



# DUKE STREET (ROUTE 236) AT W. TAYLOR RUN PARKWAY INTERSECTION IMPROVEMENT PROJECT

## FINAL REPORT



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Duke Street (Route 236) at W. Taylor Run Parkway Intersection Improvement Project

From N. Quaker Lane (Route 404) to Dove Lane/Robert's Lane

Final Report

March 18, 2024 |

Prepared for



Prepared by



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## EXECUTIVE SUMMARY

The City of Alexandria (City) has identified the need to evaluate existing and future conditions for Duke Street (VA Route 236) corridor. Duke Street, which traverses the City, is a critical east-west route roadway corridor in Northern Virginia, functions as an important route for access to retail centers, commerce/office centers and residences. Significant congestion, high number of crashes, transit routes and facilities, pedestrian activity and access management issues are noted on Duke Street between N. Quaker Lane and W. Taylor Run Parkway. This corridor experiences severe/chronic congestion lasting over multiple hours per day. AADT data posted on VDOT website shows daily volume of 31,000 (year 2019) between N. Pickett Street and Telegraph Road.

During the PM peak period, queues on the rightmost eastbound lane at the intersection of Duke Street and West Taylor Run Parkway spill over into upstream intersections, and on many occasions onto North Quaker Lane. Such traffic loads encourage cut-through traffic in neighborhood streets, resulting in heavy backups on southbound West Taylor Run Parkway. Multiple north-south streets (e.g., Fort Williams Parkway, North Quaker Lane, West Taylor Run Parkway) are used as routes for cut-through traffic, which all converge at the intersection of Duke Street and West Taylor Run Parkway and eastbound Duke Street on-ramp to Telegraph Road. Excessive queuing on the eastbound right-turn lane also creates unsafe conditions for bus operations, where buses are blocked by the eastbound queues and have to merge with fast moving traffic on Duke Street. Lack of pedestrian facilities and connection to transit stop on Witter Drive creates unsafe conditions for the pedestrians.

The primary goal of this study is to determine and assess measures to reduce congestion, recommend multimodal improvements to alleviate access management issues and address safety at the intersection of Duke Street and W. Taylor Run Parkway, improve pedestrian safety, and provide additional access to the southbound Telegraph Road from the eastbound Duke Street.

The *operational* issues intended to be addressed by this study include existing and future projected congestion within the corridor. This congestion is centered at the intersection of Duke Street and W. Taylor Run Parkway within the corridor, which is currently heavily utilized by pedestrians, transit vehicles, passenger cars and some truck traffic. Reduction in intersection delays would mitigate congestion, discourage cut-through traffic, protect neighborhoods, improve safety and mobility, and reduce travel time.

This study also intends to address existing and future *safety* concerns within the study corridor. During the recent seven-year period, 446 crashes resulting in 110 visible injuries, were reported within this corridor. The types of crashes frequently reported include rear-end and sideswipe – same direction. These crash types are typically associated with recurring congestion for a corridor. Reduction in congestion along the corridor may have a corresponding safety benefit, in terms of reduction in number of crashes along the corridor.

Duke Street corridor in the study area serves a mix of institutional, recreational, commercial, retail, and residential uses. The corridor is well served by transit lines AT8, 29K, and 29N providing service to and from the King Street Metrorail station. This study also intends to address *transit access* within the limits of the study corridor by identifying and documenting deficiencies in pedestrian and transit facilities, with the objective of recommending improvements to those facilities at the intersection of Duke Street and W. Taylor Run Parkway. The study will collaborate with Duke Street Transitway project.

These study intersections are listed below and shown in Figure 1ES.

### Study Area Intersections

1. Duke Street and N. Quaker Lane
2. Duke Street and S. Quaker Lane
3. Duke Street and Alexandria Commons
4. Duke Street and Sweeley Street
5. Duke Street and Roth Street/Cambridge Road
6. Duke Street and Witter Drive
7. Duke Street and West Taylor Run Pkwy
8. Duke Street westbound and Telegraph Rd off-ramp
9. Duke Street westbound and Telegraph Rd on-ramp
10. Duke Street and Dove Lane/Robert's Lane

Figure 1ES – Study Area Map for Duke Street and W. Taylor Run Improvement Project



The traffic operational assessment was conducted in two stages. The first stage involved an assessment of existing traffic conditions (Year 2019) within the study area. The second stage involved development and evaluation of potential improvement alternatives for the study area, which included conducting a Warrant Study for Duke Street eastbound and Telegraph Road on-ramp new. The years 2026 and 2036 were selected as the Opening and Design Years for all future conditions analyses.

The annual growth rate was determined by evaluating the Metropolitan Washington Council of Governments (MWCOG) model's Household and Employment rates, and comparing the traffic volume growth in the model to historical Average Annual Daily Traffic (AADT) volumes from a continuous count station data recorded by VDOT from 2010 through 2019. Growth rates were also compared with the growth recorded on I-395 Seminary Road HOV ramp Interchange Modification Report (IMR). Based upon the evaluation, the project team has identified and agreed upon an annual growth rate of 0.25% for No-Build conditions. The suggested growth rate of 0.25% per year was applied to the Existing 2018 traffic volumes to generate projected 2026 and 2036 AM and PM peak hour traffic volumes for No-Build conditions. Growth rate of 0.25% (compound method) was applied to all movements including Service Road. VISSIM was used to evaluate operations at signalized and unsignalized intersections for existing, and 2026 and 2036 No-Build conditions.

Based upon the MWCOG model evaluation, the project team identified and agreed upon an annual growth rate of 0.25% for Build conditions. Travel demand model output for the year 2045 is based on the assumption that the southbound left-turn traffic from W. Taylor Run Parkway to the on-ramp is restricted, and new access to Telegraph Road on-ramp from Duke Street to the east of Telegraph Road is assumed. The Future year demand model produced a growth rate of -0.3% per year for the section of Duke Street between N. Quaker Lane and Diagonal Road. Growth rate of 0.25% per year is the conservative approach to analyze the Build conditions. This growth rate is also consistent with the growth rate used for the East Eisenhower Small Area Plan (EESAP) and Duke Street Transitway Project.

Based on the community input from previous meetings, SMART SCALE application proposed improvements, the No-Build operational analysis results, safety analysis, as well as field investigations, the study team identified operational and safety deficiencies within the study area and developed a preliminary list of design opportunities and constraints. Alternative Analysis was performed for an initial screening using Synchro software to determine the optimal configuration of Duke Street and W. Taylor Run Parkway, Duke Street eastbound and Telegraph Road on-Ramp, and Telegraph Road on-ramp at New Ramp (from eastbound Duke Street). Four (4) alternatives (Alternative 1, Alternative 1A, Alternative 2 and Alternative 3) were developed and analyzed using Synchro. Alternatives were compared to the No-Build conditions. All analysis scenarios were evaluated using Synchro during the weekday AM and PM peak hours only for the design year 2036. Based on the comparison of operational results for the No-Build and Alternatives, and safety benefits, Alternative 1 and Alternative 3 were carried forward for the further analysis using VISSIM.

Growth rate of 0.25% per year was used to develop build and design year traffic volumes. In addition to that adjustments were made to the traffic volume based on the Duke Street Traffic Mitigation Pilots (<https://www.alexandriava.gov/transportation-planning/duke-street-traffic-mitigation-pilots>). Growth rate of 0.25% per year is also consistent with the growth rate used for Duke Street Transitway Study. An engineering study was conducted to determine if a signal is appropriate for the intersection of Duke Street eastbound and Telegraph Road on-ramp new. The engineering study indicated that Warrant 1, and Condition A—Minimum Vehicular Volume and Condition B (Interruption of Continuous Traffic) using ADT Estimates, and Warrant 3 (Peak Hour) are met for the opening year 2026 conditions. The conventional signalized intersection provides increased safety for pedestrians. Even though signals generally have potential to increase rear-end crashes, it may reduce the angle and left-turn crashes at the intersection. New signalized intersection will also reduce or eliminate rear-end and sideswipe crashes occurring on Duke Street westbound and Telegraph Rd off-ramp. Therefore, a conventional intersection with a signal, is justified. Signal Justification Report (SJR) was prepared at this location.

WSP conducted a traffic operations analysis of the selected two (2) future Build alternatives using VISSIM. VISSIM models were developed for Build year 2026 and Design year 2036 for AM and PM peak hours. Alternative 1 and modified Alternative 3 (Alternative 3A) were carried forward for the VISSIM analysis. Alternative 1 provided the right-turn slip lane from the westbound Duke Street onto service road and free flow was maintained for the Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street. Slip lane was provided midway between E. Taylor Run Parkway and Moncure Drive. Alternative 3A maintained the westbound right-turn lane at Duke Street and W. Taylor Run Parkway. Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street was eliminated. Dual southbound right-turn lanes were provided at the intersection.

Both alternatives restricted the southbound left-turn movement from W. Taylor Run Parkway onto Telegraph Road on-ramp and include the signalization for the new intersection for Duke Street eastbound and Telegraph Road on-ramp. The projected traffic volumes were balanced and distributed in accordance to projected regional distribution. MOEs for the Build alternatives were reported and summarized in tabular format consistent with earlier tasks and in accordance with TOSAM guidelines. After the results of the VISSIM analysis were evaluated for Alternatives 1 and 3A, the team identified preferred alternative for the study area.

Preferred alternative, Alternative 3C, was analyzed using VISSIM for 2026 and 2036 conditions. Preferred Alternative 3C provided the right-turn slip lane from the westbound Duke Street onto service road. Slip lane was provided at the intersection of Service Road and Moncure Drive. Telegraph Road off-ramp from the northbound Telegraph Road to the westbound Duke Street was retained. Preferred Alternative 3C restricted the southbound left-turn movement from W. Taylor Run Parkway onto Telegraph Road on-ramp. Signalization of the new intersection for Duke Street eastbound and Telegraph Road on-ramp was included in the alternative. VISSIM results for existing (2019), Opening Year (2026) No-Build/Build, and Design Year (2036) No-Build/Build for the weekday AM/PM peak hours is presented in the Table ES1.

For 2026 and 2036 AM peak hour with exception of the intersection of Duke Street and N. Quaker Lane, LOS for all the study intersections improved or remained unchanged for the build conditions when compared to the corresponding no-build condition. For 2026 and 2036 PM peak hour with exception of the intersection of Cambridge Road and Service Road, LOS for all the study intersections remained unchanged or improved for the build conditions when compared to the corresponding no-build condition.



Intersection	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS
	AM PEAK						PM Peak						AM Peak				PM Peak			
	2018 Existing		2026 No-Build		2026 Preferred Alternative 3C		2018 Existing		2026 No-Build		2026 Preferred Alternative 3C		2036 No-Build		2036 Preferred Alternative 3C		2036 No-Build		2036 Preferred Alternative 3C	
Duke St and N Quaker Ln	18.1	B	18.2	B	25.2	C	37.8	D	42.1	D	34.7	C	19.2	B	25.3	C	54.8	D	39.7	D
Duke St and S Quaker Ln	6.4	A	6.3	A	6.5	A	22.3	C	22.7	C	12.1	B	6.5	A	6.5	A	27.4	C	13.3	B
Duke St and Alexandria Commons	5.2	A	5.5	A	6.0	A	26.1	C	25.1	C	15.6	B	5.4	A	5.9	A	30.6	C	16.5	B
Duke St and Sweeley St	7.4	A	7.8	A	7.9	A	34.1	C	34.9	C	11.9	B	8.4	A	8.0	A	38.7	D	13.3	B
Duke St at Roth St / Cambridge Rd	16.4	B	16.5	B	17.1	B	38.8	D	38.6	D	13.7	B	17.2	B	17.5	B	39	D	15.5	B
Cambridge Rd and Service Rd	89.5	F	88	F	22.7	C	25.3	D	28.1	D	53.2	F	88.1	F	26.6	D	30.8	D	50.8	F
Duke St and Witter Dr	8.0	B	8.5	A	8.9	A	36.8	D	35.3	D	7.8	A	10.6	B	9.0	A	35.7	D	10.8	B
Duke St and W Taylor Run Pkwy	23.4	B	20.6	B	10.1	B	37.9	D	25.3	C	10.6	B	21.5	C	10.0	A	25.5	C	11.3	B
W Taylor Run Pkwy and Service Rd	23	C	22.9	C	15.3	B	107.8	F	109.3	F	27.4	C	24	C	14.8	B	114.4	F	31.1	C
Duke St WB to WTR Pkwy Service Rd	--	--	--	--	4.4	A	--	--	--	--	3.7	A	--	--	4.6	A	--	--	3.9	A
Duke St WB and Telegraph Rd Off-Ramp	1.1	A	1.1	A	1.2	A	0.9	A	0.8	A	1.0	A	1.9	A	1.3	A	0.9	A	1.1	A
Duke St EB to Telegraph Rd On-ramp (New)	--	--	--	--	10.0	A	--	--	--	--	13.3	B	--	--	9.7	A	--	--	13.3	B
Telegraph Rd On-Ramp at New Ramp from /duke St WB	--	--	--	--	0.3	A					2.2	A	--	--	0.3	A			2.3	A
Duke St WB to Telegraph Rd On-Ramp	0.3	A	0.3	A	0.4	A	0.9	A	0.9	A	1.2	A	0.4	A	0.4	A	1.1	A	1.4	A
Duke St and S Dove St/Roberts Ln	14.0	B	14.8	B	12.5	B	13.0	B	13.8	B	13.5	B	14.4	B	12.3	B	13.9	B	14.2	B



The evaluation Preferred Alternative 3C is primarily focused on the intersections of Duke Street and W. Taylor Run Parkway, Duke Street eastbound and Telegraph Road on-ramp new, and Duke Street westbound and Telegraph Rd on-ramp. No traffic control or geometric changes were made at the other study intersections. The recommended improvements for the preferred alternative in the study area are described below and presented in Figure ES2.

Figure ES2 – Conceptual Design Alternative 3C for Duke Street and W. Taylor Run Improvement Project



Duke Street and W. Taylor Run Parkway (See Figure ES2)

- The southbound left-turn traffic restricted from entering onto the Telegraph Road on-ramp at the intersection. Concrete median between the eastbound through lanes on Duke Street and Telegraph Road ramp is extended to restrict this movement.
- Extending the median between the eastbound receiving lane on Duke Street and Telegraph Road on-ramp will provide easy access to the bus shelter and improve pedestrian access to the Old Town Alexandria. To cross Telegraph Road on-ramp, existing signalized crosswalk at the intersection of Duke Street and W. Taylor Run Parkway will be maintained.
- Bus stops on the eastbound Duke Street, the nearside and the far side of the intersection, will be consolidated to a bus shelter just east of the crosswalk. This will eliminate the existing crosswalk on Telegraph Road on-ramp which is located approximately 300 ft. to the east of the intersection.
- Curb extensions and curb radii reduction at the NE and NW quadrants to reduce crossing distances and improve the safety for pedestrians and bicyclists.

- Single lane is provided for the southbound W. Taylor Run Parkway approach.
- Right-turn slip lane from the westbound Duke Street to service road is provided. Slip lane will be provided at the intersection of Service Road and Moncure Drive. Westbound right-turn lane at Duke Street and W. Taylor Run Parkway is removed. Vehicles will use slip lane to access W. Taylor Run Parkway, E. Taylor Run Parkway and Moncure Drive from the westbound Duke Street. Existing conditions will be maintained for the vehicles coming from the eastbound Duke Street.
- Three thru lanes are maintained on the westbound approach of Duke Street.
- The eastbound left-turn lane is maintained.
- Service road is realigned at the intersection. Vehicles will be allowed to travel in both direction on the service road, eastbound and westbound, to the east of W. Taylor Run Parkway and between W. Taylor Run Parkway and Moncure Drive. Service road will be one-way westbound to the east of Moncure Drive.
- An exclusive pedestrian phase will be maintained at the intersection. Vehicles traveling from eastbound Duke Street to Telegraph Road will be uninterrupted except when pedestrian pushes the button to cross the east leg of the intersection.

Duke Street eastbound and Telegraph Road on-ramp new (See Figure ES2)

- Intersection will provide additional access for the eastbound traffic on Duke Street to the southbound Telegraph Road. Intersection will be signalized and will be controlled by the signal controller at Duke Street and S. Dove Street/Robert's Lane.
- Cross walk on the north leg to the intersection will be controlled by the pedestrian signals.
- Existing Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street will be maintained.
- Existing crosswalk on Telegraph Road off-ramp will be maintained. Crosswalk will be controlled by existing Rectangular Rapid Flashing Beacon (RRFB).
- The eastbound left turn traffic after exiting the intersection will have to yield to the Telegraph Road on-ramp traffic from the westbound Duke Street.

Duke Street westbound and Telegraph Rd on-ramp (See Figure ES2)

- Existing crosswalk on Telegraph Road on-ramp will be maintained. Crosswalk will be controlled by existing RRFB.

The “Preferred Alternative 3C” considered in this evaluation will most likely reduce cut-through traffic on neighborhood streets, reduce traffic spilling onto eastbound Duke Street from Telegraph Road on-ramp, improve transit operation on Duke Street, and improve safety and mobility for pedestrians and cyclists within the study area, while maintaining vehicular level of service. Preferred Alternative 3C aligns with the Duke Street Transitway project requiring less construction cost in the future.

# 1 INTRODUCTION

## 1.1 Background

Many of the City's major arterials that provide access points to I-395 and I-495 are routinely congested during peak hours. Although Alexandria is adopting smart growth policies and multi modal approaches, many of its major arterials are routinely congested during peak hours which provide multiple access points to I-395 and I-495. Congestion worsens with the occurrence of incidents on I-395 or I-495 when many commuters cut through City streets.

During the PM peak period, queues on the rightmost eastbound lane at the intersection of Duke Street and West Taylor Run Parkway spill over into upstream intersections, and on many occasions onto North Quaker Lane. Such traffic loads encourage cut-through traffic in neighborhood streets, resulting in heavy backups on southbound West Taylor Run Parkway. Multiple north-south streets (e.g., Fort Williams Parkway, North Quaker Lane, West Taylor Run Parkway) are used as routes for cut-through traffic, which all converge at the intersection of Duke Street and West Taylor Run Parkway and eastbound Duke Street on-ramp to Telegraph Road. Excessive queuing on the eastbound right-turn lane also creates unsafe conditions for bus operations, where buses are blocked by the eastbound queues and have to merge with fast moving traffic on Duke Street. Lack of pedestrian facilities and connection to transit stop on Witter Drive creates unsafe conditions for the pedestrians. Understanding the underlying causes of traffic cut-through in the study area and the commuting patterns through and beyond the study area plays a critical role in determining the optimum mitigations measures for this intersection improvement project. The study area map is shown in Figure 1.

In June 2016, City Council directed staff to conduct a comprehensive traffic study that examined traffic volumes, speeds, and traffic origins and destinations as a response to residents' concerns about increased traffic and traffic diversion to neighborhoods in central Alexandria. The Central Alexandria traffic study specifically focused on the Seminary Hill, Seminary Ridge, Clover College Park, and Taylor Run Civic Associations' areas. Traffic counts were performed, and vehicle volumes, speeds, and Bluetooth origin-destination data were collected at checkpoints throughout the study area.

Final recommendations from the Central Alexandria Traffic Study were shared with City Council members outlining the short- and long-term recommendations of study. The short-term recommendations included afternoon turn restrictions on certain streets (PM peak period right-turn restriction pilot from southbound East Taylor Run Parkway and Moncure Drive), traffic calming measures, pedestrian safety upgrades and a redesign of the Duke Street at West Taylor Run Parkway intersection. Long-term recommendations included:

1. Initiate a Complete Street redesign of the intersection at Duke Street and West Taylor Run Parkway, with the primary goal of reducing cut-through traffic, improving safety, and providing more efficient mobility.
2. Accelerate Duke Street corridor (Corridor B), between Landmark Mall to the west and King Street Metrorail Station to the east, design with the goal of reducing cut-through traffic in Central Alexandria neighborhoods.
3. Prioritize Duke Street for Traffic Adaptive Signal Control implementation.
4. Promote and encourage greater use of transportation alternatives in Alexandria and in neighboring jurisdictions.

The City of Alexandria (City) has identified the need to evaluate existing and future conditions for Duke Street (VA Route 236) corridor. Duke Street, which traverses the City, is a critical east-west route roadway corridor in Northern Virginia, functions as an important route for access to retail centers, commerce/office centers and residences. Significant congestion, high number of crashes, transit routes and facilities, pedestrian activity and access management issues are noted on Duke Street between N. Quaker Lane and W. Taylor Run Parkway. This corridor experiences severe/chronic congestion lasting over multiple hours per day. AADT data posted on VDOT website shows daily volume of 31,000 (year 2019) between N. Pickett Street and Telegraph Road.

The project involves two parts: 1) conducting traffic analysis of the study network and 2) developing design plans for the preferred option. Recently completed or ongoing studies or projects in the vicinity of the study area will be referenced as needed during this project including:

1. Central Alexandria Transportation Study (2018)
2. Eisenhower East Small Area Plan (EESAP) 2019 Update
3. Traffic impact studies, and adjacent projects
4. Duke Street BRT Planning/Preliminary Design/Survey (started in April 2022)

## 1.2 Purpose of Study

The primary goal of this study is to determine and assess measures to reduce congestion, recommend multimodal improvements to alleviate access management issues and address safety at the intersection of Duke Street and W. Taylor Run Parkway, improve pedestrian safety, and provide additional access to the southbound Telegraph Road from the eastbound Duke Street. Framework document for the traffic study is presented in the Appendix A.

The *operational* issues intended to be addressed by this study include existing and future projected congestion within the corridor. This congestion is centered at the intersection of Duke Street and W. Taylor Run Parkway within the corridor, which is currently heavily utilized by pedestrians, transit vehicles, passenger cars and some truck traffic. Reduction in intersection delays would mitigate congestion, improve safety and mobility, and reduce travel time.

This study also intends to address existing and future *safety* concerns within the study corridor. During the recent seven-year period from 2015-2022, 446 crashes resulting in 110 visible injuries, were reported within this corridor. The types of crashes frequently reported include rear-end and sideswipe – same direction. These crash types are typically associated with recurring congestion for a corridor. Reduction in congestion along the corridor may have a corresponding safety benefit, in terms of reduction in number of crashes along the corridor.

Duke Street corridor in the study area serves a mix of institutional, recreational, commercial, retail, and residential uses. The corridor is well served by transit lines AT8, 29K, and 29N providing service to and from the King Street Metrorail station. This study also intends to address *transit access* within the limits of the study corridor by identifying and documenting deficiencies in pedestrian and transit facilities, with the objective of recommending improvements to those facilities at the intersection of Duke Street and W. Taylor Run Parkway.

Key features that will be considered in this study include the following.

1. Achieve consensus through early and proactive public outreach among the civic associations (specifically Seminary Hill, Seminary Ridge, Clover College Park, and Taylor Run), other stakeholders and the City to find an acceptable solution to the referenced traffic issues.
2. Collaborate with Duke Street Transitway Project.



3. Consider impact of the major developments and employment centers such as BRAC-133 at Mark Center.
4. Develop mitigation measures using exiting traffic data to discourage cut-through traffic and to protect neighborhoods.
5. Reconfigure the intersection of Duke Street and West Taylor Run Parkway/Telegraph Road on-ramp, and simplify signal phasing to improve safety and operations, especially for pedestrians and bicyclists and to relieve the congestion.
6. Improve safety of the pedestrians crossing midblock of Duke Street (west of West Taylor Run Parkway) and Telegraph Road off-ramp.
7. Improve eastbound operations for AT8 bus service especially during the PM peak period.
8. Prepare alternatives within existing right-of-way by maintaining already implemented short-term restrictions, such as right-turn restrictions from southbound E. Taylor Run Parkway and Moncure Drive onto Duke Street Service Road.
9. Create and analyze additional access on Duke Street eastbound near Telegraph Road on-ramp to relieve the congestion at Duke Street and West Taylor Run Parkway.
7. Duke Street and West Taylor Run Pkwy
8. Duke Street westbound and Telegraph Rd off-ramp
9. Duke Street westbound and Telegraph Rd on-ramp
10. Duke Street and Dove Lane/Robert's Lane

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### 1.3 Study Work Group

The Study Work Group (SWG) includes local stakeholders, who provide local and institutional knowledge of the corridor, review study goals and methodologies, provide input on key assumptions, and review and approve proposed improvement concepts developed through the study process. The key members included in the SWG represent the following Agencies:

- City of Alexandria
- VDOT Northern Virginia District Office and Central Office
- WSP Team

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### 1.4 Project Location

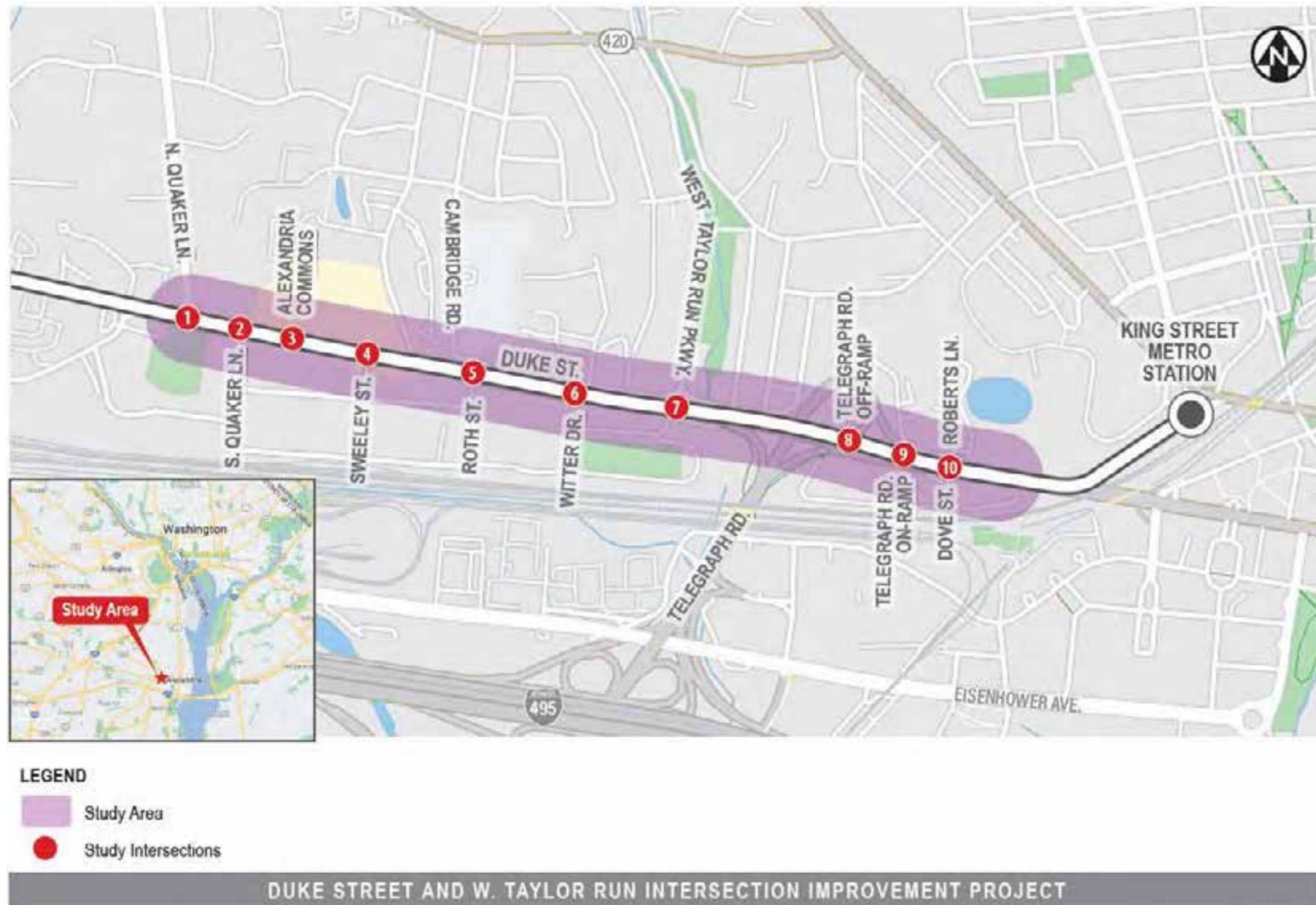
Duke Street (Route 236), in the study area, between N. Quaker Lane and Dove Lane/Robert's Lane is classified as Other Principal Arterial per *VDOT Functional Classification*. Route 236 is one of the major backbone arterials in the City and Fairfax County. Within the study area, Duke Street is a 4-lane divided roadway between Dove Lane/Robert's Lane and Roth Street/Cambridge Road, and a 4-lane undivided Roadway between Roth Street/Cambridge Road and S. Quaker Lane. The posted speed limit is 35 miles per hour along the corridor. This east-west corridor is approximately 1.10 miles in length that includes ten (10) study intersections. These study intersections are listed below and shown in Figure 1.

#### Study Area Intersections

1. Duke Street and N. Quaker Lane
2. Duke Street and S. Quaker Lane
3. Duke Street and Alexandria Commons
4. Duke Street and Sweeley Street
5. Duke Street and Roth Street/Cambridge Road
6. Duke Street and Witter Drive



Figure 1. Study Area Map



## 2 EXISTING CONDITIONS

### 2.1 Existing Land Use

Land use in the immediate vicinity of the study corridor between N. Quaker Lane to Dove Lane/Robert's Lane is mixed and primarily consists of commercial and government properties, retail stores, car dealership, light industrial uses, office/business/commerce centers, shopping plazas, restaurants, school, recreational fields and residential properties. Land use and transit routes generate fair amount of pedestrian and bicycle traffic. Existing zoning in the project area is shown on Figure 2.

### 2.2 Existing Roadway Network

An inventory of the existing roadway condition was prepared along Duke Street, based on field reviews. Traffic, crash and Geographic Information System (GIS) data was used to document existing conditions. During the field review, following data was collected and documented:

Digital photographs, videos, and observation to capture:

- Roadway geometry to include lane configuration, lane/shoulder widths
- Signs and pavement markings
- Posted speed limits
- Sight distance issues
- Safety concerns
- Existing driveway locations, their spacing and potential impact on crashes
- Observation of traffic operations (traffic mix, congestion, driver behavior)
- Inventory of existing roadway conditions to determine potential for safety improvements
- Inventory of intersection operations (signal phasing, queuing)

The study corridor includes eight (8) signalized and two (2) unsignalized intersections as discussed in Sections 2.2.2 through 2.2.8 below:

#### 2.2.1 Multimodal Facilities

##### Pedestrian and Bicycle Facilities

The pedestrian network in and around the project area is generally well established. Sidewalks are present on both sides of Duke Street between N. Quaker Lane and Roth Street/Cambridge Road and between E. Taylor Run Parkway and Dove Street/Robert's Lane. However, sidewalks are present only on the south side of the Duke Street and on the north side of service road between Roth Street/Cambridge Road and E. Taylor Parkway. Sidewalks on the southside of the Duke Street between S Quaker Lane and Roth Street are wider, approximately 8' wide, does not include any grass buffer zone, thus placing pedestrians uncomfortably close to the traffic. Most other sidewalks have grass buffer zone that varies between 2' to 16'. Overall, the sidewalks are in fair conditions, except for locations which may require spot improvements.

There are currently on-street and off-street pedestrian facilities located along the corridor. Most intersections in the study area have some sort of pedestrian facilities such as sidewalks, laddered or standard crosswalks, pedestrian ramps, Rectangular Rapid Flashing Beacons (RRFBs), and pedestrian push buttons and pedestrian crossing signals at the signalized intersections are currently present. There are multiple locations along the corridor where pedestrian ramps do not meet the current ADA standards with proper landings and truncated domes of contrasting color. Sight

distance for pedestrians crossing Telegraph Rd off-ramp (intersection #8) and Telegraph Rd on-ramp (intersection #9) is limited due to horizontal curvature of the roadway. As the corridor develops, pedestrian facilities will be improved such that they meet or exceed the City of Alexandria requirements and provide an improved pedestrian environment. Existing pedestrian facilities are shown on Figure 3.

Shared bicycle lanes are provided on Duke Street Service Road between W. Taylor Run Parkway and Cambridge Street. Shared lanes continue onto Roth Street to Colvin Street between Roth Street and S. Quaker Lane, and Duke Street between S. Quaker Lane and Wheeler Avenue. These shared lanes connect bike lanes on W. Taylor Run Parkway and Wheeler Avenue. Off-street bicycle paths provided along eastbound ramp from Duke Street to southbound Telegraph Road, and along the northbound Telegraph Road ramp to eastbound Duke Street. Existing bicycle facilities are shown on Figure 4.

The study area does not contain any Capital Bikeshare station.

##### Public Transit Service

VRE: The Virginia Railway Express (VRE) Station is located 0.5 miles outside the project area on Callahan Drive. VRE provides commuter-oriented rail service from the Northern Virginia suburbs to Alexandria, Crystal City and downtown Washington, D.C., along the I-66 and I-95 corridors. The station serves both VRE and Amtrak trains.

Metro: The King Street-Old Town Metrorail Station is located 0.5 miles outside the project area on King Street between Callahan Drive and Daingerfield Road. The station serves the Blue and Yellow Lines and is located between 0.5- and 1.0-miles walking distance of all blocks within the project area. The Eisenhower Avenue Metrorail Station is located on Eisenhower Avenue between Swamp Fox Road and Mill Race Lane. The station serves the Yellow Line. The Blue and Yellow Lines provide direct connections to areas in Virginia and the District, with access to Maryland via connecting lines.

Bus: Duke Street study corridor and surrounding area is well served by transit lines AT8, 29K, and 29N providing service to and from the King Street Metrorail station. Transit service schedule for these lines is presented in the Appendix H. Location of the bus stops/shelters in the eastbound and westbound direction are shown on Figures 5. Bus shelter and sitting are provided in the westbound direction at W. Taylor Run Parkway and Alexandria Commons bus stops. Streetlighting is provided at all bus stops. Sidewalks along Duke Street and on the service road provide the access to bus stops/shelters. Boarding and alighting information for three bus lines, AT8, is provided by the City, are summarized in Table 1.

Table 1. Duke Street Bus Stop Boardings/lightings

Eastbound (AT8)						
StopID	Stop Name	Bus Shelter	Boardings	Alightings	Sidewalk	Streetlighting
4000029	Duke St @ Dove St	No	0	2	Yes	Yes
4000034	Duke St @ Moncure Dr	No	17	6	Yes	Yes
4000038	2712 Duke St	No	73	6	Yes*	Yes
4000041	Duke St @ Witter Dr	No	4	3	Yes*	Yes
4000044	Duke St @ Roth St	No	10	9	Yes	Yes
4000053	Duke St @ Sweeley St	No	42	24	Yes	Yes
4000056	Duke St @ Opp. Alexandria Commons	No	31	12	Yes	Yes
4000061	Duke St @ S Quaker Ln	No	22	11	Yes	Yes



Westbound (AT8)						
StopID	Stop Name	Bus Shelter	Boardings	Alightings	Sidewalk	Streetlighting
4000030	Duke St @ Roberts Ln	No	3	8	Yes*	Yes
4000035	Duke St @ Moncure Dr	No	16	97	Yes*	Yes
4000039	Duke St @ W Taylor Run Pkwy	Yes	17	40	Yes*	Yes
4000050	Duke St @ Cambridge Rd	No	12	56	Yes	Yes
4000055	Duke St @ Yale Dr	No	11	42	Yes*	Yes
4000058	Duke St @ Alexandria Commons	Yes	41	48	Yes*	Yes
4000067	Duke St @ N Quaker Ln	No	6	33	Yes	Yes

\*ADA Landing Pad



Figure 2. Existing Land Use

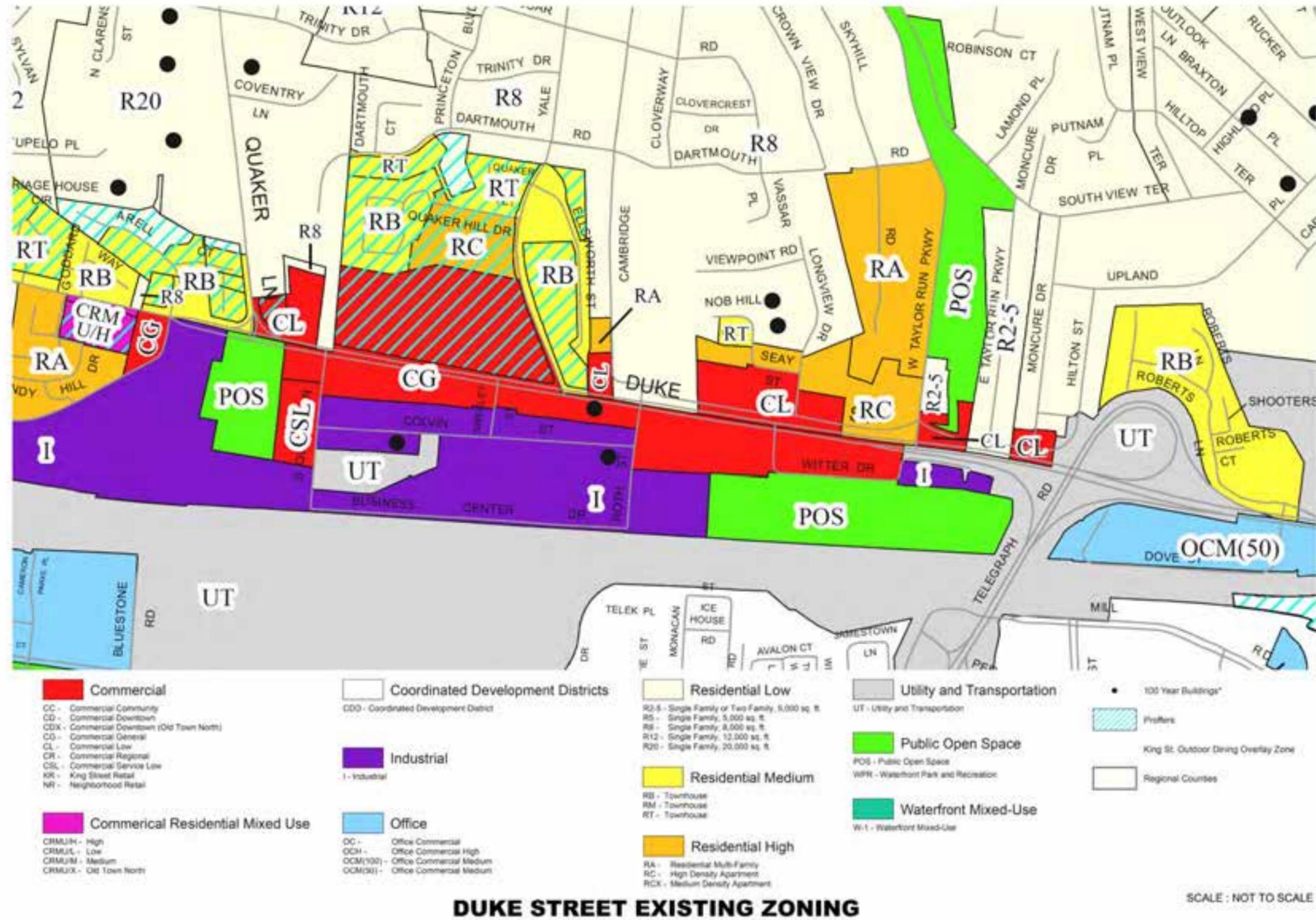


Figure 3. Existing Pedestrian Facility



**LEGEND:**  
— Existing Sidewalk  
— Existing Crosswalk

**DUKE STREET EXISTING PEDESTRIAN FACILITY**



Figure 4. Existing Bike Facility

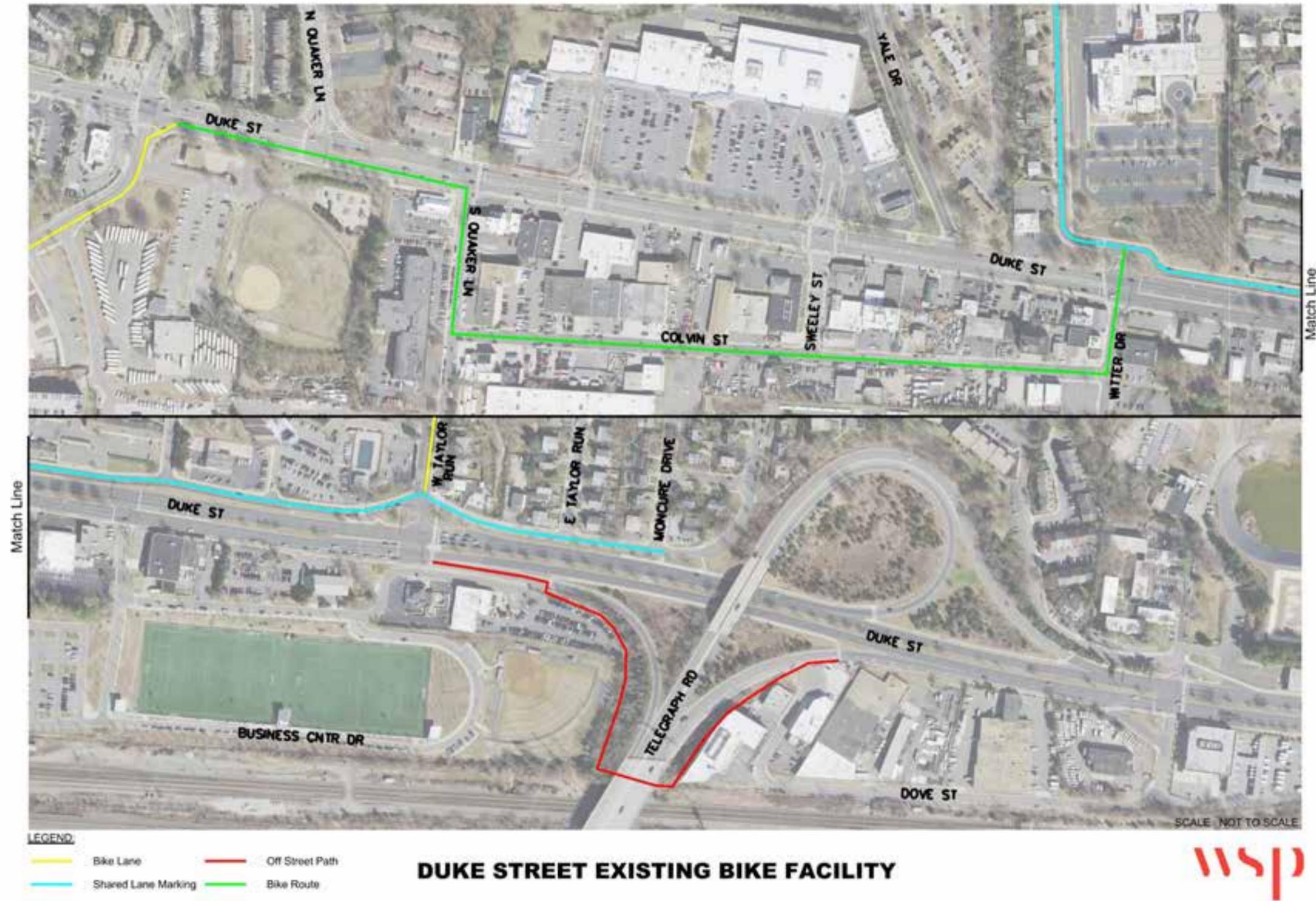
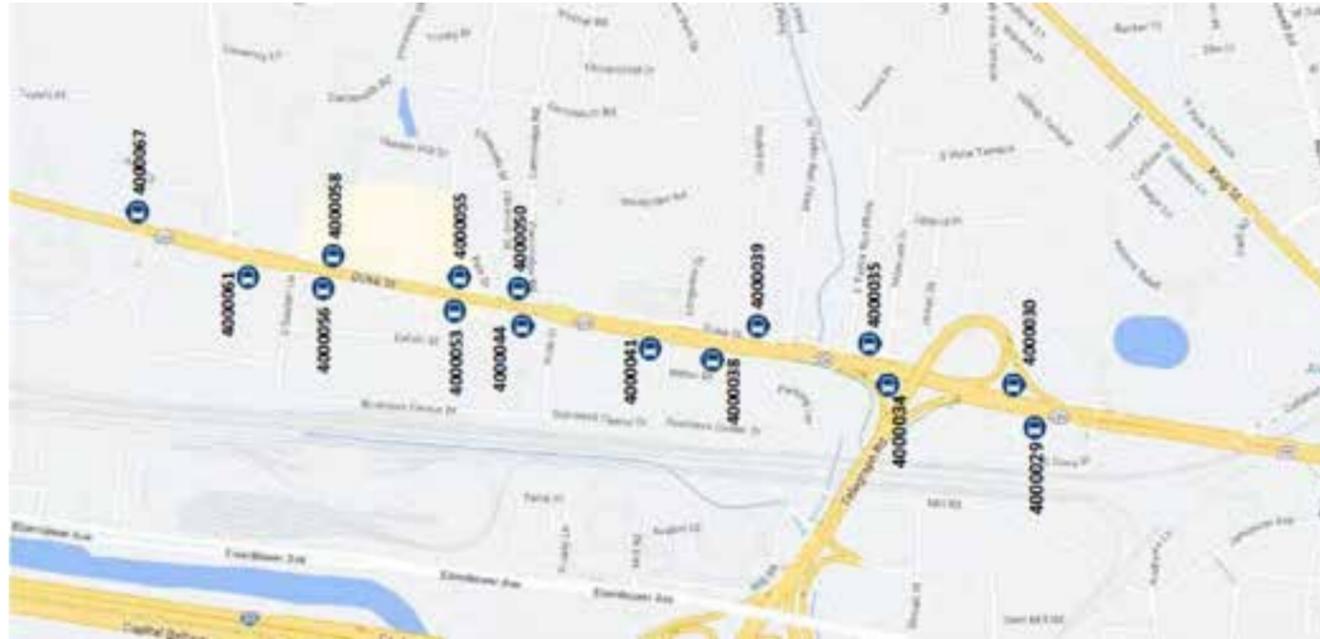


Figure 5: DASH and WMATA Stop Locations



### 2.2.2 Intersection 1: Duke Street at N. Quaker Lane

Duke Street is a major east-west route classified as Other Principal Arterial per *VDOT Functional Classification*. It is a four to six-lane street with a posted speed limit of 35 miles per hour. N. Quaker Lane is classified as Minor Arterial per *VDOT Functional Classification*. The intersection of Duke Street at N. Quaker Lane is a 3-leg signalized intersection. The posted speed limit along N. Quaker Lane is 25 miles per hour. The southbound approach of N. Quaker Lane has one left-turn lane, and one shared left-right lane. Right turn movement is channelized with an acceleration lane on the westbound Duke Street. The eastbound approach of Duke Street has one left-turn lane, and three through lanes. The westbound approach has two through lanes, and one right-turn channelized lane. The signal operations include protected-permitted (Flashing Yellow Arrow) left turn phasing for the eastbound approach, and protected right-turn phasing for the westbound approach, with right-turn overlapping with the southbound left-turn movement. Sidewalks are present on the either side of Duke Street and N. Quaker Lane. Pedestrian facilities (high visibility laddered crosswalks, pedestrian signals, pushbuttons, ADA ramps) are present across the eastbound, southbound, and westbound right-turn approaches. No Turn On Red restrictions are present for the westbound right-turn approach. Figure 6 shows an aerial of the intersection.

Figure 6: Duke Street at N. Quaker Lane



Source: Google Imagery

### 2.2.3 Intersection 2: Duke Street at S. Quaker Lane

S. Quaker Lane is not classified on *VDOT Functional Classification*. The intersection of Duke Street at S. Quaker Lane is a 4-leg signalized intersection. Alexandria Fire Station forms the north leg of the intersection. There is no posted speed limit along S. Quaker Lane or Alexandria Fire Station Driveway. The northbound approach of S. Quaker Lane has one shared left-right lane. The eastbound approach of Duke Street has one left-turn lane, two through lanes, and one right-turn lane. The westbound approach has one left-turn lane, and two through lanes. The signal operations include protected-permitted left turn phasing for the westbound approach, permitted left-turn phasing for the eastbound approach, and emergency pre-emption for the southbound approach. Northbound and southbound approaches have concurrently running signal phasing. Sidewalks are present on the either side of Duke Street and S. Quaker Lane. Pedestrian facilities (standard or high visibility laddered crosswalks, ADA/pedestrian ramps) are present across the northbound, and westbound approaches. Pedestrian signals and pushbuttons are present for the westbound approach but missing on the northbound approach. Figure 7 shows an aerial of the intersection.

### 2.2.4 Intersection 3: Duke Street at Alexandria Commons

The intersection of Duke Street at Alexandria Commons is a 4-leg signalized intersection. Alexandria Commons and Business Driveway form the north and south legs of the intersection, respectively. There is no posted speed limit along Alexandria Commons or Business Driveway. The southbound approach of Alexandria Commons has one shared left-thru-right lane. The eastbound and westbound approaches of Duke Street have one left-turn lane, one through lane, and one shared thru-right lane. The northbound approach, Business Driveway, is not controlled by the signal. The signal operations include protected-permitted left turn phasing for the eastbound approach, and permitted left-turn phasing for the westbound approach. Sidewalks are present on the either side of Duke Street and Alexandria Commons. Pedestrian facilities (high visibility laddered crosswalks, ADA/pedestrian ramps) are present across the southbound, and westbound approaches. Pedestrian signals and pushbuttons are present for the westbound approach but missing on the southbound approach. Figure 7 shows an aerial of the intersection.

Figure 7: Duke Street at S. Quaker Lane and Alexandria Commons



Source: Google Imagery

### 2.2.5 Intersection 4: Duke Street at Sweeley Street

Sweeley Street is not classified on *VDOT Functional Classification*. The intersection of Duke Street at Sweeley Street is a 4-leg signalized intersection. Alexandria Commons Driveway forms the north leg of the intersection. There is no posted speed limit along Sweeley Street or Alexandria Commons Driveway. The northbound approach of Sweeley Street has one shared left-thru-right turn lane. The southbound approach of Alexandria Commons Driveway has one shared left-thru lane, and one right-turn lane. The eastbound and westbound approaches of Duke Street have one left-turn lane, one through lane, and one shared thru-right lane. The signal operations include protected-permitted (Flashing Yellow Arrow) left turn phasing for the eastbound and westbound approaches. Northbound and southbound approaches have concurrently running signal phasing. Sidewalks are present on the either side of Duke Street, Sweeley Street, and Alexandria Commons. Pedestrian facilities (high visibility laddered crosswalks, ADA/pedestrian ramps) are present across all approaches. Pedestrian signals are present for the eastbound, westbound and southbound approaches but missing on the northbound approach. Pedestrian pushbuttons are present on the eastbound and westbound approaches but missing on the northbound and southbound approaches. Figure 8 shows an aerial of the intersection.

Figure 8: Duke Street at Alexandria Commons/Sweeley Street



Source: Google Imagery

### 2.2.6 Intersection 5: Duke Street at Roth Street/Cambridge Road

Roth Street or Cambridge Road are not classified on *VDOT Functional Classification*. The intersection of Duke Street at Roth Street/Cambridge Road is a 4-leg signalized intersection. There is no posted speed limit along Roth Street. Posted speed limit on Cambridge Road is 25 miles per hour. Cambridge Road serves Bishop Iteron High School which is a major traffic generator in the morning peak and early on during the afternoon peak. The northbound approach of Roth Street has one shared left-thru-right lane. The southbound approach of Cambridge Road has one shared left-thru lane, and one right-turn lane. Cambridge Road also provides the access to the service road which runs north of Duke Street. The eastbound approach of Duke Street has one left-turn lane, one through lane, and one shared thru-right lane. The westbound approach of Duke Street has one left-turn lane, two through lanes, and one right-turn lane. The signal operations include protected and protected-permitted left turn phasing for the eastbound and westbound approaches, respectively. Northbound and southbound approaches have concurrently running signal phasing. Sidewalks are present on the either side of Duke Street (west leg and south side of east leg), Roth Street, and Cambridge Road. Sidewalk is present only on the northside of the service Road. Pedestrian facilities (high visibility laddered crosswalks, pedestrian ramps, pedestrian signals, pedestrian pushbuttons) are present across the eastbound, and northbound approaches. Pedestrian signals and pedestrian pushbuttons are present for the eastbound, and northbound approaches. No Turn On Red and No Turn on Red when pedestrians are present restrictions are present for the westbound and northbound right-turn approaches. Figure 9 shows an aerial of the intersection.

Figure 9: Duke Street at Roth Street/Cambridge Road



### 2.2.7 Intersection 6: Duke Street at Witter Drive

Witter Drive is not classified on *VDOT Functional Classification*. The intersection of Duke Street at Witter Drive is a 3-leg signalized intersection. There is no posted speed limit along Witter Drive. The northbound approach of Witter Drive has one shared left-right lane. The eastbound approach of Duke Street has on two through lanes and one shared thru-right lane. The westbound approach of Duke Street has one left-turn lane, and three through lanes. The signal operations include protected-permitted left-turn phasing for the westbound approach. Sidewalks are present on the south side of Duke Street. Pedestrian facilities (high visibility laddered crosswalk, ADA ramps, pedestrian signals, pedestrian pushbuttons) are present across the northbound approach. Figure 10 shows an aerial of the intersection.

Figure 10: Duke Street at Witter Drive



Source: Google Imagery

### 2.2.8 Intersection 7: Duke Street at W. Taylor Run Parkway

W. Taylor Run Parkway is classified as Minor Collector per on *VDOT Functional Classification*. The intersection of Duke Street at W. Taylor Run Parkway is a 3-leg signalized intersection. The posted speed limit along W. Taylor Run Parkway is 25 miles per hour. The southbound approach of W. Taylor Run Parkway has one left-turn lane and one right-turn lane. The eastbound approach of Duke Street has one left-tun lane and three through lanes. Right most eastbound through lane becomes on-ramp to Telegraph Road. The westbound approaches of Duke Street have

three through lanes, and one right-turn lane. The service road runs to the north of Duke Street. Both the eastbound and westbound approaches of service road have one shared left-thru-right turn lane. The signal operations include protected left-turn phasing for the eastbound approach and protected right-turn phasing for the westbound approach, with right-turn overlapping with the southbound left-turn movement. Service road approaches have concurrent running signal phasing with through movements on the Duke Street. Sidewalks are present on the south side of Duke Street, north side of service road, and both sides of W. Taylor Run Parkway. Dedicated and shared bicycle lanes are present on the northbound and southbound approaches of W. Taylor Run Parkway, respectively. Pedestrian facilities (high visibility laddered and standard crosswalks, Pedestrian/ADA ramps) are present across the westbound approach of Duke Street, eastbound and westbound approaches of service road and southbound approach of W. Taylor Run Parkway. Pedestrian signals and pedestrian pushbuttons are present on the westbound approach of Duke Street. Exclusive pedestrian phase is provided at the intersection. Figure 11 shows an aerial of the intersection.

Figure 11: Duke Street at W. Taylor Run Parkway



Source: Google Imagery

### 2.2.9 Intersection 8: Duke Street westbound and Telegraph Road off-ramp

Telegraph Road (Route 611) is a north-south route classified as Minor Arterial per *VDOT Functional Classification*. Within the study area, it provides grade-separated access (partial cloverleaf interchange) to Duke Street. Single lane ramp from the northbound Telegraph Road provides access to westbound Duke Street. The posted speed limit on the ramp is 25 miles per hour. Sidewalks are present on the either side of Duke Street. Pedestrian facilities (high visibility laddered crosswalk, ADA ramps, RRFB, advance RRFB, Yield Line markings) are present across the ramp approach. Figure 12 shows an aerial of the intersection.

### 2.2.10 Intersection 9: Duke Street westbound and Telegraph Road on-ramp

Single lane ramp from westbound Duke Street provides access to southbound Telegraph Road. There is no posted speed limit along this ramp. Sidewalks are present on the either side of Duke Street. Pedestrian facilities (high visibility laddered crosswalk, ADA ramps, RRFB, advance pedestrian crossing sign, Yield Line markings) are present across the westbound approach to the ramp. Figure 12 shows an aerial of the intersection.

Figure 12: Duke Street at Telegraph Road off-ramp



Source: Google Imagery

### 2.2.11 Intersection 10: Duke Street at Dove Lane and Robert's Lane

Dove Lane or Robert's Lane is not classified on *VDOT Functional Classification*. The intersection of Duke Street at Dove Lane/Robert's Lane is a 4-leg signalized intersection. There is no posted speed limit both side streets. The northbound and southbound approaches of Robert's Lane and Dove Lane have one shared left-thru-right turn lane. The eastbound and westbound approaches of Duke Street have three through lanes and one right-turn lane. At this intersection, left-turns are prohibited from the eastbound and westbound approaches. Left-turning vehicles on Duke Street use right-turn lane or slip road to loop back to Dove Lane or Robert's Lane. Eastbound slip ramp at Dove Street is used by the motorists as an alternative access to the westbound Duke Street from Telegraph Road off-ramp during the AM peak period. It provides additional access point to Telegraph Road on-ramp due to heavy traffic on the eastbound Duke Street during the PM peak period. Eastbound and westbound approaches have concurrently running signal phasing. Similarly, northbound and southbound approaches have concurrently running signal phasing. Sidewalks are present on the either side of Duke Street. Pedestrian facilities (high visibility laddered and standard crosswalks, Pedestrian/ADA ramps, pedestrian signal heads) are present across the westbound, northbound, and southbound approaches. Pedestrian pushbuttons are present on the westbound approach of Duke Street. Figure 13 shows an aerial of the intersection.

Figure 13: Duke Street at Telegraph Road on-ramp and Dove Street/Robert's Lane



Source: Google Imagery

## 2.3 Traffic Data

### 2.3.1 Existing Traffic Volumes, Queues and Travel Runs

Existing traffic volume data along the study corridor was collected in June, 2018 and May, 2022 (see Appendices B and C), while school was in session:

- AM and PM peak period turning movement counts (TMCs) were collected within the study area on June 6, 2018 from 6:30 am – 9:30 am and 4:00 – 7:00 pm at the following intersections:
  - Duke Street and N. Quaker Lane
  - Duke Street and S. Quaker Lane
  - Duke Street and Alexandria Commons
  - Duke Street and Sweeley Street
  - Duke Street and Roth Street/Cambridge Road
  - Duke Street and Witter Drive
  - Duke Street and W. Taylor Run Parkway
  - Duke Street westbound and Telegraph Road off-ramp (AM and PM Peak Hours)
  - Duke Street westbound and Telegraph Road on-ramp (AM and PM Peak Hours)
  - **Duke Street and Dove Lane/Robert's Lane**
  
- As part of the Duke Street Transitway project, new TMCs were collected on May 18, 2022 at the following intersections, which will be used to compare and validate the data collected in 2018.
  - Duke Street and N. Quaker Lane
  - Duke Street and Yale Drive
  - Duke Street and W. Taylor Run Pkwy
  
- In addition to TMCs, travel times were collected from 6:30AM to 9:30AM, and 4:00PM to 7:00PM on May 18, 2022 for the following segments:
  - Eastbound along Duke Street: Starting after the S Walker Street intersection and ending after Dulany Street intersection.
  - Westbound along Duke Street: Starting after the Dulany Street intersection and ending after the S. Walker Street intersection.
  
- Queue length measurements to be used in the calibration of the existing VISSIM models. Queue data collection and field observations were conducted within the study area on May 18, 2022 from 6:30 am – 9:30 am and 4:00 – 7:00 pm at the following intersections:
  - Duke Street and N. Quaker Lane
  - Duke Street and S. Quaker Lane
  - Duke Street and Alexandria Commons
  - Duke Street and Sweeley Street/Duke Street and Roth Street/Cambridge Road
  - Duke Street and Witter Drive
  - Duke Street and W. Taylor Run Pkwy

- 24-hour classification counts were collected on May 17 and May 18, 2022 at the following locations:
  - Duke Street east of Fort Williams Parkway and west of N Quaker Lane
  - Duke Street east of Roth Street and west of Witter Drive
  - Duke Street east of Telegraph Road and west of Callahan Drive

The existing (2018) peak hour volumes are summarized in Figure 14.

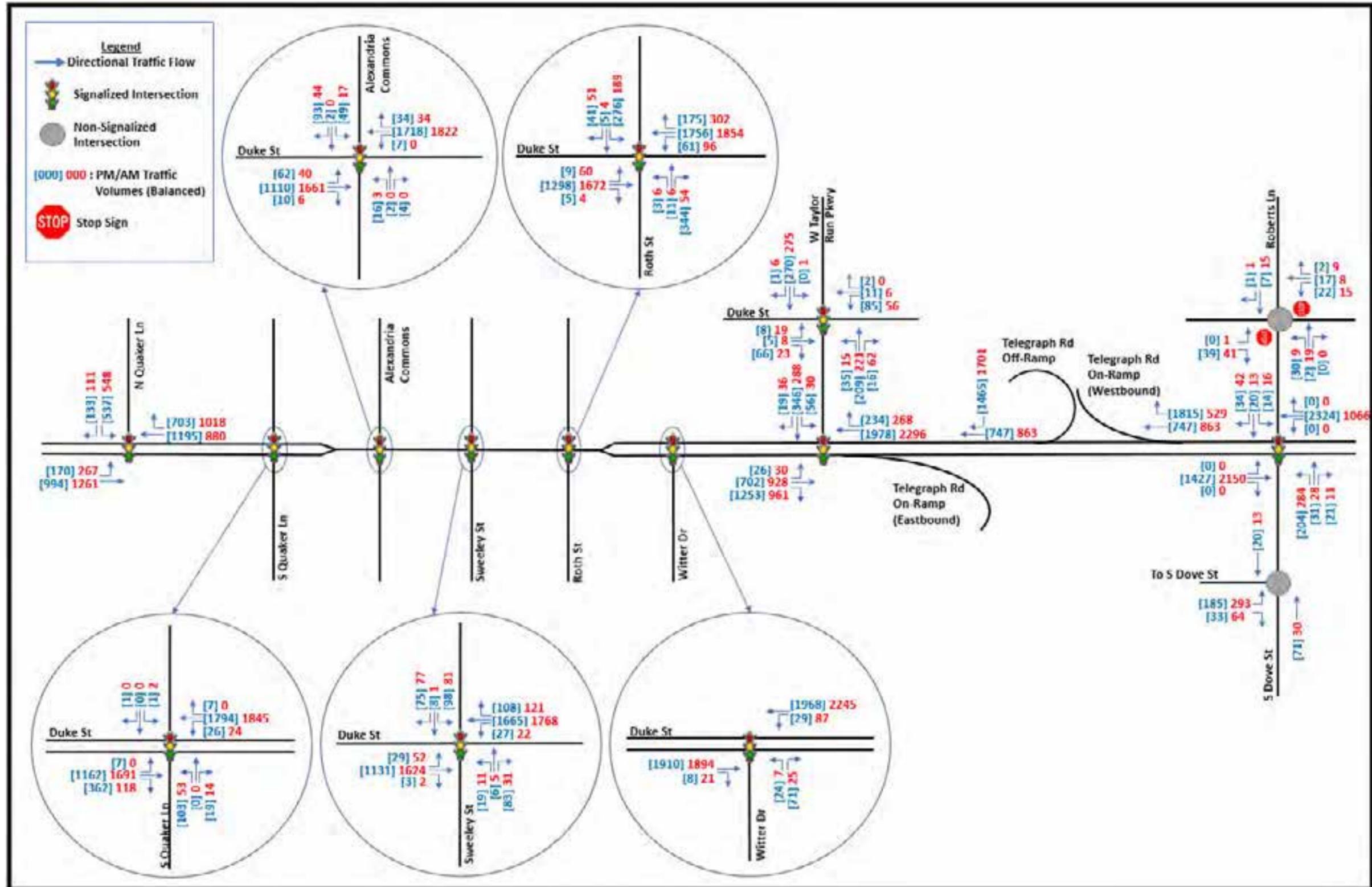
### 2.3.2 Additional Data

In addition to traffic volumes, following supplemental data was collected to support this study:

- Crash Data from 2015 to 2022, last seven (7) years, to perform the crash analysis.
- Signal timing data from the City. Synchro files provided by the City were used for an input into the VISSIM analysis models.
- VISSIM model files from EESAP 2019 update.
- StreetLight traffic volumes, speed and travel time data (Appendix G).
- INRIX speed and travel time data.
- Approved and planned development plans within the project area. City is in talk with American Water about the development of their site which is located to the north of Duke Street and to the east of Dove **Street/Robert's Lane. Currently, there are no plans** available for this development. The Land Rover dealership lot will be redeveloped for a residential building (Witter Place). Development is located to the south of Duke Street and to the east of Witter Lane.
- Transit ridership/boarding information.



Figure 14: Existing (2018) Peak Hour Volumes



### 3 TRAFFIC OPERATIONAL ANALYSIS

#### 3.1 Analysis Peak Periods

The traffic data from the EESAP 2019 update were reviewed to determine the AM and PM peak hours. The AM and PM peak hours for this analysis were determined to be 7:30 AM – 8:30 AM and 5:00 PM – 6:00 PM, respectively.

#### 3.2 Analysis Tools

The traffic operations analysis for the corridor was conducted using VISSIM 11 software, with signal timing data imported from the City's Synchro model of the corridor. VISSIM is a stochastic traffic microsimulation analysis tool that utilizes driver and vehicle characteristics determined by statistical distributions using random number seeds. The traffic simulation analysis and methodology were performed per Virginia Department of Transportation (VDOT) Traffic Operation and Safety Analysis Manual (TOSAM) – Version 2.0 guidelines. Section 3.3 below presents a summary of Measures of Effectiveness (MOEs) that were evaluated for this study.

#### 3.3 Measures of Effectiveness

The Measures of Effectiveness quantify the traffic flow through intersections and freeway facilities and provides a basis for evaluating the performance of a transportation network. MOEs are reported based on the type of facility, as well as the analysis software utilized. Reported MOEs are consistent with VDOT TOSAM guidance. A summary of the VISSIM MOEs evaluated for the study corridor are presented below:

- o Intersections
  - Microsimulation Delay (seconds/vehicle)
  - Maximum Queue Length (feet)
- o Arterials
  - Average travel time (minutes)

Level of Service (LOS) is a graded scale used to represent intersection delay (the delay associated with vehicles slowing in advance of an intersection, the time spent stopped on an intersection approach, the time spent as vehicles move up in the queue, and the time needed for vehicles to accelerate to their desired speed). It is important to point out that delay calculations from the Highway Capacity Manual (HCM) methodology (deterministic) and simulation (stochastic) are different, especially for congested conditions (e.g., queue spillover between intersections, etc.). Therefore, the LOS represented in the results tables does not necessarily provide information on congestion caused by complicated interactions between intersections. To provide a measurement/threshold for intersection operations, microsimulation delay has been translated to the same levels of service used by the HCM methodology. LOS is measured on a scale of "A" through "F," with LOS A representing the best operating conditions and LOS F representing the worst, based on the delay experienced at the intersection during the analysis period.

As indicated in the Highway Capacity Manual (6th Edition), LOS at an intersection is based upon the average amount of delay (seconds/vehicle) experienced by vehicles approaching the intersection. LOS thresholds for the varying analysis types are shown in Table 2.

Table 2. HCM Intersection LOS Criteria Based on Average Control Delay

LOS	Signalized Intersection Delay Thresholds (sec/veh)	Unsignalized Intersection Delay Thresholds (sec/veh)
A	< 10	< 10
B	> 10 – 20	> 10 – 15
C	>20 – 35	>15 – 25
D	>35 – 55	>25 – 35
E	>55 – 80	>35 – 50
F	>80	>50

Source: Highway Capacity Manual (6th Edition)

#### 3.4 Microsimulation Sample Size

In addition to conducting model calibration, determining and applying an appropriate number of microsimulation runs is a very important step in developing accurate microsimulation results. The guidelines provided in Section 5.4 of the VDOT TOSAM and the macro-enabled VDOT Sample Size Determination Tool were utilized to determine the number of VISSIM runs necessary for correctly reporting freeway and intersection MOEs. Based upon the results of the calculation, ten (10) VISSIM microsimulation runs meet the required tolerance error and confidence interval. Results of the VDOT Sample Size Determination Tool are included in the Appendices D & E.

#### 3.5 Base Model Development and Calibration

Traffic data collected in June 2018 is primarily used to calibrate the VISSIM microsimulation models. Due to the effects of the COVID-19 pandemic on travel patterns and traffic volumes, pre-pandemic data is compared to the new data collected in 2022. Comparison with turning movement counts collected in June 2018 and May 2022 for the following major intersections in the study area shown in Table 3.

- Duke Street at N. Quaker Lane
- Duke Street at W. Taylor Run Parkway

Table 3. Comparison of 2018 and 2022 total intersection traffic volumes

Intersection	Total Intersection Peak hour Raw volume (2018)	Total Intersection Peak hour Raw volume (2022)	% Difference
Duke Street at N. Quaker Lane	4152 (AM) 3660 (PM)	3552 (AM) 3444 (PM)	-14.4% -5.9%
Duke Street at W. Taylor Run Parkway	4775 (AM) 4590 (PM)	4233 (AM) 4274 (PM)	-11.3% -6.8%

Based on the volume comparison, 2022 volumes are lower than 2018 volume, however, close to 2018 volumes. 2018 volumes were considered adequate for representing base year traffic counts and for the application in future scenarios. Development of the AM and PM existing 2018 VISSIM models requires input of traffic volumes, routing decisions, signal timing, and roadway geometry.



### 3.5.1 Model Parameters and Inputs

The VISSIM models were developed using guidelines from *VDOT's TOSAM*. The parameters and inputs used in the model are summarized in Table 4.

#### Simulation Parameters

Simulation seeding time was based on the time required for the network to reach equilibrium and needed to be greater than the time it takes for the first vehicle to traverse the entire network. The simulation was run for two (2) hours (7200 seconds), with simulation seeding/warmup time from 0 – 3600 seconds and data collection from 3600 – 7200 seconds.

#### Vehicle Inputs

Vehicle inputs within the study area were based on the hourly balanced flow maps developed from the TMC data. Unlike HCS or Synchro, VISSIM does not take peak hour factor into consideration. Per *VDOT's TOSAM*, volumes were inputted into VISSIM in 15-minute increments.

#### Routing Decisions

Relay routing, with the combined routes option activated, were developed for the VISSIM models using the 2018 balanced turning movement counts.

#### Signal Timings

**Signal timings from the City's Synchro models were applied to the intersections within the VISSIM model study area.** Signal timing for the existing conditions is presented in Appendix I.

#### Driving Behavior

Driving behavior attributes for arterial operations remained at the default settings. Some driving behavior settings (such as number of observed vehicles, Wiedemann 74 model parameters, and lane change parameters) were adjusted for some segments for calibration purposes.

#### Simulation Runs

To account for simulation variance, initial 10 simulation runs were conducted using different random seeds and averaged together. The number of runs was determined using the VDOT Sample Size Determination Tool, Version 2.0. Based on the results of an initial 10 model runs as shown in Appendices D & E, statistical analysis verified that 10 runs are sufficient to reach a 95 percent confidence level for each of the AM and PM peak periods.

Table 4: VISSIM Parameters and Inputs

Simulation Parameters	
VISSIM Version	11.00-14
Simulation Resolution	10 time steps/second
Seeding Time	0 - 3600 seconds
Recording Time	3600 – 7200 seconds
Number of Runs	10
Random Seeds	Starting from 100 with an increment of 10
Other Parameters	
Intersection Turning Speed	Used reduced speed areas Right: 7.5 - 15.5 mph, Left: 12.4 - 18.6 mph High speed right turns: 15 - 20 mph

Ramp Curve Speed	Used the posted speed limits
Roadway Speed Limit	Used speed decision points Arterials: Existing posted speed +5/- 5 mph
Lane Change Distance	default (656ft); adjusted for calibration
Vehicle Inputs	
Heavy Vehicle Percentage	Based on available traffic data from 2019 EESAP study
Traffic Signal Parameters	
Controller Type	Default actuated RBC controller
Signal Timing	<b>Based on timings from the City's Synchro files</b>
Coordination	<b>Based on timings from the City's Synchro files</b>

### 3.5.2 Calibration and Validation

To provide a more accurate representation of field conditions, the existing conditions VISSIM models were calibrated to reasonably replicate balanced field observed traffic volumes and observed queue lengths. This calibration process is an essential part of the model development process because it ensures that the simulation reasonably replicates existing field conditions and can be used as the base for the evaluation of future scenarios.

Appendices B & C provides the detailed calibration results for the AM and PM peak hours. The results show that both AM and PM models satisfy the *VDOT's TOSAM* thresholds for simulated traffic volume, travel time, and queue length. The models reflect simulated traffic volumes and travel times along the Duke Street corridor are TOSAM standards. Table 5 presents the summary of calibration results.

Table 5: VISSIM Calibration Results

Simulated Measure	Calibration Threshold	Current Model Standard	
		AM	PM
Simulated Traffic Volume (vehicles per hour) - 85% of the network links shall meet the calibration thresholds	Within ± 20% for <100 vph	97.5%	92.0%
	<b>Within ± 15% for ≥100 vph to &lt;1,000 vph</b>		
	<b>Within ± 10% for ≥1,000 vph to &lt;5,000 vph</b>		
	<b>Within ± 500 vph for ≥5,000 vph</b>		
Simulated Travel Time (seconds) - 85% of the travel time routes shall meet the calibration thresholds.	Within ± 30% for average observed travel times on arterials	100%	100%
Simulated Queue Length	Visually acceptable maximum queue lengths are represented at critical locations.	Acceptable	Acceptable

*Findings Represent Results from 10 Simulation Runs.*

#### Volume Calibration

The full VISSIM volume calibration results tables are shown in the Appendices D & E. The volume calibration includes a comparison between simulated volumes and balanced field counts modeled in Synchro for the AM and PM Peak Hour, respectively. The tables in the Appendices D & E show the difference and percentage difference between field counts and the average volumes from the simulation runs.



VDOT TOSAM requirements indicate that at least 85% the selected locations should meet the designated criteria, which is based on the total volume for each movement. In the AM model, the simulated volumes meet the calibration criteria for 97.5% of identified locations. In the PM model, the simulated volumes meet the calibration criteria for 92.0% of identified locations.

Travel Time Calibration

The full VISSIM travel time calibration results tables are shown in the Appendices D & E. Note that travel time runs for the entire study corridor, from Callahan Drive to N. Quaker Lane, were not available from 2018 EESAP. Travel time data available from 2018 EESAP included EB Duke from Witter Street to Dove Street, and WB Duke Street from Callahan Drive and W. Taylor Run Parkway. Travel runs (Appendix C) collected for Duke Street Transitway were collected in May 2022. These runs did not correctly represent the traffic counts collected in 2018. Streetlight data was validated using 2022 field runs for both AM and PM peak hours. 2018 Streetlight travel time data was used for Duke and WTR project to compare the results generated by VISSIM analysis. WSP also reviewed travel times using INRIX. INRIX data did not validate well with 2022 travel runs (EB PM hour) compared to Streetlight. Screenshots from June 2018 Streetlight data for travel times which were used in the calibration of the existing conditions are shown in Appendix C.

The travel time calibration includes a comparison between simulated travel times (the average of 10 runs for AM and PM models) and travel time data collected from StreetLight in June 2018 for the AM and PM Peak Hours. The tables in the Appendices D & E show the difference and percentage difference between StreetLight data, and the average travel times from the simulation runs. Single segment along Duke Street between N. Quaker Lane and Callahan Drive was considered for the comparison. Difference between simulated and StreetLight travel time data is less than 12% and 4% during the AM and PM peak hours, respectively. Duke Street travel time data and StreetLight travel time data is shown in Appendix C.

VDOT TOSAM requirements indicate that at least 85% the selected segments should meet the designated (within ± 30%) criteria. In AM and PM peak hours, modeled travel time for the segment falls within 30% of the Streetlight Data collected travel times. This means the model meet the calibration criteria for 100.00 % for both AM and PM peak hours.

Queue Calibration

The methodology for calculating field count vehicle queue differs significantly from the methodology for calculating vehicle queue in VISSIM. In the field, queue is measured by the number of vehicles left at the intersection approach after the light turns green. Field queues were also observed from the ground and therefore field queue data represents the limit of what the observer could visually verify. In VISSIM, the queue is measured by the number of vehicles that slow to speeds significantly less than driving speed, i.e. a rolling stop, regardless of whether or not the vehicle actually gets stopped at the light. VISSIM also considers a maximum headway between vehicles during driving, as well as a maximum length back to which stopped vehicles will be considered part of queue.

As per the TOSAM guidelines, simulated maximum queue lengths at critical locations were collected and visually compared to maximum queue lengths measured in the field on May 18, 2022. Field data collected in 2022 was supplemented with live Google traffic condition. Currently, data recorded in 2018 is not sufficient. Comparison of queue lengths indicate that visually acceptable maximum queue lengths are represented at critical locations. Each simulated intersection showed queues that reflected field conditions, resulting in adequately calibrated queue representation. Acceptability of queue calibration was determined by considering whether the operational impact of the queue (e.g., turn lane blocked, queue exceeding storage, queue reaching upstream intersection) is represented. Queue data collected on May 18, 2022, is shown in Appendix C.

Due to the consistency between the VISSIM model results, collected data, and field observation, Duke Street and W. Taylor Run Parkway intersection improvement project VISSIM models reflect existing operations and are considered calibrated. The models are recommended to be used as the basis for other analysis scenarios required for the project Traffic Analysis.

**3.6 Intersection Operations: 2018 Existing Conditions**

Traffic operations analyses were conducted using VISSIM to evaluate overall performance of the study intersections within the Duke Street corridor. Operational analyses were performed at each of the study intersections for the Existing 2018 Conditions scenario.

*Delay and LOS* are reported from VISSIM for all the signalized intersections of the study intersections throughout the study area. Tables 6 and 7 provide a summary of the average AM and PM peak hour delay and LOS for each movement for the study intersections along the Duke Street corridor. Note that node number in the bracket shown on Tables 6 and 7 indicates node number in VISSIM files.

Table 6: Existing (2018) AM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	267	275	27.5	C	18.1	B	358
		EBT	1261	1270	12.4	B			358
		WBT	880	837	15.6	B			414
		WBR	1018	956	4.8	A			379
		SBL	548	545	50.1	D			458
		SBR	111	112	34.7	C			406
2	Duke St and S Quaker Ln	EBL	0	0	0.0	A	6.4	A	437
		EBT	1691	1702	7.5	A			437
		EBR	118	113	3.0	A			466
		WBL	24	26	19.3	B			356
		WBT	1845	1741	4.0	A			356
		WBR	0	0	0.0	A			370
		NBL	53	51	46.4	D			130
		NBT	0	0	0.0	A			130
		NBR	14	15	27.1	C			131
		SBL	2	2	38.1	D			19
		SBT	0	0	0.0	A			19
		SBR	0	0	0.0	A			22



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)	Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
3	Duke St and Alexandria Commons	EBL	40	40	34.3	C	5.2	A	326	51	Cambridge Rd and Service Rd	EBT	9	8	252.1	F	89.5	F	1291				
		EBT	1661	1671	2.4	A			326			EBR	217	189	245.0	F			1291				
		EBR	6	7	1.4	A			360			WBL	27	25	80.2	F			74				
		WBL	0	0	0.0	A			644			WBT	0	0	0.0	A			87				
		WBT	1822	1719	6.2	A			644			NBL	359	308	0.7	A			61				
		WBR	34	31	11.5	B			637			NBR	41	34	0.4	A			61				
		NBL	3	3	39.3	D			23			6	Duke St and Witter Dr	EBT	1894	1882			7.5	A	8.0	A	552
		NBT	0	0	0.0	A			23					EBR	21	20			11.5	B			559
		NBR	0	0	0.0	A			22					WBL	87	81			18.8	B			657
		SBL	17	19	56.5	E			134					WBT	2245	2131			7.7	A			657
		SBT	0	0	0.0	A			134					NBL	7	7			47.3	D			72
SBR	44	42	17.9	B	145	NBR	25	24	18.0	B	92												
4	Duke St and Sweeley St	EBL	52	54	27.2	C	7.4	A	495	7	Duke St and W Taylor Run Pkwy	EBL	30	27	65.2	E	23.4	C	77				
		EBT	1624	1634	7.0	A			496			EBT (Continue on Duke St)	928	926	15.9	B			786				
		EBR	2	2	2.8	A			504			EBT (to Telegraph Rd)	961	949	18.5	B			789				
		WBL	22	24	25.2	C			589			WBT	2296	2181	21.2	C			1394				
		WBT	1768	1668	4.1	A			589			WBR	268	248	49.5	D			1168				
		WBR	121	112	4.3	A			605			SBL (To Duke St)	30	29	53.0	D			470				
		NBL	11	10	51.0	D			82			SBL (To Telegraph Rd)	288	284	50.4	D			470				
		NBT	5	5	43.8	D			82			SBR	36	37	34.2	C			487				
		NBR	31	29	18.4	B			93			71	W Taylor Run Pkwy and Service Rd	EBL	19	19			23.0	C	23.0	C	84
		SBL	81	82	53.2	D			150					EBT	8	8			22.3	C			84
		SBT	1	1	31.3	C			150					EBR	23	22			36.1	D			84
SBR	77	73	11.5	B	150	WBL	56	54	51.0	D	98												
EBL	60	56	82.2	F	807	WBT	6	7	33.7	C	98												
5	Duke St at Roth St	EBT	1672	1683	16.3	B	16.4	B	807	WBR	0	0	0.0	A	98								
		EBR	4	4	16.6	B			815	NBL	15	14	5.0	A	125								
		WBL	96	93	29.8	C			759	NBT	221	205	0.9	A	144								
		WBT	1854	1753	13.1	B			759	NBR	62	57	0.4	A	141								
		WBR	302	281	10.9	B			759	SBL	1	1	23.5	C	389								
		NBL	6	5	35.6	D			96	SBT	275	273	38.0	D	389								
		NBT	6	6	44.0	D			96	SBR	6	6	40.7	D	389								
		NBR	54	53	14.7	B			97														
		SBL	189	166	32.8	C			123														
		SBT	4	3	37.8	D			123														
		SBR	51	46	8.0	A			146														



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
8	Duke St WB and Telegraph Rd Off-ramp	WBT	863	861	0.3	A	1.1	A	0
		SBR	1701	1580	1.5	A			855
9	Duke St WB and Telegraph Rd On-ramp	WBR	529	519	0.3	A	0.3	A	25
10	Duke St and S Dove St/Roberts Ln	EBT	2150	2052	14.7	B	14.0	B	1496
		EBR	357	328	17.5	B			1160
		WBT	1066	1078	9.9	A			284
		WBR	32	32	6.3	A			45
		NBL	284	262	20.6	C			1274
		NBT	28	24	24.9	C			1274
		NBR	11	10	21.7	C			1277
		SBL	16	15	29.1	C			115
		SBT	13	13	27.0	C			115
		SBR	42	42	6.6	A			115

Table 7. Existing (2018) PM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	170	168	36.6	D	37.8	D	1785
		EBT	994	923	50.0	D			1785
		WBT	1195	1268	22.4	C			455
		WBR	703	733	8.2	A			410
		SBL	537	508	89.4	F			908
		SBR	133	124	69.2	E			878
2	Duke St and S Quaker Ln	EBL	7	6	49.7	D	22.3	C	441
		EBT	1162	1078	39.9	D			441
		EBR	362	336	9.0	A			471
		WBL	26	28	23.5	C			367
		WBT	1794	1897	12.4	B			367
		WBR	7	7	7.7	A			381
		NBL	103	102	59.6	E			210
		NBT	0	0	0.0	A			210
		NBR	19	19	44.5	D			211
		SBL	1	1	34.1	C			23
SBT	0	0	0.0	A	23				
SBR	1	1	8.5	A	27				

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	62	56	49.4	D	26.1	C	311
		EBT	1110	1034	33.2	C			311
		EBR	10	8	20.7	C			344
		WBL	7	7	14.7	B			656
		WBT	1718	1831	18.1	B			656
		WBR	34	36	18.0	B			707
		NBL	16	15	53.3	D			50
		NBT	2	1	40.7	D			50
		NBR	4	4	26.0	C			49
		SBL	49	50	71.1	E			181
		SBT	2	2	52.8	D			181
		SBR	93	89	66.5	E			192
		4	Duke St and Sweeley St	EBL	29	27			52.4
EBT	1131			1041	71.1	E	687		
EBR	3			2	65.4	E	698		
WBL	27			31	23.4	C	741		
WBT	1665			1782	12.0	B	741		
WBR	108			114	12.7	B	757		
NBL	19			19	56.4	E	194		
NBT	6			5	54.0	D	194		
NBR	83			81	49.6	D	204		
SBL	98			98	58.2	E	158		
SBT	8			7	54.4	D	158		
SBR	75			73	15.7	B	158		
5	Duke St at Roth St			EBL	9	7	78.1	E	38.8
		EBT	1298	1196	62.1	E	828		
		EBR	5	4	98.9	F	836		
		WBL	61	67	54.3	D	772		
		WBT	1756	1888	23.5	C	772		
		WBR	175	191	23.5	C	772		
		NBL	3	2	83.9	F	202		
		NBT	11	9	81.3	F	202		
		NBR	344	263	68.6	E	204		
		SBL	276	246	19.0	B	117		
		SBT	5	6	19.4	B	117		
		SBR	41	36	12.2	B	141		
		51	Cambridge Rd and Service Rd	EBT	44	34	36.1	E	
EBR	275			242	36.9	E	295		
WBL	47			46	67.9	F	98		
WBT	0			0	0.0	A	111		
NBL	190			177	0.7	A	45		
NBR	35			31	0.2	A	45		
6	Duke St and Witter Dr	EBT	1910	1731	63.0	E	36.8	D	810
		EBR	8	7	110.0	F			817
		WBL	29	34	42.4	D			762
		WBT	1968	2124	13.9	B			762
		NBL	24	25	92.8	F			178
		NBR	71	69	54.8	D			198



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
	Duke St and W Taylor Run Pkwy	EBL	26	22	66.9	E	37.9	D	63
		EBT (Continue on Duke St)	702	643	13.0	B			795
		EBT (to Telegraph Rd)	1253	1134	33.7	C			807
		WBT	1978	2138	24.7	C			1881
		WBR	234	242	56.6	E			1806
		SBL (To Duke St)	56	54	155.3	F			971
		SBL (To Telegraph Rd)	346	326	145.6	F			971
		SBR	19	17	179.0	F			989
71	W Taylor Run Pkwy and Service Rd	EBL	8	9	97.5	F	107.8	F	189
		EBT	5	6	99.2	F			189
		EBR	66	62	111.9	F			189
		WBL	85	71	621.3	F			837
		WBT	11	8	548.7	F			837
		WBR	2	2	572.8	F			837
		NBL	35	34	7.3	A			124
		NBT	209	214	1.6	A			115
		NBR	16	17	0.8	A			141
		SBL	0	0	0.0	A			586
		SBT	270	265	58.2	E			586
8	Duke St WB and Telegraph Rd Off-ramp	WBT	916	918	0.2	A	0.9	A	0
		SBR	1465	1468	1.4	A			846
9	Duke St WB and Telegraph Rd On-ramp	WBR	1815	1646	0.9	A	0.9	A	103
10	Duke St and S Dove St/Roberts Ln	EBT	1427	1369	9.8	A	13.0	B	375
		EBR	218	212	8.3	A			165
		WBT	2324	2336	13.9	B			766
		WBR	41	43	11.1	B			62
		NBL	204	198	26.1	C			279
		NBT	31	32	26.1	C			279
		NBR	21	20	17.4	B			280
		SBL	14	14	30.6	C			132
SBT	20	20	23.5	C	132				
SBR	34	32	7.6	A	134				

maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 14 are the movements where the reported average and maximum queue length values exceed the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement storage bays during both peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 ft. is projected to experience a maximum queue length of 1785 ft. during the PM peak hour.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersections of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. However, the eastbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. It is to be noted that the westbound left-turn movement with storage of 70 ft. is projected to experience a maximum queue length of 589 ft. and 741 ft. during the AM and PM peak hours, respectively.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, westbound right-turn, and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 1168 ft. and 1806 ft. during the AM and PM peak hours, respectively. The results indicates that the same movement is projected to experience an average queue length of 131 ft. and 223 ft. during the AM and PM peak hours, respectively. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 789 ft. and 807 ft. during the AM and PM peak hours, respectively. Simulation shows extensive queuing occurring on the eastbound rightmost through lane of Duke Street to SB Telegraph Road ramp which extends from W. Taylor Run Parkway to N. Quaker Lane.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound right-turn movements are projected to experience maximum queue lengths 389 ft. and 585 ft. during the AM and PM peak hours. The westbound left-

Signal timings for 2018 Existing condition are shown on Appendix I. VISSIM results for 2026 No-Build Conditions is presented in the Appendices D and E.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2018 Existing conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 14 provides a summary of the average and



turn and right-turn movements are projected to experience maximum queue lengths of 837 ft. during the PM peak hour.

At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 1274 ft. and 279 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1160 ft. during the AM peak hour and 165 ft. during the PM peak hour.

Table 8. Existing (2018) AM and PM Summary of Intersection Queues (feet)

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak Hour		PM Peak Hour	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	Signalized	EBL	200	63	358	489	1785
			EBT	360	63	358	489	1785
			WBT	330	52	414	135	455
			WBR	300	15	379	31	410
			SBL	1290	124	458	341	908
			SBR	1270	42	406	271	878
2	Duke St and S Quaker Ln	Signalized	EBL	200	62	437	182	441
			EBT	330	62	437	182	441
			EBR	300	70	466	202	471
			WBL	80	19	356	94	367
			WBT	210	19	356	94	367
			WBR	210	21	370	101	381
			NBL	335	17	130	43	210
			NBT	335	17	130	43	210
			NBR	335	13	131	39	211
			SBL	40	0	19	0	23
			SBT	40	0	19	0	23
			SBR	40	0	22	0	27
3	Duke St and Alexandria Commons	Signalized	EBL	105	10	326	122	311
			EBT	210	10	326	122	311
			EBR	210	12	360	142	344
			WBL	315	66	644	158	656
			WBT	520	66	644	158	656
			WBR	520	24	637	131	707
			NBL	50	1	23	4	50
			NBT	50	1	23	4	50
			NBR	50	1	22	4	49
			SBL	215	9	134	55	181
			SBT	215	9	134	55	181
			SBR	215	12	145	63	192

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak Hour		PM Peak Hour	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
4	Duke St and Sweeley St	Signalized	EBL	190	38	495	412	687
			EBT	520	40	496	412	687
			EBR	520	41	504	421	698
			WBL	70	25	589	96	741
			WBT	225	25	589	96	741
			WBR	225	25	605	102	757
			NBL	230	6	82	25	194
			NBT	230	6	82	25	194
			NBR	230	9	93	33	204
			SBL	110	26	150	34	158
			SBT	110	26	150	34	158
			SBR	110	26	150	34	158
5	Duke St at Roth St	Signalized	EBL	115	196	807	634	828
			EBT	350	196	807	634	828
			EBR	350	196	815	641	836
			WBL	230	190	759	402	772
			WBT	670	190	759	402	772
			WBR	670	190	759	402	772
			NBL	150	6	96	144	202
			NBT	150	6	96	144	202
			NBR	150	7	97	146	204
			SBL	40	76	123	57	117
			SBT	40	76	123	57	117
			SBR	40	96	146	73	141
51	Cambridge Rd and Service Rd	Unsignalized	EBT	1330	823	1291	51	296
			EBR	1330	820	1291	49	295
			WBL	825	8	74	13	98
			WBT	825	8	87	15	111
			NBL	40	3	61	1	45
			NBR	40	3	61	1	45
6	Duke St and Witter Dr	Signalized	EBT	675	59	552	681	810
			EBR	675	60	559	688	817
			WBL	215	68	657	99	762
			WBT	700	68	657	99	762
			NBL	170	3	72	23	178
			NBR	170	4	92	33	198



Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak Hour		PM Peak Hour	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	Signalized	EBL	165	10	77	8	63
			EBT (Continue on Duke St)	710	156	786	104	795
			EBT (to Telegraph Rd)	710	221	789	500	807
			WBT	1955	242	1394	325	1881
			WBR	110	131	1168	223	1806
			SBL (To Duke St)	140	100	470	737	971
			SBL (To Telegraph Rd)	140	100	470	737	971
			SBR	140	111	487	755	989
71	W Taylor Run Pkwy and Service Rd	Signalized	EBL	70	7	84	46	189
			EBT	70	7	84	46	189
			EBR	70	7	84	46	189
			WBL	320	11	98	570	837
			WBT	320	11	98	570	837
			WBR	320	11	98	570	837
			NBL	40	2	125	6	124
			NBT	40	2	144	5	115
			NBR	40	2	141	7	141
			SBL	650	72	389	122	586
			SBT	650	72	389	122	586
			SBR	180	72	389	122	585
8	Duke St WB and Telegraph Rd Off-ramp	Unsignalized	WBT	700	0	0	0	0
			SBR	2400	478	855	34	846
9	Duke St WB and Telegraph Rd On-ramp	Unsignalized	WBR	225	0	25	0	103
10	Duke St and S Dove St/Roberts Ln	Signalized	EBT	1965	552	1496	37	375
			EBR	260	154	1160	7	165
			WBT	855	30	284	139	766
			WBR	855	0	45	1	62
			NBL	185	210	1274	51	279
			NBT	185	210	1274	51	279
			NBR	185	208	1277	50	280
			SBL	50	7	115	9	132
			SBT	50	7	115	9	132
SBR	50	7	115	9	134			



## 4 CRASH ANALYSIS

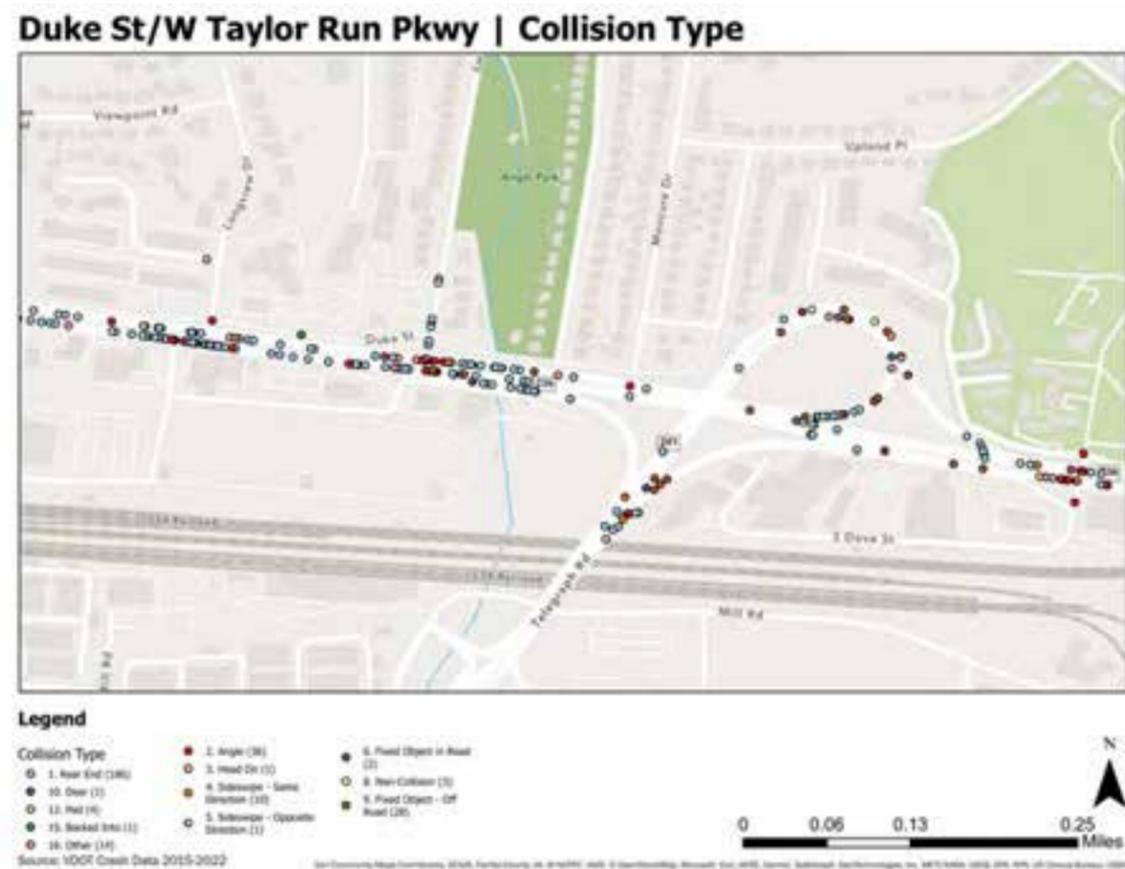
The safety analysis has been prepared as a preliminary step in mitigating cut-through traffic, and improving safety for all users in the Duke Street and West Taylor Run Parkway intersection improvement project area.

The maps and graphs included in this report comprehensively illustrates trends in traffic collisions by year, severity, type, time of day, roadway surface condition, location, identification of crash patterns, and causes for all road users. Specifically, all crash incidents elaborated on in this report are those recorded by the Virginia State Police, maintained by the Virginia Department of Motor Vehicles, and provided in an open, interactive format by the Virginia Department of Transportation ([VDOT's Crash Analysis Tool](#)) online, which were verified by field work at three locations in the project area during the AM Peak, Midday Peak, and PM Peak time periods. Our analysis extends from 2015 to 2022 to best understand travel trends in the area before and after the COVID-19 pandemic. Crash data and Crash Maps are presented in Appendices F and G.

### 4.1 Crash Characteristics (By Type, Severity, and Concentration)

As seen in Figure 15 above, from 2015-2022, rear-end collisions were the most common collision type, totaling 65% of all collisions. Collisions occurring at an angle (16%), in areas without traffic controls (17%) incidents, and by off-road obstructions (7%) by fixed objects also contributed to collisions during this period.

Figure 15: Crashes by Type



The majority of collisions occurred at either traffic signals (42% of the 446 recorded incidents) or in marked traffic lanes (28% of all collisions) during this period. It was determined that 17% of the recorded collisions occurred without traffic controls.

In particular, the following are key findings from crash data that was analyzed from January 2016 to December 2020 at the intersection of Duke Street and W. Taylor Run Parkway and Telegraph Road ramps:

1. The intersection of Duke Street and West Taylor Run Parkway has a heavy concentration of collisions occurring at either rear-end, an unspecified angle, an off-road fixed object, as a sideswipe from a car travelling in the same direction, a head-on, or other type of collisions.
2. Rear-end collisions are predominant at Duke Street and West Taylor Run Parkway, and Telegraph Road entry and exit ramps to and from westbound Duke Street.
3. There were several off-road fixed object collisions reported primarily at the westbound Duke Street and Telegraph Road on and off ramps.
4. A total of one hundred seventeen (117) crashes were recorded between January 2016 to December 2020 at Duke Street and West Taylor Run Parkway, and Telegraph Road entry and exit ramps to and from westbound Duke Street. A total of seventy-three (73) rear-end, eleven (11) sideswipe, fifteen (15) fixed object, twelve (12) other type, four (4) angle, one (1) head-on, and one (1) pedestrian type crashes were recorded. However, stopping for pedestrian in the crosswalk was the reason for thirty-eight (38) recorded crashes.
5. A total of twenty (20) rear-end, two (2) sideswipe and five (5) fixed object type crashes were recorded on the eastbound approach of Duke Street at W. Taylor Run Parkway. Most of the vehicles involved in these crashes were approaching Telegraph Road on-ramp from eastbound Duke Street. At the intersection, the rightmost lane on Duke Street has flexible posts to separate traffic going to Telegraph Road from the through traffic on the eastbound Duke Street. To avoid a very long queue on Duke Street, on many occasions vehicles try to enter the ramp after crossing the stop bar on the eastbound direction. Six (6) of the rear-end crashes were related to the crosswalk at the intersection of Duke Street and W. Taylor Run Parkway. One (1) pedestrian crash was recorded at the intersection when an eastbound vehicle ran a red light and struck a bike in the crosswalk.
6. In addition to these crashes on eastbound Duke Street at W. Taylor Run Parkway, additional six (6) rear end crashes related to the crosswalk located on Telegraph Road on-ramp, east of the intersection were recorded. This crosswalk is controlled by RRFB and connects the sidewalks on the south side of Duke Street which are separated by the Telegraph Road on-ramp.
7. A total of twelve (11) rear-end, eight (8) sideswipe, and two (2) angle crashes were recorded in the westbound direction.



8. A total of eighteen (18) rear-end, and three (3) fixed object type crashes were recorded on the Telegraph Road off-ramp to the westbound Duke Street. Rear-end crashes were related to the crosswalk at the end of the ramp. These crashes were recorded when the vehicle in the front stopped for the pedestrian in the crosswalk or the pedestrian waiting at the crosswalk, while the vehicle following the first vehicle did not stop in time, either collided with the vehicle in the front or collided with a fixed object. Due to the curvature of the ramp, it is difficult for the vehicle to notice the pedestrian in the crosswalk or vehicle in front trying to stop for a pedestrian.

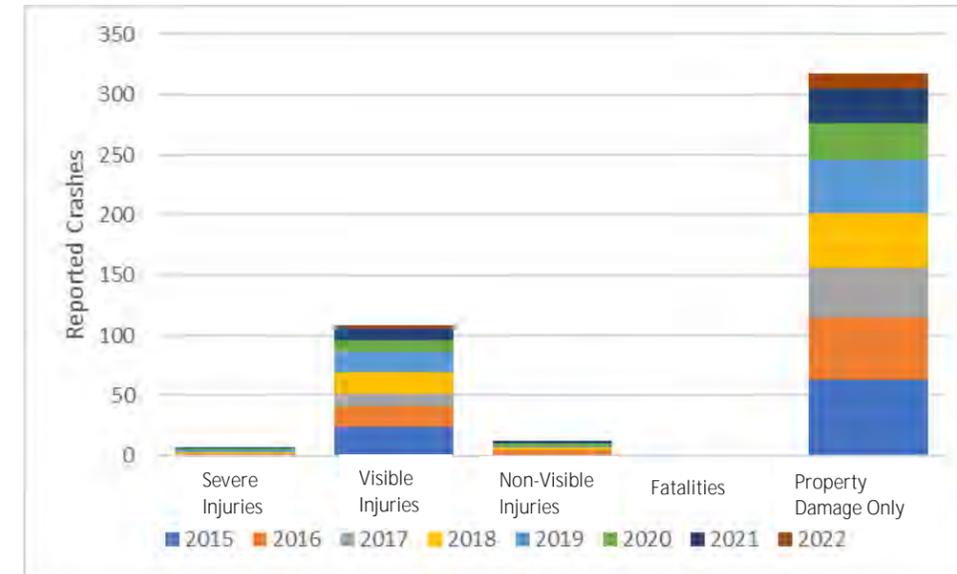


9. Another nine (9) rear-end and one (1) sideswipe crashes were recorded on Telegraph Road on-ramp from the westbound Duke Street. Rear-end crashes were related to the crosswalk on the off-ramp. Due to horizontal curvature of the ramp and tree branches, it is difficult for the drivers to see the pedestrians waiting to cross the ramp. Vehicles gain speed **after leaving the signal at Dove Street/Robert's Lane** and end up stopping suddenly for crossing pedestrians.



As noted in Figure 16, fatalities have not been recorded for this project area by the Virginia State Police between 2015-2022. However, 71% of all 446 collisions occurred along the corridor resulted in property damage and 24% of all collisions resulted in visible injuries.

Figure 16: Crashes by Severity



In particular, the following are key findings to note:

1. The most severe injuries have occurred on Duke Street at West Taylor Run Parkway and Telegraph Road interchange.
2. Multiple crashes have resulted in visible injuries within 100-foot proximity of these two locations, as indicated in Figure 16.
3. There have been sixty-seven (67) crashes at the Telegraph Road and Duke Street on-ramp and off-ramps that have resulted in injury between 2015-2022.

Figure 17: Map of Crashes by Severity

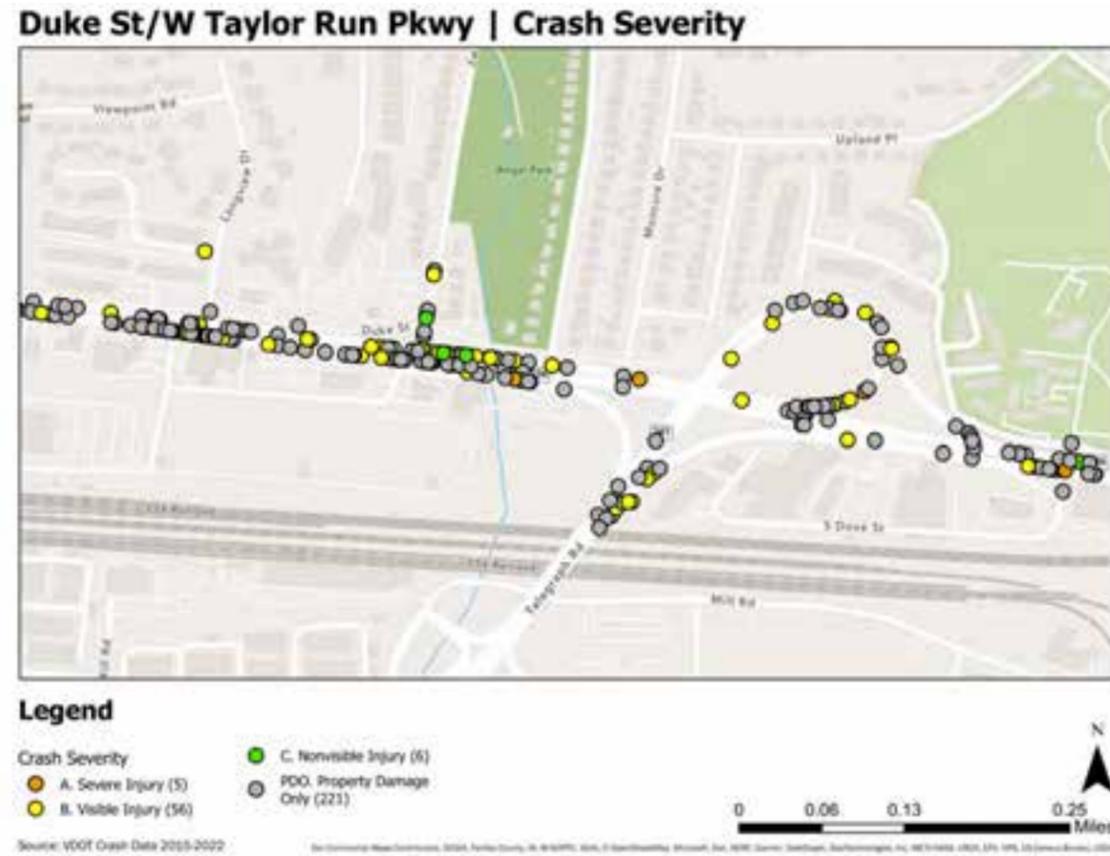
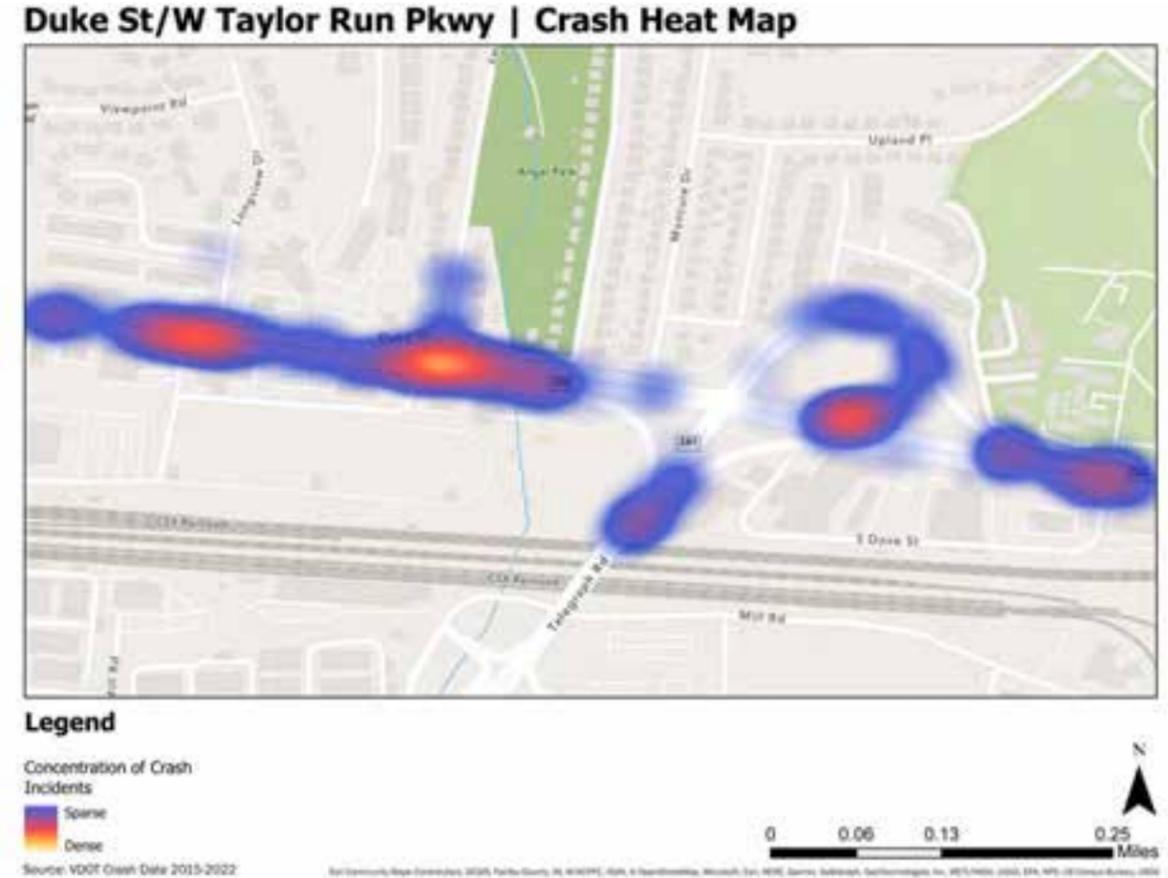


Figure 18: Heat Map of Crashes by Spatial Concentration

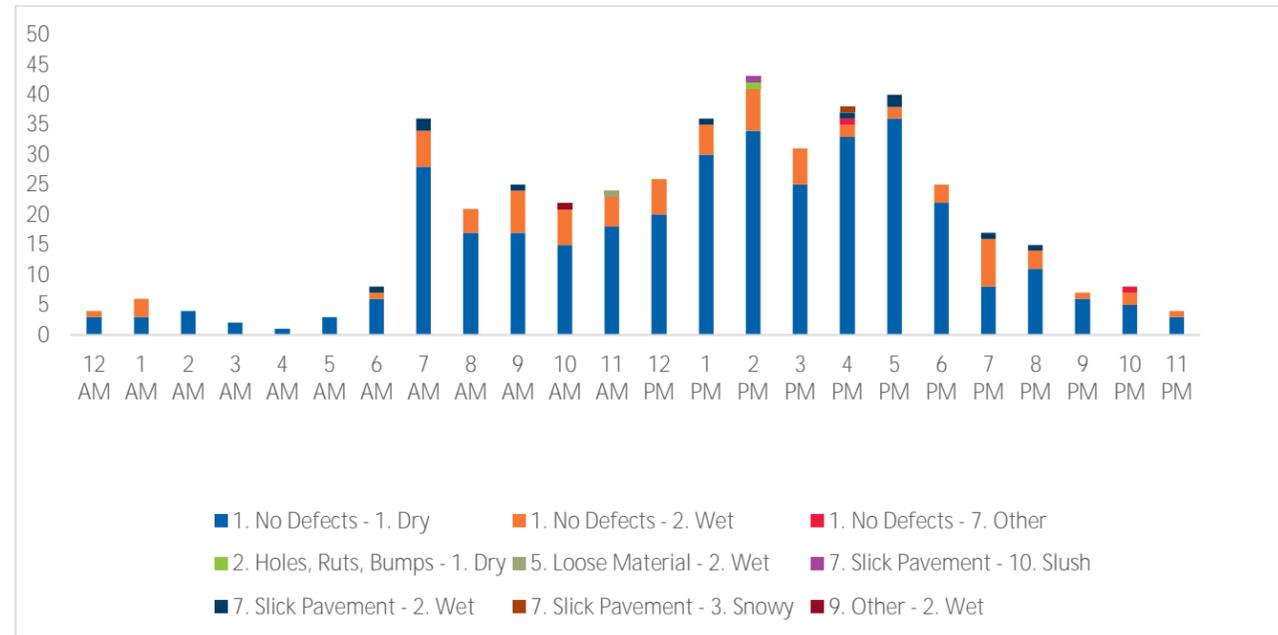


The heat map in Figure 18 above primarily shows a concentration of crashes on and near Duke Street and West Taylor Run Parkway, Duke Street and Witter Drive, and westbound Duke Street and Telegraph Road on and off-ramps.

## 4.2 Crash Roadway Conditions

The majority of collisions, illustrated in Figure 19 below, have occurred between 2015-2022 on roadway surfaces that are dry (81%), and the remainder in wet conditions (17%) on roads with no defects (amounting to 97% of the roadways where collisions occurred in the project area).

Figure 19: Crash Roadway Conditions



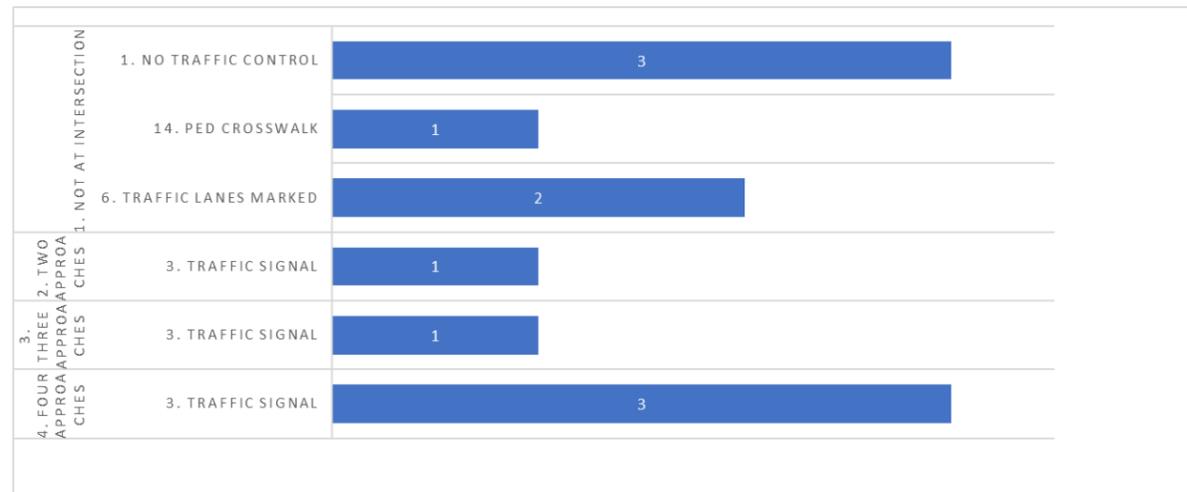
### 4.3 Pedestrian and Bicyclist Involved Crashes

Following national trends, the majority of pedestrian-involved collisions in the Duke Street and West Taylor Run Parkway project area have occurred midblock, meaning in the roadway between two intersections. Specifically, as illustrated in Figure 20 below:

- Midblock collisions amount to 74% of all pedestrian collisions nation-wide and to 55% of all collisions in this segment of Duke Street (NTSA, 2020 and VDOT, 2022).
- Street segments without traffic control devices and at four-leg traffic signal-controlled intersections accounted for 55% of all pedestrian-involved collisions between 2015-2022.

Only two (2) collisions involving bicycles were reported by Virginia State Police. One (1) of these two (2) collisions occurred midblock with no traffic controls present, and the other collision occurred at a pedestrian crosswalk at an intersection with two approaching roadways.

Figure 20: Pedestrian-Involved Collisions by Traffic Condition

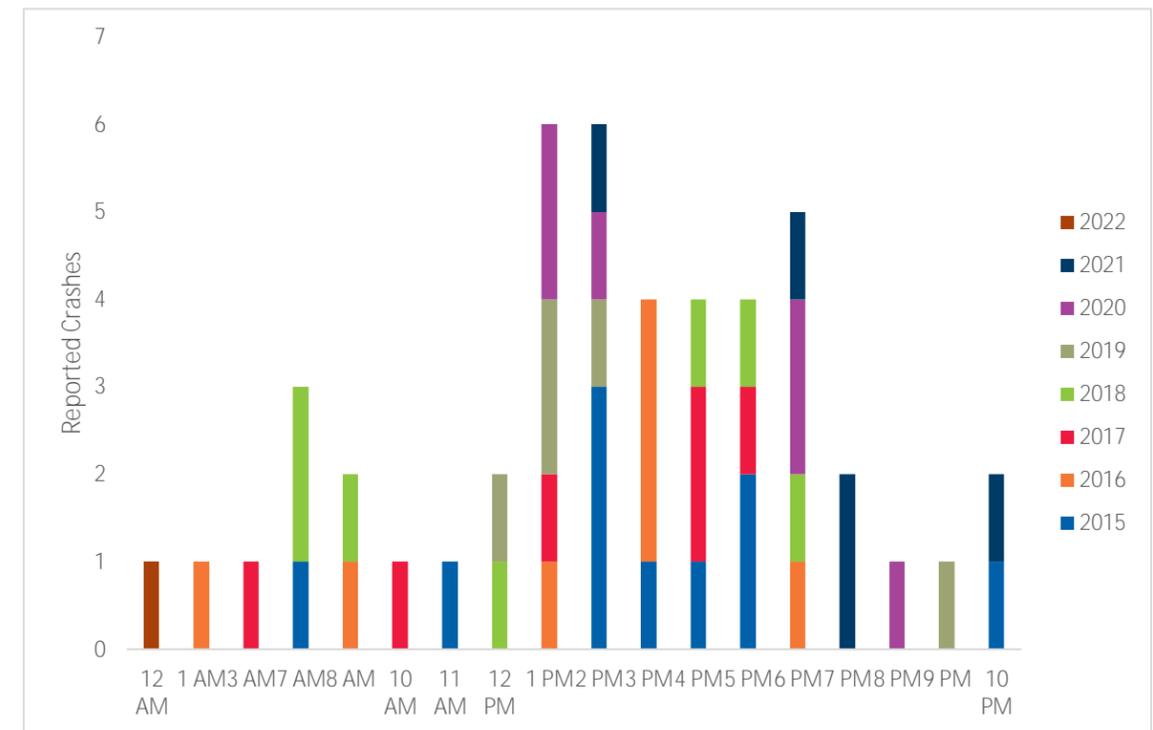


### 4.4 Youth-Involved Crashes

Youth-involved collisions peaked in 2015 with 10 (21%) of the 47 total collisions. The number of youth-involved collisions steadily decreasing over time down to five (5) youth-involved collisions in 2021 and only one (1) collision so far as of August 2022.

Youth-involved collisions, illustrated in Figure 21 below, have primarily occurred during the hours of 7-8am, 1-3pm, and 6-7pm, which likely correspond with school start and dismissal times and extracurricular dismissal times.

Figure 21: Youth-Involved Crashes



### 4.5 Senior-Involved Crashes

As seen in Figure 22, Crashes involving senior citizens within the project area were also highest in 2015 (12 collisions), as well as in 2016 and in 2019 (11 collisions per year). Each of these years represented approximately 16 of the total 69 senior-involved crashes from 2015-2022.

Seniors have been involved in collisions primarily during the hours of 10 AM thru 5 PM.

Figure 22: Senior-Involved Crashes

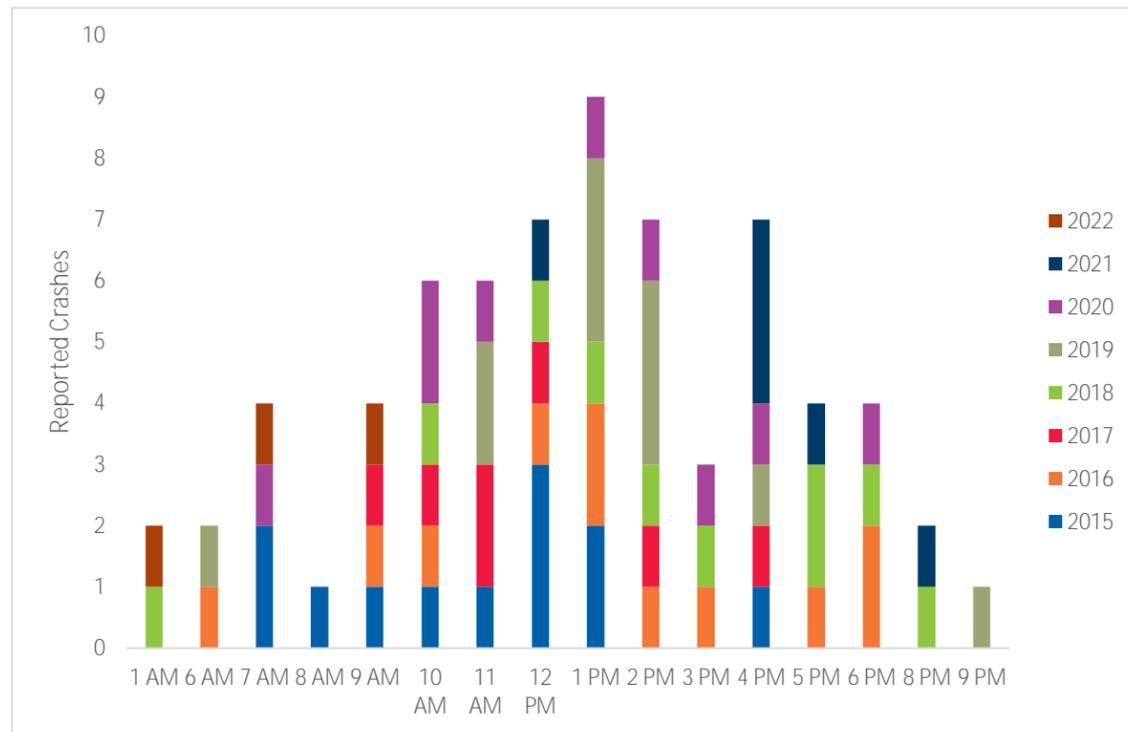


Figure 23: Time of Reported Crashes by Year

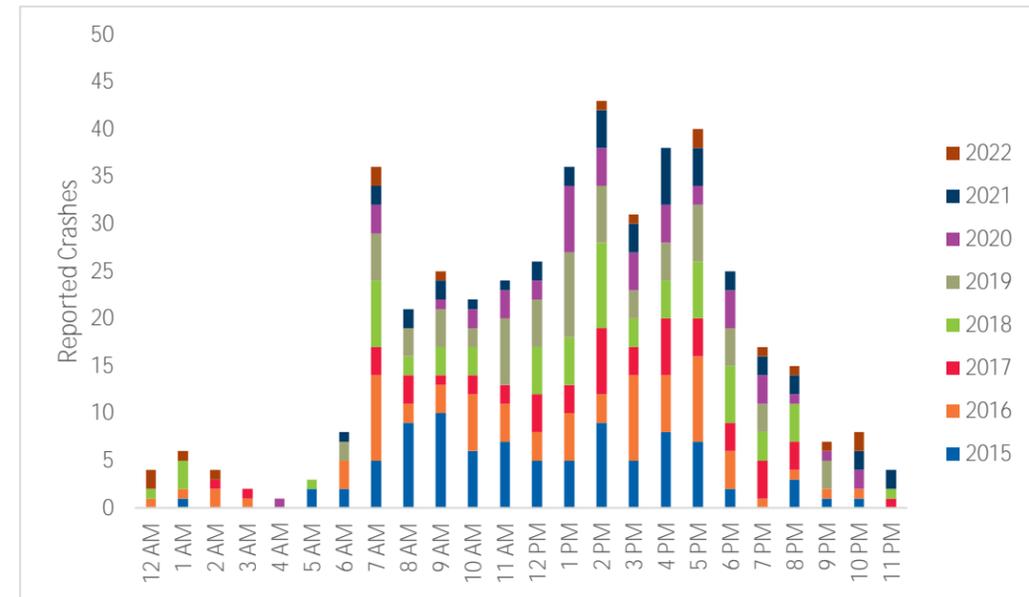
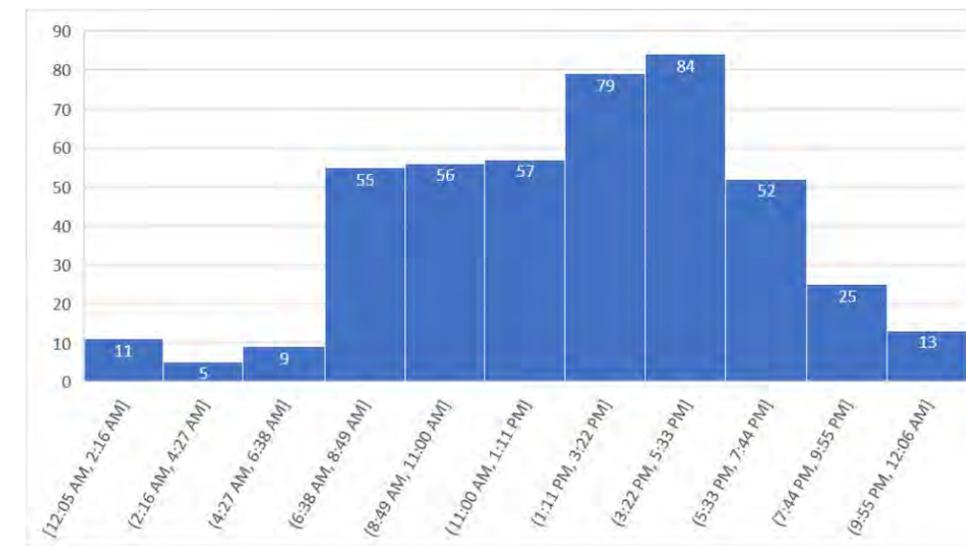


Figure 24: Time Ranges of Reported Crashes by Cumulative Year (2015-2022)



### 4.6 Peak Crash Periods

The most common year for collisions on this corridor overall was 2015 (88 collisions, representing 20% of all crashes) with dramatic drops in collisions every proceeding year, down to only 16 collisions in the first eight months of 2022, as seen in Figure 23 below.

As seen in the histogram in Figure 24, peak hours for collisions overall appear to be concentrated between the AM Peak period between 6:40am to 1:10pm, with a Midday Peak period between 1:10m to 5:30pm, and a PM Peak period between 5:30pm to 7:45pm.



## 4.7 Field Review Summary

To verify and validate the historical collision trends previously discussed in Section 1.1 Background, the Nspiregreen Consultant team conducted a field review of three collision hotspots along Duke Street on Tuesday, August 23, 2022 and on Friday, August 26, 2022, noted in Figure 25 below:

1. Duke Street and West Taylor Run Pkwy
2. Duke Street and Telegraph Road Off-Ramp
3. Duke Street and Telegraph Road On-Ramp

The field work observations noted in the following sections of this report capture near-misses, erratic driving behavior, infrastructure/curbside conditions, and counts of heavy vehicles, buses, bicycles, pedestrians, and scooters during rush hour, specifically the AM Peak (6:00-9:00AM) and the Midday Peak (1:30-3:30PM) on Tuesday, August 23<sup>rd</sup>, 2022 and the PM Peak (4:00-7:00PM) on Friday, August 26<sup>th</sup>, 2022.

Figure 25: Study Area (Aerial) with field observation locations marked in the white circles.



### 4.7.1 Duke Street and West Taylor Run Parkway

There is currently a crosswalk available on the east side of W Taylor Run Parkway for bicyclists and pedestrians to access four bus stops within 600 feet of the intersection. These bus stops have no seating and poor wayfinding (directional or informational) signs. Pedestrian activity also included infrequent wheelchair and stroller ramps within close proximity to the intersection. Pedestrians, primarily coming from the Carydale East multifamily apartments, in the northwest quadrant of the intersection, were frequently observed jaywalking across Duke Street (as seen in Figures 26 and 27). Jaywalkers primarily crossed to gain quick access to the eastbound DASH Bus Line 30 from Braddock Road to the King Street Metro, which has scheduled headways every 15 minutes. This observed jaywalking route helped transit riders avoid the downhill and uphill climb to the bus stop and to minimize long wait times on unshaded sidewalks.

Only eastbound signal heads have the backplates, but do not have yellow retroreflective borders installed. Based on the historical crash data, rear-end collisions were prominent at this intersection. Exclusive pedestrian phase was recorded at the intersection which affects the capacity at the intersection, however, allows the pedestrians to cross the intersection safely.

Bicyclists were frequently observed using the Duke Street Service Road which had fewer lanes, lower traffic volumes, and lower speeds of traffic compared to Duke Street itself. Typical field conditions are presented on Figures 26 through 30.



Figure 26: Start of the jaywalking path taken by many pedestrians across Duke Street



Figure 27: A bicyclist riding eastbound on the Duke Street Service Road



Figure 28: A bicyclist with bike trailer pushing a button to cross at the Duke Street/West Taylor Run Intersection



Figure 29: A pedestrian preparing to jaywalk across West Taylor Run



Figure 30: Back-up of vehicles on right-turn lane on eastbound Duke Street

Traffic congestion and cut-through traffic was observed at the intersection. In particular, the consultant team observed:

1. Traffic backing-up from the westbound right-turn lane (approximately 150 ft) into the through-lane, during the AM Peak period.
2. Long queues on the southbound West Taylor Run Parkway approach, during the PM peak period.
3. Queues on the rightmost lane of Duke Street extending to N. Quaker Lane, especially during the PM Peak period.
4. Distracted drivers were frequently observed checking their phones in the right-turn lane at Duke Street and West Taylor Run. These conditions often resulted in several seconds of delay for right-turning vehicles.
5. Speed differential between right-turn lane and two through lanes on the eastbound Duke Street.

6. High-visibility crosswalk markings at the intersection are in good condition.

#### 4.7.2 Duke Street and Telegraph Road On-and-Off-Ramps

For bicyclists, pedestrians, and disabled individuals:

1. The sidewalks at both the on-ramp and off-ramp at Duke Street and Telegraph Road are narrow (4' 6" on westbound Duke Street, and 5' 2" at the ramp), unshaded, and in fair condition, particularly on the westbound side.
2. An overgrowth of bushes and flowers provided pedestrians, bicyclists, and the occasional scooter or stroller user some respite from the sun, but only near the on-ramp, which blocked clear sightlines of on-ramp traffic.
3. High-visibility crosswalk markings were faded at both the Telegraph Road ramps, and at the intersection of Duke and S. Dove Street/Robert's Lane.
4. The RRFBs were observed not flashing, only beeping, with the exception of several times during the AM Peak rush hour. Especially on this ramp, the crossing push button was rarely observed being used by pedestrians or bicyclists.
5. Sidewalk bicycle riding was observed along Duke Street eastbound and westbound as no bicycle facilities were provided.
6. While the DASH Line headways run every 15 minutes, riders were observed using these bus stops about once every 30 minutes.

Erratic driving behaviors were observed at the on-ramp and off-ramps at Telegraph Road including:

1. Use of the shoulder to cut ahead of the queued traffic at off-ramps, especially when queueing at the overpass was observed.
2. Erratic lane changes on eastbound Duke Street to avoid Telegraph Road on-ramp at W. Taylor Run Parkway, causing a few observed near-misses with drivers behind them.
3. Tailgating and near-miss sideswiping of cars with an unsafe following distance and speed, especially in the right-through lane, the left-through lane on the westbound Duke Street at on-ramp overpass approach.
4. Speeding and drifting across lanes, occasionally the shoulder, with no turn signal used by drivers.
5. Failure to yield to bicyclists, scooters, and/or pedestrians, particularly on the Telegraph Road on-ramp.
6. Illegal left-turns were frequently observed at the Robert's Lane/Dove Street and Duke Street Interchange. The interchange there is a jug-handle intersection noted by a hard-to-read informational sign.

### 4.8 Preliminary Safety Recommendations

The following initial transportation safety recommendations will be expanded and studied in greater depth in future reports.

Transportation Safety Issue Observed	Preliminary Recommendation for Further Study
<p>1. High rear-end crashes in the eastbound direction, crosswalk related crashes and overall congestion at Duke Street and West Taylor Run Parkway and on the study corridor</p> <p>2. Speeding and Near-Misses</p>	<p>Consider re-evaluating signal timing throughout the corridor to determine if improvements can be made to alleviate the congestion and queuing issues, especially during the PM peak hour along the eastbound Duke Street. City is planning to implement a potential short-term pilot programs and improvements, such as restrictions on left turns from the southbound West Taylor Run Parkway to Telegraph Road on-ramp, modify signal phasing to maintain free flow conditions on exit lane to on-ramp (except during pedestrian activation), re-evaluating the signal timing on the corridor and providing more green time to the traffic on Duke Street thereby encouraging traffic to stay on N. Quaker Lane instead of using local streets.</p> <p>Consider also adjusting the clearance timing at West Taylor Run for the Duke Street approaches.</p> <p>Consider re-evaluating the service road that interact with Duke Street corridor, by reconfiguring the geometry, and providing additional signage, in combination with the existing signage, to better indicate the right-of-way priority and directional information for drivers.</p> <p>Providing additional access point to the east of Telegraph Road bridge from the eastbound Duke Street to Telegraph Road on-ramp.</p> <p>Provide signage on the eastbound Duke Street indicating alternate route for traffic to Telegraph Road on-ramp using slip ramp at Dove Street. Improve informational signage</p>
<p>3. Jaywalking to DASH Bus Stops at Duke Street and West Taylor Run Parkway</p>	<p>One way to reduce single occupant vehicles along the corridor is to promote transit. While high frequency transit service is provided along the corridor, improvements can be made, including improving the crosswalk on the east leg of Duke Street and West Taylor Run Parkway, converting</p>

	<p>existing bus stops into bus shelters and relocating or combining bus stops from intersection approaches (near side) to receiving lanes beyond the intersection (far side), providing Transit Signal Priority (TSP) and ultimately providing dedicated transit lanes on the corridor in long run.</p>
<p>4. Crosswalk related crashes on the eastbound Telegraph Road on-ramp at W. Taylor Run Parkway</p>	<p>Consider eliminating the crosswalk on the ramp and provide sidewalk connection to the crosswalk on the east leg of Duke Street and W. Taylor Run Parkway.</p>
<p>5. Missing Backplates and reflective borders</p>	<p>Consider installing backplates with retroreflective borders to all traffic signal heads for all approaches at all study area intersections. The installation of yellow retroreflective borders on the backplates can be used to improve visibility and could reduce the occurrence of rear-end collisions in the future.</p>
<p>6. Sidewalks that are narrow (<b>4' 6" on Duke Street westbound, and 5' 2" at the ramp</b>), unshaded, and cracked/uneven.</p>	<p>Widen sidewalks where possible.</p> <p><b>Plant shade trees near the children's school and multifamily residential homes.</b></p>
<p>7. Crosswalk related crashes on Telegraph Road off-ramp at westbound Duke Street</p>	<p>Consider bringing off-ramp traffic to the new intersection east of Telegraph Road and provide signalized crosswalk on the north leg. Further traffic analysis is required to modify free-flow condition on the off-ramp since traffic will be controlled by a signal.</p>
<p>8. Faded crosswalks and broken Rectangular Flashing Beacons at Telegraph Road on-ramp at westbound Duke Street.</p> <p>9. Vision of the RRFB on the right side is blocked by the tree branches. Crosswalk related crashes on Telegraph Road on-ramp.</p> <p>10. Weaving conflicts on westbound Duke Street</p>	<p>Refurbish crosswalk and pavement markings.</p> <p><b>Repair broken Rectangular Flashing Beacons'.</b> Consider trimming the tree branches and/or provide overhead RRFB at the ramp exit.</p> <p>Advance lane designation sign in the median to provide positive guidance to the westbound traffic <b>prior to Dove Street/Robert's Lane.</b></p>
<p>11. Bicycle Riding on Sidewalks and the Service Road</p>	<p>Provide bicycle amenities, wayfinding signs, and infrastructure on currently unmarked segments of the Duke Street Service Road.</p>
<p>12. Inaccessible Curbside Ramps</p>	<p>Provide ADA-accessible curbside ramps to meet pushbutton side reach requirements, Accessible Pedestrian Signals and Accessible Pedestrian Signal Detectors (APS and APD), if possible, at:</p> <ol style="list-style-type: none"> <li>1. All legal crossings</li> <li>2. Curbsides to popular destinations (such as the school and multifamily residential)</li> </ol>



## 5 PEDESTRIAN LEVEL OF TRAFFIC STRESS:

The City of Alexandria (City) has identified the need to assess the intersection of Duke St and West Taylor Run Parkway, and the Telegraph Road on and off-ramps by using the Pedestrian Level of Traffic Stress (PLTS) methodology, a high-level performance rating of pedestrian facility. The performance rating is based on the level of pressure or strain experience by pedestrians and other sidewalk users. This project adapts the PLTS methodology from the [Oregon DOT analysis manual](#).

The following metrics are collected for the PLTS determination:

Segment data:

- Sidewalk condition and width
- Buffer type and width
- Bike lane width
- Parking width
- Number of lanes, posted speed, and Illumination presence
- General land use

Crossing data:

- Functional class
- Number of lanes and posted speeds
- Roadway average daily traffic (ADT) and sidewalk ramps
- Median refuge & illumination presence
- Signalized general intersection features

PLTS uses four levels of traffic stress with PLTS 1 being the lowest stress level and PLTS 4 represents the highest stress level.

PLTS was assessed at five (5) locations at the intersection of Duke Street and W. Taylor Run Parkway. Figure 31 shows an aerial of the five (5) locations for PLTS. Additional PLTS evaluation results are presented in Appendix J.

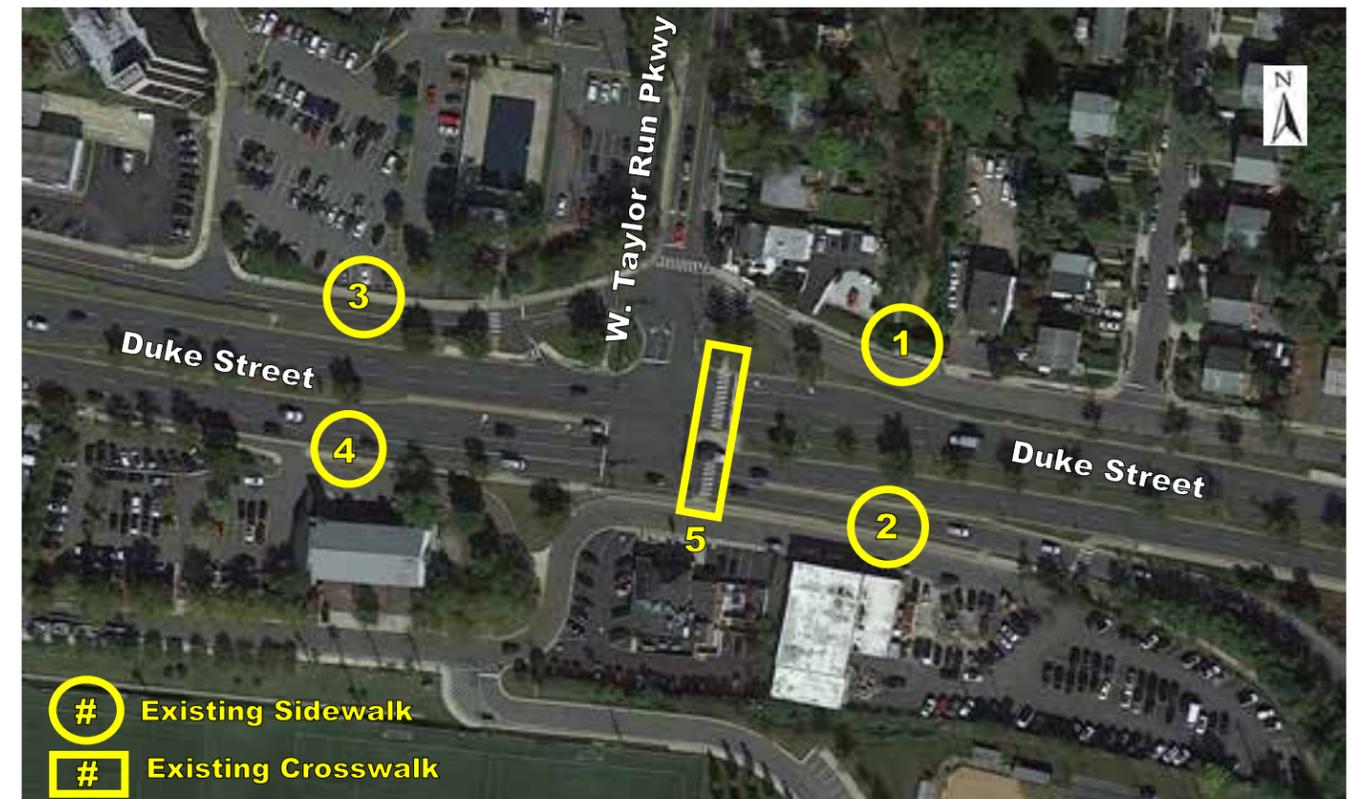
Segment 1: This location was assessed along the service road on the east leg of the intersection. The posted speed limit along this segment is 25 mph. The pedestrians using this section of the sidewalk often have their origin/destination as the King Street Metro Station along the Diagonal Road and Virginia Railway Express (VRE) Alexandria Station along the Callahan Drive. A small number of pedestrian trips has their origin/destination as Duke St & Moncure Dr westbound bus stop.

This location contains a 5-foot sidewalk and a landscaped buffer of 2 feet, which leads to PLTS 3 in sidewalk criteria and PLTS 1 in physical buffer criteria. This location has no parking and bike lane buffer, leading to a PLTS 2. The general land use on this segment is commercial and high density residential, so the PLTS is 1. Overall PLTS for Segment 1 is PLTS 2.

Segment 2: This location was assessed along the road leading into the Telegraph Road on-ramp on the east leg of the intersection. The posted speed limit along this segment is 25 mph. The pedestrians using this section of the sidewalk often have their origin/destination as the commercial area to the south of

Duke Street and the bus stop at Duke Street and Witter Drive. There is a substantial amount of pedestrian trips generated from the commercial facilities to the south of the intersection. This location contains a 5 foot sidewalk and a landscaped buffer of 2 feet which leads to PLTS 3 in sidewalk criteria, and PLTS 1 in physical buffer criteria. This location has no parking and bike lane buffer, leading to a PLTS 2. The general land use on this segment is commercial and high density residential, so the PLTS is 1. Overall PLTS for segment 1 is PLTS 2.

Figure 31: Duke Street at W. Taylor Run Parkway



Segment 3: This location was assessed along the service road on the west leg of the intersection. The posted speed limit along this segment is 25 mph. The pedestrians using this section of the sidewalk often have their origin/destination as the VRE Alexandria Station, King Street Metro station, and the bus stops at Duke Street and Witter Drive. A small number of pedestrian trips have their origin/destination as westbound Duke St & the Moncure Dr bus stop.

This location contains a 6 foot sidewalk and no buffer, which leads to PLTS 2 in sidewalk criteria and PLTS 1 in physical buffer criteria. This location has no parking and bike lane buffer, leading to a PLTS 2. The general land use on this segment is commercial and high density residential, so the PLTS is 1. Overall PLTS for Segment 1 is PLTS 1

Segment 4: This location was assessed along the west leg of the intersection of Duke Street at W. Taylor Run Parkway. The posted speed limit along this segment is 35 mph and has more than three (3) number of lanes. The speed limit and number of lanes are the most significant factors in determining PLTS for this segment 4. The pedestrians using this section of the sidewalk often have their

origin/destination as the VRE Alexandria Station, King Street Metro station, and the bus stops at Duke Street and Witter Drive. A small number of pedestrians have their origin/destination as eastbound Duke St & the Moncure Dr bus stop. This location contains a 5 foot sidewalk and a landscaped buffer of 2 feet, which leads to PLTS 3 in sidewalk criteria and PLTS 2 in the physical buffer criteria. This location has no parking and bike lane buffer, leading to a PLTS 4. The general land use on this segment is commercial and high density residential so the PLTS is 1. Overall PLTS for Segment 1 is PLTS 3.

The crosswalk along the east leg of Duke Street at W. Taylor Run Parkway intersection was assessed for PLTS ratings. This crosswalk is controlled by a traffic signal. This methodology states that any signalized crossing usually provide a protected way across the roadway, and are typically rated at PLTS1. A signalized crossing on the east leg of the intersection provides a protected way across the roadway and is rated at PLTS 1. PLTS was assessed at four (4) locations along the Telegraph Road on ramps and off ramps. Figure 32 shows an aerial of the four (4) locations, crosswalk numbers 6 thru 9, for PLTS. All four (4) crosswalks along the on ramps and off ramps are traffic controlled via a RRFB. However, a high number of rear-end crashes are recorded at the crosswalks at the on and off ramps, contributed mainly due to the poor visibility of the pedestrians at the crosswalk and limited sight distance. Considering these significant factors, PLTS 3 is assigned at all four (4) crosswalks even though they are controlled by RRFB. Additional PLTS evaluation results are presented in Appendix J.

The proposed intersection along Duke Street will have one (1) crosswalk to cross the future ramp connection. This crosswalk will be traffic signal controlled. A signalized crossing on the north leg of the new intersection will provide a protected way across the roadway and is rated at PLTS 1. Results of the PLTS rating is shown in Table 9.

Figure 32: Duke Street at Telegraph Road on and off Ramps



Source: Google Imagery

Table 9. PLTS Rating

Segment & Crosswalk	Location	PLTS
Segment 1	DUKE STREET WESTBOUND SERVICE ROAD	PLTS 2
Segment 2	DUKE STREET EASTBOUND RAMP	PLTS 2
Segment 3	DUKE STREET WESTBOUND SERVICE ROAD	PLTS 1
Segment 4	DUKE STREET EASTBOUND SERVICE ROAD	PLTS 3
Existing Crosswalk 5	DUKE STREET EASTLEG CROSSWALK	PLTS 1
Existing Crosswalk 6	TELEGRAPH ROAD OFF RAMP (WESTBOUND) RRFB CROSSWALK	PLTS 3
Existing Crosswalk 7	TELEGRAPH ROAD ON RAMP (WESTBOUND) RRFB CROSSWALK	PLTS 3
Existing Crosswalk 8	TELEGRAPH ROAD ON RAMP (EASTBOUND) RRFB CROSSWALK	PLTS 3
Existing Crosswalk 9	TELEGRAPH ROAD OFF RAMP (EASTBOUND) RRFB CROSSWALK	PLTS 3
Proposed Crosswalk 10	TELEGRAPH ROAD WESTBOUND CROSSWALK	PLTS 1

## 6 NO-BUILD TRAFFIC ANALYSIS

This section summarizes the assumptions and results of the No-Build Conditions VISSIM model Analysis for the Duke Street (Route 236) and W. Taylor Run Parkway Intersection Improvement Project. The weekday AM and PM peak hour No-Build Conditions models follows the agreed-upon methodology, as documented in the project Framework Document approved by the City and VDOT. These study intersections are shown in Figure 33.

The existing traffic volumes were forecasted to the Future Years 2026 and 2036, which were determined as the build (opening year) and design years for the improvements. Projecting the traffic volumes at the study intersections to the design year with an appropriate growth rate was the first step in developing future conditions analysis. The methodology that was followed for development of the growth rate and traffic analysis for future years is discussed below.

### 6.1 Traffic Forecasting Methodology

The annual growth rate was determined by evaluating the Metropolitan Washington Council of Governments (MWCOC) model's Household and Employment rates, and comparing the traffic volume growth in the model to historical Average Annual Daily Traffic (AADT) volumes from a continuous count station data recorded by VDOT from 2010 through 2019. Growth rates were also compared with the growth recorded on I-395 Seminary Road HOV ramp Interchange Modification Report (IMR).

The forecasting process used the latest Metropolitan Washington Council of Governments (MWCOC) travel demand forecasting model (version 2.4). The outputs from the base year and future-year travel demand models were then used to develop post-processed traffic volumes. Using the outputs from the travel demand model base year (2018) and future-year (2030 and 2045) scenarios, growth rates were developed for individual network links on Duke Street corridor, and applied to the 2018 base conditions traffic analysis volumes to develop the traffic forecasts for the 2026 and 2036 traffic analysis years.

To determine the growth rate on Duke Street, the growth rates for the eastbound and westbound directions were combined. In addition to that, the weighted average was taken for the links, from N. Quaker Lane to Telegraph Road, and from Telegraph Road to Diagonal Road, to determine the single growth rate for Duke Street between N. Quaker Lane and Diagonal Road. For the segment on Duke Street between N. Quaker Lane to Diagonal Street, COG's model produced an annual growth of -0.3% for year 2045. Average growth rates for the Duke Street corridor for No-Build conditions are shown in Figure 34 and Appendix N.

To validate this growth rate, historic AADT volumes published by VDOT were reviewed from year 2010 to 2019 for Duke Street for segments between N. Pickett Street and Telegraph Road, and between Telegraph Road and Route 1. The growth from VDOT's historic volumes over several time periods were reviewed in order to establish a recent and expected future growth along the corridor. According to the historical trends, the average historical growth rate on the roadway network has been zero (from 2014 to 2019) or negative (from 2010 to 2014) in recent years. Table 10. provides a summary of the AADT volumes from 2010 through 2019 along the corridor.

Table 10. VDOT Historic Traffic Volumes

Year	Roadway Segment/AADT Volume on Duke Street	
	Between N. Pickett Street and Telegraph Road	Between Telegraph Road and Route 1
2010	34000	23000
2011	34000	23000
2012	32000	22000
2013	32000	22000
2014	31000	21000
2015	31000	21000
2016	31000	21000
2017	31000	21000
2018	31000	21000
2019	31000	21000

Additionally, growth rates used in the IMR prepared for I-395 at the Seminary Road Ramp: High Occupancy Vehicle (HOV) to High Occupancy Toll Conversion were reviewed. The future (2020 and 2040) conditions volumes were developed for the No Build and Build conditions using the Strategic Travel Demand Model for the Washington region for I-395 Seminary Road HOV ramp IMR - [https://www.virginiadot.org/projects/resources/NorthernVirginia/I-395\\_Seminary\\_Road\\_HOV\\_Ramp\\_Interchange\\_Modification\\_Report\\_-\\_Oct\\_2019.pdf](https://www.virginiadot.org/projects/resources/NorthernVirginia/I-395_Seminary_Road_HOV_Ramp_Interchange_Modification_Report_-_Oct_2019.pdf). Outputs were used to estimate growth on IMR study area roadway links using NCHRP 765 industry-standard practices. The growth rate for I-395 varied from slight positive to negative for 2020 and 2040 conditions. Negative growth of was recorded for 2020 conditions. For 2040 conditions, growth rate of 0.1% and -0.2% was recorded for AM and PM peak hours, respectively.

Based upon the evaluation, the project team has identified and agreed upon an annual growth rate of 0.25% for this study. The suggested growth rate of 0.25% per year was applied to the Existing 2018 traffic volumes to generate projected 2026 and 2036 AM and PM peak hour traffic volumes. Growth rate of 0.25% (compound method) was applied to all movements including Service Road. These volumes for 2026 and 2036 are presented in Figures 35 and Figure 36, respectively.

For both No-build conditions, the morning peak hourly volume in the westbound direction exceeds the eastbound direction with a directional distribution of approximately 57% favoring the westbound direction at the intersection of Duke Street and W. Taylor Run Parkway. Pattern is remains similar for the evening peak hourly volume with directional distribution of approximately 53% favoring the westbound direction. During the morning and evening peak hours, approximately 50% and 66% of the total eastbound vehicles travel toward the southbound Telegraph Road on-ramp, respectively. The southbound approach volume from W. Taylor Run Parkway constitutes approximately 7-9% of the total intersection volume. However, during both peak hours, approximately 82% of the southbound volume travel toward the southbound Telegraph Road on-ramp. Approximately 11% of the total westbound volumes make right-turn at the intersection.



Figure 33. No-Build Condition Study Intersections

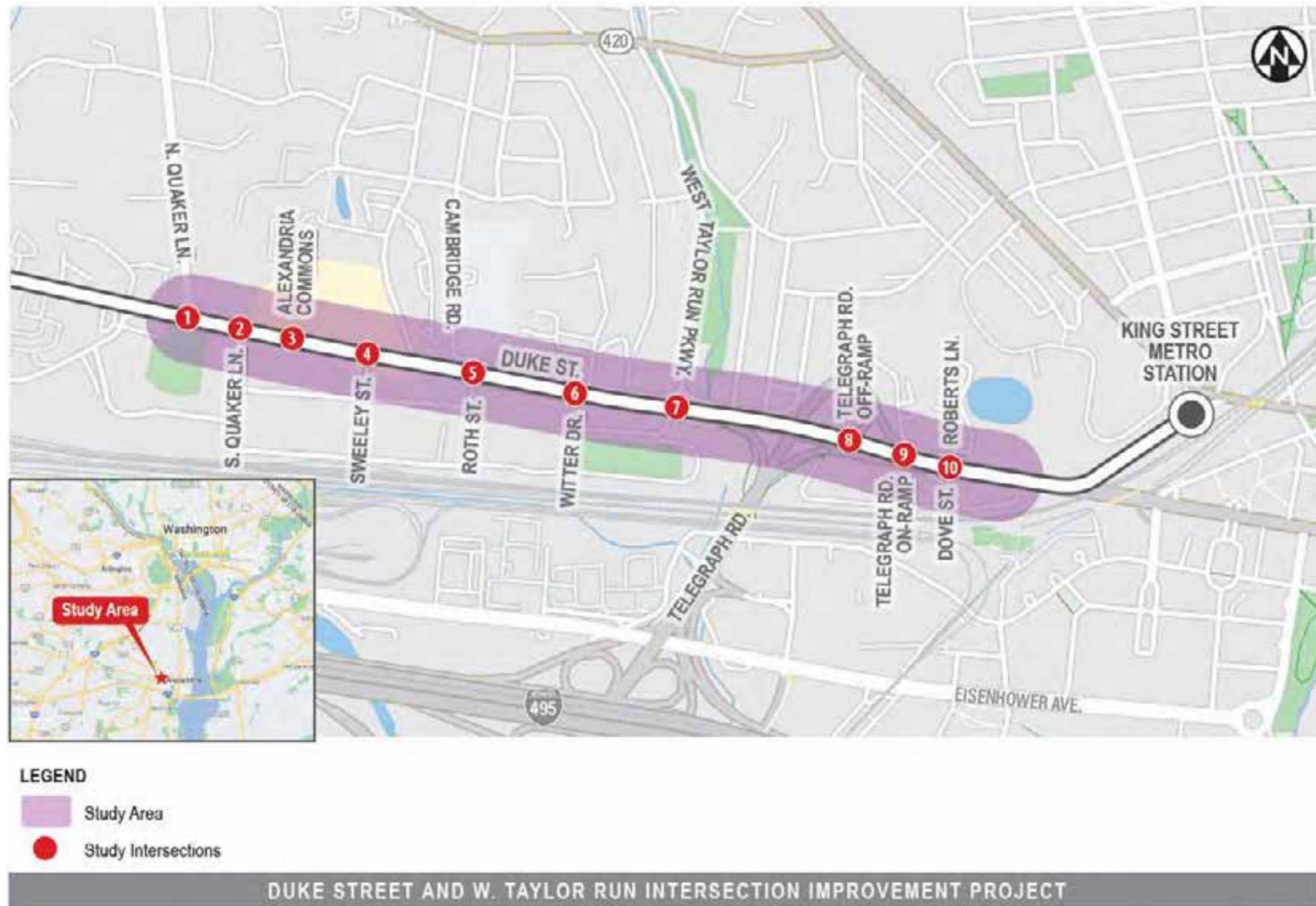


Figure 34: Compound Average Growth Rates

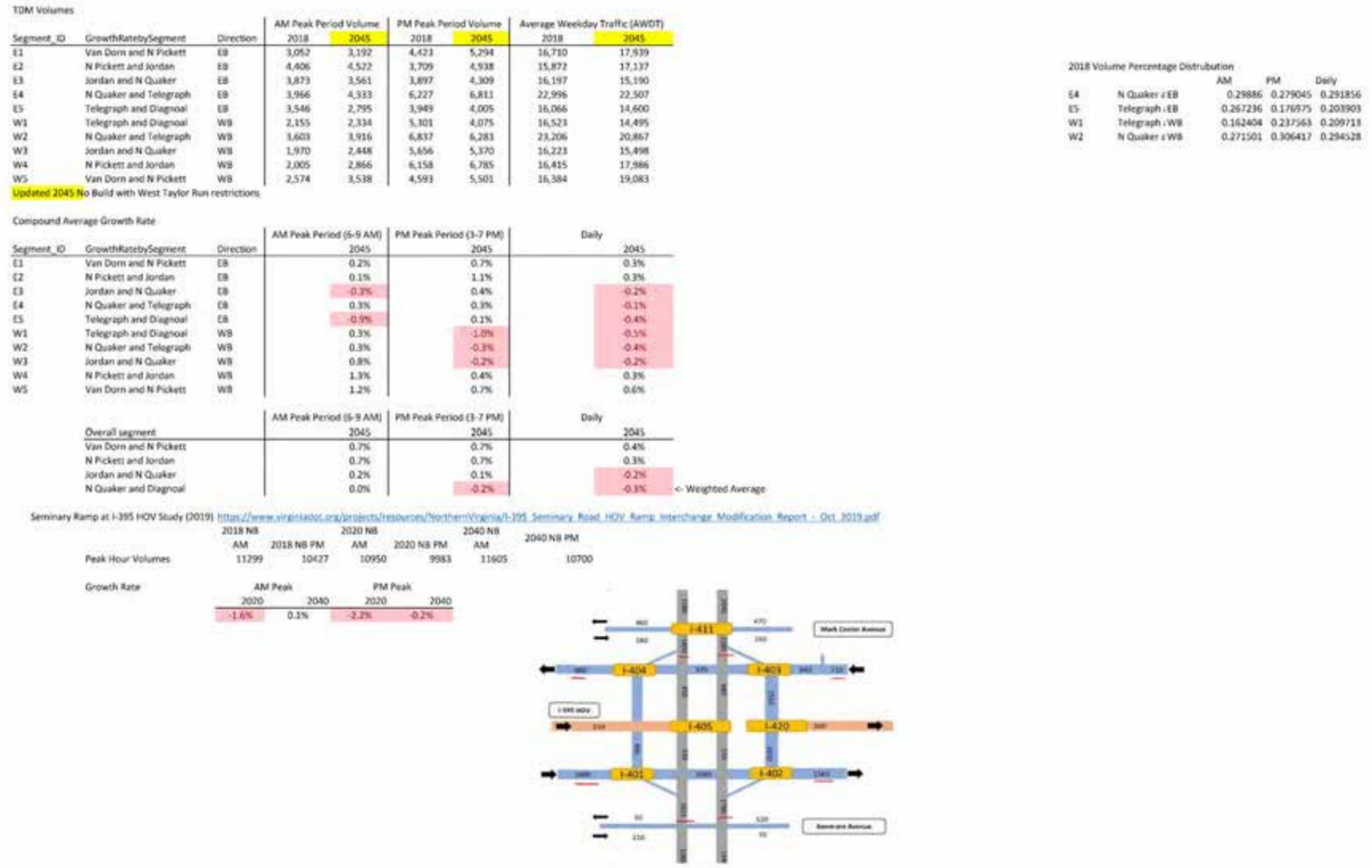


Figure 35: No-Build Opening Year (2026) Peak Hour Volumes

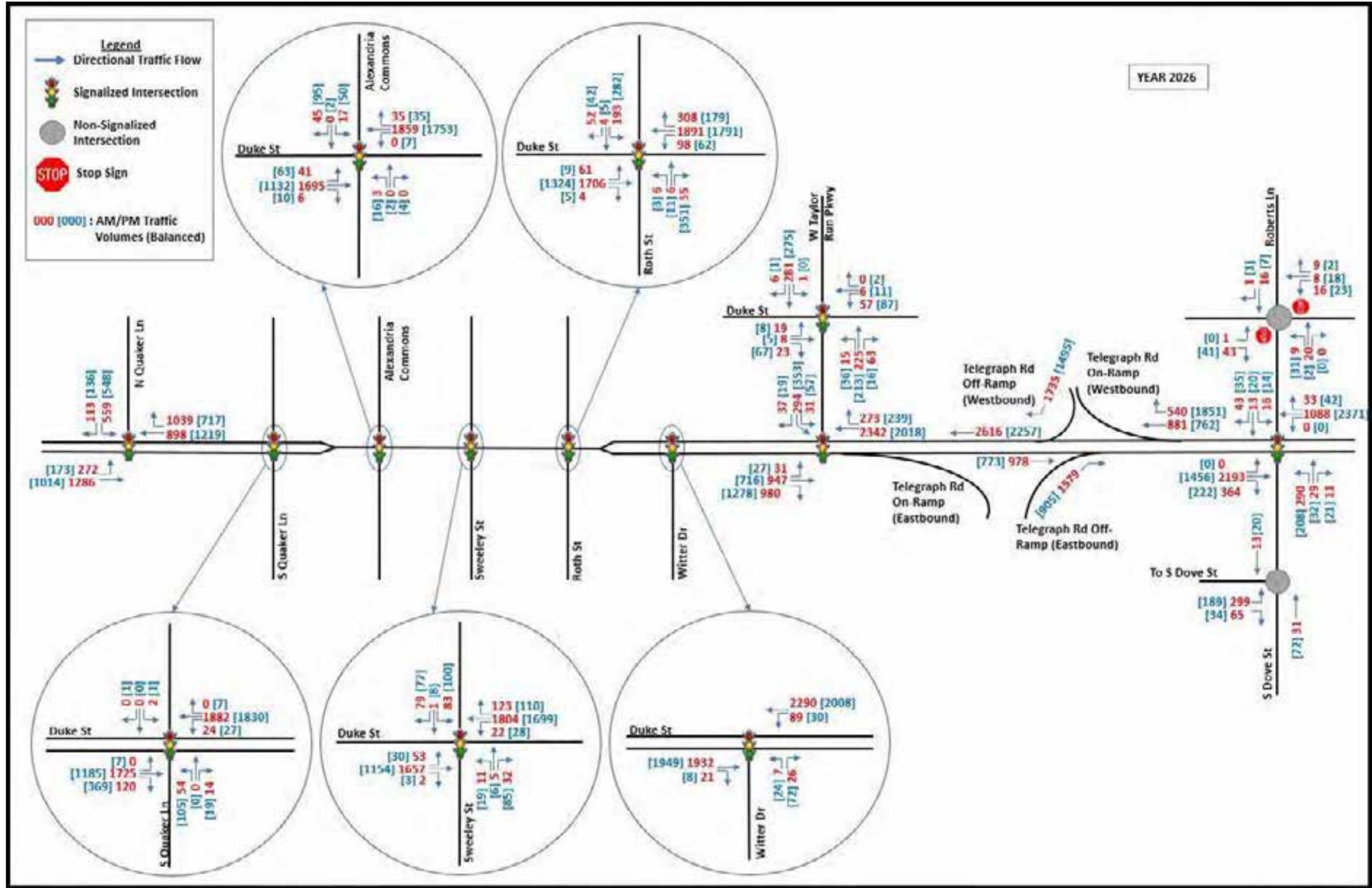
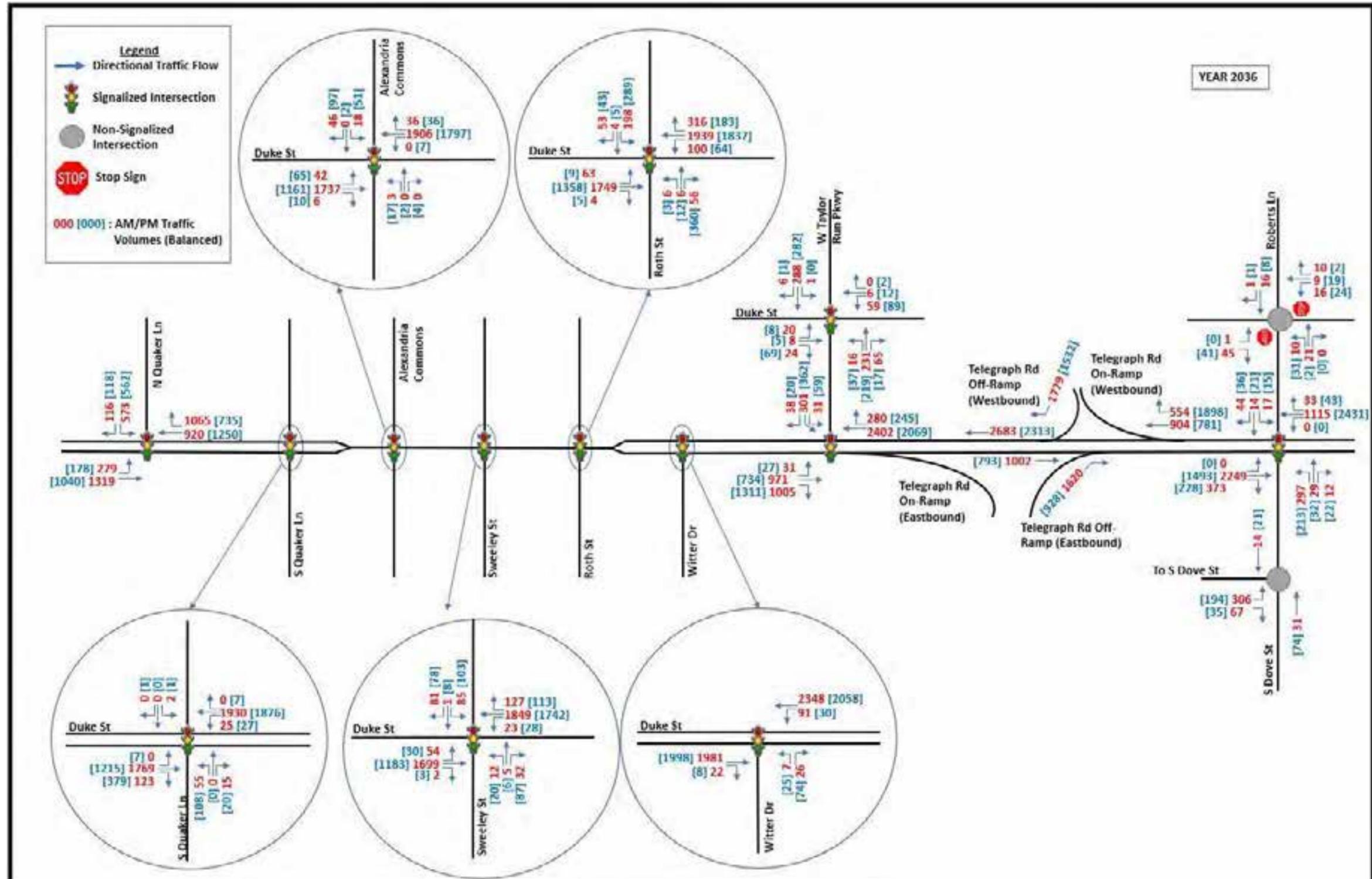


Figure 36: No-Build Design Year (2036) Peak Hour Volumes



## 6.2 Analysis Tools

The traffic operations analysis for the corridor was conducted using VISSIM 11 software, with signal timing data imported from the Synchro models developed for the No-Build opening year 2026 and No-Build design year 2036. VISSIM is a stochastic traffic microsimulation analysis tool that utilizes driver and vehicle characteristics determined by statistical distributions using random number seeds. The traffic simulation analysis and methodology were performed per *Virginia Department of Transportation (VDOT) Traffic Operation and Safety Analysis Manual (TOSAM)* – Version 2.0 guidelines.

## 6.3 Measures of Effectiveness

The Measures of Effectiveness quantify the traffic flow through intersections and freeway facilities and provides a basis for evaluating the performance of a transportation network. MOEs are reported based on the type of facility, as well as the analysis software utilized. Reported MOEs are consistent with *VDOT TOSAM* guidance. A summary of the VISSIM MOEs evaluated for the study intersections are presented below:

- Microsimulation Delay (seconds/vehicle)
- Maximum Queue Length (feet)

Level of Service (LOS) is a graded scale used to represent intersection delay (the delay associated with vehicles slowing in advance of an intersection, the time spent stopped on an intersection approach, the time spent as vehicles move up in the queue, and the time needed for vehicles to accelerate to their desired speed). It is important to point out that delay calculations from the Highway Capacity Manual (HCM) methodology (deterministic) and simulation (stochastic) are different, especially for congested conditions (e.g., queue spillover between intersections, etc.). Therefore, the LOS represented in the results tables does not necessarily provide information on congestion caused by complicated interactions between intersections. To provide a measurement/threshold for intersection operations, microsimulation delay has been translated to the same levels of service used by the HCM methodology. LOS is measured on a scale of “A” through “F,” with LOS A representing the best operating conditions and LOS F representing the worst, based on the delay experienced at the intersection during the analysis period.

As indicated in the Highway Capacity Manual (6th Edition), LOS at an intersection is based upon the average amount of delay (seconds/vehicle) experienced by vehicles approaching the intersection. LOS thresholds for the varying analysis types are shown in Table 11.

Table 11. HCM Intersection LOS Criteria Based on Average Control Delay

LOS	Signalized Intersection Delay Thresholds (sec/veh)	Unsignalized Intersection Delay Thresholds (sec/veh)
A	< 10	< 10
B	> 10 – 20	> 10 – 15
C	>20 – 35	>15 – 25
D	>35 – 55	>25 – 35
E	>55 – 80	>35 – 50
F	>80	>50

Source: Highway Capacity Manual (6th Edition)

## 6.4 Microsimulation Runs

Based upon the results of sample size for existing conditions model calibration calculation, ten (10) VISSIM microsimulation runs meet the required tolerance error and confidence interval. The VISSIM MOEs evaluated for the study corridor were based on the ten (10) simulation runs for both No-Build future year conditions.

## 6.5 No-Build Condition Assumptions

Following assumptions were made for development of future year No-Build conditions:

- Access from the southbound W. Taylor Run Parkway to the Telegraph Road on-ramp was maintained and exclusive pedestrian phase was included for operational analysis of Duke Street and W. Taylor Run Parkway.
- No Turn On Red (NTOR) restrictions were maintained for the westbound right-turn approach at Duke Street and N. Quaker Lane, and the westbound and northbound right-turn approaches of Duke Street and Roth Street/Cambridge Road.
- A Cycle length of 120 seconds is maintained for all the signalized intersections of the No-Build conditions scenarios, which also matches the cycle length of the existing conditions. The signal timing splits and offsets also match with existing conditions.
- The forecasting process used the latest Metropolitan Washington Council of Governments (MWCOG) travel demand forecasting model (version 2.4) that took into consideration future development in the City and surrounding jurisdictions. High frequency transit service assumed on Duke Street.



### 6.6 Intersection Operations: Future 2026 No-Build Conditions VISSIM Analysis

Operational analysis was performed at each of the study intersections for the Future 2026 No-Build Conditions scenario. Table 12 and Table 13 provide summary of the average AM and PM peak hour delay, LOS and maximum queue length for each movement for the study intersections along the study corridor of Duke Street.

The results show that almost of the intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak hours, except for Cambridge Road and Service Road which is projected to operate with overall intersection LOS F during the AM peak hour and W. Taylor Run Parkway and Service Road is projected to operate with overall intersection LOS F during the PM peak hour.

The southbound left-turn movement at the intersection of Duke Street and N. Quaker Lane is projected to operate at LOS D during the AM peak hour and LOS F during the PM peak hour. The westbound right-turn movement at the intersection of Duke Street at Roth Street is projected to operate at LOS B and LOS C during the AM and PM peak hours, respectively. Southbound left-turns to Telegraph Road at the intersection of Duke Street and W. Taylor Run Parkway are projected to operate at LOS A and LOS B during the AM and PM peak hours, respectively.

Table 12: No-Build Year (2026) AM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	272	280	28.4	C	18.2	B	366
		EBT	1286	1293	11.8	B			366
		WBT	898	855	16.1	B			422
		WBR	1039	972	5.3	A			399
		SBL	559	557	50.2	D			438
		SBR	113	114	34.2	C			396
2	Duke St and S Quaker Ln	EBL	0	0	0.0	A	6.3	A	438
		EBT	1725	1734	6.8	A			438
		EBR	120	116	2.8	A			466
		WBL	24	26	17.2	B			356
		WBT	1882	1774	4.3	A			356
		WBR	0	0	0.0	A			371
		NBL	54	52	49.5	D			136
		NBT	0	0	0.0	A			136
		NBR	14	15	26.5	C			137
		SBL	2	2	39.0	D			21
		SBT	0	0	0.0	A			21
		SBR	0	0	0.0	A			24

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	41	41	38.7	D	5.5	A	332
		EBT	1695	1702	2.5	A			332
		EBR	6	7	2.3	A			366
		WBL	0	0	0.0	A			651
		WBT	1859	1755	6.7	A			651
		WBR	35	32	12.2	B			673
		NBL	3	3	39.3	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	17	19	58.0	E			135
		SBT	0	0	0.0	A			135
SBR	45	42	18.1	B	145				
4	Duke St and Sweeley St	EBL	53	55	27.6	C	7.8	A	500
		EBT	1657	1667	7.2	A			500
		EBR	2	2	4.0	A			508
		WBL	22	23	27.1	C			581
		WBT	1804	1699	4.7	A			581
		WBR	123	114	5.2	A			597
		NBL	11	10	50.7	D			84
		NBT	5	5	52.5	D			84
		NBR	32	30	18.3	B			95
		SBL	83	84	53.4	D			145
		SBT	1	1	39.8	D			145
SBR	79	76	12.3	B	145				
5	Duke St at Roth St/Cambridge Rd	EBL	61	57	80.4	F	16.5	B	820
		EBT	1706	1716	16.3	B			820
		EBR	4	4	17.9	B			827
		WBL	98	93	30.7	C			756
		WBT	1891	1782	13.5	B			756
		WBR	308	285	10.5	B			756
		NBL	6	5	32.9	C			91
		NBT	6	6	39.1	D			91
		NBR	55	54	14.7	B			93
		SBL	193	168	33.1	C			118
		SBT	4	3	24.1	C			118
		SBR	52	47	8.4	A			141



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
51	Cambridge Rd and Service Rd	EBT	9	7	244.4	F	88.0	F	1331
		EBR	221	192	241.2	F			1331
		WBL	28	26	79.7	F			75
		WBT	0	0	0.0	A			88
		NBL	366	314	0.6	A			37
		NBR	42	34	0.4	A			37
6	Duke St and Witter Dr	EBT	1932	1918	8.5	A	8.5	A	528
		EBR	21	21	12.0	B			535
		WBL	89	82	19.8	B			677
		WBT	2290	2151	7.8	A			677
		NBL	7	7	55.4	E			78
		NBR	26	25	19.2	B			97
7	Duke St and W Taylor Run Pkwy	EBL	31	27	58.9	E	20.6	C	92
		EBT (Continue on Duke St)	947	946	15.7	B			781
		EBT (to Telegraph Rd)	980	969	18.8	B			787
		WBT	2342	2195	21.8	C			1005
		WBR	273	246	48.1	D			941
		SBL (To Duke St)	31	29	10.6	B			118
		SBL (To Telegraph Rd)	294	290	9.7	A			118
		SBR	37	37	4.5	A			135
71	W Taylor Run Pkwy and Service Rd	EBL	19	19	22.8	C	22.9	C	90
		EBT	8	8	20.5	C			90
		EBR	23	22	35.0	D			90
		WBL	57	55	48.6	D			98
		WBT	6	6	29.7	C			98
		WBR	0	0	0.0	A			98
		NBL	15	14	5.4	A			123
		NBT	225	204	0.9	A			141
		NBR	63	57	0.4	A			138
		SBL	1	1	26.4	C			347
		SBT	281	278	38.0	D			347
SBR	6	6	37.5	D	346				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
8	Duke St WB and Telegraph Rd Off-ramp	WBT	881	876	0.3	A	1.1	A	10
		SBR	1735	1564	1.5	A			1366
9	Duke St WB and Telegraph Rd On-ramp	WBR	540	525	0.3	A	0.3	A	20
10	Duke St and S Dove St/Roberts Ln	EBT	2193	2062	15.4	B	14.8	B	459
		EBR	364	327	19.1	B			454
		WBT	1088	1100	10.8	B			310
		WBR	33	33	6.9	A			43
		NBL	290	260	21.3	C			565
		NBT	29	24	22.1	C			565
		NBR	11	10	17.1	B			568
		SBL	16	15	33.5	C			116
		SBT	13	14	24.1	C			116
SBR	43	42	6.1	A	118				



Table 13: No-Build Year (2026) PM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
1	Duke St and N Quaker Ln	EBL	173	167	40.2	D	42.1	D	2177				
		EBT	1014	914	60.3	E			2177				
		WBT	1219	1227	21.6	C			454				
		WBR	717	705	7.5	A			407				
		SBL	548	532	95.6	F			801				
		SBR	136	131	77.4	E			778				
		EBL	7	6	58.1	E			443				
2	Duke St and S Quaker Ln	EBT	1185	1094	41.3	D	22.7	C	443				
		EBR	369	339	8.4	A			472				
		WBL	27	29	25.7	C			364				
		WBT	1830	1826	12.0	B			364				
		WBR	7	6	8.3	A			379				
		NBL	105	103	55.0	E			210				
		NBT	0	0	0.0	A			210				
		NBR	19	19	39.6	D			211				
		SBL	1	1	27.8	C			23				
		SBT	0	0	0.0	A			23				
		SBR	1	1	8.3	A			27				
		3	Duke St and Alexandria Commons	EBL	63	57			47.5	D	25.1	C	326
				EBT	1132	1045			34.0	C			326
EBR	10			8	25.6	C	359						
WBL	7			6	20.8	C	650						
WBT	1753			1753	16.1	B	650						
WBR	35			34	16.1	B	701						
NBL	16			16	51.0	D	48						
NBT	2			1	31.6	C	48						
NBR	4			4	22.7	C	48						
SBL	50			51	66.3	E	182						
SBR	95			92	57.2	E	193						

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
4	Duke St and Sweeley St	EBL	30	28	48.8	D	34.9	C	688				
		EBT	1154	1051	74.2	E			688				
		EBR	3	3	68.2	E			698				
		WBL	28	30	21.1	C			739				
		WBT	1699	1694	10.7	B			739				
		WBR	110	109	10.3	B			755				
		NBL	19	18	55.3	E			186				
		NBT	6	5	49.7	D			186				
		NBR	85	86	47.6	D			197				
		SBL	100	100	58.5	E			158				
		SBT	8	7	46.0	D			158				
		SBR	77	76	15.0	B			158				
		5	Duke St at Roth St/Cambridge Rd	EBL	9	7			84.2	F	38.6	D	840
				EBT	1324	1222			60.9	E			840
EBR	5			4	99.4	F	848						
WBL	62			64	53.4	D	765						
WBT	1791			1788	22.5	C	765						
WBR	179			177	21.8	C	765						
NBL	3			2	61.3	E	204						
NBT	11			7	89.2	F	204						
NBR	351			246	73.9	E	206						
SBL	282			250	19.2	B	117						
SBT	5			6	10.6	B	117						
SBR	42			37	12.6	B	141						
51	Cambridge Rd and Service Rd			EBT	45	35	41.1	E	28.1	D			315
				EBR	281	247	39.6	E					315
		WBL	48	46	70.6	F	101						
		WBT	0	0	0.0	A	114						
		NBL	193	163	0.7	A	34						
		NBR	36	29	0.2	A	34						
		EBT	1949	1753	62.9	E	807						
6	Duke St and Witter Dr	EBR	8	6	118.4	F	35.3	D	814				
		WBL	30	32	42.2	D			693				
		WBT	2008	2012	10.1	B			693				
		NBL	24	25	72.9	E			169				
		NBR	72	68	48.7	D			189				



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
7	Duke St and W Taylor Run Pkwy	EBL	27	22	67.5	E	25.3	C	74				
		EBT (Continue on Duke St)	716	650	13.3	B			788				
		EBT (to Telegraph Rd)	1278	1143	33.8	C			807				
		WBT	2018	2031	23.0	C			900				
		WBR	239	232	55.2	E			852				
		SBL (To Duke St)	57	55	10.5	B			139				
		SBL (To Telegraph Rd)	353	332	11.6	B			139				
		SBR	19	17	23.6	C			156				
		71	W Taylor Run Pkwy and Service Rd	EBL	8	9			110.0	F	109.3	F	206
				EBT	5	6			117.1	F			206
EBR	67			62	129.6	F	206						
WBL	87			71	613.1	F	860						
WBT	11			8	544.4	F	860						
WBR	2			2	542.9	F	860						
NBL	36			33	7.9	A	128						
NBT	213			207	1.5	A	119						
NBR	16			15	1.3	A	145						
SBL	0			0	0.0	A	530						
SBT	275			270	57.8	E	530						
SBR	1	1	33.0	C	530								
8	Duke St WB and Telegraph Rd Off-ramp	WBT	762	767	0.1	A	0.8	A	0				
		SBR	1495	1500	1.2	A			177				
9	Duke St WB and Telegraph Rd On-ramp	WBR	1851	1846	0.9	A	0.9	A	180				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	EBT	1456	1387	10.5	B	13.8	B	368
		EBR	222	213	9.0	A			182
		WBT	2371	2379	14.9	B			882
		WBR	42	40	10.0	A			43
		NBL	208	200	25.6	C			296
		NBT	32	33	24.5	C			296
		NBR	21	20	19.2	B			299
		SBL	14	13	30.4	C			117
		SBT	20	19	20.2	C			117
		SBR	35	33	7.5	A			118

Signal timings for 2026 No-Build condition are shown on Appendix K. VISSIM results for 2026 No-Build Conditions is presented in the Appendix M.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2026 No-Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 14 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 14 are the movements where the reported maximum queue length value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement storage bays during both peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 ft. is projected to experience a maximum queue length of 2961 ft. during the PM peak hour.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersections of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. However, the eastbound



right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. It is to be noted that the westbound left-turn movement with storage of 70 ft. is projected to experience a maximum queue length of 628 ft. and 731 ft. during the AM and PM peak hours, respectively.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, westbound right-turn, and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 1594 ft. and 841 ft. during the AM and PM peak hours, respectively. The results indicates that the same movement is projected to experience an average queue length of 173 ft. and 137 ft. during the AM and PM peak hours, respectively. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 792 ft. and 806 ft. during the AM and PM peak hours, respectively.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound right-turn movements are projected to experience maximum queue lengths 357 ft. and 514 ft. during the AM and PM peak hours. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 918 ft. during the PM peak hour. Simulation shows extensive queuing occurring on the eastbound rightmost through lane of Duke Street which extends from W. Taylor Run Parkway to N. Quaker Lane.

At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 1373 ft. and 300 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1259 ft. during the AM peak hour and 186 ft. during the PM peak hour.

Table 14: No-Build Year (2026) AM and PM Summary of Intersection Queues (feet)

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	200	67	368	1943	2961
		EBT	360	67	368	1943	2961
		WBT	330	58	429	128	451
		WBR	300	19	406	20	412
		SBL	1290	140	498	525	1158
		SBR	1270	48	451	463	1144
2	Duke St and S Quaker Ln	EBL	200	56	443	239	451
		EBT	330	56	443	239	451
		EBR	300	63	472	262	480
		WBL	80	19	353	95	371
		WBT	210	19	353	95	371
		WBR	210	20	367	102	386
		NBL	335	19	137	49	252
		NBT	335	19	137	49	252
		NBR	335	15	138	47	253
		SBL	40	0	21	0	23
		SBT	40	0	21	0	23
		SBR	40	0	24	0	27
3	Duke St and Alexandria Commons	EBL	105	12	320	164	326
		EBT	210	12	320	164	326
		EBR	210	14	353	190	359
		WBL	315	73	643	165	656
		WBT	520	73	643	165	656
		WBR	520	33	670	137	706
		NBL	50	1	23	4	50
		NBT	50	1	23	4	50
		NBR	50	1	22	4	49
		SBL	215	9	134	56	182
		SBT	215	9	134	56	182
		SBR	215	12	145	64	193
4	Duke St and Sweeley St	EBL	190	45	502	495	699
		EBT	520	46	502	495	699
		EBR	520	48	511	505	709
		WBL	70	34	628	92	731
		WBT	225	34	628	92	731
		WBR	225	36	643	97	747
		NBL	230	6	79	26	197
		NBT	230	6	79	26	197
		NBR	230	9	89	34	208
		SBL	110	27	148	33	159
		SBT	110	27	148	33	159
		SBR	110	27	148	33	159
5	Duke St at Roth St / Cambridge Rd	EBL	115	213	815	655	830
		EBT	350	213	815	655	830
		EBR	350	215	822	663	838
		WBL	230	234	761	357	771
		WBT	670	234	761	357	771
		WBR	670	234	761	357	771
		NBL	150	6	97	146	200
		NBT	150	6	97	146	200
NBR	150	8	99	147	202		



Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak			
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)		
		SBL	40	76	121	62	117		
		SBT	40	76	121	62	117		
		SBR	40	96	144	79	141		
51	Cambridge Rd and Service Rd	EBT	1330	1119	1591	71	341		
		EBR	1330	1115	1590	68	341		
		WBL	825	7	71	17	102		
		WBT	825	7	84	19	116		
		NBL	40	1	44	2	68		
		NBR	40	1	44	2	68		
		6	Duke St and Witter Dr	EBT	675	78	542	682	806
				EBR	675	80	549	690	814
WBL	215			107	721	70	700		
WBT	700			107	721	70	700		
NBL	170			3	78	21	177		
NBR	170			5	97	30	196		
7	Duke St and W Taylor Run Pkwy	EBL	165	10	76	8	69		
		EBT (Continue on Duke St)	710	177	788	124	793		
		EBT (to Telegraph Rd)	710	255	792	512	806		
		WBT	1955	335	1962	223	900		
		WBR	110	173	1594	137	841		
		SBL (To Duke St)	140	29	127	61	139		
		SBL (To Telegraph Rd)	140	29	127	61	139		
71	W Taylor Run Pkwy and Service Rd	SBR	140	38	144	72	156		
		EBL	70	7	93	54	211		
		EBT	70	7	93	54	211		
		EBR	70	7	93	54	211		
		WBL	320	12	109	740	918		
		WBT	320	12	109	740	918		
		WBR	320	12	109	740	918		
		NBL	40	2	120	6	124		
		NBT	40	2	139	5	115		
		NBR	40	2	136	7	141		
		SBL	650	73	358	116	515		
8	Duke St WB and Telegraph Rd Off-Ramp	SBT	650	73	358	116	515		
		SBR	180	73	357	115	514		
9	Duke St WB and Telegraph Rd On-Ramp	WBT	700	0	7	0	0		
		SBR	2400	1597	2197	1	70		
10	Duke St and S Dove St/Roberts Ln	WBR	225	0	35	2	226		
10	Duke St and S Dove St/Roberts Ln	EBT	1965	663	1501	42	506		
		EBR	260	193	1259	9	186		
		WBT	855	33	323	216	936		
		WBR	855	0	43	0	47		
		NBL	185	249	1373	54	300		
		NBT	185	249	1373	54	300		
		NBR	185	244	1376	53	303		
		SBL	50	7	116	7	117		
		SBT	50	7	116	7	117		
SBR	50	7	116	8	118				



### 6.7 Intersection Operations: Future 2036 No-Build Conditions VISSIM Analysis

Operational analysis was performed at each of the study intersections for the Future 2036 No-Build Conditions scenario. Table 15 and Table 16 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor.

The results show that all intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak hours, except for Cambridge Road and Service Road which is projected operate with overall intersection LOS F during the AM; W. Taylor Run Parkway and Service Road is projected to operate with overall intersection LOS F during the PM peak hour.

The southbound left-turn and right-turn movements at the intersection of Duke Street and N. Quaker Lane is projected to operate at LOS F during the PM peak hour. The westbound right-turn movement at the intersection of Duke Street at Roth Street is projected to operate at LOS B and LOS C during the AM and PM peak hours, respectively. Southbound left-turns to Telegraph Road at the intersection of Duke Street and W. Taylor Run Parkway are projected to operate at LOS A and LOS B during the AM and PM peak hours, respectively.

Table 15: No-Build Year (2036) AM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	279	289	30.6	C	19.2	B	368
		EBT	1319	1326	12.4	B			368
		WBT	920	853	16.5	B			441
		WBR	1065	975	5.2	A			416
		SBL	573	570	53.0	D			482
		SBR	116	117	38.6	D			413
2	Duke St and S Quaker Ln	EBL	0	0	0.0	A	6.5	A	437
		EBT	1769	1777	7.2	A			437
		EBR	123	120	3.0	A			466
		WBL	25	26	21.8	C			348
		WBT	1930	1775	4.3	A			348
		WBR	0	0	0.0	A			363
		NBL	55	53	48.9	D			137
		NBT	0	0	0.0	A			137
		NBR	15	16	28.2	C			139
		SBL	2	2	38.4	D			21
		SBT	0	0	0.0	A			21
		SBR	0	0	0.0	A			24

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	42	43	41.2	D	5.4	A	321
		EBT	1737	1746	2.6	A			321
		EBR	6	6	1.3	A			354
		WBL	0	0	0.0	A			652
		WBT	1906	1756	6.4	A			652
		WBR	36	32	11.8	B			647
		NBL	3	3	43.4	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	18	19	57.7	E			141
		SBT	0	0	0.0	A			141
4	Duke St and Sweeley St	EBL	54	55	30.5	C	8.4	A	576
		EBT	1699	1710	8.3	A			576
		EBR	2	2	9.9	A			585
		WBL	23	24	29.0	C			713
		WBT	1849	1701	4.7	A			713
		WBR	127	115	5.7	A			729
		NBL	12	12	46.8	D			85
		NBT	5	5	52.5	D			85
		NBR	32	32	17.8	B			95
		SBL	85	86	52.3	D			150
		SBT	1	1	35.9	D			150
5	Duke St at Roth St/Cambridge Rd	SBR	81	78	12.4	B	17.2	B	150
		EBL	63	60	82.1	F			821
		EBT	1749	1760	16.3	B			821
		EBR	4	5	13.8	B			828
		WBL	100	93	33.2	C			762
		WBT	1939	1786	14.6	B			762
		WBR	316	288	11.8	B			762
		NBL	6	5	35.9	D			96
		NBT	6	6	39.4	D			96
		NBR	56	57	15.7	B			98
		SBL	198	171	32.1	C			120
5	Duke St at Roth St/Cambridge Rd	SBT	4	3	41.9	D	17.2	B	120
		SBR	53	47	8.1	A			143



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
51	Cambridge Rd and Service Rd	EBT	10	8	231.8	F	88.1	F	1582
		EBR	227	192	245.1	F			1582
		WBL	28	29	77.0	F			77
		WBT	0	0	0.0	A			91
		NBL	375	319	0.6	A			38
		NBR	43	36	0.2	A			38
6	Duke St and Witter Dr	EBT	1981	1968	10.4	B	10.6	B	609
		EBR	22	21	15.0	B			616
		WBL	91	82	22.5	C			722
		WBT	2348	2162	10.0	A			722
		NBL	7	7	56.6	E			77
		NBR	26	25	20.2	C			97
7	Duke St and W Taylor Run Pkwy	EBL	31	27	64.9	E	21.5	C	84
		EBT (Continue on Duke St)	971	972	15.8	B			788
		EBT (to Telegraph Rd)	1005	996	19.6	B			796
		WBT	2402	2208	23.3	C			1045
		WBR	280	250	48.6	D			951
		SBL (To Duke St)	31	30	9.3	A			126
		SBL (To Telegraph Rd)	301	299	9.8	A			126
		SBR	38	37	4.8	A			143
71	W Taylor Run Pkwy and Service Rd	EBL	20	20	20.3	C	24.0	C	96
		EBT	8	8	19.0	B			96
		EBR	24	22	34.1	C			96
		WBL	59	58	60.6	E			124
		WBT	6	7	47.1	D			124
		WBR	0	0	0.0	A			124
		NBL	16	14	4.9	A			129
		NBT	231	206	0.9	A			148
		NBR	65	57	0.4	A			145
		SBL	1	1	32.8	C			381
		SBT	288	286	37.7	D			381
		SBR	6	6	31.1	C			381

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
8	Duke St WB and Telegraph Rd Off-ramp	WBT	904	896	0.3	A	1.4	A	0
		SBR	1779	1567	1.6	A	1.9	A	1818
9	Duke St WB and Telegraph Rd On-ramp	WBR	554	540	0.3	A	0.4	A	38
10	Duke St and S Dove St/Roberts Ln	EBT	2249	2089	14.8	B	14.4	B	436
		EBR	373	330	18.7	B			426
		WBT	1115	1129	10.4	B			299
		WBR	33	33	7.6	A			47
		NBL	297	265	21.5	C			540
		NBT	29	24	23.6	C			540
		NBR	12	10	19.4	B			542
		SBL	17	15	36.9	D			119
SBT	14	14	24.2	C	119				
SBR	44	42	7.1	A	121				



Table 16: No-Build Year (2036) PM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	178	149	54.1	D	54.8	D	3005
		EBT	1040	824	99.4	F			3005
		WBT	1250	1258	21.6	C			452
		WBR	735	725	7.4	A			416
		SBL	562	525	120.6	F			1164
		SBR	118	110	100.0	F			1148
		2	Duke St and S Quaker Ln	EBL	7	5			54.3
EBT	1215			1022	56.9	E	450		
EBR	379			319	9.2	A	479		
WBL	27			28	21.6	C	366		
WBT	1876			1874	12.2	B	366		
WBR	7			6	7.5	A	380		
NBL	108			105	63.1	E	241		
NBT	0			0	0.0	A	241		
NBR	20			20	60.2	E	243		
SBL	1			1	36.3	D	23		
SBT	0			0	0.0	A	23		
SBR	1			1	14.4	B	27		
3	Duke St and Alexandria Commons			EBL	65	54	54.8	D	30.6
		EBT	1161	985	46.8	D	328		
		EBR	10	8	35.2	D	361		
		WBL	7	6	16.7	B	651		
		WBT	1797	1798	18.2	B	651		
		WBR	36	36	19.1	B	703		
		NBL	17	17	61.0	E	64		
		NBT	2	1	32.7	C	64		
		NBR	4	4	35.7	D	63		
		SBL	51	52	69.5	E	181		
SBR	97	94	59.2	E	192				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
4	Duke St and Sweeley St	EBL	30	25	54.7	D	38.7	D	696				
		EBT	1183	1014	85.7	F			696				
		EBR	3	2	86.4	F			706				
		WBL	28	30	21.2	C			774				
		WBT	1742	1741	11.9	B			774				
		WBR	113	112	12.1	B			790				
		NBL	20	19	56.4	E			201				
		NBT	6	5	58.5	E			201				
		NBR	87	87	52.1	D			212				
		SBL	103	103	56.5	E			158				
		SBT	8	8	57.3	E			158				
		SBR	78	78	16.3	B			158				
		5	Duke St at Roth St/Cambridge Rd	EBL	9	6			83.6	F	39.0	D	837
				EBT	1358	1194			63.4	E			837
				EBR	5	3			101.5	F			845
WBL	64			66	52.3	D	774						
WBT	1837			1843	23.0	C	774						
WBR	183			183	22.1	C	774						
NBL	3			3	64.7	E	200						
NBT	12			8	90.0	F	200						
NBR	360			259	69.4	E	202						
SBL	289			256	18.9	B	117						
SBT	5			6	26.7	C	117						
SBR	43			38	11.1	B	141						
51	Cambridge Rd and Service Rd			EBT	45	34	43.8	E	30.8	D			332
				EBR	288	254	44.3	E					331
				WBL	49	46	75.1	F					101
		WBT	0	0	0.0	A	115						
		NBL	198	168	1.3	A	78						
		NBR	38	31	0.2	A	78						
		6	Duke St and Witter Dr	EBT	1998	1746	62.8	E			35.7	D	811
				EBR	8	6	107.9	F					819
WBL	30			32	43.1	D	693						
WBT	2058			2073	11.6	B	693						
NBL	25			26	75.3	E	170						
NBR	74	73	46.9	D	190								



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
7	Duke St and W Taylor Run Pkwy	EBL	27	22	65.7	E	25.5	C	67				
		EBT (Continue on Duke St)	734	648	13.8	B			791				
		EBT (to Telegraph Rd)	1311	1141	33.4	C			798				
		WBT	2069	2085	23.7	C			908				
		WBR	245	236	54.9	D			883				
		SBL (To Duke St)	59	55	12.0	B			139				
		SBL (To Telegraph Rd)	362	339	10.9	B			139				
		SBR	20	18	26.3	C			156				
		71	W Taylor Run Pkwy and Service Rd	EBL	8	9			112.9	F	114.4	F	234
				EBT	5	7			118.8	F			234
EBR	69			65	141.8	F	234						
WBL	89			68	664.1	F	940						
WBT	12			9	637.2	F	940						
WBR	2			2	640.8	F	940						
NBL	37			33	8.8	A	132						
NBT	219			209	1.6	A	123						
NBR	17			16	1.1	A	148						
SBL	0			0	0.0	A	595						
SBT	282			277	56.3	E	595						
SBR	1	1	22.9	C	594								
8	Duke St WB and Telegraph Rd Off-ramp	WBT	781	788	0.2	A	0.9	A	2				
		SBR	1532	1537	1.3	A			406				
9	Duke St WB and Telegraph Rd On-ramp	WBR	1898	1902	1.1	A	1.1	A	194				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	EBT	1493	1412	10.4	B	13.9	B	361
		EBR	228	215	9.8	A			221
		WBT	2431	2456	15.2	B			927
		WBR	43	42	10.8	B			51
		NBL	213	199	25.1	C			335
		NBT	32	34	27.3	C			335
		NBR	22	20	17.0	B			338
		SBL	15	14	29.8	C			124
		SBT	21	20	17.2	B			124
		SBR	36	35	6.5	A			123

Signal timings for 2036 No-Build condition are shown on Appendix L. VISSIM results for 2036 No-Build Conditions is presented in the Appendix M.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2036 No-Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 17 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 17 are the movements where the reported maximum queue lengths value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement during AM and PM peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 feet is projected to experience a maximum queue length of 3005 ft during the PM peak hour.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, westbound left-turn, and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour.



Table 17: No-Build Year (2036) PM Summary of Intersection Queues (feet)

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound left-turn movement with storage of 70 feet is projected to experience a maximum queue length of 713 ft and 774 ft. during the AM and PM peak hours, respectively.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement length has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, westbound right-turn, and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 951 ft. and 883 ft. during the AM and PM peak hours, respectively. The results indicates that the same movement is projected to experience an average queue length of 160 ft. and 137 ft. during the AM and PM peak hours, respectively. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 126 ft. and 139 ft. during the AM and PM peak hours, respectively.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound right-turn movements are projected to experience maximum queue lengths 381 ft. and 594 ft. during the AM and PM peak hours. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 940 ft. during the PM peak hour. Simulation shows extensive queuing occurring on the eastbound rightmost through lane of Duke Street which extends from W. Taylor Run Parkway to N. Quaker Lane.

At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn, and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 ft. is projected to experience a maximum queue length of 540 ft. and 335 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 426 ft. and 221 ft. during the AM and PM peak hours, respectively.

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	200	72	368	1995	3005
		EBT	360	72	368	1995	3005
		WBT	330	59	441	129	452
		WBR	300	20	416	24	416
		SBL	1290	139	482	556	1164
		SBR	1270	53	413	475	1148
2	Duke St and S Quaker Ln	EBL	200	61	437	246	450
		EBT	330	61	437	246	450
		EBR	300	69	466	270	479
		WBL	80	21	348	95	366
		WBT	210	21	348	95	366
		WBR	210	22	363	101	380
		NBL	335	19	137	49	241
		NBT	335	19	137	49	241
		NBR	335	15	139	46	243
		SBL	40	0	21	0	23
		SBT	40	0	21	0	23
		SBR	40	0	24	0	27
3	Duke St and Alexandria Commons	EBL	105	14	321	169	328
		EBT	210	14	321	169	328
		EBR	210	15	354	196	361
		WBL	315	69	652	160	651
		WBT	520	69	652	160	651
		WBR	520	31	647	138	703
		NBL	50	1	23	5	64
		NBT	50	1	23	5	64
		NBR	50	1	22	5	63
		SBL	215	9	141	52	181
		SBT	215	9	141	52	181
		SBR	215	12	152	59	192
4	Duke St and Sweeley St	EBL	190	50	576	497	696
		EBT	520	51	576	497	696
		EBR	520	53	585	507	706
		WBL	70	32	713	90	774
		WBT	225	32	713	90	774
		WBR	225	33	729	96	790
		NBL	230	7	85	28	201
		NBT	230	7	85	28	201
		NBR	230	10	95	36	212
		SBL	110	26	150	34	158
		SBT	110	26	150	34	158
		SBR	110	26	150	34	158
5	Duke St at Roth St	EBL	115	213	821	655	837
		EBT	350	213	821	655	837
		EBR	350	213	828	663	845
		WBL	230	217	762	359	774
		WBT	670	217	762	359	774
		WBR	670	217	762	359	774
		NBL	150	6	96	145	200
		NBT	150	6	96	145	200
NBR	150	8	98	147	202		



Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
		SBL	40	75	120	61	117
		SBT	40	75	120	61	117
		SBR	40	95	143	78	141
51	Cambridge Rd and Service Rd	EBT	1330	1070	1582	69	332
		EBR	1330	1067	1582	66	331
		WBL	825	8	77	14	101
		WBT	825	8	91	17	115
		NBL	40	1	38	2	78
		NBR	40	1	38	2	78
6	Duke St and Witter Dr	EBT	675	86	609	679	811
		EBR	675	88	616	686	819
		WBL	215	99	722	73	693
		WBT	700	99	722	73	693
		NBL	170	3	77	20	170
		NBR	170	5	97	29	190
7	Duke St and W Taylor Run Pkwy	EBL	165	10	84	7	67
		EBT (Continue on Duke St)	710	163	788	102	791
		EBT (to Telegraph Rd)	710	252	796	502	798
		WBT	1955	292	1045	228	908
		WBR	110	160	951	137	883
		SBL (To Duke St)	140	31	126	61	139
71	W Taylor Run Pkwy and Service Rd	SBL (To Telegraph Rd)	140	31	126	61	139
		SBR	140	39	143	72	156
		EBL	70	6	96	65	234
		EBT	70	6	96	65	234
		EBR	70	6	96	65	234
		WBL	320	16	124	772	940
		WBT	320	16	124	772	940
		WBR	320	16	124	772	940
		NBL	40	2	129	7	132
		NBT	40	2	148	6	123
		NBR	40	2	145	8	148
		SBL	650	74	381	126	595
		SBT	650	74	381	126	595
SBR	180	73	381	125	594		
8	Duke St WB and Telegraph Rd Off-Ramp	WBT	700	0	0	0	2
		SBR	2400	1025	1818	27	406
9	Duke St WB and Telegraph Rd On-Ramp	WBR	225	0	38	1	194
10	Duke St and S Dove St/Roberts Ln	EBT	1965	111	436	41	361
		EBR	260	36	426	9	221
		WBT	855	33	299	190	927
		WBR	855	1	47	0	51
		NBL	185	90	540	53	335
		NBT	185	90	540	53	335
		NBR	185	87	542	51	338
		SBL	50	8	119	7	124
SBT	50	8	119	7	124		
SBR	50	9	121	7	123		

### 6.8 Overall Summary for No-Build Conditions

The MOEs from the Existing conditions (2018) were compared with the MOEs for the No-Build conditions for 2026 and 2036. The results show that delays at all intersections are projected to get worse for No-Build future conditions compared to the Existing conditions for both AM and PM peak hours. Intersection MOE table for 2026 & 2036 No-Build condition are shown on Appendix M.

The intersection of Duke Street and N. Quaker Lane is projected to degrade from overall LOS D to LOS E during the PM peak hour. The intersection of Cambridge Road and Service Road is projected to degrade from overall LOS D to LOS E during the PM peak hour. The intersection of W. Taylor Run Parkway and Service Road is projected to operate at the same overall LOS F during the PM peak hour when 2036 No-Build conditions are compared to the Existing condition MOE results.

The queue lengths highlighted in Table 14 and Table 17 identify the turn bays whose lengths are insufficient to manage the queues, or the locations where through movement queuing blocks the turn bays. During both AM and PM peak hours, extensive queuing beyond the storage bays is seen for most of the eastbound and westbound approaches of Duke Street. Similar to the Existing conditions, during the PM peak period, extensive queuing occurs on the eastbound rightmost through lane on Duke Street which extends from W. Taylor Run Parkway to N. Quaker Lane and the southbound approach at the intersection of Duke Street and W. Taylor Run Parkway. Heavy queuing also occurs during the AM and PM peak hours for the westbound right-turn movements at Duke Street at N. Quaker Lane, and Duke Street at W. Taylor Run Parkway.

Based on the operational results for the No-Build conditions, future Build condition analysis will be performed with a focus on improving the safety and operations at Duke Street and W. Taylor Run Parkway and overall Duke Street corridor. Restricting left-turn movement from the southbound W. Taylor Run Parkway onto Telegraph Road on-ramp and adding new access from the eastbound Duke Street to the Telegraph Road on-ramp will be considered.



## 7 BUILD ANALYSIS OVERVIEW

This section summarizes the assumptions and results of the Build Conditions HCM Analysis using Synchro model for the Duke Street (Route 236) and W. Taylor Run Parkway Intersection Improvement Project, and provides the screening for VISSIM analysis. The weekday AM and PM peak hour Build Conditions models follows the agreed-upon methodology with the City. The study intersections, existing and proposed, are listed below and shown in Figure 37. Synchro results are presented in the Appendices O, P, Q, and R.

### Study Area Intersections - Existing

7. Duke Street and West Taylor Run Parkway
- 71(7a). West Taylor Run Parkway and Service Road
9. Duke Street and Dove Street/Robert's Lane

### Study Area Intersections - Proposed

- 81(8a). Duke Street eastbound and Telegraph Road on-ramp new
- 82(8b). Telegraph Road on-ramp at New Ramp from eastbound Duke Street

The existing traffic volumes were forecasted to the Future Year 2036, which was determined the design year for the project. The annual growth rate was determined by evaluating the Metropolitan Washington Council of Governments (MWCOC) model's Household and Employment rates, and future-year travel demand models were then used to develop post-processed traffic volumes. Travel demand model output for the year 2045 is based on the assumption that the southbound left-turn traffic from W. Taylor Run Parkway to the on-ramp is restricted, and new access to Telegraph Road on-ramp from Duke Street to the east of Telegraph Road is assumed. Growth rates were developed for the individual links on Duke Street. The following links were evaluated to determine the growth rate on the different sections of the Duke Street corridor:

1. From S. Van Dorn Street to N Pickett Street, EB and WB
2. From N Pickett Street to Jordan Street, EB and WB
3. From Jordan Street to N Quaker Lane, EB and WB
4. From N Quaker Lane to Telegraph Road, EB and WB
5. From Telegraph Road to Diagonal Road, EB and WB

To determine the growth rate on Duke Street, the growth rates for the eastbound and westbound directions were combined. In addition to that, the weighted average was taken for the links, from N. Quaker Lane to Telegraph Road, and from Telegraph Road to Diagonal Road, to determine the single growth rate for Duke Street between N. Quaker Lane and Diagonal Road. The Future year demand model produced a growth rate of -0.3% per year for the section of Duke Street between N. Quaker Lane and Diagonal Road.

Based upon the evaluation, the project team identified and agreed upon an annual growth rate of 0.25% for build conditions. Growth rate of 0.25% per year is the conservative approach to analyze the Build conditions, considering possible high-density development on the Duke Street corridor which is not included in the MWCOC model. Growth rate of 0.25% (compound method) was applied to all movements including Service Road. This growth rate is also

consistent with the growth rate used for the East Eisenhower Small Area Plan (EESAP) and Duke Street Transitway Project.

### 7.1 Build Condition Alternatives

Based on the community input from previous meetings, SMART SCALE application proposed improvements, the No-Build operational analysis results, safety analysis, as well as field investigations, the study team identified operational and safety deficiencies within the study area and developed a preliminary list of design opportunities and constraints. Alternative Analysis was performed for an initial screening using Synchro software to determine the optimal configuration of Duke Street and W. Taylor Run Parkway, Duke Street eastbound and Telegraph Road on-Ramp, and Telegraph Road on-ramp at New Ramp (from eastbound Duke Street). Alternatives were compared to the No-Build conditions. No-Build conditions do not include new intersections: Duke Street eastbound at Telegraph Road on-ramp, and Telegraph Road on-ramp at New Ramp (from eastbound Duke Street). No-Build conditions also maintains the access from W. Taylor Run Parkway to the southbound Telegraph Road on-ramp.

Alternatives considered for Synchro analysis are shown on Figure 38 through Figure 41. Figure 38 through Figure 40 presents the alternatives for the intersections of Duke Street eastbound and Telegraph Road on-ramp new, and Telegraph Road on-ramp at New Ramp from eastbound Duke Street. Figure 41 present the concept for the intersection of Duke Street at W. Taylor Run Parkway. Note that Figure 41 shows both the slip lane from the westbound Duke Street to service road, and the westbound right-turn lane at Duke Street and W. Taylor Run Parkway. For the Alternative analysis, slip lane was considered for Build conditions and the westbound right-turn lane was considered for No-Build conditions at the intersection of Duke Street and W. Taylor Run Parkway. Alternatives were analyzed for 2036 Build conditions using HCM methodology in Synchro software. For better comparison of the results, 2036 No-Build conditions were also analyzed using HCM methodology in Synchro software. Note that the results in the Section 6 of this document are for No-Build conditions using VISSIM analysis.

Two (2) selected alternatives for these study intersections will advance for a more detailed screening using VISSIM analysis. All analysis scenarios were evaluated using Synchro during the weekday AM and PM peak hours only for the design year 2036. A Cycle length of 120 seconds is maintained for all the signalized intersections of the Build conditions alternatives, which also matches the cycle length of the existing and No-Build conditions. However, the signal timing splits and offsets were optimized for the Build conditions. WSP developed the following alternatives for the Build conditions.:

#### Alternative 1:

Alternative 1 proposed concept plan is presented in Figure 37, Figure 38 and Figure 41. A brief description for the new intersections and cluster intersection of Duke Street and W. Taylor Run Parkway with the Service Road, and traffic control assumptions are listed below.

#### Duke Street eastbound and Telegraph Road on-ramp new:

The proposed intersection is a traffic signal controlled three-legged intersection. Duke Street forms the east and west legs of the intersection. The north leg is formed by a one-way single lane connecting the proposed intersection to the Telegraph Road on-ramp from the westbound Duke Street. Eastbound left-turns from Duke Street operate with protected left turn phasing, while the eastbound through movement is free flowing.



Telegraph Road on-ramp at New Ramp (from eastbound Duke Street):

The left-turning vehicles from the eastbound Duke Street will be controlled by a Yield sign when merging onto the Telegraph Road on-ramp. No geometric and operational changes are proposed to the Telegraph Road off-ramp and on-ramps.

Duke Street and West Taylor Run Parkway, and West Taylor Run Parkway and Service Road:

The westbound right-turn movements are eliminated at the intersection of Duke Street and West Taylor Run Parkway, and a right-turn slip ramp is proposed from the westbound Duke Street to Service Road resulting in elimination of an exclusive right-turn signal phase for the westbound right-turn movement.

**Alternative 1A:**

Alternative 1A concept plan is presented in Figure 38 and Figure 41. A brief description for the new intersections and cluster intersection of Duke Street and W. Taylor Run Parkway with the Service Road, and traffic control assumptions are also listed.

Duke Street eastbound and Telegraph Road on-ramp new:

All geometric and operational features are the same as Alternative 1.

Telegraph Road on-ramp at New Ramp (from eastbound Duke Street):

The intersection is signalized. Two lanes are maintained on Telegraph Road on-ramp from westbound Duke Street.

Duke Street and West Taylor Run Parkway and West Taylor Run Parkway and Service Road.

All geometric and operational features are the same as Alternative 1. Slip lane option is considered at Duke Street and W. Taylor Run Parkway.

**Alternative 2:**

Alternative 2 concept plan is presented in Figure 39 and Figure 41. A brief description for the new intersections and cluster intersection of Duke Street and W. Taylor Run Parkway with the Service Road, and traffic control assumptions are also listed.

Duke Street eastbound and Telegraph Road on-ramp:

All geometric and operational features are the same as Alternative 1.

Telegraph Road on-ramp at New Ramp (from eastbound Duke Street):

The intersection will be controlled by a Yield sign, however, the on-ramp from the westbound Duke Street is reduced from two lanes to one lane.

Duke Street and West Taylor Run Parkway and West Taylor Run Parkway and Service Road.

All geometric and operational features are the same as Alternative 1.

**Alternative 3:**

Alternative 3 concept plan is presented in Figure 40 and Figure 41. A brief description for the new intersections and cluster intersection of Duke Street and W. Taylor Run Parkway with the Service Road, and traffic control assumptions are also listed.

Duke Street eastbound and Telegraph Road on-ramp:

All geometric and operational features are the same as Alternative 1. However, Telegraph Road off-ramp to the westbound Duke Street is eliminated. The off-ramp is replaced by two (2) right-turn lanes at the intersection which is signalized.

Telegraph Road on-ramp at New Ramp (from eastbound Duke Street):

All geometric and operational features are the same as Alternative 1.

Duke Street and West Taylor Run Parkway and West Taylor Run Parkway and Service Road.

All geometric and operational features are the same as Alternative 1.



Figure 37: Study Intersections – Build Analysis



Figure 38: Duke Street eastbound and Telegraph Road on-ramp new, and Telegraph Road on-ramp at New Ramp from eastbound Duke Street concept for Alternatives 1 and 1A



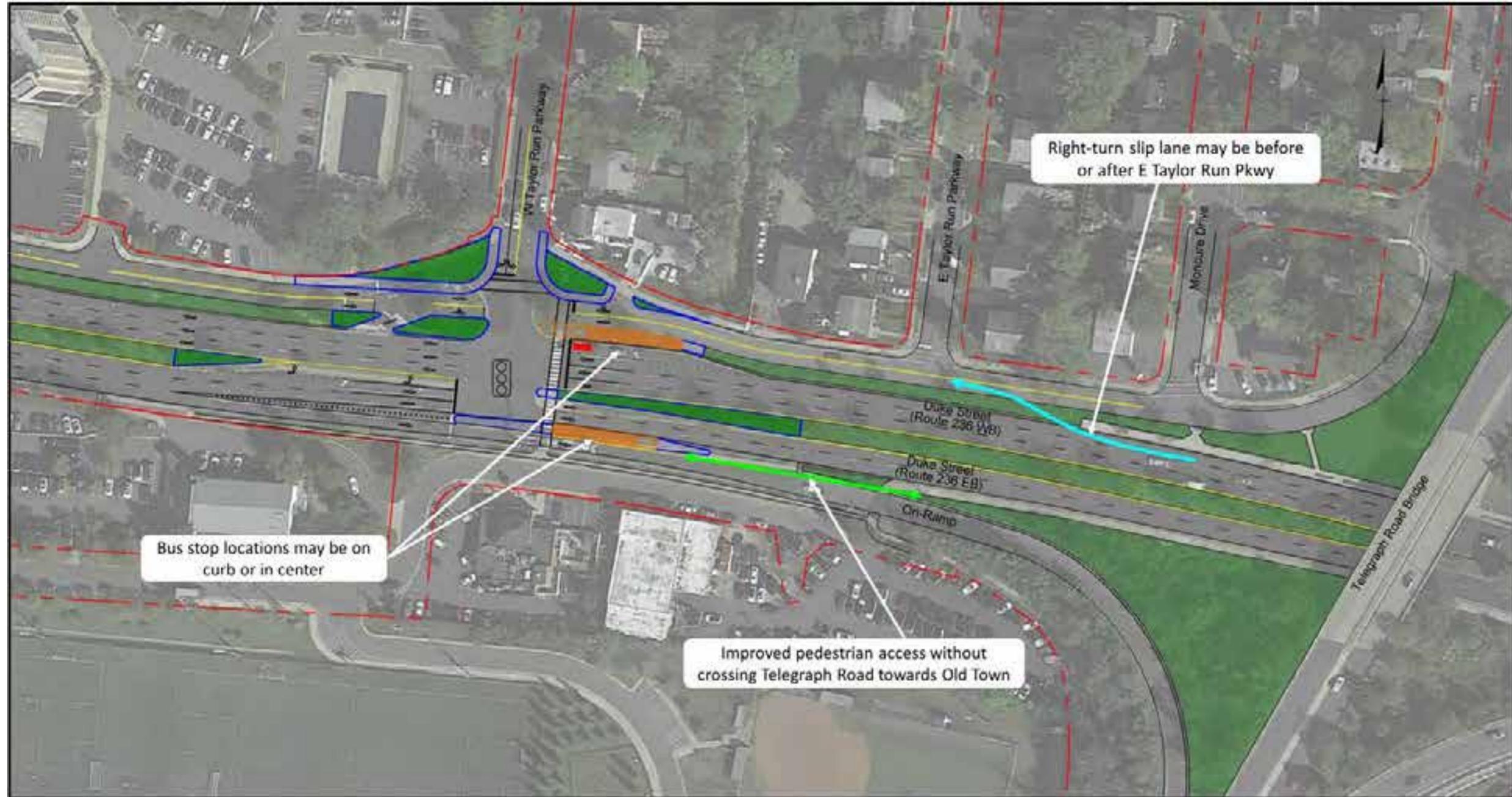
Figure 39: Duke Street eastbound and Telegraph Road on-ramp new, and Telegraph Road on-ramp at New Ramp from eastbound Duke Street concept for Alternative 2



Figure 40: Duke Street eastbound and Telegraph Road on-ramp new, and Telegraph Road on-ramp at New Ramp from eastbound Duke Street concept for Alternative 3



Figure 41: Concept for Duke Street and West Taylor Run Parkway improvements



## 8 DESIGN YEAR 2036 SYNCHRO ANALYSIS

### Measures of Effectiveness

The Measures of Effectiveness (MOEs) in traffic operations analyses quantify the operational results and provide a basis for evaluating the performance of a transportation network. A summary of the MOEs evaluated for the study intersection is presented below:

- Intersection Control Delay (seconds/vehicle) and resulting Level of Service (LOS)
- 95<sup>th</sup> Percentile Queue Length (feet)

Level of service (LOS) describes traffic conditions in terms of the amount of traffic congestion at an intersection or on a roadway. LOS ranges from A to F, where LOS A indicates a condition of little or no congestion, and LOS F indicates a condition with severe congestion, unstable traffic flow, and stop-and-go conditions. Results from Synchro for a signalized or unsignalized intersections are used for conducting traffic operational analyses. LOS thresholds for signalized and unsignalized intersections, Two-way stop controlled (TWSC) and All-way stop controlled (AWSC), are shown in Table 18. HCM 2000 results for the No-Build and Alternatives for design year 2036 are presented in the subsequent sections.

Table 18. HCM Intersection LOS Criteria Based on Average Delay

LOS	Signalized Intersection Delay Thresholds (sec/veh)	Unsignalized Intersection (TWSC and AWSC) Delay Thresholds (sec/veh)
A	< 10	< 10
B	> 10 – 20	> 10 – 15
C	>20 – 35	>15 – 25
D	>35 – 55	>25 – 35
E	>55 – 80	>35 – 50
F	>80	>50

Source: Highway Capacity Manual 2000

Table 19: No- Build - Year (2036) AM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	59.8	E	49.0	D	180	m48
		EBT (Continue on Duke St)	6.0	A			--	134
		EBT (to Telegraph Rd)	44.5	D			--	#1449
		WBT	50.3	D			--	#1185
		WBR	122.4	F			--	#448
		SBL (To Duke St)	119.7	F			--	m#369
		SBL (To Telegraph Rd)		D			--	m1
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	12.6	B	46.4	D	--	43
		WBLTR	13.1	B			--	75
		NBLTR	7.4	A			--	m20
		SBLT	101.5	F			--	#446
		SBR	40.1	D			--	0
Duke St and S Dove St/Roberts Ln	Signalized	EBT	29.3	C	28.5	C	--	#639
		WBT	14.1	B			--	200
		NBLTR	65.8	E			--	#362
		SBLTR	20.3	C			--	45

### 8.1 Intersection Operations: 2036 No-Build Conditions Synchro Analysis

Operational analysis was performed at each of the study intersections for the Future 2036 No-Build Conditions scenario. Table 19 and Table 20 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. Note that the westbound right-turn lane at Duke Street and W. Taylor Run Parkway is maintained. Signal timings for 2036 No-Build condition are shown on Appendix L.



Table 20: No-Build - Year (2036) PM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	43.4	D	64.7	E	180	m43
		EBT (Continue on Duke St)	15.3	B			--	322
		EBT (to Telegraph Rd)	122.5	F			--	#1811
		WBT	30.4	C			--	#1007
		WBR	65.3	E			--	#358
		SBL (To Duke St)	151.1	F			--	m#614
		SBL (To Telegraph Rd)		D			--	m0
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	13.8	B	26.0	C	--	41
		WBLTR	15.2	B			--	115
		NBLTR	4.3	A			--	m23
		SBLT	56.1	E			--	#367
		SBR	37.6	D			--	0
Duke St and S Dove St/Roberts Ln	Signalized	EBT	11.2	B	17.2	B	--	278
		WBT	18.4	B			--	#680
		NBLTR	36.6	D			--	239
		SBLTR	22.5	C			--	64

The results show that all intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak periods, except for Duke Street and W Taylor Run Parkway which is projected to operate with overall intersection LOS E during the PM peak hour. The intersection of W. Taylor Run Parkway and Service Rd is projected to operate with overall intersection LOS D during the AM peak hour and LOS C during the PM peak hour. The southbound left-turns at Duke Street and W. Taylor Run Parkway operate with LOS F and experience a delay of more than 100 sec/veh during both peak hours. The westbound right-turns at Duke Street and W. Taylor Run operate with LOS F and E, and experience a delay of more than 120 sec/veh and 60 seconds during the AM and PM peak hours, respectively.



## 8.2 Intersection Operations: 2036 Design Year - Build Conditions Alternative 1 Synchro Analysis

Operational analysis was performed at each of the study intersections for the Alternative 1 – 2036 Design Year Build Conditions scenario. Table 21 and Table 22 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. Note that the intersection of the westbound slip lane with service road is not analyzed considering very low traffic volume on service road. However, slip lane is analyzed during the VISSIM analysis. Synchro analysis results are presented in the Appendix O.

Table 21: Alternative 1 - Design Year (2036) – Build Conditions AM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	55.6	E	39.1	D	180	m47
		EBT (Continue on Duke St)	14.7	B			--	433
		EBT (to Telegraph Rd)	49.2	D			--	#1422
		WBT	39.9	D			--	#1144
		WBR	--	-			--	--
		SBL (To Duke St)	72.6	E			--	m#412
		SBL (To Telegraph Rd)	--	-			--	--
		SBR	37.8	D			--	m0
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	12.6	B	44.4	D	--	43
		WBLTR	13.1	B			--	72
		NBLTR	1.8	A			--	3
		SBLT	63.2	E			--	#384
		SBR	37.6	D			--	0
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	47.4	D	12.0	B	300	m190
		EBT	0.2	A			--	m0
		WBT	13.3	B			--	m313
Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)	Yield	EBL	14.2	B	5.0	A	--	56
		NB	--	--			--	--

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and S Dove St/Roberts Ln	Signalized	EBT	29.5	C	28.9	C	--	663
		WBT	16.7	B			--	244
		NBLTR	59.6	E			--	359
		SBLTR	24.1	C			--	48



Table 22: Alternative 1 - Design Year (2036) – Build Conditions PM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	68.4	E	56.1	E	180	m35
		EBT (Continue on Duke St)	4.3	A			--	170
		EBT (to Telegraph Rd)	86.9	F			--	#1784
		WBT	36.4	D			--	#973
		WBR	--	-			--	--
		SBL (To Duke St)	151.9	F			--	#607
		SBL (To Telegraph Rd)	--	-			--	--
		SBR	37.7	D	--	m0		
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	13.2	B	29.8	C	--	41
		WBLTR	19.9	B			--	310
		NBLTR	3.1	A			--	4
		SBLT	53.6	D			--	#346
		SBR	37.6	D			--	0
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	39.5	D	12.1	B	300	m173
		EBT	0.1	A			--	m0
		WBT	11.5	B			--	294
Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)	Yield	EBL	243.9	F	39.0	D	--	501
		NB	--	--			--	--
Duke St and S Dove St/Roberts Ln	Signalized	EBT	9.6	A	16.5	B	--	226
		WBT	15.5	B			--	495
		NBLTR	54.3	D			--	292
		SBLTR	32.2	C			--	77

The Alternative 1 build conditions results indicate that the proposed intersection of Duke Street eastbound and Telegraph Road on-ramp is projected to operate at an acceptable overall LOS B for both AM and PM peak hours. The eastbound left-turn movement operates with LOS D during the AM and PM peak hours. The intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street) is projected to operate at overall intersection LOS A and D during the AM and PM peak hours, respectively. However, the eastbound left-turn movement from the new ramp on to the existing Telegraph Road on-ramp experiences an extreme delay of more than 240 sec/veh during the PM peak hour.

The results indicate that the intersection of Duke St and W Taylor Run Pkwy operates at an overall LOS of D and E during the AM and PM peak hours, respectively. However, overall intersection and the southbound left-turn movement delays are less than the corresponding delays for the No-Build conditions.

### 8.3 Intersection Operations: 2036 Design Year - Build Conditions Alternative 1A Synchro Analysis

Operational analysis was performed at each of the study intersections for the Alternative 1A - 2036 Build Conditions scenario. Tables 23 and 24 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. Note that the intersection of the westbound slip lane with service road is not analyzed considering very low traffic volume on service road. However, slip lane is analyzed during the VISSIM analysis. Synchro analysis results are presented in the Appendix P.

Table 23: Alternative 1A – Design Year (2036) - Build Conditions AM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	55.6	E	37.8	D	180	m47
		EBT (Continue on Duke St)	14.7	B			--	433
		EBT (to Telegraph Rd)	49.2	D			--	#1422
		WBT	37.2	D			--	#1143
		WBR	--	-			--	--
		SBL (To Duke St)	72.6	E			--	m#412
		SBL (To Telegraph Rd)	--	-			--	--
		SBR	37.8	D	--	m0		
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	12.6	B	44.4	D	--	43
		WBLTR	13.1	B			--	72
		NBLTR	1.8	A			--	3
		SBLT	63.2	E			--	#384
		SBR	37.6	D	--	0		
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	47.4	D	8.5	A	300	m187
		EBT	0.2	A			--	m0
		WBT	4.8	A			--	m120
Telegraph Road on-ramp at New Ramp (from	Signalized	EBL	1.2	A	3.1	A	--	0
		NB	4.2	A			--	m71



Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
eastbound Duke Street								
Duke St and S Dove St/Roberts Ln	Signalized	EBT	30.2	C	29.3	C	--	759
		WBT	16.7	B			--	244
		NBLTR	59.6	E			--	359
		SBLTR	24.1	C			--	48

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
New Ramp (from eastbound Duke Street)		NB	6.8	A			--	#300
Duke St and S Dove St/Roberts Ln	Signalized	EBT	12.6	B	17.2	B	--	394
		WBT	14.9	B			--	672
		NBLTR	54.3	D			--	292
		SBLTR	32.2	C			--	77

Table 24: Alternative 1A – Design Year (2036) – Build Conditions PM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	68.4	E	51.6	D	180	m35
		EBT (Continue on Duke St)	4.3	A			--	170
		EBT (to Telegraph Rd)	86.9	F			--	#1784
		WBT	26.7	C			--	#973
		WBR	--	-			--	
		SBL (To Duke St)	151.9	F			--	#607
		SBL (To Telegraph Rd)	--	-			--	--
W Taylor Run Pkwy and Service Rd	Signalized	SBR	37.7	D			--	m0
		EBLTR	13.2	B	29.8	C	--	41
		WBLTR	19.9	B			--	310
		NBLTR	3.1	A			--	4
		SBLT	53.6	D			--	#346
SBR	37.6	D	--	0				
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	32.3	C	7.4	A	300	m151
		EBT	0.1	A			--	m0
		WBT	3.2	A			--	61
Telegraph On-Ramp at	Signal	EBL	10.9	B	7.4	A	--	26

The Alternative 1A build conditions results indicate that the proposed intersection of Duke Street eastbound and Telegraph Road on-ramp is projected to operate at an acceptable overall LOS A for both AM and PM peak hours. The eastbound left-turn movement operates with LOS D and C during the AM and PM peak hours, respectively. The intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street) is projected to operate at overall intersection LOS A during both AM and PM peak hours. The eastbound left-turn movement from the new ramp on to the existing Telegraph Road on-ramp operates at LOS A and B during the AM and PM peak hours, which is a major improvement compared to Alternative 1 which experiences an extreme delay of more than 240 sec/veh during the PM peak hour.

The results indicate that the intersection of Duke St and W Taylor Run Pkwy operates at an overall LOS of D during the AM and PM peak hours. Overall intersection delays are less than the corresponding delays for the No-Build conditions.



### 8.4 Intersection Operations: 2036 Design Year - Build Conditions Alternative 2 Synchro Analysis

Operational analysis was performed at each of the study intersections for the Alternative 2 - 2036 Design Year Build Conditions scenario. Tables 25 and 26 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. Note that the intersection of the westbound slip lane with service road is not analyzed considering very low traffic volume on service road. However, slip lane is analyzed during the VISSIM analysis. Synchro analysis results are presented in the Appendix Q.

Table 25: Alternative 2 – Design Year (2036) – Build Conditions AM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	55.6	E	39.1	D	180	m47
		EBT (Continue on Duke St)	14.7	B			--	433
		EBT (to Telegraph Rd)	49.2	D			--	#1422
		WBT	39.9	D			--	#1144
		WBR	--	-			--	--
		SBL (To Duke St)	72.6	E			--	m#412
		SBL (To Telegraph Rd)	--	-			--	--
W Taylor Run Pkwy and Service Rd	Signalized	SBR	37.8	D	--	m0		
		EBLTR	12.6	B	--	43		
		WBLTR	13.1	B	--	72		
		NBLTR	1.8	A	--	3		
		SBLT	63.2	E	--	#384		
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	SBR	37.6	D	--	0		
		EBL	47.4	D	300	m190		
		EBT	0.2	A	--	m0		
		WBT	13.3	B	--	m313		
Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)	Yield	EBL	23.2	C	8.2	A	--	101
		NB	--	--			--	--
Duke St and S Dove St/Roberts Ln	Signalized	EBT	29.5	C	28.9	C	--	663
		WBT	16.7	B			--	244
		NBLTR	59.6	E			--	359
		SBLTR	24.1	C			--	48

Table 26: Alternative 2 – Design Year (2036) – Build Conditions PM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	68.4	E	56.1	E	180	m35
		EBT (Continue on Duke St)	4.3	A			--	170
		EBT (to Telegraph Rd)	86.9	F			--	#1784
		WBT	36.4	D			--	#973
		WBR	--	-			--	--
		SBL (To Duke St)	151.9	F			--	#607
		SBL (To Telegraph Rd)	--	-			--	--
W Taylor Run Pkwy and Service Rd	Signalized	SBR	37.7	D	--	m0		
		EBLTR	13.2	B	--	41		
		WBLTR	19.9	B	--	310		
		NBLTR	3.1	A	--	4		
		SBLT	53.6	D	--	#346		
		SBR	37.6	D	--	0		
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	39.5	D	12.1	B	300	m173
		EBT	0.1	A			--	m0
		WBT	11.5	B			--	294
Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)	Yield	EBL	ERR	F	1599.0	F	--	ERR
		NB	--	--			--	--
Duke St and S Dove St/Roberts Ln	Signalized	EBT	9.6	A	16.5	B	--	226
		WBT	15.5	B			--	495
		NBLTR	54.3	D			--	292
		SBLTR	32.2	C			--	77

The Alternative 2 build conditions results indicate that the proposed intersection of Duke Street eastbound and Telegraph Road on-ramp is projected to operate at an acceptable overall LOS B for both AM and PM peak hours. The eastbound left-turn movement operates with LOS D during the AM and PM peak hours. The intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street) is projected to operate at overall intersection LOS A and F during the AM and PM peak hours, respectively. The eastbound left-turn movement from the new ramp on to the existing Telegraph Road on-ramp experiences an extremely high delays during the PM peak hour. Changing



the lane configuration from two (2) lanes to one (1) lane for the existing on-ramp configuration results into the overall intersection delays of more than 1599.0 sec/veh.

The intersection of Duke St and W Taylor Run Pkwy operates at an overall LOS of D and E during the AM and PM peak hours, respectively. However, overall intersection delays are less than the corresponding delays for the No-Build conditions.

### 8.5 Intersection Operations: 2036 Design Year - Build Conditions Alternative 3 Synchro Analysis

Operational analysis was performed at each of the study intersections for the Alternative 3 - 2036 Build Conditions scenario. Tables 27 and 28 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. Note that the intersection of the westbound slip lane with service road is not analyzed considering very low traffic volume on service road. However, slip lane is analyzed during the VISSIM analysis. Synchro analysis results are presented in the Appendix R.

Table 27: Alternative 3 - Design Year (2036) – Build Conditions AM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	55.6	E	37.1	D	180	m47
		EBT (Continue on Duke St)	14.7	B			--	433
		EBT (to Telegraph Rd)	49.2	D			--	#1422
		WBT	35.8	D			--	m#1076
		WBR	--	-			--	--
		SBL (To Duke St)	72.6	E			--	m#412
		SBL (To Telegraph Rd)	--	-			--	--
		SBR	37.8	D			--	m0
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	12.6	B	44.4	D	--	43
		WBLTR	13.1	B			--	72
		NBLTR	1.8	A			--	3
		SBLT	63.2	E			--	#384
		SBR	37.6	D			--	0
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	76.1	E	42.9	D	300	m#362
		EBT	22.2	C			--	m463
		WBT	53.2	D			--	m#459
		SBR	43.7	D			--	#989

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)	Yield	EBL	14.2	B	1.6	A	--	56
		NB	--	--			--	--
Duke St and S Dove St/Roberts Ln	Signalized	EBT	32.3	C	30.5	C	--	643
		WBT	16.7	B			--	244
		NBLTR	59.6	E			--	359
		SBLTR	24.1	C			--	48



Table 28: Alternative 3 - Design Year (2036) – Build Conditions PM Peak Hour Delay, LOS and Queues

Intersection	Control	Movement	Delay (s)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Turn Bay Storage (ft)	95th. Queue (ft)
Duke St and W Taylor Run Pkwy	Signalized	EBL	68.4	E	50.4	D	180	m35
		EBT (Continue on Duke St)	4.3	A			--	170
		EBT (to Telegraph Rd)	86.9	F			--	#1784
		WBT	24.1	C			--	#966
		WBR	--	-			--	--
		SBL (To Duke St)	151.9	F			--	#607
		SBL (To Telegraph Rd)	--	-			--	--
		SBR	37.7	D	--	m0		
W Taylor Run Pkwy and Service Rd	Signalized	EBLTR	13.2	B	29.8	C	--	41
		WBLTR	19.9	B			--	310
		NBLTR	3.1	A			--	4
		SBLT	53.6	D			--	#346
		SBR	37.6	D			--	0
Duke Street eastbound and Telegraph Road on-ramp new	Signalized	EBL	38.1	D	26.2	C	300	m195
		EBT	18.6	B			--	m122
		WBT	38.3	D			--	395
		SBR	21.2	C			--	618
Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)	Yield	EBL	243.9	F	23.3	C	--	243.9
		NB	--	--			--	--
Duke St and S Dove St/Roberts Ln	Signalized	EBT	9.0	A	16.3	B	--	226
		WBT	15.5	B			--	495
		NBLTR	54.3	D			--	292
		SBLTR	32.2	C			--	77

The intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street) is projected to operate at overall intersection LOS A and C during the AM and PM peak hours, respectively. However, the eastbound left-turn movement from the new ramp on to the existing Telegraph Road on-ramp experiences an extreme delay of more than 240 sec/veh during the PM peak hour.

The intersection of Duke St and W Taylor Run Pkwy operates at an overall LOS of D and E during the AM and PM peak hours, respectively. However, overall intersection delays are less than the corresponding delays for the No-Build conditions.

### 8.6 Alternative selection for VISSIM Analysis

The MOEs in Synchro (HCM) traffic operations analyses provide a basis for evaluating the performance of a transportation network. A summary of the MOEs evaluated for the study intersections. As shown in the results for Alternative 1A, signalizing the intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street) improves the operation compared to the Yield traffic control. However, it will result in closely spaces signalized intersections on the new ramp. It is recommended to signalize the crosswalk at Duke Street westbound and Telegraph Rd on-ramp (Intersection #9 in Figure 1). Signalizing the crosswalk will improve the pedestrian safety and likely to reduce the conflict between the vehicles and pedestrians which has resulted in number of sideswipes and rear-end crashes at that location. It is also recommended to control the signals at Duke Street westbound and Telegraph Rd on-ramp (Pedestrian signal), and Duke Street eastbound and Telegraph Road on-ramp new with the traffic signal controller at Duke Street and S. Dove Street/ Robert's Lane. Using the single controller will also allow signal phasing that will create safe gaps for the traffic exiting the new ramp before merging with the traffic on Telegraph Road on-ramp from the westbound Duke Street. Alternative 1 with single traffic controller for three signals is expected to reduce the delays at the intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street).

Results for the Alternative 2 show that changing the lane configuration from two (2) lanes to one (1) lane for the existing on-ramp results in extreme degradation of the intersection operations. Alternative 3 will improve the safety by eliminating Telegraph Road off-ramp to the westbound Duke Street and adding dual southbound right-turns. Similar to intersection of Duke Street westbound and Telegraph Rd on-ramp, Telegraph Road off-ramp to the westbound Duke Street has number of rear end and sideswipe crashes prior to the crosswalk on the off-ramp. Signalizing the crosswalk and eliminating the off-ramp will improve the safety for pedestrians without causing significant delays to the traffic. However, 95th percentile queues are expected to be more that 900 ft during the AM peak hour. Extending the dual right-turn lane to Telegraph Road Bridge will alleviate the queueing issue.

The Alternative 3 Design Year Build conditions results indicate that the proposed intersection of Duke Street eastbound and Telegraph Road on-ramp is projected to operate at an acceptable overall LOS D and C during the AM and PM peak hours, respectively. The eastbound left-turn movement operates with LOS E and D during the AM and PM peak hours, respectively. In this alternative, Telegraph Road off-ramp to the westbound Duke Street is eliminated and it is replaced by two (2) right-turn lanes at this intersection. The southbound right-turn movement operates at acceptable LOS D and C during the AM and PM peak hours, respectively. Queues for the southbound right-turn movement is expected to exceed 900 ft and 600 ft during the AM and PM peak hours, respectively.



Providing the right-turn slip lane from the westbound Duke Street to the service road will eliminate exclusive westbound right-turn phase at Duke Street and W. Taylor Run Parkway. It will also eliminate the conflict between the westbound right-turn traffic and pedestrians. Eliminating the signal phase will improve overall LOS at the intersection. Slip lane will also preserve the access to W. Taylor Run Parkway, E. Taylor Run Parkway and Moncure Drive.



Curb extensions and curb radii reduction at the NE and NW quadrants will reduce crossing distances and improve the safety for pedestrians and bicyclists. Extending the median between the eastbound receiving lane on Duke Street and Telegraph Road on-ramp will provide easy access to the bus shelter and improve pedestrian access to the Old Town Alexandria by eliminating the need for crossing Telegraph Road on-ramp. Bus stops on the eastbound Duke Street, the near side and the far side of the intersection, will be consolidated to a bus shelter just east of the crosswalk. This will eliminate the crosswalk (circled in the picture) which has a history of rear-end crashes.

Exclusive pedestrian phase will be maintained at the intersection. Extending the ramp lane and the eastbound Duke Street travel lanes will prevent vehicles from West Taylor Run entering the ramp from eastbound Duke Street. Unless a pedestrian pushes the button to cross Duke Street, ramp traffic will flow uninterrupted. By reducing this congestion along Duke Street, using the arterials was a preferable alternative for cut-through traffic, further reducing traffic on residential streets.

Based on the operational results for the No-Build and Alternatives, and safety benefits, Alternative 1 and Alternative 3 are carried forward for the further analysis using VISSIM.

## 9 OPENING YEAR 2026 AND DESIGN YEAR 2036 VISSIM ANALYSIS

An initial screening using Synchro software evaluated the traffic operational performance of the four (4) concepts, for AM and PM peak hours, for the intersection of West Taylor Run Parkway and Duke Street and the proposed ramp intersection for eastbound Duke Street to Telegraph Road connection. Based on the results of the initial screening using Synchro, the No-Build operational analysis results, safety analysis, as well as field investigations and the public input received on the concepts, two (2) concepts were advanced for a more detailed analysis using VISSIM. Public meetings were held on November 15, 2022 and April 17, 2023.

WSP conducted a traffic operations analysis of the selected two (2) future Build alternatives using VISSIM. VISSIM models were developed for Opening Year 2026 and Design Year 2036 for AM and PM peak hours. Alternative 1 and modified Alternative 3 (Alternative 3A from now onwards) were carried forward for the VISSIM analysis. Alternative 3A eliminated the slip lane from the westbound Duke Street onto service road and the westbound right-turn lane was maintained at Duke Street and W. Taylor Run Parkway. More detailed description is presented in the following section of this chapter. The projected traffic volumes were balanced and distributed in accordance to projected regional distribution. MOEs for the Build alternatives were reported and summarized in tabular format consistent with earlier tasks and in accordance with TOSAM guidelines.

### 9.1 Traffic Volumes for VISSIM Analysis

Similar to the No-Build analysis, the existing traffic volumes were forecast to the Opening Year 2026 and Design Year 2036. Growth rate of 0.25% per year was used to develop Opening Year and Design Year traffic volumes for Build conditions. In addition to that adjustments were made to the traffic volume based on the Duke Street Traffic Mitigation Pilots (<https://www.alexandriava.gov/transportation-planning/duke-street-traffic-mitigation-pilots>). Growth rate of 0.25% per year is also consistent with the growth rate used for Duke Street Transitway Study.

The first pilot (Phase I) for Duke Street traffic mitigation ran for four (4) months from January through April 2022. Phase I focused on changing signal timing to allow more green time for Quaker Lane and Duke Street and shortening green time from the local streets. The second phase (Phase II) the pilot reinstated the signal timing changes from Phase I and restricted access to the Telegraph Road ramp directly from West Taylor Run Parkway. The Phase II pilot ran all week and all day from September 2022 to March 2023. The goals of this phase are to reduce congestion on Duke Street stemming from the backup at the West Taylor Run Parkway signal. The ramp traffic will only have a red light if pedestrians push the button but otherwise will be unrestricted flow. A physical temporary divider (Flexible PVC posts) were installed between the ramp lane and the eastbound Duke Street travel lanes, preventing vehicles from West Taylor Run entering the ramp from eastbound Duke Street. Additional traffic signal heads were installed for the Duke Street to Telegraph Road ramp movement, unless a pedestrian pushes the button, a constant green signal was provided for ramp traffic. By reducing this congestion along Duke Street, using the arterials was a preferable alternative for cut-through traffic, further reducing traffic on residential streets. Overall, both pilots were largely successful in reducing the cut-through traffic and increasing throughput on Duke Street and N. Quaker Lane.

To evaluate the traffic conditions after the implementation of the Pilot, the City collected traffic volumes on N Quaker Lane, Duke Street, and W. Taylor Run Parkway when Phase II was in progress. Data was also collected on other side streets on Duke Street. Data tube counters was collected when school was in session, on a typical weekday, Tuesday through Thursday, from January 10, 2023 to January 12, 2023. Traffic volumes on the southbound approach of N. Quaker Lane increased by approximately 200 and 300 vehicles during the AM and PM peak hour, respectively. While traffic volumes on the southbound approach of W. Taylor Run Parkway decreased by approximately 200 and 135

vehicles during the AM and PM peak hour, respectively. The volumes developed for the corridor by applying the MWCOG growth rate of 0.25% for 2026 and 2036 conditions were modified to take into consideration the traffic shift due to Duke Street Traffic Mitigation Pilot. Growth rates from MWCOG model are presented in the Appendix N. Growth rate of 0.25% (compound method) was applied to all movements including Service Road. Volumes for 2026 and 2036 build conditions are presented in Figure 42 and Figure 43, respectively.

### 9.2 Warrant Study and Signal Justification

An engineering study was conducted to determine if a signal is appropriate for the intersection of Duke Street eastbound and Telegraph Road on-ramp new. This study considered the criteria found in Part IV of the Manual on Uniform Traffic Control Devices (MUTCD) 2009 Edition. The MUTCD is published by the Federal Highway Administration (FHWA) and is nationally recognized and adopted by all fifty states as the standard for determining traffic control signal needs. The existing traffic operations, crash history, and physical characteristics at the study intersection were collected and compared to the conditions or “warrants” as specified in the MUTCD, to investigate the need for a traffic control signal.

The evaluation was performed with a two-lane approach on Duke Street and on New Ramp. The traffic volumes on Duke Street are greater than those on New Ramp, thus Duke Street is considered the major road and New Ramp is considered the minor road. Since the 85th percentile speed on Duke Street was not measured, the posted speed on Duke Street is utilized for the warrant analysis. Because the posted speed limit is 35 mph, which is less than 40 mph, the signal warrant volume thresholds are not reduced to 70% of the original values.

Since proposed intersection is in the preliminary engineering phase and therefore not yet open to traffic, Average Daily Traffic (ADT) projections were utilized to satisfy Warrant 1. ADT projections were developed utilizing the 2026 peak hour volumes at the intersection. Warrant 3 (Peak Hour) was considered for the analysis.

The engineering study indicated that Warrant 1, and Condition A—Minimum Vehicular Volume and Condition B (Interruption of Continuous Traffic) using ADT Estimates, and Warrant 3 (Peak Hour) are met for the opening year 2026 conditions.

Signal Justification Report (SJR) was prepared at this location. VJuST screening was conducted at the intersection for 2026 Opening Year conditions with signalized conventional control, a roundabout and Continuous Green-T configuration. Continuous Green-T will provide uninterrupted traffic flow for the southbound traffic but will require eliminating the proposed pedestrian crosswalk on north leg which is not acceptable. Roundabout option does not provide effective traffic operations. Both options have significant environmental, cost, and right-of-way impacts. SJR is provided in the Appendix S.

The conventional signalized intersection provides increased safety for pedestrians. Even though signals generally have potential to increase rear-end crashes, it may reduce the angle and left-turn crashes at the intersection. New signalized intersection will also reduce or eliminate rear-end and sideswipe crashes occurring on Duke Street westbound and Telegraph Rd off-ramp. Therefore, a conventional intersection with a signal, is justified.



Figure 42: Build Conditions - Opening Year (2026) Peak Hour Volumes

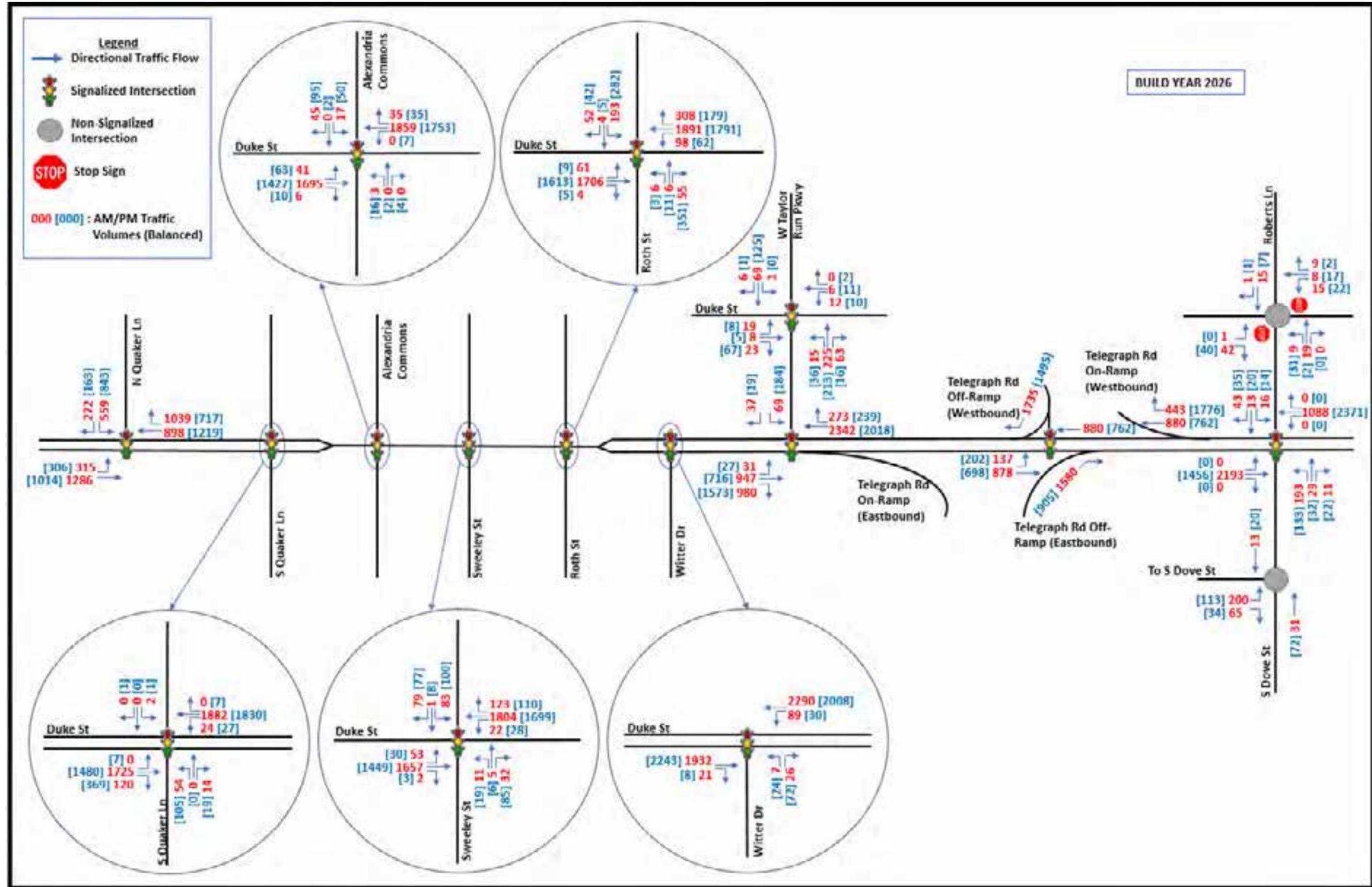
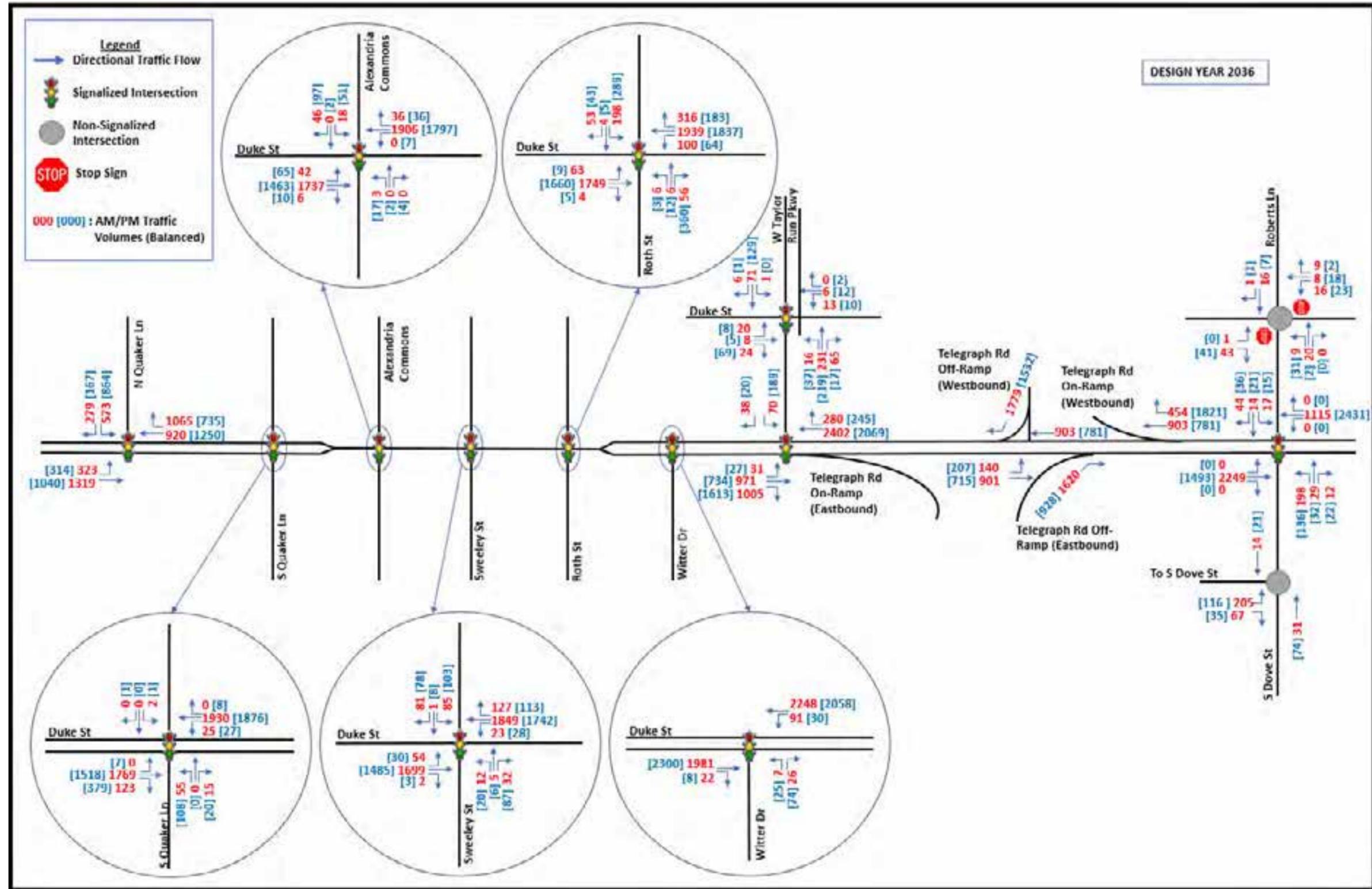


Figure 43: Build Conditions - Design Year (2036) Peak Hour Volumes



### 9.3 VISSIM Alternatives

After the results of the Synchro analysis were evaluated, the team identified a total of four (4) recommendations or two (2) alternatives for the VISSIM analysis. Four (4) recommendations included two (2) improvement alternatives for the intersection of Duke Street & West Taylor Run Pkwy and two (2) improvement alternatives for the new intersection at Duke Street eastbound and Telegraph Road on-ramp. Traffic signal control was proposed for both the alternatives at Duke Street eastbound and Telegraph Road on-ramp. Results of the VISSIM analysis for two (2) alternatives, Alternative 1 and Alternative 3A were utilized to develop the preferred option for the project.

Alternative 1: Alternatives is described below and presented on Figures 44 and 45.

#### Duke Street and W. Taylor Run Parkway (See Figure 44)

- The southbound left-turn traffic restricted from entering onto the Telegraph Road on-ramp at the intersection. Concrete median between the eastbound through lanes on Duke Street and Telegraph Road ramp is extended to restrict this movement.
- Single lane is provided for the southbound W. Taylor Run Parkway approach.
- Right-turn slip lane from the westbound Duke Street to service road is provided. Westbound right-turn lane at Duke Street and W. Taylor Run Parkway is removed thus vehicles will have to use slip lane to access W. Taylor Run Parkway from the westbound Duke Street. Slip lane service road is provided between E. Taylor Run Parkway and Moncure Drive.
- Three thru lanes are maintained on the westbound approach.
- The eastbound left-turn lane is maintained.
- Service road is realigned at the intersection. Vehicles will be allowed to travel in both direction on the service road, eastbound and westbound, on service road to the west of W. Taylor Run Parkway and between W. Taylor Run Parkway and E. Taylor Run Parkway. Service road will be one-way westbound to the east of E. Taylor Run Parkway.
- An exclusive pedestrian phase will be maintained at the intersection. Traffic from eastbound Duke Street to Telegraph Road will move uninterrupted except when pedestrian pushes the button to cross the east leg of the intersection.

#### Duke Street eastbound and Telegraph Road on-ramp (See Figure 45)

- Intersection will provide additional access for the eastbound traffic on Duke Street to the southbound Telegraph Road. Intersection will be signalized and will be controlled by the signal controller at Duke Street and S. Dove Street/Robert's Lane.
- Free flow will be maintained for the Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street.
- Conflict between pedestrians and traffic on off-ramp will not be eliminated.
- The eastbound traffic after exiting the intersection will have to yield to the Telegraph Road on-ramp traffic from the westbound Duke Street.

#### Duke Street westbound and Telegraph Rd on-ramp (See Figure 45)

- Intersection will be signalized to provide safe crossing for the pedestrian.

- Intersections **will be controlled by the signal controller at Duke Street and S. Dove Street/Robert's Lane.**

Alternative 3A: Alternatives is described below and presented on Figures 46 and 47.

#### Duke Street and W. Taylor Run Parkway (See Figure 46)

- The southbound left-turn traffic restricted from entering onto the Telegraph Road on-ramp at the intersection. Concrete median between the eastbound through lanes on Duke Street and Telegraph Road ramp is extended to restrict this movement.
- Single lane is provided for the southbound W. Taylor Run Parkway approach.
- Westbound right-turn lane at Duke Street and W. Taylor Run Parkway is maintained thus vehicles can access W. Taylor Run Parkway, E. Taylor Run Parkway and Moncure Drive from the westbound Duke Street.
- Three thru lanes are maintained on the westbound approach.
- The eastbound left-turn lane is maintained.
- Service road is realigned at the intersection. Vehicles will be allowed to travel in both direction on the service road.
- An exclusive pedestrian phase will be maintained at the intersection. Traffic from eastbound Duke Street to Telegraph Road will move uninterrupted except when pedestrian pushes the button to cross the east leg of the intersection.

#### Duke Street eastbound and Telegraph Road on-ramp (See Figure 47)

- Intersection will provide additional access for the eastbound traffic on Duke Street to the southbound Telegraph Road. Intersection will be signalized and will be controlled by the signal controller at Duke Street and S. Dove Street/Robert's Lane.
- Cross walk on the north leg to the intersection will be controlled by the pedestrian signals.
- Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street will be eliminated. Dual southbound right-turn lanes will be provided at the intersection.
- Eliminating the off-ramp and signalizing the crosswalk on the north leg will improve the pedestrian safety.
- The eastbound traffic after exiting the intersection will have to yield to the Telegraph Road on-ramp traffic from the westbound Duke Street.

#### Duke Street westbound and Telegraph Rd on-ramp (See Figure 47)

- Intersection will be signalized to provide safe crossing for the pedestrian.
- Intersections **will be controlled by the signal controller at Duke Street and S. Dove Street/Robert's Lane.**



Figure 44: Alternative 1 - Duke Street and W. Taylor Run Parkway



Figure 45: Alternative 1 - Duke Street eastbound and Telegraph Road on-ramp new



Figure 46: Alternative 3A - Duke Street and W. Taylor Run Parkway



Figure 47: Alternative 3A - Duke Street eastbound and Telegraph Road on-ramp new



### 9.4 2026 VISSIM Analysis

After performing the initial screening using the Synchro software, operational analysis was performed at each of the study intersections for the Future 2026 Build Conditions scenario for all the selected Alternatives (Alternative 1, Alternative 3A and Alternative 3C) using the VISSIM software. Alternatives were compared to the No-Build conditions. The following will describe the summary of the average AM and PM peak hour delay, LOS and the maximum queue length for each of the three (3) Alternatives.

#### 9.4.1 Alternative 1

Operational analysis was performed at each of the study intersections for the Opening Year 2026 Alternative 1 scenario. Table 29 and Table 3030 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. The Alternative 1 build conditions 2026 VISSIM results indicate that the proposed intersection of Duke Street eastbound and Telegraph Road on-ramp is projected to operate at an acceptable overall LOS B for both the AM and PM peak hours. The eastbound left-turn movement operates with LOS C during the AM and LOS D during the PM peak hours. Overall, all the intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak hours.

Table 29: Alternative 1 - Design Year (2026) – Build Conditions AM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	315	326	39.4	D	22.2	C	408
		EBT	1286	1291	14.3	B			408
		WBT	898	860	19.7	B			444
		WBR	1039	980	5.7	A			421
		SBL	559	564	54.2	D			619
		SBR	272	265	41.3	D			593
		2	Duke St and S Quaker Ln	EBL	0	0			0.0
EBT	1725			1738	6.9	A	442		
EBR	120			116	2.7	A	471		
WBL	24			26	20.9	C	359		
WBT	1882			1787	5.4	A	359		
WBR	0			0	0.0	A	373		
NBL	54			52	47.6	D	136		
NBT	0			0	0.0	A	136		
NBR	14			15	25.3	C	137		
SBL	2			2	38.9	D	19		
SBT	0			0	0.0	A	19		
SBR	0			0	0.0	A	22		

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	41	41	37.9	D	5.9	A	318
		EBT	1695	1706	2.2	A			318
		EBR	6	7	2.3	A			351
		WBL	0	0	0.0	A			653
		WBT	1859	1765	7.7	A			653
		WBR	35	33	13.0	B			662
		NBL	3	3	43.4	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	17	19	58.4	E			141
		SBT	0	0	0.0	A			141
		SBR	45	43	19.0	B			152
		4	Duke St and Sweeley St	EBL	53	54			28.0
EBT	1657			1664	7.9	A	444		
EBR	2			2	2.9	A	452		
WBL	22			24	25.4	C	652		
WBT	1804			1714	5.1	A	652		
WBR	123			116	5.3	A	668		
NBL	11			10	47.7	D	82		
NBT	5			5	52.5	D	82		
NBR	32			30	18.3	B	93		
SBL	83			84	52.6	D	148		
SBT	1			1	34.4	C	148		
SBR	79			76	12.6	B	148		
5	Duke St at Roth St/ Cambridge Rd			EBL	61	57	81.5	F	20.6
		EBT	1706	1717	17.9	B	827		
		EBR	4	4	18.9	B	835		
		WBL	98	94	36.4	D	763		
		WBT	1891	1798	20.5	C	763		
		WBR	308	289	19.6	B	763		
		NBL	6	5	36.9	D	97		
		NBT	6	6	39.4	D	97		
		NBR	55	54	15.2	B	99		
		SBL	193	186	25.0	C	121		
		SBT	4	4	17.0	B	121		
		SBR	52	50	9.9	A	144		
		51	Cambridge Rd and Service Rd	EBT	9	9	38.2	E	
EBR	221			214	40.6	E	308		
WBL	28			25	60.2	F	69		
WBT	0			0	0.0	A	83		
NBL	366			316	0.5	A	32		
NBR	42			36	0.7	A	32		



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
6	Duke St and Witter Dr	EBT	1932	1937	5.0	A	9.9	A	541				
		EBR	21	21	6.7	A			548				
		WBL	89	83	19.7	B			728				
		WBT	2290	2184	13.8	B			728				
		NBL	7	7	55.5	E			77				
		NBR	26	25	16.5	B			97				
7	Duke St and W Taylor Run Pkwy	EBL	31	31	64.8	E	9.5	A	109				
		EBT (Continue on Duke St)	947	951	3.8	A			557				
		EBT (to Telegraph Rd)	980	981	6.3	A			773				
		WBT	2342	2230	12.4	B			640				
		SBL	68	65	21.6	C			78				
		SBR	37	35	5.0	A			96				
		71	W Taylor Run Pkwy and Service Rd	EBL	19	19			7.2	A	15.5	B	71
				EBT	8	8			6.7	A			71
EBR	23			22	11.4	B	71						
WBL	12			11	6.4	A	161						
WBT	20			17	6.9	A	161						
WBR	203			187	7.2	A	161						
NBL	2			1	0.1	A	0						
NBT	23			25	0.8	A	0						
NBR	6			5	0.3	A	0						
SBL	1			1	14.9	B	106						
SBT	69			68	50.9	D	106						
SBR	6			7	45.9	D	106						
72	Duke St WB to West Taylor Run Parkway Service Rd	WBT	19	16	8.6	A	4.3	A	40				
		Slip Lane from Duke St WB	274	255	4.1	A			0				
8	Duke St WB and Telegraph Rd Off-ramp	WBT	881	879	0.4	A	0.9	A	0				
		SBR	1735	1617	1.2	A			0				
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	137	134	32.7	C	10.5	B	194				
		WBT	880	881	7.1	A			244				
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	441	433	0.1	A	0.1	A	0				
		NBT	137	134	0.2	A			0				

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
9	Duke St WB and Telegraph Rd On-ramp	WBR	441	434	3.5	A	3.5	A	68
10	Duke St and S Dove St/Roberts Ln	EBT	2193	2087	15.2	B	14.6	B	1505
		EBR	265	246	14.0	B			542
		WBT	1088	1101	10.8	B			314
		WBR	33	33	7.5	A			41
		NBL	193	175	28.0	C			656
		NBT	29	24	29.9	C			656
		NBR	11	10	20.4	C			659
		SBL	16	15	39.1	D			120
		SBT	13	14	33.3	C			120
SBR	43	42	9.0	A	120				



Table 30: Alternative 1 - Opening Year (2026) – Build Conditions PM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
1	Duke St and N Quaker Ln	EBL	306	308	75.4	E	38.8	D	982				
		EBT	1014	1017	36.7	D			982				
		WBT	1219	1165	41.0	D			465				
		WBR	717	673	12.4	B			430				
		SBL	843	843	46.0	D			619				
		SBR	163	160	37.5	D			562				
		2	Duke St and S Quaker Ln	EBL	7	7			61.1	E	21.4	C	440
EBT	1480			1493	15.5	B	440						
EBR	369			360	7.4	A	468						
WBL	27			28	25.0	C	377						
WBT	1830			1738	20.2	C	377						
WBR	7			6	13.8	B	391						
NBL	105			100	159.1	F	328						
NBT	0			0	0.0	A	328						
NBR	19			18	136.3	F	329						
SBL	1			1	23.6	C	23						
SBT	0			0	0.0	A	23						
SBR	1			1	25.5	C	23						
3	Duke St and Alexandria Commons			EBL	63	63	44.9	D	24.5	C			273
				EBT	1427	1440	6.0	A					273
		EBR	10	10	3.4	A	298						
		WBL	7	6	20.6	C	668						
		WBT	1753	1665	34.4	C	668						
		WBR	35	32	28.4	C	719						
		NBL	16	15	58.9	E	51						
		NBT	2	2	29.0	C	51						
		NBR	4	4	16.6	B	50						
		SBL	50	50	80.9	F	182						
		SBT	2	2	84.6	F	182						
SBR	95	89	88.2	F	193								

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
4	Duke St and Sweeley St	EBL	30	32	17.1	B	21.5	C	371				
		EBT	1449	1463	7.8	A			371				
		EBR	3	3	5.9	A			382				
		WBL	28	29	30.8	C			814				
		WBT	1699	1613	31.4	C			814				
		WBR	110	103	27.7	C			830				
		NBL	19	19	50.1	D			165				
		NBT	6	5	34.7	C			165				
		NBR	85	86	18.7	B			175				
		SBL	100	100	52.2	D			158				
		SBT	8	7	42.9	D			158				
		SBR	77	76	21.0	C			158				
		5	Duke St at Roth St/ Cambridge Rd	EBL	9	9			76.4	E	24.9	C	773
				EBT	1619	1634			15.8	B			773
EBR	5			4	16.6	B	781						
WBL	62			62	44.2	D	781						
WBT	1791			1703	35.2	D	781						
WBR	179			169	23.9	C	781						
NBL	3			3	21.9	C	200						
NBT	11			10	35.2	D	200						
NBR	351			345	19.2	B	202						
SBL	282			251	18.8	B	118						
SBT	5			6	15.2	B	118						
SBR	42			37	13.3	B	141						
51	Cambridge Rd and Service Rd			EBT	36	35	33.9	D	26.3	D			346
				EBR	281	248	37.8	E					345
		WBL	48	47	62.9	F	101						
		WBT	0	0	0.0	A	115						
		NBL	193	160	0.8	A	54						
		NBR	36	28	0.4	A	54						
		6	Duke St and Witter Dr	EBT	2243	2231	8.5	A			24.3	C	493
EBR	8			8	12.2	B	504						
WBL	30			29	46.3	D	797						
WBT	2008			1918	39.5	D	797						
NBL	24			25	139.1	F	185						
NBR	72	69	60.8	E	205								



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	EBL	27	27	68.0	E	23.9	C	88
		EBT (Continue on Duke St)	716	722	9.9	A			358
		EBT (to Telegraph Rd)	1573	1554	10.6	B			752
		WBT	2018	1952	39.2	D			2138
		SBL	184	180	19.0	B			105
		SBR	19	18	42.0	D			122
71	W Taylor Run Pkwy and Service Rd	EBL	8	8	28.4	C	29.5	C	130
		EBT	5	5	31.7	C			130
		EBR	67	64	39.2	D			130
		WBL	10	10	23.8	C			252
		WBT	43	39	16.2	B			252
		WBR	194	185	15.1	B			252
		NBL	4	3	2.5	A			2
		NBT	21	22	0.8	A			0
		NBR	2	2	0.3	A			0
		SBL	0	0	0.0	A			248
		SBT	125	125	56.5	E			248
		SBR	1	1	23.1	C			247
72	Duke St WB to West Taylor Run Parkway Service Rd	WBT	23	22	8.0	A	9.6	A	46
		Slip Lane from Duke St WB	239	225	9.7	A			8
8	Duke St WB and Telegraph Rd Off-ramp	WBT	762	766	0.9	A	2.5	A	87
		SBR	1495	1447	3.4	A			1800
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	202	193	35.8	D	12.7	B	315
		WBT	762	767	6.9	A			189
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	1776	1782	2.9	A	2.6	A	279
		NBT	201	193	0.3	A			11

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
9	Duke St WB and Telegraph Rd On-ramp	WBR	1776	1783	4.1	A	4.1	A	221
10	Duke St and S Dove St/Roberts Ln	EBT	1456	1457	12.0	B	13.9	B	485
		EBR	147	142	8.6	A			122
		WBT	2371	2395	13.6	B			805
		WBR	42	40	17.4	B			71
		NBL	133	128	35.1	D			239
		NBT	32	32	33.2	C			239
		NBR	21	20	20.5	C			235
		SBL	14	13	39.1	D			147
		SBT	20	20	35.2	D			147
		SBR	35	33	9.0	A			149

Signal timings for Alternative 1 2026 Build conditions are shown on Appendix T. VISSIM results for 2026 Build Conditions is presented in the Appendix Z.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2026 Opening Year Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 14 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 14 are the movements where the reported maximum queue length value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement storage bays during both peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 ft. is projected to experience a maximum queue length of 982 ft., which is far less than queue length of 2961 ft. for the 2026 No-Build conditions during the PM peak hour.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, and westbound left-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersections of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.



At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. However, the eastbound right movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. It is to be noted that the westbound left-turn movement with storage of 70 ft. is projected to experience a maximum queue length of 652 ft. and 814 ft. during the AM and PM peak hours, respectively. These queue lengths are similar to 2026 No-Build conditions.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, southbound left-turn and right-turn movements are projected to experience maximum queue lengths that will not exceed the available storage bay lengths during AM and PM peak hours. For 2026 No-Build conditions, it is to be noted that the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 1594 ft. and 841 ft. during the AM and PM peak hours, respectively. The westbound right-turn movement is eliminated in the Alternative 1. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 773 ft. and 752 ft. during the AM and PM peak hours, respectively. The queue lengths for the eastbound movement are similar to 2026 No-Build conditions.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 106 ft. and 248 ft. during the AM and PM peak hours. This queue lengths are far less than the 2026 No-Build conditions when the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 358 ft. and 515 ft. during the AM and PM peak hours. This is mainly due to restricting the southbound movement to Telegraph Road ramp. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 252 ft. during the PM peak hour. The westbound queue lengths are far less than the 2026 No-build conditions when the westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 918 ft. during the PM peak hour. Reduction in queues is mainly due to eliminating the exclusive westbound right-turn phase and giving that time to other movements even though the westbound traffic is much heavier for the Alternative 1 compared to No-Build conditions.

At the intersection of Duke Street westbound and right-turn slip lane to the W. Taylor Run Parkway Service Road, the westbound movement is projected to experience maximum queue lengths 46 ft. during the PM peak hour. Traffic from the slip lane does not experience any queues during both peak hours. Note that this movement is free and not controlled by any traffic control device.

At the intersection of Duke Street eastbound and Telegraph Road on-ramp new, the eastbound left-turn movement is projected to experience maximum queue lengths 315 ft. and 194 ft. during the AM and PM peak hours, respectively. Note that Telegraph Road off-ramp to westbound Duke Street is maintained in this option.

**At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn movements and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 656 ft. and 239 ft. during the AM and PM peak hours, respectively. These queue lengths are less than 2026 No-Build conditions when the northbound left-turn movement is projected to experience a maximum queue length of 1373 ft. and 300 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 512 ft. during the AM peak hour and 122 ft. during the PM peak hour. Note that, for 2026 No-Build conditions, the eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1259 ft. during the AM peak hour and 186 ft. during the PM peak hour.**

Intersection MOE tables for 2026 & 2036 Build conditions are shown on Appendix Z.



Table 31: Alternative 1 - Opening Year (2026) – Build Conditions Summary of Intersection Queues (feet)

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	Signalized	EBL	200	93	408	350	982
			EBT	360	93	408	350	982
			WBT	330	73	444	229	465
			WBR	300	25	421	16	430
			SBL	1290	181	619	182	619
			SBR	1270	114	593	65	562
2	Duke St and S Quaker Ln	Signalized	EBL	200	54	442	113	440
			EBT	330	54	442	113	440
			EBR	300	62	471	126	468
			WBL	80	30	359	151	377
			WBT	210	30	359	151	377
			WBR	210	32	373	160	391
			NBL	335	18	136	121	328
			NBT	335	18	136	121	328
			NBR	335	14	137	121	329
			SBL	40	0	19	0	23
3	Duke St and Alexandria Commons	Signalized	EBL	105	10	318	31	273
			EBT	210	10	318	31	273
			EBR	210	11	351	38	298
			WBL	315	83	653	323	668
			WBT	520	83	653	323	668
			WBR	520	40	662	315	719
			NBL	50	1	23	4	51
			NBT	50	1	23	4	51
			NBR	50	1	22	4	50
			SBL	215	9	141	70	182
SBR	215	9	141	70	182			
SBR	215	12	152	79	193			

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
4	Duke St and Sweeley St	Signalized	EBL	190	42	440	35	371
			EBT	520	43	444	35	371
			EBR	520	44	452	38	382
			WBL	70	33	652	364	814
			WBT	225	33	652	364	814
			WBR	225	34	668	377	830
			NBL	230	6	82	13	165
			NBT	230	6	82	13	165
			NBR	230	9	93	17	175
			SBL	110	26	148	33	158
			SBT	110	26	148	33	158
			SBR	110	26	148	33	158
5	Duke St at Roth St/ Cambridge Rd	Signalized	EBL	115	228	827	129	773
			EBT	350	228	827	129	773
			EBR	350	230	835	132	781
			WBL	230	307	763	495	781
			WBT	670	307	763	495	781
			WBR	670	307	763	495	781
			NBL	150	6	97	42	200
			NBT	150	6	97	42	200
			NBR	150	7	99	44	202
			SBL	40	57	121	56	118
			SBT	40	57	121	56	118
			SBR	40	74	144	72	141
51	Cambridge Rd and Service Rd	Unsignalized	EBT	1330	44	309	53	346
			EBR	1330	42	308	51	345
			WBL	825	6	69	12	101
			WBT	825	6	83	13	115
			NBL	40	1	32	1	54
			NBR	40	1	32	1	54
6	Duke St and Witter Dr	Signalized	EBT	675	38	541	54	493
			EBR	675	39	548	56	504
			WBL	215	163	728	442	797
			WBT	700	163	728	442	797
			NBL	170	3	77	35	185
NBR	170	4	97	43	205			



Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	Signalized	EBL	165	12	109	10	88
			EBT (Continue on Duke St)	710	17	557	17	358
			EBT (to Telegraph Rd)	710	65	773	93	752
			WBT	1955	94	640	607	2138
			SBL	140	9	78	29	105
			SBR	140	15	96	40	122
71	W Taylor Run Pkwy and Service Rd	Signalized	EBL	70	2	71	14	130
			EBT	70	2	71	14	130
			EBR	70	2	71	14	130
			WBL	320	8	161	20	252
			WBT	320	8	161	20	252
			WBR	320	8	161	20	252
			NBL	40	0	0	0	2
			NBT	40	0	0	0	0
			NBR	40	0	0	0	0
			SBL	650	25	106	53	248
SBT	650	25	106	53	248			
SBR	180	24	106	52	247			
72	Duke St WB to West Taylor Run Parkway Service Rd	Unsignalized	WBT	800	1	40	1	46
			Slip Lane from Duke St WB	150	0	0	0	8
8	Duke St WB and Telegraph Rd Off-ramp	Unsignalized	WBT	700	0	0	1	87
			SBR	2400	0	0	569	1800
81	Duke St EB and Telegraph Rd On-ramp (New)	Signalized	EBL	250	27	194	43	315
			WBT	375	23	244	19	189
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	Unsignalized	WBT	550	0	0	2	279
			NBT	300	0	0	0	11
9	Duke St WB and Telegraph Rd On-ramp	Signalized	WBR	225	6	68	22	221

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	Signalized	EBT	1965	459	1505	52	485
			EBR	260	38	542	4	122
			WBT	855	34	314	147	805
			WBR	855	0	41	2	71
			NBL	185	83	656	44	239
			NBT	185	83	656	44	239
			NBR	185	81	659	42	235
			SBL	50	10	120	14	147
			SBT	50	10	120	14	147
SBR	50	10	120	15	149			

9.4.2 Alternative 3A

Operational analysis was performed at each of the study intersections for the Opening Year 2026 Alternative 3A scenario. Table 32 and Table 33 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. The Alternative 3A 2026 VISSIM results indicate that the proposed intersection of Duke Street eastbound and Telegraph Ramp is projected to operate at an acceptable overall LOS D for the AM and LOS C for the PM peak hours. The eastbound left-turn movement operates with LOS D during the AM and LOS C during the PM peak hours. Overall, all the intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak hours.

Table 32: Alternative 3A – Opening Year (2026) – Build Conditions AM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	315	324	38.7	D	23.2	C	432
		EBT	1286	1290	14.6	B			432
		WBT	898	859	20.3	C			448
		WBR	1039	979	5.6	A			424
		SBL	559	563	57.8	E			730
		SBR	272	266	46.3	D			713



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
2	Duke St and S Quaker Ln	EBL	0	0	0.0	A	6.7	A	441
		EBT	1725	1738	6.8	A			441
		EBR	120	116	2.7	A			470
		WBL	24	26	22.2	C			363
		WBT	1882	1785	5.3	A			363
		WBR	0	0	0.0	A			377
		NBL	54	52	48.2	D			136
		NBT	0	0	0.0	A			136
		NBR	14	15	24.9	C			137
		SBL	2	2	38.2	D			19
		SBT	0	0	0.0	A			19
		SBR	0	0	0.0	A			22
3	Duke St and Alexandria Commons	EBL	41	41	36.9	D	5.8	A	313
		EBT	1695	1706	2.3	A			313
		EBR	6	7	3.0	A			346
		WBL	0	0	0.0	A			653
		WBT	1859	1763	7.4	A			653
		WBR	35	33	12.4	B			687
		NBL	3	3	43.2	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	17	19	59.5	E			150
		SBT	0	0	0.0	A			150
		SBR	45	42	20.1	C			160
4	Duke St and Sweeley St	EBL	53	55	25.9	C	8.2	A	489
		EBT	1657	1666	7.6	A			490
		EBR	2	2	3.8	A			499
		WBL	22	24	27.8	C			727
		WBT	1804	1715	5.2	A			727
		WBR	123	115	5.8	A			743
		NBL	11	10	52.6	D			82
		NBT	5	5	46.7	D			82
		NBR	32	30	17.8	B			93
		SBL	83	84	52.6	D			151
		SBT	1	1	33.8	C			151
		SBR	79	76	12.5	B			151

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
5	Duke St at Roth St/ Cambridge Rd	EBL	61	57	82.8	F	18.8	B	830
		EBT	1706	1717	17.1	B			830
		EBR	4	4	15.4	B			838
		WBL	98	94	34.4	C			763
		WBT	1891	1802	17.8	B			763
		WBR	308	291	15.1	B			763
		NBL	6	5	36.9	D			91
		NBT	6	6	39.3	D			91
		NBR	55	54	15.4	B			92
		SBL	193	186	24.4	C			120
		SBT	4	4	26.3	C			120
		SBR	52	51	10.1	B			144
51	Cambridge Rd and Service Rd	EBT	9	9	32.1	D	16.3	C	282
		EBR	221	215	36.8	E			281
		WBL	28	26	58.4	F			67
		WBT	0	0	0.0	A			81
		NBL	366	319	0.5	A			34
		NBR	42	36	0.2	A			34
6	Duke St and Witter Dr	EBT	1932	1938	6.9	A	10.0	A	557
		EBR	21	21	9.1	A			564
		WBL	89	84	20.7	C			752
		WBT	2290	2188	12.0	B			752
		NBL	7	7	55.5	E			77
		NBR	26	25	17.8	B			97
7	Duke St and W Taylor Run Pkwy	EBL	31	32	55.7	E	17.2	B	96
		EBT (Continue on Duke St)	947	950	10.7	B			771
		EBT (to Telegraph Rd)	980	979	14.0	B			778
		WBT	2342	2238	17.4	B			726
		WBR	273	252	48.9	D			560
		SBL	68	65	19.2	B			82
		SBR	37	35	4.3	A			98



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
71	W Taylor Run Pkwy and Service Rd	EBL	19	19	12.4	B	8.5	A	71
		EBT	8	8	12.1	B			71
		EBR	23	22	15.0	B			71
		WBL	12	11	9.0	A			32
		WBT	6	5	5.3	A			32
		WBR	0	0	0.0	A			32
		NBL	15	13	0.6	A			36
		NBT	225	212	0.6	A			37
		NBR	63	59	0.2	A			36
		SBL	1	1	14.9	B			102
		SBT	69	68	35.8	D			102
		SBR	6	7	31.8	C			102
		81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	137	133			41.1
WBT	880			886	44.4	D	565		
SBR	1735			1608	34.0	C	3034		
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	441	437	0.3	A	0.3	A	0
		NBT	137	133	0.2	A			0
9	Duke St WB and Telegraph Rd On-ramp	WBR	441	438	8.2	A	8.2	A	150
10	Duke St and S Dove St/Roberts Ln	EBT	2193	2097	14.1	B	27.2	C	1495
		EBR	265	248	18.4	B			979
		WBT	1088	1109	53.2	D			520
		WBR	33	33	14.9	B			43
		NBL	193	176	33.4	C			1093
		NBT	29	24	36.9	D			1093
		NBR	11	10	27.0	C			1095
		SBL	16	15	48.3	D			126
		SBT	13	14	44.1	D			126
		SBR	43	42	11.2	B			126

Table 33: Alternative 3A - Opening Year (2026) – Build Conditions PM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	306	307	59.8	E	37.1	D	771
		EBT	1014	1014	32.6	C			771
		WBT	1219	1189	41.6	D			467
		WBR	717	687	12.9	B			436
		SBL	843	842	47.1	D			647
		SBR	163	160	38.5	D			633
		2	Duke St and S Quaker Ln	EBL	7	7			57.4
EBT	1480			1486	16.2	B	442		
EBR	369			359	7.8	A	472		
WBL	27			29	24.8	C	377		
WBT	1830			1786	21.2	C	377		
WBR	7			6	9.2	A	392		
NBL	105			89	344.0	F	502		
NBT	0			0	0.0	A	502		
NBR	19			17	296.7	F	503		
SBL	1			1	13.2	B	21		
SBT	0			0	0.0	A	21		
SBR	1			1	5.6	A	24		
3	Duke St and Alexandria Commons			EBL	63	63	47.2	D	21.9
		EBT	1427	1435	3.8	A	257		
		EBR	10	10	2.4	A	292		
		WBL	7	6	25.7	C	660		
		WBT	1753	1716	29.8	C	660		
		WBR	35	33	26.6	C	712		
		NBL	16	15	61.3	E	50		
		NBT	2	2	28.8	C	50		
		NBR	4	4	10.7	B	49		
		SBL	50	49	86.4	F	182		
		SBT	2	2	111.5	F	182		
SBR	95	88	97.7	F	193				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
4	Duke St and Sweeley St	EBL	30	31	20.1	C	18.4	B	402
		EBT	1449	1457	8.4	A			402
		EBR	3	3	8.1	A			412
		WBL	28	29	28.2	C			814
		WBT	1699	1663	24.0	C			814
		WBR	110	107	22.3	C			830
		NBL	19	19	50.5	D			165
		NBT	6	5	34.7	C			165
		NBR	85	86	20.2	C			176
		SBL	100	100	52.5	D			158
		SBT	8	7	43.1	D			158
		SBR	77	76	18.0	B			158
5	Duke St at Roth St/ Cambridge Rd	EBL	9	9	74.9	E	25.0	C	814
		EBT	1619	1627	18.4	B			814
		EBR	5	4	26.6	C			821
		WBL	62	64	56.8	E			784
		WBT	1791	1761	31.8	C			784
		WBR	179	175	29.7	C			784
		NBL	3	3	22.7	C			193
		NBT	11	10	39.9	D			193
		NBR	351	347	18.8	B			195
		SBL	282	250	18.2	B			118
		SBT	5	6	12.3	B			118
		SBR	42	37	9.9	A			141
51	Cambridge Rd and Service Rd	EBT	45	35	36.6	E	27.4	D	377
		EBR	281	247	39.8	E			377
		WBL	48	46	65.5	F			103
		WBT	0	0	0.0	A			117
		NBL	193	165	0.8	A			41
NBR	36	29	0.2	A	41				
6	Duke St and Witter Dr	EBT	2243	2222	10.9	B	22.5	C	796
		EBR	8	8	17.8	B			816
		WBL	30	31	35.3	D			773
		WBT	2008	1989	29.0	C			773
		NBL	24	23	236.6	F			185
NBR	72	60	145.8	F	205				

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	EBL	27	27	71.3	E	17.1	B	89
		EBT	1449	1457	8.4	A			248
		EBR (Continue on Duke St)	716	716	6.0	A			777
		EBT (to Telegraph Rd)	1573	1541	8.1	A			801
		WBT	2018	2021	22.7	C			782
		WBR	239	231	56.6	E			98
		SBL	184	180	16.3	B			116
		SBR	19	19	23.0	C			122
		EBL	8	8	28.0	C			122
		EBT	5	5	38.2	D			122
71	W Taylor Run Pkwy and Service Rd	EBR	67	64	34.6	C	17.9	B	39
		WBL	10	10	19.2	B			39
		WBT	11	11	9.4	A			39
		WBR	2	2	10.8	B			127
		NBL	36	33	2.1	A			118
		NBT	213	209	0.8	A			144
		NBR	16	16	0.4	A			198
		SBL	0	0	0.0	A			198
		SBT	125	125	43.4	D			197
		SBR	1	1	25.4	C			235
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	202	193	29.8	C	24.0	C	207
		WBT	762	765	11.9	B			880
		SBR	1495	1499	29.5	C			346
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	1776	1782	4.0	A	3.6	A	54
		NBT	202	193	0.5	A			335
9	Duke St WB and Telegraph Rd On-ramp	WBR	1776	1779	9.3	A	9.3	A	



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	EBT	1456	1451	20.0	B	22.6	C	597
		EBR	147	144	12.3	B			134
		WBT	2371	2384	24.6	C			978
		WBR	42	40	21.2	C			73
		NBL	133	129	28.7	C			251
		NBT	32	33	26.9	C			251
		NBR	21	20	16.6	B			254
		SBL	14	13	30.6	C			145
		SBT	20	19	26.9	C			145
		SBR	35	33	8.0	A			148

Signal timings for Alternative 3A 2026 Build conditions are shown on Appendix U. VISSIM results for 2026 Build Conditions is presented in the Appendix Z.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2026 Opening Year Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 144 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 144 are the movements where the reported maximum queue length value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement storage bays during both peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 ft. is projected to experience a maximum queue length of 771 ft., which is far less than queue length of 2961 ft. for the 2026 No-Build conditions during the PM peak hour.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, and westbound left-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersections of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum

queue lengths exceeding the available storage bay lengths during AM and PM peak hours. However, the eastbound right movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. It is to be noted that the westbound left-turn movement with storage of 70 ft. is projected to experience a maximum queue length of 727 ft. and 814 ft. during the AM and PM peak hours, respectively. These queue lengths are similar to 2026 No-Build conditions.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, southbound left-turn and right-turn movements are projected to experience maximum queue lengths that exceeds the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 560 ft. and 782 ft. during the AM and PM peak hours, respectively. The westbound right-turn movement queue lengths are far less than the queue lengths for 2026 No-Build conditions. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 778 ft. and 777 ft. during the AM and PM peak hours, respectively. The queue lengths for the eastbound movement are similar to 2026 No-Build conditions.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 102 ft. and 198 ft. during the AM and PM peak hours. This queue lengths are far less than the 2026 No-Build conditions when the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 358 ft. and 515 ft. during the AM and PM peak hours. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 39 ft. during the PM peak hour. The westbound queue lengths are far less than the 2026 No-build conditions when the westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 918 ft. during the PM peak hour.

At the intersection of Duke Street eastbound and Telegraph Road on-ramp new, the southbound right-turn movement is projected to experience maximum queue lengths 3034 ft. and 880 ft. during the AM and PM peak hours, respectively. Note that the 2400 ft. of storage is the storage length available up to Telegraph Road bridge and addition storage is available beyond the bridge.

**At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn movements and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 1093 ft. and 251 ft. during the AM and PM peak hours, respectively. These queue lengths are less than 2026 No-Build conditions when the northbound left-turn movement is projected to experience a maximum queue length of 1373 ft. and 300 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 979 ft. during the AM peak hour and 134 ft. during the PM peak hour. Note that, for 2026 No-Build conditions, the eastbound right-turn movement with storage**



of 260 ft. is projected to experience a maximum queue length of 1259 ft. during the AM peak hour and 186 ft. during the PM peak hour.

Intersection MOE tables for 2026 & 2036 Build conditions are shown on Appendix Z.

Table 34: Alternative 3A - Opening Year (2026) – Build Conditions Summary of Intersection Queues (feet)

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	Signalized	EBL	200	94	432	201	771
			EBT	360	94	432	201	771
			WBT	330	76	448	250	467
			WBR	300	24	424	24	436
			SBL	1290	223	730	198	647
2	Duke St and S Quaker Ln	Signalized	SBR	1270	165	713	181	633
			EBL	200	53	441	121	442
			EBT	330	53	441	121	442
			EBR	300	61	470	137	472
			WBL	80	31	363	141	377
			WBT	210	31	363	141	377
			WBR	210	33	377	149	392
			NBL	335	18	136	287	502
			NBT	335	18	136	287	502
			NBR	335	14	137	287	503
3	Duke St and Alexandria Commons	Signalized	SBL	40	0	19	0	21
			SBT	40	0	19	0	21
			SBR	40	0	22	0	24
			EBL	105	10	313	21	257
			EBT	210	10	313	21	257
			EBR	210	11	346	26	292
			WBL	315	81	653	271	660
			WBT	520	81	653	271	660
			WBR	520	42	687	269	712
			NBL	50	1	23	4	50
4	Duke St and Sweeley St	Signalized	NBT	50	1	23	4	50
			NBR	50	1	22	3	49
			SBL	215	9	150	78	182
			SBT	215	9	150	78	182
			SBR	215	13	160	87	193
			EBL	190	43	489	39	402
			EBT	520	45	490	39	402
			EBR	520	46	499	42	412
			WBL	70	36	727	231	814
			WBT	225	36	727	231	814
5	Duke St at Roth St/ Cambridge Rd	Signalized	WBR	225	38	743	241	830
			NBL	230	6	82	13	165
			NBT	230	6	82	13	165
			NBR	230	9	93	18	176
			SBL	110	27	151	33	158
			SBT	110	27	151	33	158
			SBR	110	27	151	33	158

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
5	Duke St at Roth St/ Cambridge Rd	Signalized	EBL	115	212	830	157	814
			EBT	350	212	830	157	814
			EBR	350	214	838	161	821
			WBL	230	267	763	549	784
			WBT	670	267	763	549	784
			WBR	670	267	763	549	784
			NBL	150	6	91	40	193
			NBT	150	6	91	40	193
			NBR	150	7	92	42	195
51	Cambridge Rd and Service Rd	Unsignalized	SBL	40	55	120	55	118
			SBT	40	55	120	55	118
			SBR	40	72	144	71	141
			EBT	1330	39	282	58	377
			EBR	1330	37	281	56	377
6	Duke St and Witter Dr	Signalized	WBL	825	5	67	13	103
			WBT	825	5	81	15	117
			NBL	40	1	34	1	41
			NBR	40	1	34	1	41
6	Duke St and Witter Dr	Signalized	EBT	675	51	557	203	796
			EBR	675	53	564	215	816
			WBL	215	116	752	267	773
			WBT	700	116	752	267	773
			NBL	170	3	77	76	185
			NBR	170	4	97	89	205
7	Duke St and W Taylor Run Pkwy	Signalized	EBL	165	10	96	11	89
			EBT (Continue on Duke St)	710	93	771	15	248
			EBT (to Telegraph Rd)	710	162	778	86	777
			WBT	1955	155	726	179	801
			WBR	110	86	560	136	782
			SBL	140	8	82	26	98
71	W Taylor Run Pkwy and Service Rd	Signalized	SBR	140	13	98	35	116
			EBL	70	3	71	12	122
			EBT	70	3	71	12	122
			EBR	70	3	71	12	122
			WBL	320	1	32	1	39
			WBT	320	1	32	1	39
			WBR	320	1	32	1	39
			NBL	40	0	36	1	127
			NBT	40	0	37	1	118
			NBR	40	0	36	2	144
81	Duke St EB and Telegraph Rd On-ramp (New)	Signalized	SBL	650	18	102	41	198
			SBT	650	18	102	41	198
			SBR	180	18	102	40	197
			EBL	250	35	217	35	235
			WBT	375	152	565	33	207
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	Unsignalized	SBR	2400	2334	3034	265	880
			WBT	550	0	0	3	346
			NBT	300	0	0	0	54



Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
9	Duke St WB and Telegraph Rd On-ramp	Signalized	WBR	225	13	150	57	335
10	Duke St and S Dove St/Roberts Ln	Signalized	EBT	1965	469	1495	90	597
			EBR	260	69	979	4	134
			WBT	855	167	520	312	978
			WBR	855	0	43	2	73
			NBL	185	127	1093	37	251
			NBT	185	127	1093	37	251
			NBR	185	125	1095	35	254
			SBL	50	13	126	12	145
			SBT	50	13	126	12	145
SBR	50	13	126	13	148			



### 9.5 2036 VISSIM Analysis

After performing the initial screening using the Synchro software, operational analysis was performed at each of the study intersections for the Future 2036 Build Conditions scenario for all the Alternatives using the VISSIM software. Alternatives were compared to the No-Build conditions. The following will describe the summary of the average AM and PM peak hour delay, LOS and the maximum queue length for each of the three Alternatives.

#### 9.5.1 Alternative 1

Operational analysis was performed at each of the study intersections for the Design Year 2036 Alternative 1 scenario. Table 35 and Table 36 provide a summary of the average delay, and LOS for each movement for the study intersections along the Duke Street corridor for Alternative 1 during the AM and PM peak hours, respectively.

The results show that all intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak hours, except for Cambridge Road and Service Road which is projected operate with overall intersection LOS F during the AM peak hour.

The southbound left-turn movement at the intersection of Duke Street and N. Quaker Lane is projected to operate at LOS F during the AM peak hour and LOS D during the PM peak hour. The eastbound right-turn movement at the intersection of Duke Street at Roth Street is projected to operate at LOS F and LOS E during the AM and PM peak hours, respectively.

Table 35: Alternative 1 - Design Year (2036) – Build Conditions AM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	323	331	36.1	D	31.3	C	427
		EBT	1319	1325	13.0	B			427
		WBT	920	876	17.5	B			445
		WBR	1065	995	5.6	A			419
		SBL	573	509	119.2	F			1049
		SBR	279	237	98.1	F			1034

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
2	Duke St and S Quaker Ln	EBL	0	0	0.0	A	6.6	A	436
		EBT	1769	1719	7.0	A			436
		EBR	123	114	3.1	A			465
		WBL	25	26	24.3	C			359
		WBT	1930	1818	4.9	A			359
		WBR	0	0	0.0	A			373
		NBL	55	53	46.4	D			137
		NBT	0	0	0.0	A			137
		NBR	15	16	29.1	C			138
		SBL	2	2	38.2	D			19
		SBT	0	0	0.0	A			19
SBR	0	0	0.0	A	22				
3	Duke St and Alexandria Commons	EBL	42	41	37.1	D	5.8	A	320
		EBT	1737	1690	2.4	A			320
		EBR	6	6	2.6	A			353
		WBL	0	0	0.0	A			647
		WBT	1906	1800	7.3	A			647
		WBR	36	34	12.3	B			698
		NBL	3	3	44.0	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	18	19	57.8	E			141
		SBT	0	0	0.0	A			141
SBR	46	42	19.7	B	152				
4	Duke St and Sweeley St	EBL	54	54	27.6	C	8.3	A	473
		EBT	1699	1647	7.6	A			473
		EBR	2	2	5.6	A			482
		WBL	23	25	24.2	C			716
		WBT	1849	1742	5.4	A			716
		WBR	127	118	5.5	A			731
		NBL	12	12	49.1	D			88
		NBT	5	5	55.4	E			88
		NBR	32	32	16.9	B			99
		SBL	85	86	52.6	D			152
		SBT	1	1	36.0	D			152
SBR	81	78	12.6	B	152				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
5	Duke St at Roth St/ Cambridge Rd	EBL	63	57	81.5	F	19.7	B	823
		EBT	1749	1701	16.6	B			823
		EBR	4	5	16.2	B			830
		WBL	100	96	33.6	C			759
		WBT	1939	1827	19.5	B			759
		WBR	316	294	17.3	B			759
		NBL	6	5	37.6	D			100
		NBT	6	6	41.6	D			100
		NBR	56	57	15.5	B			101
		SBL	198	171	32.2	C			118
		SBT	4	3	28.3	C			118
		SBR	53	48	9.7	A			142
		51	Cambridge Rd and Service Rd	EBT	10	9			38.1
EBR	227			219	42.8	E	1610		
WBL	28			28	73.1	F	86		
WBT	0			0	0.0	A	100		
NBL	375			322	0.6	A	48		
NBR	43			36	0.2	A	48		
6	Duke St and Witter Dr	EBT	1981	1911	5.8	A	10.3	B	522
		EBR	22	22	7.1	A			529
		WBL	91	84	19.5	B			746
		WBT	2348	2213	13.7	B			746
		NBL	7	7	55.9	E			77
7	Duke St and W Taylor Run Pkwy	EBL	31	30	58.9	E	9.5	A	93
		EBT (Continue on Duke St)	971	937	4.8	A			732
		EBT (to Telegraph Rd)	1005	968	7.0	A			777
		WBT	2402	2262	11.6	B			893
		SBL	70	67	21.3	C			85
		SBR	38	36	4.2	A			102

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
71	W Taylor Run Pkwy and Service Rd	EBL	20	20	6.4	A	15.4	B	65
		EBT	8	8	5.0	A			65
		EBR	24	22	9.9	A			65
		WBL	13	11	7.1	A			164
		WBT	20	18	7.3	A			164
		WBR	208	191	7.5	A			164
		NBL	2	1	0.1	A			0
		NBT	23	23	0.7	A			0
		NBR	7	6	0.3	A			0
		SBL	1	1	13.0	B			110
		SBT	71	70	49.3	D			110
		SBR	6	6	50.1	D			110
		72	Duke St WB to West Taylor Run Parkway Service Rd	WBT	19	17			8.2
Slip Lane from Duke St WB	280			257	6.1	A	0		
8	Duke St WB and Telegraph Rd Off-ramp	WBT	904	901	0.6	A	1.4	A	34
		SBR	1779	1616	1.8	A			907
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	140	136	31.9	C	10.4	B	194
		WBT	903	902	7.2	A			225
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	453	449	0.2	A	0.2	A	0
		NBT	140	135	0.2	A			0
9	Duke St WB and Telegraph Rd On-ramp	WBR	453	450	3.2	A	3.2	A	76



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	EBT	2249	2114	15.1	B	14.5	B	439
		EBR	272	248	14.2	B			349
		WBT	1115	1132	11.0	B			335
		WBR	33	33	8.5	A			53
		NBL	198	177	27.6	C			463
		NBT	29	24	29.8	C			463
		NBR	12	10	20.3	C			466
		SBL	17	15	39.9	D			126
		SBT	14	14	32.3	C			126
		SBR	44	42	8.1	A			127

Table 36: Alternative 1 - Design Year (2036) – Build Conditions PM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	314	310	80.7	F	43.6	D	1154
		EBT	1040	1035	48.1	D			1154
		WBT	1250	1154	42.0	D			468
		WBR	735	670	13.0	B			395
		SBL	864	867	51.3	D			766
		SBR	167	164	41.6	D			705
		2	Duke St and S Quaker Ln	EBL	7	6			48.8
EBT	1518			1524	16.7	B	448		
EBR	379			370	7.5	A	476		
WBL	27			28	26.7	C	380		
WBT	1876			1723	21.5	C	380		
WBR	7			6	18.2	B	395		
NBL	108			104	193.7	F	387		
NBT	0			0	0.0	A	387		
NBR	20			20	162.2	F	388		
SBL	1			1	17.0	B	21		
SBT	0			0	0.0	A	21		
3	Duke St and Alexandria Commons	EBL	65	65	48.5	D	26.3	C	282
		EBT	1463	1472	6.3	A			282
		EBR	10	10	6.7	A			311
		WBL	7	5	28.5	C			660
		WBT	1797	1648	36.9	D			660
		WBR	36	30	32.5	C			712
		NBL	17	16	65.1	E			55
		NBT	2	2	32.3	C			55
		NBR	4	4	10.3	B			55
		SBL	51	49	89.2	F			182
		SBT	2	2	85.8	F			182
SBR	97	89	102.0	F	193				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
4	Duke St and Sweeley St	EBL	30	32	16.0	B	23.3	C	347
		EBT	1485	1493	7.9	A			347
		EBR	3	3	5.6	A			357
		WBL	28	27	32.7	C			818
		WBT	1742	1583	35.3	D			818
		WBR	113	102	30.8	C			834
		NBL	20	19	50.0	D			175
		NBT	6	5	49.0	D			175
		NBR	87	87	20.5	C			185
		SBL	103	102	48.4	D			157
		SBT	8	8	56.3	E			157
		SBR	78	78	22.7	C			157
5	Duke St at Roth St/ Cambridge Rd	EBL	9	9	77.9	E	27.1	C	811
		EBT	1660	1670	15.8	B			811
		EBR	5	4	21.0	C			818
		WBL	64	60	46.3	D			788
		WBT	1837	1672	40.4	D			788
		WBR	183	167	29.3	C			788
		NBL	3	3	32.0	C			193
		NBT	12	11	41.9	D			193
		NBR	360	351	19.8	B			195
		SBL	289	258	18.1	B			117
		SBT	5	6	26.5	C			117
		SBR	43	38	13.5	B			141
51	Cambridge Rd and Service Rd	EBT	37	34	36.6	E	29.1	D	387
		EBR	288	256	41.3	E			386
		WBL	49	47	69.7	F			109
		WBT	0	0	0.0	A			122
		NBL	198	159	1.2	A			72
NBR	38	29	0.4	A	72				
6	Duke St and Witter Dr	EBT	2300	2275	11.6	B	32.0	C	588
		EBR	8	8	9.6	A			600
		WBL	30	27	51.3	D			837
		WBT	2058	1875	53.5	D			837
		NBL	25	26	153.3	F			189
NBR	74	72	68.5	E	209				

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
7	Duke St and W Taylor Run Pkwy	EBL	27	27	67.9	E	32.4	C	98				
		EBT (Continue on Duke St)	734	739	12.8	B			588				
		EBT (to Telegraph Rd)	1613	1591	11.3	B			791				
		WBT	2069	1899	58.3	E			2678				
		SBL	188	184	19.5	B			110				
		SBR	20	19	55.1	E			127				
		71	W Taylor Run Pkwy and Service Rd	EBL	8	9			38.7	D	35.6	D	168
				EBT	5	5			45.0	D			168
EBR	69			67	56.3	E	168						
WBL	10			11	30.7	C	284						
WBT	44			39	19.7	B	284						
WBR	199			177	19.2	B	284						
NBL	4			3	0.0	A	0						
NBT	22			22	0.8	A	0						
NBR	2			2	0.3	A	0						
SBL	0			0	0.0	A	278						
SBT	129	127	59.6	E	278								
SBR	1	1	22.0	C	278								
72	Duke St WB to West Taylor Run Parkway Service Rd	WBT	24	24	8.2	A	14.9	B	50				
		Slip Lane from Duke St WB	245	220	15.6	C			0				
8	Duke St WB and Telegraph Rd Off-ramp	WBT	781	781	2.2	A	4.8	A	170				
		SBR	1532	1390	6.2	A			2732				
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	207	196	35.5	D	12.7	B	357				
		WBT	781	784	6.9	A			192				
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	1821	1830	3.1	A	2.9	A	194				
		NBT	207	197	0.3	A			24				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
9	Duke St WB and Telegraph Rd On-ramp	WBR	1821	1835	4.2	A	4.2	A	225
10	Duke St and S Dove St/Roberts Ln	EBT	1493	1434	12.1	B	14.1	B	504
		EBR	151	139	9.1	A			136
		WBT	2431	2447	13.9	B			851
		WBR	43	42	18.9	B			68
		NBL	136	124	34.4	C			254
		NBT	32	34	33.9	C			254
		NBR	22	20	20.3	C			257
		SBL	15	14	41.0	D			145
		SBT	21	19	37.0	D			145
SBR	36	35	7.2	A	147				

Signal timings for Alternative 1 2036 Build conditions are shown on Appendix W. VISSIM results for 2036 Build Conditions is presented in the Appendix Z.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2036 No-Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 37 Provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 37 are the movements where the reported maximum queue lengths value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement during AM and PM peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 feet is projected to experience a maximum queue length of 1154 ft during the PM peak hour which is far less than a maximum queue length of 3055 ft during the PM peak hour observed for 2026 No-Build conditions.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, westbound left-turn and west bound righ-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and

northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements, are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound left-turn movement with storage of 70 feet is projected to experience a maximum queue length of 716 ft and 818 ft. during the AM and PM peak hours, respectively.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during AM and PM peak hours. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement length has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, and southbound left-turn and right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. For 2036 No-Build condition, the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 2062 ft. and 2454 ft. during the AM and PM peak hours, respectively. Note that the westbound right-turn movement is eliminated in Alternative 1. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 777 ft. and 791 ft. during the AM and PM peak hours, respectively.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 110 ft. and 278 ft. during the AM and PM peak hours. This queue lengths are far less than the 2026 No-Build conditions when the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 426 ft. and 478 ft. during the AM and PM peak hours. This is mainly due to restricting the southbound movement to Telegraph Road ramp. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 284 ft. during the PM peak hour. The westbound queue lengths are far less than the 2026 No-build conditions when the westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 940 ft. during the PM peak hour. Reduction in queues is mainly due to eliminating the exclusive westbound right-turn phase and giving that time to other movements even though the westbound traffic is much heavier for the Alternative 1 compared to No-Build conditions.

At the intersection of Duke Street westbound and right-turn slip lane to the W. Taylor Run Parkway Service Road, the westbound movement is projected to experience maximum queue lengths 50 ft. during the PM peak hour. Traffic from the slip lane does not experience any queue during the Am or PM peak hour. Note that this movement is free and not controlled by any traffic control device.

At the intersection of Duke Street eastbound and Telegraph Road on-ramp new, the eastbound left-turn movement is projected to experience maximum queue lengths 357 ft. and 194 ft. during the AM and PM peak hours, respectively. Note that Telegraph Road off-ramp to westbound Duke Street is maintained in this alternative.



At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn movements and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 463 ft. and 254 ft. during the AM and PM peak hours, respectively. These queue lengths are less than 2026 No-Build conditions when the northbound left-turn movement is projected to experience a maximum queue length of 1363 ft. and 312 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 349 ft. during the AM peak hour and 136 ft. during the PM peak hour. Note that, for 2026 No-Build conditions, the eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1249 ft. during the AM peak hour and 198 ft. during the PM peak hour.

Intersection MOE tables for 2026 & 2036 Build conditions are shown on Appendix Z.

Table 37: Alternative 1 - Design Year (2036) – Build Conditions Summary of Intersection Queues (feet)

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak				
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)			
1	Duke St and N Quaker Ln	Signalized	EBL	200	85	427	398	1154			
			EBT	360	85	427	398	1154			
			WBT	330	65	445	236	468			
			WBR	300	23	419	14	395			
			SBL	1290	872	1049	228	766			
			SBR	1270	853	1034	107	705			
2	Duke St and S Quaker Ln	Signalized	EBL	200	57	436	133	448			
			EBT	330	57	436	133	448			
			EBR	300	65	465	147	476			
			WBL	80	25	359	160	380			
			WBT	210	25	359	160	380			
			WBR	210	27	373	170	395			
			NBL	335	18	137	160	387			
			NBT	335	18	137	160	387			
			NBR	335	14	138	160	388			
			SBL	40	0	19	0	21			
			SBT	40	0	19	0	21			
			SBR	40	0	22	0	23			
			3	Duke St and Alexandria Commons	Signalized	EBL	105	10	320	35	282
						EBT	210	10	320	35	282
EBR	210	12				353	41	311			
WBL	315	85				647	349	660			
WBT	520	85				647	349	660			
WBR	520	45				698	349	712			
NBL	50	1				23	4	55			
NBT	50	1				23	4	55			
NBR	50	1				22	3	55			
SBL	215	9				141	83	182			
SBT	215	9				141	83	182			
SBR	215	12				152	93	193			

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak				
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)			
4	Duke St and Sweeley St	Signalized	EBL	190	41	473	36	347			
			EBT	520	43	473	36	347			
			EBR	520	44	482	39	357			
			WBL	70	36	716	402	818			
			WBT	225	36	716	402	818			
			WBR	225	38	731	415	834			
			NBL	230	7	88	14	175			
			NBT	230	7	88	14	175			
			NBR	230	10	99	19	185			
			SBL	110	27	152	33	157			
5	Duke St at Roth St/ Cambridge Rd	Signalized	EBL	115	203	823	130	811			
			EBT	350	203	823	130	811			
			EBR	350	203	830	133	818			
			WBL	230	302	759	568	788			
			WBT	670	302	759	568	788			
			WBR	670	302	759	568	788			
			NBL	150	6	100	45	193			
			NBT	150	6	100	45	193			
			NBR	150	8	101	47	195			
			SBL	40	76	118	57	117			
51	Cambridge Rd and Service Rd	Unsignalized	EBT	1330	1147	1610	64	387			
			EBR	1330	1143	1610	61	386			
			WBL	825	10	86	14	109			
			WBT	825	10	100	15	122			
			NBL	40	1	48	1	72			
			NBR	40	1	48	1	72			
			6	Duke St and Witter Dr	Signalized	EBT	675	42	522	73	588
						EBR	675	44	529	77	600
						WBL	215	158	746	594	837
						WBT	700	158	746	594	837
NBL	170	3				77	38	189			
NBR	170	4				97	48	209			
7	Duke St and W Taylor Run Pkwy	Signalized	EBL	165	11	93	10	98			
			EBT (Continue on Duke St)	710	30	732	30	588			
			EBT (to Telegraph Rd)	710	71	777	110	791			
			WBT	1955	111	893	1776	2678			
			SBL	140	9	85	33	110			
SBR	140	15	102	45	127						



Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
71	W Taylor Run Pkwy and Service Rd	Signalized	EBL	70	2	65	23	168
			EBT	70	2	65	23	168
			EBR	70	2	65	23	168
			WBL	320	8	164	26	284
			WBT	320	8	164	26	284
			WBR	320	8	164	26	284
			NBL	40	0	0	0	0
			NBT	40	0	0	0	0
			NBR	40	0	0	0	0
			SBL	650	25	110	56	278
72	Duke St WB to West Taylor Run Parkway Service Rd	Unsignalized	Slip Lane from Duke St WB	150	0	0	0	0
			WBT	800	1	45	1	50
8	Duke St WB and Telegraph Rd Off-ramp	Unsignalized	WBT	700	0	34	3	170
			SBR	2400	569	907	1569	2732
81	Duke St EB and Telegraph Rd On-ramp (New)	Signalized	EBL	250	27	194	45	357
			WBT	375	23	225	19	192
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	Unsignalized	WBT	550	0	0	1	194
			NBT	300	0	0	0	24
9	Duke St WB and Telegraph Rd On-ramp	Signalized	WBR	225	6	76	23	225
10	Duke St and S Dove St/Roberts Ln	Signalized	EBT	1965	107	439	51	504
			EBR	260	16	349	4	136
			WBT	855	36	335	156	851
			WBR	855	1	53	3	68
			NBL	185	60	463	42	254
			NBT	185	60	463	42	254
			NBR	185	58	466	40	257
			SBL	50	10	126	18	145
			SBR	50	10	127	18	147

9.5.2 Alternative 3A

Operational analysis was performed at each of the study intersections for the Design 2036 No-Build Conditions scenario. Table 38 and Table 39 provide a summary of the average delay, and LOS for each movement for the study intersections along the Duke Street corridor for Alternative 3A during the AM and PM peak hours, respectively.

The results show that all intersections are projected to operate at acceptable overall LOS of D or better for both AM and PM peak hours.

Table 38: Alternative 3A - Design Year (2036) – Build Conditions AM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	323	332	48.4	D	23.8	C	498
		EBT	1319	1325	16.5	B			498
		WBT	920	867	20.2	C			443
		WBR	1065	989	5.3	A			420
		SBL	573	578	54.5	D			638
		SBR	279	274	41.8	D			620
2	Duke St and S Quaker Ln	EBL	0	0	0.0	A	6.8	A	439
		EBT	1769	1783	7.2	A			439
		EBR	123	120	3.4	A			468
		WBL	25	26	23.2	C			364
		WBT	1930	1803	5.0	A			364
		WBR	0	0	0.0	A			379
		NBL	55	53	46.4	D			143
		NBT	0	0	0.0	A			143
		NBR	15	16	28.8	C			145
		SBL	2	2	38.7	D			19
SBR	0	0	0.0	A	19				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	42	42	38.5	D	6.0	A	316
		EBT	1737	1753	2.8	A			316
		EBR	6	6	1.7	A			349
		WBL	0	0	0.0	A			649
		WBT	1906	1787	7.4	A			649
		WBR	36	33	11.9	B			687
		NBL	3	3	39.3	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	18	19	57.0	E			134
		SBT	0	0	0.0	A			134
		SBR	46	42	19.1	B			145
4	Duke St and Sweeley St	EBL	54	55	29.3	C	8.9	A	541
		EBT	1699	1713	8.7	A			546
		EBR	2	2	8.4	A			555
		WBL	23	24	25.1	C			679
		WBT	1849	1732	5.5	A			679
		WBR	127	118	6.2	A			695
		NBL	12	12	49.4	D			88
		NBT	5	5	56.4	E			88
		NBR	32	32	19.2	B			99
		SBL	85	86	53.6	D			148
		SBT	1	1	35.9	D			148
		SBR	81	78	12.3	B			148
5	Duke St at Roth St/ Cambridge Rd	EBL	63	60	82.4	F	19.3	B	831
		EBT	1749	1762	16.8	B			831
		EBR	4	5	13.1	B			839
		WBL	100	94	37.1	D			768
		WBT	1939	1816	19.0	B			768
		WBR	316	293	16.3	B			768
		NBL	6	5	36.9	D			89
		NBT	6	6	41.1	D			89
		NBR	56	57	16.3	B			92
		SBL	198	191	23.6	C			119
		SBT	4	4	33.3	C			119
		SBR	53	52	11.4	B			143

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
51	Cambridge Rd and Service Rd	EBT	10	9	32.4	D	17.1	C	305				
		EBR	227	220	37.5	E			304				
		WBL	28	28	66.6	F			83				
		WBT	0	0	0.0	A			96				
		NBL	375	323	0.5	A			25				
		NBR	43	35	0.1	A			25				
6	Duke St and Witter Dr	EBT	1981	1990	7.2	A	11.6	B	544				
		EBR	22	22	12.1	B			551				
		WBL	91	83	23.2	C			817				
		WBT	2348	2205	14.9	B			817				
		NBL	7	7	55.8	E			77				
		NBR	26	25	17.8	B			97				
7	Duke St and W Taylor Run Pkwy	EBL	31	32	63.8	E	18.0	B	104				
		EBT (Continue on Duke St)	971	976	10.8	B			780				
		EBT (to Telegraph Rd)	1005	1004	13.9	B			787				
		WBT	2402	2256	18.9	B			825				
		WBR	280	256	49.5	D			743				
		SBL	70	67	18.5	B			83				
		SBR	38	36	5.2	A			100				
		71	W Taylor Run Pkwy and Service Rd	EBL	20	20			11.3	B	8.7	A	63
				EBT	8	8			10.8	B			63
				EBR	24	22			15.1	B			63
WBL	13			11	7.3	A	31						
WBT	6			6	8.4	A	31						
WBR	0			0	0.0	A	31						
NBL	16			14	0.4	A	10						
NBT	231			214	0.7	A	10						
NBR	65			60	0.2	A	10						
SBL	1			1	13.9	B	107						
SBT	71			70	36.7	D	107						
SBR	6			6	35.9	D	107						



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	140	136	41.3	D	39.7	D	210
		WBT	903	911	49.3	D			609
		SBR	1779	1615	34.2	C			3036
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	453	451	0.3	A	0.3	A	0
		NBT	140	136	0.2	A			0
9	Duke St WB and Telegraph Rd On-ramp	WBR	453	450	10.3	B	10.3	B	152
10	Duke St and S Dove St/Roberts Ln	EBT	2249	2126	13.8	B	27.8	C	1495
		EBR	272	246	18.1	B			1037
		WBT	1115	1141	55.7	E			552
		WBR	33	33	17.0	B			55
		NBL	198	178	32.8	C			1151
		NBT	29	24	39.5	D			1151
		NBR	12	10	24.9	C			1154
		SBL	17	15	47.5	D			128
		SBT	14	14	35.9	D			128
		SBR	44	42	11.1	B			129

Table 39: Alternative 3A - Design Year (2036) – Build Conditions PM Peak Hour Delay and LOS

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	314	315	69.7	E	40.5	D	939
		EBT	1040	1044	41.5	D			939
		WBT	1250	1181	42.3	D			472
		WBR	735	684	12.8	B			435
		SBL	864	863	48.4	D			665
		SBR	167	164	39.6	D			651
2	Duke St and S Quaker Ln	EBL	7	7	54.3	D	29.0	C	441
		EBT	1518	1526	16.8	B			441
		EBR	379	372	7.7	A			471
		WBL	27	28	32.6	C			374
		WBT	1876	1781	22.0	C			374
		WBR	7	6	17.5	B			389
		NBL	108	89	400.8	F			526
		NBT	0	0	0.0	A			526
		NBR	20	18	364.5	F			527
		SBL	1	1	13.3	B			21
		SBT	0	0	0.0	A			21
		SBR	1	1	5.3	A			24
3	Duke St and Alexandria Commons	EBL	65	64	52.5	D	23.8	C	259
		EBT	1463	1469	5.3	A			259
		EBR	10	10	3.4	A			294
		WBL	7	6	27.2	C			663
		WBT	1797	1704	31.5	C			663
		WBR	36	32	26.8	C			716
		NBL	17	16	63.9	E			55
		NBT	2	1	32.4	C			55
		NBR	4	4	11.6	B			54
		SBL	51	49	97.1	F			182
		SBT	2	2	111.3	F			182
SBR	97	88	111.3	F	193				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
4	Duke St and Sweeley St	EBL	30	32	20.6	C	22.3	C	537
		EBT	1485	1489	16.2	B			537
		EBR	3	3	12.2	B			548
		WBL	28	29	30.6	C			795
		WBT	1742	1654	25.6	C			795
		WBR	113	107	22.6	C			811
		NBL	20	19	50.6	D			175
		NBT	6	5	48.9	D			175
		NBR	87	87	22.8	C			186
		SBL	103	103	47.9	D			155
		SBT	8	8	55.2	E			155
		SBR	78	78	19.2	B			155
5	Duke St at Roth St/ Cambridge Rd	EBL	9	9	85.6	F	30.7	C	826
		EBT	1660	1665	24.4	C			826
		EBR	5	4	22.5	C			834
		WBL	64	63	66.4	E			785
		WBT	1837	1746	38.4	D			785
		WBR	183	173	40.9	D			785
		NBL	3	3	30.1	C			193
		NBT	12	10	42.3	D			193
		NBR	360	352	20.4	C			195
		SBL	289	258	17.7	B			117
		SBT	5	6	19.8	B			117
		SBR	43	38	11.8	B			141
51	Cambridge Rd and Service Rd	EBT	45	34	35.7	E	27.8	D	370
		EBR	288	256	40.8	E			370
		WBL	49	47	62.6	F			93
		WBT	0	0	0.0	A			107
		NBL	198	163	0.9	A			65
		NBR	38	30	0.2	A			65
6	Duke St and Witter Dr	EBT	2300	2277	14.6	B	34.0	C	798
		EBR	8	8	21.5	C			817
		WBL	30	30	44.1	D			835
		WBT	2058	1977	46.3	D			835
		NBL	25	17	428.2	F			192
		NBR	74	46	314.6	F			212

Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
7	Duke St and W Taylor Run Pkwy	EBL	27	27	72.5	E	24.2	C	81				
		EBT (Continue on Duke St)	734	729	6.5	A			192				
		EBT (to Telegraph Rd)	1613	1572	8.9	A			783				
		WBT	2069	2006	37.9	D			1294				
		WBR	245	230	64.7	E			1292				
		SBL	188	185	16.8	B			99				
		SBR	20	19	38.8	D			116				
		71	W Taylor Run Pkwy and Service Rd	EBL	8	9			32.9	C	20.5	C	155
				EBT	5	5			42.5	D			155
				EBR	69	68			50.9	D			155
WBL	10			11	24.7	C	36						
WBT	12			12	11.7	B	36						
WBR	2			2	3.8	A	36						
NBL	37			33	2.1	A	125						
NBT	219			207	0.9	A	115						
NBR	17			16	0.2	A	139						
SBL	0			0	0.0	A	198						
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	207	199	29.0	C	28.0	C	266				
		WBT	781	786	13.8	B			235				
		SBR	1532	1498	35.3	D			1306				
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	1821	1830	4.2	A	3.9	A	356				
		NBT	207	198	0.8	A			82				
9	Duke St WB and Telegraph Rd On-ramp	WBR	1821	1825	11.1	B	11.1	B	345				



Node	Intersection	Movement	Balanced Count (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	EBT	1493	1484	19.9	B	23.9	C	696
		EBR	151	149	12.6	B			163
		WBT	2431	2444	27.0	C			1012
		WBR	43	41	21.4	C			66
		NBL	136	133	27.8	C			281
		NBT	32	34	27.3	C			281
		NBR	22	20	19.7	B			276
		SBL	15	14	33.3	C			142
		SBT	21	20	29.4	C			142
		SBR	36	35	8.5	A			143

Signal timings for Alternative 3A 2036 Build conditions are shown on Appendix X. VISSIM results for 2036 Build Conditions is presented in the Appendix Z.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2036 No-Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 40 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 40 are the movements where the reported maximum queue lengths value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement during AM and PM peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 feet is projected to experience a maximum queue length of 939 ft during the PM peak hour which is far less than a maximum queue length of 3055 ft during the PM peak hour observed for 2026 No-Build conditions.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, westbound left-turn and west bound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements, are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound left-turn movement with storage of 70 feet is projected to experience a maximum queue length of 695 ft and 811 ft. during the AM and PM peak hours, respectively.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement length has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, westbound right-turn, and southbound left-turn and right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 743 ft. and 1292 ft. during the AM and PM peak hours, respectively. The queue lengths for this movement for Alternative 3A are far less than 2036 No-Build condition maximum queue lengths of 2062 ft. and 2454 ft. during the AM and PM peak hours, respectively. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 787 ft. and 783 ft. during the AM and PM peak hours, respectively.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 107 ft. and 198 ft. during the AM and PM peak hours. This queue lengths are far less than the 2026 No-Build conditions when the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 426 ft. and 478 ft. during the AM and PM peak hours. This is mainly due to restricting the southbound movement to Telegraph Road ramp. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 36 ft. during the PM peak hour. The westbound queue lengths are far less than the 2026 No-build conditions when the westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 940 ft. during the PM peak hour.

At the intersection of Duke Street eastbound and Telegraph Road on-ramp new, the southbound right-turn movement is projected to experience maximum queue lengths 3036 ft. and 1306 ft. during the AM and PM peak hours, respectively. Note that the 2400 ft. of storage is the storage length available up to Telegraph Road bridge and addition storage is available beyond the bridge.

**At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn movements and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 1151 ft. and 281 ft. during the AM and PM peak hours, respectively. These queue lengths are less than 2026 No-Build conditions when the northbound left-turn movement is projected to experience a maximum queue length of 1363 ft. and 312 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1037 ft. during the AM peak hour and 153 ft. during the PM peak hour. Note that, for 2026 No-Build conditions, the eastbound right-turn movement with**



storage of 260 ft. is projected to experience a maximum queue length of 1249 ft. during the AM peak hour and 198 ft. during the PM peak hour.

Intersection MOE tables for 2026 & 2036 Build conditions are shown on Appendix Z.

Table 40: Alternative 3A - Design Year (2036) – Build Conditions Summary of Intersection Queues (feet)

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	Signalized	EBL	200	117	498	323	939
			EBT	360	117	498	323	939
			WBT	330	74	443	255	472
			WBR	300	22	420	16	435
			SBL	1290	193	638	205	665
			SBR	1270	124	620	190	651
2	Duke St and S Quaker Ln	Signalized	EBL	200	61	439	135	441
			EBT	330	61	439	135	441
			EBR	300	70	468	151	471
			WBL	80	29	364	146	374
			WBT	210	29	364	146	374
			WBR	210	31	379	154	389
			NBL	335	19	143	364	526
			NBT	335	19	143	364	526
			NBR	335	14	145	365	527
			SBL	40	0	19	0	21
			SBT	40	0	19	0	21
			SBR	40	0	22	0	24
3	Duke St and Alexandria Commons	Signalized	EBL	105	13	316	29	259
			EBT	210	13	316	29	259
			EBR	210	15	349	37	294
			WBL	315	79	649	290	663
			WBT	520	79	649	290	663
			WBR	520	43	687	289	716
			NBL	50	1	23	4	55
			NBT	50	1	23	4	55
			NBR	50	1	22	4	54
			SBL	215	9	134	90	182
SBT	215	9	134	90	182			
SBR	215	12	145	99	193			

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
4	Duke St and Sweeley St	Signalized	EBL	190	54	541	96	537
			EBT	520	56	546	96	537
			EBR	520	57	555	100	548
			WBL	70	37	679	247	795
			WBT	225	37	679	247	795
			WBR	225	39	695	257	811
			NBL	230	7	88	15	175
			NBT	230	7	88	15	175
			NBR	230	10	99	20	186
			SBL	110	27	148	32	155
SBT	110	27	148	32	155			
SBR	110	27	148	32	155			
5	Duke St at Roth St/ Cambridge Rd	Signalized	EBL	115	227	831	256	826
			EBT	350	227	831	256	826
			EBR	350	229	839	262	834
			WBL	230	293	768	671	785
			WBT	670	293	768	671	785
			WBR	670	293	768	671	785
			NBL	150	6	89	46	193
			NBT	150	6	89	46	193
			NBR	150	8	92	48	195
			SBL	40	55	119	56	117
			SBT	40	55	119	56	117
			SBR	40	72	143	72	141
			51	Cambridge Rd and Service Rd	Unsignalized	EBT	1330	43
EBR	1330	41				304	60	370
WBL	825	7				83	12	93
WBT	825	8				96	13	107
NBL	40	0				25	1	65
NBR	40	0				25	1	65
6	Duke St and Witter Dr	Signalized	EBT	675	58	544	293	798
			EBR	675	60	551	307	817
			WBL	215	165	817	478	835
			WBT	700	165	817	478	835
			NBL	170	3	77	141	192
NBR	170	4	97	159	212			



Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	Signalized	EBL	165	12	104	11	81
			EBT (Continue on Duke St)	710	105	780	17	192
			EBT (to Telegraph Rd)	710	173	787	108	783
			WBT	1955	187	825	496	1294
			WBR	110	113	743	463	1292
			SBL	140	8	83	29	99
			SBR	140	13	100	39	116
71	W Taylor Run Pkwy and Service Rd	Signalized	EBL	70	3	63	20	155
			EBT	70	3	63	20	155
			EBR	70	3	63	20	155
			WBL	320	1	31	1	36
			WBT	320	1	31	1	36
			WBR	320	1	31	1	36
			NBL	40	0	10	2	125
			NBT	40	0	10	1	115
			NBR	40	0	10	2	139
			SBL	650	19	107	41	198
			SBT	650	19	107	41	198
			SBR	180	19	107	41	197
81	Duke St EB and Telegraph Rd On-ramp (New)	Signalized	EBL	250	35	210	35	266
			WBT	375	176	609	38	235
			SBR	2400	2413	3036	628	1306
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	Unsignalized	WBT	550	0	0	4	356
			NBT	300	0	0	0	82
9	Duke St WB and Telegraph Rd On-ramp	Signalized	WBR	225	16	152	71	345
10	Duke St and S Dove St/Roberts Ln	Signalized	EBT	1965	521	1495	94	696
			EBR	260	241	1037	5	163
			WBT	855	188	552	378	1012
			WBR	855	0	55	2	66
			NBL	185	305	1151	39	281
			NBT	185	305	1151	39	281
			NBR	185	304	1154	37	276

Node	Intersection	Control	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
					Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
			SBL	50	11	128	14	142
			SBT	50	11	128	14	142
			SBR	50	12	129	15	143

### 9.6 Preferred Alternative for VISSIM Analysis

The MOEs in VISSIM traffic operations analyses for Alternatives 1 and 3A provide a basis for evaluating the performance of a transportation network and developing the preferred option for the project. A summary of the MOEs evaluated for the study intersections is presented in Tables 29 through 40. Study intersections were analyzed for Opening Year 2026 and Design Year 2036.

Providing the right-turn slip lane from the westbound Duke Street to the service road will eliminate exclusive westbound right-turn phase at Duke Street and W. Taylor Run Parkway. This configuration is part of Alternative 1. It will also eliminate the conflict between the westbound right-turn traffic and pedestrians. Eliminating the signal phase will improve overall LOS at the intersection. Slip lane will also preserve the access to W. Taylor Run Parkway, E. Taylor Run Parkway and Moncure Drive. Curb extensions and curb radii reduction at the NE and NW quadrants will reduce crossing distances and improve the safety for pedestrians and bicyclists. Extending the median between the eastbound receiving lane on Duke Street and Telegraph Road on-ramp will provide easy access to the bus shelter and improve pedestrian access to the Old Town Alexandria by eliminating the need for crossing Telegraph Road. Bus stops on the near side and on the far side of the intersection will be consolidated to a bus shelter just east of the crosswalk. This will eliminate the crosswalk (circled in the picture) which has a history of rear-end crashes.

Alternative 3A will improve the safety by eliminating Telegraph Road off-ramp to the westbound Duke Street and adding dual southbound right-turns. Signalizing the crosswalk on the north leg and eliminating the off-ramp will improve the safety for pedestrians without causing significant delays to the traffic. However, 95th percentile queues are expected to be more than 900 ft during the AM peak hour. It is recommended to signalize the crosswalk at Duke Street westbound and Telegraph Rd on-ramp (Intersection #9 in Figure 1). Signalizing the crosswalk will improve the pedestrian safety and likely to reduce the conflict between the vehicles and pedestrians which has resulted in number of sideswipes and rear-end crashes at that location. It is also recommended to control the signals at Duke Street westbound and Telegraph Rd on-ramp (Pedestrian signal), and Duke Street eastbound and Telegraph Road on-ramp **new with the traffic signal controller at Duke Street and S. Dove Street/ Robert's Lane. Using the single controller** will also allow signal phasing that will create safe gaps for the traffic exiting the new ramp before merging with the traffic on Telegraph Road on-ramp from the westbound Duke Street. Alternative 1 with single traffic controller for three signals is expected to reduce the delays at the intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street).

Based on the operational results, and safety benefits for Alternatives 1 and 3A, right-turn slip lane configuration at Duke Street and W. Taylor Run Parkway, and eliminating Telegraph Road off-ramp to the westbound Duke Street and adding dual southbound right-turns at Duke Street eastbound and Telegraph Road on-ramp new will be analyzed as the preferred option for the project. VISSIM results are presented in the following section.



## 10 PREFERRED ALTERNATIVE 3C - VISSIM ANALYSIS

After the results of the VISSIM analysis were evaluated for Alternatives 1 and 3A, the team identified preferred alternative for the study area. Preferred alternative was analyzed using VISSIM for 2026 and 2036 conditions. This evaluation is primarily focused on the intersections of Duke Street and W. Taylor Run Parkway, Duke Street eastbound and Telegraph Road on-ramp new, and Duke Street westbound and Telegraph Rd on-ramp. No traffic control or geometric changes were made at the other study intersections. The recommended improvements for the preferred alternative in the study area are described below and presented in Figure 48.

### Duke Street and W. Taylor Run Parkway (See Figure 48)

- The southbound left-turn traffic restricted from entering onto the Telegraph Road on-ramp at the intersection. Concrete median between the eastbound through lanes on Duke Street and Telegraph Road ramp is extended to restrict this movement.
- Extending the median between the eastbound receiving lane on Duke Street and Telegraph Road on-ramp will provide easy access to the bus shelter and improve pedestrian access to the Old Town Alexandria. To cross Telegraph Road on-ramp, existing signalized crosswalk at the intersection of Duke Street and W. Taylor Run Parkway will be maintained. .
- Bus stops on the eastbound Duke Street, the nearside and the far side of the intersection, will be consolidated to a bus shelter just east of the crosswalk. This will eliminate the existing crosswalk on Telegraph Road on-ramp which is located approximately 300 ft. to the east of the intersection.
- Curb extensions and curb radii reduction at the NE and NW quadrants to reduce crossing distances and improve the safety for pedestrians and bicyclists.
- Single lane is provided for the southbound W. Taylor Run Parkway approach.
- Right-turn slip lane from the westbound Duke Street to service road is provided. Slip lane will be provided at the intersection of Service Road and Moncure Drive. Westbound right-turn lane at Duke Street and W. Taylor Run Parkway is removed. Vehicles will use slip lane to access W. Taylor Run Parkway, E. Taylor Run Parkway and Moncure Drive from the westbound Duke Street. Existing conditions will be maintained for the vehicles coming from the eastbound Duke Street.
- Three thru lanes are maintained on the westbound approach of Duke Street.
- The eastbound left-turn lane is maintained.
- Service road is realigned at the intersection. Vehicles will be allowed to travel in both direction on the service road, eastbound and westbound, to the east of W. Taylor Run Parkway and between W. Taylor Run Parkway and Moncure Drive. Service road will the one-way westbound to the east of Moncure Drive.

- An exclusive pedestrian phase will be maintained at the intersection. Vehicles traveling from eastbound Duke Street to Telegraph Road will be uninterrupted except when pedestrian pushes the button to cross the east leg of the intersection.

### Duke Street eastbound and Telegraph Road on-ramp new (See Figure 48)

- Intersection will provide additional access for the eastbound traffic on Duke Street to the southbound Telegraph Road. Intersection will be signalized and will be controlled by the signal controller at Duke Street and S. Dove Street/Robert's Lane.
- Cross walk on the north leg to the intersection will be controlled by the pedestrian signals.
- Existing Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street will be maintained.
- Existing crosswalk on Telegraph Road off-ramp will be maintained. Crosswalk will be controlled by existing Rectangular Rapid Flashing Beacon (RRFB).
- The eastbound left turn traffic after exiting the intersection will have to yield to the Telegraph Road on-ramp traffic from the westbound Duke Street.

### Duke Street westbound and Telegraph Rd on-ramp (See Figure 48)

- Existing crosswalk on Telegraph Road on-ramp will be maintained. Crosswalk will be controlled by existing RRFB.



Figure 48: Preferred Alternative 3C-- Duke Street and W. Taylor Run Parkway and Duke Street eastbound and Telegraph Road on-ramp new configuration



10.1.1 Preferred Alternative 3C – Opening Year 2026 VISSIM Analysis

Operational analysis was performed at each of the study intersections for the Opening Year 2026 Alternative 3C scenario. Table 411 and Table 422 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor. The Alternative 3C 2026 VISSIM results indicate that the proposed intersection of Duke Street eastbound and Telegraph Ramp is projected to operate at an acceptable overall LOS A for the AM and LOS B for the PM peak hours. The eastbound left-turn movement operates with LOS C during the AM and LOS D during the PM peak hours. The intersection of Telegraph Road on-ramp at New Ramp (from eastbound Duke Street) is projected to operate at overall intersection LOS A during the AM and PM peak hours.

Overall, all the intersections are projected to operate at acceptable overall LOS of C or better for both AM and PM peak hours, except for Cambridge Road and Service Road which is projected operate with overall intersection LOS F during the PM peak hours.

Table 41: Preferred Alternative 3C – Opening Year (2026) – Build Conditions AM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	315	325	45.9	D	25.2	C	441
		EBT	1286	1292	14.9	B			441
		WBT	898	873	16.0	B			445
		WBR	1039	993	5.2	A			407
		SBL	559	558	71.9	E			943
		SBR	272	261	57.4	E			928
		2	Duke St and S Quaker Ln	EBL	0	0			0.0
EBT	1725			1735	7.0	A	452		
EBR	120			115	3.0	A	481		
WBL	24			26	21.0	C	362		
WBT	1882			1814	4.7	A	362		
WBR	0			0	0.0	A	376		
NBL	54			52	48.4	D	136		
NBT	0			0	0.0	A	136		
NBR	14			15	25.0	C	137		
SBL	2			2	38.2	D	19		
SBT	0			0	0.0	A	19		
SBR	0	0	0.0	A	22				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	41	41	38.1	D	6.0	A	313
		EBT	1695	1703	2.4	A			313
		EBR	6	7	2.3	A			347
		WBL	0	0	0.0	A			651
		WBT	1859	1794	7.8	A			651
		WBR	35	34	12.9	B			702
		NBL	3	3	39.3	D			23
		NBT	0	0	0.0	A			23
		NBR	0	0	0.0	A			22
		SBL	17	19	58.2	E			137
		SBT	0	0	0.0	A			137
SBR	45	42	19.9	B	148				
4	Duke St and Sweeley St	EBL	53	55	23.5	C	7.9	A	518
		EBT	1657	1667	7.2	A			519
		EBR	2	2	3.9	A			527
		WBL	22	24	24.1	C			716
		WBT	1804	1745	5.0	A			716
		WBR	123	118	5.2	A			732
		NBL	11	10	52.5	D			85
		NBT	5	5	50.2	D			85
		NBR	32	30	18.2	B			95
		SBL	83	84	54.4	D			148
		SBT	1	1	33.6	C			148
SBR	79	75	12.3	B	148				
5	Duke St at Roth St	EBL	61	57	79.8	E	17.1	B	820
		EBT	1706	1720	14.5	B			820
		EBR	4	4	13.4	B			828
		WBL	98	97	33.7	C			755
		WBT	1891	1828	16.5	B			755
		WBR	308	294	13.4	B			755
		NBL	6	5	35.4	D			101
		NBT	6	6	38.1	D			101
		NBR	55	54	16.7	B			102
		SBL	193	186	26.5	C			122
		SBT	4	4	7.1	A			122
		SBR	52	51	9.9	A			145



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
51	Cambridge Rd and Service Rd	EBT	10	8	53.3	F	22.7	C	321
		EBR	227	214	51.3	F			321
		WBL	28	25	81.9	F			75
		WBT	0	0	0.0	A			88
		NBL	375	321	0.7	A			62
		NBR	43	37	0.4	A			62
6	Duke St and Witter Dr	EBT	1932	1939	5.4	A	8.9	A	478
		EBR	21	21	8.2	A			485
		WBL	89	85	20.6	C			679
		WBT	2290	2218	11.3	B			679
		NBL	7	7	55.5	E			78
		NBR	26	25	17.5	B			98
7	Duke St and W Taylor Run Pkwy	EBL	31	31	56.6	E	10.1	B	90
		EBT (Continue on Duke St)	947	949	6.8	A			710
		EBT (to Telegraph Rd)	980	978	9.5	A			778
		WBT	2342	2275	10.8	B			577
		SBL	68	66	21.7	C			89
		SBR	37	36	5.5	A			106
		71	W Taylor Run Pkwy and Service Rd	EBL	19	19			7.5
EBT	8			8	5.6	A	65		
EBR	23			22	11.1	B	65		
WBL	12			12	7.5	A	138		
WBT	20			17	5.8	A	138		
WBR	208			191	7.0	A	138		
NBL	2			1	0.1	A	0		
NBT	23			25	0.8	A	0		
NBR	7			5	0.3	A	0		
SBL	1			0	14.9	B	106		
SBT	69			68	51.3	D	106		
SBR	6			7	43.5	D	106		

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
72	Duke St WB to West Taylor Run Parkway Service Rd	EBL	15	14	7.2	A	4.4	A	41
		WBT	14	12	9.6	A			41
		SBR	5	4	7.4	A			33
		Duke St WB to Moncure Dr	57	55	4.1	A			0
		Duke St WB to West Taylor Run Parkway Service Rd	217	204	3.9	A			0
		8	Duke St WB and Telegraph Rd Off-ramp	WBT	880	891			0.3
SBR	1735			1646	1.7	A	362		
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	137	133	32.7	C	10.0	A	187
		WBT	880	890	6.6	A			242
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	443	436	0.1	A	0.3	A	0
		NBT	137	133	0.6	A			55
9	Duke St WB and Telegraph Rd On-ramp	WBR	443	437	0.4	A	0.4	A	39
10	Duke St and S Dove St/Roberts Ln	EBT	2193	2142	12.8	B	12.5	B	453
		EBR	265	257	12.3	B			245
		WBT	1088	1100	8.6	A			301
		WBR	33	33	7.6	A			43
		NBL	193	182	27.9	C			359
		NBT	29	25	30.1	C			359
		NBR	11	10	21.5	C			362
		SBL	16	15	38.5	D			117
		SBT	13	14	32.5	C			117
		SBR	43	42	8.2	A			119



Table 42: Preferred Alternative 3C - Opening Year (2026) – Build Conditions PM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
1	Duke St and N Quaker Ln	EBL	314	312	70.2	E	39.7	D	974				
		EBT	1040	1042	24.7	C			974				
		WBT	1250	1251	31.4	C			466				
		WBR	735	721	8.7	A			415				
		SBL	864	842	80.0	F			1274				
		SBR	167	157	72.0	E			1260				
		EBL	7	7	41.8	D			439				
2	Duke St and S Quaker Ln	EBT	1518	1512	11.6	A	13.3	B	439				
		EBR	379	366	6.5	A			469				
		WBL	27	28	22.9	C			373				
		WBT	1876	1864	11.5	B			373				
		WBR	7	6	5.3	A			388				
		NBL	108	105	81.7	F			248				
		NBT	0	0	0.0	A			248				
		NBR	20	20	61.1	E			249				
		SBL	1	1	28.0	C			21				
		SBT	0	0	0.0	A			21				
		SBR	1	1	3.3	A			25				
		3	Duke St and Alexandria Commons	EBL	65	65			32.4	C	16.5	B	312
				EBT	1463	1460			4.0	A			312
EBR	10			10	2.9	A	345						
WBL	7			6	25.4	C	657						
WBT	1797			1789	23.1	C	657						
WBR	36			35	23.6	C	709						
NBL	17			16	52.1	D	55						
NBT	2			1	33.6	C	55						
NBR	4			4	10.5	B	55						
SBL	51			52	55.6	E	180						
SBT	2			2	42.0	D	180						
SBR	97	94	43.5	D	191								

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
4	Duke St and Sweeley St	EBL	30	32	21.4	C	13.3	B	589
		EBT	1485	1483	6.6	A			589
		EBR	3	3	4.7	A			599
		WBL	28	30	27.0	C			738
		WBT	1742	1737	14.9	B			738
		WBR	113	112	14.9	B			754
		NBL	20	19	51.7	D			163
		NBT	6	5	47.3	D			163
		NBR	87	87	21.6	C			174
		SBL	103	102	51.6	D			159
		SBT	8	8	52.5	D			159
		SBR	78	78	20.2	C			159
		5	Duke St at Roth St	EBL	9	9			74.8
EBT	1660			1657	13.2	B	784		
EBR	5			4	14.9	B	792		
WBL	64			66	40.7	D	753		
WBT	1837			1838	13.9	B	753		
WBR	183			185	12.4	B	753		
NBL	3			3	36.2	D	193		
NBT	12			11	44.0	D	193		
NBR	360			351	25.1	C	195		
SBL	289			257	20.4	C	117		
SBT	5			6	24.9	C	117		
SBR	43			38	13.2	B	140		
51	Cambridge Rd and Service Rd			EBT	37	34	71.1	F	50.8
		EBR	288	255	74.4	F	432		
		WBL	49	46	123.7	F	118		
		WBT	0	0	0.0	A	131		
		NBL	198	174	1.8	A	92		
		NBR	38	31	1.0	A	92		
		EBT	2300	2268	14.2	B	784		
6	Duke St and Witter Dr	EBR	8	8	17.3	B	10.8	B	804
		WBL	30	32	37.2	D			525
		WBT	2058	2071	5.4	A			525
		NBL	25	26	59.3	E			176
		NBR	74	73	30.8	C			196



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	EBL	27	27	56.5	E	11.3	B	76
		EBT (Continue on Duke St)	734	734	7.4	A			423
		EBT (to Telegraph Rd)	1613	1581	9.7	A			787
		WBT	2069	2088	12.5	B			592
		SBL	188	185	18.7	B			101
		SBR	20	20	16.4	B			119
71	W Taylor Run Pkwy and Service Rd	EBL	8	9	42.9	D	31.1	C	154
		EBT	5	5	39.7	D			154
		EBR	69	68	52.2	D			154
		WBL	10	10	18.3	B			240
		WBT	44	40	13.4	B			240
		WBR	199	193	12.7	B			240
		NBL	4	3	0.1	A			0
		NBT	22	23	0.7	A			0
		NBR	2	2	0.2	A			0
		SBL	0	0	0.0	A			279
		SBT	129	127	59.6	E			279
		SBR	1	1	34.1	C			278
		72	Duke St WB to West Taylor Run Parkway Service Rd	EBL	7	7			8.7
WBT	19			17	9.8	A	44		
SBR	5			4	7.2	A	39		
Duke St WB to Moncure Dr	15			14	3.4	A	0		
Duke St WB to West Taylor Run Parkway Service Rd	230			223	3.3	A	0		
8	Duke St WB and Telegraph Rd Off-ramp	WBT	781	788	0.2	A	1.1	A	0
		SBR	1532	1534	1.5	A			0

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	207	200	37.0	D	13.3	B	293
		WBT	781	787	7.3	A			208
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	1821	1828	2.3	A	2.3	A	0
		NBT	207	199	2.4	A			187
9	Duke St WB and Telegraph Rd On-ramp	WBR	1821	1824	1.4	A	1.4	A	314
10	Duke St and S Dove St/Roberts Ln	EBT	1493	1489	11.8	B	14.2	B	394
		EBR	151	149	9.1	A			131
		WBT	2431	2439	14.2	B			817
		WBR	43	42	21.5	C			124
		NBL	136	132	33.8	C			249
		NBT	32	34	32.6	C			249
		NBR	22	20	20.8	C			252
		SBL	15	14	37.6	D			197
		SBT	21	20	38.3	D			197
		SBR	36	35	8.0	A			197

Signal timings for Alternative 3C 2026 Build conditions are shown on Appendix V. VISSIM results for 2036 Build Conditions is presented in the Appendix Z.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2026 Opening Year Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 14 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 14 are the movements where the reported maximum queue length value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement storage bays during both peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 ft. is projected to experience a maximum queue length of 655 ft., which is far less than queue length of 2961 ft. for the 2026 No-Build conditions during the PM peak hour.



At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, and westbound left-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersections of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. However, the eastbound right movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. It is to be noted that the westbound left-turn movement with storage of 70 ft. is projected to experience a maximum queue length of 639 ft. and 738 ft. during the AM and PM peak hours, respectively. These queue lengths are similar to 2026 No-Build conditions.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, southbound left-turn and right-turn movements are projected to experience maximum queue lengths that will not exceed the available storage bay lengths during AM and PM peak hours. For 2026 No-Build conditions, it is to be noted that the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 1594 ft. and 841 ft. during the AM and PM peak hours, respectively. The westbound right-turn movement is eliminated in the Alternative 3C. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 778 ft. and 781 ft. during the AM and PM peak hours, respectively. The queue lengths for the eastbound movement are similar to 2026 No-Build conditions.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 106 ft. and 246 ft. during the AM and PM peak hours. This queue lengths are far less than the 2026 No-Build conditions when the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 358 ft. and 515 ft. during the AM and PM peak hours. This is mainly due to restricting the southbound movement to Telegraph Road ramp. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 232 ft. during the PM peak hour. The westbound queue lengths are far less than the 2026 No-build conditions when the westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 918 ft. during the PM peak hour. Reduction in queues is mainly due to eliminating the exclusive westbound right-turn phase and giving that time to other movements even though the westbound traffic is much heavier for the Alternative 3C compared to No-Build conditions.

At the intersection of Duke Street westbound and right-turn slip lane to the W. Taylor Run Parkway Service Road, the westbound movement is projected to experience maximum queue lengths 42 ft. during the PM peak hour.

Traffic from the slip lane does not experience any queues during both peak hours. Note that this movement is free and not controlled by any traffic control device.

At the intersection of Duke Street eastbound and Telegraph Road on-ramp new, the southbound right-turn movement is projected to experience maximum queue lengths 362 ft. during the AM peak hour. Note that the 2400 ft. of storage is the storage length available up to Telegraph Road bridge and addition storage is available beyond the bridge.

**At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn movements and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 359 ft. and 231 ft. during the AM and PM peak hours, respectively. These queue lengths are less than 2026 No-Build conditions when the northbound left-turn movement is projected to experience a maximum queue length of 1373 ft. and 300 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 245 ft. during the AM peak hour and 113 ft. during the PM peak hour. Note that, for 2026 No-Build conditions, the eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1259 ft. during the AM peak hour and 186 ft. during the PM peak hour.**

Intersection MOE tables for 2026 & 2036 Build conditions are shown on Appendix Z.

Table 43: Alternative 3C - Opening Year (2026) – Build Conditions Summary of Intersection Queues (feet)

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	200	105	441	137	655
		EBT	360	105	441	137	655
		WBT	330	58	445	155	460
		WBR	300	18	407	18	402
		SBL	1290	431	943	380	896
		SBR	1270	370	928	362	882



Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
2	Duke St and S Quaker Ln	EBL	200	60	452	83	441
		EBT	330	60	452	83	441
		EBR	300	68	481	95	471
		WBL	80	26	362	69	369
		WBT	210	26	362	69	369
		WBR	210	28	376	74	383
		NBL	335	18	136	48	236
		NBT	335	18	136	48	236
		NBR	335	14	137	45	237
		SBL	40	0	19	0	23
		SBT	40	0	19	0	23
		SBR	40	0	22	0	27
3	Duke St and Alexandria Commons	EBL	105	10	313	20	311
		EBT	210	10	313	20	311
		EBR	210	12	347	26	345
		WBL	315	88	651	202	652
		WBT	520	88	651	202	652
		WBR	520	47	702	170	703
		NBL	50	1	23	4	57
		NBT	50	1	23	4	57
		NBR	50	1	22	4	56
		SBL	215	9	137	37	181
		SBT	215	9	137	37	181
		SBR	215	12	148	44	192
4	Duke St and Sweeley St	EBL	190	41	518	33	551
		EBT	520	42	519	33	551
		EBR	520	44	527	35	562
		WBL	70	31	716	92	678
		WBT	225	31	716	92	678
		WBR	225	32	732	98	693
		NBL	230	6	85	14	161
		NBT	230	6	85	14	161
		NBR	230	9	95	19	172
		SBL	110	27	148	33	152
		SBT	110	27	148	33	152
		SBR	110	27	148	33	152

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
5	Duke St at Roth St	EBL	115	189	820	96	779
		EBT	350	189	820	96	779
		EBR	350	189	828	98	787
		WBL	230	247	755	160	753
		WBT	670	247	755	160	753
		WBR	670	247	755	160	753
		NBL	150	6	101	52	197
		NBT	150	6	101	52	197
		NBR	150	8	102	54	199
		SBL	40	63	122	72	117
		SBT	40	63	122	72	117
		SBR	40	80	145	90	141
51	Cambridge Rd and Service Rd	EBT	1330	60	321	139	503
		EBR	1330	57	321	136	503
		WBL	825	8	75	26	124
		WBT	825	8	88	30	137
		NBL	40	1	62	3	81
		NBR	40	1	62	3	81
6	Duke St and Witter Dr	EBT	675	39	478	166	782
		EBR	675	40	485	176	801
		WBL	215	131	679	16	397
		WBT	700	131	679	16	397
		NBL	170	3	78	15	181
		NBR	170	4	98	20	201
7	Duke St and W Taylor Run Pkwy	EBL	165	10	90	8	80
		EBT (Continue on Duke St)	710	46	710	23	558
		EBT (to Telegraph Rd)	710	113	778	100	781
		WBT	1955	71	577	73	606
		SBL	140	10	89	28	110
		SBR	140	16	106	38	127



Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
71	W Taylor Run Pkwy and Service Rd	EBL	70	2	65	12	121
		EBT	70	2	65	12	121
		EBR	70	2	65	12	121
		WBL	320	8	138	17	232
		WBT	320	8	138	17	232
		WBR	320	8	138	17	232
		NBL	40	0	0	0	3
		NBT	40	0	0	0	0
		NBR	40	0	0	0	0
		SBL	650	25	106	52	246
		SBT	650	25	106	52	246
		SBR	180	24	106	52	245
72	Duke St WB to West Taylor Run Parkway Service Rd	EBL	220	1	41	0	37
		WBT	220	1	41	1	42
		SBR	500	0	33	0	38
		Duke St WB to Moncure Dr	65	0	0	0	12
		Duke St WB to West Taylor Run Parkway Service Rd	65	0	0	0	12
8	Duke St WB and Telegraph Rd Off-ramp	WBT	700	0	0	0	0
		SBR	2400	252	362	0	0
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	250	27	187	46	261
		WBT	375	21	242	19	193
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	550	0	0	0	0
		NBT	300	0	55	1	150
9	Duke St WB and Telegraph Rd On-ramp	WBR	225	0	39	3	293

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
10	Duke St and S Dove St/Roberts Ln	EBT	1965	89	453	49	384
		EBR	260	12	245	4	113
		WBT	855	26	301	133	773
		WBR	855	0	43	2	59
		NBL	185	57	359	45	231
		NBT	185	57	359	45	231
		NBR	185	55	362	43	233
		SBL	50	10	117	14	135
		SBT	50	10	117	14	135
		SBR	50	10	119	15	138

10.1.2 Preferred Alternative 3C – Design Year 2036 VISSIM Analysis

Operational analysis was performed at each of the study intersections for the Design Year 2036 Alternative 3C scenario. Table 44 and Table 45 provide a summary of the average AM and PM peak hour delay, and LOS for each movement for the study intersections along the Duke Street corridor.

Overall, all the intersections are projected to operate at acceptable overall LOS of C or better for both AM and PM peak hours, except for Cambridge Road and Service Road which is projected operate with overall intersection LOS D with few individual movements operating at LOS F during the PM peak hour.



Table 44: Preferred Alternative 3C - Design Year (2036) - Build Conditions AM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	323	331	47.6	D	25.3	C	560
		EBT	1319	1325	15.6	B			560
		WBT	920	877	17.1	B			430
		WBR	1065	998	5.2	A			408
		SBL	573	574	68.6	E			817
		SBR	279	272	54.4	D			793
		2	Duke St and S Quaker Ln	EBL	0	0			0.0
EBT	1769			1780	7.0	A	440		
EBR	123			120	3.1	A	469		
WBL	25			26	24.6	C	360		
WBT	1930			1823	4.6	A	360		
WBR	0			0	0.0	A	374		
NBL	55			53	46.6	D	137		
NBT	0			0	0.0	A	137		
NBR	15			16	28.2	C	138		
SBL	2			2	38.2	D	19		
SBT	0			0	0.0	A	19		
SBR	0			0	0.0	A	22		
3	Duke St and Alexandria Commons			EBL	42	42	36.1	D	5.9
		EBT	1737	1748	2.3	A	313		
		EBR	6	6	2.3	A	346		
		WBL	0	0	0.0	A	660		
		WBT	1906	1805	7.6	A	660		
		WBR	36	34	12.6	B	703		
		NBL	3	3	39.6	D	23		
		NBT	0	0	0.0	A	23		
		NBR	0	0	0.0	A	22		
		SBL	18	19	57.6	E	135		
		SBT	0	0	0.0	A	135		
SBR	46	42	19.9	B	146				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
4	Duke St and Sweeley St	EBL	54	55	24.9	C	8.0	A	499				
		EBT	1699	1706	7.4	A			499				
		EBR	2	2	8.5	A			508				
		WBL	23	25	24.7	C			639				
		WBT	1849	1746	4.9	A			639				
		WBR	127	118	5.0	A			655				
		NBL	12	12	48.6	D			88				
		NBT	5	5	55.5	E			88				
		NBR	32	31	18.2	B			99				
		SBL	85	86	53.2	D			154				
		SBT	1	1	35.9	D			154				
		SBR	81	78	12.9	B			154				
		5	Duke St at Roth St	EBL	63	59			81.7	F	17.5	B	821
				EBT	1749	1758			14.4	B			821
EBR	4			5	9.3	A	828						
WBL	100			96	36.4	D	762						
WBT	1939			1834	17.3	B	762						
WBR	316			294	13.2	B	762						
NBL	6			5	45.4	D	122						
NBT	6			6	49.8	D	122						
NBR	56			57	18.0	B	123						
SBL	198			191	26.4	C	119						
SBT	4			4	26.4	C	119						
SBR	53			52	10.4	B	143						
51	Cambridge Rd and Service Rd			EBT	10	9	53.2	F	26.6	D			378
				EBR	227	219	59.3	F					377
		WBL	28	28	94.1	F	81						
		WBT	0	0	0.0	A	94						
		NBL	375	322	0.7	A	79						
		NBR	43	37	0.2	A	79						
		6	Duke St and Witter Dr	EBT	1981	1985	6.0	A			9.0	A	496
EBR	22			22	8.6	A	503						
WBL	91			84	22.0	C	664						
WBT	2348			2223	11.0	B	664						
NBL	7			7	55.7	E	78						
NBR	26			25	17.2	B	97						



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	EBL	31	32	54.7	D	10.0	A	96
		EBT (Continue on Duke St)	971	975	6.7	A			728
		EBT (to Telegraph Rd)	1005	1004	9.3	A			781
		WBT	2402	2278	10.9	B			587
		SBL	70	68	21.9	C			84
		SBR	38	36	4.0	A			104
71	W Taylor Run Pkwy and Service Rd	EBL	20	20	6.8	A	14.8	B	65
		EBT	8	8	4.7	A			65
		EBR	24	22	10.6	B			65
		WBL	13	12	7.1	A			146
		WBT	20	16	7.6	A			146
		WBR	208	191	6.2	A			146
		NBL	2	1	0.0	A			0
		NBT	23	24	0.8	A			0
		NBR	7	7	0.3	A			0
		SBL	1	1	13.0	B			110
		SBT	71	70	49.2	D			110
		SBR	6	6	50.2	D			110
		72	Duke St WB to West Taylor Run Parkway Service Rd	EBL	16	15			7.8
WBT	14			12	9.5	A	42		
SBR	5			4	7.4	A	33		
Duke St WB to Moncure Dr	58			54	4.2	A	0		
Duke St WB to West Taylor Run Parkway Service Rd	222			203	4.2	A	0		
8	Duke St WB and Telegraph Rd Off-ramp	WBT	903	906	0.3	A	1.3	A	8
		SBR	1779	1635	1.8	A			762
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	140	135	31.1	C	9.7	A	188
		WBT	903	906	6.6	A			232

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	454	450	0.2	A	0.3	A	0
		NBT	140	135	0.7	A			59
9	Duke St WB and Telegraph Rd On-ramp	WBR	454	451	0.4	A	0.4	A	37
10	Duke St and S Dove St/Roberts Ln	EBT	2249	2139	12.8	B	12.3	B	451
		EBR	272	252	11.5	B			300
		WBT	1115	1134	8.7	A			311
		WBR	33	33	8.6	A			55
		NBL	198	179	26.1	C			414
		NBT	29	24	29.6	C			414
		NBR	12	10	17.9	B			417
		SBL	17	15	38.2	D			128
		SBT	14	14	33.1	C			128
		SBR	44	42	8.2	A			129



Table 45: Preferred Alternative 3C - Design Year (2036) – Build Conditions PM Peak Hour Delay and LOS

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	314	312	70.2	E	39.7	D	974
		EBT	1040	1042	24.7	C			974
		WBT	1250	1251	31.4	C			466
		WBR	735	721	8.7	A			415
		SBL	864	842	80.0	F			1274
		SBR	167	157	72.0	E			1260
		2	Duke St and S Quaker Ln	EBL	7	7			41.8
EBT	1518			1512	11.6	A	439		
EBR	379			366	6.5	A	469		
WBL	27			28	22.9	C	373		
WBT	1876			1864	11.5	B	373		
WBR	7			6	5.3	A	388		
NBL	108			105	81.7	F	248		
NBT	0			0	0.0	A	248		
NBR	20			20	61.1	E	249		
SBL	1			1	28.0	C	21		
SBT	0			0	0.0	A	21		
SBR	1			1	3.3	A	25		
3	Duke St and Alexandria Commons			EBL	65	65	32.4	C	16.5
		EBT	1463	1460	4.0	A	312		
		EBR	10	10	2.9	A	345		
		WBL	7	6	25.4	C	657		
		WBT	1797	1789	23.1	C	657		
		WBR	36	35	23.6	C	709		
		NBL	17	16	52.1	D	55		
		NBT	2	1	33.6	C	55		
		NBR	4	4	10.5	B	55		
		SBL	51	52	55.6	E	180		
		SBT	2	2	42.0	D	180		
SBR	97	94	43.5	D	191				

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)				
4	Duke St and Sweeley St	EBL	30	32	21.4	C	13.3	B	589				
		EBT	1485	1483	6.6	A			589				
		EBR	3	3	4.7	A			599				
		WBL	28	30	27.0	C			738				
		WBT	1742	1737	14.9	B			738				
		WBR	113	112	14.9	B			754				
		NBL	20	19	51.7	D			163				
		NBT	6	5	47.3	D			163				
		NBR	87	87	21.6	C			174				
		SBL	103	102	51.6	D			159				
		SBT	8	8	52.5	D			159				
		SBR	78	78	20.2	C			159				
		5	Duke St at Roth St	EBL	9	9			74.8	E	15.5	B	784
				EBT	1660	1657			13.2	B			784
EBR	5			4	14.9	B	792						
WBL	64			66	40.7	D	753						
WBT	1837			1838	13.9	B	753						
WBR	183			185	12.4	B	753						
NBL	3			3	36.2	D	193						
NBT	12			11	44.0	D	193						
NBR	360			351	25.1	C	195						
SBL	289			257	20.4	C	117						
SBT	5			6	24.9	C	117						
SBR	43			38	13.2	B	140						
51	Cambridge Rd and Service Rd			EBT	37	34	71.1	F	50.8	F			433
				EBR	288	255	74.4	F					432
		WBL	49	46	123.7	F	118						
		WBT	0	0	0.0	A	131						
		NBL	198	174	1.8	A	92						
		NBR	38	31	1.0	A	92						
		6	Duke St and Witter Dr	EBT	2300	2268	14.2	B			10.8	B	784
				EBR	8	8	17.3	B					804
WBL	30			32	37.2	D	525						
WBT	2058			2071	5.4	A	525						
NBL	25			26	59.3	E	176						
NBR	74			73	30.8	C	196						



Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
7	Duke St and W Taylor Run Pkwy	EBL	27	27	56.5	E	11.3	B	76
		EBT (Continue on Duke St)	734	734	7.4	A			423
		EBT (to Telegraph Rd)	1613	1581	9.7	A			787
		WBT	2069	2088	12.5	B			592
		SBL	188	185	18.7	B			101
		SBR	20	20	16.4	B			119
71	W Taylor Run Pkwy and Service Rd	EBL	8	9	42.9	D	31.1	C	154
		EBT	5	5	39.7	D			154
		EBR	69	68	52.2	D			154
		WBL	10	10	18.3	B			240
		WBT	44	40	13.4	B			240
		WBR	199	193	12.7	B			240
		NBL	4	3	0.1	A			0
		NBT	22	23	0.7	A			0
		NBR	2	2	0.2	A			0
		SBL	0	0	0.0	A			279
		SBT	129	127	59.6	E			279
		SBR	1	1	34.1	C			278
72	Duke St WB to West Taylor Run Parkway Service Rd	EBL	7	7	8.7	A	3.9	A	35
		WBT	19	17	9.8	A			44
		SBR	5	4	7.2	A			39
		Duke St WB to Moncure Dr	15	14	3.4	A			0
		Duke St WB to West Taylor Run Parkway Service Rd	230	223	3.3	A			0
8	Duke St WB and Telegraph Rd Off-ramp	WBT	781	788	0.2	A	1.1	A	0
		SBR	1532	1534	1.5	A			0
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	207	200	37.0	D	13.3	B	293
		WBT	781	787	7.3	A			208

Node	Intersection	Movement	Peak Hour Demand (vph)	VISSIM Throughput (vph)	Movement Delay (sec/veh)	Movement Equivalent LOS	Average Delay by Intersection (sec/veh)	Intersection Equivalent LOS	Max. Queue (ft)
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	1821	1828	2.3	A	2.3	A	0
		NBT	207	199	2.4	A			187
9	Duke St WB and Telegraph Rd On-ramp	WBR	1821	1824	1.4	A	1.4	A	314
10	Duke St and S Dove St/Roberts Ln	EBT	1493	1489	11.8	B	14.2	B	394
		EBR	151	149	9.1	A			131
		WBT	2431	2439	14.2	B			817
		WBR	43	42	21.5	C			124
		NBL	136	132	33.8	C			249
		NBT	32	34	32.6	C			249
		NBR	22	20	20.8	C			252
		SBL	15	14	37.6	D			197
		SBT	21	20	38.3	D			197
		SBR	36	35	8.0	A			197

Signal timings for Preferred Alternative 3C 2036 Build conditions are shown on Appendix Y. VISSIM results for 2036 Build Conditions is presented in the Appendix Z.

Queuing analysis was completed for the study intersections during the AM and PM peak hours for 2036 No-Build conditions. VISSIM average and maximum queue lengths in feet were reported for each lane or lane group. These queue lengths are based on an average of 10 simulation runs. Table 46 provides a summary of the average and maximum queue lengths during the AM and PM peak hours as compared to the available storage bay lengths. The highlighted queue lengths in Table 46 are the movements where the reported maximum queue lengths value exceeds the storage length available for that turning movement. Note that for some movements that include significant through- movement queuing, the left and right turn queues may appear extensive because left and right-turning vehicles are caught in the through movement queues.

The results indicates that at the intersection of Duke Street and N. Quaker Lane, the eastbound left-turn and westbound right-turn maximum queues are projected to exceed the available turning movement during AM and PM peak hours. It is to be noted that the eastbound left-turn movement with storage of 200 feet is projected to experience a maximum queue length of 974 ft during the PM peak hour which is far less than a maximum queue length of 3055 ft during the PM peak hour observed for 2036 No-Build conditions.

At the intersection of Duke Street and S. Quaker Lane, the eastbound left-turn, eastbound right-turn, westbound left-turn and west bound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours.



At the intersection of Duke Street and Alexandria Commons, the eastbound left-turn, eastbound right-turn, westbound left-turn and westbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour.

At the intersection of Duke Street and Sweeley Street, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements, are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. It is to be noted that the westbound left-turn movement with storage of 70 feet is projected to experience a maximum queue length of 685 ft and 702 ft. during the AM and PM peak hours, respectively.

At the intersection of Duke Street at Roth Street/Cambridge Road, the eastbound left-turn, eastbound right-turn, westbound left-turn, westbound right-turn, southbound left-turn and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. The northbound left-turn and northbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths only during PM peak hour. The westbound right-turn movement has a storage length of 670 ft., northbound right-turn movement has a storage length of 150 ft., and the southbound left-turn movement length has a storage length of 40 ft.

At the intersection of Duke Street and W Taylor Run Parkway, and southbound left-turn and right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during AM and PM peak hours. For 2036 No-Build condition, the westbound right-turn movement with storage of 110 ft. is projected to experience a maximum queue length of 2062 ft. and 2454 ft. during the AM and PM peak hours, respectively. Note that the westbound right-turn movement is eliminated in Preferred Alternative 3C. The eastbound movement heading towards the Telegraph Road on-ramp experiences a maximum queue length of 781 ft. and 787 ft. during the AM and PM peak hours, respectively.

At the intersection of W. Taylor Run Parkway and Service Road, the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 110 ft. and 279 ft. during the AM and PM peak hours. This queue lengths are far less than the 2026 No-Build conditions when the southbound left-turn and right-turn movements are projected to experience maximum queue lengths 426 ft. and 478 ft. during the AM and PM peak hours. This is mainly due to restricting the southbound movement to Telegraph Road ramp. The westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 240 ft. during the PM peak hour. The westbound queue lengths are far less than the 2036 No-build conditions when the westbound left-turn and right-turn movements are projected to experience maximum queue lengths of 940 ft. during the PM peak hour. Reduction in queues is mainly due to eliminating the exclusive westbound right-turn phase and giving that time to other movements even though the westbound traffic is much heavier for the Preferred Alternative 3C compared to No-Build conditions.

At the intersection of Duke Street westbound and right-turn slip lane to the W. Taylor Run Parkway Service Road, the westbound movement is projected to experience maximum queue lengths 44 ft. during the PM peak hour. Traffic from the slip lane does not experience any queue during the Am or PM peak hour. Note that this movement is free and not controlled by any traffic control device.

At the intersection of Duke Street eastbound and Telegraph Road on-ramp new, the southbound right-turn movement is projected to experience a queue of 762 ft during AM peak and no queued for the PM peak hour. Note

that the 2400 ft. of storage is the storage length available up to Telegraph Road bridge and addition storage is available beyond the bridge.

At the intersection of Duke Street and S. Dove Street/Robert's Lane, the northbound left-turn, northbound right-turn, southbound left-turn movements and southbound right-turn movements are projected to experience maximum queue lengths exceeding the available storage bay lengths during both peak hours. It is to be noted that the northbound left-turn movement with storage of 185 feet is projected to experience a maximum queue length of 414 ft. and 249 ft. during the AM and PM peak hours, respectively. These queue lengths are less than 2036 No-Build conditions when the northbound left-turn movement is projected to experience a maximum queue length of 1363 ft. and 312 ft. during the AM and PM peak hours, respectively. The eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 300 ft. during the AM peak hour and 131 ft. during the PM peak hour. Note that, for 2036 No-Build conditions, the eastbound right-turn movement with storage of 260 ft. is projected to experience a maximum queue length of 1249 ft. during the AM peak hour and 198 ft. during the PM peak hour.

Table 46: Preferred Alternative 3C - Design Year (2036) – Build Conditions Summary of Intersection Queues (feet)

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
1	Duke St and N Quaker Ln	EBL	200	114	560	209	974
		EBT	360	114	560	209	974
		WBT	330	64	430	179	466
		WBR	300	20	408	17	415
		SBL	1290	370	817	709	1274
		SBR	1270	300	793	694	1260
2	Duke St and S Quaker Ln	EBL	200	61	440	93	439
		EBT	330	61	440	93	439
		EBR	300	69	469	105	469
		WBL	80	24	360	84	373
		WBT	210	24	360	84	373
		WBR	210	26	374	90	388
		NBL	335	18	137	57	248
		NBT	335	18	137	57	248
		NBR	335	14	138	55	249
		SBL	40	0	19	0	21
SBT	40	0	19	0	21		
SBR	40	0	22	0	25		



Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
3	Duke St and Alexandria Commons	EBL	105	10	313	19	312
		EBT	210	10	313	19	312
		EBR	210	12	346	24	345
		WBL	315	86	660	224	657
		WBT	520	86	660	224	657
		WBR	520	48	703	193	709
		NBL	50	1	23	4	55
		NBT	50	1	23	4	55
		NBR	50	1	22	4	55
		SBL	215	9	135	38	180
		SBT	215	9	135	38	180
		SBR	215	12	146	46	191
4	Duke St and Sweeley St	EBL	190	43	499	40	589
		EBT	520	44	499	40	589
		EBR	520	46	508	42	599
		WBL	70	31	639	114	738
		WBT	225	31	639	114	738
		WBR	225	32	655	121	754
		NBL	230	7	88	14	163
		NBT	230	7	88	14	163
		NBR	230	10	99	19	174
		SBL	110	27	154	35	159
		SBT	110	27	154	35	159
		SBR	110	27	154	35	159
5	Duke St at Roth St	EBL	115	202	821	120	784
		EBT	350	202	821	120	784
		EBR	350	202	828	124	792
		WBL	230	258	762	202	753
		WBT	670	258	762	202	753
		WBR	670	258	762	202	753
		NBL	150	8	122	60	193
		NBT	150	8	122	60	193
		NBR	150	9	123	62	195
		SBL	40	66	119	70	117
		SBT	40	66	119	70	117
		SBR	40	84	143	88	140

Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
51	Cambridge Rd and Service Rd	EBT	1330	76	378	133	433
		EBR	1330	73	377	130	432
		WBL	825	10	81	27	118
		WBT	825	11	94	31	131
		NBL	40	1	79	3	92
		NBR	40	1	79	3	92
		6	Duke St and Witter Dr	EBT	675	43	496
EBR	675			45	503	265	804
WBL	215			120	664	29	525
WBT	700			120	664	29	525
NBL	170			3	78	17	176
NBR	170			4	97	23	196
7	Duke St and W Taylor Run Pkwy			EBL	165	10	96
		EBT (Continue on Duke St)	710	45	728	20	423
		EBT (to Telegraph Rd)	710	113	781	142	787
		WBT	1955	86	587	78	592
		SBL	140	9	84	33	101
		SBR	140	16	104	44	119
		71	W Taylor Run Pkwy and Service Rd	EBL	70	2	65
EBT	70			2	65	20	154
EBR	70			2	65	20	154
WBL	320			6	146	17	240
WBT	320			6	146	17	240
WBR	320			6	146	17	240
NBL	40			0	0	0	0
NBT	40			0	0	0	0
NBR	40			0	0	0	0
SBL	650			25	110	56	279
SBR	180	24	110	56	278		



Node	Intersection	Movement	Turn Bay Storage (ft)	AM Peak		PM Peak	
				Avg. Queue (ft)	Max. Queue (ft)	Avg. Queue (ft)	Max. Queue (ft)
72	Duke St WB to West Taylor Run Parkway Service Rd	EBL	220	1	41	0	35
		WBT	220	1	42	1	44
		SBR	500	0	33	0	39
		Duke St WB to Moncure Dr	65	0	0	0	0
		Duke St WB to West Taylor Run Parkway Service Rd	65	0	0	0	0
8	Duke St WB and Telegraph Rd Off-ramp	WBT	700	0	8	0	0
		SBR	2400	294	762	0	0
81	Duke St EB and Telegraph Rd On-ramp (New)	EBL	250	26	188	46	293
		WBT	375	22	232	21	208
82	Telegraph Rd On-ramp at New Ramp from Duke St WB	WBT	550	0	0	0	0
		NBT	300	0	59	2	187
9	Duke St WB and Telegraph Rd On-ramp	WBR	225	0	37	4	314
10	Duke St and S Dove St/Roberts Ln	EBT	1965	90	451	51	394
		EBR	260	13	300	4	131
		WBT	855	27	311	154	817
		WBR	855	0	55	4	124
		NBL	185	55	414	45	249
		NBT	185	55	414	45	249
		NBR	185	52	417	42	252
		SBL	50	10	128	19	197
		SBT	50	10	128	19	197
		SBR	50	11	129	20	197

operations analyses were conducted using VISSIM to evaluate overall performance of the study intersections for the 2026 and 2036 Build Conditions scenario. VISSIM outputs were also used to analyze the queues formed for each intersection approach.

Average intersections delays, and LOS for the AM and PM peak hours for existing (2018), Opening Year (2026) No-Build/Build, and Design Year (2036) No-Build/Build are presented in Tables 47 and 48. Table 47 and Table 48 provide the comparison LOS and delays for 2026 and 2036, respectively. Overall, average intersection delays and LOS improves for the Build conditions Alternatives 1, 3A and 3C (Preferred), compared to the No-Build conditions. During the PM peak hour, intersection of Duke Street and N. Quaker Lane operates at LOS E and average delay of 63.3 seconds/vehicle for 2036 No-Build Conditions. For 2036 Build conditions, for all three alternatives, intersection operates at LOS D and average delays slightly over 40 seconds/vehicle. Similar pattern is observed during both peak periods for other intersections where LOS improves by at least one letter compared to No-Build Conditions. Preferred Alternative 3C shows lower delays and better LOS compared to Alternatives 1 and 3A.

As observed in the Duke Street Traffic Mitigation Pilots, restricting the left-turns from the southbound W. Taylor Run Parkway to Telegraph Road ramp reduced traffic on W. Taylor Run Parkway and other neighborhood street. It also shifted traffic to major arterials such as N. Quaker Lane and Duke Street increased. Retiming the signals on Duke Street and maintaining unrestricted flow on Telegraph Road on-ramp (except when pedestrian push button) reduced congestion on Duke Street stemming from the backup at the West Taylor Run Parkway signal. Recommendations of the Pilots were included in the build Alternatives. However, existing exclusive pedestrian phase at Duke Street and W. Taylor Run Parkway was maintained in the build alternatives.

By eliminating the right-turn lane at the intersection of Duke Street and W. Taylor Run Parkway, and providing slip right-turn lane from the westbound Duke Street onto Service Road reduces the delays and improves the LOS for Preferred Alternative 3C compared to Alternative 3A. Improvement is seen for 2026 and 2036 Build conditions for both peak periods. Slight delays are seen at the slip lane, however, much greater improvement in delays is observed at Duke Street and W. Taylor Run Parkway. Providing the storage of 150 ft for slip right-turn lane also prevents vehicular queues spilling onto the westbound Duke Street. Without providing storage for the slip lane, as modeled in Alternative 3A, results in longer queues spilling onto Duke Street. Removing the westbound right-turn lane also aligns the intersection for the Duke Street Transitway project requiring less construction cost in the future.

New intersection, intersection of Duke Street eastbound and Telegraph Road on-ramp, provides additional access for the traffic traveling to the southbound Telegraph Road. This intersection shows higher delays for Preferred Alternative 3C compared to Alternative 3A. Alternative 3A retains the existing Telegraph Road Off-ramp to the westbound Duke Street. However, providing dual right-turn lanes will likely reduce the conflict between pedestrians and traffic exiting the Telegraph Road. Preferred Alternative 3C provides signalized crossing for pedestrians traveling to and from King Street Metro station. Safety benefits by providing signalized crossing outweighs reduced delays for vehicles at the Telegraph Road off-ramp. This configuration also aligns with the Duke Street Transitway project.

Results of travel time summary for no-build, Alternative 1, Alternative 3A, and Alternative 3C conditions is included in Appendix Z for both 2026 and 2036. Westbound Duke Street shows slight improvement in the travel time for both AM and PM peak hours for 2036. Eastbound Duke Street shows slight improvement for AM Peak hour but shows significant improvement in the PM peak hour for 2036.

### 10.1.3 Comparison of Preferred Alternative 3C with Alternatives 1 and 3A

An operational analysis was performed at each of the study intersections for the projected Opening Year 2026 and Design Year 2036 volumes with proposed geometric improvements for Alternatives 1, 3A and 3C (Preferred). Traffic



Table 47: Existing, No-Build and Build Year (2026) Overall Intersection AM and PM Peak Hour Delay & LOS

Node	Intersection	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS						
		AM PEAK										PM Peak									
		Existing		No-Build		Alternative 1		Alternative 3A		Preferred Alternative 3C		Existing		No-Build		Alternative 1		Alternative 3A		Preferred Alternative 3C	
1	Duke St and N Quaker Ln	18.1	B	18.2	B	22.2	C	23.2	C	25.2	C	37.8	D	42.1	D	38.8	D	37.1	D	34.7	C
2	Duke St and S Quaker Ln	6.4	A	6.3	A	6.8	A	6.7	A	6.5	A	22.3	C	22.7	C	21.4	C	26.9	C	12.1	B
3	Duke St and Alexandria Commons	5.2	A	5.5	A	5.9	A	5.8	A	6.0	A	26.1	C	25.1	C	24.5	C	21.9	C	15.6	B
4	Duke St and Sweeley St	7.4	A	7.8	A	8.3	A	8.2	A	7.9	A	34.1	C	34.9	C	21.5	C	18.4	B	11.9	B
5	Duke St at Roth St / Cambridge Rd	16.4	B	16.5	B	20.6	C	18.8	B	17.1	B	38.8	D	38.6	D	24.9	C	25.0	C	13.7	B
51	Cambridge Rd and Service Rd	89.5	F	88	F	17.9	C	16.3	C	22.7	C	25.3	D	28.1	D	26.3	D	27.4	D	53.2	F
6	Duke St and Witter Dr	8.0	B	8.5	A	9.9	A	10.0	A	8.9	A	36.8	D	35.3	D	24.3	C	22.5	C	7.8	A
7	Duke St and W Taylor Run Pkwy	23.4	B	20.6	B	9.5	A	17.2	B	10.1	B	37.9	D	25.3	C	23.9	C	17.1	B	10.6	B
71	W Taylor Run Pkwy and Service Rd	23	C	22.9	C	15.5	B	8.5	A	15.3	B	107.8	F	109.3	F	29.5	C	17.9	B	27.4	C
72	Duke St and Telegraph Ramp	--	--	--	--	4.3	A	--	--	4.4	A	--	--	--	--	9.6	A	--	--	3.7	A
8	Duke St WB and Telegraph Rd Off-Ramp	1.1	A	1.1	A	0.9	A	--	--	1.2	A	0.9	A	0.8	A	2.5	A	--	--	1.0	A
81	Duke St EB to Telegraph Rd On-ramp (New)	--	--	--	--	10.5	B	37.9	D	10.0	A	--	--	--	--	12.7	B	24.0	C	13.3	B
82	Telegraph Rd On-Ramp at New Ramp from /duke St WB	--	--	--	--	0.1	A	0.3	A	0.3	A	--	--	--	--	2.6	A	3.6	A	2.2	A
9	Duke St WB to Telegraph Rd On-Ramp	0.3	A	0.3	A	3.5	A	8.2	A	0.4	A	0.9	A	0.9	A	4.1	A	9.3	A	1.2	A
10	Duke St and S Dove St/Roberts Ln	14.0	B	14.8	B	14.6	B	27.2	C	12.5	B	13.0	B	13.8	B	13.9	B	22.6	C	13.5	B



Table 48: Existing, No-Build and Build Year (2036) Overall Intersection AM and PM Peak Hour Delay & LOS

Node	Intersection	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS	Average Delay sec/veh	LOS						
		AM PEAK										PM Peak									
		Existing		No-Build		Alternative 1		Alternative 3A		Preferred Alternative 3C		Existing		No-Build		Alternative 1		Alternative 3A		Preferred Alternative 3C	
1	Duke St and N Quaker Ln	18.1	B	19.2	B	31.3	C	23.8	C	25.3	C	37.8	D	54.8	D	43.6	D	40.5	D	39.7	D
2	Duke St and S Quaker Ln	6.4	A	6.5	A	6.6	A	6.8	A	6.5	A	22.3	C	27.4	C	23.7	C	29.0	C	13.3	B
3	Duke St and Alexandria Commons	5.2	A	5.4	A	5.8	A	6.0	A	5.9	A	26.1	C	30.6	C	26.3	C	23.8	C	16.5	B
4	Duke St and Sweeley St	7.4	A	8.4	A	8.3	A	8.9	A	8.0	A	34.1	C	38.7	D	23.3	C	22.3	C	13.3	B
5	Duke St at Roth St / Cambridge Rd	16.4	B	17.2	B	19.7	B	19.3	B	17.5	B	38.8	D	39	D	27.1	C	30.7	C	15.5	B
51	Cambridge Rd and Service Rd	89.5	F	88.1	F	19.5	C	17.1	C	26.6	D	25.3	D	30.8	D	29.1	D	27.8	D	50.8	F
6	Duke St and Witter Dr	8.0	B	10.6	B	10.3	B	11.6	B	9.0	A	36.8	D	35.7	D	32	C	34.0	C	10.8	B
7	Duke St and W Taylor Run Pkwy	23.4	B	21.5	C	9.5	A	18.0	B	10.0	A	37.9	D	25.5	C	32.4	C	24.2	C	11.3	B
71	W Taylor Run Pkwy and Service Rd	23	C	24	C	15.4	B	8.7	A	14.8	B	107.8	F	114.4	F	35.6	D	20.5	C	31.1	C
72	Duke St and Telegraph Ramp	--	--	--	--	6.2	A	--	--	4.6	A	--	--	--	--	14.9	B	--	--	3.9	A
8	Duke St WB and Telegraph Rd Off-Ramp	1.1	A	1.9	A	1.4	A	--	--	1.3	A	0.9	A	0.9	A	4.8	A	--	--	1.1	A
81	Duke St EB to Telegraph Rd On-ramp (New)	--	--	--	--	10.4	B	39.7	D	9.7	A	--	--	--	--	12.7	B	28.0	C	13.3	B
82	Telegraph Rd On-Ramp at New Ramp from /duke St WB	--	--	--	--	0.2	A	0.3	A	0.3	A	--	--	--	--	2.9	A	3.9	A	2.3	A
9	Duke St WB to Telegraph Rd On-Ramp	0.3	A	0.4	A	3.2	A	10.3	B	0.4	A	0.9	A	1.1	A	4.2	A	11.1	B	1.4	A
10	Duke St and S Dove St/Roberts Ln	14.0	B	14.4	B	14.5	B	27.8	C	12.3	B	13.0	B	13.9	B	14.1	B	23.9	C	14.2	B



## 11 SUMMARY OF FINDINGS AND CONCLUSION

In order to justify the merits of constructing the proposed improvements, study provides traffic operational analysis for existing, Opening Year and Design Year traffic conditions. Hence, analyses are provided for existing (2018), Opening Year (2026) No-Build/Build, and Design Year (2036) No-Build/Build for the weekday AM/PM peak hours. The No-Build scenario was analyzed to provide future Opening Year 2026 and Design Year 2036 baseline traffic conditions assuming only existing geometric conditions without any of the improvements.

During the recent seven-year period from 2015 to 2022, 446 crashes resulting in 110 visible injuries, were reported within this corridor. The types of crashes frequently reported include rear-end and sideswipe – same direction. These crash types are typically associated with recurring congestion for a corridor. Reduction in congestion along the corridor may have a corresponding safety benefit, in terms of reduction in number of crashes along the corridor. A total of one hundred seventeen (117) crashes were recorded between January 2016 to December 2020 at Duke Street and West Taylor Run Parkway, and Telegraph Road entry and exit ramps to and from westbound Duke Street. Additional six (6) rear end crashes related to the crosswalk located on Telegraph Road on-ramp, east of the intersection were recorded. A total of eighteen (18) rear-end, and three (3) fixed object type crashes were recorded on the Telegraph Road off-ramp to the westbound Duke Street. Rear-end crashes were related to the crosswalk at the end of the ramp. Another nine (9) rear-end and one (1) sideswipe crashes were recorded on Telegraph Road on-ramp from the westbound Duke Street. Rear-end crashes were related to the crosswalk on the off-ramp.

Based on the community input from previous meetings, SMART SCALE application proposed improvements, the No-Build operational analysis results, safety analysis, as well as field investigations, the study team identified operational and safety deficiencies within the study area and developed a preliminary list of design opportunities and constraints. Alternative Analysis was performed for an initial screening using Synchro software to determine the optimal configuration of Duke Street and W. Taylor Run Parkway, Duke Street eastbound and Telegraph Road on-Ramp, and Telegraph Road on-ramp at New Ramp (from eastbound Duke Street). Alternatives were compared to the No-Build conditions. No-Build conditions do not include new intersections: *Duke Street eastbound at Telegraph Road on-ramp, and Telegraph Road on-ramp at New Ramp (from eastbound Duke Street)*. No-Build conditions also maintains the access from W. Taylor Run Parkway to the southbound Telegraph Road on-ramp. Synchro was utilized to evaluate each of the aforementioned No-Build and Build traffic conditions with regards to delay/levels of service (LOS), and 95th percentile queue along the study roadway intersections. Four (4) build alternatives were analyzed during the initial screening phase.

Based on the results of the initial screening using Synchro, and the public input received on the concepts, two (2) concepts were advanced for a more detailed analysis using VISSIM. Public meetings were held on November 15, 2022 and April 17, 2023. VISSIM models were developed for Opening Year 2026 and Design year 2036 for AM and PM peak hours. Alternative 1 and modified Alternative 3 (Alternative 3A) were carried forward for the VISSIM analysis. Both alternatives restricted the southbound left-turn movement from W. Taylor Run Parkway onto Telegraph Road on-ramp. Both alternatives include the signalization for the new intersection for Duke Street eastbound and Telegraph Road on-ramp. New intersection will provide additional access for the eastbound traffic on Duke Street to the southbound Telegraph Road. In both alternatives, crosswalk on the north leg was signalized. Intersection of Duke Street westbound and Telegraph Rd on-ramp was signalized to provide safe crossing for the pedestrians.

An engineering study was conducted to determine if a signal is appropriate for the intersection. Since proposed intersection is in the preliminary engineering phase and therefore not yet open to traffic, Average Daily Traffic (ADT)

projections were utilized to satisfy Warrant 1. ADT projections were developed utilizing the 2026 peak hour volumes at the intersection. Warrant 3 (Peak Hour) was considered for the analysis. The engineering study indicated that Warrant 1, and Condition A—Minimum Vehicular Volume and Condition B (Interruption of Continuous Traffic) using ADT Estimates, and Warrant 3 (Peak Hour) are met for the opening year 2026 conditions. Signal Justification Report (SJR) was prepared at this location.

Alternative 1 provided the right-turn slip lane from the westbound Duke Street onto service road. Free flow condition was maintained for the Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street. Alternative 3A maintained the westbound right-turn lane at Duke Street and W. Taylor Run Parkway. Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street was eliminated. Dual southbound right-turn lanes were provided at the intersection. The projected traffic volumes were balanced and distributed in accordance to projected regional distribution. MOEs for the Build alternatives were reported and summarized in tabular format consistent with earlier tasks and in accordance with TOSAM guidelines. After the results of the VISSIM analysis were evaluated for Alternatives 1 and 3A, the team identified preferred alternative for the study area. Preferred alternative was analyzed using VISSIM for 2026 and 2036 conditions.

**The “Preferred Alternative 3C” considered in this evaluation have been developed from Alternatives 1 and 3A to reduce cut-through traffic on neighborhood streets, reduce traffic spilling onto eastbound Duke Street from Telegraph Road on-ramp, improve transit operation on Duke Street, and improve safety and mobility for pedestrians and cyclists within the study area, while maintaining vehicular level of service. This evaluation is primarily focused on the intersections of Duke Street and W. Taylor Run Parkway, Duke Street eastbound and Telegraph Road on-ramp new, and Duke Street westbound and Telegraph Rd on-ramp. No traffic control or geometric changes were made at the other study intersections. The “Preferred Alternative 3C” provided the right-turn slip lane from the westbound Duke Street onto service road at Moncure Drive, and restricted the southbound left-turn movement from W. Taylor Run Parkway onto Telegraph Road on-ramp. Exclusive pedestrian phase was maintained at the intersection of Duke Street and W. Taylor Run Parkway. Telegraph Road off-ramp traffic from the northbound Telegraph Road to the westbound Duke Street was maintained. Crosswalk on the north leg was signalized at Duke Street westbound and Telegraph Rd on-ramp. Existing crosswalk on Telegraph Road on-ramp at Duke Street westbound will be maintained. Crosswalk will be controlled by existing RRFB to provide safe crossing for the pedestrians. Preferred Alternative 3C aligns with the Duke Street Transitway project requiring less construction cost in the future.**

