Metropolitan Highway System Investment Study

Final Report

PARSONS BRINCKERHOFF

September 2010

FINAL REPORT

Metropolitan Highway System Investment Study

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FIGURES

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EXECUTIVE SUMMARY

The 2030 Regional Transportation Policy Plan (TPP, adopted in 2009) provides a context for upcoming mobility and accessibility challenges in the Twin Cities from the year 2000: population growth of 966,000, employment growth of 520,000, and absent structural changes to transportation energy and infrastructure, daily increase of 15.3 million vehicle miles traveled (VMT). Recognizing no growing metropolitan area in the U.S. is able to build their way out of congestion, the Metropolitan Council (MetCouncil) and Minnesota Department of Transportation (Mn/DOT), through this effort and subsequent incorporation within the 2030 TPP, Statewide Transportation Plan (STP), and Mn/DOT Metro District Highway Investment Plan, endeavor to develop a future transportation investment strategy that optimizes the investments already made in the region through the use of multimodal-oriented managed lanes and comprehensive system management strategies. The consideration of managed lane elements provides an opportunity for travelers to opt their way out of congestion, even if system congestion may persist.

The Metropolitan Highway System Investment Study (MHSIS) is a contributing input to the 2030 Regional Transportation Policy Plan adopted in 2009. Similar efforts conducted by Mn/DOT and the Metropolitan Council in recent years (such as the 2009 Congestion Mitigation and Safety Plan, CMSP) have focused upon particular transportation policies in order to advance the TPP master plan. In the case of the MHSIS, this focus was the use of management strategies as a possible alternative for costly general purpose capacity expansion in the TPP. The MHSIS concentrated upon how active traffic management (ATM) and managed lane components could be combined and implemented in the Twin Cities. The purpose of these strategies is not to fix congestion, but rather to provide residents, employees, and visitors with a consistently congestion-free alternative throughout the regional highway system. Although other management strategies were initially considered in the MHSIS, such as access management and interchange consolidation, as these strategies did not further the primary purpose of providing a congestion-free alternative, these strategies (and the facilities upon which they were considered) were transferred to the CMSP and are not a component of this report.

MANAGED LANES

Managed lanes have been in existence for nearly 30 years and represent a family of operational strategies designed to address a wide array of transportation goals. Managed lanes have a distinct advantage over general purpose lanes: through eligibility, access control, and pricing, managed lanes can provide for regular and predictable free-flow travel speeds on the managed lanes. In turn, free-flow managed lanes avoid traffic saturated general purpose lanes, yielding not only improved vehicular throughput in saturated conditions, but also improved person throughput based upon the encouragement (through price signals) of higher vehicle occupancies and bus ridership.

A variety of managed lane configurations are available for corridor-wide projects. The MHSIS concentrated upon those that have the likeliest application for the broadest number of facilities in the Minneapolis / St. Paul area. One of the principal objectives of the MHSIS was to identify how new managed capacity could be provided with higher value and less cost. To meet this objective, the MHSIS considered the deployment of managed lanes in the context of dedicated and dynamic shoulder use. As successfully demonstrated on the I-35W corridor, new managed lanes can be safely implemented with an alternative design to established managed lanes.

Active Traffic Management

Although ATM may be successfully implemented in an arterial corridor, ATM in this study provides for operating conditions that enable complete use of a freeway corridor's pavement, an important component of the MHSIS. ATM does this by dynamically managing traffic flow and lane assignment based on prevailing traffic conditions and presence of collisions or other incidents. ATM has been defined by Mn/DOT as including ITS strategies which may be implemented on non-freeway arterials, including strategies such as signal coordination, cameras for incident and traffic management, and changeable messaging signs. However, for the purpose of this analysis, ATM has been confined to freeway systems with the specific components identified below.

Focusing on trip reliability, its goal is to maximize the effectiveness and efficiency of the facility under recurring congestion and non-recurring incidents or road work. Through the flexible use of the roadway, it aims to increase system performance as well as traveler throughput and safety through the use of strategies that actively regulate the flow of traffic on a facility to match current operating conditions.

Study Process

In preparing and conducting the MHSIS, the project team first assembled information on peer communities, to determine how other metropolitan areas are evaluating the efficacy of management and operations strategies in the context of their long range plans. The findings from this assessment were used to inform the development of the MHSIS analysis. From this exercise, the project team prepared the performance measures for the MHSIS modeling activities. Findings from the evaluation of specific projects provide detailed findings for each project identified in the MHSIS draft plan. Additionally, econometric analyses were conducted for managed lane projects as well as for ATM implementation. As ATM will likely be a necessary complementary strategy to managed lanes in order to mitigate concerns when using shoulder lanes, this analysis is conducted concurrent to the capacity analysis. Finally, phasing and other conclusions for incorporation within the 2030 TPP was examined.

Four categories of performance measures were used to examine the MHSIS alternatives:

- Increase the person-moving capability of the metropolitan highway system
- Manage and optimize, to the greatest extent possible, the existing system
- Reduce future demand on the highway system
- Implement strategic and affordable investments

MHSIS Project Evaluation

Initially, a total of 41 separate projects were identified for analysis in the MHSIS. Thirty-four of these projects were developed by the MHSIS Project Management Team (PMT), comprised of Mn/DOT and MetCouncil representatives, prior to the conduct of the MHSIS study. Seven additional facilities were added to the MHSIS analysis based upon preliminary study corridors identified by the MnPass System Study Phase 2. These projects included managed lane expansion projects (building a new concurrent flow managed lane), managed lane conversion projects (adapting an existing general purpose lane into managed lane operations), interchange closure, multiple interchange consolidation, limited access design conversion, strategic capacity expansion, and expressway expansion. However, as the MHSIS PMT focused the MHSIS analysis upon managed lanes, the other strategy elements were placed within the purview of other efforts – including the Congestion Mitigation and Safety Program (CMSP), 2030 TPP Update, and related planning. Finally, during the course of the MHSIS, Mn/DOT conducted an update to the MnPass System Study, which adopted a policy of managed lane expansion only. Given the desire for concurrence and performance metrics which indicated a preference for expansion over conversion, only managed lane expansions were forwarded for analysis in this Final Report (full analysis of the conversion projects may be found in the technical appendices).

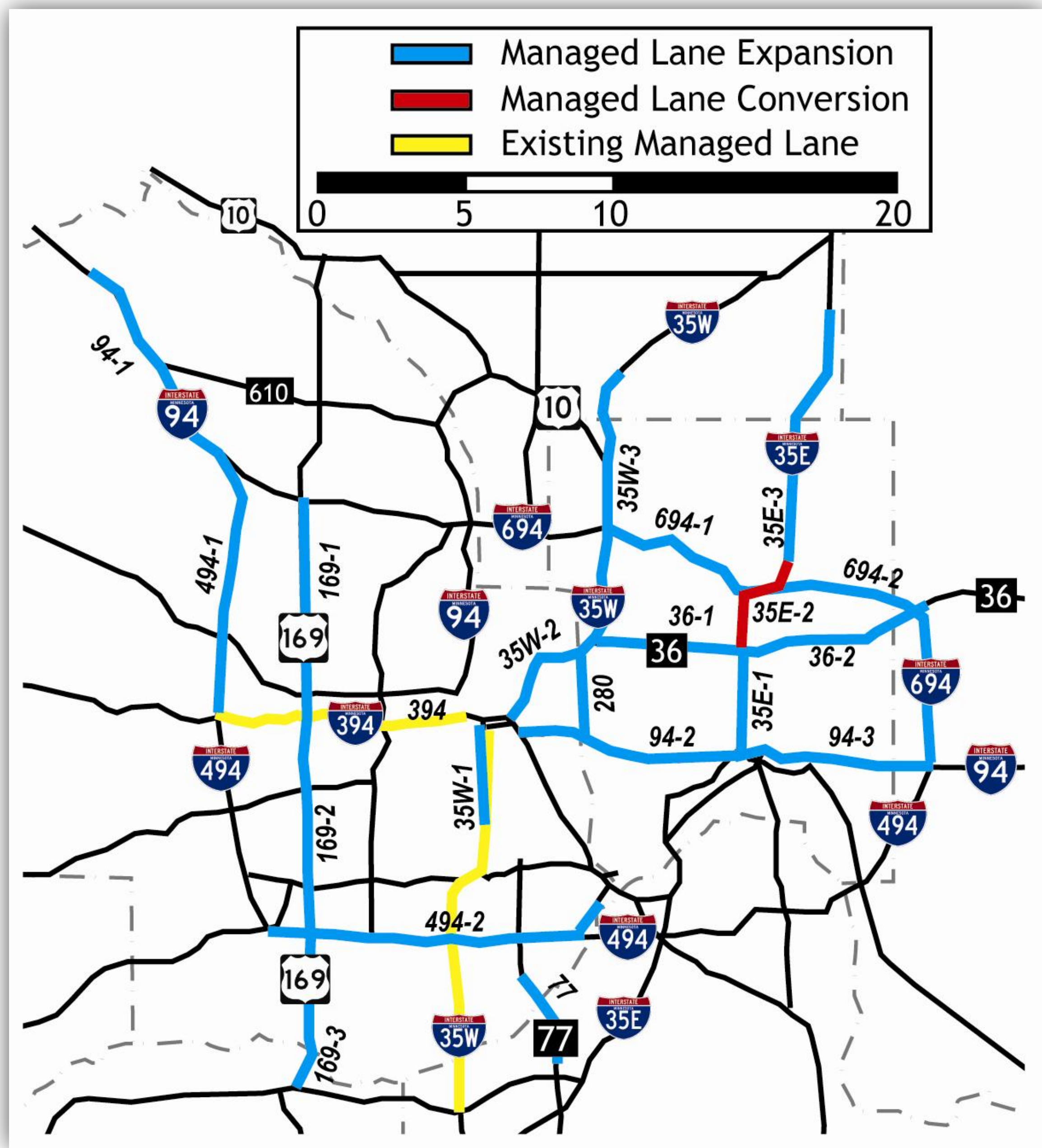


FIGURE 1: MANAGED LANE UNIVERSE OF PROJECTS

The MHSIS Study was completed concurrently with the MnPass System Study Phase 2. Although these studies were conducted with different objectives and timeframes for analysis, the measurements used for cost were mirrored closely between the two studies; however there are four primary areas where the MHSIS study differed from the MnPass Study. First, the MHSIS did not include any cost for direct connections between managed lane facilities; however, the MnPass System Study Phase 2 did look into the geometrics and cost for how a managed left lane structure would connect into the downtown exits. As the presence of direct connection was not included in the performance modeling, these costs are excluded from the MHSIS. However, the benefit of the connections has been evaluated as a part of the MnPass System Study Phase 2 and should be considered valid for correlation to MHSIS projects. Second, the MHSIS applied a lower miscellaneous cost for the corridors, but was balanced out by the risk factors. The MnPass System Study Phase 2 applied the same risk factor to the low and high range. In contrast, the MHSIS used risks that varied by 10% between the low and high ranges. Third, the MnPass System Study Phase 2's timeframe for analysis was 2-10 years, with a keystone analysis of year 2015, whereas the MHSIS used a 20-year timeframe with the year 2030 as the keystone. Finally, the study corridors did not perfectly align between both studies. As a result, segment consideration may drive differences between the MnPass and MHSIS study corridors.

One of the main recommendations of the MHSIS is for the continued communication and coordination between the agencies on implementation of the desired project concurrently with the preservation of other maintenance or design projects. Examples of these situations could vary from an existing bridge that is programmed for replacement or a standard mill and overlay preservation project to a strategic capacity enhancement that would perform even better with additional ATMs.

Analytical Findings

In the Table 1 and Figure 2 summary, the overall performance rating of the managed lane corridors indicate which improvements best correspond with the objectives of the MHSIS for assumed potential implementation by 2030. Corridors with a rating of "High" or "Moderate" are likely in keeping with the guiding principles of the MHSIS. By contrast, those with a "Low" rating may not correspond from a performance perspective. Although some facilities may not be appropriate for the short term (2030), these managed lanes may work for the longer term (2030 – 2060), and as a result remain within the long-term vision of the managed lane network for the region.

TABLE 1: MANAGED LANE PRIORITIZATION SUMMARY

Corridor	Throughput	Optimization	Demand Reduction	Cost Effectiveness	Transit Suitability	Investment Parity	Opportunity	Composite
169-2	Moderate	Moderate	Moderate	Low	High	Moderate	High	**Moderate**
169-3	High	Moderate	Moderate	Low	Moderate	High	High	**Moderate**
35E-1	High	Low	Low	Moderate	Moderate	High	High	**High**
35E-2	Moderate	Low	Moderate	High	Low	Low	Moderate	**Moderate**
35E-3	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate	**Low**
35W-1	Low	Moderate	Moderate	Moderate	High	High	High	**High**
35W-2	High	Low	Moderate	Moderate	High	Moderate	Moderate	**Moderate**
35W-3	Moderate	Moderate	Moderate	Moderate	High	Moderate	High	**High**
36-1	Moderate	Moderate	Moderate	High	High	High	High	**High**
36-2	Low	Moderate	Moderate	High	High	Low	High	**Moderate**
494-1	Moderate	Moderate	High	Moderate	Low	High	Low	**Moderate**
494-2	Moderate	Moderate	Low	Low	Low	Moderate	Low	**Low**
694-1	High	Low	High	Moderate	Low	High	High	**High**
694-2	Moderate	Moderate	Moderate	Low	Low	High	Low	**Low**
77	High	Low	Low	Low	High	Moderate	High	**Moderate**
94-1	Low	High	High	Moderate	Moderate	Moderate	Moderate	**Moderate**
94-2	High	Low	Moderate	Low	High	Moderate	High	**Moderate**
94-3	Low	Low	Low	Low	High	Moderate	Moderate	**Low**

FIGURE 2: MANAGED LANE PRIORITIZATION SUMMARY

2030 MANAGED LANES PLAN

Of capacity expansion projects, certain managed lane projects stand-out as advantageous for action within the 2010 – 2030 timeframe:

- I-35E, from downtown St. Paul to north of I-694 (35E-1 and 35E-2). Although not as high a performer as other managed lane corridors, there are extenuating circumstances that advance this corridor. First, the Cayuga Bridge reconstruction project provides an opportunity to cost effectively add managed lanes. Furthermore, the reconstructed interchange at I-694 has abundant pavement availability, allowing for managed lane expansion in this segment without substantial additional cost. Together, this permits a greater return on investment from the reconstruction activities. Second, this section of the metropolitan highway system rates well for parity purposes (addressing previously planned facilities in the long range plan).

- I-494, from I-394 to I-94/I-494 interchange (494-1). The I-494 corridor would significantly benefit from the implementation of managed lanes, as evidenced from the modeling activities. Furthermore, this corridor has a high rating for investment parity, based upon prior commitments in the long range plan. Finally, the corridor helps the I-394 MnPass lanes constitute the beginning of a system, with the possibility to serve managed lane trips from the south to northwest Metro across much of the system. The key limitation of this corridor will be the likely lack of connectivity between the I-394 MnPass lanes and the I-494 managed lanes, although this could be addressed in the future if the interchange must be reconstructed. However, given the strength in performance and moderately rated cost effectiveness, this corridor's opportunities outweigh its weaknesses.

- I-35W, from downtown Minneapolis to 95th (35W-1 and 35W-2). I-35W north is one of the strongest transit corridors for the managed lane system, and deserves special consideration here. In addition to its transit suitability, this corridor has moderate-to-high ratings for performance, including throughput, optimization and SOV travel reduction. The ability to serve regional and inter-regional trips on the managed lane system is high, with close connections to I-394 and I-35W to the south. Finally, given the presence of existing bus-only-shoulder operations, the ability to convert this facility to managed lanes is strong.

- TH-36, between I-35E and I-35W (36-1). TH-36 held moderate ratings throughout all performance criteria. This segment also performs well for transit suitability, investment parity, and cost effectiveness. Finally, this segment is programmed for interchange work on Lexington and Rice, providing an efficiency opportunity to address managed lanes as it pertains to these structures. As a result, TH-36 is recommended for managed lanes development in the MHSIS. However, one crucial concern with TH-36 is its connections with I-35W an I-35E. Without direct connection ramps, which are cost prohibitive without appropriately sized accompanying benefit, the termini for TH-36 median-based managed lanes would require weaving to a right-side ramp in both conditions. In the case of westbound TH-36 to southbound I-35W, this movement would likely severely curtail corridor operations. Additional simulation study is recommended to determine the operational impacts of managed lanes on this corridor without direct connections. In the next 20 years, it may be possible to implement asynchronous managed lanes on this corridor, featuring an eastbound-only treatment. Again, additional study should evaluate the effectiveness of an asynchronous treatment if a bi-directional treatment cannot be affirmed.

- I-94, between downtown Minneapolis and downtown St. Paul (94-2). The I-94 managed lane project rated well for throughput, but low for optimization primarily due to the constraints imposed upon the corridor by the Lowry Hill tunnel and the Capitol interchange. Furthermore, the need to replace structures in the corridor yields an elevated cost versus other facilities in the region, thereby depressing the corridor's overall cost effectiveness rating. Pending deployment of ATM in the corridor may assist in addressing some of the corridor's traffic effects, while providing for enhanced bus operations. Furthermore, a parallel light rail transit facility will soon open, providing a corridor alternative for transit riders. All of these conditions lend to a conclusion that I-94 should remain a medium priority for managed lane development, with an understanding that upcoming opportunities may arise for reconstruction purposes that can positively affect the return on investment in this corridor.

The MHSIS Project Management Team has developed a working budget estimated at approximately $450 to $500 million (2010 dollars) for the years 2014 – 2020 for deployment on managed lane facilities, and an additional $50 to $100 million anticipated for ATM deployment. As ATM as a concept has been refined as a supplement to managed lane deployment, an independent budget may be counterproductive. The consolidated budget is estimated at approximately $500 to $600 million. As such, the following estimates include the deployment of ATM as a complementary strategy to managed lanes. Given managed lanes and ATM deployment share some infrastructure, the specific cost for ATM is reduced from $2.0 M per mile to $1.6 M per mile. Using cost estimates refined by the MnPass System Study Phase 2 for the early action corridors (where available), this yields a simple division of expenditure (2010 dollars) in Table 13.

TABLE 2: COST ESTIMATE BY 2030 MANAGED LANE CORRIDOR

Project	Construction ($M 2010)	ATM ($M 2010)	Total (inc. risk) ($M 2010)
I-35E	$75	$12	$120
I-494	50	11	61
I-35W	165	24	255
TH-36 (est. asynch.)	16	6	28
I-94	88	15	103
TOTAL	$ 394 M	$ 68 M	$ 567 M

Additional facilities that are recognized for the long-term (2030 – 2060 timeframe) implementation include:

- TH-77, between 141st Street and TH-62. The TH-77 corridor is currently under study by Mn/DOT for managed lane feasibility, with a planned Bus Rapid Transit lane to be constructed in the vicinity of the Apple Valley Transit Center in the next few years. Although the performance modeling did not rate favorably for the corridor, this is due to the length of the modeled facility. Current planning activities indicate a shorter segment may be feasible and meet project needs. In order to avoid biasing the results of this planning study, the MHSIS is avoiding a prioritized determination of feasibility for 2030, but has included the facility for planning purposes.

- I-94, between TH-101 and I-494 (94-1). The market for this project may be significantly affected by the completion of TH-610. Managed lane implementation may be warranted in the future, but 2030 performance metrics indicate the usefulness of managed lanes for person throughput may be constrained. It is recommended to evaluate the efficacy of this project as an extension of I-494 managed lanes (upon deployment) and post-completion of TH-610.

- I-694, between I-35E and I-35W (694-1). The I-694 segment between I-35W and I-35E rates highly for performance metrics, including throughput and SOV demand reduction. Additionally, this corridor rates well for investment parity purposes, based upon previous commitments in the 2030 plan, and rates moderately well for cost effectiveness. The benefit-cost calculation, though, did not account for programmed improvements to the I-35W / I-694 interchange as well as additional investment on I-694 in this segment. As a result, this cooperative opportunity would benefit the implementation of managed lanes in this segment. Additional study should assess the specific value of bi-directional and asynchronous (westbound only) treatments, especially in light of potential asynchronous treatment on TH-36 in the opposing direction.

- US 169, between TH-62 and the Minnesota River (169-3). Managed lanes on US 169 offer moderately strong performance metrics, but poor cost effectiveness due to the limited market for this facility relative to cost. As population expands in the southwest Twin Cities, this facility may become more necessary in order to enhance mobility options from the growth sectors to the urbanized area. Planned improvements to the I-494 and US 169 interchange provide an opportunity to reduce the cost of development of managed lanes. At a minimum, it is recommended that this interchange effort consider the future implementation of managed lanes on not only US 169, but also I-494 in the design of the facility.

- US 169, between TH-62 and I-394 (169-2). If an opportunity for cost reduction is available for US 169 in this segment, the performance metrics suggest a productive corridor for managed lanes. Key questions concern the connectivity between I-394 and I-494. Without an opportunity for cost reduction, this project is not recommended for the 50-year horizon.

- I-494, between I-394 and Minneapolis / St. Paul airport (494-2). Whereas I-494 in the vicinity of I-35W has been designated as a potential strategic capacity expansion, it may be more productive to consider this segment as a managed lane corridor and extending the facility to MSP airport, which has acceptable performance metrics. However, given the high cost of this project, only an opportunistic perspective should be use for long-term development.

- TH-36, between I-35W and I-694 (36-1 and 36-2). Assuming TH-36 has an asynchronous development in the 20-year plan, the 50-year horizon suggests a bidirectional deployment may be warranted if connections to I-35W and I-35E can be resolved. Additionally, opportunities to extend the managed lane corridor to I-694 may be viewed favorably based upon performance estimates. This should be viewed opportunistically for cost reduction.

- I-694, between I-94 and I-35E (694-2). This segment of I-694 had moderate levels of performance benefit associated with managed lanes; however, the cost of development yielded low cost effectiveness relative to those benefits. As a result, the region should review this corridor in the perspective of opportunity for cost reduction.

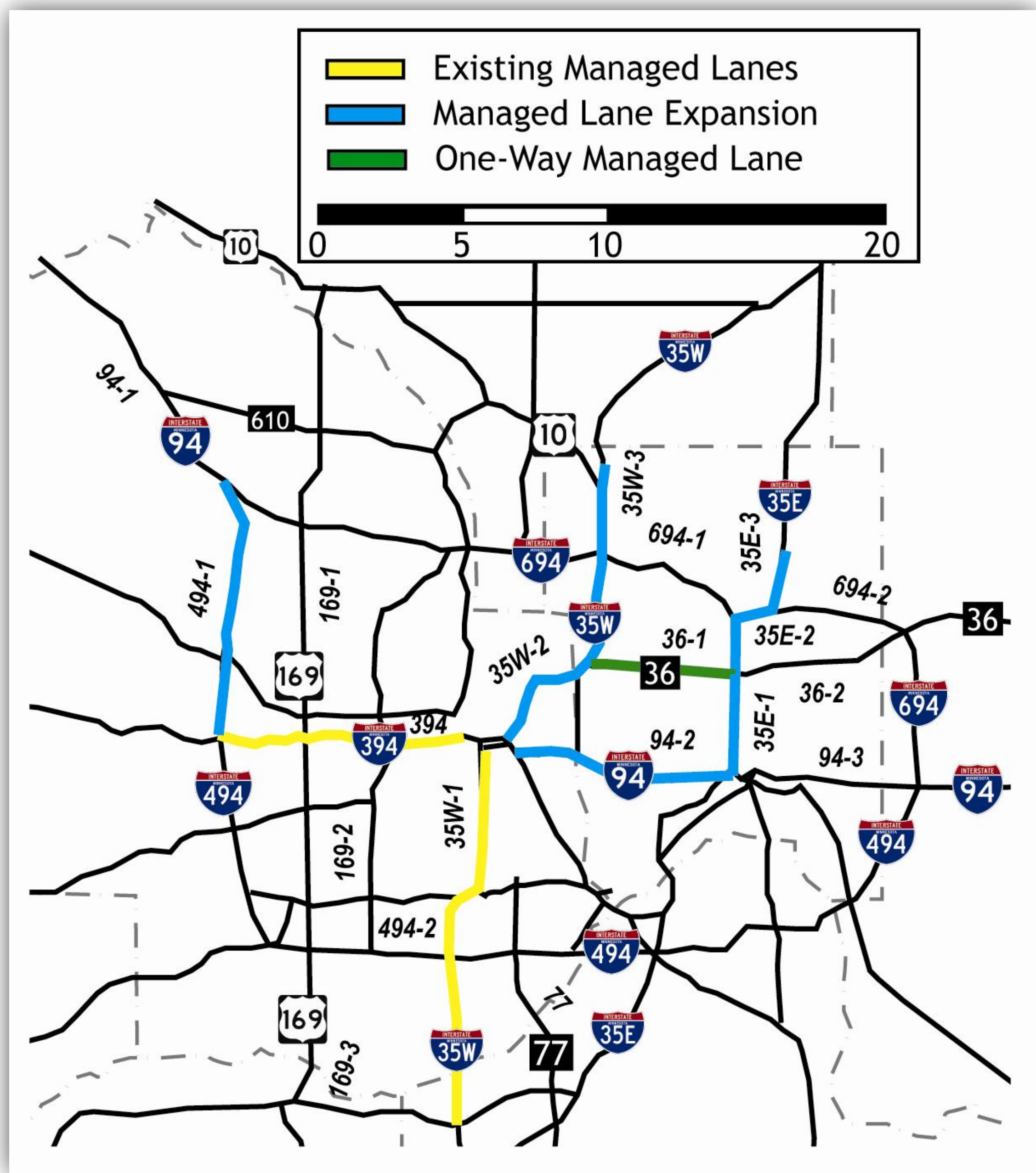


FIGURE 3: 20-YEAR MANAGED CAPACITY RECOMMENDED PROJECTS

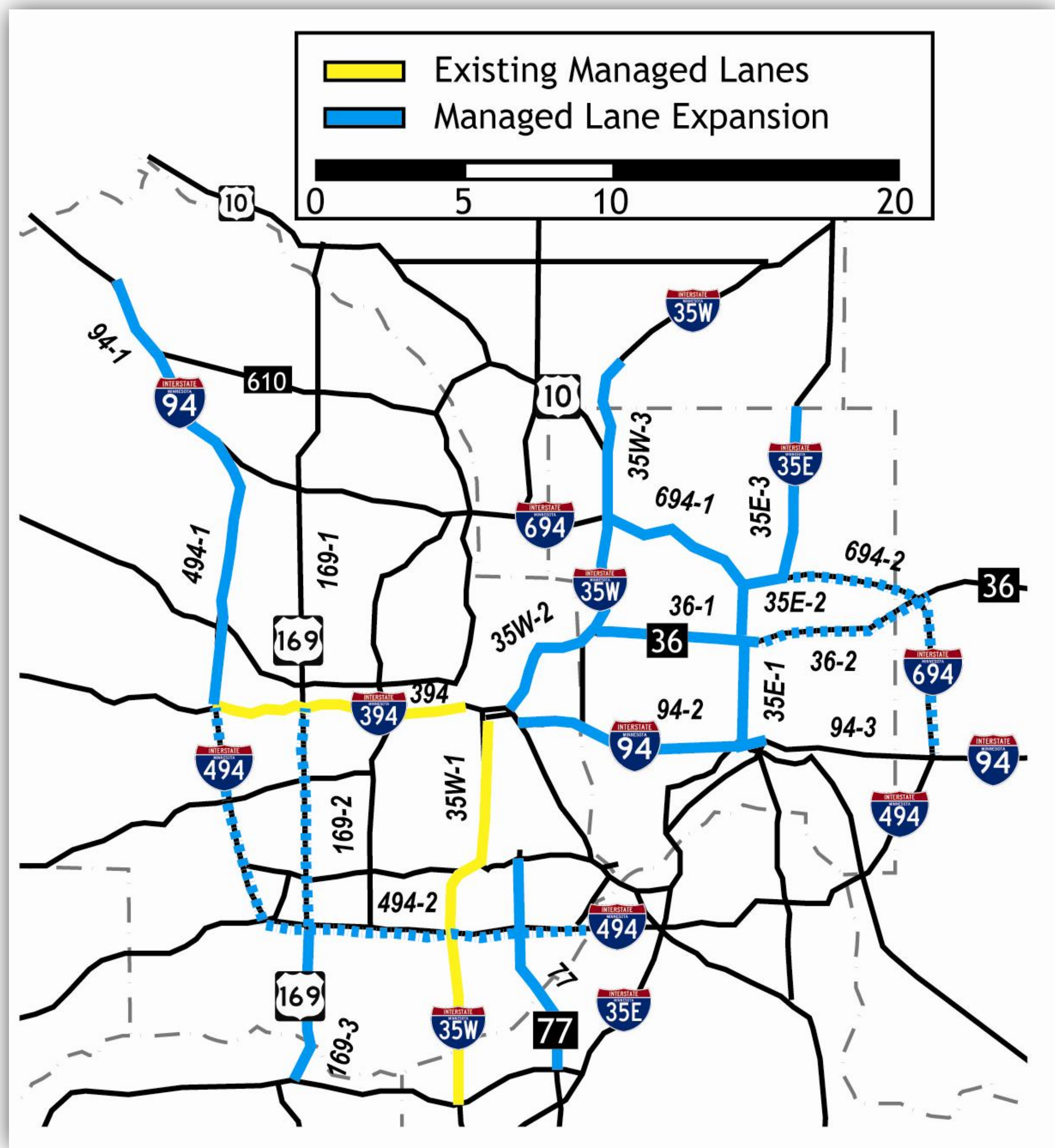
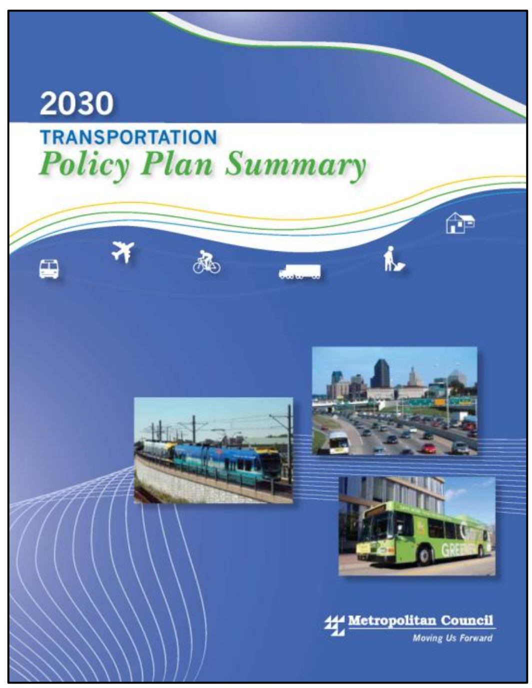


FIGURE 4: 50-YEAR MANAGED CAPACITY RECOMMENDED PROJECTS

1.0 INTRODUCTION

The need for timely, essential transportation infrastructure rehabilitation and development is apparent. According to the Texas Transportation Institute's 2009 Urban Mobility Study, annual hours of delay per peak traveler in the Minneapolis / St. Paul area has increased from 6 hours in 1982 to 39 hours in 2007 – an increase of 650 percent. Approximately 60 percent of Twin Cities peak period vehicle-miles of travel is now congested. As the effect of congestion upon Twin Cities person hours of delay (55 million hours in 2007) and fuel consumption (39 million gallons of wasted fuel) compound the impacts upon other economic measures (delivery times, unproductive labor time, business relocations, ineffective recruitment and retention, etc.), advancing viable congestion-relief projects across all modes of travel has become essential.

The 2030 Regional Transportation Policy Plan (TPP, adopted in 2009) provides a context for upcoming mobility and accessibility challenges in the Twin Cities from the year 2000: population growth of 966,000, employment growth of 520,000, and absent structural changes to transportation energy and infrastructure, daily increase of 15.3 million vehicle miles traveled (VMT). This constitutes, respectively, a 37 percent increase in population, 32 percent increase in employment, and 58 percent increase in VMT. In short, the existing transportation network will be challenged to accommodate this increase without consideration of more active management of the system. Furthermore, the 2007 Principal Arterial Study indicated approximately $40 billion would be needed in this timeframe to eliminate congestion on the network, a number that easily dwarfs the anticipated $6 billion in revenue to the Metropolitan area for the same time period (with only $900 million designated for capacity and safety enhancements).



Recognizing no growing metropolitan area in the U.S. is able to build their way out of congestion, the Metropolitan Council (MetCouncil) and Minnesota Department of Transportation (Mn/DOT), through this effort and subsequent incorporation within the 2030 TPP, Statewide Transportation Plan (STP), and Mn/DOT Metro District Highway Investment Plan, endeavor to develop a future transportation investment strategy that optimizes the investments already made in the region through the use of multimodal-oriented managed lanes and comprehensive system management strategies. As will be shown in this study, the consideration of management strategies and managed lane elements provides an opportunity for travelers to opt their way out of congestion, even if system congestion may persist.

The 2030 TPP recommends strategies that provide alternatives to single occupant vehicle (SOV) travel, targeted capacity mitigation where it will be the most effective in reducing congestion and a re-assessment of current highway expansion plans in terms of cost effectiveness and financial and implementation feasibility. The need for these strategies guided this study. The end result, to be described here, is the infusion of managed lane system concepts into the long-range transportation planning process.

Purpose of the MHSIS

The Metropolitan Highway System Investment Study (MHSIS) is a contributing input to the 2030 Regional Transportation Policy Plan adopted in 2009. Similar efforts conducted by Mn/DOT and the Metropolitan Council in recent years (such as the 2009 Congestion Mitigation and Safety Plan, CMSP) have focused upon particular transportation policies in order to advance the TPP master plan. In the case of the MHSIS, this focus was the use of management strategies as a possible alternative for costly general purpose capacity expansion in the TPP.

The MHSIS Project Management Team, comprised of Mn/DOT and Metropolitan Council staff, with Steering Committee concurrence, provided the project team with the guiding principles for the MHSIS study and evaluation. These guiding principles are as follows:

- *Utilize the most cost-effective operational and management techniques to optimize system performance*.
- *Managed lanes are a higher priority for improvement than general purpose lanes.*
- *There are some areas where traditional capacity will not be added; this does not preclude management, operational and pricing solutions.*
- *Needed segments of general purpose lanes may be converted to managed lanes*.
- *Highway improvements should enhance and support transit use where existing or planned express transit service exists.*
- *Flexible design may be needed to accommodate an improvement or project within the existing right-of-way. Overall safety must be maintained or improved.*
- *Complete the six-lane beltway and unfinished connections to utilize existing and planned investments*.
- *Do not add inbound capacity outside the beltway that cannot be accommodated by projects or operational changes/strategies on, or within, the beltway*.
- *Manage access to Interregional Corridors (IRC's) and other Principal Arterials*.
- *Asymmetrical improvements may be considered*.

Various efforts have been conducted throughout the past two decades that lead the Twin Cities toward an operations and management mindset for the metropolitan highway system. Transportation Demand Management (TDM), Transportation System Management (TSM), and Intelligent Transportation Systems (ITS) treatments are intended to mitigate traffic congestion and improve traffic safety, through introduction of lower-cost improvements that could be developed within the existing roadway right-of-way, thus avoiding the high right-of-way and construction costs associated with adding lanes on limited access highways to keep pace with traffic growth.

Recently, four strategies have received attention for their ability to enhance the return on investment in the Minneapolis / St. Paul region's transportation infrastructure. *Active Traffic Management* (ATM), as deployed on I-35W south of downtown Minneapolis and to be developed on I-94 between downtown St. Paul and downtown Minneapolis, denotes application of advanced electronics to assign traffic priority, lane assignment and speed/queue control, and includes such systems as ramp metering, speed harmonization, queue warning, and dynamic re-routing. *Managed Lanes* include provision of dedicated lanes for use by high-occupancy vehicles, trucks, or any vehicle willing to pay a price to use lanes which operate at a higher speed than adjacent general purpose lanes. *Use of Shoulders* involves either operating buses on roadway shoulders in slower speed application to bypass general purpose lane traffic queuing during peak periods (as on the existing freeway system in the Twin Cities) or using the shoulders for general traffic during peak periods to maintain or provide added capacity, potentially in conjunction with the application of managed lanes on the inside of the roadway. Finally, *Bus Rapid Transit* (BRT) includes the provision of enhanced express bus services and introduction of limited-stop service with on-line stops.

The MHSIS concentrated upon how these four principal components could be combined and implemented in the Twin Cities. The purpose of these strategies is not to fix congestion, but rather to provide residents, employees, and visitors with a consistently congestion-free alternative throughout the regional highway system. Managing one or more lanes of traffic for congestion-free conditions is the primary purpose of the strategies listed above. Although other management strategies were initially considered in the MHSIS, such as access management and interchange consolidation, as these strategies did not further the primary purpose of providing a congestion-free alternative, these strategies (and the facilities upon which they were considered) were transferred to the CMSP and are not a component of this report.

Study Area

The initial study area of the MHSIS was comprised of the counties of Hennepin, Ramsey, Carter, Anoka, Dakota, Scott, Carver, and Washington. However, as the focus of the MHSIS study through the guiding principles involved providing options for systemic congestion relief, the applied corridors concentrated upon the metropolitan core of these counties. Exterior counties, such as Wright county, may benefit from the implementation of management concepts in the metropolitan core; however, the baseline conditions for these strategies' success do not exist outside the metropolitan area, and as such, were not studied.

Types of Projects

The universe of projects initially comprised a broad range of transportation demand and system management strategies. The existing implementation of various system management strategies, such as extensive Intelligent Transportation Systems (ITS) and access management programs, allowed the MHSIS to focus upon those projects which directly addressed the core objective of providing a consistently congestion-free alternative on metropolitan highways. The primary strategy meeting this definition is managed lanes, with a complementary strategy of active traffic management.

Other strategies, such as access management, interchange consolidation, and interregional corridor designation were not addressed in the MHSIS final report, and may be considered in other contributing components to the 2030 Regional TPP.

MANAGED LANES

Managed lanes have been in existence for nearly 30 years and represent a family of operational strategies designed to address a wide array of transportation goals. The term itself is ambiguous and can mean different things to different stakeholders in the transportation industry. One key aspect that all managed lane facilities share in common is active demand and system management. Oftentimes, the development of managed lanes has come from the realization that high demand on existing facilities necessitates the efficient management of those facilities. This holds especially true in situations where options for constructing new capacity are limited. Latent demand in moderate to severely congested corridors can quickly fill added capacity that is not managed. Managed lanes, including those applied in Minnesota, typically comprise three principal elements:

- <u>Eligibility</u>. Eligibility refers to the restriction of certain vehicles and vehicle types from accessing a given facility, which is most often based on occupancy or vehicle type. Restrictions based on occupancy generally stipulate that only vehicles carrying a certain number of occupants – usually 2 or greater – may enter a facility for free. In the case of traditional HOV lanes, SOV's are barred completely from accessing such facilities, whereas in HOT lane applications, they are allowed to access facilities with the payment of a toll. Restrictions based on vehicle type generally bar certain types of vehicles from entering a facility, such as large commercial trucks, or provide free access for others, such as inherently low emission vehicles or motorcycles. Eligibility may also vary by time of day or change over the life of the facility in response to changing volumes of various vehicle classes. HOT lane facilities, for example, may experience growth in the volume of users such that congestion begins to occur and the level of service on the facility is degraded. In this case, a hierarchy of users is established, and eligibility requirements may be adjusted so as to price out lower priority users such as SOVs.
- <u>Access Control</u>. A common feature of managed lanes is the physical separation of vehicles on managed facilities from those on adjacent general purpose lanes. Access control is often accomplished by physically separating a managed lane facility from other facilities via barrier or buffer, such as those found on the portion of the I-394 MnPass lane east of TH-100. For managed lanes utilizing shoulders (such as I-35W's PDSL system), right of way may be insufficient to construct a barrier or buffer, and a simple stripe with supplemental signing has to suffice.
- <u>Pricing</u>. The pricing aspect of managed lanes refers to the use of price controls for the purposes of controlling volumes and generating revenue on managed lanes facilities. Managed lanes need not feature a pricing component. However, many recent facilities do include a pricing element that can be structured to accomplish a number of goals. Pricing may be fixed, with one flat rate being charged for all users during all times of the day; set on a variable schedule, where rates change pursuant to a pre-established schedule; or dynamic such as on I-394 and I-35W, where the price for access increases during times of day when volumes are the highest. Dynamic pricing entails adjusting the price for facility access in real time in relation to the vehicular volume on the facility. As the number of vehicles increases, so does the price. Currently, Mn/DOT's policy for pricing on the MnPass system is for demand management prioritization, with revenue generation only as a secondary consideration.

Managed lanes have a distinct advantage over general purpose lanes: through eligibility, access control, and pricing, managed lanes can provide for regular and predictable free-flow travel speeds on the managed lanes. In turn, free-flow managed lanes avoid traffic saturated general purpose lanes, yielding not only improved vehicular throughput in saturated conditions, but also improved person throughput based upon the encouragement (through price signals) of higher vehicle occupancies and bus ridership. Recent evidence as published in the *US DOT Congestion Pricing Primer* illustrates this advantage (Figure 5).

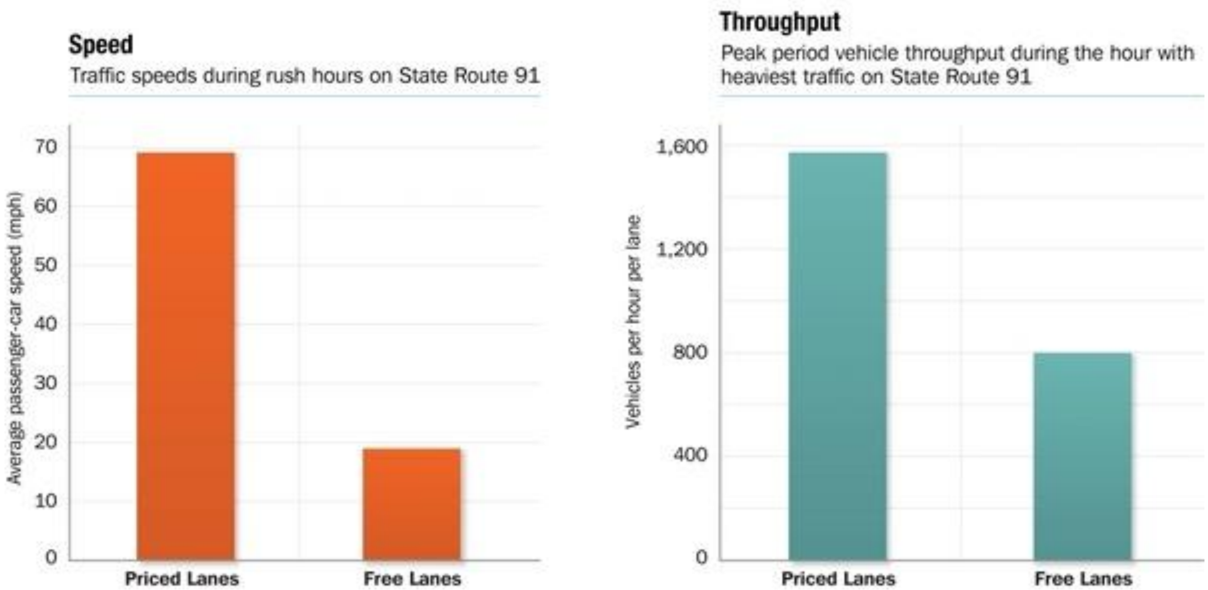


FIGURE 5: COMPARISON OF SPEED AND THROUGHPUT (MANAGED LANES VS. GENERAL PURPOSE LANES)

A variety of managed lane configurations are available for corridor-wide projects. The MHSIS concentrated upon those that have the likeliest application for the broadest number of facilities in the Minneapolis / St. Paul area. As most corridors have neither sufficient dominant peak directionality, nor the apparent ability to significantly expand the right of way envelope to accommodate widening, the project team examined managed lane strategies which incorporated use of shoulders and asynchronous deployment. Conversely, this investigation discounted a variety of options, including reversible flow, contra-flow, and dual-dual facilities.

One of the principal objectives of the MHSIS was to identify how new managed capacity could be provided with higher value and less cost. To meet this objective, the MHSIS considered the deployment of managed lanes in the context of dedicated and dynamic shoulder use. As such, the use of shoulders deserves some attention here.

As successfully demonstrated on the I-35W corridor, new managed lanes can be safely implemented with an alternative design to established managed lanes. Since the 1950 publication of the Highway Capacity Manual and 1973 AASHTO Red Book, 10 ft shoulders have been the Interstate minimum design standard for urban freeways, with 12 ft shoulders desirable on routes with heavy truck traffic. Furthermore, a minimum of 4.5 ft lateral clearance is required, with 6 – 8 ft recommended in the vicinity of pier structures. However, by the 1980s in response to rising levels of congestion and a lack of right-of-way for contemporary expansion of capacity, many states adopted the use of dedicated shoulder lanes sometimes in conjunction with or instead of narrowed lane widths. By the 1990s, only four states had chosen to extensively use shoulders and/or narrow lanes on freeways: California (Los Angeles and Bay Area), Texas (Houston), Virginia (Fairfax County), and Washington (Seattle).

In dedicated shoulder lane operations, either general purpose or HOV-specific capacity has been added through the permanent conversion of shoulders. Most HOV applications use the interior or left lane for HOV operations while the exterior or right shoulder is used for general purpose traffic so as to maintain the same number of general purpose lanes as existed prior to implementation. A typical application would convert a three-lane freeway with 12 ft lanes, 10 ft exterior shoulder, and 8 ft interior shoulder to 11 ft general purpose lanes, 14 ft (including buffer striping) HOV lane, 5 ft exterior shoulder, and 2 ft interior shoulder.

In most cases, the shoulders have been converted to general purpose capacity, at least for a short distance. However, in a few applications, the implementing agency has attempted to recover use of the shoulder for refuge purposes during some portions of the day. On Massachusetts state highways 128 and 3 in the Boston area, all vehicles are permitted on shoulders in the peak periods only. Similarly, in Virginia on I-66, the shoulder carries general purpose traffic from 5:30 – 11 am (eastbound) and 2 pm – 8 pm (westbound); however, during this time, the interior general purpose lane is open to HOV traffic only. I-66 uses extensive lane use signage in order to communicate the active times of shoulder lane service.

Bus Only Shoulders (BOS) is the most common shoulder-lane application in the United States. Additionally, Minnesota has served as a continental leader in the state of the practice, both in the extent of application of BOS lanes as well as development of policies and authorizing legislation for BOS. Minnesota's network is comprehensive, having established approximately 300 miles of BOS lanes throughout the Twin Cities since 1991. Today, BOS operations exist throughout the Twin Cities network, including long segments of I-694, I-35W, I-35E, I-94, I-494, US 169, SH 36, and US 10. Of all active BOS projects, only the Seattle region's SR-520 allows for HOV-3+ use of shoulders concurrent with buses (not including dynamically assigned HOV lanes, such as Virginia's I-66).

Dynamic (temporary) shoulder lanes is a congestion management strategy used extensively in Europe and typically deployed in conjunction with complementary traffic management strategies – such as variable speed limits (speed harmonization), queue warning, and ramp metering – to address capacity bottlenecks on the freeway network. The strategy provides additional vehicle-moving capacity during times of congestion and reduced travel speeds. When travel speeds are reduced, dynamic signs over or next to the shoulder indicate that travel on the shoulder is permitted. A complete series of traffic signs indicate operations related to temporary shoulder use, including one with a supplemental speed limit indication (used when overhead gantries are not present). Temporary shoulder use is permitted only when speed harmonization is active and speed limits are reduced, thus providing an operating environment only when speeds are managed below posted levels. In addition to allowing temporary use of the right shoulder, the Dutch also deploy the use of traveling on a shoulder on the median side of the roadway, locally termed a "plus lane," a narrowed extra travel lane provided by reconstructing the existing roadway while keeping the right hard shoulder open for travel use when traffic volumes reach levels that indicate congestion is growing.

Active Traffic Management

Although ATM may be successfully implemented in an arterial corridor, ATM in this study provides for operating conditions that enable complete use of a freeway corridor's pavement, an important component of the MHSIS. ATM does this by dynamically managing traffic flow and lane assignment based on prevailing traffic conditions and presence of collisions or other incidents. ATM has been defined by Mn/DOT as including ITS strategies which may be implemented on non-freeway arterials, including strategies such as signal coordination, cameras for incident and traffic management, and changeable messaging signs. However, for the purpose of this analysis, ATM has been confined to freeway systems with the specific components identified below.

Focusing on trip reliability, its goal is to maximize the effectiveness and efficiency of the facility under recurring congestion and non-recurring incidents or road work. Through the flexible use of the roadway, it aims to increase system performance as well as traveler throughput and safety through the use of strategies that actively regulate the flow of traffic on a facility to match current operating conditions. ATM strategies can be automated, combined, and integrated to fully optimize the existing infrastructure and provide measurable benefits to the transportation network and the motoring public.

ATM enables the use of shoulders for traffic through the dynamic assignment of lane availability. Under normal operating conditions, lane control signals inform travelers of the availability of the shoulder lane, and, eligibility for its use. In times of lane blockage or other event requiring a closure of the shoulder lane, the ATM system warns travelers upstream to merge out of the blocked lane. Coupled with other ATM efforts including speed harmonization, this merging is done at a safe speed. The combined purpose of the lane controls is to allow emergency response personnel to quickly clear the primary incident while minimizing the conditions that facilitate secondary collisions. Together, this mitigates the loss of shoulders during incidents.

ATM consists of a combination of operational strategies that, when implemented in concert with dynamic shoulder lanes, more fully optimize use of the existing infrastructure and provide measurable benefits to the transportation network and the motoring public. These strategies include but are not limited to speed harmonization, junction control, and dynamic signing and rerouting:

- <u>Speed Harmonization / Queue Warning</u>. Speed harmonization (also known as Variable Speed Limits) helps manage traffic by varying posted speed limits on a roadway or over each lane on an advisory or regulatory basis in real time. The deployment of the speed harmonization is automatic and begins immediately upstream of the congestion point; it does not require remote operator intervention. The system incrementally decreases speeds upstream in a cascading manner often in increments of 5 to 10 mph to smooth the deceleration of the traffic and help ensure more uniform flow while avoiding crashes.

- Junction Control. A variation of dynamic shoulder lanes involves dynamic lane assignment. Typically, the concept is applied at entrance ramps or merge-points where the number of downstream lanes is fewer than upstream lanes. This may be useful in select areas on the metropolitan network. The typical U.S. application to this geometric condition would be a lane drop for one of the outside lanes or a forced merge of two lanes, both of which are static treatments. The dynamic solution is to install lane control signals over both upstream approaches before the merge, and provide downstream lane priority to the higher volume and dynamically post a lane drop to the lesser volume roadway or approach. This is particularly effective when implemented with dynamic shoulder use at on-ramp locations where bottlenecks frequently form.
- Dynamic Rerouting. The practice involves utilizing dynamic overhead message signs or other changeable roadway signs and route markers that dynamically change the primary routing of a major thoroughfare to an alternate route where capacity is available, in response to changing with traffic conditions. If an incident occurs downstream, operators at the Traffic Management Center deploy alternate guide sign information combinations that provide alternate route information to roadway users. Similar information is also provided on full-matrix DMS installed on other roadways.

Study Process

In preparing and conducting the MHSIS, the project team first assembled information on peer communities, to determine how other metropolitan areas are evaluating the efficacy of management and operations strategies in the context of their long range plans. The findings from this assessment are provided in Section 2 (State of the Practice), and were used to inform the development of the MHSIS analysis. From this exercise, the project team prepared the performance measures for the MHSIS modeling activities. After much iteration with the Metropolitan Council / Mn/DOT project management team, the final performance measures are provided in Section 3 (Performance Measures).

Findings from the evaluation of specific projects in the MHSIS are provided in Section 4 (MHSIS Project Evaluation). This section contains detailed findings for each project identified in the MHSIS draft plan. Additionally, econometric analyses were conducted for managed lane projects as well as for active traffic management implementation. As ATM will likely be a necessary complementary strategy to managed lanes in order to mitigate concerns when using shoulder lanes, this analysis is conducted concurrent to the capacity analysis. Finally, phasing and other conclusions for incorporation within the 2030 TPP is provided in Section 5 (Prioritization Analysis).

2.0 STATE OF THE PRACTICE

Metropolitan Planning Organization (MPO) and transit agency staff from seven urban areas around the U.S. (Atlanta, Dallas-Ft. Worth, Honolulu, Houston, Miami-South Florida, San Francisco-Oakland Bay Area, and Seattle) were contacted to obtain information on how they are addressing future investments in their major highway systems, including corridor identification, application of new technology, performance measures, and funding for implementation. The detailed literature review and description of findings from this effort are provided in the Appendices. As the focus of this study is upon managed lanes and ATM analysis, this summary pertains to these topics; however, the detailed memorandum in Appendix F provides substantial findings on management strategies beyond managed lanes and ATM.

The principal finding from this effort indicates that the Minneapolis – St. Paul metropolitan area is not alone in recognizing there are insufficient funds to undertake major capacity improvement projects to meet anticipated travel demand. The Twin Cities has identified a preference for incorporating operations and management strategies into its long range transportation plan. Operations and management strategies are actively pursued to one extent or another by many peer communities. Of particular interest in the Twin Cities region are those applications that provide a long-term return on investment, so as to provide a credible alternative to unaffordable capacity expansion. These strategies would be expected to enhance traffic operations through flow maximization, improve person throughput through increases in average vehicle occupancies and transit ridership, reduce incidents and crashes, and improve travel time reliability. In the United States, common types of managed lanes are HOV lanes, HOT lanes, Express Toll Lanes, and limited-access express lanes. Active traffic management as deployed in Europe attempts to regulate the flow of all vehicles across all lanes of traffic through the implementation of speed harmonization, queue warning, lane controls, junction controls, dynamic rerouting, and dynamic travel time information.

The nature of managed lanes in certain communities has evolved from a short-term, corridor-specific, operationally-focused strategy to a long-term, system-wide, mobility-focused strategy. Although project development still occurs at a corridor level for managed lanes, capacity planning and systems integration are increasingly conducted at a regional / system level. In this context, managed lanes are often considered side-by-side with active traffic management.

There is no established guidance for the incorporation of management and operational strategies within the context of the long-range plan. Indeed, the development of the long-range plan as a 20- or 30-year snapshot of the future network is inherently biased towards identifying capacity improvements.

Although many communities have attempted to incorporate managed lanes within the long range plan, these projects are often simply identified as an alternative line on a map compared to a capacity expansion. The one exception to this practice is the San Francisco Bay Area, which has fundamentally changed the development of the long range plan through the Freeway Performance Initiative (FPI). The FPI created a system-wide evaluation of regional project priorities, but developed the list of priorities in partnership with the project sponsors. Thus, when projects were proposed for development or inclusion with the long range plan, the phasing of the project in the FPI determined its suitability for inclusion. If iterative steps (as identified in the FPI) were not conducted first, the project was not included. This prevents big-capacity projects from absorbing regional funds. Furthermore, it shows a preference for operational and management treatments that maximize the use of available capacity before new capacity is added to the system.

A common element amongst all peer communities is an active avoidance of "big infrastructure" projects from absorbing identified and anticipated regional funding. Big infrastructure projects include bridges, tunnels, and interchanges that exist within a constrained environment, making substantive improvements and/or capacity enhancement cost prohibitive. In such cases, many urban areas (such as the Seattle, Dallas-Fort Worth, and San Francisco-Oakland regions) have established a policy preference for evaluating and implementing user-based financing as a means of paying-down the cost of these facilities. In most cases, these big infrastructure projects involve tolls across all lanes of traffic into perpetuity, providing a base of funding for the large capital outlay and for lifecycle considerations for operations and maintenance. In all cases, the intent is to separate the obligations for building these structures from available highway trust fund revenue.

Outside of big projects, tolls remain an important force for infrastructure development. In Texas, the legislature provided a range of new transportation financing options for regional MPOs to consider in funding needed infrastructure. These tools include loans from the state infrastructure bank, local community-financed shadow-tolling, traditional toll financing, and public-private partnerships allowing for private activity bond financing and comprehensive development agreements. Other states have also enabled greater use of private-sector and toll financing for infrastructure. Unlike the big infrastructure projects, in most applications, tolls are to be applied for new lanes of traffic only or on converted HOV / shoulders.

In the project development process, toll viability screening has been successfully used to ensure revenue production possibilities are examined to complement public revenue. For example, the Dallas-Fort Worth region evaluates all new highway capacity using federal aid funds for toll road viability. Since adoption in 1993, the region expanded the policy to include express toll lanes and managed lanes. As a result, the region has an extensive projected network of toll and managed lanes facilities, with little new "traditional highway" capacity due to be constructed, unless it is concurrent with new toll lane capacity (such as improvements to frontage roads).

An interesting development witnessed in various metropolitan areas is the extensive use of regional partnerships to implement operational and management strategies for congested freeway corridors, and, to deliver new managed lane capacity projects. Although financing is a key consideration within the development, it should be noted that this extends beyond financial considerations. Partnerships with regional / county authorities, as well as non-profits (transportation management associations) and private-sector enterprises, have helped bring projects to fruition quicker and with greater regional concurrence.

3.0 Performance Measures

The performance measures considered in the evaluation of the MHSIS alternatives were based on the recommendation of the Mn/DOT Metro District and the Metropolitan Council to provide "a lower-cost/high-benefit approach [that] may be an effective way to address specific problems and that pricing can provide an alternative for managing congestion." This recommendation was developed from the transportation investment policy framework of the 2030 TPP, adopted in 2009. Furthermore, during outreach efforts associated with the TPP and MHSIS, members of the public provided their opinions on how the performance measures should be prioritized.

The MHSIS performance measures were derived from the policy direction of the 2030 TPP, adopted in 2009. This derivation provides evaluation guidance for corridor-based alternatives, including the designation, design, and components of managed lane strategies upon the highway system. To measure the impact of the managed lane strategies, it is essential to make comparisons between managed lane alternatives and to a baseline – often know as a "build" and "no-build" concept comparison. This comparison lends itself to quantifiable measures of effectiveness that allow for comparability.

Ideally, a comprehensive managed lane performance analysis would examine the contribution of managed lanes to differing operational conditions, land uses within treatment corridors, and recurring / non-recurring traffic congestion situations. However, the performance measures used in the MHSIS are limited by the capabilities of the modeling. Furthermore, the performance measures utilized for the MHSIS focus upon traditional system measures, as the benefits to the system (reflected in aggregate metrics) are more directly relevant to the MHSIS policy direction for "lower-cost / higher-benefit" approaches to congestion relief. Conversely, individual benefits from managed lanes (such as individual travel time savings and reliability) are inherently understood by users, but may not reflect the regional choice for a managed lanes strategy.

Based on this approach, the MHSIS has focused on the following performance categories to guide the future investments in the Metropolitan Highway System.

Increase the People-Moving Capacity of the Metropolitan Highway System

Person throughput is an important measure of mobility and congestion reduction. Person throughput refers to the number of persons traversing the corridor on both transit and in private vehicles. Increases in the number of persons using a corridor would imply that the operations and management strategies evaluated were effective in serving more persons who are not serviced in the corridor because of the congestion that is present in a no-build context. The identified measures of effectiveness for person throughput are:

- Daily new vehicular trips per lane mile
- Daily new person trips per lane mile

MANAGE AND OPTIMIZE, TO THE GREATEST EXTENT POSSIBLE, THE EXISTING SYSTEM

Travel time is strongly influenced by the speed that the vehicle is able to travel, as well as any delays experienced due to bottlenecks or other queues caused by congestion. Generally, travel times are measured for specific points on a section of roadway and can be collected separately for different types of facilities (e.g., general purpose lanes versus managed lanes, freeway versus arterial). The MHSIS evaluated the travel time savings by examining changes in travel times before (no-build) and after (treatment) the strategies have been applied to treatment corridors. The temporal extent of congestion refers to how many hours in the day the corridor is operating under congested conditions. As freeway corridors have varying levels of operations and management strategies deployed across treatment sections, this will affect the percentage of VMT experiencing congestion on the metropolitan system. The intent of the evaluation will be to identify the level of success the strategies have upon treatment corridors to this objective.

The identified measures of effectiveness for optimization are:

- Daily reduction in Congested VMT
- Daily reduction in Peak Hours of Delay per Trip
- Daily reduction in Average Travel Time per Trip

REDUCE FUTURE DEMAND ON THE HIGHWAY SYSTEM

A desired outcome of the MHSIS is to increase the use of transit relative to the private auto, leading to a mode shift to transit. Mode shift may result from potential users being attracted to transit, or from increased transit use among occasional users. Thus, the central transit evaluation issue is the identification and measurement of mode shift. In theory, a mode shift to transit should then facilitate higher transit ridership, reduced levels of traffic congestion, more efficient use of existing road capacity, net reduction in greenhouse gas emissions and fuel consumption, improved freight movements, and potentially higher levels of person throughput.

The identified measures of effectiveness for demand reduction are:

- Change in transit mode share
- Change in corridor attractiveness for SOV trips

IMPLEMENT STRATEGIC AND AFFORDABLE INVESTMENTS

Given the need for a lower-cost/high-benefit approach for the MHSIS, cost effectiveness is an important consideration. The most important element to maximize the potential of cost effectiveness is having a strong working knowledge of the phasing of many of these corridors. If there are plans to develop a certain segment of a corridor from another office or agency, there should be understanding of how that project will fit in with the long term vision of the MHSIS. This could be something as major as a bridge reconstruction or something as minor as a mill and overlay that could save millions in future investment in the corridor. The MHSIS endeavored to incorporate a qualitative investment opportunity rating to reflect these opportunities for consolidation of expenditure.

Another way of optimizing cost effectiveness is to identify an appropriate staging between ATM and managed lane projects. For managed lanes in constrained conditions and/or where it is anticipated utilizing the shoulder, then those projects may be phased in conjunction with appropriate ATM strategies. Furthermore, this could be done concurrently with strategic capacity projects in other areas of the region, thereby spreading around projects that provide immediate benefit.

- Cost effectiveness, calculated as a benefit / cost valuation
- Standard deviation in cost effectiveness
- Investment opportunity rating
- Investment parity rating

PUBLIC COMMENTS ON PERFORMANCE MEASURES

The MetCouncil and Mn/DOT conducted selected public outreach efforts concerning the MHSIS in April 2010. During those meetings, participants were asked to rank their preferred prioritization for performance measures to be used in the MHSIS. The findings, shown in Table 3, indicate overall preference for enhancing person throughput and providing travel time savings. These measures have been incorporated in the performance analysis that follows.

TABLE 3: PUBLIC OUTREACH FINDINGS FOR PRIORITIZATION OF PERFORMANCE MEASURES

Objective	Performance Measure	Transport Alliance	Hennepin County	Carver County	Anoka County	Total
Increase people-moving capacity of metropolitan highway system	Person throughput	21 50.0%	12 30.0%	10 35.7%	9 20.5%	52 35.9%
Provide alternatives to traveling in congested conditions	Travel time savings	5 11.9%	4 10.0%	10 35.7%	16 36.4%	35 24.1%
Implement strategic and affordable investments to manage use of existing facilities	Cost effectiveness	8 19.0%	5 12.5%	4 14.3%	6 13.6%	23 15.9%
Increase trip reliability for corridor users	Reductions in trip delay	6 14.3%	2 5.0%	1 3.6%	1 2.3%	10 6.9%
Encourage increased transit use	Transit suitability assessment	2 4.8%	8 20.0%	3 10.7%	12 27.3%	25 17.2%

4.0 MHSIS Project Evaluation

Initial Project Concepts

Initially, a total of 41 separate projects were identified for analysis in the MHSIS. Thirty-four of these projects were developed by the MHSIS Project Management Team (PMT), comprised of Mn/DOT and MetCouncil representatives, prior to the conduct of the MHSIS study. Seven additional facilities were added to the MHSIS analysis based upon preliminary study corridors identified by the MnPass System Study Phase 2. These projects included managed lane expansion projects (building a new concurrent flow managed lane), managed lane conversion projects (adapting an existing general purpose lane into managed lane operations), interchange closure, multiple interchange consolidation, limited access design conversion, strategic capacity expansion, and expressway expansion. However, as the MHSIS PMT focused the MHSIS analysis upon managed lanes, the other strategy elements were placed within the purview of other efforts – including the Congestion Mitigation and Safety Program (CMSP), 2030 TPP Update, and related planning. Finally, during the course of the MHSIS, Mn/DOT conducted an update to the MnPass System Study, which adopted a policy of managed lane expansion only. Given the desire for concurrence and performance metrics which indicated a preference for expansion over conversion, only managed lane expansions were forwarded for analysis in this Final Report (full analysis of the conversion projects may be found in the technical appendices).

TABLE 4: MHSIS PROJECT LIST

Corridor	Label	From	To	Type of Project
I-35E	35E-1	Maryland	TH-36	Managed Lane Expansion
I-35E	35E-2	TH-36	County Rd E	Managed Lane Conversion
I-35E	35E-3	CR E	CSAH 14	Managed Lane Expansion
I-35W	35W-1	42nd St.	Minneapolis CBD	Asynchronous Managed Lane
I-35W	35W-2	University Ave	TH-280	Managed Lane Expansion
I-35W	35W-3	TH-280	95th Ave. N.	Managed Lane Expansion
I-394	394	I-494	I-94	Managed Lane Expansion
I-494	494-1	TH-55	I-94 / I-494	Managed Lane Expansion
I-494	494-2	TH-169	TH5	Managed Lane Expansion
I-694	694-1	I-35W	I-35E	Managed Lane Expansion
I-694	694-2	I-94	I-35E	Managed Lane Expansion
I-94	94-1	TH-101	I-94 / I-494	Managed Lane Expansion
I-94	94-2	Cedar	Marion	Managed Lane Expansion
I-94	94-3	St. Paul	I-694	Managed Lane Expansion
TH-280	280	I-94	I-35W	Managed Lane Expansion
TH-36	36-1	I-35W	I-35E	Managed Lane Expansion
TH-36	36-2	I-35E	I-694	Managed Lane Expansion
TH-77	77	CSAH 42	I-494	Managed Lane Expansion
US-169	169-1	I-394	I-694	Managed Lane Expansion
US-169	169-2	TH-62	I-394	Managed Lane Expansion
US-169	169-3	Minnesota River	TH-62	Managed Lane Expansion

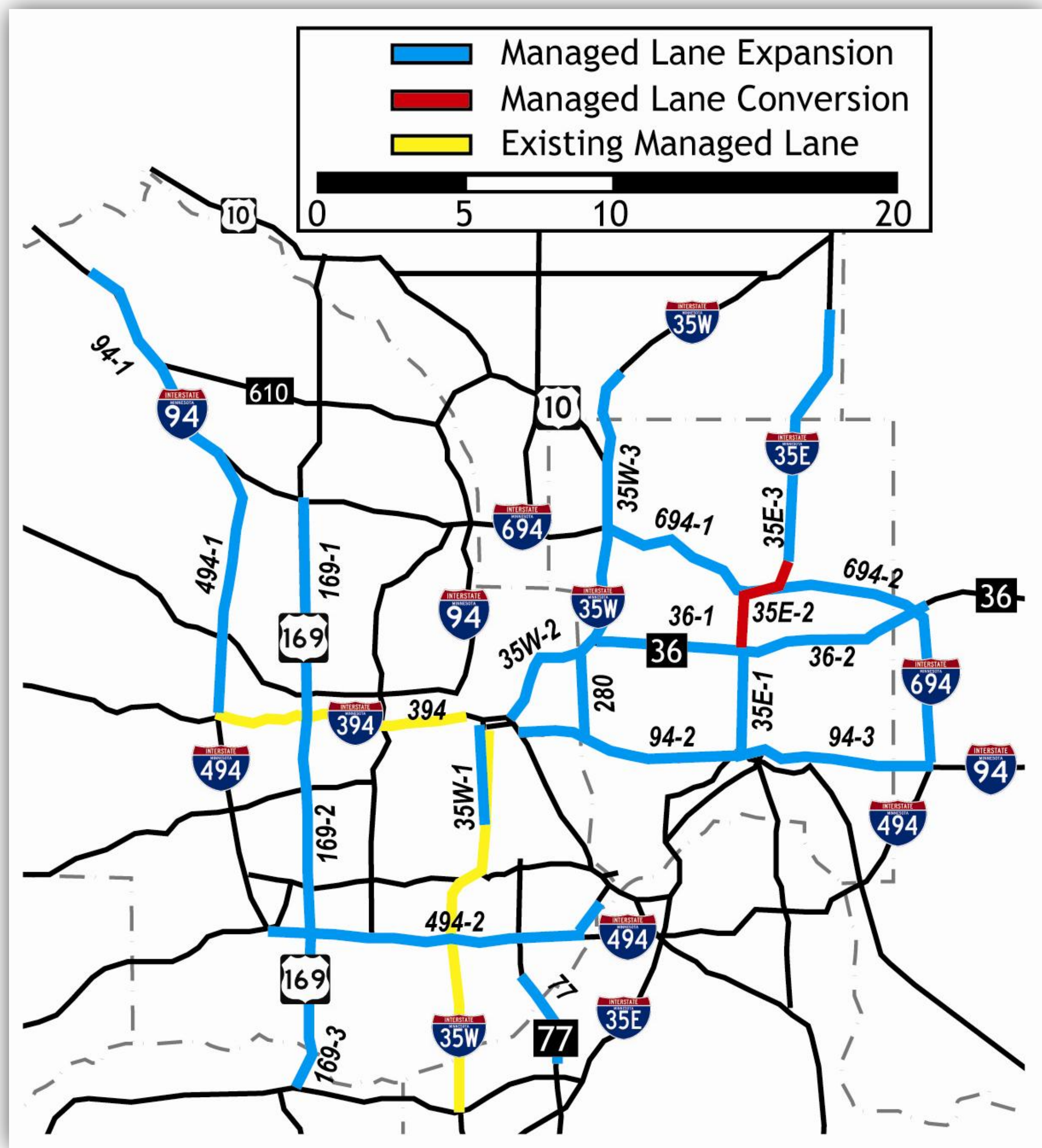


FIGURE 6: MHSIS MANAGED LANE UNIVERSE OF PROJECTS (MAP)

CONCEPTUAL APPLICATIONS IN THE MHSIS

The MHSIS combines a number of management and operations strategies in order to achieve the vision of a lower-cost, higher-value highway improvement program. Early in the project and continuing through subsequent analyses, the project team developed the concepts and associated cost estimates for active traffic management and managed lanes strategies for the metropolitan highway network. Input for identification of conceptual design came from a review of established concepts developed by Mn/DOT and the Metropolitan Council, available and collected traffic and related data, corridor field visits, and input from project management team and steering committees.

MANAGED LANE DESIGN COMPONENTS

The following comprise the current design standards as established by the AASHTO *Guide for High Occupancy Vehicle (HOV) Facilities, 3rd Edition (2004).* These standards represent established preferred design components for contiguous single-lane managed lane facilities, added in freeway corridors without HOV lanes. Currently, deviations from these standards require a design exception from the Federal Highway Administration (FHWA).

- *Widths:* 12-ft lane widths, with a 2-ft buffer; 10-ft residual shoulders on one or both sides of the mainline roadway
- *Access:* Where access is restricted for left side lane orientations, minimum weaves per lane are 600 ft per main lane weave upstream and downstream of respective ingress and egress zones. For entrance ramp to the managed lane, from the nearest upstream right side ramp where ramp taper joins the main lanes to the beginning of the solid stripe leading into the lane. For exit ramp from the managed lane, the distance from where the managed lane exit ramp stripe tapers to join the left mainline edge stripe to the right side gore of the next downstream right side exit from the main lanes.
- *Design Speed*: Same as freeway or ramp (35-65 mph)
- *Grade (maximum):* 3% for mainline, 6% for ramps
- *Design vehicles*: All classes except trucks of more than three axles

Concurrent-flow managed lanes were the preferred approach to identified concepts for the metropolitan highway system. Contraflow, reversible and barrier-separated treatments were not considered as discrete options in the MHSIS, due to operational and design challenges with these implementations (except for ramp connections to/from Downtown Minneapolis, downtown St. Paul, and the existing I-394 MnPass lanes). As the regional managed lane system moves from conceptual planning, in this document, to preliminary engineering and interim design, these design options may be considered in appropriate corridors. For consistency, concurrent flow treatments, focused primarily on the inside shoulders, were assumed for all managed lane implementations.

Some form of delineation is needed for any kind of concurrent-flow lane to differentiate it from adjacent lanes, at least during the operating periods. AASHTO's latest guidance recommends buffers for concurrent-flow lanes, consistent with existing Mn/DOT implementation on I-394. Figure 7 shows typical sections for desirable and minimum conditions. A variety of design techniques exist for buffer separated lanes. The buffer width should nominally be 2 to 4 feet and no less than 1.5 feet. A much wider buffer width of 6 to 8 feet may appear as a refuge for vehicle breakdowns where high speed traffic exposes the driver to a safety hazard on both sides. It is difficult to accommodate the requisite pavement markings in a buffer of less than 18 inches. A buffer separated lane may apply a conventional 4-foot buffer and reduce the buffer area around such isolated restrictions as bridge columns for short distances. Ideally such conditions are appropriately facilitated by varying the inside shoulder width to keep the lane alignment straight through the impediment. If continuous access is allowed, a single wide or double skip stripe placed around and within the buffer area is appropriate. If access is restricted, single or dual solid stripes are applied and broken wherever access is permitted.

Although the current guidance provides for buffer separation as noted, the implementation of MnPass lanes on I-35W south of TH-62 provide for 70 percent continuous access striping, without any differential separation between the managed lanes and the leftmost general purpose lane. This striping is a notable departure from practice around the U.S. and is the subject of evaluation by Mn/DOT and the FHWA. If this evaluation indicates positive findings from continuous access striping, the buffer requirements may be further reduced from the established guidelines. This will be an important consideration in preliminary engineering and/or interim design activities for MHSIS recommended facilities.

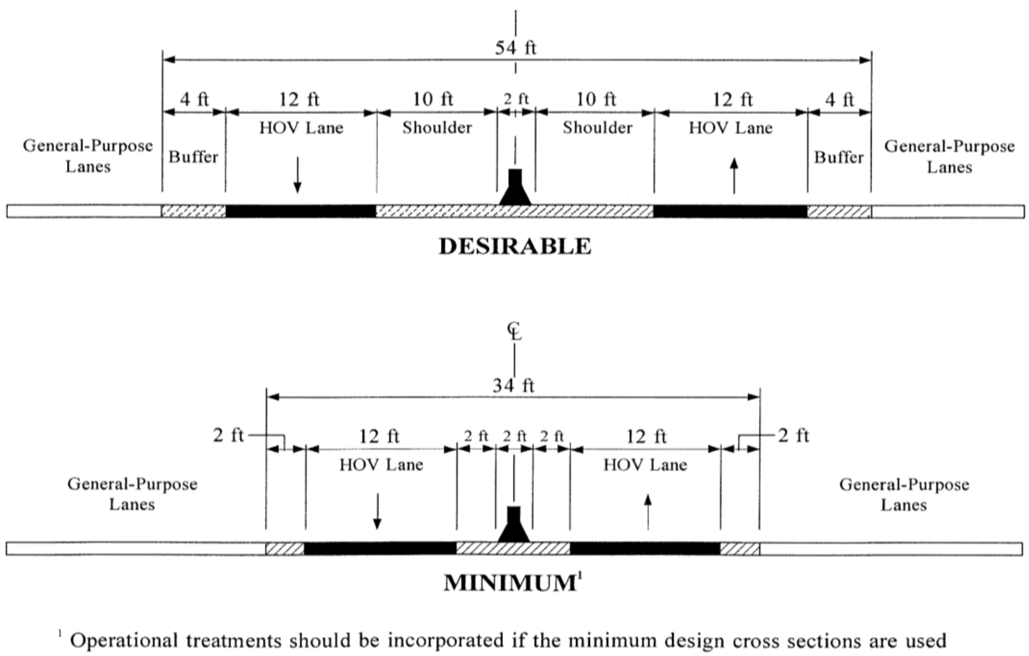


FIGURE 7: CONCURRENT FLOW BUFFER SEPARATED CROSS SECTIONS

Most MHSIS candidate settings for concurrent flow managed lanes have right-of-way, bridges and related impediments that make widening to full design standards extremely difficult or cost prohibitive. As such, careful study of the proper trade-offs for lane, shoulder and buffer widths are warranted. These conditions are herein referred to as minimal designs, which often involve the removal or reduction in existing inside breakdown shoulders and perhaps slight reductions in some lane widths for the added lane. While trade-offs in each case will vary depending on site conditions, Table 5 provides a reference of commonly applied priorities when trying to accommodate key design features in constrained settings.

TABLE 5: SUGGESTED SEQUENCE OF CONCEPTUAL TRADE-OFFS FOR CONCURRENT-FLOW LANES

Sequence	Cross Section Design Change
First	Reduce managed lane left lateral clearance to no less than 2 feet.
Second	Reduce freeway right lateral clearance (shoulder) from 10 feet to no less than 8 feet.
Third	Reduce buffer separation between the managed and general purpose lane to no less than 1.5 feet.
Fourth	Reduce managed lane width to no less than 11 ft. (Some agencies prefer reversing the fourth and fifth trade-offs when buses or trucks are projected to use the managed lane. The buffer markings may encroach on the 11-foot width.).
Fifth	Reduce selected mixed-flow lane widths to no less than 11 feet. (Leave at least one 12-foot outside lane for trucks).
Sixth	Transition barrier shape at columns to vertical face, or remove buffer separation between the managed lane and general purpose lanes.

Whereas the above trade-offs represent existing guidelines for facility design, the future network envisioned in the MHSIS suggests an aggressive deployment of ATM to complement the implementation of managed lanes for capacity expansion. Based upon established practice in Europe, ATM is useful as a safety and operational mitigation device in the use of shoulder lanes. The managed lane concepts under consideration in the MHSIS were determined to benefit from selective application of available ATM strategies, notably connector and ramp metering, lane control signals, queue warning, and speed harmonization. Ramp metering is already prevalent throughout the network and provides benefits in smoothing critical merge activity and in delaying the onset of congestion. However, if the new managed lanes were to use shoulders, any sudden and unexpected formation of queues can contribute to unstable flow, loss of throughput and higher incidence of crashes. These treatment segments in the respective peak periods would appear to be appropriate for the implementation of speed harmonization and queue warning to compliment ramp and connector metering and the shoulder lane control options being considered for managed lanes.

Much like the I-35W Priced Dynamic Shoulder Lane (PDSL) project, speed harmonization and queue warning increase efficiency and improve operational safety. Together, such systems provide a means of advising an approaching traffic slow-down and slowing traffic down gradually so that crashes and secondary incidents are avoided. Desirable placement of gantries for mounting the speed harmonization and queue warning signing would be approximately every ¼ to ½ mile such that one is always in sight. If desired, use of the large number of overhead bridge structures to support the added signs could minimize the potential cost associated with installation of this strategy, although free-standing gantries are currently preferred by Mn/DOT.

As applied on I-35W, the right side shoulder is permanently converted to a general-purpose lane, with ramps realigned to meet the shoulder treatment. The inside shoulder is expanded to 14 feet, with use allowed for eligible traffic during peak periods, reverting to breakdown / refuge only in off-peak periods. ATM is used to manage flows, and provide warnings of downstream incidents. Additionally, emergency refuge areas are constructed every ¼ mile whenever an interchange is not available downstream.

In order to meet the policy of objective of the MHSIS, the reduced shoulder option is the evaluated design concept for managed lane facilities in the MHSIS. As shown in Figure 8, the existing pavement width is maintained with the conversion of the shoulder to managed lane operations. As appropriate, the managed lane may be closed in the off-peak periods, as is currently conducted on I-35W. This is a noted departure from the existing AASHTO standards (2004) and would require a review and design exception from the FHWA prior to implementation. That said, many of the managed lanes may be constructed within standards and meeting the MHSIS policy objective, as concluded by the MnPass System Study Phase 2. Individual corridor and segment design will be dependent upon the completion of a preliminary engineering and interim design process, with full participation of all affected parties. However, for the purpose of this planning study, the reduced shoulder option was applied consistently across all corridors and segments.

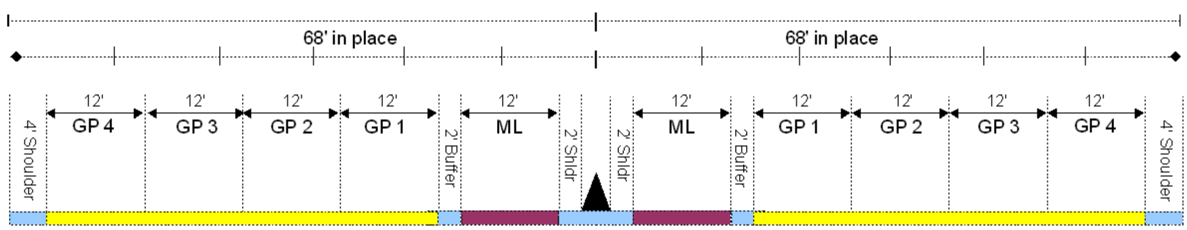


FIGURE 8: MHSIS TYPICAL CROSS SECTION FOR REDUCED SHOULDER MANAGED LANES (BI-DIRECTIONAL)

COST ESTIMATION

The cost estimation used in the evaluation of the MHSIS alternatives are based on the recommendation of the Mn/DOT Metro District and the Metropolitan Council to provide "a lower-cost/high-benefit approach may be an effective way to address specific problems and that pricing can provide an alternative to manage congestion and for managing congestion."

METHODOLOGY

The application used for providing lower-cost/higher-benefit was to maximize the amount of proposed roadway that could be used on the existing footprint of the highway system. This creates areas where the proposed roadway may need to squeeze under an existing bridge structure (such as the existing northbound I-35W to westbound I-494 ramp under I-494) or have areas that may need design exemptions to be approved prior to construction. In the event that a roadway width will need to increase, the less right-of-way that would need to be acquired would go a long way towards finding a lower-cost/high-benefit solution. Right of way costs may also need to be consider noise abatement, ponding, drainage, and other mitigation activities, which are not incorporated as line item in the MHSIS (rather, areas with anticipated issues carry a higher risk factor).

Providing a full pavement reconstruction may also greatly increase the cost of a corridor that is in need of congestion management. One other way to provide a lower-cost/higher-benefit approach to the project is to consider using a mill and overlay on the existing roadway surface and creating a full pavement structure on the areas that are either existing shoulders that are below standards for a general purpose lane or grass areas that are currently adjacent to the existing roadway that would need a pavement section for the shoulders or drive lanes. Ideally, such projects would occur at the time a pavement preservation and/or a bridge(s) replacement project is due to take place, in order to create cost effective synergies in activities.

The costs for each corridor studied in the MHSIS are for construction cost only. Although operations and maintenance (O&M) costs are significant for managed lanes and ATM infrastructure, these costs are currently offset (by policy and practice) with toll revenue. As revenue generation was not a component of the MHSIS analysis, O&M costs are likewise excluded. Delivery cost will be excluded due to many unknown funding conditions and to maintain consistency between alternatives. The cost estimates also include a low and high range. The range is used to help clarify complexities within certain corridors that may have more factors associated with those corridors than a standard add lane/mill and overlay project. The most significant line item for these factors is bridge structures. Finally, some facilities have specific estimates developed by either 1) previous or current Mn/DOT analyses, or, 2) the MnPass System Study Phase 2 effort. In order to provide consistency in comparisons, the MHSIS methodology for cost estimation was used on all corridors; if these cost estimates from other efforts are known, they are noted in the project documentation. In many cases, these specific estimates may change the cost effectiveness analysis.

The line items used for the cost estimation are divided into the following categories:

- Pavement Construction (New pavement and mill and overlay of existing pavement)
- Managed Lane ATM Infrastructure
- Grading and Drainage
- Miscellaneous (Sign Bridge Relocation, Median Barriers, etc.)
- Bridge Structures
- Risk Factors

The line items that were not included within the MHSIS study are listed below:

- Right-of-Way Property Acquisition
- Upgrade to the Lighting System
- Proposed Retaining Wall Structures

Detailed corridor-by-corridor cost estimates are provided in the appendices.

The ATM infrastructure cost estimate recognizes the information that was provided by Mn/DOT for the I-35W corridor located south of downtown Minneapolis. The cost estimates used for the managed lane corridors using ATMs assume a half mile gantry spacing similar to I-35W. These numbers also assume an upgrade to the existing fiber and power mainlines that run in parallel with the roadway. There has also been some allowance for the adjustment of existing infrastructure including Closed Circuit Television (CCTV) cameras and adding dynamic messaging signs. Due to the sign bridge widths needing to expand wider than the proposed roadway, the costs will vary based on the width of the roadway.

A standard unit of cost was applied to each corridor on a per mile basis. This number was not changed between the low and high range; however in areas that may have more drainage concerns, a higher risk factor has been applied to the corridor. Unlike the low range, the higher range took into account a potential need for noise walls, as well as more cost allocated to sign bridges or more median barriers.

The corridors that had bridges that are in need of widening were given a range based on if the overpass could add the new infrastructure on to either side of the roadway or if a new bridge replacement and signal upgrade was warranted. If a bridge was in need of an overpass replacement or the widening required a bridge replacement, a lump sum $5 million was applied to these conditions for the higher range. In most cases the goal of providing lower-cost/higher benefit solutions was used to try to fit the new roadway infrastructure within the existing bridge footprint wherever possible.

Since the cost of acquiring right-of-way is not included in the estimates, a higher risk factor was applied to areas within the I-694/I-494 ring. These areas should place a higher priority of fitting as much proposed roadway into the existing pavement footprint given the value of the adjacent land. Also included in the higher risk category were areas with known drainage concerns that would not have been captured in the standard drainage line item. Corridors with many bridge structures that have some areas of concern, but would require design exemptions were also given a higher risk factor. The higher risk corridors used a risk of 25% for the low range and 35% for the higher range. The risks used for areas with less variance and right-of-way concerns were given a risk of 15% for the low range and 25% for the higher range.

Comparison to MnPass System Study Phase 2

The MHSIS Study was completed concurrently with the MnPass System Study Phase 2. Although these studies were conducted with different objectives and timeframes for analysis, the measurements used for cost were mirrored closely between the two studies; however there are four primary areas where the MHSIS study differed from the MnPass Study. First, the MHSIS did not include any cost for direct connections between managed lane facilities; however, the MnPass System Study Phase 2 did look into the geometrics and cost for how a managed left lane structure would connect into the downtown exits. As the presence of direct connection was not included in the performance modeling, these costs are excluded from the MHSIS. However, the benefit of the connections has been evaluated as a part of the MnPass System Study Phase 2 and should be considered valid for correlation to MHSIS projects. Second, the MHSIS applied a lower miscellaneous cost for the corridors, but was balanced out by the risk factors. The MnPass System

Study Phase 2 applied the same risk factor to the low and high range. In contrast, the MHSIS used risks that varied by 10% between the low and high ranges. Third, the MnPass System Study Phase 2's timeframe for analysis was 2-10 years, with a keystone analysis of year 2015, whereas the MHSIS used a 20-year timeframe with the year 2030 as the keystone. Finally, the study corridors did not perfectly align between both studies. As a result, segment consideration may drive differences between the MnPass and MHSIS study corridors. These differences are reflected in Table 6 prepared by the MnPass System Study Phase 2.

TABLE 6: COST ESTIMATE DIFFERENCES BETWEEN MHSIS AND MNPASS SYSTEM 2 STUDIES

Corridor	Length (mi)	MHSIS (low)	MHSIS (high)	MnPass (low)	MnPass (high)	Reason for Discrepancy
TH 36: I-35W to I-35E	5.0	$39 M	$56 M	$35 M	$60 M	Roughly equivalent
I-94: TH 101 to I-494	9.0	72	101	70	95	Roughly equivalent
I-35E: I-94 to TH 36	3.9	35	48	75	90	Different segment limits
I-35E: TH 36 to CR E	3.8	7	12	30	40	MHSIS studied lane conversion
I-35W: DT Minneapolis to TH 36	5.3	47	60	95	115	Different segment limits
I-35W: TH 36 to Blaine	10.8	140	190	130	180	Different segment limits
I-494: TH 212 to I-394	9.0	130	167	70	125	Different segment limits
I-494: I-394 to I-94	8.5	61	61	61	61	Mn/DOT estimate
TH 169: CR 17 to I-494	10.0	93	116	80	115	Different limits and design
TH 77: 141st Street to I-494	6.9	41	41	41	41	Mn/DOT estimate
I-94: DT Minneapolis to TH 280	3.0	41	41	41	41	Mn/DOT estimate
I-94: TH 280 to DT St. Paul	5.1	62	62	62	62	Mn/DOT estimate
I-494: TH 212 to MSP Airport	10.6	130	155	150	185	Different segment limits

Opportunity-Driven Cost Reduction

One of the main recommendations of the MHSIS is for the continued communication and coordination between the agencies on implementation of the desired project concurrently with the preservation of other maintenance or design projects. Examples of these situations could vary from an existing bridge that is programmed for replacement or a standard mill and overlay preservation project to a strategic capacity enhancement that would perform even better with additional ATMs. The corridors listed below have been funded for future enhancements.

The I-35E corridor was studied in the MHSIS with the potential of performing well in the cost benefit analysis. If the Cayuga bridge project implements some of the ATM infrastructure studied in the MHSIS, the impact could be equally as high at a fraction of the cost. Also, receiving funding is the I-694 corridor between the Highway 10 / Snelling Ave / Hamline Interchanges. This corridor may have more funds added to connect the Highway 10 Project with the "unweave the weave" project at Rice St. These improvements coupled with new interchange improvements at I-35W and I-694, and the corridor will perform at a much higher level. Also programmed for improvements along the I-35W corridor are two bridges just south of downtown Minneapolis.

Performance Analysis

A total of 41 candidate projects were evaluated. While representative of the overall set of new projects being considered, these corridor alternatives should not be considered an exhaustive or exclusive list. The performance evaluation for these projects was conducted using two approaches.

To measure the benefits of capacity enhancement, the regional travel demand forecast model (the regional model) was used. Secondly, the project team used the ITS Deployment Analysis System (IDAS) to measure the benefits of ATM strategies. Detailed descriptions of both models' methodologies and findings are provided in Appendices.

The Metropolitan Council technical planning support staff coded 23 separate network scenarios for forecast years 2030 and 2060 that contained the 41 selected corridor projects. In addition, model runs were done for 2030 and 2060 for the no-build condition. Using this approach, the project team developed a database of corridor-specific performance measures on a link and origin-destination trip basis, computing the measures of effectiveness identified previously. Each of these measures could be summarized by several different categories, including facility/lane type, volume/capacity ratio, trip length and/or time of day.

The IDAS model evaluated the various ATM techniques that would best serve the needs of the Minneapolis / St. Paul region. After considering 1) a dynamic re-routing system, and 2) a speed harmonization (including queue warning) and lane control system, it was decided by Mn/DOT and the project team that the latter alternative would be the preferred ATM strategy for analysis. Six corridors, comprising most of the capacity projects under consideration, were selected for studying the deployment of the ATM system. The selection of the corridors was based on the 2005-2007 freeways and major expressway crash map and the 2008 metro freeway congestion maps for the morning and evening peak periods.

A comparative cost-benefit analysis was used to analyze the different alternatives. The analysis enabled the development of an ATM deployment strategy and helped integrate it into the managed lane vision for the region.

MHSIS Analytical Findings

The results of the evaluation efforts are described based upon the analytical tools. As the two primary tools yield incomparable results, they cannot be combined. However, as the ATM deployment is viewed as a supporting element to capacity projects envisioned in the managed lane and strategic capacity expansion considerations, it is not necessary to integrate the results. The ATM analysis is described first, as it provides a basis for understanding the benefits of ATM as a discrete system and how it can support the managed lanes system.

ATM Evaluation

The first step in the analysis process using IDAS was to run trip assignment for each of the ATM alternatives, so as to redistribute trips on the network based on the ATM elements deployed on the network. Once trip assignment was run it computed changes in vehicle miles of travel (VMT), vehicle hours of travel (VHT), average speed, number of person trips, etc. Using these measures, IDAS identifies the dollar value for the benefits of the improvement relative to the cost of implementation of the system. The benefits values were annualized and total of all these benefits values was calculated as the "Total Annual Benefits". Similarly during the analysis process the capital costs and the operations and maintenance costs for the ATM equipment deployed were computed and annualized. This was reported as the "Total Annual Cost". In order to compare between the various alternatives, IDAS provided the values for the "Net Benefits" (Total Annual Benefits – Total Annual Costs) and the benefit to cost ratio.

Looking at the benefit cost summary for both the AM peak period and the PM peak period, implementing speed harmonization / lane control system yields positive net benefits on all the identified corridors. This means that investment in deploying the ATM system on the corridors would yield benefits for the metropolitan highway system and help improve the operation of the system, as shown in Table 7. It should be noted that this list does not reflect the costs of ATM deployment already conducted in the I-94 and I-35W corridors, which would improve the relative rating.

TABLE 7: BENEFIT-COST RATIO OF ATM ALTERNATIVES

Corridor	Benefit / Cost Ratio (AM peak; PM peak)
TH-36	17.14 / 60.52
TH-62	17.03 / 62.12
I-35W	15.42 / 49.99
I-35E / I-694	15.42 / 56.87
I-494	13.42 / 45.12
I-94 / I-394	6.81 / 27.54

Overall, it can be said that the results of the analysis show that ATM deployment on the corridors would provide an effective means of managing these corridors and would make for an efficient and cost effective strategy for mitigating operational and safety concerns when utilizing shoulder lanes. As such ATM should be an integral part of the long range transportation plan for the region.

Managed Lane Project Findings

The managed lane projects were examined using the travel demand forecast model as described in the methodology. As noted previously, the measurement of these findings is on a *system* scale. As a result, the benefits accrue to all participants in the managed lane's commuter shed. Thus, if the project affects trips not only using the managed lane corridor (both users and non-users) but also those of parallel facilities, the findings translate to aggregate benefits across the entire commuter shed. At times, this may yield contradictory or confusing results based upon what would be anticipated for a *commuter using the managed lane*. It is worth reiterating that the benefits shown here do not reflect that commuter, but rather, the aggregate experience across *all travelers* in the commuter shed for that managed lane improvement.

THROUGHPUT

As the travel demand model held regional vehicular trip-making static, the measures of effectiveness for person and vehicular throughput in the model results only reflect how much the project expands the market it is serving. An expansion of one market by the project yields a contraction of another market (e.g., I-494 drawing more vehicles from US 169, not necessarily serving more people in aggregate). So, this measure provides a perspective on the size of the market affected by the project. When calculated as person / vehicle throughput per directional lane mile, the effect is to evaluate how many travelers are potentially served by the project. The greater the service per mile, the greater the spatial scope of effectiveness. The results of the throughput analysis are seen in Table 8 and Figure 9.

TABLE 8: MANAGED LANE PERFORMANCE ASSESSMENT: THROUGHPUT

Corridor	From	To	Net Vehicles per Lane Mile	Net Persons per Lane Mile	Throughput Rating
169-2	TH-62	I-394	1,045	2,504	Moderate
169-3	Minnesota River	TH-62	1,468	5,941	High
35E-1	Maryland	TH-36	2,619	6,431	High
35E-2	TH-36	CR E	1,210	1,404	Moderate
35E-3	CR E	CSAH 14	729	1,245	Moderate
35W-1	42nd St.	Minneapolis CBD	256	1,504	Low
35W-2	University	TH-280	1,567	3,804	High
35W-3	TH-280	95th Ave	691	1,426	Moderate
36-1	I-35W	I-35E	573	1,509	Moderate
36-2	I-35E	I-694	320	798	Low
494-1	I-394	I-94 /I-494	781	1,999	Moderate
494-2	TH-212	MSP Airport	1,448	1,057	Moderate
694-1	I-35W	I-35E	1,895	3,853	High
694-2	I-94	US 61	810	726	Moderate
77	CSAH 42	I-494	1,075	4,434	High
94-1	TH-101	I-94 /I-494	304	801	Low
94-2	Cedar	Marion	1,674	2,351	High
94-3	St. Paul CBD	I-694	359	784	Low

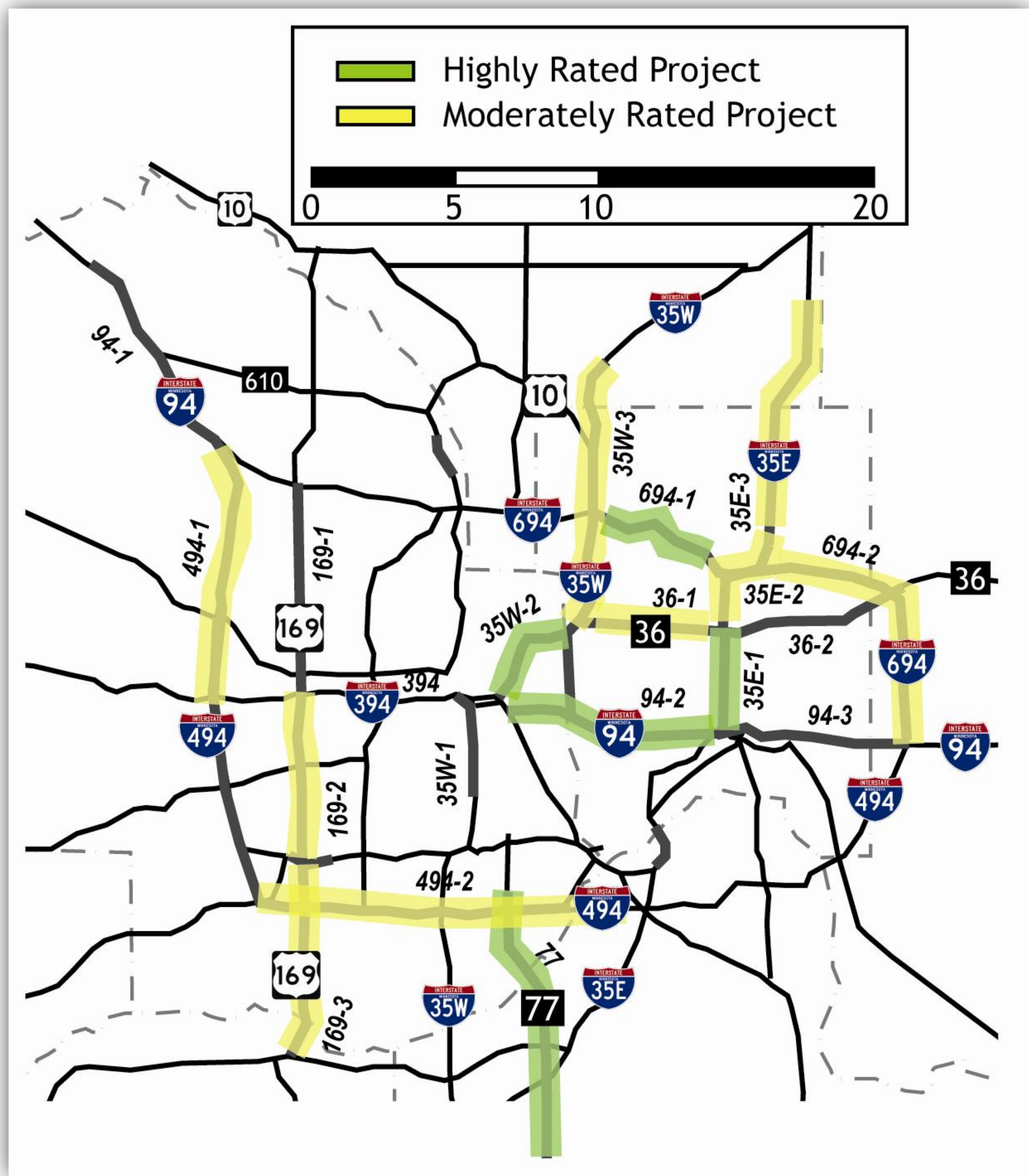


FIGURE 9: MANAGED LANE PERFORMANCE ASSESSMENT: THROUGHPUT (MAP)

Optimization

Positive findings for improvements in travel time reliability are largely correlated with congested facilities and peak periods. As such, the reliability measure would best be examined as change in delay hours, separated by lane type (managed lane vs. general purpose lane). As the managed lane conditions will be congestion-free, then the real comparison points are: 1) between build / no-build conditions in the general purpose lanes, and, 2) vehicular delay differences between managed lane / general purpose lanes. Appropriate measures of effectiveness are vehicle minutes of delay by trip categorized by facility type. Peak period separation may accentuate the differences. Examining the potential benefit (as proxied by mileage normalization) that a project can provide for travel time reduction, vehicle hours of delay reduced per centerline mile were examined. This offers an easy-to-describe means of articulating benefits from the project. The reduction in congested VMT shows an unscaled performance measure, which provides a measure of the total magnitude of the intended improvement and examines (throughout the network) how many sections of roadway are relieved by the project. It should be noted that the optimization measures of effectiveness, with their emphasis upon high-volume facilities, tend to favor suburban routes with high rates of single-occupant vehicle mode share. As a result, corridors that may be effective at improving transit travel times and enhancing person-carrying capacity of buses will not necessarily be reflected in these results. The results of all three analyses are shown in Table 9 and Figure 10.

TABLE 9: MANAGED LANE PERFORMANCE ASSESSMENT: OPTIMIZATION

Corridor	From	To	Congested VMT Reduced	Peak Delay / Trip Reduced	Average Trip Time Reduced	Optimization Rating
169-2	TH-62	I-394	195,729	0.11	4.57	Moderate
169-3	Minnesota River	TH-62	22,035	3.38	3.20	Moderate
35E-1	Maryland	TH-36	88,251	0.88	1.79	Moderate
35E-2	TH-36	CR E	131,531	0.43	1.67	Low
35E-3	CR E	CSAH 14	106,631	0.46	2.04	Low
35W-1	42nd St.	Minneapolis CBD	91,109	0.74	2.79	Moderate
35W-2	University	TH-280	91,687	0.30	2.21	Low
35W-3	TH-280	95th Ave	233,879	0.58	2.40	Moderate
36-1	I-35W	I-35E	224,568	0.69	2.16	Moderate
36-2	I-35E	I-694	302,410	0.77	2.58	Moderate
494-1	I-394	I-94 /I-494	96,685	0.55	3.63	Moderate
494-2	TH-212	MSP Airport	183,630	0.90	1.86	High
694-1	I-35W	I-35E	8,615	0.97	1.56	Low
694-2	I-94	US 61	212,827	0.65	2.47	Moderate
77	CSAH 42	I-494	69,211	0.93	1.61	Low
94-1	TH-101	I-94 /I-494	277,055	1.51	4.31	High
94-2	Cedar	Marion	110,646	0.09	1.99	Low
94-3	St. Paul CBD	I-694	35,257	0.12	0.98	Low

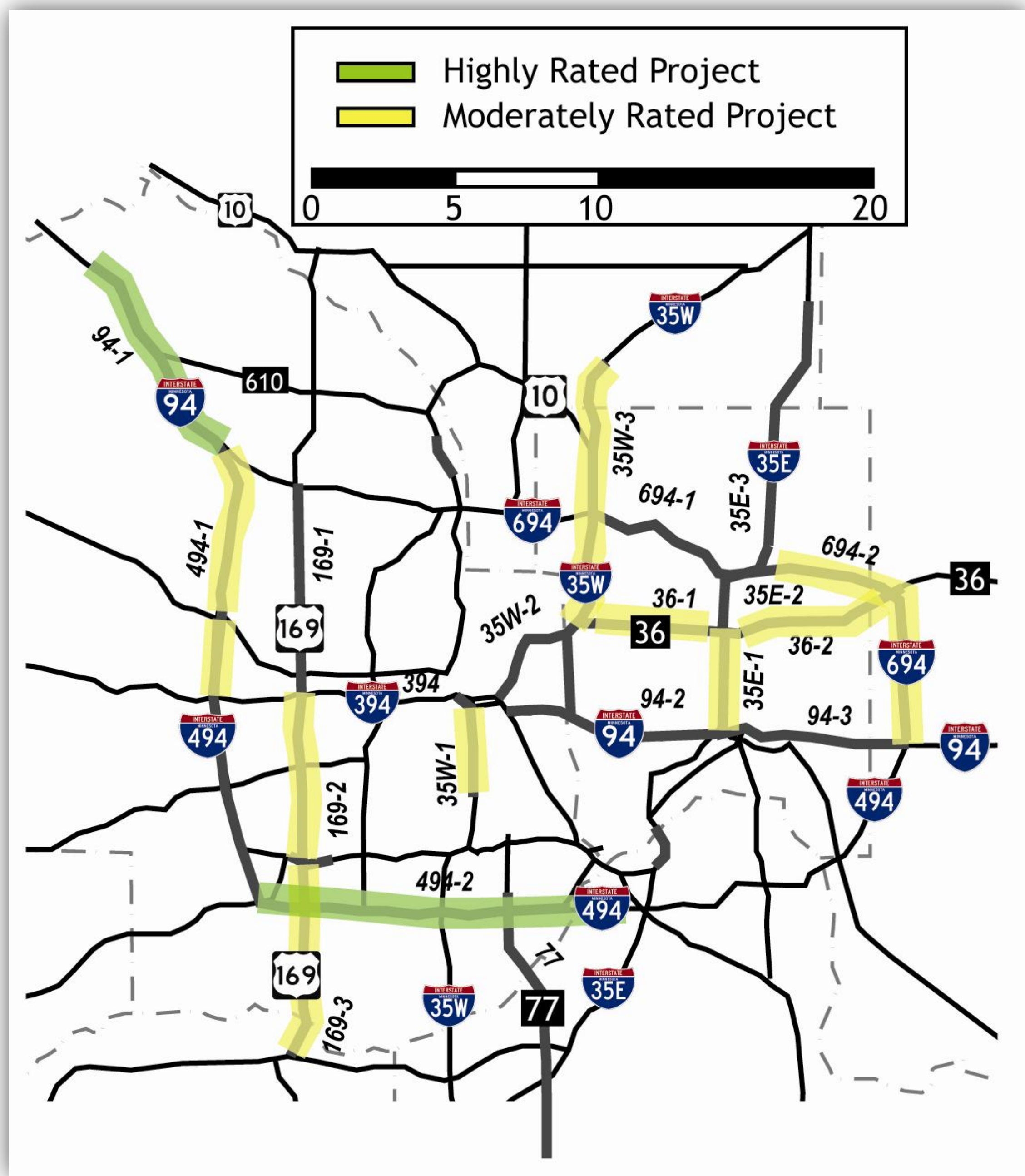


FIGURE 10: MANAGED LANE PERFORMANCE ASSESSMENT: OPTIMIZATION (MAP)

Reduce Single Occupant Vehicle Demand

Reducing SOV demand on the metropolitan highway system was shown with two metrics. The first metric is an increase in transit mode share. The mode choice component of the travel demand forecast model was not included by the Metropolitan Council for this effort. Furthermore, transit service levels (e.g., speeds, fares, headways) were not changed in the build scenarios. Therefore, the resulting trip assignments do not reflect changes in transit service levels that may result from the proposed improvements. However, changes in mode shares result since the level of service will often change as a result of the alternatives' capacity enhancements. This is reflected in the findings.

An additional pivot analysis of mode shift was conducted, evaluating the attractiveness of the capacity enhancements for single occupant vehicles as a percent of overall new trip attraction. In this analysis, a project that attracts more (as a percent) SOV's than HOV's and transit relative to the initial mode distribution rates negatively. Roadways that rate highly in this pivot analysis tend to favor corridors generally lacking in transit service, as the new managed lanes will disproportionately shift travelers to HOV's instead as the mode of choice.

Altogether, these two measures attempt to capture the primary modes for reducing SOV mode share: transit and HOV use increases. These results are shown in Table 10 and Figure 11.

TABLE 10: MANAGED LANE PERFORMANCE ASSESSMENT: SOV DEMAND REDUCTION

Corridor	From	To	Transit Mode Share Change	SOV Use Change	Demand Reduction Rating
169-2	TH-62	I-394	0.40%	-0.75%	Moderate
169-3	Minnesota River	TH-62	0.70%	-1.23%	Moderate
35E-1	Maryland	TH-36	0.20%	-8.27%	Low
35E-2	TH-36	CR E	0.30%	-3.75%	Moderate
35E-3	CR E	CSAH 14	0.30%	-1.81%	Moderate
35W-1	42nd St.	Minneapolis CBD	0.30%	2.47%	Moderate
35W-2	University	TH-280	0.40%	-3.99%	Moderate
35W-3	TH-280	95th Ave	0.30%	-3.01%	Moderate
36-1	I-35W	I-35E	0.30%	-5.66%	Moderate
36-2	I-35E	I-694	0.40%	-0.17%	Moderate
494-1	I-394	I-94 /I-494	0.70%	3.93%	High
494-2	TH-212	MSP Airport	0.20%	-9.69%	Low
694-1	I-35W	I-35E	0.60%	1.12%	High
694-2	I-94	US 61	0.20%	0.43%	Moderate
77	CSAH 42	I-494	0.10%	-7.06%	Low
94-1	TH-101	I-94 /I-494	0.50%	7.58%	High
94-2	Cedar	Marion	0.40%	-5.61%	Moderate
94-3	St. Paul CBD	I-694	0.00%	-17.11%	Low

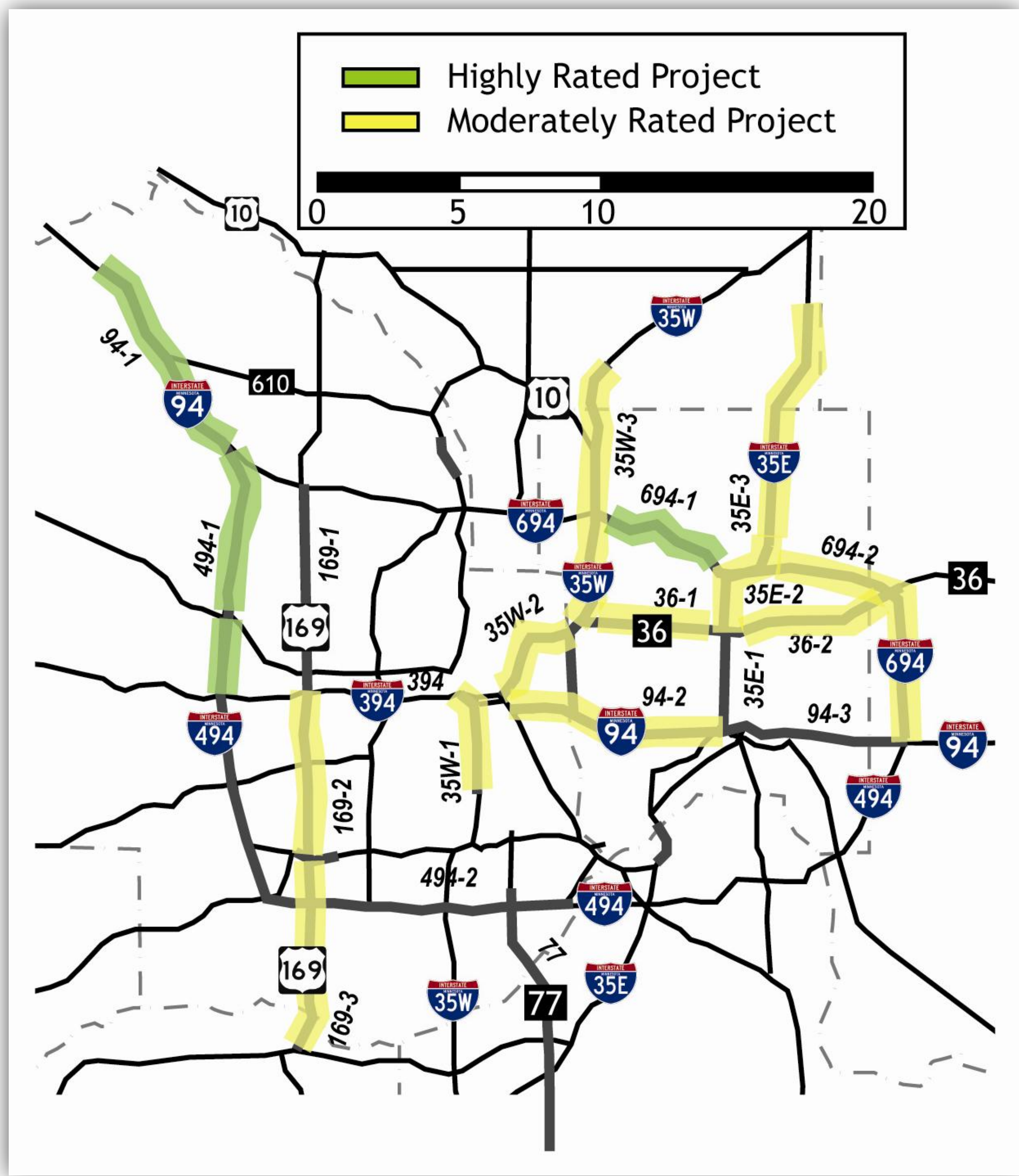


FIGURE 11: MANAGED LANE PERFORMANCE ASSESSMENT: SOV DEMAND REDUCTION (MAP)

Strategic and Affordable Investments

Cost effectiveness calculations constitute an econometric analysis of the annualized value of benefits relative to the capital and operations / maintenance costs to produce the improvement. Benefits are valued as the annualized benefit of travel time reduction, net operational benefits in system costs (minus O&M costs), and operating benefits for the traveler's reduction in delay conditions. Costs involve an annualized estimate of capital construction costs (including managed lane deployment, mill and overlay, grading, drainage, structures, utilities, engineering, escalation, and risk). Any positive finding of 1.0 or higher in the benefit / cost ratio indicates a net beneficial project, shown in Table 11 and Figure 12.

TABLE 11: MANAGED LANE PERFORMANCE ASSESSMENT: COST EFFECTIVENESS

Corridor	From	To	Benefit Cost Analysis	Cost Effectiveness Standard Deviation	Cost Effectiveness Rating
169-2	TH-62	I-394	10.445	0.185305	Low
169-3	Minnesota River	TH-62	7.615	0.135098	Low
35E-1	Maryland	TH-36	19.08	0.338499	Moderate
35E-2	TH-36	CR E	139.575	2.476209	High
35E-3	CR E	CSAH 14	12.165	0.21582	Moderate
35W-1	42nd St.	Minneapolis CBD	21.22	0.376465	Moderate
35W-2	University	TH-280	18.055	0.320315	Moderate
35W-3	TH-280	95th Ave	13.64	0.241988	Moderate
36-1	I-35W	I-35E	38.45	0.682144	High
36-2	I-35E	I-694	43.08	0.764285	High
494-1	I-394	I-94 /I-494	14.43	0.256004	Moderate
494-2	TH-212	MSP Airport	12.07	0.214135	Low
694-1	I-35W	I-35E	16.395	0.290865	Moderate
694-2	I-94	US 61	12.44	0.220699	Low
77	CSAH 42	I-494	9.31	0.165169	Low
94-1	TH-101	I-94 /I-494	17.73	0.314549	Moderate
94-2	Cedar	Marion	9.57	0.169782	Low
94-3	St. Paul CBD	I-694	3.085	0.054731	Low

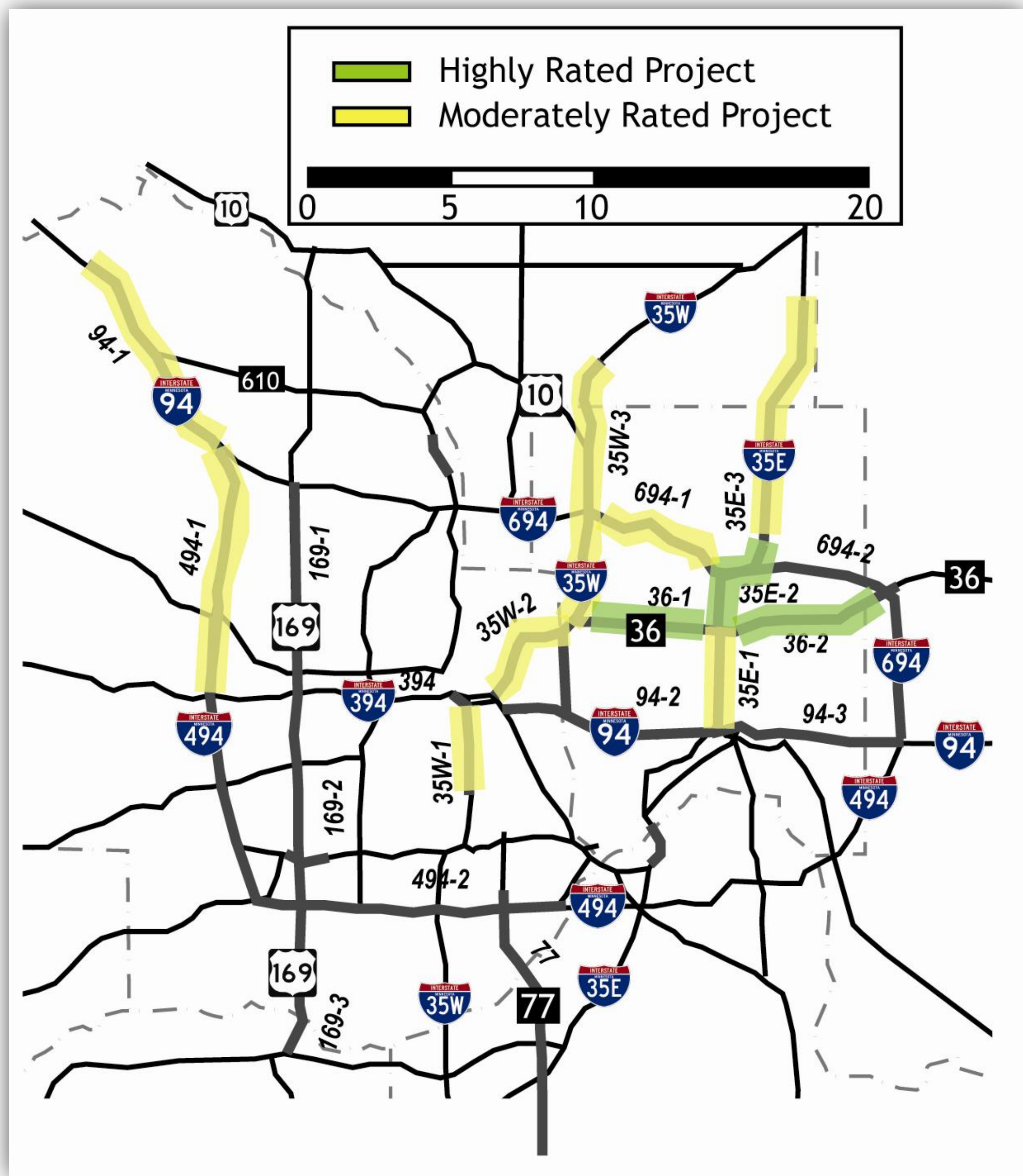


FIGURE 12: MANAGED LANE PERFORMANCE ASSESSMENT: COST EFFECTIVENESS (MAP)

5.0 Prioritization Analysis

Through the course of the MHSIS project development and analysis, the MHSIS project management team in conjunction with the project team determined that select categories of improvement, including arterial-based access management and signalization projects, would best be developed under the context of the Congestion Management and Safety Program (CMSP), a Mn/DOT initiative intended to make short-term, lower-cost improvements to the freeway and arterial systems. Additionally, two classification of projects – interchange closure / consolidation and strategic capacity expansion – were analyzed but set aside from the MHSIS. These facilities will be considered in the 2030 TPP update process, as appropriate.

Project Analysis

Twenty four managed lane projects were analyzed, including two conversions of general purpose lanes (on I-35E and I-494), four asynchronous managed lanes (on I-35E, I-35W I-94, and TH-252), and 18 bi-directional managed lanes. The appendices provide detailed composite analyses of each project.

Some projects were excluded by the project management team from the final analysis, due to low performance metrics across the spectrum of analysis, and, removal from the MnPass System Study Phase 2 (US 169 north of I-394, I-394, and TH-280). Secondly, the conversion projects (originally considered for lane balancing reasons) were excluded from the final analysis, due to policy maturation as a result of the MnPass System Study Phase 2. For these two projects, the identified segments would continue as expansion projects instead. Finally, the small-size asynchronous were forwarded to the CMSP for consideration and inclusion as appropriate. Overall, the asynchronous projects rate highly for performance due to their short length (with corresponding low cost), and targeted implementation. In all four cases, these projects are envisioned as providing outbound capacity in bottleneck areas.

In the Table 12 and Figure 13 summary, the overall performance rating of the managed lane corridors indicate which improvements best correspond with the objectives of the MHSIS for assumed potential implementation by 2030. Corridors with a rating of “High” or “Moderate” are likely in keeping with the guiding principles of the MHSIS. By contrast, those with a “Low” rating may not correspond from a performance perspective. Although some facilities may not be appropriate for the short term (2030), these managed lanes may work for the longer term (2030 – 2060), and as a result remain within the long-term vision of the managed lane network for the region.

TABLE 12: MANAGED LANE PRIORITIZATION SUMMARY

Corridor	Throughput	Optimization	Demand Reduction	Cost Effectiveness	Transit Suitability	Investment Parity	Opportunity	Composite
169-2	Moderate	Moderate	Moderate	Low	High	Moderate	High	**Moderate**
169-3	High	Moderate	Moderate	Low	Moderate	High	High	**Moderate**
35E-1	High	Low	Low	Moderate	Moderate	High	High	**High**
35E-2	Moderate	Low	Moderate	High	Low	Low	Moderate	**Moderate**
35E-3	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate	**Low**
35W-1	Low	Moderate	Moderate	Moderate	High	High	High	**High**
35W-2	High	Low	Moderate	Moderate	High	Moderate	Moderate	**Moderate**
35W-3	Moderate	Moderate	Moderate	Moderate	High	Moderate	High	**High**
36-1	Moderate	Moderate	Moderate	High	High	High	High	**High**
36-2	Low	Moderate	Moderate	High	High	Low	High	**Moderate**
494-1	Moderate	Moderate	High	Moderate	Low	High	Low	**Moderate**
494-2	Moderate	Moderate	Low	Low	Low	Moderate	Low	**Low**
694-1	High	Low	High	Moderate	Low	High	High	**High**
694-2	Moderate	Moderate	Moderate	Low	Low	High	Low	**Low**
77	High	Low	Low	Low	High	Moderate	High	**Moderate**
94-1	Low	High	High	Moderate	Moderate	Moderate	Moderate	**Moderate**
94-2	High	Low	Moderate	Low	High	Moderate	High	**Moderate**
94-3	Low	Low	Low	Low	High	Moderate	Moderate	**Low**

FIGURE 13: MANAGED LANE PRIORITIZATION SUMMARY

2030 MANAGED LANES PLAN

Of capacity expansion projects, certain managed lane projects stand-out as advantageous for action within the 2010 – 2030 timeframe:

- I-35E, from downtown St. Paul to north of I-694 (35E-1 and 35E-2). Although not as high a performer as other managed lane corridors, there are extenuating circumstances that advance this corridor. First, the Cayuga Bridge reconstruction project provides an opportunity to cost effectively add managed lanes. Furthermore, the reconstructed interchange at I-694 has abundant pavement availability, allowing for managed lane expansion in this segment without substantial additional cost. Together, this permits a greater return on investment from the reconstruction activities. Second, this section of the metropolitan highway system rates well for parity purposes (addressing previously planned facilities in the long range plan).

  The MnPass System Study Phase 2 identified the section including 35E-1 as a good performer, with a moderate benefit-to-cost ratio and up to 17 percent capital cost recovery from tolling. However, the segment comprising the same limits as 35E-2 and 35E-3 were not as strong of performers, with a low benefit-cost ratio and only two percent of capital cost recovered by tolling.

  It should also be noted that the MnPass System Study Phase 2 proposes extending the I-35E managed lanes south of the 35E-1 segment limit into downtown St. Paul with a direct connection ramp. Based upon the finding from the MnPass System Study Phase 2 and the overall positive findings from the MHSIS, this study adopts the MnPass System Study Phase 2 limits for the corridor (including direct connection) as the preferred corridor. The cost estimate table, below, incorporates the MnPass System Study Phase 2 estimate, not the initial MHSIS limits as initially developed.

- I-494, from I-394 to I-94/I-494 interchange (494-1). The I-494 corridor would significantly benefit from the implementation of managed lanes, as evidenced from the modeling activities. Furthermore, this corridor has a high rating for investment parity, based upon prior commitments in the long range plan. Finally, the corridor helps the I-394 MnPass lanes constitute the beginning of a system, with the possibility to serve managed lane trips from the south to northwest Metro across much of the system. The key limitation of this corridor will be the likely lack of connectivity between the I-394 MnPass lanes and the I-494 managed lanes, although this could be addressed in the future if the interchange must be reconstructed. However, given the strength in performance and moderately rated cost effectiveness, this corridor's opportunities outweigh its weaknesses.

  The MnPass System Study Phase 2 findings indicate that the corridor comprising limits between I-394 and I-94 as a moderate-to-high cost-to-benefit performer. Although the corridor's capital cost for construction is low, the cost recovery from tolling is estimated at six percent by the MnPass System Study Phase 2.

- I-35W, from downtown Minneapolis to 95th (35W-1 and 35W-2). I-35W north is one of the strongest transit corridors for the managed lane system, and deserves special consideration here. In addition to its transit suitability, this corridor has moderate-to-high ratings for performance, including throughput, optimization and SOV travel reduction. The ability to serve regional and inter-regional trips on the managed lane system is high, with close connections to I-394 and I-35W to the south. Finally, given the presence of existing bus-only-shoulder operations, the ability to convert this facility to managed lanes is strong.

  Like I-35E, the MnPass System Study Phase 2 is developing a direct connection concept for downtown Minneapolis. With this connection, the cost effectiveness ratio was a moderate performer; however, the capital cost recovered from tolling approached 16 percent as estimated by the Study. Furthermore, the MnPass System Study Phase 2 shows high performance improvement from this corridor. Thus, both studies confirm the appropriateness of this corridor's inclusion within the 20 year development horizon.

- TH-36, between I-35E and I-35W (36-1). TH-36 held moderate ratings throughout all performance criteria. This segment also performs well for transit suitability, investment parity, and cost effectiveness. Finally, this segment is programmed for interchange work on Lexington and Rice, providing an efficiency opportunity to address managed lanes as it pertains to these structures. As a result, TH-36 is recommended for managed lanes development in the MHSIS. However, one crucial concern with TH-36 is its connections with I-35W an I-35E. Without direct connection ramps, which are cost prohibitive without appropriately sized accompanying benefit, the termini for TH-36 median-based managed lanes would require weaving to a right-side ramp in both conditions. In the case of westbound TH-36 to southbound I-35W, this movement would likely severely curtail corridor operations. Additional simulation study is recommended to determine the operational impacts of managed lanes on this corridor without direct connections. In the next 20 years, it may be possible to implement asynchronous managed lanes on this corridor, featuring an eastbound-only treatment. Again, additional study should evaluate the effectiveness of an asynchronous treatment if a bi-directional treatment cannot be affirmed.

  The MnPass System Study Phase 2 evaluated the asynchronous treatment for TH-36. Under this analysis, performance was not significantly enhanced with this project, and the project yielded a low-to-moderate cost effectiveness rating. This finding confirms the concerns on the asynchronous design of the project. However, the opportunity to develop the lane at lower cost due to programmed improvements may warrant its consideration.

- I-94, between downtown Minneapolis and downtown St. Paul (94-2). The I-94 managed lane project rated well for throughput, but low for optimization primarily due to the constraints imposed upon the corridor by the Lowry Hill tunnel and the Capitol interchange. Furthermore, the need to replace structures in the corridor yields an elevated cost versus other facilities in the region, thereby depressing the corridor's overall cost effectiveness rating. Pending deployment of ATM in the corridor may assist in addressing some of the corridor's traffic effects, while providing for enhanced bus operations. Furthermore, a parallel light rail transit facility will soon open, providing a corridor alternative for transit riders. All of these conditions lend to a conclusion that I-94 should remain a medium priority for managed lane development, with an understanding that upcoming opportunities may arise for reconstruction purposes that can positively affect the return on investment in this corridor.

The MnPass System Study Phase 2 found this project to be a good performer from a revenue generation perspective (25 percent cost recovery) and moderate performer for cost effectiveness. However, the Study also highlights this corridor as a high risk, making its inclusion in the 20-year MHSIS also risky. If additional study finds the cost reductions and traffic operations as projected by the MnPass System Study Phase 2 to be of merit, this project fits within the established budget due to revenue generation potential.

The MHSIS Project Management Team has developed a working budget estimated at approximately $450 to $500 million (2010 dollars) for the years 2014 – 2020 for deployment on managed lane facilities, and an additional $50 to $100 million anticipated for ATM deployment. As ATM as a concept has been refined as a supplement to managed lane deployment, an independent budget may be counterproductive. The consolidated budget is estimated at approximately $500 to $600 million. As such, the following estimates include the deployment of ATM as a complementary strategy to managed lanes. Given managed lanes and ATM deployment share some infrastructure, the specific cost for ATM is reduced from $2.0 M per mile to $1.6 M per mile. Using cost estimates refined by the MnPass System Study Phase 2 for the early action corridors (where available), this yields a simple division of expenditure (2010 dollars) in Table 13.

TABLE 13: COST ESTIMATE BY 2030 MANAGED LANE CORRIDOR

Project	Construction ($M 2010)	ATM ($M 2010)	Total (inc. risk) ($M 2010)
I-35E	$75	$12	$120
I-494	50	11	61
I-35W	165	24	255
TH-36 (est. asynch.)	16	6	28
I-94	88	15	103
TOTAL	$ 394 M	$ 68 M	$ 567 M

Additional facilities that are recognized for the long-term (2030 – 2060 timeframe) implementation include:

- TH-77, between 141st Street and TH-62. The TH-77 corridor is currently under study by Mn/DOT for managed lane feasibility, with a planned Bus Rapid Transit lane to be constructed in the vicinity of the Apple Valley Transit Center in the next few years. Although the performance modeling did not rate favorably for the corridor, this is due to the length of the modeled facility. Current planning activities indicate a shorter segment may be feasible and meet project needs. In order to avoid biasing the results of this planning study, the MHSIS is avoiding a prioritized determination of feasibility for 2030, but has included the facility for planning purposes.

  The MnPass System Study Phase 2 included the project in its analysis of a northbound lane. This analysis indicates that the asynchronous managed lane would have a moderate performing benefit-to-cost ratio and low cost of construction. However, this facility would also yield relatively low rates of revenue.

- I-94, between TH-101 and I-494 (94-1). The market for this project may be significantly affected by the completion of TH-610. Managed lane implementation may be warranted in the future, but 2030 performance metrics indicate the usefulness of managed lanes for person throughput may be constrained. It is recommended to evaluate the efficacy of this project as an extension of I-494 managed lanes (upon deployment) and post-completion of TH-610.

- I-694, between I-35E and I-35W (694-1). The I-694 segment between I-35W and I-35E rates highly for performance metrics, including throughput and SOV demand reduction. Additionally, this corridor rates well for investment parity purposes, based upon previous commitments in the 2030 plan, and rates moderately well for cost effectiveness. The benefit-cost calculation, though, did not account for programmed improvements to the I-35W / I-694 interchange as well as additional investment on I-694 in this segment. As a result, this cooperative opportunity would benefit the implementation of managed lanes in this segment. Additional study should assess the specific value of bi-directional and asynchronous (westbound only) treatments, especially in light of potential asynchronous treatment on TH-36 in the opposing direction.

- US 169, between TH-62 and the Minnesota River (169-3). Managed lanes on US 169 offer moderately strong performance metrics, but poor cost effectiveness due to the limited market for this facility relative to cost. As population expands in the southwest Twin Cities, this facility may become more necessary in order to enhance mobility options from the growth sectors to the urbanized area. Planned improvements to the I-494 and US 169 interchange provide an opportunity to reduce the cost of development of managed lanes. At a minimum, it is recommended that this interchange effort consider the future implementation of managed lanes on not only US 169, but also I-494 in the design of the facility.

  The MnPass System Study Phase 2 determined this corridor had a very high benefit-to-cost ratio and revenue generation (21 percent cost recovery from tolls). However, as this facility does not serve regional trips and does not comprise a system, it is inappropriate to include the facility as a part of the 20-year planning horizon for the MHSIS.

- US 169, between TH-62 and I-394 (169-2). If an opportunity for cost reduction is available for US 169 in this segment, the performance metrics suggest a productive corridor for managed lanes. Key questions concern the connectivity between I-394 and I-494. Without an opportunity for cost reduction, this project is not recommended for the 50-year horizon.

- I-494, between I-394 and Minneapolis / St. Paul airport (494-2). Whereas I-494 in the vicinity of I-35W has been designated as a potential strategic capacity expansion, it may be more productive to consider this segment as a managed lane corridor and extending the facility to MSP airport, which has acceptable performance metrics. However, given the high cost of this project, only an opportunistic perspective should be use for long-term development.

  Like I-94 between the two cities, the MnPass System Study Phase 2 found this project to be a good performer from a revenue generation perspective (25 percent cost recovery) and high performer for cost effectiveness. However, the Study also highlights this corridor as a high risk, making its inclusion in the 20-year MHSIS also risky. If additional study finds the cost reductions and traffic operations as projected by the MnPass System Study Phase 2 to be of merit, this project could move into the 20-year horizon.

- TH-36, between I-35W and I-694 (36-1 and 36-2). Assuming TH-36 has an asynchronous development in the 20-year plan, the 50-year horizon suggests a bidirectional deployment may be warranted if connections to I-35W and I-35E can be resolved. Additionally, opportunities to extend the managed lane corridor to I-694 may be viewed favorably based upon performance estimates. This should be viewed opportunistically for cost reduction.

- I-694, between I-94 and I-35E (694-2). This segment of I-694 had moderate levels of performance benefit associated with managed lanes; however, the cost of development yielded low cost effectiveness relative to those benefits. As a result, the region should review this corridor in the perspective of opportunity for cost reduction.

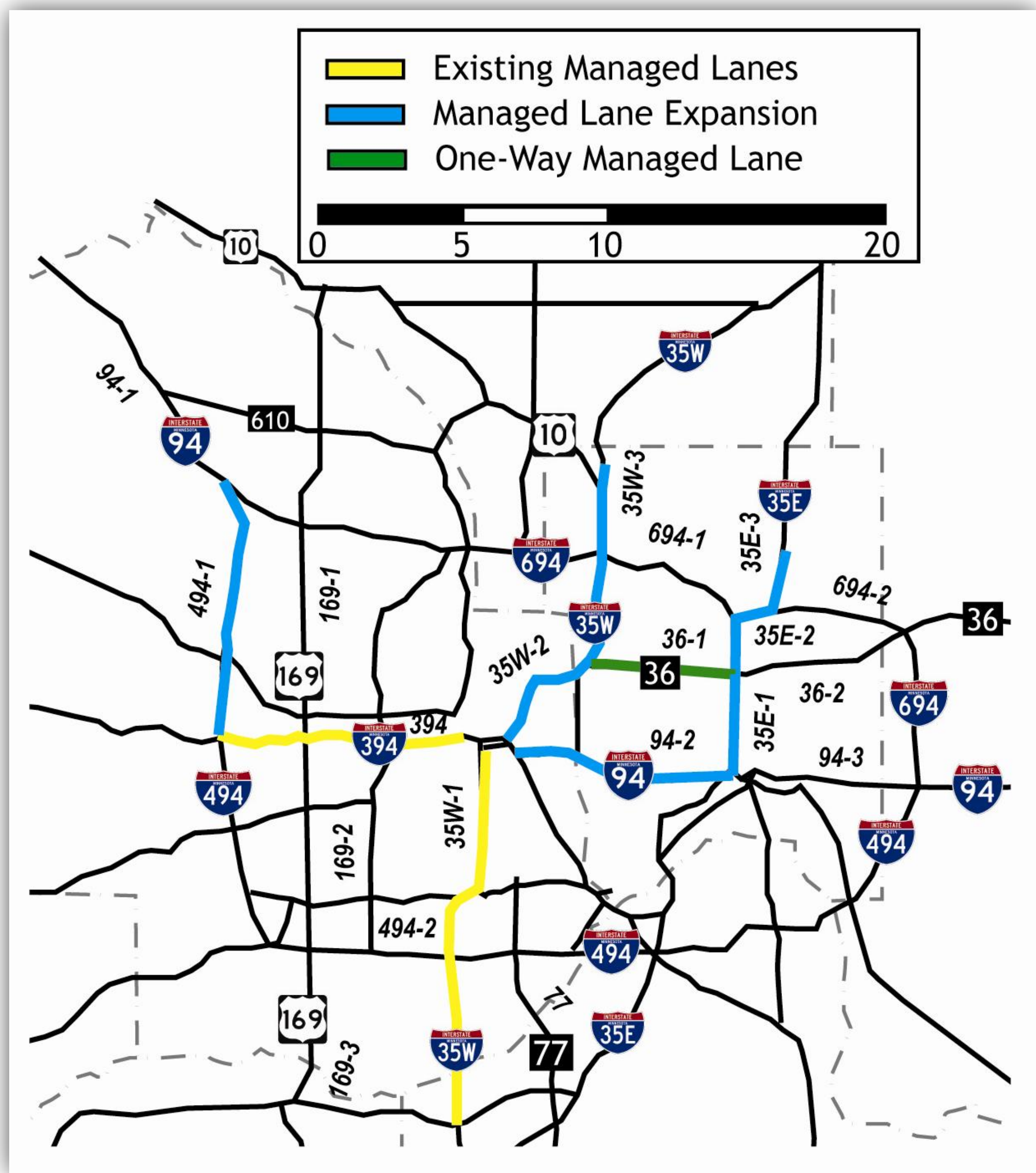


FIGURE 14: 20-YEAR MANAGED CAPACITY RECOMMENDED PROJECTS

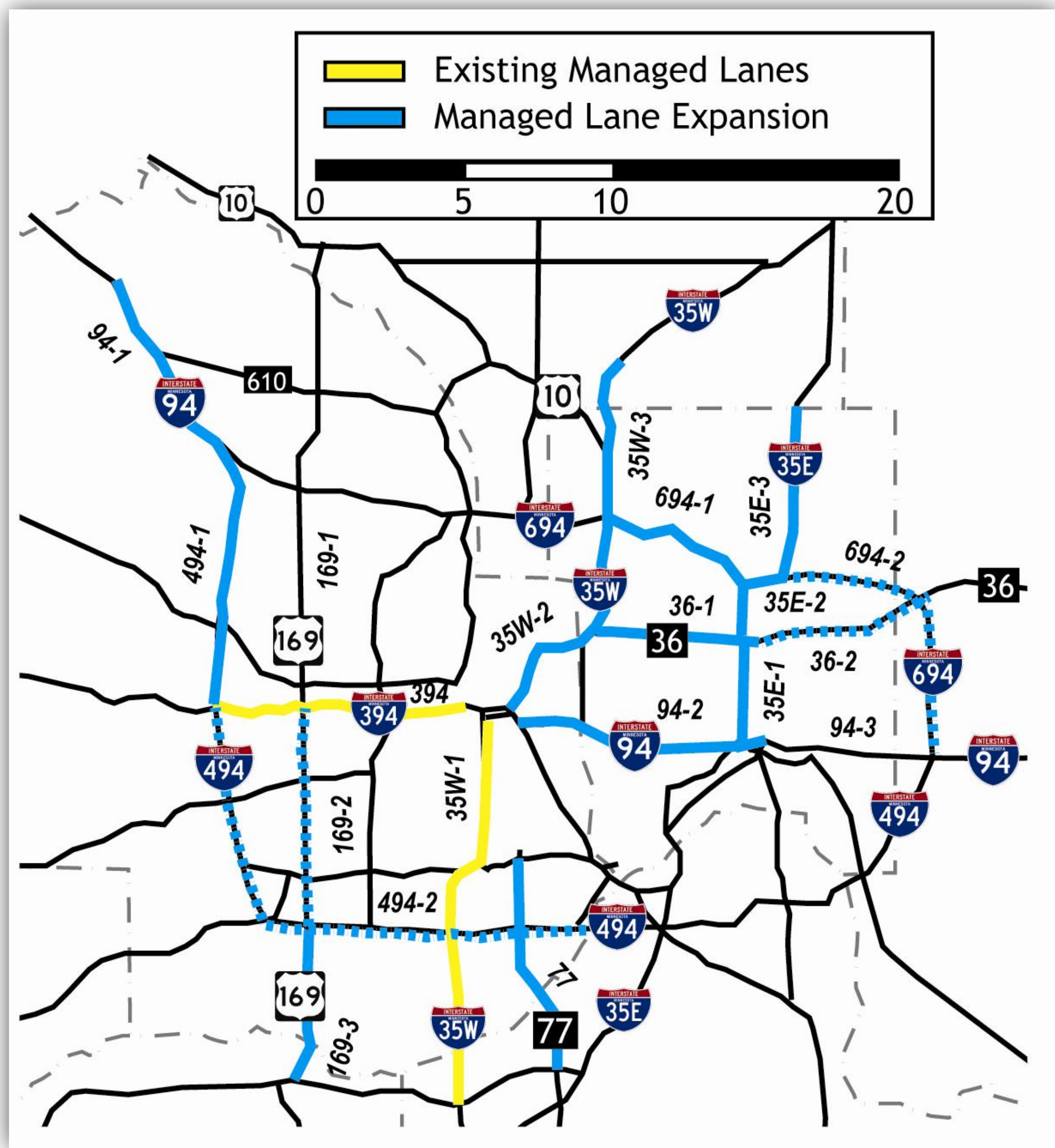


FIGURE 15: 50-YEAR MANAGED CAPACITY RECOMMENDED PROJECTS

6.0 OTHER CONSIDERATIONS

The MHSIS represents the first stage in a series of planning, technical, institutional and financial analyses that will successively lead to implementation of the regional managed lanes network and lower-cost / high benefit improvements in the Twin Cities. In addition to the ongoing MnPass System 2 effort, MHSIS study findings should be considered within the outreach and technical development for the 2030 Metropolitan Transportation Policy Plan (TPP). Additional data and studies will be needed on a corridor-by-corridor basis to identify the physical attributes and operational characteristics of each managed lanes corridor. Phasing of improvements will be important in achieving the highest potential for early success and in minimizing impacts and risk associated with managed lanes implementation. Phasing of improvements also will consider the programming of other projects in the study corridors to the extent possible, yielding positive return-on-investment.

Given the expanding inter-regional nature of the managed lanes, and, reliance upon managed lanes as the primary capacity expansion tool, a formal interagency process and mechanism should be established to ensure coordination is maintained throughout all facets of planning, data collection, design, forecasting, operations, and revenue distribution. The formal group (which may involve continuation of established procedures between the Metropolitan Council and Mn/DOT) should focus on issues such as determining the pricing/vehicle eligibility requirements for managed lanes as consistent with the 2030 TPP objectives, collecting data on travel behavior characteristics and managed lanes use, and identifying financing strategies to cover the operations and maintenance costs of the system, so that the regional plan is unaffected.

The advancement of MnPass on the MHSIS corridors will require more detailed operations analysis and refined engineering design of potential managed lanes at the individual corridor level. Work elements that could be undertaken in these corridor studies include, but likely are not limited to:

- Revised demand projections. The focus of this work will be to revise the demand estimates for managed lanes treatments along a corridor based on updated design and phasing assumptions, and incorporating additional managed lanes in the model as each is developed and implemented (the MHSIS treated each corridor in isolation from each other). The effort will provide for feedback between corridor-specific pricing models (such as that conducted for the MnPass System Study Phase 2) and the regional travel demand model. The task also would include traffic simulation modeling to evaluate potential bottlenecks / weaving at facility termini and identify possible mitigation strategies. This is particularly critical for TH-36 and a few other select facilities.

- Revenue estimates and potential tolls. The updated demand forecasts will generate estimates of traffic, travel behavior and revenue for MnPass priced managed lanes. This task will identify optimal tolls for each proposed facility and the corresponding revenues which could be generated from these tolls. The optimal toll rates will be designed to manage demand, as is currently performed on I-394 and I-35W and corresponds with existing policy. If desired by new policy, optimal toll rates could also be designed to minimize the commitment of non-project revenue to pay construction costs and/or bonds.

- Preliminary engineering, interim design, and concept of operations. This effort would include detailed operations analysis and designs based on more detailed planning and engineering. Design considerations would address the feasibility of implementing the ATM-dependent design alternatives. This task would include capital cost estimates based on the approved designs. Operational issues would be addressed based on the managed lanes treatment being considered for each corridor, followed by estimating corresponding O&M costs. This task also would involve identification of cost-effective enhancements such as direct access ramps and transit park-and-ride facilities in order to maximize the benefits of the Managed Lanes treatment. To illustrate the type of work to be undertaken in this portion of the study, the following issues or questions would be explored and answered:
    - What operational issues would establish project limits?
    - Are there special enforcement needs or ability to place monitoring areas?
    - What are the incident management needs?
    - For tolling, how many tolling zones and installations are envisioned for each direction?
    - What will be the preferred delivery and maintenance approach for tolling systems?
    - Are there needs for traffic detection in the pavement? Will cameras be employed?
    - What other Intelligent Transportation Systems (ITS) should be considered?

- Financial feasibility and phasing. This effort will involve a comparison of forecasted toll revenues and costs attributable to a priced facility over its life cycle. A comprehensive cash flow analysis will match revenue/funding sources and financing with capital and O&M costs to identify potential funding gaps and possible phasing of improvements. The timing of other programmed improvements in the corridor and their impacts on the proposed project would be considered as part of this work element. Other factors such as the planned implementation of supportive transit services or corridor maintenance/improvement projects should also be considered in phasing decisions.

Given the reliance of the MHSIS on priced-managed lanes for capacity development, it is important to recognize that a managed lane system will generate disproportionate revenues on a corridor by corridor basis relative to cost. A decision-making and consultation structure should be developed for allocating these revenues. The consultation structure would include Mn/DOT, Metropolitan Council, city and county agencies in addition to possible managed lanes operating partners (if pursued as a public-private partnership). The group could establish strategies when 1) annual revenues do not meet operating costs, 2) costs and revenues are equal, and 3) yearly revenues exceed O&M costs.

GLOSSARY

- AASHTO: American Association of State Highway and Transportation Officials
- ARC: Atlanta Regional Commission.
- ATM: Active Traffic Management. ATM is a package of intelligent transportation systems strategies that are specifically oriented towards improving safety and operational performance on managed freeway corridors.
- BOS: Bus Only Shoulders. BOS operations, predominant in the Minneapolis / St. Paul region, allow buses to use right-side shoulders during certain conditions.
- BRT: Bus Rapid Transit. BRT provides for express bus services within highway-based fixed guideways, often using inline stations.
- Caltrans: California Department of Transportation.
- CCTV: Closed Circuit Television
- CMA: Congestion Management Agencies (California). CMA's are county-based planning, development, and implementation agencies for highway capacity.
- CRD: Congestion Reduction Demonstration. The CRD is an FHWA program designed to showcase managed lane projects' ability to reduce congestion.
- EIR: Environmental Impact Record. The EIR follows the successful completion of the environmental process.
- FDOT: Florida Department of Transportation.
- FHWA: Federal Highway Administration.
- FPI: Freeway Performance Initiative (San Francisco / Oakland). The FPI is a systemwide study and implementation plan for operations and management strategies in the San Francisco Bay Area.
- FTA: Federal Transit Administration.
- GDOT: Georgia Department of Transportation.
- GPS: Global Positioning Satellite system.
- GRTA: Georgia Regional Transportation Authority.
- HCTRA: Harris County Toll Road Authority (Houston).
- HOT: High Occupancy Toll. HOT lanes allow access to fixed guideways, typically reserved for buses and carpools, for toll-paying single occupant vehicles.
- HOV: High Occupancy Vehicle. An HOV typically connotes a carpool, with HOV-2 indicating a 2-person carpool and HOV-3+ indicating 3-or-more person carpool. HOV lanes allow access to fixed guideways, typically reserved for buses , for carpools.
- ITS: Intelligent Transportation Systems. ITS is a package of technologies oriented towards enhancing the operational effectiveness of the highway system.
- LRT: Light Rail Transit. LRT is an electrically-powered surface rail transit which operates in both exclusive and/or shared right of way.
- MetCouncil: Metropolitan Council.
- Mn/DOT: Minnesota Department of Transportation.
- MPH: Miles Per Hour (speed).
- MPO: Metropolitan Planning Organization.
- MTC: Metropolitan Transportation Commission (San Francisco / Oakland).
- NCHRP: National Cooperative Highway Research Program.
- O&M: Operations and Maintenance.
- P&R: Park and Ride.

- PPP: Public Private Partnership. In the context of this study, a PPP is a contractual relationship between various public and private sector entities towards the development and operations of transportation infrastructure and/or services.
- PSRC: Puget Sound Regional Council.
- ROW: Right of Way.
- RTC: Regional Transportation Commission (Dallas - Ft. Worth).
- RTP: Regional Transportation Plan. The RTP is another way of entitling a long range transportation plan.
- SOV: Single Occupant Vehicle. An SOV connotes only one person (the driver) per vehicle.
- TCRP: Transit Cooperative Research Program.
- TDM: Travel (Transportation) Demand Management. TDM strategies aim to reduce the demand for highway capacity through encouraging greater utilization rates of carpools, transit, non motorized methods of travel, and alternative work arrangements (such as telework).
- TIP: Transportation Improvement Program.
- TOD: Transit Oriented Design.
- TPP: Transportation Policy Plan. The TPP is the Minneapolis / St. Paul region's long range transportation plan.
- TSM: Transportation System Management. TSM strategies aim to improve the operational efficiency of road and highway systems.
- TTI: Texas Transportation Institute.
- TxDOT: Texas Department of Transportation.
- UPA: Urban Partnership Agreement. Like the CRD program, the FHWA UPA program demonstrates the effectiveness of congestion pricing and transit strategies in reducing congestion in partner communities.
- USDOT: U.S. Department of Transportation.
- VMT: Vehicle Miles Traveled.
- WSDOT: Washington State Department of Transportation.

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