KINGSPORT
TENNESSEE

TRANSPORTATION SYSTEM MANAGEMENT & OPERATIONS PLAN

SIGNAL SYSTEM EVALUATION & OPTIMIZATION

SR 1 & SR 93

September 2023

TN TDOT Department of Transportation

Prepared by:

CDM Smith

RESOLUTION NO. 2024-085

A RESOLUTION TO ENDORSE THE STATE ROUTE 93 AND STATE ROUTE 1 CORRIDOR STUDY FINAL REPORT AND RECOMMENDATIONS IN COMPLIANCE WITH THE TENNESSEE DEPARTMENT OF TRANSPORTATION URBAN TRANSPORTATION PLANNING GRANT

WHEREAS, in the Fall of 2022, the Tennessee Department of Transportation (TDOT) began the State Route 93 and State Route 1 Corridor Study and this study was funded by the Urban Transportation Planning Grant (UTPG); and

WHEREAS, as part of this grant program, TDOT selected CDM Smith as the consultant, and funded 90% of the study through the UTPG, the city provided the remaining 10%; and

WHEREAS, the study area includes SR-93/John B Dennis Highway from Bloomingdale Road to SR-126/Memorial Boulevard and SR-1/East Stone Drive from Brookside Drive to the Kingsport Pavilion Shopping Center; and

WHEREAS, over the past several months a Steering Committee, made up of City of Kingsport and Kingsport MTPO staff, has met with the consultant to offer input and provide feedback; and

WHEREAS, in addition to the Steering Committee meetings, there was an online public survey which had over 500 respondents and two public meetings. The final report provides a detailed transportation planning level analysis of the study area and identifies the existing conditions along the corridors, identifies issues and opportunities, and provides recommendations for the City of Kingsport moving forward with an emphasis on safety and capacity improvements; and

WHEREAS, the study deliverables include the Corridor Study Report, a Transportation System & Management Operations Plan, and a Technical Appendix; and

WHEREAS, approval of this resolution will fulfill the requirement TDOT places on UTPG recipients to adopt a resolution endorsing the study document and to implement, to the best of their ability the recommendations from the study.

Now therefore,

BE IT RESOLVED BY THE BOARD OF MAYOR AND ALDERMEN AS FOLLOWS:

SECTION I. That the State Route 93 and State Route 1 Corridor Study, prepared by the Tennessee Department of Transportation through the Urban Transportation Planning Grant (attached as EXHIBIT A) is adopted as part of the municipality's general plan.

SECTION II. That the board finds that the actions authorized by this resolution are for a public purpose and will promote the health, comfort and prosperity of the citizens of the city.

SECTION III. That this resolution shall take effect from and after its adoption, the public welfare requiring it.

ADOPTED this the 3rd day of October, 2023.

Patrick W. Shull

ATTEST: PATRICK W. SHULL, Mayor

Angela Marshall

ANGELA MARSHALL
Deputy City Recorder

APPROVED AS TO FORM:

Rodney B. Rowlett, III

RODNEY B. ROWLETT, III, City Attorney

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INTRODUCTION

The City of Kingsport was awarded a Tennessee Department of Transportation (TDOT) Transportation Planning Grant (TPG) in 2022 for a corridor study of E Stone Drive (US 11W/SR 1) and N John B Dennis Highway (SR 93). To streamline the corridor study report, a separate TSMO Plan was written to concentrate on the safe and efficient operation of all signalized intersections within the study area. This plan strives to improve the overall signalized transportation system and address the community's evolving needs by analyzing existing conditions, identifying key issues and opportunities, and providing recommendations.

Kingsport, TN is an important location in Tennessee for locals, businesses, and visitors. With a growing population and increasing traffic demands, effectively managing traffic signals and signalized intersections has become essential for maintaining a reliable and efficient transportation network. By optimizing signal timing, improving pedestrian and bicycle accommodations, and leveraging intelligent transportation systems, Kingsport can enhance mobility, reduce congestion, and ensure the safety of all road users.

The TSMO Plan is built upon a thorough assessment of existing conditions at the traffic signals within the study area. It incorporates valuable input from transportation agencies, community organizations, and the public. This plan aims to provide practical and actionable recommendations that align with Kingsport's long-term goals and objectives by understanding the unique challenges and opportunities along the corridor. By adopting the strategies outlined in this plan, Kingsport can become a model for effective traffic signal management, fostering a safe and efficient transportation network that caters to current and future needs.

The following sections of the TSMO Plan delve into signalized intersections' existing operations and safety conditions, identify key issues and opportunities, and outline the goals and objectives that guide the recommendations. By conducting a comprehensive analysis of these aspects, the plan aims to address operational inefficiencies, enhance safety measures, optimize traffic flow, and improve the overall performance of the signalized intersections within the study area.

In conclusion, this TSMO Plan provides a roadmap for Kingsport to enhance its transportation network through effective traffic signal management. By leveraging the findings and recommendations presented in this plan, Kingsport can achieve its vision of a safe, efficient, and future-ready transportation system.

PROJECT BACKGROUND

TDOT's Office of Community Transportation (OCT) coordinates the State's transportation planning, local land use decisions, and community visions to guide the development of a safe and efficient statewide transportation system. As part of this effort, TDOT initiated the Transportation Planning Grant (TPG) program to assist communities with creating planning documents that support improvements in traffic flow, safety, and overall efficiency of the transportation system.

The goals of the TPG are to:

- Assist urban jurisdictions with transportation-related solutions that strengthen the multimodal cohesiveness of the transportation system.
- Guide communities with developing potential strategies that will support improvements in traffic flow, safety, mobility, and overall efficiency of the transportation system.
- Provide jurisdictions with planning resources to achieve the community visions related to transportation and land use needs that promote future economic growth.[1]

In December 2021, the City of Kingsport applied for TPG funding for an E Stone Drive (US 11W/SR 1) and N John B Dennis Highway (SR 93) Corridor Study. A copy of the TPG application can be found in *Appendix A*.

STUDY AREA

The E Stone Drive (US 11W/SR 1) and N John B Dennis Highway (SR 93) corridors, hereinafter referred to as Stone Drive and John B Dennis Highway, study area encompasses approximately 1.6 and 3.7 miles of roadway within Metropolitan Kingsport, respectively. The Stone Drive study area goes from Brookside Drive to Kingsport Pavilion Shopping Center. The John B Dennis Highway study area stretches between the Memorial Boulevard (SR 126) interchange to Bloomingdale Road. An overview of the study's corridor and signalized intersections are illustrated in *Figure 1*.

The Stone Drive study area is classified as a Principal Arterial by TDOT. The portion of John B Dennis Highway north of Stone Drive is classified as a Minor Arterial, while the southern portion is classified as a freeway. *Figure 2* displays the study within the TDOT Functional Classification Map. Both roads are primary transportation corridors within Kingsport, TN. It serves as the principal conduit through which the City's residential, commercial, and industrial traffic travel regardless of destination. Consequently, most of Kingsport's commercial land uses have gravitated to the Stone Drive area. In a regional context, John B Dennis Highway is a vital linkage between Interstate 26 and 81 to the south and the State of Virginia to the north.

[1] Transportation Planning Grants (tn.gov)

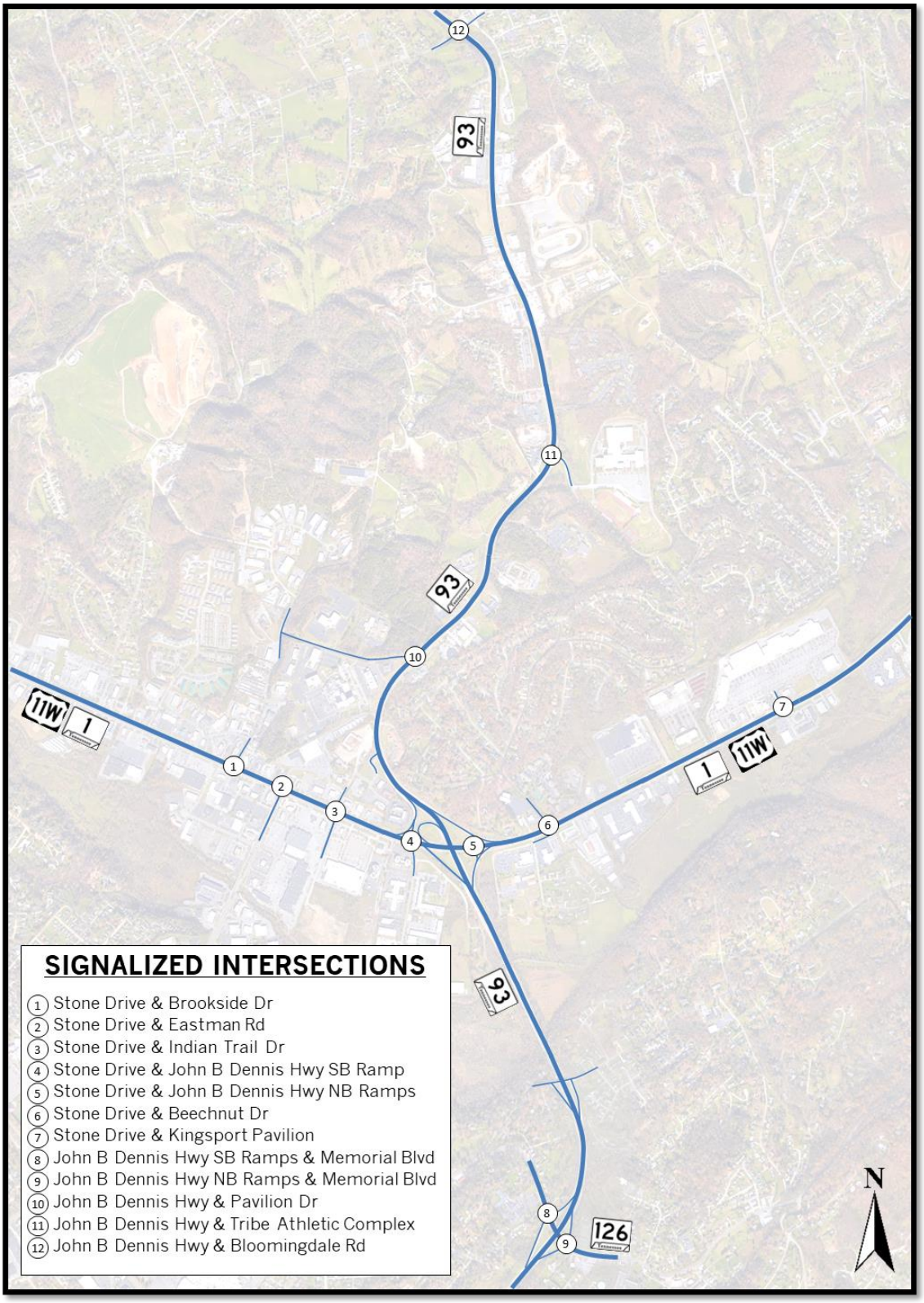

Figure 1. Kingsport, TN Traffic Signal Locations within Study Area

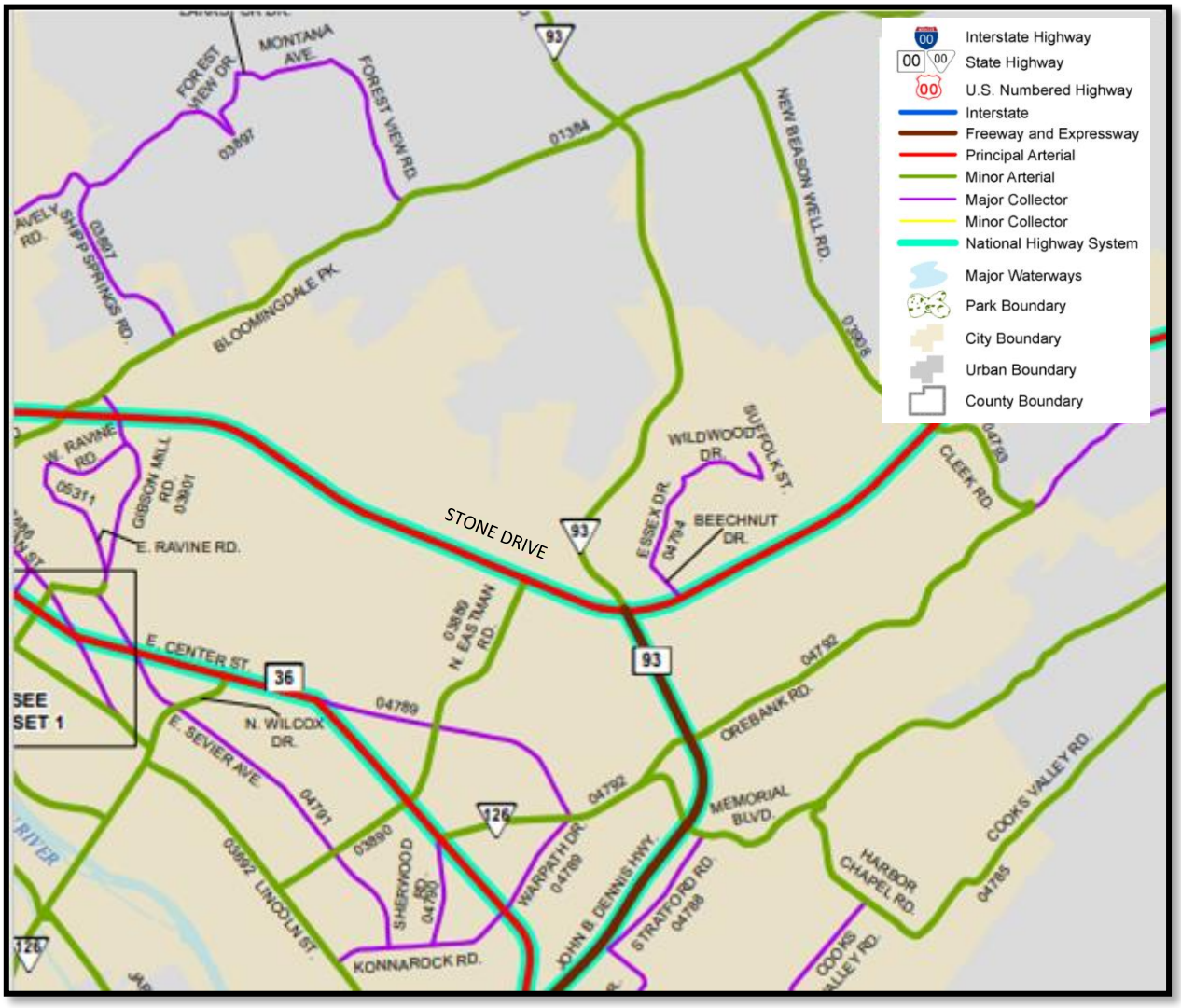

Figure 2. TDOT's Functional Classification Map - Kingsport, TN

EXISTING CONDITIONS

Data collection and analysis is a critical component of the TSMO plan and plays a vital role in understanding the existing conditions and operational performance of the signalized intersections. The following data collection efforts were undertaken to gather comprehensive information for analysis and decision-making.

24-Hour Segment Counts and Turning Movement Counts (TMC)

Traffic volume counts were conducted to gather data on vehicular movements at roadway segments and signalized intersections. Volume data provides insights into traffic patterns, intersection capacity, and assists in evaluating the effectiveness of existing signal timing plans.

Identification of Intersection Attributes

Detailed information on intersection attributes was gathered to better understand the signalized intersections' geometric layout and design features. This included documenting intersection geometry, lane configurations, the presence of turn lanes, crosswalks, pedestrian signals, and other infrastructure elements.

Procurement of Crash Reports

Crash reports from the Tennessee Integrated Traffic Analysis Network (TITAN) were procured to gain insights into intersection safety performance. These reports provided valuable information on the types of crashes, contributing factors, and severity levels at signalized intersections. Analyzing crash data helps identify high-crash locations, potential safety issues, and guides the development of strategies to enhance intersection safety.

Field Inventory of Traffic Signal Equipment

A thorough field inventory was conducted to assess the condition and functionality of traffic signal equipment. This involved documenting the type, model, and physical condition of signal controllers, pedestrian signals, detection systems, and other components. The inventory aimed to identify any maintenance issues, malfunctions, or outdated equipment that may impact signal operations.

Documentation of Existing Signal Operation

The existing signal timing plans, including cycle lengths, phase sequences, and green time allocations, were carefully documented. This data collection effort aimed to establish a baseline understanding of the current timing strategies employed at signalized intersections. Analyzing the existing signal timing plans is essential for identifying potential areas of improvement, optimizing traffic flow, and reducing congestion.

The comprehensive data collected through these efforts form the foundation for a robust analysis of existing conditions, enabling informed decision-making and the development of targeted recommendations within the TSMO plan. The integration of equipment inventory, intersection attributes, signal timing, turning movement counts, traffic volume data, and crash reports ensures a holistic understanding of the study area. It supports the identification of critical issues and opportunities for improving the safe and efficient operation of traffic signals and signalized intersections. *Table 1* contains the signalized intersections involved in the data collection efforts.

Table 1. Signalized Intersections

Major Street	Minor Street
Stone Drive	Brookside Drive
	N Eastman Road
	Indian Trail Drive
	John B Dennis Hwy SB Off-Ramp/American Way
	John B Dennis Hwy NB Ramps
	Beechnut Drive/Springdale Lane
	Kingsport Pavilion Shopping Center
John B Dennis Highway	SB Ramps at Memorial Blvd
	NB Ramps at Memorial Blvd
	Pavilion Drive
	Tribe Athletic Complex
	Bloomingdale Road

CORRIDOR TRAFFIC VOLUMES

Traffic volume analysis plays a crucial role in understanding traffic patterns, evaluating intersection performance, and identifying areas for improvement. The findings from this analysis provide valuable insights for optimizing traffic flow, enhancing safety, and improving the overall operational efficiency of the transportation network. The traffic volumes are utilized for the crash rate calculations and level of service and capacity analysis.

The turning movement counts collected for these signalized intersections are found in *Appendix B*, respectively. *Figure 3* contains the annual average daily traffic (AADT) volumes published by the Tennessee Department of Transportation for 2022.

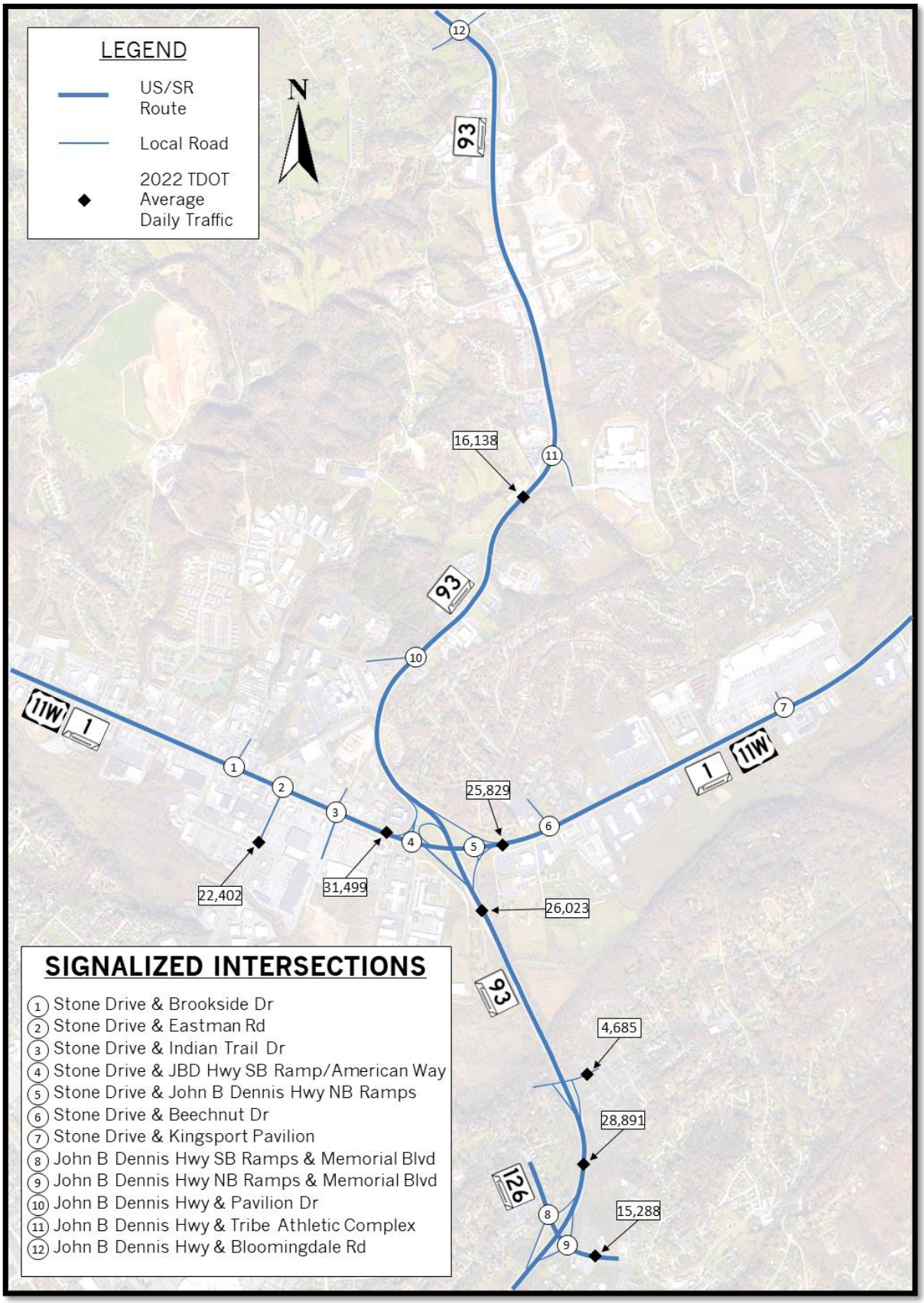

Figure 3. Annual Average Daily Traffic Volumes

SAFETY ANALYSIS

A comprehensive review of signalized intersections was conducted to assess the need for safety improvements and optimize signal operations in Kingsport. The analysis included examining the traffic crash history, development of crash rates, and quantification of crash severity for each intersection. The review period encompasses five years, from January 2018 to December 2022, to capture sufficient crash data and identify patterns over time.

Crash data was collected within an approximate 250-foot radius of each signalized intersection's approach, depending on intersection spacing encompassing crashes that signal operations may have influenced. If intersections are closer than 500 feet from each other, half the distance was used for assigning crashes to the respective intersection. Emphasis was placed on analyzing angle, left-turn, and rear-end collisions, as these types of crashes are often associated with signal operations, including signal phasing, timing, and configuration. Crash diagrams were created for each signalized intersection, providing visual representations of the crash patterns and identifying potential improvement opportunities. Please refer to *Appendix C* for the corridor crash diagrams.

Crash rates were calculated using the crash history data and intersection turning movement counts (TMC) explicitly obtained for this study. To determine the intersection crash rate, entering Average Daily Traffic (ADT) volumes and K-factors were developed. The PM peak-hour entering traffic was extrapolated to estimate an average daily traffic (ADT) volume using K-factors derived from traffic counts conducted during the study. The K-factor is the relationship between the design hour volume and the ADT.

Table 2 presents the crashes and crash rates for the signalized intersections along Kingsport's Stone Drive and John B Dennis Highway corridors. Additionally, average rates and critical rates were determined from the Kingsport crash data to identify intersections with higher-than-average crash rates within the corridor. Statewide averages for urban spot locations are provided for comparison in Table 2. It is worth noting that signalized intersections typically experience higher crash rates than statewide averages due to traffic flow disruptions caused by signal operations, potentially leading to increased crash occurrences. Statewide critical rates indicate significantly higher values than the average signalized crash rate, signifying intersections requiring immediate attention and targeted safety interventions.

More specifically, the statewide average crash rate for urban signalized multilane divided and with turn lanes is 0.714/MEV[2] and 0.618/MEV, respectively. The crash rates were compared to the Tennessee statewide averages based on the following metrics:

- **Below Average**: Locations with crash rates below the statewide average
- **Average**: Locations with crash rates at or within 15 percent above the statewide average
- **Above Average**: Locations with crash rates 15 percent above the statewide average
- **Significantly Above Average**: Locations with crash rates at or above the critical statewide average

[2] Million Entering Vehicles

Table 2. Corridor Crash Summary

Major Street	Minor Street	Entering PM Peak Hour Volume	Entering ADT Volume	Total Crashes	Actual Avg. Rate (Acc/MEV)	Statewide Crash Rate (Acc/MEV)	Critical Crash Rate (Acc/MEV)	Actual/ Critical Ratio
Stone Drive	Brookside Drive	3382	42919	115	1.468	0.618	0.831	1.77
	N Eastman Road	4007	50213	107	1.168	0.714	0.925	1.26
	Indian Trail Drive	3289	41216	84	1.117	0.714	0.947	1.18
	John B Dennis Hwy SB Off-Ramp/American Way	3289	41216	37	0.492	0.714	0.947	0.52
	John B Dennis Hwy NB Ramps	3020	37845	14	0.203	0.714	0.958	0.21
	Beechnut Drive/Springdale Lane	3393	38777	40	0.565	0.618	0.843	0.67
	Kingsport Pavilion Shopping Center	2861	32697	83	1.391	0.714	0.977	1.42
John B Dennis Highway	SB Ramps at Memorial Blvd	1602	19950	8	0.220	0.714	1.054	0.21
	NB Ramps at Memorial Blvd	1917	23873	5	0.115	0.714	1.023	0.11
	Pavilion Drive	2022	22668	32	0.774	0.714	1.032	0.75
	Tribe Athletic Complex	1790	20067	8	0.218	0.714	1.053	0.21
	Bloomingdale Road	2400	26906	105	2.138	0.714	1.005	2.13

From the analysis, the following signalized intersections have crash rates exceeding the statewide average rates:

Stone Drive at:

- Brookside Drive
- N Eastman Road
- Indian Trail Drive
- Kingsport Shopping Pavilion

John B Dennis Highway at:

- Pavilion Drive
- Bloomingdale Road

Only five signalized intersections surpassed the critical rate threshold, indicating crash rates significantly higher than the statewide average. The following intersections were identified as having crash rates that are above the critical rate:

Stone Drive at:

- Brookside Drive
- N Eastman Road
- Indian Trail Drive
- Kingsport Shopping Pavilion

John B Dennis Highway at:

- Bloomingdale Road

INTERSECTION CRASH SUMMARY

This section summarizes the crash history and rates for each signalized intersection within the study area. The focus is placed on rear-end, angle, and left-turn collisions, as these types of crashes are commonly associated with signal operations, including signal phasing, timing, and the configuration of the signals. The analysis spans five years, allowing for a comprehensive understanding of crash

patterns and trends. The values within the paratheses represent the respective number of crashes in the five years.

Stone Drive & Brookside Drive

- 115 Total Collisions
- Rear-end collisions represent 57% of the crashes (66)
- Angle/Left-turn collisions represent 37% of the crashes (42)
- Property damage accounted for 77% of the crashes (89), and injury accounted for 23% (26)
- The crash rate exceeds the statewide average and critical crash rate.

Rear-end collisions are the dominant pattern for crashes at the intersection and may be associated with the higher speed westbound approach. The higher yellow and all red clearances should be maintained.

Stone Drive & Eastman Road

- 107 Total Collisions
- Rear-end collisions represent 43% of the crashes (46)
- Angle/Left-turn collisions represent 38% of the crashes (41)
- Property damage accounted for 83% of the crashes (89), and injury accounted for 17% (18)
- The crash rate exceeds the statewide average and critical crash rate.

Stone Drive & Indian Trail Drive

- 84 Total Collisions
- Rear-end collisions represent 56% of the crashes (47)
- Angle/Left-turn collisions represent 33% of the crashes (28)
- Property damage accounted for 79% of the crashes (66), and injury accounted for 21% (18)
- The crash rate exceeds the statewide average and critical rate.

Stone Drive & American Way/John B Dennis Highway SB Off-Ramp

- 37 Total Collisions
- Rear-end collisions represent 38% of the crashes (14)
- Angle/Left-turn collisions represent 46% of the crashes (17)
- Property damage accounted for 78% of the crashes (29), and injury accounted for 22% (8)
- The crash rate is below the statewide average and critical rate.

Stone Drive & John B Dennis Hwy NB Ramps

- 14 Total Collisions
- Rear-end collisions represent 36% of the crashes (5)
- Angle/Left-turn collisions represent 57% of the crashes (8)
- Property damage accounted for 43% of the crashes (6), injury accounted for 20% (7) with one fatality for 7%
- The crash rate is below the statewide average and critical rate. The signalized intersection did experience a single fatality.

Rear-end collisions are a lower occurrence and may be associated with greater signal density and system progression. Angle and left-turn collisions are a more dominant pattern that may have resulted in side street queues and some driver frustrations.

Stone Drive & Beechnut Drive/Springdale Lane

- 40 Total Collisions
- Rear-end collisions represent 68% of the crashes (27)
- Angle/Left-turn collisions represent 23% of the crashes (9)
- Property damage accounted for 83% of the crashes (33), and injury accounted for 18% (7)
- The crash rate is below the statewide average and critical rate.

Stone Drive & Kingsport Shopping Pavilion

- 83 Total Collisions
- Rear-end collisions represent 60% of the crashes (50)
- Angle/Left-turn collisions represent 30% of the crashes (25)
- Property damage accounted for 86% of the crashes (71), and injury accounted for 14% (12)
- The crash rate exceeds the statewide average and critical rate.

John B Dennis Highway SB Ramps & Memorial Boulevard

- 8 Total Collisions
- Rear-end collisions represent 63% of the crashes (5)
- Angle/Left-turn collisions represent 13% of the crashes (1)
- Property damage accounted for 100% of the crashes (8)
- The crash rate is below the statewide average and critical rate.

John B Dennis Highway NB Ramps & Memorial Boulevard

- 5 Total Collisions
- Rear-end collisions represent 60% of the crashes (3)
- Angle/Left-turn collisions represent 40% of the crashes (2)
- Property damage accounted for 100% of the crashes (5)
- The crash rate is below the statewide average and critical rate.

John B Dennis Highway & Pavilion Drive

- 32 Total Collisions
- Rear-end collisions represent 34% of the crashes (11)
- Angle/Left-turn collisions represent 47% of the crashes (15)
- Property damage accounted for 78% of the crashes (25), injury accounted for 19% (6) and 1 fatality, 3%
- The crash rate exceeds the statewide average but is below the state critical rate. The signalized intersection did experience a single fatality.

John B Dennis Highway & Tribe Athletic Complex

- 8 Total Collisions
- Rear-end collisions represent 25% of the crashes (2)
- Angle/Left-turn collisions represent 25% of the crashes (2)

- Property damage accounted for 87% of the crashes (7), and injury accounted for 13% (1)
- The crash rate is below the statewide average and critical rate.

John B Dennis Highway & Bloomingdale Road

- 105 Total Collisions
- Rear-end collisions represent 54% of the crashes (57)
- Angle/Left-turn collisions represent 38% of the crashes (40)
- Property damage accounted for 73% of the crashes (77), and injury accounted for 27% (28)
- The crash rate exceeds the statewide average and critical rate.

SIGNAL EQUIPMENT & COMMUNICATIONS

The Stone Drive corridor study area has seven traffic signals, but for existing evaluation and future analysis, the TSMO plan includes all the signals within the coordinated signal group. The traffic signals along John B Dennis Highway are broken into two signal groups: the two coordinated signals at Memorial Boulevard and the three isolated signals north of the Stone Drive interchange.

The City currently has dedicated fiber communications for the City signals. The current signal cabinet standard is the TS2 with an Advanced Transportation Controller (ATC) standard controller. The traffic signals for this corridor use Econolite Cobalt controllers. Table 3 presents the current inventory of the study area's traffic signal controllers.

Table 3. Traffic Signal Inventory

Signal Location	Controller Manufacturer	Controller Date	Controller Age (yr)	Cabinet Date	Communications Type
COORDINATED SIGNAL GROUP AT STONE DRIVE					
1. Stone Drive & Idle Hour Road	Econolite Cobalt	2017	6	1995	Dedicated Fiber
2. Stone Drive & Pinebrook Drive	Econolite Cobalt	2022	1	1998	Dedicated Fiber
3. Stone Drive & Brookside Drive	Econolite Cobalt	2017	6	1998	Dedicated Fiber
4. Stone Drive & Eastman Road	Econolite Cobalt	2017	6	1996	Dedicated Fiber
5. Stone Drive & Indian Trail	Econolite Cobalt	2017	6	2009	Dedicated Fiber
6. Stone Drive & JBD Hwy SB Off-Ramp/American Way	Econolite Cobalt	2017	6	1998	Dedicated Fiber
7. Stone Drive & John B Dennis Hwy NB Ramp	Econolite Cobalt	2017	6	1998	Dedicated Fiber
8. Stone Drive & Beechnut Drive/Springdale Lane	Econolite Cobalt	2017	6	1998	Dedicated Fiber
9. Stone Drive & Pavilion Shopping Center	Econolite Cobalt	2017	6	2007	Isolated-NIC
COORDINATED SIGNAL GROUP AT MEMORIAL BOULEVARD					
1. Memorial Blvd & John B Dennis Hwy SB Ramps	Econolite ASC/3-2100	1995	28	1995	Dedicated Fiber
2. Memorial Blvd & John B Dennis Hwy NB Ramps	Econolite ASC/3-1000	1995	28	1995	Dedicated Fiber
ISOLATED SIGNALS ON JOHN B DENNIS HIGHWAY					
John B Dennis Hwy & Pavilion Drive	Econolite ASC/3-2100	2010	13	2010	Isolated
John B Dennis Hwy & Tribe Athletic Complex	Econolite ASC/3-2100	2010	13	1990	Isolated
John B Dennis Hwy & Bloomingdale Road	Transyt 1880EL	1989	34	1989	Isolated

Signal controllers at the signalized intersections date to 2017 on Stone Drive, 1995 on Memorial Boulevard, and 1989 on John B Dennis Highway intersections. Most of the corridor signal controllers have been upgraded since 2010 and are 1-13 years old, below the recommended life of 10-15 years. The two traffic signals on Memorial Boulevard and the one at Bloomingdale Road require updating but should be addressed with upcoming TDOT projects.

The City of Kingsport has dedicated fiber cable connecting (last column) the majority of coordinated traffic signals and central control at Kingsport City Hall located at 415 Broad Street. Traffic operations at 1155 Konnarock Road have satellite access to the signal system for monitoring. Centracs, Econolite's management system, manage the citywide signal communications network.

Pedestrian phasing and control are limited to the following intersections:

- Stone Drive & Eastman Road
- Stone Drive & Indian Trail Drive

The corridor signals operate with current Econolite Cobalt advance traffic controllers operating traffic responsive with 9 available timing plans for varying directional flow and volume traffic conditions.

INTERSECTION GEOMETRY & INFRASTRUCTURE

A brief description of the existing intersection geometry and signal design is provided in the following paragraphs. Discussion of mitigation for intersections is also highlighted. *Appendix I* presents short-term and long-term concept designs recommended for each studied signalized intersection. These signalized intersections should be improved for increased vehicular efficiency and include pedestrian crosswalks and traffic control. Pedestrian control should be provided for current ADA compliance.

Many of the Stone Drive and John B Dennis Highway corridor signals are box span wire configurations with strain pole structures with vehicular loop detection. The exceptions to the span wire configurations are the mast arm configurations at the following:

- Stone Drive & Indian Trail Drive
- Stone Drive & Kingsport Pavilion
- John B Dennis & Pavilion Drive

Stone Drive & Brookside Drive

The traffic signal is a steel strain pole and span wire installation providing signalized access for Brookside Drive to the north and a driveway to the south. The signal is located at the western project limits. The north and south approaches are split-phased (Phases 3 and 4). The Brookside Drive and driveway approaches include separate left-turn lanes. These minor approaches are also provided with right-turn overlaps but without the right-turn lanes, limiting the efficiency it could provide. Stone Drive has protected-only left-turn phasing.

The intersection has a sidewalk in the northwest quadrant adjacent to the McDonald's with a center handicap curb ramp. Stone Drive has a marked bike lane through the intersection with an eastbound bike lane ending east of Brookside Drive. There are not any pedestrian crosswalks or signal control.

The dominant crash patterns at the intersection are rear-end and angle collisions resulting in mainly property damage.

Stone Drive & N Eastman Road

The signal is a steel strain pole and span wire installation providing signalized access for N Eastman Road to the south and a driveway to the north. The north and south approaches are split-phased (Phases 3 and 4). Stone Drive has protected-only left-turn phasing. The northbound approach is a major arterial approach with double left-turn movement and a separate right-turn lane with a right-turn overlap. Similar geometry is provided for the driveway approach.

The intersection does not have sidewalks or curb handicap ramps. There are pedestrian heads and push buttons provided for the N Eastman Road approach (Phase 3), but the pushbutton for the southeast corner is inaccessible due to brush. The dominant crash patterns at the intersection are rear-end and angle collisions resulting in mainly property damage.

Stone Drive & Indian Trail Drive

The signal is a mast arm installation. The north and south approaches are split-phased (Phases 3 and 4). Stone Drive has protected-permissive left-turn phasing.

The intersection has a sidewalk limited to the north side to the west. Crosswalks are provided across Stone Drive and Indian Trail Drive north approach with markings and signal control. A refuge area is provided in the median. The dominant accident pattern at the intersection is rear-end collisions, but angle collisions also result in mainly property damage.

This Stone Drive intersection with Indian Trail Drive includes the system detection for the current traffic-responsive operation.

Stone Drive & John B Dennis Highway SB Off-Ramp / American Way

The signal is a steel strain pole and span wire installation. The northbound and southbound approaches to the signal control are single lanes with a the large southbound channelized YIELD-controlled right-turn movement from John B Dennis Highway. The intersection does not have sidewalks with handicap curb ramps. The north and south approaches are concurrently phased (Phases 4 and 8). Stone Drive has protected/permissive left-turn phasing.

The dominant accident patterns at the intersection are rear-end collisions and angle collisions resulting in mainly property damage.

The channelized yielding right-turn movement from southbound John B Dennis Highway to westbound Stone Drive can significantly conflict with westbound traffic on Stone Drive. This conflict is increased if traffic from John B Dennis Highway is destined for any commercial businesses on Stone Drive's southside.

Stone Drive & John B Dennis Highway NB Ramps

The signal is a steel strain pole and span wire installation. The northbound off-ramp approach includes a double left-turn movement and a large, channelized YIELD-controlled right-turn movement. Eastbound Stone Drive has protected/permissive left-turn phasing. Adverse traffic queues develop during the afternoon peak hours, which spill over to the eastbound thru traffic movement, impeding the traffic movement and presenting a significant conflict that could result in rear-end collisions.

The intersection does not have any sidewalks or pedestrian signal phasing. This intersection had one crash fatality during the five-year analysis period (January 2018 to December 2022); another fatality occurred during the study of the intersection involving the eastbound left-turn movement.

Stone Drive & Beechnut Drive

The signal is a steel strain pole with a span wire configuration. The northbound approach is a single lane, and the southbound approach includes two lanes with a separate right-turn lane. The intersection does not have sidewalks or pedestrian traffic control. The north and south approaches are concurrently phased (Phases 4 and 8), and Stone Drive has protected/permissive left-turn phasing.

The dominant accident pattern occurring at the intersection is rear-end collisions resulting in mainly property damage which may be attributed to possible higher speed for the westbound approach and the distance from the easternmost signal of the project limit.

Stone Drive & Kingsport Pavilion

The signal is a mast arm installation. The north and south approaches are split-phased (Phases 3 and 4). Stone Drive has protected-only left-turn phasing. Vehicle detection is video for the driveway approaches.

The intersection has a sidewalk limited to the north side with curb handicap ramps. There are not any pedestrian crosswalks or signal control.

The dominant accident pattern at the intersection is rear-end collisions resulting in primarily property damage, which may be attributed to the westbound approach's possible speed.

Memorial Boulevard & John B Dennis Highway SB Ramps

This signal is a steel strain pole with diagonal span wire installation providing signalized access from John B Dennis Highway. It has protected/permissive left-turn phasing from westbound Memorial Boulevard to southbound John B Dennis Highway.

There are not any sidewalks or pedestrian traffic control. Adverse queuing from the southbound off-ramp extending back to mainline John B Dennis Highway is observed.

Crashes for the signalized intersection are not found significant. The cabinet and controller are among the older TS2 standard equipment past the recommended life of the controller.

Improvements are planned for Memorial Boulevard (SR 126) to increase the capacity and storage of the southbound off-ramp and upgrade the traffic signal. The upgrade should include nearside auxiliary signal heads for the westbound approach for increased visibility due to the horizontal alignment and the overpass structure, which may limit the visibility of the approach displays.

Memorial Boulevard & John B Dennis Highway NB Ramps

The signal is a steel strain pole with diagonal span wire installation providing signalized access from John B Dennis Highway. It has protected/permissive left-turn phasing from eastbound Memorial Boulevard to northbound John B Dennis Highway.

There are not any sidewalks or pedestrian traffic control. Crashes for the signalized intersection are not found significant. The cabinet and controller are among the older TS2 standard equipment past the recommended life of the controller.

Improvements are planned for Memorial Boulevard (SR 126), which will increase the capacity and storage of the southbound off-ramp and upgrade the traffic signal. The upgrade should include nearside auxiliary signal heads for the westbound approach for increased visibility due to the horizontal alignment and the overpass structure, which may limit the visibility of the approach displays.

John B Dennis Highway & Pavilion Drive

The signal installation is a mast arm signal configuration. The Pavilion Drive and driveway approaches are split-phased (Phases 3 and 4). John B Dennis Highway has protected-permissive left-turn phasing. The controller is an older Econolite ASC/3-2100 and an age that exceeds the recommended life of the controller.

The intersection does not have sidewalks or pedestrian traffic control. Crashes are predominantly rear-end and angle collisions attributed to higher speeds and horizontal alignment of John B Dennis Highway in the intersection vicinity.

John B Dennis Highway & Tribe Athletic Complex

The signal is a steel strain pole with a span wire configuration. The westbound driveway approach is two lanes. John B Dennis Highway has protected-permissive left-turn phasing. The controller is an older Econolite ASC/3-2100 and an age that exceeds the recommended life of the controller.

The intersection does not have sidewalks or pedestrian traffic control. Crashes experienced at the intersection are predominantly other collisions unrelated to signal operations.

John B Dennis Highway & Bloomingdale Road

This signal is a wood pole with a span wire configuration. The intersection operates with a 4-phase Peak Transyt traffic signal with left-turn phasing provided for the John B Dennis Highway and Bloomingdale Road approaches. The signal is a Sullivan County signal. The controller is very aged, over 30 years.

The Tennessee Department of Transportation identified this signalized intersection for reconstruction in its Traffic Signal Modernization and Maintenance (TSM&M) Program conducted by CDM Smith in the Spring of 2021. This survey and review identified many deficiencies of the intersection requiring improvements.

VEHICLE DETECTION

Kingsport's vehicle detection system employed for traffic signals primarily consists of inductive loops embedded in the street pavement. Inductive loop technology has been widely used for vehicle detection for many decades and remains a prevalent method in traffic control. However, the maintenance of loops can present challenges over time, as their performance may deteriorate due to factors such as pavement conditions and weather. Ensuring proper operations and effective control of traffic signals requires diligent maintenance of both the signals and associated detection systems. In recent years, advancements in intelligent transportation systems have led to significant improvements in vehicle detection technology, necessitating exploring alternative detection methods.

One alternative to inductive loops is video detection, which utilizes cameras to monitor and analyze traffic flow. Video detection systems have witnessed increased deployment and have proven to be an excellent alternative to inductive loops. The technology has improved, and video detection provides reliable vehicle detection capabilities. Similarly, radar detection has emerged as another viable alternative, offering accurate vehicle detection without the need for physical infrastructure in the roadway.

Installing and repairing inductive loops are labor-intensive and can significantly impact traffic flow, as lane closures are often required during these activities. This places workers close to moving traffic, posing safety risks. The improved reliability and performance of video and radar detection devices have made them increasingly preferred alternatives, offering accurate vehicle detection while being less disruptive to traffic. Furthermore, their maintenance work can be conducted at a greater distance from prevailing traffic conditions, enhancing safety for maintenance crews. Vehicle detection can also be maintained during roadway or utility work within or near signalized intersections.

Kingsport currently conducts loop maintenance on an ongoing basis. However, considering the advancements and widespread adoption of alternative technologies, the City of Kingsport may want to explore vehicle detection options that are less invasive and easier for city personnel to maintain. Video and radar technologies are currently being utilized by progressive jurisdictions, offering reliable and efficient vehicle detection capabilities.

In terms of cost, the initial investment for video and radar detection systems is comparable to that of inductive loops, particularly for multilane arterial highways where multiple loops (both presence and advance) are typically installed, necessitating pull boxes, conduits, and cables. The less invasive nature of video and radar detection makes them highly competitive alternatives to inductive loops. The cost competitiveness of alternative detection methods may vary for 2-lane arterials, where fewer loops are required due to the number of lanes and lower speeds typically observed. However, it is essential to note that the maintenance of these detection devices should be less demanding and more manageable with limited personnel, potentially offsetting any cost differences.

Instead of installing new loops, an ongoing maintenance activity could involve replacing faulty loops with alternative detection systems. This gradual replacement approach allows a smoother transition from inductive loops to alternative technologies, minimizing disruptions and optimizing maintenance efforts.

By considering the implementation of video and radar detection systems as alternatives to inductive loops, Kingsport can benefit from reduced maintenance needs, improved reliability, and increased ease of maintenance, all while ensuring consistent and accurate vehicle detection across the signalized intersections.

SIGNAL TIMING CLEARANCES

The City of Kingsport provided the current signal timing for evaluating the present signal operations. The initial signal timing review focused on the YELLOW and RED clearances. The YELLOW clearance is determined based on approach speeds, typically corresponding to the posted speed limit. In contrast, the RED clearance, also known as the "all red" interval, allows sufficient time for a vehicle to clear the intersection at the end of the YELLOW clearance. The minimum duration for the YELLOW clearance is set at 3.0 seconds. Suppose vehicle enters the intersection just prior to the YELLOW clearance termination, the RED clearance should provide enough time for the vehicle to clear the intersection before the next conflicting signal phase. Typically, the total clearance time should not exceed 7 seconds, but certain specific conditions may necessitate a longer duration. It is generally not recommended to exceed a RED clearance time of 2.5 seconds unless particular conditions exist, such as wider-than-usual intersections, off-set intersections, or single-point interchanges.

Signal clearances for the Kingsport traffic signals were calculated in accordance with the guidelines outlined in the Manual on Uniform Traffic Control Devices (MUTCD), Institute of Transportation Engineers (ITE) recommended practices and TDOT standards. The calculated clearances can be found in *Appendix D*, and these recommended clearances were incorporated into the optimized signal timing developed for the study. Specifically, the recommended minimum YELLOW clearance is 3.2 seconds for a 30 mph approach or speed zone and 4.3 seconds for a 45 mph approach or speed zone.

YELLOW CLEARANCE VIOLATIONS

Most of the traffic signals in the study area currently have the required minimum YELLOW clearance with two exceptions. The following YELLOW clearance violations should be addressed.

- Stone Drive & N Eastman Road, Phases 2,6
- John B Dennis Highway & Tribe Athletic Complex, Phase 2
- John B Dennis Highway & Bloomingdale Road, Phase 2

ALL RED CLEARANCE VIOLATIONS

Most YELLOW and RED intervals (total clearance time) in City of Kingsport can be adjusted for increased efficiencies. Stone Drive and John B Dennis Highway corridor signals; however, have the

recommended/appropriate total clearance time, but for some intersections the RED interval should be reduced or increased for improved signal operations and safety.

- Stone Drive & N Eastman Road, Phases 2,4,5,6
- Stone Drive & Beechnut Drive, Phase 1
- Memorial Boulevard & NB John B Dennis Highway, Phase 2

PEDESTRIAN CLEARANCE

Pedestrian signal clearances were included in the signal clearance review. This review determined that intersections with pedestrian phasing should be adjusted for several of the signal phases at the following signals.

- Stone Drive & N Eastman Road, Pedestrian Phase 4

Appendix D includes a table detailing the calculated clearance time, TDOT recommended clearances and minimum clearances.

TRAFFIC SIGNAL ANALYSIS

CAPACITY AND LEVEL OF SERVICE

To evaluate the current operations of the traffic control devices, capacity and level of service (LOS) were calculated using the Highway Capacity Manual (HCM), published by the Transportation Research Board (TRB). Signalized and unsignalized intersections are evaluated based on estimated intersection delays, which may be related to LOS.

The capacity of an intersection represented by the intersection V/C (volume/capacity) ratio is the calculation of traffic volumes in relation to the intersection geometry, signal phasing, and the green time assignment for any traffic movement. Capacity ratios between 0.80 and 0.90 represent acceptable and efficient use of the intersection's geometry, whereas capacity ratios over 0.90, intersections operating near or over capacity, may be less stable and greater delays may occur more often. Signalized delays are attributed to the intersection geometry and the signal timing employed. In saturated traffic or over-capacity conditions, delay may be reduced, but capacity may only be marginally improved. Signal phasing improvements may improve capacity and decrease delays, but capacity issues often require intersection geometric improvements.

LOS and capacity measure an intersection's ability to accommodate traffic volumes. LOS for intersections ranges from A to F. LOS A is the best, and LOS F is failing. For signalized intersections, a LOS of A has an average estimated intersection delay of less than 10 seconds, and LOS F has an estimated delay of greater than 80 seconds. A LOS of C and D are typical design values. Within urban areas, a LOS D, with a delay between 35 and 55 seconds, is considered acceptable by the Institute of Transportation Engineers (ITE) for signalized intersections. *Table 4* presents a description of the signalized LOS.

The existing Kingsport signal timing was modeled using Synchro, Version 11, a signal modeling software developed by Trafficware. Synchro is often used in the evaluation of signal timing and its optimization. Traffic turning movement count (TMC) data collected, signal phasing, and timing were entered in the Synchro models for the AM and PM peak hours. In *Appendix E,* the turning movements modeled in Synchro are provided for the peak hours, including the AM, midday, and two PM peak hours. The PM peak hour varied with Stone Drive intersections. The signalized intersections peak hours for Kingsport are identified below. The signalized intersections' peak hours for Kingsport are in *Table 5*.

Table 4. Level of Service Description for Signalized Intersection

LOS	Average Control Delay per Vehicle (seconds)	Description
A	≤ 10	Very low delay with extremely favorable progression. Most vehicles don't stop.
B	> 10.0 and ≤ 20.0	Generally good progression. Increased number of stops from that described for LOS "A" resulting in higher delays.
C	> 20.0 and ≤ 35.0	Fair Progression with increased delay. Number of stopping vehicles become significant; however, many still pass through the intersection without stopping. Stable flow.
D	> 35.0 and ≤ 55.0	The influence of congestion becomes more noticeable. Longer delays resulting from unfavorable progression, longer cycles, or high V/C ratios. Approaching unstable flow.
E	> 55.0 and ≤ 80	Limit of acceptable delay. Long delays associated with poor progression, long cycles, or high V/C ratios.
F	> 80.0	Unacceptable operation resulting from oversaturation (flow rates exceed capacity). Poor progression, long cycles, and high V/C ratios.

SOURCE: Highway Capacity Manual, TRB Special Report 209

Table 5. Peak Hour Period for Intersections

Major Street	Minor Street	AM Peak Hour	Midday Peak Hour	PM Peak Hour
Stone Drive	Brookside Drive	7:45-8:45	12:00-1:00	4:45-5:45
	N Eastman Road	7:45-8:45	12:00-1:00	4:45-5:45
	Indian Trail Drive	8:00-9:00	12:00-1:00	4:45-5:45
	John B Dennis Hwy SB Off-Ramp/American Way	8:00-9:00	12:00-1:00	4:45-5:45
	John B Dennis Hwy NB Ramps	7:45-8:45	12:00-1:00	4:30-5:30
	Beechnut Drive/Springdale Lane	8:00-9:00	12:00-1:00	4:30-5:30
	Kingsport Pavilion Shopping Center	8:00-9:00	12:00-1:00	4:45-5:45
John B Dennis Highway	SB Ramps at Memorial Blvd	7:00-8:00	11:30-12:30	5:00-6:00
	NB Ramps at Memorial Blvd	7:15-8:15	11:45-12:45	5:00-6:00
	Pavilion Drive	7:30-8:30	12:00-1:00	4:30-5:30
	Tribe Athletic Complex	7:30-8:30	12:00-1:00	4:45-5:45
	Bloomingdale Road	7:30-8:30	12:00-1:00	4:45-5:45

For the Stone Drive corridor, the intersection peak hours periods varied between 7:45-9:00AM, 12:00-1:00PM, and 4:30-5:45PM. For the John B Dennis Highway corridor, the peak hour periods varied between 7:30-8:30AM, 12:00-1:00PM, and 4:30-5:45PM. The peak hours for the Memorial Boulevard varied between 7:00-8:15AM, 11:30-12:45PM, and 5:00-6:00PM.

OPTIMIZED CYCLE LENGTH

During the peak hours, the majority of the signalized intersections are currently operating below the intersection capacity, and delays are acceptable, with a minimum LOS D. However, improvements can be provided with optimized signal timing, thereby reducing the delays and providing some signal coordination for the reduction of stops that are now experienced for Stone Drive. Optimized traffic signal timings were developed for the Stone Drive and Memorial Boulevard corridors for the peak hours. Signal cycles for the existing and optimized signal timing are identified in *Table 6*.

Table 6. Existing and Optimized Cycle Length for Stone Drive and Memorial Boulevard

Coordinated Corridor	Peak Hour	Existing Cycle Length (s)	Optimized Cycle Length (s)
Stone Drive	AM	110	120
	Midday	100	100
	PM	110	110
Memorial Boulevard	AM	95	100
	Midday	85	80
	PM	90	90

The measures of effectiveness of the existing and optimized corridor signal system are presented in *Table 7* and *Table 8*.

Table 7. Stone Drive Signal System Measures of Effectiveness

MEASURE OF EFFECTIVENESS	AM Peak Hour		Mid-Day Peak Hour		PM Peak Hour	
	Existing	Optimized	Existing	Optimized	Existing	Optimized
Cycle (s)	110	120	100	100	110	110
Total Delay/Vehicle (s/veh)	8	5	13	10	14	12
Total Delay (hrs)	43	29	103	78	129	112
Stops/Vehicle	0.32	0.22	0.44	0.39	0.41	0.43
Stops	6172	4217	12419	11156	13639	14250
Average Speed (mph)	29	33	24	27	23	25
Total Travel Time (hrs)	124	110	220	195	264	247
Distance Traveled (mi)	3644	3644	5270	5270	6076	6076
Unserved Vehicles	0	0	0	0	0	0

Table 8. Memorial Boulevard Signal System Measures of Effectiveness

MEASURE OF EFFECTIVENESS	AM Peak Hour		Mid-Day Peak Hour		PM Peak Hour	
	Existing	Optimized	Existing	Optimized	Existing	Optimized
Cycle (s)	95	100	85	80	90	90
Total Delay/Vehicle (s/veh)	6	5	6	6	13	13
Total Delay (hrs)	4	3	3	3	9	10
Stops/Vehicle	0.29	0.24	0.28	0.29	0.5	0.56
Stops	637	544	483	488	1344	1515
Average Speed (mph)	18	19	20	20	15	15
Total Travel Time (hrs)	9	8	8	8	19	19
Distance Traveled (mi)	159	159	166	166	272	272
Unserved Vehicles	0	0	0	0	0	0

As presented in *Table 7*, Stone Drive improvements are indicated with the optimized signal timing, reducing delays and some improvement in the progression speed. Memorial Boulevard and the John B Dennis Highway (SR 93) interchange, the optimization is more limited in improving the traffic conditions thereby indicating the current signal timing is providing good traffic progression and operations. As presented in *Table 8*, the Memorial Boulevard (SR 126) interchange with John B Dennis Highway (SR 93) optimization can provide some minor improvement of the AM peak hour but the current timing for the midday and PM peak hours are acceptable and differences with optimization are insignificant.

Table 9 presents both current and optimized capacity and LOS of the corridor signalized intersections in 2022. A minimum LOS D is currently provided for the corridor intersections. Though the intersection levels of service are acceptable for the corridor intersections, adverse queuing may continue for the northbound John B Dennis Highway on-ramp from Stone Drive. *With optimization of the signal timing for the corridors, a minimum LOS C is provided for all signalized intersections during all three peak periods for 2022 volumes.*

Table 9. 2022 Existing and Optimized Capacity and Level of Service Analysis with Proposed Improvements

SIGNAL GROUP	PEAK HOUR	EXISTING			OPTIMIZED			OPTIMIZED w/ IMPROVEMENT A JBD NB Free-Flow RT Lane JBD SB Approach LT & RT			OPTIMIZED w/ IMPROVEMENT B JBD NB Double RT Lanes JBD SB Approach LT & RT			OPTIMIZED w/ IMPROVEMENT C JBD NB-Double RT Lanes & Stone Non-Permissive LT, JBD SB Approach LT & RT		
		V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service
Stone Drive & Brookside Drive	AM	0.61	23.3	C	0.6	16.3	B	0.6	16.7	B	0.6	16.7	B	0.6	16.7	B
	MID	0.76	39.3	D	0.76	25.3	C	0.76	27.5	C	0.76	32.6	C	0.76	32.7	C
	PM	0.76	37.8	D	0.76	28.5	C	0.76	32.8	C	0.76	32.8	C	0.76	32.3	C
Stone Drive & N Eastman Road	AM	0.39	18.1	B	0.38	20.8	C	0.38	19.5	B	0.38	20.1	C	0.39	19.8	C
	MID	0.74	25.2	C	0.74	29.3	C	0.74	27.9	C	0.74	26.7	C	0.74	26.5	C
	PM	0.76	40.7	D	0.75	23.2	C	0.74	36.9	D	0.74	37	D	0.76	28.5	C
Stone Drive & Indian Trail	AM	0.38	24	C	0.37	15.8	B	0.37	14.4	B	0.37	14.5	B	0.38	14.7	B
	MID	0.63	21.9	C	0.63	19.4	B	0.63	23.2	C	0.63	20	B	0.63	20.5	C
	PM	0.73	30.4	C	0.73	27.8	C	0.71	22.8	C	0.71	23	C	0.74	24.8	C
Stone Drive & JBD Hwy SB/ American Way	AM	0.32	11.6	B	0.31	7.6	A	0.31	6.7	A	0.31	8.8	A	0.31	8.8	A
	MID	0.51	18.1	B	0.51	7.3	A	0.51	8.4	A	0.51	9.6	A	0.51	9.6	A
	PM	0.61	12.3	B	0.61	8.6	A	0.57	10.8	B	0.57	13.2	B	0.57	12.9	B
Stone Drive & John B Dennis Hwy NB	AM	0.37	18.8	B	0.4	21	C	0.37	13.8	B	0.39	23.1	C	0.39	23.1	C
	MID	0.66	25.4	C	0.66	20.4	C	0.53	14	B	0.53	19.6	B	0.53	19.6	B
	PM	0.87	45.2	D	0.85	30	C	0.65	13.8	B	0.69	22.7	C	0.68	25.6	C
Stone Drive & Beechnut Drive/Springdale Lane	AM	0.35	9.3	A	0.34	9.5	A	0.26	9.2	A	0.26	9.2	A	0.26	9.2	A
	MID	0.55	10.1	B	0.55	10.1	B	0.43	9.1	A	0.43	9.1	A	0.43	9.1	A
	PM	0.73	15.2	B	0.73	15	B	0.57	12	B	0.57	12	B	0.57	12	B
Stone Drive & Pavilion Shopping Center	AM	0.37	14.8	B	0.33	14.3	B	0.33	14.3	B	0.33	14.2	B	0.34	14.5	B
	MID	0.63	25.6	C	0.65	25.7	C	0.65	25.7	C	0.65	25.7	C	0.65	25.7	C
	PM	0.74	29.2	C	0.75	29.7	C	0.72	30.5	C	0.72	30.5	C	0.77	29.4	C
Memorial Blvd & John B Dennis Hwy SB	AM	0.47	10.8	B	0.47	10.1	A									
	MID	0.32	16.6	B	0.33	15.8	B									
	PM	0.61	22.1	C	0.61	23.4	C									
Memorial Blvd & John B Dennis Hwy NB	AM	0.5	9.9	A	0.5	9.9	A									
	MID	0.24	9.1	A	0.25	8.7	A									
	PM	0.48	14	B	0.48	12.6	B									
John B Dennis Hwy & Pavilion Drive	AM	0.32	13.7	B	0.31	13.1	B									
	MID	0.36	19.4	B	0.38	17.4	B									
	PM	0.59	29.9	C	0.58	20	B									
John B Dennis Hwy & Tribe Athletic Complex	AM	0.28	2.7	A	0.26	2.8	A									
	MID	0.27	3.5	A	0.26	3.4	A									
	PM	0.44	4.2	A	0.42	3.8	A									
John B Dennis Hwy & Bloomingdale Road	AM	0.49	34.4	C	0.54	26.7	C	0.62	21.5	C						
	MID	0.33	27.3	C	0.35	23.5	C	0.42	19.7	B						
	PM	0.57	30.6	C	0.59	26.6	C	0.66	22.1	C						

GEOMETRIC IMPROVEMENTS

The last three columns of *Table 9* present the capacity and LOS analysis for which geometric improvements are proposed.

Stone Drive & John B Dennis Highway Northbound Ramps

For the intersection of Stone Drive and John B Dennis Highway northbound ramps, the eastbound thru movement is a non-critical movement and the drop in eastbound traffic to southbound John B Dennis Highway permits the reduction of the eastbound thru lane from 3 to 2 lanes, thereby allowing the left thru lane to be assigned for the eastbound left-turn movement to northbound John B Dennis Highway (*Figure 4*). This would permit an eastbound left-turn storage of approximately 300 feet from the existing available storage of 100-125 feet. This proposed lane reduction is included in all improvements in Table 8.

Figure 4. EB Lane Reduction on Stone Drive to allow additional storage at EB Left Turn onto John B Dennis Hwy

With the provision of a longer left-turn storage lane, it is possible to modify the existing protected/permissive left-turn phase to a protected only signal phase, a recommended practice with three opposing lanes. The protected only left-turn signal phase would address the more recent fatality occurring during a left-turn movement from eastbound Stone Drive to northbound John B Dennis Highway (shown in Improvement C).

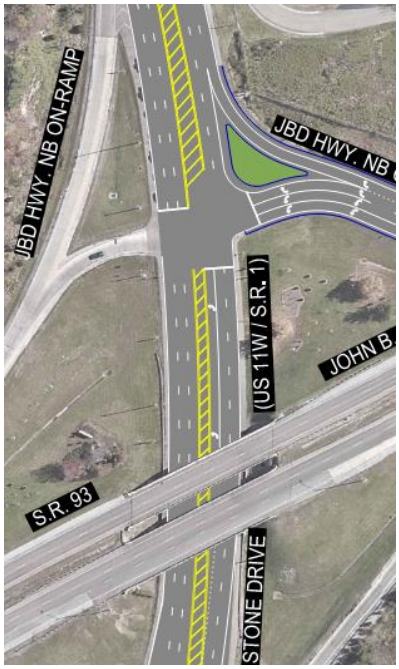

Figure 5. Proposed NB Off-Ramp Geometry for Improvement A

The John B Dennis Highway northbound off-ramp was analysed by looking at two options: (1) a free flow right turn lane with dual left turn lanes and one right turn lane at the intersection (*Figure 5*) and (2) dual left turn lanes and dual right turn lanes at the intersection (*Figure 6*).

Figure 6. Geometric Improvement B & C For Stone Drive and John B Dennis Highway Interchange

Stone Drive & John B Dennis Highway Southbound Off-Ramp/American Way

In addition to the northbound John B Dennis Highway, the southbound off-ramp conflicts with the American Way approach and with eastbound E Stone Drive were identified that may be mitigated with some geometric improvements. The channelized yielding right-turn movement from southbound John B Dennis Highway to westbound Stone Drive at American Way can be a significant conflict with westbound traffic on Stone Drive. This conflict is increased if traffic from John B Dennis Highway is destined for any of the commercial businesses on the southside of Stone Drive. The addition of a right-turn lane from the off ramp at the American Way signal would better manage this conflict and could be constructed with the addition of left-turn lanes from both the off ramp as well as American Way, providing an increased understanding opposing traffic intentions and efficiency (seen in Figure 4 & 6). This proposed geometric mitigation at John B Dennis Highway southbound off ramp is included in all improvements in Table 8.

Turn Lane Size

Proposed improvements indicated some improved levels of service from the minor approaches but more importantly added intersection capacity and provided increased storage for traffic queues, enhancing the intersection operation and efficiency. Proposed intersection improvements are identified as follows:

Stone Drive & John B Dennis Highway Southbound Off-Ramp/American Way

- Northbound 100' Left-Turn Lane
- Southbound 300' Left- and Right-Turn Lanes, removing the yielding right-turn movement

Stone Drive & John B Dennis Highway Northbound Ramps

- Northbound 50'-100' Right-Turn Lane
- Eastbound 300' Left-Turn Lane, storage gained by removing a Thru-Lane and leaving 2 eastbound Thru-Lanes

25-YEAR ANALYSIS

Further analyses were conducted for a 25-year horizon (2047) of the corridor and its proposed intersection geometric improvement to determine capacity and level of service of the horizon year. Traffic for the corridor were grown 20-percent, reflecting 0.8 annual growth rate estimated from the Kingsport Travel Demand Model. This analysis determined optimized corridor signalized intersections can continue operating at an acceptable level of service. With existing intersection geometry, intersection capacity would be exceeded for the Stone Drive and John B Dennis Highway northbound ramps will reach capacity. The proposed geometric improvement of these intersections would mitigate the capacity and result in acceptable levels of service. Projected levels of service are presented in *Table 10*.

Table 10. Level of Service for Existing 2022 Timing, Optimized 2022 Timing, and 2047 Optimized Timing with Improvements (Planned & Proposed)

SIGNAL GROUP	PEAK HOUR	2022 VOLUMES EXISTING TIMING & GEOMETRY			2022 VOLUMES OPTIMIZED TIMING & EXISTING GEOMETRY			2047 PROJECTED VOLUMES OPTIMIZED TIMING & EXISTING GEOMETRY			2047 PROJECTED VOLUMES OPTIMIZED TIMING& PROPOSED IMPROVEMENT C		
		V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service	V/C	Average Delay	Level of Service
Stone Drive & Brookside Drive	AM	0.61	23.3	C	0.60	16.3	B	0.65	19.3	B	0.65	19.7	B
	MID	0.76	39.3	D	0.76	25.3	C	0.84	34.4	C	0.84	26.7	C
	PM	0.76	37.8	D	0.76	28.5	C	0.84	31.4	C	0.84	30.6	C
Stone Drive & N Eastman Road	AM	0.39	18.1	B	0.38	20.8	C	0.46	12.6	B	0.46	12.8	B
	MID	0.74	25.2	C	0.74	29.3	C	0.84	34.0	C	0.84	34.0	C
	PM	0.76	40.7	D	0.75	23.2	C	0.86	37.6	D	0.86	36.3	D
Stone Drive & Indian Trail	AM	0.38	24.0	C	0.37	15.8	B	0.41	11.0	B	0.41	12.8	B
	MID	0.63	21.9	C	0.63	19.4	B	0.73	19.3	B	0.73	19.2	B
	PM	0.73	30.4	C	0.73	27.8	C	0.85	29.4	C	0.85	26.3	C
Stone Drive & JBD Hwy SB/ American Way	AM	0.32	11.6	B	0.31	7.6	A	0.37	7.5	A	0.37	7.8	A
	MID	0.51	18.1	B	0.51	7.3	A	0.60	7.7	A	0.60	8.7	A
	PM	0.61	12.3	B	0.61	8.6	A	0.72	11.7	B	0.70	11.3	B
Stone Drive & John B Dennis Hwy NB	AM	0.37	18.8	B	0.40	21.0	C	0.54	19.4	B	0.51	20.4	C
	MID	0.66	25.4	C	0.66	20.4	C	0.82	24.4	C	0.69	21.8	C
	PM	0.87	45.2	D	0.85	30.0	C	**1.02**	41.6	D	0.88	28.7	C
Stone Drive & Beechnut Drive/Springdale Lane	AM	0.35	9.3	A	0.34	9.5	A	0.41	8.9	A	0.30	8.4	A
	MID	0.55	10.1	B	0.55	10.1	B	0.66	11.2	B	0.49	9.5	A
	PM	0.73	15.2	B	0.73	15.0	B	0.81	16.8	B	0.64	12.3	B
Stone Drive & Pavilion Shopping Center	AM	0.37	14.8	B	0.33	14.3	B	0.41	13.4	B	0.41	13.4	B
	MID	0.63	25.6	C	0.65	25.7	C	0.77	28.2	C	0.77	28.2	C
	PM	0.74	29.2	C	0.75	29.7	C	0.89	38.4	D	0.89	38.4	D
Memorial Blvd & John B Dennis Hwy SB	AM	0.47	10.8	B	0.47	10.1	A	0.44	10.0	A	0.44	10.0	A
	MID	0.32	16.6	B	0.33	15.8	B	0.28	15.4	B	0.28	15.4	B
	PM	0.61	22.1	C	0.61	23.4	C	0.57	19.3	B	0.57	19.3	B
Memorial Blvd & John B Dennis Hwy NB	AM	0.50	9.9	A	0.50	9.9	A	0.51	9.3	A	0.51	9.3	A
	MID	0.24	9.1	A	0.25	8.7	A	0.28	8.8	A	0.28	8.8	A
	PM	0.48	14.0	B	0.48	12.6	B	0.60	12.9	B	0.60	12.9	B
John B Dennis Hwy & Pavilion Drive	AM	0.32	13.7	B	0.31	13.1	B	0.36	12.5	B	0.36	12.5	B
	MID	0.36	19.4	B	0.38	17.4	B	0.42	16.8	B	0.42	16.8	B
	PM	0.59	29.9	C	0.58	20.0	B	0.69	21.9	C	0.69	21.9	C
John B Dennis Hwy & Tribe Athletic Complex	AM	0.28	2.7	A	0.26	2.8	A	0.34	2.6	A	0.34	2.6	A
	MID	0.27	3.5	A	0.26	3.4	A	0.30	3.1	A	0.30	3.1	A
	PM	0.44	4.2	A	0.42	3.8	A	0.51	4.5	A	0.51	4.5	A
John B Dennis Hwy & Bloomingdale Road	AM	0.49	34.4	C	0.54	26.7	C	0.67	23.3	C	0.67	23.3	C
	MID	0.33	27.3	C	0.35	23.5	C	0.48	21.0	C	0.48	21.0	C
	PM	0.57	30.6	C	0.59	26.6	C	0.75	26.5	C	0.75	26.5	C

SIGNAL TIMING PLANS

Stone Drive Coordinated Signal Group

In reviewing the average weekday daily traffic data collected for Stone Drive, this corridor exhibits a very bidirectional flow of traffic which varies from 1,500 to 2,150vph (vehicles per hour) east of John B Dennis Highway and from 1,820 to 2,780 west of John B Dennis Highway. From noon to approximately 7:30PM, the traffic for Stone Drive is relatively constant between 2,500 and 2,900vph west of John B Dennis Highway. The examination of these daily volume profiles, available in the *Appendix B*, finds that 3 timing plans could well satisfy the traffic flow along the Stone Drive corridor. In *Appendix H*, three timing plans are available for implementing for the system operations. The proposed system would operate as follows:

Clock Schedule	Cycle	C/O/S
6:30AM-9:00AM	120s	1/1/1
9:00AM-3:00PM	100s	2/1/1
3:00PM-6:30PM	110s	3/1/1
6:30PM-11:00PM	100s	2/1/1

With the optimized cycles and the bidirectional traffic flow through the corridor, the system operations should be very stable and flexible. The timing plan schedule should be very flexible in addressing the traffic flow for the corridor.

Memorial Boulevard Coordinated Signal Group

Memorial Boulevard at the John B Dennis Highway interchange indicate more pronounced AM and PM peak hours and are currently addressed acceptably in the current timing plans and can be maintained with the proposed.

John B Dennis Highway traffic flow is more directional as exhibited by its daily volume profile with southbound traffic exhibited from 6:00AM to noon, bidirectional from noon to 3:00PM, and northbound from 3:00PM to 7:00PM. The northbound flow appears to continue through the evening but is more bidirectional. Timing is provided for the three peak hours but can be operated as isolated signals as they are now. Offsets as provided in the proposed timing sheets which can be implemented in a time base or non-interconnected (NIC) mode; however, any progression would be minimal as the distance between signals would not maintain traffic platoons effectively.

RECOMMENDATIONS

The City of Kingsport Public Works Department has been very effective in upgrading the City's signal operations with the most current technology, including signal ATC controllers, fiber communications, and central software in a traffic management office. The following recommendations are proposed as part of the final TSMO Plan for improving the safe and efficient operation of signalized intersections within the study area in Kingsport.

SIGNAL TIMING

Implement the optimized signal timing and vehicular and pedestrian phase clearances developed in the study and report. This will reduce delays and improve progress for eastbound and westbound traffic movements along the corridor. It is important to ensure adherence to recommended practices of the traffic engineering profession and standards outlined in the Manual on Uniform Traffic Control Devices (MUTCD).

TURN LANES

Address specific intersections that benefit from turn lanes to enhance safety and improve traffic flow. The following recommendations are proposed:

Stone Drive & John B Dennis Highway Southbound Off-Ramp/American Way

- Northbound 100' Left-Turn Lane
- Southbound 300' Left- and Right-Turn Lanes, removing the yielding right-turn movement

Stone Drive & John B Dennis Highway Northbound Ramps

- Northbound 50'-100' Right-Turn Lane
- Eastbound 300' Left-Turn Lane, storage gained by removing a Thru-Lane and leaving 2 eastbound Thru-Lanes

PEDESTRIAN

Upgrade pedestrian facilities to improve accessibility and ensure compliance with the American Disabilities Act (ADA) and TDOT Design Standards. This includes ramps, signals, and push buttons. By enhancing pedestrian control and sidewalk accessibility, safety and convenience for pedestrians will be significantly improved. The Corridor Study expands upon the proposed pedestrian improvements at each intersection.

VEHICLE DETECTION

Consider incorporating alternative vehicle detection technologies, such as radar detection, as part of signal upgrades. This can provide more accurate and reliable vehicle detection, reducing reliance on traditional inductive loops. Assess the feasibility and benefits of deploying radar detection systems to enhance signal operations and optimize traffic flow.

By implementing these recommendations, the Kingsport Public Works Department can enhance signal operations, resulting in safer and more efficient traffic flow along the corridor. These improvements align with industry best practices, standards, and guidelines, ensuring that the transportation infrastructure in Kingsport meets the evolving needs of the community and supports a sustainable and effective transportation system.

CONCLUSION

In conclusion, the TSMO Plan for the City of Kingsport presents a comprehensive strategy to enhance signalized intersections' safe and efficient operation within the study area. Through a thorough review of existing conditions, identification of key issues and opportunities, and the development of practical recommendations, this plan aims to improve the overall transportation system and address the community's evolving needs.

Kingsport has demonstrated a commitment to upgrading its signal operations by embracing current technologies, including signal ATC controllers, fiber communications, and central software in a traffic management office. The recommended improvements outlined in this TSMO Plan will further enhance traffic operations, ensuring safer and more efficient travel along the Stone Drive and John B Dennis Highway corridors.

By implementing the recommended signal timing strategies, including vehicular and pedestrian phase clearances, delays will be reduced, and traffic progression will be enhanced. Adding minor street turn lanes at strategic intersections will improve safety and alleviate congestion. At the same time, upgrades to pedestrian facilities in compliance with ADA standards will create a more inclusive and accessible transportation network.

Furthermore, the consideration of alternative vehicle detection technologies, such as radar detection, offers the potential for more accurate and reliable detection, reducing the maintenance and operational challenges associated with inductive loops.

In summary, the TSMO Plan provides Kingsport with a roadmap for implementing targeted improvements prioritizing safety, efficiency, and accessibility. By following the recommendations outlined in this plan, the City of Kingsport can position itself as a model for effective traffic signal management, ensuring a reliable and efficient transportation network that serves the needs of residents, businesses, and visitors now and in the future.