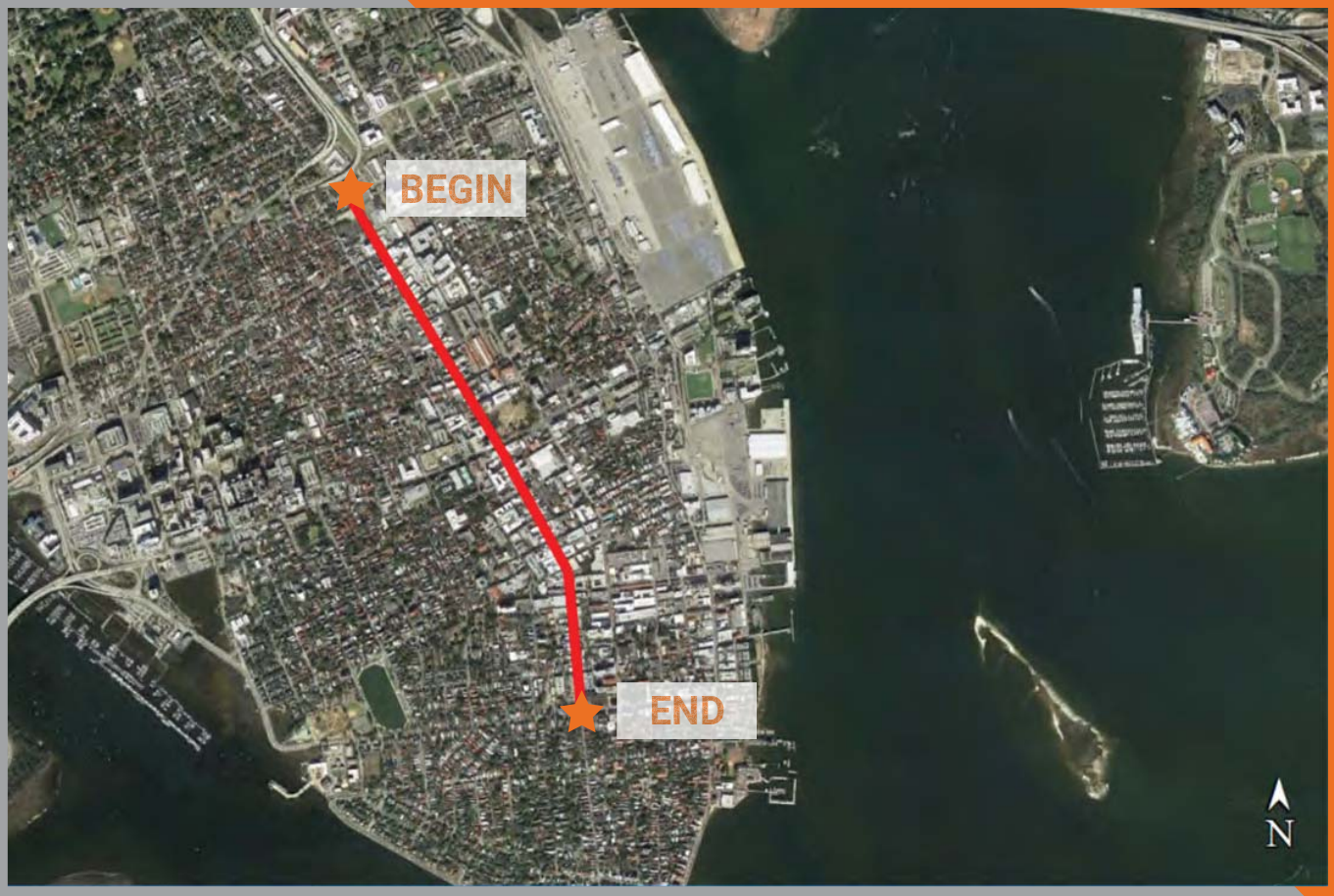
S-104 KING STREET

Road Safety Audit

Charleston, SC



MAY 2020

SCDOT
South Carolina Department of Transportation

Stantec

S-104 King Street

Bicycle and Pedestrian Road Safety Audit

Downtown Charleston, South Carolina

Prepared for:

South Carolina Department of Transportation (SCDOT)

Prepared by:

Stantec Consulting Services Inc.
Project Number: 171002155

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LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Background

Effective bicycle and pedestrian programs often consider the six “Es”:

- Evaluation – Review and analysis of crash data and information from surveys, walking audits, and other research to determine strategies for improving safety
- Engineering – Design of physical infrastructure to improve safety
- Enforcement – Engagement of law enforcement to patrol problem locations and increase community awareness of safety issues
- Education – Methods to teach motorists and pedestrians about their responsibilities and traffic rules
- Encouragement – Strategies that develop awareness and build enthusiasm for cycling and walking
- Equity – Consideration for the diverse needs of all roadway users

This Bicycle and Pedestrian Road Safety Audit covers the first “E”, Evaluation. The RSA process identifies safety issues through an intensive and collaborative forum and uses brainstorming and local knowledge to enhance analysis findings in developing a range of improvement ideas. This RSA provides specific recommendations for Engineering, but also recognizes Enforcement, Education, Encouragement and Equity needs. A multi-disciplinary team performed the RSA, bringing a variety of perspectives to the study. Detailed crash data from the most recent six years along with extensive analyses was used to identify high crash patterns and/or rates throughout the study area to share with the study team.

1.2 Project Overview

In 2018, SCDOT identified S-104 (King Street), as a high crash corridor involving non-motorized users, i.e. bicyclists and pedestrians. The corridor was #3 in the statewide ranking of SCDOT’s non-motorized safety project list, which was based on the total number of bike / pedestrian crashes per mile. Between 2013 and 2018, there were 36 crashes along S-104 involving bicycles and pedestrians. 32 of these crashes resulted in injuries and no fatal crashes were reported. 21 crashes involved bicycles, while the remaining 15 involved pedestrians.

The original analysis area is a 1.9-mile section of King Street, which begins at Line Street and extends southwards to Murray Blvd. However, based on roadway geometry and crash history, the study terminates at Broad Street in the southern end. Over the six-year period, 526 crashes have been reported along the study area, at a rate of approximately 88 crashes per year. Of the 526 crashes, 117 resulted in injuries with no fatalities. The number and severity of these crashes warranted a closer evaluation for potential safety improvements for drivers, bicyclists and pedestrians.

The RSA process identifies safety issues through an intensive and collaborative forum and uses brainstorming and local knowledge to enhance analysis findings in developing a range of improvement ideas. A multi-disciplinary team performed the road safety assessment, bringing a variety of perspectives

to the study. Detailed crash data from the most recent six years along with extensive analyses was used to identify high crash patterns and/or rates throughout the study area to share with the study team.

1.3 Road Safety Assessment Interdisciplinary Team

A multidisciplinary team was formed to evaluate safety needs and identify the recommended improvements. The team consisted of engineers, law enforcement, and local municipality representatives. The team conducted field visits on August 5 and 6, 2019. The members of the RSA team were as follows:

- Shawn Salley – SCDOT
- Joey Riddle – SCDOT
- Robert Amick – SCDOT
- Josh Johnson – SCDOT
- Eric Hall – SCDOT
- Keith Benjamin – City of Charleston
- Belen Vitello – City of Charleston
- Michael Mathis – City of Charleston
- Allen Davis – City of Charleston
- Troy Mitchell - City of Charleston
- Robert Somerville – City of Charleston
- Kristy McFadden - Charleston PD
- Katie Zimmerman – Charleston Moves
- Savannah Brennan – Charleston Moves
- Jordan Amaker – Lowcountry Local First
- Bret Gillis – Stantec Consulting Services
- Stuart Day – Stantec Consulting Services
- Nabarjun Vashisth – Stantec Consulting Services

1.4 Report Objectives

The purpose of this Road Safety Assessment is to evaluate safety issues and other areas of concern along S-104 between Line St. and Murray Blvd. including the intersections located along the route. The study identifies opportunities for improving bicycle, pedestrian and vehicular safety.

The assessment has three basic components:

- Pre-assessment

  - Analyze crash data – Crash data over a six-year period were analyzed, with results based on different crash types and trends depicted through various charts, tables and spreadsheets.
  - Speed Study - Conduct speed study of the corridor at 3 different locations to gauge average and 85th percentile speeds during non-rush hour traffic.
  - The audit team reviews location characteristics and crash analysis
- Field meeting/Site visit
  - Study team gathers to review/discuss crash details and share local knowledge of existing issues and concerns.
  - Study team walks the corridor to examine conditions along the corridor.
- Post-assessment – the study team gathers to share findings and develop a list of issues and potential strategies.

2.0 EXISTING CONDITIONS

2.1 PROJECT LOCATION

The project study area begins at the intersection of Line Street in the northern end and extends southward to Broad Street. These limits are shown below in Figure 2.1. S-104 has active bicycle, pedestrian, vehicular, and transit traffic. It serves residential, office and retail properties, with several attractions for both tourists and local residents. In addition to numerous shops and restaurants, some popular destinations along this corridor include Marion Square, Visitors Center, Gibbes Museum of Art and White Point Garden. The College of Charleston is also nearby, adding to nonvehicular and vehicular traffic when school is in session.

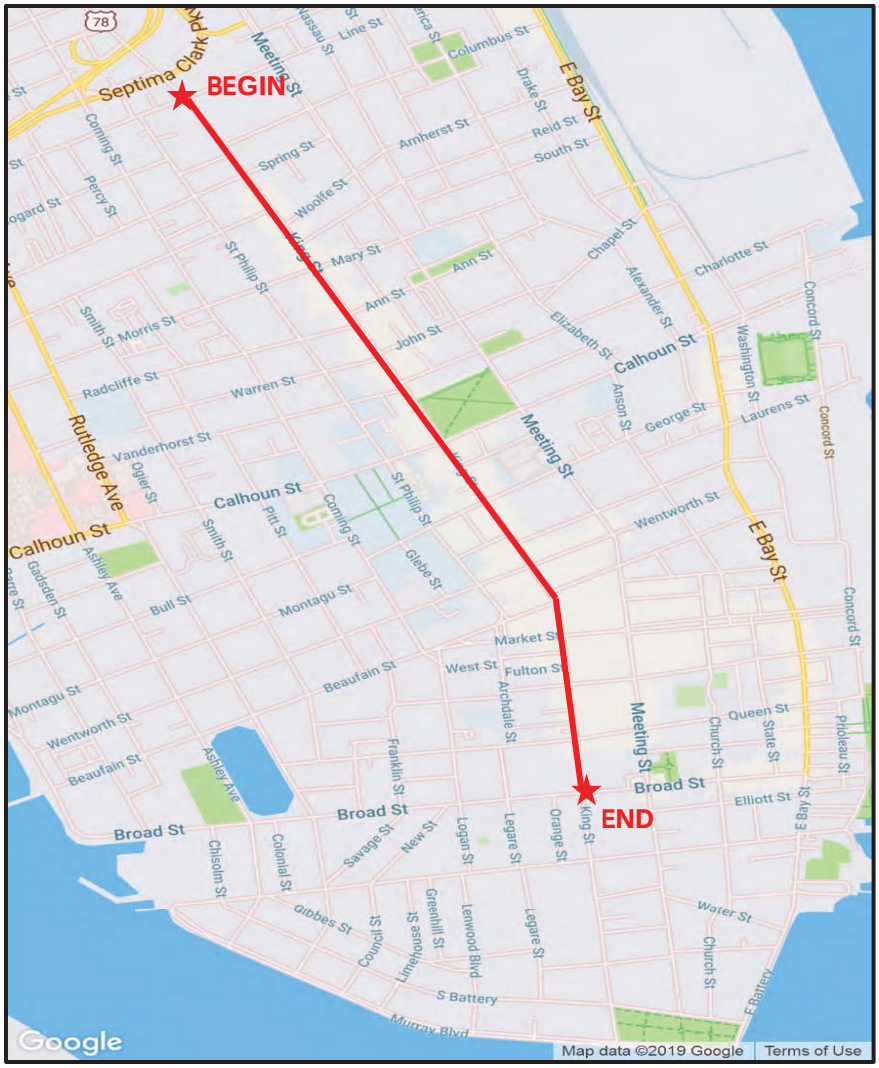


Figure 2.1- Project Study Area

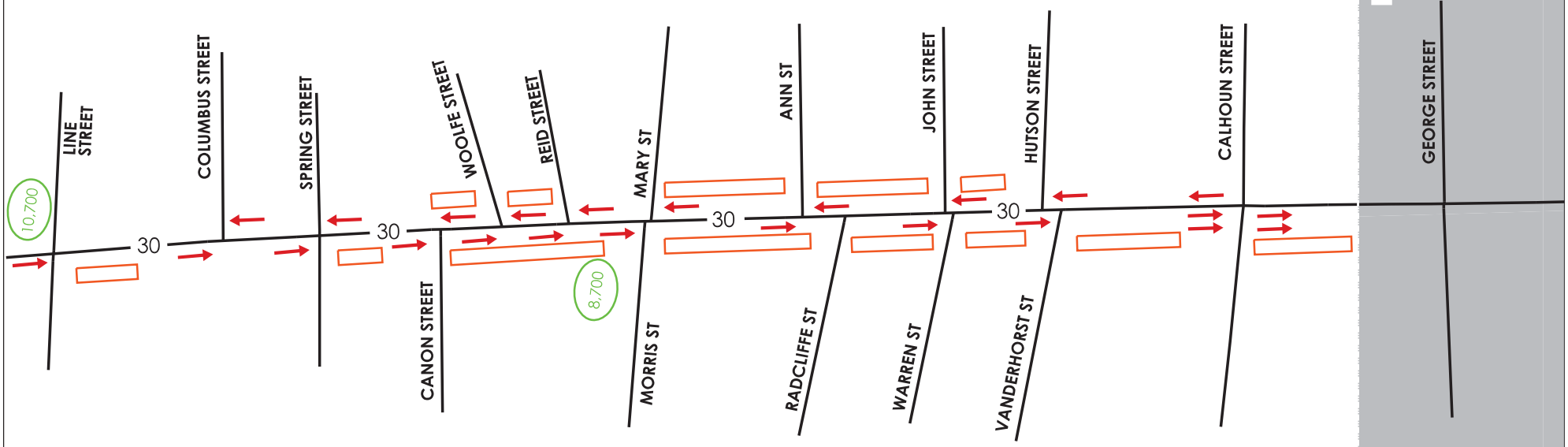
2.2 EXISTING ROADWAYS

King St. is a two-lane principal arterial/major collector roadway that serves residential and commercial traffic. It has parallel on-street parking in segments along its length. South of Calhoun St., King Street is a one-way road for southbound traffic only. Through lanes, posted speeds, on-street parking, and 2018 ADT counts are mapped on the following pages. The City of Charleston owns King Street from Hutson St. to Calhoun St.

Key intersections include:

- ***Columbus St.*** is a two-lane major collector in the north end of the study area. The posted speed limit is 20 mph and 2018 AADT was 4,000 vehicles per day (vpd).
- ***Spring St.*** is a two-lane (one-way) minor arterial in the north end of the study area. The posted speed limit is 25 mph. The 2018 AADT was 6,200 vpd.
- ***Calhoun St.*** is a four-lane principle arterial. The posted speed limit is 25 mph and 2018 AADTs were: 20,100 vpd at the west end of the road, 18,800 vpd from Barre St to Rutledge Ave, 16,300 vpd from Rutledge Ave to East Bay St and 5,200 vpd from East Bay St to Concord St, at the east end of the road.
- ***Wentworth St.*** is a two-lane major collector. The posted speed limit is 25 mph on the west side of the intersection and 20 mph on the east side. The 2018 AADT was 4,200 vehicles per day (vpd).
- ***Hasell St.*** is a two-lane major collector in the south end of the study area. The posted speed limit is 20 mph. The 2018 AADTs were: 4,600 vpd from King St to Meeting St and 2,900 from Meeting St to East Bay St.
- ***Broad St.*** is a two-lane minor arterial in the south end of the study area. The posted speed limit is 25 mph. The 2018 AADT was 12,300 vpd.

KING STREET
TRAFFIC FEATURES



LEGEND

- —25— SPEED LIMIT ON SECTION (MPH)
- → EXISTING THROUGH LANES
- ▭ EXISTING STREET PARKING
- (10,700) 2018 AADT (VEHICLES PER DAY)

SCALE IN FEET

0 500 1000 2000

SHEET 1

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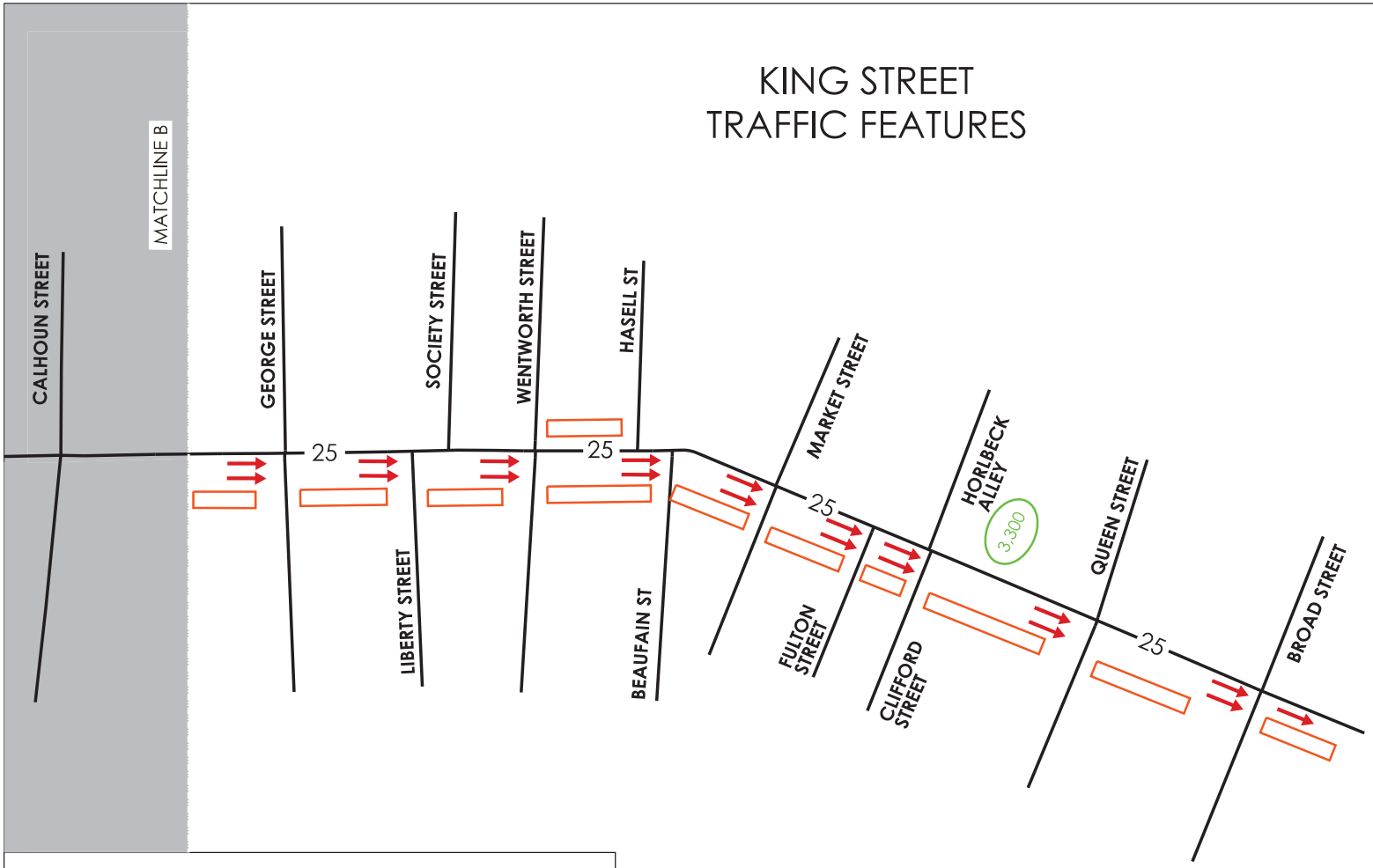
KING STREET
TRAFFIC FEATURES



LEGEND

- 25 — SPEED LIMIT ON SECTION (MPH)
- EXISTING THROUGH LANES
- EXISTING STREET PARKING
- 10,700 — 2018 AADT (VEHICLES PER DAY)

SCALE IN FEET

0 500 1000 2000

SHEET 2

N

2.3 CRASH DATA

Crash data for the study corridor was provided by SCDOT for a six-year period between January 2013 and December 2018. The crash data supplied by SCDOT was grouped into street blocks (from north to south), and then reviewed to identify trends in collision types and locations that experienced a high crash frequency. In total, there were 526 reported crashes along the entire route.

See summaries of the crash data in Figures 2.3.1-2.3.16 below, as well as in tabular form in Appendix A. *Note that the 2013-2018 time frames used in Appendix C- Crash Diagrams- Specific Intersections and Appendix D- Bicycle and Pedestrian Crash Diagram. Appendix C uses 1-1-2016 to 3-31-2019, while Appendix D uses 1-1-12 to 3-31-2018.*

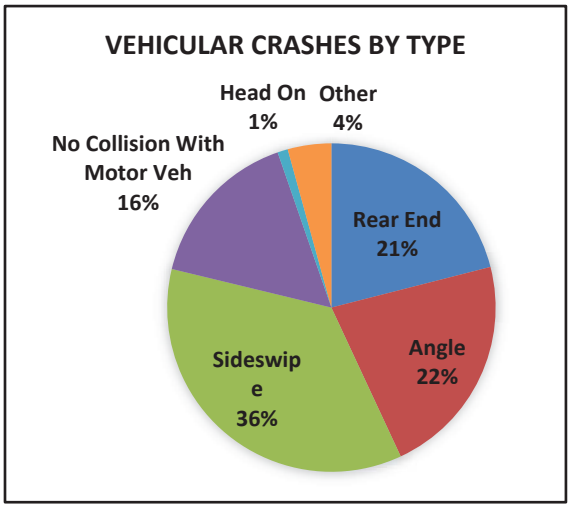


Figure 2.3.1- S-104 Crashes by Type

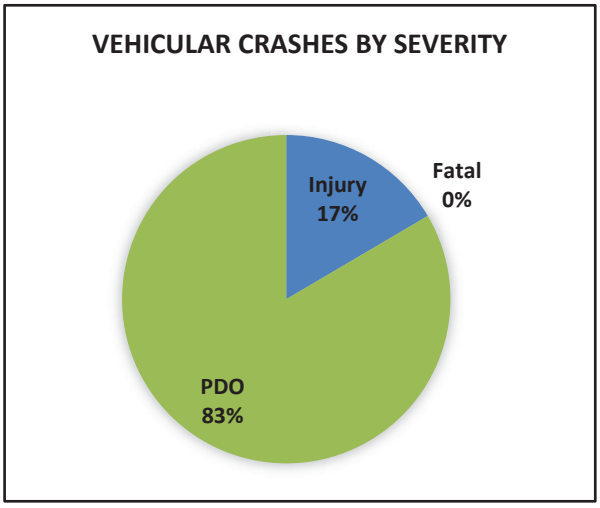


Figure 2.3.2 – S-104 Crashes by Severity

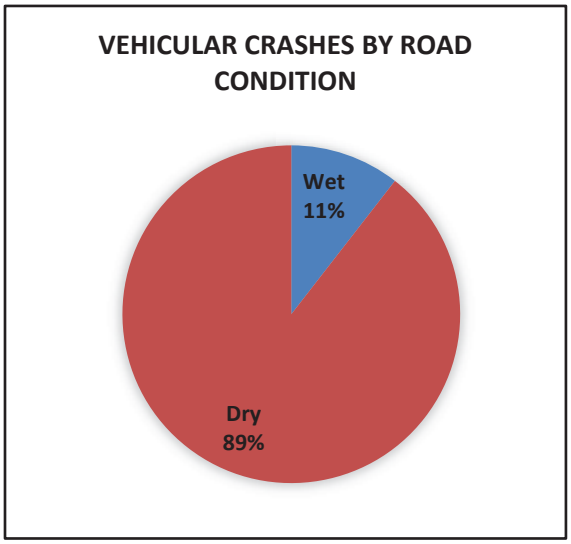


Figure 2.3.3 – S-104 Crashes by Road Condition

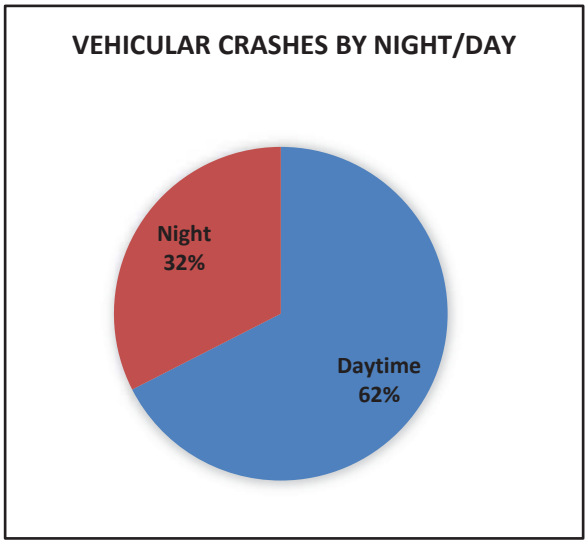


Figure 2.3.4 – S-104 Crashes by Day/night

As seen in Figure 2.3.1, sideswipe crashes are the most common type, at 36% of vehicular crashes. There were no fatal crashes reported over the entire period. Crashes designated as no collision with motor vehicle are typically collisions with a fixed object. Figure 2.3.2 depicts crashes by severity, which shows 17% of vehicular crashes resulted in injuries. Around 83% of the crashes were reported to be property damage only (PDO). Figure 2.3.5 shows various cause of vehicular crashes along the study area.

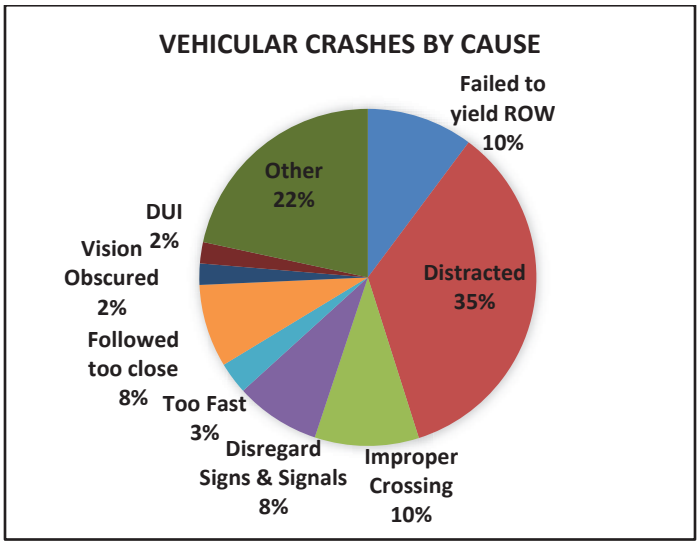


Figure 2.3.5 – S-104 Crashes by Cause

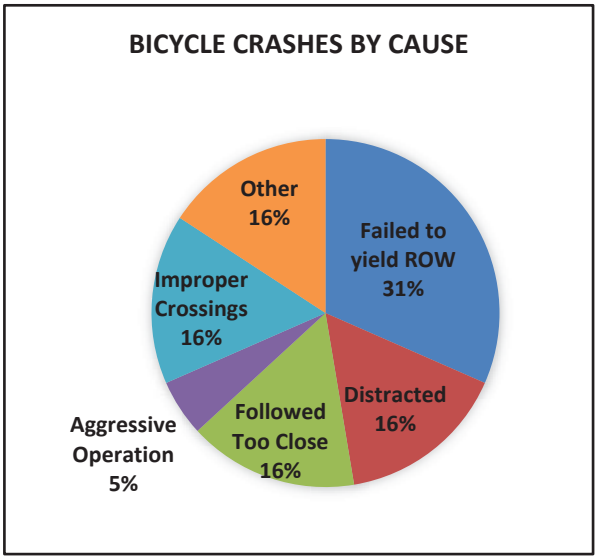


Figure 2.3.6 - S-104 Bicycle Crashes by Cause

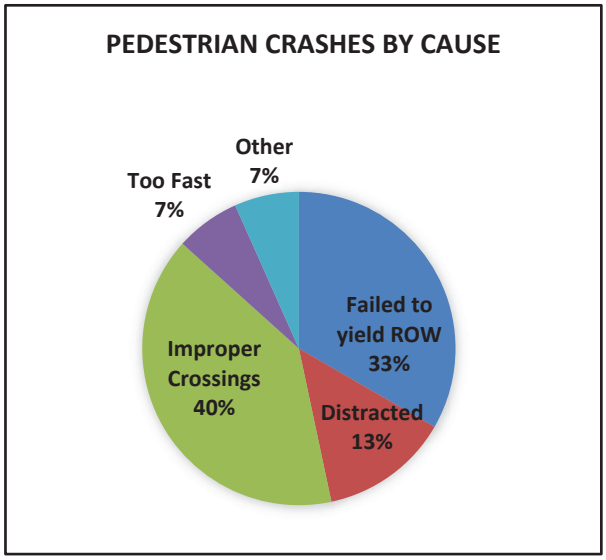


Figure 2.3.7 - S-104 Pedestrian Crashes by Cause

Figures 2.3.6 and 2.3.7 depict bicycle and pedestrian crashes by probable cause, respectively along the study area. Most of the crashes are caused by some form of improper maneuver (Failed to Yield Right of Way and Improper Crossings). Bicycle and pedestrian crashes occurring due to failure to yield right of way account for 31% and 33% respectively.

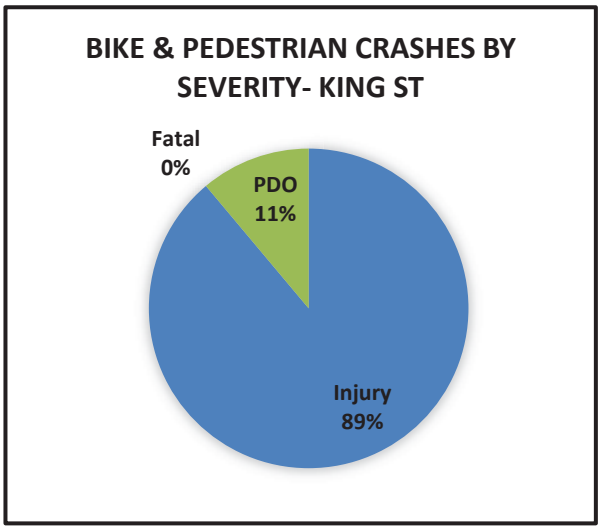


Figure 2.3.8 - S-104 Bicycle and Pedestrian Crashes by Severity

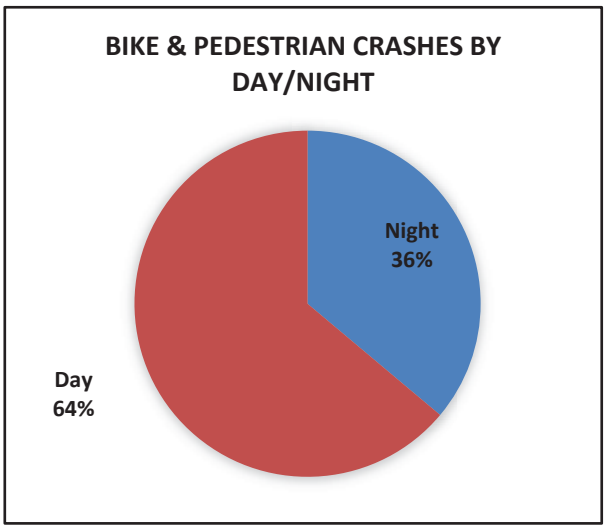


Figure 2.3.9 - S-104 Bicycle and Pedestrian Crashes by Day/Night

Figures 2.3.8 and 2.3.9 depict bicycle and pedestrian crashes by severity and day/night, respectively along the study area. 32 of the 36 crashes resulted in injuries. 36% of the bicycle and pedestrian crashes occurred at night.

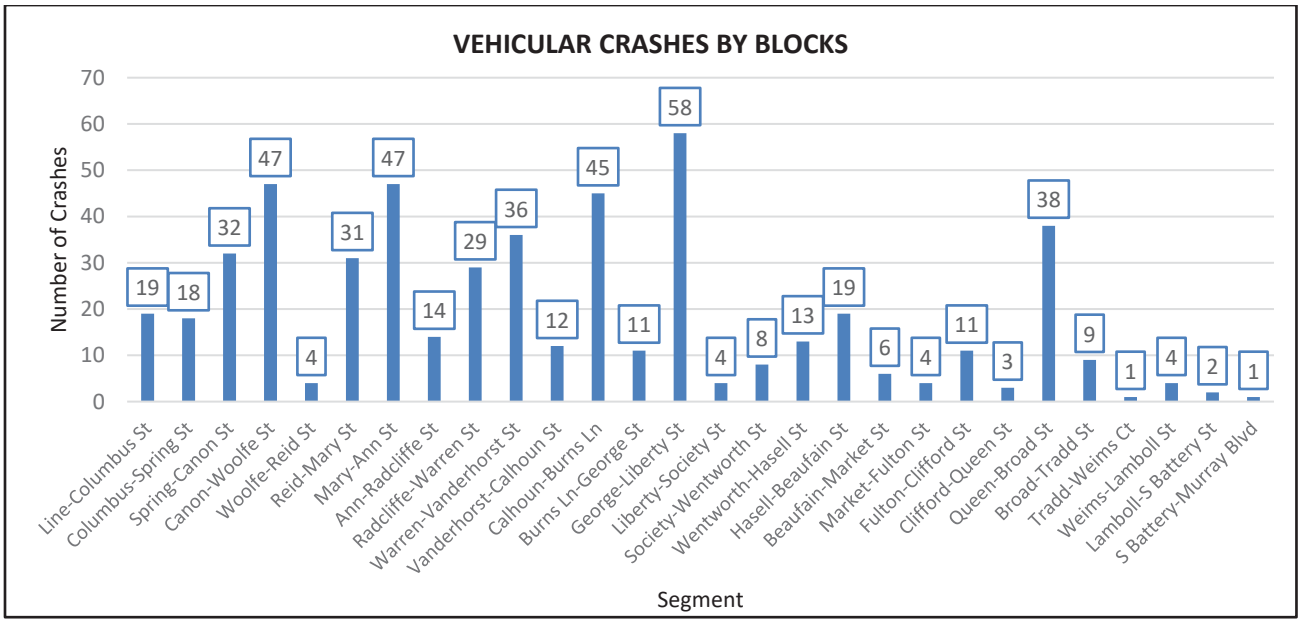


Figure 2.3.10 - S-104 Vehicular Crashes by Block

From Figure 2.3.10, it is observed that George-Liberty St. had the highest number of crashes overall.

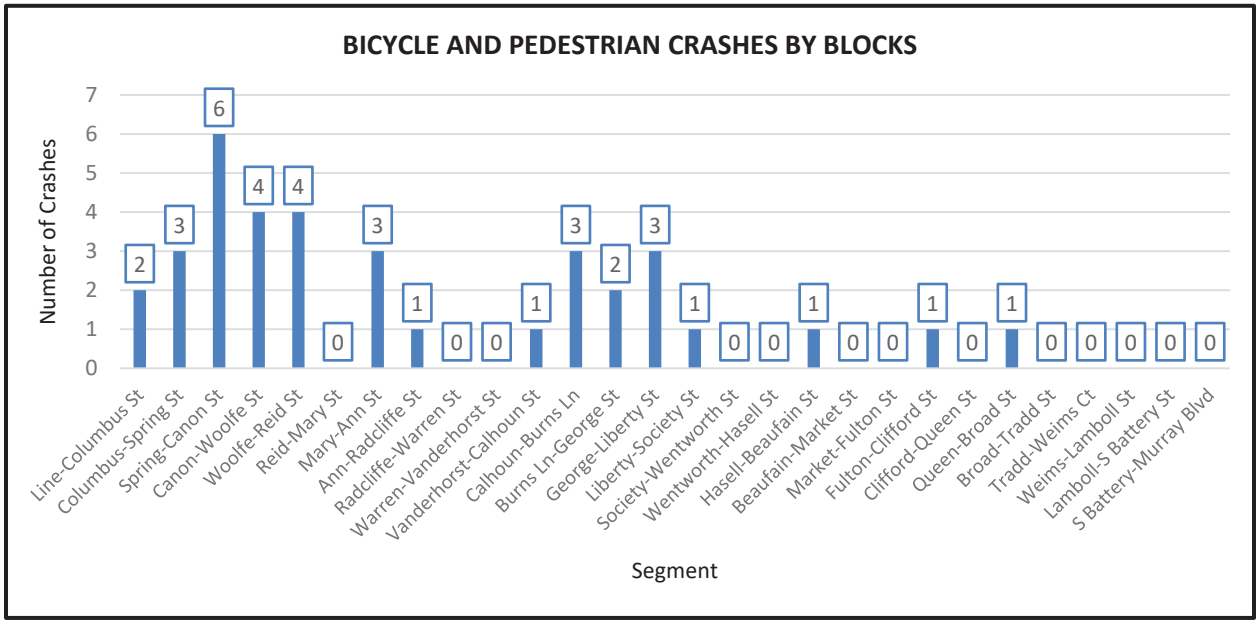


Figure 2.3.11- S-104 Bicycle and Pedestrian Crashes by Block

As seen from Figure 2.3.11, bicycle and pedestrian crashes were concentrated in the northern half of the project, from Line St. to Liberty St.

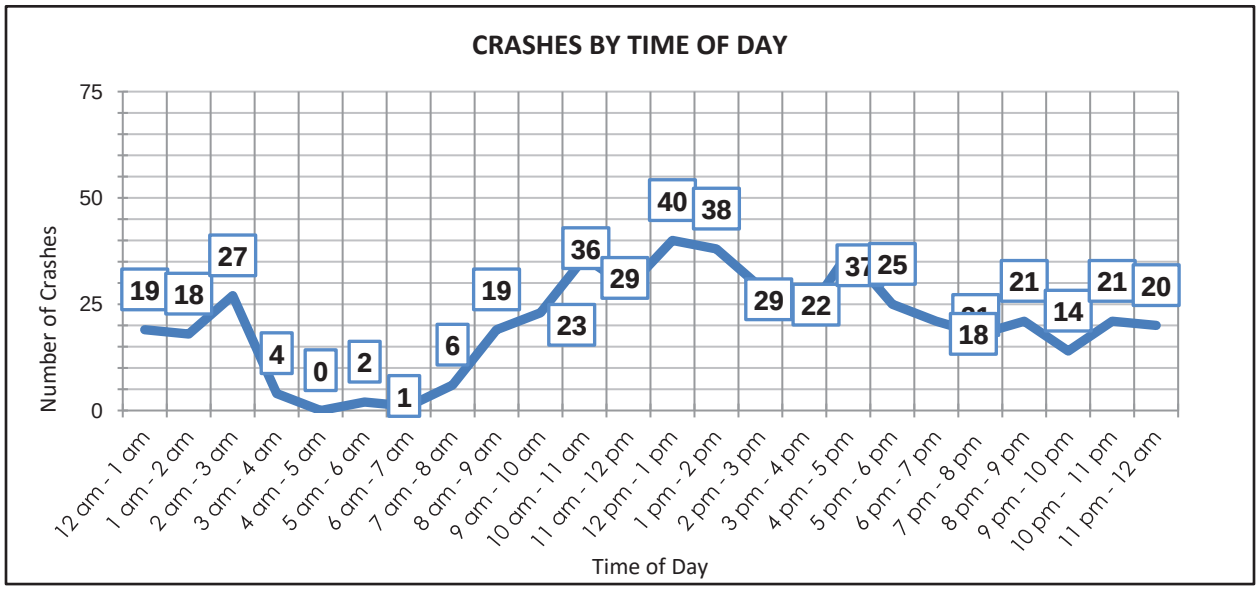


Figure 2.3.12 – S-104 Crashes by Time of Day

As seen in Figure 2.3.12, the majority of the crashes occur between 8:00 AM and 7:00 PM, but night-time crashes continue until 3:00 AM. This is likely due to higher overall traffic and pedestrian volumes, with a lot of movements around popular restaurants and bars at night. From Figure 2.3.13 below, it is observed that bicycle and pedestrian crashes occur from 7:00 AM to 3:00 AM.

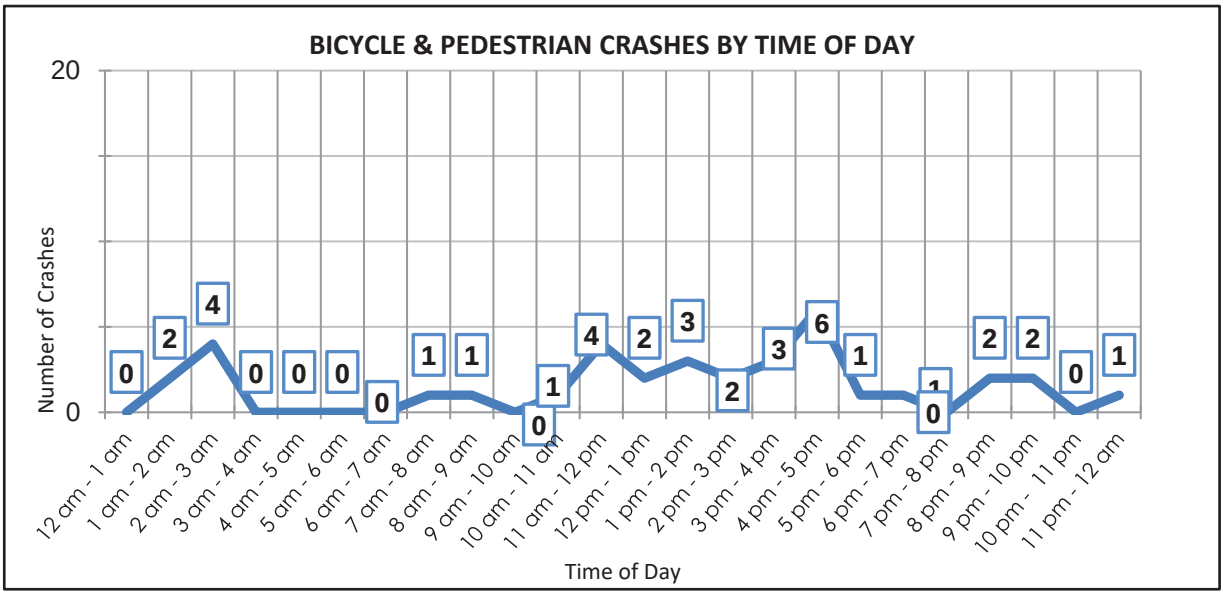


Figure 2.4.13- S-107 Bicycle & Pedestrian Crashes by Time of Day

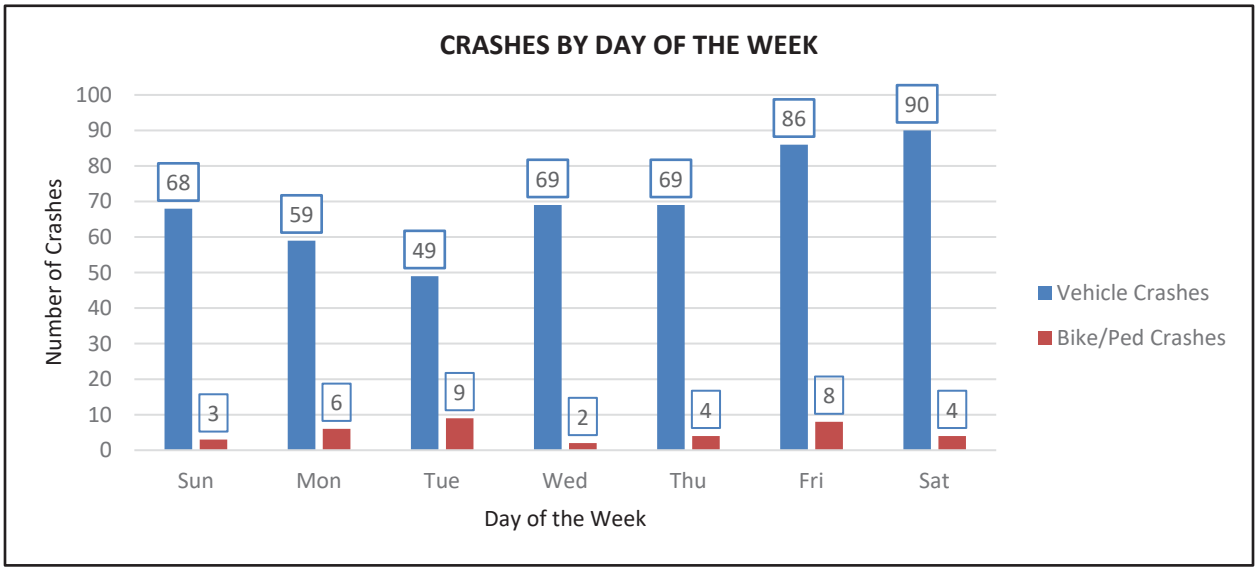


Figure 2.3.14 – S-104 Crashes by Day of the Week

As seen in Figure 2.3.14, most crashes are spread throughout the week, with vehicular crashes being the highest on Fridays and Saturdays.

Crashes by month are depicted in Figure 2.3.15 below.

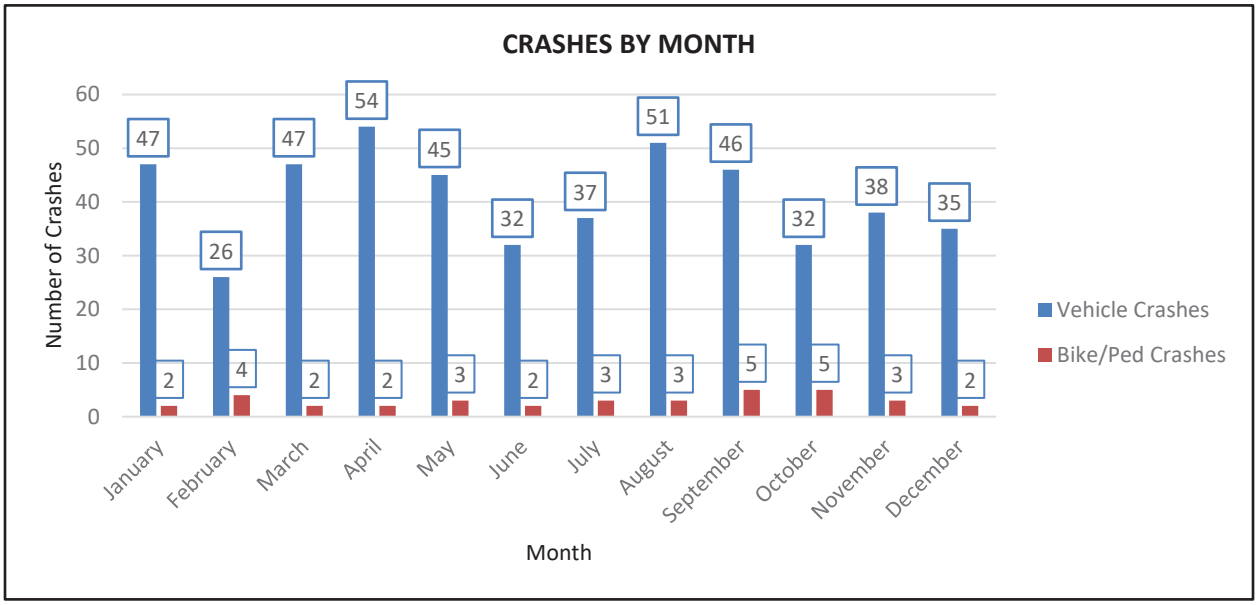


Figure 2.3.15 – S-104 Crashes by Month

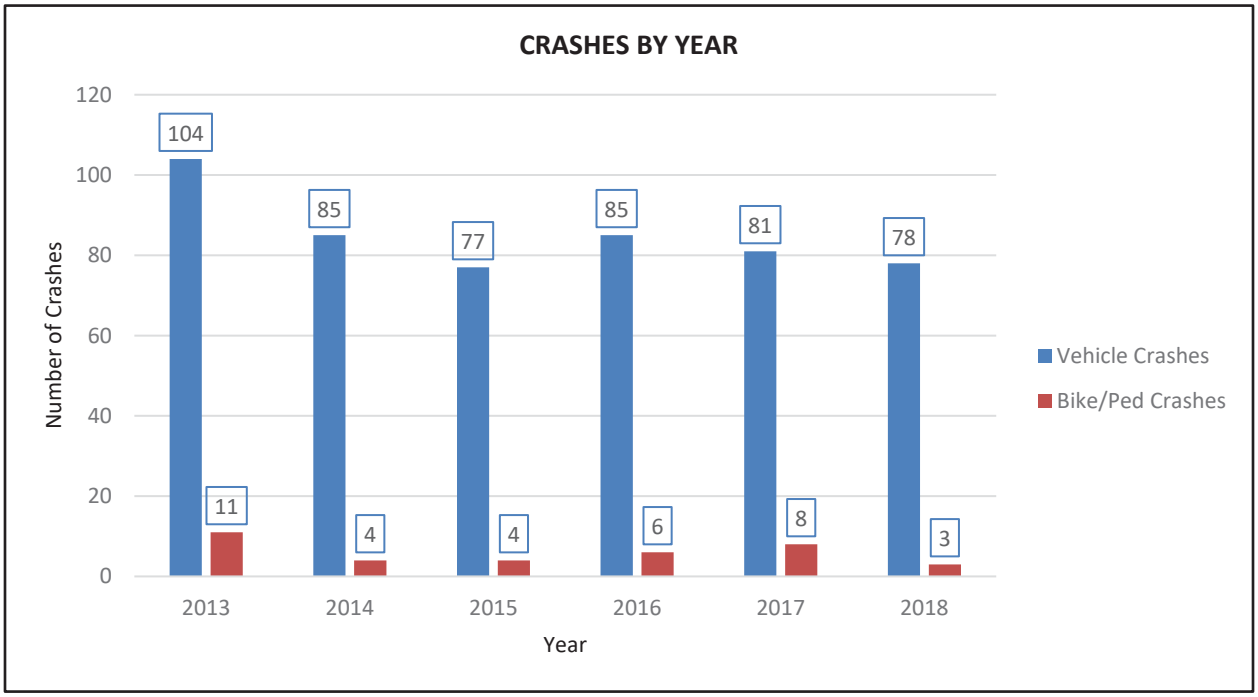


Figure 2.3.16 – S-104 Crashes by Year

Crashes by year are depicted in Figure 2.3.16.

2.4 SPEED STUDY

A speed study at 3 different locations along the corridor was conducted to gauge normal speed variations during non-rush hours. As seen from Figure 2.4.1 and Table 2.1, average and 85th percentile speeds are higher at the north end of the study area. The posted speed limit is 30 mph from the beginning of the study area and decreases to 25 mph beyond the Calhoun St intersection at the southern end.

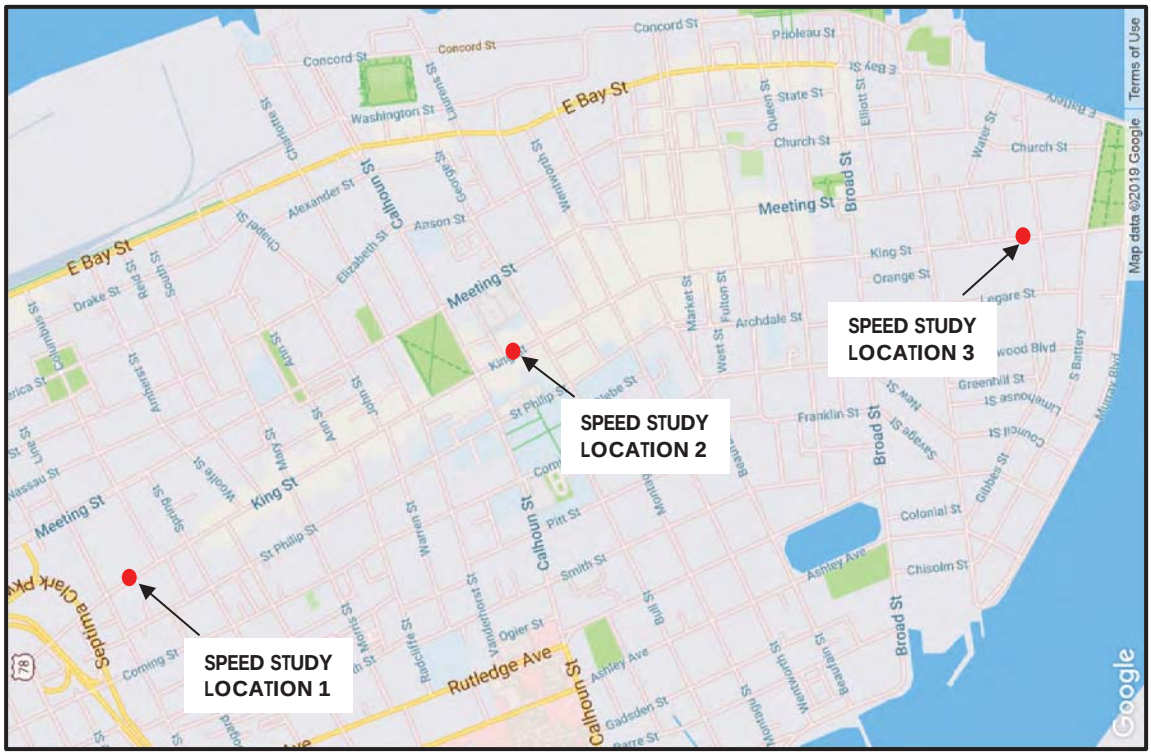


Figure 2.4.1 – S-104 Speed Study Locations

Location	1	2	3
Time	10:45am to 11:00am	11:00am to 11:30am	11:30am to 11:45am
Limit (mph)	30	25	25
Average (mph)	22	20	14
85th percentile (mph)	25	22	15

Table 2.1 – S-104 Speed Limits & Study Results

Results of the speed study show mid-day 85th percentile speeds below the posted speed limits. This aligns with Figures 2.3.5 to 2.3.7, which shows only 3% of vehicular crashes and none of the bicycle or pedestrian crashes were caused by “driving too fast for conditions”.

2.5 OTHER IMPROVEMENTS AND STUDIES

- **Traffic Signal Mast Arms**

Traffic signals at the intersections of King Street & George Street and King Street & Queen Street had pedestal mounted signal heads replaced with mast arms between October 2015 and October 2016. The signal at Spring Street intersection was upgraded in 2017.

- **Holy Spokes**

The Charleston bike share system, Holy Spokes, was launched in May 2017. Hubs on or closest to Meeting Street include 558 King Street, 1883 Ann Street, and 297 King Street.

- **People Pedal Plan**

The City's People Pedal Plan provides recommendations for bicycle and pedestrian improvements throughout the peninsula (Figure 2.5.1). For King Street, the plan recommends bicycle lanes southward to its intersection with Columbus Street. From Columbus Street to Broad Street, it recommends traffic calming. The plan also calls for several intersection improvements along King Street that will need to occur as separate projects, with the S-104 recommendations in the study intended to not conflict with those improvements. The plan shows 85th percentile speeds that are close to those listed in this study. In both cases, the speed data collected only represents short periods of time for a given day. The plan is shown in Appendix G.

- **Charleston Comprehensive Parking Study**

Published in January 2019, the study provided a comprehensive analysis and set of recommendations for the city's parking system.

Figure 2.5.1- People Pedal Plan

2.6 EXISTING ROADWAY FEATURES

The following were identified as positive measures and features that are already in place within the study area that enhance road user safety:

- Continuous sidewalks: Sidewalks within the corridor are continuous and provide a mostly comfortable walking environment.
- Vehicular speed along the corridor is largely controlled.
- Sight triangles: Intersection sight distance was not obstructed by signs or other obstacles for most of the intersection approaches.
- Crosswalks are present at most intersections, including ladder-style crosswalks in some intersections
- Pavement markings: The roadway markings and existing pedestrian crosswalks were in generally good condition.
- Sidewalks at intersections have ramps.
- Existing bus stops were well marked and appear to be heavily used
- King St. has adequate capacity for vehicular traffic.
- Most traffic signals have pedestrian signals
- Acceptable traffic volumes for existing lane alignments.
- Good access control at most locations.
- The corridor has lighting.

3.0 RECOMMENDATIONS

Recommendations for improving safety along S-104 are provided under two categories:

1. Improvements to be applied along the corridor
2. Intersection specific improvements

3.1 CORRIDOR IMPROVEMENTS

This section provides findings and recommendations for improvements to be applied along the S-104 corridor.

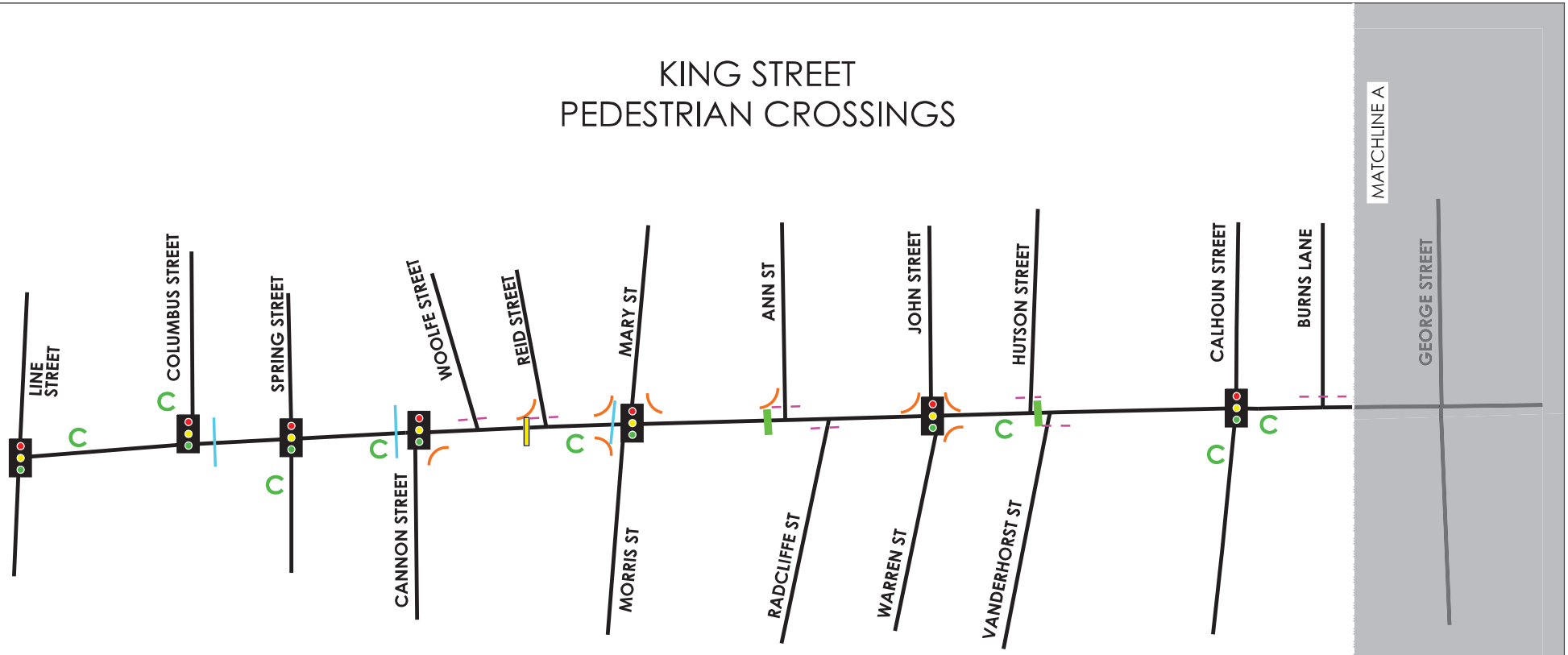
BICYCLE & PEDESTRIAN ACCOMMODATIONS

This study recognizes the need to provide safe pedestrian crossings that reflect pedestrian routing demand. Efforts are made to provide direct crossing routes as feasible. The exhibits on the following page show existing and proposed pedestrian crossings for the S-104 corridor using signalized crosswalks, stop controlled crosswalks, pedestrian refuge islands, curb extensions, and Rectangular Rapid Flashing Beacons (RRFBs). These safety countermeasures address both side street approach crossings and mainline S-104 crossings. Each countermeasure is recommended where found to be applicable per FHWA, MUTCD, and NACTO guidelines.

S-104 Midblock Typical Section

The following exhibits focus solely on pedestrian crossing routes. For simplicity, they exclude Leading Pedestrian Intervals, pedestrian scramble phases, ramps, and various other improvements listed elsewhere in this report.

KING STREET
PEDESTRIAN CROSSINGS



LEGEND

- SIGNAL WITH CROSSWALK UPGRADES
- SIGNALIZED CROSSWALK (NEW)
- STOP-CONTROLLED CROSSWALK (UPGRADE)
- STOP-CONTROLLED CROSSWALK (NEW)
- UNCONTROLLED CROSSWALK (UPGRADE)
- UNCONTROLLED CROSSWALK (NEW)
- CURB EXTENSION (NEW)
- RRFB (NEW)
- C CARTA BUS STOP

SCALE IN FEET

0 500 1000 2000

SHEET 1

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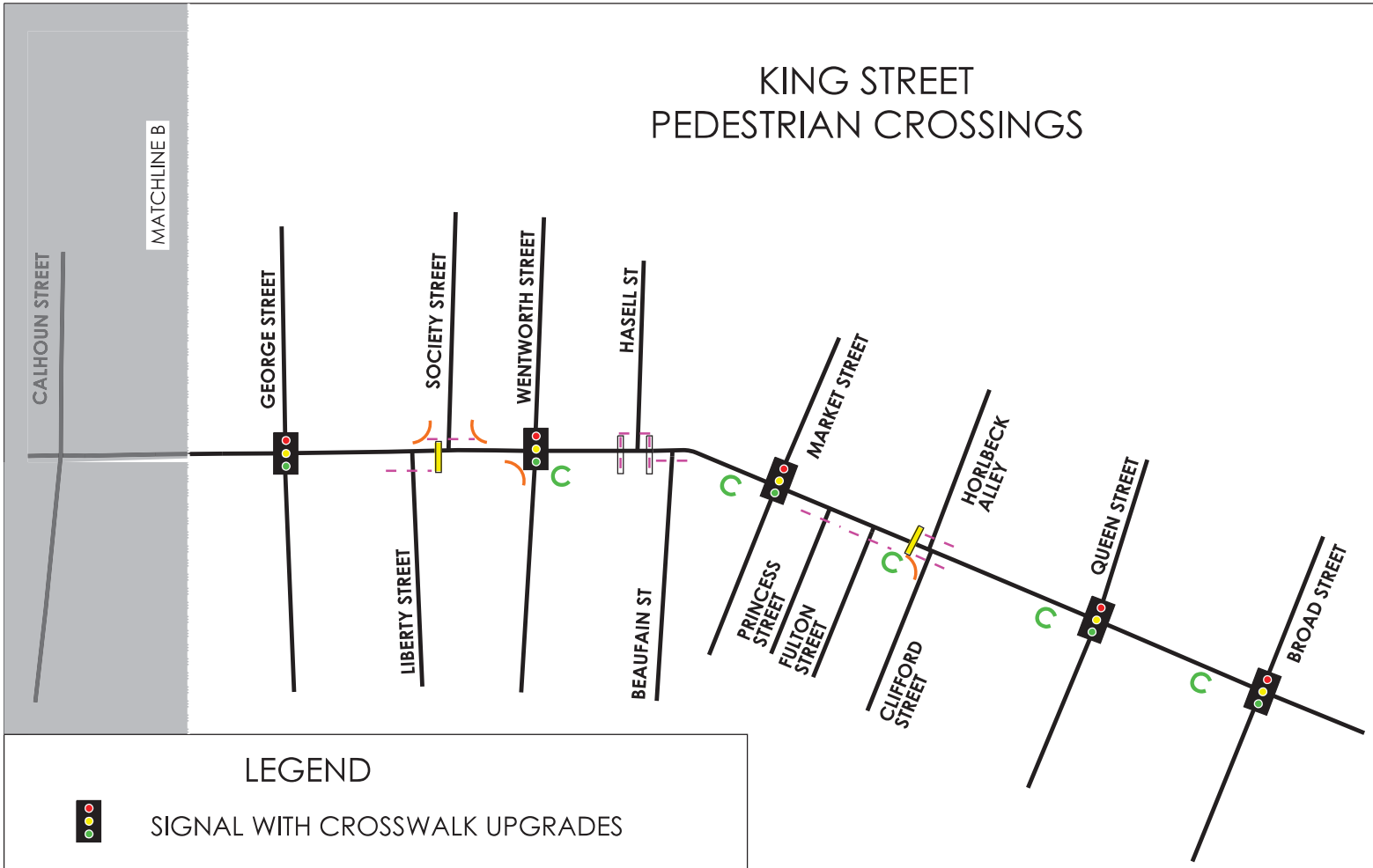
KING STREET
PEDESTRIAN CROSSINGS



LEGEND

- SIGNAL WITH CROSSWALK UPGRADES
- SIGNALIZED CROSSWALK (NEW)
- STOP-CONTROLLED CROSSWALK (UPGRADE)
- STOP-CONTROLLED CROSSWALK (NEW)
- UNCONTROLLED CROSSWALK (UPGRADE)
- UNCONTROLLED CROSSWALK (NEW)
- CURB EXTENSION (NEW)
- RRFB (NEW)
- C CARTA BUS STOP

SCALE IN FEET

0 500 1000 2000

SHEET 2

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BICYCLE & PEDESTRIAN ACCOMMODATIONS

FINDINGS:
Crosswalks are missing across some uncontrolled approaches and at several signalized intersection approaches.

Missing crosswalk at the Mary St. intersection (southbound approach)

IMPROVEMENTS:
Consider adding ladder-style crosswalks to the uncontrolled approaches and at the signalized intersection approaches that don't have them (or decorative stamped asphalt crosswalks) already (Approximately 6 approaches)
Typical pedestrian crash reduction of 50% for installation of crosswalks

FINDINGS:
Some crosswalks along the corridor could be shortened to reduce pedestrian exposure time while crossing.

IMPROVEMENTS:
Consider constructing curb extensions at intersection corners as shown in the Pedestrian Crossings map to reduce crosswalk lengths. The following pages show two representative concept sketches of the curb extensions. Each curb extension should be designed to account for CARTA bus turning movements, drainage, and utilities. In order to materially reduce crosswalk lengths, some crosswalks will need to be relocated away from the intersection as shown in the concepts. The concepts show raised concrete curb extensions, but thermoplastic paint and bollards may be considered as well. The paint and bollard option simplifies construction of the extension itself, but still may require crosswalk relocation.

Truck turning movements, drainage, and utility issues may prove to make curb extensions prohibitive at some locations. Detailed design and coordination will be needed prior to implementation.


CURB EXTENSIONS AT
MARY STREET
NEW CROSSWALK
(TYP.)
CATCH BASIN
(TYP.)
PROPOSED
CURB EXTENSION
(TYP.)
MARY/MORRIS ST
NEW STOP BAR
KING STREET
BUS-40
AASHTO 2001 (US)


CURB EXTENSIONS AT WENTWORTH STREET
WENTWORTH ST
KING STREET
CATCH BASIN (TYP.)
PROPOSED CURB EXTENSION (TYP.)
BUS-40 AASHTO 2001 (US)
N

BICYCLE & PEDESTRIAN ACCOMMODATIONS

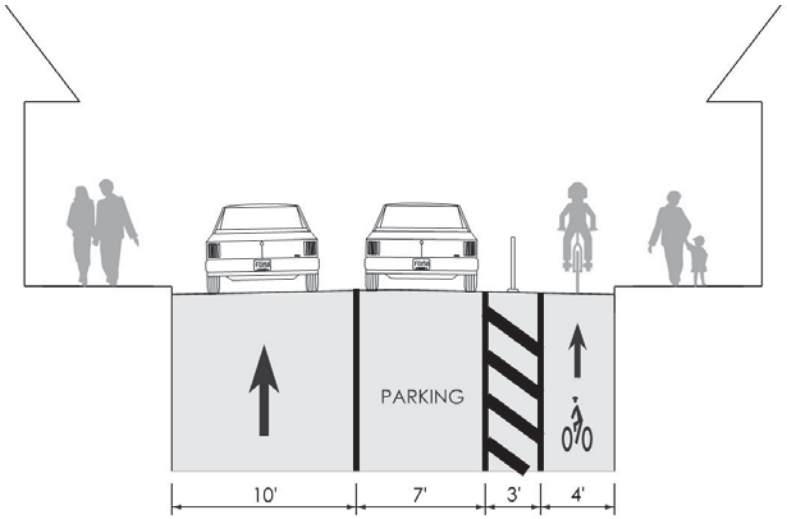
FINDINGS:
Pedestrians crossing the signalized intersections are dependent on right turning vehicles yielding to them. Also, more visible crosswalks could help alert drivers of their presence.

IMPROVEMENTS:
To enhance pedestrian safety, consider implementing Leading Pedestrian Intervals (LPIs) for the signalized pedestrian crossings. LPIs give pedestrians the opportunity to enter a signalized intersection 4–7 seconds before vehicles are given green indications. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles begin entering the intersection. Right turn on red movements will need to be prohibited. A traffic analysis is needed to verify the LPIs will not materially affect congestion and delays.
Typical crash reduction of 59% for installation of LPIs.

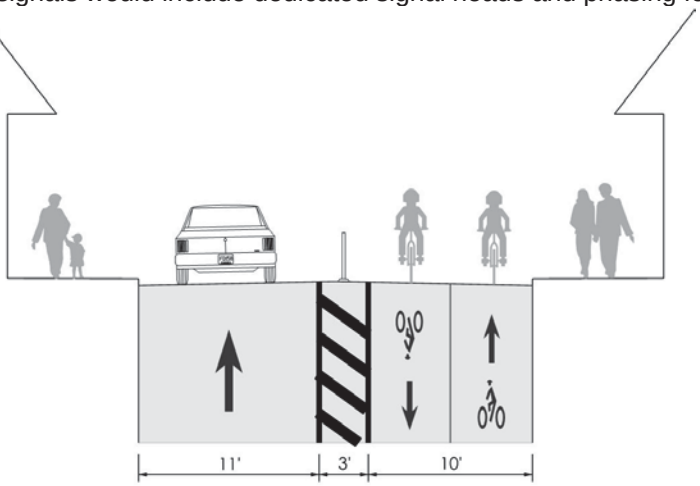
FINDINGS:
King St. has two 9-feet southbound lanes from Calhoun St. to Wentworth St., with on-street parking on the west side. There are frequent truck loading/unloading activities in this area and this section has experienced 63 sideswipe crashes. Drivers tend to avoid driving adjacent to each other, so capacity is not fully utilized.

Tight spacing and narrow lanes between Calhoun St and Wentworth St.

IMPROVEMENTS:
Consider a road diet to reduce S-104 to one through lane and a southbound bicycle lane. A representative typical section is shown below:



Should removal of on-street parking be determined feasible, a two-way cycle track could be implemented as shown below. Traffic signals would include dedicated signal heads and phasing for the contra-flow lane.



These typical sections could apply to S-104 from Calhoun Street to Broad Street, with two exceptions as noted below:

- From Wentworth Street to Hasell Street, S-104 has brick pavement, on-street parking on both sides and two travel lanes with 21 feet of total width. Treatment of the brick pavement will need to be determined.
- From Hasell Street to Queen Street, S-104 returns to on-street parking on the western side only. Southbound through lanes are 10.5 feet wide.

Consider adding colored pavement at conflict points such as driveways and intersections. The example below illustrates colored pavement, with a bicycle box application for signalized intersections.

Colored Pavement at Intersection

(Source: https://nacto.org/publication/urban-bikeway-design-guide/

Further traffic analysis is needed to confirm the lane reduction before implementation. Impacts of on-street must also be considered.

BICYCLE & PEDESTRIAN ACCOMMODATIONS

FINDINGS:
Bicyclists routinely use S-104, with no designated bicycle facilities. In the 7-year period from 2012-2018, 24 bicycle crashes occurred.

IMPROVEMENTS:
The previous improvement covers S-104 from Calhoun Street southward. The remaining section from Line Street to Calhoun Street typically has 12 to 13 feet travel lanes with narrow on-street parking as shown below:

For this section, consider marking the through lanes, with shared lane markings (sharrows) to alert road users of the bicycles and assist bicyclists with lateral positioning. The shared lane markings are to be applied in conjunction with the bike lane.

FINDINGS:
Detectable warning surfaces are missing at several locations throughout the corridor.

Sidewalk without detectable warning surface at Broad St.

IMPROVEMENTS:
Consider adding detectable warning surfaces on ADA ramps where missing. (Approximately 6 ramps)

PAVEMENT MARKINGS AND SIGNING

FINDINGS:
The following stamped asphalt crosswalks are missing white lines along their edges in these intersections: Hutson St., Calhoun St., Burns Ln., Wentworth St. and Broad St.

Existing brick crosswalk at Broad St. without white edge lines

IMPROVEMENTS:
Consider placing white thermoplastic lines along both edges of these crosswalks.

FINDINGS:
The speed data suggests the 30mph speed limit posting might be reduced to 25mph. Also, the City of Charleston has noted citizens asking what the posted speed limits are.

IMPROVEMENTS:
Perform a complete speed study to further evaluate speeds. Consider reducing speed limits, if determined appropriate. Also, consider installing additional R2-1 speed limit signs to inform drivers.

FINDINGS:
Pavement marking and RPM markings in several sections are worn out.

Existing pavement markings worn out

IMPROVEMENTS:
Consider upgrading pavement markings and RPM throughout the corridor. King St. is scheduled for resurfacing from Hasell St. to South Battery, which should cover that section. Coordination with recommendations from this study may be needed.
Typical crash reduction of 5% for installation of RPMs.

PAVEMENT MARKINGS AND SIGNING

FINDINGS:

Some stop bars appear too far from their respective crosswalks.

Stop bar placed too far from the crosswalk at the Queen St intersection (SB)

IMPROVEMENTS:

Evaluate relocating stop bars based on turning movement templates. Locations include southbound S-107 approaches at: Line Street, Columbus Street, Calhoun Street, George Street and Queen Street.

Typical crash reduction of 5% for stop bar relocation.

MAINTENANCE

FINDINGS:

Some sidewalk and pedestrian ramps need to be cleaned. Additionally, tree limbs along the corridor block visibility for drivers.

IMPROVEMENTS:

Consider cleaning sidewalks. Also, consider pruning trees for better visibility.

TRAFFIC SIGNALS

FINDINGS:
Certain intersection signals (Line St. and Columbus St.) are currently programmed to flash at night, beginning at 10pm.

IMPROVEMENTS:
Consider programming these intersection signals to have timed phasing to align with national practices. Cycle lengths will be short.
Typical crash reduction of 30% for signal timing changes.

FINDINGS:
The following signalized intersections lack retroreflective backplates: Line St., Columbus St., Spring St., Calhoun St. and Wentworth St.

Existing Calhoun St. signal heads without retroreflective backplates.

IMPROVEMENTS:
Consider installing retroreflective backplates to improve signal head visibility.
Typical total crash reduction of 15%.

FINDINGS:
The following intersection approaches appear to have 8" signal heads, which are no longer MUTCD compliant:

- Canon Street
- Mary/Morris Street
- John/Warren Street
- Wentworth Street
- Market Street
- Broad Street

IMPROVEMENTS:
Evaluate the viability of replacing each approach with 12" signal heads per MUTCD requirements. Also consider replacing the pedestal pole signals with overhead signals. A combination of overhead and side mount signal heads may be needed. Data on utility attachment heights and vertical clearances will be needed, as well as coordination with Dominion Energy and telecom providers.

EDUCATION AND OUTREACH

FINDINGS:

Several of the bicycle and pedestrian crashes list “Improper Crossing” or “Wrong Side” as the contributing factor. These crashes and possibly others result in part because of cyclists and pedestrians crossing at undesignated locations or when the proper pedestrian signal indication is not provided at signalized intersections. During site visits, activities such as crossing S-104 at midblock and travelling down the two-way left-turn lane were observed. Likewise, other crashes appear to result from drivers failing to yield to cyclists and pedestrians. Improvements in behavior of all users are needed.

IMPROVEMENTS:

Education and outreach programs for bicycles and pedestrians are designed to alert roadway users on the importance of safe travel practices, educate them on safe practices, and encourage active transportation modes for a healthy lifestyle. Typically, these programs are local initiatives, led by a combination of local governments, schools, and community groups. Various municipalities across the US have developed and implemented their own education and outreach programs. Among the typical elements that may be appropriate for this corridor area include:

- Public Awareness Campaigns – Intermittent educational / advertising programs that notify the public on the program’s initiatives and importance. They can be delivered through local media such as radio, television, billboards, and transit vehicle ads, as well as non-media methods such as classroom programs and partnering with community events. Targeting specific age and ethnic groups has demonstrated effective results for some programs. Targeted campaigns have helped pedestrians understand how to interpret traffic signals, how to be more visible at night, how to be more aware of turning vehicles at intersections, and how to travel defensively through techniques like making eye contact with a driver. For drivers, these campaigns often focus on yielding to pedestrians and expanding awareness of bicycling and crosswalk laws.
- Public Service Announcements (PSAs) – Social media, radio, and/or television are used to promote safe cycling, walking, and driving behaviors.
- Promotional Items – Tote bags, T-shirts, magnets, coffee cup sleeves, or other items with printed logos and content can be distributed to the public.
- Partnerships – Government organizations, schools, non-profits, universities, businesses groups, and community groups combine efforts to interact with the public.
- Community Events – Safety education can be included at public events like festivals, school events, and health fairs.
- Skills Practice – Lectures, videos, and/or on-street simulations for college students, school children, and older adults.
- How-To Guides – Printed brochures or internet content.
- Budgeting – Many program components require funding. Social media and volunteer efforts can be very cost effective.

ENFORCEMENT

FINDING:

Crash data involving bicyclists and pedestrians show that most crashes were caused by some form of improper maneuver (Failed to Yield Right of Way, Disregard Signs and Signals, Wrong Way, Darting or Illegal Crossings). Each of these above can potentially be mitigated with targeted enforcement.

IMPROVEMENTS:

While design improvements can provide safer means to cross the roadway, enforcement is needed regardless to change these behaviors. Increased enforcement will play a critical role in the reduction of fatal and serious injury crashes along the corridor.

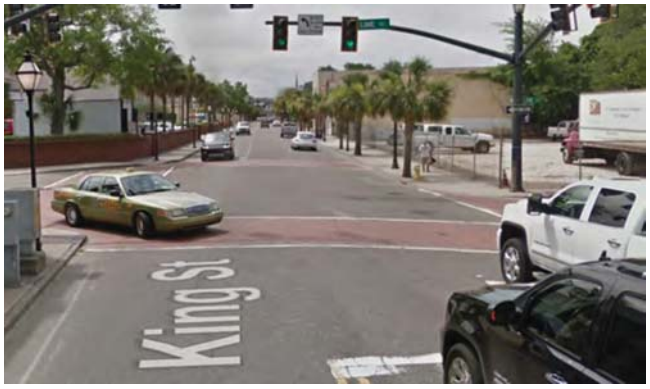
3.2 INTERSECTION SPECIFIC IMPROVEMENTS

The following sections contain findings and recommendations for improvements at individual intersections.

S-104 and Line St.:

Findings:

- The southbound inside lane is currently signed as “Left Turn Only”, except 4-6 PM and 7-9 AM. This coincides with the southbound outside lane parking restrictions immediately south of Line St. When parking is allowed, southbound through lane traffic has to shift immediately after crossing the intersection and then shift back over again prior to Columbus Street to access the through lane. This routing is confusing for drivers.



S-104 Southbound at Line St.

- Pedestrian crossing for the eastern Line Street approach is long.
- There are no detectable warning surfaces on sidewalk ramps.

Improvements:

- Perform a traffic study to see if the southbound Left Only designation could remain during AM and PM peak hours. This would simplify the intersection and maintain consistency throughout the day. King St. southbound could be restriped from Line St. to Columbus St. to maintain a consistent southbound through lane. The parking spaces (approximately 4) would be removed. A concept sketch is provided on the following page.
- Apply updated and additional left turn arrows for King St. southbound to better alert drivers.
- For the eastern Line Street approach, shift the stop bar and crosswalk back as shown in the concept sketch below to reduce pedestrian crossing distance. New ADA ramps will be needed. Prohibit right turns on red to address sight distance obstruction.

Concept Sketch for Line to Columbus Street

- Install detectable warning surfaces on sidewalk ramps.

S-104 and Columbus St.:

Findings:

- Crosswalk is missing at the southern approach of the intersection.
- There are no detectable warning surfaces on sidewalk ramps.

Improvements:

- Add a crosswalk across the southern King Street approach, with ADA ramp improvements.
- Install detectable warning surfaces on sidewalk ramps.

S-104 and Cannon St.:

Findings:

- Crosswalk is missing at the northern approach of the intersection.
- Pedestrian crossing of Cannon Street could be shortened if the Cannon Street right turn lane was removed.
- Pavement markings are worn out the intersection.

- Sight visibility is restricted for the Cannon Street approach.

Improvements:

- Add a crosswalk across the northern approach, with ADA ramps.
- Perform a traffic analysis to determine the feasibility of removing the Cannon St. right turn lane and shortening its crosswalk with a curb extension. The curb extension should not impede the turning radius of CARTA buses.
- Consider repainting worn out right and left turn arrows on the pavement, at the Cannon St approach.
- Prohibit Canon Street right turns on red to address sight distance limitations.

S-104 and Woolfe St.:

Findings:

- There are no detectable warning surfaces on sidewalk ramps.

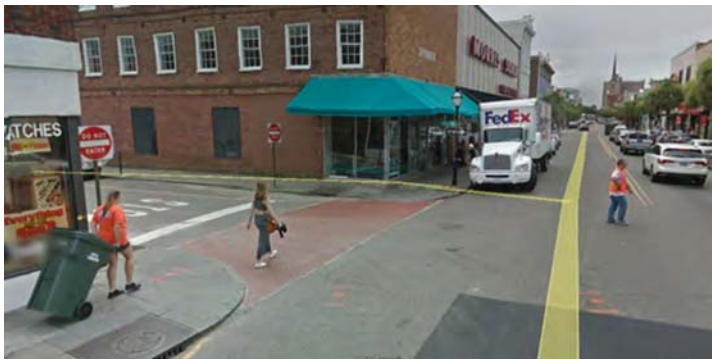
Improvements:

- Install detectable warning surfaces on sidewalk ramps.

S-104 and Reid St.:

Findings:

- The side street turns from Reid St onto S-104 are difficult because of limited sight distance.
- There are no detectable warning surfaces on sidewalk ramps.
- No pedestrian accommodations for crossing S-104 exist between Cannon Street and Mary Street/Morris Street which are 620 feet apart.



Limited sight distance for Reid St.

Improvements:

- Consider restricting parking in the southern corner of this intersection to improve sight visibility and safety.
- Install detectable warning surfaces on sidewalk ramps.

- Consider installing a high visibility crosswalk across S-104, with W11-2 pedestrian signs, and W16-7P diagonal arrow signs. The crosswalk may be shortened with a curb extension on the eastern side.

S-104 and Morris St./Mary St.:

Findings:

- Missing crosswalk at the northern approach of the intersection.
- There are no detectable warning surfaces on sidewalk ramps.
- Sight visibility is restricted for the Morris Street and Mary Street side street approaches.

Morris St. crosswalk

Improvements:

- Add a crosswalk at the northern approach of the intersection. Include curb extension to shorten it and the Morris St. crosswalk. The loading zone on the eastern side will need to be restricted to be beyond the crosswalk.
- Install detectable warning surfaces on sidewalk ramps.
- Prohibit Morris Street and Marry Street right turns on red to address sight distance limitations.

S-104 and Ann St.:

Findings:

- There are no detectable warning surfaces on sidewalk ramps at the side street approach.
- The uncontrolled crosswalk near the Ann St intersection has alternating signals that flash constantly, which appears to cause drivers to not notice when a pedestrian is actually present. Additionally, parking space adjacent to the uncontrolled crosswalk at the Ann St intersection confuses drivers and hinders visibility.

Improvements:

- Install detectable warning surfaces on sidewalk ramps.
- This crossing has been evaluated for crosswalk improvements. The existing crosswalk is a stamped asphalt crosswalk with outer white lines, alternating signals that flash constantly, and W11-2 Pedestrian signs with W16-7P diagonal arrow signs. S-104 has two lanes and is currently posted for 30 mph. Potential improvements considered for the crosswalk include high-visibility

crosswalk markings, raised crosswalk, in-street pedestrian crossing signs, curb extensions, and Rectangular Rapid Flashing Beacons (RRFBs). Among the guidance documents used were:

- FHWA's Field Guide for Selecting Countermeasures of Uncontrolled Pedestrian Crossing Locations
- NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings.

FHWA's Field Guide provides a matrix with guidance on when each safety countermeasure is a candidate treatment and when each countermeasure should be considered. It lists high visibility crosswalk markings and raised crosswalks as potential countermeasures based on laneage, posted speed, and ADT. Given the stamped asphalt and other streetscape elements, high visibility markings are not preferred. Further protection would be beneficial. Given emergency response needs, traffic volumes, and lack of presence elsewhere, raised crosswalks are not preferred.

The field guide gives additional considerations for the use of RRFBs:

- Noted conflicts at crossing locations
- Inadequate conspicuity/visibility of the crosswalk and pedestrian
- Insufficient pedestrian separation from traffic

No pedestrian crashes are shown for this location. However, the RSA team noted conflicts previously observed with insufficient separation from traffic.

NCHRP Report 562 provides the following guidance on implementing an RRFB:

- A pedestrian beacon is proposed to be considered for installation at a midblock location that does not meet other traffic signal warrants to facilitate pedestrian crossings. The pedestrian phase for a pedestrian beacon would be activated by a pedestrian.
- If gaps in traffic are not adequate to permit reasonably safe pedestrian crossings, or if the speed for vehicles approaching on the major street is too high to permit reasonably safe street crossings for pedestrians, or if pedestrian delay is excessive.

A two-hour pedestrian count was performed with the following results:

15-min Intervals	Pedestrian Counts
6:00 to 6:15 pm	42
6:15 to 6:30 pm	38
6:30 to 6:45 pm	40
6:45 to 7:00 pm	23
7:00 to 7:15 pm	16
7:15 to 7:30 pm	13
7:30 to 7:45 pm	15
7:45 to 8:00 pm	10

Peak Hour Count: 143 pedestrians (6:00pm to 7:00pm)

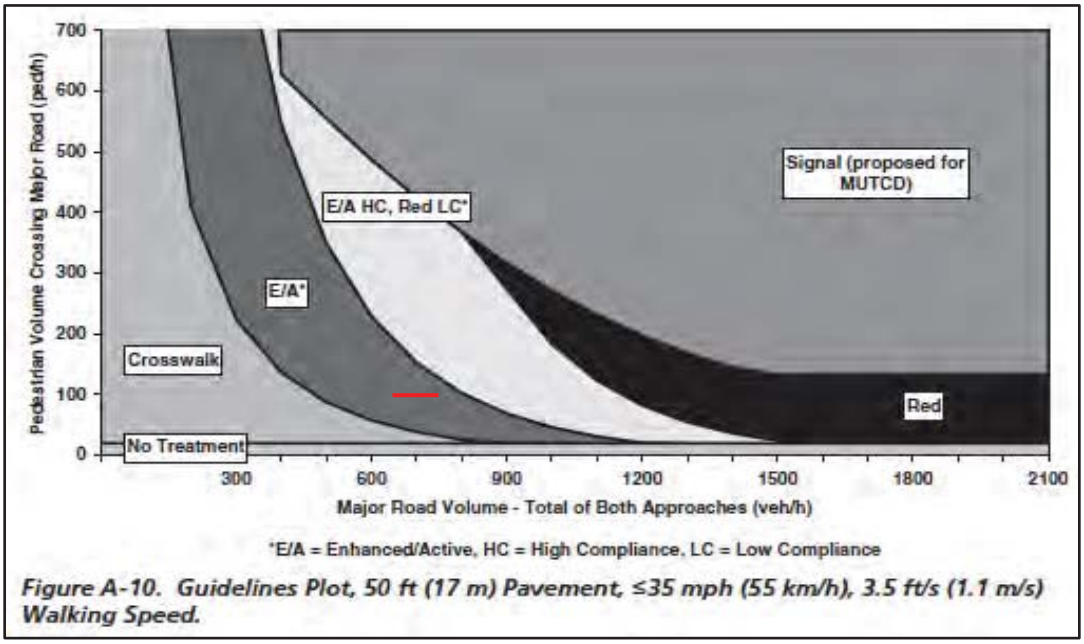


Figure 3.2.1- Pedestrian Volume Analysis (NCHRP report)

— Count Period: 6:00 PM to 7:00 PM, with estimated volume

Results of the analysis show an RRFB is warranted.

Based on these results, the following safety countermeasures are recommended for consideration:

- RRFB on each side of the crosswalk, with W11-2 Pedestrian and W16-7P diagonal arrow signs
- Yield bars on each King Street approach to the crosswalk, with R1-5 Yield Here to Pedestrian Signs
- Curb extensions to reduce crossing width and provide RRFB placement closer to the travel lanes for improved visibility. The existing bike stand could be included in the western curb extension.
- Parking spaces immediately adjacent to the crosswalk may require removal

Typical pedestrian crash reduction of 50% for installation of RRFB.

S-104 and Warren St./John St.:

Findings:

- There are no detectable warning surfaces on sidewalk ramps.
- Pedestrian crossing at both Warren St. and john St. could be shortened, to enhance walkability.

Improvements:

- Install detectable warning surfaces on sidewalk ramps.

S-104 and Vanderhorst St. and Hutson St.:

Findings:

- There are no detectable warning surfaces on sidewalk ramps.
- The crosswalk at the Vanderhorst St. and Hutson St. intersection is heavily used by pedestrians and could use additional protective measures. Additionally, parking space adjacent to the crosswalk at this intersection hinders visibility.

Improvements:

- Install detectable warning surfaces on sidewalk ramps.
- This crossing has been evaluated for crosswalk improvements, similar to that of the Ann Street intersection crossing. The existing crosswalk is a stamped asphalt crosswalk with outer white lines. S-104 has two lanes and is currently posted for 30 mph.

A two-hour pedestrian count study was performed with the following results:

15-min Intervals	Pedestrian Counts
3:30 to 3:45 pm	8
3:45 to 4:00 pm	5
4:00 to 4:15 pm	4
4:15 to 4:30 pm	3
4:30 to 4:45 pm	4
4:45 to 5:00 pm	2
5:00 to 5:15 pm	5
5:15 to 5:30 pm	6

Peak Hour Count: 20 pedestrians (3:30pm to 4:30pm)

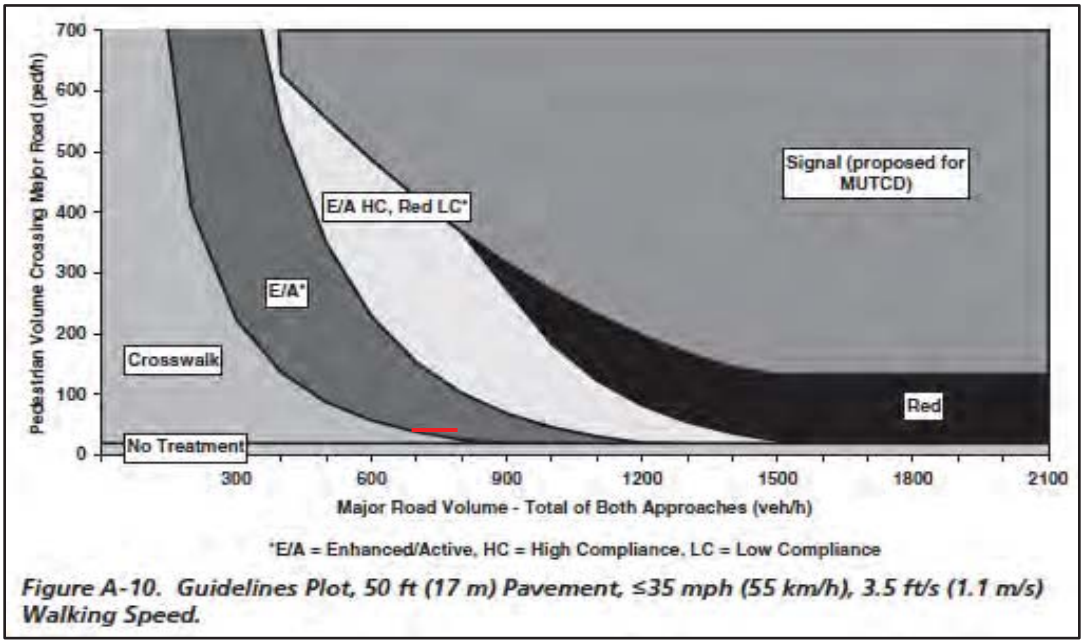


Figure 3.2.2- Pedestrian Volume Analysis (NCHRP report)

— Count Period: 3:30pm to 4:30pm, with estimated volume

Results of the analysis show an RRFB is warranted.

Based on these results, the following safety countermeasures are recommended for consideration:

- RRFB on each side of the crosswalk, with W11-2 Pedestrian and W16-7P diagonal arrow signs
- Yield bars on each King Street approach to the crosswalk, with R1-5 Yield Here to Pedestrian signs
- Curb extensions to reduce crossing width and provide RRFB placement closer to the travel lanes for improved visibility.
- Parking spaces immediately adjacent to the crosswalk may require removal

Typical pedestrian crash reduction of 50% for installation of RRFB.

S-104 and Calhoun St.:

Findings:

- Pedestrian activity is high at this intersection, at times conflicting with vehicular demand.

Pedestrian wait to cross intersection

Improvements:

- Perform a traffic analysis to evaluate converting this intersection to include a pedestrian scramble phase that accommodates diagonal crossings.

S-104 and Society St.:

Findings:

- No pedestrian accommodations for crossing S-104 exist between George Street and Wentworth Street, which are 670 feet apart.

Improvements:

- Consider installing a high visibility crosswalk across S-104, with W11-2 pedestrian signs and W16-7P diagonal arrow signs. The crosswalk may be shortened with a curb extension on the eastern side.

S-104 and Market St.:

Findings:

- Pedestrian activity is high at this intersection, at times conflicting with vehicular demand.
- Sidewalk at the southwest corner is damaged.

Pedestrian wait to cross intersection

Improvements:

- Perform a traffic analysis to evaluate converting this intersection to include a pedestrian scramble phase that accommodates diagonal crossings.
- Add a “No Right Turns on Red” sign.
- Repair sidewalk at the southwest corner of the intersection.

S-104 and Clifford St./Horlbeck Alley.:

Findings:

- No pedestrian accommodations for crossing S-104 exist between Market Street and Queen Street, which are 970 feet apart.

Improvements:

- Consider installing a high visibility crosswalk across S-104, with W11-2 pedestrian signs and W16-7P diagonal arrow signs. The crosswalk may be shortened with a curb extension on the western side.

S-104 and Queen St.:

Findings:

- Sight distance at the western approach is limited.

Improvements:

- Add a “No Right Turns on Red” sign at the western approach.

4.0 SUMMARY OF CONSTRUCTION COSTS

Probable construction costs for the recommended improvements are provided below. Note these costs do not include preliminary engineering, right of way, utility relocation or CE&I costs.

CORRIDOR RECOMMENDATIONS (SECTION 3.1)	
IMPROVEMENT	COST
Add crosswalks to side street approaches. (Approx. 3 approaches)	$4,500
Install curb extensions. (Up to 16 intersection corners)	$192,000
Consider implementing leading Pedestrian Intervals (LPIs) (up to 12 signals)	$36,000
Consider a road diet to reduce King St. to one through lane and one southbound bicycle lane, from Calhoun St. to Broad St.	$310,000
Apply sharrows from Line St. to Calhoun St.	$15,000
Add detectable warning surfaces to ADA ramps at signalized and unsignalized side street crossings. (Approx. 6 ramps)	$2,500
Add white thermoplastic lines along both edges of stamped asphalt crosswalks. (Approx. 5 intersections)	$1,000
Revise speed limits.	$4,000
Upgrade pavement markings and raised pavement markers. (Includes some crosswalks)	$56,000
Relocate stop bars. (Approx. 5 approaches)	$3,000
Convert signals from night-time flash to timed phasing. (2 intersections)	$200
Install retroreflective backplates to improve signal head visibility. (Approx. 5 intersections)	$8,000
Replace 8” signal heads with 12” signal heads, as per MUTCD. Note: Utility pole availability must be coordinated with Dominion Energy. (Approx. 6 intersections)	$109,500
Subtotal	$741,700
Contingency (30%)	$222,510
INTERSECTION SPECIFIC IMPROVEMENTS (SECTION 3.2)	
IMPROVEMENT	COST
Line St. – Consider restriping King St. southbound from Line St. to Columbus St. and making southbound left turn lane at Line St. to be Left Turn Only at all times (other improvements included in section 3.1).	$15,000
Columbus St. – Add a crosswalk at the southern approach of the intersection with ADA ramp improvements (other improvements included in section 3.1).	$7,500
Cannon St. – Add crosswalk across the northern approach with ADA ramps, prohibit RTOR from Cannon St. (other improvements included in section 3.1).	$8,000
Woolfe St. - Improvement included in section 3.1	N/A
Reid St. – Restrict parking in the southern corner of the intersection, install crosswalk with signs (other improvements included in section 3.1).	$2,000
Morris/Mary St. – Install crosswalk across the northern approach (other improvements included in section 3.1).	$4,000
Ann St. - Install RRFB, yield bars and remove adjacent parking space (other improvements included in section 3.1).	$40,000
Warren/John St. – Improvements included in section 3.1.	N/A
Hutson St. - Improvements included in section 3.1.	N/A

INTERSECTION SPECIFIC IMPROVEMENTS (SECTION 3.2)	
Vanderhorst/Hutson St. - Install RRFB, yield bars and remove adjacent parking space (other improvements included in section 3.1).	$40,000
Calhoun St. – Potential improvements for pedestrian scramble phase.	$30,000
Society St. – Install crosswalk with signs.	$2,000
Market St. - Install "No Right Turn On Red" sign. Potential improvements for pedestrian scramble phase.	$31,000
Market St. - Repair sidewalk at the southwest corner.	$1,000
Clifford St./Horlbeck Alley - Install crosswalk with signs.	$2,000
Queen St. - Install "No Right Turn On Red" sign.	$250
Subtotal	$182,750
Contingency (30%)	$54,825
Total (Sections 3.1 and 3.2)	**$1,201,785**

5.0 PRIORITIZATION

Appendix E shows the annualized cost and benefit for each improvement, as applicable. Costs are based on conceptual construction costs only. Costs are annualized based on the following life cycle of improvements:

- Thermoplastic pavement markings – 5 years
- Roadway signs – 10 years
- Other items – 20 years

Benefits are based on the estimated savings from potential crash reductions. The predictions for crash reductions used in the analysis are based on national research of engineering studies that used crash data to quantify the safety effect of the corresponding countermeasure. Application of the crash modification factors to this particular corridor is somewhat subjective, so the computed benefits should only be considered as generally applicable. This report also recognizes some improvements have intangible benefits beyond crash reductions. For example, improvements to bicycle and pedestrian facilities can provide a level of comfort for its users. They can also lead to increased usage, providing public convenience, health, and/or economic benefits from the improved transportation system.

In this section, each suggested improvement is evaluated based on its cost, ease of construction, impacts, benefit cost (B/C) ratio, and how it relates to other improvements. Based on these evaluations, improvements are grouped into potential short term and long-term categories. These categories are for planning purposes only and can be subject to change based on funding and other factors. The B/C ratios are calculated for each improvement individually. So, cumulative benefits from performing all the recommended improvements may be less than what is shown.

SHORT TERM		
IMPROVEMENT	**COST**	**B/C**
Add crosswalks to side street approaches. (Approx. 3 approaches)	$4,500	63.40
Consider implementing leading Pedestrian Intervals (LPIs) (up to 12 signals)	$36,000	9.52
Add detectable warning surfaces to ADA ramps at signalized and unsignalized side street crossings. (Approx. 6 ramps)	$2,500	N/A
Add white thermoplastic lines along both edges of stamped asphalt crosswalks. (Approx. 5 intersections)	$1,000	N/A
Revise speed limits.	$4,000	N/A
Upgrade pavement markings and raised pavement markers. (Includes some crosswalks)	$56,000	7.31
Relocate stop bars. (Approx. 5 approaches)	$3,000	4.31
Convert signals from night-time flash to timed phasing. (2 intersections)	$200	>100
Install retroreflective backplates to improve signal head visibility. (Approx. 5 intersections)	$8,000	80.05
Replace 8” signal heads with 12” signal heads, as per MUTCD. Note: Utility pole availability must be coordinated with Dominion Energy. (Approx. 6 intersections)	$109,500	6.18

Line St. – Consider restriping King St. southbound from Line St. to Columbus St. and making southbound left turn lane at Line St. to be Left Turn Only at all times (other improvements included in section 3.1).	$15,000	N/A
Columbus St. – Add a crosswalk at the southern approach of the intersection with ADA ramp improvements (other improvements included in section 3.1).	$7,500	0.00
Cannon St. – Add crosswalk across the northern approach with ADA ramps, prohibit RTOR from Cannon St. (other improvements included in section 3.1).	$8,000	0.00
Woolfe St. - Improvement included in section 3.1	N/A	N/A
Reid St. – Restrict parking in the southern corner of the intersection, install crosswalk with signs (other improvements included in section 3.1).	$2,000	>100
Morris/Mary St. – Install crosswalk across the northern approach (other improvements included in section 3.1).	$4,000	0.00
Ann St. - Install RRFB, yield bars and remove adjacent parking space (other improvements included in section 3.1).	$40,000	19.76
Warren/John St. – Improvements included in section 3.1.	N/A	N/A
Hutson St. - Improvements included in section 3.1.	N/A	N/A
Vanderhorst/Hutson St. - Install RRFB, yield bars and remove adjacent parking space (other improvements included in section 3.1).	$40,000	0.00
Calhoun St. – Potential improvements for pedestrian scramble phase.	$30,000	46.91
Society St. – Install crosswalk with signs.	$2,000	18.82
Market St. - Install "No Right Turn On Red" sign. Potential improvements for pedestrian scramble phase.	$31,000	0.00
Market St. - Repair sidewalk at the southwest corner.	$1,000	N/A
Clifford St./Horlbeck Alley - Install crosswalk with signs.	$2,000	0.00
Queen St. - Install "No Right Turn On Red" sign.	$250	0.00
Subtotal	$407,450	
Contingency (30%)	$122,235	
Total	**$529,685**	

LONG TERM		
IMPROVEMENT	**COST**	**B/C**
Road diet- to reduce King St. to one through lane and one southbound bicycle lane.	$310,000	2.64
Curb Extensions (Up to 16 intersection corners)	$192,000	N/A
Apply sharrows from Line St. to Calhoun St.	$15,000	N/A
Subtotal	$517,000	
Contingency (30%)	$155,100	
Total	**$672,100**	