Reconstruction of Eastern Avenue Bridge Over Kenilworth Avenue in Washington, DC

Final Report
August 2011

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

U.S.Department of Transportation
Federal Highway Administration

FOREWORD

The purpose of the Highways for LIFE (HfL) pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up the widespread adoption of proven innovations in the highway community. “Innovations” is an inclusive term used by HfL to encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community’s culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decisionmakers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

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16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE program, the District Department of Transportation (DDOT) was awarded a $1 million grant to demonstrate the use of proven, innovative technologies to deliver a $10.4 million bridge construction project in less time than conventional construction.

The project is located along Eastern Avenue in the northeastern corner of Washington, DC, at the border with Prince George's County, MD. The single-span existing bridge constructed in 1956 serves as a vital vehicle and pedestrian link between communities separated by Kenilworth Avenue and allowed for a minimum vertical clearance of only 14 feet (ft). At this clearance, it had been struck multiple times, causing extensive traffic jams in the area. The reconstructed bridge has a minimum vertical clearance of 16 ft and two spans, with prefabricated units for the superstructure and pier. The prefabricated pier units rest on a cast-in-place foundation. Each superstructure segment consists of two W16x100 steel beams spaced at 5 ft supporting a 7.5-inch (in) lightweight concrete deck. Shear keys tie the superstructure units together. The prefabricated superstructure is covered by a waterproof membrane and a 3-in asphalt concrete overlay.

DDOT minimized construction congestion, queuing, and related back-of-queue crashes by diverting one lane of traffic on busy Kenilworth Avenue (average daily traffic of 155, 000) in each direction to adjacent service roads during pier and abutment construction, maintaining three lanes of traffic in each direction. Additional safety measures during construction included use of median barriers to separate workers from traffic, increased enforcement, and closing of the roadway in both directions during nighttime installation of the prefabricated superstructure. Project construction was accelerated and quality enhanced through use of prefabricated units for the superstructure and pier.

An economic analysis indicates the innovative traffic plan and accelerated construction schedule saved $660.4 million compared to traditional construction methods, largely by drastically reducing delay costs. This project effectively met the Highways for LIFE goals of increased safety during construction, reduced traffic congestion, and quality.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
(none)	mil	25.4	micrometers	µm
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	Newtons	N
lbf/in^2 (psi)	poundforce per square inch	6.89	kiloPascals	kPa
k/in^2 (ksi)	kips per square inch	6.89	megaPascals	MPa
		DENSITY		
lb/ft^3 (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m^3
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
µm	micrometers	0.039	mil	(none)
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	Newtons	0.225	poundforce	lbf
kPA	kiloPascals	0.145	poundforce per square inch	lbf/in^2 (psi)
MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of Federal Highway Administration Highways for LIFE Team Leader Byron Lord and Program Coordinators Mary Huie and Kathleen Bergeron, who served as the technical panel on this demonstration project. Their vast knowledge and experience with the various aspects of construction, technology deployment, and technology transfer helped immensely in developing both the approach and the technical matter for this document. The team is also indebted to District Department of Transportation engineers Maduabuchi Udeh, Ali Shakeri, Bruke Siraga, and Luan Tran for the tireless advice, assistance, and coordination they provided on this project. Finally, the project team is also grateful to FHWA's Robert Mihalek, Robert Mooney, and Vinh Hoang for their support.

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ABBREVIATIONS AND SYMBOLS

ADT	annual daily traffic
ANC	Advisory Neighborhood Commission
dB(A)	A-weighted decibels
DOT	department of transportation
DDOT	District Department of Transportation
FHWA	Federal Highway Administration
HfL	Highways for LIFE
HMA	hot-mix asphalt
IRI	International Roughness Index
LCAP	Lane Closure Analysis Program
MOT	maintenance of traffic
MVMT	million vehicle-miles traveled
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
veh-hrs	vehicle-hours
VOC	vehicle operating cost

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, the Federal Highway Administration's (FHWA) initiative to accelerate innovation in the highway community, provides incentive funding for demonstration construction projects. Through these projects, the HfL program promotes and documents improvements in safety, construction-related congestion, and quality that can be achieved by setting performance goals and adopting innovations.

The HfL program—described in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—may provide incentives to a maximum of 15 demonstration projects a year. The funding amount may total up to 20 percent of the project cost, but not more than $5 million. Also, the Federal share for a HfL project may be up to 100 percent, thus waiving the typical State-match portion. At the State's request, a combination of funding and waived match may be applied to a project.

To be considered for HfL funding, a project must involve constructing, reconstructing, or rehabilitating a route or connection on an eligible Federal-aid highway. It must use innovative technologies, manufacturing processes, financing, or contracting methods that improve safety, reduce construction congestion, and enhance quality and user satisfaction. To provide a target for each of these areas, HfL has established demonstration project performance goals.

The performance goals emphasize the needs of highway users and reinforce the importance of addressing safety, congestion, user satisfaction, and quality in every project. The goals define the desired result while encouraging innovative solutions, raising the bar in highway transportation service and safety. User-based performance goals also serve as a new business model for how highway agencies can manage the highway project delivery process.

HfL project promotion involves showing the highway community and the public how demonstration projects are designed and built and how they perform. Broadly promoting successes encourages more widespread application of performance goals and innovations in the future.

Project Solicitation, Evaluation, and Selection

FHWA issued open solicitations for HfL project applications in fiscal years 2006, 2007, 2008, 2009, and 2010. State highway agencies submitted applications through FHWA Divisions. The HfL team reviewed each application for completeness and clarity, and contacted applicants to discuss technical issues and obtain commitments on project issues. Documentation of these questions and comments was sent to applicants, who responded in writing.

The project selection panel consisted of representatives of the FHWA offices of Infrastructure, Safety, and Operations; the Resource Center Construction and Project Management team; the Division offices; and the HfL team. After evaluating and rating the applications and supplemental information, panel members convened to reach a consensus on the projects to recommend for approval. The panel gave priority to projects that accomplish the following:

- Address the HfL performance goals for safety, construction congestion, quality, and user satisfaction.
- Use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States.
- Include innovations that will change administration of the State's highway program to more quickly build long-lasting, high-quality, cost-effective projects that improve safety and reduce congestion.
- Will be ready for construction within 1 year of approval of the project application. For the HfL program, FHWA considers a project ready for construction when the FHWA Division authorizes it.
- Demonstrate the willingness of the applicant department of transportation (DOT) to participate in technology transfer and information dissemination activities associated with the project.

HfL Project Performance Goals

The HfL performance goals focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. States are encouraged to use all applicable goals on a project:

- **Safety**
    - Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
    - Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported via Occupational Safety and Health Administration (OSHA) Form 300.
    - Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.

- **Construction Congestion**
    - Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
    - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
    - Queue length during construction—A moving queue length of less than 0.5 mile (mi) (0.8 kilometer (km)) in a rural area or less than 1.5 mi (2.4 km) in an urban area (in both cases at a travel speed 20 percent less than the posted speed).

- **Quality**
    - Smoothness—International Roughness Index (IRI) measurement of less than 48 inches per mile.

- Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

- **User satisfaction**—An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4-plus on a 7-point Likert scale.

REPORT SCOPE AND ORGANIZATION

This report discusses DDOT's HfL demonstration project, which consists of reconstruction of a single-span, prestressed beam bridge with a two- span bridge, making full use of prefabricated components to increase vertical clearance. The project details most relevant to the HfL program—including traffic management during construction, innovative design and construction highlights, and HfL performance metrics measurement—as well as economic analysis are presented in this report. A record of the technology transfer activities that took place during the construction of this project and a summary of the lessons learned are also presented.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

This project includes reconstructing a structure over a major expressway with low underclearance to increase vertical clearance, reducing the probability of it being struck by vehicles and causing traffic jams in the metropolitan area.

Key innovations include the following:

- Rapid construction of the bridge through the use of prefabricated bridge elements
- Innovative application of maintenance-of-traffic methods and technology to decrease traffic congestion and increase safety in the construction zone
- Use of a no-excuse clause with disallowance of partial suspension or time extension because of inclement weather

HFL PERFORMANCE GOALS

Safety, construction congestion, and qualitywere collected before, during, and after construction to demonstrate that the innovations can be deployed while simultaneously meeting the HfL performance goals. The following steps enabled construction of the project with no contractor injuries or incidents, successfully meeting the HfL goal on work zone safety.

- **Safety**
    - Work zone safety during construction—By closing the intersection of Kenilworth Avenue and Eastern Avenue, possible crashes, which historically averaged 30 a year, were avoided altogether. A more traditional approach of phased construction would have maintained traffic on Eastern Avenue with substantial potential for worker-vehicular conflicts. Furthermore, the successful traffic maintenance plan to handle vehicles on Kenilworth Avenue reduced the crash rate during construction from the preconstruction rate of 156 crashes per million vehicle-miles traveled (MVMT) to less than 1 crash per MVMT. The HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate was met for the work zones both above and below Eastern Avenue Bridge.
    - Worker safety during construction—By closing the roadway in both directions during nighttime installation of prefabricated superstructure units and placing temporary traffic barriers to separate workers from traffic, injuries to contractor personnel were avoided. The calculated value on OSHA Form 300 was 0, meeting the HfL goal of less than 4.0.
    - Facility safety after construction—It is anticipated that with the placement of signal lights to maximize visibility at the intersection and clearly defined sidewalks to channel pedestrians across the bridge, safety at the intersection should improve. Furthermore, the increased vertical clearance of the Eastern Avenue Bridge decreases the likelihood of crashes and injuries caused by trucks hitting the bridge superstructure. In the past, this has caused massive traffic jams.

- **Construction Congestion**
  - Faster construction—The innovations adopted on this project helped DDOT meet its accelerated schedule of completing work in one construction season. A conventional approach using phased construction would have required two construction seasons, so the HfL goal of 50 percent reduction in the time highway users are impacted, compared to traditional methods, was met.
  - Trip time—On average, the peak trip time actually *decreased* by 13 percent compared to the average preconstruction speed, meeting the HfL goal of less than a 10 percent increase in trip time.
  - Queue length during construction—With no measurable impact in the southbound direction and only minor impact in the northbound direction, queue lengths were minimal, much less than the HfL goal of less than 1.5 mi in an urban setting.

- **Quality**
  - Smoothness and noise—These goals were not applicable to this project.
  - User satisfaction—A survey was not conducted to measure the level of user satisfaction.
  - Durability, while not a specific metric in the HFL program, is nonetheless an important aspect of quality that will result in an anticipated longer service life for the new bridge because of the following:
    - The use of prefabricated elements manufactured under controlled conditions and piers cast horizontally at ground level
    - The use of low-permeability concrete and waterproof membrane with a 3-inch (in) asphalt overlay over the prefabricated deck, which will reduce moisture penetration and chloride intrusion

ECONOMIC ANALYSIS

Accelerated construction methods and the innovative use of service roads to divert one lane of traffic over the conventional option of reducing a lane in each direction for construction resulted in substantial reduction in delay costs, far exceeding the added costs from construction and diverting a portion of Eastern Avenue Bridge traffic to detour routes. The accelerated construction methods saved an estimated $660.4 million compared to traditional construction methods.

LESSONS LEARNED

The following are lessons learned from this demonstration project:

- Use of parallel service roads or frontage roads near the work area created substantially less congestion, queuing, and related back-of-queue crashes versus the more traditional approach of closing through lanes ahead of and through the work area.
- Use of a no-excuse clause with disallowance of partial suspension or time extension because of inclement weather enabled DDOT to meet an aggressive schedule despite loss of time because of major snow events in the region.

- The project team’s excellent working relationships and agile behavior enabled it to quickly address concerns about the pier foundation because of unanticipated poor and saturated subgrade conditions encountered during construction. The experience gained in applying the technique of undercutting 1.5 ft of subgrade and wrapping aggregate in geofabric to provide stable support to the pier can be extended to other sites where similar conditions are encountered.
- Mechanical couplers were used on this project to connect the steel reinforcement of the cast-in-place footing to the precast pier units. The use of mechanical couplers was labor intensive during construction, primarily because of inadequate room for making adjustments with conventional tools such as heavy-duty wrenches. Provision for greater clearance should be considered in the future.
- The use of pier units prefabricated offsite successfully reduced pier construction time because they could be made while other operations proceeded at the bridge site. Furthermore, prefabrication eliminated the need to bring reinforcement steel to and splice it at the project site and to transport, pour, and cure substantial amounts of concrete.
- The prefabricated pier cast horizontally eliminated the need for high formwork or scaffolding. The prefabricated pier and superstructure units manufactured at ground level improved accessibility compared to conventional techniques, enhancing the quality of these products.
- Prefabrication of pier and superstructure units offsite was done independently of each other and did not need to be in sequence as with cast-in-place construction. Also, prefabrication offsite avoided conflicts with other operations at the bridge site.
- Offsite prefabrication and accelerated techniques can be successfully used to build projects faster and minimize disruption to the traveling public.

CONCLUSIONS

This project to increase the vertical clearance under the Eastern Avenue Bridge on I-295 in Washington, DC, was fully successful in meeting the project goals for safety, construction congestion, and quality. The number of clearance-related crashes and related traffic jams are expected to decrease with the improved clearance. The superstructure should improve safety at the crossing for both pedestrians and vehicular traffic.

DDOT gained considerable experience with the innovations used on this project and because of the success is encouraged to include these innovations in future projects, especially those that need to be completed in far less time than with traditional methods.

PROJECT DETAILS

BACKGROUND

The DDOT HfL project included the reconstruction of Eastern Avenue Bridge over Kenilworth Avenue in Washington, DC. The HfL grant amount of $1 million was used to aid in implementing innovative approaches to decrease construction time, increase construction zone safety, and minimize traffic impact. Rapid reconstruction of the existing bridge was achieved through the use of prefabricated elements for the center pier and superstructure and the use of service roads in the traffic management plan. DDOT was able to decrease reconstruction time and complete the work in one construction season, while conventional construction techniques would have required two construction seasons. The reconstructed bridge was opened to traffic on October 27, 2010.

This project is located along Eastern Avenue in the northeastern corner of Washington, DC, at the border with Prince George's County, MD. The bridge crosses over Kenilworth Avenue, which is the continuation of the Baltimore Washington Parkway/I-295 through Washington, DC. Kenilworth Avenue is a six-lane principal urban expressway that serves as a primary north-south gateway between Washington, DC, and Prince George's County, MD, and is the only expressway facility available for trips between downtown Washington, DC, and points to the north and east. Figure 1 shows the project location.

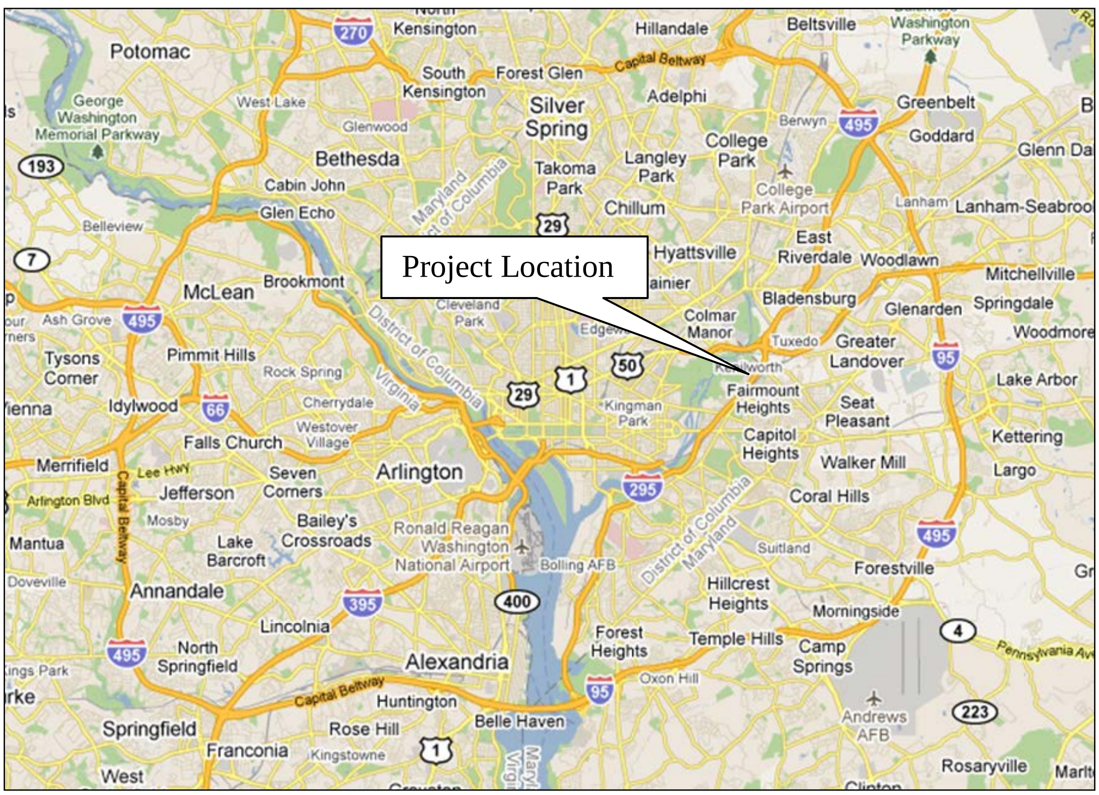

Figure 1. Project location.

Kenilworth Avenue carries an annual daily traffic (ADT) of 155,000 (2009) vehicles,[1] including 7 percent commercial vehicles. It also serves as a homeland security evacuation route for DC wards 7 and 8. U.S. 50 (John Hanson Highway/New York Avenue) just north of the project site feeds a large portion of traffic to this segment of DC 295. Parallel to Kenilworth Avenue and on either side are two one-way service roads more than 24 ft wide that provide access to local homes and businesses.

Eastern Avenue is a minor arterial with 37,000 ADT[1] and 7 percent commercial vehicles that runs in a northwest-to-southeast direction beginning at Kenilworth Avenue and continues southeast along the boundary between Washington, DC, and Prince George's County, MD.

Figure 2 shows conditions at the intersection of Eastern Avenue and Kenilworth Avenue before reconstruction. The profile of Kenilworth Avenue is depressed to cross under Eastern Avenue at their intersection. The Eastern Avenue Bridge before reconstruction was a single-span bridge crossing all six lanes of Kenilworth Avenue. The intersection is signalized on top for turns between Eastern Avenue and Kenilworth Avenue service roads. Ramps between mainline Kenilworth Avenue and its parallel service roads provide access between Kenilworth Avenue and Eastern Avenue. Kenilworth Aquatic Gardens, administered by the National Park Service, are located northwest of the intersection. The bridge serves as a pedestrian crossing, truck turnaround, and link between portions of northeast DC.

Figure 2. Preconstruction aerial photograph of Eastern Avenue bridge.

[1] Traffic data obtained from approved drawings prepared by project consultant Greenehorne & O'Mara dated June 3, 2009.

The Eastern Avenue Bridge was built in 1956 to the standard minimum vertical clearance of 14 ft over Kenilworth Avenue and had been struck multiple times since construction, causing extensive traffic jams. Figures 3 and 4 show the damage to the bridge beams from vehicular impacts. DDOT reconstructed the bridge to increase the minimum vertical clearance to 16 ft, the maximum extent practicable, and to increase safety at the crossing for both pedestrians and vehicular traffic.

Figure 3. View of vehicular damage to the bridge beams.

Figure 4. Closeup of damage to the bridge beams.

PROJECT DESCRIPTION

The project consisted of replacing the existing single-span, prestressed beam bridge with a two-span bridge, using prefabricated components for the superstructure supported by prefabricated pier units resting on a cast-in-place foundation. Work for the bridge included the following:

- Reconstruction of the existing abutment and retaining wall
- Construction of the bridge pier foundation and traffic barrier
- Fabrication and installation of prefabricated pier units
- Fabrication and installation of reinforced elastomeric bearings
- Fabrication and installation of prefabricated superstructure units
- Construction of the cast-in-place superstructure
- Construction of superstructure parapets, barriers, and medians

Limited space for mainline Kenilworth Avenue traffic under the existing Eastern Avenue Bridge and heavy traffic volumes on Kenilworth Avenue, especially during peak periods, were the key project constraints.

The following three alternatives were considered to achieve the needed clearance between the bottom of the bridge and the Kenilworth Avenue roadway surface:

1. **Lowering Kenilworth Avenue—**This option would have eliminated the need for a pier, but it was rejected because of the following:
    - It would have required extensive excavation under severely constrained conditions.
    - Foundations for the bridge abutments were too shallow.
    - It would have had severe traffic impacts on Kenilworth Avenue and its service roads.
2. **Raising Eastern Avenue and service road profiles—**This option would have replaced the single-span bridge with a new single-span bridge and provided 18 in of additional clearance by raising the profiles of Eastern Avenue and service roads. This option was rejected because of significant impacts on existing driveways and properties along Eastern Avenue and service roads, particularly because of the proximity of buildings to the edge of the roadway.
3. **Constructing a two-span bridge—**This option allowed a reduction in the depth of the girders for each span and, along with raising the profile of the roadways by up to 6 in, provided the necessary increase in clearance. This alternative became the selected option. The length of the bridge would be 84 ft, 8 in with two 42-ft, 4-in spans. The width would vary from 180 ft at the abutments to 156 ft at the pier.

The project goals also included minimizing construction duration and traffic impacts, especially along Kenilworth Avenue. Offsite construction with self-propelled modular transporters was considered, but nearby sites for construction were unavailable. Consideration was also given to laying the proposed bridge girders temporarily across Kenilworth Avenue, just to the north or south of the existing bridge, and constructing the entire new bridge deck on top of the girders while maintaining all lanes of traffic both below and on the existing bridge. The concept was to move the newly constructed bridge once the existing bridge was demolished using a system specifically designed for this purpose. The option was rejected because it was believed that it would add more expense to the project (details were not available).

Two alternative schemes were considered for the maintenance of traffic (MOT):

- **Option 1—**Provide space for construction of the pier in the Kenilworth Avenue median by closing one of the three lanes in each direction on mainline Kenilworth Avenue.
- **Option 2—**Provide space for construction of the pier on the Kenilworth Avenue median by diverting one lane in each direction from mainline Kenilworth Avenue onto the Kenilworth Avenue ramps and service roads and shifting the remaining two lanes in each direction to the right.

Option 2 was selected because of significantly lesser adverse impacts on Kenilworth Avenue traffic (see "Data Acquisition and Analysis"). As it turned out, the actual impacts during construction were less than anticipated and minor. In the northbound direction, impacts were negligible in the a.m. peak period (northbound is the a.m. offpeak direction). During the p.m. peak period, speeds were somewhat lower in the vicinity of the Eastern Avenue Overpass. These reduced speeds resulted in travel times 1.1 to 1.7 minutes longer than before construction (depending on whether one took the exit ramp to the service road or remained on Kenilworth Avenue). Southbound, the impacts of the traffic control plan were negligible during both the a.m. and p.m. peak periods.

Consideration was given to staged construction by removing half of the existing bridge deck, maintaining traffic on the other half, and constructing the new pier below in two phases, but this was rejected because it would lengthen the duration of impact to mainline Kenilworth Avenue. Further, this would be feasible only under MOT Option 1 because the diverted expressway lanes under MOT Option 2 required that no turning movements be made at the Eastern Avenue intersection to allow free-flowing traffic.

The traffic across Eastern Avenue Bridge originating from Kenilworth Avenue, Eastern Avenue, and local trips, estimated at 33,033 ADT including 7 percent commercial vehicles, was diverted onto two separate detours. A portion (21,033 ADT) of the traffic that would have crossed the bridge heading northwest (westbound) was detoured 1.5 mi via Kenilworth Avenue and US 50. The southeast (eastbound) traffic across the bridge (12,000 ADT) was diverted 1.8 mi via the service roads parallel to Kenilworth Avenue and the Nannie Helen Burroughs Avenue Bridge. The Eastern Avenue Bridge detour routes are highlighted in figure 5.

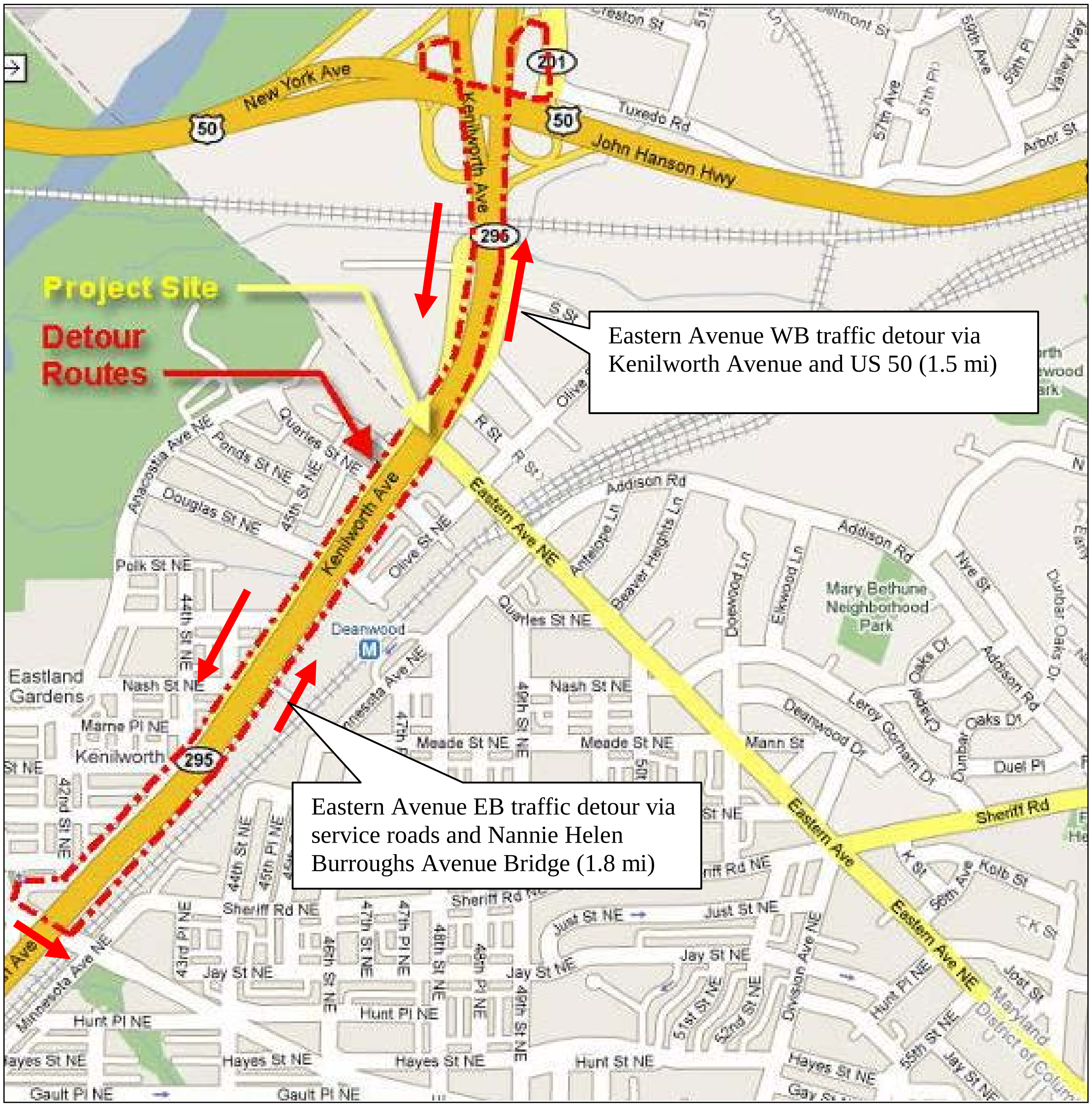

Figure 5. Eastern Avenue Bridge detour routes.

DDOT selected the option of prefabricated pier units and superstructure units for minimizing onsite construction duration with offsite fabrication. Besides enabling reduction in construction duration and disruption to the traveling public, the prefabrication would have other advantages:

- Better quality because of plant-cast concrete produced in a controlled environment
- Production of products in a safer work environment away from traffic
- Better inspection of materials and finished prefabricated members before they are incorporated into the project

Successful use of prefabricated elements by highway agencies in Connecticut, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Texas, Vermont, Virginia, and Washington ensured that the concept was both feasible and tested. Each superstructure unit was 9-ft-wide and 7.5-in-thick lightweight concrete deck with two W16x100 rolled steel beams spaced at 5-ft centers. In all, each span had 14 prefabricated units with each unit weighing 50 tons. The superstructure units rest on prefabricated pier units. The pier units were 1-ft-thick hammerhead columns that weighed 12 tons and supported two bridge beams. Figures 6 through 11 show the manufacturing of the pier units at the plant and their installation at the project location.

Figure 6. Reinforcement for precast pier unit.

Figure 7. Manufactured precast pier unit.

Figure 8. Installation of precast pier units.

Figure 9. Pier installation (abutment reconstruction in background).

Figure 10. End pier installation.

Figure 11. Connection between footing and precast pier units.

Two unanticipated challenges were encountered during construction of the cast-in-place footing for the pier units. The first challenge was saturated subgrade conditions at the pier footings, shown in figure 12. The project team resolved it by undercutting 1.5 ft of subgrade soil and placing aggregate wrapped in geofabric.

Figure 12. Saturated subgrade conditions.

Use of mechanical couplers to connect the reinforcement steel of the cast-in-place footing and the precast pier units (shown in figure 13) presented the second challenge. It was found to be very labor intensive, primarily because of inadequate room for making adjustments with conventional tools such as heavy-duty wrenches. The activity added 4 days more than the contractor anticipated.

Figure 13. Closeup of the reinforcement steel couplers.

The manufacture and placement of the superstructure units are shown in figures 14 through 19. These units were installed during the night without any unusual problems.

Figure 14. Steel assembly for a precast superstructure unit.

Figure 15. Formwork for a precast superstructure unit.

Figure 16. Steel reinforcement for a precast superstructure unit.

Figure 17. Finished precast superstructure unit.

Figure 18. Installation of superstructure unit.

Figure 19. Adjacent superstructure units with connection reinforcement.

A key innovative approach on this project was the use of service roads for one lane of traffic. Figure 20 shows the flow of traffic during construction on Kenilworth Avenue and the service road at the higher elevation. Figure 21 shows traffic flow upon completion of Kenilworth Avenue work.

Figure 20. Traffic flow during construction of cast-in-place footing for the pier.

Figure 21. Traffic flow upon completion of work on Kenilworth Avenue.

DATA ACQUISITION AND ANALYSIS

Data on safety, traffic flow, and qualitybefore, during, and after construction were collected to determine if this project met the HfL performance goals. The primary objective of acquiring these types of data was to quantify project performance and provide an objective basis from which to determine the feasibility of the project innovations and to demonstrate that the innovations can be used to do the following:

- Achieve a safer work environment for the traveling public and workers.
- Reduce construction time and minimize traffic interruptions.
- Produce a high-quality project and gain user satisfaction.

This section discusses how well the DDOT project met the specific HfL performance goals related to these areas.

SAFETY

There were no reports of any injuries or lost time work incidents by the contractor’s employees. As a result, the incident rate according to the OSHA Form 300 was 0. Table 1 shows the traffic incident log denoting incidents that occurred within the project limits of construction during the contractor's working hours. The construction management firm representative indicated that none of the incidents recorded were attributable to the contractor’s actions or improper lane closures. In most cases, crashes were due to excessive speed in the work zone or an impaired driver.

Table 1. Traffic incident log.

Date	Time	Location	Station / Lane	Work Incursion	Injury	Description
1/7/2010	14:30	SBL KWA	Left	No	Passenger	Rear End collision due to speed in work zone with water, ice contribuiting
1/12/2010	22:00	NBL KWA	Left	No	No	Police chase ending in TA near work zone at EAB
1/21/2010	9:15	SWSR at 42nd	N/A	No	Driver	Rear End collision due to speed. Not in EAB project limits, at NHB
1/22/2010	11:00	SBL KWA	Left	No	No	Single Car Rollover, no lane closures
1/23/2010	10:00	SB KWA on Eastern Ave Exit	N/A	No	No	Lane Encroachment from Shoulder, no lane closures
1/26/2010	17:00	SBL KWA	Left	No	Passenger	Rear End collision due to speed
1/28/2010	13:00	NBL KWA	N/A	No	Passenger	three car collision
1/29/2010	14:30	SBSR at Exit NHB	Left	No	No	Three car collision due to driver under the influence
2/16/2010	13:45	SBL KWA	center	No	No	Windshied damaged by falling debris
3/1/2010	12:00	NBL KWA	center	No	No	Windshied damaged by falling debris
3/3/2010	23:00	NBL KWA	Left	No	No	Rear end collision due to speed, 5 vehicles involved, 3 driven away 2 totaled
3/5/2010		NBL KWA	Left	No	Passenger	Rear end collision at lane closure restriction due to speed
3/8/2010	15:10	NBL KWA	Center	No	No	Windshied damaged by falling debris
4/23/2010	4:15	SBSR split at Express Lane	right	No	No	Driver struck attenuator at split, rear end collision followed
5/28/2010	10:05	SBL KWA	Center	No	No	Dump truck hit passenger vehicle in merge lane at taper entering work zone.
6/7/2010	10:35	Eastern at Addison	Intersection	No	No	Truk turning against light struck right-of-way vehicle
8/11/2010	9:25	SBSR	Rt Side	No	No	Over size commercial vehicle struck and damaged visual screen barrier
9/23/2010	22:15	BW Parkway SBL	right / median	No	No	Vehicle left roadway at high rate and crashed into stationary VMS board prior to project limits

Historical crash data from 2001 to 2003 indicates a crash rate of 156 crashes per MVMT on the segment of Kenilworth Avenue south of the Eastern Avenue Bridge. Disregarding incidents not directly involving vehicle crashes (i.e., police chase, falling debris, or periods when no lane closures occurred), the incidents in table 1 drop to six crashes, three of which resulted in injuries. The resulting crash rate was determined given the following:

- Length of the Kenilworth Avenue work zone = 0.218 mi
- ADT on Kenilworth Avenue = 155,000
- Duration of construction contract = 360 days

As can be noted only a 0.218 mi segment of the Eastern Avenue Bridge was chosen as the "influence area" for crash analysis. Typically, all roadway segments affected by the construction including the designated detours would also be considered as part of the influence area for crash analysis. However, due to the lack of readily available information on pre- and during construction crashes for the other affected roadway segments, namely, the detour routes (see Figure 5), they were not considered in the crash analysis.

The crash rate for the selected influence area is calculated as follows:

$$\text{Crash Rate }(_{\text{Kenilworth Ave during const}}) = 6 \text{ crashes} / 155{,}000 \text{ (ADT)} * 360 \text{ (days)} * 0.218 \text{ (mi)}$$
$$\text{Crash Rate }(_{\text{Kenilworth Ave during const}}) = 0.49 / \text{MVMT}$$

Assuming that the segment of Kenilworth Avenue south of the Eastern Avenue Bridge represents the preconstruction crash rate for the entire work zone, the 0.49 crash rate during construction was far less than the 156 preconstruction crash rate.

The intersection on top of the Eastern Avenue Bridge experienced an annual average of 30 crashes (with 11 injuries) from 2004 to 2006. By completely closing the bridge, possible crashes caused by traffic on the Kenilworth ramp making turns to cross the bridge conflicting with through traffic crossing the bridge were avoided.

CONSTRUCTION CONGESTION

The HfL program specifies performance goals for reducing both total construction duration and construction impacts on traffic by 50 percent. Under conventional methods, the construction impact on both roads was estimated at two construction seasons. With the use of accelerated construction techniques and innovative traffic management, the impact was reduced to one construction season. During the one season, the work specified in the contract was completed in 320 calendar days.

The use of precast pier units and superstructure units reduced congestion several ways:

- By improving traffic flow during construction and reducing motorist impact because of the shortened construction period. Use of pier units prefabricated offsite successfully reduced pier construction time because they could be made at the same time other operations were carried out at the project site. Furthermore, prefabrication of pier and superstructure units offsite could be performed independently of each other without the need to be in sequence as in cast-in-place construction.

- By reducing materials deliveries. Prefabrication eliminated the need to transport reinforcement steel to and splice it at the project site and to transport, pour, and cure substantial amounts of fresh concrete. The need for concrete forms was also eliminated.
- By requiring less onsite storage area.

The longer life of the structure because of the improved quality previously described is also expected to reduce congestion because of reduced future maintenance activities. Both the reduction in total construction time and the impacts on motorists compared to conventional construction methods far exceeded the HfL performance goals for this project.

TRAFFIC STUDY

The transportation management plan for this project involved the use of the service or frontage road on each side of Kenilworth Avenue as an additional through lane, effectively splitting Kenilworth traffic between the existing remaining through lanes and the service road lane. Cross-streets with access to the service roads were closed, and the exit and entrance ramps to and from Kenilworth at Eastern Avenue served as the extra (diversion) lane.

To assess the impacts of the total bridge closure, researchers conducted a series of travel time runs on Kenilworth Avenue before and during the project. Travel time studies were conducted before the bridge closure during the first week of February 2010. Researchers returned to the site and collected travel times during the third week of July 2010.

Researchers used the floating vehicle methodology to collect travel times, attempting to mimic the typical driving speed of other vehicles along the various roadway segments of the detour route. Data were collected in both studies from about 6 to 10 a.m., 3:30 to 7 p.m., and on one night during construction when an additional lane in each direction was closed from 7 to 9:15 p.m. (the temporary lane closure began slightly before 8 each night).

Figure 22 illustrates the study region and identifies key nodes used in the travel time data collection process. Table 2 identifies the travel distance between nodes and the typical travel times on each segment when uncongested and operating at about 55 miles per hour (mi/h). A total of 52 travel time runs were performed over the 3-day period (February 2010) before construction and 41 travel time runs were performed during construction. Traffic flows were highly directional. Peak-direction traffic speed dropped significantly during peak periods and returned to uncongested travel speed after the peak period. The offpeak direction speed was only slightly reduced, if at all, during the peak period.

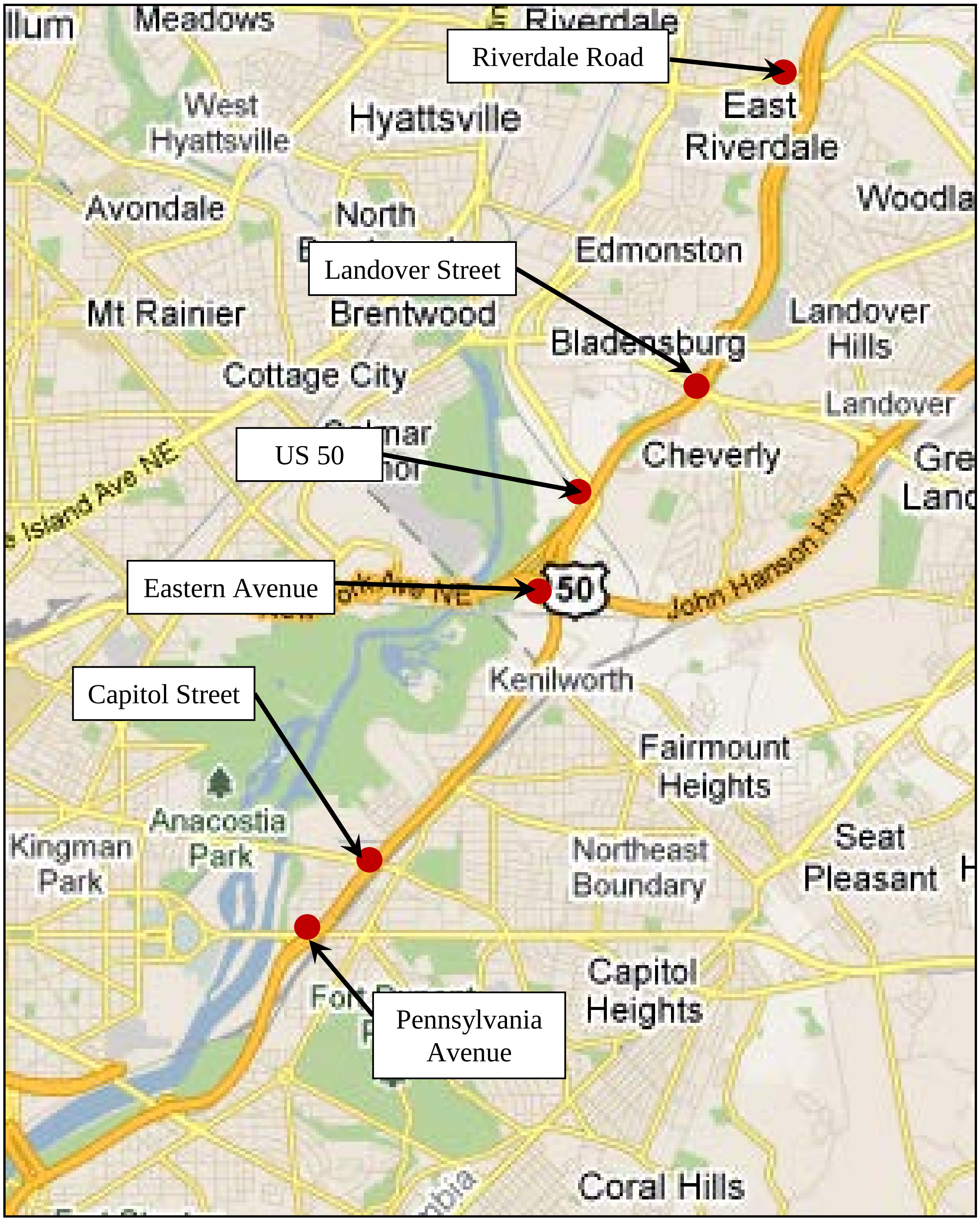

Figure 22. Corridor map and node locations.

Table 2. Nodes and distances from the southbound direction.

Node Points		Approximate Distance (mi)	Approximate Travel Time (min)
Riverside Road (R)	Landover Street (L)	1.8	1.9
Landover Street (L)	US 50 (H)	1.5	1.6
Highway 50 (H)	Eastern Avenue (E)	0.5	0.5
Eastern Avenue (E)	Capitol Street (C)	2.0	2.2
Capitol Street (C)	Pennsylvania Avenue (P)	1.3	1.4
Corridor Total		**7.0**	**7.6**

Note: The single capitalized letters are node abbreviations. Distances were measured from Google Earth and travel time was calculated with a 55 mi/h free-flow speed.

A comparison of northbound segment average speeds and travel times between the two data collection periods is presented in table 3. Southbound segment speeds and travel times are provided in table 4.

The during-construction travel time runs were divided between those that remained on Kenilworth Avenue and passed underneath Eastern Avenue (labeled as "through") and those that took the exit ramp to Eastern Avenue and used the frontage road as an additional lane past Eastern Avenue (labeled as "divided").

Table 3. Northbound speed and time results.

Scenario		Speed (mi/h)					Time (min)					
		P-C	C-E	E-H	H-L	L-R	P-C	C-E	E-H	H-L	L-R	**Total**
A.M. Peak	Before	40	52	54	56	58	1.9	2.3	0.5	1.5	1.8	**8.0**
	During-Divided	56	50	49	57	50	1.3	2.4	0.6	1.5	2.1	**7.9**
	During-Through	56	53	55	57	62	1.3	2.3	0.5	1.5	1.7	**7.3**
P.M. Peak	Before	35	36	44	49	35	2.1	3.4	0.7	1.7	2.9	**10.7**
	During-Divided	34	24	28	56	42	2.1	5.1	1.0	1.5	2.6	**12.4**
	During-Through	34	23	43	57	49	2.2	5.3	0.7	1.5	2.2	**11.8**
Night Work	During-Divided	58	48	48	55	56	1.3	2.5	0.6	1.5	1.9	**7.8**
	During-Through	51	19	49	59	61	1.4	6.3	0.6	1.5	1.7	**11.5**

Table 4. Southbound speed and time results.

Scenario		Speed (mi/h)					Time (min)					
		R-L	L-H	H-E	E-C	C-P	R-L	L-H	H-E	E-C	C-P	**Total**
A.M. Peak	Before	50	42	38	33	36	2.1	2.1	0.8	3.7	2.1	**10.8**
	During-Divided	54	56	41	48	45	2.0	1.6	0.7	2.5	1.7	**8.4**
	During-Through	57	58	39	43	44	1.9	1.5	0.8	2.8	1.7	**8.7**
P.M. Peak	Before	51	56	51	45	34	2.1	1.6	0.6	2.7	2.2	**9.1**
	During-Divided	59	63	45	51	44	1.8	1.4	0.7	2.4	1.7	**8.0**
	During-Through	59	63	50	52	46	1.8	1.4	0.6	2.3	1.6	**7.8**
Night Work	During-Divided	57	41	15	51	57	1.8	2.1	1.9	2.4	1.3	**9.6**
	During-Through	58	47	11	49	55	1.8	1.9	2.6	2.5	1.4	**10.2**

Overall, the effect of the traffic control plan adopted for this project on traffic flow was minor. In the northbound direction, impacts were negligible in the a.m. peak period (northbound was the offpeak direction in the a.m.). During the p.m. peak period, speeds were found to be somewhat lower in the during-construction period within the Capitol-to-Eastern segment and the Eastern-to-Highway 50 segment. These reduced speeds (presumably because of an increase in congestion around the Eastern Avenue Overpass) resulted in travel times that were an average of 13 percent longer than in the before condition (depending on whether one took the exit ramp to the frontage road or remained on Kenilworth Avenue). Southbound, the impacts of the traffic control plan were negligible during both the a.m. and p.m. peak periods. In fact, travel times southbound in the a.m. and p.m. peak periods (as well as the northbound a.m. peak period) were actually less than in the before condition. Moreover, the average peak trip time from both directions actually decreased by 13 percent. It was not possible to determine whether natural diversion of some of the traffic using Kenilworth Avenue or some other aspect of the traffic control plan was responsible for this reduction.

On one night during construction, researchers collected data during the initial portions of the temporary closure of one additional lane in each direction to facilitate work on the Eastern Avenue bridge deck. Researchers used the free-flow (55 mi/h) estimated travel time of 7.6 minutes as the basis of comparison because data collectors noted before construction that travel speeds returned to uncongested conditions by about 7 each night. Examining the night work data in both tables, one sees that the temporary lane closures did create some minor congestion early in the evening in both directions. Northbound, this congestion did not back up beyond the exit to Eastern Avenue (as evidenced by the lower travel times for those runs where the exit ramp and diverted travel path on the frontage road was taken). Southbound, congestion extended beyond the exit ramp to Eastern Avenue, so both travel time paths evaluated (through and diverted) experienced slightly longer travel times (2.0 to 2.6 minutes longer). This congestion generally lasted only until about 9:15 p.m. in either direction.

Researchers computed the estimated additional delays to Kenilworth Avenue traffic resulting from the Eastern Avenue project. As noted above, the only measureable impact during daytime traffic flows appears to have occurred in the northbound direction and only during the p.m. peak period. Researchers averaged the through and diverted delay times during this period (estimated to be 1.1 minutes), and multiplied this by the hourly volumes assumed to be using Kenilworth Avenue during the peak period (no diversion was assumed to have occurred). Assuming that the peak period existed from 4 to 7 p.m., a total of 301 vehicle-hours (veh-hrs) of delay were estimated to occur each work day on this project. Table 5 summarizes the computations.

Table 5. Delay computations of the northbound peak period.

Scenario	**Time Period**		**Directional Volume**	**Increased Travel Time (min/veh)**	**Added Travel Time (veh-hrs)**
NB P.M. Peak	4 p.m.	5 p.m.	5,558	1.1	100
	5 p.m.	6 p.m.	5,643		102
	6 p.m.	7 p.m.	5,537		100
NB PM Peak Total Added Delay (veh-hrs)					**301**

The impact of temporary lane closures at night to allow Eastern Avenue bridge work was likewise minimal. Assuming that the closures began around 8 p.m. and that congestion had dissipated by 9 p.m., it appears that 201 veh-hrs of delay were generated by each night of temporary lane closures (table 6).

Table 6. Delay computations for night work activity.

Scenario	**Time Period**		**Directional Volume**	**Increased Travel Time (min/veh)**	**Added Travel Time (veh-hrs)**
NB Night Work	8 p.m.	9 p.m.	2,704	2.4	106
SB Night Work	8 p.m.	9 p.m.	2,518	2.3	95
Night Work Total Added Delay (veh-hrs)					**201**

Note: Travel time calculations were generated only for the times when data was collected and for the periods that saw an increase in travel time from before to during construction.

It should be noted that these delay values are significantly lower than those predicted via traffic analysis computations performed during the transportation management plan development.[2] Closure of the middle lanes on Kenilworth Avenue and use of the frontage road as a diversion lane in each direction was expected to generate 687 veh-hrs of delay per day northbound and 1,705 veh-hrs of delay per day southbound, but actual travel times found delays to be negligible southbound and less than half of what was predicted in the northbound direction. Possible reasons for the discrepancy include a higher per-lane operating capacity in each direction during construction and some diversion by commuters to other routes in the corridor to avoid

[2] Greenhorne & O'Mara, Inc. *Eastern Avenue Over Kenilworth Avenue, N.E. Work Zone Transportation Management Plan, Washington, D.C.* Prepared for District Department of Transportation Infrastructure Project Management Administration/Team 4. May 2009.

construction. Unfortunately, traffic volume counts during construction were not available to investigate these possibilities in detail.

QUALITY

Quality measurements on HFL projects often include measurement of smoothness in terms of the IRI and measurement of pavement-tire noise in terms of sound intensity. Because of the short bridge length and congested area surrounding the project, it was not practical or safe to collect these measurements.

The project design called for construction of a cast-in-place footing for the pier units after removal of the existing superstructure. The prefabricated pier units manufactured offsite were then connected to the footing. The connection between the footing and the pier units was made with mechanical rebar couplers and closure pours. Once the pier was constructed and the modifications were made to existing abutments, prefabricated superstructure elements were placed. The superstructure segments were connected by rebar loops and closure pours. A waterproof membrane was applied over the concrete deck. The membrane will improve long-term durability of the structure. A 3-in-thick hot-mix asphalt (HMA) overlay was placed to provide the final grade. The overlay is expected to prevent damage to the waterproof membrane during future HMA mill and overlay operations.

The use of prefabricated bridge components will improve the durability and quality of the bridge compared to conventional construction methods. The units were fabricated in a controlled environment, where it was easier to maintain quality control. Prefabrication also allows assembly of units at the plant to proactively determine any installation and assembly problems and avoid them in the field during installation.

Prefabricated piers cast horizontally eliminated the need for high formwork or scaffolding. The prefabricated pier units and superstructure units manufactured at ground level improved accessibility compared to conventional techniques, enhancing quality of these products.

The specifications[3] for the prefabricated components are in Appendix A. They include plant certification requirements; requirements on the qualifications of the manufacturer, erector, welders, and tackers; and quality control requirements that include allowable casting tolerances.

Allowable casting tolerances are summarized as follows:

- For precast concrete pier units, variation from plumb shall be not more than 0.5 in over 15 ft. Variation in cross-sectional dimensions shall be not more than -0.25 in to +0.5 in.
- For precast concrete superstructure units, variation in deck slab thickness shall be not more than -0.25 in to +0.5 in.

[3] Specifications, Invitation No.: DCKA -2009-B-0183-JBW. *Reconstruction of Eastern Avenue Bridge Over Kenilworth Avenue, N.E., F.A.P. Nos.: ARA-3207(003) and ARA-3207(004).* Prepared for District Department of Transportation Infrastructure Project Management Administration.

USER SATISFACTION

As part of the public information and outreach plan, a stakeholder meeting was held on March 19, 2009, at the First Baptist Church of Deanwood to explain the construction process and phasing. Three representatives from the Advisory Neighborhood Commission (ANC) attended, along with one from DC Councilmember Yvette Alexander's office. No significant concerns with the construction phasing scheme were identified. A followup brochure was provided to the ANC representatives to assist in informing their constituents about the upcoming project. Per contract special provisions, the contractor was required to inform the public about construction progress and upcoming roadway lane changes.

The bridge was opened to traffic on October 27, 2010. The following blog entry appeared on the Washington Post's Web site (http://voices.washingtonpost.com/dr-gridlock/2010/10/dc_reopens_eastern_ave_bridge.html). The text of the article is as follows:

> **D.C. reopens Eastern Ave. bridge**
> It was impossible to tell while staring into the heavy rains along Kenilworth Avenue, but the District reopened the bridge that takes Eastern Avenue over Kenilworth today. This follows a complete rebuilding of the bridge that took less than 10 months, thanks to $10.4 million in federal stimulus funds, a $1 million federal grant and innovative construction techniques.
>
> Though it's been just 10 months, drivers may only dimly remember the ugly, old bridge that hung over the avenue and showed the dents where trucks had clipped it. The total reconstruction involved lane closings and reroutings of traffic. But the impact was reduced by pre-casting big sections of the bridge and trucking them to the site for assembly at night. Otherwise, the project could have taken two years.

A formal survey was not conducted to gauge user satisfaction after the project was completed. The results of such a survey likely would have been favorable, given the active outreach program and the accelerated construction schedule.

TECHNOLOGY TRANSFER

DDOT organized a project demonstration showcase as part of its technology transfer plan to highlight the following:

- Rapid construction of the bridge through the use of prefabricated bridge elements
- Innovative application of maintenance-of-traffic methods and technology to decrease traffic congestion and increase safety in the construction zone
- Use of a no-excuse contract clause with disallowance of partial suspension or time extension because of inclement weather

A team consisting of representatives from DDOT, FHWA's District Division, FHWA's HfL team, Applied Research Associates, and the University of Florida planned and implemented the showcase. The showcase was held on July 20, 2010, at the Reeves Center (DC government building) at 2000 14th Street NW in Washington, DC. Invitations were extended to DDOT representatives, academia, consultants, and contractors. Representatives from neighboring States were also invited. Registration filled up quickly and about 50 people participated. The list of participants is in Appendix B.

The showcase consisted of a morning session of presentations at the Reeves Center, an afternoon visit to construction site, and a return to the Reeves Center for question-and-answer and wrap-up sessions. The showcase agenda is in Appendix C.

The showcase benefited greatly from FHWA Administrator Victor Mendez and DDOT Director Gabe Klein enthusiastically encouraging innovation and technology deployment. This was followed by a presentation by Jim McMinimee, Applied Research Associates principal engineer, on "Why Accelerated Bridge Construction, Why Now, and How?" McMinimee cited the benefits of prefabricated bridge elements and systems, including the minimization of traffic and community impacts demonstrated with this project. He also quoted statistics on how congestion robs the Nation of productivity and quality of life, causing 4.2 billion hours of delay annually, wasting 2.9 billion gallons of gas, and costing $78.2 billion in 437 urban areas alone. McMinimee also directed the audience to available tools and resources on accelerated construction, including the FHWA Web site www.fhwa.dot.gov/bridge/prefab and FHWA contacts Kathleen Bergeron, at kathleen.bergeron@dot.gov, on the HfL team and Claude Napier, at claude.napier@dot.gov, in the Office of Bridge Technology.

A discussion of the Eastern Avenue Bridge replacement was the next topic, with program DDOT managers Maduabuchi Udeh and Ali Shakeri, civil engineer Luan Tran, and project engineer Bruke Siraga making a joint presentation. They introduced the project team, which included the following:

- Greenhorne & O'Mara—Consultant, Vice President Simon Simon, Project Manager Bimal Patel, and Structural Engineer Michael Chamberland
- Fort Myer Construction Corporation—Contractor
- The Fort Miller Co., Inc.—Precast manufacturer

The DDOT team discussed project objectives, the accelerated construction options they considered, highlights of the traffic management plan for the project, and their decision to use precast piers and superstructure. They also showed photographs of these units during the manufacturing process.

Austin Anderson, Fort Myer Construction Corporation project engineer, shared the contractor's perspective on the innovative features of the project, some of the challenges faced, the tightness of the construction schedule, and the midcourse changes made to stay on schedule. Project completion milestones included the following:

- Bridge closure—February 1, 2010
- Bridge demolition—April 5, 2010
- Abutment and pier reconstruction—July 1, 2010
- Modular bridge sections—July 23, 2010
- Bridge reopening—October 20, 2010

Hector Sealey, Fort Myer Construction Corporation safety officer, presented a safety briefing. Both design and construction perspectives generated considerable interest and participation by the attendees, who asked a number of questions on the innovative features of the project.

In the afternoon, participants traveled by bus to the project site. The weather cooperated during the site visit. The contractor stopped enough construction activity to enable visitors to freely walk around and view the innovative features. The project was in the deck construction stage and some of the precast superstructure units had been placed. The attendees could see how one lane of traffic in each direction was diverted to the service road, how the project was free of construction backups because of this action, the urbanized location and challenges of the project, the condition of the precast pier units, the integration of the new abutment with the old, and the early stages of precast superstructure placement. Siraga and Matthew Jahns, Jacobs Engineering construction manager, were on hand to answer questions on the project. The contractor was cooperative and the construction workforce eagerly shared their experiences and answered questions from showcase participants. After about 2 hours at the work site, the participants returned to the conference center for the question-and-answer and wrap-up sessions. The presentations made at the DDOT showcase are available at www.pdshowcase.org/home/completed.

The DDOT project HfL showcase was deemed a success. Participants had an opportunity to hear about and see firsthand the positive attributes of setting high project goals and meeting those goals with innovation and minimal construction delays. DDOT project personnel were also lauded for their efforts. This public acknowledgement and the success of the innovative approach will undoubtedly spur more innovation on future DC bridge projects.

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is to quantify, as much as possible, the value of innovations deployed. This quantification entails a comparison of the benefits and costs associated with the innovative project delivery approach adopted on the HfL project with those of a more traditional delivery approach (i.e., an approach that does not include the project's highlighted innovations) for a project of similar size and scope. The latter type of project is referred to as the baseline case and is an important component of the economic analysis.

This section discusses the cost comparisons for the Eastern Avenue Bridge reconstruction project. DDOT provided the traffic information. As background, the ADT on mainline Kenilworth Avenue in 2009 was 155,000 with 7 percent commercial vehicles. The ADT on Eastern Avenue in 2009 was 37,000 with 7 percent commercial vehicles.

CONSTRUCTION TIME

Conventional staged construction and cast-in-place construction methods would have been used for the baseline case. This would have left the Eastern Avenue Bridge partially open during construction, but would have required two construction seasons to complete as opposed to one season for the actual or as-built scenario. The actual full closure of the Eastern Avenue Bridge lasted 262 days, from February 1 to October 20, 2010.

CONSTRUCTION COSTS

Table 7 presents the itemized construction cost differences between the baseline alternative and the as-built project. The total as-built construction cost was $3.2 million approximately ($8,667,808 - $5,500,730) or 56 percent more than the baseline estimate. As-built costs were taken from the actual bid tabulation and baseline values originate from DDOT's estimate. Several assumptions were made on the estimated baseline values, so the information presented is a subjective analysis of the likely cost differential rather than a rigorous computation of a cost differential.

Table 7. Construction cost table.

Cost Category	Baseline Case	As-Built Case
Design and Engineering[1]	$ --	$ --
Roadway[2]	$ 884,200	$ 1,675,090
Bridge[3]		
Substructure	$ 561,150	$ 1,223,340
Superstructure	$ 1,845,380	$ 3,265,866
Mobilization[4]	$ 110,000	$ 446,000
Signs, Signals, and Electrical Work[5]	$ 450,000	$ 1,278,045
Protective Shield	$ 250,000	--
Staged Construction	$ 550,000	--
MOT	$ 850,000	$ 779,467
Total Construction Cost	**$ 5,500,730**	**$ 8,667,808**
Contingency[6]	$ 1,650,219	**--**
Architectural Feature[7]	$ 1,100,146	--
Grand Total	**$ 8,300,146**	**$ 8,667,808**

Notes:
[1] Design and engineering costs were not available.
[2] As-built costs include additional road work related to preparing the service ramps for detour traffic.
[3] The differential in bridge costs is assumed to have been partially influenced by the cost of the precast bridge elements. Also, unexpected costs for the pier was higher than expected for the as-built case becouse of poor soil conditions. It could be argued that the baseline case would have also incurred similar costs due to the same reason.
[4] As-built mobilization costs are assumed to be higher because of the larger equipment necessary to place the precast bridge elements.
[5] As-built costs are assumed to be higher because of the additional signage required for the detour routes.
[6] DDOT applied 30 percent contingency cost to the baseline case. This cost was not considered in the computing the difference between as-built and baseline construction costs.
[7] DDOT anticipated an additional 20 percent of the total construction cost for an architectural feature. This cost was not considered in the computing the difference between as-built and baseline construction costs.

USER COSTS

Generally, three categories of user costs are used in an economic analysis: vehicle operating costs (VOC), delay costs, and safety-related costs. The closure of Eastern Avenue Bridge had the greatest effect on the operating costs of the vehicles that normally would have used the bridge to cross Kenilworth Avenue. Delay costs were the greatest consideration for traffic on Kenilworth Avenue. Unfortunately, reliable data on the safety costs for the baseline case could not be determined or reasonably approximated, so the cost savings could not be estimated.

VOC

The baseline construction alternative would have reconstructed the Eastern Avenue Bridge in phases while maintaining traffic across a portion of the bridge and on Kenilworth Avenue without the additional mileage and VOC associated with detours. The as-built case completely closed the Eastern Avenue Bridge and routed traffic onto detours, accumulating an estimated $4.3 million in VOC approximately. The following assumptions and calculations provided a basis for this conclusion:

- The average unit costs were $0.24 per mile for passenger vehicles and $0.65 per mile for commercial vehicles for the VOC[4] (including costs for fuel, maintenance and repair, tires, and depreciation), based on city driving.

- The bridge closure detoured westbound traffic (21,033 ADT) 1.5 mi and eastbound traffic (12,000 ADT) 1.8 mi. Seven percent of all traffic was commercial vehicles.
- It is assumed that all diverted traffic traveled the detours rather than traveled another route or avoided the area altogether.
- The additional distance vehicles traveled because of the diversion from Kenilworth Avenue onto the parallel service roads was negligible.

The calculation of the as-built VOC is as follows:

$VOC_{passenger}$ = 21,033 (ADT)* 0.93 (percent passenger vehicles)* 1.5 (mi) * $0.27 (per mi)* 262 (days)
+ 12,000 (ADT)* 0.93 (percent passenger vehicles)* 1.8 (mi) * $0.27 (per mi)* 262 (days)
= $3,496,610

$VOC_{commercial}$ = 23,033 (ADT) * 0.07 (percent commercial vehicles)* 1.5 (mi)* $0.80 (per mi)* 262 (days)
+12,000 (ADT) * 0.07 (percent commercial vehicles)* 1.8 (mi) * $0.80 (per mi) * 262 (days)
= $779,809

The total as-built VOC is as follows:
$VOC_{as\text{-}built}$ = $3,496,610 + $779,809
= **$4.3 million approximately**

DELAY COSTS

The baseline approach to this project would have been to employ MOT Option 1, discussed in the "Project Description" section, which would have lengthened the duration of the impact on mainline Kenilworth Avenue and would have required closing one of the three lanes in each direction on mainline Kenilworth Avenue. This option would have allowed the Kenilworth ramps to and from the Eastern Avenue bridge to operate normally with vehicles free to turn from the ramps across the bridge while the bridge was under staged construction. The as-built option of dedicating the Kenilworth Avenue ramps to the free flow of diverted Kenilworth Avenue traffic allowed for no such turning movements. Detailed traffic analysis using simulation techniques considered the baseline and as-built scenarios:

- **Baseline—**Provide space for construction of the pier in the Kenilworth Avenue median by closing one of the three lanes in each direction on mainline Kenilworth Avenue and allowing normal use of the Kenilworth Avenue ramps for turning across the Eastern Avenue bridge.
- **As-built—**Provide space for construction of the pier on the Kenilworth Avenue median by diverting one lane in each direction from mainline Kenilworth Avenue onto the Kenilworth Avenue ramps and shifting the remaining two lanes in each direction to the right.

[4] Barnes and Langworthy (2003), *The Per-Mile Costs of Operating Automobiles And Trucks*, Report No. MN/RC 2003-19, Submitted to Minnesota Department of Transportation. Adjusted for fuel price increase and inflation in 2009.

A Synchro/SimTraffic model was not created for the baseline case because the SimTraffic model was not expected to capture the full extent of delay represented by queues spilling out of the network with a full-time lane closure. Instead, the Maryland State Highway Administration's Lane Closure Analysis Program (LCAP, Version 1.0) was used to estimate delays along mainline Kenilworth Avenue from the lane closure.

The LCAP program implements the same analysis procedure as QuickZone, listed on page 3 of Appendix B of the "District of Columbia Work Zone Safety and Mobility Policy, October 2007" for freeway lane closure analysis, but it uses a simplified user interface for data input. The assumed work zone capacity was 1,490 vehicles per hour per lane for a normal three-lane section that is reduced to two lanes during construction. Traffic demand volumes for a 48-hour (Wednesday through Thursday) period were entered into the LCAP program to determine the expected impacts of the lane closures. The average of the 2 days was taken as the result.

Based on the traffic analysis, the average veh-hrs delay per workday is estimated as follows:

- Preconstruction delay = 19,490 veh-hrs
- Baseline delay = 920,885 veh-hrs
- As-built delay = 85,220 veh-hrs

For a full set of delay calculations, see the report prepared by project consultant Greenhorne & O'Mara, Inc., of Baltimore, MD.[5]

A 2-month period to complete the median and pier construction on Kenilworth Avenue was selected as the basis for comparing delay values for the preconstruction, baseline, and as-built scenarios.

For **preconstruction**, assuming 22 weekdays a month and weekend delays as negligible, the total delay was as follows:

= 19,490 x 22 x 2
= 857,538 veh-hrs

For the **baseline** case, using the same assumptions as above, the total delay was as follows:

= 920,885 x 22 x 2 +857,538
= 41,374,463 veh-hrs

For the **as-built** case the total delay is split in the following categories:

- Delay because of shifting traffic onto service roads = 143,481 veh-hrs
- Signal and merging delays on Kenilworth Avenue, service roads, Eastern Avenue, and Nannie Helen Burroughs Avenue = 4,907,340 veh-hrs
- Travel time delay for detoured traffic = 61,961 veh-hrs

[5] Greenhorne & O'Mara, Inc. *Eastern Avenue Over Kenilworth Avenue, N.E. Work Zone Transportation Management Plan, Washington, D.C.* Prepared for District Department of Transportation Infrastructure Project Management Administration/Team 4. May 2009.

- Pedestrian detour delay (assume 1 person-hour = 1 veh-hr) = 429 veh-hrs

  Total = 5,113,211 veh-hrs

Note: Weekend impact is assumed to be the same as weekday impact and was included in the estimates.

The project consultant's traffic management plan included road user costs calculated using a method prescribed in the New Jersey DOT's *Road User Cost Manual*, using data from the November 2008 Bureau of Labor Statistics indices for the average U.S. urban area. The average hourly cost of delay for the combined value of time plus idling fuel and maintenance costs was estimated at $18.42 per hour. At this hourly cost, delay costs for the 2-month period are estimated as follows:

Preconstruction = $15.8 million approximately (857,538 veh-hrs * $18.42/veh-hr)
Baseline = $762.1 million approximately (41,374,463 veh-hrs * $18.42/veh-hr)
As-built = $94.2 million approximately (5,113,211 veh-hrs * $18.42/veh-hr)

The innovative approach yields a reduction in delay costs of **$667.9 million** ($762.1 million - $94.2 million) over the baseline approach.

COST SUMMARY

The innovative as-built approach to this project added approximately $3.2 million in construction costs and approximately $4.3 million in VOC. However, as a direct result of bringing the project to completion in half the time of conventional construction methods, the additional costs were marginalized by the much larger savings of $667.9 million in delay costs. The total savings was therefore $660.4 million ($667.9 million - $3.2 million – $4.3 million).

APPENDIX A: PRECAST SPECIAL PROVISIONS

This Special Provision supplements Division 700 Structures of the Standard Specifications.

790 PRECAST CONCRETE UNITS

790.01 DESCRIPTION

Fabricate precast nonstressed concrete units (precast concrete units). Nonstressed is defined as concrete member that have not been prestressed or post-tensioned. Refer to 705.01 for definition of Prestressed and Post-tensioned concrete.

790.02 MATERIALS

(A) PCC Concrete Mixtures–703 and 817, Class A, B or H as applicable

(B) Structural Steel–706 and 815.01

(C) Reinforcing Steel–704 and 812

(D) Cast-in Anchors–706 and 708.09

(E) Coatings–707 and 811

(F) Grout– 806.05(E)

790.03 QUALITY ASSURANCE

(A) The precast concrete manufacturing plant shall be certified by the Precast/Prestressed Concrete Institute (PCI), Plant Certification Program, prior to the start of production. At the Contractor's option, in lieu of PCI certification, the manufacturer shall, at no cost to the District, meet the following requirements.

(1) Retain an independent testing or consulting firm approved by the Chief Engineer.

(2) The basis of inspection shall be the Precast/Prestressed Concrete Institute's "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products," MNL-116 and "Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products," MNL-117.

(3) This firm shall inspect the precast plant at two week intervals during production and issue a report, certified by a registered Professional Engineer, verifying that materials, methods, products and quality control meet all the requirements of the specifications, drawings, and MNL-116 and/or MNL-117. If the report indicates to the contrary, the Chief Engineer will inspect and, at the Chief Engineer's option, may reject any or all products produced during the period of non compliance with the above requirements.

(B) Qualifications of Manufacturer:

(1) Manufacturer shall have a minimum of five (5) years of production experience in precast concrete work of the quality and scope required on this project.

(C) Qualifications of Erector:

(1) Erection of precast concrete units shall be performed by an established firm regularly engaged for at least two (2) years in the erection of precast concrete units of sizes similar to those required on this project.

(2) Perform inspection of panels under the supervision of a foreman employed by the erection firm for this type of work.

(D) Qualifications of Welders and Tackers:

(1) Welder qualifications shall be in accordance with 706.18.

(E) Testing:

(1) All testing shall be performed by the manufacturer’s in-house quality control inspectors and in accordance with all provisions in “Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products,” MNL-117 as published by PCI.

(F) Allowable Casting Tolerances:

(1) For precast concrete pier units, variation from the plumb - 1/2 inch in 15 feet, Variation in cross-sectional dimensions - Minus 1/4 inch to Plus 1/2 inch.

(2) For precast concrete superstructure units, variation in deck slab thickness - Minus 1/4 inch to Plus 1/2 inch.

790.04 EQUIPMENT

(A) The Contractor shall provide all equipment necessary for the construction of the precast concrete units.

(B) Safety measures shall be taken by the Contractor to prevent accidents during placement and transportation of the precast units.

790.05 CONCRETE CONSTRUCTION

Necessary formwork, concrete placing, exposed surface finishing and other construction requirements shall conform to 703 unless otherwise stipulated.

The units shall be constructed on a rigid base which will not deflect or settle unevenly, to prevent any vertical distortion, and shall be braced transversely so as to prevent any buckling sideways. No concrete shall be deposited in the forms until the formwork, reinforcing, anchorages and other appurtenances have been inspected and approved by the Chief Engineer. Approval, however, does not relieve the Contractor of his responsibility to produce a satisfactory unit, and any unit not meeting the requirements as specified herein will be rejected and the Contractor will be required to replace the unit at his expense.

If the Chief Engineer so directs, the Contractor will be required to vibrate the concrete externally as well as internally. Vibrating shall be done with extreme care and in such a manner as to prevent displacement, crushing or damaging of reinforcement or any other appurtenances which are a part of the construction.

Curing of concrete shall be per 703.18 except as follows:

(A) **STEAM CURING.** Steam curing will be permitted and shall be done under a suitable enclosure to contain the live steam in order to minimize moisture and heat losses. The initial application of the steam shall commence 2 to 4 hours after the final placement of concrete to allow the initial set of the concrete to take place. If the use of retarders is approved, the waiting period before application of the steam shall be from 4 to 6 hours. The steam shall be at least 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the temperature of the member shall increase at a rate not to exceed 40ºF per hour until a maximum temperature of from 140ºF to 160ºF is reached. The maximum temperature shall be held until the concrete has reached the desired strength. Suitable probes shall be inserted into the members for monitoring the temperature.

(B) **RADIANT HEAT CURING.** Precast members may be cured by the radiant heat method provided that the members are enclosed in approved rubberized canvas tarpaulins or other approved enclosures. The application of heat shall be as specified for steam curing. The Contractor shall submit a curing plan which includes procedures to be used for approval by the Chief Engineer before curing may begin.

The Contractor shall submit a curing plan which includes procedures to be used for approval by the Chief Engineer before curing may begin.

790.06 SUBMITTALS

(A) All submittals shall conform to the requirements of 105.02.

(B) Samples:

- **(1)** Before starting the manufacture of precast concrete units, submit for review to the Chief Engineer one (1) sample which represents the finished product and which clearly indicates the color and texture of the units.
- **(2)** Samples are to be 12" x 12" face size by 1 1/2" thick.
- **(3)** Label each sample to indicate name of manufacturer and finish code.

(4) After standard samples are accepted for color and texture, submit three (3) mock-up units at least 4'-0" x 5'-0" for review of the Chief Engineer to show the extreme maximum variations which may occur in the color and texture of the production pieces.

(5) The mock-up units are to be the standard of quality for precast concrete units' work, when they are accepted by the Chief Engineer.

(6) The Chief Engineer should visit the precast plant shortly after the start-up of production in order to inspect actual production pieces. The Contractor will be responsible for all costs incurred by the Chief Engineer to inspect the actual production pieces at the precast plant.

(C) Shop Drawings:

(1) The Contractor shall expedite the submittal with the Chief Engineer to conform to the allotted shop drawing approval time, shown on the precast concrete supplier's order acknowledgment.

(2) The content shall be as follows:

(a) Temporary support configuration at the precast plant. For precast superstructure units this shall entail laying out units in same position as final configuration (i.e. proposed beam seat elevations at pier and abutments shall be used to construct similar temporary supports). Bearing type and design for support of precast superstructure units shall be included in shop drawing submission.

(b) Unit shapes (elevations and sections) and dimensions.

(c) Finishes.

(d) Joint and connection details.

(e) Lifting and erection inserts.

(f) Location, dimensional tolerances and details of anchorage devices that are embedded in or attached to structure or other construction.

(g) Other items cast into precast concrete units.

(h) Handling procedures, plans and/or elevations showing panel location and sequence of erection for special conditions.

(i) Relationship to adjacent material.

(3) Show location of unit by same identification mark placed on unit.

(4) Individual unit details may be submitted at the request of the Chief Engineer. It is recognized that a review of the unit details prior to actual release for production will greatly impact the construction schedule.

(D) Test Reports:

(1) The Contractor shall submit reports on materials, compressive strength tests on concrete, and water absorption test on units to the Chief Engineer for review and approval.

(E) Design Calculations:

(1) The Contractor shall submit structural design calculations to the Chief Engineer for review and approval. The Contractor shall submit the QA/QC procedure for design calculations to the Chief Engineer for review and approval.

(F) Design Modifications:

- **(1)** Submit design modifications necessary to meet performance requirements and field coordination. Submission of modifications does not guarantee their acceptance by the Chief Engineer.
- **(2)** Variations in details or materials shall not adversely affect the appearance, durability or strength of the units.
- **(3)** Maintain general design concept without altering the size of members, profiles and alignment.

790.07 MANUFACTURING

(A) Finishes:

- **(1)** Exposed face surfaces of precast concrete pier units: Finished to match the approved sample unit where there is architectural treatment. Finished to match the requirements of 703.19 where there is no architectural treatment.

- **(2)** Exposed surfaces of precast concrete superstructure unit: Finished to match the requirements of 703.21 and 703.19. The requirement to texture the bridge deck per 703.19(C) shall be verified with the Chief Engineer.

(B) Precast Unit Identification:

- **(1)** Mark each precast concrete unit to correspond to the code markings appearing on the shop drawings for unit location. Do not mark on the finish surfaces.

- **(2)** Maintain a record of casting date.

(C) Precast Superstructure Units Temporary Supports

- **(1)** Precast superstructure units shall be laid out according to the shop drawings in a manner duplicating the final position. The profile and cross slope of precast superstructure units shall be approved by the Chief Engineer. Units not matching profile and cross slope requirements shall be replaced by the Contractor at his expense.

790.08 JOBSITE CONDITIONS

(A) Before starting to erect the precast concrete unit, the Contractor shall verify that the structure and anchorage inserts not within the tolerances required to erect the units have been corrected.

(B) Determine field conditions before commencing erection.

790.08 PRODUCT DELIVERY, HANDLING AND STORAGE

(A) Delivery and Handling:

(1) Deliver all precast concrete units to project site in such quantities and at such times as to assure the continuation of erection.

(2) Handle and transport units in a position consistent with their shape and design in order to avoid stresses which would cause cracking or damage.

(3) Lift or support units only at the points shown on the shop drawings.

(4) Place non-staining resilient spacers of even thickness between each unit.

(5) Support units during shipment on non-staining shock-absorbing material.

(6) Do not place units directly on the ground.

(B) Storage at Jobsite:

(1) Store and protect units to prevent contact with soil, staining and physical damage.

(2) Store units, unless otherwise specified, with non-staining resilient supports located in the same positions as when transported.

(3) Store units on firm, level and smooth surfaces to prevent cracking, distortion, warping or other physical damage.

(4) Place stored units so that identification marks are discernible and so that product can be inspected.

Care shall be taken during storage, hoisting and handling of the precast units to prevent cracking or damage. Units damaged by improper storing or handling or in any other manner, shall be replaced by the Contractor at his expense.

790.09 ERECTION

(A) Clear, well-drained unloading areas and road access around and in the structure shall be provided and maintained by the Contractor, to include providing and maintaining accessible roadways in which cranes and trucks can maneuver under their own power.

(B) The Contractor shall erect adequate barricades, warning lights or signs to safeguard traffic in the immediate area of hoisting and handling operations. Any overhead obstructions interfering with the erection must be removed by others and any underground equipment installed where cranes and trucks must maneuver is installed at the risk of the trade requiring them and be protected by that contractor.

(C) Set precast concrete unit level, plumb, square and true within the allowable tolerances. The Contractor shall provide true, level bearing surfaces on all field placed concrete which are to receive precast concrete units. The Contractor shall be responsible for providing offset lines and elevations in sufficient detail to allow installation.

(D) Provide temporary supports and bracing, as required, to maintain position, stability and alignment as units are being permanently connected.

(E) Set non-load bearing units dry without mortar, attaining specified joint dimension with, steel or plastic cement spacing shims.

(F) Set precast concrete units in place with closure pours and grouted keys as indicated on the contract drawings and approved erection drawings.

(G) Temporary lifting and handling devices cast into the precast concrete units shall be completely removed, or if protectively treated remove only where they interfere with the work of any other trade.

790.10 REPAIR

(A) Concrete repair and replacement shall meet the requirements of 716.

(B) Repair exposed exterior surface to match color and texture of surrounding concrete.

(C) Adhere large patch to hardened concrete with bonding agent.

790.11 CLEANING

(A) Precast concrete units will be clean upon completion of erection and leaving the job site.

(B) After installation and joint treatment the Contractor should protect the precast concrete units against damage and maintain the cleanliness of the units. Any final wash-down of the precast units should be the responsibility of the Contractor.

790.12 PROTECTION

(A) All work and materials of other trades shall be adequately protected by the Erector at all times.

(B) A fire extinguisher, of an approved type and in operating condition, shall be located within reach of all burning and welding operations at all times.

790.13 WARRANTY

(A) The Precast Concrete Manufacturer shall guarantee the precast concrete products against defects in material and workmanship, for a period of two (2) years, after acceptance of the units by the owner.

790.14 MEASURE AND PAYMENT

This work will be paid for through the concrete, reinforcing steel and structural steel items which are used to construct the precast concrete units. For structural concrete measurement and payment details, see 703.25. For reinforcing steel measure and payment details, see 704.10. For structural steel measurement and payment details, see 706.24 and 706.25.

APPENDIX B: SHOWCASE LIST OF ATTENDEES

id	fname	lname	agency	city	abbn	phone	email
615	Fred	Aicholtz	Louis Berger Group	Richmond	VA	804-221-2676	jaicholtz@louisberger.com
675	Nina	Barker	Florida T2 Center	Gainesville	FL	3522731674	nbarker@ufl.edu
684	Rudy	Barry	Whitmer & Worrall (Road Gang Member)	Washington	DC	202-744-3673	rbarry@whitmerworrall.com
620	Amar	Bhajandas	Applied Research Associates, Inc.	Center Valley	PA	717-574-9080	abhajandas@ara.com
587	Mark S	Bush	AASHTO	Washington	DC	202-624-8913	mbush@aashto.org
670	Michael	Chamberland	G&O;	Laurel	MD	240-542-3109	mchamberland@g-and-o.com
696	Waseem	Dekelbab	TRB	Washington	DC	571-723-5022	wdekelbab@nas.edu
673	Keith	Duerling	Baltimore County DPW	Towson	MD	410-887-3764	kduerling@baltimorecountymd.gov
694	John	Gonyea	The Fort Miller Co., Inc.	Schuylerville	NY	(518) 695-5000 x234	jgonyea@fmgroup.com
695	Scott	Harrigan	The Fort Miller Co., Inc.	Schuylerville	NY	518-695-5000	sharrigan@fmgroup.com
687	Debra	Herrmann	Jacobs	Arlington	VA	5712181000	debra.herrmann@jacobs.com
686	Kimberly	Hudgins	Jacoba	Arlington	VA	5712181518	kimberly.hudgins@jacobs.com
573	Mary	Huie	FHWA	Washington	DC	2023663039	mary.huie@dot.gov
569	Scott	James	DDOT/IPMA	Washington	DC	202.671.4585	scott.james@dc.gov
697	Michael	Joyce	OOIDA	Washington	DC	202.347.2007	mike_joyce@ooida.com
607	Nitin	Kadoo	Baltimore County, Department of Public Works	Towson	MD	410-887-3764	nkadoo@baltimorecountymd.gov
698	Dawit	Kebede	DDOT	Washington	DC	202-957-5931	dawitmariam@yahoo.com
700	Hayat	Keli-Brown	District Department Of Transportation	Washington	DC	2024370609	hayat.keli-brown@aol.com
691	Sue	Lane	Portland Cement	Washington	DC	2024089494	slane@cement.org
689	Richard	Lawrie	Lawrie & Associates, LLC	Alexandria	VA	703-719-6191	RALawrie@cs.com
701	Erik	Maninga	AASHTO	Suite 249	DC	(202) 624-8562	emaninga@aashto.org
692	Butch	Marcelle	The Fort Miller Co., Inc.	Schuylerville	NY	518-695-5000	butch@fmgroup.com
677	Rodolfo	Maruri	FHWA - Virginia Division	Richmond	VA	(804) 775-3361	rodolfo.maruri@dot.gov
674	Lan	Mond	NDF Heavy Industry	New York	NY	212-845-9500	lan.mond@yahoo.com
671	Bimal	Patel	G&O;	Laurel	MD	240-542-3184	bpatel@g-and-o.com
683	Laura	Perrotta	ATSSA	Washington	DC	2024545246	laura.perrotta@atssa.com
602	Kevin	Sabolcik	Baltimore Co. Department of Public Works/Design	Towson	MD	410-887-3737	ksabolcik@baltimorecountymd.gov
672	Simon	Simon	G&O;	Laurel	MD	240-542-3181	ssimon@g-and-o.com
699	BRUKE	SIRAGA	DDOT	WASHINGTON DC	DC	2023697917	bruke.siraga@dc.gov
682	Nate	Smith	ATSSA	Washington	DC	2024545246	nathan.smith@atssa.com
681	Monica	Starnes	Transportation Research Board	Washington	DC	202-3341894	mstarnes@nas.edu
690	John	Sullivan	Portland Cement Association	Washington	DC	2024089494	jsullivan@cement.org
688	Yvonne	Thelwell	Lawrie & Associates, LLC	Alexandria	VA	703-719-6191	ythelwell@cs.com
669	Luan	Tran	DDOT	Washington	DC	202-671-2800	luan.tran@dc.gov
693	Michael	Trentacoste	Federal Highway Administration	McLean	VA	202-493-3999	michael.trentacoste@dot.gov
678	Hank	Webster	Metropolitan Washington Road and Transportation Builders Association	Washington	DC	202-289-4434	hwebster@artba.org
679	Allison	Wenograd	ARTBA	Washington	DC	2022894434	awenograd@artba.org
685	Martin	Whitmer	Whitmer & Worrall (Road Gang Member)	Washington	DC	202-558-6000	martin@whitmerworrall.com
680	Connie	Yew	FHWA	Washington	DC	202-366-1078	connie.yew@dot.gov
676	Michele	Zambelli	Florida T2 Center	Gainesville	FL	3522731687	mzambelli@ufl.edu

APPENDIX C: SHOWCASE AGENDA

July 20, 2010

DDOT and Highways for LIFE
Eastern Avenue Bridge Replacement Showcase
AGENDA

Tuesday, July 20, 2010

Meeting Moderator: Ronaldo Nicholson, Chief Engineer - DDOT

8:30am - 9:00am	**Registration and Sign In**
9:00am – 9:10am	**Welcome** Victor Mendez, Administrator - Federal Highway Administration Gabe Klein, Director - DDOT
9:10am – 9:30am	**FHWA Activities & Highways for LIFE Overview** ***Video Presentation*** Chris Lawson, Division Administrator - FHWA DC Division
9:30am – 9:45am	**Why Accelerated Bridge Construction, Why Now & How?** Jim McMinimee, Principal Engineer - Applied Research Associates
9:45am – 10:30am	**DDOT Presentation** Maduabuchi Udeh, Program Manager - DDOT Ali Shakeri, Program Manager - DDOT Luan Tran, Civil Engineer - DDOT Bruke Siraga, Project Engineer - DDOT
10:30am – 10:45am	**Break**
10:45am - 11:15am	**Contractor's Perspective** Austin Anderson, Project Engineer - Fort Myer Construction Corporation
11:15am – 11:30am	**Questions**
11:30am - 12:45pm	**Lunch *(on your own)***
12:45pm	**Safety Briefing and Load Bus** Hector Sealey, Safety Officer - Fort Myer Construction Corporation
1:00pm	**Depart for Eastern Avenue Bridge**
1:00pm - 3:30pm	**Eastern Avenue Bridge Site Visit** Bruke Siraga, Project Engineer - DDOT Matthew Jahns, Construction Manager - Jacobs Engineering
3:30pm	**Return to Reeves Center**
3:30pm - 4:00pm	**Open Panel Discussion** All Speakers
4:00pm	**Evaluations and Adjourn**

U.S. Department of Transportation
Federal Highway Administration

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience

District Department of Transportation