Minnesota Demonstration Project: Reconstruction of Trunk Highway 36 in North St. Paul

Final Report
June 2013

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 Minnesota Department of Transportation (Mn/DOT) was awarded a $1 million grant to demonstrate the use of proven, innovative technologies to deliver a $30.7 million project in less time than conventional construction. This report documents the use of full closure to reconstruct a four-lane, 2-mile (approximate) section of Trunk Highway 36 in North St. Paul. The finished project has enhanced transportation safety and reduced travel times by eliminating six at-grade intersections. Local transportation has been improved with newly constructed crossover bridges and a pedestrian bridge.

This report discusses the use of full closure on a major highway reconstruction project, which until now has not been used on a main thoroughfare in Minnesota. The project incorporated A+B contract bidding, a locked incentive date specification, and lane rental as an innovative approach to minimize traffic disruption by getting the highway rebuilt and open to traffic as early as possible. The result was that the newly reconstructed roadway was completely open to traffic in 145 days, 65 percent sooner than if traditional staged construction had been used.

During full closure, traffic was diverted to detour routes, which presented the opportunity to use an intelligent transportation system, integrated with the existing Mn/DOT traffic monitoring system, to route motorists around the construction. Mn/DOT also explored the use of intelligent compaction equipment to expedite site work and lightweight deflectometers for acceptance testing, a first for Minnesota. While not a recent innovation, machine control using Global Positioning System technology was used extensively on this project and was a key component in streamlining grading operations.

Completely closing the highway to traffic, even for a short time, increased costs associated with diverting motorists, but it reduced overall costs that would have been incurred with traffic impacts over a longer period. The alternate staging plan to get the project built was cost prohibitive and would have been unacceptable to roadway users. The high level of user satisfaction with the speed of project delivery attests to the project's success. The successes and knowledge gained on this project will encourage Mn/DOT to consider full closure as a viable alternative to traditional staged construction on future projects.

17. Key Words
A+B contract bidding, full lane closure, intelligent compaction, intelligent transportation system, lane rental, lightweight deflectometer, locked incentive date specification, machine control.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**	**Symbol**	**When You Know**	**Multiply By**	**To Find**	**Symbol**
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ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
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in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.0016	square inches	in^2
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yd^2	square yard	0.836	square meters	m^2	m^2	square meters	1.195	square yards	yd^2
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi^2	square miles	2.59	square kilometers	km^2	km^2	square kilometers	0.386	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft^3	cubic feet	0.028	cubic meters	m^3	m^3	cubic meters	35.71	cubic feet	ft^3
yd^3	cubic yards	0.765	cubic meters	m^3	m^3	cubic meters	1.307	cubic yards	yd^3
NOTE: volumes greater than 1000 shall be shown in m^3									
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.202	pounds	lb
T	short tons (2000 lb)	0.907	megagrams (metric tons)	Mg (or t)	Mg (or t)	megagrams (metric tons)	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)					**TEMPERATURE (exact degrees)**		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C	°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION					**ILLUMINATION**		
fc	foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2	cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS					**FORCE and PRESSURE or STRESS**		
lb	pounds	4.45	Newtons	N	N	Newtons	0.225	pounds	lb
lb/in^2 (psi)	pounds per square inch	6.89	kiloPascals	kPa	kPa	kiloPascals	0.145	pounds per square inch	lb/in^2 (psi)
k/in^2 (ksi)	kips per square inch	6.89	megaPascals	MPa	MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)
		DENSITY					**DENSITY**		
lb/ft^3 (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m^3	kg/m^3	pounds per cubic foot	0.062	kilograms per cubic meter	lb/ft^3 (pcf)

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised September 1993)

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The project team would like to acknowledge the invaluable insights and guidance of Federal Highway Administration (FHWA) 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 also is indebted to Phil Forst, area engineer for the FHWA Minnesota Division, and Steve Kordosky, Jay Hietpas, and Tom Ravn of the Minnesota Department of Transportation for their unstinting support in conducting and documenting this demonstration project. Finally, the team also appreciates the technical support for this report provided by Progressive Contractors, Inc.

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ABBREVIATIONS AND SYMBOLS

AADT	annual average daily traffic
ARAN	Automatic Road Analyzer
dB(A)	A-weighted decibel
DOT	department of transportation
FHWA	Federal Highway Administration
GPS	Global Positioning System
HfL	Highways for LIFE
HMA	hot-mix asphalt
Hz	hertz
IC	intelligent compaction
ITS	intelligent transportation system
IRI	International Roughness Index
LID	locked incentive date
LWD	lightweight deflectometer
Mn/DOT	Minnesota Department of Transportation
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SI	sound intensity
SRTT	standard reference test tire
TERRA	Transportation Engineering and Road Research Alliance
TH	Trunk Highway

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, and 2009. 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 documents the Minnesota Department of Transportation's (Mn/DOT) demonstration project, which involved reconstructing a four-lane, 2-mi section of Trunk Highway 36 (TH 36) through North St. Paul, MN. The report presents project details relevant to the HfL program, including innovative full closure, locked incentive date (LID) contract specification, A+B contract bidding, lane rental, intelligent compaction, and intelligent transportation system (ITS) technology used to accelerate construction and produce a high-quality finished project. HFL performance metrics measurement, economic analysis, technology transfer activities that took place during the project, and lessons learned are also discussed.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

Minnesota's TH 36 is a major east-west, four-lane urban highway connecting the suburb of North St. Paul to the downtown areas of St. Paul and Minneapolis. The project encompasses about 2.2 mi (3.5 km) of TH 36 through North St. Paul from White Bear Avenue to TH 120 (Century Avenue). Several retail businesses line this corridor, as well as a popular recreation trial and a high school.

The project design addressed two key needs: 1) improving safety for highway users and pedestrians and 2) improving travel efficiency through the corridor. The major design feature was the construction of overpasses to separate crossroad and pedestrian traffic from TH 36, which eliminated inefficient and hazardous intersections.

Traditional staged construction methods would have impacted traffic on TH 36 for an estimated 19 months for a project of this scope. Mn/DOT's decision to use both contracting and construction innovations reduced the impact on TH 36 traffic to 6.5 months. Speed of construction, user and worker safety, and quality were enhanced by incorporating innovations throughout the project:

- **Full closure of TH 36.** Full closure of a major urban freeway is a new concept to Mn/DOT and in the past was reserved for low-volume roads. Including full closure in this project helped Mn/DOT evaluate the cost, time savings, motorist and worker safety benefits, and quality of and public reaction to this innovative approach compared to multiyear staged construction.
- **Intelligent compaction equipment.** Intelligent compaction rollers and lightweight deflectometers were used on the project to improve the quality of grading operations. Theses rollers allow operators to monitor embankment and paving material compaction in real time and make adjustments as needed. This project was the first time Mn/DOT used intelligent compaction and lightweight deflectometer acceptance testing in lieu of test rolling and sand cone density testing.
- **Locked incentive date.** An LID specified in the contract would not allow extensions to the contract date and eliminated the possibility of claims. This served as an incentive for the contractor to complete the project early.
- **A+B contract bidding.** A+B (cost-plus-time) contract bidding was used to reduce contracting time.
- **Lane rental.** A rental fee was imposed if a lane on TH 36 needed to be closed before or after the full closure to accommodate maintenance or cleanup operations. Lane rental fees helped ensure minimal impacts on motorists.
- **Intelligent transportation system.** This system allowed Mn/DOT to monitor traffic on the detour routes around the construction.

Full closure was the highlighted innovation on this project and the focus of Mn/DOT's in-house market research team. The team's efforts to capture the DOT's and public's experience with full closure will benefit future projects of similar scope.

HfL Performance Goals

Safety, construction congestion, quality, and user satisfaction data were collected before, during, or after construction to demonstrate that innovations can be deployed while simultaneously meeting the HfL performance goals in these areas.

- **Safety**
  - Work zone safety during construction—No motorist incidents occurred in the TH 36 construction zone. The full closure eliminated through traffic and any possibility of traffic-related incidents in the work zone.
  - Worker safety during construction—No worker injuries were reported, which exceeded the HfL goal for worker injuries of less than 4.0, based on incidents reported by the contractor via OSHA Form 300.
  - Facility safety after construction—Reported injuries and property damages for the first 3year after construction were down 17 and 43 percent, respectively, compared to the 3-year averages before the project started. No fatalities were reported before and after construction. The HfL goal of twenty percent reduction in fatalities and injuries was only marginally achieved; however, this trend is likely to continue because six at-grade intersections were removed from the TH 36 corridor, making it a safer throughway.

- **Construction Congestion**
  - Faster construction—Traditional construction methods using partial roadway closures to reconstruct TH 36 coupled with traditional contracting methods would have impacted traffic for an estimated 19 months. The full closure and innovative contracting methods allowed the contractor to reopen all lanes of TH 36 in only 6.5 months and exceeded the goal of 50 percent reduction in traffic impact.
  - Trip time—Measurement of trip time is a valuable tool to evaluate the impact of construction on motorists traveling through the work zone. While trip time measurement applies to other HfL projects, full closure prevented the use of this technique.
  - Queue length during construction—Full closure necessitated moving traffic onto detour routes, which eliminated queue lengths associated with lane reduction and traffic interruptions from conventional partial roadway closures.

- **Quality**
  - Smoothness and noise—The tire-pavement noise and smoothness quality indicators measured for the highway were slightly higher than the goals set for the HfL program. Specifically, the noise level was 1.0 dB(A) higher than the goal of 96 dB(A) and the smoothness was 2 inches per mile higher than the goal of 48 inches per mile.
  - User satisfaction—Mn/DOT sponsored a comprehensive evaluation of the public's assessment of the project. Survey results of area businesses, residents, and commuters indicate an overwhelming approval of the way the project was executed, exceeding

the goal of achieving 80 percent or greater satisfaction with the methods used to keep traffic disruption to a minimum during construction. Construction speed was cited as the top reason for satisfaction. The study did not directly address user satisfaction with the new facility compared with its previous condition. However, nearly half of those surveyed indicated there was nothing the DOT could have done better, suggesting that overall satisfaction with the newly reconstructed corridor was high.

ECONOMIC ANALYSIS

The costs and benefits of this innovative project approach were compared with building the project under more traditional methods. The cost assumptions for the traditional approach were determined from discussions with Mn/DOT staff and national literature.

The economic analysis revealed that Mn/DOT's innovative approach increased project costs by about $2.1 million, or 7 percent, compared to conventional construction practices. User cost associated with detouring traffic to alternate routes during the full closure exceeded the savings in construction costs.

LESSONS LEARNED

The project was a success in terms of safety, cost, and traffic impact on TH 36. Several firsts occurred on this project and many lessons were learned with the use of new methods. The University of Minnesota undertook a multiple task study[1] to document the experience gained from this full closure project. The following are among the lessons learned:

- It is important to predetermine detour routes well in advance of the project and make necessary improvements to detour pavements to handle increased traffic volume during the project.
- Surrounding signalized intersections and those directly affected by the detours should be observed for backups and congestion. Based on observations, signal timing was adjusted to accommodate the change in traffic brought on by the full closure.
- Part of the success of routing the traffic around the full closure resulted from Mn/DOT's effort to work closely with county and city engineers to assemble a comprehensive traffic plan.
- Good weather played a role in the success of the full closure. The weather for the construction season was relatively good and rain affected production for only a couple of days. Heavy rains lasting several days could have slowed grading operations considerably and negatively affected the ability of the contractor to complete the full closure on time.
- The decision to use full closure or even consider it as a construction method option should be made early in the design process to allow for a complete analysis of the benefits. The decision to use full closure on the TH 36 project occurred late in the design process as a method to reduce construction cost by reducing construction time.

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[1] University of Minnesota. August 2009. *TH 36 Full Closure Construction: Evaluation of Traffic Operations Alternatives, Task 8 Deliverable: Lessons Learned from the TH 36 Full Closure Construction Project*.

Additional time would also provide designers with more opportunities to educate the public on the advantages of completely closing a roadway for reconstruction.

- Closing the roadway should begin on a Tuesday rather than a Monday (as was the case for this project) so the posted information on alternate travel routes is fresh in the minds of motorists driving through the project area the day before the closure.

CONCLUSIONS

Implementation of the many project innovations, particularly full closure, was an important accomplishment for Mn/DOT, and the experience gained will be a valuable asset to draw from on future projects. Success measures on this project included completing it in less time than if traditional contracting and construction methods had been used, and doing so safely and with a high level of quality.

PROJECT DETAILS

BACKGROUND

The highway within the project limits is a busy commercial and light industrial corridor with a 2005 average annual daily traffic (AADT) of about 43,450, with 2.9 percent heavy commercial vehicles. Within the project limits, the existing highway had three at-grade signalized intersections and three at-grade nonsignalized intersections with significant congestion and numerous safety issues. The general project location is indicated in figure 1. Figure 2 shows the project limits.

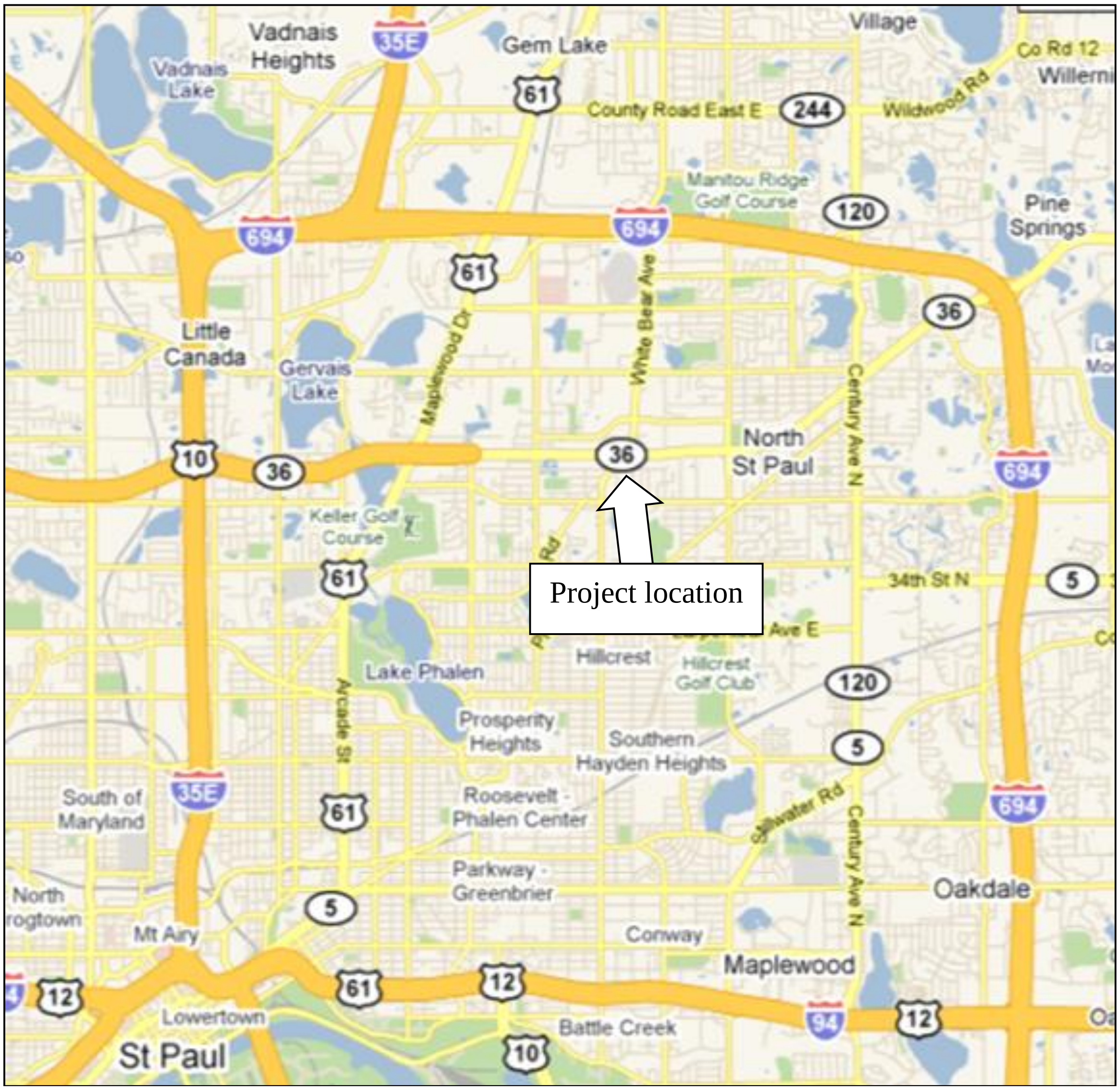

Figure 1. General project location. (Source: Google Maps)

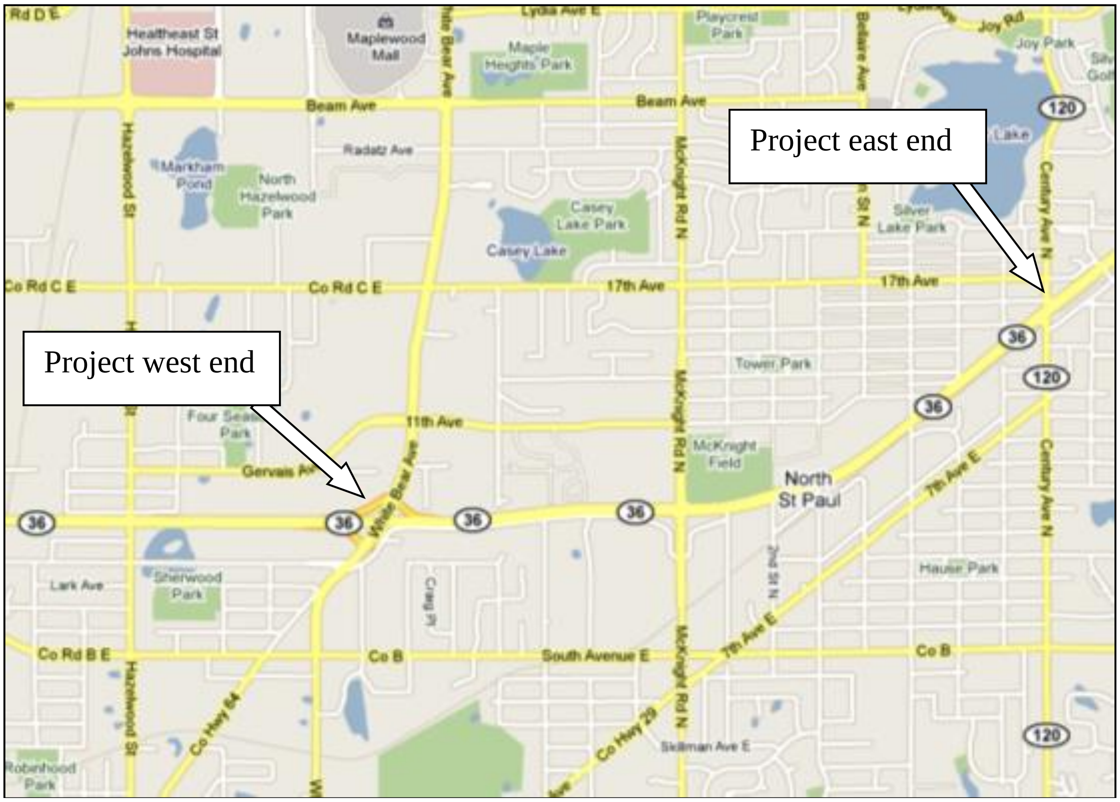

Figure 2. Project limits. (Source: Google Maps)

Pedestrian traffic was a concern because North St. Paul High School is located on the north side of the highway and a bicycle-pedestrian trail (Gateway Trail) runs parallel to the south side of the highway. The Gateway Trail is the most heavily used Minnesota Department of Natural Resources trail in the State.

In fact, this project was born of concern for high school students crossing the busy four-lane highway twice a day, on their way to school in the morning and returning home in the afternoon. Safety concerns coupled with the need to alleviate congestion for motorists traveling through six interchanges on this portion of the highway expanded the project from the need for a safe pedestrian crossing to a complete reconstruction.

Limited funds for this project focused designers on coming up with ways to save construction time and costs while maintaining a high level of safety and delivering a quality product. These challenges were an ideal match for the HfL goals and led to the use of innovation to make this project a reality.

When design was 50 percent complete, designers conducted a constructability review meeting and asked qualified contractors for input on how fast they could build the project and what maintenance of traffic would be the most beneficial. Given the sheer volume of earthwork, the most effective way to ensure safety was to keep all traffic away from the many trucks and earth-moving equipment. Completely eliminating traffic from TH 36 was determined to be the best-case scenario from a safety standpoint, one that would allow the contractor unrestricted access to all parts of the projects and expedite construction.

Public involvement was sought in the early stages of planning to help engineers decide whether to use a full roadway closure, which would disrupt traffic for an estimated 5 months, or stay with traditional staged construction techniques lasting up to 19 months. The result of a preconstruction telemarketing survey conducted for Mn/DOT by a private marketing firm concluded that among the local residents, commuters, and businesses, about 50 percent were in favor of a full road closure and 50 percent were opposed.

Considering the absence of strong public opinion and the anticipated cost and time savings of using the full closure, Mn/DOT took the opportunity to apply this innovative technique as a cornerstone to minimizing motorist impact on the TH 36 project.

PROJECT DESCRIPTION

TH 36 was converted to a four-lane freeway by removing the three at-grade signalized intersections at McKnight Road, First Street, and Margaret Street and the three at-grade nonsignalized intersections at Second Street, Third Street, and Charles Street. Figure 3 shows the project plan. The project includes the following newly built features:

- Newly reconstructed hot-mix asphalt (HMA) lanes for TH 36 from White Bear Avenue to TH 120
- Diamond interchange at McKnight Road
- Overpass to carry traffic on Margaret Street over TH 36
- Pedestrian bridge over TH 36 at North St. Paul High School
- A tunnel for the Gateway Trail to pass under Margaret Street and removal of the at-grade crossing at Margaret Street to improve pedestrian safety
- Frontage road from McKnight Road to First Street

The milestones in the construction schedule activities are as follows:

- April 2007: Begin preliminary work.
- May 1 2007: Implement full closure and implement official detour routes. Begin constructing the southbound McKnight Bridge and the pedestrian bridge, and reconstruct the eastbound lanes of TH 36.
- August 30 2007: End the full closure.
- August 31 2007: Open the two newly constructed eastbound lanes to one lane of traffic each way. Begin construction of TH 36 westbound lanes and the northbound McKnight Bridge. Open the pedestrian bridge and path to North St. Paul High School.
- November 16 2007: Open all four newly constructed lanes of TH 36 to traffic and construct the Margaret Street overpass, Gateway Trail tunnel, and frontage road.
- Fall 2008: Complete project.

Figure 3. TH 36 project plan. (Source: Mn/DOT)

Grading operations were guided by machine control technology based on GPS instead of traditional construction staking carried out by surveyors. Bulldozers, scrapers, road graders, and other excavation equipment were equipped with GPS technology (GPS instrumentation indicated by arrows in figure 4) to enable operators to monitor in real time where fill needed to be placed and cuts made. This eliminated the need for surveyors to install (and reinstall) embankment layout and elevation stakes. Only minimal staking was required.

Figure 4. Bulldozer equipped with GPS receivers for grade control.

The complete reconstruction of TH 36 required cuts and fills in excess of 20 feet on the mainline. The project included about 750,000 cubic yards (573,416 cubic meters) of excavation, 500,000 cubic yards (382,277 cubic meters) of embankment, and 75,000 tons (68,038 metric tons) of HMA. Steel sheet piling was used to shore excavations during construction (figure 5) for areas of TH 36 that were lowered below the existing grade.

Figure 5. Shoring being placed along TH 36.

A major component of the project was the construction of the McKnight Road diamond-type interchange over TH 36. Separate bridges were built for the northbound and southbound lanes of McKnight Road to match alignment of the rest of McKnight Road. Figure 6 shows the early stages of construction for the two bridges. Precast bridge elements (other than the bridge beams) were not used because the interchange was not on the project's critical path and bridgework could continue after the full closure was over.

Figure 6. McKnight Road bridges under construction.

Standard precast box culvert sections were placed to form the Gateway Trail tunnel under Margaret Street (figure 7). Before construction, the trail crossed Margaret Street at grade. The new tunnel will increase safety for trail users. Likewise, the pedestrian bridge shown under construction in figure 8 will make it safer to cross TH 36.

Figure 7. Gateway Trail box culvert tunnel at Margaret Street.

Figure 8. Pedestrian bridge under construction.

During peak a.m. and p.m. periods, traffic was encouraged to take marked detour routes around the full closure. Eastbound traffic was routed onto northbound TH 61 to eastbound Interstate 694 and back to TH 36 for a 6.7 mi detour. Westbound traffic on TH 36 outside the I-694 loop was routed onto southbound I-694 to westbound I-94 and then to northbound I-35 to rejoin TH 36 for a 17.7 mi detour.

Full closure was the chief innovation on this project used to promote safety, speed construction, and eliminate congestion through the work zone. Innovative contracting methods were also employed to help shorten project time, including LID and lane rental to promote on-time completion and A+B bidding to speed contract time. These and other innovations, such as using a lightweight deflectometer and intelligent compaction to ensure quality and ITS, are discussed in the following sections.

Full Closure

Closing TH 36 is an innovative concept that Mn/DOT had not attempted before on a major urban freeway. Of paramount importance was to keep the duration of the full closure to the absolute minimum while allowing enough time to get the eastbound lanes open and a substantial portion of the earthwork and bridgework finished. The full closure allowed the contractor maximum mobility during grading, which increased the efficiency of hauling and placing materials. When it came time to pave the eastbound lanes of TH 36 with HMA, the full closure allowed for uninterrupted paving, fewer cold joints, and more uniform HMA compaction. After the full closure ended, the eastbound lanes were opened to one lane of traffic in each direction (figure 9).

Figure 9. Eastbound lanes carrying head-to-head traffic. (Source: TERRA)

The alternative to full closure was to reconstruct the corridor under traffic and manage traffic in stages using three bypasses (during various stages) from one end of the project to the other. This option would have intensified the complexity of the traffic management plan and increased the amount of total project construction to include building and removing the bypass lanes.

The University of Minnesota multiple task study[2] used this opportunity to document and evaluate the benefits of full closure on a major highway. The aim of the study was to develop a simulation model to analyze the traffic impact and benefits of completely removing live traffic from the work zone. Researchers developed a microsimulation network based on the geometry of the surrounding roadways and regional travel demand data collected during the project and from the Mn/DOT traffic database. The results were not available when this report was published, but it is anticipated that modeling this real-world example will assist in future decision-making on the appropriate closure type (partial or full closure) for highway construction.

Intelligent Compaction

Intelligent compaction (IC) rollers and lightweight deflectometers (LWD) were used on this project to improve the quality of grading operations. The IC rollers are equipped with sensors that allowed the operator to easily self-monitor the compaction of the material beneath the roller in real time through an onboard compaction monitoring display screen (figure 10). This helped optimize compaction operations and made it possible for the operator to easily identify soft spots in the compacted embankment. The operator could then apply additional compaction effort to soft areas in the fill as needed.

Figure 10. Intelligent compaction roller (left) equipped with compaction display (right). (Source: Mn/DOT)

IC rollers were also beneficial in preventing overcompaction of the pavement layers, which could result in crushing the aggregates and weakening the finished pavement. Compaction was verified with the LWD (figure 11). This was the first time Mn/DOT used IC and LWD as acceptance testing in lieu of test rolling and sand cone density checks. Traditional methods of quality acceptance were used to verify compaction with test rolling and sand cone density testing.

[2] University of Minnesota. December 2008. *TH 36 Full Closure Construction: Evaluation of Traffic Operations Alternatives, Task 5 Deliverable: Development of Traffic Simulation Model*.

Figure 11. Technicians check the embankment compaction with an LWD. (Source: Mn/DOT)

Iowa State University[3] researchers collected field data during construction to help Mn/DOT further develop its IC specifications. This study considered the data from this and other projects to examine the relationships among IC-measured compaction values, test rolling rut measurements, in situ point measurements, and LWD measurements.

Locked Incentive Date

Mn/DOT took a new approach to the LID specification in this contract. On past projects, incentives often were paid even though deadlines were extended because of delays caused by the owner, bad weather, change orders, or late material deliveries. The new approach gave the contractor two options. The first option provided the contractor with a lump sum incentive, but did not allow time extensions and claims. The second option allowed contract extensions, but no incentives. The contractor chose to receive the lump sum incentive.

LID is new for Mn/DOT and provided a no-excuse bonus as an incentive for the contractor to complete the project early. The LID specification had the full closure targeted for 145 days, but with the help of good weather the contractor used only 122 days, allowing the eastbound lanes to be opened sooner than anticipated. As a result, the contractor earned the maximum incentive bonus of $650,000 ($350,000 plus $75,000 for each five days, not to exceed $650,000).

Cost-Plus-Time (A+B) Contract Bidding

Mn/DOT selected A+B contract bidding to reduce the amount of contract time. This contracting procedure selects the low bidder based on a monetary combination of the contract bid items (A) and the time (B) needed to complete the critical portion of the project. The cost of time in this case is a function of a road user cost ($15,000) for each day the contractor needed to keep the full closure in operation. The allowable time was 145 to 210 days, giving each bidding contractor the

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[3] White, D.J., P. Vennapusa, J. Zhang, H. Gieselman, and M. Morris. July 2009. *Implementation of Intelligent Compaction Performance-Based Specifications in Minnesota.* Earthworks Engineering Research Center, Department of Civil, Construction and Environmental Engineering, Iowa State University.

flexibility to balance time with cost. This method favors contractors that explore innovative construction methods to reduce cost and motivates the contractor through incentives to minimize the delivery time.

Six contractors submitted bids ranging from $27.6 million to $32.7 million and from 145 to 195 days for the full closure. The winning bid was for $30.7 million and 145 days to complete the full closure.

Lane Rental

A lane rental fixed fee of $15,000 a day was charged to the contractor as a disincentive in case the lanes on TH 36 needed to be closed outside of the scheduled full closure's beginning and end dates. The lane rental fee is the same as the road user cost in A+B bidding. In essence, the total amount of road user cost is a "lane rental working fund" in which any money not used to rent the lanes during full closure becomes an incentive given to the contractor and overruns are disincentives charged to the contractor.

A good example of lane rental is when all four lanes of TH 36 were open after the full closure and final cleanup work was needed. This type of work was allowed during offpeak times and, since every hour counted against the bottom line, the contractor had the incentive to coordinate work and get in and out quickly with full use of the closure. This not only gets work done quickly and keeps closures to a minimum, but it also discourages idle lane closures during which the public perceives inconvenience for no reason.

Intelligent Transportation System

ITS was implemented to monitor traffic on the alternate routes. The system included cameras placed on the detour routes to monitor traffic flow. This information was linked to Mn/DOT's Regional Transportation Management Center, which allowed Mn/DOT to adjust signal timing and other traffic management systems in real time. An additional feature of the ITS was providing travel-time systems on the alternate routes, which helped motorists decide which route to take.

DATA ACQUISITION AND ANALYSIS

Data on safety, traffic flow, quality, and user satisfaction before, 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 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 Mn/DOT project met the specific HfL performance goals related to these areas.

SAFETY

Table 1 shows vehicular crashes from 2005 to 2007 at the intersection of TH 36 and McKnight Road. Crashes resulted in 20 injuries and no fatalities at the busiest intersection within the project limits during the 3-year study period before construction. This is a significant number of crashes. A key aspect of this project was to increase safety for all roadway users during and after reconstruction.

Table 1. Historical 3-year crash data at the intersection of TH 36 and McKnight Road.

Year	Number of Crashes	Property Damage	Number of Injuries	Number of Fatalities
2005	19	13	6	0
2006	17	11	6	0
2007	24	16	8	0
Total	60	40	20	0
Average	20	13.3	6.7	0

Data supplied by Mn/DOT

Full closure created a safe work environment by eliminating conflicts between motorists and construction workers and equipment. Full closure also helped condense construction time to one season instead of the two seasons that would have been required under conventional staged construction. This minimized the safety risk to motorists, who would have had to negotiate complicated lane changes during hazardous winter driving conditions. By closing TH 36, Mn/DOT eliminated the need to stage traffic next to 20-ft embankment cuts.

No motorist incidents occurred and no worker injuries were reported during the construction project, which means Mn/DOT exceeded the HfL goal for reducing incident rates and worker safety (incident rate of less than 4.0 based on the OSHA 300 rate).

Facility safety after construction of the new design features will be greatly improved by the following:

- Converting the intersection at McKnight Road to a diamond interchange
- Passing TH 36 under Margaret Street
- Constructing a pedestrian bridge over TH 36 near North St. Paul High School
- Constructing a tunnel for the Gateway Trail under Margaret Street
- Closing the intersections at First Street, Second Street, Third Street, and Charles Street

In summary, the newly reconstructed design features have achieved a safer environment by separating pedestrian and vehicular traffic and eliminating traffic conflicts associated with at-grade intersections. The future safety record is anticipated to be considerably better than before reconstruction. In fact, crashes with injuries at TH 36 and McKnight Road for the first year (2008) after construction dropped 40 percent from an annual average of 6.7 to four, and no fatalities were reported. Table 2 shows the breakdown of the reported crashes after TH 36 was reopened.

Table 2. Postconstruction crash data at the intersection of TH 36 and McKnight Road.

Year	**Fatalities**	**Injuries**	**PDO**	**AADT MN_TH36**	**AADT Mcknight Ave**
2008	0	4	12	38,000	16,550
2009	0	3	6	38,000	15,700
2010	0	4	13	39,250	15,700
2011	0	6	5	39,250	15,750
2012	0	10	8	39,250*	15,750*
Total	0	27	44		

*data assumed to be same as 2011

The safety performance of the facility after construction was evaluated using pre and post construction crash rates. Table 3 presents the crash rates by severity type for both pre and post construction periods. As indicated in the table, the total crashes decreased by 33.3 percent after construction; the injury rates decreased by 16.9 percent, while the property damage rates decreased by 43.4 percent. No fatal event occurred after construction. While the safety of the facility has improved after construction, the HfL goal of twenty percent reduction in fatalities and injuries was marginally achieved.

Table 3. Pre and post construction crash rates

	Preconstruction	**Post construction**	**Difference**
Days of Coverage	1095	1825	
Average ADT	57726	54640	
Section Length	2.2	2.2	
Million Vehicle Miles Travelled	139.1	219.4	
Total Crashes	0.43	0.32	-33.3%
Fatalities	0.00	0.00	-
Injuries	0.14	0.12	-16.9%

PDO	0.29	0.20	-43.4%

CONSTRUCTION CONGESTION

Full closure in conjunction with the locked incentive date gave the contractor an incentive to “get in and get out” and was instrumental in reducing construction time and associated traffic congestion on TH 36. Conventional staged construction methods would have interrupted traffic on TH 36 for at least 20 months. The total impact to traffic flow on TH 36 was shortened by nearly 68 percent to 6.5 months (4 months of full closure and 2.5 months of single-lane traffic). After that, bridgework continued with all four lanes of TH 36 open to traffic.

QUALITY

Pavement Test Site

Test data were collected from both eastbound and westbound directions of TH 36 for about 2.2 mi (3.5 km) from White Bear Avenue to TH 120 (Century Avenue). The existing pavement was a weathered, dense-graded asphalt surface with transverse cracking. Figure 12 shows the existing surface texture and a typical section of pavement. Figure 13 shows the newly constructed pavement.

Figure 12. Existing TH 36 HMA pavement.

Figure 13. Newly constructed TH 36 HMA pavement.

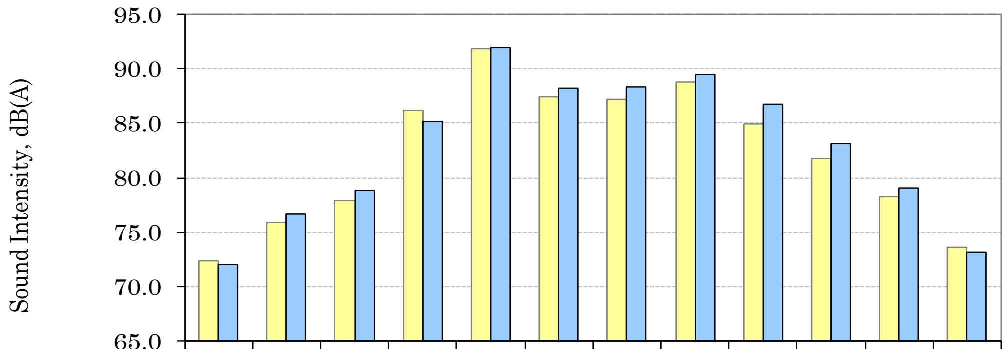
Sound Intensity Testing

Mn/DOT does not use the onboard sound intensity (OBSI) test method on any projects. However, this method was used to measure tire-pavement sound intensity (SI) on the existing and newly constructed pavements of this project for comparison.

SI measurements were made using the current accepted OBSI technique, AASHTO TP 76-08, which includes dual vertical sound intensity probes and an ASTM standard reference test tire (SRTT). Sound testing was done before construction and on the new pavement surface shortly after it was opened to traffic. OBSI measurements were obtained from the right wheelpath of the outside lane in both directions at 45 miles per hour (mi/h) (72.4 kilometers per hour (km/h)). A minimum of three runs were made with the two phase-matched microphone probes simultaneously capturing noise data from the leading and trailing tire-pavement contact areas. Figure 14 shows the dual probe instrumentation and the tread pattern of the SRTT.

Figure 14. OBSI dual probe system and the SRTT.

The average of the front and rear OBSI values was computed over the full length of the pavement sampled to produce SI values. Raw noise data were normalized for the ambient air temperature and barometric pressure at the time of testing. The resulting mean SI levels are A-weighted to produce the sound intensity frequency spectra in one-third octave bands, as shown in figure 15 for both the pre- and postconstruction pavement surface. The figure shows that the new pavement surface has slightly higher decibel levels above 800 hertz (Hz).



	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
Preconstruction	72.4	75.8	78.0	86.2	91.9	87.4	87.2	88.8	85.0	81.8	78.3	73.6
Postconstruction	72.0	76.7	78.8	85.1	92.0	88.3	88.3	89.5	86.8	83.1	79.1	73.2

Frequency, Hz

Figure 15. Mean A-weighted sound intensity frequency spectra.

SI levels were calculated using logarithmic addition of the one-third octave band frequencies across the spectra. The SI levels were 96.4 and 97.0 dB(A) for the pre- and post construction pavements, respectively. The old and new pavements were very similar. However, the SI level from the newly constructed pavement is 1.0 dB(A) higher than the HfL goal of 96.0 dB(A) or less.

Smoothness Measurement

Smoothness measurements were collected by the Auburn University Automatic Road Analyzer (ARAN) van (figure 16). The ARAN is a high-speed inertial profiler able to perform smoothness measurements of the pavement surface in both wheelpaths. Smoothness is reported in inches per mile as recommended by the International Roughness Index (IRI) approach and consists of a mathematical assessment of the section profile aimed at quantifying the quality of the ride in a passenger car. The ARAN van performed three runs in each direction of the outside lane at a speed of 45 mi/h (72.4 km/h).

Figure 16. Auburn University ARAN van.

The overall IRI values were 58 and 50 inches per mile for pre- and postconstruction, respectively. Post construction IRI is close to the HfL goal of HfL goal of 48 inches per mile or less.

User Satisfaction

The HfL requirement for user satisfaction includes a performance goal of 4-plus on a Likert scale of 1 to 7 (54 percent or more showing favorable response) for the following two questions:

- How satisfied is the user with the new facility compared with its previous condition?
- How satisfied is the user with the approach (full closure) used to construct the new facility in terms of minimizing disruption?

Mn/DOT market research staff commissioned a survey[4] to determine how Mn/DOT did on the project. A total of 400 residents, 100 businesses, and 400 commuters familiar with the project were surveyed by telephone. Residents and businesses were selected from the area surrounding the project. Commuters who made at least four or more round trips per week through the TH 36 corridor were selected from the surrounding communities. The survey was conducted in August 2008 during the final stages of the project and long after the full closure was completed.

Results of a preconstruction survey indicated an even divide among residents and commuters on the use of either a quick in-and-out approach by implementing a full closure or the traditional construction method of partial closures over 2 years. Before construction, the most opposition came from businesses, with seven out of 10 not in favor of full closure.

[4] *2008 Community Construction Evaluation: TH36 Post-Closure*. Prepared by Readex Research for Mn/DOT Market Research.

The Mn/DOT study found that toward the end of the project, the overall response was overwhelmingly positive (nine out of 10 residents and through commuters) about the way the project was executed. Eighty-three percent of local businesses had the same opinion. This means the goal of achieving high satisfaction with the approach to reconstruct the corridor was exceeded.

Speed of project completion was cited as the most common reason for the positive feelings. Improved traffic flow was also given as a reason for the favorable response, as was a general lack of inconvenience or disruption. Figure 17 shows the top reasons, both positive and negative, those surveyed gave for why they feel the way they do about the project.

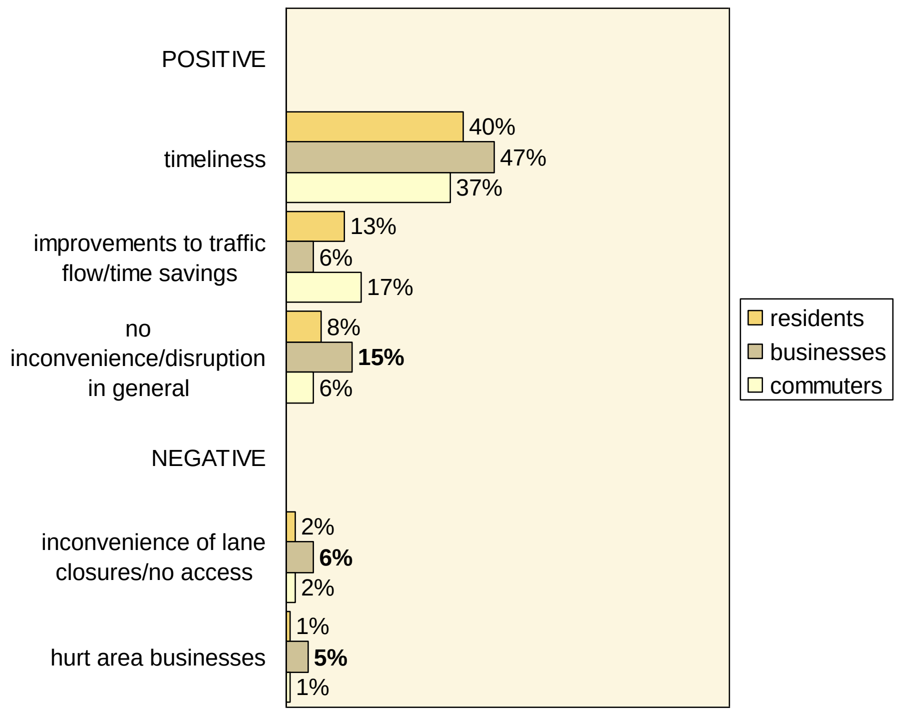


Figure 17. Top reasons why people feel the way they do about the project. (Source: *2008 Community Construction Evaluation: TH36 Post-Closure*, Mn/DOT).

The study did not address user satisfaction with the new facility compared with its previous condition. However, nearly half of those surveyed indicated there was nothing the DOT could have done better, suggesting that overall satisfaction with the newly reconstructed corridor was high. Comments to the contrary suggest removing additional stoplights (assumed outside of the project limits), completing Margaret Bridge (assumed during the full closure), and improving detour signage.

News media (print, TV, and radio), meetings, Mn/DOT's Web site, and local events all played a role in keeping the public informed during the project. In fact, the post-construction survey report indicated that the effectiveness of communications was captured by the survey results:

> At least 76 percent of respondents in each segment [residents, commuters, and businesses] said that before construction began on TH 36, they were aware that a decision was made to close the road completely during construction rather than leaving a lane open for traffic.
>
> Most also said that before construction began, they were aware the project would continue even after the road was reopened, with through commuters the least likely of the segments to indicate awareness of this aspect, at 65 percent, and the other segments closer to three in four.

Mn/DOT engaged the local businesses of North St. Paul with workshops such as “Open for Business—Surviving and Thriving During Construction.” Workshops provided the opportunity for Mn/DOT to explain anticipated traffic patterns as construction evolved and how to tailor advertising during this time. Community involvement included special events sponsored by Mn/DOT to celebrate milestones, such as groundbreaking on the first day of the full closure and opening of the pedestrian bridge. Three public open houses were held at city hall to provide an official forum to discuss the project with DOT personnel.

Throughout the project, Mn/DOT kept the community informed of reconstruction progress with weekly updates from the project engineer and photographs posted on the project Web site. The updates were also sent by e-mail directly to anyone interested in the project. Mn/DOT's efforts to keep the public up to date on construction activities helped the project succeed.

TECHNOLOGY TRANSFER

Nearly 100 highway professionals attended a technology transfer showcase on November 1, 2007, at the North St. Paul community center next to the construction site. The Transportation Engineering and Road Research Alliance (TERRA) of the University of Minnesota hosted the 1-day event in cooperation with FHWA and Mn/DOT.

The showcase featured presentations by local, State, and national agency representatives and panel discussions detailing the contracting and construction methods used to accelerate construction, project communications, community outreach, and marketing research. The showcase included a site tour (figure 18) so participants could see the project firsthand. The itinerary and showcase evaluation summary are in the Appendix.

Figure 18. Showcase participants touring site. (Source: TERRA)

Tom Sorel of FHWA presented an overview of the HfL program in which he explained the program’s fundamental concepts and performance goals. Steve Adamsky of Mn/DOT discussed project details, including planning the project to improve safety and eliminate at-grade crossings of busy cross streets along the highway corridor. Adamsky also addressed the innovations that helped make the project a success, focusing on how the full closure construction method was chosen and the safety and time-cost benefits were realized by completely closing the road to traffic. Glen Engstrom of Mn/DOT covered intelligent compaction from the equipment and field process implementation to the theory and data analysis. Dave Kotilinek of the city of North St. Paul reviewed the project's funding history from 2001 to the start of construction. Tom Ravn, Mn/DOT’s acting State construction engineer, explained the constructability review process that helped make the project possible. He discussed accelerated construction techniques, such as A+B contract bidding, lane rental, and locked incentive date.

Marketing the project scope was an important element in ensuring that community transportation needs were identified and met in the most cost-effective way possible. Kathleen Bergeron of

FHWA explained the importance of marketing and market research and how they are effective in creating better highways through innovation. Kent Barnard of Mn/DOT discussed communication and marketing efforts specifically for the TH 36 project. Barnard presented examples of the engineering reports posted on the State's Web site to inform the public about construction progress and marketing materials circulated to promote local commerce and community events during construction. Lori Laflin of the Minnesota Department of Human Services presented the methodology and results of a study to determine the public's preference of two highway closure alternatives (a 5-month full closure or a 2-year partial closure).

The full closure and other innovations used to make this project a success were discussed in detail during this showcase, giving attendees a clear understanding of the advantages of using such methods to reduce overall construction time, save money, and deliver a high-quality finished highway.

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This entails comparing the benefits and costs associated with the innovative project delivery approach adopted on an HfL project with those from a more traditional delivery approach on a project of similar size and scope. The latter type of project is referred to as a baseline case and is an important component of the economic analysis.

For this economic analysis, Mn/DOT supplied most of the cost figures for the as-built project. The assumptions for the baseline case were determined from discussions with Mn/DOT and pertinent national literature.

CONSTRUCTION TIME

Full closure was in effect for 4 months (122 days). All four lanes of TH 36 were open to traffic in 6.5 months (200 days). Traditional staged construction methods would have impacted traffic for an estimated 19 months (580 days). Therefore, the resulting impact to those who rely on the highway was shortened by 380 days, affecting them less than half the time required by traditional construction methods. The full closure allowed the contractor unfettered access to the roadway to haul materials, begin the overhead bridgework, and conduct paving operations without the interruptions caused by contending with live traffic. The locked incentive date encouraged the contractor to open the roadway no later than scheduled, while lane rental provided the flexibility to temporarily close a lane when needed to address finishing and cleanup activities.

CONSTRUCTION COSTS

Table 4 presents the differences in construction costs between the baseline and the as-built alternatives. All of the cost estimates and construction assumptions were provided by Mn/DOT and stem from a technical meeting of the Mn/DOT construction and estimating staff held to examine different approaches to construct the project. In the baseline scenario, the project would have been constructed with traditional methods in which traffic on TH 36 would have been maintained on a four-lane bypass built next to the existing highway. The as-built case used shorter bypass lanes to accommodate traffic crossing the median at the ends of the project and short access lanes to McKnight Street. Bypass costs for the baseline scenario are based on the as-built bid items and increased by 15 percent to account for inefficiencies inherent in working around live traffic. Traffic control also would have been a major contributor to the baseline costs, resulting from additional items such as barriers, delineators, and temporary lighting.

Mn/DOT staff concluded that special provisions in the contract for contract time ($2,925,000) and lane rental ($220,000) would not apply to the baseline case and should be eliminated from the winning bid for a more accurate cost comparison. The comparison in table 4 assumes that both alternatives would have the same end design and the major differences between the two options are from the bypasses and traffic control. Building the project under traffic would have resulted in $3,884,493 ($32,097,055 - $28,212,562) in additional construction costs, or an extra 14 percent, when compared with the as-built scenario.

Table 4. Capital cost calculation table.

Cost Category	Baseline Case (Under Traffic)	As-Built Case (Full Closure)
Design and Engineering[1]	$ 3,209,706	$ 3,135,756
Bypass Construction Cost		
Bypass Lanes	$ 9,094,507	$ 5,623,073
Traffic Control	$ 1,244,103	$ 181,045
Total Cost of Bypass Construction	$ 10,338,610	$ 5,804,118
Other Construction Items	$ 18,548,740	$ 21,767,688
LID Contract Incentive	-	$ 650,000
Awarded As-Built Contract	-	$ 30,707,562
Total Cost	**$ 32,097,055**	**$ 31,357,562**
Lane Rental	-	$ -220,000
Contract Time	-	$ -2,925,000
Total Adjusted Cost	**$ 32,097,055**	**$ 28,212,562**

Notes:
[1] Assumed to be 10 percent of Total Cost.

TRAFFIC IMPACTS DURING TH 36 FULL ROADWAY CLOSURE

Overview of Anticipated Detour Routes

The full closure of TH 36 during May and June 2007 between White Bear Avenue and Century Avenue (TH 12) required diversion of between 39,400 and 47,500 vehicles per day. Project planners identified through and local detours in both the eastbound and westbound directions of travel. The through detour westbound began at the interchange between I-694 and TH 36, followed I-694 southbound to I-94, continued on I-94 westbound until reaching I-35E, and then traveled north on I-35E until it reconnected with TH 36. For the eastbound through detour, planners assumed that drivers would exit TH 36 at Maplewood Drive (TH-61), travel north to I-694, and follow I-694 eastbound until reconnecting with TH 36. This detour was identified because project planners assumed that motorists would want to avoid ongoing construction on I-35E and I-694 north of TH 36.

For drivers with local origins and destinations in the vicinity of the full roadway closure, project planners assumed that County Highway C to the north of TH 36 and County Road B to the south would serve as the primary detour routes. Drivers were expected to access those routes using White Bear Avenue or Century Avenue, depending on whether they were traveling from west to east or east to west.

Traffic Impacts Examined

Baseline Scenario

Mn/DOT's project staff projected that the traffic impacts of a more conventional or baseline approach could be divided into three distinct stages. The first stage includes the construction of two temporary bypass lanes in each direction along the southern limits of TH 36. The duration of this stage (stage 1) was estimated to extend from April 15 2007 to July 15 2007 and have the following impacts:

- TH 36 within the project limits had signalized intersections at McKnight Road, First Street, and Margaret Street. On the first day of building the bypass, Margaret Street and First Street would have been closed while McKnight Road would have stayed open.
- Periodic off peak lane closures would occur on McKnight Road.
- Eastbound TH 36 would have required off peak lane closures to facilitate bypass construction. These off peak closures would begin at 7 a.m. and end at 2:30 p.m.

The second stage (stage 2) would consist of constructing the permanent westbound roadway over the course of a full year (July 15 2007 to July 15 2008). The traffic impacts would have been the following:

- Margaret Street and First Street would have remained closed and traffic would have been detoured onto McKnight Road.
- Periodic off peak lane closures would have continued on McKnight Road.
- Traffic on TH 36 would have been routed onto the four temporary bypass lanes.
- Off peak lane closures would have likely occurred on the westbound bypass lanes to accommodate the construction of the new westbound TH 36 permanent roadway.

Construction of the permanent eastbound TH 36 roadway would have taken place in stage 3 from July 15 2008 to June 15 2009 with the following traffic impacts:

- Margaret Street and First Street would have remained closed and traffic would have been detoured to McKnight Road.
- Periodic offpeak lane closures would have continued on McKnight Road.
- TH 36 traffic would have been switched from the bypass to a single lane in each direction on the new westbound roadway.
- No temporary or off peak closures would have been expected because there would have been only one lane of traffic in each direction.

Thus the projected three stages of construction would have extended between April 2007 and July 2009 for a total of 26 months. Such construction would have necessitated construction with live traffic in close proximity which would have offered tremendous logistical challenges to construction operations considering the volumes of earthwork that was moved on the project particularly at certain locations where deep cuts were made and 20+ ft retaining walls were built to allow for a facility with no at-grade intersections. The safety considerations for such construction would also have been substantial.

As-Built Scenario

Analysis of the impacts of the full closure on traffic was accomplished using traffic volume data collected on the surrounding freeway segments by the Minneapolis-St. Paul Transportation Management Center. On the arterial streets assumed to be the primary detour routes for local drivers, a number of portable traffic counters were installed at key locations to track diversion during the closure. Analyses were limited to evaluating changes in traffic volumes during the morning and evening travel periods; no speed or travel time data were gathered during the project. Volume-to-capacity computations on the detour routes identified few locations where congestion may have occasionally developed, so it was assumed that diverted traffic had a minimal effect on detour route speeds and travel times. Consequently, only the travel impacts on diverted traffic (the additional travel distances and differences in travel speeds on the detour routes compared with TH 36) had to be considered in the analysis. That is, traffic already using the various alternative routes was not significantly affected by the addition of the diverted traffic on those routes.

Summary of Results

As Built Scenario—Changes in Traffic Volumes

Overall, for the as-built scenario, each of the identified detour routes experienced some increase in traffic volumes during the roadway closure, indicating that they were being used by diverted drivers. Table 5 summarizes the change in traffic counts on the identified detour routes during the 6 a.m. to 10 a.m. and 2 p.m. to 9 p.m. analysis periods. Also shown is the estimate of traffic normally on TH 36 during those same time periods between McKnight Road and White Bear Avenue, assuming that 20.5 percent of the AADT occurs during the 6 a.m. to 10 a.m. period and 42.2 percent occurs during the 2 p.m. to 9 p.m. period (these assumptions were made from a sample of automatic traffic recorder count data in four States—California, North Carolina, Ohio, and Washington—obtained through the FHWA Highway Safety Information System as part of a National Cooperative Highway Research Program study).

Table 5. Changes in traffic volumes during total closure of TH 36.

Time Period	TH 36	I-694	CR C	CR B	I-94	∑
6–10 a.m.	-9,740	+3,120	+1,300	+2,380	+2,900	-40
2–9 p.m.	-20,050	+5,400	+2,060	+3,250	+3,650	-5,690

In the morning period, nearly all of the TH 36 traffic that was forced to divert by the full roadway closure can be accounted for on the four major facilities serving as alternative routes. The difference (40 vehicles) is only 0.4 percent of the traffic normally using TH 36. In the afternoon period, however, a more significant proportion (28.3 percent) of normal TH 36 traffic could not be accounted for on the four major alternative routes. As has been found in other evaluations of travel pattern changes during major highway projects, most of this difference may be the result of drivers searching out their own alternative route to TH 36 in the afternoon rather than using those designated as part of the traffic management plan for the project.

Additional Road User Costs

As stated above, the results of the traffic volume analysis implied that the addition of traffic on the detour routes did not have a significant effect on speeds or travel times during the total roadway closures. Therefore, road user costs caused by the closure were the result of the traffic normally using TH 36 having to travel an additional distance and time each day when the closure was in place. Project planners performed a simple travel time analysis to assess the additional travel distance and time of the four alternative routes (eastbound through, eastbound local, westbound through, and westbound local). In reality, the traffic volume data indicated that drivers did not follow the prescribed detours by direction. Instead, both directions of travel on each facility designated as a detour route saw increases occur in both the morning and afternoon-evening periods. Consequently, the changes in travel times for each alternative route could be applied to the total amount of additional traffic on each facility listed in table 6, which summarizes the additional travel times and distances associated with each route. The portion of the afternoon traffic that could not be accounted for on the four detour facilities was distributed in proportion to the traffic increases measured on those facilities, as it was assumed that drivers finding their own alternative route experienced similar additions to their trip times and distances as measured for the defined alternatives.

Table 6. Estimated road user impacts during TH 36 closure.

Detour Facility	**Additional Travel Time per Trip (minutes)**	**Total Additional Travel Time per Day (vehicle-hours)**	**Additional Travel Distance per Trip (miles)**	**Total Additional Distance per Day (vehicle-miles)**
I-694	0.0	0.0	1.5	15,590
CR C	4.2	292.6	0.5	2,090
CR B	3.2	369.1	0.9	6,230
I-94	7.1	946.7	9.6	76,800
TOTAL PER DAY		1,608.4		100,710

Project planners indicated that 2.9 percent of the TH 36 traffic consisted of commercial vehicles and used the following values of time and vehicle operating costs for commercial vehicles and automobiles:

- Values of Time
  - Automobile = $12.63/h
  - Commercial Vehicle = $20.41/h
- Vehicle Operating Costs
  - Automobile = $0.27/mi
  - Commercial Vehicle = $0.75/mi

Applying these unit costs to the values in table 6 results in the following estimated additional road user costs per day of closure:

1,608.4*(.029*$20.41 + 0.971*$12.63) + 100,710*(.029*$0.75 + 0.971*$0.27)
= $20,677+$28,594
= $49,271/day

The road user cost from employing the full lane closure was $6,011,062 (122 days*$49,271/day).

The road user costs associated with traditional staged construction were not computed but considering that the construction would have been spread over a time span that was at least 6 time greater than the as built scenario (780 days for the traditional construction versus 122 days for the as built), the road user costs in terms of delay cost and safety costs would have been very high. Mn/DOT's assessment was that the neglible vehicle operating costs due to temporary by passes for the traditional construction would have been more than easily offset by the increased delay and safety costs. However, these higher costs were not quantified due to the unavailability of reliable user delay information.

COST SUMMARY

Traditional construction methods would have cost $3,884,493 more to complete this project compared to the as-built case. The impact to motorists in terms of vehicle operating costs added $6,011,062 in road user costs to the as-built case. However, according to Mn/DOT, the additional road user cost would have in terms of increases in delay and safety costs for the traditional staged construction would have made this method of construction cost-prohibitive. Moreover, this option presented many logistical challenges for construction and motorist safety. As a result, the as built scenario was the only robust and viable option available for the construction of TH 36.

APPENDIX

Showcase Agenda: November 1, 2007

9:00 a.m. **Registration**

9:30 **Welcome and Opening Remarks**

- Tom Sorel, Minnesota Division Administrator, Federal Highway Administration (FHWA)
- Tim Worke, Cochair, Transportation Engineering and Road Research Alliance (TERRA)
- Khani Sahebjam, Metro District Engineer, Minnesota Department of Transportation (Mn/DOT)

10:00 **Trunk Highway 36 Project Overview**

- Highways for LIFE: Tom Sorel, FHWA
- Project Details: Steve Adamsky, Mn/DOT

10:30 **Project Innovations**

Road Closure

- Steve Adamsky, Mn/DOT

Intelligent Compaction

- Glenn Engstrom, Mn/DOT

City Perspective

- Dave Kotilinek, City of North St. Paul

11:30 **Lunch**

12:15 p.m. **Accelerated Construction Panel Discussion**

Moderator:

- Rick Arnebeck, TERRA Board Member, Mn/DOT

Panelists:

- Chris Roy, Mn/DOT
- Phil Forst, Minnesota Division, FHWA (invited)
- Larry Butts, Progressive Contractors, Inc.

1:15 **Break**

1:30 **Communications, Outreach, and Market Research Panel Discussion**

Moderator:

- Terrence Beltz, Minnesota Division, FHWA

Panelists:

- Kent Barnard, Metro Public Affairs Coordinator, Mn/DOT
- Kathleen Bergeron, Highways for LIFE, FHWA

2:30 **Closing Comments and Optional Tour of Project Site**

TRUNK HIGHWAY 36 OPEN HOUSE
North Saint Paul Community Center
Thursday, November 1, 2007

EVALUATION FORM SUMMARY

Number of Registrants: 97
Number of Evaluations Received: 25

Arrangements	Average Score (out of 4.00)
Convenience of the registration process	4.00
Location of the Community Center	3.46
Facilities were comfortable and appropriate for the event	2.29
Food served was satisfying	3.77
Participant materials were helpful and useful	3.45

Comments on the arrangements of the event:

- Should have had a laser pointer for speakers!
- Remote/wireless mouse needed so speaker can control slide show!
- Smooth-seamless registration
- Good location/facility
- Well done
- Lunch—good caterer
- Cold
- Need directions around construction since people unfamiliar with area do not know what is open/closed
- Couldn't find the Community Center—had to ask a gas station attendant
- Freezing
- Too cool
- Better directions for exit
- Loud doors were a problem
- Also door behind podium was open and a distraction
- Room was OK—different location might have been good
- Lunch was very good and generous
- Why was the program taped? It was distracting.
- Cold in the Community Center
- Chairs were pretty uncomfortable
- Several other people mentioned to me that they were cold too!

- Maybe we could have had one break before lunch—it was a little too long to have to sit (9:30-11:30)
- Also had to find the community center
- Room was very cold
- Cart holding data projector was way too tall. It created site blocks from several angles.
- This was very well planned and carried out
- Would have liked handouts for all slides

Please evaluate how informative and interesting the sessions were to you by placing a check in the box that best describes your opinion.

Sessions	Average Score (out of 4.00)
Welcome and Opening Remarks	3.50
Trunk Highway 36 Project Overview	3.76
Project Innovations	3.60
Accelerated Construction Panel Discussion	3.50
Communications, Outreach, and Market Research Panel Discussion	3.61

Comments on the sessions of the Open House:

- Good information by the right people
- The room was a little chilly
- Very well put together
- Intelligent compaction was very useful
- The communications, outreach, and market research panel discussion was the best thing by far
- Speaker could have used laser pointer to highlight things
- Slides were useful as well as handouts.
- Glenn Engstrom was informative but I was left with some major questions
- I wish there had been a little more on Intelligent Compaction
- Kathleen Bergeron was really good
- Information was very useful. Thanks
- Make text on nametags bigger so us old folks can read them from a reasonable distance. Thanks
- Very enjoyable

Do you have suggestions for topics you would like to see offered at future TERRA Innovation Series events?

- Like when ‘based’ around a successful project so know how specifically worked (and not just theories)
- How much does transportation cost? The public needs to get a better handle on this.
- I travel 94 from W to E every day. The traffic gets worse and worse each year. Any suggestions for traffic alleviation? Any improvements to Lowry tunnel? What can be done in Twin Cities area to handle all of the increased traffic? Light rail between Minneapolis and St. Paul?