CAMPO
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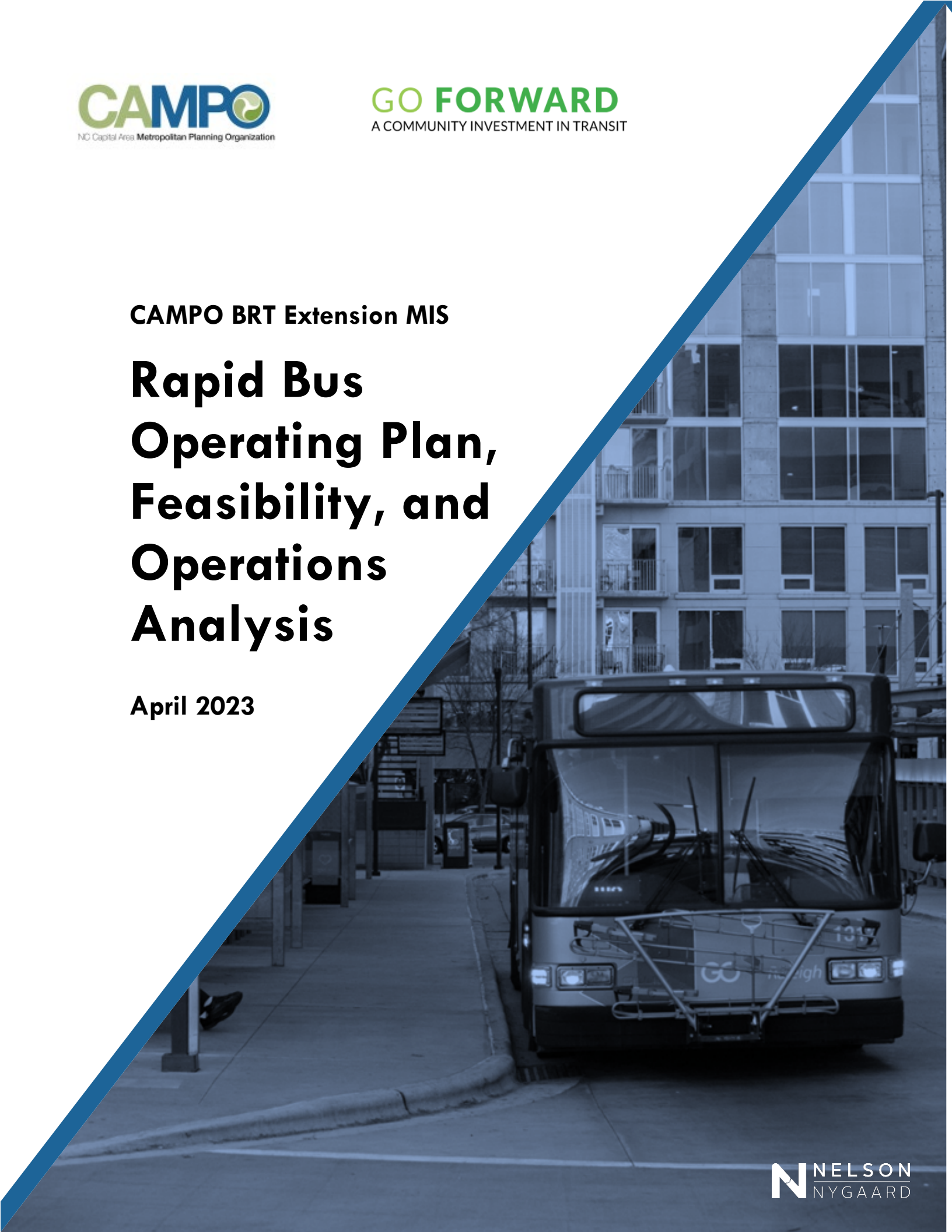
CAMPO BRT Extension MIS

Rapid Bus Operating Plan, Feasibility, and Operations Analysis

April 2023



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EXECUTIVE SUMMARY

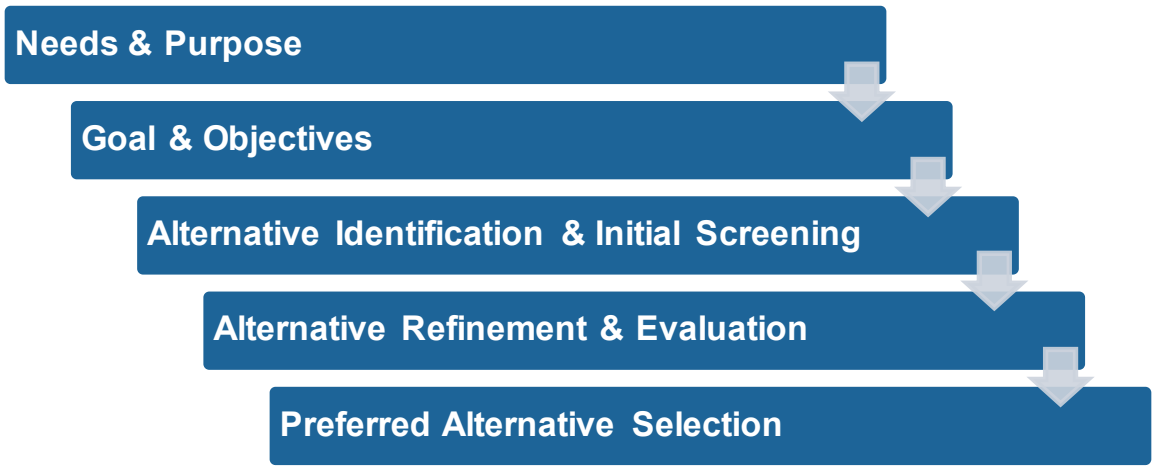
The Wake BRT Rapid Bus Extension Study's Alternatives Analysis (AA) identifies, evaluates, and recommends potential rapid bus extension alternatives for two corridors in the Wake Transit Plan Bus Rapid Transit program. The rapid bus service would connect Cary to Research Triangle Park (RTP) in the Western rapid bus extension (Western Extension) and the Towns of Garner to Clayton in the Southern rapid bus extension (Southern Extension).

These rapid bus connections would be extensions of the planned Western Corridor BRT, connecting downtown Raleigh with Cary, and the planned Southern Corridor BRT that would connect Raleigh with Garner. Both corridors were identified in the Capital Area Metropolitan Planning Organization's (CAMPO) *2045 Metropolitan Transportation Plan* (MTP) and the *2020 – 2029 Transportation Improvement Program* (TIP) as a regional project connecting Clayton to RTP. Two time horizons will be considered: a planned revenue service opening year beyond 2030 and a future horizon year in 2050.

A multi-step Alternatives Analysis framework (Figure 1) has been developed to identify various alternatives for each corridor extension and to assess the efficacy of these alternatives against regional and community goals and objectives. The measures incorporate, but are not limited to, project justification criteria used by the Federal Transit Administration (FTA) for New Starts/Small Starts funding.

This report documents the final recommended alternatives resulting from the initial screening process of potential alignments, as well as the operating plans and travel times that were estimated for alternatives within each corridor.

Figure 1 CAMPO Rapid Bus Extension Alternative Analysis Process



Operating Plans Development Overview

The initial implementation of "core" Wake BRT service in the Western (Cary to Raleigh) and Southern (Garner to Raleigh) Corridors is projected to open in 2024 and 2026, respectively. These BRT services will be operated by GoRaleigh and will serve stations between downtown Raleigh and Cary and Garner. Western and Southern Extension rapid bus services are

envisioned as seamless extensions of the core BRT service in the long-term, 2050 planning time horizon.

For independent utility, rapid bus alternatives were comparatively evaluated as separate services from core Wake BRT. Recommendation of roadways most supportive of rapid bus service implementation only considered the performance of alternatives within the defined boundaries of this rapid bus extension study. The Operating Plan includes assumptions and analyses that align directly with inputs and metrics used in the evaluation of roadway alignment options such as, but not limited to: projected transit travel times, ridership forecasts, fleet requirements, and capital and operating costs. Operating plans were developed using travel time estimates in tandem with proposed daily rapid bus service span and frequency targets as their foundation.

Travel times were developed for alternative alignments based on operating conditions along defined roadways and assumptions about future roadway capital improvements, rapid bus stations, and strategic deployment of transit priority treatments. The development of travel time estimates is described in detail in this report as well as results and subsequent service statistics resulting from the analysis. Incremental travel time improvements and savings owing to rapid bus capital improvements such as transit signal priority (TSP) and queue jump lanes as extensions of core Wake BRT service are also provided.

In accordance with forecasts of transit demand indicators and travel markets within the extensions, rapid bus service assumptions operate at lower frequencies in their opening year than BRT in the core segments. As population growth and land use changes within the region continue towards the 2050 planning horizon, rapid bus service is ultimately envisioned to operate as a seamless extension of the core Southern and Western BRT. The option of operating continuous BRT service from downtown Raleigh to RTP and Clayton was not precluded within this study. Components of this Operating Plan also consider the potential incremental capital and operating costs, as well as ridership impacts, of operating one-seat-ride service between Raleigh and Clayton and Raleigh and Garner.

Wake BRT Program and Rapid Bus Extensions Descriptions

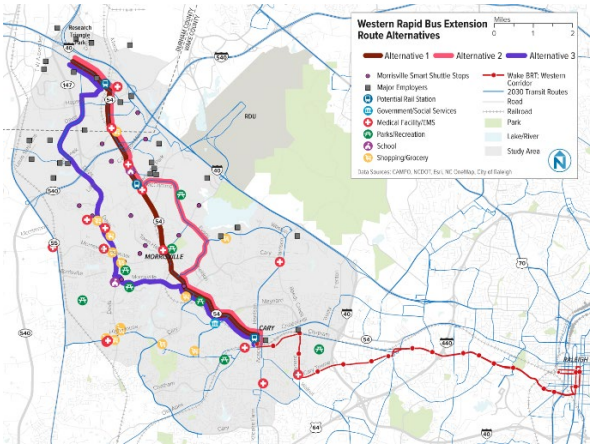
Initial screening results from step one of the route evaluation process identified three (3) final alternative alignments for consideration of the Western Extension rapid bus service between Downtown Cary and the HUB at RTP:

Alternative 1 is aligned primarily on Chapel Hill Road and NC 54.

Alternative 2 uses Chapel Hill Road but deviates mid-alignment along Evans Road/McCrimmon Parkway and Weston Parkway before returning to NC 54.

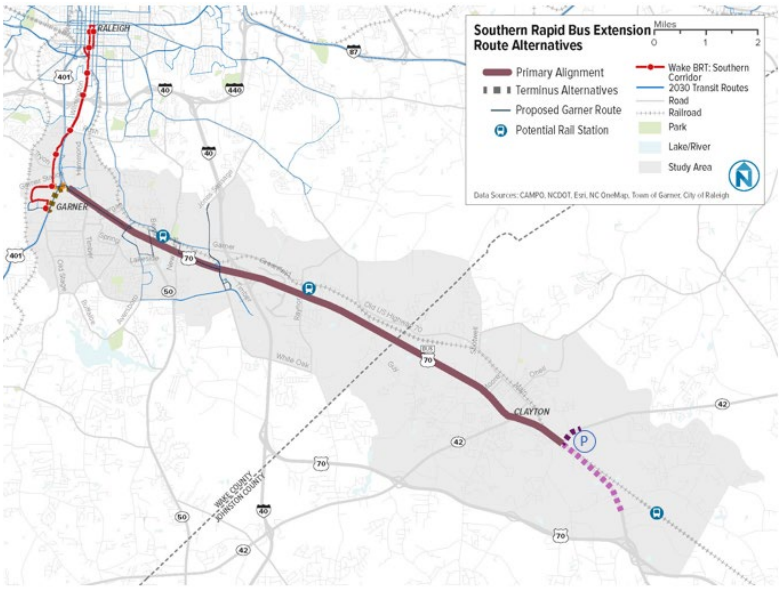
Alternative 3 begins on Chapel Hill Road but primarily uses Davis Drive via Morrisville Parkway.

Figure 2: Western Corridor Extension Alternative Alignments



The Southern Extension features one primary alignment on US 70/US 70 Business that would operate between approximately Timber Drive in Garner and NC 42 in Clayton. Detailed analyses and public input helped identify preferred routing alternatives at both the Garner Station and Clayton termini, including a potential extension beyond NC 42 to the East Clayton Industrial Area (ECIA).

Figure 3: Southern Corridor Extension Alternative Alignments



Service Profiles

The core BRT service (Raleigh's 4 original BRT lines) exists within a dense urban environment and along major suburban corridors while the proposed rapid bus extensions are more regional and less urban in nature and may warrant different service levels by the 2050 opening year horizon. Core BRT routes will also employ segments of center running and curb side dedicated transitways, with complementary station platform configurations.

Dedicated transitway for rapid bus service is currently not assumed within either the Western and Southern Extensions, due to the regional nature of the rapid bus service areas, their current land uses, and roadway configurations. For this analysis, service frequencies on the rapid bus alternatives are also at lower levels than core BRT (Table 1).

While the span (hours) of operation for both corridors are assumed the same, the proposed service frequencies of Southern and Western rapid bus alternatives differ based on existing transit service levels, land uses, and travel demand patterns in each corridor.

Table 1 Proposed Spans of Service and Levels of Service

Service Days	Time Period	Hours	Southern Corridor Headways		Western Corridor Headways	
			Core BRT	Rapid Bus Extensions	Core BRT	Rapid Bus Extensions
Weekday	AM Peak	5 a.m. – 8 a.m.	10 min.	30 min.	10 min.	20 min.
	Midday (off-peak)	8 a.m. – 3 p.m. 7 p.m. – 8 p.m.	15 min.	60 min.	20 min.	40 min.
	PM Peak	3 p.m. – 7 p.m.	10 min.	30 min.	10 min.	20 min.
	Evening	8 p.m. – 12 a.m.	20 min.	60 min.	20 min.	40 min.
Saturday	All Day	6 a.m. – 12 a.m.	20 min.	60 min.	20 min.	40 min.
Sunday	All Day	8 a.m. – 9 p.m.	20 min.	60 min.	20 min.	40 min.

Typical station configurations assumed for rapid bus service were based on New Bern BRT 30% design plans (Peripheral 1 and 2 typologies). While these stations will include 24-foot branded shelters with updated components and will accommodate either 40-foot typical buses or 60-foot articulated buses, an as of yet unresolved issue is matching differing platform heights on rapid bus stations with core BRT stations.

Future changes in regional travel demand may warrant more frequent service within the limits of rapid bus extensions. Proposed rapid bus improvements can be flexible to allow for service levels tailored for specific needs of the communities served. The evaluation of Southern and Western Extension alignment alternatives was not charged with comparing the potential impacts of extending core BRT service frequencies and vehicle types (60', articulated buses) to operate along the entire corridor extents (to Clayton and RTP, respectively).

Estimated Travel Time Results

For the Southern Corridor extension, two (2) combinations of primary alignment that incorporate each of the alternative routing choices at termini were used to estimate travel times and ridership potential.

Alternative 1: Garner Station Blvd (G2) to NC 42 (C1)

Alternative 2: Fayetteville Rd (G1) to Powhatan Rd (C2)

Each of these two alternatives include a mid-route connection at the proposed Auburn Commuter Rail (CRT) station. One-way trips for both alternatives range between 38 to 48 minutes during peak periods and between 27 and 36 minutes during off-peak times. The travel time from Garner into downtown Raleigh adds another 16 to 17 minutes to the trip (see Table 2).

Table 2 Southern Corridor Alternatives Travel Time Summary

Alternative	Distance (mi.)	Peak Period		Offpeak Period	
		1-Way Travel Time	Avg. Speed (mph)	1-Way Travel Time	Avg. Speed (mph)
NC-42 P&R to Garner Station Blvd	13.9	0:38:09	21.9	**0:27:52**	30.0
Powhatan Rd to Fayetteville Rd (Walmart)	17.9	0:47:25	22.7	**0:35:48**	30.0
Garner Station Blvd. to Downtown Raleigh	4.6	**0:16:30**	16.8	**0:16:30**	16.8

The Western Corridor Extension included three alternatives between the Hub at RTP and Downtown Cary.

Alternative 1: NC 54/Chapel Hill Road

Alternative 2: NC 54/Chapel Hill Road, Evans Road/McCrimmon Parkway

Alternative 3: Davis Drive (via NC 54/Chapel Hill Road, Morrisville Parkway)

One-way travel times for these alternatives range between 28 to 34 minutes in the peak periods and 23 to 29 minutes in off-peak times. Travel times on the core BRT transitway with limited stops between Downtown Cary and downtown Raleigh was estimated at 26 minutes. One-seat rides between downtown Raleigh and RTP would take between approximately 50 and 54 minutes during peak periods (see Table 3).

Table 3 Western Corridor Alternatives Travel Time Summary

Alternative	Distance (mi.)	Peak Period		Offpeak Period	
		1-Way Travel Time	Avg. Spd. (mph)	1-Way Travel Time	Avg. Spd. (mph)
Alt. 1: NC 54	10.0	**0:28:19**	21.3	**0:23:35**	25.5
Alt. 2: Hub RTP to Cary via Evans, Weston	11.5	**0:30:34**	22.7	**0:27:04**	25.6
Alt 3: Hub RTP to Cary via Davis	12.4	**0:33:39**	22.1	**0:28:26**	26.1
Core BRT Alignment Cary to Raleigh in Transitway	12.0	**0:26:22**	24.1	**0:26:22**	24.1

Estimated Service Statistics

Service requirements and operating statistics are based on estimated travel times and currently assumed operating plans for each corridor (Table 1). The proposed service plan includes daily service with 19 hours of service on weekdays, 18 hours on Saturdays and 13 on Sundays and holidays. Weekday service is proposed to run between 5 a.m. and midnight, 6 a.m. and midnight on Saturdays, and 8 a.m. to 9 p.m. on Sundays and holidays. Service frequency is proposed to be higher during peak periods and lower during off-peak periods to account for differing levels of demand. Peak service on the Southern Extension is proposed for every 30 minutes, reduced to hourly service in off-peak periods and on weekends. Western Extension service is proposed at every 20 minutes and every 40 minutes during off-peak periods and weekends. Despite having a

shorter route, its more frequent service profile means the Western Corridor alternatives requires approximately the same daily revenue hours as Southern Corridor alternatives.

For all alternatives, peak vehicles are estimated at four vehicles, and with an industry standard twenty percent (20%) spare vehicle requirement, fleet requirements total 5 vehicles. Both extensions would require approximately 16,700 revenue hours to operate. If service is not combined with the Core BRT, it would require another 15,000-16,700 revenue hours to extend service to downtown Raleigh at the same frequency.

Table 4 Southern Extension Rapid Bus Service Statistics

Alternative	(Pk/Off-Pk) Frequency	(Pk/Total) Vehicles	Annual Rev Hrs.	Annual Rev Mi.
NC-42 P&R to Garner Station Blvd	30/60 min	4/5	16,700	246,000
NC-42 P&R to Garner Station Blvd via Auburn Hills CRT Station	30/60 min	4/5	16,700	258,000
Powhatan Rd to Fayetteville Rd (Walmart) Station	30/60 min	4/5	16,700	284,000
Powhatan Rd to Fayetteville Rd via Auburn Hills CRT Station	30/60 min	4/5	16,700	295,000
Garner Station to Downtown Raleigh	30/60 min	+3/4	+15,000	+77,000

Table 5 Western Extension Rapid Bus Service Statistics

Alternative	(Pk/Off-Pk) Frequency	(Pk/Off-Pk) Vehicles	Annual Rev Hrs.	Annual Rev Mi.
Alt 1: NC 54 / Chapel Hill Road	20/40 min	4/5	16,700	251,000
Alt 2: Evans Road / McCrimmon Parkway	20/40 min	4/5	16,700	288,000
Alt 3: Davis Drive	20/40 min	4/5	16,700	309,000
Cary to Downtown Raleigh	20/40 min	+4/5	+16,700	+264,000

CORRIDOR ALTERNATIVES & ASSUMPTIONS

OVERVIEW

Following preliminary screening of potential roadway segments most suitable to support rapid bus service, independent end-to-end alignments and routing alternatives were identified for both extensions for further refinement and detailed evaluation of potential benefits, impacts, and tradeoffs. For each rapid bus extension, this section describes the physical operating environment of proposed alternatives, including but not limited to:

- Final alternative alignment and routing options
- Capital projects and roadway improvements
- Transit priority treatment opportunities
- Transit connections and first/last mile circulators

Descriptions of final alignments identify the specific and primary roadways used by the proposed alternatives, as well as any optional route deviations or extensions. The physical operating environment, number of proposed stations, and opportunities to install transit speed and reliability improvements associated with final end-to-end rapid bus alternatives were considered in developing service profiles and estimating potential travel times.

The service profile of final alternatives, including span of service, frequency, and network integration assumptions are described in subsequent sections of this document. Potential rapid bus station area identification considerations included proximity to signalized intersections, activity centers and development nodes, as well as pedestrian network connectivity and accessibility.

The alternative alignments described within Operating Plans were comparatively evaluated to determine locally preferred alternatives in the extensions of Cary to the Hub at RTP, and Garner to Clayton. These alternatives would support and not preclude a seamless extension of the core BRT service in the future, as mobility demand continues to grow.

SOUTHERN EXTENSION RAPID BUS ALTERNATIVES

Final Southern Extension alternatives utilize US 70/US 70 Business for primary connections between Clayton and Garner Station, with two routing alternatives at terminal endpoints shown in Figure 4. The primary alignment also includes an option to deviate to a potential future Auburn CRT station.

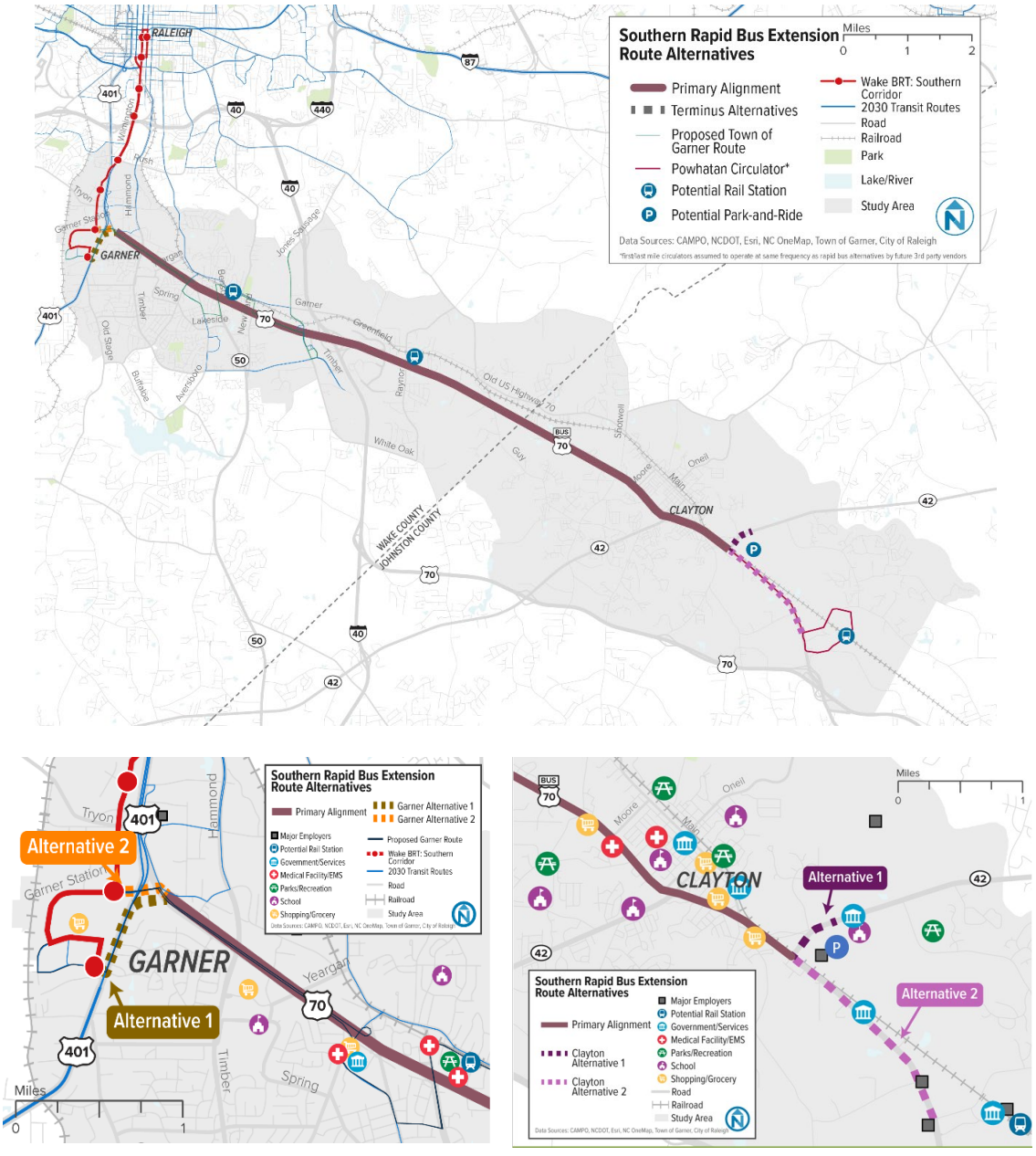
The two alternative terminal routing options evaluated in Town of Garner were:

- **Alternative G1:** Connects at the US 401/Fayetteville Rd Walmart
- **Alternative G2:** Connects to the BRT station at Garner Station Blvd.

Near Clayton, two alternative terminus locations were evaluated:

- **Alternative C1:** Connects to a potential future park and ride lot option at the NC 42 intersection.
- **Alternative C2:** Connects to the potential future park and ride at NC 42, and continues farther south to Powhattan Road serving the East Clayton Industrial Area (ECIA).

Figure 4 Southern Corridor Rapid Bus Extension Alternatives



With marginal changes to the overall corridor ridership expected to result from a single terminal routing choice (at either end), the ridership forecasts developed for the Southern Extension considered only two end-to-end alignment alternatives representing the shortest and longest potential transit trips within the corridor. Each end-to-end alternative assumed approximately 10 to 12 stations, with average spacing varying based on surrounding land uses.

Alternative Alignment 1: Garner Station Blvd to NC 42

This 14.4-mile alternative provides a connection between the core BRT at Garner Station Boulevard and a (future) park and ride south of Clayton near the intersection of US 70 Business and NC 42. A mid-route deviation connects with the Auburn CRT station via Raynor Road. Ten stations are proposed for this alternative.

Routing using Garner Station Boulevard / Mechanical Boulevard to NC 42 and represents the shortest transit trip (by distance and time) between Garner and Clayton. Transfer to the core Southern BRT would occur at the planned BRT station at Garner Station Boulevard. This alternative does not preclude continued rapid bus service to the core Southern BRT terminus along Purser Drive near Fayetteville Road (Walmart).

Alternative Alignment 2: Fayetteville Rd to Powhatan Rd

This 18.6-mile alternative provides a connection between the core Southern BRT terminus in Garner and the ECIA south of Clayton, at approximately Powhatan Road. Service would begin along Purser Drive near (Walmart) and uses Fayetteville Road (US 401) to transition to US 70 and extends south to turn around via Powhatan Road, Best Wood Drive, and North Tech Drive.

Service would still connect with a proposed park and ride south of Clayton near US 70 Business & NC 42 and represents the possible longest transit trip. However, this alternative does not extend to directly serve a proposed commuter rail station at GLP One Way in Powhatan. A mid-route deviation connects with the proposed Auburn CRT station via Raynor Road. Eleven stations are proposed for this alternative.

Operating Environment

Southern Extension alternatives operate primarily along US 70/US 70 Business. The corridor is currently a constrained capacity corridor with high levels of traffic congestion throughout, especially in the morning and evening peak periods, and particularly north of I-40. The entire corridor is mostly free flow during off-peak periods, indicating a high level of peak period commuting.

This multilane highway generally has two lanes in each direction, an unimproved median, limited at-grade crossing opportunities with deceleration lanes provided at intersections and at many businesses fronting the highway. Speeds range from 45 mph to 55 mph. Free-flow traffic is typical along the unsignalized sections between US 401 and Guy Road. Traffic queues and transit delay are high along:

- Fayetteville Road (US 401) between Purser Drive and the US 70 interchange,
- US 70 westbound approach to the interchange of US 401,
- US 70 in both directions of the approach to the Jones Sausage Road/White Oak Road shopping center and the I-40 interchange,
- US 70 Business between Guy Road and Robertson Street in Clayton northbound in the morning and southbound in the afternoon peak periods.

Additional information related to assumed impacts of traffic conditions on future Southern Extension travel times is provided in later sections of this document.

Generally, proposed rapid bus station locations are proposed at signalized intersections and may include deceleration/turn lanes which provide access to nearby activity centers, as well as opportunities for transit priority treatments such as queue jumps. Wherever possible station platform locations are assumed located on the far side of intersections.

All rapid bus stations are assumed to be in-line or located along the right of way of the proposed alignment. Exceptions to this would include termini/turnaround points and offline stations where rapid bus vehicles would deviate off the US 70/US 70 Business alignment, or to circulate to a major/regional or intermodal transfer opportunity, such as a proposed park and ride facility or commuter rail (CRT) station.

Specific investments and policies such as the *Garner Transit Service Plan* and the CAMPO *Bus on Shoulder System (BOSS) Implementation Blueprint* have been assumed to be in place for rapid bus operations. Several capital projects are also planned and proposed within the US 70/US 70 Business corridor prior to the rapid bus horizon operating period (beyond 2030).[1]

Capital Projects and Roadway Improvements

Planned roadway improvements (new construction and upgraded facilities) outside the scope of rapid bus alternatives are assumed to be constructed prior to rapid bus operations in the Southern Corridor. The project team conducted a review of adopted and planned capital projects that may potentially support (or conflict) with rapid bus station areas and potential transit priority treatments.[2] The adopted and planned capital projects were sourced from several state and municipal planning documents including:

- NCDOT *State Transportation Improvement Program* (STIP) 2020 – 2029
- *Adopted Research Triangle Region – Connect 2050 Metropolitan Transportation Plan* (MTP)
- NCDOT *State Transportation Improvement Program* (STIP) *BRT Funding 2022*

In addition to planning documents, reports and discussions with stakeholders (e.g., CAMPO, Town of Clayton) identified additional, specific roadway improvement project plans and designs. While many of the projects adopted and planned for the Southern Corridor have smaller footprints or lower scales of implementation, there were a few projects that would have a larger implementation scale and would improve the operating environment for rapid bus service. The following major capital projects and additional major roadway improvements were considered conducive to the implementation of transit speed and reliability treatments:

Vandora Springs Road (Figure 5): The bridge over US 70 at Vandora Springs Road is assumed to be reconstructed and brought up to date to include safe pedestrian infrastructure. Rapid bus alternatives assumed that transit-only deceleration/acceleration lanes and rapid bus platforms will

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[1] NCDOT. 31 Mar 2022. State Transportation Improvement Program 2020 – 2029. Accessed 30 August 2022. https://www.ncdot.gov/initiatives-policies/Transportation/stip/Pages/stip-projects-map.aspx

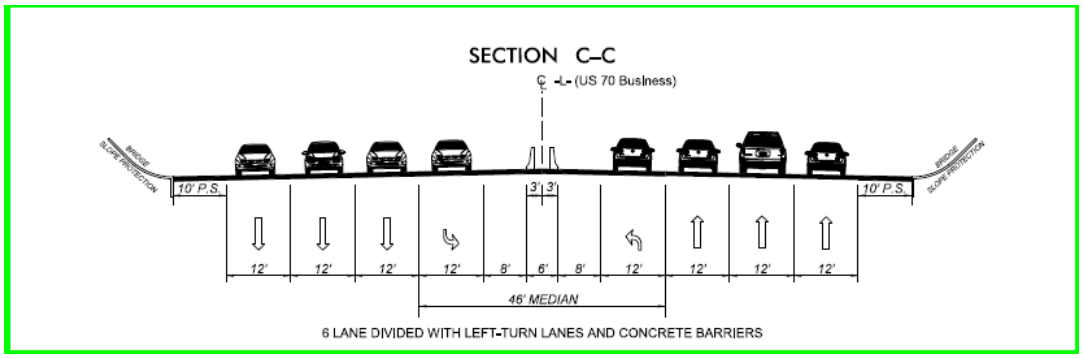
[2] CAMPO, DCHC. 13 July 2022. Research Triangle Region – Connect 2050 Metropolitan Transportation Plan. Accessed 30 August 2022. < chrome extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nmcdn.io/e186d21f8c7946a19faed23c3da2f0da/8bfec28a290449a7b10eb1fee3a0e264/files/transportation-plan/2050-MTP/Final-Plan/August-2022/Connect-2050-Joint-MTP-Full-Report-with-Appendices-Jul-13-2022.pdf>

be incorporated under the structure in both directions so that buses can pull out of travel lanes and, aided by vertical circulation to include sidewalk, stairs, and ADA-accessible ramps, offer connections to the nearby Forest Hills Shopping Center. At present, these changes are not programmed and would need to be coordinated with NCDOT and nearby stakeholders.

Figure 5 US 70 at Vandora Springs Rd (existing condition)

US70 Superstreet: Outlined within the NCDOT STIP, the US 70 corridor is planned to be upgraded to a superstreet between Greenfield Parkway and NC 42. According to NCDOT, a superstreet is a synchronized street that would reduce and simplify conflicts at intersections along the roadway.[3] The superstreet project would improve roadway safety and improve travel times, through widening of travel lanes and emergency lanes (shoulder) as well as signalization improvements within the project limits.

Figure 6 US 70 Business Superstreet Conceptual Design Cross Section (May 2022)



[3] NCDOT Traffic Engineering and Safety Systems Branch. n.d. Superstreets "A Tool for Safely and Efficiently Managing Congestion". PowerPoint Presentation. Accessed 30 August 2022. https://www.partnc.org/DocumentCenter/View/331/NCDOT-Superstreet-Presentation-PDF

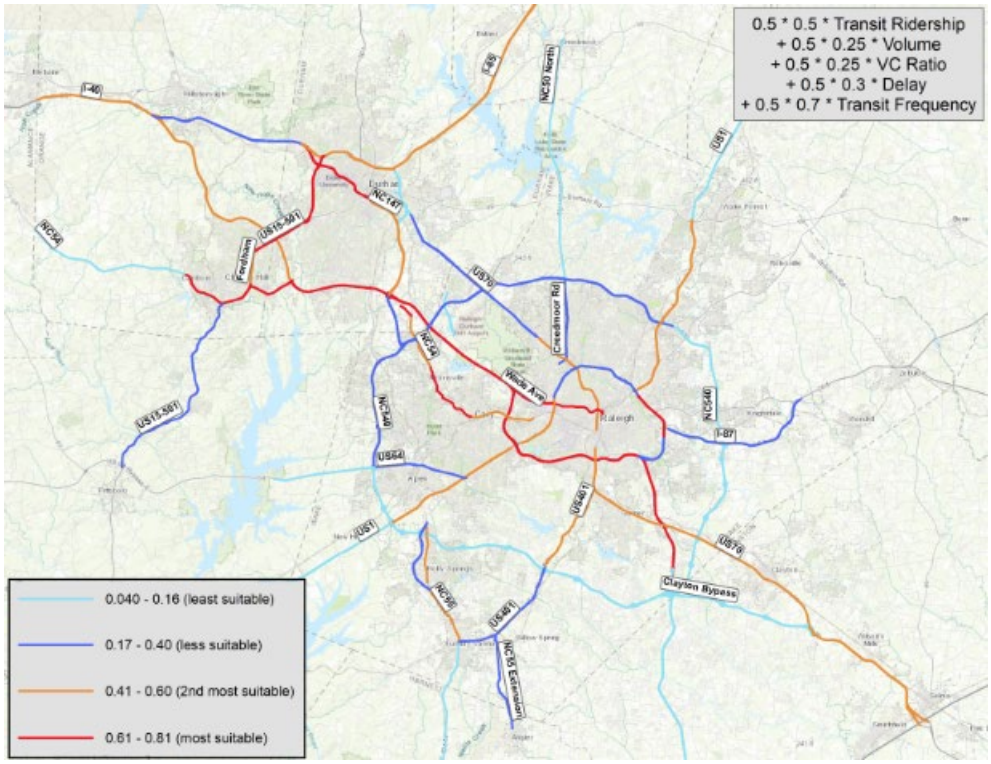
Source: NCDOT Division 4

To minimize rapid bus operational conflicts with the increased auto volumes within the superstreet project area, a Bus on Shoulder System (BOSS) could improve the operating environment for rapid bus travel and improve the surrounding station environment for rapid bus riders. BOSS use has been implemented in several US cities and allows transit vehicles to continue operating along shoulder lanes of highways when adjacent highway travel lanes are congested or at a standstill. Generally, BOSS use is only available during peak periods or when congestion is present and usually has a speed restriction based on the prevailing speed of adjacent traffic. Shoulders would need to be included in NCDOT projects for US 70/US 70 Business and constructed in this area prior to rapid bus operations for BOSS use to be available.[4] The analysis conducted by CAMPO was intended to show locations/roadways where BOSS is most likely to provide the greatest benefit. According to the *BOSS Implementation Blueprint*, the US 70 corridor is described as "second most suitable" for BOSS implementation (Figure 7).

With the increased vehicle capacity, wider footprint, and high speeds, the superstreet project should consider including additional investments to support rapid bus operations beyond BOSS, to mitigate the limited pedestrian access and unsafe bicycle and pedestrian conditions.

[4] NCDOT. 31 Mar 2022. State Transportation Improvement Program 2020 – 2029. Accessed 30 August 2022. https://www.ncdot.gov/initiatives-policies/Transportation/stip/Pages/stip-projects-map.aspx

Figure 7 CAMPO BOSS Corridor Suitability Map



WESTERN EXTENSION RAPID BUS ALTERNATIVES

Screening results from the step one evaluation process identified three (3) alternative alignments for the Western Extension between Downtown Cary and the Hub at RTP, including connection to the future Regional Transit Center (RTC). Starting at Downtown Cary, final alternatives share the same alignment along Chapel Hill Road/NC 54 but begin diverging into different routes at Morrisville Parkway and Weston Parkway. All three alignments also have a shared segment as they approach the Hub at RTP on NC 54/Slater Road, west of S Miami Boulevard (Figure 8).

Each end-to-end alternative features approximately 10 to 15 stations, with average spacing varying based on surrounding land uses. Station area selection considerations included, but were not limited to:

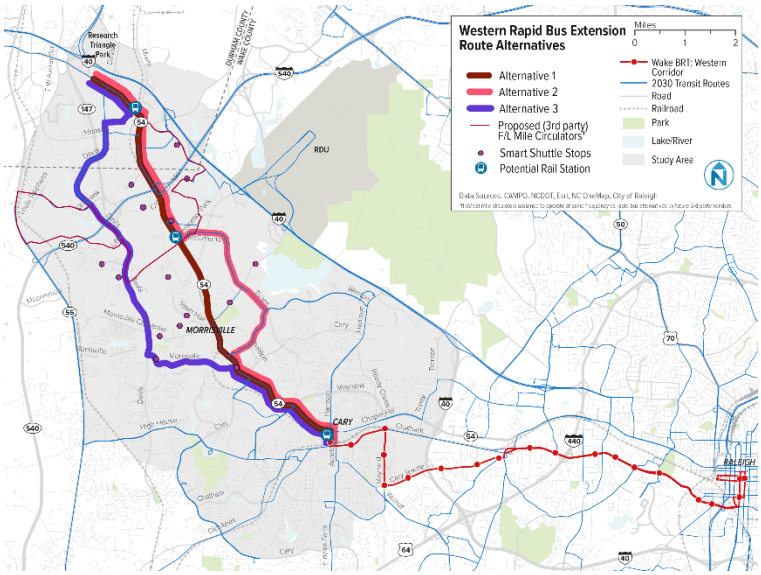
- Activity centers and development nodes
- Signalized intersections
- Pedestrian network and accessibility

Alternative 1 is approximately 10 miles long and provides the most direct route for rapid bus service between Downtown Cary and the Hub at RTP via Chapel Hill Road/NC 54. At the northern end of the corridor, the alignment turns onto Slater Road, connecting to the proposed relocation site of the future Regional Transit Center (RTC) before terminating at the Hub at RTP. Other major points of interest along the alignment include Park West Village and Wake Technical Community College. Twelve stations were assumed.

Alternative 2 travels primarily along Chapel Hill Road/NC 54, taking a deviation along Weston Parkway, Evans Road, McCrimmon Parkway before reconnecting to NC 54. At Slater Road, the alignment connects to the future RTC before terminating at the Hub at RTP. This 11.5-mile alternative connects major points of interest along the alignment including Park West Village, Wake Competition Center, and Wake Technical Community College. Fourteen stations were assumed.

Alternative 3 diverges from NC 54 along Morrisville Parkway and Davis Drive. This 12.4-mile alternative turns onto Merrion Avenue and utilizes an assumed future extension of Faulkner Street north to NC 54/Slater Road allowing direct connection to the future RTC, before terminating at the Hub at RTP. Other major points of interest along the alignment include Park West Village, and the campuses of Apple and Cisco Systems in RTP. Twelve stations were assumed.

Figure 8 Western Rapid Bus Extension Route Alternatives



Operating Environment

The majority of roadways proposed for rapid bus alternatives are multilane divided roadways with at least two lanes in each direction. The exception includes segments of NC 54/Chapel Hill Road as well as the local roadway segments of Merrion Avenue and Faulkner Street. As noted above, NC 54/Chapel Hill Road between Downtown Cary and Morrisville Parkway is a shared segment among alternatives. Over time, segments of the facility have also been slowly expanded and progressively widened from two lanes to four- and five-lane cross sections. Morrisville has programmed widening of the facility to accommodate a minimum of two travel lanes in each direction between N Harrison Avenue and NW Maynard Road, benefiting all three alternatives.

Alternatives 1 and 2 travel along roadways with posted speed limits typically between 35 to 45 mph, while Alternative 3 has speeds up to 55 mph on Davis Drive between Merrion Avenue and Parkside Valley Drive. Roadways considered in each Western Extension alternative feature similar travel lane striping and geometry, including lane transitions and drops throughout the corridor.

The **Alternative 1** alignment stays exclusively on NC 54 through Morrisville and as it approaches the future RTC. It is highly signalized and is aligned with moderate density commercial and retail land uses and large trip generators at major intersections. It currently experiences the most traffic congestion among the three alternatives and congestion is projected to increase over time. It has segments that are only one lane in each direction, which limits vehicular capacity. The alignment is developmentally constrained from its adjacency to the North Carolina Railroad (NCRR) running parallel north of Weston Pkwy. The railroad also acts as a barrier to pedestrian access for residential communities south and west of NCRR.

The **Alternative 2** alignment along Evans Road and McCrimmon Parkway avoids some of the most congested segments of NC 54. This section of the alignment has two travel lanes in both directions with additional plans for widening and signalization to accommodate a significant amount of transit-oriented mixed use and multi-unit residential development planned by Morrisville. The alignment faces similar right-of-way (ROW), roadway widening, and land use constraints along the northern and southern ends shared with Alignment 1.

Despite avoiding high levels of traffic along NC 54, multiple segments of Davis Drive in **Alternative 3** are projected to experience traffic congestion or operate near their planned capacity in the future. Continued residential growth is forecast in the RTC area, as well as major employer growth within campuses north of I-540 (such as Apple, Cisco, and Lenovo). Wide public ROW, with two travel lanes in each direction, emergency shoulder lanes, and an unimproved median with dedicated (double, on occasion) turn lanes supports the possibility of converting existing mixed traffic lanes to dedicated bus lanes.

Additional information related to assumed impacts of traffic conditions on future Western Extension travel times is provided in later sections of this document.

Capital Projects and Roadway Improvements

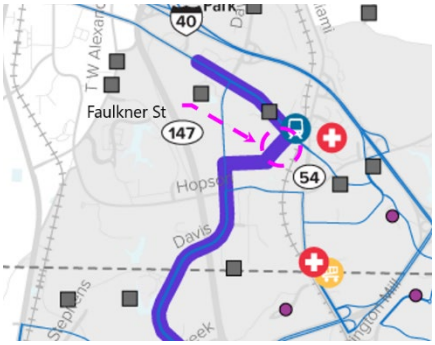
Similar to the Southern Corridor, capital projects and roadway improvements were reviewed for the Western Corridor. Projects were included from the CAMPO *Connect 2050 MTP*, NCDOT STIP, and local/municipal roadway improvement plans. Based on discussions with local stakeholders, the following planned/programmed roadway improvements have been considered for impacts to the potential implementation of transit speed and reliability treatments:

NC 54 (Chapel Hill Road) Widening (See Figure 22 in **Appendix A**): The current conditions of this roadway segment do not allow for safe pedestrian access, vehicle turning movements, or safe biking. The proposed design concepts to improve NC 54 (Chapel Hill Road) would include the expansion of NC 54 (Chapel Hill Road) between Downtown Cary and Maynard Road to accommodate additional roadway capacity, specifically for pedestrian, bicycle, and transit infrastructure. This study was a part of the *Cary 2040 Community Plan* and with the suggested improvements these projects could potentially allow for added travel for transit priority treatments along the NC 54 corridor leaving Downtown Cary.[5]

McCrimmon Parkway Widening and Grade Separation (see Figure 23 of **Appendix A**)**:** The limits of this programmed improvement by Morrisville are along SR 1635 (McCrimmon Parkway) from Louis Stephens Drive to Perimeter Park Drive. The project would split McCrimmon Parkway into a grade separated flyover of NC 54 and the NCRR as well as create an at-grade spur that ends at a T-intersection with NC 54 east of the NCRR; two lanes of travel would be available for each direction of each roadway. The project would remove the ability for at-grade through movements for autos along McCrimmon Parkway across the NCRR. Station platform placement may vary between Alternatives 1 and 2 to accommodate turning movements, as needed.

Alternative 3 operations may be impacted by the realignment of McCrimmon Parkway east of Davis Drive. The Project would realign the intersection of Morrisville-Carpenter Road and Davis Drive into a diverging diamond interchange (DDI) resulting in approximately 170 feet of travel and turning lanes for northern and southern approaches on Davis Drive and 95 feet of travel and turning lanes along McCrimmon Parkway. While the DDI reconfigurations and right turn only lanes may support queue jump installation, the pedestrian environment would require additional investment to support safe circulation and rapid bus station access.

Faulkner Street Extension: Alternative 3 rapid buses operating on Davis Drive approaching the terminus at The Hub would utilize a new extension of (existing) Faulkner Street between Eagleson Street and NC 54. Based on discussions with representatives of Research Triangle Park (RTP), covenants of Davis Park site plans require the developer to construct this roadway extension in concert with planned phases of construction. Although service would experience reduced speeds for enhanced pedestrian safety as it maneuvers through the Davis Park neighborhood, this new intersection at NC 54 would also provide access into the new RTC commuter rail and bus transfer facility across the street.



[5] Town of Cary. 24 January 2017. Cary 2040 Community Plan. Accessed 8 September 2022. <https://www.townofcary.org/projects-initiatives/cary-community-plan>

MODE/VEHICLE ASSUMPTIONS

The proposed Wake BRT: Southern and Western Corridor BRT services will operate compressed natural gas (CNG) fueled 60-foot articulated BRT vehicles. To serve passenger activity at core BRT stations sited along proposed median dedicated transitways, these BRT vehicles will also feature additional left-side doors. To remain compatible with maintenance and storage facility (MSF) requirements associated with Wake BRT and GoRaleigh preliminary engineering designs and specifications, rapid bus extensions assume deployment of 40-foot, CNG-fueled buses.

The Wake BRT: Southern Corridor Project would not include construction of a new MSF, nor would the project include expansion of the existing GoRaleigh maintenance facility at 4104 Poole Road, in Raleigh. The existing GoRaleigh MSF has sufficient vehicle parking, maintenance bays, fuel stations, and staff to accommodate the additional BRT vehicles without expansion or additional funding.

While operating 40-foot CNG rapid buses can be supported out of the planned BRT MSF facility, additional refinement of vehicle specifications should be considered following selection of a locally preferred alternative (LPA) alignment. The evaluation of Southern and Western Extension alternatives was not charged with comparing potential effects of extending core BRT service frequencies and vehicle types (60-foot, articulated buses) to operate along the entire corridor extents (to Clayton and RTP, respectively). Additional permutations of rapid bus alternative capital cost estimates were developed to allow for conceptual variations that support potential one-seat ride extensions of the core Wake BRT service (with termini in Downtown Cary and Garner) using left-door capable, 40-foot and articulated 60-foot buses.

For purposes of this rapid bus Alternatives Analysis, travel time estimates related to fleet size requirements, speed, and acceleration/deceleration rate assumptions have been made using performance characteristics of conventional buses currently in local use. For rolling stock needs, an industry standard 20 percent spare ratio was applied to the peak fleet estimate.

STATION ASSUMPTIONS

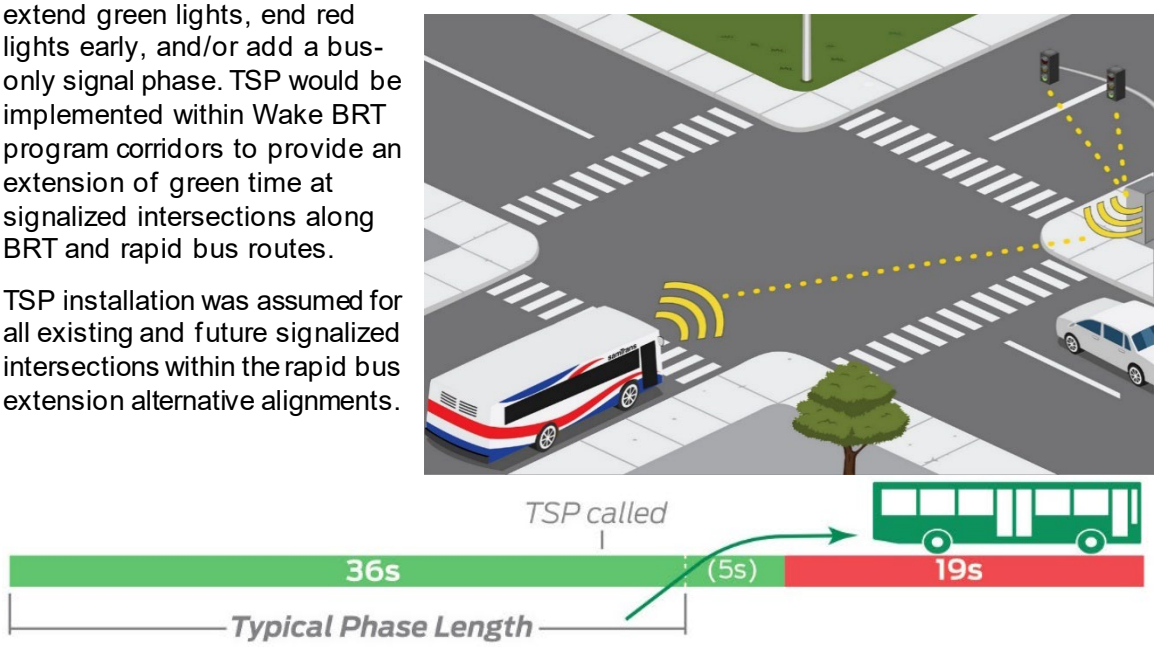
Wake BRT station designers have developed modular BRT station canopy and platform typologies to customize the level of infrastructure and amenity according to site-specific conditions and anticipated demands. Assumptions of typical station area improvements at rapid bus stations supporting transit speed and reliability include real time arrival displays, as well as ticket vending and fare collection systems. Rapid bus stations are not assumed to include elevated platforms to achieve near-level boarding. Capital improvements associated with final alternatives are documented within the *CAMPO Rapid Bus Extension Cost Estimate Memorandum, May 2023.*

TRANSIT PRIORITY TREATMENT FEASIBILITY

Specific transit priority and enabling infrastructure treatments that were considered when developing detailed rapid bus alternatives included transit signal priority (TSP), transit queue jumps, and dedicated transitway configurations.

Transit signal priority (TSP) is a collection of policies and technologies that gives transit vehicles precedent at signalized intersections, reducing delay for transit passengers over lower-occupancy vehicles in general purpose lanes. There are multiple variations in how TSP can be implemented. At the basic level, TSP allows transit vehicles to communicate with signals to extend green lights, end red lights early, and/or add a bus-only signal phase. TSP would be implemented within Wake BRT program corridors to provide an extension of green time at signalized intersections along BRT and rapid bus routes.

TSP installation was assumed for all existing and future signalized intersections within the rapid bus extension alternative alignments.



Green Extension example.

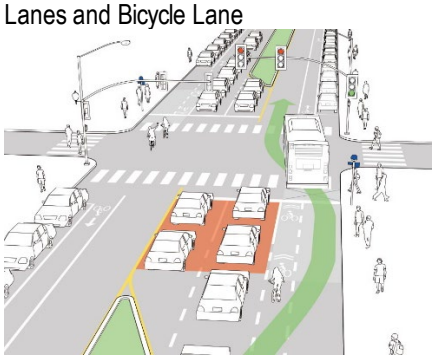
Source: NACTO

Transit Queue Jump and bypass lanes are designated spaces that allow buses to proceed through a signalized intersection ahead of general traffic. TSP technology is also instrumental in initializing the bus-only phase to allow for early procession. These roadway treatments can reduce bus delays due to traffic queues spanning multiple signal phases at congested intersections.

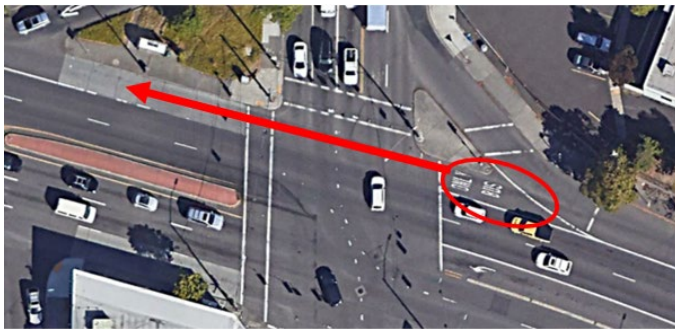
Opportunities that consider use of potential queue jump or bypass lanes were identified by the existing lane geometry at signalized intersections having deceleration/right turn only lanes at the intersection approach. Ideally, candidate intersections would also have ROW on the far side of the intersection for "receiving" lanes where buses could smoothly transition back into general purpose lanes. In some instances, assumptions were made for future queue jump space based on current and planned roadway conditions. Refer to **Appendix B** for further information.

Figure 9 Example Transit Queue Jump Configurations

Ex: Utilizing Utilizing Existing Parking Lanes and Bicycle Lane



Ex: Utilizing Outside Lane Drop and Pedestrian Refuge Area



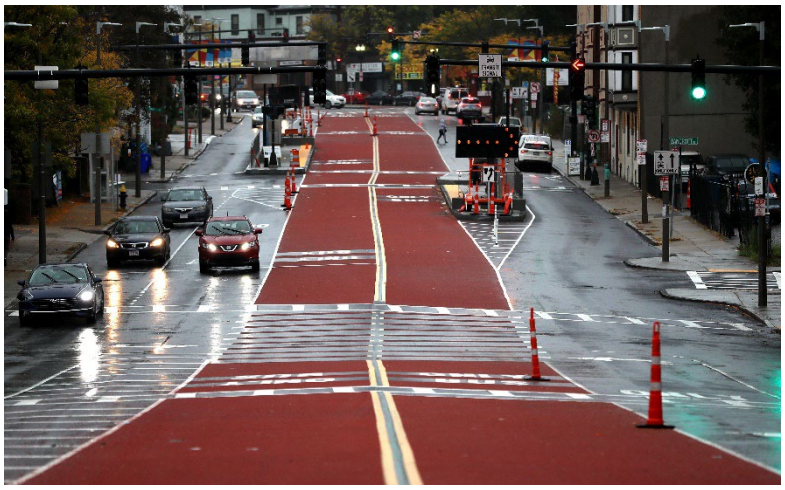
Source: NACTO

Though an atypical configuration, this rapid bus study identified precedence for transit queue jump striping and signalization on local NCDOT roads, noting an existing bus stop at the intersection of NC 55 and Odyssey Drive (below).

Dedicated Transitway (or bus lanes) provide a dedicated travel lane for transit vehicles to operate, which improve reliability and reduce travel times by keeping buses out of traffic congestion. Transitways may be segments of existing or new construction roadways converted for exclusive or restricted use by transit vehicles in support of rapid bus and BRT operations. They can have many variations in how they operate in space and time, ranging from barrier separation for dedicated BRT lanes or non-separated facilities that allow mixed traffic or limited auto operations. Bus lanes could be exclusive to transit or permit other vehicles under certain conditions. Hours of operation may also range from all hours every day to peak commute hours only.

The Wake BRT program has identified and in progress of designing segments of the Southern and Western BRT Corridors that will feature combinations of: Mixed Traffic; Right, Business Access, and Transit (RBAT) Lanes; and Median Running Transitway.

Ex - Median Transitway in center lanes of Boston



Source: Boston Globe

Ex – RBAT lanes in Washington DC

Source: GGWash.org

Ex - Median Transitway Along New Bern Avenue at Raleigh Boulevard

Source: GoRaleigh

Ex – Proposed RBAT Lanes Along Blount Street

Source: GoRaleigh

Transit Priority Operations Assessment

The analysis of existing conditions as well as adopted and planned capital projects were considered when examining roadway geometry conditions that may be conducive to or supportive of transit speed and reliability improvements including TSP, potential queue jumps, and transitways. The following speed and reliability improvements were assumed as part of Southern and Western Extension rapid bus service operation and travel time calculations, fleet requirements, and operating costs performed by this analysis.

For horizon year (2050) scenarios where one-seat rides are in operation to downtown Raleigh, the Wake BRT transitway infrastructure is assumed available for use by rapid bus vehicles. Additional discussion of rapid bus operability in transitways is provided in later sections of this document.

Southern Extension

Transit Signal Priority

TSP has been assumed at all 25 existing signals including both routing options at termini. No new traffic signals have been assumed in this corridor. Because the Southern Corridor alternative and terminal options are generally aligned along US 70/US 70 Business or NC 42, NCDOT is the prevailing operator of signals in the corridor.

Queue Jumps

Within the Southern Corridor, twenty-five (25) existing or proposed signalized intersects were identified as. Of these, 12 locations were identified with existing or planned lane configurations potentially supporting queue jump implementation in one or both directions of travel. Refer to **Appendix B** for additional information.

Table 6 Southern Extension Signalization and Potential Queue Jump Opportunities

Alternative Alignment	Signalized Intersections	Intersections w Potential QJ	Intersection Approaches w Potential Receiving Lanes
Mainline US 70/US 70 Bus (to NC 42)	20	9	7
C2 – Powhatan Extension	3	2	1
G1 – Fayetteville Rd (US 401)	2	1	2

NOTE: Terminal routing options C1 and G2 do not include any additional signalized intersections beyond those identified in the Primary alignment of US 70/US 70 Business.

Transitways

As previously described, NCDOT has identified capital improvements to US 70/US 70 Business south of the I-540 interchange that would include significant widening and additional lane capacity, including emergency lanes (shoulder).

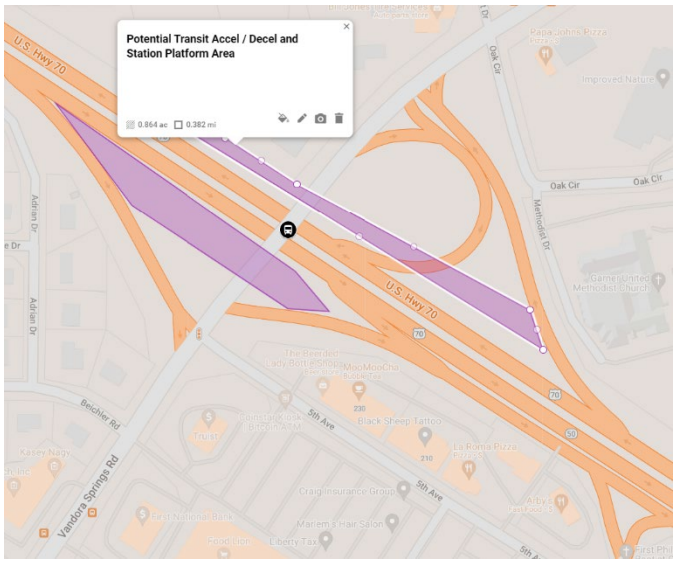
The North Carolina Capital Area Metropolitan Planning Organization (CAMPO) and its partners, GoTriangle, the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC-MPO),

and the North Carolina Department of Transportation (NCDOT) initiated a study to create a programmatic approach for identifying, prioritizing, and developing best practices for **Bus on Shoulder System (BOSS)** deployment in the Triangle and across North Carolina. As part of this project, a systematic approach to identify subject roads and analyze their potential suitability for BOSS was developed.

Bus on shoulder system (BOSS) use is assumed to be available to rapid buses operating in the Southern Extension to avoid some of the worst peak period traffic congestion along US 70/US 70 Business. For purposes of this analysis, BOSS use was assumed to allow transit vehicles to operate at least 25 mph but not more than 35 mph along shoulder lanes and was assumed between Jones Sausage Road/White Oak Road and South Moore Street, a distance of just under seven miles.

Transit Acceleration/Deceleration Lanes. With high travel speeds along the mainline of US 70/US 70 Business, rapid bus alternatives recommended installation of separate bus pull-outs at proposed rapid bus station locations, where possible, utilizing emergency lanes (shoulder) or turning lanes for deceleration/acceleration. Additional transit supportive infrastructure would be associated with planned roadway capital improvements. An example of a rapid bus station location to consider additional transit infrastructure is at the Vandora Springs Road overpass. This potential station location is near the Forest Hills Shopping Center located south of the highway (Figure 5), which is an important local transit trip generator. The interchange is proposed (unfunded) for reconstruction to improve vehicular circulation as well as pedestrian safety and access. With the overpass providing the only connectivity across the freeway for northbound rapid bus passengers, optimal placement would site station platforms as near to the overpass as possible.

Figure 10. Vandora Springs Road Overpass



An alternative to bus pullouts is the reconfiguration of existing travel lanes freeway ingress/exit ramps at the interchange to support a transit only bypass lane and rapid bus platform area. Additional analysis and design are required to clearly define potential pullout and acceleration/deceleration lane function and installation as well as rapid bus station platform locations.

Western Extension

Transit Signal Priority

All existing and planned signalized intersections along alternative alignments are assumed to have been upgraded to include TSP. New signals are assumed for Alternative 2 in the Western

Corridor along McCrimmon Parkway near the Wake Competition Center as well as the new intersection of Faulkner Street and NC 54/Slater Road for Alternative 3. A total of 52 signalized intersections were identified and assumed across alternatives (Table 7), with several shared signals along common segments of NC 54.

According to the *Western Wake Traffic Signal Integration Guidebook*, Cary is the only municipality in the Western Corridor area that maintains a municipal traffic signal system and operates and maintains signals within Morrisville, while NCDOT operates the vast majority of signals in the state. The Towns of Cary and Morrisville may integrate their systems into a unified municipal traffic signal system in the future. A ten-year road map for integration recommends build-out of the traffic signal fiber system along major corridors, and an integrated corridor management for corridors parallel and intersecting with I-40 such as NC 54, Aviation Parkway, Airport Boulevard, and Harrison Avenue; additional cameras at intersections on major corridors, and future "smart" connectivity applications for traffic signals. Implementation of Managed Motorways along I-40 would include ramp metering, which has potential to impact arterials leading to I-40 access ramps and nearby segments of the Western Corridor.

Queue Jumps

Of the 52 signals across all three alternatives in the Western Corridor, 33 locations were identified with existing or planned lane configurations potentially supporting queue jump implementation in one or both directions of travel. Refer to **Appendix B** for additional information.

Table 7 Western Extension Signalization and Potential Queue Jump Opportunities

Alternative Alignment	Signalized Intersections	Intersections w Potential QJ	Intersection Approaches w Potential Receiving Lanes
Alt 1: NC 54/Chapel Hill	23	18	8
Alt 2: Evans/McCrimmon	29	19	7
Alt 3: Davis	29	16	16

Transitways

This Alternatives Analysis did not assume, nor recommend installation of dedicated transitway within the Western Extension. Based on a review of programmed capital projects aligning with Western Extension alternative routing, there may be segments of existing and planned roadways (ex – Davis Drive) that could physically accommodate conversion of an outside travel lane for RBAT use while maintaining a minimum of 2 travel lanes in each direction. However, the space would be underutilized due to the low frequency of the proposed rapid bus service and high levels of peak period congestion in the corridor.

OPERATING PLAN

This operating plan details the assumptions surrounding final alternatives developed for the rapid bus service operating within the Southern (Garner to Clayton) and Western (Cary to RTP) Extensions. Service operating parameters at opening year of deployment (beyond 2030), including how long the service operates each day (span), as well as how often it runs (frequency) are described below. Additional discussion provides context and a high-level operational assessment of how rapid bus service assumptions may interact with transit priority treatments within the extensions and core BRT segments, as well as potential effects on vehicle and station area design specifications.

For the purpose of this evaluation of alternatives, rapid bus service assumed independent utility, operating as a separate service from core Wake BRT between Raleigh, Cary, and Garner. Rapid bus passengers would be required to transfer to core BRT vehicles at Downtown Cary and Garner Station termini. However, this analysis does not preclude the buses from the Core BRT alignments onto the rapid bus extensions. This operational assessment also considered the circumstances for the planning horizon of 2050 to one day transition rapid bus service into a seamless extension of core BRT service.

SPAN AND FREQUENCIES

Since the Southern and Western Extensions serve different regional travel markets, operating plans have been tailored for these corridors. At revenue opening, weekday service for both extensions will operate all day between 5 a.m. and midnight with peak period service (5 a.m. to 8 a.m. and 3 p.m. to 7 p.m.) generally provided at higher frequencies than off-peak service. Rapid bus alternatives are assumed to operate at service frequencies and hours of operation as summarized in Table 8.

Table 8 Southern and Western Extension Spans of Service and Frequencies

Service Days	Time Period	Hours	Frequency Headways	
			Southern Extension	Western Extension
Weekday	AM Peak	(5 a.m. – 8 a.m.)	30 min.	20 min.
	Midday	(8 a.m. – 3 p.m.)	60 min.	40 min.
	PM Peak	(3 p.m. – 7 p.m.)	30 min.	20 min.
	Evening	(7 p.m. – 12 a.m.)	60 min.	40 min.
Saturday	All Day	(6 a.m. – 12 a.m.)	60 min.	40 min.
Sunday	All Day	(8 a.m. – 9 p.m.)	60 min.	40 min.

Differences in all-day travel markets and patterns within the more densely populated and developed Western Corridor informed recommendations for more frequent peak period service than the Southern Corridor. Peak period frequencies were doubled to achieve the off-peak frequencies identified below. A maximum off-peak frequency of 60 minutes was established for both weekday and weekend service.

INTEROPERABILITY WITH WAKE BRT SERVICE TO DOWNTOWN RALEIGH

This operational assessment considered the potential for rapid buses to provide one-seat ride service to Downtown Raleigh as regional travel markets evolve in the future. In such a case, the Wake BRT Southern and Western Corridors include construction of various sections of dedicated transitway that may be utilized by rapid bus vehicles.

This operational assessment included considerations relevant to the calculation of potential travel times, peak fleet requirements, and annual revenue hours for cost estimating purposes only. Determining other specific benefits, impacts, and tradeoffs of one-seat ride operations were not within the scope of this study.

Wake BRT Transitways

The assumptions for rapid bus service in the horizon year (2050) include vehicles utilizing Wake BRT transitway infrastructure improvements to provide one-seat ride service from extension termini at the future HUB at RTC (Western Extension) and the East Clayton Industrial Area (Southern Extension) to downtown Raleigh. Transitway configuration types include:

- Mixed Traffic
- Right, Business Access, and Transit (RBAT) Lanes
- Dedicated Median Transitway - one lane in each direction without passing lanes

Southern Corridor and Extension

The 5.1-mile Southern Corridor BRT features approximately 3.8 miles of transitway between downtown Raleigh and Garner Station. Ongoing design of transitway treatments for the Southern Corridor BRT (Raleigh to Garner Station) has segmented the corridor into three (3) distinct sections having different transitway configurations with elements to guide and facilitate BRT vehicle transitions between treatment types (Figure 11).

Segment 1

- RBAT lanes along Wilmington and Blount Streets to South Street and continuing on Wilmington Street to City Farm Drive/Keeter Center Road.
- BRT operates in mixed traffic for short segments of South Street and Salisbury Street as it enters/leaves downtown.

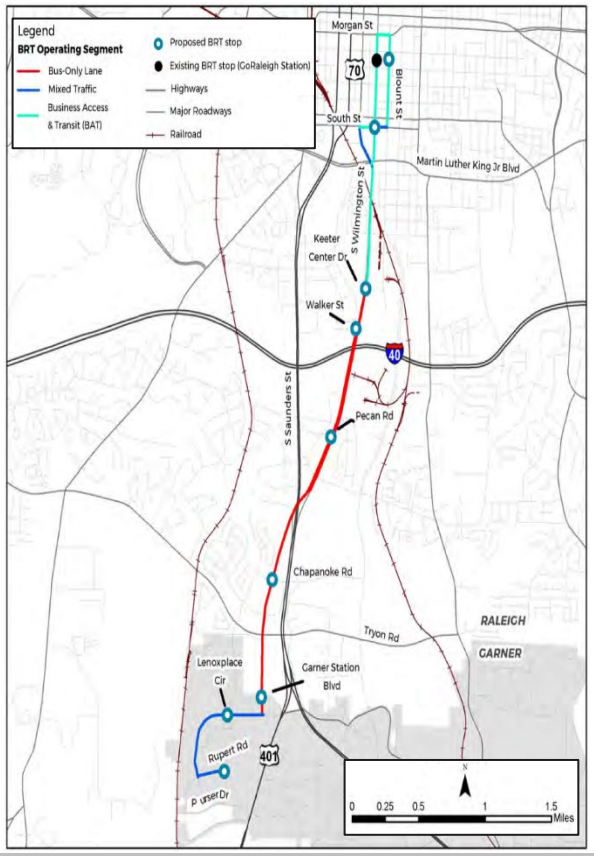
Segment 2

- Dedicated Median Transitway along S Wilmington Street from City Farm Drive/Keeter Center Road to Garner Station Boulevard.
- This includes a short segment operating in mixed traffic along the S Wilmington Street flyover of S Saunders Street before entering a newly constructed extension of S Wilmington south of Chapanoke Road to a planned tie-in at Garner Station Boulevard.

Segment 3

- Mixed traffic operation between Garner Station Boulevard and Rupert Road terminus.

Figure 11 Wake BRT Southern Corridor Transitways



The operational assessment of rapid bus extension alternatives along the US 70/US 70 Business alignment assumed benefits of the following transit speed and reliability infrastructure improvements:

- TSP and queue jump opportunities corridor wide.
- Bus On Shoulder System (BOSS) opportunities between Greenfield Parkway and Roberson Street.
- Transit acceleration/deceleration lane opportunities at the US 70 and Vandora Springs Road interchange.

Rapid buses approaching Garner Station utilizing alignment option G1 – Fayetteville Road, or G2 – Garner Station Boulevard have options of connecting directly with core BRT service at the Rupert Road terminus or Garner Station Boulevard before entering the dedicated transitway heading north for continued through service to Raleigh.

Western Corridor and Extension

The Wake BRT Western Corridor is approximately 12 miles long between termini at Downtown Cary and downtown Raleigh. Ongoing design of transitway treatments has segmented the corridor into several sections having different transitway configurations with elements to guide and facilitate BRT vehicle transitions between treatment types. This corridor will include median-running fully dedicated transit lanes, side-running RBAT lanes, and buses operating in mixed traffic lanes as follows and illustrated by Figure 12 and Table 9.

- Four (4) segments of the Western Corridor utilize dedicated median-running transitways for a total of approximately 6.4 miles.
- RBAT Lanes are proposed along two segments of the alignment totaling almost 2 miles of lane striping.
- BRT operates in mixed traffic for approximately 2.4 miles across three different segments of the alignment.

Rapid bus service did not assume nor recommend installation of dedicated transitway within the Western Extension.

Figure 12 Wake BRT Western Boulevard Corridor Transitway Types

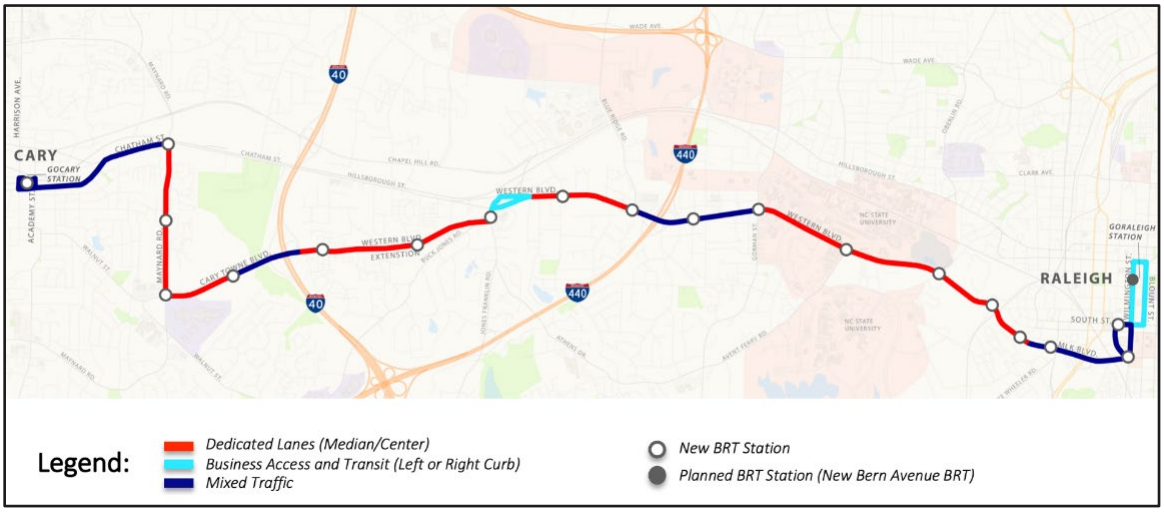


Table 9 Wake Western BRT Corridor Transitway Types (by Roadway)

Mainline	From†	To†	Transitway	Length (Mi.)
E Chatham Street	Downtown Cary	SE Maynard Drive	Mixed Traffic	1.5
Cary Towne Boulevard SE Maynard	E Chatham Street	Trinity Road	Dedicated Median	1.6
Western Boulevard	Trinity Road	Eastern approach to I-40	Mixed Traffic	0.5
Western Boulevard	Eastern approach to I-40	Jones Franklin/Buck Jones Roads	Dedicated Median	1.4
Western Boulevard, Hillsborough Street	Jones Franklin/ Buck Jones Roads	Powel Drive	RBAT	0.7
Western Boulevard	Powell Drive	Blue Ridge Road	Dedicated Median	0.8
Western Boulevard	Blue Ridge Road	Whitmore Drive / Clanton Street	Mixed Traffic	0.8
Western Boulevard	Whitmore Drive/ Clanton Street	S Saunders Street	Dedicated Median	2.6
Martin Luther King Jr. Boulevard	S Saunders Street	Wilmington Street	Mixed Traffic	1.1
Wilmington, Blount Streets	Martin Luther King Jr. Boulevard	Morgan Street (DT Raleigh)	RBAT	1.2

† - Limits of core BRT transitway treatments, including transition areas are approximate and subject to further refinement during Final Design.

BRT Station Connectivity and Compatibility

Horizon year (2050) planning for a one-seat ride rapid bus service from Powhatan and the Hub at RTP to downtown Raleigh assumes vehicles operate on Wake BRT transitways and connect seamlessly with station platform configurations within core BRT project limits. At BRT stations located in segments with a dedicated median transitway, station boarding platforms may be configured for either center island platform or side platform boarding and alighting, based on available ROW and other conditions of the built environment. Center island platforms require vehicles with left-door boarding and alighting capabilities, while side platform boarding accommodates traditional (right-door boarding) vehicles.

Assuming Southern and Western rapid bus vehicles are permitted to operate within (and are compatible with) all BRT transitway and station platform configurations, they also have an operational choice as to which core BRT stations to serve. Three potential (3) types of rapid bus station-stop patterns within core BRT limits were identified by the project team:

- **Saturated service:** rapid bus service would serve every BRT station, regardless of its location within the BRT transitway, or curbside along RBAT lanes or general purpose lanes.

- **Limited service:** rapid bus service would stop at a 'select' set of BRT stations that would only include major route connection points and activity centers.
- **Express service:** rapid bus service would travel non-stop from the extension termini of Cary and Garner to downtown Raleigh and would only serve one or two stations downtown.

For the purpose of estimating potential travel times and future ridership, the one-seat ride rapid bus service assumed limited stop operations to represent a balanced approach to transit travel speed optimization with serving market connectivity needs. Stations served were selected based on their proximity to key destinations as well as for transit network transfer opportunities.

Rapid bus frequencies proposed are lower than core BRT service and are assumed to be scheduled offset from core BRT arrivals as to avoid negative interactions with core BRT service. This includes minimizing the chances of buses with different scheduled station-stop patterns needing to wait behind other buses. If rapid bus vehicles are not permitted to operate within BRT transitways or equipped to serve left-door boarding stations a median-running dedicated transitway, alternative stop-spacing patterns would be developed in mixed-traffic using general purpose lanes.

One other operational option is to extend every second or third core BRT trip on the Rapid Bus corridor, so that customers will not need to transfer at Garner Station or Cary Station. Due to the potential complexity of this from a scheduling perspective, as well as understanding the potential service reliability implications, further study is recommended to refine associated operational issues.

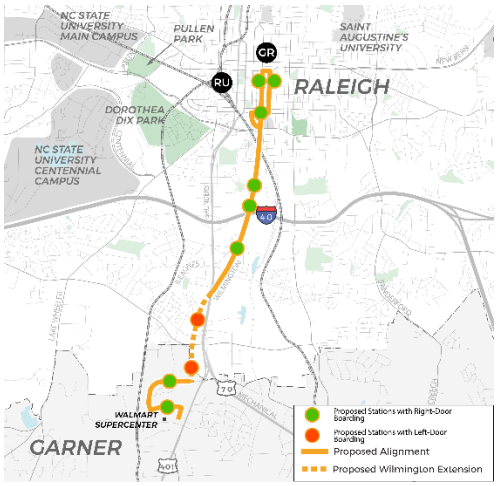
Southern Extension

Rapid bus vehicles are assumed to utilize the BRT transitway and RBAT lanes to downtown Raleigh shown in Figure 13, but with limited service at the four (4) core BRT stations listed below.

All proposed stations would be configured for right-door boarding, eliminating the need for customized left-door CNG vehicles.

However, vehicle specifications would be re-evaluated should future travel trends and mobility demands dictate additional core BRT stations are served during one-seat ride operations.

Figure 13 Wake Southern BRT Station Platform Boarding Configuration

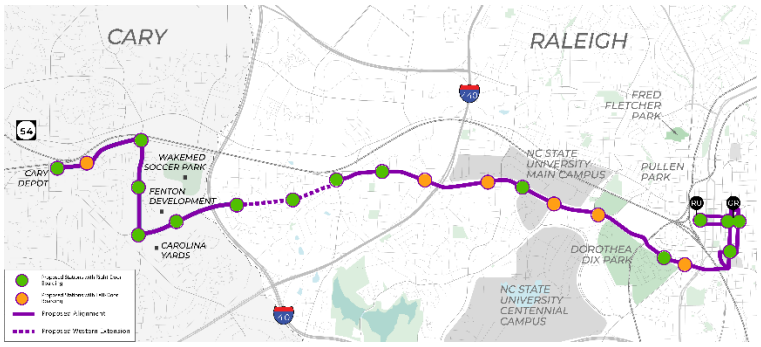


Core BRT Station Location	Transitway Type	Platform Boarding
Garner Station (terminus)	Mixed traffic	Right Side
Layden Street/Pecan Road	Median Transitway	Right Side
City Farm Road/Keeter Center Drive	RBAT Lane	Right Side
Downtown Raleigh	RBAT Lane	Right Side

Western Extension

Rapid bus service is assumed to utilize the BRT transitway and RBAT lanes to downtown Raleigh shown in Figure 14. Vehicles will serve five select core BRT stations east of Downtown Cary including downtown Raleigh and are summarized below.

Figure 14 Wake Western BRT Station Platform Boarding Configuration



At least one proposed core BRT station is assumed to feature left-door boarding within a median transitway, requiring specialized CNG buses. Rapid bus service to additional or alternate core BRT stations may be considered in future project development activities and may require re-evaluation of vehicle specifications.

Station Location	Transitway Type	Platform Boarding
Downtown Cary (terminus)	Mixed traffic	Right Side
Maynard Road/Cary Towne Boulevard	Mixed traffic	Right Side
Jones Franklin Road/Buck Jones Road	RBAT Lane	Right Side
Avent Ferry Road	Median Transitway	Left Side
Downtown Raleigh	RBAT Lane	Right Side

SUPPORTIVE TRANSIT NETWORK MODIFICATIONS

The rapid bus extensions are envisioned as regional services providing connections to both existing and planned local bus service for circulation, as well as regional transit transfer facilities for expanded travel options across the region. Local and regional bus connections are available for some rapid bus station locations co-located at proposed CRT stations and regional transit facilities (transfer centers, park and rides, etc.) within the Southern and Western Extensions. In addition, existing and future local circulators were assumed to provide first/last mile connectivity at rapid bus stations to access nearby destinations and major employers.

For purposes of this analysis, the horizon year regional transit network included in the Triangle Regional Model was assumed to be in place. The horizon background transit network consists of several local and regional bus services provided by GoCary, GoRaleigh, and GoTriangle bus service operators, illustrated Figure 16 and Figure 17, as well as circulators identified within the following section. These services were included within horizon year ridership forecasts to inform future planning efforts and to provide rapid bus riders with better connecting mobility services.

The updated Wake Transit Plan, covering network recommendations for the 2030 planning horizon, was under development and pending local adoption throughout the process of this

Alternatives Analysis evaluation. Recommendations and findings of the plan are not included. Future regional transit network changes will be consistent with future updates to the Wake Bus Plan.

Local fixed route service and first/last mile mobility providers (third parties) are assumed to be operational to connect rapid bus passengers with other corridor destinations by opening year. Finalization of the circulator operating profile, routing, and local stop connections will take place following adoption of a locally preferred alternative (LPA). However, it is generally assumed, particularly for ridership modeling purposes, that circulator service would be aligned with service levels of rapid bus operations to provide convenient transfer opportunities. The ownership and operating responsibilities for circulators were not defined by this Alternatives Analysis.

Southern Extension

Fixed Route Transit

GoRaleigh currently operates three routes on the western side of the Southern Corridor study area: Route 20-Garner, 7-South Saunders, and 40X-Wake Tech Express. Route FRX also runs through the study area but does not stop in Garner. The *Garner Transit Study (2020)* also recommended two new fixed routes within its jurisdictional boundaries (Figure 16), which will connect the Southern Corridor BRT terminus in Garner Station with nearby commercial and retail destinations, as well as Forest Hills Shopping Center, Downtown Garner, and the Amazon Fulfillment Center on Jones Sausage Road.

There are three potential CRT stations planned within the Southern Extension study area: Downtown Garner station, Auburn Hills station, and Powhatan station. The Downtown Garner station is approximately located at the intersection of NCRR and Benson Road and would be served directly by local fixed routes (above). Connectivity to Auburn Hills station would deviate rapid buses from US 70 Business via Auburn Knightdale Road only during CRT operating hours (up to 4 trains per day), requiring 2 morning/evening peak trips to divert and provide connections. The proposed Powhatan station is located approximately two miles south of the NC 42 park and ride at approximately Gordon Road/GLP One Way loop and the NCRR corridor.

Figure 15 Southern Extension Alternatives and Network Connections

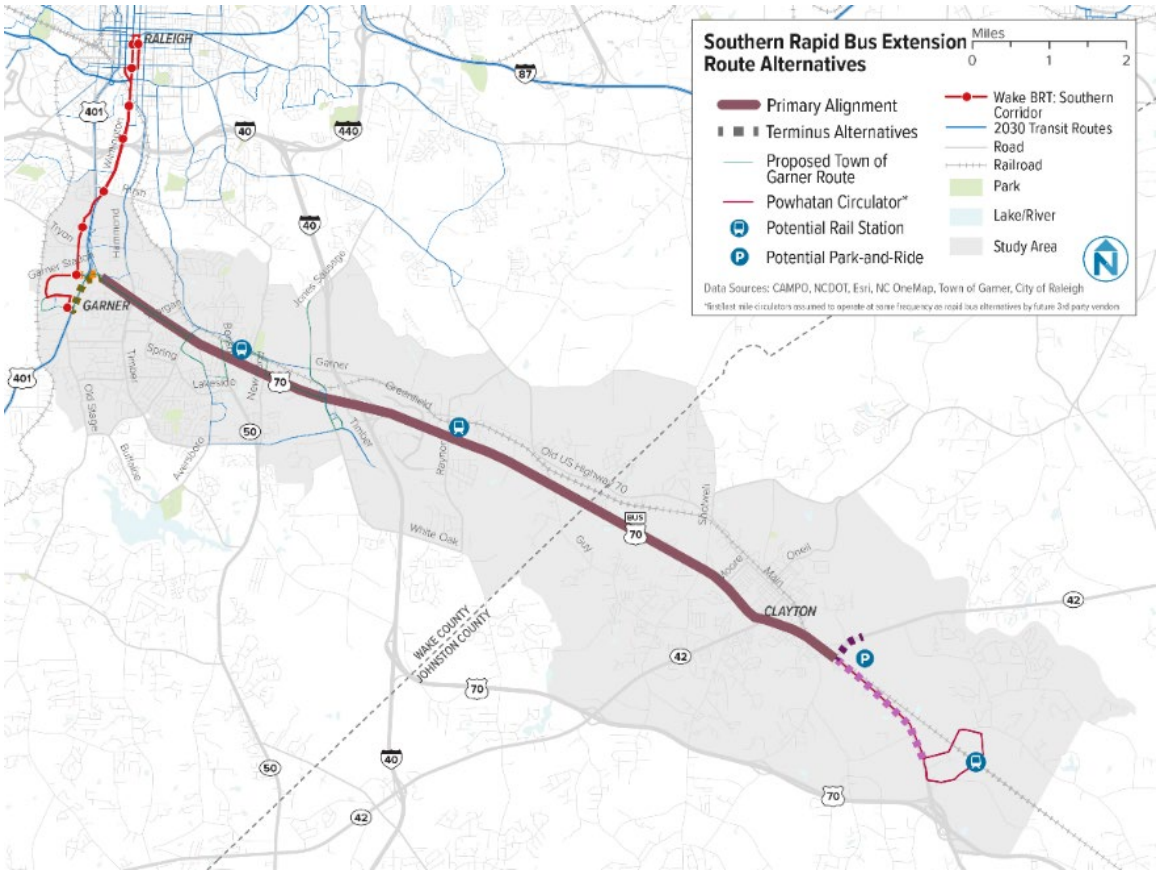
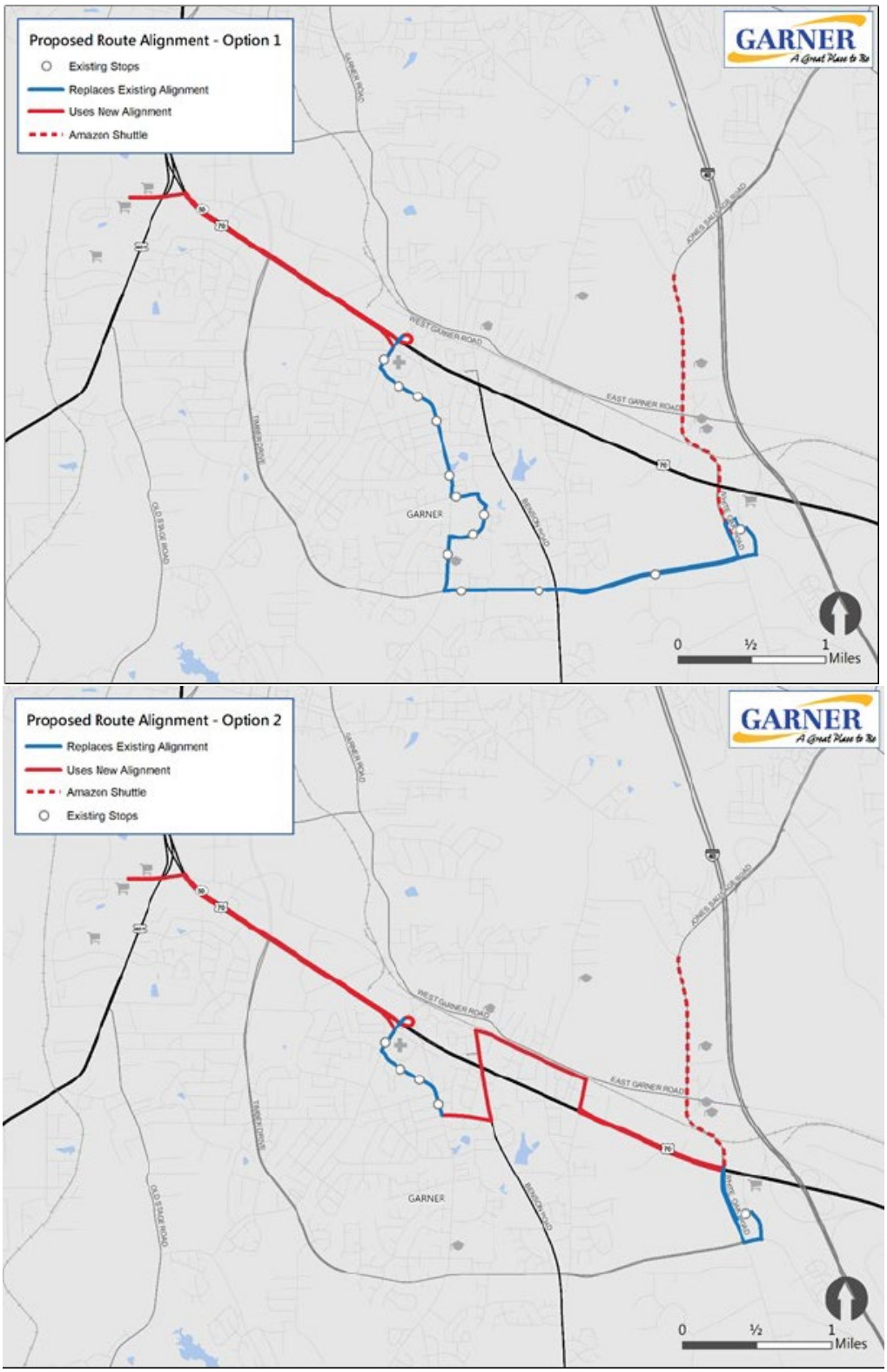


Figure 16 Town of Garner (Proposed) Transit Fixed Routes



First-Last Mile

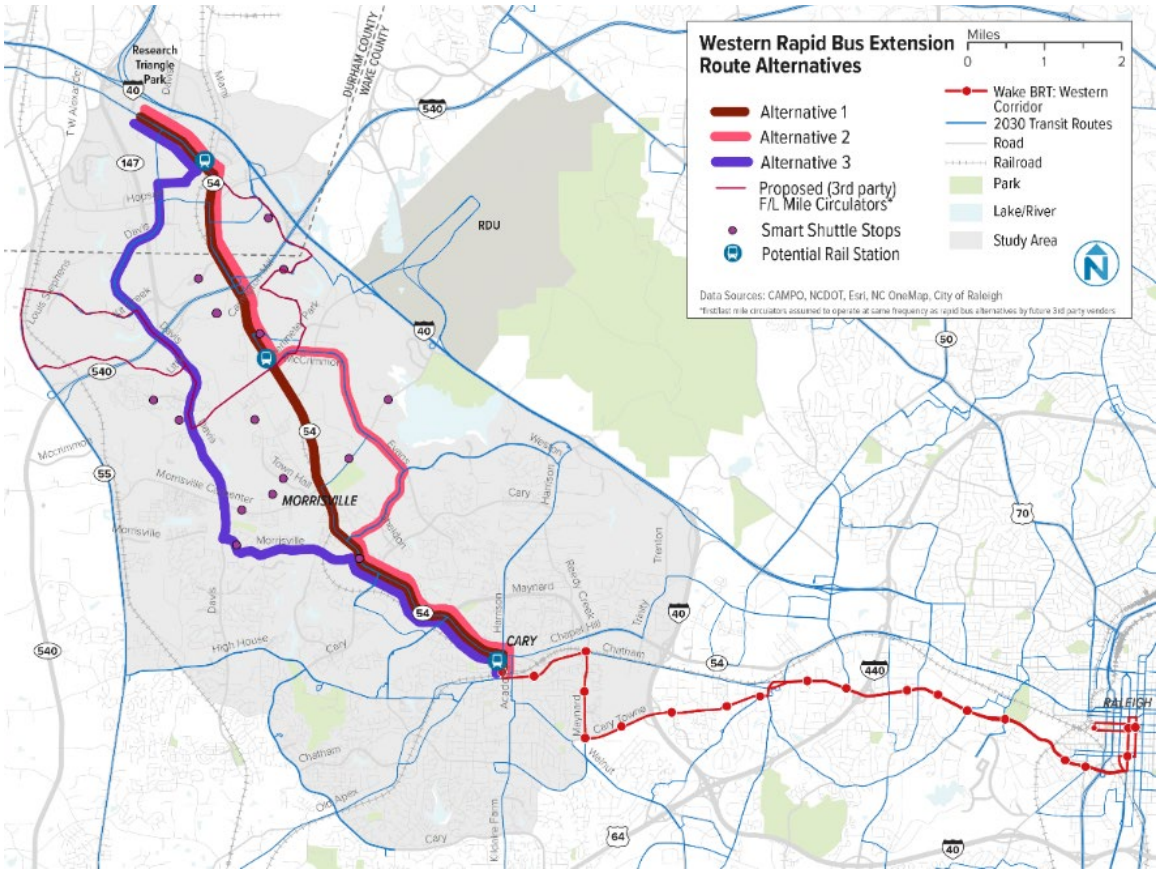
To support the Clayton terminal option (C1) at the proposed park and ride at NC 42, a new third-party circulator is assumed to provide extended connections between the park and ride, East Clayton Industrial Area (ECIA), and (future) Powhatan CRT station. This circulator is assumed to operate at 30-minute headways all day while the rapid bus service is in operation, providing employee shuttle service to major employers such as Grifols and Novo Nordisk.

Western Extension

Fixed Route

In the horizon year regional transit network, the existing Regional Transit Center (RTC) is relocated to a new site along the north side of NC 54/Slater Road, west of NCRR. The local fixed route bus network is realigned in response to the new location as shown in Figure 17. Of the GoCary bus routes and three GoTriangle Routes serving the study area in the horizon year, only GoTriangle Route 310 is assumed to be replaced by Western Extension Alternative 2. No fixed routes were modified in response to implementation of extension Alternatives 1 or 3.

Figure 17 Western Extension Alternatives and Transit Network Connections



There are three potential CRT stations planned within the Western Extension study area: Cary station, Morrisville station, and the future RTC. Cary CRT station is proposed at the site of the (future) Cary Multimodal Center, just west of existing Cary Station and is served directly by all alternatives (1, 2, 3). Morrisville CRT station at proposed at McCrimmon Parkway and NCRR and

Alternatives 1 and 2 would pass by the station on NC 54. The future RTC is located on NC 54/Slater Road, west of Miami Boulevard and served by all three alternatives before terminating at the HUB at RTP.

First/Last Mile Circulation

Two on-demand mobility services currently operate within the Western Extension study area. RTP Connect is a pilot program developed through a partnership between Research Triangle Park and GoTriangle (Figure 18). The program aims to serve commuting RTP employees and requires registration to receive a subsidized cost for use of on-demand (third-party vendor) trips within the service boundary. Morrisville currently offers a Smart Shuttle Service (Figure 19) to residents that is assumed to remain in operation through the 2050 horizon year. The service provides residents, commuters, and visitors free and on-demand transit to 15 locations throughout Morrisville as well as the RTC.

Figure 18 RTP Connect On-Demand Service

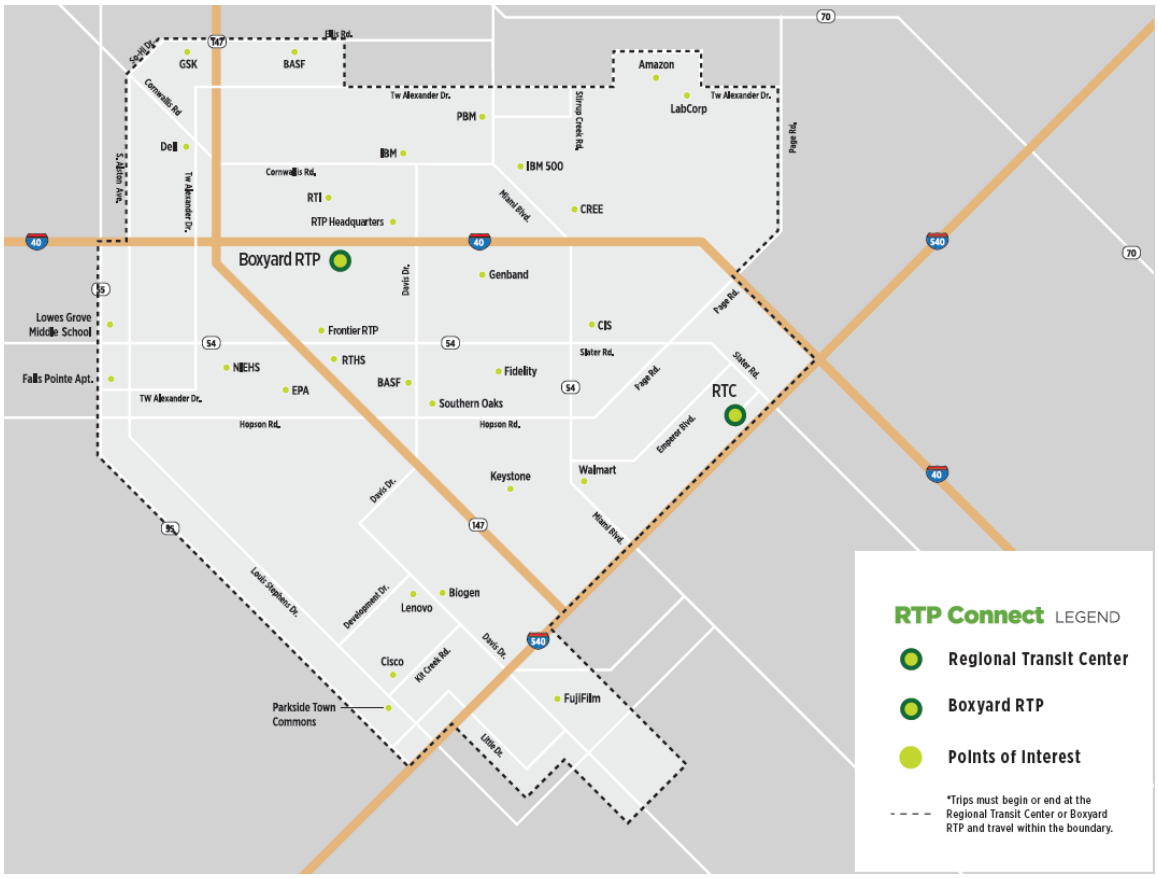
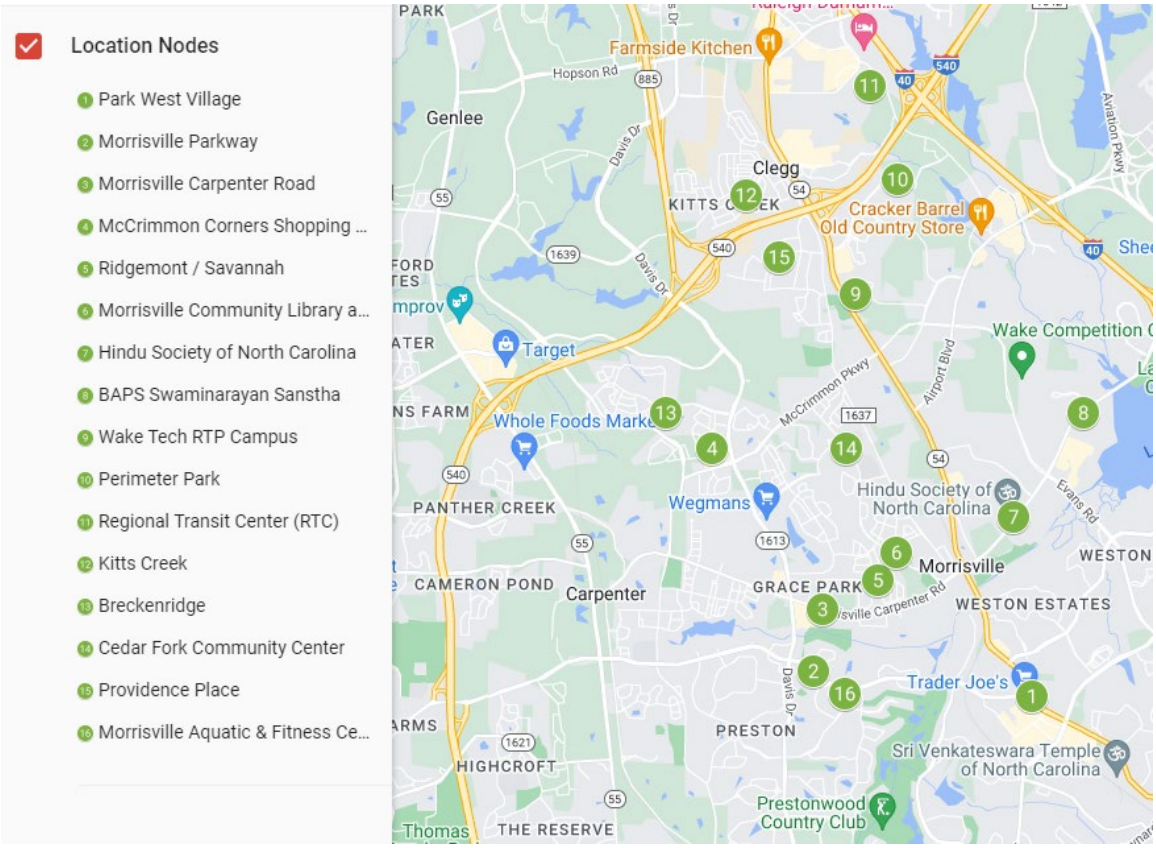


Figure 19 Morrisville Smart Shuttle Stop Locations



In addition to the on-demand mobility, two (2) additional circulators are proposed to operate in tandem with the rapid bus service in the Western Extension (Figure 17). Both circulators follow a fixed alignment with one terminus anchored at the proposed Morrisville CRT station and would operate at 20-minute headways all day, while the rapid bus is in operation.

One circulator would operate between the Morrisville CRT station and the future RTC primarily along highly commercial segments of McCrimmon Parkway, Perimeter Park Drive, Carrington Mill Boulevard, and Slater Road. The other circulator is proposed to operate between the Morrisville CRT station and major regional employers at corporate campuses on Kit Creek Road and Little Drive. The route connects Morrisville residents outside of the NC 54 corridor with local destinations such as the Parkside Town Commons retail center located at O'Kelly Chapel Road/Little Drive as well as major RTP employers via McCrimmon Parkway, Davis Drive, Little Drive, Kit Creek Road, and NC 55.

CONCEPTUAL TRAVEL TIMES

This section provides an overview of the assumptions used for estimating peak and off-peak period travel times for each of the final alternatives for the Southern and Western Extensions. Travel times were inputs for ridership modeling as well as calculation of service statistics were used in estimating the annual operating and maintenance costs of providing rapid bus service.

ASSUMPTIONS

Several assumptions are included in the estimated travel times. These include conditions while vehicles are in motion, assumptions made about the time waiting for passenger movements at stations, and assumptions made about future travel conditions.

Distances

Station to station and intersection to intersection distances were manually measured with Google Maps and Google Earth as well as geographic information systems (GIS) analysis. Distances were measured on roadway centerlines and from the center of each station or intersection to negate differences of station placement by direction.

Posted Speed Limits

Posted speed limits have been sourced from data contained within CAMPO's 2020 TRM. Posted speeds were available for all major segments of concept alignments and were verified with field work and Google Street View where needed.

Stations & Dwell Times

Rapid bus stations are assumed to be sited (and of the length needed) to accommodate articulated buses. Rapid bus station dwell times are assumed to be of two typologies based on assumed passenger volumes: "low" dwell stations with 15 seconds of passenger dwell time and "high" dwell stations that use 20 seconds of dwell time. Higher dwell stations are assumed at major connection or terminal locations such as Downtown Cary, RTP, the NC 42 park and ride station, the Powhatan CRT station, or locations with a high likelihood of having many passengers, such as at Wake Technical Community College.

Transit Priority Improvements

Transit improvements located at signalized intersections such as transit signal priority and queue jump infrastructure were assumed to be included in targeted locations to reduce delay due to traffic congestion and assist in maintaining a consistent schedule into the future for rapid bus service.

- **Transit signal priority:** has been assumed at all signals and is assumed to reduce the red time that buses incur. Reductions in delay are based on information from the Transit Cooperative Research Program (TCRP) Report 118.
- **Queue jumps:** have been assumed where there are right-turn only lanes or lane drops with space across the intersection that would allow buses to merge into general purpose through lanes. Some assumptions have also been made based on future roadway configurations based on input from local stakeholders.
- **Bus on shoulder system (BOSS):** BOSS use has been assumed for a segment of the US 70/US 70 Business between Greenfield Parkway and Roberson Street in Clayton. Maximum

allowable speeds in BOSS segments is assumed to be 35 mph, as specified within the *BOSS Implementation Blueprint,* as well as with general national standards.

Signal Delay

Signalized intersection delay assumes that on average some amount of signal delay will occur at every signal. This delay time is a function of the class of the intersection based on signal cycle length, application of transit priority treatments, and the level of service (LOS) of the intersection. LOS for current (2020) and future (2040) conditions were based on highway network inputs in CAMPO's 2020 and 2045 TRM, specifically traffic volume to roadway capacity (v/c) ratios converted to assumed LOS.

Vehicle Acceleration and Deceleration Rates

Rates used for this analysis for acceleration are a constant 1.5 miles per hour per second (mphps) from 0 to 25 mph with a decreasing rate until maximum speeds, and a constant 2.0 mphps for deceleration. Though specific rates for articulated and standard-length CNG vehicles planned for Wake BRT Program were not yet available, these rates generally fall in line with bus procurement guidelines.

Driver Layover and Recovery

A 15 percent layover has been assumed at both ends, totaling to a 30 percent layover round trip.

Travel Time Variation & Future Conditions

Estimating travel times involves applying a reasonable set of assumptions regarding traffic flow to approximate as best as possible for both current and forecasted conditions. For this analysis, travel times were estimated for the peak period (generally 6 a.m. to 9 a.m. and 3 p.m. to 7 p.m.) and for off-peak periods. Peak periods will represent times of the day when traffic congestion is worst and subsequent travel times are longest, requiring additional service requirements, such as additional buses, to provide the same level of service as in off-peak periods.

Peak period congestion factors were based on traffic volume to roadway capacity (v/c) ratios from CAMPO's TRM. For current conditions, CAMPO's 2020 TRM's v/c ratios were used and its 2045 forecasted v/c ratios were used for future conditions.

Future year 2045 conditions are depicted in Figure 20 for the Southern Corridor. Relevant roadway segments above capacity include much of US 70/US 70 Business between Garner Station and Guy Road.

Future conditions for the Western Corridor are shown in Figure 21. Relevant roadway segments above capacity include NC 54/Chapel Hill Road between Morrisville and Park West Village, segments of Evans Road, and several segments of Davis Drive.

Volume-to-capacity ratios were available at the segment level and assumptions were made as to the level of service (LOS) at subsequent intersections along conceptual alignments. These LOS values were then used to adjust the potential maximum speed a bus would be able to travel. For both years, v/c data fit into three categories of capacity: below, at, or above capacity. These categories roughly correspond to three LOS categories that generally describe roadway congestion conditions. To streamline analysis, three levels of LOS were coded into the travel time models and are summarized in Table 10.

Off-peak travel times assumed free-flow conditions with roadways "below capacity" and roadway segments were assigned a LOS of B throughout to approximate free-flow conditions for buses encountering minor amounts of traffic "friction.".

Table 10 Volume-to-Capacity and Level of Service Model Assumptions

Volume-to-Capacity (v/c) Ratio	Equivalent Level of Service (LOS)	Coded LOS
Below Capacity (v/c < 0.8)	A - B	B
At Capacity (0.8 < v/c < 1.0)	C - D	D
Above Capacity (v/c >1.0)	E - F	F

Figure 20 Southern Corridor Rapid Bus Extension 2045 Traffic Congestion

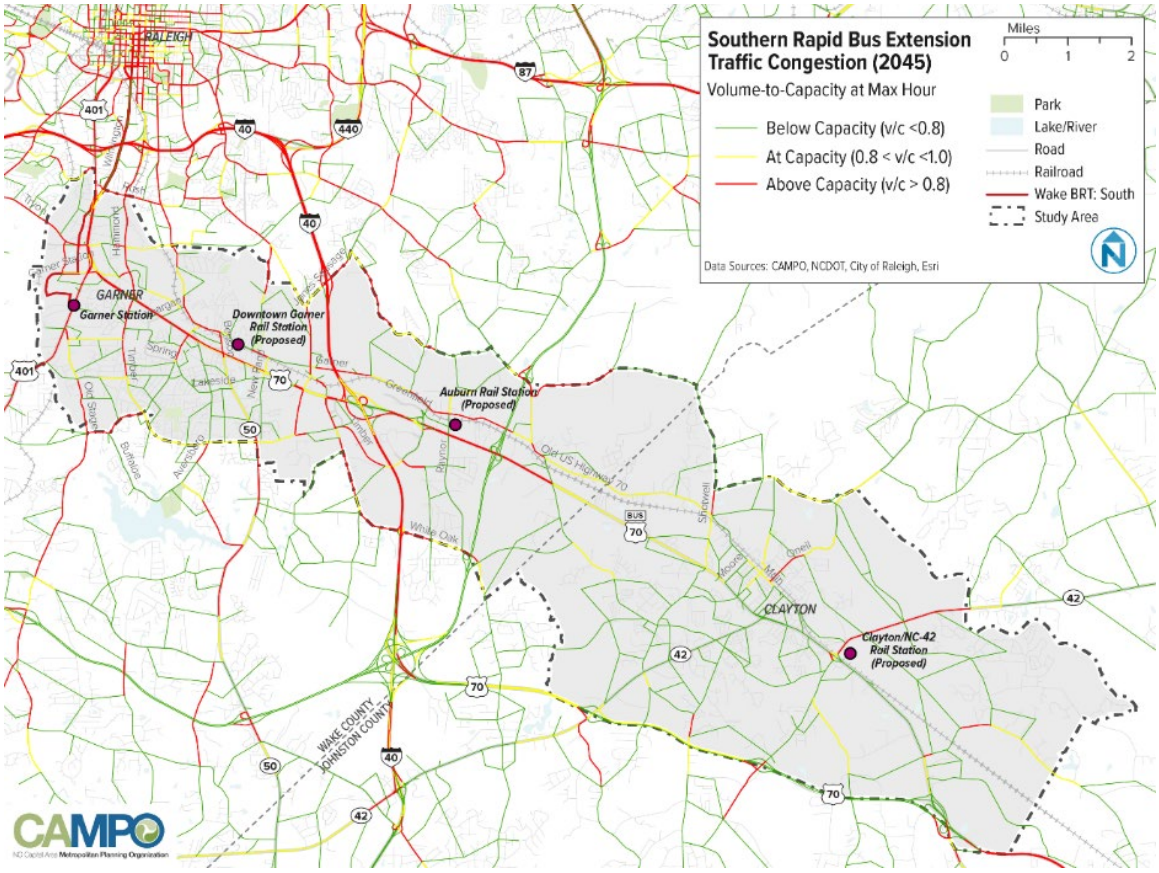
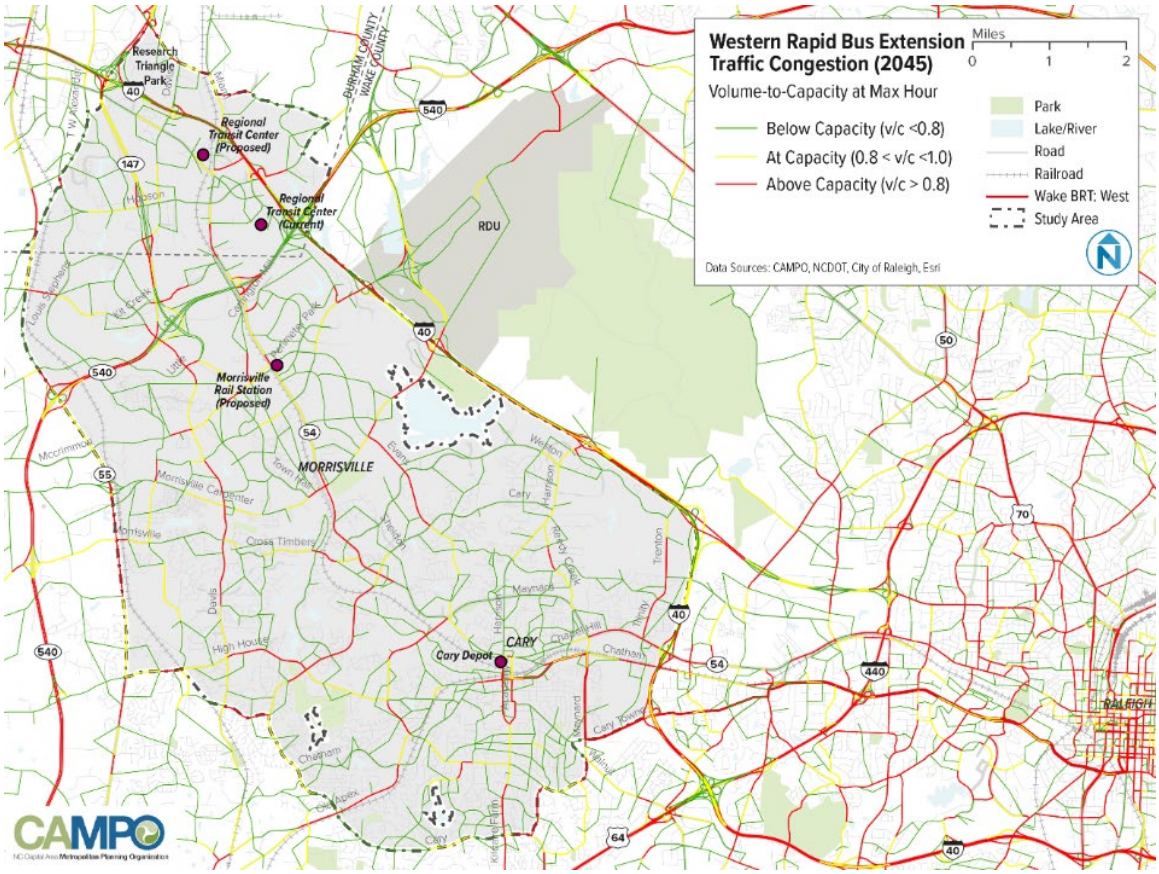


Figure 21 Western Corridor Rapid Bus Extension 2045 Traffic Congestion



TRAVEL TIME ESTIMATES

Travel time estimates were created for both Southern and Western Corridors and for both peak period and off-peak period conditions. Times were parsed into three components:

- Running time, or the time spent in operation between stations excluding the amount of delay and dwell time.
- Delay time accounting for signalized delay at intersections due to cycle times and varying amounts of estimated and forecasted traffic congestion, and
- Dwell time, or the time spent waiting at stations to serve passengers.

Southern Extension

Since the Southern Extension primary alignment along US 70/US 70 Business is shared by all potential end-to-end alternative combinations, data points used in the detailed evaluation alternative endpoints compared only the characteristics of those terminal connections (where appropriate). Individual travel time estimates were prepared for each endpoint routing alternative, however limited resources did not support the generation of ridership forecasts to assess all possible end-to-end alignment permutations. In order to establish a reasonable range of potential transit travel times in the Southern Extension, the shortest and longest possible routes were assumed.

Alternative Alignment 1: Garner Station Blvd (G2) to NC 42 (C1)

Alternative Alignment 2: Fayetteville Rd (G1) to Powhatan Rd (C2)

For both end-to-end alignments, an additional travel time estimate was prepared to include an en route deviation to the proposed Auburn Hills CRT Station. The total one-way length of alternatives ranged from approximately 13.9 miles to 18.6 miles.

Peak period travel ranged from around 42 minutes to 46 minutes and average speeds were between 21 and 23 miles per hour. Offpeak travel times for these options ranged from just under 30 minutes to just over 35 minutes with average speeds of around 30 miles per hour. All alternatives experienced similar levels of signalized delay (around 5 minutes) and dwell times of around 2 minutes in total.

Additional considerations were given for the distance and time that would be required for rapid buses to provide one-seat ride service to downtown Raleigh. Assuming a maximum speed of approximately 20 mph for the core Southern Corridor BRT (roughly 5 miles) would yield a one-way run time of approximately 16.5 minutes, including station dwell times.

Table 11 Southern Corridor Peak Period Travel Time Estimates Summary

Alternative	Mileage	Peak Period		Travel Time Component		
		1-way Total	Avg Speed	Run	Delay	Dwell
NC-42 P&R to Garner Station Blvd	13.9	0:38:09	21.9	*0:32:04*	*0:04:00*	*0:02:05*
NC-42 P&R to Garner Station Blvd via Auburn Hills CRT Station	14.6	0:39:36	22.1	*0:33:16*	*0:04:00*	*0:02:20*
Powhatan Rd to Fayetteville Rd (Walmart)	17.9	0:47:25	22.7	*0:39:55*	*0:05:05*	*0:02:25*
Powhatan Rd to Fayetteville Rd (Walmart) via Auburn Hills CRT Station	18.6	0:48:53	22.9	*0:41:07*	*0:05:05*	*0:02:40*
Fayetteville Rd to Downtown Raleigh	*4.6*	*0:16:30*	*16.8*	*0:12:56*	*0:02:14*	*0:01:20*

Western Extension

Three final rapid bus alternatives were developed to extend service from Downtown Cary to the Hub at RTP.

- **Alternative 1:** NC 54/Chapel Hill Road
- **Alternative 2:** NC 54/Chapel Hill Road, Evans Road/McCrimmon Parkway
- **Alternative 3:** Davis Drive (via NC 54/Chapel Hill Road, Morrisville Parkway)

The total one-way length of alternatives ranged from approximately 10 miles to 12.4 miles, with peak period travel times between just over 28 minutes and approaching 34 minutes. Projected average speeds were over 21 to almost 23 miles per hour, with Alternative 2 estimated to have a slightly higher speed than Alternatives 3 and 1, respectively. The overall length of the alignments was a factor in total 1-way travel time, however, as Alternative 1 is expected to have the fastest trip time by about two to five minutes. The most signalized delay was encounted on Alternative 2 along with more stations and therefore more station dwell time.

Table 12 Western Corridor Peak Period Travel Time Estimates Summary

Alternative	Dist.	Peak Period		Travel Time Component		
		1-way Total Time	Avg Speed	Run	Delay	Dwell
Alt 1: NC 54/Chapel Hill Road	10.0	0:28:19	21.3	*0:21:26*	*0:03:48*	*0:03:05*
Alt 2: Evans Road/McCrimmon Parkway	11.5	0:30:34	22.7	*0:22:08*	*0:04:51*	*0:03:35*
Alt 3: Davis Drive	12.4	0:33:39	22.1	*0:22:34*	*0:04:40*	*0:02:35*
Hub RTP to Downtown Raleigh	*12.0*	*0:26:22*	*27.3*	*0:21:16*	*0:03:26*	*0:01:40*

OPERATING STATISTICS AND COSTS

Operating plan assumptions along with results of travel time estimates informed the development of assumed fleet requirements and service operating statistics (daily and annual fleet requirements, revenue hours and miles) for both corridors.

Operating Statistics

The average daily operating statistics of rapid bus corridors were calculated by determining the number of vehicles required to achieve the desired service frequencies during peak and off-peak periods identified in the Operating Plan within this document. The number of buses operating in each period is multiplied by the span of the period (number of hours per day) to calculate the total revenue hours for a given day. For purposes of annualizing daily estimates of service requirements, 255 weekdays, 52 Saturdays and 58 Sundays and holidays were assumed. These daily service requirements or service statistics were used to estimate annual costs related to operating rapid bus shown in Table 13 and Table 14.

Both Southern and Western Extensions were estimated to require four (4) buses during peaks and factoring a 20 percent spare ratio yields a total fleet of five (5) vehicles in both the extensions. Due to the less frequent service profile of the Southern Extension, the longer one-way transit trip time is expected to require the same fleet size to operate as the Western Extension during peak periods.

Although the lengths of Southern Extension alignment alternatives have a variance of several miles, the 30-minute peak/60-minute offpeak frequency still allows for the conservative driver

recovery periods factored into the round-trip travel times. The analysis concluded that either alignment configuration could be operated within the desired frequencies using the same operating fleet. Similarly, the additional revenue miles associated with alternatives extending service to Powhatan Road and the (proposed) deviation to Auburn CRT Station would increase annual revenue miles but would not likely affect annual revenue hours and associated operating and maintenance (O&M) costs.

To assess the potential service statistics for one-seat ride service from Clayton terminus and the Hub at RTP to Downtown Raleigh, independent transit travel time and service estimates were conducted for only the route segments shared with core BRT service. The five-mile Southern Corridor BRT and 12-mile Western Corridor BRT are projected to require three (3) and four (4) vehicles to align with the rapid bus service peak period frequencies, respectively.

Table 13 Southern Extension Rapid Bus Service Statistics

Alternative	(Peak/Off-Peak) Frequency	(Pk/Total) Vehicles	Annual Rev Hrs.	Annual Rev Mi.
NC-42 P&R to Garner Station Blvd	30/60 min	4/5	16,700	246,000
NC-42 P&R to Garner Station Blvd via Auburn Hills CRT Station	30/60 min	4/5	16,700	258,000
Powhatan Rd to Fayetteville Rd (Walmart)	30/60 min	4/5	16,700	284,000
Powhatan Rd to Fayetteville Rd (Walmart) via Auburn Hills CRT Station	30/60 min	4/5	16,700	295,000
Powhatan Rd. to Downtown Raleigh	30/60 min	+3/4	+15,000	+77,000

Table 14 Western Extension Rapid Bus Service Statistics

Alternative	(Peak/Off-Peak) Frequency	(Pk/Off-Pk) Vehicles	Annual Rev Hrs.	Annual Rev Mi.
Alt 1: NC 54 / Chapel Hill Road	20/40 min	4/5	16,700	251,000
Alt 2: Evans Road / McCrimmon Parkway	20/40 min	4/5	16,700	288,000
Alt 3: Davis Drive	20/40 min	4/5	16,700	309,000
Hub RTP to Downtown Raleigh	20/40 min	+4/5	+16,700	+264,000

Maintenance and Storage Facility (MSF) Requirements

For the purpose of estimating potential maintenance and storage facility (MSF) capacity impacts, the effects if implementing rapid bus service are estimated as a percentage of current available

garage space. Assuming the rapid bus Project Sponsor (to be determined following LPA selection) will have sufficient CNG vehicle capacity at an existing MSF at the time of revenue opening. A standard garage is assumed to house and service 250 total vehicles, so for a fleet requirement of five vehicles, amounts to 2 percent of existing space.

Based on the *Wake Transit Bus Maintenance Facility Assessment*, GoRaleigh's Poole Road Operations and Maintenance Facility has a future expansion plan that would have capacity to maintain just over 200 buses. Currently, the facility maintains a fleet of around 103 buses and has parking capacity for 214 buses, however an alternate parking layout could house around 300 buses.

GoTriangle's Nelson Road Operations and Maintenance Facility currently has a much lower capacity than GoRaleigh at 77 standard vehicles and is currently over-capacity. Based on the Wake Transit Bus Maintenance Facility Assessment findings, this facility is currently over-capacity with service vans requiring storage off-site and the total fleet exceeds the current operations and maintenance areas. GoTriangle would need to find additional storage, operations, and maintenance space not only to accommodate their existing fleet but vehicle requirements of the rapid bus project if GoTriangle were to become the project sponsor.

Operating and Maintenance (O&M) Cost

To estimate the potential annual O&M costs of rapid bus service operation, the total annual revenue hours calculated for each alternative were applied to current unit costs for both GoRaleigh and GoTriangle, derived from the ongoing Wake Transit Planning effort. GoRaleigh reported a unit cost per revenue hour of $109.33, and GoTriangle a cost of $143.50 for a standard, 40-foot bus.

Given the similar forecasts for annual revenue hours for alternatives with both Southern and Western Extensions the comparative O&M cost presented in Table 15 illustrates the potential implications of operating rapid bus as a route of independent utility versus a one-seat ride operation to downtown Raleigh, which may contribute to a saturation of service in the core BRT segments.

Table 15 Rapid Bus Alternative Operating & Maintenance (O&M) Cost Estimates

Alternative	Annual Rev Hrs	Annual O&M Cost (GoRaleigh)	Annual O&M Cost (GoTriangle)
Southern Extension	16,700	$1.8 M	$2.4 M
Southern Core+Extension: Clayton to Downtown Raleigh	*31,600*	*$3.5 M*	*$4.5 M*
Western Extension	16,700	$1.8 M	$2.4 M
Western Core+Extension: Hub RTP to Downtown Raleigh	*33,400*	*$3.7 M*	*$4.8 M*

ADDITIONAL CONSIDERATIONS

The development of rapid bus alternatives and their evaluation took place concurrently with the preliminary stages of detailed engineering and architectural design of the Southern and Western BRT Corridors. As such, the anticipated opening year of revenue service for rapid bus alternatives is beyond the 2030 planning horizon of typical transit network short range planning efforts. Therefore, the Operating Plans developed for proposed rapid bus alternatives identified several key operating parameters and conditions where assumptions were made in order to assess potential performance. The considerations below will be further refined and analyzed once an LPA has been selected.

Independent Utility of Extensions or One-Seat Ride Operations

High-level assumptions regarding the independent utility of rapid bus service in the study area were considered within this Alternatives Analysis process. However, a detailed analysis of the comparative benefits, impacts, and tradeoffs of these operating strategies is recommended.

- Requiring rapid bus passengers to transfer to Wake BRT service in Cary or Garner to travel to points closer to Raleigh would place an additional burden on those riders. However, there are incremental financial and operational capacity constraints on the additional resources required to maintain rapid bus headways with longer route lengths and travel times.
- This Alternatives Analysis process was unable to determine the feasibility of operating both core BRT and one-seat ride rapid bus service using a single fleet of vehicles. Appropriate rapid bus service frequencies should be determined in concert with the decision of operating service as an overlay to or an extension of the core BRT at the opening year of service (beyond 2030).
- Final turn-by-turn alignments and service tie-ins at the termini are also important to refine in the case of the Garner Station alternative alignments (G1, G2), where both are found to be viable routing options to connect with the Southern Corridor BRT terminus. There may be potential tradeoffs regarding routing efficiency for continued one-seat ride service to Raleigh along Garner Station Boulevard (G2) due to the out of direction travel and potential traffic queuing issues at the US 70 westbound to US 401 (Fayetteville Road) southbound turn movement (G1).

A detailed concept of operations (ConOps) involving scheduling analyses is recommended to identify and test potential BRT and rapid bus operating strategies, as well as assess station stop-spacing and compatibility with BRT transitway and station platform infrastructure configurations within the core segments in detail.

Project Sponsor and Operator Considerations

Currently, no agency has been specifically identified as the Project Sponsor and eventual operator of rapid bus services on the Western and Southern Extensions. However, likely operators would be either GoRaleigh or GoTriangle due to their transit service operations experience and current provision of service in the metro Raleigh area. For the purposes of this analysis, costing will be conducted using service unit costs for both operators.

The determination of a Project Sponsor will consider the current and planned MSF capacity of candidate agencies, as well as compatibility with Wake BRT Program vehicle specifications.

As a Project Sponsor was undetermined at the time of this analysis, the rapid bus MSF needs are assumed to be met by existing and planned facility investments. No siting or costing of a new or modified MSF was undertaken for this analysis.

Deployment of Transit Priority Treatments

While observing the condition of the built and natural environment within the extensions, several opportunities for transit speed and reliability improvements such as TSP and queue jump lanes were identified. While TSP is recommended corridor-wide at each signalized intersection, only the general conditions conducive for implementing a transit queue jump were identified, along with candidate site locations within each corridor meeting the basic criterion. Site-specific analyses of potential queue jump locations is required to determine feasibility and appropriate infrastructure and signalization solutions.

Facilities and Services Provided by Others

This Alternatives Analysis assumes the continued development and land use changes associated with population and employment growth in the region will catalyze transit supportive infrastructure projects, mobility services, and/or policy implementation by third parties.

- BOSS implementation on US 70 Business is dependent upon the (proposed) NCDOT project widening and reconstruction of the facility. The final design package of the facility is recommended to include specifications to accommodate BOSS. The project is not currently funded in the TIP/STIP.
- Potential rapid bus travel times and overall corridor ridership will be affected by the presence of CRT. Horizon year (2050) ridership demand forecasts for rapid bus alternatives assume CRT between Cary and Clayton are in operation. The implementation and operating profile of commuter rail service in the Triangle Region will have an indirect effect on the travel market and future of rapid bus service.
- Transit connectivity, as well as pedestrian safety and circulation improvements included within planned and programmed capital projects (e.g., US 70 at Vandora Springs Road interchange reconstruction; future park and ride at US 70 and NC 42).
- First/last mile shuttle and local circulator services would be needed to link the preferred rapid bus alignments to major activity centers and employment and residential concentrations offset from the primary alignment and unable to be directly served by rapid bus. Since the customer market and operating needs of these services may not align with traditional fixed route transit, they were assumed to be operated or sponsored by third-party stakeholders. The implementation costs and recurring O&M costs of first/last mile circulators was not included rapid bus alternative cost estimates.

The LPA for rapid bus extensions will include preferred alignment, mode, transit priority treatments, and operations for service between the study area limits. Preliminary LPA component recommendations will be refined with completion of subsequent studies and analyses.

APPENDIX A RELEVANT ROADWAY AND CAPITAL IMPROVEMENT PROJECTS

Figure 22 NC 54 Widening Between Shiloh Glen and Perimeter Park Dr (NCDOT Project U-5750)

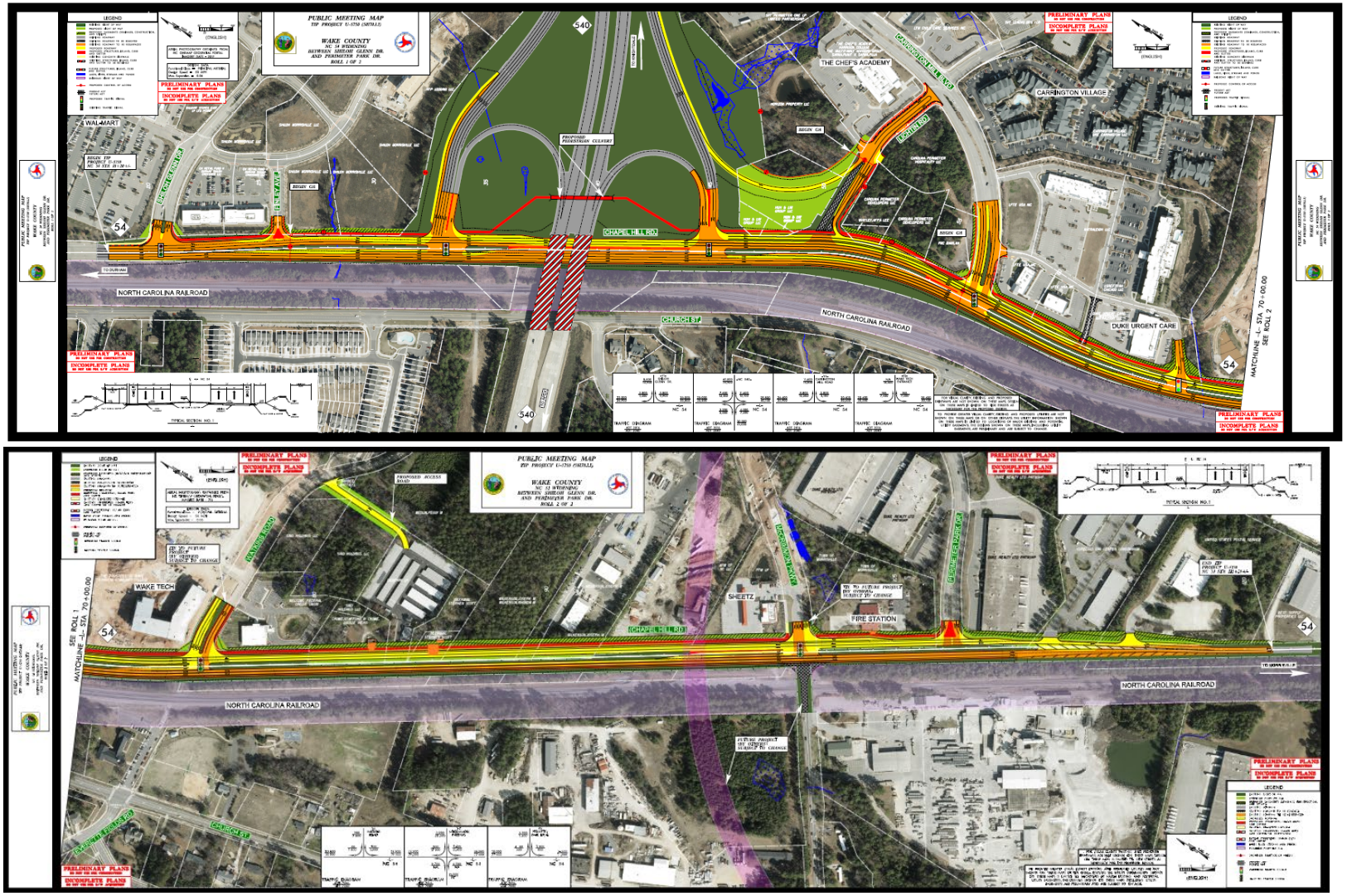
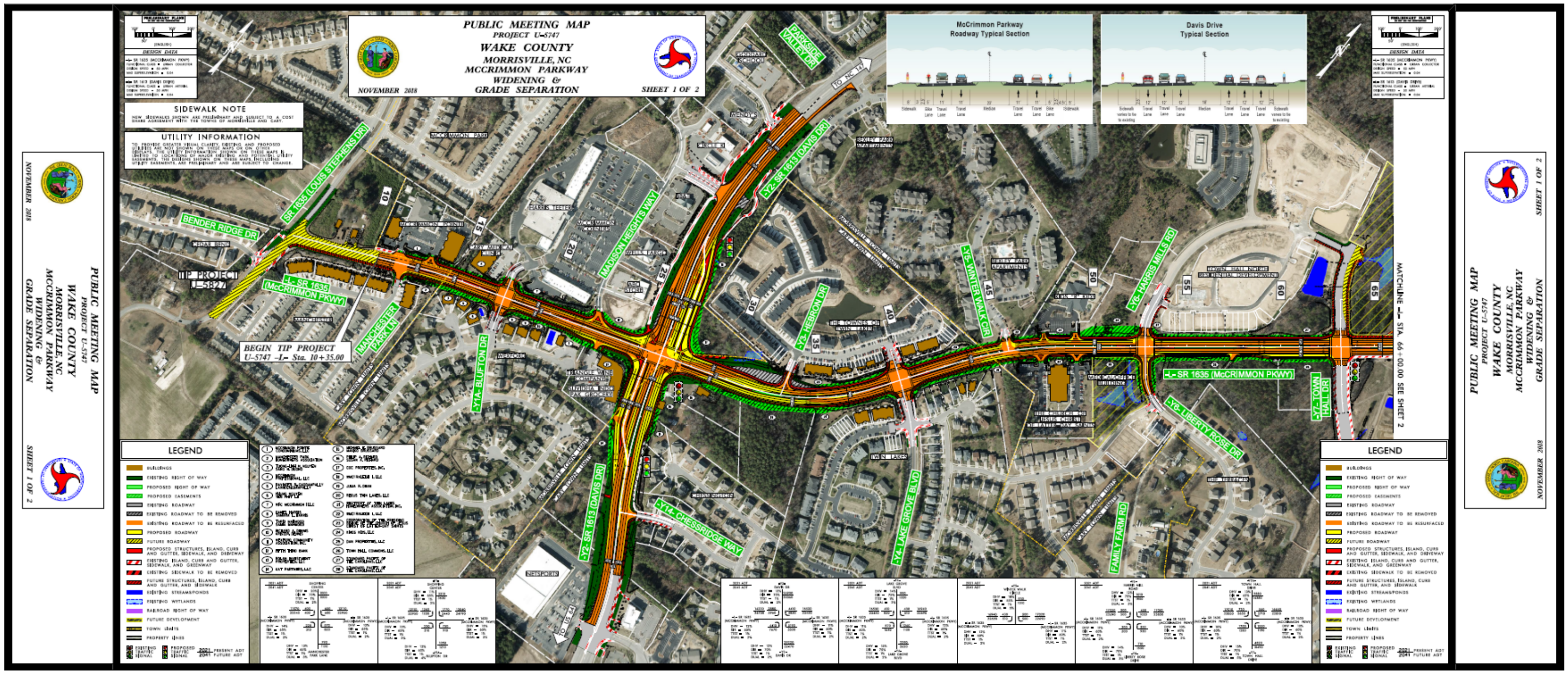
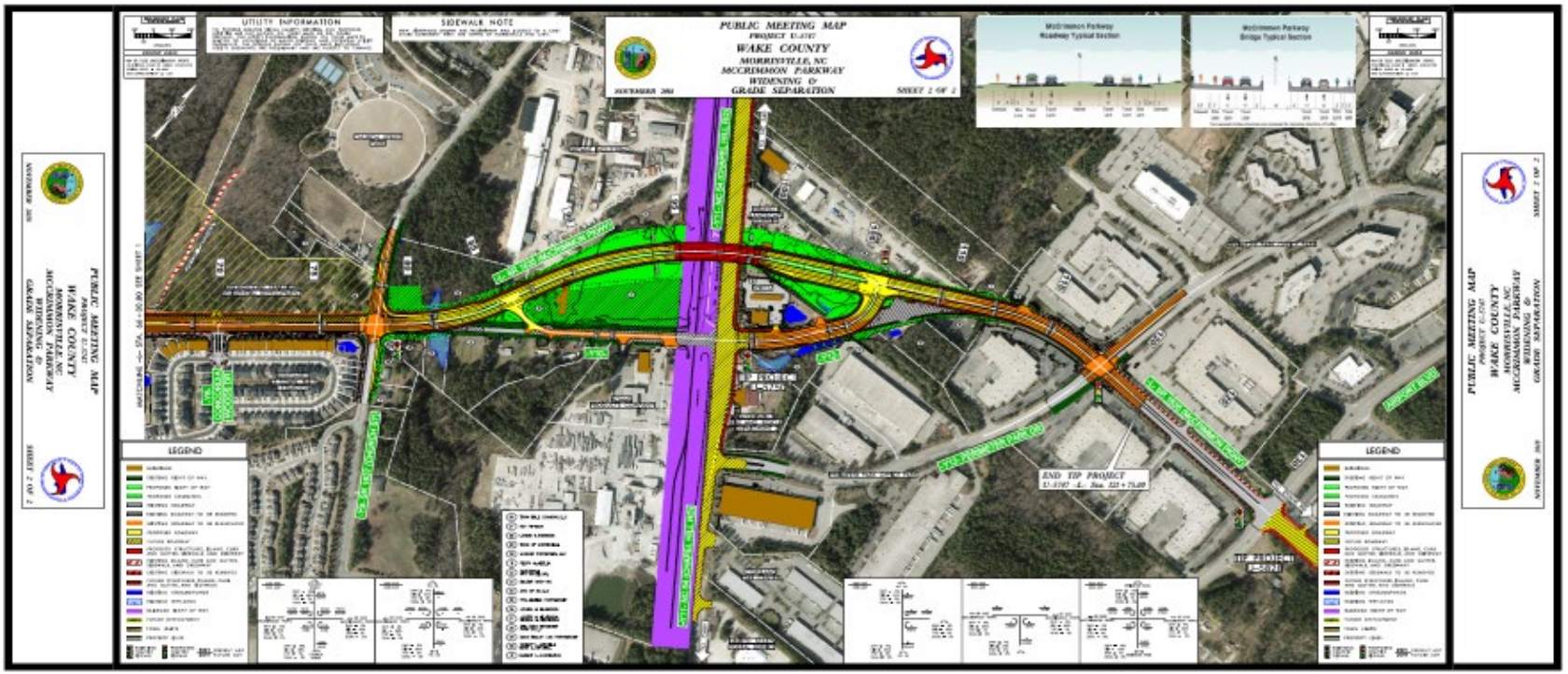


Figure 23 McCrimmon Parkway Widening and Grade Separation (NCDOT Project U-5747)

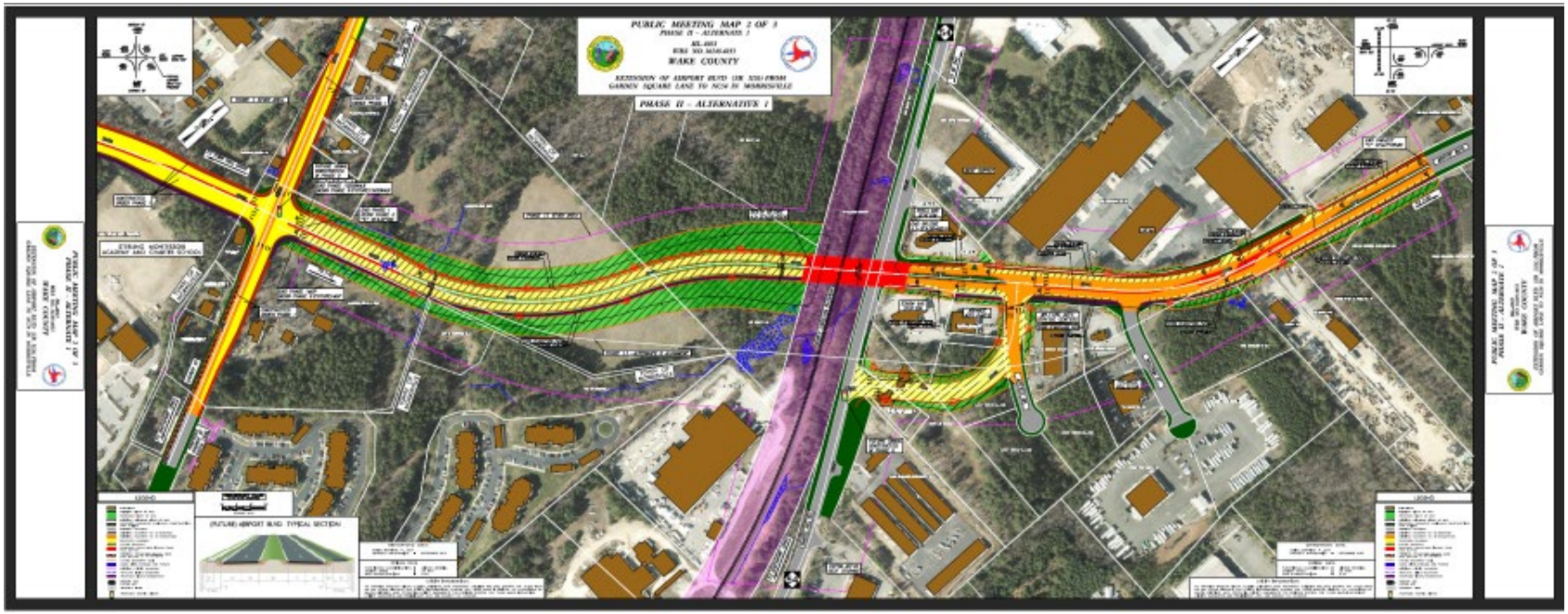


(Sheet 1 of 2)


PUBLIC MEETING MAP
WAKE COUNTY
MORRISVILLE, NC
McCRIMMON PARKWAY
WIDENING &
GRADE SEPARATION
UTILITY INFORMATION
SIDEWALK NOTE
LEGEND
END TIP PROJECT

(Sheet 2 of 2)

Figure 24: Airport Blvd at Chapel Hill Rd Roadway Improvements



APPENDIX B RAPID BUS EXTENSION TSP AND QUEUE JUMP OPPORTUNITIES

Alternative	Signals	Potential QJs	Rec Lane
Southern			
Main + C1	20	9	2
C2	3	2	1
G1	2	1	1

Figure 25 Southern Extension - Potential TSP & Queue Jump Locations

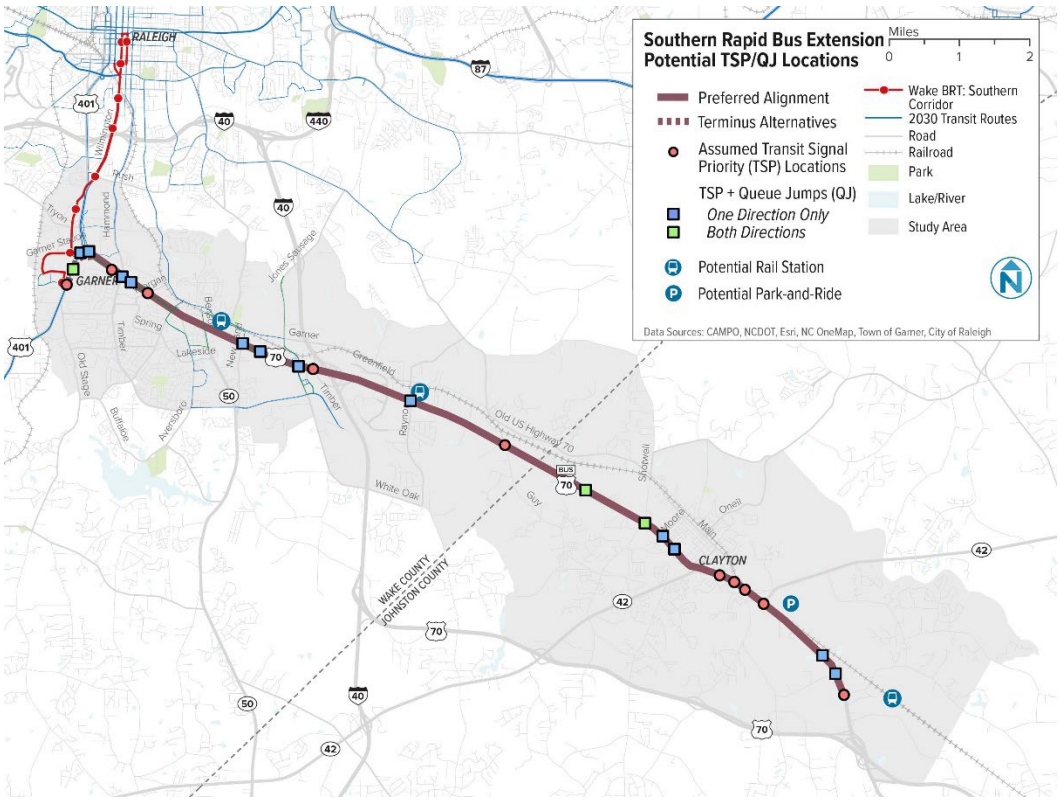


Table 16 Southern Corridor TSP/QJ Summary by Intersection

Alt.	Intersection	TSP	QJ	QJ Direction 1	Rec. Lane 1	QJ Direction 2	Rec. Lane 2
G1	Pinewinds Dr @ Fayetteville Rd/US-401	Yes	No				
G1	Fayetteville Rd/US-401 @ Annaron Ct	Yes	Yes	NB	Yes	SB	Yes
Main	Fayetteville Rd/US-401 @ Mechanical Blvd/Garner Stn Blvd	Yes	Yes			EB	No
Main	US-70 @ Mechanical Blvd	Yes	Yes	WB	No		
Main	US-70 @ Jessup Dr	Yes	No				
Main	US-70 @ Timber Dr	Yes	Yes*	WB	No	EB	No
Main	US-70 @ Garner Town Square	Yes	Yes			EB	No
Main	US-70 @ Yeargan Rd	Yes	No				
Main	US-70 @ New Rand Rd	Yes	Yes*	WB	No	EB	No
Main	US-70 @ Medical Park Ct	Yes	Yes	WB	No	EB	Yes
Main	US-70 @ Jones Sausage Rd/White Oak Rd	Yes	Yes	WB	No	EB	No
Main	US-70 @ I-40 EB Ramps (WB Only)	Yes	No				
Main	BUS-70 @ Raynor Rd	Yes	Yes*	WB	No	EB	TBD
Main	BUS-70 @ Guy Rd	Yes	No				
Main	BUS-70 @ Town Centre Blvd	Yes	Yes	WB	Yes	EB	Yes
Main	BUS-70 @ Shotwell Rd	Yes	Yes	WB	Yes	EB	Yes
Main	BUS-70 @ S Moore St	Yes	Yes	WB	No	EB	Yes
Main	BUS-70 @ S Robertson St	Yes	Yes	WB	No	EB	Yes
Main	BUS-70 @ John St	Yes	No				
Main	BUS-70 @ Champion St	Yes	No				
Main	Bus-70 @ Clayton Village	Yes	No				
Main	Bus-70 @ NC-42	Yes	No				
C2	BUS-70 @ Cutter Lab Access Rd	Yes	Yes	WB	No		
C2	BUS-70 @ Pony Farm Rd	Yes	Yes	WB	Yes	EB	No
C2	BUS-70 @ Powhatan Rd	Yes	No				

Alternative	Signals	Potential QJs	Rec Lane
Western			
Alt 1: NC 54 / Chapel Hill Road	23	18	8
Alt 2: Evans Road / McCrimmon Parkway	29	19	7
Alt 3: Davis Drive	29	16	16

Extension	Alternative	Potential Queue Jumps
Western	ALL	5
Western	1 & 2	10
Western	1	3
Western	2	4
Western	3	11

Figure 26 Western Extension - Potential TSP & Queue Jump Locations

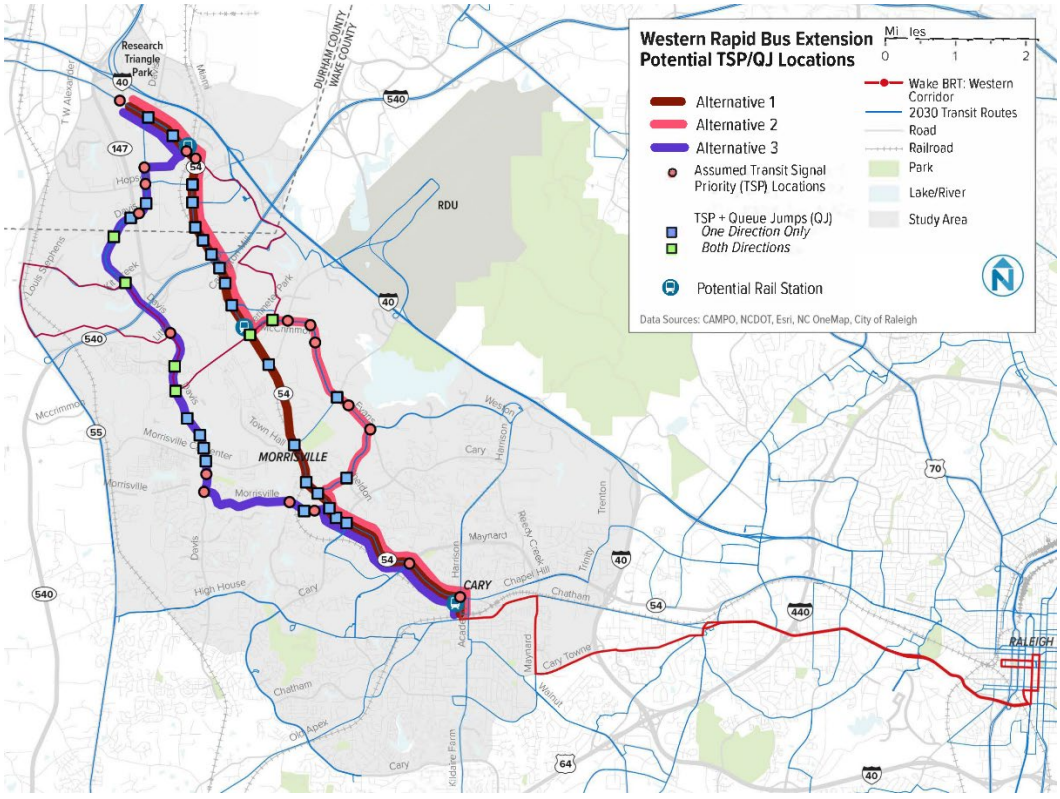


Table 17 Western Corridor TSP/QJ Summary by Intersection

Alt.	Intersection	TSP	QJ	QJ Direction 1	Rec. Lane 1	QJ Direction 2	Rec. Lane 2
ALL	N Harrison Ave @ Chapel Hill Rd	Yes	No				
ALL	Chapel Hill Rd/NC-54 @ NW Maynard Rd	Yes	No				
ALL	Chapel Hill Rd/NC-54 @ NW Cary Pkwy	Yes	Yes			EB	No
ALL	Chapel Hill Rd/NC-54 @ Market Ctr Dr	Yes	Yes			EB	No
ALL	Chapel Hill Rd/NC-54 @ Morrisville Pkwy	Yes	Yes			EB	Yes
1&2	Chapel Hill Rd/NC-54 @ Weston Pkwy	Yes	Yes	WB	Yes		
1	Chapel Hill Rd/NC-54 @ Rise Dr	Yes	Yes	WB	Yes		
1	Chapel Hill Rd/NC-54 @ Aviation Pkwy / Morrisville Carpenter Rd	Yes	Yes	WB	Yes		
1	Chapel Hill Rd/NC-54 @ Airport Blvd	Yes	Yes	WB	Yes		
1&2	Chapel Hill Rd/NC-54 @ McCrimmon Pkwy	Yes	Yes	WB	Yes	EB	Yes
1&2	Chapel Hill Rd/NC-54 @ Watkins Rd	Yes	Yes	WB	Yes		
1&2	Chapel Hill Rd/NC-54 @ Carrington Mill Blvd	Yes	Yes	WB	No		
1&2	Chapel Hill Rd/NC-54 @ NC-540 NB Ramps	Yes	Yes			EB	No
1&2	Chapel Hill Rd/NC-54 @ NC-540 SB Ramps	Yes	Yes			EB	No
1&2	Chapel Hill Rd/NC-54 @ Shiloh Glenn Dr	Yes	Yes			EB	No
1&2	Chapel Hill Rd/NC-54 @ Surles Ct	Yes	Yes			EB	No
1&2	S Miami Blvd/NC-54 @ Emperor Blvd	Yes	Yes			EB	No
1&2	S Miami Blvd/NC-54 @ Hopson Rd/Page Rd	Yes	Yes			EB	No
1&2	S Miami Blvd/NC-54 @ Slater Rd	Yes	No				
ALL	NC-54 @ Future RTC Signal (planned/future)	Yes	No				
ALL	NC-54 @ New Millennium Wy	Yes	Yes	WB	No	EB	No
ALL	NC-54 @ Davis Dr	Yes	Yes	WB	No	EB	No
ALL	NC-54 @ Park Offices Dr	Yes	No				
2	Weston Pkwy @ Sheldon Dr (planned/future)	Yes	Yes	NB	No	SB	No
2	Weston Pkwy @ Evans Rd	Yes	No				
2	Evans Rd @ Crabtree Creek Greenway PED	Yes	No				
2	Evans Rd @ Aviation Pkwy	Yes	Yes	NB	No	SB	TBD
2	McCrimmon Pkwy @ Competition Ctr Dr (planned/future)	Yes	Yes	NB	No	SB	TBD
2	McCrimmon Pkwy @ (planned/future) Signal 1	Yes	No				
2	McCrimmon Pkwy @ (planned/future) Signal 2	Yes	No				
2	McCrimmon Pkwy @ Airport Blvd	Yes	No				
2	McCrimmon Pkwy @ Perimeter Park Dr	Yes	Yes	NB	Yes	SB	Yes
3	Morrisville Pkwy @ Pheasant Wood Ct	Yes	No				
3	Morrisville Pkwy @ Bristol Creek Dr	Yes	Yes	NB	No	SB	Yes
3	Morrisville Pkwy @ Crabtree Crossing Pkwy	Yes	No				
3	Morrisville Pkwy @ Davis Dr	Yes	No				
3	Davis Dr @ Morrisville Market (Walmart)	Yes	No				
3	Davis Dr @ Morrisville Carpenter Rd	Yes	Yes	NB	Yes	SB	No
3	Davis Dr @ Lake Grove Blvd	Yes	Yes	NB	No	SB	Yes
3	Davis Dr @ Hatches Pond Ln	Yes	Yes	NB	Yes	SB	No
3	Davis Dr @ Airport Blvd	Yes	Yes	NB	No	SB	Yes
3	Davis Dr @ McCrimmon Pkwy	Yes	Yes	NB	Yes	SB	Yes
3	Davis Dr @ Parkside Valley Dr	Yes	Yes	NB	Yes	SB	Yes
3	Davis Dr @ Little Dr/Future NC-147	Yes	No				
3	Davis Dr @ Kit Creek Rd	Yes	Yes	NB	Yes	SB	Yes
3	Davis Dr @ Development Dr	Yes	Yes	NB	Yes	SB	Yes
3	Davis Dr @ NC-147 SB Ramps	Yes	Yes	NB	Yes	SB	No
3	Davis Dr @ NC-147 NB Ramps	Yes	No				
3	Davis Dr @ Park Knoll Dr	Yes	Yes	NB	No	SB	Yes
3	Davis Dr @ Hopson Rd	Yes	No				
3	Davis Dr @ Merrion Ave	Yes	No				
3	NC-54 @ Faulkner St (planned/future)	Yes	No				