



## Demonstrating Performance-Based Practical Design through Urban Freeway Reconstruction

### PURPOSE OF THE TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS PERFORMANCE-BASED PRACTICAL DESIGN CASE STUDY SERIES AND SUMMARY OF CASE STUDY 2

As states and local agencies become increasingly challenged with addressing their system performance, mobility, and safety needs in the current era of financial limitations, Federal Highway Administration (FHWA) is providing guidance, delivering technical assistance, and sharing resources related to performance-based practical design (PBPD; source: [FHWA](#)). The FHWA Office of Operations is supporting the overall Agency PBPD effort by highlighting the role Transportation Systems Management and Operations (TSMO) alternatives and analysis tools can play in supporting PBPD.

To illustrate the range of TSMO strategies and tools and how they can be applied by transportation planners and designers in a PBPD context, five case studies were developed. This **Case Study 2** illustrates how a PBPD approach can be used to analyze and make trade-offs when designing major freeway reconstruction in a constrained urban area—specifically, the reconstruction of Interstate 94 (I-94), the east-west freeway, in Milwaukee, Wisconsin. Wisconsin Department of Transportation's (WisDOT's) study of the I-94 east-west freeway corridor included extensive safety, operational, and environmental analyses of multiple alternatives, leading to the identification of an alternative that has some features that do not meet current standards (and, therefore, require a design exception), but nevertheless meet the project needs and objectives in a cost-effective manner.

Other case studies in this series include implementing of high-occupancy toll (HOT) lanes, regional performance-based planning, use

of alternative intersections on arterials, and the role of Active Traffic Management (ATM) in support of PBPD activities.

### CASE STUDY BACKGROUND

The I-94 east-west corridor study area is located in central Milwaukee County. This portion of the I-94 east-west freeway corridor opened to traffic in 1961 and 1962, and it plays a key role in moving commuters, tourists, freight, and other travelers to major sites around and beyond the Southeast region of the state. Many major institutions and tourist attractions, such as Miller Park and the Veterans Administration complex, are also in close proximity.

WisDOT has maintained and rehabilitated the bridges, pavements, and other structures many times over the past 50 years, but the corridor is nearing the end of its useful life. Accordingly, WisDOT initiated analyses to determine how the corridor should be rebuilt to ensure that it serves the economy of southeastern Wisconsin for decades to come. The option of merely rebuilding the six-lane freeway was eliminated early in the process based on a WisDOT analysis showing the need for eight lanes to reduce congestion and accommodate future traffic growth. This case study focuses on the alternatives and associated analyses of the western segment of the corridor that shares property lines with three cemeteries—Wood National and Spring Hill to the south and Beth Hamedrosh Hagodel to the north (Figure 1).

### CORRIDOR AND SYSTEM NEEDS AND OBJECTIVES

**PBPD strengthens the emphasis on planning-level corridor or system performance needs and objectives when planning, scoping, and developing individual projects.**

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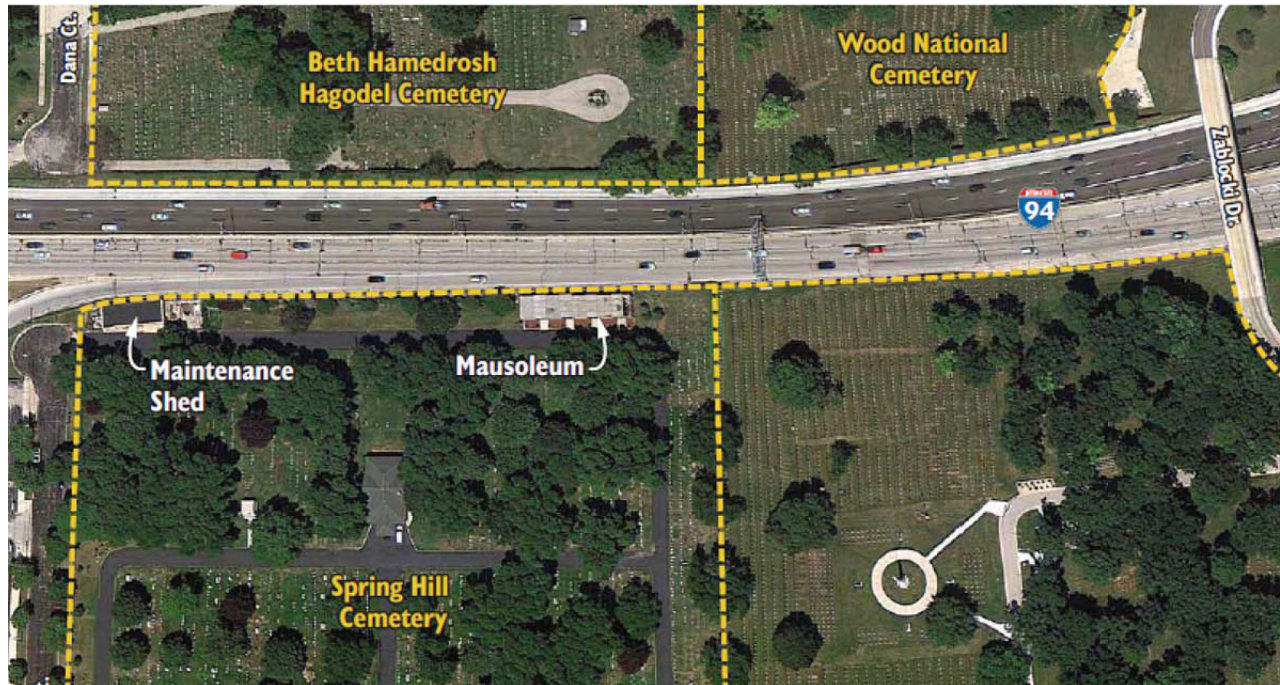


Figure 1. Graphic. Case Study Project Area (Source: WisDOT)

The purpose and needs for the I-94 east-west freeway corridor project developed in coordination with resource agencies, local governments, and the public, included the following objectives and factors:

- Address the obsolete design of I-94 to improve safety and decrease crashes.
- Accommodate existing and future traffic demand at an acceptable level of service (LOS).
- Maintain a key link in the local, state, and national transportation network.
- Replace deteriorating pavement.

Several alternatives were developed and evaluated regarding their ability to meet these needs and corridor objectives. Moreover, the analyses included more than just the freeway facility; the impacts on local streets and on nearby businesses and residences, as well as the cemeteries bordering the freeway, were also addressed.

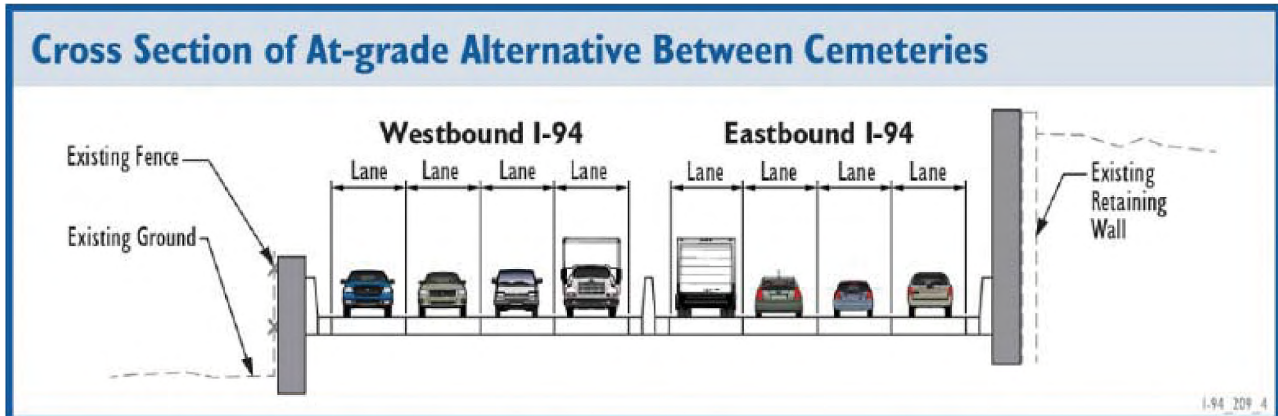
## PERFORMANCE IMPROVEMENTS

**PBPD focuses on performance improvements that benefit both project and system-wide needs.**

PBPD makes the best use of limited available financial resources. Projects are scoped to achieve the purpose and need. All the alternatives for the western segment of the I-94 corridor were scoped to avoid direct impacts to the adjacent cemeteries. As a result of this screening process, the following two alternatives were considered for implementation.

### At-Grade Alternative

The At-Grade Alternative would reconstruct I-94 to eight travel lanes (four in each direction) at essentially the same elevation as the existing freeway (Figure 2). To avoid encroaching on the cemeteries, the reconstructed freeway mainline would include converting the outside shoulder to the fourth lane in each direction. As a result, the freeway would have less than standard 12-foot driving lanes between the adjacent



**Figure 2. Graphic. At-Grade Alternative (Source: WisDOT)**

cemeteries. Eastbound and westbound traffic would travel in 11-foot lanes for roughly 30 feet in each direction, with the lanes transitioning from 12 feet to 11 feet (and back to 12 feet) for several hundred feet east and west of the 11 foot-lane segment. The shoulder widths would vary in this segment as the available right-of-way varies (with the shoulders being as narrow as 2 feet). East and west of the cemeteries, the freeway would have standard 12-foot lanes and full shoulders.

The At-Grade Alternative would have the options for either no interchange or a half interchange at Hawley Road. The half interchange would have an entrance ramp to westbound I-94 and an exit ramp from eastbound I-94 to Hawley Road. The half interchange option at Hawley Road was included based on extensive public and local government input stating that removing the entire Hawley Road interchange would have a socioeconomic impact on businesses and residents that currently use the Hawley Road interchange.

ATM tools—such as advance warning signs alerting drivers to the narrow lanes and shoulders, and dynamic lane assignment and

dynamic speed limits to warn drivers of any reduced speeds or closed lanes in the narrow segment—may also be implemented to make the narrower segment operate with better safety performance. Other strategies, such as reflectors on the center median barrier wall and the outside barrier wall, would also be included in the design.

### **Double Deck Alternative**

The Double Deck Alternative would reconstruct I-94 to eight travel lanes (four in each direction) plus two auxiliary lanes connecting the ramps at Hawley Road to the west and the stadium interchange to the east (Figure 3). A double deck (with one set of freeway lanes elevated over the other) would be constructed in the area between the cemeteries to avoid direct impacts to the cemeteries. All I-94 lanes would be 12 feet wide under this alternative. The shoulder widths would vary slightly in this segment because insufficient right-of-way is available near the cemeteries to provide full shoulder width. East and west of the cemeteries, the freeway would have standard 12-foot lanes and full shoulders in both directions. This alternative would also reconstruct Hawley Road as a full interchange.



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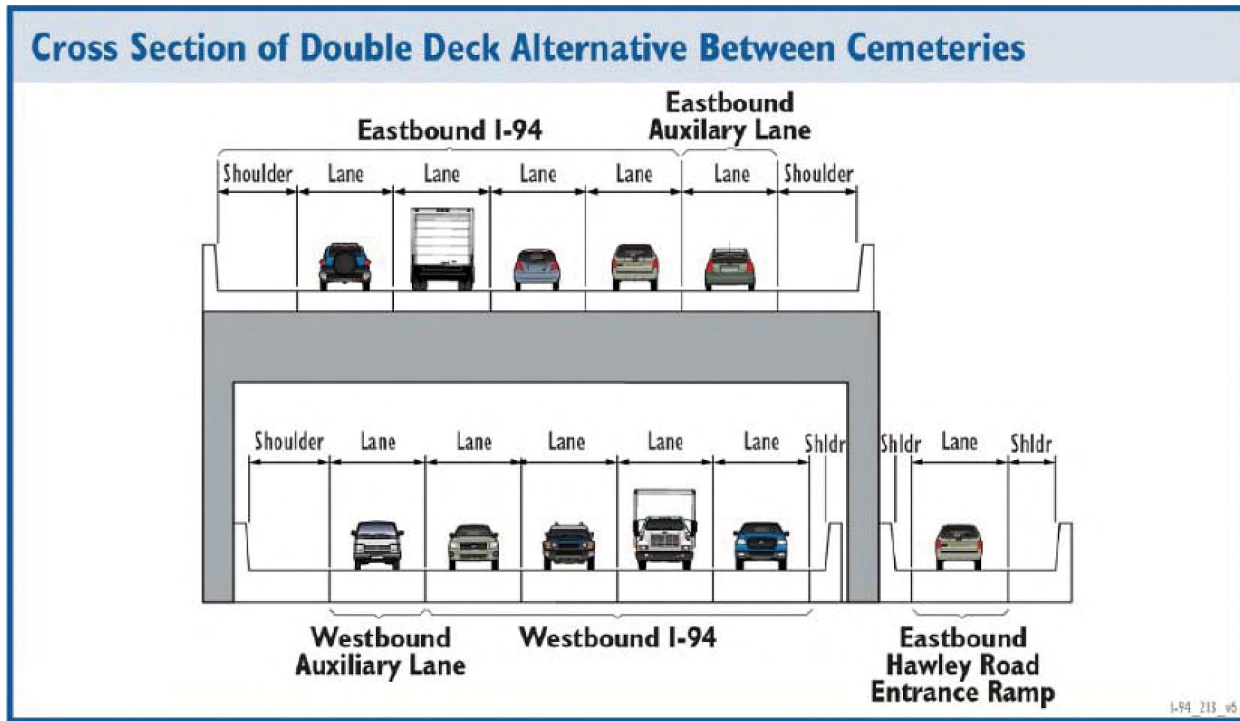


Figure 3. Graphic. Double Deck Alternative (Source: WisDOT)

## PERFORMANCE ANALYSIS

PBPD uses performance tools and analyses to promote sound decisions and greater return on investments.

Analyses of the I-94 corridor reconstruction in the area of the cemeteries were conducted on the following three alternatives to compare benefits:

- Eight-lane at-grade section with no interchange at Hawley Road.
- Eight-lane at-grade section with a half interchange at Hawley Road.
- Eight-lane plus two auxiliary lanes on the double-deck section with a full interchange at Hawley Road.

Table 1 lists several analytical tools that were used for the alternative analyses. Analyses were conducted for the various scenarios for the design year 2040 conditions using the proposed geometric alternatives and projected traffic

Table 1: Analysis Tools

- Enhanced Interchange Safety Analysis Tool (ISATe)— Predictive safety analysis on freeway, interchanges, and ramps.
- Highway Capacity Software (HCS)— Capacity analyses for freeways and ramps.
- Synchro—Capacity analysis at intersections.
- Paramics—Microsimulation modeling.

data. The analyses' results relative to the system needs and objectives are summarized below.

### Safety

Using the crash prediction analysis to measure the number of annual crashes, the Double Deck Alternative would have fewer crashes on I-94 but more crashes on the ramps to and from I-94 (the result of this alternative having more ramp access and weaving movements) than the At-Grade Alternative.

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Traffic would be diverted to the local road network under the At-Grade Alternative because of the geometric and capacity constraint on I-94 (i.e., narrower lanes) and the complete or partial elimination of the Hawley Road interchange. To fully compare the At-Grade and Double Deck Alternatives, crashes on local roads that result from this diverted traffic needed to be considered. When adding the number of crashes predicted to occur on the local roadway network, the Double Deck Alternative would have fewer total crashes than the At-Grade Alternative, over the 20-year analysis period. The At-Grade Alternative, with a half interchange at Hawley Road, would have 23 percent fewer crashes than the “replace in kind” alternative (with the current lane configuration) over the 20-year period, thereby addressing improved safety and reduced crashes on I-94.

## Traffic Volumes and Operations

Another goal of the I-94 project is to accommodate existing and future traffic demand at an acceptable LOS. The At-Grade (with half-interchange at Hawley Road) and the Double Deck alternatives would provide LOS C or D in the A.M. and P.M. peak periods in 2040. Accordingly, this operational goal would be satisfied.

## Costs and Greater Return on Investment

While the Double Deck Alternative would provide the greater benefits, the At-Grade Alternative (with the half Hawley Road interchange) would satisfy the project purpose and needs at a significantly reduced cost, specifically as follows:

- At-Grade Alternative (half Hawley Road interchange)—\$125 million.
- Double Deck Alternative—\$295 to \$345 million (depending on final design option). The Double Deck alternative would also cost about \$1.2 million more to maintain.

A related consideration is constructability and impact to traffic during construction. The At-Grade Alternative would result in fewer impacts to traffic during construction. The Double Deck Alternative would take longer to construct, resulting in a longer duration of impacts to I-94 traffic.

Identifying a preferred alternative was based on resource agency, local government, and public input; the extent to which alternatives achieved the project needs and goals; costs; and impacts to the human and natural environment; and input from public, state, and federal resource agencies, cooperating and participating agencies, and local officials. WisDOT has identified the At-Grade Alternative, with the half interchange at Hawley Road, as the preferred alternative. The following was noted in the WisDOT press release:

*“The alternative selected provides the community with the best balance when all critical factors are evaluated together. We are recommending an approach which addresses the problems of crumbling infrastructure, congestion, and integration with the local street network. The at-grade alternative is the least expensive to construct and have lower potential for community and cultural resources impacts.”*

## Design Standards and Regulatory Requirements

**PBPD can be implemented within the Federal-aid Highway Program regulatory environment utilizing existing flexibility.**

Although PBPD may lead to more thorough and effective vetting of potential alternatives, agencies are not exempt from adhering to the state and federal regulatory standards that govern the selection of alternative solutions.

The National Environmental Policy Act (NEPA) documentation is still required, and existing

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NEPA decision-making regulations remain in place, as is the case for the I 94 project.

In addition to environmental regulations, alternatives are subject to design standards and guidelines, and design exceptions must be documented if minimum controlling criteria are not met.

The 11-foot travel lanes and narrow shoulders through the cemetery area (with the At-Grade Alternative) do not meet WisDOT and American Association of State Highway and Transportation Officials (AASHTO) criteria for the approximately 2,000-foot distance between the cemeteries and require design exceptions. The At-Grade Alternative also requires a design exception for inadequate sight distance in the cemetery area (that is, the slight curve on I-94 through the cemeteries, combined with the 2 foot shoulders, would cause the concrete median barrier to reduce sight distance.) These design exceptions do not reach a level that makes proceeding with the project in light of the stated purpose and need unreasonable, nor do they result in unacceptable safety or operational problems. When considering all factors, the At-Grade Alternative with the half interchange at Hawley Road sufficiently meets the project and systemwide purpose and need. Moreover, potential safety concerns with the designs would be mitigated to some extent by the inclusion of TSMO strategies such as ATM.

## PERFORMANCE-BASED PRACTICAL DESIGN

PBPD encourages the evaluation of the performance impacts of highway design decisions relative to the cost of providing various design features. PBPD can be articulated as modifying a traditional design approach from a “top down,” standards first approach, to a “design up” approach where transportation decision makers exercise engineering judgment to build up the improvements from existing conditions to meet both project and system objectives. Following a PBPD approach can help make more efficient use of scarce resources so that a greater number of improvements can be made. Notable attributes of PBPD include the following:

- Focuses on performance improvements that benefit both project and system-wide needs.
- Uses performance tools and analyses—scrutinizing each element of a project’s scope relative to value, need, and urgency—to promote a greater return on investments.
- Strengthens the emphasis on planning-level corridor and system performance needs and objectives when scoping and developing individual projects.
- Can be implemented within the Federal-aid Highway Program regulatory environment using existing flexibility (e.g., design exceptions).
- Does not eliminate, modify, or compromise existing design standards or regulatory requirements.

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