Working Paper #2

Metrics for Transportation Investments that Support Economic Competitiveness, Social Equity, Environmental Stewardship, Public Health, and Livability

The Economics of Land Use

Prepared for:

Project Stakeholder Group (PSG) Meeting #2

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I. Readers Guide

This is the second in a series of Working Papers prepared for the Minnesota Department of Transportation (MnDOT) and Smart Growth America that presents a new framework for evaluating transportation projects based on established and emerging practices in the field of public sector Return on Investment (ROI). The Working Paper #2 is organized around the following chapters:

Chapter II: Purpose and Scope. This Chapter provides an overview of Working Paper #2 and its role in the overall study process. Ultimately the broader study may provide direction for implementing a broad-based ROI process that helps inform MnDOT policy and budget decision-making.

Chapter III: ROI Summary for "Test Case" MnDOT Projects. This Chapter presents an overview of an illustrative ROI analysis conducted for a selected set of MnDOT transportation projects. The calculations are designed to serve as a template to test the utility of this type of analysis going forward. A detailed description of these calculations is provided in **Appendices A - C**. The selected projects are described below with a summary of their ROI performance provided in **Figure S-1**:

1. **Downtown Red Wing Main Street/US 61 Improvements**: Multiple "Complete Streets" improvements to Main St (US 61) in Downtown Red Wing that will improve accessibility and safety, support active transportation, economic development and tourism, and reduce environmental impacts.

2. **Winona Bridge Rehabilitation and Expansion**: Rehabilitation of a historic and potentially unsafe bridge over the Mississippi River and development of an adjacent bridge with improved bike/ped facilities and links to existing trails and recreational facilities. The project also expands vehicular capacity from two to four lanes and avoids costly detour during the construction period or in the event of other needed closures of one of the adjacent bridges.

3. **I-35W North Managed Lanes Corridor**: A set of improvements and transportation management initiatives (including expansion of MnPASS) along this heavily traveled corridor designed to reduce congestion while accommodating increased auto and transit trips. These improvements and initiatives are expected to increase total trips without affecting total vehicle emissions due to improved vehicle flow and optimized travel speeds that lower emissions per vehicle.

Chapter IV: Next Steps: This chapter recommends a course of action for further analysis and solicits input from the Project Stakeholder Group (PSG) related to the selected projects, applied ROI methodologies, and implications. It also provides a summary of the next steps in this study effort in terms of future meetings and related research and deliverables.

Appendices A, B and C: Provide details on the illustrative ROI calculations conducted for each of the three projects described above, including methodology and assumptions.

Figure S-1: Summary of ROI Metrics Applied to Selected MnDOT Projects

	Downtown Red Wing Main Street/US 61 Improvements		Winona Bridge Rehabilitation and Expansion		I-35W North Managed Lanes Corridor	
ROI Category	Monetized Impacts	Equity Considerations	Monetized Impacts	Equity Considerations	Monetized Impacts	Equity Considerations
Economic Development & Competitiveness						
Travel time savings	**$2,423,000**		**$28,000,000**		**$429,710,000**	
Improved travel reliability (less non-re-occurring delay)	**$626,000**		Not quantified / likely moderate		Not quantified / likely significant	
Vehicle operating costs	Not quantified / negligible		Not quantified / negligible		**($41,190,000)**	
Improved market access	Not quantified / likely significant but partially overlap with livability estimates below		Not quantified / likely small		Not quantified / likely significant	
Market agglomerations						
Environmental Stewardship						
Improved energy efficiency / pollution reduction	Not quantified / likely moderate		Not quantified / likely moderate and short-term		Pollution reduction per trip offset by increased VMT	
Land preservation	Not quantified / likely small		Not quantified / likely small		Not quantified / negligible	
Reduced stormwater run-off	**$722,000**	The primary beneficiaries are residents of rural communities in and around Red Wing with a mean household income of ≈ 95% of State Avg. Project also improves ADA facilities.	Not quantified / likely moderate and negative	The primary beneficiaries are residents of rural communities in and around Winona County with a mean household income of ≈ 80% of State Avg. According to the EA "There are no readily-identifiable low-income or minority populations (adversely) affected by the Project"	Not quantified / negligible	Mapping of population and income-profiles along the route of the proposed managed lanes as well as at the major origin and destination concentrations is needed to address perceptions that key benefits accrue to wealthy. Transit improvements may also result, depending on implementation.
Habitat preservation	Not quantified / negligible		Not quantified / likely moderate and negative		Not quantified / negligible	
Public Health						
Safety (reduced crashes)	**$5,395,000**		Not quantified / likely significant		**$720,000**	
Supporting active transportation choices	**$1,600,000**		**$2,600,000**		Not quantified / likely moderate	
Improved access to health care	Not quantified / likely small		Not quantified / likely small		Not quantified / likely moderate	
Human exposure to contaminants	Not quantified / negligible		Not quantified / likely negligible		Not quantified / likely moderate	
Livability						
Supporting "Place-making" efforts	Captured by bike / ped. accessibility		**$1,700,000**		Not quantified / likely moderate	
Improved access to commercial, cultural, recreational assets	**$1,900,000**		Not quantified / likely high		Not quantified / likely moderate	
Improves the commute experience	Not quantified / likely moderate		Not quantified / likely small		Not quantified / likely moderate	

II. PURPOSE AND SCOPE

This Working Paper #2 provides illustrative calculations for a select set of ROI metrics applied to three separate MnDOT projects. It builds on Working Paper #1 which introduced a new framework and set of metrics for evaluating transportation investment "returns" focused on outcomes likely to be of interest to a broad set of stakeholders and the general public. These outcomes include traditional metrics such as travel time, reliability, and safety, as well as broader considerations such as economic competitiveness, social equity, environmental stewardship, public health, and livability.

The goal of Working Paper #2 is to drill down on the ROI metrics and methodologies described in Working Paper #1 to illustrate how they can be applied to specific projects. Detailed ROI calculations are provided for three transportation projects selected in consultation with MnDOT staff to cover a range of issues and circumstances that are likely to be relevant to future transportation programming, prioritization, and planning going forward. In addition to demonstrating the rationale and overall utility of applying a broad-based ROI framework to inform MnDOT policy and budget decision-making, the illustrative ROI calculations presented here help answer the following inter-related questions:

- What types of transportation projects and programs are likely to be the most amendable to broad-based ROI analysis?
- Are the available analytical approaches and methodologies applied to the ROI categories described herein likely to generate results that are reliable and credible?
- What are the data limitations and potential solutions to developing more accurate ROI results? What additional data should be collected by MnDOT to better assess the performance of the state highway system?
- How and where can/should MnDOT best expand its use of ROI analysis going forward to incorporate the metrics and methodologies being developed through this project?

III. ROI SUMMARY FOR "TEST CASE" MNDOT PROJECTS

This chapter presents the results of illustrative ROI analysis for a selected set of MnDOT transportation projects. The calculations are designed to serve as a template to test the utility of this type of analysis going forward. As noted, projects were selected based on consultation with MnDOT staff and cover a range of circumstances and issues. In addition, the analysis focuses on projects and metrics that demonstrate discernable impacts related to the key ROI categories identified as important to this study effort.

Finally, data availability is also a consideration since by definition effective ROI analysis requires accurate information related to costs and expected outcomes under "build" and "no-build" scenarios. The analysis is based on readily available data and information gathered by EPS or provided by MnDOT staff. While the scope, resources, and schedule for this current study effort do not allow for extensive primary research (e.g., surveys, on site data collection, extensive review of pertinent data bases), we seek input from PSG members on additional data and information that might improve accuracy.

Three initial "test case" MnDOT projects are considered here:

1. Downtown Red Wing Main Street/US 61 Improvements
2. Winona Bridge Rehabilitation and Expansion
3. I-35W North Managed Lanes Corridor

The sections that follow provide information for each of the above projects related to:

- **Project scope and purpose**: Provides a description of the size, primary purpose, cost, and other key features of the project, including assumed baseline and "no-build" conditions.
- **Overview of Project ROI analysis**: Provides an overview of the project's performance for each of the ROI categories considered in this study.
- **Findings and implications for future ROI**: Discusses the issues and implications presented by ROI calculations for the test case projects.
- **Illustrative calculations for selected ROI Metrics (Appendix A)**: This detailed Appendix presents a methodology and illustrative calculations for particular ROI categories.

1. RED WING MAIN STREET/US 61 IMPROVEMENTS

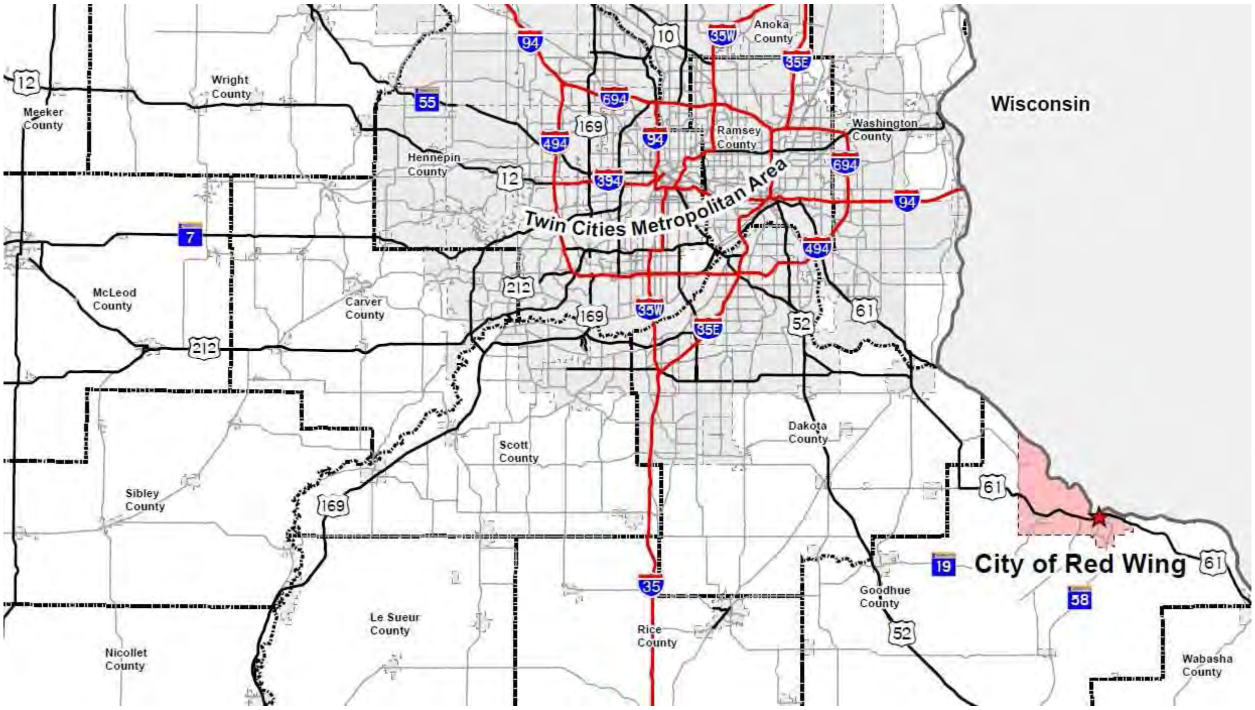

Image courtesy of City of Red Wing TH 61 CIMS Application

The portion of Highway 61 that runs through Red Wing includes a .7 mile stretch, known locally as Main Street, that serves as the primary transportation corridor through a thriving downtown (outlined in dotted red in the map below). It functions as the commercial focal point for a City that attracts tourists from throughout the United States (and abroad) and is included in the "distinctive destinations list" by the National Trust for Historic Preservation. This segment of Minnesota Trunk Highway (TH) 61 is also part of the "Great River Road", a national Scenic Byway of the Mississippi that runs from the headwaters south to New Orleans.

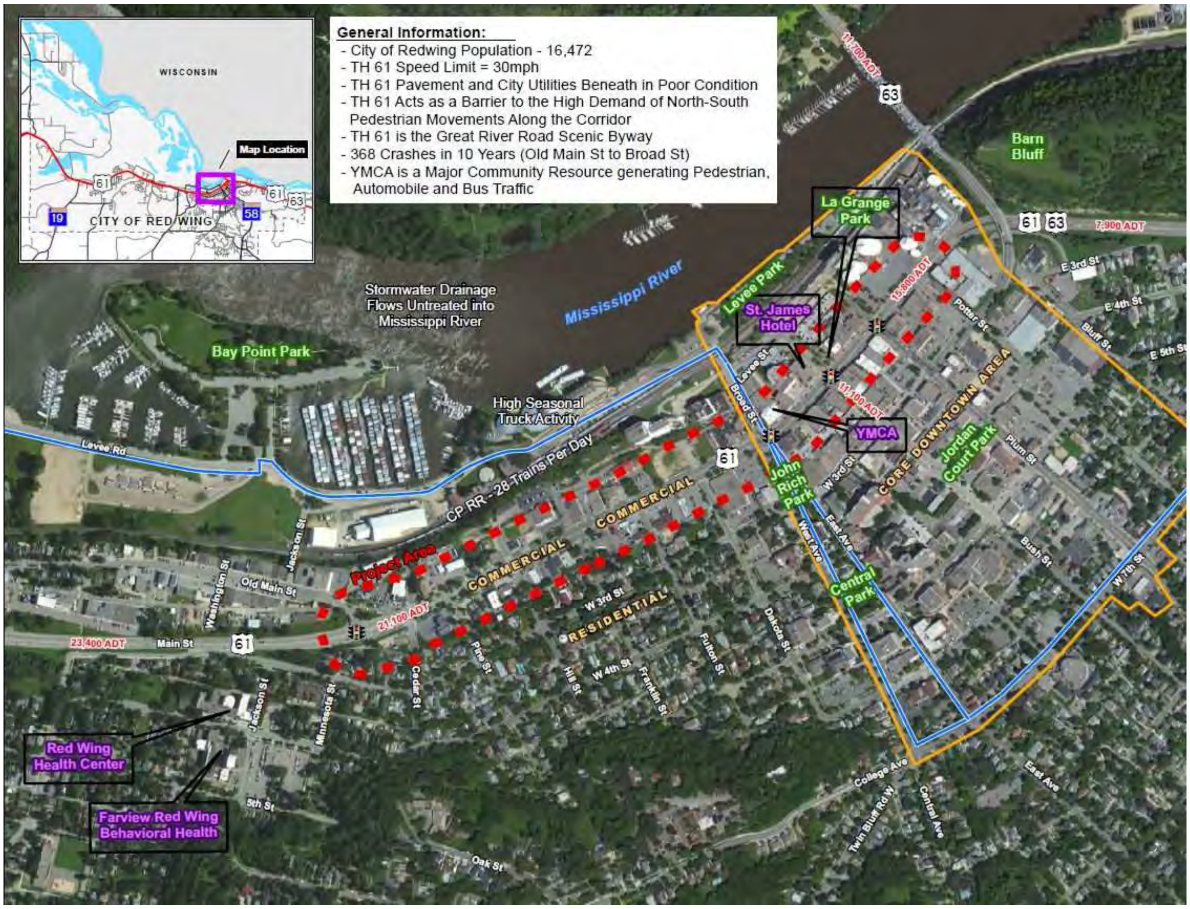

Image courtesy of City of Red Wing TH 61 CIMS Application

The proposed $5.4 million joint MnDOT/City of Red Wing investment would enhance the circulation and access in this central corridor through a variety of “Complete Streets” improvements that include narrowing of travel lanes, enhancing multimodal travel, adding key streetscaping elements, and replacing utilities. The specific improvements include:

- Full pavement reconstruction and utilities replacement (water, storm, sanitary);
- New and improved median islands, pedestrian bump-outs, and bike/ped amenities (seating, waste receptacles/recycling, bike racks);
- Closure of 12 out of 25 driveway accesses in the project corridor and narrowing overall roadway pavement section with the use of 11' travel lanes (thus increasing the boulevard width by 3' on either side of the roadway);
- Improved Americans with Disabilities Act (ADA) facilities; includes redesigning existing curb ramps;
- Mid-block pedestrian crossings, including median refuge and High-Intensity Activated crossWalk (HAWK) signal system

- Re-configured parking, Accessible Pedestrian Signal (APS) system, narrowed roadway crossings, improved pedestrian plaza, removed free U-turn movement, and a bus pullout; and
- Decorative and efficient pedestrian/roadway lighting and landscaping (street trees, planted boulevards medians as well as gateway and historic district identity features (way finding signage, banners, bollards).

Overview of Project ROI Analysis

Figure 1 summarizes the Red Wing Main Street/US 61 improvements based on the ROI framework proposed for this study. The information includes analysis conducted previously using MnDOT PRISM methodology as well as additional ROI analysis by EPS (as detailed in **Appendix A**). As shown, this "complete streets" project improves transportation accessibility and safety, supports multi-modal travel options, enhances "place-making" efforts, and reduces TH 61's environmental impacts. The monetized value of these benefits is estimated at $12.6 million which results in a total benefit-cost ratio of about 3.6 (assuming future costs and benefits over a 20 year period are converted to current values based on a 2.5 percent discount rate).

Figure 1 ROI Overview for Red Wing Main St. Improvements

ROI Category	Potential Impacts Identified	Estimated Monetized Impacts		Equity Considerations
Economic Development & Competitiveness				The primary beneficiaries are residents of rural communities in and around Red Wing with a mean household income of ≈ 95% of State Avg. Project also improves ADA facilities.
Travel time savings	Improved vehicle flow	**$2,423,000**	MnDOT analysis	
Improved travel reliability (reduced non-re-occurring delay)	From improved vehicle flow and reduced crashes	**$626,000**	MnDOT analysis	
Improved market access	Potential induced travel demand and related economic activity	Not quantified / likely significant but partially overlap with livability estimates below		
Market agglomerations	Resulting from improved Downtown market conditions and increase in development intensity			
Environmental Stewardship				
Improved energy efficiency / pollution reduction	From improved vehicle flow and less congestion / potentially offset by induced travel demand	Not quantified / likely moderate		
Land preservation	Supporting access, circulation in existing urban infill location	Not quantified / likely small		
Reduced stormwater run-off	Reduced impervious land area	**$722,000**	See Figure 11	
Habitat preservation	Unlikely since located in existing urban area	Not quantified / negligible		
Public Health				
Improved travel safety (reduced crashes)	Signalization / closure at dangerous intersections	**$5,395,000**	MnDOT analysis	
Supporting active transportation choices	Increased bike / ped. activity	**$1,600,000**	See Figure 7	
Improved access to health care	Resulting from improved travel conditions	Not quantified / likely small		
Human exposure to contaminants	Unknown	Not quantified / negligible		
Livability				
Supporting "Place-making" efforts	Improved circulation, walkability, bike / ped. access, and urban design, of a historic district	Captured by bike / ped. Accessibility		
Improved access to local commercial, cultural, recreational assets		**$1,900,000**	See Figure 6	
Improves the commute experience	Due to mode shift and streetscape improvements	Not quantified / likely moderate		

The key ROI benefits illustrated in **Figure 1** are also summarized below.

- **Economic Competitiveness**: MnDOT has previously calculated the direct user benefits associated with travel time and reliability improvements that are expected from closing some of the existing accesses lanes on TH 61, reducing the number of locations where right turning vehicles can slow down traffic. The "complete street" improvements may also increase customer traffic in the downtown for tourists and local residents, incentivize additional development intensity, and ultimately foster unique mix of synergistic uses and interactions that increases economic productivity. These impacts are not quantified and may partially overlap with "livability" benefits discussed below that are monetized based on increased property values.

- **Environmental Stewardship**: The primary environmental benefit evaluated as part of this analysis relates to reduced stormwater runoff that results from a decline in the total impervious square feet within the project area (e.g. more landscaped areas). While the values are small relative to total project costs, the data and calculations are relatively straight-forward and could easily be incorporated into future ROI analysis.
- **Public Health (improved safety)**: MnDOT has also previously calculated direct user benefits associated with reduced auto-related crashes due to access management, median treatments, and geometric improvements. MnDOT has estimated that the monetized value of these safety improvements alone exceed the initial capital investment associated with the project.
- **Public Health (other)**: In addition, EPS has estimated significant public health benefits could result from increased pedestrian activity facilitated by the "complete streets" improvements. Active transportation has been linked with numerous health benefits including reduced risk of heart disease, stroke, diabetes, hypertension, and others. This analysis combines local data related to existing walking patterns by Red Wing residents with a variety of other studies related to induced impacts of pedestrian facilities and the monetized health benefits per mile walked.
- **Livability**: A variety of studies have shown that "complete street" improvements that enhance the access, circulation, and walkability to and within particular neighborhoods can be positively correlated with increases in property values. These benefits can be particularly relevant when they enhance access to / within "unique" locations that offer a set of attributes and qualities that are not easily replicated (e.g., a historic downtown). The calculations presented here assume the low end of this appreciation at one percent of value for properties that are within a walking distance from the downtown.

Methodological Consideration

Both the public health and livability estimates described above rely on a so-called "benefit transfer" methodology whereby impacts estimated in other settings are applied to Red Wing. Key methodological issues associated with this approach include: (1) how comparable are the transportation improvements relative to baseline conditions, (2) how similar are the affected populations and thus associated behavioral responses, and (3) other contextual circumstances such as the geography, climate, and existing land uses. **Appendix A** provides further discussion of these issues for the Red Wing context.

Image courtesy of streets.mn

Another methodological issue relates to the use of property value increases as a proxy for economic benefits attributable to the transportation improvements. This approach, while theoretically valid, can present a variety of measurement complexities related to double counting and distinguishing distributional from net new effects. For example, while "complete street" improvements may enhance property values, it can be difficult to disentangle or isolate the unique contribution of various factors, which may include improved auto travel, safety, market access, or the combined effect of all of these. Likewise, property value increases in one location may be the result of its improved competitive position visa-vi another, suggesting that at least a portion of the gains are distributional rather than net new.

Given these caveats, a one percent and one-time (e.g. non-compounding) property value increase is used in this case as a conservative estimate (at the bottom of value impacts found in other studies). Moreover, while property value appreciation may represent the combined effect of improved market access (e.g. increased customer traffic to the downtown), pedestrian safety, or other factors, double counting is less of an issue in this case since monetized values for these other impacts are not included in the ROI calculation. The vehicle travel time and safety, as well as public health benefits that are included are more clearly assigned to direct users than property owners per se.

Finally, in terms of net new versus distributional effects, it is worth noting that downtown Red Wing is already a key focal point within a City that itself serves as a super-regional, if not national, destination for "heritage" or cultural tourism. The attributes and amenities it provides are relatively unique and non-replicable within the local market. To the extent that the "complete streets" improvements further leverage the "sense of place" that already exists and supports the tourism trade, properties outside the downtown may experience spill-over market benefits that more than off-set any increase in local competition.

Implications for Future MnDOT Analysis

Complete streets type improvements can provide broad-based and inter-related benefits that, if monetized, can generate relatively high ROI results, especially since costs are often low in comparison to traditional capacity expansion projects. These benefits can include both direct user benefits such as travel time, vehicle operation and safety as well as benefits that are typically more difficult to quantify such as public health and livability. Accurately assessing these less traditional transportation performance metrics often requires case specific analysis of the existing urban context and land uses served by the new improvements as well as estimates of existing and projected multi-modal travel patterns. Of course, any such assessment should control for general trends and market growth and not assign 100 percent of a change to a transportation project.

The potential benefits from improved bicycle and pedestrian facilities can be especially hard to quantify because, unlike vehicle travel, data on existing participation rates (e.g., bicycle and pedestrian counts by location) is not generally tracked on a systematic basis. Nevertheless, studies on both the potential health and property value benefits derived from improved "walkability" and/or "bikeability" demonstrate positive impacts that can be monetized as part of an ROI analysis. Consequently, future MnDOT transportation planning should seek ways to more systematically incorporate bike/ped counts and projections, in the same way such analysis is currently conducted for auto travel.

Another way to improve the accuracy of ROI analysis going forward would be to develop an inventory of "before and after" data for particular projects related to multi-modal travel patterns, land use changes, and economic performance indicators (e.g. property values, vacancy rates, retail sales, etc.). While evolving databases such as CoStar and GIS can provide useful land use inventories in most cities, additional analysis is required to adapt them for ROI purposes and accuracy is often less reliable for smaller geographies and past periods (i.e. "the before"). Working closely with local jurisdictions and entities (such as the Red Wing Mainstreet Association) can also yield additional data resources and insights.

With regard to environmental stewardship, the data required to evaluate likely changes in stormwater runoff and associated monetary impacts is often readily available as part of a project investment planning and engineering analysis. While estimating the percentage of runoff that contributes to combined sewer outflows (CSOs) can be more complex, the likely environmental and associated monetary impacts are likely to be more significant.

2. *Winona Bridge Rehabilitation and Expansion*

Built in 1942, the 1.5-mile Winona Bridge provides the only local auto and bike/pedestrian crossing of the Mississippi River between Wabasha (approximately 35 miles northwest) and the I-90 Dresbach Bridge (approximately 25 miles southeast). The bridge is part of Minnesota Trunk Highway (TH) 43 that connects Winona to Wisconsin TH 54, an important regional and interstate route (designated as a System-Level Priority Corridor in Connections 2030, the Wisconsin Department of Transportation's long-range multimodal transportation plan). The crossing is also critical for the rural communities in Wisconsin to reach Winona, the nearest regional destination for smaller towns such as Marshland and Fountain City.

Image courtesy of Winona Bridge Project Environmental Assessment

Several laws passed by the Minnesota Legislature in the aftermath of the I-35W Bridge collapse required and provided funding for rehabilitation or replacement of certain types of bridges in the State. Winona Bridge was subject to these laws given its age and physical condition, and subsequently MnDOT developed a "Recommended Alternative" for a "two-bridge solution" that rehabilitates the existing bridge to carry two lanes of northbound traffic while maintaining its historic character (it is currently eligible for listing on the National Register of Historic Places). The Recommended Alternative also includes development of a new girder-type bridge immediately upstream with two lanes of southbound traffic and significantly enhanced bicycle and pedestrian accommodations.


Image courtesy of MnDOT

Overview of Project ROI Analysis

An overview of the Winona Bridge "Recommended Alternative" based on the ROI framework proposed for this study is provided in **Figure 2** and summarized below. Detailed calculations for several ROI metrics are further described in **Appendix B**. While MnDOT has not conducted a formal ROI analysis of the Winona Bridge project (or potential alternatives), the "two bridge solution" is premised on the following primary benefits:

Figure 2 ROI Overview for Winona Bridge Rehabilitation and Expansion

ROI Category	Potential Impacts Identified	Estimated Monetized Impacts	Equity Considerations
Economic Development & Competitiveness			
Travel time savings	• Avoided construction period detour of ≈ 50 minutes / one-way trip • Added lane in both directions improves traffic flow	**$28,000,000** for prevented detour	
Improved travel reliability (reduced non-re-occurring delay)	Alternative route and 2 new lanes to better accommodate temporary bridge or lane closures	Not quantified / likely moderate	
Improved market access	Potential induced travel demand and related economic activity	Not quantified / likely small	
Market agglomerations	Resulting from improved travel conditions	Not quantified / likely small	
Environmental Stewardship			
Improved energy efficiency / pollution reduction	From avoided detour and less congested travel / potentially offset by induced travel demand	Not quantified / likely moderate and short-term	The primary beneficiaries are residents of rural communities in and around Winona County with a mean household income of ≈ 80% of State Avg. According to the EA "There are no readily-identifiable low-income or minority populations (adversely) affected by the Project"
Land preservation	Supporting access to existing urban infill location	Not quantified / likely small	
Reduced stormwater run-off	Potential increase due to added impervious area / mitigated by on-site improvements	Not quantified / likely moderate and negative	
Habitat preservation	Temporary impact in Mississippi during construction / .2 acres of wetlands permanently removed	Not quantified / likely moderate and negative	
Public Health			
Improved travel safety (reduced crashes)	Existing bridge is deemed unsafe	Not quantified / likely significant	
Supporting active transportation choices	Increased bike / ped. activity	**$2,600,000** See Figure 17	
Improved access to health care	Resulting from improved travel conditions / alternative access	Not quantified / likely small	
Human exposure to contaminants	Unknown	Not quantified / likely negligible	
Livability			
Supporting "Place-making" and community cohesion	Preservation of historic structure / impact on view sheds	**$1,700,000** See Figure 13	
Improved access to recreational / cultural assets	To historic downtown, trails, Mississippi River	Not quantified / likely high	
Improves the commute experience	Views of new and historic bridge	Not quantified / likely small	

- **Safety**: The primary purpose of the project is to provide a structurally sound bridge-crossing of the Mississippi River to safely accommodate existing and future transportation needs. Given that a bridge failure could potentially result in significant public health and property damage, monetization of the improved safety resulting from the project would likely demonstrate significant benefits.

- **Access and travel time savings**: The second bridge doubles the total number of lanes crossing the Mississippi at this location from two to four. This increased capacity is expected to accommodate projected travel demand needs that arise by 2030. Another key justification for the second bridge is that it would prevent a 50 minute or longer detour required to cross the Mississippi at another location while the existing span is being rehabilitated (a two- to three-month project). Finally, a second bridge at this location provides redundancy benefits that reduce the economic disruption associated with potential future failures of one of the structures.

- **Historic Preservation**: As noted, the Winona Bridge is eligible for listing on the National Register of Historic Places and the Recommended Alternative rehabilitates and preserves it in its historic form and function. Historic preservation has been shown to provide important "place-making" benefits that support overall "livability" as well as potential support for secondary tourism and business attraction efforts. These benefits are quantified based on studies from other locations on "existence value" associated with places, structures, monuments, or other heritage assets with perceived historical or cultural significance.

- **Improved bicycle/pedestrian facilities**: The existing Winona Bridge provides a 4.5-foot wide walkway for pedestrians and bicyclists; however, the sidewalk/bike path does not meet the current MnDOT standard of a minimum 6-foot width for pedestrian use, or minimum 10-foot width for a combined bike/pedestrian facility. The adjacent roadway network includes bicycle facilities and trails, but connection to these facilities via the bridge is lacking. The new bridge would include a 12-foot shared use bicycle and pedestrian facility on the west side of the new bridge with bulbs for views and connections to existing trail networks. This analysis monetizes the public health benefits of this feature in terms of its support for increased physical exercise.

ROI Impacts not Quantified

The total project cost estimate for the Winona Bridge project Recommended Alternative is $150 million to $175 million, excluding changes in annual maintenance cost. While MnDOT did not conduct an ROI analysis of this project, these costs far exceed the total monetized benefits from the project estimate ($40 million). However, the benefit estimates exclude safety considerations, one of the primary drivers of the project and an issue that must be addressed pursuant to State legislation, as well as other potential impacts (e.g., from increased road capacity). A quantification of these benefits, using widely accepted methodologies and metrics related to the economic benefits of reduced property damage, injuries, and casualties, could further substantiate the overall rationale for the project Recommended Alternative.

The Environmental Assessment did include a number of less expensive alternatives that would have satisfied State safety requirements. Consequently, the Winona Bridge project is an example of the potential benefits of ROI analysis. In this case, such analysis could be a useful tool in evaluating the benefits of various project design and capacity improvements relative to their itemized costs.

Similarly, preventing the loss of bridge access during the construction phase (about 3 months) is stated as a key rationale for the two bridge "Recommended Alternative". In other words, travelers seeking to cross the Mississippi River would need to take a detour that could add anywhere from 30 to 60 minutes to their trip. The monetization of these impacts based on reduced travel time savings is not provided. Of course, other considerations, such as economic disruption, emergency medical response time, and equity also come into play.

Implications for Future MnDOT Analysis

The Winona Bridge project presents an excellent example of the important role ROI can play in evaluating the relative merits of various project alternatives and attributes. The Recommended Project was the result of a highly detailed analysis of various project alternatives that were designed to meet State legal safety requirements. Various project elements considered as part of the alternatives analysis, but not required by State law, included an improved bike/ped facility and preservation of the existing historic structure.

As further described in **Appendix B**, transportation investments can provide important historic preservation benefits, especially when providing access or contributing to existing historic neighborhoods. These benefits can be an important component of the overall economic benefit of a project, especially in cases when significant capacity expansion is not justified by projected travel patterns. However, the monetization of these benefits can be difficult and values will depend on a variety of factors, including the quality or significance of the resource itself and the geographic breadth of benefiting population groups.

In cases where historic preservation is a "driving factor" in a design or investment decision and a large contributor to total costs, MnDOT can employ a variety of analytical techniques to estimate associated benefits. These techniques, and the time and resources needed to collect data and conduct analysis, will vary depending on the local context and whether use or non-use values are being considered.

The findings from both historic preservation and public health benefits of the Winona Bridge suggest that the magnitude of economic benefits is highly influenced by the density of the affected population groups. For example, regardless of the effects the bridge has on biking and walking frequency in Winona, the population that is likely to benefit from these added facilities is likely to remain small. Likewise, the perceived value from preserving historic attributes of the Winona Bride will be strongest among those who are most likely to be aware of its existence to begin with. In both cases, if the bridge improvements / expansion were intended to serve a larger population center, the monetized benefits would likely be higher.

In addition, there may be important distributional impacts at play. If these areas or populations are not reflective of the population as a whole, other adjustments in the calculation may be necessary. For instance, if the most affected population is lower income or less healthy than the population as a whole, there may be greater benefit to the project's bicycle and pedestrian components. Likewise, if Winona is identified as a rural area that has historically been under-served by regional transportation infrastructure, additional geographic equity and economic development considerations may be appropriate.

3. *I-35W NORTH MANAGED LANES CORRIDOR*

Image courtesy of MnPass System Study Phase 2

I-35W is a major freeway which connects the growing suburbs of the North Metro to downtown Minneapolis. With growth and development, traffic volumes within the I-35W Corridor have increased to the extent that significant congestion occurs at several points within the corridor on a daily basis. This congestion of the existing network and infrastructure is anticipated to worsen by 2030, with the continuing development and growth of communities throughout the region.

MnDOT has been actively planning for the forecasted increase in traffic demand and investigating mitigations for potential added congestion, seeking ways to combine needed expenditures for infrastructure maintenance and repair with investments in safety and mobility to cost-effectively accommodate new users as well as provide trip experience benefits to all future corridor users.

The MnPASS System Study Phase II effort completed in 2010[1] identified the approximately 25-mile long I-35W North corridor from 3rd/4th Street in Downtown Minneapolis to Hwy 97 in the Columbus/Forest Lake area as a candidate for MnPASS lanes and/or a managed corridor (shown as routes 4A and 4B in the map below). The I-35W Managed Lanes study which followed investigated feasible types of managed lane systems and associated policies, and the potential locations and designations for I-35W managed lanes. The final report and technical appendices for that recent study[2] document the preferred managed lane concepts and the proposed improvements at locations along the I-35W North corridor.

The analysis presented in the Working Paper #2 focuses on potential impact of the I-35W North Managed Lanes Corridor "Base Scenario" on air emissions, with a focus on carbon dioxide (CO_2), a leading contributor to greenhouse gas (GHG). The Base Scenario includes all of the future improvements on I-35W that have been identified for construction in the coming years and adds one managed lane in each direction along I-35W between University Avenue in Minneapolis and Lexington Avenue in Blaine. These managed lanes would function using current guidelines for

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[1] Cambridge Systematics, August 2010. *MnPASS System Study Phase 2*, prepared for the Minnesota Department of Transportation.

[2] SRF Consulting Group, Inc. in conjunction with Kimley-Horn & Associates, Inc. and ZAN Associates, Inc., June 2013. *I-35W North Managed Lanes Corridor Study Final Executive Summary,* 272 pg.; *Appendices,* 261 pg.; prepared for the Minnesota Department of Transportation.

MnPASS lanes, where buses and high-occupancy vehicles would be allowed to use the lanes for free, and single-occupant vehicles would be allowed to use it if willing to pay a congestion-sensitive toll.

Overview of Project ROI Analysis

Figure 3 summarizes the expected ROI benefits of the I-35W North Managed Lanes Corridor project under the Base Scenario (managed lanes in each direction between University Ave. in Minneapolis and Lexington Ave. in Blaine along with other approved corridor improvements) based on a previous MnDOT study and additional EPS analysis, as provided in **Appendix C**. The *MnPASS System Study Phase 2* and *I-35W North Managed Lanes Corridor Study Final Executive Summary and Appendices* estimated about $390 million in present value project benefits over 20 years, mostly from travel time savings, compared to $270 million in present value costs, a benefit cost ratio of 1.45.

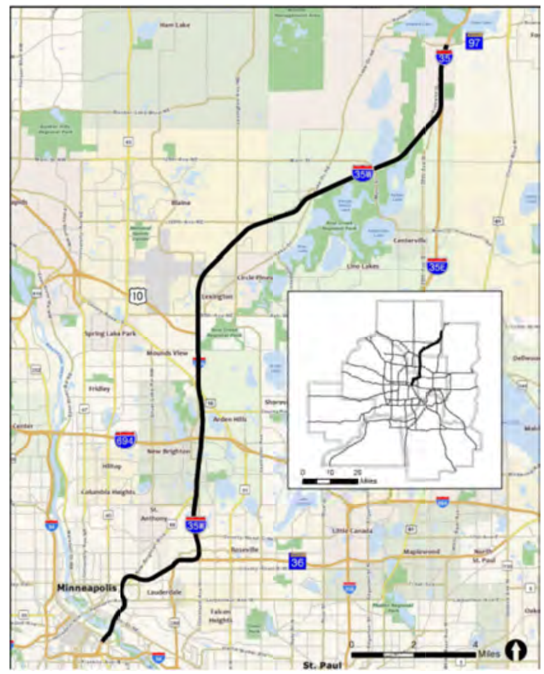

Image courtesy of I-35W North Managed Lanes Corridor Study Final Executive Summary

The quantified benefits are entirely attributable to improved travel time saving relative to baseline conditions. The benefits greatly exceed increased vehicle operating costs that result from increased VMT and tolls.

Figure 3 ROI Benefits Summary for the I-35W North Managed Lanes Corridor

ROI Category	Potential Impacts Identified	Estimated Monetized Impacts	Equity Considerations
Economic Development & Competitiveness			Mapping of population and income-profiles along the route of the proposed managed lanes as well as at the major origin and destination concentrations is needed to address perceptions that key benefits accrue to wealthy. Transit improvements may also result, depending on implementation.
Travel time savings	Improved vehicle flow	**$429,710,000** MnDOT analysis	
Vehicle operating costs	Induced VMT from increased capacity	**($41,190,000)** MnDOT analysis	
Improved travel reliability (reduced non-re-occurring delay)	From improved vehicle flow and reduced crashes	Not quantified / likely significant	
Improved market access	Likely induced travel demand and related economic activity	Not quantified / likely significant	
Market agglomerations	Resulting from improved "on-the-clock" travel	Not quantified / likely moderate	
Environmental Stewardship			
Pollution reduction	From improved vehicle speeds and change in VMT	Quantified by EPS (see Figure #20) – pollution reduction / trip offset by increased VMT	
Land preservation	Supporting access, circulation in existing urban infill location	Not quantified / likely small	
Reduced stormwater run-off	Reduced impervious land area	Not quantified / likely small	
Habitat preservation	Unlikely since located in existing urban area	Not quantified / negligible	
Public Health			
Improved travel safety (reduced crashes)	From improved traffic flow and lane improvements	**$720,000** MnDOT analysis	
Supporting active transportation choices	Increased transit ridership	Not quantified / likely moderate	
Improved access to health care	Resulting from improved travel conditions	Not quantified / likely moderate	
Human exposure to contaminants	From reduced emissions	Not quantified / likely moderate	
Livability			
Supporting "Place-making" efforts	Due to less congestion, smoother travel	Not quantified / likely moderate	
Improved access to local commercial, cultural, recreational assets	From increased travel capacity	Not quantified / likely moderate	
Improves the commute experience	Due to less congestion, smoother travel	Not quantified / likely moderate	

ROI Impacts Not Quantified

While the overall ROI for the I-35W North Managed Lanes Corridor project is highly positive, a number of significant benefits are not quantified. Probably most notable among these is the total increase in Vehicle Miles Traveled (VMT) or vehicle throughput that is achieved with negligible (less than zero) increase in environmental detrimental air emissions. This is accomplished by optimizing vehicle flow and average speeds to significantly reduce emissions per VMT.

Increasing vehicle throughput has clear economic advantages associated with improved market access, and to a lesser extent, agglomeration-related productivity gains. While previous MnDOT analysis provided estimates of increased VMT from the Managed Lanes improvements, it did not attach economic benefits to these new, induced trips (other than safety, travel time, and vehicle operating costs). Presumably, these trips provide a variety of economic benefits to travelers depending on their purpose (e.g. recreation, shopping, commuting, etc.). Further MnDOT analysis related to origin and destination and trip purpose could provide a basis for estimated net changes in the economic activity.

Equity Considerations

In its primer on the equity impacts of congestion pricing projects[3] (such as the proposed I35W Corridor managed lanes system), the Federal Highway Administration (FHWA) identifies three principal types of equity considerations related to possible differences in the proportional distribution of social benefits and impacts of toll or congestion pricing projects:

- Income Equity: Is the proposed congestion pricing structure regressive? (i.e., does the cost-burden of travel-behavior changes and costs disproportionately affect low- and/or middle-income individuals and households?)
- Geographic Equity: Will some parts of the affected region or corridor receive significantly more benefits or burdens than others? Do neighborhoods potentially advantaged or disadvantaged by changes in travel costs and/or vehicle-related emissions also correspond to the income levels of those neighborhoods' residents or workers?
- Modal Equity: Do the vehicle mile and/or vehicle- and person-hour savings of the proposed congestion pricing structure extend to transit riders and high-occupancy (e.g., carpool) vehicles? Will transit and high-occupancy vehicles have expanded access to managed lanes?

Literature reviews and case studies by the FHWA, the RAND Corporation[4] and others include the following findings and considerations with regard to:

- Income Equity: If viewed as a tax, congestion pricing is typically mildly regressive but often less so than sales- or motor-fuel taxes [RAND]. Studies and surveys of actual operating systems indicate high-approval (60 to 80 percent) of managed lane systems operated in parallel to toll-free general purpose (GP) lanes across all income groups, as all groups value the option for reliable trip time when they absolutely need it [FHWA].

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[3] Federal Highway Administration, December 2008. *Income-Based Equity Impacts of Congestion Pricing: A Primer*, part of the FHWA Congestion Pricing Primer Series.

[4] FHWA, *ibid*. RAND Corporation, 2009. *Equity and Congestion Pricing: A Review of the Evidence*, prepared by Lisa Ecola and Thomas Light. Sponsored by the Environmental Defense Fund.

High-income individuals tend to use and benefit most from managed lane systems proportionally[5], due to their higher discretionary incomes and the opportunity cost-value of their in-vehicle hours, while lower-income individuals may 'need the insurance' of reliable trip times most due to relative inflexibility of their schedules (e.g., to meet child-care and time-clock deadlines) [FHWA].

As the likely heaviest users of express lanes (i.e., total persons and vehicles), middle-income individuals paying tolling fees for access may pay more than they would if sales tax revenues were used to pay for construction bonds and operations [RAND]. Studies of operating SR-91 express lanes in California also indicate that middle-income travelers are the most sensitive to changes in congestion pricing, reducing their use significantly as cost rises and increasing their use significantly as cost falls [FHWA].

- Geographic Equity: Careful mapping of the existing and anticipated residences and employment sites proximate to the proposed managed corridors and of the origins and destinations of travelers is necessary to evaluate potential issues of geographic equity. Higher-income workers are more likely to commute long distances in single-occupancy vehicles, so to the extent that residential areas and employment centers which would benefit differentially from managed lanes are often areas with higher-income profiles, early perceptions of proposed express lanes may be that they are 'mostly for the well-off'. It is therefore important to evaluate access and travel time impacts of the proposed managed lane improvements for middle- and lower-income workers [FHWA].

  Mapping of income-profiles along the route of the proposed managed lanes as well as at the major origin and destination concentrations will inform evaluation of relative air emissions and environmental justice issues. Communities at risk will typically be located proximate to air emission hot-spots and along heavily-travelled roadways, and methodologies such as dasymetric mapping may be applied to facilitate evaluations where non-homogenous distributions of residences or workplaces occur (e.g., where residences or workplaces might be concentrated close to or distant from major roadways within a census tract that is adjacent to the roadway)[6].

  As shown in the example calculations explained above, increasing VMT along a roadway does not necessarily imply increasing air emissions, if the VMT changes are accompanied by related and offsetting improvements in fuel economy and vehicle efficiency. It is therefore important that planners and stakeholders have access to relatively simple-to-apply tools so as to anticipate the likely overall direction and scale of air emission changes early in the evaluation process.

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[5] High-income travelers tend to use express lanes with congestion pricing for a higher percentage of their trips where both express and general purpose lanes are available, and to continue their usage of express lanes when costs increase. FHWA, *ibid*.

[6] Juliana A. Maantay, Andrew R. Maroko, and Holly Porter-Morgan, 2008. *Research Note—A New Method For Mapping Population And Understanding The Spatial Dynamics Of Disease In Urban Areas: Asthma In The Bronx, New York,* in Urban Geography, 2008, 29, 7, pp. 724–738.

- Modal Equity: Low-income workers who take transit or car-pool more frequently will benefit from congestion pricing and managed lanes to the extent that HOV and transit service improvements accompany the pricing and managed lane programs. Such improvements may take the form of access by HOV transit vehicles to the managed lanes themselves at exempted or reduced tolling prices; of improved headways for HOV and transit vehicles travelling on parallel general purpose lanes; and where toll-financed improvements are included in the pricing program [FHWA]. The allocation of toll-revenues to directly subsidize transit improvements or to provide discounts or rebates (such as for transponder fees) to lower-income travelers must be carefully evaluated, however, especially where toll-revenues are paying off bonds that funded the managed lane improvements and or managed lane operating costs. As pricing structure is critical to attracting maximum efficiencies in use of managed lanes by middle-income travelers, there are practical limits to the benefit-loading of express lane prices to the general user.

Implications for Future MnDOT Analysis

The results of this analysis may be initially surprising; while total VMT in the study area are estimated to increase with the proposed I-35W North Corridor managed lanes, total VHT are estimated to decrease in comparison to the No Build scenario. The projected benefits of the managed lanes at 2030 include both a modest increase in average speed along roadways in the study area, and a negligible change in CO2 emissions compared to the No Build scenario. In sum, the managed lanes are projected to increase transportation system efficiency and capacity without at the same time increasing total annual vehicle-related CO2 production.

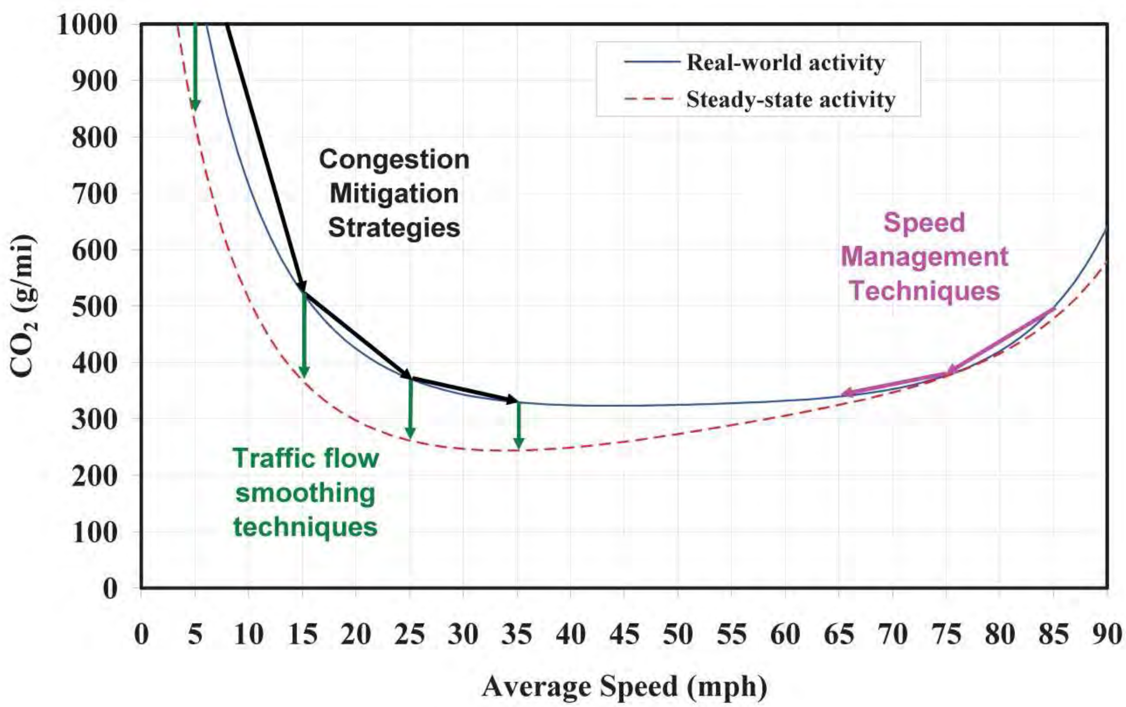
The vehicle-related emission calculation methodology used in this ROI analysis and described in Appendix C can be applied in other studies where transportation and land use scenarios are being evaluated and VMT and VHT estimates are available. While the I-35W example has focused on CO2 emissions, the same methodology can be used with alternate coefficient sets to calculate emissions of other gas and of particulates. Alternately, spreadsheet tools and step-function estimation can be used where simpler 'look-up' tables of emissions in grams-per-mile are available only by average speed-ranges rather than as calculated as the result of polynomial regressions.[7]

One additional sensitivity adjustment that may be applied involves variation in speed (as contrasted to average speed). Where speeds of vehicles over measured routes varies significantly (e.g., stop-and-go or fast-and-slow) from their average speed, the vehicles may actually be emitting significantly higher amounts than if they were travelling at a steady velocity over the same miles. For the CO2 estimates demonstrated above, we have used the 'Real World'

[7] See also: Minnesota Department of Transportation, April 29th, 2013. *PRISM Methodology Documentation: Final Report,* prepared by Parsons Brinkerhoff; Page 52, Table 2-51: Selected Emissions Rates (grams per VMT), Automobiles; and Kanok Boriboonsomsin, Center for Environmental Research & Technology, UC Riverside, University of California at Riverside, May 2014. *Deployment of Prior HOV Lanes Research Results in Developing Analysis Tools for New Managed Lanes Projects: Final Report,* prepared for California Department of Transportation; Section 4.3. Deriving Lane Type Emission Adjustment Factors.
http://www.caltrans.ca.gov/newtech/researchreports/reports/2014/final_report_task_2329.pdf

coefficients shown in **Figure 4**. As displayed in the lower curve, where traffic flow can be smoothed and speed variations brought closer to a steady state, emissions can be reduced further, especially in the range of 5 to 35 mph. In other words, if we assumed more constant speeds could be achieved from managed lanes, emission reduction benefits would actually be positive rather than zero as currently quantified (more travel, less pollution, a big win-win).

Figure 4 Potential traffic operation strategies in reducing on-road CO2 emission



From: *Real-World CO2 Impacts of Traffic Congestion*, Matthew Barth and Kanok Boriboonsomsin, 2008, Figure 4.

The methodology described herein can be applied wherever Vehicle Miles Traveled (VMT) and VHT are available or can readily be obtained for 'existing conditions' or for a defined Base Case and Base Year and for the alternative Scenario(s) and Year(s). The resulting approximations of emissions produced for the evaluated alternate scenarios might not be suitable as substitutes for more rigorous formal modeling of air emissions (as needed for EIR/EIS preparation), but have value in anticipating the likely direction and scale of the emissions results from more formal modeling; in helping both practitioners and stakeholders understand underlying relationships and what might otherwise be counter-intuitive outcomes; and in enabling 'what-if' inquiry with a relatively low investment in time and cost.

It is worth noting that the emission factors used in this analysis are based on a detailed study of freeway driving in Southern California conducted in the mid-2000s.[8] Recommended methodological refinements of the examined method would include calibration of emission coefficients to Minnesota-specific conditions, and possibly the adoption of use of a structured model which incorporates similar speed-sensitive vehicle emissions calculations, such as the EPA's MOVES model,[9] or a new MnDOT spreadsheet model, perhaps similar to the spreadsheet reported as in preparation for the California Department of Transportation.[10]

To address equity issues, mapping of the anticipated managed lanes passenger OD flows with respect to place of work and residence and with respect to proximity of residences and workplaces by income profile to air emission hotspots and to intermodal stations and transit routes will also be useful.

[8] Based on a review of updated EPA MOVES 2010 data, it appears that newer vehicles are being modeled as producing less CO2 at higher speeds (60+ mph), relative to the slightly older data used in calculations provided herein. However, this analysis is focused on emission reductions from system wide improvements that bring average trip speed up from the lower range into the efficient cruising speeds where the shape of the emission curves remains similar to the ones referenced. Given this we would not expect significant change from the calculations presented herein from using updated coefficients.

[9] http://www.epa.gov/otaq/models/moves/

[10] Kanok Boriboonsomsin, Center for Environmental Research & Technology, UC Riverside, University of California at Riverside, May 2014. *Deployment of Prior HOV Lanes Research Results in Developing Analysis Tools for New Managed Lanes Projects: Final Report,* prepared for California Department of Transportation; Section 4.4. Developing Spreadsheet Tool.
http://www.caltrans.ca.gov/newtech/researchreports/reports/2014/final_report_task_2329.pdf

IV. NEXT STEPS

Working Paper #1 outlined a framework for evaluating transportation ROI for future MnDOT projects and programs based on a broad set of metrics that take into account impacts that are likely to be of concern to the public at large. This second Working Paper has provided ROI calculations for three selected MnDOT projects to illustrate how such analysis might be applied going forward. The key goal of this "first-cut" evaluation was to test the utility of the various metrics and methodologies identified in Working Paper #1 and solicit input from the PSG. Specifically, we seek continued input on the following:

- ROI impact categories
- ROI methodology and metrics
- Data sources and additional research
- Specific projects/programs for future analysis

Based in the input received on questions above and additional research by the Project Team, we will prepare Working Paper #3 for presentation at the next PSG meeting. Working Paper #3 will expand the findings presented herein with additional research and analysis on key ROI metrics and selected MnDOT projects, as directed. Finally, the Project Team will present additional discussion on the lessons learned and implications for future application of ROI in Minnesota.

APPENDIX A:

Illustrative ROI Calculations for Red Wing Main Street/US 61 Improvements

Appendix A: Illustrative ROI Calculations for Red Wing Main Street/US 61 Improvements

This Appendix provides detailed ROI calculations for the following likely benefits from the Red Wing Main St. / U.S. 61 improvements:

- Impact of increased bicycle and pedestrian access on property values (Livability)
- Impact of increased pedestrian access on physical activity (Public Health)
- Impact of impervious area on stormwater runoff (Environmental Stewardship)

Impact of Bike/Ped Access on "Livability"

Overview of Methodology

The Main Street US 61 Downtown project includes a range of "Complete Street" improvements designed to enhance access, circulation, and overall appeal within an already successful historic commercial district. Specific elements will facilitate and enhance the pedestrian and bicycle experience with better access, comfort, and overall appeal, including streetscape and sidewalk enhancements, better signalization, pedestrian bump-outs, trees, benches, improved lighting, and other aesthetic elements. This analysis assumes the combined effect of these "Complete Street" improvements will be to enhance the overall "livability" in this district.

Numerous studies have shown a quantifiable relationship between improving active transportation mode conditions (better sidewalks, crosswalks, traffic speed reductions, bicycle infrastructure, etc.), which directly benefits both existing and new users, and economic performance indicators. Some studies have attempted to quantify these benefits based on increases in property values (Buchanan, 2007; Cotright, 2009; Pivo and Fisher, 2010; Racca and Dhanju, 2006; and Toneguzzi, 2013, among many others). Methodologies utilized in quantifying increased property values often rely on measures of pedestrian and bicycle access, referred to as "walkability" or "bikability." For instance, in a 2010 study by Gary Pivo and Jeffrey Fisher, office, retail and residential apartment values were shown to increase between 1 and 9 percent for each 10-point WalkScore increase (or an increase of between .1 and 1 percent per WalkScore point).[11] However, other studies utilize independent metrics to evaluate the walkability or livability of a particular location. A summary of studies analyzing hedonic pricing for complete streets improvements is listed below in **Figure 5**.

[11] Walkscore is calculated by Walkscore.com, which has developed an algorithm measuring the quantity of amenities (such as restaurants, shops, parks, schools, etc.) based on walking route in and around a specific location. These amenities are weighted based on proximity and total walking so that the closer the walk, the more weight a specific amenity receives in the overall score.

Figure 5 Hedonic Pricing Literature Review for Livability Improvements

Study / Source	Metric	Value Increase: Per WalkScore Point	Value Increase: Other Walkability Metrics
Cotright, Joe. How Walkability Raises Home Values in U.S. Cities, 2009.	Per WalkScore point increase	$500 - $3,000	
Litman, T. Evaluating Non-Motorized Transportation Benefits and Costs. Victoria: Victoria Transport Policy Institute, 2013.	Office, retail and apartment value increase for each 10-point WalkScore increase	0.1% - 1%	
Kooshian, C., & Winkelman, S. Growing Wealthier: Smart Growth, Climate Change and Prosperity. Center for Clean Air Policy, 2011.	WalkScore of 20 vs WalkScore of 80	0.1%	
Buchanan, John. Paved with Gold. London: Commission for Architecture and the Built Environment, 2007	Walkable neighborhoods compared to non walkable neighborhoods		5.2%
Eppli, M., & Tu, C. C. Valuing the New Urbanism: The Impact of New Urbanism on Prices of Single-Family Homes, 2000.	Propoerty values in New Urbanist neighborhoods compared to conventional, auto-dependent neighborhoods		11.0%
Song, Y., & Knaap, G.-J. The Effects of New Urbanism on Housing Values: A Quantitative Assessment, 2003.	Walkable home values over non-walkable home values		15.5%

As shown in **Figure 5**, livability improvements such as streetscaping, active mode infrastructure and other complete streets amenities have been shown to be positively correlated with property value increases from between .1 and 15.5 percent. The wide range reflects different methodologies as well as different types and scopes of active mode infrastructure under consideration. In addition, care must be taken when using property value increases as part of an ROI analysis due to the wide range of variables that causes such impacts. Key methodological issues include double counting (e.g. increases may be partially attributable to factors such as improved access) distributional or transfer effects (e.g., the economic gain in one location may be off-set by a loss elsewhere), or factors unrelated to the project itself (e.g. subsequent developer investments or generalized market appreciation).

In the case of Red Wing, a significant component of the transportation improvements is designed to improve the pedestrian experience. While these investments generate economic benefits that are distinct from those calculated from improved travel time, safety, or even public health (see below), disentangling all of the various factors can be complicated. In addition, the scope of improvements for the Main Street US 61 Downtown project may be more limited than those covered by the literature review summarized in **Figure 5** above. Therefore, with a goal of being conservative (i.e. not over-stating the impacts) a property value increase of 1 percent is assumed for this "livability" metric.

Detailed Calculations

To estimate the potential impacted inventory of the Main Street US 61 Downtown Improvements in Red Wing, EPS calculated the total impacted existing commercial and residential property value. For the residential property valuation, EPS first estimated the total geographic area in Red Wing located within a 20-minute walk of the centroid of the Project Area. Using Walkscore.com, which analyzes hundreds of potential pedestrian routes, and Goodhue County parcel data, EPS estimates that roughly 820 single-family homes located within a walkable distance of the Project Area. Applying these data to the estimated 820 homes located within a twenty-minute walk of the Project Area, EPS calculated a total of roughly 1.5 million square feet of impacted residential property valued at $122.5 million as shown in **Figure 6**. [12]

For nonresidential uses EPS used CoStar's commercial database to identify 46 commercial properties totaling approximately 625,000 square feet within the Project Area.[13] To calculate commercial valuation, EPS utilized an average current lease rate of $10 per square foot (adjusted to reflect full service leases), a 7 percent vacancy rate, and a capitalization rate of 8.5 percent.[14] Applied to the 625,000 square feet of commercial real estate in the Project Area, these calculations result in an impacted commercial valuation of $68.4 million as shown in **Figure 6**.

Figure 6 Downtown Red Wing Complete Streets Impact Property Value Calculation

Item	Assumption (3)		Estimated Valuation
Impacted Commercial Property (1)	46	Properties	
Total Estimated Square Footage	625,385	Sq Ft.	
Current Lease Rates	$10	Per Sq. Ft	
Est. Vacancy	7.0%		
Capitalization Rate	8.5%		
Total Impact Commercial			$68,400,000
Impacted Residential Property (2)	820	Single Family Homes	
Total Estimated Square Footage	1,558,000	Sq Ft.	
Value per Square Foot	$79	Per Sq. Ft	
Total Impacted Residential			$122,500,000
Property Value Impact	1%	Increase	
Increase in Commercial Property Value			$700,000
Increase in Residential Property Value			$1,200,000
Total Increase for Impacted Properties			**$1,900,000**

(1) Assumes all commercial property located within the project area will be impacted.

(2) Assumes all residential property located within a 20 minute walk of the project area will be impacted. Estimates based on walkscore.com and current Goodhue County parcel data.

(3) Commercial only includes office and retail properties, as defined by CoStar in the project area. The average single family home in Red Wing is assumed to be 1,900 square feet.

Sources: Redfin.com; CoStar; Goodhue County; Walkscore.com; EPS.

[12] Home sales and sizes based on data from the past 12 months available on Redfin.com. Square footage estimate assumes 1,900 square feet per single family residential home.

[13] Commercial estimate is based on available CoStar data and includes only office and retail uses.

[14] Lease rates are based on average asking rents in downtown Red Wing, adjusted to reflect full-service lease structure. Vacancy rates are based on available data from CoStar.com. The capitalization rate is from 2014 Mid-Year *IRR Viewpoint*.

Assuming a property value increase of 1 percent due to the increased pedestrian and bicycle access, livability improvements and aesthetic enhancements following completion of the Main Street US 61 Downtown Improvements in the Red Wing Project, commercial property would increase in value by $700,000 and residential property would increase by $1.2 million, resulting in a net impact in the City of Red Wing of approximately $1.9 million.

The implications of the property value increase due to the Main Street improvements are significant as the total value added due to livability improvements ($1.9 million) makes up more than a third of the total project cost ($5.4 million). Furthermore, benefits would be greater if the affected area were higher density and thus included a larger number of residential and commercial properties.

Impact of Pedestrian Access on Public Health

The pedestrian component of the Main Street US 61 Downtown Improvements will encourage active transportation in and around the downtown district. Active transportation has been linked with numerous health benefits including reduced risk of heart disease, stroke, diabetes, hypertension, and others. Therefore an increase in active transportation from the pedestrian improvements along Main Street will have a correlated, quantifiable benefit for the residents of Red Wing. Below, EPS illustrates the estimated economic impacts from public health benefits associated with the Main Street US 61 Downtown Improvements.

The economic benefit calculation for the pedestrian component of the Main Street project utilizes findings from a nationwide study investigating the average miles walked per day by American adults. The study, *Pedometer-Measured Physical Activity and Health Behaviors in US Adults,* finds that the average American adult walks 2.6 miles per day. Adjusting per day walking miles to reflect only the distance walked outside of the home or place of work, EPS estimates the average American adult walks approximately 1.9 miles per day (a 25 percent reduction). Applying this adjusted average to the number of Red Wing adults (12,924[15]) results in roughly 24,800 walking miles per day, or 9 million walking miles per year.

[15] American Community Survey 2012.

Assuming a 2 percent estimated increase in walking miles results in a net new 181,037 walking miles per year due to the Main Street US 61 Downtown Improvements.[16] According to the New Zealand Transport Agency (NZTA), walking miles are valued at $.55 per mile. Therefore the health benefit value associated with net new walking miles is approximately $100,000 annually, or $1.6 million if calculated as a net present value, as shown in **Figure 7**.[17]

[16] A number of studies have attempted to quantify the increase in pedestrian activity due to infrastructure improvements. Findings range from showing no change in activity to more than a fifty percent increase from baseline participation. For example, a recent report assessing the efficacy of the federal Nonmotorized Transportation Pilot Program (NTPP) found walking increased 56 percent following NTTP-funded improvements. However, the NTPP results, along with other active transportation participation studies, reflect very localized effects (such as documenting the change on a single path, sidewalk or intersection). For the purposes of this analysis, a conservative estimate of a 2 percent increase was assumed for the Red Wing pedestrian analysis as the methodology assumes an impact on a broader population (all Red Wing adults). It should be noted that the 2 percent increase is for illustrative purposes only and an actual change in active mode participation could have far greater implications in public health than are assumed in this analysis.

[17] Per km health benefits are based on the LTNZ (2006), *Economic Evaluation Manual (EEM) – Volumes 1 & 2,* Land Transport New Zealand. Health benefits section is found in Volume 2, section 3.8 p. 3-22. A table adjusting the metric to dollars/mile is shown in *Transportation Costs and Health Benefits Analysis II – Safety and Health Costs* (2013), Victoria Transportation Policy Institute, p. 5.3-49. EPS adjusted these benefit findings to 2014 dollars. It should be noted that, as in the case with all benefit transfer studies, metrics taken from different locations and studies may need to be adjusted to better reflect the behavior of different populations. In this instance, it may be necessary to adjust the metrics developed based on New Zealand walking and biking behavior to better reflect that of Minnesota.

Figure 7 Estimated Pedestrian Health Impacts

Item	Assumptions		Estimate
Average Distance Walked per Day per Person (1)	1.9	Miles	
City of Red Wing Population (2)	16,444		
City of Red Wing Adults (2)	12,924		
Average Red Wing Miles Walked Per Day			24,800
Average Red Wing Miles Walked Per Year			9,051,832
Walking Mile Impact for Project (3)	2%		181,037
Value of Increase Walking on Health Impacts (4)	$0.55	per Mile	$100,000
Net Present Value (5)			**$1,600,000**

(1) Reflects average American miles walked per day based on *Pedometer-Measured Physical Activity and Health Behaviors in US Adults* . Bassett, David R. Jr; Wyatt, Holly R.; Thompson, Helen; Peters, John C.; Hill, James O. Study results were adjusted downward by 25 percent to reflect only the distance walked outside of the home or place of work.

(2) American Community Survey 2012.

(3) Impacts on walking from the Project is based on a literature review of quantified effects of new trail systems, walking/biking paths and other recreational amenities on the frequency of active modes of transportation. Many of these studies, such as *New Walking and Cycling Routes and Increased Physical Activity: One- and 2- Year Findings from the UK iConnect Study* conducted in 2014, found significant increases in total biking and walking exercise per week (the study found an increase for those within .5 miles of the new facility of nearly 10 miles per week). To be conservative, EPS assumes a 2 percent increase in total activity for both walking and biking in Red Wing.

(4) Based on active transportation health benefits based on the New Zealand Transport Agency's *Economic Evaluation Manual* (2010), adjusted to 2014 dollars. Note that the per mile health benefits from walking were found to be higher for walking than for biking. This finding is consistent with other reviewed studies of this kind.

(5) Assumes a discount rate of 2.5 percent, an annual growth rate of 1.2 percent and a twenty year period. Growth rate is based on planning-level roadway capacities for the Winona Bridge, which is used as a proxy for population growth in the Red Wing area.

Sources: Pedometer-Measured Physical Activity and Health Behaviors in US Adults; American Community Survey; EPS.

As in the previous section regarding property value, the economic impacts of increased walking miles due to pedestrian improvements are significant in comparison to the total cost of the Main Street project.

Impact of Impervious Area on Reduced Runoff (Environmental Stewardship)

Impervious surfaces such as concrete and asphalt prevent stormwater from soaking into the ground, causing runoff that can burden local storm and wastewater systems, exacerbate flood conditions, and/or pollute nearby lakes, rivers and streams. Consequently, transportation projects that change impervious area can produce positive or negative environmental (and economic) consequences depending on specific conditions and mitigation measures. The Red Wing Main Street improvements actually reduce total impervious square feet within the project area resulting in improved runoff conditions and corresponding monetary benefits, as calculated herein.

The cost of stormwater runoff is a function of site area, site composition, and annual precipitation. Each ground cover type results in a different volume of stormwater runoff, as indicated in its runoff coefficient. Multiplying the area of each ground cover type for the site by its runoff coefficient and Red Wing's annual average precipitation yields the annual runoff entering the water system from each ground cover type, which is then summed to show the total site runoff entering the water system. As the amount of the site covered by lawn or forest increases under the build scenario, the percentage of runoff contributing to the water system decreases.

Figure 8 Change in Total Runoff Acre Feet

Ground Cover	Site Area by Ground Cover (acre)		Annual Average Precipitation (ft.)	Runoff Coefficient	Runoff (acre ft.)		Change in Total Runoff
	No Build	Build			No Build	Build	
Concrete/Asphalt	10.17	9.47	2.76	0.85	23.86	22.21	1.65
Lawn/Forest	0.43	1.13	2.76	0.10	0.12	0.31	-0.19
Total Annual Runoff					**23.97**	**22.52**	**1.45**

Sources: Minnesota Department of Transportation; City of Red Wing

There are two types of runoff which hold different cost implications for the city. The majority is regular runoff which induces costs due to water treatment. However, older communities often have a combined sewer system at certain locations in which wastewater and stormwater are collected in a single pipe system. In a combined sewer system, if stormwater flows exceed treatment plant capacity the combined wastewater and stormwater flow is discharged into surrounding bodies of water. As such, runoff contributing to combined sewer outflows (CSOs) carries a higher cost than non-CSO outflows, as there are additional flooding and water pollution impacts.

In this calculation we assume that 1 percent of runoff contributes to combined sewer outflow. By valuing the water treatment cost of the excess stormwater runoff (both regular and CSO) produced under the no-build scenario, we estimate that the decrease in stormwater runoff under the build scenario represents an annual likely benefit of $45,204. These monetized cost values are shown below.

Figure 9 Monetization of Per-Acre Foot Runoff

Runoff Type	Cost Per Acre Foot		
	Low Value	Likely Value	High Value
Regular Runoff[1]	$21,324	$29,581	$125,103
CSO Runoff	$81,463	$149,240	$576,105

[1] Cost valuation based on MnDOT Prism Methodology Documentation. For regular runoff, original cost values were based on Minnesota Department of Transportation, Local Road Research Board, The Cost and Effectiveness of Stormwater Management Practices. These values were adjusted in 2013 to amortize the capital costs of treatment and account for annual operations and maintenance of water treatment strategies. CSO cost values were derived from studies of combined sewer outflow treatment cost data in three different locations.

Sources: Minnesota Department of Transportation

Figure 10 Annual Monetized Benefit from Reduced Runoff

Ground Cover	Annual Benefits from Avoided Runoff (per acre foot)								
	Regular Runoff			CSO Runoff			Total Runoff		
	Low Value	Likely Value	High Value	Low Value	Likely Value	High Value	Low Value	Likely Value	High Value
Concrete/Asphalt	$35,157	$48,771	$206,260	$1,343	$2,461	$9,498	$36,500	$51,231	$215,758
Lawn/Forest	-$4,136	-$5,738	-$24,266	-$158	-$289	-$1,117	-$4,294	-$6,027	-$25,383
Total Annual Benefit	**$31,021**	**$43,033**	**$181,994**	**$1,185**	**$2,171**	**$8,381**	**$32,206**	**$45,204**	**$190,375**

Sources: Minnesota Department of Transportation; Economic and Planning Systems, Inc.

Assuming a 2.5 percent discount rate over twenty years, we estimate a likely $722,313 present value of the project.

Figure 11 Present Value of Reduced Runoff Benefit

Ground Cover	Present Value of Benefits from Avoided Runoff (per acre foot)		
	Low Value	Likely Value	High Value
Concrete/Asphalt	$583,237	$818,621	$3,447,580
Lawn/Forest	-$68,616	-$96,308	-$405,598
Total Benefit	**$514,621**	**$722,313**	**$3,041,983**

Sources: Minnesota Department of Transportation; Economic and Planning Systems, Inc.

APPENDIX B:

Illustrative ROI Calculations
for Winona Bridge Rehabilitation and Expansion

Appendix B: Illustrative ROI Calculations for Winona Bridge Rehabilitation and Expansion

This Appendix provides detailed ROI calculations for the following likely benefits from the Winona Bridge Rehabilitation and Expansion:

- Impact of historic preservation on creating a sense of place (Livability)
- Impact of improved bicycle / pedestrian access on physical activity (Public Health)

Impact of Historic Preservation on "Livability"

Framework and Methodology

The preservation of cultural and historical resources provides important contributions to community cohesion, identity, a "sense of place," and overall livability. Transportation infrastructure and services can enhance historical resources either directly, such as rehabilitation of a historic bridge, or indirectly by improving access. While the economic benefits of historical and cultural heritage are widely recognized they are also notoriously difficult to monetize, especially on a project by project basis. Nevertheless, numerous academic and professional studies and research papers have documented a variety of methodologies and estimates that are broadly applicable to the Winona Bridge project.

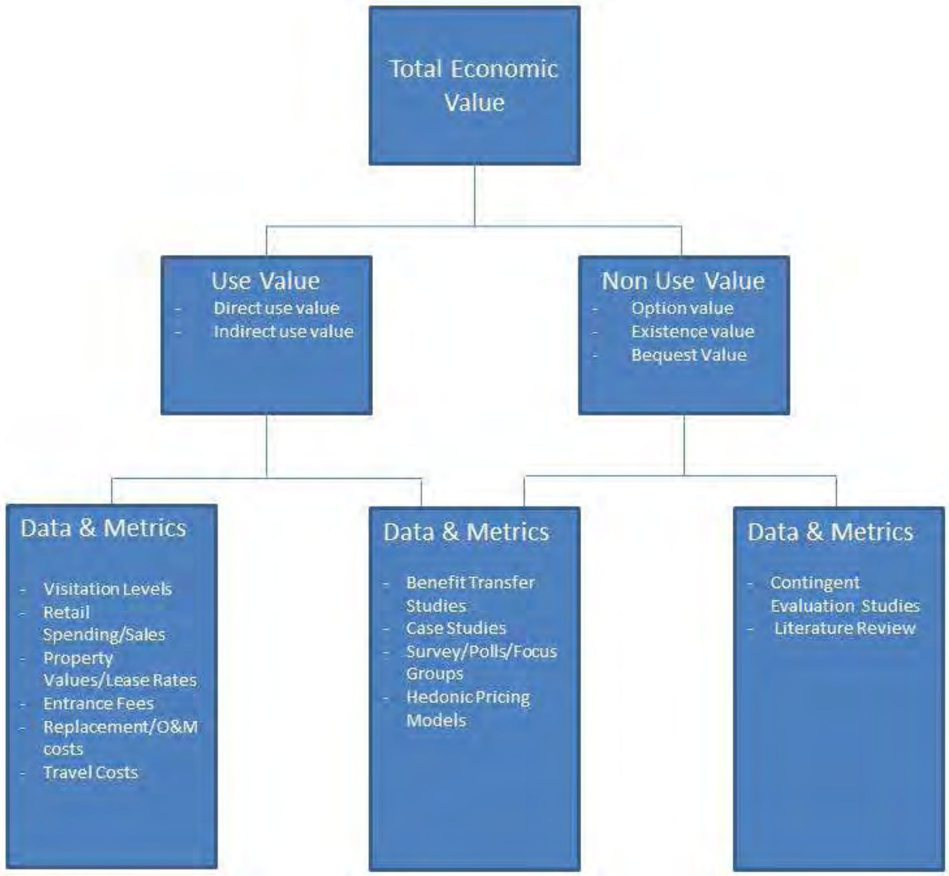
The Winona Highway Crossing is eligible under National Register Criterion A in the area of Transportation History for the role it played as a main arterial route over a major river crossing. In addition, the crossing was vital to the economic life of Winona and the movement of defense materials during World War II. The Winona Highway Crossing is also eligible under Criterion C in the area of Bridge Design and Engineering for its contribution to design and construction in Minnesota (when built it was the largest single undertaking by MHD) and is the state's only surviving example of a cantilever thru-truss dating from before 1946. The cantilever design, used for long spans over navigable water, requires significant engineering.

It is also worth noting that the Winona Bridge contributes to a Broadway Historic District, which encompasses Downtown Winona and the entrance way to the bridge going south. This would suggest that the existence of the Winona Bridge helps define and link the City and Downtown to its historic past, supporting place-making and overall identity.

As illustrated in **Figure 12**, the literature generally identifies two types of economic value derived from historic resources: use value and non-use value. Use value is generally easier to quantify because it represent value premiums associated with the actual use of a resource or area, such as visitation and associated spending, rent and price premiums for benefiting properties, and changes in costs (e.g., from using an existing rather than new structure).

By definition, non-use "existence value," relates to the benefit that historic resources provide society (e.g., a community, State, or nation) because of the knowledge that it exists, independent of actual visitation or rent it might command in the market. As a non-exclusive public good, the historic value of the Winona Bridge is primarily based on its existence rather than its use.[18]

Figure 12 Framework for Historic and Cultural Heritage Valuation



Assumptions and Calculations

Figure 13 estimates the non-use or existence value of the Winona Bridge based on a series of academic studies of similar historic or cultural resources. As shown, the values range significantly depending geography. If one assumes that the preservation of Winona Bridge confers benefits to residents throughout the State, than its existence value is estimated at upwards of $245 million. Conversely, if residents of Winona County are the primary beneficiaries, then its existence value is estimated closer to $2.3 million. In this context it is worth noting that there are about 200 historic bridges in Minnesota. If one viewed historic bridges as a singular class of historic resource in the State, of which the Winona Bridge is a contributor, then its proportional contribution could be estimated at $1.45 million ($245 million/200 historic bridges).

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[18] The "use" of Winona Bridge is primarily related to its function as a transportation facility rather than a historic resource. The economic benefits of the bridge to users (i.e. passengers, pedestrians, bicyclists) is captured by other ROI metrics,

Although the estimated "non-use" historic value benefits from preservation of the Winona Bridge are likely to be small relative to total project costs, additional cultural heritage benefits related to livability (e.g., community cohesion, and "place-making") may accrue to local residents, especially in the historic downtown. Monetization of such benefits could be based on projected increase in property values and/or tourist visitation, for example.

Figure 13 Range of Estimated Non-Use Values for Historic Resources

	Willingness to Pay		Translation to Winona Bridge	
Cultural Asset	Amount	/ Unit	County (20,000 residents)	State (2.1 million households)
Preservation of Bulgarian Monasteries	$0.80	annual / household	$272,377	$28,599,589
Preservation of Hulton Getty Picture Library, UK	$7.00	annual / household	$2,383,299	$250,246,404
Value of Surrey History Centre, UK	$26.83	annual / household	$9,133,143	$958,979,971
Preservation of Northern Hotel, Fort Collins	$106.00	One-time / household	$2,120,000	$222,600,000
Value of St. Louis public libraries,	$4.00	annual / household	$1,361,885	$142,997,945
Preservation of St. Genevieve Academy	$5.50	One-time / household	$110,000	$11,550,000
Preservation of Monuments in Washington, DC	$23.00	One-time / household	$460,000	$48,300,000
Civilization, Quebec, Canada	$8.00	annual / household	$2,723,770	$285,995,891
Average			**$1,740,943**	**$182,798,973**

Impact of Bike/Ped Access on Public Health

The bicycle and pedestrian component of the new Highway 43 Winona Bridge section would encourage active transportation on the facility itself as well as through its linkage to existing trails and open space. Parks within proximity and directly connected to the Winona Bridge bike/ped facility include Latsch Island Park, the Winona Municipal Harbor, Levee Park, and Windom Park. Incorporation of the bike/ped facility in the new Winona Bridge section will provide needed connections between these park and recreation areas as well as commercial and residential land uses. These connections and enhancements are expected to increase active mode participation, especially for recreational purposes (the bridge is not a major local commute corridor).

Active transportation has been linked with numerous health benefits including reduced risk of heart disease, stroke, diabetes, hypertension and others. Therefore an increase in active transportation from the bike/ped facility on the Highway 43 Bridge will have a correlated quantifiable public health benefit for the local population and recreation visitors. Below, EPS illustrates the estimated economic impacts from public health benefits associated with the bridge project to local residents only.

In order to estimate the economic benefit of active transportation, it is necessary to estimate the total increase in biking and walking that would result. As no bike/ped projection has been developed specifically for this project and the City of Winona does not currently have reliable data on travel mode split, EPS calculated an estimated baseline activity using the City of Red Wing *Bicycle and Pedestrian Master Plan* survey results, which was completed in 2011.[19] The survey provides estimates for the frequency and length of bike rides as well as the type of walks (recreational vs. transportation/commuting).

Biking Health Benefits

As shown in **Figure 14**, using survey averages for bike rides and applying them to the population of Winona, local residents participate in nearly 1 million bike rides per year as a baseline. This total is adjusted to reflect only the recreation-related rides, reducing the total baseline rides to approximately 840,000.[20] Using survey results regarding the average distance travelled per bike ride (also adjusted to reflect recreation-related rides), EPS estimates baseline miles ridden per year of 7 million as shown in **Figure 14**.

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[19] The City of Winona does not currently have reliable bike/ped statistics for total ridership, purpose, mode split, etc. Therefore due to the similarity between Winona and Red Wing regarding density, size, weather, proximity to the river and open space, and other factors, survey results for Red Wing are used as a proxy. It should be noted that estimated rides for recreational activity may be underestimated in this analysis as the City of Winona possesses more accessible parks, open space, and most importantly, links to existing and planning trail systems than does Red Wing.

[20] Recreation-related rides are adjusted assuming all "Recreational" and half of "Recreational and Commuting" categorized rides. The adjusted results are shown in **Figure 15** for "Recreation-Related Weighted Average."

Figure 14 City of Winona Annual Rides Per Year Estimate

Item	Assumptions		Ride Frequency: Every Day	1-6 Times / Week	1-3 Times / Month	Less than 1 / Month	Never	Total Annual Rides
Time of Year (1)								
May to October (1)	a		3%	28%	22%	19%	28%	
November to April (1)	b		0%	6%	10%	32%	52%	
Annual Average (1)	c = a + b		2%	17%	16%	25%	40%	
Population of Winona (2)	d	27,944						
Adult Population of Winona (2)		23,835						
Riders per Category	e = c * d		417	3,945	3,837	6,066	9,558	
Ride Frequency (3)	f		1 Ride / Day	3.5 Rides/	2 Rides / Mo	.5 Rides /	0 Rides /	
Est. Annual Rides	g = f * e		152,246	717,934	92,098	36,396	-	**998,675**

(1) Ride frequency is derived from the City of Red Wing Bicycle and Pedestrian Master Plan survey conducted in 2011. The City of Winona does not currently have reliable bike/ped statistics. Therefore due to the similarity between Winona and Red Wing regarding density, size, weather, proximity to the river and open space, and other factors, for the purposes of this analysis, survey results for Red Wing were used as a proxy for ridership estimates in Winona.
(2) US Census 2010 adjusted to 2013.
(3) A midpoint of the survey response was assumed for all categories representing a range of rides. For example, 1-6 Times / Week was assumed to equal 3.5 rides per week.

Source: City of Red Wing Bicycle and Pedestrian Master Plan survey results, 2011; EPS.

To calculate the economic impact of increased ridership, assumptions are required regarding the increase in miles ridden due to the project as well as a per mile economic benefit attributable to health benefits. Literature on changes in active transportation participation and frequency due to improved or additional infrastructure generally shows increases in both walking and biking, especially for those located near the facility.[21]

[21] There are some contradictions in the literature, especially regarding bicycle infrastructure. Certain studies find significant positive impacts to bike participation due to new bike lanes but not for bike paths. Other studies have found significant impacts from new bike paths, but report less of a correlation for new or lengthened bike trips for bike lanes. More case-specific research on this subject is necessary to better understand the impacts of a variety of active transportation improvements for different populations.

Figure 15 Estimated Annual Economic Health Benefits from Biking

Item	Assumptions		Average Ride Distance						
			< 1 Mi.	1-3 Mi.	4-10 Mi.	11-20 Mi.	> 20 Mi.	N/A	Total Annual Rides
Type of Ride									
Recreational (1)	70%		4%	19%	34%	23%	12%	7%	
Transportation / Commuting	2%		13%	17%	11%	0%	0%	58%	
Recreational and Commuting	28%		9%	18%	23%	12%	6%	33%	
Weighted Average	998,675	Total Rides	6%	19%	30%	20%	10%	15%	
Recreation-Related Weighted Average (2)	839,885	Adj. Rides	4%	17%	30%	21%	11%	9%	
Est. Annual Rides by Trip Length (3)			37,236	145,346	254,435	172,327	89,466	72,018	839,885
Est. Miles per Ride (4)			0.50	2.00	7.00	15.50	25.00	0.25	
Est. Annual Miles			18,618	290,692	1,781,045	2,671,071	2,236,647	18,004	7,016,078
Increase in Ride Miles Due to Project (5)	2%	Increase							140,322
Economic Benefits of Improved Health due to Bike Miles Annually (6)	$0.22	per Mile							**$30,000**

(1) Includes responses that do not specify the type of ride (approximately 4 percent of responses). Ride type is derived from the City of Red Wing Bicycle and Pedestrian Master Plan survey conducted in 2011as the City of Winona does not currently have reliable bike/ped statistics. Therefore due to the similarity between Winona and Red Wing regarding density, size, weather, proximity to the river and open space, and other factors, for the purposes of this analysis, survey results for Red Wing were used as a proxy for ridership estimates in Winona.
(2) Adjusted the total rides from **Table 13** and length of ride to reflect Recreational and half of Recreational and Commuting rides only.
(3) See **Table 13**.
(4) Assumed to be midpoint of survey range. For example, 1-3 Miles was assumed to represent 2 miles. Less than 1 mile was assumed to be .5 mile and greater than 20 miles was assumed to be 25 miles to be conservative.
(5) Impacts on biking from the Project is based on a literature review of quantified effects of new trail systems, walking/biking paths and other recreational amenities on the frequency of active modes of transportation. Many of these studies, such as *New Walking and Cycling Routes and Increased Physical Activity: One- and 2- Year Findings* from the UK iConnect Study conducted in 2014, found significant increases in total biking and walking exercise per week (the study found an increase for those within .5 miles of the new facility of nearly 10 miles per week). To be conservative, EPS assumes a 2 percent increase in total activity for both walking and biking in Winona.

(6) Based on active transportation health benefits based on the New Zealand Transport Agency's (NZTA) *Economic Evaluation Manual* (2010), adjusted to 2014 dollars. A number of studies have quantified the economic benefits of active transportation on a per mile basis. These calculations often account for non-health related metrics such as infrastructure savings, decreased congestions, security, branding/tourism and others. For the purposes of this analysis, which is concerned with only the economic benefits of health impacts due to increased active transportation, the NZTA study provides the best comparison.

Sources: City of Red Wing Bicycle and Pedestrian Master Plan survey results, 2011; New Zealand Transport Agency; EPS

The Federal Highway Administration (FHWA) recently reported that in locations where better infrastructure was installed under the Nonmotorized Transportation Pilot Program (NTPP), walking increased 56 percent and biking increased 115 percent. The FHWA also utilized a peer-reviewed model that investigated the impacts on four specific communities and found similarly significant increases in walking (22.8 percent) and biking (48.3 percent) trips.[22] Other studies looking at localized impacts of active transportation impacts on bike/ped participation find similar results. [23]

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[22] FHWA Nonmotorized Transportation Pilot Program: *2014 Report*. http://www.fhwa.dot.gov/environment/bicycle_pedestrian/ntpp/2014_report/page00.cfm

[23] A study conducted in 2005 by Vernez-Moudon et. al reported that household proximity to bike paths increased the likelihood of biking by 20 percent. Furthermore, a 2014 study conducted as part of the UK iConnect found increased bike/ped participation of nearly 10 miles per week for individuals

Although there is no perfect comparative study from which to derive an estimated increase in biking and walking from the Winona Bridge improvements (and due to the lack of localized baseline data for the Winona area), for the purposes of this analysis, a conservative estimate for bike/ped mile increase of 2 percent is assumed. An increase of 2 percent over the estimated baseline, results in approximately 140,000 additional miles ridden by Winona adults annually. Using a metric developed by New Zealand Transport Agency (NZTA), which calculated a per mile active transportation health benefit of $.22 per ride mile, the economic benefit for the bicycle component of the Highway 43 Bridge is approximately $30,000 per year as shown in **Figure 15**.[24]

Pedestrian Health Benefits

The economic benefit calculation for the pedestrian component of the Highway 43 Bridge utilizes the same City of Red Wing survey data (since Winona data is lacking but Red Wing is assumed to be comparable) to better estimate the types of walks the new infrastructure may directly affect. As shown in **Figure 16**, "Social or Recreational" walks constitute two-thirds of the walks among survey respondents. For the purposes of this analysis, only this type of walking is assumed to be affected by the new bridge facility.[25]

However, as the survey does not provide information on the lengths of walks (miles), findings from a nationwide study investigating the average miles walked per day by American adults were used. The study, *Pedometer-Measured Physical Activity and Health Behaviors in US Adults,* finds that the average American adult walks 2.6 miles per day. Adjusting per day walking miles to reflect only the distance walked outside of the home or place of work, EPS estimates the average American adult walks approximately 1.9 miles per day (a 25 percent reduction). Applying this adjusted average adult walking miles to the number of Winona adults (23,835[26]) results in roughly 45,700 walking miles per day, or 16.7 million walking miles per year. Assuming that two-thirds of the walking miles are recreational (based on the Red Wing survey results), we find that the residents of Winona walk approximately 11 million recreational walking miles per year. If we apply the 2 percent estimated increase in walking miles[27], we find a net new 219,600

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living within a half mile of the new facility, which adjusting to the baseline, represents an increase of approximately 25 percent.

[24] Per km health benefits are based on the LTNZ (2006), Economic Evaluation Manual (EEM) – Volumes 1 & 2, Land Transport New Zealand. Health benefits section is found in Volume 2, section 3.8 p. 3-22. A table adjusting the metric to dollars/mile is shown in Transportation Costs and Health Benefits Analysis II – Safety and Health Costs (2013), Victoria Transportation Policy Institute, p. 5.3-49. EPS adjusted these benefit findings to 2014 dollars.

[25] In comparison, the survey data for biking is broken into Recreational, Transportation/Commuting and Recreational/Commuting, of which Recreational and half of Recreational/Commuting rides are assumed for the analysis.

[26] American Community Survey 2013.

[27] The two percent increase in walking is equal to the increase assumed for biking. As discussed in the biking analysis, there is no perfect comparative study from which to derive an estimated increase in biking and walking from the Winona Bridge improvements and based on the literature available, a two percent increase represents a conservative estimate for active mode improvements.

walking miles per year due to the Highway 43 Bridge. According to NZTA, walking miles are valued at $.55 per mile. Therefore the health benefit value associated with net new walking miles is approximately $120,000, as shown in **Figure 16**.[28]

[28] Per km health benefits are based on the LTNZ (2006), *Economic Evaluation Manual (EEM) – Volumes 1 & 2,* Land Transport New Zealand. Health benefits section is found in Volume 2, section 3.8 p. 3-22. A table adjusting the metric to dollars/mile is shown in *Transportation Costs and Health Benefits Analysis II – Safety and Health Costs* (2013), Victoria Transportation Policy Institute, p. 5.3-49. EPS adjusted these benefit findings to 2014 dollars.

Figure 16 Estimated Health Impacts for Winona Residents from Pedestrian Component of New Bridge Facility

Item	Assumptions		Estimate
Type of Walk (1)			
Social or Recreational	66%		
Transportation / Commuting	34%		
Average Distance Walked per Day per Person (2)	1.9	Miles	
City of Winona Population (3)	27,944		
City of Winona Adults (3)	23,835		
Average Winona Miles Walked Per Day			45,736
Average Winona Miles Walked Per Year			16,693,781
Estimated Recreational Walking Miles Per Year (4)			10,980,472
Walking Mile Impact for Project (5)	2%		219,609
Value of Increase Walking on Health Impacts (6)	$0.55	per Mile	**$120,000**

(1) City of Red Wing Bicycle and Pedestrian Master Plan survey results, 2011.

(2) Reflects average American miles walked per day based on *Pedometer-Measured Physical Activity and Health Behaviors in US Adults* . Bassett, David R. Jr; Wyatt, Holly R.; Thompson, Helen; Peters, John C.; Hill, James O. Study results were adjusted downward by 25 percent to reflect only the distance walked outside of the home or place of work.

(3) US Census.

(4) Assumes that due to the nature of the Winona Bridge pedestrian bridge, only social or recreational activity would be increased.

(5) Impacts on walking from the Project is based on a literature review of quantified effects of new trail systems, walking/biking paths and other recreational amenities on the frequency of active modes of transportation. Many of these studies, such as New Walking and Cycling Routes and Increased Physical Activity: One- and 2- Year Findings from the UK iConnect Study conducted in 2014, found significant increases in total biking and walking exercise per week (the study found an increase for those within .5 miles of the new facility of nearly 10 miles per week). To be conservative, EPS assumes a 2 percent increase in total activity for both walking and biking in Winona.

(6) Based on active transportation health benefits based on the New Zealand Transport Agency's *Economic Evaluation Manual* (2010). Note that the per mile health benefits from walking were found to be higher than for biking. This finding is consistent with other reviewed studies of this kind.

Sources: City of Red Wing Bicycle and Pedestrian Master Plan survey results, 2011; US Census; EPS.

As summarized in **Figure 17** below, the total health benefits attributed to the bike and pedestrian components of the Highway 43 Bridge are estimated to be $150,000 annually. Calculated as a Net Present Value, bicycle and pedestrian benefits total approximately $2.6 million.

Figure 17 City of Winona Estimated Health Benefits From Bike/Ped Improvements

Health Benefit	Valuation
Value of Increased Walking on Health Impacts for Winona Residents(1)	$120,000
Value of Increased Biking on Health Impacts for Winona Residents (2)	$30,000
Annual Bike/Ped Health Benefits	**$150,000**
Net Present Value (3)	**$2,600,000**

(1) See Table 2.

(2) See Table 3.

(3) Assumes a discount rate of 2.5 percent, an annual growth rate of 1.2 percent and a twenty year period. Growth rate is based on planning-level roadway capacities for the Winona Bridge, which anticipates daily capacity to increase from 12,400 in 2018 to 15,300 in 2038.

The net present value of added health benefits attributed to the bike/ped facility on the new Winona Bridge represents a relatively small fraction of the overall cost of the bridge. While assumptions regarding the increase in active mode participation may have tempered the outcome to some degree (i.e., if the assumed percentage increase in activity were 5 or 10 percent as opposed to the assumed 2 percent, the resulting economic benefit would be far greater), the total benefit is hindered primarily by the small population served. While it is assumed that all residents benefit from the bike/ped improvements, certain populations (likely in close proximity to the facility) may show greater increases in usage.

APPENDIX C:

Illustrative ROI Calculations
for I-35W North Managed Lanes Corridor

APPENDIX C: ILLUSTRATIVE ROI CALCULATIONS FOR I-35W NORTH MANAGED LANES CORRIDOR

This Appendix provides a description and detailed ROI calculations for the potential impact of the I-35W North Managed Lanes Corridor on air emissions, with a focus on carbon dioxide (CO2), a leading contributor to greenhouse gas (GHG). The analysis considers the "Base Scenario" which includes all future improvements on I-35W that have been identified for construction in the coming years plus one managed lane in each direction along I-35W between University Avenue in Minneapolis and Lexington Avenue in Blaine. These managed lanes would function using current guidelines for MnPASS lanes, where buses and high-occupancy vehicles would be allowed to use the lanes for free, and single-occupant vehicles would be allowed to use it if willing to pay a congestion-sensitive toll. The analysis is intended to illustrate how transportation ROI analysis can inform assessments of "Environmental Stewardship".

Framework and Methodology

Motorized vehicles cause air pollution, either by emitting combustion products directly, in the form of particulate matter and gasses, or indirectly (e.g., all-electric vehicles) at the point at which their motive energy is originally generated. The air emissions have impacts on the environment, climate and on human health and are generally classified into greenhouse gasses (GHG) and non-GHG components.

While MnDOT analysis of the *I-35W North Managed Lanes Corridor alternatives* did not explicitly address air emissions, the latter study did provide sufficiently detailed VMT, Vehicle Hours Traveled (VHT) and Average Speed information and data to support first-pass, or approximate estimates of vehicle-related air emissions under the Project (i.e., managed lane alternatives) and No Project (i.e., no managed lanes) scenarios. Such approximate estimates are not substitutes for the more formal assessments to be performed as part of the Environmental Assessment (EA), but can provide an order-of-magnitude perspective of the likely differences between the scenarios, and even assist stakeholders and the public in understanding the potential air quality benefits and trade-offs in managed lane systems, which may not be obvious and for many may even be counterintuitive.

Emissions of these components vary by type, age and condition (i.e., tuning and maintenance) of vehicles, with ambient air temperature and elevation of the traveled roadways, with average speed of travel and variations of speed during trips, etc. When alternate land use and transportation scenarios are being evaluated, additional consideration must be given to differences in the mix of vehicles, e.g., passenger cars vs. trucks and/or transit vehicles, assumed to travel the studied transportation network. Any significant differences in ridership behaviors, e.g., the numbers and ratios of total travelers travelling in single-occupancy vehicles (SOV) as compared to high-occupancy vehicles (HOV) or by transit, must also be considered.

Rigorous estimates of air emissions related to proposed or operating congestion pricing and managed lane systems require complex formal modeling such as provided by the Environmental

Protection Agency's MOVES (Motor Vehicle Emission Simulator)[29], but as indicated above, useful approximations of vehicle-related emissions can be made using more generalized tools such as the Atlanta Regional Commission's Congestion Mitigation and Air Quality Improvement (CMAQ) Emissions Calculator[30] or even relatively simple spreadsheet calculations, as illustrated in this section.

Among the range of vehicle-related emissions carbon dioxide (CO2) is frequently afforded the most attention in terms of overall impact, as it is an inevitable product of the combustion of carbon-based fuels in internal-combustion engines and is a leading contributor to GHG. Transportation-related emissions have been estimated to account for about one-third of all CO2 emissions for the United States, with about 80 percent of the transportation-related emissions coming from cars and trucks travelling on roadways.[31]

An increase in CO2 emissions is not necessarily or in all cases the inevitable consequence of a projected increase in VMT. CO2 emissions per mile travelled can be reduced if vehicles are made lighter and smaller with compensating improvements in passenger safety; with improvements in powertrain efficiency; and with changes of fuel and power technologies, such as for electric and hybrid vehicles and alternate fuels (biofuels, synthetics, fuel-cells, etc.). Significant changes in CO2 per vehicle mile travelled can also occur as a function of traffic congestion, i.e., as a function of average speed and variation in speed of travel, as has been examined in several studies by Kanok Boriboonsomsin of the Center for Environmental Research and Technology at the University of California, Riverside, working in collaboration with Matthew Barth and others.

Detailed Calculations

This analysis monetizes expected changes in CO2 emissions as a result of the changes in both VMT and VHT due to the proposed I-35W North Managed Lanes Corridor improvements. The technical appendices to the final report for the I-35W North Managed Lanes Corridor Study provide SRF Consulting Group (SRF) estimates of annual VMT and VHT within the 19-county transportation model region influenced by the proposed managed lanes and other corridor improvements**32**. (This area is bound by and including I-35E on the East, I-94 and TH 252 on the West, TH 62 on the South, and CSAH 14 on the North).

Average speed in miles per hour can be calculated as the ratio of VMT to VHT:

$$x = \text{Average speed in miles per hour} = VMT/VHT$$

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[29] http://www.epa.gov/otaq/models/moves/

[30] http://atlantaregional.com/environment/air/cmaq-calculator

[31] M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds, April 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability,* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

[32] SRF Consulting Group, January 26, 2013. I-35W North Managed Lanes Corridor Study VMT-VHT Forecast Memorandum from Paul Morris, Senior Engineer to Todd Polum, Principal. Attachment B in Appendix G – Benefit Cost Memorandum, *I-35W North Managed Lanes Corridor Study Appendices.*

Gas emissions are generally calculated and reported in terms of metric tons per year (TE), with one (1) metric ton being equal to one million ($1x10^{6)}$ grams so that:

$$TE = \text{metric tons of emissions per year} = y \cdot VMT_{(annual)}/1 \cdot 10^6$$

Where, as explained above, y is CO2 emissions in grams per mile.

We can apply these CO2 emissions relationships and formulae to the VMT, VHT and Average Speed estimates for the I-35W North Managed Lanes influence area under the 'No Build' or 'Program' scenario and the 'Build' or 'Base' scenario defined by SRF, in order to estimate and compare CO2 emissions with and without I-35W North managed lanes.[33]

Figure 18 shows estimated CO2 emissions in metric tons per year (TE) for 2010 and 2030 under the Program or No Build scenario; **Figure 19** shows estimated CO2 emissions for 2010 and 2030 under the Base or Build scenario; and **Figure 20** shows the estimated net impacts of implementation of the proposed I-35W managed lane project on vehicle-related CO2 emissions in the influence area (Build emissions minus No Build emissions). The VMT, VHT and average speed numbers in **Figures 18** through **20** are as estimated by the SRF Consulting Group; the CO2 emissions are as calculated by Economic & Planning Systems, applying the polynomial formulae and coefficients derived by Barth and Boriboonsomsin in their cited 2008 study.

[33] SRF Consulting Group, January 26, 2013, *ibid*. The SRF-defined Program Scenario includes the 4th Street entrance and northbound auxiliary lane, the I-694 and TH 51 interchange, the TH 10 and CSAH 96 grade separation, the TH 36 eastbound MnPASS lane, and the I-35E MnPASS lanes. The Base Scenario includes all of the Program Scenario and adds managed lanes on I-35W between University Ave. in Minneapolis and Lexington Ave. in Blaine.

Figure 18 Estimated CO2 Emissions without I-35W North Managed Lanes

2010	**Program [Without I-35 W North Managed Lanes]**			
	VMT	**VHT**	**Avg Spd (mph)**	**CO2 (TE)**
Freeway	12,220,444	302,815	40.4	3,958.6
Expressway	1,327,131	42,836	31.0	450.7
Divided Arterial	1,885,837	77,236	24.4	708.9
Undivided Arterial	4,007,474	168,120	23.8	1,526.2
Collector	1,468,145	81,195	18.1	668.6
MnPass	70,861	1,500	47.2	22.9
Total	**20,979,892**	**673,702**	**31.1**	**7,335.9**
2030	**Program [Without I-35 W North Managed Lanes]**			
	VMT	**VHT**	**Avg Spd (mph)**	**CO2 (TE)**
Freeway	14,120,028	405,730	34.8	4,657.7
Expressway	1,623,432	66,637	24.4	611.0
Divided Arterial	2,298,589	110,263	20.8	949.3
Undivided Arterial	5,041,641	245,338	20.5	2,101.7
Collector	1,809,812	109,237	16.6	879.0
MnPass	86,341	1,983	43.5	27.9
Total	**24,979,843**	**939,188**	**26.6**	**9,226.6**
Notes:	**VMT, VHT and TE in units per year; 1 TE = 1 metric ton = 1 million grams**			

Figure 19 Estimated CO2 Emissions with I-35W North Managed Lanes

2010	**Base [Program + I-35 W North Managed Lanes]**			
	VMT	**VHT**	**Avg Spd (mph)**	**CO2 (TE)**
Freeway	12,198,355	300,928	40.5	3,950.5
Expressway	1,324,025	42,598	31.1	449.2
Divided Arterial	1,881,560	76,808	24.5	706.0
Undivided Arterial	3,995,271	167,228	23.9	1,519.7
Collector	1,465,828	80,906	18.1	666.6
MnPass	134,902	2,673	50.5	43.8
Total	**20,999,941**	**671,141**	**31.3**	**7,335.8**
2030	**Base [Program + I-35 W North Managed Lanes]**			
	VMT	**VHT**	**Avg Spd (mph)**	**CO2 (TE)**
Freeway	14,086,886	401,278	35.1	4,639.2
Expressway	1,618,579	65,981	24.5	606.9
Divided Arterial	2,291,854	109,390	21.0	943.4
Undivided Arterial	5,027,663	243,466	20.7	2,089.2
Collector	1,807,098	108,675	16.6	875.3
MnPass	179,868	3,917	45.9	58.2
Total	**25,011,948**	**932,707**	**26.8**	**9,212.2**
Notes:	**VMT, VHT and TE in units per year; 1 TE = 1 metric ton = 1 million grams**			

Figure 20 Difference in VMT, VHT & CO2 Emissions with I-35W N. Managed Lanes

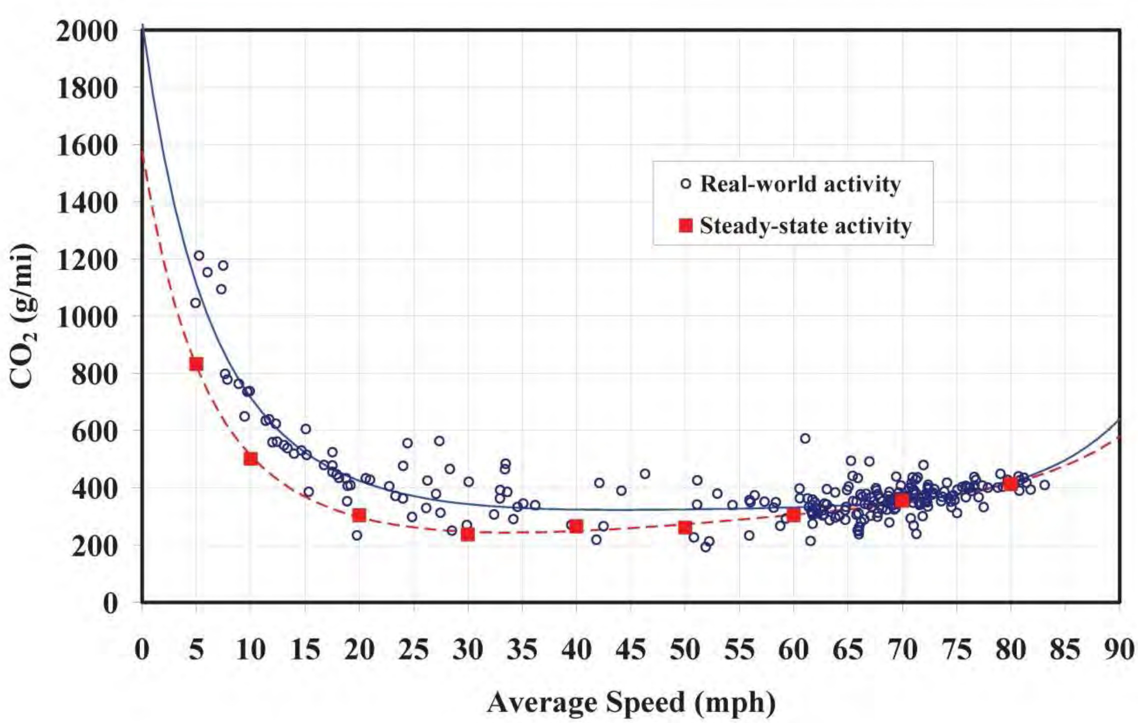
2010	Difference [with I-35W North Managed Lanes]				Social Cost
	VMT	VHT	Avg Spd (mph)	CO2 (TE)	(2014$)
Freeway	-22,089	-1,887	0.2	-8.1	-$200
Expressway	-3,106	-238	0.1	-1.5	-$37
Divided Arterial	-4,277	-428	0.1	-2.8	-$70
Undivided Arterial	-12,203	-892	0.1	-6.6	-$161
Collector	-2,317	-289	0.0	-2.0	-$49
MnPass	64,041	1,173	3.2	20.9	$514
Total	**20,049**	**-2,561**	**0.1**	**-0.2**	**-$4**
2030	**Difference [with I-35W North Managed Lanes]**				**Social Cost**
	VMT	**VHT**	**Avg Spd (mph)**	**CO2 (TE)**	**(2014$)**
Freeway	-33,142	-4,452	0.3	-18.5	-$961
Expressway	-4,853	-656	0.2	-4.1	-$212
Divided Arterial	-6,735	-873	0.1	-5.9	-$304
Undivided Arterial	-13,978	-1,872	0.1	-12.5	-$652
Collector	-2,714	-562	0.1	-3.7	-$193
MnPass	93,527	1,934	2.4	30.3	$1,574
Total	**32,105**	**-6,481**	**0.2**	**-14.4**	**-$749**
Notes:	**VMT, VHT and TE in units per year; 1 TE = 1 metric ton = 1 million grams**				

Interpretation of Results

The results shown in **Figure 21** may be initially surprising; while total Vehicles Miles Travelled (VMT) in the study area are estimated to increase with addition and operation of the proposed I-35W North Corridor managed lanes, total Vehicle Hours Traveled are estimated to decrease in comparison to the No Build scenario. The projected benefits of the managed lanes at 2030 include both a modest increase in average speed along roadways in the study area, and an overall modest reduction in CO2 emissions compared to the No Build scenario. In sum, the managed lanes are projected to increase transportation system efficiency and capacity without at the same time increasing total annual vehicle-related CO2 production.

The crucial factors that underlie these estimates are the differing rates of air emissions as a function of vehicle speed and the changes in proportional shares of VMT and in average speeds along the separate types of roadway segments (freeway vs. collector, etc. and managed vs. general purpose) in the study area with and without the proposed project. As documented by Barth and Boriboonsomsin, CO2 emissions per mile change with speed, especially when average speed drops below 30 mph or rises above 60 mph (see **Figure 21**).

Figure 21 CO2 emissions (grams/mile) as a function of Average Speed (mph)



From: *Real-World CO2 Impacts of Traffic Congestion***,** Matthew Barth and Kanok Boriboonsomsin, 2008, Figure 3.

While **Figures 19** and **20** display significant increases in VMT, VHT and CO2 emissions for MnPass roadway segments at 2030 if the proposed I-35W North Corridor express lanes are implemented, the overall transfer of vehicles and VMT from the other general purpose (GP) and toll-free roadway segments causes VHT to drop and average speed to improve for other vehicles travelling those GP roadways, with the concomitant CO2 emission reductions for those segments more than offsetting CO2 emission increases from vehicles travelling the MnPass managed lanes.

Although the finding of no significant increase in CO2 emissions for the Build scenario is very important, in this specific example of emission calculations, the net annual 14.4 metric tons reduction of CO2 emissions is small relative to the total emissions estimates for the compared scenarios (i.e., only tens of metric tons reduced relative to tens of millions of metric tons produced in total). **Figure 20** also includes an estimate of the Social Cost of Carbon (SCC)[34] net difference at 2030 with the managed lanes, but ***comparing only the aggregate net reduction in vehicle-related emissions*** and not annual social cost per vehicle or vehicle mile travelled, the SCC benefit is only about $750. In other words more travel can be accommodated with negligible impact (i.e. less than zero) on total CO2 emissions.

The key assumption in making speed-based emission calculation is that the set of factors being used is appropriate; that is, appropriate to the place and environmental conditions of the study area, to the mix and type of vehicles assumed to travel there, and to the time intervals being examined (the latter requiring adjustments in the assumed fuel economies and emission limits for new vehicles under Federal and local regulations and air quality targets). Vehicle-related emission calculations are sensitive and may need adjustment to reflect conditions including:

- Emission Type (CO_2, CO, ROG, TOG, NO_x, PM_{10}, $PM_{2.5}$, etc.)
- Geographic area (location and elevation)
- Vehicle type and age
- Fuel type (gas, diesel, hybrid, electric, etc.)
- Air temperature and relative humidity
- Calendar years (for the desired emission estimates and projections)

[34] SCC per metric ton of CO2 factors derived by EPS from *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* pg. 39 Table A1, U.S. Environmental Protection Agency, Interagency Working Group on Social Cost of Carbon (Update, February 2010), with 1.14907 cost adjustment from 2007$ to 2014$ made using Bureau of Labor Statistics CPI Inflation Calculator. http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf http://www.bls.gov/data/inflation_calculator.htm.

Average speed estimates should be broken out by type of roadway, as has been done by SRF for the I-35W North Corridor managed lanes study described above. In recent research on managed lanes performed for the California Department of Transportation[35], emissions per mph speed curves for CO2, CO, THC, NOx, PM_{10}, and $PM_{2.5}$ were developed for the following 6 lane types:

- Limited access High Occupancy Vehicle (HOV) lanes
- General Purpose (GP) lanes parallel to limited access HOV lanes
- Continuous access HOV lanes
- GP lanes parallel to continuous access HOV lanes
- Express/High Occupancy Toll (HOT) lanes
- GP lanes parallel to express/HOT lanes

[35] *Deployment of Prior HOV Lanes Research Results in Developing Analysis Tools for New Managed Lanes Projects: Final Report, ibid.*