Memorandum

To: Zahid Baloch, PE
NCDOT – Highway Division 5
1000 Birch Ridge Drive
Raleigh, NC 27610

Date: June 14, 2017

Project #: 38412.14

From: Andrew Topp, PE, PTOE

Re: Capacity Analysis for U-5825 - SR 1010 (Center Street/ Ten-Ten Road) Improvements, Apex, Wake County

Project Background

North Carolina Department of Transportation (NCDOT) State Transportation Improvement Program (STIP) U-5825 proposes to widen SR 1010 (Center Street/Ten-Ten Road) to a multi-lane facility between SR 1306 (Apex Peakway/Schieffelin Road) and SR 1300 (Kildare Farm Road) in Apex, North Carolina. Center Street/Ten-Ten Road is an east-west minor arterial connecting central Apex to US Highway 1 (Claude E. Pope Memorial Highway), a freeway facility that connects to US Highway 64 and I-40/440 in Raleigh/Cary in the northeast and to Sanford and Southern Pines in the south. VHB Engineering NC, P.C. (VHB) was retained by NCDOT to analyze the Center Street/Ten-Ten Road corridor area and identify potential improvement alternatives that would improve the mobility, access and safety of the corridor. This memorandum provides a summary of traffic operations and capacity analysis for improvement alternatives associated with the Center Street/Ten-Ten Road widening project.

There are five major intersections along Center Street/Ten-Ten Road that are key to traffic operations along the corridor. Among them, two intersections formed by the US 1 northbound and southbound ramps, and the intersection of Ten-Ten Road at Reliance Avenue, also within the US 1 interchange impact area. These three intersections were included in a previous Hotspot Analysis funded by the Capital Area Metropolitan Planning Organization (CAMPO), and the findings of the Hotspot Analysis have been incorporated into this project. The other two major intersections reside on opposite ends of the Center Street /Ten-Ten Road corridor, both already operating at levels of service E or F, and approaching oversaturated conditions under the existing conditions. All the major intersections are projected to degrade to LOS E or F under design year conditions with long queues and significant delay times, requiring improved design alternatives to provide desired traffic operations along the corridor.

This report examines traffic operations for the base year (2016) as well as the design year (2040) with and without the potential improvements. In terms of improvement alternatives, this report evaluates a traditional widening scenario (Alternative A) and a synchronized street ("superstreet") intersection configuration along the corridor (Alternative B), along with two additional unconventional designs at Apex Peakway.

Study Process

The purpose of this study is to determine the operational impacts that the forecasted travel volumes will have on the corridor in 2040 and to develop alternatives that will provide sufficient capacity to accommodate the anticipated future travel demand. The peak hour volumes for this corridor were obtained from a forecast completed for the project. The daily traffic forecasts for NCDOT STIP U-5825 SR 1010 (Center Street/Ten-Ten Road) are contained in Appendix A. This study uses the forecast to develop traditional widening as well as several unconventional alternatives along the SR 1010 (Center Street/Ten-Ten Road) corridor.

This report examines the following scenarios during the typical weekday AM and PM peak hours. All Design Year (2040) scenarios assume all fiscally-constrained projects documented in the CAMPO MTP expected to be completed by 2040.

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- *2016 Base Year No-Build Scenario* - The traffic forecast for this scenario was developed to establish existing conditions of the project. It assumes the existing roadway cross-sections in the forecasted area.
- *2040 Design Year No-Build Scenario* - This scenario represents the future year traffic conditions without the subject project. All other fiscally constrained projects expected to be constructed by 2040 are included under this scenario. As a result of nearby new projects, particularly realignment of SR 1306 (Schieffelin Road) to complete the Apex Peakway Loop and intersection improvements at Ten-Ten Road/Kildaire Farm Road, travel patterns are adjusted and will affect the operations on Ten-Ten Road.
- *2040 Design Year Build Alternative A (Conventional Widening)* - This scenario represents the 2040 future year traffic conditions with the subject traditional widening of SR 1010 (Center Street/Ten-Ten Road) and other conventional intersection improvements along the length of the corridor. Compared to the 2040 Design Year No-Build Scenario, travel patterns are adjusted due to the added capacity associated with Ten-Ten Road widening to a multi-lane facility.
- *2040 Design Year Build Alternative B (Superstreet)* - This scenario represents the 2040 future year traffic conditions with the subject widening of SR 1010 (Center Street/Ten-Ten Road) to add a superstreet system along SR 1010 between Apex Peakway/Schieffelin Road and Penny Road except at the US 1 interchange area, and traditional widening along Ten-Ten Road between Penny Road and Kildaire Farm Road. At the US 1 interchange intersections, the 4th legs at the two ramp intersections are restricted to right-turn only to reduce movement conflicts, simplify signal operations, and improve traffic flow. Other intersection improvements such as signalization and exclusive turn lanes are added where they are warranted and necessary. Alternative B is developed based on the same traffic demand as Alternative A, except that traffic is rerouted based on the superstreet configurations at the affected intersections.
- *2040 Design Year Build Alternative C (Median U-Turn)* - This scenario focuses on improving traffic operations at the intersection of SR 1010 (Center Street) at Apex Peakway. Instead of restricting left-turn and through movement on the eastbound/westbound directions as shown in Alternative B, a median U-turn system along Apex Peakway was added to allow through and right-turn movements only at the Apex Peakway and Center Street intersection. Traffic demand was rerouted with the proposed unconventional intersection configurations.
- *2040 Design Year Build Alternative D (Jug-Handle)* - This scenario also focuses on the intersection of SR 1010 (Center Street/Ten-Ten Road) at Apex Peakway/Schieffelin Road. Jug-handle slip roads were added to the northeastern and southwestern quadrants at this intersection to separate left-turn movements from the main intersection. With the proposed intersection configurations, traffic demand was rerouted and two new signals were added at the two auxiliary intersections.

Study Area

The Center Street/Ten-Ten Road widening project extends from SR 1306 (Apex Peakway/Schieffelin Road) to SR 1300 (Kildare Farm Road) in Apex, North Carolina (Figure 1, located at the end of this memorandum). The study network, including existing lane geometrics and traffic control, is displayed in Figure 2. The Center Street/Ten-Ten Road network includes thirteen (13) existing intersections and extends 3.3 miles east-west along the study roadway.

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The following intersections are included in the study area of this analysis:

1. SR 1010 (Center Street) at Apex Peakway/SR 1306 (Schieffelin Road)
2. SR 1010 (Center Street) at Satinwood Road
3. SR 1010 (Center Street) at Old Grove Lane
4. SR 1010 (Center Street) at Investment Boulevard
5. SR 1010 (Center Street) at Parkfield Drive
6. SR 1010 (Center Street) at US 1 (Claude E. Pope Memorial Hwy)
    a. SR 1010 (Center Street) at US 1 SB Ramps/Waterford Green Drive
    b. SR 1010 (Ten-Ten Road) at US 1 NB Ramps/Lufkin Road
7. SR 1010 (Ten-Ten Road) at Reliance Avenue
8. SR 1010 (Ten-Ten Road) at Kiftsgate Lane
9. SR 1010 (Ten-Ten Road) at Arbordale Court
10. SR 1010 (Ten-Ten Road) at SR 1379 (Penny Road)
11. SR 1010 (Ten-Ten Road) at Smith Road
12. SR 1010 (Ten-Ten Road) at SR 1300 (Kildaire Farm Road)

When superstreet, median U-turn, or other unconventional roadway improvement concepts are introduced in the Build Alternatives, auxiliary intersections are included in the traffic analysis where needed. For all scenarios, intersection levels of service (LOS) analyses were performed for the typical weekday AM and PM peak hours using *Synchro/SimTraffic Professional Version 9* and *Highway Capacity Software (HCS 2010)*.

Existing Roadway Conditions

This section describes the characteristics of the primary streets within the study area. Annual Average Daily Traffic (AADT) data for the surrounding roadway network were obtained from the project forecast prepared for U-5825 (Appendix A).

SR 1010 (Center Street/Ten-Ten Road)
Center Street/Ten-Ten Road is a minor east-west arterial roadway that connects downtown Apex to US 1 (Claude E. Pope Memorial Highway) leading to the Town of Cary. This roadway provides a parallel route to NC 55 (E. Williams Street) which is a principal arterial in the area. SR 1010 is a two-lane roadway with a few three-lane sections where subdivisions have been built. The roadway has a speed limit of 35 miles per hour (mph) for most of the corridor; however, there are several areas in which the speed limit is posted at 45 mph. These two locations are before US 1 SB Ramps/Waterford Green Drive to Kiftsgate Lane and Smith Road to Kildaire Farm Road. The land uses along Ten-Ten Road are a mix of residential, commercial, office and a drew industrial uses typically found in an urban setting within the study area. The U-5825 forecast estimates 21,400 vpd on SR 1010 south of Apex Peakway. There are 31,400 vpd on SR 1010 south of the US 1 interchange and 19,200 vpd north of Kildaire Farm Road.

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SR 1306 (Apex Peakway/Schieffelin Road)
Apex Peakway is partially-completed ring road for the Town of Apex. In the study area, Apex Peakway is mostly a two-lane road running north-south, and it becomes Schieffelin Road south of Ten-Ten Road. The roadway has a speed limit of 35 mph. The land uses along Apex Peakway/Schieffelin Road are a mix of residential, commercial, and industrial uses within the study area. The U-5825 forecast estimates 18,200 vpd along Apex Peakway north of Ten-Ten Road, and 6,200 vpd along Schieffelin Road south of Ten-Ten Road.

Satinwood Drive
Satinwood Drive is a two-lane, residential street in the study area. The U-5825 forecast estimates 1,400 vpd on Satinwood Drive.

Old Grove Lane
Old Grove Lane is a two-lane, residential street in the study area. The U-5825 forecast estimates 500 vpd on Old Grove Lane.

Investment Boulevard
Investment Boulevard is a two-lane street in the study area. The land uses along Investment Boulevard are mostly commercial and industrial. The U-5825 forecast estimates 2,000 vpd on Investment Boulevard.

Parkfield Drive
Parkfield Drive is a two-lane, residential street in the study area. The U-5825 forecast estimates 1,600 vpd on Parkfield Drive.

US 1 (Claude E. Pope Memorial Highway)
US Highway 1 (US 1) is a four-lane freeway facility that connects to US Highway 64 and I-40/440 in Raleigh/Cary in the northeast and to Sanford and Southern Pines in the south. In the study area, a partial-cloverleaf Type B (also known as folded diamond) interchange is formed at the US 1 at Ten-Ten Road/Center Street interchange, with loop ramps exiting the freeway in the northeastern and southwestern quadrants and traffic signal control at both intersections. The U-5825 forecast estimates 12,400 vpd on US 1 southbound ramps and 12,400 vpd on the northbound US 1 ramps.

Waterford Green Drive
Waterford Green Drive is a residential street aligned across Ten-Ten Road from the US 1 southbound ramps. The U-5825 forecast estimates 3,200 vpd on Waterford Green Drive.

Lufkin Road
Lufkin Road is a two-lane roadway street aligned across Ten-Ten Road from the US 1 northbound ramps. Lufkin Road functions as a frontage road parallel to US 1 between Ten-Ten Road and NC 55 (E. Williams Street). The U-5825 forecast estimates 6,400 vpd on Lufkin Road.

Reliance Avenue
Reliance Avenue is a two-lane street in the study area. The land uses along Reliance Avenue are mostly commercial and industrial. The U-5825 forecast estimates 5,400 vpd on Reliance Avenue.

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Arbordale Court
Arbordale Court is a two-lane, residential street in the study area. The U-5825 forecast estimates 1,400 vpd on Arbordale Court.

SR 1379 (Penny Road)
Penny Road is a three-lane, minor thoroughfare connecting to Kildare Farm Road and Holly Springs Road, mostly parallel to the eastern section of Ten-Ten Road. The U-5825 forecast estimates 6,200 vpd on Penny Road west of Kildaire Farm Road.

Smith Road
Smith Road is a two-lane roadway, mostly parallel to Kildare Farm Road, connecting Ten-Ten Road to Sunset Lake Road. The land uses along Smith Road are mostly residential and agricultural. The U-5825 forecast estimates 8,600 vpd on Smith Road.

SR 1300 (Kildaire Farm Road)
Kildaire Farm Road is a four-lane, major thoroughfare connecting Cary to the north to Apex and Holly Springs to the south. The U-5825 forecast estimates 24,400 vpd south of, and 26,000 vpd north of Ten-Ten Road.

Level of Service Analysis

Peak hour level of service (LOS) measures the adequacy of the intersection geometrics and traffic controls of a particular intersection or approach for the given turning volumes. Levels of service range from A through F, based on the average control delay experienced by vehicles traveling through the intersection during the peak hour. Control delay represents the portion of total delay attributed to traffic control devices (e.g., signals or stop signs). The engineering profession generally accepts LOS D as an acceptable operating condition for signalized intersections in urban areas and LOS C for rural areas.

At unsignalized intersections, LOS E is generally considered acceptable only if the side street encounters delay. Nevertheless, side streets sometimes function at LOS F during peak traffic periods; however, the traffic volumes often do not warrant a traffic signal to assist side street traffic. **Error! Reference source not found.** provides a general description of various levels of service categories and delay ranges.

Base Year (2016) No-Build Conditions Analysis Results

This scenario is based on the existing lane geometrics and configurations in the study area. Traffic volumes were obtained from the U-5825 Forecast (dated August 2016). The NCDOT Intersection Analysis Utility (IAU) program was utilized to convert these daily forecasts into AM and PM peak hour volumes. In addition, signal phasing information was obtained from NCDOT was applied to the intersection network (Appendix B). Balancing adjustments were made to the mainline through movement by distributing the total difference evenly across the corridor. This adjustment was made to all scenarios.

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Table 1: Level of Service Description for Intersections

Level of Service	Description	Signalized Intersection	Unsignalized Intersection
A	Little or no delay	<= 10 sec.	<= 10 sec.
B	Short traffic delay	10-20 sec.	10-15 sec.
C	Average traffic delay	20-35 sec.	15-25 sec.
D	Long traffic delay	35-55 sec.	25-35 sec.
E	Very long traffic delay	55-80 sec.	35-50 sec.
F	Unacceptable delay	> 80 sec.	> 50 sec.

As reported in Table 2, all of the intersections are operating at unacceptable overall levels of service (LOS), with one exception. Smith Road (signalized), LOS C, is the only intersection to operate with acceptable level of service for both peak periods. In general, the morning peak hour exhibits worse operating conditions than the evening peak as four additional intersections operate at acceptable level of service: Apex Peakway/Schieffelin Road, US 1 SB Ramp/Waterford Green Drive, US 1 NB Ramp/Lufkin Road, and Reliance Avenue. The stop-controlled intersections along SR 1010 (Ten-Ten Road) are operating at LOS F under both peak hour conditions as side-street vehicles are unable to find acceptable gaps to turn onto Ten-Ten Road. Figure 3 shows the Base Year (2016) No-Build conditions AM and PM peak hour volumes for the study area. Detailed Synchro output results are contained in Appendix C.

The project forecast included a Base Year (2016) Build scenario, which projects 2016 volumes with the four lane Center Street/Ten-Ten Road cross-section in place. Having these volumes assist with forecasting design year Build volumes as well as testing interim year scenarios or failure year analyses. Although a Base Year (2016) Build capacity analysis was not deemed necessary for this project, the Base Year Build volumes are illustrated in Figure 4 for informational purposes only.

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Table 2: Base Year (2016) No-Build Conditions LOS Results

ID	Intersection and Approach	Traffic Control	Base Year (2016) No-Build	
			AM	PM
1	**SR 1306 (Schieffelin Road)/Apex Peakway & Center Street/Ten-Ten Road**	Signalized	**E (69.9 sec/veh)**	**D (44.1 sec/veh)**
	Eastbound		D-52.9	C-23.9
	Westbound		E-71.2	D-46.1
	Northbound		B-10.5	C-22.4
	Southbound		F-101.1	E-56.2
2	**Center Street & Satinwood Drive**	Unsignalized	-	-
	Southbound		F-121.5	F-67.2
3	**Center Street & Ten-Ten Road**	Unsignalized	-	-
	Northbound		F-71.2	F-66.3
	Southbound		F-78.9	F-67.2
4	**Investment Boulevard & Center Street**	Unsignalized	-	-
	Northbound		F-62.1	F-115.3
5	**Center Street & Parkfield Drive**	Unsignalized	-	-
	Southbound		F-217.0	F-99.5
6A	**US 1 SB Ramps/Waterford Green Drive & Center Street**	Signalized	**E (61.1 sec/veh)**	**D (39.6 sec/veh)**
	Eastbound		F-108.0	D-38.9
	Westbound		C-31.8	B-17.0
	Northbound		D-38.2	E-68.4
	Southbound		D-45.3	D-47.9
6B	**Lufkin Road/US 1 NB Ramps & Ten-Ten Road**	Signalized	**F (94.5 sec/veh)**	**D (45.6 sec/veh)**
	Eastbound		B-14.7	D-49.8
	Westbound		F-152.2	C-24.5
	Northbound		D-44.1	E-56.9
	Southbound		F-95.4	E-73.1
7	**Ten-Ten Road & SR 4070 (Relaince Avenue)/Driveway**	Signalized	**E (56.0 sec/veh)**	**D (49.2 sec/veh)**
	Eastbound		F-167.5	F-125.7
	Westbound		F-104.8	F-152.7
	Northbound		E-67.4	C-31.7
	Southbound		A-8.7	D-37.5
8	**Ten-Ten Road & Kiftsgate Lane**	Unsignalized	-	-
	Southbound		F-271.2	F-212.7
9	**Mastec Driveway/Arbordale Court & Ten-Ten Road**	Unsignalized	-	-
	Northbound		F-445.9	F-381.0
	Southbound		F-720.6	F-728.0
10	**Ten-Ten Road & Penny Road**	Unsignalized	-	-
	Westbound		F-1258.8	F-1233.1
11	**Smith Road & Ten-Ten Road**	Signalized	**C (25.6 sec/veh)**	**C (21.7 sec/veh)**
	Eastbound		C-20.9	B-16.3
	Westbound		B-15.9	B-14.0
	Northbound		D-51.1	E-62.3
12	**Kildaire Farm Road & Ten-Ten Road**	Signalized	**E (69.2 sec/veh)**	**E (60.4 sec/veh)**
	Eastbound		C-27.2	E-58.3
	Westbound		F-91.3	D-46.8
	Northbound		E-76.0	E-59.1
	Southbound		E-63.9	E-67.8

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

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Crash Analysis

Five-year crash data (3/1/2011 – 2/29/2016) was obtained from the NCDOT for SR 1010 (Ten-Ten Road/Center Street) from SR 1300 (Kildaire Farm Road) to SR 1306 (Schieffelin Road/Apex Peakway). The NCDOT crash summary memorandum and 5-year strip analysis is attached (Appendix D). As shown in Table 3 below, Ten-Ten Road has a total crash rate that is lower than the state average rate and critical rate over the five-year time period. In addition, the fatal, non-fatal injury, night, and wet crash rates are below statewide averages for similar facilities. No fatalities occurred during the study period; however, three (3) pedestrian crashes were recorded along this section of Ten-Ten Road. As shown in Table 4, predominant crash types along the corridor were, in order: rear ends, left-turns, and angles, indicating a congestion issue. As shown in Table 5, the intersection with Lufkin Road and the US 1 northbound ramps had the highest number of collisions (50) over the five-year period.

Table 3: SR 1010 (Ten-Ten Road) from SR 1300 (Kildaire Farm Road) to SR 1306 (Schieffelin Road)/Apex Peakway Crash Rates (3/1/2011 – 2/29/2016)

Rate	Crashes	Crashes per 100 MVM	Statewide Rate[1]	Critical Rate[2]
Total	351	243.04	324.59	349.60
Fatal	0	0.00	1.66	3.77
Non-Fatal Injury	92	63.70	99.33	113.32
Night	71	49.16	74.81	87.00
Wet	44	30.47	60.4	71.38

[1]2013-2015 statewide crash rate for urban 2-lane, continuous left turn lane Secondary Routes in North Carolina
[2]Based on the statewide crash rate (95% level of confidence)

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Table 4: Crash Type

Crash Type	Crashes	%
Angle	43	12%
Backing Up	2	1%
Fixed Object	6	2%
Left Turn, Different Roadway	24	7%
Left Turn, Same Roadway	36	10%
Other Collision with Vehicle	2	1%
Ran off Road – Right	9	3%
Rear End, Slow or Stop	176	50%
Right Turn, Same Roadway	4	1%
Sideswipe, Opposite Direction	6	2%
Sideswipe, Same Direction	13	4%
Pedestrian	3	1%
Other	27	8%

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Table 5: Total Crashes by Intersection

Intersection	Traffic Control	Rear End	Angle	Left Turn	Right Turn	Sideswipe	Ran off Road	Other	Total Crashes
Kildaire Farm Rd	Signalized	14	5	13	0	1	0	1	**34**
Smith Rd	Signalized	4	0	2	0	0	0	2	**8**
Littleman Ln	Unsignalized	6	0	0	1	0	0	0	**7**
Summercrest Dr	Unsignalized	2	0	0	0	0	0	2	**4**
Jessie Dr	Unsignalized	10	0	0	0	0	1	1	**12**
Penny Rd	Unsignalized	3	5	4	0	1	0	1	**14**
Arbordale Ct	Unsignalized	5	1	1	0	0	0	2	**9**
Kiftsgate Ln	Unsignalized	4	0	1	1	0	1	1	**8**
Reliance Ave	Signalized	9	3	3	0	1	0	0	**16**
Lufkin Rd/US 1-NB Ramp	Signalized	15	11	20	0	0	4	0	**50**
US 1-Bridge	Unsignalized	3	0	0	0	0	0	0	**3**
Waterford Green Dr/US 1-SB Ramp	Signalized	13	4	2	0	1	1	1	**22**
Schieffelin Dr	Unsignalized	9	1	1	0	0	0	3	**14**
Parkfield Dr	Unsignalized	3	0	0	0	0	1	1	**5**
Investment Blvd	Unsignalized	4	0	1	1	0	0	1	**7**
Myrtle Grove Ln	Unsignalized	4	0	1	0	0	0	1	**6**
Old Grove Ln	Unsignalized	1	0	0	1	0	1	2	**5**
Forest Grove Dr	Unsignalized	1	0	0	0	0	0	1	**2**
Satinwood Dr	Unsignalized	0	0	0	2	1	0	0	**3**
Apex Peakway/Schieffelin Dr	Signalized	12	12	6	1	0	2	3	**36**

The four locations with the highest number of rear end crashes were at signalized locations where there is additional stopping and congestion along the mainline. The unsignalized location with the highest angle and left-turn crashes was Penny Road (9 total) and all others have 2 or less. Penny Road is recommended for signalization as part of this project, which is expected to improve this crash pattern. The Schieffelin Drive intersection had the highest number of crashes for an unsignalized intersection (14 total, equal to Penny Road); however, this intersection will be converted to a right-in/right-out (RIRO) intersection which will reduce the total number of conflict points at this location.

A graphical representation of the five-year crash data is shown in Figure 5.

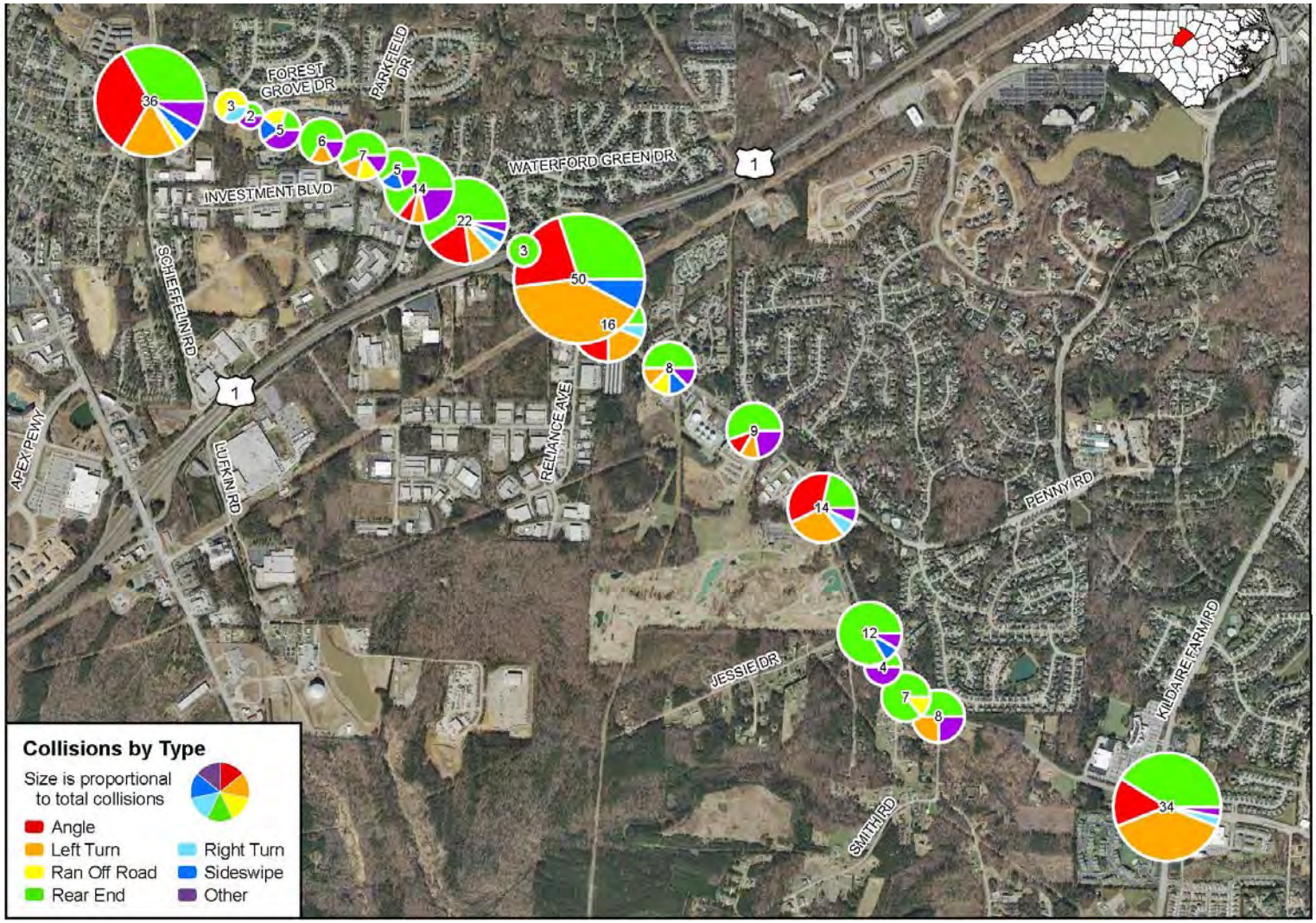

Figure 5: U-5825 Crash Summary

Traffic Forecasting

The U-5825 forecast report details the base assumptions and approach for forecasting design year (2040) volumes with and without the Center Street/Ten-Ten Road widening in place. As shown in Table 6, traffic volumes along Center Street/Ten-Ten Road are expected to increase substantially by 2040 with the widening in place. The eastern end of corridor experiences the highest growth, with a 2.72% annual growth rate just west of Kildaire Farm Road. The forecast accounts for the completion of the Apex Peakway loop, resulting in a more than doubling of traffic on that road by 2040.

Table 6: U-5825 Forecast Scenario Summary

Roadway	Location	Base Year (2016) No-Build	Design Year (2040) No-Build	Design Year (2040) Build	Annual Growth (2040-2016)
SR 1010 (Center Street)	East of Apex Peakway	21,400	22,200	32,800	1.80%
SR 1010 (Ten-Ten Road)	East of US 1	31,400	29,800	57,400	2.55%
SR 1010 (Ten-Ten Road)	West of Kildaire Farm Road	19,200	24,400	36,600	2.72%
Apex Peakway	North of Center Street	18,200	47,400	51,900	4.46%
US 1 SB Ramps	South of Center Street	12,400	16,400	19,500	1.90%
US 1 NB Ramps	North of Ten-Ten Road	12,400	16,400	19,500	1.90%
Kildaire Farm Road	South of Ten-Ten Road	26,000	40,200	36,200	1.39%

Design Year (2040) No-Build Conditions

The Design Year (2040) No-Build volumes were obtained from the projected forecast and converted to peak hour volumes using the NCDOT Intersection Analysis Utility (IAU) spreadsheet. The resulting No-Build (2040) peak hour trips are shown in Figure 6. The lane geometry analyzed in this scenario assumes no improvements to the existing (2016) laneage, except for the implementation of two completed projects: Apex Peakway completion and planned improvements at the Kildaire Farm Road intersection as planned by Town of Cary. The No-Build geometry and traffic control assumptions are illustrated in Figure 7.

As reported in Table 7 operations degrade throughout the corridor under No-Build (2040) conditions. The AM and PM overall intersection delays increase by approximately 10-40 seconds during both peaks, reducing operations at most intersections to LOS F during both AM and PM peaks. The degradation of operations indicates that the intersections will be approaching capacity and improvements are needed to improve traffic mobility throughout the study corridor. Operations at the unsignalized approaches are projected to significantly worsen as all intersections experience a LOS F in the both peak hours.

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Table 7: No-Build (2040) LOS Results

ID	Intersection and Approach	Traffic Control	No-Build (2040)	
			AM	PM
1	**SR 1306 (Schieffelin Road)/Apex Peakway & Center Street/Ten-Ten Road**	Signalized	**F (151.7 sec/veh)**	**F (115.9 sec/veh)**
	Eastbound		E-60.2	D-45.1
	Westbound		E-75.3	E-75.0
	Northbound		F-240.6	F-121.6
	Southbound		F-108.3	F-147.8
2	**Center Street & Satinwood Drive**	Unsignalized	-	-
	Southbound		F-147.0	F-78.9
3	**Center Street & Ten-Ten Road**	Unsignalized	-	-
	Northbound		F-83.5	F-66.3
	Southbound		F-92.4	F-68.3
4	**Investment Boulevard & Center Street**	Unsignalized	-	-
	Northbound		F-134.8	F-212.1
5	**Center Street & Parkfield Drive**	Unsignalized	-	-
	Southbound		F-231.5	F-107.7
6A	**US 1 SB Ramps/Waterford Green Drive & Center Street**	Signalized	**F (83.1 sec/veh)**	**E (59.7 sec/veh)**
	Eastbound		F-113.2	E-79.6
	Westbound		E-74.2	B-11.5
	Northbound		D-48.9	F-96.3
	Southbound		E-71.9	E-69.4
6B	**Lufkin Road/US 1 NB Ramps & Ten-Ten Road**	Signalized	**F (132.9 sec/veh)**	**E (64.7 sec/veh)**
	Eastbound		C-28.9	D-50.4
	Westbound		F-160.4	D-52.2
	Northbound		E-78.2	F-103.5
	Southbound		F-208.9	F-113.5
7	**Ten-Ten Road & SR 4070 (Relaince Avenue)/Driveway**	Signalized	**F (176.9 sec/veh)**	**F (182.7 sec/veh)**
	Eastbound		F-169.3	E-77.0
	Westbound		F-283.6	F-320.1
	Northbound		F-265.4	F-158.6
	Southbound		C-24.0	F-215.1
8	**Ten-Ten Road & Kiftsgate Lane**	Unsignalized	-	-
	Southbound		F-1422.2	F-1168.4
9	**Mastec Driveway/Arbordale Court & Ten-Ten Road**	Unsignalized	-	-
	Northbound		F-3712.2	F-3712.2
	Southbound		F-5080.0	F-5005.5
10	**Ten-Ten Road & Penny Road**	Unsignalized	-	-
	Westbound		---	F-4715.2
11	**Smith Road & Ten-Ten Road**	Signalized	**D (42.6 sec/veh)**	**C (25.2 sec/veh)**
	Eastbound		C-22.1	B-12.9
	Westbound		D-36.2	B-18.3
	Northbound		F-88.6	F-98.1
12	**Kildaire Farm Road & Ten-Ten Road**	Signalized	**F (158.9 sec/veh)**	**F (115.7 sec/veh)**
	Eastbound		C-24.2	F-136.8
	Westbound		F-153.5	F-90.3
	Northbound		F-222.9	F-98.5
	Southbound		F-148.6	F-123.0

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

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Development of Alternatives

As previously discussed five major intersections along SR 1010 (Ten-Ten Road) within the study area – Center Street at Apex Peakway, Center Street at US 1 Southbound Ramp/Waterford Green Drive, Ten-Ten Road at US 1 NB Ramp/Lufkin Road, Ten-Ten Road at Reliance Avenue, and Ten-Ten Road at Kildaire Farm Road – were determined to be the critical intersections along the corridor. These each operate at unacceptable LOS (E or F) under the base year (2016) existing conditions. The operations are projected to degraded further in the No-Build scenario as a result of additional traffic being added to the network due to the traffic forecast and completion of Apex Peakway. This is primarily due to the insufficient capacity to handle the heavy demand in multiple directions, in particular the movements to and from Apex Peakway and the US 1 on and off-ramps.

Several potential design alternatives were developed to address the existing capacity limitations. Traditional geometric improvements such as additional lanes were considered, as well as more unconventional or modern alternatives that rerouted left-turning traffic in order to reduce the total number of phases at the central signalized intersections. The alternatives considered were as follows:

- Traditional Widening
- Rerouted Left-Turns
- Median U-Turn
- Quadrant Roadway
- One-way Paired Intersection
- Displaced Left-Turn Intersection/Continuous Flow Intersection
- Synchronized Street (Superstreet)
- Jug-Handle

Prior to conducting a detailed analysis, the Cap-X tool provided by FHWA was used to initially screen the above referenced options. The following sections provide a general description of the alternatives selected for detailed analysis, discuss any special operational changes, and provide preliminary lists of advantages and disadvantages for each alternative. From this initial stage, four alternatives were developed and operational analyses were conducted along the corridor and at specific locations (i.e. Apex Peakway). A summary of Alternatives A and B is included in Table 8, indicating the type of future access tested at each intersection along the SR 1010 corridor for each scenario.

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Table 8: Proposed Intersection Access and Traffic Control

Ten-Ten Road/Center Street Intersection	Existing Access	Future Access (Alternative A)	Future Access (Alternative B)
Apex Peakway/Schieffelin Road	Signalized, Full Access	Signalized, Full Access	Signalized, Left In, RIRO
Satinwood Road	Unsignalized, Full Access	Unsignalized, Full Access	Unsignalized, Left In, RIRO
Old Grove Lane	Unsignalized, Full Access	Unsignalized, Full Access	Unsignalized, Left In, RIRO
Investment Boulevard	Unsignalized, Full Access	Unsignalized, Full Access	Unsignalized, Left In, RIRO
Parkfield Drive	Unsignalized, Full Access	Unsignalized, Full Access	Unsignalized, Left In, RIRO
US 1 SB Ramp/Waterford Green Drive	Signalized, Full Access	Signalized, Full Access	Signalized, Full Access*
US 1 NB Ramp/Lufkin Road	Signalized, Full Access	Signalized, Full Access	Signalized, Full Access*
Reliance Avenue	Signalized, Full Access	Signalized, Full Access	Signalized, Left In, RIRO
Kiftsgate Lane	Signalized, Full Access	Signalized, Full Access	Signalized, Left In, RIRO
Arbordale Court	Unsignalized, Full Access	Unsignalized, Full Access	Unsignalized, Left In, RIRO
Penny Road	Unsignalized, Full Access	Signalized, Full Access	Signalized, Left In, RIRO
Smith Road	Signalized, Full Access	Signalized, Full Access	Signalized, Full Access
Kildaire Farm Road	Signalized, Full Access	Signalized, Full Access	Signalized, Full Access

* The US 1 off-ramps have full access, while Waterford Green Drive and Lufkin Road have left in, RIRO access

Note that the Old Grove Lane and Kiftsgate Lane intersections are located within 1,200 feet to the nearest median opening, which is less than NCDOT's 1,200-foot minimum recommended access spacing for 45 mph roads. NCDOT will need to balance access, mobility, and property owner convenience when determining the level of access at these locations as part of Alternative A. As a worst-case condition for operations in Alternative A, these intersections were assumed to be full access as part of this study.

Traditional Widening

The traditional widening alternative at SR 1010 (Ten-Ten Road) consists of making standard capacity improvements such as constructing turn lanes and an additional through lane (four lane roadway) with a 23-foot divided median (Alternative A).

Advantages

- Conventional widening efforts improve operations by increasing the saturated flow rate during each green phase through the increased capacity of additional lanes.
- The additional right-turn lanes allow vehicles to move out of the through stream of traffic to make the lane changes, allow vehicles to bypass short queues in the through lanes, and allow for improved overlap phasing.

- Drivers can continue to travel through the intersection in a similar manner as they do currently, with no rerouted turning movements.

Disadvantages

- The additional widening will require right-of-way acquisition that affects businesses and other developments.
- The alternative does not substantially improve signal efficiency.
- Intersection footprints are increased, making crossing distances greater for pedestrians.

Synchronized Street (Superstreet)

The standard superstreet redirects traffic from going straight through or left at a divided highway intersection. All side-street traffic must turn right, but can then access a U-turn to proceed in the desired direction. This concept provides an effective alternative for heavily traveled arterial roadways in areas with anticipated commercial and residential growth, such as Apex. The design concept is contingent upon a series of features that reduce potential conflict points while maintain traffic flow along the mainline.

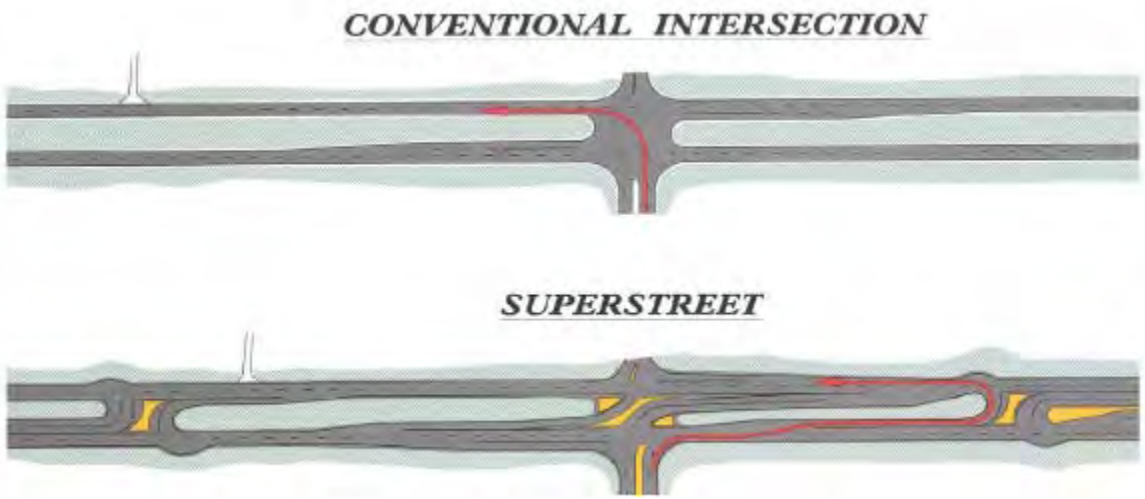

Figure 8: Illustration of Superstreet Crossover

Advantages

- Increases safety by reducing conflict points at major cross streets.
- Increases capacity and improves traffic flow.
- Typically has dedicated U-Turn lanes for efficiency.

Disadvantages

- Widening is still necessary to add the median and other improvements.

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- Some driver confusion may result from U-turn movements.
- Maintenance costs can be higher than typical street designs.
- Left-turning vehicles can experience larger delays and travel distances due to displaced left movement.

Median U-Turn

The standard median U-turn design eliminates all left-turn movements at the primary intersection by rerouting left-turning vehicles onto downstream one-way crossovers in the median. Figure 9 illustrates the U-turn bulb design and Figure 10 details how the left-turn movements are conducted under this type of design.

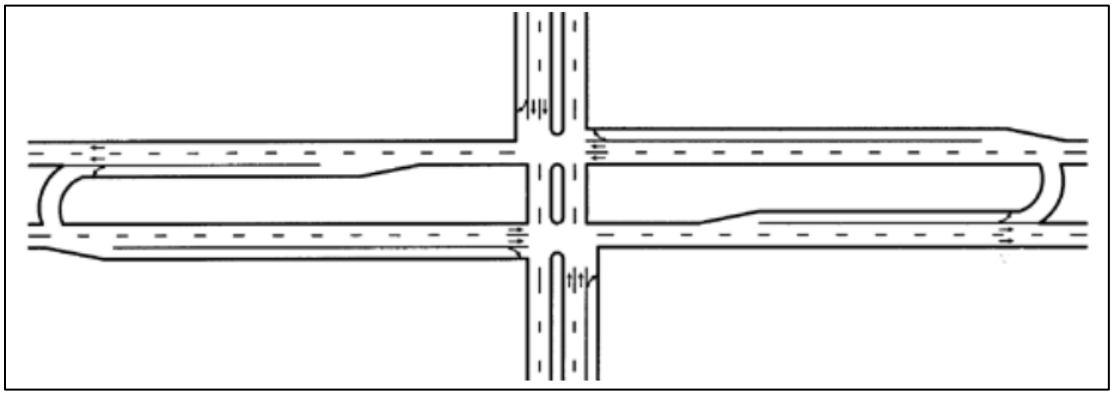

Figure 9: Illustration of Median U-Turn Crossover

*Adapted from FHWA Publication No.: FHWA-HRT-04-091, Chapter 10; August 2004

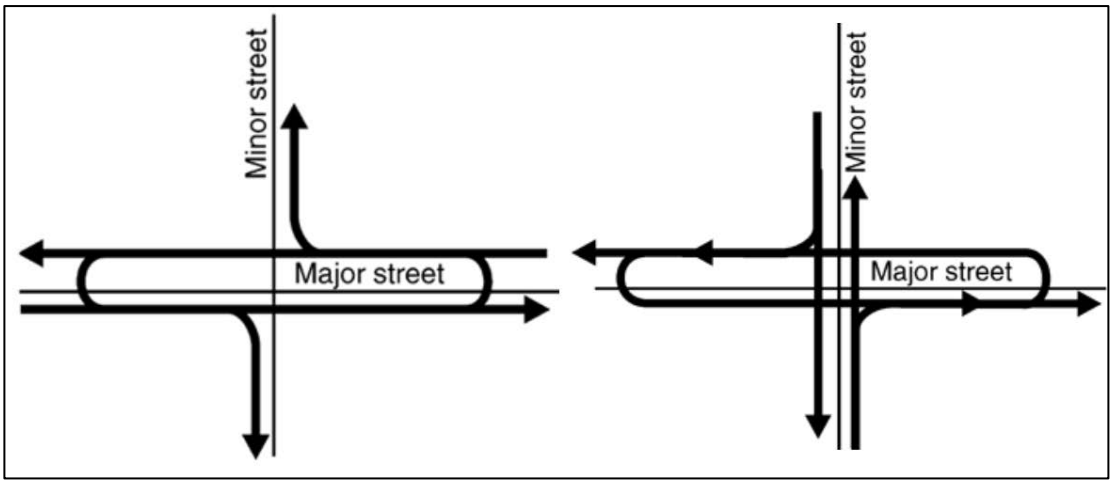

Figure 10: Vehicular Movements at Median U-Turn

*Adapted from FHWA Publication No.: FHWA-HRT-04-091, Chapter 10; August 2004

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Advantages

- An eight-phase signal can be simplified to a two-phase signal resulting in increased capacity.
- The removed left-turn lanes provide space to be used for a median or additional through capacity.

Disadvantages

- If implemented at the Center Street and Apex Peakway intersection (Alt C), two new signals will be needed north and south of the main intersection for U-turns. The new signals would be closely spaced, approximately 700 feet to the north and 800 feet to the south; however, each new signal will have one direction of travel that will continue without interruption (northbound traffic at the northern signal, southbound traffic at the southern signal).
- Widening is still necessary to add the median, U-turn bulbs and other improvements.
- Some driver confusion may result from U-turn movements.

Jug Handle

A jug handle acts as an "at-grade ramp" provided at or between intersections to permit motorists to make indirect left turns and/or U-turns. These ramps exit from the right lane of the highway either in advance of the intersection or beyond the intersection. This design, which eliminates all left turns from the major road at the intersection, provides greater safety and reduces delays to the through traffic that left-turning vehicles usually create. The rerouted left turns from the major road cross the major road as through traffic from the minor road. The intersection of the major road and minor road is signalized. Optionally, reverse ramps can be added to allow left-turning traffic use the rightmost lane downstream of the intersection into a loop ramp. Figure 11 illustrates a Jug handle intersection with a "reverse" ramp under this type of design.

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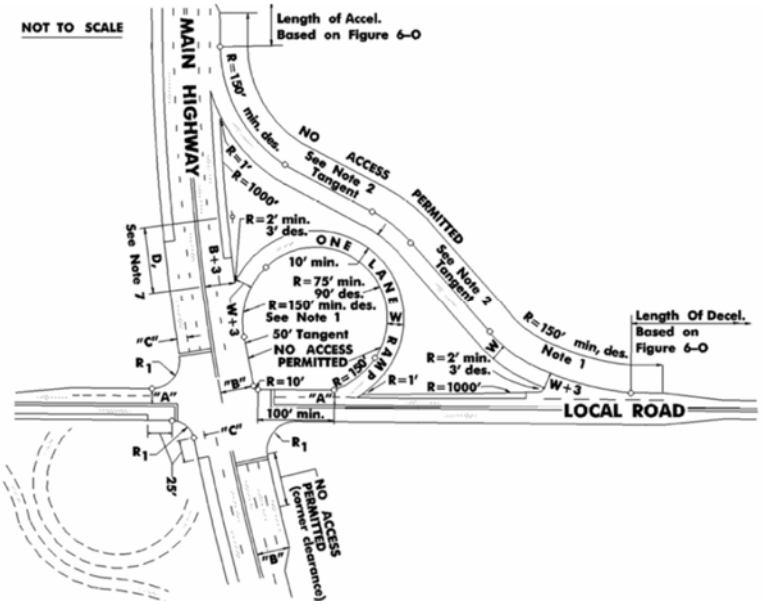

Figure 11: Illustration of A Jug Handle Intersection with a "Reverse" Ramp

*Adapted from FHWA Publication No.: FHWA-HRT-07-032 (Source: NJDOT Roadway Design Manual)

Advantages

- The current Center Street and Apex Peakway eight-phase signal can be simplified to a two-phase signal as a result of eliminating all the left-turn movements (Alternative D).
- The removed left-turn lanes provide space to be used for additional through capacity.

Disadvantages

- Two new signals will be needed north and south of the main intersection along Apex Peakway/Schieffelin Road. The new signals would be closely spaced, and signal coordination is needed to ensure the northbound and southbound directions of travel that will continue without interruption.
- Additional right-of-way is needed at the northeastern and southwestern quadrant to accommodate the reverse loop ramps.
- A considerable amount of additional signing and pavement markings need to be provided to avoid driver confusion and wrong way movements.

Design Year (2040) Build Alternatives Testing

Daily volume forecasts for 2040 for the study area were taken from the NCDOT STIP Project No. U-5825 SR 1010 (Center Street/Ten-Ten Road) Widening Forecast report finalized by VHB in August 2016. The volume forecasts for the No-Build and Build scenarios differ due to the inclusion of the subject project, the widening of SR 1010 (Ten-Ten Road) and the

altered travel patterns as a result of the widening. All Design Year (2040) volumes; however, include effects of all fiscally constrained projects within the study area.

In addition to the traditional widening along SR 1010 (Alternative A) a Superstreet design was considered along the corridor (Alternative B). Since there were still operational deficiencies at the Center Street at Apex Peakway intersection under both Alternative A and Alternative B, two other unconventional alternatives (Alternative C and Alternative D) were developed to improve the level of service at this location. A summary of the alternatives is shown in Table 9.

Table 9: Design Year (2040) Alternatives

Alt.	Center Street at Apex Pkwy Intersection	US 1 Interchange	Corridor Cross-Section		
			Apex Peakway to US 1	US 1 to Penny Road	Penny Road to Kildaire Farm Road
A	Traditional Widening	Traditional Widening (8-lane bridge)	Traditional Widening	Traditional Widening	Traditional Widening
B	North-South Superstreet	Traditional Widening (7-lane bridge)	East-West Superstreet	East-West Superstreet	Traditional Widening
C	Median U-Turn	N/A	N/A	N/A	N/A
D	Jug Handle	N/A	N/A	N/A	N/A

Design Year (2040) Build Alternative A Conditions

The Build (2040) analysis scenario includes the No-Build (2040) traffic with following proposed turn lane improvements in place to address the capacity issues seen in the No-Build (2040) analysis. These improvements are shown in Figure 13 and include:

- Increased capacity throughout the SR 1010 (Ten-Ten Road) corridor from a two-lane undivided cross-section to a four-lane divided cross-section.
- A signalized intersection has been utilized at the intersection of Ten-Ten Road and SR 1379 (Penny Road).

As reported in the Table 10, the projected traffic growth in the future year results in some additional delays at the study area intersections. The proposed improvements mitigate some of these impacts by reducing side-street delay at some stop-controlled intersections; however, the majority of the stop controlled approaches within the corridor, as well as the Apex Peakway intersection still operate at an unacceptable level, LOS E or LOS F. Intersections 2, 3, 4, 8, and 9 all operate at poor levels of service; however, the side street left-turn volume is only 50 veh/hour or less, which does not meet signal warrants. No substantial queuing on the side streets were projected due to the low side street volume. If there are no substantial safety or median access spacing concerns, these may remain open to maximize access. If there are these concerns, then reducing access to left-in, right-in, right-out or just right-in, right-out access may be considered.

All the signalized intersections operate at an acceptable LOS D or better with the exception of the Ten-Ten Road at Apex Peakway intersection, which operates at a LOS E in the AM peak hour. Further widening of Apex Peakway or use of an unconventional intersection treatment (Alt. B, C, D) is necessary to bring operations to a LOS D or better at this location.

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Table 10: Build (2040) Alternative A LOS Results

ID	Intersection and Approach	Traffic Control	Build (2040) Alternative A	
			AM	PM
1	**SR 1306 (Schieffelin Road)/Apex Peakway & Center Street/Ten-Ten Road**	Signalized	**E (59.4 sec/veh)**	**D (51.0 sec/veh)**
	Eastbound		F-96.2	E-76.2
	Westbound		D-43.0	E-55.5
	Northbound		E-63.3	D-37.8
	Southbound		D-51.7	D-50.8
2	**Center Street & Satinwood Drive**	Unsignalized	-	-
	Southbound		F-201.1	F-245.2
3	**Center Street & Ten-Ten Road**	Unsignalized	-	-
	Northbound		F-578.6	F-327.8
	Southbound		F-344.9	F-493.6
4	**Investment Boulevard & Center Street**	Unsignalized	-	-
	Northbound		F-203.9	F-217.3
5	**Center Street & Parkfield Drive**	Unsignalized	-	-
	Southbound		C-15.0	C-18.6
6A	**US 1 SB Ramps/Waterford Green Drive & Center Street**	Signalized	**D (36.0 sec/veh)**	**B (19.8 sec/veh)**
	Eastbound		E-61.6	B-16.3
	Westbound		C-21.5	C-21.2
	Northbound		B-17.7	B-18.4
	Southbound		D-51.7	D-49.6
6B	**Lufkin Road/US 1 NB Ramps & Ten-Ten Road**	Signalized	**C (31.4 sec/veh)**	**C (32.2 sec/veh)**
	Eastbound		C-23.7	C-32.0
	Westbound		C-22.0	C-20.3
	Northbound		D-51.1	E-57.1
	Southbound		E-58.7	E-58.6
7	**Ten-Ten Road & SR 4070 (Relaince Avenue)/Driveway**	Signalized	**C (30.3 sec/veh)**	**C (27.0 sec/veh)**
	Eastbound		E-58.9	E-61.1
	Westbound		E-68.8	E-64.0
	Northbound		C-25.9	C-23.4
	Southbound		C-22.5	B-16.5
8	**Ten-Ten Road & Kiftsgate Lane**	Unsignalized	-	-
	Southbound		F-845.8	F-539.2
9	**Mastec Driveway/Arbordale Court & Ten-Ten Road**	Unsignalized	-	-
	Northbound		F-2167.7	F-2167.7
	Southbound		F-1732.5	F-657.1
10	**Ten-Ten Road & Penny Road**	Signalized	**C (20.6 sec/veh)**	**B (18.7 sec/veh)**
	Westbound		D-52.7	D-50.9
	Northbound		B-18.1	B-15.8
	Southbound		B-15.7	B-12.1
11	**Smith Road & Ten-Ten Road**	Signalized	**C (20.4 sec/veh)**	**B (17.6 sec/veh)**
	Eastbound		B-14.1	B-12.1
	Westbound		B-12.1	B-13.3
	Northbound		D-47.1	D-53.6
12	**Kildaire Farm Road & Ten-Ten Road**	Signalized	**D (54.5 sec/veh)**	**D (53.8 sec/veh)**
	Eastbound		D-36.3	D-48.1
	Westbound		D-53.4	D-40.0
	Northbound		E-61.2	E-57.7
	Southbound		E-62.9	E-63.5

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

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Design Year (2040) Build Alternative B Conditions

The Build (2040) Alternative B analysis scenario represents the 2040 future year traffic conditions with the subject widening of SR 1010 (Center Street/Ten-Ten Road) to add a superstreet system to reduce movement conflicts, simplify signal operations, and improve traffic flow. Alternative B is developed based on the same traffic demand as Alternative A, except that traffic is rerouted based on the superstreet configurations at the affected intersections. These improvements are shown in Figure 15 and include:

- Increased capacity throughout the SR 1010 (Ten-Ten Road) corridor from a two-lane undivided cross-section to a minimum four-lane divided cross-section.
- Superstreet design along SR 1306 (Apex Peakway/Schieffelin Road) across Ten-Ten Road.
- Superstreet design along Ten-Ten Road between Apex Peakway and Penny Road except at the US 1 interchange area.
- Traditional widening along Ten-Ten Road between Smith Road and Kildaire Farm Road.
- At the US 1 interchange intersections, the fourth legs at the two ramp intersections are restricted to right-turn only to reduce movement conflicts, simplify signal operations, and improve traffic flow.
- Other intersection improvements such as signalization and exclusive turn lanes are added where they are warranted and necessary.

As reported in the Table 11, the projected traffic growth in the future year results in some additional delays at the study area intersections. The proposed improvements mitigate some of these impacts by reducing side-street delay at some stop-controlled intersections; however, some unsignalized intersections of the corridor still operate at unacceptable levels of service during peak hours, although traffic on the side streets are not expected to meet warrants for traffic signalization.

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Table 11: Build (2040) Alternative B LOS Results

ID	Intersection and Approach	Traffic Control	Build (2040) Alternative B	
			AM	PM
1A	**Schieffelin Road NB & Apex Peakway SBL/Center Street WB**	Signalized	**C (30.2 sec/veh)**	**C (25.9 sec/veh)**
	Eastbound		D-51.3	C-22.3
	Westbound		C-32.8	D-38.9
	Northbound		C-22.0	C-21.2
1B	**Apex Peakway SB & Center Street/Apex Peakway NBL**	Signalized	**C (20.1 sec/veh)**	**C (20.1 sec/veh)**
	Eastbound		D-36.7	D-48.4
	Westbound		C-23.5	C-24.1
	Southbound		B-14.0	B-14.0
1C	**Apex Peakway SB & Apex Peakway NB U-Turn**	Signalized	**B (13.5 sec/veh)**	**B (18.2 sec/veh)**
	Westbound		C-31.1	C-30.6
	Southbound		A-9.7	B-13.6
1D	**Schieffelin Road NB & Schieffelin Road SB U-Turn**	Signalized	**C (30.9 sec/veh)**	**B (17.7 sec/veh)**
	Eastbound		D-51.6	D-38.5
	Northbound		C-24.6	B-11.9
2A	**Center Street EB & Median Crossover at Satinwood Dr**	Unsignalized	-	-
	Southbound		C-19.5	B-13.1
2B	**Center Street WB & Satinwood Drive/Median Crossover**	Unsignalized	-	-
	Northbound		C-24.8	F-95.9
	Southbound		B-14.5	C-20.9
3A	**Center Street EB & Old Grove Lane/Median Crossover**	Unsignalized	-	-
	Northbound		C-19.6	B-13.3
	Southbound		F-54.7	D-26.0
3B	**Center Street WB & Old Grove Lane/Median Crossover**	Unsignalized	-	-
	Northbound		C-24.6	F-58.6
	Southbound		B-13.5	C-18.7
4A	**Center Street EB & Investment Boulevard/Median Crossover**	Unsignalized	-	-
	Northbound		C-22.4	C-17.1
	Southbound		F-274.4	E-40.4
4B	**Center Street WB & Median Crossover at Investment Blvd**	Unsignalized	-	-
	Northbound		B-13.8	C-18.1
5A	**Center Street EB & Median Crossover at Parkfield Dr**	Unsignalized	-	-
	Southbound		D-26.6	C-16.5
5B	**Center Street WB & Parkfield Drive/Median Crossover**	Unsignalized	-	-
	Northbound		D-30.1	F-74.5
	Southbound		C-16.7	C-19.4
6A	**Center Street & US 1 SB Ramps/Waterford Green Drive**	Signalized	**C (25.2 sec/veh)**	**C (25.0 sec/veh)**
	Eastbound		C-30.3	C-28.1
	Westbound		B-17.3	B-12.7
	Northbound		C-30.4	D-35.6
	Southbound		E-60.8	E-59.9

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

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Table 11: Build (2040) Alternative B LOS Results (*continued*)

ID	Intersection and Approach	Traffic Control	Build (2040) Alternative B	
			AM	PM
6B	**Center Street & US 1 NB Ramps/Lufkin Road**	Signalized	**D (52.0 sec/veh)**	**C (34.6 sec/veh)**
	Eastbound		E-58.5	D-36.1
	Westbound		D-35.4	C-22.2
	Northbound		D-40.9	D-54.9
	Southbound		F-86.4	E-67.7
7A	**Ten-Ten Road EB & SR 4070 (Reliance Avenue)/Median Crossover**	Signalized	**C (23.1 sec/veh)**	**D (46.8 sec/veh)**
	Eastbound		E-55.4	E-72.5
	Westbound		E-59.7	D-53.2
	Southbound		B-11.7	D-38.7
7B	**Ten-Ten Road WB & Driveway/Median Crossover at Reliance Ave**	Signalized	**C (27.2 sec/veh)**	**C (22.8 sec/veh)**
	Eastbound		D-53.6	E-60.9
	Westbound		E-60.1	E-61.4
	Northbound		B-19.7	B-13.3
8A	**Ten-Ten Road EB & Median Crossover at Kiftsgate Ln**	Unsignalized	-	-
	Southbound		C-24.0	D-31.6
8B	**Ten-Ten Road WB & Kiftsgate Lane**	Signalized	**B (16.0 sec/veh)**	**B (17.8 sec/veh)**
	Westbound		B-10.3	A-8.7
	Northbound		D-46.5	D-52.2
	Southbound		D-43.5	D-35.8
9A	**Ten-Ten Road EB & Mastec Driveway**	Unsignalized	-	-
	Northbound		C-21.8	D-30.5
	Southbound		F-82.2	F-186.4
9B	**Ten-Ten Road WB & Arbordale Court**	Unsignalized	-	-
	Northbound		F-729.6	F-335.9
	Southbound		F-70.3	D-32.7
9C	**Ten-Ten Road EB & U-Turn Bulb (East of Arbordale)**	Unsignalized	-	-
	Eastbound		C-17.4	B-14.8
10A	**Ten-Ten Road EB & WB U-Turn (West of Penny)**	Signalized	**A (5.7 sec/veh)**	**C (28.4 sec/veh)**
	Westbound		E-62.4	E-76.8
	Southbound		A-2.6	C-24.1
10B	**Ten-Ten Road EB & Penny Road**	Unsignalized	-	-
	Westbound		C-16.9	D-27.2
10C	**Ten-Ten Road WB & Penny Road**	Signalized	**B (18.7 sec/veh)**	**C (22.6 sec/veh)**
	Eastbound		C-29.7	C-27.4
	Westbound		C-34.5	D-38.5
	Northbound		B-13.4	B-14.7
11	**SR 1010 (Ten-Ten Road) at Smith Road**	Signalized	**B (20.0 sec/veh)**	**B (17.5 sec/veh)**
	Eastbound		B-15.5	B-13.1
	Westbound		B-11.4	B-12.1
	Northbound		D-44.2	D-51.2
12	**SR 1010 (Ten-Ten Road) at SR 1300 (Kildaire Farm Road)**	Signalized	**E (58.5 sec/veh)**	**E (63.3 sec/veh)**
	Eastbound		C-33.7	D-41.8
	Westbound		D-52.4	D-35.5
	Northbound		E-75.4	E-55.5
	Southbound		E-62.4	F-99.5

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

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Design Year (2040) Build Alternative C Conditions

The Build (2040) Alternative C analysis is limited to improving traffic operations at the intersection of SR 1010 (Center Street/Ten-Ten Road) at Apex Peakway/Schieffelin Road. Instead of restricting left-turn and through movement on the eastbound/westbound directions as shown in Alternative B, a median U-turn system along SR 1306 (Apex Peakway/Schieffelin Road) was added to allow through and right-turn movements only at the Apex Peakway/Schieffelin Road and Center Street/Ten-Ten Road intersection, from all directions. Traffic demand was rerouted with the proposed unconventional intersection configurations. These improvements are shown in Figure 16 and include:

- Increased capacity on the Apex Peakway/Schieffelin Road corridor from a two-lane cross-section to a six-lane cross-section.
- Increased capacity throughout the SR 1010 (Ten-Ten Road) corridor from a two-lane cross-section to a four-lane cross-section.
- Two signalized, median U-turn intersections are added on Apex Peakway and Schieffelin Road north of and south of the main intersection. Note that access to the adjacent properties (Old Mill Village Drive/PetroChoice) may need to be modified or relocated to create u-turn bulbs.
- Reduced signal phases and simplified traffic signal operations at the main intersection.

As reported in the Table 12, with the median U-turn system in place, the main intersection and two auxiliary intersections are all projected to operate acceptably during both the AM and PM peak hours.

Table 12: Build (2040) Alternative C LOS Results

ID	Intersection and Approach	Traffic Control	Build (2040) Alternative C	
			AM	PM
1A	**SR 1010 (Center Street) at Apex Peakway/SR 1306 (Schieffelin Road)**	Signalized	B (13.0 sec/veh)	B (12.6 sec/veh)
	Eastbound		D-38.3	D-35.1
	Westbound		C-22.2	C-22.9
	Northbound		A-9.5	A-8.1
	Southbound		A-8.6	A-8.6
1B	**Apex Peakway SB & Apex Peakway NB U-Turn**	Signalized	**A (5.3 sec/veh)**	**A (7.8 sec/veh)**
	Northbound		A-3.1	A-6.0
	Southbound		A-7.7	A-10.0
1C	**Schieffelin Road NB & Schieffelin Road SB U-Turn**	Signalized	**B (17.4 sec/veh)**	**B (10.3 sec/veh)**
	Northbound		C-24.0	B-12.2
	Southbound		B-12.2	A-9.1

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

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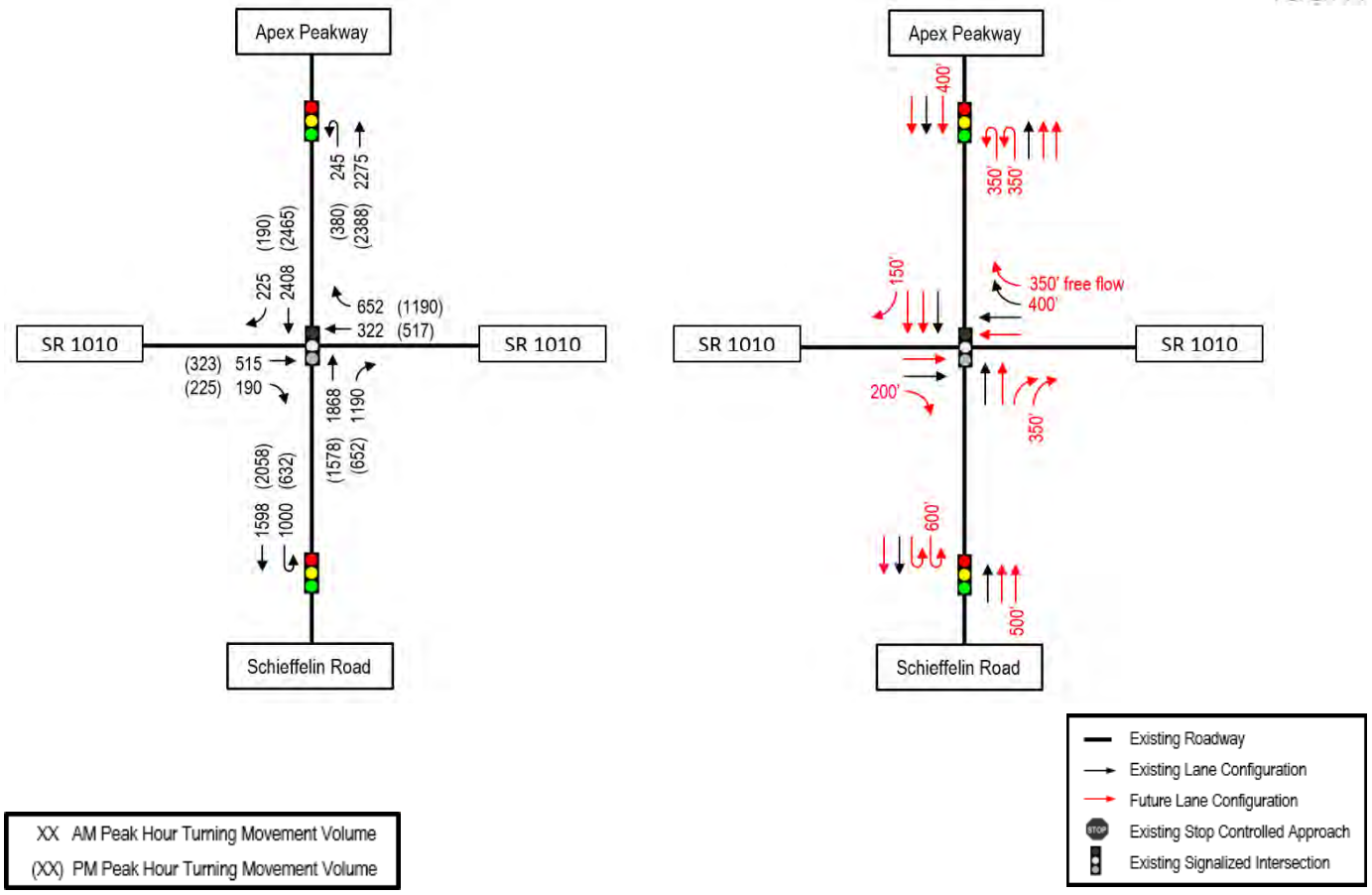

Figure 16: Design Year (2040) Build Alternative C Peak Hour Volumes, Lane Configuration and Traffic Control

Design Year (2040) Build Alternative D Conditions

The Build (2040) Alternative D analysis scenario is also limited to the intersection of SR 1010 (Center Street/Ten-Ten Road) at Apex Peakway/Schieffelin Road. Jug-handle slip roads were added to the northeastern and southwestern quadrants at this intersection to separate left-turn movements from the main intersection. With the proposed intersection configurations, traffic demand was rerouted and two new signals were added at the two auxiliary intersections. with following proposed turn lane improvements in place to address the capacity issues seen in the No-Build (2040) analysis. These improvements are shown in Figure 17 and include:

- Slip ramps and reverse loop ramps are added at the northeastern and southwestern quadrants to separate left- and right-turning traffic from Center Street, and left-turning traffic from Apex Peakway/Schieffelin Road from the main intersection.
- Two signalized intersections are added at the two auxiliary intersections on Apex Peakway/Schieffelin Road.

As reported in the Table 13, with the jug-handle system in place, the main intersection and two auxiliary intersections are all projected to operate acceptably during both the AM and PM peak hours.

Table 13: Build (2040) Alternative D LOS Results

ID	Intersection and Approach	Traffic Control	Build (2040) Alternative D	
			AM	PM
1A	**SR 1010 (Center Street) at Apex Peakway/SR 1306 (Schieffelin Road)**	Signalized	C (24.1 sec/veh)	B (18.4 sec/veh)
	Eastbound		D-41.6	D-40.6
	Westbound		C-32.0	D-48.3
	Northbound		B-13.2	A-7.7
	Southbound		C-22.5	B-11.6
1B	**Apex Peakway & North Jug Handle**	Signalized	**A (7.4 sec/veh)**	**A (8.4 sec/veh)**
	Westbound		B-12.2	B-14.8
	Northbound		A-7.5	A-3.8
	Southbound		A-6.0	A-8.2
1C	**Schieffelin Road & South Jug Handle**	Signalized	**A (6.9 sec/veh)**	**A (7.3 sec/veh)**
	Eastbound		D-48.6	E-60.6
	Northbound		A-7.8	A-4.6
	Southbound		A-2.9	A-4.2

LEGEND: X (X sec/veh) = Overall intersection LOS (average delay), X-XX = Approach LOS and average delay (red for LOS E or F)

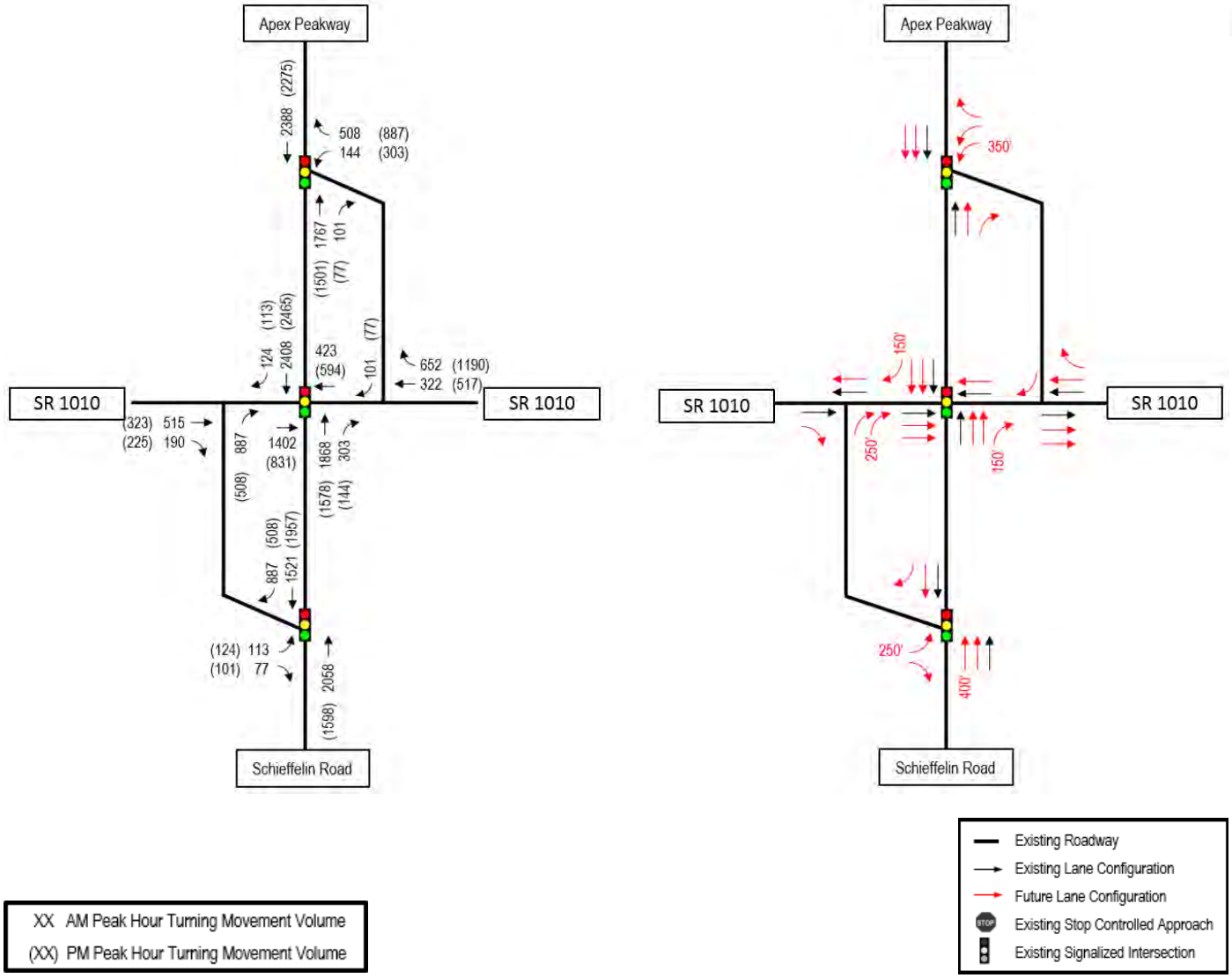

Figure 17: Design Year (2040) Build Alternative D Peak Hour Volumes, Lane Configuration and Traffic Control

Findings and Conclusions

Below is a summary of recommended improvements, by scenario, to achieve satisfactory operations at study intersections.

Alternative A (Figure 13)

SR 1010 (Center Street) and Apex Peakway/SR 1306 (Schieffelin Road)

- Construct an additional eastbound through lane to provide at least 600 feet of storage with appropriate taper.
- Construct an eastbound right-turn lane to provide at least 250 feet of storage with appropriate taper.
- Extend the eastbound left-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct a westbound right-turn lane and extend the existing westbound right-turn lane to provide dual right-turn lanes with at least 650 feet of storage with appropriate taper.
- Construct a westbound left-turn lane and extend the existing westbound left-turn lane to provide dual left-turn lanes with at least 300 feet of storage with appropriate taper.
- Construct two additional northbound through lanes.
- Construct a northbound right-turn lane to provide at least 350 feet of storage with appropriate taper.
- Construct an additional southbound through lane.
- Construct a southbound left-turn lane and extend the existing southbound left-turn lane to provide dual left-turn lanes with at least 800 feet of storage with appropriate taper.
- Construct a southbound right-turn lane to provide at least 200 feet of storage with appropriate taper.

SR 1010 (Center Street) and Satinwood Drive

- Construct an additional eastbound through lane.
- Extend the eastbound left-turn lane to provide at least 150 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct a southbound right-turn lane to provide at least 150 feet of storage with appropriate taper.

SR 1010 (Center Street) and Old Grove Lane

- Construct a shared eastbound through/right-turn lane.
- Extend the eastbound left-turn lane to provide at least 150 feet of storage with appropriate taper.
- Construct a shared westbound through/right-turn lane.
- Extend the westbound left-turn lane to provide at least 150 feet of storage with appropriate taper.

SR 1010 (Center Street) and Investment Boulevard

- Construct an additional eastbound through lane.
- Construct an eastbound right-turn lane to provide at least 100 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Extend the westbound left-turn lane to provide at least 175’ feet of storage with appropriate taper.
- Construct a northbound right-turn lane.

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SR 1010 (Center Street) and Parkfield Drive

- Extend the existing westbound right-turn lane to provide a shared though/right-turn lane.
- Convert existing southbound shared left-turn/right-turn lane to an exclusive right-turn lane.

SR 1010 (Ten-Ten Road) and US 1 Southbound Ramps/Waterford Green Drive

- Construct an additional eastbound through lane.
- Extend the eastbound left-turn lane to provide at least 200 feet of storage with appropriate taper.
- Extend the eastbound right-turn lane to provide at least 200 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct a westbound left-turn lane and extend the existing westbound left-turn lane to provide dual left-turn lanes with at least 550 feet of storage with appropriate taper.
- Construct a shared westbound through/right-turn lane.
- Construct a northbound left-turn lane to provide at least 400 feet of storage with appropriate taper.
- Extend the northbound right-turn lane to provide at least 400 feet of storage with appropriate taper.
- Extend the southbound left-turn lane to provide at least 150 feet of storage with appropriate taper.
- Extend the southbound right-turn lane to provide at least 150 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and US 1 Northbound Ramps/Lufkin Road

- Construct an additional eastbound through lane.
- Construct an additional eastbound left-turn lane.
- Extend the existing eastbound left-turn lane to provide at least 500 feet of storage with appropriate taper.
- Extend the existing eastbound right-turn lane to provide at least 325 feet of storage with appropriate taper.
- Construct two additional westbound through lanes.
- Extend the existing westbound right-turn lane to provide at least 300 feet of storage with appropriate taper.
- Extend the existing northbound left-turn lane to provide at least 200 feet of storage with appropriate taper.
- Extend the existing northbound right-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct a southbound left-turn lane.
- Extend the existing southbound shared through/right-turn lane to provide at least 250 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and SR 4070 (Reliance Avenue)/Driveway

- Construct two additional eastbound through lanes.
- Extend the existing eastbound left-turn lane to provide at least 350 feet of storage with appropriate taper.
- Construct two additional westbound through lanes.
- Construct a westbound left-turn lane and extend the existing westbound left-turn lane to provide dual left-turn lanes with at least 250 feet of storage with appropriate taper.
- Construct a northbound left-turn lane and extend the existing northbound left-turn lane to provide dual left-turn lanes with at least 450 feet of storage with appropriate taper.

- Construct a northbound right-turn lane to provide at least 450 feet of storage with appropriate taper.
- Construct a shared southbound through/right-turn lane.
- Modify the existing southbound left-turn lane to provide at least 200 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and Kiftsgate Lane

- Construct two additional eastbound through lanes.
- Construct two additional westbound through lanes.
- Modify the existing eastbound left-turn lane to provide at least 150' of storage with appropriate taper.
- Construct a southbound right-turn lane to provide at least 150 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and Arbordale Court

- Construct two additional eastbound through lanes.
- Construct two additional westbound through lanes.
- Modify the existing westbound left-turn lane to provide at least 150 feet of storage with appropriate taper.
- Construct a shared southbound through/right-turn lane to provide at least 100 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and SR 1379 (Penny Road)

- Construct two additional eastbound through lanes.
- Construct an eastbound left-turn lane and extend the existing eastbound left-turn lane to provide dual left-turn lanes with at least 350 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct an additional westbound through lane to provide at least 600 feet of storage with appropriate taper.
- Construct a westbound right-turn lane to provide at least 150 feet of storage with appropriate taper.
- Extend the existing southbound left-turn lane to provide at least 500 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and Smith Road

- Construct an additional eastbound through lane.
- Extend the existing eastbound right-turn lane to provide at least continuous storage (through lane drop).
- Construct an additional westbound through lane.
- Extend the existing westbound left-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional northbound left-turn lane.
- Extend the existing northbound left-turn lane to provide at least 600 feet of storage with appropriate taper.
- Modify the existing northbound right-turn lane to provide at least 200 feet of storage with appropriate taper.

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SR 1010 (Ten-Ten Road) and SR 1300 (Kildaire Farm Road)

- Construct an eastbound left-turn lane and extend the existing eastbound left-turn lane to provide dual left-turn lanes with at least 350 feet of storage with appropriate taper.
- Construct dual eastbound right-turn lanes with at least 500 feet of storage with appropriate taper.
- Construct dual westbound right-turn lanes to provide at least 500 feet of storage with appropriate taper.
- Construct a northbound left-turn lane and extend the existing northbound left-turn lane to provide dual left-turn lanes with at least 700 feet of storage with appropriate taper.
- Construct a northbound right-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct a southbound left-turn lane and extend the existing southbound left-turn lane to provide dual left-turn lanes with at least 600 feet of storage with appropriate taper.
- Construct a southbound right-turn lane to provide at least 250 feet of storage with appropriate taper.

Alternative B (Figure 15)

SR 1010 (Center Street) and Apex Peakway/SR 1306 (Schieffelin Road) (Future Apex Peakway)

- Install a new traffic signal.
- Remove existing eastbound left-turn lane.
- Convert existing eastbound shared/right-turn lane to exclusive right-turn lane.
- Construct an additional eastbound right-turn lane.
- Remove existing westbound through and left-turn lanes.
- Construct an additional, continuous westbound right-turn lane and a free-flow channelized right-turn lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional northbound through lane.
- Construct an additional continuous northbound right-turn lane.
- Extend the existing northbound left-turn lane to provide at least 350 feet of storage with appropriate taper.
- Construct two additional southbound through lanes.
- Construct an additional southbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 500 feet of storage with appropriate taper.

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Apex Peakway SB and Apex Peakway NB U-Turn

- Install a traffic signal.
- Construct two additional southbound through lanes. One continuous southbound through lane and a southbound through lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional northbound through lane.
- Construct three northbound U-turn lanes to provide at least 650 feet of storage with appropriate taper.

SR 1306 (Schieffelin Road) NB and SR 1306 (Schieffelin Road) SB U-Turn

- Install a traffic signal.
- Construct an additional northbound through lane.
- Construct an additional southbound though lane.
- Construct two southbound U-turn lanes. One continuous lane and one to provide at least 500 feet of storage with appropriate taper.

SR 1010 (Center Street) and Satinwood Drive

- Construct an additional eastbound through lane.
- Extend the existing eastbound left-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct a westbound right-turn lane to provide at least 100 feet of storage with appropriate taper.
- Construct a westbound U-turn lane to provide at least 400 feet of storage with appropriate taper.
- Convert existing southbound shared left-turn/right-turn lane to an exclusive right-turn lane.
- Construct a westbound left-turn crossover approximately midway between Apex Peakway and Satinwood Drive to provide at least 150 feet of storage with appropriate taper.

SR 1010 (Center Street) and Old Grove Lane

- Construct an additional eastbound through/right-turn lane.
- Extend the existing eastbound left-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional westbound through/right-turn lane.
- Extend the existing westbound left-turn lane to provide at least 350 feet of storage with appropriate taper.
- Convert existing southbound shared left-turn/through/right-turn lane to an exclusive right-turn lane.
- Convert existing northbound shared left-turn/through/right-turn lane to an exclusive right-turn lane.

SR 1010 (Center Street) and Investment Boulevard

- Construct an additional eastbound through lane.
- Construct an eastbound right-turn lane to provide at least 100 feet of storage with appropriate taper.
- Construct an eastbound U-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Extend the existing westbound left-turn lane to provide at least 300 feet of storage with appropriate taper.

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- Convert existing northbound shared left-turn/right-turn lane to an exclusive right-turn lane.

SR 1010 (Center Street) and Parkfield Drive

- Construct an additional eastbound through lane.
- Extend the existing eastbound left-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct a westbound U-turn lane to provide at least 350 feet of storage with appropriate taper.
- Construct a westbound right-turn lane to provide at least 350 feet of storage with appropriate taper.
- Convert existing southbound shared left-turn/right-turn lane to an exclusive right-turn lane.

SR 1010 (Ten-Ten Road) and US 1 Southbound Ramps/Waterford Green Drive

- Construct two additional eastbound through lanes. One continuous lane and one to provide 500 feet of storage with appropriate taper.
- Extend the existing eastbound left-turn lane to provide at least 250 feet of storage with appropriate taper.
- Extend the existing eastbound right-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct an additional westbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 350 feet of storage with appropriate taper.
- Extend the existing westbound right-turn lane to provide at least 200 feet of storage with appropriate taper.
- Construct an additional northbound left-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional northbound right-turn lane and extend the existing right-turn lane to provide dual right-turn lanes with at least 300 feet of storage with appropriate taper.
- Remove southbound left-turn lane.
- Convert existing southbound through lane to an exclusive right-turn lane.
- Construct an additional right-turn lane to provide at least 100 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and US 1 Northbound Ramps/Lufkin Road

- Construct an additional eastbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 575 feet of storage with appropriate taper.
- Extend the existing eastbound right-turn lane to provide at least 200 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct an additional westbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 450 feet of storage with appropriate taper.
- Remove northbound left-turn lane.
- Convert existing northbound shared through/right-turn lane to an exclusive right-turn lane.
- Construct an additional northbound right-turn lane.
- Convert existing southbound through lane to shared through/left-turn lane.
- Construct an additional southbound left-turn lane.

- Extend existing southbound left-turn lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional southbound right-turn lane to provide at least 300 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and SR 4070 (Reliance Avenue)/Driveway

- Install a new traffic signal.
- Construct two additional eastbound through lanes.
- Construct an additional eastbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 300 feet of storage with appropriate taper.
- Construct two additional westbound through lanes.
- Construct an additional westbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 300 feet of storage with appropriate taper.
- Extend the existing westbound right-turn lane to provide at least 200 feet of storage with appropriate taper.
- Convert existing southbound shared left-turn/right-turn lane to an exclusive right-turn lane.
- Construct an additional southbound right-turn lane.
- Remove northbound left-turn lane.
- Convert existing northbound shared through/right-turn lane to an exclusive right-turn lane.
- Construct an additional northbound right-turn lane.

SR 1010 (Ten-Ten Road) and Kiftsgate Lane

- Install a traffic signal.
- Construct an additional eastbound through lane.
- Construct an additional eastbound left-turn lane with continuous storage and extend the existing left-turn lane to provide at least 300 feet of storage with appropriate taper.
- Construct an additional westbound through lane to provide at least 300 feet of storage with appropriate taper.
- Construct a westbound U-turn lane to provide at least 300 feet of storage with appropriate taper.
- Convert existing southbound shared left-turn/right-turn lane to an exclusive right-turn lane.

SR 1010 (Ten-Ten Road) and Arbordale Court

- Construct an additional eastbound shared through/right-turn lane.
- Construct an eastbound left-turn lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Construct a westbound left-turn lane to provide at least 250 feet of storage with appropriate taper.
- Convert existing northbound shared left-turn/through/right-turn lane to an exclusive right-turn lane.
- Convert existing southbound shared left-turn/through/right-turn lane to an exclusive right-turn lane.

SR 1010 (Ten-Ten Road) and SR 1379 (Penny Road)

- Install a traffic signal.

- Construct an additional eastbound through lane.
- Construct an additional eastbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 350 feet of storage with appropriate taper.
- Construct two additional westbound through lanes. One continuous lane and one to provide at least 500 feet of storage with appropriate taper.
- Construct an additional westbound right-turn lane to provide at least 200 feet of storage with appropriate taper.
- Convert existing southbound left-turn lane to an additional exclusive right-turn lane.
- Construct a westbound left-turn crossover approximately midway between Penny Road and Arbordale Court to provide at least 150 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and Smith Road

- Construct an additional eastbound through lane.
- Extend the existing eastbound right-turn lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional westbound through lane.
- Extend the existing westbound left-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct an additional northbound left-turn lane.
- Extend the existing northbound left-turn lane to provide at least 500 feet of storage with appropriate taper.
- Shorten the existing northbound right-turn lane provide at least 250 feet of storage with appropriate taper.

SR 1010 (Ten-Ten Road) and SR 1300 (Kildaire Farm Road)

- Construct an additional eastbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 350 feet of storage with appropriate taper.
- Construct dual eastbound right-turn lanes to provide at least 500 feet of storage with appropriate taper.
- Construct dual westbound right-turn lanes to provide at least 500 feet of storage with appropriate taper.
- Extend the existing westbound left-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct an additional northbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 750 feet of storage with appropriate taper.
- Construct a northbound right-turn lane to provide at least 150 feet of storage with appropriate taper.
- Construct an additional southbound left-turn lane and extend the existing left-turn lane to provide dual left-turn lanes with at least 600 feet of storage with appropriate taper.
- Construct a southbound right-turn lane to provide at least 250 feet of storage with appropriate taper.

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Alternative C (Figure 16)

SR 1010 (Center Street) and Apex Peakway/SR 1306 (Schieffelin Road)

- Remove existing eastbound left-turn lane.
- Construct an additional eastbound through lane.
- Construct an eastbound right-turn lane to provide at least 200 feet of storage with appropriate taper.
- Remove existing westbound left-turn lane.
- Construct an additional westbound through lane.
- Extend the existing westbound right-turn lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional, free-flow channelized westbound right-turn lane to provide at least 350 feet of storage with appropriate taper.
- Remove existing northbound left-turn lane.
- Construct an additional northbound through lane.
- Construct a northbound right-turn lane.
- Construct an additional northbound right-turn lane to provide at least 350 feet of storage with appropriate taper.
- Remove existing southbound left-turn lane.
- Construct two additional southbound through lanes.
- Construct a southbound right-turn lane to provide at least 150 feet of storage with appropriate taper.

Apex Peakway SB and Apex Peakway NB U-Turn

- Install a traffic signal.
- Construct two additional northbound through lanes.
- Construct two northbound U-turn lanes to provide at least 350 feet of storage with appropriate taper.
- Construct an additional southbound through lane.
- Construct an additional southbound through lane to provide at least 400 feet of storage with appropriate taper.

SR 1306 (Schieffelin Road) NB and SR 1306 (Schieffelin Road) SB U-Turn

- Install a traffic signal.
- Construct an additional northbound through lane.
- Construct an additional northbound through lane to provide at least 500 feet of storage with appropriate taper.
- Construct an additional southbound through lane.
- Construct a southbound U-turn lane.
- Construct an additional southbound U-turn lane to provide at least 600 feet of storage with appropriate taper.

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Alternative D (Figure 17)

SR 1010 (Center Street) and Apex Peakway/SR 1306 (Schieffelin Road)

- Remove existing eastbound left-turn lane.
- Construct two additional eastbound through lanes.
- Remove existing westbound left-turn lane.
- Construct an additional westbound through lane.
- Remove existing northbound left-turn lane.
- Construct two additional northbound through lanes.
- Construct a northbound right-turn lane to provide at least 150 feet of storage with appropriate taper.
- Remove existing southbound left-turn lane.
- Construct two additional southbound through lanes.
- Construct a southbound right-turn lane to provide at least 150 feet of storage with appropriate taper.

Apex Peakway and North Jug Handle

- Install a traffic signal.
- Construct an additional northbound through lane.
- Construct a northbound right-turn lane.
- Construct two additional southbound through lanes.
- Construct a westbound left-turn lane.
- Construct an additional westbound left-turn lane to provide at least 350 feet of storage with appropriate taper.
- Construct a westbound right-turn lane.

Apex Peakway and South Jug Handle

- Install a traffic signal.
- Construct an additional northbound through lane.
- Construct an additional northbound through lane to provide at least 400 feet of storage with appropriate taper.
- Construct an additional southbound through lane.
- Construct a southbound right-turn lane.
- Construct an eastbound left-turn lane to provide at least 250 feet of storage with appropriate taper.
- Construct an eastbound right-turn lane.

SR 1010 (Center Street) and East Jug Handle

- Construct two additional eastbound through lanes.
- Construct an additional westbound through lane.
- Construct a westbound right-turn lane.
- Construct a southbound right-turn lane.

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SR 1010 (Center Street) and West Jug Handle

- Construct an eastbound right-turn lane.
- Construct an additional westbound through lane.
- Construct a northbound right-turn lane.
- Construct an additional northbound right-turn lane to provide at least 250 feet of storage with appropriate taper.

Alternative Microsimulation Comparison

A comparison of each of the alternatives was conducted using microsimulation software packages to evaluate measures of effectiveness at the intersection of SR 1010 (Center Street) and Apex Peakway/SR 1306 (Schieffelin Road). Microsimulation models simulate individual vehicles as they move through the network as opposed to macroscopic models such as Synchro, which evaluate traffic as an aggregate flow using calculations. Unconventional intersection designs often improve operations at the main intersection as a result of more efficient phasing, however introduce new delay at other intersections as new signals are added or vehicles are rerouted away from the central intersection. As a result, network-wide measures of effectiveness, such as average delay per vehicle, is a better means of comparing conventional and unconventional designs than intersection LOS alone. These microsimulation software packages also have other advantages such as dynamic routing of left-turns through the network, modelling queue spillback interactions between intersections, weaving intersection, and providing animations useful for verifying and displaying the operations of these designs. SimTraffic was used to develop network-wide comparisons for this location. Network-wide results reflect an average of ten 60-minute runs using random number seeds.

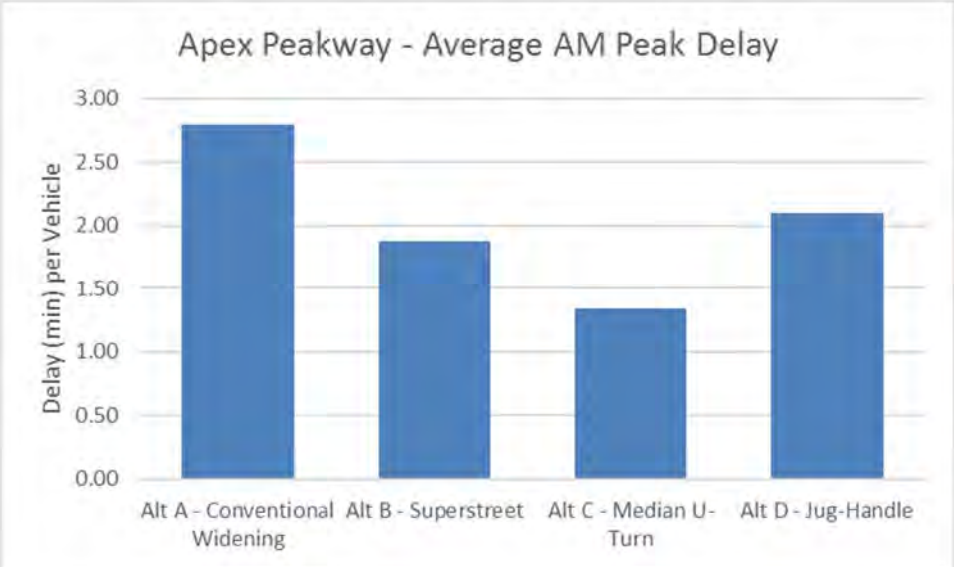
From a simulation-based delay perspective, Alterative C (Median U-Turn) out-performs the other options during both peaks. Alternative B performed well during the AM peak, but operates with more delay than the other three alternatives during the PM peak and requires a triple left-turn north of the intersection, which is undesirable for a U-turn movement. Alternative A operates with more delay than the other three alternatives in the AM peak. Alternatives C and D out-perform the other two options, however other factors such as construction cost, right-of-way impacts, constructability, local context, and driver acceptance/confusion should all be weighed when selecting a preferred alternative. Table 14 and Figure 18 include results for the AM peak. Table 15 and Figure 19 show results for the PM peak.

Memorandum

Table 64: Network Analysis Alternative Comparison – SR 1010 and Apex Peakway (AM Peak)

Measure of Effectiveness	AM			
	Alt A	Alt B	Alt C	Alt D
Vehicles Entered (veh/hr)	6,316	6,848	6,805	6,627
Vehicles Exited (veh/hr)	6,119	6,737	6,716	6,490
Travel Distance (mi)	4,778	5,637	5,596	5,313
Travel Time (hr)	609	407	330	447
Total Delay (hr)	285	211	150	227
Total Stops	10,851	15,551	10,259	11,775
Fuel Useage (gal)	263	245	227	242
Distance (mi) per veh.	0.78	0.84	0.83	0.82
Time (min) per veh.	5.97	3.62	2.95	4.13
Delay (min) per veh.	**2.79**	**1.88**	**1.34**	**2.10**
Stops per veh.	1.77	2.31	1.53	1.81
Fuel (gal) per veh.	0.04	0.04	0.03	0.04

Figure 18: Network Analysis Alternative Comparison – SR 1010 and Apex Peakway (AM Peak)



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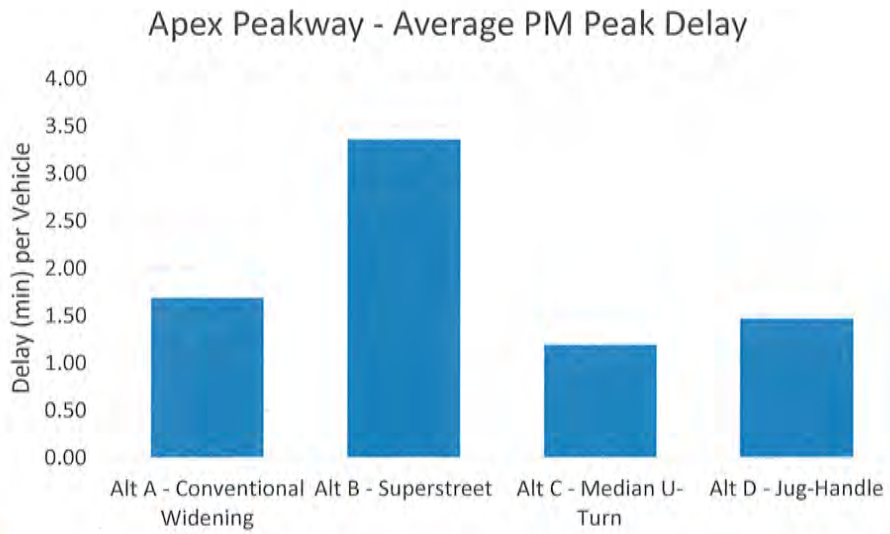
Memorandum

Table 15: Network Analysis Alternative Comparison – SR 1010 and Apex Peakway (PM Peak)

Measure of Effectiveness	PM			
	Alt A	Alt B	Alt C	Alt D
Vehicles Entered (veh/hr)	6,722	6,114	6,402	6,688
Vehicles Exited (veh/hr)	6,621	5,866	6,401	6,596
Travel Distance (mi)	5,146	4,999	5,241	5,310
Travel Time (hr)	364	794	488	354
Total Delay (hr)	186	328	127	161
Total Stops	9,001	16,148	7,057	7,698
Fuel Useage (gal)	213	217	253	217
Distance (mi) per veh.	0.78	0.85	0.82	0.81
Time (min) per veh.	3.30	8.12	4.57	3.22
Delay (min) per veh.	**1.69**	**3.35**	**1.19**	**1.46**
Stops per veh.	1.36	2.75	1.10	1.17
Fuel (gal) per veh.	0.03	0.04	0.04	0.03

Figure 19: Network Analysis Alternative Comparison – SR 1010 and Apex Peakway (PM Peak)



VHB Engineering NC, P.C. (C-3705)
Venture I
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Figures

Figure 1: Project Vicinity

Figure 2: Base Year (2016) Lane Configuration and Traffic Control

Figure 3: Base Year (2016) No-Build Peak Hour Turning Movement Volumes

Figure 4: Base Year (2016) Build Peak Hour Turning Movement Volumes

Figure 5: U-5825 Crash Summary

Figure 6: Design Year (2040) No-Build Peak Hour Turning Movement Volumes

Figure 7: Design Year (2040) No-Build Lane Configuration and Traffic Control

Figure 8: Illustration of Superstreet Crossover

Figure 9: Illustration of Median U-Turn Crossover

Figure 10: Vehicular Movements at Median U-Turn

Figure 11: Illustration of A Jug Handle Intersection with a "Reverse" Ramp

Figure 12: Design Year (2040) Build (Alternative A) Peak Hour Turning Movement Volumes

Figure 13: Design Year (2040) Build (Alternative A) Lane Configuration and Traffic Control

Figure 14: Design Year (2040) Build (Alternative B) Peak Hour Turning Movement Volumes

Figure 15: Design Year (2040) Build (Alternative B) Lane Configuration and Traffic Control

Figure 16: Design Year (2040) Build Alternative C Peak Hour Volumes, Lane Configuration and Traffic Control

Figure 17: Design Year (2040) Build Alternative D Peak Hour Volumes, Lane Configuration and Traffic Control

Figure 18: Network Analysis Alternative Comparison – SR 1010 and Apex Peakway (AM Peak)

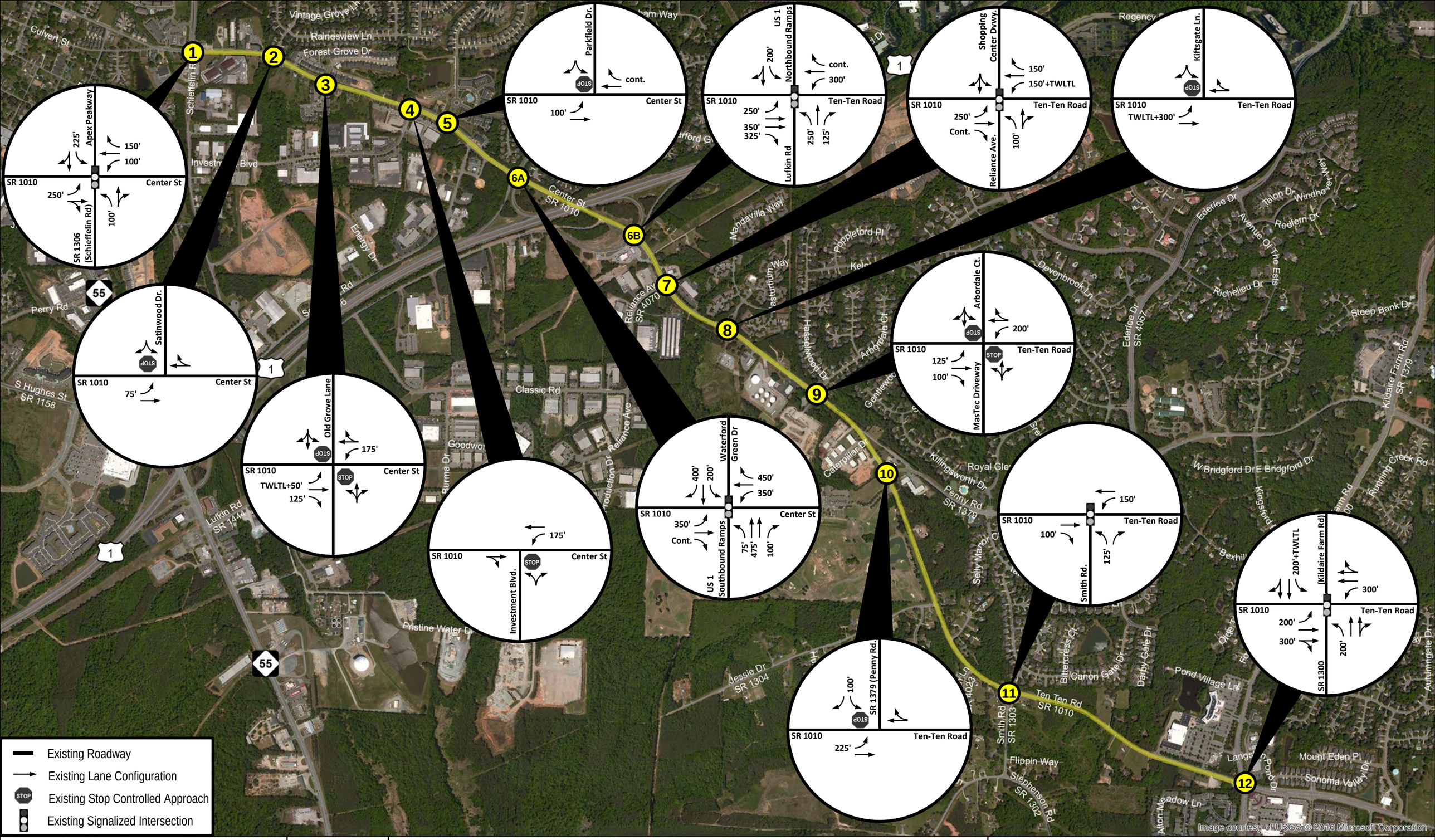
Figure 19: Network Analysis Alternative Comparison – SR 1010 and Apex Peakway (PM Peak)

Study Intersection

Scale
0 0.5 1 2 Miles

NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

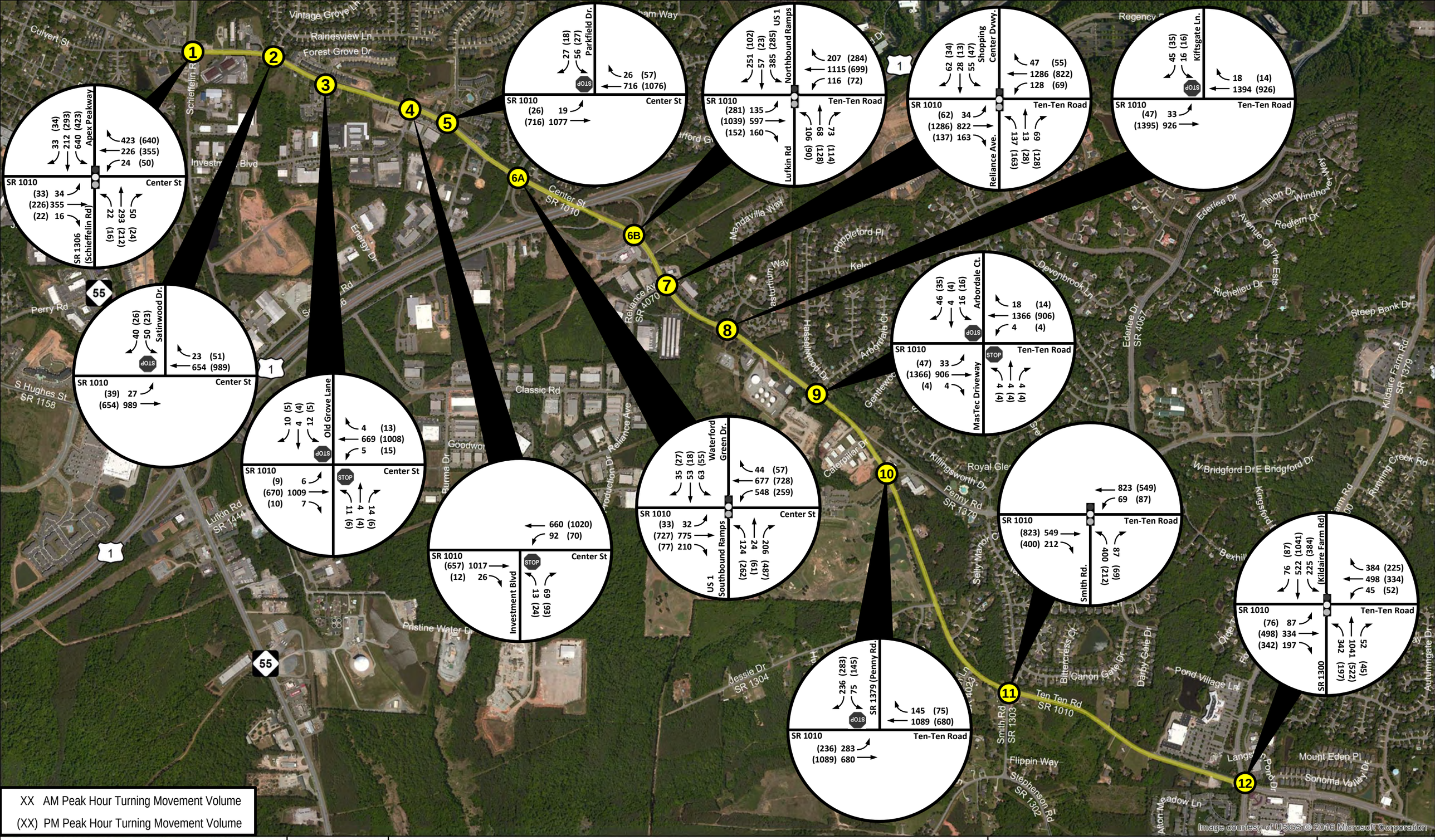
Figure 1
Project Vicinity



Scale
0 750 1,500 3,000 Feet

NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 2
Base Year (2016) Lane Configuration and Traffic Control



XX AM Peak Hour Turning Movement Volume

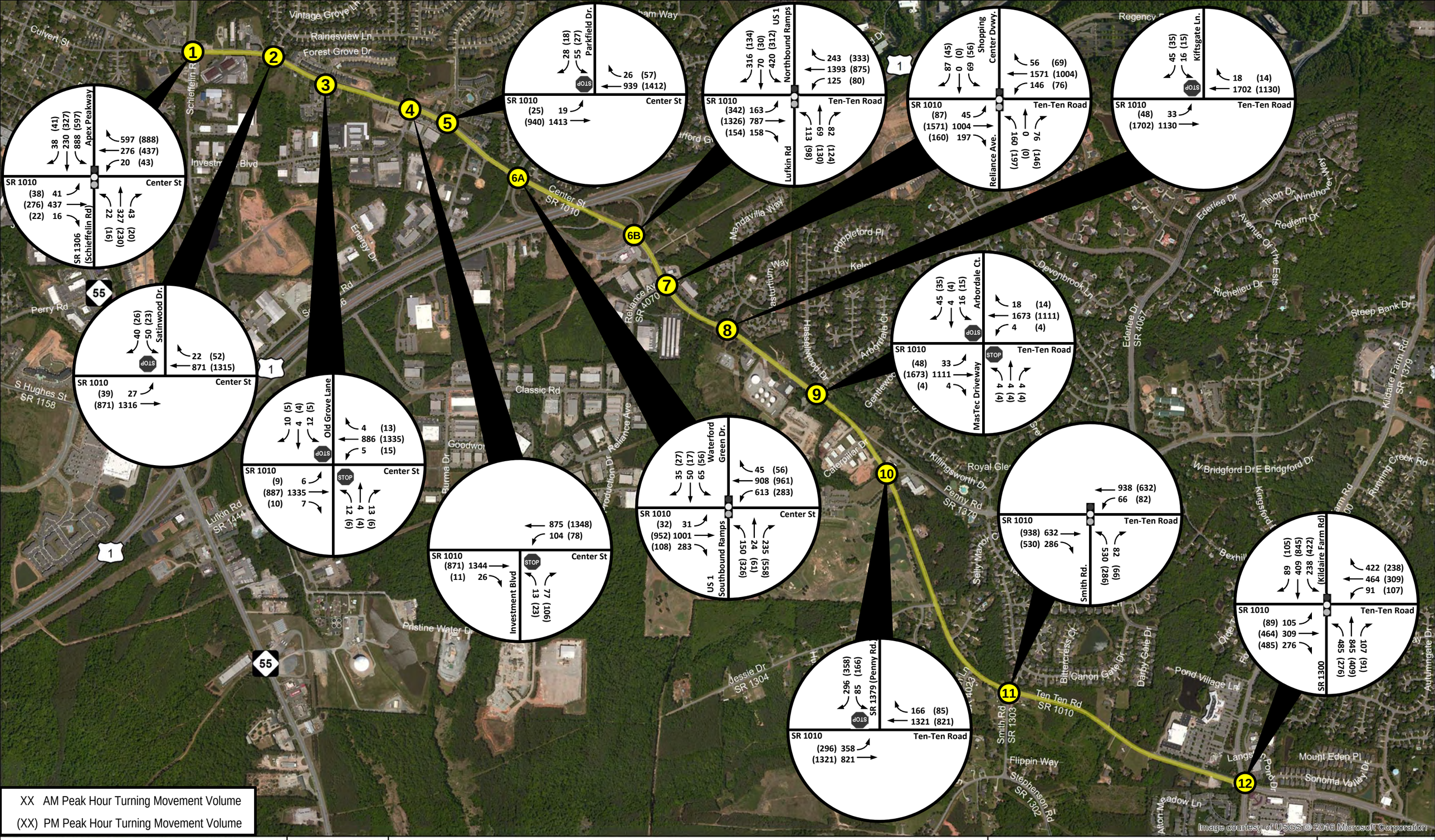
(XX) PM Peak Hour Turning Movement Volume

Scale

0 750 1,500 3,000 Feet

NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 3
Base Year (2016) No-Build Peak Hour
Turning Movement Volumes



XX AM Peak Hour Turning Movement Volume

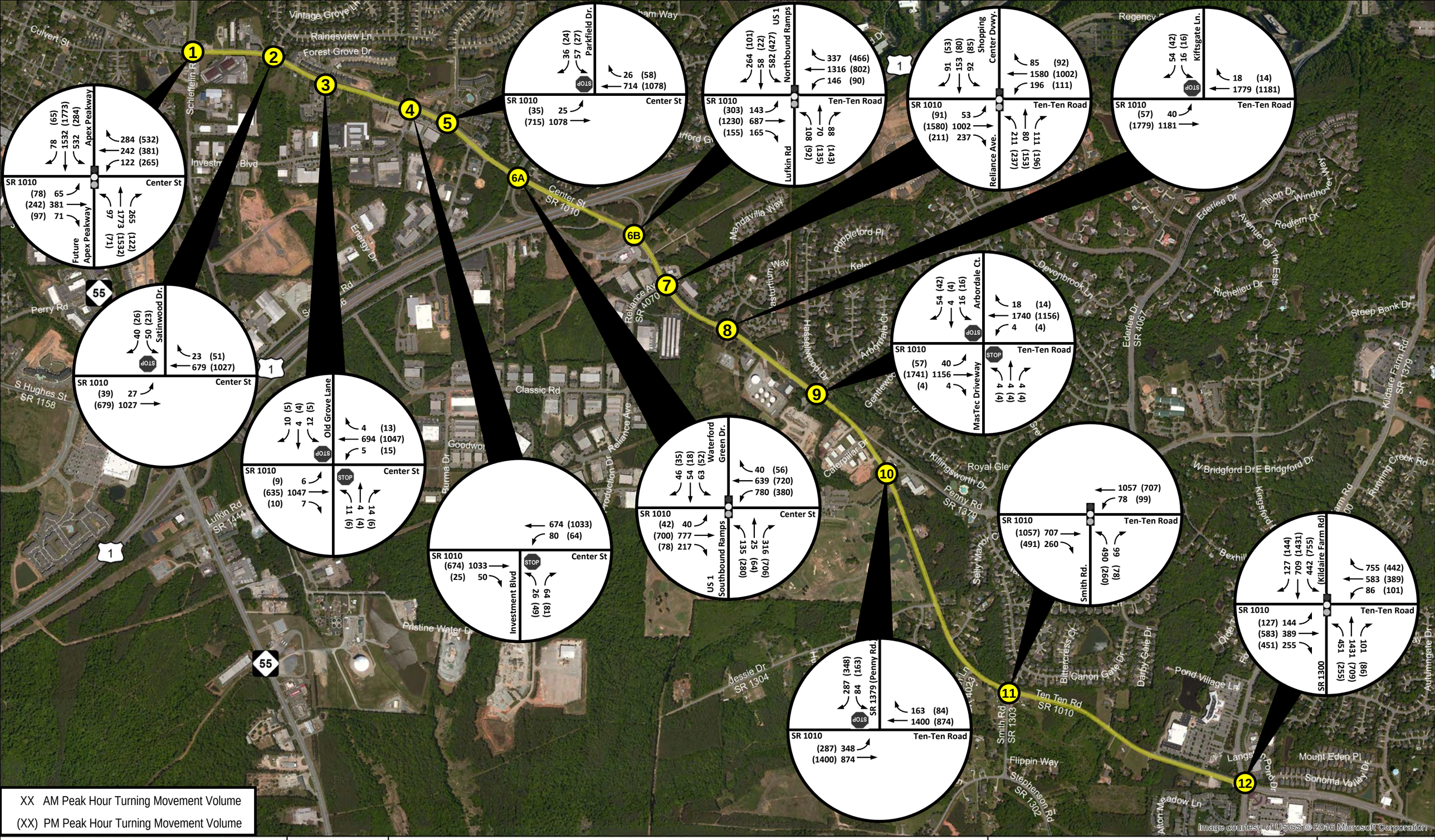
(XX) PM Peak Hour Turning Movement Volume

Scale

0 750 1,500 3,000 Feet

NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 4
Base Year (2016) Build Peak Hour
Turning Movement Volumes



XX AM Peak Hour Turning Movement Volume

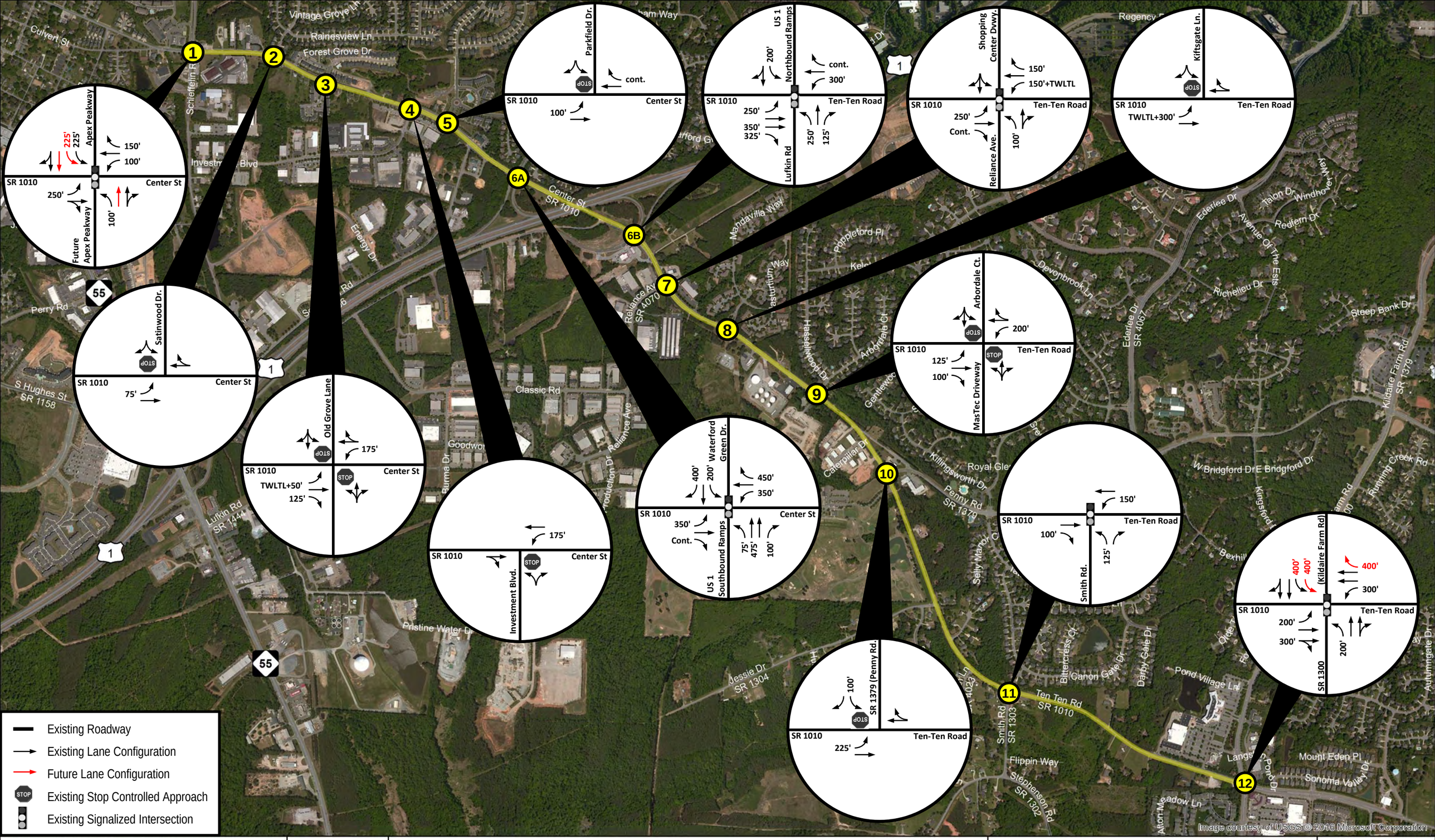
(XX) PM Peak Hour Turning Movement Volume

Scale

0 750 1,500 3,000 Feet

NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 6
Design Year (2040) No-Build Peak Hour
Turning Movement Volumes



Scale
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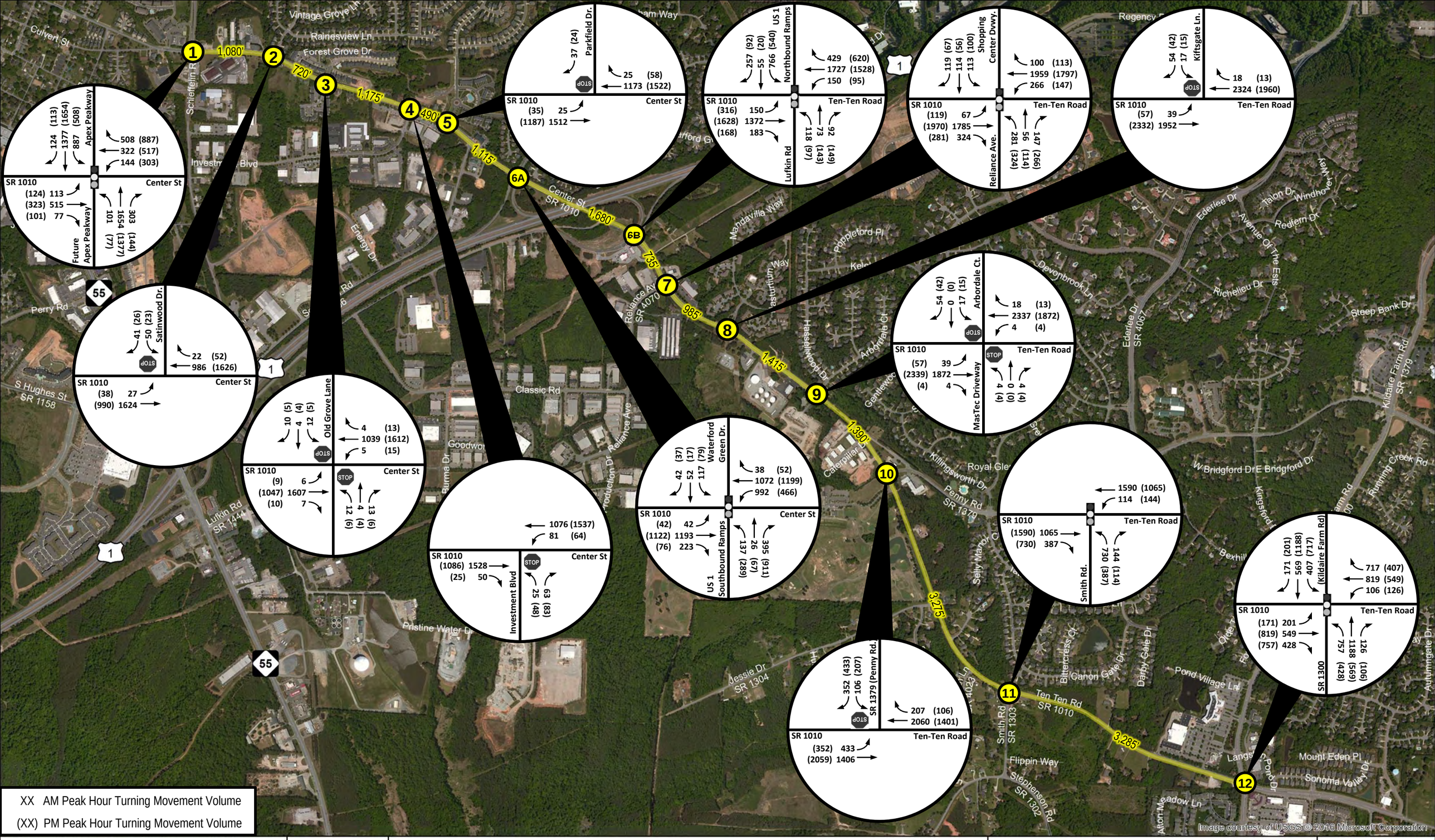
NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 7
Design Year (2040) No-Build
Lane Configuration and Traffic Control



XX AM Peak Hour Turning Movement Volume

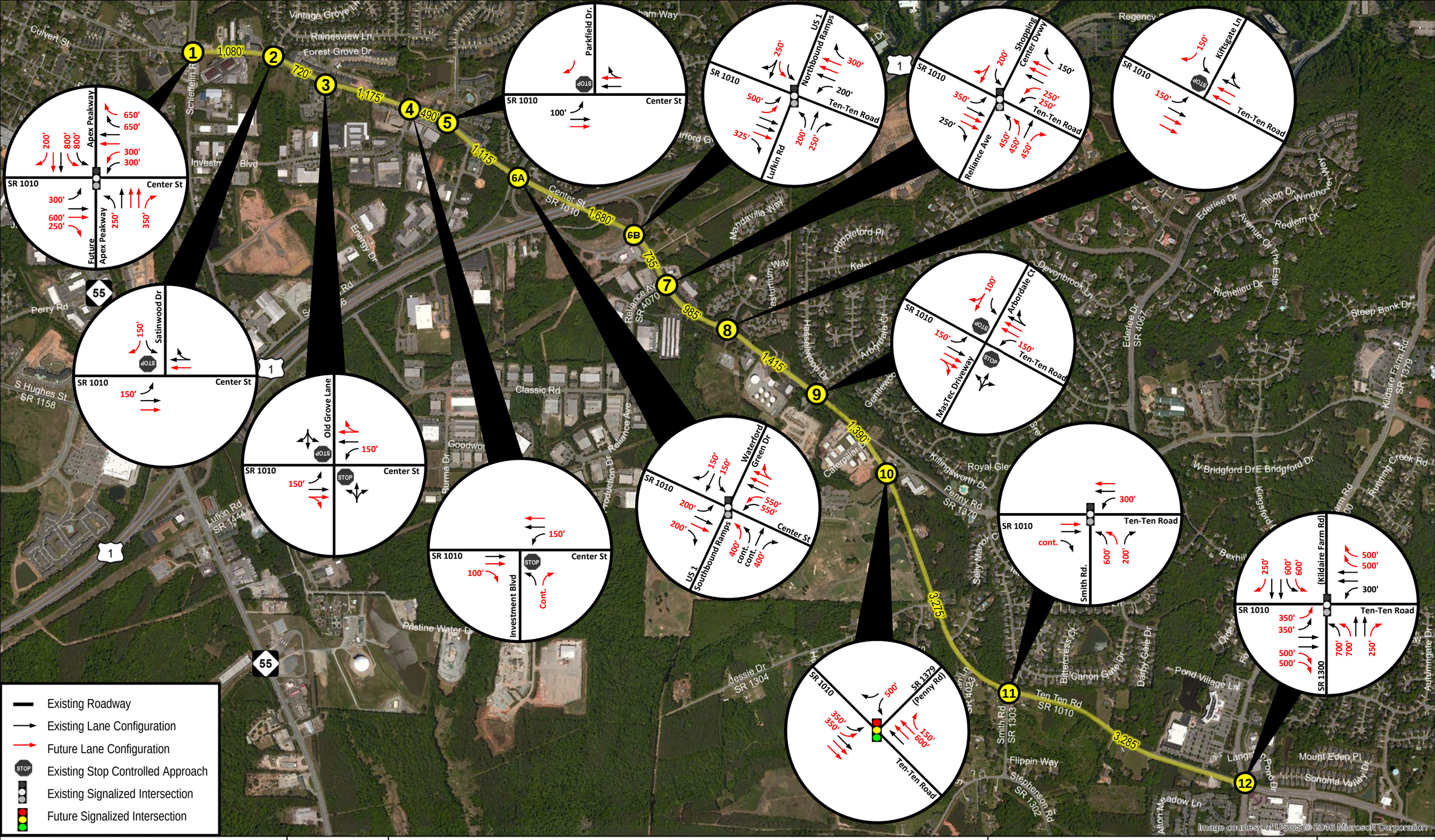
(XX) PM Peak Hour Turning Movement Volume

Scale

0 750 1,500 3,000 Feet

NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 12
Design Year (2040) Build
Conventional Widening (Alternative A)
Peak Hour Turning Movement Volumes



Scale
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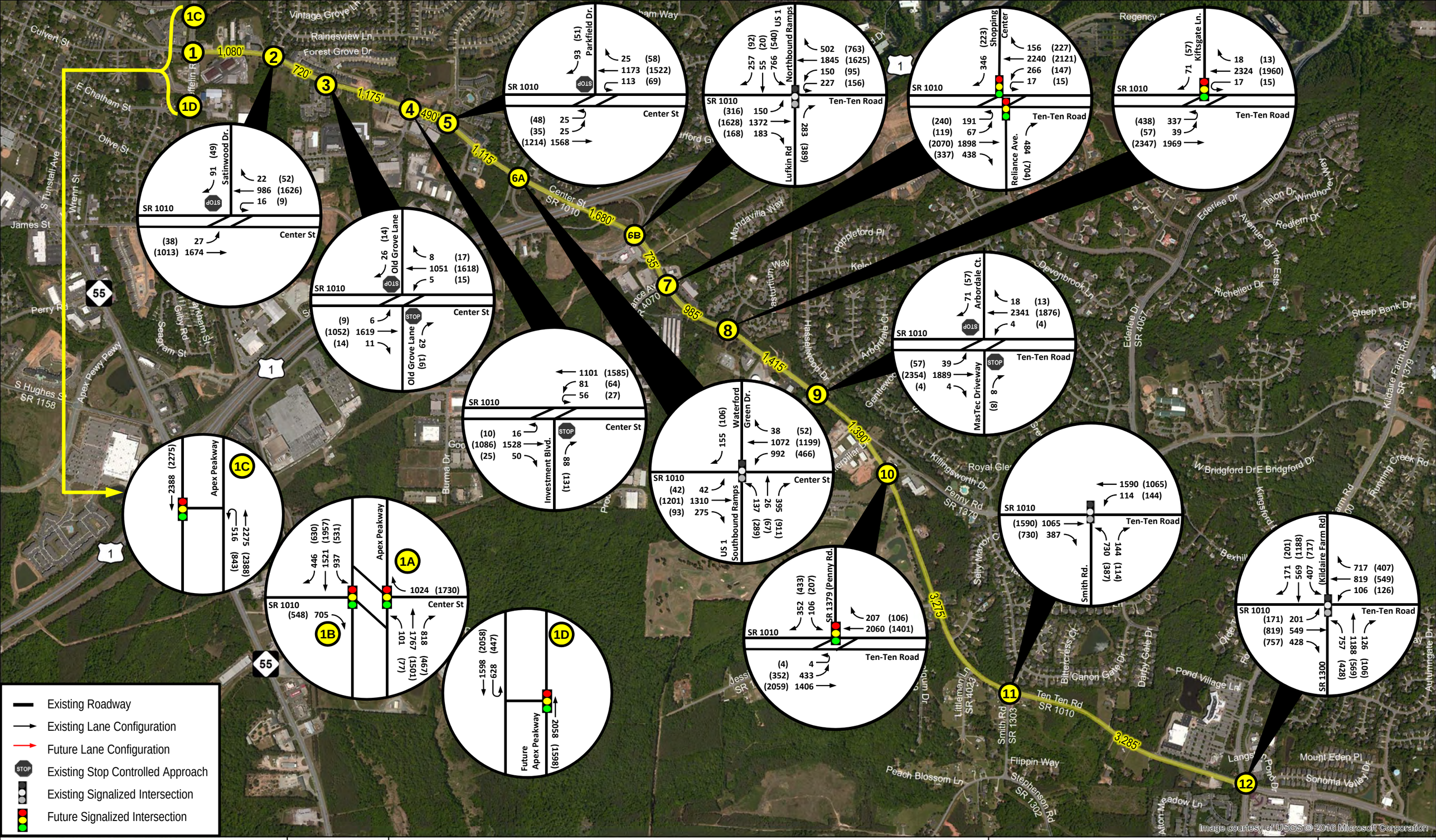
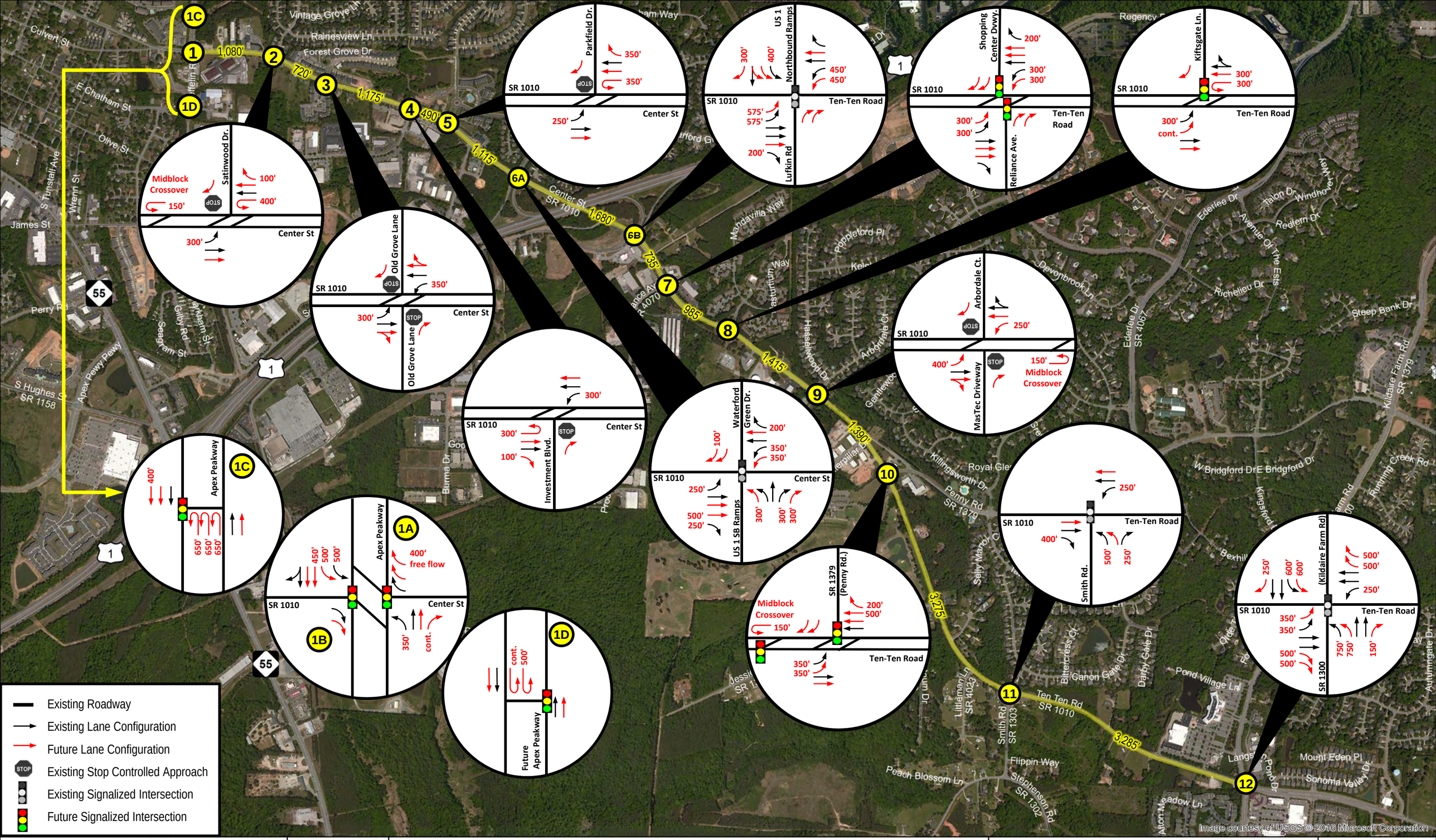
NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 13
Design Year (2040) Build
Conventional Widening (Alternative A)
Lane Configuration and Traffic Control



NCDOT STIP Project No. U-5825
Traffic Capacity Analysis
Apex, NC

Figure 14
Design Year (2040) Build
Four-Lane Superstreet (Alternative B)
Peak Hour Turning Movement Volumes


1C
1
1D
1,080'
2
720'
3
1,175'
4
490'
5
1,115'
6A
1,680'
6B
735'
7
985'
8
1,415'
9
1,390'
10
3,275'
11
Ten Ten Rd SR 1010
3,285'
12
Vintage Grove Ln
Rainesview Ln
Forest Grove Dr
Culvert St
E Chatham St
Olive St
Wrenn St
James St
Perry Rd
Seagram St
Apex Pewy Pewy
S Hughes St SR 1158
Center St SR 1010
Mandaville Way
Poppleford Pl
Hasselwood Dr
Arbordale Ct
Devonbrook Ln
Ederlee Dr
Ederlee Dr SR 4067
Avenue Of The Ests
Richelieu Dr
Steep Bank Dr
Kildaire Farm Rd SR 1379
Redfern Dr
Windhover Way
Talon Dr
Royal Glen
Killingsworth Dr
Penny Rd SR 1379
Selly Manor Ct
W Bridgford Dr
E Bridgford Dr
Kingsford Dr
Running Creek Rd
Bexhill Dr
Littleman Ln SR 4023
Smith Rd SR 1303
Flippin Way
Stephenson Rd SR 1302
Peach Blossom Ln
Bittercress Ct
Canon Gate Dr
Darby Gate Dr
Pond Village Ln
Mount Eden Pl
Sonoma Valley Dr
Alton Meadow Ln
Autumngate Dr
Parkfield Dr.
Center St
Northbound Ramps
US 1
Lufkin Rd
Ten-Ten Road
Shopping Center Dwwy.
Reliance Ave.
Kiftsgate Ln.
Midblock Crossover
Satinwood Dr.
Old Grove Lane
Waterford Green Dr.
Investment Blvd.
US 1 SB Ramps
Arbordale Ct.
MasTec Driveway
Apex Peakway
Future Apex Peakway
SR 1379 (Penny Rd.)
Smith Rd.
(Kildaire Farm Rd)
SR 1300
400' free flow
cont.
Image courtesy of USGS © 2016 Microsoft Corporation
Existing Roadway
Existing Lane Configuration
Future Lane Configuration
Existing Stop Controlled Approach
Existing Signalized Intersection
Future Signalized Intersection
Scale
0 750 1,500 3,000 Feet
N
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Traffic Capacity Analysis
Apex, NC
Figure 15
Design Year (2040) Build
Superstreet (Alternative B)
Lane Configuration and Traffic Control
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