Capital Area MPO

US 401 Interim Improvements Analysis

Wake County, NC

Prepared for CAMPO

July 2, 2013

Project Number 13-405

DAVENPORT

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Executive Summary

The Capital Area Metropolitan Planning Organization (CAMPO) provides regional and comprehensive transportation planning for North Carolina's capital region including Franklin, Granville, Harnett, Johnston and Wake Counties. The MPO has identified several transportation projects for inclusion in the region's Comprehensive Transportation Plan (CTP). Some areas were determined to require additional detailed analyses to identify feasible solutions and improvement recommendations. DAVENPORT has been retained to perform a hot spot study for two intersections:

- US 401 at Ten-Ten Road
- US 401 at Hilltop-Needmore Road

These intersections are located south of Raleigh along US 401 north of SR 42 in Wake County. A vicinity map is provided in Figure 1.


US 401 & Ten-Ten Road looking east

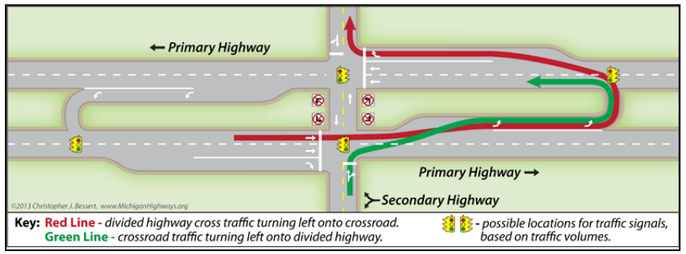
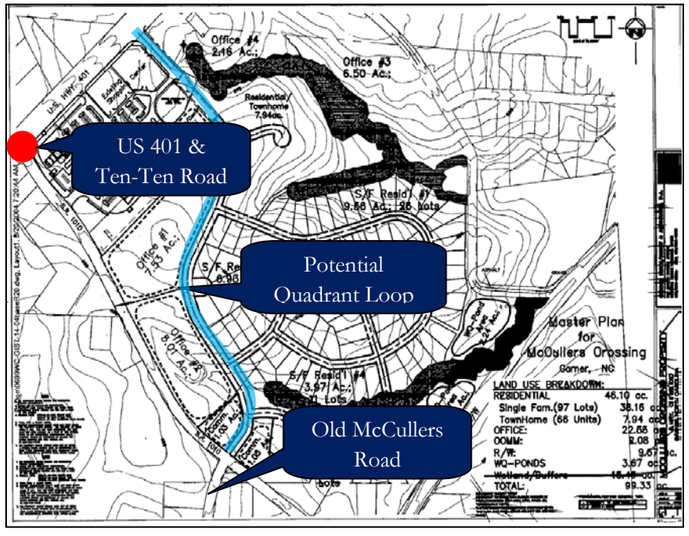

US 401 & Hilltop-Needmore Road looking north

These intersections currently experience significant delay and operational deficiencies. Traffic is anticipated to increase at these intersections as the surrounding area continues to experience growth. Ultimately, the roadway will be widened by the North Carolina Department of Transportation (NCDOT) in the future to six lanes with a superstreet configuration. However, improvements are needed in the interim to improve the safety and operation of the intersections.

DAVENPORT was retained by CAMPO to assess the study intersections to identify improvement options to accommodate future and existing traffic, and provide planning-level cost estimates. Future year analyses were carried out for short-term conditions in 2020 and long-term conditions in 2040.

The following tables present the recommendations from this analysis.

US 401 & Ten-Ten Road

<table>
<tr><th>Improvement Option</th><th colspan="2">Short Term 2020 Solution?</th><th colspan="2">Long Term 2040 Solution?</th><th>2020 Cost</th><th>Impacts</th><th>Other Modes</th><th>Other Advantages</th><th>Other Disadvantages</th></tr>
<tr><td rowspan="5">Michigan Lefts
 
</td><td colspan="2">Yes</td><td colspan="2">No</td><td rowspan="5">$3,000,000</td><td>Environmental:
Low</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.
• May need pedestrian bridge in long term 2040.</td><td rowspan="5">• Enhanced safety with fewer conflict points.
• Minor street through traffic is not rerouted.</td><td rowspan="5">• Unconventional intersection configuration.
• Major street left turns are rerouted.
• Minor street left turns are rerouted.</td></tr>
<tr><td>Cultural:
Low</td></tr>
<tr><td>Right-of-Way:
Low</td></tr>
<tr><td>Business Driveways:
Medium
(Altered access to nearby driveways at Gelder Drive and at the AutoZone / Smithfield's access)</td><td>Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left will be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td></tr>
<tr><td>US 401 NB</td><td>D/B</td><td>US 401 NB</td><td>C/B</td></tr>
<tr><td>US 401 SB</td><td>A/E</td><td>US 401 SB</td><td>A/D</td></tr>
<tr><td>Ten-Ten Rd. EB</td><td>D/D</td><td>Ten-Ten Rd. EB</td><td>D/E</td></tr>
<tr><td>Ten-Ten Rd. WB</td><td>D/D</td><td>Ten-Ten Rd. WB</td><td>E/D</td></tr>
<tr><td rowspan="5">Michigan Lefts with a Single Quadrant Loop
 
</td><td colspan="2">Yes</td><td colspan="2">Yes</td><td rowspan="5">$4,100,000

(Does not include cost of Loop Road construction - assumed to be completed by developer. Loop Road has an estimated 2020 cost of $1,900,000)</td><td>Environmental:
Low/Medium
(Water Supply Area/ Nutrient Sensitive Waters; 50 foot buffer and BMP requirements on surface waters)</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.
• May need pedestrian bridge in long term 2040.</td><td rowspan="5">• Enhanced safety with fewer conflict points.
• Minor street through traffic is not rerouted.</td><td rowspan="5">• Unknown construction of development and quadrant loop road.
• Unconventional intersection configuration.
• Major street left turns are rerouted.
• Minor street left turns are rerouted.</td></tr>
<tr><td>Cultural:
Low</td></tr>
<tr><td>Right-of-Way:
Medium</td></tr>
<tr><td>Business Driveways:
Medium
(Altered access to nearby driveways at Gelder Drive and at the AutoZone / Smithfield's access)</td><td>Transit:
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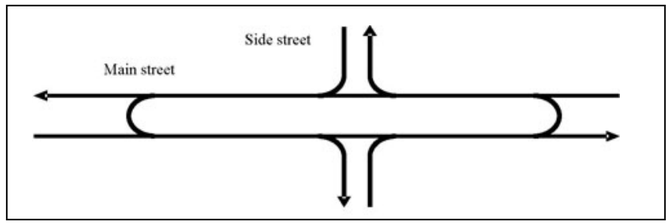
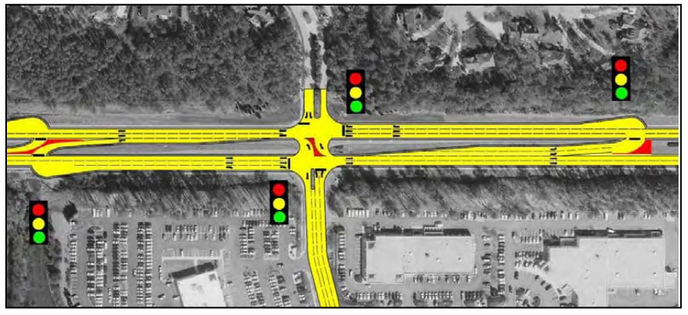
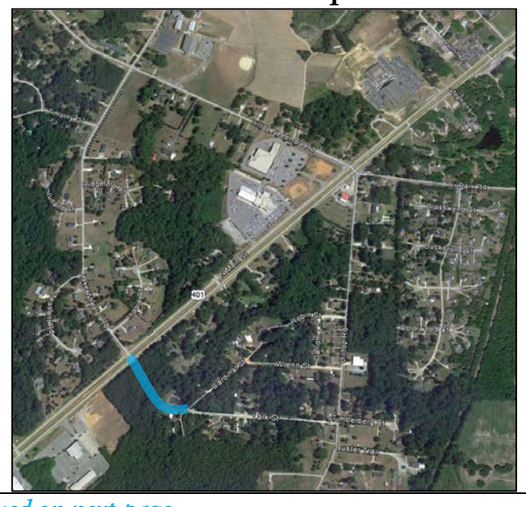
• Buses turning left will be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td></tr>
<tr><td>US 401 NB</td><td>D/B</td><td>US 401 NB</td><td>C/B</td></tr>
<tr><td>US 401 SB</td><td>A/C</td><td>US 401 SB</td><td>A/C</td></tr>
<tr><td>Ten-Ten Rd. EB</td><td>D/D</td><td>Ten-Ten Rd. EB</td><td>D/C</td></tr>
<tr><td>Ten-Ten Rd. WB</td><td>C/D</td><td>Ten-Ten Rd. WB</td><td>D/D</td></tr>
</table>

US 401 & Hilltop-Needmore Road

Improvement Option	Short Term 2020 Solution?		Long Term 2040 Solution?		2020 Cost	Impacts	Other Modes	Other Advantages	Other Disadvantages
Superstreet with No Direct Left Turns 	**Yes**		**Yes**		$2,000,000	**Environmental:** Low **Cultural:** Low **Right-of-Way:** Low **Business Driveways:** Low	**Pedestrian/Bicycle:** • Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time. • Longer pedestrian phase without left turns. **Transit:** • Improved LOS and delay for buses on US 401. • Buses turning left or straight from the side streets will be rerouted. • Provide bus pullouts.	• Enhanced safety with fewer conflict points.	• Major street left turns are rerouted. • Minor street left turns are rerouted. • Minor street through traffic is rerouted. • Long term solution may require connection between Air Park Road and Hilltop Road. • Unconventional intersection configuration.
	Approach	**LOS AM/PM**	**Approach**	**LOS AM/PM**					
	US 401 NB	A/A	US 401 NB	A/A					
	US 401 SB	A/A	US 401 SB	A/B					
	Hilltop-Needmore Rd. EB	D/D	Hilltop-Needmore Rd. EB	C/C					
Reverse Superstreet 	**Yes**		**Yes**		$1,850,000	**Environmental:** Low **Cultural:** Low **Right-of-Way:** Low **Business Driveways:** Low	**Pedestrian/Bicycle:** • Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time. • Longer pedestrian phase without left turns. **Transit:** • Improved LOS and delay for buses on US 401. • Buses turning left from US 401 or westbound from the side streets will be rerouted. • Provide bus pullouts.	• Eastbound approach of Hilltop-Needmore Road is not rerouted. • Enhanced safety with fewer conflict points.	• Intersection still experiences queuing, especially in the short term analysis without a six-lane US 401. • Major street left turns are rerouted. • Air Park Road and Hilltop Road through traffic is rerouted. • Air Park Road and Hilltop Road left turns rerouted. • Unconventional intersection configuration.
	Approach	**LOS AM/PM**	**Approach**	**LOS AM/PM**					
	US 401 NB	C/B	US 401 NB	C/C					
	US 401 SB	B/B	US 401 SB	B/C					
	Hilltop-Needmore Rd. EB	E/E	Hilltop-Needmore Rd. EB	E/D					
Relocated Hilltop Road 	**Yes**		**Yes**		$2,400,000	**Environmental:** Low/Medium Possible threatened species. Would require further study. **Cultural:** Low **Right-of-Way:** Medium/High Construction of Lark St. Extension **Business Driveways:** Low	**Pedestrian/Bicycle:** • Traditional pedestrian accommodations can be provided. **Transit:** • Improved LOS and delay for buses on US 401. • Buses will not be rerouted. • Provide bus pullouts.	• Meets driver expectations with a traditional intersection configuration. • Traffic movements at the main intersection are not rerouted. • Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.	• Intersection still experiences queuing, especially in the short term analysis without a six-lane US 401. • Traffic on Hilltop Road is rerouted.
	Approach	**LOS AM/PM**	**Approach**	**LOS AM/PM**					
	US 401 NB	C/A	US 401 NB	C/A					
	US 401 SB	B/C	US 401 SB	B/C					
	Hilltop-Needmore Rd. EB	E/E	Hilltop-Needmore Rd. EB	E/D					
	Relocated Hilltop Rd. WB	E/D	Relocated Hilltop Rd. WB	D/D					

continued on next page

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US 401 & Hilltop-Needmore Road (continued)

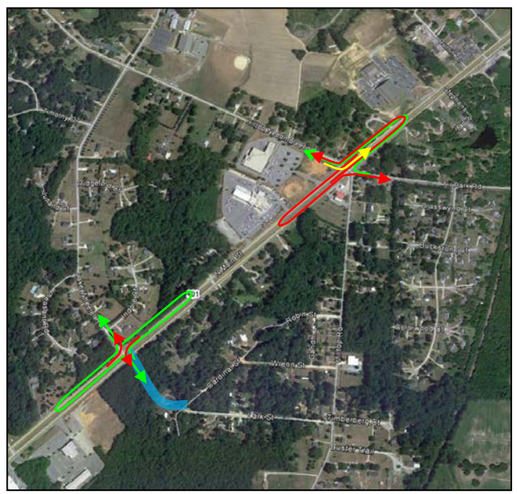
<table>
<tr><th>Improvement Option</th><th colspan="2">Short Term 2020 Solution?</th><th colspan="2">Long Term 2040 Solution?</th><th>2020 Cost</th><th>Impacts</th><th>Other Modes</th><th>Other Advantages</th><th>Other Disadvantages</th></tr>
<tr><td rowspan="6">Reverse Superstreet and Relocated Hilltop Road with No Direct Left Turns
  </td><td colspan="2">Yes</td><td colspan="2">Yes</td><td rowspan="6">$3,300,000</td><td>Environmental:
Low/Medium
Possible threatened species. Would require further study.</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.</td><td rowspan="6">• Enhanced safety with fewer conflict points.
• Eastbound approach of Hilltop-Needmore Road is not rerouted.
• Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.</td><td rowspan="6">• Major street left turns are rerouted.
• Air Park Road through traffic and left turns are rerouted.
• Lake Wheeler Road and Hilltop Road through traffic and left turns are rerouted.
• Unconventional intersection configuration.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td><td>Cultural:
Low</td></tr>
<tr><td>US 401 NB</td><td>A/A</td><td>US 401 NB</td><td>A/A</td><td rowspan="2">Right-of-Way:
Medium/High
Construction of Lark St. Extension</td><td rowspan="3">Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left from US 401 or from the side streets, with the exception of eastbound on Hilltop-Needmore Road, will be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>US 401 SB</td><td>A/A</td><td>US 401 SB</td><td>A/A</td></tr>
<tr><td>Hilltop-Needmore Rd. EB</td><td>D/C</td><td>Hilltop-Needmore Rd. EB</td><td>C/C</td><td rowspan="2">Business Driveways:
Low</td></tr>
<tr><td>Relocated Hilltop Rd. WB</td><td>D/C</td><td>Relocated Hilltop Rd. WB</td><td>C/C</td></tr>
<tr><td rowspan="6">Reverse Superstreet and Relocated Hilltop Road with Direct Main Street Lefts
  </td><td colspan="2">Yes</td><td colspan="2">Yes</td><td rowspan="6">$3,500,000</td><td>Environmental:
Low/Medium
Possible threatened species. Would require further study.</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.</td><td rowspan="6">• Enhanced safety with fewer conflict points.
• Main street left turns are not rerouted at Lake Wheeler Road intersection.
• Eastbound left turns from Hilltop-Needmore Road are not rerouted.
• Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.</td><td rowspan="6">• Major street left turns are rerouted at Hilltop-Needmore Road.
• Hilltop-Needmore Road through traffic is rerouted.
• Air Park Road through traffic and left turns are rerouted.
• Lake Wheeler Road and Hilltop Road through traffic and left turns are rerouted.
• Unconventional intersection configuration.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td><td>Cultural:
Low</td></tr>
<tr><td>US 401 NB</td><td>A/A</td><td>US 401 NB</td><td>A/A</td><td rowspan="2">Right-of-Way:
Medium/High
Construction of Lark St. Extension</td><td rowspan="3">Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left may be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>US 401 SB</td><td>A/A</td><td>US 401 SB</td><td>A/A</td></tr>
<tr><td>Hilltop-Needmore Rd. EB</td><td>D/C</td><td>Hilltop-Needmore Rd. EB</td><td>C/C</td><td rowspan="2">Business Driveways:
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Table of Contents

1.0 Introduction

The Capital Area Metropolitan Planning Organization (CAMPO) provides regional and comprehensive transportation planning for North Carolina's capital region including Franklin, Granville, Harnett, Johnston and Wake Counties. The MPO has identified several transportation projects for inclusion in the region's Comprehensive Transportation Plan (CTP). Some areas were determined to require additional detailed analyses to identify feasible solutions and improvement recommendations. DAVENPORT has been retained to perform a hot spot study for two intersections:

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- US 401 at Hilltop-Needmore Road

These intersections are located south of Raleigh along US 401 north of SR 42 in Wake County. A vicinity map is provided in Figure 1.


US 401 & Ten-Ten Road looking east


US 401 & Hilltop-Needmore Road looking north

These intersections currently experience significant delay and operational deficiencies. Traffic is anticipated to increase at these intersections as the surrounding area continues to experience growth. Ultimately, the roadway will be widened by the North Carolina Department of Transportation (NCDOT) in the future to six lanes with a superstreet configuration. However, improvements are needed in the interim to improve the safety and operation of the intersections.

DAVENPORT was retained by CAMPO to assess the study intersections to identify improvement options to accommodate future and existing traffic, and provide planning-level cost estimates. Future year analyses were carried out for short-term conditions in 2020 and long-term conditions in 2040.

This report is organized so that the methodology used for the analysis is discussed first, then each intersection is discussed separately, and finally the natural and cultural impact analysis follows.

2.0 Methodology

The same methodology was applied to both intersections and is discussed below.

2.1 Traffic Data Collection

DAVENPORT collected turning movement counts at the study intersections as well as at nearby intersections. Sixteen-hour (16-hour) turning movement counts were conducted at the study intersections and AM (7-9 am) and PM (4-6 pm) peak period counts were conducted at the nearby intersections. More information regarding the count locations is provided in the subsequent sections.

Data collection was conducted in accordance to NCDOT standards. Vehicles, trucks, pedestrians, and bicycles were included in the counts. Area schools were in session at the time of traffic counts.

2.2 Base Assumptions and Standards

In general, the analysis for this project was conducted utilizing commonly accepted NCDOT standards. The following table contains a summary of the base assumptions:

Table 2.1 - Assumptions	
Peak Hour Factor	0.90
Background Traffic Forecasts	Obtained from Triangle Regional Model
Base Signal Timing/Phasing	Provided by NCDOT
Analysis Software	Synchro/SimTraffic Version 7.0
Lane widths	12-feet
Truck percentages	2%

2.3 Signal Timing/Phasing Data

Signal timing and phasing data were obtained directly from NCDOT. The traffic signal at the intersection of US 401 and Ten-Ten Road is coordinated with other nearby traffic signals, whereas the signal at the intersection of US 401 and Hilltop-Needmore Road is not coordinated. Note that for existing conditions, the timings were not optimized using Synchro's automatic optimization feature. All future analyses were optimized and were assumed to operate under actuated control.

2.4 Future Traffic Volumes

Per the scoping discussions with CAMPO, future year analyses were carried out for:

- Short-term conditions in 2020
- Long-term conditions in 2040

Triangle Regional Model

Future traffic volumes were projected based on the Triangle Regional Model (TRM). The model uses socio-economic, demographic, land use, and transportation data to project future traffic volumes. The Institute for Transportation Research and Education (ITRE) at NC State University maintains the TRM for CAMPO and provided information for use in this analysis. As determined during the scoping meeting with CAMPO, the future traffic forecasts from the TRM are assumed to account for approved and planned development in the area.

As a result, a 4% growth rate was used at the intersection of US 401 & Hilltop-Needmore Road for the short term 2020 analysis, and 1.5% growth rate was used for the long term 2040 analysis. At the intersection of US 401 & Ten-Ten Road, a 3% growth rate was used for the short term analysis year of 2020, and a 1.5% growth rate was used for the long term analysis year of 2040.

Historical Average Daily Traffic

For comparison purposes, the historical growth of the area was assessed. Growth rates from historical average daily traffic (ADT) indicate an average growth rate of 1.7% in the area. The historical ADT is summarized in Table 2.2 below and Figure 2.

Table 2.2 – Historical ADT

AADT	US 401 South of Hilltop	US 401 North of Hilltop	Hilltop West of US 401	US 401 South of Ten Ten	US 401 North of Ten Ten	Ten Ten West of US 401	Ten Ten East of US 401
2001		24,000	6,700	26,000			13,000
2003		24,000	6,100	33,000			13,000
2005	22,000	25,000	6,600	32,000	31,000	15,000	14,000
2007	20,000	27,000	7,300	34,000	33,000	15,000	16,000
2009	21,000	27,000	7,400	33,000	31,000	15,000	15,000
2011		26,000	7,600	32,000	31,000	15,000	15,000
% Growth	**-1.2%**	**1.2%**	**1.7%**	**1.4%**	**-0.3%**	**0.0%**	**1.7%**

2.5 Level of Service Evaluation Criteria

The Transportation Research Board's Highway Capacity Manual (HCM) utilizes a term "level of service" to measure how traffic operates in intersections and on roadway segments. There are currently six levels of service ranging from A to F. Level of service "A" represents the best conditions and Level of Service "F" represents the worst. Synchro Traffic Modeling software was used to determine the level of service for studied intersections. All worksheet reports from the analyses can be found in the Appendix.

Table 2.3 – Highway Capacity Manual

Levels of Service and Control Delay Criteria

Signalized Intersection		**Unsignalized Intersection**	
Level of Service	Control Delay Per vehicle (sec)	Level of Service	Delay Range (sec)
A	≤ 10	A	≤ 10
B	> 10 and ≤ 20	B	> 10 and ≤ 15
C	> 20 and ≤ 35	C	> 15 and ≤ 25
D	> 35 and ≤ 55	D	> 25 and ≤ 35
E	> 55 and ≤ 80	E	> 35 and ≤ 50
F	> 80	F	> 50

3.0 US 401 & Ten-Ten Road

3.1 Existing Conditions

A field investigation was conducted by DAVENPORT staff to determine the existing roadway conditions of the study intersection. Figure 3 illustrates the existing lane geometry and a review of the roadways is provided below.

US 401

- US 401 is a regionally significant route which connects Raleigh to Fayetteville. It is a four-lane divided roadway and posted at 45 miles per hour.
- The pavement width is approximately 100 feet and the median is about 30 feet wide.
- The land uses along US 401 near the study area are primarily retail and residential.
- The roadway is maintained by NCDOT and has an ADT of approximately 32,000 near the intersection with Ten-Ten Road.
- A wide paved shoulder is provided along most of the roadway with no sidewalks, with the exception of a few sidewalk segments near retail.

US 401 & AutoZone / Smithfield's Access looking north

Ten-Ten Road

- Ten-Ten Road is a two-lane undivided roadway with a posted speed limit of 45 miles per hour.
- The roadway is maintained by NCDOT and the Secondary Route number is 1010.
- The ADT is approximately 15,000 vehicles per day.
- The pavement width is approximately 24 feet and widens to 65 feet near the intersection with US 401.
- The land uses along Ten-Ten Road are mostly residential with retail near the intersection with US 401.
- There are no sidewalks along the roadway with a few sidewalk segments near the retail at US 401.

Ten-Ten Road at US 401 looking west

Gelder Drive

- Gelder Drive is a two-lane undivided roadway and the speed limit is unposted.
- The pavement width is approximately 24 feet.
- The land uses along Gelder Drive are mostly industrial and commercial.
- There is an existing median opening at the intersection with US 401. The shopping center on the opposite side of US 401 has a driveway at median opening.

Shopping Center Entrance at AutoZone / Smithfield's Access

- This shopping center driveway is between the existing AutoZone and Smithfield's Chicken N Bar-B-Q. It also connects to the remainder of the Food Lion plaza.
- There is currently no driveway or roadway on the western side of US 401 connecting at this median opening.
- The cross section of this driveway is four lanes: one westbound left turn lane, one westbound right turn lane, one eastbound through lane, one eastbound right turn lane.
- The pavement width is approximately 52 feet and the road is divided by a concrete median.
- The speed limit is unposted.

Shopping Center Entrance at AutoZone / Smithfield's Access looking east

3.2 Existing Traffic Volumes

Existing traffic volumes for this project were collected by DAVENPORT staff. Table 3.1 below contains the dates these counts were conducted and Figure 4 shows a map of the count locations. Figure 5 shows existing AM and PM peak hour volumes. The full reports for these volumes can be found in the appendix.

Table 3.1 - Traffic Volume Data

Count Location:	Date Taken:	By:
US 401 & Ten-Ten Road	5/1/2013	DAVENPORT
US 401 & AutoZone / Smithfield's Access	5/1/2013	DAVENPORT
US 401 & Gelder Drive	5/1/2013	DAVENPORT
Ten-Ten Road & Harris Teeter Full Access	5/1/2013	DAVENPORT

3.3 Crash History

In order to assess the existing traffic safety issues, crash history for the last three (3) years was provided by NCDOT and reviewed for this intersection. The results are summarized in Figure 6 and Table 3.2.

Table 3.2 – Crash Data Summary from April 1, 2010 to March 31, 2013

Intersection	Head-on	Left turn	Right turn	Rear end	Ran off road, fixed object	Angle	Side-swipe	Other*	Total	Severity Index
US 401 & Ten-Ten Road	0	7	2	50	1	7	6	4	77	2.92
US 401 & AutoZone / Smithfield's Access	0	4	0	6	0	1	0	1	12	4.7
US 401 & Gelder Drive	0	1	1	2	0	1	0	1	6	4.7
Ten-Ten Road & Harris Teeter Full Access	0	4	0	4	0	0	2	2	12	4.08

* Other crashes include crashes caused by backing up, animal, vehicle rollover, and non-collision

Discussion of Crash History

A total of 77 crashes were reported at the intersection of US 401 and Ten-Ten Road from April 1, 2010 to March 31, 2013. The crash severity index for the intersection is 2.92. The majority of the crashes were C-level injury and property damage. There were three (3) B-level injury crashes reported. The noted crash patterns are discussed below.

- The most common crash type was rear-end, slow or stop with 50 reported crashes during the three year history. There were 20 southbound, 14 westbound, 8 northbound, and 8 eastbound rear-end crashes. Rear-end collisions at traffic signals are frequently caused by large turning volumes, driver inattentiveness, excessive speeds, poor visibility of traffic control devices, pedestrians crossing the street, and inadequate signal timing.
    - Southbound rear-end crashes: A contributing factor to this crash pattern is likely the queuing of the US 401 southbound approach. A high volume of 317 southbound left turns were observed during the PM peak hour. These left turns were observed to queue beyond the existing storage provided in the left turn lane and into the southbound travel lanes on US 401. This spillback would then cause additional queuing on the southbound approach of US 401.
    - Westbound rear-end crashes: The rear-end crashes on the westbound approach may be caused by queuing issues as well. Excessive queuing was observed on Ten-Ten Road in the westbound direction during both the AM and PM peaks. During the AM peak, the westbound left turning vehicles were observed to queue beyond the provided storage in the left turn lane. This spillback would then cause queuing on the westbound approach of Ten-Ten Road. During the PM peak, queuing was observed for the westbound through movement on Ten-Ten Road. The queue of the through traffic would often block the westbound right turn lane and the left turn lane.

- The second most common crash type was left turn and angle with seven (7) reported crashes for each.
    - Left turn crashes: There were three (3) eastbound left turn crashes, three (3) westbound left turn crashes, and one (1) southbound left turn crash. The left turn crashes involving eastbound and westbound movements are likely due to a combination of heavy traffic congestion and the signal phasing at the intersection. The existing signal timing plan has a permitted plus protected phase for left-turning traffic on Ten-Ten Road. Given the congestion of the intersection, eastbound and westbound left turning vehicles may be attempting to make left turn maneuvers during the permitted phase with inadequate gaps.
    - Angle crashes: There were seven (7) reported angle crashes. These crashes were varied with no particular patterns noted.
- The third most common crash type at this intersection was sideswipe crashes with six (6) occurrences. No crash patterns were noted.
- Other reported crashes include four (4) others caused by backing up, vehicle rollover, non-collision, two (2) right turn crashes, and one (1) fixed object. These crashes were varied with no particular patterns noted.

3.4 Future Traffic Volumes

As previously discussed, future traffic volumes for the short-term analysis year of 2020 and long-term analysis year of 2040 were estimated based on the Triangle Regional Model. Future traffic volumes for the intersection of US 401 & Ten-Ten Road are shown in Figure 7 for short-term year 2020 and Figure 8 for long-term year 2040.

3.5 Capacity Analysis

The level of service results for existing conditions and future conditions with the existing geometry are discussed below. Level of service and queuing results are summarized in Tables 3.3 through 3.5.

Currently, the intersection of US 401 & Ten-Ten Road operates at LOS F during the AM and PM peaks. The analysis shows excessive queuing on the eastbound approach of Ten-Ten Road during the AM peak. During the PM peak, there is excessive queuing on the eastbound approach of Ten-Ten Road as well as the northbound and southbound approaches of US 401.

Maintaining the intersection's existing geometry with no improvements, the intersection was analyzed for future short-term analysis year of 2020 and long-term analysis year of 2040. The intersection is anticipated to remain at LOS F during both the AM and PM peaks in the future. The delay and queuing experienced at the intersection is anticipated to worsen.

Table 3.3 - Existing 2013 Level of Service and Queuing Summary
US 401 & Ten-Ten Road

2013 Existing	AM Peak			PM Peak		
	LOS (Delay)	95% Queue (feet)		LOS (Delay)	95% Queue (feet)	
		Synchro	Sim Traffic		Synchro	Sim Traffic
EB L	F (250.6)	#586	152	D (53.3)	209	148
EB T	E (59.8)	300	1470	F (255.7)	#1105	1176
EB R	D (54.7)	86	229	E (58.6)	185	175
EB Overall	F (152.6)	-	-	F (184.5)	-	-
WB L	D (49.4)	134	525	F (74.5)	#365	239
WB T	F (216.7)	#936	579	E (69.0)	#547	341
WB R	E (62.4)	247	347	D (52.4)	65	41
WB Overall	F (145.8)	-	-	E (68.4)	-	-
NB L	F (81.3)	138	117	F (209.7)	#539	1227
NB T	D (48.9)	#1082	553	D (42.4)	446	1217
NB T	D (48.9)	#1082	559	D (42.4)	446	963
NB R	B (18.0)	66	77	C (22.5)	m114	97
NB Overall	D (49.0)	-	-	E (73.5)	-	-
SB L	F (86.1)	m249	247	F (178.0)	#701	786
SB T	C (23.6)	m265	252	D (45.5)	752	1080
SB T	C (23.6)	m265	263	D (45.5)	752	1067
SB R	C (20.0)	m63	68	C (28.6)	153	241
SB Overall	C (34.9)	-	-	E (69.2)	-	-
Intersection Overall	**F (82.2)**	**-**	**-**	**F (91.8)**	**-**	**-**

LOS (delay in seconds)
# indicates 95th percentile volume exceeds capacity

Table 3.4 - Future 2020 Level of Service and Queuing Summary
US 401 & Ten-Ten Road

2020 Short Term	AM Peak			PM Peak		
	LOS (Delay)	95% Queue (feet)		LOS (Delay)	95% Queue (feet)	
		Synchro	Sim Traffic		Synchro	Sim Traffic
EB L	F (288.0)	#593	154	E (61.9)	#234	182
EB T	D (42.7)	284	1349	F (197.9)	#1086	1259
EB R	D (38.3)	75	189	D (42.7)	174	200
EB Overall	F (162.2)	-	-	F (146.3)	-	-
WB L	C (32.9)	118	500	F (243.6)	#449	671
WB T	F (172.4)	#898	551	E (57.5)	#500	736
WB R	D (48.3)	310	259	D (40.4)	57	439
WB Overall	F (114.9)	-	-	F (115.2)	-	-
NB L	E (63.3)	134	101	F (217.1)	m#566	1090
NB T	F (161.1)	#1275	539	E (78.9)	m#691	1079
NB T	F (161.1)	#1275	545	E (78.9)	m#691	1045
NB R	B (17.8)	65	41	C (33.1)	m165	1049
NB Overall	F (150.7)	-	-	F (101.3)	-	-
SB L	F (223.7)	m#376	400	F (128.6)	m#700	780
SB T	C (31.2)	m338	224	F (143.5)	m#1179	952
SB T	C (31.2)	m338	248	F (143.5)	m#1179	988
SB R	C (25.1)	m78	65	C (33.3)	m199	352
SB Overall	E (66.5)	-	-	F (131.2)	-	-
Intersection Overall	**F (126.6)**	**-**	**-**	**F (123.8)**	**-**	**-**

LOS (delay in seconds)
# indicates 95th percentile volume exceeds capacity

Table 3.5 - Future 2040 Level of Service and Queuing Summary
US 401 & Ten-Ten Road

2040 Long Term	AM Peak			PM Peak		
	LOS (Delay)	95% Queue (feet)		LOS (Delay)	95% Queue (feet)	
		Synchro	Sim Traffic		Synchro	Sim Traffic
EB L	F (318.3)	#828	170	F (111.8)	#430	168
EB T	D (38.0)	354	779	F (292.6)	#1503	787
EB R	C (33.2)	99	187	D (39.8)	231	160
EB Overall	F (174.6)	-	-	F (216.1)	-	-
WB L	D (35.7)	148	473	F (280.2)	#608	552
WB T	F (300.0)	#1349	539	F (80.7)	#770	537
WB R	E (58.8)	417	235	D (38.5)	90	45
WB Overall	F (189.0)	-	-	F (139.0)	-	-
NB L	E (73.6)	183	142	F (303.1)	m#763	1047
NB T	F (245.0)	#1329	537	F (115.8)	m#676	1086
NB T	F (245.0)	#1329	535	F (115.8)	m#676	1067
NB T	F (245.0)	#1329	547	F (115.8)	m#676	1090
NB R	C (27.7)	118	80	D (36.8)	m230	703
NB Overall	F (228.1)	-	-	F (144.4)	-	-
SB L	F (263.1)	m#477	818	F (344.4)	m#1069	765
SB T	D (40.1)	m350	1025	F (256.2)	m#1191	1011
SB T	D (40.1)	m350	679	F (256.2)	m#1191	1056
SB T	D (40.1)	m350	402	F (256.2)	m#1191	1021
SB R	C (34.0)	m119	138	D (48.4)	m#314	377
SB Overall	F (81.2)	-	-	F (255.1)	-	-
Intersection Overall	**F (180.7)**	**-**	**-**	**F (202.3)**	**-**	**-**

LOS (delay in seconds)
# indicates 95th percentile volume exceeds capacity

3.6 Improvement Options

In order to improve the operation and safety of the intersection of US 401 and Ten-Ten Road, potential network, operational and safety improvements were identified and analyzed. The improvement options were assessed for their ability to improve the level-of-service at the intersection as well as having minimal impacts to natural and cultural resources. The following improvement options were considered:

1. Restriped Eastbound Approach
2. Indirect Major Street Left Turns
3. Michigan Lefts
4. Michigan Lefts and Single Quadrant Loop

A right-of-way map for this intersection is provided in Figure 9. A general discuss of each alternative is provided below.

3.6.1 Restriped Eastbound Approach

This traditional improvement option involves restriping the eastbound approach to include two (2) left turn lanes and a shared through-right lane. There is a high volume of eastbound left turns on Ten-Ten Road, especially during the AM peak. This improvement would increase the intersection's capacity to accommodate eastbound left turns. However, the intersection is anticipated to experience excessive delay and queuing with this option and therefore it was not further analyzed.

US 401 & Ten-Ten Road looking east

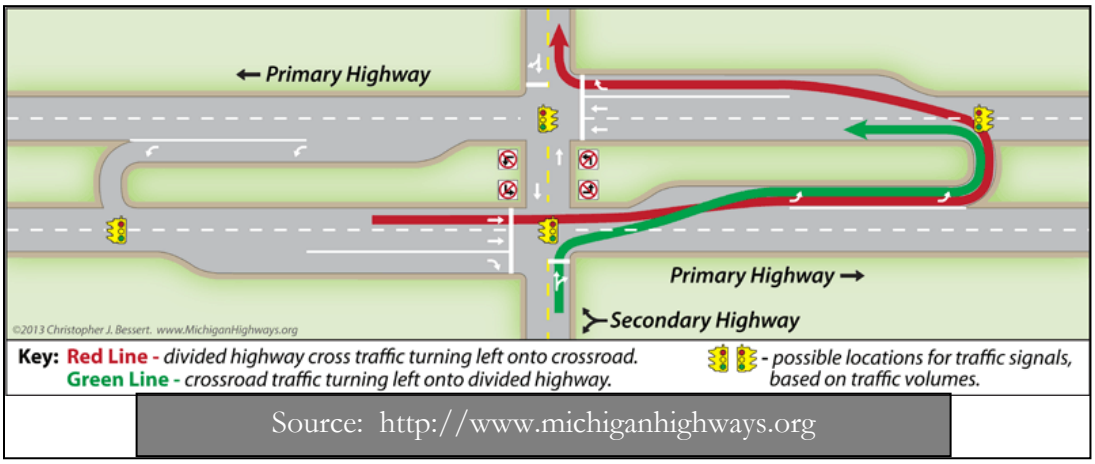
3.6.2 *Indirect Major Street Left Turns*

In this improvement option, left turns from US 401 are restricted and rerouted to nearby median crossovers where they can perform a U-turn to complete their maneuver as shown below. This improvement option can improve the operation of the intersection by reducing the signal phasing and increasing green time for the heavy through traffic on the major street. In addition, removing the major street left turns from the intersection can enhance the safety of the intersection by reducing the number of conflict points and potential for crashes. However, this option did not improve the intersection's operation and queuing and therefore was not further analyzed.

Indirect Major Street Left Turns

3.6.3 *Michigan Lefts*

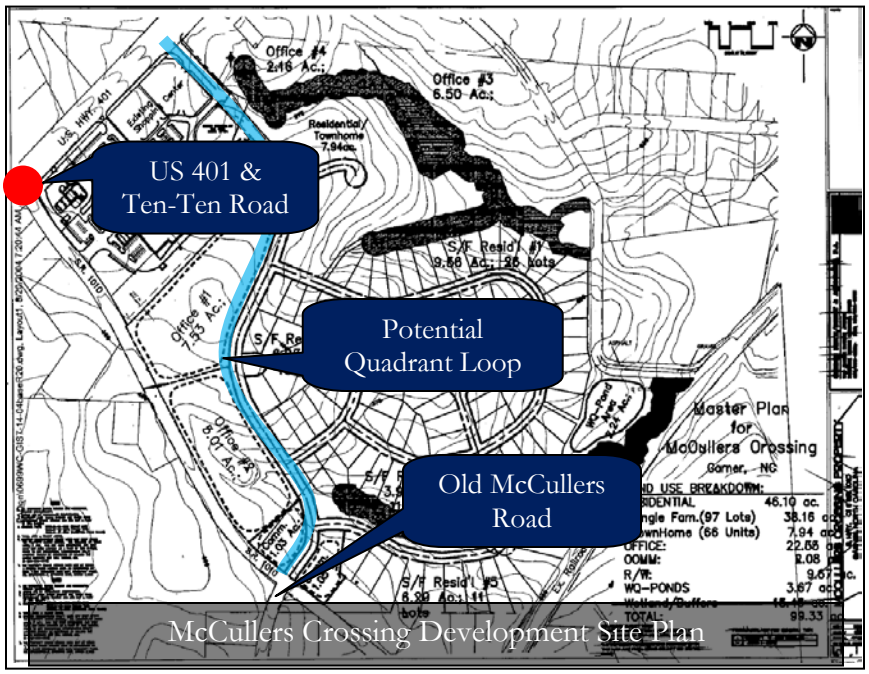
The Michigan Left turn, also known as a Median U-turn Crossover, removes all left turns from the intersection and reroutes them to nearby median crossovers where they can perform a U-turn (see diagram below). This improvement option reduces the required signal phasing at the intersection which results in increased green time and improved delay for the heavy through movement. Another advantage of Michigan Lefts is improved safety by eliminating conflict points. This improvement option was analyzed for short term and long term conditions.



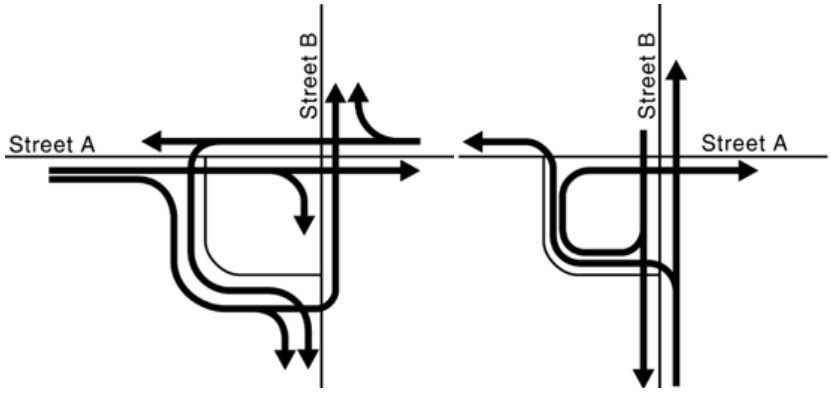
Source: http://www.michiganhighways.org

3.6.4 Michigan Lefts with a Single Quadrant Loop

This option involves a Michigan Lefts intersection treatment as well as a single quadrant loop on the northeastern quadrant of the intersection. The McCullers Crossing development is planned to build a roadway in this quadrant which will connect the AutoZone / Smithfield's access to Old McCullers Road. A quadrant roadway intersection removes left turn movements from the main intersection by rerouting them through the loop roadway, as shown in the diagrams below. This improvement reduces the signal phasing at the main intersection, thus reducing delay and increasing green time for the through movements. The overall traffic volume through the intersection is also reduced due to the removal of left and right turning traffic on certain movements. In addition, the number of left-turn conflict points is reduced with this improvement option, which can enhance the safety of the main intersection. This improvement option was analyzed for short term and long term conditions.



McCullers Crossing Development Site Plan



Source: FHWA Publication Number: FHWA-HRT-04-091

3.7 Short Term Results

The improvement options were analyzed for the short term analysis year of 2020 in order to assess their ability to accommodate future traffic volumes. The results for each improvement alternative are discussed below.

3.7.1 Michigan Lefts

The following configuration was assumed for this improvement option in 2020: two (2) eastbound and westbound right turn lanes onto Ten-Ten Road, two (2) eastbound and westbound through lanes on Ten-Ten Road, and dual U-turn lanes at both U-turn locations with traffic signals. The proposed lane geometry for this recommended improvement is provided in Figure 10.

This improvement option has a preliminary cost estimate of approximately $3,000,000 in the year 2020. Cost estimate information can be found in the Appendix.

This improvement option and configuration ultimately reduced the signal phasing to two (2) phases at the main study intersection. Traffic signals were assumed at each U-turn location, also with two (2) phases. The traffic signals were coordinated to provide optimal progression for each direction of travel.

The level of service results are provided in Table 3.6. As shown, the overall southbound approach of US 401 is anticipated to operate at LOS A during the AM peak and LOS E during the PM peak. The overall northbound approach of US 401 is anticipated to operate at LOS D during the AM peak and LOS B during the PM peak. Both of the U-turn locations are anticipated to operate at an acceptable LOS. Detailed level of service results can be found in the Appendix.

Table 3.6 - Level of Service Summary 2020 (Michigan Lefts)

Approach	LOS AM/PM
US 401 NB	D/B
US 401 SB	A/E
Ten-Ten Rd. EB	D/D
Ten-Ten Rd. WB	D/D

3.7.2 Michigan Lefts and Single Quadrant Loop

The following configuration was assumed for this improvement option in 2020: two (2) eastbound and westbound right turn lanes onto Ten-Ten Road, two (2) eastbound and westbound through lanes on Ten-Ten Road, and dual U-turn lanes at both U-turn locations with traffic signals. The new quadrant loop road will be a four-lane roadway. At the intersection with US 401, two (2) southbound left turn lanes will be needed on US 401. At the intersection with Ten-Ten Road, two (2) southbound left turn lanes and a shared through-right turn lane will be needed on the quadrant loop road. An eastbound left turn lane and westbound right turn lane will be needed on Ten-Ten Road. In addition, a northbound left turn lane will be needed on Old McCullers Road. The proposed lane geometry for this recommended improvement is provided in Figure 11.

This improvement option has a preliminary cost estimate of approximately $4,100,000 in the year 2020. This assumes that the loop road will be constructed by the developer. Cost estimate information can be found in the Appendix.

The AutoZone / Smithfield's access is located approximately 900 feet to the north of the intersection of US 401 and Ten-Ten Road. Old McCullers Road is over 2,000 feet to the east of the study intersection. Given the offset of this quadrant loop on Ten-Ten Road, it was assumed that the quadrant loop will only serve southbound left turns from US 401 and a portion of westbound right turns from Ten-Ten Road. Southbound left turns from US 401 onto Ten-Ten Road were prohibited and rerouted to the new quadrant loop.

The level of service results for this improvement option are presented in Table 3.7. As shown, the overall southbound approach of US 401 at Ten-Ten Road are anticipated to operate at LOS A during the AM peak and LOS C during the PM peak. The northbound approach of US 401 at Ten-Ten Road are anticipated to operate at LOS D during the AM peak and LOS B during the PM peak. The U-turn locations are anticipated to operate at LOS C or better. The intersection of Ten-Ten Road and the quadrant loop road is anticipated to operate at LOS C during the AM and PM peaks. Detailed level of service results can be found in the Appendix.

The queuing was assessed by utilizing SimTraffic modeling software. The queuing results are presented in the screenshots on the following pages. During the PM peak, reduced queuing is anticipated for the southbound approach of US 401 as well as the eastbound approach of Ten-Ten Road compared to the short term option without the quadrant loop.

Table 3.7 - Level of Service Summary 2020 (Michigan Lefts with Single Quadrant)

Approach	LOS AM/PM
US 401 NB	D/B
US 401 SB	A/C
Ten-Ten Rd. EB	D/D
Ten-Ten Rd. WB	C/D


2020 AM Peak Hour SimTraffic
Queuing Results
Ten Ten Road
Harris Teeter Access
US 401 NB Lanes
US 401 SB Lanes
Shopping Center Access
US 401
Gelder Drive
Gelder Dr
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2020 AM Peak Hour SimTraffic
Queuing Results
Loop Road
US 401 NB Lanes
US 401 SB Lanes
US 401
US 401
US 401 NB Lanes
US 401 SB Lanes
401 NB Lanes
US 401 SB Lanes
Ten Ten Road
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2020 PM Peak Hour SimTraffic Queuing Results
Michigan Lefts with Single Quadrant Loop Option
Ten Ten Road
Harris Teeter Acce
US 401 NB Lanes
US 401
Shopping Center Access
US 401
US 401
US 401
401 NB Lanes
Gelder Drive
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2020 PM Peak Hour SimTraffic Queuing Results
Michigan Lefts with Single Quadrant Loop Option
US 401 NB Lanes
US 401
US 401
US 401
US 401
US 401 NB Lanes
US 401
Ten Ten Road
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed

3.8 Long Term Results

The improvement options were analyzed for the long term analysis year of 2040 in order to assess their ability to accommodate future traffic volumes. Based on the scoping meeting with CAMPO, the future widening of US 401 to six-lanes was assumed to be in place for this future analysis year. The results for each improvement alternative are discussed below.

3.8.1 Michigan Lefts

The same lane geometry configuration used in the short term 2020 analysis was also used in the long term 2040 analysis with the exception of six-lanes on US 401. Figure 12 provides the proposed lane geometry for this improvement option in 2040.

The level of service results for this improvement option are presented in Table 3.8. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis. As shown, the overall northbound approach of US 401 is anticipated to operate at LOS C during the AM peak and LOS B during the PM peak. The southbound approach is anticipated to operate at LOS A during the AM peak and LOS D during the PM peak. The eastbound approach of Ten-Ten Road is anticipated to operate at LOS E during the PM peak. The westbound approach of Ten-Ten Road is anticipated to operate at LOS E during the AM peak. Detailed level of service results can be found in the Appendix.

This improvement option was determined to not be a viable solution to accommodate future traffic volumes in the long term analysis year of 2040.

Table 3.8 - Level of Service Summary 2040 (Michigan Lefts)

Approach	LOS AM/PM
US 401 NB	C/B
US 401 SB	A/D
Ten-Ten Rd. EB	D/E
Ten-Ten Rd. WB	E/D

3.8.2 Michigan Lefts and Single Quadrant Loop

The same lane geometry configuration used in the short term 2020 analysis was also used in the long term 2040 analysis with the following exceptions: US 401 is six-lanes, the eastbound right turn lanes on Ten-Ten Road at US 401 were extended. Figure 13 provides the proposed lane geometry for this improvement option in 2040.

Assuming the Michigan Lefts improvement option is in place, the addition of the single quadrant loop has a preliminary cost estimate of approximately $2,200,000 in the year 2040. This assumes that the loop road will be constructed by the developer. In addition, this does not include the cost of widening US 401. Cost estimate information can be found in the Appendix.

The level of service results for this improvement option are presented in Table 3.9. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis. As shown, the overall southbound approach of US 401 at Ten-Ten Road is anticipated to operate at LOS A during the AM peak and LOS C during the PM peak. The northbound approach of US 401 at Ten-Ten Road is anticipated to operate at LOS C during the AM peak and LOS B during the PM peak. The U-turn locations are anticipated to operate at LOS C or better. The intersection of Ten-Ten Road and the quadrant loop road is anticipated to operate at LOS C during the AM and PM peaks. Detailed level of service results can be found in the Appendix.

The queuing was assessed by utilizing SimTraffic modeling software. The queuing results are presented in the screenshots following the LOS table. As shown, some queuing is anticipated for the eastbound and westbound approaches of Ten-Ten Road during the AM peak. During the PM peak, reduced queuing is anticipated for the southbound approach of US 401 which is likely due to a six-lane US 401. Some queuing is anticipated for the eastbound approach of Ten-Ten Road.

Table 3.9 - Level of Service Summary 2040 (Michigan Lefts with Single Quadrant)

Approach	LOS AM/PM
US 401 NB	C/B
US 401 SB	A/C
Ten-Ten Rd. EB	D/C
Ten-Ten Rd. WB	D/D


2040 AM Peak Hour SimTraffic Queuing Results
Michigan Lefts with Single Quadrant Loop Option
Loop Road
Ten Ten Road
Harris Tepler Access
US 401 NB Lanes
US 401 SB Lanes
Shopping Center Access
US 401
Gelder Drive
Gelder Dr
Daddy Rd
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2040 AM Peak Hour SimTraffic Queuing Results
Michigan Lefts with Single Quadrant Loop Option
Loop Road
US 401 NB Lanes
US 401 SB Lanes
US 401
Ten Ten Road
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2040 PM Peak Hour SimTraffic Queuing Results
Michigan Lefts with Single Quadrant Loop Option
Loop Road
Ten Ten Road
Harris Tower Access
US 401 NB Lanes
US 401 SB Lanes
Shopping Center Access
Daddy Rd
Gelder Drive
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2040 PM Peak Hour SimTraffic Queuing Results
Michigan Lefts with Single Quadrant Loop Option
Loop Road
US 401 NB Lanes
US 401 SB Lanes
Ten Ten Road
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed

3.9 Summary of Recommended Improvements

The improvement options were analyzed for both short term and long term analysis years in order to assess their ability to accommodate future traffic volumes. A summary of each option with the advantages and disadvantages is provided below.

3.9.1 Michigan Lefts

The Michigan Left turn, also known as a Median U-turn Crossover, removes all left turns from the intersection and reroutes them to nearby median crossovers where they can perform a U-turn. This improvement option is anticipated to cost approximately $3,000,000 in 2020.

There are currently full access movements on US 401 at Gelder Drive and at the AutoZone / Smithfield's Access. These locations will be reconfigured to allow only right turn movements onto US 401. Motorists seeking to make a left turn or go straight out from these accesses will be able to turn right onto US 401 and make a U-turn or a left-turn at an adjacent median break, or in other cases use driveways on Ten-Ten Road to reach their destination. Also, the restriction of left turns at the signalized intersection of US 401 and Ten-Ten Road will affect the traffic pattern of some motorists who make a left turn at this traffic signal before accessing a nearby property. These trips can be accommodated by using an adjacent u-turn location or in some cases by using a driveway on Ten-Ten Road.

In 2020, the overall southbound approach of US 401 is anticipated to operate at LOS A during the AM peak and LOS E during the PM peak. The overall northbound approach of US 401 is anticipated to operate at LOS D during the AM peak and LOS B during the PM peak.

In 2040, the overall northbound approach of US 401 is anticipated to operate at LOS C during the AM peak and LOS B during the PM peak. The southbound approach is anticipated to operate at LOS A during the AM peak and LOS D during the PM peak. The eastbound approach of Ten-Ten Road is anticipated to operate at LOS E during the PM peak. The westbound approach of Ten-Ten Road is anticipated to operate at LOS E during the AM peak. Analysis results show extensive queuing for the eastbound and westbound approach of Ten-Ten Road in 2040 with this improvement option.

Some of the advantages of this option include:

- Intersection is anticipated to have improved operation and reduced delay for the short term analysis year.
- Low cost alternative and minimal impacts to right-of-way.
- Enhanced safety with fewer conflict points.
- Minor street through traffic is not rerouted.

Some of the disadvantages of this option include:

- Unconventional intersection configuration.
- Major street left turns are rerouted.
- Minor street left turns are rerouted.
- Altered access to nearby driveways at Gelder Drive and at the AutoZone / Smithfield's access.
- This option will not serve as a long term solution without the addition of a quadrant loop.

3.9.2 Michigan Lefts and Single Quadrant Loop

This option involves a Michigan Lefts intersection treatment as well as a single quadrant loop on the northeastern quadrant of the intersection. If built in 2020, this improvement will cost approximately $4,100,000. This cost estimate does not include the cost of the Loop Road itself, estimated at $1,900,000, which is assumed to be completed McCullers Crossing.

There are currently full access movements on US 401 at Gelder Drive and at the AutoZone / Smithfield's Access. These locations will be reconfigured to allow only right turn movements onto US 401. Motorists seeking to make a left turn or go straight out from these accesses will be able to turn right onto US 401 and make a U-turn or a left-turn at an adjacent median break, or in other cases use driveways on Ten-Ten Road to reach their destination. Also, the restriction of left turns at the signalized intersection of US 401 and Ten-Ten Road will affect the traffic pattern of some motorists who make a left turn at this traffic signal before accessing a nearby property. These trips can be accommodated by using an adjacent u-turn location or in some cases by using a driveway on Ten-Ten Road.

In the short term and long term analysis years, the southbound through lanes on US 401 at Ten-Ten Road are anticipated to operate at LOS C or better. In 2020, the northbound lanes on US 401 at Ten-Ten Road are anticipated to operate at LOS D during the AM peak and LOS B during the PM peak. In 2040, the northbound lanes on US 401 at Ten-Ten Road are anticipated to operate at LOS C during the AM peak and LOS B during the PM peak.

During the PM peak in 2020, reduced queuing is anticipated for the southbound approach of US 401 as well as the eastbound approach of Ten-Ten Road compared to the short term option without the quadrant loop. In 2040, some queuing is anticipated for the eastbound and westbound approaches of Ten-Ten Road during the AM peak. During the PM peak, reduced queuing is anticipated for the southbound approach of US 401 which is likely due to a six-lane US 401. Some queuing is anticipated for the eastbound approach of Ten-Ten Road.

Some of the advantages of this option include:

- Intersection is anticipated to have improved operation and reduced delay for both short term and long term analysis years.
- Enhanced safety with fewer conflict points.
- Minor street through traffic is not rerouted.

Some of the disadvantages of this option include:

- Unknown construction of development and quadrant loop road.
- Additional cost associated with construction of new quadrant loop.
- Unconventional intersection configuration.
- Major street left turns are rerouted.
- Minor street left turns are rerouted.
- Altered access to nearby driveways at Gelder Drive and at the AutoZone / Smithfield's access.

3.10 Recommended Improvement

The Michigan Lefts and Single Quadrant Loop improvement option is recommended for the intersection of US 401 & Ten-Ten Road. This improvement option is anticipated to provide the best operation and level of service for both short term and long term analysis years. In addition, the safety of the intersection will be improved with fewer conflict points. This improvement option has the opportunity for phasing since the Michigan Lefts option works in the short term analysis year of 2020 without the quadrant loop.

Consideration of Other Modes

Pedestrian and bicycle safety is anticipated to be enhanced given fewer conflict points at the intersection. Pedestrians will be able to cross one direction of US 401 at a time and wait in the median to safely finish crossing. Also, increased green time can be assigned to pedestrians since left turns are not permitted at the intersection. Given the future volume of traffic anticipated on US 401 in the long term analysis year of 2040, a pedestrian bridge may need to be considered as a long term safe solution for pedestrians.

Transit will benefit from this improvement option given the improved level of service and reduced delay along US 401. However, buses desiring to turn left at the intersection will be rerouted to the nearby median openings or the Loop Road. Bus pullouts could be considered on US 401 to provide safer bus stops along US 401.

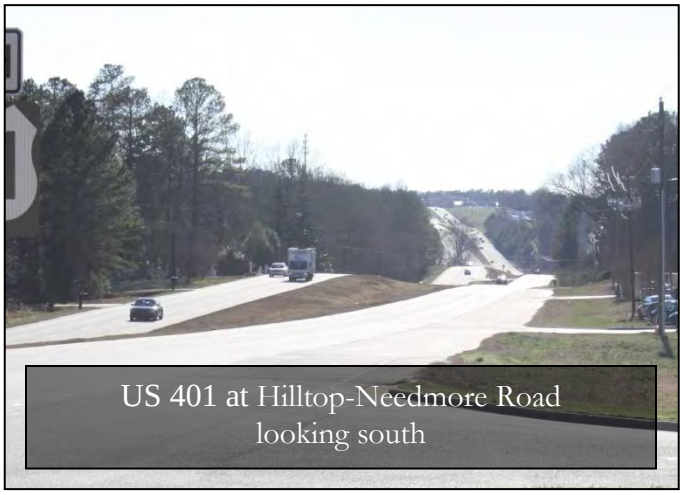
4.0 US 401 & Hilltop-Needmore Road

4.1 Existing Conditions

A field investigation was conducted by DAVENPORT staff to determine the existing roadway conditions of the study intersection. Figure 14 illustrates the existing lane geometry and a review of the roadways is provided below.

US 401

- US 401 is a regionally significant route which connects Raleigh to Fayetteville. It is a four-lane divided roadway and posted at 45 miles per hour.
- The pavement width is approximately 100 feet and the median is about 30 feet wide.
- The land uses along US 401 near the study area are primarily retail and residential.
- The roadway is maintained by NCDOT and has an ADT of approximately 32,000 near the intersection with Ten-Ten Road.



US 401 at Hilltop-Needmore Road looking south

- A wide paved shoulder is provided along most of the roadway with no sidewalks, with the exception of a few sidewalk segments near retail.

Hilltop-Needmore Road

- Hilltop-Needmore Road is a two-lane undivided roadway with a posted speed limit of 45 miles per hour.
- The roadway is maintained by NCDOT and the Secondary Route number is 1393.
- The ADT is approximately 7,600 vehicles per day.
- The pavement width is approximately 24 feet and widens to 33 feet near the intersection with US 401.

Hilltop-Needmore Road at US 401 looking west

- The land uses along Hilltop-Needmore Road are primarily residential.
- There are no sidewalks along the roadway with a few sidewalk segments near US 401.

Hilltop Road

- Hilltop Road is two-lane undivided roadway with a posted speed limit of 45 miles per hour.
- It is maintained by NCDOT and the Secondary Route is 2751.
- The ADT is approximately 4,000 vehicles per day.
- The pavement width is approximately 20 feet.
- The land uses along Hilltop Road are primarily residential.

Hilltop Road at US 401
looking east

Air Park Road

- Air Park Road is a two-lane undivided roadway with a posted speed limit of 45 mile per hour.
- It is maintained by NCDOT and the Secondary Route number is 2752.
- The pavement width is approximately 24 feet.
- The land uses along Hilltop Road are primarily residential and industrial.

4.2 Existing Traffic Volumes

Existing traffic volumes for this project were collected by DAVENPORT staff. Table 4.1 below contains the dates these counts were conducted and Figure 15 shows a map of the count locations. Figure 16 shows existing AM and PM peak hour volumes. The full reports for these volumes can be found in the appendix.

Table 4.1 - Traffic Volume Data

Count Location:	Date Taken:	By:
US 401 & Hilltop-Needmore Road	5/1/2013	DAVENPORT
US 401 & median opening north of Hilltop-Needmore Road	5/1/2013	DAVENPORT

4.3 Crash History

In order to assess the existing traffic safety issues, crash history for the last three (3) years was provided by NCDOT and reviewed for this intersection. The results are summarized in Figure 17 and Table 4.2.

Table 4.2 – Crash Data Summary from April 1, 2010 to March 31, 2013

Intersection	Head-on	Left turn	Right turn	Rear end	Ran off road, fixed object	Angle	Side-swipe	Other*	Total	Severity Index
US 401 at Hilltop-Needmore Road	0	1	2	13	0	4	4	0	24	2.23
US 401 & median opening north of Hilltop-Needmore Road	0	0	0	3	0	0	1	0	4	4.70

Discussion of Crash History

A total of 24 crashes were reported at the intersection of US 401 and Hilltop-Needmore Road from April 1, 2010 to March 31, 2013. The crash severity index for the intersection is 2.23. The majority of the crashes were property damage only. There were two (2) B-level injury crashes reported and two (2) C-level injury crashes reported. The observed crash patterns are discussed below.

- The most common crash type was rear-end with 13 reported occurrences. There were six (6) northbound rear-end crashes, six (6) southbound, and one (1) eastbound. Rear-end collisions at traffic signals are frequently caused by large turning volumes, driver inattentiveness, excessive speeds, poor visibility of traffic control devices, pedestrians crossing the street, and inadequate signal timing. No particular patterns were noted.

- Other reported crashes include four (4) angle crashes, four (4) sideswipes, two (2) right turns, and one (1) left turn. These crashes were varied with no particular patterns noted.

4.4 Future Traffic Volumes

As previously discussed, future traffic volumes for the short-term analysis year of 2020 and long-term analysis year of 2040 were estimated based on the Triangle Regional Model. Future traffic volumes for the intersection of US 401 & Hilltop-Needmore Road are shown in Figure 18 for short-term year 2020 and Figure 19 for long-term year 2040.

4.5 Capacity Analysis

The level of service results for existing conditions and future conditions with the existing geometry are discussed below. Level of service and queuing results are summarized in Tables 4.3 through 4.5.

The intersection of US 401 & Hilltop-Needmore Road currently operates at LOS E during the AM peak and LOS D during the PM peak. Analysis results show queuing on the northbound approach of US 401 as well as some queuing on the side streets during the AM peak. During the PM peak, there is queuing on the southbound approach of US 401 as well as queuing on the side streets.

The intersection was analyzed for future short-term analysis year of 2020 and long-term analysis year of 2040 with no improvements and maintaining the intersection's existing geometry. The intersection is anticipated to degrade to LOS F during the AM and PM peaks in the future. In addition, the delay and queuing experienced at the intersection is anticipated to worsen.

US 401 & Hilltop Road looking east

Table 4.3 – Existing 2013 Level of Service and Queuing Summary
US 401 & Hilltop-Needmore Road

2013 Existing	AM Peak			PM Peak		
	LOS (Delay)	95% Queue (feet)		LOS (Delay)	95% Queue (feet)	
		Synchro	Sim Traffic		Synchro	Sim Traffic
EB L	F (264.9)	#466	499	F (146.1)	#449	241
EB TR	D (47.7)	53	1169	D (45.1)	222	193
EB Overall	F (241.5)	-	-	F (104.8)	-	-
WB Overall	D (54.9)	234	503	D (52.4)	#234	693
NB L	E (65.3)	56	178	E (56.5)	84	74
NB T	D (40.2)	715	431	C (29.5)	302	211
NB TR	D (40.7)	715	478	C (29.5)	302	230
NB Overall	D (40.7)	-	-	C (31.3)	-	-
SB L	E (63.8)	91	63	E (59.6)	#231	198
SB T	C (24.9)	292	204	C (33.9)	#663	425
SB TR	C (24.9)	292	247	C (33.9)	#663	446
SB Overall	C (27.6)	-	-	D (36.6)	-	-
NW Approach	F (94.5)	#470	427	E (55.4)	204	165
Intersection Overall	**E (61.9)**	**-**	**-**	**D (47.1)**	**-**	**-**

LOS (delay in seconds)
# indicates 95th percentile volume exceeds capacity

Table 4.4 – Future 2020 Level of Service and Queuing Summary
US 401 & Hilltop-Needmore Road

2020 Short Term	AM Peak			PM Peak		
	LOS (Delay)	95% Queue (feet)		LOS (Delay)	95% Queue (feet)	
		Synchro	Sim Traffic		Synchro	Sim Traffic
EB L	F (86.9)	#429	262	F (245.6)	#566	410
EB TR	C (30.3)	48	49	D (45.7)	264	1152
EB Overall	F (80.6)	-	-	F (164.0)	-	-
WB Overall	C (34.8)	228	269	F (102.7)	#333	1602
NB L	E (58.5)	62	144	E (60.7)	101	114
NB T	F (345.1)	#1308	1322	D (37.4)	436	355
NB TR	F (345.1)	#1308	1234	D (37.4)	436	369
NB Overall	F (339.9)	-	-	D (39.0)	-	-
SB L	E (63.2)	104	106	E (59.5)	237	263
SB T	D (45.7)	#542	320	F (80.9)	#979	559
SB TR	D (45.7)	#542	339	F (80.9)	#979	593
SB Overall	D (46.9)	-	-	E (78.7)	-	-
NW Approach	F (197.7)	#628	1522	F (125.7)	#352	420
Intersection Overall	**F (205.3)**	**-**	**-**	**F (85.0)**	**-**	**-**

LOS (delay in seconds)
# indicates 95th percentile volume exceeds capacity

Table 4.5 – Future 2040 Level of Service and Queuing Summary
US 401 & Hilltop-Needmore Road

2040 Long Term	AM Peak			PM Peak		
	LOS (Delay)	95% Queue (feet)		LOS (Delay)	95% Queue (feet)	
		Synchro	Sim Traffic		Synchro	Sim Traffic
EB L	F (531.4)	#745	400	F (293.6)	#736	465
EB TR	C (37.6)	68	892	D (41.4)	329	1125
EB Overall	F (476.9)	-	-	F (190.9)	-	-
WB Overall	D (53.7)	#372	1587	F (148.5)	#446	1374
NB L	E (59.7)	76	124	E (64.0)	#152	240
NB T	F (229.5)	#1099	1047	D (49.1)	404	333
NB T	F (229.5)	#1099	1044	D (49.1)	404	359
NB TR	F (229.5)	#1099	1044	D (49.1)	404	399
NB Overall	F (226.4)	-	-	D (50.1)	-	-
SB L	E (69.7)	#142	138	F (106.4)	#448	284
SB T	D (38.2)	406	174	F (161.5)	#986	431
SB T	D (38.2)	406	226	F (161.5)	#986	476
SB TR	D (38.2)	406	279	F (161.5)	#986	488
SB Overall	C (40.3)	-	-	F (155.8)	-	-
NW Approach	F (306.0)	#856	622	F (194.1)	#480	680
Intersection Overall	**F (197.9)**	**-**	**-**	**F (135.9)**	**-**	**-**

LOS (delay in seconds)
# indicates 95th percentile volume exceeds capacity

4.6 Improvement Options

This section provides a summary of the improvement options considered for the intersection of US 401 and Hilltop-Needmore Road. A right-of-way map for this intersection is provided in Figure 20. Short term and long term solutions were assessed to determine improvement options that would enhance mobility and safety at the intersection.

Potential network, operational and safety improvements were identified and analyzed for the intersection of US 401 and Hilltop-Needmore Road. The improvement options were assessed for their ability to improve the level-of-service at the intersection as well as having minimal impacts to natural and cultural resources. The following improvement options were considered:

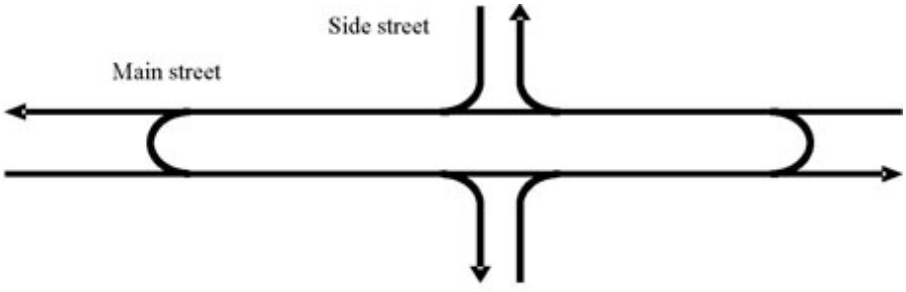
1. Superstreet with No Direct Left Turns
2. Reverse Superstreet
3. Relocated Hilltop Road
4. Reverse Superstreet and Relocated Hilltop Road with No Direct Left Turns
5. Reverse Superstreet and Relocated Hilltop Road with Direct Main Street Left Turns

A general discussion of each alternative is provided below.

4.6.1 Superstreet with No Direct Left Turns

This improvement option involves a superstreet concept with no direct left turns from the major street. Left turns and minor street through traffic are rerouted to nearby median crossovers where they can perform a U-turn, as shown in the diagram below. This concept can reduce delay and improve the operation of the major road by reducing the signal phasing and increasing green time for the major street through traffic. In addition, the safety of the intersection is enhanced by reducing the number of conflict points and the potential for crashes.

This improvement option was analyzed for short term and long term conditions. The westbound approach of Air Park Road was channelized with a yield condition and without signalization. A signal phase was provided for northbound traffic on Hilltop Road turning right onto US 401.

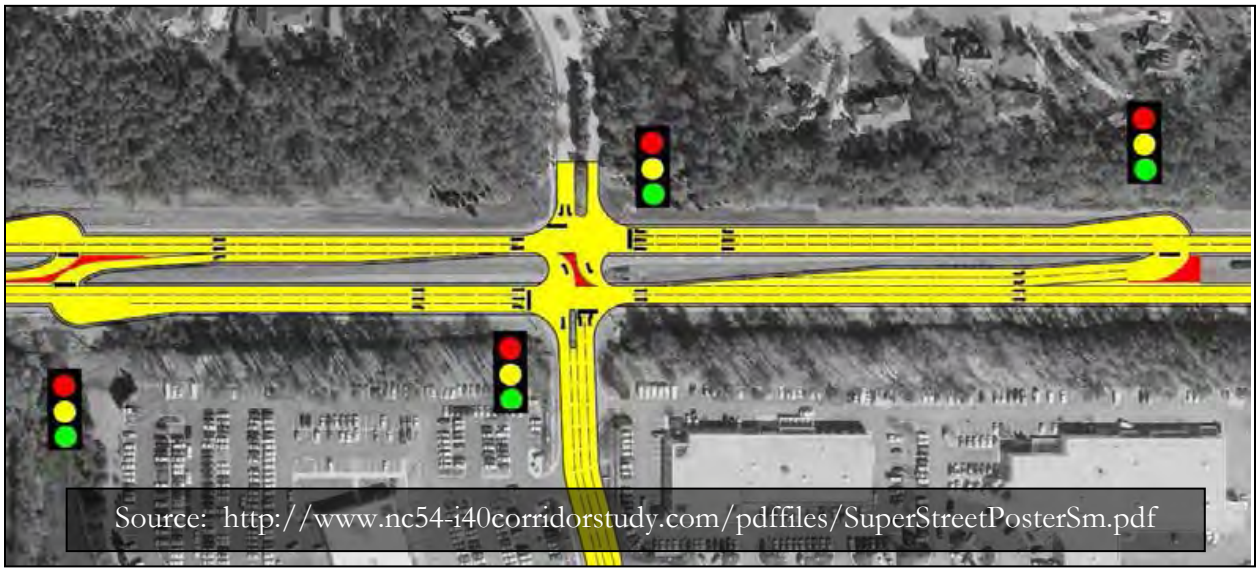


Source: FHWA Publication Number: FHWA-HRT-09-060

4.6.2 Reverse Superstreet

As shown in the diagram below, a reverse superstreet allows direct left turns from the minor street and restricts major street left turns and minor street through traffic. The restricted movements are rerouted to nearby median crossovers where they can perform a U-turn, as shown in the diagram below. As with other superstreet concepts, this option can reduce delay and improve operation of the major street through traffic. Also, the safety of the intersection is improved due to a reduced number of conflict points.

This improvement option was analyzed for short term and long term conditions. The eastbound approach (left, through, right) Hilltop-Needmore Road approach was permitted. Through traffic and left turns from Hilltop Road and Air Park Road were restricted. Similar to the Superstreet with no Direct Left Turns alternative, this option also involved channelization of Air Park Road's westbound approach. A signal phase was provided for northbound traffic on Hilltop Road turning right onto US 401.



4.6.3 Relocated Hilltop Road

According to CAMPO staff, a prior study (completed by others) resulted in a recommendation to relocate Hilltop Road further to the south and connect to Lake Wheeler Road. As shown below, Lark Street could be extended to the west to provide this connection. This option would benefit the intersection of US 401 & Hilltop-Needmore Road by eliminating the skewed and fifth leg of the intersection. A traditional intersection configuration was maintained (no movements were restricted). This improvement option was analyzed for short term and long term conditions.

Lake Wheeler Road begins at this intersection with US 401 then parallels US 401 to the north past I-40, where an interchange is provided, all the way to Raleigh. Therefore, Lake Wheeler Road could serve as an ideal alternative route for through traffic on this section of US 401. Relocating Hilltop Road to connect with Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity, and further promote its use as an alternative route.

4.6.4 Reverse Superstreet and Relocated Hilltop Road with No Direct Left Turns

This improvement option combines the Reverse Superstreet option with the Relocated Hilltop Road option. In addition, a superstreet configuration is applied to the intersection of Lake Wheeler Road with left turns prohibited.

4.6.5 Reverse Superstreet and Relocated Hilltop Road with Direct Main Street Lefts

This improvement option combines the Reverse Superstreet option with the Relocated Hilltop Road option. In addition, a superstreet configuration is applied to the intersection of Lake Wheeler Road with main street left turns permitted.

Reverse Superstreet & Relocated Hilltop Road w/ Direct Main Street Lefts

4.7 Short Term Results

The improvement options were analyzed for the short term analysis year of 2020 in order to assess their ability to accommodate future traffic volumes. The results for each improvement alternative are discussed below.

4.7.1 Superstreet with No Direct Left Turns

The following configuration was assumed for this improvement option in 2020: two (2) eastbound right turn lanes on Hilltop-Needmore Road; a southbound right turn lane on US 401; a northbound right turn lane on US 401; two (2) northwestbound right turn lanes on Hilltop Road; and a channelized westbound right turn lane on Air Park Road. In addition, dual U-turn lanes were assumed at both U-turn locations on US 401. Figure 21 depicts the geometry of this improvement option.

This improvement option has a preliminary cost estimate of approximately $2,000,000 in the year 2020. Cost estimate information can be found in the Appendix.

This improvement option and configuration ultimately reduced the signal phasing to two (2) phases at the main study intersection. Traffic signals were assumed at each U-turn location, also with two (2) phases. The traffic signals were coordinated to provide optimal progression for each direction of travel.

The level of service results for this improvement option in year 2020 is provided in Table 4.6. As shown, this improvement option is expected to operate at an acceptable LOS in the short term analysis year of 2020. Detailed level of service results can be found in the Appendix.

Table 4.6 - Level of Service Summary 2020 (Superstreet)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/A
Hilltop-Needmore Rd. EB	D/D

4.7.2 Reverse Superstreet

Figure 22 depicts the geometry assumed for this improvement option. The following configuration was assumed: an eastbound right turn, shared left-through, and left turn lane on Hilltop-Needmore Road, a southbound right turn lane on US 401, a northbound right turn lane on US 401, two (2) northwestbound right turn lanes on Hilltop Road, and a channelized westbound right turn lane on Air Park Road. Dual U-turn lanes were assumed at the northern U-turn location on US 401.

This improvement option has a preliminary cost estimate of approximately $1,850,000 in the year 2020. Cost estimate information can be found in the Appendix.

The signal phasing at the intersection of US 401 & Hilltop-Needmore Road resulted in three (3) phases. Traffic signals were also assumed at the U-turn locations, each with two (2) phases. The traffic signals were optimized and coordinated, however the ability to optimize the traffic progression was limited due to the extra signal phase of main intersection.

Table 4.7 presents the LOS results for the reverse superstreet improvement option in year 2020. As shown, the eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS E during the AM and PM peaks. Detailed level of service results can be found in the Appendix.

Table 4.7 - Level of Service Summary 2020 (Reverse Superstreet)

Approach	LOS AM/PM
US 401 NB	C/B
US 401 SB	B/B
Hilltop-Needmore Rd. EB	E/E

4.7.3 Relocated Hilltop Road

The lane geometry associated with this improvement option is depicted in Figure 23. The following was assumed at the intersection of US 401 & Hilltop-Needmore Road: two (2) eastbound left turn lanes on Hilltop-Needmore Road, an eastbound right turn lane on Hilltop-Needmore Road, a southbound right turn lane on US 401, a northbound right turn lane on US 401, and a left turn lane and right turn lane on Air Park Road.

The following geometry was assumed at the intersection of US 401 & Lake Wheeler Road/relocated Hilltop Road: eastbound left turn lane and right turn lane on Lake Wheeler Road, westbound left turn lane and right turn lane on relocated Hilltop Road, two (2) northbound left turn lanes on US 401, a northbound right turn lane on US 401, and a southbound left turn lane and right turn lane on US 401. This intersection was also signalized for this analysis scenario.

This improvement option has a preliminary cost estimate of approximately $2,350,000 in the year 2020. Cost estimate information can be found in the Appendix.

Table 4.8 provides the LOS results for the short term year 2020 with a relocated Hilltop Road. The northbound approach of US 401 at Hilltop-Needmore Road is anticipated to operate at LOS C during the AM peak and LOS A during the PM peak. The southbound approach is anticipated to operate at LOS B during the AM peak and LOS C during the PM peak. Detailed level of service results can be found in the Appendix.

Table 4.8 - Level of Service Summary 2020 (Relocated Hilltop Road)

Approach	LOS AM/PM
US 401 NB	C/A
US 401 SB	B/C
Hilltop-Needmore Rd. EB	E/E
Relocated Hilltop Rd. WB	E/D

4.7.4 Relocated Hilltop Road with No Direct Left Turns

The lane geometry associated with this improvement option is depicted in Figure 24. The following was assumed at the intersection of US 401 & Hilltop-Needmore Road: two (2) eastbound left turn lanes on Hilltop-Needmore Road, an eastbound right turn lane on Hilltop-Needmore Road, two (2) southbound right turn lanes on US 401, a northbound right turn lane on US 401, and a right only condition on Air Park Road.

The following geometry was assumed at the intersection of US 401 & Lake Wheeler Road/relocated Hilltop Road: two (2) eastbound right turn lanes on Lake Wheeler Road, two (2) westbound right turn lanes on relocated Hilltop Road, and a northbound and southbound right turn lane on US 401. This intersection was also signalized for this analysis scenario.

This improvement option has a preliminary cost estimate of approximately $3,300,000 in the year 2020. Cost estimate information can be found in the Appendix.

Table 4.9 provides the LOS results for the short term year 2020 with a relocated Hilltop Road. The northbound approach of US 401 at Hilltop-Needmore Road is anticipated to operate at LOS A during the AM and PM peaks. The southbound approach is anticipated to operate at LOS A during the AM and PM peaks. Detailed level of service results can be found in the Appendix.

Table 4.9 - Level of Service Summary 2020 (Relocated Hilltop Road with No Direct Left Turns)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/A
Hilltop-Needmore Rd. EB	D/C
Relocated Hilltop Rd. WB	D/C

4.7.5 Relocated Hilltop Road with Direct Main Street Left Turns

The lane geometry associated with this improvement option is depicted in Figure 25. The following was assumed at the intersection of US 401 & Hilltop-Needmore Road: two (2) eastbound left turn lanes on Hilltop-Needmore Road, an eastbound right turn lane on Hilltop-Needmore Road, two (2) southbound right turn lanes on US 401, a northbound right turn lane on US 401, and a right only condition on Air Park Road.

The following geometry was assumed at the intersection of US 401 & Lake Wheeler Road/relocated Hilltop Road: two (2) eastbound right turn lanes on Lake Wheeler Road, two (2) westbound right turn lanes on relocated Hilltop Road, a northbound left turn lane and right turn lane on US 401, and a southbound left turn lane and right turn lane on US 401. This intersection was also signalized for this analysis scenario.

This improvement option has a preliminary cost estimate of approximately $3,500,000 in the year 2020. Cost estimate information can be found in the Appendix.

Table 4.10 provides the LOS results for the short term year 2020 with a relocated Hilltop Road. The northbound approach of US 401 at Hilltop-Needmore Road is anticipated to operate at LOS A during the AM and PM peaks. The southbound approach is anticipated to operate at LOS A during the AM and PM peaks. Detailed level of service results can be found in the Appendix.

The queuing results for this improvement option are presented in the screenshots on the next pages. As shown, no queuing issues are anticipated during the AM and PM peaks.

Table 4.10 - Level of Service Summary 2020 (Relocated Hilltop Road with Direct Main Street Left Turns)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/A
Hilltop-Needmore Rd. EB	D/C
Relocated Hilltop Rd. WB	D/C


2020 AM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Air Park Rd
Brasswynd Ct
Air Park Road
Hilltop Needmore Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2020 AM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Wrenn St
Cardinal St
Indore Ct
Lake Wheeler Rd
Pleasant Rd
Relocated Hilltop Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2020 PM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Air Park Rd
Brasswynd Ct
Air Park Road
Hilltop Needmore Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2020 PM Peak Hour SimTraffic Queuing Results - St
Relocated Hilltop Road with Direct Main Street Left Turns
Wrenn St
Cardinal St
Indore Ct
Pleasant Rd
Lake Wheeler Rd
Relocated Hilltop Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed

4.8 Long Term Results

The improvement options were analyzed for the long term analysis year of 2040 in order to assess their ability to accommodate future traffic volumes. Based on the scoping meeting with CAMPO, the future widening of US 401 to six-lanes was assumed to be in place for this future analysis year. The results for each improvement alternative are discussed below.

4.8.1 Superstreet with No Direct Left Turns

The lane geometry configuration used for the short term 2020 analysis was also assumed for the long term 2040 analysis with the exception of US 401 widened to six lanes. Figure 26 shows the recommended geometry for this improvement option in 2040.

The level of service results for this improvement option in year 2020 is provided in Table 4.11. As shown, this improvement option is expected to operate at an acceptable LOS in the long term analysis year of 2040. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis in addition to the widening of US 401. Detailed level of service results can be found in the Appendix.

A long term solution to relieve the queuing anticipated for the westbound approach of Air Park Road is provide a connection between Air Park Road and Hilltop Road so that traffic can be rerouted to the signal provide at the main study intersection.

Table 4.11 - Level of Service Summary 2040 (Superstreet)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/B
Hilltop-Needmore Rd. EB	C/C

4.8.2 Reverse Superstreet

Compared to the short term 2020 analysis, the lane geometry associated with this improvement option for the long term 2040 analysis has the following differences: two (2) eastbound left turn lanes on Hilltop-Needmore Road, two (2) southbound right turn lanes on US 401, and six-lanes on US 401. Figure 27 shows the recommended geometry for this improvement option in 2040.

The level of service for the long term analysis of this improvement option is provided in Table 4.12. As shown, the eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS C during the AM and PM peaks. The northbound approach of US 401 is anticipated to operate at LOS A during the AM and PM peaks. The southbound approach of US 401 is anticipated to operate at LOS A during the AM peak and LOS B during the PM peak. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis in addition to the widening of US 401. Detailed level of service results can be found in the Appendix.

Table 4.12 - Level of Service Summary 2040 (Reverse Superstreet)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/B
Hilltop-Needmore Rd. EB	C/C

4.8.3 Relocated Hilltop Road

The configuration used in the short term 2020 analysis was used in the long term 2040 analysis with the following modifications: a second westbound through lane on Air Park Road, and six-lanes on US 401. The geometry at the intersection of US 401 & Lake Wheeler Road remained the same as the short term 2020 analysis. Figure 28 shows the recommended geometry for this improvement option in 2040.

The level of service results for this improvement option in 2040 are provided in Table 4.13. At the main study intersection the eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS E during the AM peak and LOS D during the PM peak. The westbound approach of the relocated Hilltop Road is anticipated to operate at LOS D during the AM and PM peaks. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis in addition to the widening of US 401. Detailed level of service results can be found in the Appendix.

Table 4.13 - Level of Service Summary 2040 (Relocated Hilltop Road)

Approach	LOS AM/PM
US 401 NB	C/A
US 401 SB	B/C
Hilltop-Needmore Rd. EB	E/D
Relocated Hilltop Rd. WB	D/D

4.8.4 Relocated Hilltop Road with No Direct Left Turns

The configuration used in the short term 2020 analysis was used in the long term 2040 analysis with the following modifications: a third eastbound left turn lane on Hilltop-Needmore Road, and six-lanes on US 401. The geometry at the intersection of US 401 & Lake Wheeler Road remained the same as the short term 2020 analysis. Figure 29 shows the recommended geometry for this improvement option in 2040.

The level of service results for this improvement option in 2040 are provided in Table 4.14. At the main study intersection the northbound and southbound approaches of US 401 are anticipated to operate at LOS A. The eastbound approach of Hilltop-Needmore Road and the westbound approach of the relocated Hilltop Road are anticipated to operate at LOS C. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis in addition to the widening of US 401. Detailed level of service results can be found in the Appendix.

Table 4.14 - Level of Service Summary 2040 (Relocated Hilltop Road with No Direct Left Turns)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/A
Hilltop-Needmore Rd. EB	C/C
Relocated Hilltop Rd. WB	C/C

4.8.5 Relocated Hilltop Road with Direct Main Street Left Turns

The configuration used in the short term 2020 analysis was used in the long term 2040 analysis with the following modifications: a third eastbound left turn lane on Hilltop-Needmore Road, and six-lanes on US 401. The geometry at the intersection of US 401 & Lake Wheeler Road remained the same as the short term 2020 analysis. Figure 30 shows the recommended geometry for this improvement option in 2040.

The level of service results for this improvement option in 2040 are provided in Table 4.15 At the main study intersection the northbound and southbound approaches of US 401 are anticipated to operate at LOS A. The eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS C during the AM and PM peaks. The signal timing and coordination was optimized for the long term analysis, which can account for slight improvements in LOS compared to the short term analysis in addition to the widening of US 401. Detailed level of service results can be found in the Appendix.

The queuing results for this improvement option are presented in the screenshots on the next pages. As shown, no queuing issues are anticipated during the AM and PM peaks, with the exception of the westbound approach of Air Park Road.

Table 4.15 - Level of Service Summary 2040 (Relocated Hilltop Road with Direct Main Street Left Turns)

Approach	LOS AM/PM
US 401 NB	A/A
US 401 SB	A/A
Hilltop-Needmore Rd. EB	C/C
Relocated Hilltop Rd. WB	C/B


2040 AM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Air Park Rd
Brasswynd Ct
Air Park Road
Hilltop Needmore Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2040 AM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Wrenn St
Cardinal St
Robin St
Indore Ct
Pleasant Rd
Relocated Hilltop Rd
Lake Wheeler Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2040 PM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Air Park Rd
Brasswynd Ct
Buckstone Ct
Air Park Road
Hilltop Needmore Rd
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed


2040 PM Peak Hour SimTraffic Queuing Results
Relocated Hilltop Road with Direct Main Street Left Turns
Poplin St
Wrenn St
Cardinal St
Indore Ct
Lake Wheeler Rd
Pleasant Rd
Relocated Hilltop Rd
US 401
US 401 NB Lanes
US 401 SB Lanes
Queue Lengths
All Intervals
Color
Queue Type
Average
95th Percentile
Max Observed

4.9 Summary of Recommended Improvements

The improvement options were analyzed for both short term and long term analysis years in order to assess their ability to accommodate future traffic volumes. A summary of each option with the advantages and disadvantages is provided below.

4.9.1 Superstreet with No Direct Left Turns

This improvement option involves a superstreet concept with no direct left turns from the major street. Left turns and minor street through traffic are rerouted to nearby median crossovers where they can perform a U-turn. This improvement option is anticipated to cost approximately $2,000,000 in 2020.

Currently, there are right-in right-out only driveways on US 401, and there is full access driveway to Food Lion Shopping Center on Hilltop-Needmore Road. These driveway configurations can be maintained. Left turns and U-turns at the existing intersection of US 401 and Hilltop-Needmore Road will not be possible under the proposed superstreet configuration. These left turns and U-turns will be rerouted to the adjacent signalized U-turn locations on US 401.

Analysis results show that this improvement option is expected to operate at an acceptable LOS in the short term and long term analysis years. A long term solution to relieve the queuing anticipated for the westbound approach of Air Park Road is provide a connection between Air Park Road and Hilltop Road so that traffic can be rerouted to the signal provide at the main study intersection.

Some of the advantages of this option include:

- Intersection is anticipated to have improved operation and reduced delay for both short term and long term analysis years.
- Low cost alternative and minimal impacts to right-of-way.
- Enhanced safety with fewer conflict points.

Some of the disadvantages of this option include:

- Major street left turns are rerouted.
- Minor street left turns are rerouted.
- Minor street through traffic is rerouted.
- Long term solution may require connection between Air Park Road and Hilltop Road.
- Unconventional intersection configuration.

4.9.2 Reverse Superstreet

A reverse superstreet allows direct left turns from the minor street and restricts major street left turns and minor street through traffic. The restricted movements are rerouted to nearby median crossovers where they can perform a U-turn. This improvement option is anticipated to cost approximately $1,850,000 in 2020.

Currently, there are right-in right-out only driveways on US 401, and there is full access driveway to Food Lion Shopping Center on Hilltop-Needmore Road. These driveway configurations can be maintained. Left turns and U-turns at the existing intersection of US 401 and Hilltop-Needmore Road will not be possible under the proposed superstreet configuration. These left turns and U-turns will be rerouted to the adjacent signalized U-turn locations on US 401.

With this improvement option in place, Hilltop-Needmore Road is anticipated to operate at LOS E during the AM peak and the northwest approach of Hilltop Road is anticipated to operate at LOS E during the PM peak for both the short term and long term analysis. All other approaches are anticipated to operate at an acceptable LOS.

Some of the advantages of this option include:

- Low cost alternative and minimal impacts to right-of-way.
- Eastbound approach of Hilltop-Needmore Road is not rerouted.
- Enhanced safety with fewer conflict points.

Some of the disadvantages of this option include:

- Intersection still experiences queuing, especially in the short term analysis without a six-lane US 401.
- Major street left turns are rerouted.
- Air Park Road and Hilltop Road through traffic is rerouted.
- Air Park Road and Hilltop Road left turns rerouted.
- Unconventional intersection configuration.

4.9.3 Relocated Hilltop Road

According to CAMPO staff, a prior study (completed by others) resulted in a recommendation to relocate Hilltop Road further to the south and connect to Lake Wheeler Road. Lark Street could be extended to the west to provide this connection. This option would benefit the intersection of US 401 & Hilltop-Needmore Road by eliminating the skewed and fifth leg of the intersection. A traditional intersection configuration was maintained (no movements were restricted). This improvement option is anticipated to cost approximately $2,400,000 in 2020.

Currently, there are right-in right-out only driveways on US 401, and there is full access driveway to Food Lion Shopping Center on Hilltop-Needmore Road. These driveway configurations can be maintained. Under this scenario, the signalized intersection of US 401 and Hilltop-Needmore Road will remain full access, with the exception that Hilltop Road east of US 401 will be relocated to the south to tie into US 401 at Lake Wheeler Road.

The northbound and southbound approaches of US 401 at Hilltop-Needmore Road are anticipated to operate at LOS C or better for both short term and long term analysis years. The eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS E during the AM peak in both analysis years. The westbound approach of the relocated Hilltop Road is anticipated to operate at LOS E during the AM peak in the short term 2020 analysis year.

Some of the advantages of this option include:

- Meets driver expectations with a traditional intersection configuration.
- Traffic movements at the main intersection are not rerouted.
- Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity

Some of the disadvantages of this option include:

- Intersection still experiences queuing, especially in the short term analysis without a six-lane US 401.
- Acquisition of additional right-of-way is required with construction of Lark Street extension.
- Traffic on Hilltop Road is rerouted.

4.9.5 Relocated Hilltop Road with No Direct Left Turns

This improvement option combines the Reverse Superstreet option with the Relocated Hilltop Road option. In addition, a superstreet configuration is applied to the intersection of Lake Wheeler Road with left turns prohibited. This improvement option is anticipated to cost approximately $3,300,000 in 2020.

Currently, there are right-in right-out only driveways on US 401, and there is full access driveway to Food Lion Shopping Center on Hilltop-Needmore Road. These driveway configurations can be maintained.

The northbound and southbound approaches of US 401 at Hilltop-Needmore Road are anticipated to operate at LOS A in both short term and long term analysis years. The eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS D during the AM peak in both analysis years. The westbound approach of the relocated Hilltop Road is anticipated to operate at LOS D during the AM peak in the short term 2020 analysis year.

Some of the advantages of this option include:

- Enhanced safety with fewer conflict points.
- Eastbound approach of Hilltop-Needmore Road is not rerouted.
- Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.

Some of the disadvantages of this option include:

- Major street left turns are rerouted.
- Air Park Road through traffic and left turns are rerouted.
- Lake Wheeler Road and Hilltop Road through traffic and left turns are rerouted.
- Unconventional intersection configuration.

4.9.6 Relocated Hilltop Road with Direct Main Street Left Turns

This improvement option combines the Reverse Superstreet option with the Relocated Hilltop Road option. In addition, a superstreet configuration is applied to the intersection of Lake Wheeler Road with main street left turns permitted. This improvement option is anticipated to cost approximately $3,500,000 in 2020.

Currently, there are right-in right-out only driveways on US 401, and there is full access driveway to Food Lion Shopping Center on Hilltop-Needmore Road. These driveway configurations can be maintained.

The northbound and southbound approaches of US 401 at Hilltop-Needmore Road are anticipated to operate at LOS A in both short term and long term analysis years. The eastbound approach of Hilltop-Needmore Road is anticipated to operate at LOS D during the AM peak in the short term analysis year. The westbound approach of the relocated Hilltop Road is anticipated to operate at LOS D during the AM peak in the short term 2020 analysis year.

Analysis results show that no queuing issues are anticipated with this improvement option in both short term and long term analysis years. The exception is some queuing is anticipated for the westbound approach of Air Park Road in 2040.

Some of the advantages of this option include:

- Enhanced safety with fewer conflict points.
- Main street left turns are not rerouted at Lake Wheeler Road intersection.
- Eastbound left turns from Hilltop-Needmore Road are not rerouted.
- Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.

Some of the disadvantages of this option include:

- Major street left turns are rerouted at Hilltop-Needmore Road.
- Hilltop-Needmore Road through traffic is rerouted.
- Air Park Road through traffic and left turns are rerouted.
- Lake Wheeler Road and Hilltop Road through traffic and left turns are rerouted.
- Unconventional intersection configuration.

4.10 Recommended Improvement

The Relocated Hilltop Road with Direct Main Street Left Turns improvement option is recommended for the intersection of US 401 & Hilltop-Needmore Road. This improvement option is anticipated to provide the best operation and level of service for both short term and long term analysis years. In addition, the safety of the intersection will be improved with fewer conflict points. This improvement option has the opportunity for phasing with implementing the reverse superstreet option at Hilltop-Needmore Road in the short term.

Consideration of Other Modes

Pedestrian and bicycle safety is anticipated to be enhanced given fewer conflict points at the intersection. Pedestrians will be able to cross one direction of US 401 at a time and wait in the median to safely finish crossing. Also, increased green time can be assigned to pedestrians since left turns are not permitted at the intersection.

Transit will benefit from this improvement option given the improved level of service and reduced delay along US 401. However, buses desiring to turn left at the intersection may be rerouted. Bus pullouts could be considered on US 401 to provide safer bus stops along US 401.

5.0 Natural and Cultural Impact Analysis

An initial review of potential environmental and cultural impacts related to the implementation of the transportation improvement options was performed. The purpose of this evaluation is to provide a "screening" type analysis of potential impacts early in the process. More detailed analysis and evaluation, including survey, will occur during the project planning and environmental documentation process. The information utilized for the evaluation was obtained from readily available database information from EPA, State, and County GIS. In addition, a preliminary field investigation was performed. Potential cultural and natural impacts were identified near the study intersections of US 401 & Ten-Ten Road and US 401 & Hilltop-Needmore Road in Wake County, North Carolina. Figure 31 shows the water-related environmental features, and Figure 32 shows the locations of other potential environmental issues.

5.1 Stream Classifications

The study intersections are located in the Neuse River Basin. US 401 crosses both Middle Creek and Mills Branch in the vicinity of the study intersections. Middle Creek is classified as Class "C" waters with the supplemental Nutrient Sensitive Waters ("NSW") classification, which has been established for lakes and rivers that need additional nutrient management due to their inherent excessive growth in vegetation. The area north of Ten-Ten Road along US 401 crosses into the Swift Creek Watershed. Swift Creek, at the extreme north end of the study area, is classified as Water Supply III ("WS III"), defined as waters used as sources of water supply for drinking, culinary, or food processing purposes where a more protective WS-I or II classification is not feasible. In addition, areas within this watershed are further classified as critical areas (Class "CA"). The regulations concerning this watershed area are provided in the Water Supply Watershed Protection Rules, sections 15A NCAC 2B .0248 through .0251, defined by the North Carolina Department of Environmental and Natural Resources (NCDENR), Division of Water Quality (DWQ).

In the late 1980s and early 1990s, Wake County, Raleigh, Cary, Garner and Apex jointly developed (with the North Carolina Division of Water Quality) and adopted the Swift Creek Land Management Plan as a guide to managing development in the watersheds of Lake Wheeler and Lake Benson, so as to protect water quality in those existing or potential water supply reservoirs. The Wake County Board of Commissioners adopted the Swift Creek Land Management Plan on April 19, 1990.


Bridge at Middle Creek


Multiple Box Culvert at Mills Branch

Wake County (and other parties to the Plan) are prohibited from adopting any development ordinance or granting any development permit that would be inconsistent with the standards and provisions of the Swift Creek Land Management Plan. The Swift Creek Land Management Plan ("LMP") indicates that the US 401 / Ten Road intersection area as "New Urban."

There are existing dual (North and South bound) two-lane bridges, ranging from approximately 115 (NB) to 170 feet (SB) in length, crossing Middle Creek approximately 0.7 miles north of Hilltop-Needmore Road. In addition, there is a Dual Box culvert for Mills Branch crossing below US 401 located approximately 400 feet south of Associate Drive. These water courses will be surveyed and have the appropriate coordination with NCDENR and the U.S. Army Corps of Engineers (USACE) during any environmental document study.

5.2 Floodplains

Wake County is a regular participant in the National Flood Insurance Program. Digital Federal Emergency Management Agency (FEMA) floodplain maps and the Wake County iMaps database were reviewed to determine whether the study intersections and any proposed improvements would cross the 100-year floodplain. The 100-year floodplain is located along Middle Creek and Mills Branch, and the width of the Middle Creek floodplain at the US 401 crossing is approximately 1200 feet. Special Flood Hazard Areas have been designated along the Middle Creek and Mills Branch floodways likely in anticipation of conditions resulting from future development. No base flood elevations were provided. When constructing this project, local and state regulations regarding the 100-year floodplain and special flood hazard areas will be followed.

Bridge at Middle Creek

5.3 Wetlands

National Wetland Inventory (NWI) map coverage provided by the U.S. Fish and Wildlife Service were reviewed to determine whether the proposed transportation improvements impact any wetlands. No Wetlands are encountered by the subject study intersection areas. Wetlands located in the vicinity of the study intersections are those Freshwater Forested/Shrub Wetlands associated with Middle Creek and Mills Branch and are in excess of ½ mile from the Hilltop Needmore Road and US 401 intersection.

Should proposed improvements encroach upon these wetlands, it is recommended that these wetlands be surveyed and delineated during the preparation of any environmental documentation. Proper permitting from the U.S. Army Corps of Engineers and North Carolina Division of Water Quality are required to be obtained prior to construction of any project, and appropriate mitigation measures will need to be taken. A listing of wetlands near the proposed project area can be found below.

Table 5.1
U.S. Fish & Wildlife Service National Wetland Inventory Results Report

Wetland Types	NWI Classification Code	Approximate Acres
Freshwater Forested/Shrub Wetland	PFO1A	19.87
Freshwater Forested/Shrub Wetland	PFO1F	0.96
Freshwater Forested/Shrub Wetland	PSS1C	15.67


Middle Creek Wetland Area Adjacent to Bridges


Mills Branch Riparian Area Downstream of Box Culvert

5.4 Historic Properties and Archaeological Sites

As part of the environmental screening process, the North Carolina State Historic Preservation Office (SHPO) and the Wake County Historic Preservation Commission were contacted to determine if any historic resources on the National Register of Historic Places or state lists exist near the study intersections. No historic properties were found on the National Register or any North Carolina surveys.

A number of structures or features near the study intersections are listed as "surveyed" in the SHPO database. Most are noted as "ineligible" for historic preservation. However, three-(3) features are noted as houses dating from the 1920's to 1950, and do not have any determination noted. Another, McCullers Crossroads, which the database indicates that the above ground structure is "gone."

5.5 Threatened and Endangered Species

The U.S. Fish & Wildlife Service Information, Planning and Conservation System ("iPaC") database and the North Carolina Natural Heritage Program were reviewed to determine the presence of any threatened and endangered species near the study intersections. One Bird species, one Clam species and one Plant species are found on Federal Threatened and Endangered Species lists in the vicinity of the proposed project. No critical habitat rules have been published and No conservation plans have been created for the Dwarf wedgemussel or Michaux's sumac. Table 5.2 provides a summary of the results.

Habitat Conservation and Safe Harbor plans have been enacted for the Red-cockaded woodpecker. However, no critical habitat rules for the Red-Cockaded woodpecker have been published. A survey for these species may need to be completed during preparation of any environmental documentation, and if the species is found to be present, additional investigations may be warranted.

According to the North Carolina Natural Heritage Program, two "Managed Areas" are within one mile of the intersection of Hilltop Needmore Road and US 401. These Managed Areas are defined as a diverse collection of properties and easements that are managed in some degree for conservation of biodiversity and ecosystem function. However, also included are a number of properties and easements that are not primarily managed for conservation, but that are of conservation interest. This conservation interest ranges from properties and easements which support rare species and intact, high-quality natural communities to those that are simply open spaces in places where open space is scarce.

No Significant Natural Heritage Areas are located within one mile of the study intersections. This information was gathered from the North Carolina Natural Heritage Program Online Map Viewer. May 7, 2013. Department of Environment and Natural Resources, Office of Conservation, Planning, and Community Affairs, Raleigh, NC. Available at: www.ncnhp.org.

Table 5.2
U.S. Fish & Wildlife Service Wake County Results Report

Group	Species Name	Population	Status
Birds	Red-cockaded woodpecker (Picoides borealis)	Entire	Endangered
Clams	Dwarf wedgemussel (Alasmidonta heterodon)	Entire	Endangered
Flowering Plants	Michaux's sumac (Rhus michauxii)	-	Endangered

5.6 Hazardous Materials

Because of the liability associated with purchasing properties containing hazardous materials, State and Federal hazardous materials databases were reviewed using information provided by the USEPA MyEnvironment Multisystem and the NCDENR Division of Waste Management LUST Database. Nine-(9) sites were found in the vicinity of the study intersections. Three-(3) were determined to contain potential hazardous materials. One site contains registered underground storage tanks, and three-(3) sites have reported incidents of leaking underground storage tanks. Three-(3) facilities are registered related to events and activities that generate, transport, treat, store, or dispose of some type of hazardous waste. One facility, Hi-Tech Cleanersys, is noted as permanently closed. However, as a dry cleaning facility, potential Perchloroethylene contamination may be a concern. Figure 32 shows the location of sites of potential concern; Table 5.3 provides information regarding each site. Before purchasing right-of-way property for the proposed transportation improvements, a Phase I environmental audit will be conducted to determine potential hazardous materials impacts.

Table 5.3
Potential Hazardous Materials Impacts (RCRA Info)

	Facility Name	Address	Type of Potential Impact
Within 0.5 Mile Radius of Study Intersections	Nc Steel Inc	8005 FAYETTEVILLE RD	LUST[a] / RCRA[c]
	Rite Aid #11386	8005 FAYETTEVILLE RD	RCRA
	HI Tech Cleanersys	7945 FAYETTEVILLE RD	RCRA
	McCullers Community Store	7930 FAYETTEVILLE RD	LUST
	Sheetz #507	7900 FAYETTEVILLE RD	UST[b]
	Pleasant Properties	8113 FAYETTEVILLE RD	LUST
Within Vicinity of US 401	Russell Carroll Cabinet Shop	2009 CARR-PUR DRIVE	RCRA
	Wake Technical Community College	9101 FAYETTEVILLE RD	UST
	Darryl Burke Chevrolet/Geo	3100 N MAIN ST	UST / RCRA

[a] LUST = Leaking Underground Storage Tank - Facility has reported leaking underground storage incident(s)
[b] UST = Underground Storage Tank - Facility manages registered underground storage tank(s)
[c] RCRA = events and activities related to facilities that generate, transport, and treat, store, or dispose of hazardous waste.
Source: USEPA MyEnvironment Multisystem Search Results, May 7, 2013

5.7 Noise Contour

The Raleigh-Durham International Airport Composite Noise Contour map, dated 1/12/2011, was reviewed. The subject section of US 401 does not lie within any noise contour related to the existing RDU Airport runways.

5.8 Natural & Cultural Impact Analysis Conclusions

Based upon the preliminary environmental screening for the general area surrounding the study intersections of US 401 & Ten-Ten Road and US 401 & Hilltop-Needmore Road, documented environmental elements have been identified that may impact the development of some types of transportation improvement projects. Further Environmental Assessment may be required depending on the type and size of any future project proposed.

Mills Branch Riparian Area
Downstream of Box Culvert

6.0 Conclusion

DAVENPORT has been retained by CAMPO to perform a hot spot study for two intersections: US 401 at Ten-Ten Road, and US 401 at Hilltop-Needmore Road.

The intersections were assessed for existing and future conditions in order to identify feasible and low-cost solutions to improve the operation and safety. Future year analyses were carried out for short-term conditions in 2020 and long-term conditions in 2040. The improvement options were assessed for their ability to improve the level-of-service at the intersection as well as having minimal impacts to natural and cultural resources. Planning-level cost estimates were also prepared for each improvement option.

6.1 US 401 & Ten-Ten Road

The intersection of US 401 & Ten-Ten Road has a crash severity index of 2.92. A total of 77 crashes were reported from April 1, 2010 to March 31, 2013. The majority of the crashes were C-level injury and property damage. There were three (3) B-level injury crashes reported. The most common crash type was rear-end, slow or stop with 50 reported crashes during the three year history. There were 20 southbound, 14 westbound, 8 northbound, and 8 eastbound rear-end crashes.

The intersection of US 401 & Ten-Ten Road currently operates at LOS F during the AM and PM peaks. Queuing is currently experienced during the AM peak on the eastbound and westbound approaches of Ten-Ten Road as well as the northbound approach of US 401. During the PM peak, there is excessive queuing on the eastbound approach of Ten-Ten Road as well as the southbound approach of US 401. The intersection is anticipated to remain at LOS F during the AM and PM peaks in the future and the delay and queuing experienced at the intersection is anticipated to worsen.

Two improvement options were identified for this intersection in the short term analysis year of 2020: Michigan Lefts, and Michigan Lefts with Single Quadrant Loop. In the long term analysis year of 2040, only the Michigan Lefts with Single Quadrant Loop was identified as a viable improvement option.

1. The Michigan Left turn, also known as a Median U-turn Crossover, removes all left turns from the intersection and reroutes them to nearby median crossovers where they can perform a U-turn. This improvement option is anticipated to cost approximately $3,000,000 in 2020.

2. The second option involves a Michigan Lefts intersection treatment as well as a single quadrant loop on the northeastern quadrant of the intersection. This improvement is anticipated to cost approximately $4,100,000 in 2020, which does not include the cost of the Loop Road or the cost of widening US 401.

The Michigan Lefts and Single Quadrant Loop improvement option is recommended for the intersection of US 401 & Ten-Ten Road. This improvement option is anticipated to provide the best operation and level of service for both short term and long term analysis years. In addition, the safety of the intersection will be improved with fewer conflict points. This improvement option has the opportunity for phasing since the Michigan Lefts option works in the short term analysis year of 2020 without the quadrant loop.

6.2 US 401 & Hilltop-Needmore Road

A total of 24 crashes were reported at the intersection of US 401 & Hilltop-Needmore Road from April 1, 2010 to March 31, 2013. The crash severity index for the intersection is 2.23. The majority of the crashes were property damage only. There were two (2) B-level injury crashes reported and two (2) C-level injury crashes reported. The most common crash type was rear-end with 13 reported occurrences.

The intersection of US 401 & Hilltop-Needmore Road currently operates at LOS E during the AM and PM peaks. Analysis results show queuing on the northbound approach of US 401 as well as some queuing on the side streets during the AM peak. During the PM peak, there is excessive queuing on the southbound approach of US 401 as well as queuing on all of the side streets. The intersection is anticipated to degrade to LOS F during the AM and PM peaks in the future. In addition, the delay and queuing experienced at the intersection is anticipated to worsen.

Five feasible improvement options were identified for this intersection including Superstreet with No Direct Left Turns, Reverse Superstreet, Relocated Hilltop Road, Reverse Superstreet and Relocated Hilltop Road with No Direct Left Turns, and Reverse Superstreet and Relocated Hilltop Road with Direct Main Street Lefts.

1. Superstreet with No Direct Left Turns. This improvement option involves a superstreet concept with no direct left turns from the major street. Left turns and minor street through traffic are rerouted to nearby median crossovers where they can perform a U-turn. This improvement option is anticipated to cost approximately $2,000,000 in 2020.

2. Reverse Superstreet. A reverse superstreet allows direct left turns from the minor street and restricts major street left turns and minor street through traffic. The restricted movements are rerouted to nearby median crossovers where they can perform a U-turn. This improvement option is anticipated to cost approximately $1,850,000 in 2020.

3. Relocated Hilltop Road. This improvement option involves relocating Hilltop Road further to the south to connect to Lake Wheeler Road. Lark Street could be extended to the west to provide this connection. This option would benefit the intersection of US 401 & Hilltop-Needmore Road by eliminating the skewed and fifth leg of the intersection. A traditional intersection configuration was maintained (no movements were restricted). This improvement option is anticipated to cost approximately $2,400,000 in 2020.

4. Reverse Superstreet and Relocated Hilltop Road with No Direct Left Turns. This improvement option combines the Reverse Superstreet option with the Relocated Hilltop Road option. In addition, a superstreet configuration is applied to the intersection of Lake Wheeler Road with left turns prohibited. This improvement option is anticipated to cost approximately $3,300,000 in 2020.

5. Reverse Superstreet and Relocated Hilltop Road with Direct Main Street Lefts. This improvement option combines the Reverse Superstreet option with the Relocated Hilltop Road option. In addition, a superstreet configuration is applied to the intersection of Lake Wheeler Road with main street left turns permitted. This improvement option is anticipated to cost approximately $3,500,000 in 2020.

6.3 Natural and Cultural Impact Analysis

Based upon the preliminary environmental screening for the general area surrounding the study intersections of US 401 & Ten-Ten Road and US 401 & Hilltop-Needmore Road, documented environmental elements have been identified that may impact the development of some types of transportation improvement projects. Further Environmental Assessment may be required depending on the type and size of any future project proposed.

In conclusion, the study intersections currently experience operational and safety issues. These issues are expected to worsen in the future as the traffic demand increases at these intersections and the surrounding area continues to grow. As such, improvement options were identified for the two study intersection for both short term (2020) and long term (2040) conditions. The potential impacts of the transportation improvements were identified, including natural and cultural impacts. The advantages and disadvantages of each option were identified and planning level cost estimates were prepared for each alternative. This report provides a recommended improvement option for each intersection that is anticipated to enhance the intersection's operation and safety while having minimal impacts to the environment, cultural, right-of-way, and business driveways.

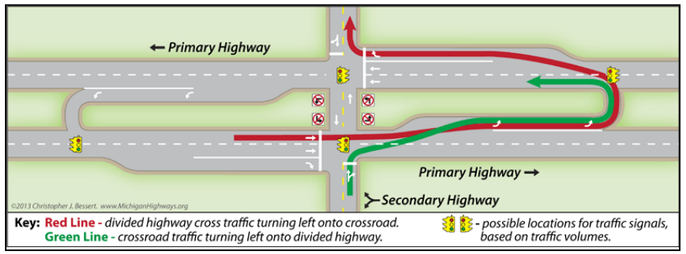
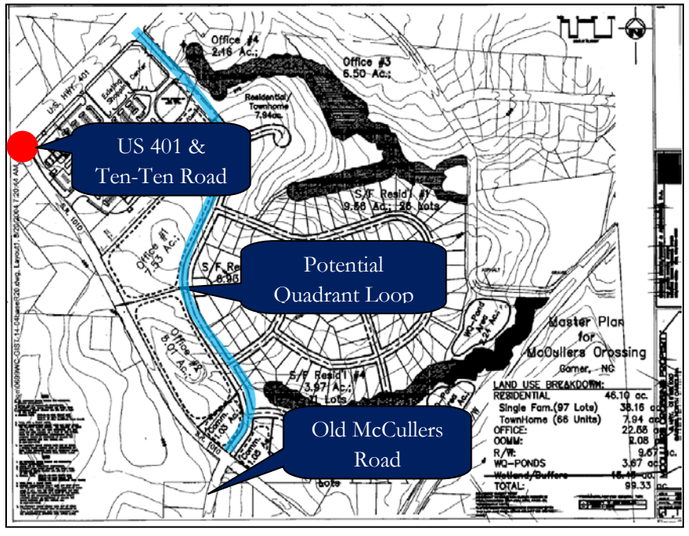
6.4 Recommended Improvements

The Michigan Lefts and Single Quadrant Loop improvement option is recommended for the intersection of US 401 & Ten-Ten Road. This improvement option has the opportunity for phasing with the Michigan Lefts option in the short term analysis year of 2020 and adding the quadrant loop in the long term.

The Relocated Hilltop Road with Direct Main Street Left Turns improvement option is recommended for the intersection of US 401 & Hilltop-Needmore Road. This improvement option has the opportunity for phasing with implementing the reverse superstreet option at Hilltop-Needmore Road in the short term and relocating Hilltop Road in the long term.

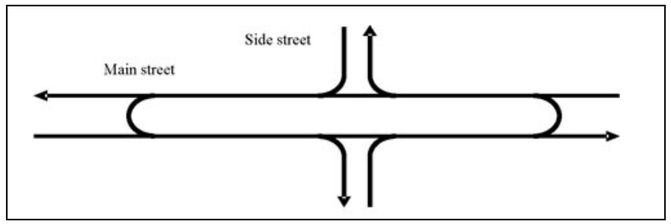
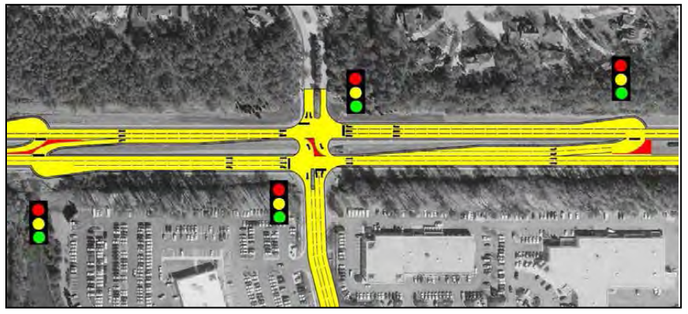
These improvement options are anticipated to provide the best operation and level of service for both short term and long term analysis years. In addition, the safety of the intersections will be enhanced with fewer conflict points.

US 401 & Ten-Ten Road

<table>
<tr><th>Improvement Option</th><th colspan="2">Short Term 2020 Solution?</th><th colspan="2">Long Term 2040 Solution?</th><th>2020 Cost</th><th>Impacts</th><th>Other Modes</th><th>Other Advantages</th><th>Other Disadvantages</th></tr>
<tr><td rowspan="5">Michigan Lefts
 
</td><td colspan="2">Yes</td><td colspan="2">No</td><td rowspan="5">$3,000,000</td><td>Environmental:
Low</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.
• May need pedestrian bridge in long term 2040.</td><td rowspan="5">• Enhanced safety with fewer conflict points.
• Minor street through traffic is not rerouted.</td><td rowspan="5">• Unconventional intersection configuration.
• Major street left turns are rerouted.
• Minor street left turns are rerouted.</td></tr>
<tr><td>Cultural:
Low</td></tr>
<tr><td>Right-of-Way:
Low</td></tr>
<tr><td>Business Driveways:
Medium
(Altered access to nearby driveways at Gelder Drive and at the AutoZone / Smithfield's access)</td><td>Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left will be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td></tr>
<tr><td>US 401 NB</td><td>D/B</td><td>US 401 NB</td><td>C/B</td></tr>
<tr><td>US 401 SB</td><td>A/E</td><td>US 401 SB</td><td>A/D</td></tr>
<tr><td>Ten-Ten Rd. EB</td><td>D/D</td><td>Ten-Ten Rd. EB</td><td>D/E</td></tr>
<tr><td>Ten-Ten Rd. WB</td><td>D/D</td><td>Ten-Ten Rd. WB</td><td>E/D</td></tr>
<tr><td rowspan="5">Michigan Lefts with a Single Quadrant Loop
 
</td><td colspan="2">Yes</td><td colspan="2">Yes</td><td rowspan="5">$4,100,000

(Does not include cost of Loop Road construction - assumed to be completed by developer. Loop Road has an estimated 2020 cost of $1,900,000)</td><td>Environmental:
Low/Medium
(Water Supply Area/ Nutrient Sensitive Waters; 50 foot buffer and BMP requirements on surface waters)</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.
• May need pedestrian bridge in long term 2040.</td><td rowspan="5">• Enhanced safety with fewer conflict points.
• Minor street through traffic is not rerouted.</td><td rowspan="5">• Unknown construction of development and quadrant loop road.
• Unconventional intersection configuration.
• Major street left turns are rerouted.
• Minor street left turns are rerouted.</td></tr>
<tr><td>Cultural:
Low</td></tr>
<tr><td>Right-of-Way:
Medium</td></tr>
<tr><td>Business Driveways:
Medium
(Altered access to nearby driveways at Gelder Drive and at the AutoZone / Smithfield's access)</td><td>Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left will be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td></tr>
<tr><td>US 401 NB</td><td>D/B</td><td>US 401 NB</td><td>C/B</td></tr>
<tr><td>US 401 SB</td><td>A/C</td><td>US 401 SB</td><td>A/C</td></tr>
<tr><td>Ten-Ten Rd. EB</td><td>D/D</td><td>Ten-Ten Rd. EB</td><td>D/C</td></tr>
<tr><td>Ten-Ten Rd. WB</td><td>C/D</td><td>Ten-Ten Rd. WB</td><td>D/D</td></tr>
</table>

US 401 & Hilltop-Needmore Road

Improvement Option	Short Term 2020 Solution?		Long Term 2040 Solution?		2020 Cost	Impacts	Other Modes	Other Advantages	Other Disadvantages
Superstreet with No Direct Left Turns 	**Yes**		**Yes**		$2,000,000	**Environmental:** Low **Cultural:** Low **Right-of-Way:** Low **Business Driveways:** Low	**Pedestrian/Bicycle:** • Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time. • Longer pedestrian phase without left turns. **Transit:** • Improved LOS and delay for buses on US 401. • Buses turning left or straight from the side streets will be rerouted. • Provide bus pullouts.	• Enhanced safety with fewer conflict points.	• Major street left turns are rerouted. • Minor street left turns are rerouted. • Minor street through traffic is rerouted. • Long term solution may require connection between Air Park Road and Hilltop Road. • Unconventional intersection configuration.
	Approach	**LOS AM/PM**	**Approach**	**LOS AM/PM**					
	US 401 NB	A/A	US 401 NB	A/A					
	US 401 SB	A/A	US 401 SB	A/B					
	Hilltop-Needmore Rd. EB	D/D	Hilltop-Needmore Rd. EB	C/C					
Reverse Superstreet 	**Yes**		**Yes**		$1,850,000	**Environmental:** Low **Cultural:** Low **Right-of-Way:** Low **Business Driveways:** Low	**Pedestrian/Bicycle:** • Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time. • Longer pedestrian phase without left turns. **Transit:** • Improved LOS and delay for buses on US 401. • Buses turning left from US 401 or westbound from the side streets will be rerouted. • Provide bus pullouts.	• Eastbound approach of Hilltop-Needmore Road is not rerouted. • Enhanced safety with fewer conflict points.	• Intersection still experiences queuing, especially in the short term analysis without a six-lane US 401. • Major street left turns are rerouted. • Air Park Road and Hilltop Road through traffic is rerouted. • Air Park Road and Hilltop Road left turns rerouted. • Unconventional intersection configuration.
	Approach	**LOS AM/PM**	**Approach**	**LOS AM/PM**					
	US 401 NB	C/B	US 401 NB	C/C					
	US 401 SB	B/B	US 401 SB	B/C					
	Hilltop-Needmore Rd. EB	E/E	Hilltop-Needmore Rd. EB	E/D					
Relocated Hilltop Road 	**Yes**		**Yes**		$2,400,000	**Environmental:** Low/Medium Possible threatened species. Would require further study. **Cultural:** Low **Right-of-Way:** Medium/High Construction of Lark St. Extension **Business Driveways:** Low	**Pedestrian/Bicycle:** • Traditional pedestrian accommodations can be provided. **Transit:** • Improved LOS and delay for buses on US 401. • Buses will not be rerouted. • Provide bus pullouts.	• Meets driver expectations with a traditional intersection configuration. • Traffic movements at the main intersection are not rerouted. • Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.	• Intersection still experiences queuing, especially in the short term analysis without a six-lane US 401. • Traffic on Hilltop Road is rerouted.
	Approach	**LOS AM/PM**	**Approach**	**LOS AM/PM**					
	US 401 NB	C/A	US 401 NB	C/A					
	US 401 SB	B/C	US 401 SB	B/C					
	Hilltop-Needmore Rd. EB	E/E	Hilltop-Needmore Rd. EB	E/D					
	Relocated Hilltop Rd. WB	E/D	Relocated Hilltop Rd. WB	D/D					

continued on next page

US 401 & Hilltop-Needmore Road (continued)

<table>
<tr><th>Improvement Option</th><th colspan="2">Short Term 2020 Solution?</th><th colspan="2">Long Term 2040 Solution?</th><th>2020 Cost</th><th>Impacts</th><th>Other Modes</th><th>Other Advantages</th><th>Other Disadvantages</th></tr>
<tr><td rowspan="6">Reverse Superstreet and Relocated Hilltop Road with No Direct Left Turns
  </td><td colspan="2">Yes</td><td colspan="2">Yes</td><td rowspan="6">$3,300,000</td><td>Environmental:
Low/Medium
Possible threatened species. Would require further study.</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.</td><td rowspan="6">• Enhanced safety with fewer conflict points.
• Eastbound approach of Hilltop-Needmore Road is not rerouted.
• Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.</td><td rowspan="6">• Major street left turns are rerouted.
• Air Park Road through traffic and left turns are rerouted.
• Lake Wheeler Road and Hilltop Road through traffic and left turns are rerouted.
• Unconventional intersection configuration.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td><td>Cultural:
Low</td></tr>
<tr><td>US 401 NB</td><td>A/A</td><td>US 401 NB</td><td>A/A</td><td rowspan="3">Right-of-Way:
Medium/High
Construction of Lark St. Extension</td><td rowspan="3">Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left from US 401 or from the side streets, with the exception of eastbound on Hilltop-Needmore Road, will be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>US 401 SB</td><td>A/A</td><td>US 401 SB</td><td>A/A</td></tr>
<tr><td>Hilltop-Needmore Rd. EB</td><td>D/C</td><td>Hilltop-Needmore Rd. EB</td><td>C/C</td></tr>
<tr><td>Relocated Hilltop Rd. WB</td><td>D/C</td><td>Relocated Hilltop Rd. WB</td><td>C/C</td><td>Business Driveways:
Low</td></tr>
<tr><td rowspan="6">Reverse Superstreet and Relocated Hilltop Road with Direct Main Street Lefts
  </td><td colspan="2">Yes</td><td colspan="2">Yes</td><td rowspan="6">$3,500,000</td><td>Environmental:
Low/Medium
Possible threatened species. Would require further study.</td><td rowspan="2">Pedestrian/Bicycle:
• Enhanced safety with fewer conflict points and pedestrians will be able to cross one direction of traffic at a time.
• Longer pedestrian phase without left turns.</td><td rowspan="6">• Enhanced safety with fewer conflict points.
• Main street left turns are not rerouted at Lake Wheeler Road intersection.
• Eastbound left turns from Hilltop-Needmore Road are not rerouted.
• Hilltop Road connection to Lake Wheeler Road would enhance the region's overall roadway network and interconnectivity.</td><td rowspan="6">• Major street left turns are rerouted at Hilltop-Needmore Road.
• Hilltop-Needmore Road through traffic is rerouted.
• Air Park Road through traffic and left turns are rerouted.
• Lake Wheeler Road and Hilltop Road through traffic and left turns are rerouted.
• Unconventional intersection configuration.</td></tr>
<tr><td>Approach</td><td>LOS AM/PM</td><td>Approach</td><td>LOS AM/PM</td><td>Cultural:
Low</td></tr>
<tr><td>US 401 NB</td><td>A/A</td><td>US 401 NB</td><td>A/A</td><td rowspan="3">Right-of-Way:
Medium/High
Construction of Lark St. Extension</td><td rowspan="3">Transit:
• Improved LOS and delay for buses on US 401.
• Buses turning left may be rerouted.
• Provide bus pullouts.</td></tr>
<tr><td>US 401 SB</td><td>A/A</td><td>US 401 SB</td><td>A/A</td></tr>
<tr><td>Hilltop-Needmore Rd. EB</td><td>D/C</td><td>Hilltop-Needmore Rd. EB</td><td>C/C</td></tr>
<tr><td>Relocated Hilltop Rd. WB</td><td>D/C</td><td>Relocated Hilltop Rd. WB</td><td>C/B</td><td>Business Driveways:
Low</td></tr>
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Figures

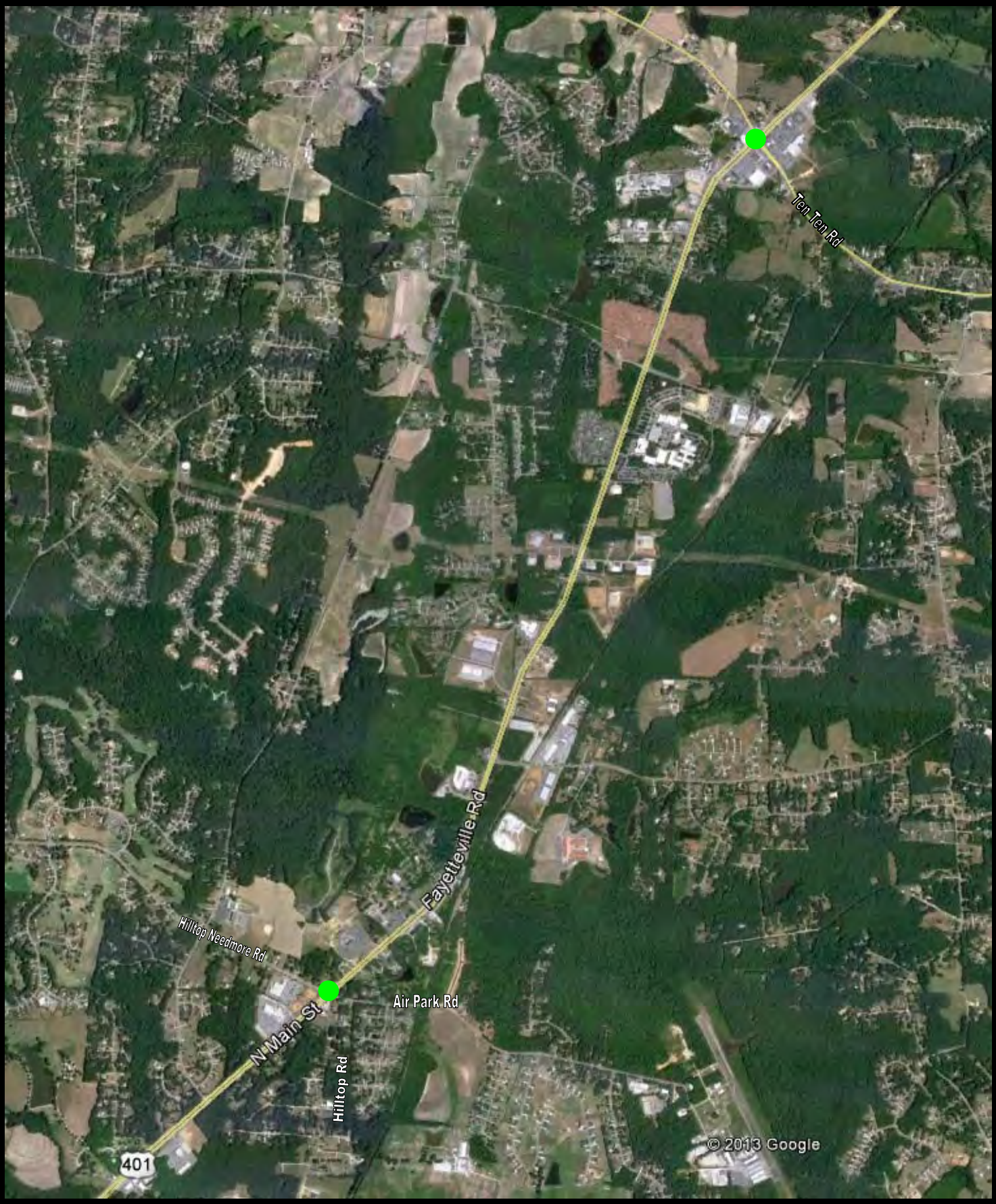

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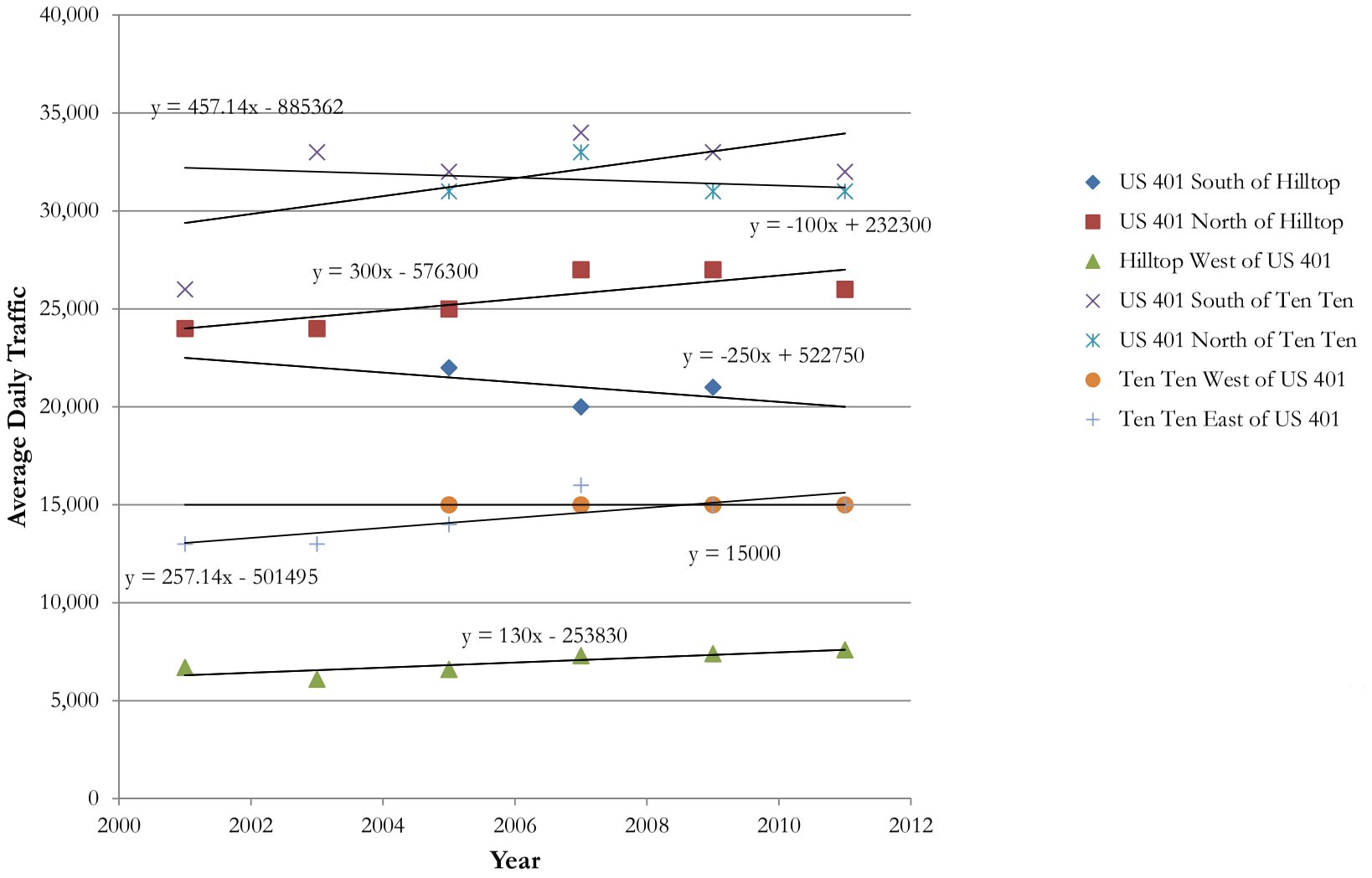
FIGURE 1
VICINITY MAP

STUDY
INTERSECTIONS

Figure 2 - Average Annual Daily Traffic



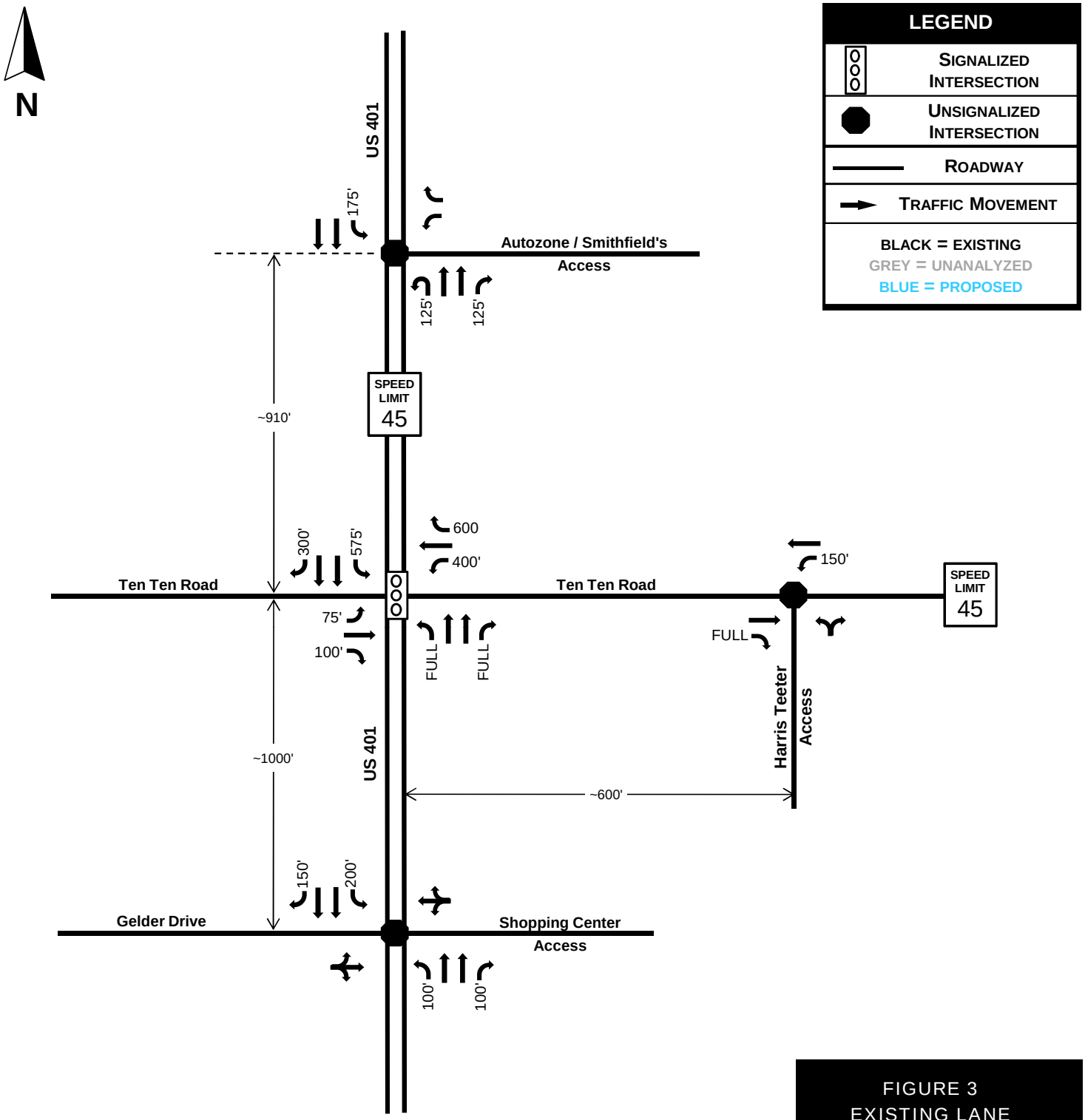


FIGURE 3
EXISTING LANE GEOMETRY

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

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Figure 4
US 401 & Ten Ten Road

Proposed Count Locations
- 16-hour
- AM (7-9 am) & PM (4-6 pm)

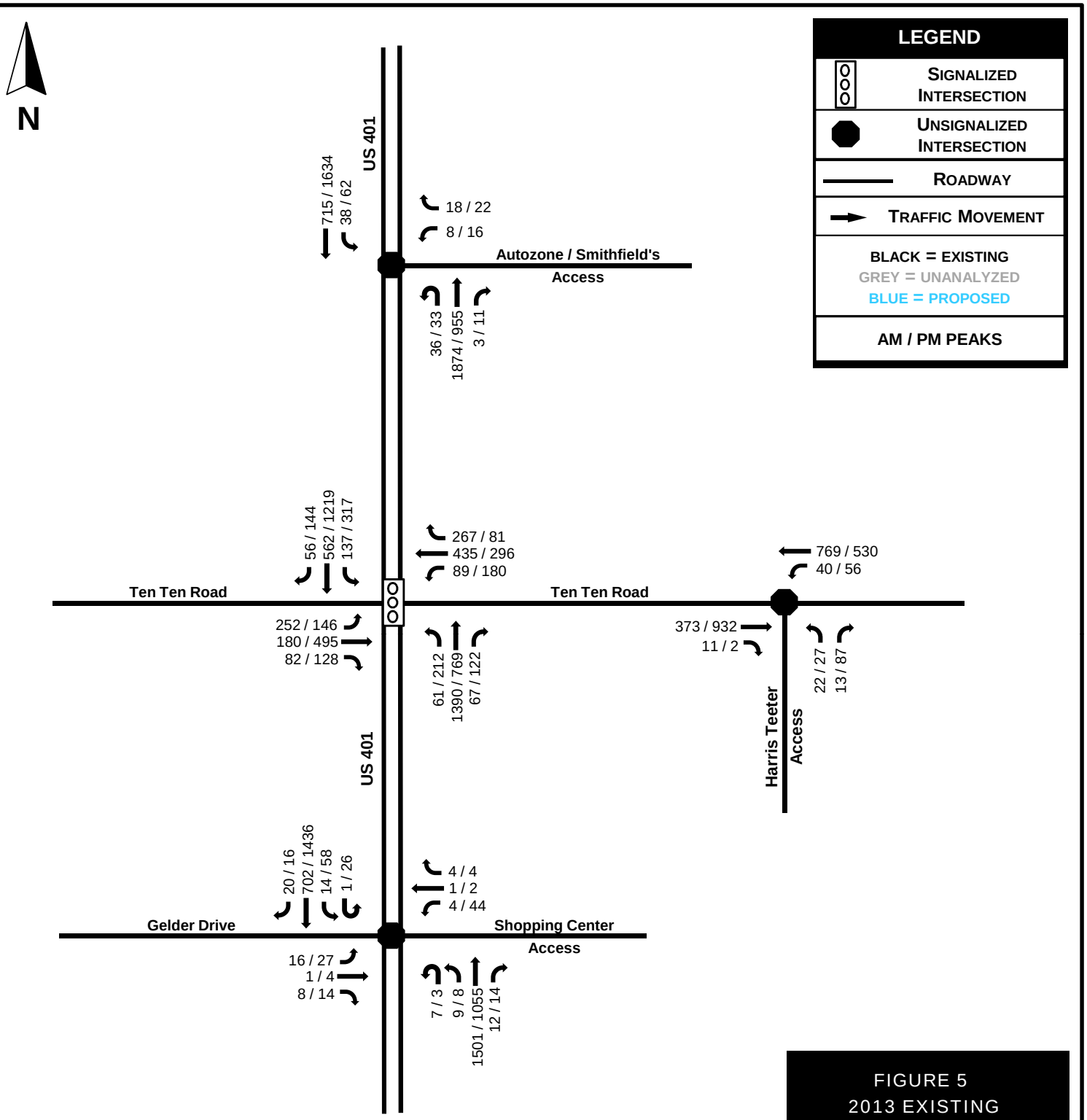

FIGURE 5
2013 EXISTING TRAFFIC VOLUMES

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

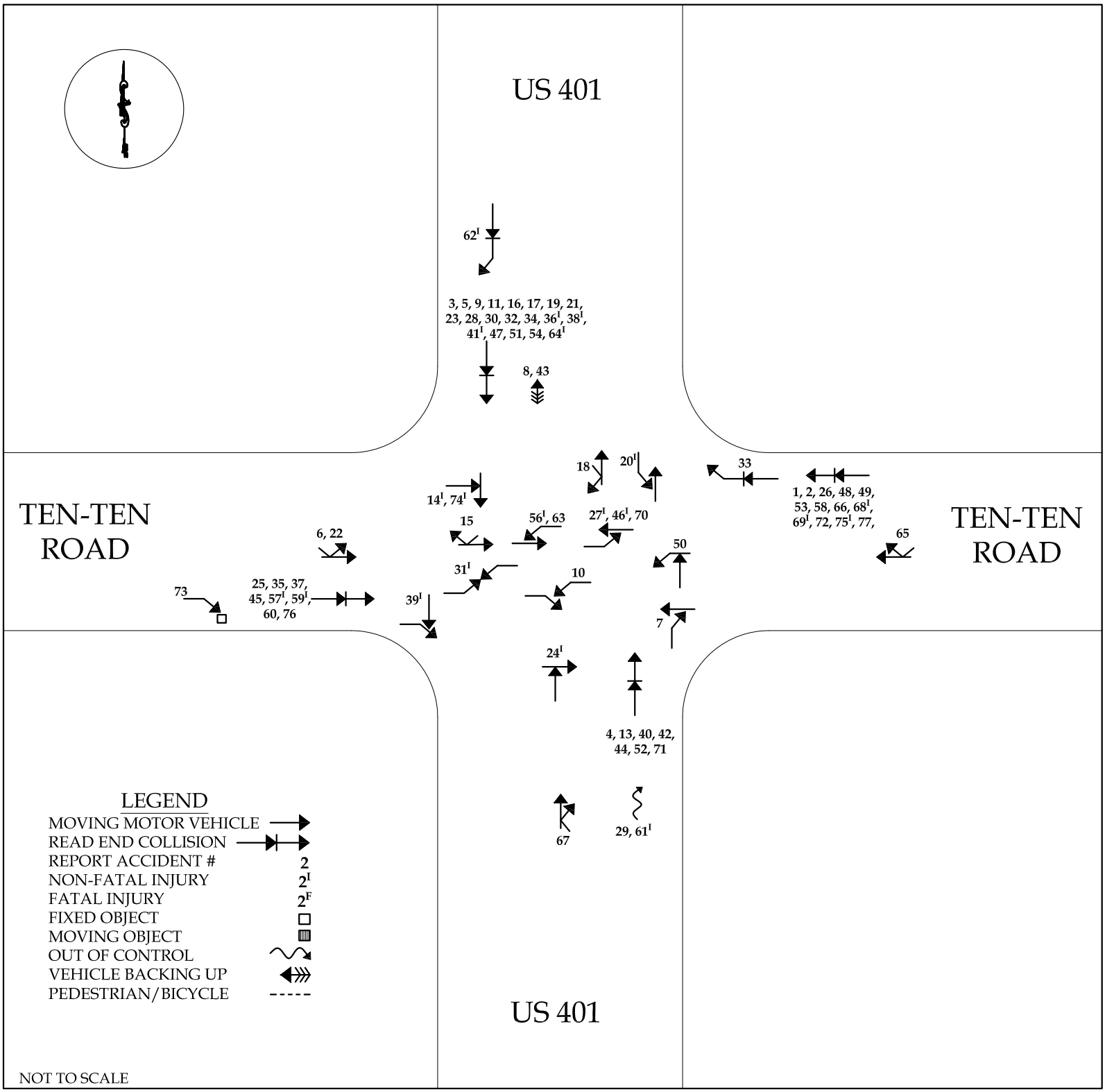

Figure 6 - US 401 & Ten-Ten Road Collision Diagram

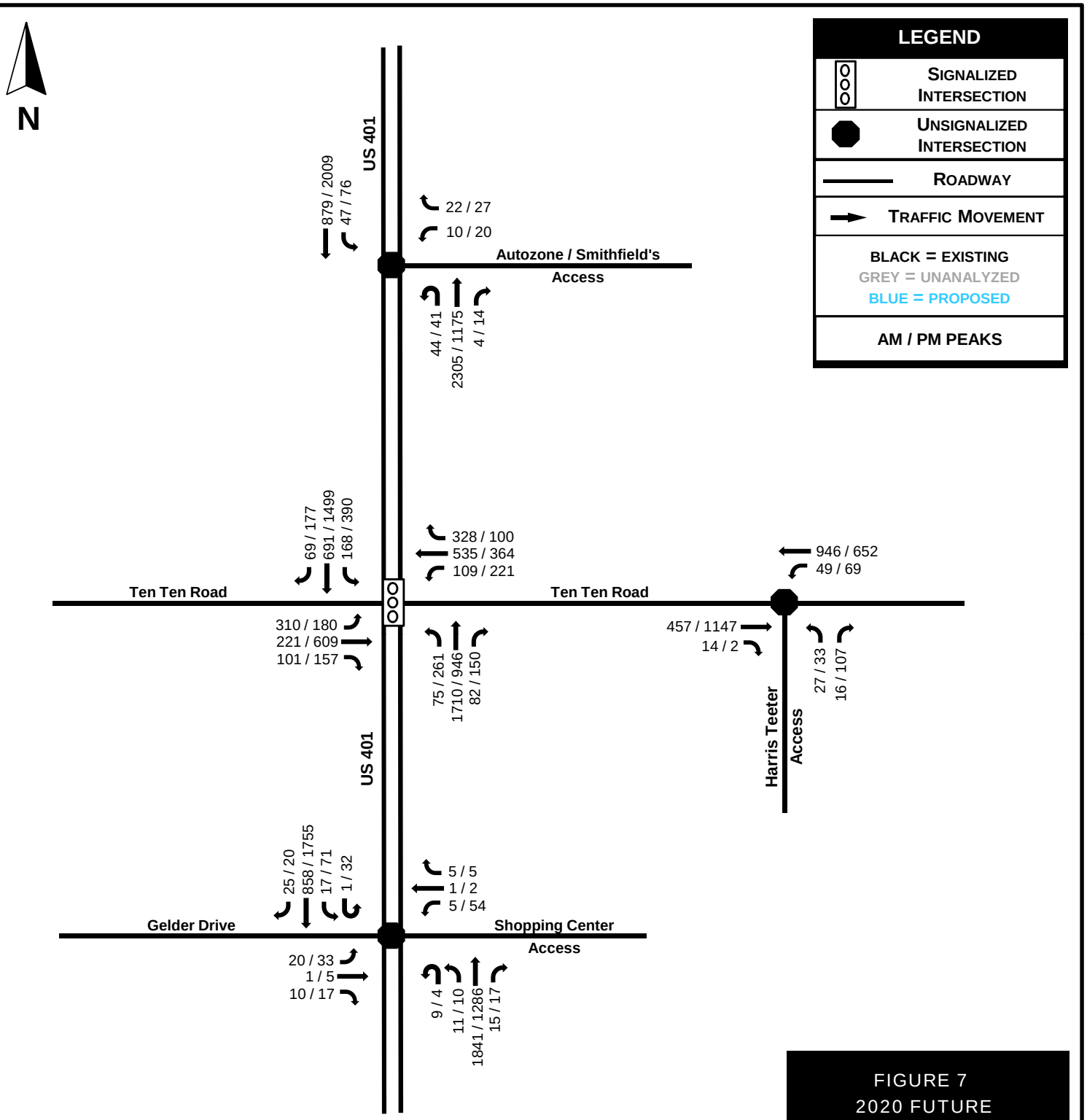

FIGURE 7
2020 FUTURE TRAFFIC VOLUMES

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

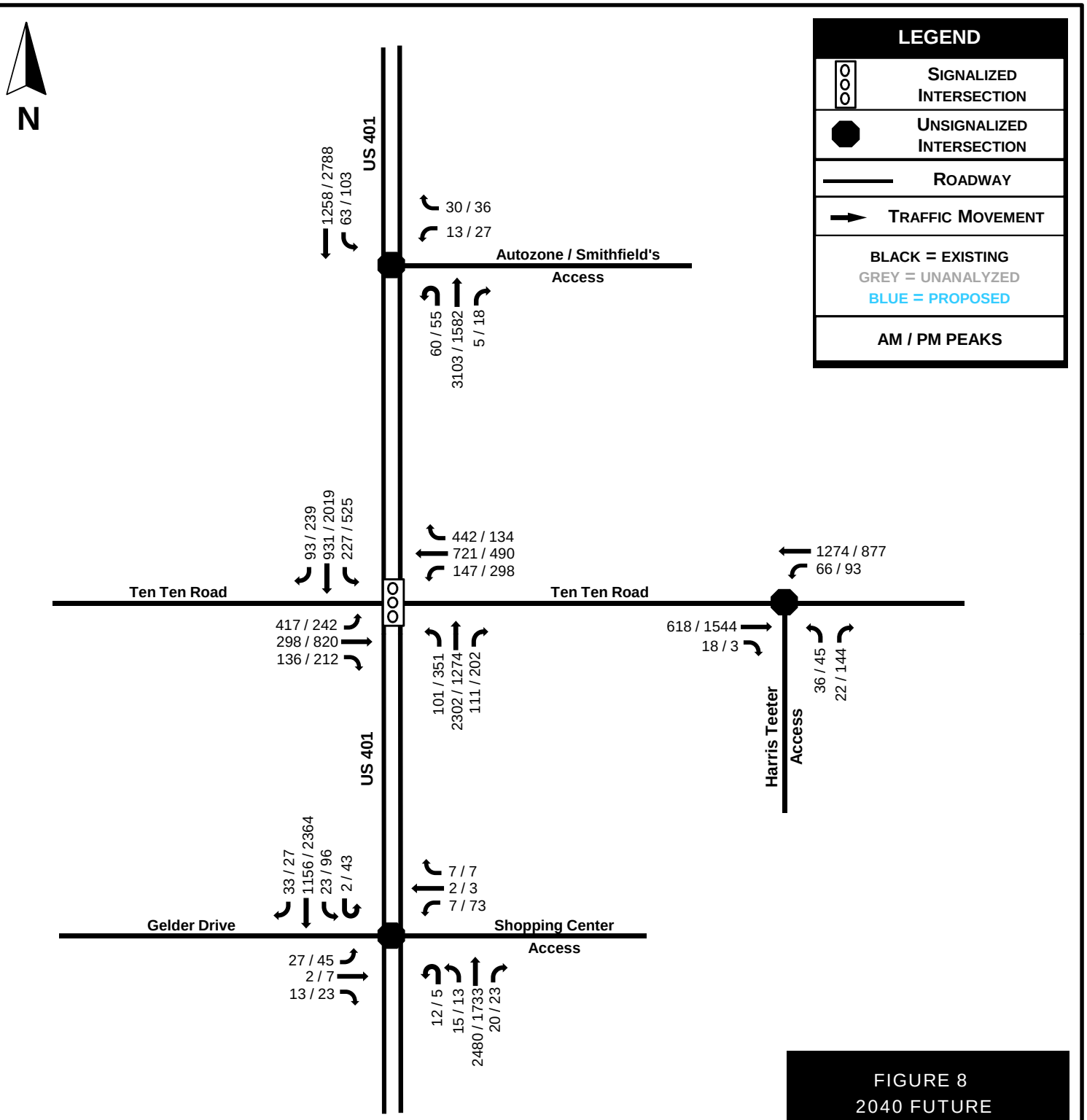

FIGURE 8
2040 FUTURE
TRAFFIC VOLUMES

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

Figure 9 - US 401 & Ten-Ten Road Right-of-Way Map

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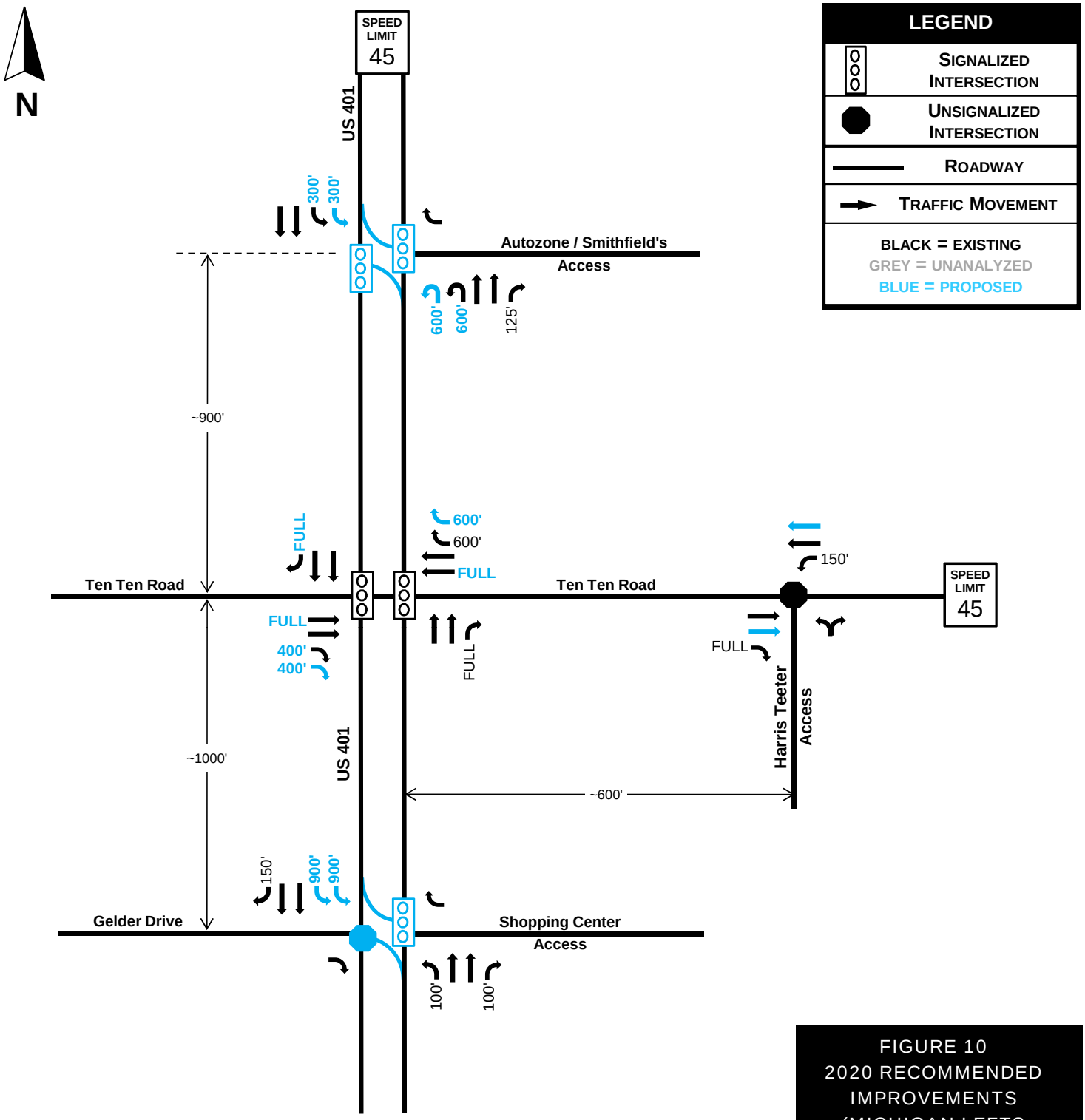

FIGURE 10
2020 RECOMMENDED IMPROVEMENTS (MICHIGAN LEFTS OPTION)

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

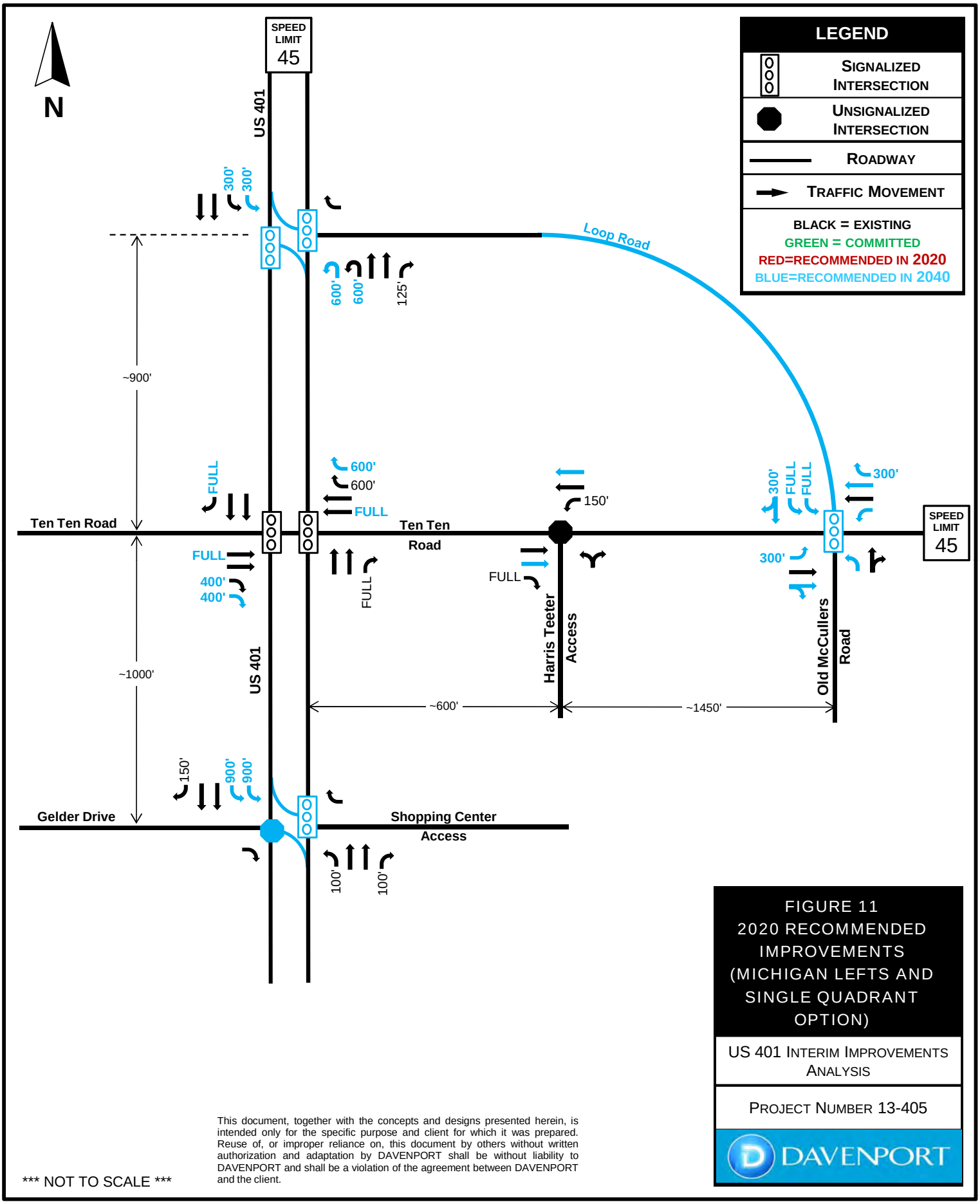

FIGURE 11
2020 RECOMMENDED IMPROVEMENTS (MICHIGAN LEFTS AND SINGLE QUADRANT OPTION)

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

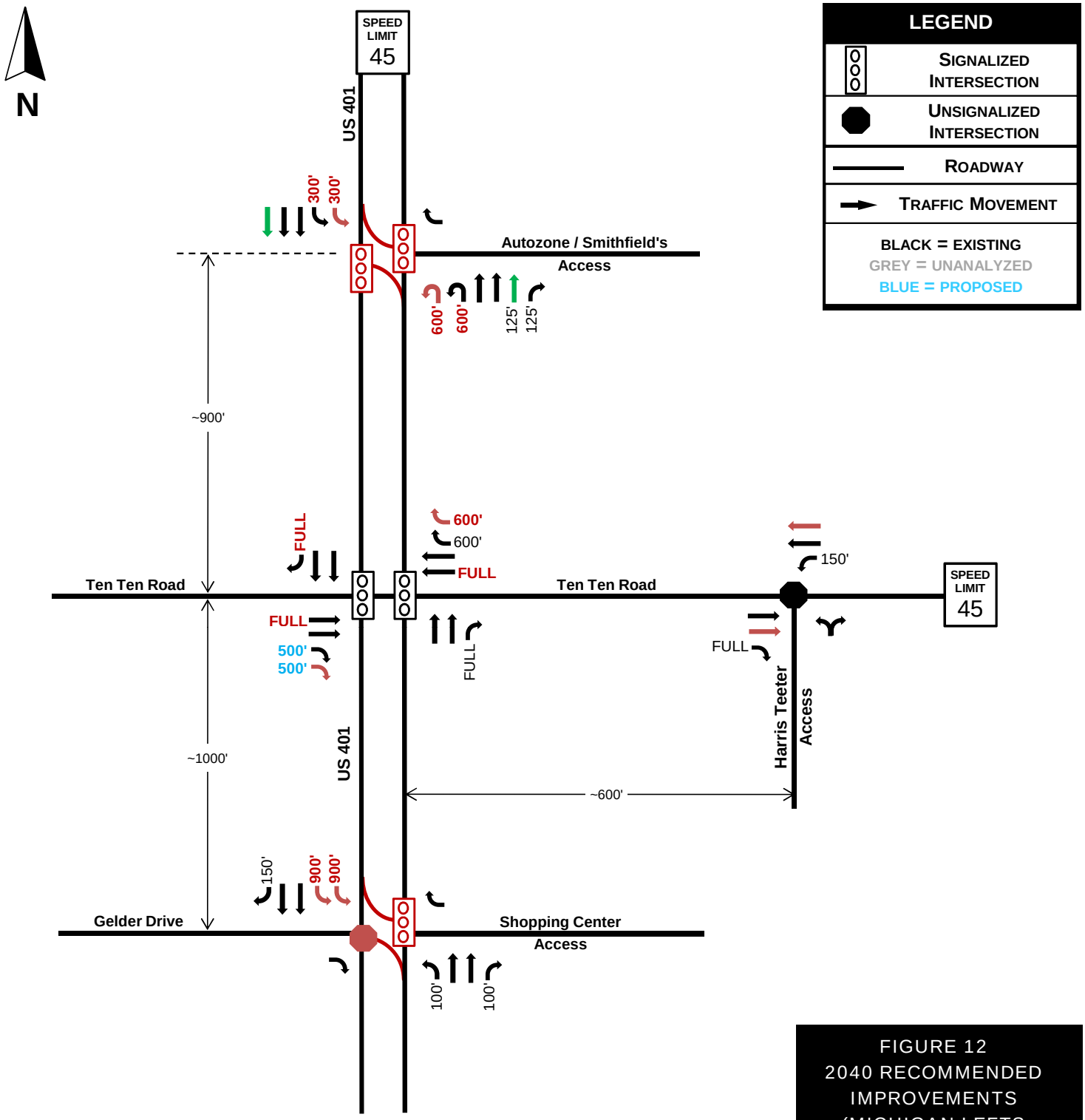

FIGURE 12
2040 RECOMMENDED IMPROVEMENTS (MICHIGAN LEFTS OPTION)

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

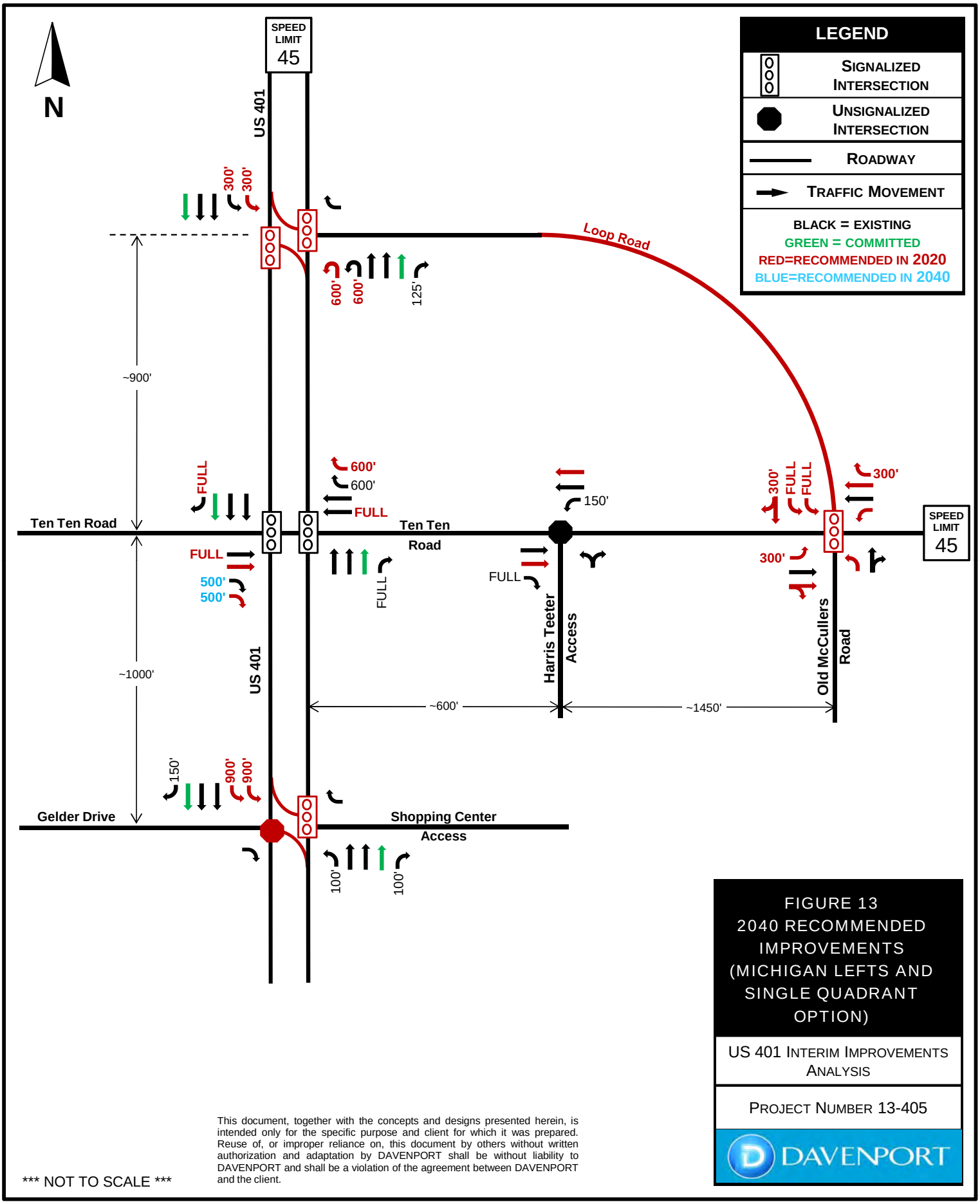

FIGURE 13
2040 RECOMMENDED IMPROVEMENTS (MICHIGAN LEFTS AND SINGLE QUADRANT OPTION)

US 401 INTERIM IMPROVEMENTS ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

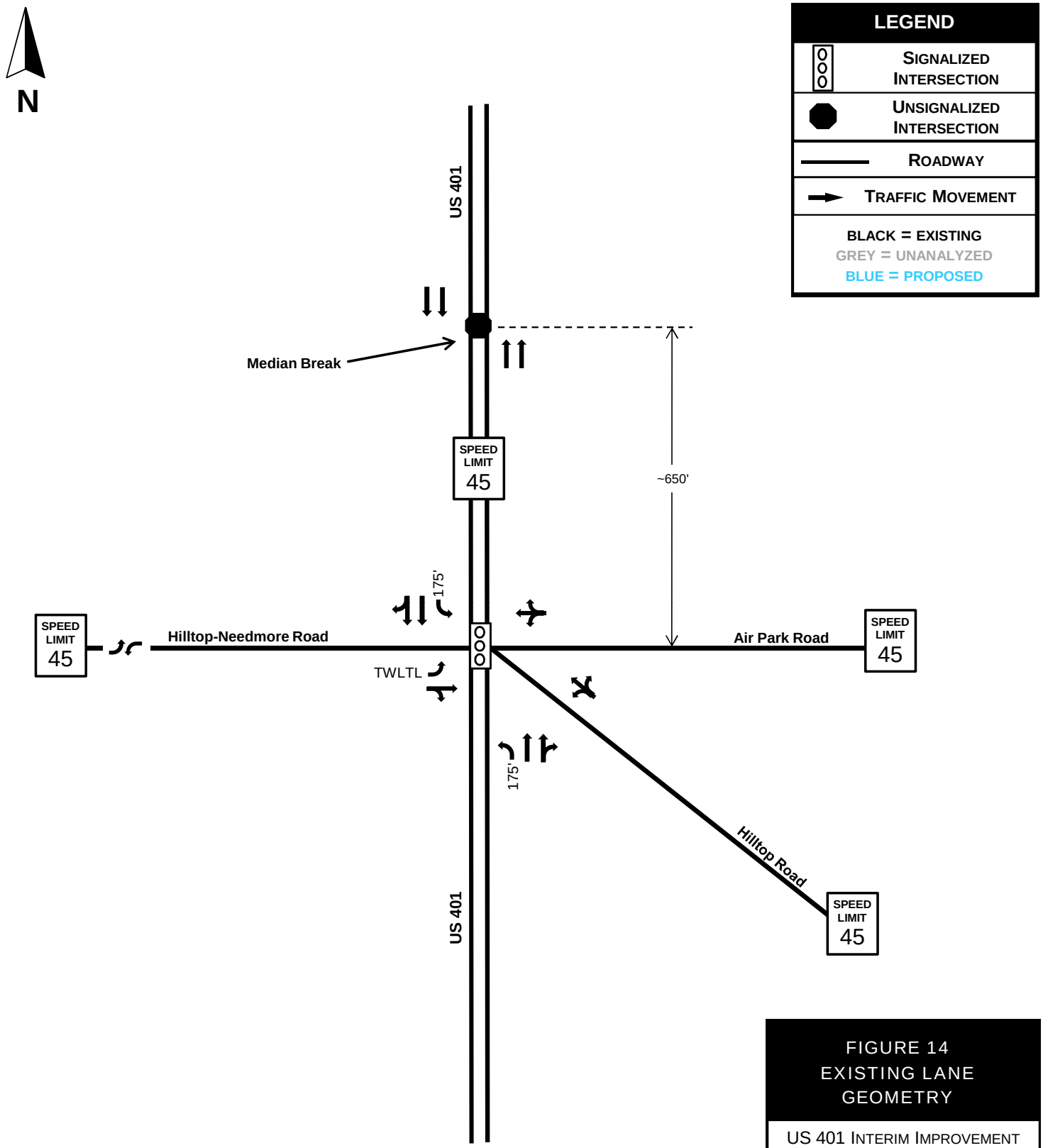

FIGURE 14
EXISTING LANE GEOMETRY

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

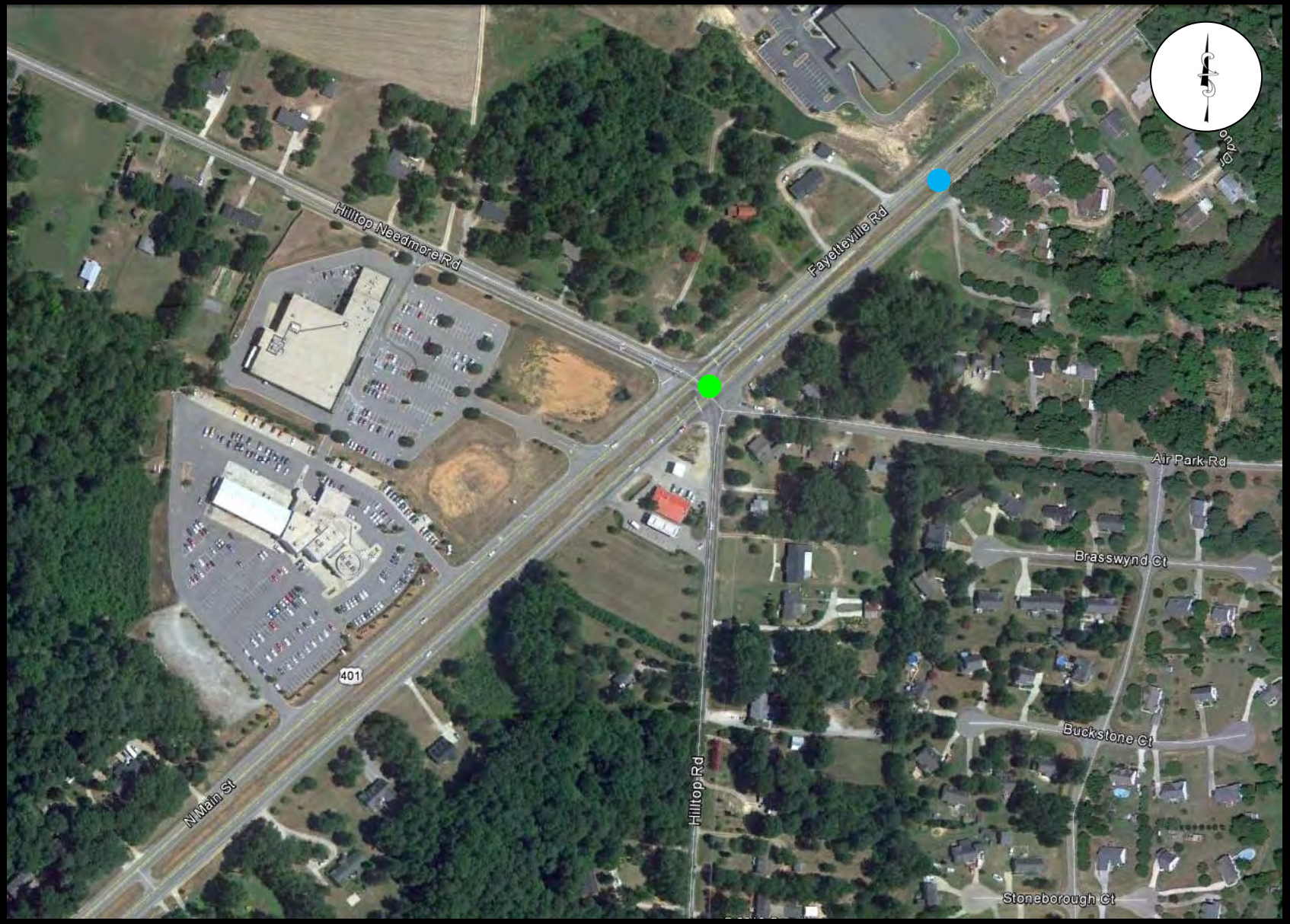

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Figure 15
US 401 & Hilltop
Needmore Road

Proposed Count Locations
- 16-hour
- AM (7-9 am) & PM (4-6 pm)

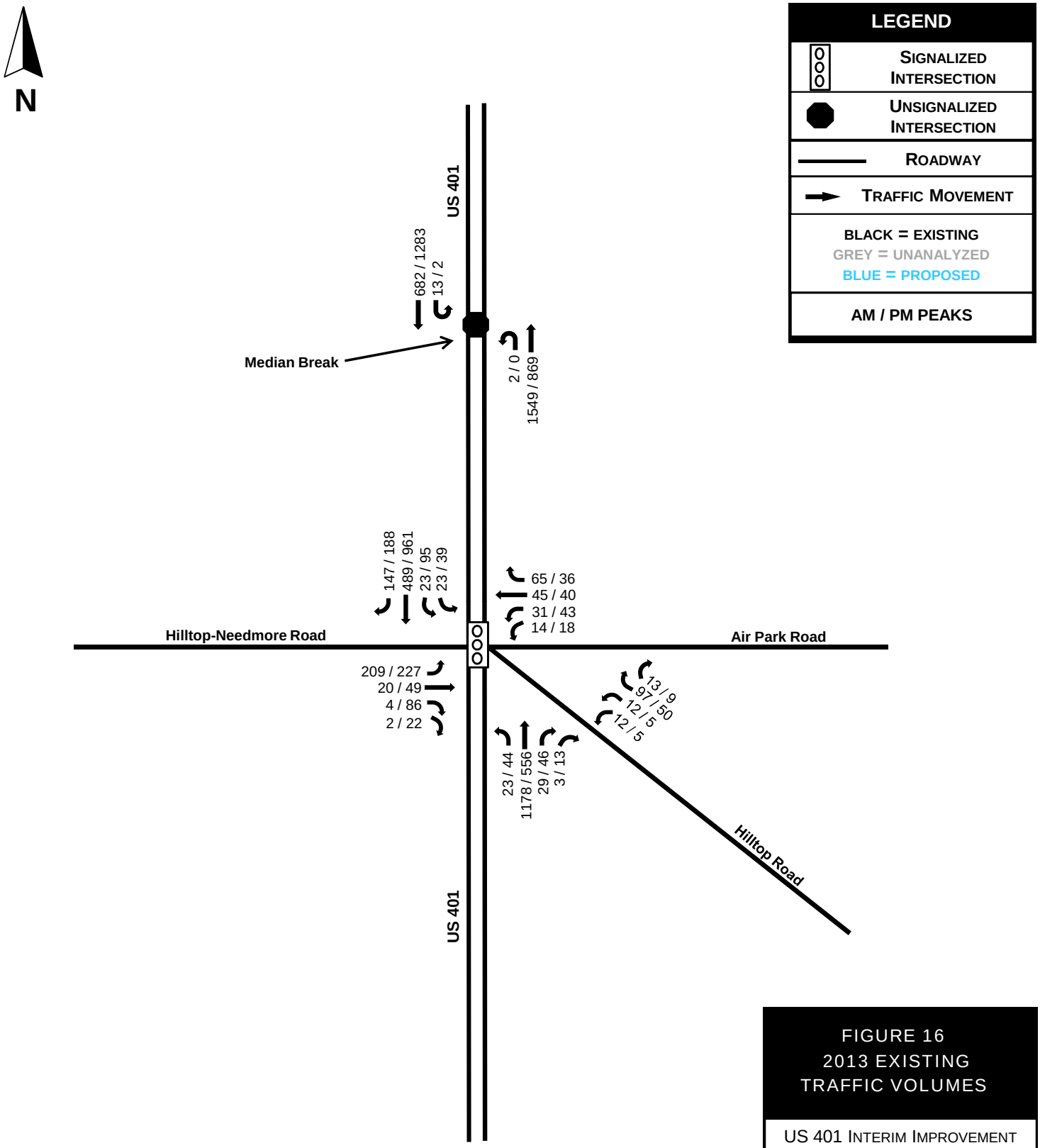

FIGURE 16
2013 EXISTING
TRAFFIC VOLUMES

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

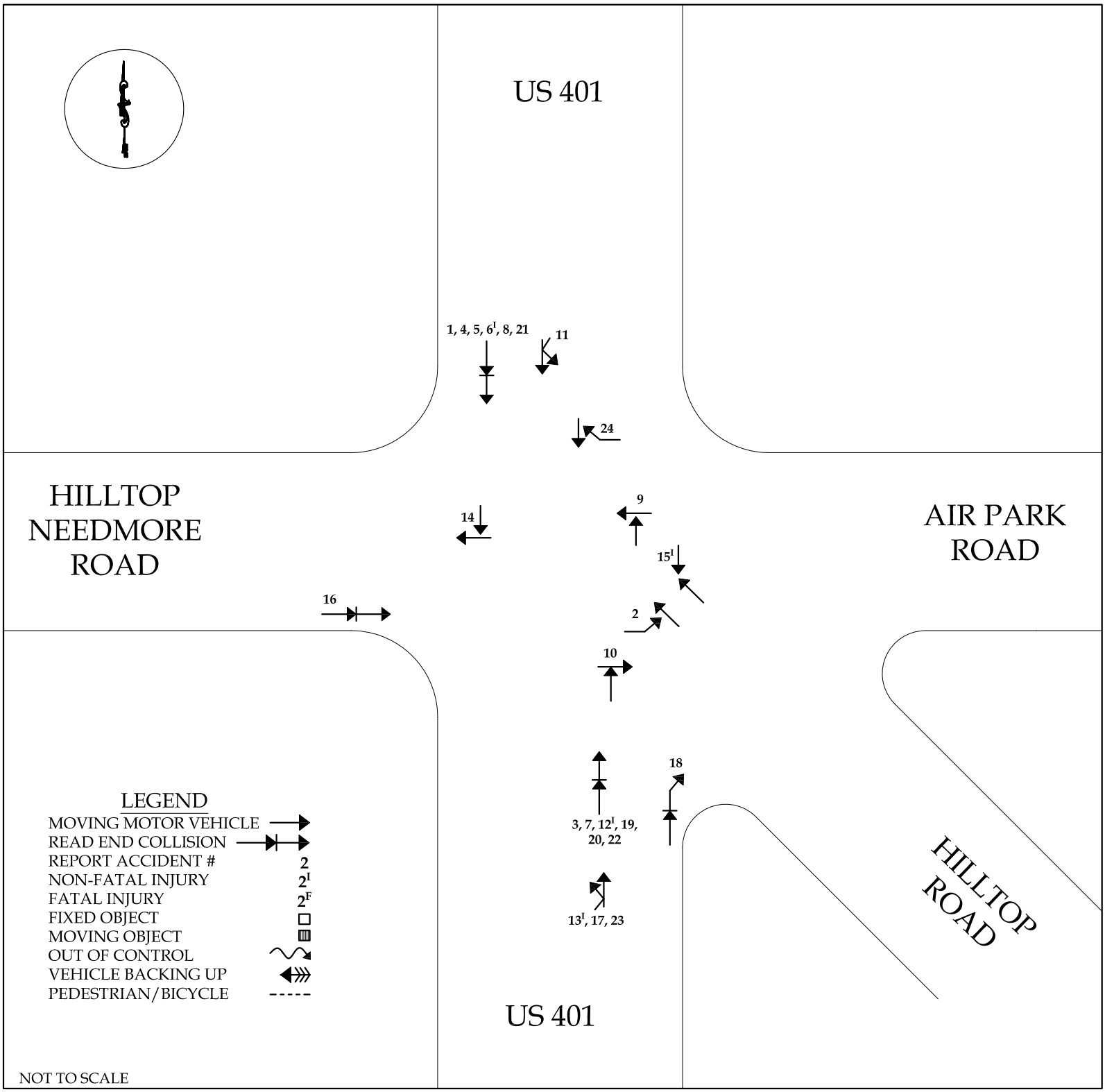

Figure 17. US 401 & Hilltop-Needmore Road Collision Diagram

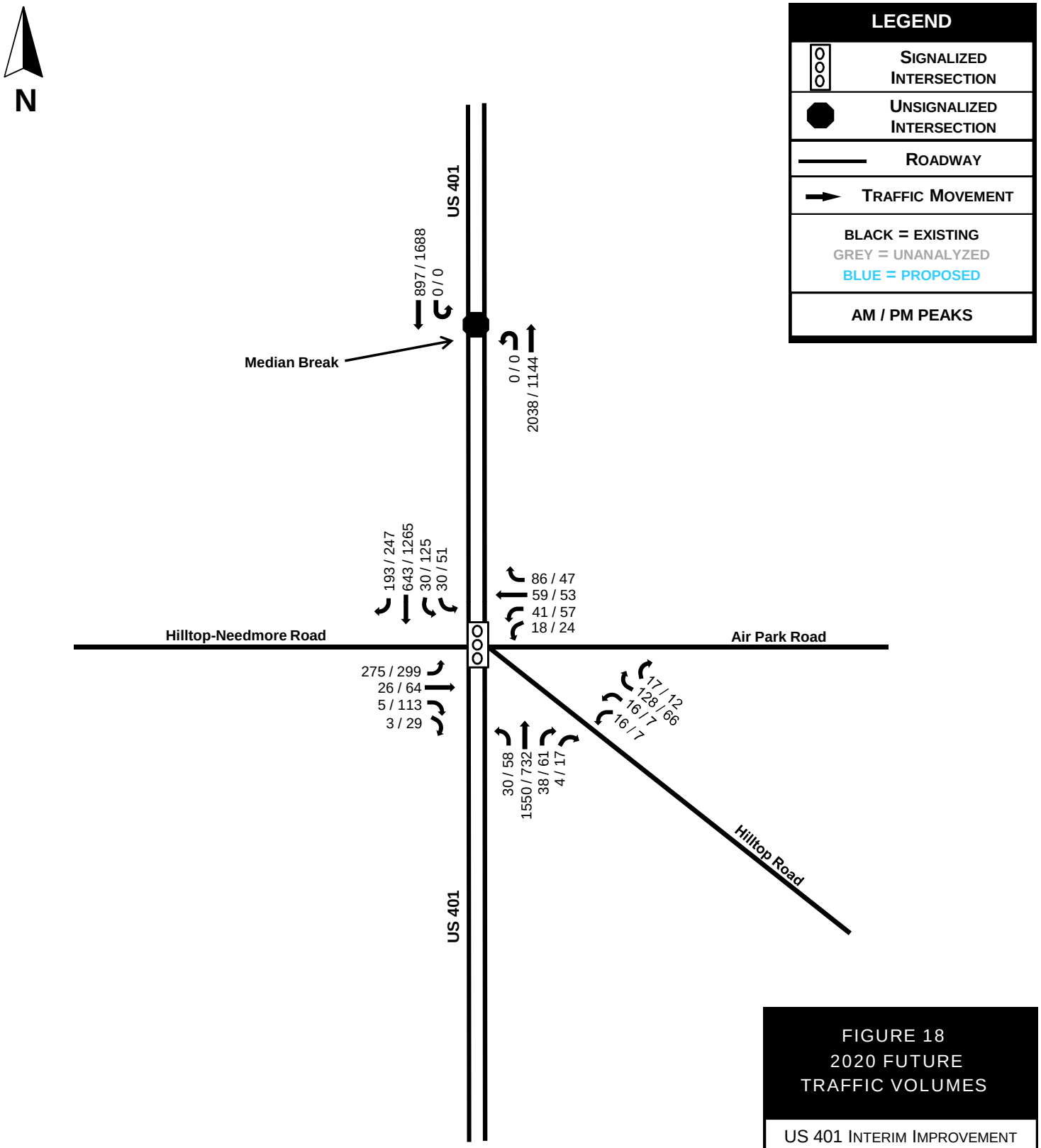

FIGURE 18
2020 FUTURE
TRAFFIC VOLUMES

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

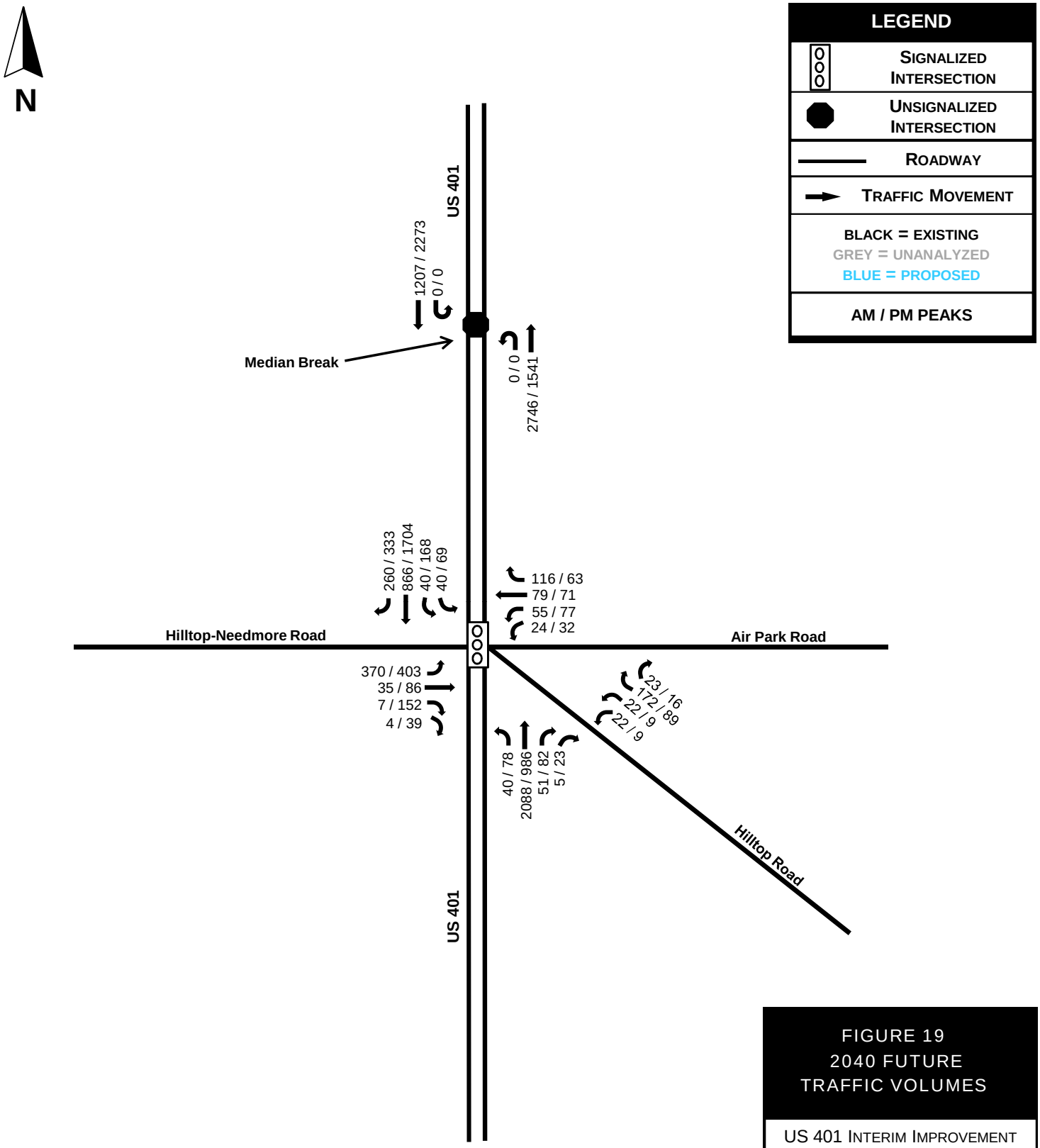

FIGURE 19
2040 FUTURE
TRAFFIC VOLUMES

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

Figure 20 - US 401 & Hilltop-Needmore Road Road-of-Way Map

N

0 100 200 400 Feet

1 inch = 200 feet

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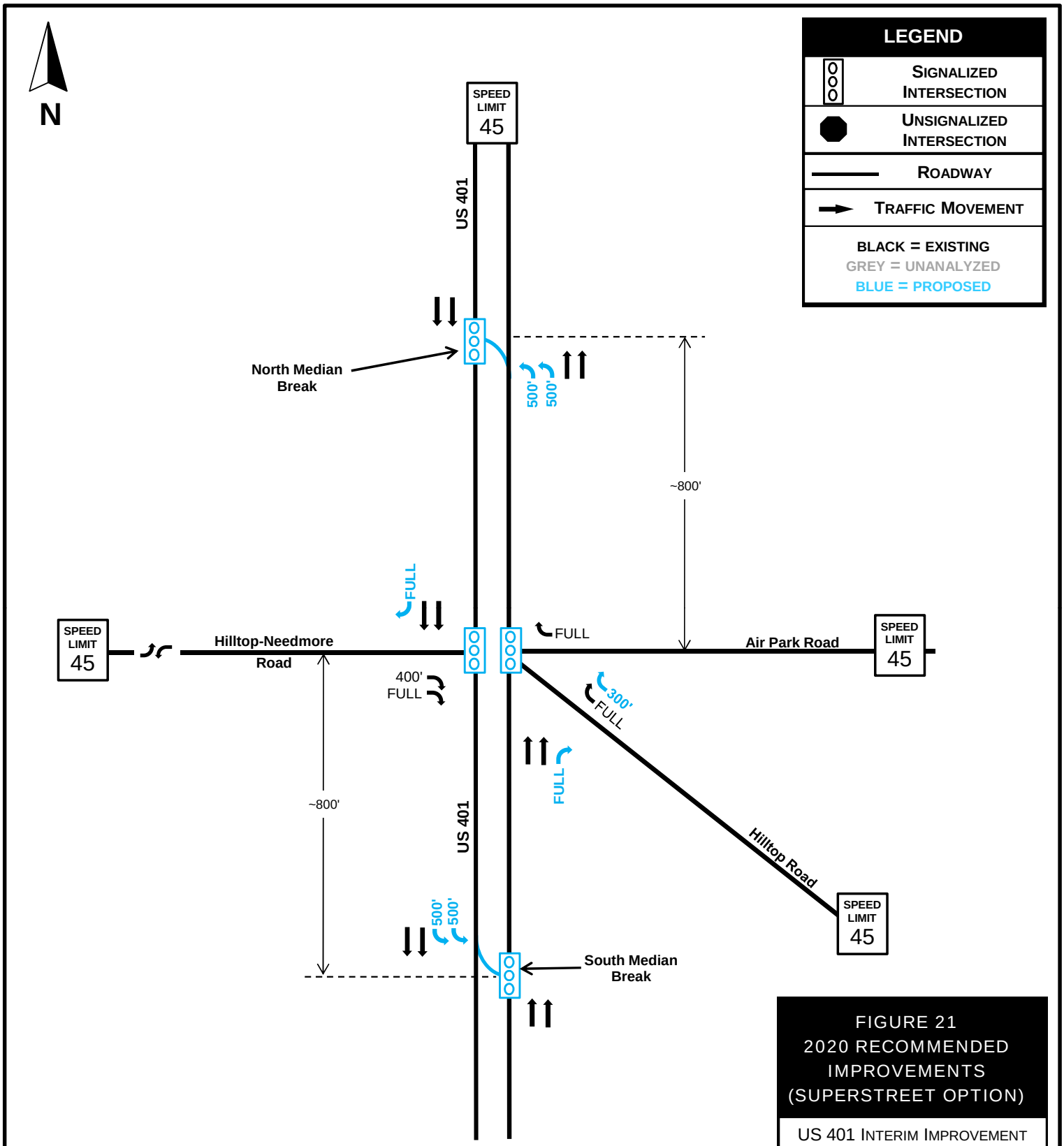

FIGURE 21
2020 RECOMMENDED IMPROVEMENTS
(SUPERSTREET OPTION)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

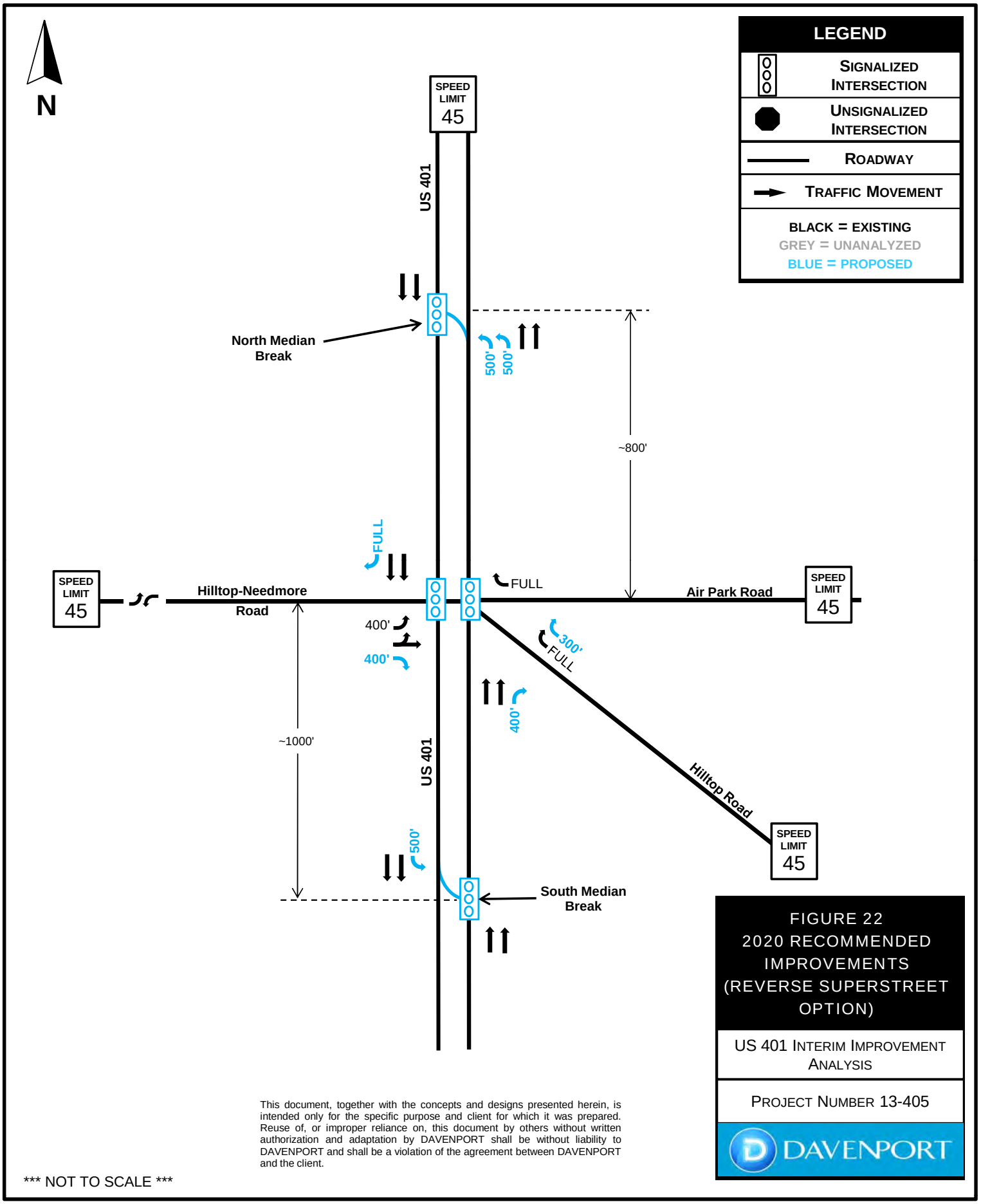

FIGURE 22
2020 RECOMMENDED IMPROVEMENTS (REVERSE SUPERSTREET OPTION)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

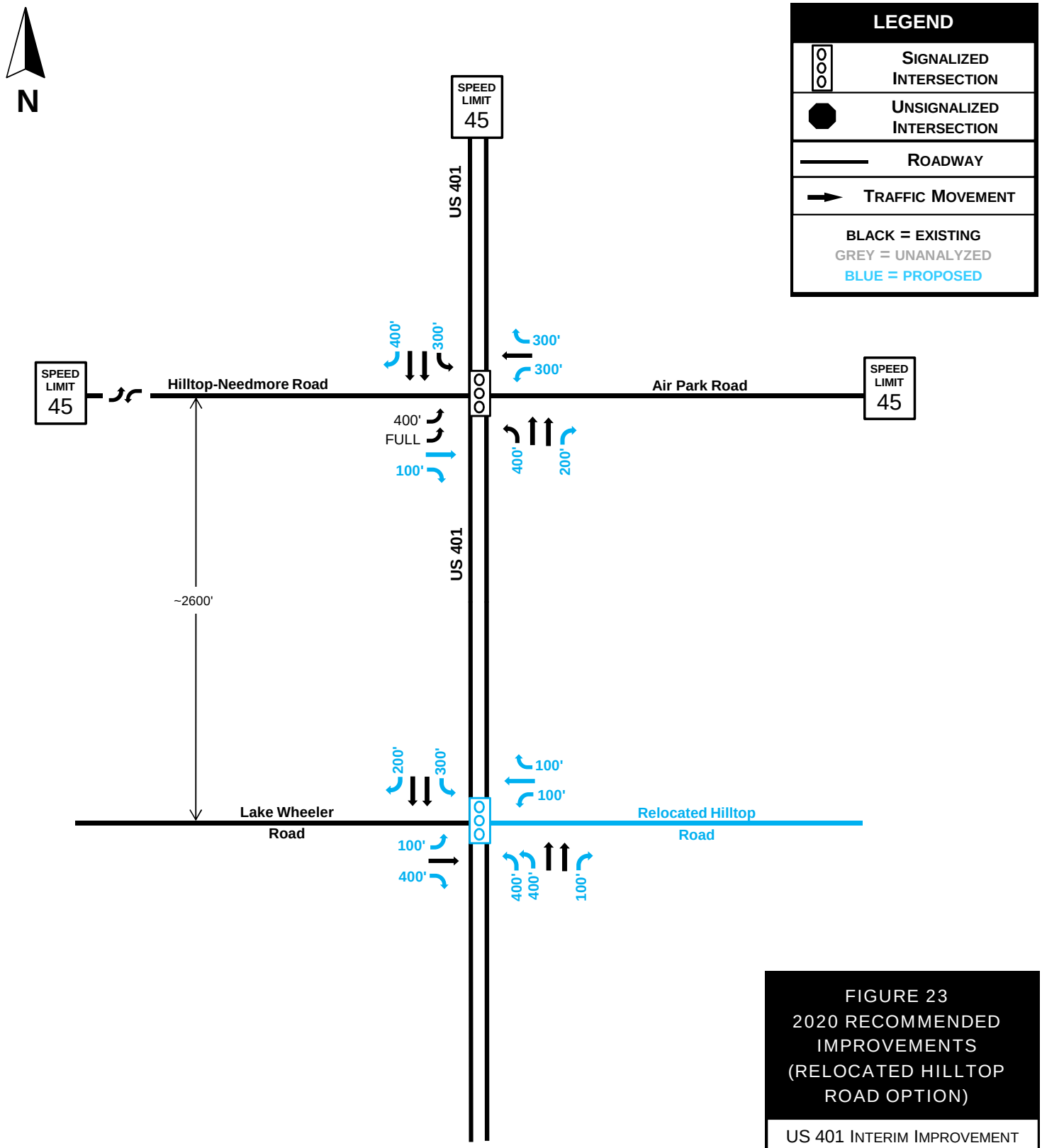

FIGURE 23
2020 RECOMMENDED IMPROVEMENTS (RELOCATED HILLTOP ROAD OPTION)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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*** NOT TO SCALE ***

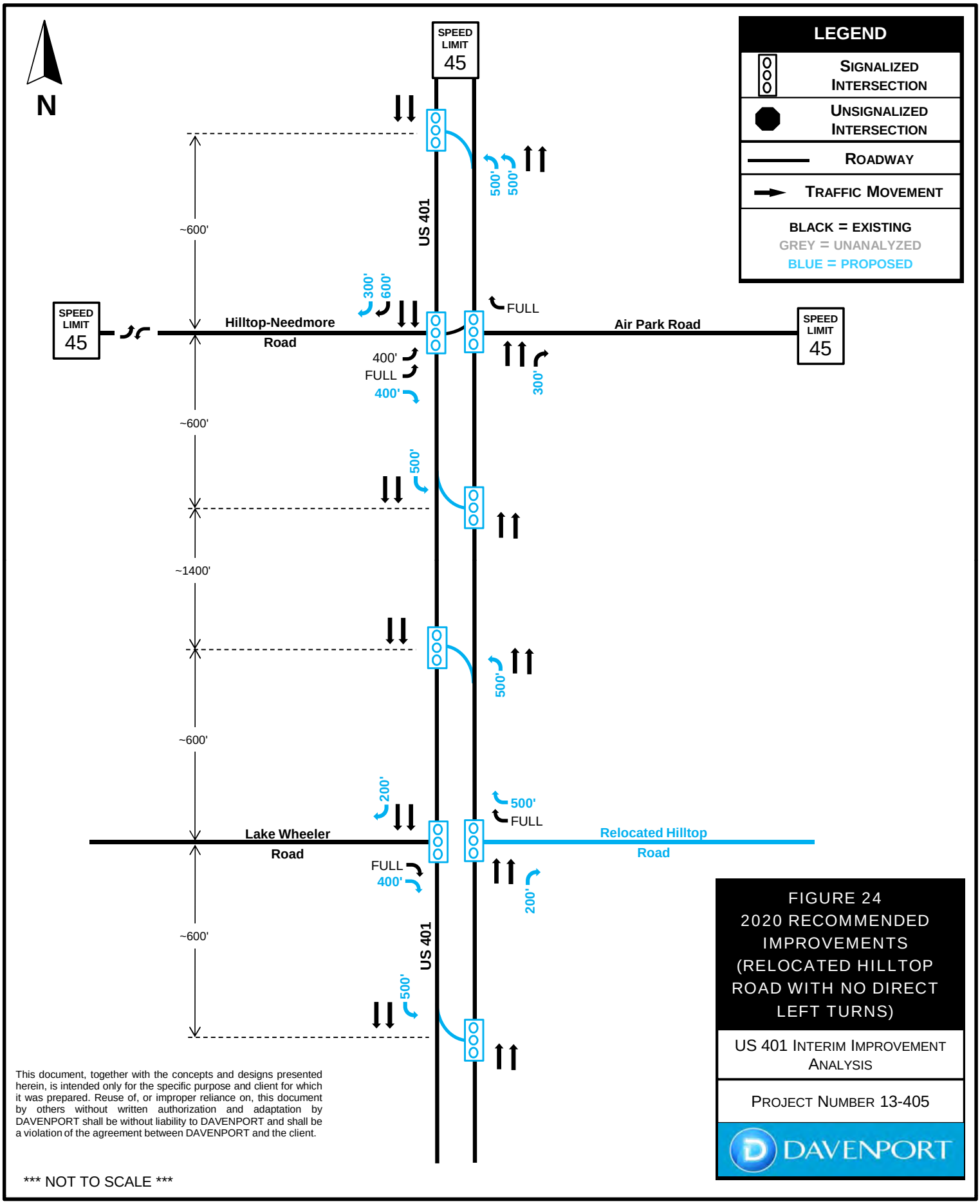

FIGURE 24
2020 RECOMMENDED IMPROVEMENTS (RELOCATED HILLTOP ROAD WITH NO DIRECT LEFT TURNS)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

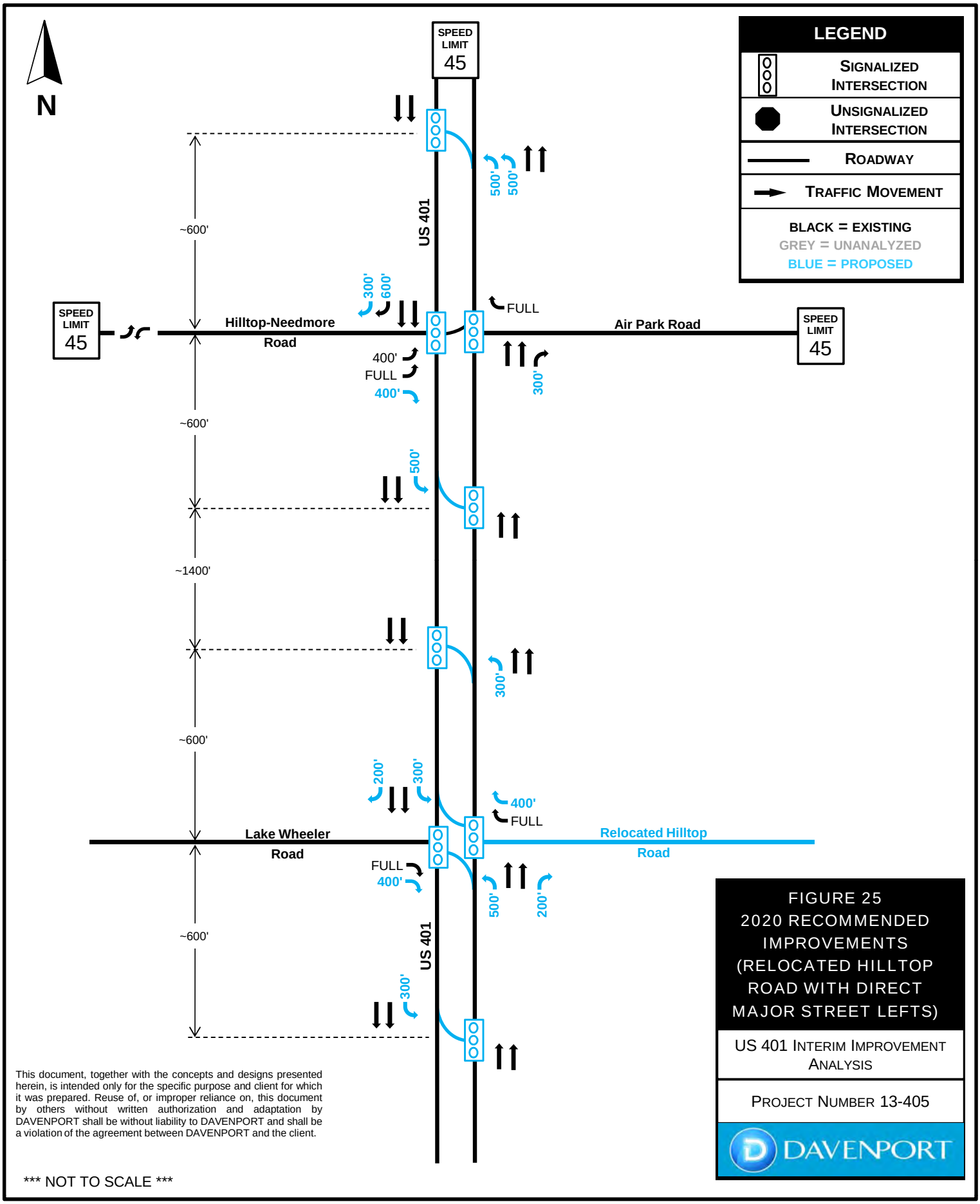

FIGURE 25
2020 RECOMMENDED IMPROVEMENTS (RELOCATED HILLTOP ROAD WITH DIRECT MAJOR STREET LEFTS)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

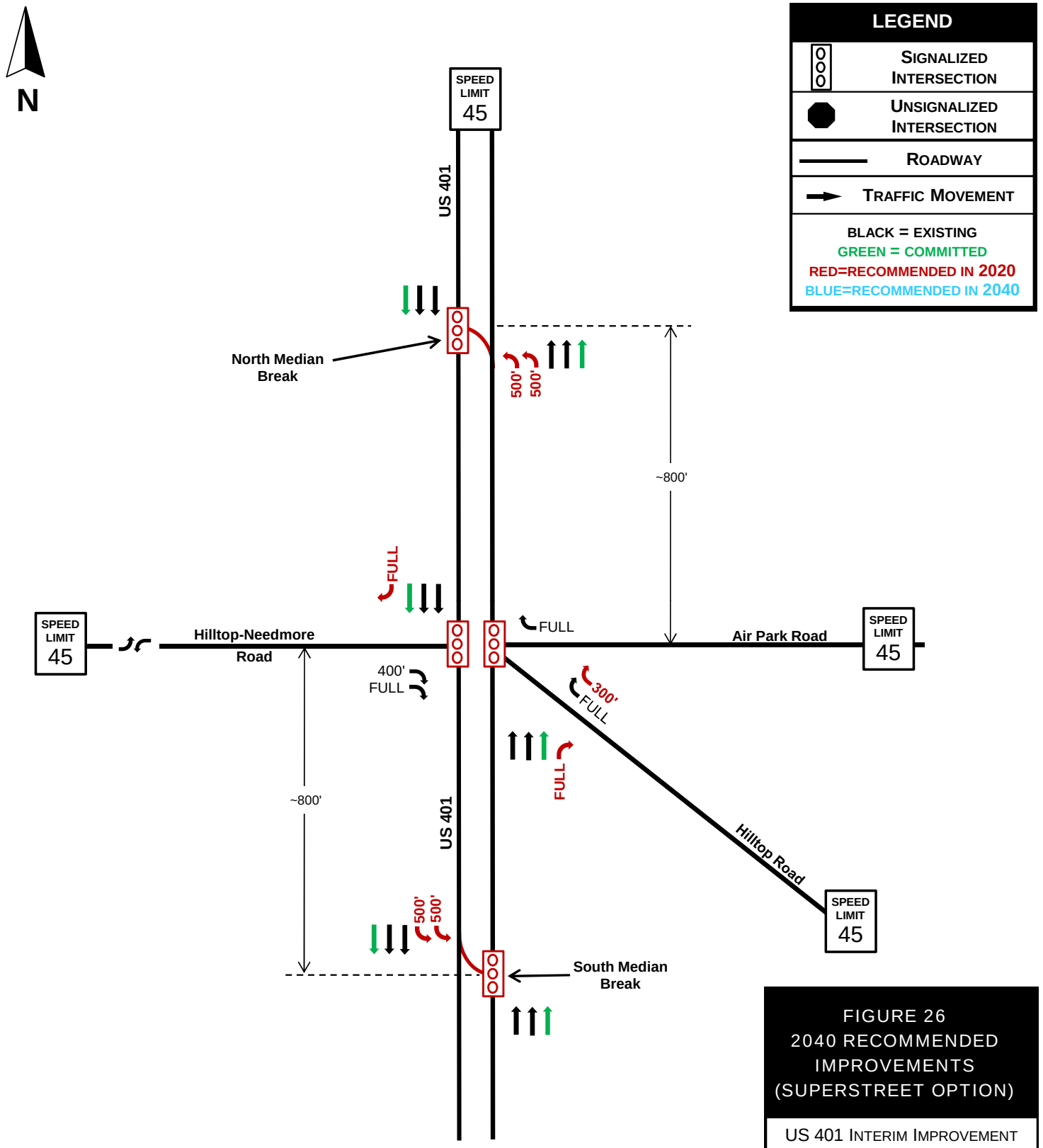

FIGURE 26
2040 RECOMMENDED IMPROVEMENTS
(SUPERSTREET OPTION)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

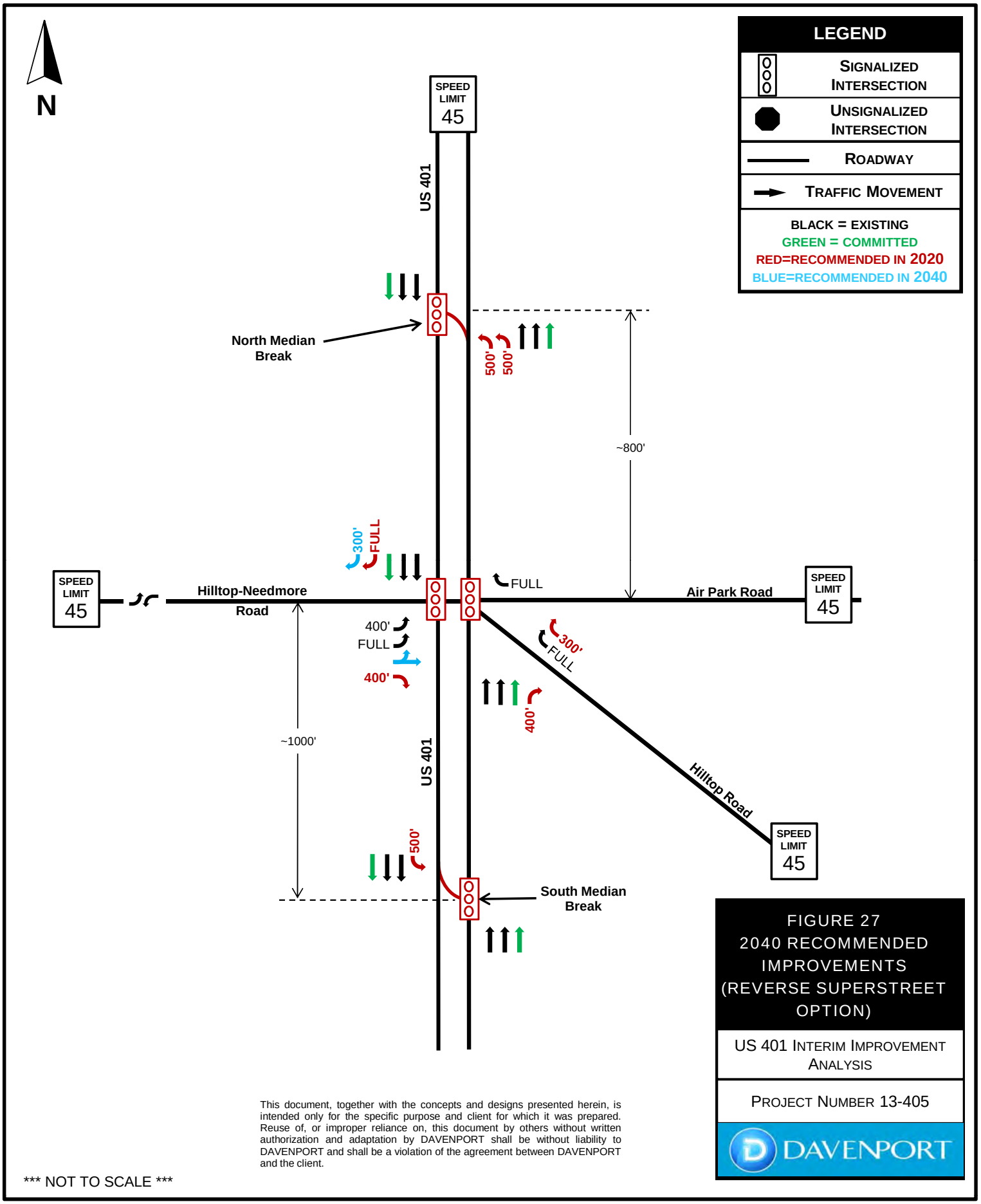

FIGURE 27
2040 RECOMMENDED IMPROVEMENTS (REVERSE SUPERSTREET OPTION)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

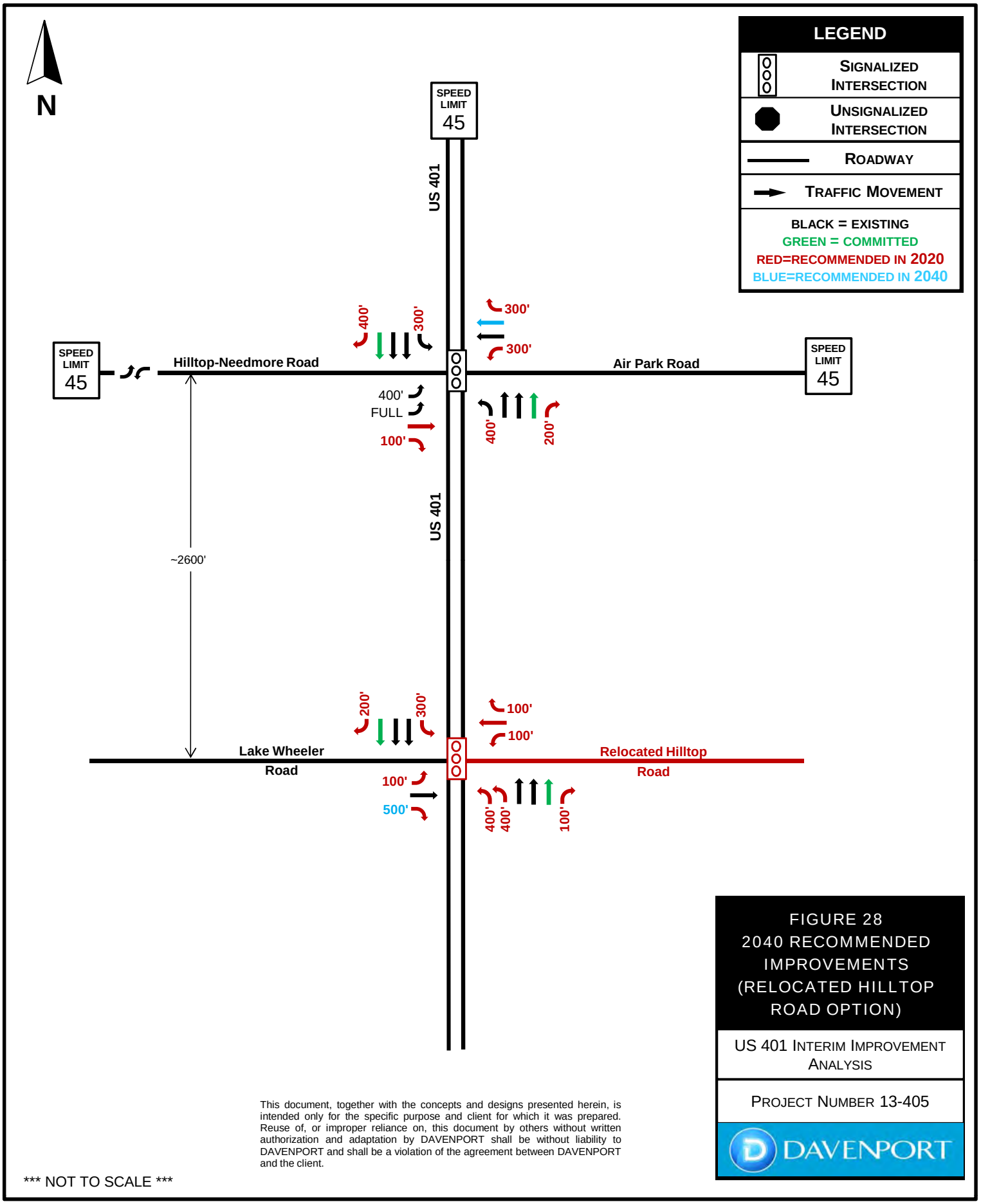

FIGURE 28
2040 RECOMMENDED IMPROVEMENTS (RELOCATED HILLTOP ROAD OPTION)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

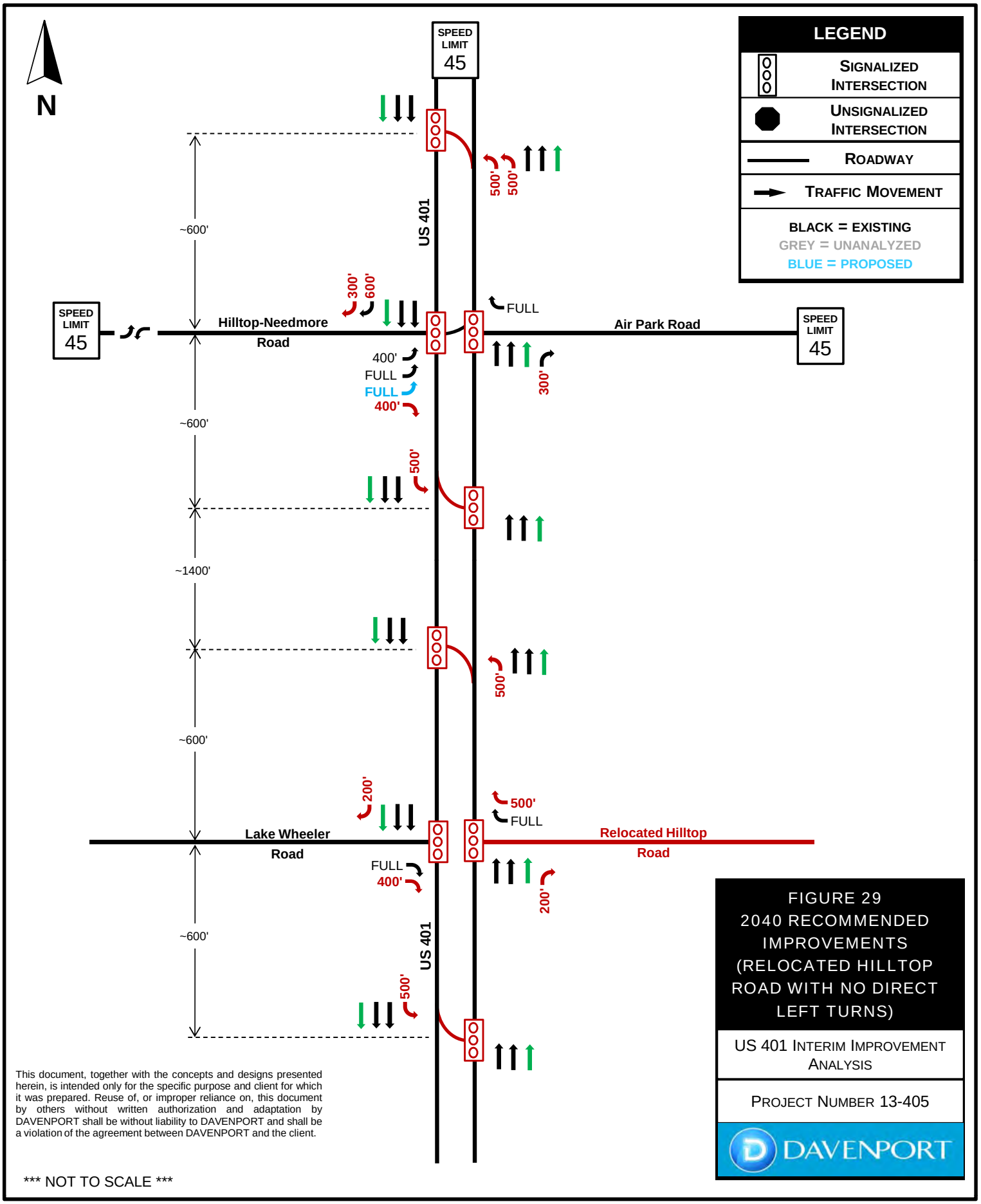

FIGURE 29
2040 RECOMMENDED IMPROVEMENTS (RELOCATED HILLTOP ROAD WITH NO DIRECT LEFT TURNS)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

DAVENPORT

*** NOT TO SCALE ***

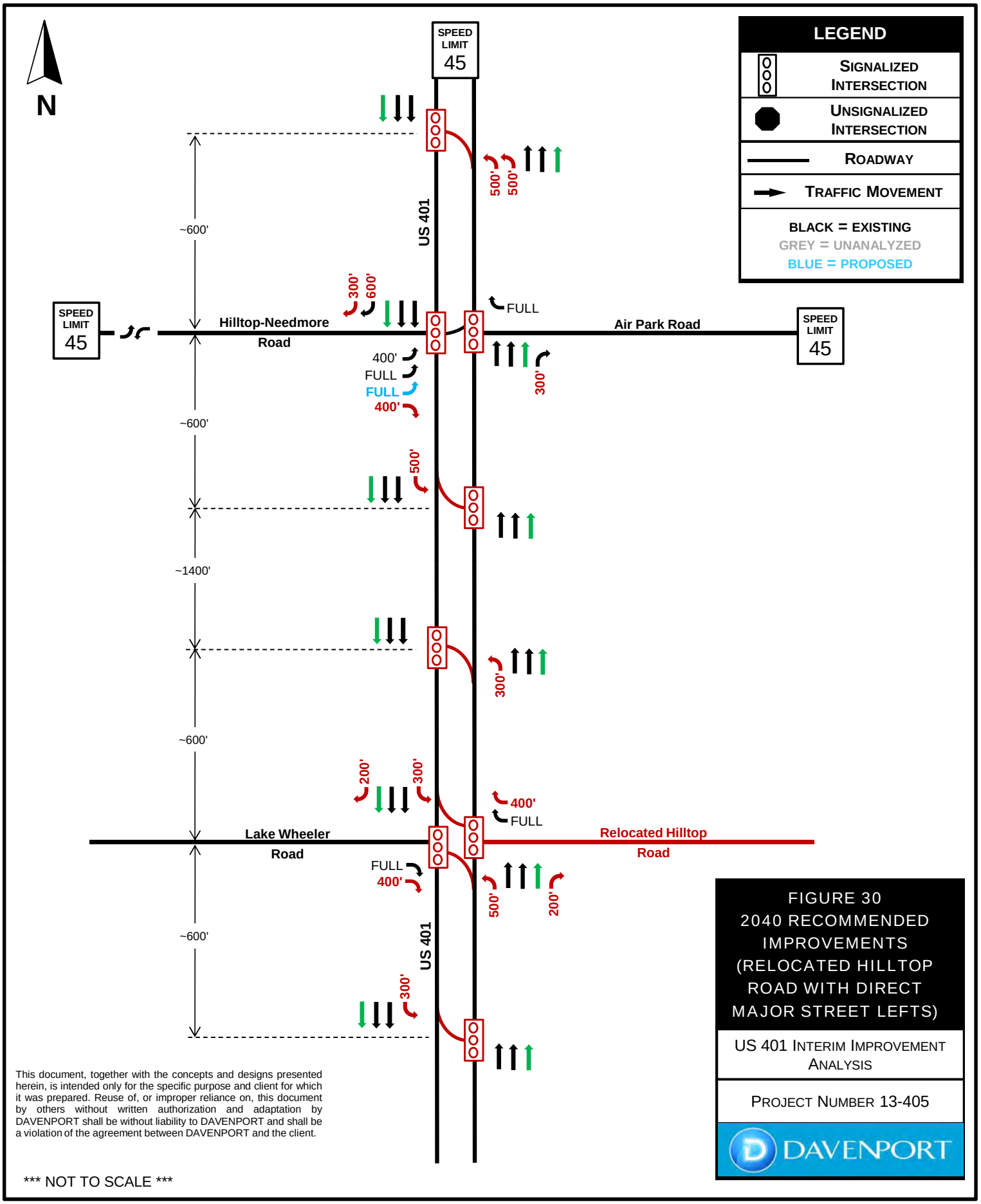

FIGURE 30
2040 RECOMMENDED IMPROVEMENTS (RELOCATED HILLTOP ROAD WITH DIRECT MAJOR STREET LEFTS)

US 401 INTERIM IMPROVEMENT ANALYSIS

PROJECT NUMBER 13-405

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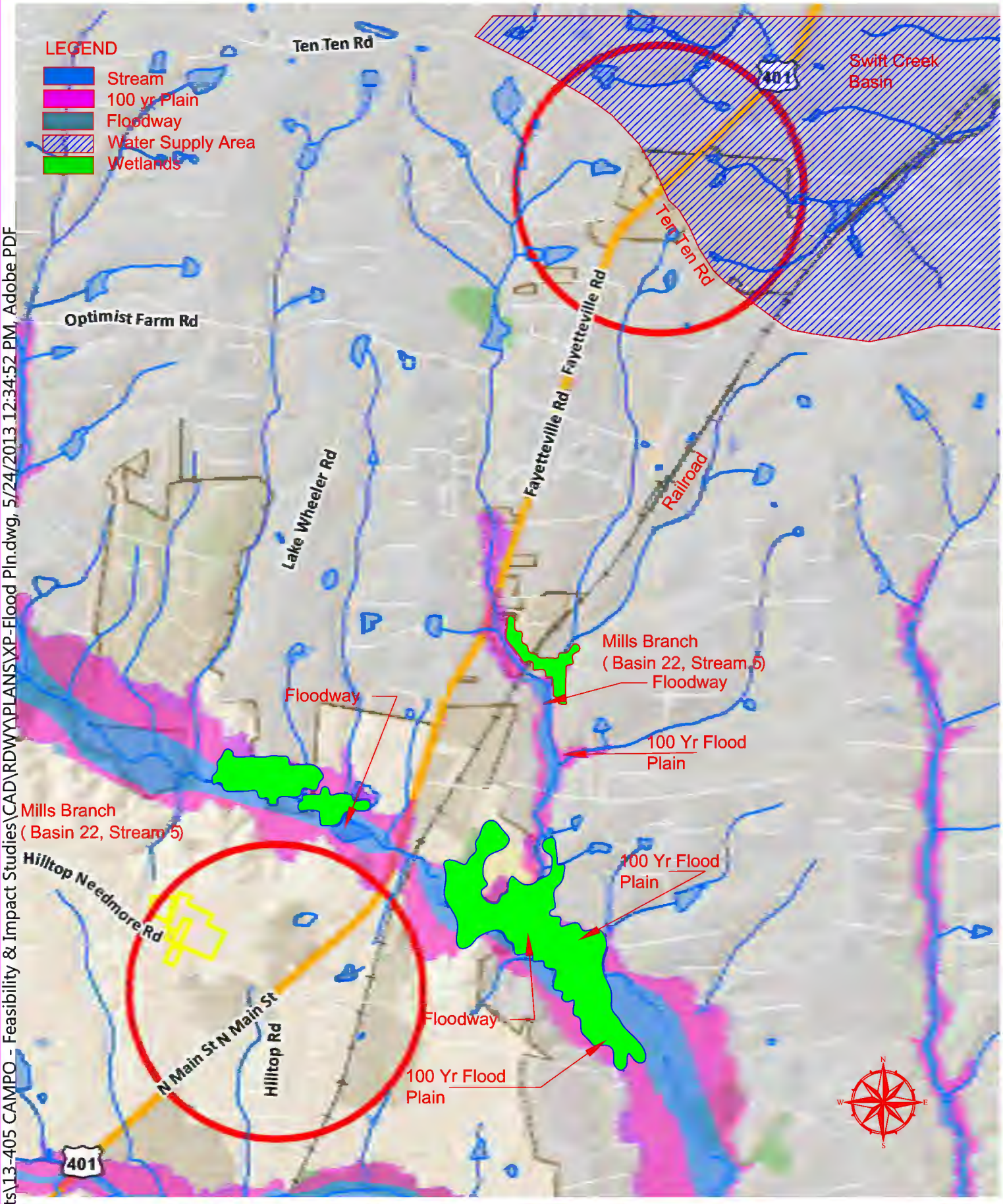

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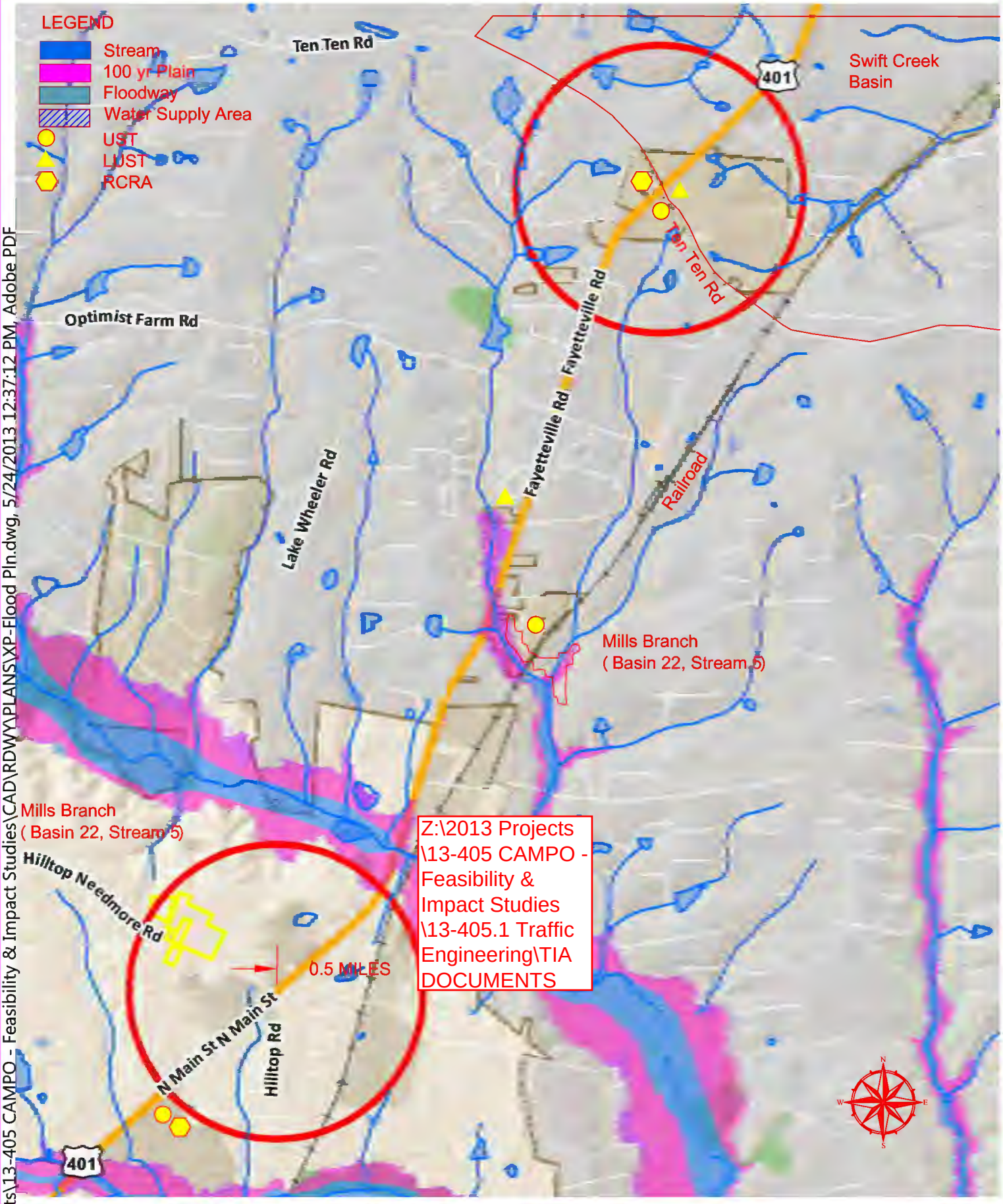
WATER FEATURES	US 401 HILLTOP-NEEDMORE ROAD	CAPITAL AREA MPO 127 W HARGETT ST., SUITE 800 RALEIGH, NC 27601 P: (919) 996-4392 F: (919)	PROJECT: 13–405 DATE: 05/21/13 DESIGNED BY: WVP DRAWN BY: WVP CHECKED BY: DH SCALE: AS NOTED	DAVENPORT HOME OFFICE 305 WEST FOURTH STREET, SUITE 2A (27101) PO BOX 4131, WINSTON-SALEM, NC 27115-4131 336.744.1636 www.davenportworld.com NCBELS FIRM LICENSE NO. C-2522	FIGURE Figure 31



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ENVIRONMENTAL FEATURES	US 401 HILLTOP-NEEDMORE ROAD	CAPITAL AREA MPO 127 W HARGETT ST., SUITE 800 RALEIGH, NC 27601 P: (919) 996-4392 F: (919)	PROJECT: 13–405 DATE: 05/21/13 DESIGNED BY: WVP DRAWN BY: WVP CHECKED BY: DH SCALE: AS NOTED	DAVENPORT HOME OFFICE 305 WEST FOURTH STREET, SUITE 2A (27101) PO BOX 4131, WINSTON-SALEM, NC 27115-4131 336.744.1636 www.davenportworld.com NCBELS FIRM LICENSE NO. C-2522	Figure 32