Riverside at Stephen Richards Congestion Mitigation

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Existing Conditions Report

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Alaska Department of Transportation and Public Facilities Northern Region

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Abbreviations

AADT	Annual Average Daily Traffic
CAR	Critical Accident Rate
CBJ	City and Borough of Juneau
DOT&PF	Alaska Department of Transportation and Public Facilities
Green Book	*A Policy on Geometric Design of Highways and Streets*
HCM	*Highway Capacity Manual*
KE	Kinney Engineering
LOS	Level of Service (performance grade)
MEV	Million Entering Vehicles
mph	Miles per Hour
MVM	Million Vehicle Miles
TMV	Turning Movement Volume
v/c or V/C	Volume to Capacity Ratio

Definition of Terms

Average Annual Daily Traffic (AADT): A measurement of the number of vehicles traveling on a segment of highway each day, averaged over the year.

Capacity: Value of the maximum flow rate.

Control Delay: Portion of total delay a vehicle experiences at a traffic-controlled intersection, given in seconds per vehicle.

Crash Rate: Number of crashes per a unit of exposure. Common units of exposure include million vehicle miles traveled for roadway segments and million entering vehicles for intersections.

Crash Severity: Scale of bodily harm up to and including death, suffered by the occupants of the vehicle involved in a crash. There are four levels of crash severity used: property damage only (PDO), non-incapacitating/possible injury (minor injury), incapacitating injury (major injury), and fatal.

Critical Accident Rate (CAR): Statistical measure used in crash rate analysis to determine statistical significance. If the crash rate of the location in question is above the CAR for that location, the crash rate is above the average crash rate for similar facilities to a statistically significant level.

Flow Rate: Measurement of the number of vehicles passing a given point within a set amount of time, usually an hour.

Level of Service (LOS): Performance measure concept used to quantify the operational performance of a facility and present the information to users and operating agencies. The actual performance measure used varies by the type of facility; however, all use a scale of A (best conditions for individual users) to F (worst conditions). Often, LOS C or D in the most congested hours of the day will provide the optimal societal benefits for the required construction and maintenance costs.

Peak Hour: Hour-long period in which the volume of a given road is the highest for the day or other time period. Morning, midday, and evening peak hours are often used for analysis, although peak hours may occur at other times, such as at school dismissal.

Peak Hour Factor (PHF): Measure of traffic variability over an hour period calculated by dividing the hourly flowrate by the peak 15-minute flowrate. PHF values can vary from 0.25 (all traffic for the hour arrives in the same 15-minute period) to 1.00 (traffic is spread evenly throughout the hour).

Volume to Capacity Ratio (v/c): Measure of how much of the available capacity of a facility is being used, calculated by dividing the demand volume by the capacity of a facility. Values of

0.85 or less indicate adequate capacity to serve the demand volume. When v/c is greater than 0.85, drivers begin to feel uncomfortably crowded.

85th Percentile Speed: The speed at which 85% of all observed drivers were driving at or below. The operating speed of the roadway is usually measured by the observed 85th percentile speed.

Executive Summary

The Riverside at Stephen Richards Congestion Mitigation project is being undertaken by the Alaska Department of Transportation and Public Facilities (DOT&PF) to analyze the intersection of Riverside Drive at Stephen Richards Memorial Drive in Juneau, Alaska. Identified problems include congestion and delay with long queue lengths during the morning and evening commute. DOT&PF has retained Kinney Engineering, LLC to examine existing traffic operations and safety at the study intersection and to propose improvements to mitigate identified concerns.

Speed limits on the intersection legs vary from 20 to 35 mph. All approaches have two 12-foot travel lanes, one in each direction. Non-motorized traffic is accommodated by sidewalks and 6-foot bike lanes on Riverside Drive and on the segment of Stephen Richards Memorial Drive to the east of the study intersection. Additionally, there are crosswalks on all four legs of the intersection.

While the intersection control and low approach speeds help maintain low crash rates at the study intersection and facilitate pedestrian and bicycle crossings, delay for some vehicle movements is significant. Southbound/northbound traffic experiences directional delay and failing level of service (LOS) in conjunction with AM and PM peak directional traffic flows. Consideration should be given to alternatives that improve vehicle traffic flow, reduce vehicle delay, and increase vehicle LOS, while maintaining adequate pedestrian and bicycle operations and maintaining overall safety.

1 Introduction

The Alaska Department of Transportation and Public Facilities (DOT&PF) has retained Kinney Engineering, LLC (KE) to prepare this Existing Conditions Report for the Riverside at Stephen Richards Congestion Mitigation project. The project is located within the City and Borough of Juneau, Alaska, as depicted in Figure 1.

The study area is in the Mendenhall Valley, Juneau's most populated area. Riverside Drive extends north from Egan Drive almost to the east-west segment of Mendenhall Loop Road (also known as Back Loop Road). Roughly parallel to the Mendenhall River, Riverside Drive offers the only north-south alternate route to Mendenhall Loop Road. The intersection of Riverside Drive at Stephen Richards Memorial Drive thus serves as a major conduit for north/south traffic through the Mendenhall Valley area. The study area is surrounded by residential neighborhoods. South of the study intersection, Riverside Drive provides access to several schools, parks, a church and a public library.

The purpose of the project is to examine existing conditions at the study intersection to develop an understanding of the concerns, and then to propose alternatives to address those concerns.

This report documents the analysis of the existing traffic operations and crash history in the project area and will act as the foundation for the project's Traffic Analysis Report. Future-year volumes and intersection operations under the no-build condition are included in the analysis. However, potential mitigation strategies for any deficiencies will be addressed in the Traffic Analysis Report.

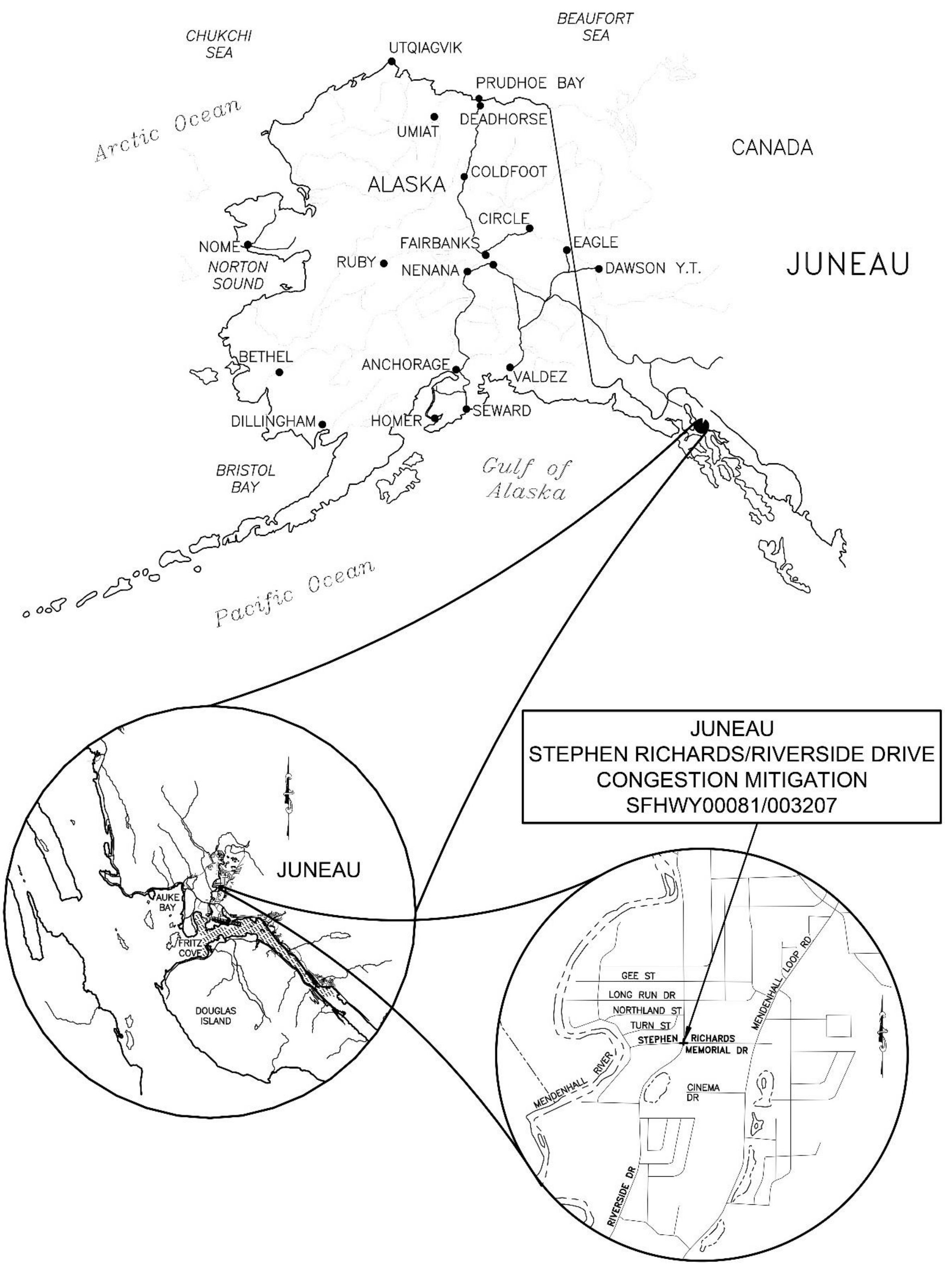

Figure 1: Project Vicinity Map

2 Existing Infrastructure

2.1 Intersection Characteristics

The study intersection is four-leg unsignalized with all-way stop control, as shown in Figure 2 and Figure 3. In 2008, the intersection was modified from two-way stop control to the current all-way stop control configuration.

All legs of the intersection have two 12-foot lanes, one in each direction. The speed limit on Riverside Drive is 35 mph. West of Riverside Drive, Stephen Richards Memorial Drive has a speed limit of 20 mph. East of Riverside Drive, Stephen Richards Memorial Drive has a speed limit of 30 mph.

Section Highlights

- The study intersection is under all-way stop control.
- Non-motorized traffic is accommodated by 6-foot bike lanes, attached sidewalks, and marked crosswalks.
- Transit buses travel to and make northbound right turns at the intersection hourly on weekdays. One bus a day travels south through the intersection and one bus a day travels north through the intersection.

Figure 2: Looking North at the Study Intersection

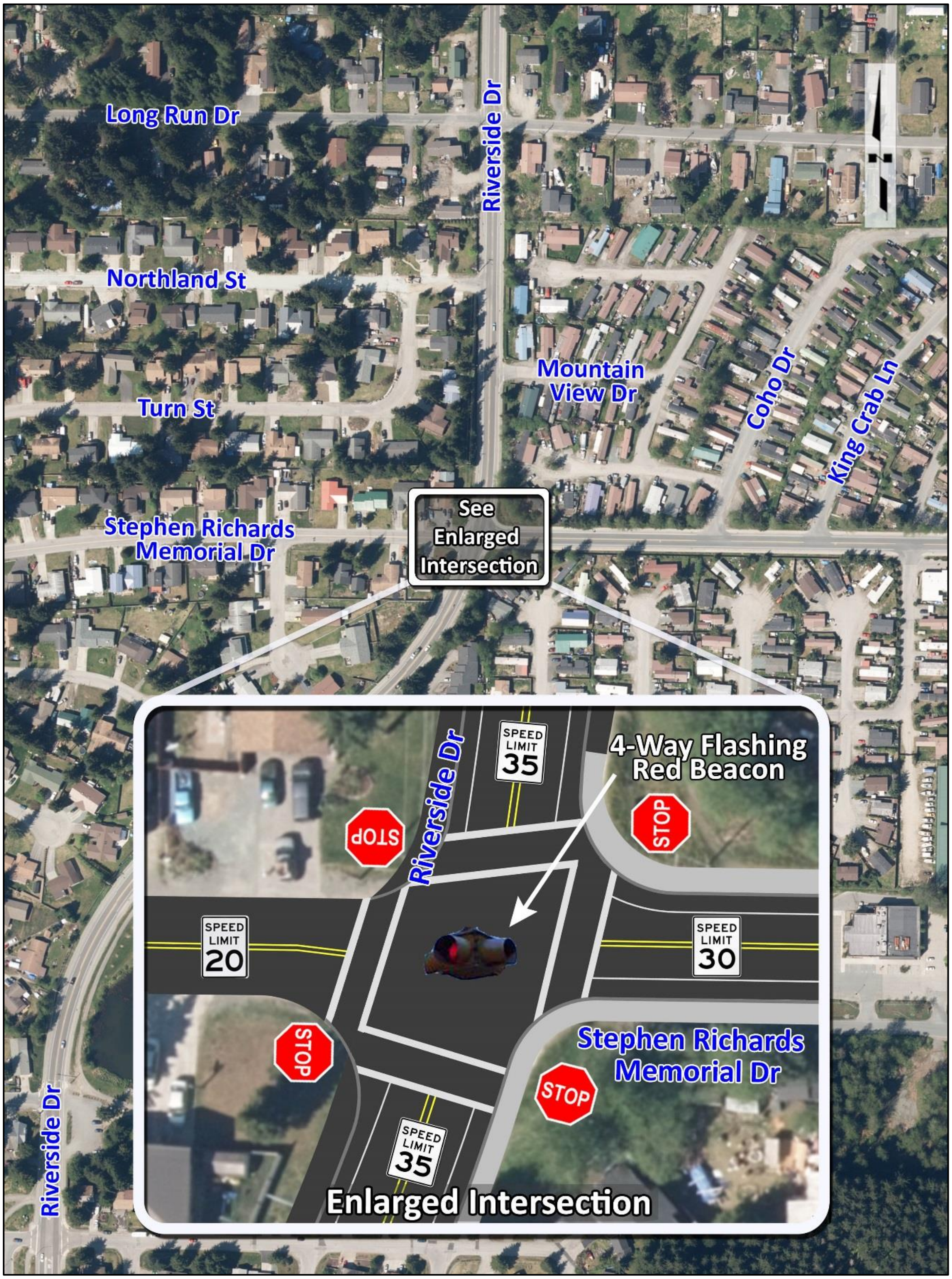

Figure 3. Existing Configuration

2.1.1 Functional Classification

DOT&PF uses the functional classification of a roadway for selecting level of service (LOS), design speed, and other geometric criteria.

Within the study area, Riverside Drive is classified as a minor arterial. To the west of Riverside Drive, Stephen Richards Memorial Drive is classified as a local road; to the east of Riverside Drive, Stephen Richards Memorial Drive is classified as a major collector. Arterial roads are intended for high mobility and low access and are designed to carry higher volumes at an efficient speed. Collector roads balance access and mobility and are designed to gather and distribute trips between local streets and arterials.

The project study area is within the City and Borough of Juneau which has a population of over 30,000. The American Association of State Highway and Transportation Officials (AASHTO)'s *A Policy on the Geometric Design of Highways and Streets*, 2011 (Green Book) describes urban areas as "those places within boundaries set by the responsible State and local officials having a population of 5,000 or more."

The Green Book has guidelines for design LOS values for different functional classifications and area and terrain types. Table 1 presents these recommendations. Note that this guideline refers to the intersection as a whole, and not to specific movements. Based on the classification of Riverside Drive as a minor arterial roadway, the study intersection is recommended to operate at a minimum LOS C or D in the design year.

Table 1: Level of Service Recommendation

Functional Class	Appropriate Level of Service for Specified Combinations of Area and Terrain Type			
	Rural Level	Rural Rolling	Rural Mountainous	Urban and Suburban
Freeway	B	B	C	C or D
Arterial	B	B	C	C or D
Collector	C	C	D	D
Local	D	D	D	D

Source: Modified from AASHTO Green Book, 2011 Table 2-5

2.1.2 Pedestrian and Bicycle Facilities

As shown in Figure 3, all four legs of the intersection have marked crosswalks. Due to the all-way stop control, vehicles are expected to yield to pedestrians on every approach.

Marked 6-foot bike lanes and attached sidewalks run in both directions along Riverside Drive, connecting to a separated pathway along Egan Drive to the south and to Mendenhall River Elementary School and other community resources to the north. Marked 6-foot bike lanes and raised sidewalks also extend along Stephen Richards Memorial Drive from Riverside Drive to the separated pathways on Mendenhall Loop Road, and the facilities continue on Haloff Way to Tongass Boulevard. There are no bike lanes or sidewalks on Stephen Richards Memorial Drive west of Riverside Drive.

2.1.3 Summary of Intersection Characteristics

Table 2 summarizes the characteristics of the study intersection.

Table 2: Intersection Characteristics

Segment Name	CDS Route #	Classification	Cross Section	Speed Limit (mph)	Bike/Ped Treatment
Riverside Drive (North and South Legs)	296500	Minor Arterial	2-Lane with Marked Bike Lanes	35	Marked Bike Lanes Raised, Attached Sidewalks
Stephen Richards Memorial Drive (West Leg)	296440	Local	2-Lane	20	None
Stephen Richards Memorial Drive (East Leg)	-	Major Collector	2-Lane with Marked Bike Lanes	30	Marked Bike Lanes Raised, Attached Sidewalks

2.2 School Zones

Thunder Mountain High School and Riverbend Elementary School are located south of the study intersection on Riverside Drive. The *Juneau Safe Routes to Schools Plan* states that the school zone for both schools extends approximately half a mile from the JRC Alaska Club south of James Boulevard to between Riverwood Drive and Parkwood Drive. The school day at Riverbend Elementary School begins at 8:00 AM and ends at 2:30 PM, while most classes at Thunder Mountain High School start at 9:15 AM and end at 3:45 PM. Per personnel at Riverbend Elementary School, the speed limit in the school zone is lowered from 35 mph to 20 mph from 7:45 AM to 8:00 AM and from 2:30 PM to 2:45 PM, during elementary school arrival and dismissal. The elementary school arrival time occurs during the AM traffic peak hour which is from 7:15 to 8:15 AM. However, since the PM traffic peaks from 5:00 to 6:00 PM, it does not coincide with school dismissal times.

2.3 Transit

Capital Transit operates four bus routes through the study intersection, as shown in Figure 4.

- Route 6, the Riverside Express, runs Monday through Friday from 8 AM until about 6:30 PM, with hourly headways. It travels from downtown Juneau to the Juneau International Airport before looping north on Mendenhall Loop Road, west on Mendenhall Mall Road, north on Riverside Drive, east on Stephen Richards Memorial Drive, and south back onto Mendenhall Loop Road.

- Route 10, the Mendenhall Valley Commuter, operates Monday through Friday once a day. It leaves from Auke Lake Way at 6:45 AM and travels east along Mendenhall Loop Road (Back Loop), heads back west on Taku Boulevard, and then heads south on Riverside Drive towards the airport, where it then heads east to downtown Juneau, arriving at 7:40 AM.
- Route 14, the Mendenhall/Riverside Commuter, runs once daily, Monday through Friday. At 6:30 AM, it departs from the Job Center on Glacier Highway and heads east to Riverside Drive where it turns north and travels to the study intersection. At the study intersection, it turns east onto Stephen Richards Memorial Drive, then south at Mendenhall Loop Road, and then back east on Egan Drive and Glacier Highway, arriving in downtown Juneau at 6:58 AM.
- Route 16, the Taku Express, operates Monday through Friday once a day. The Taku Express leaves the Job Center on Glacier Highway at 6:15 AM, travels east to Riverside Drive, north through the study intersection, and east on Julep Street. It then curves north on Julep Street, east on Taku Boulevard, south on Mendenhall Loop Road, and east on Egan Drive to downtown Juneau, arriving at 6:48 AM.

There are two bus stops near the study intersection. Stop #549 is located approximately 390 feet to the east of the study intersection on Stephen Richards Memorial Drive. It provides service for patrons traveling east on Route 6 (Riverside Express) and Route 14 (Mendenhall/Riverside Commuter). Stop #561, approximately 85 feet north of the study intersection on Riverside Drive, provides access to patrons traveling north on Route 16 (Taku Express). The closest bus stop that services southbound patrons on Route 10 (Mendenhall Valley Commuter) is Stop #510, located about a quarter mile south of the study intersection on Riverside Drive at Rivercourt Way.

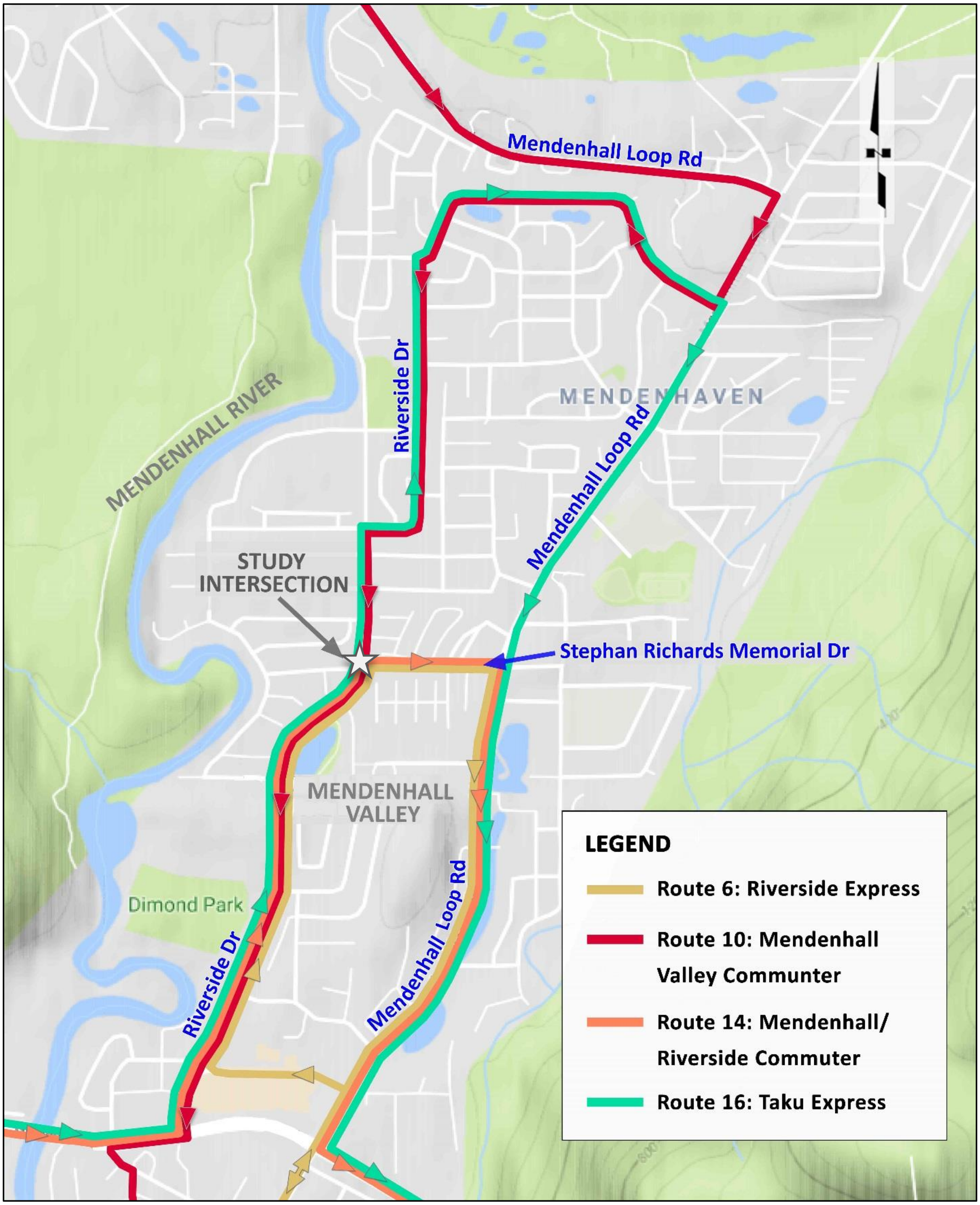

Figure 4: Transit System through Study Intersection

3 Planning and Construction Background

Several planning level documents and past construction projects related to this intersection were reviewed to ensure that improvements analyzed in this study support community goals.

Section Highlights

- Many of the improvements that have been suggested in planning documents for Riverside Drive have been implemented.
- In 2008, control at the study intersection was changed from two-way to four-way stop control.
- The CBJ transit system was upgraded in 2015 to provide service along Riverside Drive.

3.1 Planning Documents

3.1.1 Comprehensive Plan of the City & Borough of Juneau (CBJ, 2013)

The *Comprehensive Plan of the City & Borough of Juneau (Comprehensive Plan)* provides a guide for the long-range growth, development, and conservation of valued resources in the state capital.

The *Comprehensive Plan* lists the following implementation actions near the study area:

- Implement the subarea improvements for the Mendenhall Valley called for in the *Area Wide Transportation Plan* as funding becomes available.
- Explore the feasibility of a Mendenhall Valley shuttle service and/or park and ride linked to downtown by express buses.

Improvements recommended in the *Area Wide Transportation Plan* are discussed below.

3.1.2 City and Borough of Juneau (CBJ) Area Wide Transportation Plan (2001)

The CBJ *Area Wide Transportation Plan*, Volume 1, Transportation Plan Recommendations outlined transportation problems and recommended solutions within the CBJ for a 20-year timeframe. The following solutions were recommended for areas near the study intersection:

- <u>Improved Local Transit Service in the Mendenhall Valley.</u> Restructure local service on the existing Mendenhall Valley/Lemon Creek/Downtown route and provide a circle route using Mendenhall Loop Road and Riverside Drive.
- <u>Riverside Drive Corridor Improvement</u>. Evaluate appropriate intersection control at the new Dimond Park intersection with Riverside Drive, provide bus pullouts/shelters, and develop strong pedestrian connections from neighborhoods to Dimond Park area and retail areas to the south.

Portions of the recommended solutions have been implemented. In November 2015, the transit system was upgraded to provide service along Riverside Drive. Additionally, the intersection at

Riverside Drive and Riverwood Drive (Dimond Park intersection) was reconstructed and signal control was implemented.

3.1.3 CBJ Transit Development Plan (2008 and 2014)

The 2008 CBJ *Transit Development Plan* (TDP) identified and fulfilled two main goals: assess the CBJ's public transit services and create practical strategies to meet existing and future demand for transit service. The TDP outlines three scenarios for alignment and/or schedule alternatives: baseline, intermediate, and optimum. The baseline scenario only included minor schedule changes, the intermediate scenario suggested the introduction of hourly service along Riverside Drive, and the optimum scenario recommended a complete overhaul of the transit system.

The 2008 TDP was updated by the 2014 *Transit Development Plan.* The 2014 TDP echoed suggestions from the 2008 TDP and outlined the following goal: "Provide service to new residential and employment areas including Riverside Drive…"

As previously mentioned, in November 2015, hourly transit service and morning commuter service was implemented along Riverside Drive. Current transit operations near and through the study area are discussed in Section 2.3.

3.1.4 Juneau Non-Motorized Transportation Plan (CBJ, 2009)

The *Juneau Non-Motorized Transportation Plan* aims to improve bicycling and walking facilities to encourage residents to more frequently choose active forms of transportation. The plan lists the intersection of Stephen Richards Drive and Riverside Drive as one of seventeen intersections with the most vehicle and pedestrian or bicycle accidents; between October 1999 and October 2008, 4 crashes involving pedestrians/cyclists occurred at the study intersection. Note that all-way stop control was implemented in 2008 and no pedestrian or bicycle crashes have occurred since that date. The plan outlines key considerations for pedestrian friendly design, include safe crossings, such as crosswalks, and continuous and direct routes for pedestrian movement. No recommendations specific to the study area are delineated.

Existing pedestrian and bicycle facilities at the study intersection are described in Section 2.1.2, while pedestrian and cyclist operations are discussed in Section 5.2.

3.1.5 Juneau Safe Routes to Schools Plan (CBJ, 2012)

The *Juneau Safe Routes to Schools Plan* states that it aims "to create safe, convenient and fun opportunities for Juneau children to walk and bicycle to and from school and thus encourage more children to be physically active." The plan lists recommended improvements/actions within the CBJ. At the study intersection, it recommends adding a pathway on one side of Stephen Richards Memorial Drive between Meander Way and Riverside Drive (west leg of study intersection) as this segment is commonly used by neighborhood children to get to both

Riverbend Elementary School and Floyd Dryden Middle School. The study intersection is identified on the school route maps as a “difficult intersection;” however, the report gives no indication of what difficulties are encountered at the study intersection.

Existing pedestrian and bicycle facilities and operations are discussed in Section 2.1.2 and Section 5.2.

3.1.6 Riverside Drive Corridor Transportation Study and Plan (CBJ, 2001)

The *Riverside Drive Corridor Transportation Study and Plan* was completed by the CBJ to identify safety, multi-modal mobility, and access concerns for Riverside Drive and to develop short-, mid-, and long-term solutions. The study identified an emerging peak-hour level of service issue for traffic operations at the study intersection. It recommended the installation of a traffic signal on Riverside Drive at Stephen Richards Memorial Drive as a mid-term solution option. Written prior to the completion of the Dimond Complex and Thunder Mountain High School, the study recommended an analysis of traffic conditions at the study intersection after the new facilities opened, under the assumption that increased traffic would necessitate a traffic signal or a roundabout.

The study also identified sight distance concerns at the study intersection due to overgrown foliage. As a short-term solution option, it recommended establishing a vegetation control program that would include pruning vegetation that limits sight distance for eastbound movements on Stephen Richards Memorial Drive.

3.1.7 Summary of Planning Documents

The intersection of Riverside Drive with Stephen Richards Memorial Drive serves pedestrians (including elementary, middle, and high school children), transit vehicles, and automobile traffic. Plans for the Mendenhall Valley indicate a desire for a strong network of pedestrian and bicycle facilities, improved safety, and a reduction in vehicle delay. Numerous studies have indicated that a change in intersection control at the study intersection may be needed to meet these identified needs.

3.2 Area Construction Projects

3.2.1 CBJ Riverside Drive Improvements and Traffic Signal (2007)

In conjunction with the Dimond Park project, the intersection of Riverside Drive at Riverwood Drive was converted from 3-leg to 4-leg. The intersection was signalized, and pedestrian facilities were upgraded to provide improved access to the Dimond Park facilities, the Mendenhall Public Library, and Thunder Mountain High School.

3.2.2 Implementation of All – Way Stop Control on Riverside Drive at Stephen Richards Memorial Drive (2008).

In 2008, the intersection of Stephen Richards Memorial Drive and Riverside Drive was converted from two-way stop control to all-way stop control.

4 Safety

DOT&PF provided crash data for the 15-year period from 2000 to 2014 for the Riverside Drive intersection at Stephen Richards Memorial Drive. For each crash listed in the DOT&PF database, the crash type and location were carefully reviewed and adjusted using engineering judgement to improve the analysis.

In 2008, the intersection control changed from two-way stop control to all-way stop control. A comparison of crashes before and after 2008 shows that the frequency of crashes after 2008 decreased, as shown in Figure 5.

Under all-way stop control, the occurrence of crashes decreased from 2.4 to 1.3 crashes per year. Looking at crash types, there were two bicycle crashes under two-way stop control, while there have been no bicycle or pedestrian crashes since the installation of all-way stop control. In addition, the number of head on and right-angle crashes has decreased (from 1.8 crashes per year under two-way stop control to 0.3 crashes per year under all-way stop control). While rear end crashes have increased under all-way stop control (from 0.3 crashes per year to 1 crash per year), rear end crashes tend to result in fewer injuries or less severe injuries when compared to other crash types.

Section Highlights

- Prior to 2008, the intersection crash rate was at or above the statewide average for similar intersections. The most commonly occurring type of crashes were right-angle (68%), and half of the crashes resulted in injuries.
- In 2008, all-way stop control was implemented at the study intersection, reducing the frequency and severity of crashes.
- Since 2008, the crash rate dropped significantly and there has only been one injury crash (13%).

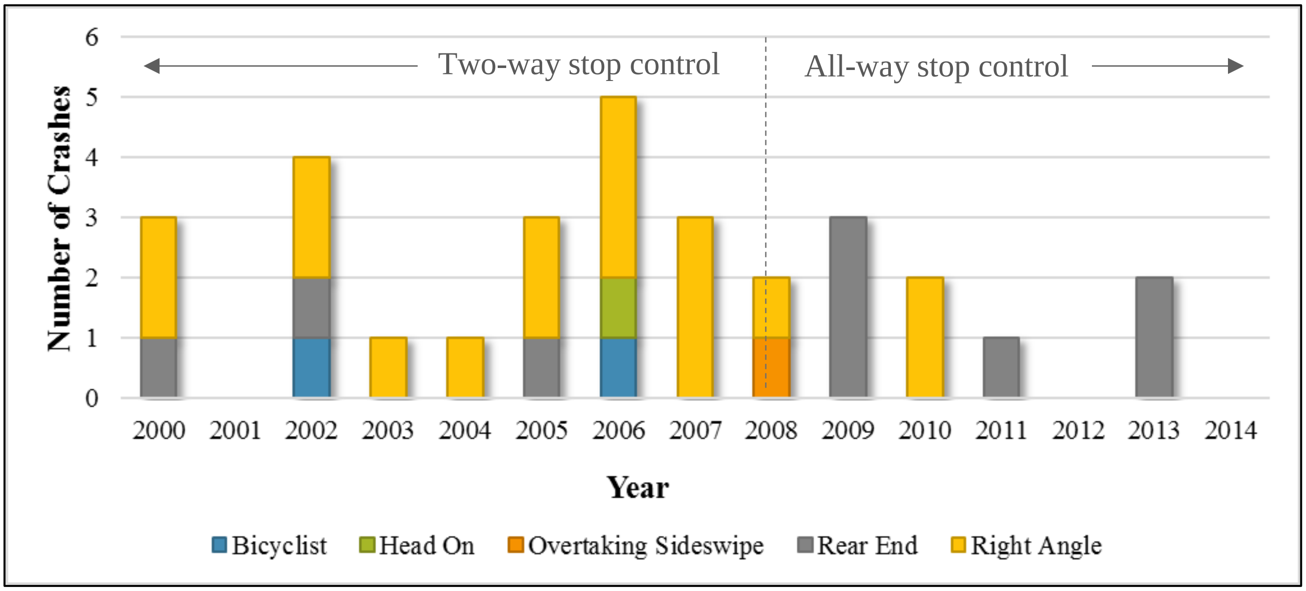

Figure 5: Occurrence of Crash Types by Year (2000 – 2014)

Figure 6 shows crash severity before and after the intersection control change. Under all-way stop control, only one crash resulted in a minor injury, with the remaining 7 crashes resulting in property damage only (PDO). Meanwhile, between 2000 and 2008, 50 % (11 out of 22) of crashes resulted in minor or major injuries.

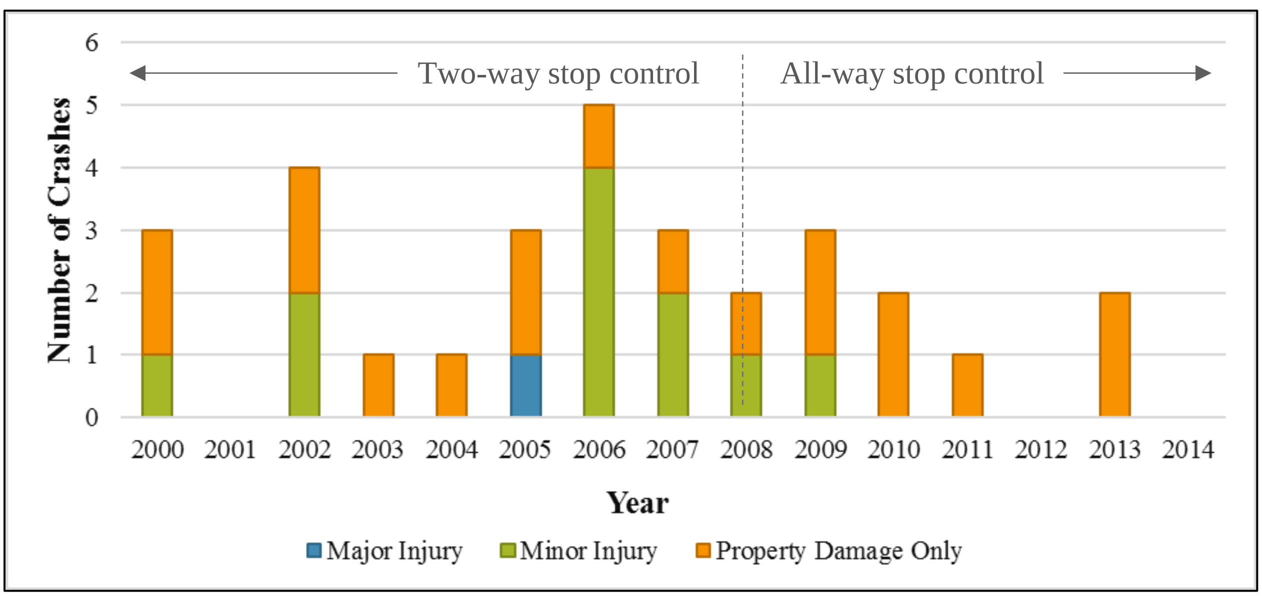

Figure 6. Crash Severity by Year (2000 – 2014)

4.1 Intersection Crash Rate

Crash rates for the two types of intersection control were calculated based on the number of crashes, the number of years in the study period, and average annual daily traffic (AADT) over the period of study. Average crash rates were calculated from the most recent 5-year period (2010-2014). Since stop control changed in 2008, the crash data for the 5-year period prior to the change (2003-2007) was also analyzed. Using the 2017 *Highway Safety Improvement Program Handbook* and High Accident Location Screening spreadsheet, the crash rates were compared to statewide average crash rates for similar facilities and corresponding time periods as well as the Critical Accident Rate (CAR). The CAR is a threshold above which the observed rate at a given location is considered statistically higher than average at a 95% confidence level. When a crash rate exceeds the CAR, there is strong evidence that crashes are caused by underlying contributing factors and are not just random occurrences. The crash rate at intersections is given in terms of crashes per million entering vehicles (MEV). Table 3 presents the 5-year intersection crash rates under the two-way stop control (2003-2007) and all-way stop control (2010-2014) configurations.

Table 3: Riverside Drive at Stephen Richards Memorial Drive Intersection Crash Rates

Intersection Configuration	Total Crashes	Entering AADT	Crashes/ MEV	Statewide Averages (Crashes/ MEV)	CAR @ 95.00% Confidence (Crashes/ MEV)	Above Average?	Above CAR?
2-Way Stop Control (2003-2007)	13	9,711	0.73	0.55	0.87	Yes	No
4-Way Stop Control (2010-2014)	5	9,684	0.28	0.73	1.09	No	No

The study intersection crash rate exceeded the state average under the two-way stop control but was below the CAR, indicating that the crash rate was not statistically above the average rate. The crash rate under the current all-way stop control is below both the statewide average and CAR for all-way stop controlled intersections, indicating that the all-way stop control configuration improved safety over the two-way stop control.

4.2 Crash Types

Figure 7 looks more closely at crash types that occurred from 2000 to 2014 at the study intersection under the two-way stop control and all-way stop control configurations.

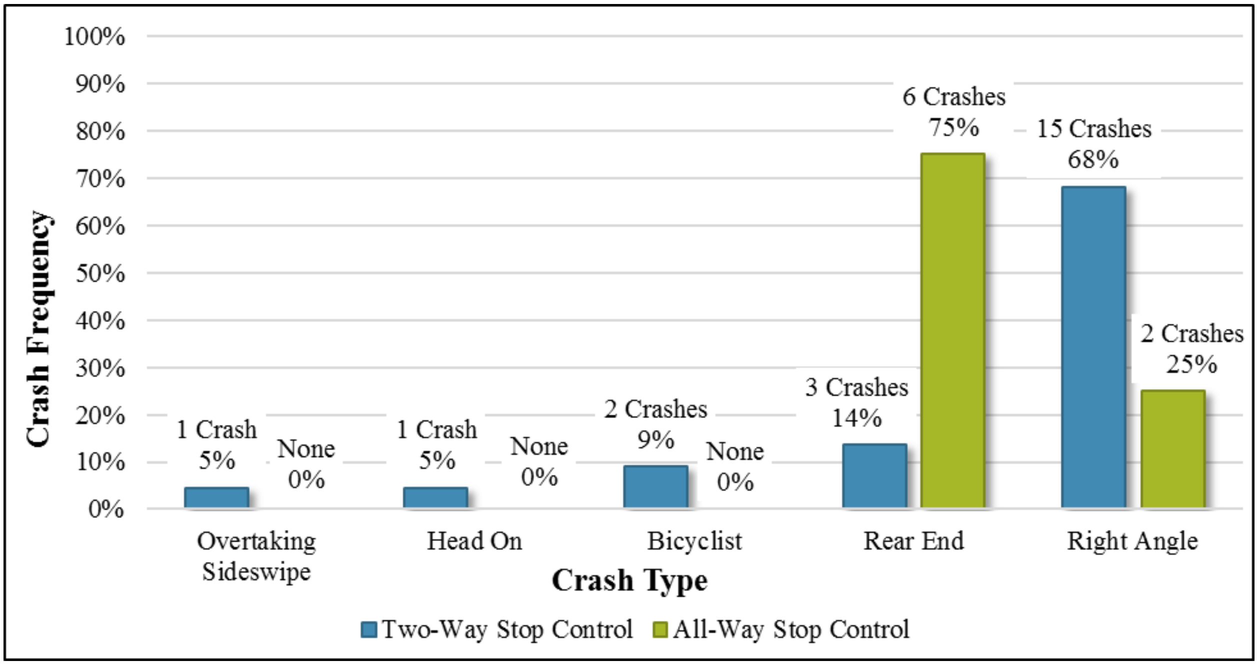

Figure 7: Crash Type Distribution in Study Area (2000 – 2014)

From 2000 until 2008 when the intersection control changed, a total of 22 crashes occurred at the study intersection. The predominant crash type was angle crashes (68%) followed by rear end crashes (14%). Nine of the 15 angle crashes occurred when the vehicle at fault was traveling in the westbound direction. Four of the 9 westbound angle crashes occurred in the evening in November on wet or icy roads. Common reasons for angle crashes of this type include: side-street drivers finding it difficult to correctly gauge gaps in oncoming traffic (because of limited sight distance or speeding in oncoming traffic, for example), and side-street drivers not perceiving the intersection (not seeing the stop sign, for example). The installation of all-way stop control likely eliminated the difficulty with gauging gaps. The overhead beacon that was also installed has likely improved westbound drivers' perception of the intersection.

Two bicycle crashes occurred at the study intersection under two-way stop control. In April 2002, a northbound cyclist sustained minor injuries after being hit by an eastbound driver who was turning right at the study intersection. The traffic report lists driver inattention and pedestrian error as human circumstances contributing to the crash. The second bicycle crash occurred in June 2006. A westbound driver, distracted by her cell phone, failed to stop at the stop sign when turning right at the study intersection, striking an eastbound cyclist. The crash type was listed as PDO.

Under all-way stop control between 2009 and 2014, 8 crashes were recorded. The predominant crash type was rear end crashes (75%), followed by angle crashes (25%). A comparison of the percentages of crash types that occurred indicates that the all-way stop control significantly reduced the occurrence of right angle crashes. All crashes under all-way stop control occurred when the road surface was covered with water, snow, slush or ice.

4.3 Crash Severity

Figure 8 compares the distribution of crash severity within the study area under two-way stop control and all-way stop control. No fatalities occurred during the analysis period (2000-2014). Under two-way stop control, one major injury occurred, and the remainder of the crashes were nearly evenly divided between minor injury and PDO. The major injury crash occurred when a westbound driver failed to yield when turning left, colliding with a northbound vehicle and totaling both vehicles. After all-way stop control was implemented, the percentage of minor injury crashes significantly decreased and 88% of the recorded crashes were PDO, again indicating that all-way stop control improved safety of the intersection over two-way stop control.

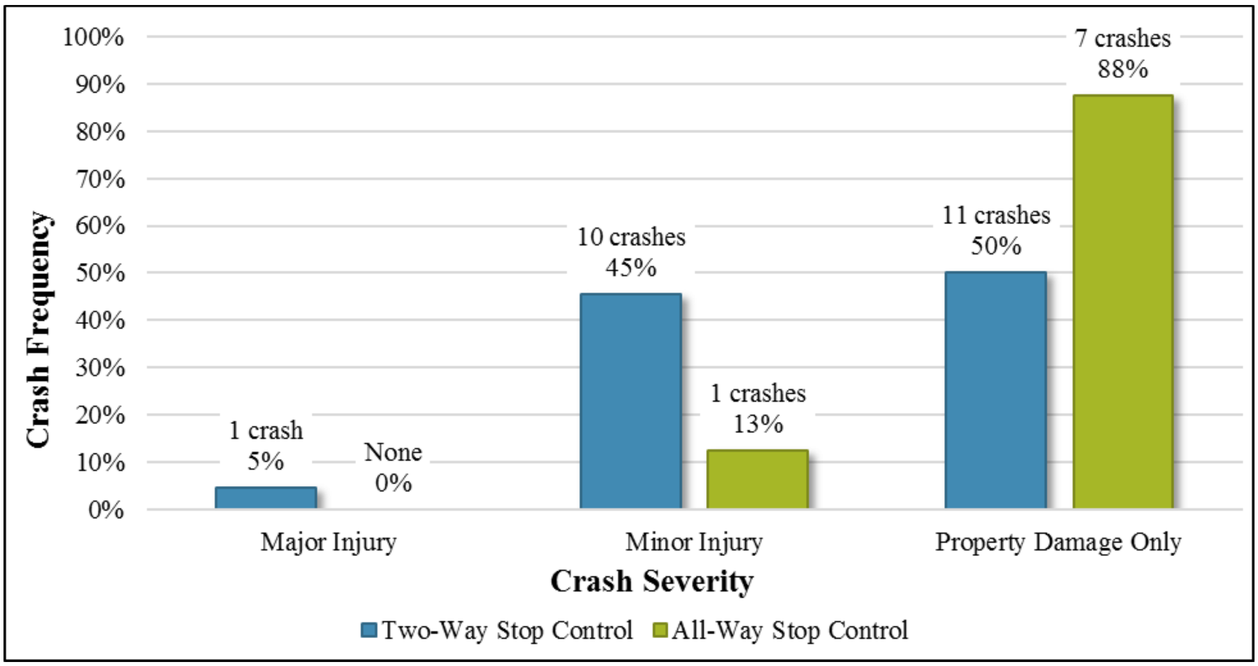

Figure 8: Crash Severity (2000 – 2014)

4.4 Crash Summary

Analysis of crash data indicates that all-way stop control improved safety over two-way stop control at the study intersection. The annual crash frequency dropped from 2.4 to 1.3, and the severity decreased from 50% of crashes causing injury to 13 % causing injury. Between 2009 (after all-way stop control was implemented) and 2014, eight crashes were recorded. Six of the crashes were rear-end crashes and the remaining two were angle crashes.

5 Existing Operations

5.1 Vehicular Operations

5.1.1 Historical AADT

AADT volumes for segments in the study area were collected from the DOT&PF's *Southcoast Region 2013 Traffic and Safety Report* and online *Annual Average Daily Traffic (AADT) GIS Map*. Table 4 summarizes historical AADT for road segments leading to the study intersection.

Since 2016 volumes are the most recent available and are the highest observed volumes, these have been used for the "existing year" volumes. Historical AADT for the west leg of the intersection was not available, so AADT for this segment was estimated from AM peak hour turning movement counts.

Figure 9 presents the existing volumes used to analyze existing operations.

Section Highlights

- 8,000 to 9,000 vehicles travel along Riverside Drive each day.
- Southbound movements during the AM Peak, and northbound movements during the PM Peak experience level of service F, with queues almost 800 feet in length.
- All other movements experience little delay.
- Counts from September 2014 show peak pedestrian volumes of 10 to 20 pedestrians crossing Riverside Drive in an hour.

Table 4: Historical AADTs.

Segment Name	Extents	2010	2011	2012	2013	2014	2015	2016
Riverside Drive	Dimond Park to Stephen Richards Drive	9,012	8,811	8,700	8,020	-	8,020	9,514
Riverside Drive	Stephen Richards Drive to Julep Street	7,960	7,783	7,690	7,040	-	7,040	8,404
Stephen Richards Drive	King Crab Lane to Riverside Drive	3,329	3,269	2,769	2,805	3,062	2,757	3,221

NOTE: AADTs are unavailable for Riverside Drive in 2014.

Figure 9: Existing AADT Volumes

5.1.2 Existing Turning Movement Volumes

Turning movement volumes (TMVs) for the study intersection were provided by the DOT&PF. Analysis of the TMVs identified 7:15 to 8:15 AM as the morning peak hour and 5:00 to 6:00 PM as the PM peak hour. Field observations indicate that long queues form at the study intersection in the southbound direction during the AM peak and in the northbound direction during the PM peak. When TMVs were modeled in Synchro and analyzed using HCM deterministic analysis, estimated queue lengths were initially much shorter than observed queue lengths. The discrepancy between calculated and observed queue lengths indicate that the TMVs reflect the number of cars moving through the intersection during 15-minute periods rather than the number of cars accumulating at the end of the queue and waiting for a turn to enter the intersection (i.e., the TMVs reflect the throughput of the intersection, not necessarily the demand to use the intersection).

To better simulate the flow of traffic through the study intersection, the Synchro model was adjusted to include the signalized intersections of Riverside Drive at Riverwood Drive and Riverside Drive at Vintage Boulevard/Mendenhall Mall Road. In addition, the northbound demand volume in the PM peak was estimated by comparing the northbound volume leaving the Riverwood Drive intersection with the northbound volume entering the Stephen Richards Memorial Drive intersection. The excess traffic leaving the Riverwood Drive intersection was added to the Stephen Richards Memorial Drive intersection.

The PM peak hour factor (PHF) at the Stephen Richards Memorial Drive intersection was also adjusted. The PHF represents the uniformity of traffic volumes over an hourly period. The measured PHF at the Stephen Richards intersection was 0.95, higher than the PHF of 0.92 at the Riverwood intersection, indicating that traffic departs the Stephen Richards intersection at a more uniform rate than it does at Riverwood Drive. By using the Riverwood Drive PHF at the Stephen Richards intersection, demand values at the study intersection are better represented.

Upstream TMVs and PHFs were not available for the southbound approach during the AM peak period. Therefore, the AM peak period demand volume was estimated by increasing the southbound AM volume by the same percentage that the northbound PM volume was increased.

Figure 10 and Figure 11 depict the adjusted TMVs used for existing condition analysis of the study intersection for the AM and PM peak hours.

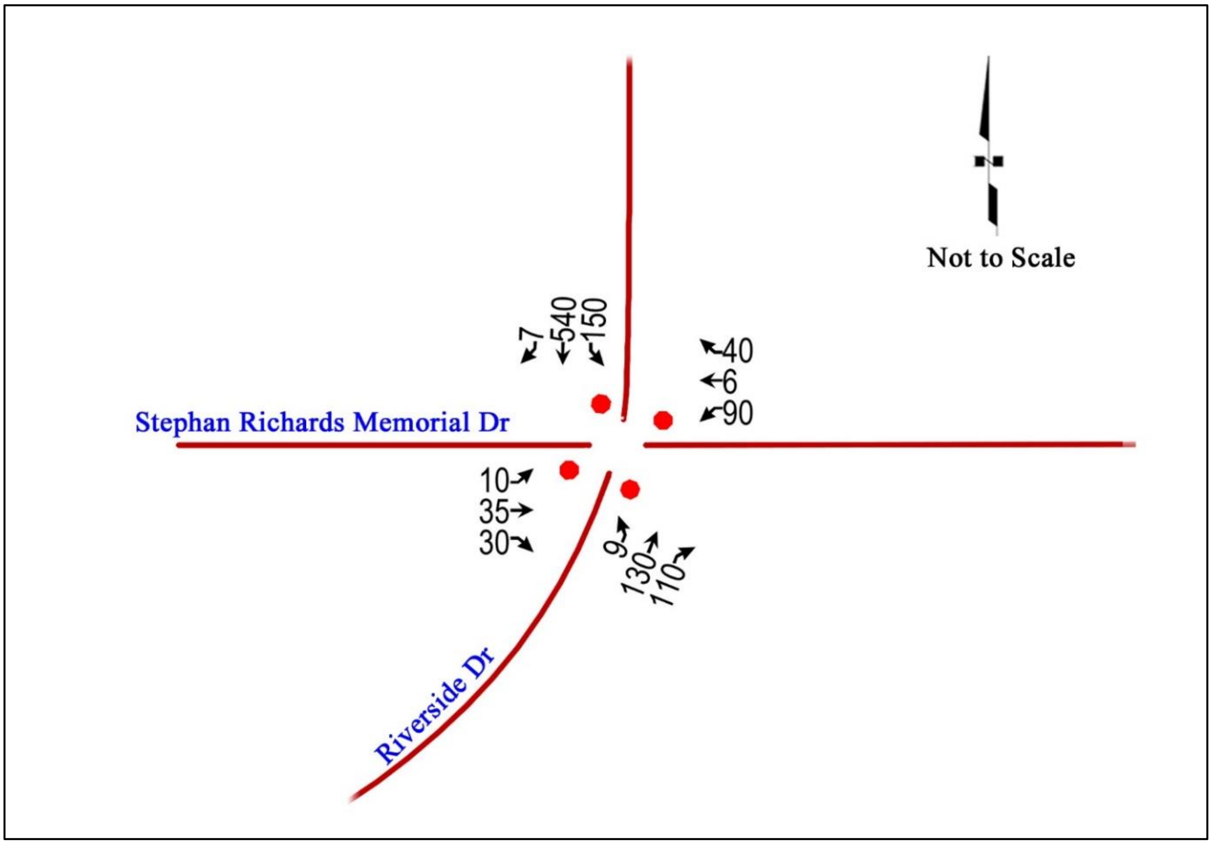

Figure 10: Existing TMVs, AM Peak

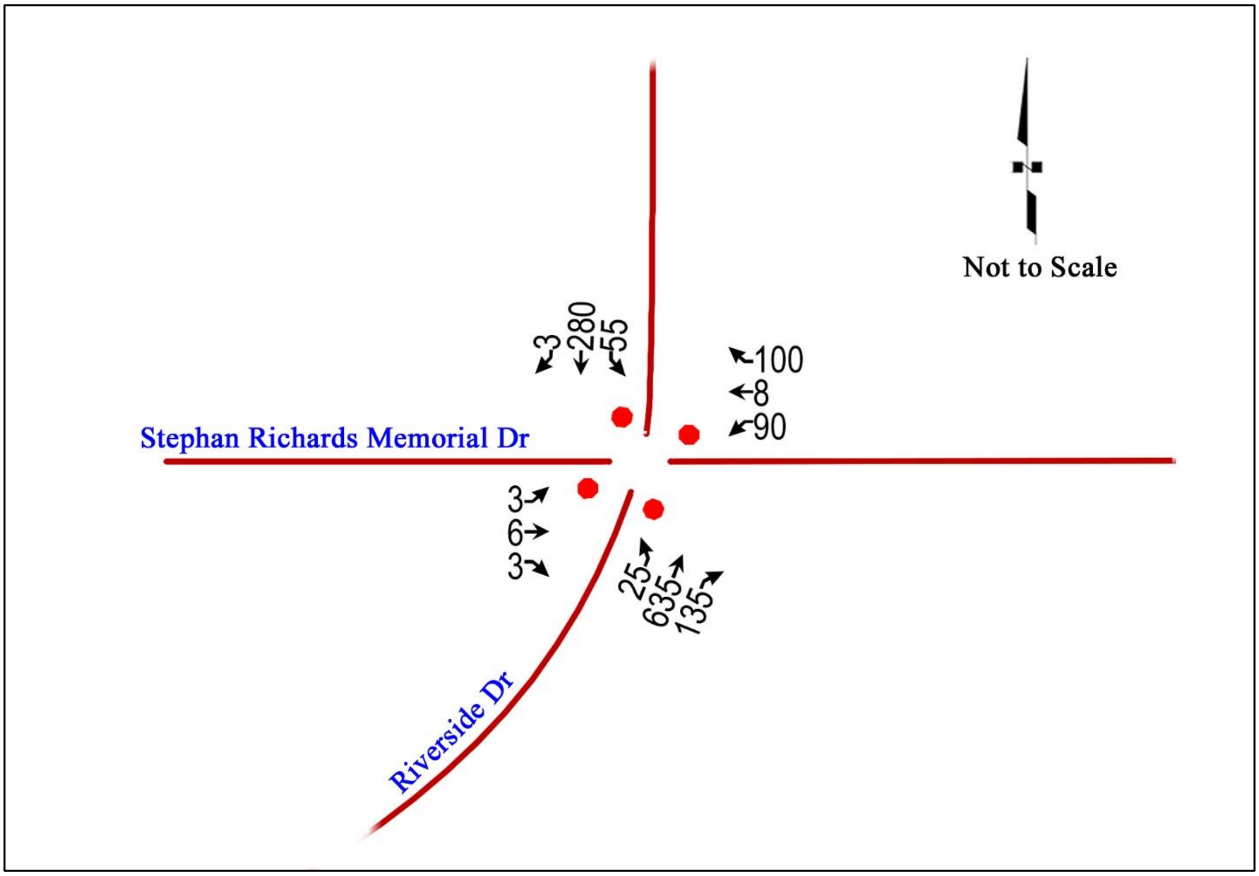

Figure 11: Existing TMVs, PM Peak

5.1.3 Peak Hour Factors

Peak hour factors (PHFs) convert hourly volumes to 15-minute design flow rates for capacity analyses. They represent the uniformity of traffic volumes over an hourly period and range from 0.25 (all traffic arrives in one 15-minute period and no additional traffic arrives for the rest of the hour) to 1.0 (equal number of vehicles arrive during each 15-minute period).

Table 5 shows the adjusted PHFs used for analysis of the AM and PM peaks at the study intersection.

Table 5: Existing Peak Hour Factors

Peak Period	Peak Hour Factor
AM Peak	0.83
PM Peak	0.92

5.1.4 Heavy Vehicle Percentages

Heavy vehicle percentages (HV%) are taken into account during analysis of intersection capacity. The turning movement data provided by the DOT&PF included information about the HV% on each leg of the study intersection during the AM and PM peak hours. The HV% used for analysis are shown in Table 6.

Table 6: Heavy Vehicle Percentages

Peak Period	Heavy Vehicle Percentages by Movement			
	Eastbound	Westbound	Northbound	Southbound
AM Peak	1%	4%	4%	1%
PM Peak	1%	1%	1%	1%

Note that the DOT&PF counts included 3 buses and 2 single unit trucks traveling eastbound in the morning peak and 1 articulated truck traveling eastbound in the evening peak. Because of the low eastbound volumes throughout the day, this small volume of heavy vehicle traffic is equivalent to a high heavy vehicle percentage (8%). After review of school bus routes for 2018, it was concluded that daily heavy vehicle percentages are likely much lower than what was counted in 2014. Thus, the eastbound heavy vehicle percentages are estimated at 1%.

5.1.5 Existing Intersection Capacity

Capacity analyses for the AM and PM peak hours were conducted using Synchro Trafficware, which relies on *Highway Capacity Manual* (HCM) methodologies. Table 7 and Table 8 summarize the existing intersection operations in the study area during the AM and PM peaks. The analysis indicates that the southbound movements during the AM peak and northbound movements during the PM peak experience significant delay and a failing level of service (LOS). Other movements exhibit an acceptable LOS.

Table 7: Existing Intersection Capacity at the AM Peak Hour

AM Peak	Approach				
	EB	WB	NB	SB	Intersection
V/C Ratio	0.2	0.3	0.5	1.2	-
Control Delay (sec)	11.8	13.3	14.0	139.6	**89.4**
Lane LOS	B	B	B	F	**F**
95th % Queue (feet)	25	50	75	775	-

V/C = volume to capacity ratio

Table 8: Existing Intersection Capacity at the PM Peak Hour

PM Peak	Approach				
	EB	**WB**	**NB**	**SB**	**Intersection**
V/C Ratio	0.0	0.4	1.2	0.6	-
Control Delay (sec)	10.9	13.8	139.2	16.6	**88.7**
Lane LOS	B	B	F	C	**F**
95th % Queue (feet)	25	50	800	100	-

V/C = volume to capacity ratio

5.2 Non-Motorized Operations

5.2.1 Pedestrian and Cyclist Counts

The turning movement counts provided by DOT&PF included pedestrian and cyclist counts. Figure 12 and Figure 13 depict peak pedestrian and cyclist movements at the study intersection.

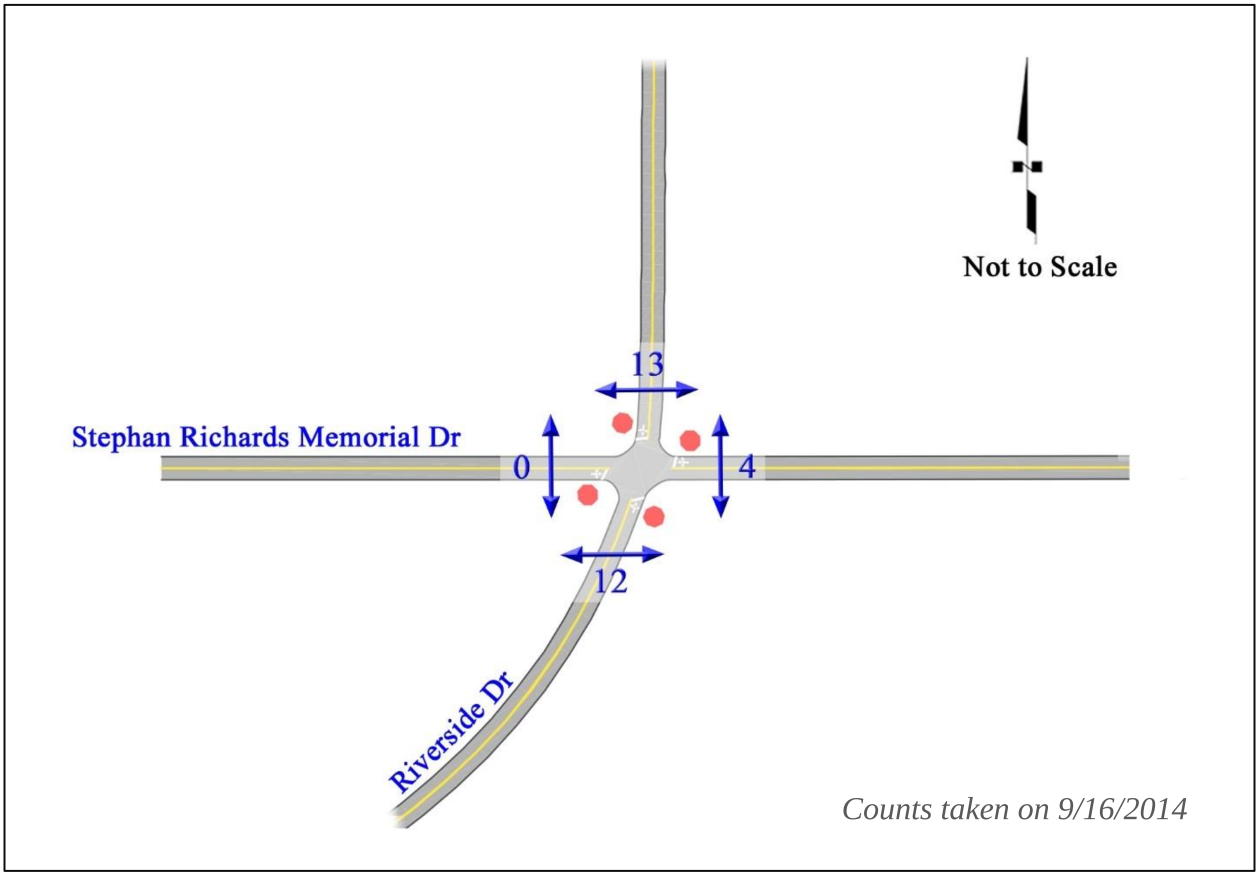

Figure 12: Peak AM Pedestrian and Cyclist Movements, (8:15 AM – 9:15 AM)

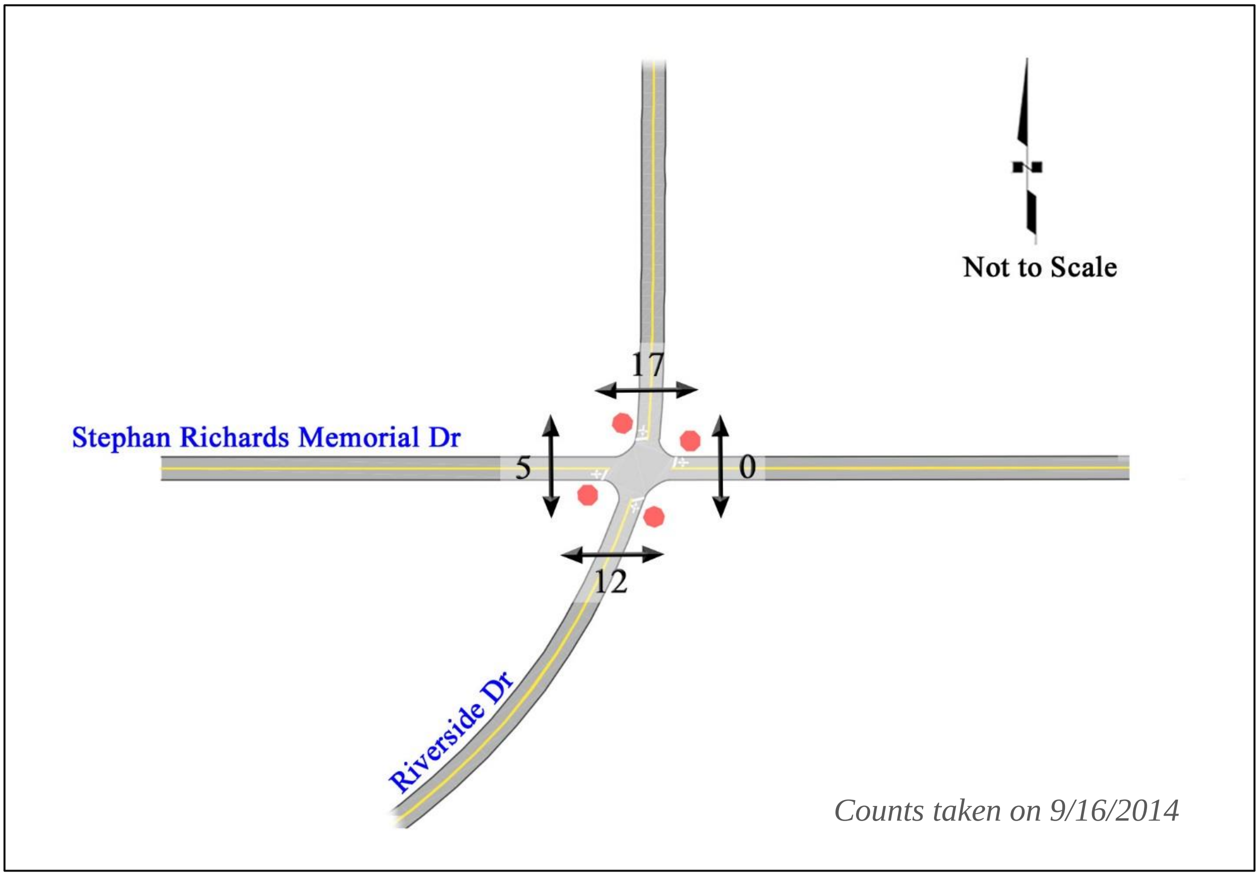

Figure 13: Peak PM Pedestrian and Cyclist Movements, (4:00 PM – 5:00 PM)

5.2.2 Pedestrian and Cyclist Crossing Analyses

Since the study intersection is all-way stop control, there is no pedestrian delay. Pedestrians wishing to cross will have the right of way.

6 Future No-Build Operations

Section Highlights

- TMVs for the year 2040 were forecasted using a 0.25% annual growth rate.
- Southbound delay and queues in the AM peak and northbound delay and queues in the PM peak are forecast to worsen by the year 2040 under the no build alternative.

6.1 Vehicular Operations

6.1.1 2040 AADT

Based on an estimated construction year close to 2020 and a design life of 20 years, 2040 was chosen as the design year for this project. To forecast 2040 design year AADTs, historical AADTs were first analyzed. Since 2016 volumes are the most recent available volumes and also represent the highest observed volumes over the most recent 5-year period, they were used for the “existing year” volumes. As recommended by the DOT&PF, an annual growth rate of 0.25% was applied to the existing year volumes to project design year volumes. Forecasted 2040 AADT values are shown in Table 9.

Table 9. 2040 AADT

Segment Name	Extents	2016	2040
Riverside Drive	Dimond Park to Stephen Richards Drive	9,514	10,000
Riverside Drive	Stephen Richards Drive to Julep Street	8,404	8,900
Stephen Richards Drive	King Crab Lane to Riverside Drive	3,221	3,400

6.1.2 2040 Turning Movement Volumes

A continuous count station (CCS) that records traffic volumes is located on Riverside Drive, north of the study intersection. The most recent available data from the CCS is summarized in the *Southcoast Region 2013 Traffic and Safety Report.* To forecast design year TMVs, peak hour volume percentages developed from the CCS data were identified. In accordance with guidance from the Green Book, the PM peak hour design volume was based on the 30th highest hourly AADT volume percentage of 12.7%. The 30th highest hourly volume percentage was rounded down to 12% to remain in the range of values suggested in the Green Book (9% to 12% of AADT). According to the CSS, the average AM peak hourly percentage was 4.5% to 5.8% of AADT, while the average PM peak hourly percentage was 9.3% of AADT. The design AM peak hour percentage was chosen as 8% (the ratio of the average AM peak percentage to the average PM peak percentage multiplied by the 30th highest hourly volume percentage).

For the eastbound approach, it was noted that AM peak hour traffic is significantly heavier than the PM peak hour traffic. Design hour percentages for this approach were chosen to mimic the relative daily volumes compared to those on Riverside Drive. Table 10 shows the design hour percentages for each approach.

Table 10. Chosen Design Hour Percentage by Approach

	AM Design Hour Percentage	PM Design Hour Percentage
Northbound Approach	8%	12%
Southbound Approach	8%	12%
Eastbound Approach	14%	8%
Westbound Approach	8%	12%

The estimated peak hour percentages were applied to forecasted 2040 AADTs to estimate future TMVs. Figure 14 and Figure 15 depict the adjusted TMVs used for analysis of the study intersection under 2040 traffic volumes for the AM and PM peak hours.

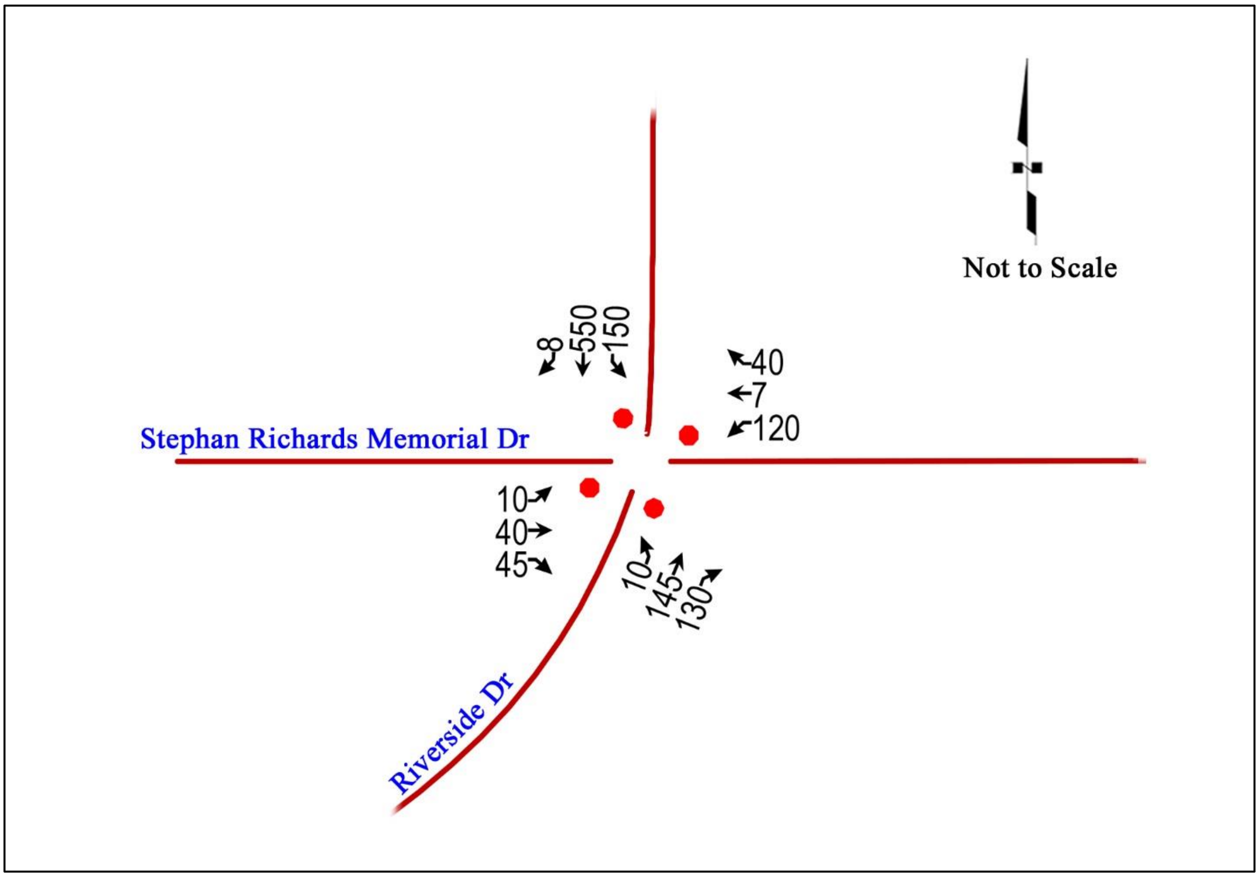

Figure 14: 2040 TMVs, AM Peak Hour

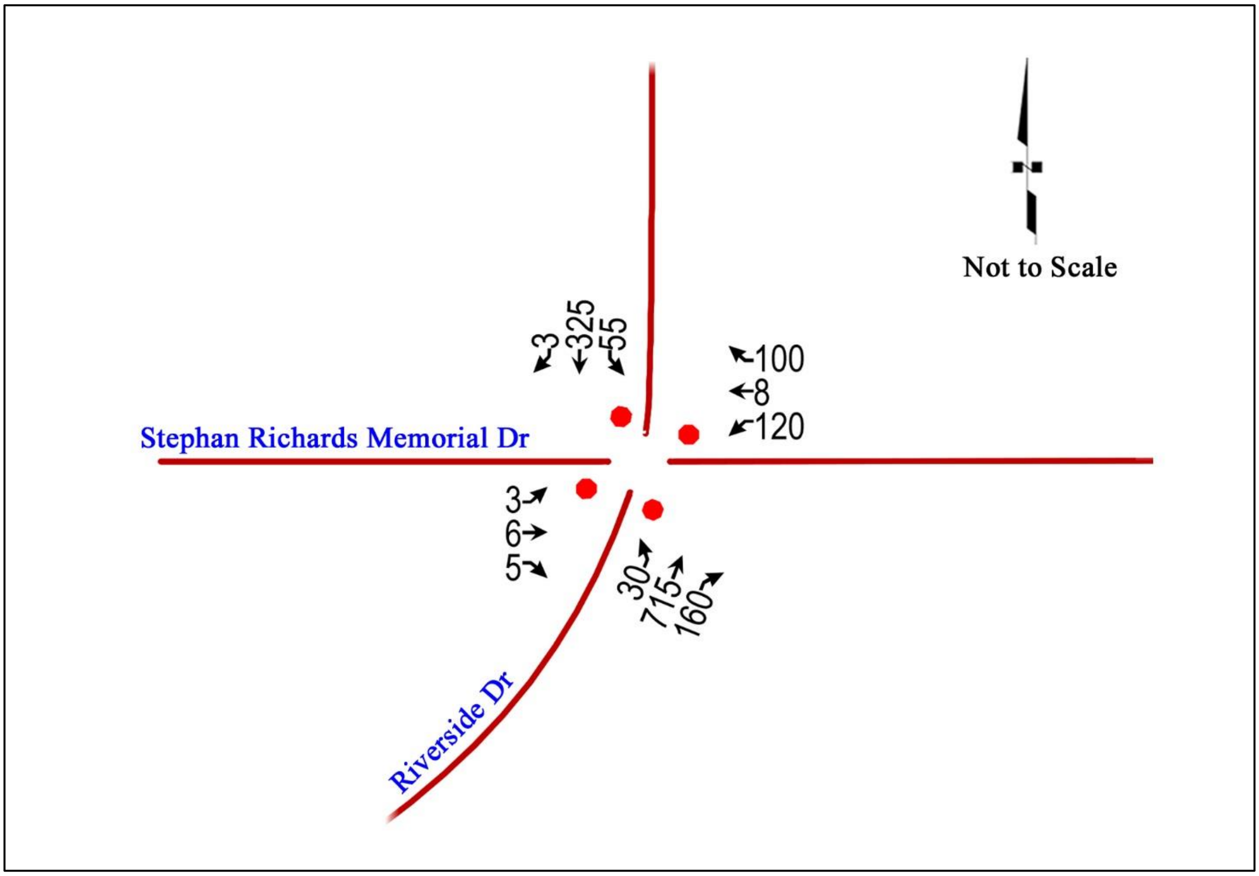

Figure 15. 2040 TMVs, PM Peak Hour

6.1.3 Peak Hour Factors and Heavy Vehicle Percentages

For analysis of operations under the no-build condition, the same peak hour factors and heavy vehicle percentages used for analysis of existing conditions were utilized.

6.1.4 2040 Intersection Capacity

Since 2008, the study intersection has operated under all-way stop control, which improved safety over two-way stop control. The no build-alternative would leave the existing lane configuration and existing all-way stop control. The no-build alternative under 2040 traffic volumes was analyzed using Synchro Trafficware and the overall intersection was determined to continue to operate at LOS F, with increased delay and queue lengths. Table 11 and Table 12 summarize the future intersection operations for each movement during the AM and PM peaks. The primary concern is still the directional queues for southbound and northbound Riverside Drive in the morning and evening, respectively.

Table 11: 2040 Intersection Capacity under All-Way Stop Control – AM Peak

AM Peak	**EB**	**WB**	**NB**	**SB**	**Intersection**
V/C Ratio	0.3	0.4	0.6	1.3	**-**
Control Delay (sec)	13.0	15.5	17.4	186.4	**112.2**
Lane LOS	B	C	C	F	**F**
95th % Queue (feet)	25	50	100	925	**-**

Table 12: 2040 Intersection Capacity under All-Way Stop Control - PM Peak

PM Peak	**EB**	**WB**	**NB**	**SB**	**Intersection**
V/C Ratio	0.0	0.5	1.4	0.7	**-**
Control Delay (sec)	11.7	16.1	242.	21.3	**151.1**
Lane LOS	B	C	F	C	**F**
95th % Queue (feet)	25	75	1200	125	**-**

7 Summary of Identified Concerns

The analysis of existing conditions at the study intersection under existing and projected traffic volumes identified the following intersection characteristics and concerns:

- *Safety:* The intersection crash experience under two-way stop control suggests that vehicles from the side streets had difficulty selecting gaps in the main street traffic. After conversion to all-way stop control, the intersection crash frequency was reduced from 2.4 to 1.3 crashes per year and injury crashes were greatly reduced. Any changes proposed to the intersection to improve operations should carefully consider safety effects.
- *Operations:* The intersection operates over capacity for the southbound direction in the morning and for the northbound direction in the evening. Under projected traffic volumes, delay and queue lengths increase still further for southbound and northbound vehicles. LOS, delay, and queue lengths remain acceptable for all other approaches.
- *Pedestrians and bicyclists:* The intersection provides a controlled crossing on all four approach legs with minimal delay to pedestrians and bicyclists. There were two bicycle crashes at the intersection when it was under two-way stop control. There have been no pedestrian or bicycle crashes since all-way stop control was installed. Any changes proposed to the intersection to improve vehicle operations should carefully consider the effect on pedestrian and bicycle operations and safety.

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