DEPARTMENT OF TRANSPORTATION

MnPASS System Study – Phase 3

MnPASS System Study Phase 3

Final Report
4/21/2018

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Acronyms

ABM – activity based model

CMSP – Congestion Management Safety Plan

HOV – high occupancy vehicle

MPH – miles per hour

PMT (1) – Project Management Team

PMT (2) – person miles travelled

2030 TPP – Transportation Policy Plan with a planning horizon year of 2030, published by the Metropolitan Council in 2010 and updated in 2013 and 2014

2040 TPP – Transportation Policy Plan with a planning horizon year of 2040, published by Metropolitan Council in 2015 and to be updated in 2018

SOV – single occupancy vehicle

TAZ – transportation analysis zone

TSC – Technical Steering Committee

V/C – volume to capacity ratio

VHT – vehicle hours travelled

VMT – vehicle miles travelled

Executive Summary

The primary purpose of the *MnPASS System Study Phase 3* is to assist in updating the MnPASS system vision and prioritized list of MnPASS corridors in the 2018 update to the region's *2040 Transportation Policy Plan* (2040 TPP). The 2040 TPP, published in 2015, defines the region's transportation investment priorities. The *MnPASS System Study Phase 3* builds on the first *MnPASS System Study* (2005) and *MnPASS System Study Phase 2* (2010).

The results of the first *MnPASS System Study*, coupled with the opening of the region's first MnPASS Express Lanes on I-394 in 2005, demonstrated the benefits that MnPASS lanes could provide to the region's highway and transit systems. The next MnPASS lanes on I-35W opened in three phases between 2009 and 2011. During that time, the *MnPASS System Study Phase 2* and the *Metropolitan Highway System Investment Study* were completed. These studies evaluated a potential regional MnPASS system that could be constructed at a lower cost while still providing significant benefits. These studies used a variety of evaluation criteria such as person throughput, travel-time savings and reliability, vehicle speed, change in congested VMT, transit demand, and a benefit/cost analysis. The result was a tiered list of priority MnPASS expansion corridors. Tier 1 and 2 corridors were adopted into the *2030 Transportation Policy Plan* (2030 TPP) published in 2010 for implementation within 2-10 years; the Tier 3 corridors were also included in the 2030 TPP as mid- to longer-term corridors.

Since the MnPASS Phase 2 study was completed, a significant amount of change has occurred within the Tier 1-3 MnPASS corridors. As a result, there was a need to conduct a MnPASS System Study Phase 3, and the 2040 TPP Work Program (2015) lists this study as a priority.

Study Process

The study process followed several steps, described below and shown in Figure 1:

1. The Project Management Team (PMT) and the Technical Steering Committee (TSC) established a list of corridors for initial consideration as MnPASS corridors. The list of corridors started with the Tier 3 corridors listed in the 2040 TPP. PMT and TSC members then added several corridors that were expected to perform reasonably well. The initial list of corridors excluded corridors that were recently expanded or planned for near-term expansion, before MnPASS would be built. Development of the initial list of corridors is further discussed on page 21. The current Tier 1 and 2 MnPASS corridors in the 2040 TPP were not reevaluated as part of this study since they continue to be priority corridors for MnPASS expansion in the region.

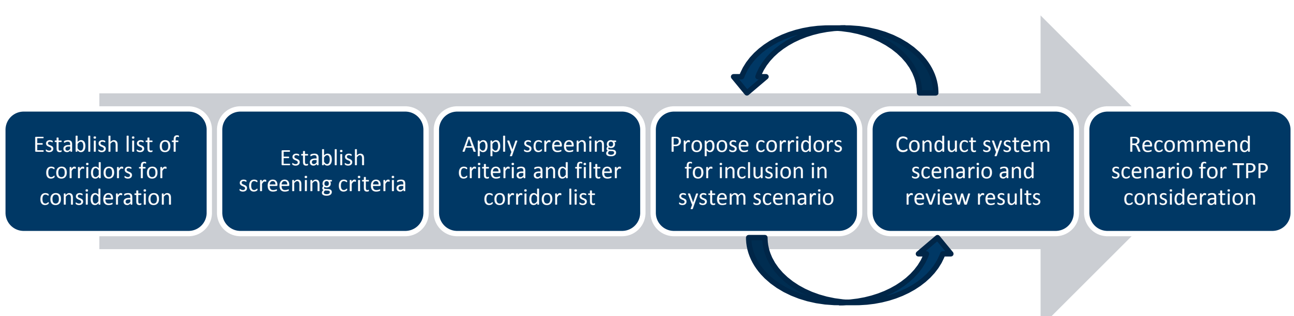
2. The PMT and TSC arrived upon a set of screening criteria that effectively communicates key characteristics about each corridor and its suitability for MnPASS implementation. These criteria include severity of congestion, proximity to employment centers, connections to other MnPASS corridors and major destinations, express commuter bus demand, constructability/affordability, and connection affordability. These criteria are described in detail on page 27.

3. The PMT and TSC considered the results of the corridor screening, the results of the 2040 base model forecast, and qualitative factors such as parallel corridors, redundancy, and regional balance to select a group of corridors for the initial system scenario. Selection of corridors for subsequent system scenarios were based on these same results and factors, as well as the results from the detailed system scenario evaluation described below. The system scenario corridor selection is discussed in detail on page 37.

4. Each system scenario was evaluated in detail using a variety of system and corridor level criteria and measures such as vehicle hours traveled, vehicle miles traveled, system speed, congested lane miles, mode shift, change in average daily person throughput, total person-hours saved, percent travel time savings, estimated cost, cost per lane mile and cost variability. Using the results from this evaluation, as well as the other factors described above, the PMT and TSC went through an iterative process of reviewing and selecting three system scenarios. This process is outlined in detail on pages 37-45.

5. The process culminated in the evaluation results from the third and final system scenario (System Scenario 3) being recommended for consideration in the 2040 TPP update process to be completed in 2018. A summary of results is located on page 66.

Figure 1: Study Process



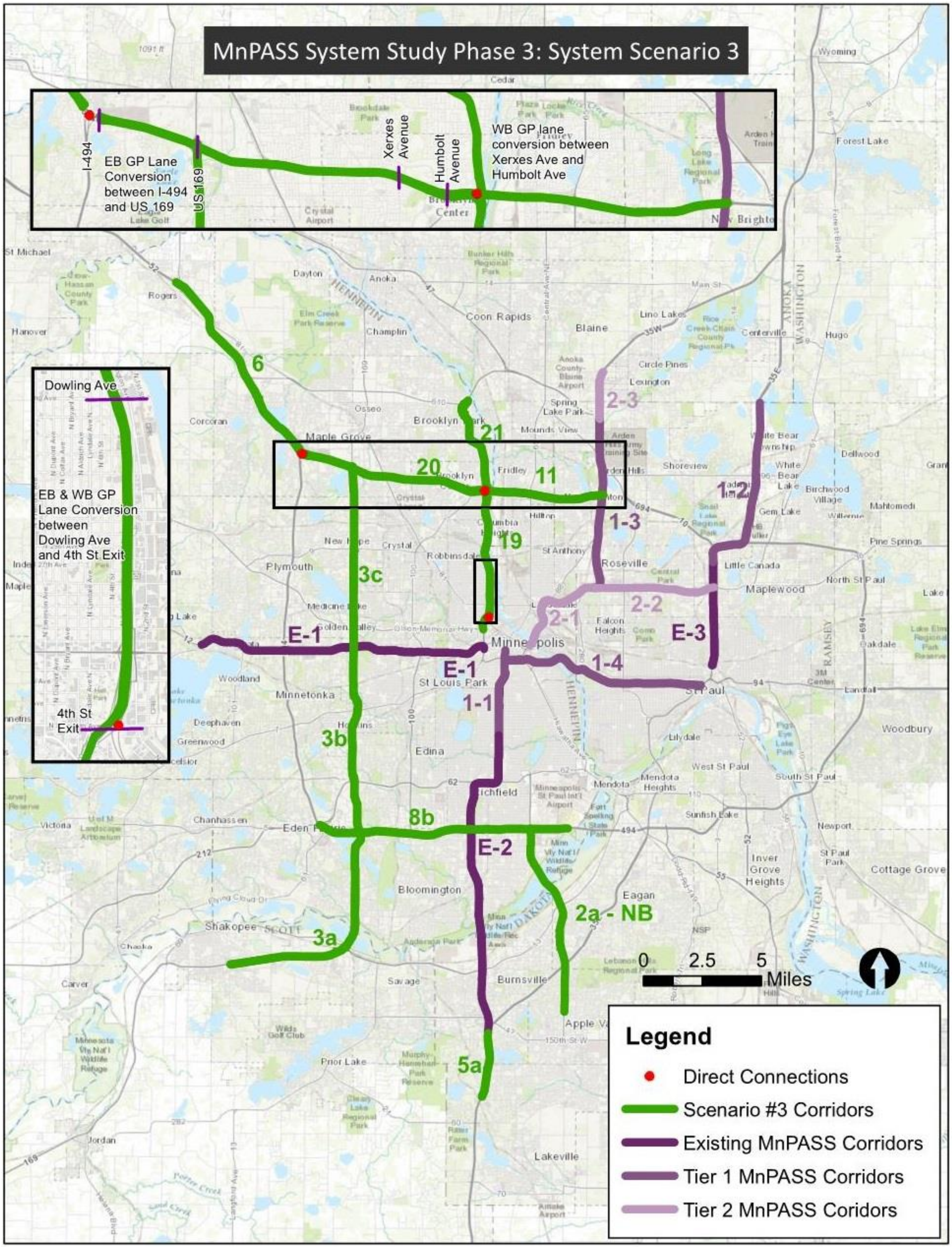
Scenario 3 MnPASS Corridors

The list of corridors included in the final System Scenario 3 are listed in Table 1 below. The list includes the three existing MnPASS corridors, the seven current 2040 TPP Tier 1 and 2 MnPASS corridors, and the 11 System Scenario 3 corridors evaluated in the study. Figure 2 is a map of the System Scenario 3 corridors, including direct connections, and locations where general purpose (GP) lanes are converted to MnPASS lanes.

Table 1: Scenario 3 MnPASS Corridors

Corridor	Highway	Corridor Limits
		Existing MnPASS Corridors
E-1	I-394	Hennepin Co 15/Carlson Pkwy to Downtown Minneapolis
E-2	I-35W	Crystal Lake Rd/Cliff Rd to 46th St/26th St
E-3	I-35E	Cayuga St/Ramsey Co E to Little Canada Rd
		2040 TPP Tier 1 Corridors (Current Revenue Scenario)
1-1	I-35W	Downtown Minneapolis to 46th St (Under Construction)
1-2	I-35E	Little Canada Rd to Ramsey Co J/Ramsey Co 96 (Completed)
1-3	I-35W	MN 36/280 to US 10
1-4	I-94	Downtown Minneapolis and Downtown St. Paul
		2040 TPP Tier 2 Corridors (Increased Revenue Scenario)
2-1	I-35W	Downtown Minneapolis to MN 36/280
2-2	TH 36 Eastbound	I-35W to I-35E
2-3	I-35W	US 10 to 95th Ave in Blaine (Funded)
		Scenario 3 Corridors
2a-NB	TH 77 Northbound	138th Street to I-494
3a	US 169	Marschall Road to I-494
3b	US 169	I-494 to I-394
3c	US 169	I-394 to I-694
5a	I-35	Crystal Lake Rd/Southcross Dr to Dakota Co 50
6	I-94	I-494 to TH 101
8b	I-494	US 212 to TH 5/MSP Airport
11	I-694	I-94 to I-35W
19	I-94	TH 55 to TH 252
20	I-94	TH 252 to I-494/694
21	TH 252	I-94 to TH 610

Figure 2: System Scenario 3 Corridor Map



Implementing System Scenario 3 would have significant benefits for the region's highway and transit systems. This MnPASS System would reduce and better manage congestion in a manner that is more sustainable over the long-term. It would significantly increase person-throughput through congested corridors during peak travel times. A single MnPASS lane can carry twice as many people during peak-hour congestion as a regular general purpose lane. This MnPASS system would also improve travel time reliability for bus transit, small commercial vehicles and other motorists in the metro area who currently have little choice but to endure congested, unreliable general purpose lanes.

Implementing System Scenario 3 would also improve transit service, increase bus ridership, and increase carpooling. Approximately 85% of the people using the current MnPASS system are either riding on transit or in carpools.

At present, Twin Cities' motorists only have a MnPASS option in approximately 11% of the metro's congested freeway corridors. Implementing System Scenario 3 would provide commuters with a congestion-free MnPASS option on nearly 60% of the current congested freeway system. MnPASS is a strategy that will provide a strong long-term return on the region's limited mobility investment. More information on the benefits of the MnPASS system can be found on pages 68-74.

Issues and Opportunities

The study also evaluated key issues, risks, and opportunities affecting the current and future MnPASS system. An analysis of seven focus areas covering a wide range of issues was completed. Of particular importance are issues of operations, advanced technology, and enforcement.

With the expansion of the MnPASS system, MnDOT will inevitably encounter capacity issues on some of its MnPASS facilities. To address these operational issues, MnDOT should first consider lower cost, less controversial strategies such as adjusting the pricing algorithm, modifying lane access, improving enforcement, and implementing lower cost/high benefit improvements such as adding auxiliary lanes or extending exit/entrance ramps in MnPASS corridors. If these strategies are insufficient, MnDOT should consider raising the maximum fee, increasing the carpool exemption to three occupants, requiring carpoolers to have a MnPASS account and tag, implementing license plate/video tolling, and/or adding MnPASS lanes.

Advancing technology not only changes how things are done, it changes the underlying cost structure, altering the incentives for customer behavior. Connected and automated vehicles will lead to increased roadway capacity as a result of decreased headways, but may also increase the number of vehicle trips affecting both MnPASS lanes and the corresponding GP lanes. Interoperability will become increasingly important, not only among toll facilities, but among other transportation systems like parking and transit; and through improved connectivity and interoperability, changes to MnPASS lane infrastructure will result.

The presence of MnPASS lane violators has several adverse impacts on the system, including decreased speeds, safety concerns, lost revenue, and higher tolls. To mitigate these impacts, MnDOT has tried several approaches to improve enforcement efficiency and decrease overall violation rates, such as utilizing dedicated State Patrol officers and technology tools like flashing beacons and vehicle imaging systems. While these have been helpful, MnDOT continues to look for options to improve enforcement and reduce costs. License plate/video tolling is currently one of the most effective methods for reducing violation rates and optimizing the performance of a High Occupancy Toll (HOT) lane system and is utilized extensively on HOT lane facilities around the country.

1. Introduction

Study Purpose

The primary purpose of the *MnPASS System Study Phase 3* is to assist in updating the MnPASS system vision and prioritized list of MnPASS corridors in the 2018 update to the Met Council's *2040 Transportation Policy Plan* (2040 TPP), which defines the region's transportation investment priorities. The *MnPASS System Study Phase 3* builds on the first *MnPASS System Study* (2005) and *MnPASS System Study Phase 2* (2010). The study also evaluated key issues, risks, and opportunities affecting the current and future MnPASS system.

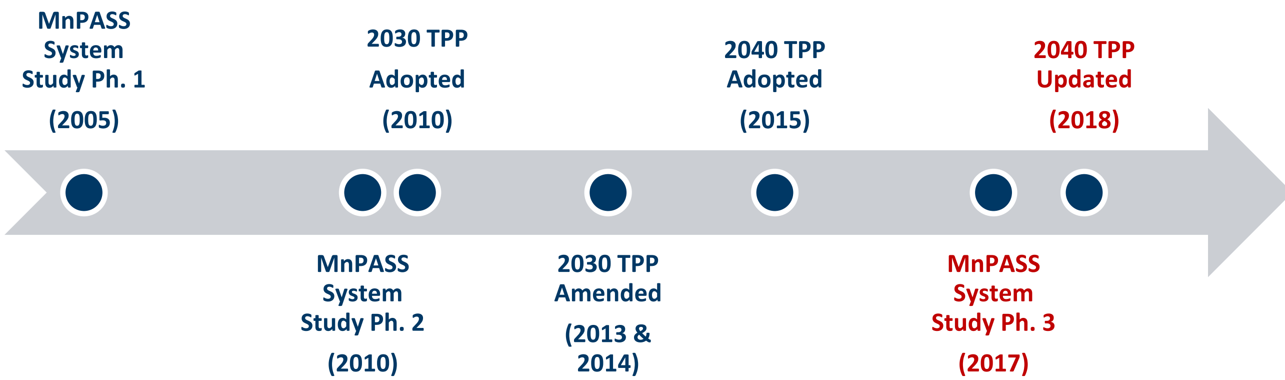
Background

The results of the first *MnPASS System Study*, coupled with the opening of the region's first MnPASS Express Lanes on I-394 in 2005, demonstrated the benefits that MnPASS lanes could provide to the region's highway and transit systems. The next MnPASS lanes on I-35W opened in three phases between 2009 and 2011. During that time, the *MnPASS System Study Phase 2* and the *Metropolitan Highway System Investment Study* were completed. These studies evaluated a potential regional MnPASS system that could be constructed at a lower cost while still providing significant benefits. These studies used a variety of evaluation criteria such as person throughput, travel-time savings and reliability, vehicle speed, change in congested VMT, transit demand, and a benefit/cost analysis. The result was a tiered list of priority MnPASS expansion corridors. In 2010, the Tier 1 and 2 MnPASS corridors were adopted into the 2030 Transportation Policy Plan (2030 TPP) for implementation within 2-10 years; the Tier 3 corridors were also included in the 2030 TPP as mid- to longer-term corridors. In 2015, this vision was updated in *Chapter 5: Highway Investment Direction and Plan* of the 2040 TPP. The 2040 TPP also states:

> "The regional objective of providing a congestion-free, reliable option for transit users, carpoolers and those willing to pay through MnPASS lanes is the region's priority for expansion improvements. General purpose lane strategic capacity enhancements should only be considered if adding capacity through MnPASS lanes has been evaluated and found to not be feasible" (see 2040 TPP, p. 5-9).

The figure below provides a timeline of past, present, and future efforts, including the MnPASS System Studies and TPP updates. Current and future efforts are shown in red.

Figure 3: MnPASS System Study and TPP Timeline



Since the MnPASS Phase 2 study was completed, a significant amount of change has occurred within the Tier 1-3 MnPASS corridors. The only Tier 1 corridor identified in the MnPASS Phase 2 study – I-35E north of St. Paul – was substantially completed in 2015/16.

All Tier 2 corridors identified in the Phase 2 study are either:

- under construction (I-35W MnPASS extension south of Minneapolis)
- programmed for construction beginning in 2019 (I-35W North Roseville-Blaine) or
- under further study (I-94 Minneapolis-St. Paul; I-35W North Roseville-Minneapolis; Hwy. 36 eastbound Roseville-Little Canada)

One Tier 3 corridor has a completed feasibility study and is awaiting future funding (Highway 77 northbound Apple Valley - Bloomington). Two Tier 3 corridors are being studied to determine feasibility including the I-494/Highway 62 Congestion Relief Study and Highway 169 Mobility Study. Several other Tier 3 corridors have undergone or are planned for non-MnPASS capacity improvements.

As a result, there is a need to conduct a MnPASS System Study Phase 3, and the 2040 TPP Work Program lists this study as a priority.

Study Process

The study process followed several steps, described below and shown in Figure 4:

1. The The Project Management Team (PMT) and the Technical Steering Committee (TSC) established a list of corridors for initial consideration as MnPASS corridors. The list of corridors started with the Tier 3 corridors listed in the 2040 TPP. PMT and TSC members then added several corridors that were expected to perform reasonably well. The initial list of corridors excluded corridors that were recently expanded or planned

for near-term expansion, before MnPASS would be built. Development of the initial list of corridors is further discussed on page 21. The current Tier 1 and 2 MnPASS corridors in the 2040 TPP were not reevaluated as part of this study since they continue to be priority corridors for MnPASS expansion in the region.

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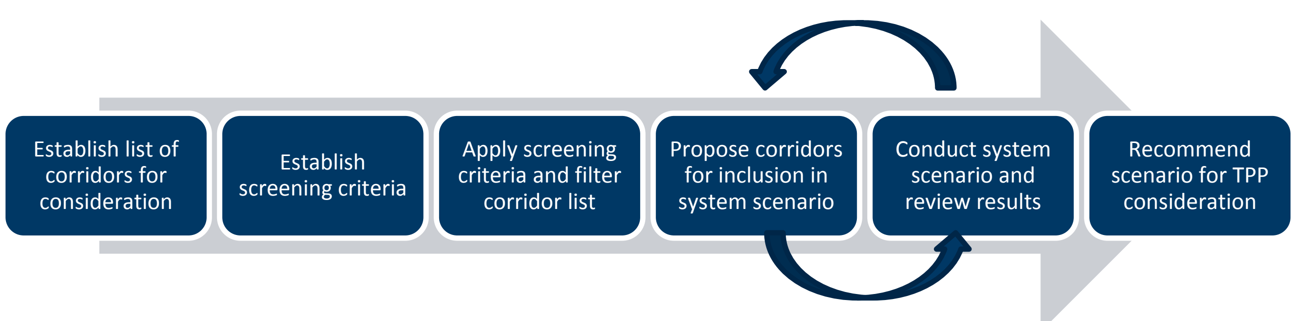
Figure 4: Study Process



2. Review of Previous Studies and Plans

As one of the initial steps of the study, sub-consultant staff at Sambatek reviewed previous studies and relevant to MnPASS system and prepared a technical memorandum summarizing the key findings of studies, policy documents, and planned and programed capital improvements. As part of this process, 21 study and planning documents consisting of over 3,000 pages were reviewed.

The findings of this review helped inform the following aspects of the *MnPASS Systems Study Phase 3*:

- Development of Study Goals
- Analysis Methods
- Screening Process and Evaluation Criteria

Study Review Criteria:

The following criteria was used in reviewing the studies, and the final technical memorandum included the summary results of these criteria:

- Study Purpose
- Study Methodology Including Screening and Evaluation Methods
- Study Results
- Why is the Study Relevant to MnPASS Phase 3

Studies and Plans:

1. 2040 Transportation Policy Plan—Chapter 5: Highway Investment Direction and Plan
   (Study Date: Adopted by the Metropolitan Council January 14, 2015)
2. MnPASS System Study Phase 1
   (Study Date: April 2005)
3. MnPASS System Study Phase 2
   (Study Date: September 2010)
4. Congestion Management Safety Plan: Phase 1
   (Study Date: May 2007)
5. Congestion Management Safety Plan: Phase 2

(Study Date: November 2009)

6. Congestion Management Safety Plan: Phase 3
   (Study Date: February 2013)
7. Congestion Management Safety Plan: Phase 4
   (Study Date: March 2016—November 2017— Project In Progress)
8. MN 20-Year State Highway Investment Plan (MnSHIP) 2014-2033
   (Study Date: December 2013)
9. Metropolitan Highway System Investment Study (MHSIS)
   (Study Date: September 2010)
10. 2016–2019 STIP (And 2017 – 2020 STIP Draft)
    (Study Date: September 2016)
11. 10-Year Capital Highway Investment Plan (2016 – 2025)
    (Study Date: December 2015)
12. County Transportation Plans
    (Study Date: Current County CIPs—Dates Vary County To County)
13. I-35W Minnesota Urban Partnership Agreement (UPA) Traffic Forecast and Analysis
    (Study Date: May 2008)
14. I-35 Corridor South; I-35E/I-35W Split to Cr 70- Lakeville
    (Study Date: January 2016)
15. I-35W North Managed Lanes Corridor Study
    (Study Date: June 2013)
16. Highway 77 Managed Lane & Cedar Grove Transit Access Engineering
    (Study Date: April 2014)
17. I-394 MnPASS Technical Evaluation Report
    (Study Date: November 2006)
18. I-35W MnPASS Extension Land Use Study Support, Encourage and Enhance Transit & Carpool Use
    (Study Date: 2015)
19. I-94 Managed Lanes Study
    (Study Date: January 2010)
20. Katy Freeway: Evaluation of a Second-Generation Managed Lanes Project
    (Study Date: September 2013)
21. Caltrans Traffic Operations-Managed Lanes Case Studies

    (Study Date: March 2013)

The technical memorandum summarizing the findings of review of previous studies can be found in Appendix E.

3. Initial Corridor Screening

Initial Screening Method

Candidate Corridors for MnPASS Consideration

For the purposes of this study, the existing MnPASS corridors, corridors listed in Tier 1 of the 2040 TPP under the current revenue scenario, and corridors listed in Tier 2 of the 2040 TPP under the increased revenue scenario were not reevaluated because they continue to be MnPASS priorities for the region. As a result, they included in the study's 2040 base model, referred to throughout this document as the "base condition". The corridors listed in Tier 3 of the 2040 TPP under the increased revenue scenario, as well as an additional list of corridors generated through the study process, are the focus of this study and are the candidate corridors for the system scenarios. In generating the additional list of corridors, the PMT and TSC considered all freeway segments in the metro area. Corridors were removed from this list if:

- They were recently expanded from four to six lanes, such as I-494 between I-394 and I-94/I-694
- Expansion is planned before MnPASS implementation would occur, such as I-694 between US 10 and I-35E
- Corridors would not have sufficient MnPASS capacity needs within the 2040 timeframe

All existing MnPASS corridors are listed below, with the prefix ("E") and are displayed in dark purple in Figure 5.

Existing MnPASS Corridors

- I-394 Eastbound: Downtown Minneapolis - Hennepin County 15 - (E-1)
- I-394 Westbound: Downtown Minneapolis - Carlson Parkway - (E-1)
- I-35W Northbound: 26th Street - Southcross Drive – (E-2)
- I-35W Southbound: 46th Street – Hwy. 13 – (E-2)
- I-35E Northbound: Cayuga Street - Little Canada Road. - (E-3)
- I-35E Northbound: Ramsey County E - Ramsey County J – (E-3)
- I-35E Southbound: Cayuga Street – Ramsey County 96 – (E-3)

2040 TPP Current Revenue Scenario Tier 1 Corridors: Included in the 2040 Base Condition

Four corridors are listed in the 2040 TPP Current Revenue Scenario Tier 1 Corridors, which are included in the 2040 Base Condition. These corridors are listed with the prefix (“1”) and are displayed in Figure 5: Existing and 2040 TPP Corridors.

- I-35W Southbound: Downtown Minneapolis - 46th Street – (1-1)
- I-35E: Little Canada Road - Ramsey County J/Ramsey County 96 *(has now been constructed)* - (1-2)
- I-35W: MN 36/280 - US 10 – (1-3)
- I-94: Downtown Minneapolis - Downtown St. Paul – (1-4)

2040 TPP Increased Revenue Scenario Tier 2 Corridors: Included in the 2040 Base Condition

Three corridors are listed in the 2040 TPP Increased Revenue Scenario Tier 2 Corridors, which are included in the 2040 Base Condition. These corridors are listed with the prefix (“2”) and are displayed in Figure 5: Existing and 2040 TPP Corridors.

- I-35W: Downtown Minneapolis - MN 36/280 – (2-1)
- TH 36 Eastbound: I-35W - I-35E – (2-2)
- I-35W: US 10 - 95th Avenue in Blaine – (2-3)

2040 TPP Increased Revenue Scenario Tier 3 Corridors: Considered for System Scenarios

Eleven corridors are listed in the 2040 TPP Increased Revenue Scenario Tier 3 Corridors, which are considered for System Scenarios. These corridors are displayed in pink in Figure 5: Existing and 2040 TPP Corridors.

- TH 36 Westbound: I-35W - I-35E – (1a)
- TH 36: I-35E - I-694 – (1b)
- TH 77: 138th Street in Apple Valley - Old Shakopee Road (divided into separate northbound and southbound corridors) - (2a / 2c)
- US 169: Scott County 17 - I-494 – (3a)
- I-35E: Ramsey County J/96 - Anoka County 14 - (4)
- I-35: Crystal Lake Road /Southcross Drive - Dakota County 70 (divided into two corridors north/south of Dakota County 50) – (5a / 5b)

- I-94: MN 101 in Rogers - I-494/694 – (6)
- I-94: Downtown St. Paul (where MnPASS lanes end in 2040 base scenario) - US 61 – (7a)
- I-94: US 61 - I-94/494 in Woodbury – (7b)
- I-494: I-394 - US 212 – (8a)
- I-494: US 212 - MN 5/MSP Airport – (8b)

Additional Corridors: Considered for System Scenarios

These corridors are displayed in Figure 6: Additional Corridors.

- TH 77/TH 62: I-494 - I-35W
- US 169: I-494 - I-394
- US 169: I-394 - I-694
- US 169: I-694 - TH 610
- TH 610: US 169 - TH 10
- US 10: I-35W - TH 610
- US 10: TH 610 - TH 47
- I-694: I-94 in Brooklyn Center - I-35W
- TH 100: I-94 - I-394
- US 212/TH 62: I-494 - I-35W
- US 212: I-494 - TH 41
- I-494: TH 5/MSP Airport - TH 52
- I-35E: I-494 - Shepard Road
- I-35E: Shepard Road - I-94
- I-394 EB: US 169 - TH 100
- I-394: TH 100 - Downtown Minneapolis
- I-35W Northbound: TH 62 - 26th Street

- I-94: Downtown Minneapolis (where MnPASS lanes end in 2040 base scenario) - TH 55
- I-94: TH 55 - TH 252
- I-94: TH 252 - I-494/694
- TH 252: I-94 – TH 610

Figure 5: Existing and 2040 TPP Corridors (2015 Version)

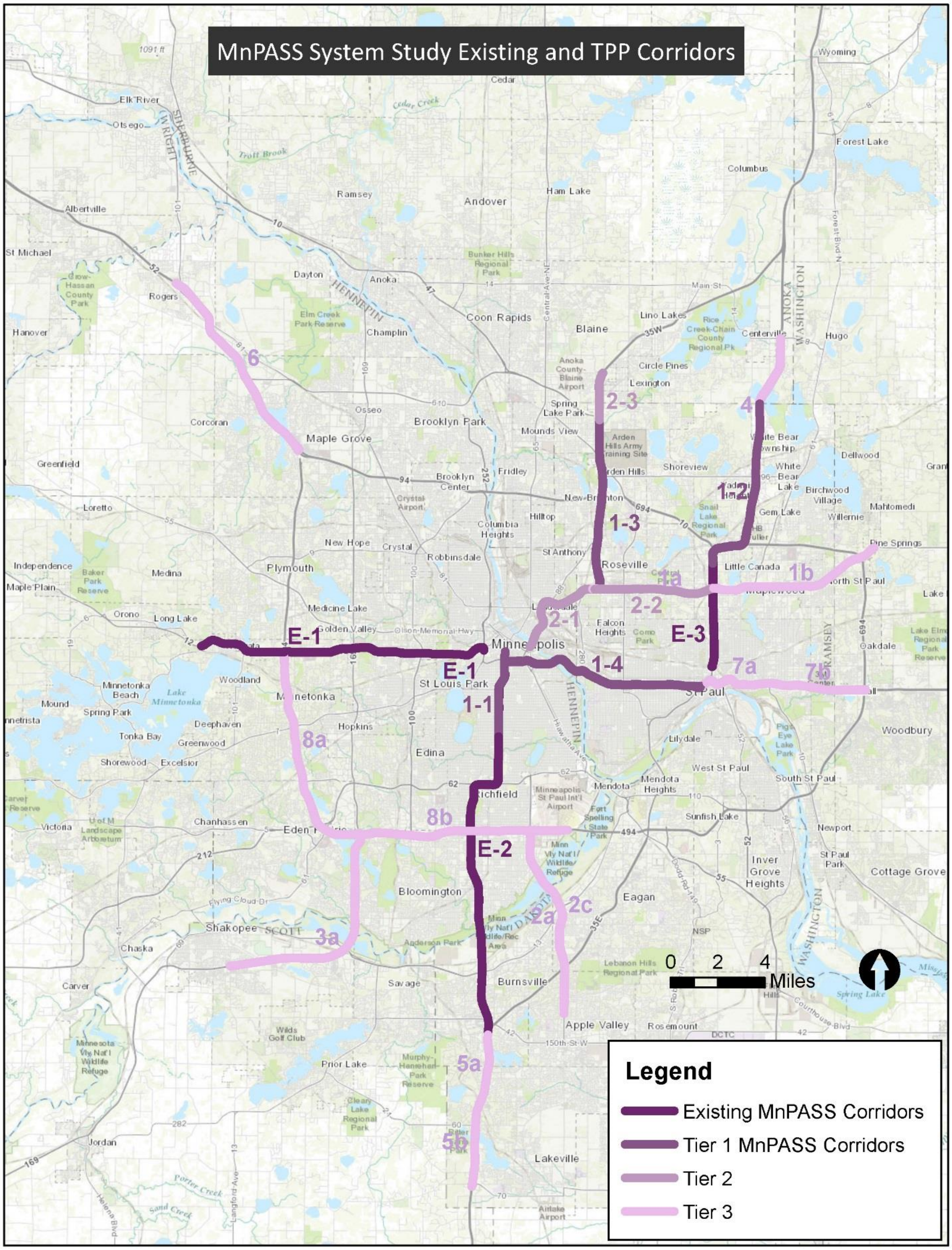
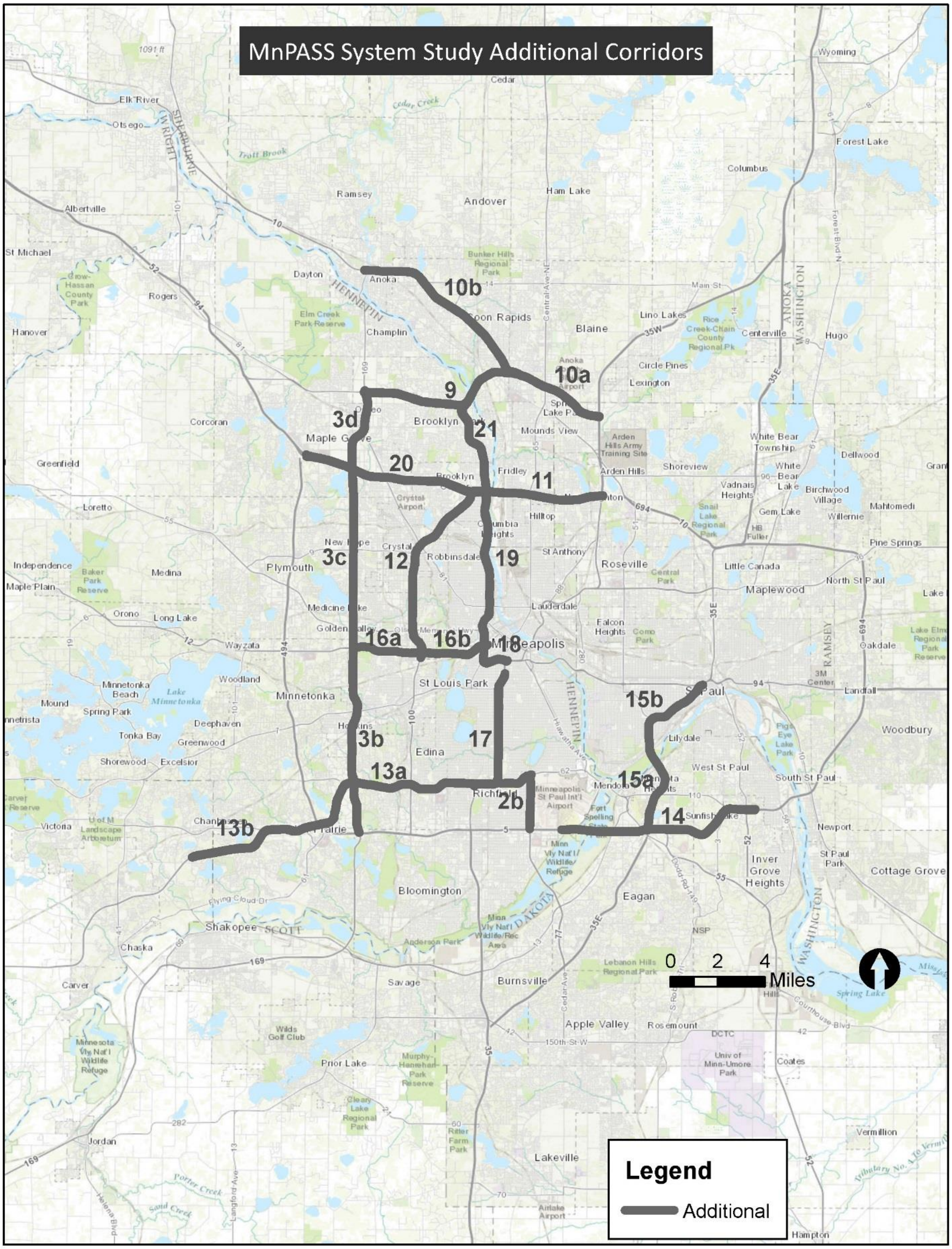


Figure 6: Additional Corridors



Screening Criteria

Five criteria were used to screen the candidate corridors. The criteria are intended to provide information about each corridor that facilitates decisions regarding its suitability as a MnPASS corridor. The five criteria are:

- Severity of congestion
- Proximity to employment centers
- Connections to other MnPASS corridors and major destinations
- Express commuter bus demand
- Constructability/Affordability
- Connection affordability (if required)
- Other considerations

The methods used to evaluate each corridor according to each criterion are described below.

Severity of Congestion

The severity of current congestion was measured as the mile-hours of congestion (speeds below 45 mph) for each freeway segment. The congestion data was obtained from the *MnDOT 2015 Congestion Report*, and was used as part of the Congestion Management Safety Plan (CMSP) analysis. By multiplying the congestion durations (during peak periods) and corridor length, and considering the average congestion severity per mile, a set of logical breakpoints were developed to quantify the congestion level for each corridor, as shown in Table 2 below. A few manual adjustments were made for some shorter corridors.

Table 2: Congestion Severity

Category	Average Congestion/Mile*	Total Congestion/Direction*
Low	Less than 30 minutes	Less than 3 mile*hours
Medium	30 – 90 minutes	3-9 mile*hours
High	Over 90 minutes	Over 9 mile*hours

*Typical ranges; some exceptions for shorter segments

By considering congestion for peak directions and peak periods, some corridors were reviewed for suitability for reversible or one direction MnPASS facilities. For corridors with higher mile-hours of congestion in one direction during AM peak and in the other direction during PM peak, reversible facilities would be a potential solution. For corridor segments with only higher mile-hours of congestion in one direction for both AM and/or PM peak, consideration of a one direction MnPASS facility would be a potential solution.

Proximity to Employment Centers

Employment center data came "from the Minnesota Dept. of Employment and Economic Development's (DEED) 2010 Quarterly Census of Employment and Wages (QCEW). U.S. Census's, Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES) data was used for centers where employment data needed to be suppressed in accordance with the data sharing agreement with Minnesota DEED." (Metropolitan Council)

A one-mile buffer was drawn around each corridor. Scores were developed for each corridor based on the number and size of employment centers within one mile of that corridor. These scores were based on average employment totals for each employment center type (regional, large, medium, and small) as shown in Table 3.

The total corridor score was derived from the number of each type of employment centers near the corridor to arrive at an overall score. The ranges used for categorizing the scoring can be found in Table 4.

Table 3: Employee Scoring

Employment Center Type	Number of Employees	Score
Regional	> 20,0000	14
Large	15,000 – 20,000	5
Medium	10,000 – 15,000	4
Small	3,500 – 10,000	2

Table 4: Overall Classification Scoring

Overall Classification	Score
High	> 25
Medium	10 – 25
Low	< 10

Connection to other MnPASS Corridors and Major Destinations

A corridor was rated "high" if it had a logical terminus, meaning that it connected on at least one end to an existing MnPASS lane, or a major destination. Major destinations for the purposes of this analysis are downtown Minneapolis, downtown Saint Paul, the University of Minnesota, MSP Airport, or the Mall of America.

A corridor was rated "medium" if it had a logical terminus at a MnPASS lane in Tier 1 or 2 of the 2040 TPP, as these corridors are considered part of the 2040 base alternative for the MnPASS System Study Phase 3 and are more likely to be constructed.

Finally, a corridor was rated "low" if it connected only to another corridor listed in Tier 3 or the Additional Corridors, as these corridors are as likely as the given corridor to be implemented.

Express Commuter Bus Demand

Tier 3 and additional MnPASS corridors were isolated one-by-one and each express route and its daily ridership was assigned to each of the corridors that it uses. Where routes use a corridor only from one entrance ramp to the next exit ramp, they were excluded from the ridership count for that corridor. Boardings were then summed by routes in each corridor. Natural breaks generated by GIS were at 2,000 and 6,000 daily boardings, so boardings were rated as follows:

- Less than 2,000 daily boardings = low rating
- 2,000-5,999 daily boardings = medium rating
- Greater than 6,000 daily boardings = high rating

Three corridors rated "high" based on daily boardings of greater than 6,000. Two of these corridors are existing MnPASS corridors (I-394 and I-35W). The other highly rated corridor for transit demand was I-94 between Highways 55 and 252. Because I-394 and I-35W are already receiving a transit demand advantage from the existing MnPASS lanes, they weren't assigned a "high" transit demand rating and are instead noted with "Existing (high)" in Table 1 below.

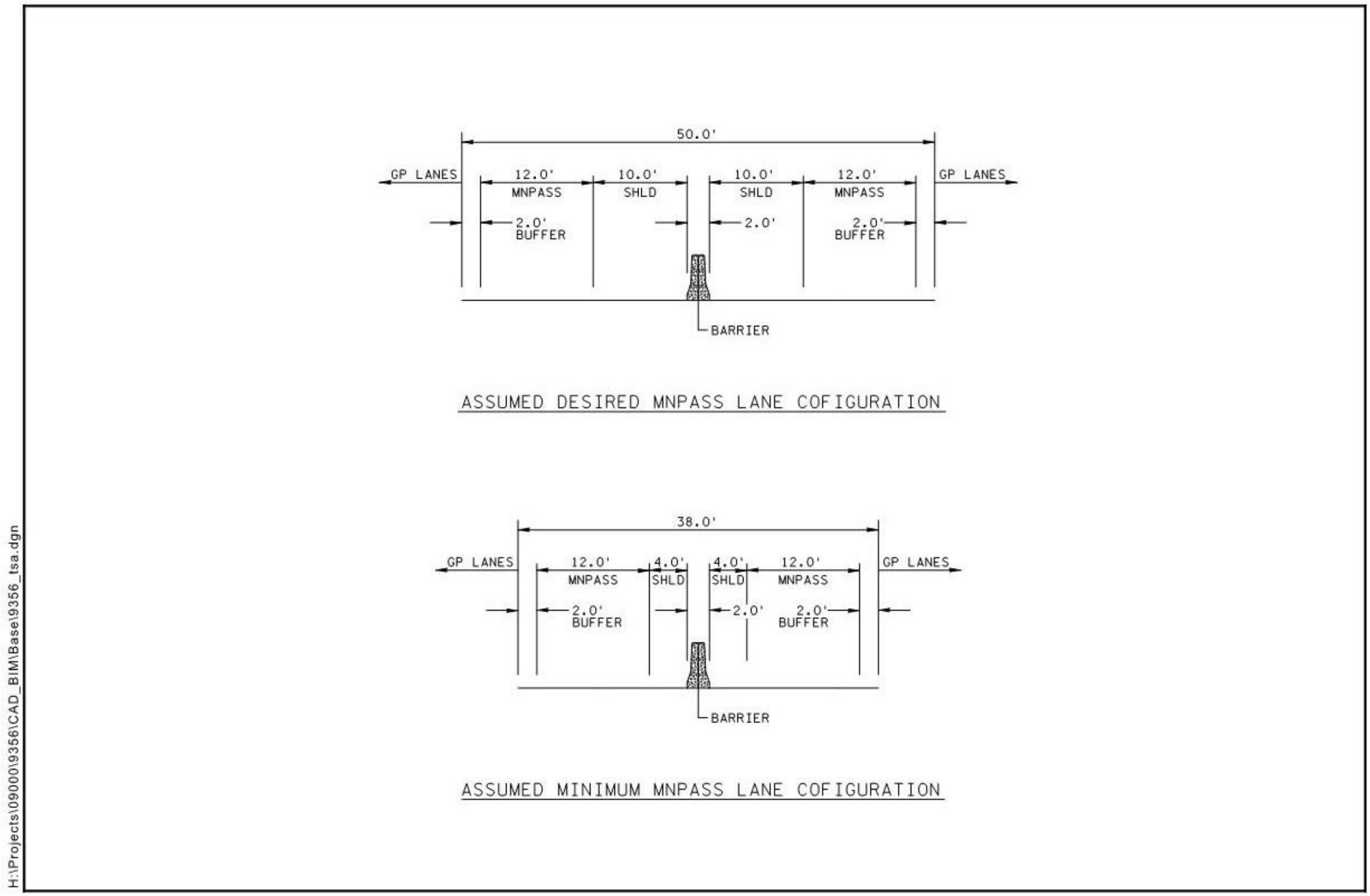
Metro Transit and Suburban Transit Provider boarding data (2014), was used for the analysis. The data set identifies routes as urban local, suburban local, and express. Only express routes were included in this analysis because they use highway facilities for much greater distances and therefore, are more likely to be affected by provision of MnPASS facilities.

Constructability/Affordability

Cost ranges were developed for each corridor by considering its length and physical characteristics such as existing bridge structures, capacity, and available right-of-way. Figure 7 provides cross section diagrams for the desired and minimum MnPASS lane configurations.

The corridors were reviewed and where a connection was necessary to make the corridor viable, (segment is not functional without it), the cost estimate for that connection was included in the total cost amount. The median of the cost ranges developed for each corridor are shown in the screening results below.

Figure 7: Typical Sections



Corridor Scoring Criteria

Each corridor received a score for each of the five criteria. These scores were considered in three weighted options:

- Option 1 – Congestion and cost scores weighted 3, other criteria weighted 2
- Option 2 – All criteria weighted evenly
- Option 3 – Congestion weighted 3, costs weighted 2, other criteria weighted 1

Each corridor received an overall score for weighted options 1, 2, and 3. These scores were characterized as high, medium, or low using the following method:

- The 33rd and 67th percentiles of the corridor score distribution were used as a starting point for setting the low/medium and medium/high breakpoints
- Significant gaps in the ranked corridor scores were identified near these percentiles, to set the logical cutoff points for low, medium, and high ranked corridors
- Corridors were then assigned a high, medium, or low rating based on their score and the cutoff points

Initial Screening Results

Results Summary

The initial corridor screening provides existing conditions information about each of the corridors. Corridors were screened as independent segments, and not in a system context.

The initial screening process applied to the potential MnPASS corridors focused on high-level assessments of physical challenges in each corridor. These included structural issues with bridges, available pavement widths, and issues where major corridors intersect (i.e., need for direct connections). The typical section used for the initial screening was a 14’ MnPASS Lane with 4’ shoulders and median barrier, where widening could not be accommodated between directional traffic the roadway was widened to the outside keeping existing lane widths at existing dimensions.

Each section of roadway was reviewed and placed in one of five categories as identified below to apply a cost per mile cost with a low and high range assumptions. For each of the categories, the following base assumptions were used:

- Does not include pavement rehabilitation to adjacent mainline

- Construction cost only - does not account for design or project delivery
- Does not include right of way costs

Table 5: Constructability/Affordability

Constructability/ Affordability	Range	Cost per Mile	Construction	Drainage	Bridges Affected	Pavement Type	Mainline Lighting	Noise Wall (total miles)
High	Low Range	$2M	IE	Rural	None	Bituminous	None	None
	High Range	$8M	IE + MB	Urban	1 (widening)	Concrete	Yes	½ mile
Medium - High	Low Range	$8M	IE + MB	Urban	2 (widening)	Bituminous	None	½ mile
	High Range	$14M	OE	Urban	2 (widening)	Concrete	Yes	½ mile
Medium	Low Range	$14M	OE	Urban	2 (widening)	Bituminous	Yes	½ mile
	High Range	$24M	IE + MB	Urban + CG	2 (widening)	Concrete	Yes	1 mile
Medium – Low	Low Range	$24M	IE + MB	Urban	2 (widening)	Bituminous	Yes	1 mile
	High Range	$35M	MR + MB	Urban + CG	1 (reconst.)	Concrete	Yes	2 miles
Low	Low Range	$35M	MR + MB	Urban + CG	1 (reconst.)	Bituminous	Yes	2 miles
	High Range	$50M	MR + MB	Urban + CG	2+ (reconst.)	Concrete	Yes	4 miles

CG = Curb & Gutter
MB = Median Barrier
IE = Inside Expansion of Pavement
OE = Outside Expansion of Pavement
MR = Mainline Reconstruction

Additional features were also considered such as tunnel reconstruction and direction connections and were added onto the per mile cost. With a cost per mile associated with each section of roadway, an overall cost range along with a median cost was developed. A table summarizing's the initial screening costs can be found in Appendix A.

Table 6 below shows the results of the initial screening for each corridor considered, and whether the corridor was included in a system scenario. While the initial corridor screening reveals many corridor characteristics relevant to selection of future MnPASS corridors, the screening results are not predictors of system scenario model results, nor are they intended to be the only results on which system scenarios were proposed. Generally, the three-part logic below was applied to corridors for selection into a system scenario:

- Corridors that scored “high” on at least one weighted option were included in at least one system scenario
- Corridors that scored “medium” on three of three weighted options were included in at least one system scenario
- Corridors that scored “low” on one or more weighted options were not included in a system scenario, unless otherwise noted

Table 6: Initial Screening Results Summary

Corridor	Initial Definition	Corridor Length (miles)	Severity of Congestion	Proximity to Employment Centers	Connections to Other MnPASS Corridors & Major Destinations	Express Commuter Bus Demand	Constructability/ Affordability	Total Construction Cost ($ millions)	AM V/C	PM V/C	Score under Weighted Option 1	Score under Weighted Option 2	Score under Weighted Option 3	Included in System Scenario (SS)	Rationale
1a	TH 36: I-35W to I-35E	4.8	High	Medium	High	Medium	High	100	1.30	0.92	High	High	High	1,2	
1b	TH 36: I-35E to I-694	6.7	Medium	Low	High	Low	Medium	150	1.05	0.87	Medium	Medium	Medium	2	
2a NB	NB TH 77: 138th St to I-494	6.7	Medium	Medium	High	Medium	High	50	1.17	0.48	High	Medium	Medium	1,2,3	Included 2A-NB in all system scenarios; performed well in past corridor study
2a SB	SB TH 77: 138th St & I-494	6.7	Low	Medium	High	Medium	High	50	0.39	0.97	Medium	Medium	Medium	None	Did not perform well in past corridor study
2b	TH 77/TH 62: I-494 to I-35W	6.7	Medium	Medium	High	Medium	Medium-High	50	0.98	0.96	High	Medium	Medium	1	
3a	US 169: I-494 to Scott CR 17	10	Medium	Medium	Low	Low	Medium-High	150	1.05	1.06	Low	Low	Low	1,2,3	
3b	US 169: I-494 to I-394	8.1	High	High	High	Low	Medium-Low	250	1.04	1.02	High	High	High	1,3	
3c	US 169: I-394 to I-694	7.6	High	Medium	High	Low	Medium-High	100	1.15	1.11	High	High	High	1,3	
3d2	US 169: I-694 to TH 610	3.5	Medium	Low	Low	Low	High	50	1.41	1.43	Low	Low	Medium	None	
4	I-35E: Ramsey Co J/96 to Anoka Co 14	6.1	Low	Low	High	Low	High	50	1.05	1.00	Medium	Medium	Low	2	Included because it's an extension of existing lanes
5a	I-35: Crystal Lake Road to Dakota Co 50	3.7	Low	Low	High	Low	Low	50	1.38	1.22	Medium	Medium	Low	2,3	Included because it's an extension of existing lanes
5b	I-35: Dakota Co 50 to Dakota Co 70	2.7	Low	Low	Low	Low	Low	50	1.02	1.04	Low	Low	Low	None	
6	I-94: TH 101 to I-494/694	8.9	Medium	Low	Low	Low	High	100	1.42	1.10	Low	Low	Low	2,3	2040 TPP Tier 3; Included for district cooperation
7a	I-94: DT St. Paul to US 61	1.7	Medium	Medium	High	Medium	Low	200	1.50	1.75	Medium	Medium	Medium	1	
7b	I-94: US 61 to I-694/494	6.2	Low	Medium	Low	Medium	Medium-Low	150	1.02	1.02	Low	Low	Low	None	
8a	I-494: I-394 to US 212	7.5	Medium	High	High	Medium	Medium	200	0.98	0.94	High	High	Medium	2	
8b	I-494: US 212 to MN 5	10.8	High	High	High	Low	Medium-Low	350	1.31	1.24	High	High	High	1,3	
9	TH 610: US 169 to US 10	6.8	Low	Low	Low	Medium	Medium-High	100	0.81	0.84	Low	Low	Low	None	
10a	US 10: I-35W to TH 610	4.3	Low	Low	Medium	Low	High	100	1.03	0.94	Low	Low	Low	None	

Corridor	Initial Definition	Corridor Length (miles)	Severity of Congestion	Proximity to Employment Centers	Connections to Other MnPASS Corridors & Major Destinations	Express Commuter Bus Demand	Constructability/ Affordability	Total Construction Cost ($ millions)	AM V/C	PM V/C	Score under Weighted Option 1	Score under Weighted Option 2	Score under Weighted Option 3	Included in System Scenario (SS)	Rationale
10b	US 10: TH 610 to TH 47	7.8	Medium	Low	Low	Low	Medium	200	1.40	1.15	Low	Low	Low	None	
11	I-694: I-94 to I-35W	5.6	Medium	Low	Medium	Low	High	50	1.14	1.07	Medium	Medium	Medium	2	
12	TH 100: I-94 to I-394	7.9	Medium	Medium	High	Low	Medium-Low	300	1.23	1.18	Low	Medium	Low	None	
13a	US 212/TH 62: I-494 to I-35W	7.6	High	High	High	Low	Medium	200	1.44	1.38	High	High	High	2	
13b	US 212: I-494 to TH 41	9.8	Low	Medium	Low	Medium	Medium-High	150	1.36	1.22	Low	Low	Low	2	Terminus changed to TH 101, then included
14	I-494: TH 5 to TH 52	7.9	Low	High	High	Low	Low	300	1.05	0.96	Medium	Medium	Low	None	
15a	I-35E: I-494 to Shepard Road	3.6	Medium	Medium	Low	Low	Medium	100	1.32	1.07	Medium	Low	Medium	None	
15b	I-35E: Shepard Road to I-94	3.9	Medium	Medium	Medium	Low	Low	200	1.19	0.87	Medium	Low	Medium	None	
16a	EB I-394: US 169 to TH 100	2.9	Medium	Medium	High	Existing (high)	Medium	100	0.84	0.78	Medium	Medium	Medium	2	
16b	I-394: TH 100 to Downtown Minneapolis (fill missing reversible)	3.3	High	Medium	High	Existing (high)	Low	150	1.08	0.87	High	Medium	High	1,2	
17	NB I-35W: TH 62 to 26th Street	4.3	High	Medium	High	Existing (high)	Low	250	1.10	1.26	Medium	Medium	High	2	
18	I-94: 11th Street exit to TH 55	2.2	High	High	High	Low	Low	500	2.00	1.98	Medium	Medium	High	1	
19	I-94: TH 55 to TH 252	6	Low	Medium	High	High	Medium	150	0.82	0.74	Medium	High	Medium	1,2,3	
20	I-94: TH 252 to I-494/694	7.7	Low	Low	Low	Medium	Medium-Low	300	1.14	1.09	Low	Low	Low	2,3	Included with conversion to connect 6 to system
21	TH 252: I-94 to TH 610	3.9	High	Low	Low	Medium	Low	200	1.50	1.35	Medium	Medium	Medium	1,2,3	

Individual Corridor Results

Individual Corridor Results can be found in Appendix D.

System Scenario Selection

While the initial screening results were important criteria in selecting the system scenarios, other factors were considered as well. These include local knowledge about the corridors, the results of previous corridor studies, dependencies on other corridors, planned preservation work, and other overall system considerations like geographic balance. Table 6 notes some of the rationale used for including or omitting corridors in the system scenarios. Details regarding the selection of each system scenario are outlined below.

System Scenario 1

The first system scenario was selected using the results of the initial screening criteria. The top scoring corridors from the initial screening process were considered first, and many of these corridors were included. Where there were parallel corridors such as I-494 and TH 62, one corridor was selected for system scenario one (I-494) with the intention of including the other corridor (TH 62) in the second system scenario. No unlinked corridors were considered for system scenario one; all proposed corridors were connected to an existing MnPASS lane, or a Tier 1 or 2 MnPASS lane, which was included in the no-build alternative.

Finally, following MnPASS System Study Phase 2, several corridors were the subject of additional corridor-specific studies. These corridors (I-494, TH 62, US 169, and TH 77) were included so that their viability could be tested as part of the overall system.

System Scenario 2

Corridors selected for system scenario two were chosen based on the results of system scenario one. Some corridors, such as TH 252, were chosen for inclusion in system scenario two because of their superlative performance in system scenario one, some corridors were chosen to see how they would interact with the other corridors in system scenario two, and some corridors were included to test the viability of other corridors. In this system scenario, unlinked corridors were tested on Highway 169 south of I-494, and on TH 77 south of I-494, as well.

TH 610 was not selected for system scenario evaluation due to it’s low scoring in the initial screening, reliance on TH 252 and I-94 to connected to Downtown Minneapolis, lower anticipated demand, and its relative infancy as a freeway corridor.

System Scenario 3

System scenario three was considered a test case for the system that would be included in the 2018 update to the 2040 TPP. To that end, top-performing corridors from system scenarios one and two were chosen to create the most optimal system scenario, with consideration also given to dependencies on other corridors, planned or recent preservation work, and other overall system considerations like geographic balance. All corridors were linked in System Scenario 3, so that all MnPASS facilities provide continuous access to downtown Minneapolis or Saint Paul or to other existing or programmed MnPASS facilities.

The criteria and tools used to complete the system scenario evaluations, as well as results of the three scenarios are discussed in the following chapters.

4. System Scenario Evaluation Method

The initial corridor screening provided a high-level assessment of benefits and costs of each corridor, including severity of congestion, proximity to employment centers, connection to other MnPASS corridors or major destinations, express commuter bus demand, and constructability/affordability. These factors were used to determine overall weighted scores, which were an important criterion in determining whether a corridor was included in the system scenario evaluation. The criteria and tools then used in conducting the system scenarios and evaluating the results are outlined in more detail below.

System Scenario Evaluation Criteria

System Evaluation

The system evaluation compares the system performance of each MnPASS scenario to 2040 base scenario. The evaluation covers system Vehicle Miles Traveled (VMT), system Vehicle Hours Traveled (VHT), overall system speed and mode shift. Several MnPASS operation assumptions were made for this evaluation:

1. 24-hour operation of MnPASS facility;
2. Transit, HOV2+ and motorcycles use for free;
3. Variable pricing (min. $0.25 – max. $8.00);
4. MnPASS lane striping is fully open (no access restrictions);
5. Each future corridor segment represents one toll segment.

The criteria used to evaluate system performance include Vehicle Miles Traveled (VMT), Vehicle Hours Traveled (VHT), Overall System Speed, and Mode Shift. These are described below.

Vehicle Miles Traveled

Vehicle Miles Traveled (VMT) is computed as a combination of the number of vehicles in the system and the distance they travel. For each link in the network, VMT is the product of link volume and link distance. The system VMT is the sum of VMT for each link. For MnPASS built scenarios, VMT is expected to increase due to increasing demand on MnPASS lanes and improved accessibility.

Vehicle Hours Traveled

Vehicle Hours Traveled (VHT) is computed as the product of link volume and link travel time, summed over all links. For MnPASS built scenarios, VHT is expected to decrease due to travel time savings on MnPASS lanes.

Overall System Speed

Overall system speed is computed as the ratio of VMT and VHT. For MnPASS built scenarios, overall system speed is expected to increase since MnPASS lanes provide free-flow options to certain travel groups.

Congested Lane Miles

Congested lane miles are the total lanes miles that have volume over capacity (V/C) ratios higher than certain thresholds during peak hours. The V/C ratio threshold is set as 1.2 for freeway facilities and 1.0 for non-freeway facilities. For MnPASS built scenarios, the system congested lane miles are expected to decrease since MnPASS lanes provide free-flow options to certain travel groups.

Mode Shift

The mode shift measures the shift of number of trips among different modes which include single occupancy vehicle (SOV), high occupancy vehicle (HOV) and transit. For MnPASS built scenarios, SOV trips are expected to decrease, and HOV and transit trips are expected to increase since one of the goals of building MnPASS is to promote carpooling and transit use.

Corridor Evaluation

The criteria used for corridor evaluation include Change in Average Person Throughput, Total Person Hours Saved, Percent Travel Time Savings, Cost Estimates, and Cost Variability. Each is described below.

Change in Average Person Throughput, Total Person Hours Saved, Percent Travel Time Savings were selected as evaluation criteria as they align with the MnPASS goals of improving person throughput and time savings and providing a reliable, congestion-free option.

Change in Average Person Throughput

Change in average person throughput measures the difference of person throughput between MnPASS built scenarios and 2040 base scenario. Corridor person throughput is computed as the corridor person miles traveled (PMT) divided by corridor distance. Vehicle occupancies are applied to convert VMT to PMT. For MnPASS build scenarios, average person throughput is expected to increase due to increased accessibility to MnPASS. Higher average person throughput indicates high MnPASS demand, especially HOV and transit use.

Total Person Hours Saved

Total person hours saved measures the difference of total person delays between MnPASS built scenarios and 2040 base scenario. The delay is computed as the extra travel time (against free-flow travel time) times number of road users on the corridor. Corridors that are highly congested or with high demand of HOV and transit use are expected to have more total person hours saved.

Percent Travel Time Savings

Percent travel time savings is measured by the present of speed increase. Corridor speeds are computed as the ratio of total VMT to VHT for each corridor. Corridors with consistently congested segments are expected to have more percent travel time savings.

Cost Estimates

The assumptions for cost estimates are:

1. Costs provided in 2017 dollars;
2. Evaluation does not include rehabilitation costs of existing lanes adjacent to MnPASS construction;
3. Evaluation includes design and construction administration, noise wall and right of way costs (no right of way was assumed for storm water treatment areas);
4. Each segment is assigned a corridor cost variability based on potential design impacts.

For each corridor identified in a system scenario a CADD drawing was developed to determine physical impacts and actual pavement, median barrier, retaining wall and bridge quantities. The lane, shoulder and bridge widths where set by the following hierarchy:

- Existing rural median areas – the median would be filled in with MnPASS lanes, shoulder and median barrier. A 14’ MnPASS lane in each direction would be built and the rest of the area is filled with shoulder with a minimum of 4’. Actual shoulder width was quantified for each corridor.
- Existing filled in median with barrier areas – In areas where the existing roadway is completely built out, the inside lane would be converted it a MnPASS lane and widening

would be completed to the outside. Impacts to ramps and other roadside features (CD roads, frontage roads, retaining walls and bridges) were also accounted for.

- Special cases – on some corridors the entire existing roadway will need to be reconstructed to accommodate implementation of MnPASS lanes. On these corridors, the cost to reconstruct mainline has been accounted for and noted on the estimate.

Based on the CADD concepts developed quantities were developed for the following categories and sub categories.

Construction Cost

- Paving and Grading
    - Includes earthwork, pavement (mainline, ramps, frontage roads and shoulders) median barrier and pavement removals
- Drainage and Erosion Control
    - These quantities are based on percentages of the paving and grading costs
- Bridge
    - Accounts for bridge reconstruction and bridge widening by square footage, Intersection to Interchange, system connections and tunnel reconstruction
- Retaining Wall and Noise Wall
    - Assumes CIP retaining walls on piling and noise walls on a per square foot cost
- Signing and Striping
    - Signing is divided into two sub categories per mile for C and D type signs and each for A, OH and Bridge Mounted
    - Striping is based on a per mile cost

Miscellaneous Cost

- All the miscellaneous costs are based on percentages of the construction cost and are broken down into the following elements
    - Mobilizations
    - Non-quantified minor items (guardrail, fences, etc.)
    - Environmental & Wetland Mitigation Costs
    - Temporary Pavement and Drainage – Staging pavements during construction
    - ITS – MnPASS signing and readers
    - Traffic Control – Signing and Striping during construction

Contingency Cost

- The contingency cost or risk is percentage based of the sum of the construction and miscellaneous cost. This cost covers the unknowns such as soil conditions, utilities and ponding requirements/locations/sizes. It also covers the risk of the level of concept that has been developed. As these concepts are further vetted and reviewed begin and end points may change slightly and further refinements to profiles may require additional walls, widening or replacement of bridges. This cost accounts for those risks and will be lessened as more information and design refinement is completed in future studies.

Other Project Cost

- These costs include right of way and design engineering/construction administration. The right of way cost is based on a unit cost of $25/sq. ft and where a total take is needed (home or business building is impacted) the taxable value from the counties website was used for the cost. The design engineering/construction administration cost is percentage based off the sum of the construction, miscellaneous and contingency costs.

A table summarizing's the secondary screening costs for system scenarios 1, 2 & 3 can be found in Appendix A. The table shows the quantities and unit prices used for each corridor along with notes about each corridor that impact the overall cost.

Cost Variability

Each segment of roadway was reviewed and placed in one of five categories as identified below to identify potential for variability in the cost estimates developed. For each of the categories, the following base assumptions were used:

Table 7: Cost Variability Criteria

	Low	Low-Medium	Medium	Medium-High	High
Lane Expansion	Widen to inside	Widen to outside	Widen to outside	Widen to outside	Significant reconstruction of mainline
Right of Way Impacts			Minor	Moderate	Significant
Bridge Impacts	Widening existing structures	Widening existing structures	Widening and replacement	Widening and replacement	Replacement, interchange, flyover, and tunnel reconstruction

Retaining wall construction / reconstruction			Potential	Yes	Yes
Noise wall construction			Yes	Yes	Yes
Impacts to local frontage roads			Yes	Yes	Yes
Impacts to existing system interchanges				Some impact	Reconstruction necessary

Evaluation Tools

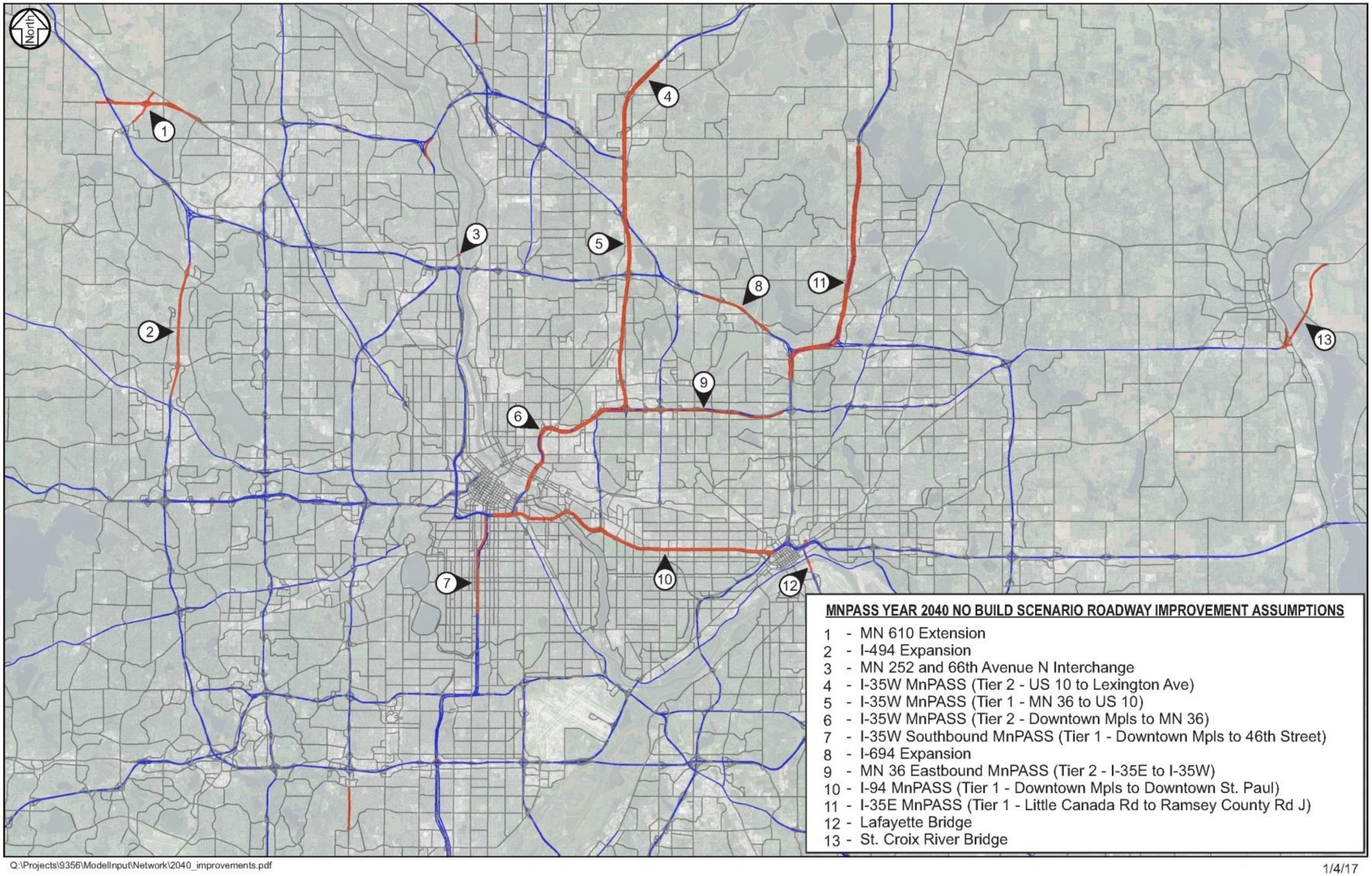
Activity-Based Forecast Model

Activity-based models (ABM) are based on the principle that travel demand is derived from people's daily activity patterns. Activity-based models predict which activities are conducted when, where, for how long, for and with whom, and the travel choices they will make to complete them. *(Reference: http://tfresource.org/Category:Activity-based_models).* The model used for this study was received from Metropolitan Council. A few updates were made to calibrate the model:

1. Updated existing highway network to reflect the most recent road improvements;
2. Updated existing socioeconomic assumptions from 2010 to 2014;
3. Updated 2040 networks to include programmed roadway improvements in the STIP
4. Recalibrated MnPASS transponder ownership model;
5. Recalibrated tolling method in the model.

All programmed roadway improvements included in the STIP as of October 2016 were assumed and shown in Figure 8.

Figure 8: Roadway Improvement Assumptions



5. System Scenario No.1

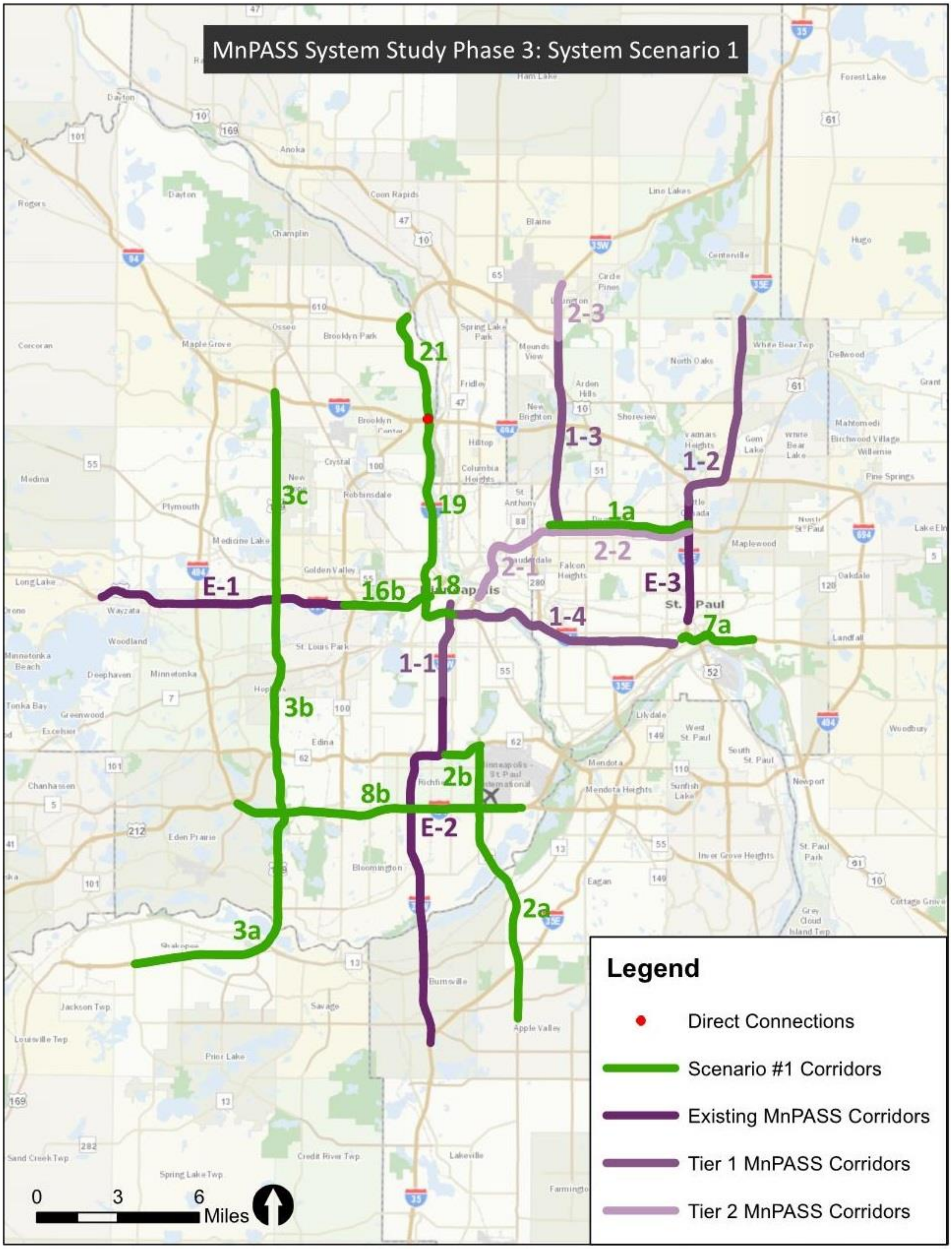
System Scenario No.1 Definition

System scenario #1 consists of the corridors listed in Table 8 and is shown in Figure 9.

Table 8: System Scenario #1 Definition

Corridor	Corridor Limits	Corridor Description
1a	TH 36 between I-35W and I-35E	Construct one MnPASS lane in the westbound direction
2a	TH 77 between 138th Street and I-494	Construct one MnPASS lane in both directions
2a NB	TH 77 between 138th Street and I-494	Construct one MnPASS lane in the northbound direction
2b	TH 77 between I-494 and TH 62 and TH 62 between TH 77 and I-35W	Construct one MnPASS lane in both directions; Construct bidirectional direct connection between TH 77 and TH 62
3a	US 169 between Marschall Road and I-494	Construct one MnPASS lane in both directions
3b	US 169 between I-494 and I-394	Construct one MnPASS lane in both directions
3c	US 169 between I-394 and I-694	Construct one MnPASS lane in both directions
7a	I-94 between Cedar Street and TH 61	Construct one MnPASS lane in both directions
8b	I-494 between US 212 and TH 5/MSP Airport	Construct one MnPASS lane in both directions
16b	I-394 between TH 100 and downtown Minneapolis	Fill missing reversible section
18	I-94 between TH 55 and I-35W	Construct one MnPASS lane in both directions
19	I-94 between TH 252 and TH 55	Construct one MnPASS lane in each direction; Construct bidirectional direct connection between I-94 and TH 252
21	TH 252 between I-94 and TH 610	Convert to freeway and construct all interchanges except 66th Avenue; Construct one MnPASS lane in both directions

Figure 9: System Scenario #1 Map



System Scenario No.1 Results

System Results

System scenario #1 represents an increase of 133 MnPASS lane miles in addition to the existing, Tier 1 and Tier 2 MnPASS lane miles included in the 2040 base model.

Table 9: MnPASS Lane Miles

	2014 Existing	2040 Base	2040 System Scenario #1	Difference*
MnPASS Lane Miles	61	137	270	133

* Difference between 2040 base and 2040 system scenario #1

Table 10: Daily Vehicle Miles Traveled (in thousands)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #1	Difference**
Freeway – General Purpose	35,159	40,558	39,387	-1,171
Freeway – MnPASS	240	1,384	3,422	2,038
Other	35,978	43,611	42,976	-635
Total	71,377	85,553	85,785	232

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #1

Table 11: Daily Vehicle Hours Traveled (in thousands)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #1	Difference**
Freeway – General Purpose	606	712	683	-29
Freeway – MnPASS	4	21	51	30
Other	969	1,201	1,180	-21
Total	1,579	1,934	1,914	-20

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #1

Table 12: Average Speed (miles per hour)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #1	Difference**
Freeway – General Purpose	58	57	58	1
Freeway – MnPASS	65	65	67	2
Other	37	36	36	0
Total	45	44	45	1

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #1

Table 13: Congested Lane Miles*

Alternatives	2014 Existing		2040 Base		2040 System Scenario #1	
Facility Type	Lane Miles Congested**	Percent Congested	Lane Miles Congested**	Percent Congested	Lane Miles Congested**	Percent Congested
Freeway – General Purpose	585	23	788	32	648	26
Freeway – MnPASS	3	5	8	6	7	3
Other	901	6	1,223	8	1,121	7
Total	1,489	9	2,019	11	1,776	10

*Model results in Seven-County Metro Area; local streets not included; AM and PM peak hour
** A lane is considered congested if: volume/capacity >1.2 for freeways (45 mph congested speed for a 60 mph freeway) or volume/capacity >1.0 for all other facility types

Table 14: Mode Shift (thousands of daily person trips)*

	2014 Existing	2040 Base	2040 System Scenario #1	Difference**
SOV Trips	5,619	6,537	6,527	-10
HOV Trips	5,312	6,252	6,268	16
Transit Trips	246	346	348	2
Regional Total	11,177	13,135	13,143	8

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #1

Table 15: Scenario Cost for System Scenario #1

Cost Estimate	$2.46 Billion
Lane Miles	270 miles
Cost Per Lane Mile	$9.11 Million

Corridor Results

Benefits

Table 16: System Scenario #1 Corridor Benefits

Corridor	Benefit		
	Change in Average Person Throughput	Total Person Hours Saved	Percent Travel Time Savings
1a	829	321	2.4%
2a	6,005	1,444	4.0%
2a - NB	5,139	1,022	3.5%
2b	6,245	548	4.2%
3a	6,811	2,300	5.4%
3b	14,956	931	4.0%
3c	8,212	840	4.1%
7a	7,342	1,922	15.3%
8b	18,901	4,697	9.8%
16b	33,034	165	2.5%
18	10,196	717	6.8%
19	15,788	189	0.4%
21	37,396	1,263	39.8%

Costs

Table 17: System Scenario #1 Corridor Costs

Corridor	Lane Miles	Cost Estimate (M)	Estimated Cost Per Lane Mile	Cost Variability
1A	4.8	$80	$16.7	High
2A	16.8	$90	$10.7	Medium
2A - NB	8.4	$70	$8.3	Medium
2B	7.8	$110	$14.1	High
3A	19.4	$130	$6.7	Low
3B	16.5	$200	$12.1	High
3C	14.6	$180	$12.3	Medium
7A	5.4	$300	$55.5	High
8B	21.1	$220	$10.4	Medium
16B	3.6	$110	$30.6	Med / High
18	4.4	$810	$184	High
19	12.1	$90	$7.4	Low / Med
21	9.3	$140	$15.1	Medium

6. System Scenario No.2

System Scenario No.2 Definition

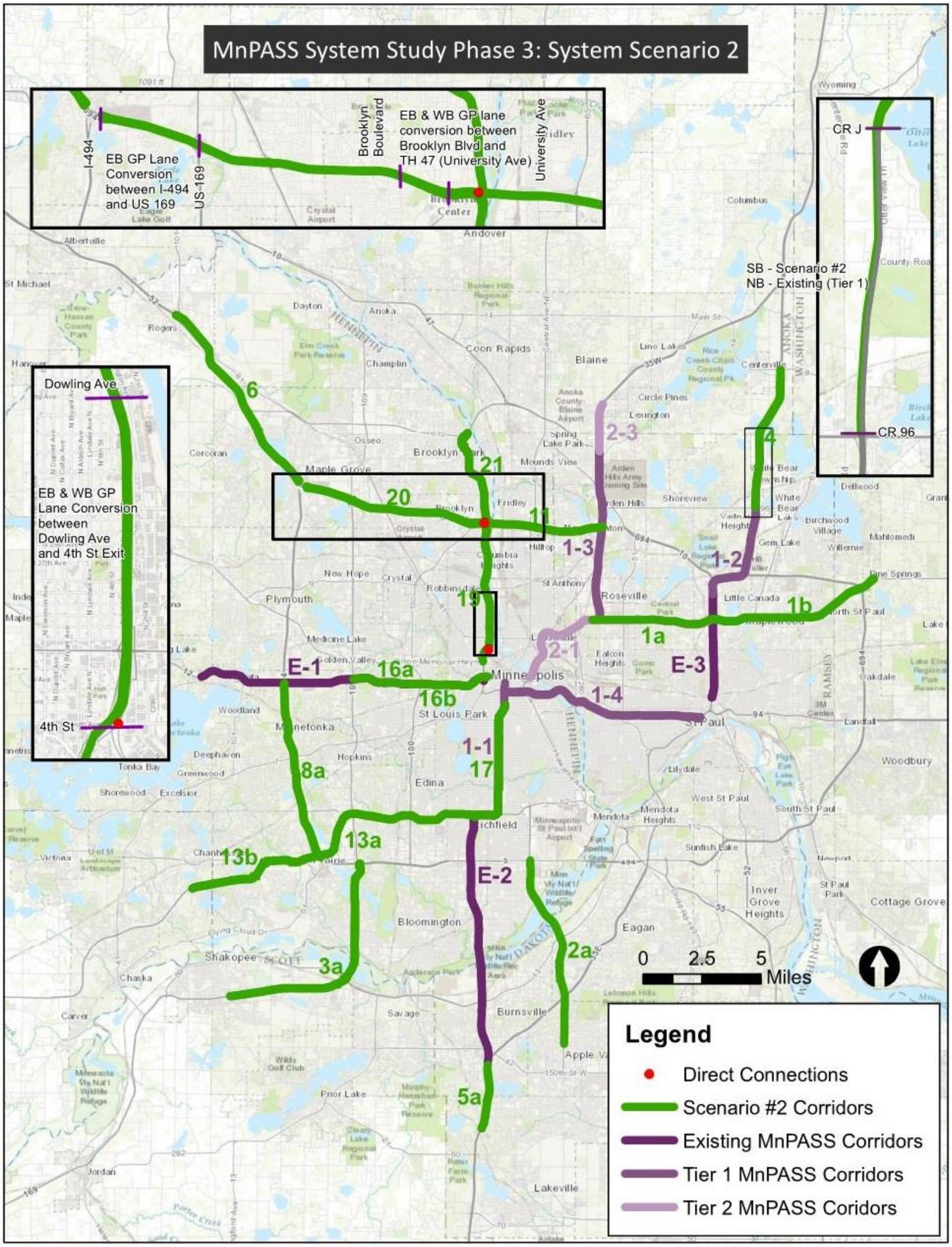
System scenario #2 consists of the corridors listed in Table 16 and is shown in Figure 10.

Table 18: System Scenario #2 Definition

Corridor	Corridor Limits	Corridor Description
1a	TH 36 between I-35W and I-35E	Construct one MnPASS lane in the westbound direction
1b	TH 36 between I-35E and I-694	Construct one MnPASS lane in both directions
2a	TH 77 between 138th Street and I-494	Construct one MnPASS lane in both directions
2a NB	TH 77 between 138th Street and I-494	Construct one MnPASS lane in the northbound direction
3a	US 169 between Marschall Road and I-494	Construct one MnPASS lane in both directions
4	I-35E between Ramsey County J/96 and Anoka County 14	Construct one MnPASS lane in SB direction between CR 96 and CR J; Construct on MnPASS lane in both directions between CR J and CR 14
5a	I-35 between Crystal Lake Road/Southcross Drive and Dakota County 50	Construct one MnPASS lane in both directions
6	I-94 between I-494 and TH 101	Construct one MnPASS lane in both directions
8a	I-494 between US 212 and I-394	Construct one MnPASS lane in both directions
11	I-694 between I-94 and I-35W	Construct one MnPASS lane in both directions
13a	US 212 and TH 62 between I-494 and I-35W	Construct one MnPASS lane in both directions
13b	US 212 between TH 5 and I-494	Construct one MnPASS lane in both directions
16a	I-394 between US 169	Construct one additional MnPASS lane in eastbound

Corridor	Corridor Limits	Corridor Description
	and TH 100	direction
16b	I-394 between TH 100 and downtown Minneapolis	Fill missing reversible section
17	I-35W between TH 62 and 26th Street	Construct one additional MnPASS lane in both directions
18	I-94 between TH 55 and I-35W	Construct one MnPASS lane in both directions
19	I-94 between TH 252 and TH 55	Construct one MnPASS lane in each direction between Dowling Avenue and I-694; Convert existing general purpose lanes to one MnPASS lane in each direction between 4th Street exit and Dowling Avenue; Construct bidirectional direct connection between I-94 and TH 252; Construct bidirectional direct connection between I-94 and 4th Street exit
20	I-94 between I-494/I-694 and TH 252	Convert one eastbound existing general purpose lane to MnPASS lane between I-494 and US 169; Construct new MnPASS lane westbound between I-494 and US 169; Construct one MnPASS lane in each direction between US 169 and Brooklyn Boulevard; Convert one existing general purpose lane to one MnPASS lane in each direction between Brooklyn Boulevard and University Avenue
21	TH 252 between I-94 and TH 610	Convert to freeway and construct all interchanges except 66th Avenue; Construct one MnPASS lane in both directions

Figure 10: System Scenario #2 Map



System Scenario No.2 Results

System Results

System scenario #2 represents an increase of 185 MnPASS lane miles in addition to the existing, Tier 1 and Tier 2 MnPASS lane miles included in the 2040 base model.

Table 19: MnPASS Lane Miles

	2014 Existing	2040 Base	2040 System Scenario #2	Difference*
MnPASS Lane Miles	61	137	322	185

*Difference between 2040 base and 2040 system scenario #2

Table 20: Daily Vehicle Miles Traveled (in thousands)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #2	Difference**
Freeway – General Purpose	35,159	40,558	39,287	1,1271
Freeway – MnPASS	240	1,384	3,639	2,255
Other	35,978	43,611	42,886	725
Total	71,377	85,553	85,812	259

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #2

Table 21: Daily Vehicle Hours Traveled (in thousands)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #2	Difference**
Freeway – General Purpose	606	712	683	-29
Freeway – MnPASS	4	21	54	33
Other	969	1,201	1,178	-23
Total	1,579	1,934	1,915	-19

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #2

Table 22: Average Speed (miles per hour)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #2	Difference**
Freeway – General Purpose	58	57	58	1
Freeway – MnPASS	65	65	67	2
Other	37	36	36	0
Total	45	44	45	1

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #2

Table 23: Congested Lane Miles*

Alternatives	2014 Existing		2040 Base		2040 System Scenario #2	
Facility Type	Lane Miles Congested**	Percent Congested	Lane Miles Congested**	Percent Congested	Lane Miles Congested**	Percent Congested
Freeway – General Purpose	585	23	788	32	633	25
Freeway – MnPASS	3	5	8	6	7	2
Other	901	6	1,223	8	1,091	7
Total	1,489	9	2,019	11	1,730	9

*Model results in Seven-County Metro Area; local streets not included; AM and PM peak hour
** A lane is considered congested if: volume/capacity >1.2 for freeways (45 mph congested speed for a 60 mph freeway) or volume/capacity >1.0 for all other facility types

Table 24: Mode Shift (thousands of daily person trips)*

	2014 Existing	2040 Base	2040 System Scenario #2	Difference**
SOV Trips	5,619	6,537	6,527	-10
HOV Trips	5,312	6,252	6,267	15
Transit Trips	246	346	348	2
Regional Total	11,177	13,135	13,142	7

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #2

Table 25: Scenario Cost for System Scenario #2

Cost Estimate	$1.89 Billion
Lane Miles	322 miles
Cost Per Lane Mile	$5.87 Million

Corridor Results

Benefits

Table 26: System Scenario #2 Corridor Benefits

Corridor	Benefit		
	Change in Average Person Throughput	Total Person Hours Saved	Percent Travel Time Savings
1a	4,129	201	1.4%
1b	10,609	512	2.0%
2a	7,841	1,227	4.3%
2a-NB	4,050	782	3.9%
3a	5,519	1,684	5.2%
4	839	-70	2.0%
5a	3,076	786	8.8%
6	3,366	1,064	3.6%
8a	1,195	776	2.9%
11	-62	627	1.7%
17	-5,818	-1,420	-1.7%
19	19,555	-229	-1.4%
20	4,341	1,123	2.8%
21	38,284	1,153	39.3%
13a	22,351	2,012	8.9%
13b	12,219	2,138	7.5%
16a	-4,475	-141	0.1%
16b	12,032	1,805	N/A

Costs

Table 27: System Scenario #2 Corridor Costs

Corridor	Lane Miles	Cost Estimate (M)	Estimated Cost Per Lane Mile	Cost Variability
1A	4.8	$80	$16.7	High
1B	17.2	$160	$9.3	Medium
2A	16.8	$90	$5.4	Medium
2A – NB	8.4	$70	$8.3	Medium
3A	19.4	$130	$6.7	Low
4	9.9	$40	$4.0	Low
5A	5.8	$40	$6.9	Medium
6	17.7	$80	$4.5	Low
8A	15.1	$160	$10.6	Medium
11	10.9	$90	$8.3	Med / High
13A	17.5	$200	$11.4	High
13B	10.8	$60	$5.6	Low
16A	5.6	$60	$8.9	Med / High
16B	3.6	$110	$30.6	Med / High
17	9.1	$220	$24.2	High
19	12.1	$120	$9.9	Med / High
20	16.3	$110	$6.7	Med / High
21	9.3	$140	$15.1	Medium

7. System Scenario No.3

System Scenario No.3 Selection Method

In selecting corridors for System Scenario #3, the results of Scenarios #1 and #2 were considered, including both corridor costs and benefits. Additionally, complimentary corridors were selected and parallel, competing corridors avoided, with the goal of creating an evaluation scenario most closely in line with the recommended MnPASS vision.

The results of Scenario #3 are an important factor MnDOT and the Metropolitan Council will use in 2018 to develop the MnPASS Vision update to the 2040 TPP. Other factors include local knowledge about the corridors, the results of previous corridor studies, dependencies on other corridors, planned preservation work, and other overall system considerations like geographic balance.

System Scenario No.3 Definition

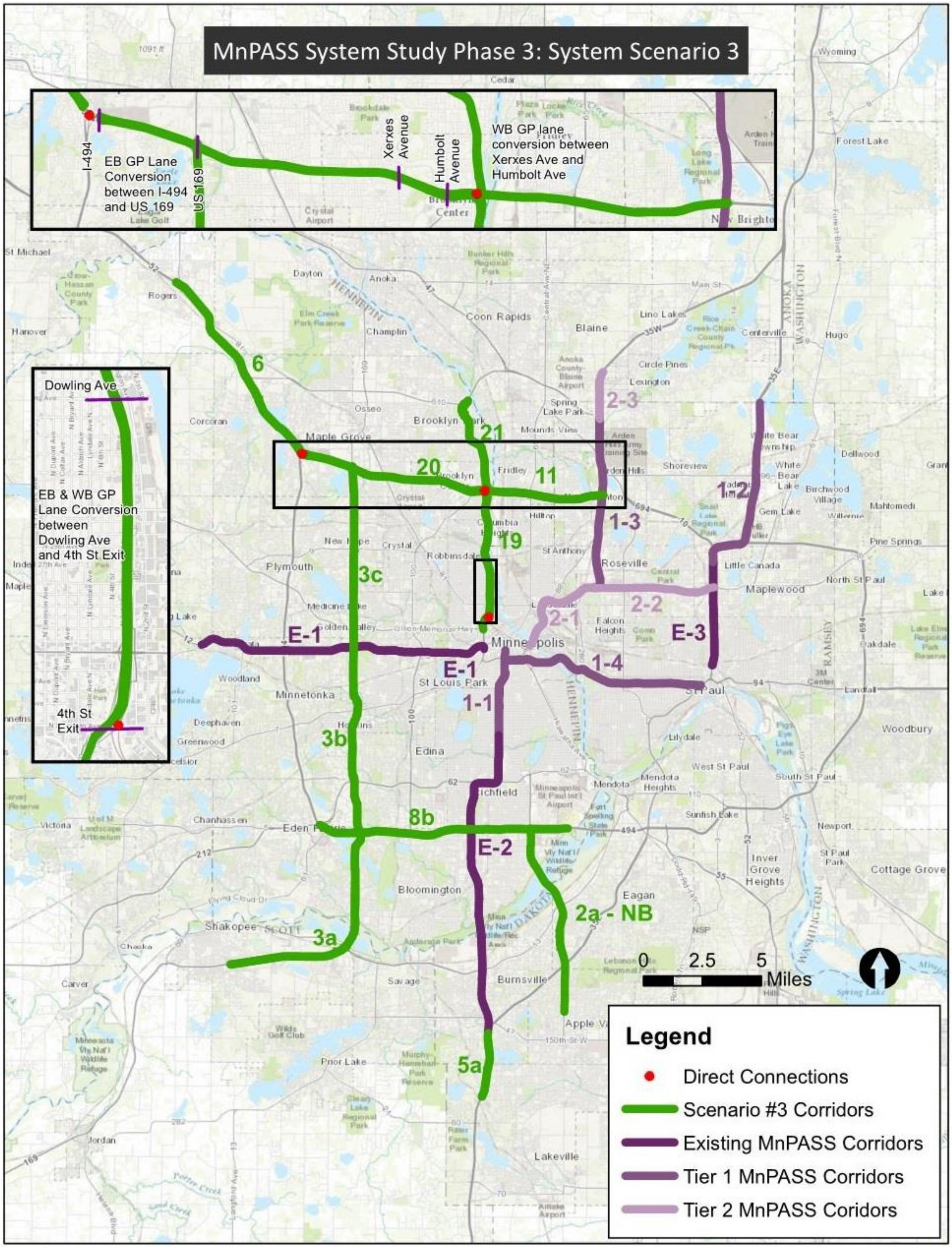
System Scenario #3 consists of the corridors listed in Table 28 and is shown in Figure 11.

Table 28: System Scenario #3 Definition

Corridor	Corridor Limits	Corridor Description
2a NB	TH 77 between 138th Street and I-494	Construct one MnPASS lane in the northbound direction
3a	US 169 between Marschall Road and I-494	Construct one MnPASS lane in both directions
3b	US 169 between I-494 and I-394	Construct one MnPASS lane in both directions
3c	US 169 between I-394 and I-694	Construct one MnPASS lane in both directions
5a	I-35 between Crystal Lake Road/Southcross Drive and Dakota County 50	Construct one MnPASS lane in both directions
6	I-94 between I-494 and TH 101	Construct one MnPASS lane in both directions
8b	I-494 between US 212 and TH 5/MSP Airport	Construct one MnPASS lane in both directions
11	I-694 between I-94 and I-35W	Construct one MnPASS lane in both directions
19	I-94 between TH 252 and TH 55	Construct one MnPASS lane in each direction between Dowling Avenue and I-694; Convert existing general purpose lanes to one MnPASS lane in each direction between 4th

		Street exit and Dowling Avenue; Construct bidirectional direct connection between I-94 and TH 252; Construct bidirectional direct connection between I-94 and 4th Street exit
20	I-94 between I-494/I-694 and TH 252	Convert one eastbound existing general purpose lane to MnPASS lane between I-494 and US 169; Construct new MnPASS lane westbound between I-494 and US 169; Construct one MnPASS lane in each direction between US 169 and Brooklyn Boulevard; Convert one existing general purpose lane to one MnPASS lane in each direction between Brooklyn Boulevard and University Avenue
21	TH 252 between I-94 and TH 610	Convert to freeway and construct all interchanges except 66th Avenue; Construct one MnPASS lane in both directions

Figure 11: System Scenario #3 Map



System Scenario No.3 Results

System Results

System scenario #3 represents an increase of 150 MnPASS lane miles in addition to the existing, Tier 1 and Tier 2 MnPASS lane miles included in the 2040 base model.

Table 29: MnPASS Lane Miles

	2014 Existing	2040 Base	2040 System Scenario #3	Difference*
MnPASS Lane Miles	61	137	287	150

*Difference between 2040 base and 2040 system scenario #3

Table 30: Daily Vehicle Miles Traveled (in thousands)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #3	Difference**
Freeway – General Purpose	35,159	40,558	39,427	-1,131
Freeway – MnPASS	240	1,384	3,485	2,101
Other	35,978	43,611	42,912	-699
Total	71,377	85,553	85,824	271

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #3

Table 31: Daily Vehicle Hours Traveled (in thousands)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #3	Difference**
Freeway – General Purpose	606	712	683	-29
Freeway – MnPASS	4	21	52	31
Other	969	1,201	1,178	-23
Total	1,579	1,934	1,913	-21

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #3

Table 32: Average Speed (miles per hour)*

Facility Type	2014 Existing	2040 Base	2040 System Scenario #3	Difference**
Freeway – General Purpose	58	57	58	1
Freeway – MnPASS	65	65	67	2
Other	37	36	36	0
Total	45	44	45	1

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #3

Table 33: Congested Lane Miles*

Alternatives	2014 Existing		2040 Base		2040 System Scenario #3	
Facility Type	Lane Miles Congested**	Percent Congested	Lane Miles Congested**	Percent Congested	Lane Miles Congested**	Percent Congested
Freeway – General Purpose	585	23	788	32	638	25
Freeway – MnPASS	3	5	8	6	8	3
Other	901	6	1,223	8	1,089	7
Total	1,489	9	2,019	11	1,735	9

*Model results in Seven-County Metro Area; local streets not included; AM and PM peak hour

** A lane is considered congested if: volume/capacity >1.2 for freeways (45 mph congested speed for a 60 mph freeway) or volume/capacity >1.0 for all other facility types

Table 34: Mode Shift (thousands of daily person trips)*

	2014 Existing	2040 Base	2040 System Scenario #3	Difference**
SOV Trips	5,619	6,537	6,527	-10
HOV Trips	5,312	6,252	6,267	15
Transit Trips	246	346	347	1
Regional Total	11,177	13,135	13,141	6

*Model results in Seven-County Metro Area; local streets not included ** Difference between 2040 base and 2040 system scenario #3

Table 35: Scenario Cost for System Scenario #3

Cost Estimate	$1.38 Billion
Lane Miles	287 miles
Cost Per Lane Mile	$4.81 Million

Corridor Results

Benefits

Table 36: System Scenario #3 Corridor Results

Corridor	Benefit		
	Change in Average Person Throughput	Total Person Hours Saved	Percent Travel Time Savings
11	2,361	936	3.9%
19	16,552	-119	-1.2%
20	3,044	1,487	4.9%
21	36,925	1,186	39.7%
2a -NB	3,118	747	3.2%
3a	7,985	1,765	5.8%
3b	15,492	768	3.8%
3c	7,788	760	4.2%
5a	3,490	795	8.9%
6	3,846	1,106	3.7%
8b	18,786	4,121	9.8%

Costs

Table 37: System Scenario #3 Corridor Costs

Corridor	Lane Miles	Cost Estimate (M)	Estimated Cost Per Lane Mile	Cost Variability
2A – NB	8.4	$50	$5.6	Medium
3A	19.4	$130	$6.7	Low
3B	16.5	$200	$12.1	High
3C	14.6	$180	$12.3	Medium
5A	5.8	$40	$6.9	Medium
6	17.7	$80	$2.8	Low
8B	21.1	$220	$10.4	High
11	10.9	$120	$11.0	Medium
19	12.1	$110	$9.1	Med/High
20	15.4	$110	$7.1	Medium/High
21	9.3	$140	$15.1	Medium

8. Results Summary

This section provides a summary of System Scenario #3 corridor level results. System Scenario #3 corridors were selected based on corridor results from Scenarios #1 and #2, including both corridor costs and benefits. Additionally, complimentary corridors were selected and parallel, competing corridors avoided, with the goal of creating an evaluation scenario most closely in line with the recommended MnPASS vision.

Using Scenario #3 results, the following evaluation ranking table was created based on the ratio of corridor benefits (change in average person throughput) to cost, where increasing person throughput is a primary goal of MnPASS.

Table 38: Corridor Evaluation Ranking

Rank	Corridor	Change in Average Person Throughput	Cost (M)	Change in Average Person Throughput per $M
1	21	36,925	$140	264
2	19	16,552	$110	151
3	5a	3,490	$40	87
4	8b	18,786	$220	85
5	3b	15,492	$200	78
6	2a -NB	3,118	$50	62
7	3a	7,985	$130	61
8	6	3,846	$80	48
9	3c	7,788	$180	43
10	20	3,044	$110	28
11	11	2,361	$120	20

The corridors producing the greatest increases in person throughput include 21, 19, and 8b. While 5a results in a smaller increase in person throughput, the corridor is very low cost, resulting in a high-ranking. 3b, 2a-NB, 3a, and 6 ranked moderately, with 3c, 20, and 11 scoring lower.

Based simply on requiring a new MnPASS corridor to have a connection to another MnPASS lane or a major destination (downtown Minneapolis, downtown St. Paul or MSP Airport), each was given a level of dependency. Corridors which would immediately connect to another MnPASS lane or major destination were level 0 (no dependency). These include 3b, 5a, 8b, 11, and 19. Corridors requiring one MnPASS corridor to be constructed first to achieve connectivity were level 1. These include 2a-NB (requires 8b), 3a (requires 3b or 8b), 20 (requires 11 or 19), and 21 (requires 19). Finally, level 2 corridors are dependent on two or more new MnPASS corridors to be constructed to achieve connectivity. Corridor 6 (requires 20, which in turn requires 11 or 19) was the only corridor in Scenario #3 with this level of dependency.

9. MnPASS System Scenario 3 Benefits

This section summarizes anticipated benefits provided through the expansion of the MnPASS system, including increased person throughput, fewer congested lane miles, and increase in trips with a congestion-free option.

Congestion-Free Option

MnPASS offers users the option for a congestion-free freeway trip along an otherwise congested corridor. Using the 2016 MnDOT Congestion Report, this analysis determined currently congested vehicle trips in the AM and PM peak periods, which would benefit from a MnPASS congestion-free option. The AM peak period includes 6:00 AM to 10:00 AM and PM peak 3:00 PM to 7:00 PM, Monday through Friday. A trip is considered congested if any part of the freeway portion of the trip uses a “congested” segment from the 2016 Congestion Report without an option to utilize MnPASS. All colored segments in the Congestion Report are considered congested. Only those marked as “No recurring congestion” and colored white are considered uncongested.

By combining the congestion information from the CongestionReport and the various scenarios of MnPASS lanes (existing, add Tier 1, add Tier 2, add Scenario 3), this analysis calculated how many previous congested trips could benefit from the addition of MnPASS. Trips are only considered to have a congestion-free option if the entire freeway portion of the trip is either uncongested or provides the congestion-free option of MnPASS.

The series of figures below show the percent increase of peak period freeway trips with a congestion-free option traveling to or from each transportation analysis zone (TAZ) under various scenarios. Each figure displays the percent increase compared to the system with no MnPASS lanes.

Figure 12 shows trips with a congestion-free option with the existing MnPASS lanes, Figure 13 adds the 2040 TPP Tier 1 corridors, Figure 14 adds Tier 2 corridors, and Figure 15 adds all Scenario 3 corridors.

Figure 12: Percent Increase of Peak Period Freeway Trips with Congestion-Free Option (System with Existing MnPASS)

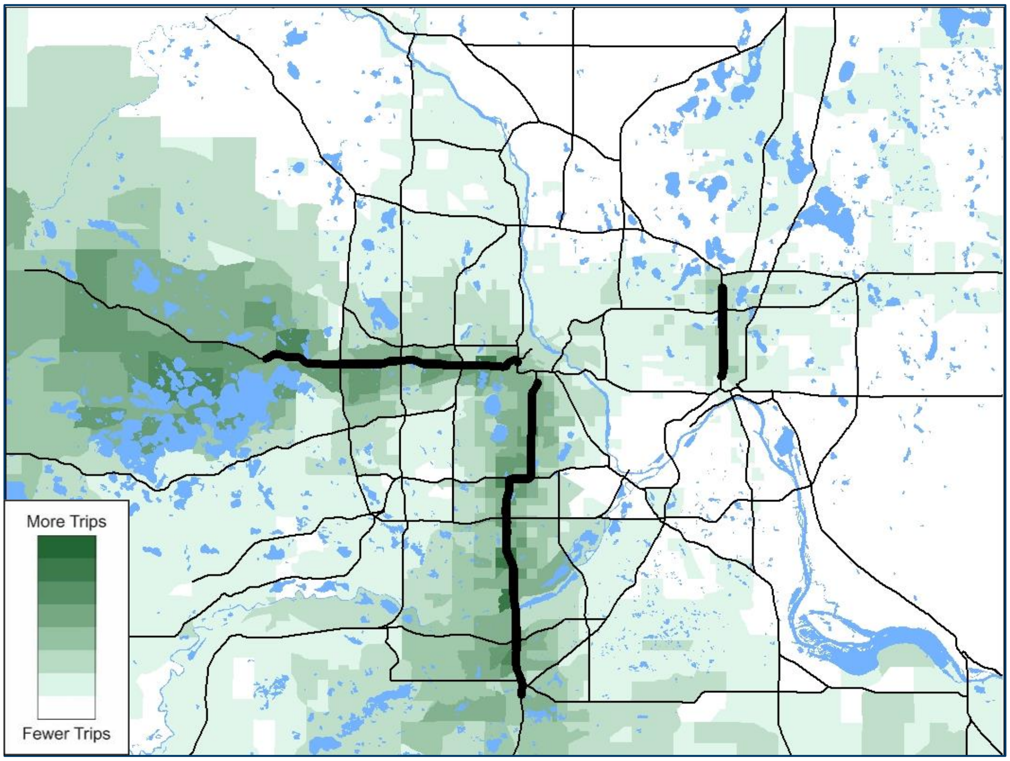


Figure 13: Percent Increase of Peak Period Freeway Trips with Congestion-Free Option (System with Existing and Tier 1 MnPASS)

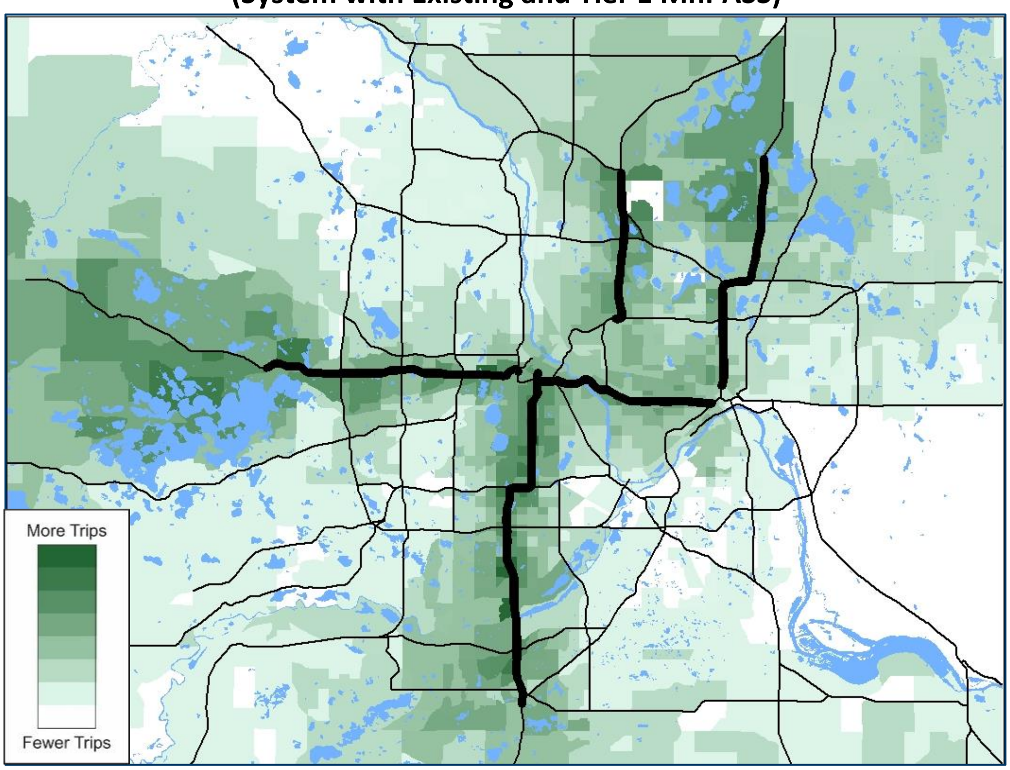


Figure 14: Percent Increase of Peak Period Freeway Trips with Congestion-Free Option (System with Existing, Tier 1, and Tier 2 MnPASS)

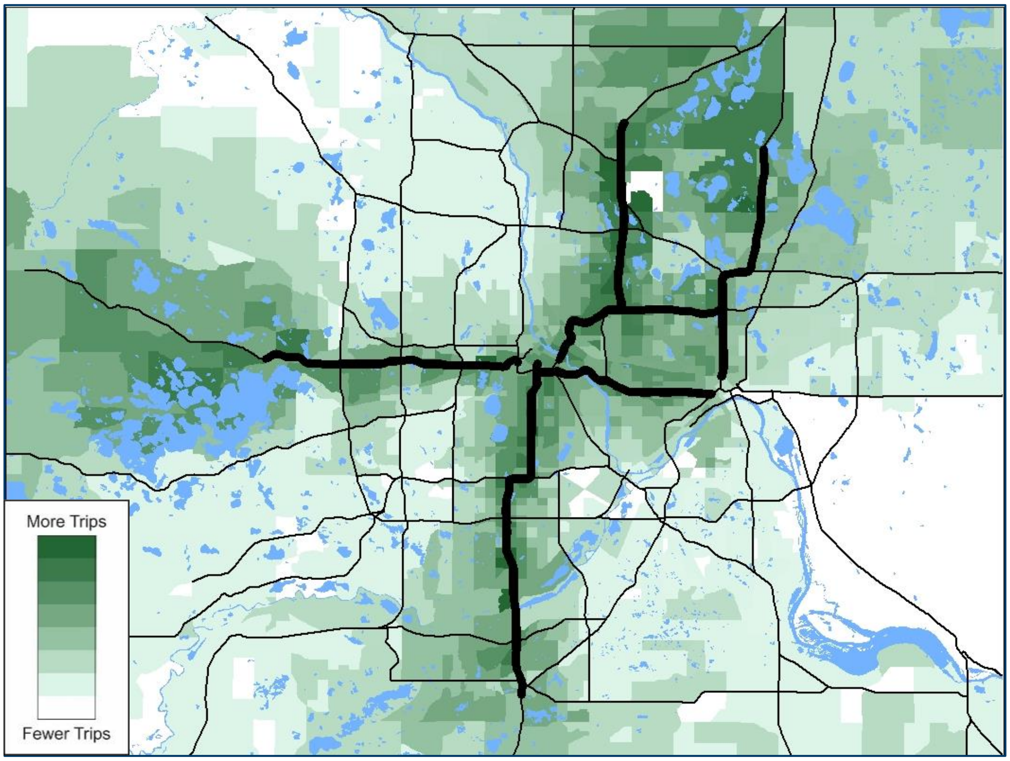


Figure 15: Percent Increase of Peak Period Freeway Trips with Congestion-Free Option (System with Existing, Tier 1, Tier 2, and Scenario 3 MnPASS)

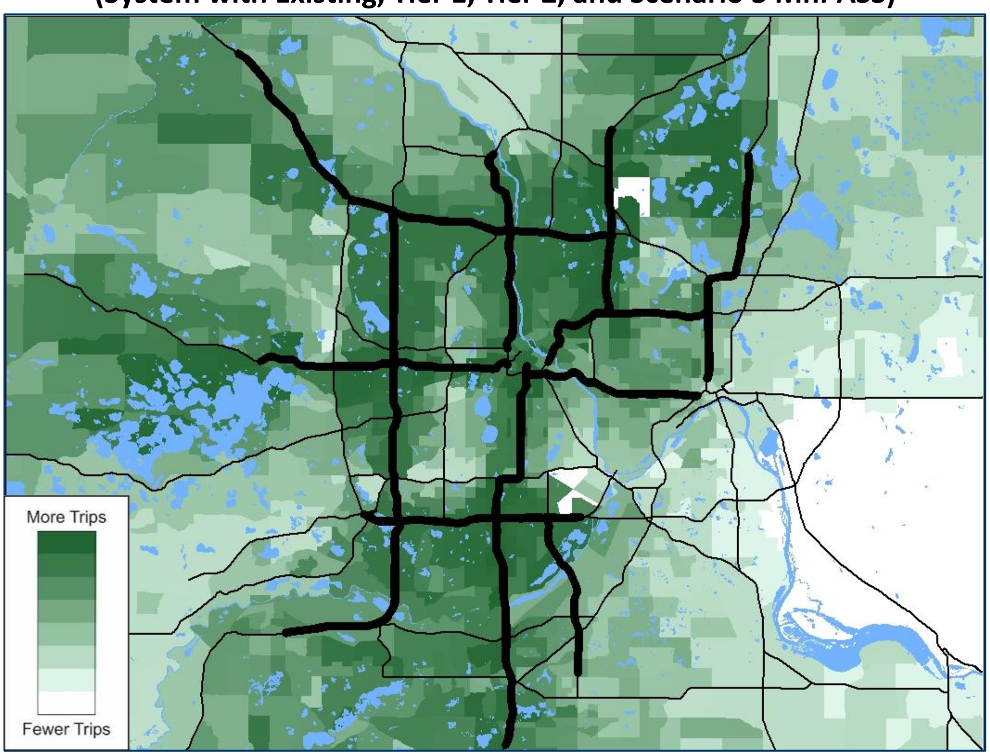


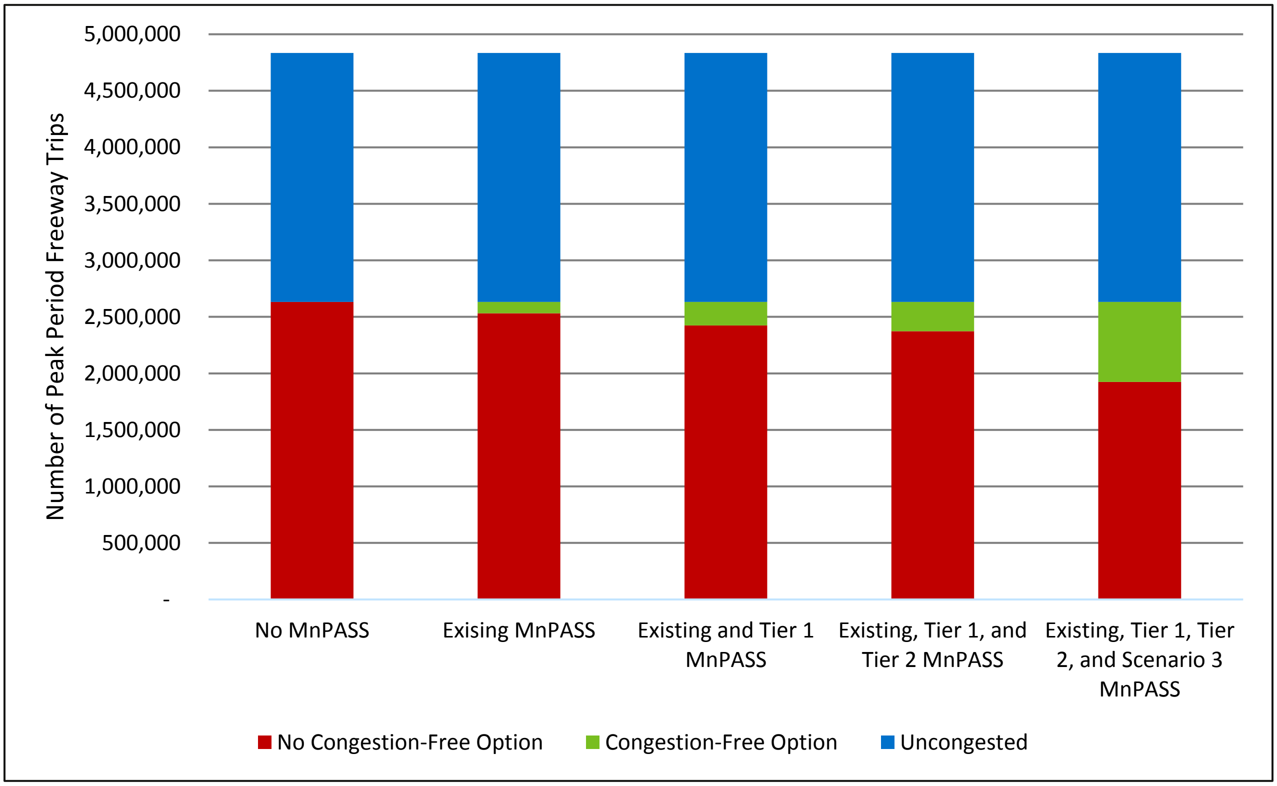
Table 39 shows the number of freeway trips with a congestion-free option and the number of congested freeway lane miles covered by MnPASS under the various tiers of MnPASS corridors. Under Scenario 3, over 700,000 peak period trips would have a completely congestion-free option, with many others offered a partially congestion-free trip, and over 50% of the congested lane miles would have a congestion-free MnPASS option.

Table 39: Trips and Congested Lane Miles with Congestion-Free Option

	Increase in Peak Period Trips with Congestion-Free Option	Percent of Congested Freeway Lane Miles Covered by MnPASS	Congested Freeway Lane Miles Covered by MnPASS
No MnPASS	N/A	0%	0
Existing MnPASS	101,000	10%	93
Existing and 2040 TPP Tier 1 MnPASS	209,000	22%	213
Existing, 2040 TPP Tier 1, and Tier 2 MnPASS	260,000	25%	246
Existing, 2040 TPP Tier 1, Tier 2, and Scenario 3 MnPASS	708,000	51%	497

Figure 16 is a stacked bar chart showing the number of freeway trips, which are 1) Uncongested, 2) Have a Congestion-Free Option, and 3) Have No Congestion-Free Option under five scenarios (No MnPASS, Existing MnPASS, Add Tier 1, Add Tier 2, Add Scenario 3). As MnPASS lanes are added, the number of trips with a congestion-free option (green) increases, while the number of trips with no-congestion free option (red) reduces. The number of trips with an uncongested freeway trips remains static.

Figure 16: Change in Number of Peak Period Freeway Trips with Congestion-Free Option



MnPASS/GP/HOV Lane Comparison (I-35W Example)

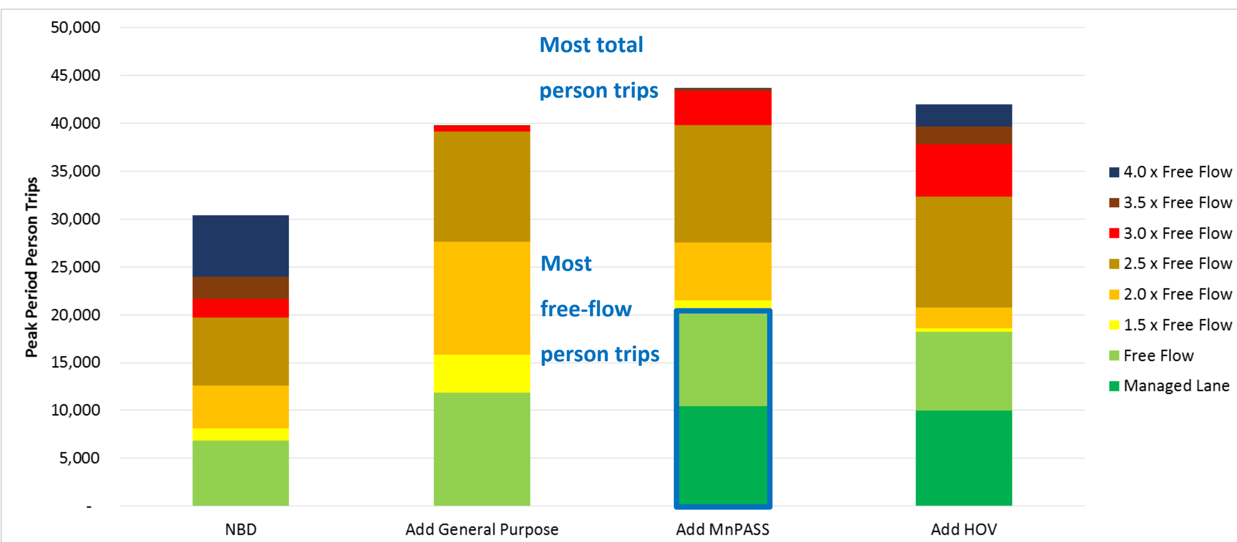
As part of the I-35W North Corridor Preliminary Design Project, an extensive travel time reliability analysis was conducted. The analysis compared travel times under the various alternatives: No-build, add GP, add MnPASS, and add HOV. This analysis provides an example of the benefits of MnPASS compared directly with GP and HOV build alternatives.

Person Trips

Given the MnPASS goal of increasing person throughput, a stacked bar chart was produced showing the number of users being served under each alternative and their respective travel times. Figure 17 represents the person throughout along I-35W during peak hours and peak directions by travel time index (TTI) level. TTI is the ratio of the observed travel time to the free flow travel time. For example, 2.5 x Free Flow are trips which took 2.5 times longer than the free flow travel time to traverse the corridor. Higher TTI values represent more congested conditions. The legend values represent the upper limits of each TTI bin. Person throughput values are calculated by multiplying vehicle volumes by vehicle occupancy estimates.

Figure 17 shows that the MnPASS alternative offers a 10 percent increase in total person-throughput over the GP alternative. Even more importantly, the MnPASS alternative provides a 75 percent increase in the number of reliable trips.

Figure 17: Peak Period Person Trips



Travel Time Savings

In addition to providing more free-flow person trips during the peak periods, the MnPASS alternative also provides a faster travel time on average for all users (MnPASS and GP). This can be seen in Table 40, where the MnPASS alternative has the least amount of delay and largest decrease in Person Hours Traveled (PHT).

Table 40: Travel Time Savings

Criteria	Add General Purpose	Add MnPASS	Add HOV
Person Hours Traveled (PHT) and Delay	PHT: 8.1 M (-3.8M) Delay: 2.6M Pct Decr: 59%	7.5 M (-4.4M) Delay: 2.0M Pct Decr: 69%	8.1 M (-3.8M) Delay: 2.6M Pct Decr: 59%

10. MnPASS System Issues and Opportunities

Introduction

As MnDOT continues to invest in and build MnPASS lanes, it's become increasingly important to investigate key issues, risks, and opportunities affecting the current and future MnPASS system. This chapter identifies and analyzes key MnPASS issues, risks, and opportunities to help inform future MnPASS-related decisions.

Identifying Key Issues, Risks, and Opportunities

Input was solicited from the Project Management Team (PMT), Technical Steering Committee (TSC), and MnDOT project leaders to determine the research questions for this task. Seven initial focus areas were presented with a wide range of issues. These issues were refined and prioritized to fit within the scope of this task with additional topics listed for future research.

Operations

Figure 18: I-35W MnPASS

The operation of HOT lanes includes numerous complex elements, such as dynamic pricing, lane access, and lane exemptions. Each of these affect demand and ultimately, performance of the lanes. While different HOT lane systems have varying goals, MnDOT strives to achieve maximum person throughput on its MnPASS lanes by maintaining speeds of 45 miles per hour or higher at least 90 percent of the time as required by MnDOT's Operations Agreement with the Federal Highway Administration (FHWA).

The initial MnPASS lanes on I-394 were deployed in 2005. Since then, MnDOT has added MnPASS lanes on I-35W and I-35E. As the system continues to expand, MnDOT will inevitably encounter capacity issues on some of its MnPASS lanes that will require steps to improve lane performance. There are a variety of tools MnDOT can utilize to address capacity constraints ranging in cost. These options are discussed below.

Pricing Algorithm

The MnPASS lanes use a dynamic, demand-responsive pricing algorithm to adjust prices based on congestion levels. Currently, the system updates prices every three minutes based on downstream congestion levels within the MnPASS lanes. Congestion levels in the General Purpose (GP) lanes do not influence the price, which is common among demand-responsive HOT lanes around the county. Prices are directly proportional to congestion (density) levels within the MnPASS lane with the goal of encouraging users (with low prices) when the lane has unused capacity and discouraging users (with high prices) when the lane approaches congestion. While users may use the price of MnPASS as a signal for GP lane congestion, the two are not directly correlated.

Figure 19: Segmented Pricing

Prices for the MnPASS lanes are determined by tolling zone. The zones are predetermined segments, typically several miles long and stretching a common section of roadway. Prices are calculated based on the highest density downstream of that tolling station. This prevents users from paying for upstream congestion they are not contributing to.

Up until recently, the software for the pricing algorithm was provided by a third-party outside of MnDOT. MnDOT is now using its own in-house traffic management software known as IRIS (Intelligent Roadway Information System) to control the pricing algorithm. It is now easier for MnDOT staff to adjust the algorithm to achieve the best performance on the MnPASS lanes. A possible future enhancement could include different algorithmic parameters for different MnPASS corridors, allowing MnDOT additional flexibility.

In addition to the dynamic, demand-responsive pricing used by MnPASS, there are several other pricing strategies which could be implemented on HOT lanes. Some examples include:

- Time-of-day
- Specific pricing algorithm parameters to direction or corridor
- Different rates based on vehicle type

Pricing strategies often aim to strike a balance between simplicity and accuracy. Simple approaches, such as time-of-day pricing, can be straightforward to implement and are well understood by travelers. More complex methods, such as self-learning algorithms, have the potential to more accurately price the HOT lanes based on current demand, but are more complex to implement and require detection infrastructure. Below is a summary of the pricing strategies by other HOT lane systems around the country.

Table 41: HOT Lane Pricing Strategies

HOT Lane	Pricing Strategy
I-394, I-35W, I-35E, Minneapolis	Dynamic
I-10, Houston	Only fixed schedules
I-10, I-110, Los Angeles	Dynamic
I-15, Salt Lake City	Dynamic
I-15, San Diego	Dynamic, skewed per-mile tolls
I-25, Denver	Fixed schedule
I-580, I-680, Bay Area	Dynamic
I-595, Fort Lauderdale	Dynamic
I-85, Georgia	Dynamic
I-95, I-495, Virginia (Washington, D.C. area)	Dynamic
I-95, Miami	Dynamic
LBJ Express, Dallas	Dynamic
North Tarrant Express, Fort Worth	Dynamic
SR 167, Seattle	Dynamic tolls for congestion relief
SR 91X, Los Angeles	Fixed schedule
TEXpress, Dallas	Initially fixed schedules, transitions to dynamic

Lane Exemptions

Figure 20: Lane Exceptions

Currently, the MnPASS lanes allow free use to carpools, buses, and motorcycles. Carpools are defined as two or more people in a vehicle. Buses may use the lanes at all times, even when deadheading (a non-revenue trip).

Some HOT lanes systems include other lane exemptions, such as for alternative fuel vehicles. The exemptions utilized by each system depends on the motivations of the DOT and the demand and capacity of the HOT lanes.

Carpool requirements vary across the country. MnDOT's policy is one of the least restrictive with a minimum of two occupants and no requirement to pre-register as a carpool or to have a MnPASS account or transponder (tag). More restrictive carpool policies require three or more occupants and require registration in advance to receive the lane exemption. Registration aims at encouraging formal carpools which are more likely to result in trip reduction than informal carpools. Formal carpools typically include more organized arrangements between two recurring locations, while informal carpools are generally more ad-hoc and include family members riding together. The table below summarizes the lane exemptions of HOT lane systems around the country.

Table 42: Toll Exemptions for HOT Lane Systems

HOT Lane	Toll Exemptions
I-394, I-35W, I-35E, Minneapolis	HOV2+, buses, motorcycles
I-10, Houston	HOV2+, motorcycles (during peak hours only)
I-10, I-110, Los Angeles	HOV2+
I-15, Salt Lake City	HOV2+, buses, emergency vehicles, motorcycles, select clean-fuel vehicles
I-15, San Diego	HOV2+, vanpool, motorcycle, buses, Clean Air Vehicle
I-25, Denver	HOV2+, buses, motorcycles
I-580, I-680, Bay Area	HOV2+, transit, vanpools, motorcycles, Clean-Air Vehicles
I-85, Georgia	Transit, HOV3+ (registered), motorcycles, emergency vehicles, alternative fuel vehicles with proper plates (does not include hybrid vehicles)

I-95, I-495, Virginia (Washington, D.C. area)	HOV3+ with transponder, buses, motorcycles
I-95, Miami	HOV3+ (registered), registered vanpools, registered hybrid vehicles, registered buses, motorcycles, emergency vehicles
LBJ Express, Dallas	None (discount for HOV2+ and motorcycles)
North Tarrant Express, Fort Worth	None (discount for HOV2+ and motorcycles)
SR 167, Seattle	HOV2+, vanpool, buses, motorcycle
SR 91X, Los Angeles	HOV3+ (registered), registered motorcycles, registered zero-emission vehicle, transit
TEXpress, Dallas	None (discount for HOV2+ and motorcycles)

See Table 41 for references

Figure 21: Switchable Tag Transponder

As noted above, some HOT lane systems require exempt vehicles to be registered. In addition to encouraging formal carpools, registration also eases enforcement as all vehicles are typically equipped with tolling tags. This allows law enforcement to more easily identify violators. MnPASS, on the other hand, doesn't require registration and carpools may use the lanes without a tag. MnPASS users with a switchable tag an also change their tag when travelling as a carpool to avoid payment. These less restrictive carpool policies require law enforcement to determine the validity of untolled vehicles in the field and can be difficult to enforce, as discussed later in this chapter.

HOT lane exemptions tend to be consistent across the system. Therefore, agencies must typically set their toll exemption policies based on the lanes with the highest demand to ensure performance goals are met. While specific exemptions for specific corridors would allow for maximum lane utilization, the inconsistency would likely confuse users.

Additional Exemptions

MnDOT has received past requests to add new MnPASS lane exemptions, such as for military veterans or alternative fuel vehicles. The primary goal of the MnPASS lanes is to maximize person throughput by incentivizing carpooling and transit, so there will be less congestion and less need for expansion of the freeway system. MnDOT's Operations Agreement with the FHWA requires speeds in the MnPASS lanes to be maintained at or above 45 mph at least 90% of the time. This is achieved by controlling the number of MnPASS users through dynamic pricing for single-occupant vehicles.

Allowing additional lane exemptions on MnPASS would limit MnDOT's ability to keep the MnPASS lanes free flowing. Specific locations on the I-35W and I-394 MnPASS lanes periodically approach capacity during the morning peak period and experience congestion. Allowing new toll exemptions on the lanes without meeting the occupancy requirement (2 or more people) or paying a toll may cause the MnPASS lanes to become congested sooner, and for longer periods, thus limiting the primary benefits of the lanes (i.e. improving transit and carpool use, making the highway more efficient in terms of person throughput, and improving travel-time reliability).

Similar initiatives to allow free HOT lane use for special-use vehicles have been implemented in other states. Some of these cases have resulted in unintended consequences, such as degraded performance in HOV/HOT lanes that has made carpooling and transit use less attractive. Several states have eliminated their exemptions for electric/hybrid vehicles. An FHWA report entitled "Impact of Exempt Vehicles on Managed Lanes" summarizes the experiences and issues in other states (Turnbull, 2014). For HOV/HOT lanes nearing operating capacity, the addition of exempt vehicles can reduce travel-time savings and trip-time reliability for transit buses, vanpools and carpools. MAP 21 requires state agencies to demonstrate that a HOV/HOT facility will not become congested before exempting all-electric/hybrid vehicles from occupancy and toll requirements (Federal Highway Administration, 2014).

Geometrics/Lane Access

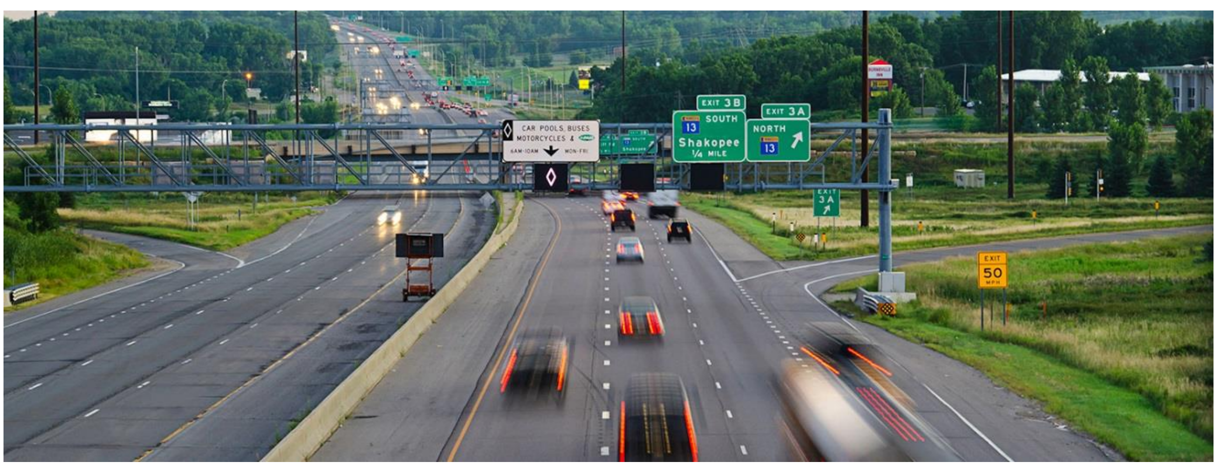
The geometrics and lane access of HOT lanes can greatly influence lane performance and usability of the lanes. HOT lanes can range from barrier separated facilities to running concurrently with GP lanes with completely open lane access. Most HOT lanes around the country fall somewhere in the middle and are concurrent lanes with some lane-access restrictions to minimize congestion, relying either on solid lane striping or physical barriers at particular locations. Congestion reduces mobility by obstructing traffic flow and cause safety concerns because they increase opportunities for rear-end collisions.

The initial MnPASS lanes on I-394 utilized a mostly closed-lane design with limited access points, MnDOT has since modified the striping to a much more open design. Similarly, more recently deployed MnPASS lanes on I-35W and I-35E also utilize a more open lane design. However, segments near bottlenecks are typically closed to limit lane friction. In 2014, a MnDOT study completed by the Minnesota Traffic Observatory titled "Evaluation of the Effect MnPASS Lane Design has on Mobility and Safety" (Stanitsas, Hourdos, & Zitzow, 2014) looked closely at MnPASS lane access. The study used detailed video analysis to determine whether the lane designs were well suited for their respective corridors. The study concluded that both open and closed designs can be safe and effective. The closed-access design on I-394 was effective because most traffic enters at three specific interchanges (I-494, US-169, MN-100). I-

35W and I-35E, on the other hand, have more frequent interchange access which suite the open-access design. The study recommends building HOT lanes with open access and periodically evaluating to see if limiting access is appropriate based on the lane utilization and performance.

Figure 22: Double White Striping Restricting Access to MnPASS

Figure 23: Dashed Striping Allowing Access to MNPASS



In addition to employing a mix of open and closed lane access on concurrent lanes, the MnPASS lanes also use direct ramp access, reversible lanes, barrier separated lanes, and a dynamic shoulder lane in various portions of the system. The table below summarizes the geometries utilized by HOT lanes around the country:

Table 43: HOT Lane Access/Geometries

HOT Lane	Lane Access/Geometries
I-394, Minneapolis	Double Solid White Lines, Barrier Separated and Reversible
I-35W and I-35E, Minneapolis and St. Paul	Double Solid White Lines at bottleneck locations only
I-10, Houston	Barrier Separated
I-10, I-110, Los Angeles	Double Solid White Lines
I-15, Salt Lake City	Double Solid White Lines
I-15, San Diego	Barrier Separated
I-25, Denver	Reversible
I-580, I-680, Bay Area	Double Solid White Lines
I-595, Fort Lauderdale	Reversible
I-85, Georgia	Double Solid White Lines
I-95, I-495, Virginia (Washington, D.C. area)	Reversible
I-95, Miami	Double Solid White Lines
LBJ Express, Dallas	Barrier Separated
North Tarrant Express, Fort Worth	Barrier Separated
SR 167, Seattle	Double Solid White Lines
SR 91X, Los Angeles	Barrier Separated
TEXpress, Dallas	Reversible

See Table 41 for references

Hours of Operation

MnPASS lanes are only tolled during peak periods, except for the I-394 reversible lanes, which are tolled 24 hours a day when open. Specifically, much of the MnPASS system is only tolled during the AM peak period (6 AM – 10 AM) in the inbound direction and PM peak (3 PM – 7 PM) in the outbound direction. During non-tolled hours, MnPASS dynamic message signs (DMS) indicate “OPEN” or “OPEN TO ALL TRAFFIC”. MnDOT doesn’t operate the MnPASS lanes during all hours, because MnPASS corridors typically don’t experience congestion outside of peak periods, except during special events or road construction. MnDOT occasionally alters MnPASS hours for certain planned special events on the I-394 reversible lanes and priced dynamic shoulder lane (PDSL) on I-35W.

The concept of dynamic operating hours has been discussed by MnPASS stakeholders. Dynamic operating hours would allow MnDOT the flexibility to adjust tolling times to match congestion along each of the MnPASS corridors. This would be particularly beneficial during inclement weather, special events, or incidents where congestion is experienced outside of normal peak operating hours. Instead of presenting drivers with varying hours, MnDOT would essentially toll the lanes at all times. However, during uncongested periods, the price for using the lanes would be $0.00 or state that the lanes are open to all traffic. While dynamic tolling hours offer increased flexibility, it comes at the cost of possible driver confusion and public resistance to increased tolling. Additionally, enforcement would become increasingly complicated if prices are allowed to frequently fluctuate between $0.00 and $0.25.

The table below summarizes hours of operation for other HOT lane systems. While nearly half of the lanes are tolled 24 hours a day, they each charge a minimum toll (as discussed in the following section), meaning none of the systems operate with dynamic hours of operation as discussed above.

Table 44: HOT Lane Hours of Operation

HOT Lane	Hours of Operation
I-394, I-35W, I-35E, Minneapolis	24 hours a day for reversible lanes Peak periods for all others
I-10, Houston	24 hours a day
I-10, I-110, Los Angeles	Mon-Fri 5-9am & 4-7pm
I-15, San Diego	24 hours a day
I-25, Denver	SB 5-10 am & NB 12pm- 3am
I-580, I-680, Bay Area	Mon-Fri 5am-8pm

I-595, Fort Lauderdale	EB: Mon-Fri 4am-1pm, Sat 4am-Mon 1pm WB: Mon-Fri 2pm-2am
I-85, Georgia	24 hours a day
I-95, I-495, Virginia (Washington, D.C. area)	24 hours a day
LBJ Express, Dallas	24 hours a day
North Tarrant Express, Fort Worth	24 hours a day
SR 167, Seattle	Everyday 5am-7pm
SR 91X, Los Angeles	24 hours a day
TEXpress, Dallas	24 hours a day, discount for HOV peak times

See Table 41 for references

Minimum and Maximum Toll

Since the first MnPASS lanes were deployed in 2005, a maximum MnPASS toll of $8.00 per corridor has been charged with a minimum toll of $0.25 per corridor section during operating hours. These minimum and maximum tolls are standard MnDOT practice, but are not required by statute. Beyond the $8.00 maximum toll, MnDOT may also switch the HOT lanes to HOV only to further reduce demand when the lane begins to break down at the $8.00 level.

While a maximum toll can help with public acceptance of HOT lanes and limit negative feedback from drivers who feel they are overpaying or being price gauged, the thresholds also limit the effectiveness of the pricing algorithm. As demand rises, particularly in irregular events such as a snow storm, the MnPASS toll often reaches the maximum price. At that point, the system is unable to raise the price further to reduce demand and the lanes may become congested.

The table below shows the minimum and maximum toll prices for HOT lanes around the country. About half of the HOT lane systems charge on a per mile basis while the remaining corridors charger per segment or corridor, like MnPASS. Overall, many of the flat rate maximum tolls are similar to MnPASS's $8.00 toll (except I-85). However, the per mile tolls would lead to much higher prices on longer MnPASS corridors like I-35W, which is approximately 16 miles long in the northbound direction. For example, the $1.00/mile toll on I-15 in Salt Lake City would result in tolls up to $16.00 on the I-35W northbound MnPASS lane.

Table 45: HOT Lane Minimum and Maximum Tolls

HOT Lane	Minimum Toll	Maximum Toll
I-394, I-35W, I-35E, Minneapolis	$0.25	$8.00
I-10, Houston	$0.30	$3.20

I-10, I-110, Los Angeles	$0.25/mile	$1.40/mile
I-15, Salt Lake City	$0.25/mile	$1.00/mile
I-15, San Diego	$0.50	$8.00
I-25, Denver	$0.70	$6.98
I-580, I-680, Bay Area	$0.50	$9.00
I-85, Georgia	$0.01/mile	$13.95
I-95, I-495, Virginia (Washington, D.C. area)	$0.20/mile	$1.00/mile
I-95, Miami	$0.25	$7.10
LBJ Express, Dallas	$0.15/mile	$0.75/mile
North Tarrant Express, Fort Worth	$0.10/mile	$0.75/mile
SR 167, Seattle	$0.50	$9.00
SR 91X, Los Angeles	$1.55	$10.45
TEXpress, Dallas	$0.20	$3.95 (no dynamic)

See Table 41 for references

As MnDOT continues to reach capacity on its MnPASS facilities, it may consider increasing or eliminating the maximum toll as one method to help meet the lanes' performance standards, along with adjusting the carpool requirement or closing access. Raising or eliminating the maximum toll would be particularly beneficial during weather, special events, and incidents when the lanes see an influx of demand. MnDOT may also consider spot mobility Improvements to help address MnPASS lane capacity issues. These improvements are discussed in more detail in the next chapter.

Evolving Technologies

Advancing technology not only changes how things are done, it changes the underlying cost structures, altering the incentives for customer behavior. While technological changes are difficult to forecast with accuracy, general trends can be identified and used as guidance for planning activities.

There are several advances being made in the transportation arena, many of which will affect the mode choices and payment mechanisms available to travelers. This analysis groups trends by functional area, and then presents a description of the potential effects they may have on HOT lane operations.

Vehicles and Modes

Technological advances are changing both how vehicles function and how they are used. Of the myriad of ways that vehicles are changing, two areas of change stand out: who owns the vehicle a passenger travels in and who (or what) is controlling the vehicle as it moves along a roadway. These are described in the Trends section below.

Trends

Non-Owner Operated Vehicles

While options such as buses, taxis, and various paratransit options have been available for decades, the early 21st century has seen the explosive growth in the "ride sharing" mode, in which private citizens use their own vehicles to provide end-to-end trips for travelers. These providers, commonly known as a Transportation Network Company (TNC), offer only a platform for travelers to request service, drivers to accept a request, and a billing mechanism. Where a traditional taxi or other shuttle would employ a professional driver with a dedicated vehicle guided by a dispatch system, TNCs consist largely of a request processing and a payment "back office" system.

The largest TNC in the United States is Uber, which was founded in 2009 and currently serves some 570 cities worldwide. Lyft, which received a $500 million investment from General Motors in late 2015, is a smaller service with service in roughly 300 US cities. TNCs have established a significant presence worldwide as well, with Didi Chuxing in China, providing over 200 million trips in one month (December, 2016) and roughly twice the number of trips in one year (1.4 billion) of all taxis in the U.S. combined.

In addition to TNCs, which provide both vehicle and driver, there are various "car sharing" providers that provide only a vehicle for travelers. These are distinct from traditional car rental services in that the vehicles are rented for short periods or distances and customers generally have a "membership" or similar on-going business relationship with the provider. Car sharing also typically dispenses with storage lots used by rental companies and simply parks vehicles on the street at the traveler's destination.

These non-owner operated options present several potential issues when interacting with HOT facilities. These issues will be important for MnDOT to consider in short term with the popularity of TNCs.

- If the vehicle is not transponder equipped, can it use the facility, paying via mobile app or some other method? The car owner may not provide a transponder, but the passenger may wish to use the HOT lane.

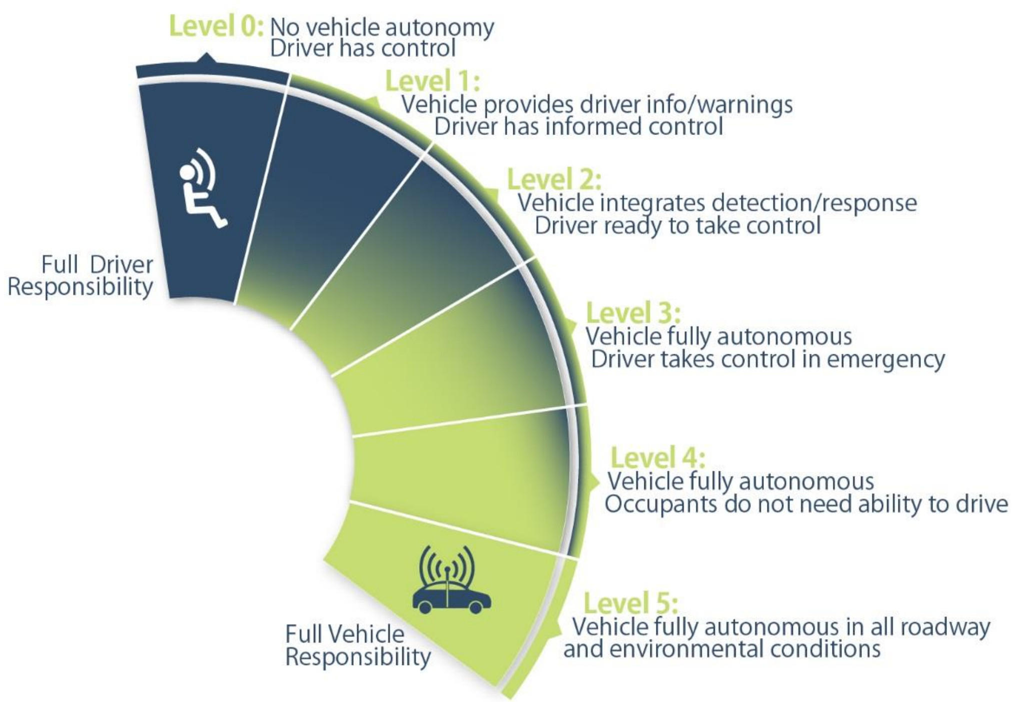
- For ride-sharing services, should a single driver-single passenger vehicle be considered an HOV, as the vehicle is not reducing vehicle trips along the facility (which is the goal of the HOV exemption)?
- Who is responsible for toll charges? The driver in a ride sharing arrangement, the passenger, or the TNC itself? How is payment made? Unlike rental car companies, the vehicles are not part of a fleet, but are independently owned and operated.

Self-Driving

Beginning with the first DARPA Grand Challenge autonomous vehicle competition in 2004, rapid progress has been made in developing vehicles that could potentially operate without a human driver. Today, there are several commercially available vehicles that can perform limited autonomous driving functions.

To guide development and regulation activities, the Society of Automotive Engineers has created a six-level classification of automated functions:

Figure 24: SAE Automated Function Classification (Fehr and Peers, 2017)



Levels 0 through 2 will operate much like existing vehicles, with the exception that the automated systems may actively intervene for safety reasons, such as lane-keeping and active collision avoidance.

Beginning with Level 3, the dynamics of vehicle operation, the selection of lanes, and even the route itself shift from the occupant to the vehicle itself. As such, decisions on whether to use a HOT facility may be made by the vehicle, possibly without any direct intent from the occupant. Thus, some mechanism will be needed to guide vehicle activities relative to HOT lanes. This mechanism may allow for input from the occupant prior to the trip or may make decisions based on pre-programmed conditions.

Levels 4 and 5 vehicles are fully autonomous without the need for driver intervention. Travel at these levels introduces an overall question of whether the occupants intend to use an HOT facility if available. If occupants simply specify a destination, mechanisms must exist for determining the intent to use or not use an HOT lane. Several elements would be required to enable decisions by occupants of a Level 4 or 5 autonomous vehicle:

- HOT facilities, along with their ingress/egress points, must be accurately mapped and made available to navigation systems as some automated systems rely on detailed mapping instead of cameras for lane guidance
- Vehicles must provide a mechanism to receive current toll values.
- Occupants must be able to indicate to the vehicle whether they wish to use an HOT facility

Without these mechanisms in place, it will be difficult for autonomous vehicles to use HOT facilities in a non-ambiguous way.

Level 4 and 5 autonomous vehicles also introduce different operational dynamics that can also affect HOT facilities. The primary difference is an expected decrease in “safe” headway spacing between vehicles due to faster, more consistent reaction times and more consistent flow on roadways.

From an operations standpoint, the largest impact of decreased headways will be an effective increase in capacity on the roadway (in terms of vehicles per hour). In one possible outcome, HOT facilities would be able to accommodate increased numbers of vehicles without a negative effect of speeds. The overall impact of this change may be to make HOT use more attractive.

However, the effect will not be limited to just vehicles in the HOT lanes. Barring regulatory action to restrict Level 4 and 5 operation to just HOT lanes, the GP lanes will also see an effective increase in capacity. The resulting decrease in congestion may then make HOT lanes less attractive as they offer less of an advantage to travelers.

Effects

The emergence of non-owner operated vehicles and advanced autonomous vehicles is anticipated to have several effects.

1. Mechanisms are needed to allow a traveler to specify a preference on HOT lane use when they are not actively driving the vehicle.
2. Payment mechanisms are needed to accommodate services, such as ride-sharing, where toll payment may be made by the driver, passenger, or TNC.
3. Improvements in capacity emerging from new vehicle dynamics should be considered. A regulatory/policy discussion should be conducted to assess whether these dynamics should be restricted to or allowed to be more pronounced on HOT facilities.

Connectivity

Wireless communications have undergone rapid evolution over the last two decades. Where in 1997 private data networks struggled to provide 2 Mbit/sec connections over short ranges and mobile networks could only offer 14.4 Kbit/sec, in 2017 technologies offer ubiquitous connectivity with speeds in the hundreds of megabits per second. These advances now allow for data-intensive applications in moving vehicles.

Trends

Vehicle to Infrastructure (V2I)

The most common implementation of vehicle connectivity has been use of a cellular data router as a gateway for various entertainment or vehicle telemetry. One of the earliest examples of V2I systems is General Motors’ OnStar. Initially, OnStar consisted of an analog cellular telephone with an integrated speaker/microphone assembly and activation switch in the vehicle interior. Current models (Generation 10) incorporate 4G LTE data routers and extensive connections to vehicle control systems. Many other manufactures have implemented similar systems, allowing for high-speed connectivity on most roadways.

Two companies have leveraged these systems to interface with traffic management systems. Traffic Technology Services (TTS) has partnered with Audi USA to provide signal phase and timing data directly to the vehicle instrument panel. Connected Signals has a similar product, but focuses on delivering data to an application installed on a user’s cellular phone rather than to the vehicle itself.

Parallel to the development of ubiquitous, high-speed data networks has been the emergence of Dedicated Short Range Communications (DSRC) as a V2I specific technology. Originally established in 1999 through an FCC allocation of 75 MHz of spectrum in the 5.9 GHz band, DSRC is characterized by high throughput and low latency for connections. These aspects of DSRC make it attractive for communications between vehicles and roadside infrastructure as well as among vehicles.

The upcoming 5G (ITU-2020) mobile communication standard promises to provide the coverage of a cellular network with the high throughput and low latency of DSRC. This technology offers manufacturers the promise of a "one-chip" solution to enable all vehicle to anything (V2X) communications with a low cost, low component count design. 5G will also be suitable for safety critical applications (anti-collision, etc.), making its use attractive for many purposes.

Personal Connectivity

Advances in vehicle connectivity have largely been driven by the development of extremely compact, high-performance handsets carried by individual users. In 1997, approximately 27 percent of Americans had a cellular phone, which was used primarily for voice calls, with SMS or data being less common. By 2017, over 81 percent of the population had cellular phones, with 19 percent relying on it for primary access to on-line content and 7 percent having no alternate method for accessing data.

This shift in data connectivity methods has shifted the software market to cater to these users, with applications optimized for mobility and smaller displays. The compliment of sensors included with modern handsets includes GPS, accelerometers, digital compasses and in some cases proximity and temperature sensors.

Combined with the emergence of 5G networks, the advances in handsets may compete directly with in-vehicle systems. In addition, they provide the ability to work outside the vehicle, enabling pedestrian safety applications and universal payment mechanisms.

Infrastructure Free Tolling (mileage user fee)

The advances in V2I and personal connectivity enable radical changes in how HOT facilities operate. Current designs rely on fixed points to determine use and implement billing mechanisms. These may be overhead transponder or license plate recognition systems or (less commonly) a toll plaza with some combination of physical cash payment booths and free flow payment systems. The availability of ubiquitous positioning and communications systems may make these designs obsolete.

An application running on a vehicle or cellular handset could compare its position to a set of "geofenced" coordinates that define an HOT facility. Users could then be charged for only that section of the lane used, and could enter and exit at any point (where the lane geometry allows). The system would eliminate the need for HOT transponders and roadside infrastructure.

If this model of operation is practical to implement, there is no technical constraint preventing it to be used elsewhere. All roads could be geofenced and mileage based user fees implemented in place (or in addition to) gasoline sales, wheelage, and registration taxes. By providing "back-end" integration with other systems, this mechanism could also be used for parking payment and even mileage-based transit payment, where users are charged only for the portion of the route on which they rode.

There are several equity, security and privacy issues that emerge with large-scale implementation of infrastructure-free systems, including:

- Ensuring that users cannot be improperly or illegally charged
- Management of the data to ensure that individual locations cannot be accessed by unauthorized parties
- Payment mechanisms for those who do not have or cannot afford data services
- Application development, testing, and distribution across multiple hardware and operating system platforms

These issues will need to be addressed for infrastructure-free systems to successfully replace the traditional methods.

Effects

The effects of evolving communications technology are wide-ranging and momentous. These include:

- The ability to track not just the location of every vehicle, but the specific travelers in each vehicle.
- Elimination of electronic HOT lane specific roadside and in-vehicle infrastructure systems, leaving only signing and striping.
- Coordination of payment systems across multiple modes and services without requiring any additional devices or systems at either the user or facility level.
- Some parsing mechanism will also need to be implemented to deal with multiple passengers in a single vehicle, all of which may pay the HOT lane tolls.

Interoperability

All the above trend areas carry a common theme: exchanges of data between disparate systems or "interoperability". Integration of data handling systems has been the dominant theme in information technology for decades and with the emergence of "cloud"-based storage and computing systems, nearly all data can be made ubiquitously available.

Trends

There are several major areas of interoperability that will be affected by the evolution of communications and vehicle technologies. These are summarized below.

Ride-Share to Toll System

Ride sharing may be using driver-operated private vehicles (Lyft, Uber, etc.) or via some future service employing autonomous vehicles. In each case, the question of who is responsible for the toll (passenger or provider) and mechanism of payment must be resolved. Interoperability between the provider payment mechanism and the HOT payment mechanism may resolve these issues.

Toll System to Toll System

Electronic toll payments were introduced in the United States in 1989 and are now the dominant model for HOT facilities. Early systems used a variety of proprietary solutions, leading to the establishment of the E-ZPass network in 1996. Currently used by 14 states, this system allowed for travelers to pass through multiple tolling systems while using a single transponder and payment mechanism.

In 2012, the MAP-21 (Section 1512(b)) act mandated that:

"Not later than 4 years after the date of enactment of this Act, all toll facilities on the Federal-aid highways shall implement technologies or business practices that provide for the interoperability of electronic toll collection programs."

However, in 2017, nationwide interoperability has still not been achieved. For example, integration of Florida's SunPass with the E-ZPass network is an on-going effort.

Minnesota's approach to interoperability has been to install multi-protocol readers in an effort to support the transponder technology from different systems used in other parts of the country. MnDOT is also currently working with the Illinois Tollway Authority and the EZ Group to become interoperable.

However, all interoperability efforts are comprised of the same two basic functions: reading data from a tolling device in a vehicle and processing payment. The advances in communications noted above may make the technical resolution of these issues much simpler: a personal or vehicle device may communicate using a standard "over the air" protocol to either a roadside device or simply to a data center in an "Infrastructure Free" system. This model is unlikely to be implemented in the short term (one to two years) as suitable 5G products are not yet available and transportation systems have recently made investments in toll collection systems to promote interoperability. However, as the current generation of tolling systems is eventually replaced, a system based on standard communications technology may become increasingly attractive for cost and ease of implementation reasons.

Toll System to Parking and Transit

As communications systems become more capable and ubiquitous, unified payment mechanisms become possible across nearly all transactions, including parking, transit and even non-transportation applications. Numerous systems are beginning to pursue this model, such as Apple Pay, Google Wallet and Samsung Pay. Currently these systems use Near Field Communications (NFC) to engage in transactions. However, if this approach were adapted to work over somewhat larger differences (such as a DSRC or 5G short-range, ad-hoc connection,) payment for any transportation (or other) services could be integrated.

Effects

The effects of large scale integration of payments for public services are difficult to predict. These are even more difficult to predict when factoring in integration with general purpose payment systems that can be used for any private or public exchange. However, some general effects seem likely:

- In the short term, multiprotocol systems will be the most common way to enable national interoperability among toll systems.
- Over the longer term, the cost and complexity of maintaining multiprotocol systems will make a national standard for payment attractive.
- There will be several digital payment mechanisms available commercially when a national standard is adopted, which will immediately allow integration with payment systems generally.
- Tolling systems (and other public services that accept digital payment) will have larger security concerns, since compromising a parking or toll system can now allow access to an individual's payment mechanism for anything. Therefore, they will be more attractive for attackers.

Environmental Justice and Equity

Environmental justice and equity is a complex issue covering many different facets. Most existing research in this area looks at income-equity or whether wealthier individuals benefit more from HOT lane systems than others. While the ability to use transit and therefore, the HOT lane system, is open to all income levels, a perception still exists that the HOT lane system is only for wealthier individuals. One specific concern is the barrier to entry managed lanes create by often requiring electronic tag transponder ownership linked to a bank account or credit card. Currently, opening a MnPASS account requires a credit or debit card and a minimum initial balance of $25, plus an additional $15 if a customer opts for a switchable tag rather than the free sticker tag (MnDOT, 2017).

The number of individuals lacking access to a bank account by choice or circumstance is as high as 10-20% in parts of the country (Parkany, 2005). In many cases, these individuals have no method to obtain a tag and use the managed lane as a paying user. Some facilities offer video tolling, which charges users based on their license plate instead of a tag. However, license plate tolling rates are often higher than tag rates due to the additional operating costs required (Madi, Wiegmann, Parkany, Swisher, & Symoun, 2013). Other states, such as Texas, allow users to add money to their accounts at cash "top up" kiosks or service centers. The Texas DOT (TxDOT) is trying to expand options for adding cash to transponder accounts to other retail outlets, such as gas stations and grocery stores (Federal Highway Administration, 2008).

Trip-length equity, specifically whether MnPASS' segment-based pricing approach is equitable compared to mileage-based pricing approaches on other HOT lane systems, is another area some MnPASS stakeholders have expressed concern over.

MnPASS segments vary in length from several miles to over eight miles long. As shown in earlier, about half HOT lanes charge per mile, while others charge by segment. While MnPASS segments tend to be longer in outer regions of the metro and shorter closer to downtown Minneapolis and St. Paul, MnDOT divides MnPASS corridors based on bottlenecks. For example, I-394 is divided into two segments, one from CR 101/I-494 to TH 100 and the other from TH 100 to I-94. While the wester segment is nearly double in length, it experiences less congestion than the eastern segment. MnPASS users are mostly paying for express access through the bottleneck between TH 169 and TH 100. Similarly, the shorter eastern segment is not only more congested on average (than the western segment), but experiences long queues to access I-94 in the eastbound direction. MnPASS users on this segment have the additional benefit of bypassing this queue when heading east on I-94.

MnDOT's segmentation of MnPASS lanes based on bottlenecks is also apparent in the differentiation between segments in opposite directions. MnDOT tends to divide the lanes so that users are carried through a given bottleneck. For example, I-35W in the northbound direction goes through the I-494 bottleneck to TH 62. However, in the southbound direction, the bottleneck occurs at TH 62. Therefore, the southbound lanes are divided at I-494, allowing southbound MnPASS users express access through the TH 62 bottleneck.

Future Research Topics

Studying the demographics of MnPASS users/non-users such as income, race, sex, etc. is of particular interest. This analysis requires detailed data sources, which are not always readily available for the respective corridors/areas, and an in-depth analysis to determine correlations. However, with the recent advancements in GPS probe data, which provides origins, destinations, and detailed route information, future research will be able to more easily ascertain this information.

Other topics considered for future research include examining low income discounts to address income-equity concerns. MnDOT is currently developing a pilot low-income discount program to improve MnPASS equity.

A particularly useful resource for environmental justice and equity issues on HOT lanes is the *Guidebook for State, Regional, and Local Governments on Addressing Potential Equity Impacts of Road Pricing* (Federal Highway Administration, 2013).

Transit

Figure 25: Transit using MnPASS

Transit is incredibly important to the MnPASS lanes. One of the biggest benefits of building MnPASS is the increased person throughput along the corridor. While some of the increased person throughput is a result of carpools using MnPASS, transit accounts for much of the benefit. By providing transit with free flow travel times along MnPASS corridors instead of being delayed by congestion, average person throughput rises. The improved level of transit service also attracts additional ridership further improving person throughput. In selecting potential future MnPASS corridors, the extent of existing transit service along the corridor is included in the selection criteria.

To better understand the areas in which MnPASS is currently meeting the needs of transit agencies and areas which need improvement, the project team met with representatives from several agencies. Topics discussed included lane access, station type, park and rides, merging issues, signage, and transit incentives.

Credits

The topic of greatest interest was transit incentives, specifically providing MnPASS credits for those using transit along MnPASS corridors or vice-versa (providing transit credits for MnPASS users). With the former, regular transit users along MnPASS corridors would receive MnPASS toll credits. These toll credits could be used on other days when taking transit isn't an option. The hope is that could attract additional transit riders. However, the incentive could also encourage existing transit users to drive occasionally due to the accumulation of MnPASS credits. This approach also includes some logistical complications, such as identifying eligible transit routes and a method of providing the toll credits to transit users, but with electronic accounts for both systems, linking the two is possible.

The Peach Pass HOT lanes in Atlanta have implemented such a system through a pilot program which began in early 2015. The program provides transit users on particular routes a $2 toll credit per trip ($10/month maximum). Users are required to register their electronic transit card with their Peach Pass number through an online system (State Road and Toll Authority, 2017) .

MnDOT is planning to continue discussions with Metro Transit to evaluate options for incentivizing greater transit use in MnPASS lanes.

Driver Surveys

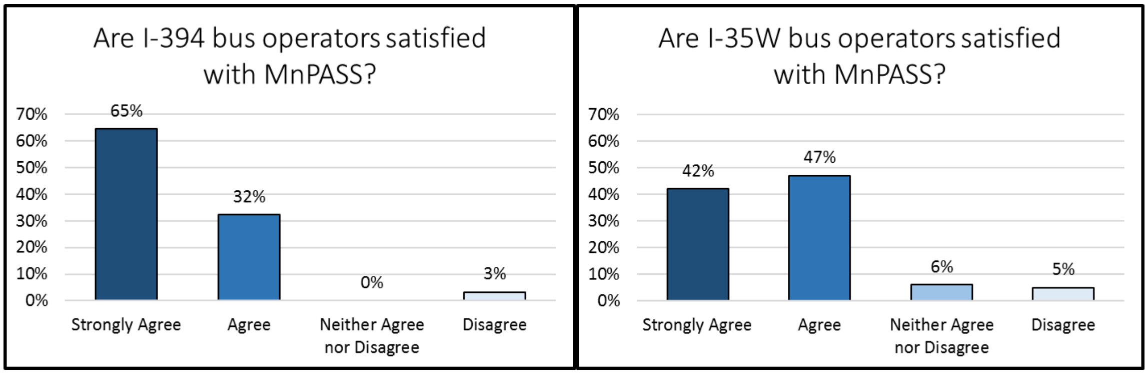
While transit agency representatives had some information on the advantages and disadvantages of the current MnPASS operations, many of the issues are better evaluated by bus drivers experiencing the issues first-hand. An external effort was led by MnDOT to survey Metro Transit bus drivers on their experiences with MnPASS. The Minnesota Valley Transit Authority (MVTA) agreed to extend this survey to their drivers, as well.

A total of 204 bus drivers, 73 from Metro Transit and 131 from MVTA, elected to take part in the MnDOT survey, providing insight into the operation and functionality of the I-35W and I-394 MnPASS lanes. MVTA bus drivers utilize MnPASS lanes more frequently than Metro Transit bus drivers and tend to use I-35W, while Metro Transit bus drivers tend to use I-394. 83% of MVTA bus drivers frequently use MnPASS lanes, as opposed to 56% from Metro Transit bus drivers.

Metro Transit and MVTA bus drivers perceive MnPASS lane benefits in the following order: faster trips, safer trips, and less stressful trips. MnPASS lane benefits were perceived higher by

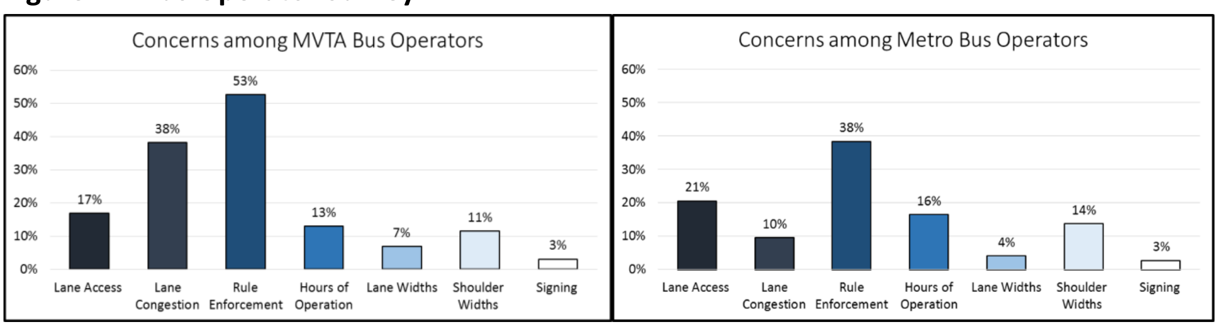
Metro Transit bus drivers, but both groups had 90+% agree or strongly agree perceptions of the overall satisfaction of the MnPASS lanes. There was a higher satisfaction rating among I-394 users, as 65% strongly agree and 32% agree. The satisfaction rating among I-35W users was 42% strongly agree and 47% agree.

Figure 26: Bus Operator Survey 1



Both groups show high concerns with rule enforcement, followed by intermediate level concerns with lane access, hours of operation, and shoulder widths. The one key concern difference between the two companies lies with MVTA bus drivers also having a high concern with lane congestion, likely due to MVTA's greater use of I-35W. Suggested improvements for MnPASS lanes from MVTA and Metro Transit bus drivers include improving lane access, safety, hours of operation, and system expansion.

Figure 27: Bus Operator Survey 2



Freight

There are several issues associated with implementing HOT lane freight policies, such as allowing or prohibiting trucks and charging higher tolls for trucks. This document provides a first look at the various challenges and opportunities to consider before deciding to move forward with further research and feasibility planning.

Policy

In 2016, the Texas Transportation Institute completed a study to look at the viability of allowing trucks in HOT lanes (Chrysler, 2016). It found only one facility, TEXpress in Dallas, that carries significant truck volumes (nine percent). The study stated that the facility has been successful, because unlike the others, it was designed with the purpose of facilitating truck movement. Payment schedules vary, but truck tolls are normally more significant than those of cars. For example, three facilities that actively allow truck users:

Figure 28: Truck Restrictions

- Katy Freeway: Constant $7.00 per payment point → $21.00 for 11 miles
- TEXpress: Tolls are generally 3-5 times higher than for passenger vehicles
- I-595: Same toll for trucks but corridor (HOT and GP lanes) nearly always operates at free flow speed

Figure 29: Tolls for 3+ Axle Trucks/Trailers

The current policy on the MnPASS lanes is not to provide toll tags to vehicles over 26,000 pounds. However, there are no lane restrictions for trucks during non-tolled hours or if they follow the HOV policy.

Operational Challenges

It is important to understand the operational trade-offs that must be accounted for in the physical design and operation of a HOT facility with trucks. HOT facilities are designed (and in some cases required) to maintain free flow speed. Trucks accelerate, decelerate and turn very differently that passenger vehicles, therefore making it difficult to maintain overall facility speed. Similarly, unless necessary, trucks avoid traveling through metropolitan areas during commuter peak hours. Therefore, the overall willingness to pay to traverse a congested segment during peak hour is limited. However, that willingness may increase greatly for certain freight customers who must meet tight delivery windows during peak hours. Other operational challenges include:

Left exits, right travel:	HOT lanes are generally located in the center of a freeway facility. On the other hand, trucks generally operate in the right lanes of the mainline. To access the HOT, a truck must move across several lanes of traffic, disrupting traffic flow.
Geometrical Issues:	Many current HOT facilities evolved from HOV facilities designed for commuting traffic and therefore some have geometrical impediments that limit effective truck use.
Signage/Pricing Clarity:	The clear display of variable pricing and related signage is critical to allowing a motorist to make usage decisions at highway speed. A major drawback of including trucks is adding signs and pricing information at entrance and exit points. Adding confusion not only for truckers, but the HOT lanes' primary customer, commuters.
Safety Concerns:	The TTI report identifies survey results that show that one of the reasons commuters use HOT lanes is the allusion of a safer facility due to the lack of the trucks.

Engineering

As mentioned above, many HOT facilities were developed by upgrading existing HOV facilities with ITS improvements. Because these roadways were designed primarily for commuters, often within a tight geometric envelop, they often cannot physically handle truck traffic adequately. If an agency is interested in expanding HOT usage by commercial vehicles, the design of the facility must include the following to be successful:

Incident Clearance Areas:	Shoulders and pull-off areas must be wide enough to handle the removal of trucks from travel lanes during emergency incidents or for maintenance issues
Shoulder Width:	Shoulders must be present to safely handle the operational envelop of a truck
Lane Width:	Lane widths must be wide enough to handle the geometric and operational characteristics of trucks
Roadway/Ramp Curves:	Curves on HOT mainline and ramps must be designed to handle truck movements at speed

Clearance:	Vertical clearance for trucks must be maintained. Any restrictions clearly posted on bridges and HOT entrance points (without causing confusion for commuters)
Pavement Thickness:	Pavement must be designed to handle truck movement
Crash Barriers	Ensure all crash barriers are rated for trucks (particularly on center ramps)
Turning Radii:	Ramp intersections with the surface street network must have adequate turning radii to facilitate wide truck turns
Center Ramp:	Extra care must be taken with all the above factors with the specific nature of center ramps
Multiple Lanes:	Due to the operational characteristics of trucks, considerations to maintain traffic free flow for commuters must be considered

Enforcement

Overview

Discouraging unauthorized use of the HOT facilities has been a goal of MnPASS operations since the first facilities opened on I-394. The presence of violations has several adverse impacts on the system:

- Higher volumes in the HOT lane can decrease travel speeds and increase fees
- Enforcement activities have substantial costs
- The lane geometry poses significant safety concerns when violators are pulled to the left shoulder
- Pulling vehicles over on either the inside or outside shoulder can adversely impact traffic
- Revenue is lost when single occupant vehicles use the lane without a valid transponder

Violation rates vary by location on the system, time of day and congestion conditions. Segments with higher traffic volumes and/or specific enforcement challenges generally have higher violation rates.

To mitigate these impacts, MnDOT has tried several approaches to improve enforcement efficiency and decrease overall violation rates.

Current Enforcement Approaches

MnDOT contracts with the Minnesota State Patrol to enforce the MnPASS lanes. There are currently six troopers assigned full time to enforcing the lanes, with two additional troopers starting in August 2018. Prior to this date, troopers on overtime enforced the MnPASS lanes. Each MnPASS corridor is patrolled by at least one trooper in the morning and afternoon peak. The troopers patrol the corridors and primarily look for vehicles with only one passenger and no MnPASS tag or vehicles crossing the double solid white lines. The troopers have equipment in their squads that can read a MnPASS tag and provide information on when the tag was last read, at what location and whether the individual's MnPASS account is in good standing. Several other tools are also used by the troopers to assist with their enforcement of the lanes.

Flashing Beacons

Flashing beacons originally used on I-394 are currently being upgraded and deployed system wide.

The beacon system interfaces directly with the roadside tolling equipment, and helps the trooper identify whether a vehicle has a MnPASS tag. If a beacon flashes a certain color when a vehicle goes under it, it has a MnPASS tag. The beacon flashes another color if no tag is read.

Vehicle Imaging

Figure 30: Enforcement Assistance CCTV Camera

Recognizing the need for additional tools for enforcement, MnDOT began testing a prototype Enforcement Assistance System (EASy) in 2014.

EASy leveraged the beacon mechanism by using the output, which indicated a successful tag read, in combination with a separate vehicle detector and camera system. By combining a vehicle detector with the reader confirmation signal, it was possible to determine which vehicles had valid transponders and use the camera to take a still image of the passenger side of vehicle which did not have a valid transponder.

When a possible violator was detected, the image was acquired and sent to a simple web interface viewed by a patrol officer who could then assess whether there were passengers in the vehicle. The EASy approach had several advantages, including allowing patrol officer to position themselves where it was safe and convenient and reduce the number of ‘false’ pursuits.

The false pursuit reduction is particularly significant since patrol officers must accelerate to highway speeds, intercept the possible violator, pull the suspect car to the inside (left) shoulder and then issue a citation near of moving traffic. Figure 30 shows the camera assembly used for EASy, with both a visible light and infrared camera installed for evaluation.

While the vehicle detection, imaging and web interface worked as planned for the EASy prototype, image quality for both the visible light and infrared cameras was highly variable. As a result, system performance was not consistently high enough to be a reliable tool for patrol officers.

Notably, varying lighting conditions presented a significant issue for image quality. In direct sunlight, enough light would penetrate the vehicle interior to successfully image the passenger seat. However, under other conditions (notable night and overcast sky) polarized reflections on the vehicle window would obscure the passenger seat and the officer would be unable to determine whether a passenger was present.

 shows the difference between a clearly visible passenger (left), a low-light image (center) and polarized reflections obscuring the passenger (right).

Figure 31: Image Quality Problems

The initial EASy prototype test ran for approximately 14 months, during which time the reliability of the detection, MnPASS interface, imaging, communications and web interface were established with only minor and easily correctable issues encountered. The prototype also established the need for a different imaging system if the approach was to be successful.

Phase 2

Figure 32: Illuminator and CCTV Camera

Building on the successes of the first phase of the EASy prototype, MnDOT began evaluating a more sophisticated combination of a high frame rate, infrared camera synchronized to a high-precision laser vehicle detector and a large infrared LED illuminator array.

By using frame rates exceeding 100 fps, several images can be captured of each vehicle as is passes under a detector and different filters applied. Combined with a much more powerful LED illuminator than was tested in the first phase, the system can deliver enough infrared light to penetrate the vehicle windows and overcome reflections.

Evaluation of the second prototype will occur in two stages: a proof of concept simulating conditions of the Phase I test sites and, if approved, deployment of the system at the same sites used in Phase I for a direct comparison of performance.

Early results from the proof of concept were promising and deployment of the full test is proceeding. Figure 33 shows sample images from the Phase II EASy prototype.

Figure 33: Phase 2 Enforcement Images

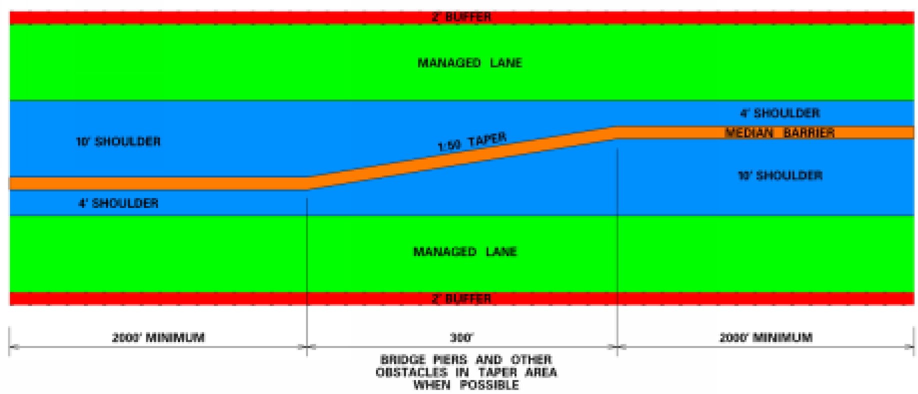
Enforcement Challenges

The unique, mixed-use format and lack of physical separation from the GP lanes present several challenges for enforcement, both from an operational and technological standpoint.

Operational Challenges

The location of the MnPASS HOT lane in the inside lane can create difficulties for enforcement if adequate shoulder space is not available. When designing MnPASS, MnDOT strives for a 12-14 foot inside shoulder. This allows enough space for safe enforcement of the lane. Oftentimes, adequate right-of-way is not available for a 12-14 foot shoulder. MnDOT's "MnPASS Lanes Design and Implementation Guidelines" technical memorandum provides recommendations for these scenarios included reduced inside shoulder widths, intermittent shoulders, and reduced lane widths (MnPASS and GP). Traffic may be adversely impacted by reduced inside shoulder widths as troopers instead pull vehicles over to the outside shoulder. To help address this challenge, MnDOT has developed a new approach for alternating the median barrier to allow for wider intermittent inside enforcement shoulders as shown in Figure 34.

Figure 34: Intermittent Enforcement Shoulders



Technological Challenges

The geometry also makes applying technological aids difficult. The HOT lane is meant to operate at free-flow speeds under all conditions, unlike toll plazas or other dedicated tolling facilities.

The high speeds and lack of separation from the GP lanes limit structures where cameras and illuminators could be placed close to the vehicle, giving rise to the image quality issues observed in EASy Phase I. Therefore, larger, more powerful illumination systems and precise vehicle positioning detectors must be used to allow cameras to be placed 50-70 feet from the vehicle. The current design of MnPASS readers (at which the violation detection system must be placed) has a large gantry directly overhead of the reader location, but typically there are few other options for equipment mounting. These larger systems are more expensive, more challenging to integrate and more susceptible to damage and/or contamination from roadway spray than the simpler devices evaluated in Phase I.

The communications and web interfaces supporting these systems will also be stressed by high volumes of vehicles during peak times. With a peak volume of 1800 vehicles per hour and roughly 50 percent of all vehicles being carpools/vanpools or SOV violators, an officer will be presented with an image, on average, every four seconds. However, vehicle spacing is not uniform, and vehicles are often seen traveling with one second or less headway between them. In practice, officers may receive large streams of images at a rate of one per second or faster. Developing a user interface to accommodate this rate will be a challenge.

Enforcement Alternatives

The challenges described above are a result of the physical and operational characteristics of the MnPASS facility. If these characteristics are flexible, alternative approaches to enforcement may be viable. This section describes some alternatives in use and the changes to MnPASS that would be needed to implement them.

License Plate-Based Tolling/Carpool Registration

One approach to dealing with violations in HOT lanes is to charge vehicles based on the vehicle license plate and send invoices to either the registered vehicle owner or a party that registers the plate on the HOT lane web site. To determine whether toll-free use is permitted, the vehicle owner would register as an "official" carpool on the HOT lane site. Any vehicles not registered as either toll paying or carpools are then invoiced for their use of the HOT lane.

License plate tolling requires installation of cameras that can capture a license plate image at existing toll tag reader locations, implementation of a back-office computer system that can process license plate identification and invoicing, as well as the carpool registration system; and addition of personnel to administer the system.

License plate tolling also requires all HOT users to have an account and tag mounted on their windshield. Currently, MnPASS does not require carpoolers to have a MnPASS account and tag.

The existing infrastructure for mounting equipment does not lend itself to simple adaptation for license plate cameras. Upstream detection device (in-pavement or non-intrusive) may also be necessary to ensure that the vehicle is in the proper position when an image is captured of the license plate.

Despite the above requirements, license plate tolling is currently one of the most effective methods for reducing violation rates and optimizing the performance of a HOT lane system. Virtually all HOT lane facilities throughout the country now utilize license plate tolling.

Automated Enforcement Approaches

Using an automated system to identify vehicle occupancy and issue citations has been attempted at a demonstration level. Typically, an infrared camera and processing system captures an image of the car and then sophisticated algorithms determine if passengers are present. This data is then combined with a license recognition system to identify the specific vehicle and deliver a citation via mail to the owner's home.

The reliability of automated passenger detection systems is not yet well established, but there are several promising systems available.

Use of an automated enforcement system will require the vehicle to be imaged from several angles: the passenger side, the front (windshield) and possibly a separate front license plate camera. For MnPASS, it is likely that a separate structure downstream of the current tag reader gantries would be required.

Automated enforcement is not currently possible in Minnesota. State law requires that an officer issue a citation, and an automated red light enforcement system in Minneapolis was found to be in violation of this requirement and discontinued. Changes to state law will be required if automated enforcement is to be considered and additional equipment mounting locations added at existing tag reader sites.

Future Research Topics

Future research topics could explore the effectiveness of soft enforcement methods, such as posting violation fine signs along the HOT lane corridor. There is currently no signage along MnPASS corridors indicating the fine for violators, however MnDOT is currently considering testing several signs.

Figure 35: HOV/Carpool Violation Signs

Finance

Throughput vs Revenue Maximizing

The primary goal of the MnPASS lanes is to increase person throughput on freeways by providing an incentive to carpool or ride transit, so there will be less congestion and less need for expansion of the freeway system. Some HOT lane systems are focused on maximizing revenue instead of person throughput. Ideally, maximizing performance and revenue would align, but unfortunately, they don't in many cases. This section will discuss the differences between revenue and throughput maximizing HOT lanes and what factors determine the optimal approach for a system.

As discussed earlier, MnDOT's Operations Agreement with the Federal Highway Administration requires speeds in the MnPASS lanes to be maintained at or above 45 mph at least 90 percent of the time, which is managed by dynamically charging SOVs. With tolls capped by a maximum of $8 and exemptions for carpools and transit, the MnPASS lanes are not major revenue generators. Revenue from mature facilitates is approximately equivalent to operating and some maintenance costs.

Ultimately, most of the differences between throughput-maximizing and revenue-maximizing HOT lanes hinge on demand and congestion on the facilities. The greater the demand and resulting congestion on the facility, the more revenue can be generated from them with more tolled lanes, longer operating hours, fewer exemptions, and higher tolls. The largest revenue-generating toll facilities tend to be fully tolled (shoulder to shoulder) roads and bridges in highly congested corridors with few alternative routes, while throughput-maximizing facilities often run concurrent to untolled lanes and exist on facilities with moderate congestion, thereby allowing them to provide exemptions for carpools, transit, etc. and charge lower tolls.

The table below describes common characteristics of throughput and revenue-maximizing facilities.

Table 46: Throughput vs Revenue Maximizing

	Throughput-Maximizing	Revenue-Maximizing
Tolling Hours	Limited to peak periods	24 hours a day
Congestion	Moderate to high	Extremely high
Number of Lanes	One, sometimes 2	2 or more (each direction)
Concurrent Non-Tolled Lanes	Yes	No
Exemptions	Transit, carpools motorcycles, electric vehicles	Limited – possibly transit and larger carpools

Carpool Registration	Often not	Likely (if no transponder)
Transponders Required	Only SOVs	All vehicles
Toll Limitations	Usually less than $10	None or very high
Alternate Routes	Several may exist	Very few or none
Enforcement	Manual	Camera tolling

Financing

Just as throughput and revenue maximizing HOT lane systems have different operating characteristics, the funding mechanism for these systems also tend to differ greatly. The following table looks at the different funding and procurement methods and capital costs associated with small, medium, and large HOT and toll facilities. MnPASS lanes may include a combination of the small and medium HOT lane characteristics depending on the specific corridor.

Table 47: Financial Characteristics of HOT Lanes

	General Characteristics	Funding/Financing	Procurement	Typical Capital Cost
Small (SR 167 HOT Lanes)*	Single lane HOV2 free service generally provided	Pay-as-you-go, substantially grant funded	Traditional, accommodated in DOT work program	$5–50 million
Medium (I-95 Express Lanes)*	Potential capacity enhancement	Mix of grant funding, dedicated and traditional resources	Potential for greater private involvement	$50–500 million
Large (495 Express Lanes)*	Multilane Emphasis on revenue	Debt financed	Candidate for P3, potentially multiphase	$500 million+

(Federal Highway Administration, 2017)

* Example HOT lanes denoted in parentheses

MnPASS Revenue

As mentioned above, revenue from mature MnPASS lanes is generally equivalent to operating expenses and some maintenance. As the system continues to expand, the operating expenses per corridor will decrease and the system will generate more overall revenue.

Future Research

Topics of future research regarding HOT lane finance include new, innovative revenue sources and funding tools

11. Coordination with the Congestion Management Safety Plan (CMSP)

The Congestion Management Safety Plan (CMSP) focuses on identifying locations on MnDOT roadways where spot improvements would provide safety and mobility benefits within a limited return period. Given the overlapping goals of CMSP and MnPASS, it's important to consider each in the context of the other. With the CMSP 4 Study underway, this project conducted a coordination effort to ensure both studies were providing recommendations consistent with one another. In terms of MnPASS, the goals was to determine whether any CMSP improvements would preclude MnPASS from being built by greatly diminishing the benefits or inflating the costs to a point where the return period was too great.

The CMSP 4 and MnPASS 3 coordination effort involved identifying corridors with recommended improvements under both projects and evaluating the benefits and costs of completing one or both sets of improvements. Some affected corridors have concurrent corridor studies, such as I-494/TH 62 and TH 169 south of I-394. In these cases, evaluation between spot mobility improvements and a MnPASS lane was conducted within the corridor study.

Figure 36 shows the CMSP recommended locations along with the System Scenario #3 corridors from this study. CMSP locations in blue are being evaluated within the corridor studies. Therefore, the resulting affected corridors include Corridor 6 (I-94) and Corridor 3c (TH 169). These corridors are discussed in more detail below.

Corridor 6 (I-94)

The CMSP improvement (5102) along this corridor involves the addition of an auxiliary lane. The operational benefits of the auxiliary lane are mostly independent of the addition of a MnPASS lane on the inside of the facility. Additionally, the bridges along this segment could accommodate the addition of both MnPASS and an auxiliary lane without the need for expansion. Therefore, the construction of the auxiliary lane has little impact on the cost of constructing MnPASS as a later date. Given the independence of the costs and benefits of the two improvements, it makes sense to consider constructing both improvements.

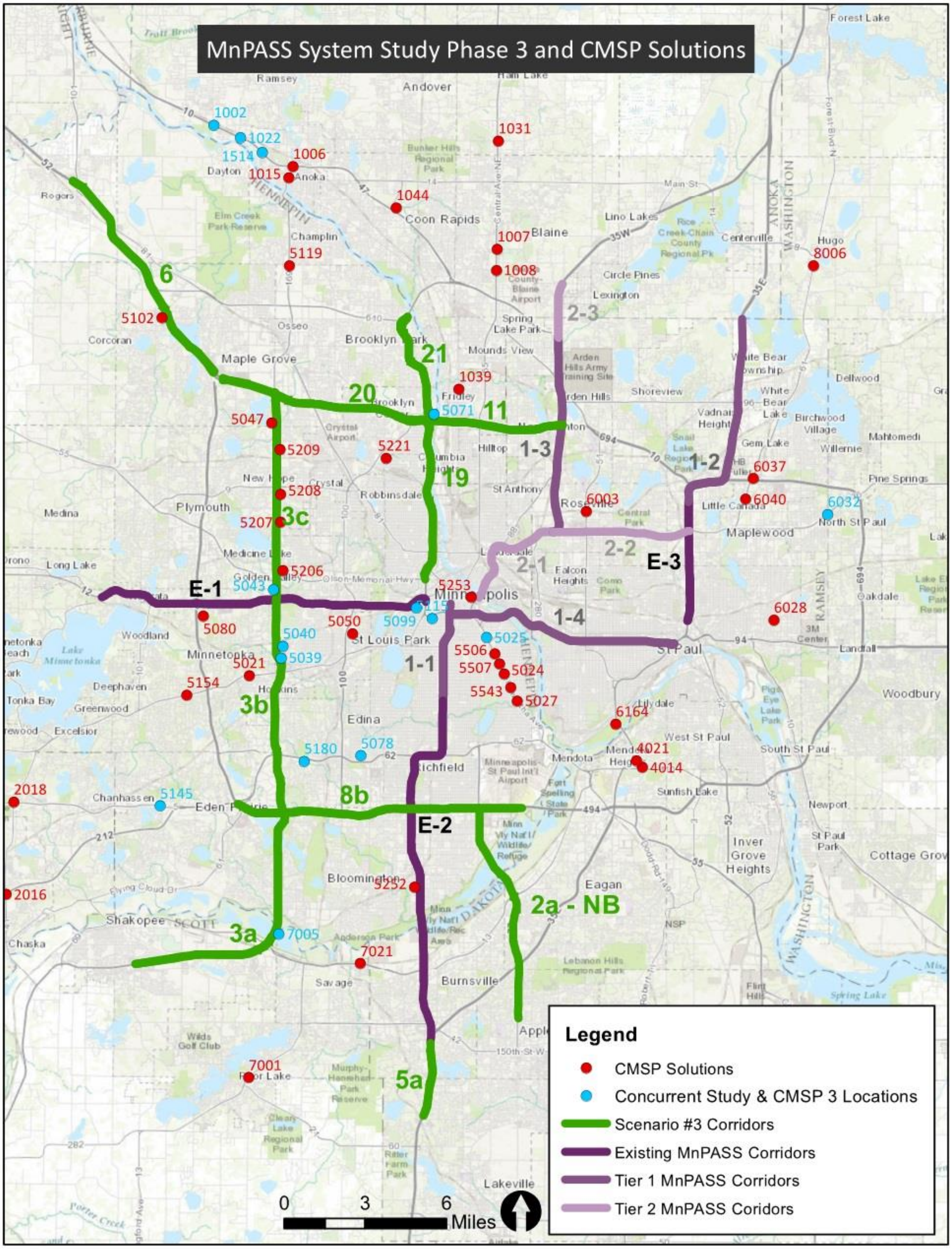
Corridor 3c (TH 169)

The southbound CMSP improvement (5047) includes a merge lane extension with the goal of improving safety. Similar to Corridor 6, the benefits and costs of the CMSP improvement are largely independent of MnPASS. Therefore, both improvements may be considered without precluding the other.

With four proposed CMSP improvements (5206, 5207, 5208, 5209) in the northbound direction of TH 169, a more detailed analysis was conducted. Full results of this analysis are provided in the TH 169 Mobility Study Report. A summary is included here.

The construction of all four CMSP improvements along northbound TH 169 provide a return period of approximately five years. The addition of MnPASS to the corridor would require some additional costs, such as bridge expansions, which wouldn't be necessary if only CMSP or only MnPASS were constructed. Similarly, the benefits of each set of improvements is not entirely complementary. For these reasons, constructing the CMSP improvements is only recommended if the addition of MnPASS is expected to be at least 10 years out. On the other hand, if MnPASS is expected within 10 years of CMSP construction, building just MnPASS would provide a better return on investment.

Figure 36: CMSP 4 and MnPASS 3 Locations



12. MnPASS Spot Mobility Improvements

MnPASS Spot Mobility Improvements are CMSP-like improvements aimed at improving existing MnPASS operations at a particular location without extensive capacity additions. In most cases, the recommendations are focused on improving operations in the adjacent GP lanes, which are creating bottlenecks adversely affecting the MnPASS lanes. Sudden bottlenecks in the GP lanes can cause abrupt merging into the MnPASS lane, as well as a general slowing because of the large speed differential. The following problem locations and recommended improvements have been developed for future consideration.

- I-394 EB – Bottleneck in GP lanes at Louisiana Ave causing influx/slowdown of MnPASS lane

Extend the auxiliary lane under Louisiana Ave. This may require the wall separating I-394 EB from the frontage road (Wayzata Blvd) to be pushed back in order to accommodate the auxiliary lane and the Louisiana Ave entrance ramp.

- I-394 EB – Bottleneck at 12th Street exit to downtown causing delay for vehicles coming from reversible lanes

Add a lane on the right, just before the merge of the EB MnPASS lane with the EB GP lanes and the bridge over I-94. Then provide a two-lane exit to 12th Street.

- I-394 WB – Slowdown in GP lanes coming from downtown causing delay to vehicles entering reversible lane section.

Add a GP lane from downtown to TH 100. Remove the lane drop just west of I-94 and carry lane through to TH 100 by restriping.

- I-35W NB – Slowing of traffic after truck climbing lane ends north of 106th Street

Extend the truck climbing lane north to 98th Street exit ramp.

- I-394 WB – Bottleneck between TH 169 and Hopkins Crossroad

Add slip ramp from CD road for TH 169 NB traffic merging onto I-394 WB forcing an earlier merge and reducing the later merge to only TH 169 SB traffic. An alternative would be to more heavily meter the traffic entering from TH 169.

13. Transit Agency Feedback

To further investigate the benefits of MnPASS expansion, transit agencies were contacted to determine which routes in Scenario #3, if any, these agencies would be interested in adding or increasing service along. Agencies contacted included Metro Transit, Southwest Transit, Minnesota Valley Transit Authority (MVTA), and Plymouth Metro Link. Feedback was received by Metro Transit and MVTA. In general, corridors expected to see the largest increases in transit service are those currently seeing the highest demand rather than corridors with little to no transit service.

Metro Transit

Employees from Metro Transit tended to agree that MnPASS along Corridor 21 (TH 252) and Corridor 19 (I-94) would be most likely to result in increased transit service, although expressed the possibility of new ridership being absorbed by existing service. Additional corridors mentioned included Corridor 2-2 (TH 36) and Corridor 1-4 (I-94).

Employees generally felt that MnPASS along TH 169 (Corridors 3b and 3c) would be most advantageous only if the route provided a faster alternative to I-94 from Maple Grove or I-35W from the southwest metro.

Corridors most likely to see increased Metro Transit service on as a result of MnPASS:

- 1-4
- 19
- 1-4
- 21

MVTA

MVTA expressed their priority routes to include three highways: TH 77, I-35W, and TH 169 in decreasing order of priority. The majority of MVTA express routes utilize these routes heading to downtown Minneapolis and the University of Minnesota. Because of the connection I-494 provides between TH 77, I-35W, and TH 169, MVTA also sees the opportunity for increased service along Corridor 8b.

Corridors most likely to see increased MVTA service on as a result of MnPASS:

- 2a-NB
- 1-1
- 3a
- 3b
- 8b

14. Conclusion

The primary purpose of the *MnPASS System Study Phase 3* is to assist in updating the MnPASS system vision and prioritized list of MnPASS corridors in the 2018 update to the Met Council's *2040 Transportation Policy Plan* (2040 TPP).

MnPASS System Study Phase 3 built on the first *MnPASS System Study* (2005) and *MnPASS System Study Phase 2* (2010). Since the MnPASS Phase 2 study was completed, a significant amount of change has occurred within the Tier 1-3 MnPASS corridors. As a result, there was a need to conduct a MnPASS System Study Phase 3, and the 2040 TPP Work Program listed this study as a priority.

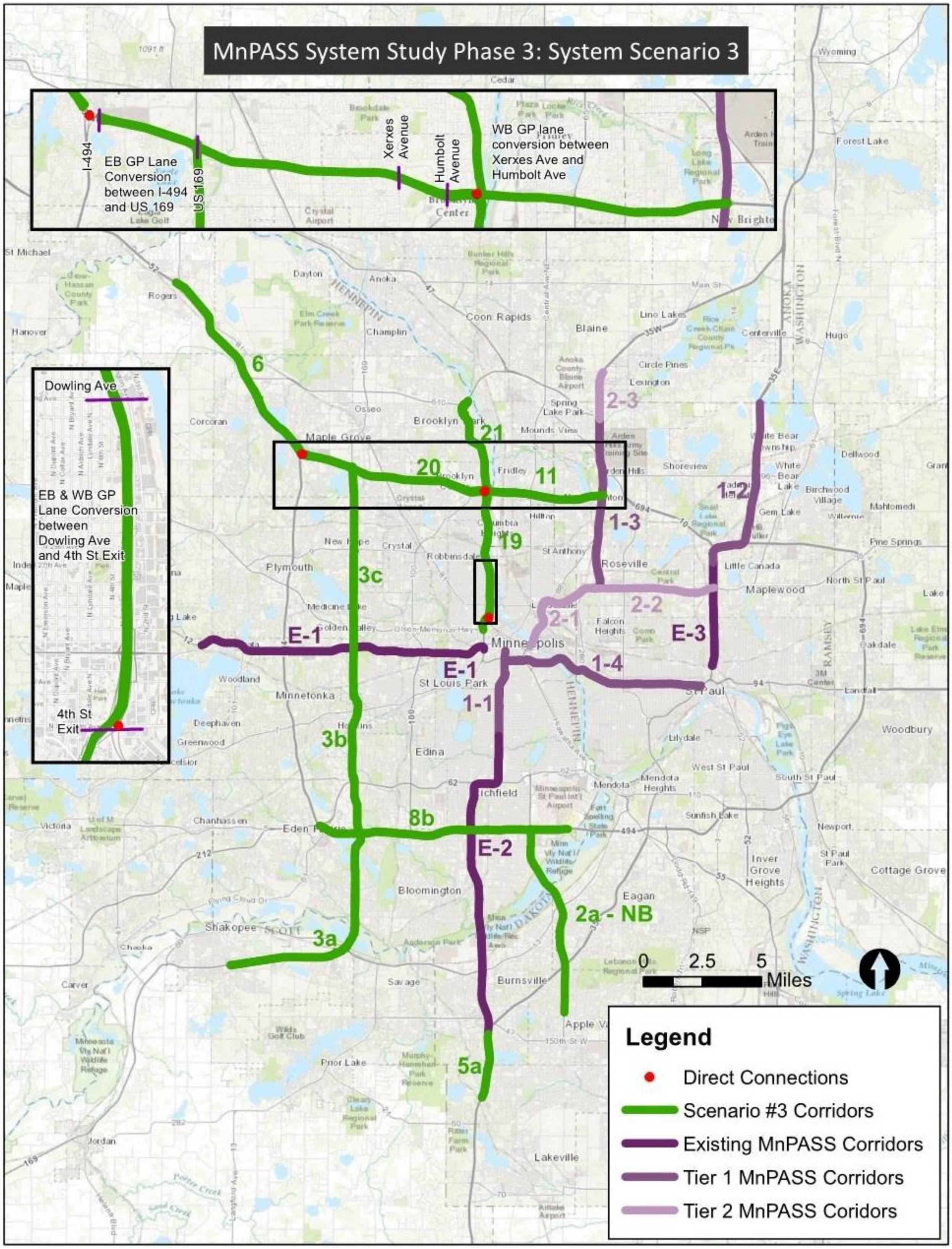
The study process involved working closely with the PMT and TSC throughout, from the initial corridor list development and screening to evaluating the three system scenarios. Resulting from the detailed analysis were a series of key takeaways for consideration in updating the MnPASS vision.

The System Scenario 3 Corridor Map below represents the optimal MnPASS system evaluated in the study. The TPP process should consider these corridors for inclusion, while evaluating other factors like planned preservation work and construction opportunities, mobility funding levels, other recommended improvements such as CMSP, and the I-494/TH 62 and TH 169 studies.

In addition to corridor prioritization, the study evaluated several benefits resulting from MnPASS, including increased person throughput, fewer congested lane miles, and more congestion-free trips. The addition of MnPASS to all Scenario 3 corridors results in providing a congestion-free option along 58% of the Twin Cities congested lane miles. The MnPASS lanes not only maximize total person throughput during the peak periods, but maximize the number of free-flow person trips as well, leading to the minimum total delay for all users (as demonstrated in the I-35W North Corridor Preliminary Design Project).

As MnDOT continues to invest in and build MnPASS lanes, it becomes increasingly important to investigate key issues, risks, and opportunities affecting the current and future MnPASS system. An analysis of seven focus areas covering a wide range of issues was completed. Of particular importance will be the need for MnDOT to consider operational and enforcement challenges, and changes as a result of advancing technology.

Figure 37: System Scenario 3 Corridors



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16. Appendices

Appendix A. MnPASS Phase 3 - Constructability / Affordability Evaluation Table

Corridor ID	Route	From (or at)	To	Length (miles)	Cost per Mile	Corridor Constructability / Affordability	Direct Connection Cost Range	Cost Range for Report
1a	TH 36	I-35W	I-35E	5.2	$2M-$8M	High	$15M-$25M	< $100M
1b	TH 36	I-35E	I-694	6.7	$14M-$24M	Medium		< $150M
2a (NB)	TH 77	138th St. in Apple Valley	Old Shakopee Rd.	8.2	$4M-$7M	Medium-High		< $50M
2a	TH 77	138th St. in Apple Valley	Old Shakopee Rd.	8.2	$8M-$14M	Medium-High		< $100M
2b	TH 77/TH 62	I-494	I-35W	3.8	$8M-$14M	Medium-High		< $50M
3a	US 169	Scott County 17	I-494	10	$8M-$14M	Medium-High		< $150M
3b	US 169	I-494	I-394	8.1	$24M-$35M	Medium-Low		< $250M
3c	US 169	I-394	I-694	7.6	$8M-$14M	Medium-High		< $100M
3d	US 169	I-694	TH 610	3.5	$2M-$8M	High		< $50M
4	I-35E	Ramsey County J/96	Anoka County 14	6.1	$2M-$8M	High		< $50M
5a	I-35	Crystal Lk Rd./ Southcross Dr.	Dakota County 50	3.7	$8M-$14M	Medium-High		< $50M
5b	I-35	Dakota County 50	Dakota County 70	2.7	$8M-$14M	Medium-High		< $50M
6	I-94	MN 101 in Rogers	I-494/694	8.9	$2M-$8M	High	$1M-$5M	< $100M

7a	I-94	Downtown St. Paul (where MnPASS lanes are assumed to end as part of the no-build scenario)	US 61	2.8	$35M-$50M	Low	$15M-$25M	<$200M
7b	I-94	US 61	I-694/494 in Woodbury	4.1	$24M-$35M	Medium-Low		< $150M
8a	I-494	I-394	US 212	7.5	$14M-$24M	Medium		< $200M
8b	I-494	US 212	MN 5/MSP Airport	10.8	$24M-$35M	Medium-Low		< $350M
9	TH 610	US 169	TH 10	6.8	$8M-$14M	Medium-High		< $100M
10a	US 10	I-35W	TH 610	4.3	$2M-$8M	High	$40M-$60M	< $100M
10b	US 10	TH 610	TH 47	7.8	$14M-$24M	Medium		< $200M
11	I-694	I-94 in Brooklyn Center	I-35W	5.6	$2M-$8M	High		< $50M
12	TH 100	I-94	I-394	7.9	$24M-$35M	Medium-Low		< $300M
13a	US 212/TH 62	I-494	I-35W	7.6	$14M-$24M	Medium		< $200M
13b	US 212	I-494	TH 41	9.8	$8M-$14M	Medium-High		< $150M
14	I-494	TH 5/MSP Airport	TH 52	7.9	$35M-$50M	Low		< $300M
15a	I-35E	I-494	Shepard Road	3.6	$14M-$24M	Medium		< $100M
15b	I-35E	Shepard Road	I-94	3.9	$35M-$50M	Low		< $200M
16a	I-394 EB	US 169	TH 100	2.9	$14M-$24M	Medium		< $100M
16b	I-394	TH 100	Downtown Mpls	3.3	$35M-$50M	Low		< $150M

17	I-35W NB	TH 62	26th Street	4.3	$35M-$50M	Low		< $250M
18	I-94	Downtown Mpls (where MnPASS lanes end in no-build scenario)	TH 55	2.2	$35M-$50M	Low		> $500M
19	I-94	TH 55	TH 252	6.0	$14M-$24M	Medium	$5M-$10M	< $150M
20	I-94	TH 252	I-494/694	7.7	$24M-$35M	Medium-Low	$5M-$10M	< $300M
21	TH 252	I-94	TH 610	3.9	$35M-$50M	Low		< $200M

Appendix B. PMT and TSC Members

Project Management Team (PMT) Members

Organization	Name
Minnesota Department of Transportation	Brad Larsen (Project Manager)
	Pat Bursaw
	Mark Nelson
	April Crockett
	Jon Solberg
	Michael Corbett
	Gina Mitteco
	Jason Junge
	Ken Buckeye
	Brian Kary
	Paul Czech
	Jim Henricksen
	Carl Jensen
Metropolitan Council	Mark Filipi
	Steve Peterson
	Carl Ohrn
	Tony Fischer

Technical Steering Committee (TSC) Members

Organization	TSC Member(s)
Minnesota Department of Transportation	Brad Larsen (Project Manager)
	Pat Bursaw
	Sheila Kauppi
	April Crockett
	Jon Solberg
	Michael Corbett
	Gina Mitteco
	Mike Sobolewski
	Jason Junge
	Ken Buckeye
	Brian Kary
	Paul Czech
	Jim Henricksen
	Sheila Kauppi
	Carl Jensen
	Mark Nelson
Metropolitan Council	Mark Filipi
	Steve Peterson
	Amy Vennewitz
	Carl Ohrn
	Tony Fischer
Anoka County	Doug Fischer
Carver County	Dan McCormick
Dakota County	Mark Krebsbach/Brian Sorenson
Hennepin County	Bob Byers
Ramsey County	Joe Lux
Scott County	Tony Winiecki

Organization	TSC Member(s)
Washington County	Wayne Sandberg
Metro Transit	Craig Lamothe
Maple Grove Transit	John Hagen
Plymouth Metrolink	Same as SouthWest Transit
SouthWest Transit	Matt Fyten
Minnesota Valley Transit Authority	Jen Lehmann
Federal Highway Administration	Ryan Hixson
	Jim McCarthy
Association of Metro Cities	Patricia Nauman (invited)

*When the MnPASS study commenced, SouthWest Transit was managing Plymouth Metrolink. This arrangement has since been dissolved.

Appendix C. System Scenario Corridor Inclusion

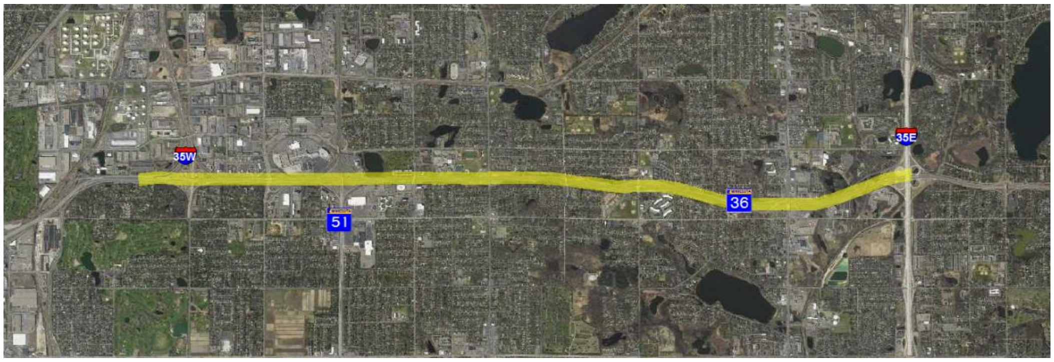
Corridor	Scenario #1/#2	Scenario #3	Rationale for Including or Omitting (from Scenarios #1/#2 or from Scenario #3)
1a	X		Low benefits in system evaluation
1b	X		Low benefits in system evaluation
2a NB	X	X	Performed well in past corridor study and in system evaluation
2a SB	X		Did not perform well in past corridor study
2b	X		Low benefits in system evaluation
3a	X	X	No alternative route. Performed well enough.
3b	X	X	Performed better than parallel route (8a)
3c	X	X	Provides continuity
3d2			Low scoring in initial screening
4	X		Included in system evaluation because it's an extension of existing lanes, but was a low performer
5a	X	X	Included in system evaluation because it's an extension of existing lanes. Moderate benefits but very low cost
5b			Low scoring in initial screening
6	X	X	Tier 3 in TPP. District priority.
7a	X		High cost and cost variability
7b			Low scoring in initial screening
8a	X		Didn't perform as well as competing corridor (3b)
8b	X	X	High performer
9			Low scoring in initial screening
10a			Low scoring in initial screening
10b			Low scoring in initial screening
11	X	X	Provides connectivity at relatively low cost
12			Low scoring in initial screening
13a	X		Strong performer, but didn't perform as well as parallel corridor (8b)

Corridor	Scenario #1/#2	Scenario #3	Rationale for Including or Omitting (from Scenarios #1/#2 or from Scenario #3)
13b	X		Terminus changed to TH 101, then included in system evaluation. Not included in Scenario #3 due to recent preservation work.
14			Low scoring in initial screening
15a			Low scoring in initial screening
15b			Low scoring in initial screening
16a			Low scoring in initial screening
16b	X		On existing MnPASS corridor making it a lower priority. Some dependency on 3b or 3c for higher benefits.
17	X		High cost on an existing MnPASS corridor
18	X		Extremely expensive due to tunnel reconstruction
19	X	X	Moderate to high benefits, relatively low cost. Provides connectivity to other Scenario #3 corridors.
20	X	X	Provides connection to Corridor 6. Moderate benefits and relatively low cost.
21	X	X	Very high performer

Appendix D. Individual Corridor Results

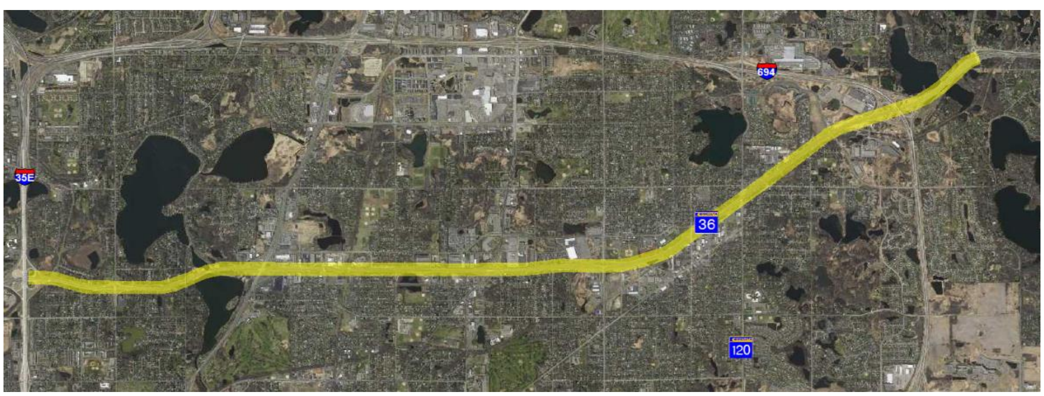
All corridors listed are for consideration of construction of bidirectional MnPASS lanes unless otherwise noted.

Corridor 1A – TH 36 Westbound: I-35W to I-35E



- Segment Length: 4.8 miles
- Severity of congestion: High
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: $50 - $100M
- AM V/C: 1.3 PM V/C: 0.92

Corridor 1B – TH 36: I-35E to I-694



- Segment Length: 6.7 miles
- Severity of congestion: Medium
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low

- Total Construction Cost: $100 - $150M
- AM V/C: 1.05 PM V/C: 0.87

Corridor 2A – TH 77 Northbound: 138th Street (Apple Valley) to I-494

- Segment Length: 6.7 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: $41M[1]
- AM V/C: 1.17 PM V/C: 0.48

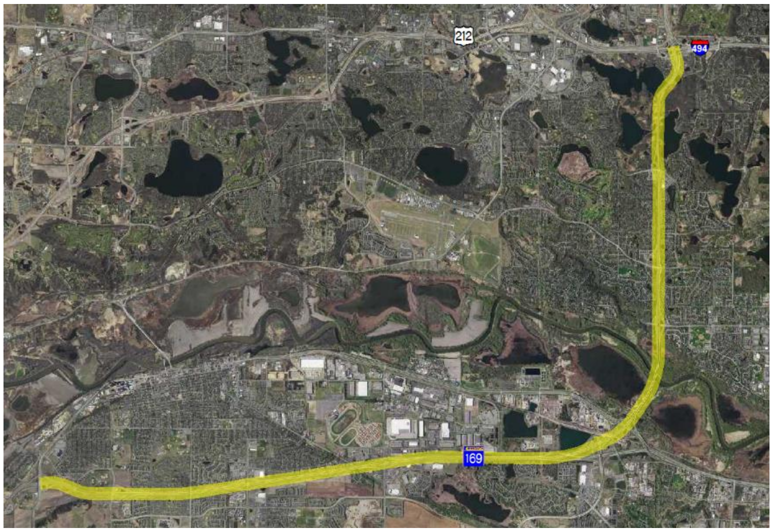
Corridor 2A – TH 77 Southbound: 138th St. (Apple Valley) to I-494

- Segment Length: 6.7 miles
- Severity of congestion: Low
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: <$50 M
- AM V/C: 0.39 PM V/C: 0.97

[1] Source: Highway 77 Managed Lane and Cedar Grove Transit Access Engineering Study, 2014

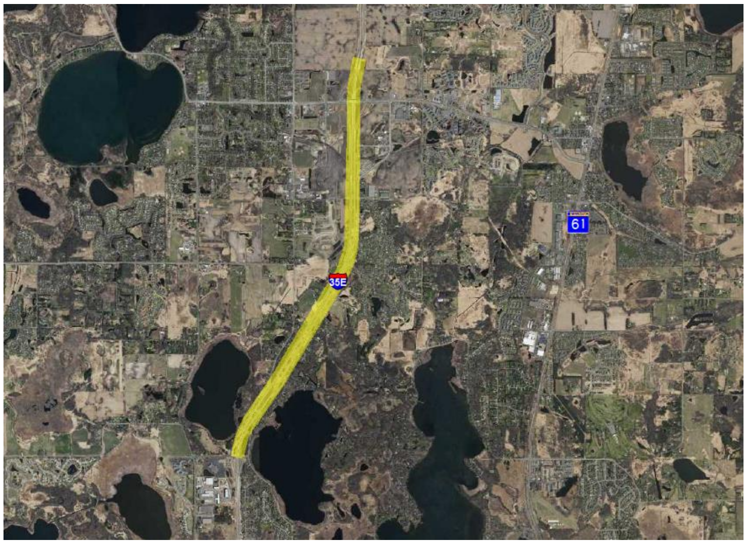
Corridor 3A – US 169: Scott County 17 to I-494

- Segment Length: 10 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Low
- Total Construction Cost: $100 - $150M
- AM V/C: 1.05 PM V/C: 1.06



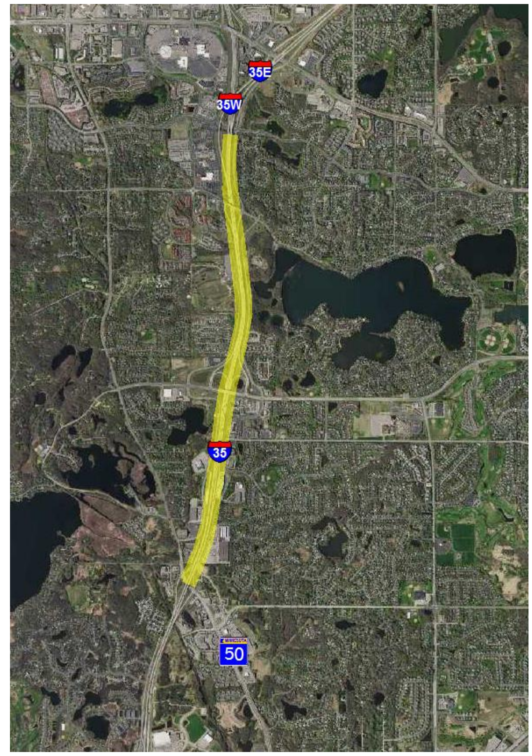
Corridor 4 – I-35E: Ramsey County J/96 to Anoka County 14

- Segment Length: 6.1 miles
- Severity of congestion: Low
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: < $50M
- AM V/C:1.05 PM V/C: 1.00



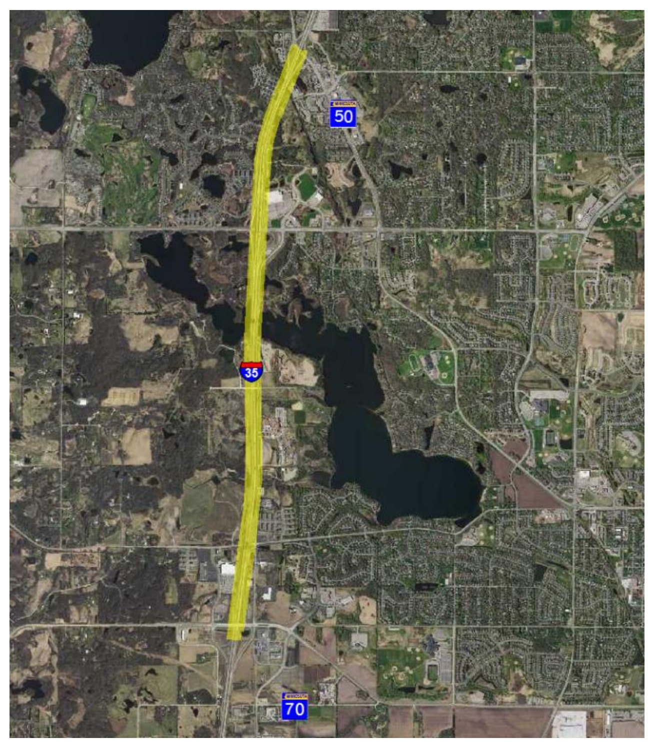
Corridor 5A – I-35: Crystal Lake Road /Southcross Drive to Dakota County 50

- Segment Length: 3.7 miles
- Severity of congestion: Low
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: <$50M
- AM V/C: 1.38 PM V/C: 1.22

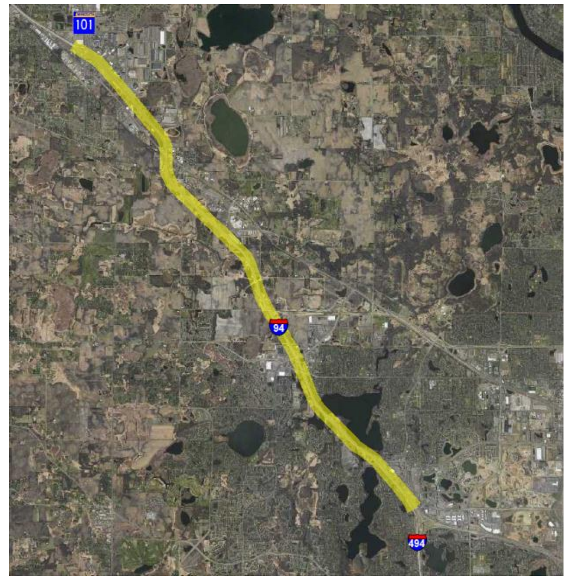


Corridor 5B – I-35: Dakota County 50 to Dakota County 70

- Segment Length: 2.7 miles
- Severity of congestion: Low
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Low
- Total Construction Cost: <$50M
- AM V/C: 1.02 PM V/C: 1.04



Corridor 6 – I-94: MN 101 (Rogers) to I-494/694



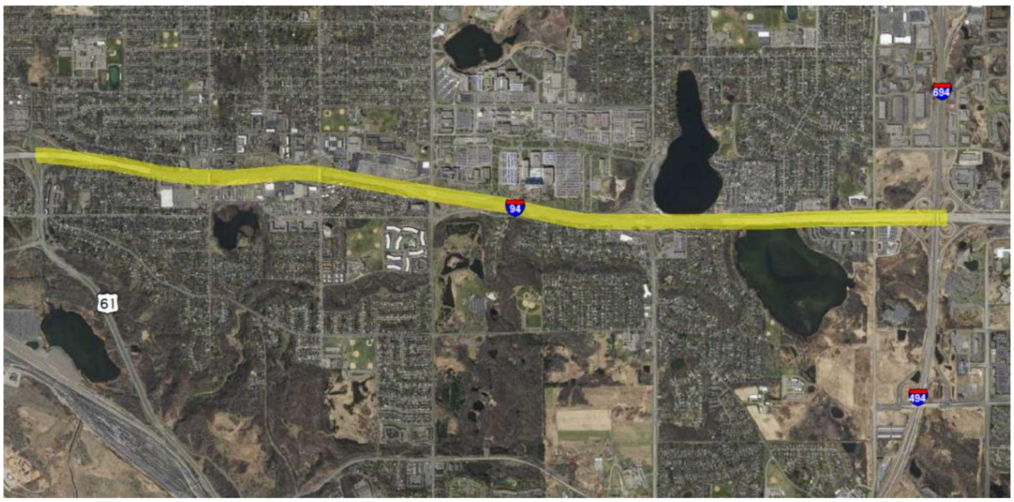
- Segment Length: 8.9 miles
- Severity of congestion: Medium
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Low
- Total Construction Cost: $50 - $100M
- AM V/C: 1.42 PM V/C: 1.10

Corridor 7A – I-94: Downtown St. Paul (where MnPASS lanes are assumed to end as part of the 2040 base scenario) to US 61

- Segment Length: 1.7 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: $150 - $200M
- AM V/C: 1.50 PM V/C: 1.75

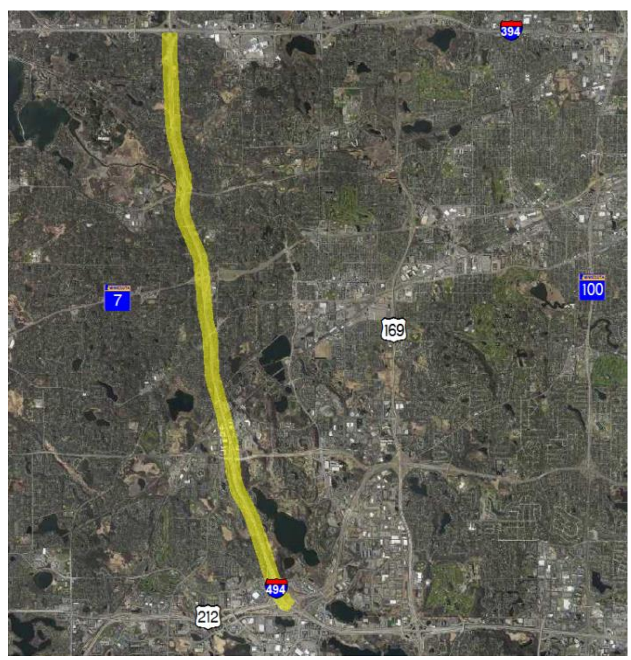
Corridor 7B – I-94: US 61 to I-694/494 (Woodbury)

- Segment Length: 6.2 miles
- Severity of congestion: Low
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Medium
- Total Construction Cost: $100 - $150M
- AM V/C: 1.02 PM V/C: 1.02



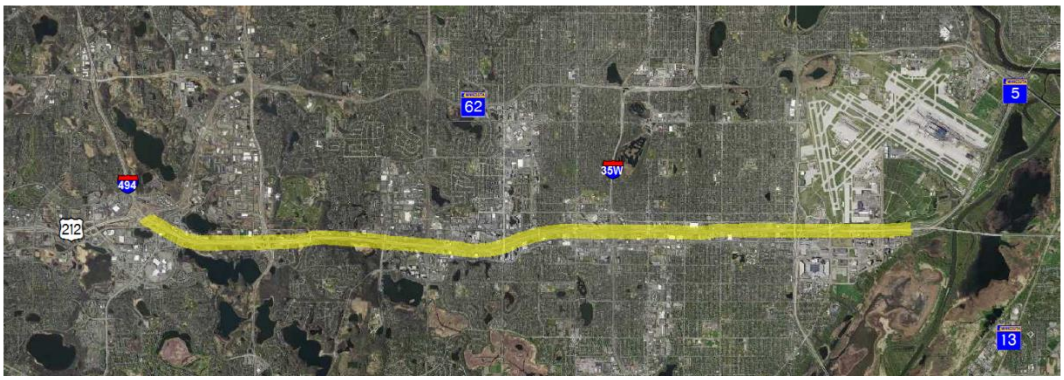
Corridor 8A – I-494: I-394 to US 212

- Segment Length: 7.5 miles
- Severity of congestion: Medium
- Proximity to employment centers: High
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: $150 - $200M
- AM V/C: .98
  PM V/C: 0.94



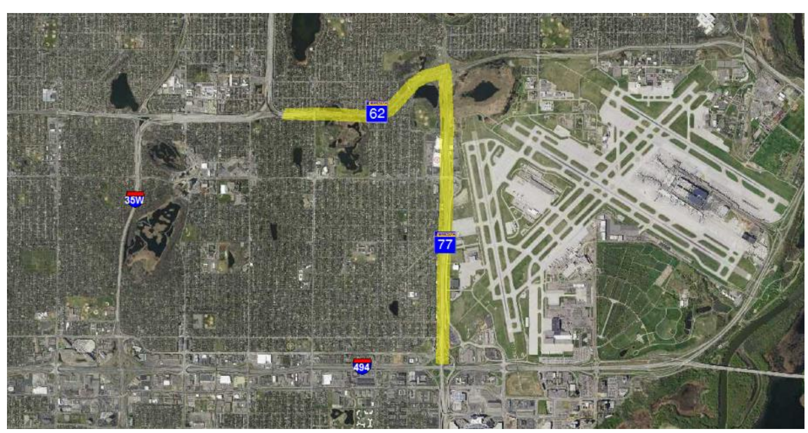
Corridor 8B – I-494: US 212 to MN 5 / MSP Airport

- Segment Length: 10.8 miles
- Severity of congestion: High
- Proximity to employment centers: High
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: $300 - $350M
- AM V/C: 1.31 PM V/C: 1.24

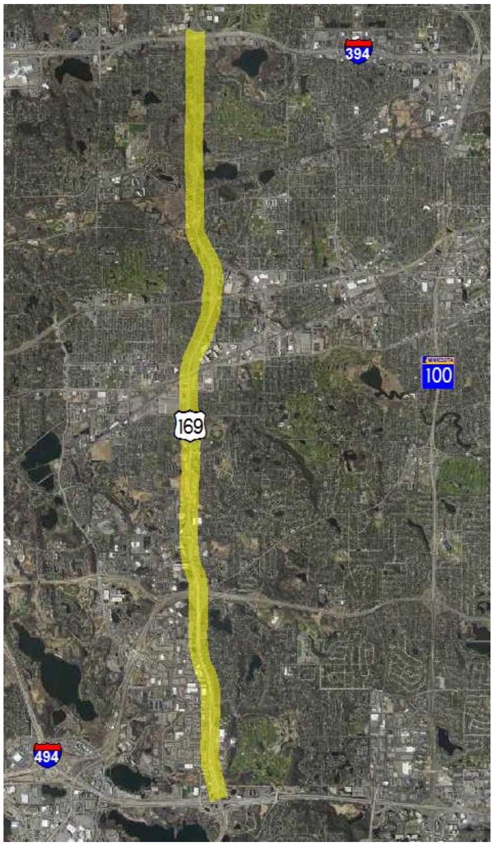


Corridor 2B – TH 77/TH 62: I-494 to I-35W

- Segment Length: 3.8 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: < $50M
- AM V/C: 0.98 PM V/C: 0.96



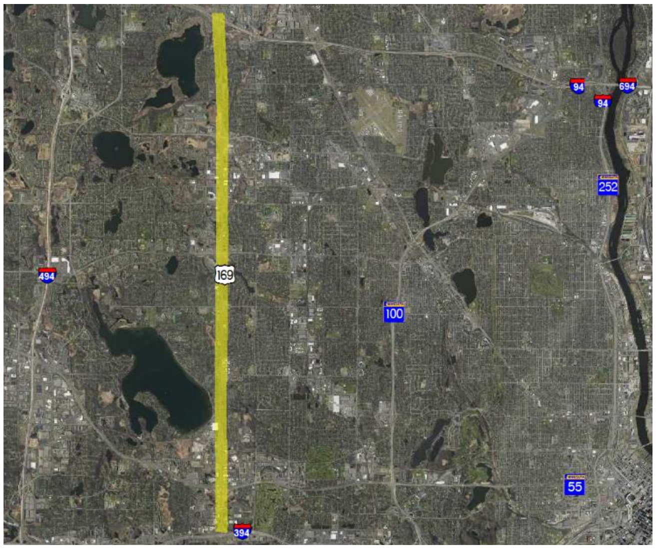
Corridor 3B – US 169: I-494 to I-394



- Segment Length: 8.1 miles
- Severity of congestion: High
- Proximity to employment centers: High
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: $200 - $250M

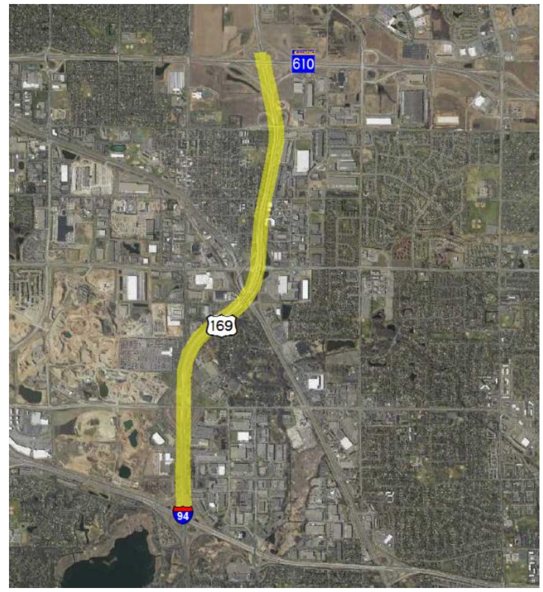
AM V/C: 1.04 PM V/C: 1.02

Corridor 3C – US 169: I-394 to I-694



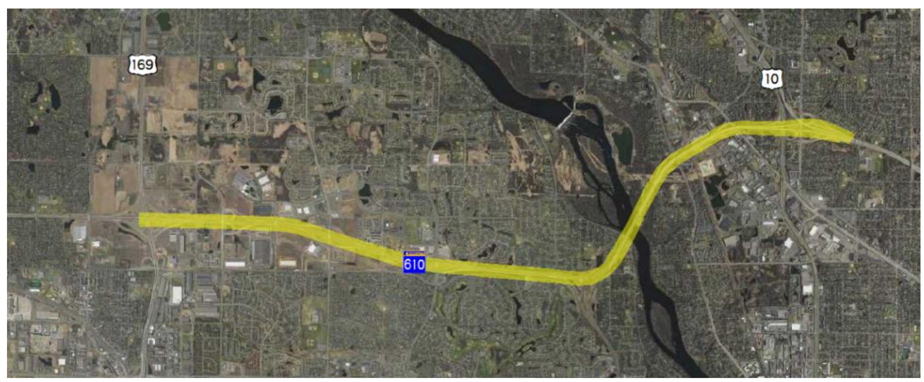
- Segment Length: 7.6 miles
- Severity of congestion: High
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: $50 - $100M
- AM V/C: 1.15
  PM V/C: 1.11

Corridor 3D – US 169: I-694 to TH 610



- Segment Length: 3.5 miles
- Severity of congestion: Medium
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Low
- Total Construction Cost: < $50M
- AM V/C: 1.41 PM V/C: 1.43

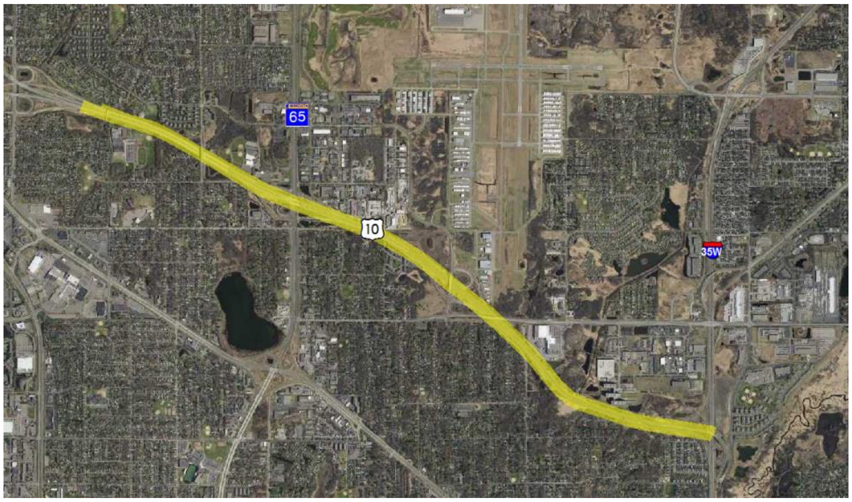
Corridor 9 – TH 610: US 169 to US 10



- Segment Length: 6.8 miles
- Severity of congestion: Low
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Medium
- Total Construction Cost: $50 - $100M
- AM V/C: 0.81 PM V/C: 0.84

Corridor 10A – US 10: I-35W to TH 610

- Segment Length: 4.3 miles
- Severity of congestion: Low
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Medium
- Express commuter bus demand: Low
- Total Construction Cost: $50 - $100M
- AM V/C: 1.03 PM V/C: 0.94



Corridor 10B – US 10: TH 610 to TH 47

- Segment Length: 7.8 miles
- Severity of congestion: Medium
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Low
- Total Construction Cost: $150 - $200M
- AM V/C: 1.4 PM V/C: 1.15

Corridor 11 – I-694: I-94 to I-35W

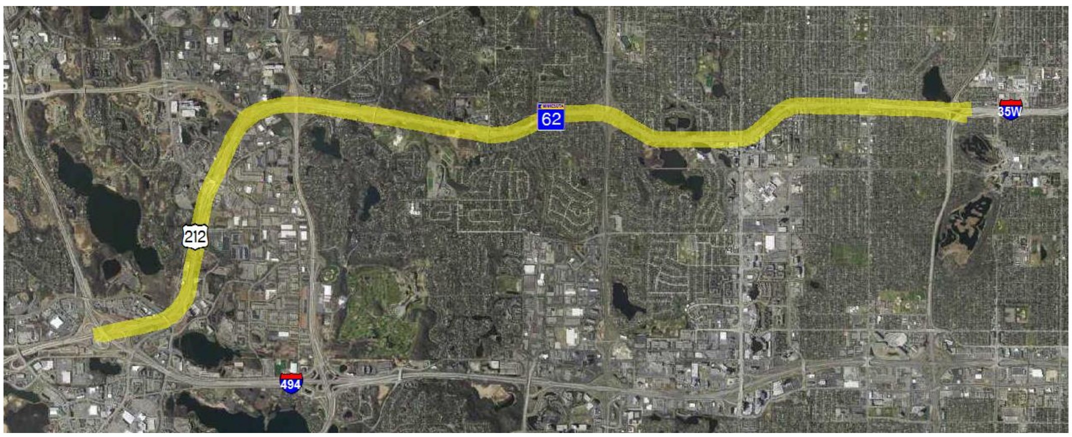
- Segment Length: 5.6 miles
- Severity of congestion: Medium
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Medium
- Express commuter bus demand: Low
- Total Construction Cost: < $50M
- AM V/C: 1.14 PM V/C: 1.07

Corridor 12 – TH 100: I-94 to I-394

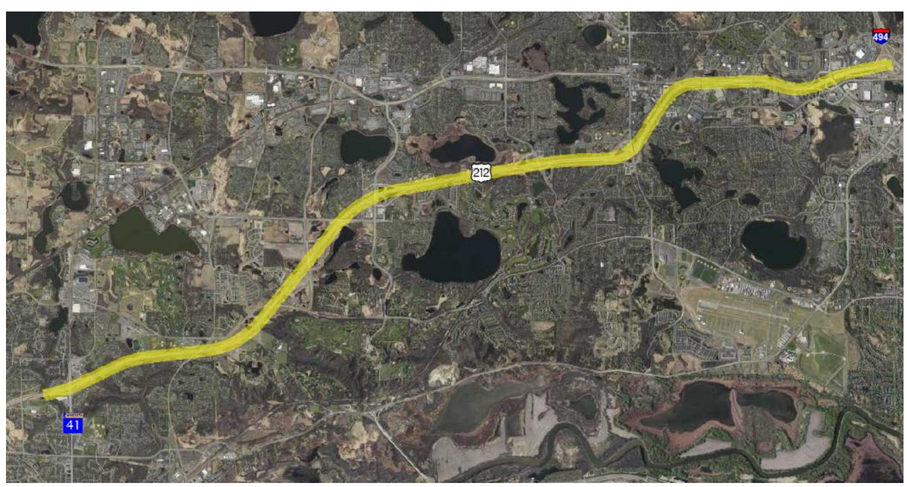
- Segment Length: 7.9 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: $250 - $300M
- AM V/C: 1.23
- PM V/C: 1.18

Corridor 13A – US 212/TH 62: I-494 to I-35W

- Segment Length: 7.6 miles
- Severity of congestion: High
- Proximity to employment centers: High
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: $150 - $200M
- AM V/C: 1.44 PM V/C: 1.38



Corridor 13B – US 212: I-494 to TH 41

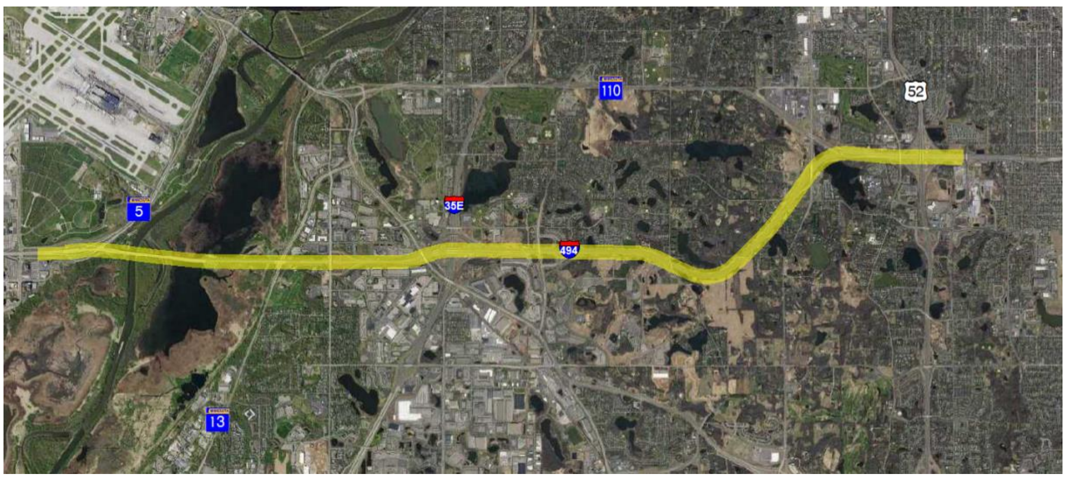


- Segment Length: 9.8 miles
- Severity of congestion: Low
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Medium
- Total Construction Cost: $100 - $150M
- AM V/C: 1.36 PM V/C: 1.22

Corridor 14 – I-494: TH 5/Airport to TH 52

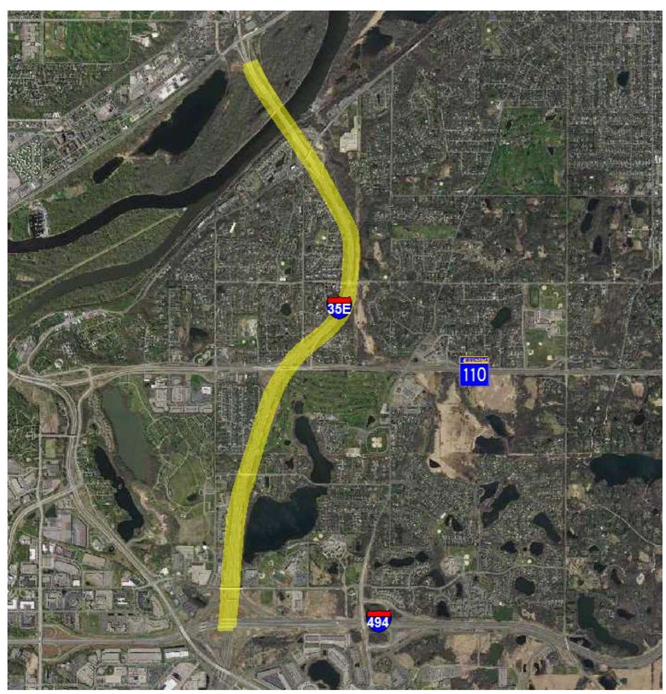
- Segment Length: 7.9 miles
- Severity of congestion: Low
- Proximity to employment centers: High
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: $250 - $300M

AM V/C: 1.05 PM V/C: 0.96

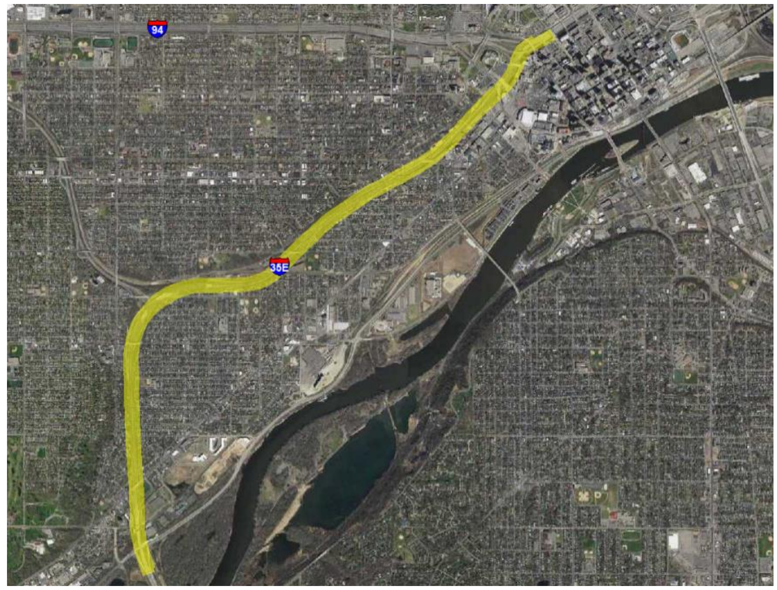


Corridor 15A – I-35E: I-494 to Shepard Road

- Segment Length: 3.6 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Low
- Total Construction Cost: $50 - $100M
- AM V/C: 1.32
  PM V/C: 1.07



Corridor 15B – I-35E: Shepard Road to I-94

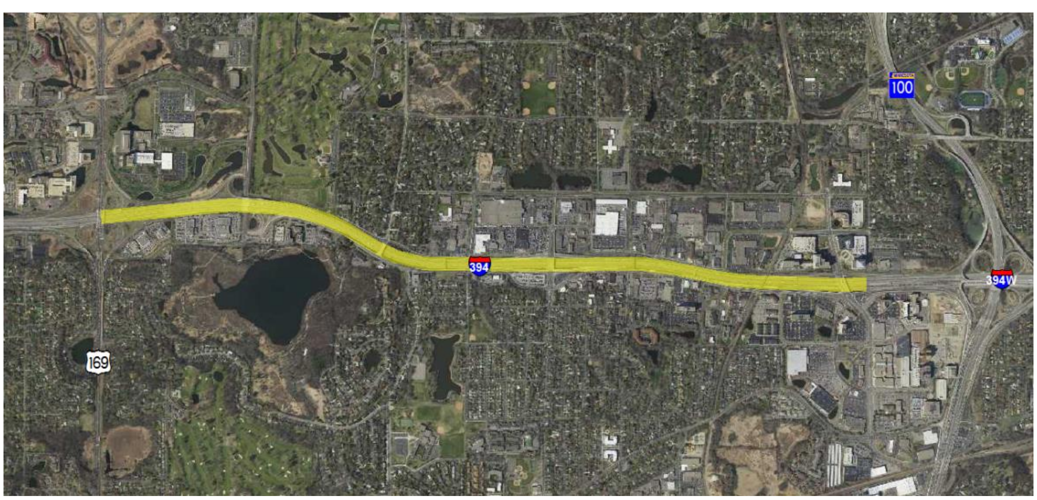


- Segment Length: 3.9 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: Medium
- Express commuter bus demand: Low
- Total Construction Cost: $150 - $200M
- AM V/C: 1.19
  PM V/C0.87

Corridor 16A – I-394 Eastbound: US 169 to TH 100

Construct additional MnPASS lane

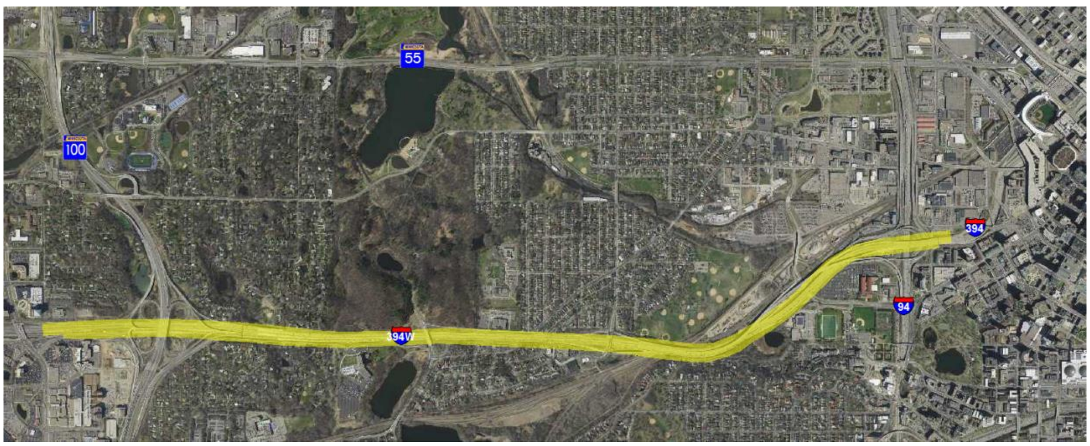
- Segment Length: 2.9 miles
- Severity of congestion: Medium
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Medium
- Total Construction Cost: $50 - $100M
- AM V/C: 0.84 PM V/C: 0.78



Corridor 16B – I-394: TH 100 to Downtown Minneapolis

Fill missing reversible MnPASS section

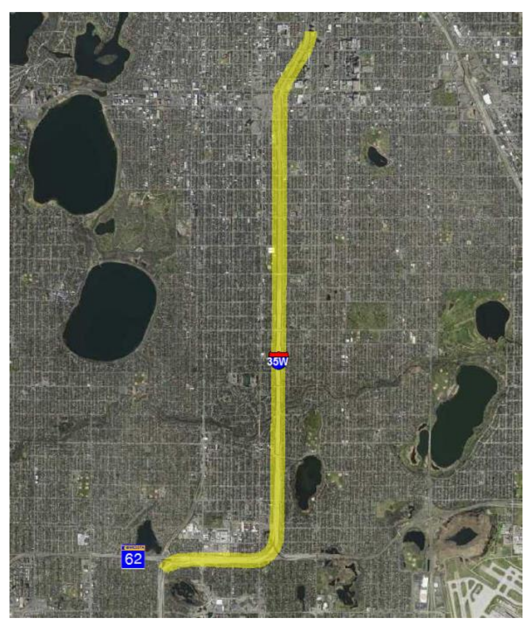
- Segment Length: 3.3 miles
- Severity of congestion: High
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: N/A
- Total Construction Cost: $100 - $150M
- AM V/C: 1.08 PM V/C: 0.87



Corridor 17 – I-35W Northbound: TH 62 to 26th Street

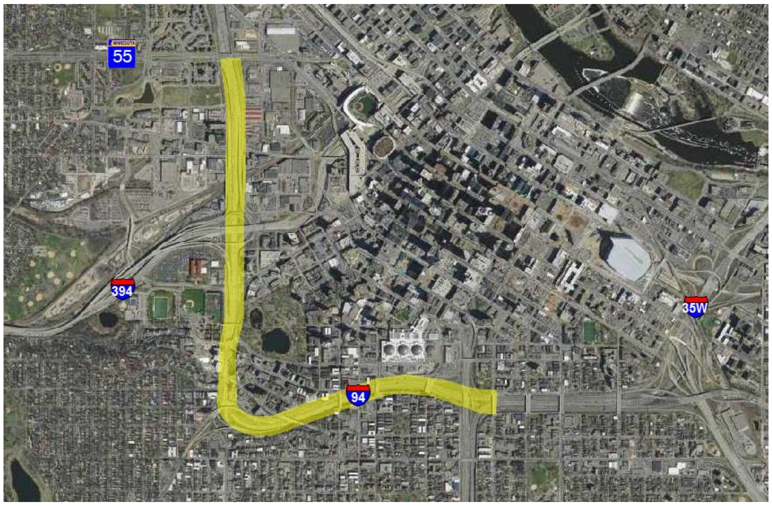
Construct additional MnPASS lane

- Segment Length: 4.3 miles
- Severity of congestion: High
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: N/A
- Total Construction Cost: $200 - $250M
- AM V/C: 1.10 PM V/C: 1.26



Corridor 18 – I-94: Downtown Minneapolis to TH 55

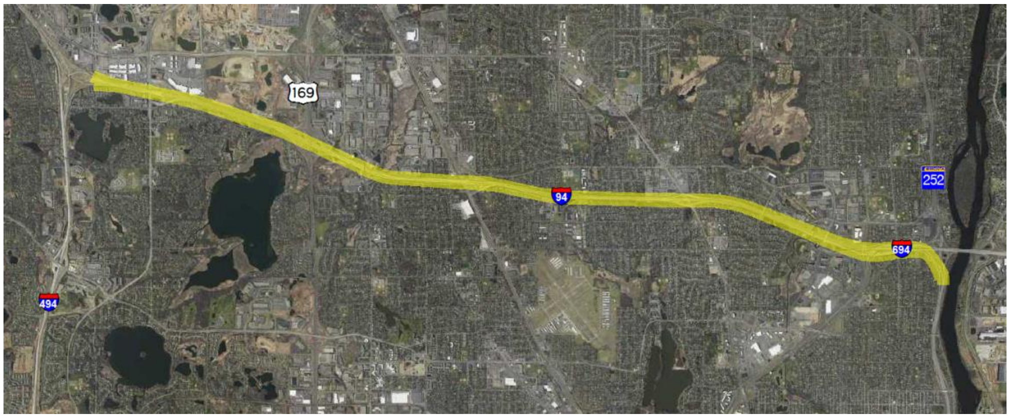
- Segment Length: 2.2 miles
- Severity of congestion: High
- Proximity to employment centers: High
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: Low
- Total Construction Cost: > $500M
- AM V/C: 2.00 PM V/C: 1.98



Corridor 19 – I-94: TH 55 to TH 252

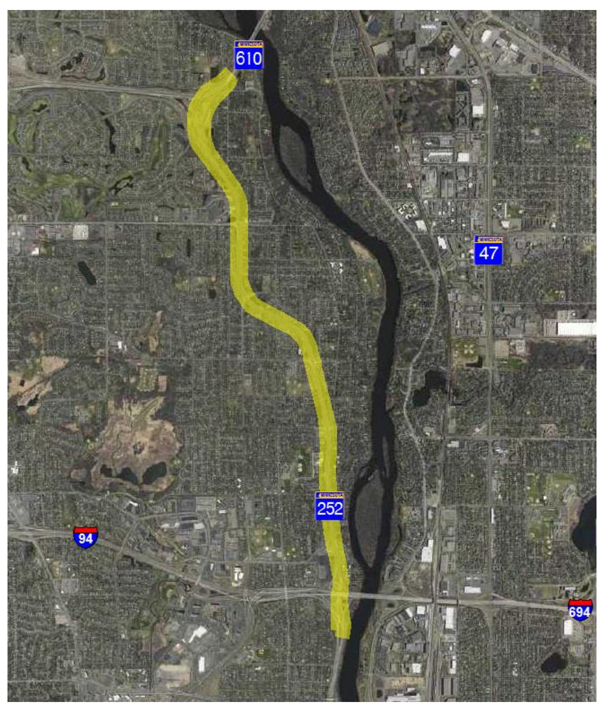
- Segment Length: 6.0 miles
- Severity of congestion: Low
- Proximity to employment centers: Medium
- Connections to other MnPASS corridors & major destinations: High
- Express commuter bus demand: High
- Total Construction Cost: $100 - $150M
- AM V/C: 0.82 PM V/C: 0.74

Corridor 20 – I-94: TH 252 to I-494/I-694



- Segment Length: 7.7 miles
- Severity of congestion: Low
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Medium
- Total Construction Cost: $250 - $300M
- AM V/C: 1.14 PM V/C1.09

Corridor 21 – TH 252: I-94 to TH 610



- Segment Length: 3.9 miles
- Severity of congestion: High
- Proximity to employment centers: Low
- Connections to other MnPASS corridors & major destinations: Low
- Express commuter bus demand: Medium
- Total Construction Cost: $150 - $200M
- AM V/C: 1.5
  PM V/C: 1.35

Appendix E. Review of Previous Studies Technical Memorandum

01 – 2040 Transportation Policy Plan—Chapter 5: Highway Investment Direction and Plan

Study Date: Adopted by the Metropolitan Council January 14, 2015

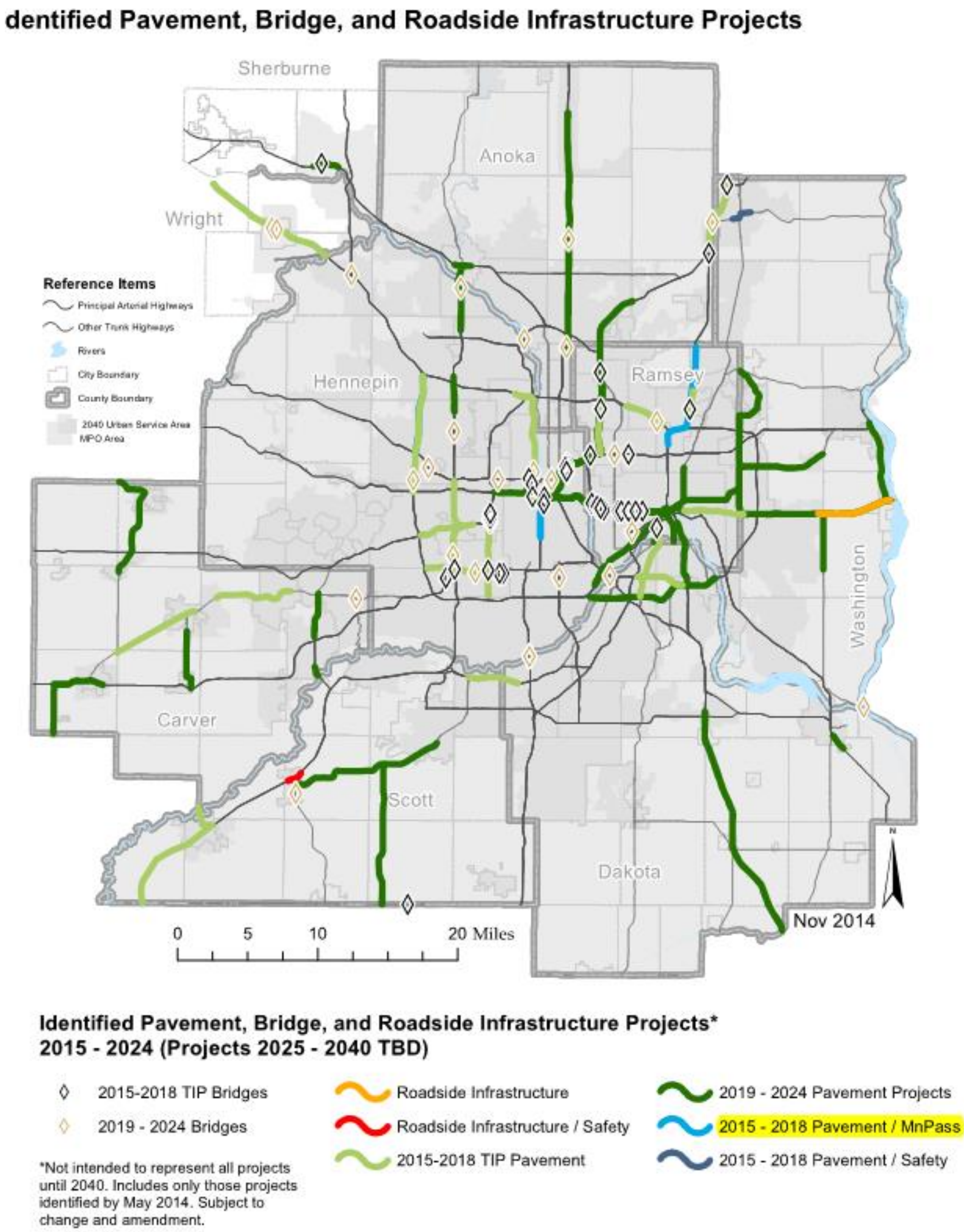
Study Purpose

The 2040 Transportation Policy Plan (TPP) sets policies based on goals and objectives for the regional transportation system. It is one of the major system plans that result from the region's development guide.

Highway Investment Direction and its Relevance to the MnPASS System Study Phase 3

Regional Highway System Investment Prioritization Factors

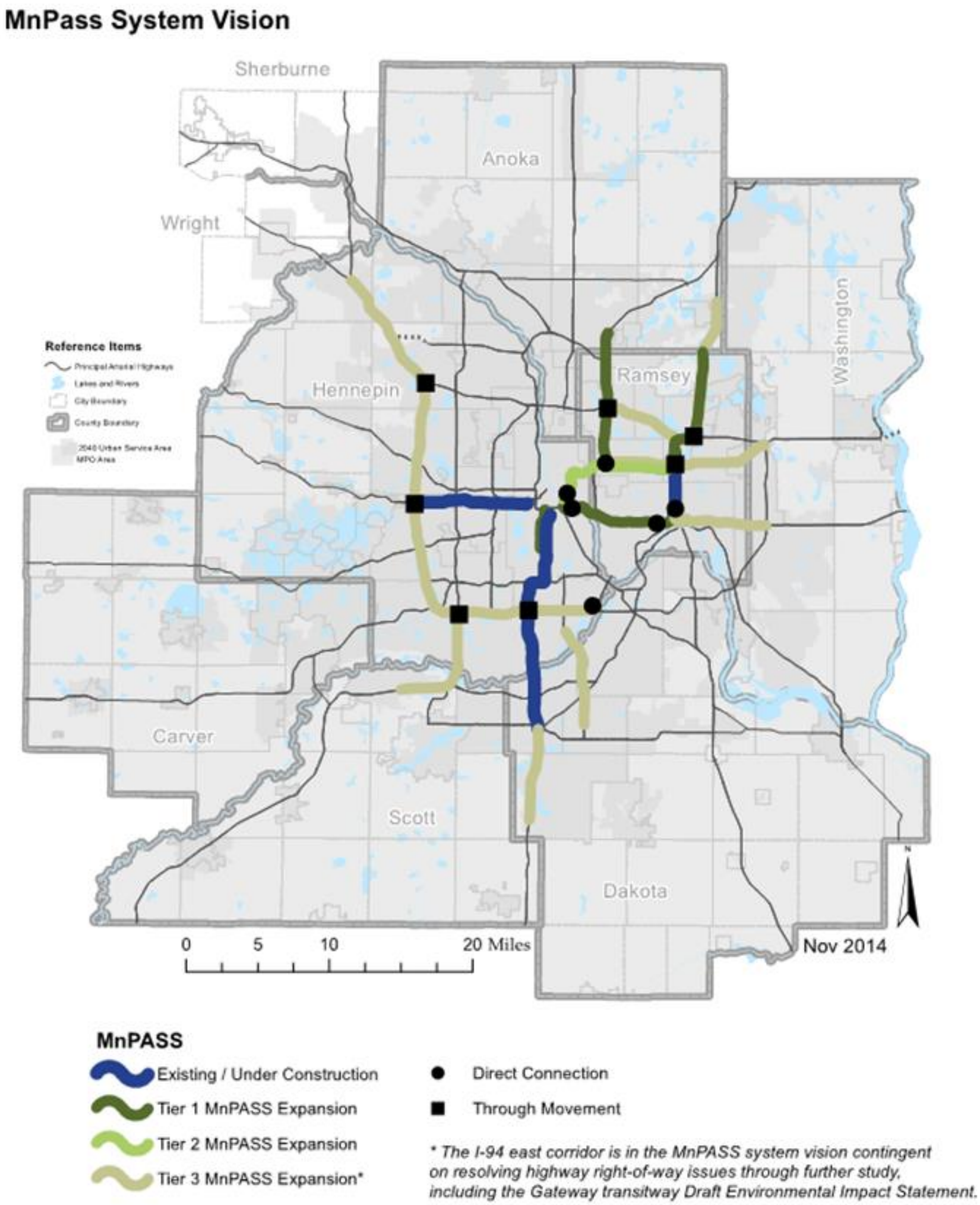
- Investments that Increase Regional Highway System Travel Time Reliability
  - Investments like MnPASS and those made to minor arterial highways seek to provide an affordable and reliable alternative to highway congestion. These types of investments advance the "Access to Destinations" goal and objectives of the Transportation Policy Plan.
- The MnPASS System is identified as the regional mobility improvements under the highway investment categories
- Expansion improvements include new or extended MnPASS lanes, strategic capacity enhancements, and highway access investments. The regional objective of providing a congestion-free, reliable option for transit users, carpoolers and those willing to pay through MnPASS lanes is the region's priority for expansion improvements. General purpose lane strategic capacity enhancements should only be considered if adding capacity through MnPASS lanes has been evaluated and found to not be feasible, the improvement is affordable, and the improvement is approached with a lower cost/high-return-on-investment philosophy. This plan refers to the collection of traffic management technology investments, lower cost/high-return-on-investment spot mobility improvements, MnPASS lanes, strategic capacity enhancements, and highway access investment categories as "regional mobility improvements."
- Identified Pavement, Bridge, and Roadside Infrastructure Projects that are relevant to MnPASS are shown in the following map:



- Regional Mobility Improvements: Traffic Management Technologies:
  - On freeways, full ATM implementation can be more effective when done in conjunction with other corridor-wide improvements such as the construction of a new or extended MnPASS lane.

MnPASS System Vision

- The MnPASS System Vision is estimated to cost $1.8 to $2.4 billion (2014 dollars) which is beyond the funding available in the Current Revenue Scenario. To promote cost-effectiveness and allow for building more of the MnPASS system, this estimate assumes most MnPASS projects will be built in conjunction with major pavement and bridge reconstruction or rehabilitation projects, and with little or no new right-of-way. In some cases, MnPASS projects may require use of flexible design principles to maximize the use of available pavement and right-of-way.
- Between 2015 and 2024, MnDOT will complete two new MnPASS lanes and extend two existing MnPASS lanes. Because of increasing highway operations and rebuilding needs, limited available revenues, and rising cost of construction, MnDOT does not anticipate being able to construct additional MnPASS lanes after 2024 under the Current Revenue Scenario.
- The four projects scheduled for construction prior to 2024 are:
  - I-35W south of downtown Minneapolis
  - I-35W north of Minneapolis
  - I-94 between downtown Minneapolis and Saint Paul
  - I-35E north of Saint Paul
- The following the map of MnPASS System Vision:



MnPASS System Investment Priorities for Current Revenue Scenario

Tier	Route	From (or at)	To	Description	Estimated Cost* (year of expenditure dollars)	Investment Scenario
0	I-394	I-494	I-94 near downtown Minneapolis	MnPASS lanes	Complete	Complete
0	I-35W	I-35W/E south split	South of downtown Minneapolis	MnPASS lanes	Complete	Complete
0	I-35E	I-94	Little Canada Road	MnPASS lanes	Under construction	Under construction
1	I-35W	Downtown Minneapolis	46th Street	Complete southbound MnPASS lane in conjunction with pavement reconstruction and I-35W/Lake Street transit station	Cost in highway asset management	Current Revenue Scenario, 2015-2018
1	I-35E	Little Canada Road	Ramsey County J	Construct MnPASS lanes	$16 million	Current Revenue Scenario, 2015-2018
1	I-35W	MN 36/280	US 10	Construct MnPASS lanes	Approx. $100 million	Current Revenue Scenario, 2019-2024
1	I-94	Downtown Minneapolis	Downtown Saint Paul	Construct MnPASS lanes including direct connections to and from both downtowns	Approx. $100 million	Current Revenue Scenario, 2019-2024

Regional Mobility Improvements

- Regional mobility improvements consist of several types of the 10 investment categories including: (6) traffic management technologies, (7) spot mobility improvements, (8) the MnPASS system, (9) highway strategic capacity enhancements, and (10) highway access to jobs, education, and industry. Potential regional mobility improvements are expected to increase by $4 to $5 billion, but the breakdown by each of these six categories has not yet been determined.

- The Increased Revenue Scenario includes funding for the Tier 2 and Tier 3 MnPASS projects and would result in completing the MnPASS system vision. Consistent with the findings from the MnPASS 2 Study completed by MnDOT in 2010 and the Metropolitan Council's Metropolitan Highway System Investment Study, Tier 2 MnPASS projects should be completed before Tier 3 MnPASS projects unless subsequent corridor studies provide a basis for reprioritizing.

MnPASS System Investment Priorities Under Increased Revenue Scenario

Tier	Route	From (or at)	To	Description	Estimated Cost for MnPASS
2	I-35W	Downtown Minneapolis	MN 36/280	Construct MnPASS lanes	$160-180 million
2	TH 36	I-35W	I-35E	Construct eastbound MnPASS lane	$35-60 million
2	I-35W	US 10	95th Avenue in Blaine	Construct MnPASS lanes	To be developed
3	TH 36	I-35W	I-35E	Construct westbound MnPASS lane	To be developed
3	TH 36	I-35E	I-694	Construct MnPASS lanes	To be developed
3	TH 77	138th Street in Apple Valley	Old Shakopee Road in Bloomington	Construct MnPASS lanes	$41 million
3	US 169	Scott County 17 in Shakopee	I-494	Construct MnPASS lanes	$80-$115 million
3	I-35E	Ramsey County J	Anoka County 14	Construct MnPASS lanes	To be developed
3	I-35	Crystal Lake Road/ Southcross Drive in Lakeville	Dakota County 70	Construct MnPASS lanes	To be developed
3	I-94	MN 101 in Rogers	I-494/694	Construct MnPASS lanes with southbound direct connection to I-494	$70 to $95 million
3	I- 94	Downtown Saint Paul	I-694/494 in Woodbury	Construct MnPASS lanes	To be developed
3	I-494	I-94/694	I-394	Construct MnPASS lanes	To be developed
3	I-494	I-394	US 212	Construct MnPASS lanes	$70 to $150 million
3	I-494	US 212	MN 5/MSP Airport	Construct MnPASS lanes	$150 to $185 million
3	I-694	I-35W	I-35E	Construct MnPASS lanes	To be developed

Highway Investment Summary

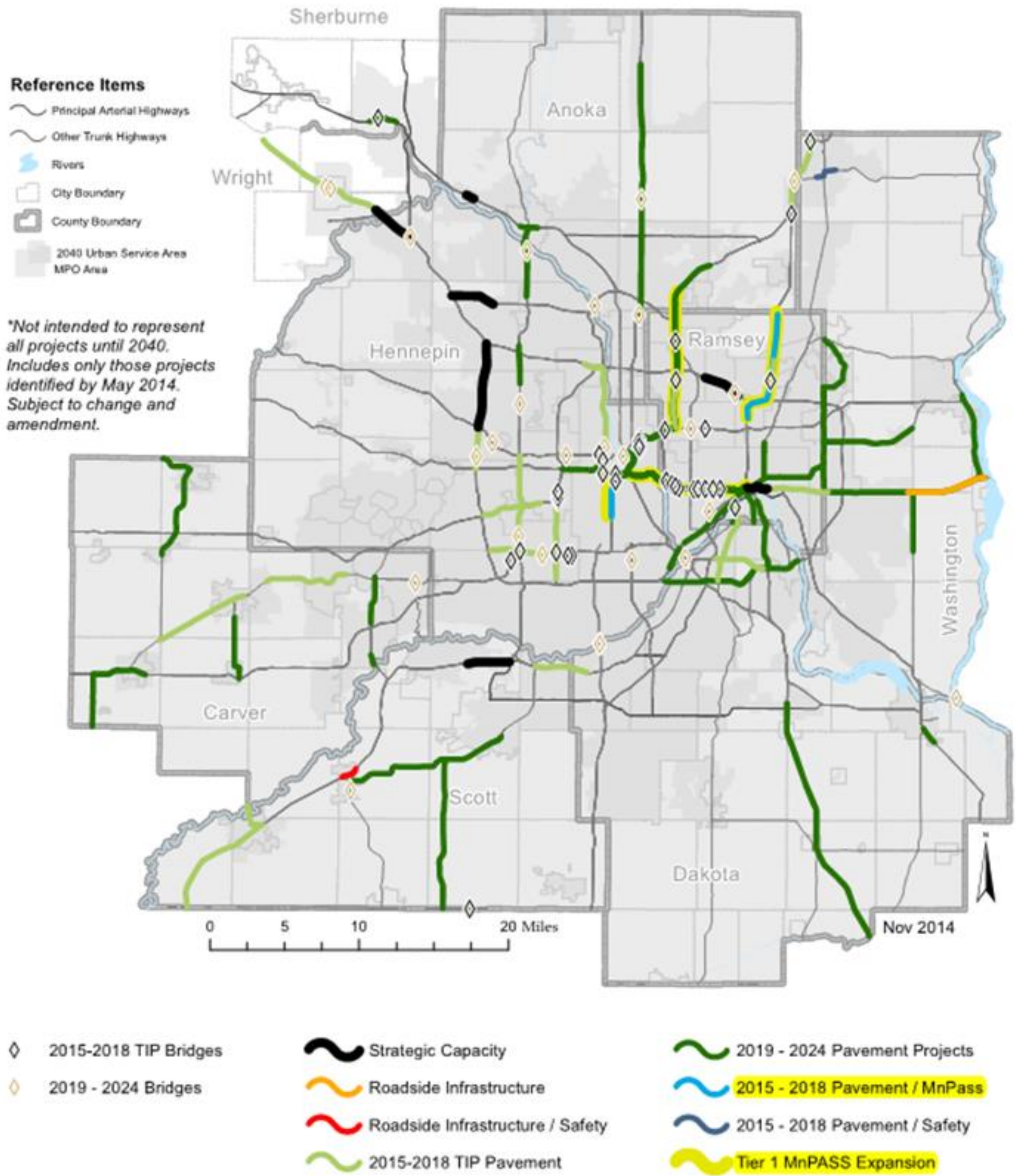
- Between 2015 and 2024 in the Current Revenue Scenario, MnDOT will also invest approximately $721 million (6% of the Current Revenue Scenario) in regional mobility improvements. These include traffic management technology, spot mobility improvement, the MnPASS system, highway strategic capacity enhancements, and regional highway access investments, known as "regional mobility improvements."

- MnDOT will continue to improve and expand traffic management technologies throughout the metropolitan area and deliver spot mobility improvements identified through its Congestion Management and Safety Plan. It will also continue to expand the MnPASS system of priced managed lanes. And in response to special funding like the state's Corridor Investment Management Strategy (CIMS), Transportation Economic Development (TED), and Corridors of Commerce programs, MnDOT will complete or contribute to several strategic capacity enhancements and regional highway access projects.
- If new revenues become available, MnDOT would continue to invest in operations and maintenance in the metropolitan area. This would include addressing a backlog of priority projects, as well as operating and maintaining new highway facilities, such as new or improved traffic management technologies and an expanded MnPASS system. MnDOT would also develop and deliver additional safety, bicycle, accessible pedestrian, and regional mobility improvements, such as the MnPASS, strategic capacity, and regional highway access projects discussed. These projects would help the region work toward the outcomes identified in Thrive MSP 2040 and the goals and objectives identified in this plan. As shown in Table 5-7, the investments under the Increased Revenue Scenario are estimated to cost $8 billion to 10 billion (constant dollars).
- The following table shows the Highway Investment Summary 2015 to 2040 (MnDOT Spending Only):

Investment Category	Current Revenue Scenario** (reported in year-of-expenditure dollars)				Increased Revenue Scenario
	2015-2024 (10 years)	2025-2034 (10 years)	2035-2040 (6 years)	2015-2040 (26 years)	2015-2040 (26 years)
Operate and Maintain Highway Assets	$0.6 billion	$0.8 billion	$0.6 billion	$2.0 billion	+ $1 billion
Program Support	$0.4 billion	$0.3 billion	$0.2 billion	$0.9 billion	+ $0.7 billion
Rebuild and Replace Highway Assets (Pavement, Bridge, and Roadside Infrastructure)	$1.8 billion	$3.0 billion	$2.1 billion	$6.9 billion	+ $2 to 2.5 billion
Specific Highway Safety Improvements	$100 million	$200 million	$100 million	$0.4 billion	+ $300 million
Highway Bicycle and Accessible Pedestrian Improvements	$100 million	$100 million	$100 million	$300 million	+ $300 million
Regional Mobility Improvements	Approx. $720 M	$0	$0	Approx. $700 million	+ $4 to 5 billion
ATM	$40-60 M	$0	$0	$40-60 M	To be developed
Spot Mobility	$75-125 M	$0	$0	$75-125 M	To be developed
MnPASS***	$275-325 M	$0	$0	$275-325 M	To be developed
Strategic Capacity***	$225-275 M	$0	$0	$225-275 M	To be developed
Highway Access***	$15-25 M	$0	$0	$15-25 M	To be developed
TOTAL*	$3.7 billion (10 years)	$4.4 billion (10 years)	$3.1 billion (6 years)	$11 billion (26 years)	+ $8 to 10 billion (26 years)

Identified Projects in Highway Current Revenue Scenario

Identified Projects* in Highway Current Revenue Scenario



02 – MnPass System Study Phase 1

Study Date: April 2005

Study Purpose

The purpose of this study was to evaluate and report the potential impacts of adding a MnPASS toll lane system to the Twin Cities Metropolitan transportation system including the costs, operation, revenue, and system and policy implications. The study also sought to identify potential corridors for early implementation. The study did not assess the benefit of a tolled versus nontolled system expansion.

Study Methodology (Screening and Evaluation Methods)

Steering Committee and Technical Group provided stakeholder input and developed evaluation methods and criteria. The group provided two rounds of analysis. Any existing or proposed highway in the metropolitan area was included in the analysis.

The study considered two types of MnPASS lanes, High Occupancy Toll (HOT) lanes (single occupancy vehicles use existing or proposed high occupancy vehicle lanes for a fee) and new capacity adjacent to existing highways, with the following assumptions:

- Pricing would vary with demand in order to maintain speeds at or near posted limits.
- Real time toll rates using changeable signs will inform drivers of applicable rates.
- Toll collection would be an automated electronic collection with no toll booths or cash transactions.
- No trucks in excess of 26,000 pounds would be allowed on MnPASS lanes.
- Transit vehicles would use MnPASS lanes for free.
- Access in and out of MnPASS lanes would be provided by slip ramps consistent with the I-394 MnPASS lanes that were under construction at the time of this report.

The study considered four types of highway segments for screening for a total of 50 segments. Screening of these 50 corridor segments used the following criteria:

1. Current and Future Congestion
2. Short-Term Revenue Potential

3. Constructability
4. Other Considerations

Segments that scored well using these criteria were shared with the Technical Team for further consideration. Based on the screening results and Technical Team input, potential viable segments were eventually narrowed down to four systems for further study.

These four systems were then evaluated based on overall transportation and financial performance using the following and utilizing Metropolitan Council's travel demand model:

- Travel demand at varying toll rates
- Capital costs
- Operating expenses

Study Results

The study considered both the performance of the system as a whole and the performance of individual segments. The financial viability of potential segments began as important criteria in developing segment recommendations because at the start the study focused on the segments that could be built quickly in partnership with private investors. When it became clear that toll fees would not recoup the capital investment the study shifted focus to a long term MnPASS system managed by the public sector.

Through the study it was determined that financial payback should not be used as criteria to select projects. MnPASS would generate some revenue (approximately 22 percent of capital investment costs). However, it was concluded that MnPASS should be considered a long-term traffic management solution and not a way to accelerate projects through toll revenue financing.

MnPASS is anticipated to result in small regional increases in vehicle miles traveled as travelers shift from transit or change their travel patterns to take advantage of the new capacity. However, because congestion decreases vehicle hours traveled decreases more than vehicle miles traveled increases. Regional vehicle miles traveled decrease.

Key outcomes from the evaluation include:

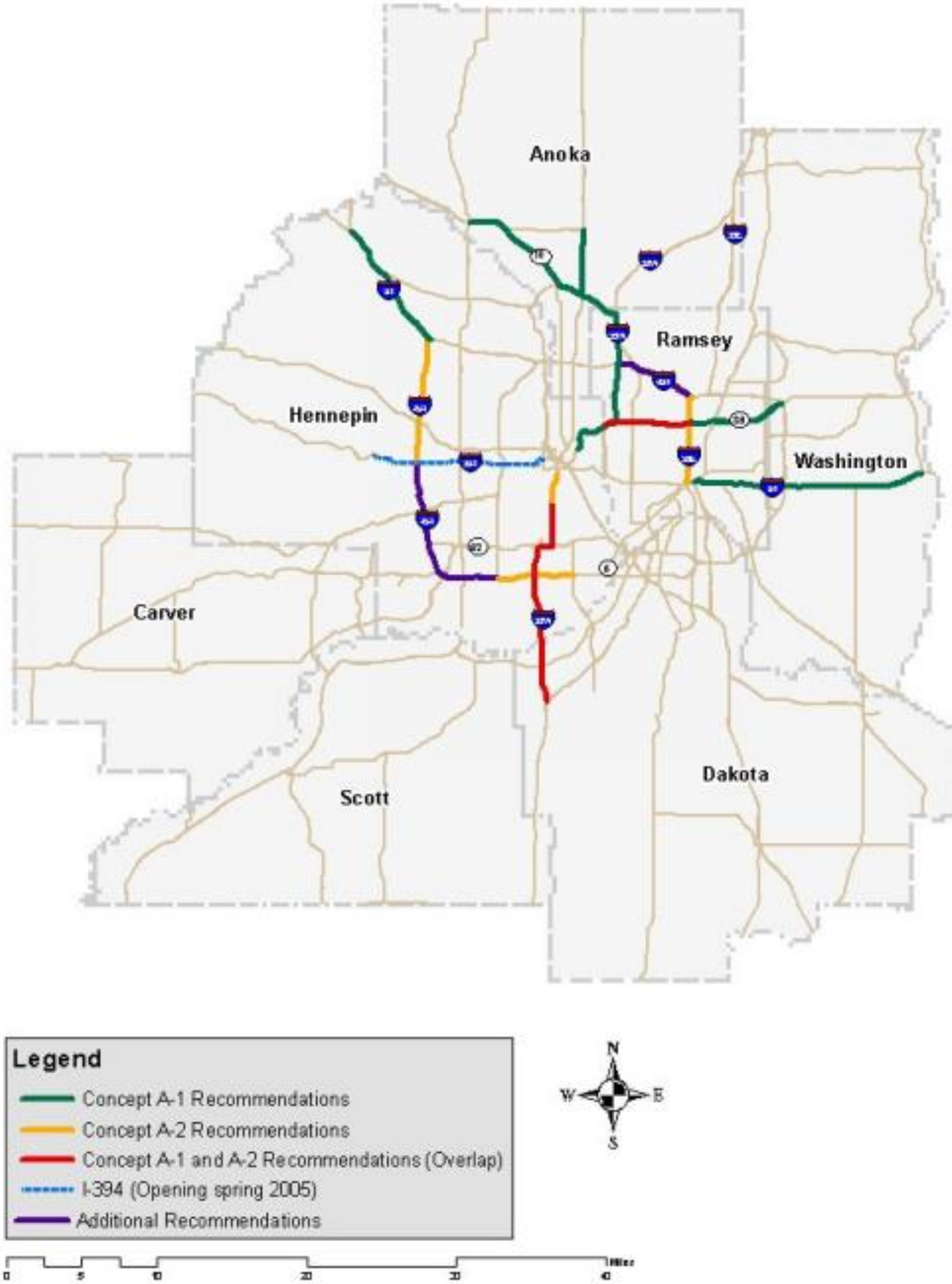
- MnPASS lanes will offer an uncongested travel option during congested travel periods for those willing to pay the toll.
- Forecasts indicated that high occupancy vehicles will occupy most of the lane capacity leaving little capacity to sell to single occupant vehicles.
- Revenue generation from tolls would not repay the capital investment.
- Metropolitan Council's travel demand model does not account for peak spreading.

The study also considered the policy and traffic impacts of allowing high occupancy and hybrid vehicles free access to MnPASS lanes and impacts to transit service.

Relevance to the MnPASS System Study Phase 3

The methodology and model changes utilized in the Phase 1 study should be assessed for relevancy and continued use in Phase 2.

Figure 11. Potential 2030 MnPASS Vision



03 –MnPass System Study Phase 2

Study Date: September 2010

Study Purpose

In the MnPASS Phase 2 study MnDOT reassessed its priorities for short term (2 to 10 years) MnPASS lane implementation in light of evolving Federal policies, actual experience with the two existing MnPASS lanes, and in close coordination with the MHSIS study.

An important change in this MnPASS Phase 2 study is the desire to avoid the need for costly road widening and right-of-way takings – factors which contributed to the high price tag of potential projects in MnPASS Phase 1. Therefore, this study the existing road widths could be used to incorporate managed MnPASS lanes similar to the I-35W corridor. Previously assessed corridors were reevaluated based on priced dynamic shoulder lane (PDSL). This avoids costly road widening and right-of-way takings. Lane options were compared to each other but not to other types of transportation investments or traffic management strategies.

The study assumed that new MnPASS lanes would be managed toll lanes that provide new capacity parallel to general purpose traffic lanes, in which all vehicles (except transit), are required to pay a toll. To maintain uncongested lanes, price would increase dynamically with real time congestion levels.

Model Updates for the MnPASS 2 Study

The current tolling procedure was updated to allow for the testing of new MnPASS lanes within the region. These new tolling lanes would require any vehicle using them to pay the toll. This is different from the current MnPASS lanes that allow vehicles (HOVs) with two or more persons to use the lanes without paying a toll. Therefore, it was necessary to update the model so that the existing MnPASS lanes would still perform in their current manner of allowing HOVs for free, while testing the possibility of charging these same vehicles if they use the new MnPASS lanes.

Study Methodology (Screening and Evaluation Methods)

The study began by identifying 19 possible corridor options. These corridors were identified by prioritizing the following factors:

- priority in the MnPASS Phase 1 Study
- current congestion levels
- local connectivity to employment centers and/or other MnPASS corridors
- amount of transit use

- existing bus-only shoulder lanes

Screening

While the MnPASS Phase 1 study assumed that any new MnPASS lanes would have to involve construction of new capacity to full highway standards, this Phase 2 study assumed a smaller envelope (i.e., corridor width) could be used to develop a MnPASS corridor.

The initial screening process applied to the potential MnPASS corridors focused on high-level assessments of physical challenges in each corridor. These included structural issues with bridges, available pavement widths, and issues where major corridors intersect (i.e., need for connections).

These existing physical limitations were used to categorize the corridors based on whether:

- MnPASS lanes could be developed as new lanes using the median or inside shoulders
- Insufficient space would require use of modified design criteria with minimum design criteria
- Unique characteristic that provided insufficient width for the addition of MnPASS lanes

The corridors were then assigned a category based on design options and cost/feasibility:

Category 1. Corridors evaluated based on Standard Design criteria and require relatively modest capital investments to implement MnPASS lanes.

Category 2. Corridors evaluated based on Standard Design, Modified Design (Design Exception), and PDSL criteria and would require more substantial widening, replacement, and resurfacing improvements to implement MnPASS lanes. Corridors in this category were subdivided to differentiate between corridors where system connections might be difficult and/or had other physical challenges.

Category 3. Corridors with physical challenges so significant that MnPASS lanes would not be feasible.

Using this screening methodology, six corridors were eliminated from further consideration because of engineering challenges, lack of congestion, and professional judgment.

Conceptual managed lane engineering designs were developed for each remaining corridor, a range of low and high construction costs estimated, traffic and revenue forecasts developed, operating and maintenance costs estimated, performance measures analyzed, and financing and benefit/ cost estimates prepared.

An overview of policy, technical, and legal issues associated with the development of new managed lanes in the region was performed. This filtering process resulted in 13 corridors proceeding through the full analysis in various combinations of individual and combined subsections.

Travel Demand

These 13 corridors were assessed using a modified version of Met Councils travel demand model to evaluate the impacts of short-term investments on new MnPASS facilities. The model does not capture mode shifting regardless of the toll being applied. However the technical steering committee agreed that for the high level analysis reflected in the study this limitation was acceptable. The model was also found to overestimate revenue when observed revenue generated for I-394 was compared to model outputs. Additionally, the model assumes any vehicle using toll lanes would be required to pay the toll. However, the current MnPASS system allows high occupancy vehicles to use MnPASS lanes for free. Therefore, the following are the major changes that were made to the model for this study. The differences in the models used account for some of the differences in the results between this study and the MHSIS.

- High occupancy vehicles were put through the same toll/no toll procedure as single occupancy vehicles so that the existing MnPASS lanes would still perform in their current manner of allowing HOVs for free, while testing the possibility of charging these same vehicles if they use the new MnPASS lanes.
- Tolls were applied all day, not just in the AM and PM peak.
- Model was calibrated to reduce the gross overestimation in PM peak revenue generation. Even with the modification model outputs were still higher than observed revenue generation.

The model determined that at a cost per hour saved of $4.80, 50% of single occupancy vehicle drivers would be willing to pay the toll.

Cost Estimates

A high and low end cost estimate was developed for each corridor. The average of the high and low cost estimate was used to for other considerations in this study including financing and cost/benefit analysis. The unit costs include categories of structures, roadway construction, advanced traffic management, roadway connections, and risk. Corridors were assigned either low (15%), medium (25%), or high (35%) risk that was applied to the high and low cost estimates.

Performance Measures

The following performance measures were used to evaluate the corridors and the combination of corridors:

- Travel-Time Reliability, measured through vehicle-minutes of delay saved per trip both daily and during the peak period and for both managed and general purpose lanes;
- Throughput, measured as the change in vehicle throughput in a corridor as well as the change divided by the total centerline miles of the corridor;

- Travel-Time Reduction, measured by the reduction in vehicle-hours traveled for both general purpose and managed lanes in a corridor;
- Change in Congested Vehicle-Miles Traveled, measured directly system wide and as a percentage of total vehicle-miles traveled; and
- Transit Suitability.

Cost/Benefit Analysis

Three types of costs were included in the cost/benefit analysis: 1) capital costs, 2) operating and maintenance costs, and 3) salvage costs. Operation and maintenance costs were conservatively assumed to be $50,000 per mile per year. Salvage costs were based on MnDOT cost/benefit methodologies. The value of the toll itself is considered neither a benefit nor a cost because it is transferred from an individual to the government and does not affect the economic value of the investment.

Policy, Technical, and Legal Issues

In addition, the study explored the following issues:

- Policy
    - Purpose of future MnPass lanes
    - Should HOVs pay?
    - Equity
    - Transit Advantages
    - Revenue Use
- Legal and Institutional
- Technical and Implementation
    - System Design
    - Freight
    - Business Rules
    - Financing

STUDY RESULTS

Through the assessment process an additional five corridors were eliminated from consideration leaving eight possible corridors for implementation. The following are the remaining eight corridors (corridor number does not imply priority):

- Corridor 1A TH 36 Eastbound (I-35W to I-35E) • Corridor 3 I-35E (A: I-94 to TH 36; B: TH 36 to CR E)
- Corridor 4 I-35W (A: Downtown Minneapolis to TH 36; B: TH 36 to Blaine)
- Corridor 5 I-494 (A: TH 212 to I-394 B: I-394 to I-94)
- Corridor 6A TH 169 (TH 101 to I-494)
- Corridor 7 TH 77 Northbound (141st Street to Old Shakopee Road)

These were then ranked from highest short-term priority (Tier 1) to long-term opportunities (Tier 3):

- Tier 1: Corridor 3
- Tier 2: Corridors 1A, 4 and 8
- Tier 3: Corridors 5A, 5B, 6A, 7 and 10

Some Tier 1 and 2 recommendations that can be built early, easily, and at the same time as other planned projects. These corridors also have strong transit services, provide direct linkages to downtown Minneapolis or Saint Paul, provide regional equity, and build on the existing MnPass system. Tier 3 corridors should be implemented in the mid to long range timeframe.

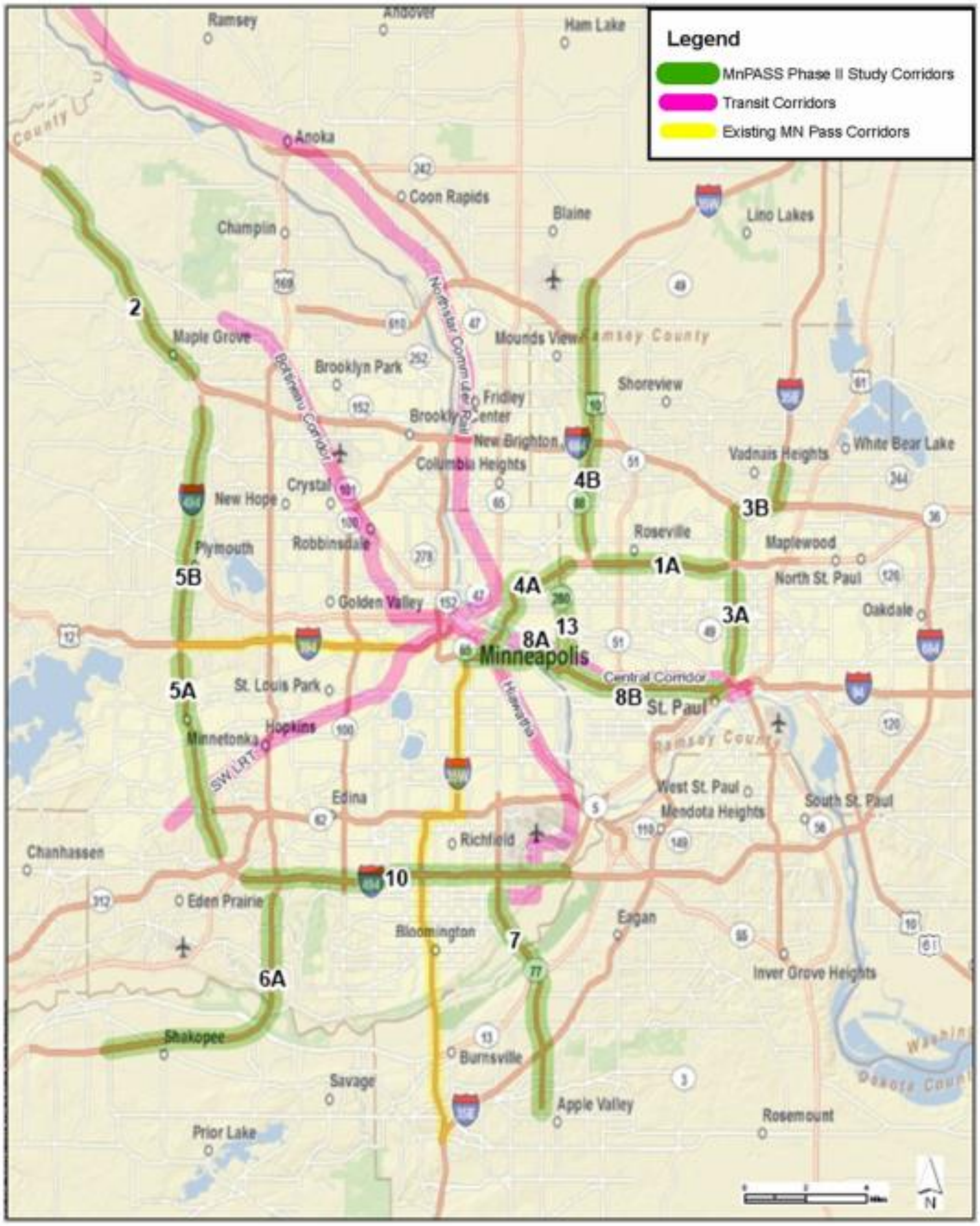
Although there are no legal or technical issues to MnPASS lanes, the following issues warrant continued analysis and consideration:

- Establish a regional consensus on the purpose of the lanes
- Ensure equitable treatment of travelers
- Work with Federal Highway Administration (FHWA) to develop safe and cost-effective design
- Develop new strategies to pay for new MnPASS lanes including the use of system revenue, state bonding, federal grants, FHWA Surface Transportation Program (STP), County Board Transit Investment (CBTI), and public private partnerships
- Ensure continued transit incentives

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

The methodology and model changes utilized in the Phase 2 study should be assessed for relevancy and continued use in Phase 3.

Figure ES.1 Corridor Location Map



Source: SRF.

Table ES.1 MnPASS Corridor Short-Term Evaluation Summary

	Performance Measures					Other Model Outputs			Financial Analysis				
Corridor	Travel-Time Reliability	Throughput	Travel-Time Reduction	Change in Congested VMT	Transit Suitability	Managed Lane Daily Vehicles	Corridor Daily Vehicles	Change in Speed	Percent of Total Capital Funding Requirement	Additional Investment Required	B/C	Annual Revenue	Capital Cost
1A. TH 36: I-35W to I-35E (EB only)	◑	◔	○	○	●	◑	○	◔	◑	●	◔	$1.0	$47.5
2. I-94: TH 101 to I-494	◔	○	◔	◑	○	◔	◔	◑	○	◑	○	$0.4	$82.5
3A. I-35E: I-94 to TH 36	◑	●	◔	◑	◑	●	◕	◔	◑	◕	◑	$1.9	$82.5
3B. I-35E: TH 36 to CR E	○	○	○	◔	◑	◔	◑	○	○	●	◔	$0.3	$35.0
4A. I-35W: DT Minneapolis to TH 36	◑	●	◑	◑	●	●	●	◑	◑	◑	◑	$2.3	$105.0
4B. I-35W: TH 36 to Blaine	◕	◑	◕	◑	●	◕	◑	◕	◑	◔	◕	$3.3	$155.0
5A. I-494: TH 212 to I-394 (peak only)	◔	◔	◔	◑	○	◑	◑	◑	◔	◑	◔	$1.0	$97.5
5B. I-494: I-394 to I-94	◑	◑	◑	◔	○	◕	◑	◕	◔	◕	◕	$1.6	$61.0
6A. TH 169: CR 17 to I-494	●	◑	●	◕	◑	◑	◔	●	◕	◑	●	$3.1	$97.5
7. TH 77: 141st Street to Old Shakopee Road (NB only)	◑	○	○	◔	●	○	○	◕	◔	●	◕	$0.6	$41.0
10. I-494: TH 212 to MSP Airport	◕	●	●	●	○	●	●	◑	●	◔	●	$5.9	$167.5
2. I-94: TH 101 to I-494 5B. I-494: I-394 to I-94	◑	◑	◕	◕	○	◑	◔	◑	◔	◔	◑	$2.2	$192.5
1A. TH 36: I-35W to I-35E 4B. I-35W: TH 36 to Blaine 4A. I-35W: DT Minneapolis to TH 36	◕	◑	●	●	●	◕	◑	◑	◑	○	◑	$7.3	$377.5
8A. I-94: DT Minneapolis to TH 280 8B. I-94: TH 280 to DT St. Paul	◑	◔	◕	◕	●	●	●	◔	●	◔	◕	$4.8	$140.0
3A. I-35E: I-94 to TH 36 3B. I-35E: TH 36 to CR E	◔	◕	◑	◑	◑	◕	◕	◔	◑	◑	◑	$2.5	$117.5

Ratings Key:
○ = Low.
◔ = Low Medium.
◑ = Medium.
◕ = Medium High.
● = High.

Figure 2.1 Typical MnPASS Cross Sections

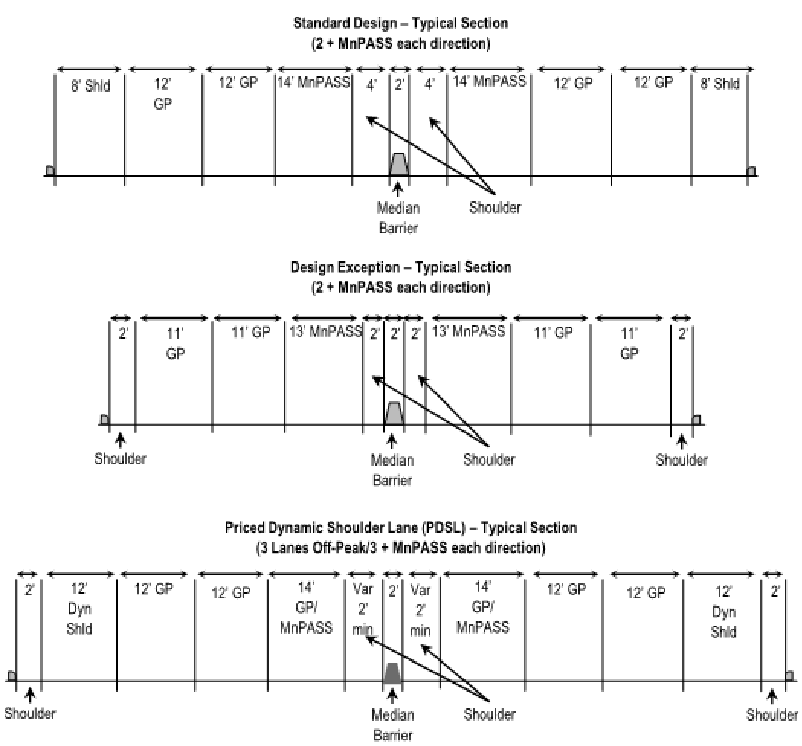


Table 2.1 Initial Corridor Screening Summary

				Major Physical Issues									
				Overpass Bridge Widening (Square Feet)		Underpass Bridge Replacements		Construction (In Miles)			Interchange Modifications		
Corridor		Length (Miles)	MnPASS Design	Current	2018	Current	2018	MnPASS	Mainline	Shoulder		Connectivity	Category
1. TH 36	1A: I-35W to I-35E	5	Std.	13,000	13,000	None	None	10	2	None	1	I-35W South: Complicated	1
1. TH 36	1B: I-35E to I-694	6.7	Exc.	7,000	5,000	Ped Only	Ped Only	14	10	None	None	N/A	2b
2. I-94	2: TH 101 to I-494	9	Std.	None	None	None	None	18	None	None	1	I-494: Moderate/Complicated	1
3. I-35E	3A: I-94 to TH 36	3.9	Exc.	5,000	None	None	None	8	23	None	1	DT St. Paul: Simple	2a
3. I-35E	3B: TH 36 to CR E	3.8	Std.	None	None	None	None	8	None	None	None	N/A	1
4. I-35W	4A: Downtown Minneapolis to TH 36	5.3	Exc.	4,000	4,000	None	None	11	19	None	3	DT Minneapolis: Complicated TH 36: Complicated	2a
4. I-35W	4B: TH 36 to Blaine	10.8	Exc.	9,000	9,000	None	None	22	16	None	3	N/A	2b
5. I-494	5A: TH 212 to I-394	7.6	PDSL	18,000	18,000	None	None	None	None	16	None	I-394: Complicated	2b
5. I-494	5B: I-394 to I-94	8.5	Std.	12,000	12,000	None	None	17	None	None	None	I-394: Complicated	1
6. TH 169	6A: CR 17 to I-494	6.2	Exc.	3,000	3,000	None	None	13	None	None	1	N/A	2a
6. TH 169	6B: I-494 to I-394	8.1	Std.	202,000	202,000	None	None	17	32	None	None	I-394: Complicated	3
6. TH 169	6C: I-394 to I-94	7.5	Exc.	10,000	10,000	1	1	15	30	None	1	I-394: Complicated	2b
7. TH 77	7: 141st Street to Old Shakopee Road	6.9	Exc.	None	None	None	None	22	6	None	None	TH 62: Moderate	2b
8. I-94	8: Downtown Minneapolis to Downtown St. Paul	8.1	Exc.	None	None	None	None	17	65	None	11	DT Minneapolis: Moderate DT St. Paul: Moderate	2b
9. I-394	9: TH 100 to I-94	2.7	Exc.	None (67,000)	None (67,000)	None	None	6	9	None	1	DT Minneapolis: Moderate TH 100: Simple	2a
10. I-494	10: TH 212 to MSP Airport	10.6	Exc.	11,000	11,000	1	None	22	68	None	2	MSP Airport: Moderate	2b
11. TH 212/ TH 62	11: TH 5 to TH 77	10.3	Exc.	8,000	8,000	None	None	21	12	None	5	N/A	2b
12. I-94	12: Downtown St. Paul to I-694	6.7	PDSL	28,000	28,000	None	None	1	3	14	3	DT St. Paul: Simple	2b
13. TH 280	13: I-94 to I-35W	3.3	Std.	72,000	72,000	None	None	7	11	None	None	I-94: Complicated I-35W: Complicated	3

Source: SRF.

Table 5.2 Average Daily Volume Comparison

2015

MnPASS Alternative			Average Daily Volume			
			Base	MnPASS Alternative		
Corridor	Length (Miles)	Corridor Description	Mainline	Mainline	Managed	Corridor Total
1A	4.63	TH 36: I-35W to I-35E (EB Only)	52,400	50,100	5,200	55,300
2	8.53	I-94: TH 101 to I-494	99,300	96,600	3,700	100,300
3A	3.56	I-35E: I-94 to TH 36	145,800	140,900	11,200	152,100
3B	3.29	I-35E: TH 36 to CR E	126,600	123,700	3,600	127,300
4A	4.15	I-35W: Downtown Minneapolis to TH 36	161,100	154,300	13,800	168,100
4B	12.21	I-35W: TH 36 to Blaine	112,000	106,500	10,000	116,500
5A	6.82	I-494: TH 212 to I-394 (Peak Only)	109,600	106,200	6,700	112,800
5B	7.77	I-494: I-394 to I-94	96,300	91,500	9,700	101,300
6A	9.49	TH 169: CR 17 to I-494	79,100	76,000	7,300	83,300
7	5.98	TH 77: 141st Street to Old Shakopee Road (NB Only)	43,600	42,000	2,700	44,700
10	10.73	I-494: TH 212 to Minneapolis-Saint Paul Airport	155,300	149,100	15,200	164,300
Combined Corridors						
2 + 5B	16.30	2 + 5B	96,600	93,100	6,700	99,700
4A + 4B + 1A	21.64	4A + 4B + 1A	108,700	104,400	9,700	114,100
3A + 3B	6.85	3A + 3B	136,500	132,800	8,400	141,200
8A + 8B	7.77	I-94: Downtown Minneapolis to Downtown Saint Paul	166,500	159,800	12,700	172,500

04 – CONGESTION MANAGEMENT SAFETY PLAN: PHASE 1

STUDY DATE: MAY 2007

STUDY PURPOSE

The purpose of Phase I of the Congestion Management Planning Study (CMPS Phase I) is to set the groundwork for the development of a comprehensive Congestion Management Plan and recommend a list of specific congestion mitigation projects that can be implemented within the next two years. The CMPS provides guidance and identifies strategies for relieving congestion in the Twin Cities Metropolitan Area with a two-phased approach. This report focuses primarily on Phase I, which includes strategies and projects that can be implemented in the short term (1 to 2 years). MnDOT and the Metropolitan Council have developed numerous strategies to reduce congestion and improve safety. Among these strategies is to pursue smaller-scale investments in targeted areas where capacity improvements would have significant benefits. Three of these types of projects have been completed in recent years.

- I-394 completed in November 2005: Addition of a westbound auxiliary lane on I-394 between Louisiana Avenue and the exit to TH 169.
- I-94 completed in December 2005: Addition of one lane in each direction of I-94 over McKnight Road.
- TH 100 in October 2006: Addition of one lane northbound and a collector/distributor lane southbound to TH 100 between TH 7 and I-394.

These three projects have been successful in significantly reducing congestion on over 19 miles of freeway. Additionally, the projects resulted in an annual reduction of over 1.2 million hours of congestion, which translates to approximately $16 million in annual user travel time benefit. Over the estimated project service lives, the combined user travel time benefit exceeds $149 million. When compared to the $20.2 million capital outlay for the three projects, the benefits significantly outweigh the costs. In addition, preliminary safety data shows that for two of the three projects the number of injury and property damage crashes has been significantly reduced since the projects were completed.

STUDY METHODOLOGY (SCREENING AND EVALUATION METHODS)

An iterative identification and evaluation process was used to screen over 150 potential CMPS Phase I projects. Step one of this process included data collection and project identification.

Step 2 was preliminary screening. This screening was Binary and included: Project cost of less than 15 Million, Projects not in a3 year TIP, Could require Project Memo or lesser environmental documentation, Annual hours of delay > 25,000 hours of congestion, Freeway or Arterial greater than 2 hours of congestion, Arterial relieves parallel congested freeway or directly responsible for freeway congestion.

Step 3 was refined screening. This screening was Qualitative and included: Project implementation/design readiness, Cost range, Congestion benefit (weighted delay), Traffic management for construction, Future demand changes, Relieves congestion without adverse downstream affects

Step 4 was prioritization by a group of key transportation experts during a half-day workshop.

Step 5 resulted in a list of 19 recommended projects.

STUDY RESULTS

The study resulted in 19 projects being recommended by the CMPS Steering Committee for implementation in the next two years. Ten projects costed between $1 and $15 million. The next three projects are $1 million or less and may be completed by Mn/DOT Metro Maintenance. The remaining six projects are operational improvements including implementing signal timing on arterials and adding ramp meters. The total estimated cost for these last six projects is less than $1 million. Overall, the 19 recommended projects total $60.8 million and are estimated to significantly reduce congestion in their respective corridors.

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

CMSP projects provide guidance and identify strategies for relieving congestion in the Twin Cities Metropolitan Area.

05 – Congestion Management Safety Plan: Phase 2

Study Date: November 2009

Study Purpose

The purpose of study is to clearly define the congestion and safety problems in the TCMA, and identify a range of relevant congestion management strategies and tools, as well as their potential for application. In addition, this study sets the context for evaluation of congestion and safety management tools, focusing on before and after analyses.

Study Methodology (Screening and Evaluation Methods)

The Study activities were guided by a project management team in consultation with a Working Committee composed of senior staff from MnDOT, the Metropolitan Council, and FHWA; a Technical Committee which comprised a range of transportation professionals representing various stakeholder agencies throughout region; and a Policy Committee composed of state, county, and city policymakers. Key products of the study included:

- Problem Statement: Outlines the congestion and safety problems in the Twin Cities Metropolitan Area (TCMA).
- Congestion Management Strategies, Tools, and Application Framework: Identifies the relevant congestion management strategies and tools and considerations for application in the TCMA.
- Project-Specific Before and After Studies: Sets the context for project-specific before and after studies for congestion management and safety strategies and tools.
- Congestion Management Case Studies: Documents the effectiveness of innovative congestion management strategies, tools, and techniques that have been implemented in other areas, both nationally and internationally.
- Flexible Design and Managed Corridor Workshop Summaries: Documentation of workshop presentations and discussion. The workshops included presentations from national experts on their respective topics, followed by a facilitated group discussion.

Study Results

The following is a summary of the key findings and recommendations that have resulted from the study:

- The TCMA will continue to face congestion and safety problems throughout the region and competition for resources is expected to be more challenging. Congestion and safety issues are complex and inter-related as such there is a need for a wide-variety of strategies and tools.

- Congestion and safety issues in the Twin Cities area affect all jurisdictions; inadequacies in individual system elements spill over from one jurisdiction to another. Congestion and safety management planning needs to involve federal, state, county, and local stakeholders as these agencies are an integral part of the discussion in terms of impacts and improvements to supporting arterial systems.

- A significant portion of congestion (55 percent) is non-recurring (i.e., weather, crashes, breakdowns, incidents etc.); since this is such a significant percentage of overall congestion and it is more unpredictable than recurring congestion, the types of strategies and tools are different (more operational and reactive) for mitigating these occurrences. The TCMA is considered to have one of the most managed transportation systems in the world and this system allows for better responses to incidents as well as an ability to react to changing travel demands.

- There is clear evidence that recurring congestion and safety are inextricably linked. As traffic flow becomes unstable, it not only results in lower person and vehicle throughput and longer travel times, but it also results in less safe conditions for users of the facilities (more crashes

- Implementing lower cost improvements sooner (i.e., improvements that focus on main recurring congestion problems) may generate more user benefits than waiting many years for a funding a higher cost improvement. Doing nothing or waiting for a large project has user costs (i.e., crashes and congestion occur on a regular basis) and many times this cost is not recognized or acknowledged in the decision process.

- Continued growth and development in the region combined with limited planned roadway expansions will require more multi-modal travel and more innovative management techniques to maintain current mobility and safety as well as enhance user satisfaction. The region has plans for implementing a number of major transit improvements over the next 10 years. In addition, MnDOT has implemented one managed lane corridor (I-394 MnPASS) and is opening a second corridor in the fall of 2009 (I-35W MnPASS). Feedback from users overwhelmingly have supported these kinds of corridors that provide incentives for transit and promote user choice (i.e., users can use free-flow lanes for a fee if they need to have a more reliable trip). These corridors have also increased transit service and bicycle and pedestrian connections to transit stations thereby increasing accessibility.

- Conducting “before” and “after” studies to assess effectiveness and/or impacts of improvements is not a common practice. However, this practice is needed, especially for newer strategies and tools where benefits and effectiveness are not fully known. Building a collection of experience for these newer strategies and tools will help practitioners’ more accurately assess potential benefits and effectiveness as well as their applicability to different types of problems.

- MnDOT has developed many performance measures for the metropolitan freeway system; however, better measures are needed to measure the following:

    - Multi-modal aspects of corridors

    - Travel time reliability

- Minor arterial performance
- Person Throughput
- Origin Destination Information
- Customer satisfaction

- As part of its MnDOT's strategic plan, it embraced innovation as one of the key directions for improving mobility and safety. Congestion management and safety strategies have been separated in three categories: established, emerging, and experimental. MnDOT should continue to invest in all three of these areas
- Design flexibility was one of the key issues explored during the study. This is a complex issue that involves policy, design standards and processes, as well as liability and risk issues
- A managed corridor concept was introduced as a potential decision-making model with a purpose of providing a more comprehensive, systematic and inclusive way for agencies to better integrate solutions among jurisdictions and modes. This concept would require more thorough vetting and discussion with the goal of building more multimodal and multi-jurisdictional approaches to moving people and goods.

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

CMSP projects provide guidance and identify strategies for relieving congestion in the Twin Cities Metropolitan Area.

06 – Congestion Management Safety Plan: Phase 3

Study Date: February 2013

Study Purpose

The purpose of the study was to identify a list of lower-cost/high-benefit projects that seek to maximize mobility and reduce crash risk at key congestion and safety problem locations. The final result of CMSP Phase III is an opportunity list that was provided to MnDOT decision makers so that they can select solutions for additional scoping and eventual programming/implementation.

Study Methodology (Screening and Evaluation Methods)

The project selection was accomplished through three distinct stages:

- Problem location identification
- Primary screening to identify the highest-priority problem locations
- Secondary screening to identify the strongest potential improvement locations

Two guiding principles for project identification were the Right-Sizing of Projects and the Time Value of Resources. Both principles were referenced extensively in all Phase III outreach efforts and used to direct the path of the study. CMSP Phase III undertook an extensive outreach effort through a series of interactive work sessions with local stakeholders and transit officials. The purposes of these work sessions were to inform and educate stakeholders on the goals and objectives of CMSP and to gather information about specific congestion and safety problem locations on MnDOT's trunk highway system.

A primary screening was then performed to quantitatively identify those problem locations with the most severe operational and safety issues. Traffic volume and crash costs were used to compare all of the problem locations considered, with those having the highest levels being carried forward for the development of solution concepts.

The proposed solutions developed at the Design Charrettes were scored and ranked in the secondary screening process. The scoring used the quantified attributes for the proposed solutions of problem magnitude, concept estimates, and effectiveness. The score for each solution was expressed as a return period, or the length of time needed for accrued benefits to cover the concept estimate. Supplemental information for the solutions was added to the list to assist decision-makers in selecting projects for scoping.

Study Results

CMSP Phase III exposed a wide variety of challenges on the way to achieving its final outcome. These challenges required unique solutions that sought to be inclusive, creative, and a departure from traditional design methods. Some of these approaches have become hallmarks of CMSP such as the Local Agency Work Sessions and Design Charrettes. Innovative and creative methods developed through CMSP have an opportunity to reshape some of the strategies employed by MnDOT and other agencies. While the CMSP Opportunity List is the final product of the Phase III study, it represents a snapshot of candidate lower-cost/high-benefit improvements to address critical problem locations. There are a number of additional steps to be undertaken by MnDOT Metro District before solutions become programmed improvements.

MnDOT anticipates that many CMSP solutions will be implemented as “opportunity driven projects”. This means that projects are implemented as part of another programmed investment, such as pavement or roadway preservation projects to take advantage of cost saving synergies. These considerations are expected to influence the order in which projects are scoped and implemented. Projects that are not implemented will remain on the list to be considered for reevaluation in future cycles.

Relevance to the MnPASS System Study Phase 3

CMSP projects provide guidance and identify strategies for relieving congestion in the Twin Cities Metropolitan Area.

07 – Congestion Management Safety Plan: Phase 4

Study Date: March 2016—August 2017 *(Project in Progress)*

Study Purpose

The Congestion Management Safety Plan (CMSP) is a funding program that seeks to implement lower-cost/high-benefit improvements to address congestion and safety problems on MnDOT's Metro District highway system. Identification of problem locations and selection of solutions is completed using a data driven process to maximize the return on investment in terms of benefits for highway users. Solutions are intended to address specific problems under existing conditions, and while they are not always intended to be 100 percent effective, they should make conditions noticeably better than they are today. Solutions are also typically lower-cost and smaller in scope than traditional highway investments, with the intent to allow them to be delivered more quickly and simply.

CMSP 4 will build on the successes of previous CMSP efforts and incorporate new features to enhance the CMSP process. Starting with data collection and problem statement, CMSP 4 will utilize a data-driven process to identify high priority locations and develop beneficial solutions. Carrying promising solutions into the scoping process and actively engaging key stakeholders through a CMSP 4 Scope Work Group and Metro Program Committee will ensure informed decision making.

Study Methodology (Screening and Evaluation Methods)

The project is currently in progress; Scope of Work for the project includes:

- Review Previous CMSP Outcomes and CMSP Opportunity Lists
- System Problem Statement Development
- Primary and Secondary Screening
- Cooperative Refinement with Traffic/Safety Improvements
- Preliminary Scoping of Refined Solutions
- Project Selection
- Meetings and Outreach

Study Results

As mentioned above the study is currently in progress.

Relevance to the MnPASS System Study Phase 3

Phase 4, the current phase of CMSP, will repeat many of the key activities undertaken in Phases 2 and 3, by updating the System Problem Statement and developing a new list of opportunities that reflect changes to the Metro District highway system over recent years. Travel time reliability has also been added as an additional performance measure as part of the System Problem Statement. Reliability describes the variability in travel time experienced by highway users, due to factors such as weather, crashes, and changes in demand.

Some main key takeaways that are relevant to MnPASS System Study Phase 3 are the following:

- CMSP is a limited regional funding for Mobility and Safety improvements which is mostly committed to preservation investments
- Mobility and Safety funding is split into 3 categories: Active Traffic Management, Lower-Cost/High-Benefit, and Strategic Capacity
- The Strategic Capacity category is primarily targeted at MnPASS investments; corridors that are prioritized for this funding represent key linkages in an ultimate regional MnPASS system
- Lower-Cost/High-Benefit investments are spot mobility improvements intended to address existing congestion and safety problems on the region's trunk highway network that might not otherwise receive Mobility & Safety investments
- Identifying these improvements focuses on a data-driven process to identify the highest-priority problem locations across the system, and pursuing solutions that provide the highest return on investment

08 – MN 20-Year State Highway Investment Plan (MnSHIP) 2014-2033

Study Date: December 2013

Study Purpose

This study is a tool to assist MnDOT in selecting and communicating capital investment priorities for the state's highway system for the next 20 years (2033). The number of roads and bridges in poor condition will more than double and perhaps even triple within 20 years. Planned expenditures identified in the plan cannot exceed expected revenue of $18 billion although the state highway system has an identified need of $30 billion in improvements/investment. With this projected $12 billion funding gap, many needed projects will not be funded within the next 20 years.

Priorities through 2025 balance preservation of existing infrastructure with investments in safety, new connections for multiple modes of transportation, and other projects that advance economic development and quality of life objectives. Priorities in the second 10 years of the plan focus almost exclusively on preserving existing infrastructure.

Notable changes and improvements in MnSHIP relative to the last state highway investment plan update—completed in 2009—include:

- Evolving revenue distribution and programming processes to respond to a new federal transportation bill;
- Identifying planned projects for three years beyond commitments in the four-year STIP to respond to a 2010 state law as well as to improve coordination with local units of government;
- Classifying projects into 10 investment categories to better track and analyze the impact of investments on performance targets and other goals;
- Pursuing a more robust public input process to influence planning decisions;
- Integrating risk-based planning as a means to better understand the tradeoffs associated with various funding levels; and
- Identifying two new investment categories, Bicycle Infrastructure and Accessible Pedestrian Infrastructure, to better account for investments that support non-motorized modes of travel.

STUDY METHODOLOGY (SCREENING AND EVALUATION METHODS)

Investments on the state highway system are allocated into 10 categories that make up five investment areas: Asset Management, Traveler Safety, Critical Connections, Regional and Community Improvement Priorities, and Project Support. Priorities are set using considerations such as federal and state laws, system conditions, and public input. Several key factors and assumptions were considered in setting priorities.

- MN Go Policy Direction for MnSHIP
    - Eight guiding principles: leverage public investments to achieve multiple purposes; ensure accessibility; build to maintain scale; ensure regional connections; integrate safety; emphasize reliable; and predictable options; strategically fix the system; and use partnerships.
    - Objectives and strategies: accountability, transparency, and communication; traveler safety; transportation in context; critical connections; asset management; and system security.
- New federal and state requirements
    - Moving Ahead for Progress in the 21st Century (MAP-21) established national goals and requires USDOT to establish performance measures for the NHS in several categories. MnDOT must analyze and track the impact of recent investments, identify needs, establish priorities for projected revenue, and identify strategies to ensure the efficient use of resources. Also requires states to report progress in achieving performance targets for each of the yet-to-be established measures.
    - Minnesota' adopted the Government Accounting Standards Board Statement 34 (GASB 34) financial reporting requirements for the value and condition of its major infrastructure assets in 2001. MnDOT set performance thresholds for highway infrastructure, such as the condition of pavements and bridges.
- Construction costs and slow revenue growth
    - MnDOT estimates that it will have approximately $18 billion to invest over the next 20 years. This amount will lose buying power over time as unit construction costs (e.g. fuel, raw materials, equipment, and labor) continue to grow at an annual rate of approximately 5%, exceeding the annual revenue growth rate of approximately 2%. This results in a nearly 60% decrease in buying power by 2033.

Because transportation infrastructure can last up to 50 years or longer, it is important for MnDOT to monitor and assess the trends and adapt. Included in these considerations are: an aging population; increased population in urban areas; energy/gasoline price shifts; transportation technology; budget challenges; health impacts; increased global competition; changing work environments, telecommunications, and access to services; and floods and water quality.

MnSHIP was developed using were three central planning approaches: performance-based planning using MnDOT used performance measures, targets, and trends; scenario planning to evaluate performance and risk tradeoffs associated with different funding levels; and risk-based planning systematically identifying the likelihood and impact of different risks.

MnDOT engaged the public with a variety of communication and outreach techniques to educate and receive feedback including statewide public outreach meetings, an interactive website tool, and educational webinars. MnDOT also established a Partnership Advisory Committee composed of representatives of Metropolitan Planning Organizations (MPOs), Regional Development Commission (RDCs), counties, cities, and other key stakeholders from across the state. The 30-person committee helped to steer the public outreach process and general plan development, and to ensure consistency with other plans.

A Transportation Finance Advisory Committee (TFAC) was also established to analyze potential revenue sources and non-traditional approaches to transportation funding and finance. The committee recommended pursuing a revenue increase that supports an economically competitive, world-class transportation system. For capital improvements on the state highway system, this means closing the $12 billion funding gap.

Corridors of Commerce is a new Minnesota program that targets transportation routes identified as vital links for regional and statewide economic growth. MnSHIP does not reflect the projects selected as part of the 2013 Corridors of Commerce solicitation.

In the absence of or in addition to new revenue, MnDOT will pursue a mix of internally and externally oriented strategies that would stretch existing revenue to accomplish additional priorities beyond those identified in the plan.

Study Results

10 year work plans detailing planned capital investments and/or programs were developed for each MnDOT district 10-year Work Plan through 2023.

http://www.mndot.gov/planning/mnship/pdf/districts-ten-year-work-plan.pdf

Relevance to the MnPASS System Study Phase 3

Methods for public and stakeholder input could be applied to MnPASS Phase 3. Additionally, the potential to leverage planned projects should be considered in selecting MnPASS corridors. Therefore, the projects identified for implementation in MnSHIP should be included in the MnPASS assessment as applicable.

Figure 1-1: MnSHIP Chapters and Development Process

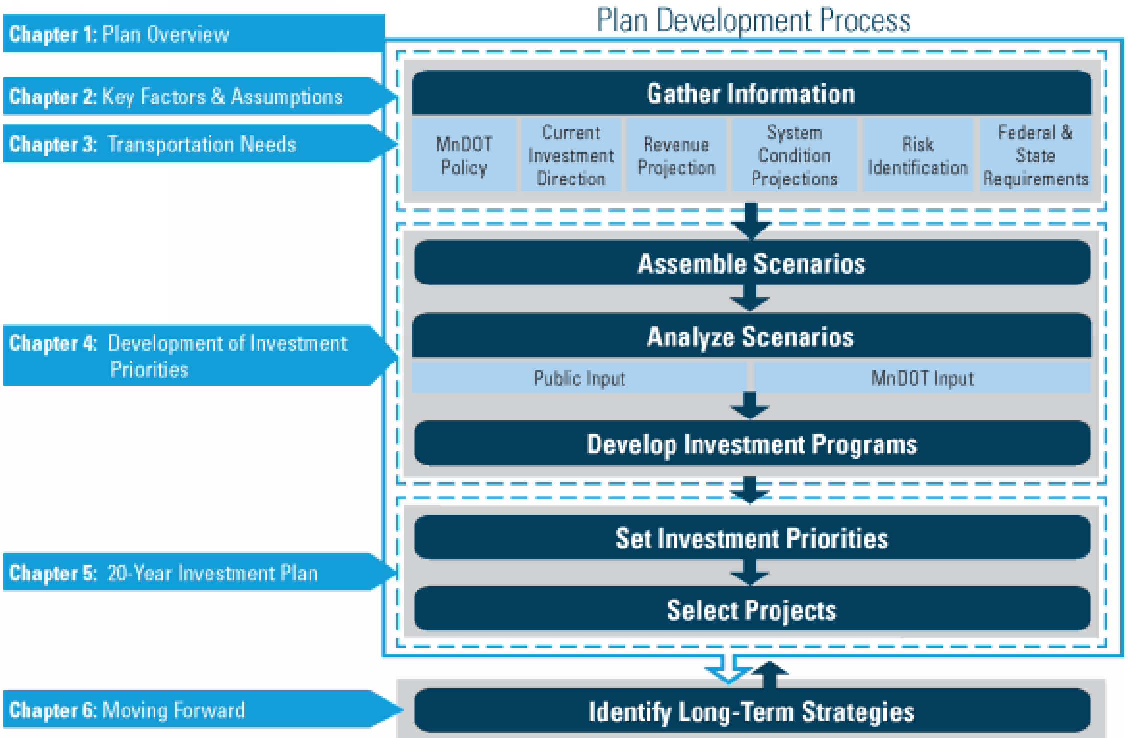


Figure 1-4: Plans and Programs

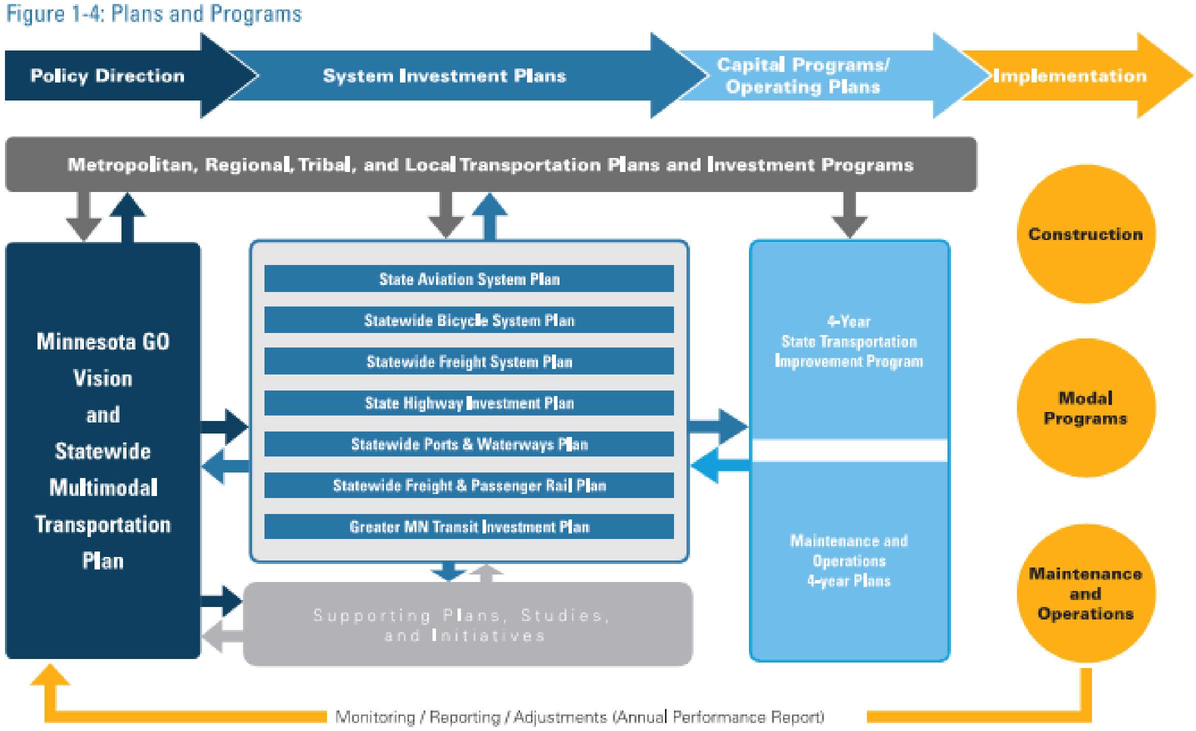


Figure 4-2: Investment Approaches Developed for Scenario Planning

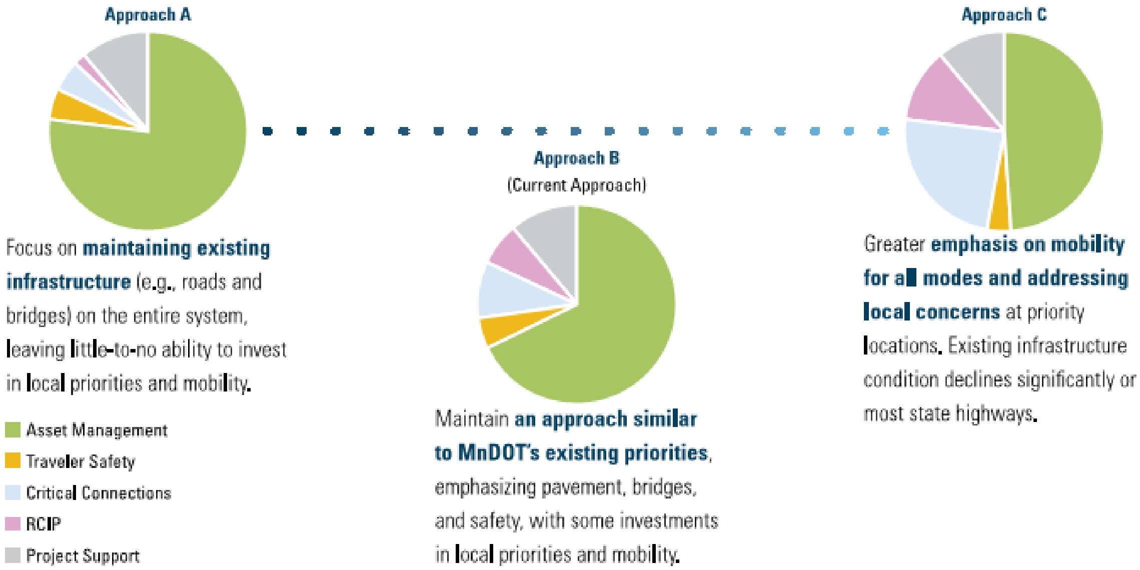


Figure ES-3: Transportation Needs Over Next 20 Years by Investment Category

Investment Category		20-Year Outcomes Based on Aspirational Performance Targets or Other Key System Goals	20-Year Need	Total (%)
Asset Management	Pavement Condition	Meet pavement performance targets of 2% Poor condition and 70% Good condition on NHS and 3% Poor condition and 65% Good condition on non-NHS roads.	$10.76 billion	35.6%
Asset Management	Bridge Condition	Invest in state highway bridges at optimal points in their life cycles; meet performance targets of ≤2% Poor condition and ≥84% Good or Satisfactory condition on NHS bridges, ≤8% Poor and ≥80% in Good or Satisfactory condition on non-NHS bridges.	$5.11 billion	16.9%
Asset Management	Roadside Infrastructure Condition	Reduce the number of poor culverts, maintain rest areas, and meet federal standards.	$1.71 billion	5.7%
Traveler Safety		Meet an aggressive traffic fatalities target by implementing District Safety Plans more quickly than current rate (2012), address most sustained crash rate locations, and invest $3 million/year for Toward Zero Deaths programming.	$1.34 billion	4.4%
Critical Connections	Twin Cities Mobility	Implement the Metropolitan Council's Transportation Policy Plan, which includes Active Traffic Management, spot mobility improvements, implement the MnPASS system vision, and strategic capacity enhancements.	$3.90 billion	12.9%
Critical Connections	Interregional Corridor Mobility	Meet system performance targets by completing major improvements on three of four underperforming corridors (I-94, US 10, US 63, and MN 210).	$810 million	2.7%
Critical Connections	Bicycle Infrastructure	Strategically improve the bicycle network and continue implementing bicycle accommodations as part of pavement and bridge projects.	$540 million	1.8%
Critical Connections	Accessible Pedestrian Infrastructure	Install accessible pedestrian signals at all signalized intersections by 2030, bring all intersections into compliance with Americans with Disabilities Act (ADA) curb ramp standards, and fund identified priority pedestrian projects.	$490 million	1.6%
Regional + Community Improvement Priorities (RCIP)		Partner with stakeholders to address regional and local priorities through several stand-alone projects and design add-ons, deliver projects that respond to non-performance-based needs and enhance the state's transportation network, and allocate money for statewide and district-level programs.	$1.75 billion	5.8%
Project Support		Efficiently deliver projects through adequate consultant services, supplemental agreements, construction incentives, and right-of-way acquisition.	$2.88 billion	9.5%
Small Programs		Continue to fund unforeseen issues and one-time specialty program needs.	$900 million	3.0%
		TOTAL	**$30.19 billion**	

09 – Metropolitan Highway System Investment Study (MHSIS)

Study Date: September 2010

Study Purpose

Assess how active traffic management, managed lanes, use of shoulders, and bus rapid transit could be combined and implemented in the Twin Cities as possible alternative to costly capacity expansion. Inform the 2030 Regional Transportation Policy Plan. These strategies would not fix congestion but provide residents, employees, and visitors with a consistently congestion-free alternative throughout the regional highway system.

Study Methodology (Screening and Evaluation Methods)

Study was completed at the same time as the MnPASS System Study Phase 2. Two studies had different objectives and timelines but used the similar cost measurements. There are four primary differences between the two studies:

1. MHSIS did not include any cost for direct connections between managed lane facilities; however, the MnPass Phase 2 did look into the geometrics and cost for how a managed left lane structure would connect into the downtown exits.
2. MHSIS applied a lower miscellaneous cost for the corridors, but was balanced out by the risk factors. The MnPass Phase 2 applied the same risk factor to the low and high range.
3. MnPass 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.
4. Study corridors did not perfectly align between both studies.

Study area included all metropolitan counties but focused on metro core for congestion relief. No established guidance for incorporating management and operational strategies within a long-range plan.

Four categories of performance measures were used to access the alternatives:

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

Initially, a total of 41 separate projects were identified for analysis. These projects included managed lane expansion projects, managed lane conversion, interchange closure, multiple interchange consolidation, limited access design conversion, strategic capacity expansion, and expressway expansion.

Study Results

The following managed lane projects are recommended for implementation within the 2010 – 2030 timeframe:

- I-35E from downtown St. Paul to north of I-694 (35E-1 and 35E-2)
- I-494 from I-394 to I-94/I-494 interchange (494-1)
- I-35W from downtown Minneapolis to 95th (35W-1 and 35W-2)
- TH-36 between I-35E and I-35W (36-1)
- I-94 between downtown Minneapolis and downtown St. Paul (94-2)

The following managed lane projects are recommended for implementation within the 2030 – 2060 timeframe:

- TH-77 between 141st Street and TH-62
- I-94 between TH-101 and I-494 (94-1)
- I-694 between I-35E and I-35W (694-1)
- US 169 between TH-62 and the Minnesota River (169-3)
- US 169 between TH-62 and I-394 (169-2)
- I-494 between I-394 and Minneapolis / St. Paul airport (494-2)
- TH-36 between I-35W and I-694 (36-1 and 36-2)
- I-694 between I-94 and I-35E (694-2)

Relevance to the MnPASS System Study Phase 3

The potential to leverage planned projects should be considered in selecting MnPASS corridors. Therefore, the projects identified for implementation in MSIS should be included in the MnPASS assessment as applicable.

FIGURE 2: MANAGED LANE PRIORITIZATION SUMMARY

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

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**

10 – 2016–2019 STIP (AND 2017 – 2020 STIP DRAFT)

STUDY DATE: (2016–2019 STIP: SEPTEMBER 2015) AND (2017 – 2020 STIP: SEPTEMBER 2016)

STUDY PURPOSE

We studied the MnDOT's State Transportation Improvement Plan (STIP) to determine what MnPASS work is programmed and funded to be constructed in the next few years. This bridges the gap between what has historically been done with MnPASS and what will be planned and envisioned for MnPASS in the future.

STUDY METHODOLOGY (SCREENING AND EVALUATION METHODS)

We reviewed the STIP tables to identify any MnPASS projects per the project descriptions. We reviewed both the Approved 2016 – 2019 STIP and the 2017 – 2020 draft STIP. While the draft STIP is not yet approved, it contains more up-dated information than the previous STIP and may provide insight on how MnDOT has progressed on allocating funding on relatively expensive MnPASS projects.

STUDY RESULTS

Appendix A contains the filtered projects from both the Approved current STIP and the pending draft STIP.

2016 – 2019 STIP:

The current STIP reveals six total projects: three projects scheduled in fiscal year (FY) 2016, one project in FY 2017, one payback for the FY 2017 project in FY 2018, and a set-aside for MnPASS in FY 2019. One 2016 project is for the I-35E MnPASS from Little Canada Rd to County Rd J, and another is for the I-394 MnPASS from I-494 to Washington Ave. The third 2016 project is for an Environmental Assessment and preliminary design for the I-35W MnPASS from MN-36 to Lexington Ave. The 2017 and 2018 projects are for the I-35W MnPASS from 43rd St S to the I-94/I-35W commons. The 2019 project is general set-aside for I-35W MnPASS.

2017 – 2020 STIP (draft):

The pending STIP reveals five total projects: one project scheduled in fiscal year (FY) 2017, one payback in FY 2018, two projects (one payback) in FY 2019, and one payback in FY 2020. The 2017 project is the I-35W MnPASS from 43rd St S to the I-94/I-35W commons, with paybacks in 2018 and 2019. The 2019 project is I-35W MnPASS from County Rd C to Lexington Ave, with payback in 2020.

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

Because the STIP contains programed projects with allocated funds, the MnPASS System Study Phase 3 must assume that these projects will be completed as Approved in the STIP (or pending Approval in the draft STIP). Therefore, the Study will need to proceed under the impression that these projects will be completed as programed for the purpose of directing the Study efforts.

11 – 10-YEAR CAPITAL HIGHWAY INVESTMENT PLAN (2016 – 2025)

STUDY DATE: DECEMBER 2015

STUDY PURPOSE

MnDOT will complete many important projects during the next ten years. The following projects are highlighted for their complexity and/or their advancement of the Minnesota GO Vision. The years listed refer to state fiscal year, which runs July 1 - June 30th. Multi-year projects are listed in their first year of construction.

STUDY RESULTS

2016

- US 53 Realignment: The project will relocate US 53 near Virginia and reconstruct it outside of a mining company easement.
- I-694: This project will construct a third lane and reconstruct existing lanes between Rice Street and Lexington Avenue.

2017

- Lake Street Access Project: This project combines planned work for an improved transit station at Lake Street and I-35W in Minneapolis with the replacement of two major bridges and pavement resurfacing. Hennepin County is the lead agency on this project.
- MN 1: Eagles Nest Lake Area Reconstruction. The highway will be reconstructed and realigned to straighten out curves. The project will also add turn lanes and select passing zones.
- MN 371: The project will consist of the reconstruction of MN 371 from Nisswa to Pine River. The proposed improvements include a four-lane, divided, controlled access highway.

2018

- Red Wing Bridge: The project is in the preliminary phase to rehabilitate or replace US 63 bridge over the Mississippi River and the US 63 bridge over US 61, as well as the highway connections. Existing bridge is fracture critical and is being replaced as part of a bridge bonding program.
- US 14: Bridge/interchange in New Ulm

2019

- I-94 managed lane: Project will build a managed lane (MnPASS) from downtown St. Paul to downtown Minneapolis. The project will last two years.

- US 12: Pavement urban reconstruction project. Project will repair pavement from 4th street to MN 22 in Litchfield.

2020

- I-35W Bridge over Minnesota River: Project will replace the I-35W Bridge over the Minnesota River in Bloomington. The project will last over three years.
- I-35: Replace two bridges over the Snake River in District 1.

2021

- I-94: Unbonded concrete overlay from Clearwater to Monticello. Project will provide long lasting fix to I-94 pavement.
- US 10: Reconstruction in Elk River from Joplin Street to Norfolk Avenue.

2022

- MN 1: Reclaim pavement and replace two bridges in Beltrami County from County Road 18 to MN 219.

2023

- I-94: Pavement resurfacing from MN120 to Wisconsin border.
- US 169: Replace 63rd ave bridge over US 169 in Hennepin County.
- MN 210: Replace Bridge over Mississippi River in Brainerd.

2024

- MN 23: Pavement reconstruction from the Pine-Carlton county line to St. Louis River Bridge.
- MN 27: Replace bridge over the Mississippi river in Little Falls.

2025

- I-94: Overlay project from Monticello to St. Michael.
- MN 11: Pavement resurfacing in International Falls

12 – County Transportation Plans

Study Date: Current County CIPs *(dates vary county to county)*

Study Purpose

Capital Improvement Plans (CIPs) for the Eight Counties within the MnDOT Metro District consisting of Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott, and Washington Counties were reviewed to identify the county roadway improvements that intersect MnDOT facilities.

Study Results

ANOKA County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
TH 10 Interchanges		TH 10	2018	$ 5,120,000
TH 10 Interchange	Thurston/Fairoak	TH 10	2018	$ 9,000,000

CARVER County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
140/212 Interchange	CR 140	TH 212	2019	$ 12,000,000
TH 41 Reconstruction from 212 to Pioneer Trail	CSAH 14	TH 212	2017	N/A

CHISAGO County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
CSAH 10 - I 35 Interchange	CSAH 10	I-35	2018	N/A

DAKOTA County

Project Name	County Roadway	MnDOT Roadway	Year	Total Cost
117th St: CSAH 71 to TH 52	CSAH 71	TH 52	2017	$ 4,000,000
CSAH 42 /TH 52 Interchange Area	CSAH 42	TH 52	2017	$ 12,500,000
E. jct TH 55 to "old" CR 87 Lock Blvd	CR 87	TH 55	2018	$ 7,202,200

HENNEPIN County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
CSAH 53/ 66th Street	CSAH 53/ 66th Street	I-35W	2018	N/A
CSAH 81	CSAH 81	I-94	2017	N/A
CSAH 112	CSAH 112	TH 12	2019	N/A

ISANTI County
Project Name
No Interstate through the county

RAMSEY County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
CSAH 65/White Bear Avenue	CSAH 65	I-694	2018	$ 20,500,000
County Road D/ HWY 19	CSAH 19	I-35 W	2018	$ 2,700,000
Rice St CSAH 49 Interchange	CSAH 49	I-694	2017	$ 26,000,000

SCOTT County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**

TH169/ TH41 CR 78 Interchange	CR 78	TH169/ TH41	2018	$30,996,830
CH 2 Reconstruction	CH 2	I-35	2018	$7,480,930

SHERBURNE County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
I-94/TH 10 River Crossing (in STIP)				N/A
TH 10 / CSAH 11 Interchange	CSAH 11	TH 10		$ 15,700,000

WASHINGTON County				
Project Name	**County Roadway**	**MnDOT Roadway**	**Year**	**Total Cost**
CSAH 15 & CSAH 17 - TH 36 Interchange	CSAH 15 and CSAH 17	TH 36	2021	$ 20,500,000

WRIGHT County
Project Name
No projects that would affect a MnPASS system

13 – I-35W Minnesota Urban Partnership Agreement (UPA) Traffic Forecast and Analysis

Study Date: May 2008

Study Purpose

The memorandum summarizes the methodology and results of travel demand forecasts prepared for the roadway components of the I-35W Minnesota UPA project with particular focus on vehicular traffic forecasts for roadway improvements. The UPA funding was intended to facilitate HOT lane implementation and conversions along the corridor. The primary components of the program were:

- A priced dynamic shoulder (PDSL) on I-35W from 46th St. South to downtown Minneapolis.
- The High Occupancy Vehicle (HOV) being constructed as part of the TH 62 Crosstown reconstruction projects from 66th to 46th Streets to be opened as a High Occupancy Toll (HOT) lane.
- The existing High Occupancy Vehicle (HOV) lane on I-35W (from approximately I-494 to Burnsville Parkway) would be converted to a High Occupancy Toll (HOT) lane

The study addresses the sub-projects of the above referenced projects (as discussed below) that are the subject of environmental assessment worksheets. A sub-alternative for the I-494 interchange was also tested.

Study Methodology (Screening and Evaluation Methods)

The Twin Cities regional travel demand model is discussed as having limitations for modeling HOT lane configurations where pricing is dependent on the capacity of the lane not used by HOVs. An alternative method was available that estimates the HOT lane users within the highway assignment process. This process uses a diversion curve for estimated value of time and time saved, and a second diversion curve to assess the price required to control the demand in the lane. The process is described as being more sensitive in dealing with capacity-constrained highway assignments. The overall model was validated as part of the I-494/34th Ave. Study. Models were adjusted on a link-by-link basis to compensate for the base year discrepancy in the 2005 Twin Cities Regional Model. Roadway Network assumptions are detailed for the three projects as for the Base Network for years 2010 and 2030. The environmental process/EAW requires that the projects be considered to have “independent utility” and not rely on the assumptions of other projects. For this reason, four separate alternatives were modeled for each of the 2010 and 2030 analysis years. A sub-alternative for the I-494 interchange was also tested. The fourth alternative combines all three alternatives analyzed modeling the entire I-35W corridor as a HOT lane project. Each of the three projects is summarized in the study.

The basis for the forecasts were the travel demand modeling for SP 2785-349, the I-494 & TH 77 Forecasting and Concept Development (also referred to as I-494 & 34th Avenue Study). Socioeconomic forecasts were adjusted to conform to the Metropolitan Development Framework as of January 2007. HOT lanes were modeled at an assumed capacity of 1,500 vehicles per hour, which would maintain a high level of service on the roadway.

Study Results

Traffic impacts were analyzed for each of the following sub-projects and for a system-wide effect:

The **PDSL Alternative** (from 46th St. to the I-35WTH65 Split): the priced dynamic shoulder was found to increase roadway capacity by the equivalent of an HOV lane; increasing traffic flow in the northbound direction while reducing traffic levels on the mainline roadway. The build over no-build scenario reduces congestion conditions to only 2 hours per day versus over 5 hours with no-build. Overall transportation benefits are accrued as discussed in the study.

The **Auxiliary lane/CD Road System Improvement** (from 90th St. to I-494) adds an additional northbound lane and provides adequate lane continuity through the I-494 interchange area by providing queuing for vehicles waiting to enter westbound I-494 and by separating weaving movements to/from I-494 from the general traffic stream. The additional auxiliary lane capacity in the build scenario provides additional storage capacity for vehicles exiting I-35W to I-494. The additional storage capacity is said to be required until I-494 is expanded and thus better able accept the traffic demand from I-35W. A projected 5 hour congestion period by year 2030 under no-build would be eliminated or reduced with this enhancement.

The Additional Lane I-35W Southbound across the Minnesota River (between 106th and TH 13) would be constructed as part of the overall UPA program. The change in designation of the inside lane from an HOV lane to a priced HOT lane increases the use to its design capacity of 1500 vehicles per hour. This includes 1.440 HOVs and 160 HOT lane paying SOVs. Overall transportation benefits are realized with the movement of traffic to the HOT lane from a more congested lane. New Minnesota River crossings are expected mainly due to diverted traffic from TH 77. The study concludes that while there is a capacity increase and improved travel times, the overall increase in capacity due to the project is not significant enough to induce more traffic across the river. This is due in part to up and downstream capacity issues expected to worsen by 2030.

A **"Full-Build"** alternative was also completed combining each alternative to observe the full-effect of the improvements studied. The study found that the HOT lane segment of I-35W north of I-494 would be better utilized under a *full system approach* rather than as a stand-alone segment. This is due to relative lower congestion levels between I-494 and 42nd St. (than on the corridor as a whole) and lack of excess capacity in the HOT lane in the vicinity of the PDSL segment, offering a relatively high cost for a short trip. The Hot lane was found to be more attractive to users for longer trips from the south of I-494. Lastly, as modeled, most sections could experience pricing at or near the maximum of $8.00 on a regular basis by 2030 regardless of whether the full system improvements existed. This negative may be off-set by full system implementation and longer distance users more willing to pay the higher fee. An analysis of vehicle miles and vehicle hours traveled for each of the three sub-projects (analyzed for build and no-build scenarios for 2010 and 2030) to assess user benefits is also provided.

Relevance to the MnPASS System Study Phase 3

The relevance of the study is strong in the potential for replication of its methodology and comprehensive approach. Although the study is eight years old, it provides a detailed overview of the analysis undertaken at the time of the I-35W HOT lane implementation focusing on three key sub-projects which were evaluated independently (for EAW purposes) as well as in concert to obtain a corridor wide impact.

14 – I-35 Corridor South; I-35E/I-35 W Split to CR 70- Lakeville

Study Date: January 2016

Study Purpose:

The I-35 Corridor South Study, (the study) analyzes the needs, issues and options associated with extending the MnPASS Express lane on I-35 between the I-35 E and I-35W Split (the split) and Dakota County Rd. 70 (CR70) in Lakeville. The *draft* study (reviewed as of October 2016) was undertaken by MnDOT and the Met Council and aided by local government staff. The analysis was performed in a manner consistent with the evaluation methodologies and criteria from MnPASS System 2 and other related studies. The stated goals of the study are to: reduce congestion and improve safety, improve travel time, better utilize infrastructure, increase transit and HOV use and provide commuter choice during peak travel times.

Study Methodology (Screening and Evaluation Methods)

The corridor was evaluated for future MnPASS extension by studying the following elements: the review and analysis of the existing conditions and issues in the corridor including traffic flow, congestion, vehicle crashes, transit and park and ride, MnPASS use, freight and infrastructure condition; review of traffic and transit forecasting data; review of planned and programmed transportation improvements in the corridor; and high level concept development and cost estimating

Study Results (Conclusions)

The study highlights existing conditions including two distinct cross sections; an Urban 6-Lane segment (from the split to CR46) and Rural- 4 Lane segment (from CR46 to CR70) with the highest level of congestion occurring is in the urban section with levels exceeding 100K VPD. And, while the study found that the heaviest traffic is highly directional in both the peak AM and PM, the corridor does *NOT* experience ***recurring congestion*** as defined in the Metro System 2015 Congestion Report. Note however that some significant backups can occur in the northbound peak AM as a result of delays on I-35W north of the study area. This spill-back can be exacerbated by weather and/or traffic incidents. The study references 2013 and 2015 MnDOT detector studies which confirm the 2015 Congestion Report findings. The study also found strong transit usage with roughly 600 of 750 Lakeville park/ride stalls currently utilized and further that Lakeville has the most MnPASS users in the I-35W corridor with 2,360 pass holders. Also, use of existing I-35W, MnPASS lanes, north of the study area, has increased from 473K to over 941K VPD between 2010 and 2015. Study area truck traffic is heaviest in the northerly/ urban section of the corridor, accounting for up to 10% of total traffic.

The study also dealt with traffic forecasts, transit usage and conceptual development as follows:

UPA Travel demand land use models were utilized to develop forecasts for 2012 and 2032. Both the build and no build alternatives are expected to result in similar traffic volumes. Traffic in the corridor is expected to increase from 89K VPD to 143K VPD between 2012 and 2032. *Detailed forecast tables are cited but were not yet available in the reviewed draft.*

Transit use is anticipated to grow with the planned Orange line BRT extension to the Lakeville Park and Ride. Upon extension, 2040 transit use is expected to grow from 11,400 to 12,900 rides per day.

Concept Development for the MnPASS extension includes an Eight-lane Urban section (between the split and CR 42) and a Six-lane Rural component (south of CR 42 to CR 70). The rough estimates for the improvements are $42M to $100 M.

The Evaluation section of the report was not developed at the time of this summary. An outline of the proposed Evaluation sections include: projected MnPASS demand, impact on highway performance, transit advantages, operations, and future construction impacts and opportunities.

Relevance to the MnPASS System Study Phase 3

This *draft* study directly addresses the relevance of the MnPASS lane extension in the I-35 Lakeville Corridor as referenced in the 2040 Transportation Policy Plan. The study methodology is consistent with MnPASS System 2 and *should upon completion*; provide a comprehensive overview of the subject corridor's viability for continued inclusion and prioritization in the MnPASS system. The overall takeaway is that this portion of the Metro area will continue to grow due to available land and that increased congestion will follow. The study concludes that while some segments of the corridor are at or near capacity, the corridor in general is not experiencing reoccurring congestion. The study's traffic forecast results are incomplete at this time so informed assumptions regarding the impact of MnPASS lane extension were not available for review.

15 – I-35W North Managed Lanes Corridor Study

Study Date: June 2013

Study Purpose

The purpose of the “I-35W North Managed Lane Study (the study) was to identify and evaluate lower-cost/high-benefits options for improving traffic operations along I-35W and to evaluate managed lane options. The Study was performed by SRF and is dated June 2013. The stated goals of the study include: reduced congestion, better utilization of existing and future infrastructure, increased transit use and providing better choice for peak use commuters.

Study Methodology (Screening and Evaluation Methods)

The study methodology was intended to evaluate the benefit of a managed lane improvement in the corridor and included the following study process: background review of all corridor information; development of screening criteria; study framework discussion including light rail, BRT and managed lanes; alternative improvements including local and managed lanes; primary screening to narrow alternatives; secondary screening of remaining alternatives; managed lane vision and implementation plan; management and outreach and documentation. The study utilized a Project Management Team and Technical Advisory Committee as well as public outreach.

Study Results

Three major congestion causes in the corridor are identified, including: two areas on southbound I-35W one where a weave occurs with vehicles entering from CSAH 96 and those exiting to westbound 694 and a second south of 694 due to vehicles entering from southbound I-694. The third identified problem is northbound I-35W due to a lane drop on eastbound TH 36 at CR 46 which causes traffic queues on TH 36 to spill back onto northbound I-35W. [Include congestion map Fig. ES-2]. The study analyzed travel demand for highway, transit and freight modes for years 2010/2011 and 2030, *no-build* and *build* scenarios are addressed using the Met Council Regional Travel Demand Model. The *no-build* analysis shows greater growth in the north segments of the corridor. *No-build* growth rates include: 0.5 percent south of TH 36, 0.5 percent to 1 percent between TH 36 and TH 10 and slightly more that 1 percent north of TH 10. Some segments are expected to approach capacity during peak periods including SB I-35 W between TH 10 and CR 88 and NB I-35W between CR 88 and Lexington Ave. Transit ridership under 2030 “No-build” conditions in the corridor is expected to grow from 2,750 to 4,425 daily riders.

Results of the *build* alternative model runs indicate that the addition of managed lanes in the corridor would result in increased traffic on the roadway (including both the general purpose and managed lanes). Under the *build* scenario, volume increased for all segments (from Washington Ave. to TH 97) included in the corridor study. The estimated (*no-build to build)* increase for each segment where managed lanes are proposed, was less than the predicted managed lane volume itself. [See Table ES-1]. Transit forecasts for the *build* scenario shows increased corridor ridership of 4,825 versus 4,425 for the *no-build* scenario.

The study identifies a preferred managed lane alternative with three developed cross sections. The preferred alternative scored well on both primary and secondary screening with no fatal flaws identified. The design includes a full outside shoulder which can be used as a bus only shoulder for shorter distance transit service, not in competition with managed lanes.

The study also includes a Managed Lanes Vision which includes a set of all improvements selected for the corridor. These improvements include, managed lanes capacity through the corridor and localized improvements to both relieve congestion and to facilitate the implementation of the managed lanes concept.

Relevance to the MnPASS System Study Phase 3

The study will be of direct benefit to the MnPASS 3 System Study initiative in that it provides a broad evaluation of the implementation of managed lanes in the I-35W north corridor. It further includes a comprehensive overview of corridor wide improvements including: managed lanes between downtown Minneapolis and Lexington Ave.; interchange improvements at I-35W and TH 10; interchange improvements at I-694 and I-35W; managed lane direct connections to downtown Minneapolis; left lane extension to Snelling Ave. along TH 36 eastbound and north ramp access to Hennepin Ave. The study outlines the cost to implement the managed lanes and other corridor improvements at $715M with $430M for managed lanes implementation. A cost synergy is estimated to reduce the overall corridor enhancements by $165M for a reduced total of $550M.

16 – Highway 77 Managed Lane & Cedar Grove Transit Access Engineering

Study Date: April 2014

Study Purpose

The Highway 77 Managed Lane and Cedar Grove Transit Access project (the Study) addresses two related transportation planning and design needs on Highway 77 in Dakota County. The Hwy. 77 Managed Lane component involves building stakeholder consensus for one of three previously identified projects for creating a managed northbound lane on the corridor from 138th St. to Old Shakopee Rd. The Cedar Grove Transit Access project seeks to enhance performance of the Metro Red Line by improving access to the Cedar Grove Transit Station in Eagan and thus reducing travel time.

The two project components are considered to be related geographically and functionally. The managed lane deployment on Hwy 77 would address growing concerns with peak a.m. northbound congestion while the Red Line performance is directly affected by the efficiency of Highway 77 which it operates on. Also the busses accessing a new transit station would likely take advantage of the proposed managed lane making coordinated planning and design imperative.

Study Methodology (Screening and Evaluation Methods)

The study was conducted to build consensus around options for improving vehicular and transit travel in the Highway 77 Corridor. The methodology evolved around a committee oriented structure to involve a broad base of stakeholders and the general public. Two standing advisory committees were formed. A Technical Advisory Committee/Staff Advisory Committee (TAC/SAC) made up of staff from 11 agencies functioned to review and provide input on technical information and to provide input to the Policy Advisory Committee (PAC). The Policy Advisory Committee (PAC) made up of elected officials, or management-level staff, from nine agencies was formed to consider input from the TAC/SAC and the general public and to make recommendations to MnDOT and Dakota County.

The study focused on both a managed lane concept for the highway and improved access from the highway to the Cedar Grove Transit Station in Eagan. The managed lane component references a 2010 (SEH) study which suggested two managed lane concepts for consideration. A third hybrid option was identified following the study. The 2010 study concluded without stakeholder consensus on which option to advance.

As a basis for the decision making process for the Highway 77 managed lane options, the project team developed 24 evaluation criteria. Each of the three managed lane concepts was evaluated against each criterion. The evaluation results focused on “key differentiators” – those ways in which the options were distinct from each other in relation to the project objectives. Traffic modeling was undertaken using an expanded study area including intersecting roadways along with the Hwy. 77 and I-494 interchange influence area. Freeway traffic models (CORSIM, version 6.2) were developed using the 2010 study models to evaluate traffic operations of the corridor area. The modeling found poor levels of service in the a.m. peak hours along northbound Hwy. 77 from 138th St. to Diffley Rd. and from Hwy. 13 to Old Shakopee Rd. The primary constraints identified were the two-lane road geometry between 138th and Diffley and the three-lane Minnesota River Bridge. In addition, poor service was also identified on westbound I-494 in the study area.

The Cedar Grove Transit Access component of the study looked at numerous concepts for improving bus access from the highway to the Cedar Grove Transit Station in Eagan. Concepts were developed to address the current off-line travel delays affecting travel-time and thus performance of the Red Line. Several initial concepts were screened at a high level and dismissed; others were carried forward for more detailed review. Concepts evaluated for further viability were reviewed functionally by the four access/egress transit movements they would serve: northbound inbound, northbound outbound, southbound inbound and southbound outbound. The process evolved to further analyze four primary concepts and their subcomponents. The project team developed 27 evaluation criteria to utilize in evaluating each of the four primary access concepts.

STUDY RESULTS

Hwy 77 Managed Lane

Three managed lane options were evaluated against 24 separate criteria. The PAC recommendation was influenced by the key determinants of travel time, congestion and cost. Option 2B was selected as the design which would deliver the best option for both managed lane and general purpose lane travel time and the greatest cost effectiveness. The recommendation includes: the addition of a northbound managed MnPASS lane with open access at multiple locations constructed in the existing median from 138th St. to Diffley Road; conversion of the existing general purpose lane to a managed MnPASS lane, with open access at multiple locations, from Diffley Rd. to the Old Shakopee Rd. off ramp and restriping the remaining pavement to provide a northbound general purpose lane from Diffley Rd. to the Old Shakopee Rd. off ramp. The concept includes removal of the bus shoulder on the Minnesota River Bridge. This design effectively adds a managed lane over the entire length of the project while maintaining the general purpose lanes that exist today. Two other options (not recommended) both also utilized a managed lane for at least a portion of the corridor, but also included a “contraflow” lane alternative. The contraflow model, which has been used in other parts of the country, would shift some peak traffic volumes to the other, non-congested, side of the highway. The use of moveable barriers and a barrier transfer machine is involved. The contraflow model option was apparently heavily debated and not recommended due to both up-front capital and long-term maintenance costs and winter weather concerns. The study recommends that the contraflow model be considered in other future applications; especially where right of way costs and/or constraints are limiting factors. Key reasons for recommending Option 2B over the others are: travel time and performance superiority, the favorable cost relative to the other two options and the highest benefit-cost ratio and the overall compatibility with alternative being considered for the Cedar Grove Access enhancement. The conclusion stressed that the recommended option needed to be addressed along with enhancements to westbound I-494 between I-35W and Hwy 77 in order to achieve optimized results.

Cedar Grove Transit Access

Four primary concepts (along with sub-options) were evaluated against 27 separate criteria developed to test each option against the objectives developed for the project. A list of key differentiators/objectives emerged from which general themes followed for each of the four concepts. Key differentiators centered around cost, cost-benefit ratio, user experience, travel time, user experience (walk distance) bus weaving issues and consistency with other Red Line stations. The Center Access and Center Station Concepts (Concepts F and G) emerged as the most-favorable. Concept F involves a left-hand center lane bus access to the existing station on the east side of Hwy. 77 by way of a bridge over the highway. Buses would make the opposite move to return to the highway. This option reduced bus access and exiting time to the station by reducing travel time off-line. Concept G, *the recommended concept*, involves the construction of a new center transit platform in the Hwy. 77 center median. This Center Station concept moves buses to the left hand lane and to a new center platform similar to the I-35W/46th St. Station in Minneapolis. Passengers would access the platform from the existing Cedar Grove station via a new pedestrian crossing over the northbound Hwy 77 lanes. Busses would re-enter the highway via the left hand center lane. The same pattern would apply for either direction. Despite disadvantages including more walk time and less convenient transfers, *Option G was advanced for recommendation* as it presented the most advantages including: best Red Line travel time savings, fastest option for through passengers and lowest construction cost and greatest bus operator savings. With design engineering, the initial estimated cost of concept G was reduced from $22.9m to $14.6m.

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

The Hwy. 77 Managed Lane and Cedar Grove Transit Access Study has significant relevance to MnPASS Phase 3 in that it provides a technical evaluation of both a managed lane option for the corridor and a major transit access improvement for the Red Line BRT. The Highway 77 Corridor is identified as a candidate for MnPASS managed lane expansion in several key documents including: the MnPASS Phase II Study and both the 2030 and 2040 Regional Transportation Policy Plans. The Hwy. 77 study included input from numerous affected stakeholder agencies and the general public. The study capitalized on a 2010 SEH study which advanced three options for managed lane deployment but lacked consensus on a specific recommendation. The study and its appendixes thoroughly document the study process and results, including: existing operational issues, the development and evaluation of alternatives, analysis of build and no-build scenarios and cost benefit evaluation. The study concludes with documented formal support for the PAC's recommendations from numerous agencies and local governments, including the projects potential implementing agencies (MnDOT, Dakota County and Metropolitan Council).

17 – I-394 MnPASS Technical Evaluation Report

Study Date: November 2006

Study Purpose

The 2006 I-394 MnPASS Technical Evaluation study focuses on the technical evaluation of the MnPASS HOT lane implementation on the I-394 corridor between downtown Minneapolis and I-494. Recognizing that the MnPASS deployment provided a test bed for possible expanded use of the concept, MnDOT commissioned a comprehensive study of the HOT lane's effectiveness. This study tested several predetermined hypotheses to measure the value of the conversion from HOV type use to a HOT Lane function. This was the first such conversion in the state and one of a handful nation-wide to utilize dynamic lane pricing techniques to influence HOT lane use. The stated goals and objectives were to: provide MnDOT an assessment of the success of the project with respect to stated project goals; to provide stakeholders with information on observed impacts; to provide feedback on system performance; to augment evaluation of public perception by coordinating with a companion Attitudinal Evaluation study; to provide a basis for future decisions regarding MnPASS use and to provide a reproducible evaluation framework.

Study Methodology (Screening and Evaluation Methods)

The technical evaluation of the I-394 MnPASS deployment was conducted according to guidelines specified in a 2003 Technical Evaluation Test Plan. This test plan specified multiple evaluation objectives to be assessed in the course of the evaluation. The evaluation methods used in the study attempted to isolate the before and after change in conditions associated with the implementation of MnPASS. In order to isolate the impact of MnPASS, the evaluation approach was designed to analyze before and after data collected over broad time periods to provide a wide sampling of conditions. The study made maximum use of archived automated data sources. Select field data was collected to augment automated sources, including vehicle occupancies. The evaluation further relied on before and after I-35W HOV corridor data to provide adjustments for regional changes in travel patterns. In order to support the assessment of key evaluation objectives and hypotheses, the following data sets were collected: vehicle volumes, vehicle speeds, vehicle occupancy, crash occurrence, incident occurrence, noise impacts, emission impacts, enforcement data, MnPASS System performance, MnPASS System revenues and transit operational impacts.

Study Results

Key findings of the study are as follows: MnPASS has been popular with users as evidenced by the demand for transponders; 10,000 transponders were in use and holders utilized the toll lanes on average of twice a week; toll modifications implemented in 2005 resulted in increased revenues and less volatility in rate changes at lower traffic levels; increased enforcement has resulted in reduced illegal use of the facilities due to providing SOV users a legal option to use the underutilized HOV lane and, most transit providers reported minimal negative impacts on operations (mainly focused on difficulty merging at specific points in the corridor).

In addition to the above findings, the study discusses several Outcomes/Findings to predetermined Evaluation Hypotheses. Key findings identified are as follows: the implementation of the MnPASS HOT lane resulted in a 5% increase in vehicle throughput in the I-394 corridor; MnPASS deployment resulted in increased vehicle speeds in the general purpose lanes of 6%; increased travel speeds in both MnPASS and general purpose lanes resulted in reduced travel times; a reduction in carpool use was observed but was not considered to be directly attributable to MnPASS implementation; MnPASS did not contribute to illegal use by SOV users; MnPASS was not found to result in more crashes and conversely resulted in 14% fewer crashe; MnPASS did result in a decrease in speed differential between MnPASS lanes and general purpose lanes; no significant increase in noise levels resulted from the deployment and lastly, the deployment did not result in increased CO emissions.

Relevance to the MnPASS System Study Phase 3

The I-394 MnPASS Technical Evaluation Study recognized that the deployment of MnPASS in the corridor was a “test bed” for evaluating the viability of the HOT lane concept for broader use in the metropolitan system. The study recommends that vehicle occupancy data provided as part of the evaluation be considered in any future assessment of the MnPASS system.

18 – I-35E MnPASS Extension Land Use Study Support, Encourage and Enhance Transit & Carpool Use

Study Date: 2015

Study Purpose

This study addressed the practicality of extending MnPASS on Interstate 35E between Little Canada Road and County Road 96, and ultimately northward to the intersection with County Road 14. This study studied the corridor communities associated with three chosen intersections to identify design concepts and strategies that illustrated options for Corridor communities to facilitate and foster greater transit, carpool, and vanpool use of the MnPASS investment in the I-35E Corridor.

Study Methodology (Screening and Evaluation Methods)

Using I-35E communities as its focus for study, the physical realities of the Corridor & its communities were studied in the context of each community's uniqueness, history, human capital, cultural assets, environmental assets, current challenges, and future aspirations. The study looked at each community and asked the question," What are the challenges and opportunities in supporting, encouraging, and enhancing transit, van pool, and carpool use within the I-35E Corridor in this community?" Topics that we looked into were: Transportation Impact on community location, Freeway Impact on Communities, Road and Streets, Trails, Bicycle Routes, Sidewalks, transit.

Study Results

This study came up with design strategies to increase transit, vanpool, and carpool use of MnPASS. These design strategies were:

- Respond to Each Community's Historic Character + Development Pattern to Support and Encourage MnPASS, Carpool, and Transit Use
- Use Large Park-and-Ride Facilities as Civic Places to Support and Encourage MnPASS, Carpool, and Transit Use
- Make a Network of Pedestrian-Friendly and Bicycle-Friendly Streets and Trails to Support and Encourage MnPASS, Carpool, and Transit Use
- Promote Denser Housing + Mixed-Use Development/Redevelopment to Support and Encourage MnPASS, Carpool, and Transit Use

- Recycle Existing Underutilized Retail Properties to Support and Encourage MnPASS, Carpool, and Transit Use
- Develop/Redevelop with Ecological Sensitivity
- Use Environmental Attributes as Amenities to Create Value Support and Encourage MnPASS, Carpool, and Transit Use
- Address Unintended Consequences of Large Environmental Interventions
- Respond to Opportunities that 21st Century Technology Present
- Create Park + Pool and Gather + Go: Multi Neighborhood and Neighborhood Scaled Places to Support and Encourage MnPASS, Carpool, and Transit Use

Relevance to the MnPASS System Study Phase 3

You need to understand the geographic region that you are serving to realize the impact and ridership you will obtain. For the system to be of great use we have to encourage the use of the system by offering amenities that promote the use of the system.

19 – I-94 MANAGED LANES STUDY

STUDY DATE: JANUARY 2010

STUDY PURPOSE

The Minnesota Department of Transportation (Mn/DOT) conducted this study of the I-94 corridor between downtown Minneapolis and downtown St. Paul. Mn/DOT‟s purpose was to identify potential improvements to the physical facilities and traffic operations that existed prior to the I-35W bridge collapse in August 2007, while establishing an overall vision for potential improvements in the I-94 corridor, including improvements for both general traffic operations and transit services. Recommendations that result from this study were focused on meeting or exceeding the established project goals: Better utilize existing infrastructure investments; Preserve or enhance advantages for transit and carpoolers, as well as for general traffic; Provide a congestion-free choice for Single Occupancy Vehicles (SOV) and Preserve or enhance corridor safety.

STUDY METHODOLOGY (SCREENING AND EVALUATION METHODS)

The study identified options that would fit in the existing corridor envelope ranging from a no-build alternative, to added general purpose lanes, to managed lanes. Worldwide experience with High Occupancy Vehicle (HOV) lanes, priced Managed Lanes (ML) and Dynamic Shoulder Lanes (DSL), as well as narrowed lanes and bus-only shoulders were researched with regards to success, safety, and best practices. Four basic alternatives, including High Occupancy Toll (HOT) lanes, Priced Dynamic Shoulder Lanes (PDSL), DSL and bus shoulders, along with hybrid scenarios were developed, reviewed and analyzed. Alternatives included three-lane and four-lane segments, and right and left entering/exiting ramps.

The Twin Cities Regional Model was used to develop the travel demand forecasts for this study. The model was developed in the 2001-2003 timeframe as a part of the Twin Cities Travel Behavior Inventory (the 2000 TBI), and used information from the 2000 Census, the year 2000 Regional Home Interview Survey and a concurrent set of external surveys done as a part of the 2000 TBI. Based on the high level travel demand analysis for the corridor and recommendations from project technical and advisory committees, the Minor Rehabilitation Alternative and the Full Reconstruction Alternative, along with the no build option, were selected for CORSIM simulation analysis of traffic operations.

STUDY RESULTS

The resulting recommendation of the study identified an overall vision for the corridor with respect to managed lanes, along with minor rehabilitation and full reconstruction implementation strategies. The benefits of Active Traffic Management (ATM) in addressing the serious safety issues in the I-94 corridor were recognized and the most promising options were evaluated for cost-effectiveness.

The I-94 corridor connecting downtown Minneapolis and downtown St. Paul is a key link in the regional transportation network serving a broad range of trip purposes, through trips and local trips, and a significant number of truck and transit trips. The operational capacity and safety of the corridor are greatly impacted by the bottleneck conditions at the two ends of the study area: the Lowry Tunnel at the west end; and the Capitol Interchange at the east end. The congestion and queues resulting from these two bottlenecks greatly reduce the effectiveness of any concept to increase capacity on I-94 since the queues will persist because of the difficulty and impacts associated with reconstructing interchanges at the two bottlenecks. The study has focused on both short and long term opportunities to better manage the existing facility, to maintain mobility, to encourage use of transit and to improve safety.

This study recommends a limited investment in managing the investment in the existing freeway, recognizing that 1) the limited availability of funds rules out major reconstruction and expansion of I-94 between Minneapolis and St. Paul, and 2) the impacts of the bottlenecks presented by the Lowry Tunnel to the west and the Capitol Interchange to the east will not disappear. To improve traffic flow for transit and general traffic and to enhance safety, limited spot improvements are proposed to provide four continuous lanes in each direction between I-35W and TH 280 together with an ATM system of variable speed and queue warning signs along with in-road lighting for the WB right lane between the Dartmouth Bridge and the downtown Minneapolis exit to provide improved reliability for Metro Transit bus operations. Interchange ramps at I-35W and at TH 280 would be revised to eliminate lane drops and to provide lane continuity. Between TH 280 and downtown St. Paul, the roadways of I-94 would be reconstructed to provide wider BOS operations, the purpose of which is to permit 45 mph operations of buses. The Minor Rehabilitation Alternative, which included these short-term improvements, is estimated to cost $49 Million. This would include milling and overlaying the existing roadways to replace deteriorated pavement and to improve roadway drainage. Looking to the long range, a continuous managed lane in each direction in the median of I-94 is recommended, together with direct connecting ramps to both downtown Minneapolis and downtown St. Paul. This would require the major reconstruction of the I-94 interchange with TH 280 to eliminate the left hand ramps. This widening and reconstruction would also require replacement of many of the overhead bridges which limit the space currently available for the I-94 roadways. This would include replacement of three railroad bridges over I-94. This total reconstruction of I-94 is estimated to cost $485 Million in 2010 dollars. This does not include any reconstruction of the Lowry Tunnel interchange or the Capitol Interchange, but does include the cost of an ATM system for the entire corridor to manage traffic operations and to improve safety.

Relevance to the MnPASS System Study Phase 3

This study is relevant to the MnPass System Study because we learned that you can provide vast improvements to the system but you may have constraints just outside of the project limits that need consideration.

20 – Katy Freeway: Evaluation of a Second-Generation Managed Lanes Project

Study Date: September 2013

Study Purpose

The Katy Tollway is the first constructed managed lane project in Texas and the first variably priced operation in the state since the implementation of the QuickRide program on US 290 and I-10 high-occupancy vehicle (HOV). The four-lane facility, constructed within the center of the existing freeway, is more complex than earlier-generation conversions from HOV to high-occupancy toll (HOT) lanes. Two managed lanes operate in each direction in the median of the facility, bound by eight general-purpose lanes, with four traveling eastbound and four traveling westbound.

The purpose of the study is a comprehensive evaluation of the Katy Freeway Managed Lanes, including aspects such as congestion, safety, enforcement, maintenance, pricing, access design, lane separation, operating policy, public perception, and project delivery mechanism.

Study Methodology (Screening and Evaluation Methods)

The off-peak direction has shown a significant growth in volume and travel time savings, so the off-peak direction was evaluated as well.

A user survey, safety analysis and traffic analysis were conducted. The user survey was designed to examine ways to improve traffic flow, understand Houston road users' decision-making process (specifically with regard to managed lane usage), and evaluate the managed lanes with the purpose of supporting successful implementation of managed lanes across Texas. The traffic analysis looked at changes over time in traffic volume, travel time, and transit usage within the HOV and managed lanes using data obtained from several sources, including TxDOT, METRO, HCTRA, and the Texas A&M Transportation Institute (TTI). Additionally, enforcement data was reviewed and assessed.

Study Results

Travel time savings are approximately 5 minutes in the morning and 14 minutes in the afternoon in the peak directions, and the travel time advantage over the general-purpose lanes has increased as volumes have grown.

LANE PERFORMANCE IS CONTINUALLY MONITORED AND ADJUSTMENTS IN TOLL RATES, LANE CONFIGURATION AT THE TOLLING ZONES, AND ACCESS OPERATIONS ARE MADE AS NEEDED. THESE ADJUSTMENTS ARE CRITICAL TO MAINTAINING THE PERFORMANCE STANDARDS FOR THE LANES.

A SAFETY ANALYSIS OF THE CORRIDOR SHOWS THAT THE IMPROVED GEOMETRIC DESIGN AND REDUCTION IN CONGESTION HAD A POSITIVE EFFECT ON REDUCING CRASHES, WHICH DROPPED FROM 128.3 CRASHES PER MILLION VEHICLE-MILES BEFORE CONSTRUCTION TO 57.3 CRASHES PER MILLION VEHICLE-MILES AFTER THE PROJECT OPENED.

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

Other studies access potential corridors, while this study illustrates usage, safety, access design, tolling and pricing, enforcement, and user data for an operational system.

Table 1. Katy Lane Geometry Before and After Construction.

Criteria	Before/During Construction	After Construction
Managed Lanes	One lane reversible HOV	Two lanes each direction HOV/Toll
General-Purpose Lanes	3	4
Occupancy	HOV3+ in peak hours	HOV 2+ and Toll
Hours of Operation	M-F 5AM to 11AM IB M-F 1PM to 8PM OB Sat OB & Sun IB	M-F 5AM to 11AM IB & OB M-F 1PM to 8PM IB & OB Toll 24/7/365
Separation	Barrier	Buffer with pylons
Operating Agency	TxDOT/METRO	HCTRA

Table 55. Evaluation Measures and Relationship to Katy Freeway Project Goals (*8*).

Goal	Description	Relevant Measures Evaluated under This Study
Project Goal 1:	Improve corridor mobility and safety in a cost-effective manner	Congestion, travel time, safety, enforcement, maintenance, access, lane separation, tolling
Project Goal 2:	Provide a transportation system that has minimal negative impact on aesthetics, environment, and community	Public perception, operational policy, project delivery
Project Goal 3:	Provide a balanced and coordinated transportation system	Not addressed under the scope of this study
Project Goal 4:	Provide a transportation system that serves the regional land use/development patterns now and in the future	Not addressed under the scope of this study
Operating Goal:	Maintain level of service C in the managed lanes	Travel time, congestion

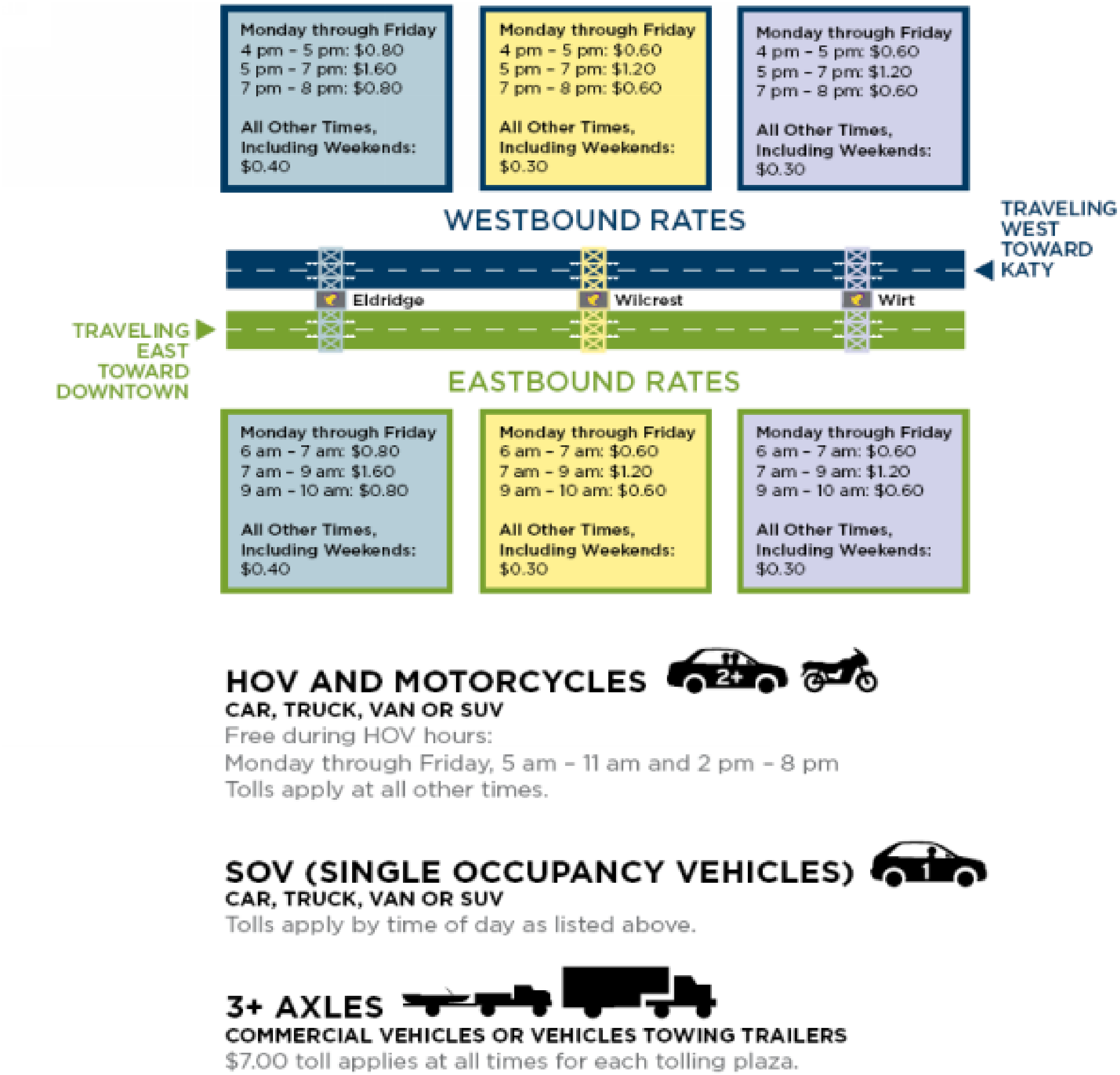


Figure 41. Toll Rates on the KML (https://www.hctra.org/katymanagedlanes/index.html).

21 – Caltrans Traffic Operations-Managed Lanes Case Studies

Study Date: March 2013

Study Purpose

The purpose of the Caltrans Traffic Operations study was to evaluate the impact of increasing vehicle occupancy requirements on HOV/HOT lanes on four HOT lane systems in three different parts of the country; Miami, Atlanta and Houston. The four corridor programs reviewed include I-95 in Miami, I-85 in Atlanta and U.S. 290 and I-10 Highways in Houston. All four case studies involve increased occupancy standards initiated on HOT lanes to increase travel efficiencies.

Study Methodology (Screening and Evaluation Methods)

The Case studies relied on both state and federal studies to provide an evaluation of the effectiveness of increased occupancy requirements along with HOV to HOT lane conversions. For each corridor reviewed, state department of transportation studies and Federal Highway Administration sources are referenced. The managed lanes Case studies for each metropolitan area breaks down the analysis into the following categories: 1) Project Description, 2) Why Occupancy was Increased, 3) Other Actions Taken, 4) Public and Political Outreach, 5) Impacts and Lessons Learned, 6) Revenue Control and Use and 7) Sources. Study evaluation for the Georgia model was less detailed as other related studies were still underway at the time.

Study Results

The results of the Case studies are summarized below for each corridor referenced.

I-95 Express, Miami. The 21-mile HOV was converted to two-high-occupancy toll (HOT) lanes in each direction. Toll exempt vehicles are restricted to registered carpools of three or more passengers, vanpools, hybrid vehicles and motorcycles. The conversion of the I-95 HOV lanes to HOT lanes focuses on the throughput enhancement of the whole corridor not only the HOV lanes. Preference given to 3+ carpools was enacted to encourage ridesharing. The “95 Express Annual Report” concludes that the program has considerably improved the overall operational performance of I-95. Customers including transit riders using the express lanes have significantly increased travel speed during peak travel times from average speeds of 20 mph to averages of 50 to 60 mph. Travel times in the general purpose lanes improved as well. Travel time reliability also improved with peak AM travel at 45 mph nearly 100% of the time and 92% of the time in peak PM. Direct bus ridership impacts were not clearly reflected. While the study noted that Express bus service (in the general area) increased by 30% after the transition, this increase was not reflected at the corridor level which actually experienced a small decrease. However transit benefitted by the overall decreased travel times associated with the Express lane conversion (a savings of 17 minutes) for all vehicles using the HOT lanes. The report found that there was a 4.6% increase in person throughput in the corridor. The change in toll requirements also resulted in a shift in mode users. SOV use increased 256% in HOV lanes and 33.5% overall (GPLs and Express) while HOV2 use decreased 37.5% in managed lanes and 21.6% overall. The decrease in HOV2 users show that carpools shifted to SOV mode and HOV3 the later which was up 9.6% overall. (See Table 4 from the Case Study).

Table 4 Person Throughput by Vehicle Type in Managed Lanes 2008 vs 2009 (Northbound; PM Peak Period- 4 to 6 PM) (Cain, 2009)

Vehicle Type	Managed Lanes			Facility (GPLs + Express)		
	Total Person Volume per Peak Period			Total Person Volume per Peak Period		
	2008	2009	% Change	2008	2009	% Change
SOV	1061	3778	256.1%	9141	12206	33.5%
HOV2	3040	1899	-37.5%	10437	8181	-21.6%
HOV3	477	171	-64.2%	2335	2558	9.6%
Transit	810	821	1.4%	810	821	1.4%
Total	5387	6669	23.8%	22723	23766	4.6%

I-85 Atlanta. GDOT converted 16 miles of HOV lanes on I-85 into HOT lanes. Toll-exempt vehicles include (registered vehicles only): HOV3+, motorcycles, transit and emergency vehicles and alternate fuel vehicles. Usage in the managed lanes has more than quadrupled since opening, increasing from 3,200 to 16,000 trips per day on average. First year performance data indicates a Total ADT of 18,600 trips with roughly 85% of users tolled versus only15% non-tolled. The morning peak average speeds ranged from 39 to 63 mph compared with the general lanes where averages were 30 to 57 mph. *Note; more in-depth evaluation by Georgia Tech was underway at the time of this study.*

U.S. 290 (Northwest Freeway) and I-10 (Katy Highway) Houston. *U.S.* 290 is a 14-mile single lane, reversible flow facility. The I-10/Katy Highway is a 12 mile HOT facility providing two lanes in each direction. These two HOV facilities became congested under the HOV2+ status in the late 1980’s and 1990’s. As a result, first the U.S. 290 and a decade later, the I-10 corridors instituted HOV3+ requirements for toll free usage and charges for HOV2 users. The “Quick Ride” program allows a limited number of two-person carpools to buy into the lanes in peak periods. Two-person carpools pay $2.00 per trip toll while higher occupancy vehicles pay nothing. The Quick Ride participants are typically users who formerly were SOV mode travelers on the regular general purpose lanes. The revenues from the several hundred vehicles each day pay for all the program's operational costs.

Before and after analysis by the manager of the I-10/Katy HOV lanes (described as anecdotal) includes the following: before the conversion, (during 2+ operations) peak volumes were 1700 vph with significant stop and go traffic and merging which led to a LOS of F. After the 3+ operation requirements, peak hour volumes dropped to 600 vph. And traffic flowed smoothly with average speeds of 53 mph with a LOS of A. During the past 10 years, 3+ HOVs has grown to about 1200 vph. A small number of about 10 % of the total vph are (tolled) HOV2 users. The number of carpoolers has remained about the same indicating that people changed their driving habits as a result of the 3+ occupancy requirement. The 15 minute time savings encouraged people to find additional passengers, including recruitment at the park and ride sites. Busses continued to move so ridership continued to grow.

A reference to a Value Pricing study (see Sources) cited average speed on the I-10 general purpose lane of 25 mph while the average on the HOT lane was 59 mph (over 17-minute time saving for a 13 mile trip). On U.S. 290, relative time savings were 11 minutes for a 15 mile trip and exceeded 20 minutes in the afternoon peak.

Other findings referenced include the following: The Quick Ride program receives relatively modest use (an average of 208 trips per day in 2003) Many users use the facility on an infrequent basis (less than 2.5 trips per month). Also, although HOT lane speeds on U.S. 290 often fall below the 45 mph threshold, average speeds are significantly better than in the general purpose lanes. I-10/Katy speeds were similar leading to significant time savings in HOT lanes. Lastly, a 2009 source found that since 2005, violation rates as high as 40 percent during HOV3+ requirement periods.

RELEVANCE TO THE MNPASS SYSTEM STUDY PHASE 3

The study provides valuable information on the impacts of increasing vehicle-occupancy requirements on HOV/HOT lanes. Three major metropolitan areas experience with changes to vehicle-occupancy requirements on their corridors are featured including, Miami's I-95, Atlanta's I-85 and two corridors in Houston, U.S. 290 and I-10. The study evaluates each transportation department's program using the same format/outline and draws on before and after surveys of commuters, DOT annual reports/evaluations of performance and Federal Highway Administration national studies of HOT lane conversions. The three case studies provide both empirical and attitudinal review of the effectiveness of modifying vehicle-occupancy requirements on managed lanes to affect mode shifts by users in order to improve travel-time and person throughput. The study is relevant to MnPASS in that it evaluates the evolution of HOV lane occupancy requirements in other parts of the country where managed lanes became overly congested and as a result were further restricted to improve mobility. The analysis focuses on how vehicle-occupancy requirements can affect mode shift by analyzing before and after use of the managed lanes by various user types including; SOV, HOV2, HOV3+ and transit riders. Lastly, the study looks at the revenues generated from each facility and the use of these funds.