and time of day are also associated with more severe crashes.

2.5.7 Pedestrians and Bicycles

One of the crashes (4.3%) at the intersection was with a pedestrian. As noted previously, the MVT crossing is just after the turn from the Parkway onto Wellington Road.

2.5.8 Crash Diagram

The following crash diagram (Figure 89) illustrates the location of crashes for this intersection to which data regarding location within the intersection was available.

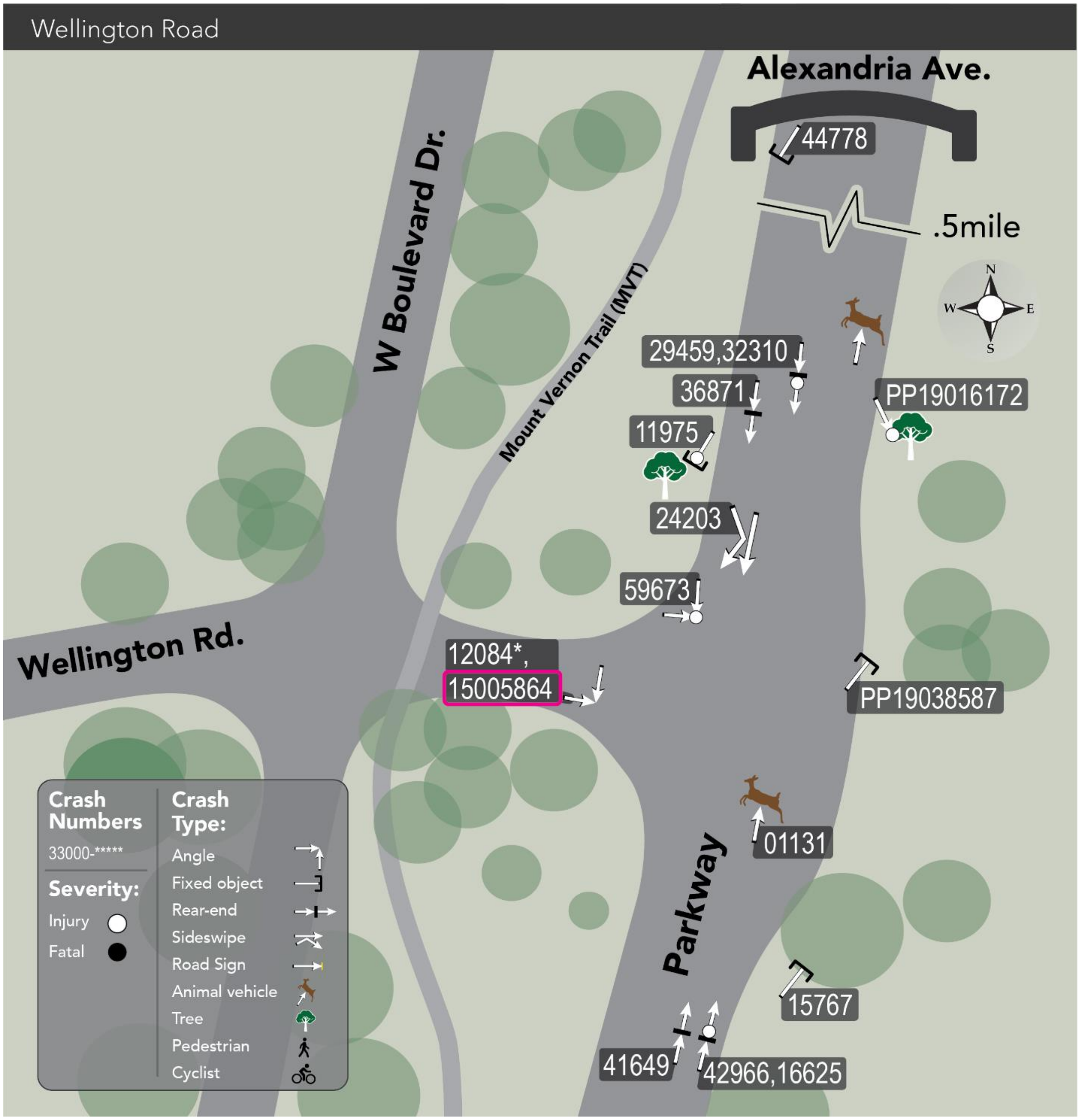


Figure 89. The Parkway and Wellington Road, Crash Diagram* •

---

* There was no indication if the pre-crash was northbound or southbound; this direction was assumed in the safety study.

• The following crashes did not have enough information to allow them to be placed on the crash diagram:
3300011399 — FAT
3300059683 — PDO

The crash diagram does not show one clear type of crash or recurring location. Two of the 23 crashes were with an animal (8.7%). While the animal crashes are depicted as deer for the diagram, it is unclear what types of animals were involved.

Rear-end crashes are occurring in both the northbound and southbound directions of the Parkway and overall have the greatest representation among crash types. These crashes could be the result of turning movements or speeding.

2.5.9 Summary — Wellington Road

Of the 23 crashes recorded for Wellington Road, most occurred in 2011; in April; most often between 4:00 p.m. and 5:00 p.m.; and on Fridays (Table 31). While there are few crashes that occur at this intersection, they are relatively severe. Driving under the influence was not reported.

Table 31. The Parkway and Wellington Road, Summary of Key Data Findings

Criteria	Count
Number of Crashes	23
Year (of greatest frequency)	2011
Month (of greatest frequency)	April
Day (of greatest frequency)	Friday
Percent from 12:00 a.m.–12:00 p.m.	26%
Most Frequent 1-Hour Block	4:00 p.m.–5:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	p.m. Peak
Most Typical Crash Type	Rear End
Most Typical Reported Cause	Failed to Yield ROW; Other (4 of 23, respectively)
Driving Under the Influence	Zero crashes (0 of 23)
Hit and Run	4.3% of crashes (1 of 23)
Percent of Injury and Fatal Crashes (measure of severity)	30% (7 of 23)
Total Number of People Injured in Crashes	12 People*
Pedestrian/Bicycle Involved Crashes?	Yes; 4.3% (1 of 23)
Animal Involved Crashes?	Yes; 8.7% (2 of 23)

* 11 injured; 1 died

2.6 The Parkway and Collingwood Road

Figure 90 shows the orientation of the Parkway and Collingwood Road, a four-legged intersection with a median.

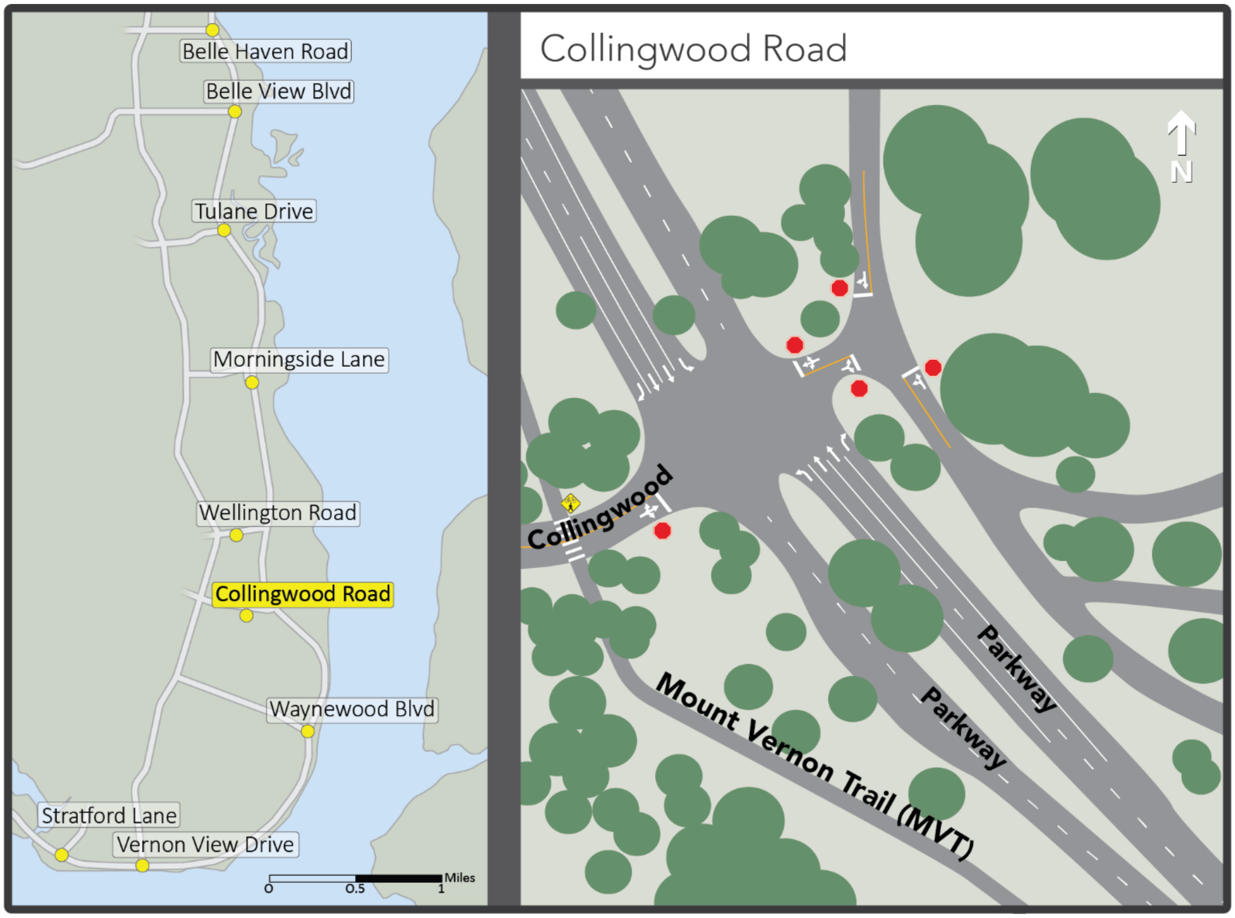


Figure 90. Intersection of the Parkway and Collingwood Road

There are a few interesting geometric considerations at this intersection. First, there is an intersection in close proximity to the main one on either side of the Parkway and Collingwood Road intersection and along with the MVT crossing on the south leg. The intersection to the northeast is Collingwood Road and East Boulevard Drive and the intersection to the southwest is Collingwood Road and West Boulevard Drive.

During 2005–2015 and 2018–2019, 46 crashes occurred at the intersection of the Parkway and Collingwood Road. The annual occurrence of crashes appears to be random, although 2006 had the greatest number of crashes reported (Figure 91). The year 2015 did not have any crashes at this intersection. In addition, either the change in crash reporting has impacted the number of crashes recorded or there seems to be a downward trend.

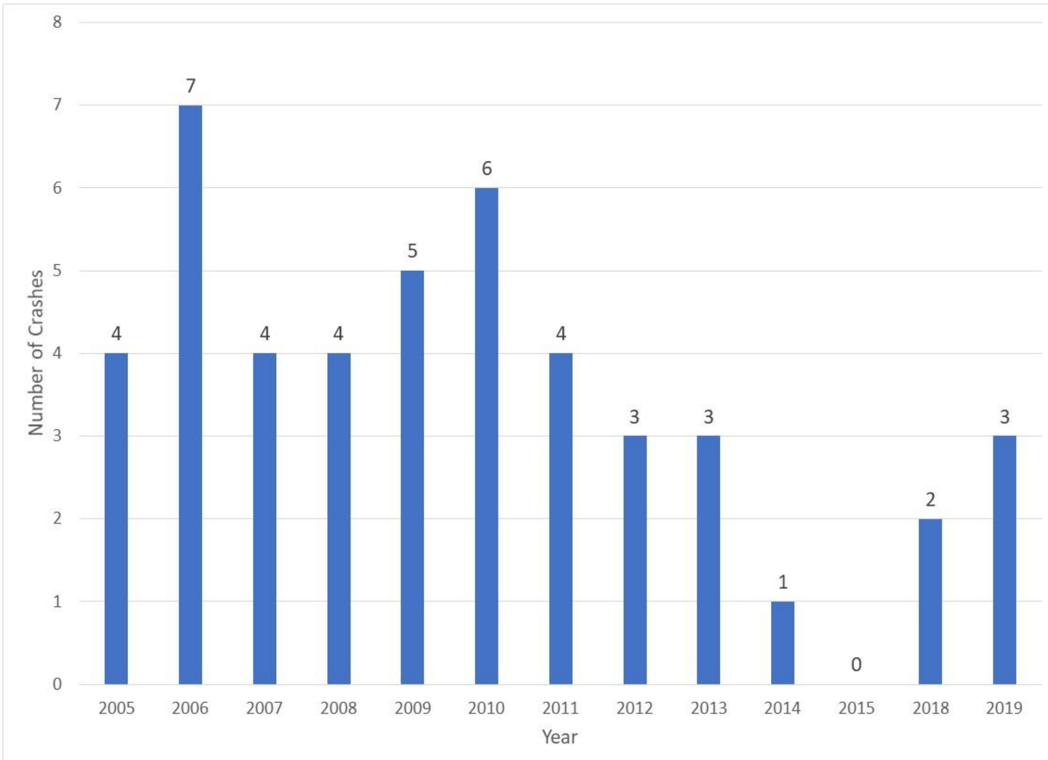


Figure 91. The Parkway and Collingwood Road, Total Crashes by Year

2.6.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on the data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in April (Figure 92).

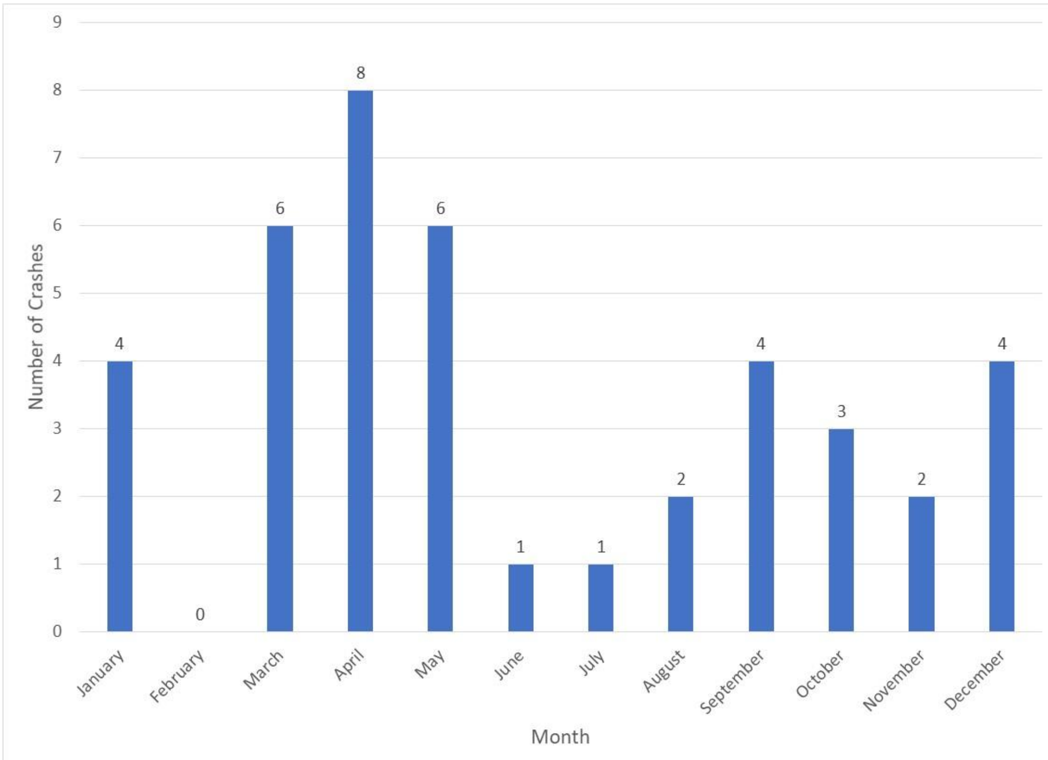


Figure 92. The Parkway and Collingwood Road, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate when crashes occurred more often. The data show that 50% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between period 7:00 a.m. and 8:00 a.m. and 8:00 a.m. and 9:00 a.m. (Figure 93).

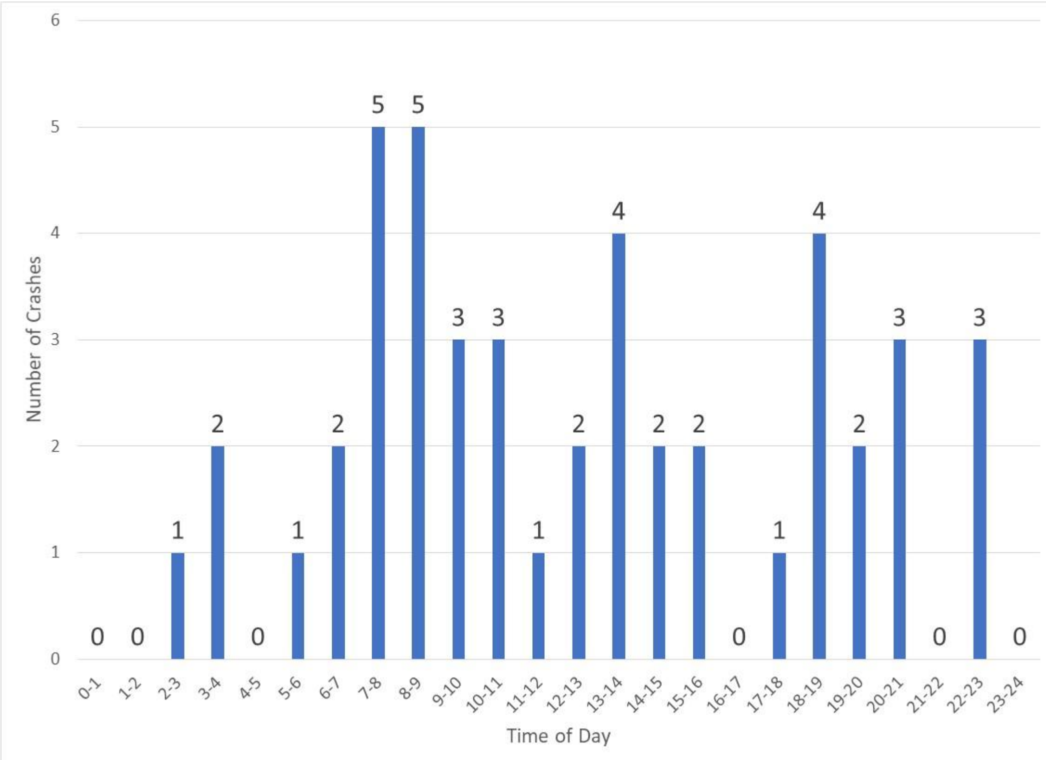


Figure 93. The Parkway and Collingwood Road, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the highest rate of crashes occurred during the a.m. peak period. Table 32 shows the number of crashes within these groups.

Table 32. The Parkway and Collingwood Road, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	4	0.7
6:00 a.m.–9:00 a.m.	a.m. Peak	12	4.0
9:00 a.m.–3:00 p.m.	Midday	15	2.5
3:00 p.m.–6:00 p.m.	p.m. Peak	3	1.0
6:00 p.m.–12:00 a.m.	post-p.m. Peak	12	2.0
TOTAL		**46**	–

The day of the week that is most represented in the crash records is Friday (Figure 94). Monday was close in count, with one fewer crash.

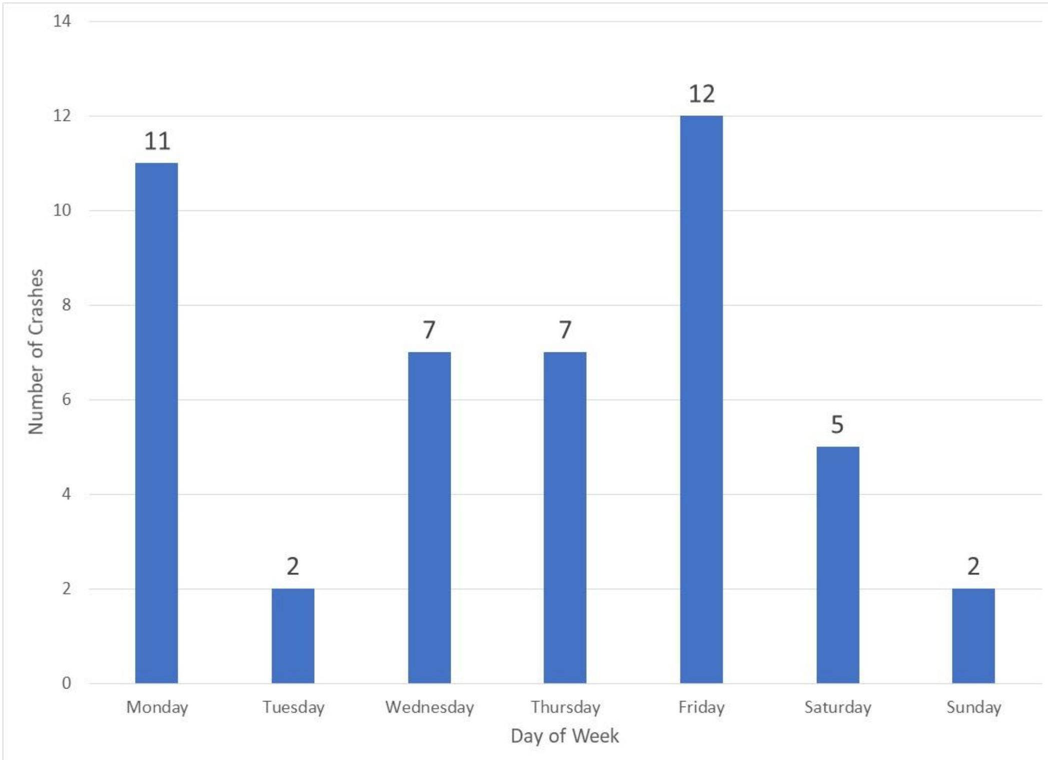


Figure 94. The Parkway and Collingwood Road, Crashes by Day of Week

2.6.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Figure 95 shows an analysis of the lighting conditions during crashes.

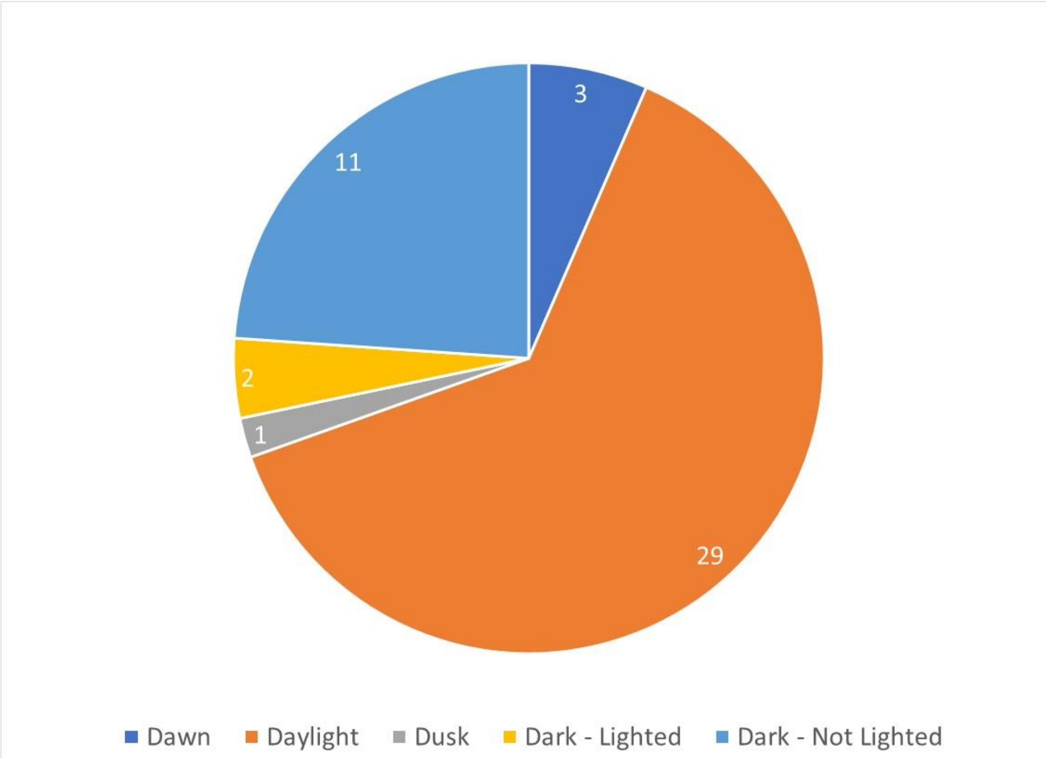


Figure 95. The Parkway and Collingwood Road, Lighting (Number of Crashes during Each Lighting Condition)

The data shows that most crashes (29) occurred during "Daylight." Looking at the crashes in more detail, of the crashes that occurred during "Daylight," 9 of these crashes were indicated as "Cloudy" or "Rain." These conditions would suggest that the crashes occurred when there was reduced visibility. The remaining 22 crashes occurred during "Daylight." The researchers also considered whether the "Daylight" crashes occurred during peak periods. (*Note:* The team anticipated that "Daylight" crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 33 shows the number of crashes within these groups.

Table 33. The Parkway and Collingwood Road, "Daylight" Crash counts and Rates by Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	0	0
6:00 a.m.–9:00 a.m.	a.m. Peak	8	2.7
9:00 a.m.–3:00 p.m.	Midday	15	2.5
3:00 p.m.–6:00 p.m.	p.m. Peak	3	1
6:00 p.m.–12:00 a.m.	post-p.m. Peak	3	0.5
TOTAL "Daylight" Crashes		**29**	–

"Daylight" crashes were most likely to occur during the a.m. peak from a rate perspective and midday based on count and least likely to occur from 12:00 a.m. to 6:00 a.m. (pre-a.m. peak).

With regard to weather, a slight majority of the crashes (30) occurred during "Clear" periods (Figure 96).

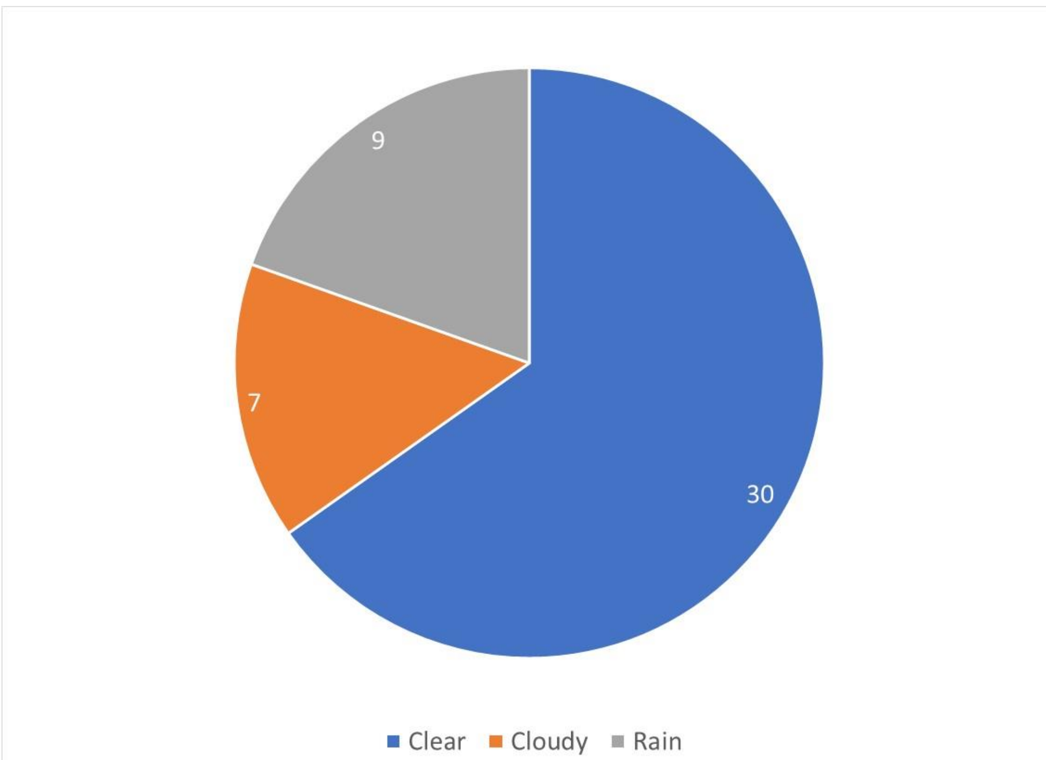


Figure 96. The Parkway and Collingwood Road, Weather

There is some suggestion that weather may be contributing to crash occurrence.

The majority of crashes (37) occurred when surface conditions were "Dry" (Figure 97).

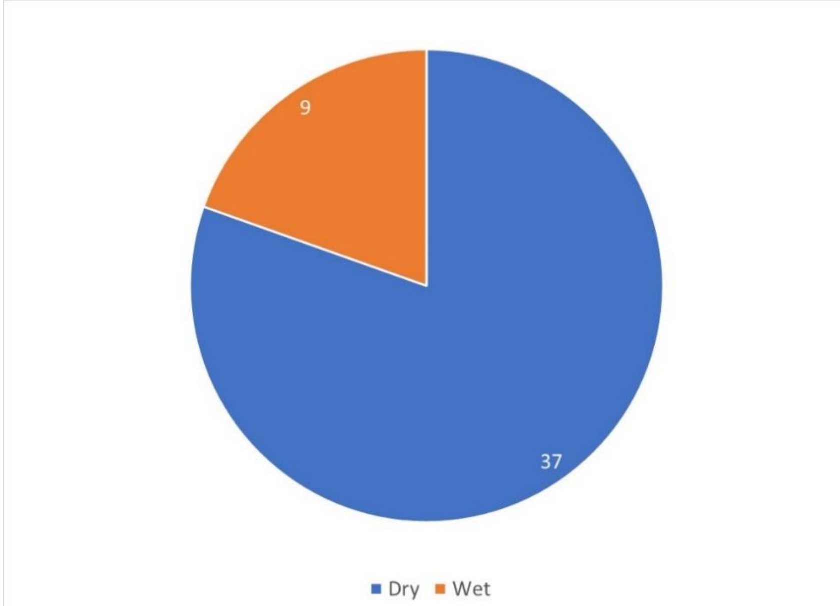


Figure 97. The Parkway and Collingwood Road, Surface Condition

2.6.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the primary cause of the crash, and whether the crash was between vehicles or with an object.

One category of the tabular data provided information about the vehicle crash type. The most frequently identified vehicle collision was "Not Applicable" (Figure 98).

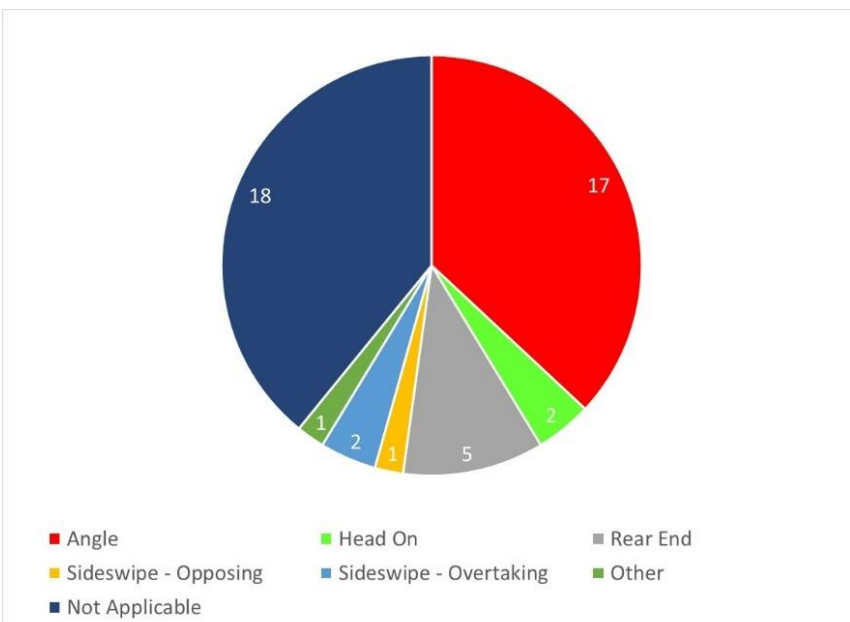


Figure 98. The Parkway and Collingwood Road, Crash Type

Eighteen crashes were identified as “Not Applicable” and involved collisions with a tree/shrub (10), sign (3), animal (2), other fixed object (2), or drainage structure (1).

The most frequently reported “Primary Cause” was “Failed to Yield ROW” (Figure 99), which was reported in 9 of 46 crashes (20%). (*Note:* Figure 99 only shows 32 of the 46 crashes that occurred at the intersection, as 14 crashes provided no information on the “Primary Cause.”)

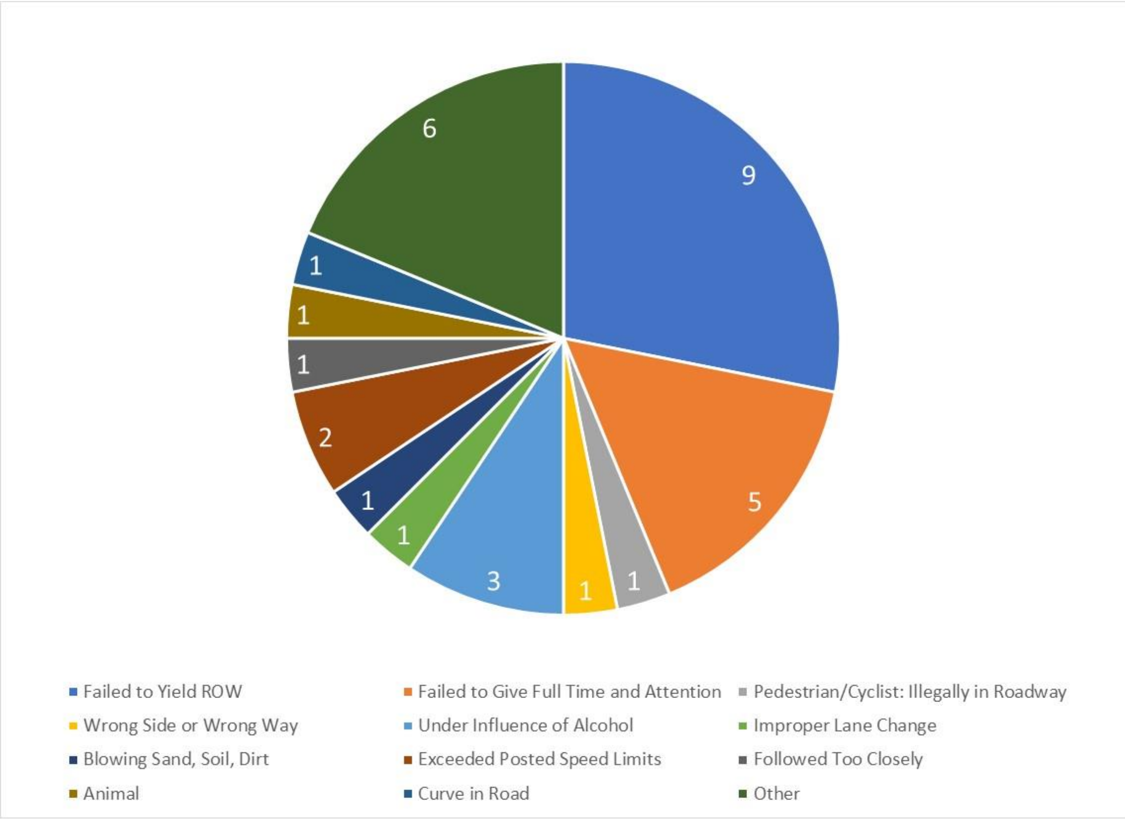


Figure 99. The Parkway and Collingwood Road, Primary Cause

2.6.4 Driving Under the Influence

Of the 46 crashes identified at the intersection during 2005–2015 and 2018–2019, 3 crashes, or 6.5% of all crashes at the intersection, were identified as having a driver that was under the influence of alcohol or other substances. This number seems relatively high, and a further investigation as to what is causing the high rate of driving under the influence crashes could be conducted.

2.6.5 Hit and Run

Four of the 46 crashes (8.7%) were identified as hit and run.

2.6.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. Nearly a quarter of the crashes (11) at Collingwood Road were injury crashes (Figure 100). (*Note:* One of the crashes during 2018–2019 did not provide severity.)

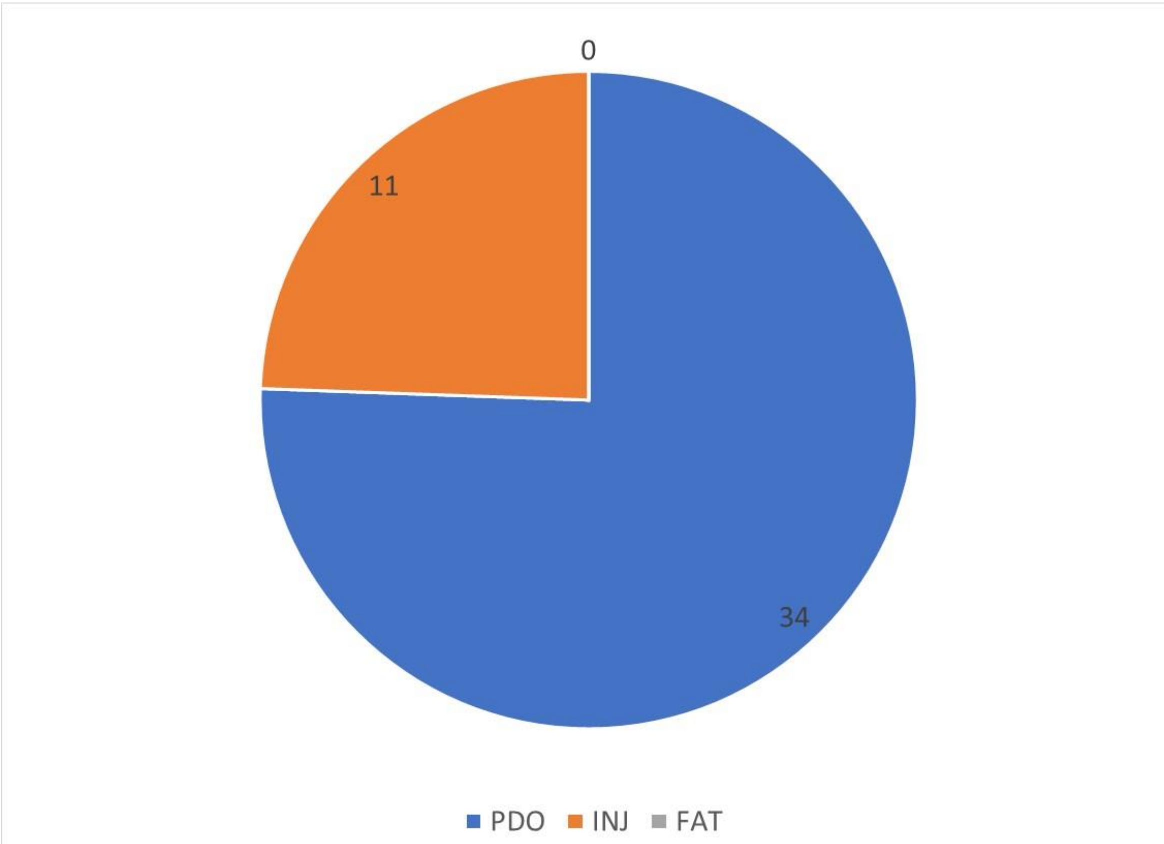


Figure 100. The Parkway and Collingwood Road, Crash Severity

Across the injury crashes, there were 12 injuries.

The occurrence of the injury crashes by month, day of week, and time of day was investigated (Figure 101, Figure 102, and Figure 103). Overall, the occurrence of injury crashes by month seems randomly distributed, as the greatest difference between the counts in a month is two; however, April, August and September have the greatest counts (Figure 101). April also had the greatest count of total crashes.

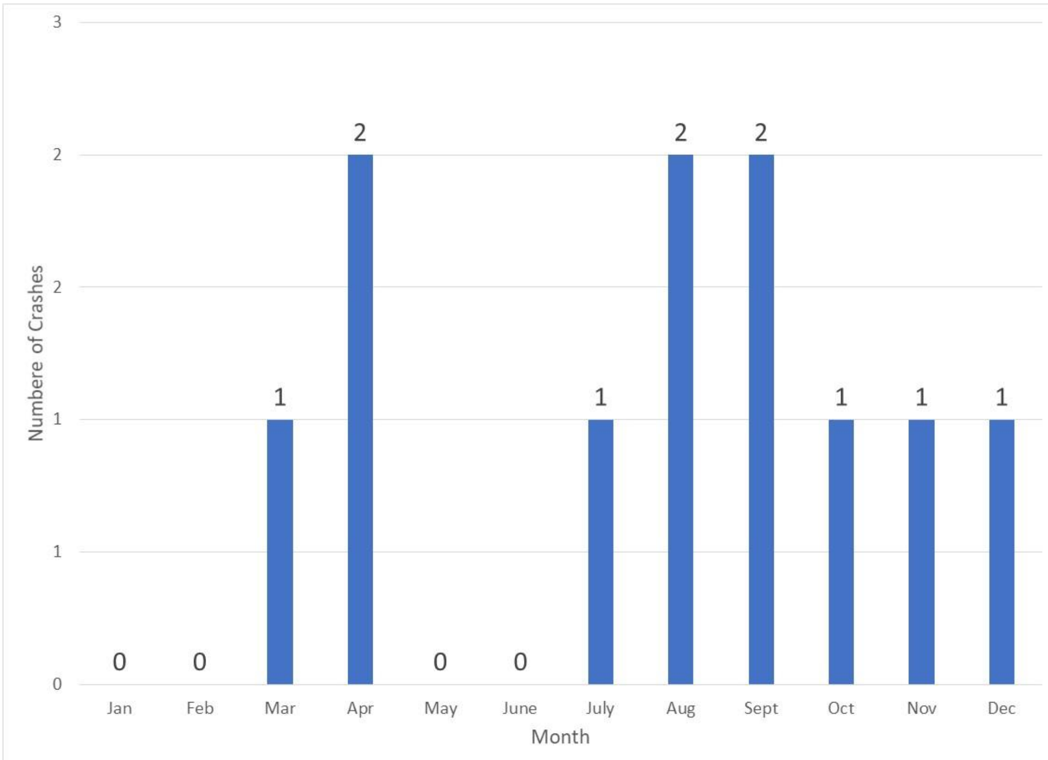


Figure 101. The Parkway and Collingwood Road, Injury Crashes by Month

It would appear that there are contributing factors to injury crashes on Mondays and Thursdays. These days could be further investigated to determine what might be contributing to a larger count of injury crashes (Figure 102).

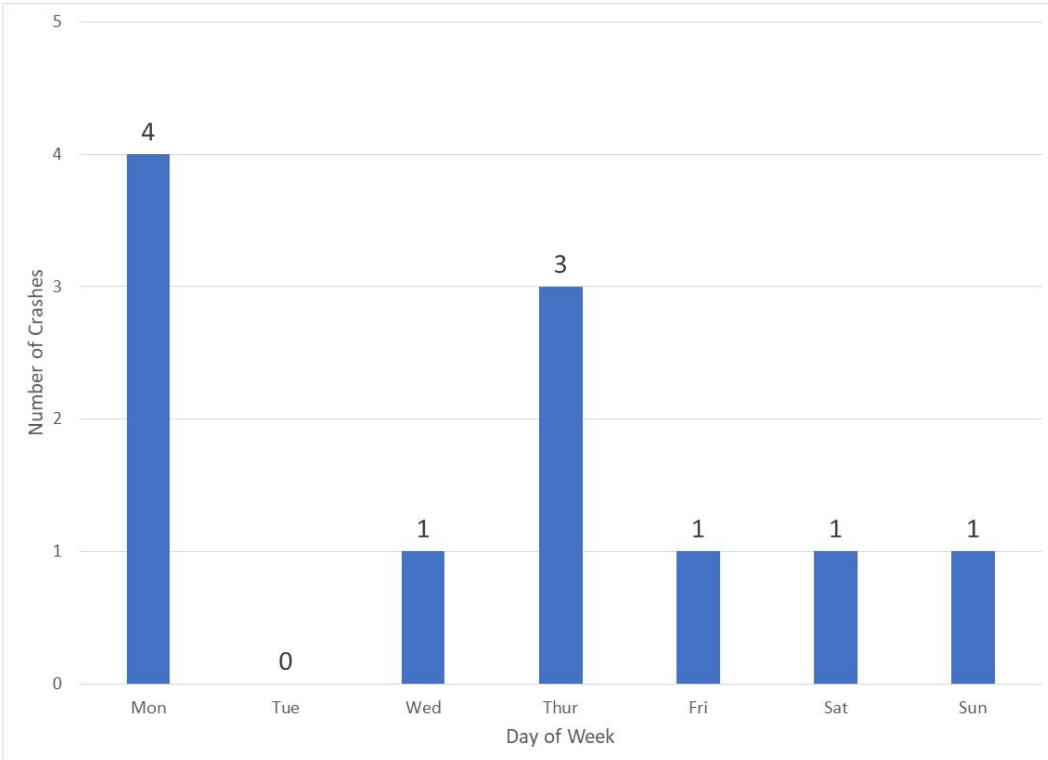


Figure 102. The Parkway and Collingwood Road, Injury Crashes by Day of the Week

There is a suggestion that 6:00 p.m.–7:00 p.m. might have some contributing factors to injury crash occurrence (Figure 103); again, this is different from the peak periods of 7:00 a.m.–8:00 a.m. and 8:00 a.m.–9:00 a.m. (which had the highest counts for crashes overall), although the 6:00 p.m.–7:00 p.m. period was a close second in count.

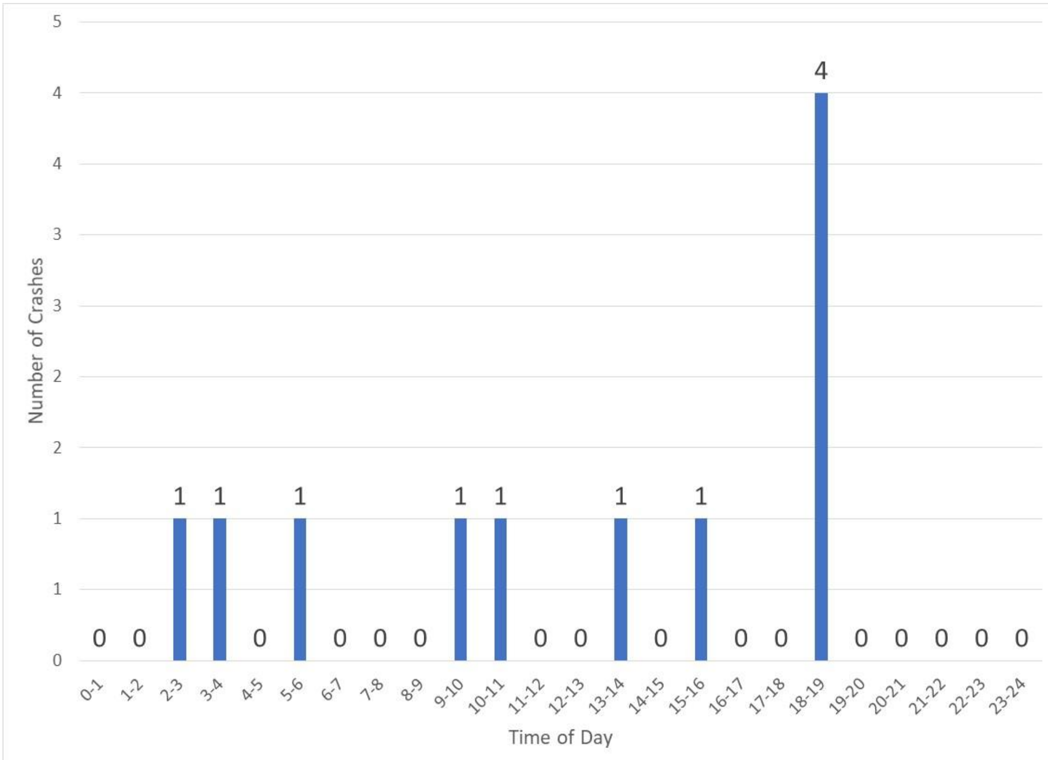


Figure 103. The Parkway and Collingwood Road, Injury Crashes by Time of Day

2.6.7 Pedestrians and Bicycles

One crash (2.2%) was reported as occurring between a vehicle and a bicyclist. The tabular data indicated that the bicyclist was illegally present in the roadway. (*Note*: Bicyclists are currently not allowed on the roadway.)

2.6.8 Crash Diagram

The following crash diagram (Figure 104) illustrates the location of crashes for this intersection for which data regarding location within the intersection was available. In some cases, this information was not available; however, further details are provided in the footnote.

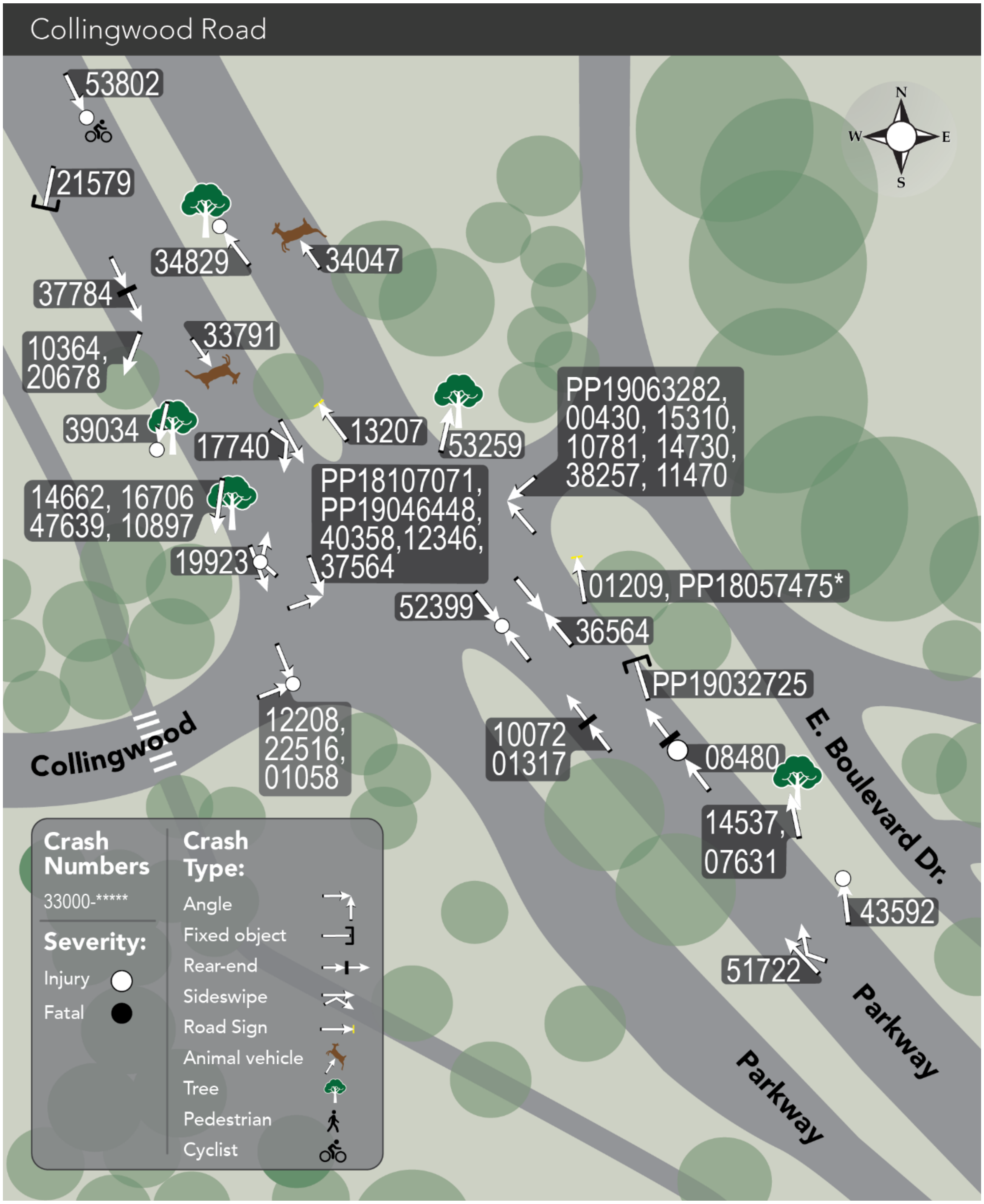


Figure 104. The Parkway and Collingwood Road, Crash Diagram*†

* Severity information was unavailable for this crash

† The following crashes did not have enough information to allow them to be placed on the crash diagram: 3300041567 — PDO

Many of the crashes at this intersection appear to involve drivers not staying on the road (e.g., crashing with trees, drainage structures, signs). Therefore, it would be of value to consider a different type of lane markings or a more defined schedule for reapplication of typical lane markings. In addition, there could be a review to determine if existing signs warn approaching motorists of the horizontal curvature found at the intersection. There are also a relatively high number of angle crashes between vehicles traveling northbound on the Parkway and vehicles traveling westbound on Collingwood Road. Similarly, for vehicles traveling southbound on the Parkway and eastbound on Collingwood Road, there is a high number of crashes, including more injury crashes.

2.6.9 Summary — Collingwood Road

Of the 46 crashes recorded for Collingwood Road, most occurred in 2006; in April; most often between 7:00 a.m. and 9:00 a.m.; and on Fridays (Table 34). There were no fatal crashes at this intersection. Hit-and run-crashes and driving under the influence (both alcohol and other substances) resulted in crashes at the intersection. There is some indication that lighting may be an issue at the intersection. There is also a suggestion that navigating the curve is a problem; this could be the result of delineation or the speed of traffic traveling on the Parkway. The speed of traffic on the Parkway could also explain the large number of angle collisions.

Table 34. The Parkway and Collingwood Road, Summary of Key Data Findings

Criteria	Count
Number of Crashes	46
Year (of greatest frequency)	2006
Month (of greatest frequency)	April
Day (of greatest frequency)	Friday
Percent from 12:00 a.m.–12:00 p.m.	50%
Most Frequent 1-Hour Block	7:00 a.m.–8:00 a.m.; 8:00 a.m.–9:00 a.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	a.m. Peak
Most Typical Crash Type	Not Applicable
Most Typical Reported Cause	Failed to Yield ROW (9 of 46)
Driving Under the Influence	6.5% of Crashes (3 of 46)
Hit and Run	8.7% of Crashes (4 of 46)
Percent of Injury and Fatal Crashes (measure of severity)	24% (11 of 46)
Total Number of People Injured in Crashes	12 People
Pedestrian/Bicyclist Involved Crashes?	Yes; 2.2% (1 of 46)
Animal Involved Crashes?	Yes; 4.3% (2 of 46)

2.7 The Parkway and Waynewood Boulevard

Figure 105 shows the orientation of the Parkway and Waynewood Boulevard, a three-legged intersection without a median.

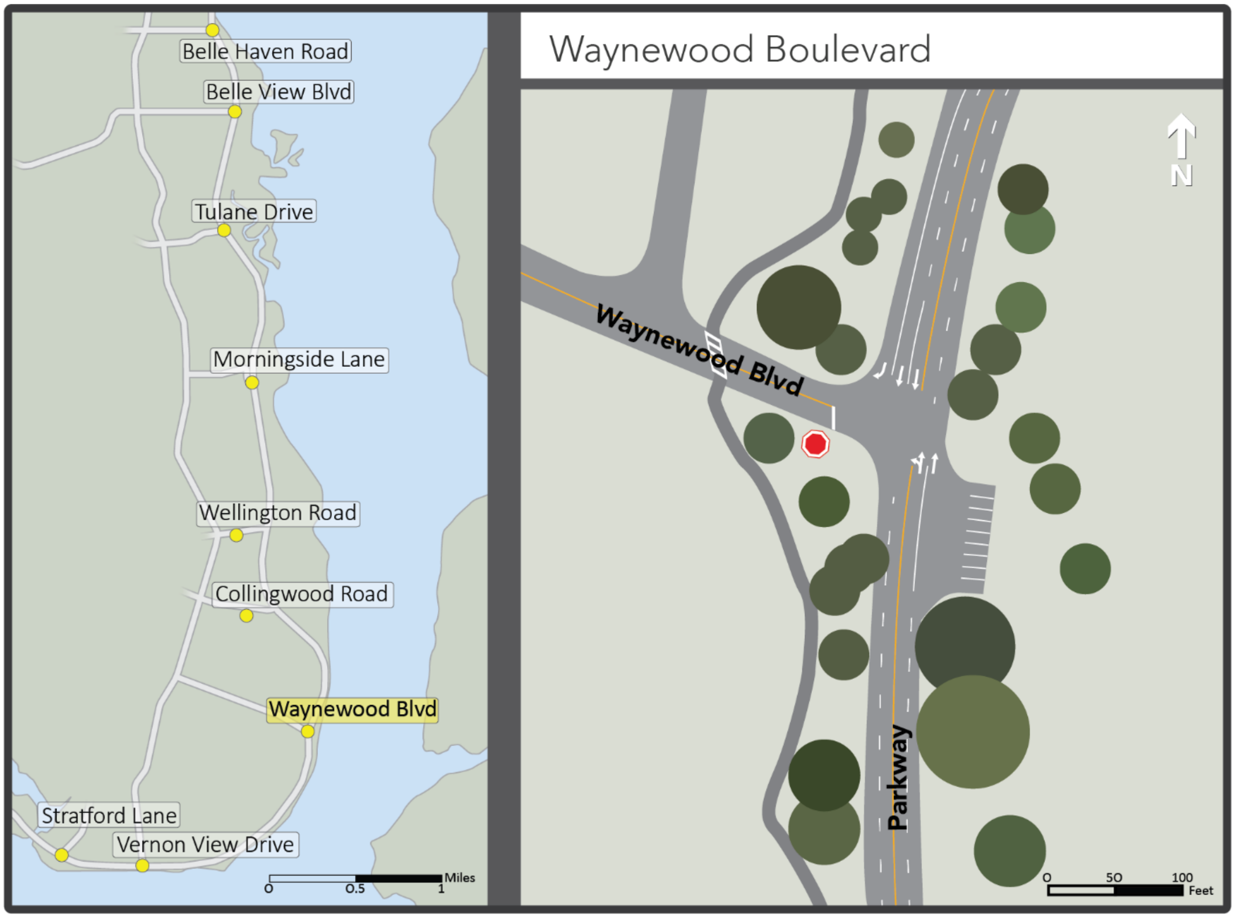


Figure 105. The Parkway and Waynewood Boulevard

There are a few interesting geometric considerations at this intersection. First, the Mount Vernon Trail crosses Waynewood Boulevard approximately 150 feet west of Waynewood Boulevard's intersection with the Parkway. A parking lot on the east side of the intersection does not have a single point of entry, and a driver can pull into any of the parking spaces that are marked.

During 2005–2015 and 2018–2019, 17 crashes occurred at the intersection of the Parkway and Waynewood Boulevard. The annual occurrence of crashes appears to be random, although both 2010 and 2011 had the greatest number of crashes reported (Figure 106). The years 2015 and 2019 did not have any reported crashes at Waynewood Boulevard.

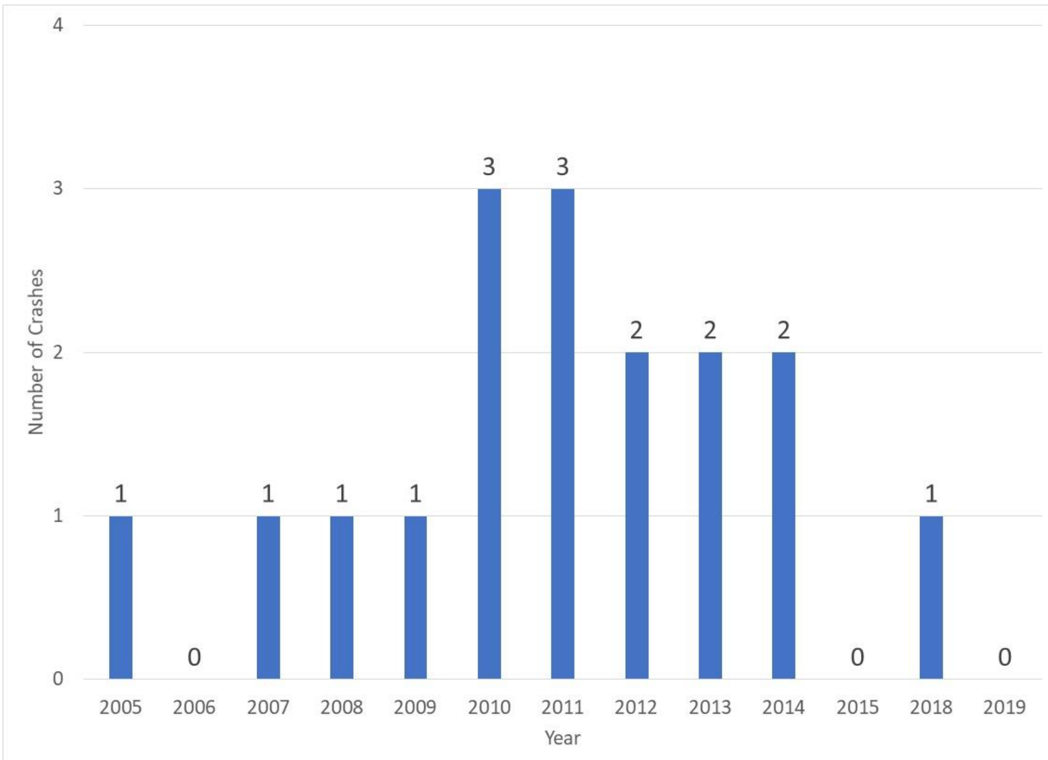


Figure 106. The Parkway and Waynewood Boulevard, Total Crashes by Year

2.7.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in October (Figure 107).

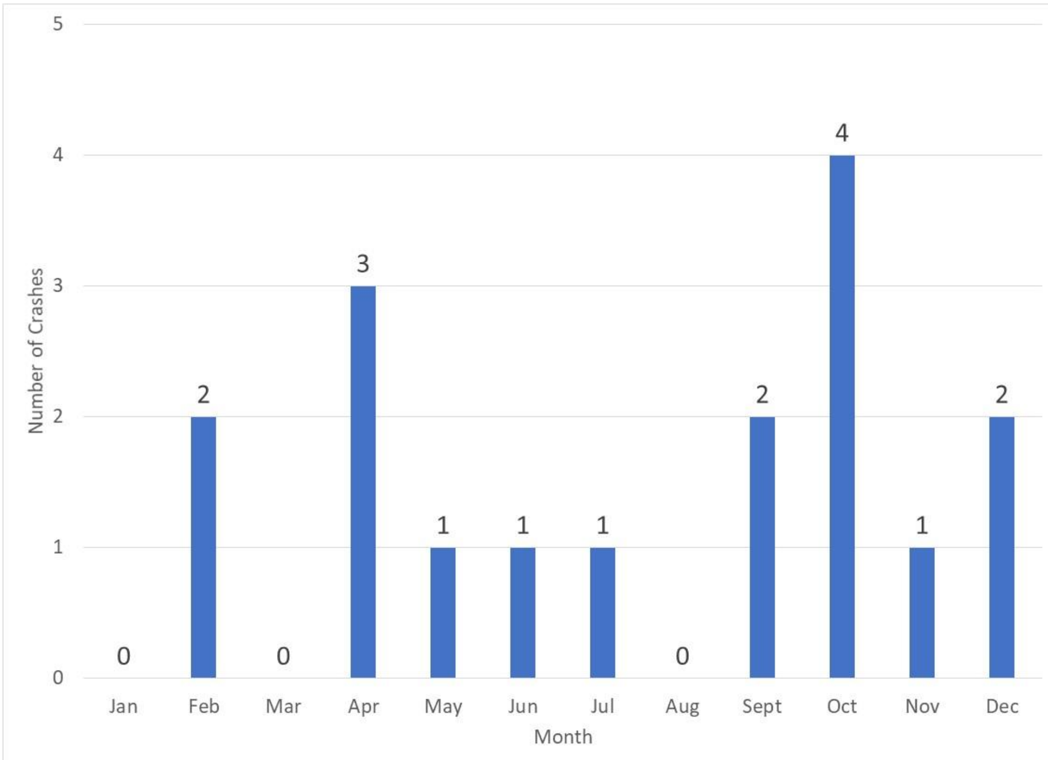


Figure 107. The Parkway and Waynewood Boulevard, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate when crashes occurred more often. The data show that 18% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 4:00 p.m. and 5:00 p.m. (Figure 108).

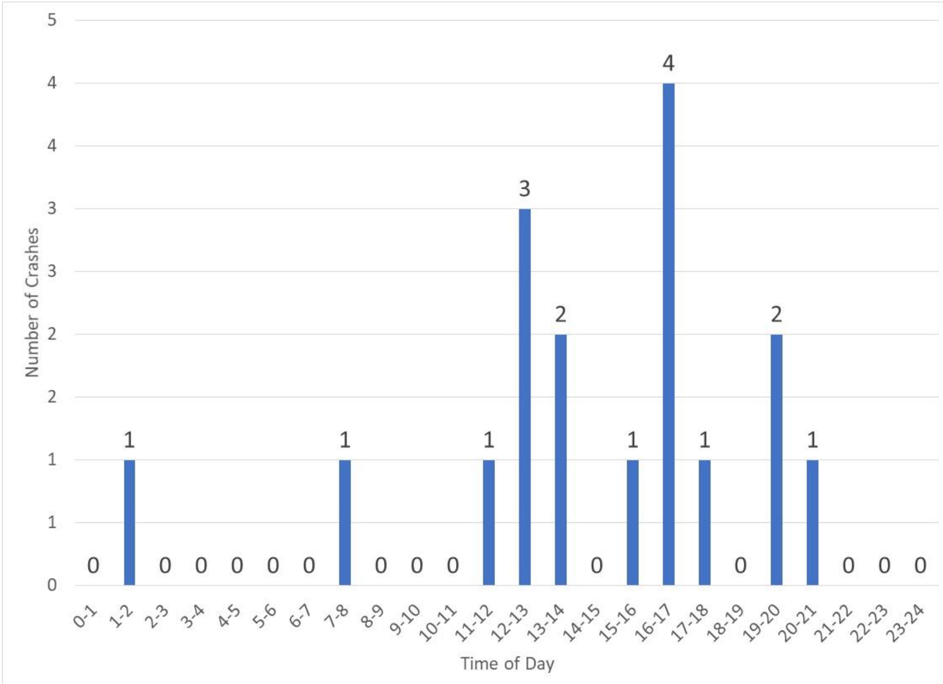


Figure 108. The Parkway and Waynewood Boulevard, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the highest rate of crashes occurred during the p.m. peak period. Table 35 shows the number of crashes within these groups.

Table 35. The Parkway and Waynewood Boulevard, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	1	0.17
6:00 a.m.–9:00 a.m.	a.m. Peak	1	0.33
9:00 a.m.–3:00 p.m.	Midday	6	1
3:00 p.m.–6:00 p.m.	p.m. Peak	6	2
6:00 p.m.–12:00 a.m.	post-p.m. Peak	3	0.5
TOTAL		**16**	–

The day of the week that is most represented in the crash records is Wednesday (Figure 109). Thursday, Friday, and Sunday have only one less crash than Wednesday.

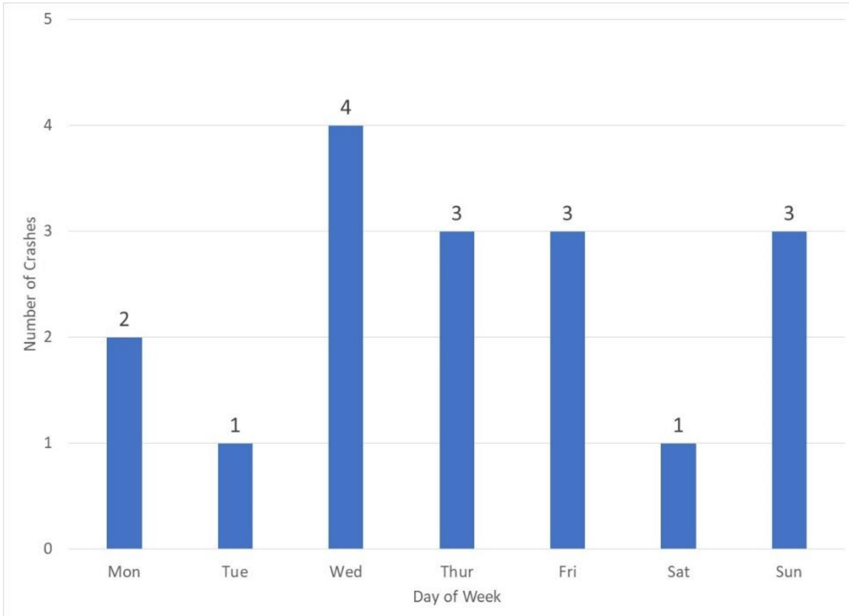


Figure 109. The Parkway and Waynewood Boulevard, Crashes by Day of the Week

2.7.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Figure 110 shows an analysis of the lighting conditions during crashes.

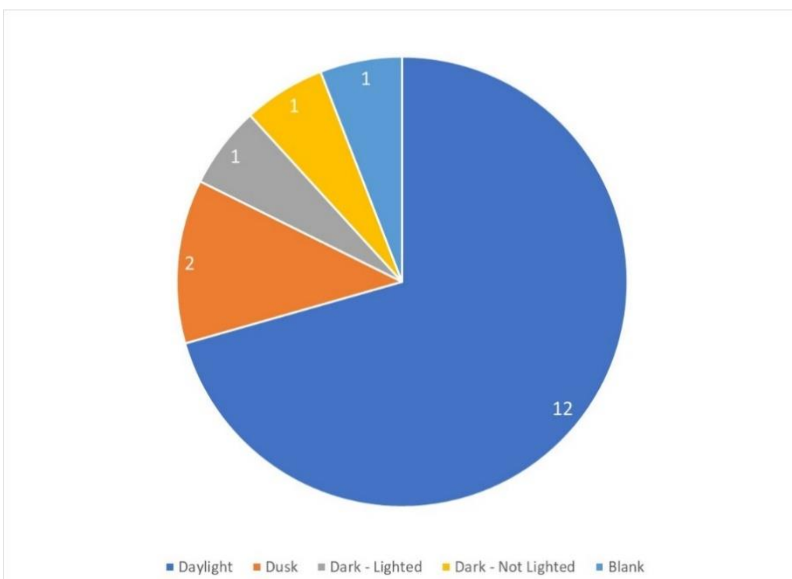


Figure 110. The Parkway and Waynewood Boulevard, Lighting (Number of Crashes during Each Lighting Condition)

The data show that most crashes (12) occurred during "Daylight." Looking at the data in more detail, of the crashes that occurred during "Daylight," three of these crashes were during periods when conditions were indicated as "Cloudy," "Rain," "Snow," or "Sleet, Hail, Freezing Rain." These conditions would suggest that the crashes occurred when there was reduced visibility. The remaining nine crashes occurred during "Daylight." Therefore, approximately half of the crashes occurred during hours when visibility was good, while the other half occurred during periods when it was not.

The researchers also considered whether the "Daylight" crashes occurred during peak periods. (*Note:* The team anticipated that "Daylight" crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 36 shows the number of crashes within these groups.

Table 36. The Parkway and Waynewood Boulevard, "Daylight" Crash Counts and Rates by Periods

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	0	0
6:00 a.m.–9:00 a.m.	a.m. Peak	0	0
9:00 a.m.–3:00 p.m.	Midday	6	1.0
3:00 p.m.–6:00 p.m.	p.m. Peak	4	1.3
6:00 p.m.–12:00 a.m.	post-p.m. Peak	2	0.3
TOTAL "Daylight" Crashes		**12**	–

"Daylight" crashes were most likely to occur during the p.m. peak and least likely to occur from 12:00 a.m. to 9:00 a.m. (pre-a.m. peak and a.m. peak).

With regard to weather, half of the crashes (nine) occurred during "Clear" periods (Figure 111).

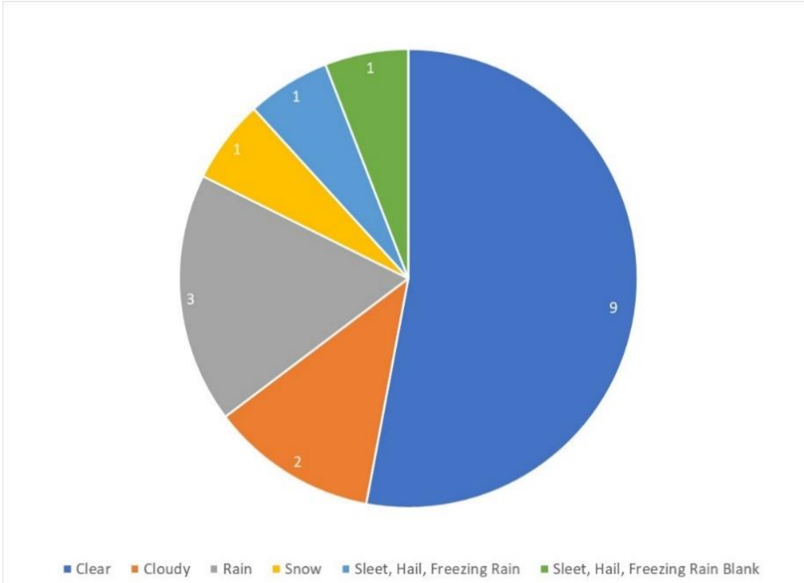


Figure 111. The Parkway and Waynewood Boulevard, Weather

The majority of the crashes (10) occurred when surface conditions were "Dry," which suggests that *surface condition is unlikely to be an issue* (Figure 112).

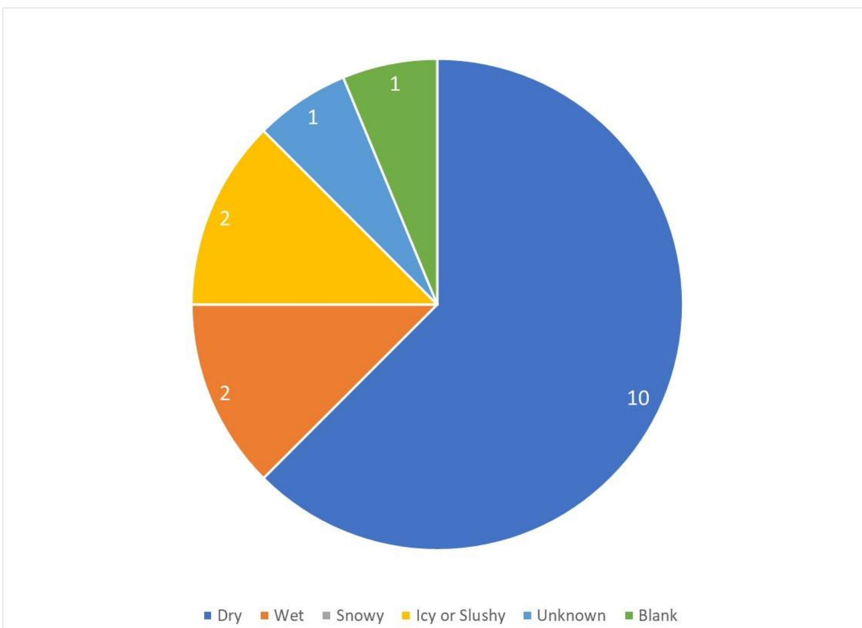


Figure 112. The Parkway and Waynewood Boulevard, Surface Condition

2.7.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the indicated primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. “Angle” and “Not Applicable” were the most common crash types (both had five) (Figure 113).

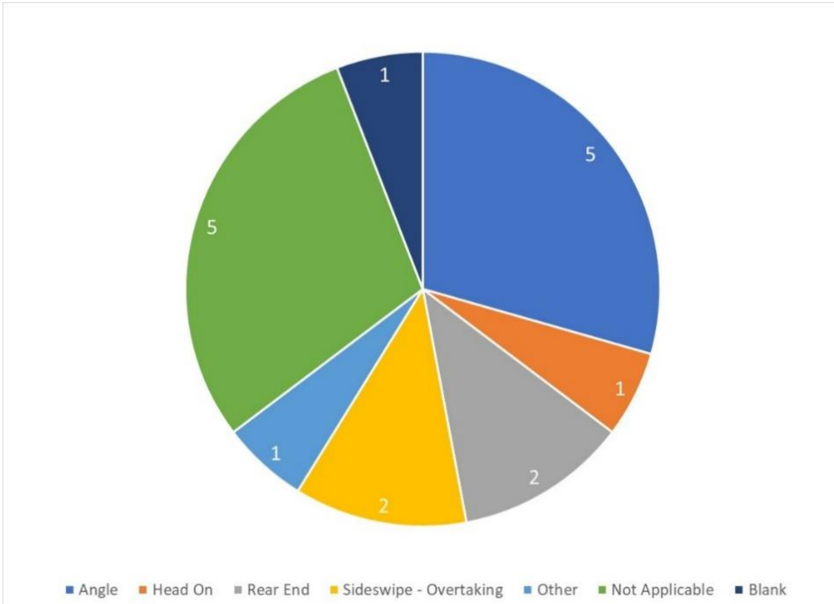


Figure 113. The Parkway and Waynewood Boulevard, Crash Type

Five crashes were identified as “Not Applicable” and involved a collision with a tree/shrub (3), drainage structure (1), or debris or obstruction (1). The “Other” crash (which occurred in 2018) identified that the vehicle struck a median/curb, which was only identifiable because of the manner in which the new crash data were presented (the file included crash information, vehicle information, and information about people).

The most frequently reported "Primary Cause" was "Failed to Give Full Time and Attention" (Figure 114), although by only one more crash than the other reported "Primary Causes": "Failed to Yield ROW," "Too Fast for Conditions," "Followed Too Closely," "Debris or Obstruction," "Disregarded Traffic Signs, Signals, or Road Markings," "Animal," "Sleet, Hail, Freezing Rain," or "Other." (*Note:* Figure 114 only shows 10 of the 17 crashes that occurred at the intersection, as 7 crashes provided no information on the "Primary Cause.")

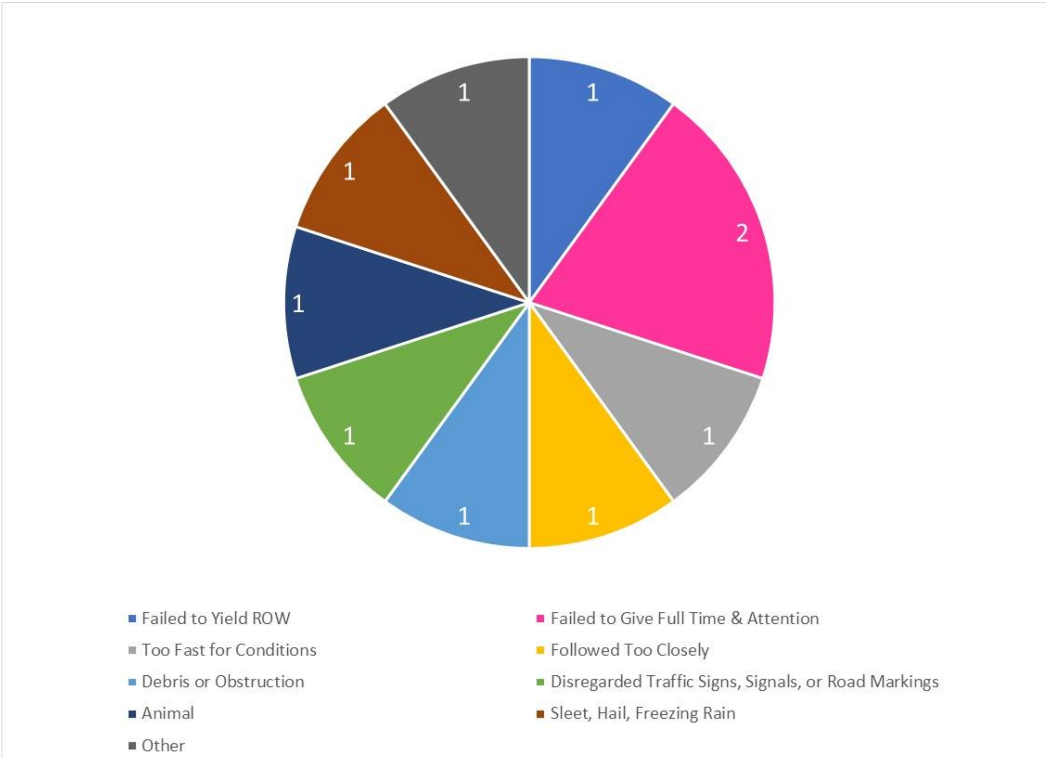


Figure 114. The Parkway and Waynewood Boulevard, Primary Cause

2.7.4 Driving Under the Influence

As noted in the "Primary Cause" section, of the 17 crashes identified at the intersection during 2005–2015 and 2018–2019, zero crashes were identified as having a driver that was under the influence of alcohol or other substances.

2.7.5 Hit and Run

One of the 17 crashes (6.3%) was identified as hit and run.

2.7.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. While Waynewood Boulevard has the second fewest number of total crashes across all study intersections, just under half of these crashes (8) are either injury/fatal crashes (Figure 115).

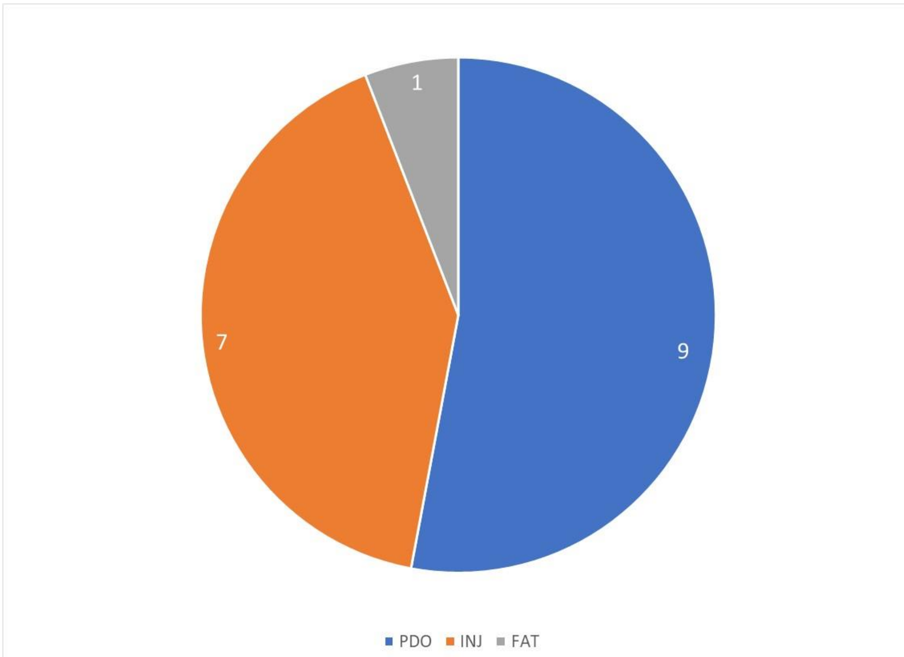


Figure 115. The Parkway and Waynewood Boulevard, Crash Severity

Across the injury and fatal crashes, there were a total of nine injuries and one fatality.

The occurrence of the injury and fatal crashes by both month, day of week, and time of day was investigated. In Figure 116, Figure 117, and Figure 118, blue represents injury crashes and orange represents the fatal crash.

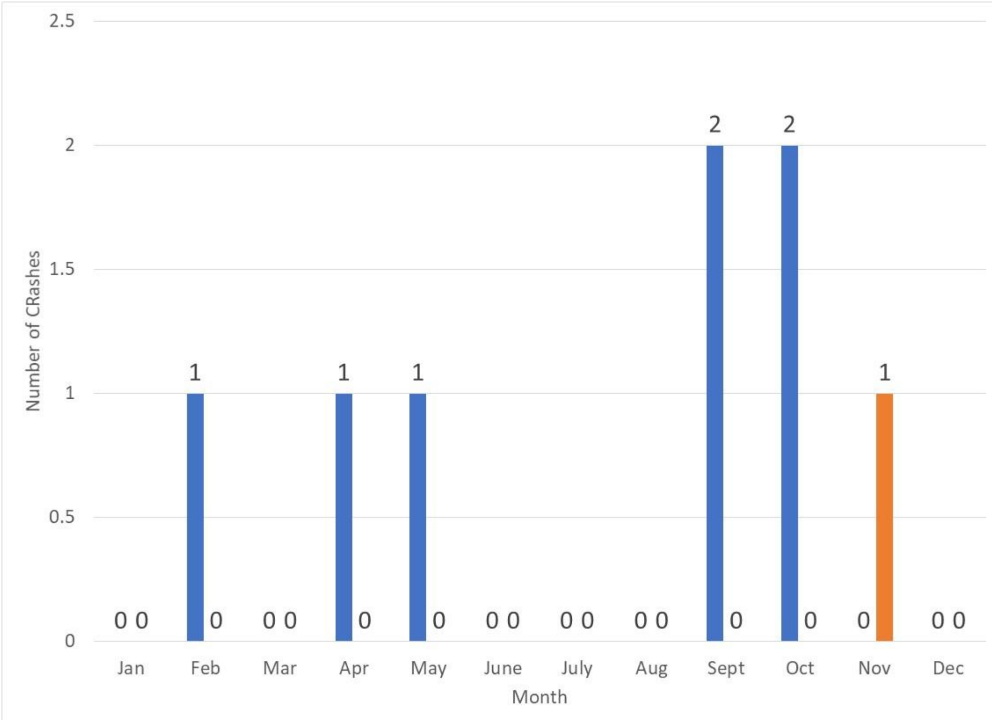


Figure 116. The Parkway and Waynewood Boulevard, Injury and Fatal Crashes by Month

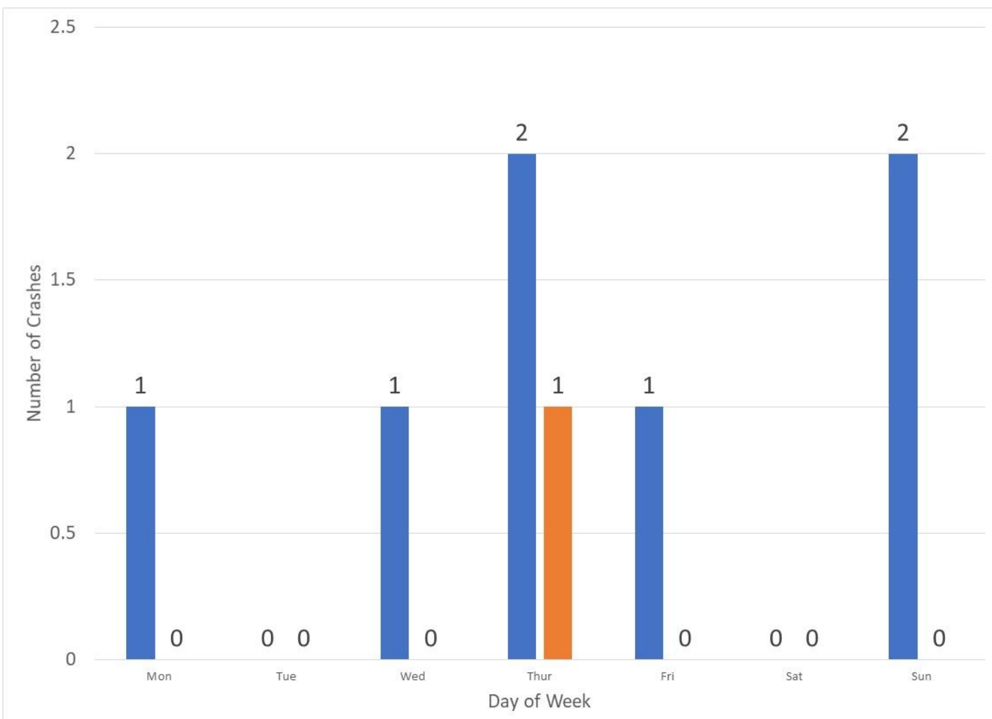


Figure 117. The Parkway and Waynewood Boulevard, Injury and Fatal Crashes by Day of the Week

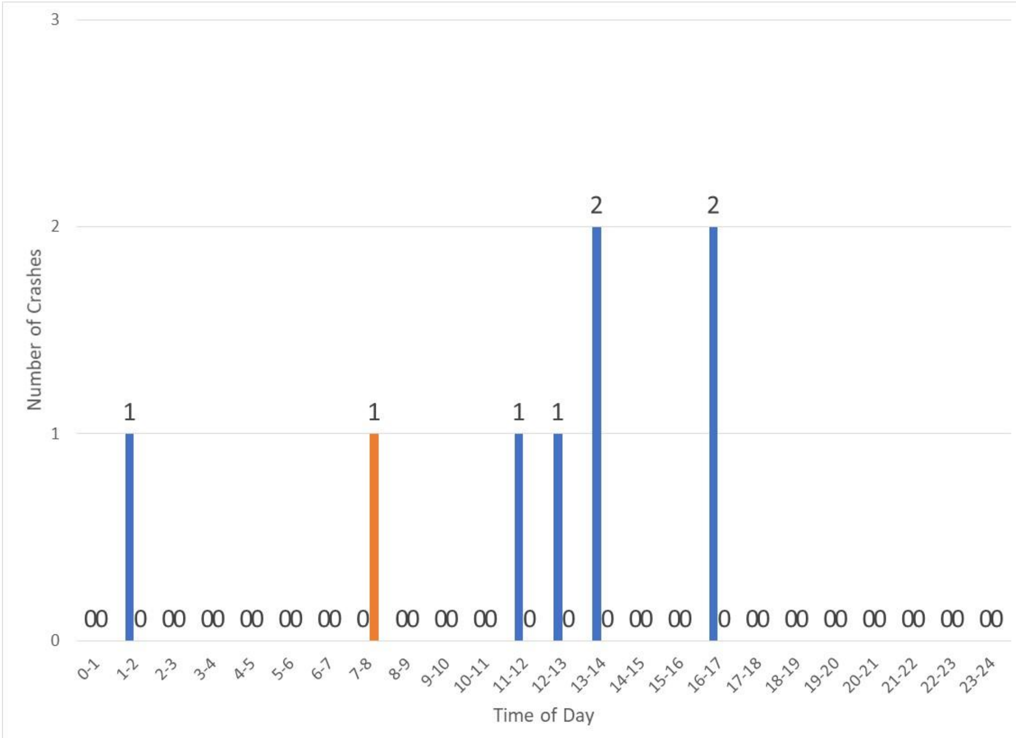


Figure 118. The Parkway and Waynewood Boulevard, Injury and Fatal Crashes by Time of Day

September and October had the greatest number of injury crashes (Figure 116); October also had the greatest number of crashes at the intersection. Considering that two injury crashes and the only fatal crash occurred on a Thursday, an examination of why Thursdays may result in higher crash severity for this intersection may be warranted (Figure 117). Wednesday had the highest overall crash count, although Thursday only had one crash less than Wednesday. The period during which injury crashes occur appears to be random, although 1:00 p.m.–2:00 p.m. and 4:00 p.m.–5:00 p.m. have the greatest frequency (Figure 118); the 4:00 p.m.–5:00 p.m. period also had the greatest crash count.

2.7.7 Pedestrians and Bicycles

No crashes between pedestrians/bicyclists and a motor vehicle were reported at this intersection.

2.7.8 Crash Diagram

The following crash diagram (Figure 119) illustrates the location of crashes for this intersection for which data regarding location within the intersection was available. In some cases, this information was not available; however, further details are provided in the footnotes.

Figure 119. The Parkway and Waynewood Boulevard, Crash Diagram*

---

* The assumption was made in the safety study that a vehicle involved in the crash was traveling southbound.

A large number of the crashes occurring at this intersection appear to be from a vehicle leaving the roadway and striking an object on the roadside.

2.7.9 Summary — Waynewood Boulevard

Based on crash data (2005–2015, 2018–2019), the largest number of crashes occurred in 2010 and 2011; in October; between 4:00 p.m. and 5:00 p.m.; and on Wednesdays (Table 37). What is most surprising about the crash history for this intersection is that although there are relatively few crashes, the overall severity of the crashes is concerning.

Table 37. The Parkway and Waynewood Boulevard, Summary of Key Data Findings

Criteria	Count
Number of Crashes	17
Year (of greatest frequency)	2010 and 2011
Month (of greatest frequency)	October
Day (of greatest frequency)	Wednesday
Percent from 12:00 a.m.–12:00 p.m.	18%
Most Frequent 1-Hour Block	4:00 p.m.–5:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	p.m. Peak
Most Typical Crash Type	Angle and Not Applicable
Most Typical Reported Cause	Failed to Yield ROW (2 of 17)
Driving Under the Influence	Zero Crashes (0 of 17)
Hit and Run	5.9% of Crashes (1 of 17)
Percent of Injury and Fatal Crashes (measure of severity)	47% (8 of 17)
Total Number of People Injured in Crashes	10 People*
Pedestrian/Bicyclist Involved Crashes?	No; 0% (0 of 17)
Animal Involved Crashes?	Yes; 5.9% (1 of 17)

* 9 injured; 1 died

2.8 The Parkway and Vernon View Drive

Figure 120 shows the orientation of the Parkway and Vernon View Drive, a three-legged intersection without a median.

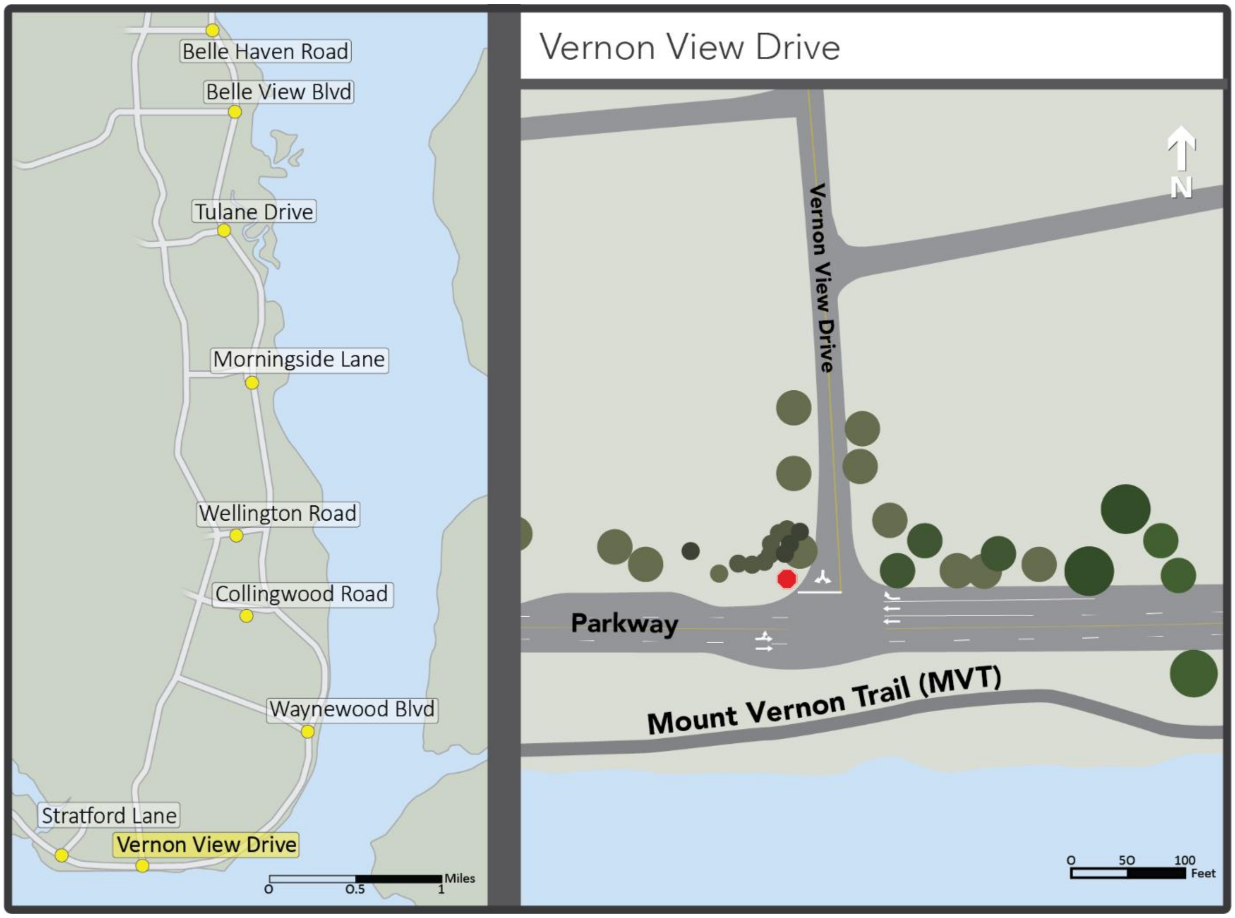


Figure 120. The Parkway and Vernon View Drive

There are a few interesting geometric considerations at this intersection. While River Farm Drive is near the intersection, there is more of a gap between the two intersections of the Parkway/Vernon View Drive and Vernon View Drive/River Farm Drive than at other intersections in the corridor where a parallel roadway exists. The pull outs west of the intersection on both the north side and south side of the Parkway (which appear to be bus stops) could potentially present challenges for drivers when following pavement markings. Also, the Mount Vernon Trail is in close proximity to the south side of the intersection. While there is not a clearly established pedestrian/bicyclist crossing, residents to the east may be interested in accessing the trail at this intersection.

During 2005–2015 and 2018–2019, 24 crashes occurred at the intersection of the Parkway and Vernon View Drive. The annual occurrence of crashes appears to be random, although 2009 had the greatest number of crashes reported (Figure 121). There were no reported crashes at this intersection in 2012, 2014, 2015, and 2019.

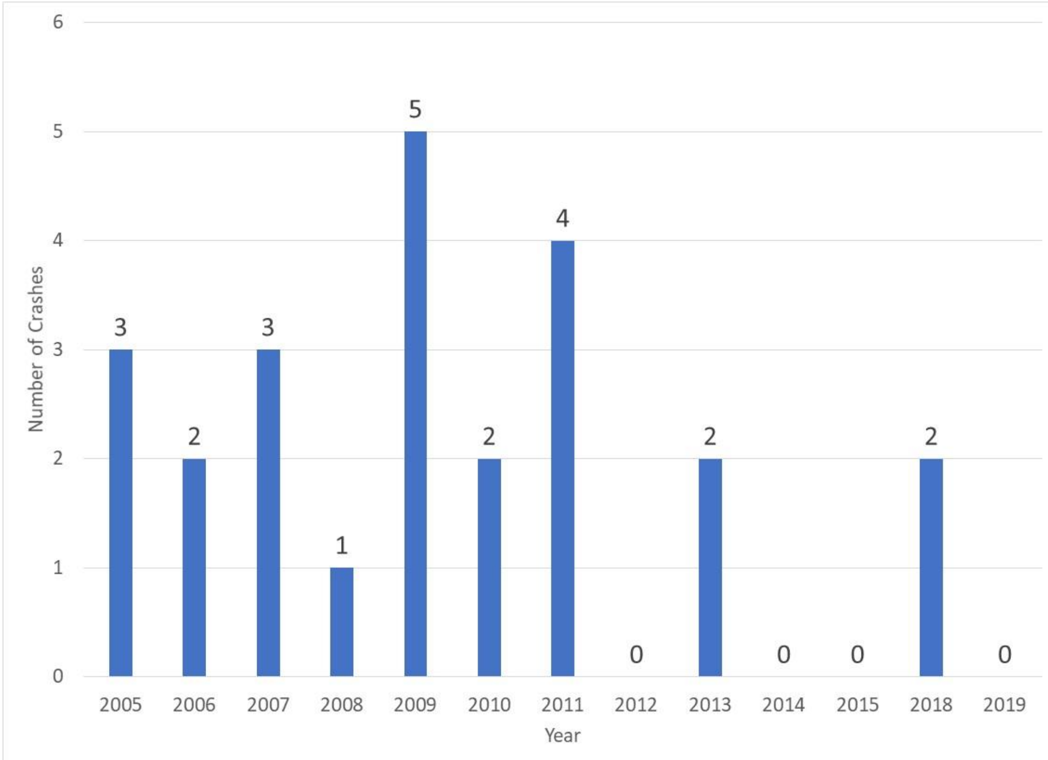


Figure 121. The Parkway and Vernon View Drive, Total Crashes by Year

2.8.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crashes occurred most frequently in April (Figure 122).

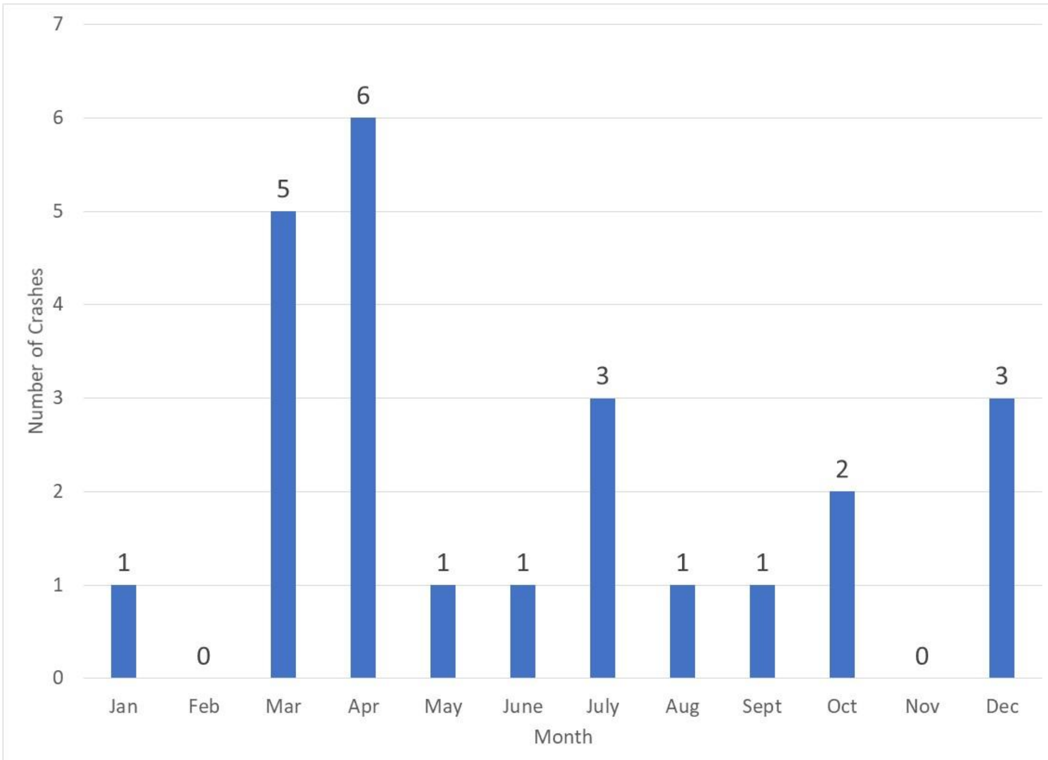


Figure 122. The Parkway and Vernon View Drive, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate when crashes occurred more often. The data show that 24% of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 3:00 p.m. and 4:00 p.m., 5:00 p.m. and 6:00 p.m., and 6:00 p.m. and 7:00 p.m. (Figure 123). Generally speaking, this is during the p.m. peak period.

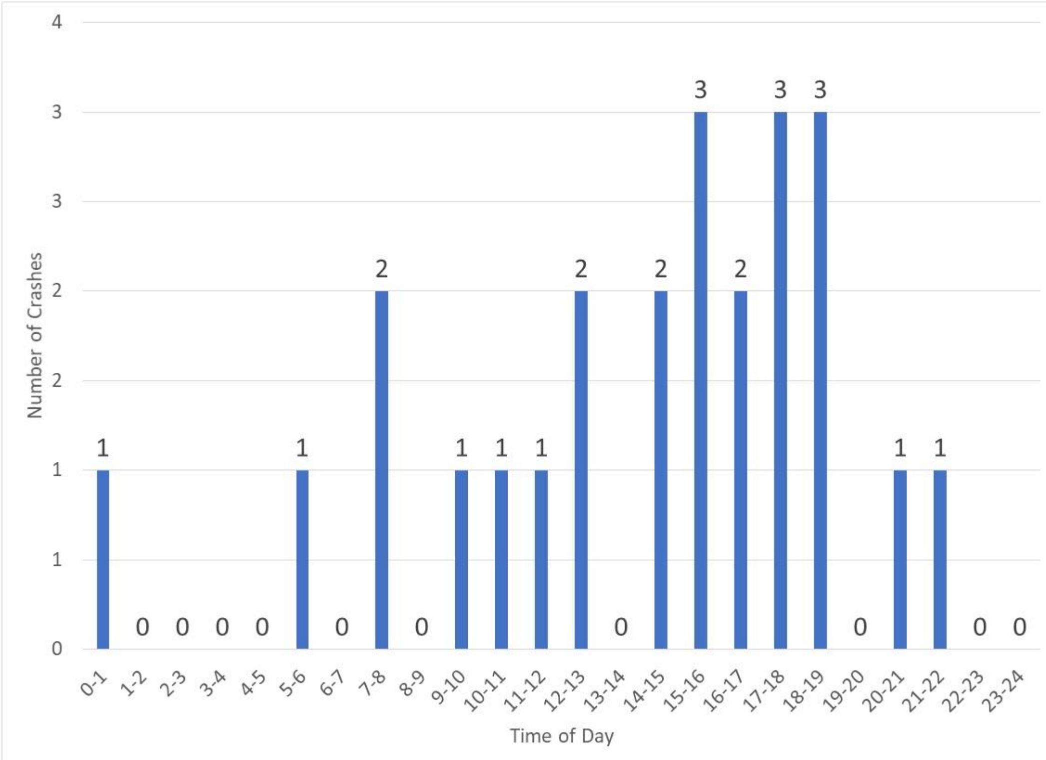


Figure 123. The Parkway and Vernon View Drive, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the largest number and highest rate of crashes occurred during the p.m. peak period. Table 38 shows the number of crashes within these groups.

Table 38. The Parkway and Vernon View Drive, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. peak	2	0.33
6:00 a.m.–9:00 a.m.	a.m. peak	2	0.67
9:00 a.m.–3:00 p.m.	midday	7	1.2
3:00 p.m.–6:00 p.m.	p.m. peak	8	2.3
6:00 p.m.–12:00 a.m.	post-p.m. peak	5	0.9
TOTAL		22	–

The day of the week that is most represented in crash records is Saturday (Figure 124).

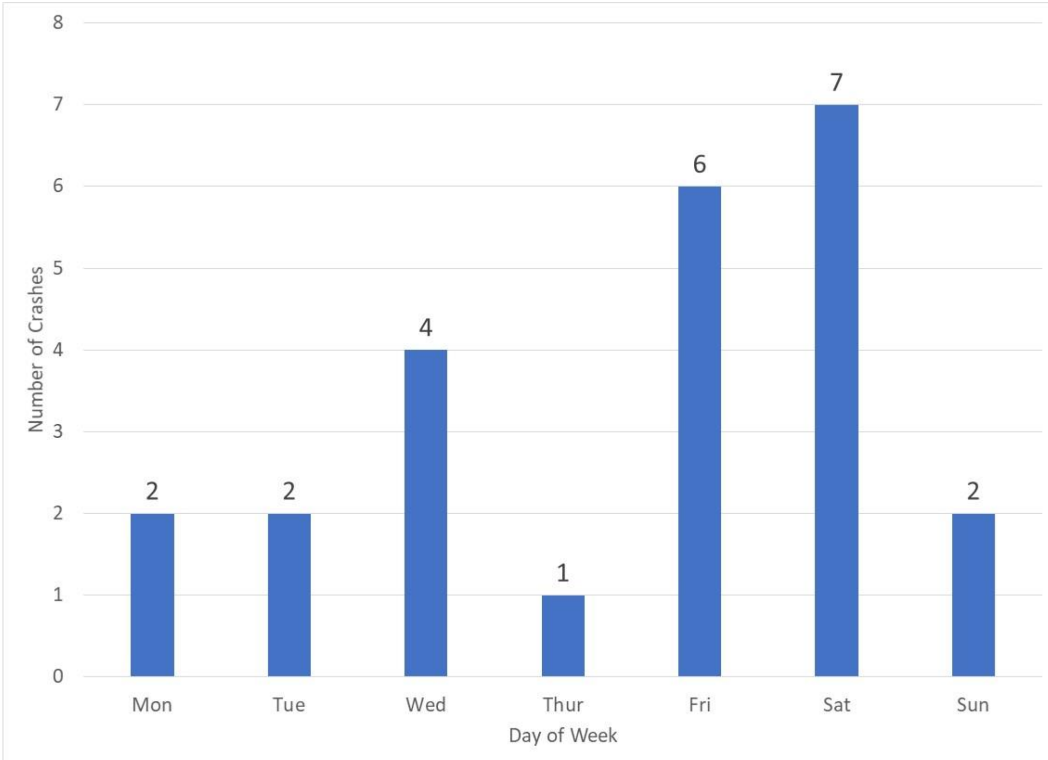


Figure 124. The Parkway and Vernon View Drive, Crashes by Day of the Week

The results suggest the possibility of contributing factors that are increasing the number of crashes on Saturdays; Friday is only one crash behind.

2.8.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Figure 125 shows an analysis of lighting conditions during crashes.

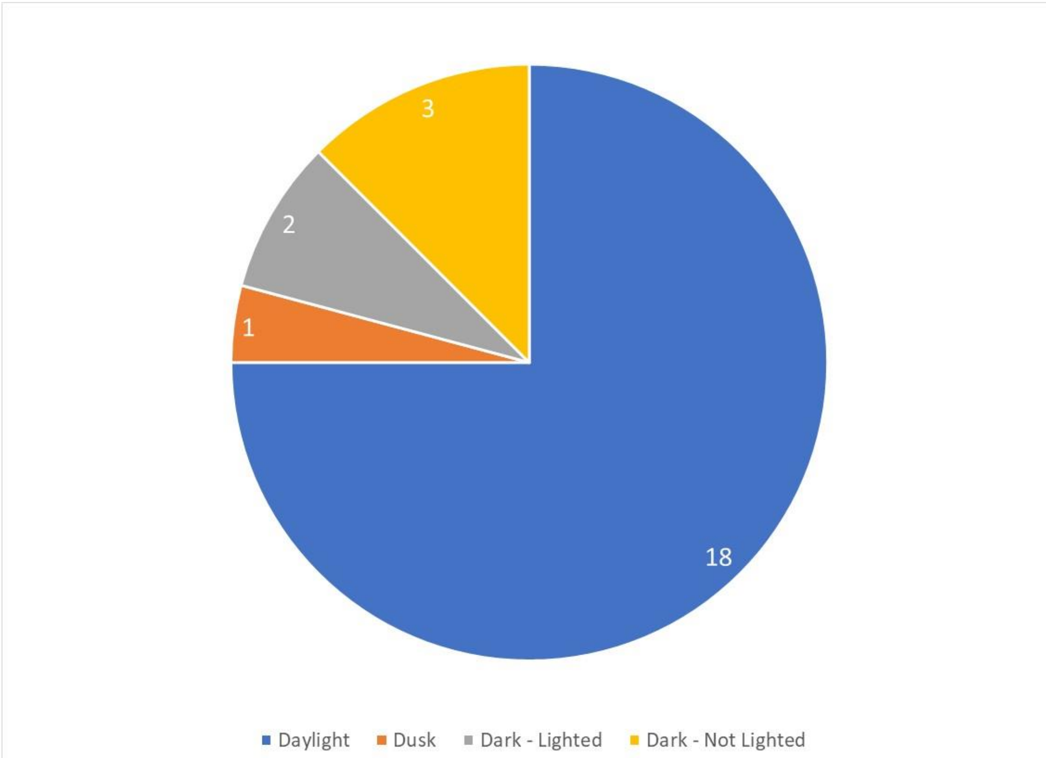


Figure 125. The Parkway and Vernon View Drive, Lighting (Number of Crashes during Each Lighting Condition)

Some of the data were inconsistent, showing that three crashes occurred when the intersection was “Dark – Not Lighted” and two when the intersection was “Dark – Lighted.” The Parkway does not have lighting on the roadway in the study section; therefore, “Dark – Lighted” must be an error.

The data show that most crashes (18) occurred during “Daylight.” Looking at the data in more detail, of the crashes that occurred during “Daylight,” two of these crashes were during periods when conditions were indicated as “Cloudy” or “Rain.” These conditions would suggest that the crash occurred when there was reduced visibility. The remaining 16 crashes occurred during “Daylight.” The majority of crashes still occurred during “Daylight.”

The researchers also considered whether the “Daylight” crashes occurred during peak periods. (*Note:* The team anticipated that “Daylight” crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6 p.m.-12 p.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), 6:00 p.m.–12:00 a.m. Table 39 shows the number of crashes within these groups.

Table 39. The Parkway and Vernon View Drive, "Daylight" Crash Counts and Rates by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. peak	1	0.2
6:00 a.m.–9:00 a.m.	a.m. peak	1	0.3
9:00 a.m.–3:00 p.m.	midday	7	1.2
3:00 p.m.–6:00 p.m.	p.m. peak	7	2.3
6:00 p.m.–12:00 a.m.	post-p.m. peak	2	0.3
TOTAL "Daylight" Crashes		**18**	–

"Daylight" crashes were most likely to occur during the p.m. peak and least likely to occur from 12:00 a.m. to 6:00 a.m. (pre-a.m. peak).

With regard to weather, more than three quarters of the crashes (19) occurred during "Clear" periods (Figure 126).

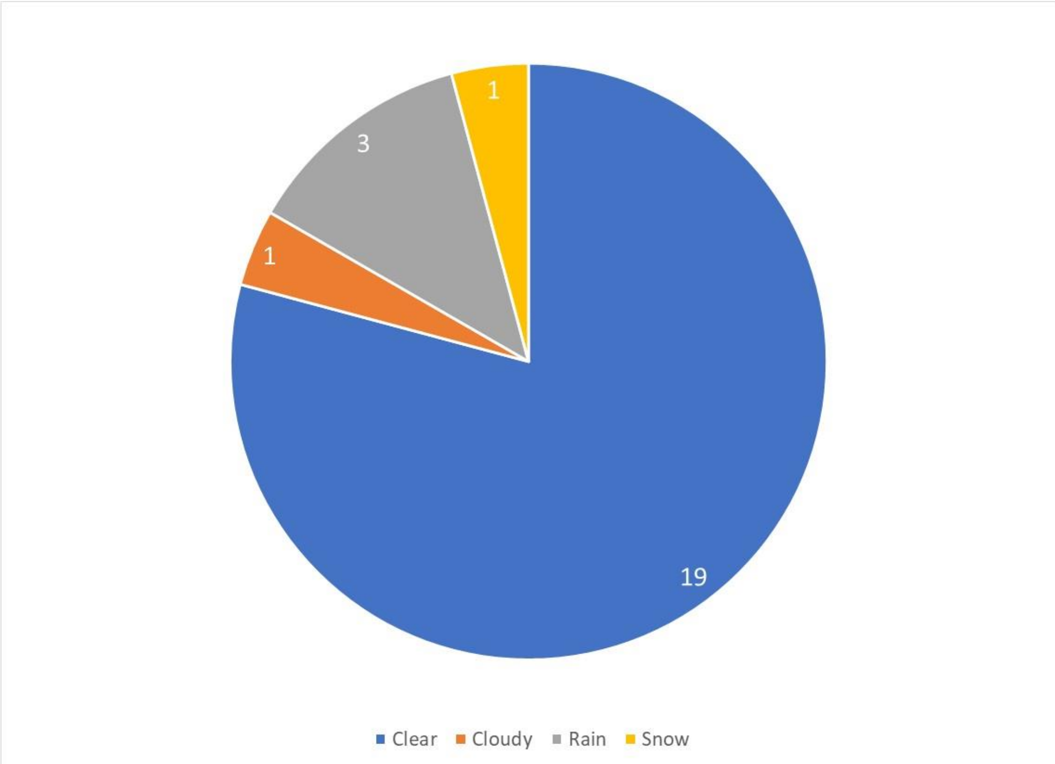


Figure 126. The Parkway and Vernon View Drive, Weather

The majority of the crashes (20) occurred when surface conditions were “Dry” (Figure 127).

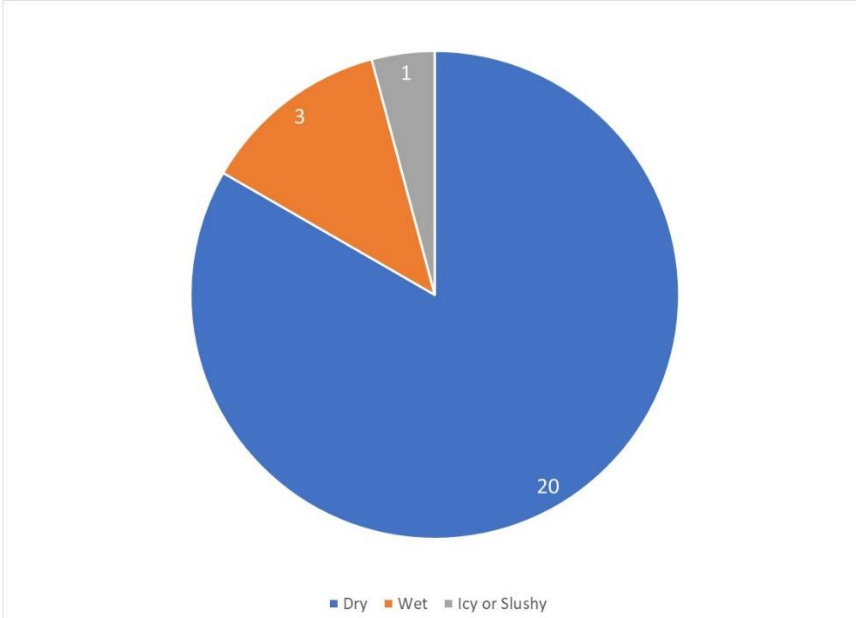


Figure 127. The Parkway and Vernon View Drive, Surface Condition

2.8.3 Crashes Contributing to Crashes

This section discusses the vehicle collision type, the indicated primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. “Rear End” was the most common crash type (15) (Figure 128), accounting for approximately 63% of all crashes.

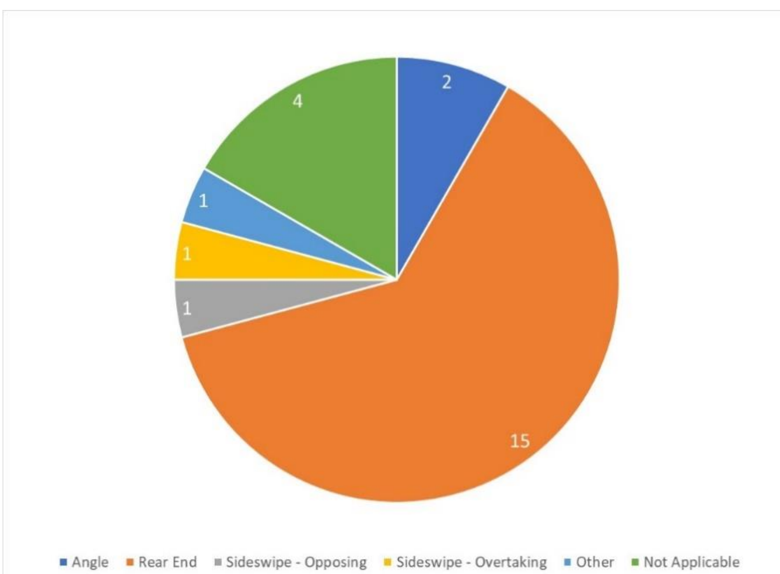


Figure 128. The Parkway and Vernon View Drive, Crash Type

Four crashes were identified as "Not Applicable." In the crash report, there is an option to include data in the "collision with?" column. The crashes were identified as having occurred with a tree/shrub (2), bridge structure (1), and ditch (1).

The most frequently reported "Primary Cause" was "Other" (Figure 129), which was reported in 7 of the 24 crashes (29%). (*Note:* Figure 129 only shows 19 of the 24 crashes that occurred at the intersection, as 5 crashes provided no information on the "Primary Cause.")

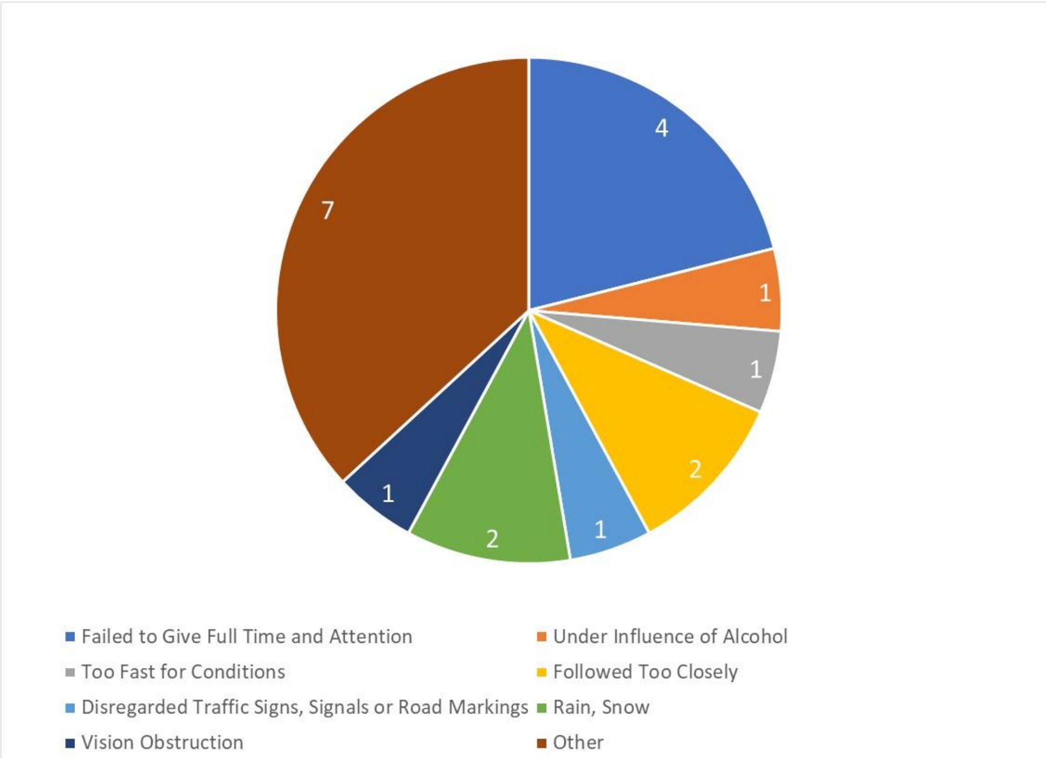


Figure 129. The Parkway and Vernon View Drive, Primary Cause

"Failed to Give Full Time and Attention" was the second most frequently identified "Primary Cause" (four), which is expected considering the most frequently reported crash type (i.e., rear end).

2.8.4 Driving Under the Influence

Of the 24 crashes identified at the intersection during 2005–2015 and 2018–2019, 1 crash (4.2%) was identified as having a driver that was under the influence of alcohol or other substances. However, this information was left blank on both of the 2018–2019 crashes.

2.8.5 Hit and Run

Interestingly, 2 of the 24 crashes (8.3%) were identified as hit and run.

2.8.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. About 38% of the crashes (9) at Vernon View Drive were injury crashes. However, the level of severity was not provided for the 2018–2019 crashes. Overall, there is a high occurrence of severe accidents (Figure 130).

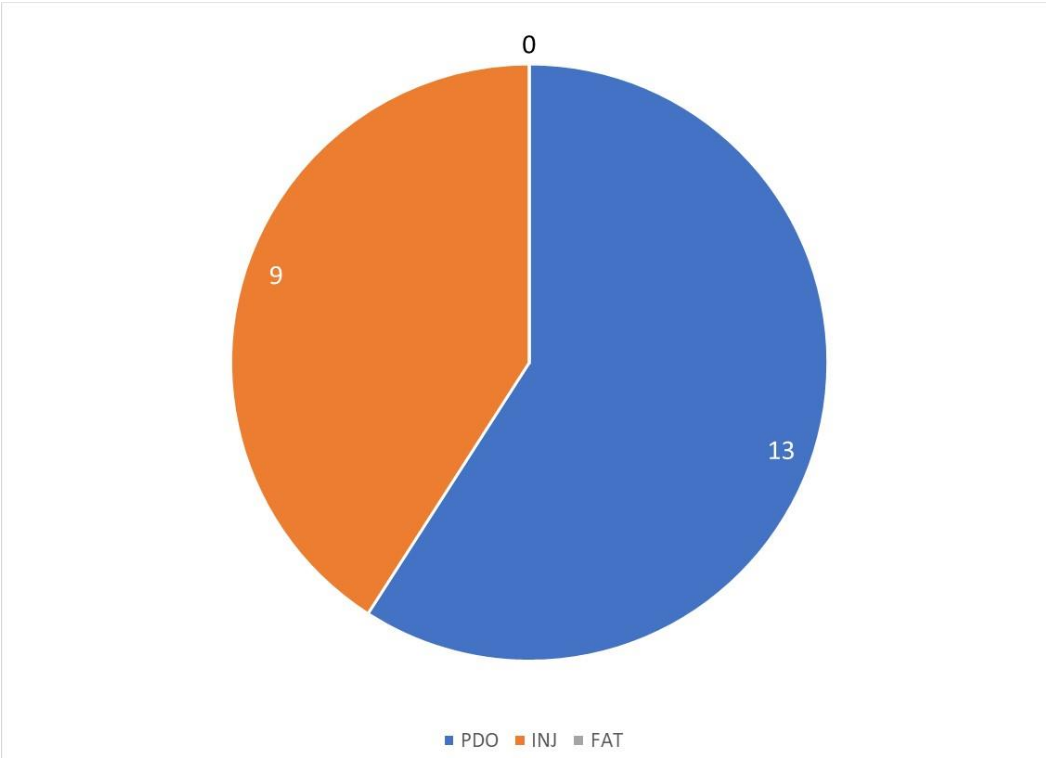


Figure 130. The Parkway and Vernon View Drive, Crash Severity

Across the injury crashes, there were a total of 15 injuries; this information was not provided for the 2018–2019 crashes.

The occurrence of the injury crashes by month, day of week, and time of day was investigated (Figure 131, Figure 132, and Figure 133). (*Note*: This information was not provided for the 2018–2019 crashes).

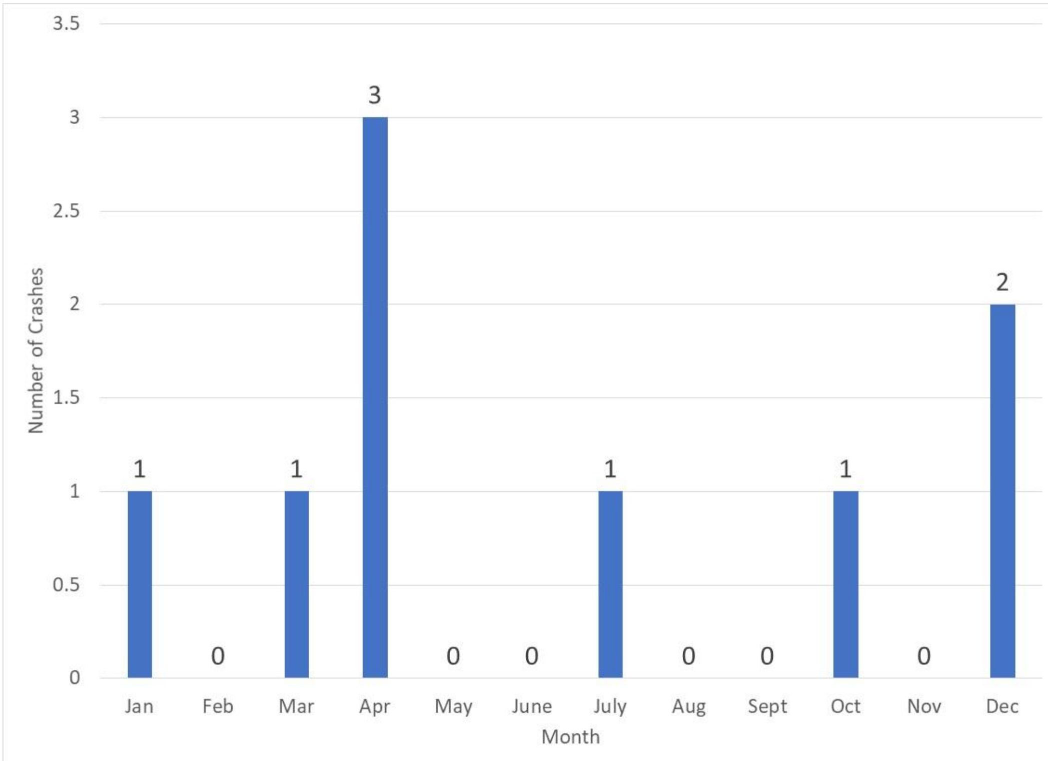


Figure 131. The Parkway and Vernon View Drive, Injury Crashes by Month

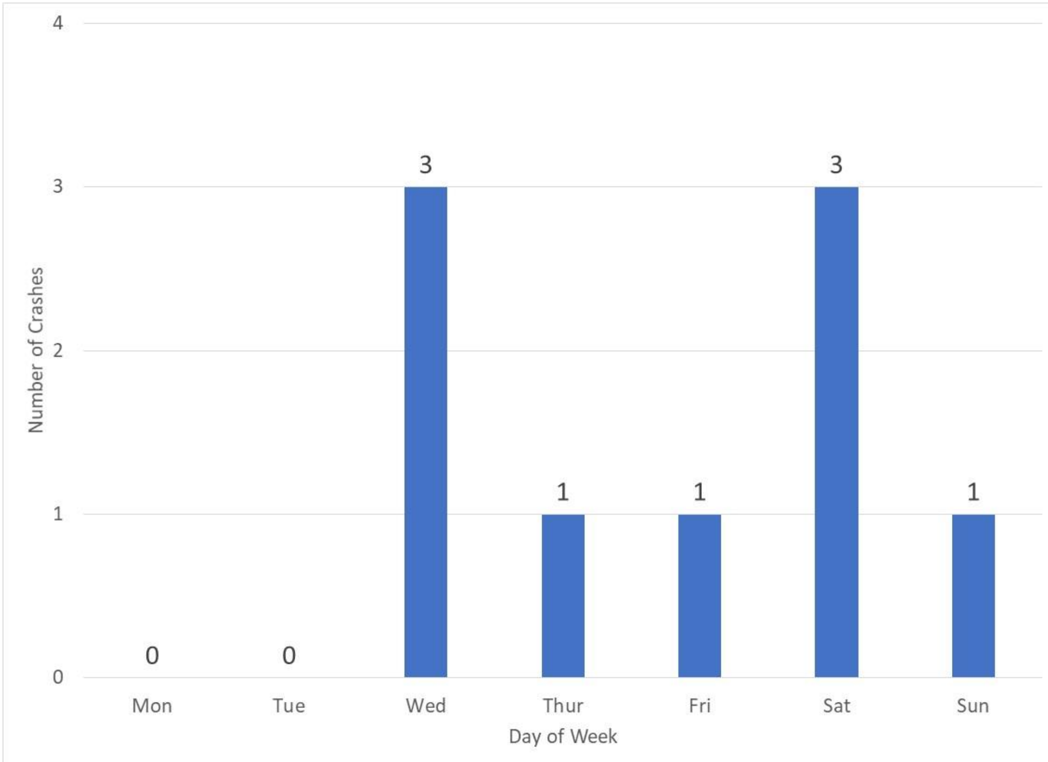


Figure 132. The Parkway and Vernon View Drive, Injury Crashes by Day of the Week

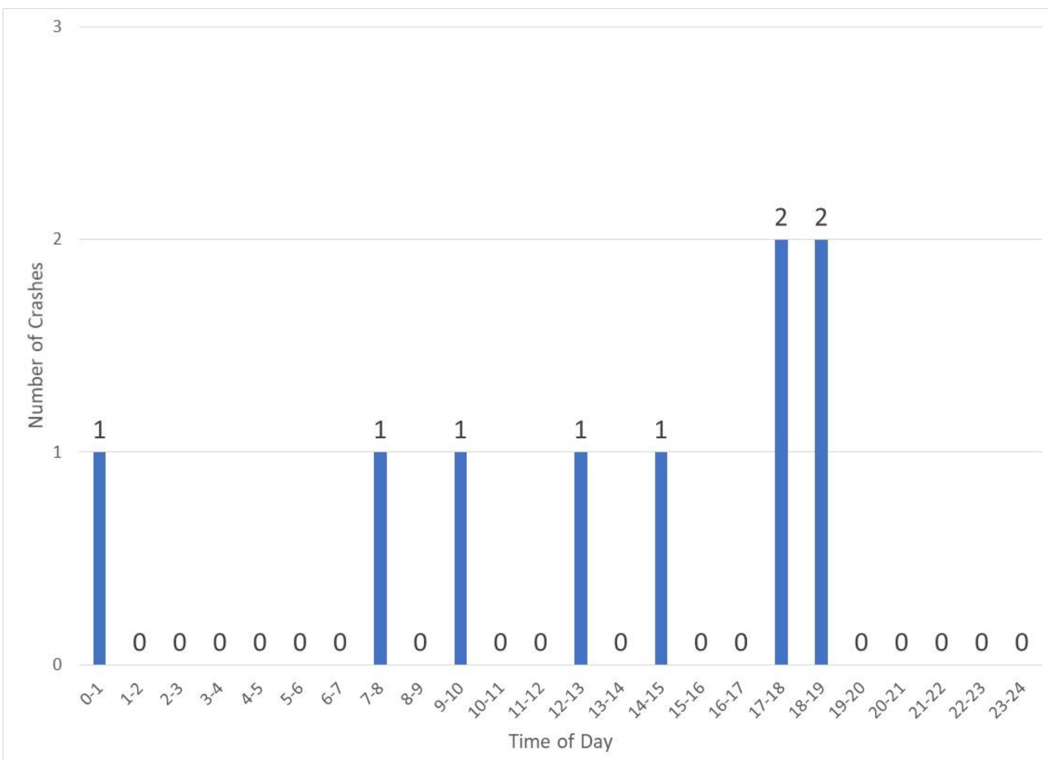


Figure 133. The Parkway and Vernon View Drive, Injury Crashes by Time of Day

The data suggest a higher probability of injury crashes in April; on Wednesdays, and Saturdays; and between 5:00 p.m.–6:00 p.m. and 6:00 p.m.–7:00 p.m. (Figure 131, Figure 132, and Figure 133). April was also the month with the highest crash count; Saturday was also the day of the week with the highest crash count; and 5:00 p.m.–6:00 p.m. and 6:00 p.m.–7:00 p.m. were also the periods with the highest crash counts. This means that the month, day of the week, and time of day with the highest crash counts also have the highest potential for injury crashes.

2.8.7 Pedestrians and Bicycles

No crashes between pedestrians/bicyclists and a motor vehicle were reported at this intersection.

2.8.8 Crash Diagram

The following crash diagram illustrates the location of crashes for this intersection to which data regarding location within the intersection was available. In some cases, this information was not available and information as such is included in the footnote. Figure 134 shows the crash diagram.

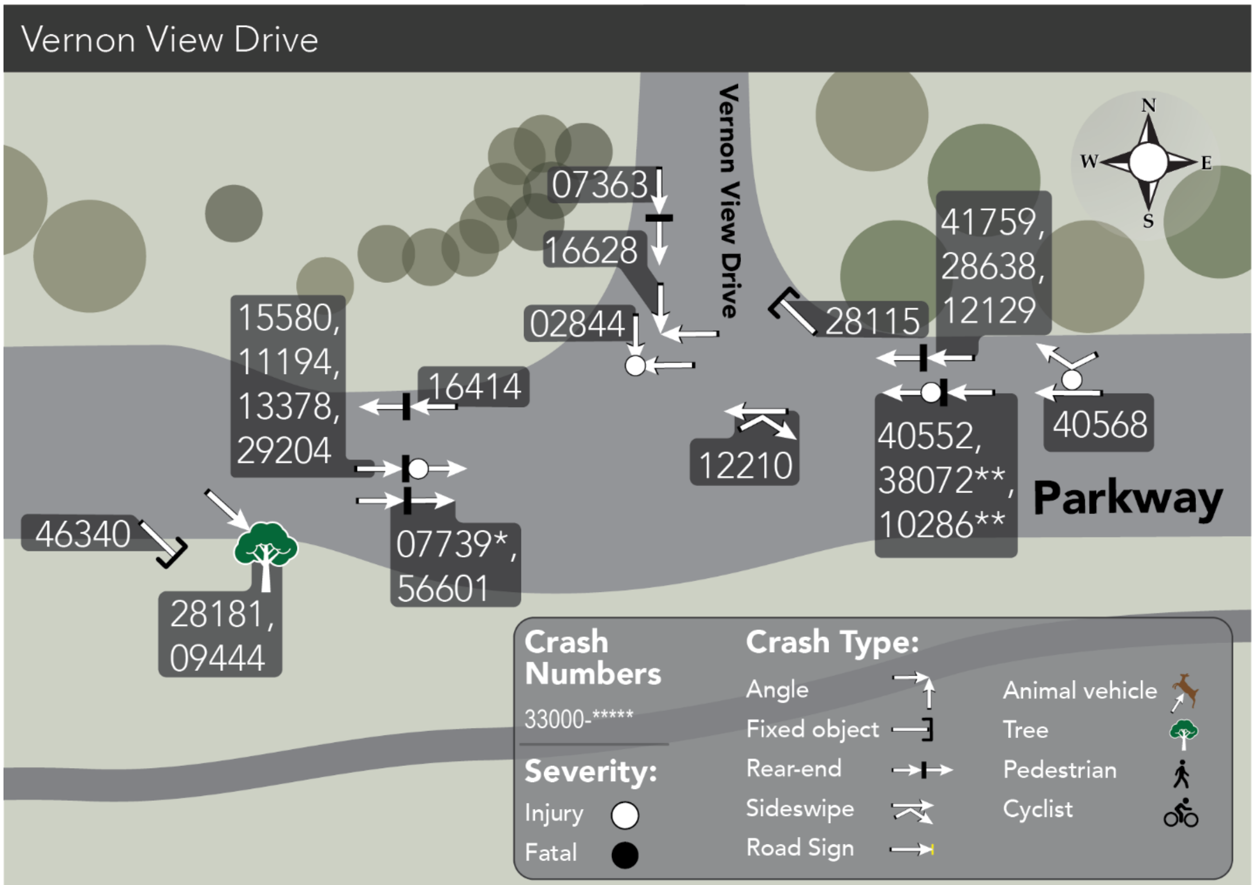


Figure 134. The Parkway and Vernon View Drive, Crash Diagram* ** †

* The assumption was made in the safety study that a vehicle involved in the crash was traveling eastbound.
** The assumption was made in the safety study that a vehicle involved in the crash was traveling westbound.
† Neither of the two crashes from 2018–2019 could be placed. The information for PP18035665 indicated that it was a rear-end crash in the northbound direction. This could potentially be eastbound along the Parkway (as there is no northbound direction; it is a T-intersection); however, it is unclear. No information was available regarding severity. PP18051762 indicated that the vehicle was traveling northbound and crashed into a median/curb. No information was available regarding the severity, and it is unclear if the vehicle was heading east or was trying to turn northbound onto Vernon View Drive and hit a median/curb.

The rear-end crash type appears most frequently at the Parkway and Vernon View Drive. This could potentially suggest that vehicles may be "tailgating" (traveling with not enough distance between them given the travel speeds). This seems to be more of the concern than vehicles not being able to accelerate fast enough, as the tabular crash data seemed to suggest that the rear-end crashes occurred on the approach to the intersection, regardless of whether or not the vehicles were traveling north or south. A turn-bay to facilitate left turns in the northbound direction could help, although a turn lane already exists in the southbound direction. Additionally, there seems to be indecision or impatience by motorists at this location because there are reported sideswipes in addition to rear-end crashes. Speed is therefore likely a factor contributing to crashes.

2.8.9 Summary — Vernon View Drive

Based on crash data during 2005–2015 and 2018–2019, the largest number of crashes occurred in 2009; in April; between 3:00 p.m. and 4:00 p.m., 5:00 p.m. and 6:00 p.m., and 6:00 p.m.-7:00 p.m.; and on Saturdays (Table 40). Of the small number of crashes at the intersection, a notable percentage was attributed to hit-and-run crashes.

Table 40. The Parkway and Vernon View Drive, Summary of Key Data Findings

Criteria	Count
Number of Crashes	24
Year (of greatest frequency)	2009
Month (of greatest frequency)	April
Day (of greatest frequency)	Saturday
Percent from 12:00 a.m.–12:00 p.m.	24%
Most Frequent 1-Hour Block	3:00 p.m.–4:00 p.m.; 5:00 p.m.–6:00 p.m.; 6:00 p.m.–7:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	p.m. Peak
Most Typical Crash Type	Rear End
Most Typical Reported Cause	Other (7 of 24)
Driving Under the Influence	4.2% of Crashes (1 of 24)
Hit and Run	8.3% of Crashes (2 of 24)
Percent of Injury and Fatal Crashes (measure of severity)	38% (9 of 24)
Total Number of People Injured in Crashes	15 People
Pedestrian/Bicycle Involved Crashes?	No; 0% (0 of 24)
Animal Involved Crashes?	No; 0% (0 of 24)

2.9 The Parkway and Stratford Lane

Figure 135 shows the orientation of the Parkway and Stratford Lane, a four-legged intersection with a median.

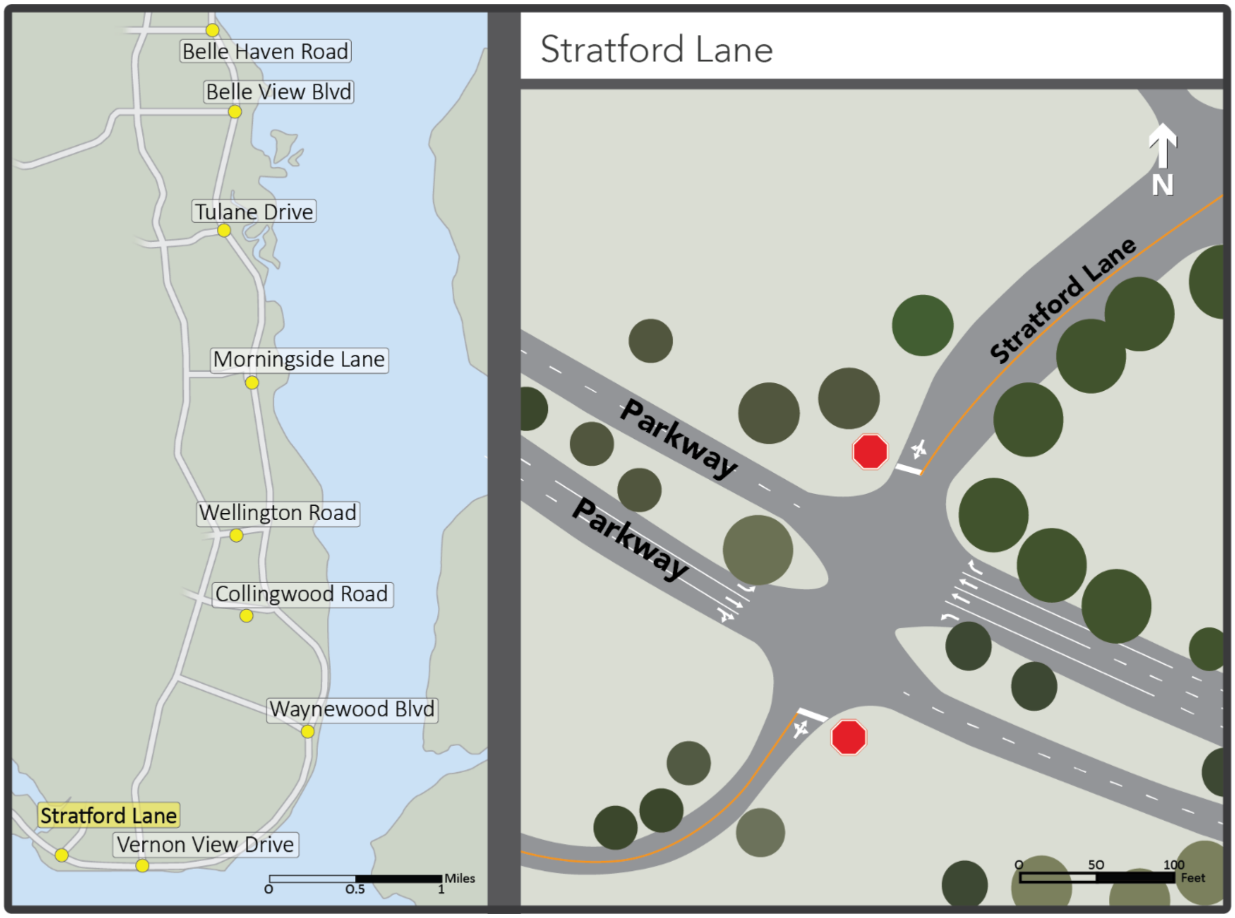


Figure 135. The Parkway and Stratford Lane

Riverside Park is accessed by the east side of this intersection; therefore, those accessing the park are likely recreational users. Just a bit north of the intersection on the west side is a bus stop with no facilities for people waiting or walking to/from the bus stop.

During 2005–2015 and 2018–2019, 12 crashes were identified at the intersection of the Parkway and Stratford Lane; this intersection had the lowest crash occurrence. Stratford was incorrectly spelled with the following versions: Stradford, Strafford, Stratford Landing, Stradford Land, and Strathman Lane. Generally speaking, the annual occurrence of crashes appears random, although 2007 had the greatest number of crashes reported (Figure 136); if there is a trend that can be observed, it would be decreasing for this intersection. Several years did not have any crashes, including 2005, 2008, 2010, 2014, and 2015.

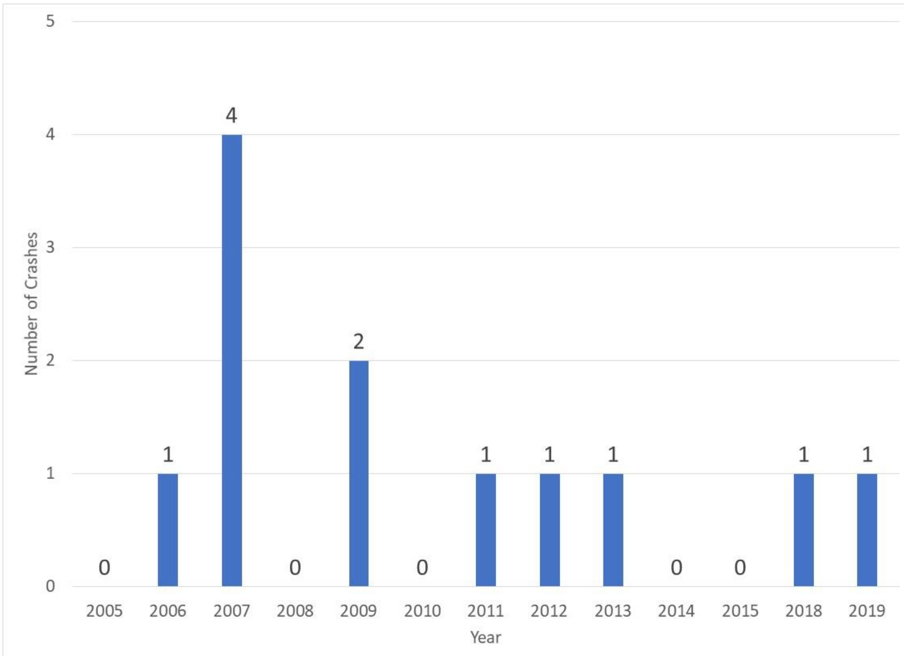


Figure 136. The Parkway and Stratford Lane, Total Crashes by Year

2.9.1 Temporal

This section discusses patterns identified by month, time, and day of the week. Based on data from the available years (2005–2015, 2018–2019), crash occurrence appears random, although the highest counts occurred in February, April, September, November, and December (Figure 137).

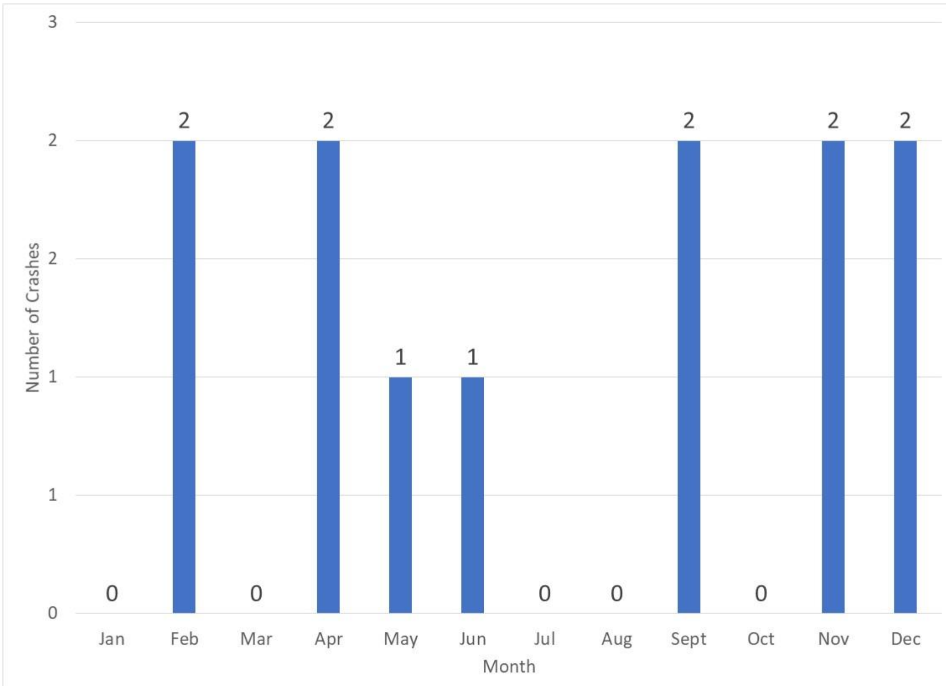


Figure 137. The Parkway and Stratford Lane, Crashes by Month

Crashes were separated into an a.m. period (12:00 a.m.–12:00 p.m.) and a p.m. period (12:00 p.m.–12:00 a.m.) to investigate if crashes occurred more often in the a.m. or p.m. Thirty-three percent of all crashes occurred in the a.m. period.

Assigning each crash to a one-hour period across the entire day, the most frequent number of crashes occurred between 9:00 a.m. and 10:00 a.m. and 5:00 p.m. and 6:00 p.m., although the count was only one greater than the rest of the periods when a crash was recorded (Figure 138).

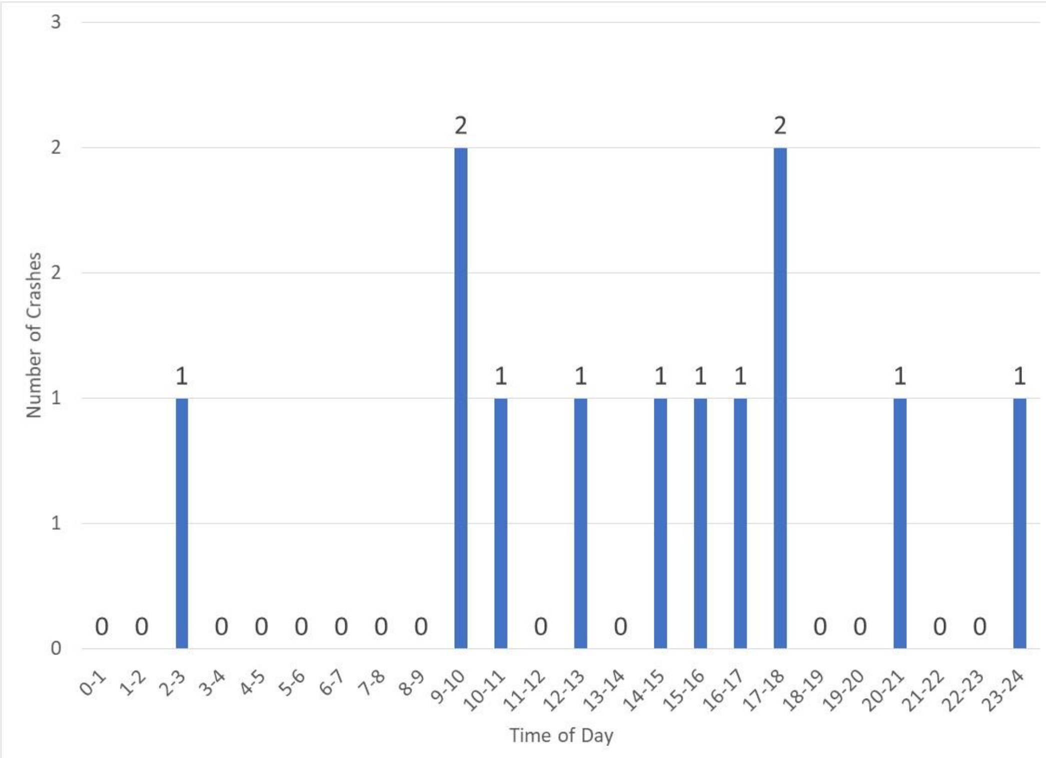


Figure 138. The Parkway and Stratford Lane, Crashes by Time of Day

Crashes were separated into pre-a.m. peak, a.m. peak, midday, p.m. peak, and post-p.m. peak crash periods. Considering the frequency of crashes per hour, the highest rate of crashes occurred during the p.m. peak period. Table 41 shows the number of crashes within these groups.

Table 41. The Parkway and Stratford Lane, Crash Counts and Rate by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. peak	1	0.2
6:00 a.m.–9:00 a.m.	a.m. peak	0	0
9:00 a.m.–3:00 p.m.	midday	5	0.8
3:00 p.m.–6:00 p.m.	p.m. peak	4	1.3
6:00 p.m.–12:00 a.m.	post-p.m. peak	2	0.3
TOTAL		**10**	–

The days of the week that are most represented in the crash records are Thursday and Sunday (Figure 139).

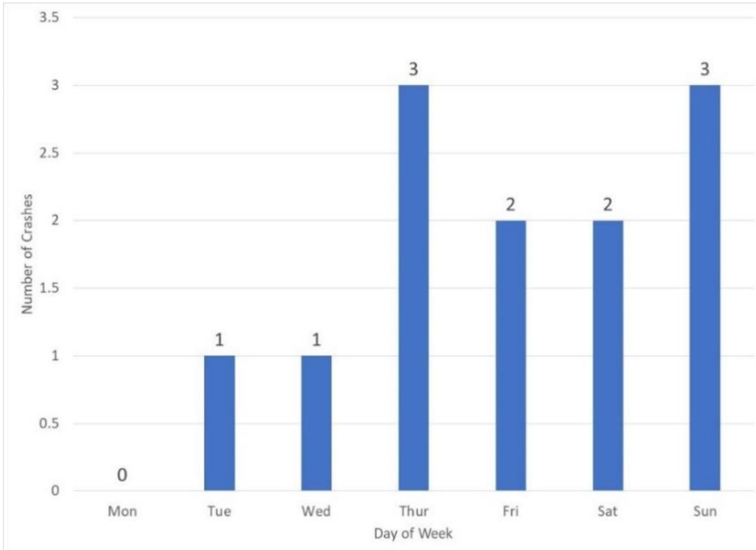


Figure 139. The Parkway and Stratford Lane, Crashes by Day of the Week

Overall, crash occurrence appears random when considering day of the week, although Monday, with no observed crashes, might have some differences as compared with the rest of the days of the week.

2.9.2 Environment

This section discusses how lighting, weather, and the road surface may have influenced crash occurrence.

Analysis of the lighting condition identified during a crash (Figure 140). (*Note:* Lighting information was not provided for one of the 2018–2019 crashes.)

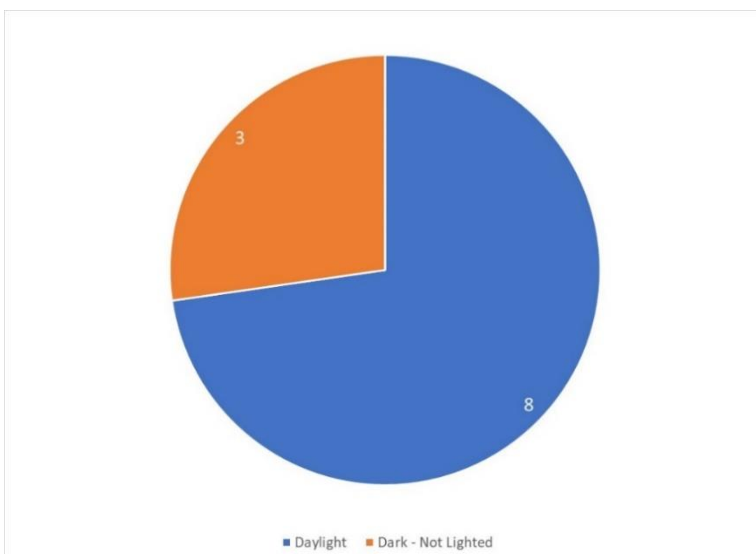


Figure 140. The Parkway and Stratford Lane, Lighting (Number of Crashes during Each Lighting Condition)

Most of the crashes (eight) occurred during “Daylight.” Looking at the data in more detail, of the crashes that occurred during “Daylight,” two crashes were during a period when conditions were indicated as “Cloudy.” Cloudy skies could potentially limit visibility. Reducing the eight crashes by two crashes results in a total of six crashes occurring during “Daylight.” It was considered whether the “Daylight” crashes occurred during peak periods. (*Note:* The team anticipated that “Daylight” crashes should be reported less frequently during the 12:00 a.m.–6:00 a.m. and 6:00 p.m.–12:00 a.m. periods, as the sun may have set or may not have risen.) Crashes were grouped into non-peak and peak-periods: 12:00 a.m.–6:00 a.m., 6:00 a.m.–9:00 a.m. (a.m. peak), 9:00 a.m.–3:00 p.m., 3:00 p.m.–6:00 p.m. (p.m. peak), and 6:00 p.m.–12:00 a.m. Table 42 shows the number of crashes within these groups.

Table 42. The Parkway and Stratford Lane, “Daylight” Crash Counts and Rates by Period

Period		Number of Crashes	Crashes/Hour
12:00 a.m.–6:00 a.m.	pre-a.m. Peak	0	0
6:00 a.m.–9:00 a.m.	a.m. Peak	0	0
9:00 a.m.–3:00 p.m.	Midday	5	0.83
3:00 p.m.–6:00 p.m.	p.m. Peak	3	1.0
6:00 p.m.–12:00 a.m.	post-p.m. Peak	0	0
TOTAL “Daylight” Crashes		**8**	–

“Daylight” crashes had the greatest frequency during the midday period (9:00 a.m.–3:00 p.m.) and the highest rate of frequency during the p.m. peak (3:00 p.m.–6:00 p.m.).

With regard to weather, almost three quarters of the crashes (eight) occurred during “Clear” periods (Figure 141). (*Note:* One of the 2018–2019 crashes did not provide information regarding weather.)

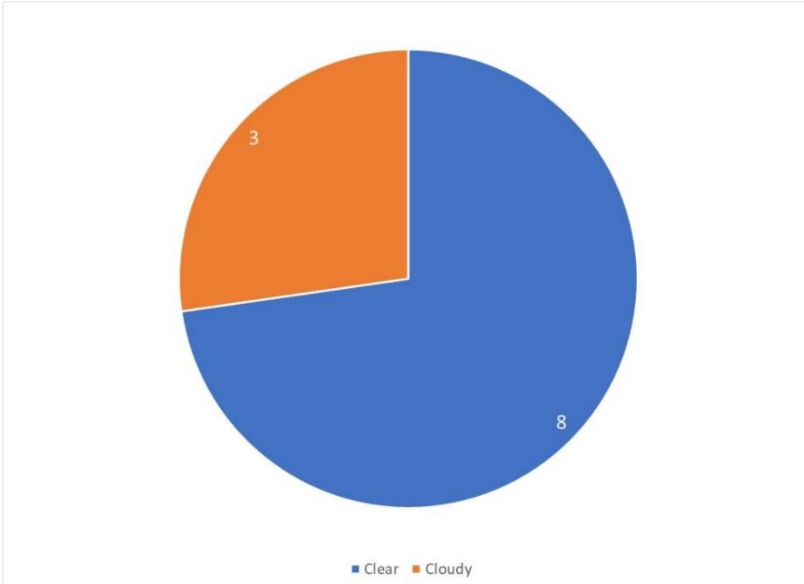


Figure 141. The Parkway and Stratford Lane, Weather

All but one crash occurred when surface conditions were "Dry" (Figure 142). (*Note:* No information was provided for one of the 2018–2019 crashes regarding surface condition.)

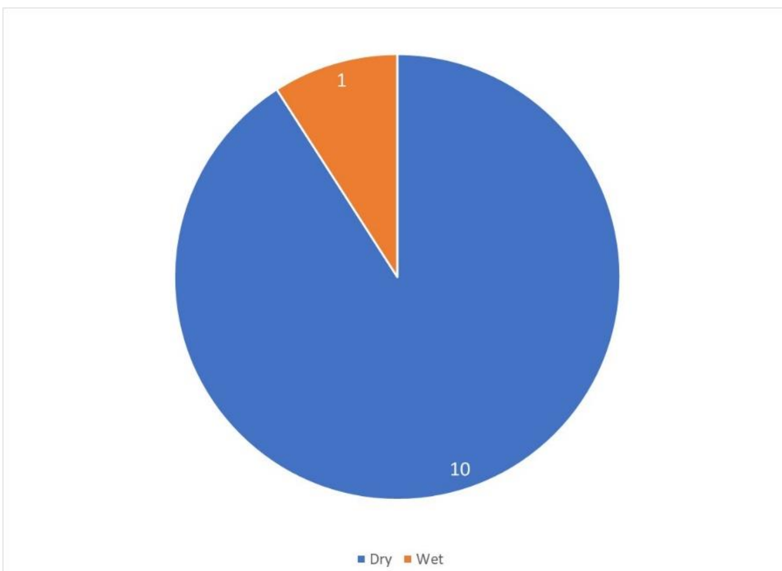


Figure 142. The Parkway and Stratford Lane, Surface Condition

2.9.3 Factors Contributing to Crashes

This section discusses the vehicle collision type, the indicated primary cause of the crash, and whether the collision was between vehicles or with an object.

One category of the tabular data provided information about the vehicle collision type. "Not Applicable" and "Angle" were the most common crash types (both with four) (Figure 143). (*Note:* One of the 2018–2019 crashes did not provide crash type.)

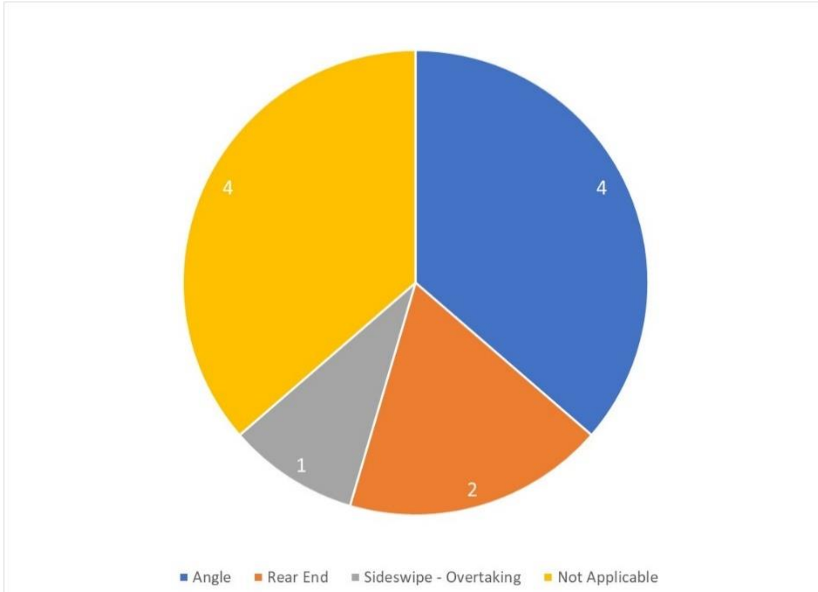


Figure 143. The Parkway and Stratford Lane, Crash Type

All “Not Applicable” crashes (four) involved the motorists striking a tree/shrub.

The most frequently reported “Primary Cause” was “No Information” (Figure 144), which was reported in 3 of 12 crashes (25%). Because of the small number of crashes, this means that any of the other primary causes (e.g., “Failed to Give Full Time and Attention”) could potentially be the primary cause resulting in a crash. (*Note:* Neither of the 2018–2019 crashes provided information about “Primary Cause.”)

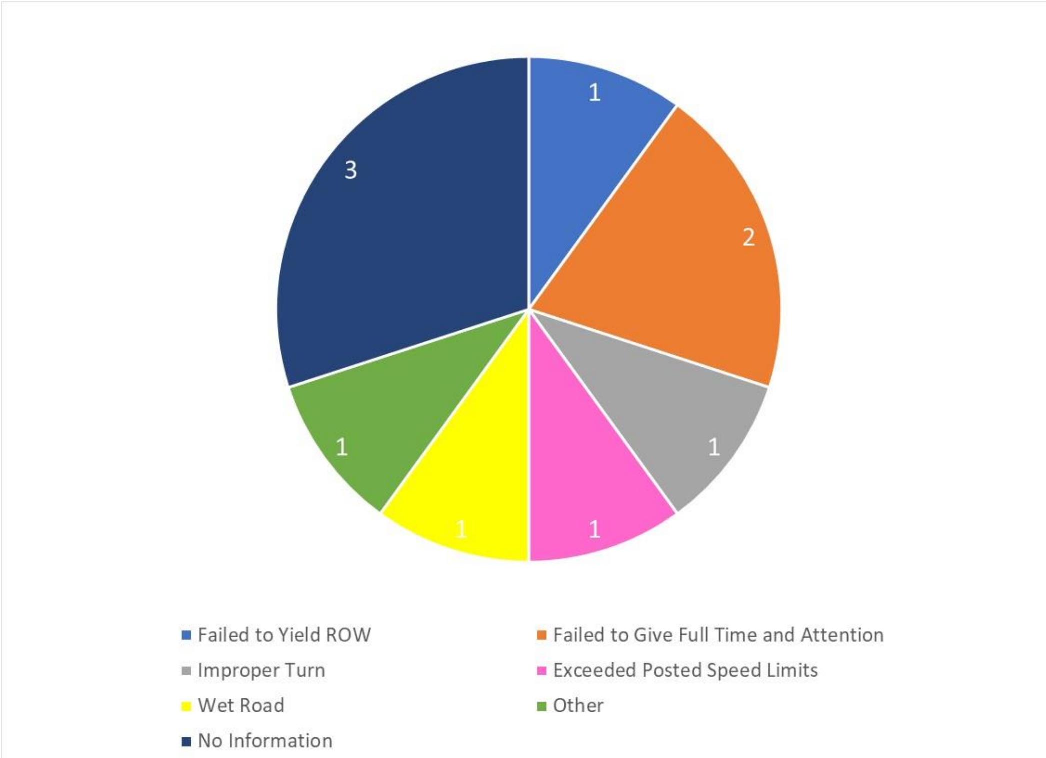


Figure 144. The Parkway and Stratford Lane, Primary Cause

2.9.4 Driving Under the Influence

Of the 12 crashes identified at the intersection during 2005–2015 and 2018–2019, zero crashes were identified as having a driver that was under the influence of alcohol or other substances. However, with the majority of crashes having "No Information" identified as the "Primary Cause," any of these crashes could have been related to driving under the influence. (*Note:* One of the 2018–2019 crashes did not provide information about "Primary Cause.")

2.9.5 Hit and Run

None of the 12 crashes were identified as hit and run. (*Note:* One of the 2018–2019 crashes did not provide information.)

2.9.6 Crash Severity

This section identifies the number of PDO, INJ, and FAT crashes. While few crashes occurred at Stratford Lane, a third of the crashes (four) resulted in injuries (Figure 145).

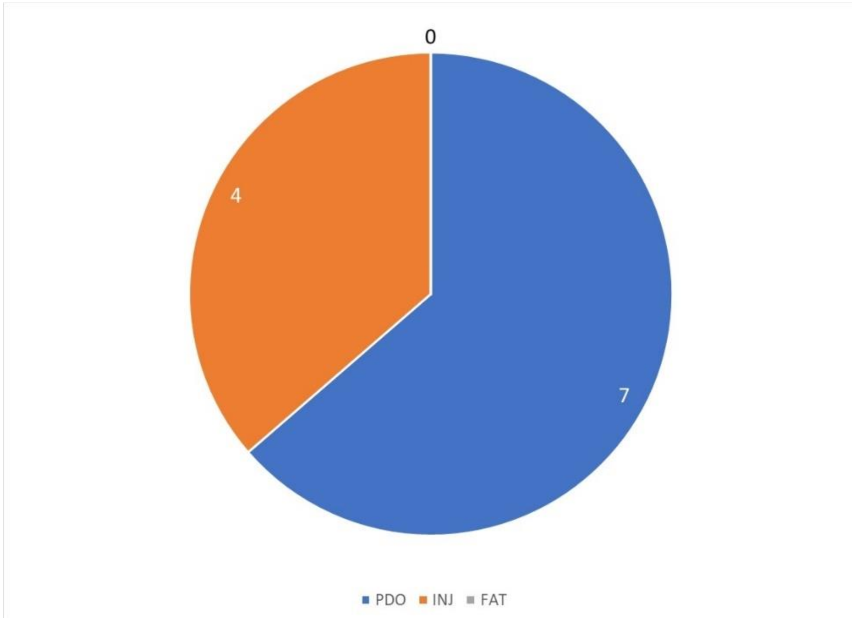


Figure 145. The Parkway and Stratford Lane, Crash Severity

Across the injury crashes, there were a total of eight injuries.

The occurrence of the injury crashes by month, day of week, and time of day was investigated. Overall, there does not appear to be any dominating trend from these viewpoints (Figure 146, Figure 147, and Figure 148). Sunday does have one more crash than the other days.

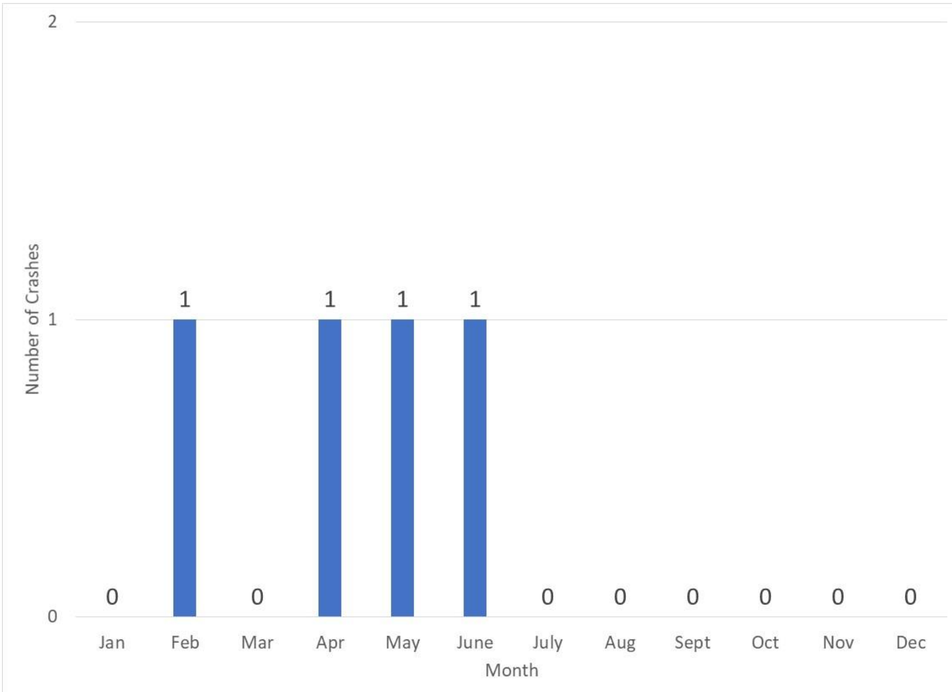


Figure 146. The Parkway and Stratford Lane, Injury Crashes by Month

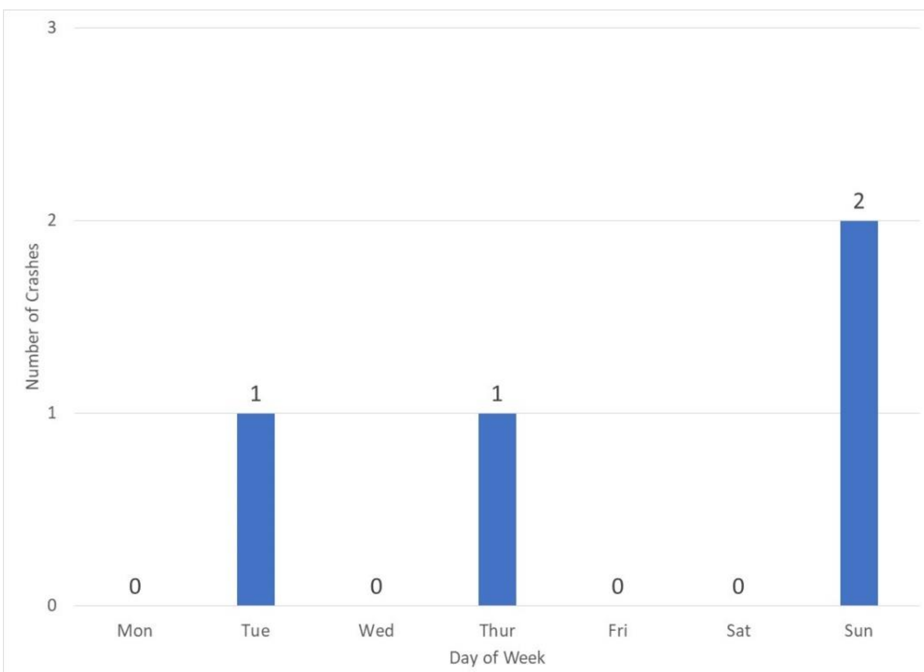


Figure 147. The Parkway and Stratford Lane, Injury Crashes by Day of Week

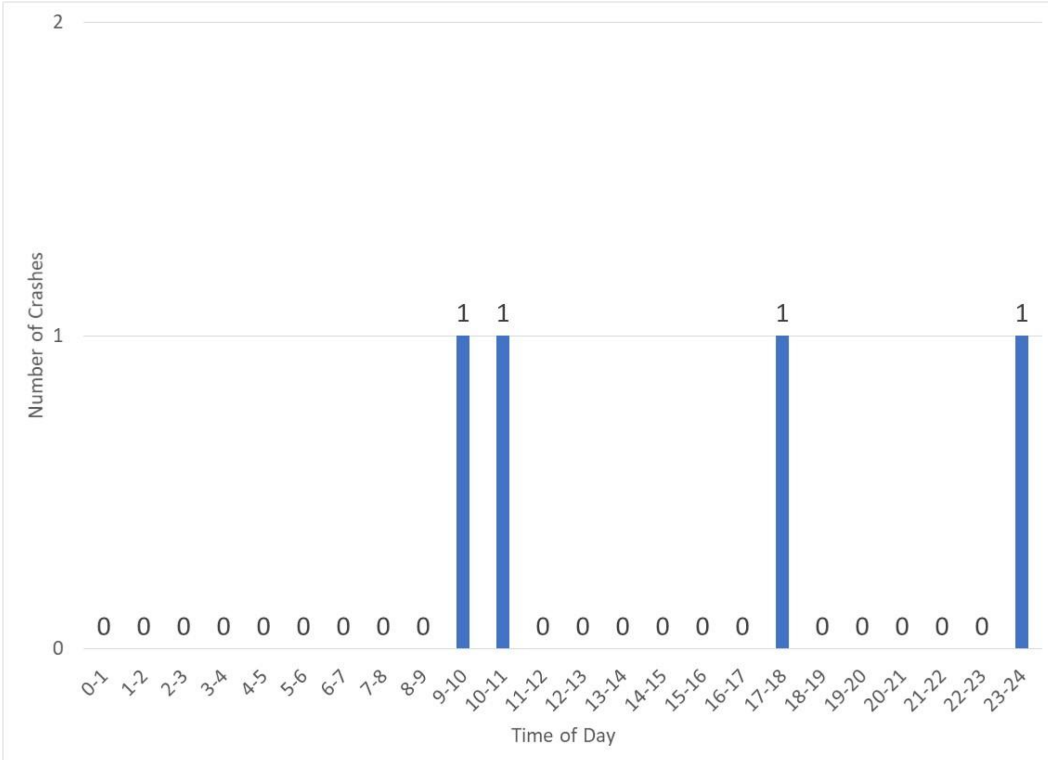


Figure 148. The Parkway and Stratford Lane, Injury Crashes by Time of Day

2.9.7 Pedestrians and Bicycles

No crashes between pedestrians/bicycles and a motor vehicle were reported at this intersection.

2.9.8 Crash Diagram

The following crash diagram (Figure 89) illustrates the location of crashes for this intersection for which data regarding location within the intersection was available.

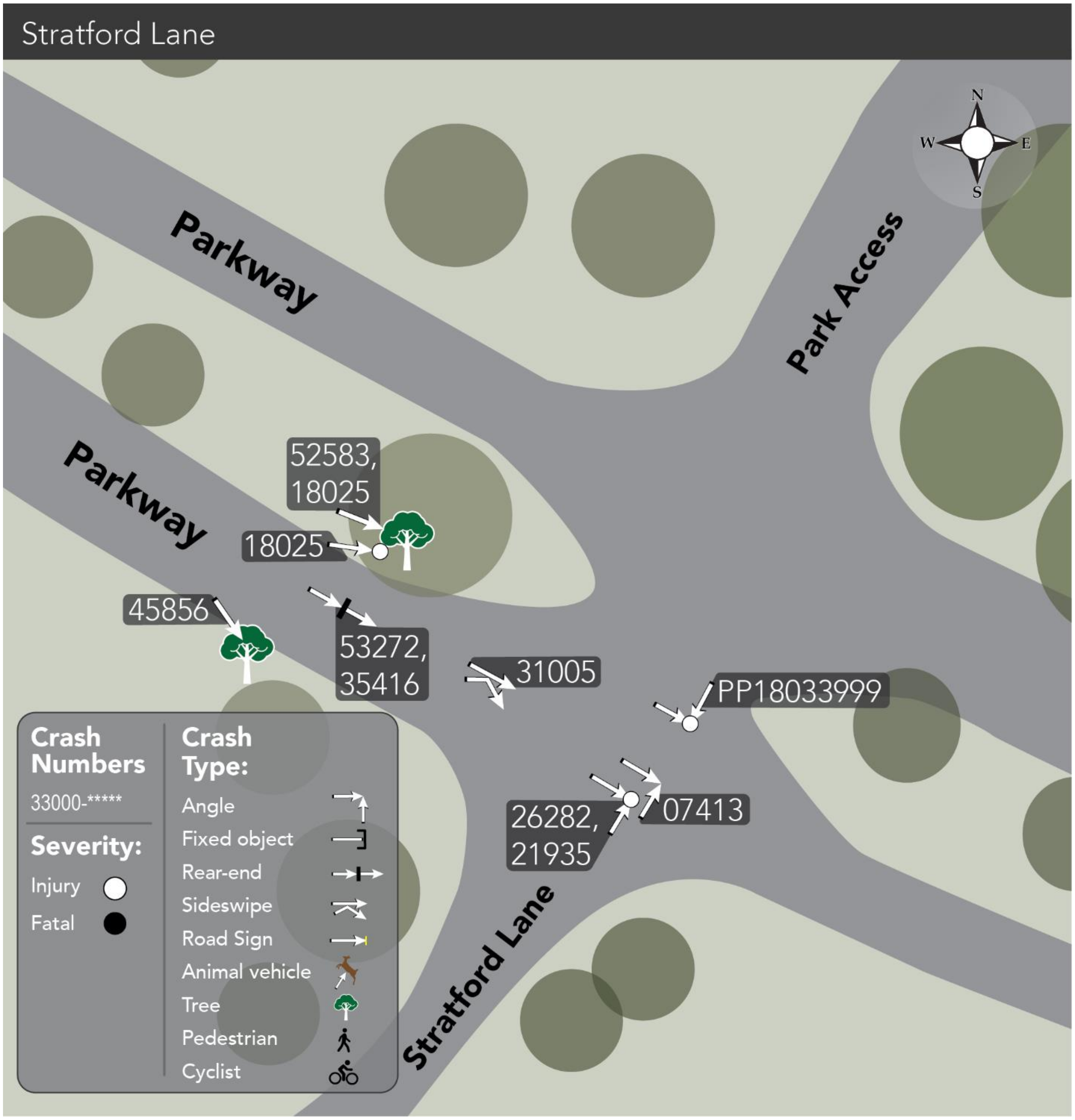


Figure 149. The Parkway and Stratford Lane, Crash Diagram*

* No information was provided about the severity or direction for crash PP19071055.

The most interesting observation about this intersection is that all of the crashes occurred in the southbound direction. Speed is again, likely a factor in the occurrence of crashes, as vehicles leaving the roadway can suggest that drivers are traveling at speeds too fast for their ability to remain on the roadway. Lane markings could assist vehicles with staying in the lane, as leaving the roadway seems to be a significant factor.

2.9.9 Summary — Stratford Lane

Overall, few (12) crashes were observed at the intersection of the Parkway and Stratford Lane compared to the other intersections within the project boundary based on crash data during 2005–2015 and 2018–2019. The majority of crashes occurred in 2007; in February, April, September, November, and December; between 9:00 a.m. and 10:00 a.m. or 5:00 p.m. and 6:00 p.m.; and on Thursdays and Sundays (Table 43). However, of the crashes that did occur, there was a larger than anticipated likelihood of an injury crash for otherwise infrequently occurring crashes. It would have been useful to have had more details for the four crashes that provided little information. There seems to be a number of individuals leaving the road and hitting a tree/shrub, which can often result in severe crashes. Therefore, there is likely a need to reduce speeds or ensure that motorists remain on the roadway (removing trees/shrubs is not a viable solution due to context sensitivity associated with the corridor). There is a potential need for regular maintenance of pavement markings, particularly so that they are visible at night when there is no lighting in the corridor.

Table 43. The Parkway and Stratford Lane, Summary of Key Data Findings

Criteria	Count
Number of Crashes	12
Year (of greatest frequency)	2007
Month (of greatest frequency)	February, April, September, November and December
Day (of greatest frequency)	Thursday and Sunday
Percent from 12:00 a.m.–12:00 p.m.	33%
Most Frequent 1-Hour Block	9:00 a.m.–10:00 a.m.; 5:00 p.m.–6:00 p.m.
Most Frequent Period (pre-a.m. peak; a.m. peak; midday; p.m. peak; post-p.m. peak)	p.m. Peak
Might Lighting Be an Issue?	Yes
Is Weather a Contributing Factor?	No
Might the Surface Condition Be an Actor?	No
Most Typical Crash Type	Not Applicable and Angle
Most Typical Reported Cause	No Information (3 of 12)
Driving Under the Influence	Zero Crashes (0 of 12)
Hit and Run	Zero Crashes (0 of 12)
Percent of Injury and Fatal Crashes (measure of severity)	33% (4 of 12)
Total Number of People Injured in Crashes	8 people
Pedestrian/Bicycle Involved Crashes?	No; 0% (0 of 12)
Animal Involved Crashes?	No; 0% (0 of 12)

2.10 Summary of Intersections

This section provides a summary of some of the key aspects that were analyzed for each intersection, viewed from the lens of the corridor, and concluding with a summary highlighting potential concerns associated with each intersection.

Crash occurrence was analyzed to understand if crashes happened more often in the first half of the day (12:00 a.m.–12:00 p.m.) or the second half of the day (12:00 p.m.–12:00 a.m.). The majority of crashes appear to occur in the second half of the day (Figure 150).

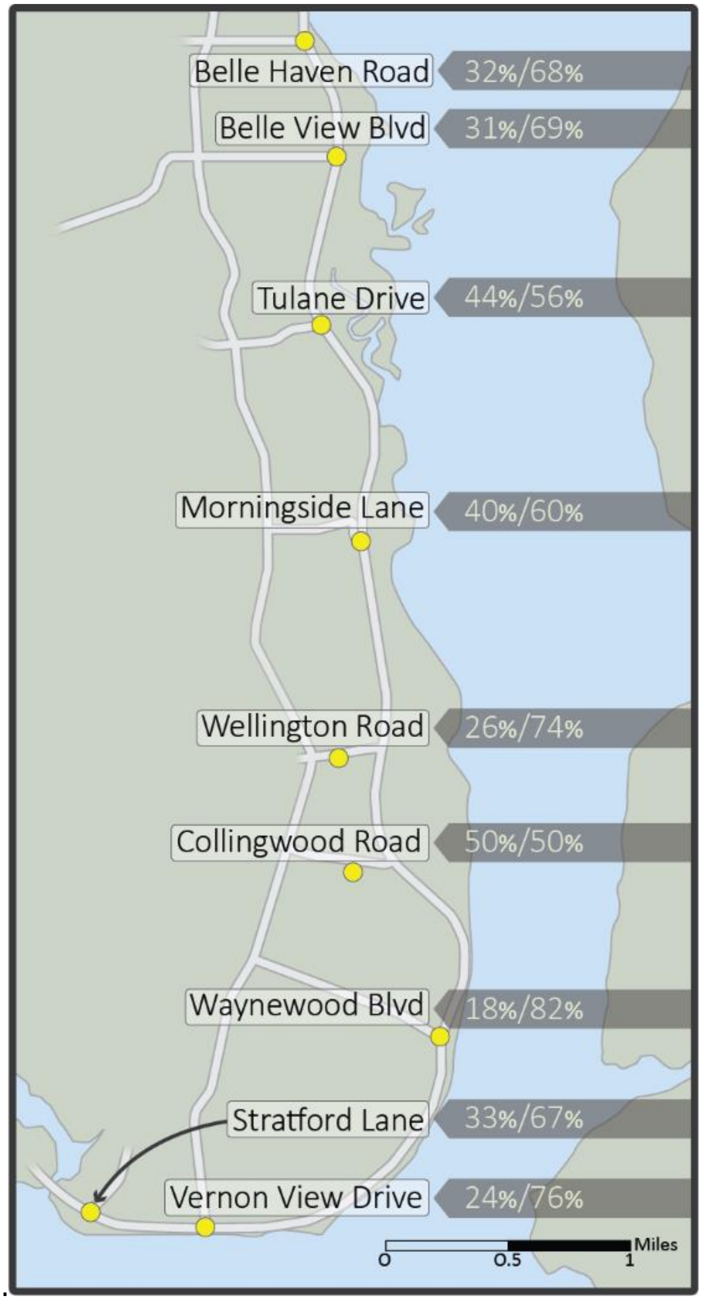


Figure 150. The South Parkway Corridor, Percent of Crashes in the a.m./p.m.

However, while the second half of the day had the majority of crashes, the period with the greatest number of crashes across all intersections was from 8:00 a.m. to 9:00 a.m. (Belle Haven Road, Morningside Lane, and Collingwood Road) (Figure 151).

Figure 151. The South Parkway Corridor, Peak Crash Period

Therefore, overall, it appears that accidents most likely occur during the peak periods in the morning and the afternoon rush when traffic numbers are higher. The year with the most crashes at these intersections was 2011 (Figure 152). However, as suggested by the number of intersections without any observed crashes in 2015, the number of crashes seems to be underreported to the database.

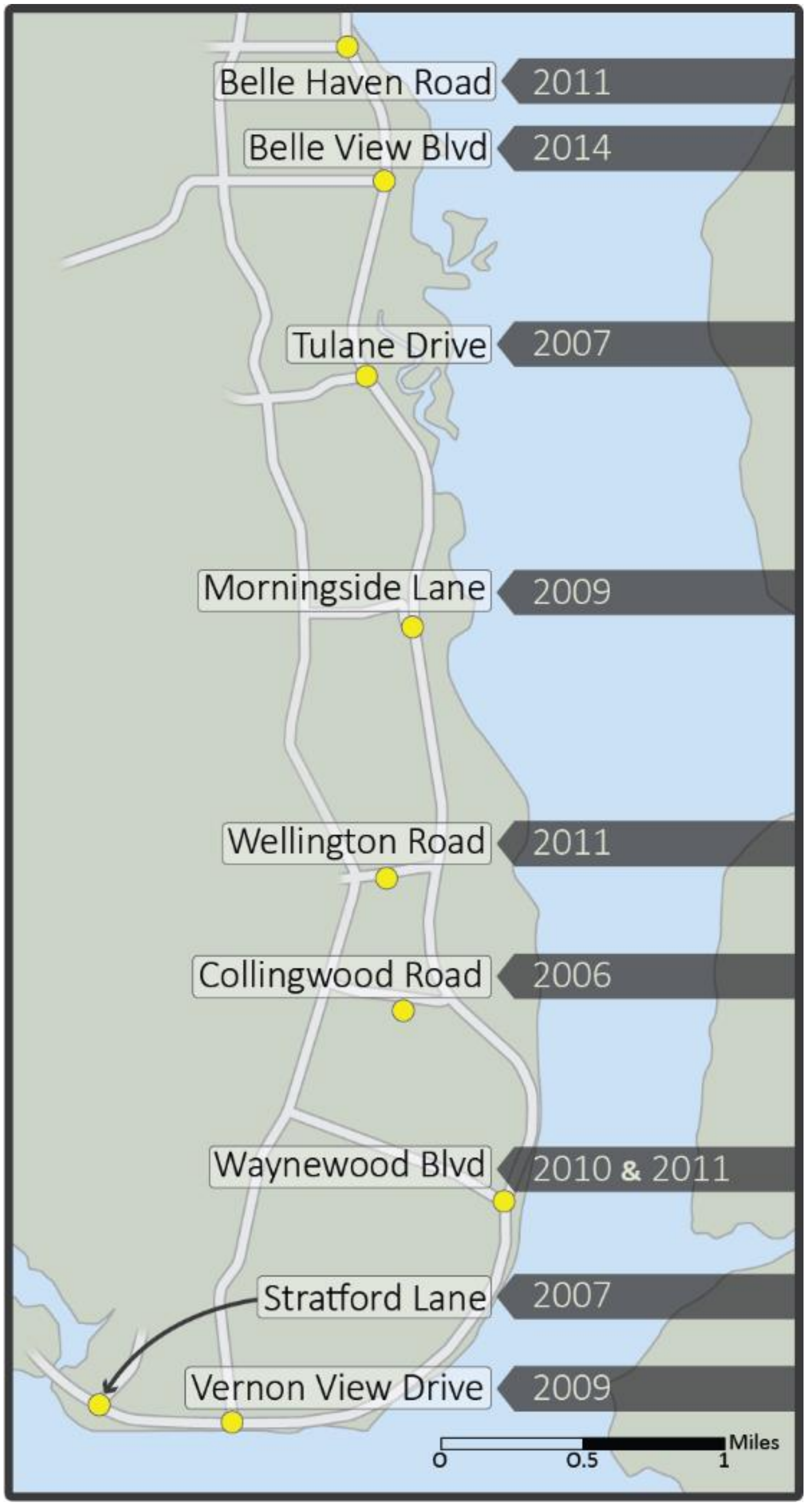


Figure 152. The South Parkway Corridor, Year of Most Frequent Crashes

April had the highest number of observed crashes at five of the intersections (Figure 153).

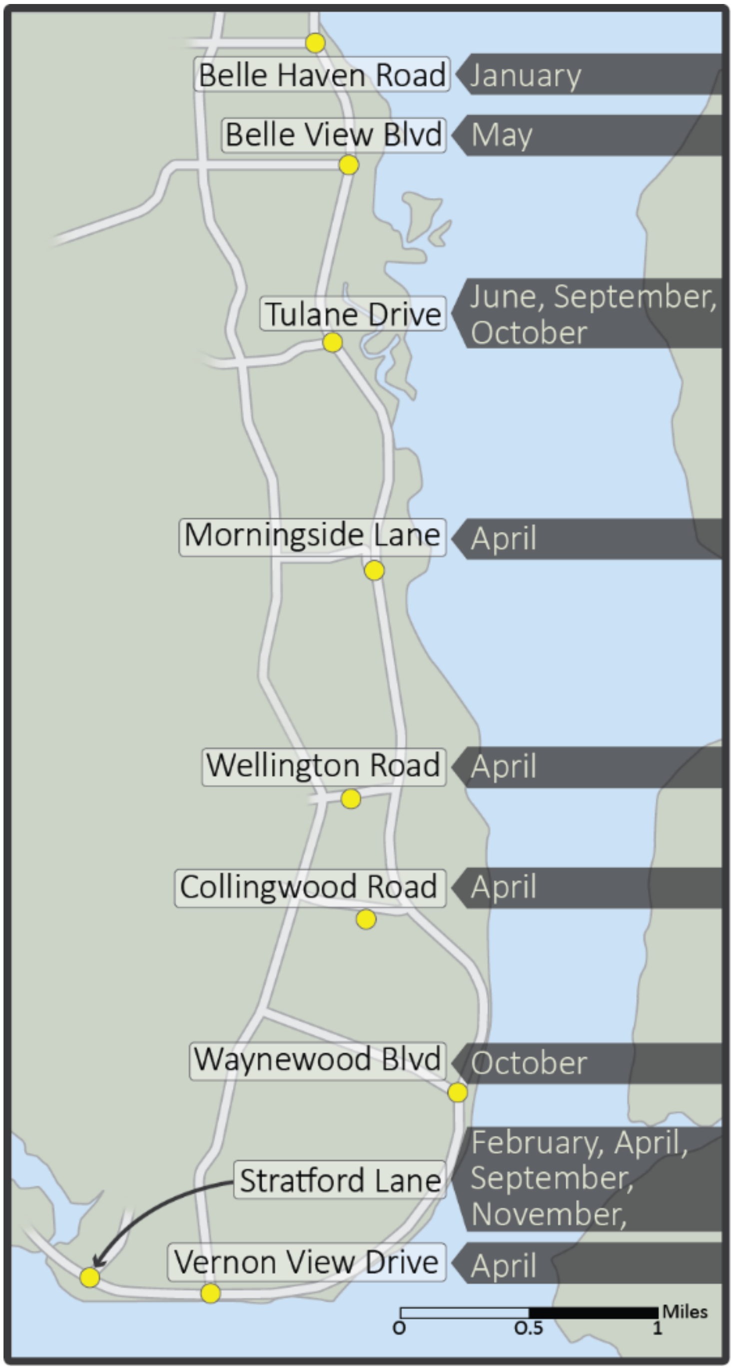


Figure 153. The South Parkway Corridor, Month of Most Frequent Crashes

Higher crash rates in April could potentially be attributed to an increase in the number of pedestrians/bicyclists accessing the Mount Vernon Trail, a reduction in sight lines as a result of foliage returning, and an increase in the number of motorcycles. As an example of how the data supports some of these theories, Belle View Boulevard had a pedestrian/bicycle crash that occurred in April. This is also likely the time when foliage is coming into full bloom, so there is the potential that motorists may have become accustomed to slightly greater sight lines during winter. There is also the potential that motorcyclists may be riding again come April, and other motorists may have gotten out of the habit of looking for them. Searching through the 2018–2019 crash data, which provides information about vehicle type, there was at least one crash in April that was identified as involving a motorcycle.

At five intersections, Friday had the greatest number of crashes (Figure 154).

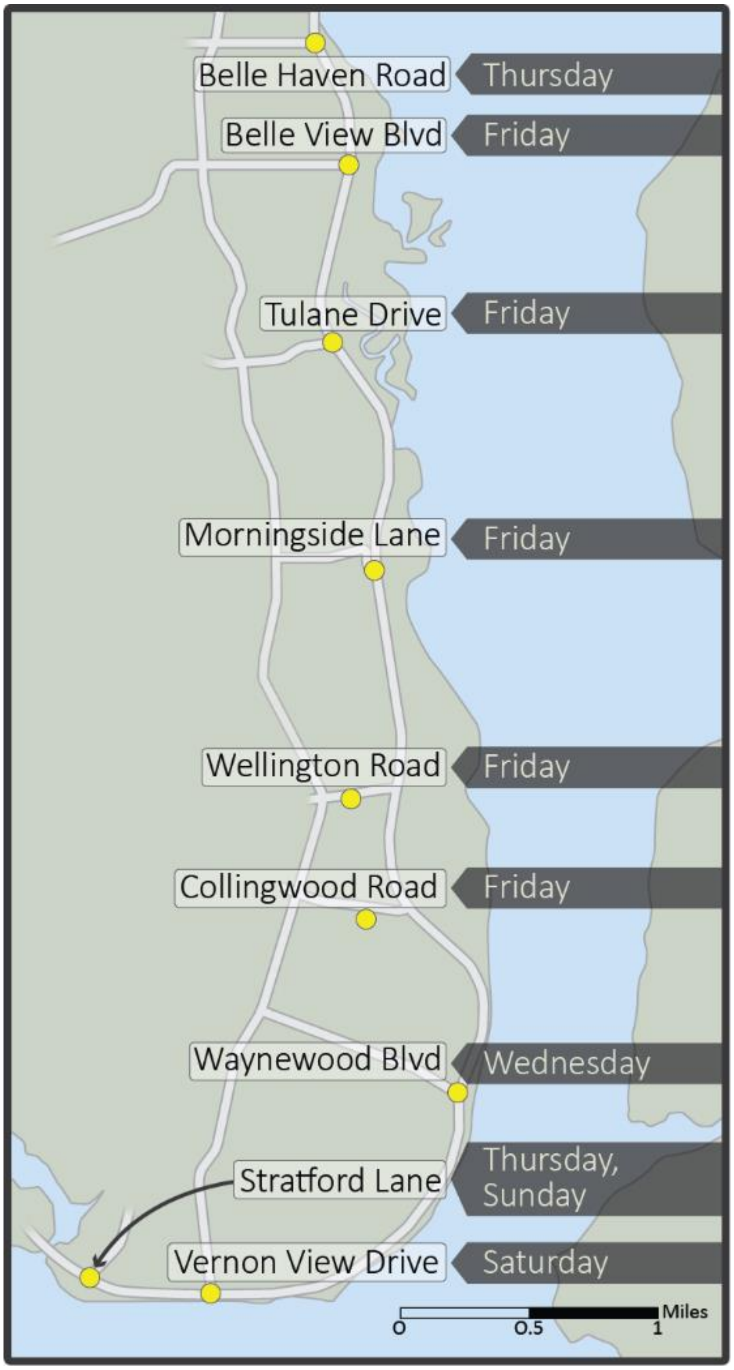


Figure 154. The South Parkway Corridor, Day of Most Frequent Crashes

Belle Haven Road, Belle View Boulevard, Morningside Lane, and Collingwood Road had the greatest number of crashes in the corridor (Figure 155).

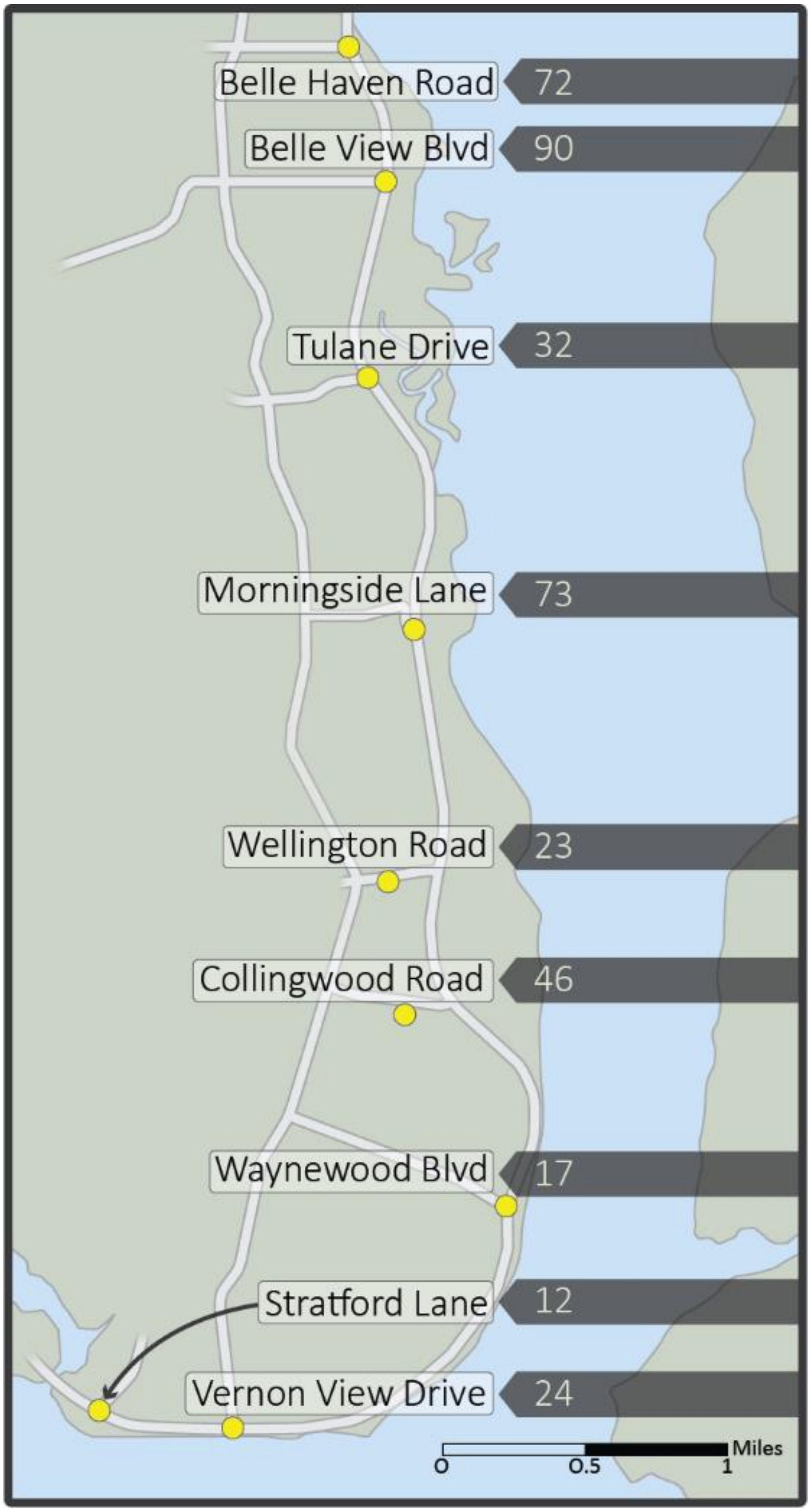


Figure 155. The South Parkway Corridor, Number of Crashes

The severity of crashes at these intersections is most notable (Figure 156). While Belle Haven Road and Belle View Boulevard have the greatest number of crashes, they have considerably lower crash severity when compared with intersections like Waynewood Boulevard and Vernon View Drive. Morningside Lane has both a high crash count and high crash severity.

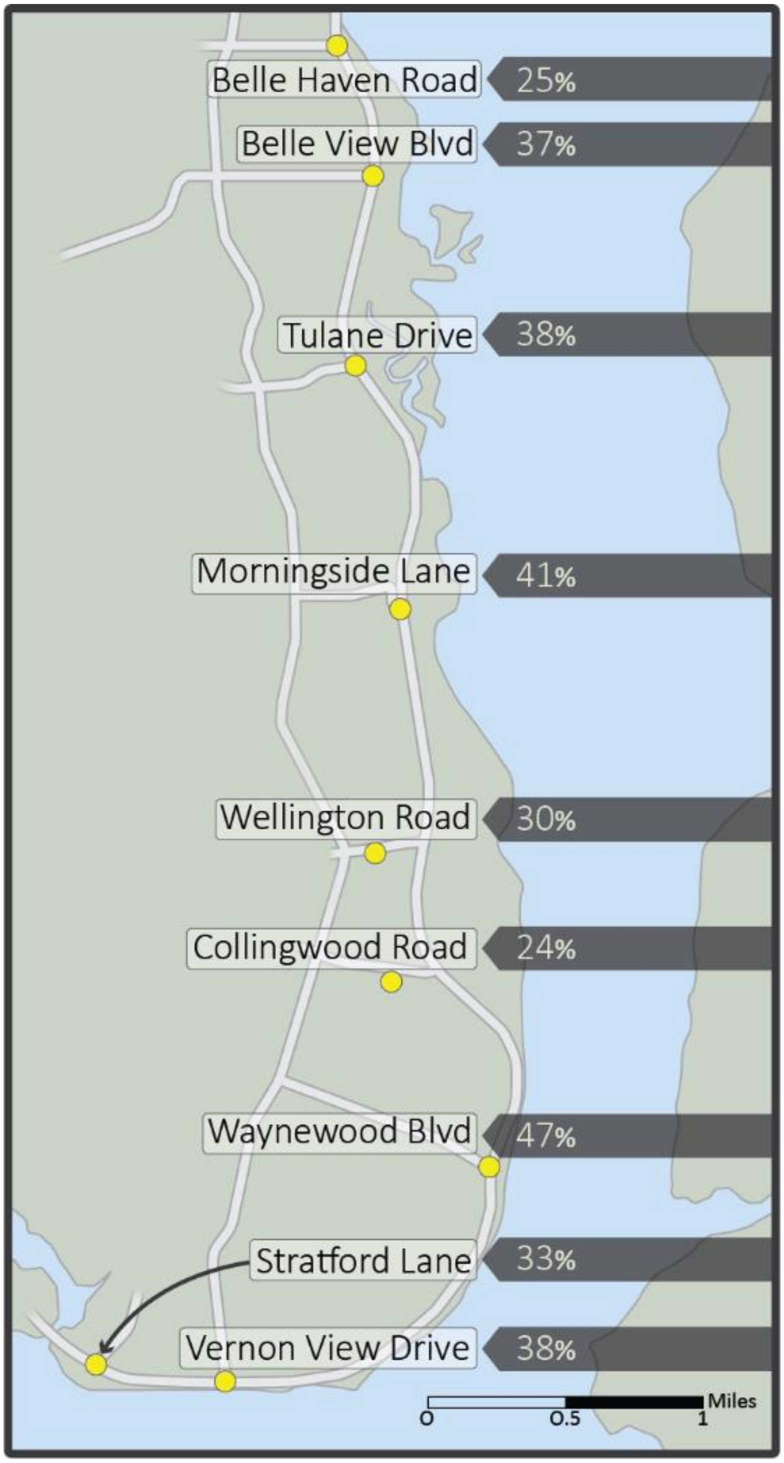


Figure 156. The South Parkway Corridor, Severity of Crashes

Pedestrian and bicycle crashes were reported at Belle Haven Road, Belle View Boulevard, Wellington Road, and Collingwood Road (Figure 157). Geometric modifications to support pedestrians and bicyclists crossing the Parkway to access the Mount Vernon Trail could, at a minimum, be addressed at these intersections.

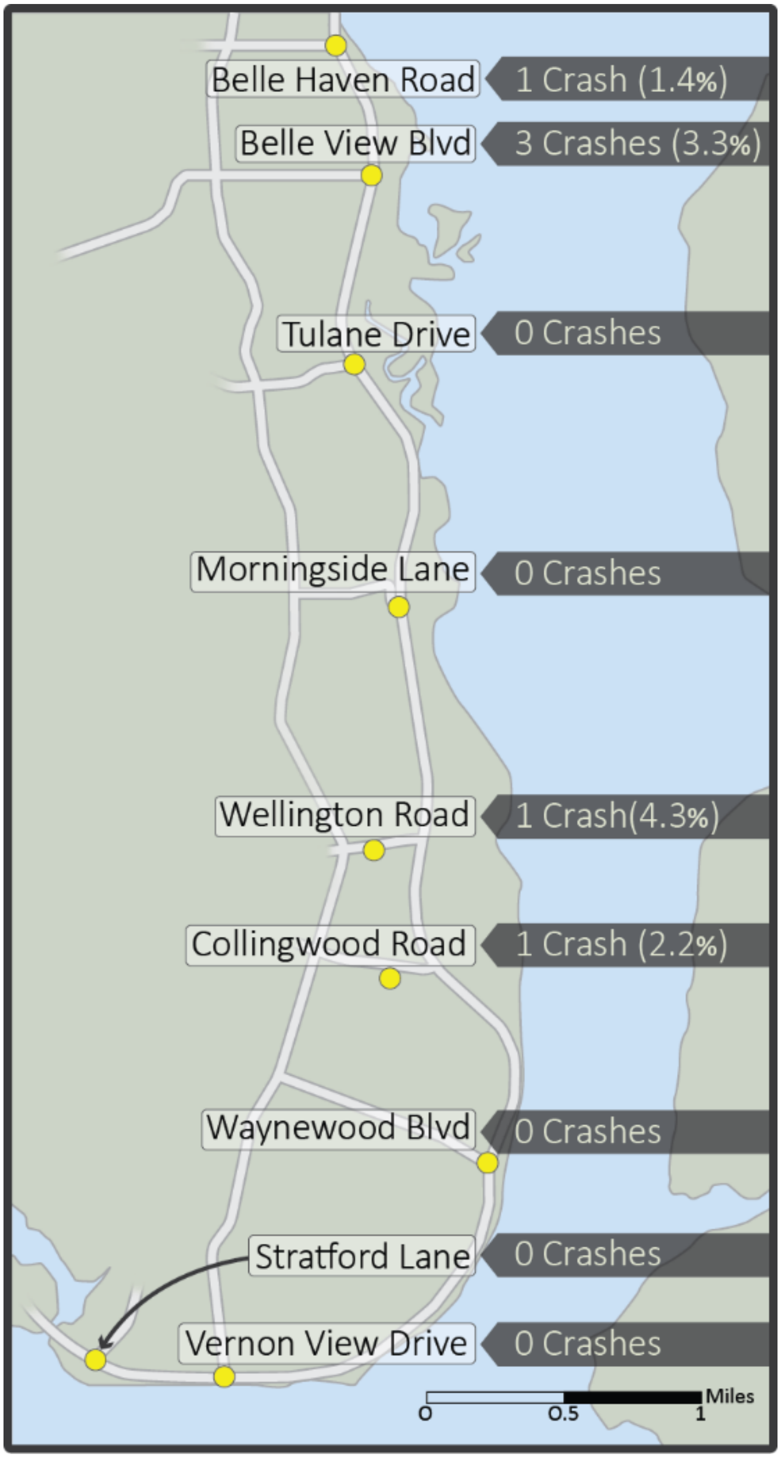


Figure 157. The South Parkway Corridor, Number and Percent of Pedestrian/Bicycle Crashes

Animal collisions, particularly in the northern intersections of the corridor, are causing crashes (Figure 158). Mitigation efforts for these types of crashes could be considered.

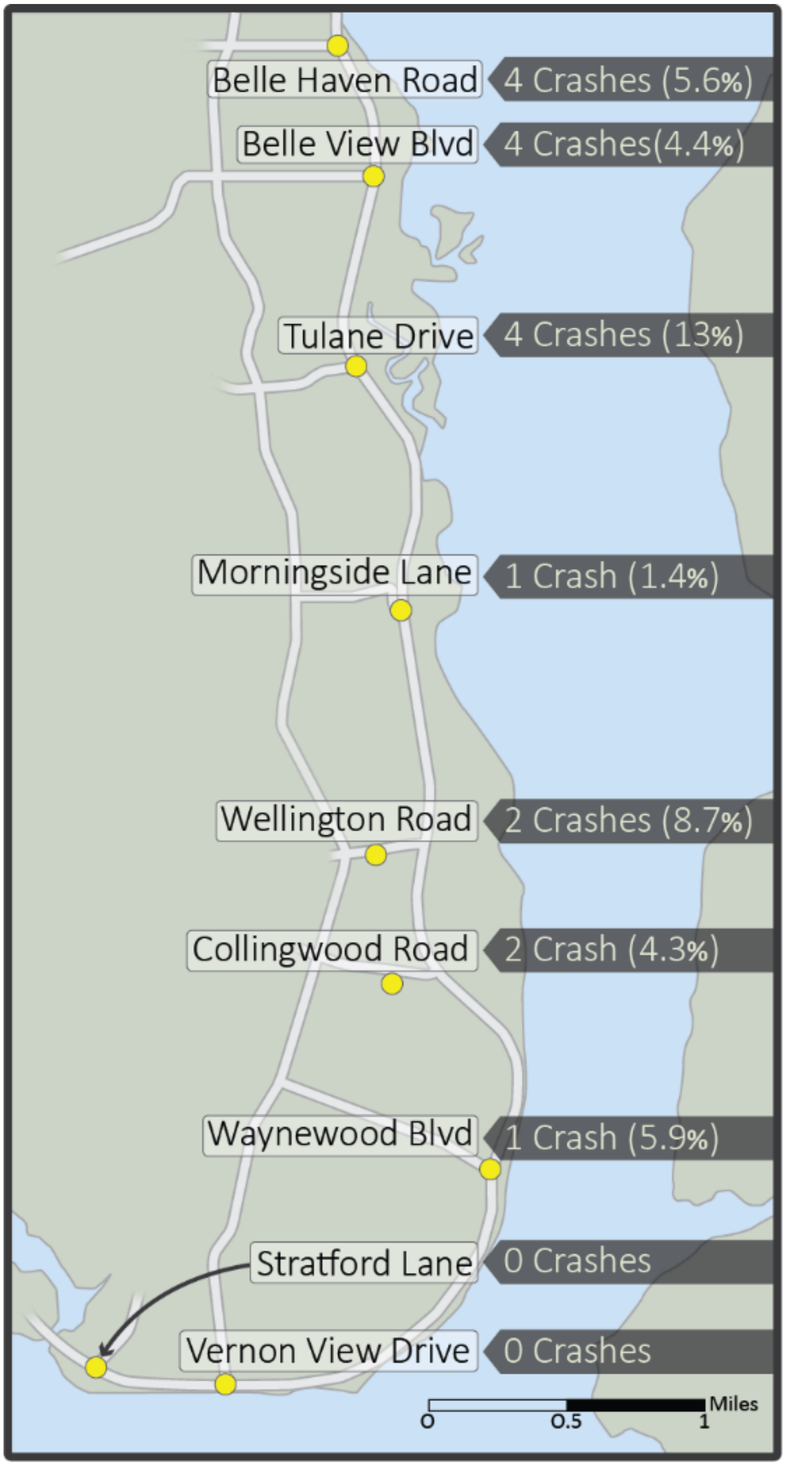


Figure 158. The South Parkway Corridor, Animal Crashes

Table 44 summarizes the details of the animal crashes.

Table 44. Summary of Crashes with Animals

Intersection	Date	Month	Time	Day of Week
Belle Haven Road	10/02/07	October	05:35	Tuesday
	11/07/09	November	20:46	Saturday
	01/05/11	January	19:22	Wednesday
	10/20/13	October	19:21	Sunday
Belle View Boulevard	03/16/08	March	06:38	Saturday
	07/23/08	July	15:30	Wednesday
	10/24/11	October	06:39	Monday
Tulane Drive	11/24/10	November	19:07	Wednesday
	10/12/11	October	06:50	Wednesday
	03/29/12	March	19:51	Thursday
	09/04/19	September	11:59	Friday
Morningside Lane	11/11/11	November	04:40	Friday
Wellington Road	01/09/08	January	23:05	Wednesday
	03/15/14	March	23:15	Saturday
Collingwood Road	10/19/09	October	17:34	Monday
	10/22/09	October	08:59	Thursday
Waynewood Boulevard	04/22/10	April	01:17	Thursday

Clearly, October has the largest number of crashes with animals and could therefore be a large contributor to the occurrence of crashes in the fall. A possible solution would be to use dynamic message signs to notify drivers entering the corridor during the month of October that they should drive slower due to the presence of animals. It is also clear that early morning or late evening hours seem to be contributing factors to these crashes, also likely because of the limited lighting in the corridor and potential migration patterns of wildlife.

“Angle” and “Not Applicable” crashes are the most common reported crash types (Figure 159). Most angle crashes are between vehicles, whereas the latter are with trees/shrubs, animals, and other roadside objects (e.g., drainage structures, signs). Implementing measures that will keep vehicles on the roadway (e.g., slower speeds, more forgiving roadside) can help to mitigate these crashes.

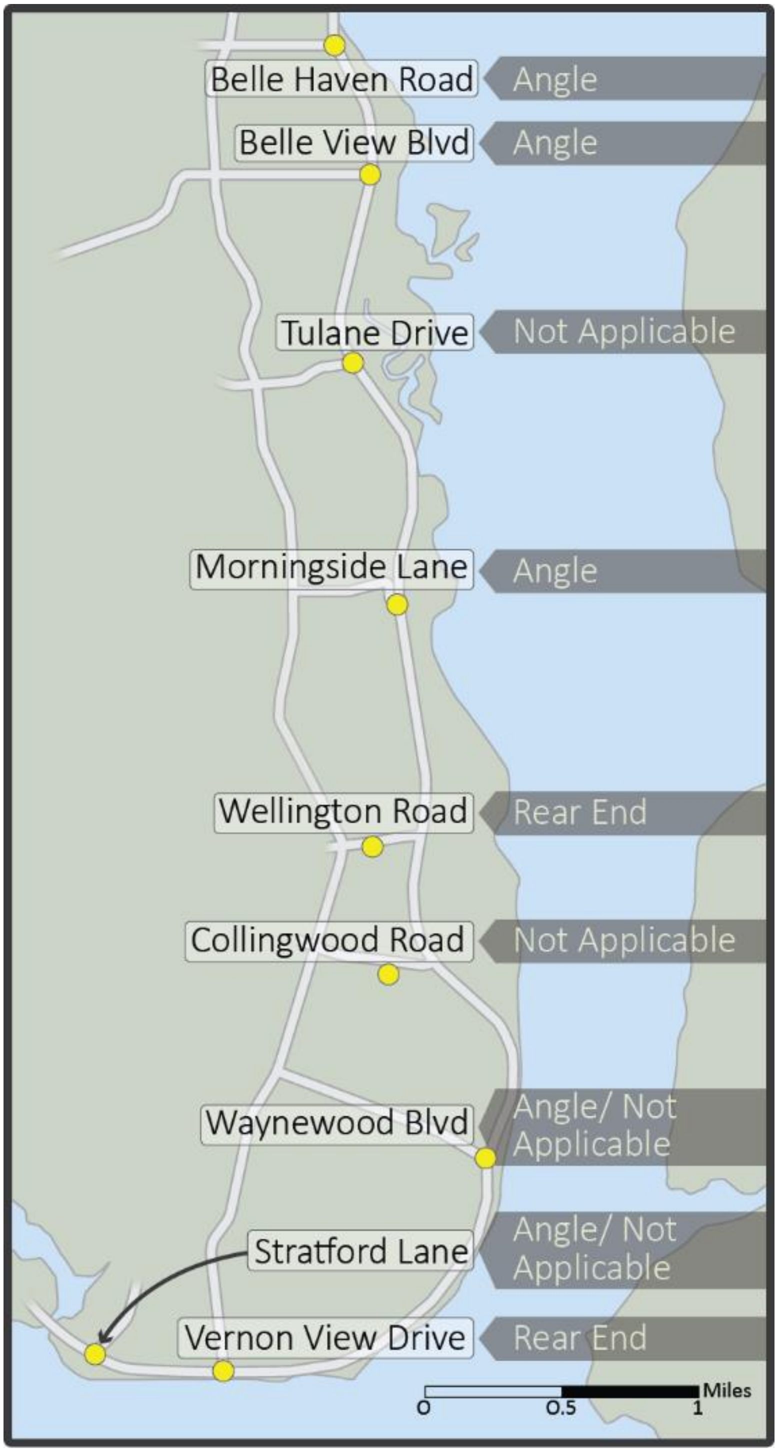


Figure 159. The South Parkway Corridor, Crash Type

Hit-and-run crashes are a problem across all intersections except Stratford Lane (however, it is also notable that there was no information for the majority of crashes at this intersection) (Figure 160).

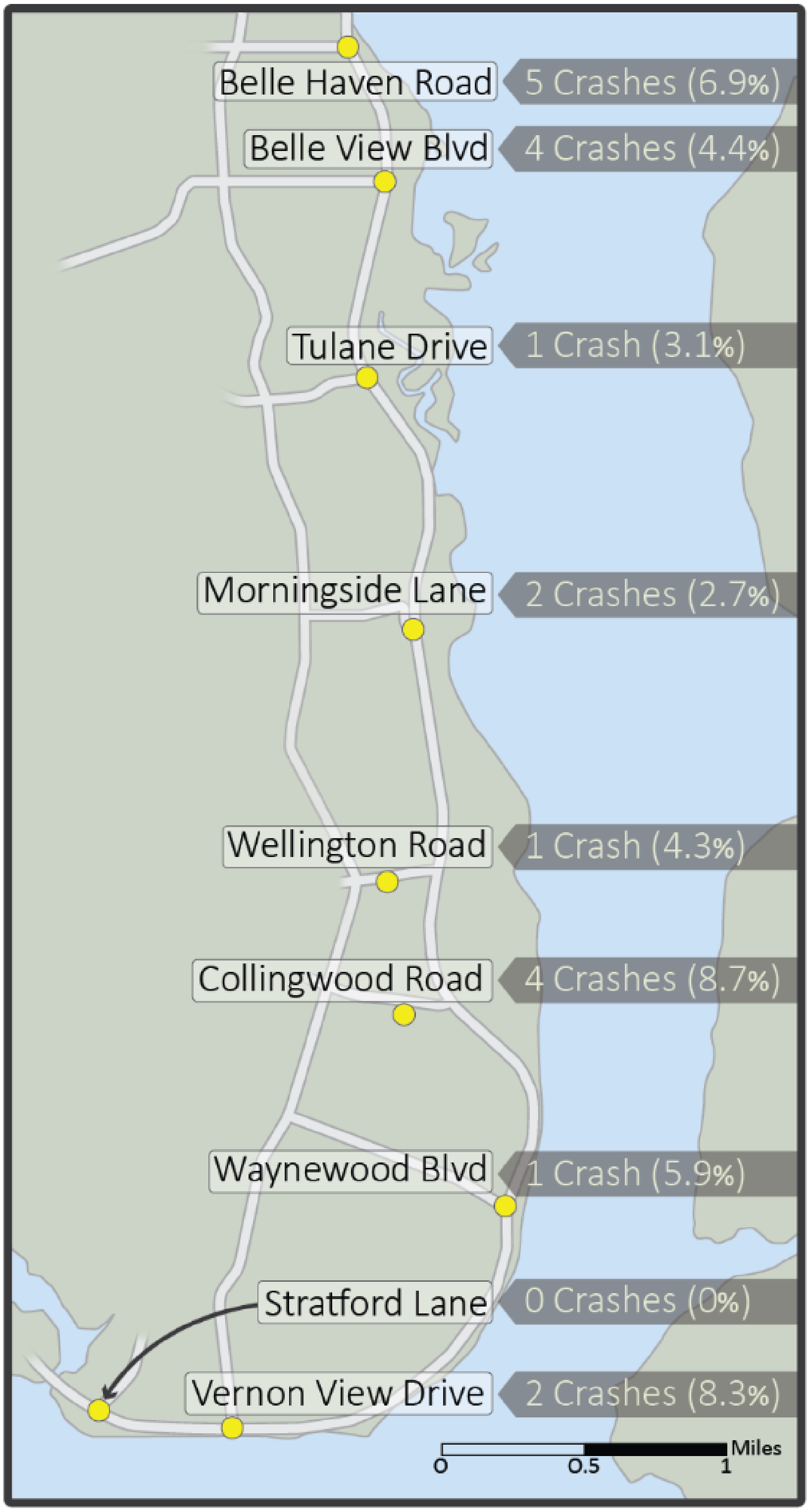


Figure 160. The South Parkway Corridor, Hit–and-Run Crashes

Table 45 presents the date, month, time, day of week, crash type, and severity of hit-and-run crashes.

Table 45. Summary of Hit-and-Run Crashes

Intersection	Date	Month	Time	Day of Week	Crash Type	Severity
Belle Haven Road	11/10/06	November	8:12	Friday	Sideswipe - Opposing	PDO
	03/01/08	March	19:54	Saturday	Rear End	PDO
	02/14/11	February	18:46	Monday	Angle	PDO
	06/01/13	June	21:41	Saturday	Rear End	PDO
	06/20/18	June	20:00	Wednesday	Unknown	PDO
Belle View Boulevard	06/04/07	June	12:30	Monday	Sideswipe - Overtaking	PDO
	11/29/11	November	7:24	Tuesday	Sideswipe – Overtaking	PDO
	06/22/12	June	15:35	Friday	Sideswipe - Opposing	INJ
	05/26/19	May	14:20	Tuesday	Other	PDO
Tulane Drive	09/27/12	September	14:26	Thursday	Rear End	PDO
Morningside Lane	03/03/05	March	18:34	Thursday	Angle	PDO
	06/24/14	June	7:15	Tuesday	Sideswipe - Overtaking	PDO
Wellington Road	11/10/11	November	18:55	Thursday	Unknown	PDO
Collingwood Road	05/19/06	May	13:18	Friday	Sideswipe – Overtaking	PDO
	09/04/06	September	5:27	Monday	Hit Tree/Shrub	INJ
	11/29/10	November	15:41	Monday	Angle	INJ
	09/28/11	September	6:30	Wednesday	Sideswipe - Overtaking	PDO
Waynewood Boulevard	02/13/13	February	16:09	Wednesday	Hit Tree/Shrub	INJ
Vernon View Drive	03/12/11	March	16:31	Saturday	Sideswipe – Opposing	PDO
	08/05/11	August	20:54	Friday	Rear End	PDO

Overall, the primary cause reported most frequently in the corridor was “Failed to Yield ROW” (Figure 161). This suggests that either this is the primary cause chosen most frequently by those completing the crash reports or that there is a lack of clarity for drivers regarding ROW.

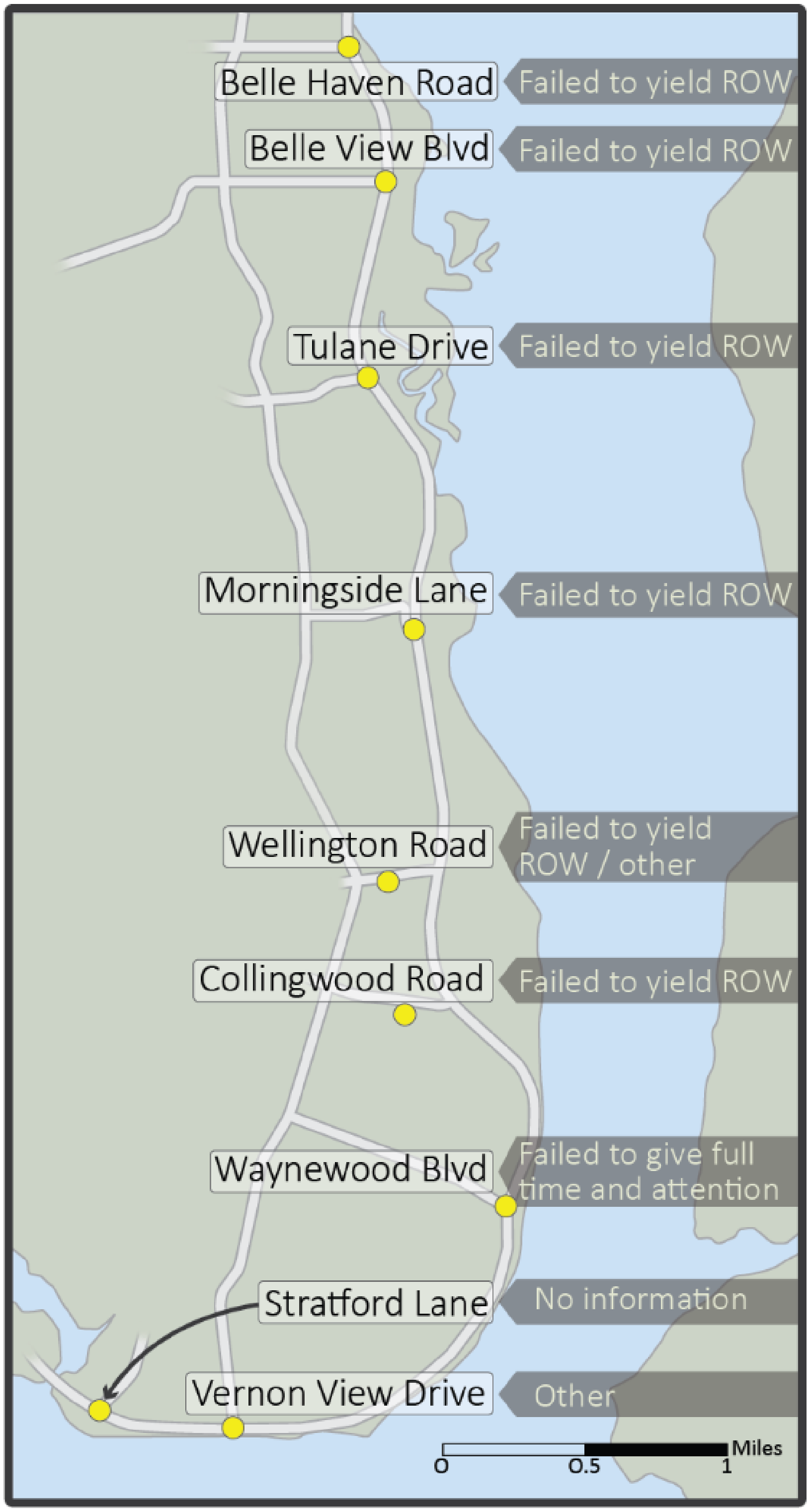


Figure 161. The South Parkway Corridor, Primary Cause

Weather only seems to be a factor for crashes at Waynewood Boulevard (Figure 162).

Figure 162. The South Parkway Corridor, Are Weather-Related Crashes a Factor?

Overall, the factors contributing to crashes at each intersection appear to vary widely. To demonstrate this, Table 46 shows issues or concerns for each intersection in red. Green indicates that the factor is not contributing to crashes, and yellow indicates that there is a potential that the criteria may be contributing to crashes. Notice that no two lines have exactly the same color pattern. As an example, for Belle Haven Road, addressing the following factors could reduce the number and severity of the crashes at the intersection: providing lighting, and addressing the underlying factors that are resulting in hit-and-run crashes (data were limited regarding why hit-and-run crashes may be occurring), finding a way to mitigate interactions between animals and vehicles, and providing safe crossing options for bicyclists and pedestrians. In contrast, for Waynewood Boulevard, it might be necessary to consider the following: providing lighting, investigating surfaces, investigating why weather may be having an impact (e.g., the need for more traction for vehicle tires, water standing on the roadway when it rains), addressing hit-and-run crashes, mitigating animal crashes, and identifying if there are specific trees/shrubs that motorists are hitting.

Table 46. Summary of Intersection Crash Analysis

Intersection	Count	Severity	Lighting a Potential Factor	Weather a Potential Factor	Surface Condition a Potential Factor	Drugs/Alcohol a Potential Factor	Hit and Run a Potential Factor	Animal Crashes a Potential Factor	Trees/Shrubs a Potential Factor	Fatalities	Injuries	Pedestrian/ Bicycle Involved?
Belle Haven Road	72	25%	Yes	No	No	2 (2.8%)	5 (6.9%)	4 (5.6%)	3 (4.2%)	No	32	Yes
Belle View Boulevard	90	37%	Yes	Maybe	Maybe	0 (0%)	4 (4.4%)	4 (4.4%)	5 (5.6%)	Yes	47	Yes
Tulane Drive	32	38%	No	No	No	3 (9.4%)	1 (3.1%)	4 (13%)	5 (16%)	No	16	No
Morningside Lane	73	41%	Yes	No	No	3 (4.1%)	2 (2.7%)	1 (1.4%)	6 (8.2%)	Yes	40	No
Wellington Road	23	30%	No	No	No	0 (0%)	1 (4.3%)	2 (8.7%)	3 (13%)	Yes	11	Yes
Collingwood Road	46	24%	Yes	Maybe	No	3 (6.5%)	4 (8.7%)	2 (4.3%)	10 (22%)	No	12	Yes
Waynewood Boulevard	17	47%	Yes	Yes	Yes	0 (0%)	1 (5.9%)	1 (5.9%)	3 (18%)	Yes	9	No
Vernon View Drive	24	38%	No	No	No	1 (4.2%)	2 (8.3%)	0 (0%)	2 (8.3%)	No	15	No
Stratford Lane	12	33%	Yes	No	No	0 (0%)	0 (0%)	0 (0%)	4 (33%)	No	8	No

2.11 Intersection Sight Distance

Another factor that could be contributing to collisions is intersection sight distance. The Western Transportation Institute team conducted field observations to collect data and analyze sight distance, as described in this section.

Figure 163 illustrates a clear sight triangle, which is the unobstructed view that a driver needs to avoid potential conflicts with approaching vehicles.

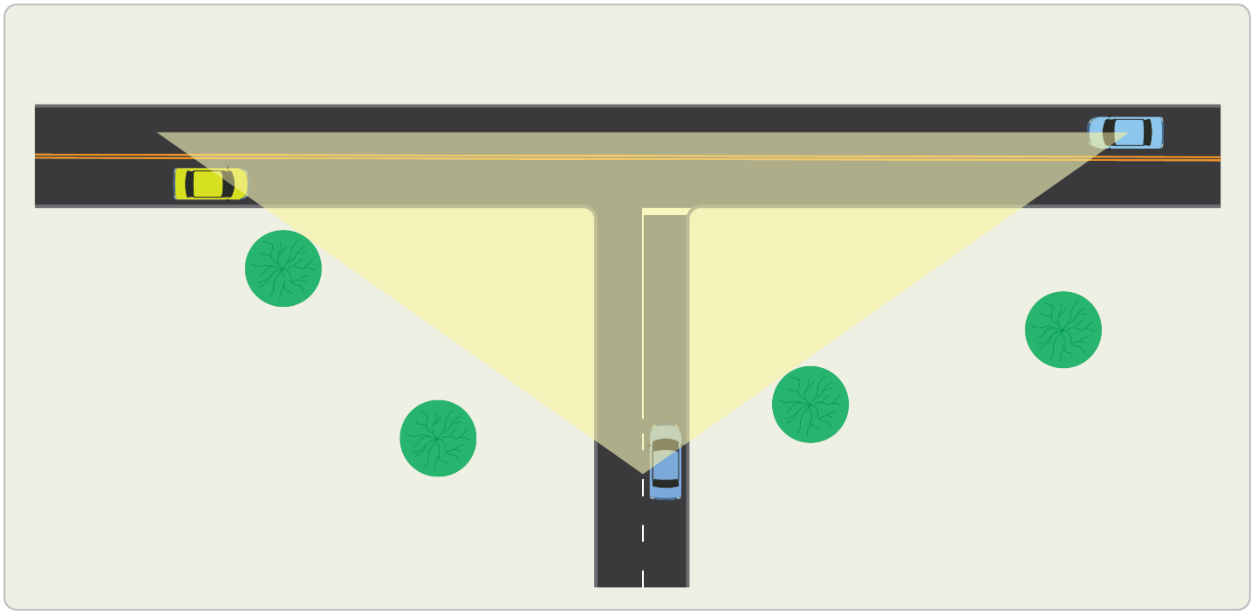


Figure 163. Sight Distance Triangles

Figure 164 shows the existing line of sight for making a right or left turn at each stop-controlled intersection in the study area.

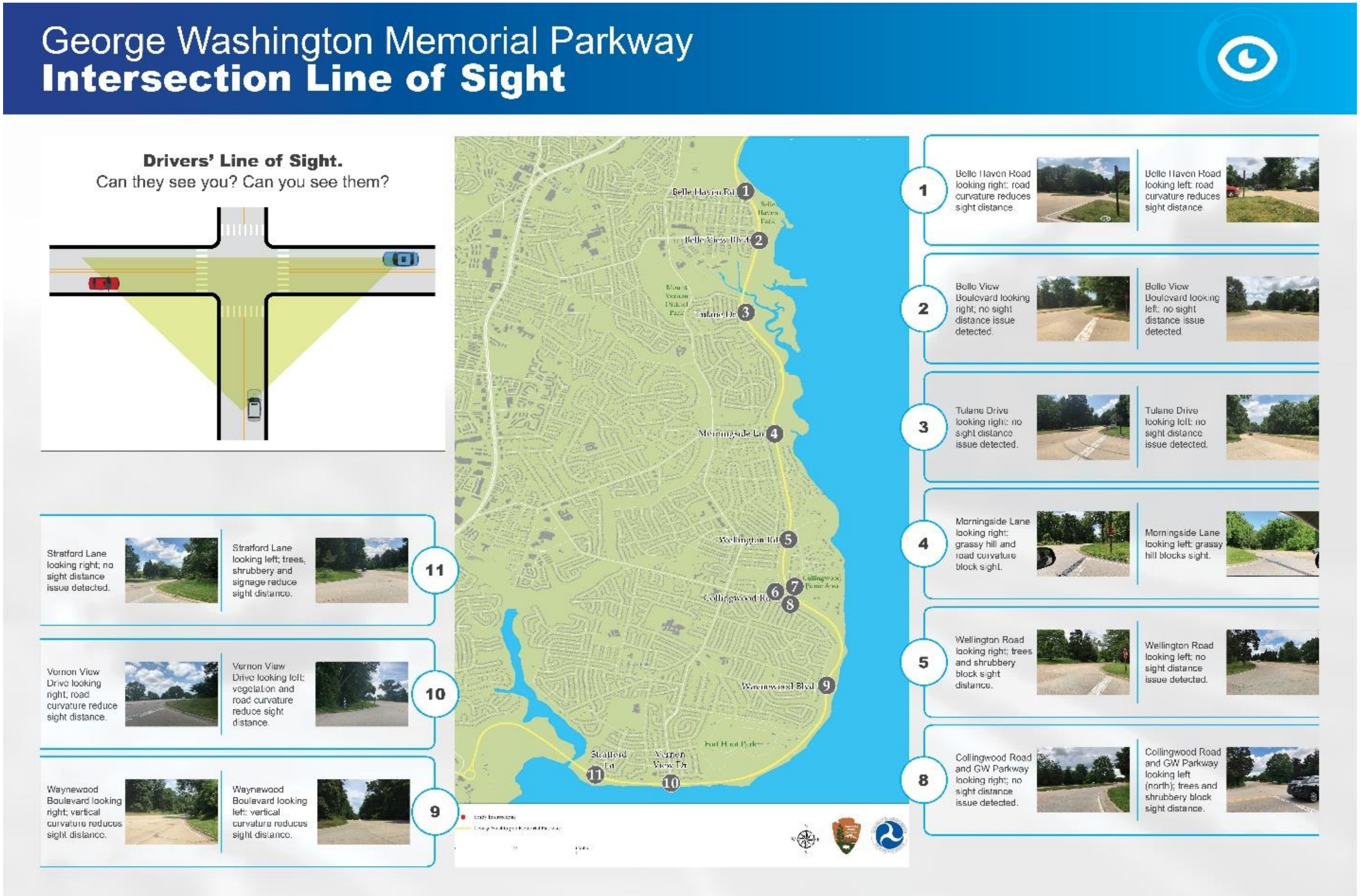


Figure 164. Driver's Line of Sight at Study Intersections

Table 47 summarizes field observations regarding sight distances. The results compare the available line of sight for stopping and for crossing maneuvers based on the required stopping sight distance using the prevailing roadway speeds. For example, a vehicle traveling at 50 mph (prevailing speed) requires about 425 feet to stop on a level terrain. Making a left turn from a stop onto the Parkway when vehicles on the Parkway are traveling at 50 mph requires a minimum of 555 feet of sight distance and 480 feet if making a right turn (AASHTO 2018). For left turns, an additional 0.5 seconds of delay must be added for each lane that the turning vehicle has to traverse, resulting in 590–625 feet (less if they turn into the near lane, more if they turn into the far lane) needed to safely allow the turning vehicle to enter the Parkway. As can be seen from Table 47, drivers traveling along the Parkway have an adequate stopping sight distance when traveling at the prevailing speeds. At intersecting streets, road curvature and vegetation present sight obstructions for drivers turning left or right when merging onto the Parkway. Also, changes in slopes, skewed intersecting angles, and vegetation present sight obstructions at most of the intersections, including Belle Haven Road, Tulane Drive, Morningside Lane, Wellington Road, Collingwood Road, Waynewood Boulevard, Vernon View Drive, and Stratford Lane. Figure 165 includes photographs of obstructions for vehicles entering the Parkway from side streets.

Based on these findings, most intersecting roads do not provide adequate sight lines. Reducing vehicles speeds, as well as removing some obstructions such as vegetation, would improve intersection sight lines.

Table 47. Stopping Sight Distance and Design Intersection Sight Distance for Passenger Cars

Intersection	Approach	Adequate Stopping Sight Distance on the Parkway	Minor Street Adequate Intersection Sight Distance	Sight Obstruction
Belle Haven Road	Eastbound Right Turn	Yes	No	Road Curvature
	Eastbound Left Turn		No	Road Curvature
Belle View Boulevard	Eastbound Right Turn	Yes	Yes	None
	Eastbound Left Turn		Yes	None
Tulane Drive	Eastbound Right Turn	Yes	Yes	None
	Eastbound Left Turn		Yes	None
	Westbound Right Turn		No	Vegetation
	Westbound Left Turn		No	Vegetation
Morningside Lane	Eastbound Right Turn	Yes	No	Vegetation/Road Curvature
	Eastbound Left Turn		No	Vegetation

Intersection	Approach	Adequate Stopping Sight Distance on the Parkway	Minor Street Adequate Intersection Sight Distance	Sight Obstruction
Wellington Road	Eastbound Right Turn	Yes	No	Vegetation
	Eastbound Left Turn		Yes	None
Collingwood Road	Eastbound Right Turn	Yes	Yes	None
	Eastbound Left Turn		Yes	None
	Westbound Right Turn		Yes	None
	Westbound Left Turn		No	Vegetation
Waynewood Boulevard	Eastbound Right Turn	Yes	No	Vertical Curve
	Eastbound Left Turn		No	Vertical Curve
	Westbound Right Turn		No	Road Curvature/Vegetation
	Westbound Left Turn		No	Road Curvature/Vegetation
Vernon View Drive	Eastbound Right Turn	Yes	No	Road Curvature
	Eastbound Left Turn		No	Vegetation/Road Curvature
Stratford Lane	Eastbound Right Turn	Yes	Yes	None
	Eastbound Left Turn		No	Vegetation/Sign
	Westbound Right Turn		No	Vegetation
	Westbound Left Turn		No	Vegetation

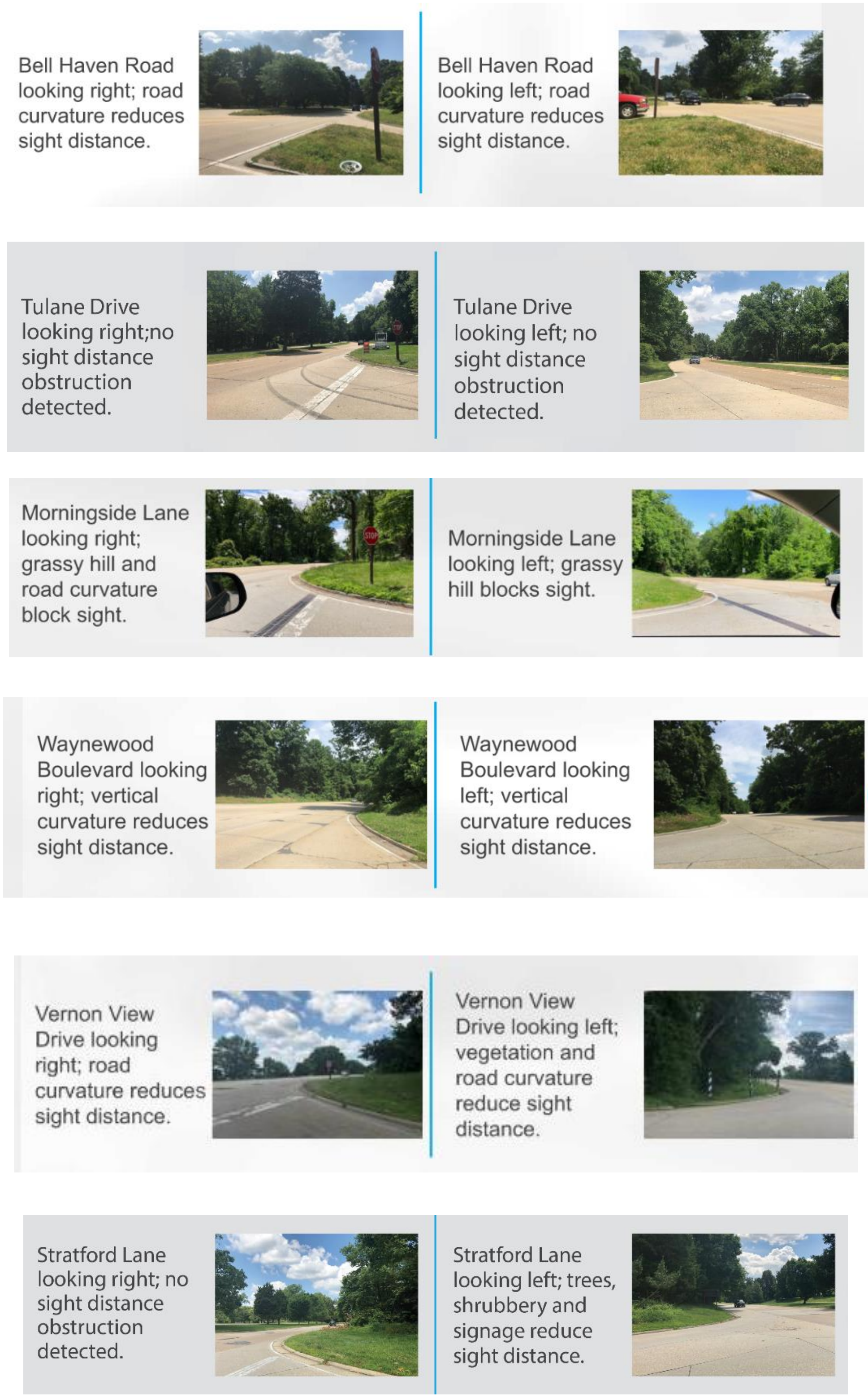


Figure 165. Intersections with Sight Obstructions

2.12 Traffic Safety Evaluation and Crash Experience Conclusions and Recommendations

Safety cannot often be improved with a single solution. There are many potential improvements that can be made to address the safety concerns that exist in this corridor. Speed is a primary contributing factor of crash severity and likely a primary cause of crashes. It was recommended that the US Park Police (USPP) and the Parkway staff apply for a grant through the Governor's Highway Association to pilot speed management. Unfortunately, this has not been successful due to the state selecting non-federal applicants. Meanwhile, coordinated efforts between the Parkway and the US Park Police regarding expanded enforcement efforts are encouraged. The majority of public feedback expressed support for more enforcement.

Overall, while there is some variation across intersections, crashes seem to be overrepresented in April (Morningside Lane, Wellington Road, Collingwood Road, Vernon View Drive, and Stratford Lane) and on Fridays (Belle View Boulevard, Tulane Drive, Morningside Lane, Wellington Road, and Collingwood Road). Therefore, in addition to the proposed geometric and traffic operation modifications that may assist with clarifying rights-of-way (at some intersections) and reducing speeds at other locations, the Parkway, in cooperation with the US Park Police, could consider a traffic enforcement blitz during the month of April and on Fridays. This, in cooperation with education (e.g., look for pedestrians in the month of April), could assist with improving safety in the corridor.

There seems to be missing data, which limited the depth and comprehensiveness of analysis. Some of these gaps are the result of the transition from one database to the other (where it seems that most of the 2015 crash data were lost). However, for some of the more recent crash data (2018–2019), there was not information about crash severity, whether or not the driver was tested for driving under the influence, or whether or not the crash was a result of a hit and run.

Detailed crash data can help pinpoint contributing circumstances to crashes. The results and analysis contained herein were conducted to the best of the ability of the project team with the available data. This study recommends that training be conducted with the individuals collecting the data and creating the crash reports to emphasize the importance of thorough, accurate data. As an example, through training, the impacts of erroneous data (e.g., Dark – Lighted versus Dark – Not Lighted) could be discussed and emphasized. Furthermore, it was conveyed to the project team that as compared with providing more detailed crash data, some agencies are moving towards providing crash reports only in the case of a fatality. This is not recommended. Crash reports, particularly narratives, can provide insight into what the tabular data doesn't capture. As an example, recording insights from those involved or observers of the crash that could better explain the underlying crash mechanism. In addition, the USPP should ensure they are reporting all fatal crashes in the Fatality Analysis Reporting System. Federal land management agencies are increasingly making the case for funding and need accurate data to justify funding requests. By not reporting the data, they are limiting availability and access to data, which will in turn hamper their ability to address critical safety concerns like those identified in this project.

3. STAKEHOLDER AND PUBLIC ENGAGEMENT PROCESS

Two sets of meetings were held to inform and engage elected officials, stakeholders, and the public. The first set occurred in July 2019, and the second in December 2019.

3.1 Outreach Meeting, July 2019

In July 2019, the project team conducted outreach meetings with elected officials, stakeholders, and the public.

3.1.1 Stakeholder Meeting

The first Stakeholder Meeting was held on July 8, 2019, at the Mount Vernon District Station-Fairfax County Police Department in Alexandria, Virginia. This meeting provided a briefing on the safety study and a preview of the information that would be sharing during the public meeting on July 11, 2019. The attendees represented the following organizations:

- National Park Service, George Washington Memorial Parkway
- Federal Highway Administration, Eastern Federal Lands Highway Division
- Fairfax County Department of Transportation
- Western Transportation Institute at Montana State University
- Mead and Hunt

During the meeting, stakeholders discussed the purpose of and need for the study, emphasizing the traffic safety and access concerns that the community had expressed to their local governments and which resulted in the first study conducted by Eastern Federal Lands (Ocel 2019). The stakeholders recognized that understanding the public input is crucial in identifying themes, important issues, and location-specific concerns when providing temporary and long-term safety solutions for the Parkway study corridor. Stakeholders mentioned previous studies conducted in 2017 at Morningside Lane, which were expanded to include crash data, corridor recommendations, and other strategies to improve the Parkway. This meeting provided a review of how people are using the Parkway based on traffic volumes collected, actual travel speeds, gaps and delays at intersecting arterials, crash frequency, and an inventory of transit and parking. Stakeholders identified the following traffic and safety concerns based on the data collected on delays, queueing, gaps, crashes, and turning movements:

- High volumes of commuters use the Parkway to bypass congestion and traffic signals on Route 1 and then must cut through neighborhoods to reach Route 1 and the beltway. This creates few gaps for residents to turn from side streets onto the Parkway and causes higher traffic volumes on residential side streets.
- The Parkway was designed for slower travel speeds that were based on lower capacity.
- Four locations out of the 11 study intersections on the corridor have a large number of crashes.
- The lack of gaps for residents to turn off their streets is causing drivers to misjudge gaps and make aggressive turns, resulting in crashes. The lack of gaps also causes queues.
- Encroaching vegetation reduces sight distance for stopping and turning and needs regular maintenance.

- There is an unbalanced traffic flow in the corridor. The Parkway and neighboring roads are a system, and changes to the Parkway will affect traffic on those roads.
- Poor pedestrian access and sight distance are concerns at several locations along the Parkway.

Additionally, stakeholders discussed budget, temporary countermeasures, and maintenance issues. Following is a summary of key points:

- Traffic calming and other projects have been proposed for Fairfax County Department of Transportation roads. There is currently no dedicated funding for any projects near the Parkway.
- The National Park Service has a small budget for transportation infrastructure, and the project would need funding help from a larger organization.
- The Virginia Department of Transportation has a program that will provide 50% of the funding on certain projects if other agencies will fund the other 50%.

Temporary solutions to improve safety are both low cost and high impact. For example:

- Preliminary mitigation methods currently being investigated include speed management and enforcement, restriping of the corridor, and trimming vegetation along the roadway.
- Turn restrictions, which will redirect traffic back to Route 1, will be considered where other mitigations will not be effective in improving safety.

3.1.2 Elected Officials Meeting

The meeting with elected officials occurred on July 11, 2019, at the Mount Vernon District Station of the Fairfax County Police Department in Alexandria, Virginia, before the public meeting scheduled on the same day. The purpose of the meeting was to preview public meeting materials, provide a summary of constituent concerns, and describe strategies to encourage citizen and visitor feedback on context-sensitive solutions. The attendees represented the following organizations:

- US Office of Representative Don Beyer (VA)
- Mount Vernon Board of Supervisors
- Mount Vernon District, Fairfax County Board of Supervisors
- National Park Service, George Washington Memorial Parkway
- National Park Service, Region 1, National Capital Area
- Federal Highway Administration, Eastern Federal Lands Highway Division
- 44th District, Virginia House of Delegates
- Virginia State Senate
- Fairfax County Police Department
- Mead and Hunt

The project team presented an overview of the poster boards to the elected officials and representatives that attended the meeting and introduced the stakeholders involved in the traffic safety study project. Team members presented the existing operational, geometric, and safety conditions at the 11 selected intersections located in the southern segment of the Parkway between the City of Alexandria and Mount Vernon. In addition, there was a description of the materials to be presented during the public meeting, the logistics for delivering information, and the proposed methods to capture public input.

3.1.3 Public Open House Meeting

The first public meeting occurred on July 11, 2019, at Walt Whitman Middle School in Alexandria, Virginia, from 6:00 p.m. to 8:00 p.m. This meeting facilitated discussions between stakeholders and the public on concerns and suggested safety improvements. There were approximately 124 participants from the public.

Figure 166. First Public Outreach Meeting Held July 11, 2019

As shown in Figure 166, more than 12 posters were distributed along the nine stations in the meeting room. Members of the public were encouraged to visit each station to discuss traffic and safety concerns and share their experience using the Parkway.

Each station focused on one of the following topics:

- Station 1 — Sign-in sheet, project overview flyer, comment card collection box
- Station 2 — Project Purpose and Goals
- Station 3 — Project Schedule
- Station 4a — What Is a Parkway?
- Station 4b — Current Projects
- Station 5 — Existing Typical Roadway Sections
- Station 6a — Existing Pedestrian and Bicycle Network
- Station 6b — Existing Transit Stops and Parking
- Station 7a — Traffic Volumes
- Station 7b — Traffic Operations
- Station 8a — Crash Data
- Station 8b — Sight Distance
- Station 9 — Roll Plan Base Map and Comments

3.1.4 Comments from First Outreach Meetings

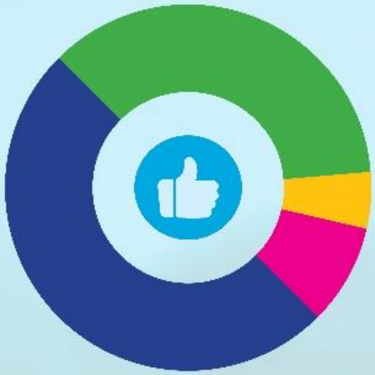
The project team collected comments from the public and elected officials during the outreach meeting through comment cards. Members of the public also had the option to post notes on maps to identify areas of major safety concerns. The period to submit comments was extended through August 21, 2019, allowing the public to submit comments using other venues such as mail, e-mail, and the NPS Planning, Environment and Public Comment (PEPC) web page.

The project team collected 704 comments after the first public meeting. The team received about half of the comments at the public meeting, with 144 comment cards and 201 comments posted on the maps. In addition, the Parkway staff received 66 mailed letters and 40 emails, and members of the public posted 253 comments in the PEPC portal.

Figure 167 illustrates the range of concerns that were provided during the comment period.

George Washington Memorial Parkway
What We Heard - Over 700 Comments from the Public

What We Heard



Over 345 Comments During the Last Public Meeting

Over 250 Comments through the PEPC Portal

Over 60 Comments by Mail

Over 35 Comments by E-Mail

Major Concerns Identified by the Public

Item	Concern	Count	Percentage
1	Pedestrian Safety and Access (to trail, bus stops)	71	10%
2	Need for Speed Enforcement	65	9%
3	Difficult Intersection Geometric Design	63	9%
4	High Rate of Vehicle Speeds	56	8%
5	High # of Conflicts Making Left-Turns (in/ out of neighborhood streets)	48	7%
6	Limited Intersection Sight Lines	35	5%
7	Bicycle Safety and Access (to trail)	34	5%
8	Illegal Use of the Parkway by Trucks	30	4%
9	Lack of Appropriate Intersection Traffic Controls	30	4%
10	Faded or Lack of Roadway Markings	19	3%
11	Other	253	36%
	Total	704	

Comments by Intersection

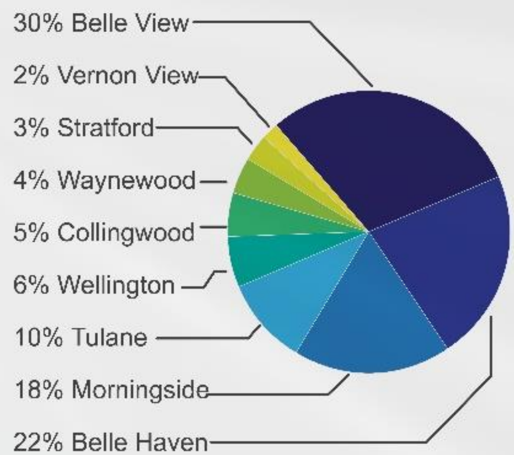


Figure 167. Feedback Received from the First Public Outreach Meeting Held on July 11, 2019

Other specific concerns received were related to speed enforcement, complex geometric designs, high rates of vehicle speeding on the Parkway, and sight distance issues. The intersections at Belle View Boulevard, Belle Haven Road, and Morningside Lane received the most comments. These intersections are adjacent to each other and located in the upper segment of the Parkway.

The cards received at the public meeting described speeding concerns, poor pedestrian/bicycle access, and the lack of speed enforcement. On the maps, people identified locations for pedestrian access improvements and sight distance concerns. Public feedback submitted through e-mail, mail, and the PEPC website also showed a high level of concern for speeding and suggested speed enforcement strategies, as well as geometric modifications to improve safety.

3.2 Outreach Meeting, December 2019

The second set of outreach meetings were held in December 2019. The project team again conducted outreach with the stakeholders, elected officials, and the public.

3.2.1 Stakeholder Meeting

The Stakeholder Meeting occurred on December 3, 2019, at the Mount Vernon District Station of the Fairfax County Police Department in Alexandria, Virginia. This meeting provided a briefing on the safety study and a preview of the information that would be sharing during the public meeting that evening. The attendees represented the following organizations:

- National Park Service, George Washington Memorial Parkway
- National Park Service, Region 1, National Capital Area
- National Park Service, Legislative Affairs
- Federal Highway Administration — Eastern Federal Lands Highway Division
- Fairfax County Board of Supervisors
- US Representative Don Beyer (VA)
- US Senator Tim Kaine
- Mount Vernon
- Virginia Department of Transportation
- Fairfax County Department of Transportation
- 44th District, Virginia House of Delegates
- Western Transportation Institute at Montana State University
- Mead and Hunt

During the meeting (Figure 168), stakeholders received feedback and discussed feedback from the first round of meetings, the screening process, and next steps. They also had the opportunity to preview materials for the public meeting.

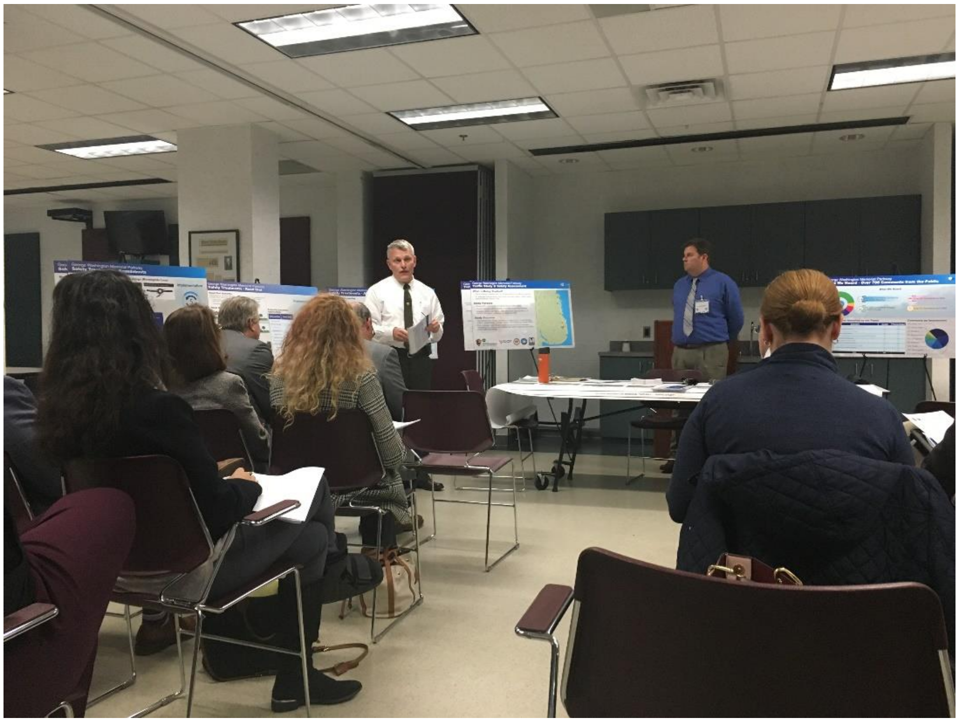


Figure 168. Second Stakeholder Meeting Held on December 3, 2019

In particular, the team shared the top three intersections that received public comments (Belle Haven Road, Belle View Boulevard, and Morningside Lane). The team shared that based on the data collected, the Parkway can carry the current traffic that uses it; the suspected underlying issue that is contributing to the high severity of the crashes is speeding. The team noted that while Parkway staff could lower speeds in order to install pedestrian crossings, this option is not expected to result in lower speeds by the traveling public.

The stakeholders emphasized the need to continually view the solutions as a three-legged stool, the legs of which comprise the NPS, elected officials, and the community. Stakeholders also:

- reported hearing that automated speed enforcement (speed cameras) were of particular interest to the public
- emphasized the need to select actionable solutions
- had questions about funding
- wanted to understand why the traffic circle at Mount Vernon was not included in the study

George Washington Memorial Parkway staff committed to reviewing other park studies such as the Memorial Circle Environmental Assessments and the National Register Nomination to determine if operational changes could be made to improve the safety of Mount Vernon Circle.

3.2.2 Elected Officials Meeting

The meeting with elected officials occurred on December 2, 2019, at the Mount Vernon District Station of the Fairfax County Police Department in Alexandria, Virginia. The purpose of the meeting was to discuss the screening process for narrowing the list of concepts, preview public meeting materials, provide a summary of proposed solutions, and describe strategies to encourage citizen and visitor feedback on context-sensitive solutions. The attendees represented the following organizations:

- Mount Vernon District, Fairfax County Board of Supervisors
- Virginia State Senate
- National Park Service, George Washington Memorial Parkway
- Mount Vernon District Police Station
- Western Transportation Institute at Montana State University
- Mead and Hunt

An overview of the presentation and poster boards were provided, along with a description of the materials to be presented during the public meeting, the logistics for delivering information, and the proposed methods to capture public input.

3.2.3 Public Open House Meeting

The second public meeting occurred on December 3, 2019, at Walt Whitman Middle School in Alexandria, Virginia from 6:00 p.m. to 8:00 p.m. This meeting facilitated discussions between stakeholders and the public regarding potential solutions to the traffic safety concerns. There were approximately 83 participants from the public (Figure 169).

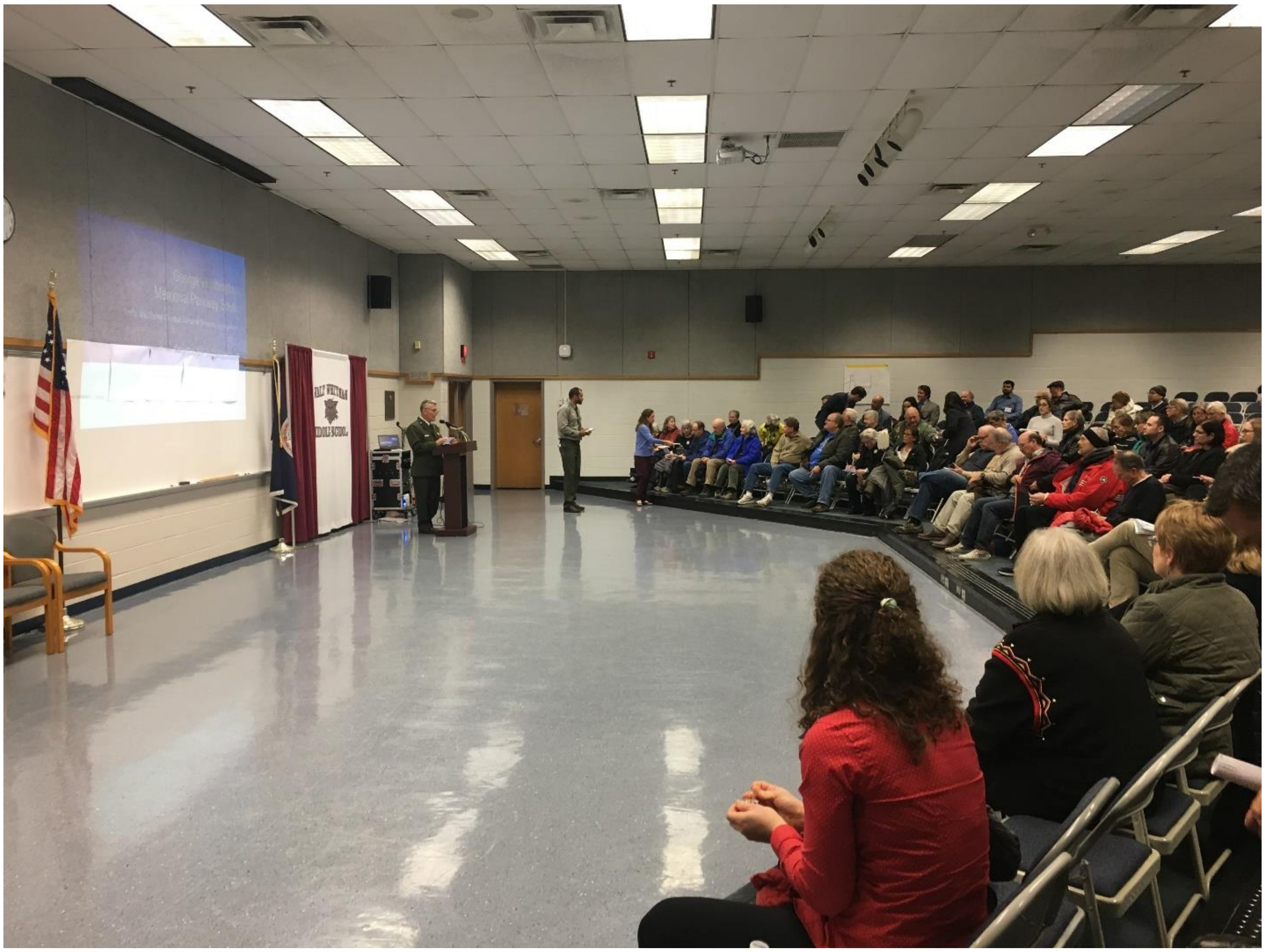


Figure 169. Second Public Outreach Meeting Held on December 3, 2019

Sixteen posters were distributed in the meeting room. Members of the public were encouraged to visit each station to discuss the conceptual solutions (e.g., road diets, roundabouts, j-turns) and share their experience regarding how the proposed solutions. The following posters were displayed:

- Poster 1 — Study Schedule
- Poster 2 — What We Heard
- Poster 3 — What Is a National Parkway?
- Poster 4 — Context Sensitive
- Poster 5 — Signing, Marking and Maintenance
- Poster 6 — Operational Changes
- Poster 7 — Road Diet
- Poster 8 — Road Diet Rendering
- Poster 9 — Roundabouts
- Poster 10 — Roundabouts vs. Traffic Circles
- Poster 11 — Roundabout Rendering
- Poster 12 — Pedestrian Crosswalks
- Poster 13 — Education
- Poster 14 — Enforcement
- Poster 15 — Concept Screening
- Poster 16 — Roadway Departure

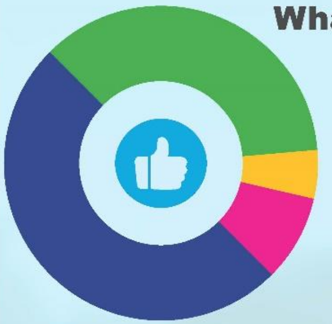
3.2.4 Comments from Second Outreach Meetings

The project team collected comments from the public and elected officials during the outreach meeting through comment cards. The period to submit comments was extended through January 15, 2020, allowing the public to submit comments using other venues such as mail, e-mail, phone, and the NPS PEPC web page.

The team collected 156 comments after the second public meeting, with 71 comment cards; 11 mailed letters, phone calls, or emails; and 74 comments posted in the PEPC portal. Figure 170 provides a summary of the comments received by topic area.

George Washington Memorial Parkway Second Public Meeting
What We Heard - Over 156 Comments from the Public

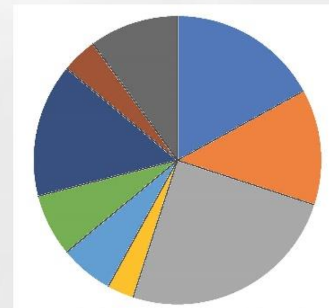
What We Heard



- 71 Comments During the Last Public Meeting
- 74 Comments through the PEPC Portal
- 11 Comments by Phone, Mail & E-Mail
- Comments by E-Mail

Comments by Proposed Solutions

17% Roundabouts
13% Road Diet
25% Turn Restrictions
3% Centerline Buffer
6% Lighting
7% Pavement Markings
15% Bike/Ped Crossings
4% Education
10% Maintenance



Major Concerns Identified by the Public

Item	Topic Area	Count	Percentage
1	Safety	30	
2	Police	28	
3	Pedestrian	28	
4	Signage	25	
5	Bicycle	15	
6	Traffic Lights	13	
7	Commercial Vehicles	8	
8	Sight Distance	8	
9	Flooding	8	
10	Tour Buses	8	
11	Bus	7	
12	Trees	7	
13	History	7	
14	Pot Holes	6	
15	Traffic Circle	3	
16	Ft. Belvoir 9, Stone Arch Bridge 8, East Blvd Dr. 5, Mt. Vernon 3, MVT 4		
	Total		

Comments by Intersection

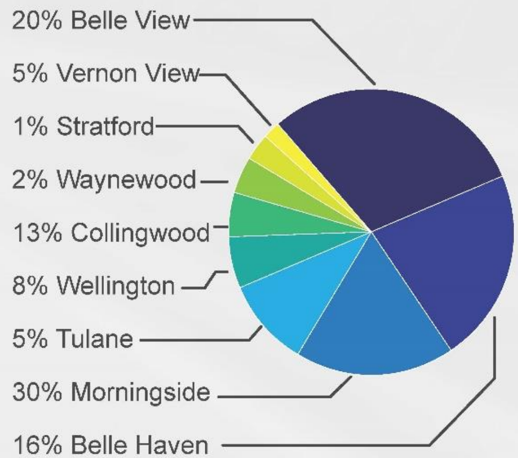


Figure 170. Feedback Received from the Second Public Outreach Meeting Held on December 3, 2019

4. CONCEPT DEVELOPMENT

This section details the process used to move from baseline input data (crash, traffic, and stakeholder, elected official and public input) informing potential safety and traffic solutions to a narrowed list of final retained candidate solutions. As no one single solution will solve all traffic safety issues at each intersection, several concepts remained after the screening process. The first section in this chapter discusses the context sensitivity of the Parkway, as it has significant weight in the solutions considered. The subsequent sections identify the categories of concepts, criteria used to evaluate concepts, and top potential solutions.

4.1 Context Sensitivity

Two factors strongly influenced the concepts that could be retained as potential solutions to the safety and traffic concerns along the Parkway: (1) significance of the Parkway and (2) the founding purpose of the Parkway (NPS 1946).

The following are Parkway design and characteristics:

- The Parkway is designed to provide scenic recreational driving experiences.
- Parkways were originally built for “recreational driving,” a popular activity during the period when vehicles were becoming more accessible to Americans. Many parkways were built in the 1930s, when the maximum speeds that vehicles could travel were 30 mph–40 mph.
- Parkways are designed for slower speeds than highways, thereby respecting the natural areas and preserving the unique visitor experience that is better appreciated by traveling at slower speeds.

The following are specific characteristics of the Parkway:

- The Parkway opened in 1932, when the automobile was becoming more common.
- The Parkway is a memorial to America’s first president, George Washington, and was designed to provide a safe and scenic transportation experience. It was not intended to serve commuters, as this was not a consideration at the time of founding.
- The landscape within the Parkway along the Potomac River to the Mount Vernon Estate defines this unique roadway.
- The Parkway is listed on the National Register of Historic Places, and the scenic vistas throughout the Parkway provide a unique visitor experience. This special status was given to the Parkway to protect unique places and cultural resources of national heritage and limits the amount and type of physical changes that can be made. Unlike most other roadways maintained by state and local governments, proposed changes to the Parkway require a formal review of Section 106 of the National Historic Preservation Act before starting any construction, repair, and ground/ visual disturbances.
- The Parkway provides habitat for local wildlife, including many rare, threatened, and endangered plant and animal species.

Key themes of the context sensitivity associated with the Parkway:

- Honor the legacy of George Washington

- Provide recreational opportunities
- Maintain ceremonial entrance
- Provide transportation
- Preserve views and vistas
- Connect historic sites, scenic overlooks, memorials, monuments, stories, and people

For the Parkway roadway design features, the implications of the context sensitivity suggest the following:

- There should be a limited number of intersections (i.e., access points).
- There should be vegetative transitions between the Parkway and woodlands.
- The roadway should follow the natural contours of the landscape.
- The rural feel of the Parkway, even though it is located in a highly urbanized area, should be retained.
- The road should remain concrete.
- The curb should be mountable.
- The guardrails should remain rustic (they have been safety tested by the Federal Highway Administration).
- The treatments of headwalls and swales should remain stone.
- Tree plantings and groves contribute to memorialization.
- Frequent pull-offs exist on the Parkway.
- There is limited sign clutter (e.g., roadway signs, billboards, business notifications).

The tie between key Parkway themes and roadway design features is shown in Figure 171. A motorist, whether using the Parkway for tourism or commuter purposes, can feel and see all of these features that make the Parkway a national treasure.

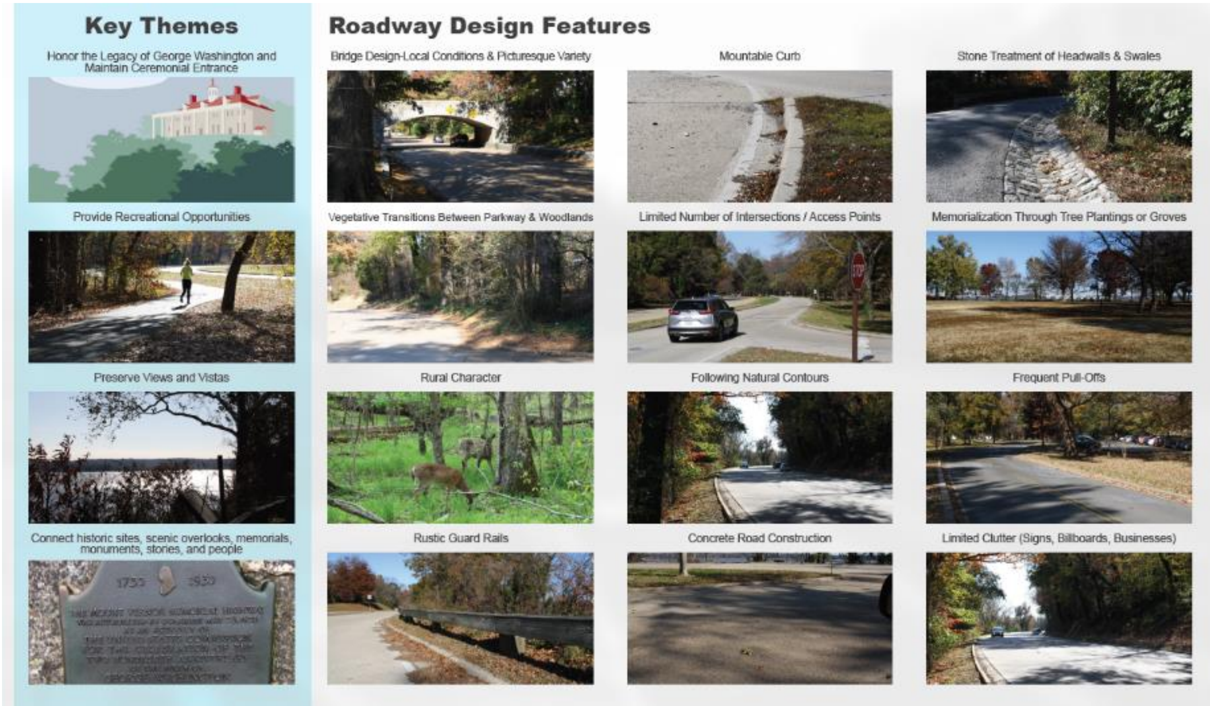


Figure 171. Roadway Features Tied to Key Parkway Themes

4.2 Concept Screening Process

The research team collected data on daily traffic volumes and peak hour intersection traffic movements (e.g., left turns) for the focus intersections identified previously. Team members also analyzed crash data and conducted several field visits of the corridor. All of this data, along with input from the elected officials, stakeholders, and the public, identified 89 potential concepts (see "Appendix G: Concepts") that could be applied to the intersections in the corridor to address safety and traffic concerns.

These alternatives were divided into nine categories:

1. Driver Behavior (A)
2. Signs and Markings (B)
3. Operational Changes (C)
4. Multi-Modal Improvements (D)
5. Geometric Modifications (E)
6. Roadway Departure Countermeasures (F)
7. Maintenance (G)
8. Environmental (H)
9. Fort Belvoir (I)

To funnel the alternatives into manageable possibilities, several filters were applied. During the first prescreening, potential solutions related to aspects outside of the scope of the project (e.g., large vehicles hitting the stone arch bridge; recommendations related to locations beyond the study limits/study intersections) were removed. Next, the context-sensitivity factors described previously were considered. Potential solutions (e.g., traffic signals) that were not consistent with the context-sensitivity considerations of this nationally significant asset were also removed.

For the final screening, the project team identified the following criteria to evaluate the alternatives:

1. Traffic Safety Benefit
2. Law, Policy, and Regulatory Compatibility
3. Implementation Timeline
4. Traffic Operational Benefits
5. Supporting Analysis
6. Construction Cost
7. Responsible Agency for Implementation
8. Right-of-Way (ROW)
9. Community Support

The team assigned points to each of the items in whole number increments. As safety was the driving force behind the current study, the team identified it as a priority and assigned it the highest number of potential points in the evaluation process. Figure 172 summarizes this process.

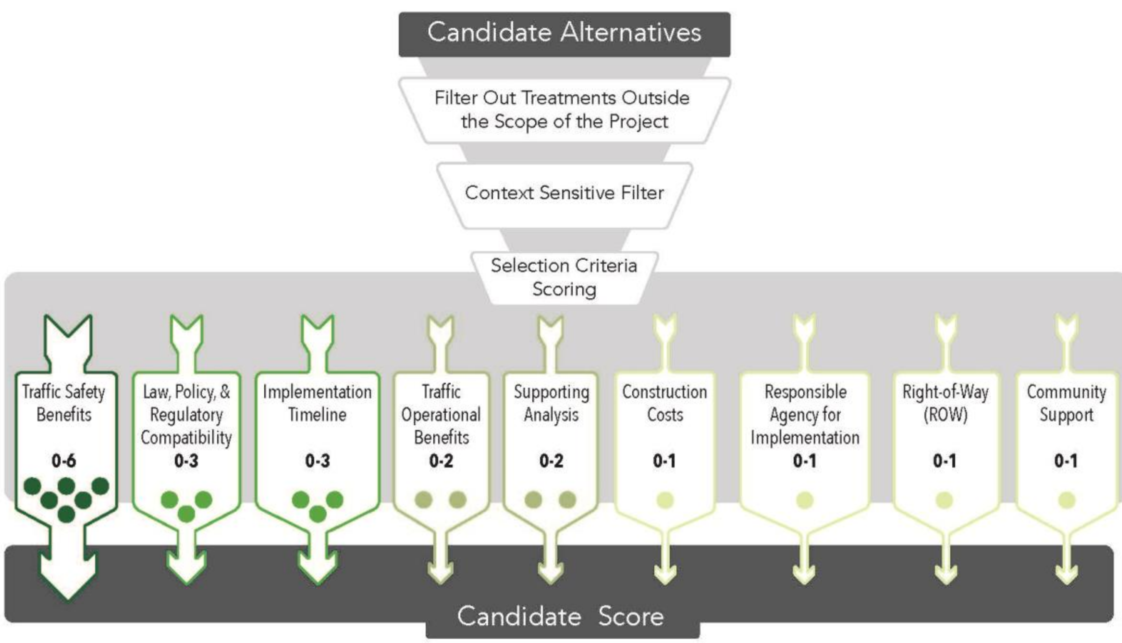


Figure 172. Concepts Screening Process

The team assigned values to each treatment in whole number increments. Within each category, the team gave treatments an estimated value based on how well the proposed treatment was expected to meet the desired outcome. Higher values indicate treatments that are more desirable.

Traffic Safety Benefit (0 to 6). If the proposed treatment is known to have a highly correlated impact on traffic safety, it was given a larger value, like 6. If there was no known or little expected impact, it was given a 0. If the results were expected to be variable, a 2, 3, or 4 was assigned to the alternative.

Law, Policy, and Regulatory Compatibility (0 to 3). If the alternative was in conflict with an existing law, policy, or regulation, it was given a 0. If it fit within or did not require changes to standing law, policy, or regulation, it was given a 3. If there was some flexibility or ambiguity, it received a 1 or 2. The Parkway provided input regarding the assigned value.

Implementation Timeline (0 to 2). Alternatives that were anticipated to require further engineering studies or design, or would need extensive permitting, long construction durations, and so forth, were given 0s. Concepts that were anticipated to be more readily implemented in the short term based on the urgency of the solutions needed were given 2s. This criterion reflected Parkway staff's desire to provide some solutions in the immediate future to address the public's concern.

Traffic Operational Benefits (0 to 2). If an alternative was expected to make the traffic operate more efficiently, it was given a 2. If it was anticipated to negatively impact the traffic movement, it was given a 0.

Supporting Analysis (0 to 2). For those alternatives that were anticipated to need a significant level of additional analysis, a 0 was given. If some analysis was needed but it was not estimated to take a significant amount of time, the study was given a 1. If there was little to no additional analysis needed, it was given a 2.

Construction Costs (0 to 1). For an alternative that was anticipated to be costly to construct from a qualitative perspective, a 0 was given. Otherwise, a 1 was given.

Responsible Agency for Implementation (0 to 1). If the Parkway team could easily implement the alternative and could drive the result, a 1 was given. If cooperation and buy-in were needed from another entity (e.g., retiming a traffic signal owned by another entity), a 0 was given, as sometimes coordination efforts or acceptance of efforts can be challenging. Where Parkway staff could lead the implementation but would require a significant amount of time either for the implementation or for staff overtime, a 0 was given, as it is anticipated that due to already limited staff, this would be an unlikely solution.

Right-of-Way (ROW) (0 to 1). If an alternative might need additional rights-of-way, it was given a 0. If an alternative could be implemented within the existing rights-of-way, a 1 was given.

Community Support (0 to 1). If the public provided a "yes," "likely," or "some" positive responses (without negative responses) to the alternative during the first outreach meeting (July 2019), the alternative was given a 1. If the comments provided by the public indicated a lack of support, it was given a 0.

Overall, the top six concepts (with four tied for third place) retained after the screening process are:

1. *Manual on Uniform Traffic Control Devices* Compliant Warning Signs (18 pts) [B]
2. Improved Delineation (17 pts) [B]
3. Commercial Vehicle/Educational Campaign (16 pts) [A]
4. Speed Public Awareness Campaign (16 pts) [A]
5. Distracted Driving Campaign (16 pts) [A]
6. Pedestrian Safety Public Awareness Campaign (16) pts) [A]

The following alternatives represent the top three results in each category. (*Note:* For those categories with less than three identified, the other potential alternatives were removed by filters during the preliminary screening; the Driver Behavior category has a four-way tie for the top three.)

4.2.1 Driver Behavior (A)

1. Commercial Vehicle/Educational Campaign (16 pts)
2. Speed Public Awareness Campaign (16 pts)
3. Distracted Driving Campaign (16 pts)
4. Pedestrian Safety Public Awareness Campaign (16 pts)

4.2.2 Signs and Markings (B)

1. *Manual on Uniform Traffic Control Devices* Compliant Warning Signs (18 pts)
2. Improved Delineation (17 pts)
3. Add Pavement Crosshatch Markings and Signs to Not Block Intersections (14 pts)

4.2.3 Operational Changes (C)

1. Reduced Speed Limits (14 pts)
2. Turn Prohibition (13 pts)
3. Corridor (Access) Management (10 pts)

4.2.4 Multi-Modal Improvements (D)

1. Pedestrian Crosswalks (12 pts)
2. Pedestrian Crossing with rectangular rapid flash beacon (RRFB) (10 pts)
3. Pedestrian Warning Application (App) (10 pts)

4.2.5 Geometric Modifications (E)

1. Remove Intersection (11 pts)
2. Roundabouts (9 pts)
3. Road Diet (e.g., Imbalanced Typical Section w/2 Lanes in One Direction and 1 Lane in the Other) (9 pts)
4. Spot Widen/Add Splitter Islands (9 pts)
5. Channelize Right-Turns with ‘Pork Chop’ Island (9 pts)

4.2.6 Roadway Departure Countermeasures (F)

1. Install Lighting (14 pts)
2. Centerline Buffer Area (10 pts)
3. Roadside Design Improvements at Curves (9 pts)
4. Longitudinal Rumble/Mumble Strips (9 pts)

4.2.7 Maintenance (G)

1. Update Existing Striping (16 pts)
2. Fix the Current Road Surface (15 pts)
3. Trim Trees/Shrubs/Grass/Edging (12 pts)

4.2.8 Environmental (H)

1. Drainage Study (6 pts)
2. Arborist Study (5 pts)

4.2.9 Fort Belvoir (I)

1. Educational Event at Fort Belvoir

4.3 Top Concepts

Solutions reflected in the overall top five concepts were drawn from the categories of Driver Behavior (A) and Signs and Markings (B). However, as suggested by the "3E model" (Enforcement, Education, and Engineering), safety requires a multifaceted effort. Therefore, the team used the "3E Model," which is a preferred approach to addressing traffic safety among many practitioners, because it includes pedestrian and bicyclist use (Brookshire, et al. 2016). Using the 3E categories, the top concepts are:

4.3.1 Enforcement

1. Commercial Vehicle Enforcement/Educational Campaign (16) [A7]
2. Law Enforcement Push on Speed, Driving Under the Influence, and Distracted Driving (15) [A5]
3. Automated Speed Enforcement (Speed Cameras) (9) [A8]
4. Crowdsource/Citizen Reporting Application (5) [A11]

4.3.2 Education

1. Speed Public Awareness Campaign (16) [A1]
2. Pedestrian Safety Public Awareness Campaign (16) [A4]
3. Distracted Driving Public Awareness Campaign (16) [A3]
4. Dynamic Message Signs (DMS) (13) [A10]
5. Infographic on Time vs. Speed (11) [A12]
6. Neighborhood Educational Event (10) [A6]
7. Parkway vs. Road Public Awareness Campaign (8) [A2]
8. Website for Public Comments/Concerns (8) [A14]
9. Speed Management Plan (8) [A13]
10. Educational Event at Fort Belvoir (7) [I1]

4.3.3 Engineering

4.3.3.1 *Signing and Markings*

1. *Manual on Uniform Traffic Control Devices* Compliant Warning Signs (18) [B1]
2. Improved Delineation (17) [B4]
3. Upgrade Existing Striping (16) [G3]
4. Add Pavement Crosshatch Markings and Signs to Not Block Intersections (14) [B5]
5. Turn Lane Pavement Arrows (13) [B2]
6. Speed Activated Feedback Sign (11) [B8]
7. Centerline Buffer Area (10) [F7]

4.3.3.2 *Multi-Modal*

1. Pedestrian Crosswalks (12) [D2]
2. Pedestrian Warning Application (App) (10) [D7]
3. Pedestrian Crossing with a RRFB (10) [D1]
4. Pedestrian Medians/Crossing Islands (8) [D4]
5. Add Capital Bikeshare Locations (8) [D11]
6. Transit Study (8) [D5]

4.3.3.3 *Maintenance and Environment*

1. Fix the Current Road Surface (15) [G2]
2. Trim Trees/Shrubs/Grass/Edging (12) [G1]
3. Drainage Study (5) [H2]
4. Arborist Study (5) [H1]

4.3.3.4 *Operational Changes*

1. Reduced Speed Limits (14) [C3]
2. Turn Prohibition (13) [C6]
3. Adjust Signal Timing on Route 1 (6) [C7]

4.3.3.5 *Roadside Design Improvements*

1. Install Lighting (14) [F4]
2. Roadside Design Improvement at Curves (9) [F1]

4.3.3.6 *Geometric Modifications*

1. Remove Intersection (11) [E15]
2. Corridor (Access) Management (10) [C5]
3. Roundabout (9) [E2]
4. Road Diet (e.g., imbalanced typical section with two-lanes in one direction and one lane in the other) (9) [E4]
5. Spot Widen/Add Splitter Islands (9) [E8]
6. Channelize Right-Turns with 'Pork Chop' Island (9) [E11]
7. Longitudinal Rumble/Mumble Strips (9) [F2]
8. Spot Left-Turn Lane Installation (8) [E6]
9. Reduced Left-Turn Conflict Intersections (8) [E10]
10. Right-Turn Lanes (7) [E9]
11. Speed Hump or Speed Table (6) [C11]
12. Two-Way Left-Turn Lane Installation (5) [E5]

4.4 Concepts Summary

Of the 89 original alternatives, 48 potential alternatives came to the forefront as potential solutions using the 3E model approach (engineering, education, and enforcement). A single solution will not solve all of the safety and traffic issues at the intersections under consideration within this corridor. Rather, safety and traffic issues will be improved by looking at each intersection, considering the refined menu of options, and treating the conditions identified based on the data collected.

This page intentionally blank.

5. ENGINEERING, EDUCATION, AND ENFORCEMENT

This section discusses and provides details about the major engineering measures used for addressing the study intersections along the Parkway corridor. These measures are *conceptual designs*. The process of developing and evaluating the conceptual designs was intended to further narrow the number of viable solutions for final recommendations, as not all concepts presented were found to be viable. Topics covered include:

- Access management
- Road diets
- Roundabouts
- Refuge islands for pedestrian and bicyclist safety

These concepts and their applications offer design flexibility and address safety while maintaining traffic operations. The following sections describe the benefits of the concepts and how these attributes can assist in providing context-sensitive solutions within the study area. Any concept that advances to the final design is subject to National Environmental Policy Act and National Historic Preservation Act Section 106 compliance and documentation of all resource impacts.

5.1 Access Management

5.1.1 Description

Access management countermeasures are effective and strategic applications for controlling traffic operations at the entry and exit points along a roadway. Access management techniques include numerous methods such as (USDOT 2017)

- driveway closure, consolidation, or relocation
- limited-movement designs for side streets or driveways (such as right-in/right-out only)
- raised medians that preclude across-roadway movements
- intersection designs such as roundabouts or those with reduced left-turn conflicts (e.g., J-turns, median U-turns)
- turn lanes (i.e., left only, right only, or interior two-way left)
- lower speed one-way or two-way off-arterial circulation/ frontage roads

Maneuvers at intersections can be controlled, restricted, and redirected by access management operations through geometric design and/or traffic control device assignments.

Access management measures are proven in restricting high-crash maneuvers along an arterial or limited access roadway. This is especially noteworthy regarding left turns into the northbound or southbound Parkway travel way, as well as in leaving the Parkway via a left turn and crossing against oncoming, opposite flow Parkway traffic. Table 48 lists potential locations for these applications.

Table 48. Potential Access Management Location Applications

Intersecting Roadway	Lefts to the Parkway, Northbound	Lefts from the Parkway, Northbound	Lefts from the Parkway, Southbound
Belle Haven Road	√	√	
Belle View Boulevard	√	√	
Tulane Drive	√	√	
Morningside Lane	√	√	
Wellington Road	√	√	
Collingwood Road	√	√	√
Waynewood Boulevard	√	√	
Vernon View Drive	√	√	
Stratford Lane	√	√	√

Access management options can be used to eliminate/restrict these left turns or reduce the areas of conflict. Examples of such measures are illustrated in Figure 173 through Figure 176 for the following intersections: Morningside Lane (right-in/right-out channelization), Collingwood Road (Z-median), Belle Haven Road (channelization), and Belle View Boulevard (median U-turn). Please note that these treatments are shown on some intersections where they may not be the best solution (e.g., the Z-median on Collingwood Road); the intent of the following is to demonstrate conceptually what such a treatment would look like. While signing can be used to restrict motorists from turning left, it is often necessary to use channelized, raised barriers or bollards to prevent the disregard of traffic control guidance measures. For right-in and right-out or Z-median applications, the restricted movement would be rerouted to a designated downstream U-turn location with supplemental U-turn signs for motorist guidance.

5.1.2 Expected Safety Benefits

The anticipated safety benefit of access management options would be an elimination of all left turn crashes at locations where the respective movement is restricted.

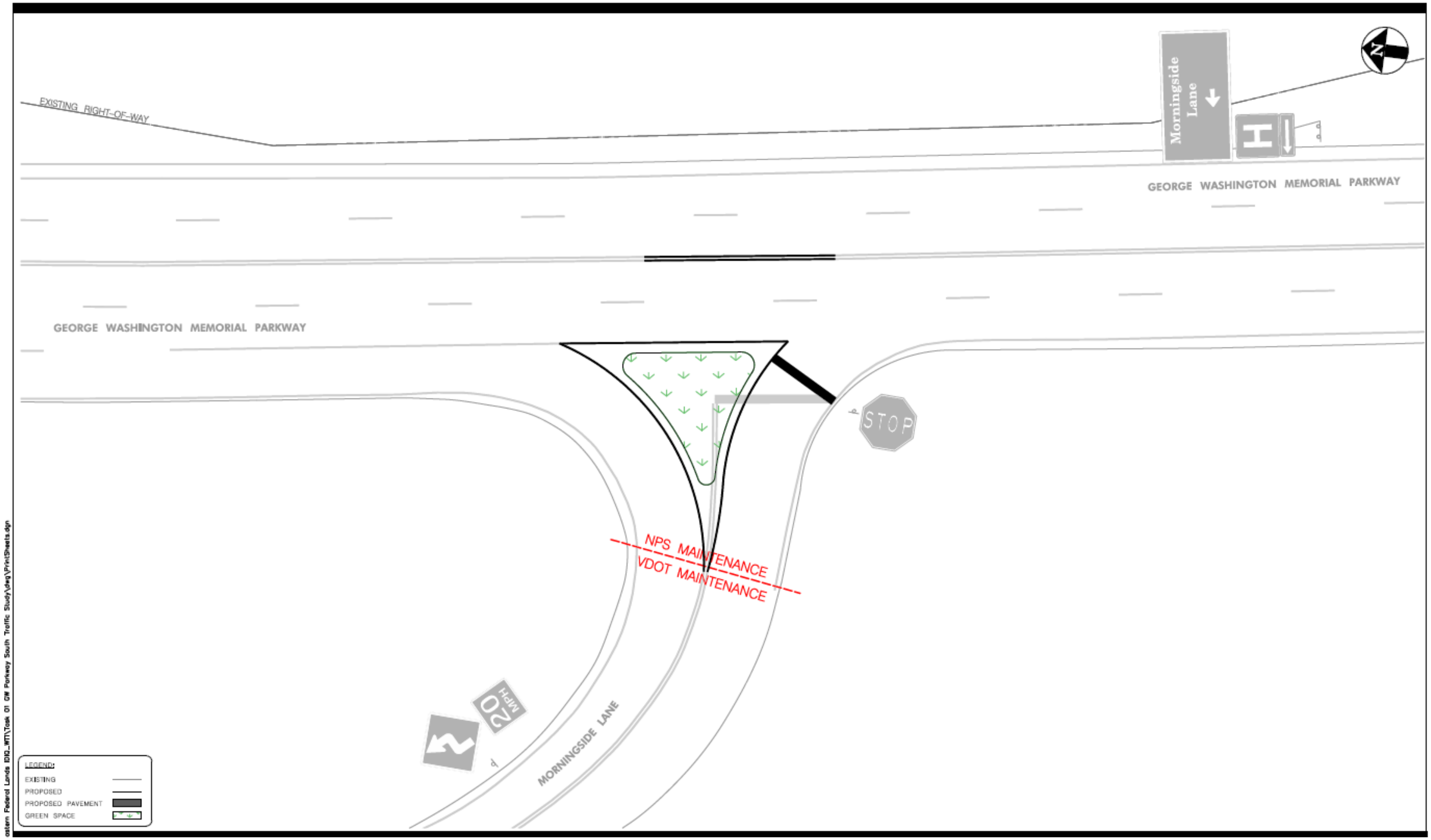


Figure 173. Example Conceptual Morningside Lane Right-In and Right-Out Access Management

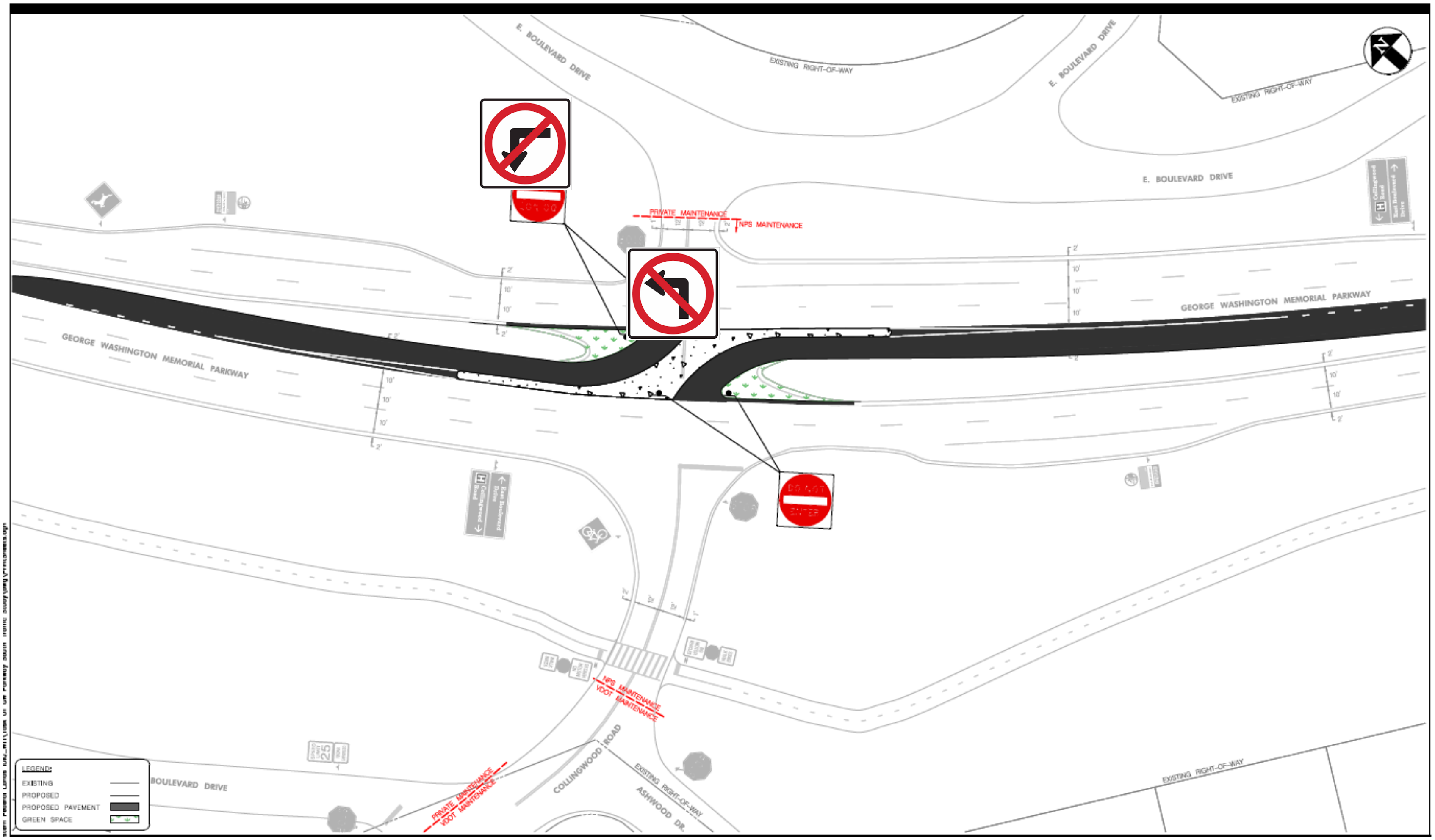


Figure 174. Example Conceptual Z-Median Access Management at Collingwood Road

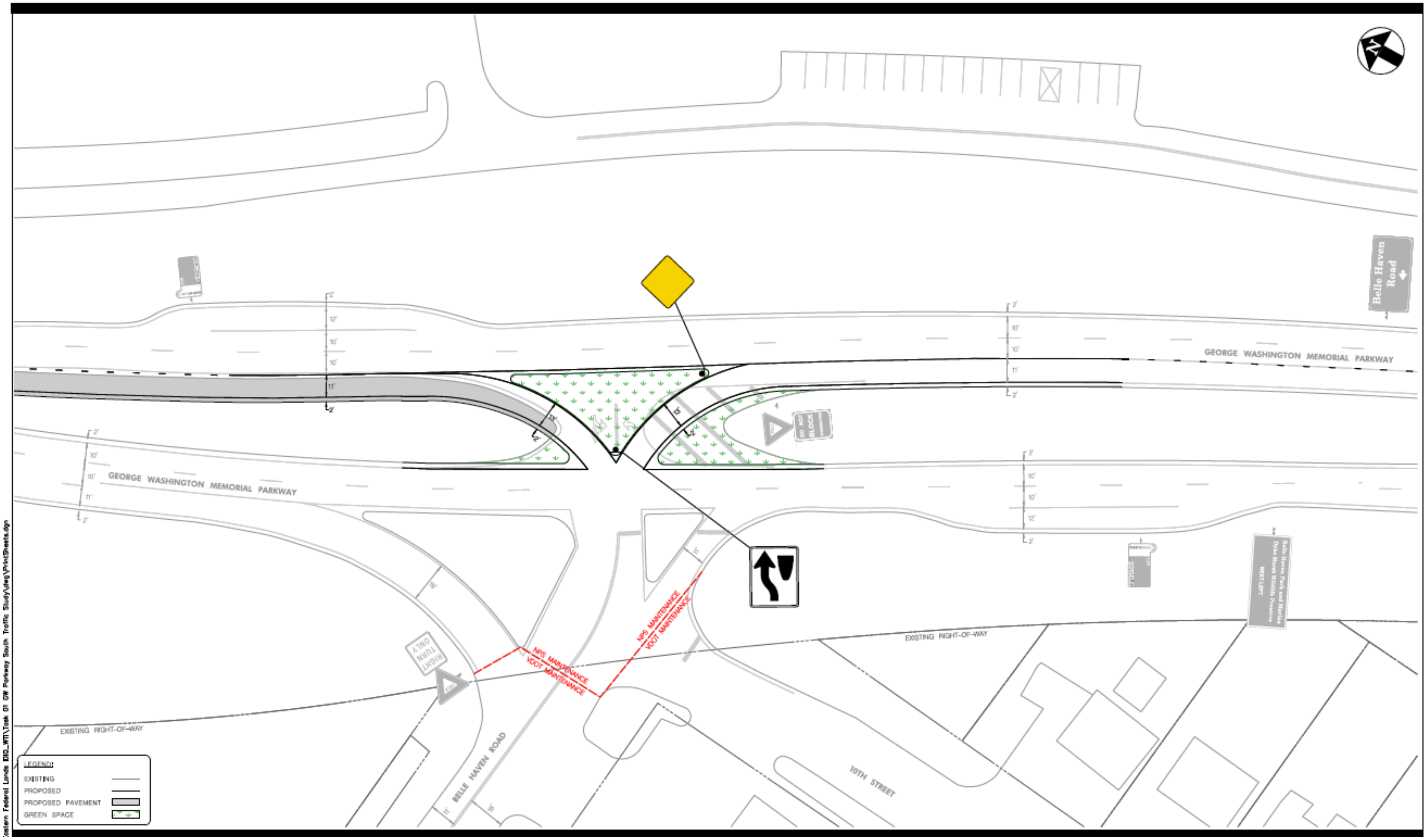


Figure 175. Example Conceptual Belle Haven Road Channelization

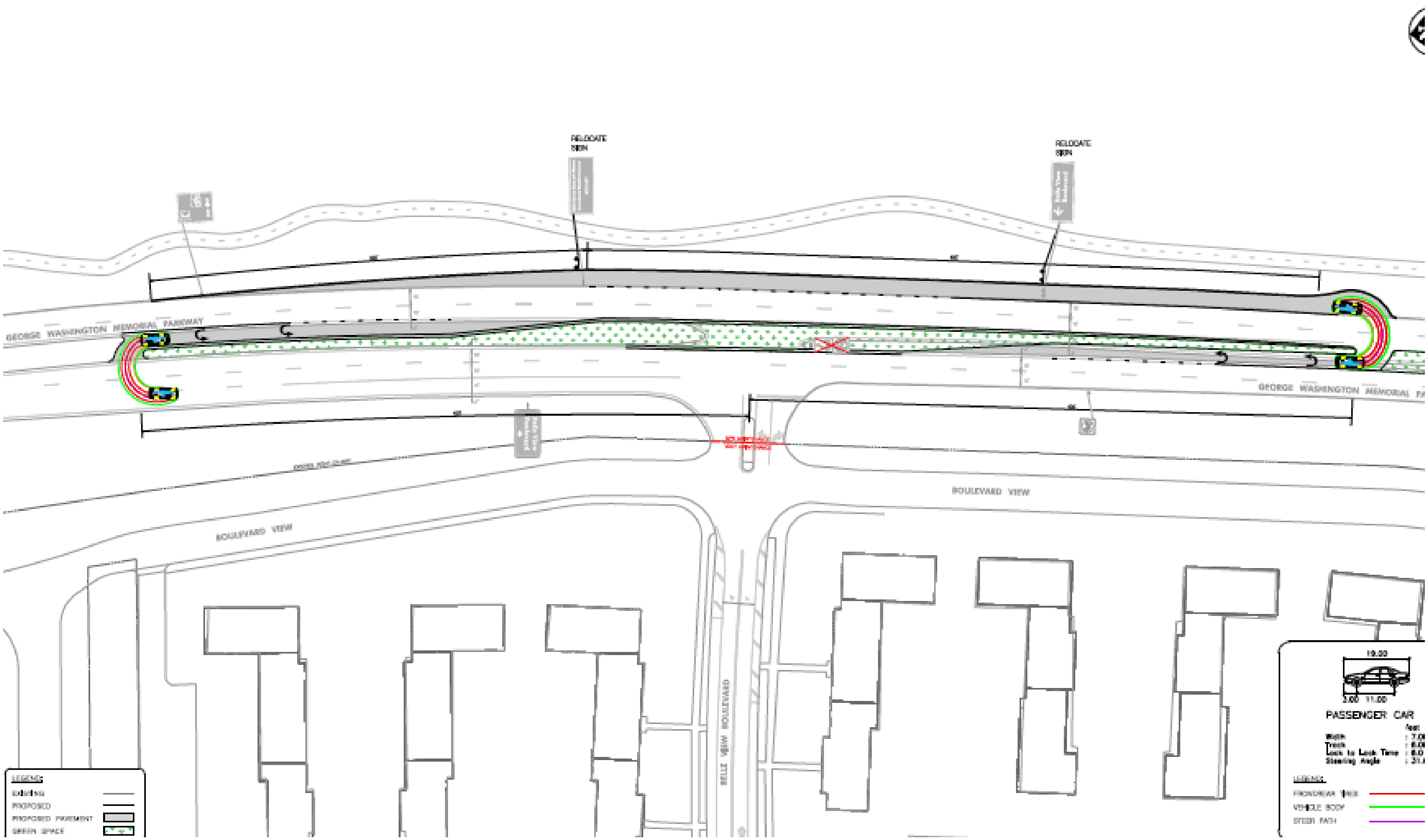


Figure 176. Example Conceptual Belle View Boulevard Median U-Turn

5.2 Potential Access Management Applications

One variation of the access management concept is to use existing adjacent intersections along the Parkway for U-turn movements in locations where there is insufficient spacing to provide a separate U-turn movement on the Parkway itself. The project team prepared conceptual designs for these options. A potential application would be to allow eastbound left turns from Belle Haven Road for drivers heading northbound on the Parkway, using the Belle Haven Marina access intersection, shown in Figure 177. To further assess the feasibility of this movement, the turning templates for buses and passenger vehicles were examined to determine the footprint required for the U-turn maneuver, shown in Figure 178 and Figure 179. Buses would need to be restricted from this maneuver, and passenger cars would need a northbound acceleration lane to complete the maneuver.

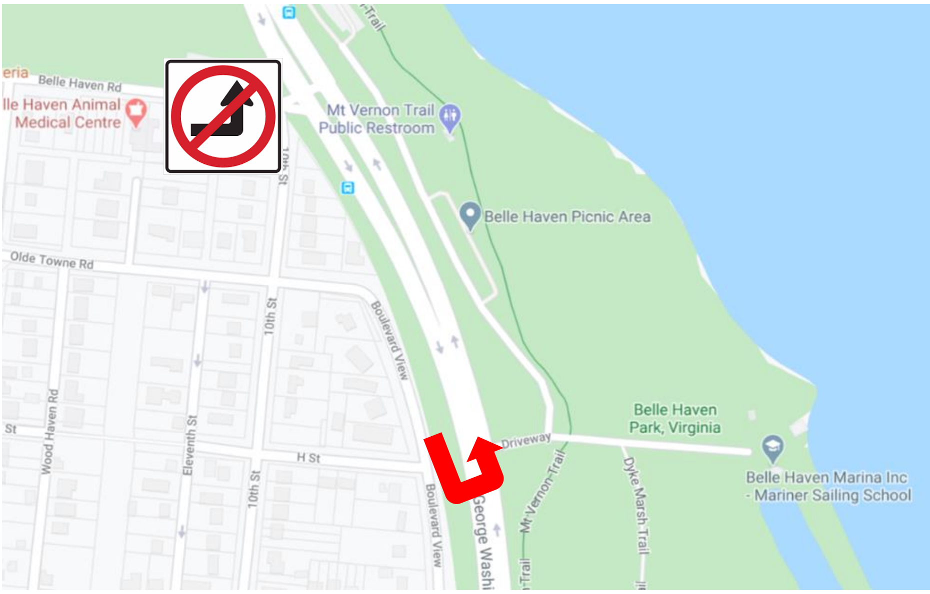


Figure 177. Example Potential Belle View Boulevard Eastbound Left-Turn Rerouting

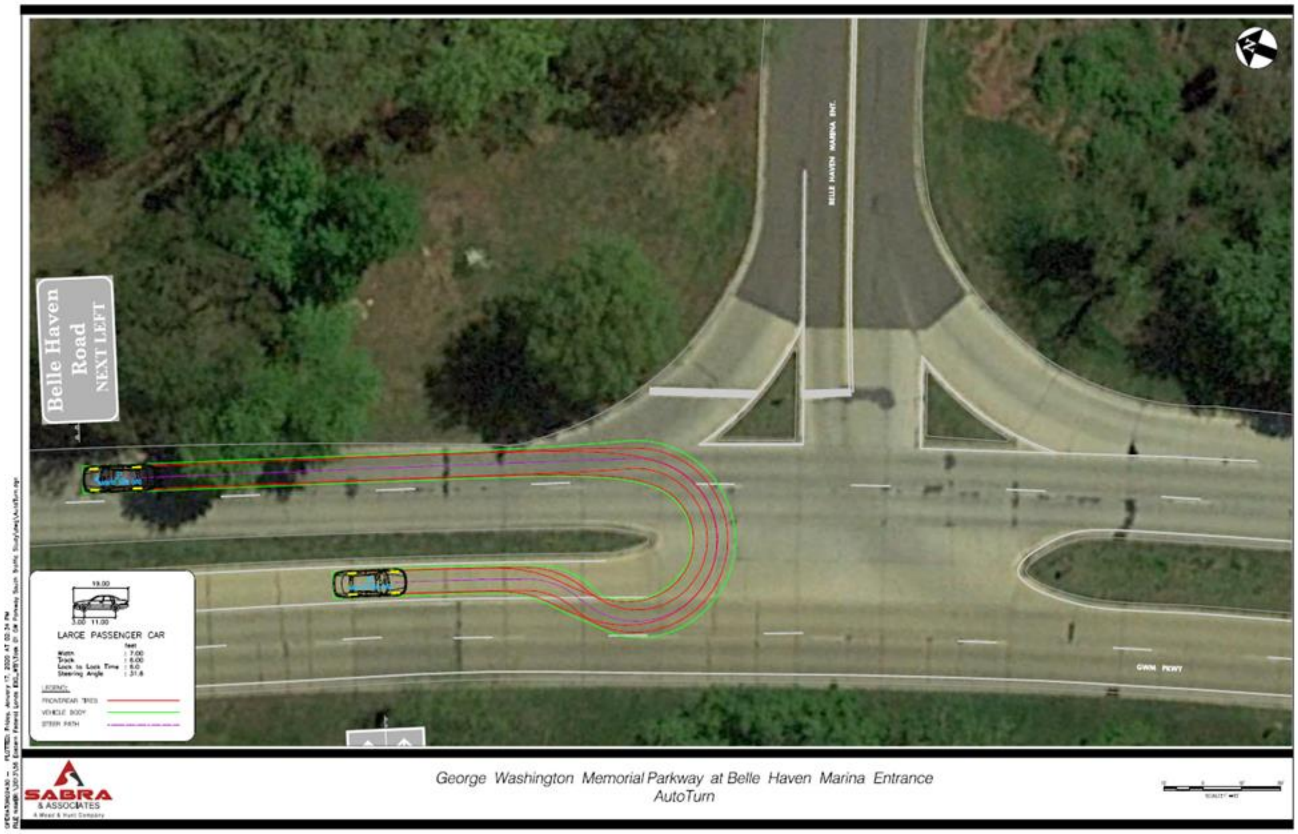


Figure 178. Example Passenger Vehicle Southbound U-Turn Radius at Belle Haven Marina

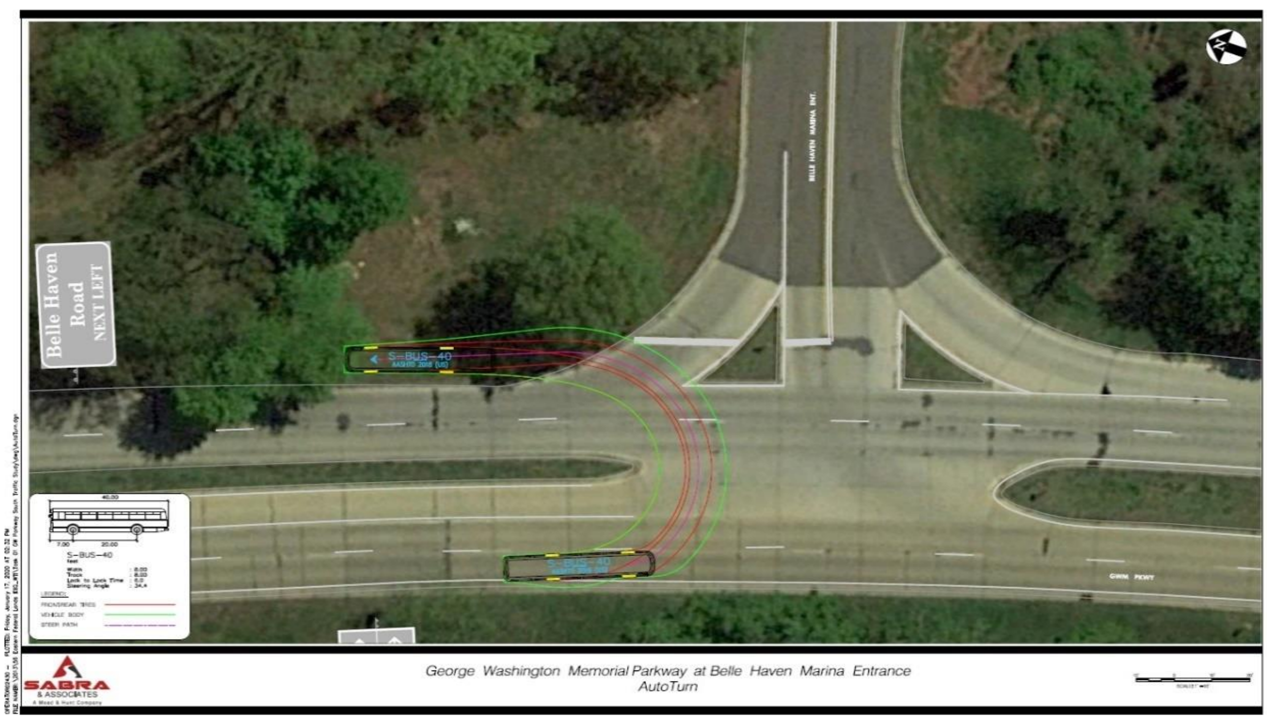


Figure 179. Example Bus U-Turn Radius at Belle Haven Marina

Figure 180 and Figure 181 illustrate the conceptual design of an acceleration lane to allow for the U-turn maneuver at Belle Haven Marina. A layout is shown for two design speeds — 35 mph and 45 mph. A higher design speed would require a longer acceleration lane, thus increasing the amount of impervious surface. Drainage would have to be installed. Some trees would have to be removed. The determination of acceleration lane length and full limits of disturbance need for retaining walls or other minor structures will be made based on a final determination of design and operating speeds for this segment of the Parkway.

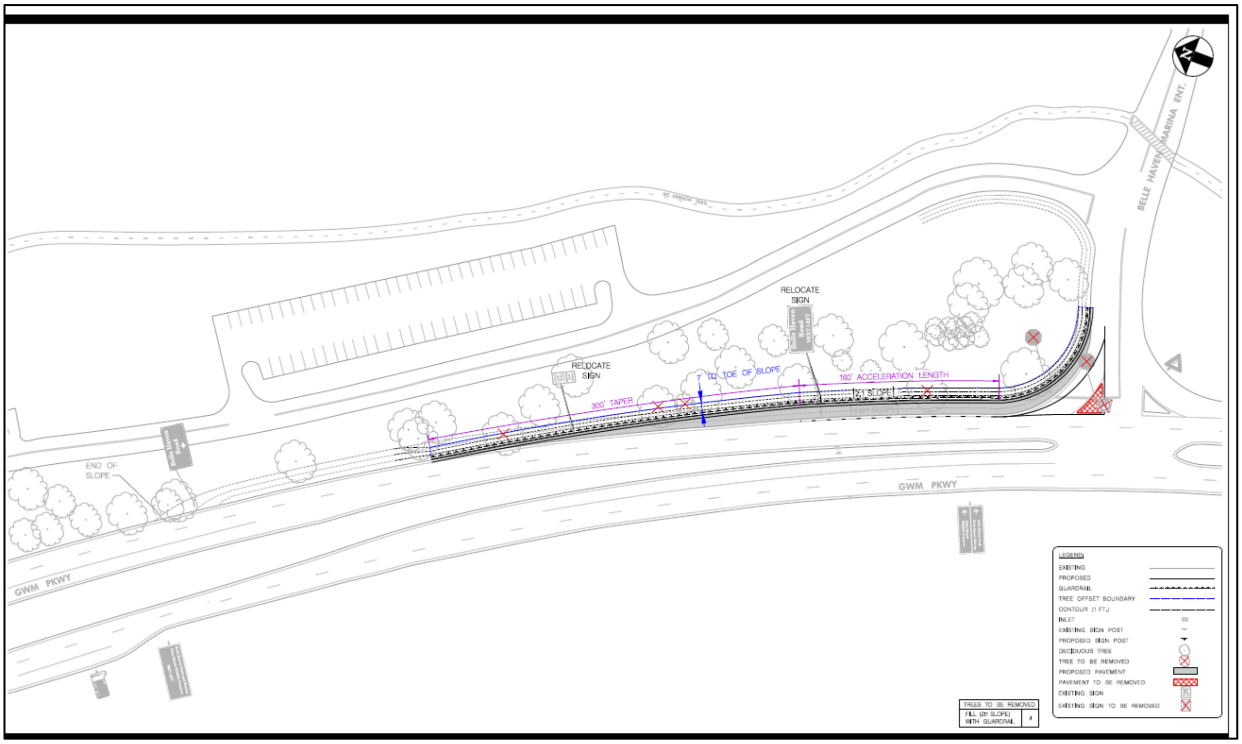


Figure 180. Example Belle Haven Marina U-Turn Acceleration Lane with 35 mph Design Speed

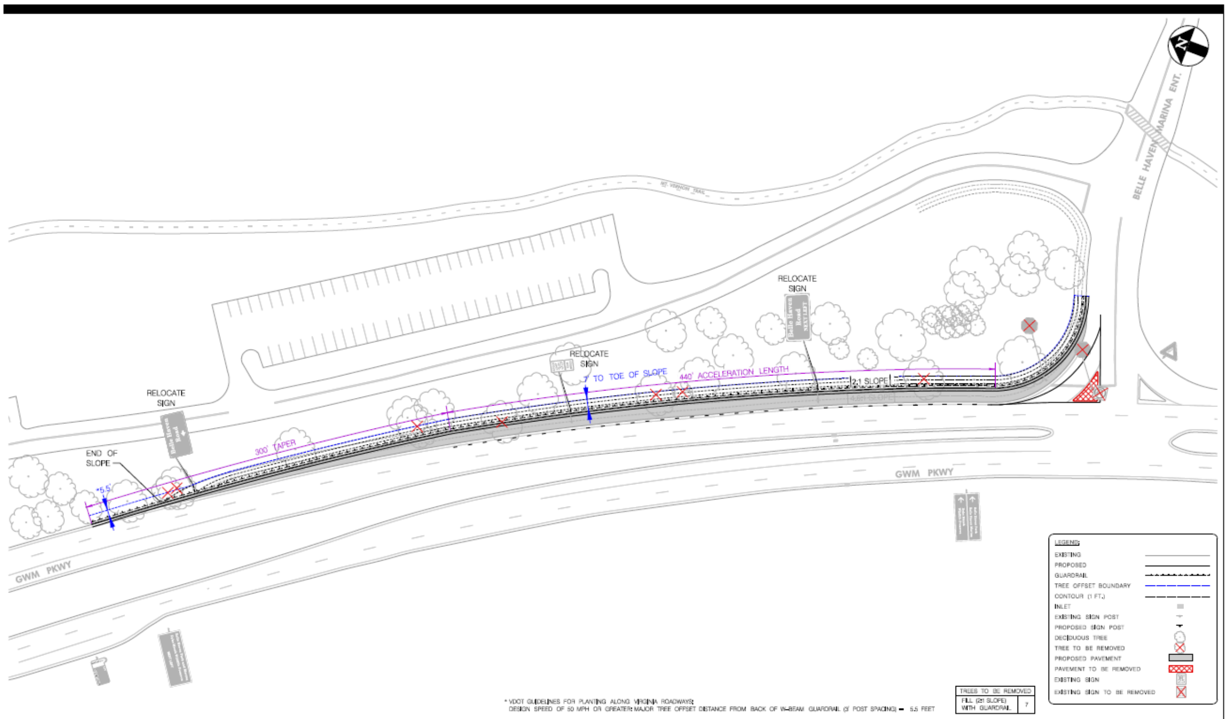


Figure 181. Example Belle Haven Marina U-Turn Acceleration Lane with 45 mph Design Speed

To assess the traffic operation's impact of the diverted left-turn movement, a capacity analysis was performed at the intersections of Belle View Boulevard and Belle Haven Marina entrance to evaluate delay, level of service, and volume-to-capacity ratios for all movements (Error! Reference source not found.). The results indicate that the diverted left-turn movement could be accommodated as a U-turn at Belle Haven Marina without excessive delays, as shown by the mostly green level of service results. A field review was also performed, and adequate sight distance is available for all movements at the Belle Haven Marina Entrance.

Table 49. Capacity Summary Based on Left Turn Restrictions at Belle Haven Road and SB U-Turns at Marina Entrance (Build Condition)

Node	Intersection	Approach	Movement	U-Turn Build Conditions a.m. (p.m.)		
				Delay	LOS	V/C
1	The Parkway and Belle Haven Road	Eastbound	Overall	12.4 (30.3)	B (D)	0.38 (0.64)
			Right	12.4 (30.3)	B (D)	0.38 (0.64)
		Northbound	Overall	1.6 (14.0)	A (B)	0.55 (0.87)
			Left	11.1 (75.3)	B (F)	0.35 (0.87)
			Through	0.0 (0.0)	A (A)	0.00 (0.00)
		Southbound	Overall	0.0 (0.0)	A (A)	0.20 (0.65)
			Through	0.0 (0.0)	A (A)	0.00 (0.00)
			Right	0.0 (0.0)	A (A)	0.00 (0.00)
1.A	The Parkway and the Marina Entrance	Westbound	Overall	69.6 (46.6)	F (E)	0.07 (0.05)
			Left	144.0 (98.6)	F (F)	0.07 (0.05)
			Right	19.9 (11.9)	C (B)	0.01 (0.01)
		Northbound	Overall	0.0 (0.0)	A (A)	0.58 (0.29)
			Through	0.0 (0.0)	A (A)	0.58 (0.29)
			Right	0.0 (0.0)	A (A)	0.00 (0.00)
		Southbound	Overall	0.1 (0.0)	A (A)	0.24 (0.69)
			Left	17.7 (10.2)	C (B)	0.01 (0.00)
			Through	0.0 (0.0)	A (B)	0.24 (0.69)

5.3 Road Diets

5.3.1 Description

A road diet is a removal, reduction, or repurposing of existing travel lanes on a roadway segment to another use. Road diets are low-cost options that can yield substantial benefits, including enhanced safety, improved mobility, and the reclaiming of space for a reallocation of other uses, such as turn lanes, pedestrian refuge islands, and increased shoulder widths. Road diet roadway reconfigurations have been used for more than three decades across the US. The traditional road diet is the conversion of a four-lane, undivided road to a three-lane, undivided road made up of two through lanes and a center two-way left-turn lane (FHWA 2014). However, there are other road diet roadway options, such as reconfigurations from four lanes to five lanes with a center turning lane. This can be accomplished by reducing lane widths within the same right-of-way or unbalanced cross-sections such as two through lanes in one direction, a center turning lane, and a single through lane in the opposite direction.

Figure 182 shows a graphical comparison of the only three practical configurations that would allow removing a travel lane and repurposing it as a turn lane. These configurations can be implemented on the Parkway where there is not currently a median.

Figure 182. Example Road Diet Concepts

A rendering of a road diet treatment for option 2 at Morningside Lane is shown in Figure 183.

5.3.2 Expected Safety Benefits

Road diets provide crash reductions of 25%–47% (four lanes to three lanes with a center turn lane) (USDOT 2017). The Federal Highway Administration deemed road diets and other roadway reconfigurations as “proven safety countermeasures” and promoted them as a safety-focused alternative cross section to a four-lane undivided roadway (USDOT 2017). Road diets have been demonstrated to reduce all crashes from 19% to 47%. Specifically, the introduction of a left-turn lane reduces rear-end and left-turn crashes. In addition, because of the two-stage crossing, angle crashes can be reduced for the side street. Pedestrians benefit because they don’t have to cross as many lanes. Road diets would also provide space for a pedestrian refuge island. Because of the reduction in the number of lanes, traffic is calmed and speeds become more consistent. Overall, the implementation of a road diet creates “a more community-focused, ‘Complete Streets’ environment that better accommodates the needs of all road users” (USDOT 2017).

Figure 183. Example Rendering of Option 2 Road Diet at Morningside Lane

5.3.3 Potential Road Diet Location Applications

The potential locations for road diet applications are focused on the segments of the corridor where the roadway is undivided (i.e., no median exists). As shown in Table 50, road diets can be considered at several intersections along the corridor, including Morningside Lane, Wellington Road, Waynewood Boulevard, and Vernon View Drive.

Table 50. Road Diet Application Locations

Intersecting Roadway	Road Diet
Belle Haven Road	
Belle View Boulevard	
Tulane Drive	
Morningside Lane	√
Wellington Road	√
Collingwood Road	
Waynewood Boulevard	√
Vernon View Drive	√
Stratford Lane	

To assess the traffic impact of a potential road diet, the project team performed a capacity analysis at each intersection for each road diet configuration. Table 51 summarizes the results, including LOS and V/C. The results indicate that the unbalanced road diet (option 2 — southbound lane reduction) performs the best, improving delays for vehicles on the entering side streets over existing conditions due to the ability to execute a left-turn movement in two stages using the center turn lane.

Table 51. Capacity Summary Based on a Road Diet along the Parkway (HCM 2000)

Node	Intersection	Approach	Option 1 – NB Direction Road Diet			Option 2 – SB Direction Road Diet			Option 3 – Road Diet Both Directions		
			a.m. (p.m.)			a.m. (p.m.)			a.m. (p.m.)		
			Delay	LOS	V/C	Delay	LOS	V/C	Delay	LOS	V/C
4	The Parkway and Morningside Lane	Eastbound	102.0 (23.7)	F (C)	0.94 (0.33)	20.2 (22.6)	C (C)	0.42 (0.32)	65.0 (21.4)	F (C)	0.79 (0.30)
		Northbound	0.0 (0.1)	A (A)	0.91 (0.37)	0.0 (0.1)	A (A)	0.46 (0.19)	0.0 (0.1)	A (A)	0.91 (0.37)
		Southbound	0.0 (0.0)	A (A)	0.14 (0.32)	0.0 (0.0)	A (A)	0.28 (0.65)	0.0 (0.0)	A (A)	0.28 (0.65)
5	The Parkway and Wellington Road	Eastbound	44.7 (17.9)	E (C)	0.65 (0.15)	18.1 (19.4)	C (C)	0.36 (0.16)	35.0 (18.2)	D (C)	0.57 (0.15)
		Northbound	0.0 (0.1)	A (A)	0.72 (0.32)	0.0 (0.1)	A (A)	0.36 (0.16)	0.0 (0.1)	A (A)	0.72 (0.32)
		Southbound	0.0 (0.0)	A (A)	0.14 (0.28)	0.0 (0.0)	A (A)	0.27 (0.57)	0.0 (0.0)	A (A)	0.27 (0.57)
9	The Parkway and Waynewood Boulevard	Eastbound	21.3 (10.9)	C (B)	0.44 (0.07)	15.8 (11.5)	C (B)	0.34 (0.08)	19.9 (11.0)	C (B)	0.41 (0.08)
		Northbound	0.1 (0.2)	A (A)	0.42 (0.34)	0.1 (0.2)	A (A)	0.21 (0.17)	0.1 (0.2)	A (A)	0.42 (0.34)
		Southbound	0.0 (0.0)	A (A)	0.13 (0.23)	0.0 (0.0)	A (A)	0.25 (0.45)	0.0 (0.0)	A (A)	0.25 (0.45)
10	The Parkway and Vernon View Drive	Northbound	1.6 (1.9)	A (A)	0.36 (0.34)	1.6 (1.9)	A (A)	0.18 (0.17)	1.6 (1.9)	A (A)	0.36 (0.34)
		Southbound	0.0 (0.0)	A (A)	0.13 (0.21)	0.0 (0.0)	A (A)	0.27 (0.42)	0.0 (0.0)	A (A)	0.27 (0.42)
		Eastbound	9.9 (10.7)	A (B)	0.20 (0.18)	10.2 (12.8)	B (B)	0.21 (0.23)	9.7 (11.6)	A (B)	0.19 (0.20)

Figure 184 shows a conceptual option 2 road diet signing and marking design for the segment between Morningside Lane and Wellington Road, including a lane shift to avoid buses in the right southbound lane underneath the Alexandria Avenue Bridge.

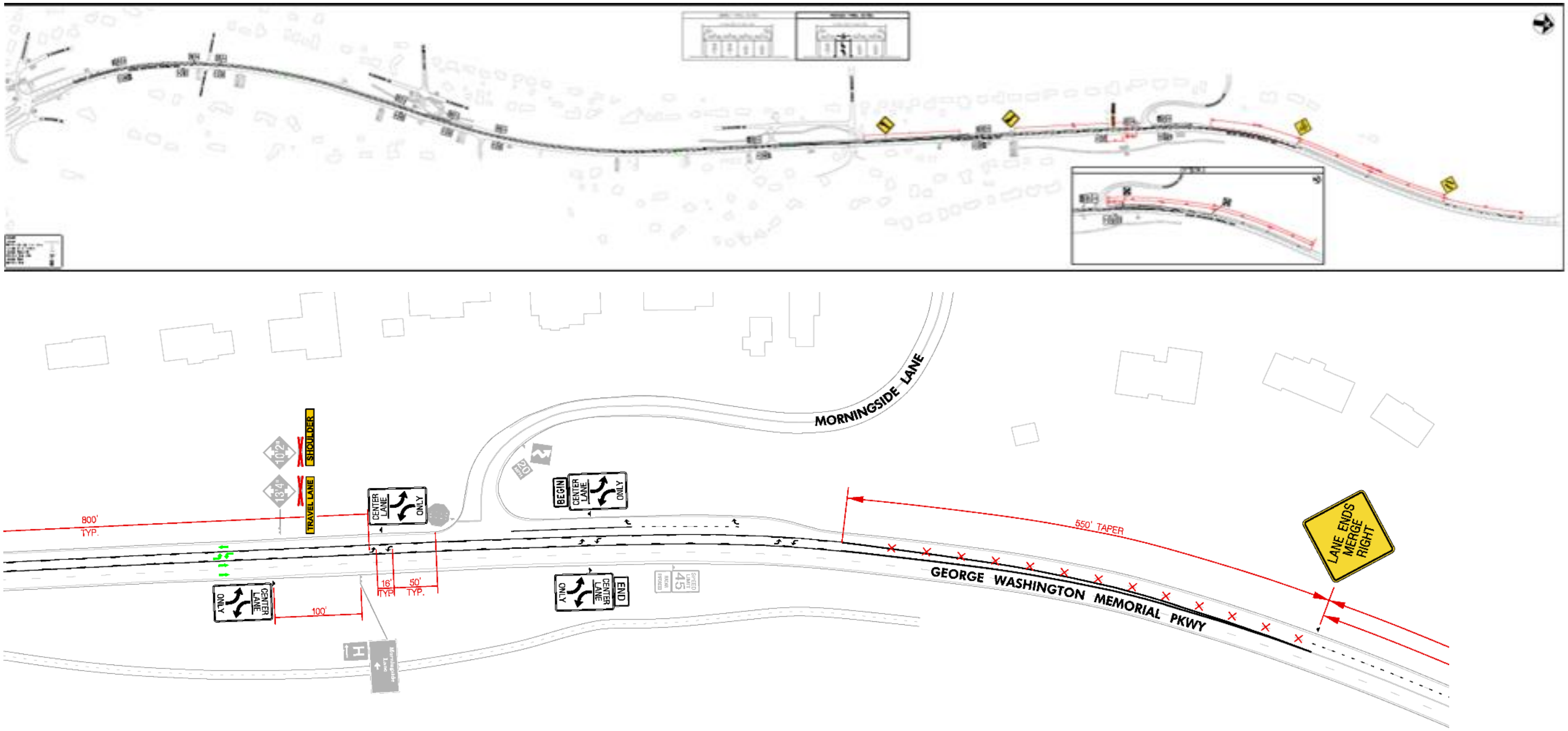


Figure 184. Road Diet Concept Plan

5.4 Roundabouts

5.4.1 Description

Roundabouts have been popular internationally but have only in the past two decades become popular in the US and specifically, Virginia. Modern roundabouts have evolved from the larger category of “traffic circles” by promoting entering traffic to “give way” or “yield to” circulating traffic in the intersection. This policy allows for continuous movement and fewer points of conflict between vehicles. Mount Vernon Circle is a traffic circle, and Parkway staff could investigate whether a modern roundabout is appropriate for this intersection. Table 52 highlights differences between a modern roundabout and traffic circle (i.e., rotary).

Table 52. Roundabout versus Traffic Circle

Roundabout	Traditional Traffic Circle/Rotary
• Entering traffic must always yield to ALL traffic in the roundabout, regardless of which lane they are in, similar to crossing a one-way road. A roundabout is a series of "crossing intersections" where traffic entering the roundabout must yield the right-of-way to all traffic from the left. Entry is always controlled by yield signs for maximum efficiency. • Drivers choose a lane before entering, similar to a standard intersection. • No lane changes occur within a roundabout, except for vehicles that are turning right. Entering a roundabout is a crossing movement. • A roundabout’s smaller diameter forces drivers to deflect their trajectory and reduce speeds upon approach, entry, and exit. • Roundabouts are able to handle heavy traffic and are used for efficiency and safety. Roundabouts were developed in the 1960s.	• It is typical to enter a rotary alongside traffic that is circulating in the inside lanes, like a freeway cloverleaf loop entrance. • No intersections occur in a rotary, only adding and dropping of lanes. • The right lane usually does not need to yield but must find a gap to change lanes. The left entry lane must merge or yield before entering. • The circle is usually not striped, though multiple vehicles may travel side by side. Lane changes occur after you have entered the circle. • A rotary is typically large, with entry speeds of 40 mph or higher. • Entering drivers who wish to circulate must change lanes while circulating and weave with vehicles trying to exit. • Rotaries work well at low volumes but poorly under heavy traffic conditions. Most were designed in the 1940s or earlier. • Entry may be controlled by yield signs, merge signs, or no signs at all.

Figure 185 shows contrasting characteristics of the modern roundabout versus the more traditional traffic circle/rotary.

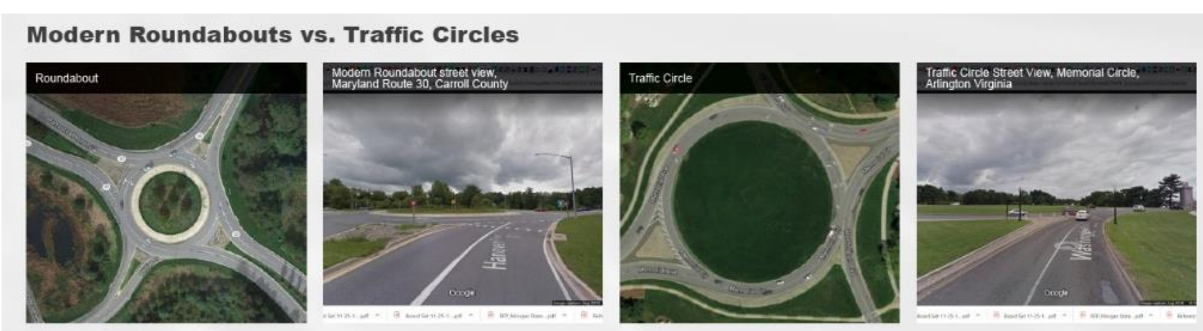


Figure 185. Modern Roundabout versus Traffic Circles

Figure 186 shows example images and design features of existing modern roundabouts in federal land settings.

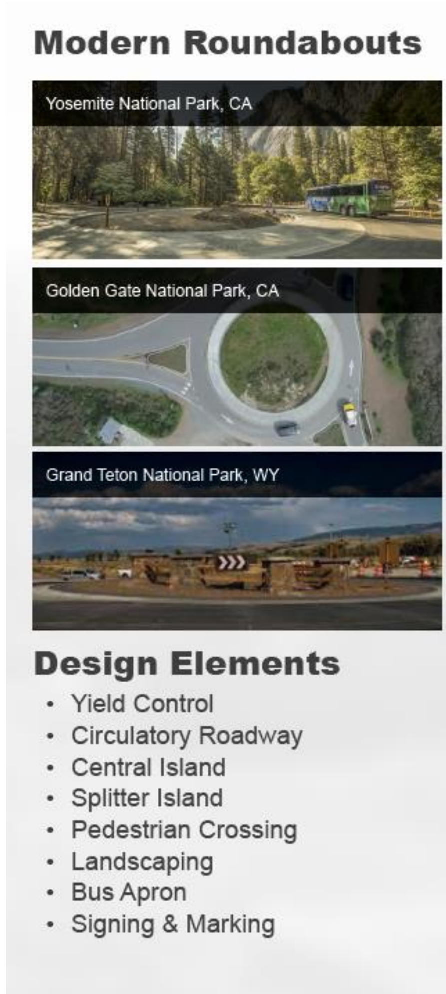


Figure 186. Images of Modern Roundabouts and Design Elements

5.4.2 Expected Safety Benefits

Modern roundabouts provide many benefits over traditional intersection designs. Roundabouts have been found to be safer than other traditional, signalized, stop-controlled intersections and larger traffic circles (or rotaries), as they provide slower speeds that create more gaps for entering traffic and reduce the number of possible conflicts. They also mitigate the severity of crashes by converting the left-turn and angle crashes to sideswipe crashes. According to the FHWA Crash Modification Factors (CMF) Clearinghouse, "Conversion of Intersection into Multi-Lane Roundabout" (USDOT/FHWA 2020), while total crashes for a multilane roundabout increase by about 6%, severe crashes (injury and fatal crashes) decrease by about 63%.

In addition to traffic safety and operational benefits, other advantages include lower maintenance costs, less environmental impact, enhanced aesthetics such as landscaping opportunities, less noise pollution, and better accommodation of pedestrians and bicyclists.

Furthermore, within the Parkway corridor, this treatment is context sensitive. A significant drawback, however, is that a typical roundabout costs from $1.5 to $2.5 million to install.

According to the FHWA publication, *Roundabouts: An Informational Guide* (Robinson, et al. 2000), intersections that are likely to benefit from roundabout control have the following characteristics:

- High crash location (left-turn or right-angle accidents)
- Capacity/delay problem
- Intersection where signal is requested but not warranted
- Restricted sight distance
- Equal distribution of volumes on all approach legs

Several intersections along the Parkway exhibit high levels of left-turn crashes, excessive delays on the minor street, and restricted sight distance. However, the majority of traffic is on the Parkway, so there is not an equal distribution of traffic volume on all approach legs.

Roundabouts provide significant improvements to intersection performance with generally free-flowing travel, slower speeds, and the ability for the motorist to find gaps. The project team conducted an examination of the major intersections along the corridor to determine whether possible roundabout applications would exhibit reasonable LOS performance. All intersections were found to exhibit reasonable LOS performance, except for Belle Haven Road and Belle View Boulevard, where delays and queues would be problematic under roundabout control. Table 53 summarizes the estimated operational performance of the roundabout concept at all study intersections.

Table 53. Capacity Summary Based on Roundabouts (HCM2000)

Intersection		Approach	Build (Roundabout)					
			Delay (sec/veh)		Volume-to-Capacity Ratio		Level of Service	
			a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
1	The Parkway and Belle Haven Road	Overall	18.5	78.1	–	–	C	F
		Eastbound	9.7	163.4	0.39	1.17	A	F
		Northbound	22.1	6.9	0.85	0.42	D	A
		Southbound	7.8	108.4	0.38	1.19	A	F
2	The Parkway and Belle View Boulevard	Overall	13.3	22.3	–	–	B	C
		Eastbound	7.5	38	0.24	0.68	A	E
		Northbound	16.1	0.42	0.77	0.40	C	A
		Southbound	5.5	0.93	0.30	0.88	A	D
3	The Parkway and Tulane Drive	Overall	14.2	11.6	–	–	B	B
		Eastbound	10.3	20.9	0.38	0.38	B	C
		Westbound	10.3	0	0.38	0.02	B	A
		Northbound	19.6	6.3	0.81	0.37	C	A
		Southbound	5.1	14.1	0.27	0.76	A	B

Intersection		Approach	Build (Roundabout)					
			Delay (sec/veh)		Volume-to-Capacity Ratio		Level of Service	
			a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
4	The Parkway and Morningside Lane	Overall	9.8	7.7	–	–	A	A
		Eastbound	5.7	9.1	0.19	0.18	A	A
		Northbound	12.6	0.25	0.19	0.26	B	A
		Southbound	4.5	8.9	0.21	0.58	A	A
5	The Parkway and Wellington Road	Overall	7.3	5.9	–	–	A	A
		Eastbound	5.4	0.08	0.16	0.08	A	A
		Northbound	8.8	4.6	0.53	0.22	A	A
		Southbound	4.2	6.6	0.18	0.42	A	A
7	The Parkway and Collingwood Road	Overall	7.6	5.7	–	–	A	A
		Eastbound	7.2	6.4	0.37	0.13	A	A
		Westbound	7.2	4.3	0.37	0.01	A	A
		Northbound	9.5	4.7	0.46	0.21	A	A
		Southbound	3.8	6.2	0.13	0.38	A	A
9	The Parkway and Waynewood Boulevard	Overall	5.2	5.1	–	–	A	A
		Eastbound	5.5	5.7	0.18	0.07	A	A
		Northbound	5.8	4.6	0.29	0.23	A	A
		Southbound	4.1	5.5	0.16	0.33	A	A
10	The Parkway and Vernon View Drive	Overall	5.1	5.5	-–	–	A	A
		Northbound	5.3	5	0.28	0.27	A	A
		Southbound	4.7	5.9	0.19	0.32	A	A
		Eastbound	5.7	6.8	0.19	0.18	A	A
11	The Parkway and Stratford Lane	Overall	7.8	5.6	–	–	A	A
		Eastbound	8.7	5.2	0.55	0.30	A	A
		Westbound	7.0	5.9	0.44	0.34	A	A
		Northbound	6.0	5.2	0.01	0.03	A	A
		Southbound	6.9	6.3	0.18	0.11	A	A

5.4.3 Potential Roundabout Location Applications

While many of these intersections could be modified into roundabouts, other options may be more viable, appropriate, or inexpensive when considering potential environmental and right-of-way impacts. Based on environmental and ROW impacts to existing natural landscapes and private property or frontage roadways, roundabouts would be considered a viable option at three intersections along the Parkway (Table 54).

Table 54. Potential Roundabout Location Applications

Intersecting Roadway	Roundabout
Belle Haven Road	
Belle View Boulevard	
Tulane Drive	√
Morningside Lane	√
Wellington Road	√
Collingwood Road	
Waynewood Boulevard	
Vernon View Drive	
Stratford Lane	

Schematic conceptual drawings of roundabouts at Tulane Drive and Belle View Boulevard are shown in Figure 187 and Figure 188.

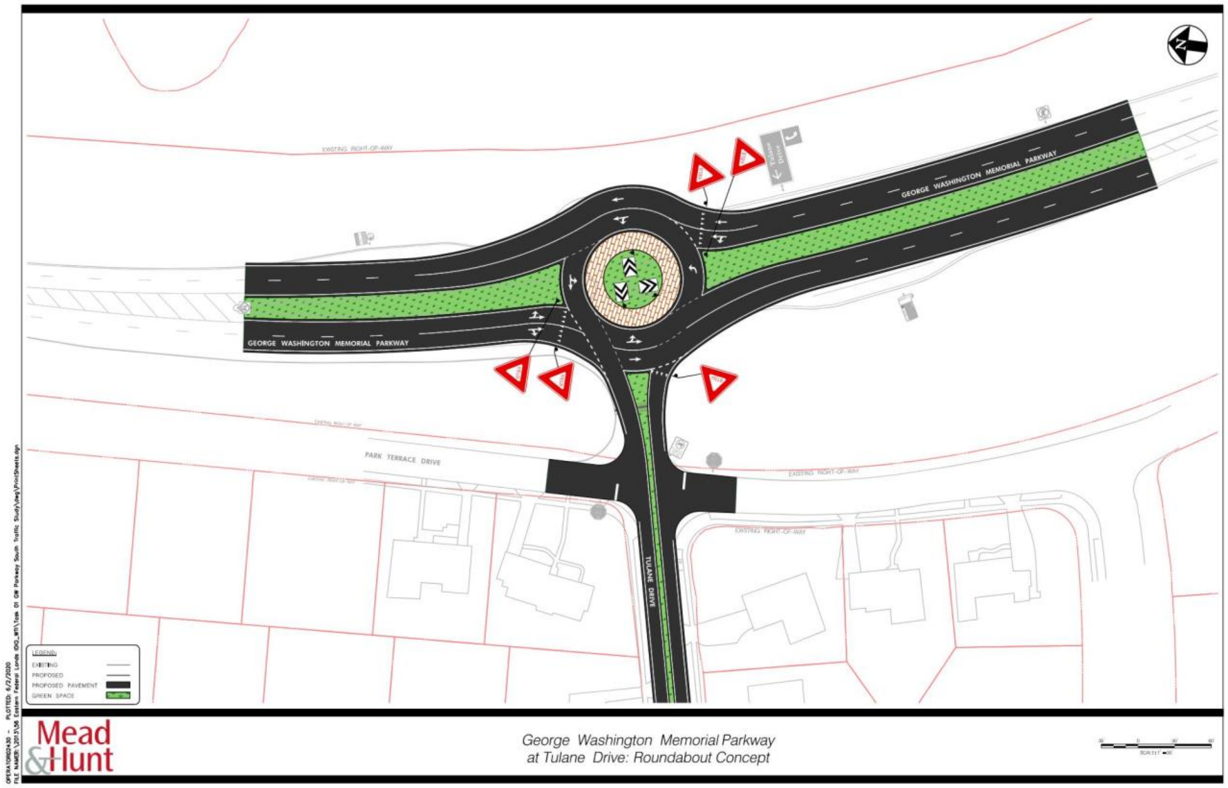


Figure 187. Example Roundabout Concept Design at Tulane Drive

The roundabout footprint at Belle View Boulevard (and likely at Belle Haven Road and Collingwood Road) would impact the frontage road, potentially requiring restricted access to and from those roads. It would also impact the Mount Vernon Trail. As a result, Figure 188 shows that geometrically, a roundabout at Belle View Boulevard does not fit. This issue, combined with the imbalanced traffic volumes resulting in poor function of a roundabout, is why a roundabout is ultimately not recommended at Belle View Boulevard. Similar findings exist for Belle Haven Road.

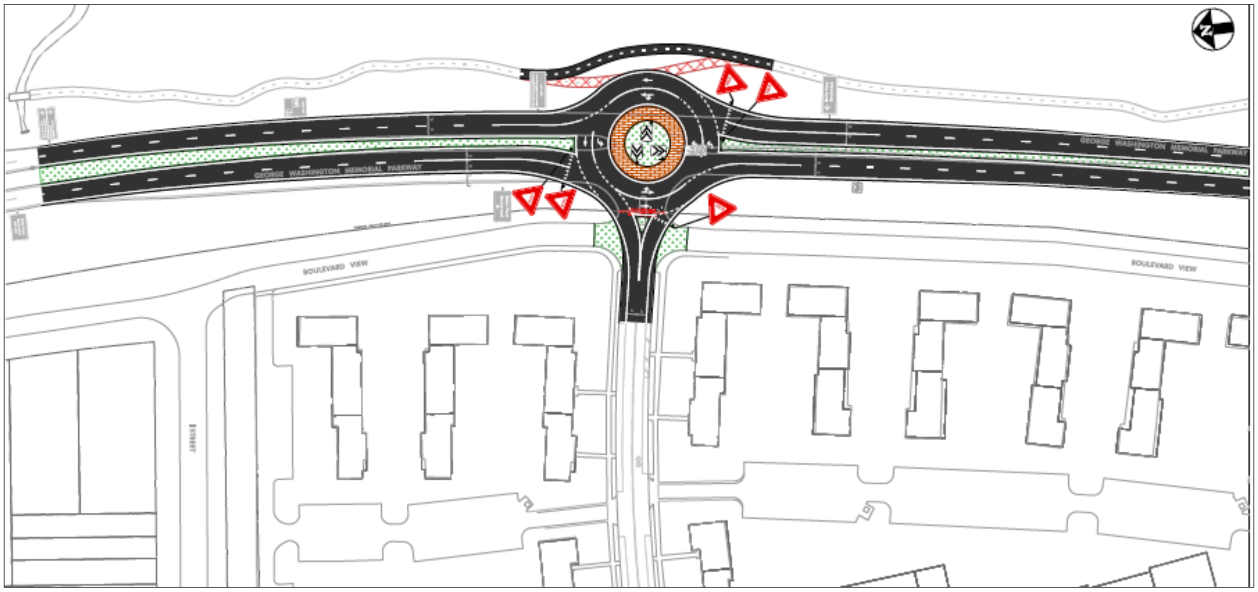


Figure 188. Roundabout Concept Design at Belle View Boulevard

A rendering of the roundabout at Morningside Lane is shown in Figure 189.

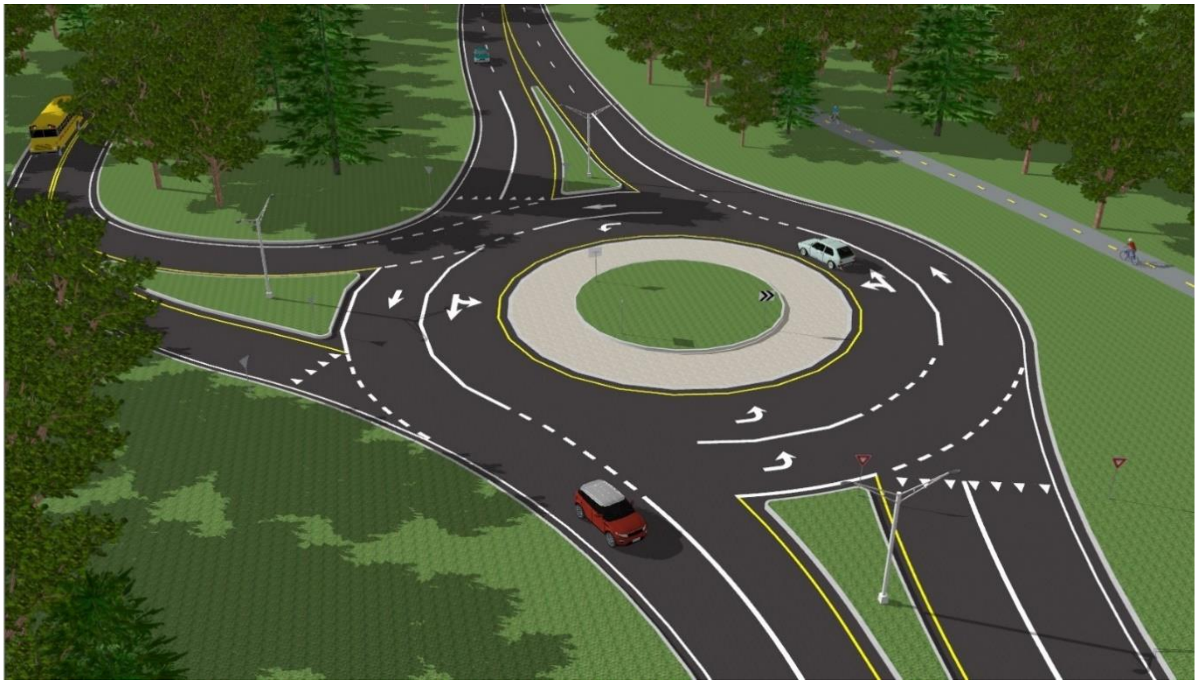


Figure 189. Conceptual Roundabout Rendering at Morningside Lane

5.5 Refuge Islands

5.5.1 Description

Refuge islands (also known as pedestrian refuge islands, center islands, or crossing islands) offer a protected location for pedestrians to avoid vehicular traffic and wait until it is safe to cross travel lanes, as shown in Figure 190. These islands are placed in the center or median of the roadway in a raised position. They allow the pedestrian to walk across one direction of traffic at a time. This type of facility has demonstrated reduced pedestrian casualties and vehicle conflicts.

Refuge islands can be combined with road diets to enhance pedestrian crossings of four-lane, undivided roadway crossings. This treatment can be installed with lane reconfigurations at mid-block locations or in combination with a left-turn lane if enough width is available.

The refuge island is particularly helpful to pedestrians crossing multilane roads by breaking up the walking distance and allowing a respite from a quick walk across both directions of traffic. Crossing islands also alert drivers to the pedestrian refuge and encourage motorists to reduce speed. For refuge islands to be effective, their implementation on the Parkway would need to have complementary speed reduction countermeasures.

Figure 190. Enhanced Pedestrian Crosswalks (Street Views from Google Maps)

5.5.2 Expected Safety Benefits

Refuge Islands have been shown to reduce pedestrian crashes by up to 30%, according to the FHWA CMF Clearinghouse (USDOT/FHWA 2020). Supplemental treatments such as high visibility crosswalk markings, yield lines, in-pavement marking text, upgraded signs, and pedestrian activated beacons (also known as RRFBs) further enhance driver awareness of pedestrian activity and motorist compliance with yielding to pedestrians (or bicyclists) in the crosswalk. Due to the potential for pedestrians facing multiple threats (e.g., a driver in one lane stops so the pedestrian enters the crosswalk, while the driver in the adjacent lane does not see the pedestrian or stop), it is recommended that the refuge islands be used in combination with lane or speed reduction engineering treatments such as road diets and roundabouts.

5.5.3 Refuge Island Potential Location Applications

Refuge islands and accompanying pedestrian crosswalks can be incorporated throughout the Parkway at many locations. It is recommended that these treatments be implemented with road diets or roundabouts at the intersection locations listed in Table 55.

Table 55. Potential Location Applications for Refuge Islands

Intersecting Roadway	Road Diet	Roundabouts
Belle Haven Road		
Belle View Boulevard		
Tulane Drive		√
Morningside Lane	√	√
Wellington Road	√	√
Collingwood Road		
Waynewood Boulevard	√	
Vernon View Drive	√	
Stratford Lane		

An example of combining the refuge island with a road diet is shown for the Wellington Road intersection in Figure 191, and a rendering is shown in Figure 192.

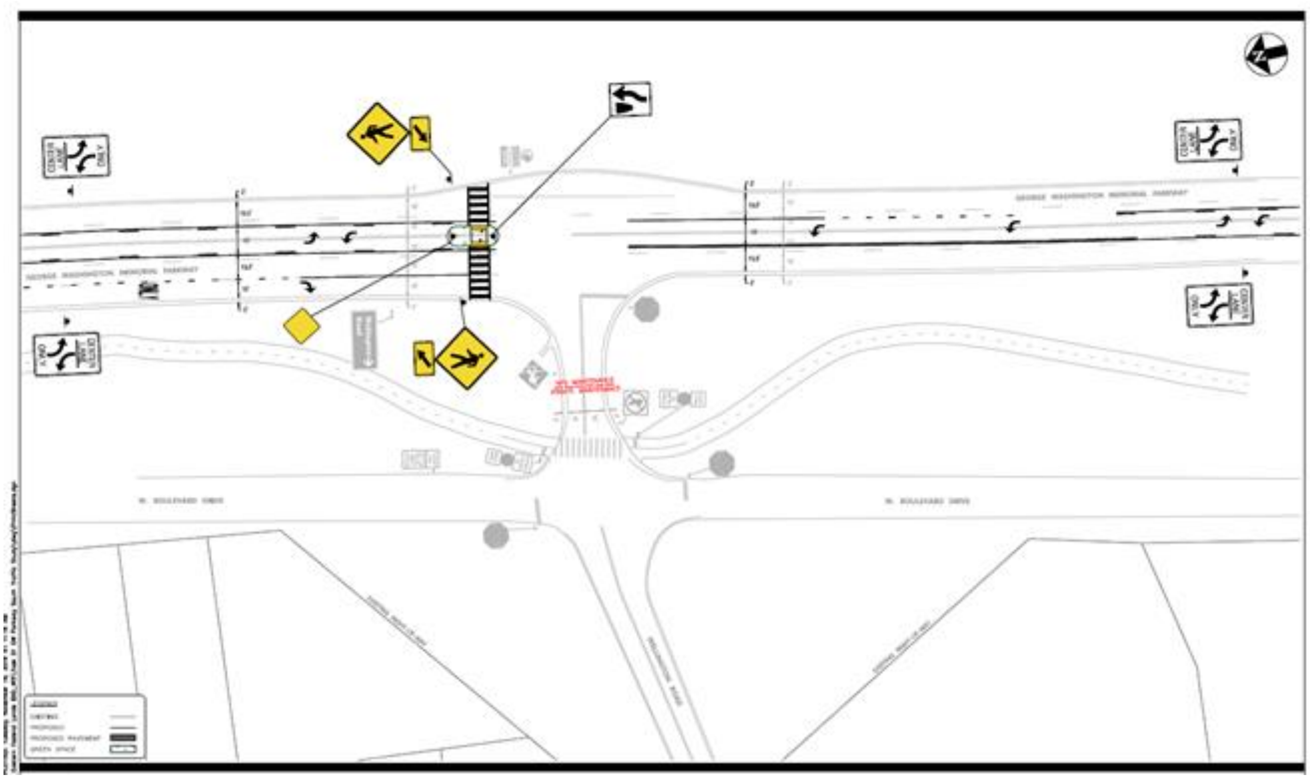


Figure 191. Example Pedestrian Refuge Island and Road Diet Concept Design at Wellington Road

Figure 192. Example Rendering of a Pedestrian Refuge Island and Road Diet at Wellington Road

5.6 Minor Engineering Measures

5.6.1 Upgraded Signing and Pavement Markings

5.6.1.1 *Description*

Upgraded signing and pavement markings are key to providing guidance to motorists at decision points along the Parkway such as intersections, the Mount Vernon Trail (pedestrian/bicyclist), crossings, and entering and exiting auxiliary lanes (Figure 193). Ensuring that signs are updated with current *Manual of Uniform Traffic Control* standards such as W1-2 intersection warning signs, W11-15 (USDOT 2017) trail crossing signs, and advisory speed subplates will provide additional positive guidance to all motorists, especially park visitors.

Figure 193. Examples of Pavement Symbols for Dedicated Turn Lanes and Pedestrian Crosswalks (Street Views from Google Maps)

Pavement markings could similarly be refreshed *routinely* and enhanced for visibility using high retroreflectivity grade tape and contrast tape to maximum conspicuity. Supplemental markings for auxiliary lanes could be installed, including right-turn and left-turn lane arrows and "only" verbiage, to provide positive guidance to Parkway motorists on auxiliary lane usage.

5.6.1.2 *Expected Safety Benefits*

Updating signing and pavement markings have been documented to reduce crash rates by 15% to 35%, according to *Enhance Pavement Marking Retroreflectivity* and *Install Advance Intersection Warning Signs*, as found in the FHWA CMF Clearinghouse (USDOT/FHWA 2020).

5.6.1.3 *Potential Location Applications*

Signing and marking upgrades are recommended at all intersections along the Parkway.

5.6.2 Intersection Lighting

5.6.2.1 *Description*

Intersection lighting refers to devices that illuminate the intersections at night. It does not include traffic signals. Pole-mounted intersection lighting provides appropriate illumination levels during dark hours for all conflict points within an isolated intersection to enhance visibility for motorists, pedestrians, and bicyclists (Figure 194).

Figure 194. Intersection Lighting, At Night and with Solar Power (Street Views from Google Maps)

5.6.2.2 *Expected Safety Benefits*

Installing intersection lighting has been documented to reduce crash rates by 31% for all crashes, up to 38% for nighttime injury and fatal crashes, and 59% for vehicle/pedestrian crashes, according to "Provide Intersection Illumination," as found in the FHWA CMF Clearinghouse (USDOT/FHWA 2020).

5.6.2.3 *Potential Location Applications*

The safety study recognizes the potential benefit of lighting at intersections within the corridor (Cottrell and Lim 2018). In particular, six intersections (Belle Haven Road, Belle View Boulevard, Morningside Lane, Collingwood Road, Waynewood Boulevard, and Stratford Lane) had a crash experience that suggests lighting would help improve visibility.

5.6.3 Roadway/Travel Lane Departure Warning

5.6.3.1 *Description*

Rumble strips, or a variation with reduced noise impacts known as mumble strips, are a series of indented pavement grooves across (e.g., transverse rumble strips) or along a roadway or travel lane edge, changing the noise a vehicle's tires make on the surface and so warning drivers of speed restrictions or of the edge of the road and providing positive guidance to avoid lane departures. Rumble strips can also be used in the center of the roadway in coordination with a double yellow centerline to make drivers aware if they start encroaching in the opposite direction of travel. Mumble strips are still a relatively new treatment, as they have evolved from rumble strips with the intent of retaining the safety benefits while reducing the noise impacts. Figure 195 shows mumble strips on asphalt.

Figure 195. Centerline Buffer Area (Street Views from Google Maps)

5.6.3.2 *Expected Safety Benefits*

Rumble/mumble strips have been documented to reduce run-off-road, single-vehicle crashes by 10% to 16%, according to "Install continuous milled-in shoulder rumble strips" found in the FHWA CMF Clearinghouse (USDOT/FHWA 2020).

5.6.3.3 *Potential Location Applications*

Mumble strips are recommended along the full length of the Parkway for the right travel lane. As there are numerous residences along the roadway, the mumble strips could bring safety benefits but provide consideration for these residences.

5.6.4 Roadway Maintenance

Roadway maintenance plays a key role in improving traffic safety. Important measures for improving traffic safety on the Parkway (Figure 196) include:

- Routine maintenance of vegetation to maintain intersection sight lines
- Clearing of storm drain inlets from debris to maintain storm water runoff and reduce standing water
- Repairing roadway surfaces such as potholes
- Refreshing faded pavement markings

Figure 196. Roadway Maintenance Examples (Street Views from Google Maps)

Specifically, maintenance activities could provide a sight distance of at least 590 feet, which corresponds to vehicles traveling 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* The sight distance can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction).)

5.7 Education

During outreach efforts, some members of the public indicated that they understood the context sensitivity associated with the Parkway. However, not all drivers or residents appear to understand how the Parkway's designation on the National Register of Historic Places (NPS n.d.) limits or requires careful consideration regarding changes to the asset. Therefore, there is a need to create educational materials on this topic. While some materials exist, most are in traditional printed formats and are not easily disseminated through other widely used methods of sharing information. Therefore, it is recommended that the Parkway develop a short video discussing context sensitivity and the associated implications. A short video implies five minutes or less, although a video that is closer to two minutes may be even more effective. Currently, succinct clips are generally preferred for conveying important information to an audience.

The speed data collected for this project demonstrated that vehicles were traveling well above the speed limits (35 mph or 45 mph) in the corridor. Excessive speeding is likely associated with much of the crash severity and is particularly concerning for vulnerable users (e.g., bicyclists and pedestrians) that need to cross the Parkway to access the Mount Vernon Trail. An informational graphic could be developed to demonstrate the difference in time when traveling at two different speeds through the corridor (35 mph versus 45 mph). The materials could also visually demonstrate the difference in how an object appears at the various speeds, showing how objects or people are less detailed or even "blurry" at higher speeds or showing the likelihood of missing a pedestrian/bicyclist at a higher speed.

Numerous animal collisions were identified at multiple intersections in the corridor, particularly those in the northern part of the Parkway study area. More recent data suggest that animals involved in the collisions are deer. These crashes tended to be in the fall and at night. The researchers are aware of portable dynamic message signs (i.e., variable message boards) placed along US 24, a rural highway, to warn motorists of the presence of wildlife.

The Colorado Department of Transportation noted that these signs were placed "temporarily/seasonally so that motorists do not become habituated and tolerant of signs" (Lawler 2020), as these animals are not present in proximity to the roadway in the summer. It was also noted that the portable signs "garner more attention than standard fixed ground signs" (Lawler 2020).

The Virginia Department of Transportation evaluated the effectiveness of deer advisory messages on dynamic message signs along I-64 between Waynesboro and Charlottesville, Virginia, in October 2015 (Donaldson and Kweon 2018). The signs were used in October and November between 5 p.m. and 9 a.m. The results showed a statistically significant reduction in the removal of deer carcasses as a result of the signs. They also showed, at four of the five stations used to evaluate speeds, a reduction of up to 2.8 mph. Therefore, the authors of that study concluded that dynamic message signs, seasonally used, were effective in reducing deer/vehicles crashes.

5.8 Enforcement

The National Park Service and US Park Police coordinated with law enforcement across the state of Maryland to support the "Drive Sober or Get Pulled Over!" safety campaign (NPS 2017). It was noted that (1) speeding, (2) aggressive driving, (3) distracted driving, and (4) impaired driving are some of the most "unsafe and illegal behaviors" observed within the Baltimore-Washington Parkway corridor, which was the impetus behind the partnership among the National Park Service, US Park Police, and Maryland law enforcement agencies.

Data collected as a part of this project identified that motorists are traveling at speeds above and beyond those posted. One of the recommendations was to develop a speed management program, and several of the specific actions (e.g., road diet, roundabout) have resulted in speed reductions. The following resources can assist with developing a speed management program:

- *Speed Management for Safety* and other technical resources (Institute of Transportation Engineers)
- *Multi-Disciplinary Speed Management*, webinar (National Center for Rural Road Safety)
- *Speed Management Program Plan* (NHTSA 2014)
- *Reducing Speed-Related Crashes Involving Passenger Vehicles* (NTSB 2017)
- *Speed Management: A Manual for Local Rural Road Owners* (Bagdade, et al. 2012)
- *Taming Speed for Safety: A Defining Approach and Leadership from Portland, Oregon* (Vision Zero Network n.d.)

A best management practice is continuous evaluation of implemented solutions to assist with the objective of managing speed. Parkway staff and the US Park Police would benefit from incorporating this best practice on a quarterly or semiannual schedule.

This page intentionally blank.

6. SUMMARY AND CONCLUSIONS

Having provided a detailed analysis of the study intersections, the summary and conclusions presented here provide reorientation. A treatment or change should be considered not only for a specific intersection but also for its cumulative effects on the park. As park staff implements the various recommendations within the study, adaptations need to be context sensitive. Park management is mindful to ensure that the Parkway character and visitor experience remains and the National Park Service has fulfilled its stewardship responsibilities.

No single solution will solve all crash occurrences at a single intersection or throughout the corridor. A myriad of solutions is needed to address crash occurrences. Similarly, different solutions regarding traffic operations may lend better to one intersection as compared with another. All of these solutions will need to be context sensitive. Furthermore, some solutions can be more readily implemented, whereas others will take some time to implement. What follows are recommendations at the corridor level followed by more intersection-specific recommendations.

The crash analysis data suggest that running-off-the-road and animal crashes occur at numerous intersections across the corridor. The following are global recommendations for study corridor treatments:

- Develop a program to trim trees and shrubs on a regular basis during the growing season.
- Initiate education and enforcement measures to reduce excessive speeds, including:
  - Speed management action plan
  - Public awareness campaign of the Parkway in a national context
- Enforce speeds via manual and automated methods.
- Reapply the pavement markings for improved conspicuity and develop a plan to reapply the markings on a regular basis.
- Reevaluate crash data collection within the corridor. Detailed crash data provides significant value in understanding crash causes along with demonstrating the impacts of implemented solutions.
- Install mumble strips to keep vehicles on the roadway.
- Decrease DUI offenses by increasing enforcement during specific periods.
- Use dynamic message signs to alert drivers of the presence of wildlife along the corridor from Belle Haven Road to Waynewood Boulevard. The signs are recommended from mid-October through the end of November and between 5:30 p.m. and 9:00 a.m. The signs could remain dark outside of these periods to increase conspicuity.
- Develop a public awareness education campaign starting at the end of March to remind motorists about the increasing presence of pedestrians, bicyclists, and motorcyclists who are also using the corridor.

The following are recommended global treatments decreasing DUI offenses, reducing animal crashes, and providing or improving pedestrian/bicyclist crossings along the Parkway.

- To decrease DUI offenses, historic crash tabular data suggest that more intensive enforcement periods could take place between 6:00 p.m. and 6:00 a.m., on Thursdays through Mondays, and in January, June, and September.
- To reduce animal crashes, dynamic message signs could notify drivers of the presence of animal crossings between Belle Haven Road and Waynewood Boulevard from mid-October through the end of November. Based on historic crash tabular data, most crashes occur between 5:30 p.m. and 9:00 a.m., so it would be best if the signs were active between these periods only.
- There is a need to provide or improve safe pedestrian/bicyclist crossings. As discussed in "Traffic Safety Evaluation and Crash Experience," as speeds increase, the likelihood of death when a pedestrian/bicyclist is struck by a vehicle exponentially increases. Most notably, the likelihood of mortality is almost certain when vehicles are traveling over 40 mph.

The crash history between pedestrians/bicyclists and motor vehicles at Belle Haven Road and Belle View Boulevard needs to be addressed. The complexity of these intersections would significantly benefit from proposed solutions to bring clarity to rights-of-way and traffic calming. Belle View Boulevard also has an existing social trail. Furthermore, consistent enforcement would ensure the safety of these vulnerable road users. Bicycle and pedestrian crashes were also present at Wellington Road and Collingwood Road.

Table 56 provides an overview of the safety recommendations for each intersection, followed by summaries of each intersection, including cost estimates and implementation timelines. "Appendix I: Cost Estimates" includes detailed itemized cost estimates for the engineering measures presented here, and "Appendix H: HCM Reports 25-142" includes final concept plans and/or typical details for all intersections.

Table 56. Safety Treatments by Intersection

Intersecting Roadway	Treatment	Issue Addressed
Belle Haven Road	• Construct channelization (e.g., acceleration lane) • Upgrade signing and marking • Analyze intersection lighting • Conduct tree trimming	• Angle crashes • ROW conflict • Animal crashes • Hit & Run (H&R) crashes
Belle View Boulevard	• Construct median U-turn • Upgrade signing and marking • Analyze intersection lighting • Conduct tree trimming	• Angle crashes • Animal crashes • H&R crashes • Weather-related crashes • Roadway surface condition crashes
Tulane Drive	• Construct roundabout • Upgrade signing and marking • Analyze intersection lighting • Conduct tree trimming	• Animal crashes • Run-off-the-road crashes • DUI crashes • H&R crashes • Tree/shrub crashes
Morningside Lane	• Implement road diet • Upgrade signing and marking • Analyze intersection lighting • Conduct tree trimming	• Angle crashes • Animal crashes • H&R crashes • Tree/Shrub crashes
Wellington Road	• Implement road diet • Install pedestrian/bicycle refuge island • Install rectangular rapid flash beacon • Upgrade signing and marking, including trail crossing on Wellington Road • Analyze intersection lighting • Conduct tree trimming	• Rear end crashes • Pedestrian/bicycle crashes • Animal crashes • H&R crashes • Tree/shrub crashes
Collingwood Road	• Upgrade signing and marking, including trail crossing on Collingwood Road • Analyze intersection lighting • Conduct tree trimming	• Animal crashes • Run-off-the-road crashes • DUI crashes • H&R crashes • Weather-related crashes • Tree/shrub crashes
Waynewood Boulevard	• Implement road diet • Upgrade signing and marking, including trail crossing on Waynewood Boulevard • Analyze intersection lighting • Conduct tree trimming	• Angle crashes • Animal crashes • H&R crashes • Weather-related crashes • Roadway surface condition crashes • Tree/shrub crashes
Vernon View Drive	• Implement road diet • Upgrade signing and marking • Analyze intersection lighting • Conduct tree trimming	• Rear end crashes • H&R crashes • Tree/shrub crashes
Stratford Lane	• Upgrade signing and marking • Analyze intersection lighting • Conduct tree trimming	• Angle crashes • Run-off-the-road crashes • Tree/shrub crashes

6.1 Belle Haven Road

The following recommendations are short term, except for channelization, which is midterm. The estimated short-term costs are $300,000 and the mid-term costs are $350,000.

6.1.1 Construct Channelization

Constructing channelization in the median will reduce conflicts with northbound left turns and eastbound left turns and provide an acceleration lane for eastbound left turns.

6.1.2 Analyze Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.1.3 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity.
- Install supplemental pavement markings, including right-turn and left-turn lane arrows, and “only” verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

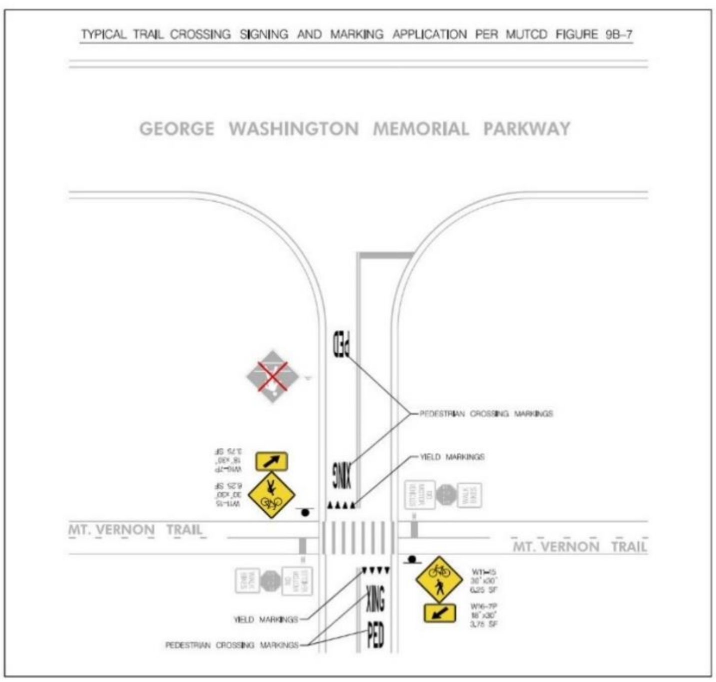


Figure 197. Example of Typical Trail Crossing Signing and Marking Application

6.1.4 Improve Sight Lines

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.2 Belle View Boulevard

The following recommendations are short term, except for the median U-turn, which is midterm. The estimated short-term costs are $300,000 and mid-term costs are $350,000.

6.2.1 Construct Median U-turn

Constructing a median U-turn will reduce conflicts with northbound left turns and eastbound left turns.

6.2.2 Analyze Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.2.3 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity.
- Install supplemental pavement markings, including right-turn and left-turn arrows, and “only” verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.2.4 Improve Sight Lines

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction).) A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.3 Tulane Drive

The following recommendations are short term, except for the roundabout which is midterm. The estimated short-term costs are $300,000 and mid-term costs are $1,700,000.

6.3.1 Construct Multilane Roundabout

The multilane roundabout will reduce vehicle speeds, reduce conflicts with northbound left turns and eastbound left turns, and should be designed to address the need to accommodate pedestrian/bicyclist crossings.

6.3.2 Analyze Intersection Lighting

Lighting that includes all the supporting utilities could be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.3.3 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity.
- Install supplemental pavement markings, including right-turn and left-turn arrows, and "only" verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.3.4 Improve Sight Lines

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as geometric solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.4 Morningside Lane

The following recommendations are short term; the estimated cost is $400,000.

6.4.1 Implement Road Diet

Implement a road diet extending from Morningside Lane to Wellington Road to reduce traffic speeds and provide a center two-way turn lane/painted median:

- Merge outside southbound travel lane to end north of Morningside Lane.
- Restripe to provide two 10-foot northbound lanes and one southbound 10-foot lane.
- Provide center turn lane for side street vehicles to perform a dual-stage left turn similar to that provided at other intersections.
- Sign and mark a gradual lane shift below Alexandria Avenue Bridge to avoid buses in the curbside lane.
- Continue the road diet south of Wellington Road.

6.4.2 Analyze Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.4.3 Upgrade Signing and Pavement Markings

- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity.
- Install supplemental pavement markings, including right-turn arrows, and "only" verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.4.4 Improve Sight Lines

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.5 Wellington Road

The following recommendations are short term; the estimated cost is $400,000.

6.5.1 Implement Road Diet

Implement a road diet extending from Morningside Lane to Wellington Road to reduce traffic speeds and provide a center two-way turn lane/painted median:

- Merge the outside southbound travel lane to the end north of Morningside Lane.
- Restripe to provide two 10-foot northbound lanes and one southbound 10-foot lane.
- Provide a center turn lane for side street vehicles to perform a dual-stage left turn similar to that provided at other intersections.
- Sign and mark a gradual lane shift below Alexandria Avenue Bridge to avoid buses in the curbside lane.
- Continue the road diet south of Wellington Road to Chadwick Avenue.

6.5.2 Install Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.5.3 Install Pedestrian/Bicycle Refuge Island

Install a pedestrian/bicycle refuge island to reduce the pedestrian/bicyclist crossing distance. Pilot the installation of a pedestrian/bicycle-activated and solar-powered rapid rectangular flash beacon to enhance driver awareness of pedestrian/bicycle activity.

6.5.4 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity and yield lines at trail crossing on Wellington Road.
- Install supplemental pavement markings, including right-turn arrows, and "only" verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.5.5 Improve Sight Lines

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.6 Collingwood Road

The following recommendations are short term; the estimated cost is $300,000.

6.6.1 Install Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.6.2 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity and yield lines at the trail crossing on Collingwood Road.
- Install supplemental pavement markings, including right-turn and left-turn arrows, and "only" verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.
- Install a center line and a stop line in the median area to provide guidance for motorists staging in the median.

6.6.3 Improve Sight Lines

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.7 Waynewood Boulevard

The following recommendations are short term; the estimated cost is $400,000.

6.7.1 Implement Road Diet

Implement a road diet to reduce traffic speeds and provide a center two-way turn lane/painted median:

- Merge the outside southbound travel lane to the end north of Waynewood Boulevard and reopen north of Fox Hunt Road.
- Restripe to provide two 10-foot northbound lanes and one southbound 10-foot lane.
- Provide a center turn lane for side street vehicles to perform a dual-stage left turn similar to that provided at other intersections.

6.7.2 Install Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.7.3 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity and yield lines at the trail crossing on Waynewood Boulevard.
- Install supplemental pavement markings, including right-turn and left-turn arrows, and “only” verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.7.4 Perform Sight Line Improvements

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.8 Vernon View Drive

The following recommendations are short term; the estimated cost is $400,000.

6.8.1 Implement Road Diet

Implement a road diet to reduce traffic speeds, address rear-end crashes occurring at the intersection, and provide a center two-way turn lane/painted median.

- Merge the outside southbound travel lane to the end north of River Farm Lane and reopen south of Lucia Lane.
- Restripe to provide two 10-foot northbound lanes and one southbound 10-foot lane.
- Provide a center turn lane for side street vehicles to perform a dual-stage left turn similar to that provided at other intersections.

6.8.2 Install Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.8.3 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity and yield lines at the trail crossing on Vernon View Drive.
- Install supplemental pavement markings, including right-turn and left-turn arrows, and "only" verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.8.4 Perform Sight Line Improvements

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

6.9 Stratford Lane

All recommendations are short term; the estimated cost is $300,000.

6.9.1 Install Intersection Lighting

Lighting that includes all the supporting utilities may be inconsistent with the historic road. Analysis of the lighting would be intersection specific through applicable law and policy associated with cultural and natural resources.

6.9.2 Upgrade Signing and Pavement Markings

- A typical application of proposed new/upgraded signs to emphasize a cross street warning (W2-1) and a trail crossing warning (W11-15) is provided in Figure 197 (USDOT 2017).
- Install retroreflective pavement markings using black contrast tape for enhanced conspicuity and yield lines at the trail crossing on Stratford Lane.
- Install supplemental pavement markings, including right-turn and left-turn arrows, and “only” verbiage to provide positive guidance to Parkway motorists on auxiliary lane usage.

6.9.3 Perform Sight Line Improvements

Provide a sight distance of at least 590 feet, which corresponds to vehicles traveling at 50 mph, to accommodate intersection sight distance for prevailing vehicle speeds. (*Note:* Sight lines can be reduced as engineering and enforcement solutions are implemented to assist with traffic calming (e.g., speed reduction)). A regular maintenance program could be developed to maintain the desired sight distance during the spring and summer months.

This page intentionally blank.

REFERENCES

AASHTO. 2018. *A Policy on Geometric Design of Highways and Streets, 7th Edition.* Washington, D.C.: AASHTO Green Book, Table 9-5.

—. 2010. *Highway Safety Manual (HSM).* Washington, DC: AASHTO.

Allen, O., and S. R. Flack. 2001. "Potomoac Gorge Site Conservation Plan. National Park Service and The Nature Conservancy." Washington D.C. and Arlington, VA, 146.

Bagdade, Jeffrey, Dan Nabors, Hugh McGee, Richard Miller, and Richard Retting. 2012. *Speed Management: A Manual for Local Rural Road Owners.* Office of Safety, Washington, D.C.: Federal Highway Administration. Accessed April 9, 2020. https://safety.fhwa.dot.gov/local_rural/training/fhwasa010413spmgmt/speedmanagementguide.pdf.

Brookshire, Kristen, Laura Sandt, Carl Sundstrom, Libby Thomas, and Richard Blomberg. 2016. *Advancing Pedestrian and Bicyclist Safety: A Primer for Highway Safety Professionals.* Washington, DC: National Highway Traffic Safety Administration (NHTSA). Accessed February 11, 2020. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812258-peds_bike_primer.pdf.

Code of Federal Regulations. 1997. *Title 36 - Chapter - Part 7 - SPECIAL REGULATIONS, AREAS OF THE NATIONAL PARK SYSTEM.* July 1. Accessed May 29, 2020. https://www.govinfo.gov/app/details/CFR-1997-title36-vol1/CFR-1997-title36-vol1-sec7-96.

—. 2012. *Title 36 - Parks, Forests, and Public Property, Chapter I - NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR - Part 5 - COMMERCIAL AND PRIVATE OPERATIONS, Section 5.6 - Commercial Vehicles.* July 1. Accessed May 29, 2020. https://www.govinfo.gov/app/details/CFR-2012-title36-vol1/CFR-2012-title36-vol1-sec5-6.

Cottrell, Benjamin H., and In-Kyi Lim. 2018. *Systemic Low-Cost Countermeasures for an Unsignalized Intersection Safety Improvement Plan for Virginia.* Richmond, VA: Virginia Department of Transportation. Accessed July 13, 2020. http://www.virginiadot.org/vtrc/main/online_reports/pdf/19-r5.pdf.

Covering the Corridor. 2019. "One killed in GW Parkway crash." *Covering the Corridor*, September 13. Accessed March 24, 2020. https://coveringthecorridor.com/2019/09/one-killed-george-washington-parkway-crash/.

Daddio, David, Jessica Baas, Travis Crayton, Rachel Galton, and Emily Navarrete. 2019. *George Washington Memorial Parkway: Mount Vernon Trail Corridor Study.* Washington, DC: National Park Service. Accessed June 2, 2020. https://parkplanning.nps.gov/document.cfm?parkID=186&projectID=95147&documentID=103209.

Dickman, Dana, Nick Fablo, Steve Durrant, Joe Gilpin, Gena Gastaldi, Collin Cheeston, Prescott Morrill, et al. 2016. *Small Towns and Rural Multimodal Networks.* Office of Planning, Environment, and Realty, Washington DC: Federal Highway Administration. Accessed April 2, 2020. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/fhwahep17024_lg.pdf.

Donaldson, Bridget, and Young-Jun Kweon. 2018. *Effectiveness of Seasonal Deer Advisories on Changeable Message Signs as a Deer Crash Reduction Tool.* Charlottesville: Virginia Transportation Research Council. Accessed April 9, 2020. http://www.virginiadot.org/vtrc/main/online_reports/pdf/19-r8.pdf.

FHWA. 2014. "Road Diet Informational Guide." *Safety - Road Diets.* November. https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/.

FOX 5 DC. 2019. *Fiery crash leaves one dead along GW Parkway.* September 13. Accessed March 19, 2020. https://www.fox5dc.com/news/fiery-crash-leaves-one-dead-along-gw-parkway.

Harwood, Douglas W., Ingrid B. Potts, and William Prosser. 2002. "New Elements of Highway Geometry." *University of California - Davis.* Transportation Research Board. Accessed June 1, 2020. http://www.des.ucdavis.edu/faculty/handy/TTP_seminar/Greenbook_update.pdf.

LaRocca, Aaron, interview by Natalie Villwock-Witte. 2020. *Chief of Staff* (June 3).

Lawler, Mark. 2020. (March 30).

Minnesota Department of Transportation. 2011. *Minnesota's Best Practices and Policies for Safety Strategies on Highways and Roads - Rural Lighting.* Minnesota Department of Transportation. Accessed July 16, 2020. http://www.dot.state.mn.us/stateaid/trafficsafety/safety/rural-lighting.pdf.

NHTSA. 2014. *Speed Management Program Plan.* National Highway Traffic Safety Administration, Federal Highway Administration, Federal Motor Carrier Safety Administration.

NPS. 2014. *Foundation Document: George Washington Memorial Parkway.* Fort Collins, CO: National Park Service.

NPS. 2005. *George Washington Memorial Parkway Long Range Interpretive Plan.* National Park Service.

NPS. 2008. "GWMP North Section Rehabilitation Environmental Assessment / Assessment of Effect."

—. 1946. "Highways in Harmony; George Washington Memorial Parkway: Virginia, Maryland, Washington D.C." *National Park Service.* National Archives and Records Administration (NARA). Accessed November 18, 2019.

http://npshistory.com/publications/highways/george_washington/george-washington-memorial-parkway.pdf.

—. n.d. "National Register of Historic Places Registration Form." Accessed April 9, 2020. https://npgallery.nps.gov/NRHP/GetAsset/8367e5e4-f7c8-4727-aeea-273db303c390/.

—. 2011. "Record of Determination Reconfirming and Restating Bicycles are not allowed on the roadways of the Clara Barton and George Washington Memorial Parkways." *George Washington Memorial Parkway.* August 3. Accessed June 1, 2020. https://www.nps.gov/gwmp/learn/management/upload/No-Bikes-on-Road_Compliant.pdf.

—. 2017. *US Park Police to increase Baltimore-Washington Parkway patrols over Labor Day Weekend.* August 31. Accessed April 9, 2020. https://www.nps.gov/bawa/learn/news/us-park-police-to-increase-baltimore-washington-parkway-patrols-over-labor-day-weekend.htm.

NTSB. 2017. "Reducing Speeding-Related Crashes Involving Passenger Vehicles." Washington, D.C.

Ocel, Norah M. 2019. *Safety Assessment Field Trip Report: NP GWMP ES (5) - Intersection of Morningside Lane and George Washington Memorial Parkway (a.k.a. Mount Vernon Parkway).* U.S. Department of Transportation, Federal Highway Administration, Eastern Federal Lands Highway Division, 1-18.

Robinson, Bruce W., Lee Rodegerdts, Wade Scarborough, Wayne Kittelson, Rod Troutbeck, Werner Brilon, Lothar Bondzio, et al. 2000. *ROUNDABOUTS: An Informational Guide.* McLean, Virginia: U.S. Department of Transportation, Federal Highway Administration. Accessed March 31, 2020. https://www.fhwa.dot.gov/publications/research/safety/00067/00067.pdf.

USDOT. 2017. *2009 Edition Part 9 Figure 9B-3. Warning Signs and Plaques and Object Markers for Bicycle Facilities.* February 5. Accessed March 29, 2020. https://mutcd.fhwa.dot.gov/htm/2009r1r2/part9/fig9b_03_longdesc.htm.

—. 2017. *Corridor Access Management.* October 17. https://safety.fhwa.dot.gov/provencountermeasures/corridor_access_mgmt/.

—. 2017. *Road Diets (Roadway Reconfiguration).* October 18. Accessed March 31, 2020. https://safety.fhwa.dot.gov/provencountermeasures/road_diets/.

USDOT, NHTSA. 1999. *Literature Review on Vehicle Travel Speeds and Pedestrian Injuries.* Springfield: USDOT, NHTSA. Accessed March 24, 2020. https://one.nhtsa.gov/people/injury/research/pub/hs809012.html.

USDOT/FHWA. 2017. *2009 Edition Part 9 Figure 9B-3. Warning Signs and Plaques and Object Markers for Bicycle Facilities.* February 5. Accessed March 20, 2020. https://mutcd.fhwa.dot.gov/htm/2009r1r2/part9/fig9b_03_longdesc.htm.

—. 2020. *Crash Modification Factors Clearinghouse.* March 23. Accessed March 29, 2020. http://www.cmfclearinghouse.org/.

Vision Zero Network. n.d. "Taming Speed for Safety: A Defining Approach and Leadership from Portland, Oregon." https://visionzeronetwork.org/project/taming-speed-for-safety-portland-case-study/.

Walsh, B. M, S. D. Costanzo, W. C. Dennison, J. P. Campbell, M. Lehman, M. Notrup, B. Steury, and S. and Monteleone. 2016. *Natural Resource Condition Assessment for George Washington Memorial Park: National Capital Region. Natural Resources Report.* Fort Collins: National Park Service.

APPENDIX A: INTERSECTION EXISTING CONDITIONS MAPPING

See appendixes in separate volume.

This page intentionally blank.

APPENDIX B: PEAK HOUR TRAFFIC VOLUMES

See appendixes in separate volume.

This page intentionally blank.

APPENDIX C: INTERSECTION TRAFFIC COUNTS

See appendixes in separate volume.

This page intentionally blank

APPENDIX D: AVERAGE DAILY TRAFFIC COUNTS

See appendixes in separate volume.

This page intentionally blank.

APPENDIX E: HCM REPORTS 1-24

See appendixes in separate volume.

This page intentionally blank.

APPENDIX F: TRAFFIC SAFETY

See appendixes in separate volume.

This page intentionally blank.

APPENDIX G: CONCEPTS

See appendixes in separate volume.

This page intentionally blank.

APPENDIX H: HCM REPORTS 25-142

See appendixes in separate volume.

This page intentionally blank.

APPENDIX I: COST ESTIMATES

See appendixes in separate volume.

This page intentionally blank.

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historic places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.

April 2021

NATIONAL PARK SERVICE • U.S. DEPARTMENT OF THE INTERIOR

GEORGE WASHINGTON MEMORIAL PARKWAY

TRAFFIC AND SAFETY CONTEXT SENSITIVE SOLUTIONS ASSESSMENT • APRIL 2021