Greater Triangle Commuter Rail (GTCR)

Phase 2 Feasibility Study

Client: GoTriangle

STV Project Number: 4020151

GTCR Phase 2 Feasibility Study Summary Report

Draft - August 2022

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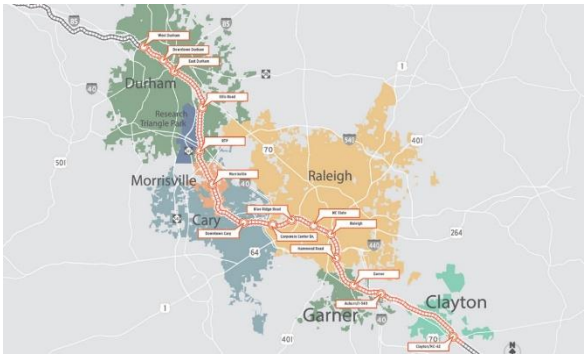
Table of Contents

1 Executive Summary

1.1 Introduction

This report summarizes Phase 2 of the Greater Triangle Commuter Rail (GTCR) Feasibility Study. The purpose of this report and subsequent activities is to support regional decision-making on whether and how to move forward with commuter rail in the Triangle region.



1.1.1 Project Description

GoTriangle is the project sponsor of the GTCR Study, which aims to evaluate the feasibility of implementing a commuter rail service in North Carolina's Triangle Region. The proposed commuter rail route is comprised of approximately 40 miles of existing shared rail corridor, beginning in West Durham and extending east either to Auburn or Clayton. Building on previous studies, the rail service evaluated here is a base case scenario of 8-2-8-2[1] service to Auburn and a potential 3-1-3[2] extension of service to Clayton.

1.1.2 Description of the Study

The study consisted of thorough technical investigations of the factors that should be considered when deciding whether and how to move forward with the commuter rail project. These technical analyses included:

- Corridor screening
- Ridership modeling
- Fare modeling
- Schedule analysis
- Engineering studies of more complicated areas on the corridor
- Site search and screening for parking and maintenance facilities
- Capital cost and operations and maintenance cost estimates
- Opportunity analyses for affordable housing, land use, travel markets, and economic impact along the corridor

Robust public and project partner involvement was conducted throughout the study. A large public survey was conducted early in the study process in the fall of 2020 and educational outreach ensured that members of the public and local organizations were able to gain an understanding of the study and provide input, and the results of the survey shaped what was examined in this study. Project partners were consistently involved in study activities through regular meetings with status updates and presentations of interim study data. Project management partners include Capital Area Metropolitan Planning Organization (CAMPO), Durham, Chapel Hill, Carrboro Metropolitan Planning Organization (DCHC MPO), Wake, Durham, and Johnston Counties, North Carolina Department of Transportation (NCDOT), and North Carolina Railroad Company (NCRR). In addition, study partners included Research

[1] 8-2-8-2 service includes eight trains during peak morning and evening periods, with two trains during each off-peak period

[2] 3-1-3 service includes three trains during peak morning and evening periods, with one train in the interim off-peak period (specifically proposed for extension of service to Clayton, combined with 8-2-8-2 service between West Durham and Auburn)

Triangle Foundation (RTF), Triangle J Council of Governments (TJCOG), Duke, North Carolina Central, and North Carolina State Universities, and municipalities throughout the project corridor.

1.2 Findings and Conclusions

- Public input on the project revealed that there is favorable sentiment towards commuter rail and an appetite for transit solutions to mobility challenges in the Triangle. Potential users want a frequent, reliable, accessible, and affordable service.
- The proposed corridor is well-placed to serve affordable housing, future land use, and travel markets.
- Commuter rail could have economic benefits for the region by connecting workers to jobs, increasing the quality of life and attractiveness of the Triangle Region, and spurring additional development in transit-oriented hubs.
- Daily commuter rail ridership in 2040 for the 8-2-8-2 service scenario from West Durham to Auburn is estimated to be between 10,000 and 18,000, depending on the fare scenario. The stations projected to have the highest boarding levels are Raleigh Union Station, Auburn, and West Durham.
- Finding a service concept that meets the needs of commuters into the future is vital. Some initial work has been done to consider the viability of service scenarios that offer more frequent service than the 8-2-8-2(3-1-3) service scenario that this study set out to consider. However, more evaluation is needed to accurately compare these options.
- Implementing the commuter rail service will require overcoming significant challenges such as: coordinating service on a corridor shared with freight and intercity rail, designing the project through downtown areas of the bigger cities along the corridor, and engineering appropriate configurations at numerous roadway crossings.
- The proposed service would come at a significant monetary cost. While the corridor takes advantage of existing rail infrastructure and right-of-way, investments in additional track, stations, trainsets, and a maintenance facility will need to be made in addition to the annual costs of operations and maintenance.
- Because of engineering challenges and coordination complications that could delay realization of the entire proposed corridor, the study considers an implementation strategy that provides a “Starter Service” in the southeastern Wake County portion of the proposed corridor. This approach would establish a valuable and viable piece of the commuter rail service that could benefit the region while local leaders and project teams work to develop the remainder of the project corridor.

1.3 Next Steps

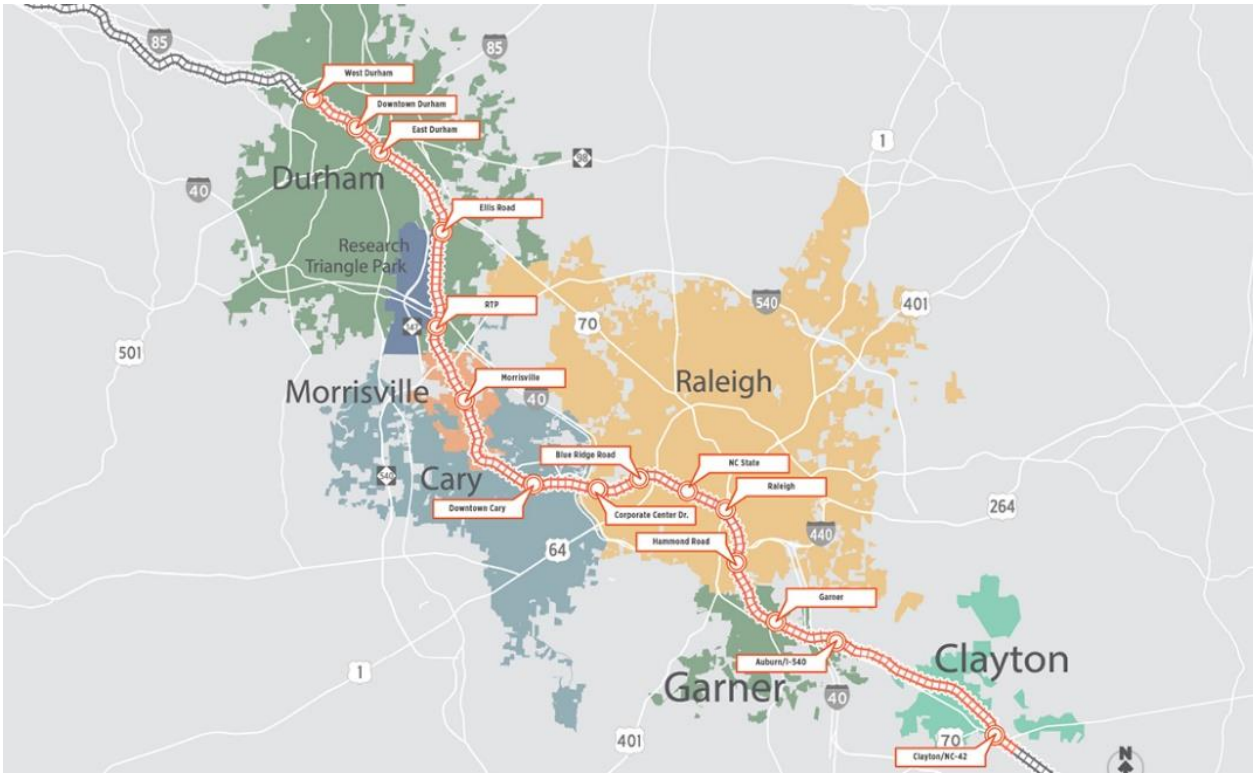
The conclusion of the study marks the start of consideration by project management partners on whether and how to move forward with pursuing implementation of the commuter rail project. If the decision is made to move forward with the project, GoTriangle and project funding partners will refine the financial plan and implementation approach. Immediate next steps would include project development activities such as preliminary engineering and environmental compliance, which is estimated to cost approximately 5-10% of the cost of construction and would be locally funded by the transit plan(s).

2 Purpose and Objectives

2.1 Project Purpose and Need

The Triangle Region of North Carolina is growing at a rapid pace. By 2050, the region is projected to add more than 1.3 million people,[3] which will bring approximately one million more vehicles to the area's already congested roadways.[4] This level of expansion has come with mobility challenges, such as rising congestion on roadways and sprawling land use. Local leaders have long recognized the need to meet the challenge of high growth with a robust local and regional transit network to provide transportation options and ensure regional mobility. The proposed commuter rail corridor would provide transportation for the Triangle that would tie together employment hubs, downtowns, universities, medical centers, and residential areas by making use of existing rail infrastructure. Rail travel within the Triangle would provide an alternative to traveling on congested roadways and allow users to reduce or eliminate time spent commuting by car. The addition of rail to the region's transit network would increase mobility for users who do not have access or ability to use personal vehicles and would provide residents throughout the Triangle with needed transit connections to the expanding regional job market.

Figure 2-1: Greater Triangle Commuter Rail Phase 2 Study Corridor Map



[3] The CAMPO planning area is projected to add 1.05 million people from 2016 to 2050. https://nmcdn.io/e186d21f8c7946a19faed23c3da2f0da/8bfec28a290449a7b10eb1fee3a0e264/files/transportation-plan/2050-MTP/SE_Data_Guide_2020-08-16.pdf
The counties within the DCHC MPO planning area is projected to add 265 thousand people during that time period. https://www.dchcmpo.org/home/showpublisheddocument/3594/637619823805170000

[4] Institute for Transportation Research and Education, Triangle Regional Model

2.2 Local Transit Planning History

Since its inception in 1989, GoTriangle (formerly Triangle Transit Authority and later Triangle Transit) has been charged with providing the Triangle region of North Carolina with public transportation services that support the region's "community, prosperity, and mobility." GoTriangle provides regional bus service, vanpool service, and regional planning services. Over the years, GoTriangle and its partners in the region have planned for the possibility of a commuter rail service in the Triangle, as first evaluated in the *Triangle Fixed Guideway Study* (1992), most recently in the Wake Transit Major Investment Study (2019) and Greater Triangle Commuter Rail Phase I Feasibility Study (2020).

This study builds on these previous evaluations and is consistent with recent local planning efforts, which have prioritized and identified funding for the expansion of public transit, including commuter rail. GoTriangle, Durham and Wake counties, Durham-Chapel Hill Metropolitan Planning Organization (DCHC MPO), and Capital Area Metropolitan Planning Organization (CAMPO) included commuter rail in the 2011 and 2016 transit plans for Durham and Wake Counties, developed in advance of voter referenda for dedicated taxes for transit. Voters in both counties at these times approved a half-cent sales tax to fund the county transit plans including commuter rail. These two plans have similar goals of connecting more residents to jobs and educational opportunities across the region, providing better regional connections to cities, and providing a reliable alternative to the congested highway links between major job centers.

2.3 Initial Study Objectives

This study aims to further evaluate the feasibility of implementing commuter rail service on the existing rail corridor in Durham and Wake Counties by refining the project concept, estimating benefits, updating cost estimates and potential for federal funding, and documenting risks to project implementation. The study originally set out to evaluate an 8-2-8-2 service concept (eight trains each way during peak morning and evening periods, two trains each way during non-peak periods) between Durham and Auburn, with the potential for more limited service extended to Clayton. The 8-2-8-2 service concept between West Durham and Auburn was identified for further study from a range of service concepts and geographies studied in the Greater Triangle Commuter Rail Phase I Feasibility Study.

A Memorandum of Understanding (MOU) signed by key project partners in April 2020 identified the service plans listed above for evaluation and identified goals for this phase of study (See section 3.1.1 for more on parties to the MOU). These goals are listed below.

1. Engage Stakeholders
    a. Build a foundation for sustained regional cooperation and meaningful stakeholder engagement necessary for development of a successful Project Concept
2. Refine the Project Concept
    a. Further refine and achieve consensus among Parties on Project Concept [project definition for purposes of initiating CIG Project Development (termini, station number and locations, grade separations, street closures, number and location of additional tracks and improvements, frequency of trains, fleet size and composition, train storage and maintenance requirements)]
3. Provide a basis for evaluation of costs and benefits
    a. To include monetary costs, non-monetary costs, and benefits
4. Obtain buy-in for the Project Concept from the operating railroads
    a. agree on the requirements and design criteria

5. Build adequate management capacity and capability to advance the project
6. Monitor risks related to likelihood of federal funding eligibility
7. Obtain local funding commitment
    a. Obtain commitment of 100% of non-CIG funds to codify local funding partner commitment and mitigate a range of project risks, in particular risks that are exacerbated by uncertainty of project viability

The MOU is included in Appendix A.

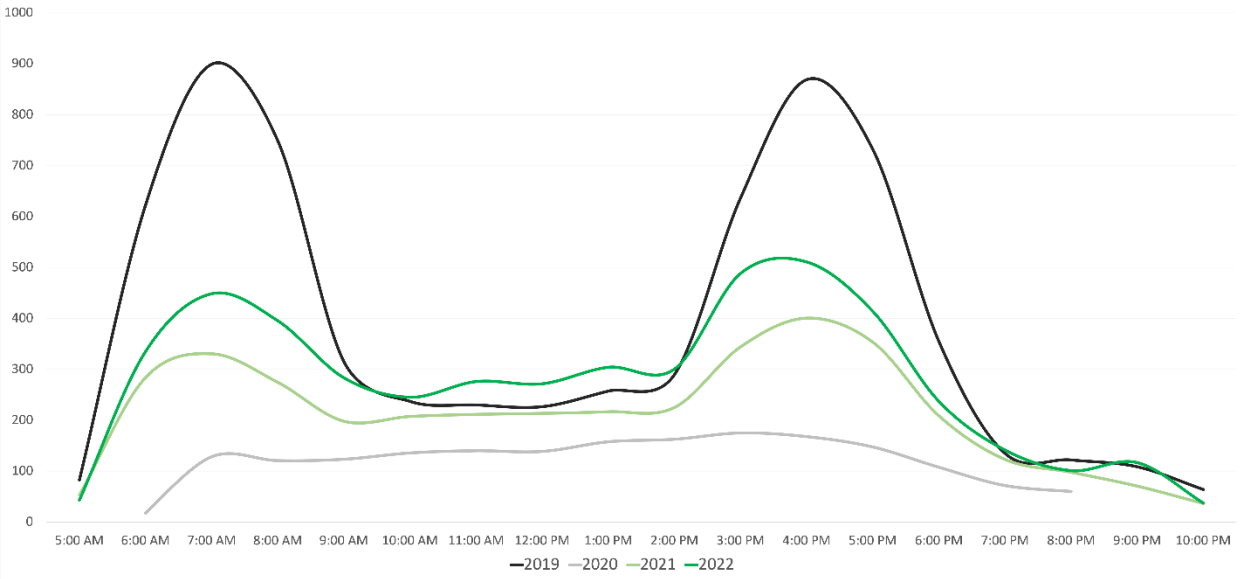
2.4 Emerging Interest in All-Day Service

Additional considerations have emerged during the study in response to public input, changing travel patterns locally and nationally, and increased emphasis on equity in transportation decision-making. Traditional commuter service has focused on weekday morning and evening peak times, often known as "rush hours" – the period when a high-capacity congestion-free alternative to driving is most advantageous compared to travel by car or by bus. As such, the original concept for this commuter rail aimed to provide more trips during these hours while offering fewer trips during non-peak times when the roadway network is better able to provide reliable trips in the corridor (exemplified by the 8-2-8-2 scenario). However, public feedback and recent trends seen both locally and nationally have emphasized the need to plan for a market for transit outside the bounds of traditional rush hours. These factors, along with feedback from project stakeholders including other MOU signatories, led GoTriangle to expand the scope of the study to consider some schedule scenarios that would offer more frequent service throughout the day in addition to the original 8-2-8-2 service.

2.4.1 Shifting Travel Patterns

Shifts in working habits and locations, either caused or accelerated by the COVID-19 pandemic, have raised questions about whether the primary regional transit need in the Triangle is, in fact, tied to traditional commuter peak hours. For context, GoTriangle provides regional bus service in the corridor today, which is the existing transit service most similar to the proposed rail service. While overall GoTriangle transit ridership has recovered to 70% of pre-pandemic levels, the majority of that recovery in ridership has been on GoTriangle's core regional routes which run all day including midday, evenings, and weekends, rather than on GoTriangle's weekday peak-only routes.

Figure 2-2: GoTriangle Ridership by Hour of Day (April of Indicated Year)



2.4.2 Service Equity

Equity of service is an important consideration in the provision of public transit and was a key theme of input received early in the study. Some users may prefer to ride transit because of cost or travel time savings, convenience, or a desire to avoid the stresses of traffic. Others rely on public transit as their primary mode of transportation because they cannot afford to own and maintain a personal vehicle. Among GoTriangle users, 47 percent have a household income of less than $35,000.[5] An essential piece of this study is to look at how commuter rail would serve all users, including those who are low-income or in traditionally underserved demographics. Lower-income residents are more likely to depend on transit as their primary mode of transportation while also being more likely to have employment that is outside of the "9-5" workday. Analysis completed as part of this study indicates that service scenarios with more midday and evening trips would carry more travelers from zero-car and one-car households. In this region and nationally, residents of zero-car and one-car households are more likely to be low income and/or members of traditionally underserved populations than residents of households with more vehicles available.

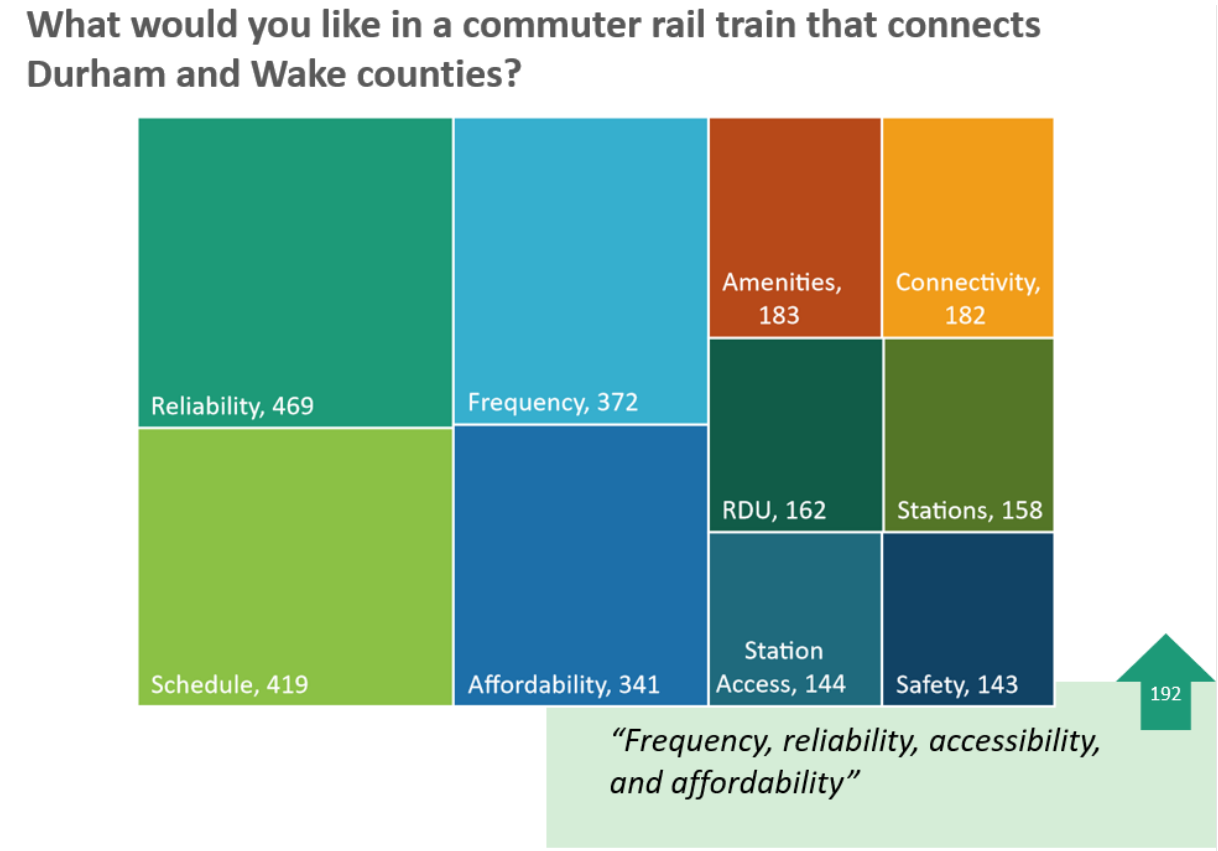
2.4.3 Public Feedback

Public input also indicated a high desire for frequency of service throughout the day. When asked in a public survey what users would like to see in a commuter rail service, the most common responses were related to reliability, frequency, and schedule ("schedule" refers to comments that indicated that the timing of the train needs to fit their needs). Survey takers were able to see and respond to other comments, and the most supported or "upvoted" comment said succinctly, "Frequency, reliability, accessibility, and affordability."

While office and traditional job centers will continue to be important travel destinations, these factors imply a need to design new regional transit with alternative schedules and flexibility in mind.

[5] https://gotriangle.org/sites/default/files/publications/2018_four_system_report.pdf

Figure 2-3: Excerpt of Public Survey Results



3 Public and Stakeholder Engagement

3.1 Stakeholder Engagement

3.1.1 Project Management Partners

The study's Project Management Partners are integral to the planning, development, funding, and implementation of the commuter rail project in the corridor. These partners have taken an active role in shaping the scope and assumptions of the proposed project. They include:

- Study funding partners with oversight roles for transportation planning and funding activities: Durham County, Wake County, Johnston County, Capital Area Metropolitan Planning Organization (CAMPO), and Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC MPO)
- Project Sponsor: GoTriangle
- Sponsor of intercity passenger rail on the corridor with other rail-highway safety mandates: North Carolina Department of Transportation (NCDOT)
- Owner and lessor of the rail corridor: North Carolina Railroad Company (NCRR)

3.1.2 Municipalities and Institutional Partners

The municipalities through which the commuter rail corridor travels are essential to understanding the needs, challenges, and opportunities for commuter rail implementation at each stop along the way. Municipalities that lie directly along the rail corridor include the City of Durham, the Town of Cary, the Town of Morrisville, the City of Raleigh, the Town of Garner, and the Town of Clayton. Municipalities functioned in an advisory capacity through this study.

Regional and major institutional partners also participated in an advisory capacity during the study, including Triangle J Council of Governments (TJCOG), Research Triangle Foundation, regional universities and colleges, and healthcare institutions.

3.1.3 Public Stakeholders

Public stakeholders include:

- **Community Partners**: Non-profits, interest groups, community advisory committees, libraries, religious institutions, and others
- **Business Partners**: Chambers of Commerce, business associations, and small businesses
- **The General Public**: Anyone with an interest in the project, for example as potential users of commuter rail, people who feel they could be impacted by the project, or simply those with curiosity, questions, or concerns about the project

3.2 Public Outreach

A multi-layered approach was employed to reach and engage the public throughout the study timeline, including a range of materials and methods to provide the public with many opportunities to learn about and provide input on the proposed commuter rail project. Outreach efforts included in-person outreach, online avenues including social media, websites, videos, email campaigns, and web-based live events, traditional media including print, local news, and advertisements, and by including commuter rail study information with existing GoTriangle outreach campaigns.

An online survey was conducted at the outset of this phase of study to gather early feedback about the commuter rail project concept. Offered both in print and online formats, the survey garnered more than 2,700 participants and 5,000 responses.

Additional detail on this topic is documented in Appendix B, Stakeholder Outreach and Participation.

4 Project Context

4.1 Project Limits

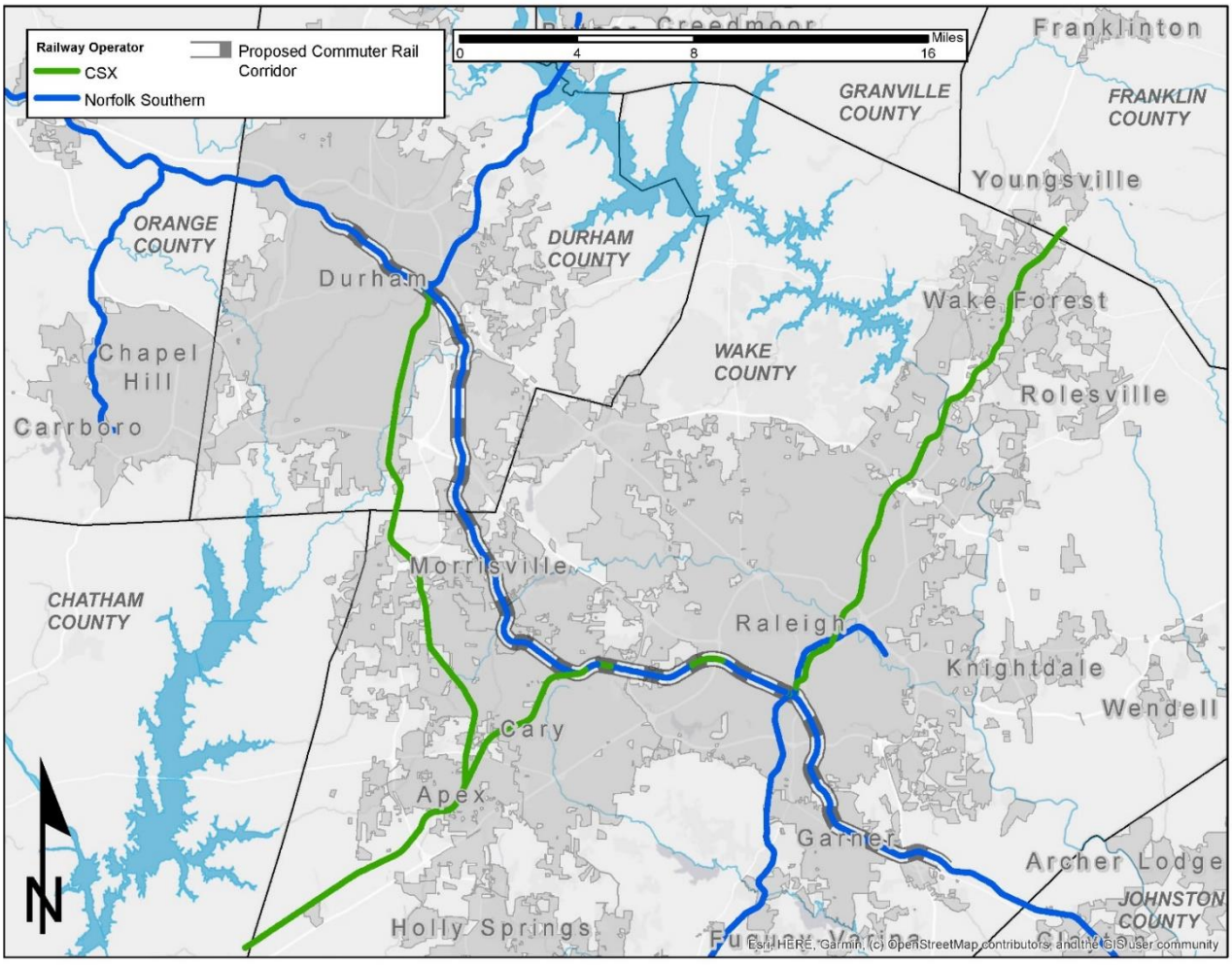
The proposed commuter rail service would cover approximately 40 miles of the existing North Carolina Railroad Company (NCRR) corridor to connect West Durham in Durham County to Auburn in Wake County, with the potential inclusion of a station in Clayton in Johnston County.

4.2 Existing Conditions

As shown in Figure 4-1, the existing NCRR corridor in the study area runs from the center of the western Durham County line, east through downtown Durham, southeast through Morrisville, and eastward through downtown Cary. In Cary, it is joined by the CSX's S Line from the south and they continue as a double track eastward to downtown Raleigh. At this point the CSX line splits off to the north and the NCRR-owned corridor continues to the southeast through Garner. Here, the line turns more to the east and runs through Auburn before exiting Wake County and continuing east through Johnston County.

Most of this railroad corridor contains a single mainline track, except for a section in RTP and Morrisville between I-40 and McCrimmon Parkway, the area between downtown Raleigh and downtown Cary

Figure 4-1: Existing Rail Lines



where the corridor merges with the CSX S Line, and an approximately 1-mile-long section of double track just north of Garner.

The existing rail corridor hosts both freight rail and intercity rail on shared track. Freight rail consists of movement of goods and cargo in freight rolling stock (e.g., boxcars, flatcars, etc.) and are typically hauled by diesel-powered locomotives. NCRR owns the corridor, and Class I freight rail providers Norfolk Southern and CSX Transportation operate on, dispatch, and maintain the railroad. Norfolk Southern dispatches and maintains 28 miles through a long-term lease with NCRR. CSX Transportation maintains one track and dispatches the portion of the corridor between downtown Cary (Control Point [CP] Fetner) and downtown Raleigh (CP Boylan). Intercity rail services provide passenger transit covering longer distances than commuter or regional trains. The Silver Star (sponsored by Amtrak) runs one roundtrip serving Raleigh and Cary by way of Selma before continuing south on the CSX S Line. The Carolinian and the Piedmont (both sponsored by NCDOT) operate between Charlotte and Raleigh (with the Carolinian continuing east of Raleigh to Selma where it turns north to Washington, DC), with three roundtrips in the study corridor on the Piedmont and one on the Carolinian. NCDOT's agreements with the railroads also permit one additional round-trip and plan for another, for a total of six operated, permitted, or contemplated intercity round trips between Charlotte and Raleigh. Three passenger rail stations used by intercity rail currently operate within the rail corridor: Durham, Cary, and Raleigh Union Station (RUS).

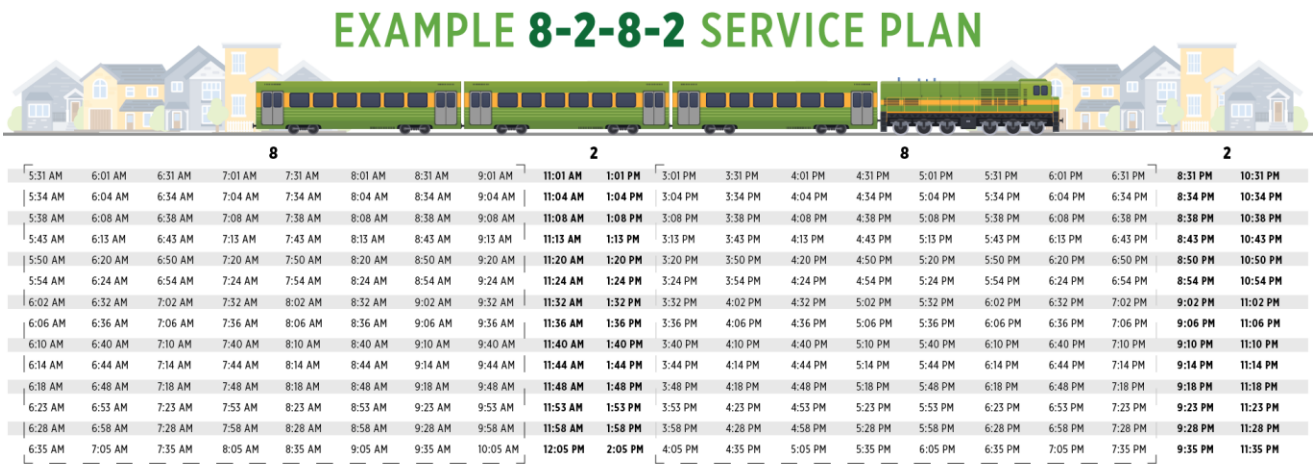
4.3 Commuter Rail Feasibility in a Shared Corridor

One of the primary goals and biggest challenges of this study is to determine whether it is feasible to run commuter rail service in a corridor already shared between freight and intercity passenger rail service without negatively impacting the reliability or efficiency of any of the three services. The study aimed to determine what additional infrastructure would be needed to provide the capacity to support these various train services to traverse the rail corridor smoothly and what commuter service concept best serves the transportation needs of users while also functioning reliably within the corridor. To answer these questions, engineering assumptions were determined and used as inputs into rail network modeling performed by Norfolk Southern. Coordination with the railroads is discussed in more detail in section 8.3.

5 Service Concepts

Building on prior work, this phase set out to evaluate the potential for commuter rail service with half-hour headways during peak periods, and limited service during midday and evenings. The weekday 8-2-8-2 service concept was the original service concept agreed to in the MOU for study during this phase. Within the project corridor between West Durham and Auburn, this concept would entail eight round trips with half-hour headways during the morning peak period, two mid-day round trips, eight round trips with half-hour headways during the afternoon peak period, and two evening round trips, for a total of 40 trains. If the initial implementation includes service to a station in Clayton, this concept would also include a 3-1-3 element, with 3 round trips in both the morning and afternoon peak times and one mid-day non-peak round trip to/from Clayton.

Figure 5-1: Sample Commuter Rail Timetable



5:31 AM	6:01 AM	6:31 AM	7:01 AM	7:31 AM	8:01 AM	8:31 AM	9:01 AM	11:01 AM	1:01 PM	3:01 PM	3:31 PM	4:01 PM	4:31 PM	5:01 PM	5:31 PM	6:01 PM	6:31 PM	8:31 PM	10:31 PM
5:34 AM	6:04 AM	6:34 AM	7:04 AM	7:34 AM	8:04 AM	8:34 AM	9:04 AM	11:04 AM	1:04 PM	3:04 PM	3:34 PM	4:04 PM	4:34 PM	5:04 PM	5:34 PM	6:04 PM	6:34 PM	8:34 PM	10:34 PM
5:38 AM	6:08 AM	6:38 AM	7:08 AM	7:38 AM	8:08 AM	8:38 AM	9:08 AM	11:08 AM	1:08 PM	3:08 PM	3:38 PM	4:08 PM	4:38 PM	5:08 PM	5:38 PM	6:08 PM	6:38 PM	8:38 PM	10:38 PM
5:43 AM	6:13 AM	6:43 AM	7:13 AM	7:43 AM	8:13 AM	8:43 AM	9:13 AM	11:13 AM	1:13 PM	3:13 PM	3:43 PM	4:13 PM	4:43 PM	5:13 PM	5:43 PM	6:13 PM	6:43 PM	8:43 PM	10:43 PM
5:50 AM	6:20 AM	6:50 AM	7:20 AM	7:50 AM	8:20 AM	8:50 AM	9:20 AM	11:20 AM	1:20 PM	3:20 PM	3:50 PM	4:20 PM	4:50 PM	5:20 PM	5:50 PM	6:20 PM	6:50 PM	8:50 PM	10:50 PM
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6:02 AM	6:32 AM	7:02 AM	7:32 AM	8:02 AM	8:32 AM	9:02 AM	9:32 AM	11:32 AM	1:32 PM	3:32 PM	4:02 PM	4:32 PM	5:02 PM	5:32 PM	6:02 PM	6:32 PM	7:02 PM	9:02 PM	11:02 PM
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6:10 AM	6:40 AM	7:10 AM	7:40 AM	8:10 AM	8:40 AM	9:10 AM	9:40 AM	11:40 AM	1:40 PM	3:40 PM	4:10 PM	4:40 PM	5:10 PM	5:40 PM	6:10 PM	6:40 PM	7:10 PM	9:10 PM	11:10 PM
6:14 AM	6:44 AM	7:14 AM	7:44 AM	8:14 AM	8:44 AM	9:14 AM	9:44 AM	11:44 AM	1:44 PM	3:44 PM	4:14 PM	4:44 PM	5:14 PM	5:44 PM	6:14 PM	6:44 PM	7:14 PM	9:14 PM	11:14 PM
6:18 AM	6:48 AM	7:18 AM	7:48 AM	8:18 AM	8:48 AM	9:18 AM	9:48 AM	11:48 AM	1:48 PM	3:48 PM	4:18 PM	4:48 PM	5:18 PM	5:48 PM	6:18 PM	6:48 PM	7:18 PM	9:18 PM	11:18 PM
6:23 AM	6:53 AM	7:23 AM	7:53 AM	8:23 AM	8:53 AM	9:23 AM	9:53 AM	11:53 AM	1:53 PM	3:53 PM	4:23 PM	4:53 PM	5:23 PM	5:53 PM	6:23 PM	6:53 PM	7:23 PM	9:23 PM	11:23 PM
6:28 AM	6:58 AM	7:28 AM	7:58 AM	8:28 AM	8:58 AM	9:28 AM	9:58 AM	11:58 AM	1:58 PM	3:58 PM	4:28 PM	4:58 PM	5:28 PM	5:58 PM	6:28 PM	6:58 PM	7:28 PM	9:28 PM	11:28 PM
6:35 AM	7:05 AM	7:35 AM	8:05 AM	8:35 AM	9:05 AM	9:35 AM	10:05 AM	12:05 PM	2:05 PM	4:05 PM	4:35 PM	5:05 PM	5:35 PM	6:05 PM	6:35 PM	7:05 PM	7:35 PM	9:35 PM	11:35 PM

As discussed in section 2.4, over the course of this study additional service concepts have been identified that include more all-day and weekend trains. More and/or differently distributed train frequencies have the potential to offer a more useful service to a broader population.

The first additional service concept includes half-hourly service in morning and afternoon peaks with hourly service other times of the day, for a total of 44 trains per day (referred to as 30/60 service). Examples of other systems operating with this service concept exist, for example SFRTA's TriRail in southern Florida. This alternate is under consideration to evaluate whether it could function on the same level of infrastructure identified as necessary for the 8-2-8-2 service.

The second additional service concept includes hourly service all day, for a total of 38 trains per day. Examples of other systems operating with this service concept exist, for example RTD's B line in Denver, CO. This concept is under consideration to evaluate whether it could function as an initial operating plan with a lower initial capital investment than either the 8-2-8-2 or 30/60 service plans.

6 Infrastructure Requirements

Implementation of the commuter rail project would require a suite of infrastructure additions or alterations throughout the project corridor. Prior phases of study identified the following requirements:

- **Double-tracking**—to allow all services to function efficiently on the shared rail corridor, a minimum of two tracks would be necessary for the entire project length. Except for a few places where a second track already exists, most of the corridor length would require the addition of a second track.
- **Stations**—aside from enhancements to the existing stations at Cary, Durham, and Raleigh, new rail stations would need to be developed in 11 or 12 locations along the corridor. At a basic level, stations would require platforms, means to safely cross from one side of the track to the other, and in most cases, parking.
- **Operations, maintenance, and administration facility**—development of a facility for train storage, maintenance, operations, and administration would be required. This facility could be located near either end of the project corridor but is considered most likely to be sited on the Wake County side due to the greater availability of undeveloped land there.
- **Trains (rolling stock)**—a fleet of trains would need to be purchased and maintained. Both typical commuter rail trains with diesel locomotive and Diesel Multiple Unit (DMU) vehicles are being considered. DMUs would require approval by the host railroads. The service requires a total of 7 trainsets, assumed to be 7 locomotives and 28 coaches (subject to refinement based on final ridership projections), plus 2 spare trainsets. The total is 9 trainsets (9 locomotives plus 36 coaches). Each trainset, consisting of a locomotive and four coach cars, has a capacity of 600 seats per train, which would meet the anticipated peak ridership needs with room for additional growth.

This phase of study looked in-depth at areas of the corridor where addition of these infrastructure requirements presents engineering challenges and would require extensive coordination, including downtown Durham, downtown Cary, and downtown Raleigh. Overcoming these challenges would be critical to the project's success. Section 8.1 provides more information about the study's analysis of the needs and recommended approaches to address those areas. Section 9.1 presents capital cost estimates.

Also, during this phase of study, Norfolk Southern performed railroad capacity modeling for the corridor to evaluate the infrastructure requirements, including any addition to the items described above. Initial results from that analysis identified the following additional infrastructure as necessary to support the 8-2-8-2 service:

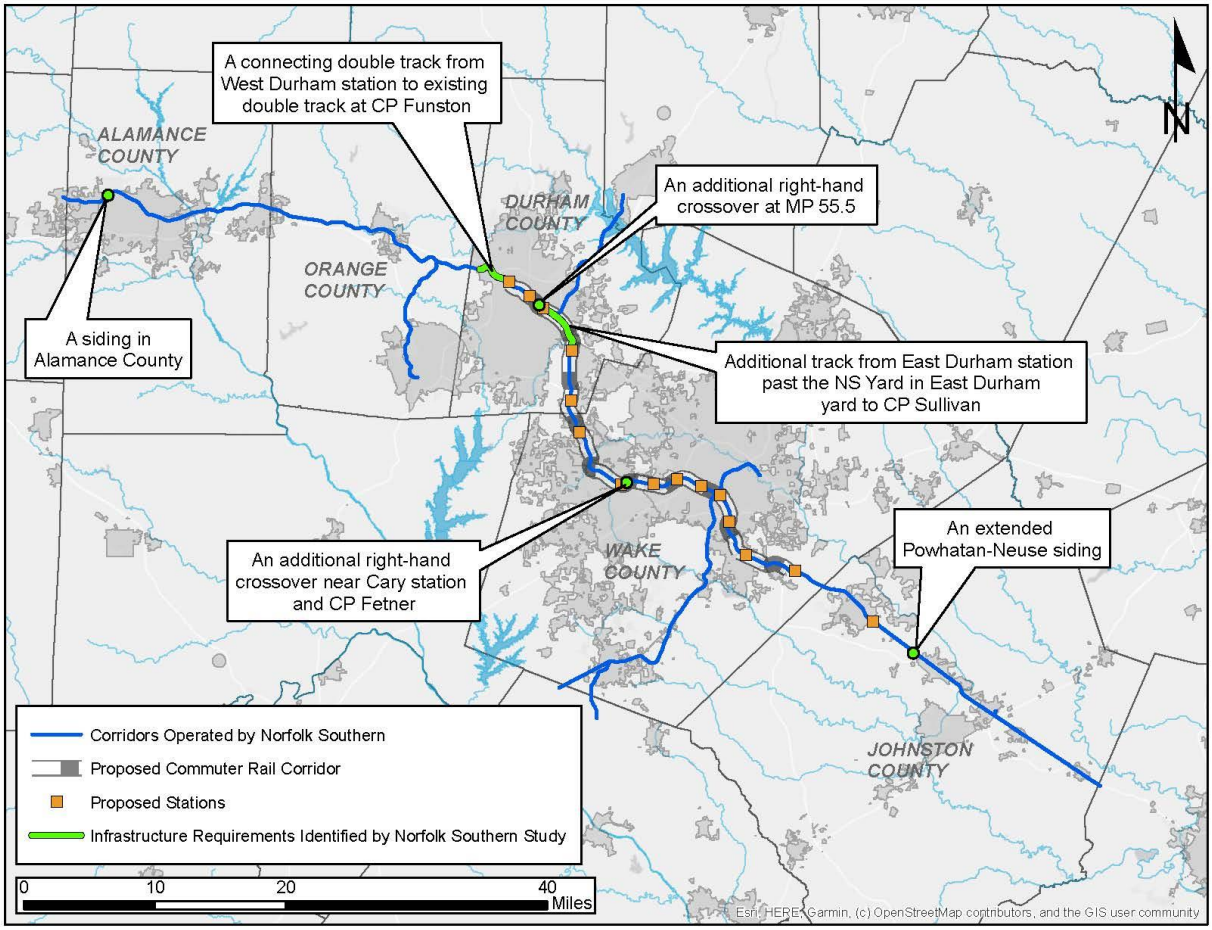
- A siding at MP 18 in Burlington[6]

[6] In the railroad capacity modeling, Norfolk Southern identified freight delays on a single-track portion of the corridor in Alamance County due to downstream impacts of commuter rail activity within the Durham-Wake commuter rail corridor. This new siding would address this problem.

- A connecting double track from West Durham station to existing double track at CP Funston, approximately three miles west of the West Durham station
- An additional right-hand crossover at MP 55.5 in Durham
- Additional track from East Durham station, past the NS Yard in East Durham yard, to CP Sullivan in Durham (north Research Triangle Park)
- An additional right-hand crossover near Cary station
- An extended Powhatan-Neuse siding in Johnston County

The cost estimates included in section 9.1 assume all the above infrastructure is necessary to support the 8-2-8-2 service pattern. In response to the initial results, GoTriangle and NCRR have requested that Norfolk Southern evaluate an alternative including lower-cost infrastructure in Durham, as well as evaluate the 30/60 and 60/60 service patterns described in section 5. As described in section 8.3, this supplemental analysis will require additional time to complete, and is therefore not available to be included in this report.

Figure 6-1: Infrastructure Requirements Identified by Norfolk Southern Study



7 Project Metrics

7.1 Opportunity Analysis

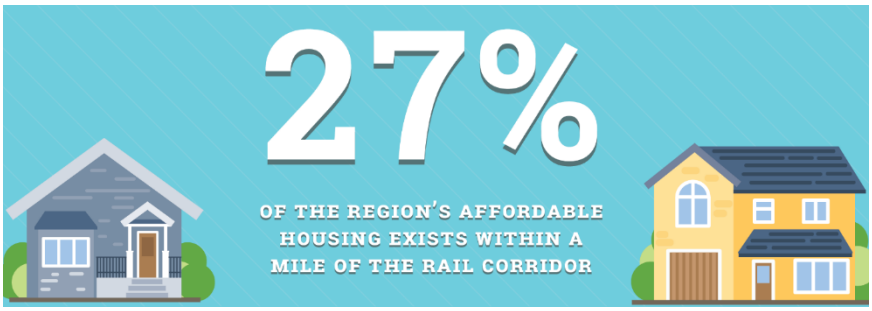
While much of the study focused on what would need to happen within the rail corridor itself, complementary reports completed during this study looked at how the area along the rail corridor might be impacted by commuter rail implementation. For purposes of the analysis, the rail corridor is defined as 2 miles wide, one mile on each side of the existing tracks within the North Carolina Railroad Company right of way. TJCOG led this effort by studying affordable housing, land use, and travel markets in and around the corridor. Together with an economic impact analysis completed by the study consultant team, these reports comprise the Opportunity Analysis for the project. The opportunity analysis strives to be descriptive rather than prescriptive in its analysis.

7.1.1 Affordable Housing

Close to Home: An Affordable Housing Analysis of the Triangle's Passenger Rail Corridor looks at affordable housing that could be served by the proposed commuter rail service. The report focuses on key components of the region's housing market and does the following:

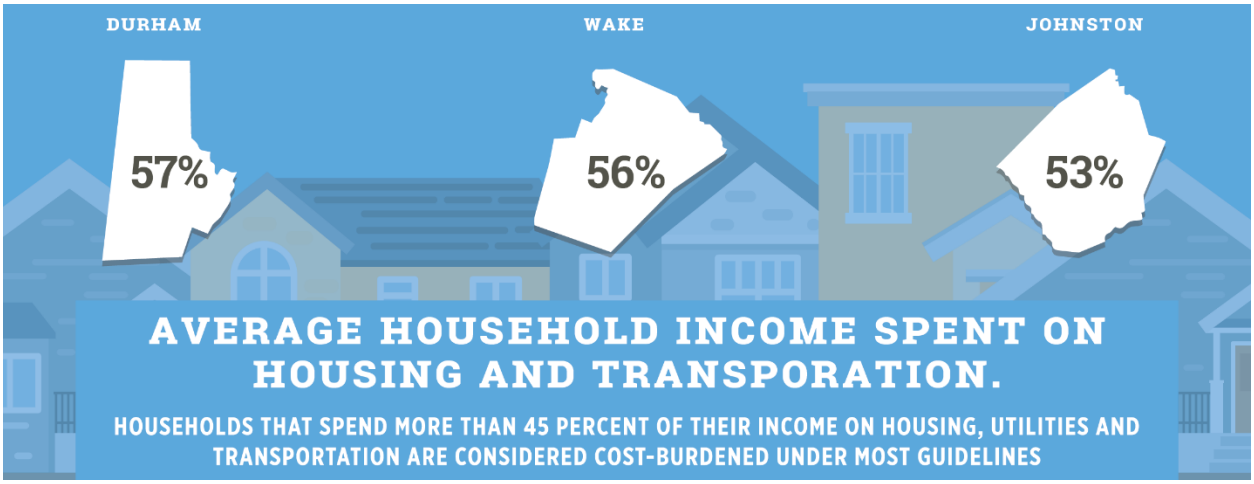
- Defines affordable housing and its two main types: housing that is affordable due to legally binding commitments (legally binding affordability restricted or LBAR) and housing that is currently affordable due to its characteristics and market conditions (naturally occurring affordable housing (NOAH).
- Summarizes the connection between housing affordability and transit access.
- Provides a detailed analysis of:
    - Legally binding affordability restricted housing (LBAR), both existing and planned.
    - Other multifamily (apartment) housing that is currently affordable due to its age, condition, or location (NOAH).
    - How the corridor would rate for affordable housing under federal transit project funding evaluation.
    - Publicly owned sites where future affordable housing could be feasible.
- Identifies locations on the corridor where additional stops might benefit residents of affordable housing.
- Indicates performance measures we can track and steps we can take to work together in the Triangle Region to preserve and create affordable housing.

The key findings of the report are as follows:



1. There is a substantial amount of legally-binding, affordability restricted (LBAR) housing along the rail corridor, especially in Wake & Durham Counties, which can be linked to major job hubs by CRT.
2. There is a substantial amount of multi-family naturally occurring affordable housing (NOAH) along the rail corridor, including a large percentage of Johnston County multi-family NOAH units.

3. Housing Authority plans and LIHTC awards would add more than a thousand LBAR affordable housing units within station study areas.
4. Existing affordable housing would support the project in federal funding competition; future affordable housing would provide further support.
5. Based on a "first pass" analysis, there are opportunities for more affordable housing using public and anchor institution land along the rail corridor, should communities and partners wish to pursue this option.
6. Safe and seamless "first-mile/last-mile" connections will be important to serve affordable housing.



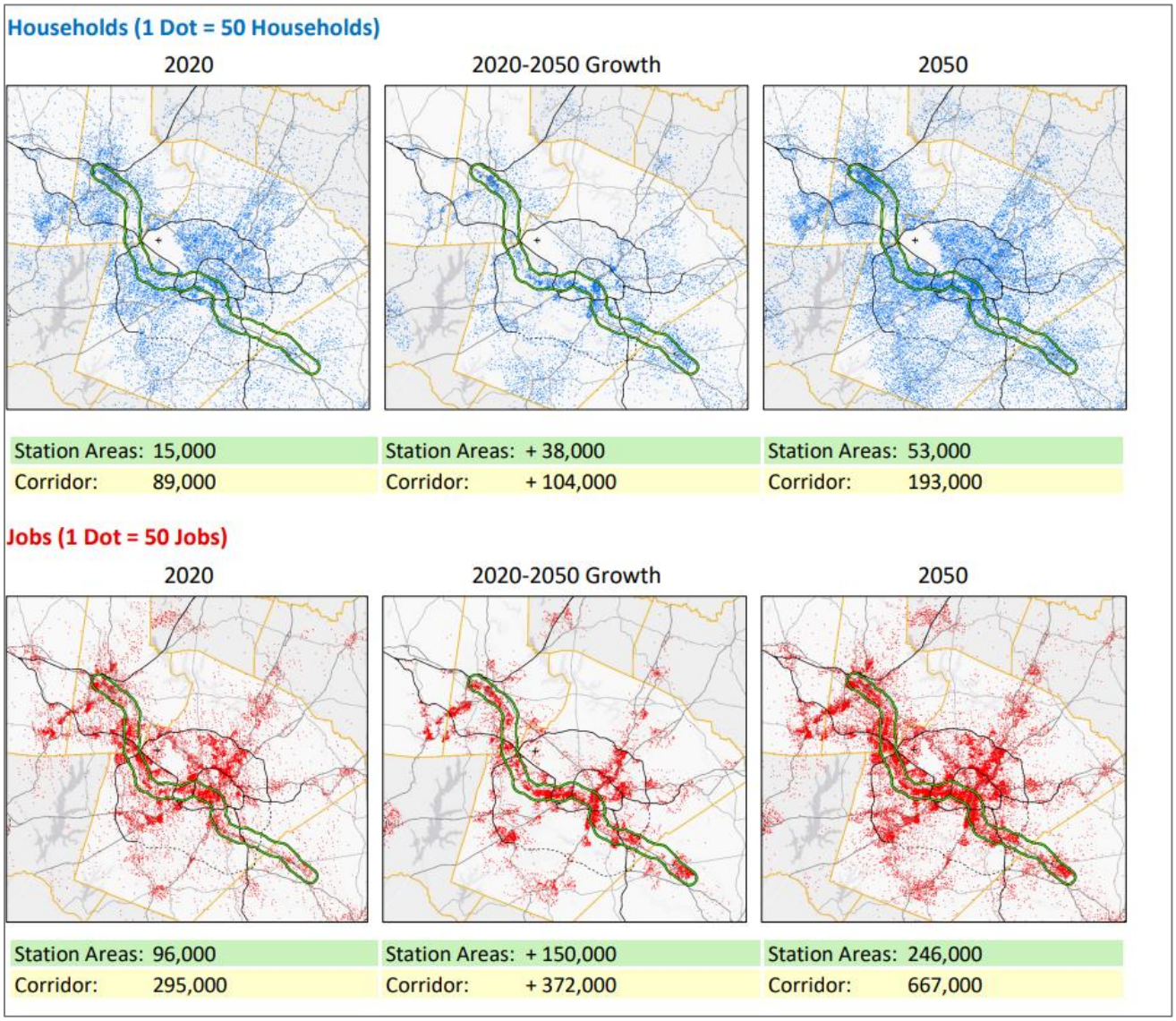
Additional detail on this topic is documented in Appendix C, Close to Home: An Affordable Housing Analysis of the Triangle's Passenger Rail Corridor.

7.1.2 Land Use

A Better Place: A Land Use Analysis of the Triangle's Passenger Rail Corridor focuses on station study areas and "first-mile-last-mile" locations, along with how community land use plans and standards align with the *Real Estate Market Analysis.* The report dives into important issues associated with land use in the region, corridor, and commuter rail station study areas:

- Regionally consistent place types and the capacity for future growth in the rail corridor and station study areas.
- Current local land use and development ordinance designations.
- Development plans and issues related to anchor institutions, including universities and the Research Triangle Park.
- The alignment of existing and planned land uses with a development market assessment.
- Key local development standards, especially building setbacks from the railroad right of way.
- Opportunities for joint development and equitable Transit-Oriented Development.

Figure 7-1: Household and Job Density Growth, 2020 through 2050



Full-size graphics and details are included in Appendix D

The key findings of the report are as follows:

1. The rail corridor is only 4% of the area of Orange, Durham, Wake and Johnston Counties, but is forecast to hold 45% of the region's jobs by 2050 (compared to 30% of the region's jobs in 2018 described below in Section 7.1.3).
2. The corridor is forecast to add 100,000 housing units and 370,000 jobs by 2050. Even more corridor housing and commercial demand may be market-realistic.
3. With this growth, there will still be room for another 100,000 housing units and 330,000 jobs beyond 2050 based on the 2050 Transportation Plan.

4. Because much of the land in the corridor is beyond walking distance (one-half mile radius) of a station, high-quality transit and active transportation connections to stations will be influential for household and job access.
5. If corridor land use is to serve a spectrum of users, then sustained, deliberate efforts to create equitable Transit-Oriented Development seem needed. Leveraging public land, federal Joint Development rules, and anchor institution collaboration may be impactful.

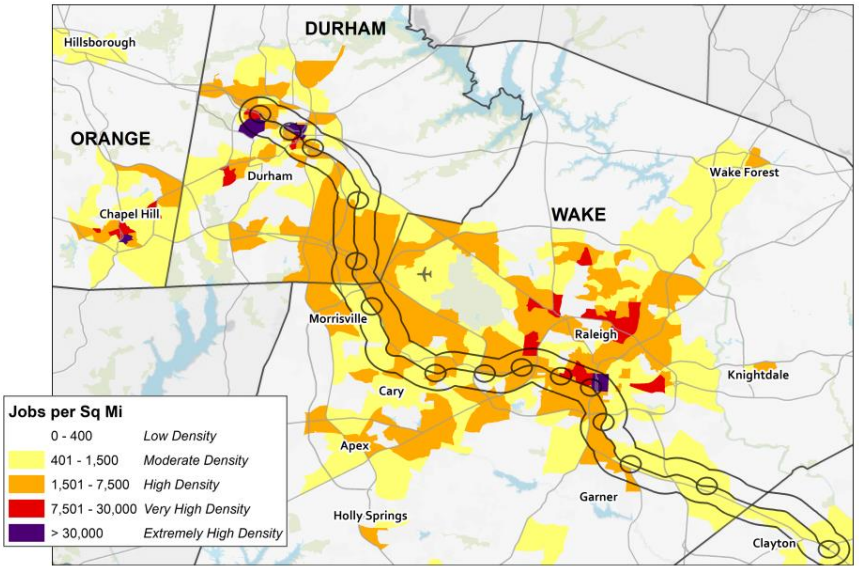
Additional detail on this topic is documented in Appendix D, A Better Place: A Land Use Analysis of the Triangle's Passenger Rail Corridor.

7.1.3 Travel Markets

Getting There: A Travel Market Analysis of the Triangle's Passenger Rail Corridor looks at the travel market that can be served by passenger rail investment in the existing railroad corridor between West Durham near Duke University and Clayton in Johnston County and the role of this travel market in the wider region. It focuses on key components of the travel market:

- The key job hubs in the region and along the corridor.
- The key neighborhoods where providing access to jobs, services, and opportunities may be especially meaningful.
- Current travel that both begins and ends along the rail corridor – the heart of the travel market.
- Commuter travel since the transit service being explored is geared primarily to connecting workers to jobs.

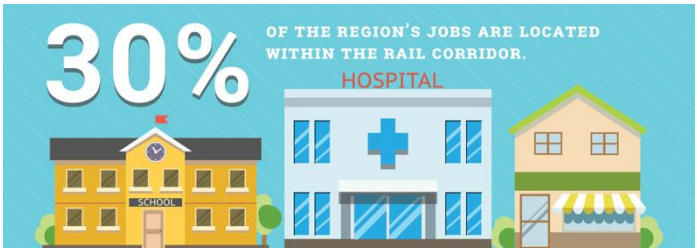
Figure 7-2. Job Density in the Project Study Area



Full-size graphic and details are included in Appendix E

The key findings of the report are as follows:

1. The rail corridor has ~30% of the region's jobs: 280,000 jobs under current conditions (2018).
2. 23% of the region's jobs with earnings below $40,000 per year are located in the rail corridor.
3. The Wake County-Durham County regional connection is the largest in North Carolina, with over 96,000 workers living in one county and working in the other.
4. 8 of the top 10 job hubs in the region are along the rail corridor, including the city centers of Raleigh and Durham, Duke University and Medical Center, North Carolina State University, and Research Triangle Park.
5. 56,000 workers both live and work in block groups along the rail corridor.
6. Almost 70,000 people live in neighborhoods that are completely or partly in the corridor and achieve thresholds for the amount and concentration of black, indigenous, and people of color populations, lower income and zero-car households, and legally binding affordability restricted housing units.
7. Safe and seamless "first-mile/last-mile" connections are key to serving these neighborhoods.



Additional detail on this topic is documented in Appendix E, Getting There: A Travel Market Analysis of the Triangle's Passenger Rail Corridor.

7.1.4 Regional Economic Impact

The *Regional Economic Impact Analysis of the Triangle's Passenger Rail Corridor* looked at how the rail project would generate economic returns by enhancing the quality of life of commuters, fostering better connectivity between workers and employers, and encouraging more compact development patterns in station areas that are economically and environmentally resilient.

Commuters benefit from transit investments that make their commute shorter and more comfortable. This improves their quality of life, giving them more time to spend on leisure activities, education, or at work, reinforcing the attractiveness of the Triangle in aggregate as a place to live and work and subsequently contributing to more spending in the region and sustained economic growth.

When it is easier to access major job centers from all parts of the Triangle, it opens the opportunity to recruit from a larger labor pool. This enables better matches between workers looking for quality jobs and employers looking for specific skills. This has real benefits to productivity for businesses that catalyze overall economic growth for the region.

The commuter rail can help anchor the new population and employment growth in the region, serving as a magnet for transit-oriented development that fosters more compact, walkable, and mixed-use communities. Having transit access increases the attractiveness of living and working near rail stations and fosters development interest and employment density in the area. Denser employment hubs promote innovation, knowledge spillovers, and economies of scale, which lead to an increase in the productivity of workers. Building the commuter rail line would increase employment density in the Triangle. The increase in employment density leads to the economic return.

The construction phase of the commuter rail project would create its own economic boost as construction companies hire more employees and consultants and those people spend more in the Triangle.

Additional detail on this topic is documented in Appendix F, GTCR Regional Economic Impact Analysis.

7.2 Affordability to Riders

The cost of the commuter rail service to those who would ride, and its affordability relative to other modes of transportation, is important. This point was reinforced by local public engagement and is also reflected in the model that is used to estimate ridership. This study used the model to test how ridership might be affected by different fare policies.

After considering fare policies in effect for similar systems in the Triangle and elsewhere in the country, the fare policies shown in the following table were tested. In the table, all fares are Year 2022 dollars. Only the full one-way fare is shown, but similar relative pricing was applied for all fare types.

Table 7-1: Fare Scenarios Tested for Effects on Ridership

Fare Policy Scenarios	Bus Services			Commuter Rail
	GoTriangle	GoRaleigh and GoCary	GoDurham	
A: All free transit	$0.00	$0.00	$0.00	$0.00
A2: Local bus free; regional fare for regional bus and rail	$2.50	$0.00	$0.00	$2.50
B: Zone-based rail fare	$2.50	$1.25	$1.00	$2.50 (1-2 Fare Zones) $3.50 (3 Fare Zones) $4.50 (4 Fare Zones)
C: Rail same as regional bus	$2.50	$1.25	$1.00	$2.50
D: Premium fare for rail	$2.50	$1.25	$1.00	$3.50

For Fare Scenario B (zone-based rail fare), stations were assigned to fare zones as follows:

- Fare Zone 1: West Durham, Downtown Durham, and East Durham
- Fare Zone 2: Ellis Road, Research Triangle Park, and Morrisville
- Fare Zone 3: Cary, Corporate Center Drive, Blue Ridge Road, Raleigh, and Hammond Road
- Fare Zone 4: Garner, Auburn, and Clayton

As summarized in the table below, weekday ridership estimates would be similar (ranging from 11,400 to 12,000) for the policies that would impose a regional rail fare similar to the existing regional bus fare. The all-free policy results in a ridership estimate 50 percent higher (18,000) and the premium fare policy results in the lowest ridership estimate.

Table 7-2: Ridership Estimates for Fare Scenario Tests

Potential Fare Policy	West Durham-Auburn 8-2-8-2 Year 2040 Weekday Ridership
A: All free transit	18,000
A2: Local bus free; regional fare for regional bus and rail	11,400
B: Zone-based rail fare	11,500
C: Rail same as regional bus	12,000
D: Premium fare for rail	9,900

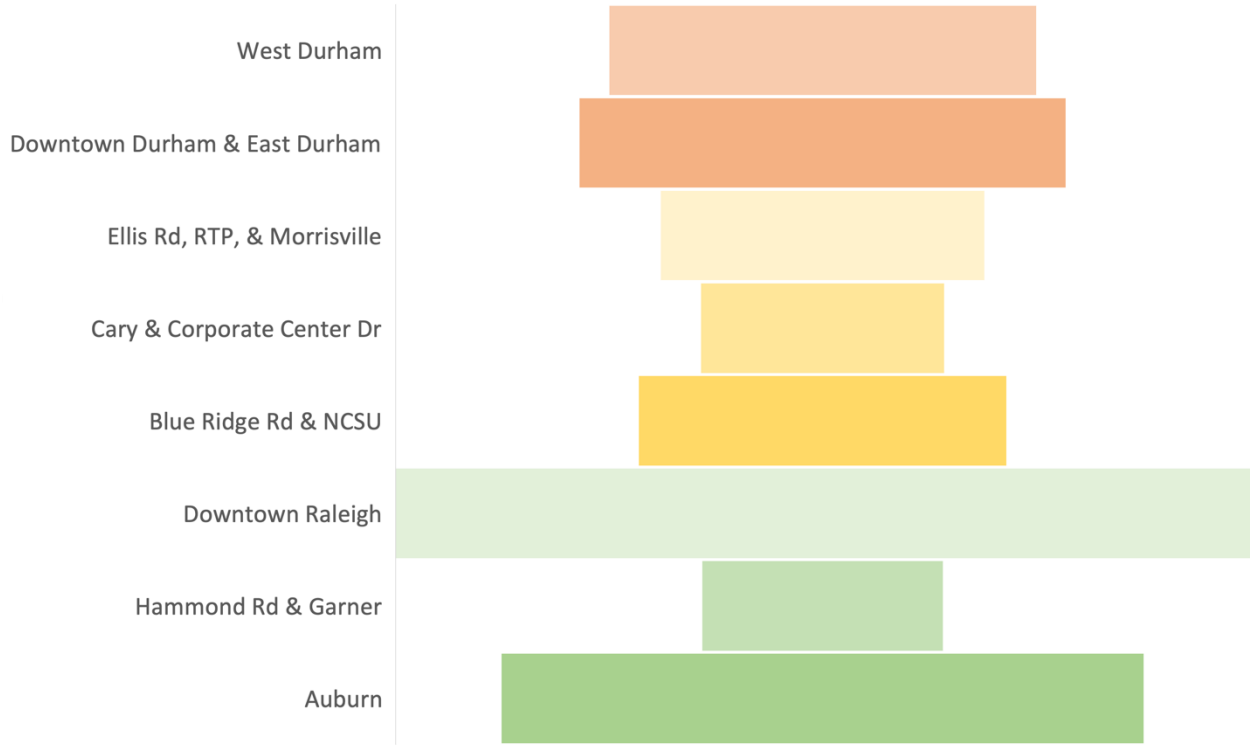
Fare policy C, rail same as regional bus, was used as the default for ridership scenario testing, described below. Fare policy is typically set close to the start of revenue service, taking into account future parameters such as regional fare policies and operating subsidies.

Additional detail on this topic is documented in Appendix G, Fare Policy Memorandum, and Appendix H, Phase 2 Ridership Analysis Technical Memorandum.

7.3 Ridership

Daily commuter rail ridership in 2040 for the 8-2-8-2 service scenario from West Durham to Auburn is estimated to be between 10,000 and 18,000, depending on the fare scenario.

Figure 7-3: Relative Boardings by Corridor Geography (West Durham to Auburn 8-2-8-2 [2040])



For 8-2-8-2 from West Durham to Auburn with limited service to Clayton, 30/60 from West Durham to Auburn, and 60/60 West Durham to Auburn ridership modeling was conducted assuming fare scenario C (same as regional bus) described in section 7.2 above. The daily commuter rail ridership for 8-2-8-2 from West Durham to Clayton in 2040 is estimated to be about 12,000. The daily commuter rail ridership for 30/60 from West Durham to Auburn in 2040 is estimated to be about 14,000. The daily commuter rail ridership for 60/60 from West Durham to Auburn in 2040 is estimated to be about 12,000. Trips in the all-day service scenarios are distributed differently from the base 8-2-8-2 scenario. In particular, stations with high bus transfer (such as Durham Station) are projected to have higher boardings in the all-day scenarios.

Additional detail on this topic is documented in Appendix H, Phase 2 Ridership Analysis Technical Memorandum.

8 Engineering Feasibility

As described in section 2.3, a key objective of this study is determining engineering feasibility and an updated cost estimate for implementing commuter rail service in this corridor. While the proposed project has the advantage of using pre-existing rail infrastructure and right of way running through the Triangle, successfully implementing commuter rail would require navigating and addressing a number of engineering challenges. There are several locations along the corridor where adding the required infrastructure is complicated due to features of the existing built environment such as utility conflicts, right of way encroachments, roadway intersections, historic properties, and more. Meeting FTA requirements for accessibility also presents a challenge that must be met thoughtfully and creatively.

This section summarizes the efforts to identify and investigate these issues and develop feasible design concepts to inform updated cost estimates included in section 9.1.

Additional detail on this topic is documented in Appendix I, Corridor Screening Report.

8.1 Key Engineering and Constructability Risk Areas

8.1.1 Downtown Durham

Downtown Durham was identified early in the study process as needing dedicated analysis for commuter rail feasibility. Challenges in downtown Durham include many roadway crossings, abutting historic properties, aging infrastructure and utilities that do not meet current standards, and environmental justice communities with a history of negative impacts due to major transportation projects.

Figure 8-1: Rendering of Downtown Durham Station Area Concept 2

Adding track and station infrastructure in downtown Durham will be highly visible and inevitably cause disruption during construction. The study has identified multiple feasible options to add necessary track, improve bridge clearances, and create more space to potentially improve pathways for buses, pedestrians, and bicyclists to move across the rail corridor. Extensive stakeholder engagement occurred during this evaluation to help identify preferred concepts and to ensure the City of Durham and others were able to provide feedback and aid in decision making. However, to move forward it will be critical to obtain and document buy-in from all affected stakeholders, and there is currently not consensus among the parties on the design.

Thirteen potential downtown Durham track concepts were developed to determine feasibility, including low-level platforms on shared tracks that would use assisted boarding and high-level platforms on dedicated tracks that would allow unassisted level boarding. To screen these concepts down to a short list of potential concepts, constraints were identified, including streams, floodplains, greenways/bike routes, historic resources, gas stations, parks, and other points of interest. Survey information was obtained for the study area using a compilation of survey data collected during development of the Durham-Orange Light Rail Transit project and new ground and top of rail shots obtained specifically for this study. Functional track and roadway designs were developed to enable a comparison of potential impacts.

Two conceptual designs are recommended for further consideration: one utilizing low-level station platforms (Concept 2) and one with high-level station platforms (Concept D). (Note: Additional information about consideration for low-level and high-level platforms is included in section 8.1.4.) Concept 2 was recommended as the best of the low-level options because it accommodates increased vertical clearance under Gregson and Chapel Hill Streets with minimal impact to roadways, utilities, and historic properties. Concept D was recommended as the best of the high-level options because it accommodates increased vertical clearance under Gregson and Chapel Hill Streets. Because of the high-level platforms and railroad design requirements, Concept D requires dedicated station tracks to separate the passenger and freight train traffic, resulting in higher costs and a wider railroad cross section at the station. If implementation includes a station in downtown Durham, it will be necessary to secure agreements with the City of Durham, NCDOT, NCRR, NS, and Amtrak that confirm the design for either Concept 2, Concept D, or a variant of one of those concepts. A variant of Concept 2 that utilizes gauntlet tracks to provide for high platforms with minimal footprint and a variant of Concept D which reduces track spacing to obtain a smaller footprint are also recommended for evaluation as discussions progress with Norfolk Southern, though acceptance of these concepts by the railroad parties would require approval of deviations from their design standards.

Traffic operations is another key area of interest for downtown Durham, particularly due to the location of the Durham Station bus transfer center on Pettigrew Street just south of the rail corridor. Analysis performed as part of this study indicates that traffic operations will degrade in the future regardless of commuter rail – with increased development and increased traffic volumes in and around downtown, it will take longer for vehicles including buses to travel around the roadway network. Preliminary analysis of commuter rail indicates:

- Under base year conditions, while most bus routes may generally experience an increase in overall delay due to additional gate down time at crossings with commuter rail, additional delay

generally fits within the available inbound buffer time built into bus schedules and would have minimal impact to on-time performance.

- Under future year conditions, the most substantial increase in delay is along Fayetteville Street, which is compounded due to the reduction in lanes as part of the bicycle improvement project.
- Improvements such as extending/adding turn bays and restriping approach lanes along Pettigrew Street, Swift Avenue, and Main Street generally decrease delay, in some cases even below future year without commuter rail, and these improvements have the potential to increase safety throughout the study area.

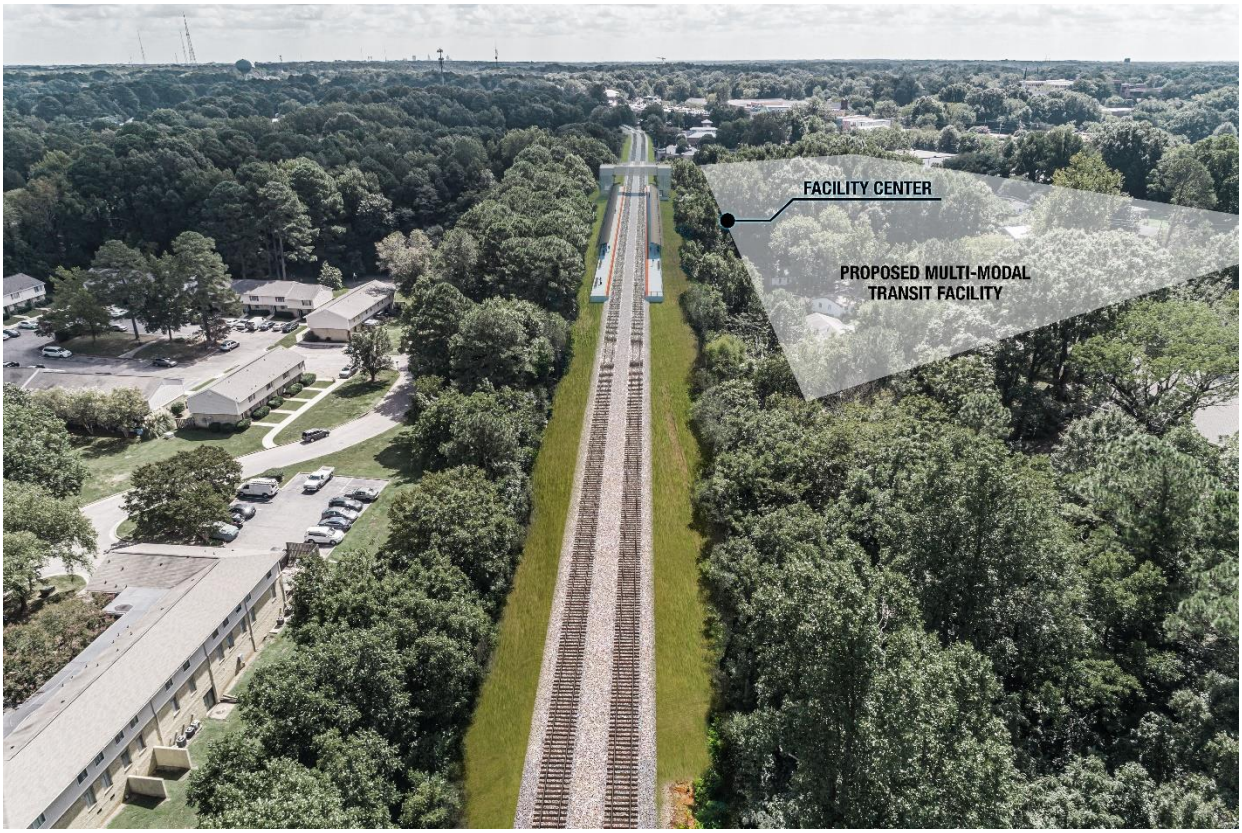
It should be noted that this traffic analysis does not include recommendations from the City of Durham's ongoing Durham Station Transit Emphasis Zone (TEZ) or Bus Speed and Reliability (BSR) studies, which would be expected to improve bus speed and reliability in this area. If implementation includes a commuter rail service through downtown Durham, options to avoid and/or mitigate potential impacts and opportunities to improve bus speed and reliability in the project area should be evaluated during future environmental studies.

Additional detail on this topic is documented in Appendix J, Downtown Durham Feasibility Report.

8.1.2 Downtown Cary

Similar to downtown Durham, downtown Cary was identified as having engineering and infrastructure needs that merited additional dedicated feasibility analysis for commuter rail.

Figure 8-2: Rendering of Downtown Cary Station Area Concept 4



Engineering challenges and considerations in downtown Cary include integration with the planned Downtown Cary Multimodal Facility, historic properties, roadway crossings, utility relocations, bridge replacements, and the proximity of complex railroad signaling infrastructure (Control Point Fetner) where the NCRR H Line and CSX S Line meet. Three initial concepts for track configurations were considered in Cary, each of which included a low-level platform. Responding to input received on the initial three, a fourth concept (Concept 4) was developed that would meet primary design objectives including avoiding both the historic Paige-Walker Hotel property and Control Point Fetner. Further discussion with the Town of Cary led to the development of a concept similar to Concept 4, but with high-level platforms for level boarding (Concept 5). To accommodate the two additional tracks required for high-level platforms while reducing impacts to Ambassador Loop and E. Cedar Street, Concept 5 adds tracks to the north side and the platforms are shifted farther to the west.

Concepts 4 and 5 would each involve relocation of the existing Amtrak station from east of Harrison Avenue to west of Harrison Avenue. Functional level preliminary engineering designs were developed for Concepts 4 and 5 in stormwater, structures, and utilities, as well as development of a traffic analysis and capital cost estimate, and input was obtained from the Town of Cary, NCDOT, and NCRR. Both concepts were confirmed to be physically and operationally feasible.

The Town of Cary is in the process of completing a feasibility study for a standalone project to relocate the existing Amtrak station west of Harrison Avenue as part of establishing a larger multi-modal transit facility. The schedule for implementation of that project has not been set. If implementation of commuter rail includes a station in downtown Cary, it will be necessary to secure agreements with Town of Cary, NCDOT, NCRR, NS, CSX, and Amtrak that confirm the design for either Concept 4, Concept 5, or a variant of one of those concepts, and define how the two overlapping projects are sequenced and coordinated.

Additional detail on this topic is documented in Appendix K, Downtown Cary Feasibility Report.

8.1.3 Raleigh Union Station

The downtown Raleigh area near Raleigh Union Station (RUS) has several potential risk items and constraints that are located within a small area, described below:

1. Single Track Station Entry – The current RUS Master Plan proposes to construct the commuter rail platform north of the existing intercity station. In order to access the platform, the commuter and intercity trains would both enter and exit their respective platform tracks utilizing a single track. Train breakdowns or schedule variations could lead to a breakdown or delay in service at the RUS commuter and intercity platforms.
2. S Line Platform – NCDOT has plans to construct a new passenger platform on the S Line north of the existing RUS and relocate some or most existing passenger train service to that location. Relocation of existing trains to this new platform may partially or fully alleviate the need for a separate dedicated commuter platform.
3. Signal Design Complexities – Numerous freight and passenger train movements in this area create complex signal design scenarios and a greater need for safety as more passenger traffic is planned at RUS.
4. West Street Extension Project – The City of Raleigh is in the early stages of design on a project to extend West Street under/over the rail corridor and the existing intercity platform. As currently envisioned, the commuter rail platform will be difficult to access from surrounding streets.

Developing direct access to the commuter rail platform from West Street as part of the West Street Extension project would be desirable.

Three options for placing an additional platform at Raleigh Union Station were explored in this phase of study: an additional platform and station track south of the existing H Line, creating a side platform layout for commuter rail; constructing half of the required length of the future S Line platform, relocating Piedmont trips to the S Line, and using the existing platform for commuter service; or constructing an additional center platform in the planned location north of the existing platform, but with improvements to create a parallel entry/exit for commuter trains. The side platform layout was determined to be infeasible because the geometry of the station track does not meet Norfolk Southern standards, and the available platform length was shorter than the anticipated commuter train length. Of the two remaining feasible options, placing the additional commuter platform north of the existing platform was included in the cost estimate described in section 9.1, to provide for a conservative analysis because it appeared to be more disruptive and likely more expensive than building the S Line platform. Major items associated with this option include reconstructing the Boylan Ave bridge, new and shifted trackwork along the S Line to create parallel entry, new and shifted trackwork along the East Leg of the wye to create parallel entry, upgraded interlockings, wider bridges east of RUS to accommodate three tracks rather than two as the parallel entry tracks tie down to double track.

If implementation includes commuter service at Raleigh Union Station, it will be necessary to secure agreements with City of Raleigh, NCDOT, NCRR, NS, CSX, and Amtrak that confirm the design and platform access arrangements.

Additional detail on this topic is documented in Appendix L, Raleigh Union Station Feasibility Report.

8.1.4 Accessibility Requirements

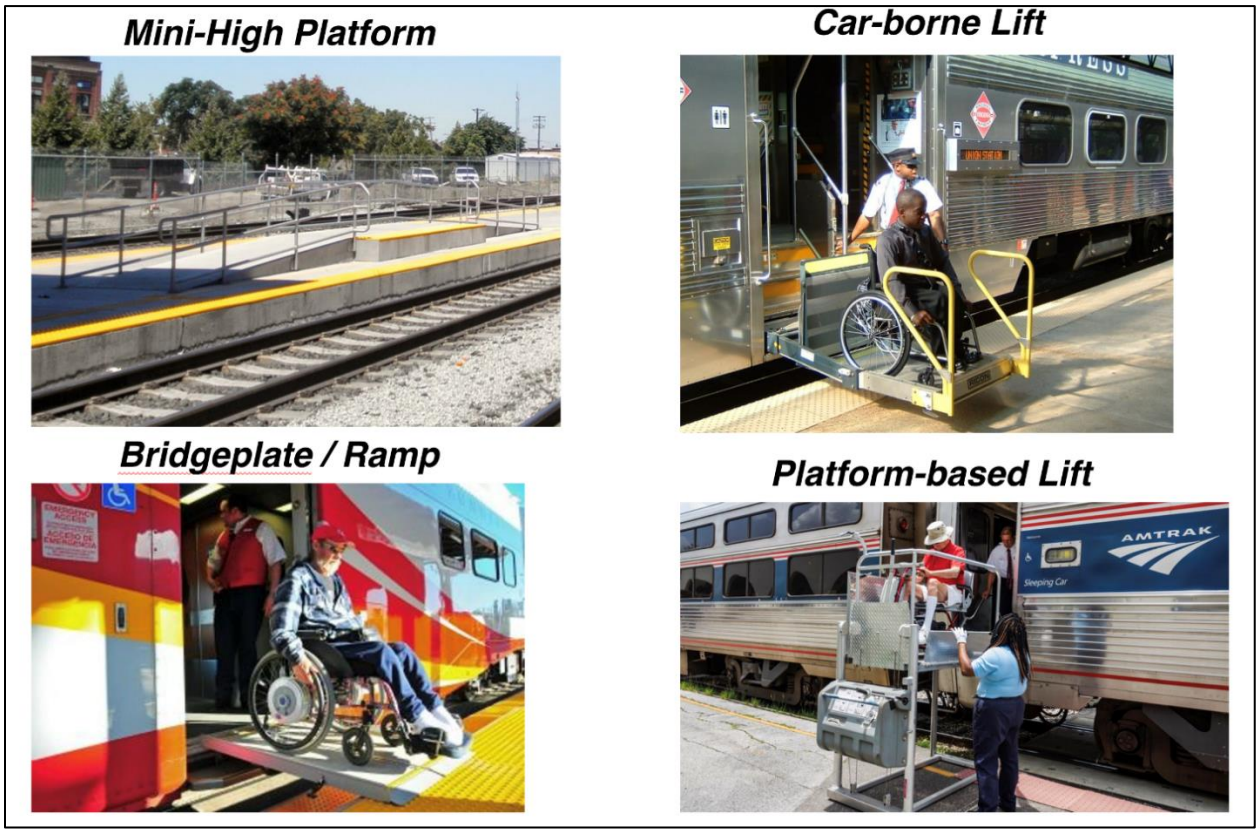
In the context of passenger rail transit, accessibility refers to ability of all users, including those with disabilities, to use the train with ease. In accordance with the Americans with Disabilities Act (ADA), FTA requires that all commuter rail systems provide accessible boarding to the trains. Initially this rule applied to each train, however in 2012 new guidance was issued requiring accessible boarding to every car of every train which poses a more complex design challenge for new systems and retrofits to existing systems, particularly those in corridors that are shared with freight trains.

On a track exclusive to passenger trains, level boarding must be used to provide accessibility, and level boarding is typically provided by building a platform at a height that matches the height of the inside of the train car.

The proposed commuter rail corridor is a shared-use corridor used by both passenger trains and freight trains. The physical characteristics of the train cars used for each of these differs. Where freight trains will pass through commuter rail stations, platforms must provide sufficient clearance for wider freight cars. Clearance requirements for the NCRR/NS corridor stipulate that passenger platforms are limited to 8 inches in height and 5’4” from the track centerline. Because no passenger train has a floor this low, a vertical gap exists on shared track where the platform and the floor of the train do not line up. When passenger trains approach platforms and users wish to board, the gap must be addressed. Most passengers use stairs to get up to the train floor, but those using mobility devices, or otherwise needing assistance, require another solution. Where track must be shared with freight, FTA allows that

alternative solutions can be used, including car-borne lifts, bridge plates or ramps, mini-high platforms, and station-based lifts.

Figure 8-3: Common Accessibility Approaches for Shared Use (Freight and Passenger) Corridors



Unassisted level boarding using high-level platforms is often preferred by users and transit providers for ease of use and efficiency. However, unassisted level boarding is not possible on shared-use tracks. If unassisted level boarding is provided, dedicated tracks are required at the station to separate freight and passenger rail. Other methods to maintain clearances include gauntlet tracks and folding platform edges; however, both these methods are uncommon on Class I freight railroads and are strongly discouraged by Norfolk Southern.

A review of peer commuter rail systems created since the implementation of the ADA showed that in corridors most similar to the NCRR corridor, where the commuter rail shares tracks with Class I freight at high levels of traffic, assisted boarding is most often used to meet accessibility requirements. Systems with all level boarding are typically in exclusive or low-traffic corridors controlled by the transit agency. Level boarding would be unique in a shared-use corridor with the characteristics of the NCRR/NS corridor.

Previous studies of commuter rail service in the NCRR corridor have assumed an assisted boarding configuration in which shared tracks with low-level platforms would be the standard design. This study evaluated an assisted boarding concept including low-level platforms with assisted boarding at all stations except the two terminal stations and RUS, which would have high-level platforms because those three locations require dedicated station tracks for operations. Assisted boarding could be achieved

using either car-borne lifts or a combination of a mini-high platform with manually deployed bridge plate for one car per platform with car-borne lifts for all other cars; each of these solutions are used on other systems around the country.

In response to stakeholder input, this study also evaluated the physical and operational feasibility of providing level boarding at each of the stations in the project corridor even though that would be a departure from the national norms described above. In this situation, a typical level boarding station concept would consist of two center tracks for freight and two sidetracks for passenger rail. Where constraints would not allow this, alternate configurations were considered. Potential property acquisitions, impacts to adjacent roadways, and reconstruction of rail and road bridges were documented.

Both concepts were tested by the study team using rail network modeling, and both are considered operationally feasible. However, the second concept with dedicated station tracks at all stations is not preferred by the corridor owner, would have a much larger physical footprint, and would be significantly more costly than the initial concept.

The cost estimate documented in section 9.1 assumes the assisted boarding concept with low-level platforms at most stations, with high-level platforms only where operationally required at the terminal stations and RUS. If the project moves forward, for each station it will be necessary to secure agreements that confirm the design of each station with each host municipality, NCRR, and NS, (and NCDOT and CSX as applicable for some stations). It may be possible to implement high platforms with dedicated station tracks at more stations; however, additional budget and approval of the railroad parties would be required.

Additional detail on this topic is documented in Appendix M, Rolling Stock and Accessibility Technical Memorandum.

8.1.5 Grade Crossings

The interface of the railroad corridor with the surrounding road network can be a critical item for acceptability of the project by local jurisdictions. Grade crossings, grade separations, and crossing closures each carry a different set of potential community impacts, and each solution can be controversial in a variety of contexts. This study evaluated the existing interfaces and identified locations that are at-grade crossings today that may require modification, closure, or separation, or could be considered for closure or separation during future environmental studies.

For the most part, from a physical geometry perspective, crossings in the corridor that are at grade today can be maintained at grade in the future with the additional track required to support commuter rail service. However, the five crossings listed in Table 8-1 were identified as potentially requiring modification due to proximity to proposed stations, suboptimal existing configuration, or conflict with special trackwork that may be required by Norfolk Southern. If implementation moves forward, the design of the modifications and opportunities to reduce or mitigate impacts should be confirmed in future environmental studies.

Table 8-1: Grade Crossings Affected by the Project Design

Locale	MP	Road	Description	Resolution
Durham	56.4	Plum St	Station location would cause conflicts with the existing at-grade crossing	Public pedestrian grade separation is assumed in the design
Durham	56.7	Driver St	Special trackwork associated with addition of a third track at East Durham Yard would require closure of the existing at-grade crossing	GoTriangle and NCRR have requested that Norfolk Southern evaluate alternative track configuration that would avoid closure; response is pending
Raleigh	83.6	Rush St	If station tracks and high-level platforms are pursued, the current at-grade crossing could require closure or grade separation	Low-level platform is assumed in the design (avoids closure); if high-level platform is introduced later, provide public pedestrian grade separation
Garner	85.6	Yeargan Rd	Skewed intersection near existing crossing, additional track may require crossing/intersection modification	Cost estimate includes an allowance for modifications to be design in later phase
Garner	86.5	St. Mary's St	Garner Station location could affect current grade crossing, requiring closure or grade separation	Cost estimate includes an allowance for modifications to be designed in later phase

Eight at-grade crossings have volumes or crash history that suggest potential for separation or closure regardless of commuter rail as shown in Table 8-2. This study assumes that the at-grade configuration would be maintained at each of these locations based on coordination with municipalities to date. A final decision of how and whether to address these crossings with other modifications such as grade separation or closure as part of the commuter rail project would be determined in subsequent environmental studies and would require additional budget if grade separation is recommended. Input from NCDOT and municipalities will be critical in determining solutions.

Table 8-2: Grade Crossings with Volumes and/or Crash History Triggering Review

Locale	MP	Road	Reason For Selection
Durham	54.2	S. Buchanan Blvd	Future Year Level of Service
Durham	55.57	Fayetteville St	Recent Crash History
Durham	56.71	S. Driver St	Recent Crash with Serious Injury or Fatality
Durham	57.58	Ellis Rd	Recent Crash History
Morrisville	68.74	Morrisville-Carpenter Rd	Recent Crash History, Recent Crash with Serious Injury or Fatality
Raleigh	162.42	Nowell Rd	Recent Crash History
Raleigh	82.05	S. Blount St	Recent Crash with Serious Injury or Fatality
Garner	88.13	Jones Sausage Rd	Recent Crash History

Additional detail on this topic is documented in Appendix I, Corridor Screening Report.

8.2 Land Availability for Facilities

8.2.1 Operations, Maintenance, and Administration Facility

A facility to house rail operations, maintenance, and administration is an essential component of the project. The location of the facility must be accessible to the corridor, would be relatively large to accommodate the fleet size envisioned by this study, and likely would require industrial zoning. Development in the corridor is increasing rapidly and land meeting these criteria is not plentiful. Potential sites were identified and screened for feasibility in a two-step process:

1. The initial step involved identifying undeveloped or underdeveloped sites of sufficient size (approximately 40 acres) that directly abut and have access to the NCRR rail line, without incompatible surrounding land uses or major environmental site constraints such as hydrology or topography. This step yielded 20 potential sites.

2. The second step further screened to eliminate the following:
    a. Parcels with floodplains (unless the site was large enough to have 40 contiguous acres outside the floodplain),
    b. Parcels with abutting residential uses
    c. Parcels under NC Department of Agriculture or State ownership for Land Grant purposes
    d. Parcels under development
    e. Parcels not sufficiently rectangular
    f. Parcels within Voluntary Agricultural Districts
    g. Parcels within the path of NC-540 were identified for potential coordination with NC Turnpike Authority.

No potential maintenance facility sites were identified on the Durham end of the project corridor, primarily due to the lack of suitable undeveloped land near the rail corridor. Five potential sites were identified on the eastern end, three in Wake County and two in Johnston County. This is considered a

favorable result from the perspective of the study. If implementation moves forward, future study to confirm and obtain federal approval for acquisition of a preferred site should be prioritized. Failure to obtain a favorably located, appropriately zoned, undeveloped site would increase project cost and implementation risk.

Additional detail on this topic is documented in Appendix N, Maintenance Facility Site Search and Screening Technical Memorandum.

8.2.2 Parking

To support mode shift and reduction in vehicle miles traveled, park and ride lots are an essential component of commuter rail. Previous phases of study have identified a need for parking at 12 of the 15 proposed stations. Three proposed stations — Downtown Durham, NCSU, and Raleigh Union Station — were not identified as park and ride locations. During this phase of study, analysis was completed to determine the high-level feasibility for parking at the 12 stations. This analysis aimed to understand land availability and suitability for parking lots that are sufficiently sized to meet anticipated demand at each station.

A two-step geospatial process was used to identify candidate parcels (or groups of adjacent parcels) for parking at stations.

1. Round one identified parcels with an edge no more than 960 feet from the center of a station location. This distance represents 1/8 mile to arrive at the station, plus an additional 300 feet to arrive at the center of the station platform (assumed to be 600 feet long). 1/8 mile is a commonly accepted metric for an acceptable walk from parking to a given use. Once identified, the number of spaces that could be supported by each parcel (or parcel group) was determined. Those not large enough to support 100 spaces, or approximately .75 acre, were screened out.

2. Round two identified and prioritized agency-owned parcels and screened out developed parcels, or any with building dollar value of greater than zero. This metric was chosen to assess the relative ease of land acquisition based on the amount of unimproved real estate at the time of the study.

The analysis found that sufficient land is available at 9 of the 12 proposed park and ride locations. Three station locations lack sufficient available land according to the parameters of this initial effort and warrant additional evaluation. Those locations are West Durham, Blue Ridge Road, and Garner. Additional coordination with third parties may be required at these locations in addition to the stations at RTP, Morrisville, Cary, and Clayton.

Additional detail on this topic is documented in Appendix O, Park and Ride Site Search and Screening Technical Memorandum.

8.3 Status of Railroad Coordination

Coordination with NCDOT, NCRR and Norfolk Southern has been an integral part of the study process, and cooperation with these entities as well as CSX is critical to project implementation and success.

8.3.1 Base Case Analysis

Concurrent with this phase of study, Norfolk Southern completed rail network modeling for the two base case scenarios: 8-2-8-2 West Durham to Auburn and 8-2-8-2 West Durham to Auburn with limited service to Clayton. As part of Norfolk Southern's work, additional infrastructure was identified that would be necessary to support the service.

As described in section 6, some elements of this additional infrastructure are costly and difficult to implement, most notably the additional track identified in west Durham and east Durham. GoTriangle and NCRR have requested that Norfolk Southern consider alternate infrastructure solutions that would be less costly and easier to implement. Resolution of that request will require additional coordination and is not confirmed at this time.

Additional detail on this topic is documented in Appendix P, Evaluation of Norfolk Southern Infrastructure Recommendations.

8.3.2 Additional Service Scenarios

As described in sections 2.4 and 5, through the course of this study, significant interest in more all-day service patterns developed. GoTriangle and NCRR have requested that Norfolk Southern consider the alternate service patterns described in section 5. Resolution of that request will require additional coordination and is not confirmed at this time.

8.3.3 Railroad Agreements

In addition to these unresolved items related to infrastructure and service levels, Norfolk Southern also identified a number of other items that must be resolved prior to implementation, such as passenger and commuter train speeds and schedule adherence in a signal environment designed to accommodate freight trains, reduced maintenance of way work windows on the ability to maintain track signals and other infrastructure in the corridor, additional delays to train crews due to increased run-times and the effects on Norfolk Southern crew bases at Greensboro and Selma, additional demand on Norfolk Southern and CSX dispatching resources, communication capability and coordination between the corridor users, and an effective system for notifying passengers at all commuter stations.

Prior to moving forward with implementation, an agreements framework must be developed that provides a pathway to successfully address in a timely manner these and other issues with potential impacts on project viability, cost, and schedule. It is not possible to obtain full approval from railroad parties of a project of this magnitude and complexity without significant design advancement beyond a feasibility level; however early memoranda of understanding, term sheets, conceptual concurrence, or other incremental frameworks are strongly recommended by Federal Transit Administration best practices guidance for this type of project and should be employed here if implementation moves forward.

9 Cost Estimate

9.1 Capital Cost

Capital cost estimates include the one-time expenditures required to establish reliable commuter rail service in the existing rail corridor without adversely affecting freight and intercity service. Capital costs are reported here for two baseline scenarios:

- Stations between West Durham and Auburn served by 8-2-8-2 service, including high level platforms at the terminal stations and Raleigh Union Station
- The West Durham to Auburn service described above plus limited service (3-1-3) to Clayton

Capital costs reflect design and construction of the infrastructure, rolling stock, and related support costs such as construction services, project management, surveys, testing, insurance, legal services, permits and other owner's costs. Contingencies were applied to costs throughout the estimate to account for uncertainty in both the estimating process and the scope of the project.

Planning-level estimates were informed by industry sources, including the Federal Transit Administration (FTA), for comparable pricing, and by NCRR and NCDOT Rail Division staff and related work. They do not reflect engineering drawings, quantity take-offs, or other specifics that will be established during design.

The cost estimate in the previous phase of this study (Phase I) was developed in 2020 base year dollars, and schedule assumptions were applied to obtain a total cost estimate range of $1.8B to $2.1B in year of expenditure dollars, which reflects inflation expected to occur during the project life cycle. The Phase I estimate assumed that the project would be developed and constructed by 2028.

The cost estimate for this phase of study was developed by adjusting the Phase I estimate to account for new information developed in this phase. Capital cost estimates developed in this phase shown in Table 9-1 are approximately 50% higher than estimated in Phase I of the feasibility study. This is primarily attributable to three factors: additional inflation, additional scope identified through rail network modeling, and additional scope identified through feasibility investigations. A cost estimate range is included to reflect the preliminary nature of both the estimates and the associated implementation schedule. Schedule assumptions used for this estimate are included in section 10. The implementation schedules used for these estimates extend further into the future than the Phase I study, with projected project completion dates of 2033 at the earliest to 2035 with a more conservative schedule.

Table 9-1: Capital Cost Estimate Summary

Service Area and Daily Roundtrips (AM peak-midday-PM peak-evening)		Range of Capital Cost (Base Year 2022$)	Range of Capital Cost (YOE$)
West Durham to Auburn	8-2-8-2	$2.15B	$2.8B – $3.1B
West Durham to Auburn + Clayton	8-2-8-2 + 3-1-3	$2.25B	$2.9B – $3.2B

Additional detail on this topic is documented in Appendix Q, Capital Cost Estimates Technical Memorandum.

9.2 Operating Cost

During Phase 2, Operations & Maintenance (O&M) costs were estimated to assess the relative cost of the proposed service scenarios evaluated in the study. The O&M estimates were prepared using the typical FTA-approved methodology, which relies on the cost experience of peer systems from the National Transit Database (NTD) and builds cost estimates on the planning-level estimates of service for the corridor.

Four primary cost categories are considered: Train Operations, Vehicle Maintenance, Non-Vehicle Maintenance, and General Administration. These categories represent the full range of costs associated with operating a transit service. The peer systems were identified as those with similar characteristics to the proposed project, including diesel power commuter rail with push-pull equipment and single lines or other small operations. Services that were omitted for being intrinsically different than the proposed service were those with large systems with many lines, legacy systems from the northeastern US, electrified commuter rail, and intercity Amtrak lines that are grouped as commuter rail for NTD reporting. This approach yielded a set of 12 peer commuter rail agencies that were used for estimating unit costs in the cost model.

Using the above methodology, O&M costs were estimated for base case service from West Durham to Auburn (8-2-8-2) and the base case service from West Durham to Clayton (8-2-8-2, 3-1-3). In addition to the two base case scenarios, O&M costs were also estimated for a 30/60 enhanced frequency (30-minute peak frequency/60-minute off-peak frequency) scenario and a phased implementation of hourly service between West Durham and Auburn.

Table 9-2: Operations and Maintenance Costs - Base Case Service

	Train Operations	Vehicle Maintenance	Non-Vehicle Maintenance	General Administration	Total O&M Cost
West Durham to Auburn (8-2-8-2)	$21.5M	$8.5M	$3.5M	$8.5M	$42.0M
West Durham to Clayton (8-2-8-2, 3-1-3)	$21.6M	$9.3M	$3.5M	$8.5M	$42.9M

O&M costs in 2022 dollars.

Additional detail on this topic is documented in Appendix R, Operations & Maintenance (O&M) Cost Methodology and Estimates.

10 Implementation Schedules

Major phases to implement the project would include project development; design; and construction, testing, and commissioning. Each of those phases would include many interrelated technical, legal, and financial activities. Preliminary schedules—one conservative, one optimistic—were developed to inform expectations about when commuter rail service might be available to the riding public and to inform financial planning. Both schedules assume a decision to move forward with implementation by the end of 2022.

Table 10-1: Implementation Schedules

Major Activities	Optimistic Duration	Conservative Duration
Environmental compliance, corridor-wide land survey, preliminary engineering, multiple stages of review and agreement between project sponsors and railroad operators.	3.5 years	4 years
Final engineering and associated reviews and agreements, including all products needed to secure federal funding.	1.5 years	2 years
Construction, testing and commissioning. Includes real estate procurement, construction of everything along rail line, construction of vehicle storage and maintenance facility, purchase of trainsets, and several operating and maintenance agreements.	5 years	6.5 years
Total	10 years	12.5 years
Commuter rail in service	**2033**	**2035**

Additional detail on this topic is documented in Appendix S, Schedule Analysis Technical Memorandum.

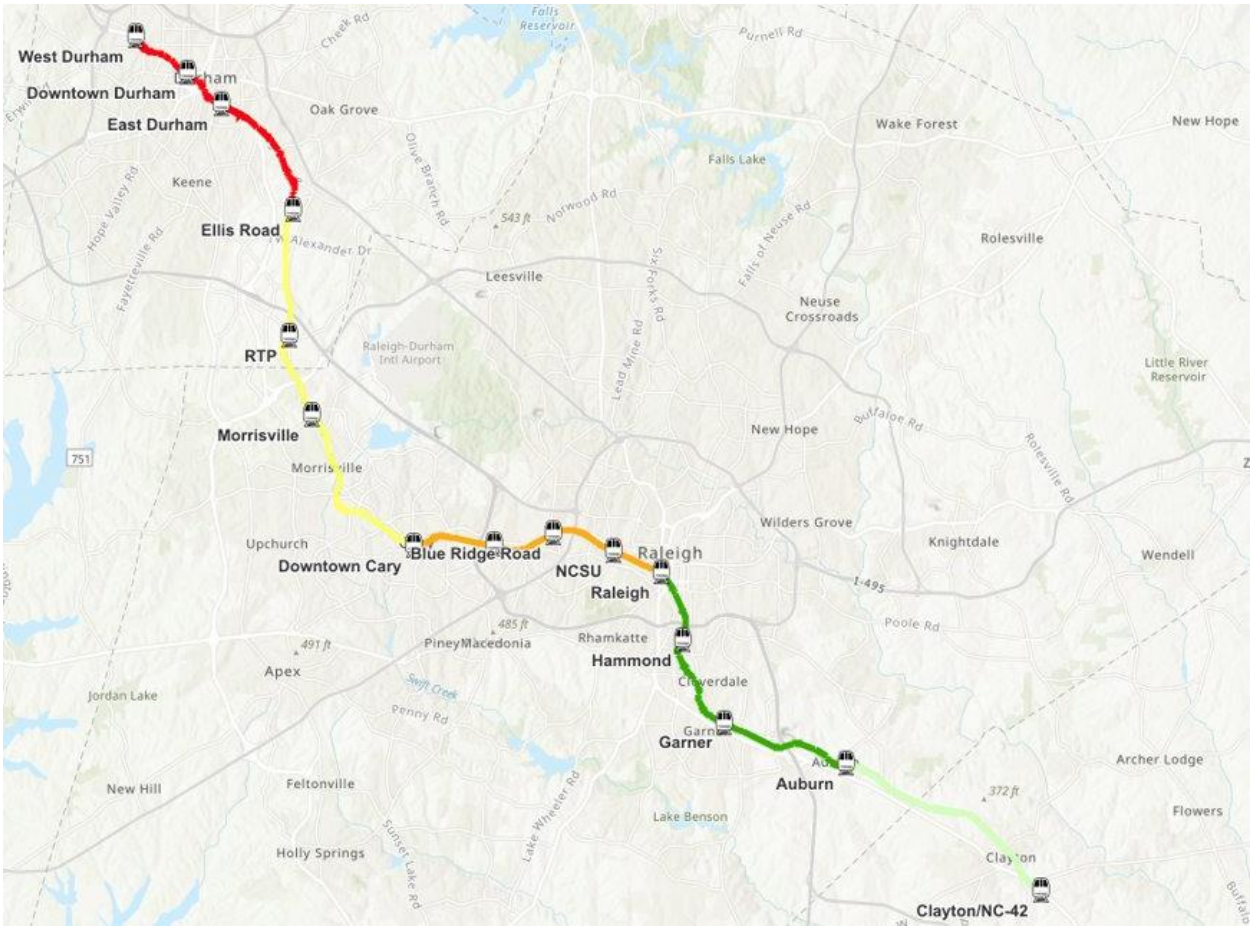
11 Project Delivery Approach

11.1 Federal Funding Programs

Earlier studies have assumed that this project would seek funding through the Federal Transit Administration Capital Investment Grants program, which can provide a grant for up to 50 percent of the capital cost of the project. This funding program requires significant local investment prior to the commitment of federal funding, and to remain eligible for federal funding, projects must meet specific project justification criteria documented in federal guidance. Earlier studies have identified that the project justification rating for this project would be close to the minimum required for funding, and the increases in costs and changes in ridership forecasts completed in this phase of study have deepened that concern. Additionally, the Federal Transit Administration is in the process of updating the rating criteria for this program. The impact of those updates on this project's rating are unknown at this time.

Concurrent with this study, Congress enacted new legislation that significantly expands funding for rail infrastructure projects over the next five years. The Bipartisan Infrastructure Law enacted in November 2021 provides an unprecedented $210 billion in authorized funds and advanced appropriations for rail and transit over the next five years. Elements of this project would be eligible for funding under multiple programs with lower local funding requirements (as low as 20 percent for some programs). Seeking funding through multiple programs is complex, takes time, and is not guaranteed, but could result in getting service underway sooner and potentially bringing more federal dollars to the project to offset rising construction costs.

Figure 11-1: Map Highlighting Areas of Project Implementation Feasibility Identified in this Study



11.2 Assessment of Project Delivery Challenges

As described in section 9, this study found that the service will cost more to implement than was previously estimated, primarily due to recent cost escalation, additional infrastructure identified by Norfolk Southern, and other updates to the base cost estimation for the project.

As described in section 10, this study also identified that a single large project from West Durham to Auburn or Clayton will take longer to deliver than is currently contemplated in the transit plans, and as described in section 8.3, several key elements of coordination with railroads remain unresolved at this time. This feasibility study also identified that implementation challenges are not distributed equally across the corridor, as illustrated in Figure 11-1 and described in this section below.

The portion of the project corridor in southeast Wake County, east of Raleigh Union Station (RUS) and depicted in dark green in Figure 11-1, has the fewest of these implementation challenges. This section has the lowest railroad complexity because no Piedmont trains operate east of RUS and this area does not overlap with the CSX-dispatched area of the corridor between Cary and Raleigh. This portion of the corridor has the lowest requirements for additional infrastructure; other than double-tracking eight miles between Raleigh and Auburn, no additional infrastructure in this area was identified by Norfolk Southern's initial study. Additionally, this area has relatively high certainty in design requirements compared to other areas of the corridor described in section 8.1.

The easternmost portion of the study area—Johnston County, depicted in light green in Figure 11-1—may not be ready for commuter rail implementation. While there is rapid growth and forecasted demand for transit, there is no dedicated funding source for transit in Johnston County and no existing local bus network. Additionally, there is not yet local consensus on the location of commuter rail stations in Johnston County, and planning for future station areas as compared to Wake and Durham Counties is limited. Ridership modeling shows similar total estimates regardless of whether the eastern terminal station is in Auburn (Wake County) or Clayton (Johnston County), indicating that trips originating in Johnston County may be well-served by a park-and-ride at Auburn in 2040.

Implementation of service is complicated in the central portion of the corridor, depicted in orange in Figure 11-1. Complex agreements are needed between Norfolk Southern, CSX, Amtrak, NCRR, NCDOT, and the Town of Cary to govern operations in the Raleigh-Cary portion, and negotiations of these agreements will take time. The recently released Draft State Transportation Improvement Program (STIP) would defer funding for construction of long-planned grade separations in Cary, which are much easier to accomplish if completed prior to commuter rail implementation. Additional coordination is needed to confirm design for the downtown Cary station with all parties, including Amtrak, and the location of the Research Triangle Park station is subject to ongoing activity related to the planned relocation of GoTriangle's regional transit center.

Lastly, there are many challenges to work through in Durham, depicted in red in Figure 11-1. There are three stations currently planned in or near downtown Durham. Implementing service in this area would be complex and costly due to the built-up nature of the land around the corridor, a limited street grid with challenging at-grade crossings and low-clearance bridges, historic buildings, universities, rapidly growing residential and commercial areas downtown, constrained land availability for park-and-ride in west Durham, and a mix of industrial and residential uses east and west of downtown.

Adding a second track west of the West Durham station as described in Section 6, would trigger additional infrastructure work including: three bridge replacements, three grade crossings, the possible need to close the private crossing west of Hillandale Road, and possible commercial impacts to buildings currently encroaching on the NCRR corridor in that area. While it was understood that these issues would ultimately need to be solved for future western service extension to Hillsborough and Mebane, compliance with Norfolk Southern's recommendations for implementing service to Durham would require addressing these issues in order to provide service in central Durham.

Adding track and station infrastructure downtown will be highly visible and inevitably cause disruption during construction. The study has identified multiple feasible options to add necessary track, improve bridge clearances, and create more space to potentially improve pathways for buses, pedestrians, and bicyclists to move across the rail corridor. However, moving forward will require buy-in from all affected stakeholders, and there is currently not consensus among the parties on the design.

Adding track and station infrastructure around the East Durham freight yard and planned East Durham rail station would trigger closure of one or both of the two existing street crossings between Alston Avenue and Ellis Road. This is a low-income area with historically Black neighborhoods that have experienced adverse impacts resulting from transportation projects in the past, specifically extreme displacement and disruption to community cohesion caused by construction of NC 147. These are the only crossings in the 1.5-mile distance between Alston Avenue and Ellis Road. Plum Street, which has a low volume of 1,300 vehicles crossing per day on average, would be closed to vehicle traffic with implementation of an East Durham Station. The station would include a bridge for people on foot or with bikes to safely cross the corridor. Driver Street, which has a moderate volume of 6,100 vehicles crossing per day, may need to be closed to vehicle traffic with implementation of the additional infrastructure recommended by Norfolk Southern to increase capacity at the East Durham yard. Additional planning, design, and public engagement would be needed to investigate options to maintain vehicle and pedestrian connectivity in this area.

11.3 Next Steps

GoTriangle and project partners are working to refine financial plan options and develop a more defined grant-seeking strategy. Ultimately, the purpose of this report and subsequent activities is to support regional decision-making on whether and how to move forward with commuter rail in this corridor.

Immediate next steps following a decision to move forward would include project development activities such as preliminary engineering and environmental compliance. Costs for these activities are estimated at 5-10% of the cost of construction, to be paid from local transit plan funding.

GoTriangle or other project partners may also seek grants for elements of the overall project scope to be implemented as standalone projects while the commuter rail is being developed (e.g., rail safety projects, double tracking). If approved, development expenses for these projects would be locally funded from the transit plan(s) as needed, and design and construction costs could be funded up to 80% from federal sources if grant applications are successful.

12 Terms and Acronyms

Acronym/Term	Meaning
30/60	Service concept with half-hourly trains during peak periods and hourly trains during non-peak periods
3-1-3	Service concept with 3 trains during peak periods and one during the interim non-peak period (proposed for the extension to Clayton)
8-2-8-2	Service concept with 8 trains during peak periods and 2 during non-peak periods
ADA	Americans with Disabilities Act
BRT	Bus Rapid Transit
CAMPO	Capital Area Metropolitan Planning Organization
CP	Control Point
CPI	Consumer Price Index
CSX	CSX Transportation (Class I Railroad)
DCHCMPO	Durham, Chapel Hill, Carrboro Metropolitan Planning Organization
FRA	Federal Rail Administration
FTA	Federal Transit Administration
LBAR	Legally binding affordability restricted (housing)
MIS	Major Investment Study
MOU	Memorandum of Understanding
NCDOT	North Carolina Department of Transportation
NCRR	North Carolina Railroad
NCSU	North Carolina State University
NEPA	National Environmental Policy Act
NOAH	Naturally occurring affordable housing
NS	Norfolk Southern Corporation (Class I Railroad)
NTD	National Transit Database
O&M	Operations and Maintenance
RTF	Research Triangle Foundation
RTP	Research Triangle Park
RUS	Raleigh Union Station
SCC	Standard Cost Category
STIP	State Transportation Improvement Program
TJCOG	Triangle J Council of Governments
YOE	Year of expenditure

13 List of Appendices

Appendix A **GTCR Memorandum of Understanding (MOU)**

Appendix B **Stakeholder Outreach and Participation**

Appendix C **Close to Home: An Affordable Housing Analysis of the Triangle's Passenger Rail Corridor**

Appendix D **A Better Place: A Land Use Analysis of the Triangle's Passenger Rail Corridor**

Appendix E **Getting There: A Travel Market Analysis of the Triangle's Passenger Rail Corridor**

Appendix F **GTCR Regional Economic Impact Analysis**

Appendix G **Fare Policy Memorandum**

Appendix H **Phase 2 Ridership Analysis Technical Memorandum**

Appendix I **Corridor Screening Report**

Appendix J **Downtown Durham Feasibility Report**

Appendix K **Downtown Cary Feasibility Report**

Appendix L **Raleigh Union Station Feasibility Report**

Appendix M **Rolling Stock and Accessibility Technical Memorandum**

Appendix N **Maintenance Facility Site Search and Screening Technical Memorandum**

Appendix O **Park and Ride Site Search and Screening Technical Memorandum**

Appendix P **Evaluation of Norfolk Southern Infrastructure Recommendations**

Appendix Q **Capital Cost Estimates Technical Memorandum**

Appendix R **Operations & Maintenance (O&M) Cost Methodology and Estimates**

Appendix S **Schedule Analysis Technical Memorandum**