



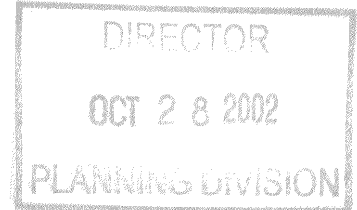
U.S. Department  
of Transportation  
**Federal Highway  
Administration**

*B. Hart / Ms. Ashby*

Tennessee Division Office  
640 Grassmere Park  
Nashville, TN 37211

October 25, 2002

Mr. Dennis Cook  
Assistant Chief Engineer for Planning  
Tennessee Department of Transportation  
Nashville, Tennessee 37243-0349



Dear Mr. Cook:

Subject: Interchange Modification Request for Interstate 24/440 at  
U.S. 41 (Murfreesboro Pike)  
Davidson County

An Interchange Modification Study and request for approval of revised Interstate access was submitted for the subject project. The existing I-24 and U.S. 41 (Murfreesboro Pike) interchange has an eastbound entrance loop ramp and eastbound exit loop ramp located approximately 950 feet apart on I-24. During the morning and evening peak hours, it is typical that queues develop within this weave section and traffic backs up beyond the major diverge of Interstate 24 and 40. This location was identified as a "Choke Point" by the Congestion Management Committee established by the Strategic Planning Goal 2 Team.

The recommended improvement includes the removal of the entrance loop ramp from westbound U.S. 41 onto I-24/440 thereby eliminating the weave section between the exit loop ramp to eastbound U.S. 41. Traffic from westbound U.S. 41 entering eastbound I-24 and westbound I-440 will turn left at a proposed traffic signal and utilize the existing entrance ramp from eastbound U.S. 41.

Based on an engineering review of the Interchange Modification Study, the proposed modification is considered operationally acceptable. Final approval of the modifications may be given upon completion of the National Environmental Policy Act (NEPA) procedures.

Sincerely,

*Mark A. Doctor*

Mark A. Doctor  
Field Operations Team Leader

# ***INTERCHANGE MODIFICATION STUDY***



***Interstate 24/440  
and  
U.S. 41 (Murfreesboro Pike)  
Davidson County  
Nashville, Tennessee***

***PREPARED BY  
CLINARD ENGINEERING ASSOCIATES, LLC  
BRENTWOOD, TENNESSEE  
FOR  
THE TENNESSEE DEPARTMENT OF TRANSPORTATION  
PLANNING DIVISION***

August 2002

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## CHAPTER 1

### Introduction

#### A. Purpose of Study

The purpose of this study is to evaluate the existing interchange at Interstate 24/440 and U.S. 41 (Murfreesboro Pike), and to request the approval for modifications of this interchange to improve its operation and safety. Goals of this project include reduced congestion and reduced crashes by attempting to eliminate the existing weave segments and conflict points within the subject interchange area.

This study was conducted to:

- Determine any operational deficiencies in the current interchange.
- Develop the needed interchange improvements to provide the desired level of service for the design year.
- Evaluate operational characteristics of the proposed improvements for the current conditions (2005) and the design year (2025).
- Develop construction cost estimates and evaluate the land use impacts of the construction.

#### B. Project Location and Description of the Area

The I-24/440 & U.S. 41 interchange is located in the southeastern portion of Nashville within the existing multidirectional interchange of I-40 and I-24/440, as shown in Figure 1. The interchange is located 0.36 miles south of the I-40/24 diverge (Photo 1) and 0.55 miles north of the I-24/440 interchange. The study section of I-24/440 is currently two-lane median-divided with one auxiliary lane between the entrance and exit loop ramps to U.S. 41 and from the eastbound entrance ramp from U.S. 41 to Interstate 440.

Within the vicinity of the subject interchange, Interstate 40 and 24/440 over the years has been widened to nearly the limits of available right-of-way. With these various widening projects, an effort has been made to barrier separate as many movements as possible to help reduce congestion caused by the numerous weaving maneuvers required by motorists that travel this busy segment of interstate.

As part of an effort by the Tennessee Department of Transportation to eliminate congestion along the interstate system, in particular in the urban areas of Tennessee, the subject location was identified as one of the “choke-points” in the state which consistently causes motorists delay and safety concerns.



Photo 1: Major Diverge of Interstate 40 and 24 North of the Study Area

As mentioned previously, this “choke-point” is located along the southern leg of the multidirectional interchange of Interstate 40 and 24/440 (Figures 2 and 3). In the design year of 2025, it is projected that over 247,000 vehicles per day will utilize this interchange with nearly ten (10) percent of those vehicles being trucks.

Adding to the complexity of the interchange, service to and from the major urban arterial of U.S. 41 (Murfreesboro Pike) occurs to provide local access for 65,000 vehicles per day in the design year. Murfreesboro Pike (Photo 2) is a four-lane depressed median divided roadway within the limits of the study area with an eastbound entrance loop ramp and eastbound exit loop ramp located approximately 950 feet apart on I-24/440. It is the weave that occurs between these ramps that will be the focus of this study and operation analysis will be discussed in further detail in Chapter 3. Both of these existing loop ramps are posted at twenty-five (25) miles per hour, with the exit loop ramp sight distance severely reduced due to the rock cut in which this ramp travels through (see Photo 3).

During both the morning and evening peak hours, it is fairly typical to observe queues that develop along this weave segment of I-24/440 back to the major diverge of Interstate 24 and 40.

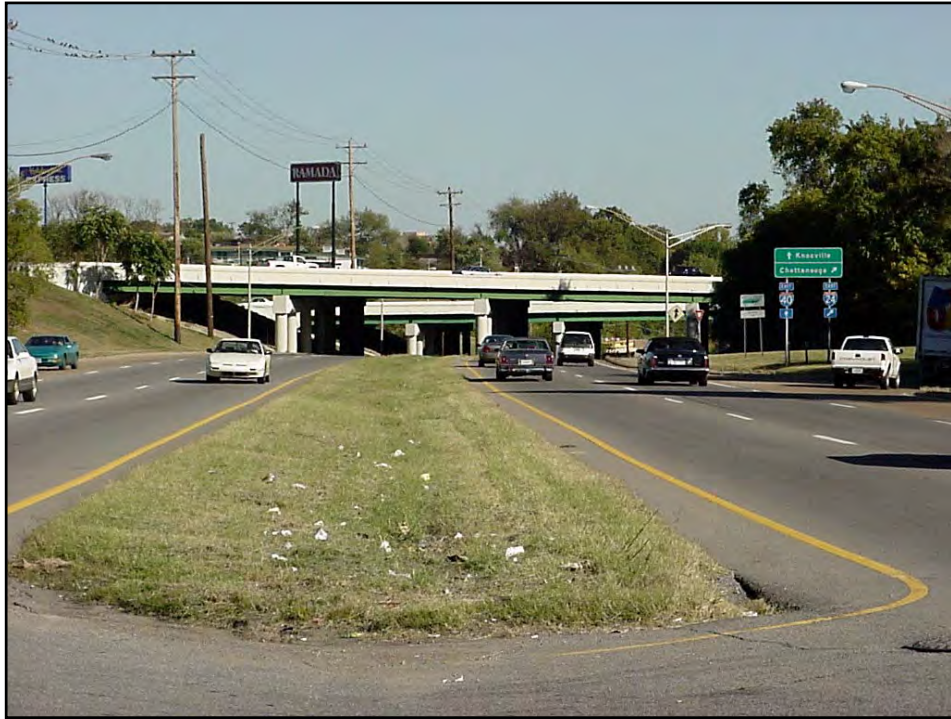
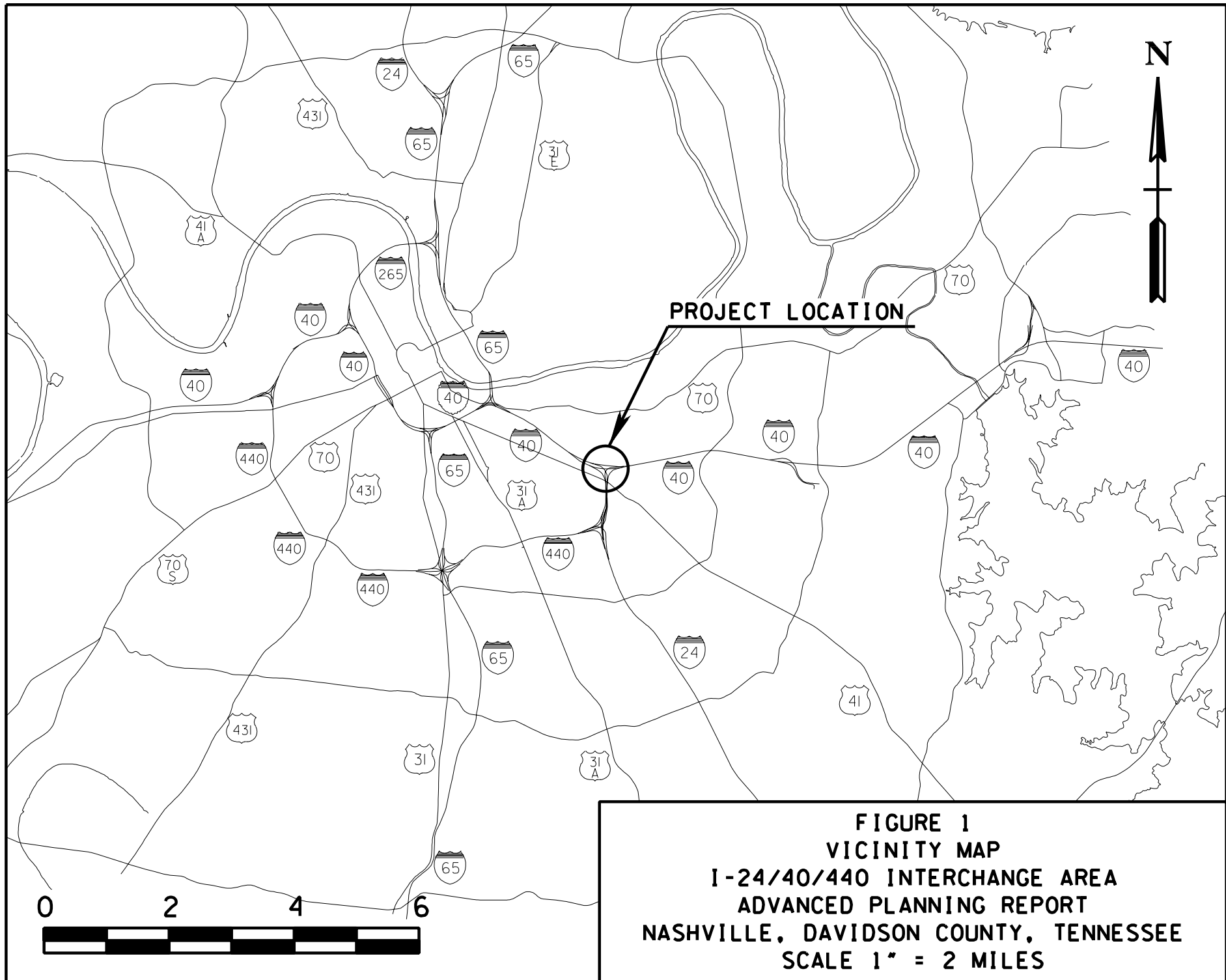


Photo 2: View Along U.S. 41 (Murfreesboro Pike) Towards the East

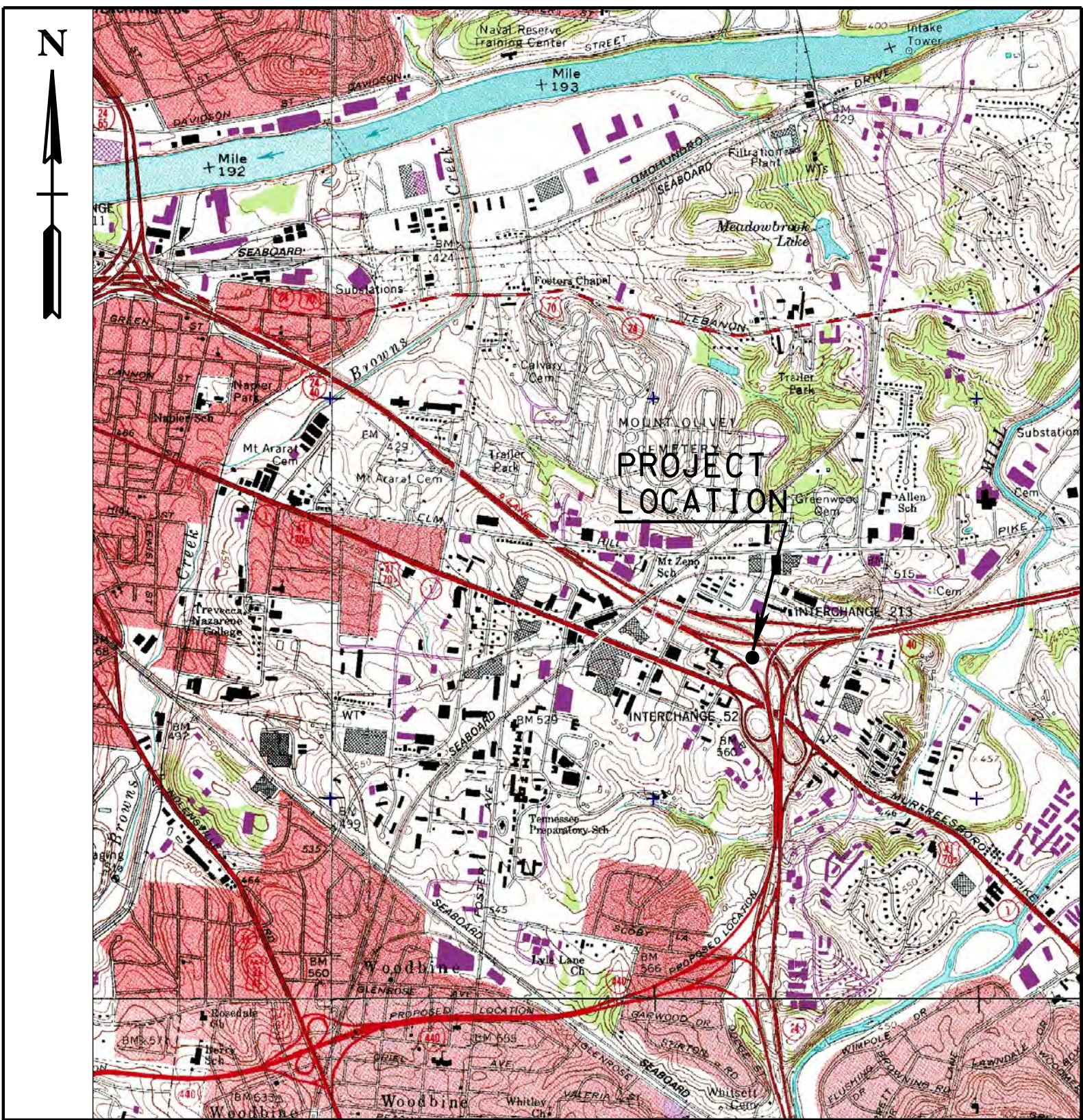


Photo 3: Eastbound I-24/440 & U.S. 41 (Murfreesboro Pike) Exit Loop Ramp









**FIGURE 3**  
**I-24/40/440 INTERCHANGE AREA**  
**ADVANCED PLANNING REPORT**  
**USGS "NASHVILLE EAST" QUAD**  
**NASHVILLE, DAVIDSON COUNTY, TENNESSEE**  
**SCALE 1" = 2000 FT.**



**C. Relationship to Other Highway Improvement Programs and Plans**

The Tennessee Department of Transportation in cooperation with the Federal Highway Administration (FHWA) currently has plans under design to improve various ramp connections within this study area as well as widen Interstate 40 from the multidirectional interchange eastward to SR-155 (Briley Parkway). It is also important to note that the FHWA has recently approved the modification of the existing I-40 and Spence Lane interchange. This modification will provide an entrance ramp from Spence Lane to eastbound I-40, which is not provided with the current configuration.

## CHAPTER 2

### Preliminary Planning Data

#### **A. Land Use**

The land use in the vicinity of the interchange is a mixture of various commercial and light industrial developments. It also includes hotels and some minor manufacturing facilities.

The majority of the developments that are located along U.S. 41 (Murfreesboro Pike) within the project limits are provided only a few access points to and from the interstate system. Primary access is provided at the subject interchange, although the existing exit loop ramp does not provide motorists the opportunity to turn left onto Murfreesboro Pike towards the west.

Access to and from the west of Nashville can be accomplished using the partial interchange of I-40/24 and Fesslers Lane. This interchange currently experiences significant congestion with a large percentage of truck traffic (17%). Access from the east of the study area can be provided at the interchange of I-40 and Spence Lane. As mentioned previously, an eastbound entrance ramp will be constructed in the future to provide the return movement for the existing westbound exiting traffic.

#### **B. Traffic Served**

The traffic data for this study was supplied by the Tennessee Department of Transportation (TDOT) and was based on proposed land use and existing conditions. The Design Hourly Volumes (DHV) for the years 2005 and 2025 are shown in Appendix A.

The year 2005 peak hour volumes are over 4,000 vehicles per hour with the design year (2025) DHV's anticipated to grow to approximately 5,600 vehicles per hour along I-24/440. The figures in Appendix A provide a complete breakdown of traffic volumes for the subject interchange for the base year (2005) and the design year (2025).

#### **C. Proposed Modifications**

The proposed modifications for the I-24/440 and U.S. 41 (Murfreesboro Pike) interchange will improve traffic flow through this historically congested segment of interstate by eliminating the existing weave section between the entrance loop ramp from westbound U.S. 41 and the exit loop ramp to eastbound U.S. 41. Westbound entrance traffic will no longer use the existing loop ramp, but will turn left at a proposed traffic signal and merge with the eastbound entrance ramp vehicles to either Interstate 24 or 440. The existing entrance loop will be removed and the remaining auxiliary lane will be extended towards the west to serve as a standard ramp taper dropping at the I-24/440 exit loop ramp to eastbound Murfreesboro Pike.



The recommended improvements also will involve removal of a large percentage of the rock cut located near the exit loop ramp and eastbound entrance ramp to I-24/440. This removal will provide improved sight distance for exiting and entering traffic (see Photo 4).



Photo 4: Existing Rock Material Between Exit Loop Ramp and Entrance Ramp

While elimination of both loop ramps would have been ideal, the proposed improvements do contain a realignment of the existing loop ramp to provide increased sight distance. Due to the skew of Murfreesboro Pike and I-24/440, as well as the close proximity of commercial establishments located in the southwest quadrant of the interchange, an exit loop ramp design speed of thirty (30) miles per hour could not be realized without significant right-of-way acquisition and business relocations.

#### U.S. 41 (Murfreesboro Pike)

As part of this project, a new signalized intersection will be constructed along Murfreesboro Pike at the eastbound entrance ramp terminal. Dual left turn lanes will be added to the westbound approach just past the I-24/440 overpass to provide for the movement that once utilized the entrance loop ramp. Construction of these turn lanes will extend for two hundred (200) feet, which should allow sufficient storage for these vehicles.

## D. Discussion of Initial Concepts

Several alternatives to improve the safety and operational inadequacies of the existing I-24/440 and U.S. 41 (Murfreesboro Pike) interchange were assessed. Upon review of the project area, various constraints became apparent. The existing commercial development located in the southwest quadrant of the interchange area is located on a substantial rock bluff directly adjacent to the existing right-of-way. Numerous ramp-to-ramp and ramp-to-interstate connections already exist in this congested portion of the interstate system. Any proposed alternative was to be sensitive to both the required design standards and cognizant of cost considerations. Appendix G contains sketches of the concepts described below.

### I-24/440 Tangent Exit Ramp

Upon preliminary review of the current geometry of the interchange, investigation to reconfigure the layout to a tight diamond interchange was attempted. This concept would have eliminated both the entrance and exit loop ramps, while providing a new movement, which is currently prohibited by the existing geometry (eastbound I-24/440 to westbound U.S. 41).

After reviewing various design considerations, it appeared this concept could be viable. However, after preliminary traffic analyses of the future ramp diverge along with the new four-legged intersection on U.S. 41, operation appeared to be inadequate. Traffic queues along this new tangent exit ramp could potentially affect (negatively) the operation of the mainline of the interstate system.

### Extended Weave Alternative

This alternative would have simply extended the existing weave segment between the entrance and exit loop ramp at U.S. 41. This concept would have provided some additional service life for this movement, but still would have left this conflict point on the interstate system. Approximately seven acres of right-of-way would have also been required to construct this lengthened weave section.

### No Weave Alternative

The final alternative developed was an elaborate modification which would have eliminated both weave sections that exist along I-24/440 within the study area by barrier separating all of the associated movements. This concept would have required numerous retaining walls and two new structures, in order to eliminate the weave segments. Right-of-way and business relocations would also have been required in order to construct this proposed alternative.

## E. Environmental Concerns

The Tennessee Department of Transportation will perform all necessary studies including ecological and historical studies. At the current time, the proposed design does not appear to impact any areas of environmental or historical significance. As stated previously, it is anticipated that the proposed improvements can be constructed with the existing right-of-way.

## CHAPTER 3

### Engineering Investigations

#### A. Traffic Operations

An initial analysis was made which determined that the existing interchange configuration was inadequate to handle design year volumes. Appendix B contains figures summarizing the levels-of-service under the existing conditions for 2005 and 2025 traffic. The levels-of-service were determined using the peak hour volumes which represent the worst case condition for each location.

#### EXISTING ROADWAY NETWORK

The capacity analysis of the existing ramp junctions within the study area are summarized below in Table 1 for the base year and design year (2025).

All of these locations are associated with either a lane addition or a lane drop on I-24/440. These locations are as follows:

- **Eastbound I-24/440 at the entrance ramp from westbound U.S. 41.** Upstream from this one-lane ramp, eastbound I-24/440 includes two lanes of travel. However, this one-lane ramp results in a third additional travel lane.
- **Eastbound I-24/440 at the exit ramp to eastbound U.S. 41.** Upstream from this one-lane ramp, eastbound I-24/440 includes three lanes of travel. However, the outermost lane drops at this location.
- **Eastbound I-24/440 at the entrance ramp from eastbound U.S. 41.** Upstream from this one-lane ramp, eastbound I-24/440 includes two lanes of travel. However, this one-lane ramp results in a third additional travel lane.

The Highway Capacity Manual (HCM) states the following about lane additions and lane drops:

“Sometimes on-ramps are associated with lane additions and off-ramps with lane drops. Where a single-lane ramp results in a lane addition or deletion, the capacity of the ramp is governed by its geometry, as indicated in Table 5-6.”

The information in Table 5-6 of the HCM indicates that for a free-flow ramp speed of 21-30 mph, a single-lane ramp has a capacity of 1,900 vehicles per hour and for speeds between 31-40 mph, a single-lane ramp has a capacity of 2,100 vehicles per hour. Table 2 includes the projected traffic volumes on each ramp, which results in a lane addition or lane drop on I-24/440 at the interchange within the study area.

**TABLE 1**  
**CAPACITY ANALYSES AT RAMP JUNCTIONS**  
**WHICH RESULT IN A LANE ADDITION OR LANE DROP**

<b>Location</b>	<b># of lanes</b>	<b>capacity (vph)</b>	<b>Year 2005</b>	<b>Year 2025</b>
E/B I-24/440 Entrance to Ramp from W/B U.S. 41 (AM)	1	1,900	404	485
E/B I-24/440 Entrance to Ramp from W/B U.S. 41 (PM)	1	1,900	558	669
E/B I-24/440 Exit Ramp to E/B U.S. 41 (AM)	1	1,900	419	502
E/B I-24/440 Exit Ramp to E/B U.S. 41 (PM)	1	1,900	555	666
E/B I-24/440 Entrance Ramp from E/B U.S. 41 (AM)	1	2,100	341	409
E/B I-24/440 Entrance Ramp from E/B U.S. 41 (PM)	1	2,100	661	793

All of the ramps which currently result in a lane addition or a lane drop on I-24/440 have adequate capacity to accommodate the traffic volumes projected on the existing roadway network in the Years 2005 and 2025.

Capacity analyses were conducted for the existing weave movements within the study area, and these results are shown in Table 2. The analyses show that the two weaving sections will operate at poor LOS in the design year.

**TABLE 2**  
**CAPACITY ANALYSES AT WEAVING AREAS**

<b>Weaving Section</b>	<b>Year 2005</b>	<b>Year 2025</b>
Eastbound I-24/440, between Entrance Loop and Exit Loop Ramps (AM)	E	F
Eastbound I-24/440, between Entrance Loop and Exit Loop Ramps (PM)	F	F
Eastbound I-24/440, between Entrance Ramp and I-24 & I-440 Diverge (AM)	C	E
Eastbound I-24/440, between Entrance Ramp and I-24 & I-440 Diverge (PM)	E	F

The results of the capacity analyses for the freeway segments within the study area are shown in Table 3. These results indicate that all of the freeway segments are projected to operate at an unacceptable LOS in the Year 2005 and 2025, based on the existing roadway network.

In order for these freeway segments to operate at an acceptable LOS in the base year, one additional travel lane would be required. In order to operate in the design year (2025), two additional travel lanes would be necessary.

TABLE 3

**CAPACITY ANALYSES OF FREEWAY SEGMENTS  
WITHIN THE STUDY AREA**

<b>Freeway Segments</b>	<b>Year 2005</b>	<b>Year 2025</b>
Eastbound I-24/440, west of U.S. 41 (AM)	D	F
Eastbound I-24/440, west of U.S. 41 (PM)	F	F
Eastbound I-24/440, east of U.S. 41 (AM)	E	F
Eastbound I-24/440, east of U.S. 41 (PM)	F	F

**PROPOSED ROADWAY NETWORK**

The results of the capacity analyses conducted for the proposed roadway network are shown in the following tables. Specifically, as shown in Table 4, all of the ramps which will result in a lane addition or lane drop on I-24/440 have adequate capacity to accommodate the traffic volumes projected on the proposed roadway network in the Years 2005 and 2025.

TABLE 4

**CAPACITY ANALYSES AT RAMP JUNCTIONS  
WHICH RESULT IN A LANE ADDITION OR LANE DROP**

<b>Location</b>	<b># of lanes</b>	<b>capacity (vph)</b>	<b>Year 2005</b>	<b>Year 2025</b>
E/B I-24/440 Exit Ramp to E/B U.S. 41 (AM)	1	1,900	419	502
E/B I-24/440 Exit Ramp to E/B U.S. 41 (PM)	1	1,900	555	666
E/B I-24/440 Entrance Ramp from E/B U.S. 41 (AM)	1	2,100	745	894
E/B I-24/440 Entrance Ramp from E/B U.S. 41 (PM)	1	2,100	1,219	1,462

Capacity analyses were conducted for the weaving movements within the proposed roadway network. It is important to note that the proposed roadway network includes one fewer weaving section than the existing roadway network.

The results of these analyses are shown in Table 5. The analyses show that the remaining weave section within the study area will operate in the AM and PM peak hours in the Year 2005. However, this weaving section will operate at poor LOS in the Year 2025.

**TABLE 5**  
**CAPACITY ANALYSES AT WEAVING AREAS**

<b>Weaving Section</b>	<b>Year 2005</b>	<b>Year 2025</b>
Eastbound I-24/440, between Entrance Ramp and I-24 & I-440 Diverge (AM)	C	E
Eastbound I-24/440, between Entrance Ramp and I-24 & I-440 Diverge (PM)	E	F

The results of the capacity analyses for the freeway segments within the study area are shown in Table 6.

As with the existing conditions, all of the freeway segments within the study area are projected to operate at poor LOS in both the base and design year. As stated previously, additional mainline lanes would be required along I-24/440 to operate at an acceptable LOS.

**TABLE 6**  
**CAPACITY ANALYSES OF FREEWAY SEGMENTS**

<b>Freeway Segments</b>	<b>Year 2005</b>	<b>Year 2025</b>
Eastbound I-24/440, west of U.S. 41 (AM)	D	F
Eastbound I-24/440, west of U.S. 41 (PM)	F	F
Eastbound I-24/440, east of U.S. 41 (AM)	E	F
Eastbound I-24/440, east of U.S. 41 (PM)	F	F

Capacity analysis was conducted for the new surface street intersection at U.S. 41 (Murfreesboro Pike) and the eastbound ramp terminal, with the results shown in Table 7. The analysis shows that the new surface street intersection will operate at acceptable LOS during the AM and PM peak hours in the Year 2005, but will not operate in the design year (2025). In order for the intersection to operate at an acceptable level of service in the design year, one additional eastbound and westbound travel lane would be required on U.S. 41 (Murfreesboro Pike).

**TABLE 7**  
**CAPACITY ANALYSES AT NEW SURFACE STREET INTERSECTION**

<b>INTERSECTION</b>	<b>Year 2005</b>	<b>Year 2025</b>
U.S. 41 (Murfreesboro Pike) & I-24/440 Ramps (AM)	C	F
U.S. 41 (Murfreesboro Pike) & I-24/440 Ramps (AM)	D	F

**B. Access Analysis**

This study has been undertaken in accordance with the Federal Highway Administration's (FHWA) policy for granting new or revised interchange access. The FHWA policy, as described in FHWA Docket 98-3460, "Additional Interchanges to the Interstate System (Federal Register 63, No. 28, February 11, 1998) is provided in the following paragraphs accompanied by comments for consideration.

***It is in the national interest to maintain the Interstate System to provide the highest level of service in terms of safety and mobility. Adequate control of access is critical to providing such service. Therefore, new or revised access points to the existing Interstate System should meet the following requirements.***

- 1. The existing interchanges and/or local roads and streets in the corridor can neither provide the necessary access nor be improved to satisfactorily accommodate the design year traffic demands while at the same time providing the access intended by the proposal.***

With the continual increase in traffic volumes along I-24/440, the merge, diverge and weave movements will continue to diminish the operation of the interstate system in the project area. This degradation will result in increased motorists delay, reduced traveler safety, and reduced air quality within the city of Nashville. No minor interchange improvements can be made (other than the recommended configuration) to eliminate the major problems outlined previously in this report.

- 2. All reasonable alternatives for design options, location and transportation system management type improvements (such as ramp metering, mass transit, and HOV facilities) have been assessed and provided for if currently justified, or provisions are included for accommodating such facilities if a future need is identified.***

There were several different design options developed and assessed in this study to improve the operation of the I-24/440 and U.S. 41 (Murfreesboro Pike) interchange. However, the proposed design is the only one that produced the desired levels of service and operational characteristics within the constraints described previously, while providing for additional improvements, if so identified in the future.

- 3. The proposed access point does not have a significant adverse impact on the safety and operation of the interstate facility based upon an analysis of current and future traffic. The operational analysis for existing conditions shall, particularly in urbanized areas, include an analysis of sections of interstate to an including at least the first adjacent existing or proposed interchange on either***

***side. Crossroads and other roads and streets shall be included in the analysis to the extent necessary to assure their ability to collect and distribute traffic to and from the interchange with new or revised access points.***

The elimination of the weave segment between the existing entrance and exit loop ramps with I-24/440 and U.S. 41 will improve traffic operations through the interchange area by reducing the number of conflict points for motorists. The proposed modifications should not have any adverse impact on the safety and operation of the interstate facility.

- 4. The proposed access connects to a public road only and will provide for all traffic movements. Less than “full interchanges” for special purpose access for transit vehicles, for HOV’s, or into park and ride lots may be considered on a case-by-case basis. The proposed access will be designed to meet or exceed current standards for Federal-Aid projects on the Interstate System.***

The proposal is a modification of the existing interchange configuration at Interstate 24/440 and U.S. 41 (Murfreesboro Pike). The proposed modifications will provide for all the movements that are currently provided for with the present configuration. The proposed design will meet the American Association of State Highway and Transportation Officials (AASHTO) criteria.

- 5. The proposal considers and is consistent with local and regional land use and transportation plans. Prior to final approval, all requests for new or revised access must be consistent with the metropolitan and/or statewide transportation plan, as appropriate, the applicable provisions of 23 CFR part 450 and the transportation conformity requirements of 40 CFR parts 51 and 93.***

The study was coordinated with both the Tennessee Department of Transportation and the City of Nashville. The proposal is consistent with all local, regional, and statewide land use and transportation plans.

- 6. In areas where the potential exists for future multiple interchange additions, all requests for new or revised access are supported by a comprehensive interstate network study with recommendations that address all proposed and desired access within the context of a long-term plan.***

There are no long-range plans for additional interchanges in this area. The existing interchanges provide adequate access to the subject area.



7. ***The request for a new or revised access generated by a new or expanded development demonstrates appropriate coordination between the development and related or otherwise required transportation system improvements***

The request is not generated by new or expanded development within the vicinity of the interchange. This interchange modification is intended to correct operational inadequacies of the existing interchange configuration.

8. ***The request for a new or revised access contains information relative to the planning requirements and the status of environmental processing of the proposal.***

The proposed modifications will be submitted to the TDOT Environmental Department to begin environmental studies at the time this report is submitted to the FHWA.

### **C. Proposed Interchange Cost**

The total cost for this proposed improvement to the I-24/440 and U.S. 41 (Murfreesboro Pike) interchange is approximately \$1,617,000. An estimated cost breakdown is shown in Appendix F.

## CHAPTER 4

### Summary of Findings and Conclusions

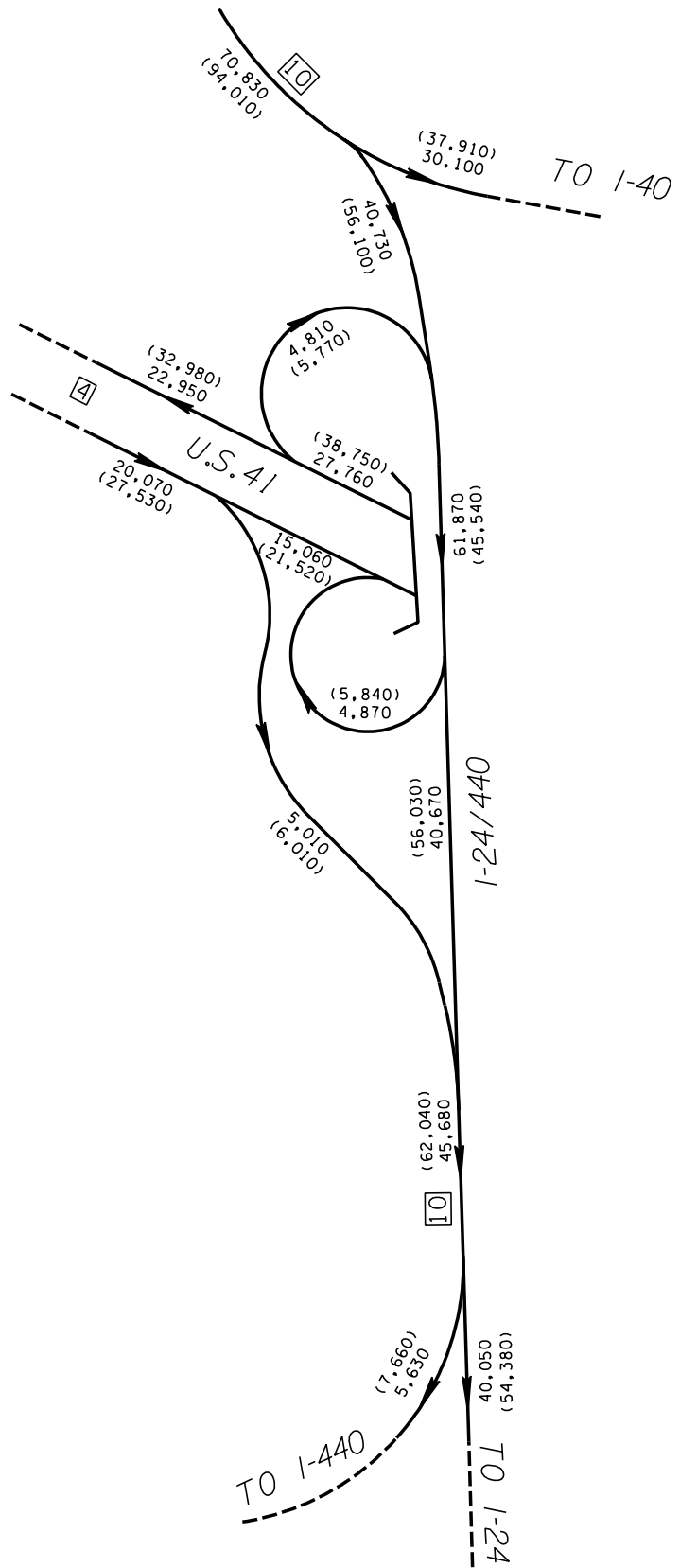
The purpose of this study was to evaluate the existing interchange at Interstate 24/440 and U.S. 41, and to request the approval for modifications of this interchange to improve its operation and safety. Benefits of this project include reduced congestion and reduced conflict points along this busy segment of interstate.

The traffic analysis indicates that the existing interchange is inadequate to handle the current and design year traffic volumes. The current configuration and close proximity of the major diverge of Interstate 24 and 40 and the associated weave problems at the U.S. 41 interchange, severely congest this area.

As stated previously in this report, in order for all the movements to operate at an acceptable LOS in the design year, the mainline of I-24/440 would require two additional mainline travel lanes. This widening would require extensive reconstruction of the interstate facility within the study area, which falls outside the scope of this improvement project. However, the appendix does contain two future alternatives which could be phased constructed over time, while the recommended improvements in this study could remain in-place.

**APPENDIX A**

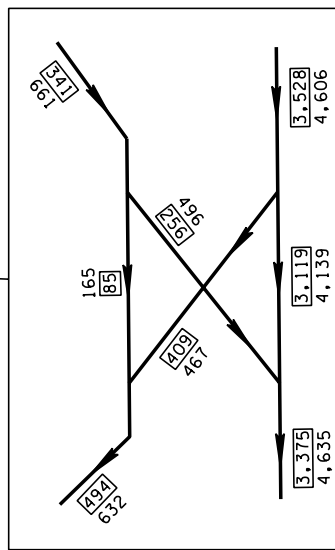
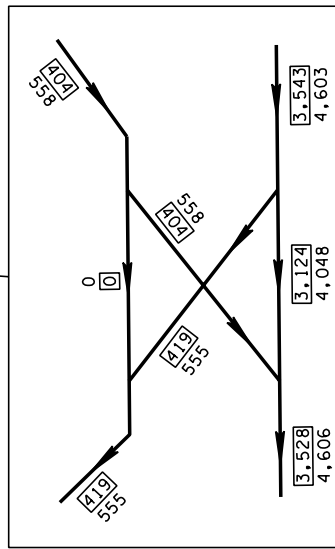
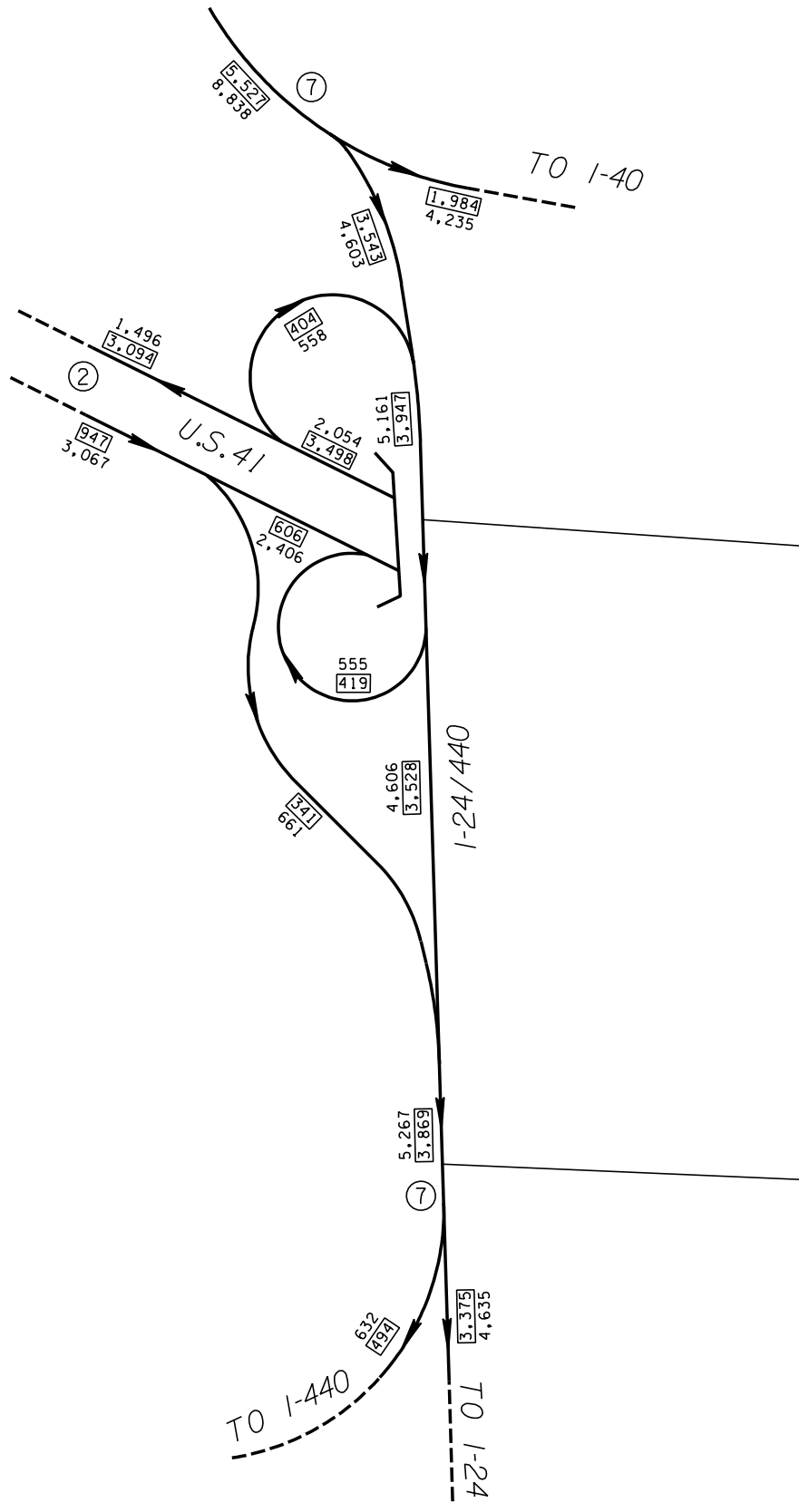
**TRAFFIC VOLUMES: 2005 AND 2025 DHV'S**



EXISTING  
CONDITIONS

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

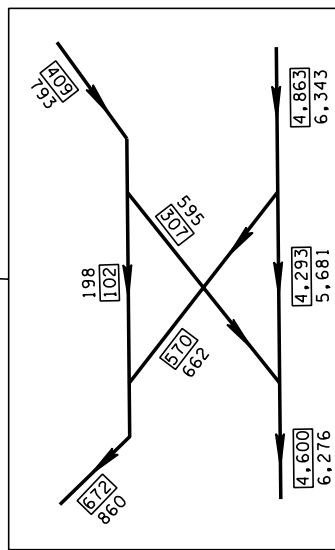
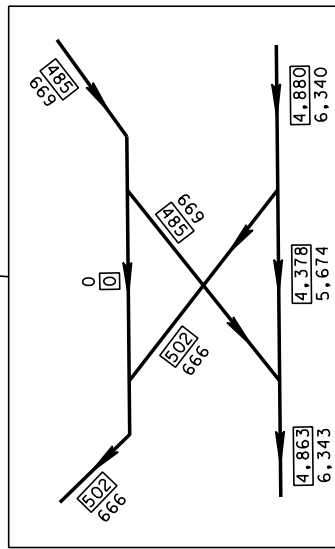
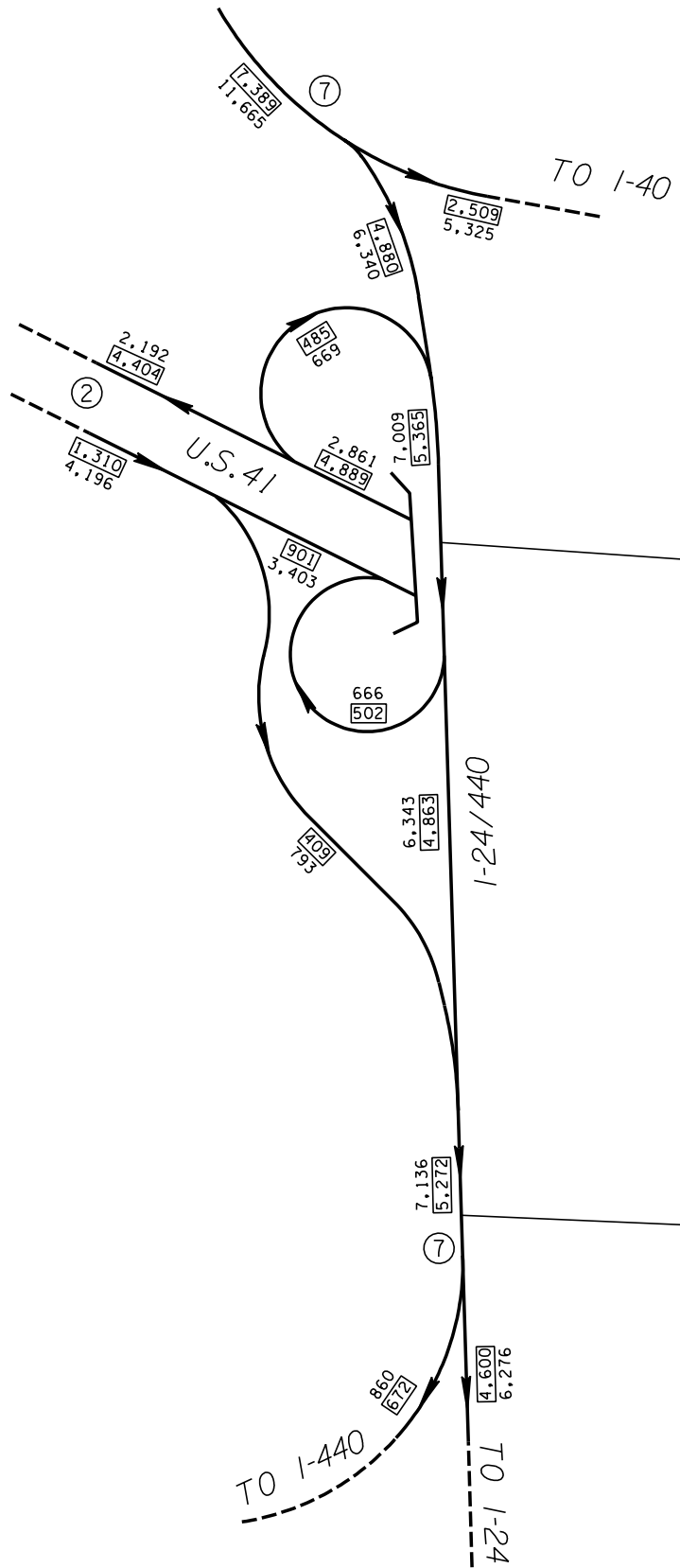
2005 ADT-000  
2025 ADT-(000)  
ADT TRUCK % - 0



EXISTING  
CONDITIONS

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

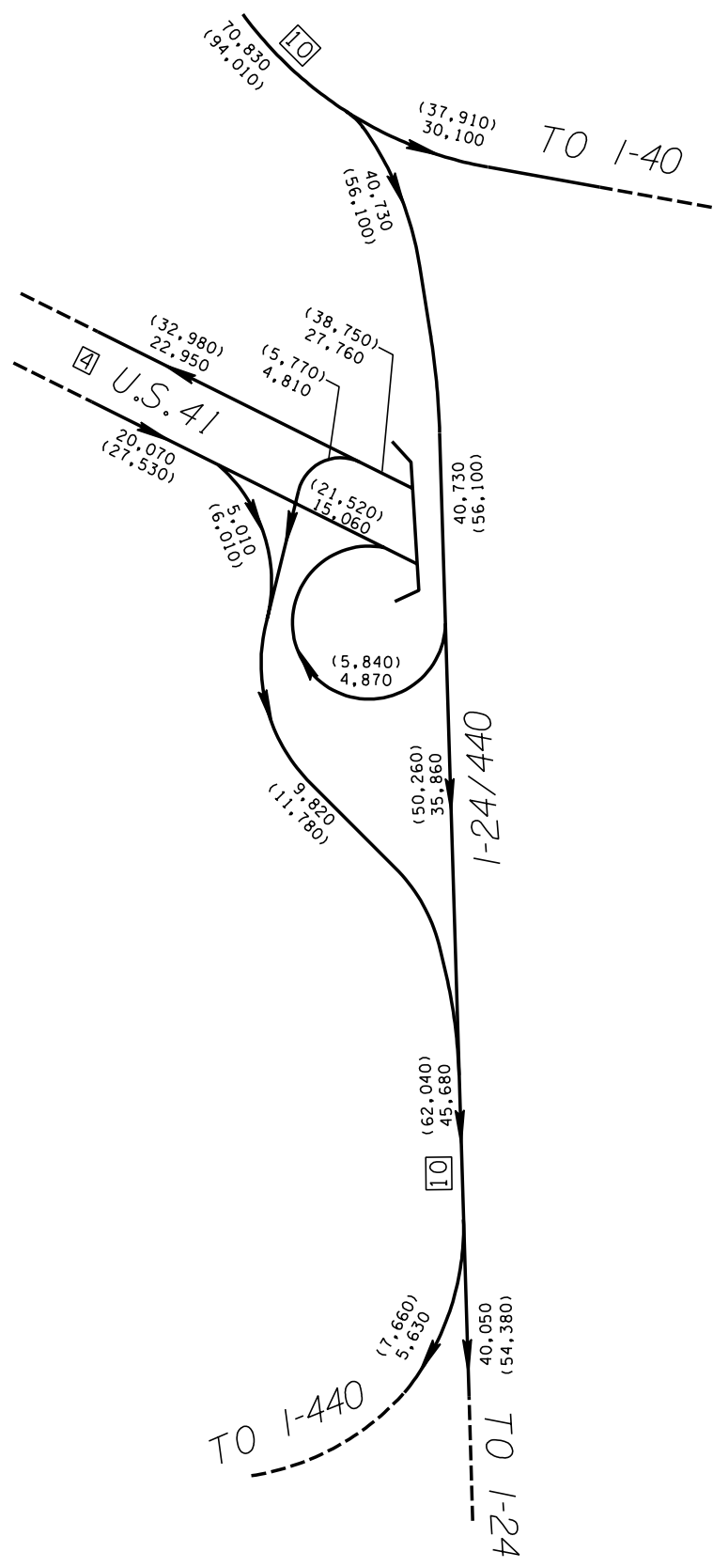
2005 DHV  
PM  
AM  
ADT TRUCK % - ①



EXISTING  
CONDITIONS

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

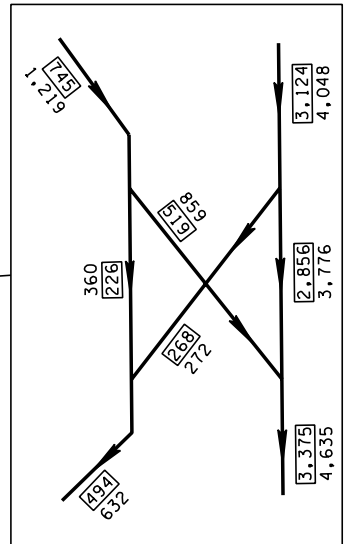
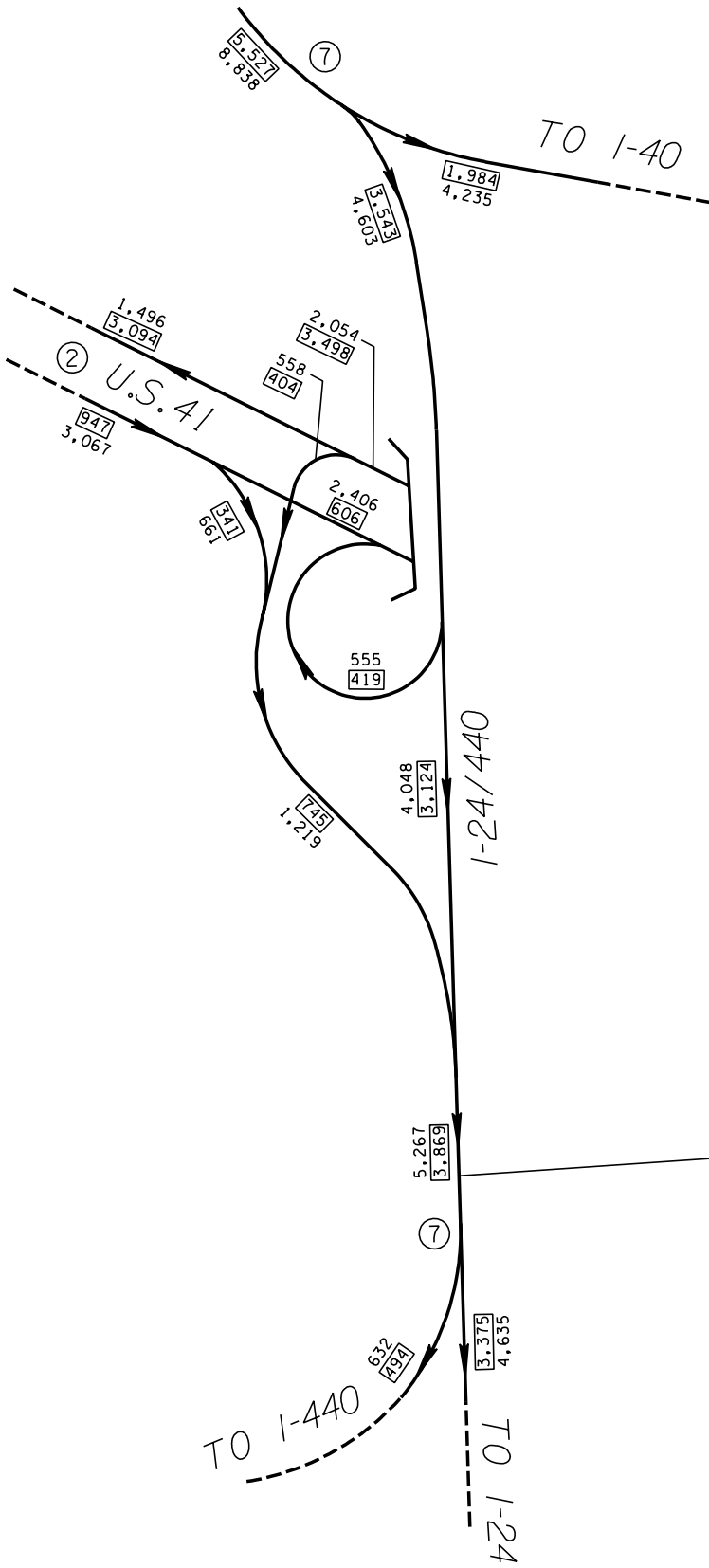
2025 DHV  
PM  
AM  
ADT TRUCK % - ①



PROPOSED  
CONDITIONS

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

2005 ADT-000  
2025 ADT-(000)  
ADT TRUCK % - 0

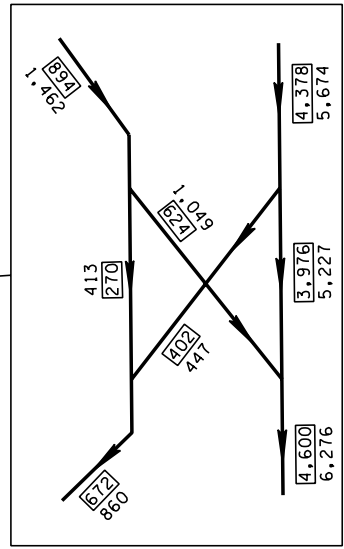
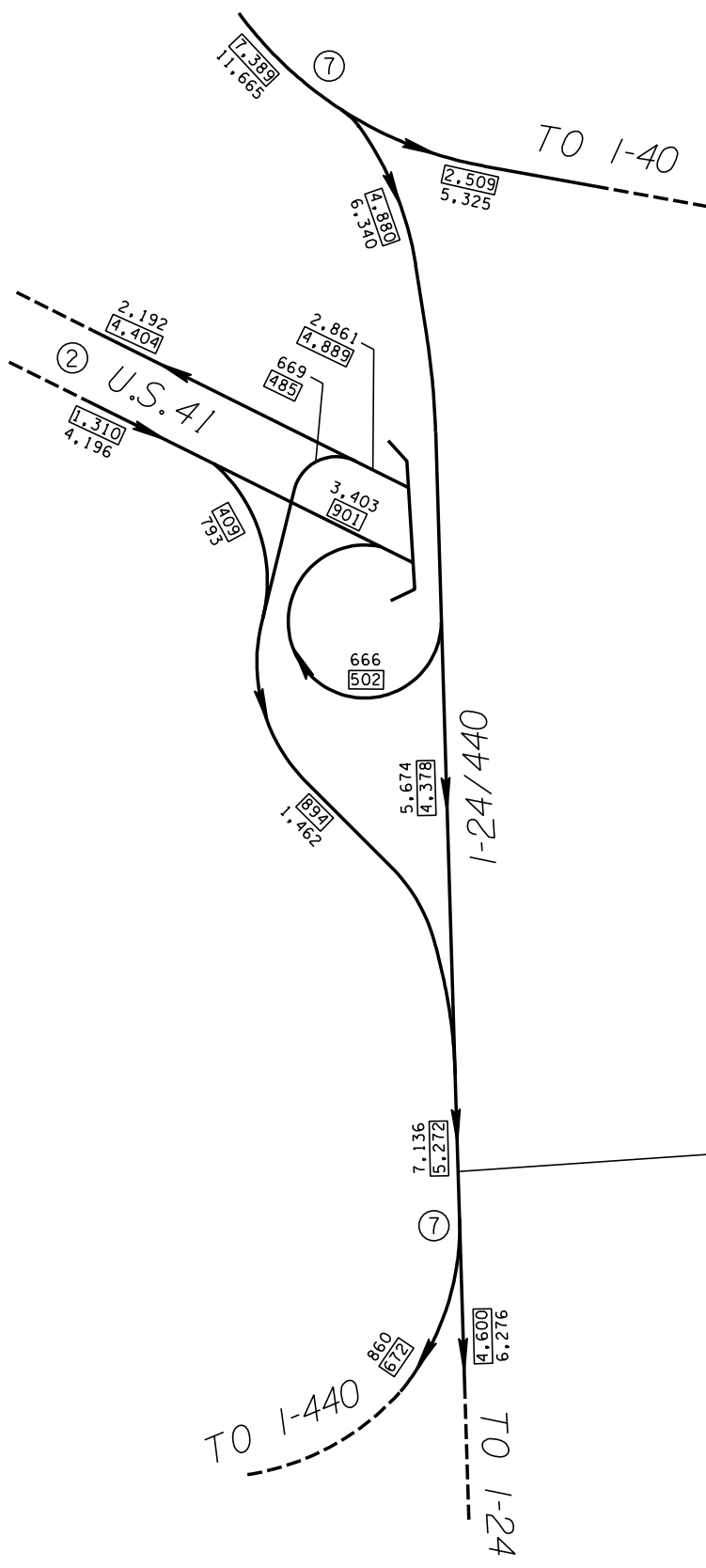


PROPOSED  
CONDITIONS

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

2005 DHV  
PM  
AM  
ADT TRUCK % - ①





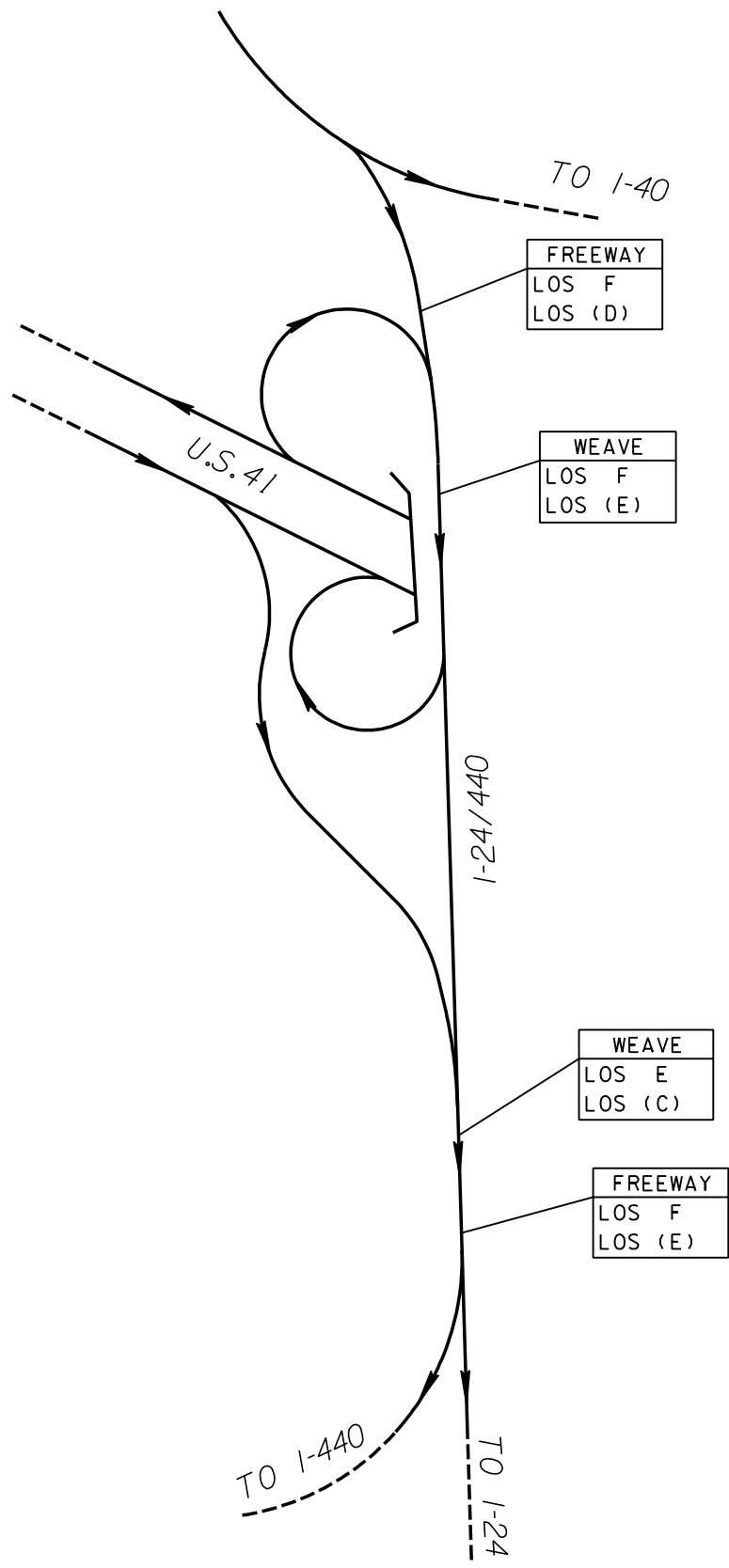
PROPOSED  
CONDITIONS

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

2025 DHV  
PM  
AM  
ADT TRUCK % - ①

**APPENDIX B**

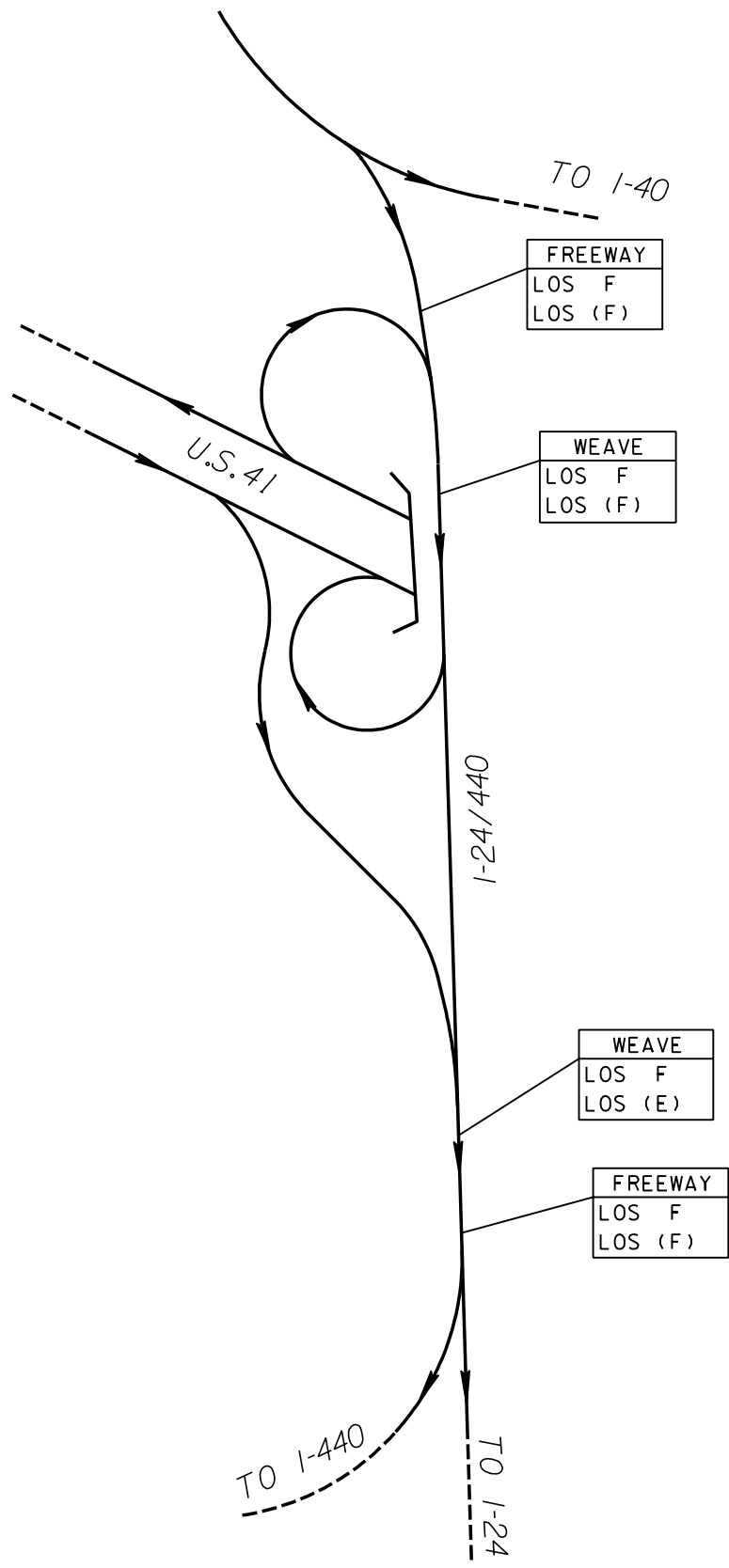
**LEVEL OF SERVICE: EXISTING AND PROPOSED**



EXISTING  
LEVEL OF SERVICE

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

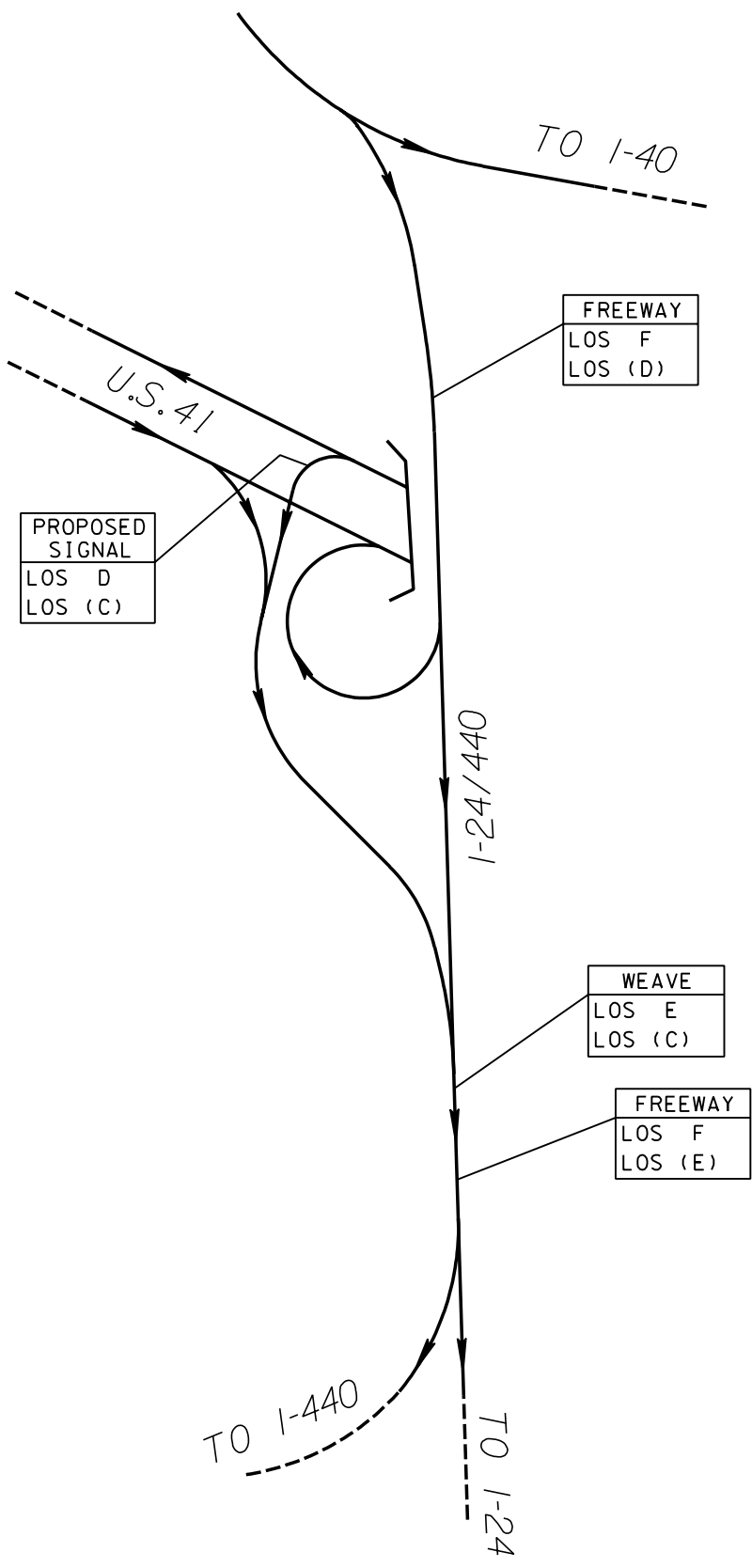
2005  
(AM)  
PM



EXISTING  
LEVEL OF SERVICE

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

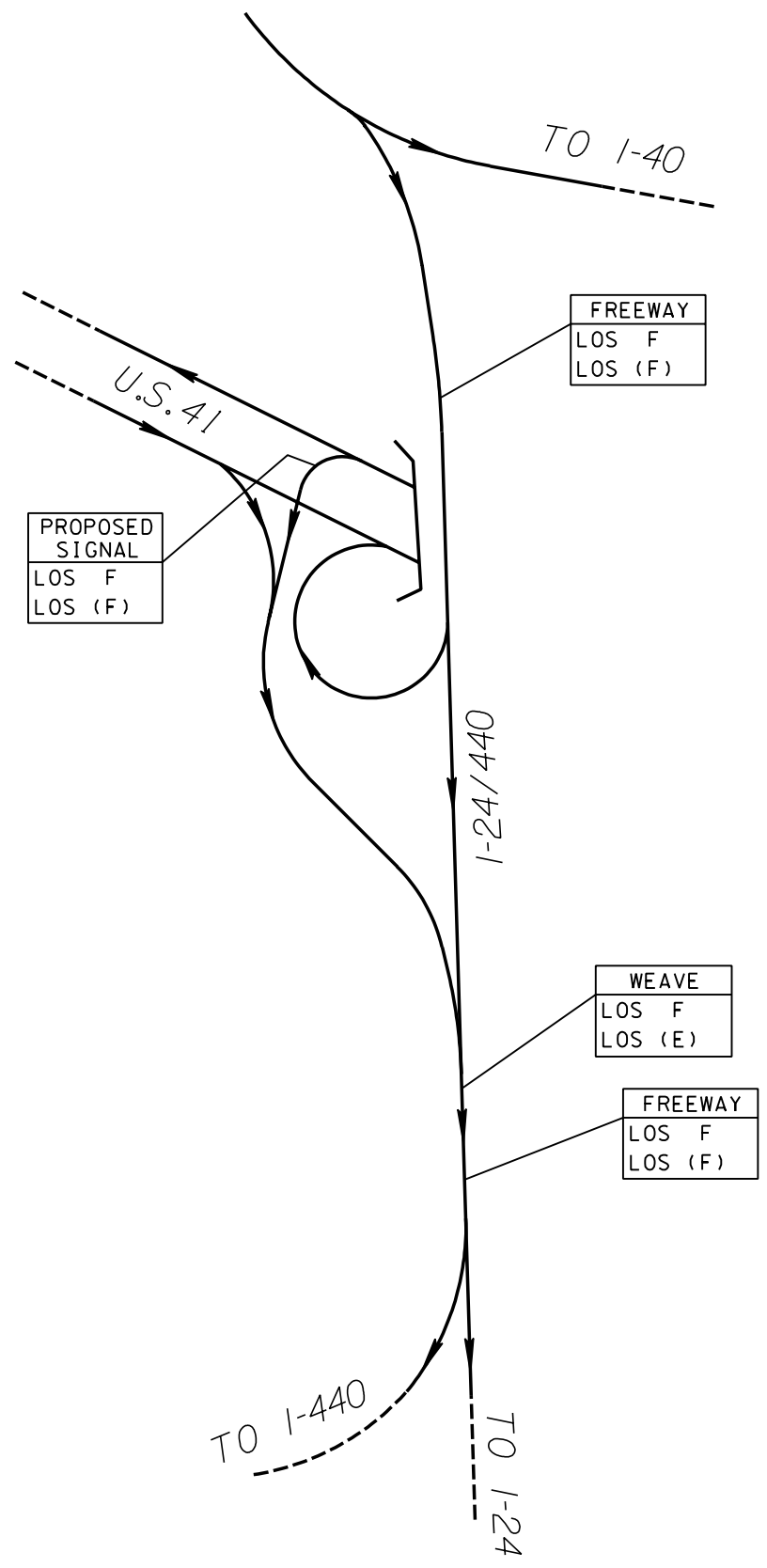
2025  
(AM)  
PM



PROPOSED  
LEVEL OF SERVICE

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

2005  
(AM)  
PM



PROPOSED  
LEVEL OF SERVICE

I-24/440 & U.S. 41  
INTERCHANGE MODIFICATION STUDY  
AUGUST 2002

2025  
(AM)  
PM

## **APPENDIX C**

### **CAPACITY ANALYSIS: EXISTING CONDITIONS**

## Freeway Analysis



HCS2000: Basic Freeway Segments Release 4.1b  
Operational Analysis

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Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Existing

Flow Inputs and Adjustments

---

Volume, V	3543	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	984	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2037	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

LOS and Performance Measures

---

Flow rate, vp	2037	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, s	60.8	mi/h
Number of lanes, N	2	
Density, D	33.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b  
Operational Analysis

---

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Existing

Flow Inputs and Adjustments

---

Volume, v	4603	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1279	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2647	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, flw	0.0	mi/h
Lateral clearance adjustment, flc	0.0	mi/h
Interchange density adjustment, fid	0.0	mi/h
Number of lanes adjustment, fn	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

LOS and Performance Measures

---

Flow rate, vp	2647	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

overall results are not computed when free-flow speed is less than 55 mph.

## HCS2000: Basic Freeway Segments Release 4.1b

S. McCoy  
 Clinard Engineering Associates  
 5210 Maryland Way, Suite 202  
 Brentwood, TN 37027

Phone: 615-377-9773

Fax:

E-mail:

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 Operational Analysis
 

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Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Existing

---

 Flow Inputs and Adjustments
 

---

Volume, V	4880	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1356	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2806	pc/h/ln

---

 Speed Inputs and Adjustments
 

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

---

 LOS and Performance Measures
 

---

Flow rate, vp	2806	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

## HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Existing

## Flow Inputs and Adjustments

Volume, V	6340	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1761	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	3645	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	3645	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

## HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Existing

## Flow Inputs and Adjustments

Volume, v	3869	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1075	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2225	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, flw	0.0	mi/h
Lateral clearance adjustment, flc	0.0	mi/h
Interchange density adjustment, fid	0.0	mi/h
Number of lanes adjustment, fn	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	2225	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	56.3	mi/h
Number of lanes, N	2	
Density, D	39.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Existing

## Flow Inputs and Adjustments

Volume, V	5267	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1463	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	3029	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, flw	0.0	mi/h
Lateral clearance adjustment, flc	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	3029	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

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 Operational Analysis
 

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Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Existing

---

 Flow Inputs and Adjustments
 

---

Volume, V	5272	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1464	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, FHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	3031	pc/h/ln

---

 Speed Inputs and Adjustments
 

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

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 LOS and Performance Measures
 

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Flow rate, vp	3031	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

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 Operational Analysis
 

---

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Existing

---

 Flow Inputs and Adjustments
 

---

Volume, V	7136	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1982	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	4103	pc/h/ln

---

 Speed Inputs and Adjustments
 

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

---

 LOS and Performance Measures
 

---

Flow rate, vp	4103	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.



## Freeway Weave Areas

HCS2000: Freeway Weaving Release 4.1

Operational Analysis

Analyst: SEM  
 Agency/Co.: TMP  
 Date Performed: 9/28/01  
 Analysis Time Period: AM Peak Hour  
 Freeway/dir or Travel: EB I-24  
 Weaving Location: Loops from Murfreesboro Pk  
 Jurisdiction: Nashville, TN  
 Analysis Year: 2005  
 Description: I-40/24 Congestion Study (Exist. Config.)

Inputs

Freeway free-flow speed, SFF	55	mph
Weaving number of lanes, N	3	
Weaving segment length, L	950	ft
Terrain type	Level	
Grade		%
Length		mi
Weaving type	A	Multilane or C-D
Volume ratio, VR	0.21	
Weaving ratio, R	0.49	

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	3124	0	419	404	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	868	0	116	112	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fhv	0.952	0.952	0.952	0.952	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	3644	0	488	471	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
Weaving intensity factor, Wi	1.16	0.60
Weaving and non-weaving speeds, Si	35.82	43.05
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.94
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S	41.31	mph
Weaving segment density, D	37.14	pc/mi/ln
Level of service, LOS	E	

Capacity for base condition, cb            5125    pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded Maximum	See Note Note
Weaving flow rate, Vw	959	2800	a
Average flow rate (pcphpl)	1534	2250	b
Volume ratio, VR	0.21	0.45	c
Weaving ratio, R	0.49	N/A	d
Weaving length (ft)	950	2500	e

Notes:

- a. Capacity constrained by maximum allowable weaving flow rate.
- b. Capacity constrained by basic freeway capacity.
- c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- d. Breakdown may occur in some cases for Type C segments.
- e. When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

HCS2000: Freeway Weaving Release 4.1

Operational Analysis

Analyst: SEM  
 Agency/Co.: TMP  
 Date Performed: 9/28/01  
 Analysis Time Period: PM Peak Hour  
 Freeway/dir or Travel: EB I-24  
 Weaving Location: Loops from Murfreesboro Pk  
 Jurisdiction: Nashville, TN  
 Analysis Year: 2005  
 Description: I-40/24 Congestion Study (Exist. Config.)

Inputs

Freeway free-flow speed, SFF	55	mph
Weaving number of lanes, N	3	
Weaving segment length, L	950	ft
Terrain type	Level	
Grade		%
Length		mi
Weaving type	A	Multilane or C-D
Volume ratio, VR	0.22	
Weaving ratio, R	0.50	

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	4048	0	555	558	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	1124	0	154	155	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fHV	0.952	0.952	0.952	0.952	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	4722	0	647	651	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
Weaving intensity factor, Wi	1.53	0.88
Weaving and non-weaving speeds, Si	32.81	38.97
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		1.00
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S	37.45	mph
Weaving segment density, D	53.58	pc/mi/ln
Level of service, LOS	F	

Capacity for base condition, cb            5099    pc/h

\_\_\_\_\_ Limitations on Weaving Segments \_\_\_\_\_

	Analyzed	If Max Exceeded Maximum	See Note Note
Weaving flow rate, Vw	1298	2800	a
Average flow rate (pcphpl)	2006	2250	b
Volume ratio, VR	0.22	0.45	c
Weaving ratio, R	0.50	N/A	d
Weaving length (ft)	950	2500	e

Notes:

- a. Capacity constrained by maximum allowable weaving flow rate.
- b. Capacity constrained by basic freeway capacity.
- c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- d. Breakdown may occur in some cases for Type C segments.
- e. When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

HCS2000: Freeway Weaving Release 4.1b

Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak Hour  
 Freeway/dir or Travel: EB I-24  
 Weaving Location: Loops from Murfreesboro Pk  
 Jurisdiction: Nashville, TN  
 Analysis Year: 2025  
 Description: I-40/24 Congestion Study (Exist. Config.)

Inputs

Freeway free-flow speed, SFF	55	mph
Weaving number of lanes, N	3	
Weaving segment length, L	950	ft
Terrain type	Level	
Grade		%
Length		mi
Weaving type	A	
Volume ratio, VR	0.18	
Weaving ratio, R	0.49	

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	4378	0	502	485	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	1216	0	139	135	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fHV	0.966	0.966	0.966	0.966	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	5034	0	577	557	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
Weaving intensity factor, Wi	1.48	0.81
Weaving and non-weaving speeds, Si	33.18	39.80
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.91
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S	38.39	mph
Weaving segment density, D	53.55	pc/mi/ln
Level of service, LOS	F	

Capacity for base condition, cb            5223    pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded Maximum	See Note
Weaving flow rate, Vw	1134	2800	a
Average flow rate (pcphpl)	2056	2250	b
Volume ratio, VR	0.18	0.45	c
Weaving ratio, R	0.49	N/A	d
Weaving length (ft)	950	2500	e

Notes:

- a. Capacity constrained by maximum allowable weaving flow rate.
- b. Capacity constrained by basic freeway capacity.
- c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- d. Breakdown may occur in some cases for Type C segments.
- e. When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

HCS2000: Freeway Weaving Release 4.1b

Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak Hour  
 Freeway/dir or Travel: EB I-24  
 Weaving Location: Loops from Murfreesboro Pk  
 Jurisdiction: Nashville, TN  
 Analysis Year: 2025  
 Description: I-40/24 Congestion Study (Exist. Config.)

Inputs

Freeway free-flow speed, SFF	55	mph
Weaving number of lanes, N	3	
Weaving segment length, L	950	ft
Terrain type	Level	
Grade		%
Length		mi
Weaving type	A	
Volume ratio, VR	0.19	
Weaving ratio, R	0.50	

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	5674	0	666	669	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	1576	0	185	186	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fHV	0.966	0.966	0.966	0.966	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	6525	0	765	769	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
Weaving intensity factor, Wi	1.93	1.18
Weaving and non-weaving speeds, Si	30.33	35.66
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.96
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S	34.50	mph
Weaving segment density, D	77.86	pc/mi/ln
Level of service, LOS	F	



Capacity for base condition, cb            5196    pc/h

\_\_\_\_\_ Limitations on Weaving Segments \_\_\_\_\_

	Analyzed	If Max Exceeded Maximum	See Note
Weaving flow rate, Vw	1534	2800	a
Average flow rate (pcphpl)	2686	2250	b
Volume ratio, VR	0.19	0.45	c
Weaving ratio, R	0.50	N/A	d
Weaving length (ft)	950	2500	e

Notes:

- a. Capacity constrained by maximum allowable weaving flow rate.
- b. Capacity constrained by basic freeway capacity.
- c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- d. Breakdown may occur in some cases for Type C segments.
- e. When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: AM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Existing E of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: I-24/440 & U.S. 41

Inputs

Freeway free-flow speed, SFF 65 mph  
 Weaving number of lanes, N 3  
 Weaving segment length, L 1750 ft  
 Terrain type Level  
     Grade %  
     Length mi  
 Weaving type A Multilane or C-D  
 Volume ratio, VR 0.17  
 Weaving ratio, R 0.38

Conversion to pc/h Under Base Conditions

	Non-weaving		Weaving		
	V	V	V	V	
Volume, v	A-C	B-D	A-D	B-C	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	866	24	114	71	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fhv	0.966	0.966	0.966	0.966	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	3586	97	470	294	pc/h

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
Weaving intensity factor, wi	0.64	0.32
Weaving and non-weaving speeds, Si	48.45	56.57
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.85
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S	54.98 mph
Weaving segment density, D	26.96 pc/mi/ln
Level of service, LOS	C
Capacity for base condition, cb	5767 pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded	See Note
Weaving flow rate, vw	764	2800	a
Average flow rate (pcphpl)	1482	2350	b
Volume ratio, VR	0.17	0.45	c
Weaving ratio, R	0.38	N/A	d
Weaving length (ft)	1750	2500	e

Notes:

- Capacity constrained by maximum allowable weaving flow rate.
- Capacity constrained by basic freeway capacity.
- Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- Breakdown may occur in some cases for Type C segments.
- When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: PM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Existing E of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: I-24/440 & U.S. 41

Inputs

Freeway free-flow speed, SFF 65 mph  
 weaving number of lanes, N 3  
 weaving segment length, L 1750 ft  
 Terrain type Level  
 Grade %  
 Length mi  
 Weaving type A Multilane or C-D  
 Volume ratio, VR 0.18  
 Weaving ratio, R 0.49

Conversion to pc/h Under Base Conditions

	Non-weaving		Weaving		
	V	V	V	V	
Volume, V	A-C	B-D	A-D	B-C	veh/h
Peak-hour factor, PHF	4139	165	467	496	
Peak 15-min volume, v15	0.90	0.90	0.90	0.90	
Trucks and buses	1150	46	130	138	v
Recreational vehicles	7	7	7	7	%
Trucks and buses PCE, ET	0	0	0	0	%
Recreational vehicle PCE, ER	1.5	1.5	1.5	1.5	
Heavy vehicle adjustment, fHV	1.2	1.2	1.2	1.2	
Driver population adjustment, fp	0.966	0.966	0.966	0.966	
Flow rate, v	1.00	1.00	1.00	1.00	pc/h
	4759	189	537	570	

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
Weaving intensity factor, wi	0.89	0.50
Weaving and non-weaving speeds, Si	44.15	51.64
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.92
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 50.08 mph  
 Weaving segment density, D 40.30 pc/mi/ln  
 Level of service, LOS E  
 Capacity for base condition, cb 6353 pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded	See Note
Weaving flow rate, Vw	1107	Maximum	Note
Average flow rate (pcphpl)	2018	2800	a
Volume ratio, VR	0.18	2350	b
Weaving ratio, R	0.49	0.45	c
Weaving length (ft)	1750	N/A	d
		2500	e

Notes:

- a. Capacity constrained by maximum allowable weaving flow rate.
- b. Capacity constrained by basic freeway capacity.
- c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- d. Breakdown may occur in some cases for Type C segments.
- e. When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: AM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Existing E of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description:

Inputs

Freeway free-flow speed, SFF 65 mph  
 Weaving number of lanes, N 3  
 Weaving segment length, L 1750 ft  
 Terrain type Level  
 Grade %  
 Length mi  
 Weaving type A Multilane or C-D  
 Volume ratio, VR 0.17  
 Weaving ratio, R 0.35

Conversion to pc/h Under Base Conditions

	Non-weaving		Weaving		
	V A-C	V B-D	V A-D	V B-C	
Volume, v	4293	102	570	307	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	1193	28	158	85	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fHV	0.966	0.966	0.966	0.966	
Driver population adjustment, fp	1.00	1.00	1.00	1.00	
Flow rate, v	4936	117	655	353	pc/h

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
Weaving intensity factor, wi	0.86	0.47
Weaving and non-weaving speeds, si	44.56	52.30
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.87
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 50.83 mph  
 Weaving segment density, D 39.74 pc/mi/ln  
 Level of service, LOS E  
 Capacity for base condition, cb 6433 pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded	See Note
weaving flow rate, vw	1008	2800	a
Average flow rate (pcphpl)	2020	2350	b
Volume ratio, VR	0.17	0.45	c
Weaving ratio, R	0.35	N/A	d
weaving length (ft)	1750	2500	e

- Notes:
- a. Capacity constrained by maximum allowable weaving flow rate.
  - b. Capacity constrained by basic freeway capacity.
  - c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
  - d. Breakdown may occur in some cases for Type C segments.
  - e. when length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: PM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Existing E of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description:

Inputs

Freeway free-flow speed, SFF 65 mph  
 Weaving number of lanes, N 3  
 Weaving segment length, L 1750 ft  
 Terrain type Level  
 Grade %  
 Length mi  
 Weaving type A Multilane or C-D  
 Volume ratio, VR 0.18  
 Weaving ratio, R 0.47

Conversion to pc/h Under Base Conditions

	Non-weaving		Weaving		veh/h
	V A-C	V B-D	V A-D	V B-C	
Volume, v	5681	198	662	595	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	1578	55	184	165	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fHV	0.966	0.966	0.966	0.966	
Driver population adjustment, fp	1.00	1.00	1.00	1.00	
Flow rate, v	6533	227	761	684	pc/h

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
Weaving intensity factor, wi	1.18	0.73
Weaving and non-weaving speeds, Si	40.27	46.84
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.94
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 45.54 mph  
 Weaving segment density, D 60.06 pc/mi/ln  
 Level of service, LOS F  
 Capacity for base condition, cb 6386 pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded	See Note
Weaving flow rate, vw	1445	Maximum	Note
Average flow rate (pcphpl)	2735	2800	a
Volume ratio, VR	0.18	2350	b
Weaving ratio, R	0.47	0.45	c
Weaving length (ft)	1750	N/A	d
		2500	e

Notes:

- a. Capacity constrained by maximum allowable weaving flow rate.
- b. Capacity constrained by basic freeway capacity.
- c. Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- d. Breakdown may occur in some cases for Type C segments.
- e. When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

## **APPENDIX D**

### **CAPACITY ANALYSIS: PROPOSED MODIFICATIONS**

## Freeway Analysis

HCS2000: Basic Freeway Segments Release 4.1b  
Operational Analysis

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Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Proposed

Flow Inputs and Adjustments

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Volume, v	3543	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	984	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2037	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

LOS and Performance Measures

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Flow rate, vp	2037	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	60.8	mi/h
Number of lanes, N	2	
Density, D	33.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.



HCS2000: Basic Freeway Segments Release 4.1b  
Operational Analysis

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Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Proposed

Flow Inputs and Adjustments

---

Volume, V	4603	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1279	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2647	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

LOS and Performance Measures

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Flow rate, vp	2647	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Proposed

## Flow Inputs and Adjustments

Volume, V	4880	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1356	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2806	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	2806	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

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 Operational Analysis
 

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Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: West of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Proposed

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 Flow Inputs and Adjustments
 

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Volume, V	6340	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1761	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	3645	pc/h/ln

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 Speed Inputs and Adjustments
 

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Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, flw	0.0	mi/h
Lateral clearance adjustment, flc	0.0	mi/h
Interchange density adjustment, fid	0.0	mi/h
Number of lanes adjustment, fn	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

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 LOS and Performance Measures
 

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Flow rate, vp	3645	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

## HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Proposed

## Flow Inputs and Adjustments

Volume, v	3869	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1075	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	2225	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	2225	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	56.3	mi/h
Number of lanes, N	2	
Density, D	39.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Proposed

## Flow Inputs and Adjustments

Volume, V	5267	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1463	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	3029	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	3029	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

## HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: AM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Proposed

## Flow Inputs and Adjustments

Volume, V	5272	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1464	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fhv	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	3031	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	3031	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1b

## Operational Analysis

Analyst: SEM  
 Agency or Company: CEA, LLC  
 Date Performed: 8/26/2002  
 Analysis Time Period: PM Peak  
 Freeway/Direction: I-24/440 EB  
 From/To: East of SR1  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Proposed

## Flow Inputs and Adjustments

Volume, V	7136	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1982	v
Trucks and buses	7	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.966	
Driver population factor, vp	1.00	
Flow rate, vp	4103	pc/h/ln

## Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed, FFS	65.0	mi/h
	Urban Freeway	

## LOS and Performance Measures

Flow rate, vp	4103	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	2	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

## Freeway Weave Areas



HCS2000: Freeway Weaving Release 4.1b  
Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: AM  
 Freeway/dir or Travel: I24/440 EB  
 Weaving Location: Proposed E. of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Remove Loop Ramp from SR-1

Inputs

Freeway free-flow speed, SFF 65 mph  
 Weaving number of lanes, N 3  
 Weaving segment length, L 1750 ft  
 Terrain type Level  
 Grade %  
 Length mi  
 Weaving type A Multilane or C-D  
 Volume ratio, VR 0.20  
 Weaving ratio, R 0.34

Conversion to pc/h Under Base Conditions

	Non-weaving		weaving		
	V	V	V	V	
Volume, V	2856	226	268	519	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	793	63	74	144	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fhv	0.966	0.966	0.966	0.966	
Driver population adjustment, fp	1.00	1.00	1.00	1.00	
Flow rate, v	3284	259	308	596	pc/h

Weaving and Non-weaving Speeds

	weaving	Non-weaving
weaving intensity factor, wi	0.68	0.36
weaving and non-weaving speeds, Si	47.68	55.46
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.94
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

weaving segment speed, S 53.68 mph  
 weaving segment density, D 27.61 pc/mi/ln  
 Level of service, LOS C  
 Capacity for base condition, cb 6257 pc/h

Limitations on Weaving Segments

	Analyzed	If Max Exceeded	See Note
weaving flow rate, vw	904	2800	a
Average flow rate (pcphpl)	1482	2350	b
Volume ratio, VR	0.20	0.45	c
weaving ratio, R	0.34	N/A	d
weaving length (ft)	1750	2500	e

Notes:

- Capacity constrained by maximum allowable weaving flow rate.
- Capacity constrained by basic freeway capacity.
- Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- Breakdown may occur in some cases for Type C segments.
- When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

HCS2000: Freeway Weaving Release 4.1b  
Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: PM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Proposed E. of interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2005  
 Description: Remove Loop Ramp from SR-1

Inputs

Freeway free-flow speed, SFF	65	mph
weaving number of lanes, N	3	
weaving segment length, L	1750	ft
Terrain type	Level	
Grade		%
Length		mi
weaving type	A	Multilane or C-D
Volume ratio, VR	0.21	
weaving ratio, R	0.24	

Conversion to pc/h Under Base Conditions

	Non-weaving		Weaving		veh/h
	V	V	V	V	
Volume, V	A-C	B-D	A-D	B-C	
Peak-hour factor, PHF	3776	360	272	859	
Peak 15-min volume, v15	0.90	0.90	0.90	0.90	
Trucks and buses	1049	100	76	239	v
Recreational vehicles	7	7	7	7	%
Trucks and buses PCE, ET	0	0	0	0	%
Recreational vehicle PCE, ER	1.5	1.5	1.5	1.5	
Heavy vehicle adjustment, FHV	1.2	1.2	1.2	1.2	
Driver population adjustment, FP	0.966	0.966	0.966	0.966	
Flow rate, v	1.00	1.00	1.00	1.00	
	4342	413	312	987	pc/h

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
weaving intensity factor, Wi	0.94	0.56
weaving and non-weaving speeds, Si	43.35	50.32
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		1.02
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

weaving segment speed, S	48.64	mph
weaving segment density, D	41.48	pc/mi/ln
Level of service, LOS	E	
Capacity for base condition, cb	6210	pc/h

Limitations on weaving Segments

	Analyzed	If Max Exceeded	See Note
weaving flow rate, Vw	1299	2800	a
Average flow rate (pcphpl)	2018	2350	b
Volume ratio, VR	0.21	0.45	c
weaving ratio, R	0.24	N/A	d
weaving length (ft)	1750	2500	e

Notes:

- Capacity constrained by maximum allowable weaving flow rate.
- Capacity constrained by basic freeway capacity.
- Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- Breakdown may occur in some cases for Type C segments.
- When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

HCS2000: Freeway Weaving Release 4.1b  
Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: AM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Proposed E. of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Removal of Loop Ramp from SR 1

Inputs

Freeway free-flow speed, SFF	65	mph
weaving number of lanes, N	3	
Weaving segment length, L	1750	ft
Terrain type	Level	
Grade		%
Length		mi
Weaving type	A	Multilane or C-D
Volume ratio, VR	0.19	
weaving ratio, R	0.39	

Conversion to pc/h Under Base Conditions

	Non-weaving		Weaving		veh/h
	V	V	V	V	
Volume, V	A-C 3976	B-D 270	A-D 402	B-C 624	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	1104	75	112	173	v
Trucks and buses	7	7	7	7	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	1.5	1.5	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	1.2	1.2	
Heavy vehicle adjustment, fhv	0.966	0.966	0.966	0.966	
Driver population adjustment, fp	1.00	1.00	1.00	1.00	
Flow rate, v	4572	310	462	717	pc/h

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
weaving intensity factor, wi	0.91	0.52
weaving and non-weaving speeds, Si	43.84	51.14
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		0.96
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

Weaving Segment Speed, Density, Level of Service and Capacity

weaving segment speed, S	49.53	mph
weaving segment density, D	40.79	pc/mi/ln
Level of service, LOS	E	
Capacity for base condition, cb	6297	pc/h

Limitations on weaving Segments

	Analyzed	If Max Exceeded	See Note
weaving flow rate, vw	1179	2800	a
Average flow rate (pcphpl)	2020	2350	b
Volume ratio, VR	0.19	0.45	c
weaving ratio, R	0.39	N/A	d
weaving length (ft)	1750	2500	e

Notes:

- Capacity constrained by maximum allowable weaving flow rate.
- Capacity constrained by basic freeway capacity.
- Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- Breakdown may occur in some cases for Type C segments.
- When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

HCS2000: Freeway Weaving Release 4.1b  
Operational Analysis

Analyst: SEM  
 Agency/Co.: CEA, LLC  
 Date Performed: 5/20/2002  
 Analysis Time Period: PM  
 Freeway/dir or Travel: I-24/440 EB  
 Weaving Location: Proposed E. of Interchange  
 Jurisdiction: Nashville  
 Analysis Year: 2025  
 Description: Removal of Loop Ramp from S.R. 1

Inputs

Freeway free-flow speed, SFF	65	mph
weaving number of lanes, N	3	
weaving segment length, L	1750	ft
Terrain type	Level	
Grade		%
Length		mi
weaving type	A	Multilane or C-D
Volume ratio, VR	0.21	
weaving ratio, R	0.30	

Conversion to pc/h Under Base Conditions

	Non-weaving		weaving		veh/h
	V	V	V	V	
Volume, v	A-C	B-D	A-D	B-C	
Peak-hour factor, PHF	5227	413	447	1049	
Peak 15-min volume, v15	0.90	0.90	0.90	0.90	
Trucks and buses	1452	115	124	291	v
Recreational vehicles	7	7	7	7	%
Trucks and buses PCE, ET	0	0	0	0	%
Recreational vehicle PCE, ER	1.5	1.5	1.5	1.5	
Heavy vehicle adjustment, fhv	1.2	1.2	1.2	1.2	
Driver population adjustment, fp	0.966	0.966	0.966	0.966	
Flow rate, v	1.00	1.00	1.00	1.00	
	6011	474	514	1206	pc/h

Weaving and Non-weaving Speeds

	Weaving	Non-weaving
weaving intensity factor, wi	1.25	0.81
weaving and non-weaving speeds, Si	39.43	45.33
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)		1.04
Maximum number of lanes, Nw (max) (Exhibit 24-7)		1.40
Type of operation is		Unconstrained

weaving segment speed, Density, Level of Service and Capacity

weaving segment speed, S	43.95	mph
weaving segment density, D	62.23	pc/mi/ln
Level of service, LOS	F	
Capacity for base condition, cb	6231	pc/h

Limitations on weaving Segments

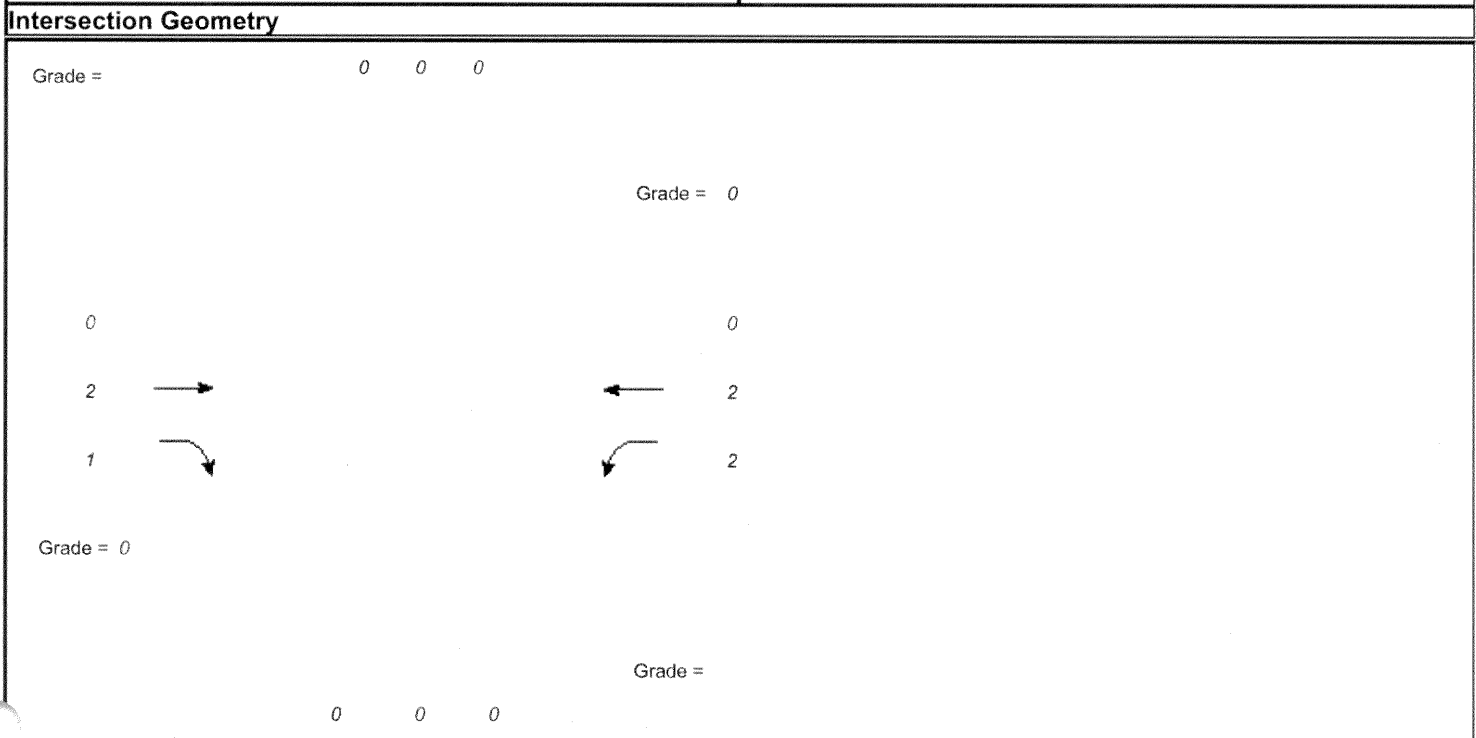
	Analyzed	If Max Exceeded	See Note
weaving flow rate, Vw	1720	2800	a
Average flow rate (pcphpl)	2735	2350	b
Volume ratio, VR	0.21	0.45	c
weaving ratio, R	0.30	N/A	d
weaving length (ft)	1750	2500	e

Notes:

- Capacity constrained by maximum allowable weaving flow rate.
- Capacity constrained by basic freeway capacity.
- Segments do not operate well at VR's exceeding max. Poor operations and some local queuing are expected in such cases.
- Breakdown may occur in some cases for Type C segments.
- When length exceeds these limits, merge and diverge are treated as isolated junctions and analyzed accordingly (HCM Chapter 25, HCS Ramps.)

**FULL REPORT**

General Information			Site Information		
Analyst	TMC		Intersection		
Agency or Co.	CEA, LLC		Area Type	CBD or Similar	
Date Performed	5/20/2002		Jurisdiction	Nashville	
Time Period	AM		Analysis Year	2005	



Volume and Timing Input												
	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		606	341	404	3094							
% Heavy veh		0	0	0	0							
PHF		0.90	0.90	0.90	0.90							
Actuated (P/A)		P	P	P	P							
Startup lost time		2.0	2.0	2.0	2.0							
Ext. eff. green		2.0	2.0	2.0	2.0							
Arrival type		3	3	3	3							
Unit Extension		3.0	3.0	3.0	3.0							
Ped/Bike/RTOR Volume	0		0									
Lane Width		12.0	12.0	12.0	12.0							
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0	0	0	0							
Ped timing		3.2										
	WB Only	Thru & RT	03	04	05	06	07	08				
Timing	G = 20.0	G = 30.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0				
	Y = 5	Y = 5	Y = 0	Y =	Y = 0	Y =	Y = 0	Y =				
Duration of Analysis (hrs) = 0.25						Cycle Length C = 60.0						

### VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

**General Information**

Project Description *Murfreesboro Rd & I-24/440*

**Volume Adjustment**

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume		606	341	404	3094							
PHF		0.90	0.90	0.90	0.90							
Adj. Flow Rate		673	379	449	3438							
Lane Group		T	R	L	T							
Adj. flow rate		673	379	449	3438							
Prop. LT or RT	0.000	--		0.000	--	0.000		--			--	

**Saturation Flow Rate**

Base satflow		1900	1900	1900	1900							
Num. of lanes	0	2	1	2	2	0	0	0	0	0	0	0
fW		1.000	1.000	1.000	1.000							
fHV		1.000	1.000	1.000	1.000							
fg		1.000		1.000								
fp		1.000	1.000	1.000	1.000							
fbb		1.000	1.000	1.000	1.000							
fa		0.90		0.90								
fLU		0.95	1.00	0.97	0.95							
fLT		1.000	--	0.950	1.000	--			--			--
Secondary fLT			--			--			--			--
fRT	--	1.000	0.850	--	1.000		--			--		
fLpb		1.000	--	1.000	1.000	--			--			--
fRpb	--	1.000	1.000	--	1.000		--			--		
Adj. satflow		3249	1454	3152	3249							
Sec. adj. satflow			--			--			--			--

**CAPACITY AND LOS WORKSHEET**

**General Information**

Project Description *Murfreesboro Rd & I-24/440*

**Capacity Analysis**

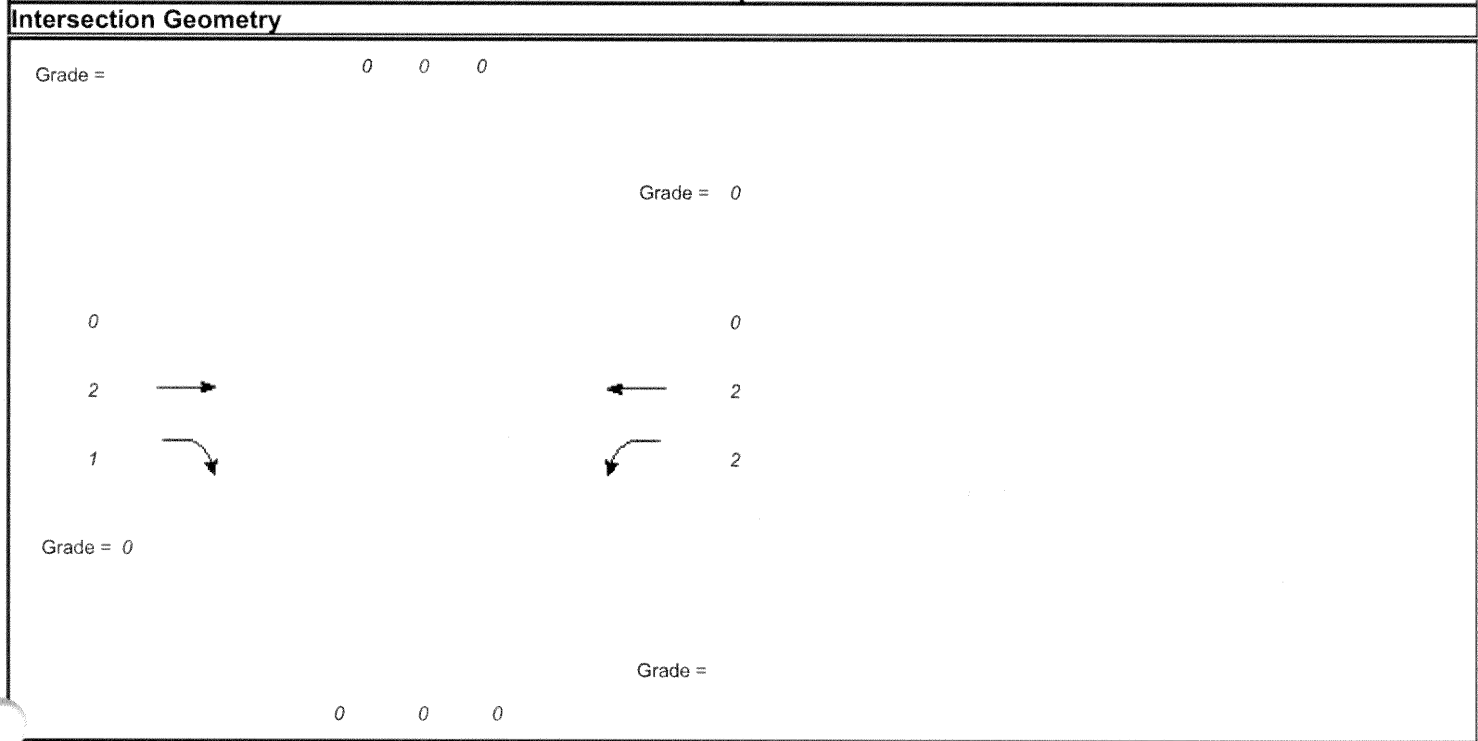
	EB		WB		NB			SB	
Lane group	T	R	L	T					
Adj. flow rate	673	379	449	3438					
Satflow rate	3249	1454	3152	3249					
Lost time	2.0	2.0	2.0	2.0					
Green ratio	0.50	0.50	0.33	1.00					
Lane group cap.	1625	727	1051	3249					
v/c ratio	0.41	0.52	0.43	1.06					
Flow ratio	0.21	0.26	0.14	1.06					
Crit. lane group	N	N	N	Y					
Sum flow ratios					1.06				
Lost time/cycle					0.00				
Critical v/c ratio					1.06				

**Lane Group Capacity, Control Delay, and LOS Determination**

	EB		WB		NB			SB	
Lane group	T	R	L	T					
Adj. flow rate	673	379	449	3438					
Lane group cap.	1625	727	1051	3249					
v/c ratio	0.41	0.52	0.43	1.06					
Green ratio	0.50	0.50	0.33	1.00					
Unif. delay d1	9.5	10.1	15.5	0.0					
Delay factor k	0.50	0.50	0.50	0.50					
Increm. delay d2	0.8	2.7	1.3	33.9					
PF factor	1.000	1.000	1.000	0.950					
Control delay	10.2	12.8	16.8	33.9					
Lane group LOS	B	B	B	C					
Apprch. delay	11.2		32.0						
Approach LOS	B		C						
Intersec. delay	27.5		Intersection LOS				C		

**FULL REPORT**

General Information				Site Information	
Analyst	TMC	Intersection			
Agency or Co.	CEA, LLC	Area Type	CBD or Similar		
Date Performed	5/20/2002	Jurisdiction	Nashville		
Time Period	PM	Analysis Year	2005		



**Volume and Timing Input**

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		2406	661	558	1496							
% Heavy veh		0	0	0	0							
PHF		0.90	0.90	0.90	0.90							
Actuated (P/A)		P	P	P	P							
Startup lost time		2.0	2.0	2.0	2.0							
Ext. eff. green		2.0	2.0	2.0	2.0							
Arrival type		3	3	3	3							
Unit Extension		3.0	3.0	3.0	3.0							
Ped/Bike/RTOR Volume	0		0									
Lane Width		12.0	12.0	12.0	12.0							
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0	0	0	0							
Ped timing		3.2										
	WB Only	Thru & RT	03	04	05	06	07	08				
Timing	G = 20.0	G = 80.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0				
	Y = 5	Y = 5	Y = 0	Y =	Y = 0	Y =	Y = 0	Y =				
Duration of Analysis (hrs) = 0.25						Cycle Length C = 110.0						



### VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

**General Information**

Project Description *Murfreesboro Rd & I-24/440*

**Volume Adjustment**

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume		2406	661	558	1496							
PHF		0.90	0.90	0.90	0.90							
Adj. Flow Rate		2673	734	620	1662							
Lane Group		T	R	L	T							
Adj. flow rate		2673	734	620	1662							
Prop. LT or RT	0.000	--		0.000	--	0.000		--			--	

**Saturation Flow Rate**

Base satflow		1900	1900	1900	1900							
Num. of lanes	0	2	1	2	2	0	0	0	0	0	0	0
fW		1.000	1.000	1.000	1.000							
fHV		1.000	1.000	1.000	1.000							
fg		1.000		1.000								
fp		1.000	1.000	1.000	1.000							
fbb		1.000	1.000	1.000	1.000							
fa		0.90		0.90								
fLU		0.95	1.00	0.97	0.95							
fLT		1.000	--	0.950	1.000	--			--			--
Secondary fLT			--			--			--			--
fRT	--	1.000	0.850	--	1.000		--			--		
fLpb		1.000	--	1.000	1.000	--			--			--
fRpb	--	1.000	1.000	--	1.000		--			--		
Adj. satflow		3249	1454	3152	3249							
Sec. adj. satflow			--			--			--			--

**CAPACITY AND LOS WORKSHEET**

**General Information**

Project Description *Murfreesboro Rd & I-24/440*

**Capacity Analysis**

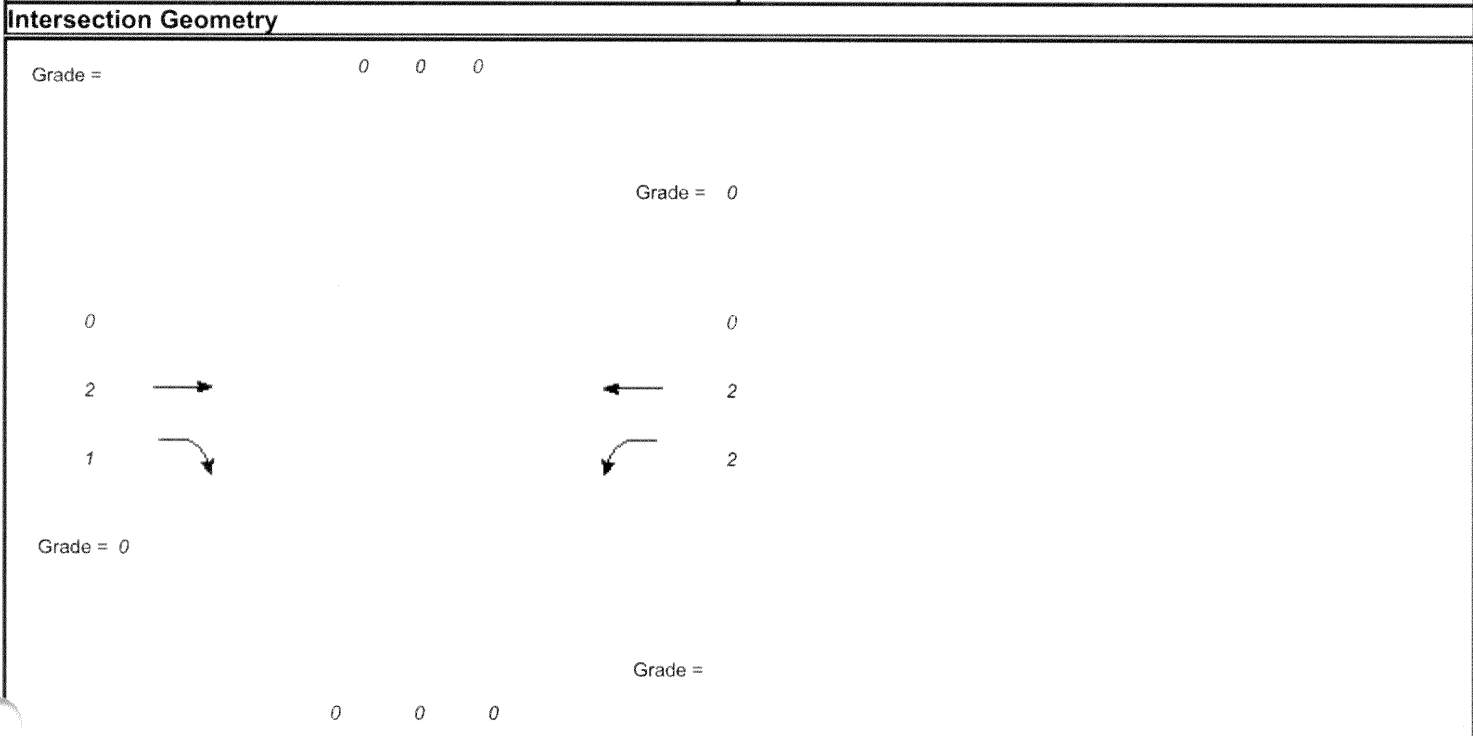
	EB		WB		NB			SB	
Lane group	T	R	L	T					
Adj. flow rate	2673	734	620	1662					
Satflow rate	3249	1454	3152	3249					
Lost time	2.0	2.0	2.0	2.0					
Green ratio	0.73	0.73	0.18	1.00					
Lane group cap.	2363	1057	573	3249					
v/c ratio	1.13	0.69	1.08	0.51					
Flow ratio	0.82	0.50	0.20	0.51					
Crit. lane group	Y	N	Y	N					
Sum flow ratios					1.02				
Lost time/cycle					10.00				
Critical v/c ratio					1.12				

**Lane Group Capacity, Control Delay, and LOS Determination**

	EB		WB		NB			SB	
Lane group	T	R	L	T					
Adj. flow rate	2673	734	620	1662					
Lane group cap.	2363	1057	573	3249					
v/c ratio	1.13	0.69	1.08	0.51					
Green ratio	0.73	0.73	0.18	1.00					
Unif. delay d1	15.0	8.3	45.0	0.0					
Delay factor k	0.50	0.50	0.50	0.50					
Increm. delay d2	65.0	3.8	61.7	0.6					
PF factor	1.000	1.000	1.000	0.950					
Control delay	80.0+	12.0	106.7	0.6					
Lane group LOS	F	B	F	A					
Apprch. delay	65.4		29.4						
Approach LOS	E		C						
Intersec. delay	50.9		Intersection LOS				D		

**FULL REPORT**

General Information				Site Information			
Analyst	TMC	Intersection		Area Type	CBD or Similar		
Agency or Co.	CEA, LLC	Jurisdiction		Analysis Year	Nashville		
Date Performed	5/20/2002						
Time Period	AM				2025		



**Volume and Timing Input**

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		901	409	485	4404							
% Heavy veh		0	0	0	0							
PHF		0.90	0.90	0.90	0.90							
Actuated (P/A)		P	P	P	P							
Startup lost time		2.0	2.0	2.0	2.0							
Ext. eff. green		2.0	2.0	2.0	2.0							
Arrival type		3	3	3	3							
Unit Extension		3.0	3.0	3.0	3.0							
Ped/Bike/RTOR Volume	0		0									
Lane Width		12.0	12.0	12.0	12.0							
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0	0	0	0							
Ped timing		3.2										
	WB Only	Thru & RT	03	04	05	06	07	08				
Timing	G = 15.0	G = 35.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0				
	Y = 5	Y = 5	Y = 0	Y =	Y = 0	Y =	Y = 0	Y =				
Duration of Analysis (hrs) = 0.25						Cycle Length C = 60.0						

## VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

### General Information

Project Description *Murfreesboro Rd & I-24/440*

### Volume Adjustment

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume		901	409	485	4404							
PHF		0.90	0.90	0.90	0.90							
Adj. Flow Rate		1001	454	539	4893							
Lane Group		T	R	L	T							
Adj. flow rate		1001	454	539	4893							
Prop. LT or RT	0.000	--		0.000	--	0.000		--			--	

### Saturation Flow Rate

Base satflow		1900	1900	1900	1900							
Num. of lanes	0	2	1	2	2	0	0	0	0	0	0	0
fW		1.000	1.000	1.000	1.000							
fHV		1.000	1.000	1.000	1.000							
f <sub>g</sub>		1.000		1.000								
f <sub>p</sub>		1.000	1.000	1.000	1.000							
f <sub>bb</sub>		1.000	1.000	1.000	1.000							
f <sub>a</sub>		0.90		0.90								
f <sub>LU</sub>		0.95	1.00	0.97	0.95							
f <sub>LT</sub>		1.000	--	0.950	1.000	--			--			--
Secondary f <sub>LT</sub>			--			--			--			--
f <sub>RT</sub>	--	1.000	0.850	--	1.000		--			--		
f <sub>Lpb</sub>		1.000	--	1.000	1.000	--			--			--
f <sub>Rpb</sub>	--	1.000	1.000	--	1.000		--			--		
Adj. satflow		3249	1454	3152	3249							
Sec. adj. satflow			--			--			--			--

### CAPACITY AND LOS WORKSHEET

#### General Information

Project Description *Murfreesboro Rd & I-24/440*

#### Capacity Analysis

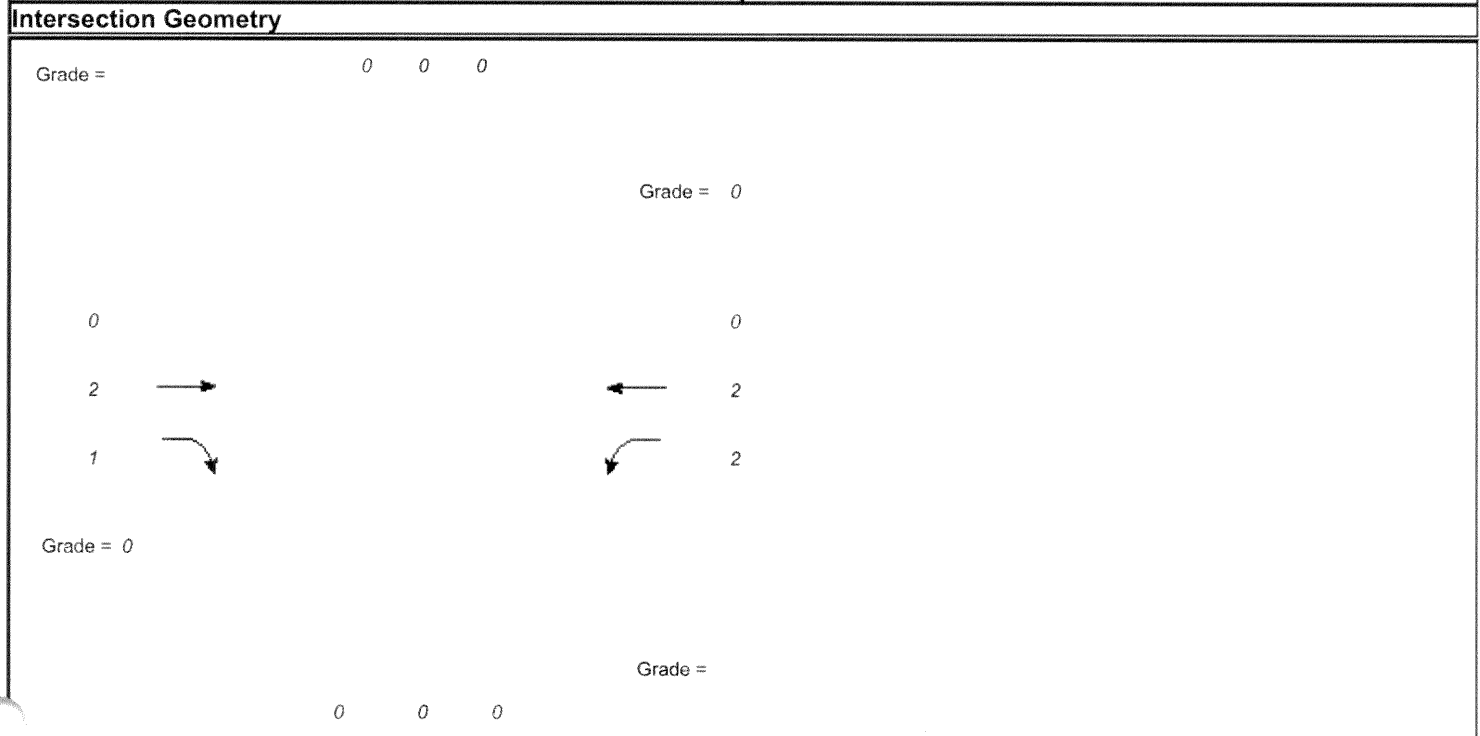
	EB		WB		NB			SB	
	T	R	L	T					
Lane group									
Adj. flow rate	1001	454	539	4893					
Satflow rate	3249	1454	3152	3249					
Lost time	2.0	2.0	2.0	2.0					
Green ratio	0.58	0.58	0.25	1.00					
Lane group cap.	1895	848	788	3249					
v/c ratio	0.53	0.54	0.68	1.51					
Flow ratio	0.31	0.31	0.17	1.51					
Crit. lane group	N	N	N	Y					
Sum flow ratios					1.51				
Lost time/cycle					0.00				
Critical v/c ratio					1.51				

#### Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB			SB	
	T	R	L	T					
Lane group									
Adj. flow rate	1001	454	539	4893					
Lane group cap.	1895	848	788	3249					
v/c ratio	0.53	0.54	0.68	1.51					
Green ratio	0.58	0.58	0.25	1.00					
Unif. delay d1	7.5	7.6	20.4	0.0					
Delay factor k	0.50	0.50	0.50	0.50					
Increm. delay d2	1.1	2.4	4.8	229.3					
PF factor	1.000	1.000	1.000	0.950					
Control delay	8.6	10.0-	25.1	229.3					
Lane group LOS	A	A	C	F					
Apprch. delay	9.0		209.1						
Approach LOS	A		F						
Intersec. delay	166.8		Intersection LOS				F		

**FULL REPORT**

General Information		Site Information	
Analyst	TMC	Intersection	
Agency or Co.	CEA, LLC	Area Type	CBD or Similar
Date Performed	5/20/2002	Jurisdiction	Nashville
Time Period	PM	Analysis Year	2025



**Volume and Timing Input**

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		3403	793	669	2192							
% Heavy veh		0	0	0	0							
PHF		0.90	0.90	0.90	0.90							
Actuated (P/A)		P	P	P	P							
Startup lost time		2.0	2.0	2.0	2.0							
Ext. eff. green		2.0	2.0	2.0	2.0							
Arrival type		3	3	3	3							
Unit Extension		3.0	3.0	3.0	3.0							
Ped/Bike/RTOR Volume	0		0									
Lane Width		12.0	12.0	12.0	12.0							
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0	0	0	0							
Ped timing		3.2										
	WB Only	Thru & RT	03	04	05	06	07	08				
Timing	G = 15.0	G = 35.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0	G = 0.0				
	Y = 5	Y = 5	Y = 0	Y =	Y = 0	Y =	Y = 0	Y =				
Duration of Analysis (hrs) = 0.25						Cycle Length C = 60.0						

### VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

**General Information**

Project Description *Murfreesboro Rd & I-24/440*

**Volume Adjustment**

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume		3403	793	669	2192							
PHF		0.90	0.90	0.90	0.90							
Adj. Flow Rate		3781	881	743	2436							
Lane Group		T	R	L	T							
Adj. flow rate		3781	881	743	2436							
Prop. LT or RT	0.000	--		0.000	--	0.000		--		--		

**Saturation Flow Rate**

Base satflow		1900	1900	1900	1900							
Num. of lanes	0	2	1	2	2	0	0	0	0	0	0	0
fW		1.000	1.000	1.000	1.000							
fHV		1.000	1.000	1.000	1.000							
fg		1.000		1.000								
fp		1.000	1.000	1.000	1.000							
fbb		1.000	1.000	1.000	1.000							
fa		0.90		0.90								
fLU		0.95	1.00	0.97	0.95							
fLT		1.000	--	0.950	1.000	--			--			--
Secondary fLT			--			--			--			--
fRT	--	1.000	0.850	--	1.000		--			--		
fLpb		1.000	--	1.000	1.000	--			--			--
fRpb	--	1.000	1.000	--	1.000		--			--		
Adj. satflow		3249	1454	3152	3249							
Sec. adj. satflow			--			--			--			--

CAPACITY AND LOS WORKSHEET											
General Information											
Project Description <i>Murfreesboro Rd &amp; I-24/440</i>											
Capacity Analysis											
	EB		WB		NB			SB			
Lane group	<i>T</i>	<i>R</i>	<i>L</i>	<i>T</i>							
Adj. flow rate	3781	881	743	2436							
Satflow rate	3249	1454	3152	3249							
Lost time	2.0	2.0	2.0	2.0							
Green ratio	0.58	0.58	0.25	1.00							
Lane group cap.	1895	848	788	3249							
v/c ratio	2.00	1.04	0.94	0.75							
Flow ratio	1.16	0.61	0.24	0.75							
Crit. lane group	<i>Y</i>	<i>N</i>	<i>Y</i>	<i>N</i>							
Sum flow ratios					1.40						
Lost time/cycle					10.00						
Critical v/c ratio					1.68						
Lane Group Capacity, Control Delay, and LOS Determination											
	EB		WB		NB			SB			
Lane group	<i>T</i>	<i>R</i>	<i>L</i>	<i>T</i>							
Adj. flow rate	3781	881	743	2436							
Lane group cap.	1895	848	788	3249							
v/c ratio	2.00	1.04	0.94	0.75							
Green ratio	0.58	0.58	0.25	1.00							
Unif. delay d1	12.5	12.5	22.1	0.0							
Delay factor k	0.50	0.50	0.50	0.50							
Increm. delay d2	449.8	41.5	20.8	1.6							
PF factor	1.000	1.000	1.000	0.950							
Control delay	462.3	54.0	42.9	1.6							
Lane group LOS	<i>F</i>	<i>D</i>	<i>D</i>	<i>A</i>							
Apprch. delay	385.1		11.3								
Approach LOS	<i>F</i>		<i>B</i>								
Intersec. delay	233.5		Intersection LOS						<i>F</i>		



**APPENDIX E**  
**COST ESTIMATES**

## COST DATA SHEET

PROJECT: I-24/40/440 & U.S. 41 (Murfreesboro Pike)  
 LOCATION: Davidson County, Tennessee  
 LENGTH: N/A  
 CROSS SECTION: N/A

### RIGHT-OF-WAY

Land, Improvements & Damages	(# Acres	0.00 )	\$0
Incidentals	(# Tracts	0 )	\$0
Relocation Payments	(Residences	0 )	\$0
	(Businesses	0 )	
	(Non-Profits	0 )	
<b>Total Right-Of-Way Cost</b>			<b>\$0</b>

### UTILITY RELOCATION

Reimbursable	\$0
Non-Reimbursable	\$45,000
<b>Total Utility Adjustment Cost</b>	
	<b>\$45,000</b>

### CONSTRUCTION

Clear and Grubbing	\$0
Earthwork	\$473,000
Pavement Removal	\$160,000
Drainage (Erosion Control =	\$13,000 )
Structures (Preserv'n/Demol'n =	\$0 )
Railroad Crossing	\$0
Paving	\$212,000
Retaining Walls (Barrier Rail)	\$30,000
Maintenance of Traffic	\$100,000
Topsoil	\$2,000
Seeding	\$1,000
Sodding	\$2,000
Signing	\$25,000
Signalization	\$75,000
Fence	\$0
Guardrail	\$5,000
Rip-rap or Slope Protection	\$2,000
Other Construction Items (8.5%)	\$98,000
Mobilization	\$61,000
10% Engineering and Contingencies	\$131,000
<b>Total Construction Cost</b>	
	<b>\$1,441,000</b>
<b>Preliminary Engineering (10% of Constr.)</b>	
	<b>\$131,000</b>

<b>TOTAL ESTIMATED COST</b>	<b>\$1,617,000</b>
-----------------------------	--------------------

	Area (ac)	Cost/Acre	Total Cost
Clearing & Grubbing	0	\$2,000	\$0

Earthwork	Length (ft)	Factor	Total (cy)	Cost/cy	Total Cost
	320	3.72	1,190		
	300	15.29	4,587		
	0	0	0		
	Total:		5,777	\$3.5	\$20,221

	Length	Factor	Total (cy)	Cost/C.Yd.	Total Cost
Rock Exc.	-	-	20,741	\$7	\$145,187
Inside Loop Ramp	-	-	36,296	\$7	\$254,072
Gore Area and Ramp	-	-	7,711	\$7	\$53,977
					<u>\$453,236</u>

Total: **\$473,457**

Drainage	Misc Pipes	Size (in)	Length (ft)	Cost	Total Cost		
		18	400	\$20	\$8,000		
		24	250	\$26	\$6,500		
		30	150	\$31	\$4,650		
	Catchbasins	Number	6	Cost \$2,500	Total Cost \$15,000		
	Curb & Gutter	Length	900	Factor 0.07953	Total (cy) 72	Cost \$150	Total Cost \$10,737
	Side Walk	Length	0	Width 5	Total 0	Cost \$2.5	Total Cost \$0
	Headwalls		Number	4	Cost \$1,500	Total Cost \$6,000	
<b>Totals</b>					<b>\$50,887</b>		

Structures	Bridge Widening	Length	Width	Total	Cost/ft	Total Cost
		0	0	0	\$50.0	\$0
	Removal of Existing Rail:					\$0

Erosion Control **\$12,722**

Pavement Removal (Concrete & Asphalt)	Length	Width	Cost	Total Cost
	1,400	38	\$3	<b>\$159,600</b>

Paving	Cost	Length	Total Cost
	\$80	2,100	\$168,000
	\$60	350	\$21,000
	\$75	300	\$22,500
	Total:		<b>\$211,500</b>

Barrier Rail	Length	Cost per ft	Total Cost
	600	\$50.00	\$30,000
	Total:		<b>\$30,000</b>

Maintenance of Traffic **\$100,000**

Topsoil	Length	Factor	Total	Cost per	Total Cost
	900	0.565	509	\$3.00	<b>\$1,526</b>



**APPENDIX F**  
**FUNCTIONAL PLANS**

Index Of Sheets

SHEET NO.	DESCRIPTION
1	TITLE SHEET
2	TYPICAL SECTIONS
3-4	PROPOSED LAYOUT SHEETS

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
PLANNING DIVISION

DAVIDSON COUNTY

I-24/40/440 AND U.S. 41 (MURFREESBORO PIKE)  
INTERCHANGE MODIFICATION STUDY

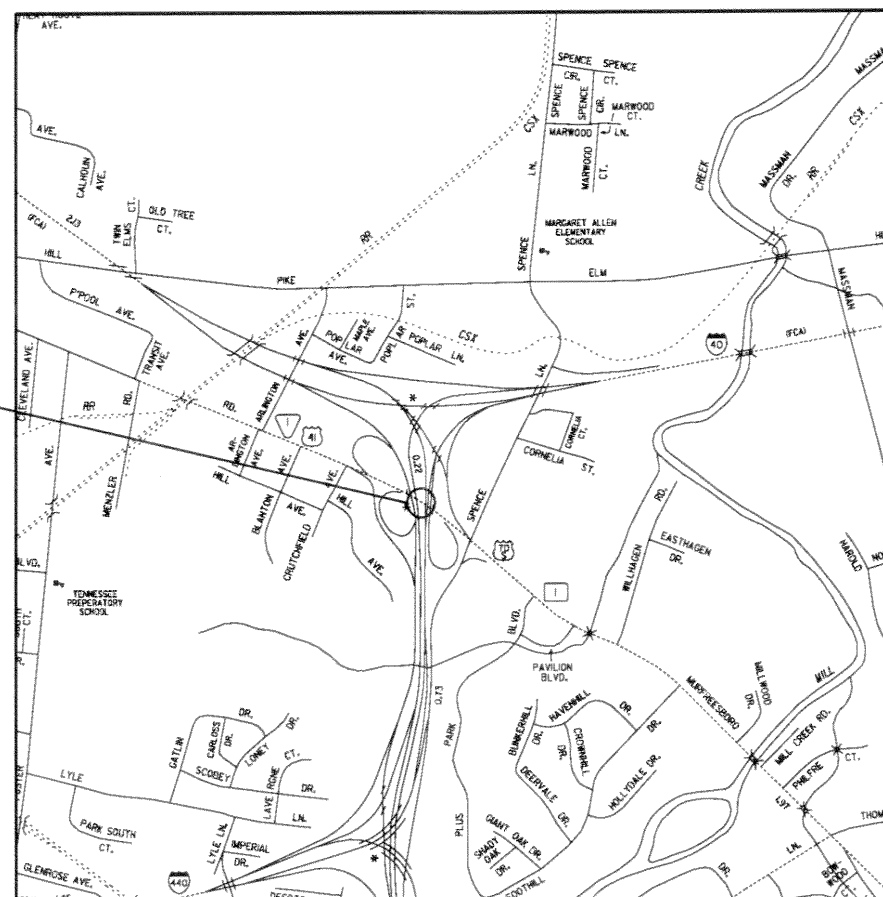
STATE HIGHWAY NO. F.A.H.S. NO.

TENN.	YEAR	SHEET NO.
	2002	1
FED. AID PROJ. NO.		
STATE PROJ. NO.		



PROJECT LOCATION

PROJECT LOCATION



SCALE: 1" = 1000'

SPECIAL NOTES

PROPOSALS MAY BE REJECTED BY THE COMMISSIONER IF ANY OF THE UNIT PRICES CONTAINED THEREIN ARE OBVIOUSLY UNBALANCED, EITHER EXCESSIVE OR BELOW THE REASONABLE COST ANALYSIS VALUE.

THIS PROJECT TO BE CONSTRUCTED UNDER THE STANDARD SPECIFICATIONS OF THE TENNESSEE DEPARTMENT OF TRANSPORTATION DATED MARCH 1, 1995 AND ADDITIONAL SPECIFICATIONS AND SPECIAL PROVISIONS CONTAINED IN THE PLANS AND IN THE PROPOSAL CONTRACT

DESIGNED BY CLINARD ENGINEERING ASSOCIATES, LLC

DESIGNER THOMAS M. CLINARD, P.E. CHECKED BY

P.E. NO.



APPROVED: \_\_\_\_\_  
DIRECTOR, DESIGN DIVISION

DATE: \_\_\_\_\_

APPROVED: \_\_\_\_\_  
COMMISSIONER

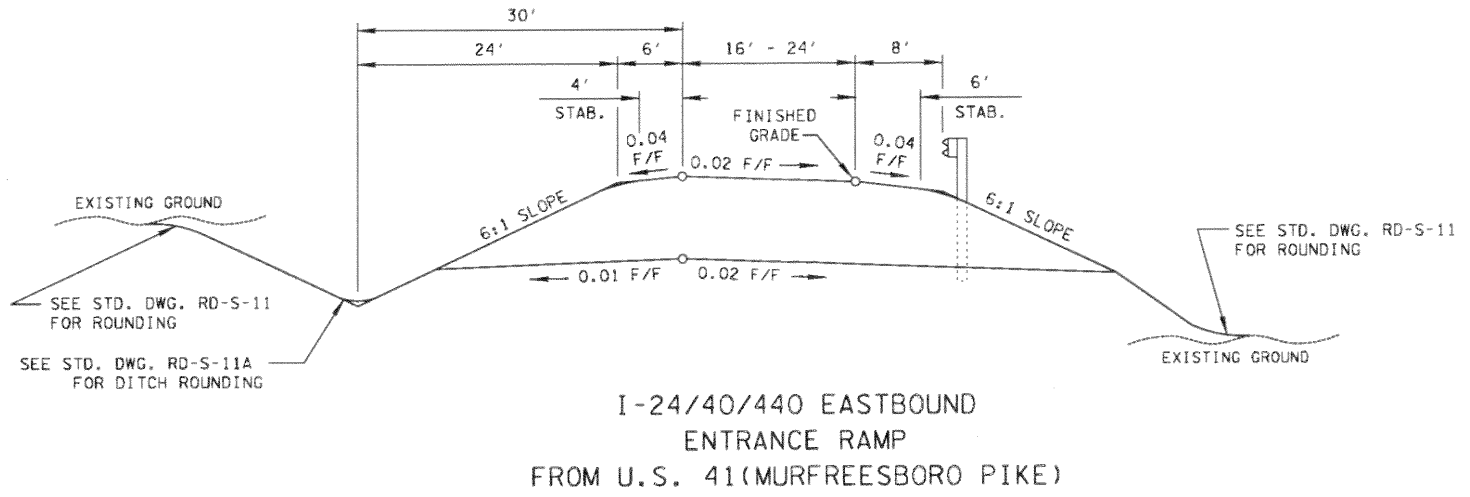
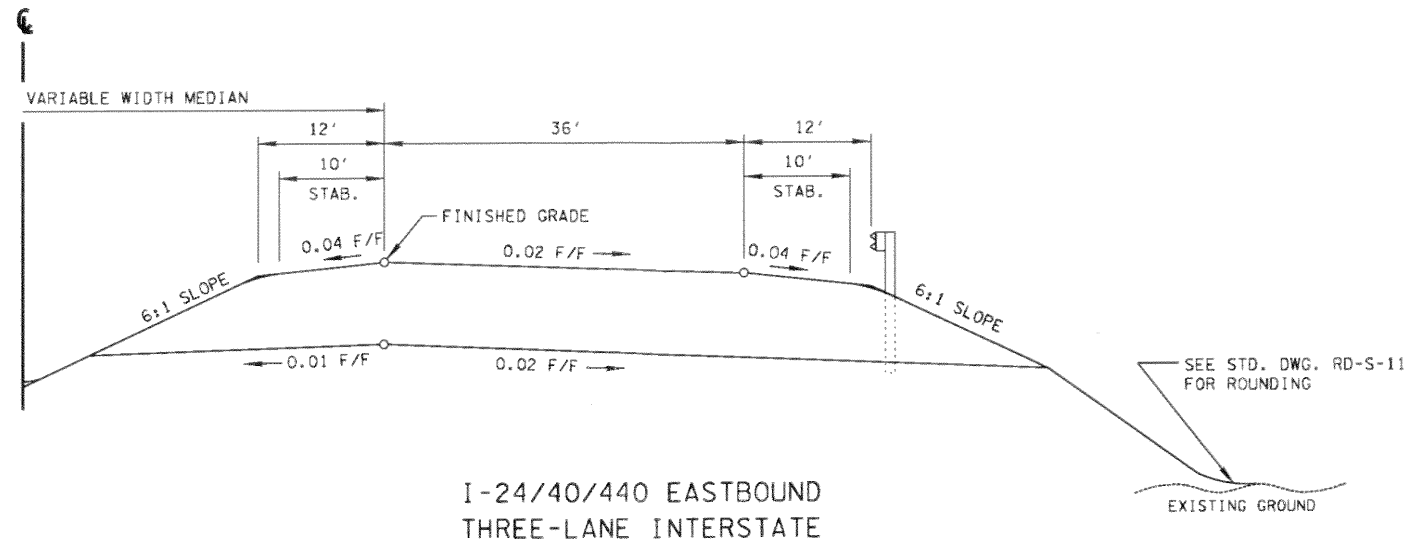
TRAFFIC DATA	
ADT (2005)	45,540
ADT (2025)	61,870
DHV (2025)	6,187
D	55 - 45
T (ADT)	10 %
T (DHV)	7 %
V	60 MPH

U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION

APPROVED: \_\_\_\_\_  
DIVISION ADMINISTRATOR DATE

TYPE	YEAR	PROJECT NO.	SHEET NO.
I.M.S.	2002	I-24/40/440	2

TENNESSEE D.O.T.  
DESIGN DIVISION  
FILE NO.

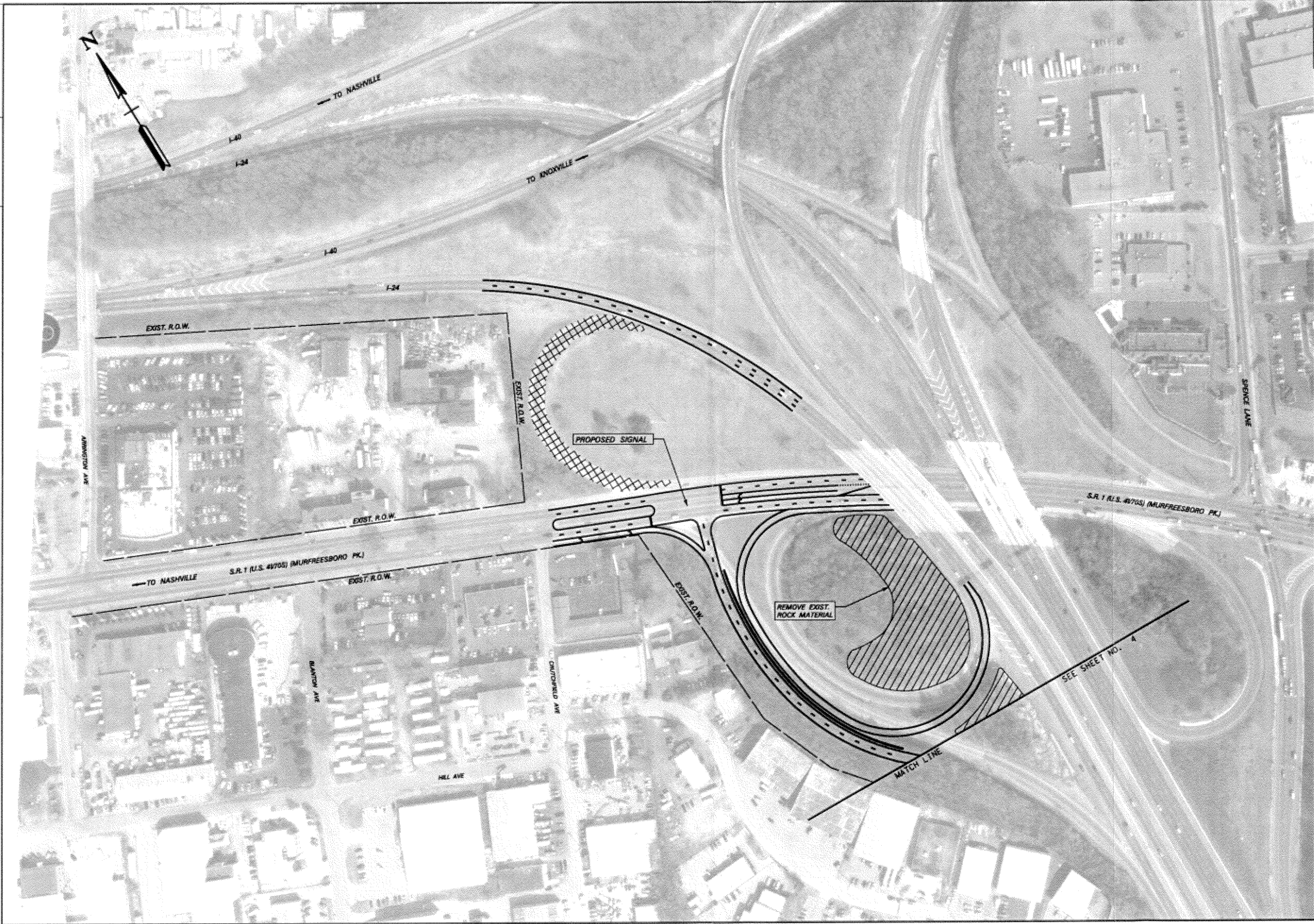


STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
BUREAU OF PLANNING & DEVELOPMENT

TYPICAL  
SECTIONS



TYPE	YEAR	PROJECT NO.	SHEET NO.
I.M.S.	2002	I-24/40/440	3



 AREA TO BE SCARIFIED

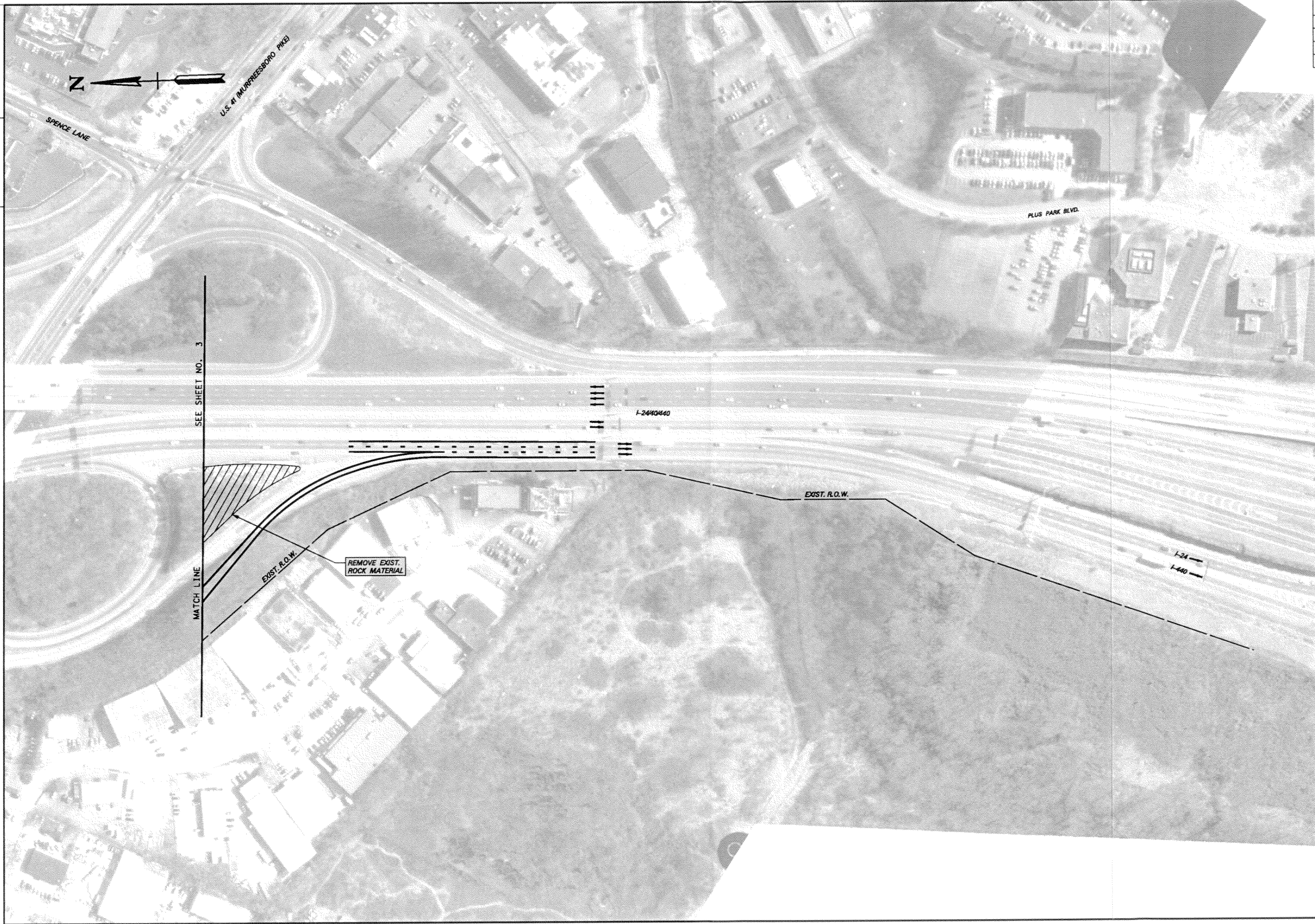


STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
BUREAU OF PLANNING & DEVELOPMENT

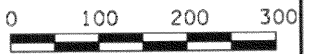
I-24/40/440  
INTERCHANGE  
AREA  
NASHVILLE, TN  
DAVIDSON CO.



TENNESSEE D.O.T.  
DESIGN DIVISION  
FILE NO.



TYPE	YEAR	PROJECT NO.	SHEET NO.
I.M.S.	2002	I-24/40/440	4

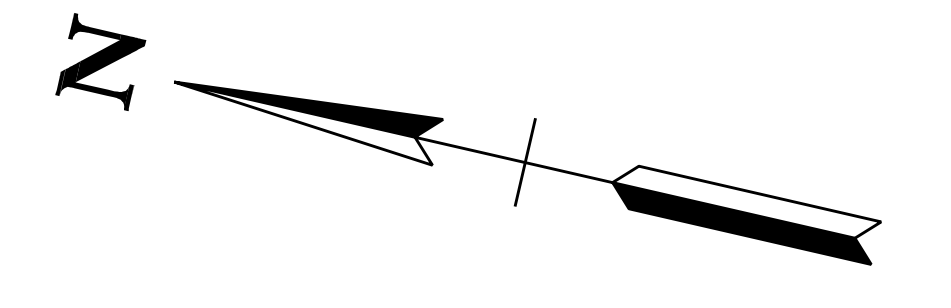


STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
BUREAU OF PLANNING & DEVELOPMENT

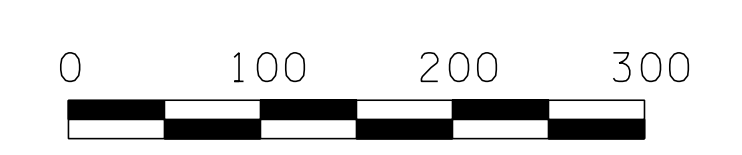
**I-24/40/440  
INTERCHANGE  
AREA  
NASHVILLE, TN  
DAVIDSON CO.**

**APPENDIX G**  
**ALTERNATES INVESTIGATED**



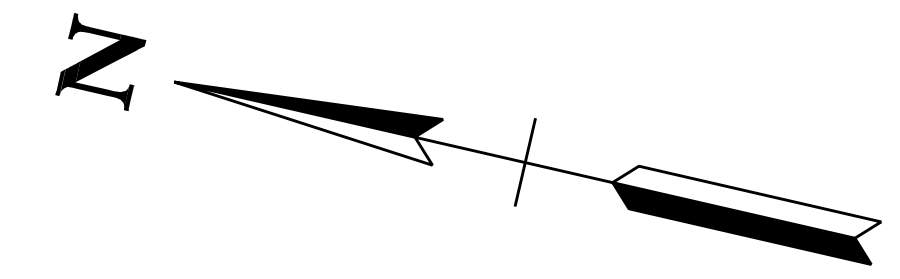
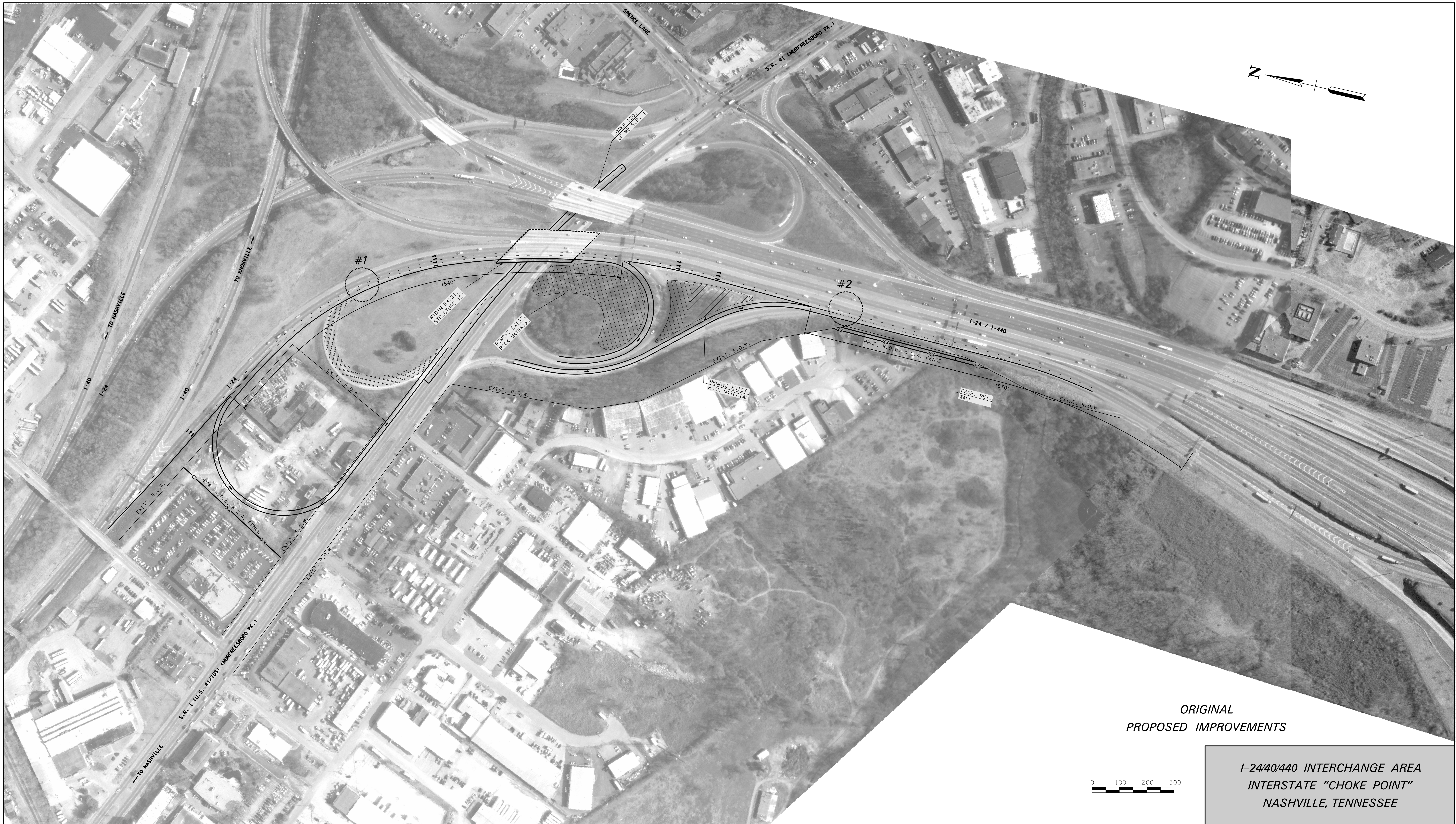


EXISTING  
WEAVE LOCATION

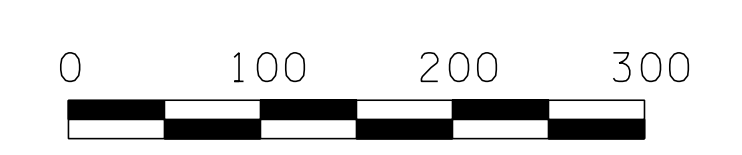


I-24/40/440 INTERCHANGE AREA  
INTERSTATE "CHOKE POINT"  
NASHVILLE, TENNESSEE





ORIGINAL  
PROPOSED IMPROVEMENTS



I-24/40/440 INTERCHANGE AREA  
INTERSTATE "CHOKE POINT"  
NASHVILLE, TENNESSEE





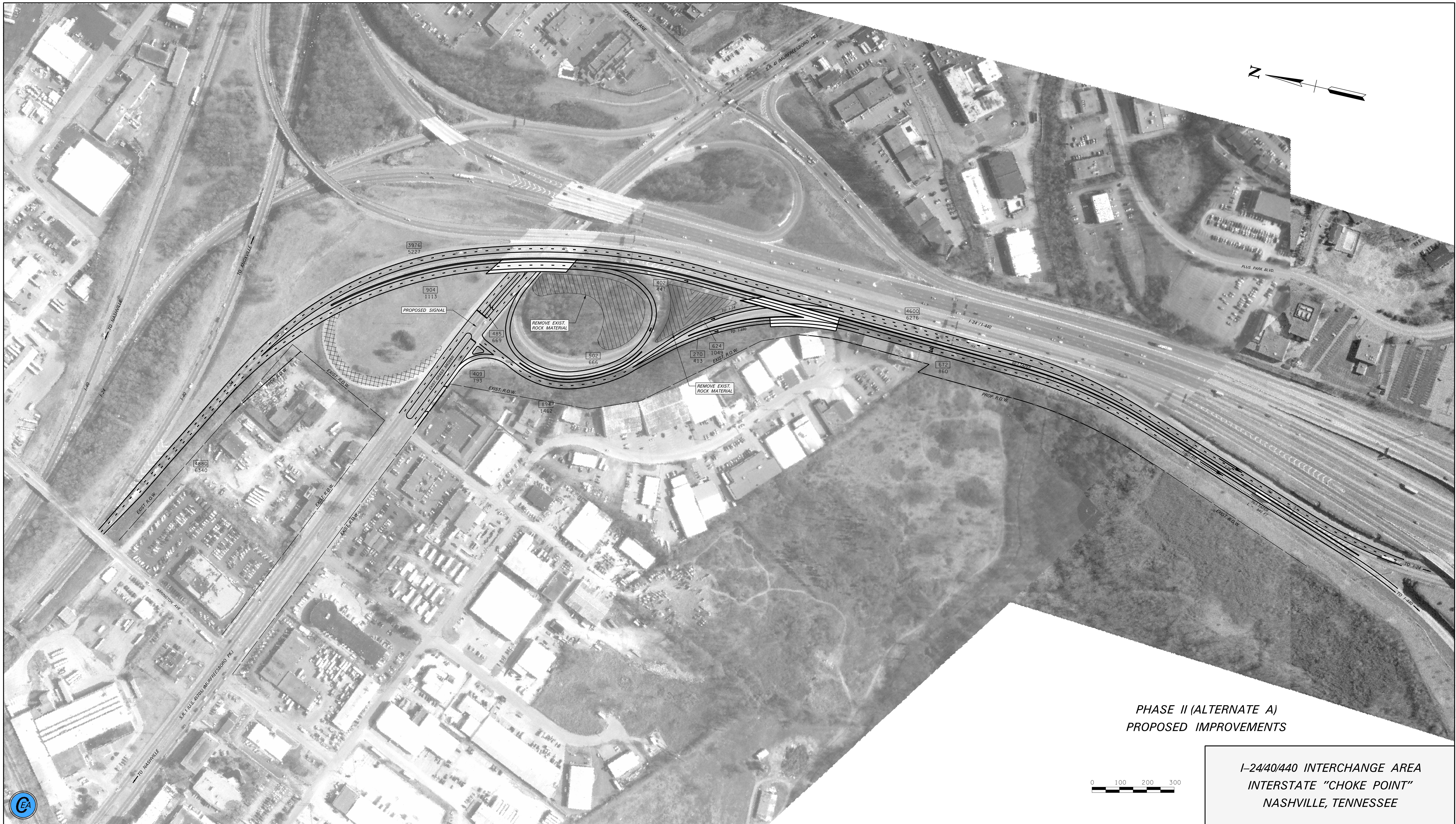
TANGENT RAMP  
PROPOSED IMPROVEMENTS



I-24/40/440 INTERCHANGE AREA  
INTERSTATE "CHOKE POINT"  
NASHVILLE, TENNESSEE





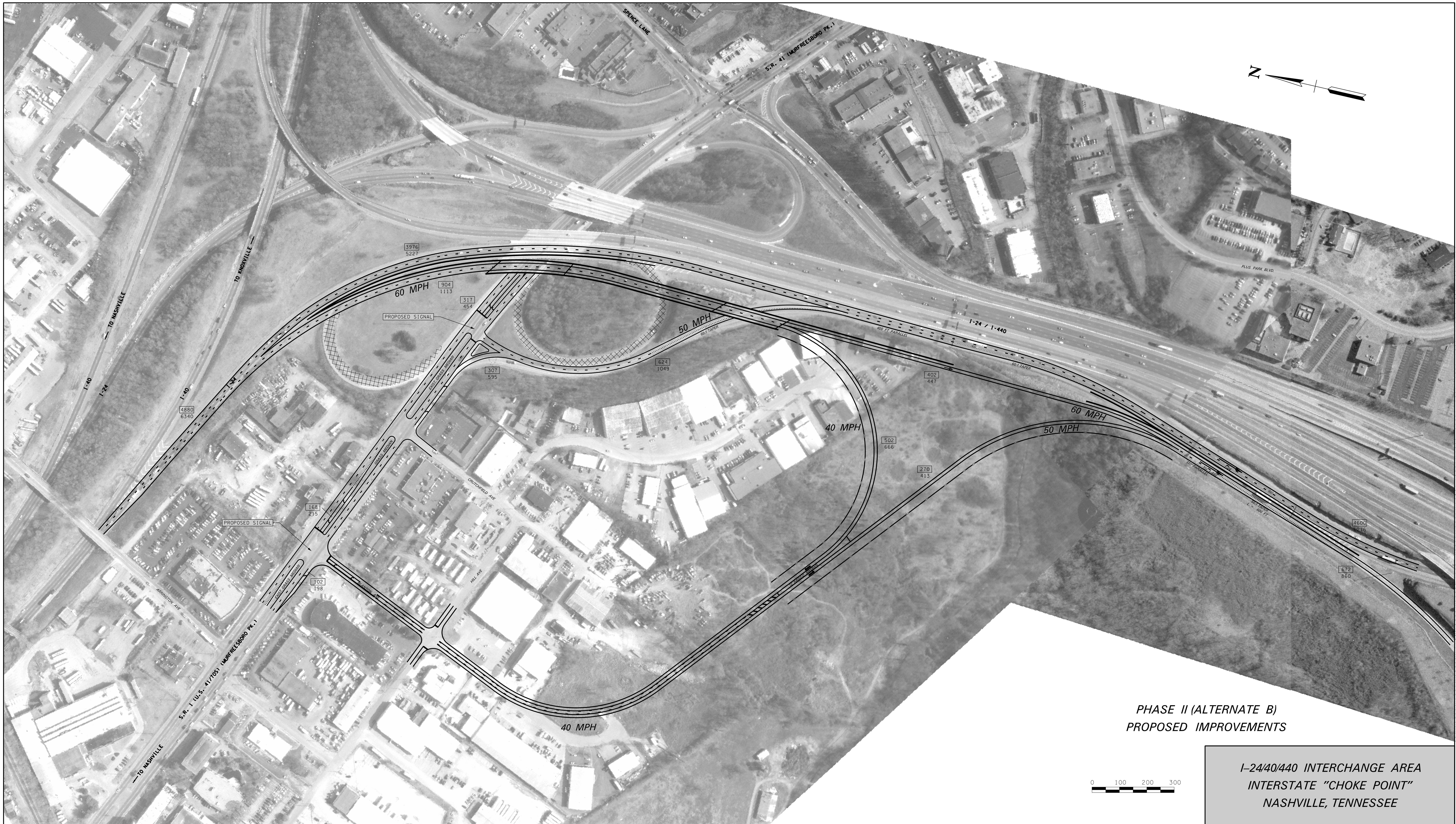


**PHASE II (ALTERNATE A)  
PROPOSED IMPROVEMENTS**

**I-24/40/440 INTERCHANGE AREA  
INTERSTATE "CHOKE POINT"  
NASHVILLE, TENNESSEE**







PHASE II (ALTERNATE B)  
PROPOSED IMPROVEMENTS

I-24/40/440 INTERCHANGE AREA  
INTERSTATE "CHOKE POINT"  
NASHVILLE, TENNESSEE