CAMBRIDGE SYSTEMATICS

Benefit/Cost Analysis for U.S. 41 Corridor ITS "New Start" - Winnebago, Outagamie, and Brown Counties

final

report

prepared for

Wisconsin Department of Transportation

prepared by

Cambridge Systematics, Inc.

WISCONSIN DEPARTMENT OF TRANSPORTATION

June 3, 2008

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1.0 Introduction and Background

1.1 PROJECT OBJECTIVES

The objective of this task is to complete a moderately detailed, planning-level analysis of the benefits of deploying selected Intelligent Transportation Systems (ITS) elements in the U.S. 41 Corridor in the Fox Cities and the greater Green Bay area (including portions of Winnebago, Outagamie and Brown Counties). The analysis uses the Metropolitan Planning Organization (MPO) travel demand models for the Fox Valley and Green Bay regions along with the ITS Deployment Analysis System (IDAS). IDAS is a tool developed specifically for benefit/cost analysis of ITS deployments. Based on the IDAS analysis and other criteria determined by WisDOT, it will be determined which, if any, ITS elements should be considered for deployment. One notable additional criterion is the comparison of the analyzed levels of deployment to the recommendations of WisDOT's concurrent statewide *Traffic Operations Infrastructure Plan* to ensure that the level of investment in U.S. 41 ITS infrastructure matches statewide operations infrastructure goals and priorities.

The elements that survive this initial screening will be subject to design-level analysis. It is assumed that the elements subjected to this initial screening will be the result a substantially enhanced and revised version of what was preliminarily proposed through the initial U.S. 41 ITS Implementation Plan prepared by TransCore. These revised elements should be defined based upon consideration of traffic operations performance-based criteria which can readily be incorporated into the Benefit/Cost (B/C) Analysis methodology applied through the scope of services conducted for this project.

The ITS elements currently being discussed for possible implementation in this corridor include:

- Traffic observation via Closed-Circuit Television (CCTV);
- Traffic volume and speed detection systems;
- Semipermanent sites for Portable Changeable Message Signs (PCMS);
- Dynamic Message Signs (DMS);
- Arterial Traffic Signal System enhancements and Integrated Corridor Traffic Management strategies;
- Provision for future Ramp Metering;
- Ramp Gates;
- Crash Investigation Sites;
- Law Enforcement Pads; and
- Other elements discussed in the Traffic Operations Sketch Planning projects.

1.2 PROJECT CORRIDOR

This task evaluated five "scenarios" or segments of roadway along the U.S. 41 Corridor between Oshkosh and Green Bay. The first three segments evaluated were on U.S. 41 itself. Two of these segments; Scenario A in the Green Bay region and Scenario C in the Oshkosh area, have been funded and are in the design phase. Scenario B in the Appleton area has not yet been funded. The specific locations and costs for these segments are defined in the report, *Northeast Region ITS Architecture and Traffic Management System Preliminary Engineering – U.S. 41 Corridor Traffic Management System Implementation Plan*, prepared for WisDOT Northeast Region by TransCore, September 2007. The description of the ITS system alternatives and all capital cost estimates for U.S. 41 segment projects were obtained originally from this report. These estimates were then modified by WisDOT during this study, based on new information developed through the design process.

During the benefit/cost analysis, two additional scenarios were identified to serve connecting roadways. One additional scenario included deployment of ITS equipment along I-43, State Highway 172, and State Highway 29/32 in the Green Bay area. The other involved ITS deployment along U.S. 441, which forms a loop with U.S. 41 in the Appleton region. Scenarios evaluated in the corridor are summarized as follows:

- **Scenario A –** U.S. 41 from Scheuring Road (CTH F) to Lineville Road (CTH M) in the Green Bay area.
- **Scenario B –** U.S. 41 from Breezewood Lane to Scheuring Road (CTH F) in the Fox Cites area.
- **Scenario C –** U.S. 41 from STH 26 to Breezewood Lane in the Oshkosh area.
- **Scenario D –** Combined deployment of areas A through C, i.e., U.S. 41 from STH 26 south of Oshkosh to Lineville Road (CTH M) north of Green Bay.
- **Scenario E –** Approach roads to U.S. 41 in the Green Bay region, including I-43, State Route 172, and State Route 29/32.
- **Scenario F –** The U.S. 441 Loop in the Appleton area.

ITS deployments are being planned along with major construction, including widening of U.S. 41 from two to three lanes along most of the corridor between 2011 and 2016.

1.3 CORRIDOR CHARACTERISTICS

The U.S. 41 Corridor is one of the faster growing areas in the State of Wisconsin. According to projections obtained through the Department of Administration, Brown and Outagamie are projected to be among the 10 fastest growing Counties in Wisconsin through 2030. The study corridor counties are projected to grow at a rate 50 percent higher than the State as a whole between 2005 and 2030. Table 1.1 summarized population projections for the three study area Counties and the State of Wisconsin.

Table 1.1 Population Projections for U.S. 41 Corridor

	Population			Growth
County	**2005**	**2015**	**2030**	**2005 to 2030**
Brown	237,515	259,192	291,862	22.9%
Outagamie	170,939	189,556	215,720	26.2%
Winnebago	162,076	171,369	188,446	16.3%
Study Area Total	**570,530**	**620,117**	**696,028**	**22.0%**
Wisconsin	5,563,896	5,931,386	6,415,923	15.3%
Study Area as PCT of State	10.3%	10.5%	10.8%	

Source: Http://www.doa.state.wi.us/subcategory.asp?linksubcatid=105&linkcatid=11&linkid=&locid=9.

Projected traffic growth in the corridor was documented in two volumes prepared by CH2M Hill as part of the design process for U.S. 41. Table 1.2 shows projected volumes in Winnebago County while Table 1.3 shows volumes projected for Brown County. Projected growth of up to 50 percent is forecast for portions of the region.

A review of the preliminary results of WisDOT's *Traffic Operations Infrastructure Plan* (TOIP), being developed concurrently, indicates that the operational needs of the U.S. 41 corridor are significant. Figure 1.1 shows the infrastructure recommendations for the U.S. 41 corridor (known as the Fox Valley Corridor in the TOIP). These recommendations are based on a review of roadway characteristics, including traffic volumes and patterns, safety, and the impact of special events and weather. The recommendations are intended to accommodate long-range statewide priorities and goals for traffic operations infrastructure.

Table 1.2 Projected U.S. 41 Traffic Growth 2005 to 2035 in Winnebago County

	AADT Volumes/Forecasts			Daily Truck Classification Percentages				
Segment	**2005**	**2015**	**2035**	**2D**	**3SU**	**2-S1, 2-S2**	**3-S2 and Above**	**Double Bottoms**
U.S. 41 – Northbound								
North of Breezewood On	38,700	45,000	57,500	3.6%	1.1%	3.6%	4.2%	0.3%
STH 76 On to Breezewood Off	32,300	38,700	51,500	3.6%	1.1%	3.6%	4.2%	0.3%
U.S. 45 On to STH 76 Off	27,700	34,300	47,500	3.3%	1.1%	3.6%	5.7%	0.3%
STH 21 On to U.S. 45 Off	34,600	41,600	55,800	3.3%	1.1%	3.6%	5.7%	0.3%
9th Avenue On to STH 21 Off	31,200	38,500	52,800	3.0%	1.1%	3.7%	7.3%	0.4%
STH 44 On to 9th Avenue Off	27,300	34,000	47,300	3.2%	1.0%	4.9%	7.5%	0.6%
STH 26 On to STH 44 Off	22,800	28,800	40,700	3.3%	1.0%	6.2%	7.8%	0.7%
South of STH 26	18,200	23,400	33,700	3.3%	1.0%	6.2%	7.8%	0.7%
U.S. 41 – Southbound								
North of Breezewood Off	37,900	44,200	56,700	3.6%	1.1%	3.6%	4.2%	0.3%
Breezewood On to STH 76 Off	31,500	37,900	50,600	3.6%	1.1%	3.6%	4.2%	0.3%
STH 76 On to U.S. 45 Off	27,800	34,200	46,900	3.3%	1.1%	3.6%	5.7%	0.3%
U.S. 45 On to STH 21 Off	33,800	41,200	56,000	3.3%	1.1%	3.6%	5.7%	0.3%
STH 21 On to 9th Avenue Off	30,800	38,200	52,700	3.0%	1.1%	3.7%	7.3%	0.4%
9th Avenue On to STH 44 Off	26,800	33,300	46,200	3.2%	1.0%	4.9%	7.5%	0.6%
STH 44 On to STH 26 Off	22,000	28,100	40,100	3.3%	1.0%	6.2%	7.8%	0.7%
South of STH 26 On	17,500	22,900	33,700	3.3%	1.0%	6.2%	7.8%	0.7%

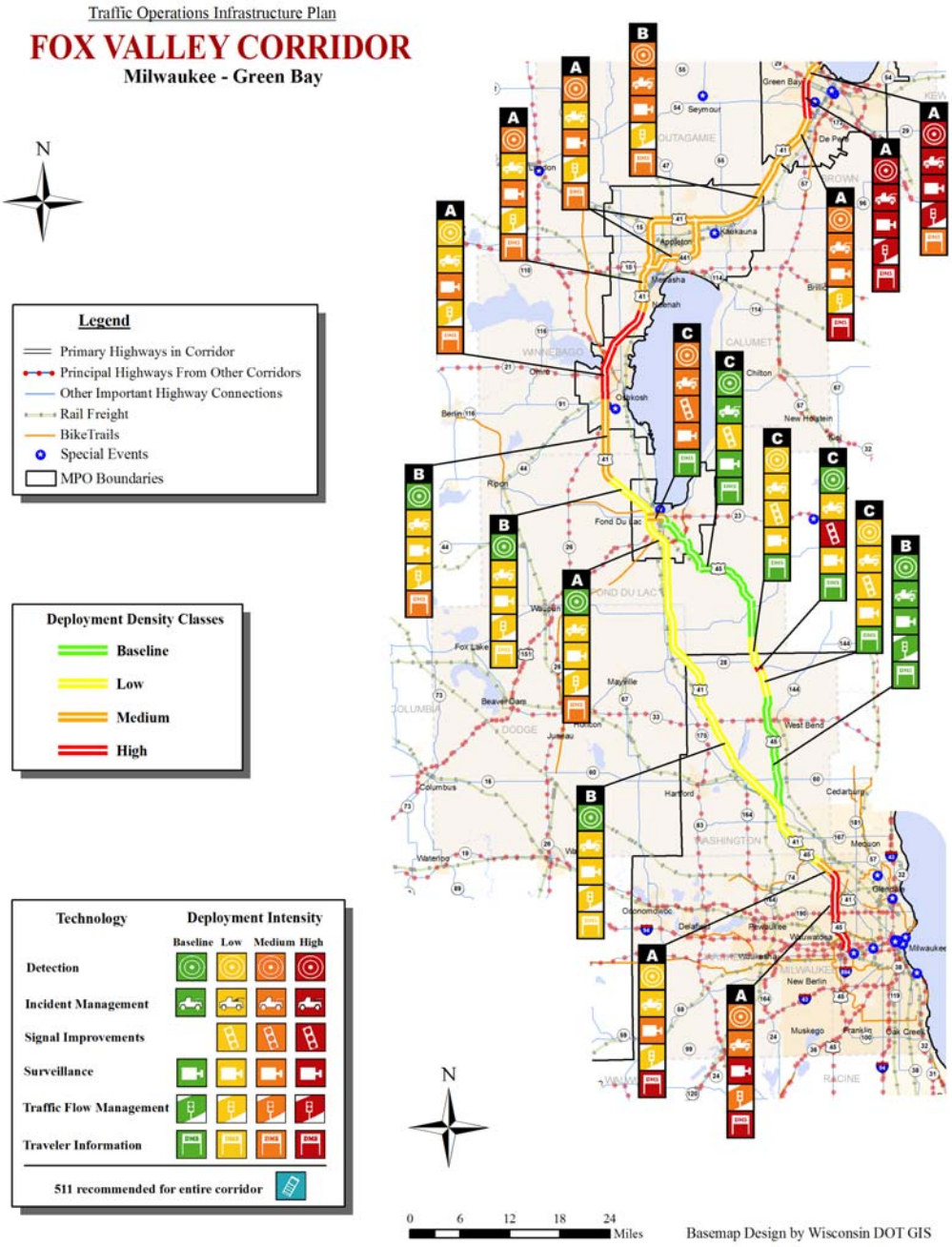
Source: U.S. 41 Traffic Study – Winnebago County Forecasted Traffic Network, submitted by CM2HHill to WisDOT Northeast Region, July 2006.

Table 1.3 Projected U.S. 41 Traffic Growth 2005 to 2035 in Brown County

	AADT Volume/Forecasts			Daily Truck Classification Percentages				
Segment	**2005**	**2015**	**2035**	**2D**	**3SU**	**2-S1, 2-S2**	**3-S2 and Above**	**Double Bottoms**
U.S. 41 – Northbound								
North of CTH M On	20,000	23,900	31,600	4.3%	3.3%	1.9%	1.2%	0.2%
IH 43 On to IH 43 Off	24,900	29,900	40,000	4.3%	3.3%	1.9%	1.2%	0.2%
U.S. 141 On to IH 43 Off	28,200	34,400	47,000	4.3%	3.3%	1.9%	1.2%	0.2%
STH 29 On to USH 141 Off	30,600	36,700	48,900	4.3%	3.3%	1.9%	1.2%	0.2%
STH 54 On to STH 29 Off	37,100	43,900	57,600	3.7%	2.7%	1.8%	1.4%	0.3%
CTH VK On to STH 54 Off	39,900	46,900	61,000	3.2%	2.0%	1.7%	1.6%	0.3%
WB STH 172 On to CTH VK Off	38,800	45,700	59,500	3.2%	2.0%	1.7%	1.6%	0.3%
CTH AAA On to STH 172 Off	37,500	42,600	52,600	3.2%	2.0%	1.7%	1.6%	0.3%
CTH G On to CTH AAA Off	32,700	36,800	45,000	3.2%	2.0%	1.7%	1.6%	0.3%
CTH F On to CTH G Off	30,000	33,800	41,400	3.2%	2.0%	1.7%	1.6%	0.3%
South of CTH F	24,400	27,100	32,500	3.2%	2.0%	1.7%	1.6%	0.3%
U.S. 41 – Southbound								
North of CTH M Off	20,200	24,000	31,700	4.3%	3.3%	1.9%	1.2%	0.2%
CTH M On to IH 43 Off	25,300	30,400	40,500	4.3%	3.3%	1.9%	1.2%	0.2%
IH 43 On to USH 141 Off	28,600	34,900	47,400	4.3%	3.3%	1.9%	1.2%	0.2%
U.S. 141 On to STH 29 Off	30,600	36,700	48,800	4.3%	3.3%	1.9%	1.2%	0.2%
STH 29 On to STH 54 Off	36,800	43,500	57,000	3.7%	2.7%	1.8%	1.4%	0.3%
STH 54 On to CTH VK Off	39,800	46,800	60,700	3.2%	2.0%	1.7%	1.6%	0.3%
CTH VK On to STH 172 Off	39,100	45,900	59,600	3.2%	2.0%	1.7%	1.6%	0.3%
EB STH 172 On to CTH AAA Off	36,600	41,500	51,300	3.2%	2.0%	1.7%	1.6%	0.3%
CTH AAA On to CTH G Off	33,000	37,200	45,500	3.2%	2.0%	1.7%	1.6%	0.3%
CTH G On to CTH F Off	29,800	33,800	41,800	3.2%	2.0%	1.7%	1.6%	0.3%
South of CTH F On	23,300	26,400	32,500	3.2%	2.0%	1.7%	1.6%	0.3%

Source: U.S. 41 Traffic Study – Brown County Forecasted Traffic Network, submitted by CM2HHill to WisDOT Northeast Region, January 2007.

Figure 1.1 Fox Valley Corridor Recommendations from the TOIP



U.S. 41 is recognized within the TOIP as being one of the most critical Priority Corridors within the State, serving as an important connection between the Fox Valley and Milwaukee and accommodating large volumes of both freight and tourist traffic. The Deployment Density Class (DDC), an assessment of roadway operational needs, is at the highest level for parts of U.S. 41 such as from central to northern Oshkosh and within portions of Green Bay. Medium to high levels of surveillance, detection, and traveler information are recommended by the TOIP

(for further details on the recommendations of the TOIP, visit http://www.topslab.wisc.edu/workgroups/toip.html).

The recommendations of the report *Northeast Region ITS Architecture and Traffic Management System Preliminary Engineering – U.S. 41 Corridor Traffic Management System Implementation Plan*, match closely with the recommended infrastructure investment in the TOIP. The TOIP indicates that a high level of infrastructure deployment and investment in the U.S. 41 corridor is recommended and will accommodate the statewide goals of the Bureau of Highway Operations.

The next section of this report, Section 2.0, summarizes the alternatives that are being analyzed for this report, including both the geographic segments and technologies proposed. Section 3.0 contains a summary of the benefit/cost analysis results by segment and for the entire corridor with overall findings summarized in Section 4.0. Appendix A provides documentation on use of the IDAS model. The summary for the standard WisDOT Project Alternatives Evaluation Report (PAER) is included in a separate document.

2.0 Description of Alternatives

The proposed alternatives are documented in detail in the report Northeast Region ITS Architecture and Traffic Management System Preliminary Engineering – U.S. 41 Corridor Traffic Management System Implementation Plan, prepared for WisDOT Northeast Region by TransCore, September 2007. For purposes of this effort, three segments were originally evaluated, as listed below from north to south:

- **Scenario A –** U.S. 41 from Scheuring Road (CTH F) to Lineville Road (CTH M) in the Green Bay area.
- **Scenario B –** U.S. 41 from Breezewood Lane to Scheuring Road (CTH F) in the Fox Cites area.
- **Scenario C –** U.S. 41 from STH 26 to Breezewood Lane in the Oshkosh area.

Deployments for Scenarios A and C are currently funded and thus are further divided into multiple construction contracts. After the initial analysis, two scenarios were added. These scenarios were developed in response to additional regional needs identified during the study. Included were feeder routes and alternate in the Green Bay region and U.S. 441 in the Appleton region, which creates a loop with U.S. 41. The scenarios were defined as follows:

Scenario E – Approach roads to U.S. 41 in the Green Bay region, including I-43, State Route 172, and State Route 29/32.

Scenario F – The U.S. 441 Loop in the Appleton area.

Figure 2.1 shows the overview of all deployments in the U.S. 41 Corridor between Green Bay and Oshkosh. Figures 2.2 through 2.4 show deployments broken down by County. Figure 2.2 shows scenarios A and E in Brown County, Figure 2.3 shows scenarios B and F in Outagamie County and Figure 2.4 shows proposed deployments under Scenario C in Winnebago County.

Figure 2.1 Overview of U.S. 41 Corridor ITS Plan

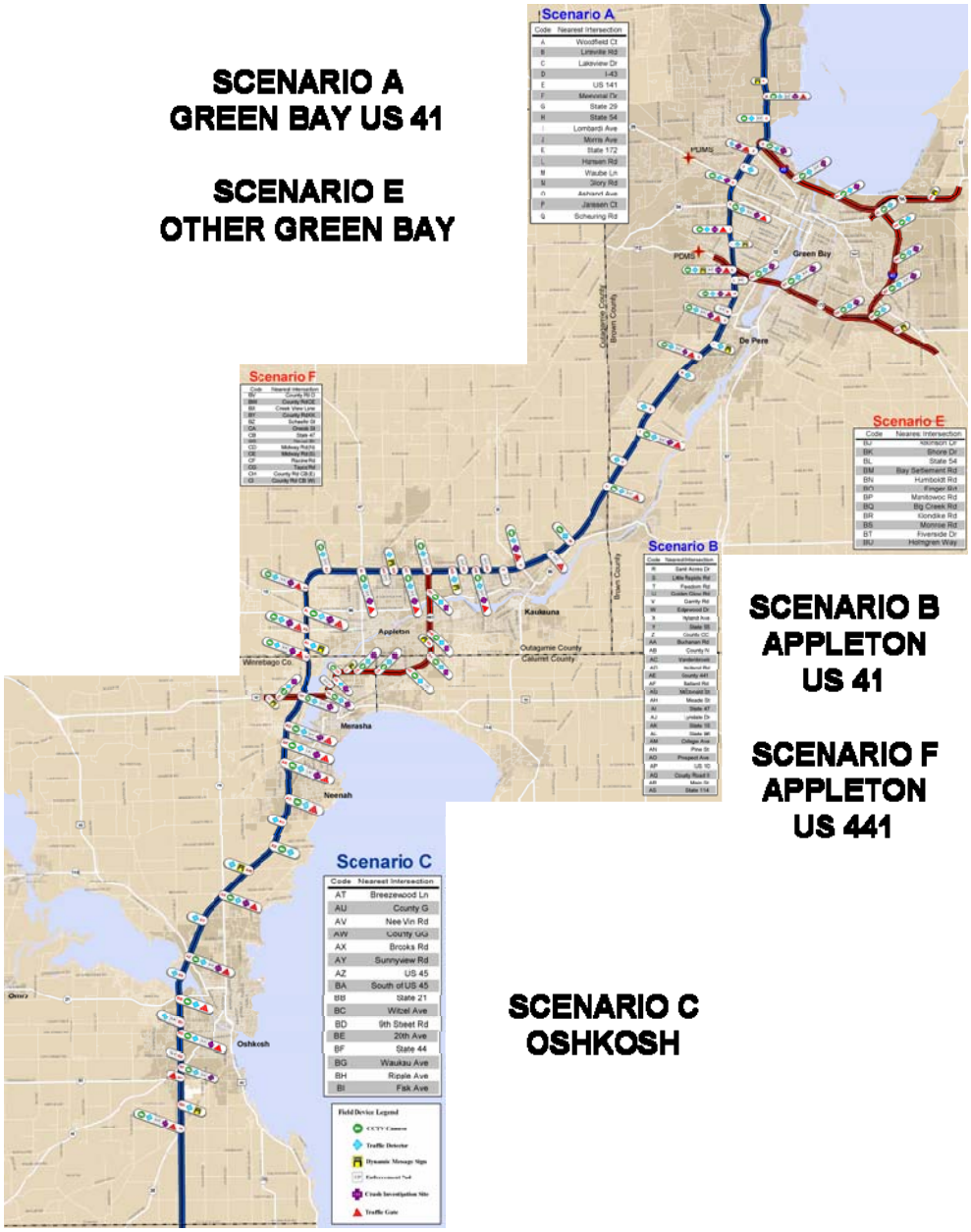


Figure 2.2 Scenario A and E Devices – Brown County

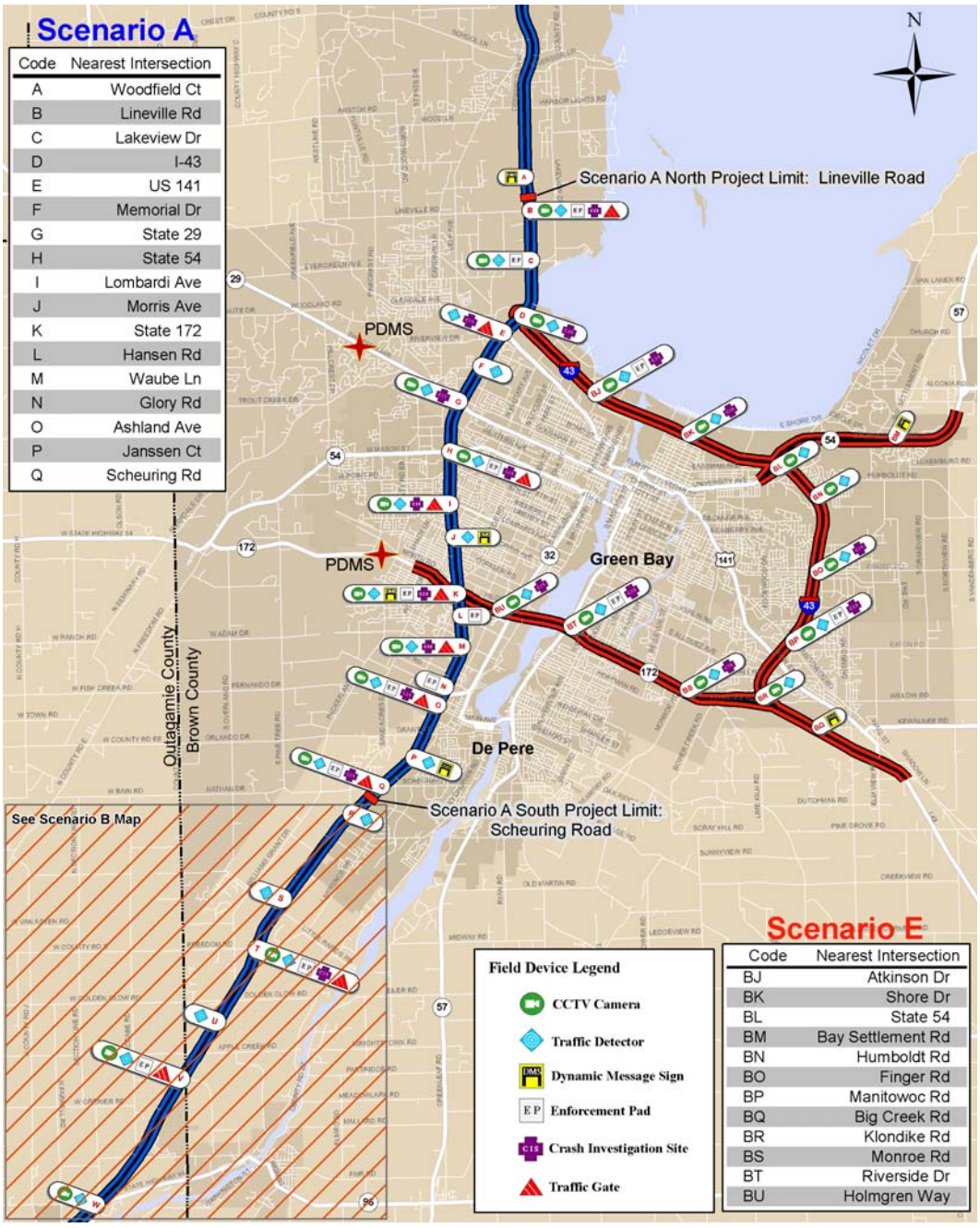


Figure 2.3 Scenario B and F Devices – Brown, Outagamie, and Winnebago Counties

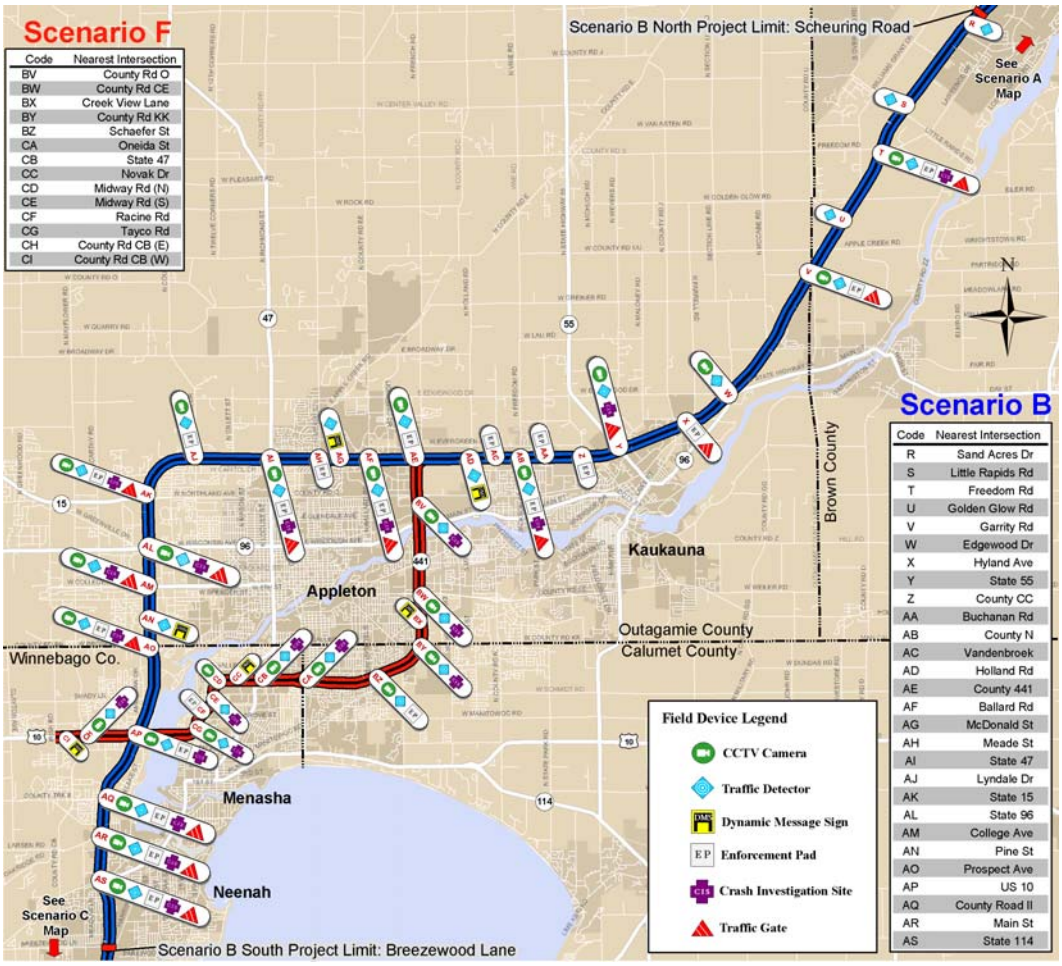
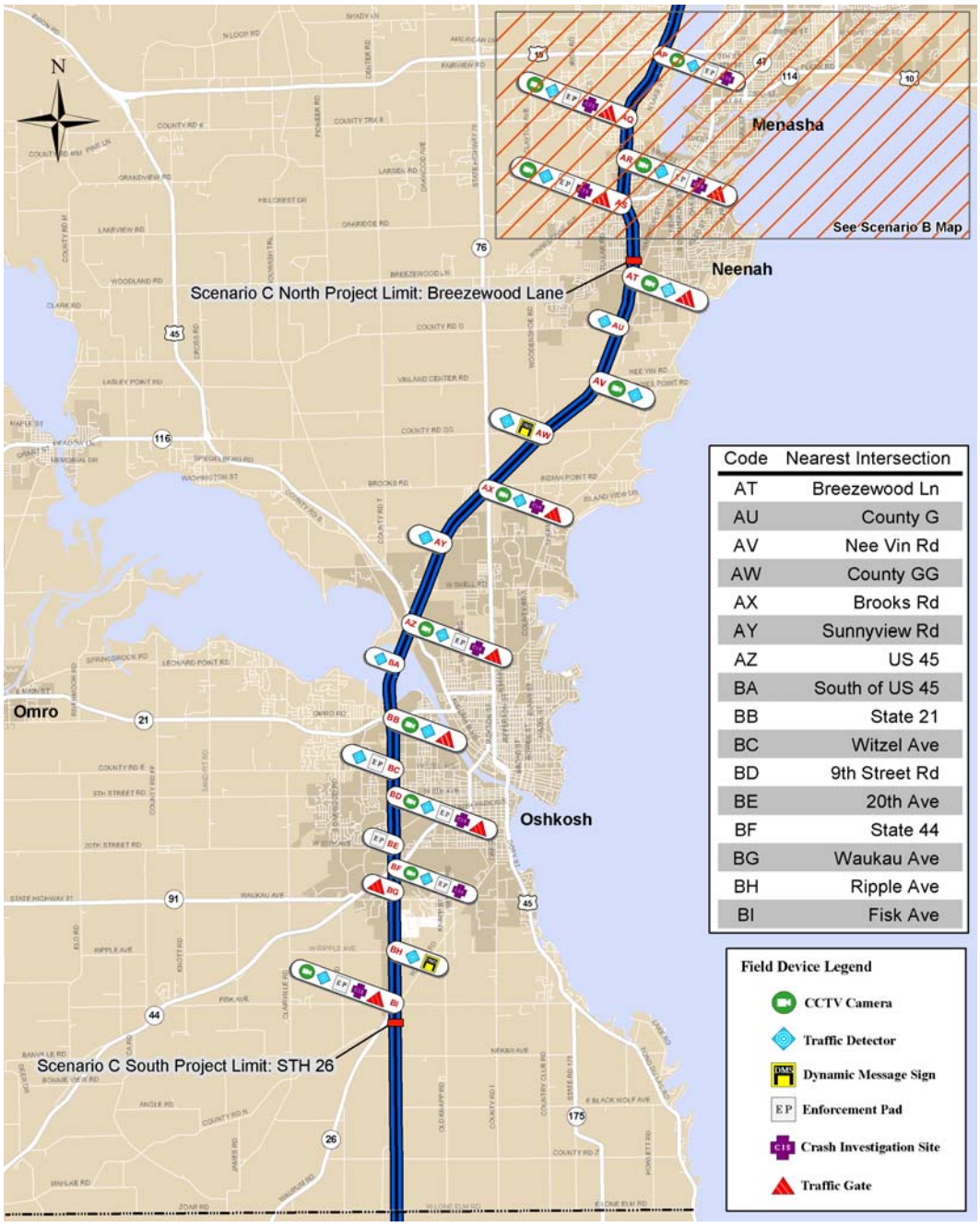


Figure 2.4 Scenario C Devices – Winnebago County



Two sources were used to summarize costs for the project. The report *Northeast Region ITS Architecture and Traffic Management System Preliminary Engineering – U.S. 41 Corridor Traffic Management System Implementation Plan*, was used for capital cost estimates. Since IDAS estimates life-cycle costs, an average life was assigned to each category of device, based on information available in the IDAS database and estimates used in other benefit/cost analyses. WisDOT reviewed

and adjusted these estimates. Basic capital cost assumptions and quantities for ITS system elements are included below in Table 2.1.

Table 2.1 Basic Capital Cost Assumptions

Device	Unit Cost	Quantities by Segment					Estimated Life
		A	B	C	E	F	
CCTV	$50,000	9	12	6	8	9	10
DMS	$235,000	4	3	2	2	3	15
Portable CMS	$50,000			6	2	1	15
Portable Detection System	$35,000	12	0	12	0	0	12.5
Portable Detection System Bases	$3,000	6	0	0	0	0	12.5
Permanent Detection System	$50,000	3	13	3	1	1	12.5
Permanent Interchange Detection	$100,000	11	2	9	7	8	12.5
Crash Investigation Site	$50,000	17	8	11	7	7	20
Enforcement Pad	$10,000	14	12	16	3	2	30
Fiber Optic (per mile)	$100,000	13.5	4	15	12.5	12.5	30
Traffic Gates	$10,000				7	4	20
Power	$5,000	19	0	14	0	0	10

Several sources were reviewed for the purpose of estimating operations and maintenance costs. The U.S. 41 Preliminary Engineering Report provided one set of estimates. These were compared with estimates compiled based on the actual experience of the Southeast Region ITS system. After extensive discussion it was decided to apply an annual operations and maintenance cost equal to 10 percent of the capital costs of the above ground equipment shown above. Maintenance costs were estimated based on the maintenance costs of similar equipment in the Southeast region. This maintenance cost was subtracted from the 10 percent total and the remainder is assumed to cover labor and related operations costs. These costs were compared with an independent estimate and appeared to be reasonable. Exceptions were made for three items that require minimal maintenance:

- Enforcement Pads = $0/annually;
- Traffic Gates = $250 annually; and
- Crash Investigation Sites = $500/annually.

It is assumed that all five segments of the project would be open in 2015. The estimated 2015 operations and maintenance cost by segment are shown in Table 2.2 below in 2007 dollars.

Table 2.2 Estimated Operations and Maintenance Cost
2007 Dollars

Scenario	Estimated Operations and Maintenance Cost 2015
A – Green Bay Area U.S. 41	$324,000
B – Appleton Area U.S. 41	$320,000
C – Oshkosh Area U.S. 41	$186,000
E – Green Bay Area – I-43, STH 172, STH 29	$170,000
F – Appleton Area U.S. 441	$209,000
D – U.S. 41 Total (A,B,C)	$830,000
All Segments	$1,209,000

Detailed estimates for each contract can be found in Northeast Region ITS Architecture and Traffic Management System Preliminary Engineering – U.S. 41 Corridor Traffic Management System Implementation Plan. These estimates were modified based on additional design work and review by WisDOT personnel. Capital costs are summarized below for each scenario in 2007 dollars. Freeway Management System costs are listed separately from other deployments which include Enforcement Pads, Traffic Gates, and Crash Investigation Sites:

- **Scenario A –** Freeway Management System = $4.2 million;
- **Scenario A –** Other Deployments = $1.0 million;
- **Scenario B –** Freeway Management System = $4.1 million;
- **Scenario B –** Other Deployments = $0.6 million;
- **Scenario C –** Freeway Management System = $2.9 million;
- **Scenario C –** Other Deployments = $0.8 million;
- **Scenario E –** Freeway Management System = $3.4 million;
- **Scenario E –** Other Deployments = $0.4 million;
- **Scenario F –** Freeway Management System = $3.4 million; and
- **Scenario F –** Other Deployments = $0.4 million.

Total costs are approximately $18 million for the full Freeway Management System and $3.2 million for the rest of the deployments.

3.0 Results of Analysis

This section includes the results of benefit/cost analysis for the five ITS program scenarios defined for the U.S. 41 corridor. The inputs to the analysis include two travel demand models. The model for the Fox Valley region was used to evaluate scenarios B, C and F, while the Green Bay region model was used to evaluate Scenarios A and E. Benefits and costs for a four-mile gap between the models in Outagamie County were estimated with the use of metamanager data. Both costs and benefits were calculated for the entire period between completion of construction and 2035. An annual discount rate of 5 percent was used and the full stream of costs and benefits were presented in 2007 dollars.

The results shown below focused on the following system elements:

- **Freeway Management System (FMS) –** The key deployments in the Freeway Management system are Dynamic Message Signs and other traveler information services. These deployments provide motorists advance notice of congestion and safety hazards. Detection equipment and CCTV cameras are supporting deployments which enable Traffic Management Center operators to identify incidents and changes in traffic conditions. Travel time savings are the primary benefit of Freeway Management Systems but there are safety and fuel savings benefits as well. Communications costs were allocated to the Freeway Management System along with improvements required for Traffic Management Centers.
- **Crash Investigation Sites (CIS) –** CIS enable the parties involved in a crash to quickly get out of the right-of-way. Full traffic flow can be restored more quickly, reducing travel time and operating cost impacts. Secondary crashes also are reduced.
- **Enforcement Pads –** The primary impact of enforcement pads is improved safety. Motorists tend to slow down, which increases travel time, but the enforcement pads reduce the number and severity of crashes.
- **Traffic Gates –** Gates are used to close the freeway during severe incidents. The primary benefit is in operating cost savings since closures currently are done by law enforcement personnel.

Two additional deployments, Freeway Service Patrol (FSP) and Smart Work Zones (SWZ) were evaluated independently and are discussed later in this report.

Figures 3.1 through 3.5 summarize capital, replacement and operations and maintenance cost by year through 2035 for each of the five scenarios. Costs are presented only for Freeway Management System deployments since this equipment generates the need for ongoing operations and maintenance funding, a major concern to WisDOT. Other deployments such as Crash Investigation

Sites and Enforcement Pads require minimal maintenance. Figure 3.6 presents a summary of FMS costs for all proposed scenarios. These costs are presented in 2007 nominal dollars.

Figure 3.1 Scenario A U.S. 41 Annual Freeway Management System Costs

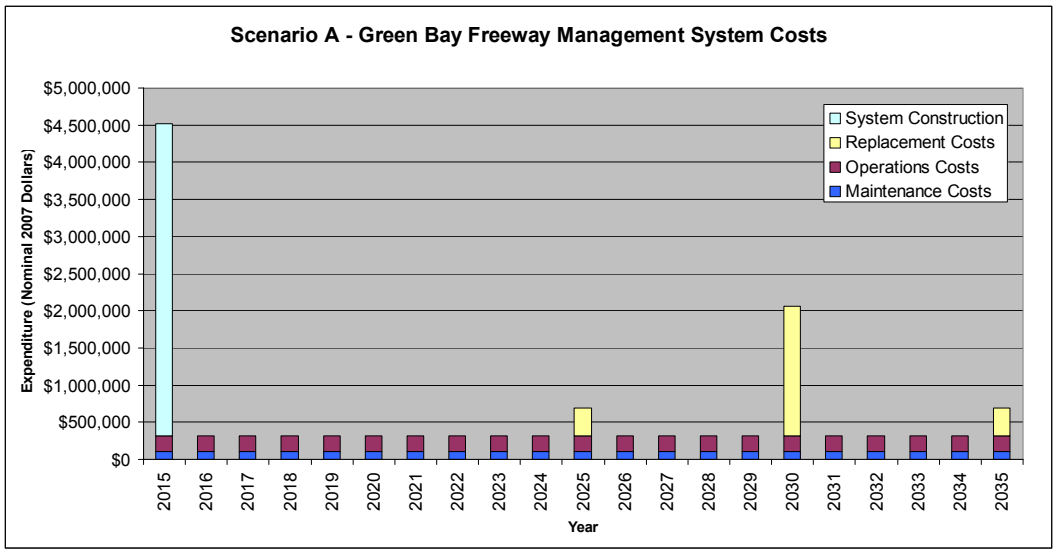


Figure 3.2 Scenario B U.S. 41 Annual Freeway Management System Costs

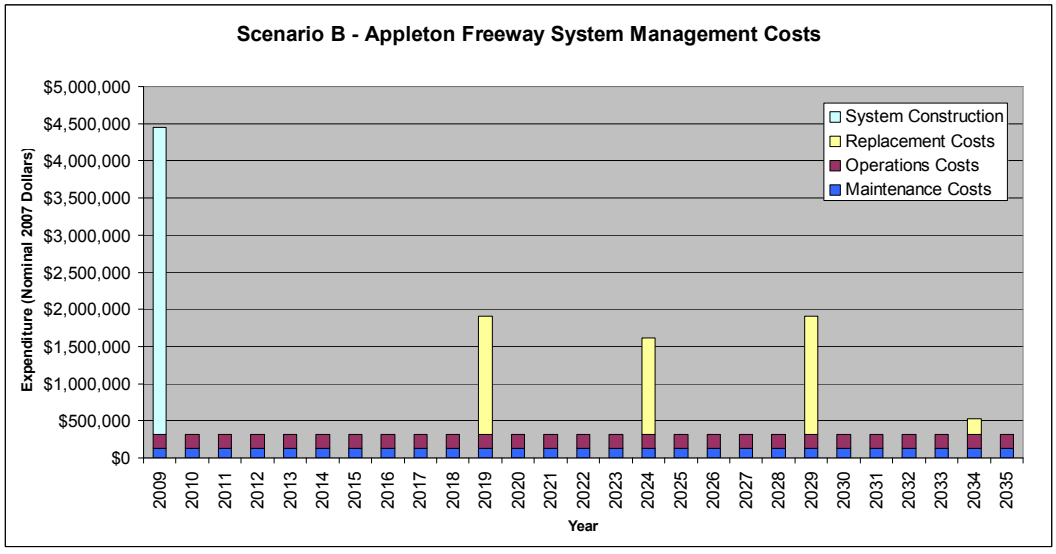


Figure 3.3 Scenario C U.S. 41 Annual Freeway Management System Costs

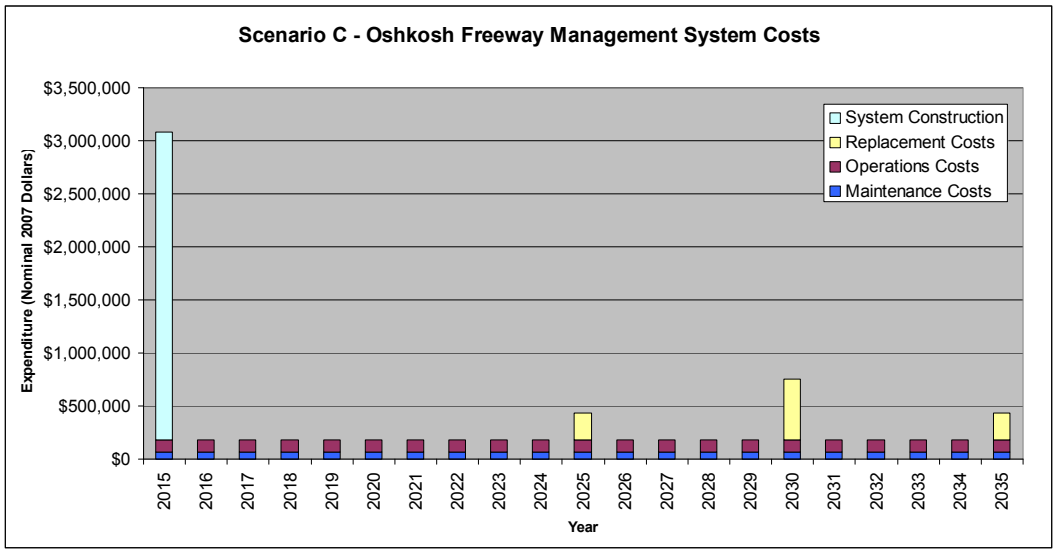


Figure 3.4 Scenario E I-43/STH 172/STH 32 Annual Freeway Management System Costs

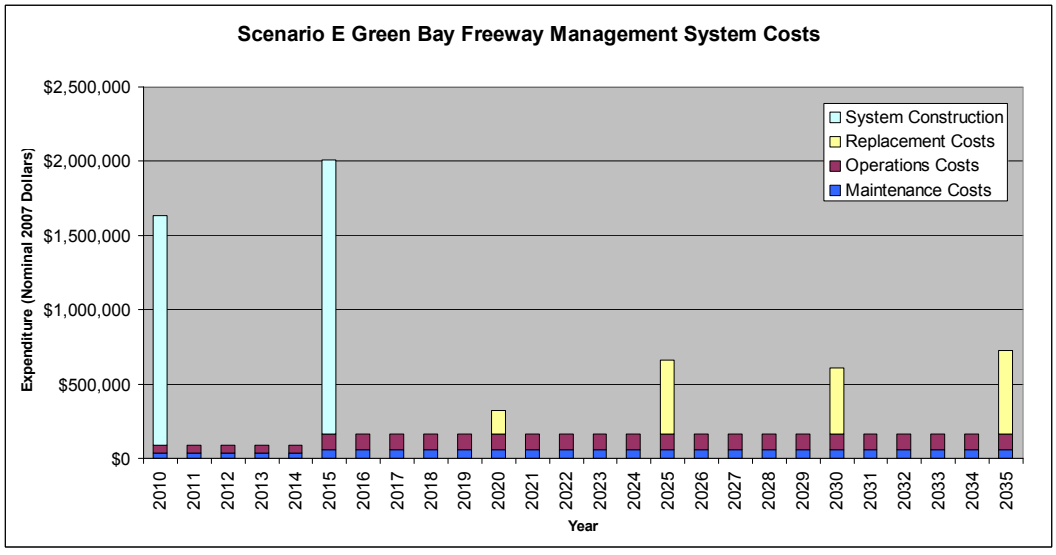


Figure 3.5 Scenario F U.S. 441 Annual Freeway Management System Costs

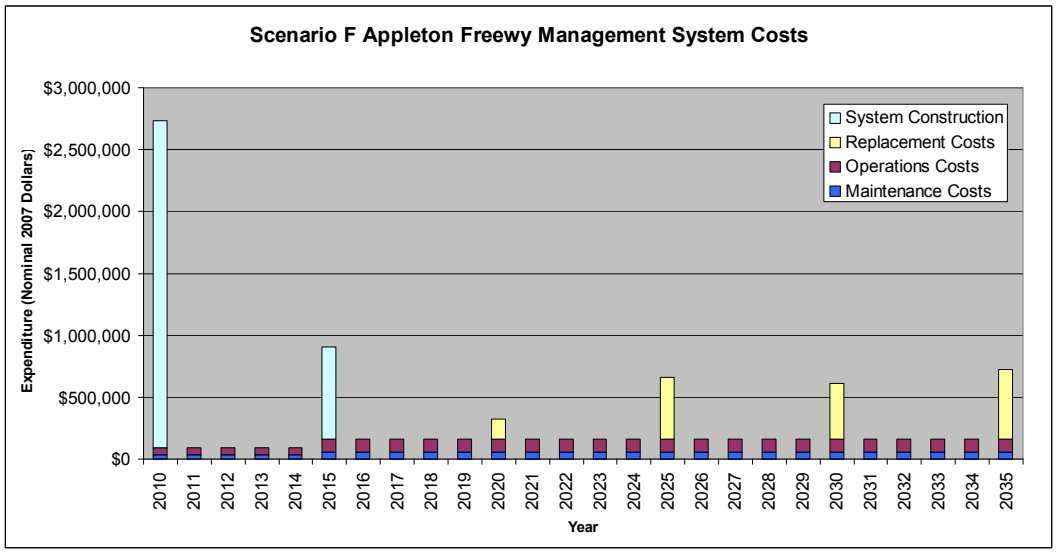
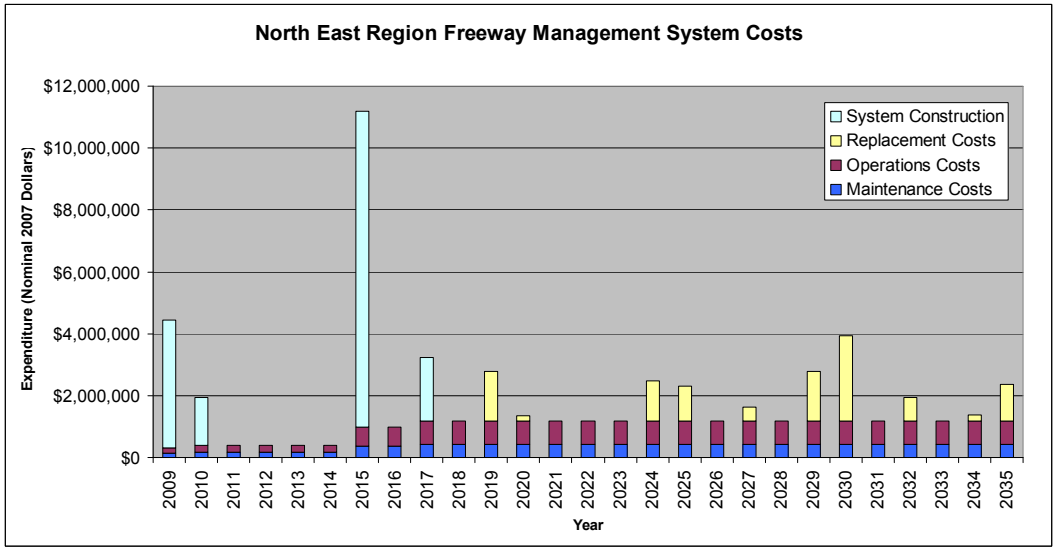


Figure 3.6 All Scenarios Annual Freeway Management System Costs



In calculating benefits there are several key inputs to the IDAS modeling effort:

- IDAS utilizes regional travel demand models as the basis of the benefit/cost analysis. A description of IDAS is found in Appendix B. In this study two regional models were utilized; one covering the Green Bay MPO region and the other covering the Fox Valley region, including Appleton, Oshkosh, and part of Outagamie County. The model was run for two different years, 2015 which represents the completion of the U.S. 41 project and the proposed ITS system and 2035 which is the long-term planning horizon year for the MPO regions. Benefits for interim years were calculated through interpolation.

Both travel demand models were recently updated as part of a statewide travel demand forecasting effort. A four mile gap existed between the two models on U.S. 41 in Outagamie County. Traffic volume data were collected from the Metamanager system and used to estimate benefits for this segment, which was included in Scenario B. Since it is a largely rural area, proposed deployment in this segment was limited.

- IDAS requires benefit parameters to estimate the impacts of various deployments. While IDAS includes default parameters based on national studies it also can accommodate information from other sources. In this project several sources were used, including national defaults, the results of customer surveys conducted in Michigan and Ohio, and the results of research conducted for this effort. The original parameters developed were reviewed by WisDOT and modified to address location conditions. The major adjustments made were for Freeway Management System. WisDOT noted that the percentage of motorists diverting to alternate routes would vary significantly throughout the corridor based on the availability and convenience of alternate routes. The parameters used are shown in Table 3.1 below.

Table 3.1 Comparison of Impact Values Used for IDAS Analysis

Deployment	Benefit	Parameter
Freeway Service Patrols[a]	Reduction in incident duration.	5%
	Reduction in fuel consumption.	1%
	Reduction in fatality rate.	1%
Freeway Management System (DMS, CCTV, Detector)[b]– Brown County (Scenarios A and E)	Percent of drivers who divert.	25%
	Percent of time useful information is provided.	5%
	Estimated time saved.	5 minutes
Freeway Management System (DMS, CCTV, Detector)[b] – Outagamie County with parts of Brown and Winnebago (Scenarios B and F)	Percent of drivers who divert.	25%
	Percent of time useful information is provided.	8%
	Estimated time saved.	7 minutes
Freeway Management System (DMS, CCTV, Detector)[b] – Winnebago County (Scenario C)	Percent of drivers who divert.	15%
	Percent of time useful information is provided.	5%
	Estimated time saved.	3 minutes
Crash Investigation Sites[c]	Reduction in incident duration.	5%
	Reduction in fuel consumption.	1%
	Reduction in fatality rate.	1%
Additional Benefits from Detection and Surveillance Deployment	Incident duration reduction.	1%
	Fuel consumption reduction.	1%
	Fatality reduction.	1%
	Emissions reduction.	1%

[a] IDAS defaults modified based on initial runs.

[b] Based on Ohio and Michigan customer survey data, WisDOT provided estimates for different segments of U.S. 41.

[c] Used same parameters as Freeway Service Patrols – no research found.

Deployment	Benefit	Parameter
Enforcement Pads[d]	Crash reduction – Fatality.	17%
	Crash reduction – Injury.	7%
	Crash reduction – PDO.	5%
	Travel time reduction.	-5%
	PCT of time pad occupied.	2%
Traffic Gates[e]	Crash reduction – Fatality.	80%
	Crash reduction – Injury.	80%
	Crash reduction – PDO.	80%
	Reduced operating costs through reduction in police presence.	$50/hour
	PCT of time gate closed (28 hours/year).	0. 30%
Smart Work Zones[b]	Amount of time useful information is displayed.	5%
	Percent of travelers responding to information.	28%
	Time saved per traveler.	5 minutes
	Additional travel time impacts from rerouting of traffic due to work zone capacity reductions.	Impacts are estimated by model and dependent on specific roadway volumes and alternative routes.

[a] IDAS defaults modified based on initial runs.

[b] Based on Ohio and Michigan customer survey data, WisDOT provided estimates for different segments of U.S. 41.

[c] Used same parameters as Freeway Service Patrols – no research found.

[d] *Desktop Reference for Crash Reduction Factors* Report No. FHWA-SA-07-015, Federal Highway Administration, U.S. DOT, September, 2007, p.89.

[e] *An Investigation of User Costs and Benefits of Winter Road Closures*, Final Report – June 2005, sponsored by University Transportation Centers Program, U.S. Department of Transportation (MTC Project 2003-01).

Once benefit parameters are calculated, they are monetized in order to permit direct comparison of the various benefits categories. IDAS contains default benefit parameters but WisDOT recently provided a set of draft parameters in a recently issued draft of the WisDOT *Traffic Guidelines Manual, 16-20-70, Financial Assumptions for Engineering Economic Analysis*, January 2008. These parameters are incorporated into the analysis and are shown in Table 3.2. All dollar values used in the analysis are in 2007 dollars, in order to facilitate comparison of alternatives across different years.

Table 3.2 Economic Parameters

General Parameters	Value
Number of travel days in a year	260
Year of dollar values	2007
Discount rate	5%
Average vehicle occupancy	1.25
Value of Time (Dollars per Hour)	
Value of in-vehicle time	$9.14
Value of in-vehicle time (commercial)	$20.44
Value of out-vehicle time (commercial)	$20.44
Value of out-vehicle time	$9.14
Value of reduced delay time	$9.14
Fuel costs (gallon)	$2.79
Emission Cost (Dollars per Ton)	
HC/ROG	$2,529.30
NOX	$5,319.51
CO	$5,544.78
PM_{10}	$15,777.47
CO_2	$5.08
SO_2	$5.08
GW	$0.00
Accident Cost (Dollars per Accident)	
Fatality	$4,092,800
Injury	$48,576
Property damage	$2,251
Operating Costs	
Fuel costs (gallon)	$2.79
Nonfuel operating costs (dollars per mile)	$0.09
Noise damage Costs (dollars per mile)	$0.009

3.1 SUMMARY OF RESULTS

The results are presented as a stream of benefits and costs between the years of 2015 and 2035 with all costs and benefits expressed in 2007 dollars. The tables represent the discounted values of the benefits and costs over the entire 20-year period. This provides a realistic look at the system benefits, which will increase over time as traffic growth occurs in the corridor.

Tables 3.3 through 3.7 summarize the five scenarios while Table 3.8 shows the total benefits and costs for the entire U.S. 41 study corridor. Net benefits equals total benefits minus annualized cost, while the benefit/cost ratio is total benefits/annualized cost. Annualized cost accounts for the initial capital cost, replacement costs based on the life of the equipment, and the annual cost of operations and maintenance.

Table 3.3 Scenario A: U.S. 41 Green Bay Area

20-Year Benefit/Cost Summary 2015 to 2035 in 2007 Dollars ($000)

Deployments	Travel Time	Accident Reduction	Operating Cost	Environmental	Cost Savings	Total	Annualized Cost	O&M Costs	Net Benefits	B/C Ratio
Freeway Management System	$14,817	$1,598	$8,131	$2,510	$0	$27,056	$9,666	$316	$17,390	2.8
Crash Investigation Sites	$7,940	$451	$2,241	$0	$0	$10,632	$1,156	$4	$9,476	9.2
Enforcement Pads	$152	$440	$49	$358	$0	$999	$120	$0	$879	8.3
Traffic Gates	$618	$770	$0	$0	$27	$1,415	$185	$5	$1,230	7.6
Total Benefits	**$23,527**	**$3,259**	**$10,421**	**$2,868**	**$27**	**$40,102**	**$11,127**	**$324**	**$28,975**	**3.6**

Table 3.4 Scenario B: U.S. 41 Appleton Area

20-Year Benefit/Cost Summary 2015 to 2035 in 2007 Dollars ($000)

Deployments	Travel Time	Accident Reduction	Operating Cost	Environmental	Cost Savings	Total	Annualized Cost	O&M Costs	Net Benefits	B/C Ratio
Freeway Management System	$20,546	$2,519	$7,306	$2,821	$0	$33,192	$10,684	$313	$22,508	3.1
Crash Investigation Sites	$2,552	$310	$1,139	$0	$0	$4,001	$578	$2	$3,423	6.9
Enforcement Pads	$644	$470	$43	-$4	$0	$1,153	$120	$0	$1,033	9.6
Traffic Gates	$1,050	$1,015	$0	$0	$27	$2,092	$205	$5	$1,887	10.2
Total Benefits	**$24,792**	**$4,314**	**$8,488**	**$2,817**	**$27**	**$40,438**	**$11,587**	**$320**	**$28,851**	**3.5**

Table 3.5 Scenario C: U.S. 41 Oshkosh Area

20-Year Benefit/Cost Summary 2015 to 2035 in 2007 Dollars ($000)

Deployments	Travel Time	Accident Reduction	Operating Cost	Environmental	Cost Savings	Total	Annualized Cost	O&M Costs	Net Benefits	B/C Ratio
Freeway Management System	$7,702	$1,588	$6,170	$2,275	$0	$17,735	$5,851	$180	$11,884	3.0
Crash Investigation Sites	$1,904	$165	$629	$0	$0	$2,698	$1,070	$3	$1,628	2.5
Enforcement Pads	$220	$632	$29	$74	$0	$955	$160	$0	$795	6.0
Traffic Gates	$670	$795	$0	$0	$27	$1,492	$144	$4	$1,348	10.4
Total Benefits	**$10,496**	**$3,180**	**$6,828**	**$2,349**	**$27**	**$22,880**	**$7,225**	**$186**	**$15,655**	**3.2**

Table 3.6 Scenario E: I-43/STH 172/STH 32 Green Bay Area

20-Year Benefit/Cost Summary 2015 to 2035 in 2007 Dollars ($000)

Deployments	Travel Time	Accident Reduction	Operating Cost	Environmental	Cost Savings	Total	Annualized Cost	O&M Costs	Net Benefits	B/C Ratio
Freeway Management System	$6,480	$1,065	$5,026	$1,471	$0	$14,042	$6,212	$164	$7,830	2.3
Crash Investigation Sites	$1,077	$141	$707	$0	$0	$1,925	$506	$2	$1,419	3.8
Enforcement Pads	$9	$66	$5	$7	$0	$87	$30	$0	$57	2.9
Traffic Gates	$367	$491	$0	$0	$27	$885	$164	$4	$721	5.4
Total Benefits	**$7,933**	**$1,763**	**$5,738**	**$1,478**	**$27**	**$16,939**	**$6,912**	**$170**	**$10,027**	**2.5**

Table 3.7 Scenario F: U.S. 441 Appleton Area

20-Year Benefit/Cost Summary 2015 to 2035 in 2007 Dollars ($000)

Deployments	Travel Time	Accident Reduction	Operating Cost	Environmental	Cost Savings	Total	Annualized Cost	O&M Costs	Net Benefits	B/C Ratio
Freeway Management System	$6,480	$1,065	$5,026	$1,471	$0	$14,042	$6,212	$164	$7,830	2.3
Crash Investigation Sites	$760	$91	$330	$0	$0	$1,181	$506	$2	$675	2.3
Enforcement Pads	-$143	$123	$15	-$25	$0	-$30	$20	$0	-$50	-1.5
Traffic Gates	$312	$364	$0	$0	$27	$703	$82	$2	$621	8.6
Total Benefits	**$7,409**	**$1,643**	**$5,371**	**$1,446**	**$27**	**$15,896**	**$6,820**	**$168**	**$9,076**	**2.3**

Table 3.8 All Scenarios Combined

20-Year Benefit/Cost Summary 2015 to 2035 in 2007 Dollars ($000)

Deployments	Travel Time	Accident Reduction	Operating Cost	Environmental	Cost Savings	Total	Annualized Cost	O&M Costs	Net Benefits	B/C Ratio
Freeway Management System	$59,813	$7,519	$29,358	$10,148	$0	$106,838	$39,291	$1,178	$67,547	2.7
Crash Investigation Sites	$14,354	$1,269	$5,466	$0	$0	$21,089	$3,814	$12	$17,275	5.5
Enforcement Pads	$881	$1,730	$138	$409	$0	$3,158	$450	$0	$2,708	7.0
Traffic Gates	$3,014	$3,432	$0	$0	$27	$6,473	$779	$19	$5,694	8.3
Total Benefits	**$78,062**	**$13,950**	**$34,962**	**$10,557**	**$27**	**$137,558**	**$44,334**	**$1,209**	**$93,224**	**3.1**

3.2 FREEWAY SERVICE PATROL ANALYSIS

An independent evaluation was conducted on the operation of Freeway Service Patrols (FSP) in the U.S. 41 Corridor. The proposed service would utilize one vehicle along the corridor during peak periods and weekends. The cost estimate and service plan are shown in Table 3.9.

Table 3.9 Proposed Freeway Service Patrol Plan for Northeast Region

Time of Service	Hours	Days per Year	Cost per Hour	Cost
AM Peak	6:00 a.m. to 9:00 a.m.	260	$65	$50,700
PM Peak	3:00 p.m. to 6:30 p.m.	208	$65	$47,320
Friday afternoon	2:00 p.m. to 8:00 p.m.	52	$70	$21,840
Saturday	10:00 a.m. to 4:00 p.m.	52	$70	$21,840
Sunday	11:00 a.m. to 6:00 p.m.	52	$70	$25,480
Total				**$167,180**

WisDOT currently runs similar services along the Beltline in the Madison area. While these services vary in the way they are now provided, WisDOT is planning to convert all services to a contract system in which private tow companies will be hired to provide the service, including vehicles. Costs used were based on actual FSP experience in the Southeast and Southwest Regions. Operation was assumed only on U.S. 41, not the highways covered under Scenarios E and F. Two different analyses were conducted; one assumed the FSP would operate for only three years, primarily to mitigate construction delay, while the second assumed permanent operation with an analysis period of 20 years. The results are shown in Table 3.10. Both scenarios showed high-benefit/cost ratios but it is important to note that this is partly due to the fact that only operating costs were allocated to the FSP. The effectiveness of FSP is enhanced by the capital investments made in the Freeway Management System, including CCTV and Dynamic Message Signs.

Table 3.10 Freeway Service Patrol Operation for U.S. 41 Only ($000)

	Benefits				Costs			
Freeway Service Patrols	Travel Time	Accident Reduction	Operating Cost	Total Present Value Benefits	Net Present Value of Cost	Average 20-Year Discounted O&M Cost	Net Present Value	B/C Ratio
Twenty-Year Operation								
Green Bay	16,943	1,075	5,402	23,420	1,125	53.5	22,295	20.8
Appleton	12,536	754	2,739	16,029	563	26.8	15,466	28.5
Oshkosh	6,891	589	2,194	9,674	563	26.8	9,111	17.2
Three-Year Operation								
Green Bay	1,954	203	1,076	3,233	239	79.6	2,994	13.5
Appleton	4,310	259	942	5,511	120	39.8	5,391	45.9
Oshkosh	2,369	203	755	3,327	120	39.8	3,207	27.7

Smart Work Zones

Both the use of Smart Work Zones and their benefits and costs will vary over time, depending on the amount and complexity of construction activity. For that reason, a single deployment was tested in the Fox Valley area for a closing of the STH 21 and STH 26 interchanges. These closures result in disbenefits that are mitigated to some degree by the Smart Work Zone. The benefits are primarily in travel time savings, as motorists receive warnings of congestion and can change their route to avoid it. This example shows that the Smart Work Zone mitigates approximately half the disbenefits caused by the construction activity and has a high-benefit/cost ratio. Like FSP's the high-benefit/cost ratio is partly a function of support from the Freeway Management System, which processes data from the SWZ and provides information to the public. The benefit/cost ratio also will vary significantly based on the volume of traffic impacted. It also should be noted that SWZ's can have a negative impact on crash rates by diverting traffic from limited access highways to lower functioning roads.

Table 3.11 Smart Work Zone Analysis ($000)

Sample Construction Project with Smart Work Zone	
Disbenefits due to Construction Delays	
Travel Time	($751,000)
Accident Reduction	($4,052,000)
Operating Cost	($229,000)
Environmental	($748,000)
Total	($5,780,000)
Smart Work Zone Benefits	
Travel Time Benefits	$2,754,000
Annualized Cost	$95,000
Net Benefits	$2,659,000
B/C Ratio	**29**

Conclusions of Analysis

All of the proposed deployments show significant net benefits over the analysis period with the Freeway Management System deployments showing positive cost benefit/ratios of $2 to $4 in benefits for each dollar spent. This is consistent with B/C ratios found in similar corridors that combine rural and small and midsized urban areas.

The majority of benefits realized are in travel time with significant savings realized in both fuel cost reduction and crash reduction. Over the five scenarios, travel time accounts for about 55 percent of the total benefits. The Freeway Management System, consisting of DMS, CCTV, and detection, provides just fewer than 80 percent of the total benefits. While enforcement pads and CIS have relatively low benefits, they also have low capital costs and minimal operations and maintenance costs. As a result these deployments show a good benefit/cost ratio over the entire analysis period. The benefits of traffic gates are mainly dependent on how often they are used. The benefit/cost ratio is relatively low across the entire 20-year analysis period.

Both Freeway Service Patrols and Smart Work Zones showed high-benefit/cost ratios, although the FSP benefits from investments made in the Freeway Management System. Smart Work Zones provide significant travel time savings but also divert traffic to lower functional roads, which can drive up crash rates. Both of these options were deferred for later consideration due to funding concerns.

WisDOT currently is continuing with the programming and design process for these projects. They are being packaged together with proposed major construction projects in the corridor. The maps in Appendix A show the proposed ITS program and programming strategy as of May 2008.

A. U.S. 41 Project Integration Maps

Included in Appendix A are a series of maps developed to demonstrate how the U.S. 41 Programmed Majors will complement and coordinate with additional planned projects, such as the STH 172/IH 43 TMP and the U.S. 41/U.S. 10/ STH 441 Major projects. Deployment locations were determined by WisDOT staff based on a review of the previously described cost-benefit analysis conducted on the project locations identified in the TransCore U.S. 41 Corridor Traffic Management Plan. These maps were prepared as a resource for WisDOT to aid the ongoing planning and long-range visioning of U.S. 41 operations/ITS investment.

Figure A.1 U.S. 41 Corridor Projects

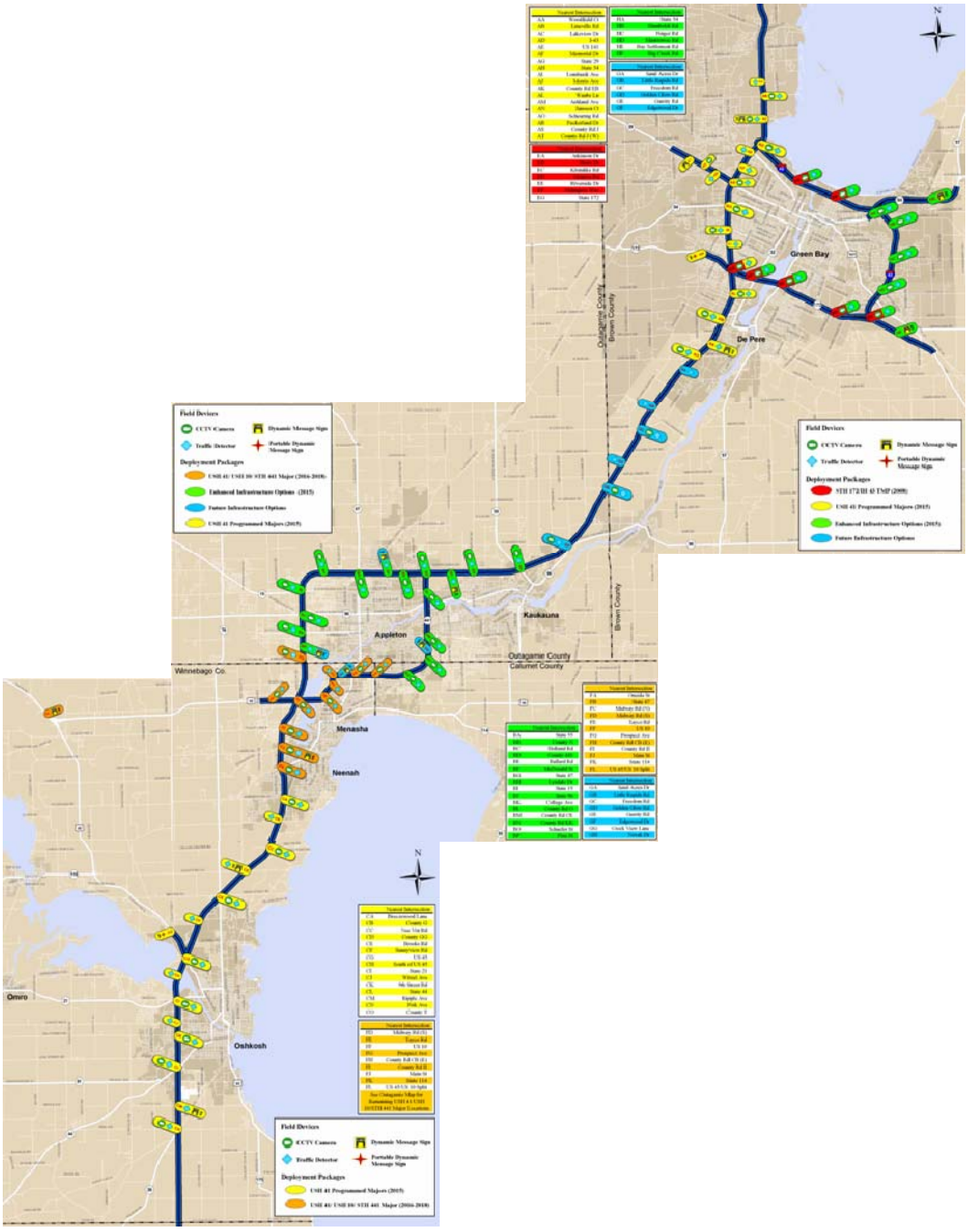


Figure A.2 Brown County Projects

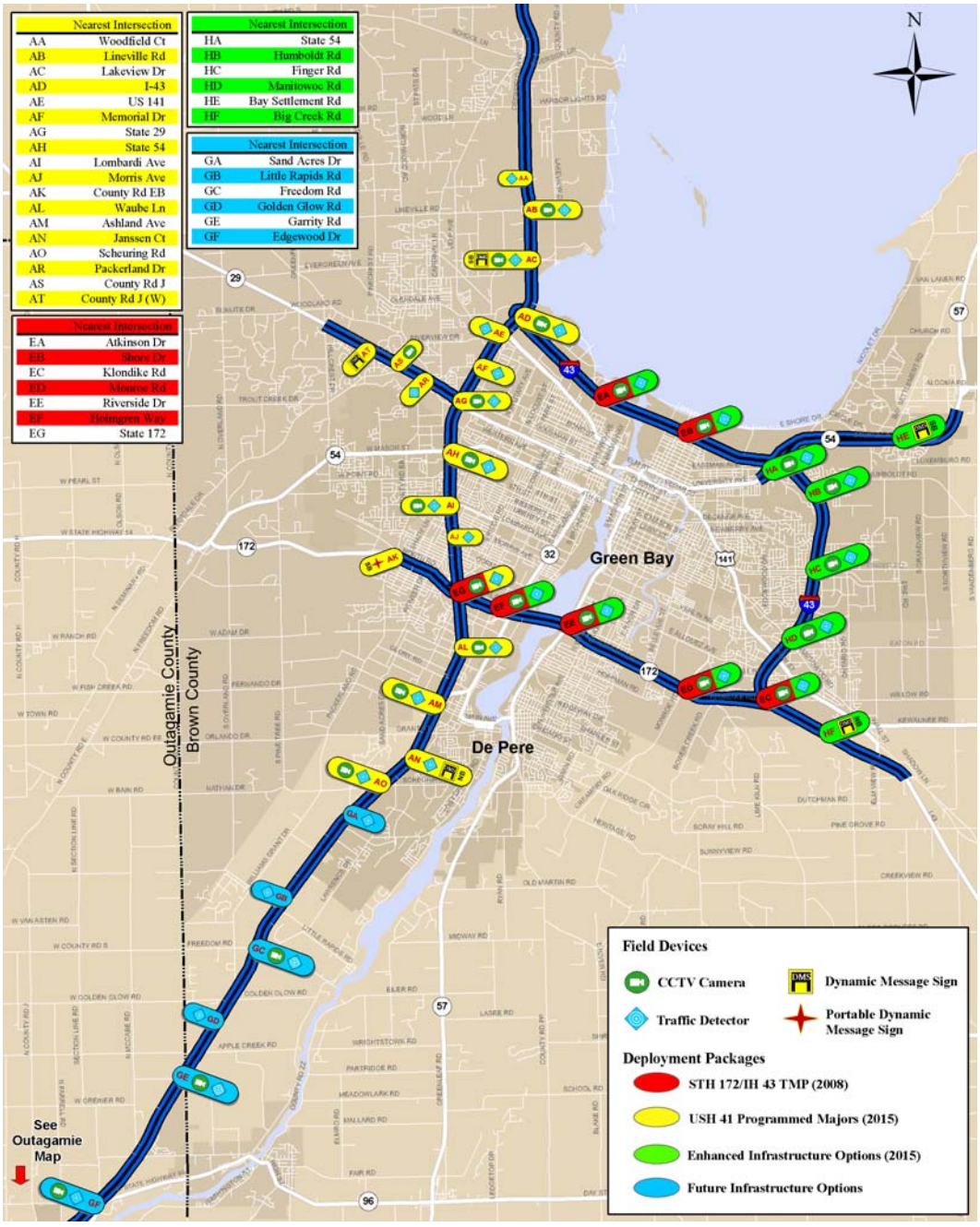


Figure A.3 Outagamie County Projects

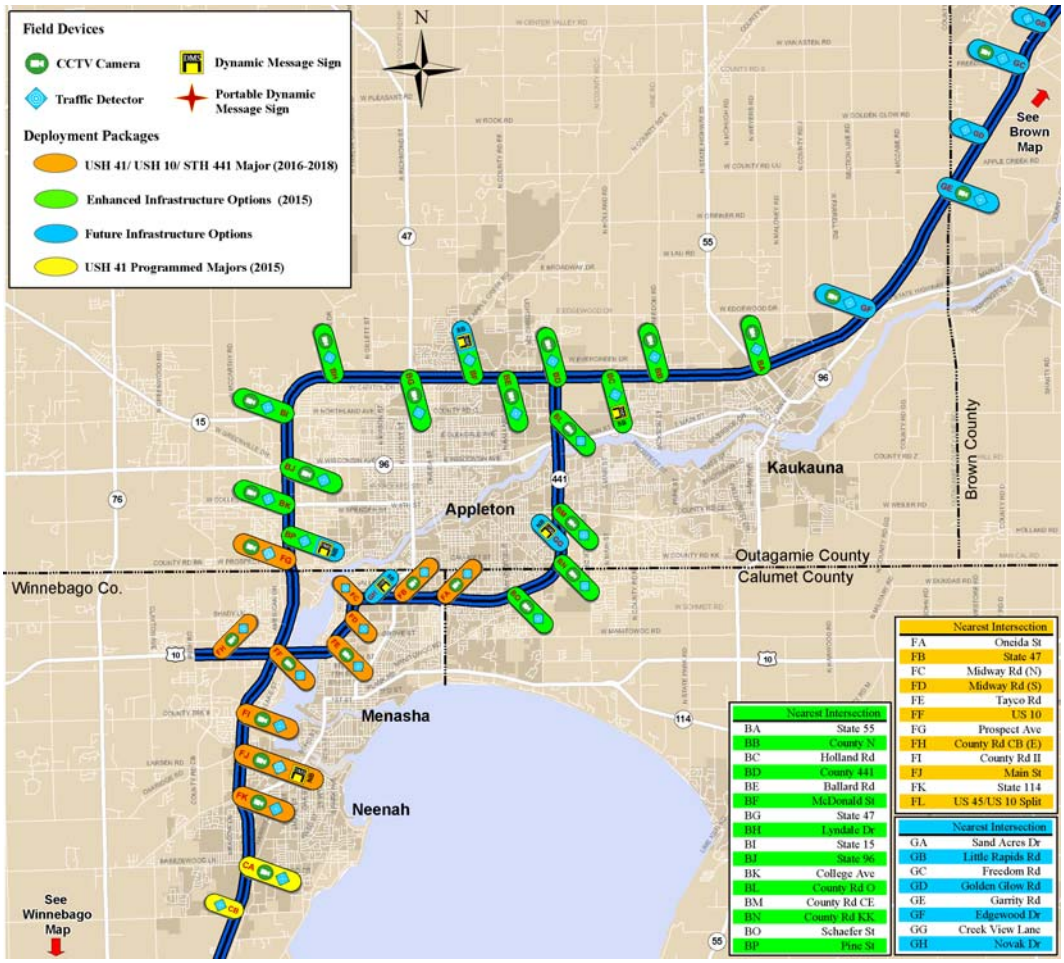
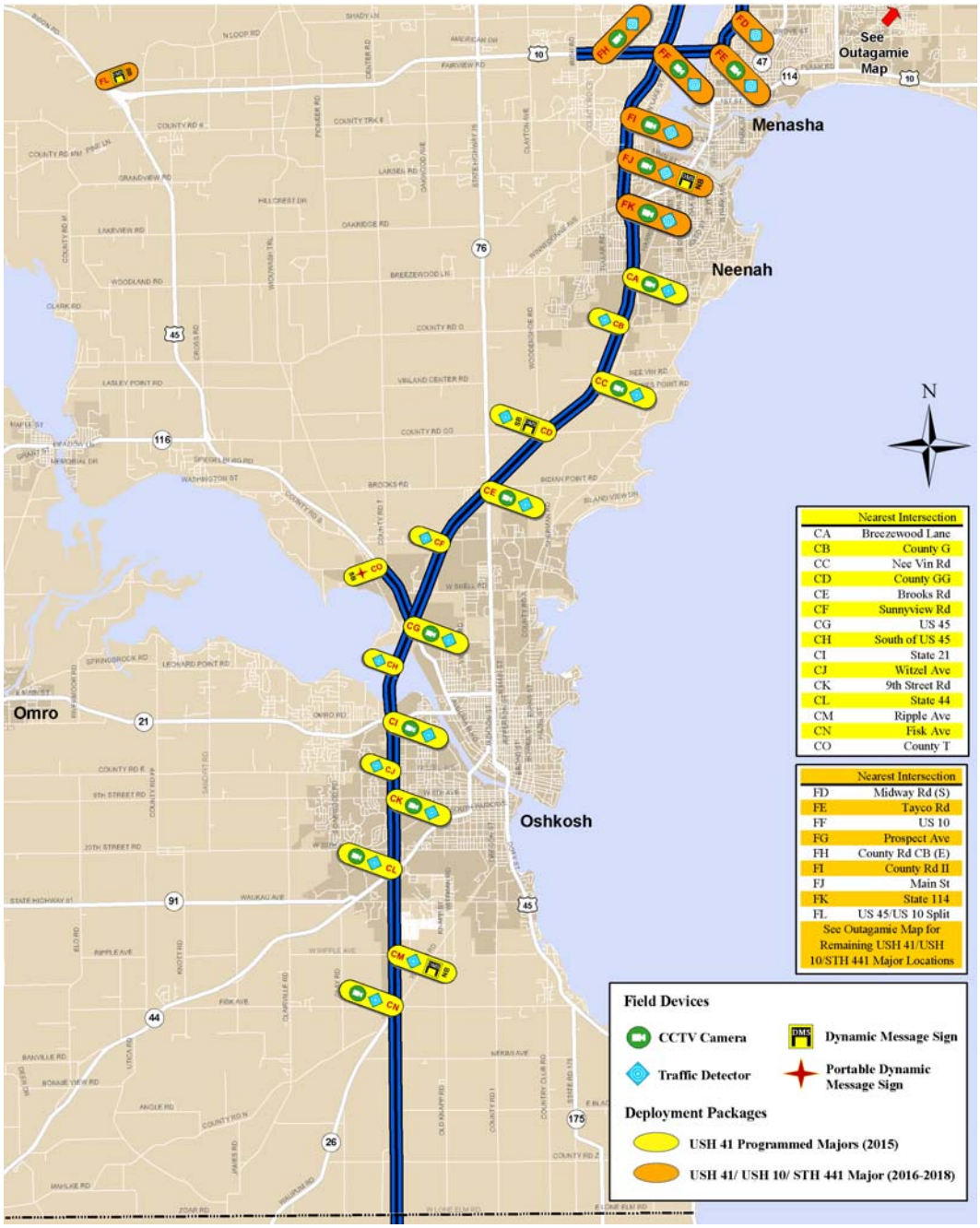


Figure A.4 Winnebago County Projects



B. IDAS Description

Appendix B presents a brief overview of the IDAS software used to conduct the benefit/cost analysis for this project. More detail on IDAS can be found at http://idas.camsys.com/. The tool being used in the evaluation is the ITS Deployment Analysis (IDAS) system. This software package was used to conduct the benefit-cost analysis of ITS alternatives. IDAS is a sketch-planning software and analysis methodology developed by Cambridge Systematics for the Federal Highway Administration (FHWA).

IDAS was developed to assist state, regional, and local agencies in integrating ITS into the transportation planning process. Planners and others can use IDAS to calculate relative costs and benefits of ITS investments. IDAS currently can predict costs, benefits, and impacts for more than 60 types of ITS investments in combination or isolation.

In order to be consistent with current transportation planning processes, IDAS operates as a postprocessor to travel demand models used by Metropolitan Planning Organizations (MPO) and by state Departments of Transportation (DOT). IDAS, although a sketch-planning tool, can implement the modal split and/or traffic assignment steps associated with a traditional planning model. These steps are key to estimating the changes in modal, route, and temporal decisions of travelers resulting from ITS technologies. For this analysis, there are two models being utilized, one from the Green Bay MPO region and one from the Fox Valley MPO region. Since these models were developed as part of a statewide model development effort, the methodology used is consistent.

There are a wide range of ITS improvements that can be assessed in IDAS, including Freeway Management Systems, Advanced Public Transit Systems, Incident Management, Emergency Management, Advanced Traveler Information Systems and many others. The set of impacts evaluated by IDAS included changes in user mobility, travel time/speed, travel time reliability, fuel costs, operating costs, accident costs, emissions, and noise. The performance of selected ITS options can be viewed by market sector, facility type, and district. IDAS is comprised of the following five different analysis modules:

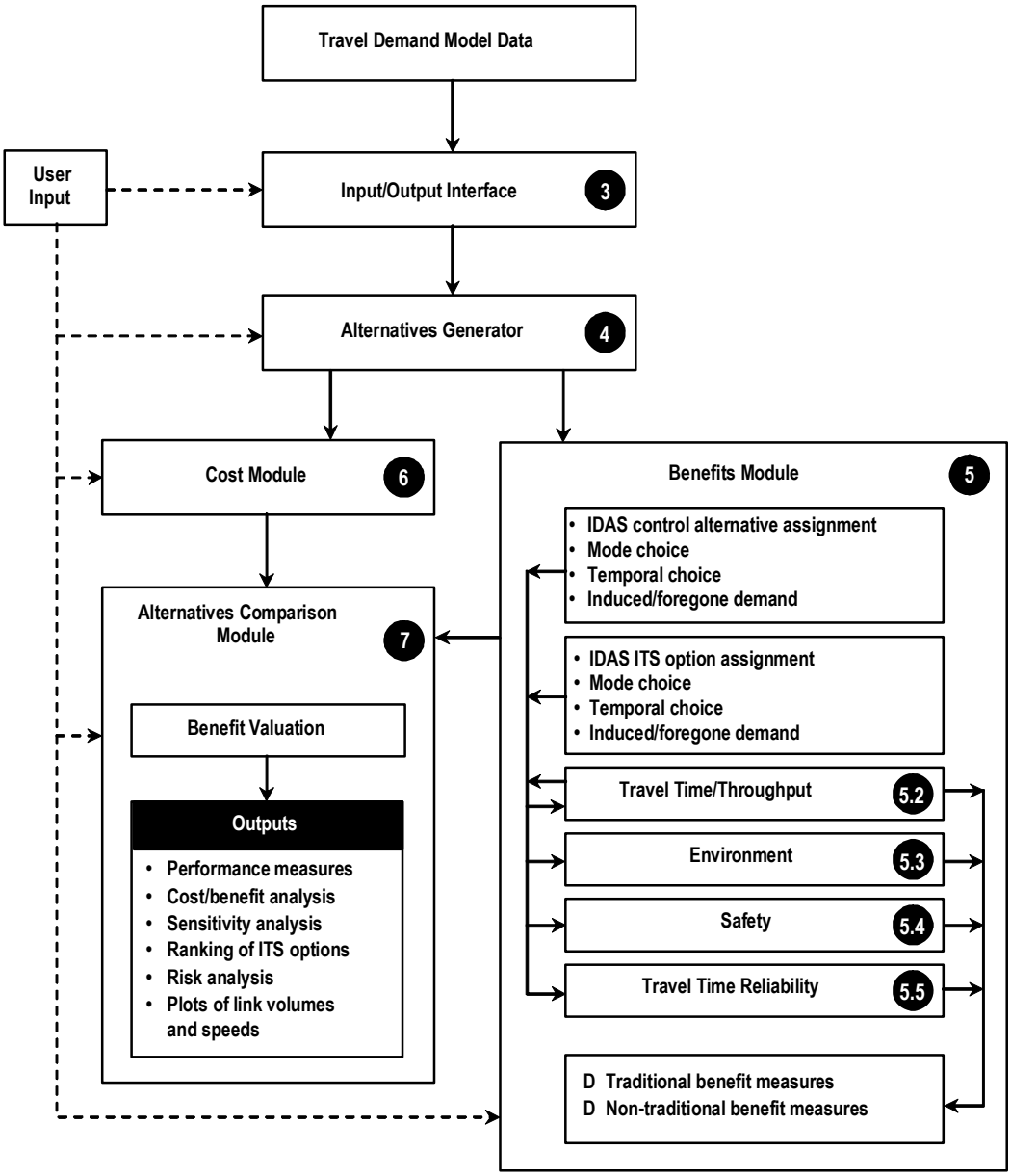
- Input/Output Interface Module (IOM);
- Alternatives Generator Module (AGM);
- Benefits Module;
- Cost Module; and
- Alternatives Comparison Module (ACM).

The input/output interface is used to specify and translate the data files provided by the regional travel demand models, and convert the data into a

format that can be used internally by the IDAS model. The alternatives generator module allows an analyst to use a graphical user interface (GUI) to define and code ITS improvements into IDAS.

IDAS estimates both traditional benefits of ITS deployment (e.g., improvement in average travel time) and nontraditional benefits (e.g., reduction in travel time variability). The cost module allows the user to define the incremental costs of the various ITS deployments being studied, including capital costs, and operating and maintenance costs. The user can modify IDAS-supplied default values for the proportion of the costs borne by the public and private sectors. Finally, the alternative comparison module provides the analyst with information regarding the value of user benefits from ITS deployments, the associated costs of the deployments, and a comparison of the benefits and costs for different ITS deployment options.

Figure B.1 IDAS Model Structure



The specific performance measures generated by IDAS include the following:

- Vehicle miles of travel (VMT);
- Vehicle hours of travel (VHT);
- Average speed;
- Person hours of travel (PHT);
- Number of person trips;

- Number of accidents:
  - Fatality;
  - Injury; and
  - Property damage only.
- Travel Time Reliability (hours of unexpected delay);
- Fuel Consumption (gallons); and
- Emissions:
  - Hydrocarbon and reactive organic gases;
  - Carbon monoxide;
  - Nitrous oxides; and
  - PM_{10}.

IDAS Benefit-Cost Summary, details the results of the benefits valuation (value of time saved, value of accident reductions, etc.), cost analysis of the ITS option, net annual benefit, and benefit-cost ratio. These include the following:

- Annual Benefits:
  - Change in user mobility;
  - Change in user travel time (in-vehicle, out-of-vehicle, and travel time reliability);
  - Change in costs paid by users (fuel costs, nonfuel operating costs, and accident costs – internal only);
  - Change in external costs (accident costs – external only, HC/ROG, NO_x, CO, PM_{10}, CO_2, global warming, noise, other mileage-based external costs, and other trip-based external costs);
  - Change in public agencies costs (efficiency included);
  - Other calculated benefits; and
  - User-defined additional benefits.
- Annual costs:
  - Average annual private sector costs; and
  - Average annual public sector costs.
  - Net benefit (annual benefit minus annual cost); and
  - B/C ratio (annual benefit/annual cost).