DIN 01610

Gateway & Patterson Place Traffic Simulation Report

Durham-Orange Light Rail Transit Project

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July 24, 2015

The NEPA Preferred Alternative for the D-O LRT Project would generally follow NC 54, I-40, US 15-501, and the North Carolina Railroad (NCRR) Corridor in downtown Durham and east Durham. The alignment would begin at UNC Hospitals, parallel Fordham Boulevard, proceed east on NC 54, travel north on I-40, parallel US 15-501 before it turns east toward the Duke University campus along Erwin Road, and then follow the NCRR Corridor parallel to NC 147 through downtown Durham, before reaching its eastern terminus near Alston Avenue. The alignment would consist of at-grade alignment, fill and cut sections, and elevated structures. In two sections of the alignment, Little Creek and New Hope Creek, multiple Light Rail Alternatives are evaluated in the DEIS.

This technical report contains information for all alternatives analyzed in the DEIS. However, pursuant to MAP 21, the Moving Ahead for Progress in the 21st Century Act (P.L. 112-141), a NEPA Preferred Alternative has been developed, which recommends C2A in the Little Creek section of the alignment, NHC 2 in the New Hope Creek section of the alignment, the Trent/Flowers Drive station, and the Farrington Road Rail Operations and Maintenance Facility.

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List of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AA	Alternatives Analysis
AM	Ante meridian/before noon
DEIS	Draft Environmental Impact Statement
D-O	Durham-Orange
D-O LRT	Durham-Orange Light Rail Transit
EB	Eastbound
FHWA	Federal Highway Administration
I-40	Interstate 40
INRIX	A mobile computer application that pertains to road traffic
LOS	Level of Service
LPA	Locally Preferred Alternative
LRT	Light rail transit
MOE	Measures of Effectiveness
NB	Northbound
NC	North Carolina
NCDOT	North Carolina Department of Transportation
NCRR	North Carolina Railroad
NHC	New Hope Creek
PM	Post meridian/after noon
ROMF	Rail operations and maintenance facility
SB	Southbound
TRM	Triangle Regional Model
UNC	University of North Carolina
US	United States
VA	Veteran Affairs
WB	Westbound

1. Executive Summary

The study segments in the Gateway and Patterson Place Traffic Simulation Report include the 0.6-mile long corridor of Old Chapel Hill Road crossing I-40 and the 0.4-mile long corridor of McFarland Drive to the east of I-40 within the City of Durham. The D-O LRT designs for the Gateway and Patterson Place segment included three alignment alternatives (NHC-LPA, NHC-1 and NHC-2) between McFarland Drive and SW Durham Drive. The NHC 1 and NHC 2 Alternatives are consistent from a geometric and traffic operations standpoint between Gateway and Patterson Place, and were therefore analyzed as a single LRT alternative (NHC 1/2) for this segment. The NHC-LPA Alternative traffic operations were assumed to be a conservative representation of the NHC 1/2 Alternative conditions at Patterson Place, as the vehicle volumes and physical constraints associated with the NHC-LPA LRT's crossing of SW Durham Drive are greater. This report evaluates the traffic conditions along this section under both AM and PM peak hours with the introduction of the proposed D-O LRT.

Traffic analysis was conducted using Vissim. The following scenarios were analyzed in this report:

- Existing Conditions
- 2040 No-Build Conditions
- Build LRT Conditions

The study intersections are primarily under the jurisdiction of the NCDOT and were evaluated accordingly. The remaining location is under the City of Durham jurisdiction. During the analysis, roadway modifications to improve traffic operations were incorporated into the LRT Build Alternative analysis model. The recommended modifications proposed as part of the LRT Alternatives are presented in Table ES-1.

Table ES-1: LRT Alternative Proposed Roadway Modifications

Intersection	Roadway Modification
Pope Road at Old Chapel Hill Road	Reconfigure proposed circular roundabout to oval shape
McFarland Drive at Witherspoon Boulevard	Increase northbound Witherspoon Boulevard left turn bay by removing parking
	Prohibit westbound McFarland Drive left turn
SW Durham Drive at Hopedale Avenue	Increase southbound SW Durham Drive left turn
	Prohibit westbound Hopedale Avenue left turn

The traffic analysis was conducted using the macro-level software Synchro for traffic signal optimization and the micro-simulation software Vissim was used to provide a comprehensive multimodal model capable of replicating traffic signal preemption and the interaction of vehicle, pedestrian and LRT operations. The 2040 No-Build and 2040 Build Alternatives were evaluated using Vissim. The overall intersection results of the No-Build versus Build LRT Alternatives Vissim analysis are shown in Table ES-2.

Table ES-2: Vissim Overall Intersection Analysis Summary – 2040 LRT Options vs. 2040 No-Build

Intersection	2040 No-Build		2040 Build	
	AM	PM	AM	PM
Mount Moriah Road at Old Chapel Hill Road[1]	A	A	A	A
Pope Road at Old Chapel Hill Road[1]	C	A	A	D
Park-and-Ride Entrance at Old Chapel Hill Road[1]*	--	--	A	A
White Oak Drive at Old Chapel Hill Road[1]	B	B	B	B
McFarland Drive at Witherspoon Boulevard[2]	B	F	B	D
SW Durham Drive at McFarland Drive[1]*	--	--	B	C
Hopedale Avenue at SW Durham Drive[1]	A	B	A	B

Footnote:
1 - NCDOT Traffic Impact Criteria is applied
2 - City of Durham Traffic Impact Criteria is applied
* Build Alternative Only

Intersections along Old Chapel Hill Road and McFarland Drive are anticipated to operate at LOS D or better under the Build Alternative during both peak hours with the roadway modifications and turning restrictions noted above.

Under the Build Alternative, the maximum queue lengths would be slightly longer than those under No-Build Conditions at the intersections of Pope Road and Old Chapel Hill Road, SW Durham Drive and McFarland Drive, and Hopedale Avenue and SW Durham Drive. These queues do not impact the adjacent intersection operations.

2. Introduction

Through the Alternatives Analysis (AA) process completed in April 2012 prior to preliminary design, which included extensive public outreach, a Locally Preferred Alternative (LPA) was selected to address the purpose and need of the Durham-Orange (D-O) Corridor. The proposed project is a 17.1 mile double-track light rail transit (LRT) line with 17 proposed stations that will greatly expand transit service in Durham and Orange Counties. The Durham-Orange Light Rail Transit (D-O LRT) project extends from its western terminus at the University of North Carolina at Chapel Hill (UNC) at the UNC Hospitals Station to the eastern terminus in Durham at the Alston Avenue Station. The proposed D-O LRT Project improves public transportation access to a range of educational, medical, employment, and other important activity centers, in the D-O Corridor including: UNC; UNC Hospitals; the William and Ida Friday Center for Continuing Education; Duke University; Durham Veterans Affairs (VA) Medical Center and Duke University Medical Center (DUMC); downtown and east Durham.

2.1 Description of the Proposed D-O LRT

The proposed D-O LRT alignment generally follows North Carolina (NC) Highway 54 (NC 54), Interstate 40 (I-40), United States (US) 15-501, and the North Carolina Railroad (NCRR) Corridor in downtown Durham and east Durham. The proposed alignment begins in Chapel Hill at UNC Hospitals, parallels Fordham Boulevard, proceeds eastward adjacent to NC 54, travels north along I-40, parallels US 15-501 before it turns east towards Duke University and runs within Erwin Road, and then follows the NCRR Corridor that parallels NC Highway 147 (NC 147) through downtown Durham, before reaching its eastern terminus in Durham near Alston Avenue. A total of 17 stations are planned, and approximately 5,000 parking spaces along the D-O LRT alignment will be provided. In addition, a rail operations and maintenance facility (ROMF) will be constructed to accommodate the D-O LRT fleet. It should be noted that the ROMF location is anticipated to generate minimal traffic during the peak hours. As such, those impacts were not evaluated as part of this report.

Bus routes will be modified to feed into the D-O LRT stations and headways will be adjusted to provide more frequent service and minimize transfer waiting times. These services will also connect LRT passengers with other area transportation hubs, including park-and-ride lots and transfer centers.

2.2 Proposed Project Alternatives

The Draft Environmental Impact Statement (DEIS) will examine the potential environmental impacts of the LRT alternative as well as a small number of alignment, station, and ROMF siting alternatives, including the following:

- Crossing of Little Creek between the Friday Center and the proposed Leigh Village Development (i.e., Alternatives C1, C1A, C2, C2A and associated station locations)
- Crossing of New Hope Creek (NHC) and Sandy Creek between Patterson Place and South Square (i.e., NHC-LPA, NHC Alternatives 1 and 2 and associated station locations)
- Station alternatives at Duke and Durham VA Medical Centers
- Five proposed locations for the ROMF

In addition to the LRT, the DEIS will consider a No-Build Alternative, which includes the existing and programmed transportation network improvements, with the exception of planned rail improvements and associated bus network modifications.

2.3 Purpose of Gateway/Patterson Place Traffic Simulation Report

The roadway network is a critical element of the transportation network, serving as a means to safely move people and goods and to support the economic development of an area. In an effort to balance safety and mobility with economic development and access, many owners of public roads have developed standards for determining the impacts of development on the roadway network and the level to which those impacts must be mitigated. The standards and mitigation levels governing projects in Durham and Orange Counties of North Carolina have been identified in the *Traffic Analysis Methodology Report* included in Appendix A.

The purpose of this technical memorandum is to analyze the traffic operations for the Gateway/Patterson Place section of the proposed D-O LRT project in light of the policies identified in the *Traffic Analysis Methodology Report.* In this section, the D-O LRT would enter at-grade from the south along the west side of I-40 transition briefly turn northwest through the center of Old Chapel Hill Road and Pope Road then turn east and elevate across I-40 to proceed at-grade along the north side of McFarland Drive towards New Hope Creek.

The goal of the traffic simulation is to provide decision makers with an evaluation of the ability of the transportation system to accommodate the future travel demand and to help determine which roadway network modifications are necessary to accommodate that demand and the LRT. As noted previously, modifications to the build roadway network will be included in this evaluation to determine if reasonable mitigations can be made to accommodate the 2040 forecasted traffic volumes and the physical and operational changes LRT in accordance with the guiding policies. This study will also aim to determine which proposed roadway improvements are necessary to mitigate any additional impacts caused by the proposed D-O LRT project.

2.4 Gateway/Patterson Place Traffic Simulation Description

This report describes the approach and summarizes the findings and results of the traffic analysis conducted on two sections (Gateway and Patterson Place) of the D-O LRT alignment. The studied sections run near Old Chapel Hill Road within the Town of Chapel Hill limits and on the north side of McFarland Drive within the City of Durham limits. The project study area includes multiple intersections as shown in Figure 1.

Preliminary designs were developed for the proposed D-O LRT alignment, including two LRT stations: Gateway Station and Patterson Place Station. These designs are included in the *Basis for Engineering Design* plans (Appendix B). The analysis evaluated both weekday AM and PM peak hour traffic volumes with the introduction of the proposed D-O LRT project. The LRT was assumed to operate in both directions with 10 minute peak period frequencies and 20 seconds of dwell time at each station for passenger boarding and alighting.

As shown in the *Basis for Engineering Design* plans, the Gateway and Patterson Place segments include three alignment alternatives (NHC-LPA, NHC-1 and NHC-2) between McFarland Drive and SW Durham Drive. The NHC 1 and NHC 2 Alternatives are consistent from a geometric and traffic operations standpoint between Gateway and Patterson Place, and were therefore analyzed as a single LRT alternative (NHC 1/2) for this segment. In this segment, the D-O LRT runs parallel to I-40 before crossing through the center of the planned roundabout at Old Chapel Hill Road and Pope Road, which would be modified as part of the D-O LRT project. After leaving the Gateway Station, north of Old Chapel Hill Road, the D-O LRT alignment would cross over the interchange of I-40 and US 15-501 and continue south of US 15-501 towards Patterson Place running parallel along the north side of McFarland Drive.

For the NHC-LPA Alternative, the LRT would cross the intersection of McFarland Drive and Witherspoon Boulevard at-grade and meet the proposed Patterson Place Station just east of Sayward Drive. The NHC-LPA LRT alignment would continue east along the McFarland Drive proposed extension to cross SW Durham Drive at-grade between Hopedale Avenue to the north and McFarland Drive to the south.

Under the NHC-1/2 Alternative, the LRT would cross the intersection of McFarland Drive and Witherspoon Boulevard at-grade and meet the proposed Patterson Place Station between Witherspoon Boulevard and Sayward Drive. The LRT alignment would then turn north, running adjacent to Sayward Drive rather than continuing east-west towards SW Durham Drive and Hopedale Avenue as in the NHC-LPA Alternative. However, for the purposes of the Patterson Place segment, these separate alignments only result in a minor shift of the proposed intersection along SW Durham Drive where the LRT would cross it.

In the Patterson Place segment, the only difference between the NHC-LPA and NHC-1/2 Alternatives would be at the crossing of SW Durham Drive. The traffic operations of the NHC-LPA Alternative are assumed to be representative of the NHC-1/2 Alternative for the following reasons: there are no roadways/intersections between the Patterson Place Station and SW Durham Drive in either Build Alternative; 2040 Build traffic volumes at the extended McFarland Drive and SW Durham Drive intersection would be forecasted to have similar volumes as the NHC-1/2 Alternative's SW Durham Drive intersection at Sayward Drive as they would both provide access to Patterson Place from SW Durham Drive; the LRT track distances between the LRT Patterson Place Station and the new intersection on SW Durham Drive would be similar for both Build Alternatives; and signal preemption events would stop traffic on the eastbound left turn, northbound SW Durham Drive through, and all southbound SW Durham Drive approach movements for both Build Alternatives. Lastly, under the NHC-LPA Alternative, the LRT would cross SW Durham Drive between two closely spaced intersections instead of the single intersection that the LRT would interact with as part of the NHC-1/2 Alternative. As such, only the more conservative NHC-LPA Alternative is modeled as part of the Build Alternative traffic analysis results presented in this report.

The intersections studied as part of this report are identified below:

- Mount Moriah Road at Old Chapel Hill Road
- Pope Road at Old Chapel Hill Road
- Park-and-Ride Entrance at Old Chapel Hill Road (Build Alternative only)
- White Oak Drive at Old Chapel Hill Road
- McFarland Drive at Witherspoon Boulevard
- Hopedale Avenue at SW Durham Drive
- McFarland Drive Extension at SW Durham Drive (Build Alternative only)

The goal of the traffic simulation report is to provide decision makers with an evaluation of the ability of the transportation system to accommodate the future travel demand and to help determine which roadway network modifications are necessary to accommodate that demand. As noted previously, modifications to the roadway network as part of the No-Build Alternative will be included in this evaluation to determine if reasonable improvements can be made to accommodate the forecasted traffic volumes for 2040 in accordance with the guiding policies. This study will also aim to determine which proposed roadway improvements are necessary to mitigate additional impacts caused by the proposed D-O LRT project.

The Vissim analysis evaluated both weekday AM and PM peak hour traffic volumes with the introduction of the proposed D-O LRT. The LRT was assumed to operate in both directions with 10 minute peak period frequencies and 20 seconds of dwell time at each station for passenger boarding and alighting.

For the purpose of this analysis it was assumed that traffic signals along McFarland Drive and Durham Drive will be programmed to operate with traffic signal preemption. Railroad crossing gates are assumed to prevent conflicting LRT and vehicular movements at the following locations:

- Pope Road at Old Chapel Hill Road (proposed roundabout intersection)
- McFarland Drive at Witherspoon Boulevard
- Hopedale Avenue at SW Durham Drive (NHC-LPA alternative only)
- McFarland Drive Extension at SW Durham Drive (NHC-LPA alternative only)

Traffic signal preemption occurs when traffic signal timing is interrupted to allow trains to remain on schedule. Triangle Transit will work with NCDOT and City of Durham to develop signal plans for each intersection during the Engineering phase of the project. The signal plans will incorporate signal preemption or transit signal priority, to accommodate the LRT operations. Signal preemption interrupts normal signal operations by preemptively transferring the traffic control signal to a special operation mode under certain events such as an approaching train. Transit signal priority alters normal signal operation to better accommodate transit vehicles by extending a vehicle phase, e.g., green time will be lengthened by 15 seconds or red time will be reduced.

For purposes of this analysis under the No-Build Conditions, the intersection of Old Chapel Hill Road and Pope Road will be converted to a roundabout intersection as part of TIP project EB-4707. Under the Build LRT Alternative, this roundabout would be modified to accommodate the LRT alignment passing through the center. The project team coordinated with NCDOT to develop a concept design of the proposed modifications to the Old Chapel Hill and Pope Road roundabout, which would involve reconstruction of the roundabout to an oval configuration. Traffic crossing the LRT tracks within the roundabout is proposed to be controlled by railroad crossing gates. Additional study of the safety and operations of this at-grade crossing, as well as all other at-grade crossings proposed as part of the D-O LRT Project will be performed during the Engineering phase of the project. The design of light rail transit tracks through the center of a roundabout is not unprecedented; there is a similar location on the Trax system in Salt Lake City, Utah where median-running LRT passes through the center of a three-legged roundabout. A discussion of the operation and design of that location is documented in “Roundabouts and Light Rail Combined: An Innovative Multimodal Solution,” presented at the Transportation Research Board (TRB) National Roundabouts conference in 2005 and included for reference in Appendix C.

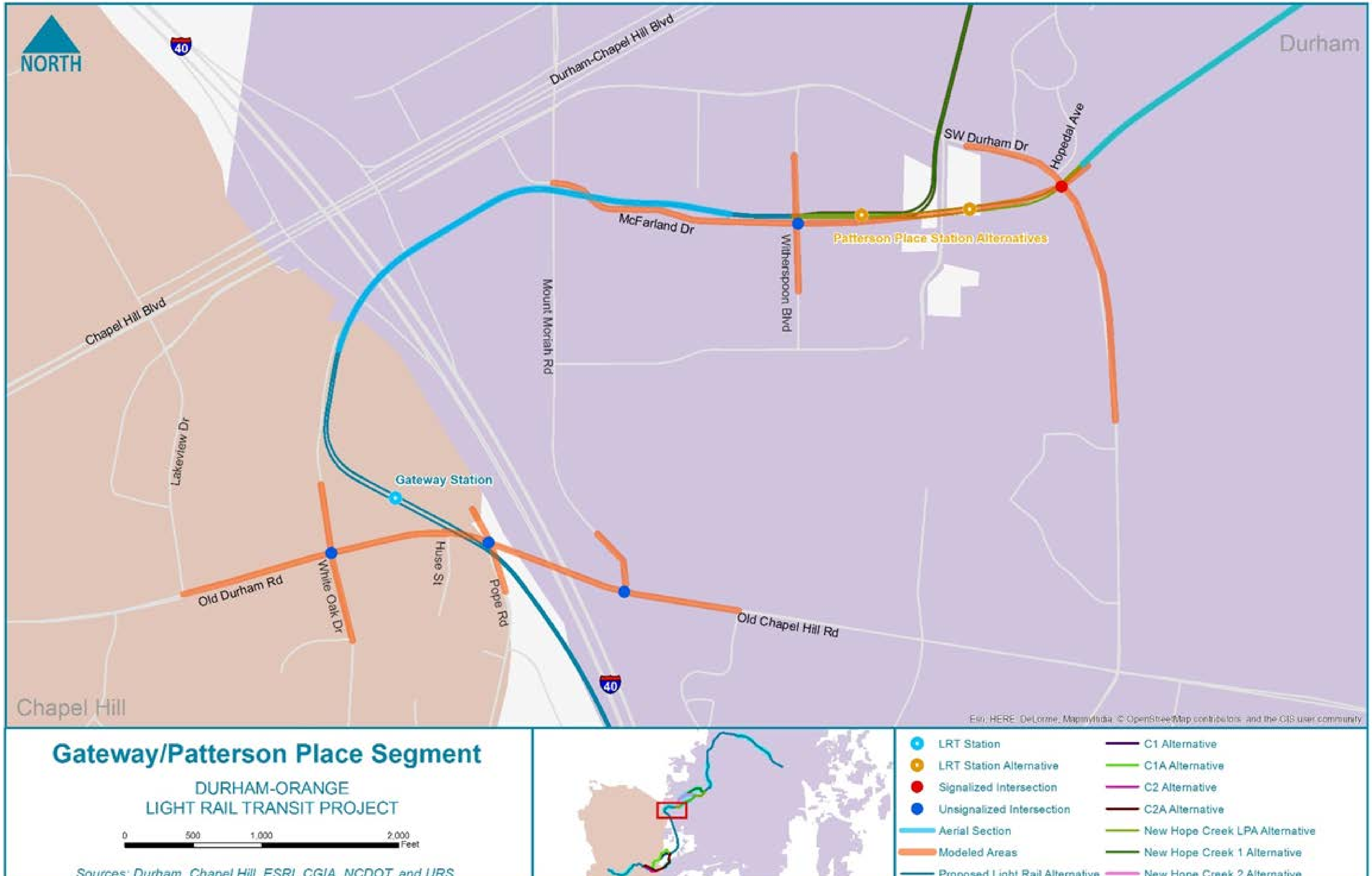
In addition to the roundabout modifications, a Park-and-Ride facility for the Gateway Station is also included as a part of the Build LRT Alternative. Additionally, McFarland Drive would be extended beyond the shopping center to intersect with SW Durham Drive south of Hopedale Avenue under the NHC-LPA Build Alternative. The D-O LRT would cross SW Durham Drive at-grade between the new intersection and Hopedale Avenue. Under the NHC-1/2 Alternative, the D-O LRT would cross the intersection of McFarland Drive at-grade and turn north after crossing the Patterson Place Station, running adjacent to Sayward Drive (rather than continuing east-west towards SW Durham Drive as under the NHC-LPA alignment) and then cross SW Durham Drive just north of the proposed intersection.

Old Chapel Hill Road is a two-lane undivided facility running east-west crossing I-40 above grade with no interchange. McFarland Drive is a two-lane undivided facility within the Patterson Place shopping center. SW Durham Drive is a two-lane undivided facility. Two LRT stations are proposed for implementation along this section of the project: Gateway Station and Patterson Place Station. The proposed specific roadway modifications for the Gateway and Patterson Place segments are listed in Table 1 for the LRT Build Alternative.

Table 1: LRT Alternative Proposed Roadway Modifications

Intersection	Roadway Modification
Pope Road at Old Chapel Hill Road	Reconfigure planned No-Build circular roundabout to oval shape
McFarland Drive at Witherspoon Boulevard	Increase northbound Witherspoon Boulevard left turn bay by removing parking
	Prohibit westbound McFarland Drive left turn
SW Durham Drive at Hopedale Avenue	Increase southbound SW Durham Drive left turn bay
	Prohibit westbound Hopedale Avenue left turn

Figure 1: Gateway and Patterson Place Study Intersections



3. Description of Alternatives

Three scenarios were analyzed for this study. These scenarios included an Existing Conditions scenario (2011 Base Year Scenario) that was also used for model calibration, a Future Year No-Build Alternative, and a Future Year Build (NHC-LPA) Alternative.

A brief description of the alternatives evaluated in Vissim, a comprehensive multimodal model capable of replicating traffic signal preemption and the interaction of vehicle, pedestrian and LRT operations, for traffic operations is as follows.

3.1 2011 Base Year Alternative

The 2011 Base Year Scenario simulated traffic conditions as they existed in 2011. The goal of the 2011 Base Year Scenario was to develop a calibrated model that would serve as the basis for the creation of the models for the future year No-Build and Build alternatives. As discussed in the *Traffic Analysis Methodology Report*, travel time and speed were calibrated.

3.2 2040 No-Build Alternative

This alternative examined what the traffic operations would be in the vicinity of the proposed D-O LRT project assuming the proposed project is not constructed. The No-Build Alternative assumed the local transportation system would evolve as currently planned, but without implementation of the proposed project.

3.3 2040 Build Alternative

The Build Alternative analysis was performed to achieve the mitigation thresholds set forth in the *Traffic Analysis Methodology Report*. The Build Alternative roadway network was developed from the No-Build network by adding the LRT and adding roadway modifications required to meet the respective traffic impact criteria thresholds. As noted in Section 2.4, the 2040 Build LRT Alternative analyzed in Vissim reflected the NHC-LPA concept design due to its similarities with the NHC 1 and NHC 2 LRT Alternatives and it also represents a more conservative analysis compared to the other two build alternatives. Preliminary designs for all three Build Alternatives are included in Appendix B.

4. Methodology

The analysis followed the methodology documented in the *Traffic Analysis Methodology Report* for the Durham-Orange Light Rail Project developed in November 2013. Two traffic analytical software tools, Synchro and Vissim, were used to provide measures of effectiveness (MOE) necessary for the analysis. This study used Synchro Version 8.0 to develop optimized signal timing plans as input for microscopic simulation modeling.

The use of microscopic traffic simulation was completed using Vissim (version 5.4). Vissim is a microscopic, behavior-based multi-purpose traffic simulation program that evaluates each vehicle individually every model time step and then assigns the appropriate behavior logic according to the traffic operations that the specific vehicle encounters. For many engineering disciplines, simulation has become an indispensable instrument for the optimization of complex technical systems. This is also true for transportation planning and traffic engineering, where simulation is an invaluable and cost-reducing tool. The microscopic simulation model was developed for the studied section of the project and was based on a calibrated base model for the area.

The methodology for microscopic simulation begins with a base model developed from data collected for the transportation network. The base model is then calibrated against data measured in the field to arrive at a calibrated base model. Once the base model is calibrated, future year alternatives can be developed and analyzed for impact study. As in real-life operations, microscopic simulation models are constrained to the capacity of a given roadway, and as such the model can only load traffic up to the capacity of a facility, with excess vehicles being denied entry and queue up outside the model network. This can happen for future scenarios when demand has been forecasted to outgrow the capacity of the existing roadways.

4.1 Measures of Effectiveness

Measures of Effectiveness (MOE) are system performance statistics that allow for comparisons between alternatives. The MOEs for microscopic simulation can be abundant due to the nature of the analysis. The primary MOEs for urban arterials are typically average speed and vehicle density for individual segments as well as average travel time and speed for individual origin-destination pairs within the network. On an overall network level MOEs such as average system speed, average system delay, and number of stops can provide overall indications of the operations of a network.

As discussed in the *Traffic Analysis Methodology Report*, corridor-level MOEs including average speed and travel time were used as the method for calibrating the base year model. Control delay, which is utilized to determine intersection LOS, and queuing were the MOEs for the future year models. The concept of Highway Capacity Manual's (HCM) Level of Service was adopted here for the purpose of simply categorizing the delays. Please note that the calculation methods of HCM delay and Vissim delay are different, as Vissim delay includes control delay as well as queue delay, whereas, HCM includes control delay only. The LOS grades are based on Vissim delays, which will provide a more conservative result than the HCM-based delays.

The acceptable levels for the future year MOEs were enumerated in the *Traffic Analysis Methodology Report*. The NCDOT has established guidelines that specify when chosen MOEs meet the required thresholds. The NCDOT's "*Policy on Street and Driveway Access to North Carolina Highways (July 2003)*" states that when comparing base network conditions to project conditions, mitigation improvements to the roadway network are required if at least one of the following conditions exists:

The acceptable levels for the future year MOEs were enumerated in the *Traffic Analysis Methodology Report*. Both NCDOT and City of Durham have established guidelines that specify when chosen MOEs meet the required thresholds. The NCDOT's "Policy on Street and Driveway Access to North Carolina Highways" states that when comparing base network conditions to project conditions, mitigation improvements to the roadway network are required if at least one of the following conditions exist:

- The total average delay at an intersection or an individual approach increases by 25% or greater, while maintaining the same Level of Service
- The Level of Service degrades by at least one level
- Level of Service is F
- Additionally, if the maximum queue for an individual intersection movement exceeds both its available storage space and its respective peak hour No-Build maximum queue length by 10 feet.

For the purposes of this analysis, traffic impacts were considered for mitigation if the Build Alternative delay was at or above a middle LOS D, or 45.0 seconds or greater for a signalized intersection. Those overall intersections or movements that reported delays greater than 45.0 seconds and experienced a LOS degradation or increase in delay greater than 25% compared to the No-Build alternative were highlighted in the Vissim LOS tables with orange. For those intersections or movements that reported a Build LOS better than middle D or less than 45.0 seconds, the impacts would not warrant roadway modifications and were highlighted with yellow.

For the study area within the City of Durham, Level of Service thresholds are summarized in Table 2. This data is obtained from the *Durham Comprehensive Plan Policy 8.1.2a, Traffic Level of Service (LOS) Standards*. According to the City of Durham, this area will be reclassified as a Compact Neighborhood Tier prior to future alternatives; hence LOS E is the threshold. More information on the applicability of these criteria to the study area intersections is identified within the tables presented in Section 6.

Table 2: City of Durham Traffic Level of Service Standards

Application	Level of Service Standard
Downtown Tier	LOS E
Compact Neighborhood Tier	LOS E
Urban Tier	LOS D
Suburban Tier	LOS D
Rural Tier	LOS C

Source: Durham Comprehensive Plan Policy 8.1.2a

In summary, Table 3 shows the traffic impact criteria applied to the various study intersections.

Table 3: Application of Traffic Impact Criteria

Segment	Location	Criteria Applied
Gateway	Mount Moriah Road at Old Chapel Hill Road	NCDOT
Gateway	Pope Road at Old Chapel Hill Road	NCDOT
Gateway	Park and Ride Entrance at Old Chapel Hill Road	NCDOT
Gateway	White Oak Drive at Old Chapel Hill Road	NCDOT
Patterson Place	McFarland Drive at Witherspoon Boulevard	City of Durham – Compact Neighborhood Tier
Patterson Place	Hopedale Avenue at SW Durham Drive	NCDOT
Patterson Place	McFarland Drive Extension at SW Durham Drive	NCDOT

4.2 Network Development

4.2.1 Geometry

The basis for developing the geometric data was a combination of aerial photographs and contour maps. Aerial photography was used as a background to digitize the network into the simulation model. The three-dimensional attributes and grades were determined based on a contour map of the study area.

The geometry in the 2011 Base Year network is based on the existing geometry of the intersections analyzed in this report. The network was created using aerials from NC OneMap, Google Maps, field verification, and contour maps from the North Carolina Department of Transportation (NCDOT).

4.2.2 Traffic Control

All intersections within the study area are currently unsignalized. Under the No-Build Alternative, the intersection of Pope Road and Old Chapel Hill Road will be converted to a roundabout intersection as part of TIP project EB-4707. The project team coordinated with NCDOT to develop the preliminary design of the proposed modifications to the Old Chapel Hill Road and Pope Road roundabout, which would involve reconstruction of the roundabout to an oval configuration under all Build Alternatives. Under all three Build Alternatives, the intersection of McFarland Drive and Witherspoon Boulevard would become signalized. As part of the analyzed Build Alternative NHC-LPA, the proposed intersection of McFarland Drive and SW Durham Drive would also be signalized.

4.2.3 Speed Data

The *Traffic Analysis Methodology Report* indicated that the Existing Conditions Vissim models would be calibrated using historical speed data from INRIX (a mobile application pertaining to vehicle traffic). However, INRIX speed data was not available for this study area. Therefore, speed calibration was performed to the posted speed limit. The desired speed distribution for turning vehicles at intersections was assumed to be 10 mph with a standard deviation of 3 mph for right turns and 15 mph with a standard deviation of 3 mph for left turns. The speed distribution used for Old Chapel Hill Road was based on a 35 mph posted speed with a range of 30 to 40 mph while McFarland Drive used a 25 mph posted speed with a range of 20 to 30 mph in Vissim.

4.2.4 Driving Behavior Parameters

The driver behavior parameters were used to guide vehicles through the network during the simulation models. Both the car-following and lane-change models in Vissim use an extensive range of parameters. Some of these may be adapted by the user to change basic driving behavior. Vissim uses five driving behavior models, of which only one was used in the base model: Urban (motorized). The Urban (motorized) parameters were used to model the surface streets within the network and were based on the Wiedemann 74 model. The Wiedemann 74 model includes three parameters which can be calibrated based on the data collected. Default values were used in developing the base model and any modifications made to the parameters were documented in the calibration section of this report.

4.2.5 Estimated Traffic Volumes

Simulation models are capable of using unbalanced input volumes and their own internal algorithms to balance the network; however using this method of traffic volume input can produce inaccuracies in actual processed volumes at particular locations. To accurately model the network, the volumes were developed into a balanced network. The traffic volumes for the proposed project were based on peak hour turning movement count data. The existing modeled traffic volumes were based on peak hour count data that were balanced with adjacent intersections by designating the Old Chapel Hill Road and Pope Road intersection as the control count. The corridors of McFarland Drive and SW Durham Drive are isolated intersections under existing conditions and therefore used the raw counts.

Volumes for the 2011 Existing, the 2040 No-Build Alternative and the 2040 Build Alternative were created using the count data and the Triangle Regional Travel Demand Model (TRM) v5 as outlined in the *Traffic Analysis Methodology Report*. Under the Build Alternative, the proposed LRT Park-and-Ride facility would be located north of Old Chapel Hill Road near the Gateway Station. Traffic accessing this facility was distributed to the intersections of Old Chapel Hill Road and White Oak Drive, the Park-and-Ride Entrance at Old Chapel Hill Road, and the Old Chapel Hill Road and Pope Road roundabout. With the extension of McFarland Drive east to SW Durham Drive, eastbound traffic from McFarland Drive currently turning left at its intersection with Witherspoon Boulevard was re-distributed to continue along McFarland Drive to SW Durham Drive. The balanced peak hour volumes for all scenarios (Existing, No-Build, and Build Conditions) are shown in Appendix D.

4.2.6 Simulation Settings and Repetitions

Each simulation was run for one hour with 15 minutes of seeding time for the network to load.

The number of simulation runs was based on the process described in Appendix B of the Federal Highway Administration (FHWA) Traffic Analysis Toolbox Volume III. The average speed of each simulation run was used as a basis for determining the number of required repetitions, with a confidence level of 95% and a confidence interval of 5 mph. It was calculated that each alternative would need to be run with 10 random seeds each for both the AM and PM peak periods.

4.2.7 Output

The output data was extracted from the model using the Travel Time evaluation and Data Collection. The Travel Time evaluation provided average travel times for user defined start and end points within the network. The Intersection Node module provided several outputs including vehicle volume, movement and intersection delay, and average/maximum queues which were utilized to determine intersection LOS.

4.2.8 Base Year Calibration

The 2011 Existing Conditions base year model was calibrated by comparing modeled travel times versus historic INRIX speed data as described in the *Traffic Analysis Methodology Report*. INRIX speed data is collected by utilizing vehicle probes that collect and transmit the locations of probe vehicles within the network. Speed calibration targets of +/- 2.5 mph (desirable) and +/- 5 mph (acceptable) were set as described in the *Traffic Analysis Methodology Report*. No changes to the base VISSIM parameters were made for calibrating the base year model to replicate the current Existing Conditions.

5. Simulation Results

5.1 2011 Base Year Scenario

The 2011 Base Year Scenario simulated traffic conditions as they existed in 2011. The goal of the 2011 Base Year Scenario was to develop a calibrated model that would serve as the basis for the creation of the models for future year No-Build and Build scenarios. As discussed in the *Traffic Analysis Methodology Report*, travel time and speed were calibrated.

Based on the data included in Table 4 the base model is considered to be calibrated and can be utilized as the basis for developing the future year alternatives. All four travel time values fell within the acceptable range while one of the four were within the desirable range.

Table 4: 2011 Existing Conditions - Calibrated Base Model Summary

Direction	Length (miles)	Peak Period	Calibrated Model		INRIX		Travel Time Difference (min)	Speed Difference (MPH)	Calibration Range
			Average Travel Time (min)	Average Speed (MPH)	Average Travel Time (min)	Average Speed (MPH)			
Eastbound (EB) Travel Time Summary									
EB Corridor Wide	**1.08**	**AM**	**1.90**	**34.13**	**1.77**	**36.68**	**0.13**	**2.56**	**Within acceptable**
		PM	**2.01**	**32.23**	**1.81**	**35.73**	**0.20**	**3.50**	**Within acceptable**
Westbound (WB)Travel Time Summary									
WB Corridor Wide	**1.08**	**AM**	**1.91**	**33.88**	**1.82**	**35.65**	**0.09**	**1.77**	**Within desirable**
		PM	**2.01**	**32.27**	**1.77**	**36.62**	**0.24**	**4.25**	**Within acceptable**

5.2 2040 No-Build Alternative

The 2040 No-Build Alternative model was based on the calibrated Existing Conditions model. The No-Build network geometry was modified to include the roadway modifications along Old Chapel Hill Road and the 2040 No-Build volumes were then input into the model. Per TIP project EB-4707, the intersection of Old Chapel Hill Road at Pope Road will be converted to a roundabout intersection under the No-Build Alternative.

The Highway Capacity Manual defines LOS for signalized and unsignalized intersections as a function of the average vehicle control delay. LOS may be calculated per movement or per approach for any intersection configuration, but LOS for the intersection as a whole is only defined for signalized and all-way stop configurations. Table 5 and Table 6 demonstrate the different HCM levels of service for signalized and unsignalized (including roundabouts) intersections based on delay and volume to capacity ratio.

Table 5: Level of Service - Signalized Intersections

Level of Service	Delay (seconds)	Description
A	≤10	This level is typically assigned when the volume-to capacity ratio is low and either progression is exceptionally favorable or the cycle length is very short. If it is due to favorable progression, most vehicles arrive during the green indication and travel through the intersection without stopping.
B	>10-20	This level is typically assigned when the volume-to-capacity ratio is low and either progression is highly favorable or the cycle length is short. More vehicles stop than with LOS A.
C	>20-35	This level is typically assigned when progression is favorable or the cycle length is moderate. Individual *cycle failures* (i.e., one or more queued vehicles are not able to depart as a result of insufficient capacity during the cycle) may begin to appear at this level. This number of vehicles stopping is significant, although many vehicles still pass through the intersection without stopping.
D	>35-55	This level is typically assigned when the volume-to-capacity ratio is high and either progression is ineffective or the cycle length is long. Many vehicles stop and individual cycle failures are noticeable.
E	>55-80	This level is typically assigned when the volume-to-capacity ratio is high, progression is unfavorable, and the cycle length is long. Individual cycle failures are frequent.
F	>80	This level is typically assigned when the volume-to-capacity ratio is very high, progression is very poor, and the cycle length is long. Most cycles fail to clear the queue.

Source: Highway Capacity Manual, 2010

Table 6: Level of Service - Unsignalized (Roundabout) Intersections

Level of Service	Delay (seconds)
A	≤10
B	>10-15
C	>15-25
D	>25-35
E	>35-50
F	>50

Source: Highway Capacity Manual, 2010

Table 7 lists the Vissim analysis turning movement volumes, delays, and LOS at the study intersection during the AM and PM peak hours under the 2040 No-Build Conditions.

Table 7: No-Build VISSIM Model Summary

Intersection	Movement	AM Peak			PM Peak		
		Volume (VPH)	Delay (sec)	LOS	Volume (VPH)	Delay (sec)	LOS
Mount Moriah Road and Old Chapel Hill Road[1] (Roundabout Intersection)	SBL	107	5.0	A	184	5.1	A
	SBR	87	4.5	A	118	5.1	A
	EBL	161	2.4	A	119	4.0	A
	EBT	434	3.0	A	433	2.8	A
	WBT	316	1.7	A	418	2.9	A
	WBR	116	2.6	A	236	2.7	A
	Overall	**1221**	**4.7**	**A**	**1508**	**5.4**	**A**
Pope Road and Old Chapel Hill Road[1] (Roundabout Intersection)	NBL	179	6.3	A	123	8.0	A
	NBR	258	6.6	A	138	8.9	A
	EBT	175	1.6	A	416	12.3	B
	EBR	141	0.5	A	269	6.2	A
	WBL	139	15.3	C	171	8.3	A
	WBT	377	14.9	B	363	7.4	A
	Overall	**1269**	**15.0**	**C**	**1480**	**9.9**	**A**
White Oak Drive and Old Chapel Hill Road[1] (Unsignalized Intersection)	NBL	9	12.7	B	10	14.5	B
	NBT	41	10.7	B	10	19.0	C
	NBR	9	5.8	A	14	8.5	A
	SBL	31	16.4	C	30	11.3	B
	SBT	60	13.6	B	31	10.2	B
	SBR	14	16.4	C	28	4.8	A
	EBL	13	3.3	A	32	2.3	A
	EBT	277	0.2	A	643	0.6	A
	EBR	9	0.5	A	19	0.7	A
	WBL	17	1.5	A	20	4.7	A
	WBT	508	0.2	A	436	0.4	A
	WBR	30	0.4	A	29	0.5	A
	Overall	**1019**	**14.8**	**B**	**1303**	**13.4**	**B**

Intersection	Movement	AM Peak			PM Peak		
		Volume (VPH)	Delay (sec)	LOS	Volume (VPH)	Delay (sec)	LOS
McFarland Drive and Witherspoon Boulevard[2] (Unsignalized Intersection)	NBL	25	1.2	A	93	4.3	A
	NBT	22	0.1	A	223	0.6	A
	NBR	1	0.2	A	7	0.7	A
	SBL	52	0.2	A	85	1.0	A
	SBT	37	0.3	A	234	1.4	A
	SBR	157	0.7	A	258	1.9	A
	EBL	100	11.8	B	231	82.1	F
	EBT	126	11.4	B	108	80.7	F
	EBR	40	10.9	B	90	78.7	F
	WBL	6	9.6	A	6	18.4	C
	WBT	70	9.2	A	164	20.3	C
	WBR	60	6.9	A	107	13.9	B
	Overall	**696**	**11.5**	**B**	**1605**	**81.0**	**F**
Hopedale Avenue and SW Durham Drive[1] (Unsignalized Intersection)	NBL	1265	0.1	A	1736	0.1	A
	NBR	29	0.0	A	3	0.0	A
	EBT	11	4.3	A	1	2.5	A
	EBR	1041	0.0	A	1155	0.0	A
	WBL	0	0.0	A	12	13.5	B
	WBT	4	6.5	A	12	9.5	A
	Overall	**2351**	**6.5**	**A**	**2919**	**11.5**	**B**

As seen in Table 7, all of the intersections are expected to operate at LOS E or better in the future except the intersection of McFarland Drive and Witherspoon Boulevard in the PM peak hour, which would operate at LOS F.

It is important to note that this is a background issue that would occur without the D-O LRT project. This will also have an impact on meeting the thresholds laid out in the City of Durham's Traffic LOS Standards and NCDOT's "Policy on Street and Driveway Access to North Carolina Highways."

A 2040 No-Build Synchro-based model was developed to further investigate the potential signal optimization in the micro-simulation software to improve traffic operation. The roadway geometry was modified to include the reconfiguration of the Pope Road and Old Chapel Hill Road intersection and the 2040 No-Build volumes were then input into the model. The Synchro output for all future 2040 alternatives can be found in Appendix E.

5.3 2040 Build Alternative

Based on the above model network elements and the methodologies defined under the MOEs section, the results from Vissim for the 2040 Build Alternative were determined. It should be noted that the Park-and-Ride facility near the proposed Gateway Station is assumed to be part of the Build Alternative. The park-and-ride facility is proposed to have three access points:

- Via the White Oak Drive north leg of the intersection of White Oak Drive at Old Chapel Hill Road
- Via the proposed Park-and-Ride driveway from Old Chapel Hill Road
- Via the proposed Pope Road north leg of the roundabout intersection of Old Chapel Hill Road at Pope Road

In addition to the park-and-ride facility and its access points, the McFarland Drive extension to SW Durham Drive is assumed to be part of the Build Alternative analysis. With the D-O LRT running at-grade along McFarland Drive, its intersections with Witherspoon Boulevard and SW Durham Drive would be signalized under all Build Alternatives. The cycle length of the traffic signals at these intersections would be 120 seconds.

In addition, to meet the respective traffic impact criteria, changes were proposed to the roadway network at the intersections of McFarland Drive at Witherspoon Boulevard and Hopedale Avenue at SW Durham Drive. The proposed roadway modifications are listed under Table 1.

At the McFarland Drive and Witherspoon Boulevard intersection, it is proposed to prohibit the westbound McFarland Drive left turn. With less than five vehicles per hour forecasted to perform this movement during both the 2040 Build Alternative AM and PM peak hours, this movement was eliminated to reduce delay to the other movements. There are multiple existing median breaks along McFarland Drive which would provide opportunities to accommodate westbound left turns. The proposed extension of the northbound Witherspoon Boulevard left turn storage bay would contain the Build Alternative maximum queue and prevent blockages of the adjacent through movement.

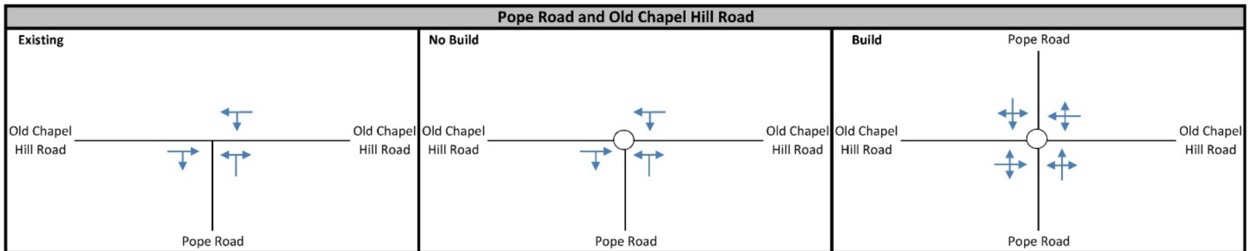
At the Hopedale Avenue and SW Durham Drive intersection, under the NHC-LPA Build Alternative only, it is recommended to prohibit the westbound Hopedale Avenue left turn. The residential traffic forecasted to perform this movement in the 2040 Build Alternative would be less than 15 vehicles per hour during both peak hours. As the D-O LRT would cross at-grade just south of this intersection, the removal of this movement would improve the safety and operations at this intersection. Since Hopedale Avenue is one of two roads (300 feet apart) that provide access to the Colonial Grand apartment complex, all westbound Hopedale Avenue left turns would be redirected to the Northcreek Drive to the north. Additionally, it is proposed to extend the southbound SW Durham Drive left turn storage bay to contain the expected maximum queue and provide easier access into the bay.

Intersection signal timing changes from 1) Existing to No-Build and from 2) No-Build to Build are shown in Table 8 for the 2040 LRT Alternative. Table 8 also includes the lane configuration modifications that are proposed between Existing to No-Build and No-Build to Build Conditions. These incorporate the roadway modifications recommended above.

Further discussion about changes between the No-Build and Build Alternatives by intersection is presented in Section 6 of this report.

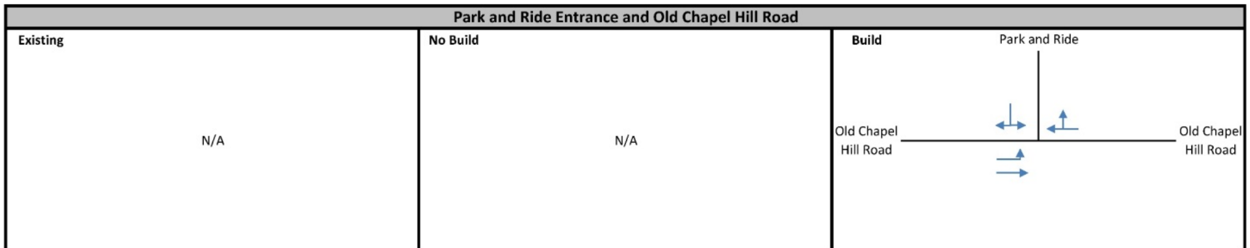
Table 8: 2040 LRT Signal & Lane Configuration Modifications

Pope Road and Old Chapel Hill Road



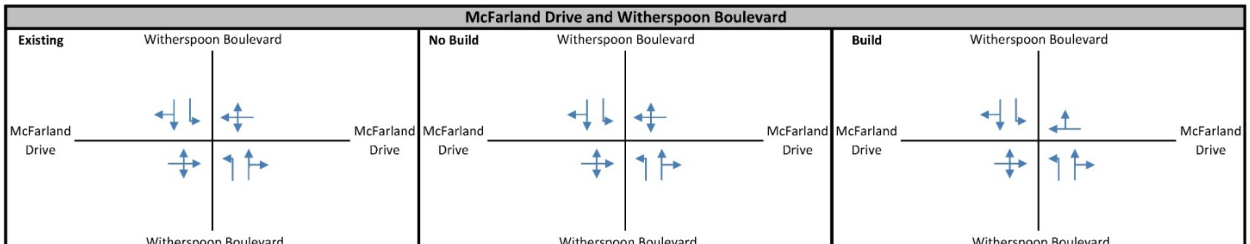
AM	Cycle Length	Phasing	PM	Cycle Length	Phasing
Existing to No Build	Unsignalized intersection converted to a roundabout.		Existing to No Build	Unsignalized intersection converted to a roundabout.	
No Build to Build	Unsignalized roundabout.	Transit gates installed.	No Build to Build	Unsignalized roundabout.	Transit gates installed.

Park and Ride Entrance and Old Chapel Hill Road



AM	Cycle Length	Phasing	PM	Cycle Length	Phasing
Existing to No Build	Intersection does not exist.		Existing to No Build	Intersection does not exist.	
No Build to Build	Unsignalized intersection added under Build.		No Build to Build	Unsignalized intersection added under Build.	

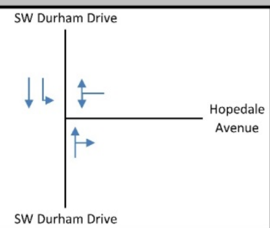
McFarland Drive and Witherspoon Boulevard



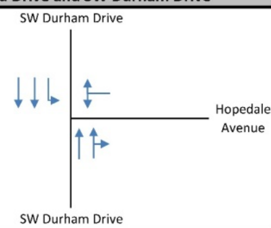
AM	Cycle Length	Phasing	PM	Cycle Length	Phasing
Existing to No Build	Unsignalized intersection.		Existing to No Build	Unsignalized intersection.	
No Build to Build	Intersection signalized with 120s cycle length.	Split phasing for EB/WB. Protected NBL. Transit Signal Preemption.	No Build to Build	Intersection signalized with 120s cycle length.	Split phasing for EB/WB. Protected NBL. Transit Signal Preemption.

McFarland Drive and SW Durham Drive

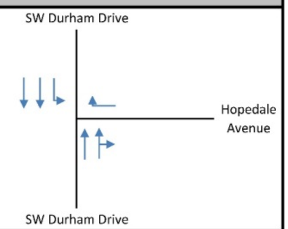
Existing



No Build



Build



AM	Cycle Length	Phasing	PM	Cycle Length	Phasing
Existing to No Build	Unsignalized intersection.		Existing to No Build	Unsignalized intersection.	
No Build to Build	Unsignalized intersection.	Transit gates installed.	No Build to Build	Unsignalized intersection.	Transit gates installed.

Hopedale Avenue and SW Durham Drive

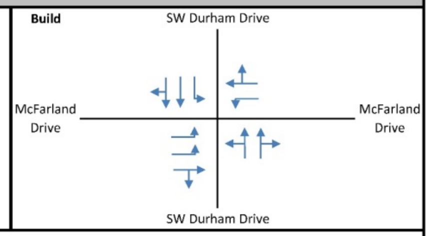
Existing

N/A

No Build

N/A

Build



AM	Cycle Length	Phasing	PM	Cycle Length	Phasing
Existing to No Build	Intersection does not exist.		Existing to No Build	Intersection does not exist.	
No Build to Build	Intersection signalized with 120s cycle length.	Split phasing for EB/WB. Protected SBL. Transit Signal Preemption.	No Build to Build	Intersection signalized with 120s cycle length.	Split phasing for EB/WB. Protected SBL. Transit Signal Preemption.

6. Summary of Results

The following section summarizes the Vissim simulation results for the 2040 No-Build versus the 2040 Build LRT Alternatives in a side-by-side manner. Table 9 and Table 10 include individual movement and overall intersection delays, LOS and queuing information as reported by Vissim for all future scenarios.

Table 9: D-O LRT: Gateway and Patterson Place Segments – Vissim Intersection Analysis Output Summary - 2040 Build Alternative vs. 2040 No-Build AM Peak Hour 8:00 - 9:00 AM

Intersection	Movement	Volumes (VPH)				Delay (seconds)				LOS		Average Queue Length (ft)				Maximum Queue Length (ft)				
		Build		No-Build		Build	No-Build	Difference Absolute	Difference %	Build	No-Build	Build	No-Build	Difference Absolute	Difference %	Storage Space Available	Build	No-Build	Difference Absolute	Difference %
		Model	Demand	Model	Demand															
Mount Moriah Road and Old Chapel Hill Road[1] (Roundabout Intersection)	SBL	108	105	107	105	4.9	5.0	-0.1	-1%	A	A	0	0	0	-84%	990	31	75	-44	-58%
	SBR	87	90	87	90	4.0	4.5	-0.5	-11%	A	A	0	0	0	-84%	990	31	75	-44	-58%
	EBL	87	115	161	115	1.8	2.4	-0.6	-23%	A	A	0	0	0	-100%	725	0	4	-4	-100%
	EBT	344	324	434	324	1.8	3.0	-1.2	-41%	A	A	0	0	0	-100%	725	0	4	-4	-100%
	WBT	412	431	316	431	2.6	1.7	1.0	58%	A	A	0	0	0	-100%	1160	2	8	-6	-75%
	WBR	161	165	116	165	2.2	2.6	-0.4	-15%	A	A	0	0	0	-100%	1160	2	8	-6	-75%
	All	1199	1230	1221	1230	4.5	4.7	-0.2	-5%	A	A	0	0	0	-89%		31	75	-44	-139%
Pope Road and Old Chapel Hill Road[1] (Roundabout Intersection)	NBL	167	177	179	177	18.7	6.3	12.5	200%	B	A	134	2	132	6018%	580	963	179	785	439%
	NBT	21	24	-	-	20.3	-	-	-	C	-	134	-	-	-	580	963	-	-	-
	NBR	244	262	258	262	17.5	6.6	10.9	165%	B	A	134	2	132	6018%	580	963	179	785	439%
	SBL	29	18	-	-	21.3	-	-	-	C	-	138	-	-	-	600	940	-	-	-
	SBT	31	36	-	-	22.4	-	-	-	C	-	138	-	-	-	600	940	-	-	-
	SBR	2	9	-	-	17.0	-	-	-	B	-	138	-	-	-	600	940	-	-	-
	EBL	8	9	-	-	9.2	-	-	-	A	-	134	-	-	-	830	963	-	-	-
	EBT	158	159	175	177	6.8	1.6	5.2	323%	A	A	134	0	134	0%	830	963	0	963	0%
	EBR	140	138	141	138	0.4	0.5	-0.1	-16%	A	A	0	0	0	0%	830	0	0	0	0%
	EB LRT	6	6	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	WBL	131	138	139	138	6.5	15.3	-8.8	-58%	A	C	14	24	-10	-43%	710	356	427	-72	-17%
	WBT	345	365	377	383	21.0	14.9	6.1	41%	C	B	138	24	114	477%	710	940	427	513	120%
	WBR	15	18	-	-	8.7	-	-	-	A	-	14	-	-	-	710	356	-	-	-
	WB LRT	6	6	-	-	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All	1206	1290	1269	1275	8.7	15.0	-6.4	-42%	A	C	134	7	127	1779%		963	427	536	56%
Park and Ride Entrance and Old Chapel Hill Road[1] (Unsignalized Intersection)	SBL	6	6			7.9				A		0				80	6			
	SBR	15	15			6.7				A		0				80	6			
	EBL	11	11			5.6				A		0				200	0			
	EBT	301	300	N/A		0.1	N/A			A	N/A	0	N/A			435	0	N/A		
	WBT	535	545			0.1				A		0				350	0			
	WBR	7	6			0.1				A		0				350	0			
	All	874	883			7.1				A		0					6			
White Oak Drive and Old Chapel Hill Road[1] (Unsignalized Intersection)	NBL	10	10	9	10	11.8	12.7	-0.8	-7%	B	B	0	0	0	0%	1020	0	0	0	0%
	NBT	8	8	41	40	9.8	10.7	-0.9	-8%	A	B	0	0	0	0%	1020	0	0	0	0%
	NBR	18	18	9	10	6.0	5.8	0.2	4%	A	A	0	0	0	0%	1020	0	0	0	0%
	SBL	7	6	31	30	13.7	16.4	-2.8	-17%	B	C	0	0	0	-100%	1000	3	48	-45	-93%
	SBT	12	12	60	60	10.7	13.6	-2.9	-21%	B	B	0	0	0	-100%	1000	3	48	-45	-93%
	SBR	2	3	14	15	6.2	16.4	-10.3	-63%	A	C	0	0	0	-100%	1000	3	48	-45	-93%
	EBL	3	3	13	15	1.7	3.3	-1.5	-47%	A	A	0	0	0	0%	1780	0	0	0	0%
	EBT	287	287	277	275	0.1	0.2	-0.1	-57%	A	A	0	0	0	0%	1780	0	0	0	0%
	EBR	9	10	9	10	0.4	0.5	-0.1	-17%	A	A	0	0	0	0%	1780	0	0	0	0%
	WBL	30	30	17	18	1.1	1.5	-0.4	-27%	A	A	0	0	0	0%	460	0	0	0	0%
	WBT	514	524	508	512	0.1	0.2	0.0	-18%	A	A	0	0	0	0%	460	0	0	0	0%
	WBR	6	6	30	30	0.4	0.4	0.0	8%	A	A	0	0	0	0%	460	0	0	0	0%
	All	905	917	1019	1025	11.1	14.8	-3.6	-25%	B	B	0	0	0	-100%		3	48	-45	-1310%

Intersection	Movement	Volumes (VPH)				Delay (sec)				LOS		Average Queue Length (ft)				Maximum Queue Length (ft)				
		Build		No-Build																
		Model	Demand	Model	Demand	Build	No-Build	Difference Absolute	Difference %	Build	No-Build	Build	No-Build	Difference Absolute	Difference %	Storage Space Available	Build	No-Build	Difference Absolute	Difference %
McFarland Drive and Witherspoon Boulevard[2] (Unsignalized Intersection - No-Build; Signalized Intersection - Build)	NBL	24	24	25	24	20.0	1.2	18.8	1623%	B	A	4	0	4	0%	500	61	0	61	0%
	NBT	21	22	22	22	12.7	0.1	12.7	18086%	B	A	4	0	4	0%	1400	61	0	61	0%
	NBR	1	2	1	2	11.3	0.2	11.1	5045%	B	A	4	0	4	0%	1400	61	0	61	0%
	SBL	52	54	52	54	13.1	0.2	12.9	7183%	B	A	5	0	5	0%	1770	132	0	132	0%
	SBT	37	36	37	36	14.1	0.3	13.8	5107%	B	A	5	0	5	0%	1770	132	0	132	0%
	SBR	155	155	157	155	7.6	0.7	7.0	1040%	A	A	5	0	5	0%	1770	132	0	132	0%
	EBL	47	49	100	97	24.5	11.8	12.7	107%	C	B	36	3	33	1300%	1700	301	134	166	124%
	EBT	181	180	126	131	23.8	11.4	12.4	109%	C	B	36	3	33	1300%	1700	301	134	166	124%
	EBR	40	42	40	42	23.2	10.9	12.3	113%	C	B	36	3	33	1300%	1700	301	134	166	124%
	EB LRT	6	6	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	WBL	0	0	6	5	0.0	9.6	-9.6	-100%	A	A	13	0	13	130900%	1520	148	22	126	566%
	WBT	74	73	70	68	17.9	9.2	8.7	95%	B	A	13	0	13	130900%	1520	148	22	126	566%
	WBR	61	63	60	63	18.4	6.9	11.5	167%	B	A	13	0	13	130900%	1520	148	22	126	566%
	WB LRT	6	6	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All	693	700	696	699	17.3	11.5	5.8	51%	B	B	12	1	12	1822%		301	134	166	55%
SW Durham Drive and McFarland Drive[1] (Signalized Intersection)	NBL	64	65			29.2				C		63				1000	498			
	NBT	1173	1172			16.9				B		63				1000	498			
	NBR	4	5			9.1				A		63				1000	498			
	SBL	5	5			56.3				E		2				60	106			
	SBT	969	969			1.7				A		8				60	111			
	SBR	66	66			0.0				A		8				60	111			
	EBL	119	118			66.4				E		32				400	153			
	EBT	4	5	N/A		47.0	N/A			D	N/A	32	N/A			1530	153	N/A		
	EBR	109	113			10.0				A		4				400	92			
	EB LRT	6	6			0.0				-		-				-	-			
	WBL	3	5			62.1				E		3				110	65			
	WBT	6	5			70.4				E		3				110	65			
	WBR	5	5			14.1				B		3				110	65			
	WB LRT	6	6			5.4				-		-				-	-			
	All	2528	2533			13.3				B		N/A					498			
Hopedale Avenue and SW Durham Drive[1] (Unsignalized Intersection)	NBT	1266	1264	1265	1264	0.5	0.1	0.4	600%	A	A	0	0	0	0%	70	110	0	110	0%
	NBR	32	31	29	31	0.0	0.0	0.0	0%	A	A	0	0	0	0%	70	110	0	110	0%
	SBL	13	13	11	13	8.6	4.3	4.4	102%	A	A	7	0	7	0%	400	234	0	234	0%
	SBT	1034	1040	1041	1040	8.5	0.0	8.5	0%	A	A	18	0	18	0%	1420	307	0	307	0%
	WBL	0	0	0	0	0.0	0.0	0.0	0%	A	A	0	0	0	0%	220	37	0	37	0%
	WBR	4	4	4	4	8.0	6.5	1.5	22%	A	A	0	0	0	0%	220	0	0	0	0%
	All	2348	2352	2351	2352	8.5	6.5	2.0	31%	A	A	5	0	5	0%		307	0	307	100%

Footnote: [1] - NCDOT Traffic Impact Criteria is applied
[2] - City of Durham Traffic Impact Criteria is applied

Indicates LRT Movement
Indicates Traffic Impact
Indicates Traffic Impact below Mid-D

Table 10: D-O LRT: Gateway and Patterson Place Segments – Vissim Intersection Analysis Output Summary - 2040 Build Alternative vs. 2040 No-Build PM Peak Hour 5:00 - 6:00 PM

Intersection	Movement	Volumes (VPH)				Delay (seconds)				LOS		Average Queue Length (ft)				Maximum Queue Length (ft)				
		Build		No-Build																
		Model	Demand	Model	Demand	Build	No-Build	Difference Absolute	Difference %	Build	No-Build	Build	No-Build	Difference Absolute	Difference %	Storage Space Available	Build	No-Build	Difference Absolute	Difference %
Mount Moriah Road and Old Chapel Hill Road[1] (Roundabout Intersection)	SBL	184	182	184	182	6.6	5.1	1.5	29%	A	A	2	1	1	130%	990	148	94	55	58%
	SBR	118	120	118	120	7.0	5.1	1.9	37%	A	A	2	1	1	130%	990	148	94	55	58%
	EBL	121	119	119	119	4.8	4.0	0.8	19%	A	A	1	0	1	137%	725	129	87	42	48%
	EBT	429	505	433	505	3.5	2.8	0.7	24%	A	A	1	0	1	137%	725	129	87	42	48%
	WBT	419	421	418	421	4.5	2.9	1.6	55%	A	A	4	1	4	453%	1,160	285	102	182	178%
	WBR	236	236	236	236	3.8	2.7	1.1	42%	A	A	4	1	4	453%	1,160	285	102	182	178%
	All	1506	1583	1508	1583	6.7	5.4	1.3	24%	A	A	3	1	2	257%		285	102	182	64%
Pope Road and Old Chapel Hill Road[1] (Roundabout Intersection)	NBL	119	123	123	123	24.3	8.0	16.3	204%	C	A	217	1	216	19135%	580	984	88	896	1020%
	NBT	5	6	-	-	20.6	-	-	-	C	-	217	-	-	-	580	984	-	-	-
	NBR	133	139	138	139	22.9	8.9	14.1	158%	C	A	217	1	216	19135%	580	984	88	896	1020%
	SBL	17	18	-	-	15.5	-	-	-	C	-	230	-	-	-	600	1,152	-	-	-
	SBT	18	18	-	-	13.2	-	-	-	B	-	230	-	-	-	600	1,152	-	-	-
	SBR	18	18	-	-	14.9	-	-	-	B	-	230	-	-	-	600	1,152	-	-	-
	EBL	16	18	-	-	20.1	-	-	-	C	-	217	-	-	-	830	984	-	-	-
	EBT	399	407	416	425	20.6	12.3	8.3	68%	C	B	217	22	195	880%	830	984	485	499	103%
	EBR	268	265	269	265	10.0	6.2	3.9	62%	B	A	10	7	3	45%	830	245	468	-223	-48%
	EB LRT	6	6	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	WBL	170	169	171	169	31.1	8.3	22.7	273%	D	A	230	9	221	2493%	710	1,152	361	792	219%
	WBT	341	354	363	372	31.1	7.4	23.7	319%	D	A	230	9	221	2493%	710	1,152	361	792	219%
	WBR	17	18	-	-	25.1	-	-	-	D	-	68	-	-	-	710	667	-	-	-
	WB LRT	6	6	-	-	7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All	1435	1463	1480	1493	30.9	9.9	21.0	212%	D	A	178	8	170	2133%		1,152	485	667	58%
Park and Ride Entrance and Old Chapel Hill Road[1] (Unsignalized Intersection)	SBL	6	6	N/A		5.1	N/A			A	N/A	0	N/A			80	0	N/A		
	SBR	12	12			2.2				A		0				80	0			
	EBL	8	8			0.3				A		0				200	0			
	EBT	679	684			3.6				A		5				435	262			
	WBT	471	489			0.4				A		0				350	0			
	WBR	8	6			0.3				A		0				350	0			
	All	1184	1205			3.6				A		1					262			
White Oak Drive and Old Chapel Hill Road[1] (Unsignalized Intersection)	NBL	10	10	10	10	11.5	14.5	-3.0	-20%	B	B	0	0	0	-100%	1,020	0	2	-2	-100%
	NBT	2	2	10	10	10.4	19.0	-8.6	-45%	B	C	0	0	0	-100%	1,020	0	2	-2	-100%
	NBR	16	17	14	15	8.2	8.5	-0.4	-4%	A	A	0	0	0	0%	1,020	3	0	3	0%
	SBL	7	6	30	30	15.0	11.3	3.7	33%	B	B	0	1	-1	-88%	1,000	33	72	-39	-54%
	SBT	6	6	31	30	12.6	10.2	2.4	24%	B	B	0	1	-1	-88%	1,000	33	72	-39	-54%
	SBR	6	6	28	30	7.6	4.8	2.9	60%	A	A	0	1	-1	-88%	1,000	33	72	-39	-54%
	EBL	7	6	32	30	2.5	2.3	0.2	9%	A	A	1	0	0	131%	1,780	92	78	13	17%
	EBT	667	669	643	645	0.5	0.6	0.0	-5%	A	A	1	0	0	131%	1,780	92	78	13	17%
	EBR	19	20	19	20	0.5	0.7	-0.2	-29%	A	A	1	0	0	131%	1,780	92	78	13	17%
	WBL	25	26	20	20	4.1	4.7	-0.5	-11%	A	A	0	0	0	0%	460	16	25	-10	-39%
	WBT	452	469	436	445	1.0	0.4	0.6	151%	A	A	0	0	0	0%	460	16	25	-10	-39%
	WBR	6	6	29	30	0.8	0.5	0.3	65%	A	A	0	0	0	0%	460	16	25	-10	-39%
	All	1223	1243	1303	1315	11.9	13.4	-1.5	-11%	B	B	0	0	0	150%		92	78	13	15%

Intersection	Movement	Volumes (VPH)				Delay (seconds)				LOS		Average Queue Length (ft)				Maximum Queue Length (ft)				
		Build		No-Build		Build	No-Build	Difference Absolute	Difference %	Build	No-Build	Build	No-Build	Difference Absolute	Difference %	Storage Space Available	Build	No-Build	Difference Absolute	Difference %
		Model	Demand	Model	Demand															
McFarland Drive and Witherspoon Boulevard[2] (Unsignalized Intersection - No-Build; Signalized Intersection - Build)	NBL	117	91	93	91	48.3	4.3	44.0	1030%	D	A	36	0	36	0%	500	222	0	222	0%
	NBT	202	225	223	225	33.1	0.6	32.4	5231%	C	A	36	0	36	0%	1,400	222	0	222	0%
	NBR	0	7	7	7	0.0	0.7	-0.7	-100%	A	A	36	0	36	0%	1,400	222	0	222	0%
	SBL	86	85	85	85	47.7	1.0	46.7	4765%	D	A	154	0	154	768000%	1,770	651	27	625	2342%
	SBT	233	236	234	236	58.6	1.4	57.3	4179%	E	A	154	0	154	768000%	1,770	651	27	625	2342%
	SBR	253	256	258	256	42.5	1.9	40.6	2115%	D	A	154	0	154	768000%	1,770	651	27	625	2342%
	EBL	181	194	231	388	56.2	82.1	-25.9	-31%	E	F	792	1,525	-733	-48%	1,700	1,379	1,641	-262	-16%
	EBT	339	386	108	192	55.5	80.7	-25.2	-31%	E	F	792	1,525	-733	-48%	1,700	1,379	1,641	-262	-16%
	EBR	142	165	90	165	53.7	78.7	-25.0	-32%	D	F	792	1,525	-733	-48%	1,700	1,379	1,641	-262	-16%
	EB LRT	6	6	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	WBL	0	0	6	6	0.0	18.4	-18.4	-100%	A	C	73	6	67	1128%	1,520	422	158	264	167%
	WBT	170	169	164	163	39.8	20.3	19.5	96%	D	C	73	6	67	1128%	1,520	422	158	264	167%
	WBR	108	109	107	109	40.4	13.9	26.5	190%	D	B	73	6	67	1128%	1,520	422	158	264	167%
	WB LRT	6	6	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All	1830	1923	1605	1923	48.4	81.0	-32.7	-40%	D	F	226	383	-157	-41%		1,379	1,641	-262	-19%
SW Durham Drive and McFarland Drive[1] (Signalized Intersection)	NBL	138	136			43.2				D		157				1,000	531			
	NBT	1491	1496			26.4				C		157				1,000	531			
	NBR	6	5			16.9				B		120				1,000	468			
	SBL	5	5			61.0				E		3				60	119			
	SBT	1017	1026			1.7				A		13				60	127			
	SBR	136	137			0.0				A		12				60	122			
	EBL	206	239			88.8				F		68				400	311			
	EBT	5	5	N/A		46.1	N/A			D	N/A	68	N/A			1,530	311	N/A		
	EBR	206	234			12.6				B		50				400	288			
	EB LRT	6	6			0.1				-		-				-	-			
	WBL	5	5			89.4				F		3				110	45			
	WBT	6	5			82.8				F		3				110	54			
	WBR	4	5			14.8				B		3				110	45			
	WB LRT	6	6			4.9				-		-				-	-			
	All	3224	3298			21.6				C		N/A				-	531			
Hopedale Avenue and SW Durham Drive[1] (Unsignalized Intersection)	NBT	1658	1737	1736	1737	0.6	0.1	0.5	540%	A	A	3	0	3	0%	70	116	0	116	0%
	NBR	36	3	3	3	0.0	0.0	0.0	-100%	A	A	3	0	3	0%	70	116	0	116	0%
	SBL	1	1	1	1	12.4	2.5	10.0	406%	B	A	16	0	16	0%	400	328	0	328	0%
	SBT	1152	1168	1155	1157	11.4	0.0	11.4	0%	B	A	29	0	29	0%	1,420	389	0	389	0%
	WBL	0	0	12	11	0.0	13.5	-13.5	-100%	A	B	1	0	1	3500%	220	51	11	40	366%
	WBR	24	24	12	13	14.4	9.5	4.9	52%	B	A	0	0	0	200%	220	15	11	4	41%
	All	2871	2933	2919	2922	14.4	11.5	2.9	25%	B	B	8	0	8	81000%	-	389	11	378	97%

Footnote: [1] **- NCDOT Traffic Impact Criteria is applied**

[2] **- City of Durham Traffic Impact Criteria is applied**

Indicates LRT Movement

Indicates Traffic Impact

Indicates Traffic Impact below Mid-D

6.1 Analysis of LOS Thresholds

All intersections in this segment would operate at LOS D or better during the AM and PM peak hours under the Build Alternative. Each intersection in this study is discussed below.

6.1.1 Mount Moriah Road and Old Chapel Hill Road

The NCDOT traffic impact criteria are applied to the roundabout intersection of Mount Moriah Road and Old Chapel Hill Road, as Old Chapel Hill Road is under NCDOT jurisdiction. Under the No-Build Alternative, the overall intersection is expected to operate at LOS A in both the AM and PM peak hours. There are no proposed changes to the roadway geometry at this intersection between the No-Build and Build Alternatives even with the construction of the Gateway Station and associated park-and-ride lot. The D-O LRT alignment is located west of this intersection.

The overall intersection is expected to operate at LOS A during both peak hours under the Build Alternative thereby meeting NCDOT criteria. Therefore, no additional roadway modifications are recommended at the intersection of Mount Moriah Road and Old Chapel Hill Road under any of the Build Alternatives.

6.1.2 Pope Road and Old Chapel Hill Road

The NCDOT traffic impact criteria are applied to the roundabout intersection of Pope Road and Old Chapel Hill Road, as Old Chapel Hill Road is under NCDOT jurisdiction. Under the No-Build Alternative, this intersection will be converted to a roundabout intersection (TIP EB-4707). The overall intersection is expected to operate at LOS C and LOS A during the No-Build Conditions AM and PM peak hours, respectively.

Under the Build Alternative, this roundabout would be modified to an oval configuration to accommodate the LRT alignment passing through its center. The park-and-ride facility would be constructed in the northwest quadrant of this intersection. One of the three access points to this facility is proposed to be via the north leg of this intersection. The overall intersection is expected to operate at LOS A and LOS D during the Build Alternative AM and PM peak hours, respectively, thereby meeting NCDOT LOS criteria.

For the Build Alternative, the maximum queue lengths for the following movements will exceed both their available storage and the respective peak hour No-Build maximum queue lengths by more than 10 feet:

- Northbound Pope Road shared lane left, through, and right turn movements exceed the storage space by 383 feet in the AM and 404 feet in the PM
- Southbound Pope Road shared lane left, through, and right turn movements exceed the storage space by 340 feet in the AM and 552 feet in the PM
- Eastbound Old Chapel Hill Road left turn exceeds the storage space by 133 in the AM and by 154 feet in the PM
- Eastbound Old Chapel Hill Road through movement exceeds the storage space by 133 feet in the AM and by 154 feet in the PM

- Westbound Old Chapel Hill Road left turn exceeds the storage space by 442 feet in the PM only
- Westbound Old Chapel Hill Road through movement exceeds the storage space by 230 feet in the AM and 442 feet in the PM

With LRT gate operations, maximum queue lengths under the Build Alternative would be longer than the respective storage spaces, but the maximum queues would not reach any signalized intersections. However, the maximum queue events are considered infrequent occurrences, whereas the movements' average queue are expected to be much shorter and would be contained within the respective storage areas. Therefore, no additional roadway modifications are recommended to this intersection for any of the Build Alternatives.

6.1.3 Park-and-Ride Entrance and Old Chapel Hill Road

The NCDOT traffic impact criteria are applied to the proposed unsignalized intersection of the Park-and-Ride Entrance and Old Chapel Hill Road, as Old Chapel Hill Road is under NCDOT jurisdiction. This intersection would not exist under the No-Build Alternative.

Under the Build Alternative, the Park-and-Ride Facility is proposed to be constructed on the north side of Old Chapel Hill Road with direct access to the roadway proposed as part of the D-O LRT project. The D-O LRT alignment would be at-grade east of this intersection. The overall intersection is expected to operate at LOS A during both peak hours under the Build Alternative. The intersection of the Park-and-Ride Entrance and Old Chapel Hill Road is not expected to exceed NCDOT traffic impact thresholds. Therefore, no additional roadway modifications are recommended to this intersection for any of the Build Alternatives.

6.1.4 White Oak Drive and Old Chapel Hill Road

The NCDOT traffic impact criteria are applied to the unsignalized intersection of White Oak Drive and Old Chapel Hill Road, as Old Chapel Hill Road is under NCDOT jurisdiction. One of the three accesses to/from the Park- and-Ride facility would be located along White Oak Drive. The overall intersection is expected to operate at LOS B during both the AM and PM peak hours under the No-Build Alternative.

Under the Build Alternative, the D-O LRT alignment would be located to the east of this intersection. The overall intersection of White Oak Drive and Old Chapel Hill Road is expected to operate at LOS B or better during both Build Alternative AM and PM peak hours and would therefore meet NCDOT criteria. Therefore, no additional roadway modifications are recommended at this intersection for any of the Build Alternatives.

6.1.5 McFarland Drive and Witherspoon Boulevard

The City of Durham - Compact Neighborhood Tier traffic impact criteria are applied to the intersection of McFarland Drive and Witherspoon Boulevard, as both roadways are under city jurisdiction. This intersection is unsignalized under Existing Conditions and No-Build Alternatives. The overall intersection would operate at LOS B and LOS F during the No-Build Conditions AM and PM peak hours, respectively.

Under the Build Alternative, the D-O LRT alignment would cross at-grade on the north side of this intersection, which would be signalized as part of the LRT design.

The cycle length of the proposed traffic signal would be 120 seconds and provide a protected northbound Witherspoon Boulevard left turn. In addition, to improve expected traffic operations and mitigate queue spillback at this intersection, the northbound Witherspoon Boulevard left turn storage bay would be extended. As part of the Build Alternative roadway modifications, the westbound McFarland Drive left turn would be prohibited to eliminate the conflict with the substantial opposing eastbound through movement.

Under the Build Alternative, with the proposed roadway network changes incorporated, this overall intersection is anticipated to operate at LOS B and LOS D during the AM and PM peak hours, respectively, which would meet the City of Durham threshold criteria. No other roadway modifications are recommended for this intersection as part of the D-O LRT project.

6.1.6 McFarland Drive and SW Durham Drive

The NCDOT traffic impact criteria are applied to the intersection of McFarland Drive and SW Durham Drive, as SW Durham Drive is under NCDOT jurisdiction. This intersection does not exist under the No-Build Alternative.

Under the NHC-LPA Build Alternative only, McFarland Drive would extend to meet Durham Drive creating a new signalized intersection. The cycle length of the traffic signal is proposed to be 120 seconds. The D-O LRT would cross Durham Drive at-grade just north of this intersection. Overall, this intersection is expected to operate at LOS B and LOS C during the Build Alternative NHC-LPA AM and PM peak hours, respectively, and is expected to meet the City of Durham threshold criteria.

Although the NHC-1/2 Alternative would cross SW Durham Drive at Sayward Drive instead of at McFarland Drive, the results of the NHC-LPA Alternative analysis can be used as a conservative analog. The NHC-LPA intersection at McFarland Drive and SW Durham Drive would have four legs compared to the three legs proposed at Sayward Drive and SW Durham Drive, which would allow Sayward Drive left and right turns for the volumes exiting Patterson Place.

The maximum queue lengths for the following movements will exceed their available storage queue length by more than 10 feet:

- Southbound SW Durham Drive left turn exceeds the storage space by 46 feet in the AM and 59 feet in the PM
- Southbound SW Durham Drive through exceeds the storage space by 51 feet in the AM and 67 feet in the PM
- Southbound SW Durham Drive right turn exceeds the storage space by 51 feet in the AM and 62 in the PM

As the upstream intersection of SW Durham Drive and Hopedale Drive is unsignalized, the southbound approach maximum queue lengths, the longest of which is 127 feet, would not substantially affect traffic operations along SW Durham Drive. The maximum queue events are also considered infrequent occurrences, whereas the movements' average queues are expected to be much shorter and contained within the respective storage areas. Therefore, no additional roadway modifications are recommended for this intersection as part of the NHC-LPA Alternative. Hopedale Avenue and SW Durham Drive

The NCDOT traffic impact criteria are applied to the unsignalized intersection of McFarland Drive and SW Durham Drive, as SW Durham Drive is under NCDOT jurisdiction. This intersection is expected to operate at LOS A and LOS B during the No-Build Alternative AM and PM peak hours.

The D-O LRT would cross at–grade just south of this intersection under the NHC-LPA Build Alternative. Railroad crossing gates would be installed along southbound SW Durham Drive prior to the at-grade crossing. To improve traffic operations at this intersection, the southbound SW Durham Drive left turn storage bay is recommended to be extended to accommodate the heavy southbound left turn movement. The westbound Hopedale Avenue left turn would also prohibited as part of the proposed Build NHC-LPA roadway modifications. Under the NHC-LPA Build Alternative, with the proposed roadway network changes incorporated, the overall intersection is anticipated to operate at LOS A and LOS B during the AM and PM peak hours and is not expected to exceed the NCDOT threshold criteria. It should be noted that this intersection is not impacted under the NHC-1/2 Alternatives and the

The maximum queue lengths for the following movements will exceed both their available storage and respective peak hour No-Build maximum queue lengths by more than 10 feet:

- Northbound SW Durham Drive through movement exceeds the storage space by 40 feet in the AM and 46 feet in the PM
- Northbound SW Durham Drive right turn exceeds the storage space by 40 feet in the AM and 46 feet in the PM

The maximum queue events are considered infrequent occurrences, whereas the movements' average queues are expected to be much shorter and contained within the respective storage areas. Therefore, only the roadway modifications previously mentioned above and in Table 1 are recommended for this intersection as part of the NHC-LPA Alternative only.

7. Conclusions/Recommendations

As part of the traffic simulation analysis, traffic impacts associated with the implementation of the LRT were identified in the forms of delay, LOS, and queues. All locations showing impacts were investigated to determine the significance of the impact and whether there was a feasible roadway modification to eliminate or reduce the impact. Table 1 above indicates the series of improvement measures that were proposed and analyzed in an effort to mitigate traffic impacts resulting from the LRT condition. These proposed mitigations eliminated a majority of the initial traffic impacts. The remaining traffic impacts in the Gateway and Patterson Place segments are not expected to appreciably deteriorate traffic operations.

In the Gateway area, all intersections along Old Chapel Hill Road are expected to operate at overall intersection LOS D or better under the Build Alternative and would meet NCDOT traffic impact criteria.

The D-O LRT alignment for Patterson Place included three alignment alternatives (NHC-LPA, NHC-1 and NHC-2) between McFarland Drive and SW Durham Drive. The NHC-1 and NHC-2 alternatives are the same, from a traffic operations standpoint and, therefore, are considered one alternative (NHC-1/2).

In the Patterson Place segment, the only traffic operations difference between the NHC-LPA and NHC-1/2 Alternatives would be at the crossing of SW Durham Drive. The traffic operations of the NHC-LPA Alternative are assumed to be representative of the NHC-1/2 Alternative.

With the roadway modifications listed in Table 1 in place for the Build Alternative, all intersections along SW Durham Drive would operate at LOS D or better during both peak hours and meet the traffic impact criteria of NCDOT. As the intersection of SW Durham Drive and McFarland Drive would not exist under Alternative NHC-1/2, the roadway modification proposed at this location under the NHC-LPA Alternative would not be required.

Although the maximum queues on the Old Chapel Hill Road and SW Durham Drive approaches may exceed their respective storage spaces, the maximum queues would not impact upstream signalized intersections. The maximum queue events represent the absolute farthest extent of the queue for a particular movement, which are infrequent occurrences. For those movements that report maximum queues exceeding the available storage space, the respective average queues would be contained within their storage space. The expected average queues for all movements would be accommodated by the available storage at all locations. Given the limited impact on traffic operations and the lack of additional practical modifications to the roadway at these locations, no further modifications are recommended to the LRT Build Alternative designs beyond those proposed in Table 1.

Appendices

Appendix A
Traffic Analysis Methodology Report

TRAFFIC ANALYSIS METHODOLOGY

Durham-Orange Light Rail Transit Project

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November 2013

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1. Introduction

The proposed Triangle Transit Durham-Orange Light Rail Transit Draft Environmental Impact Statement (D-O LRT Draft EIS) will address existing and future transportation conditions along the proposed corridor and quantify the transportation impacts of the No-Build and Build Alternatives as well as some transportation system management (TSM) improvements. For the purposes of this study the No-Build and TSM scenarios will be combined. The project will potentially have transportation and traffic impacts that will include impacts to streets and highways, bikeways, parking, railroad operations, and public transit.

Following is a description of the proposed methodology for evaluating the potential impacts to traffic and transportation services and facilities that could occur due to the implementation of the proposed D-O LRT. This proposal includes analysis methodologies used to describe existing and future travel patterns and the transportation environment, estimation of forecast year traffic volumes under the No-Build and Build Alternatives, and the analysis of impacts of the light rail operations at intersections and railroad/highway at-grade crossings.

Generally, data required for the traffic and transportation analyses will be developed by the study team, or will be provided by either Triangle Transit, the Town of Chapel Hill, City of Durham, Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC MPO), or the North Carolina Department of Transportation (NCDOT). Data from other agencies, if needed, is noted in the task descriptions. Triangle Transit will provide information on existing and planned transit services and performance. Existing conditions traffic data from the previous Alternatives Analysis (AA) study will be utilized for the base year analysis and future year volumes will be developed based on travel demand analysis completed by other members of the project teams. The analysis will include both regional travel demand data as well as specific transit route ridership forecasts. The base year for the analysis will be 2011 and the design year will be 2040 in order to be consistent with the DCHC MPO's *2040 Metropolitan Transportation Plan*.

The project team will use the Triangle Regional Travel Demand Model V5 (TRTDM) for this project. The model is based on the traditional four-step travel demand process of trip generation, trip distribution, mode split, and traffic assignment. Documentation for the model development and calibration process is maintained by NCDOT and the Institute for Transportation Research and Engineering (ITRE).

2. Existing Conditions

Following is a description of the elements that will be used to define existing transportation conditions, and the procedures to be used in developing that definition.

Calibrated base models will be constructed and validated using VisSim. The calibration and validation process is described below. For this study 2011 will serve as the base year for analysis.

2.1 Identification Of Simulation Areas

Specific segments of the D-O LRT corridor where the proposed LRT interacts with the roadway network will be analyzed. Along much of the D-O LRT corridor the track is not at grade or is routed in areas that are not near the roadway network. As such, there is no interaction between the proposed D-O LRT and the current or planned roadway network. The segments that are proposed for analysis are as follows:

- Mason Farm Road – East Drive to US 15-501
- NC 54 – Hamilton Road to Downing Creek including Prestwick Road and Meadowmont Lane (Alternative C-1)
- Leigh Village – Includes crossings of proposed Leigh Village as well as Ephesus Church Road and Farrington Road intersection if needed
- Patterson Place – McFarland Drive from Mt. Moriah Road to Witherspoon Boulevard as well as any crossing of Garrett Road
- South Square – Including University Drive from Snow Creek Trail to Shannon Road, Shannon Road from University Drive to US 15-501, and Tower Road from US 15-501 northbound ramps to Pickett Road
- Cornwallis Road – At Grade crossing near US 15/501 (as needed)
- Erwin Road – Cameron Drive to Anderson Street/15th Street, Fulton Street and Trent Drive, and Elba Street as needed
- Pettigrew Street – Erwin Road/9th Street to Sumter Street and Chapel Hill Street to Alston Avenue and proximate intersections as needed
- Peabody Street – Gregson Street to Duke Street

Maps of the proposed simulation areas and intersections are shown in Figures 1 and 2. The selection of the studied areas and intersection was based on the results from the AA. Potential changes to alignment and sunsequently crossings may require revision and correction of the current selection.

2.2 Balanced Volume Data

For the traffic analysis portion of the D-O LRT Draft EIS we will employ the data collected as part of the AA phase of the project, including peak hour turning movements for all intersections identified. Traffic counts from 2008 or before will be increased based on the growth of background traffic to represent base year conditions. If significant changes in street configuration or roadway geometry have occurred since the count was taken then newer counts in these areas reflecting such changes will be collected and used for the traffic anysis.

Background growth will be based on data from the NCDOT traffic volume maps (http://www.ncdot.gov/travel/statemapping/trafficvolumemaps/). After developing the raw peak hour turning volumes for the base year, the volumes will be balanced across the networks. Sink and source nodes will be added where necessary to account for mid-block changes in traffic volumes due to major origins or destinations. Input data for the loading points will be developed based on the balanced volumes.

2.3 Model Development

For the development of the base model in VisSim, the following will be completed:

- Develop base data including acceleration, speed distributions, vehicle classes, vehicle distributions, and link behavior types
- Develop link geometric data
- Input traffic demand data based on outcome of previous step
- Input origin-destination routing
- Input traffic control data at intersections, including signal timings
- Input traffic operations and management data for links
- Input driver behavior data
- Set simulation run control
- Code network outputs

Data Needs:

Signal Plans from Chapel Hill, Durham, and NCDOT

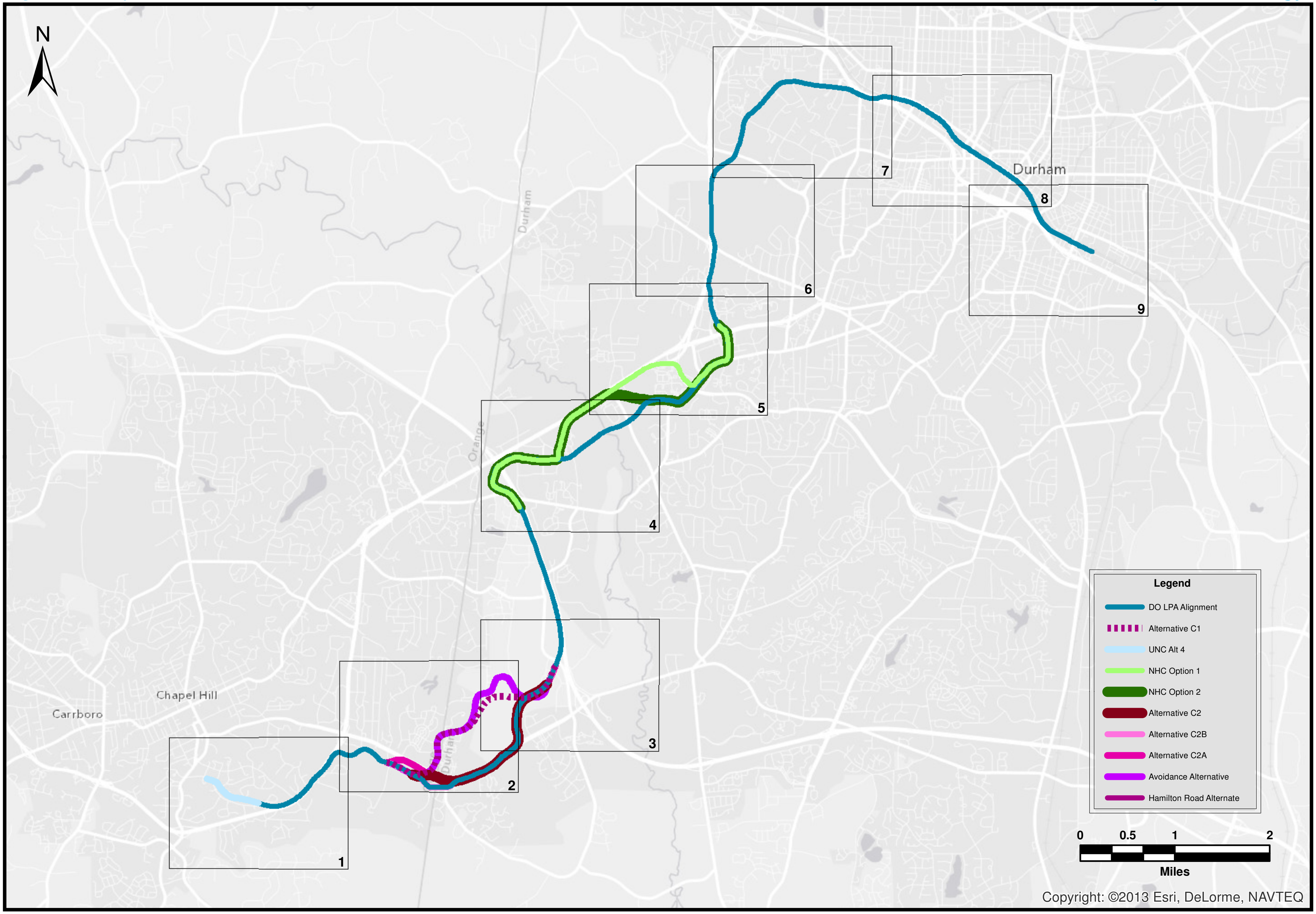
2.4 Pedestrian And Bicycle Volumes

Where necessary, pedestrian and bicycle data will be collected and utilized in the model stream. To guide this effort, *Effects of Pedestrians on Capacity of Signalized Inersections* by Milazzo et al published in Transportation Research Record 1646 was reviewed. This article serves as the basis for determining the impact of pedestrians on saturation flow rates at signalized intersections as described in chapter 31 of the *2010 Highway Capacity Manual* published by the Transportation Research Board. In that review it was found that pedestrian conflicts reduce saturation flow in a linear manner from 0 to 1000 conflicting pedestrians per hour of green time. The reduction in saturation flow at 1000 conflicting pedestrains per hour of green time is 50%. A threshold of 20% reduction in saturation flow rate will be utilized for this analysis based on the previously referenced items. This 20% reduction threshold corresponds to 400 conflicting pedestrians per hour of green time. If a conservative assumption is made that turning movements are provided green time equal to 25% of the cycle length, then we can interpolate that for a 20% reduction in turning movement saturation flow rate there must be at least 100 conflicting pedestrians for that particular movement in the peak hour. As such, we are proposing to include only pedestrian movements in the simulation where pedestrian volumes are greater than 100 conflicting pedestrians in the peak hour. To reach that threshold either the volume of conflicting pedestrians on a single crosswalk must be greater than 100 pedestrians in the peak hour or the combined volume of conflicting pedestrians of two adjacent crosswalks must be greater than 100 pedestrians in the peak hour.

A partial field review was conducted to determine locations where pedestrian and bicycle volumes were above the 100 pedestrians per hour threshold. Initial review of the proposed areas revealed that the intersection of Erwin Road and Fulton Street meets this threshold in the base year. Additional examination will be conducted later.

2.5 Calibration Of Model

Once the model is created and visually validated, model data will be extracted to ensure that the model is accurately representing base year conditions. The model will be pre-loaded for 15 minutes with volumes that are 75% of those anticipated for the peak hour. Model outputs will be compared to INRIX traffic data from the base year to ensure relatively similar travel times. The models will be considered calibrated when the travel speeds are within 5 mph of the data obtained from INRIX. That said, reasonable efforts will be made to reduce the difference between model travel time speeds and INRIX data to be within 2.5 mph. Given that INRIX data is aggregated over a period of time and that the model run is for one specific day it may not be possible to achieve the narrower band for the purposes of calibration. The model will be run for a sufficient number of iterations to ensure calibration based on Federal Highway Administration (FHWA) guidelines. The number of iterations necessary to achieve calibration for each corridor will be recorded and future year models will be run utilizing the same number of iterations. Models will be run using static trip assignment.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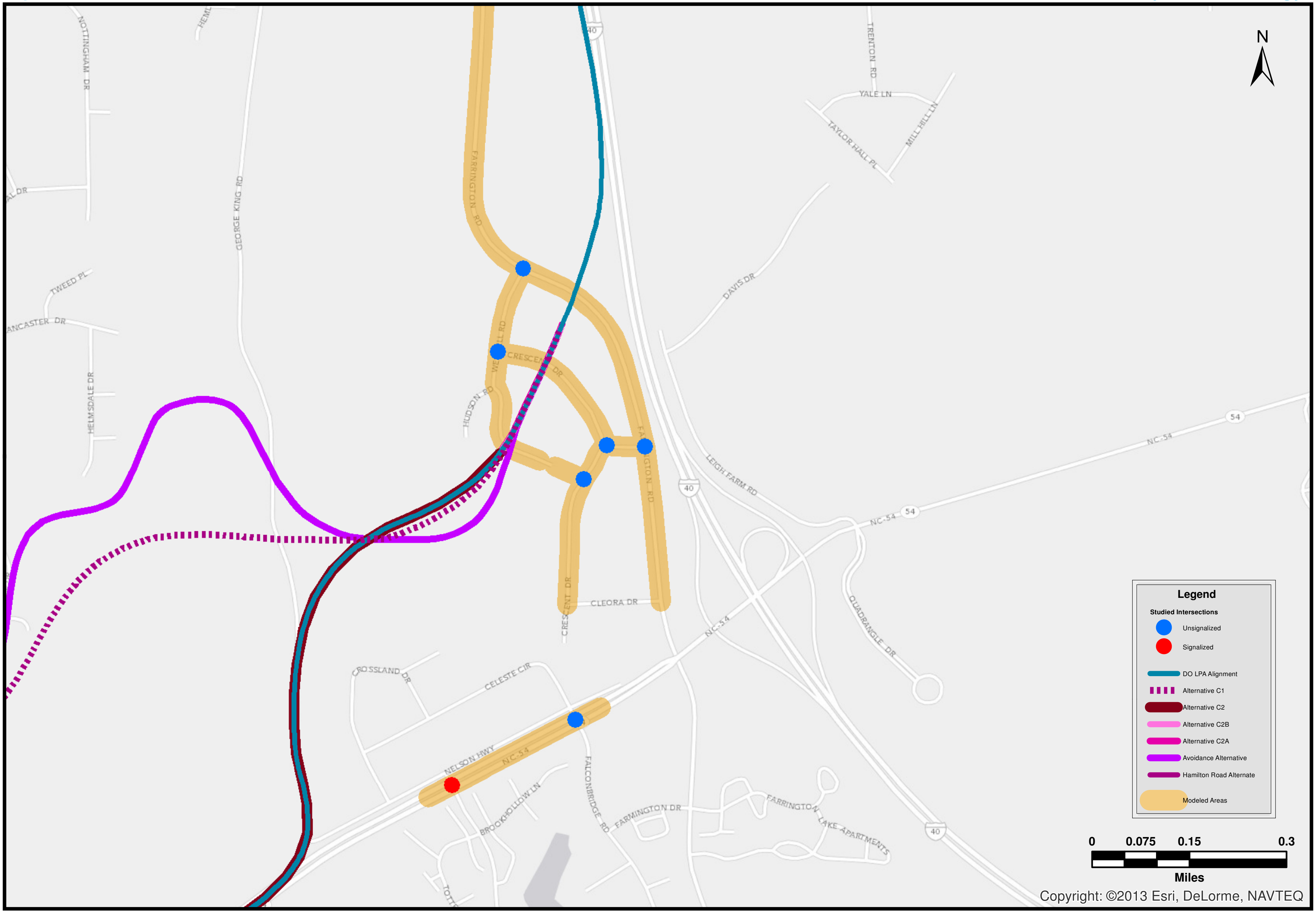
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FARRINGTON LAKE APARTMENTS
LEIGH FARM RD
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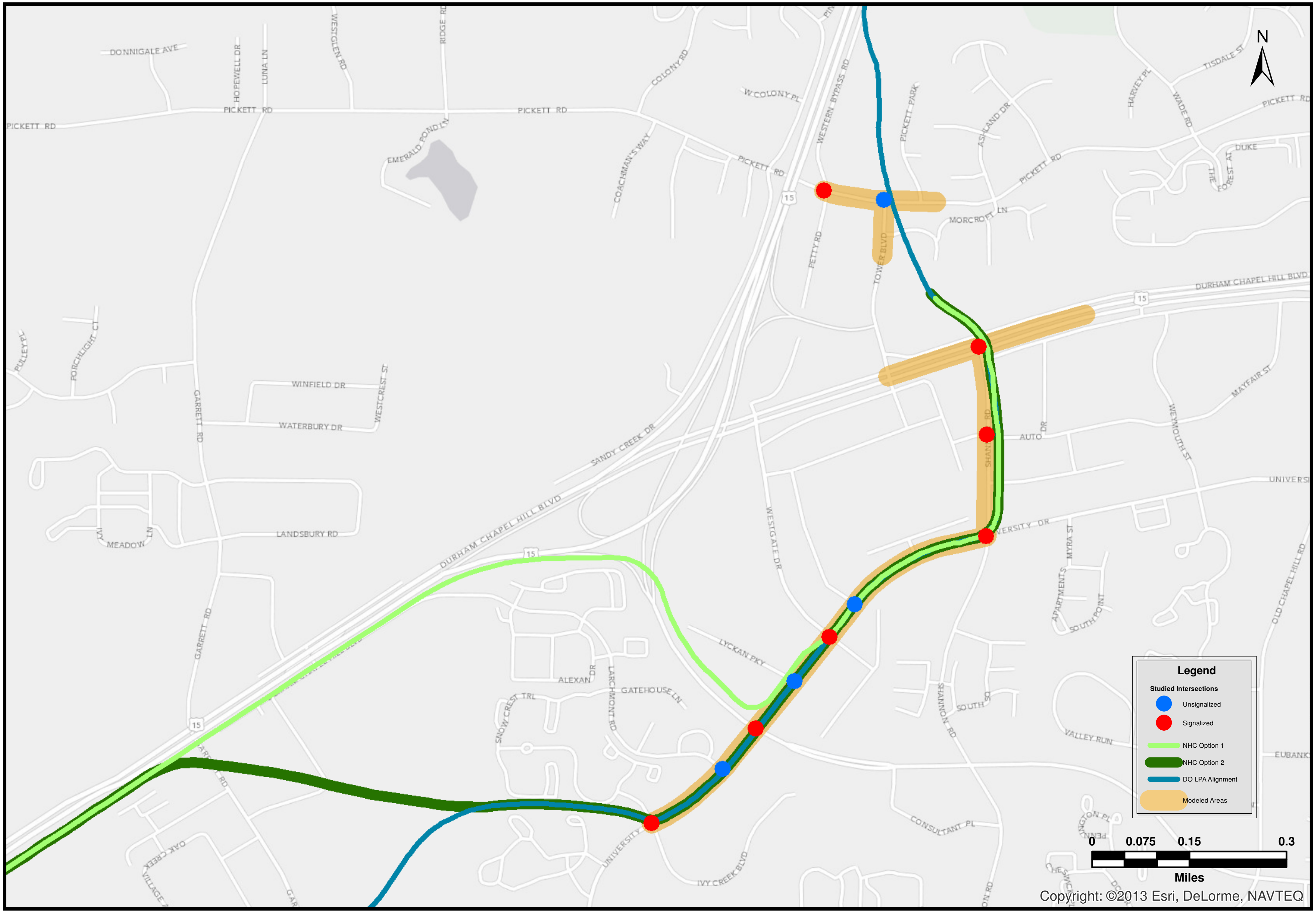

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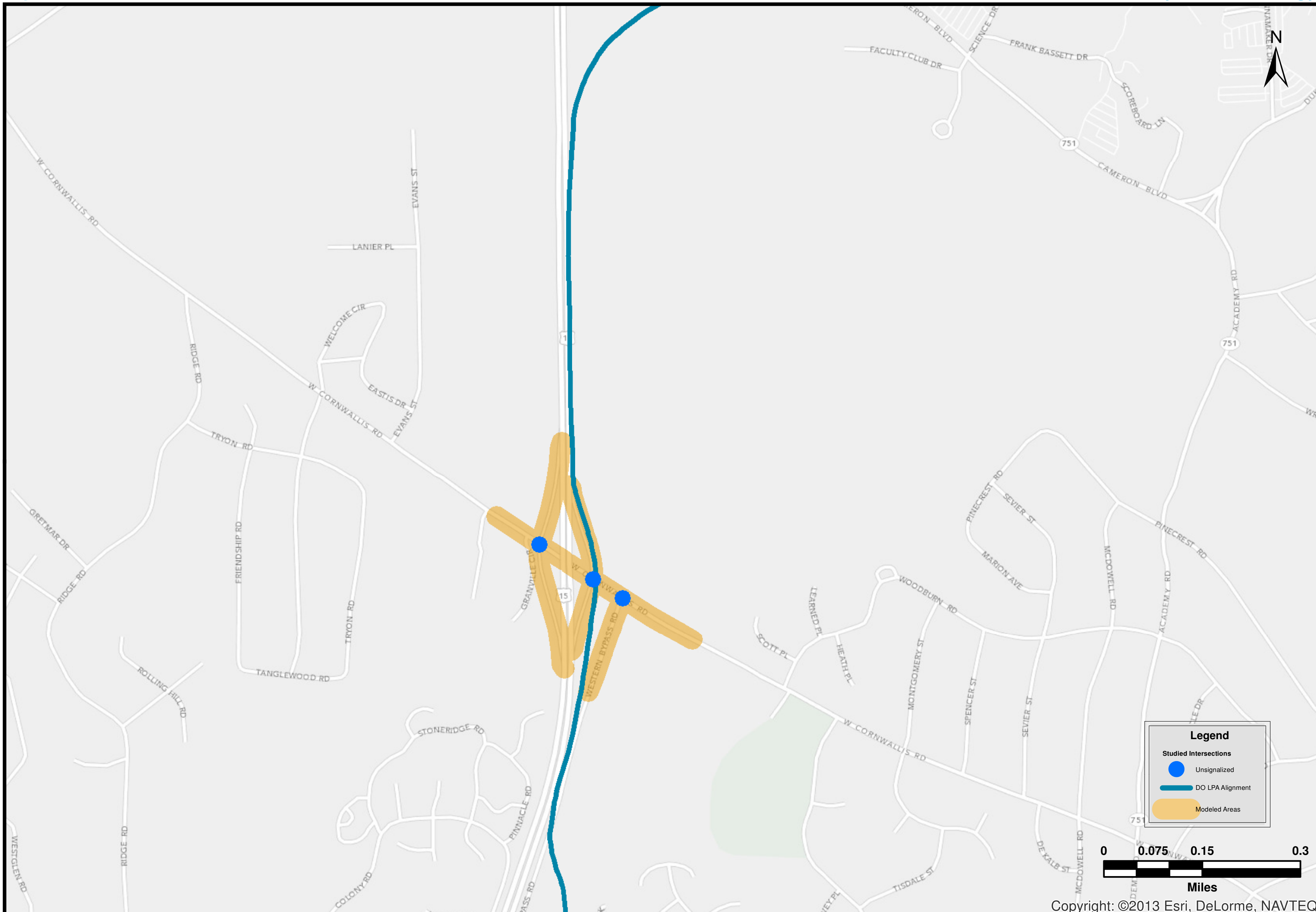
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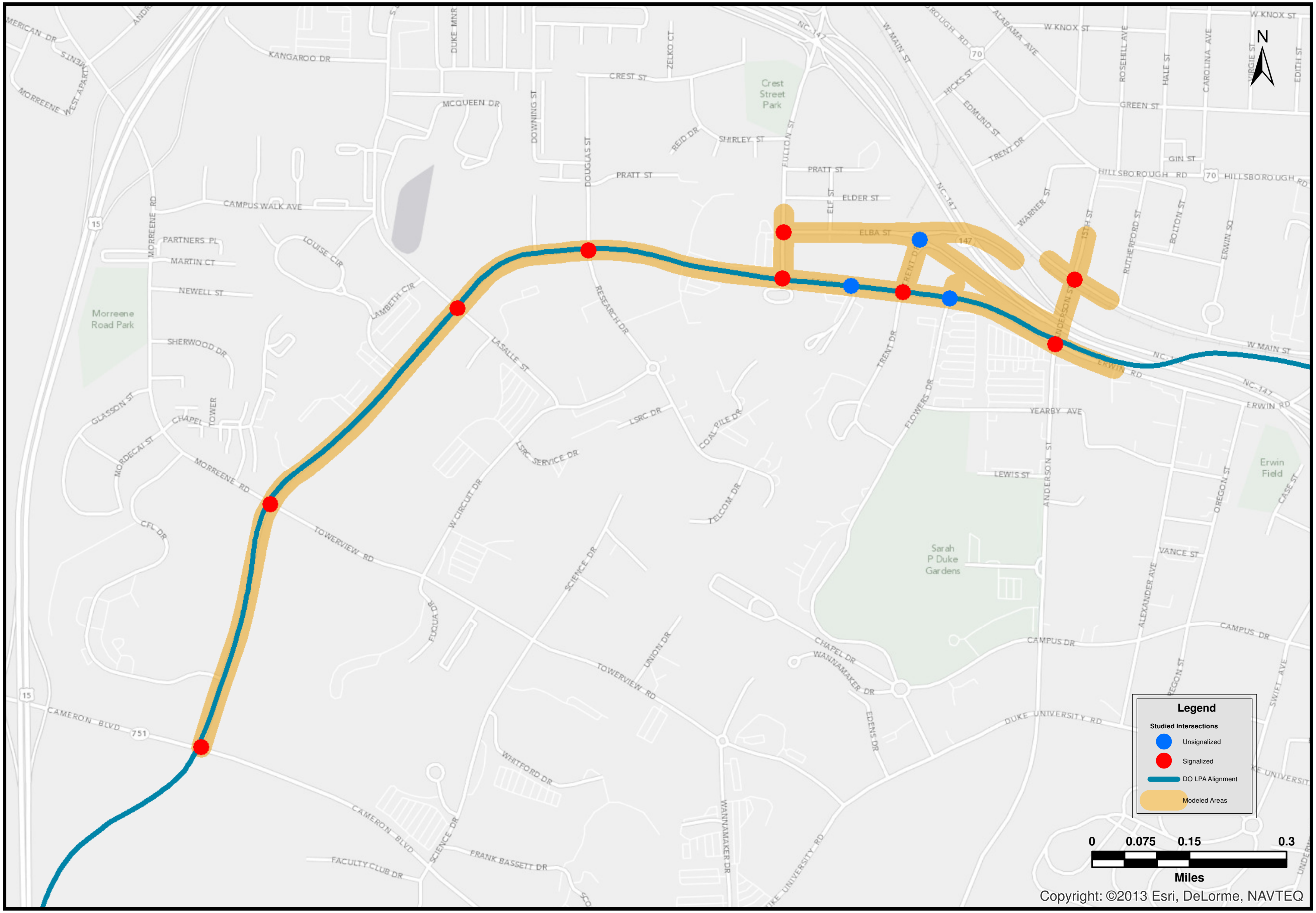
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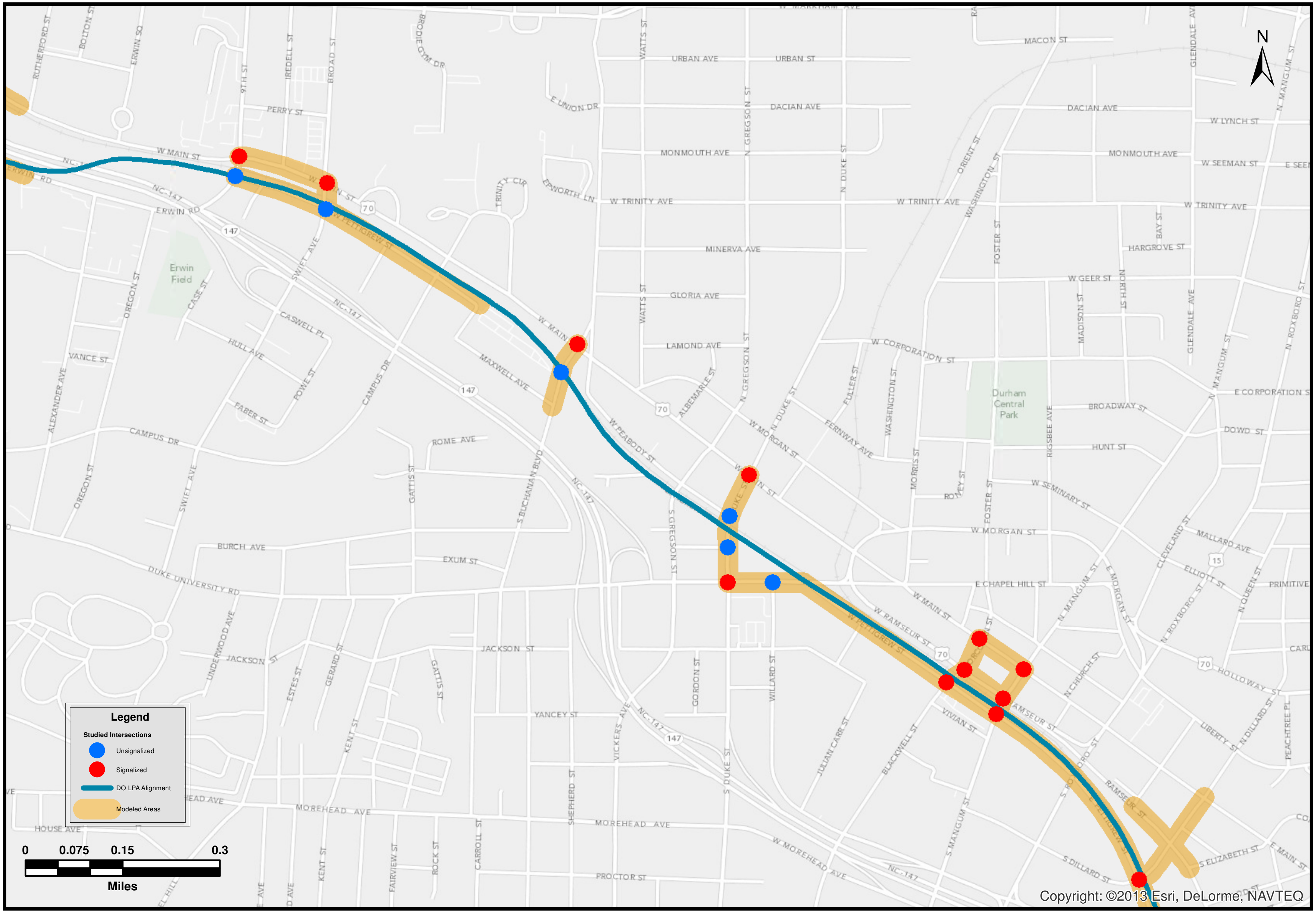
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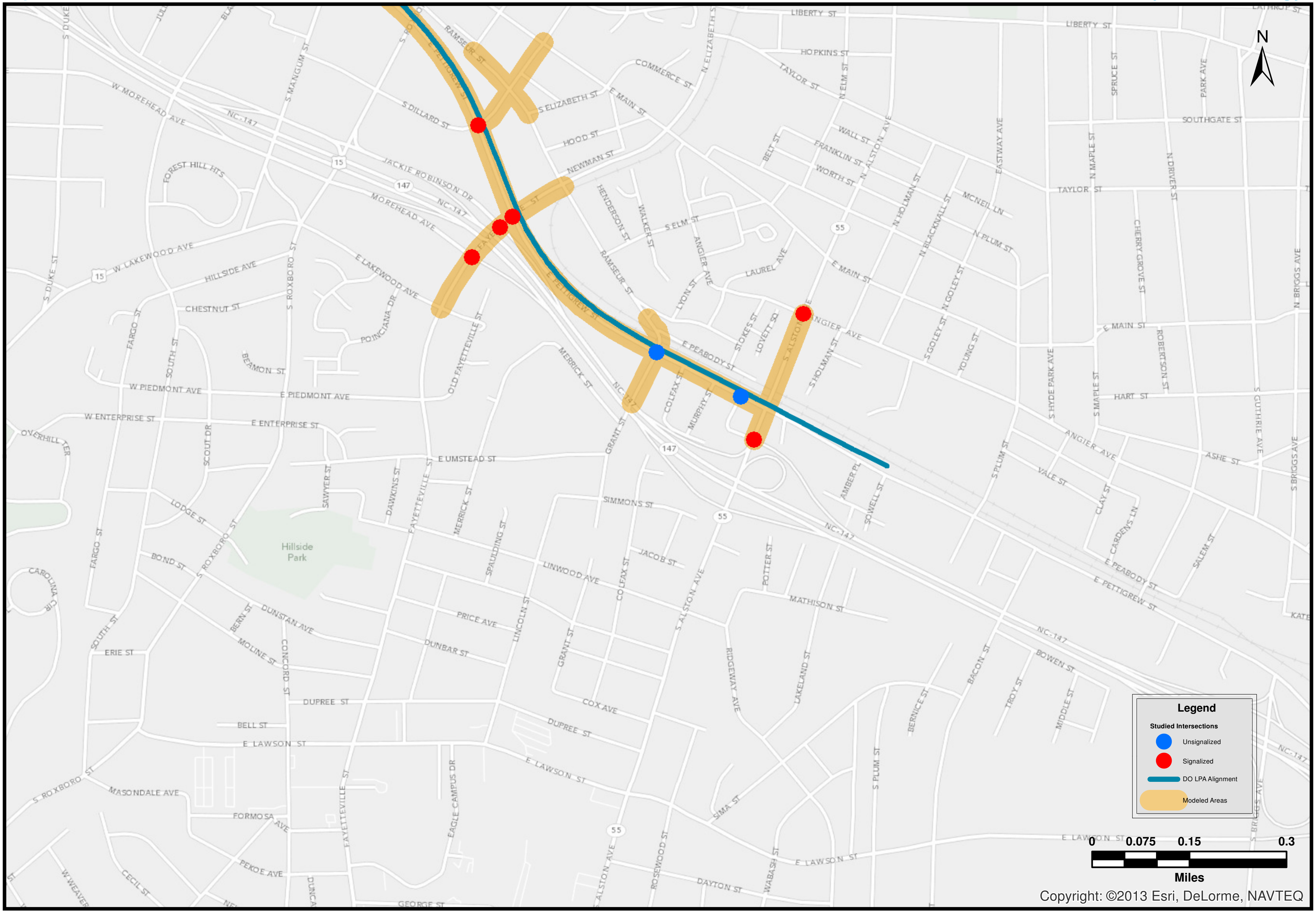
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3. Future Year No-Build/TSM Model

The No-Build and TSM alternatives are being combined as the traffic volumes are expected to be roughly similar. A future year No-Build/TSM model will be developed for each of the areas identified in section 2.1. These models will examine future conditions that could occur if the D-O LRT line were not constructed. As part of this analysis some projected deficiencies of the roadway network could be discovered. This analysis will not aim to categorize those deficiencies or to develop mitigation strategies. This analysis will be limited to determining likely future year conditions.

3.1 Develop Future Year No-Build/Tsm Volume Data

The balanced volumes developed for the base year analysis will be employed as the starting point for developing the future year No-Build/TSM volume data. Based on the balanced base-year peak-hour turning-movement, data link volumes will be generated for both the AM and PM peak hours. Data from the TRTDM will be used to obtain an appropriate growth factor for every link and this growth factor will be applied to base year link volumes to forecast future year No-Build/TSM peak-hour link volumes for the AM and PM peak hours. Data utilized for this will include daily volume growth, daily percentage growth, peak hour volume growth, and peak hour percentage growth. It will be critical to examine the peak hour data as well as the daily volume data as some peak spreading is likely to occur along the D-O LRT corridor given the developed nature of the corridor and the limited right-of-way available for additional roadway expansion. Engineering judgment will be employed to ensure that appropriate growth rates are extracted from the model.

Growth rates and projected link volumes will be reviewed in light of planned improvements in the area including projected development and changes to parking and transit operations. The model will be reviewed to determine which changes may have already been included within the socio-economic assumptions in the TRTDM. Forecasted link volumes will then be adjusted as necessary to reflect known changes that were not captured in the TRTDM.

Peak-hour turning volumes will be forecasted based on the peak-hour link volumes. Using the *TurnsW32* program (http://www.kittelson.com/toolbox/turnsw32) and the future year peak-hour link volumes and the base-year turning movements as input data, future year turning movements will be generated. These volumes will then be balanced in a manner similar to that used in the base year, although this process is likely to be less intensive.

Lastly, the sink and source nodes developed for the base year will be revisited. Based on existing development, planned development, and, to a lesser extent, sink and source nodes for the future year, a No-Build/TSM scenario will be developed.

3.2 Pedestrian And Bicycle Volumes

Local pedestrian and bicycle plans will be examined and proposed improvements that intersect the corridor will be noted. Qualitative estimates of the extent to which pedestrian and bicycle traffic will interact with the roadway network will be developed based on base year conditions and proposed developments. For this analysis cyclists will be assumed to cross at crosswalks and will not be included in the vehicular flow. At those locations where pedestrian and bicycle traffic is expected be above the 100 conflicting pedestrians per hour data will be developed and added to the model. The intersection Erwin Road and Fulton Street will include pedestrian or bicycle flow data in keeping with the base year calibration process. Additional intersections, particularly in downtown Durham or near either of the major college campuses, may also include pedestrian data in the future year No-Build/TSM analysis.

3.3 Future Year No-Build/Tsm Model Development

The base year model will be updated based on expected improvements to the roadway network. For this process the State Transportation Improvement Plan (STIP), the Metropolitan Transportation Improvement Plan (MTIP), various Capitol Improvement Plans (CIP), and bond packages will be reviewed to ensure that anticipated improvements are included in the future year model network. Unsignalized intersections will be given a cursory examination to determine if signalization is appropriate for future year conditions based on the volumes developed in the previous steps.

Signal timings will be updated using either Synchro or Vistro and the projected volumes and geometries. These new timings will be added to the model. Regardless of the development of pedestrian and bicycle data from the previous step all signals will be optimized to allow for safe pedestrian crossings.

Lastly routing information will be updated as needed to reflect changes in the roadway network based on proposed changes.

3.4 Model Simulation And Output Extraction

Upon developing the future year No-Build/TSM model, the model will run for the number of iterations necessary to achieve base year calibration. Models will be run using static trip assignments. The following data will be extracted and analyzed:

- Intersection Level of Service (LOS)
- Queuing
- Control delay
- Travel time
- Travel speeds
- Network delay (total and average per vehicle)

3.5 Comparison To Synchro

The Synchro analysis completed in the Alternative Analysis phase will be updated with new traffic volumes. The data from Synchro will be compared to the VisSim output. Differences will be noted and explained.

4. Future Year Build Models

A future year Build model will be developed for each of the areas identified in section 2.1. As noted in section 3.0 this analysis may reveal potential deficiencies in the future year roadway network. Only those areas negatively impacted above a certain threshold will be identified as part of this analysis. Areas anticipated to be deficient regardless of construction of the D-O LRT will not be identified nor will any potential mitigation strategy be developed.

4.1 Develop Future Year Build Volume Data

The balanced volumes developed for the future year No-Build/TSM analysis will be used as the starting point for developing the future year build volume data. Based on the balanced future-year No-Build/TSM turning-movement data, peak-hour link volumes will be generated for both the AM and PM peak hours. Data from the TRTDM will be used to obtain an appropriate diversion factor for every link for the AM and PM peak hours. Data utilized for this will include daily volume diversion, daily percentage diversion, peak hour volume diversion, and peak hour percentage diversion. It will be critical to examine the peak hour data as well as the daily data as some peak spreading is likely to occur along the D-O LRT corridor given the developed nature of the corridor and the limited right-of-way available for additional roadway expansion. Engineering judgment will be employed to ensure that appropriate growth rates are extracted from the model. A check will also be done between the Build and No-Build/TSM volume data to see if patterns suggested by the TRTDM are reflected in the volume data.

Growth rates and projected link volumes will be reviewed in light of planned improvements in the area including projected development and changes to parking and transit operations. The model will be reviewed to determine which changes may have already been included within the socio-economic assumptions in the TRTDM. Forecasted link volumes will then be adjusted as necessary to reflect known changes that were not captured in the TRTDM.

Peak-hour turning volumes will be forecast based on the peak-hour link volumes. Using the *TurnsW32* program (http://www.kittelson.com/toolbox/turnsw32) and the future year peak hour link volumes and the base year turning movements as input data future year turning movements will be generated. These volumes will then be balanced in a manner similar to that used in the base year, although this process is likely to be less intensive.

Lastly, the sink and source nodes developed for the base year will be revisited. Based on existing development, planned development, and, to a lesser extent, sink and source nodes for the future year, a Build scenario will be developed.

4.2 Pedestrian And Bicycle Volumes

In addition to data collected in section 3.2, station area data and ridership information will be examined to determine which areas may need to include pedestrian and bicycle flows in the analysis. The increase in pedestrian traffic due to the proposed D-O LRT will be above and beyond any increase due to future year land use. Qualitative estimates of pedestrian and bicycle flows will be developed based on base year conditions and proposed developments. In keeping with the future year No-Build/TSM analysis cyclists will be assumed to cross at crosswalks and will not be included in the vehicular flow. At those locations where pedestrians and bicycles are expected to be above the 100 conflicting pedestrians in the peak hour, data will be developed and added to the model.

4.3 Future Year Build Model Development

The future year Build model will be updated based on the proposed D-O LRT. Unsignalized intersections will be given a cursory examination to determine if signalization is appropriate for future year conditions based on the volumes developed in the previous steps.

Prior to signal optimization the project team will meet with local officials to discuss preferred interactions between the LRT and nearby signals. This will include discussions of both transit signal priority (TSP) and pre-emption. An interaction strategy for each individual signal will be identified.

Signal timings will be updated utilizing either Synchro or Vistro and the projected volumes and geometries and interaction strategy. These new timings will be added to the model. Regardless of the development of pedestrian and bicycle data from the previous step all signals will be optimized to allow for safe pedestrian crossings.

Lastly routing information will be updated as needed to reflect changes in the roadway network based on proposed changes.

4.4 Model Simulation And Output Extraction

Upon developing the future year Build model, the model will run for the number of iteration necessary to achieve base year calibration. Models will be run utilizing static trip assignment. The following data will be extracted and analyzed:

- Intersection LOS
- Queuing
- Control delay
- Travel time
- Travel speeds
- Network delay (total and average per vehicle)

4.5 Identify D-O LRT Impacts

Future year build output will be compared to future year no-build data. Those intersections that are expected to increase delay above a certain threshold will be identified. For the purposes of this study NCDOT's Policy on Street and Driveway, Chapter 5, Section J will be used to identify intersections on facilities owned by NCDOT and in the Town of Chapel Hill. The *Durham Comprehensive Plan Policy 8.1.2a, Traffic Level of Service (LOS) Standards* from the City of Durham will be applied to identify intersections on facilities owned by the City of Durham. Mitigation strategies to address the degradation in LOS and control delay will be developed for those identified intersections in the next phase of the project.

5. Friday Center Drive and Barbee Chapel Road Grade Separation Analysis

A grade separation analysis will be conducted to determine the benefit of grade separating the LRT crossings at Friday Center Drive and Barbee Chapel Road, both near NC 54. These locations were determined based on an analysis completed during the AA portion of the project and due to recent adjustments to the proposed D-O LRT alignment. The AA included a high level review of grade-separated and at-grade crossings and made definitive recommendations for the other crossings. The analysis for the Friday Center Drive and Barbee Chapel Road crossings could not be completed during the AA phase because of the more limited data available in this phase. This analysis will include altering the future year build network in the area to include a grade separated LRT crossing at Friday Center Drive. The model will then be re-run and new data will be extracted. The new model run data will be compared to the previous future year build data to determine the benefits of grade separating at this crossing. If necessary the analysis will review both alternative C1 and C2 to determine the benefits of grade separation.

6. Mitigation Plan

As noted above, a list of intersections expected to experience an increase in control above given thresholds will be developed. To reduce the impact of the D-O LRT, mitigation strategies will be identified for these locatoins. Such strategies could include additional turn lanes, improvements to alternative paths, alterations to travel patterns reducing delay, and improvements that do not add capacity such as improved wayfinding. These strategies will be tested utilizing VisSim to the extent possible. The modeled networks will be altered to include the roadway improvements or, in the case of strategies that alter travel patterns, the routing and volume data will be adjusted to reflect those new paths. The effectiveness of the strategies will be determined based on model results.

While the sections simulated are generally corridors, it is possible that some mitigation strategies may include the creation or improvement of alternative paths. Such an improvement may require the use of dynamic traffic assignment. A previously proposed mitigation strategy that would create an alternative path is the conversion of the Trent Drive and Elba Street intersection from the current configuration to a roundabout. Currently traffic on northbound Trent Drive cannot continue to westbound Elba Street. The conversion of this intersection to a roundabout would allow traffic on northbound Trent Drive to continue to westbound Elba Street. This conversion would provide an alternative path to the right-turning traffic from westbound Erwin Road to northbound Fulton Street, thus allowing this stream of traffic the opportunity to bypass the Erwin Road and Fulton Street intersection.

For this potential improvement, as well as similar improvements that create alternative paths, we are proposing to continue the use of static traffic assignment. Routing decisions will be updated such that traffic will be diverted to the new route and the model will be re-run and data on travel times extracted. The congested travel time of the new path will be compared to the existing path for the runs with the shifted traffic. If the travel time for the new path is still less than that for the existing path then no additional analysis will be required. In a case like this dynamic traffic assignment would shift all traffic to the new path as it is the shortest path. If the travel time for the new path is greater than the travel time for the existing path then dynamic traffic assignment will be used to provide the appropriate balance between traffic that will use the new path and traffic that will use the existing path. It is under this, and only this, condition that dynamic traffic assignment would be employed.

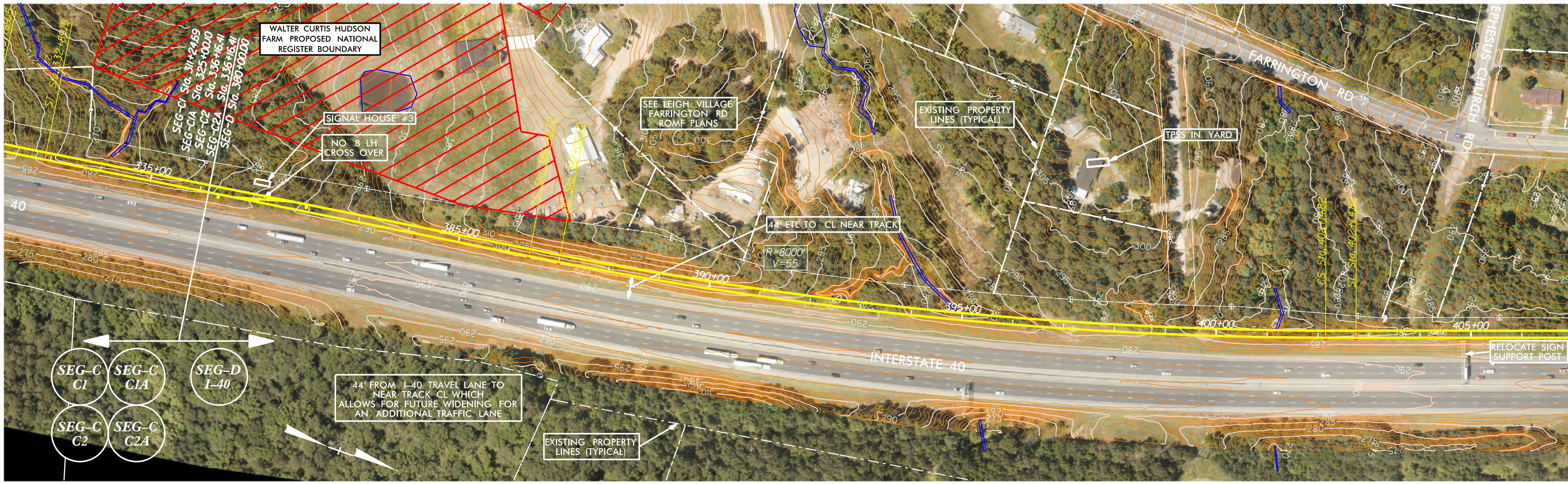
Appendix B
Basis for Engineering Plans
(LRT Alternatives Design Plans)

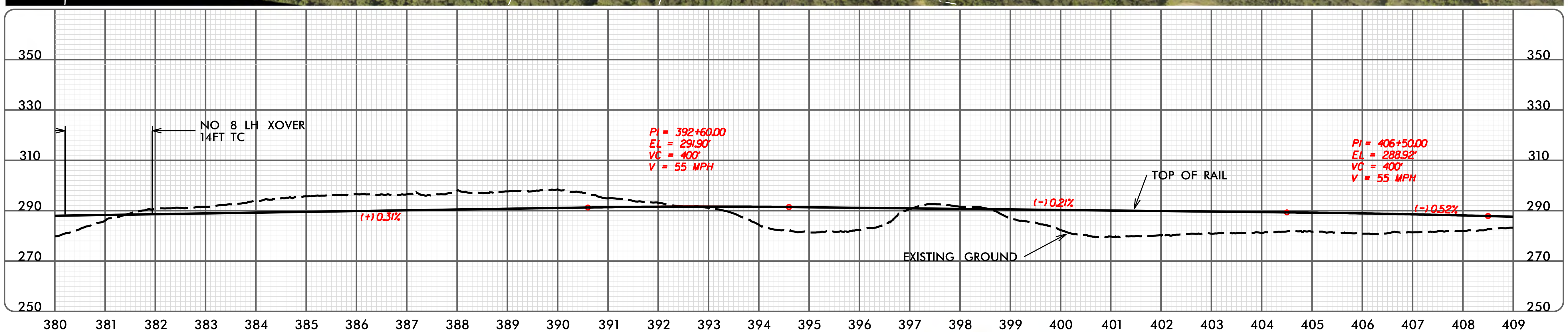
SEGMENT D – INTERSTATE 40

PLAN AND PROFILE SHEETS

OurTransit FUTURE™

ALONG INTERSTATE 40





GRAPHIC SCALES

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PLAN

100 0 100 200
PROFILE (HORIZONTAL)

20 10 0 20 40
PROFILE (VERTICAL)

4/2/2015

CONCEPT PLANS ONLY
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INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

LEGEND

- BRIDGE PIERS
- AT-GRADE TRK
- ELEVATED TRK
- WETLANDS
- STATION

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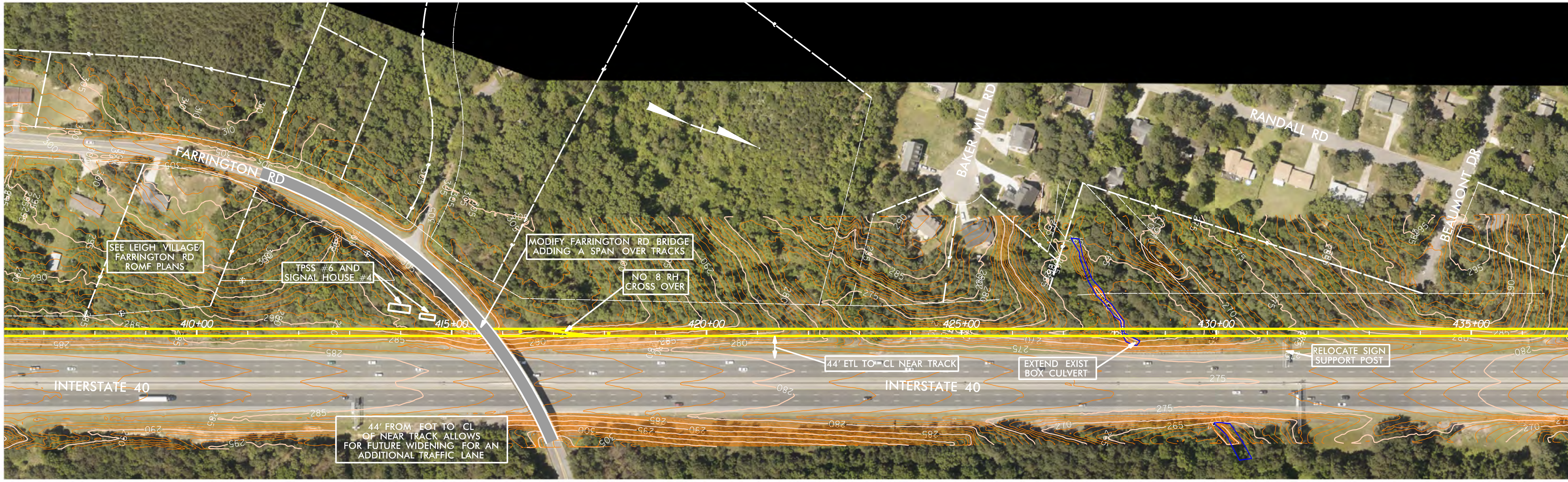
PLAN AND PROFILE

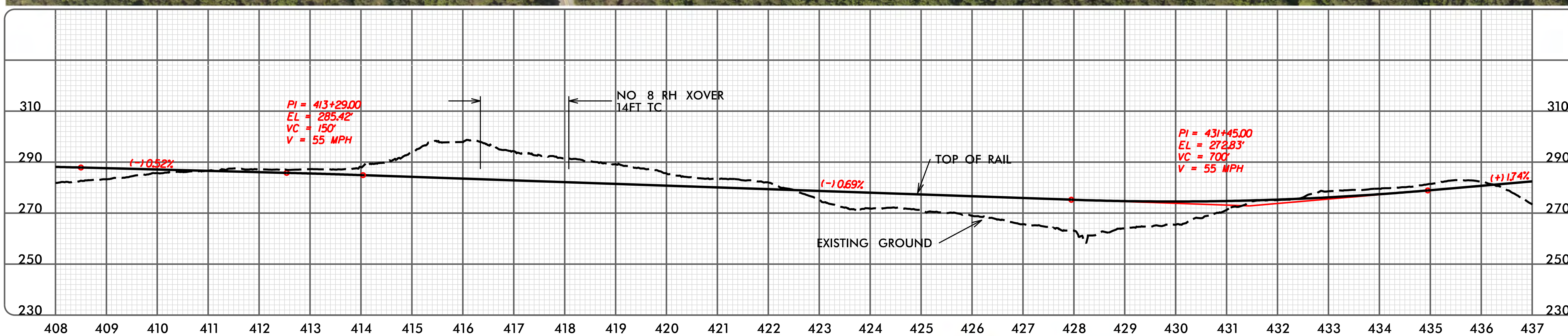
SEGMENT D

PLAN & PROFILE

SHEET: D – 01

ALONG INTERSTATE 40





GRAPHIC SCALES

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100 0 100 200 PROFILE (HORIZONTAL)

20 10 0 20 40 PROFILE (VERTICAL)

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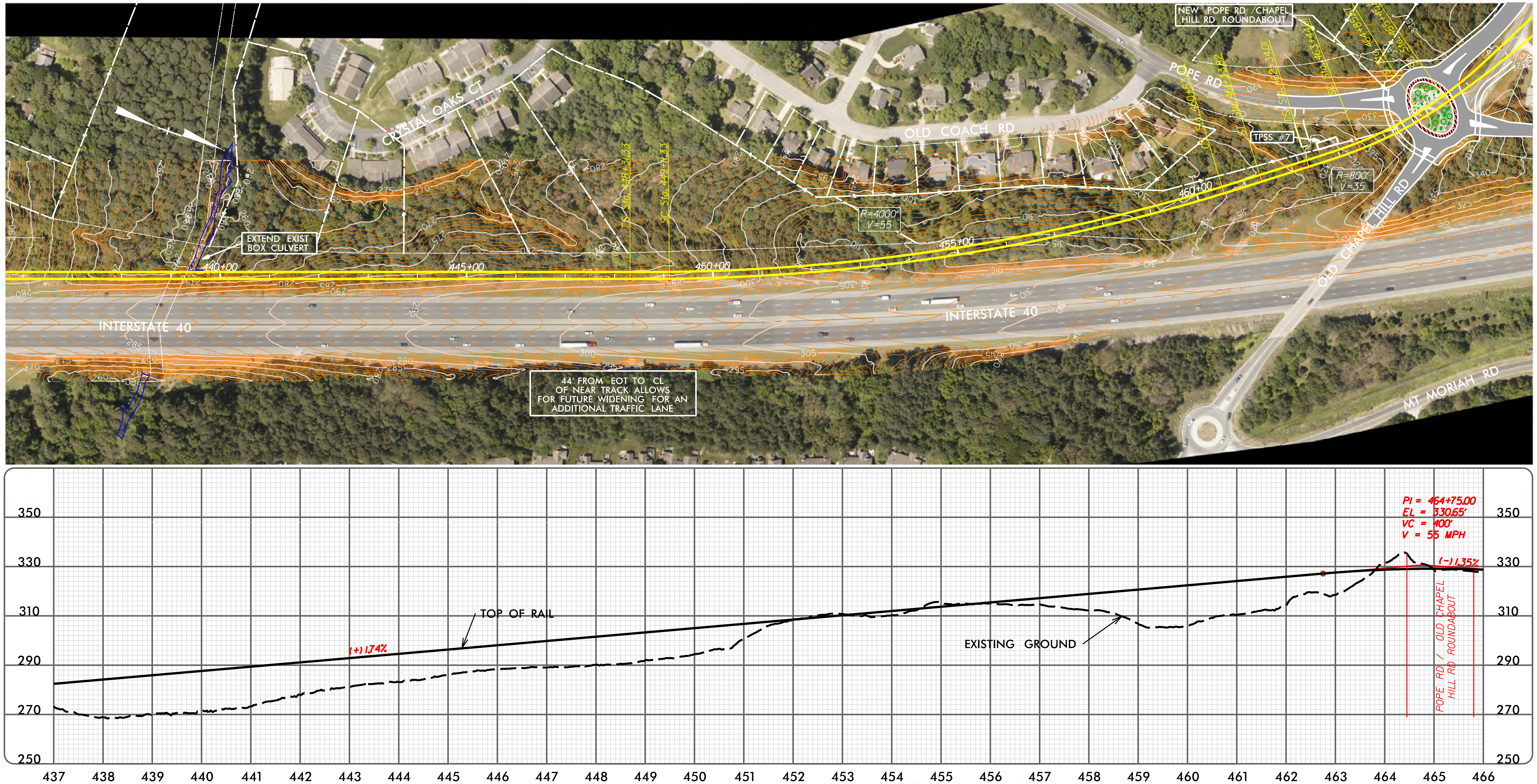
SHEET: D – 02

3/30/2015

ALONG INTERSTATE 40



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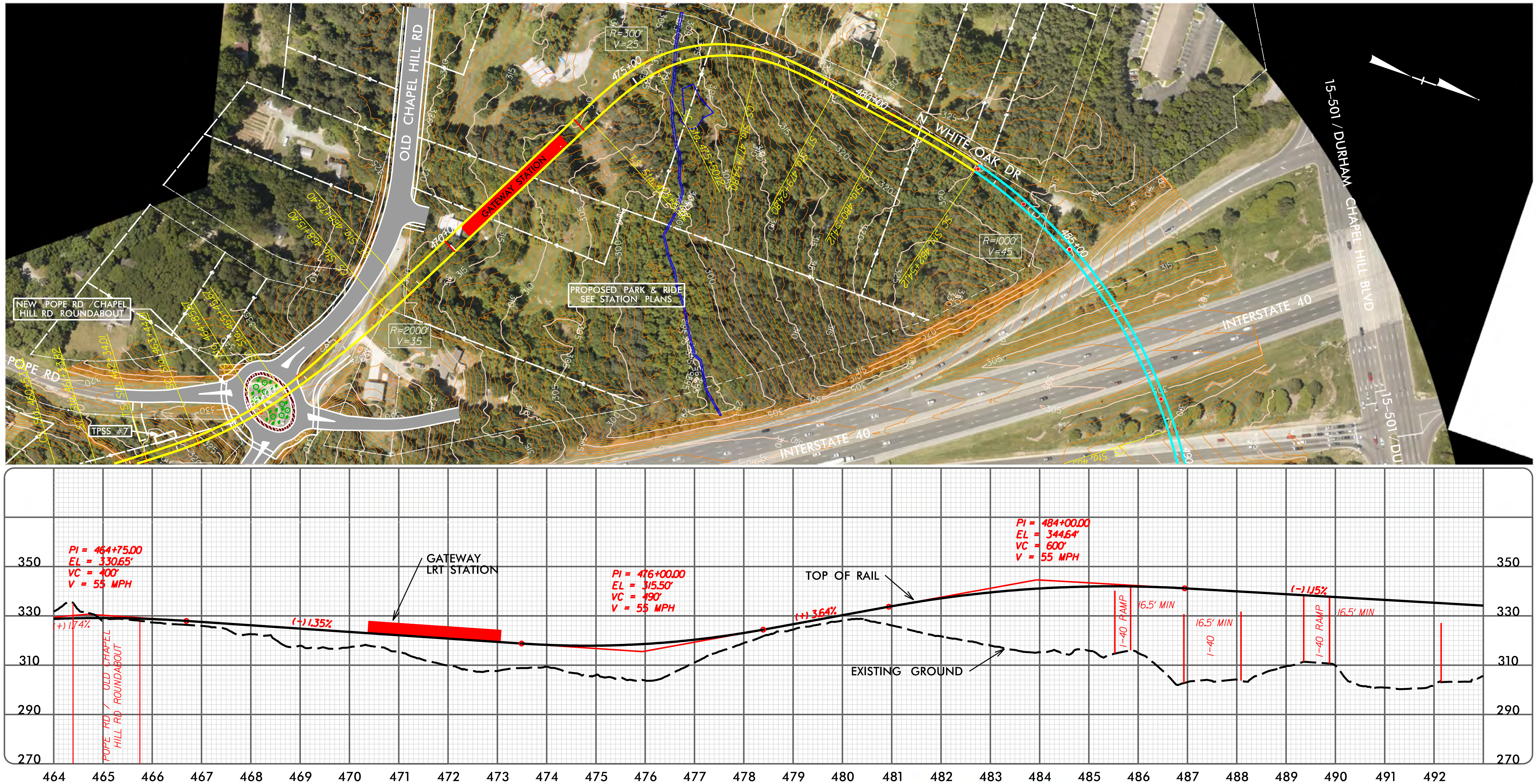
SEGMENT D

PLAN & PROFILE

SHEET: D – 03

3/30/2015

GATEWAY STATION



GRAPHIC SCALES

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PROFILE (HORIZONTAL): 100 0 100 200

PROFILE (VERTICAL): 20 10 0 20 40

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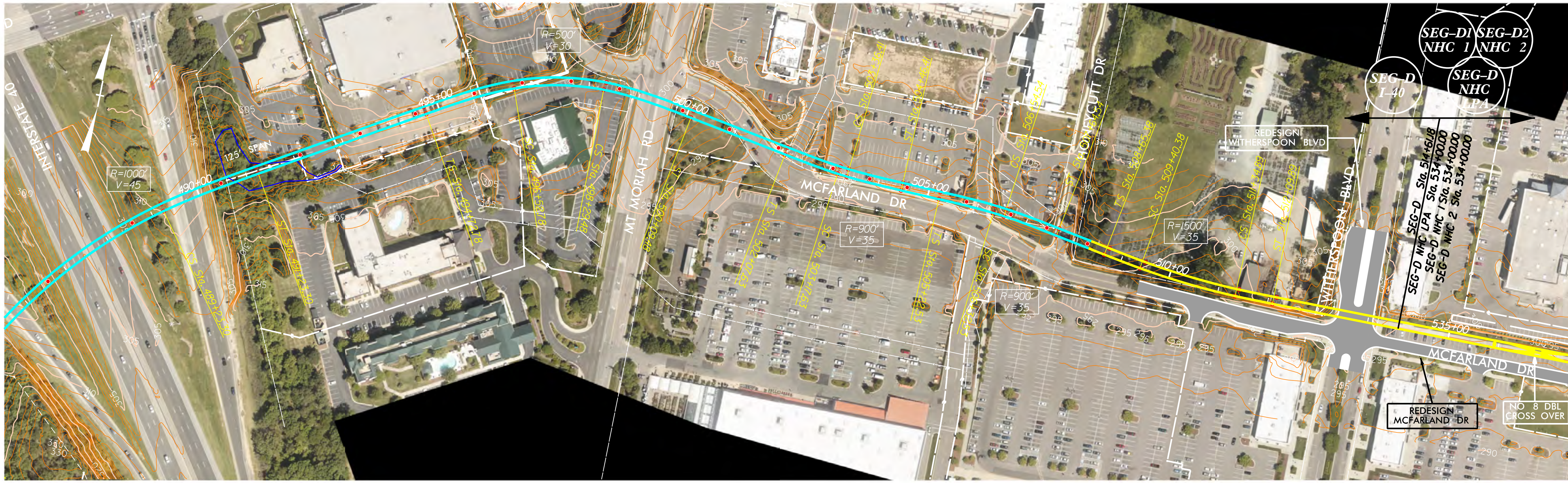
SEGMENT D

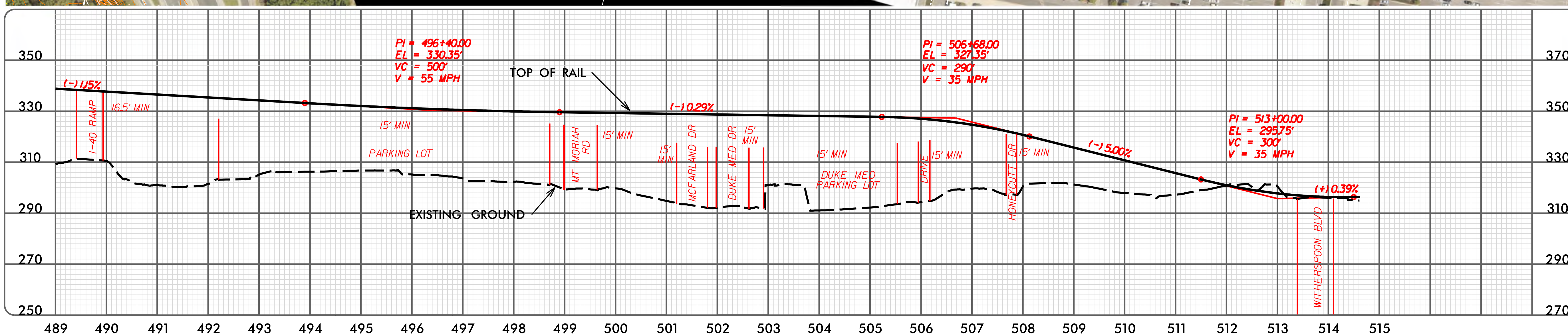
PLAN & PROFILE

SHEET: D – 04

3/30/2015

INTERSTATE 40





GRAPHIC SCALES

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PLAN

100 0 100 200
PROFILE (HORIZONTAL)

20 10 0 20 40
PROFILE (VERTICAL)

3/30/2015

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PLAN AND PROFILE

SEGMENT D

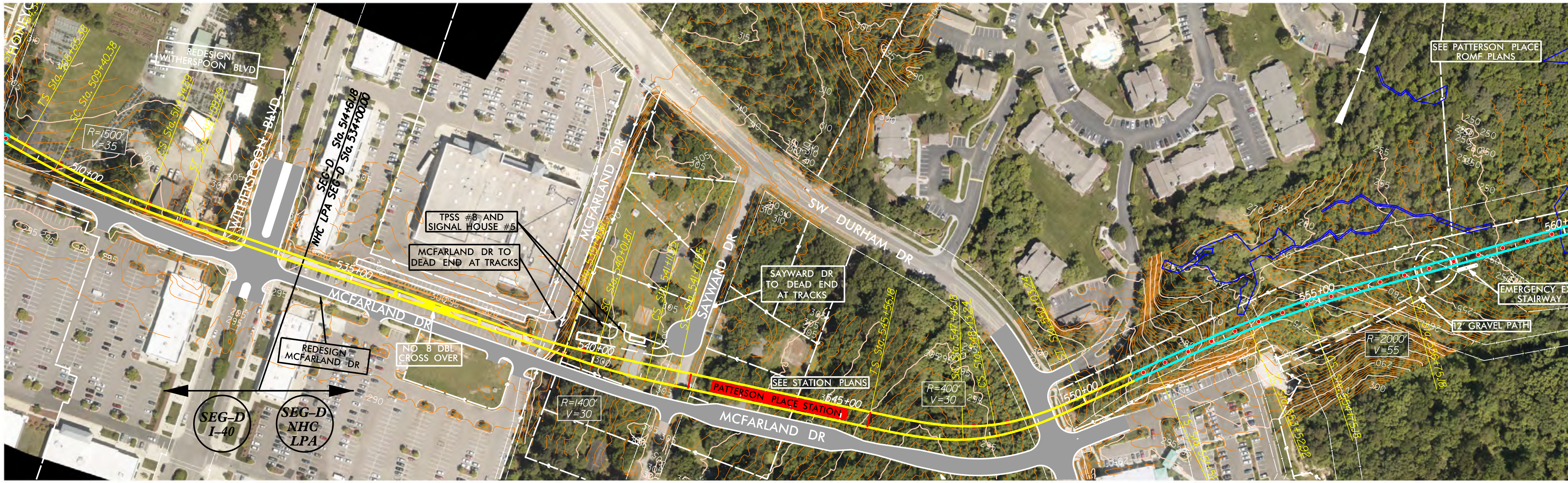
PLAN & PROFILE

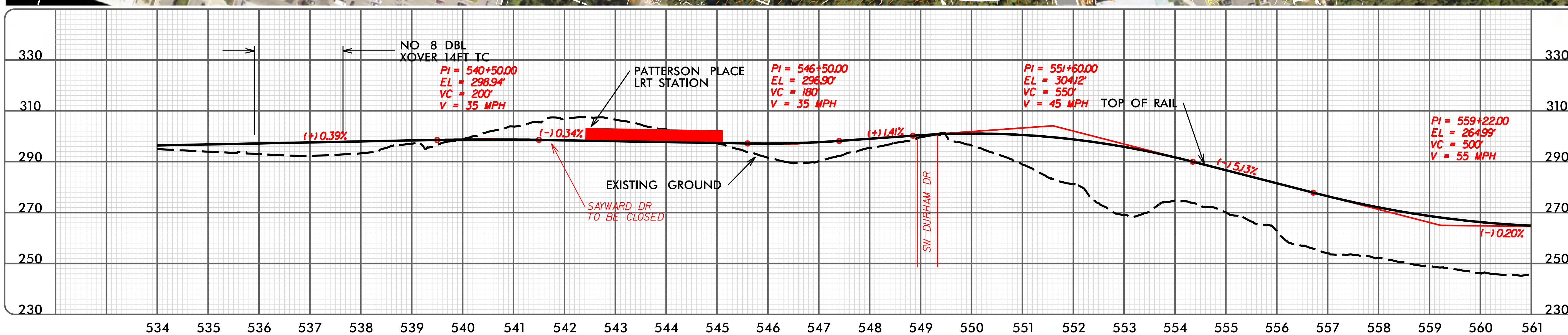
SHEET: D – 05

SEGMENT D – NEW HOPE CREEK LOCALLY PREFERRED ALTERNATIVE

PLAN AND PROFILE SHEETS

PATTERSON PLACE STATION – NEW HOPE CREEK LPA





GRAPHIC SCALES

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PLAN

100 0 100 200
PROFILE (HORIZONTAL)

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PROFILE (VERTICAL)

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SEGMENT D

PLAN & PROFILE

SHEET: D – 06

4/6/2015

SEGMENT D – NEW HOPE CREEK 1 ALTERNATIVE

PLAN AND PROFILE SHEETS

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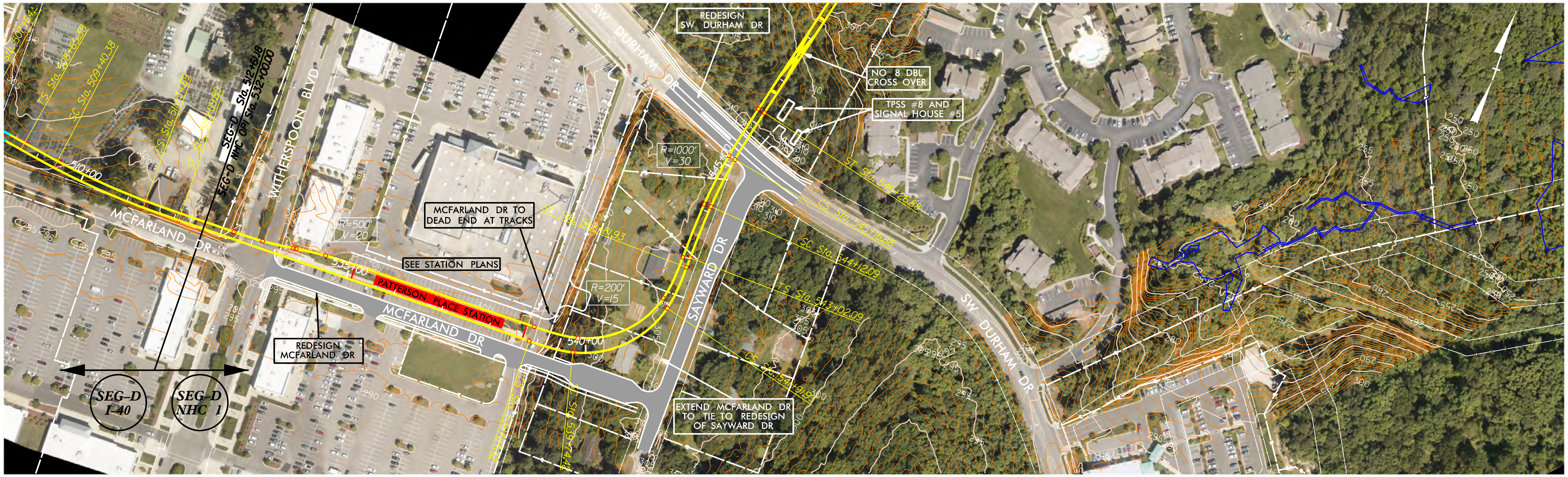
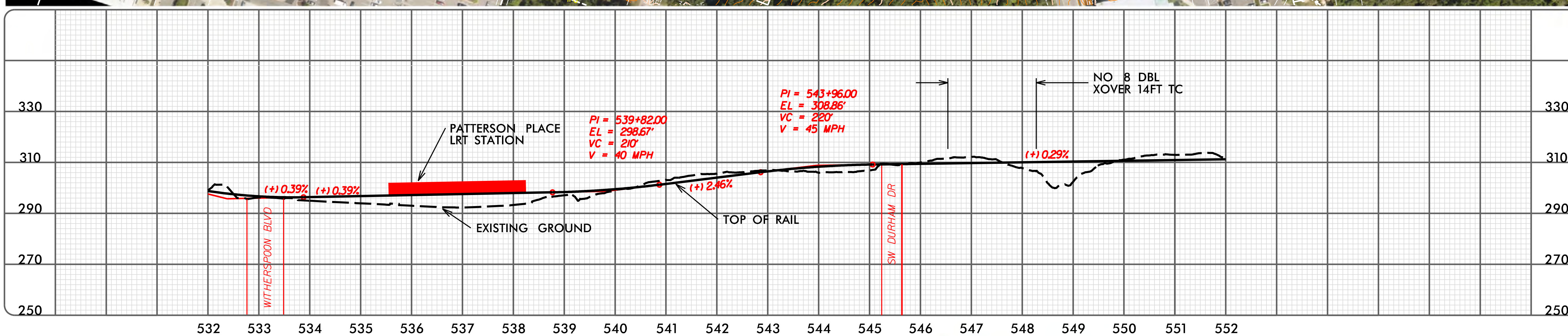
PATTERSON PLACE STATION – NEW HOPE CREEK 1 ALTERNATIVE





GRAPHIC SCALES

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PROFILE (HORIZONTAL): 100 0 100 200

PROFILE (VERTICAL): 20 10 0 20 40

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SEGMENT D

PLAN & PROFILE

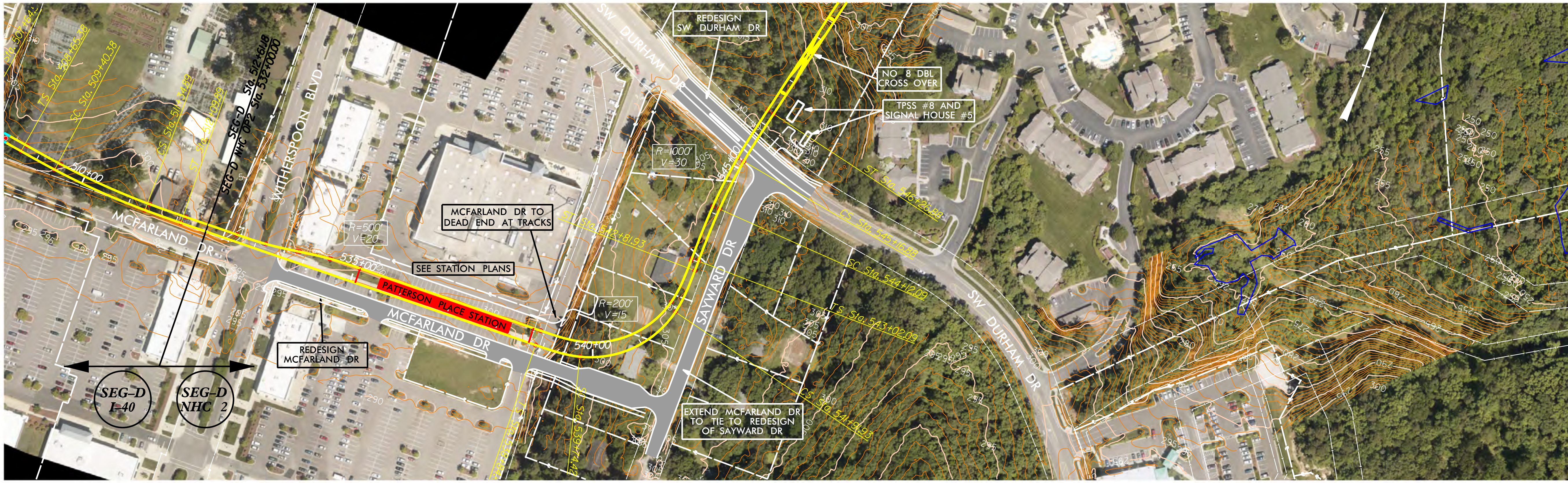
SHEET: D1 – 06

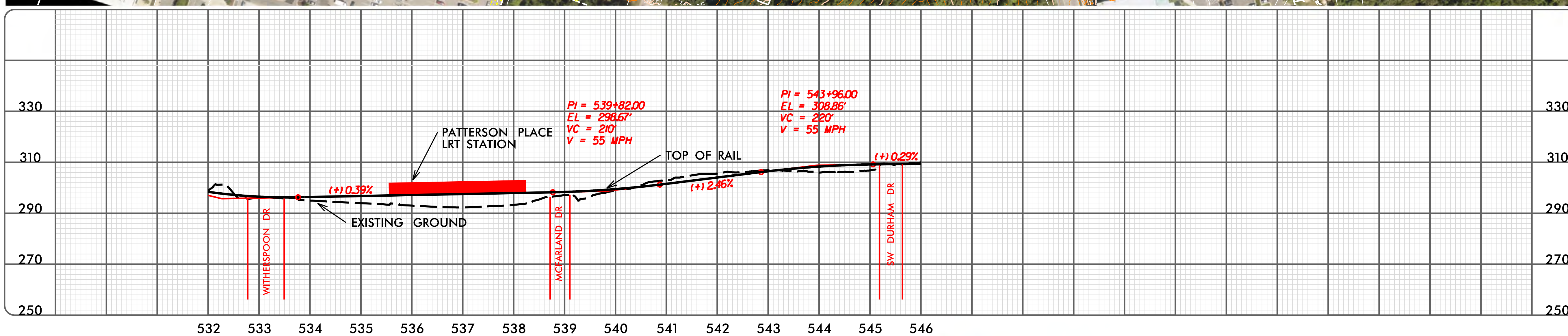
3/30/2015

SEGMENT D – NEW HOPE CREEK 2 ALTERNATIVE

PLAN AND PROFILE SHEETS

PATTERSON PLACE STATION – NEW HOPE CREEK 2 ALTERNATIVE





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PLAN

100 0 100 200
PROFILE (HORIZONTAL)

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PROFILE (VERTICAL)

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SEGMENT D

PLAN & PROFILE

SHEET: D2 – 06

Appendix C
Roundabouts and Light Rail Combined: An Innovative Multimodal Solution

Roundabouts and Light Rail Combined: An Innovative Intermodal Solution

Paper Author: Bill Baranowski, P.E. RoundaboutsUSA

References

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Steve Meyer, P.E.
(801) 466-4697

University of Utah
Anne Racer, Planning Dir.
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RoundaboutsUSA
Bill Baranowski, P.E.
(801) 569-5047

A modern roundabout intersection with light rail running through the center began full operation on September 29, 2003 as part of the University of Utah Health Sciences Center Light Rail Extension in Salt Lake City, Utah. It is located on the University Line between the Stadium station and the South Campus station. The roundabout made center-running tracks possible at a major campus intersection. The roundabout is a clear enhancement for the light rail trains as the intersection priority is switched from giving priority to vehicular traffic to allowing the trains full priority.

The use of similar roundabouts with rail crossings was observed by the author on trips to Europe and Australia. These served as the inspiration for the application in the USA. As roundabout usage becomes more common in the USA, creative uses such as this one should be considered. This project was made possible through the cooperation of the Utah Transit Authority (UTA), the Utah Department of Transportation (UDOT) and the University of Utah.

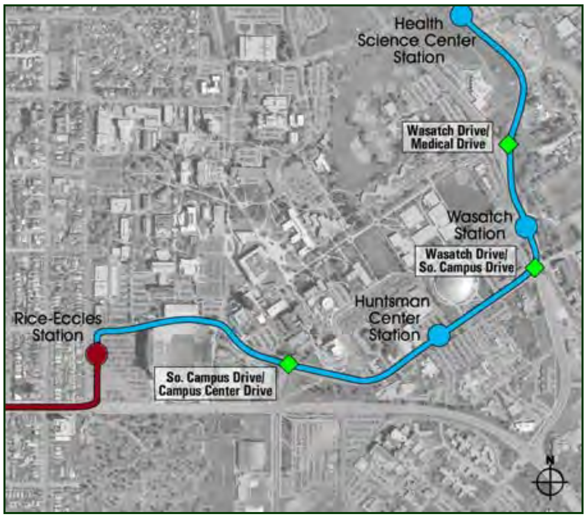
UTA TRAX

RoundaboutsUSA

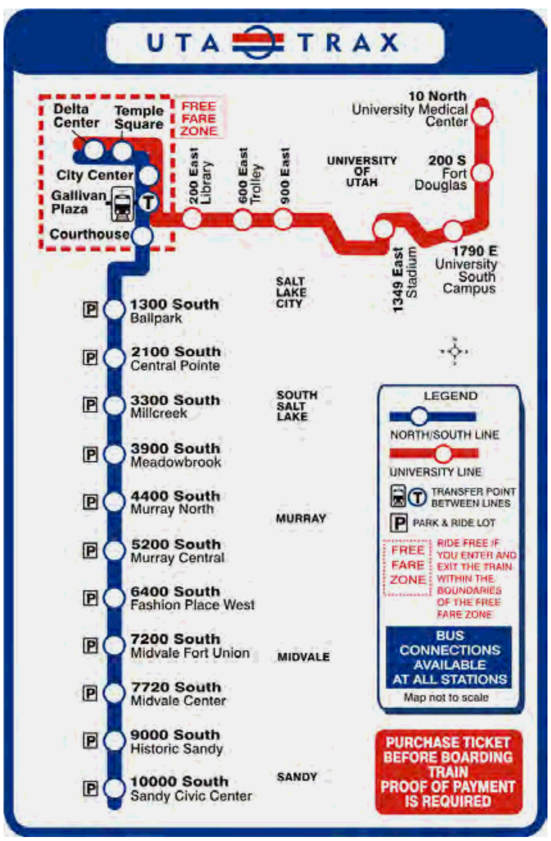
Narrative Description

Background

The original section of light rail constructed in Salt Lake County is the 15-mile north/south line between Sandy City and Salt Lake City completed in December 2000. The Main Street to University of Utah Trax line includes two sections. The first section, shown in red below, is located on 400 South/500 South between Main Street east to the Rice Eccles Stadium on the University of Utah campus. It was completed in 2001.



University of Utah Light Rail Project Stations



Existing TRAX System Map

Background

The second section shown in blue at left, is the Medical Center light rail Extension at the University of Utah Campus. It begins at the Rice-Eccles Stadium Station and follows South Campus Drive and Wasatch Drive for 1.4 miles. The extension includes three stations and three major intersections.

The Medical Center light rail Extension opened on September 29, 2003. It has the potential to serve many of the hospital campus' 9,000 employees and the 500,000 outpatient-clinic visitors per year. The existing north-south LRT line carries an average of 20,000 riders per day; the 2.5 mile extension to the Stadium carries 6,000 riders per day. During the recent Winter Olympics the LRT system carried over 140,000 riders per day on the busiest days. There is an existing shortage of parking on campus which provides an excellent opportunity for transit growth.

Several alternative light rail track alignments within the existing roadway corridors were proposed along with station locations, intersection control options, and pedestrian crossing locations. The design of the stations and intersections allowed for existing and future traffic needs along the 1.4 mile extension.

The roundabout intersection described in this report is located at South Campus Drive/Campus Center Drive. This intersection is one of the major entrances into the campus with 2,000 vehicles per hour during both the AM and PM peak travel periods.

Track Alignments and Station Locations

Several alternative light rail track alignments within the existing roadway corridors were proposed along with station locations, intersection control options, and pedestrian crossing locations. The designer was asked to review the proposed track alignments, analyze 3 key intersections and to give recommendations for the placement of the tracks and stations.

Center-running track is an operational advantage over side running on South Campus Drive. The number of track crossings is reduced to only those at signalized intersection locations. This has eliminated several gated crossings on the north side of South Campus Drive. Right-in right-out access is maintained for the driveways on both sides of South Campus Drive. Two-lanes of traffic are provided on each side of the tracks north of the roundabout and one-lane of traffic is provided on each side south of the roundabout. Automobile traffic is strictly controlled as they are allowed to cross the tracks only at gated crossings, signalized intersections and the roundabout. Center running tracks allows the continued operation of the University Shuttles and UTA transit bus stops on both sides of South Campus Drive near the Library and the Huntsman Sports Center. The roundabout option makes center-running light rail possible where a traffic signal would be possible within the given right of way constraints.

The change in track alignment on South Campus Drive from side running to center-running improved access and operation of the shuttle vehicles and buses running on both sides of the tracks. The roundabout allows center running light rail and enables left turns by automobiles in all directions at this key intersection. The photos below show where the tracks shift from side running to center running west of the Stadium.

Side-running to Center-running Transition Point

Pedestrian Undercrossing

Intersection Analysis: Roundabout and Traffic Signal Comparison

Before the roundabout was constructed, the intersection of South Campus Drive and Campus Center Drive was a “T” intersection with South Campus Drive along the top of the “T” running east west. Yield signs controlled traffic at the top of the “T”. Bypass lanes existed at the two corners and across the top of the “T”. This intersection is one of the major entrances to the campus with about 2,000 vehicles per hour in both the AM and PM peak travel periods.

South Campus Drive/Campus Center Drive Intersection before the Roundabout Construction. Yield signs control the traffic along the top of the T-intersection. Bypass lanes existed at the two corners and across the top of the “T”. Because of the existing free movements the change to a roundabout operation was not as extreme for drivers.

The south leg is Campus Center Drive, which connects to 500 South/Foothill Boulevard, which is a major 6-lane east-west arterial connecting downtown Salt Lake City to Interstate 80 near the mountains. The 500 South intersection is located approximately 320 feet to the south is controlled by a traffic signal with heavy double left-turn traffic towards the roundabout. The two light-rail tracks run in the center of South Campus Drive (the top of the “T”) with one lane of vehicle traffic in each direction to the west of the intersection and two lanes of vehicle traffic in each direction to the east of the intersection. The dual lane bypass that existed before the roundabout conversion was retained in the new intersection.

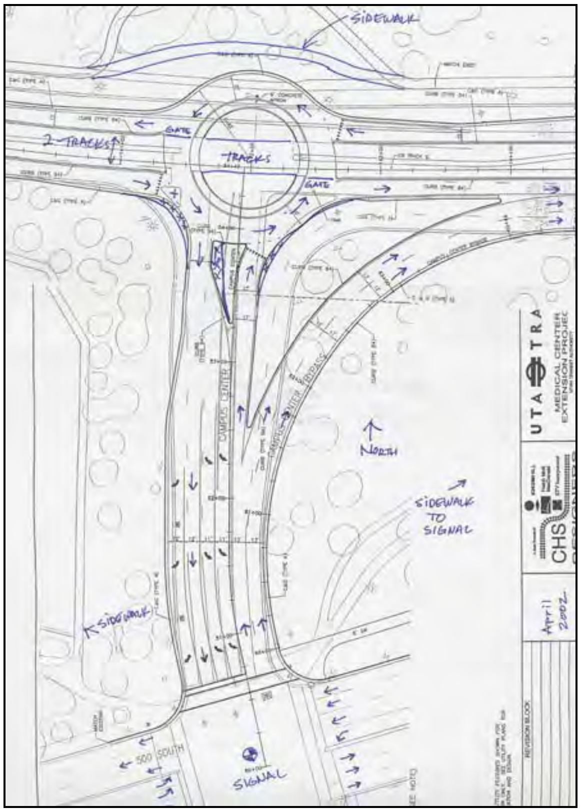
Computer analysis and simulations were prepared to show the traffic impacts with the center running Trax line on South Campus Drive at the intersection with Central Campus Drive. The two alternatives considered included a roundabout with bypass lanes on the southeast corner and a signal-controlled intersection with double left-turns in the northbound and westbound directions.

SYNCHRO (traffic signal analysis software) was used to generate the traffic capacity reports for the signal and RODEL (British roundabout analysis software) was used to produce a Level of Service (LOS) analysis based on the geometry of the roundabout. Movie type simulations of vehicles merging and making lane changes were created using VISSIM a common simulation model that is very effective at modeling both light rail and roundabouts.

The following table summarizes the results of the LOS analysis.

Intersection LOS Comparison 2020 Turning Movement Volumes (LOS/Ave. Delay)*						
	Roundabout		Signal		Signal (dual lefts)	
	AM	PM	AM	PM	AM	PM
Northbound	A / 7.8	A / 4.8	C / 34.6	F / 89.6	C / 25.1	B / 15.1
Eastbound	A / 4.2	A / 6.0	C / 28.8	D / 49.3	C / 26.9	C / 20.7
Westbound	A / 4.2	A / 7.8	D / 37.2	E / 55.9	A / 7.2	B / 11.2
Overall	**A / 6.0**	**A / 6.8**	**D / 35.3**	**E / 63.4**	**B / 17.6**	**B / 12.6**

*Does not include Trax light rail effects.



Roundabout Construction Drawing: 4 Gates

The four gates drop in succession to allow most vehicles already in the circle to exit before the train arrives. After the train leaves the circle, the two gates next to the tracks raise first allowing vehicles coming from the traffic signal to get a head start into the roundabout.

The design speed for vehicular traffic in the roundabout is 18 mph. The safety of the intersection is enhanced by low vehicular speeds and the lower number of conflict points inherent in the roundabout design.

The analysis found the roundabout option to experience less delay for vehicular traffic and no delay at all for light rail trains. The traffic signal option however, experienced at least twice the amount of delay as the roundabout option during peak traffic periods. In addition, the with the traffic signal option light rail trains had a 50% chance of stopping at the intersection to wait for the intersection to clear. Pedestrian crossings are provided at signalized locations away from the roundabout.

Intersection LRT Control and Safety

The safety concerns of allowing the trains to cross vehicle traffic was solved by installing railroad gates, flashers and bells on two of the entries and two where the vehicles cross the tracks inside the roundabout.

A total of four railroad gates with flashers, and bells are provided at the roundabout. Sensors in the tracks allow the gates to go down before a train arrives.

Roundabout during Winter Driving Conditions

Conclusions

The traffic analysis and computer simulations of the study intersection demonstrated the advantages of the roundabout alternative. The roundabout intersection alternative makes center running LRT possible on South Campus Drive. The roundabout gives the light rail trains full priority at the intersection. The low speed design of the vehicular traffic in and out of the roundabout enhanced the safety of the intersection. The project is an example of an innovative intermodal solution that may be applied at other locations in the USA.

TRAX Ribbon Cutting – October 29, 2003

Author Information

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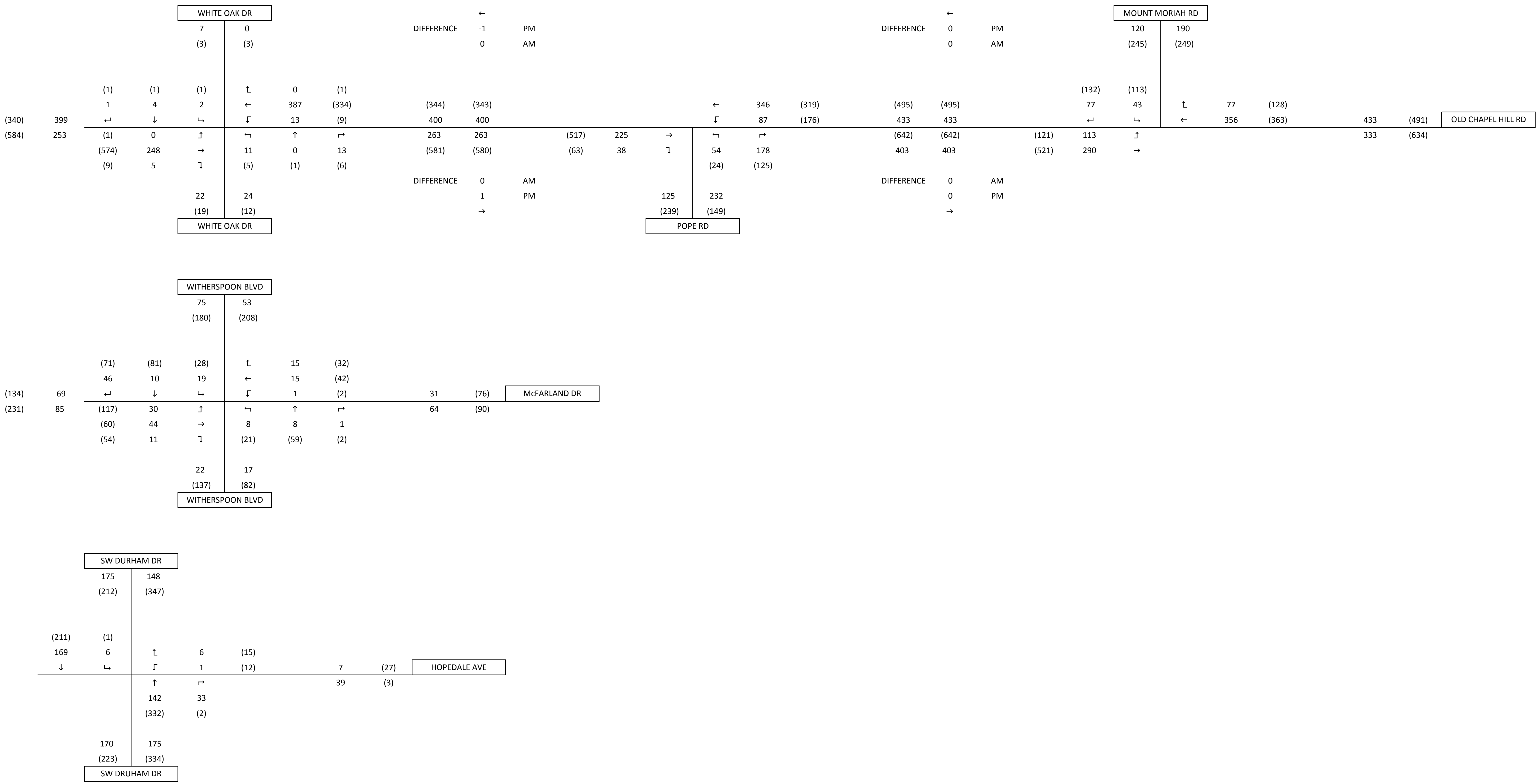
*Bill Baranowski is the President of RoundaboutsUSA and City Traffic Engineer in West Jordan City, Utah and was the consultant/project manager of the University of Utah Light-Rail Extension Study and Design. He was a transportation project manager with the Sear-Brown Group in Salt Lake City at the time of the project.

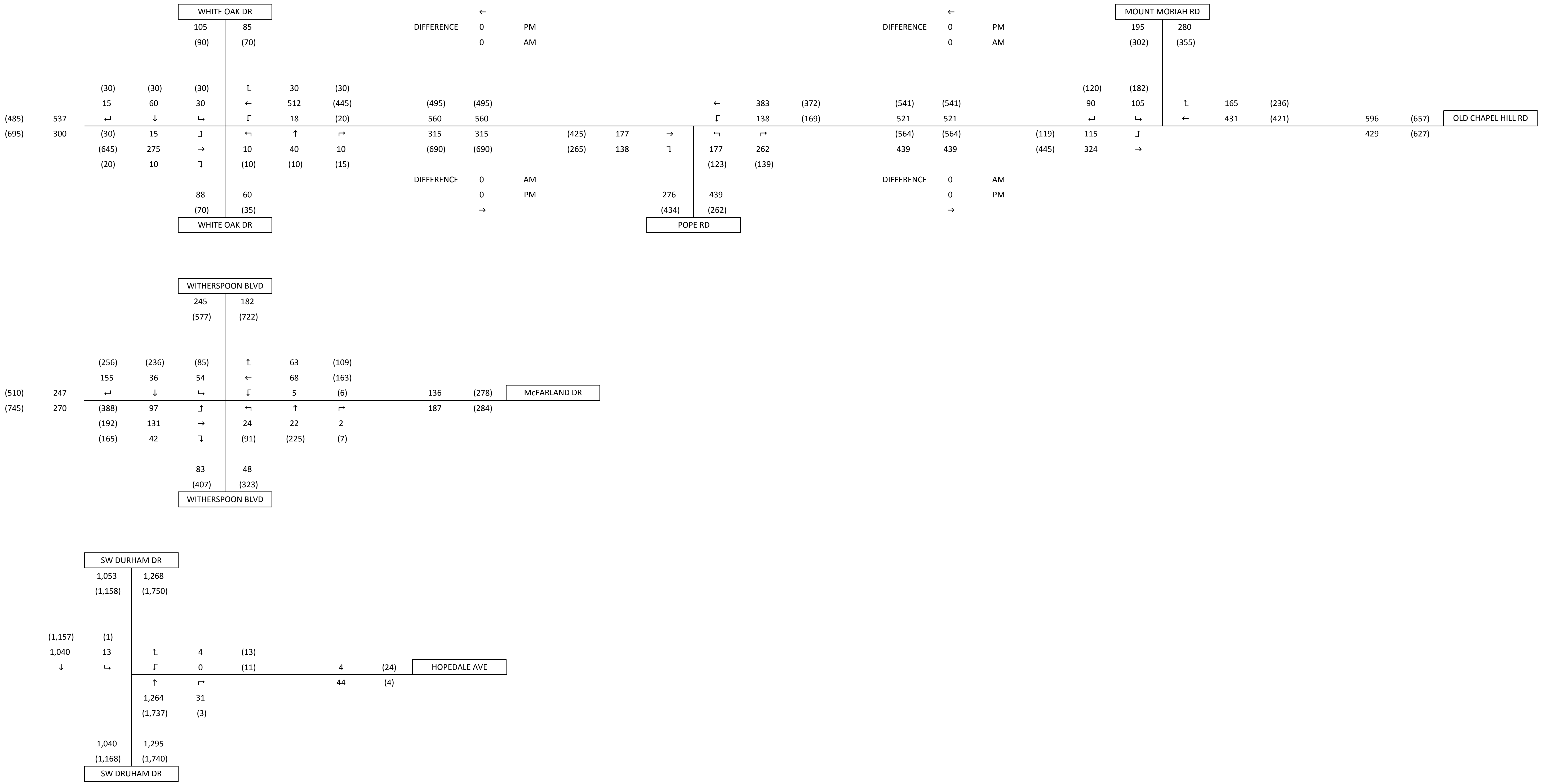
Appendix D
Balanced Peak Hour Volumes

2011 Base Year AM
2011 Base Year PM
2040 No-Build AM
2040 No-Build PM
2040 Build AM
2040 Build PM

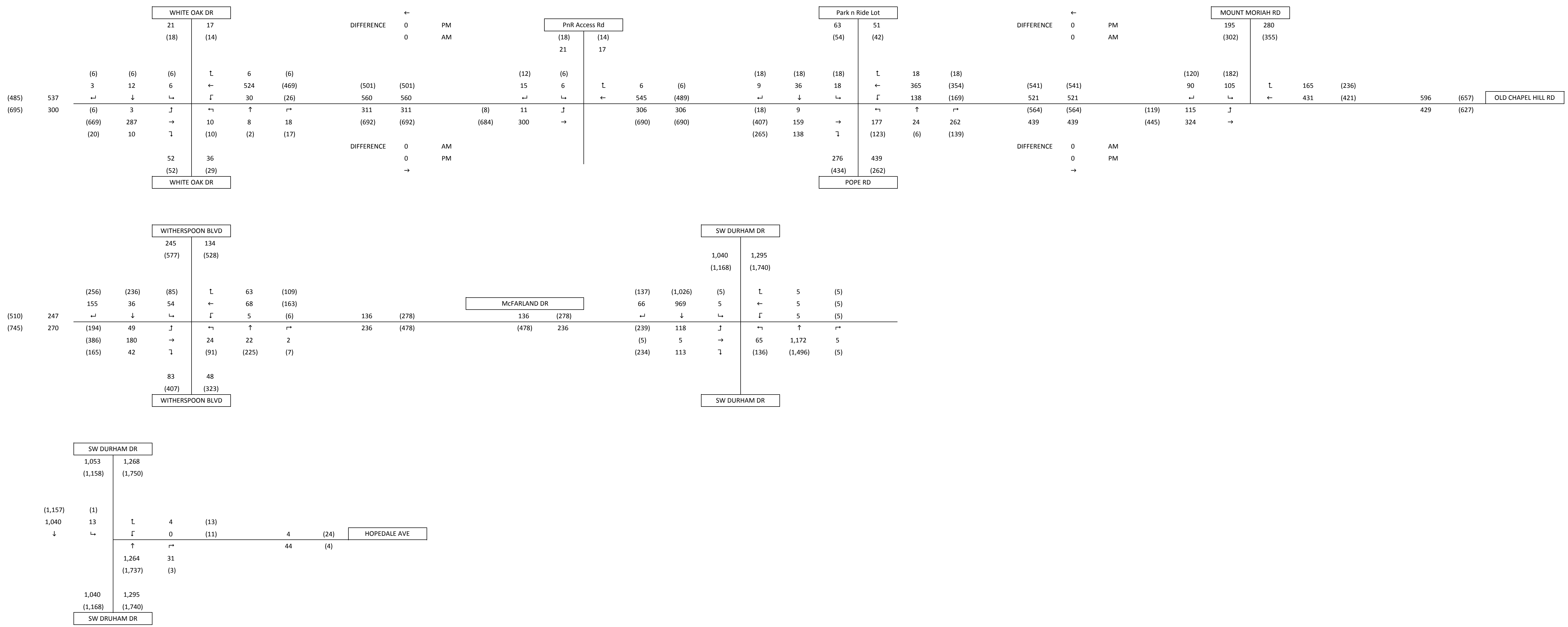
2011 Existing Balanced Volumes



2040 No Build / TSM Scenario Balanced Volumes



2040 Build Scenario Balanced Volumes



Appendix E
2040 Synchro Outputs

2040 No-Build AM
2040 No-Build PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	15	275	10	18	512	30	10	40	10	30	60	15
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	17	306	11	20	569	33	11	44	11	33	67	17
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)									2			
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	602			317			1020	987	311	998	976	586
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	602			317			1020	987	311	998	976	586
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	98			98			93	81	98	82	73	97
cM capacity (veh/h)	975			1243			160	239	729	183	243	510

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	333	622	67	117
Volume Left	17	20	11	33
Volume Right	11	33	11	17
cSH	975	1243	268	239
Volume to Capacity	0.02	0.02	0.25	0.49
Queue Length 95th (ft)	1	1	24	62
Control Delay (s)	0.6	0.4	23.6	33.7
Lane LOS	A	A	C	D
Approach Delay (s)	0.6	0.4	23.6	33.7
Approach LOS			C	D

Intersection Summary			
Average Delay	5.3		
Intersection Capacity Utilization	56.1%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	177	138	138	383	0	177	0	262	0	0	0
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	0	197	153	153	426	0	197	0	291	0	0	0
Approach Volume (veh/h)		350			579			488			0	
Crossing Volume (veh/h)		153			197			197			776	
High Capacity (veh/h)		1228			1187			1187			748	
High v/c (veh/h)		0.28			0.49			0.41			0.00	
Low Capacity (veh/h)		1019			982			982			591	
Low v/c (veh/h)		0.34			0.59			0.50			0.00	

Intersection Summary			
Maximum v/c High	0.49		
Maximum v/c Low	0.59		
Intersection Capacity Utilization	85.4%	ICU Level of Service	E

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Right Turn Channelized						
Volume (veh/h)	115	324	431	165	105	90
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	128	360	479	183	117	100
Approach Volume (veh/h)		488	662		217	
Crossing Volume (veh/h)		117	128		479	
High Capacity (veh/h)		1264	1253		949	
High v/c (veh/h)		0.39	0.53		0.23	
Low Capacity (veh/h)		1052	1042		769	
Low v/c (veh/h)		0.46	0.64		0.28	

Intersection Summary			
Maximum v/c High	0.53		
Maximum v/c Low	0.64		
Intersection Capacity Utilization	81.2%	ICU Level of Service	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	97	131	42	5	68	63	24	22	2	54	36	155
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	108	146	47	6	76	70	27	24	2	60	40	172
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	432	326	126	358	411	26	212			27		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	432	326	126	358	411	26	212			27		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	74	74	95	99	85	93	98			96		
cM capacity (veh/h)	422	559	924	434	501	1050	1358			1587		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	300	151	27	27	60	212
Volume Left	108	6	27	0	60	0
Volume Right	47	70	0	2	0	172
cSH	530	656	1358	1700	1587	1700
Volume to Capacity	0.57	0.23	0.02	0.02	0.04	0.12
Queue Length 95th (ft)	87	22	2	0	3	0
Control Delay (s)	20.3	12.1	7.7	0.0	7.4	0.0
Lane LOS	C	B	A		A	
Approach Delay (s)	20.3	12.1	3.9		1.6	
Approach LOS	C	B				

Intersection Summary			
Average Delay	11.0		
Intersection Capacity Utilization	52.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	13	1040	1264	31	0	4
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	14	1156	1404	34	0	4
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1439				2028	719
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1439				2028	719
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	97				100	99
cM capacity (veh/h)	468				48	371

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	SB 1
Volume Total	14	578	578	936	503	4
Volume Left	14	0	0	0	0	0
Volume Right	0	0	0	0	34	4
cSH	468	1700	1700	1700	1700	371
Volume to Capacity	0.03	0.34	0.34	0.55	0.30	0.01
Queue Length 95th (ft)	2	0	0	0	0	1
Control Delay (s)	12.9	0.0	0.0	0.0	0.0	14.8
Lane LOS	B					B
Approach Delay (s)	0.2			0.0		14.8
Approach LOS						B

Intersection Summary			
Average Delay	0.1		
Intersection Capacity Utilization	47.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	30	645	20	20	445	30	10	10	15	30	30	30
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	33	717	22	22	494	33	11	11	17	33	33	33
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)									2			
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	528			739			1400	1367	728	1364	1361	511
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	528			739			1400	1367	728	1364	1361	511
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	97			97			87	92	96	69	76	94
cM capacity (veh/h)	1039			867			87	139	424	108	140	563

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	772	550	39	100
Volume Left	33	22	11	33
Volume Right	22	33	17	33
cSH	1039	867	197	165
Volume to Capacity	0.03	0.03	0.20	0.61
Queue Length 95th (ft)	2	2	18	82
Control Delay (s)	0.8	0.7	31.4	55.9
Lane LOS	A	A	D	F
Approach Delay (s)	0.8	0.7	31.4	55.9
Approach LOS			D	F

Intersection Summary			
Average Delay	5.4		
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	425	265	169	372	0	123	0	139	0	0	0
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	0	472	294	188	413	0	137	0	154	0	0	0
Approach Volume (veh/h)		767			601			291			0	
Crossing Volume (veh/h)		188			137			472			738	
High Capacity (veh/h)		1196			1244			954			771	
High v/c (veh/h)		0.64			0.48			0.31			0.00	
Low Capacity (veh/h)		989			1034			773			611	
Low v/c (veh/h)		0.77			0.58			0.38			0.00	

Intersection Summary			
Maximum v/c High	0.64		
Maximum v/c Low	0.77		
Intersection Capacity Utilization	97.4%	ICU Level of Service	F

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Right Turn Channelized						
Volume (veh/h)	119	445	421	236	182	120
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	132	494	468	262	202	133
Approach Volume (veh/h)		627	730		336	
Crossing Volume (veh/h)		202	132		468	
High Capacity (veh/h)		1182	1249		958	
High v/c (veh/h)		0.53	0.58		0.35	
Low Capacity (veh/h)		977	1038		776	
Low v/c (veh/h)		0.64	0.70		0.43	

Intersection Summary			
Maximum v/c High	0.58		
Maximum v/c Low	0.70		
Intersection Capacity Utilization	98.6%	ICU Level of Service	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	388	192	165	6	163	109	91	225	7	8	23	25
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	431	213	183	7	181	121	101	250	8	9	26	28
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	721	517	39	789	527	254	53			258		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	721	517	39	789	527	254	53			258		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	0	50	82	95	57	85	93			99		
cM capacity (veh/h)	183	429	1032	147	424	785	1552			1307		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	828	309	101	258	9	53
Volume Left	431	7	101	0	9	0
Volume Right	183	121	0	8	0	28
cSH	273	492	1552	1700	1307	1700
Volume to Capacity	3.03	0.63	0.07	0.15	0.01	0.03
Queue Length 95th (ft)	Err	106	5	0	1	0
Control Delay (s)	Err	23.8	7.5	0.0	7.8	0.0
Lane LOS	F	C	A		A	
Approach Delay (s)	Err	23.8	2.1		1.1	
Approach LOS	F	C				

Intersection Summary			
Average Delay	5318.6		
Intersection Capacity Utilization	83.3%	ICU Level of Service	E
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	1	1157	1737	3	11	13
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	1	1286	1930	3	12	14
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1933				2577	967
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1933				2577	967
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				41	94
cM capacity (veh/h)	300				21	254

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	SB 1
Volume Total	1	643	643	1287	647	27
Volume Left	1	0	0	0	0	12
Volume Right	0	0	0	0	3	14
cSH	300	1700	1700	1700	1700	42
Volume to Capacity	0.00	0.38	0.38	0.76	0.38	0.64
Queue Length 95th (ft)	0	0	0	0	0	59
Control Delay (s)	17.0	0.0	0.0	0.0	0.0	188.8
Lane LOS	C					F
Approach Delay (s)	0.0			0.0		188.8
Approach LOS						F

Intersection Summary			
Average Delay	1.6		
Intersection Capacity Utilization	60.8%	ICU Level of Service	B
Analysis Period (min)	15		