Monroe Connector/Bypass
(R-3329/R-2559)

Indirect and Cumulative Effects Quantitative Analysis Update

Prepared for the North Carolina Turnpike Authority

A Division of North Carolina Department of Transportation

Prepared by Michael Baker Engineering, Inc.

Michael Baker Engineering, Inc.
8000 Regency Parkway
Suite 600
Cary, North Carolina 27518
Phone: 919.463.5488
Fax: 919.463.5490

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EXECUTIVE SUMMARY

E.1 Why Was This Report Developed?

The North Carolina Department of Transportation (NCDOT) and the Federal Highway Administration (FHWA) developed this report to update the indirect and cumulative effects analysis for the Monroe Connector/Bypass (the project). The FHWA rescinded its Record of Decision (ROD) for the project on July 3, 2012. This action was in response to the decision of the United States Court of Appeals for the Fourth Circuit to vacate the United States District Court decision in *NC Wildlife Federation v NCDOT* and remand the decision for further review and analysis by the agencies.[1]

Since that time, the NCDOT and the FHWA have conducted additional research, investigation and analysis on the potential indirect and cumulative effects on land use and water quality in the project area. The NCDOT and the FHWA published this report to update the quantitative indirect and cumulative effects analysis for Land Use (Quantitative ICE) and to determine whether a quantitative indirect and cumulative effects water quality analysis (WQA) included in the Final Environmental Impact Statement (FEIS) as Appendix H remains appropriate.

What Did We Do to Update the Quantitative ICE?

The scope of the work for the update of the quantitative ICE generally included the following activities.

1. We reviewed conditions and trends in the study area and updated the baseline land use data (Sections 1.0 and 2.0)
2. We reviewed the regional travel demand model socioeconomic projections, developed for the Mecklenburg-Union Metropolitan Planning Organization (MUMPO), including how other studies have used the projections, and determined the most appropriate data set for the ICE analysis of future land use (Section 3.0)
3. We developed the future No-Build and Build land use scenarios and thoroughly explained the methods used to estimate induced growth (Section 4.0)
4. We reported revised induced growth results and conclusions based on the updated land use scenarios (Section 5.0)
5. We review measures that localities and others could adopt to minimize any impacts of future development, whether induced or not, on sensitive environmental resources (Section 6.0).

This report summarizes the conclusions reached in the evaluation of ICE and describes the data collected, methodologies used and analysis conducted for the ICE for the project. This document also re-evaluates and considers data, analytical research relevant to the project area, and new information relevant to the analysis of the indirect and cumulative effect on land use, water quality, and federally designated threatened and endangered species and their critical habitat in the surrounding area. Since the Carolina heelsplitter (federally protected freshwater mussel) lives in two watersheds in the study area, water quality is a major focus area of this analysis. Thus, we report results for both the overall study area and at the watershed level.

How Did We Update the Study Area Land Use Data?

In reviewing conditions in the study area, the study team analyzed the following:

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[1] NC Wildlife Federation v NCDOT, US Court of Appeals for the 4th Circuit, May 3, 2012, p 15

- We conducted new interviews with local planners
- We incorporated the 2010 Census and reviewed and analyzed growth trends and conditions in the study area
- We identified and incorporated new, reasonably foreseeable proposed or approved development activity
- We reviewed new planning documents (such as new land use plans and new capital improvement plans) and identified differences in future growth plans and related infrastructure.

The additional research found some changes in existing land uses and some updates to future expectations of land use change and development. Overall, the evidence strongly indicates that Union County has a history of relatively fast growth and continues to exhibit factors that would continue to encourage growth rates that exceed the regional average regardless of whether the proposed project is completed.

E.2 How Was Existing Land Use Modeled for this Study?

Existing land use was modeled using a combination of parcel-level GIS data from Mecklenburg and Union Counties, raster (image) format GIS data describing undeveloped land cover and a cross check against aerial imagery (as described in Section 2). These sources were combined to model the land uses in the study area in a land cover raster image. Given the age of various data sources available, the most recent date to which the existing land use could be reasonably updated is 2010.

E.3 How Did We Estimate Future Growth?

Several different agencies and organizations forecast or project growth in North Carolina to the county level. Federal law requires every MPO to estimate the long-term travel needs of their respective regions in their Metropolitan Transportation Plans (MTP). Most MPOs must also assess the air quality impacts of their MTPs for compliance with the Clean Air Act. Thus, MPOs develop future demographic projections (including employment and households) for small geographic units called traffic analysis zones (TAZs). These projections typically consider projections from other state and federal agencies and private organizations. As noted above, the Quantitative ICE analysis requires a data source that enables future projection of land use at a detailed geographic level. Since the MPOs projection process and future projections have been determined to be acceptable for complying with the Clean Air Act and other federal regulations, which includes a public review process, we consider them the best available and reasonable source for estimating future growth in the context of this ICE analysis. Furthermore, as described below, we conducted an in-depth review of the MPO projection process, the data origins and assumptions, and as necessary, tested assumptions regarding the Monroe Connector/Bypass in order to fully understand the appropriate use of the data.

E.4 How Were the MPO Socioeconomic Projections Developed?

MUMPO developed its latest projections in 2009 for use in its most recent (2035) Long-Range Transportation Plan (LRTP). These projections were developed using a spreadsheet workbook based model called a Land Use Allocation Model (LUSAM). The LUSAM model relied, in turn, on previous projections developed in 2005, by MUMPO and its regional partners at other surrounding MPOs and Rural Planning Organizations (RPOs). Those projections supported the 2030 LRTP.

The 2005 Projections (which were used in the 2030 LRTP) were developed through a process with three main components, a Top-Down projection, a Bottom-Up projection and input from an advisory group on the final projections. The development of the TAZ-level projections relied first on the Top-Down process to project future growth at the regional level and then allocate the regional growth to the county level. Dr. Thomas Hammer conducted the Top-Down analysis and his report, *Demographic and Economic Forecasts for the Charlotte Region* (Appendix H), documents his methodology and results. Dr. Hammer used a highly detailed, employment and earnings based model to estimate regional growth and then allocated that growth to counties based on detailed statistical relationships based on his research into 227 other counties in 29 other metropolitan areas across the eastern US.

A subsequent Bottom-Up process allocated the county-level growth to the TAZ level within each county. Different parts of the Metrolina region used different approaches to the Bottom-Up process, but for the MUMPO area, which included most of Union County, a process prepared by Paul Smith of UNC-Charlotte provided the initial allocation. Mr. Smith's report *Mecklenburg-Union Metropolitan Planning Organization Population Projections and Employment Allocations, 2000-2030* (Appendix I) documents his methodology and results. Mr. Smith's process focused on the household (and by default population) allocation and the allocation of population-chasing employment. Population-chasing employment is that employment associated with retail and services that tend to follow population growth. Non-population-chasing employment was distributed solely based on the input of staff and expert panel participants. Mr. Smith's allocation process started with the county-level control totals developed in the Top-Down process, existing baseline data (2000), and the influence of the of land development factors chosen and ranked by expert panels. Within Union County, there were eight land development factors used to assess the attractiveness and capacity of each TAZ in the county to draw future growth. As was the case with the Top-Down projections, the Bottom-Up steps used input from local planners and jurisdictional representatives to review and refine the projections prior to adoption.

Review of Metrolina Socioeconomic Projection Versions

We reviewed and analyzed the Metrolina Regional Travel Demand Model (MRM) Socioeconomic Projections and assessed them for use in the ICE analysis. The review included an assessment of the following factors.

1. We reviewed the various socioeconomic projection versions developed by the MPO and the assumptions upon which they rely.
2. We analyzed the specific methodology used with the Travel Time to Employment factor in the allocation of growth within Union County.
3. We re-evaluated the Travel Time to Employment factor where the Monroe Bypass/Connector was removed from the analysis.
4. We assessed other studies that have used or analyzed the MPO projections and the conclusions they have drawn about those projections and from those projections.

From 2003 to 2009, the Charlotte Department of Transportation (CDOT), the official custodian of the MRM, in cooperation with the Mecklenburg Union MPO (MUMPO) and other MPOs and Rural Planning Organizations (RPOs) in the region, developed various socioeconomic projections to input into the MRM in support of the MPO LRTP development. Table ES-1 summarizes these various projections and shows a timeline of the development of these projections.

We used the 2009 Projections for this Quantitative ICE analysis because MUMPO used this data set with its most recent transportation planning approvals and the June 2013 update of its LRTP. Although MUMPO is currently working on a new set of socioeconomic projections to support its 2040 LRTP, those projections are not anticipated to be complete or fully approved nor accepted for transportation conformity purposes until May, 2014 and therefore would be inappropriate to use in this analysis.

Table ES-1: MRM Socioeconomic Projections Versions

Projections Name	TAZ File Name	Projections Completed	Use for LRTP Conformity Determination	Associated Model Version	Base and Horizon Years
2009 Projections	SE_*Year*_091028	October 2009	MUMPO 2035 LRTP	MRM 09 v1.0 MRM 11 v1.0 MRM 11 v1.1	Base: 2005 Horizon: 2015, 2025, 2035
2008 Interim Projections	SE_*Year*_081119_ MUMPO_interim	November 2008		None	Base: 2005 Horizon: 2015, 2025, 2035
2008 Projections	SE_*Year*_081024	October 2008	RFATS 2035 LRTP	MRM 08 v1.0	Base: 2005 Horizon: 2015, 2025, 2035
2005 Projections	SE_*Year*_taz2934	May 2005	MUMPO 2030 LRTP	MRM 05 v1.0 MRM 06 v1.0 MRM 06 v1.1	Base: 2000 Horizon:2010, 2020, 2030

The 2009 Projections used a spreadsheet workbook modeling process (called the Land Use Allocation Model or LUSAM) that included a number of variables. A detailed analysis of those factors showed that none of the factors used to develop the projections were affected by the proposed project. In particular, the study team worked with CDOT and Paul Smith to reanalyze the Travel Time to Employment Factor used in the Bottom Up allocation process of the 2005 Projections which were used for the 2030 LRTP and which substantially provided the basis for the 2009 Projections. When Mr. Smith ran his original land use allocation models in 2004, his roadway network for his Travel Time to Employment Factor included the proposed project. When Mr. Smith reran his allocation models in July 2012, without the proposed project in his roadway network for that factor, the results were exactly the same as the original results.

Did the Monroe Connector/Bypass Influence the MPO Projections?

A detailed assessment of the MRM socioeconomic projections (see Section 3.2) reveals the following regarding the influence of the Monroe Connector/Bypass on the 2009 Projections:

- The proposed project did not affect the Travel Time to Core Employment factor in the LUSAM process, as this factor had zero weight for all districts for all LUSAM runs.[2]
- The proposed project did not affect the Planners' Judgment factor in the LUSAM process, as this factor had zero weight for all districts in Union County for all LUSAM runs.
- The proposed project was included in the Travel Time to Employment factor used by Paul Smith in developing the 2005 Projections, but a reassessment of that factor without the proposed project (as discussed in Section 3.2) shows that the project had no influence on the projection results.

[2] See Section 3.2 and Appendix A (CDOT Staff Communications) for detail on the LUSAM process and the reasoning for giving the Travel Time to Core Employment a weight of zero.

- The proposed project did not affect Dr. Hammer's projections of households and employment that were used in the 2005 Projections for county level control totals and were used in the 2008 Interim and 2009 Projections for developing the district level targets.
- There is no evidence or indication that any other factor in the LUSAM process or the other projection processes was influenced by the proposed project, and communications with CDOT and Union County planning staff indicate that the proposed project was not a consideration in development of the projections.
- A review of the distribution of projected households and employment relative to the proposed project location shows no signs that the proposed project influenced the projections.

Our analysis shows that the various models used to develop the MRM socioeconomic projections are insensitive to the presence or absence of the proposed project. We determined the methodology used by CDOT and MUMPO to develop the socioeconomic projections is effectively insensitive to any potential induced land use effects associated with the Monroe Bypass/Connector. Dr. Hammer states that he made specific adjustments to his projections for two large roadway projects (NC 16 in Lincoln County and the Garden Parkway but not the Monroe Connector/Bypass) in the Top-Down process that was used to develop total population and employment estimates. As the sensitivity analysis of Paul Smith's Travel Time to Employment Factor showed, the proposed project made no difference in the Bottom-Up allocation process. If our ICE analysis were to follow the exact same methodology used by MUMPO to calculate induced growth impacts of the Monroe Connector/Bypass then the result would be to find no induced growth, since the methodology would be blind to the accessibility impacts of the project. Therefore, we used other methodologies to estimate potential induced growth and induced land use changes associated with the proposed project as described in Section 4.

Are There Other Information Sources that Agree with the Assessment of the MPO Forecasts?

The North Carolina Turnpike Authority (NCTA) hired Wilbur Smith Associates (WSA) to conduct a preliminary and then final comprehensive traffic and revenue study for the proposed project. WSA, in consultation with NCTA, hired the Kenan Institute of Private Enterprise at the University of North Carolina's Kenan-Flagler Business School (Kenan Institute) in 2009 to develop a set of TAZ-level socioeconomic projections specifically for the project's Comprehensive Traffic and Revenue Study. The Kenan Institute reviewed the 2008 Interim Projections and made two adjustments to MUMPO's socioeconomic estimates. "The first was to make region-wide adjustments consistent with the national growth expectations (the 2008 economic adjustment). The second was to reallocate growth in Union County in line with development factors and constraints".[3]

Looking within the project corridor, the Kenan Institute accepted the allocation of growth by the MPO in Mecklenburg County. However, it reallocated the projected population growth within Union County away from the line of high growth in the southwest quadrant of the county to the Connector/Bypass corridor because of the project. The Kenan Institute also reallocated a portion of the expansion in several high growth TAZs in the northeastern quadrant of the county towards the corridor. The Kenan Institute made these adjustments based on results of interviews with local planners, analysis of growth trends in the area,

[3] Appendix K p 29

and analysis of water and sewer demand and capacity in the area. Our analysis of the Kenan Institute adjustments to MUMPO's projections showed that the Kenan Institute reallocated about 1,800 households or about 3 percent of Union County growth towards the project corridor. Further analysis of the Kenan Institute adjustments to 2008 Interim Projections showed that the reallocation of growth was similar to the growth patterns in the DEIS Qualitative ICE.

How Did the Quantitative ICE Use the MPO Projections?

The preceding analysis of the MPO socioeconomic projections leads to the conclusion that, if we used MUMPO's land use models to evaluate future changes between the No-Build and Build scenarios, we would find no difference between the two. The conclusions of the Qualitative ICE and research into local expectations suggest that it is unlikely that there would be absolutely no difference in land use development conditions in the study area between a No-Build and Build Scenario. Therefore, we conducted an induced growth analysis to account for the potential environmental impacts of these potential land use changes. In our analysis of potential induced land use changes, we used the MPO socioeconomic projections as control totals along with local land use plans and other regulations, to develop a scenario without the project (hereafter referred to as the No-Build Scenario). We estimated the potential induced growth and induced land use changes associated with the proposed project and added that estimated induced growth to the No-Build land use scenario to create a new scenario that represents future conditions with the project and its growth-inducing impacts (i.e. the Build Scenario). This methodology was originally developed in consultation with the resource agencies and did not reallocate growth within the FLUSA, and is thus considered conservative in nature in that it might overestimate cumulative impacts since we did not reallocate growth between the No-Build and Build scenarios.

A reallocation approach might have resulted in shifting growth eastward in the study area by taking expected growth from the areas of northwestern and central Union County and shifting it eastward toward Wingate. This approach might have been reasonable as areas of eastern Union County will be relatively more accessible under a Build Scenario due to reduced travel times and therefore some growth that would have occurred in northwestern or central Union County under a No-Build Scenario would instead occur in eastern Union County. To err on the side of overestimating cumulative impacts, an additive approach was used where growth was added, over and above the No-Build Scenario, to create the Build Scenario without reallocation.

E.5 How Was Induced Growth Estimated?

We developed the No-Build Scenario using local zoning and land use plans to determine the total build-out capacity of the study area and then using the MPO projections as a control total (total population and total employment for the study area) for determining how much of that capacity would actually develop by 2030 (See Section 4.1 for details).

We developed the Build Scenario using a combination of the four analytical techniques.

1. We used a scenario writing approach to identify areas most likely to see induced growth based on planning information and interviews.
2. We conducted a build-out analysis to see which areas had the most capacity for induced growth.
3. We completed an accessibility analysis to see which areas would most benefit from the proposed project and thus be most likely to see induced growth.
4. We used a Hartgen Analysis to estimate potential commercial growth at interchange areas.

We combined these methods to estimate the likely induced development within the FLUSA and this induced development was then added to the No-Build Scenario to create a Build Scenario (See Section 4.2 for details). The accessibility analysis used to help determine land use effects associated with the project was based on the assumption of a “free” high-speed roadway. Since NCDOT intends to implement the project as a toll road or “priced” facility, it is possible that our results will represent a high range or conservative estimate of effects. A logical conclusion is that a toll captures some of the value that drivers’ gain in shorter travel times and therefore the accessibility improvements of new, tolled facilities are less likely to encourage induced land use changes than a free facility might. Nevertheless, there is insufficient research on induced land use changes associated with tolled facilities to estimate how much tolling would reduce potential induced land use changes. Therefore, we have not adjusted our estimates to account for that factor.

In the research conducted for this ICE, two noteworthy proposals surfaced that the study team specifically considered for how those proposals might need to be addressed in the future land use scenarios. The study team investigated the proposed industrial park in eastern Union County, called Legacy Park. Based on interviews with Union County officials, CSX staff and researchers familiar with the proposal, the study team determined that the proposal was not reasonably foreseeable at this time and did not include any portion of the proposal in any future land use scenario (see Section 4.2 for details). Additionally, the study team reviewed the draft US 74 Revitalization Study and its recommendations for their potential impact to future land use scenarios. Since the study is still draft and has not been adopted and since the land use and other recommendations would result in minimal changes to the land use scenario results, the study team determined it was not reasonably foreseeable to incorporate the draft plan recommendations into any future land use scenario.

E.6 What Are the Results of the Updated ICE Analysis?

The following section outlines the updated results from the three updated scenarios, the 2010 Existing (Baseline), the 2030 No-Build, and the 2030 Build scenario. As with any attempt to project the future, the accuracy of these results for future years is problematic as the typical error range for long-range forecasting of households and employment is upward of 25 percent (see Section 3.5 for details). Thus, one should interpret the future year results as the best estimate within a wide range of potential error. Table ES-2 shows the results of all updated land use scenarios. Map 3 illustrates the updates to the 2010 Baseline Land Use. Map 16 illustrates the results of the updated No-Build Scenario. Map 17 illustrates the results of the updated Build Scenario.

Table ES-2: Updated Land Use Scenario Results

Land Use	Updated Baseline (2010)		Updated 2030 No-Build			Updated 2030 Build		
	Total Area (acres)	% of Total Area	Total Area (acres)	% of Total Area	Change in % from Baseline	Total Area (acres)	% of Total Area	Change in % from No-Build
Total Residential	71,500	35%	97,900	48%	13%	99,700	49%	1%
Low Density	*55,600*	*28%*	*79,500*	*40%*	*12%*	*80,600*	*40%*	*0%*
Medium Density	*12,900*	*6%*	*14,900*	*7%*	*1%*	*15,600*	*8%*	*1%*
High Density	*3,100*	*2%*	*3,500*	*2%*	*0%*	*3,500*	*2%*	*0%*
Commercial	3,900	2%	5,600	3%	1%	5,900	3%	0%
Industrial/Office/Institutional	7,100	4%	8,700	4%	1%	8,800	4%	0%
Transportation	12,700	6%	12,800	6%	0%	13,900	7%	1%
Total Developed	**95,200**	**47%**	**125,000**	**62%**	15%	**128,200**	**63%**	**2%**
Total Agricultural	**52,900**	**26%**	**37,500**	**19%**	-8%	**35,500**	**18%**	**-1%**
Total Forested	**51,900**	**26%**	**37,700**	**19%**	-7%	**36,500**	**18%**	**-1%**
Total Other	**1,900**	**1%**	**1,800**	**1%**	0%	1,800	1%	**0%**
TOTAL	**202,000**	**100%**	**202,000**	**100%**	0%	**202,000**	**100%**	**0%**

Notes: Results have been rounded to the nearest 100 acres and whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

We calculated impervious surface based on the National Resource Conservation Service (NRCS) (formally the Soil Conservation Service) TR-55 Manual guidance for impervious surface levels by land use category. We compared the impervious surface results to the results of the prior Quantitative ICE analysis to determine whether additional water quality modeling might be needed. Given how similar the updated results are, there appears to be little need for additional water quality modeling. The results for the Baseline, No-Build and Build Scenarios compared to the prior results are shown in Tables ES-3.

Table ES-3: Percent Impervious Cover Results from 2010 Report Compared to 2013 Report

	Impervious Cover Results from 2010 Report				Impervious Cover Results from 2013 Report				Difference in Change in Build from No-Build between 2010 Report and 2013 Report
Watershed Name	2007 Baseline	2030 No-Build	2030 Build	Change in Build from No-Build	2010 Baseline Updated	2030 No Build Updated	2030 Build Updated	Change in Build from No-Build	
Study Area	18%	22%	22%	0%	18%	22%	23%	1%	1%
Beaverdam Creek	6%	7%	7%	0%	6%	7%	7%	0%	0%
Richardson Creek (Upper)	14%	18%	18%	0%	14%	18%	18%	0%	0%
Rays Fork	12%	16%	17%	1%	12%	16%	17%	1%	0%
Bearskin Creek	24%	31%	31%	0%	24%	31%	31%	0%	0%
Richardson Creek (Middle)	23%	27%	29%	2%	23%	27%	30%	3%	1%
Gourdvine Creek	6%	8%	8%	0%	6%	8%	8%	0%	0%
Salem Creek	9%	13%	14%	1%	9%	13%	16%	3%	2%
Sixmile Creek	25%	30%	30%	0%	26%	31%	31%	0%	0%
Twelvemile Creek	22%	25%	25%	0%	22%	25%	25%	0%	0%
Richardson Creek (Lower)	10%	15%	16%	1%	10%	15%	17%	2%	1%
Stewarts Creek	15%	20%	22%	2%	15%	21%	23%	2%	0%
Fourmile Creek	32%	34%	34%	0%	32%	35%	35%	0%	0%
Crooked Creek	21%	25%	27%	2%	22%	26%	28%	2%	0%
Goose Creek	13%	17%	17%	0%	13%	18%	18%	0%	0%
Irvins Creek	35%	37%	37%	0%	35%	38%	38%	0%	0%
McAlpine Creek	36%	37%	37%	0%	36%	38%	38%	0%	0%
Bakers Branch	6%	8%	8%	0%	5%	8%	8%	0%	0%
Wide Mouth Branch	10%	12%	12%	0%	10%	12%	12%	0%	0%

Notes: Results have been rounded to the nearest one whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

E.7 What Are the Impacts Associated with the Results of the Analysis?

Indirect Impacts to Land Use and Impervious Surface

Land Use Impacts

All changes in land use within the entire study area from the Baseline to the Build are within two percent (i.e., between negative one percent and one percent) of the change that is predicted for the 2030 No-Build. Additional development (including direct and indirect effects) estimated to occur under the 2030 Build Scenario totals approximately 3,400 acres more, about 2 percent more than the total development expected under the 2030 No-Build. The indirect land use effects are modest, totaling about 2,300 acres of additional development, an increase of less than 2 percent over the No-Build and an increase in development of about 1 percent of the total land area within the study area. Incremental effects to agricultural and forested lands are a reduction of 2,000 and 1,200 acres respectively as a result of the additional developed land. The 2030 No-Build shows a 29 percent reduction in agricultural land compared to the 2010 Baseline, whereas the 2030 Build shows a 33 percent reduction. The 2030 No-

Build shows a 27 percent reduction in forested land compared to the 2010 Baseline, whereas the 2030 Build shows a 30 percent reduction. For both forested and agricultural land uses, the decrease equals a change of less than one percent of total land. Overall, while there are sizeable reductions in agricultural and forested lands, the indirect impacts are small and the cumulative impacts are minimal as the small additional loss does not create a substantial overall impact. It is likely that some portion of the household increase would shift within the study area and the remainder would shift from elsewhere in the greater metropolitan area. However, in an effort to estimate the environmental impacts for each watershed without underestimating them, no portion of this induced household growth has been subtracted from elsewhere in the study area.

Impervious Surface Impacts

Findings show the incremental effect of the 2030 Build Scenario will be a one percent increase in impervious surface throughout the study area as compared to the change predicted for the 2030 No-Build Scenario. This results in approximately 2,000 additional acres of impervious surface. With the 2030 Build Scenario, increases in percent impervious surface as compared to the change predicted for the 2030 No-Build are found in six of the 18 watersheds. These increases are between one and three percent. There is no difference in impervious surface resulting from direct or indirect effects in the Goose Creek or Sixmile Creek watersheds between the 2030 No-Build and 2030 Build scenarios.

Cumulative Impacts to Water Quality

As stated above, there are small differences in impervious surfaces associated with six of the 18 watersheds in the FLUSA. It is not anticipated that these, minor changes would alter the results of the previous water quality Quantitative ICE, as they are within the standard error of such analyses. For this reason, additional water quality modeling is not required.

Cumulative Impacts to Endangered Species

No measureable differences in impervious surface were found between the 2030 No-Build and 2030 Build within the Goose Creek or Sixmile Creek watersheds. Therefore, no indirect effects are anticipated on the species associated with the Monroe Connector/Bypass project. As there are no indirect effects anticipated, the project does not contribute an incremental effect that would yield potential cumulative effects. Potential direct effects are not anticipated, and are addressed in the Biological Assessment (BA) for the species. For the 2030 Build, findings indicate a four percent greater decrease of land exhibiting habitat characteristics that might support the Schweinitz's sunflower as compared to the change predicted for the 2030 No-Build based on results of this study. These reductions are likely an overestimate as the land categories included do not constitute actual habitat for the species and there will remain substantial areas available for species habitat under both No-Build and Build Scenarios. Therefore, no ICEs to the sunflower are expected. The BA provides more detail on direct and potential indirect and cumulative impacts.

Cumulative Impacts to Land Use and Farmland

The 2030 Build is predicted to have one percent additional conversion of land to development as compared to the conversion predicted with the No-Build scenario. The composition of the development is different between the Build and the No-Build scenarios. With the 2030 Build, there is more Low Density and Medium Density Residential, Commercial, and Industrial/Office/Institutional growth. The 2030 Build is predicted to convert 2,100 additional acres of agricultural land to low density residential or other developed uses. This represents one percent greater conversion than that predicted with the No-Build scenario for farmlands in the study area. While the raw decrease in farmland acreage seems sizeable, the vast majority of farmland loss will occur with or without the project. Therefore, the modest additional loss caused by the project does not constitute a cumulative effect.

Cumulative Impacts to Wildlife Habitat

Total Habitat Impacts

The 2030 Build is predicted to convert approximately three percent more undeveloped vegetated land in the study area as compared to that predicted for the No-Build scenario. These conversions are mostly concentrated in Salem Creek and Richardson Creek – Lower, with some lesser amounts scattered among Richardson Creek – Middle, Stewarts Creek and Crooked Creek. The incremental losses represent a maximum of 9 to 12 percent additional loss relative to the Baseline conditions for the three most affected watersheds.

Forest Fragmentation Impacts

The forest fragmentation analysis indicates that indirect impacts will be modest but that cumulative effects may be more substantial. Nevertheless, most of the cumulative effects are likely to occur with or without the proposed project.

Indirect and Cumulative Impacts to Traffic

Traffic levels with and without the induced land use impacts of the Monroe Connector were calculated to test the order-of-magnitude impact of induced land use on travel and congestion. Overall, these forecasted traffic levels indicate that the growth-induced impacts of the proposed project will add to the total volume of traffic in Union County and to the total vehicle miles traveled and vehicle hours traveled within the county, but the overall regional change in VMT is just one percent. Roads that connect to the Monroe Connector/Bypass will likely see some increases in traffic. Overall, however, the increases in traffic are modest and would not likely create substantial congestion issues within the design year of the project. In addition, under the Build Scenario, 2030 traffic on US 74 would decrease by approximately 20 percent relative to the No-Build Scenario with the induced growth and travel taken into account.

Consistency with Local Plans

Overall, the projected induced growth is consistent with local plans as most jurisdictions in the eastern portions of the FLUSA, which are likely to see the greatest induced growth, have recently developed planning documents or economic plans that anticipate the proposed project.

E.8 How Can Indirect and Cumulative Impacts Be Minimized or Avoided?

Cumulative effects occur because of decisions made not just by NCTA and FHWA, but also by other local, state and federal entities as well as private institutions and citizens. Separating, quantifying and minimizing and possibly avoiding the environmental effects from individual contributors continues to prove challenging and would require collaboration and coordination among the local governments within the study area along with the efforts of FHWA and NCDOT and other agencies.

First, one should note that the assumptions used in the methodology of this report and the reports summarized herein were generally designed to overestimate impacts to sensitive resources and water quality. Thus, the actual impacts in the future may be less than estimated here, as current and future regulations may prove more effective in reducing impacts from development than past regulations.

Nevertheless, cities, counties, towns and developers could do more to limit development impacts to water quality and other sensitive environmental resources. In an effort to promote the use of "nature friendly" growth management strategies, the North Carolina Wildlife Resources Commission (NCWRC) developed the Green Growth Toolbox.[4] The handbook for the toolbox document provides a background on green growth practices, offers tips on green planning, sample land use zoning ordinances, and provides examples of green growth projects. As discussed in Section 6, practices included in the Toolbox could reduce overall cumulative effects for development throughout North Carolina. The "Green Growth Toolbox" and LID techniques offer valuable tools for local governments and NCDOT to use for reducing cumulative effects to resources within the study area.

[4] NCWRC, 2012. http://www.ncwildlife.org/Conserving/Programs/GreenGrowthToolbox.aspx

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GLOSSARY

Term/Acronym	Definition
AADT	Annual average daily traffic Total volume of a road or highway for a given year divided by 365. This is used by planners to determine the activity at specific points along the roadway.
Air Quality Conformity	Under the Clean Air Act of 1970 (as amended), states or tribes in areas that do not meet National Ambient Air Quality Standards (NAAQS) must ensure that their federally funded transportation and infrastructure projects meet established plans to improve area air quality.
Annualized Percent Change	Growth in an area over any number of years calculated as a compounded annual growth rate.
BA	Biological Assessment A document that describes the potential effects of a project on federally or state listed species. The biological assessment is used by the U.S. Fish and Wildlife Service to make an effects determination under Section 7 or Section 10 of the Endangered Species Act.
Bottom Up Process	Type of analysis that focuses on smaller components first, rather than the big picture.
Build Out	Estimate of the total amount or growth and development that an area would support given a set of environmental and regulatory constraints such as zoning restrictions and stream buffer regulations.
Build Scenario	Scenario that represents future conditions with the proposed project and its potential impacts .
CAFO	Confined animal feeding operations
Carolina heelsplitter	A species of fresh water mussel (scientific name: *Lasmigona decorata*) found only in North Carolina and South Carolina. The Carolina heelsplitter is found within the Goose Creek and Six Mile Creek watersheds in the Monroe Connector/Bypass study area.
CDOT	Charlotte Department of Transportation

Term/Acronym	**Definition**
CEQ	Council of Environmental Quality The CEQ was established by the National Environmental Policy Act of 1969 (as amended, 40 CFR Parts 1500-1508). This office is part of the Executive Branch of government and works closely with agencies and other White House offices in the development of environmental policies and initiatives.
CFR	Code of Federal Regulations
COG	Council of Governments
Cohort Component projections	A demographic projection method that focuses on fertility, mortality and net migration to estimate total population by year.
Confidence Interval	Interval estimate of a population parameter used to indicate the reliability of an estimate. The confidence interval is a statistical range in which the correct answer is most likely to be located. Estimates with a higher degree of uncertainty (such of estimates of changes over time) have a wider confidence interval and indicates that more data should be collected for greater certainty.
Conservative Estimate	An estimate developed to provide a "worst case" scenario. When developing estimates of potential environmental effects of a transportation project, conservative estimates will maximize land development caused by the new road or highway. For revenue projections of toll highways, conservative estimates would minimize potential toll revenue.
Control Totals	The total number of populations, employment, and households. For planning purposes, control totals are the anticipated totals for a region (generally County-level or larger). Using these totals, growth is allocated within the region using other methods.
CRMPO	Cabarrus Rowan Metropolitan Planning Organization The metropolitan planning organization responsible for transportation planning in Cabarrus and Rowan Counties in North Carolina.
CSO	Combined Sewer Overflow Discharge from a combined sewer system that is caused by snowmelt and stormwater runoff.

Term/Acronym	**Definition**
Cumulative Effects	Cumulative impacts are the impacts on the environment caused by an action, such as a transportation/infrastructure project or land use development. The impact is added to other past, present, and future actions regardless of who undertakes the potential action. While individually these impacts may be minor, when occurring together these impacts may be significant over time.
CWA 303(d) List	Clean Water Act Section 303(d) Under the Clean Water Act Section (1972, as amended) states are required to develop a list every two years of waters that do not meet water quality objectives, provide the cause(s) of contamination, and develop a plan or schedule to address the contamination.
DEIS	Draft Environmental Impact Statement Draft report of environmental effects of a proposed action on an area of land required by the National Environmental Policy Act for major federal actions.
Demand Side Model	A demand side model examines growth in a region based on the need for goods and services rather than from a supply side model that looks at the availability of resources such as land available for development
Developable Land	Areas of land that are currently undeveloped and identified as suitable for future development.
DSA	Detailed Study Alternative An analysis of each design alternative based on cost, environmental factors, and quality of design.
DU	Dwelling Units
NCDWQ	North Carolina Division of Water Quality
EIS	Environmental Impact Statement Document used for decision making. required by the National Environmental Policy Act for certain actions, including transportation infrastructure, that may have a significant impact on the environment.

Term/Acronym	Definition
Endangered Species Act	The Endangered Species Act (ESA) of 1973 (as amended) seeks to protect the habitats upon which species listed as federally threatened or endangered depend. By protecting these sensitive habitats, the ESA seeks to preserve the diverse environmental heritage of the US for future generations.
Extrapolate	Mathematical estimation that extends current trends into the future.
FEIS	Final Environmental Impact Statement Final report of environmental effects of a proposed action on an area of land required by the National Environmental Policy Act for major federal actions.
FHWA	Federal Highway Administration
FLUSA	Future Land Use Study Area Designated area surrounding the project that could be affected if the project is completed and analyzed.
Forest Fragmentation	A form of habitat fragmentation in which forested land is developed in such a way that leaves small patches of forests. Fragmented habitats increase the stress on species and the potential for human/wildlife interactions (animals struck by vehicles, etc.)
GIS	Geographic Information Systems Integrates, stores, edits, analyzes, shares, and displays geospatial data for informing decision making
GUAMPO	Gaston Urban Area Metropolitan Planning Organization The organization that responsible for the transportation planning process in the greater Gaston County, North Carolina region.
Hartgen Analysis	Analysis of potential commercial development at rural interchange locations that reviews traffic volumes, distance to the nearest towns, and access to sewer and water services based on research by Dr. David T. Hartgen in Beltways, Traffic and Sprawl: The Empirical Evidence, 1990- 1997 (Charlotte, NC: Center for Transportation Studies, University of North Carolina at Charlotte)

Term/Acronym	Definition
IMP	Integrated Management Practices Best practices designated by the Environmental Protection Agency to design, implement, and evaluate their stormwater management efforts.
Impervious Surface	Structures (usually artificial) that are covered by impenetrable materials such as concrete, brick, asphalt and stone. Impervious surfaces include parking lots, rooftops, roads and sidewalks. Increases in impervious surface have been linked to decreases in the overall quality of surface waters.
Indirect Effects	Effects which are caused by the project or action and occur later in time or farther in distance, but are still reasonably foreseeable. Indirect effects include land use changes, population density or growth rate, or environmental effects.
Induced Land Use Change	Changes in land use development caused by the construction of a road or other infrastructure project.
Inverse Distance Weighted Method	Analysis of distance within a scattered set of points. It assigns a greater weight to points closest to the location and the weight diminishes as a function of distance.
LID	Low Impact Development Infrastructure and urban design approach to manage stormwater runoff limiting the environmental effects and protect water quality.
LNRPO	Lake Norman Rural Planning Organization The rural planning organization responsible for Iredell, Lincoln and Cleveland Counties along with the non-urban portions of Gaston County in North Carolina.
LRTP	Long Range Transportation Plan A metropolitan planning organization's plan to assess future population growth in a metropolitan region and how to meet the growing population's mobility needs. The plan lists transportation projects that will serve the growing population and anticipated available revenue.
LUSAM	Land Use Allocation Model Analysis that measures land use changes by assigning future employment and population growth based on the current land use in a region.

Term/Acronym	Definition
MPO	Metropolitan Planning Organization A federally mandated and federally funded transportation policy-making organization in the United States that is made up of representatives from local government and governmental transportation authorities.
MRM	Metrolina Regional Model Estimation, based on socioeconomic projections, of traffic in the MUMPO region that will use transportation infrastructure in the future.
MRM05v1	2005 Metrolina Regional Model, Version 1
MRM09v1	2009 Metrolina Regional Model, Version 1
MRM11v1	2011 Metrolina Regional Model, Version 1
MRM11v1.1	2011 Metrolina Regional Model, Version 1.1
MTP	Metropolitan Transportation Plan A federal mandated document that assesses the transportation system of a region and identifies problem or shortfalls of the region's transportation system. The plan seeks to address the problems and shortfalls of the transportation system and meet demands of future growth.
MUMPO	Mecklenburg-Union Metropolitan Planning Organization responsible for the transportation development within the Charlotte, North Carolina region.
NC Data Center	A group of agencies cooperating with the US Bureau of the Census to provide the public with data about the state of North Carolina and its component geographic areas.
NCDENR	North Carolina Department of Environmental and Natural Resources
NCDOT	North Carolina Department of Transportation
NCGAP	North Carolina Gap Analysis Project State level representative of the National Gap Analysis Program sponsored by the United States Geological Survey. The GAP Analysis collects data to assess the conservation status of native terrestrial vertebrate species.
NCTA	North Carolina Turnpike Authority
NCWRC	North Carolina Wildlife Resource Commission

Term/Acronym	Definition
NEPA	National Environmental Policy Act (42 U.S.C. § 4321 United States environmental law that established national environmental policy and set up requirements for federal agencies to document environmental impacts.
No-Build Scenario	Scenario without the project or its growth-inducing impacts.
Parcel Data	Data based on County parcels. Counties will typically include information on the type(s) of development allowed and number of dwellings. This information is used to assign potential development for future land use.
Project Design Year	Time span during which a particular road, highway or bridge must adequately serve traffic needs.
Quantitative ICE	Quantitative Indirect and Cumulative Effects Assessment A report required by the National Environmental Policy Act that lists the effects of the project on the water quality and land use in the study area.
Raster Data	An image comprised of pixels that typically displays continuous data such as, land use, elevation, and weather.
RFATS	Rock Hill - Fort Mill Area Transportation Study Metropolitan Planning Organization for eastern York County, South Carolina
River Basin/Watershed	A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place
ROD	Record of Decision Document issued by the Federal Highway Administration concerning a proposed highway project. The Record of Decision authorizes the respective state transportation agency to proceed with design, land acquisition, and construction based on the availability of funds.
RPO	Rural Planning Organization A voluntary association of local governments that plans rural transportation systems and advise each state's department of transportation on rural policy.
RRRPO	Rocky River Rural Planning Organization Rural planning organization serving Anson, Stanly and Union Counties in North Carolina.

Term/Acronym	Definition
SCALDS	Social Cost of Alternative Land Development Scenarios Analysis of the estimates monetary and non-monetary costs associated with land development in a region. Estimated costs include land use development, infrastructure development, air pollution, energy consumption and estimated passenger miles traveled.
NRCS	National Resource Conservation Service
SEPA	North Carolina State Environmental Policy Act A North Carolina legislative act that to review and report the environmental effects of all activities that involve an action by a State or with public money.
Socioeconomic Data	Social and economic data parameters such as, but not limited to, education, race, income, age and employment used to analyze populations.
STIP	State Transportation Improvement Program A state's comprehensive improvement plan for spending both state and federal funds on transportation projects
Stream Buffer	A vegetated area near a stream, that is usually forested, which helps shade and partially protect a stream from the impact of adjacent land use.
T&R Study	Traffic and Revenue Study A study conducted to measure the feasibility of pursuing toll financing for construction of a roadway.
TAZ	Traffic Analysis Zone Unit of geography most commonly used in conventional transportation planning models. A full definition, including how a TAZ is used in transportation planning, is provided on page 23 of this document.
TDM	Travel Demand Model Estimation, based on socioeconomic projections, of traffic that will use transportation infrastructure in the future.

Term/Acronym	**Definition**
TMDL	Total Maximum Daily Load - Under the Clean Water Act Section (1972, as amended) states are required to develop TMDL for waters that do not meet their designated uses (such as recreational use, drinking water, or aquatic life). A TMDL calculates the amount of a contaminant that water can carry and still meet its water quality standard. This amount of contamination is then allocated to sources of pollution throughout the watershed.
Top Down Process	A method of analysis that looks at the big picture first, then smaller components.
Traditional Neighborhood Design	Urban design approach which develops residential neighborhoods with principles including, but not limited to, include building developments with a range of housing types, a well-connected street system, integrated public spaces and some mix of uses.
TSS	Total Suspended Solids are solid materials that are suspended in water and will not pass through a filter. Suspended solids are present in sanitary wastewater and many types of industrial wastewater, as well as soil erosion from urban runoff, construction sites, and agricultural sites.
US Census Data	A population survey conducted every ten years that gathers information on location, households, income, race and education.
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Services
UZA	Urbanized Area An area of higher population density surrounding a city.
VHT	Vehicle Hours Traveled The total vehicle hours expended traveling on the roadway network in a specific area during a specific time period.
VMT	Vehicle Miles Traveled The total number of vehicle miles travelled within a specific geographic area over a given period of time.

Term/Acronym	**Definition**
Water Quality Quantitative ICE	Water Quality Indirect and Cumulative Effects Assessment A report that lists the effects of a project on the water quality in the study area.
WQA	Water Quality Analysis The testing or analysis of the condition of the water, including chemical, physical and biological characteristics to measure safety for humans and wildlife.
WSA	Wilbur Smith Associates
WWTP	Waste Water Treatment Plant

1.0 INTRODUCTION

1.1 What Is the Proposed Project?

The North Carolina Turnpike Authority (NCTA), a division of the North Carolina Department of Transportation (NCDOT), in cooperation with the Federal Highway Administration (FHWA), proposes to construct a project known as the Monroe Connector/Bypass, which would be a controlled-access toll road extending from US 74 near I-485 in Mecklenburg County to US 74 between the towns of Wingate and Marshville in Union County, a distance of approximately 20 miles. Map 1 shows the proposed project and surrounding area. The proposed action is included in the NCDOT 2009–2015 State Transportation Improvement Program (STIP) as Project R-3329 (Monroe Connector) and Project R-2559 (Monroe Bypass) as a toll facility.

1.2 Why Is an Updated Quantitative Indirect and Cumulative Effects Analysis Needed?

NCTA previously analyzed indirect and cumulative effects of the Detailed Study Alternatives for the proposed action through a Qualitative Indirect and Cumulative Effects Assessment (Qualitative ICE) completed for the Draft Environmental Impact Statement (DEIS Chapter 7) and incorporated into the Final Environmental Impact Statement (FEIS Appendix G). This analysis was expanded and extended for the Preferred Alternative through a Quantitative Indirect and Cumulative Effects Analysis for Land Use (Quantitative ICE) and Quantitative Indirect and Cumulative Effects Water Quality Analysis (WQA) completed for the Final Environmental Impact Statement (FEIS Appendices H & I). These reports were summarized in Section 2.5.5 of the FEIS and together these reports comprise the FEIS ICE analysis and conclusions. In August 2010, FHWA issued a Record of Decision (ROD) selecting Detailed Study Alternative D (DSA D) as the Selected Alternative for the proposed action based on the analysis of the DEIS and FEIS showing that this alternative had lower overall impacts to the natural environment and residential areas compared to other alternatives.

In November 2010, The North Carolina Wildlife Federation, Clean Air Carolina and Yadkin Riverkeepers (Plaintiffs) filed suit to overturn the ROD. The U.S. District Court for the Eastern District of North Carolina decided the case in October 2011, finding for FHWA and NCTA that the FEIS was sufficient. Plaintiffs appealed the decision to the U.S. Court of Appeals for the Fourth Circuit and the appellate court vacated the District Court decision on May 3, 2012. The FHWA rescinded its ROD for the project on July 3, 2012 in response to the appeals court decision.

The FHWA and NCDOT conducted additional work, analysis and developed this report to address the U.S. Court of Appeals for the Fourth Circuit decision. The purpose of this report is to update the FEIS summary of the quantitative ICE effects documented in the FEIS Appendix H and to inform the public about the underlying assumptions of the models and how they were used to inform decisions for the project and the analysis. The findings of this report will be summarized and included in a draft supplemental FEIS. Furthermore, this document will

1. review the scope of this ICE analysis and conditions and trends in the study area (Section 1.0)
2. discuss the methods for developing an existing land use scenario (Section 2.0)
3. review the Metrolina Regional Model socioeconomic projections, including how other studies have used the projections, and evaluate the most appropriate use of those projections within the framework of this ICE analysis (Section 3.0)

4. explain the methods used to estimate induced growth and develop the future land use scenarios (Section 4.0)
5. report revised induced growth results and conclusions based on the updated land use scenarios (Section 5.0)
6. review measures that localities and others could adopt to minimize any impacts of future development, whether induced or not, on sensitive environmental resources (Section 6.0).

This report summarizes the conclusions reached in the evaluation of ICE and describes the data collected, methodologies used and analysis conducted for the ICE for the project. This document also re-evaluates and considers data, analytical research relevant to the project area, and new information relevant to the analysis of the indirect and cumulative effect on land use, water quality, and federally designated threatened and endangered species and their critical habitat in the surrounding area.

1.3 What Are Indirect and Cumulative Effects?

Indirect effects are addressed under CEQ regulations, 40 CFR 1508.8 and are defined as effects "which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems."

Cumulative effects are addressed under two CEQ regulations, 40 CFR 1508.7 and 40 CFR 1508.25(a)(2). As stated in 40 CFR 1508.7, a "[c]umulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

50 CFR §402.02 provides a somewhat different definition of cumulative effect to Federally listed threatened and endangered species, specifically. However, for the purposes of this analysis, Federal actions were included with the future changes that may affect protected species. This was determined to be the best approach for this study because 1) it provides a conservative (i.e., high) estimate of changes to land use, and 2) quantifying projected future Federal actions is particularly difficult. Many of the private, local, or state actions predicted in this analysis may become Federal actions in the future through permitting procedures (e.g., Clean Water Act Section 404 permit approvals by the US Army Corps of Engineers [USACE]). For this study, each reasonably foreseeable future non-Federal action was considered a contributor to the potential cumulative effect on protected species, regardless of whether it may be a Federal action in the future.

1.4 How Is an ICE Analysis Done?

The National Environmental Policy Act of 1969, as amended (NEPA), the North Carolina State Environmental Policy Act (SEPA), and the United States Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508) identify assessment of indirect and cumulative effects as a necessary component of environmental impact assessment for major Federal actions. The ICE analysis to evaluate potential land use changes and environmental effects associated with the Monroe Connector/Bypass project followed a process contained in guidance released in 2001 by the NCDOT, in consultation with the North Carolina Department of the

Environment and Natural Resources (NCDENR), the North Carolina State Attorney General's Office and the Association of Municipalities entitled *Guidance for Assessing Indirect and Cumulative Impacts for Transportation Projects in North Carolina, Volume I: Guidance Policy Report and Volume II: Practitioners' Handbook*. [5] In this guidance document, the agencies agreed to the following steps that should be taken to thoroughly assess indirect and cumulative impacts.

Step 1: Definition of the Future Land Use Study Area (FLUSA)
Step 2: Identification of the FLUSA's Direction and Goals
Step 3: Inventory of Notable Features
Step 4: Identification of Important Impact Causing Activities
Step 5: Identification and Analysis of Potential Indirect/Cumulative Effects
Step 6: Analyze Indirect/Cumulative Effects
Step 7: Evaluate Analysis Results
Step 8: Assess the Consequences and Develop Appropriate Mitigation and Enhancement Strategies.

The first five steps are undertaken for a qualitative ICE study. The last three steps are undertaken if a quantitative study is required. The ICE analysis previously conducted for the Monroe Connector/Bypass project included a qualitative analysis for inclusion and publication in the DEIS and a quantitative analysis for inclusion and publication in the FEIS.

FHWA and NCTA presented the results of the analysis of the first five steps in a Qualitative ICE, which was included in the DEIS and the FEIS as Appendix G. Based on a review of data and information available since that report was completed, the results and conclusions in the FEIS Appendix G would not be significantly different or introduce new significant impacts or information, which were not previously considered.

Subsequently, a Quantitative ICE was developed following steps six through eight and was presented in FEIS Appendix H. Because of new data, information and the results of the Fourth Circuit of the United States Court of Appeals, FHWA and NCTA have reanalyzed steps six through eight in this updated Quantitative ICE. The scope of this Quantitative ICE includes analysis of the potential of increased indirect and cumulative effects on water resources, threatened and endangered species, and in response to agency and public comment on the DEIS. The decision to use watersheds as boundaries to quantitatively analyze effects, instead of the zones presented in the Qualitative ICE, was made due to the water quality concerns expressed by resource agencies. Watershed boundaries were also used for analysis for compliance with Section 7 of the Endangered Species Act. Land use changes within watersheds were analyzed first and those results were used to estimate changes in water quality and impacts on the Carolina heelsplitter mussel. Map 2 shows each watershed within the project study area.

The Quantitative ICE analysis addresses the potential land use changes associated with the proposed project by developing three land use scenarios associated with the following conditions:

- **Existing (or Baseline) Land Use Scenario**: A scenario that reflects the land use conditions as they existed in 2010 to provide a basis for comparison for cumulative impacts assessment.

[5] NCDOT and NCDENR. *Guidance for Assessing Indirect and Cumulative Impacts for Transportation Projects in North Carolina, Volume I: Guidance Policy Report and Volume II: Practitioners' Handbook.* November 2001.

- **No-Build Land Use Scenario**: A scenario that reflects the best estimate of land use development conditions in 2030 if the proposed project is not built based on the assumptions and methods used in this report.
- **Build Land Use Scenario**: A scenario that reflects the best estimate of land use development conditions in 2030 if the proposed project is built based on the assumptions and methods used in this report.

1.5 What Is the Study Area for the ICE Analysis?

The NCDOT ICE Guidance indicates that the development effects of a new or improved roadway facility are most often found within one mile of an interchange, and approximately two to five miles along major intersecting roadways to the interchange. Using the ICE Guidance, it was determined for the purposes of the Draft EIS that the potential for ICE exists within about five miles of the various project alignments, which for the purpose of the study were evaluated as a single Build Alternative. This approximate five-mile radius is depicted in the Draft EIS, Figure 7-1, and is referred to in the Draft EIS and the Qualitative ICE Assessment as the Future Land Use Study Area (FLUSA).

For the more detailed purposes of this report, the Draft EIS FLUSA was expanded to include all of the Goose Creek watershed (14-digit Hydrologic Unit 03040105030020) as well as the headwaters of some of the area streams in the FLUSA. The Goose Creek watershed is located at its closest point approximately one mile north of the proposed project in northwestern Union County. Although some of the FLUSA watersheds overlap Anson County, the FLUSA was not expanded into Anson County because it lies outside the five-mile radius and does not contain special resources noted in comments on the Draft EIS. This expanded FLUSA is the area within which the Build Alternatives have the potential to affect the resources that are the subject of this report (water quality, threatened and endangered species, and land use). The expanded FLUSA is depicted in Map 1. The watersheds within the Study Area are shown in Map 2 and areas of each watershed within the study area are listed in Table 1; the Goose Creek watershed is the relatively large watershed along the northern border.

Table 1: Study Area Watersheds

Watershed Name	Area (Square Miles)
Beaverdam Creek	18.2
Richardson Creek (Upper)	10.6
Rays Fork	14.7
Bearskin Creek	15.2
Richardson Creek (Middle)	9.3
Gourdvine Creek	1.2
Salem Creek	21.7
Sixmile Creek	2.6
Twelvemile Creek	20.4
Richardson Creek (Lower)	23.3
Stewarts Creek	35.3
Fourmile Creek	12.1
Crooked Creek	38.3
Goose Creek	42.3
Irvins Creek	14.8
McAlpine Creek	21.2
Bakers Branch	3.6
Wide Mouth Branch	10.8

1.6 What Are the Land Use Conditions and Trends in the Study Area?

To understand existing land use conditions and estimate future land use conditions, a review and assessment of land use conditions, land use regulations, growth trends, growth factors and other factors was completed. Much of this analysis was already completed in the original Quantitative ICE analysis. Additional background research for this Quantitative ICE updated included:

- Updated interviews with local planners
- The 2010 Census and growth trends and conditions in the study area
- Additional development activity
- New planning documents (such as new land use plans and new capital improvement plans).

Interviews

In 2008, the study team interviewed planners with local jurisdictions within the FLUSA, such as the Council of Governments (COG) and city, county and town planning department representatives, as part of the Qualitative ICE Assessment. In August 2009, the study team interviewed the same organizations as part of the FEIS Quantitative ICE, with follow-up questions as necessary. In September 2012, the study team interviewed representatives of the same organizations again to determine if any new information was available to inform the update of the ICE analysis as these organizations are the most knowledgeable about current and future growth trends and land use patterns in the study area. Table 2 lists the organizations that were the focus of these recent interviews, the individual respondents, and the dates of contact. The study team was unable to schedule an interview with the mayor of Hemby Bridge. Additionally, the project team was unable to meet with staff from the Village of Lake Park, but their most recent Unified Development Ordinance was obtained. Beyond those staff and officials who were officially interviewed as documented in Table 2, the study team also coordinated with other staff and officials at NCDOT, MUMPO, the Charlotte Department of Transportation (CDOT), the Rocky River Rural Planning Organization (RRRPO) and many others, as documented in the administrative record, throughout the research, analysis and documentation phases of this report.

Each interview began with an introduction of the study and its purpose. A map of the study area was provided to facilitate communication, as were past interview summaries as applicable. The purpose of the interviews was to identify changes to future land use scenarios since the 2009 interviews for the Quantitative ICE and gather any new or updated databases or GIS data that would be useful to the analysis. The following data was requested:

- Approved developments
- Updated zoning
- Information on current stream buffer or other environmental protection areas
- Water and sewer utility information
- Water and sewer priority areas
- Future land use projections
- Existing land use
- Approved population and employment projections and anticipated variations from projections with each land use scenario.

Table 2: List of Interviews Completed in 2012

Organization	Respondent	Date of Interview
Town of Wingate	Patrick Niland – Town Manager	September 6, 2012
Centralina COG	Diane Dil – Centralina Planner I	September 12, 2012
Town of Matthews	Kathi Ingrish – Planning Director	September 10, 2012
Town of Unionville	Sonya Gaddy – Land Use Administrator	September 11, 2012
Union County Planning	Amy Helms – Water and Land Resources Division Manager Scott Huneycutt – Engineering Division Manager Richard "Dick" Black – Planning Director	September 12 & 19, 2012
Town of Marshville	Amanda Reid – Town Manager	September 12, 2012
Town of Indian Trail	Shelley DeHart – Director of Planning and Neighborhood Services Adam McLamb, Civil Engineer	September 14, 2012
Town of Mint Hill	John Hoard - Planner	September 14, 2012
Town of Weddington	Jordan Cook - Town Planner and Zoning Administrator	September 25, 2012
Town of Wesley Chapel	Josh Langen – Planning and Zoning Administrator	September 12, 2012
Charlotte – Mecklenburg Planning	Debra Campbell – Director, Charlotte-Mecklenburg Planning Department	September 14, 2012
City of Monroe	Doug Britt – Senior Planner	September 11, 2012
Town of Fairview	Ed Humphries – Land Use Administrator	September 11, 2012
Town of Stallings	Brian Matthews – Town Manager Lynne Hair – Town Planner	September 14, 2012
Union County Partnership for Progress*	Gretchen Carson – Planner Melanie O'Connell Underwood – Interim Director	September 27, 2012
Union County Planning*	Richard "Dick" Black – Planning Director	January 21, 2013
CSX Corporation*	Vance E. Bennett Jim Van Derzee	November 29-30, 2012
Monroe-Union County Economic Development	R. Christopher Platé – Executive Director Gretchen Carson – Project Manager	October 2, 2013

*-Contacted after the initial round of interviews to obtain information on the Proposed Legacy Park Development

Prior to the discussion, staff provided a list of the questions to the respondents. Appendix A contains complete minutes from all of the interviews. The following 11 questions were asked during interviews with local planners (the interviews conducted concerning Legacy Park included different questions, which are documented in the appendix):

1. *The August 2009 interview covered land use and economic development trends, growth management and natural resource protection – in general, have any of these dynamics affecting future land use changed since the previous interview?*
2. *Have any changes to future land use plans, transportation plans or other plans, policies or projections been made that incorporate information from the 2010 Census?*
3. *Have new or amended land use regulations been developed since August of 2009? Please see the list we have provided of documents we collected and reviewed during the previous environmental*

documentation effort. Are there any updates to those plans or regulations? If there have been any changes, please provide specific web link or a copy of the document.

4. *Has the local regulation of natural resources (including stream buffers) changed since August 2009? If so, how?*
5. *What can you tell us about any proposed or approved developments that have come to light since the August 2009 interviews? What information is available about any of these planned or approved developments that are not built yet? Can you provide any details and locations for these projects?*
6. *Have long-term growth expectations changed since the previous interview and if so how?*
7. *Has the city/town/county updated its Comprehensive Plan or Land Use plan since August 2009?*
    - *If so, does this updated plan reflect conditions in the future with or without the Monroe Connector/Bypass?*
8. *We are reviewing and considering the predictions of future growth (2030 forecast year) included in the previous EIS. Are there any other factors that have changed since August 2009 that might affect the level of future growth and the location of that growth in your community?*
    - *Do these changes reflect the future with the Monroe Connector/Bypass, without the Monroe Connector/Bypass, or is there no difference on that basis?*
9. *Have there been any changes in capacity of utility infrastructure or expectations about the future capacity since the last round of interviews? Do any of those changes affect growth expectations?*
10. *Are you or other planners or development review staff familiar with the North Carolina Wildlife Resources Commission "Green Growth Toolbox"? (http://216.27.39.101/greengrowth/)*
    - *Have you attempted to implement any of the practices, ordinances or other policies recommended by the toolbox?*
    - *Have you attempted to incorporate any other low-impact design type policies into zoning, subdivision or other land development ordinances?*
    - *How would you rate the likelihood of incorporating any low-impact design principles in future regulations or plans?*

Supplemental questions were asked pertaining to the specific interviewee's location or expertise. Face-to-face interviews were conducted to the extent practical. The interviews generally took between 30 and 60 minutes to complete. Notable information included:

- Often, zoning maps provided the best representation of current land use, while land use plans provided the best representation of future land use. Much of this information was available as GIS data.
- Some land use plans were in the process of being updated and were not yet available for this study. For example, Indian Trail was in the process of updating their Comprehensive Land Use Plan. Marshville indicated that the next update of their land use plan would include the Monroe Bypass/Connector. The City of Monroe was developing the US 74 Corridor revitalization Plan, which included the Monroe Bypass/Connector in its assumptions. Older land use plans tended not to include the Monroe Connector/Bypass, while the updated plans usually included the project.
- Based on the 2010 Census, the MUMPO Urbanized Area is expanding to include Marshville.
- Mecklenburg County now administers the Goose Creek Management Plan[6]

[6] This is a plan to guide restoration, retrofit and preservation efforts aimed at achieving specific goals for improving water quality conditions in the Goose Creek Watershed in Mecklenburg County such that these waters meet or

- Goose Creek Water Quality Recovery Program Plan for the Fecal Coliform TMDL (Total Maximum Daily Load) was revised in 2010. This is a plan to reduce fecal coliform impairments based on the TMDL report completed in 2005.
- Areas in the eastern portion of the study area were more likely to indicate that their future plans included the Monroe Connector/Bypass and that the implementation of certain aspects of their plans was contingent on the development of the facility.
- Water and Sewer moratoria were rescinded in Union County in 2012.

Plans and Ordinances

Specific documents or information obtained during the interview process are summarized in Table 3.

In addition, CDOT staff were interviewed on June 19, 2012 to discuss the TAZ projections and any updates to their data since they were developed in 2008. Further communications were conducted with CDOT staff as this report was prepared. Summaries of that interview and follow up communications are provided in Appendix A along with the interviews listed in Table 3.

Table 3: Zoning or Other Local Data Collected During Interviews*

Jurisdiction/Area	Document	Year
Goose Creek Watershed	Goose Creek Water Quality Recovery Program Plan for the Fecal Coliform TMDL	2010
City of Monroe	Zoning Ordinance	Modified 2010
	List of Current Developments	Modified 2009
Village of Lake Park	Unified Development Ordinance	Draft 2012
Town of Unionville	Zoning Map	Updated 2011
	Future Land Use Map	2005
	Zoning Amendments	Modified 2012
Town of Fairview	Future Land Use Map	Modified 2010
	Land Use Ordinance	Updated 2009
Town of Stallings	**Unified Development Ordinance**	Adopted 2012
	Post Construction Ordinance	Adopted 2010
Town of Mint Hill	Unified Development Ordinance	Adopted 2011
	Lawyers Road & I-485 Small Area Plan	Adopted 2011
	Pedestrian Master Plan	Adopted 2011
Town of Marshville	Urbanized Area Expansion	Updated 2010
	Comprehensive Pedestrian Plan	Adopted 2010
	Comprehensive Transportation Plan	Updated 2010

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exceed their State designated uses and are no longer rated as impaired on 303(d) lists. *Goose Creek Watershed Management Plan*. Charlotte-Mecklenburg Storm Water Services. October 31, 2009. http://charmeck.org/stormwater/Projects/Documents/GooseCreekWatershedManagementPlan.pdf

Jurisdiction/Area	Document	Year
Town of Wingate	Land Use Ordinance	Updated 2010
	Wingate 2020 Plan (Comprehensive Plan and Concept Plan)	Adopted 2010
	Wingate Mixed Use Center Plan	Draft 2012
Town of Weddington	Local Area Regional Transportation Plan	Updated 2009
	Land Use Map	Modified 2012
	Zoning Map	Modified 2011
	Land Use Plan	Modified 2011
Village of Wesley Chapel	Flood Damage Prevention Ordinance	Updated 2009
	Subdivision Ordinance	Updated 2011
	Western Union County Local Area Regional Transportation Plan	Prepared 2009
	Zoning Ordinance	Updated 2012
Town of Matthews	Zoning Code	Modified 2010
	Unified Development Ordinance	Draft 2012
	Downtown Master Plan	Draft 2012
	Town of Matthews Land Use Plan	Draft 2012
	Demographic/Economic Update	Prepared 2012
Charlotte-Mecklenburg	Growth Framework	Adopted 2010
	FY 2013-2017 Capital Improvements, including 10-Year Needs for Water and Sewer Projects	Updated 2012
	Water Quality Buffer Implementation Guidelines	Updated October 2011
	Floodplain Ordinance	Adopted 2012
Union County	Water Allocation Policy	Updated 2012
	Sewer Policy	Updated 2012
	Union County Water and Sewer Extension Ordinance	Updated 2012
	Carolina Thread Trail Master Plan	Adopted 2011
	Union County Land Use Ordinance	Adopted 2008
	Union County Thoroughfare Plan	Updated 2008
	Union County 2025 Comprehensive Plan	Adopted October 2010
	Comprehensive Water and Wastewater Master Plan	December 2011
	US 74 Corridor Revitalization Study	Underway

*Bolded documents include the Monroe Connector/Bypass

Growth Trends and Factors

A review of critical growth factors and trends indicates that Union County maintains a number of advantages relative to other suburban jurisdictions in the region. These growth trends and factors are discussed in detail in Appendix B. First, Union County has more land available for development than Mecklenburg, Gaston or Cabarrus counties. Union County has the highest median income of all surrounding counties, it has affordable housing relative to its median income level, and it has one of the best school districts in the region based on SAT scores and graduation rates. In terms of commute times, the interesting trend is that despite having one of the highest average commute times over the last decade, Union County has grown faster than any other county in the region. This finding suggests that factors other than accessibility to jobs are encouraging households to choose to locate in Union County. For the past decade, Union County has exhibited strong growth, and the factors driving those trends are poised to continue attracting growth to Union County regardless of whether the Monroe Connector/Bypass is constructed.

These findings are further supported by the analysis of the Operations Research and Education Laboratory of the Institute for Transportation Research and Education at North Carolina State University's February 28, 2007 *Land Use Study Final Report 2006-2007* (Appendix C). In its research on behalf of the Union County Public Schools, it described the leading factor of growth in Union County as its location within the Charlotte-Mecklenburg region. The Operations Research and Education Laboratory of the Institute for Transportation Research and Education determined the western area of Union County continues to experience a substantial population increase as a result of its desirable location. Marvin, Waxhaw, Weddington, Wesley Chapel and other western Union County suburbs continue to experience high demand for single-family homes. The report also listed the following other factors contributing to growth in Union County.

- Low taxes
- Good quality schools
- Comparatively reasonable land prices.

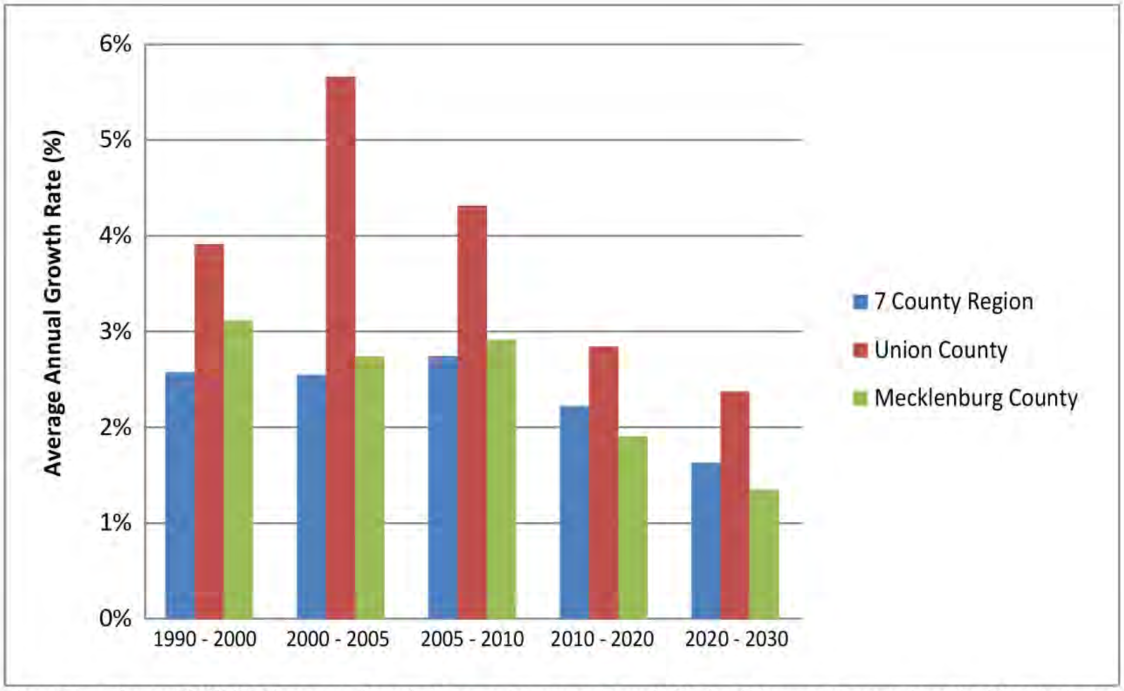
The report described the availability and cost of undeveloped land as a factor of future growth in the western part of the county. It concluded that a reduction in raw land would push development toward the eastern part of the county. The report described the eastern expansion of growth towards Monroe as constrained by a lack of easy access to Charlotte and Mecklenburg County.

Lastly, a review of current growth trends and projected growth trends suggests that while growth has slowed in Union County since 2005, it has still grown at a pace above the regional average. While the MPO projections still foresees a growth rate above the regional average into the future, the projected growth rate is expected to decline dramatically. To reach the projected 337,317 estimate of population by 2030, growth in Union County would have to slow to an average annualized growth rate of 2.6 percent, based on the 2010 Census count. Figure 1[7] shows the differences in average annual growth rates across the five different periods (1990 to 2000, 2000 to 2005, 2005 to 2010, 2010 to projected 2020 and projected 2020 to projected 2030). The difference between 2000-2005, 2005-2010, 2010-2020 and 2020-

[7] Figure 1 compares growth rates to a 7 county region as the TAZ level forecasts for whole counties are only available for Cabarrus, Gaston, Lincoln, Mecklenburg, Rowan, Union and York Counties.

2030 average annual growth rates reflects a typical "s-curve" of decreasing growth rates over time as a population base expands.

Figure 1: Average Annualized Growth Rates Comparison



Note: The adopted MUMPO forecasts for whole counties are only available for Cabarrus, Gaston, Lincoln, Mecklenburg, Rowan, Union and York Counties.
Sources: US Census 2000 and 2010, MUMPO 2009 Socioeconomic Forecasts

Specific Updates from Prior Quantitative ICE Analysis

Based on the interviews and review of documents provided by local jurisdictions, this section outlines the new information that prompted modifications to the future land use scenarios, compared to the prior Quantitative ICE analysis.

Charlotte/Mecklenburg County: There were no major changes to growth expectations or land use plans. Local planners did note one subdivision and zoning update of a 24-acre parcel on land that previously was identified as Industrial or Undeveloped in the future scenarios of the last Quantitative ICE analysis. The area is now expected to develop as High Density Residential in the future under any scenario.

Matthews: There were no major changes in growth expectations or land use plans. Local planners did note one zoning change and one planned land use change affecting about 275 acres of land. These changes affected land that was previously identified as Low Density Residential Development or Undeveloped in the future scenarios of the last Quantitative ICE analysis. These areas were now expected to develop as Commercial, High Density Residential or Low Density Residential Development in the future under any scenario.

Mint Hill: There were no major changes in growth expectations but some changes to land use plans as a small area land use plan has been developed for the area around Lawyers Road and I-485 (see Figure 2).[8] The entire small area plan covers over 1,200 acres of land. In the prior Quantitative ICE analysis, most of this area was already designated as developed, as either Commercial or Low Density Residential. With the new information, some of the land previously identified as Low Density Residential is now identified as Medium Density Residential, Commercial, Institutional or Undeveloped (in the case of those areas identified as Open Space in the Small Area Plan). These updated development plans are expected to occur under any scenario.

Stallings: There were no major changes in growth expectations, land use plans or zoning that would necessitate adjustments to the ICE land use scenarios.

Indian Trail: There were no major changes in growth expectations or land use plans. One zoning change involves a 28-acre development. In the prior Quantitative ICE analysis, this area had been identified as a Low Density Residential Area. This area is now being zoned as Commercial and is expected to develop as Commercial under any scenario.

Wesley Chapel: There were no major changes in growth expectations, land use plans or zoning that would necessitate adjustments to the ICE land use scenarios.

Fairview: The town has adopted a new land use plan with some important changes. Specifically the town has added some commercial nodes at major intersections and is working with the County on expanding water and sewer availability at the US 601 and NC 218 intersection. The new land use plan calls for a commercial district at this intersection as well as at NC 218 and Mill Grove Road (SR-1525) and at US 601 and Lawyers Road (SR-1612). The new land use plan also calls for a new Industrial node along Price Tucker Road (SR-1603) and at NC 218 and Old Dutch Road (SR-1542). All of these new nodes are expected to develop with or without the Monroe Connector/Bypass. In the prior Quantitative ICE analysis, these areas were expected to be Low Density Residential and Undeveloped areas. These areas are now expected to develop as Commercial and Industrial areas under any scenario.

Unionville: Town officials noted that their land use plan includes some commercial clusters at US 601 and Ridge Road (SR-1504) (near the proposed 601 interchange), US 601 and Unionville-Indian Trail Road (SR-1367), US 601 and Lawyers Road (SR-1612), which were not fully incorporated into the previous Quantitative ICE analysis. Most of these clusters are expected to develop under any scenario; however, the cluster near the proposed US 601 interchange with the Monroe Connector/Bypass would likely see greater development build-out if the Monroe Connector/Bypass were built. In the prior Quantitative ICE analysis, these areas were designated as Low Density Residential and Undeveloped but are now expected to develop as Commercial with more Commercial development expected if the proposed project is built.

Monroe: There were no major changes in growth expectations or land use plans that would necessitate adjustments to the ICE. Local planners noted that there were zoning changes affecting parcels totaling about 80 acres that were previously identified as Low Density Residential in the previous Quantitative ICE analysis but that would now be expected to develop as Institutional and Commercial under any scenario.

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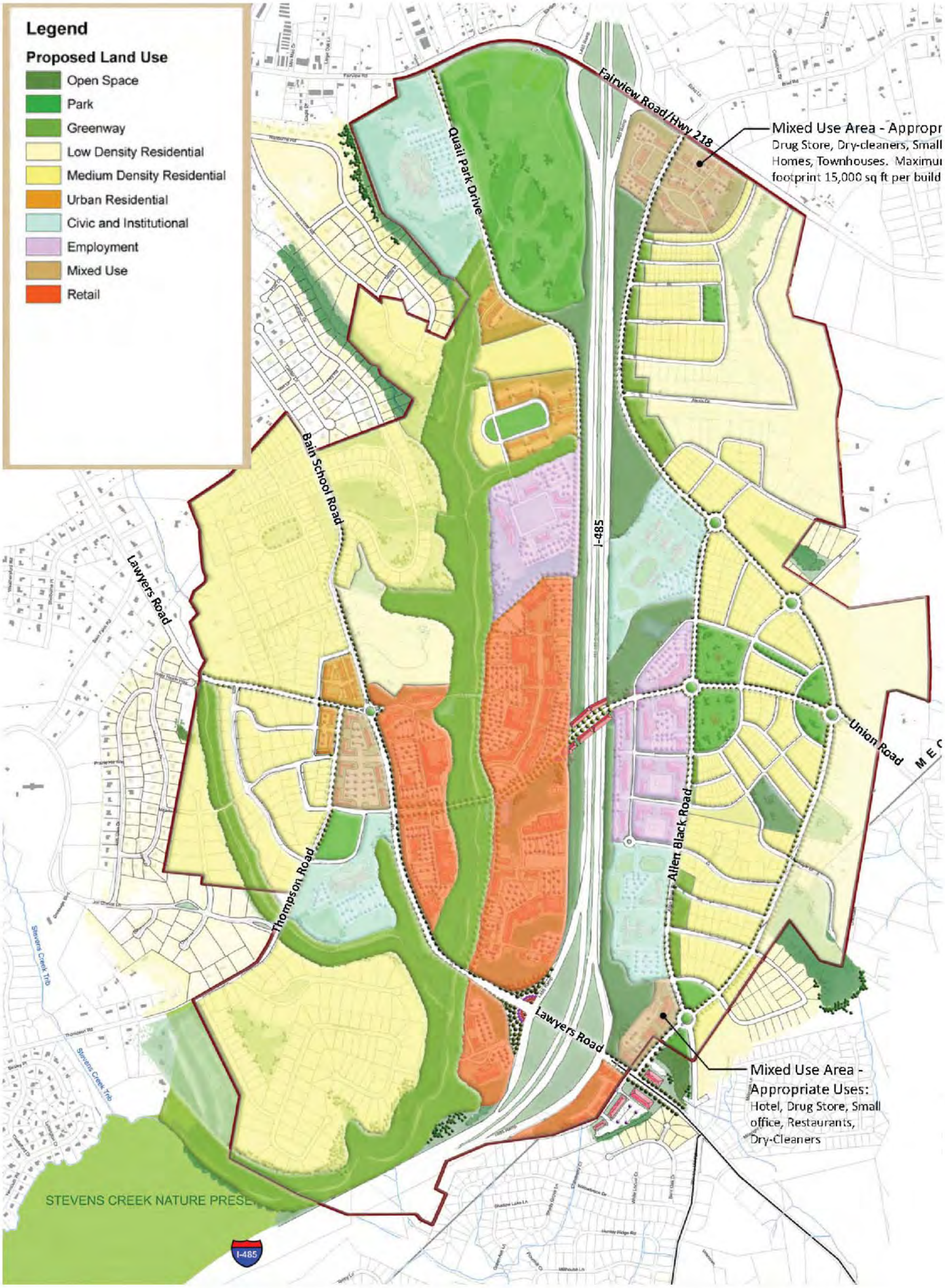
[8] *Lawyers Road & I-485 Small Area Plan*, Future Land Use Map

Figure 2: Lawyers Road and I-485 Small Area Land Use Plan, Town of Mint Hill



Union County: The County has adopted a new land use plan that provides more detailed information on growth expectations in the eastern end of the county if the proposed project is built (see Figure 3)[9]. Specifically, the county plan shows larger swaths of Medium Density Residential development at the eastern end of the Monroe Connector/Bypass corridor in response to the expectation of the proposed project. Their definition of "medium density", however, generally falls within the Low Density Residential category (2 units per acre or fewer) used in this Quantitative ICE analysis. This is the same section of the corridor where the previous Quantitative ICE analysis showed the greatest additional development. The new plan suggests planners, planning commissioners and elected officials expect the development to extend a bit farther than the previous plan anticipated.

To address these higher growth expectations, the study team analyzed the expected development in the TAZ level projections for this area. An additional 10 years of household growth was assumed to occur in this swath of the county north of Wingate and Marshville if the proposed project were built. The resulting land use adjustments affect land that was previously identified as Undeveloped; this area would now be expected to develop as Low Density Residential if the proposed project were built.

Wingate: There were no major changes in expectations, land use or zoning requiring adjustments to the ICE. The previously Quantitative ICE analysis used the town zoning to determine the most appropriate allocation and density of development under a No-Build Scenario. For the Build Scenario in the prior Quantitative ICE analysis, the study team incorporated many of the proposed zoning changes noted in the Strategic Plan for Economic Development, Town of Marshville, Town of Wingate (2008) as this plan assumes construction of the Monroe Connector/Bypass. These assumptions appear to remain reasonable and valid based on discussions with local planners.

Marshville: There were no major changes in growth expectations, land use plans or zoning that would necessitate adjustments to the ICE land use scenarios (see Wingate discussion above).

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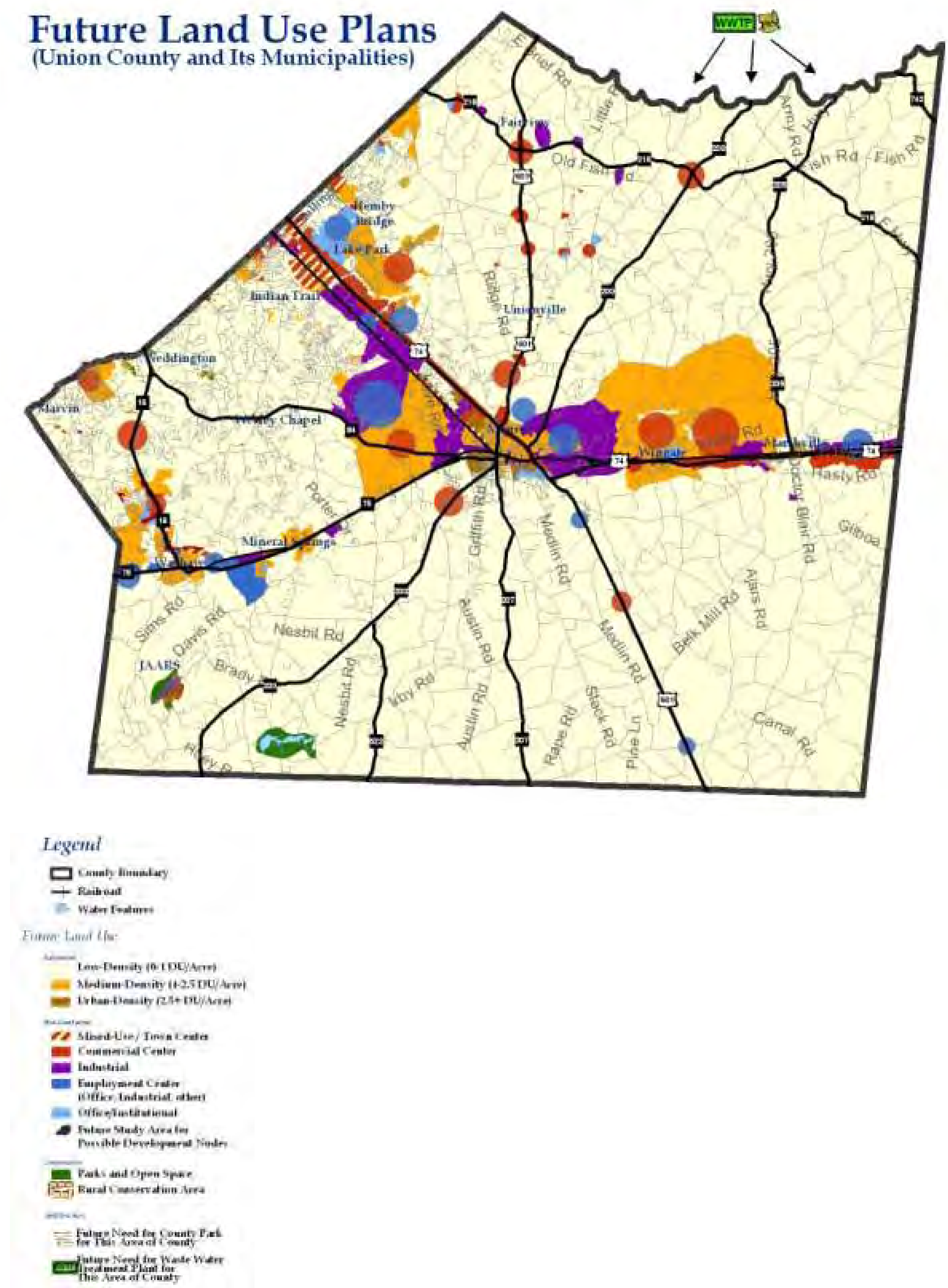
[9] *Union County 2025 Comprehensive Plan*, p 33

Figure 3: Union County Future Land Use Plan



2.0 EXISTING LAND USE

2.1 How Was Existing Land Use Modeled?

Existing land use was developed using parcel-based data from both Mecklenburg and Union counties combined with zoning layers from all the local jurisdictions and the NCGAP[10] land cover dataset, which is based on 1992 aerial photography. The existing land cover is largely a combination of these three data sets, with developed land based on current parcel data and the NCGAP data filling in the land cover types where parcels are undeveloped. Each parcel was classified as developed or undeveloped. Undeveloped properties included vacant land and farms. For parcels in the developed category, each was assigned one of five land use categories based on its zoning category and land use attributes from the parcel assessment records. The five categories were:

1. Low Density Residential
2. Medium Density Residential
3. High Density Residential
4. Commercial
5. Industrial/Office/Institutional.

Spot checks for the assessment were conducted by comparing recent aerial photography (2010) of the Study Area with the assessed land use. In addition to the zoning and parcel land use attributes, Union County provided a list of parcels that had applied for tax deferral based on agricultural use. This list was used to categorize farm properties as undeveloped. Aerial photography was used to identify farm properties in Mecklenburg County and also to check for other farms in Union County that were not included in the farm deferral list provided by the County.

Once each parcel was assigned to one of these five development categories or the undeveloped category, the parcel polygon feature class was converted to a raster image. A raster is a rectangular grid where each cell or pixel within the grid represents one unit of area and contains a value (which in this analysis represents land use). For this analysis, all rasters were formatted with a 30x30 meter cell size to match the NCGAP land cover dataset. Each raster cell is a 30x30 meter square, or about one quarter of an acre. For undeveloped properties, the NCGAP raster dataset was used to fill in the natural and farm land covers within those areas. Since parcels do not cover all land in the Study Area, a provision had to be made to account for areas outside parcel boundaries. Since nearly all land not included within a parcel boundary is a road right-of-way, these areas were categorized as transportation uses. Figure 4 illustrates how the existing land use raster was developed. It shows for an example area how the parcels were categorized and converted to a raster and then the undeveloped areas were filled in with the NCGAP land cover.

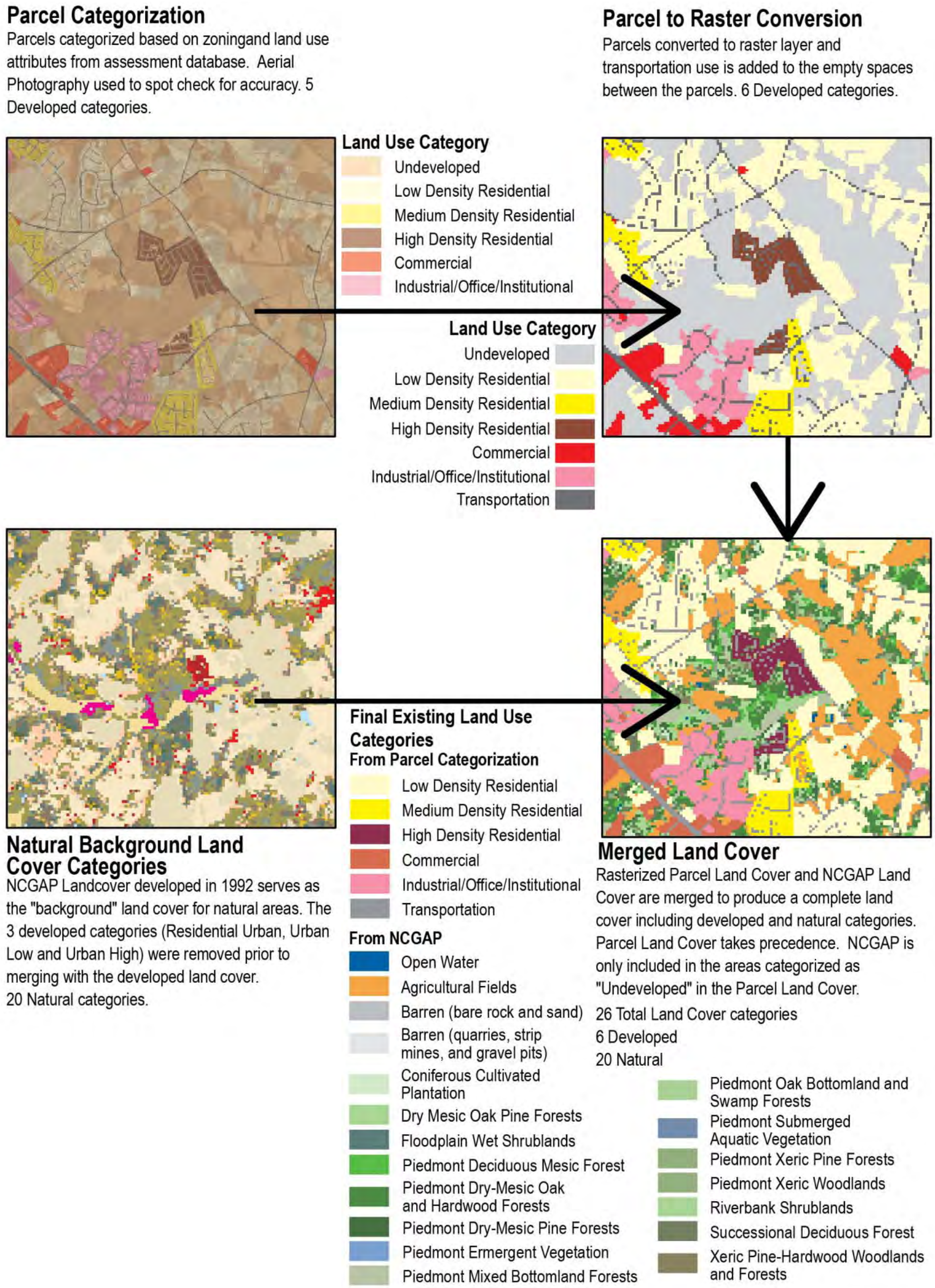
The resulting land cover is a raster image consisting of over 900,000 individual cells, each cell categorized into one of 26 land use categories. The 26 land cover categories consist of: 5 developed

[10] The Gap Analysis Program is a national program with the mission of developing key datasets needed to assess biological diversity across the nation. The North Carolina Gap Analysis Project (NCGAP) was a state affiliate based at the North Carolina Cooperative Fish and Wildlife Research Unit and charged with developing those data for the state. A map of North Carolina's land cover was developed using Landsat TM satellite imagery acquired in 1991 and 1992.

categories, 1 transportation category, 2 farm categories, 16 vegetation categories from the NCGAP land cover, and 2 barren categories from the NCGAP land cover. Existing land use, or Baseline condition, is presented in Map 3. To simplify the display of the land cover, many categories have been aggregated into larger categories in Maps 3, 16 and 18. These aggregated categories are:

- Agricultural Fields: includes both the Agricultural Fields and the Agricultural Pasture/Hay and Natural Herbaceous.
- Barren: includes both Barren (bare rock and sand) and Barren (quarries, strip mines, and gravel pits).
- Forested: includes Coniferous Cultivated Plantation (natural / planted), Successional Deciduous Forests, Piedmont Xeric Pine Forests, Piedmont Dry-Mesic Pine Forests, Piedmont Xeric Woodlands, Piedmont/ Mountains Dry-Mesic Oak and Hardwood Forests, Piedmont Mesic Forest, Xeric Pine-Hardwood Woodlands and Forests.
- Other Natural: includes Piedmont/Mountain Submerged Aquatic Vegetation, Piedmont/Mountain Emergent Vegetation, Riverbank Shrublands, Floodplain Wet Shrublands.

Figure 4: Land Use Categorization Process



3.0 REVIEW OF SOCIOECONOMIC PROJECTIONS

To assess potential impacts from induced development, two future land use scenarios are needed: a No-Build that reflects the future without the proposed project and a Build that reflects the future with the proposed project. Research on induced growth impacts of transportation investments indicates that typically induced development impacts fully arise within eight years of the opening of new roads or new capacity.[11] Therefore, if the proposed project is expected to be open to traffic before 2020, a 2030 horizon year would be an appropriate and reasonable analysis year. Since the prior Quantitative ICE analyzed 2030 conditions, it would also be appropriate to maintain that analysis year to make comparisons easier.

Since the Quantitative ICE analysis is looking at land use changes at the watershed level, the next question is how to estimate future growth under either scenario at that level of detail. Many entities, such as state level demographic agencies, private forecasters such as Woods and Poole, and even universities, produce projections of population and employment at the county, regional or state level, and these projections could be used to estimate growth in the study area. However, none of these sources provide detail on where that growth may occur below the level of individual counties. Metropolitan Planning Organizations (MPOs) develop similar projections of population and employment and, due to their federally mandated planning efforts, their projections typically include much smaller geographic divisions. MPO projections, therefore, represent the best available resource for population and employment projections at the necessary geographic and temporal scales to reasonably estimate quantitative land use impacts of transportation projects.

3.1 What Is an MPO?

MPOs have been required under federal law since the early 1970s. Federal regulations requires any Census Bureau defined urbanized area (UZA) of at least 50,000 people to have an MPO to develop regional transportation plans and programs through a continuing, cooperative and comprehensive (3-C) transportation planning process (23 U.S.C. 134 and 135). An MPO is required to develop a number of planning documents to guide the planning and funding of transportation improvements across the metropolitan region. To address the long-range transportation needs of a region, MPOs are required under federal regulations to estimate and accommodate the mobility needs for persons and goods in their Metropolitan Transportation Plans (MTP). This requirement, therefore, necessitates estimating the long-range travel needs of their respective regions. As such, most MPOs use some form of travel demand modeling to estimate the long-range travel needs for their regions and help in addressing other policy concerns such as transportation conformity (through emissions estimates), estimation of freight movement and of non-motorized trips. Most MPOs, including those in the Charlotte region, use a standard four-step travel demand model while a few MPOs have begun using more advanced modeling techniques such as activity-based models.

What Is the Metrolina Regional Travel Demand Model and How Does It Relate to the MPO Projections?

The main reason that MPOs prepare regional socioeconomic projections is to operate a regional travel demand model (TDM). The TDM is used to project future travel demand for use in transportation planning activities. In the Metrolina region, the TDM is called the Metrolina Regional Model (MRM).

[11] Cervero, Robert. "Road Expansion, Urban Growth and Induced Travel: A Path Analysis." *Journal of the American Planning Association*. Vol. 69, No. 2. Spring 2003, p 158.

This model is used for the four major tasks that MPOs must complete as part of their federally mandated planning responsibilities:

1. Identifying existing transportation conditions and deficiencies on the major segments of the transportation network within the region
2. Identifying future transportation conditions and deficiencies on the major segments of the transportation network within the region
3. Prioritizing projects for inclusion in LRTPs and a plan of implementation for inclusion in the Transportation Improvement Plan
4. Demonstrating conformity to the National Ambient Air Quality Standards established by the U.S. Environmental Protection Agency (EPA), under the Clean Air Act, for the EPA designated non-attainment area(s) within the region (also known as the air quality conformity process).

Based on the *Metrolina Regional Travel Demand Model Memorandum of Agreement* (Appendix D), the Charlotte Department of Transportation (CDOT) is the custodian for the MRM and all its constituent parts (network files, socioeconomic data and projections, programming scripts, trip tables and any other files necessary to run the model). The MRM is the main tool used by state, regional and local planning agencies to assess regional travel patterns. The MRM covers the following areas, also shown in Map 4:

- Cabarrus-Rowan Metropolitan Planning Organization (CRMPO): Cabarrus and Rowan Counties
- Gaston Urban Area Metropolitan Planning Organization (GUAMPO): Most of Gaston County
- Mecklenburg-Union Metropolitan Planning Organization (MUMPO): All of Mecklenburg and most of Union County
- Part of the Lake Norman Rural Planning Organization (LNRPO): Iredell, Lincoln and Cleveland Counties and the remainder of Gaston County
- Part of the Rocky River Rural Planning Organization (RRRPO): Stanly and Anson Counties and the remainder of Union County
- All of York County and part of Lancaster County, South Carolina, including all areas within the Rock Hill-Fort Mill Area Transportation Study (RFATS, the MPO for eastern York County).

As custodian of the model, CDOT leads the model team and leads the model development and maintenance process, including all its constituent parts such as socioeconomic projections. Most CDOT staff members who oversee the model are also staff to MUMPO.

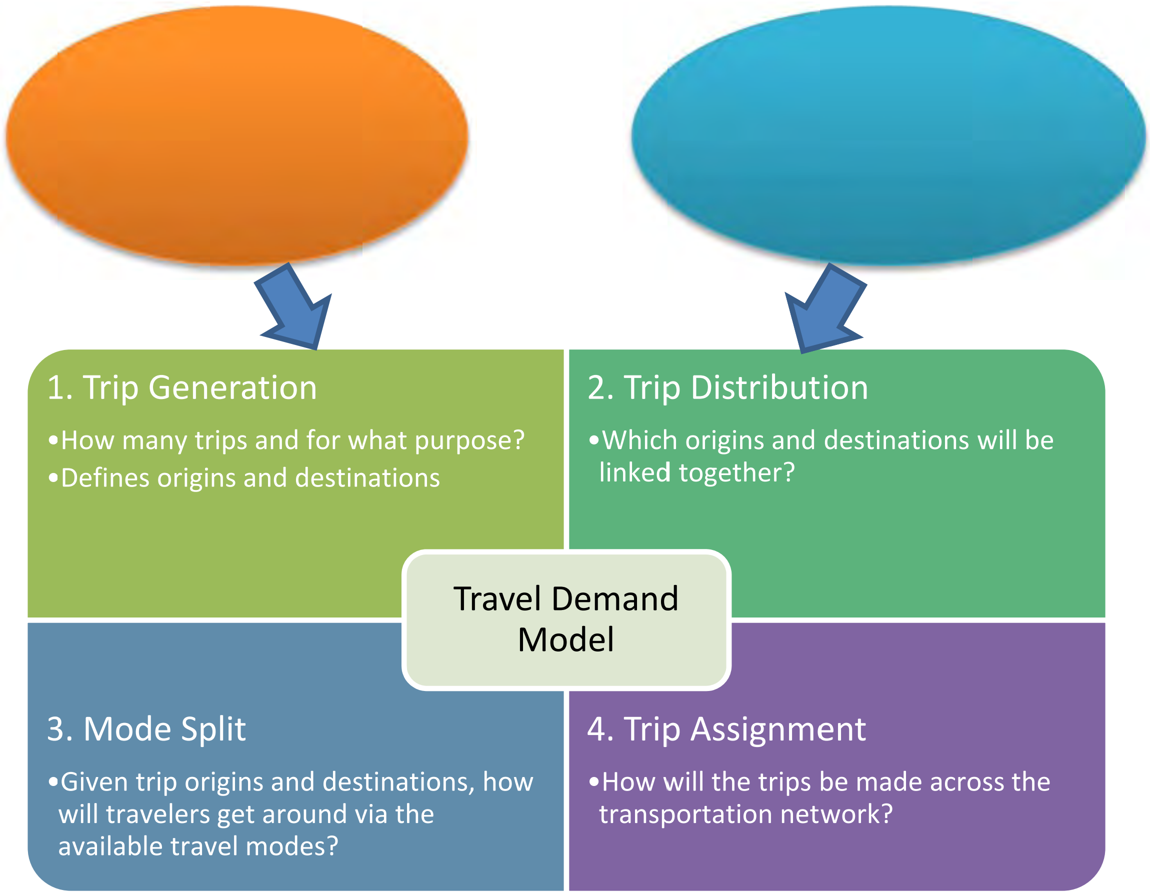
In addition to the above tasks, the MPO and others may use the travel demand model or its component parts to complete other planning or analytical tasks related to land use, transportation or environmental planning within the region. Often, in completing the necessary environmental studies, DOTs or others will use MPO socioeconomic projections and travel demand models for traffic forecasting or land use analysis as the MPO projections and travel demand models are often the only readily available source or tools available to complete the necessary analyses. As shown in Figure 5, the regional travel demand model is a "Four-Step Model" that uses the projections of population, households and employment as one key input file.

In most MPOs that use a Four-Step Model, the MPO develops the socioeconomic projections through some combination of projecting of historical trends, build-out capacity and other methods as appropriate for the specific region. To properly develop traffic forecasts, these socioeconomic projections must be provided at small geographic scales, thus the projections are allocated from a regional level, to a county level and finally to smaller geographic areas called Traffic Analysis Zones (TAZs). The TAZ projections typically include data for a base year (with data based on Census counts and other survey resources) and future horizon years based on the MPO forecasting process. The data for each year typically includes, for each TAZ,

- the number of households
- number of persons within households
- number of persons within group quarters (i.e. dorms, prisons or other non-household living arrangements)
- median income for households
- the number of students (sometime divided into sub-categories by age group)
- number of employees (typically divided into multiple sub-categories by type of employment).

The regional travel model uses this data in Step 1 of 4 to predict how many trips and what type of trips are generated in each TAZ. The MRM TAZs for the Future Land Use Study Area (or FLUSA, the study area defined for the purposes of the ICE report) are shown in Map 5 to provide a sense of scale for these important geographic subdivisions. Also shown in Map 5 is the distinction between TAZs within the jurisdiction of MUMPO and those TAZs under the jurisdiction of another MPO or RPO. Of the 383 TAZs partially or fully within the FLUSA, 349 are within the jurisdiction of MUMPO, while the remaining 34 are under the jurisdiction of the Rocky River Rural Planning Organization (RRRPO). Each planning organization is the final authority of the socioeconomic projections at the TAZ level for the TAZs under its jurisdictions. As discussed in Section 3.2, the socioeconomic projections developed for the Metrolina region have been developed through an extensive and highly cooperative regional projection process.

Figure 5: Four-Step Travel Demand Model and Inputs



TAZs are delineated by the MPO working from Census data on population and employment and criteria set by the FHWA. These criteria recommend minimum populations of 600 persons or workers but they generally recommend approximately 1,200 persons or workers per TAZ. Additionally, FHWA recommends or requires that TAZs meet the following criteria[12]:

- Compactness: TAZs should be compact in nature.
- Nesting and boundaries: TAZs must nest within a county and must not cross county or state boundaries. Where possible, TAZs should follow city or town boundaries.
- Maximize contiguity: TAZs should be contiguous across each county without any missing slivers.
- Include all water and land: TAZs must include all area within the territory of a county; water bodies must be part of a TAZ.
- Unique and identifiable: TAZs must have unique identifiers and each MPO must have a unique identifier.

A TDM generates trip "productions" based on household location and characteristics, and trip "attractions" based on the employment data, which represent not only job destinations but also shopping

[12] FHWA CTPP Data Products. March 2010. "*TAZ Delineation Business Rules*."
http://www.fhwa.dot.gov/planning/census_issues/ctpp/data_products/tazddbrules.cfm

and other activities that attract household trips. The overall number of productions and attractions are balanced, providing a set of trip origins and destinations, which is then taken into Step 2 of the Travel Demand Model for Trip Distribution – the linking of the origins and destinations into trips. At this point, the model begins to use a separate input file that represents the network of available roadways in the region, including data about the capacity, speeds, and other characteristics of each road or highway.

Other modes of transportation such as public transit are also taken into account in Step 3 of the model, which estimates the division of all trips across the available travel modes. The final "loading" of trips onto the network happens in an iterative process in Step 4 of the model, in which trips are distributed across all of the roads in the network and the impacts of congestion on travel patterns are incorporated.

What is both important and relevant to the ICE analysis process is the fact that the socioeconomic projections (the projection of where population and employment will be in the future) are a distinct input to the travel demand model from the transportation network. Consequently, the extent to which the socioeconomic projections represent the land use impacts of any given project cannot be answered by solely looking at the transportation network used in the travel demand model or its outputs. Instead, it requires examining the process and data used by the MPO in developing the population and employment projections. The assumptions behind the MRM socioeconomic projections are discussed below.

3.2 How Did the MPO and CDOT Develop the Projections?

It is important to note that regional socioeconomic models and projections are somewhat fluid in their development. Factors and variables may be created in the development stage that are either applied narrowly or omitted due to data limitations or other aspects of the extremely complex process of creating future land use projections at regional, county, and TAZ levels. This is one factor that caused confusion in the past quantitative ICE analysis and which could persist in spite of the additional information provided here. As such, it is necessary not only to conduct a very careful review of how the models were designed, but more importantly, how they were ultimately used in developing socioeconomic projections. This is necessary in order to understand fundamental questions regarding the role of the Monroe Connector/Bypass in the ultimate socioeconomic projections. For this reason, the following discussion reviews not just the model processes, but also reviews the model results and includes information from CDOT, who created and applied the many of these models. These reviews are needed to understand the true meaning and bases of the regional projections and to develop a full understanding of the projections and their appropriate use in other analyses.

Review of Projection Versions

As custodian of the MRM, CDOT and MUMPO staff oversaw the various regional socioeconomic projection processes and updates that have occurred over the last decade. As the discussions below shows, the projection process is a continuous and evolving process, so it is important to document exactly which datasets are used for any different purposes and different planning efforts.

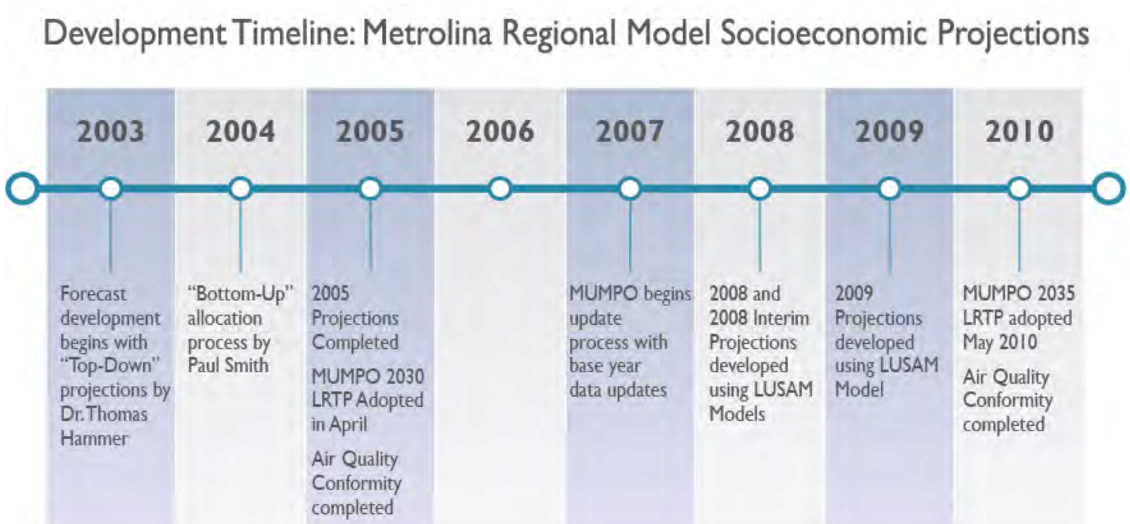
The current MRM 2011 v 1.1 uses projections finalized in 2009 and is used as the basis for air quality conformity approvals for the 2035 Long-Range Transportation Plan (LRTP) adopted May 3, 2010. These current projections (hereafter called the 2009 Projections) were the latest update to projections that were first developed beginning in 2003. Table 4 summarizes the various socioeconomic projections, the associated file naming conventions, the month and year the projections were completed, associated MRM versions and the base and horizon years for each socioeconomic projection dataset. Figure 6 shows the timeline of when the projections were developed relative to the adoption of each MUMPO LRTP. The Projection Names shown in the table and figure are not an official name but are used in this document for ease of reference. Each socioeconomic projection dataset includes projections for ten-year increments, with five-year increments interpolated between horizon years. Thus for the 2009 Projections (which were used in the 2035 LRTP), the horizon years were 2015, 2025 and 2035, but interpolated projections were also available for 2020 and 2030. Similarly, for the 2005 Projections (which were used in the 2030 LRTP), the horizon years were 2010, 2020 and 2030, but interpolated projections were also available for 2015 and 2025.

In the 2003-2004 timeframe, MUMPO and its regional partners at other MPOs and Rural Planning Organizations (RPOs) prepared the TAZ-level 2030 projections of population, households and employment in support of the development of the 2030 LRTP. The projections originally developed for this purpose were completed in 2005 and became the projections used in the official Metrolina Travel Demand Model 2005 version 1 (MRM05v1) and all versions of the model through MRM06v1.1.

Table 4: MRM Socioeconomic Projection Versions

Projection Name	TAZ File Name	Projections Completed	Use for LRTP Conformity Determination	Associated Model Version	Base and Horizon Years
2009 Projections	SE_*Year*_091028	October 2009	MUMPO 2035 LRTP	MRM 09 v1.0 MRM 11 v1.0 MRM 11 v1.1	Base: 2005 Horizon: 2015, 2025, 2035
2008 Interim Projections	SE_*Year*_081119_ MUMPO_interim	November 2008	None	None	Base: 2005 Horizon: 2015, 2025, 2035
2008 Projections	SE_*Year*_081024	October 2008	RFATS 2035 LRTP	MRM 08 v1.0	Base: 2005 Horizon: 2015, 2025, 2035
2005 Projections	SE_*Year*_taz2934	April 2005	MUMPO 2030 LRTP	MRM 05 v1.0 MRM 06 v1.0 MRM 06 v1.1	Base: 2000 Horizon:2010, 2020, 2030

Figure 6: Timeline of MRM Projection Development



Subsequent to the adoption of the 2030 LRTP, MUMPO conducted an update process for their projections in 2008-2009 and extended their projections to 2035. These updates used the 2005 Projections as a critical input as described below. All of these updates used a spreadsheet model system called a Land Use Allocation Model (LUSAM) to develop the 2008 and 2009 Projections. The details of this process are described in later sections.

The first of these updates was completed and incorporated into MRM 08 v1.0, which was the official model used to support the 2035 LRTP for the Rock Hill-Fort Mill Transportation Study Area. CDOT continued to update the regional projections based on new information and developed interim projections in 2008 for use in the Northeast Transit Corridor planning process. These projections are known as the 2008 Interim Projections. These projections were further updated and finalized in 2009 and eventually incorporated into the 2035 LRTP adopted May 3, 2010 and modeled using Metrolina Travel Demand Model 2009 version 1 (MRM09v1). Subsequent Metrolina Travel Demand Model versions (MRM11v1, MRM11v1.1) also use these same projections.

The FEIS Quantitative ICE (developed in 2009 and completed in 2010) used the 2008 Interim Projections, as they were the most up-to-date projections available at the time of that analysis. Given that CDOT has updated its projections since that report, it would be most appropriate to use the 2009 Projections. The following sections describe the 2009 Projections and the various inputs and processes used to develop those projections, as well as describing the prior process for developing projections. The purpose of this review is to fully disclose and explain what, if any, impact the Monroe Connector/Bypass had on the 2009 Projections to determine the most appropriate way to use those projections in the update of the ICE analysis.

2008 and 2009 Projections (LUSAM Process)

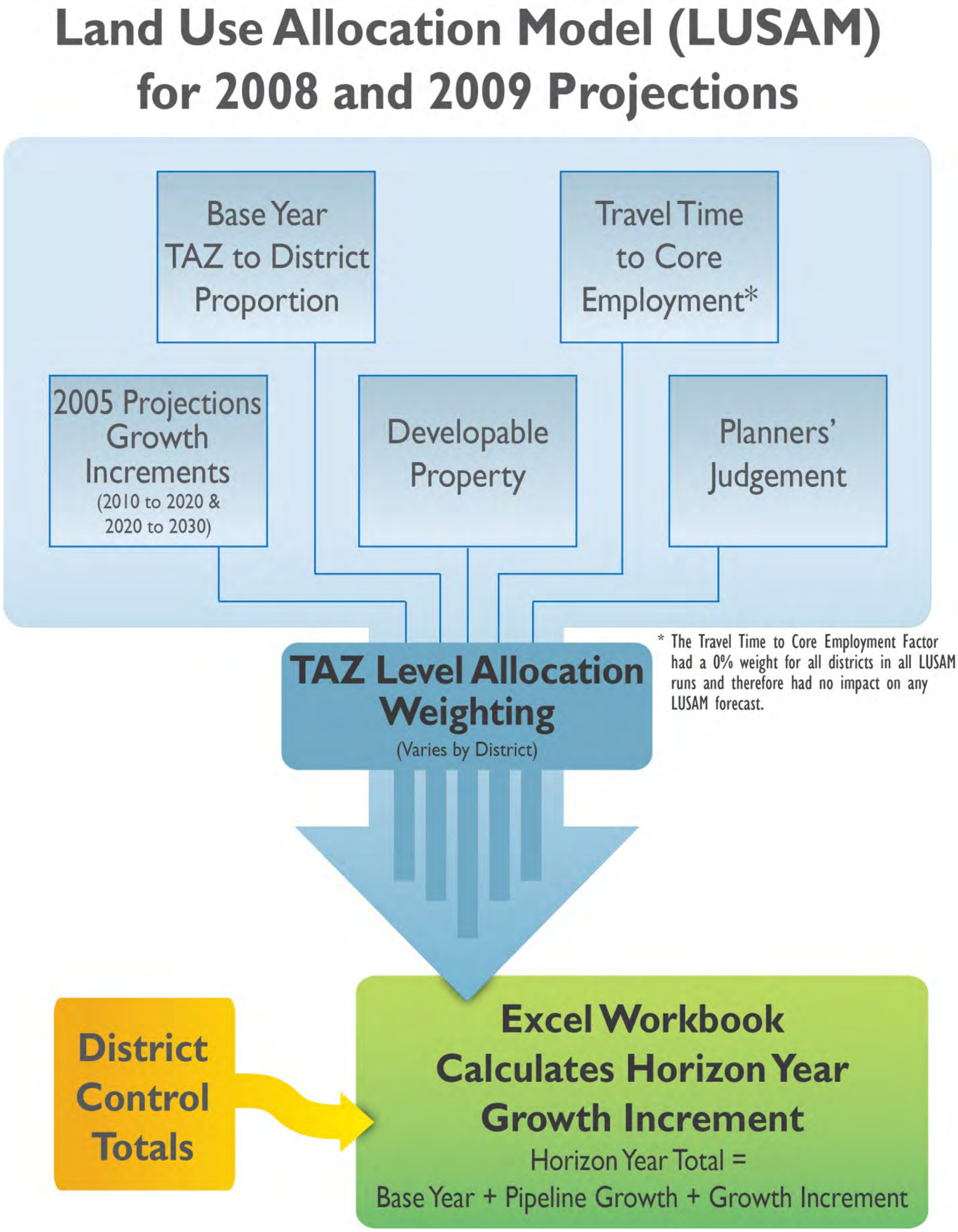
In 2008, CDOT, MUMPO and other regional MPOs began development of their 2035 LRTPs and in doing so, needed to update population and employment projections for 2015 and 2025 and develop a TAZ level projection for 2035. The initial step was to develop the socioeconomic base year of 2005 by reviewing recent development activity and updating TAZ level data on households, population and employment estimates as of 2005. Next, CDOT staff developed a spreadsheet model system called a Land Use Allocation Model (LUSAM) to consider multiple factors as part of the projection process. CDOT documented how the model worked in an internal draft document titled *Metrolina Regional Travel Demand Model LUSAM: Land Use Allocation Model Technical Documentation* dated December 4, 2007 (Appendix E).

The LUSAM model uses a number of inputs to generate the future projections of households and employment for each TAZ and uses a district level approach to determining the factors considered in the distribution of the households and employment to each TAZ. The LUSAM model requires TAZs to be grouped into districts with up to 32 districts defined in the model. This simplifies the process of entering model weights, targets and factors. The model outputs its horizon year projections in an iterative process, such that each horizon year projection builds upon the next. Each iteration requires the input of base year values. For the first iteration, which produced the 2015 projections, the 2005 base year was used as the base year in all LUSAM model runs. For later LUSAM model iterations, the prior model output was used. Thus, for the 2025 horizon year, the 2015 output would be input as the base year and for the 2035 horizon year, the 2025 output would be input as the base year. The LUSAM model uses a district level targeting approach, where target household, population and employment values are set for each horizon year and the model attempts to adjust the projections such that the totals for the TAZs within each district would equal the district target. LUSAM aggregates the base TAZ data into the same districts as the targets. The difference between the target and base is allocated by percentages to the TAZs within the district and a new TAZ land use dataset is created. These targets were developed independent of the LUSAM model and the inputs to those are discussed later.

Figure 7 provides a visual representation of the LUSAM model process. The model would use up to five weighted factors to determine how to allocate the district level target of growth to each TAZ within the district. The growth increment would then be added to the base year plus the pipeline growth (the number of households or jobs under construction or approved for construction) to yield to total for the horizon year. The five factors available in the LUSAM workbook are described below; however, as applied in the projection process, <u>not all factors were used</u>:

- **2005 Projections Growth Increment:** The change (growth) over time from an earlier projection (e.g. – projections for a new 2015 dataset would use the same growth allocation as an earlier projection between 2010 and 2020). In practice, the 2005 Projections growth increments for 2010 to 2020 and 2020 to 2030 were used as the input for this factor. Thus, the 2008 Interim and 2009 Projections relied on the growth increments in the 2005 Projections.
- **Base Year Proportion:** The same proportion of TAZ to District as in the base TAZ file (e.g. if TAZ “1” has 100 retail employees of the 1000 retail employees in the district – it would receive 10 percent of all new retail employees)
- **Developable Property:** This is based on an estimate of households or jobs per acre (and total acres). Relative development density is a primary input to this category. It differs across categories and across geographies, for example, employment density by acre is considerably higher in the center city than in suburbs.
- **Travel Time to Core Employment:** The estimated travel time to downtown Charlotte under peak highway congestion conditions. This factor was inverted as shorter travel times are preferred over longer. <u>In the LUSAM Models for the 2008 Interim and 2009 Projections the weight applied to this factor was zero. Therefore, this factor was never used</u> (See Appendix F and G).
- **Planners’ Judgment:** A direct 1-5 scale rating that could be applied to specific TAZs to reflect highly popular or unpopular TAZs for residential or non-residential development.

Figure 7: Visualization of LUSAM Workbook Process



The LUSAM model also incorporated "Pipeline" data by TAZ. The number of households or jobs under construction or planned could be added to a specific TAZ. Similarly, known decreases, such as that for a factory being closed, could be subtracted from a particular TAZ. Pipeline data would be added or subtracted to the base prior to allocation from districts.

The LUSAM model allowed for a weighting of the factors by each district. Thus, one district could have its entire weight based on the previous projections while another could have its entire allocation weight based on planners' judgment. The basic allocation equation is essentially the same for all categories and households are used in the example below.

$$
\begin{aligned}
& HH\_future_{taz} \\
& = HH\_base_{taz} + HH\_pipeline_{taz} \\
& + (HH\_t\arg et_{dist} - (HHbase_{dist}\_HH\_pipeline_{dist})* \\
& (Wgt1*(\Delta HH\_y2-y1_{taz}/\sum \Delta HH\_y2-y1) \\
& + Wgt2*(HH\_base_{taz}/\sum HH\_base) \\
& + Wgt3*(Vacant\_res_{taz}/\sum Vacant\_res) \\
& + Wgt4*(TravTime_{taz}/\sum TravTime) \\
& + Wgt5*(PlannersJudgment/\sum PlannersJudgment))
\end{aligned}
$$

Where:

HH_future_{taz}	Future (projection) year TAZ households
HH_base_{taz}	base year TAZ households
$HH\_pipeline_{taz}$	Pipeline households added to TAZ between base year & future year
$\Delta HH\_y2\text{-}y1_{taz}$	Change in no. of HH in TAZ between y1 and y2 in "old" projection set
$\sum\Delta HH\_y2\text{-}y1$	Change in no. of HH in district (sum of all TAZ) between y1 and y2 in old projection set
HH_base_{taz}	No. of base households in district
$\sum HH\_base$	Sum of base households for district
$Vacant\_res_{taz}$	Vacant residential acres for TAZ
$\sum Vacant\_res$	Sum of vacant residential acres for district
$TravTime_{taz}$	Reciprocal of travel time to core employment for TAZ
$\sum TravTime$	Sum of reciprocal of travel time to core employment for district
$PlannersJudgment_{taz}$	Planners Judgment value (1-5) for TAZ
$\sum PlannersJudgment$	Sum of Planners Judgment values for district
Wgt1 … Wgt5	Weights (0 – 1 for each factor, weights must sum to 1.0)

The 2008 Projections were the first projections developed using the LUSAM methodology. These projections were developed and used for the Rock Hill-Fort Mill Area Transportation Study 2035 LRTP air quality conformity analysis. The 2008 Projections were not used for any planning purposes within the MUMPO or RRRPO regions. Also, these projections were not used in development of the 2008 Interim or 2009 Projections, either. Therefore, they were not analyzed as part of this report.

The 2008 Interim Projections were the projections provided to NCTA for use in the FEIS Quantitative ICE analysis. The LUSAM input and output sheets for the 2008 Interim Projections are provided in Appendix F. The model inputs show that for the 2008 Interim Projections the major focus of adjustment was on Mecklenburg County, with the remainder of the region largely relying on the growth projections from the 2005 Projections to guide the LUSAM adjustments. <u>Of the factors in the model, the Travel Time</u>

to Core Employment is not used at all for any district for any horizon year. For all areas outside Mecklenburg County, the previous projections (2005 Projections, which were used in the 2030 LRTP) were the main factor in the household and population projections. For employment projections outside Mecklenburg County, the previous projections had the highest weighting but some weight (10-25 percent) was placed on the estimate of available land and densities. Within Mecklenburg County, projections of households and population were based on a mixture of the previous projections, available land and density and planners' judgment, with the exact weighting varying from district to district within the county.

The 2009 Projections are the most recently completed projections that have been fully adopted and used in regional air quality conformity analysis. These projections are very similar to the 2008 Interim Projections and, in fact, LUSAM runs were only used in Mecklenburg County to adjust between the 2008 Interim Projections and the 2009 Projections. The LUSAM input and output sheets for the 2008 Interim Projections are provided in Appendix G. Only minor adjustments were made in Union County and only to employment. Within Mecklenburg County, projections of households and population were based on a mixture of the previous projections, available land and density and planners' judgment, with the exact weighting varying from district to district within the county.

To illustrate how the LUSAM workbook produces the projections, Figure 8 shows the LUSAM process with district targets and changes for household projections for all TAZs in the Marshville District for the 2015 horizon year from the 2009 and 2008 Interim Projections LUSAM Model run. The example is somewhat simplified as there are no pipeline household adjustments and 100 percent of the weight is on the Old Projection factor. Pipeline households would be any planned or under construction households in a TAZ. The process begins with the base year households, which are the number of households in each TAZ in 2005. The model then adds the pipeline households to the base year households. Next, the model works to distribute the households from the district level targets to the TAZ level using the weighted factors. In the example of Marshville, the full weight is placed on the distribution from the Old Projections (the 2005 Projections used in the 2030 LRTP). Thus, in the example shown below, TAZ 9333 captures 16.1 percent of the district household growth in the Old Projections. Thus, it receives that same percentage of the district household growth from the new, targeted growth (16.1% x 344 = 55 households). Thus, the household projection for 2015 for TAZ 9333 is 531 households.

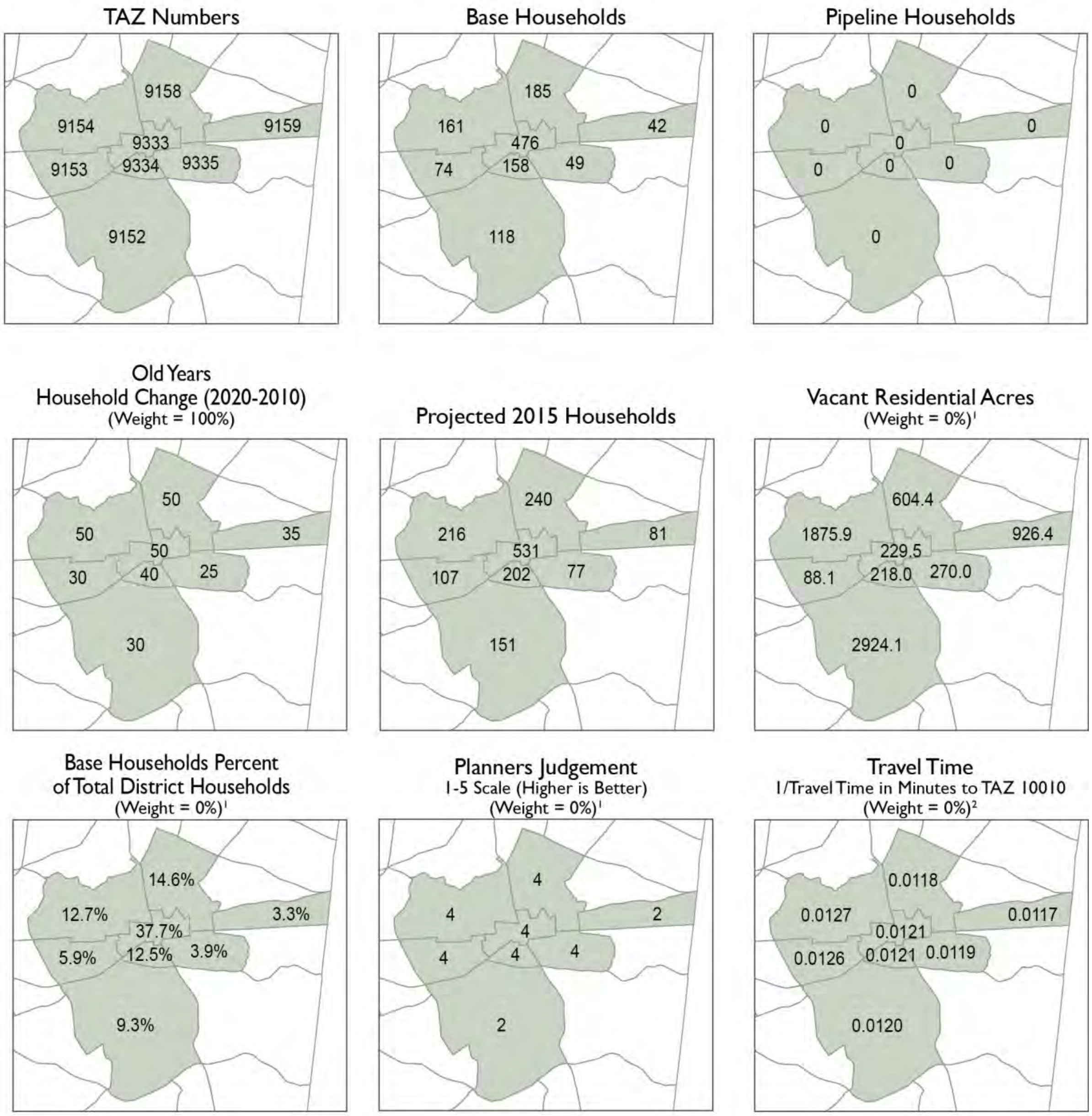
Based on these inputs and the LUSAM process, the Monroe Connector/Bypass could only have affected the LUSAM model through four possible inputs:

- The Planners' Judgment Factor
- The Travel Time to Core Employment Factor
- The Old Projections Growth Increments Factor (2005 Projections)
- District Level Targets.

As discussed above, however, the Travel Time to Core Employment Factor was not used (its weight was zero percent) for any LUSAM runs. Furthermore, the Planners' Judgment Factor was not used at all in Union County for any LUSAM run. Thus, based on the weighting of factors, the Monroe Connector/Bypass could not have influenced the projections through these two factors.

Thus, to fully assess whether the 2008 Interim or 2009 Projections were affected by the Monroe Connector/Bypass, one must fully understand the 2005 Projections (since the allocation of those projections guided the allocation of the newer projections) and the District Level Targets.

Figure 8: LUSAM Example, Marshville, 2009 and 2008 Interim Projections, 2015 Horizon Year



Marshville District		Marshville District Old Projections	
2005 Base HHs	1,263	2010 Projected HHs	1,415
2015 Target HHs	1,607	2020 Projected HHs	1,725
Difference	344	Difference	310

TAZ 9333 Example Calculation

2005 Base HHs + Pipline HHs + ((Old Years$_{TAZ}$/Old Years$_{Dist}$) x HH_Target$_{Dist}$) = 2015 HH Projection

476 + 0 + ((50 / 310) x 344) = 531 HHs

[1] These factors were not used at all in Union County for the 2008 Interim or 2009 Projections. These variables were used in Mecklenburg County projections with the weights varied by district.

[2] While the LUSAM includes values for the Travel Time to Core Employment factor, the factor was not used for any projection. The weight applied to it in all cases was 0%. It is shown here for the purposes of full transparceny. For full details please see Appendicies B, C and D.

Development of the 2005 Projections (Used in the 2030 LRTP)

The 2005 Projections (which were used in the 2030 LRTP) were developed through a process with three main components, a Top-Down projection, a Bottom-Up projection and input from an advisory group on the final projections. Each component in the process had a key role, as shown in Table 5. The development of the TAZ-level projections relied first on the Top-Down process to project future growth at the regional level and then allocate the regional growth to the county level. A subsequent Bottom-Up process allocated the county-level growth to the TAZ level within each county. Different parts of the Metrolina region used different approaches to the Bottom-Up process, but for the MUMPO area, which included most of Union County, a process prepared by Paul Smith of UNC-Charlotte provided the initial allocation. As was the case with the Top-Down projections, the Bottom-Up steps used input from local planners and jurisdictional representatives to review and refine the projections prior to adoption.

Table 5: Roles, Factors and Accessibility Considerations of the MRM Socioeconomic Projection Process Components

<table>
<tr><th></th><th>Roles</th><th>Projection Factors</th><th>Accessibility Considerations</th></tr>
<tr><td rowspan="2">Macroeconomic (Top-Down) Projections

Completed by Dr. Thomas Hammer</td><td rowspan="2">Projects regional household, population and employment totals and sets county level control totals</td><td>Regional Projection
National population and employment trends linked by economic sector to regional trends</td><td>None</td></tr>
<tr><td>County Level Allocation
Past economic and demographic trends
Economic and demographic conditions (as of 2003)
Influence of income on growth
Proximity
Land availability
Past land use and infrastructure policies</td><td>Explicitly includes two major road projects:
• NC 16 Freeway to Lincoln County
• Garden Parkway

Only considers proximity in linear terms (county centroid to county centroid); no use of roadway networks</td></tr>
<tr><td>Household and Employment Allocation: (Bottom-Up) Process

Completed by Paul Smith, UNC-Charlotte</td><td>Distributes growth from county-level to the Traffic Area Zones level</td><td>Developable Residential Land
Redevelopable Residential Land
Recent Population Change
Travel Time to nearest Employment Center
Water Availability
Sewer Availability
Expert Panel (High Growth Areas)
Growth Policy Factor</td><td>Considers travel time from each TAZ to the NEAREST employment center, NOT regional employment centers

Uses the TDM network, including the Monroe Connector/Bypass, but only in travel time to nearest employment calculations for final period (2020-2030).</td></tr>
<tr><td>Advisory/ Expert Input</td><td>County representatives agree on final county totals based on Top-Down process

Local planners refine the Bottom-Up allocation based on adopted plans and local land use expertise; serves as a reality check on the allocation</td><td>Discretionary</td><td>Reflects local advisors' expectations (in 2003-2004) of whether new roads would be built

Reflects the assumptions in adopted land use plans at the time regarding the anticipated road network</td></tr>
</table>

Regional Socioeconomic Projection and County Level Allocation (Top-Down Process)

The process to develop regional socioeconomic projections and allocate them to the county level (known as the Top-Down process) was a rigorous, research-based approach to developing a regional and county level projection of households and employment. Led by Dr. Thomas Hammer and documented in his report to the region titled *Demographic and Economic Forecasts for the Charlotte Region* (hereafter referred to as the "Hammer Report" and incorporated into this report as Appendix H), Dr. Hammer developed a long-range regional growth projection based on economic factors in the Charlotte region.

Dr. Hammer described his model as a demand-side model where the model determined economic employment (earnings) from a breakdown of different employment groups based on their link to national employment trends. The model also assumed by 2030, population demographic changes would constrain regional earnings. His report described large transportation projects and public policy land use or development controls as supply-side factors that do not necessarily contribute to the growth demand, but act as limits or constraints to where growth might occur at smaller scale projections.[13] Therefore, Dr. Hammer's projections were not sensitive to large transportation projects such as the construction of the Monroe Connector/Bypass. Therefore, his methods and approach would not be appropriate to model potential indirect and cumulative effects and thus other methods were used as described in Section 4.

Dr. Hammer's process started with descriptions of the national economy and regional economy to quantitatively link the economies based on worker earnings, referred to as employment. His modeling broke the regional economy into a 42-industry classification scheme to quantitatively link to the national economy. The procedure separated employment in each regional industry into a "basic" component and a "population-serving" component to quantitatively link the regional industry employment trends to national industry employment trends. Separate quantitative analysis was performed to create a linkage between the basic component of employment between the regional and national trends and the "population-serving" component of employment between the regional and national trends. The two separate quantitative linkages were combined to develop overall industry profiles for the region. Demographic projections were obtained by finding a regional population profile for each future year that yielded a labor force consistent with expected employment level.[14] The process yielded region-wide employment and demographic totals that became control totals to help determine where in the region the overall growth would occur.

The region-wide employment and household totals were allocated among the counties and districts with the aid of 35 equations to identify factors used in the determination of county level growth shares of the regional industry growth total. These equations included three for demographic variables of upper, middle and low-income housing, and 32 equations for employment by sector. These equations were calibrated on the experience of 227 counties in 29 separate U.S. metropolitan areas chosen for their comparability to the Charlotte region. The modeling allocation process also included factors such as available land in each county and location proximity between employment and households. The location proximity was incorporated by weighting an inverse function of distance to the county for which a variable was being measured to another county. However, the model omitted such supply side factors of large-scale transportation projects, new land use policies and provision of infrastructure, and natural land constraints

[13] Appendix H, p 10
[14] Appendix H, p 7

on development. Table 6 summarizes Dr. Hammer's description of the capacity of his projection and allocation model to capture growth influences.

Table 6: Capacity of Allocation Model to Capture Growth Influences

	Demand Side	Supply Side
Growth Factors Covered	• Past economic & demographic trends • Existing economic & demographic conditions • Economic-demographic linkages • Influence of income on growth patterns • Location	• Land area and land availability (as estimated on the basis of development magnitudes) • Past land use and infrastructure policies (to the extent they register in past growth)
Growth Factors Omitted	• Refinements o Some measures could be improved such as distance and area descriptors	• New or altered public policies governing land use and the provision of infrastructure • Large-scale transportation projects • Natural land constraints on development (if not strongly reflected in past growth)

Appendix H p 14

Dr. Hammer provided ranges of population and employment projections to account for variability and error in the model. He specifically noted, ". . . the upper and lower limits that express the ranges are specifically intended to express 90 percent or 95 percent confidence intervals. They cover only the year 2030, but could be extended to other years using the same proportions of past 2002 growth involved in their derivation"[15]. He obtained the upper and lower limits of growth by adding and subtracting amounts from the "most-likely" projection shown in Table 7.

> *The additions or subtractions at each geographic level equal a common percentage times the difference between the most likely values for 2030 and the actual values for 2002. Thus, the greater the expected growth, the wider the error margin, on the logic that unforeseen supply-side influences will operate mainly by reallocating growth rather than affecting urban development already present.*[16]

Dr. Hammer noted that different percentage margins are appropriate at different geographic levels, since the potential for error increases as area size decreases. He stated that "[s]mall margins are appropriate for the region as a whole because supply-side factors exert little influence at that scale." He calculated regional margins for population and employment by adding and subtracting 10 percent of the most likely 2002-2030 growth. He further noted that "[a]t the county level and district levels, the calculations involve larger downside margins than upside margins, on the argument that land use policies and environmental factors can have larger effect in diverting growth than in attracting development over and above location based demands." He obtained the county ranges from the 2030 most-likely projection, by applying a 25 percent deduction of the 2002-2030 most-likely growth and a 15 percent addition to the 2002-2030 most-likely growth.[17] Table 7 shows Dr. Hammer's 2030 population projection ranges.

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[15] Appendix H, p 66
[16] Appendix H, p 66
[17] Appendix H, p 66

Table 7: Dr. Hammer's Population Projection for the Charlotte Region

County	2030 Population		
	Lower	Most-Likely	Upper Limit
Anson County	36,967	40,847	43,175
Cabarrus County	247,142	283,115	304,699
Cleveland County	125,373	134,563	140,077
Gaston County	235,228	249,261	295,071
Iredell County	227,287	259,906	279,477
Lincoln County	113,206	128,857	138,247
Mecklenburg County	1,051,400	1,157,311	1,220,858
Rowan County	183,747	200,639	210,774
Stanly County	80,171	87,366	91,682
Union County	268,543	312,147	338,309
Cherokee County	83,228	93,168	99,132
Chester County, SC	52,278	58,306	61,923
Lancaster County, SC	91,781	101,680	107,619
Union County, SC	38,480	41,466	43,258
York County, SC	272,096	305,228	334,080

Appendix H p 67

Regional Projection and County Allocation (Top-Down Process) and the Monroe Connector/Bypass

Correspondence from interested parties suggests that Dr. Hammer's regional projections implicitly included the Monroe Connector/Bypass and therefore the regional projections should be used as the basis for a Build scenario or should be recalculated for the purposes of the Quantitative ICE.[18] Specifically, one comment suggests that Dr. Hammer's analysis assumed that there would be sufficient infrastructure available to accommodate any future growth and that this assumption implies that the Monroe Connector/Bypass is therefore assumed in the socioeconomic projections. As detailed above, supply side constraints were not a factor in Dr. Hammer's projections.[19] The following quotes from Dr. Hammer's report show that his process did not assume construction of the Monroe Bypass/Connector in projecting socioeconomic projections for the region or in allocation to the county level.

> *The strengths of the model approach include its objectivity and ability to capture a wide variety of relationships and spatial interactions. Its weaknesses derive from the severe limits on types of variables that can be feasibly collected for large sample model calibration. Because whole classes of variables must be omitted, the factors driving the model (other than regional totals) are limited to earlier values of the target variables themselves – i.e. to demographic and economic descriptors – plus functions of distance,*

[18] Letter from Southern Environmental Law Center to Jennifer Harris, NCTA, November 30, 2012, p 19.
[19] Appendix H, p 11

land area and density. The most important omissions are factors that typically must be measured at a fine-grain level of detail (and often are hard to quantify in a relevant fashion) such as land use controls, natural land characteristics and availability of infrastructure. Since these factors mostly affect the supply of land suitable for development, and since the factors that allocation models do cover are most predictors of development demand, the limitations of such constructs can be summarized by calling them demand-side models[20].

Two circumstances allow demand-side models to capture some supply-side influences. First such models can express the general role of land availability using crude measures that consider total land area (minus large-scale deductions like the military installations, wetlands and parks) and existing development density. Second because the model equations operate partly by extrapolation and are pegged to replicate past conditions in the subject areas, they implicitly cover all supply-side factors to the extent that future impacts of these factors equal past impacts.[21]

But what models of the given type cannot do is capture the influence of exceptionally large infrastructure projects or shifts to more or less stringent development controls. They basically assume that the tendency of public actions to restrict or encourage growth will resemble the conditions prevailing in the calibration period (at the present meaning the 1990s).[22]

Other comments from correspondence suggest that the "proximity factor" used by Dr. Hammer implicitly assumes an improved transportation network.[23] Dr. Hammer's proximity factor cannot include the transportation network. Since Dr. Hammer used the growth rates that occurred in the county between 1990 and 2000 to calibrate his model equations and there has been no controlled access freeways built in Union County in the last two decades, his projections, therefore, could not have assumed construction of a limited access roadway like the Monroe Connector/Bypass. Further, 2000-2010 growth that occurred in the region moved Union County's population rank among regional counties from sixth in 2000 to fourth in 2010. This growth occurred without a freeway. Thus, a freeway (even less so a toll-road), is not a factor contributing to the extremely high growth occurring in Union County. Rather Dr. Hammer describes major infrastructure projects as an influence that will operate by mainly reallocating growth rather than affecting the urban development that is already present.[24] As discussed in Section 3.3, this conclusion is not exclusive to the analytical work performed by Dr. Hammer.

Correspondence from interested parties also suggests that the county level population projections and employment projections should be re-calculated to exclude the Monroe Connector/Bypass.[25] Again, Dr. Hammer's model to allocate the region growth to County population and employment projections was not

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[20] Appendix H, p 10
[21] Appendix H, p 10-11
[22] Appendix H, p 11
[23] Letter from Southern Environmental Law Center to Jennifer Harris, NCTA, November 30, 2012, p 19.
[24] Appendix H, p 66
[25] Letter from Southern Environmental Law Center to Jennifer Harris, NCTA, November 30, 2012, p 19.

sensitive to a large-scale transportation project like the Monroe Connector/Bypass as he described in his report.[26]

> *In North Carolina, county-level forecasts from a calibrated allocation model should ordinarily be reliable – to the extent any forecast is reliable – with little or no adjustment for omitted supply-side influences. But supply-side factors gain potential importance at progressively smaller geographic scales, so the question is how far below the county level a model application should extend.*

Later in the report, Dr. Hammer notes how he adjusted outputs from the model to account for a particular major highway project that he believed would influence growth in a particular county.

> *The present approach is designed to avoid any need for ad hoc adjustment of results (other than systematic reconciliation with bottom-up, supply-side forecasts, if these are available). However, one after the fact adjustment has occurred here to improve the validity of the numbers in an area relevant for a particular planning project. The failure of the top-down forecasting procedure to acknowledge the impacts of special infrastructure development was judged a critical weakness in eastern Lincoln County, where the upgrading of Route 16 to a freeway will clearly yield growth increments over and above those predicted by demand-side model. This situation has been addressed by advancing the population forecast for one sub-district of Lincoln County from 2035 to 2025 and advancing the forecasts for two other Lincoln sub-districts from 2029 to 2025[27].*

Finally, explaining the ranges of population and employment projections shown in his tables, Dr. Hammer noted how he adjusted model results for the upper limit of the projections for East Gaston, Southwest Gaston, North York districts for the proposed toll road over the Catawba River.

> *The second factor is the possibility that a toll expressway will be constructed across the Catawba River to link southern Gaston County with western Mecklenburg. Such a facility would have substantial development impacts on East Gaston, Southwest Gaston, North York and the two counties in aggregate. These potential impacts are incorporated into the upper-limit population and employment values as explained in the footnotes to tables 11 and 12. Adjustments of this nature are not provided for the Route 16 freeway in Lincoln County because the impacts of this facility have already been incorporated into the forecasts, as discussed near the end of Section I. There are also not adjustments for completion of the I-485 beltway around Charlotte because it is not clear whether or how the beltway will alter district-level development patterns relative to what has already been predicted.[28]*

It should be noted that no changes were made to the "most likely" or "lower-limit" scenarios for Gaston and Mecklenburg Counties based on the proposed toll facility. In summary, Dr. Hammer's analytical approach estimated regional and county growth within the Metrolina Regional Travel Demand model

[26] Appendix H, p 11
[27] Appendix H, p 12-13
[28] Appendix H, p 69

area. This projection was designed to establish regional and county level household, population and employment control totals and as such was not influenced by projects that primarily impact accessibility within one county such as the Monroe Connector/Bypass. This means Dr. Hammer's regional and county projections would not have changed with or without the construction of the project.

MUMPO 2030 LRTP Household, Population and Employment Allocation Process (Bottom-Up Process)

In 2004, CDOT hired Paul Smith and his team from the UNC-Charlotte Center for Applied GIS to create a model to allocate households, population and employment from the county level to the TAZ level. The methodology of the process is described in Mr. Smith's report *Mecklenburg-Union Metropolitan Planning Organization Population Projections and Employment Allocations, 2000-2030* (Appendix I). Mr. Smith's process focused on the household (and by default population) allocation and the allocation of population-chasing employment. Population-chasing employment is that employment associated with retail and services that tend to follow population growth. Non-population-chasing employment was distributed solely based on the input of staff and expert panel participants. Mr. Smith's allocation process started with the county-level control totals developed in the Top-Down process, existing baseline data (2000), and the influence of the of land development factors chosen and ranked by expert panels. Within Union County there were eight land development factors used to assess the attractiveness and capacity of each TAZ in the county to draw future growth. These variables are listed in Table 8.

Table 8: Union County Land Development Factors

Factor	Weight by Year of Allocation		
	2010	2020	2030
Developable Land	3	3	3
Travel Time to Employment	3	3	3
Water	2	2	2
Sewer	2	2	2
Redevelopable Land	2	3	3
Population Change	3	1	Not used
Expert Panel	2	2	2
Growth Policy	1	1	1

Mr. Smith used a raster cell based analysis system where Union County was split into a set of 500 feet by 500 feet grid cells and the value for each land development factor was calculated for each grid cell. Each land development factor would also be normalized to a 0 to 1 scale and weighted so that all scores could be combined into a composite score. The composite grid scores were calculated for each cell and then averaged across each TAZ to calculate land attractiveness scores for each TAZ. The TAZ land attractiveness scores were used to derive the available residential acreage to be consumed during each allocation period. The 2005 Projections (which were used in the 2030 LRTP) were developed for 2010, 2020 and 2030. Thus for each allocation period (2000-2010, 2010-2020, 2020-2030) land development factors were calculated and normalized then weighted and the composite score calculated for each cell. Finally, for each TAZ, an average of the composite scores for all cells within each TAZ was calculated. Higher scores reflected higher attractiveness and would result in higher acreage consumed, until a TAZ reached its calculated maximum capacity. Allowable development densities per TAZ multiplied by the derived residential acres to be consumed were used to calculate the number of households in each TAZ. Historical household size was used to generate TAZ population at each allocation period. Existing development and available land acted as limits on further growth. Thus, while the available developable land served as a land development factor, it also served as a constraint in the model to ensure that growth in a TAZ was predicted within its capacity to accept development. Once the developable land within a TAZ was consumed, future development would be assigned to TAZs with lower composite scores in subsequent iterations. The land development factors and corresponding weights that were used in the Union County portion of the model are shown in Table 8.

The modeled predictions were subject to feedback and adjustment from the panel of experts. These experts reviewed and adjusted projections as documented in *Land Use and Socioeconomic Data and Projections for the Greater Charlotte* Region (Appendix J). No specific changes to household, population or employment projections are documented in Appendix J but the overall process of expert panel input is reviewed. Expert panel review is a common and recommended method in long-range projection to improve the acceptance of projections by political entities and data users.[29] Within Union County, however, no changes were made to the household and population projections as developed by Paul Smith at the TAZ level for the horizon years of 2010, 2020 and 2030. These projections were included as the socioeconomic projections for the adopted MUMPO 2030 LRTP.

Consultation with CDOT staff indicates that there was no influence from the Monroe Connector/Bypass on growth expectations associated with these projections (Appendix A). The travel time to employment factor did include the Monroe Connector/Bypass in the road network used to calculate travel times for the final period, but the assessment of CDOT staff was that the methodology used to calculate that factor would have minimized any impact of the Monroe Connector/Bypass on the 2005 Projections (which were used in the 2030 LRTP).[30] Furthermore, a review of Mr. Smith's results shows no indications of population or employment growth clusters along the project corridor. If the 2005 Projections had included growth expectations associated with the Monroe Connector/Bypass, one would expect to see higher than average population and employment growth and density in TAZs along the project corridor. There are no indications of such clusters of growth along the project corridor in Mr. Smith's results (Appendix I pp 42-67).

Review of the Travel Time to Employment Factor within the Bottom-Up Process

Since May 2012, NCTA has worked with CDOT staff and Paul Smith to reanalyze the travel time factor to determine if the factor affected the 2005 Projections (which were used in the 2030 LRTP) in a way that would indicate those projections include the induced growth effects of the proposed project. Specifically, NCTA engaged Paul Smith and CDOT staff in a reevaluation of the factor beginning in June 2012 and Paul Smith completed his analysis and reported his results to NCTA in September 2012.

The travel time to employment factor for Mr. Smith's model used an estimate of travel time to the nearest employment center. Mr. Smith defined an employment center as any location with 5,000 jobs within a ½-

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[29] Smith, Stanely K., Tayman, Jeff, Swanson, David A. *State and Local Population Projections: Methodology and Analysis.* Kluwere Academic/Plenum Publishers, New York, 2001. p 358

[30] Mr. Smith included the proposed project in his model as his travel time analysis for major roadways relied on speed data from the regional travel demand model in use at the time. The travel demand model in use at the time included the proposed project in its future year roadway network. See Appendix A (June 19th, 2012 discussion with CDOT Staff and follow up) for detail.

mile area. Travel time was calculated using a composite approach, combining travel speed information from the Metrolina Region Travel Demand Model (MRM), a GIS shapefile of existing roads and assumed walking speed of 2.5 miles per hour. [31] The MRM was used to estimate travel speeds for all roads within the MRM network. For the 2010 and 2020 horizon years, the 2010 model network was used and for the 2030 horizon year the 2025 model network was used. Using the speed assumptions above, travel times to the nearest employment center were then calculated for each horizon year (2010, 2020 and 2030). These travel times were then normalized to a 0 to 1 scale and averaged across each TAZ to determine the score for each TAZ.

The Monroe Connector/Bypass was included in the 2025 MRM network and thus the speed of that facility influenced the travel time to employment factor for the 2020 to 2030 period. Map 6 shows the original travel times calculated using this methodology. These travel times formed the basis of the original Travel Time to Employment Factor used in the Bottom-Up allocation process. As illustrated in the map and detailed in the discussion that follows, the Monroe Connector/Bypass does have a minor influence on the travel time used as an input to the Bottom-Up allocation process as indicated by the area of travel times of less than 10 minutes around the proposed project from Unionville-Indian Trail Road to Rocky River Road. The map also shows that many employment centers were used as destination points for the analysis in Mecklenburg and Union Counties. The closest employment centers within the FLUSA are at the following locations:

- US 74 and Rama Road in Charlotte
- Monroe Road and Sardis Road in Matthews
- US 74 at NC 51 in Matthews
- US 74 just west of Seacrest Short Cut Road in Monroe
- Downtown Monroe
- US 74 at Sutherland Ave in Monroe
- Along Secrest Avenue, north of US 74 in Monroe.

The methodology to calculate the travel time to employment for the Bottom-Up allocation calculated travel times to the *nearest* employment center, not to major destinations such as downtown Charlotte. The average distance from an employment center for the MUMPO study area Mr. Smith analyzed was only 3.8 miles, while the greatest distance was 14 miles. Thus, the methodology was a relatively localized analysis of travel time. Freeway type facilities, such as the proposed 20-mile long Monroe Connector/Bypass, tend to serve longer trip lengths. As such, the travel time to employment center analysis methodology would largely miss the travel time savings that would accrue to longer trips like those most likely to occur on the Monroe Connector/Bypass. Lastly, the location of the employment centers Mr. Smith used relative to the Monroe Bypass/Connector would tend to minimize the travel time savings the project could provide. A number of employment centers are located in and around downtown Monroe, as seen in Map 6, and since the proposed project bypasses the downtown Monroe area, Mr. Smith's travel time analysis would largely not account for travel time savings associated with the project in central and eastern Union County.

[31] FHWA guidance on signal design recommends using 3 to 5 feet per second (2 to 2.7 mph) walking speeds in developing pedestrian clearance times for signal timings. FHWA. *Traffic Signal Timing Manual.* Chapter 5, Section 5.3.3. http://ops.fhwa.dot.gov/publications/fhwahop08024/chapter5.htm

Revising the Travel Time to Employment Factor without the Monroe Connector/Bypass

Since May 2012, NCTA worked with CDOT staff and Paul Smith to rerun the MRM model and the Bottom-Up allocation process with a revised MRM network that did not include the Monroe Connector/Bypass. NCTA requested the analysis to compare the results to the original 2005 Projections to determine whether removal of the proposed project would affect the results. CDOT staff obtained the 2025 MRM model used to calculate the travel speeds for the original travel time to employment factor analysis and revised the network by removing the Monroe Connector/Bypass. They subsequently reran the travel demand model with the revised network to get new speed data for the transportation network that did not include the Monroe Connector/Bypass. Mr. Smith then incorporated this new speed data into his other speed assumptions and recalculated the travel times used to develop the travel time to employment factor score for each TAZ. He then recalculated the composite attractiveness scores and subsequently reapplied his allocation model with the new composite attractiveness scores to determine if there would be any differences in population or employment allocations with the new travel time results.

When Mr. Smith removed the Monroe Connector/Bypass from his analysis, it resulted in minor changes to the travel times and composite attractiveness index. Out of 256 TAZs in the MUMPO analysis area of Union County, most had little to no change in travel time to employment centers when the Monroe Connector/Bypass was removed from the network:

- 150 TAZs (59 percent) had no change in their travel time
- 85 TAZs (33 percent) had a travel time increase of less than 1 minute
- 21 TAZs (8 percent) experienced a travel time increase of 1 minute or more
- The maximum change for a TAZ was 5.7 minutes, and the average change throughout Union County was 16 seconds.

The areas with increased travel time are shown in Map 7. The areas with the greatest increase in travel time are in western Union County, centered around the proposed corridor between Stallings and Monroe. The impact of this travel time change is highly localized around the western end of the Monroe Connector/Bypass. As described above, the model uses travel time to employment as one of several weighted factors in the calculation of composite grid attractiveness scores, which are averaged across a TAZ to derive the percentage of available acreage to be consumed by TAZ for each period. Mr. Smith used the recalculated travel time to employment factor to recalculate the grid attractive scores and TAZ scores for the 2020 to 2030 period. When the composite attractiveness scores were recalculated to include the revised travel time results above and then further averaged for each TAZ, the results showed that most TAZs had little to no change in attractiveness score. Of those that did change, the result was a reduction in attractiveness scores, as increased travel time would result in lower attractiveness to development. Out of 256 TAZs in the MUMPO portion of the study area:

- 150 TAZs (59 percent) had no change in composite attractiveness score
- 92 TAZs (36 percent) had a reduction of less than 1 percent
- 14 TAZs (5 percent) had a reduction of 1 percent or more change in composite score
- The greatest Composite Score reduction is 3.9 percent, and the average Composite Score reduction is 0.21 percent.

Changes in composite attractiveness scores by TAZ, calculated by Mr. Smith, are shown in Map 8. The geographic distribution of the changes roughly parallels those in the travel time map.

Next, Mr. Smith reapplied the allocation model to determine specifically if the change in travel times and composite scores would result in a different allocation of households and employment. The allocation model uses the composite scores to determine the percentage of available land in each TAZ that would be consumed by growth. The higher the composite score the higher the percentage of available land that would be consumed. The model would then multiply the percentage consumed by the actual available land in each TAZ to determine the acreage of land consumed within each TAZ. Then the acreage would be multiplied by the development density for each TAZ (calculated from tax and zoning records) to determine the actual number of households to be added to each TAZ for each period. Thus any change in composite score could potentially change the percentage of land consumed and thus the number of households added to any given TAZ.

When Mr. Smith reran the allocation model with the new composite scores, the results showed that the land use projections were identical to those produced in his original report; in other words the results did not change. For the 106 TAZs where the change in travel time led to a reduction in their composite attractiveness index, the allocation model in the original allocation (i.e. before the Monroe Connector/Bypass was removed) had calculated that those TAZs would use 100 percent of available land by 2030. For those same TAZs, when the new allocation model was run (i.e. after the Monroe Connector/Bypass was removed) the lower attractiveness scores did not reduce their attractiveness in the allocation model enough to cause the allocation model to request less than 100 percent of the developable land within each of those TAZs by 2030. These 106 TAZs already had relatively high composite scores as they were in areas with sewer and water availability, where growth policy was favorable and where Expert Panel members expected growth already. The relatively small reduction in composite attractiveness that resulted from the changes in travel time did not reduce the score for these TAZs enough to reduce the percentage of land the model would consume. In addition, many of these TAZs had little available land to fill in the 2020 to 2030 period. This result is logical given that the areas where travel time and composite scores changed have experienced extensive growth since 1990 and thus are likely to reach build out sooner than most other areas of the County.

These results show clearly that removal of the Monroe Connector/Bypass from the travel time to employment factor had no effect on the results of the 2005 Projections. Therefore, it is clear that the Bottom-Up portion of the 2005 Projections was insensitive to the presence or absence of the proposed project. Since this factor was the only factor that explicitly included the project in either the Top Down or Bottom Up, it is clear that the 2005 Projections are insensitive to the presence or absence of the proposed project. As such, it is reasonable to conclude, that the proposed project had no influence on the "Old Projections" factor used in the LUSAM process for the 2008 and 2009 Projections.

District Level Targets

The only remaining area that the Monroe Connector/Bypass could have influenced the LUSAM process would be through the district level targets. The household, population and employment targets used in the LUSAM models were developed based on the following inputs:

- Interpolation and extrapolation of the previous projections (2005 Projections, which were used in the 2030 LRTP)
- NC State Data Center Demographic Projections (Summer 2007)
- Hammer Report Five-Year Projections.

As previously documented, neither the Hammer Report nor the 2005 Projections (which were used in the 2030 LRTP) were influenced by the Monroe Connector/Bypass growth expectations. The NC State Data Center develops its projections based on trend growth over the previous two decades drawing from both Census counts and estimates. The projections are then developed using the most appropriate smoothing model that best fits the trend line data.[32] Since these projections rely entirely on trend data, there is no influence in these projections from proposed transportation improvements. Therefore, it is reasonable to conclude that the district level targets were unaffected by any influence from growth associated with the Monroe Connector/Bypass.

Review of Projection Results

An examination of density levels along the project corridor is illustrative regarding the relationship (or lack thereof) between the proposed project and the MPO projections of households, population and employment. Map 9 shows the household density by TAZ in 2030 from the 2009 Interim Projections. The household density levels in TAZs along the proposed project corridor in the 2030 projections are similar to the household densities of surrounding TAZs. If the projections were representative of a Build Scenario then one would expect to see higher household density levels along the project corridor, particularly at interchange locations. Map 10 shows the employment density by TAZ in 2030 from the 2009 Interim Projections. The employment density levels in TAZs along the proposed project corridor in the 2030 projections are similar to the densities of surrounding TAZs. If the projections were representative of a Build Scenario then one would expect to see higher employment density levels along the project corridor, particularly at interchange locations. Overall, the density pattern in the 2009 Projections shows no signs of influence from the Monroe Connector/Bypass. Furthermore, CDOT staff indicated that growth impacts of the proposed road were not a consideration in the projection process.

3.3 How Have Other Studies Used the MRM Socioeconomic Projections

The NCTA hired other consultants and researchers to perform work on traffic and revenue studies to obtain investment ratings for Toll Revenue Bonds. The work performed consisted of a Preliminary Traffic and Revenue Study, an Independent Economist Evaluation of the Socio-economic Estimates Underlying the Study of the Feasibility of the Proposed Monroe Connector/Bypass, and a Comprehensive Traffic and Revenue Study. This section will provide a summary of the work and the relevance to the research performed and used in the Quantitative ICE analyses.

WSA, Proposed Monroe Connector Preliminary Traffic and Revenue Study, Final Report, October 11, 2006

The NCTA hired Wilbur Smith Associates (WSA) to conduct a preliminary traffic and revenue study for the proposed Monroe Connector. The purpose of the study was to determine the feasibility of pursuing toll financing for construction of the Monroe Connector and/or Monroe Bypass. WSA assumed that the proposed project would provide significant time savings for travelers moving between I-485 south of Charlotte and Monroe or points south and east based on their analysis of travel conditions on US 74 in 2006 and travel demand model analysis of travel speeds in their study area. It should be noted that WSA completed this preliminary study in 2006 before analysis for the EIS had begun. WSA used the 2005

[32] Smoothing models use historical data on past population or employment conditions and apply exponential functions that best fit those past trends to then forecast future conditions.

Projections socioeconomic data set (which were used in the 2030 LRTP) as it was the most recent projection available at the time of their study.

WSA collected traffic counts in the project corridor and used the information to re-calibrate the Metrolina Regional TDM model and provide traffic scenarios for No-Build, Build (Toll Free) and Build (Tolled) scenarios. They also updated the network within the model to account for proposed transportation improvements. WSA also collected information regarding regional and corridor income characteristics to aid in the development of estimated values of time for potential users of the toll facility. WSA stated that this is a critical parameter used to assess a motorist's willingness to pay for tolls and use the facility.

WSA concluded that the Monroe Connector/Bypass would help reduce congestion in the study area even with the planned widening of US 74. Its preliminary traffic and revenue study concluded that pursuing project financing with tolling was feasible and would be best served by combining the Monroe Connector and Bypass in a proposed toll financed project.

WSA's analysis relied upon the socioeconomic projections incorporated in the Metrolina Regional TDM. They concluded that the population projections contained in the Metrolina Regional TDM at that time were directly related to the growth rate of traffic predicated by the model. In their report, WSA indicated that the Monroe Connector/Bypass is included in the model and influences the growth projections therein. However, WSA did not perform a Build versus No-Build analysis for purposes of determining the project influence on the socioeconomic conditions in its study area. Furthermore, WSA provided no basis for the assumption that the Monroe Connector/Bypass influenced the growth projections in the model nor did they provide any documentation to justify the assumption. WSA's report clarified that its work was performed without the benefit of an independent economic review of the socioeconomic projections. WSA also acknowledged that such work would typically be required to support project financing.

In summary, this report was a preliminary traffic and revenue study and conducted prior to the DEIS Qualitative ICE and FEIS Quantitative ICE analyses. Furthermore, as shown through the analysis by Mr. Paul Smith discussed in section 4.4, the Monroe Connector/Bypass did not influence the 2005 Projections (which were used in the 2030 LRTP). Additionally, as discussed in the following sections, in their final *Comprehensive Traffic and Revenue Study* (October 2010), WSA did not assume the Monroe Connector/Bypass influenced growth projections in the base model, but instead, used an independent economist to develop TAZ projections specific for the final traffic and revenue study

Kenan Institute of Private Enterprise, Technical Memorandum, Proposed Monroe Connector/Bypass Comprehensive Traffic and Revenue Study, Initial Report of Independent Economist, September 28, 2009

In subsequent work on the traffic and revenue studies, the WSA team, in consultation with NCTA, hired the Kenan Institute of Private Enterprise at the University of North Carolina's Kenan-Flagler Business School (Kenan Institute) in 2009 to develop a set of TAZ projections specifically for the Monroe Connector/Bypass Traffic and Revenue Study. The Kenan Institute developed their projections based on Dr. Hammer's 2003 projections for regional and county growth, a review of the MUMPO Bottom-Up process to allocate county and district growth from Dr. Hammer's projections to TAZs; a review of recent economic, employment and population trends and estimates produced by other organizations; a regional scan of the project area; and, interviews with planners, developers and business/economic experts within the region. The Kenan Institute Report, entitled *Initial Report of Independent Economist* (Appendix K), was used in the development of WSA's *Comprehensive Traffic and Revenue Study*, October 22, 2010.

The main objective of the Kenan Institute Report was to determine the socioeconomic conditions that would be prevalent in its project study area with the construction of the Monroe Connector/Bypass toll road. As part of its work, the Kenan Institute conducted an independent economic review of the 2008 Interim Projections, which were the most up to date TAZ level projections available at the time of their study. The Kenan Institute's corridor study area for evaluation and analysis is shown in Map 11.

Map 11 also includes the Qualitative and Quantitative ICE analysis areas. One key observation is the Kenan Institute's study area is much smaller than the either the Qualitative or Quantitative ICE study areas. The Quantitative ICE study boundary was established to evaluate effects on the natural environment in consultation with resource agencies and is focused on impacts to watersheds and protected species. The Kenan Institute's study area appears to have been established based on the project's travel time savings during peak travel times. The Kenan Institute study area is 132,436 acres compared to the Quantitative ICE study area of 202,000 acres or 66 percent of the Quantitative ICE study area. This observation also highlights that the area of influence of change in socioeconomic projections is much less than the project area, the county and the region as a whole. In other words, the Kenan Institute analysis and resulting study area provide further evidence that the Monroe Connector/Bypass would have little to no effect on regional or county level growth.

The Kenan Institute reviewed the 2008 Interim Projections and determined that for the purposes of forecasting traffic for Toll Revenue Bond issuance, adjustments would be required to develop socioeconomic projections that were reasonable but did not overestimate traffic forecasts. The Kenan Institute made two adjustments to the socioeconomic estimates. "The first was to make region-wide adjustments consistent with the national growth expectations. The second was to reallocate growth in Union County in line with development factors and constraints."[33]

The Kenan Institute's analysis determined that the growth in the 2008 Interim Projections needed to be adjusted to account for the extended recession, which it determined was not accounted for in the projections. Based on its research, the Kenan Institute lowered the TAZ level projections by 8.7 percent to account for the national economic correction, which suggests that as growth resumes, the gross domestic product is expected to be 91.3 percent as high as it would have been at the same time in the absence of the national crisis.[34]. Table 9 shows the original 2008 Interim Projections of household and population, the Kenan Institute adjustments for the national economic correction, and their project specific adjustments.

Table 9: Household and Population Projections for the Corridor Study Area (132,436 acres)

	MRM 2008 Interim Projections		Kenan Adjustments for "National Correction"		Kenan Adjustments due to Project	
Year	Households	Population	Households	Population	Households	Population
2005	42,595	120,054	42,595	120,054	42,595	120,054
2010	49,393	140,267	45,164	128,258	45,346	128,732
2015	56,454	161,371	51,556	147,364	51,968	148,486
2020	62,479	178,152	57,056	162,689	57,974	165,207
2025	68,407	194,812	62,469	177,902	63,869	181,775
2030	74,497	211,973	68,029	193,573	69,843	198,613

[33] Appendix K, p 29
[34] Appendix K, p 24

Looking within the project corridor, the Kenan Institute accepted the allocation of growth by the MPO in Mecklenburg County. However, it reallocated the projected population growth within Union County away from the line of high growth in the southwest quadrant of the county to the Connector/Bypass corridor because of the project. A portion of the expansion in several high growth TAZs in the northeastern quadrant of the county was also reallocated towards the corridor. The Kenan Institute made these adjustments based on results of interviews with local planners, analysis of growth trends in the area, and analysis of water and sewer demand and capacity in the area. The Kenan Institute report notes that many of the regional planners could not recall critical details of the regional and TAZ level socioeconomic projection and allocation modeling and reasoning behind specific projections. They also concluded from the interviews that a few biases may have entered into the Union County small area projections. Dr. Appold specifically noted the line of growth in southwest Union County along and south of NC 75 that did not appear to be appropriate given limitations on growth in that area.[35]. However, that the Kenan Institute found it necessary to reallocate growth to account for the influence of the Monroe Connector/Bypass is consistent with the contention that the existing projections did not represent a Build Condition for the Monroe Connector/Bypass.

Table 10 provides a comparison between the MRM 2008 Interim Projections in the corridor to the overall adjustments made by the Kenan Institute.

The set of projections in the second column of Table 10, shown under the heading Kenan National Correction Adjusted, was calculated by multiplying the MPO projection for 2030 by 8.68 percent (the same reduction that the Kenan Institute used to adjust the projection for all TAZs). This calculation allowed a comparison of the Kenan Institute adjustments within the corridor due to the project (third column set of projections) with projections adjusted due to the national correction. Thus, the last column set in the table shows how the project would increase growth by zones in the corridor of the Kenan Institute study area. It is important to note that the Kenan Institute did not conduct a “Build versus No-Build” analysis, but only created a scenario of a 2030 projections of population and households with the project.

Although the growth rate difference in the entire corridor is rather small (3 percent), the tables show the substantial difference in the allocation of growth between the western corridor zones to the eastern corridor zones. This re-allocation of growth by zone is very similar to the growth patterns in the DEIS Qualitative ICE and FEIS Quantitative ICE. Therefore, the Kenan Institute reallocation of adjusted regional growth in Union County supports the Quantitative ICE conclusions regarding the project’s influence on accelerated growth in central and eastern Union County.

[35] Appendix K, p 24-25

Table 10: Change in Household and Population Projections within the Corridor Study Area

Year	MRM 2008 Interim Projections[1]		Kenan "National Correction" Adjusted		Kenan Project Adjusted[1]		Change in Kenan Projection due to project in 2030 (%)	
	Households	Population	Households	Population	Households	Population	Households	Population
Corridor								
2005	42,595	120,054	42,595	120,054	42,595	120,054		
2030	74,497	211,973	68,029	193,573	69,843	198,613	3%	3%
Zone 1								
2005	14,118	38,774	14,118	38,774	14,118	38,774		
2030	19,307	55,413	17,631	50,603	17,730	50,871	1%	1%
Zone 2								
2005	11,017	30,859	11,017	30,859	11,017	30,859		
2030	16,676	47,280	15,228	43,176	15,474	43,842	2%	2%
Zone 3								
2005	7,617	20,404	7,617	20,404	7,617	20,404		
2030	11,369	30,980	10,382	28,291	11,074	30,225	7%	7%
Zone 4								
2005	6,164	19,084	6,164	19,084	6,164	19,084		
2030	17,827	51,435	16,279	46,970	16,455	47,580	1%	1%
Zone 5								
2005	3,679	10,933	3,679	10,933	3,679	10,933		
2030	9,318	26,865	8,509	24,533	9,110	26,095	7%	6%

[1] Appendix K Table 11

One may argue that the Kenan Institute concluded that the growth in the corridor area would reallocate outside Union County without the project. However, the Kenan Institute acknowledged that it did not conduct a no-build versus build analysis. It also acknowledged that its analysis relied upon the regional growth allocation to the counties, which did not consider supply-side factors such as large infrastructure projects. Lastly, the Kenan Institute's study area of 132,436 acres is much smaller than the area of Union County. Therefore, any conclusion the Kenan Institute report made regarding a No-Build Scenario was not reached with the same degree of analytical work performed in developing the adjusted projections.

A final point regarding the reports prepared by the Kenan Institute for the project is the complimentary narratives regarding Dr. Hammer's methodologies, models and projections of region and county population and employment described in his report, *Demographic and Economic Forecasts for the Charlotte Region*, 2003.

> *Our basic assessment of the MPO socio-economic projections is twofold. First, although the region-wide projections were prepared with an unusual degree of competency and care, they may have been over-adapted to new information during the boom years which followed.*[36]
>
> *The large area projections performed by Thomas Hammer and summarized above appear to be thoughtfully and carefully constructed*.[37]
>
> *Recognizing that no projection is completely accurate (error bounds are discussed in the full report), our judgment is that Thomas Hammer, the consultant hired by MUMPO to estimate county and sub-county population and employment for selected years, has the most credible methodology of any known population and employment projection. His estimation process relies on Census data, the quantified detailed experiences of similar metropolitan regions, and extensive feedback from knowledgeable regional (Charlotte) informants. We feel that his estimates, modified with the best available information about development subsequent to his work, form the best possible basis for NCTA decision-making.*[38]

WSAs, Final Report, Proposed Monroe Connector/Bypass Comprehensive Traffic and Revenue Study, October 22, 2010

WSA's Comprehensive Traffic and Revenue Study (T&R Study), begun in 2009, was a follow up to the preliminary study performed in 2006. This research was conducted parallel to but separate from the NEPA analyses conducted for the FEIS and ROD. The report was not completed until after issuance of the ROD and it was not relied upon in the previous EIS process. The T&R Study used the Kenan Institute's socioeconomic projections of population, household and employment described above as inputs to the Metrolina Regional TDM. WSA also conducted an Origin-Destination Study in the project study area to identify current travel patterns and trip characteristics. They also supplemented NCDOT traffic counts with further counts during March 2009. WSA also updated the proposed transportation projects into the transportation network. Finally, based on traffic counts, WSA adjusted the model during a calibration process to achieve model predictions better aligned with current traffic observations.

WSA's T&R Study Report also compared population projections from the 2005 Projections (which were used in the 2030 LRTP), the 2008 Interim Projections, and the projections developed by the Kenan Institute in 2009 within the corridor. WSA found that the three different population projections for the corridor in the year 2030 closely correlate. For example, in 2009, the Kenan Institute estimated the 2030 population in their study area to be 198,613. This projection clearly included the effects of the project. However, the information WSA extracted from the 2005 Projections estimated the 2030 population in their study area to be 210,900. The information WSA extracted from the 2008 Interim Projections estimated the 2030 population in their study area to be 211,973. As previously discussed, none of the

[36] Appendix K, p 4
[37] Appendix K, p 23
[38] Appendix K, p 3

MRM socioeconomic projection versions included growth effects from the project. All of these projection results are within seven percent and suggest a high degree of similarity among different projection versions. Since the Kenan Institute's charge in developing their projections was to err on the side of not overestimating traffic so as to provide a conservative estimate for financing purposes, it would not necessarily be appropriate to use those adjusted projections as a basis for environmental impacts analysis. Finally, WSA's T&R Study did not construct a No-Build versus Build scenario to analyze the effects of the project on the study area. However, they did break down the project zones to more precisely describe where increased growth was likely to occur. This work is similar to the work conducted in the FEIS Quantitative ICE analysis and the implications from their analyses regarding the areas most likely to see additional growth due to the project are similar to the conclusions of the DEIS Qualitative ICE and FEIS Quantitative ICE.

3.4 How Do the MRM Socioeconomic Projections Compare to Other Projections?

The ICE Guidance recommends using adopted regional projections authored by MPOs where available.[39] FHWA guidance also recommends use of MPO projections and model forecasts when properly vetted.[40] Yet it would be best to compare those projections to others before using them. Therefore, it is instructive to compare the MPO projections to other population projections for the area. Projections from other sources show a wide range of future growth trends for Union County. Two of the most commonly cited privately developed projections are from Woods & Poole and Global Insights. Both firms use cohort-component projections, a demographic projection method that focuses on fertility, mortality and net migration to estimate total population by year. The Global Insight model incorporates the predictions of a regional macroeconomic model, thereby incorporating some economically driven assumptions of jobs growth into the process. The North Carolina State Data Center also generates population projections using a time series trends projection process. Table 11 summarizes five different projections of population to 2030 from four different sources:

1. MRM 2009 Projections (developed between 2004 and 2009)
2. Global Insights Projections (developed in 2009)
3. Woods & Poole Projections (developed in 2009)
4. NC State Data Center Projections (developed in 2009)
5. NC State Data Center Projections (developed May 2011).

As all of the projections operate from either demographic trend projection or economic modeling projections; they do not incorporate expectations of transportation infrastructure development except to the extent that past infrastructure development has affected past trends. One key to understanding the differences in these projections is to compare the actual change in each five-year increment. The demographically driven approaches used by Woods & Poole and the NC State Data Center produce very similar changes in each five-year increment of their projections, whereas the Global Insights and MPO projections, which are more economically driven models, show significant differences in each five-year increment of changes.

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[39] NCDOT & NCDENR, 2001a, p III-16

[40] FHWA. *Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA*. March 2010. p 12.

As to the actual projection of future population in Union County, the highest projection is from the NC Data Center in 2009, which projected a 2030 population of 400,683. The NC Data Center's projection from 2011, however, predicts a 2030 population of 271,289, the lowest of all the projections. The Global Insights projection from 2009 predicts a 2030 population of 393,407, while Woods & Poole from 2009 predicts a 2030 population of 283,433. The MRM 2009 Projections fall generally in the middle of all these projections, predicting a 2030 population of 337,314 for Union County. Most interesting is how closely the MPO projections predicted the 2010 populations (based on actual 2010 Census counts) of Mecklenburg and Union Counties. In the case of Mecklenburg County, the MPO projection for 2010 population of 931,666 (Table 11) is only 1.3 percent higher than the actual 2010 Census count of 919,628. In the case of Union County, the projected population in 2010 of 200,450 is only 0.4 percent lower than the actual 2010 Census count of 201,292. This compares favorably to other projections completed prior to 2010. The Global Insights projections from 2009 overestimated population in Mecklenburg and Union Counties by four percent and nine percent respectively. The Woods & Poole projection from 2009 underestimated population for Mecklenburg and Union Counties by 0.3 percent and two percent respectively. The NC State Data Center projections from 2009 underestimated Mecklenburg County population by one percent and overestimated Union County population by four percent. Given that these other projections were all completed about one year prior to the horizon year in question (the 2010 Census counts) whereas the MRM Socioeconomic projections were largely completed two years prior (and the underlying work dates back to 2004), the MRM socioeconomic projections for Mecklenburg and Union Counties compare favorably.

Table 11: Comparison of Population Projections

Global Insights (2009)									
	Mecklenburg	Change	Annualized % Change	Union	Change	Annualized % Change	Region*	Change	Annualized % Change
2005	806,834			161,765			1,314,553		
2010	956,823	149,989	3.5%	219,690	57,925	6.3%	1,570,976	256,423	3.6%
2015	1,065,308	108,485	2.2%	263,298	43,608	3.7%	1,749,656	178,680	2.2%
2020	1,171,442	106,134	1.9%	303,978	40,680	2.9%	1,920,865	171,209	1.9%
2025	1,275,768	104,326	1.7%	349,186	45,208	2.8%	2,097,412	176,547	1.8%
2030	1,382,406	106,638	1.6%	393,407	44,221	2.4%	2,280,808	183,396	1.7%
Woods & Poole (2009)									
	Mecklenburg	Change	Annualized % Change	Union	Change	Annualized % Change	Region*	Change	Annualized % Change
2005	802,400			160,876			1,307,329		
2010	916,747	114,347	2.7%	197,554	36,678	4.2%	1,497,063	189,734	2.8%
2015	1,000,055	83,308	1.8%	218,988	21,434	2.1%	1,630,535	133,472	1.7%
2020	1,084,264	84,209	1.6%	240,490	21,502	1.9%	1,765,570	135,035	1.6%
2025	1,168,900	84,636	1.5%	261,995	21,505	1.7%	1,901,371	135,801	1.5%
2030	1,253,544	84,644	1.4%	283,433	21,438	1.6%	2,037,236	135,865	1.4%
MRM 2009 Projections									
	Mecklenburg	Change	Annualized % Change	Union	Change	Annualized % Change	Region*	Change	Annualized % Change
2005	837,862			168,728			1,369,445		
2010	931,666	93,804	2.15%	200,450	31,722	3.51%	1,544,779	175,334	2.44%
2015	1,025,004	93,338	1.93%	231,986	31,536	2.97%	1,719,218	174,439	2.16%
2020	1,111,254	86,250	1.63%	266,612	34,626	2.82%	1,891,996	172,778	1.93%
2025	1,196,999	85,745	1.50%	301,053	34,441	2.46%	2,063,849	171,853	1.75%
2030	1,271,300	74,301	1.21%	337,314	36,261	2.30%	2,221,345	157,496	1.48%
NC State Data Center (2009)									
	Mecklenburg	Change	Annualized % Change	Union	Change	Annualized % Change	Region*	Change	Annualized % Change
2005	796,529			159,726			1,298,879		
2010	911,252	114,723	2.7%	210,069	50,343	5.6%	1,518,920	220,041	3.2%
2015	996,414	85,162	1.8%	257,378	47,309	4.2%	1,706,871	187,951	2.4%
2020	1,081,577	85,163	1.7%	304,688	47,310	3.4%	1,894,854	187,983	2.1%
2025	1,166,740	85,163	1.5%	351,996	47,308	2.9%	2,082,842	187,988	1.9%
2030	1,253,198	86,458	1.4%	400,683	48,687	2.6%	2,274,700	191,858	1.8%

NC State Data Center (2011)									
	Mecklenburg	**Change**	**Annualized % Change**	**Union**	**Change**	**Annualized % Change**	**Region***	**Change**	**Annualized % Change**
2005	802,998			160,260			1,305,092		
2010	923,144	120,146	2.8%	202,200	41,940	4.8%	1,510,094	205,002	3.0%
2015	1,009,658	86,514	1.8%	219,522	17,322	1.7%	1,634,793	124,699	1.6%
2020	1,095,857	86,199	1.7%	236,778	17,256	1.5%	1,758,306	123,513	1.5%
2025	1,182,056	86,199	1.5%	254,034	17,256	1.4%	1,881,818	123,512	1.4%
2030	1,268,257	86,201	1.4%	271,289	17,255	1.3%	2,005,336	123,518	1.3%

* The Regional projections here are for a four county region of Cabarrus, Gaston, Mecklenburg and Union Counties. This is due to data limitations from the various sources.

3.5 How Accurate are the MPO Projections?

Projecting socioeconomic conditions, and any projection of the future, is an uncertain process fraught with the potential for error. Available evidence on socioeconomic projection indicates that "forecast errors are generally larger for small places [such as an individual TAZ] than for large places; are generally larger for places that have very high [such as Union County] or negative growth rates than they are for places that have moderate, positive growth rates; generally increase with the length of the projection horizon; and vary from one launch year to another."[41] Errors for long-range socioeconomic projection can also be quite high, especially for smaller geographies. For county level projections of 25 years, the typical mean algebraic percentage errors are about 30 percent while for census tracts (which are typically larger than TAZs) errors are typically 45 percent for the same period.[42] Thus, despite the best efforts of researchers and forecasters, the error rates for long-range projections are still quite high and thus any projection or estimate of induced and cumulative effects must be considered the best estimate within a wide range of error. The accuracy of projected growth under any future scenario could be affected by many variables. These include individual owner or developer actions, the timing of or changes in utility provision, changes in local or state regulations on land use and, most importantly, changes in national or regional economic conditions. While the potential for error is high, the techniques used by the MPO are the best available and provide the best available data for projecting population and employment conditions in the future.

3.6 Conclusions

What Influence Did the Monroe Connector/Bypass Have on the MPO Projections?

As discussed above, an assessment of the MRM socioeconomic projections reveals the following regarding the influence of the Monroe Connector/Bypass on the projections:

- The proposed project did not affect the Travel Time to Core Employment factor in the LUSAM process as this factor had zero weight for all districts for all LUSAM runs.

[41] Smith, Stanely K., Tayman, Jeff, Swanson, David A. *State and Local Population Projections: Methodology and Analysis.* Kluwere Academic/Plenum Publishers, New York, 2001. p 292
[42] Smith, Tayman, Swanson, p 340

- The proposed project did not affect the Planners' Judgment factor in the LUSAM process as this factor had zero weight for all districts in Union County for all LUSAM runs.
- The proposed project was included in the Travel Time to Employment factor used by Paul Smith in developing the 2005 Projections, but a reassessment of that factor without the proposed project shows that the project had no influence on the projection results.
- The proposed project did not affect Dr. Hammer's projections of households and employment that were used in the 2005 Projections for county level control totals and were used in the 2008 Interim and 2009 Projections for developing the district level targets.
- There is no evidence or indication that any other factor in the LUSAM process or the other projection processes was influenced by the proposed project and communications with CDOT staff indicate that the proposed project was not a consideration in development of the projections.
- A review of the results of the projections shows no signs that the proposed project influenced the projections.

Based on this review, the overall evidence suggests that the MRM socioeconomic projections are insensitive to the presence or absence of the proposed project in the land use models used to develop the projections. The methodology used by CDOT and MUMPO to develop the projections is effectively insensitive to the Monroe Bypass/Connector. In the methodology used by Dr. Hammer, specific adjustment had to be made to account for the expected growth-induced by large roadway projects in the Top-Down process. As the sensitivity analysis of Paul Smith's Travel Time to Employment Factor showed, the proposed project made no difference in the Bottom-Up allocation process. Thus, the methodology used does not incorporate the full accessibility impacts of major roadway projects. Consequently, if the ICE analysis were to follow the exact same methodology as the MRM socioeconomic projections to calculate induced growth impacts of the Monroe Connector/Bypass, then the result would be to find no induced growth. However, the qualitative ICE analysis and all other studies point to localized land use impacts occurring with the Build Alternative, particularly in eastern Union County. Therefore, it would be inappropriate to use the MPO socioeconomic projection and allocation methods to attempt to estimate induced growth or induced land use changes associated with the Monroe Bypass/Connector. As described in Section 4, the study team has chosen other methodologies to estimate induced growth and induced land use changes associated with the proposed project.

How Did the Quantitative ICE Use the MPO Projections?

Based on the above review of the assumptions and variables used in the Top-Down and Bottom-Up processes, the inputs and variables used in the LUSAM models, a review of the actual results of the various projection versions, and a re-evaluation of the 2005 Projections without the project, we concluded that the MUMPO models did not incorporate the induced land use effects of the Monroe Connector/Bypass. Furthermore, comparisons to other projections for Union County, the MPO projections appear to be reasonable and in the middle of the range of available projections. Since the MPO projections are also the only source that provides growth projections at a small geographic scale, which is critical to a Quantitative ICE analysis, the MPO projections appear to be the best resource to developing a starting point for future land use conditions in the study area.

A review of the actual distribution of growth in the projections indicates that there is no pattern of development along the proposed project corridor that would suggest that the proposed project was considered in the projection development. Furthermore, a review of how other entities have used the MRM Projections for Traffic and Revenue analyses shows that minor adjustments were made to the MRM socioeconomic projections to account for the presence of the Monroe Connector/Bypass. These adjustments generally consisted of increases in household and employment in eastern portions of the study area. These conclusions suggest that additional analysis is needed to estimate the induced land use effects of the project. As described in Section 4, this Quantitative ICE analysis used the MPO projections as control totals, along with various other information, to develop a scenario without the project or its growth inducing impacts (i.e., the No-Build Scenario). The study team then estimated the induced growth potential of the project and added that estimated induced growth to the No-Build land use scenario to create a new scenario that represents future conditions with the project and its growth inducing impacts (i.e. the Build Scenario).

The prior Quantitative ICE analysis (2010) examined two build scenarios, one with an interchange at US 601 (the RPA) and one without an interchange at US 601. The prior analysis found very little difference in land use change between the RPA and the alternative without the US 601 interchange. Therefore, only one build scenario was used in this analysis.

4.0 INDUCED GROWTH ASSESSMENT AND FUTURE LAND USE SCENARIOS

To assess the induced growth potential of the proposed project and compare, quantitatively, the land use conditions with and without the proposed project, two land use scenarios were developed. The Build Scenario would represent the best estimate of land development conditions with the proposed project and its growth inducing impacts. The No-Build Scenario would represent the best estimate of land use conditions without the proposed project or its growth inducing impacts. As noted above, a reference point for the future growth of the study area was needed from which to base the two scenarios and that reference point was the MPO socioeconomic projections. The sections below describe specifically how each scenario was created and how the projections were used in the development of those scenarios.

4.1 How Did the ICE Analysis Project Land Use without the Proposed Project?

To estimate the land use conditions in 2030 without the proposed project or its growth-inducing impacts, the study team used three main inputs:

- Stream buffer regulations
- Land use plans or zoning ordinances (as appropriate per the research phase)
- MPO socioeconomic projections of growth.

All undeveloped parcels were isolated from the process to develop the Existing Land Use Scenario and these parcels were considered available for development unless specifically excluded by regulations. These parcels were then compared to the areas designated for stream buffers and the zoning and land use plans for the various communities to determine the potential use and density for each parcel. Then, based on the growth estimates in the TAZ level projection, the total amount of development was estimated for 2030. The specific steps and methods are detailed below.

Lands Excluded from Development

Prior to allocating growth, stream buffers were excluded from the subset of developable parcels because development within these areas is prohibited by local and/or state regulations. Buffers were developed based on the Post Construction Ordinance regulations and NCDENR's *Site Specific Water Quality Management Plan for the Goose Creek Watershed* (NCDENR, 2009). These regulations vary somewhat between jurisdictions but generally require the following buffers: 30 feet on streams draining areas less than 50 acres; 35 feet on streams draining more than 50 acres and less than 300 acres; 50 feet on streams draining areas more than 300 acres less than 640 acres; and 100 feet plus the floodplain on streams draining more than 640 acres. Special rules apply in the Goose Creek watershed where undisturbed riparian buffers within 200 feet of waterbodies within the 100-year floodplain and within 100 feet of waterbodies that are not within the 100-year floodplain are now required.[43] Buffers were developed on all

[43] North Carolina Department of Environment and Natural Resources (NCDENR). 2009. *Site Specific Water Quality Management Plan for the Goose Creek Watershed*.

streams in the National Hydrographic Dataset available for the area.[44] While it is possible to obtain an exemption to these restrictions, it is assumed that mitigation requirements would offset any impacts.

Residential Development Allocation

Once the total land available for development was determined, the next step was to estimate the level of development needed to accommodate future household growth. The study team used the projected household growth from the MPO 2009 Projections. For each TAZ, the total undeveloped (vacant or agricultural) area was determined based on the parcel categorization completed for the Existing Land Use Scenario (see Section 2.1). For the future scenario, each undeveloped parcel was re-categorized into one of the five development categories based on the future land use plans and zoning of the local jurisdictions. For residential properties, the land use categories equated to the following densities:

- Low Density Residential – two dwelling units (DU) per acre or fewer
- Medium Density Residential – greater than two DU per acre but fewer than five
- High Density Residential – five or more DU per acre.

Household growth by TAZ based on the MUMPO's projections is depicted in Map 12. The allocation for residential growth followed a four-step process, as detailed below.

<u>Step 1 - Identification of TAZ Build-Out Capacity:</u> The total acreage of currently undeveloped land that is zoned or planned for future residential development based on local land use plans was calculated for each TAZ to determine the total build-out capacity of that TAZ. Based on local future land use plans, each parcel was assigned a residential land use category, and the total number of possible dwelling units was determined.

<u>Step 2: - Identification of Projections by TAZ:</u> The build-out capacity values calculated in Step 1 were then compared to the household growth in the MUMPO TAZ projections.

<u>Step 3 - Density Adjustments for Over-Capacity TAZs:</u> Where projected growth based on MUMPO's TAZ projection exceeded capacity (determined in Step 1 above), spot checking was done to determine where infill development could be expected to increase density, and parcels were reclassified to a higher residential density appropriately to allow the projected growth to "fit" within the TAZ area.

<u>Step 4 - Distribution of Growth for Under-Capacity TAZs:</u> Where projected growth was equal to or less than capacity, a "percentage of capacity factor" was calculated by dividing the projected growth by the capacity. This factor was used to determine the reduction of the potential build-out area necessary to represent the projected level of growth.

Rather than selecting some parcels to build-out and others to remain undeveloped, the methodology spreads the growth across a proportionate amount of every potential parcel. This provides a more fragmented land use projection than that which might actually occur; therefore, it is a conservative estimate (i.e., overestimate), in terms of coverage, of the areas that may have future development. Given that TAZ boundaries are smaller than watershed boundaries, distributing growth to control totals within the TAZs does not appear to potentially skew the indirect or cumulative effects results for watersheds.

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[44] U.S. Geological Survey Water Resources Division and U.S. Department of Agricultural Natural Resources Conservation Service (USGS & USDA). 1999. National Hydrography Dataset, Watershed Boundaries Dataset.

It should be noted that only a portion of each developable parcel was converted to development for the future land use scenario, as described below, so that the total acres of development in each TAZ was maintained according to the projections. For example, if a TAZ had 1,000 acres of currently undeveloped parcels categorized for low density residential growth in the future (two DU per acre), the TAZ would have capacity for 2,000 households. If the TAZ was expected, based on the MPO projections, to add 1,000 households in the future, the TAZ would be filling only 50 percent of its capacity. Thus, a 50 percent reduction factor would be applied to all currently undeveloped parcels in that TAZ categorized for future low density residential development. Therefore, each of those parcels in that TAZ would be reduced in size by 50 percent to reflect the expectation that growth under the 2030 No-Build scenario will only fill 50 percent of the total capacity of low density residential development in that TAZ, and the remaining 50 percent was classified as undeveloped. These undeveloped areas retained the previously assigned NCGAP land cover category (as listed in Section 2.1).

Non-Residential Development Allocation

A similar process was completed for future non-residential development. All currently undeveloped parcels with non-residential zoning or future land use designations were summarized at the TAZ level to calculate the difference between projected growth and capacity.

The MPO TAZ projections include projections for the number of new employees by economic sector for each TAZ. Those sectors were aggregated into Office, Retail or Industrial/Warehouse/Distribution employment growth. Total employment growth by TAZ is depicted in Map 13. Projected new employees were used to calculate new acres of employment-related development using the Social Cost of Alternative Land Development Scenarios (SCALDS) model values provided in the NCDOT's ICE Guidance for assessing future land use (NCDOT & NCDENR, 2001b, p. A-14). These model values are presented in Table 12.

Table 12: Non-Residential Land Use by Employment

Employment Type	Employees/Acre
Office	52.32
Retail	21.78
Industrial/Warehousing/ Distribution	16.33

As with the residential land use analysis, the resulting values from the conversion of employees to acres of land developed were compared to the total capacity for each land use in each TAZ. Reduction factors were calculated in similar fashion to the residential process. These reduction factors were then applied to the non-residential parcels. As with residential development, the growth was spread across a portion of all developable parcels rather than selecting which parcels would develop and which would not within each TAZ.

Once both residential and non-residential development had been accounted for in the parcel and TAZ analysis, the "reduced" parcels categorized by land use were converted to 30x30-meter raster and overlaid on the existing land cover raster to create a new 2030 No-Build scenario raster image.

4.2 How Was Project-Induced Growth Estimated?

As National Cooperative Highway Research Program (NCHRP) Report 423A notes:

> *When a transportation project or policy makes it easier to access certain locations, these places can become attractive to more or different types of development. However, improving accessibility does not guarantee that land use changes will follow. The type, amount, and timing of land use changes will also depend upon the state of the regional economy, the current levels of accessibility, the types of development permitted by land use regulations, the availability of services such as sewer and water, the desirability of the area for development, and other factors.*[45]

This statement suggests that induced growth impacts of major road projects will be dependent upon five major factors:

- The state of the regional economy
- Current levels of accessibility
- The types of development permitted by land use regulation
- The availability services such as sewer and water
- The desirability of an area for development.

Thus, in some cases, induced growth impacts of specific projects may be negligible. The Monroe Connector/Bypass would certainly improve travel times to eastern Union County; however, most of the county is already highly accessible with a well-connected roadway network and no major barriers limiting access from Union County to the major employment centers in Mecklenburg County. Various studies have shown that accessibility improvements of highway projects have had diminishing impacts on land values since the 1950s. This is logical—as the national and regional highway systems have been more fully built out, the addition of any single additional link in the network provides a diminishing return to the overall accessibility of any given area. Boarnet and Haughwout note that:

> *As more highways are built, and the metropolitan highway network matures, the incremental effect on accessibility from new or improved highways decreases, thus accounting for a smaller change in land prices due to any access premium.*
>
> *New evidence suggests that metropolitan highway projects still influence land use in the way that theory predicts. The important difference between the new evidence and earlier studies is that the geographic scale of the land use effect appears to be somewhat smaller. A new highway or improvement might importantly reduce travel times in the immediate vicinity of a project, even if the resulting changes in metropolitan-wide transportation accessibility are small. Hence the land use effects of modern highway projects likely operate over a very fine geographic scale, rather close to the project.*[46]

Therefore, other factors that might affect land use change, such as utility availability and planned and zoned land uses were also analyzed to estimate the potential induced impacts of the project. The methods

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[45] NCHRP Report 423A. *Land Use Impacts of Transportation: A Guidebook.* Washington DC: National Academy Press, 1999.

[46] Boarnet, Marlon G. and Haughwout, Andrew F. *Do Highways Matter? Evidence and Policy Implications of Highways' Influence on Metropolitan* Development. The University of California Transportation Center, Berkley, CA. August 2000. http://escholarship.org/uc/item/5rn9w6bz. p. 9

used to estimate the induced growth potential of the proposed project can be summarized as a combination of the following analytical techniques:

- a scenario writing approach to identify areas most likely to see induced growth based on planning information and interviews
- a build-out analysis to see which areas had the most capacity for induced growth
- an accessibility analysis to see which areas would most benefit from the proposed project and thus most likely to see induced growth
- a Hartgen Analysis to estimate potential commercial growth at interchange areas.

This combination of approaches was deemed most appropriate as the local land use regulatory restrictions varied dramatically across the FLUSA and a more direct gravity model approach would likely overstate growth in some areas and understate it in others by missing the regulatory restrictions. The accessibility analysis did not consider that the cost of a toll would offset the value of the time saved using the road and therefore that portion of the analysis may actually overstate the potential for induced growth.

Build Land Use Scenario

This Quantitative ICE examines potential effects of the alternative DSA D, which was the Recommended, Preferred Alternative (RPA) for the Monroe Connector/Bypass in the Final Environmental Impact Statement (FEIS). NCTA found no reason to change the conclusions previously reached by NCTA and its agency partners as to the RPA when evaluating changes in the study area since the publication of the ROD and therefore this ICE report analyzes only the RPA in the Build Land Use Scenario.

Improvements in Accessibility/Travel Time

An analysis of accessibility was completed to determine the areas most likely to see development increases attributable to the Monroe Connector/Bypass. The main areas of employment in the region are in Mecklenburg County; therefore, improving accessibility (as measured by travel time) to I-485 and the major employment centers in Mecklenburg County would be the main reason for changes in development patterns. This assertion is supported by the Qualitative ICE Assessment and the ICE discussion in the Draft EIS. To identify the areas with substantially improved accessibility, an estimate of the improvement in travel time to the US 74/I-485 interchange attributable to the proposed project was calculated for the FLUSA.

Map 14 shows the changes in driving time under the Build scenario compared to the No-Build scenario. This analysis was completed using the Network Analyst extension of ArcGIS and a general roadway network with posted speed limit attributes. The travel time from all intersections within the Study Area to the I-485/US 74 interchange was calculated in both the No-Build and Build scenarios. The scenarios are compared on the basis of traffic operating at posted speed limits. The difference in travel time to each intersection was calculated, and the result was converted to a raster surface using the Inverse Distance Weighted method. The resulting map shows the estimated travel time improvement that the Monroe Connector/Bypass will provide to the study area, given the assumptions noted above. The results are not intended to represent the exact travel time savings that the project would provide to the study area. It is mostly an illustrative tool for determining which areas will see the greatest and least accessibility improvements because of the proposed project. The analysis shows improvement in accessibility, especially east of Monroe and around Wingate due to the proposed project. There are also improvements for some sections of Unionville along NC 200 (Morgan Mill Road).

Scenario Writing and Build Out Analyses

Other factors considered in the allocation of growth in the project area with the Monroe Connector/Bypass included the availability of water and sewer, and the inclination of local jurisdictions to new development. Availability of sewer service in the future was determined by using Future Public Sewer System coverage from the NC Center for Geographic Analysis. Map 15 shows the estimates of existing and future availability of sewer service in the FLUSA. Existing sewer service is relatively limited north of the proposed project, particularly east of Rocky River Road. In the future, sewer service is expected to be extended into Fairview and northern parts of Unionville, but these areas are relatively far from the proposed project and do not coincide with areas that see travel time savings from the proposed project. East of Morgan Mill Road, sewer service exists around each interchange and in the future sewer service is expected to be expanded especially north and south of Wingate. These areas to coincide with areas that would benefit substantially from the travel time savings of the proposed project. These areas would logically be the most likely to see some induced land use changes associated with the proposed project.

The inclination of local jurisdictions toward new development is also critical to the likelihood of induced land use changes and induced growth. Based on the interviews and review of planning documents, the localities in the western portions of the study area, particularly Indian Trail and Stallings, are less interested in fostering significant growth within their jurisdictions. Unionville, while not opposed to new development, is not interested in increasing densities and would prefer to maintain its rural character, though they are planning for a commercial node at the US 601 interchange with the proposed project.

Other jurisdictions, however, are more interested in fostering growth and development associated with the proposed project. Union County, as noted above, has a new land use plan that specifically recommends residential development north of Wingate and east of Monroe that is expected to occur with the proposed project. Additionally, Wingate and Marshville have plans to encourage development around the interchange areas within their jurisdictions. These observations were suggested in the Qualitative ICE Assessment and Draft EIS, and are supported by the GIS analysis and interviews conducted for the quantitative ICE analysis. Based on this improved accessibility, as well as the availability of sewer service, the areas east of Monroe and north of Wingate, in the eastern portions of the Study Area, are most likely to see increased growth as a result of the project.

Hartgen Analysis of Interchanges

In addition to the accessibility analysis described above, a "Hartgen analysis" was completed for each interchange area to gauge potential for development, using methods researched by Dr. David Hartgen.[47] A Hartgen analysis reviews the traffic volumes, distance to nearest towns, and access to sewer and water services to gauge the potential for induced development at interchanges in rural areas. The results of that analysis indicated that all interchanges except the Forest Hills School Road interchange have at least moderate potential for commercial development. Thus, the Build scenario analysis indicates that more dense growth would be expected where accessibility will improve and other needed infrastructure will be available in the future. Results of this analysis are shown in Appendix L.

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[47] NCDOT & NCDENR, 2001a, p. IV-27

Project-Induced Growth Allocation

The preceding analysis identified the general locations and types of development that the proposed project would induce in a Build Scenario. The amount of additional development was determined based on the availability of land in the vicinity of proposed interchanges, the density allowed by zoning and land use plans for the jurisdictions and the capacity for additional development. Capacity for additional development is limited primarily by the access to sewer services. Thus, those areas around the interchanges that are not expected to receive sewer service in the future were not considered for higher density uses. Most new commercial development was allocated in the immediate vicinity of interchanges or at major crossroads nearby. Additional residential development or increases in residential density were allocated in areas near (within roughly two to three miles) but not immediately adjacent to interchanges. The resulting adjustments in parcel-level land use from the 2030 No-Build scenario was then converted to a 30x30 meter raster land cover and overlaid on the 2030 No-Build raster.

Finally, one method often considered in induced growth analysis is the possible reallocation of growth within a study area. As accessibility improves in the eastern parts of Union County, the expanded opportunities for development may result in less development in the western portions of the FLUSA in a Build Scenario, relative to a No-Build Scenario, as new development may prefer less costly land and more growth friendly jurisdictions. Other ICE analyses have sometimes taken a reallocation approach to the issue of induced growth. In this case, the study team has specifically chosen not to reallocate growth, but instead to add the estimated induced growth over and above that growth expected under a No-Build Scenario. With this assumption, the ICE analysis is taking a more conservative approach to assuming higher possible cumulative effects across the entire study area.

Project-Induced Growth Estimates

Induced land use changes in the area of US 74 at the western terminus of the project were expected to be limited. Under the No-Build Scenario, 84 percent of the land within one mile of the interchange is already developed and many of the remaining undeveloped areas are within or near regulated riparian buffers and would therefore be more difficult to develop. Thus, most of the land in the vicinity of this interchange is already developed or planned for development and there would be little opportunity for additional development under the Build Scenario. Additionally, the proposed project does not provide substantial time savings to major regional employment centers from this area and would therefore be unlikely to spur development in this area.

At Indian Trail-Fairview Road, approximately 50 acres of additional industrial development was expected with the Build scenario. This is consistent with the Indian Trail's zoning and land use plans for the interchange area to become a major industrial park.

At Unionville-Indian Trail Road, Indian Trail land use plans projected a village center as the focal point of the interchange area. Land use plans called for additional commercial space to take advantage of the interchange and medium density residential using Traditional Neighborhood Design (TND) principles. TND principles include building developments with a range of housing types, a well-connected street system, integrated public spaces and some mix of uses. Land use changes under the Build scenario were a shift from residential to commercial for about 50 acres and increases in residential density affecting about 100 acres.

At Rocky River Road, an addition of approximately 50 acres of commercial land use was expected, with about half being converted from a different use compared to the No-Build, consistent with City of

Monroe's Rocky River Land Use Corridor Plans (November 2008) for additional commercial development in this area should the proposed project be built.

At US 601, an additional 100 acres of commercial development, with about half being converted from residential use compared to the No-Build, was expected and was consistent with the City of Monroe zoning and plans for areas near this interchange. About 100 acres of residential land use were expected to increase in density. While this was not consistent with existing zoning for the area, it was projected that additional residential density would follow commercial development in the vicinity of this interchange.

At Morgan Mill Road, additional commercial development of less than 50 acres was expected just south of the interchange, mostly converted from residential compared to the No-Build scenario. In addition, about 50 acres of increased residential density was expected in the Build scenario. Also, less than 50 acres of industrial land use, converted from residential as compared to the No-Build, was expected, which was consistent with existing land use and zoning.

At Austin Chaney Road, additional industrial/office development of about 100 acres, plus additional commercial development of about 50 acres was expected. Most of these additions would replace residential development as compared to the No-Build scenario. Additional or increased residential density of about 150 acres was also expected. These were generally consistent with the *Strategic Plan for Economic Development, Town of Marshville, Town of Wingate* (2008) indicating that this interchange area should be a focal point for non-residential development in eastern Union County. In addition, approximately 1,000 additional acres of Low Density Residential development is expected in the areas north of Wingate and east of Monroe. This is generally consistent with the expected land use changes identified in the updated Union County Comprehensive Plan.

At Forest Hills School Road, only new residential development was expected as the results of Hartgen Analysis indicated poor conditions for commercial development. About 100 acres of additional or higher density residential development was expected around this interchange.

Legacy Park Proposal

The resource agencies and others have questioned whether the Quantitative ICE should consider the effects associated with the proposed Legacy Park development in eastern Union County and include them in one or both of the future land use scenarios. The proposed Legacy Park is a potential industrial park and intermodal shipment terminal advocated by the former economic development agency for Union County (Union County Partnership for Progress) and mentioned in several regional reports, including the NCDOT Seven Portals Study. The potential development was proposed to be sited north and east of Marshville, along and north of the CSX railroad. Estimates from the Union County Partnership for Progress of the full build-out of the proposed industrial park and rail terminal included up to 5,000 acres of development and up to 20,000 jobs on site.

The Qualitative ICE and the previous Quantitative ICE addressed this development as not being reasonably foreseeable as there were no definite project plans or financing behind the project. Research by the Kenan Institute at the same time as the Quantitative ICE indicated that the proposal did not have any funding commitment and needed to surmount a significant number of hurdles before becoming a reality.[48] These hurdles include:

- a feasibility study to determine potential site constraints,
- infrastructure including water and sewer,
- a company interested in developing such a facility at a distance from the core of the Charlotte region,
- funding for feasibility studies, infrastructure development and other pre-development activities.

Further research by the study team since the FEIS has reinforced the conclusion that Legacy Park is currently not a reasonably foreseeable development, particularly in the timeframe of the ICE analysis (see interview summaries in Appendix A). There are a few factors that do indicate planning for the project is continuing. For example, the most recent Union County Water and Wastewater Master Plan (2011) does include provisions for ensuring sufficient capacity to provide service if Legacy Park is built, but the plan includes no actions items or financing recommendations for providing the specific water or sewer lines to directly serve the site. Three localities (Anson County, Marshville and Wingate) have adopted resolutions supporting the proposal, but these localities do not have jurisdiction over most of the proposed site.

The vast majority of evidence at this time suggests the proposal is highly speculative and unlikely to develop in a foreseeable timeframe, if ever. In an interview with the project's main sponsor, staff from the Union County Partnership for Progress indicated that planning for the project is "dead" and that they felt the project was highly speculative and unlikely to develop. Their most optimistic estimate was that if the Monroe Connector/Bypass were built there might be a 25 percent chance of some industrial development at the proposed site.

In an interview with the Planning Director for Union County, Richard Black noted that the site of the proposed development was marked for rural residential development in the most recent Union County Land Use Plan. The first draft of that plan did include industrial planned land use at the site of the proposal, but the planned land use was changed as Planning Commissioners and others felt the Legacy Park proposal was too speculative and highly unlikely to occur. Furthermore, the current zoning for most of the site is rural residential. Mr. Black also noted that his impression was that the proposal hinged on the participation of CSX Transportation and, in particular, the development of an intermodal (rail-truck) terminal at the site to spur connected industrial development.

The project team corresponded with CSX staff who noted that the site was topographically well suited to development and situated in a manner that would make it easy to develop rail-served industrial development or an intermodal terminal. They noted that they have previously marketed the site to a number of customers but that none had showed interest. As to the development of an intermodal terminal, CSX staff noted that they did not see the level of market demand necessary to proceed with a feasibility study at this time.

The project team communicated with Dr. Stephen J. Appold, Assistant Professor at the Kenan Institute at UNC-Chapel Hill. Dr. Appold has been involved with CDOT and the Metrolina Region on new Top-Down projections and has worked on logistics studies for the State Logistics Task Force. Dr. Appold

[48] Appendix K, p 34-35

noted that the anchor tenant for Legacy Park has expressed interest but made no commitment. He noted that the location of Legacy Park is distant from the main traffic flows in the region and that even if the Monroe Connector/Bypass were constructed as a non-toll facility, it would not be clear that Legacy Park would develop as a logistics node. Additionally, Dr. Appold noted that while many proposed developments may cite large potential “build out” projections, such projections are often inflated and that many proposals never reach their build out and some may never attract any tenants or users at all.[49]

Finally, the project team communicated with Christopher Platé and his staff at Monroe-Union County Economic Development. Mr. Platé and his staff indicated that while there was interest is seeing some industrial development in the area where Legacy Park had been planned, the ideas on the table as of 2013 were for a much smaller industrial park of up to 200 acres. While the economic development staff was taking steps to secure property options and to encourage utility infrastructure planning, the much smaller proposal was still considered speculative.

The totality of information points toward the likelihood that Legacy Park is a highly speculative proposal that is unlikely to see development within the time horizon of the ICE analysis (2030) with or without the Monroe Connector/Bypass. Therefore, no development associated with Legacy Park has been incorporated into any future land use scenarios for this analysis. However, NCDOT and FHWA will continue to monitor the Legacy Park proposal and other proposed development projects throughout the NEPA process.

US 74 Revitalization Study

Beginning in 2011, Union County, and the Towns of Stallings, Indian Trail and Monroe worked together to begin development of the US 74 Revitalization Study. The study completed a draft plan in 2013 and those draft recommendations are currently under review and consideration. The study team reviewed the draft US 74 Revitalization Study and its recommendations for their potential impact to future land use scenarios. Since the study is still draft and has not been adopted and since the land use and other recommendations would result in minimal changes to the land use scenario results, the study team determined it was not reasonably foreseeable to incorporate the draft plan recommendations into any future land use scenario.

[49] Letter from Dr. Stephen J. Appold to Jamal Alavi, NCDOT, May 29, 2013, p 3-4.

5.0 UPDATED LAND USE RESULTS

5.1 What Are the Land Use Results?

The following section outlines the updated results from the three updated scenarios, the 2010 Existing (Baseline), the 2030 No-Build, and the 2030 Build scenario. The results of the Updated 2010 Baseline Scenario are shown in Table 13. The Update 2010 Baseline Land Use is illustrated in Map 3.

Table 13: Updated 2010 Baseline Land Use

Land Use	Total Area (acres)	% of Total Area
Total Residential	71,500	35%
Low Density Residential	*55,600*	*28%*
Medium Density Residential	*12,900*	*6%*
High Density Residential	*3,100*	*2%*
Commercial	3,900	2%
Industrial/Office/Institutional	7,100	4%
Transportation	12,700	6%
Total Developed	**95,200**	**47%**
Agricultural Fields	20,100	10%
Agricultural Pasture/Hay and Natural Herbaceous	32,800	16%
Total Agricultural	**52,900**	**26%**
Coniferous Cultivated Plantation	1,100	1%
Successional Deciduous Forest	4,100	2%
Piedmont Xeric Pine Forests	1,000	0%
Piedmont Dry-Mesic Pine Forests	4,600	2%
Piedmont Xeric Woodlands	4,000	2%
Piedmont Dry-Mesic Oak and Hardwood Forests	16,200	8%
Piedmont Deciduous Mesic Forest	5,700	3%
Xeric Pine-Hardwood Woodlands and Forests	1,800	1%
Dry Mesic Oak Pine Forests	9,500	5%
Piedmont Mixed Bottomland Forests	1,800	1%
Piedmont Oak Bottomland and Swamp Forests	2,000	1%
Total Forested	**51,900**	**26%**
Barren (quarries, strip mines, and gravel pits)	100	0%
Barren (bare rock and sand)	100	0%
Piedmont Submerged Aquatic Vegetation	0	0%
Piedmont Emergent Vegetation	0	0%
Riverbank Shrublands	200	0%
Floodplain Wet Shrublands	0	0%
Open Water	1,500	1%
Total Other	**1,900**	**1%**
TOTAL	**202,000**	**100%**

Notes: Results have been rounded to the nearest 100 acres and whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

The results of the Updated No-Build Scenario compared to the Baseline are shown in Table 14. These results are analyzed in the indirect and cumulative impacts review below. Map 16 illustrates the No-Build Scenario land use conditions and Map 17 shows the changes from the Existing (Baseline) land use conditions to the the No-Build land use scenario conditions.

Table 14: Updated 2030 No-Build Land Use

Land Use	Total Area (acres)	% of Total Area	Difference in Percentage from Baseline
Total Residential	97,900	48%	13%
Low Density Residential	*79,500*	*40%*	*12%*
Medium Density Residential	*14,900*	*7%*	*1%*
High Density Residential	*3,500*	*2%*	*0%*
Commercial	5,600	3%	1%
Industrial/Office/Institutional	8,700	4%	1%
Transportation	12,800	6%	0%
Total Developed	**125,000**	**62%**	**15%**
Agricultural Fields	14,600	7%	-3%
Agricultural Pasture/Hay and Natural Herbaceous	22,900	11%	-5%
Total Agricultural	**37,500**	**19%**	**-8%**
Coniferous Cultivated Plantation	600	0%	0%
Successional Deciduous Forest	3,000	1%	-1%
Piedmont Xeric Pine Forests	600	0%	0%
Piedmont Dry-Mesic Pine Forests	3,100	2%	-1%
Piedmont Xeric Woodlands	2,700	1%	-1%
Piedmont Dry-Mesic Oak and Hardwood Forests	11,800	6%	-2%
Piedmont Deciduous Mesic Forest	4,500	2%	-1%
Xeric Pine-Hardwood Woodlands and Forests	1,200	1%	0%
Dry Mesic Oak Pine Forests	7,000	3%	-1%
Piedmont Mixed Bottomland Forests	1,600	1%	0%
Piedmont Oak Bottomland and Swamp Forests	1,500	1%	0%
Total Forested	**37,700**	**19%**	**-7%**
Barren (quarries, strip mines, and gravel pits)	0	0%	0%
Barren (bare rock and sand)	100	0%	0%
Piedmont Submerged Aquatic Vegetation	0	0%	0%
Piedmont Emergent Vegetation	0	0%	0%
Riverbank Shrublands	100	0%	0%
Floodplain Wet Shrublands	0	0%	0%
Open Water	1,500	1%	0%
Total Other	**1,800**	**1%**	**0%**
TOTAL	**202,000**	**100%**	**0%**

Notes: Results have been rounded to the nearest 100 acres and whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

The results of the updated Build Scenario are shown in Table 15. These results are analyzed in the indirect and cumulative impacts review below. Map 18 shows the 2030 Build Scenario land use conditions and Map 19 compares the Build Scenario land use conditions to the No-Build Scenario land use conditions.

Table 15: Updated 2030 Build Land Use

Land Use	Total Area (acres)	% of Total Area	Difference in Percentage from 2030 No-Build
Total Residential	99,700	49%	1%
Low Density Residential	*80,600*	*40%*	*0%*
Medium Density Residential	*15,600*	*8%*	*1%*
High Density Residential	*3,500*	*2%*	*0%*
Commercial	5,900	3%	0%
Industrial/Office/Institutional	8,800	4%	0%
Transportation	13,900	7%	1%
Total Developed	**128,200**	**63%**	**2%**
Agricultural Fields	13,800	7%	0%
Agricultural Pasture/Hay and Natural Herbaceous	21,600	11%	-1%
Total Agricultural	**35,500**	**18%**	**-1%**
Coniferous Cultivated Plantation	600	0%	0%
Successional Deciduous Forest	2,900	1%	0%
Piedmont Xeric Pine Forests	600	0%	0%
Piedmont Dry-Mesic Pine Forests	3,000	1%	0%
Piedmont Xeric Woodlands	2,600	1%	0%
Piedmont Dry-Mesic Oak and Hardwood Forests	11,500	6%	0%
Piedmont Deciduous Mesic Forest	4,300	2%	0%
Xeric Pine-Hardwood Woodlands and Forests	1,200	1%	0%
Dry Mesic Oak Pine Forests	6,800	3%	0%
Piedmont Mixed Bottomland Forests	1,600	1%	0%
Piedmont Oak Bottomland and Swamp Forests	1,500	1%	0%
Total Forested	**36,500**	**18%**	**-1%**
Barren (quarries, strip mines, and gravel pits)	0	0%	0%
Barren (bare rock and sand)	100	0%	0%
Piedmont Submerged Aquatic Vegetation	0	0%	0%
Piedmont Emergent Vegetation	0	0%	0%
Riverbank Shrublands	100	0%	0%
Floodplain Wet Shrublands	0	0%	0%
Open Water	1,500	1%	0%
Total Other	1,800	1%	**0%**
TOTAL	**202,000**	**100%**	**0%**

Notes: Results have been rounded to the nearest 100 acres and whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

5.2 How Was Impervious Surface Estimated?

In order to determine the amount of impervious surface in the FLUSA and by watershed under all the land use scenarios, each land use category was assigned an assumed level of impervious surface. This step of the analysis followed guidance in the Soil Conservation Service (SCS) TR-55 Manual. The SCS TR-55 Manual is widely used for drainage studies and runoff calculations. Land use categories with their associated percentage of impervious coverage applied in this quantitative ICE analysis are presented in Table 16.

Table 16: Percent Impervious Surface for Each Land Use Category

Land Use Category	% Impervious using SCS TR-55 Manual
Commercial	85%
Industrial/Office/Institutional	70%
High Density Residential	38%
Medium Density Residential	25%
Low Density Residential	20%
Transportation	100%
Agricultural and Natural	0%

Source: SCS, 1986

These percentages were applied to the land use acreages, and results are summarized here. Since the FEIS Quantitative ICE analyses included a Water Quality Analysis based on the results of the prior Quantitative ICE for Land Use, the results of the impervious surface analysis will be compared to the prior results from the FEIS Appendix H to determine if the changes are substantial enough to necessitate rerunning the water quality modeling. Table 17 shows the changes in impervious surface between the original 2007 Baseline and the updated 2010 Baseline results. The updated Existing 2010 Land Use shows that most watersheds have seen little to no change in impervious surface percentage since 2007. Two watersheds, Crooked Creek and Sixmile Creek have seen an increase in their impervious percentages of one percentage point. Bakers Branch Creek had a reduction in its impervious percentages of less than one percentage point due to some slight adjustments in land use classification.

Table 17: Updated 2010 Baseline Imperviousness Compared to Previous 2007 Baseline Imperviousness

Watershed Name	Original Impervious Cover	Updated Impervious Cover	Difference in Percentages
Beaverdam Creek	6%	6%	No Change
Richardson Creek (Upper)	14%	14%	No Change
Rays Fork	12%	12%	No Change
Bearskin Creek	24%	24%	No Change
Richardson Creek (Middle)	23%	23%	No Change
Gourdvine Creek	6%	6%	No Change
Salem Creek	9%	9%	No Change
Sixmile Creek	25%	26%	1%↑
Twelvemile Creek	22%	22%	No Change
Richardson Creek (Lower)	10%	10%	No Change
Stewarts Creek	15%	15%	No Change
Fourmile Creek	32%	32%	No Change
Crooked Creek	21%	22%	1%↑
Goose Creek	13%	13%	No Change
Irvins Creek	35%	35%	No Change
McAlpine Creek	36%	36%	No Change
Bakers Branch	6%	5%	1%↓
Wide Mouth Branch	10%	10%	No Change

Notes: Results have been rounded to the nearest one whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Table 18: Updated 2030 No-Build Imperviousness Compared to Previous No-Build Imperviousness

Watershed Name	Original Impervious Cover	Updated Impervious Cover	Difference in Percentages
Beaverdam Creek	7%	7%	No Change
Richardson Creek (Upper)	18%	18%	<1%↑
Rays Fork	16%	16%	<1%↑
Bearskin Creek	31%	31%	<1%↑
Richardson Creek (Middle)	27%	27%	No Change
Gourdvine Creek	8%	8%	No Change
Salem Creek	13%	13%	<1%↑
Sixmile Creek	30%	31%	1%↑
Twelvemile Creek	25%	25%	No Change
Richardson Creek (Lower)	15%	15%	<1%↑
Stewarts Creek	20%	21%	<1%↑
Fourmile Creek	34%	35%	1%↑
Crooked Creek	25%	26%	1%↑
Goose Creek	17%	18%	1%↑
Irvins Creek	37%	38%	1%↑
McAlpine Creek	37%	38%	1%↑
Bakers Branch	8%	8%	No Change
Wide Mouth Branch	12%	12%	<1%↑

Notes: Results have been rounded to the nearest one whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Table 18 shows the changes in impervious surface between the original No-Build and the updated No-Build results. Five watersheds have no change from the previous results. Seven watersheds have an increase in imperviousness of less than one percentage point. Only six watersheds (Sixmile Creek, Fourmile Creek, Crooked Creek, Goose Creek, Irvins Creek and McAlpine Creek) show an increase of at least one full percent point but none of those sees more than a one percent increase. Therefore, the overall results are similar to the previous results.

Table 19: Updated 2030 Build Imperviousness Compared to Previous 2030 Build Imperviousness

Watershed Name	Original Impervious Cover	Updated Impervious Cover	Difference in Percentages
Beaverdam Creek	7%	7%	No Change
Richardson Creek (Upper)	18%	18%	No Change
Rays Fork	17%	17%	<1%↑
Bearskin Creek	31%	31%	<1%↑
Richardson Creek (Middle)	29%	30%	1%↑
Gourdvine Creek	8%	8%	No Change
Salem Creek	14%	16%	2%↑
Sixmile Creek	30%	31%	1%↑
Twelvemile Creek	25%	25%	No Change
Richardson Creek (Lower)	16%	17%	1%↑
Stewarts Creek	22%	23%	1%↑
Fourmile Creek	34%	35%	1%↑
Crooked Creek	27%	28%	1%↑
Goose Creek	17%	18%	1%↑
Irvins Creek	37%	38%	1%↑
McAlpine Creek	37%	38%	1%↑
Bakers Branch	8%	8%	No Change
Wide Mouth Branch	12%	12%	No Change

Notes: Results have been rounded to the nearest whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Table 19 shows the changes in impervious surface between the original Build and the Updated Build results. Six watersheds show no discernible change, while two have increases of less than one percent. Nine watersheds see increases of one percent over the previous results. Only one watershed, Salem Creek, sees an increase of more than one percent. The increase in Salem Creek is mostly attributable to increases in Low Density Residential Development attributable to new information from Union County described in Section 1. Overall the results are similar to the previous results. This suggests that additional water quality modeling would find the same results as the prior water quality modeling, given the standard errors associated with both land use projections and water quality modeling. The indirect and cumulative effects of these impervious surface results are discussed further in Section 5.4.

5.3 What Were the Indirect Land Use Impacts?

Table 20 shows the indirect land use differences between the Updated No-Build and Updated Build scenarios.

Table 20: Indirect Land Use Comparison

Land Use Category	2030 Updated No-Build		2030 Updated Build		
	Total Area (acres)	% of Total Area	Total Area (acres)	% of Total Area	Difference from 2030 No-Build
Total Residential	97,900	48%	99,700	49%	1%↑
Low Density Residential	*79,500*	*40%*	*80,600*	*40%*	*<1%↑*
Medium Density Residential	*14,900*	*7%*	*15,600*	*8%*	*1%↑*
High Density Residential	*3,500*	*2%*	*3,500*	*2%*	*0%*
Commercial	5,600	3%	5,900	3%	*0%*
Industrial/Office/Institutional	8,700	4%	8,800	4%	*0%*
Transportation	12,800	6%	13,900	7%	1%↑
Total Developed	**125,000**	**62%**	**128,200**	**63%**	**<2%↑**
Total Agricultural	**37,500**	**19%**	**35,500**	**18%**	**1%↓**
Total Forested	**37,700**	**19%**	**36,500**	**18%**	**1%↓**
Total Other	**1,800**	**1%**	**1,800**	**1%**	**0%**
TOTAL	**202,000**	**100%**	**202,000**	**100%**	**0%**

Notes: Results have been rounded to the nearest 100 acres and whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Differences in land use between the 2030 Build and 2030 No-Build scenarios are small relative to the overall level of growth in development expected between the Baseline and No-Build. Total additional developed land associated with the Build is approximately 3,200 acres, less than two percent of all land in the study area. Approximately 1,100 acres of this difference, however, is directly attributable to the footprint of the roadway. Therefore, the indirect land use impacts attributable to growth-induced by the project are approximately 2,100 acres. Agricultural and forested lands decrease by about 2,000 and 1,200 acres, respectively, as a result of the additional developed land. These additional changes represent a one percent decrease, respectively, as compared to the 2030 No-Build condition.

While the aggregate numbers describing the change in developed land indicate that transportation (i.e., the proposed project itself) accounts for about one-third of the difference in land use from the No-Build Alternative, there are also important differences in the developed land use categories. There is an increase of about 1,100 acres in low density residential land use and an increase of about 700 acres in medium density residential. In total, these differences are estimated to produce the net increase of about 4,900 households in the study area with the Build Scenario. In addition, commercial and industrial land use categories increase by 300 and 100 acres, respectively.

As shown in Table 21, increases in impervious surface as a result of the 2030 Build Scenario are relatively small for the overall study area and for most watersheds. Increases in impervious surface percentages between the No-Build and Build are found in six of the 18 watersheds in the study area (Rays Fork, Richardson Creek - Middle, Salem Creek, Richardson Creek - Lower, Stewarts Creek, and Crooked Creek). Five of these watersheds see an increase in impervious surface of only one or two percent. Salem Creek sees an increase of three percent. The Build Scenario has no measurable difference in effect on the amount of impervious surface in the remaining 12 watersheds, including the Goose Creek and Sixmile Creek watersheds, which are known to support the endangered Carolina heelsplitter.

Looking at cumulative changes, the overall study area would see a four percent increase in impervious surface under the No-Build but a five percent under the Build. Each watershed is expected to experience an increase in impervious surface in the No-Build scenario and some will see slightly higher impervious surface levels under the Build scenario, with the highest increase being a seven percent increase in Bearskin Creek. Watersheds with the highest impervious surface levels will likely see modest increases; although Irvins Creek and McAlpine Creek have baseline conditions of 35 percent and 36 percent impervious surface, these levels only increase by three percent and one percent, respectively, with any of the future conditions (No-Build or Build). With the Build scenario, no watershed would see a greater than three percent increase in impervious surface as compared to the No-Build scenario.

For individual watersheds, comparisons between the 2030 No-Build and Build find no difference for 12 of the 18 watersheds, including Goose Creek and Sixmile Creek. For the remaining six watersheds, a one to two percent difference between the 2030 Build and the 2030 No-Build scenarios was found for five watersheds and a three percent increase was found for Salem Creek. It is possible that in the watersheds where there are differences from the No-Build, the incremental Build effect could also have a cumulative effect when considered in combination with the incremental effects of other reasonably foreseeable future projects. These potential effects are discussed further in Section 5.4

5.4 What Were the Indirect Impervious Surface and Cumulative Water Quality Impacts?

Indirect Impervious Surface Impacts

Impervious surface was calculated as described above. The changes in impervious surface from Baseline to No-Build and No-Build to Build in the updated analysis are show in Table 21. In all cases, the total impervious area was calculated from the raw land use results and then rounded to the nearest percent.

Table 21: Percent Impervious Surface by Watershed and Alternative

Watershed Name	2010 Baseline Impervious Cover	2030 No-Build Impervious Cover	Change from Baseline to 2030 No-Build[1]	2030 Build Impervious Cover	Change from 2030 No-Build to 2030 Build[1]
Study Area	18%	22%	4%	23%	1%
Beaverdam Creek	6%	7%	2%	7%	No Change
Richardson Creek (Upper)	14%	18%	4%	18%	No Change
Rays Fork	12%	16%	4%	17%	1%
Bearskin Creek	24%	31%	7%	31%	No Change
Richardson Creek (Middle)	23%	27%	5%	30%	2%
Gourdvine Creek	6%	8%	2%	8%	No Change
Salem Creek	9%	13%	4%	16%	3%
Sixmile Creek	26%	31%	5%	31%	No Change
Twelvemile Creek	22%	25%	3%	25%	No Change
Richardson Creek (Lower)	10%	15%	5%	17%	2%
Stewarts Creek	15%	21%	5%	23%	2%
Fourmile Creek	32%	35%	3%	35%	No Change
Crooked Creek	21%	26%	5%	28%	2%
Goose Creek	13%	18%	5%	18%	No Change
Irvins Creek	35%	38%	3%	38%	No Change
McAlpine Creek	36%	38%	1%	38%	No Change
Bakers Branch	5%	8%	3%	8%	No Change
Wide Mouth Branch	10%	12%	2%	12%	No Change

[1] Changes were calculated prior to rounding and therefore do not match exactly the difference shown in the table results.

Overall, the study area impervious surface increases one percent from the No-Build to the Build, whereas the previous scenarios showed a change that was indistinguishable at the overall study area level. By watershed, results are generally similar to the previous results with the following exceptions:

- Richardson Creek (Lower) shows a two percent change, whereas previously it showed a one percent change.
- Salem Creek shows a three percent change, where previously it showed a one percent change.

Most of these changes are relatively modest compared to the larger overall change anticipated between the Baseline and No-Build scenarios. Six of the 18 watersheds have an increase in percent impervious from the No-Build to the Build Scenario. Of these, Rays Fork shows a one percent increase, Richardson Creek – Middle, Richardson Creek – Lower, Stewarts Creek and Crooked Creek all have two percent increases and Salem Creek has a three percent increase.

Cumulative Water Quality Impacts

Of the watersheds in the area, nine include streams that are impaired in some capacity according to water quality ratings documented by the NC Department of Environment and Natural Resources (NCDENR), Division of Water Quality (NCDWQ). These watersheds and their impaired waters are documented in Table 22. Some watersheds, such as McAlpine Creek, have high levels of impervious surface and have impaired waters. Others, such as Irvins Creek and Fourmile Creek have high levels of impervious surface but no impaired waters. Beaverdam Creek has low levels of impervious surface but has impaired waters. Potential effects on each watershed with anticipated percent impervious changes under a Build Scenario are discussed below.

Table 22: 2012 Clean Water Act §303(d) Impaired Streams by Watershed

Watershed Name	Impaired Stream or Water Body	Impaired Reasons (Year)
Beaverdam Creek	Beaverdam Creek (Source to Lanes Creek)	Category 5 Copper (2008)
		Category 5 Low Dissolved Oxygen (2008)
Richardson Creek (Upper)	Lake Monroe	Category 5 Chlorophyll a (2008)
	Lake Lee	Category 5 Chlorophyll a (2008)
		Category 5 High pH (2008)
Richardson Creek (Middle)	Richardson Creek (Lake Lee to Mill Creek)	Category 5 Fair Bioclassification (1998)
Sixmile Creek	Sixmile Creek (Source to NC/SC Line)	Category 5 Fair Bioclassification (2006)
Richardson Creek (Lower)	Richardson Creek (Mill Creek to Watson Creek)	Category 5 Copper (2008)
Stewarts Creek	Lake Twitty	Category 5 Low Dissolved Oxygen (2012)
		Category 5 Copper (2008)
		Category 5 Chlorophyll a (2008)
	Stewarts Creek (Source to Stumplick Branch)	Category 5 Fair Bioclassification (2008)
Crooked Creek	Crooked Creek (Source to Rocky River)	Category 5 Turbidity (2010)
		Category 5 Fair Bioclassification (2012)
	North Fork Crooked Creek (Source to Crooked Creek)	Category 5 Turbidity (2004)
		Category 4s Poor Bioclassification
	South Fork Crooked Creek (Source to SR 1515)	Category 5 Poor Bioclassification (1998)
	South Fork Crooked Creek (SR 1515 to Crooked Creek)	Category 5 Fair Bioclassification (1998)
Goose Creek	Duck Creek (Source to Goose Creek)	Category 4b Fair Bioclassification (2008)
	Goose Creek (Source to SR 1524)	Category 4b Turbidity
	Goose Creek (SR 1524 to Rocky River)	Category 4b Fair Bioclassification (1998)
		Category 4t Fecal Coliform Violation
McAlpine Creek	McAlpine Creek (Source to NC 51)	Category 5 Fair Bioclassification (1998)
		Category 5 Fecal Coliform Violation (1998)

Source: 2012 NCDENR 2012 North Carolina 303(d) Integrated Report

The **Rays Fork Creek** watershed includes four waterbodies with water quality ratings documented by NCDWQ. None of these streams is listed as impaired at this time. The impervious surface level for this watershed is expected to increase from 12 percent to 16 percent from the Baseline to the No-Build condition. Under the Build Scenario, the level of impervious surface would increase to 17 percent. Given the small difference in induced impacts (one percent) the induced water quality impacts would likely be very small in this watershed. Cumulative impacts would also likely be minimal. The Rays Fork watershed is not listed in the 2003 or 2008 Yadkin-Pee Dee River Basinwide Water Quality Plans and therefore does not appear to be a watershed facing major water quality issues. Currently, eight of 18 watersheds have impervious surface areas of 17 percent or higher. Of these, four (McAlpine Creek, Sixmile Creek, Crooked Creek and Richardson Creek – Middle) have streams with impaired waters while four (Twelvemile Creek, Bearskin Creek, Fourmile Creek and Irvins Creek) do not have impaired waters.

The **Richardson Creek - Middle** watershed includes one waterbody segment listed as impaired at this time by NCDWQ. Richardson Creek is listed as a Category 5 impaired stream due to a fair bioclassification in 1998. The impervious surface level for this watershed is expected to increase from 23 percent to 27 percent from the Baseline to the No-Build condition. Under the Build Scenario the level of impervious surface would increase to 30 percent, although the calculated difference is only two percent, due to rounding. Given the small difference in induced impacts (two percent) the induced water quality impacts would likely be small in this watershed. Cumulative impacts would also likely be small. Currently, three of 18 watersheds have impervious surface areas of 30 percent or higher. Of these, only one (McAlpine Creek) has streams with impaired waters while the other two (Fourmile Creek and Irvins Creek) do not have impaired waters.

The **Richardson Creek - Lower** watershed includes one waterbody segment listed as impaired at this time by NCDWQ. The impervious surface level for this watershed is expected to increase from 10 percent to 15 percent from the Baseline to the No-Build condition. Under the Build Scenario the level of impervious surface would increase to 17 percent. Given the small difference in induced impacts (two percent) the induced water quality impacts would likely be small in this watershed. Cumulative impacts would also likely be small. Currently, eight of 18 watersheds have impervious surface areas of 16 percent or higher. Of these, four (McAlpine Creek, Sixmile Creek, Crooked Creek and Richardson Creek – Middle) have streams with impaired waters while four (Twelvemile Creek, Bearskin Creek, Fourmile Creek and Irvins Creek) do not have impaired waters.

The **Richardson Creek watershed (in whole)** is discussed in the 2003 and 2008 Yadkin-Pee Dee River Basinwide Water Quality Plans for Aquatic Life and Secondary Recreation Impairment. The 2003 report noted that the stream had low levels of dissolved oxygen and high levels of nutrients (nitrate/nitrite nitrogen and total phosphorous). The City of Monroe Waste Water Treatment Plant (WWTP) is located along Richardson Creek and is listed as a cause of stream impacts. The 2003 report notes that that the benthic community was improving, suggesting water quality improvements. The 2008 report noted turbidity and nutrient issues mostly associated with agricultural and pasture activity in the watershed. The report also noted the numerous confined animal feeding operations (CAFOs) within the watershed. Given these reports, many of the underlying reasons for the water quality issues in Richardson Creek are not directly related to new development and therefore the projected incremental and cumulative land use changes are unlikely to exacerbate the water quality issues in these watersheds.

The **Salem Creek** watershed includes five waterbodies assessed by the NCDWQ, none of which is listed as impaired in the 2012 assessment database. The impervious surface level for this watershed is expected to increase from nine percent to 13 percent from the Baseline to the No-Build condition. Under the Build Scenario, the level of impervious surface would increase to 16 percent. While the three percent incremental difference from the No-Build to Build scenarios is the largest of all watersheds modeled, the induced and cumulative water quality impacts would likely be very small in this watershed. Currently, eight of 18 watersheds have impervious surface areas of 16 percent or higher. Of these, four (McAlpine Creek, Sixmile Creek, Crooked Creek and Richardson Creek – Middle) have streams with impaired waters while four (Twelvemile Creek, Bearskin Creek, Fourmile Creek and Irvins Creek) do not have impaired waters. The 2008 Yadkin-Pee Dee River Basinwide Water Quality Plan notes that this stream had a Good-Fair Bioclassification in 2006 and that the stream is subject to low flow conditions. No other major issues were found.

The **Stewarts Creek watershed** includes nine waterbodies assessed by the NCDWQ. Two of these segments are listed as impaired. Stewarts Creek upstream of Lake Twitty and Lake Twitty are listed as Category 5 Impaired for various reasons noted in Table 22. The impervious surface level for this watershed is expected to increase from 15 percent to 21 percent from the Baseline to the No- Build. Under the Build Scenario the level of impervious surface would increase to 23 percent. Given the small difference in induced impacts (two percent) the induced water quality impacts would likely be small in this watershed. Currently, six of 18 watersheds have impervious surface areas of 21 percent or higher. Of these, three (McAlpine Creek, Sixmile Creek, and Richardson Creek – Middle) have streams with impaired waters while three (Bearskin Creek, Fourmile Creek, and Irvins Creek) do not have impaired waters. Stewarts Creek was noted in the 2008 Yadkin-Pee Dee River Basinwide Water Quality Plan for habitat degradation due to agricultural runoff and impervious surface runoff. The report noted that a 2006 study rated the stream fair due to degraded benthic communities. As this creek is the main water source for the City of Monroe, the City is taking steps to improve water quality by rebuilding vegetated buffers around Lake Twitty.

The **Crooked Creek watershed** includes four waterbody segments assessed by the NCDWQ and all four are listed as impaired at this time for either turbidity or bioclassification issues. The impervious surface level for this watershed is expected to increase from 21 percent to 26 percent from the Baseline to the No-Build condition. Under the Build Scenario, the level of impervious surface would increase to 28 percent. Given the small difference in induced impacts (two percent) the induced water quality impacts would likely be small in this watershed. Currently, four of 18 watersheds have impervious surface areas of 28 percent or higher. Of these, two (McAlpine Creek and Sixmile Creek) have streams with impaired waters while two (Fourmile Creek and Irvins Creek) do not have impaired waters. Crooked Creek watershed is identified in the 2008 Yadkin-Pee Dee River Basinwide Water Quality Plan as a watershed with habitat degradation, turbidity, fecal coliform and nutrient issues due to stormwater runoff and construction. The analysis of benthic communities, however, showed good to good-fair conditions for Crooked Creek in 2006, which was an improvement from previous studies.

In all cases where the Build Scenario shows greater impervious surface impacts than the No-Build Scenario (Rays Fork, Richardson Creek – Middle, Salem Creek, Richardson Creek – Lower, Stewarts Creek, Crooked Creek) those increases are less than the increases predicted between the Baseline and the No-Build. Furthermore, based on a query of the Natural Heritage Program Map View conducted on April 15, 2013, there are no federally protected listed species in these streams or watersheds and thus these small increases in impervious surface would not be affecting federally protected listed species. Overall, as these results are very similar to the results of the original Quantitative ICE, additional water quality modeling is not necessary as these differences are not large enough to see substantial differences compared to the prior water quality results and the results would likely be within the standard error of such an analysis.

5.5 What Were the Indirect and Cumulative Impacts to Endangered Species?

The cumulative definition under the ESA differs from that under NEPA in that the effects of future federal actions are not included in an ESA cumulative analysis but are included in a NEPA analysis. The cumulative analysis outlined below was performed using the NEPA definition. The Biological Assessment (BA)(Catena, 2013) of cumulative impacts similarly used the NEPA definition of cumulative effects. Therefore, the cumulative effects to endangered species may be somewhat overestimated since this Quantitative ICE analysis included the effects of future federal actions as well as non-federal actions.

Carolina Heelsplitter

The Carolina heelsplitter is found only in the Goose Creek and Sixmile Creek watersheds. As shown in previous sections of indirect effects, no measureable differences in land use and impervious surfaces were found between the 2030 No-Build and 2030 Build within the Goose Creek or Sixmile Creek watersheds. Therefore, no indirect effects are anticipated on the species associated with the Monroe Connector/Bypass project. As the BA concludes, direct effects are extremely unlikely, though cannot be unquestionably discounted. There are no anticipated indirect effects. Therefore, cumulative effects to the Carolina heelpslitter are extremely unlikely, though cannot be unquestionably discounted.

Other Endangered Species

Michaux's sumac, Schweinitz's sunflower, and the smooth coneflower are federally listed as endangered plant species. The sumac and sunflower are listed for both Mecklenburg and Union counties, but the coneflower is listed only for Mecklenburg County.[50] There are known populations of Schweinitz's Sunflower in the FLUSA, and populations of the species have been found in the vicinity of the proposed alignment for the Monroe Connector/Bypass. An evaluation of potential indirect and cumulative effects to the species is summarized below.

Michaux's sumac grows in sandy or rocky open woods on sandy or sandy loam soils with low cation-exchange capacities and appears to depend upon some form of disturbance to maintain the open quality of its habitat.[51][52] Most extant populations can be found on open disturbed areas, such as railroad, road, and utility rights-of-way that are periodically maintained and/or managed for the species. The only known occurrence of Michaux's sumac in the FLUSA was last observed in 1794 and no populations were found in surveys of suitable habitat in the FLUSA. The survey methodology is discussed in the Biological Assessment. [53] As no populations of the species have been found in the FLUSA, it is not anticipated that

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[50] NC Natural Heritage Program. "Data Services." Updated January 9, 2009.
[51] USFWS. *Michaux's Sumac Recovery Plan*. 1993. Atlanta, GA: p 30.
[52] Suiter, D. Endangered Species Biologist, USFWS. Raleigh, NC. Personal Communication regarding Draft 5-year status review of Michaux's sumac. Telephone: Feb. 2 and 18, 2010.
[53] The Catena Group for NCTA, *Biological Assessment of Carolina Heelsplitter (Lasmigona decorata) and Designated Critical Habitat, Schweinitz's Sunflower (Helianthus schweinitzii), Michaux's Sumac (Rhus michauxii), and Smooth Coneflower (Echinacea laevigata)*, Monroe Connector/Bypass, October, 2013.

the Monroe Connector/Bypass project will have any indirect or cumulative effects on the species. The BA provides more detail on direct and potential indirect and cumulative impacts.

There are no know populations of smooth coneflower in the FLUSA, and surveys of the FLUSA in areas of high quality habitat for the species found no populations. Based on the ICE analysis, indirect effects are not anticipated in the Mecklenburg County portion of the FLUSA. As the BA concludes, there will be no direct effects to the species and the ICE analysis shows no indirect effects, there is no expectation that the project will cause cumulative effects to the coneflower. Since there will be no direct or indirect effects within Mecklenburg County and the lack of EO records within or near the FLUSA, the project is anticipated to have No Effect on this species. The BA provides more detail on direct and potential indirect and cumulative impacts.

Historically, it is believed that Schweinitz's sunflower occupied open prairie and Post Oak-Blackjack Oak Savannas that were maintained by relatively frequent fire.[54] Physical investigation of all suitable habitat within forest gaps was beyond the scope of this ICE analysis. In addition, the sunflower is an opportunistic species that can colonize even disturbed areas. Therefore, indirect effects to Schweinitz's sunflower are addressed through examining the conversion of land exhibiting habitat characteristics that would support the species. The NCGAP land cover categories included in the analysis were:

- Agricultural Pasture/Hay and Natural Herbaceous
- Barren (subcategory quarries, strip mines, and gravel pits)
- and Barren (subcategory bare rock and sand).

Although this species could eventually inhabit some of the lands converted to developed land use[55], such land use categories were not included in the analysis to present a more conservative estimate of the amount of suitable habitat loss. Table 23 presents the results of this analysis.

Table 23: Total Conversion of Pasture/ Hay Natural Herbaceous and Barren Land Cover to Developed Land

	Baseline (acres)	2030 No-Build (acres)	2030 Build (acres)	Change in 2030 with No-Build (acres)	Change in 2030 with Build (acres)
Acres	33,000	23,000	21,700	-10,000	-11,300
% of Baseline	-	-	-	-30%	-34%

Notes: Results have been rounded to the nearest 100 and whole percent. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

With the 2030 No-Build, there is an estimated 30 percent decrease in land cover types presumed to provide potential suitable habitat for the Schweinitz's sunflower. The incremental effect with either the 2030 Build scenarios is approximately a four percent decrease in potential suitable habitat (34 percent versus 30 percent).

Continued development pressure is expected within the project FLUSA within the horizon year of this analysis. However, it is not anticipated that future development will cause substantial cumulative effects.

[54] USFWS. *Schweinitz's Sunflower Recovery Plan*. 1994. Atlanta, GA: p 28.
[55] For example, utility rights of way, which are periodically maintained could provide habitat for the Schweinitz's sunflower, whereas frequently maintained lawns and landscape areas would not provide suitable habitat.

It is anticipated that areas of forest fringe and maintained or disturbed environments will continue to supply potential habitat for Schweinitz's sunflower species within the FLUSA in the future. Therefore, the project is not anticipated to have substantial indirect or cumulative effects on the species. The BA provides more detail on direct and potential indirect and cumulative impacts.

Georgia aster (*Symphyotrichum georgianum*) is listed as a candidate species by USFWS for inclusion under the ESA for protection as an endangered species. As it is not officially listed, its habitat was not directly analyzed. As its habit typical overlaps substantially with that of the Schweinitz's sunflower, the analysis of potential indirect and cumulative habitat losses discussed above would be generally valid for the Georgia aster as well.

5.6 Land Use and Farmland Conversion

Table 24 (No-Build) and Table 25 (Build) present the estimated total effects to land use broken out by watershed with each of the alternatives in conjunction with reasonably foreseeable future actions compared to the Baseline condition. Table 26 summarizes the incremental effects, i.e., the differences as compared to the changes anticipated with the No-Build scenario for the Build.

Indirect and direct land use effects combined were presented previously, and these tables also break out the land use categories in detail. For analysis of cumulative effects, the following tables present aggregations of categories for the agricultural and forested land uses:

- Agricultural land includes: *Agricultural Fields* and *Agricultural Pasture/Hay and Natural Herbaceous*
- Forested includes: *Coniferous Cultivated Plantation, Successional Deciduous Forest, Piedmont Xeric Pine Forests, Piedmont Dry-Mesic Pine Forests, Piedmont Xeric Woodlands, Piedmont Dry-Mesic Oak and Hardwood Forests, Piedmont Deciduous Mesic Forest, Xeric Pine-Hardwood Woodlands and Forests, Dry Mesic Oak Pine Forests, Piedmont Mixed Bottomland Forests*, and *Piedmont Oak Bottomland and Swamp Forests*
- Other includes: *Barren (quarries, strip mines, and gravel pits), Barren (bare rock and sand), Piedmont Submerged Aquatic Vegetation, Piedmont Emergent Vegetation, Riverbank Shrublands, Floodplain Wet Shrublands*, and *Open Water*.

Table 24: Total Changes in Land Use (in acres) by Watershed with the Updated 2030 No-Build Scenario Compared to the Baseline

Area/Watershed	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Industrial/Office/ Institutional	Transportation	Total Agricultural	Total Forested	Total Other
Study Area	24,000	2,000	400	1,700	1,600	100	-15,400	-14,200	-100
Beaverdam Creek	900	0	0	0	0	0	-600	-300	0
Richardson Creek (Upper)	1,200	0	0	0	0	0	-600	-600	0
Rays Fork	1,700	0	0	0	0	0	-1,000	-800	0
Bearskin Creek	1,600	0	0	0	500	0	-1,100	-1,100	0
Richardson Creek	1,000	0	0	0	100	0	-500	-700	0
Gourdvine Creek	100	0	0	0	0	0	0	0	0
Salem Creek	2,100	100	0	100	0	0	-1,600	-600	0
Sixmile Creek	0	100	100	0	0	0	-100	-200	0
Twelvemile Creek	900	100	0	0	300	0	-500	-800	0
Richardson Creek (Lower)	3,400	0	0	0	0	0	-2,300	-1,100	0
Stewarts Creek	4,300	0	0	300	200	0	-2,900	-1,800	-100
Fourmile Creek	0	200	0	100	0	0	-100	-400	0
Crooked Creek	2,900	200	100	400	200	0	-2,100	-1,700	0
Goose Creek	2,700	600	0	600	0	0	-1,400	-2,600	0
Irvins Creek	100	300	0	100	200	0	-100	-600	0
McAlpine Creek	100	300	100	100	0	0	0	-500	0
Bakers Branch	300	0	0	0	0	0	-100	-200	0
Wide Mouth Branch	500	0	0	0	0	0	-400	-200	0

Notes: Results have been rounded to the nearest 100 acres. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Table 25: Total Changes in Land Use (in acres) by Watershed with the Updated 2030 Build Scenario Compared to the Baseline

Area/Watershed	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Industrial/Office/ Institutional	Transportation	Total Agricultural	Total Forested	Total Other
Study Area	25,000	2,700	400	2,000	1,700	1,100	-17,500	-15,400	-200
Beaverdam Creek	900	0	0	0	0	0	-600	-300	0
Richardson Creek (Upper)	1,200	0	0	0	0	0	-600	-600	0
Rays Fork	1,700	0	0	0	0	100	-1,000	-800	0
Bearskin Creek	1,600	0	0	0	500	0	-1,100	-1,100	0
Richardson Creek (Middle)	1,200	0	0	0	100	100	-600	-800	0
Gourdvine Creek	100	0	0	0	0	0	0	0	0
Salem Creek	3,200	200	0	100	0	100	-2,600	-1,000	0
Sixmile Creek	0	100	100	0	0	0	-100	-200	0
Twelvemile Creek	900	100	0	0	300	0	-500	-800	0
Richardson Creek (Lower)	3,900	200	0	0	100	100	-2,900	-1,400	0
Stewarts Creek	3,900	100	0	400	200	300	-3,100	-1,900	-100
Fourmile Creek	0	200	0	100	0	0	-100	-400	0
Crooked Creek	2,600	300	100	500	200	400	-2,200	-1,800	0
Goose Creek	2,700	600	0	600	0	0	-1,400	-2,600	0
Irvins Creek	100	300	0	100	200	0	-100	-600	0
McAlpine Creek	100	300	100	100	0	0	0	-500	0
Bakers Branch	300	0	0	0	0	0	-100	-200	0
Wide Mouth Branch	500	0	0	0	0	0	-400	-200	0

Notes: Results have been rounded to the nearest 100 acres. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Table 26: Incremental Effects of Updated 2030 Build Land Use Changes (in acres) by Watershed

Area/Watershed	Difference From Updated No-Build – Total Developed	Difference From Updated No-Build – Total Agricultural	Difference From Updated No-Build – Total Forested
Study Area	3,200	-2,100	-1,200
Beaverdam Creek	0	0	0
Richardson Creek (Upper)	0	0	0
Rays Fork	100	0	0
Bearskin Creek	0	0	0
Richardson Creek (Middle)	300	-100	-200
Gourdvine Creek	0	0	0
Salem Creek	1,400	-1,000	-400
Sixmile Creek	0	0	0
Twelvemile Creek	0	0	0
Richardson Creek (Lower)	1,000	-600	-300
Stewarts Creek	300	-200	-100
Fourmile Creek	0	0	0
Crooked Creek	300	-100	-100
Goose Creek	0	0	0
Irvins Creek	0	0	0
McAlpine Creek	0	0	0
Bakers Branch	0	0	0
Wide Mouth Branch	0	0	0

Notes: Results have been rounded to the nearest 100 acres. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Updated 2030 No-Build

The 2030 No-Build scenario is predicted to increase developed land by 29,900 acres throughout the study area as compared to the Baseline (existing) condition. This represents 15 percent of the total study area. Most of the estimated development (84 percent) is due to the increase in Low Density Residential growth. For this conversion to development, the following reductions in undeveloped lands are predicted: 15,400 acres of agricultural land, 14,200 acres of forested land and 100 acres of other land uses.

From 1984 to 2003, a loss of over 48,000 acres in tree cover was recorded in Union County, although a large portion of those acres may have been cleared for agriculture, logging, or non-urban development (NCTA, 2009). The further reduction in forested acreage predicted with the 2030 No-Build in this Technical Report (14,200 acres) represents an additional loss; however, the reduction is at a substantially lower rate. Some of that is attributable to the fact that the land use projection methodology used in this ICE analysis is converting more agricultural land than forested land to developed categories even though both categories are roughly equal in acreage in the Baseline 2010 Land Use. Part of the reason for the higher likelihood of agricultural conversion rather than forested conversion is in the land use projection methodology stream buffers were excluded from development and stream buffer areas are more likely to contain forested land than agricultural land.

Farmland comprises 52 percent of the total converted undeveloped lands. The predicted acreage of farmland conversion (15,400 acres) represents 29 percent of the total amount of farmland in the study area's Baseline condition (52,900 acres).

Updated 2030 Build

The 2030 Build scenario is predicted to increase developed land by 3,200 more acres throughout the study area as compared to the No-Build condition. This incremental effect is equivalent to less than two percent of the study area. Most of the estimated development increase with the Build scenario (79 percent) is due to the increase in Low Density Residential growth, but this number is smaller than with the 2030 No-Build scenario because a larger percentage of the development is predicted to be from Medium Density Residential, Commercial, and Industrial/Office/Institutional growth in the Build scenarios.

Farmland represents nearly the same amount of the converted undeveloped land as with the No-Build condition (53 percent versus 52 percent). As compared to the 2030 No-Build, the 2030 Build Scenario is predicted to have 2,100 additional acres of converted farmland which equals about an additional four percent loss in farmland over the No-Build condition.

5.7 What Were the Cumulative Impacts to Wildlife Habitat?

Total Habitable Land Changes

This section presents cumulative effects specific to wildlife habitat. Specifically, Table 27 presents the changes predicted for each alternative in the total amount of undeveloped vegetated land cover. The effect to potential aquatic habitat is inferred from the effect to water quality, detailed above. With regard to percent impervious cover as an indicator for effects to water quality and thus aquatic habitat, findings show only a one percent difference in percent impervious cover between the 2030 Build and 2030 No-Build scenarios for the study area as a whole. Findings also show a one percent to two percent incremental effect with the Build Scenario within any individual watershed, except for Salem Creek, which will have a three percent incremental effect with the Build.

For presentation of cumulative effects in Table 27, aggregates of the NCGAP land cover categories were used. The list of categories used to compile an "Undeveloped Vegetated Land" layer included all the categories below "Total Development," except the "Agricultural Fields" (i.e., croplands), "Barren (quarries, strip mines, and gravel pits)" and "Open Water" categories, which were presumed not to provide substantial amounts of suitable wildlife habitat.

Table 27: Total Changes in Undeveloped Vegetated Land and Land Cover Likely to Encompass Wetlands Compared to the Baseline

Watershed Name	Total Vegetated (acres)	
	Updated 2030 No-Build	Updated 2030 Build
Study Area	-24,200	-26,600
Beaverdam Creek	-700	-700
Richardson Creek (Upper)	-900	-900
Rays Fork	-1,400	-1,500
Bearskin Creek	-1,600	-1,600
Richardson Creek (Middle)	-1,000	-1,300
Gourdvine Creek	-100	-100
Salem Creek	-1,600	-2,500
Sixmile Creek	-300	-300
Twelvemile Creek	-1,200	-1,200
Richardson Creek (Lower)	-2,700	-3,500
Stewarts Creek	-4,000	-4,200
Fourmile Creek	-500	-500
Crooked Creek	-3,100	-3,300
Goose Creek	-3,300	-3,300
Irvins Creek	-700	-700
McAlpine Creek	-500	-500
Bakers Branch	-200	-200
Wide Mouth Branch	-400	-400

Notes: Results have been rounded to the nearest 100 acres. Differences were calculated prior to rounding. Totals may appear not to equal the sum of the parts because of rounding.

Updated 2030 No-Build

The 2030 No-Build scenario was predicted to decrease vegetated land cover by 24,200 acres from the Baseline condition. This represents 28 percent of the total Baseline condition vegetated land cover (85,500 acres). As shown above regarding land use changes, forest lands are predicted to be reduced by 14,200 acres with the 2030 No-Build scenario. It is likely that some of the development likely to occur by 2030 with the No-Build will fragment forest patches. Cumulative effects from this fragmentation may include effects to wildlife populations.

Updated 2030 Build

The incremental effect with the 2030 Build is 2,400 acres of additional converted vegetated land as compared to the loss predicted with the 2030 No-Build condition. This represents an additional 3 percent loss in vegetated land. These reductions are mostly concentrated in Salem Creek and Richardson Creek –

Lower, with some losses also scattered among Rays Fork, Richardson Creek – Middle, Stewarts Creek and Crooked Creek. These incremental losses represent 9 to 12 percent of the Baseline vegetated land uses for Salem Creek, Richardson Creek – Lower and Richardson Creek – Middle watersheds. The concentrated losses are a result of the Low Density Residential expected around the eastern end of the corridor. A review of the NCDENR Natural Heritage Program Map Viewer database on April 15, 2013 indicates there is only one occurrence of rare plants or animals in these three watersheds. Jesse Helms Memorial Park is designated a Significant Natural Heritage Area as it supports a population of Piedmont aster (*Eurybia mirabilis*), a Federal Species of Concern. Given that this is a public park, it is highly unlikely that this area would see development that would degrade the population. All other watersheds see incremental losses of less than 2 percent additional relative to their Baseline levels. Thus, while there may be some impacts to wildlife populations locally, these impacts are unlikely to be considerable on a regional scale nor are they likely to substantially affect habitats of protected species.

Forest Fragmentation Impacts

One of the potential effects of development is to break up previously connected habitats (fragmentation). This can impact some species that require large patches of habitat (deer, and larger predators); and the increase in edge between different types of habitat, such as forested and residential areas, can cause an increase in encounters (such as vehicle crashes) that hurt wildlife populations. To understand the effects on the wildlife habitats in the study area, a Patch Analysis was completed using ArcGIS Spatial Analyst and the FRAGSTATS program. Spatial Analyst tools were used to classify land cover categories into two classes, those land cover categories that could generally support a range of natural wildlife habitats and those that could not (i.e. developed lands). After the land covers were reclassified, the data was entered into the FRAGSTATS program for analysis.

A habitat is a continuous parcel of land that provides some wildlife habitat and is not separated by roads, structures, or other type of urban development. Patches were grouped as either a developed area or other area that would not likely be suitable as wildlife habitat (Class 1) or areas that would likely be suitable as wildlife habitat (Class 2). Land cover categories that would not likely be suitable as wildlife habitat include Transportation, Commercial, all Residential categories, Open Water, both Barren Land categories, and both Agricultural categories. Land cover categories in Class 2 that would like be suitable as wildlife habitat include Successional Deciduous Forest, Piedmont Xeric Pine Forests, Piedmont Dry-Mesic Pine Forests, Piedmont Xeric Woodlands, Piedmont Dry-Mesic Oak and Hardwood Forests, Piedmont Deciduous Mesic Forest, Xeric Pine-Hardwood Woodlands and Forests, Dry Mesic Oak Pine Forests, Piedmont Mixed Bottomland Forests, Piedmont Oak Bottomland and Swamp Forests, Piedmont Submerged Aquatic Vegetation, Piedmont Emergent Vegetation, Riverbank Shrublands, and Floodplain Wet Shrublands. A patch analysis focuses on how connected or disconnected wildlife habitats may be. The metrics used focus on the size, shape, and connections between patches of suitable habitat. Therefore, the number of patches, their density and their mean (or average) size are important factors. Table 28 summarizes the results of the analysis for the Class 2 land cover categories and the metrics are explained and the results discussed below.

An important caveat for interpreting the patch analysis results is the fact that the level of fragmentation in both future land use scenarios is likely overstated due to the methodologies used in their construction. Specifically, by allocating growth within TAZs to a proportion of all developable parcels rather than selecting entire parcels to be built-out and others to remain vacant, the projected land use pattern for this ICE analysis is more fragmented than that which would actually be expected to occur. The advantage of this approach is that it is transparent and neutral in "spreading" effects across undeveloped land within TAZs. However, by spreading growth to all developable parcels rather than specific communities, the methodology maximizes fragmentation effects. These assumptions do not affect the comparison between the No-Build and Build scenarios but rather the distribution of development in all the future land use scenarios. The assumptions thus specifically affect the comparisons of fragmentation between the existing and future land use scenarios.

Table 28: Habitat Fragmentation Analysis Results

Parameter	Existing	No-Build	Build	Difference Between Existing and No Build	Difference Between Existing and Build	Difference Between Build and No Build
# of Patches	6,642	7,856	7,785	18%	17%	-1%
Patch Density (# per 100 acres)	3.29	3.89	3.86	18%	17%	-1%
Mean Patch Area (acres)	7.86	4.82	4.72	-39%	-40%	-2%
Perimeter to Area Mean	937.19	995.25	998.12	6%	7%	<1%
Mean Nearest-Neighbor (meters)	88.59	89.77	90.79	1%	2%	1%
Clumpiness	0.71	0.66	0.66	-8%	-7%	<1%
Effective Mesh Size (acres)	109.66	39.76	37.02	-64%	-66%	-7%

The number of patches, the patch density and the mean patch area indicate how fragmented habitat may be by indicating the raw number of habitat patches, the density of those patches and the mean (average) area of each patch across the study area. The number of patches and patch density increase between the Existing and No-Build scenarios by 18 percent and between the Existing and Build scenarios by 17 percent. By these measures, the indirect effects are very small but the cumulative effects are sizeable. Similarly, the mean patch size is much smaller in both future scenarios (approximately 40 percent) while the indirect impacts are small, the cumulative effect is more substantial. The number of patches and patch density is increasing due to the encroachment of development into previously continuous patches that then reduces patch sizes and splits once continuous patches into multiple separate patches. The size of patches is decreasing for the same reasons. The mean patch area metric is a very rough approximation of habitat fragmentation, however, and can be easily skewed by adding a number of very small patches to the landscape, as might occur when new development isolates a number of small patches from a few larger patch areas.

Despite the sizable changes in density and mean area, the mean nearest-neighbor parameter shows little change, increased by only 1 to 2 percent between any scenario. The mean nearest neighbor parameter is the mean of the shortest straight-line distance between each patch and its nearest neighbor. This gives an indication of the typical distance between each patch across the study area and thus the distance wildlife might have to traverse to get from one habitat patch to another. Thus while patches may be deceasing in size, they are not necessarily getting much farther apart.

The perimeter to area mean ratio shows much less change than the density and size metrics. The perimeter to area ratio gives an indication of how complex the shapes of habitat patches are by dividing the perimeter by the area of each patch. The higher the ratio, the more complex the shape and the more edge areas would exist relative to interior area space within each patch. The perimeter to area ratio shows a 6 to 7 percent increase from the Existing to the No-Build and Build, respectively, suggesting that the shape of patches is not changing dramatically.

The clumpiness parameter measures the distribution of patches. The parameter ranges from negative one to one, where zero indicates a random distribution of patches. Less than zero indicates a greater level of dispersion and one indicates a greater level of clumping. The clumpiness parameter for the Existing Scenario is 0.71, indicating that the distribution is rather clumpy. This is to be expected as the largest continuous patches and most of the patches are in the eastern portions of the study area. Under both future scenarios the clumpiness parameter decreases to 0.66 which is a modest decrease and indicates no indirect effect and modest cumulative effect to the clumpiness of habitats through the study area.

Finally, the effective mesh size gives an indication of overall patch structure. Effective mesh size gives an indication of the likelihood that any two randomly chosen points in the study area may or may not be connected with a continuous habitat patch. That likelihood is expressed as an effective mesh size in acres. This metric shows the greatest change, both cumulatively and indirectly, as the effective mesh size decreases by about 65 percent for both future scenarios. Between the No-Build and Build Scenario, the effective mesh size decreases by seven percent. Effective mesh size is most appropriate for species, such as deer or other larger mammals, that need larger ranges of undisturbed habitat or that face dangers from crossing between fragmented habitats.

Overall, these fragmentation metrics suggest that most habitat fragmentation will occur with or without the proposed project. Furthermore, while some metrics, such as effective mesh size and mean patch area, suggest some substantial increases in fragmentation, other, such as the clumpiness and mean nearest neighbor suggest fragmentation will be more modest. The variability in results suggests that some metrics may be skewed by very small patches drawing the results in one direction. For example, the mean patch size measure would be easily skewed by the addition of many new and very small patches even many larger patches remained intact. Overall, the indirect impacts are generally small to negligible while the cumulative results vary from small to substantial. However, the cumulative impacts would appear to be likely to occur with or without the proposed project.

5.8 What Were the Indirect and Cumulative Impacts to Traffic?

To address concerns that additional traffic generated by the estimated induced growth from the project could cause additional impacts, the Metrolina Regional Model (MRM) was used to forecast raw model volumes under three scenarios. These three scenarios were then compared to determine what, if any, traffic impacts might result from the indirect and cumulative impacts of the project. A No-Build and two Build scenarios were run through the MRM and the cumulative corridor level raw model outputs are shown in Table 29. These volumes are raw model volumes that have not been fully calibrated or adjusted per standard traffic engineering principles. These volumes therefore do not represent a fully calibrated forecast of No-Build and Build traffic conditions, but because they were developed the same way from the same MRM version, the difference between them can help reveal the induced traffic impacts of the project. For the No-Build Scenario, the MRM 11 v1.1 was edited to remove the Monroe Bypass/Connector from the model network and the model was run using the 2009 Projections for the socioeconomic input. As documented in Section 4, the 2009 Projections were used to develop the No-Build scenario and therefore were used in this analysis to represent the No-Build Scenario.

For the Build Scenario, two scenarios were run to compare the differences with and without the estimated growth impacts of the proposed project. In the first scenario, the MRM 11 v1.1 was used with the Monroe Bypass/Connector in the model network and the model was run using the 2009 Projections for the socioeconomic input. For the second Build Scenario the MRM 11 v1.1 was used with the Monroe Bypass/Connector in the model network and the model was run using an adjusted version of the 2009 Projections for the socioeconomic input. The land use differences identified in the Build Scenario ICE analysis were reviewed at the TAZ level and, based on the localized density assumptions, estimates of the additional household and employment attributable to the additional development anticipated under a Build Scenario were developed at the TAZ level. These estimates of additional households and employment were then added to the 2009 Projections to create a 2009 ICE Projections version. These adjustments added, on net, approximately 4,900 households and 3,800 employees to TAZs within the FLUSA. The raw model volumes from the MRM are shown in Appendix M. Table 29 shows a comparison of the regional vehicle miles traveled (VMT) and vehicle hours traveled (VHT) under the same three scenarios.

The segment level volumes in Appendix M show that when comparing the two Build scenarios run in the model, the project's induced growth does add to the volume level on the Monroe Connector/Bypass, US 74 and intersecting roadways. The highest percent change is along the Y-Line corridors, where there would be some road segments would see sizeable percentage increase relative to a Build Scenario without the project-induced growth. Yet, the volume increase for any given road segment is less than 3,500 AADT. On average, each roadway segment only sees an additional 1,400 vehicles per day. Along the US 74 and Monroe Connector/Bypass corridors, the percent increase is much lower, less than five percent in most cases. The eastern end of US 74 sees the greatest percentage increases, but again, most of these segments see relatively modest AADT increases of less than 5,000 vehicles per day. Also of note, is the comparison between the Build (2009 Projections) and the Build (Adjusted Projections) volume along the US 74 corridor. Under both scenarios, volume on the US 74 corridor drops by between 8 and 36 percent, depending on the segment, meaning that under the Build Scenario, with or without project-induced growth, US 74 would see substantially less traffic than under a No-Build Scenario.

With respect to total vehicle miles traveled within Union County, the Build Scenario with project-induced growth shows total VMT three percent higher than the Build Scenario without project-induced growth and eight percent higher than the No-Build Scenario. At the regional level, however, the difference is only one percent relative to the No-Build. For vehicle hours traveled, within Union County, the Build Scenario with project-induced growth is three percent higher than the No-Build and four percent higher than the Build without project-induced growth.

Table 29: County and Regional Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)

County		Union	Mecklenburg	All Others	Regional Total
No-Build	VMT	9,253,669	44,616,030	51,580,950	105,450,650
	VHT	307,176	1,659,686	1,533,217	
Build (2009 Projections)	VMT	9,612,887	44,747,461	51,525,166	105,885,514
	VHT	302,260	1,664,994	1,529,494	
Build (Adj. Projections)	VMT	9,948,279	44,745,210	51,543,589	106,237,079
	VHT	315,582	1,665,283	1,529,690	
No-Build vs Build (2009 Projections)	% Change VMT	4%	0%	0%	0%
	% Change VHT	-2%	0%	0%	
No-Build vs Build (Adj. Projections)	% Change VMT	8%	0%	0%	1%
	% Change VHT	3%	0%	0%	
Build (2009 Projections) vs Build (Adj. Projections)	% Change VMT	3%	0%	0%	0%
	% Change VHT	4%	0%	0%	

Overall, these forecasted traffic levels indicate that the induced growth impacts of the proposed project will add to the total volume of traffic in Union County and to the total vehicle miles traveled and vehicle hours traveled. Roads that connect to the Monroe Connector/Bypass will likely see some increases in traffic. Overall, however, the increases in traffic are modest and would not likely create substantial congestion issues within the design year of the project, particularly given that the impacts will be spread across the many miles of transportation facilities throughout Union County. Thus, the traffic impacts of induced growth do not appear to be substantial enough to result in indirect or cumulative effects to roadway congestion or overall traffic levels.

5.9 Is the Monroe Connector/Bypass Consistent with Local Plans?

Many of the long-range planning documents for the FLUSA did not include the Monroe Connector/Bypass, or were uncertain as to when it might be constructed. The current draft of the 2035 LRTP estimates that the project will be constructed by 2015. During interviews with local planners, most indicated that their existing long-term land use plans did not include the project. This includes the communities of Unionville and Fairview, Charlotte-Mecklenburg Planning, the City of Monroe, as well as the Towns of Marshville, Mint Hill, Stallings and Wingate. It should be noted that the Wingate/Marshville Economic Development Plan does include the Monroe Connector/Bypass.

The Town of Matthews includes the Monroe Connector/Bypass in its long term land use plans, but they include a general project location without finalized designs. The Town of Indian Trail's Comprehensive Plan anticipates the project will be constructed (although it assumes an alignment different than DSA D) with the US 601 Interchange. The updated Union County Comprehensive Plan does anticipate the proposed project.

Several jurisdictions are in the process of updating their long-range land use plans, and they anticipate that the Monroe Connector/Bypass will be included in these updated documents. These jurisdictions include the Town of Wingate and the City of Monroe. Furthermore, the current US 74 corridor is under study for land use and infrastructure changes that might be completed if the Monroe Bypass/Connector is constructed through the US 74 Revitalization Study. Most of the land use recommendations included in the draft plan for the corridor are consistent with existing land use plans for the relevant jurisdictions.

5.10 Conclusions

As with any attempt to project future growth or development, there are limitations to the accuracy and certainty of the results of these analyses. Most of these analyses rely on the land use projections developed using recommended methods as described in the NCDOT ICE Guidance[56]. Specifically, the land use projections rely on the socioeconomic projections developed by CDOT, and therefore the results are only as accurate as those projections. Projection of socioeconomic conditions, and any projection of the future, is an uncertain process fraught with the potential for error. Despite the best efforts of researchers and forecasters, the error rates for long-range projections are still quite high and thus any projection or estimate of induced and cumulative effects must be considered the best estimate within a wide range of error. The accuracy of growth projections under any future scenario could be affected by many variables. These include individual owner or developer actions, the timing of or changes in utility provision, changes in local or state regulations on land use and, most importantly, changes in national or regional economic conditions. While the potential for error is high, the techniques used by the MPO are the best available and provide the best available data for trying to project population and employment conditions in the future.

As discussed above, the MRM socioeconomic projections appear to be robust in light of their basis in empirical research and the accuracy of the 2009 Projections in comparison to 2010 Census data, and while the potential for error is still large, these projections are the best resource available to estimate future growth in the study area. The methods used to distribute land use effects are based on reasonable assumptions to produce a valid comparative analysis, but these methods also result in high, conservative estimates of effects.

Land Use

- All changes in land use within the entire study area from the Baseline to the Build are within two percent (i.e., between negative one percent and one percent) of the change that is predicted for the 2030 No-Build.
- Additional development (including direct and indirect effects) estimated to occur under the 2030 Build Scenario totals approximately 3,400 acres more, about 2 percent more than the total development expected under the 2030 No-Build.
- The indirect land use effects are modest, totaling about 2,300 acres of additional development, an increase of less than 2 percent over the No-Build and an increase in development of about 1 percent of the total land area within the study area.
- Incremental effects to agricultural and forested lands are a reduction of 2,000 and 1,200 acres respectively as a result of the additional developed land. For both these land uses, the decrease equals a less than one percent change as a percent of total land.
- It is likely that some portion of the household increase would shift within the study area and the remainder would shift from elsewhere in the greater metropolitan area. However, in an effort to

[56] NCDOT & NCDENR, 2001a

estimate the environmental impacts without underestimating them, no portion of this induced household growth has been subtracted from elsewhere in the study area.

Impervious Surface

- Findings show the incremental effect of the 2030 Build Scenario will be a one percent increase in impervious surface throughout the study area as compared to the change predicted for the 2030 No-Build Scenario which results in approximately 2,000 additional acres of impervious surface throughout the study area.
- With the 2030 Build Scenario, increases in percent impervious surface as compared to the change predicted for the 2030 No-Build are found in 7 of the 18 watersheds. These increases are between one and three percent.
- There is no difference in impervious surface resulting from direct or indirect effects in the Goose Creek or Sixmile Creek watersheds between the 2030 No-Build and 2030 Build scenarios.

Water Quality

- With regard to percent impervious cover as an indicator for water quality effects and effects to aquatic species, findings show only a one percent difference in percent impervious cover between the 2030 Build and 2030 No-Build for the study area as a whole.
- With regard to individual watersheds, findings show no incremental difference from No-Build to Build scenarios for 12 of the 18 watersheds, including Goose Creek and Sixmile Creek. For the remaining six watersheds, the Build scenario will have a one to three percent greater change in impervious surfaces as compared to the change predicted for the No-Build scenario.
- Overall, as these results are very similar to the results of the original Quantitative ICE, additional water quality modeling is not necessary as these differences are not large enough to see substantial differences compared to the prior water quality results.

Endangered Species

- With regard to percent impervious cover as an indicator of potential effects that could affect habitat for the endangered mussel, findings show no direct or indirect effects within the Goose Creek or Sixmile Creek watersheds as a result of the 2030 Build. Therefore, no cumulative effect to the Carolina heelsplitter is anticipated based on results of this study.
- For the 2030 Build, findings indicate a four percent greater decrease of land exhibiting habitat characteristics that might support the Schweinitz's sunflower as compared to the change predicted for the 2030 No-Build based on results of this study.

Land Use and Farmland Conversion

- The 2030 Build is predicted to have one percent additional conversion of land to development as compared to the conversion predicted with the No-Build scenario.
- The composition of the development is different between the Build and the No-Build scenarios. With the 2030 Build, there is more Low Density and Medium Density Residential, Commercial, and Industrial/Office/Institutional growth.
- The 2030 Build is predicted to convert 2,100 additional acres of agricultural land to low density residential or other developed uses. This represents four percent greater loss of farmland compared to the No-Build but just a one percent greater overall conversion relative to the total land area than that predicted with the No-Build scenario.

Wildlife Habitat

- The 2030 Build is predicted to convert approximately three percent more undeveloped vegetated land in the study area as compared to that predicted for the No-Build scenario. These conversions are mostly concentrated in Salem Creek and Richardson Creek – Lower, with some lesser amounts scattered among Richardson Creek – Middle, Stewarts Creek and Crooked Creek. The incremental losses represent a maximum of 9 to 12 percent additional loss relative to the Baseline conditions for the three most affected watersheds.
- The forest fragmentation analysis indicates that indirect impacts will be modest but that cumulative effects may be more substantial. Nevertheless, most of the cumulative effects are likely to occur with or without the proposed project.

Traffic

- The forecasted traffic levels indicate that the growth-induced impacts of the proposed project will add to the total volume of traffic in Union County and to the total vehicle miles traveled and vehicle hours traveled. Roads that connect to the Monroe Connector/Bypass will likely see some increases in traffic. Overall, however, the increases in traffic are modest and would not likely create substantial congestion issues within the design year of the project.

6.0 POTENTIAL STEPS TO MINIMIZE DEVELOPMENT IMPACTS

Cumulative effects occur as a result of decisions made not just by NCTA and FHWA, but also by other local, state and federal entities as well as private institutions. Separating, quantifying and minimizing and possibly avoiding the environmental effects from individual contributors continues to prove challenging.

First, one should note that the assumptions used in the methodology of this report and the reports summarized herein were generally designed to overestimate impacts to sensitive resources and water quality. For example, the water quality analysis assumed that relevant stream buffer regulations would be maintained through the design year of the project, but did not apply other land use or zoning controls that are currently in place or may be adopted in the future. The DEIS Qualitative ICE, summarized the regulations currently in place and their impacts on land use.[57] Many of these ordinances have been updated since the publication of the Qualitative ICE, as shown in the FEIS Quantitative ICE, Table 4[58], and this report in Section 1. For example, the Site Specific Water Quality Management Plan for the Goose Creek Watershed, states that any new development would be required to have stormwater controls to remove 85 percent of the average annual amount of total suspended solids (TSS) and discharge the storage volume at a rate less than or equal to the pre-development discharge rate for the one-year, 24-hour storm. The methods used to reduce TSS and stormwater discharge also reduce nutrient (nitrogen and phosphorous) runoff. Other portions of this regulation place limits on ammonia concentrations, and permitted activities within riparian buffer areas. These regulations have proven to limit future potential impacts from development to water quality.

In an effort to promote the use of "nature friendly" growth management strategies, the North Carolina Wildlife Resources Commission (NCWRC) developed the Green Growth Toolbox.[59] The handbook for the toolbox document provides a background on green growth practices, offers tips on green planning, sample land use zoning ordinances, and provides examples of green growth projects. The goal of the NCWRC is to eliminate or significantly reduce incremental effects from individual contributors before they occur. When used, the tools from the "Green Growth Toolbox" equip local governments and private interests to achieve their respective development goals efficiently, economically and sustainably.

As detailed in Section 1, area planners were asked the following questions pertaining to the Green Growth Toolbox:

- *Have you attempted to implement any of the practices, ordinances or other policies recommended by the toolbox?*
- *Have you attempted to incorporate any other low-impact design type policies into zoning, subdivision or other land development ordinances?*
- *How would you rate the likelihood of incorporating any low-impact design principles in future regulations or plans?*

Among respondents, only Mint Hill expressed a familiarity with the toolbox, and they stated that their Low Impact Development (LID) policies were incorporated through the Mecklenburg County Post Construction Control Ordinance (PCCO). Charlotte-Mecklenburg Planning and Development stated that

[57] FEIS Appendix G: *Indirect and Cumulative Effects Assessment*. January 2009. p 23-39.
[58] FEIS Appendix H: *Indirect and Cumulative Effects Quantitative Analysis*. Michael Baker Engineering, Inc. April 2010. p 5.
[59] NCWRC, 2012. http://www.ncwildlife.org/Conserving/Programs/GreenGrowthToolbox.aspx

many of the Toolbox principles are incorporated in the Environment Chapter of the General Development Policies for the jurisdiction. Other respondents did not mention familiarity with the toolbox prior to the interview, but did state that they would consider aspects of the Toolbox approach. Respondents in the Union County area include several respondents who are familiar with LID concepts and practices but were not familiar with the Toolbox, suggesting additional outreach on this effort may be needed.

As stated above, the respondents did suggest support for aspects of the Green Growth Toolbox. Practices included in the Toolbox could reduce overall cumulative effects for development throughout North Carolina. For many local jurisdictions in the study area, the first step would be to begin implementing "Green Planning." The "Green Planning" tool incorporates habitat and green space conservation into a local government's planning processes/documents or creating a new planning document designed specifically for this purpose. This provides an opportunity for the public to provide input specific to these issues, communicates the importance of these issues across internal organizational boundaries and to external planning process users, and provides a necessary step towards funding for habitat conservation and new green space. Since some localities indicated that they lacked much knowledge of LID principles, "Green Planning" is a first step toward basing land use and development decisions with both the economic and environmental landscapes in mind.

Other localities that have already started implementing some LID principles would benefit from furthering those efforts through more intensive tools like "Greening Ordinances" and "Greening Development Review." "Greening Ordinances" means structuring zoning and development ordinances to conserve priority habitats beside developments. Zoning and development ordinances provide effective means for managing developmental objectives and outcomes. By using these types of land use controls, local governments within the study area can focus intensive, high density developments into areas that are less environmentally sensitive to such development. Using ordinances, local governments can do things like set minimum lot size requirements that are more compatible with sensitive habitats, establish maximum impervious cover requirements with water quality and quantity in mind, or set minimum riparian zone widths specific to stream characteristics and water quality concerns.

Examples of "Greening Ordinances" and "Greening Development Review and Site Design" in action could include a requirement for the protection of 100-foot native, forested buffers on each side of perennial streams and 50-foot native, forested buffers on each side of intermittent streams in sub-watersheds (14 digit hydrologic unit codes) without federally-listed aquatic species. Another requirement established via ordinance could exclude roads and driveways from upland areas within 750 feet of priority wetland habitats. Reviewing staff would insure compliance with these ordinance requirements and work with developers to modify development plans so that they would be more compatible with the environments in which they are located. When used by local governments and the development community, these approaches can significantly reduce cumulative effects to environmental resources like wildlife, habitat, and water. They also aid in NCDOT's transportation planning process because they can help establish avoidance areas or require specific mitigation when avoidance is not practical.

Local governments can also incorporate Low Impact Development (LID) techniques and green design criteria into project planning to further reduce incremental environmental effects, create community assets, and can lower lifecycle costs by reducing maintenance and operations expenditures. LID integrates stormwater practices into site design using a customized layout for each project. Some of the most commonly used integrated management practices (IMPs) include: permeable pavement, cisterns, grassed swales, bioretention, rain gardens, and level spreaders (North Carolina University, 2012). LID replaces the high maintenance "Collect, capture, control and release" approach by using the natural landscape for managing stormwater. As summarized in a 2007 EPA report the use of bioretention, topographical depressions, grass channels, swales, and stormwater basins at the 270-unit Poplar Street Apartment complex located in Aberdeen, North Carolina improved stormwater treatment and lowered construction costs. [60] The design allowed almost all conventional underground storm drains to be eliminated from the design. The design features created longer flow paths, reduced runoff volume, and filtered pollutants from runoff. The use of LID techniques on this private development in North Carolina resulted in a $175,000 savings (72 percent) over a traditional stormwater management approach while significantly reducing effects to water quality.

Low Impact Development (LID) practices have also been shown to reduce contaminant loads in streams. As summarized in a 2010 EPA report, which highlighted examples of LID results for 12 local governments, the City of Philadelphia passed a new stormwater standard that requires properties to retain the first inch of rainfall onsite.[61] The Philadelphia Water Department estimated that the ordinance as reduced Combined Sewer Overflow (CSO) inputs by a quarter of a billion gallons, saving the City approximately $170 million in wastewater treatment costs. Portland, Oregon, used various strategies to retain stormwater onsite. The City was able to implement these procedures on 56,000 properties, keeling 1.2 billion gallons of water out of the combined sewer system from 1994 to 2010. On a smaller scale, installing a "green roof" at the City of Chicago's City Hall reduced stormwater runoff by 50 percent. Another instructive example is that of Alachua County, Florida, which, similar to Union County, was seeing water quality impacts from fast growing development in the middle of the last decade. The County took a number of steps including requiring clustered development patterns, allowing narrower streets in subdivisions, and an aggressive land acquisition strategy to conserve open space. The Madera subdivision provides a good example of what can be done in a typical suburban development pattern. In building the subdivision, the developer retained many mature trees and used narrower streets, native landscaping, and depressed bioretention areas in each cul-de-sac to reduce runoff.

Cumulative effects to specific environmental resources occur as the result of the actions of many different public and private entities over time. Effectively minimizing or avoiding cumulative effects requires collaboration and coordination among the local governments within the study area along with the efforts of FHWA and NCDOT and other agencies. The "Green Growth Toolbox" and LID techniques offer valuable tools for local governments and NCDOT to use for reducing cumulative effects to resources within the study area.

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[60] U.S Environmental Protection Agency (EPA). 2007. Reducing Stormwater Costs through Low Impact Development (LID) Strategies. EPA Nonpoint Source Control Branch. Washington, DC http://water.epa.gov/polwaste/green/costs07_index.cfm

[61] U.S. Environmental Protection Agency (EPA). 2010. Green Infrastructure Case Studies. EPA Office of Wetlands, Oceans, and Watersheds. Washington, DC. http://water.epa.gov/polwaste/green/upload/gi_case_studies_2010.pdf

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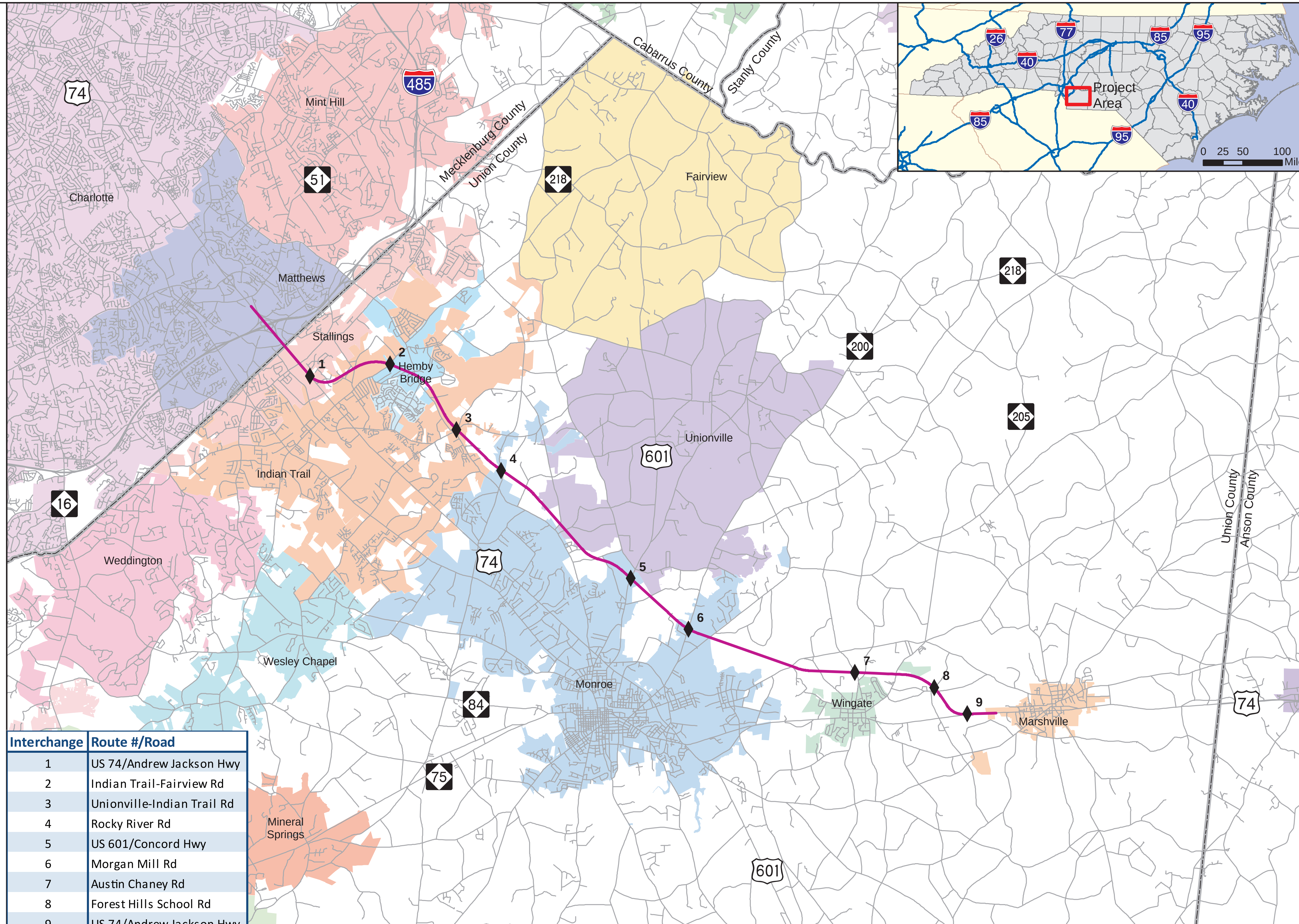
Maps

Monroe Connector/Bypass
Quantitative ICE Update

Map 1:
Project Location

Interchanges
RPA Centerline
Existing Roads

NORTH CAROLINA
Turnpike Authority



Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

N
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Miles

Monroe Connector/Bypass
Quantitative ICE Update

Map 2: Study Area Watersheds

Interchanges

Recommended Preferred Alternative Centerline

River or Stream

NORTH CAROLINA Turnpike Authority

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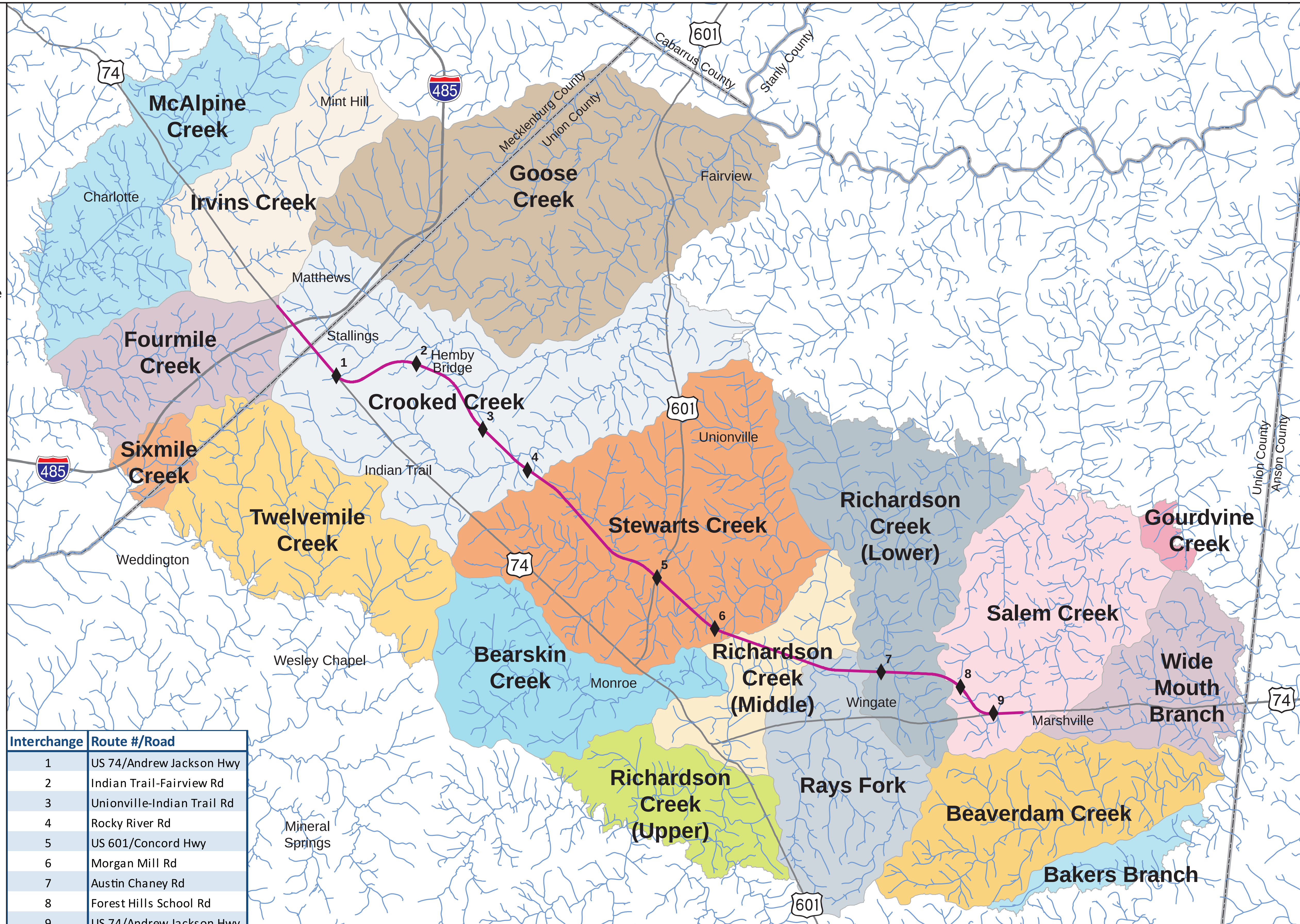

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6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

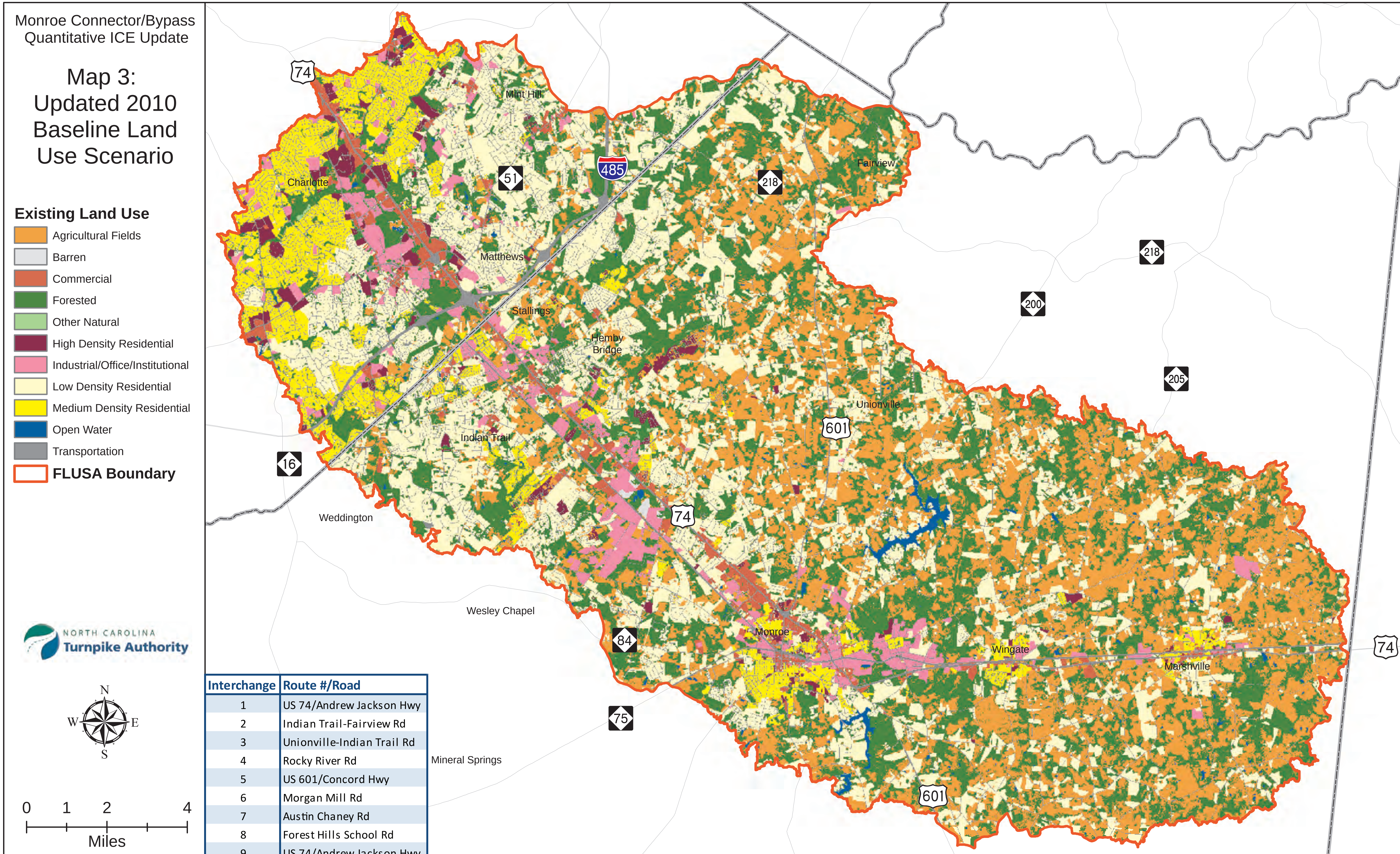
Monroe Connector/Bypass
Quantitative ICE Update

Map 3: Updated 2010 Baseline Land Use Scenario

Existing Land Use

- Agricultural Fields
- Barren
- Commercial
- Forested
- Other Natural
- High Density Residential
- Industrial/Office/Institutional
- Low Density Residential
- Medium Density Residential
- Open Water
- Transportation
- **FLUSA Boundary**

NORTH CAROLINA
Turnpike Authority



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7	Austin Chaney Rd
8	Forest Hills School Rd
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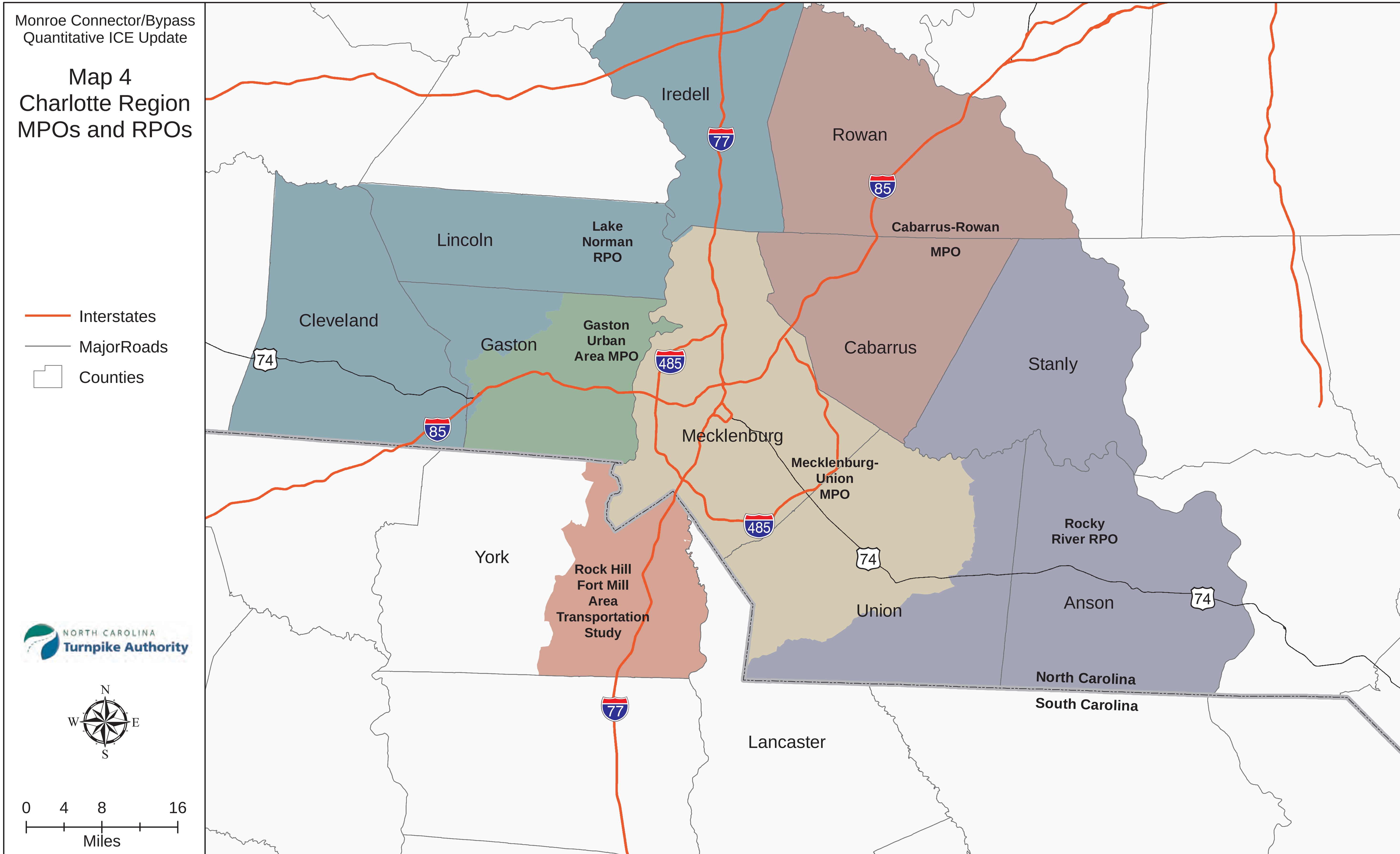
Monroe Connector/Bypass
Quantitative ICE Update

Map 4
Charlotte Region MPOs and RPOs



NORTH CAROLINA Turnpike Authority

Monroe Connector/Bypass
Quantitative ICE Update

Map 5: Metrolina Model TAZs by Planning Organization

Interchanges

Recommended Preferred Alternative Centerline

MUMPO Analysis Area

FLUSA

Metrolina Model TAZs

MUMPO

Other MPO or RPO

NORTH CAROLINA
Turnpike Authority

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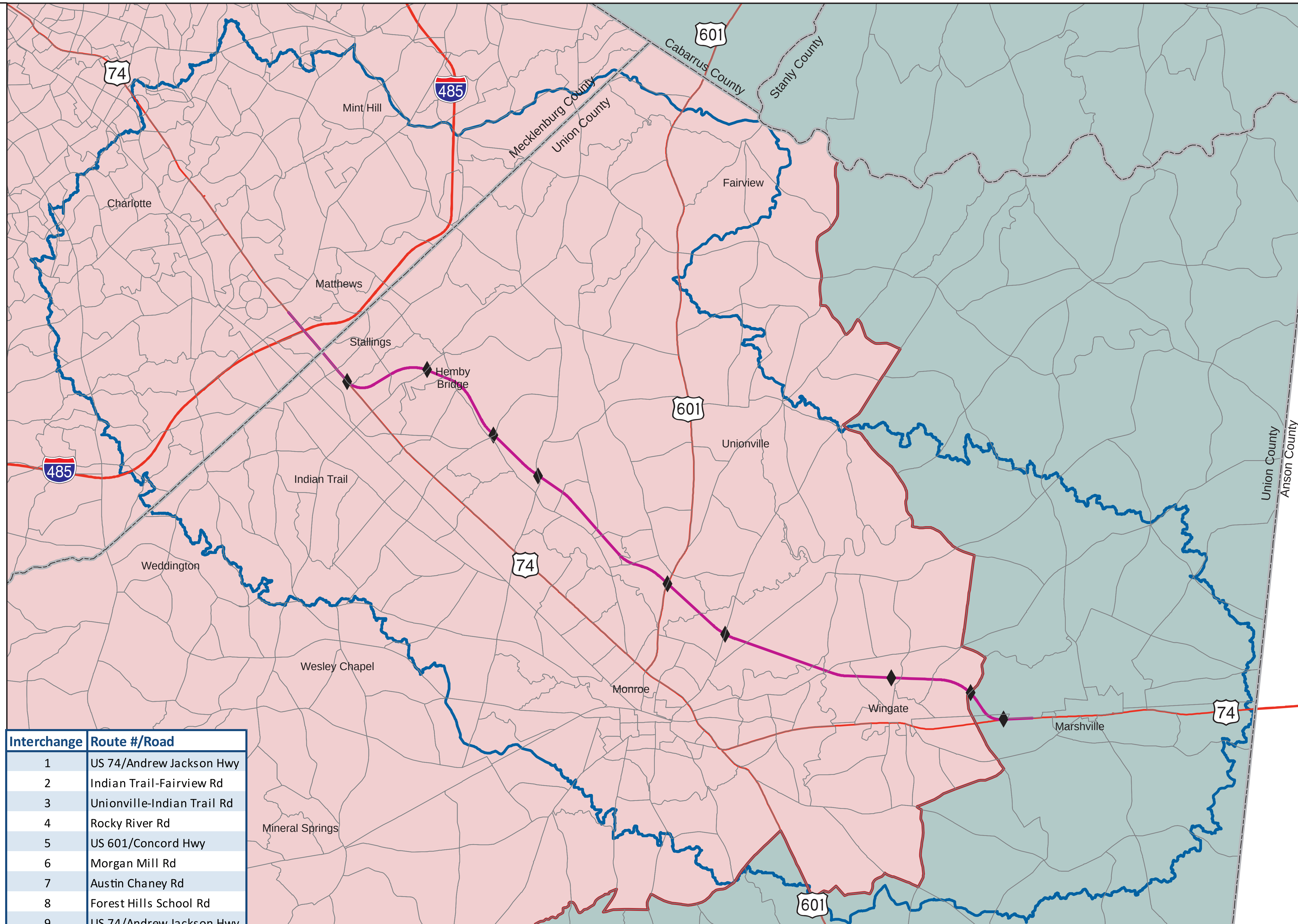
Miles



Interchange	Route #/Road
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7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

Monroe Connector/Bypass Quantitative ICE Update

Map 6: Travel Time to Employment Center Analysis - Employment Center Location and Travel Time Results

RPA Centerline

Interchanges

FLUSA

MUMPO Analysis Area

Employment Centers

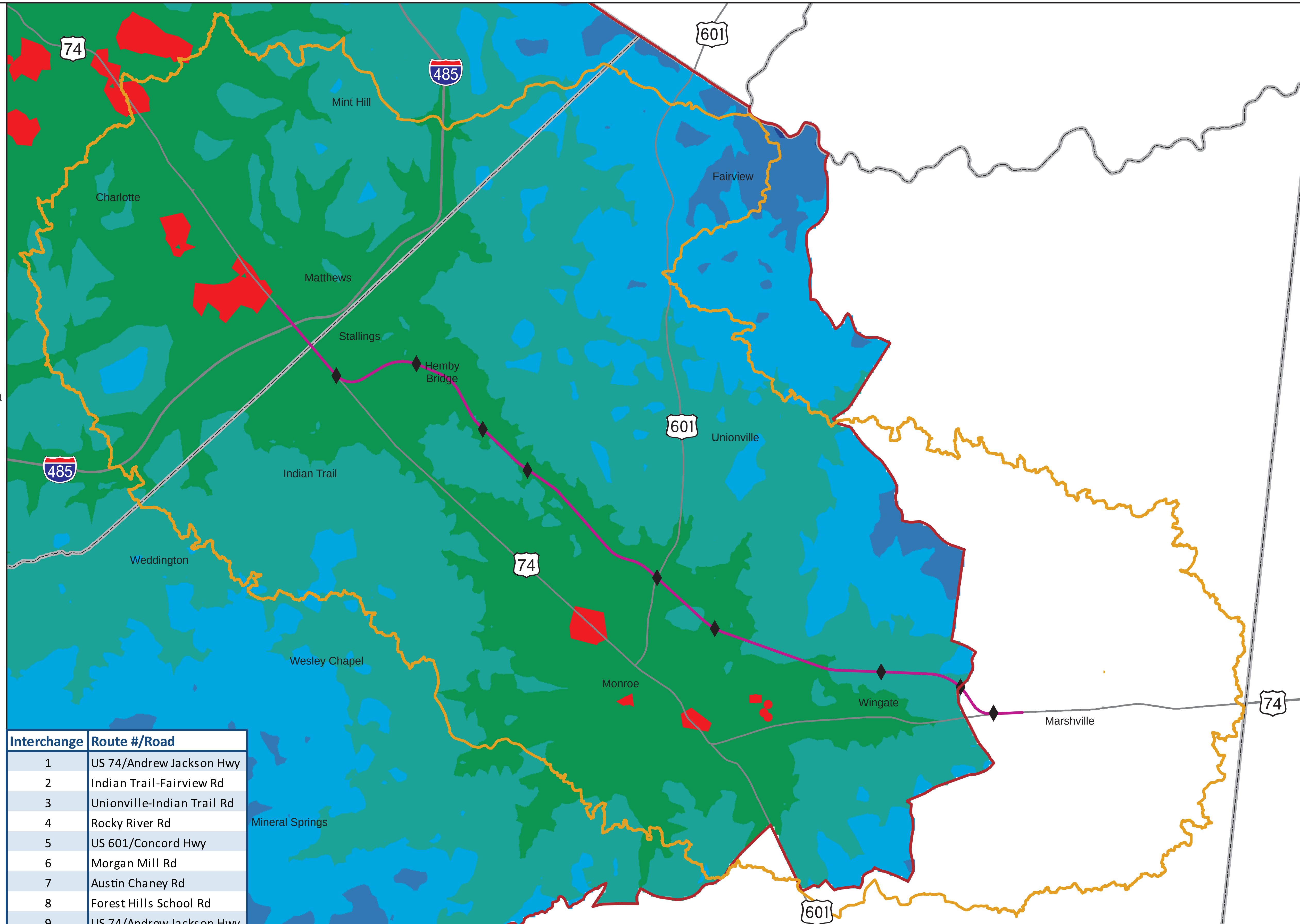
Travel Time to Employment Center

<10	Minutes
10-20	
20-30	
30-40	
>40	

NORTH CAROLINA Turnpike Authority

N W E S

0 1.5 3 Miles



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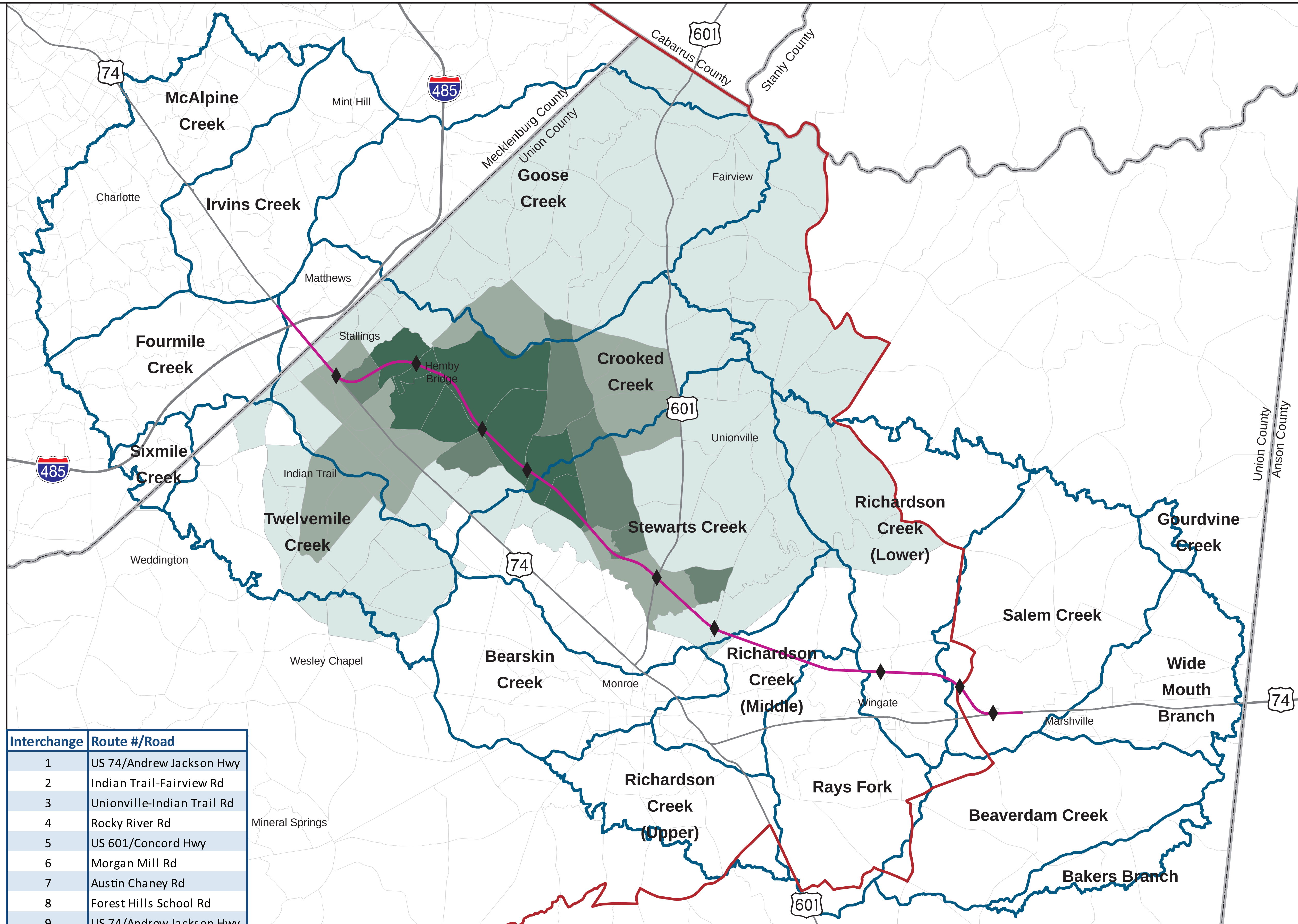
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

Monroe Connector/Bypass
Quantitative ICE Update

Map 7: Difference in Travel Time to Employment Centers Factor from Bottom Up Allocation



Interchanges

RPA Centerline

MUMPO Analysis Area

Watersheds

Travel Time to Employment Centers

Time Difference (Minutes)

- 3 to 5.7
- 1.5 to 2.99
- 0.5 to 1.49
- 0.01 to 0.49
- 0

NORTH CAROLINA Turnpike Authority

N S E W

0 1 2 4 Miles

Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

Monroe Connector/Bypass
Quantitative ICE Update

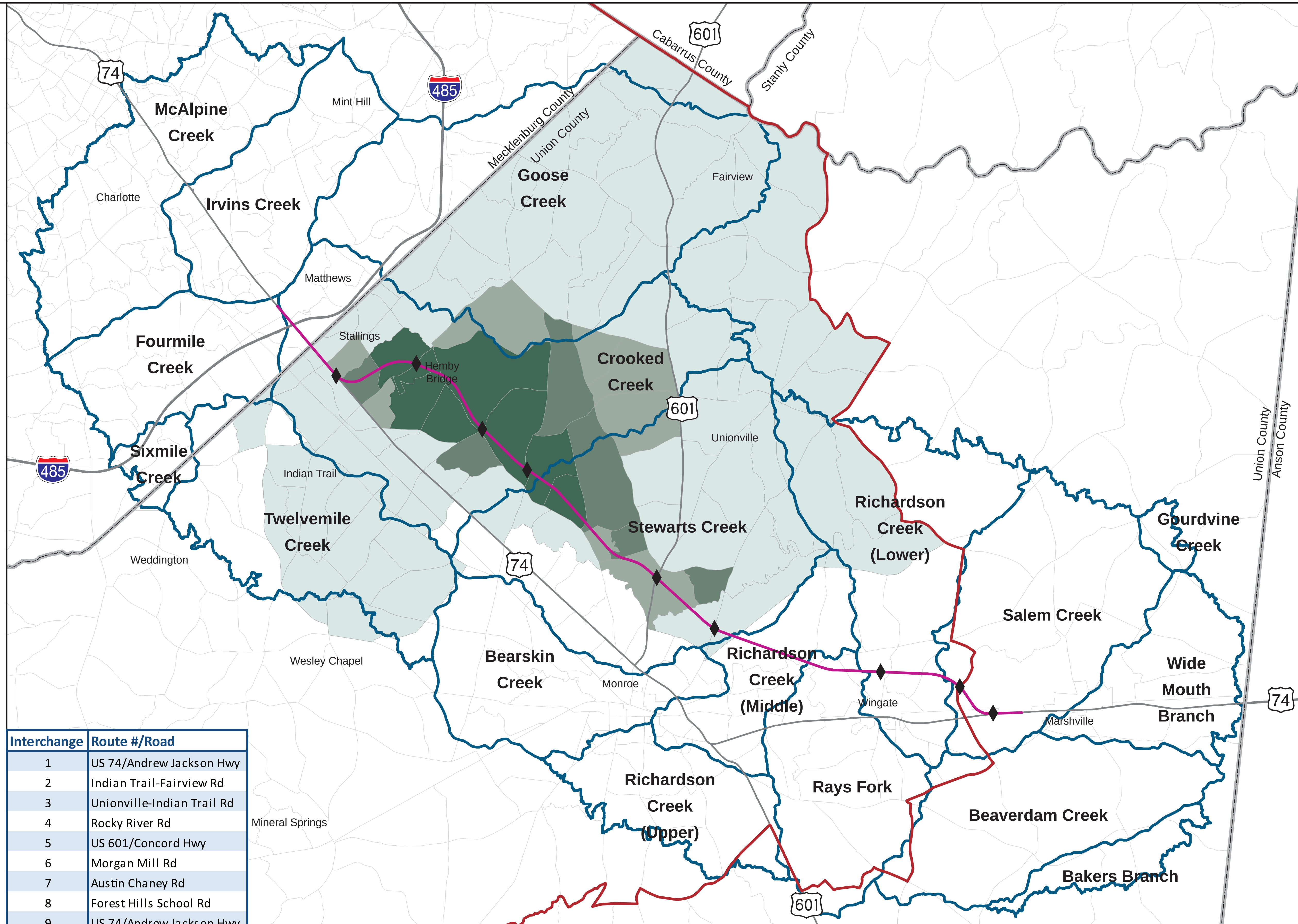
Map 8: Difference in Land Development Factor Composite Score from Bottom Up Allocation

◆ Interchanges
RPA Centerline
MUMPO Analysis Area
Watersheds

Land Development Factor Composite Score
Percent Difference

- -2% to -3.86%
- -1% to -1.99%
- -0.5% to -0.99%
- -0.01% to -0.49%
- 0%

NORTH CAROLINA Turnpike Authority



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7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

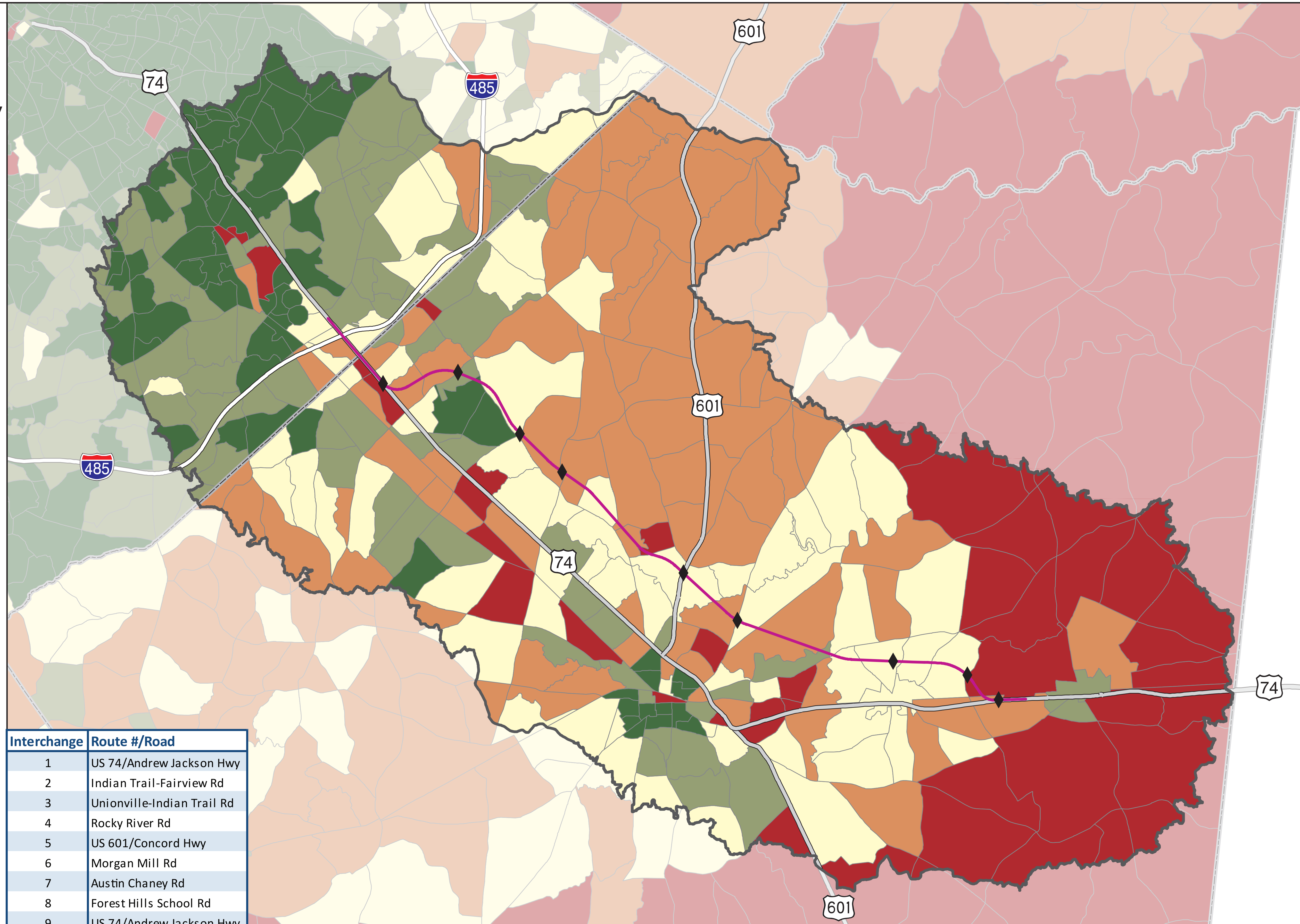
N W E S

0 1 2 4
Miles

Monroe Connector/Bypass
Quantitative ICE Update

Map 9: Household Density 2030 Horizon Year

2009 Projections



Study Area
Interchanges
RPA Centerline

Household Density per Sq. Mile

- > 1000
- 501 - 1000
- 301 - 500
- 101 - 300
- < 100

NORTH CAROLINA Turnpike Authority

N W E S

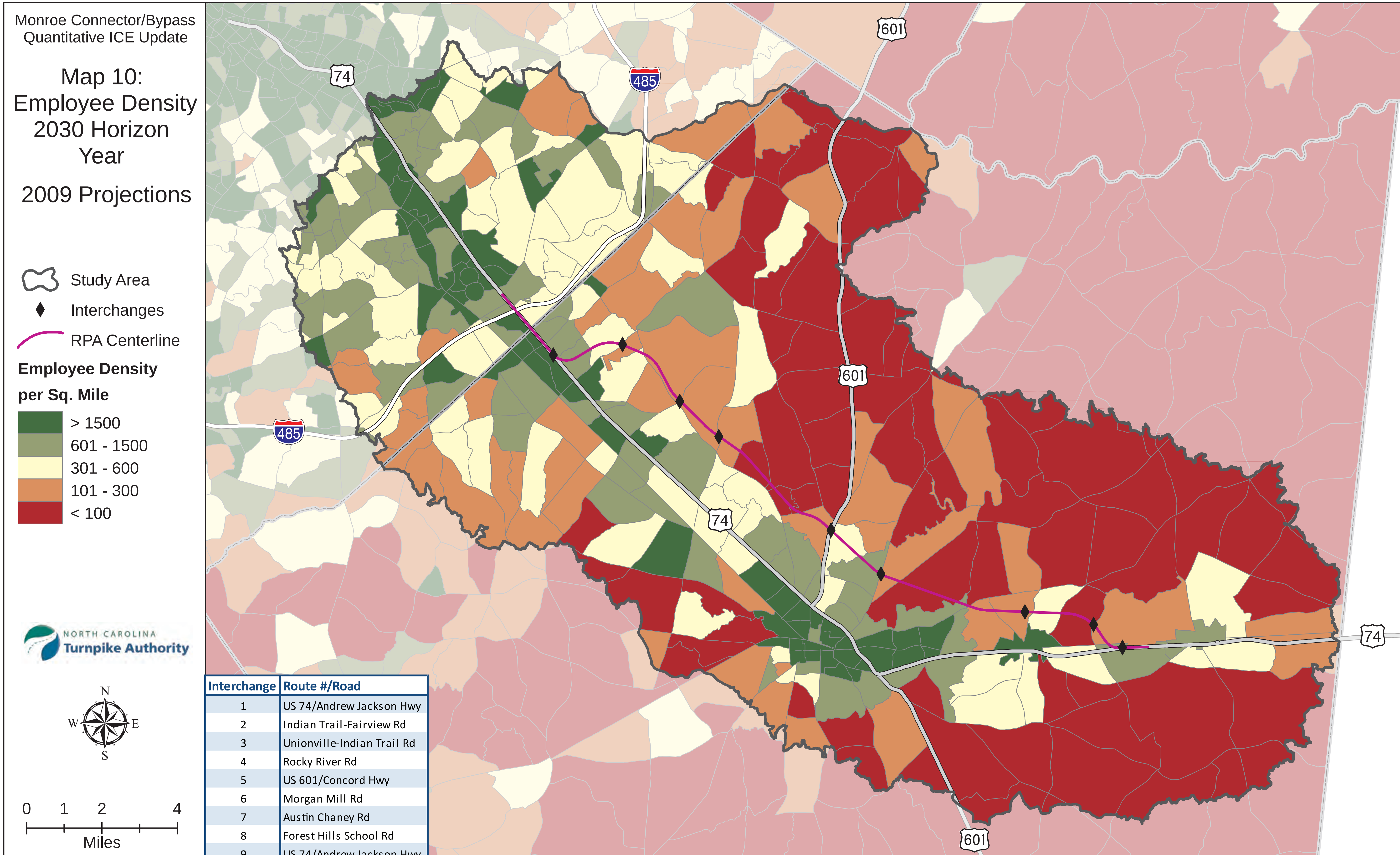
0 1 2 4
Miles

Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

Monroe Connector/Bypass
Quantitative ICE Update

Map 10: Employee Density 2030 Horizon Year

2009 Projections



Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

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Turnpike Authority

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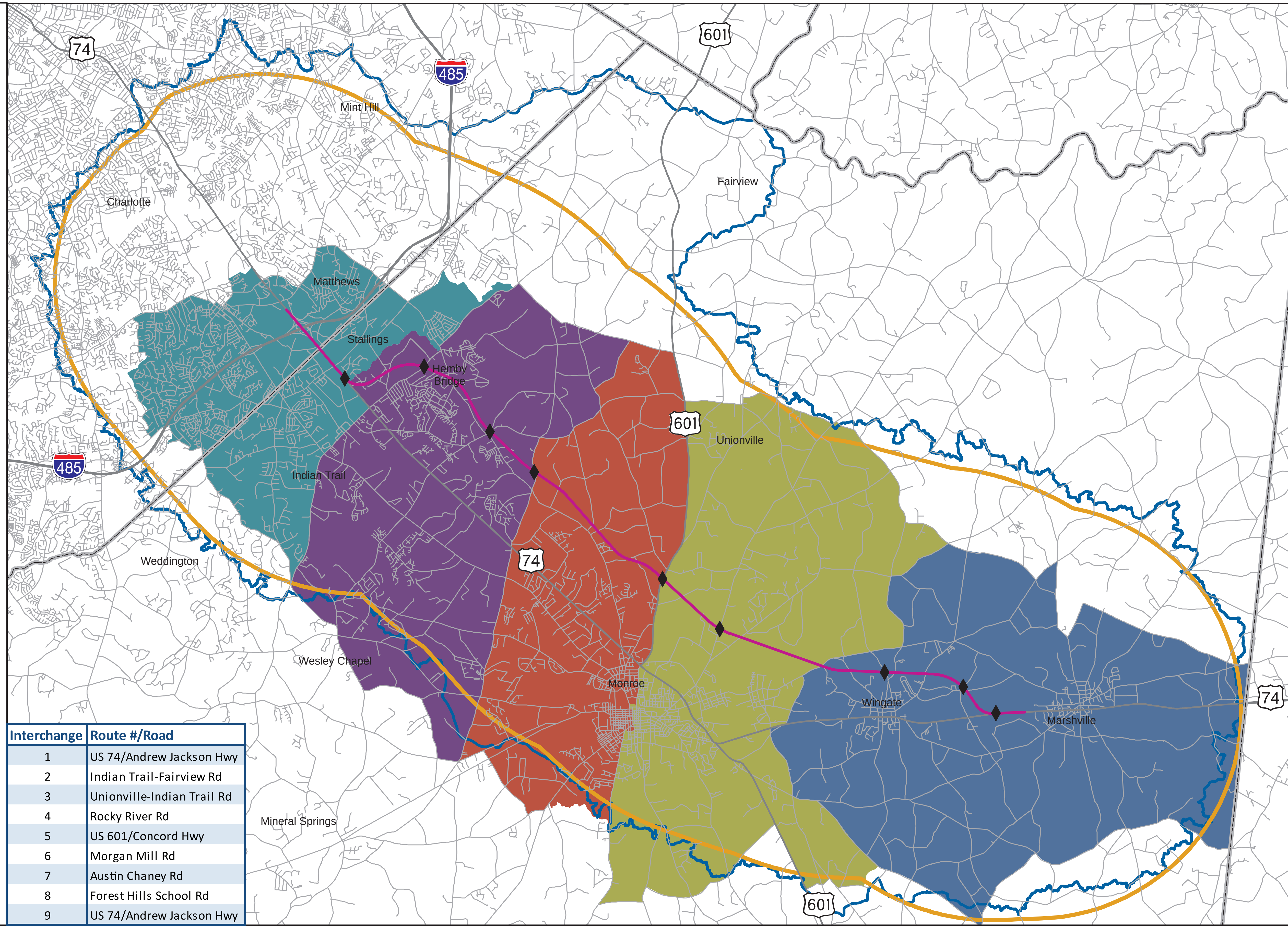
Quantitative ICE Update

Map 11: Kenan Institute Study Zones and ICE FLUSAs

Interchanges
RPA Centerline
FLUSA (Qualitative ICE)
FLUSA (Quantitative ICE)

Kenan Study Zones

1
2
3
4
5



Interchange	Route #/Road
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3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

Monroe Connector/Bypass
Quantitative ICE Update

Map 12: Household Growth by TAZ

2009 Projections

- Study Area
- Interchanges
- RPA Centerline

Household Growth 2005-2030

- < 0
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 500
- >500

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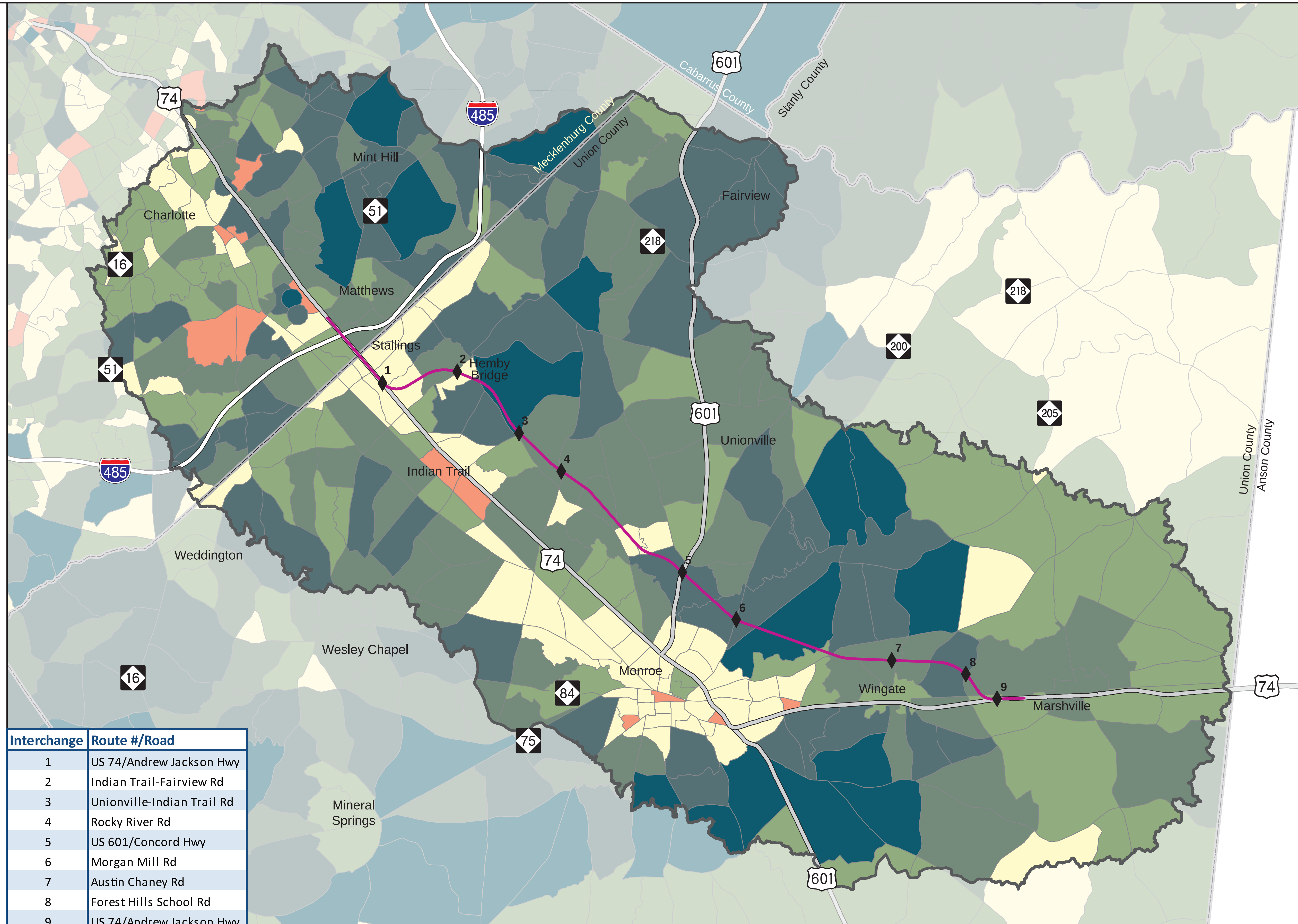

Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

N
W E
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0 1 2 4
Miles

Monroe Connector/Bypass
Quantitative ICE Update

Map 13: Employment Growth by TAZ

2009 Projections

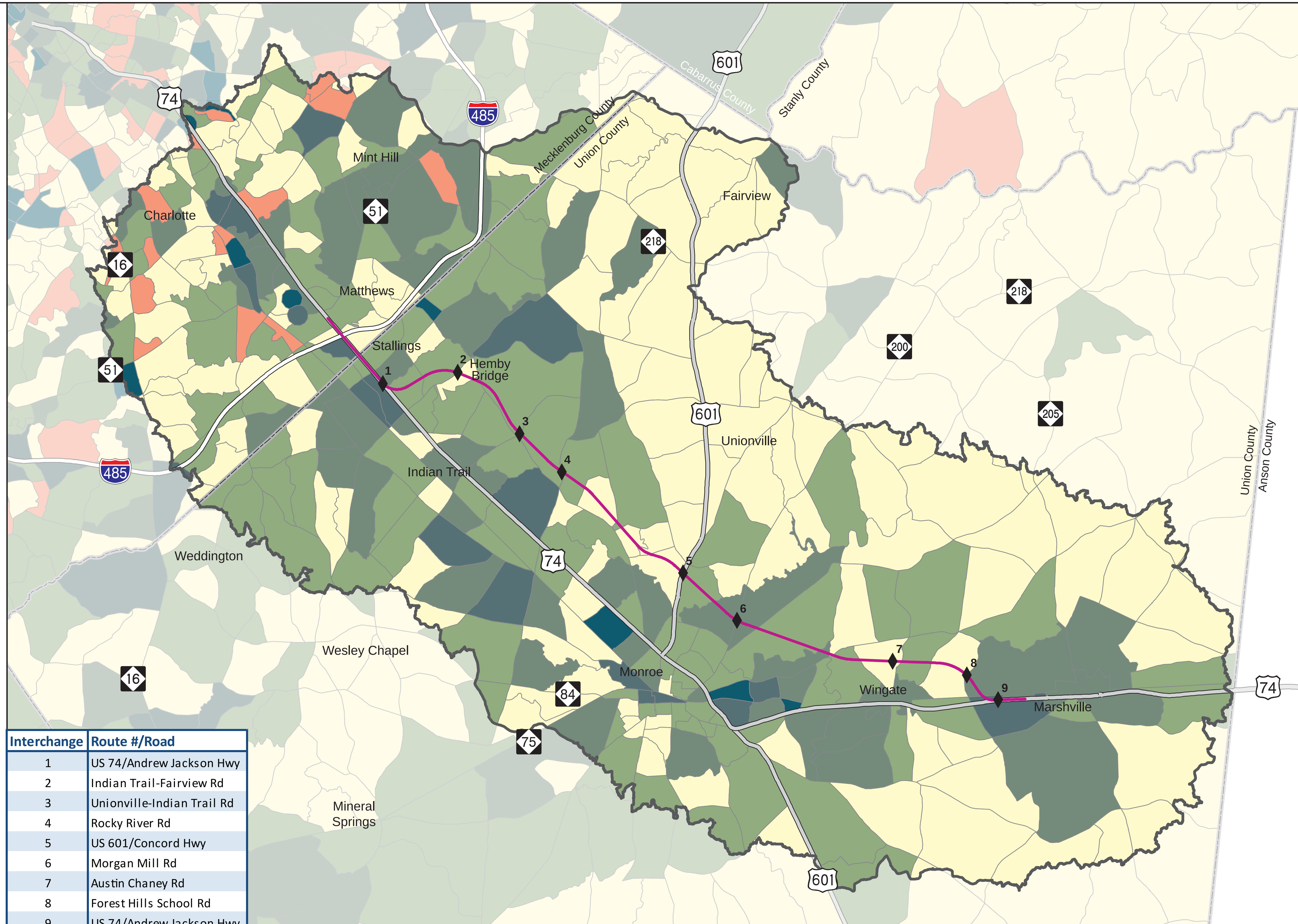
Study Area

Interchanges

RPA Centerline

Employment Growth 2005-2030

- < 0
- 1 - 150
- 151 - 350
- 351 - 700
- 701 - 1200
- > 1200



Interchange	Route #/Road
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3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

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N
W E
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0 1 2 4
Miles

Monroe Connector/Bypass Quantitative ICE Update

Map 14: Comparison of Accessibility No-Build vs Build

Interchanges

Recommended Preferred Alternative Centerline

Future Land Use Study Area Boundary

Watershed Boundary

Change in Travel Time Decrease from No Build to Build (Min)

- 0 to 2.9
- 3 to 4.9
- 5 to 7.9
- 8 to 10

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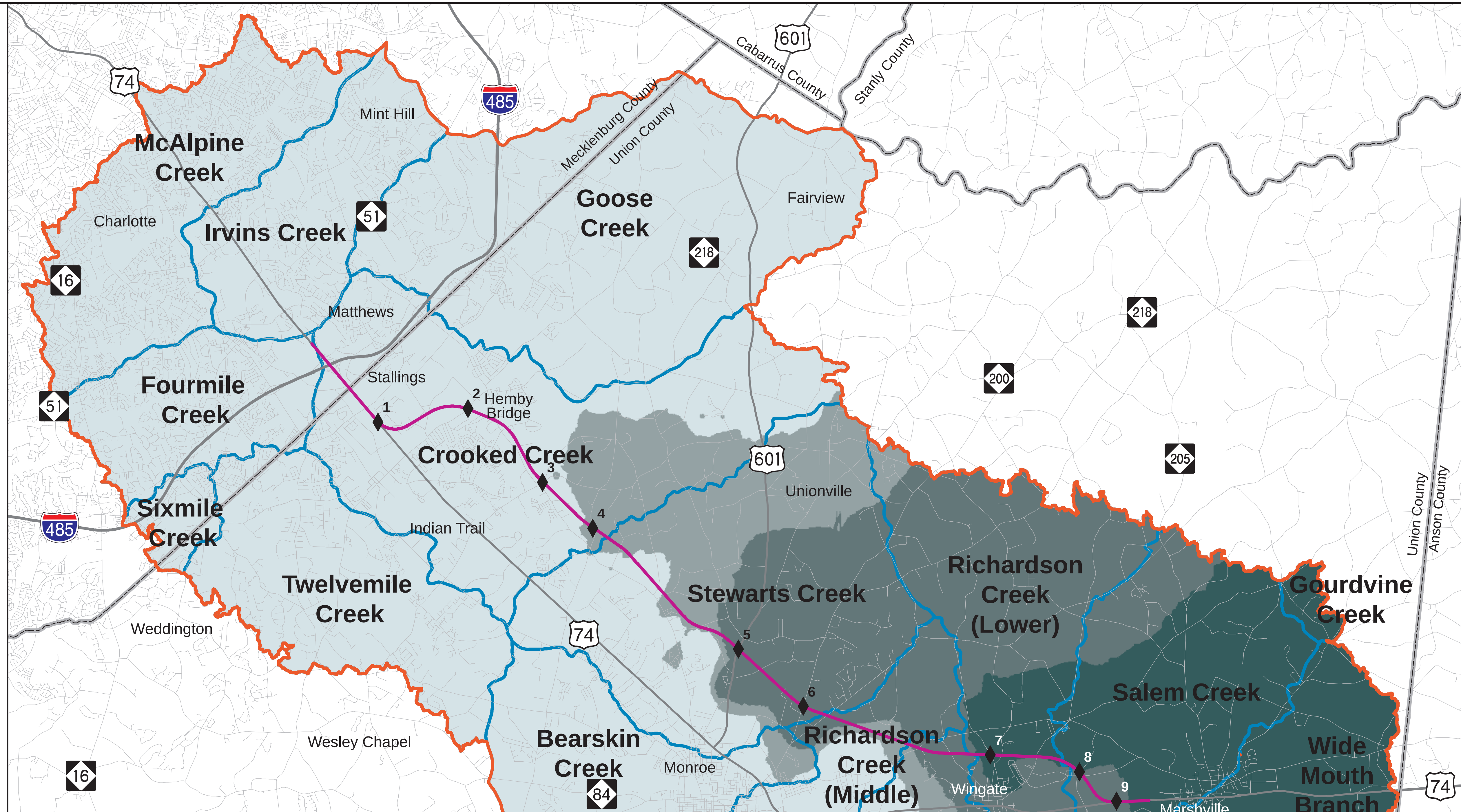
N W E S

0 1 2 4

Miles



Interchange	Route #/Road
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2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

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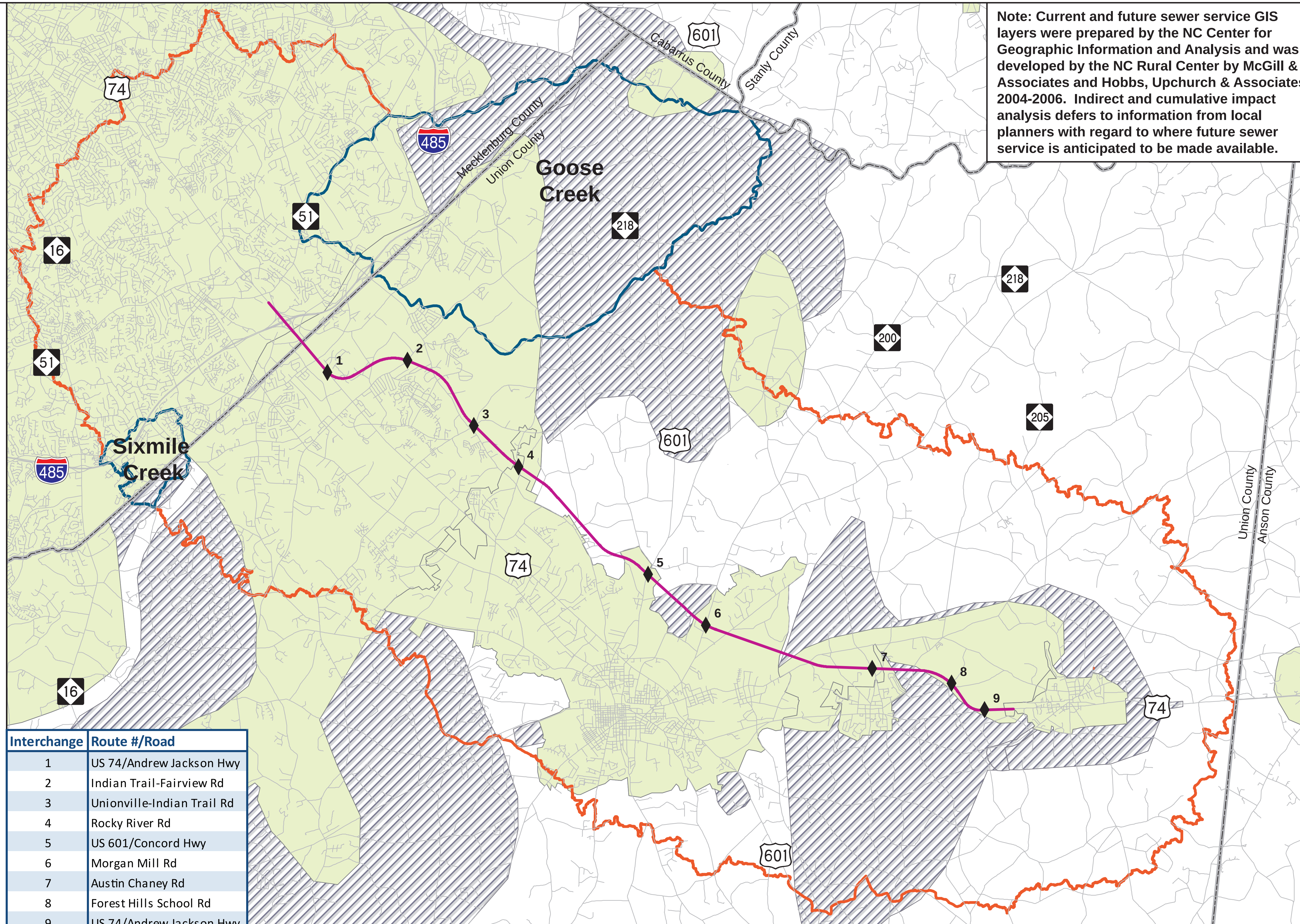
Quantitative ICE Update

Map 15: Sanitary Sewer Availability

- Interchanges
- Recommended Preferred Alternative Centerline
- Existing Roads
- Future Land Use Study Area Boundary
- Current Sewer Service
- Future Sewer Service



Note: Current and future sewer service GIS layers were prepared by the NC Center for Geographic Information and Analysis and was developed by the NC Rural Center by McGill & Associates and Hobbs, Upchurch & Associates, 2004-2006. Indirect and cumulative impact analysis defers to information from local planners with regard to where future sewer service is anticipated to be made available.

Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
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7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

NORTH CAROLINA Turnpike Authority

N
W E
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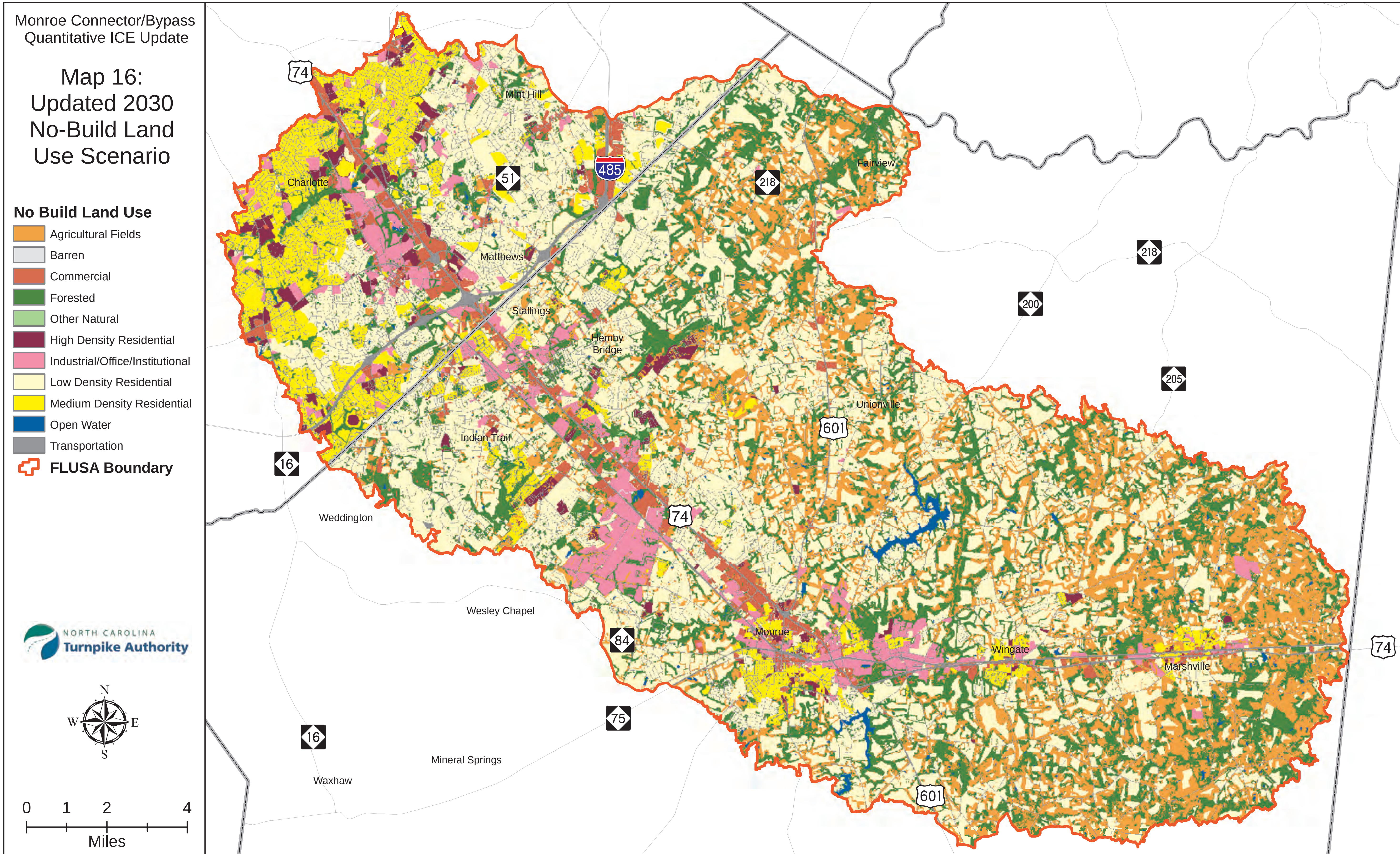
Miles

Monroe Connector/Bypass
Quantitative ICE Update

Map 16: Updated 2030 No-Build Land Use Scenario



Monroe Connector/Bypass
Quantitative ICE Update

Map 17: Change in Land Use from Baseline to No-Build By Watershed

RPA Centerline

FLUSA Boundary

Watersheds

% Land Use Change

12

Developed

Agricultural

Forested

NORTH CAROLINA
Turnpike Authority

N
W E
S

0 1 2 4
Miles

Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
2	Indian Trail-Fairview Rd
3	Unionville-Indian Trail Rd
4	Rocky River Rd
5	US 601/Concord Hwy
6	Morgan Mill Rd
7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

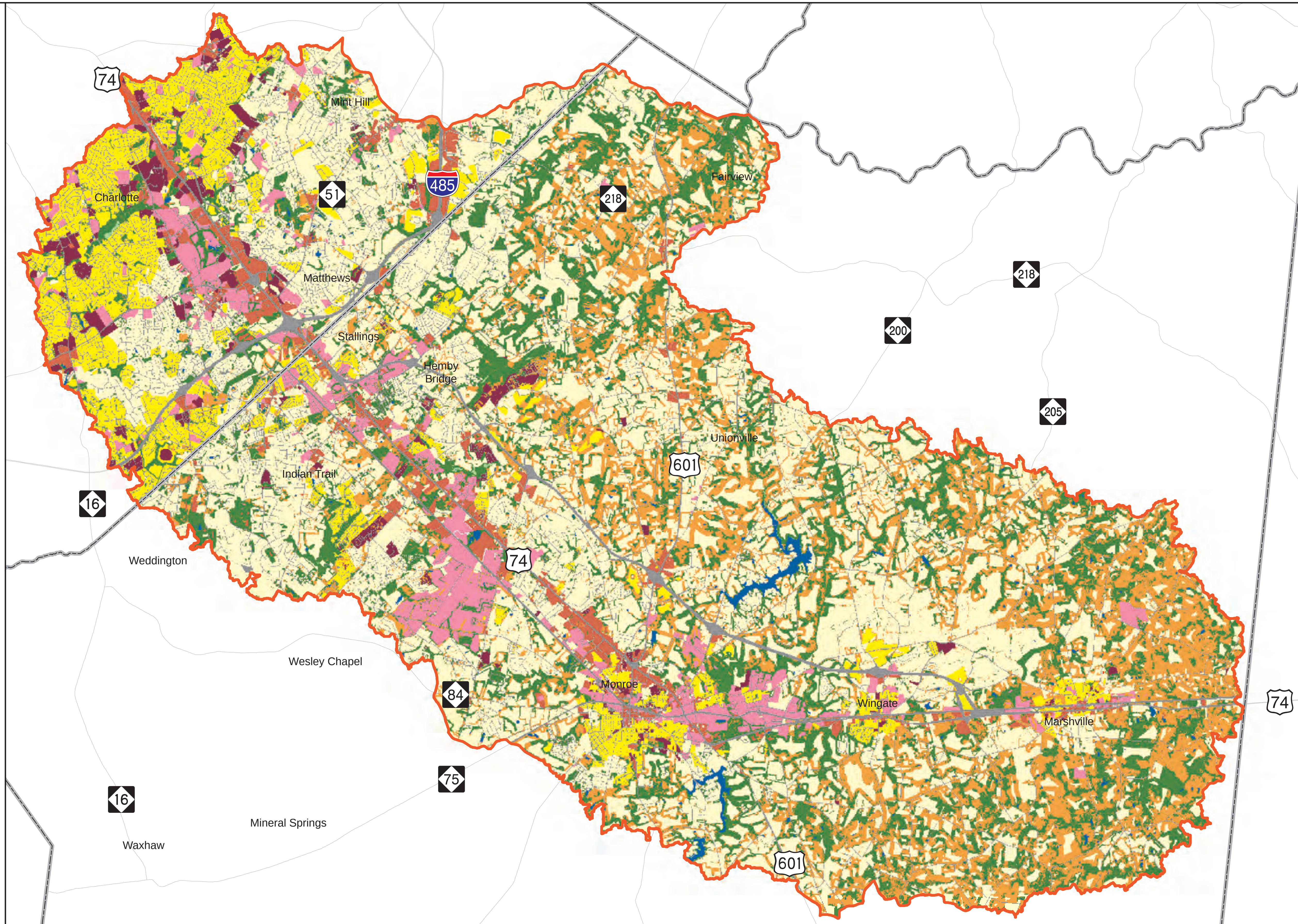
Monroe Connector/Bypass
Quantitative ICE Update

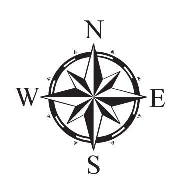
Map 18: Updated 2030 Build Land Use Scenario

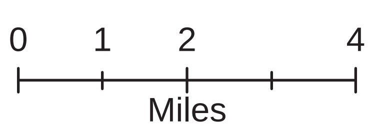
Build Land Use

- Agricultural Fields
- Barren
- Commercial
- Forested
- Other Natural
- High Density Residential
- Industrial/Office/Institutional
- Low Density Residential
- Medium Density Residential
- Open Water
- Transportation
- FLUSA Boundary

NORTH CAROLINA Turnpike Authority







Monroe Connector/Bypass
Quantitative ICE Update

Map 19: Change in Land Use from No-Build to Build Land Use

RPA Centerline

FLUSA Boundary

Watersheds

% Land Use Change

12

Developed

Agricultural

Forested

NORTH CAROLINA
Turnpike Authority

N
W
E
S

0 1 2 4
Miles

Interchange	Route #/Road
1	US 74/Andrew Jackson Hwy
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7	Austin Chaney Rd
8	Forest Hills School Rd
9	US 74/Andrew Jackson Hwy

Appendix A
Interview Summaries

Appendix B
Growth Trends and Factors Technical Memorandum

Appendix C
Operations Research and Education Laboratory Report

Appendix D
Metrolina Model Memorandum of Agreement

Appendix E
LUSAM Documentation

Appendix F
2008 Interim Projections LUSAM Model Inputs and Outputs

Appendix G
2009 Projections LUSAM Model Inputs and Outputs

Appendix H
Hammer Report

Appendix I
Smith Report

Appendix J
Land Use and Socio-Economic Data and Projections for the Greater Charlotte Region

Appendix K
Kenan Institute Report

Appendix L
Hartgen Analysis

Appendix M
MRM Raw Model Volume Traffic Comparison