



Tennessee Department of Transportation

I-240 CM/GC Technical Study

Shelby County, Memphis, Tennessee



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Executive Summary

Purpose & Need

The purpose of the proposed project is to provide an eight-lane I-240 mainline facility through the Poplar Avenue interchange to south of the existing Norfolk Southern (NS) Railroad Bridge which is owned by the State of Tennessee. Due to the condition of the three subject bridges and documented foundation issues, total replacement is required. Based upon the initial work of the study team, the purpose and need also includes:

- Improved vertical and horizontal clearance along I-240 at the bridge crossings to meet current standards
- Complete the planned widening of I-240 that was not constructed due to bridge foundation issues at the three bridge locations
- Minimize the construction time and impacts to the motoring public, area businesses and residents, while replacing the bridges using Accelerated Bridge Construction (ABC) techniques
- Minimize impacts to NS Railroad and replace the 56-year-old structure

Value Planning

Value Planning (VP) develops a range of design solutions for a project and then evaluates those alternatives to arrive at a preferred design that meets engineering performance measures, satisfies the project stakeholders and provides the most value for the anticipated cost. One of the primary advantages of utilizing the value planning process is the efficient vetting of a wide range of solutions that will stand up to the scrutiny of decision makers and the public. A multi-disciplinary team works together to:

- Identify the project's stakeholders and the constraints, needs and desires
- Distill the project down to basic functions
- Propose design ideas to accomplish the project functions
- Assemble ideas into alternates
- Evaluate the alternates based on performance (engineering measures), acceptance (by the stakeholders) and relative cost

Proposed Alternates

State Route 57 (Poplar Avenue)

Westbound Poplar Avenue	<i>Construction Days</i>	<i>Cost</i>
ALTERNATE 1: BASELINE STEEL STRUCTURE <i>305-foot, two-span steel beam structure</i>	280	\$6.8 million
ALTERNATE 2: ACCELERATED BRIDGE CONSTRUCTION <i>Same bridge as Alternative 1 (305-foot, two-span steel beam structure) utilizing aggressive ABC techniques</i>	180	\$5.6 million
Eastbound Poplar Avenue	<i>Construction Days</i>	<i>Cost</i>
ALTERNATE 1: BASELINE STEEL STRUCTURE <i>280-foot, two-span curved steel beam structure</i>	280	\$8.7 million
ALTERNATE 2: ACCELERATED BRIDGE CONSTRUCTION <i>Same bridge as Alternative 1 (280-foot, two-span curved steel beam structure) utilizing aggressive ABC techniques</i>	180	\$5.4 million

Proposed Alternates

Norfolk Southern Railroad

Norfolk Southern Railroad Bridge	Construction Days	Cost
ALTERNATE 1: BASELINE STRUCTURE WITH BRIDGE SLIDE <i>Three-span, two-track, 314-foot-long, steel through plate girder bridge</i>	600	\$18.1 million
ALTERNATE 2: 10-DAY REPLACEMENT USING SINGLE TRACK SHOOFLY <i>Same bridge as Alternate 1 (three-span, two-track, 314-foot-long, steel through plate girder bridge) utilizing several additional ABC techniques</i>	480	\$15.6 million
ALTERNATE 3A: WEEKEND REPLACEMENT USING SINGLE TRACK SHOOFLY <i>Three-span, two-track, 354-foot-long, steel through plate girder bridge</i>	480	\$18.3 million
ALTERNATE 3B: SINGLE SPAN TRUSS ROLL-IN <i>Single-span, two-track, 354-foot-long truss on the existing alignment</i>	690	\$22.5 million

Park Avenue over I-240

In addition to the replacement of the two Poplar Avenue bridges and the Norfolk Southern Railroad Bridge, the Park Avenue Bridge immediately south of the railroad is also in need of rehabilitation. The current bridges specifications include:

- Five-span, 292-foot-long structure
- General condition listed as FAIR in its last inspection in 2013
- Determined that pilings were not installed for the bents and were not driven to the plans specified depth for the abutments
- Rehabilitation of the structure’s foundations has been considered
- Retrofit of the western abutment foundation has already been considered in a previously developed plan for the recent widening of I-240
- Retrofitting for four pier foundations with micropiles also appears to be the most likely choice due to installation limitations and confirmed working spaces in I-240 work zones
- Combination of micropiles and soil nails could be utilized for stabilization of the eastern abutment
- Approximate cost to retrofit these foundations, including the previous plan for the western abutment, is \$1.8 million

Project Coordination

The Memphis area has multiple roadway construction projects planned in the near future, such as I-55 and Crump Boulevard Interchange, as well as regional and local annual events that have major impacts on traffic flow through the project area. Coordination with all other construction projects and regional events will reduce the overall impact to motorists that travel along I-240.

1.0 Project Understanding

1.1 Introduction and Background

During construction of the recently completed I-240 Widening Project (NH-I-240-1(290), CNJ411), a collector-distributor road was added along I-240 within the State Route 57 (U.S. 72 / Poplar Avenue) Interchange. This was to be accomplished under the Park Avenue, Norfolk Southern Railroad and both Poplar Avenue bridges by excavating the overpass abutments and installing retaining walls to accommodate the widening.



Westbound Poplar Ave. over I-240 (Looking North)



Eastbound Poplar Ave. over I-240 (Looking North)

The planned work was completed below the Poplar Avenue bridges, but the work below the Norfolk Southern Railroad and Park Avenue was not completed on the west side of I-240 due to the field conditions encountered. This resulted in a short section of westbound I-240 being required to merge from four lanes to three lanes to accommodate the Poplar Avenue entrance ramp. The construction plans revision for this change was April 16, 2014.

1.2. Study Scope

The scope of this Technical Study is to evaluate potential Accelerated Bridge Construction (ABC) methods to replace the three existing bridges and develop feasible alternates for each of the locations. The study will also define the project limits as required for NEPA, identify potential impacts and constraints related to the replacement of the bridges, and provide construction cost estimates to be utilized for project budgeting and programming purposes.

1.3 Project Area

I-240 contains three to four travel lanes in each direction and was planned to be four lanes in both directions after the recent widening project. Poplar Avenue consists of four to six travel lanes east and west of I-240, but is split into one-way pairs in the vicinity of the interchange. Each of the one-way pairs contains two to three lanes across I-240. Poplar Avenue has existing signalized intersections both east and west of the interchange.

The area surrounding the I-240 and Poplar Avenue interchange includes multiple businesses (commercial and retail), a hospital, a post office, a power substation and a cemetery. Restaurants and hotels are located between the Poplar Avenue one-way pairs. Memorial Park Funeral Home and Cemetery is located immediately west of I-240.

This interchange is heavily traveled with approximately 140,000 vehicles per day on I-240 and 30,000 to 54,000 vehicles per day on Poplar Avenue. (See Figure 2 for additional traffic volumes)

The Norfolk Southern Railroad tracks are located south of Poplar Avenue and less than fifty feet north of Park Avenue. To the west of I-240, the tracks have a curved horizontal alignment and are located between Park Avenue and the existing power substation. To the east of I-240, the tracks are located between Park Avenue and the Ridgeway Trace shopping center.

During the construction phase, the following issues were discovered:

- The tips of short piles were exposed under the abutments during wall excavation
- Through review of original construction field books from the 1960s, it was determined that the pier footers had no piles and were constructed as spread footings bearing on a dense sand layer

Figure 1: Project Location Map

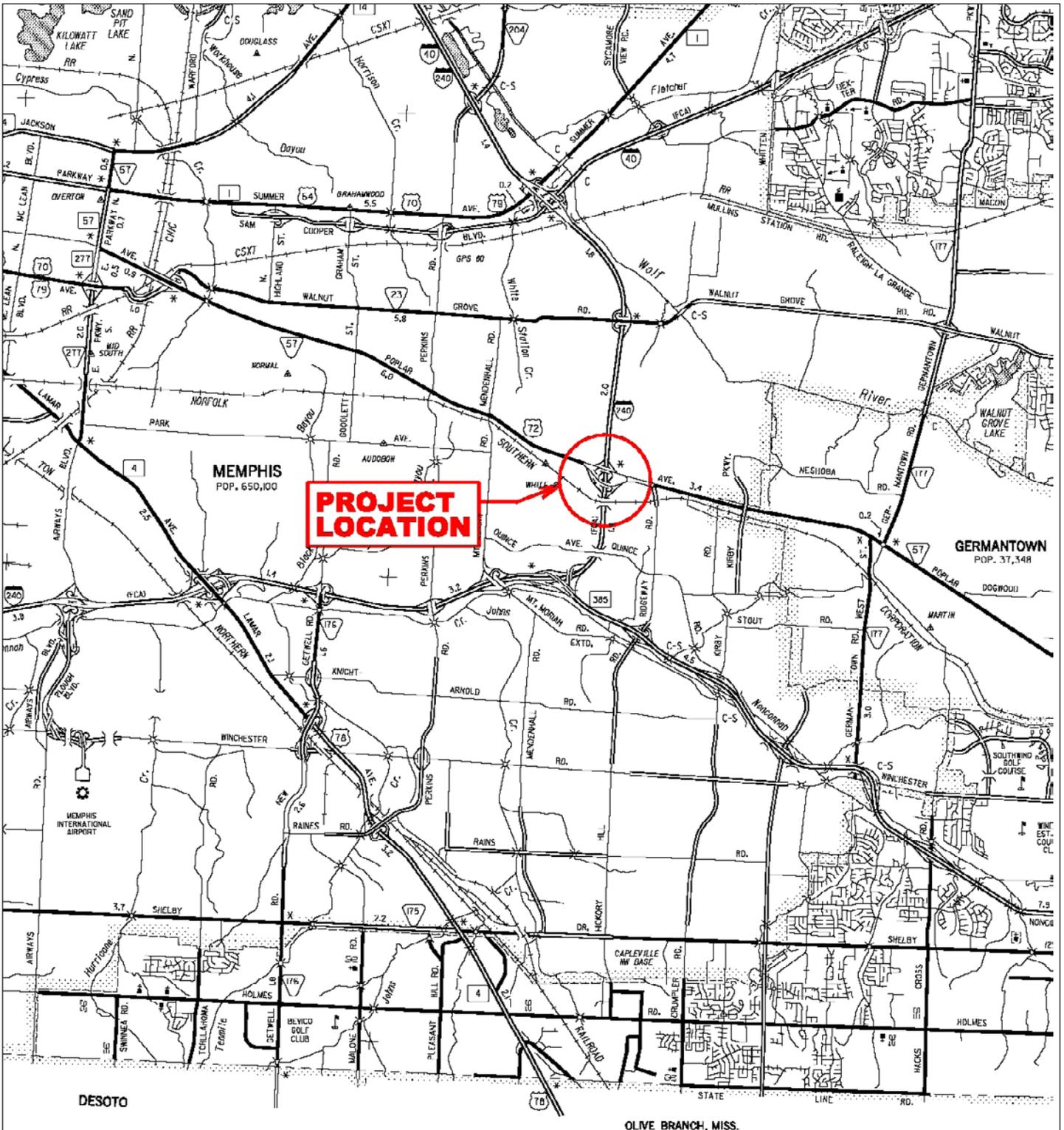


Figure 2: Project Area Map

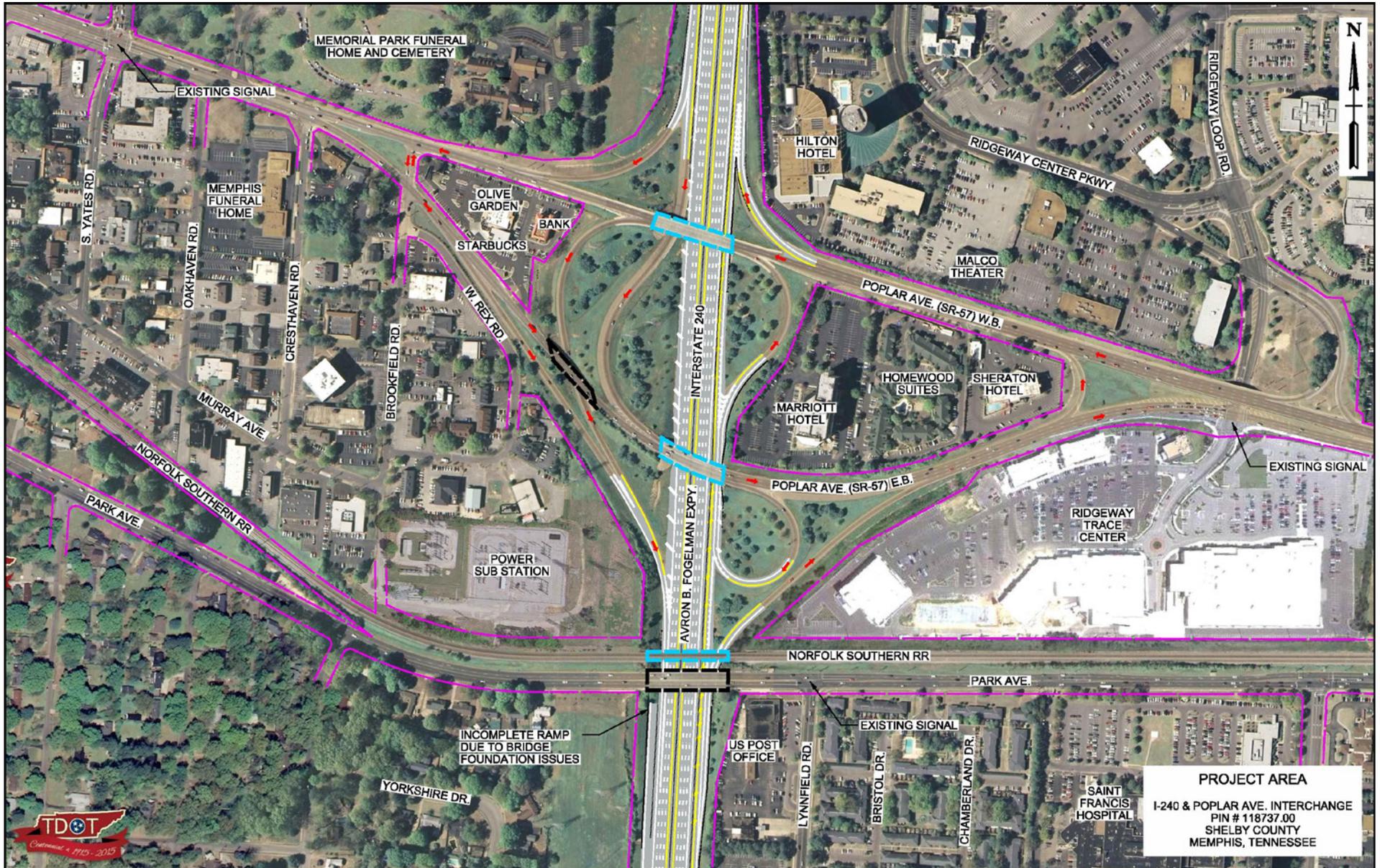
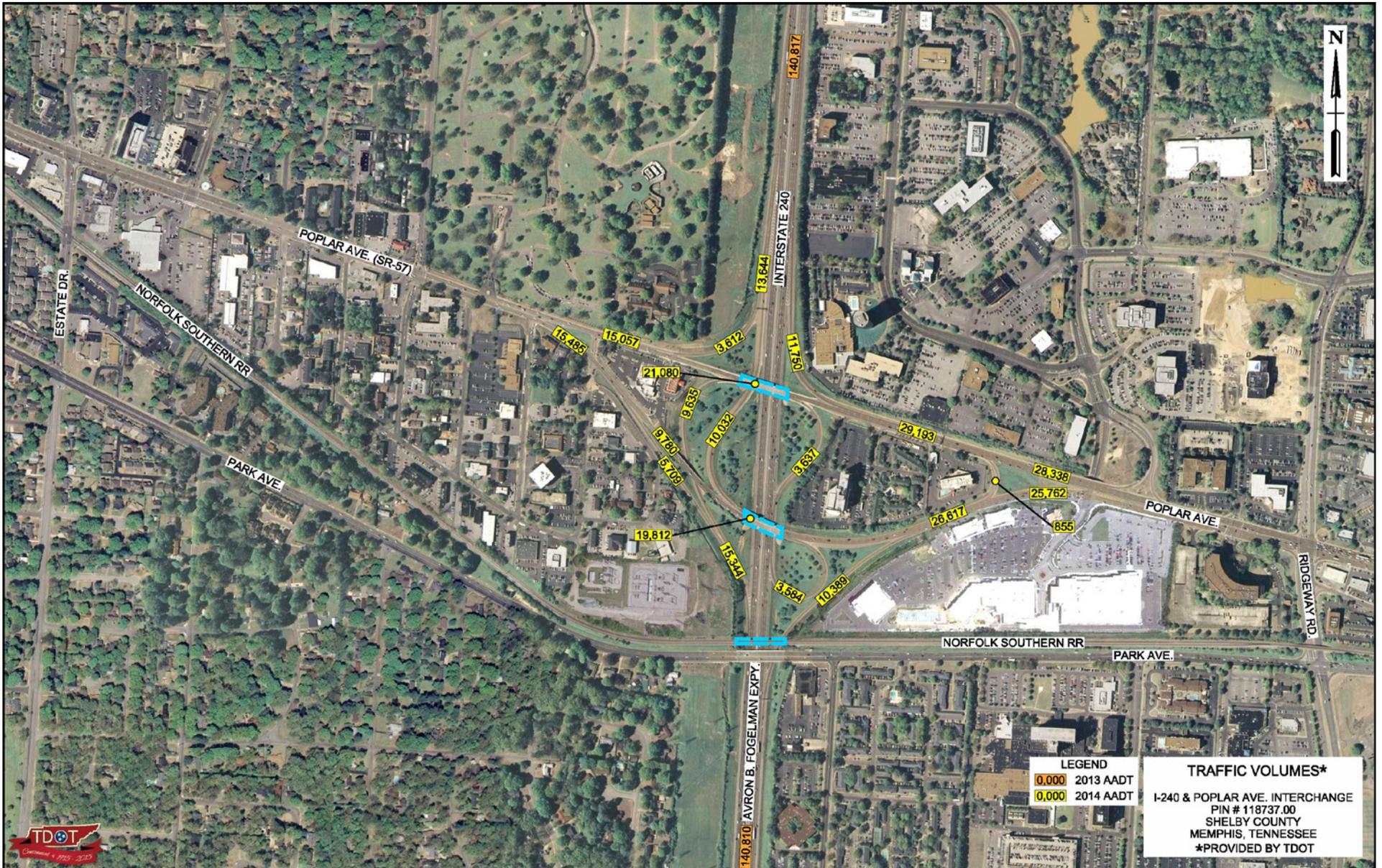


Figure 3: Project Traffic



1.4 Project Purpose and Need

The purpose of the proposed project is to provide a complete eight-lane I-240 mainline facility through the State Route 57 (U.S. 72 / Poplar Avenue) interchange to south of the existing Norfolk Southern Railroad Bridge. Due to the condition of the three subject bridges as it relates to the documented substructure and foundation issues, total replacement is required.

Based upon the initial findings and collaboration of the study team, the purpose and need also includes:

- Improved vertical and horizontal clearance along I-240 at the bridge crossings to meet current standards
- Complete the planned widening of I-240 which could not be constructed due to the bridge foundation issues at the three bridge locations
- Minimize the construction time and impacts to the motoring public and area businesses and residents while replacing the bridges using applicable Accelerated Bridge Construction (ABC) techniques
- Minimizing impacts to Norfolk Southern Railroad while replacing the existing 56 year old structure

State Route 57 (Poplar Avenue) Eastbound and Westbound Bridges

Constructed between 1958 and 1960, the eastbound and westbound Poplar Avenue bridges over I-240 are both multi-span, concrete beam bridges. The eastbound bridge supports three traffic lanes, is approximately 246-feet-long, and is in a slight curve. The westbound bridge supports three traffic lanes and is approximately 295-feet-long. Both eastbound and westbound bridges were classified as having a “POOR” condition in their 2013 TDOT inspection report, having 63.9% and 62.7% sufficiency ratings respectively. Both bridges have undergone three rehabilitations each in the past 17 years. Minimum vertical clearances measured in the 2003 TDOT inspection for the eastbound and westbound bridges were 16’-7” and 16’-3”, respectively.

The eastbound Poplar Avenue Bridge is in need of many repairs. The underside of the bridge has been shielded between beams to prevent pieces of the bridge deck from falling onto traffic below. Many of the concrete beams require repairs at the bearings, and the bridge substructures require repair.

The westbound Poplar Avenue Bridge also requires many repairs. The underside of the bridge deck requires patching and the concrete beams require repairs. The bridge’s expansion joint system and the approach sidewalks also require repair.

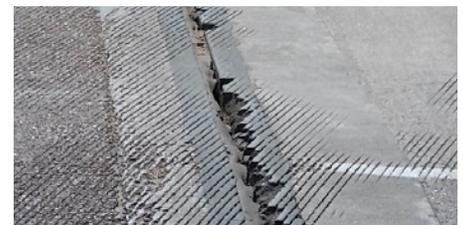
The recent widening beneath these structures added a collector-distributor (CD) road to northbound I-240 between the eastern abutments and nearest pier of these bridges. The addition of the CD road required excavation around several of the overpass abutments. As mentioned previously, during this excavation near these eastern abutments, it was discovered that the existing bridge piles were not driven to the depth specified on the original plans. The abutment piles were driven only a fraction of their specified embedment causing the bottoms of the piles to be discovered during the excavation for the CD road near the abutments. Further investigation revealed that there were no piles driven for the pier foundations as specified in the original plans.



Beam damage at bearing (EB Poplar Ave.)



Shielding protects traffic from falling debris (EB Poplar Ave.)



Expansion joints require repair (WB Poplar Ave.)



Beam repairs are required (WB Poplar Ave.)

Norfolk Southern Railroad Bridge over I-240

This approximately 320-foot-long steel beam structure was constructed around 1959. It was rated as “FAIR” in its last inspection in 2013 with no sufficiency rating given. Although this bridge is used by Norfolk Southern and its partners, this bridge is owned by the State of Tennessee. According to the original railroad agreement, the State would construct, own and maintain this underpass structure, and the Railroad would maintain the tracks. Carrying over 20 trains a day, this six-span bridge presently carries two tracks over I-240.

Although the eastbound and westbound Poplar Avenue Bridges received seismic retrofits in the last fifteen years, this railroad bridge has never been retrofitted. This bridge does not meet current code requirements for a seismic event.

During construction, it was discovered, just as with the State Route 57 (Poplar Avenue) bridges, that this structure has an inadequate foundation due to short driven piles at the abutments and no piles being driven for the pier foundations. A previous inspection report indicates that this bridge is gradually settling based upon measurements made of the vertical clearances. Clearance measurements made during the 2003 TDOT inspection indicated it had a 14’-0” vertical clearance along the ramp to eastbound Poplar Avenue and a 15’-6” clearance under the mainlines of I-240.



NS Railroad Bridge over I-240 (looking south)



The I-240 SB entrance ramp from EB Poplar Ave. was not able to be completed as designed due to inadequate foundation (looking south)



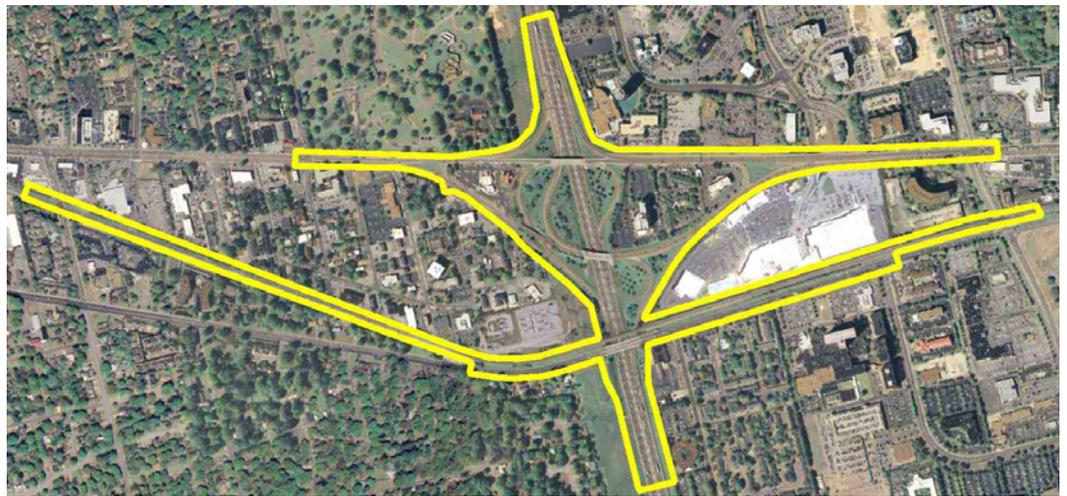
NS Railroad Bridge from below



NS Railroad Bridge along northern side

1.5 Project Limits (Environmental Boundary)

The estimated limits of this project are determined by potential impacts during construction and maintenance of traffic. The limits along the Norfolk Southern Railroad extend from the at-grade crossing at Estate Drive (west of I-240) to the overpass at Ridgeway Road (east of I-240). Poplar Avenue limits stretch from S. Yates Road (west of I-240) to S. Shady Grove Road (east of I-240). Limits along I-240 are from approximately 1,200 feet south of Park Avenue to 1,200 feet north of westbound Poplar Avenue. A complete replacement of the Norfolk Southern Railroad bridge may require additional easements from the Railroad due to a potentially larger footprint than the existing bridge. See the figure to the right for a visual representation of the anticipated Environmental Study boundary.



I-240 CM/GC Project Environmental Boundary

1.6 Value Planning Process

There are a myriad of potential design solutions to address the purpose and need for this project and meet the required roadway, railroad and environmental needs identified for the project. Ensuring that the design solution is the right solution requires a structured process to identify, develop and evaluate potential solutions to ensure that the significant capital investment required for this project will not only meet the project requirements, but also represent a high-value and prudent investment of those funds. To meet this objective, elements of the Value Planning process were conducted as part of this technical study.

Value Planning develops a range of design solutions for a project and then evaluates those alternatives to arrive at a preferred design that meets engineering performance measures, satisfies the project stakeholders and provides the most value for the anticipated cost. One of the primary advantages of utilizing the value planning process is the efficient vetting of a wide range of solutions that will stand up to the scrutiny of decision makers and the public. VP is based on the same process that has been utilized in the private sector for decades to improve product design and delivery. A multi-disciplinary team works together to:

- Identify the project's stakeholders and the constraints, needs and desires
- Distill the project down to basic functions
- Propose design ideas to accomplish the project functions
- Assemble ideas into alternatives
- Evaluate the alternatives based on performance (engineering measures), acceptance (by the stakeholders) and relative cost

Since January 16, 2015, Benesch has been working with TDOT on the I-240 CM/GC Technical Study, and through the Value Planning process, the team defined a list of Owners, Users and Stakeholders, and the constraints, needs and desires for the project. The purpose of this study is to help better define the scope of the project, anticipated durations, probable costs and anticipated project limits (ROW/NEPA). The site visit that occurred on January 22, 2015 included representatives from TDOT Design, Construction and Structures Division, Norfolk Southern Railroad, and Benesch. Through this initial meeting, the team was able to understand the issues that arose during the previous construction project, define the railroad's expectations, identify utilities, gain input from field staff and discuss replacement options for the subject bridges.



Initial team meeting at the TDOT Traffic Management Center in Memphis, Tennessee

A second meeting was held on February 11, 2015, between TDOT and Benesch to discuss initial design and construction alternates for each of the three bridges. Various span arrangements and ABC elements were evaluated and a consensus was reached as to which alternates were to be eliminated and which alternates should be carried forward.

1.7 Project Stakeholders

In order to develop a high-value solution that meets the purpose and need, the VP Team needs to understand who the stakeholders are and what they expect. Stakeholders are those who determine if the project is a success or a failure. These include Owners, who typically fund all or a portion of the project, Users, who actively use or maintain the project, and others who are financially affected by, environmentally concerned about or are otherwise affected by the project. Below is the initial list developed by the team:

- TDOT
- Norfolk Southern Railroad
- BNSF Railroad
- FHWA
- Memphis GL&W
- City of Memphis
- AT&T
- Shelby County/Memphis MPO
- Cemetery
- Memphis Funeral Home
- I-240 Commuters
- Poplar Avenue pedestrians and bicyclists
- Park Avenue pedestrians and bicyclists
- St. Francis Hospital
- Area Hotels
- Local Businesses (Commercial)
- Ridgeway Trace Shopping Center (Retail)
- Post Office (Park Avenue)
- Truck Traffic (Rail & Airport)
- Residents
- Bus (MATA)
- NEPA Resource Agencies
- FedEx
- Memphis University School
- Briarcrest Christian School

1.8 Constraints, Needs and Desires

Each stakeholder's expectations for the project are grouped into constraints, needs and desires. These terms are defined for the VP study as follows:

- **Constraints** include legal requirements, standards of the owner(s), physical conditions of the site and commitments to stakeholders
- **Needs** include expectations that must be fulfilled by the project if constraints are not violated, and limitations or restrictions that are imposed by stakeholders (can be violated)
- **Desires** include expectations that should be fulfilled if cost is not a factor

There are several points to keep in mind in identifying the stakeholder constraints, needs and desires. First, the majority of constraints are prescribed by law, applicable codes and standards. These constraints are too numerous to be listed for each VP Study. Constraints listed are those imposed by a stakeholder or by a code or standard that applies strictly to this project. Secondly, design criteria are described as a constraint, need and desire. Lastly, needs and desires are generally not executable. They are generally visions of what the project should do.

The VP Team assembled an initial list of 37 constraints, needs and desires, which is shown below:

Constraints

- Maintain track
- Accommodate four lanes in each direction on I-240 (with CD roads geometrics)
- 15'-6" clearance NS Bridge (min.)
- Accommodate pedestrians (EB and WB) on WB Poplar
- Meet NS horizontal clearance
- North and south walkways on NS Bridge
- Maintain access to infield development
- Maintain hospital access
- Maintain Post Office access
- Alternatives be developed that do not require an Interchange Access Request (IAR)
- Meet seismic criteria for bridges
- NS double tracks during construction to be maintained
- Limited NS Rail disruption; two months to get an agreement signed off; no full weekend closure for NS; eight-hour window of closure would be the likely max. (possibly once per week)
- Temporary shoofly for mainline (40 MPH min.); Temporary shoofly for siding (15 MPH min.)

Needs

- Maintain rail storage
- No rail disruptions
- Avoid relocating transmission towers
- No temporary/permanent RR impacts to Ridgeway Ctr.
- Provide required horizontal clear zones (design exception was needed on prior widening project)
- Minimize obstructions along I-240 (existing piers)
- Three tracks for final bridge (ability to add 3rd); NS OK with adjusting profile if need be
- Maintain railroad sight distance for signals during construction
- Improve drainage (ponding issues) located at east end of railroad bridge on I-240 shoulder
- Complete the unfinished portion of the current I-240 widening project

Desires

- Reduce number of piers (NS)
- Reduce number of piers (EB Poplar Ave.)
- Reduce number of piers (WB Poplar Ave.)
- 16'-6" clearance (NS Bridge)
- Accommodate widened shoulder (Poplar Ave.)
- Minimize disruptions to businesses
- Construct bridges in existing right-of-way
- Minimize delays to I-240 traffic
- Maintain three lanes in each direction (weekday)
- Avoid impacting Park Avenue
- Avoid impacting EB Poplar Ave. Ramp Bridge
- Minimize utility impacts
- Align/coordinate timing of this project with other area construction projects (specifically I-55 and Crump Blvd. Interchange Reconstruction)

2.0 State Route 57 (U.S. 72 / POPLAR AVENUE)

2.1 Westbound Poplar Avenue

2.1.1 Alternate Development

During the speculation phase of the Value Planning process, ideas and concepts were identified that would perform the basic project functions or would enhance performance at a reasonable cost. These ideas and concepts include such items as: replace at existing location, shift alignment north, various span configurations, steel or concrete superstructure, precast deck panels, slide-in superstructure, roll-in/crane installed modular bridge units, road closure with detour, and phase construction. These elements were then assembled in various combinations to develop the following alternates for the westbound Poplar Avenue Bridge:

- Three-span steel superstructure, phased construction in existing location
- Two-span steel superstructure, phased construction in existing location
- Five-span concrete superstructure, raised grade, phased construction, in existing location
- Four-span concrete superstructure, raised grade, phased construction, in existing location
- Three-span concrete superstructure, raised grade, phased construction, in existing location
- Two-span, steel superstructure with precast deck panels and precast substructure (ABC Light), phased construction in existing location
- Two-span steel superstructure, three week closure of westbound Poplar Avenue (ABC Heavy), reconfiguration of eastbound Poplar as two way route



Precast deck panels being installed on I-24 in Nashville, Tennessee

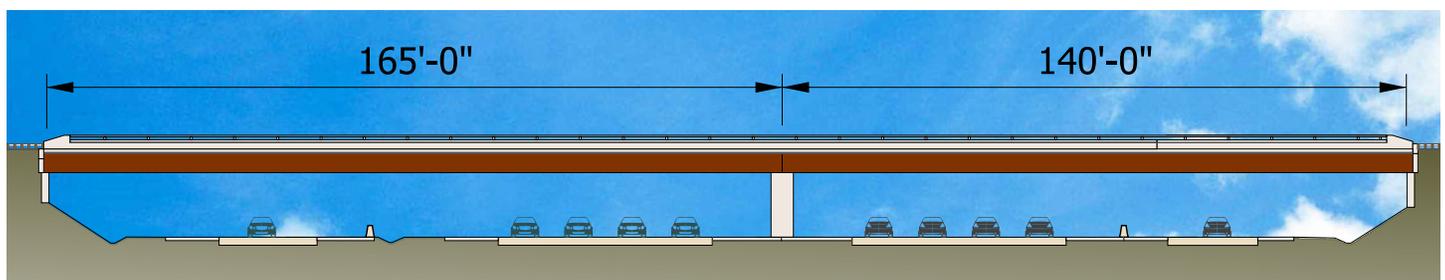


Precast substructure components

2.1.2 Evaluation

Each of the initial alternates developed were evaluated to determine if they should be eliminated or carried forward in more detail. The concrete superstructure alternates were eliminated due to the number of piers required based on the allowable span lengths without a significant grade change. When compared to the span configurations available and the cost estimates of the steel superstructure alternates, it was determined that the concrete superstructure alternates would not be carried forward. As the steel superstructure alternates were reviewed and compared, it was determined that the three-span alternate was less desirable than the two-span alternate because the potential to reduce the number of obstructions along I-240 was appealing and the cost difference was minimal.

The Accelerated Bridge Construction alternates were also evaluated to determine if both were worth carrying forward. The overall construction time reduction for the concrete structure with precast components was relatively minor when compared to the cost increase. The steel superstructure alternates (with ABC components) were selected as viable alternates because of the reduction in impact to the motorist and overall reduction in cost of the structure.



Two-span steel superstructure bridges (Westbound Poplar Ave. looking north)

2.1.3 Proposed Alternates

Alternate 1: Baseline Steel Superstructure

This proposed alternate would replace the existing five-span, concrete beam structure with a two-span steel beam structure. This alternate would maintain the existing median pier location between the northbound and southbound lanes of I-240. The eastern abutment would be constructed approximately 15 feet behind the existing bridge end to facilitate phased construction behind the soil nail retrofit of the existing abutment that was installed under the prior widening project. The proposed 305-foot-long structure would be constructed in two phases while maintaining two lanes of westbound traffic.

Although this alternate could be implemented using conventional construction methods, the application of accelerated bridge construction techniques such as precast deck panels and precast substructures could reduce the total construction time to approximately 280 days at a cost of \$6.8 million.

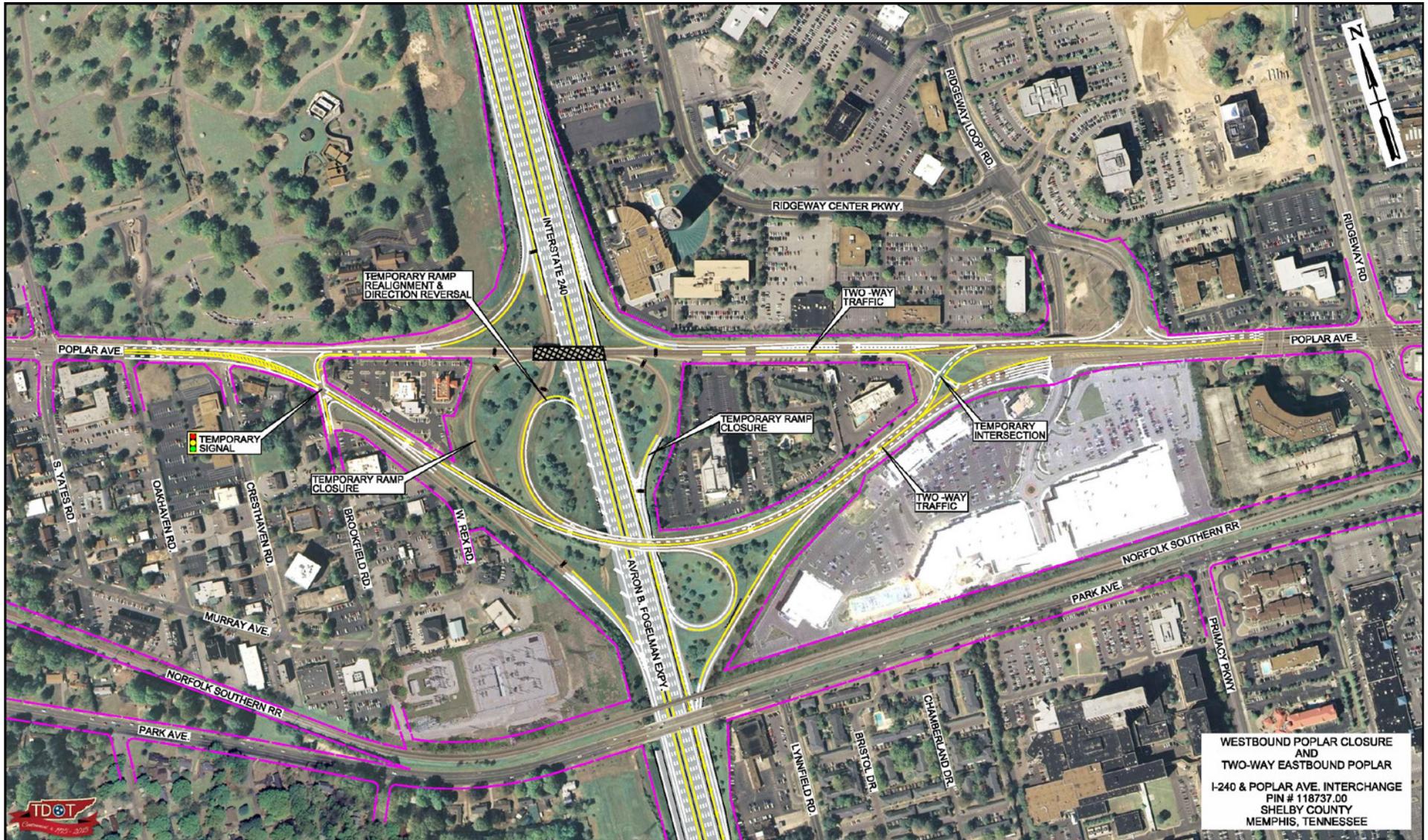
Alternate 2: Accelerated Bridge Construction

This proposed alternate would build the same bridge as proposed in Alternate 1, however, this alternate would utilize aggressive accelerated bridge construction techniques. Utilizing a three week closure of the bridge and rerouting of westbound traffic onto the eastbound Poplar Avenue Bridge, the majority of the structure would be constructed during this time. Preparatory and post westbound closure work would be required, bringing the total construction time to approximately 180 days at a cost of \$5.6 million.

The reconfiguration of eastbound Poplar Avenue to carry two-way traffic would include grading and paving at both ends of Poplar Avenue (east and west of I-240) in order to create transitions to and from Eastbound Poplar Avenue (see Figure 4). Temporary signals would not be required but the existing intersections would need to be signed to handle two-way traffic. Due to the proposed two-way configuration and closing of the westbound Poplar Avenue Bridge, three of the existing interchange ramps would need to be temporarily closed. Traffic that normally uses these ramps will be rerouted through the interchange to maintain full access. Below is a table that represents the anticipated impacts to motorists for both alternatives during construction.

WESTBOUND	I-240 IMPACTS (IN DAYS)					POPLAR AVENUE IMPACTS (IN DAYS)				
	Shoulder Closed Reduced Lane Width	Shoulder Closed Lane Reduction	Weekend Closure		Night Time Rolling Road Blocks	Ramp Detours	Shoulder Closed Reduced Lane Width	Lane Reduction	Full Closure with 1-lane Detour of WB Poplar	Ramp Detours
			Full	Directional						
A1	250	0	4	0	4	0	30	205	0	0
A2	120	0	2	0	2	45	60	30	21	45

Figure 4: Westbound Poplar Avenue Temporary Closure Layout



2.2 Eastbound Poplar Avenue

2.2.1 Alternate Development

Similar to the westbound Poplar Avenue Bridge, ideas and concepts were identified for the eastbound Poplar Avenue Bridge. These ideas and concepts include such items as: replace at existing location, various span configurations, concrete beams, curved steel beams, slide-in superstructure, roll-in/crane installed modular bridge units, orthogonal bridge with striping in a curve, road closure with detour, and phase construction. These elements were then combined in various ways to develop the following alternates for the eastbound Poplar Avenue Bridge:

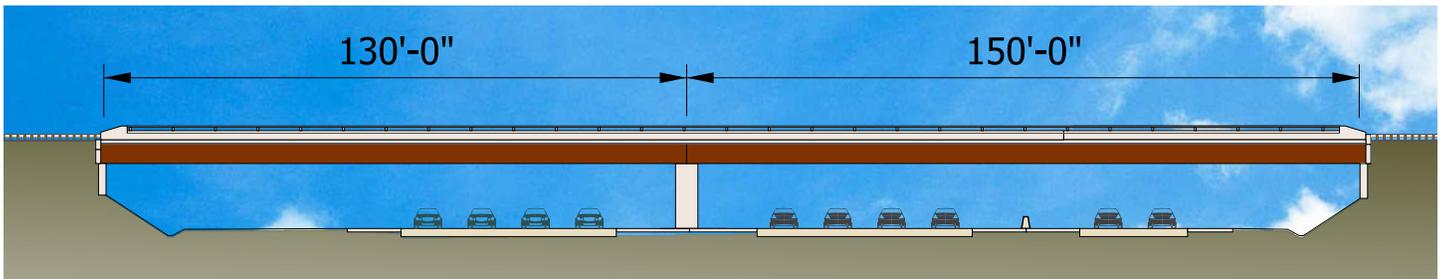
- Two-span steel superstructure, curved steel beams, phase construction in existing location
- Four-span concrete superstructure, phase construction, in existing location
- Two-span steel superstructure with precast deck panels and precast substructure (ABC Light), phase construction in existing location
- Two-span steel superstructure, three week closure of eastbound Poplar Avenue (ABC Heavy), reconfiguration of westbound Poplar as two way route

2.2.2 Evaluation

The four alternates were evaluated to determine which ones were worth carrying forward. Based on the number of piers required, the four-span concrete structure was eliminated. Similar to the westbound Poplar Avenue Bridge, reducing the number of piers along I-240 was identified as a “desire” and the cost difference, when compared to the steel superstructure alternates, was minimal.

As was the case in the westbound Poplar Avenue Bridge, the Accelerated Bridge Construction alternates were reviewed and compared to determine if either should be eliminated from consideration. Due to the cost and the relatively minimal reduction in construction time, the concrete superstructure alternates were eliminated. The steel superstructure alternates (with ABC components) were selected as viable alternates because of the reduction in impact to the motorist and overall reduction in cost of the structure.

2.2.3 Proposed Alternates



Two-span steel superstructure bridges (Eastbound Poplar Ave. looking north)

Alternate 1: Baseline Steel Superstructure

This proposed alternate would replace the existing four-span, concrete beam structure with a two-span steel beam structure. This alternate would maintain the existing median pier location between the northbound and southbound lanes of I-240. The eastern abutment would be constructed approximately 15 feet behind the existing bridge end to facilitate phased construction behind the soil nail retrofit of the existing abutment that was installed under the prior widening project. The proposed 280-foot-long structure would be constructed in two phases while maintaining two lanes of eastbound traffic.

Although this alternate could be implemented using conventional construction methods, the application of Accelerated Bridge Construction techniques such as precast deck panels and precast substructures, could reduce the total construction time to approximately 280 days at a cost of \$8.7 million.

Alternate 2: Accelerated Bridge Construction

This proposed alternate would build the same bridge as proposed in Alternate 1, however, this alternate would utilize aggressive Accelerated Bridge Construction techniques. Utilizing a three week closure of the bridge and rerouting of eastbound traffic onto the westbound Poplar Avenue Bridge, the majority of the structure would be constructed during this time. Preparatory and post eastbound lane reductions would be required, bringing the total construction time to approximately 180 days at a cost of \$5.4 million.

The reconfiguration of westbound Poplar Avenue to carry two-way traffic would include grading and paving on the east end of Poplar Avenue to create a transition to Eastbound Poplar Avenue (see Figure 5). A temporary tight diamond interchange would be developed for I-240 at Westbound Poplar Avenue. This would be completed by reconfiguring the existing ramps at westbound Poplar Avenue and installing temporary signals at each intersection location.

It is important to note that all access to the businesses in the area will be maintained but would need to be reconfigured to meet the temporary proposed two-way traffic pattern. Additional coordination with these businesses will be required to ensure all customers and employees are well-informed on what to expect during this three-week time frame. Below is a table that represents the anticipated impacts to motorists for both alternatives during construction.

EASTBOUND	I-240 IMPACTS (IN DAYS)						POPLAR AVENUE IMPACTS (IN DAYS)			
	Shoulder Closed Reduced Lane Width	Shoulder Closed Lane Reduction	Weekend Closure		Night Time Rolling Road Blocks	Ramp Detours	Shoulder Closed Reduced Lane Width	Lane Reduction	Full Closure with 1-lane Detour of WB Poplar	Ramp Detours
			Full	Directional						
A1	250	0	4	0	4	0	30	205	0	0
A2	120	0	2	0	2	45	60	30	21	45

2.3 User Impacts

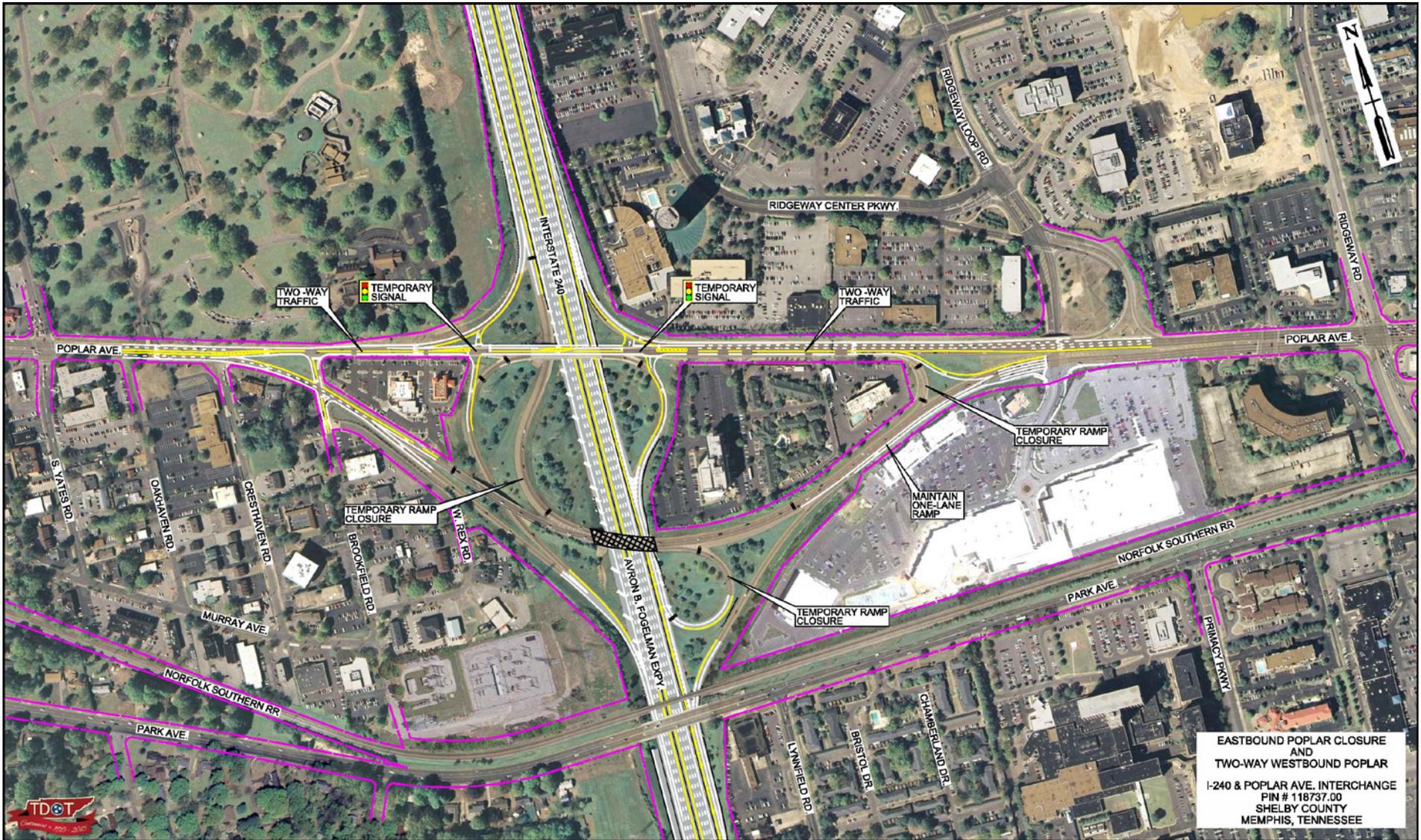
It is important to determine the impacts of the various alternates to the users within the project area. Each of the alternatives requires specific maintenance of traffic methods that will affect not only the motorists that use I-240 and Poplar Avenue, but will also impact businesses (both commercial and retail) in the area.

Alternate 1 for each of the Poplar Avenue bridges includes traditional, phased construction techniques, which requires temporary lane reductions, lane shifts, and potential lane/ramp closures. Overall, the existing traffic patterns are retained, but the reduction of speed due to the construction area and any lane shifts will cause the road users to experience more of a delay than they were previously.

Alternate 2 for each of the bridges includes a proposed three week closure along Poplar Avenue in each direction, as well as a reconfiguration of the roadway to handle two-way traffic on what is currently a set of one-way pairs. Due to the reconfiguration, certain I-240 ramps would no longer be viable, causing motorists to use alternate routes to reach their intended destination. Maintaining traffic for these closures would require detailed signing and marking in advance of the interchange to ensure the road user is aware of the changes. Many of the entrances and exits for the businesses, as well as existing roadway intersections along Poplar Avenue, would need to be temporarily reconfigured to allow two-way traffic to utilize them in the appropriate manner.

While the potential for impacts to the road user in Alternate 2 is much higher, the length of impact is much shorter than in Alternate 1. As the project progresses into the future phases of NEPA and preliminary engineering, additional stakeholder input and involvement will need to occur to fully evaluate the potential impacts of Alternate 2 for each bridge on Poplar Avenue.

Figure 5: Eastbound Poplar Avenue Temporary Closure Layout



3.0 Norfolk Southern Railroad

3.1 Alternate Development

During the speculation phase of the Value Planning process, ideas and concepts were identified for the Norfolk Southern Railroad Bridge that would perform the basic project functions or would enhance performance at a reasonable cost. These ideas and concepts included such items as: raise rail profile, various span configurations, deck plate girder, through-plate girder, through truss, shift rail alignment north or south, one or two temporary tracks to the north or south, precast concrete components, slide-in bridge, roll-in bridge and conventional build. These elements were then combined in various ways to develop the following alternates for the Norfolk Southern Railroad bridge:

- Three-span, through plate girder, conventional construction on existing alignment, eight-hour maximum closure using temporary double track to the south
- Three-span, through plate girder, conventional construction with permanent alignment shift to the south, eight-hour maximum closure
- Three-span, deck plate girder, raise rail profile, conventional construction on existing alignment, eight-hour maximum closure using temporary double track to the south
- ABC, three-span, through plate girder built off-line and set on existing alignment using cranes, temporary single track to the south during weekend replacement
- ABC, single span, through truss built off-line and rolled into place on existing alignment, weekend closures for NS
- ABC, three-span, through plate girder, construct new bridge on temporary alignment, slide into existing alignment during eight-hour closure for NS
- ABC, three-span, through plate girder, precast substructure elements, pre-built superstructure off line and set on existing alignment with cranes, temporary single track to the south for 10 days

3.2 Evaluation

Each of the Norfolk Southern Railroad bridge replacement alternates were evaluated to determine which were viable (meet the needs, desires and constraints identified) and worthy of being carried forward. The deck plate girder alternate was eliminated from consideration due to the required raising of the rail profile. The length along the track required to increase the profile was problematic due to the potential impacts to adjacent properties and the crossings to the east and west of I-240. The through-plate girder, conventional construction alternate with a permanent alignment shift to the south was not considered to be a viable alternate due to Norfolk Southern Railroad's desire to minimize or eliminate an alignment shift for the main track. The remaining conventional construction alternate was eliminated as it was very similar to the ABC Slide alternate. Most of the elements included in the conventional construction can be accomplished via the ABC alternate with minimal difference in cost.

The Accelerated Bridge Construction alternates were also reviewed to determine if any should be eliminated. Each of the four alternates were deemed to be viable alternates as they are able to construct a new bridge with minimal closures for Norfolk Southern, as well as reduced impacts to motorists utilizing I-240 under the bridge.

3.3 Proposed Alternates

Alternate 1: Baseline Structure with Optional Bridge Slide

This proposed alternate would replace the existing six-span, steel beam structure with a three-span, two-track, 314-foot-long, steel through plate girder bridge. Bridge abutments would occur in the same locations with piers occurring in-line with the barriers between the mainline of I-240 and the existing collector-distributor roadway. In order to maintain two tracks for Norfolk Southern during construction, a two-track temporary bridge, commonly referred to as a shoofly, would be constructed to the south between the existing bridge and Park Avenue. As an Accelerated Bridge Construction option, the permanent superstructure for the new bridge would be built on the shoofly alignment and then slid into place on new piers along the existing alignment during an eight-hour closure of the Norfolk Southern Railroad. The total estimated construction time for this structure is 600 days at a cost of \$18.1 million. (See Figure 6 for temporary shoofly alignment)

Figure 6: Two-Track Shoofly Alignment



Alternate 2: 10-Day Replacement Using Single Track Shoofly

This proposed alternate would build the same bridge as proposed in Alternate 1, however, this alternate would incorporate many ABC techniques and provide a one track shoofly for ten days while the mainline structure is replaced. The proposed one-track shoofly bridge is a rented structure to minimize the temporary superstructure costs. Optionally, this shoofly structure could be made permanent to provide NS with a third track. The mainline structure would be replaced in 10 days utilizing precast substructure elements and pre-built superstructure sections built off line and set with cranes or Self-Propelled Modular Transporter (SPMT). Preparatory work for foundations would be required and can be accomplished under active train traffic, bringing the total estimated construction time to 480 days at a cost of \$15.6 million.



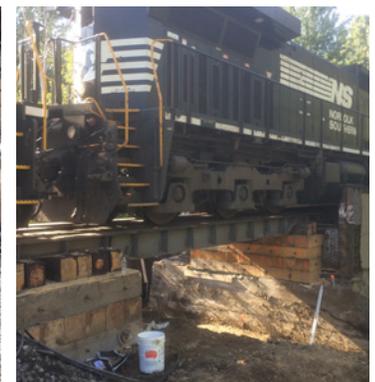
Temporary shoofly installation using ACROW modular system



Self-Propelled Modular Transporter (SPMT)

Alternate 3A: Weekend Replacement with Single-Track Shoofly

This 354-foot-long alternate would construct a similar two-track bridge on the existing alignment as proposed in Alternates 1 and 2, however, the bridge abutments would be behind the existing ones. Preparatory foundation work and off-line superstructure construction would commence prior to a weekend closure of I-240. Jump spans would be utilized to construct the new abutments behind the existing abutments. The two bridge piers would be constructed by utilizing shoring towers, I-240 lane shifts and micropile foundations. During the weekend closure, a single track shoofly bridge would be used to maintain train traffic. The bridge superstructure would then be demolished, final substructure work completed and the new bridge superstructures would be set in place with cranes or mobile transports during the weekend. Approximately 180 days are necessary for steel fabrication and NS required shop fit-up leaving 300 days of on-site construction activity. Total estimated cost for this alternate is \$18.3 million. (See Figure 7 for potential staging areas)



Alternate 3B: Single-Span Truss Roll-In

This proposed alternate would construct a 354-foot-long, two-track, single-span truss on the existing alignment. The bridge abutments would be constructed behind the existing ones utilizing jump spans. The truss would be constructed in a nearby staging area off-line. Norfolk Southern traffic would be maintained with a single track shoofly bridge for one weekend to allow for demolition of the existing structure and a roll-in installation of the truss utilizing self-propelled module transporter. Having no new piers to build for the new structure will greatly reduce the impacts



Micropiles and jump spans in use during construction

to I-240 traffic with only a single weekend closure required for the demolition of the existing bridge and installation of the truss. Although the truss requires a substantial amount of time to erect, this work would be performed off-line in a nearby staging area. It is estimated that 300 days are necessary for truss fabrication and NS required shop fit-up leaving approximately 390 days of on-site construction activity. Total estimated cost for this alternate is \$22.5 million. (See Figure 7 for potential staging areas)

Below is a table that represents the anticipated impacts to motorists for each of the alternatives during construction.

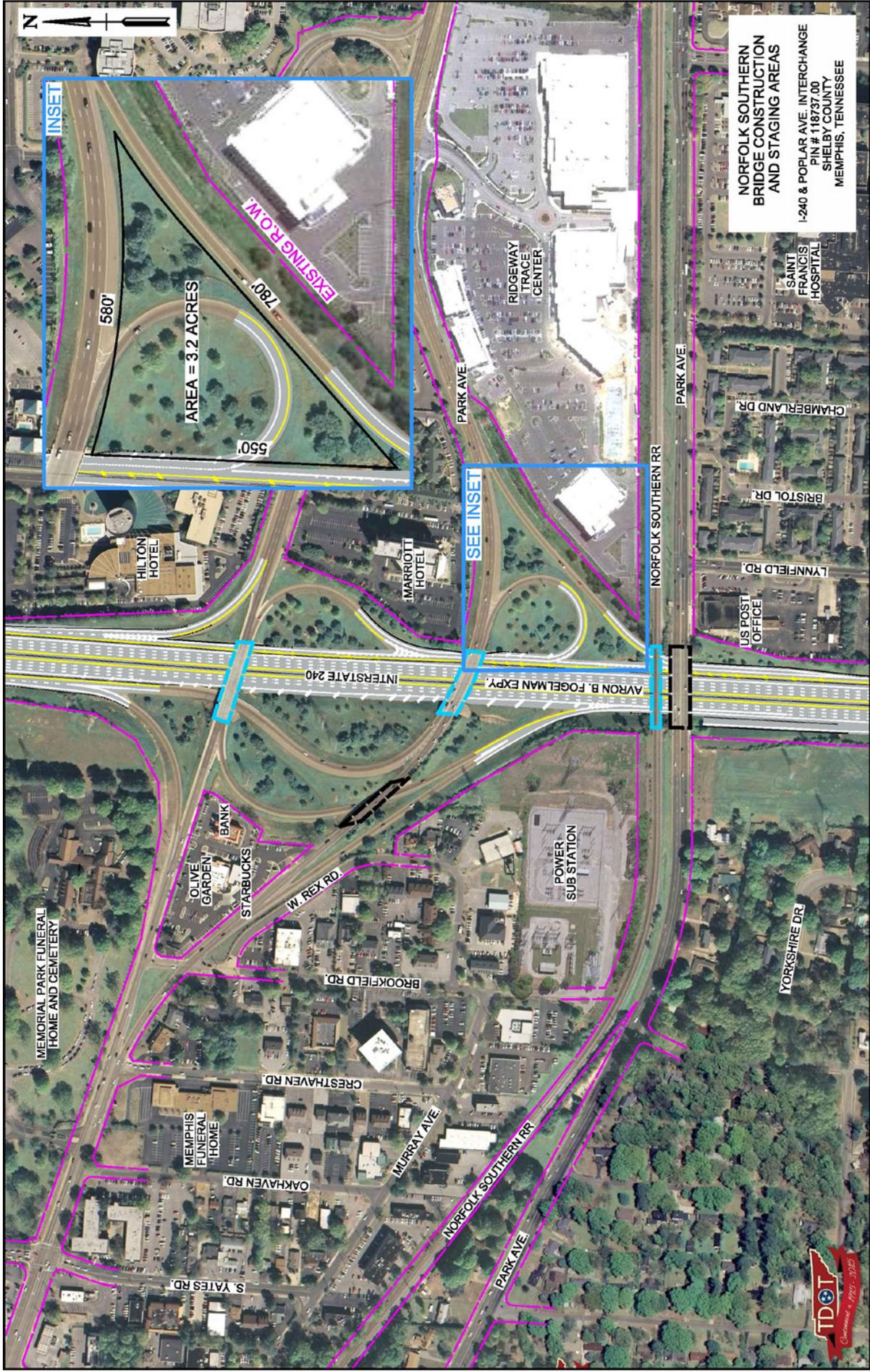
NS BRIDGE	I-240 IMPACTS (IN DAYS)					
	Shoulder Closed Reduced Lane Width	Shoulder Closed Lane Reduction	Weekend Closure		Night Time Rolling Road Blocks	Ramp Detours
			Full	Directional		
A1	270	0	2	0	14	0
A2	105	60	4	4	0	120
A3A	75	120	2	4	0	120
A3B	165	0	2	4	0	150

3.4 User Impacts

The primary impact in each of these alternates is due to closures of the Norfolk Southern tracks. Any closure of the tracks eliminates all trains on this line during the closure. The length of closure has been limited to eight hours (based upon the initial constraints as defined by NS during the site visit) to switch tracks and construct tie-ins on either side of the proposed structure. A secondary impact to Norfolk Southern will depend on which alternate is ultimately selected and the process by which the bridge is replaced. Alternate 1 provides a two-track shoofly that will maintain two-tracks for the entirety of construction. Alternate 2 provides a one-track shoofly but will limit the time that the temporary track is required to approximately ten days. Alternates 3A and 3B also provide a one-track shoofly but reduce the required time of the shoofly to a single weekend.

Additional impacts will be on the motorists that travel I-240 during the construction period. Pier work along I-240 will require lane shifts and temporary lane reductions while work is being done. Alternates 3A and 3B will require some weekend closures of I-240 to demolish the existing structure and set the proposed bridge in place.

Figure7: Norfolk Southern Railroad Bridge Construction & Staging Areas



4.0 Additional Improvements

In addition to the proposed bridge replacements on Poplar Avenue and the Norfolk Southern Railroad, some improvements will also be necessary along I-240 and on the existing Park Avenue bridge. All of these additional improvements (roadway and bridge) will be completed in conjunction with the proposed bridge replacements on Poplar Avenue and the Norfolk Southern Railroad discussed earlier in this report to minimize the length of time that the entire corridor of I-240 is impacted.

4.1 I-240

As mentioned previously in this report, there are some roadway items along I-240 that were not able to be completed during the previous widening project. The two main improvements that will be included in this project are the southbound entrance ramp from eastbound Poplar Avenue and the widening of I-240 southbound to the west to include four travel lanes throughout the entire project area. (See *Figure 8 for I-240 Improvements layout*)

4.2 Park Avenue over I-240

Constructed around 1959, this five span, 292-foot-long structure had its general condition listed as FAIR based upon the 2013 inspection report. The span lengths for this concrete beam superstructure bridge are approximately, from west to east, 43 feet, 74 feet, 74 feet, 61 feet and 36 feet. The bridge has an out-to-out width of 70 feet and carries four vehicular lanes and two six-foot sidewalks. Only a few minor maintenance items are suggested in the 2013 report. It has been determined that pilings were not installed for the pier foundations and were not driven to the plans specified depth for the abutments as with both Poplar Avenue bridges as well as the NS Railroad Bridge. Minimum vertical clearance was measured to be 16'-6" in a 2003 inspection report.

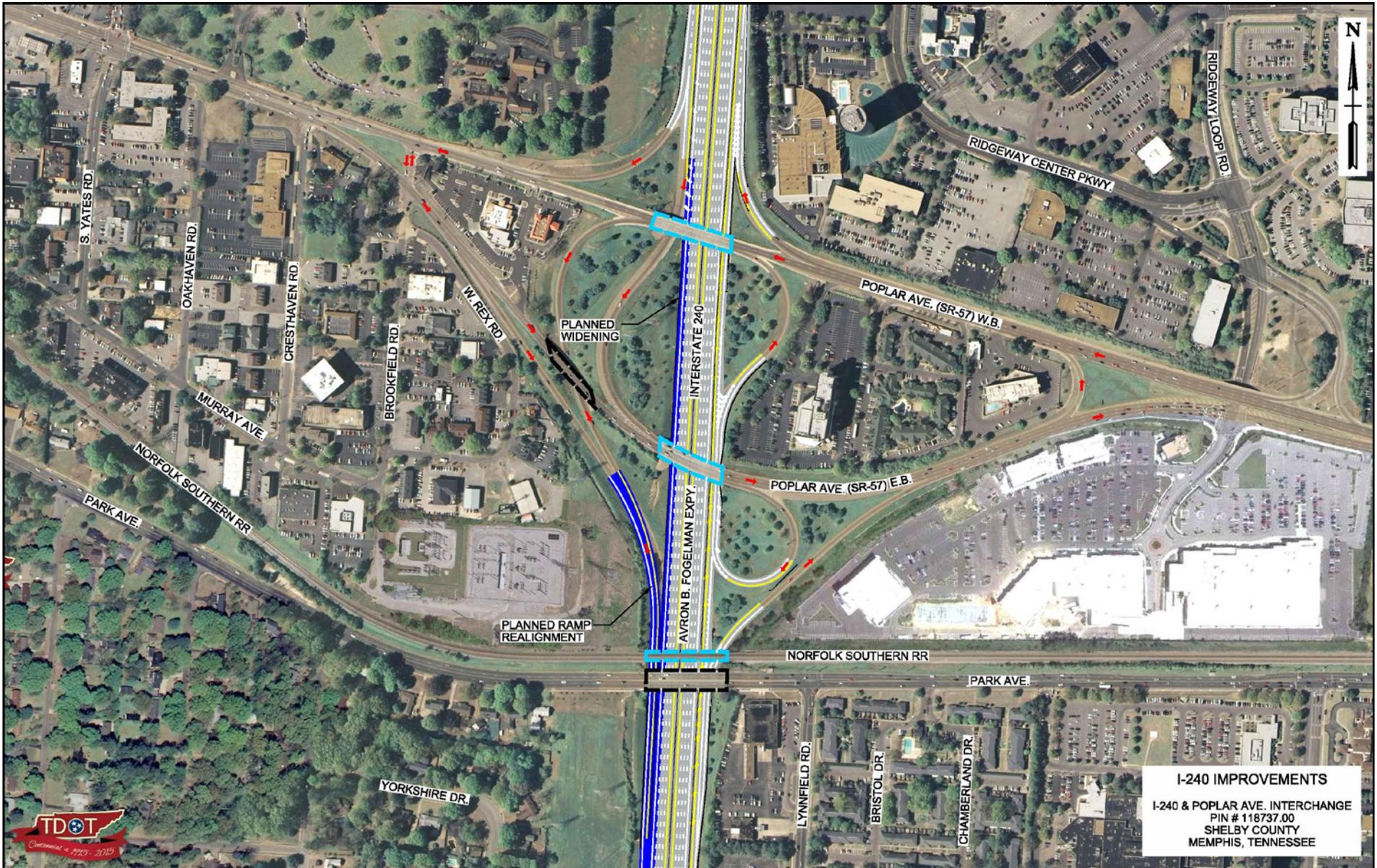


Park Avenue Bridge over I-240 (looking north)

Rehabilitation of the structure's foundations has been considered due to the lack of piles in the pier foundations and short driven piles in the abutment foundations. Retrofit of the western abutment foundation has already been considered in a previously developed plan for the recent widening of I-240 in this location. This retrofit was not conducted at the western abutment due to similar issues with the Norfolk Southern Bridge over I-240, which is adjacent to the north. Retrofitting the four pier foundations with micropiles also appears to be the most likely choice due to installation limitations and confined working spaces in I-240 work zones.

A combination of micropiles and soil nails could be utilized for stabilization of the eastern abutment. With improvements for both normal and seismic loadings, the approximate cost to retrofit these foundations, including the previous plan for the western abutment, is \$1.8 million. Once an alternate is selected for the replacement of the nearby Norfolk Southern Railroad Bridge, a cost benefit analysis of the Park Avenue Bridge may reveal that replacement is a better option, as compared to rehabilitation.

Figure8: I-240 Proposed Improvements



5.0 Project Coordination & Future Discussion

Available information on utilities were considered in the costs of the alternates discussed in this report, but additional utility relocation could be required depending on the alternates ultimately chosen for design.

The Memphis area has many large roadway construction projects in progress or planned in the near future that could have a major impact on traffic. Coordination with those projects is essential in minimizing the overall impact to motorists in the area. Projects like I-55 at Crump Boulevard will close a portion of I-55 and re-route traffic onto I-240 and I-40. Another project that is on the horizon is I-240 at Airways Boulevard. Vehicles diverted onto I-240 may have to travel through the Poplar Avenue interchange and be affected by the construction there as well.

Coordination with local and regional events will also be an important part of this project. Events such as the Memphis in May (BBQ competition), FedEx St. Jude Classic Golf Tournament and many others cause a major increase in traffic and should be considered during the design of traffic control plans.

Special attention and coordination will be necessary during the design and construction phases to ensure all of the proposed improvements are completed in the most efficient manner. When possible, the Maintenance of Traffic should attempt to minimize the amount of time motorists are impacted throughout construction.

While this study covered multiple alternates for each structure, it is important to note that additional discussion and coordination will be required throughout the design phase. The continuous exchange of information and ideas will allow this project to be designed and constructed efficiently and to encompass as many issues or concerns as possible.