TWIN CITIES HIGHWAY MOBILITY NEEDS ANALYSIS

Metropolitan Council
Minnesota Department of Transportation

SRF Consulting Group, Inc.
In partnership with:
Sambatek
Associated Consulting Services
Texas A&M Transportation Institute

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Key Messages

- Travel delay in the Twin Cities is costly and impacts all of Minnesota.
- Delay per person is recommended as the performance measure for Twin Cities highway mobility since it can be measured, forecasted, is broadly understood, and controls for population growth.
- Delay per person decreases as highway mobility investment increases. This analysis considered highway mobility investment up to $4 - $6 billion over the next 20 years and did not encounter an asymptote or point of diminishing returns.
- A target of 40 hours of annual delay per Twin Cities resident represents a five percent improvement over existing performance and significant improvement to projected 2040 performance at currently anticipated funding levels. This target was supported by project stakeholders.
- The highway mobility target performance level of 40 hours annual delay per person can be achieved using the investment strategies adopted in the region's planning documents.
- The cost to achieve a performance target of 40 hours annual delay per person is approximately $4-$6 billion in capital investment over the next 20 years.
- With this investment, a typical Twin Cities household would realize the following benefits:
    - Access to 180,000 more jobs within a 30-minute drive by 2040
    - $800 in travel time savings annually
    - 95 percent of the region's freight bottlenecks improved
    - Reduced transit delay for transit users
    - Limited impact on greenhouse gas emissions, but further analysis is planned in this area in 2022
- This study focused on a capital highway investment approach. It is expected that a range of solutions from travel demand management, transit/bicycle/pedestrian investment, land use changes, and other strategies will be needed to meet the target.
- Annual hours of delay per capita in year 2040 is highly sensitive to teleworking assumptions.

Chapter 1: Introduction

> ***What would it cost for MnDOT to meet the Twin Cities' highway mobility needs?***

The Twin Cities Highway Mobility Needs Analysis explores the highway mobility investment needs of the Minneapolis-Saint Paul Metropolitan Area (herein referred to as the Twin Cities). Highway mobility – the ability of people and goods to move efficiently and reliability along highways – is a core element of the Twin Cities' transportation system, regional vitality, and quality of life. In conducting this analysis, the Metropolitan Council (the Council) and the Minnesota Department of Transportation (MnDOT) seek to shed light on the following questions about highway mobility:

1. How does Twin Cities highway mobility contribute to state and regional goals?
2. What level of highway mobility should the Council and MnDOT target given policy direction, cost, and associated performance outcomes?

The Twin Cities Highway Mobility Needs Analysis uses the term *highway mobility need* to refer to investment in highway infrastructure for the purpose of delivering a targeted level of highway mobility. This definition advances a performance-based approach to highway mobility investment in which the type and amount of highway mobility investment is calibrated to achieve a targeted level of performance.

Key definitions

Highway mobility: The ability of people and goods to move efficiently and reliability on highways

Highway mobility need: Investment in highway infrastructure for the purpose of delivering a targeted level of highway mobility

Analysis Scope

The Twin Cities Highway Mobility Needs Analysis identifies Twin Cities highway mobility needs on the region's state highways over the next 20 years. Focusing on the state highway system aligns this analysis to the process MnDOT uses to identify capital investment needs on the state highway system. The Twin Cities metro-area state highway system consists of over 1,100 miles of Interstate, additional freeways, and MnDOT-owned highways in the seven-county area.

Analysis Stakeholders

The Twin Cities Highway Mobility Analysis was supported by staff at MnDOT and the Council with leadership roles and subject matter expertise in the planning and delivery of state highway construction projects. These stakeholders were brought together at multiple times in 2020 and 2021 to review analysis and provide direction on topics such as how to measure highway mobility and what the targeted level of highway mobility should be. Stakeholders were grouped into a Policy Advisory Committee (PAC), focused on analysis application and communication, and a Technical Advisory Committee (TAC), focused on analysis methods and results. PAC and TAC membership are provided in Table 1.

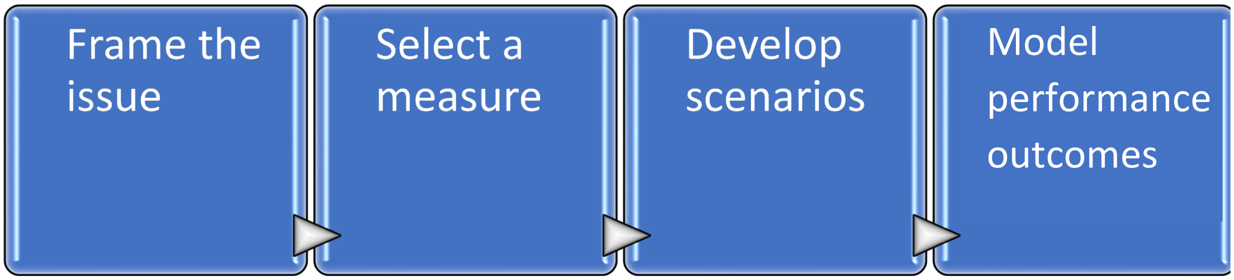
Table 1: Twin Cities Highway Mobility Needs Analysis Stakeholders

Stakeholder Committee	Members
Policy Advisory Committee	Deanna Belden (MnDOT) David Burns (Metropolitan Council) Lynn Clarkowski (MnDOT) Paul Czech (MnDOT) Sheila Kauppi (MnDOT) Steve Peterson (Metropolitan Council) Philip Schaffner (MnDOT) Jon Solberg (MnDOT) Nick Thompson (Metropolitan Council) Brad Utecht (MnDOT) Amy Vennewitz (Metropolitan Council)
Technical Advisory Committee	Andrew Andrusko (MnDOT) Chris Berrens (MnDOT) David Burns (Metropolitan Council) Michael Corbett (MnDOT) Paul Czech (MnDOT) Jonathan Ehrlich (Metropolitan Council) Tony Fischer (Metropolitan Council) Jim Henricksen (MnDOT) Brian Kary (MnDOT) Steve Peterson (Metropolitan Council) Ashley Roup (Metropolitan Council) Garrett Schreiner (MnDOT) Brad Utecht (MnDOT)

Analysis Process

The Twin Cities Highway Mobility Needs Analysis followed a four-step process that stemmed from MnDOT and Council policy direction related to highway mobility and the cost of congestion to selecting a highway mobility performance measure and recommending highway mobility target. Throughout this process, MnDOT and the Council continuously reassessed whether proposed highway mobility measures and targets provided a clear and credible basis for highway mobility investment.

Figure 1: Steps of the Twin Cities Highway Mobility Needs Analysis



Step 1: Frame the Issue

The analysis began with research and stakeholder engagement around highway mobility in the Twin Cities, focusing on the importance of Twin Cities highway mobility to the regional and state economy. This phase also established the policy basis for making investments to maintain and/or improve Twin Cities highway mobility, including the framework MnDOT uses to identify and address performance-based investment needs on the state highway system. Step 1 of the analysis concluded with a survey of how other states and regions measure highway mobility and use highway mobility results to inform investment decisions.

Step 2: Select a Measure

The second step in the analysis was to select a highway mobility measure. This step included a review of highway mobility measurement and investment planning by four regions with populations similar to the Twin Cities: Seattle, San Diego, Tampa-St. Petersburg, and Denver. The peer region review was done in conjunction with a national scan of existing highway mobility measures. Stakeholder review and evaluation of these measures revealed support for a highway mobility need estimate based on annual hours of travel delay per capita. There was also support for measuring additional outcomes associated with highway mobility, including travel time savings, greenhouse gas emissions, and job accessibility.

Step 3: Develop Scenarios

The third step in the analysis was to develop year 2040 highway mobility investment scenarios. The step began with three baseline conditions for annual hours of delay per capita in year 2040. These baselines corresponded to a year 2040 no-build scenario and two funding scenarios taken from the year 2040 Transportation Policy Plan, or TPP. Once year 2040 baselines were established, traffic analysts adjusted the highway network at spot locations and measured the resulting improvement in travel delay. These adjustments were iterated and refined to develop year 2040 scenarios that achieved a specified delay result. Year 2040 scenarios were then validated with stakeholders and used to estimate the highway mobility investment needed to realize each scenario.

A total of five 2040 highway mobility investment scenarios were advanced through the analysis. **Table 2** lists the scenarios from the scenario with the least mobility and lowest cost to the scenario with the greatest mobility and highest cost.

Table 2: Year 2040 Highway Mobility Investment Scenarios

Scenario	Annual hours of delay per capita	Cost range
1. Implement Planned Investments*	56	$0 - $375 million
2. Extend Current Investment**	52	$1-$2 billion
3. Manage decline in regional mobility***	48	$2-$3 billion
4. Sustain regional mobility	44	$3-$5 billion
5. Improve regional mobility	40	$4-$6 billion

*Approximates the level of highway mobility investment MnDOT would make in the Twin Cities over the next 20 years if it made no further investment in highway mobility beyond what is currently programmed.

**Approximates year 2040 travel modeled under the 2040 TPP Current Revenue Scenario.

***Approximates year 2040 travel modeled under the 2040 TPP Increased Revenue Scenario.

Step 4: Model Highway Mobility Performance Outcomes

The fourth and final step in the analysis was to model performance outcomes associated with highway mobility target options. These options ranged from 40 to 48 annual hours of delay per capita, a range presented to stakeholders as reasonable improvement over year 2040 baselines. The most aggressive option – 40 hours of annual delay per capita – represented a five percent decrease in annual hours of delay per capita compared to 2018, but a significant increase in total annual hours of delay across the region due to anticipated population growth.

Step 4 also tested the sensitivity of highway mobility investment scenarios to assumptions about telecommuting rates. These tests assessed the likelihood of meeting highway mobility performance targets at different levels of highway mobility investment and the reduction in MnDOT's highway mobility investment need that would occur if telecommuting are higher than baseline forecasts assume.

Impact of the COVID-19 Pandemic

The Twin Cities Highway Mobility Analysis began before the onset of the COVID-19 pandemic. This pandemic forced a dramatic increase in telecommuting and raised questions about if and how some industries would return to traditional peak-hour commute patterns.

The analysis responded to this uncertainty by acknowledging stay-at-home restrictions and telecommuting had dramatically altered highway mobility across the country, but there was no consensus about what would happen to travel demand once the pandemic subsided. In that environment, the analysis was carried out using established planning assumptions in the Council's 2040 Transportation Policy Plan (TPP). This approach was supported by the following factors:

1. Many employees that telecommuted out of necessity during the height of the pandemic were anticipated to return to traditional work settings and travel patterns once deemed safe to do so.
2. A significant portion of the workforce works in industries that are not conducive to telecommuting and/or have limited access to telecommuting opportunities.
3. Tying the analysis to 2040 TPP telecommuting levels leaves the possibility of recalibrating analysis results when the Council updates telecommuting assumptions over the planning cycle.

Baseline data and policy guidance used in this analysis

The Twin Cities Highway Mobility Analysis began before the onset of the COVID-19 pandemic. As a result, baseline conditions and future year travel forecasts draw from pre-pandemic sources. Pandemic conditions are reflected in a sensitivity test modeling the impact of telecommuting assumptions on analysis results. This sensitivity test is discussed in Chapter 5.

In addition, MnDOT and the Council expanded the analysis to test the sensitivity of highway mobility performance to telecommuting assumptions. As discussed in Chapter 5, a small increase in telecommuting rates enables the Twin Cities region to achieve higher levels of highway mobility with less highway mobility investment. Table 23 on page 47 shows that the level of highway mobility investment needed to achieve a target of 40 hours of annual delay per capita drops from $4 - $6 billion to $1 - $2 billion if telecommuting rates are increased from 5 to 10 percent.

Chapter 2: Frame the Issue

This chapter of the Twin Cities Highway Mobility Needs Analysis Final Report frames the analysis in relation to state and regional vitality. The section is divided into three parts. The first part provides the policy basis for the analysis by identifying state and regional goals that guide MnDOT investments in Twin Cities highway mobility. The second part of the chapter establishes the importance of Twin Cities highway mobility to these goals. The third part introduces the framework MnDOT and the Council use to make highway mobility investments and describes the role of this analysis in MnDOT's performance-based investment planning process.

Policy Framework

The Twin Cities Highway Mobility Needs Analysis is guided by the *Minnesota GO 50-year Statewide Vision for Transportation,* the *Statewide Multimodal Transportation Plan*, the *Thrive MSP 2040* regional vision, and the *2040 Transportation Policy Plan*. Under the planning framework provided by these documents, MnDOT and the Council maintain, operate, and improve the Twin Cities Highway System to support a broad range of policy goals. These goals are introduced in the paragraphs that follow.

Minnesota GO 50-year Statewide Vision for Transportation

MnDOT is the lead agency for the Minnesota GO 50-year Statewide Vision for Transportation. This vision is a multimodal transportation system that maximizes the health of people, the environment, and the economy. The vision imagines a system that connects Minnesota's people, natural resources, and business to each other and to markets and resources across the country and around the world. A system that maximizes the health of people, the environment, and the economy provides safe, convenient, efficient, and effective movement of people and goods.

Table 3: Minnesota GO 50-year Statewide Vision for Transportation

Minnesota's multimodal transportation system maximizes the health of people, the environment, and the economy	
The System:	• Connects Minnesota's primary assets—the people, natural resources, and businesses within the state—to each other and to markets and resources outside the state and country. • Provides safe, convenient, efficient, and effective movement of people and goods • Is flexible and nimble enough to adapt to changes in society, technology, the environment, and the economy.
Quality of Life	• Recognizes and respects the importance, significance, and context of place – not just as destinations, but also where people live, work, learn, play, and access services. • Is accessible regardless of socio-economic status or individual ability.
Environmental Health	• Is designed in such a way that it enhances the community around it and is compatible with natural systems. • Minimizes resource use and pollution.

Economic Competitiveness	• Enhances and supports Minnesota's role in a globally competitive economy as well as the international significance and connections of Minnesota's trade centers. • Attracts human and financial capital to the state.

MnDOT is also the lead agency for the 20-year Statewide Multimodal Transportation Plan, or SMTP. The SMTP, which is currently being updated, provides strategies for advancing the Minnesota GO Vision under five policy objectives. These objectives are Open Decision-Making, Transportation Safety, Critical Connections, System Stewardship, and Healthy Communities. Critical Connections is the objective with greatest relevance for this analysis. Under Critical Connections, the State of Minnesota seeks to maintain and improve multimodal transportation connections essential for Minnesotans' prosperity and quality of life.

Statewide Multimodal Transportation Plan strategies guiding the Twin Cities Highway Mobility Needs Analysis:

- Provide greater access to destinations and more efficient, affordable, and reliable movement of goods and people throughout the Twin Cities metropolitan area. (Objective: Critical Connections)
- Improve freight operations and intermodal connections for better access to the transportation system. (Objective: Critical Connections)

Thrive MSP 2040

Thrive MSP 2040 is the vision for the Twin Cities region. It sets forth five outcomes that provide the policy foundation for the Council's investment in transportation, water resources, regional parks, and housing. These outcomes are Stewardship, Prosperity, Equity, Livability, and Sustainability.

The Thrive outcomes with greatest relevancy for highway mobility are Prosperity and Livability.

- **Prosperity** is fostered by investments in infrastructure and amenities that create regional economic competitiveness, thereby attracting and retaining successful businesses, a talented workforce, and consequently, wealth.
- **Livability** focuses on the quality of residents' lives and experiences, and how places and infrastructure create and enhance the quality of life that makes our region a great place to live.

2040 Transportation Policy Plan

As the Metropolitan Planning Organization (MPO) for the Twin Cities region, the Council is responsible for developing and implementing a long-range transportation plan to guide investment in regional transportation systems. The 2040 Transportation Policy Plan (TPP) fulfills this responsibility by translating Thrive outcomes into six transportation-focused goals. These goals are Transportation System Stewardship, Safety and Security, Access to Destinations, Competitive Economy, Healthy and Equitable Communities, and Leveraging Transportation Investments to Guide Land Use.

The TPP goals with greatest relevance for this analysis are Access to Destinations and Competitive Economy.

2040 Transportation Policy Plan strategies guiding the Twin Cities Highway Mobility Needs Analysis:

- Increase travel time reliability and predictability for travel on highway and transit systems. (Goal: Access to Destinations)
- Improve multimodal access to regional job concentrations identified in Thrive MSP 2040. (Goal: Competitive Economy)
- Invest in a multimodal transportation system to attract and retain businesses and residents. (Goal: Competitive Economy)
- Support the region's economic competitiveness through the efficient movement of freight. (Goal: Competitive Economy)

- **Access to Destination.** A reliable, affordable, and efficient multimodal transportation system supports the prosperity of people and businesses by connecting them to destinations throughout the region and beyond.
- **Competitive Economy.** The regional transportation system supports the economic competitiveness, vitality, and prosperity of the region and state.

The Importance of Twin Cities Highway Mobility

One way to assess Twin Cities highway mobility in the recent past is to measure the cost of Twin Cities congestion to the region. Another way, more qualitative but no less significant, is to demonstrate the central role Twin Cities highways play in statewide commerce and the ability of people all over the state to get where they need to go. These two topics – the negative effects of Twin Cities congestion and the statewide importance of Twin Cities highways – were examined in two White Papers generated by the Council in 2020. A short summary of each white paper is provided below.

White Paper #1: The negative effects of traffic congestion on the Twin Cities

White paper #1 found that Twin Cities congestion cost the region $2.6 billion per year in impacts to commuters, shippers, and communities affected by congestion induced emissions. The white paper also assessed the effects of congestion on the region's economic competitiveness. These effects were not quantified, but research highlighted congestion's impact on supply chains, shipping costs, delivery time reliability, and consumer prices. In addition, the white paper explored how congestion limits the access of people to jobs, businesses to labor, and businesses to markets for their goods or services.

Table 4: Annual Cost of Congestion in the Twin Cities, 2018 (in millions)

Commuter Costs *(lost time and wasted fuel)*[1]	$2,078
Safety Costs *(crash costs)*[2]	$50
Freight Costs *(lost time and wasted fuel)*	$217
Environmental and Public Health Costs[3]	$225
Reduced Economic Competitiveness *(see below)*	Undetermined
Total Annual Cost of Congestion	**$2,600**

Source: Metropolitan Council. White Paper #1: The negative effects of traffic congestion on the Twin Cities, 2020

Most of the congestion costs presented in Table 4 were derived from commuter cost analysis published in the 2019 Urban Mobility Report by the Texas A&M Transportation Institute (TTI). In that report, TTI researchers assessed 2018 congestion levels in the Twin Cities and calculated the following statistics:

- $980 per year is the average "congestion tax" paid in time lost and wasted fuel by commuters due to congestion on the Twin Cities' principal arterial and minor arterial roadways.
- 56 hours per year are spent in congestion for the average auto commuter, the equivalent of seven full vacation days per year.
- 18 gallons of additional fuel are wasted each year by each peak period auto commuter in the Twin Cities from sitting in congestion.

Table 5 identifies congestion impacts that drive the congestion cost estimates presented above. This analysis supports a more comprehensive way of thinking about congestion cost. For example, under commuter and safety costs, there is the quantifiable costs of lost time, wasted fuel, and congestion-induced crashes, as well as the qualitative impact of congestion-induced stress and missed appointments.

Table 5: Negative Effects of Congestion

Commuter Costs	Lost time; wasted fuel; lack of travel time reliability; increased need for vehicle maintenance; increased stress; reduced quality of life
Safety Costs	More crashes; higher likelihood of road rage; diversion onto the local roadway system; increased emergency response times
Freight Costs	Freight delays; wasted fuel; increased shipped cost; supply chain impacts; unreliable pick-up and delivery times
Environmental and Public Health Costs	Wasted fuel; higher levels of localized air pollutants resulting in negative health effects including premature death

[1] Texas A&M Transportation Institute, "2019 Urban Mobility Report." August 2019
[2] Estimate by Metropolitan Council based on MnDOT crash costs
[3] Levy, Jonathan I., Buonocore, Jonathan J., and von Stackelberg, Katherine. "The Public Health Costs of Traffic Congestion: A Health Risk Assessment." Environmental Health, 2010, www.ibtta.org/sites/default/files/The%20Public%20Health%20Costs%20of%20Traffic%20Congestion.pdf

Reduced Economic Competitiveness	Less access to jobs; smaller labor markets; negative impacts to economic competitiveness; delays to MSP airport, river ports and freight terminals

Source: Metropolitan Council. White Paper #1: The negative effects of traffic congestion on the Twin Cities, 2020

White Paper #2: Statewide importance of addressing traffic congestion in the Twin Cities

White paper #2 presented four reasons why highway mobility in the Twin Cities is an issue of statewide importance.

1.) Metro-area highways are used by residents from all over the state for shopping, professional sporting events, higher education, recreation, cultural events, and specialized health care.
2.) Around 360,000 people travel into or out of the seven-county metro each day for work.
3.) Metro-area highways connect people and business in Greater Minnesota to the Minneapolis-Saint Paul International Airport, one of the state's competitive advantages.
4.) Nearly 60% of all truck traffic in the state travels through the Twin Cities. Congestion in the Twin Cities disrupts statewide supply chains and affects Minnesota consumers through higher prices.

Table 6 analyzes the origins of trips using six high-volume locations in the Twin Cities on an average day in 2018, showing the share of annual average daily traffic (AADT) and heavy commercial annual average daily traffic (HCAADT) by metro and Greater Minnesota counties. As shown below, estimated daily traffic volumes on Twin Cities highways originating from Greater Minnesota are high: 20,000 Greater Minnesota drivers on Highway 169 in Shakopee; 34,000 on I-494 in Bloomington; and nearly 50,000 on I-94 in Maple Grove. These traffic volumes are higher than the total traffic volumes of almost any roadway in Greater Minnesota. Relative to trips originating in metro-area counties, Greater Minnesota trips accounted for over 40% of total volume and over half of freight volume on I-94 in Maple Grove and US 212 in Carver County. This analysis demonstrates that the cost of Twin Cities congestion and benefits of mobility improvements on Twin Cities highways are shared broadly between metro and Greater Minnesota residents and businesses.

Table 6: Origin of trips using Twin Cities highway on an average day in 2018

Analysis locations	Trip Origin	All Traffic			Trucks only		
		% of Total Volume	Estimated AADT	# of Counties Served	% of Total Volume	Estimated HCAADT	# of Counties Served
I-94 (Maple Grove)	Metro	59%	70,210	7	43%	4,945	7
	Greater MN	41%	48,790	79	57%	6,555	79
	Total	100%	119,000	86	100%	11,500	86
I-494 (Bloomington)	Metro	77%	115,000	7	58%	4,350	7
	Greater MN	23%	34,000	78	42%	3,150	76
	Total	100%	149,000	85	100%	7,500	83
US 212 (Cologne, Carver County)	Metro	54%	6,858	7	44%	607	7
	Greater MN	46%	5,842	63	56%	756	60
	Total	100%	12,700	70	100%	1,350	67
	Metro	79%	78,000	7	69%	3,450	7

US 169 (Shakopee)	Greater MN	21%	20,000	74	31%	1,550	71
	Total	100%	98,000	81	100%	5,000	78
US 52 (South of downtown St. Paul)	Metro	91%	72,800	7	75%	4,125	7
	Greater MN	9%	7,200	71	25%	1,375	68
	Total	100%	80,000	78	100%	5,500	75
I-35W (Mounds View)	Metro	87%	129,630	7	71%	5,325	7
	Greater MN	13%	19,370	74	29%	2,175	72
	Total	100%	149,000	81	100%	7,500	79

AADT – Annual Average Daily Traffic volume. HCAADT – Heavy Commercial Annual Average Daily Traffic
Source: Based on Metropolitan Council analysis using StreetLight Insights, 2018 data

Twin Cities Highway Mobility and Forecasted Growth

Population forecasts from the Council released in April 2021 indicate that by year 2040 an additional 565,000 people will reside in the Twin Cities compared to year 2020, an 18 percent increase in the region's population. This growth tracks closely to population and employment forecasts used in the 2040 TPP, which projected a 2.5 percent decrease in year 2040 vehicle miles traveled (VMT) per person compared to year 2010, but a 20 percent increase in total VMT. At the same time, investment in Twin Cities highway mobility is expected to decline as MnDOT manages a growing gap between available revenue and the funding needed to maintain existing infrastructure. The combination of additional VMT and reduced investment in highway mobility infrastructure suggests that highway mobility will worsen in coming years, posing an increasingly high risk to quality of life in the Twin Cities and state and regional vitality.

What are the consequences of an additional half million Twin Cities residents to highway mobility in the region?

A core contribution of this analysis to highway planning in the Twin Cities region is a method for modeling highway mobility on future year highway networks using the Council's Regional Travel Demand Model. This method is detailed in Chapter 4. Modeling highway mobility on future year highway networks makes it possible to quantify the benefits, disbenefits, and missed opportunities of an assumed set of highway improvements. In the case of this analysis, highway mobility forecasts were used to set a year 2040 baseline illustrating the impacts of forecasted population growth on multiple performance outcomes. These outcomes are discussed in Chapter 5.

A risk assessment conducted early in the analysis identified a series of risks associated with assumed levels of regional growth and highway mobility investment. These risks are identified in Table 7.

Table 7: Risks associated with regional growth and reduced investment in highway mobility

Impacts to residents & businesses	Longer commutes/more time stuck in traffic
	Higher transportation costs
	Unreliable travel
	Reduced access to jobs and other destinations
	Reduced access to labor and markets
Impacts to the Twin Cities and Greater MN	Lost productivity and economic competitiveness
	A lower quality of life
	Increased localized emissions
Impacts to communities & local governments	Diversion of longer distance/higher speed trips onto local networks
	Increased emissions and public health disparities due to transportation
	Additional burden on local governments making investment to supply mobility not provided on state highways
Impacts to MnDOT and the Met Council	Low customer satisfaction and public trust
	Legislation that redirects financial resources

Investment Framework

The Twin Cities Highway Mobility Needs Analysis uses MnDOT's performance-based planning framework to identify needs associated with anticipated growth in Twin Cities population, employment, and travel demand. This section briefly introduces processes and policies used to guide highway mobility investment on state highways in the Twin Cities.

Minnesota State Highway Investment Plan

A key component of this framework is MnDOT's 20-year Minnesota State Highway Investment Plan, known as MnSHIP. MnSHIP is MnDOT's vehicle for deciding and communicating capital investment priorities on Minnesota state highways. These priorities determine MnDOT's investment in more than a dozen state highway investment categories dedicated to types of state highway improvement. Investment category examples include traveler safety, pavement condition, and Twin Cities highway mobility.

Table 8 identifies investment categories used to calculate investment needs and allocate available funding in the Minnesota State Highway Investment Plan, 2018 – 2037. Seven of the 13 categories listed are considered performance-based, meaning the categories are dedicated to achievement of a state highway performance goal. The seven performance-based investment categories are pavement condition, bridge condition, roadside infrastructure condition, traveler safety, Twin Cities highway mobility, Greater Minnesota highway mobility, and accessible pedestrian infrastructure.

Table 8: MnSHIP 2018-2037 Investment Categories

Investment Category	Objective Area	Performance Target or Other System Goal	20-year Need
Pavement Condition	System Stewardship	Meet pavement performance target of 2.0% Poor condition on Interstates, 4.0% percent poor condition on non-Interstate NHS, 10.0% poor condition on non-NHS.	$13.44B
Bridge Condition	System Stewardship	Meet bridge performance target of 2.0% poor condition on NHS bridges, 8.0% poor condition on non-NHS bridges.	$2.65B
Roadside Infrastructure Condition	System Stewardship	Meet bridge performance target of 2.0% poor condition on NHS bridges, 8.0% poor condition on non-NHS bridges.	$3.35B
Jurisdictional Transfer	System Stewardship	Fully implement the 2014 Minnesota Jurisdictional Realignment Report by repairing and transferring approximately 1,200 miles of roadway (centerline).	$1.14B
Facilities	System Stewardship	No rest areas or weigh stations beyond service life.	$3390M
Traveler Safety	Transportation Safety	Meet an aggressive traffic fatalities target by implementing District Safety Plans at an increased rate, investing at most sustained crash locations.	$1.37B
Twin Cities Highway Mobility	Critical Connections	Build out the majority of MnPASS Express Lane and increase investments in strategic mobility.	$4.58B
Greater Minnesota Mobility	Critical Connections	Invest in all operational and capital improvements at locations experiencing high travel time delay.	$1.39B
Bicycle Infrastructure	Critical Connections	Maintain existing bicycle facilities in good condition, complete stand-alone bikeway projects, and designate eight state bikeways.	$580M
Accessible Pedestrian Infrastructure	Critical Connections	Bring all sidewalks, curb ramps and signalized intersections to total ADA-compliance by 2037, double non-ADA pedestrian projects.	$680M
Regional and Community Improvement Priorities	Health Communities	Expand partnerships with stakeholders, cooperative agreements, regional priorities, proactive flood mitigation, main street reconstructions, and increased landscaping.	$2.62B
Project Delivery	Other	Efficiently deliver projects through adequate consultant services, supplemental agreements, construction incentives, and ROW acquisition.	$6.18B
Small Programs	Other	Continue to fund unforeseen issues and historic property improvements.	$630M
Total			$39 Billion

Table adapted from Figure 3-3: Transportation Needs During the Next 20 Years by Investment Category on page 52 of the 20-year Minnesota State Highway Investment Plan (2018-2037).

Although dedicated to a state highway performance goal, MnDOT does not manage the Twin Cities Highway Investment Category to a highway mobility target, nor does it use a target to calculate highway mobility investment needs. The current MnSHIP identifies MnDOT's 20-year highway mobility investment need as the cost to implement investments identified in the 2040 TPP Increased Revenue Scenario. This contrasts with how MnDOT manages investment categories in the System Stewardship objective area. These investment categories represent over half the total investment needs calculated in MnSHIP. Most needs in System Stewardship investment categories are calculated using statewide performance targets that quantify the share of state highway assets meeting condition thresholds. In the case of the largest category, Pavement Condition, MnSHIP calculates a 20-year investment need of $13.4 billion to meet pavement condition targets for Interstates, the non-Interstate National Highway System (NHS), and state highways off the NHS.

The importance of performance targets and performance-based needs to MnDOT's investment planning framework is a key driver of this analysis. By setting a Twin Cities highway mobility target and calculating Twin Cities highway mobility needs, MnDOT and the Council can make informed, outcome-based trade-offs between Twin Cities highway investment and investment in other categories.

Regional Highway Mobility Investment Approach

The 2040 TPP, last updated in 2020, affirms a Twin Cities regional highway mobility investment approach that uses a cost-based progression of strategies to manage congestion. Under this approach, MnDOT and the Council encourage lower cost, systemwide strategies to mitigate congestion over higher cost strategies that expand capacity on a congested corridor. This philosophy guides the approach the Twin Cities Highway Mobility Needs Analysis used to model highway mobility improvements to the year 2040 highway network. As described in Chapter 5, this analysis models improvements to the year 2040 Twin Cities regional highway network assumed under the 2040 TPP Current Revenue Scenario. Consistent with the regional highway mobility investment approach, these improvements are applied systemwide and scaled to mitigate, rather than eliminate, congestion at key bottlenecks.

The cost-based progression of highway mobility strategies guiding this analysis are introduced below:

1. **Traffic Management Technologies** – The region's first priority to address mobility issues is traffic management technologies (e.g., retiming traffic signals and comprehensive incident response). Past investments in this area have increased the capacity, reliability, and safety of the existing system. Before pursuing larger cost capital projects, an agency should be assured that traffic management technologies have been implemented to the most cost-effective extent possible.
2. **Spot Mobility** – The second priority for mobility investment is to implement low-cost spot improvements at specific locations to maximize the return on investment. Typically, these are smaller in scope than traditional highway investments with the intent to allow quicker and simpler delivery. The region programmatically identifies these spot mobility projects through the Congestion Management Safety Plan, a region-wide evaluation of MnDOT's system.
3. **E-ZPass** – If traffic management or spot mobility projects will not adequately solve the mobility problem, the third priority of mobility investment is E-ZPass lanes. These managed lanes are free to transit riders, carpools, and motorcycles, while charging a congestion-sensitive toll to single-occupant vehicle drivers during peak periods to provide a reliable travel option. E-ZPass can improve highway efficiency and effectiveness by prioritizing person throughput over vehicle throughput and providing long-term travel time reliability that is not possible with general purpose lanes. Although

E-ZPass lanes are often implemented as additional lanes, conversion of a general-purpose lane may be considered as an option in some corridors with a constrained right-of-way.

4. **Strategic Capacity Enhancements** – The fourth priority of mobility investments, strategic capacity enhancements (namely interchanges and general-purpose lanes), are implemented when other previously described investments cannot improve travel conditions for people and freight. These must utilize the existing pavement and right-of-way to the extent possible. Several criteria and conditions have been adopted to evaluate the appropriateness of implementing strategic capacity projects.

Chapter 3: Select a Highway Mobility Measure

This chapter describes the process by which the Twin Cities Highway Mobility Needs Analysis selected a measure of highway mobility in the Twin Cities region. Recognizing there are many ways to measure highway mobility, transportation agencies should consider multiple metrics when deciding where and how to invest. The objective of this measure selection process was to select a single highway mobility measure to be used as the basis for MnDOT's calculation of Twin Cities highway mobility investment needs on the state highway system.

The Twin Cities highway mobility measure selection process includes a peer region review of highway mobility investment planning, a national scan of existing highway mobility measures, input from stakeholders, and an assessment of how measures could be used to communicate system performance and direct future investment. Measures found to be effective at meeting analysis requirements were then evaluated and prioritized based on secondary criteria. The process concluded with the selection of annual hours of travel delay per capita as the basis for MnDOT's Twin Cities highway mobility investment needs. Additional measures of highway mobility were advanced as outcomes for use in year 2040 highway mobility investment scenarios (see Chapter 5).

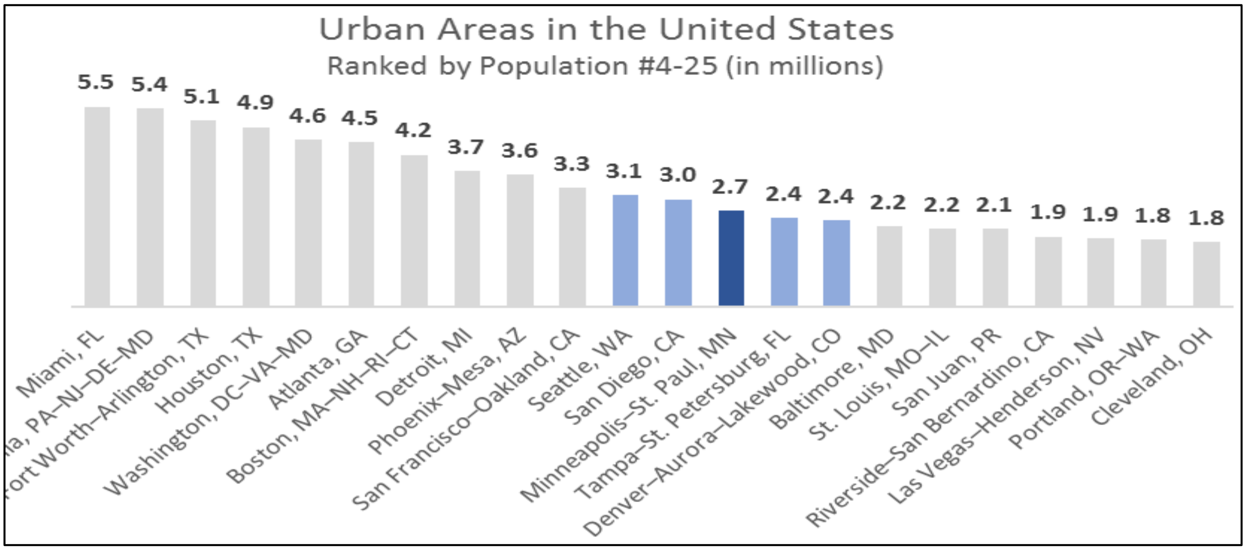
Peer Region Review

A review of peer regions was undertaken to support the highway mobility needs analysis for the Twin Cities, to provide examples of current practices in comparably sized metropolitan areas. This effort included research of regional planning documents and interviews with MPO staff from each region. These discussions provided important input to the identification and application of highway mobility performance measures.

Identification of Peer Regions

The primary factor used to select peer regions for this review was urban area population taken from the 2010 US Census. This data showed that the Minneapolis-Saint Paul region is ranked 14th among metro areas in the nation. Review of the population distribution among similar-sized metro areas showed a clear clustering among four other regions, ranging from 2.4 million to 3.1 million in population.

Figure 2: Population of Urban Areas in the United States



This clustering represented the two regions with population immediately above and below the Twin Cities. The four regions identified through this process to be included in the peer review include:

12. Seattle, WA
13. San Diego, CO
14. **Minneapolis-Saint Paul, MN**
15. Tampa-Saint Petersburg, FL
16. Denver-Aurora-Lakewood, CO

These regions were confirmed to provide a good mix geographically, being located on the east and west coasts, as well as the interior of the US. In addition, all regions show recent growth trends that are equal to or greater than the Twin Cities. This was an important consideration as a major component of the highway mobility needs analysis was to define an approach for highway mobility investment planning that accounts for continued population growth in the region.

Peer Region Performance Measures

The peer region review revealed several common themes among the metropolitan areas in terms of the performance measures used for highway mobility. These can be summarized in three broad categories including user impacts; choice, access, and equity; and economic, social, and environmental outcomes.

Table 9: Peer Region Performance Measure Summary

User impacts	VMT/VMT per capita Delay/delay per capita; travel time/travel time reliability Mode share; transit boardings; walking/biking trips Aggregate B/C ratio of transportation investments (San Diego)

Choice, access and equity	Access to jobs, access to goods/services (San Diego) Choice/access to transportation options Percent of income consumed by transportation cost Impacts in communities of concern vs. non-communities of concern (San Diego)
Economic, social, & environmental outcomes	Freight travel time on critical corridors Connectivity between regional growth and manufacturing centers (Seattle) Regional productivity gains Percent of people engaging in active transportation Air quality and GHG emissions

There were several key takeaways from the peer regions' highway mobility measures that have direct applicability to the highway mobility needs analysis. First, many regions utilize measures that express performance in terms of user benefits. Examples of these measures include VMT per capita, delay reduction, and travel time reliability. An important characteristic of these measures is that they are understood by a more general audience and are relatable on an individual or household level.

Another theme among peer regions was an attempt to connect user benefits to higher policy level goals related to transportation access, choices, environmental health, and equity. These are slightly different in the sense that they are not necessarily a direct measure of highway mobility performance. However, they do speak to perhaps more relevant topics regarding a region's well-being by focusing on how mobility affects personal, social, and environmental outcomes.

Finally, a third theme observed was measures of economic outcomes at various scales. These tended to focus on goods movement in and through the metro, and occasionally reported on specific regional centers and key corridors. These measures can be popular when they are used to demonstrate the economic benefits of specific transportation investments, or in consultation with elected officials when seeking or justifying additional transportation funding.

Performance Measure Use in Investment Planning

The next area of investigation was how the peer regions used their mobility measure in the context of regional investment planning. Without exception, all regions perform modeling and analysis on their investment scenarios to evaluate benefits and plan outcomes. This degree of use was thus found to be a baseline application that all regions achieved.

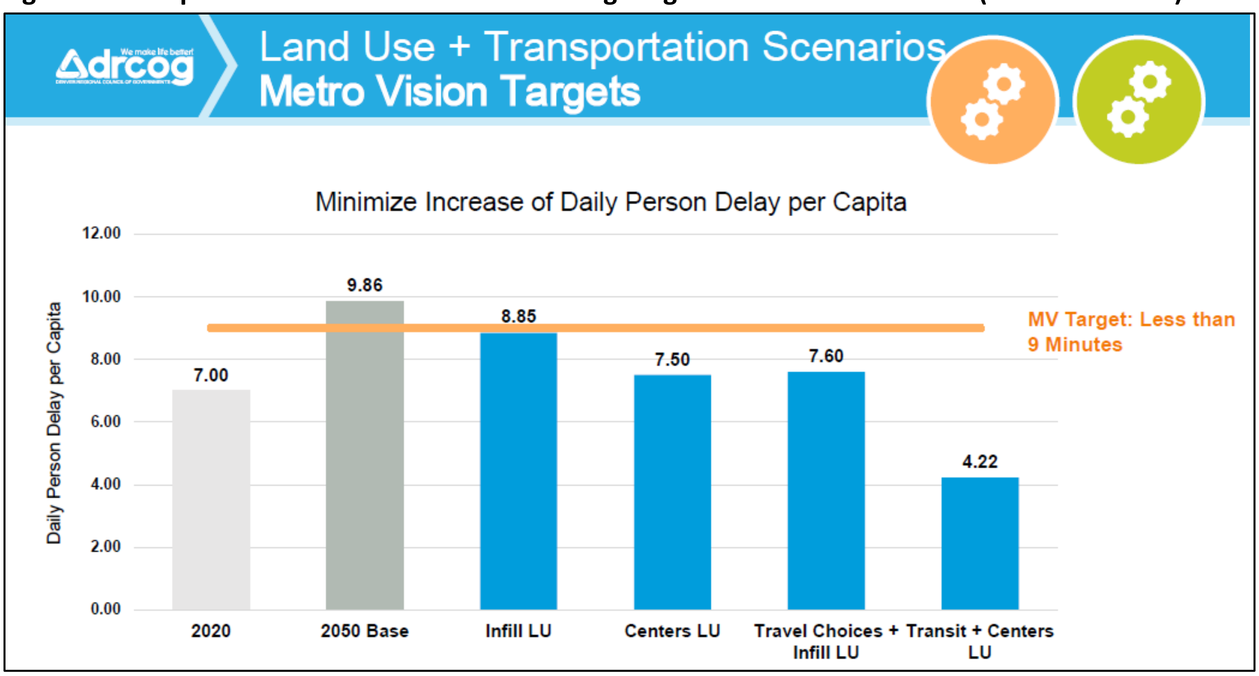
Table 10: Peer Region Use of Performance Measures in Investment Planning

Peer region	Model benefits and evaluate plan outcomes	Develop scenarios or alternatives and make trade-offs	Set targets and plan investments to achieve them
Seattle	●		
San Diego	●		
Tampa – St. Petersburg	●	◖	
Denver	●	●	◖

Less extensively, some regions used performance measures to develop and make comparisons among multiple scenarios. Among those practicing this approach, this level was seen as a real payback of the effort put into modeling estimates of performance measures since it truly influenced the regional planning process. It should be noted that regions not implementing this approach did not dispute the merits of doing so, but current practices did not lend themselves to that approach for a variety of procedural reasons. Some did remark that efforts are underway to implement performance measures at this level.

Finally, the Denver region (DRCOG) was the only peer observed to use mobility measures to help set targets and plan investments to achieve optimal performance. This approach was described in their Metro Vision and established a target of less than 9 minutes of delay per person per capita. The example in Figure 3 illustrates how land use (LU in the graphic) and transportation scenarios evaluated in the Metro Vision process were compared against the performance target.

Figure 3: Example Performance Measure in Setting Target and Plan Investments (Source: DRCOG)



In summary, all four peer regions were found to use travel demand model outputs to forecast baseline scenario conditions and evaluate benefits of highway mobility investment. Tampa-St. Petersburg uses performance measures to assess highway mobility outcomes under different levels of highway mobility investment. Denver sets targets for VMT per capita, SOV mode share, and delay and then uses the targets to evaluate and trade-off between policy scenarios.

Measure Development Process

Identify Highway Mobility Measures

The Twin Cities Highway Mobility Needs Analysis scope of work established two requirements a highway mobility measure must meet for it serve as the basis for MnDOT's Twin Cities highway mobility investment need:

1. The measures must be easy to explain to policy makers.
2. The measures must enable system performance forecasts that are sensitive to MnDOT's investment in highway mobility.

The search for highway mobility measures meeting these criteria began with a national scan of existing highway mobility measures and the development of a highway mobility measure inventory. The inventory consisted of nearly 50 highway mobility measures gathered from engineering reference manuals, agency policy plans, published research articles, and case studies from around the country. Individual measures were compiled in four categories based on the key components outlined in the Congestion Management Process (CMP) Guidebook maintained by the Federal Highway Administration (FHWA). Each of these categories captures a slightly different facet of highway mobility.

The four categories are as follows:

- **Congestion intensity.** The relative severity of congestion that affects travel has traditionally been measured through volume-based indicators such as volume-to-capacity ratios and level of service, or through travel time-based measures such as travel speed and delay.
- **Congestion extent and duration.** Congestion extent is the number of system users or components (e.g., vehicles, pedestrians, transit routes, lane-miles) affected by congestion. Congestion duration is the amount of time the congested conditions persist in the system before returning to an uncongested state.
- **Congestion variability**. Change in congestion on a day-to-day basis provides a measure of reliability. Non-recurring congestion causes unreliable travel times and is caused by events such as traffic incidents, weather conditions, work zones, or special events. This form of congestion is often the most frustrating for travelers.
- **Access.** These measures indicate the ability of the public to reach employment sites, retail centers, activity centers, and other land uses that produce or attract travel demand. Measuring accessibility can involve calculating the number or share of population that can access desired destinations within a specific amount of time and by different travel modes.

In addition, highway mobility measures that assess system productivity were also inventoried.

Table 11: Inventory of Highway Mobility Measures

Category	Measure
Access	Access to freight destinations
	Access to jobs
	Access to jobs across modes
	Access to Transit
	Access to jobs by transit
	Average job accessibility by auto
	Job-Housing Balance
Delay	Congested network travel-to-distance cost
	Congestion cost per commuter
	Excess fuel per Auto Commuter
	Freight travel time on critical corridors
	Impedance to regional travel during peak conditions
	Travel Time Index (TTI)
	Traveler delay (total or per capita)
	Truck congestion cost
	VMT by TTI Performance
Productivity	Bicycling and walking miles traveled
	Freight Value
	Freight Volume
	Increased regional VMT
	Investment per reliable trip
	Lost throughput
	Modal participation rate
	Multimodal System Productivity (MSP)
	Percent of Non-Single-Occupant-Vehicle (SOV) Travel
	Travel volume
Reliability	Average Incident Clearance Time
	Buffer Index
	Planning Time Index (PTI - 95)
	Reliability Index
	Standard Deviation
	Travel Reliability on Interstate System
	Truck Planning Time Index (PTI -95)
	Truck Reliability index
	Truck Travel Time Reliability (TTTR) Index
System Congestion	Average Speed
	Average Travel Rate (minutes per mile)
	Congested travel as a share of total travel
	Extent of congestion as share of system
	Extent of congestion as share of miles
	On-road mobile source emissions
	Populations impacted by congestion

Screen Highway Mobility Measures

The next step in the process of selecting a Twin Cities highway mobility measure was to screen out measures not meeting analysis requirements. This step was performed using the screening criteria and scoring anchors provided in Table 11. Responsiveness and simplicity criteria were adapted from analysis requirements introduced in the previous section. The additional criteria – alignment and feasibility – were added to reflect the role of regional planning guidance in the analysis and the importance of selecting a measure that can be implemented with existing data and traffic forecasting techniques.

Table 12: Measure Screening Criteria

Criterion	Purpose	Scale
Responsiveness	Identify measures that are responsive to strategies governing highway mobility investment in the Twin Cities.	• **Score of 0:** Measure does not support strategies governing highway mobility investment in the Twin Cities. • **Score of 1:** Measure supports strategies governing highway mobility investment in the Twin Cities but exhibits a low degree of sensitivity to highway mobility investment. • **Score of 2:** Measure supports strategies governing highway mobility investment in the Twin Cities and exhibits a high degree of sensitivity to highway mobility investment. • **Score of 3:** Measure supports strategies governing highway mobility investment in the Twin Cities, exhibits a high degree of sensitivity to highway mobility investment, and can be used to isolate specific locations where mobility investment is needed.
Alignment	Identify measures that assess progress toward priorities identified in Thrive MSP 2040, 2040 TPP, or Minnesota GO.	• **Score of 0:** Measure is not aligned with planning guidance. • **Score of 1:** Measure is aligned with planning guidance but provides mostly contextual information. • **Score of 2:** Measure is aligned with planning guidance and is directional (i.e., movement on the measure represents progress toward a desired outcome). • **Score of 3:** Measure provides a comprehensive representation of a regional priority.
Feasibility	Identify measures that can be forecasted using currently available data and tools.	• **Score of 0:** Measure cannot be forecasted at the system-level with available data and tools. • **Score of 1:** Measure can be forecasted at the system-level with available data and tool but requires significant investment of effort and/or resources. • **Score of 2:** Measure can be forecasted at the system-level with available data and tools and requires minimal investment of effort and/or resources. • **Score of 3:** Measure is already forecasted at the system-level with available data and tools.

Simplicity	Measure results that are easily understood by policy makers and the public.	• **Score of 0:** Measure is not understood by non-technical readers. • **Score of 1:** Measure is understood by non-technical readers, but many may not recognize changes in performance. • **Score of 2:** Measure is understood by non-technical readers who can further recognize changes in performance. • **Score of 3:** Measure can be described effectively in one sentence.

Candidate highway mobility measures were scored on screening criteria and then assessed in two ways. First, measures scoring 2 or 3 points on all four criteria were isolated. This analysis screened out measures that did not adequately meet analysis criteria. Second, measure scores across all four criteria were ranked from highest to lowest within each measure category. This analysis identified seven candidate measures with a score of 10 or higher. As shown in Table 13, at least one measure in each measure category met the 10-point threshold.

Table 13: Highway Mobility Measure Evaluation Results

Category	Measure (evaluation score)	Description
Access	Access to jobs (score: 10)	Access to jobs: average annual number of jobs accessible within a 30-minute drive.
Delay	Travel Time Index (TTI) (score: 10)	Travel Time Index: the ratio of travel time in the peak period to the travel time at free-flow conditions. A value of 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak period.
	Traveler delay (total or per capita) (score: 12)	Travel delay per capita: annual hours of extra travel time experienced by commuters during peak hours per capita.
Productivity	Travel volume (PMT and VMT) (score: 8)	Total volume: person miles traveled (PMT) or vehicle miles traveled (VMT), in total or per capita.
Reliability	Planning Time Index (PTI - 95) (score: 10)	Planning Time Index: travel time needed to avoid being late more than once per month (95^{th} percentile).
	Reliability Index (RI – 80) (score: 10)	Reliability Index: travel time needed to avoid being late more than once per week (80^{th} percentile).
System Congestion	Congested travel as a share of total travel (score: 10)	Congested travel as a share of total travel: miles of travel in stop-and-go condition, as a share of the total miles of travel.

Prioritize Highway Mobility Measures

The third step in the measure selection process was to prioritize highway mobility measures meeting analysis requirements. Having already evaluated measures for simplicity, responsiveness to highway improvements, strategic alignment, and feasibility, this step in the process considered measure applications across highway systems, geographies, and types of evaluation. The objective of the analysis was to identify the highway mobility measure that is most relevant across the broadest array of transportation decisions.

Table 14 summarizes the results of this step in the measure selection process. Table rows identify six highway mobility measures found to meet analysis requirements. Table columns identify measure applications. Table cells provide an assessment of how feasible and relevant each highway mobility measure is to a given measure application. The table indicates that of the six measures advanced to measure prioritization, only traveler delay was applied easily and relevant to all identified measure applications.

Table 14: Highway Mobility Measure Applications

	Measure Applications			
Highway Mobility Measures	System performance	Project selection	Policy analysis	Peer region comparison
Congested travel as a share of travel	Easily applied; relevant results	Easily applied; relevant results	Some difficulty applying or using	Difficult to apply; results not always relevant
Travel time index	Easily applied; relevant results	Easily applied; relevant results	Some difficulty applying or using	Easily applied; relevant results
Travel delay	Easily applied; relevant results	Easily applied; relevant results	Easily applied; relevant results	Easily applied; relevant results
Planning time index	Some difficulty applying or using	Some difficulty applying or using	Some difficulty applying or using	Some difficulty applying or using
Reliability index	Some difficulty applying or using	Some difficulty applying or using	Some difficulty applying or using	Some difficulty applying or using
Access to jobs	Some difficulty applying or using	Easily applied; relevant results	Easily applied; relevant results	Easily applied; relevant results

Results of the measure selection process were shared with MnDOT and Met Council in the summer of 2020. Consistent with the findings presented above, traveler delay was recommended as the measure for MnDOT and the Council use to evaluate Twin Cities highway mobility. Project stakeholders, consisting of policy and technical experts at MnDOT and the Council, broadly supported the recommendation and encouraged the project to proceed with calculation of MnDOT's Twin Cities highway mobility investment needs using a travel delay measure.

Recommendation
The Twin Cities Highway Mobility Needs Analysis recommends MnDOT and Metropolitan Council develop a measure using traveler delay to quantify MnDOT's 20-year Twin Cities highway mobility investment need.

In supporting traveler delay per person as a measure of Twin Cities highway mobility needs, project stakeholders also stressed the importance of considering additional performance measures when planning highway mobility investments. Three measures were called out specifically as priority outcomes effected by highway mobility: greenhouse gas (GHG) emissions, job access, and travel time savings. In addition, project stakeholders also expressed interest in measuring the impacts of highway mobility investment on vehicle miles traveled, freight movement, and transportation equity. This input informed the selection of additional measures for the purpose of evaluating highway mobility outcomes. These outcome measures, which are introduced in the next section, enabled project stakeholders to consider the broader significance of highway mobility investment when developing investment scenarios and recommending targets.

Document Measurement Methodologies

The final step in selecting a measure of highway mobility was to document measurement methodologies. As noted in the previous section, the Twin Cities Highway Mobility Needs Analysis recommended that MnDOT and the Council use travel delay per person to measure future highway mobility performance and quantify 20-year highway mobility investment needs. In addition, the analysis also recommended that MnDOT and the Council use additional measures to evaluate the significance of highway mobility improvement at different levels of investment. These measures were referred to as outcome measures.

Travel Delay per Capita

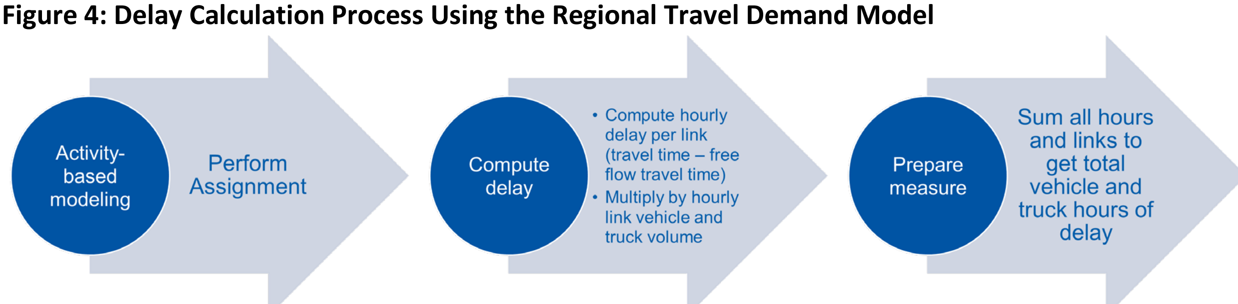
This analysis expressed travel delay in terms of annual hours of travel delay per capita. The decision to express travel delay in annual hours per capita was based on feedback that the measure should assess delay in terms that resonate with individual travelers. Annual hours of travel delay per capita conveys the impact regional congestion has on the typical Twin Cities resident over the course of year. Annual hours of delay also convey the benefit of highway mobility investment to Twin Cities residents in the form of fewer hours stuck in congestion. Furthermore, by measuring travel delay on a per capita basis, the analysis can control for expected population growth.

The analysis measured travel delay incurred over the entire length of trips using Twin Cities roadways in the 16-county metropolitan statistical area, not just the portion of trips made on state highways. Measuring regionwide delay aligns the analysis with the experience of travelers who encounter congestion across multiple roadway systems. It also captures the network benefits of state highway mobility improvements that attract traffic from parallel local routes, thereby decreasing delay on both facilities.

The analysis calculated annual hours of delay using the Metropolitan Council's activity-based Regional Travel Demand Model (RTDM). This model uses regional population and employment forecasts to estimate future travel activity across the region, assign trips to the roadway network, and generate traffic volumes and speeds on roadway links by time of day. These results can be used to compare congested travel speeds to free-flow speeds, providing the basis for travel delay calculations.

Figure 4 shows the delay calculation process in three distinct steps. In Step 1, the activity based RTDM is run on a 2040 roadway network. Activity-based models differ from traditional four-step travel demand models in that they attempt to replicate each person's travel activity and behavior across an entire day as a "tour". As a result, changes in roadway networks can lead to changes in travel activity and trip tables. Step 1 of the measure calculation process resulted in trip tables that show trip assignments by time of day.

Figure 4: Delay Calculation Process Using the Regional Travel Demand Model



Step 2 of the measure calculation process was to estimate person hours traveled (PHT) for free-flow and congested travel conditions. PHT was calculated by multiplying the person trip tables developed in Step 1 by free-flow and congested travel condition timetables. The RTDM generates timetables through a process known as skimming, in which travel times between each origin-destination pair is calculated based on congestion levels throughout the day. PHT was calculated separately for 11 time periods and then summed together to calculate daily PHT under free-flow and congested conditions.

Step 3 of the measure calculation process was to convert daily PHT and person trips to daily delay per capita. This step began by dividing daily PHT by daily person trips to produce an average trip time for free-flow and congested travel time conditions. Average trip time under free-flow conditions was then subtracted from average trip time under congested conditions to arrive at an average delay per trip. To calculate average delay per capita, average delay per trip was multiplied by the number of trips per capita, which was assumed to be 4.17 based on information from the Council's Travel Behavior Inventory. To estimate annual delay per capita, the daily delay per capita result was multiplied by 260, the approximate number of workdays in a calendar year.

Outcome measures

This section documents the methodologies used to calculate highway mobility outcome measures. These methodologies build on the travel delay methodology described above by applying post-processing steps to RTDM analysis. The role of outcome measures in the Twin Cities Highway Mobility Needs Analysis is to introduce factors that explain and assess the significance of changes in Twin Cities highway mobility to state and regional goals.

Job Access

Job access refers to a population's ability to access employment opportunities within a time threshold. As a measure of transportation system performance, job access provides an indication of how well the transportation system is connecting people to destinations. The ability to reach more destinations in less time is one of the primary benefits of congestion reduction. This analysis expressed job access as the number of jobs accessible to the typical Twin Cities resident within a 30-minute drive during the morning peak period. Job access for year 2040 conditions was calculated in three steps.

1. Identify transportation analysis zones (TAZ) accessible to each TAZ within a 30-minute drive using year 2040 RTDM trip tables.
2. For each TAZ, sum year 2040 jobs in all the TAZs that are accessible within a 30-minute drive.
3. Calculate a population-weighted average of jobs accessible within a 30-minute drive to all the TAZs.

Travel Time Cost Savings

Travel time cost savings refer to the monetary value of reduced travel time. MnDOT maintains value of time factors for auto travelers and truck drivers. To compute travel time cost savings, annual travel time savings are multiplied by the value of time parameter. This analysis expressed travel time cost savings as 2040 benefit from travel time savings for the typical Twin Cities household. Year 2040 benefit from travel time savings was calculated in four steps:

1. Identify year 2040 hours of travel delay per capita under baseline conditions.
2. Identify year 2040 hours of travel delay per capita under improved conditions.
3. Calculate the difference and multiply the difference by the value of time for auto travelers.

4. Multiply the product by the average number of persons per household.

Vehicle Emissions

Vehicle emissions refer to air pollutants emitted from vehicle tailpipes. These emissions are the subject of significant transportation policy making and regulation due to their impact on human health and climate change. Given its regional focus, this analysis concentrated on the contribution of highway mobility and highway mobility investment to regionwide greenhouse gas (GHG) emissions. Although the analysis did not consider other air pollutants, changes in regional GHG emissions provide a useful proxy for the impact of highway mobility investment on regional air quality.

Emissions are estimated using the US Environmental Protection Agency's (EPA) MOVES model. This model estimates total emissions produced by vehicles traveling on different types of roadways and at different speeds. The results of each scenario produced by the regional travel demand model are exported by including the volume of autos and trucks on each link along with the estimated link travel speed by hour of the day. MOVES then calculates the total regional emissions based on the link-level emissions rates.

Regional GHG emissions are anticipated to decrease significantly over the next 20 years, both in terms of bulk emissions and per VMT due to federally mandated vehicle efficiency improvement. It is generally understood by FHWA and EPA that the magnitude of these decreases over the next 20 years will overwhelm any differences that can be predicted for changes in highway investment, even at the regional scale.

Additional measures

The Twin Cities Highway Mobility Needs Analysis also considered additional measures when assessing the impact of highway mobility on transportation system performance. These measures include freight bottlenecks improved, job accessibility for targeted populations, transit delay, and vehicle miles traveled (VMT).

Freight bottlenecks

Most systemwide highway mobility measures can be focused on freight to isolate the impact of highway mobility investment on goods movement. Examples of systemwide freight measures include heavy commercial vehicle delay, truck travel time index, and truck travel time reliability. Another category of freight measure identifies known bottlenecks on major freight corridors and the extent to which these bottlenecks are improved in an investment scenario. Both types of freight measures were explored and ultimately freight bottlenecks improved was selected for use in the analysis.

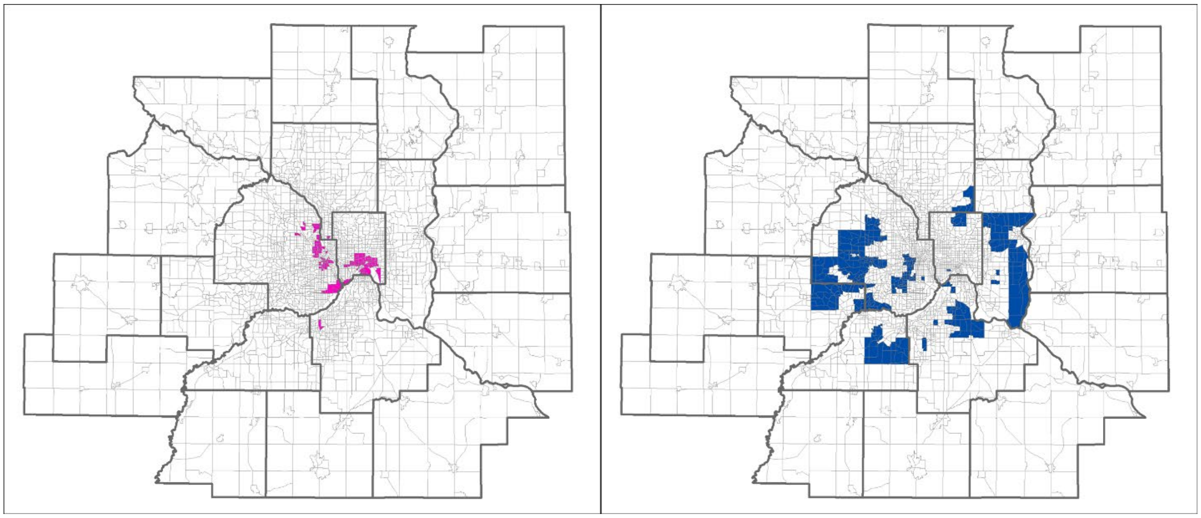
A total of 220 freight bottlenecks were identified in the Twin Cities using data from MnDOT's Minnesota Statewide Freight Bottlenecks report. Freight bottlenecks are locations where freight TTI exceeds an allowable threshold based on National Performance Management Research Data Set (NPMRDS) records. The measure "freight bottlenecks improved" assesses the share of freight bottlenecks on highway segments improved under alternative investment scenarios.

Job accessibility for targeted populations

Decision-making in transportation is increasingly taking equity into account to ask not just "how much" benefit or impact is produced by a given project, but "who" is experiencing those benefits and impacts. In this analysis, the job accessibility for areas of concentrated poverty (ACP) was compared with the job accessibility for areas of concentrated affluence (ACA) and the region. The analysis also compared job accessibility in areas with majority white population to that of areas with a plurality of non-white populations.

The job accessibility was estimated for targeted populations by identifying TAZs by ACA and ACP categories and calculating the number of jobs accessible by auto in 30 minutes or less for the TAZs in each bin. Figure 5 depicts TAZs designated as ACP or ACA for use in the analysis.

Figure 5: Areas of Concentrated Poverty (left) and Areas of Concentrated Affluence (right) by TAZ



This TAZ-based approach does not account for workers, nor the types of jobs workers may be qualified for, and it is likely auto ownership limits the actual job accessibility of underserved communities relative to the results.

Transit delay

The analysis also assessed the impact of highway mobility investment on transit system performance as measured in bus revenue hours. Bus revenue hours refer to the number of hours buses operate on transit routes. Changes in bus revenue hours as a result of highway mobility investment reflect the impact congestion reduction has on transit travel times.

Transit is one of the inputs used in the regional travel demand modeling process. The transit input file contains detailed information for all regional transit routes and frequency. The transit travel time in the model is a function of transit speeds, which are calculated based on the highway speeds by time of day and are sensitive to congestion. As a result, transit delay is sensitive to highway mobility investments that improve highway speeds.

Vehicle Miles Traveled (VMT)

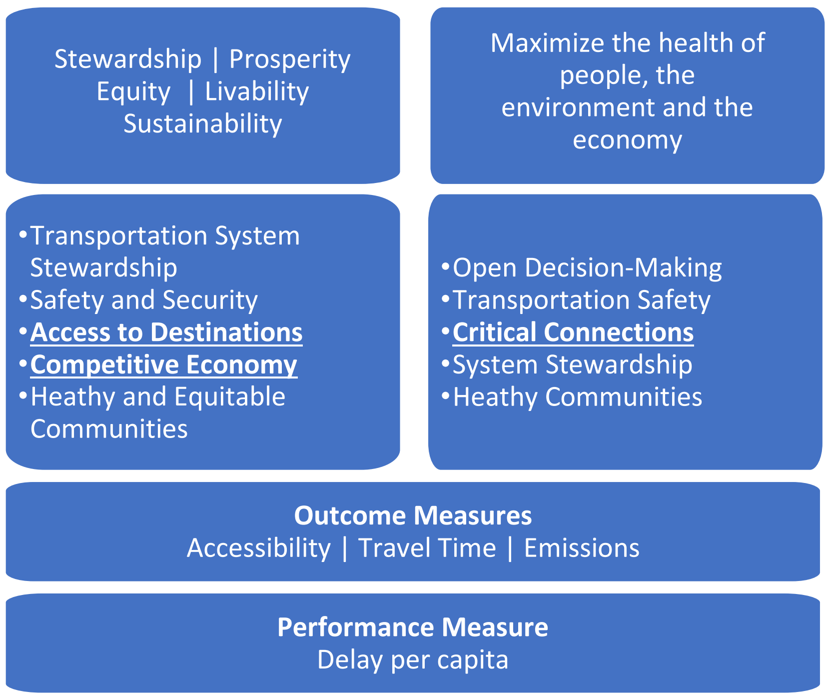
Vehicle miles traveled, or VMT, provides an indicator of overall travel demand placed on the transportation system. VMT is influenced by many factors, including land use and travel behavior. VMT is becoming a focus area for transportation agencies as a few state and local agencies set VMT reduction targets to advance livability and climate initiatives.

VMT is calculated using RTDM outputs. Each link in the roadway network has a length and an estimated daily volume from the trip assignment process. Length multiplied by volume provides the link-level VMT. Summing all the links in the roadway network provides regional VMT.

Highway Mobility Measurement Framework

The Twin Cities Highway Mobility Needs Analysis measure selection process flows from THRIVE 2040 Outcomes and the Minnesota GO Vision for Transportation, funneled through TPP goals and SMTP objectives. Figure 6 highlights the TPP goals and SMTP objectives with greatest relevance for highway mobility and identifies the measures of highway mobility outcomes used in this analysis. The intent of the figure is to show how a measure of travel delay per capita aligns with and complements a framework of considerations within which MnDOT makes decisions about highway mobility investment.

Figure 6: Twin Cities Highway Mobility Measurement Framework



Chapter 4: Develop Highway Mobility Investment Scenarios

This chapter describes the process used to develop year 2040 highway mobility investment scenarios. The purpose of these scenarios was to provide analysis stakeholders with a range of travel delay per capita outcomes that could be achieved through highway mobility investment. As discussed in the next chapter, this range of achievable outcomes framed travel delay per capita target options and the analysis's target recommendation.

Scenario Development Process

The Twin Cities Highway Mobility Needs Analysis developed year 2040 highway mobility investment scenarios in four steps.

1. Establish year 2040 highway mobility baselines
2. Identify highway mobility target options
3. Identify highway mobility improvements needed to meet target
4. Identify highway mobility investment needed to meet target

This process is designed to leverage existing plans and modeling efforts wherever possible. As described above, the scenario development process incorporates year 2040 regional highway networks, land use assumptions, and population/employment forecasts from the 2040 Transportation Policy Plan (TPP). The process is also designed to be iterative, so that steps 2-4 can be repeated and refined based on analysis, different assumptions about future travel behavior, different cost estimates, and stakeholder feedback.

Establish year 2040 highway mobility baselines

The development of year 2040 highway mobility investment scenarios began with the establishment of three travel delay per capita baselines:

1. **Year 2040 "no-build" – 56 annual hours of delay per capita.** Modeled using year 2018 roadway and year 2040 land use, population, and employment assumptions in the TPP.
2. **Year 2040 current revenue – 52 annual hours of delay per capita.** Modeled using 2040 land use, population, and employment assumptions and the 2040 highway network assumed under the 2040 TPP current revenue scenario, where highway mobility funding largely ends after 2026.
3. **Year 2040 increased revenue – 48 annual hours of delay per capita.** Modeled using 2040 land use, population, and employment assumptions and the 2040 highway network assumed under the 2040 TPP increased revenue scenario.

These baselines provided a reference for three baseline delay per capita outcomes ranging from 48 to 56 annual hours delay per capita. A key observation made at this point in the analysis was that the best/most aggressive year 2040 baseline showed a six hour or 12.5 percent increase in annual delay per capita compared to pre-pandemic conditions. Table 15 compares annual hours of travel delay per capita for each 2040 baseline to the 42 annual hours of delay per capita modeled on the year 2018 highway network.

Table 15: Annual Delay per Capita for 2040 Highway Mobility Baselines

Investment scenario	Annual delay per capita	Comparison to 2018 conditions
Year 2040 No Investment	56 hours	+14 hours
Year 2040 Current Revenue	52 hours	+ 10 hours
Year 2040 Increased Revenue	48 hours	+ 6 hours

Identify highway mobility target options

The next step in the development of year 2040 highway mobility investment scenarios was to identify a range of annual hours of travel delay per capita outcomes from which to select a target. Two principles were adopted to guide development of target options.

- **Alignment with MnDOT and Met Council policy direction guiding highway improvements.** Under this principle, MnDOT must be able to achieve a targeted level of delay reduction by making improvements that follow the regional highway mobility investment approach outlined in the 2040 TPP.
- **Improvement over year 2040 annual hour of travel delay baselines.** Under this principle, the range of potential targets considered in the analysis would include at least one option representing an improvement over travel delay in year 2018.

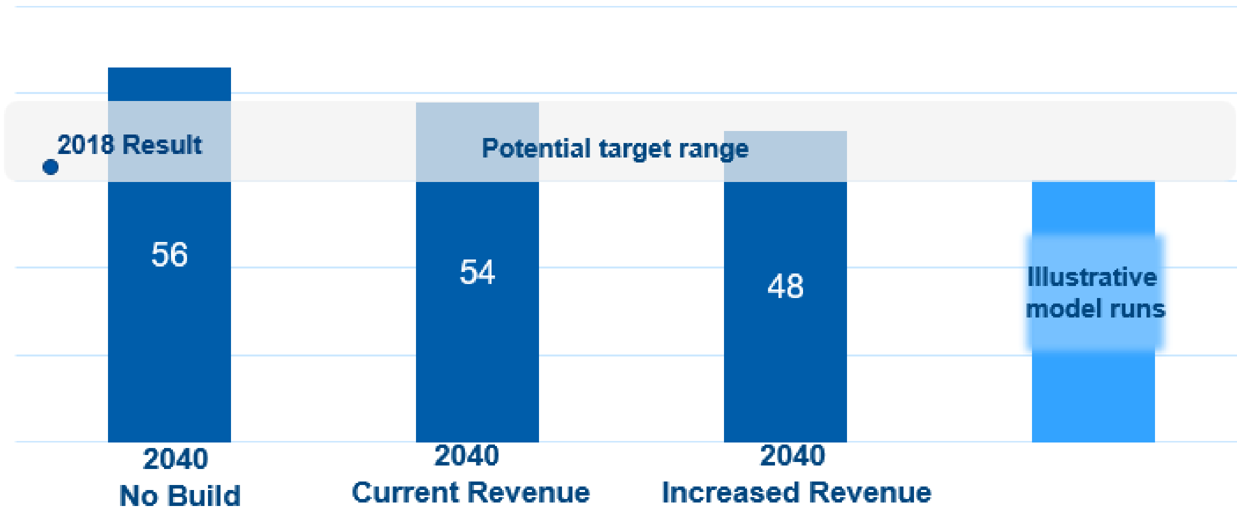
Another factor considered when identifying a range of highway mobility targets was a comparison of travel delay per capita in the Twin Cities to peer regions. This comparison revealed that daily delay in the Twin Cities is better than the peer region average but worse than Tampa-St. Petersburg by one minute per person per day. The peer region comparison also revealed that several regions are enacting strategies to improve highway mobility, suggesting that the Twin Cities will need to continue to invest in highway mobility if it is to remain competitive.

Table 16: Existing mobility performance – peer region comparison

MSP Peer Regions	Delay per person per day in 2018 (minutes)
Seattle	13.6
San Diego	12.5
Denver	11.3
Minneapolis – Saint Paul	**9.7**
Tampa – Saint Petersburg	8.7

Figure 7 presents annual hours of delay per capita for year 2040 baselines in relation to annual hours of delay in year 2018. The chart highlights a range of potential target values between 52 annual hours (year 2040 current revenue baseline) and 40 annual hours (slightly better than the 42 annual hours modeled in year 2018). Annual hours of travel delay per capita results are rounded to the nearest four-hour increment. Four-hour increments enable the analysis to express delay impacts and savings in terms understandable to the traveling public. For example, the difference between delay per capita under the 2040 no-build and 2040 current revenue scenarios is eight hours, or one workday per year.

Figure 7: Range of Potential Target Values for Annual Hours of Delay per Capita Performance Measure



The highway mobility baselines were then referenced to understand the range of delay for potential regional targets. This level of mobility improvement is represented by the light blue column on the right-hand side of Figure 7. Using four-hour increments and the concept of using workdays to communicate the significance of changes in hours of delay, highway mobility improvement scenarios were generated to produce 44 and 40 annual hours of travel delay per capita. These scenarios were labeled 2040 Beyond Increased Revenue 1 and 2040 Beyond Increased Revenue 2.

Identify highway mobility improvements needed to meet target

The third step in the development of year 2040 highway mobility investment scenarios was to identify highway mobility improvements needed to achieve target values. Highway improvements included in the year 2040 Current Revenue and Increased Revenue scenarios were already known, since these scenarios were taken from the 2040 TPP. To identity highway mobility improvements needed to implement year 2040 highway mobility improvement scenarios (Beyond Increased Revenue 1 and Beyond Increased Revenue 2), year 2040 highway networks were iterated using the RDTM and the travel delay per capita measurement methodology described in Chapter 3. This approach allowed links on the year 2040 Increased Revenue network exceeding delay thresholds to be identified and improved until a targeted level of regionwide delay per capita was achieved.

Locations exceeding travel delay thresholds

Locations on the year 2040 Increased Revenue network exceeding delay thresholders were identified using Travel Time Index (TTI) ceilings and targets that were set differently for each highway mobility improvement scenario. As shown in Table 17, excess delay under the Beyond Increased Revenue 1 scenario was located using a TTI ceiling of 1.75 and target of 1.25. Excess delay under the Beyond Increased Revenue 2 scenario was located with a TTI ceiling of 1.35 and target of 1.25 for freeways. For non-freeways, the TTI ceiling was 2.0 and the TTI target was 1.10.

Table 17: Highway Mobility Improvement Scenario Travel Time Index (TTI) Thresholds

Improvement Scenario	TTI Ceiling	TTI Target
Beyond Increased Revenue 1	1.75	1.25
Beyond Increased Revenue 2 – freeways	1.35	1.25
Beyond Increased Revenue 2 – non-freeways	2.0	1.10

Iterative capacity adjustments of year 2040 highway networks

Having located network links with delay exceeding a TTI ceiling, the additional capacity needed to achieve scenario TTI targets was identified. Two constraints were placed on capacity adjustments. The first constraint limited capacity adjustment to links on Twin Cities roadways eligible for MnDOT investment in highway mobility (i.e., state highways in the seven-county metropolitan area). The second constraint restricted capacity adjustments to no more than a single lane of additional capacity, reflecting MnDOT and Council policy direction limiting expansion of highway facilities.

Additional capacity needs were calculated for year 2040 highway networks based on TTI results, TTI targets, model volumes, and the volume-delay function used for assignment. These calculations were made for the AM and PM peak hour assignments and run iteratively until the impact of further adjustment was no longer significant. Capacity needs identified in either of the peak hours were used to adjust the input network and rerun a standard final assignment for all time periods.

Highway improvements identified under each improvement scenarios

Capacity adjustments made to meet TTI targets were binned into three classifications based on the percent of a lane added, with year 2040 Increased Revenue network capacity per lane as the denominator. These classifications mirror the cost-based progression of highway mobility strategies introduced in Chapter I, starting with traffic management technologies (adjustment of 0-5 percent the capacity of an additional lane) and continuing on to spot mobility improvements (5 – 40 percent capacity increase) and strategic capacity improvements (>40 percent capacity increase).

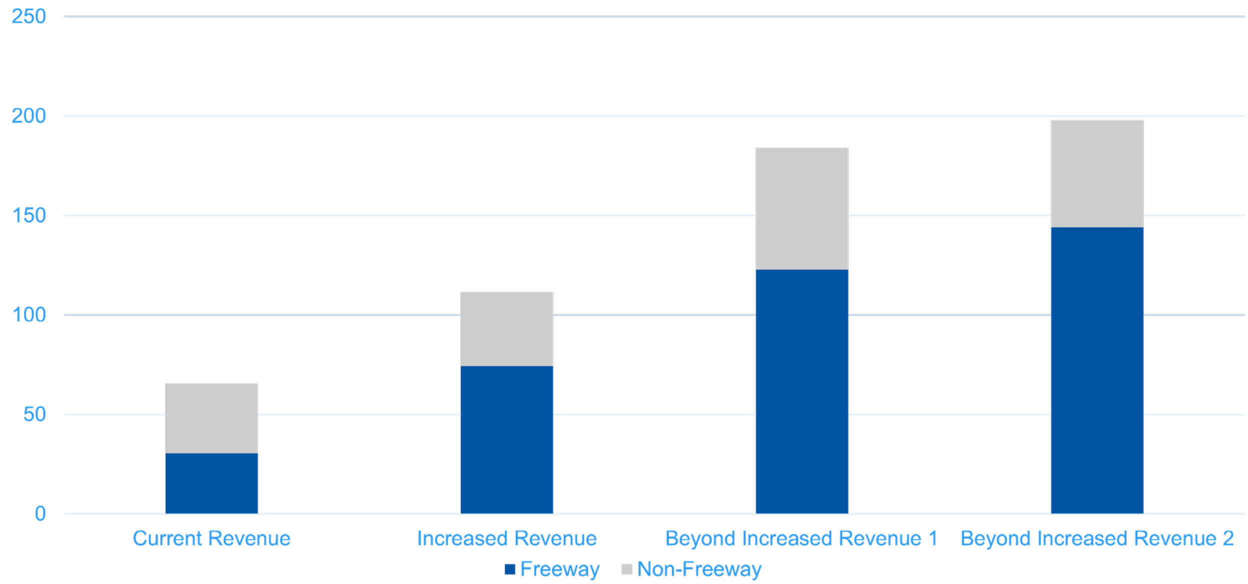
As shown in Table 18, 24 percent of MnDOT-owned freeways and non-freeways in the Twin Cities received some form of capacity improvement under the Beyond Increased Revenue 1 scenario. Under the Beyond Increased Revenue 2 scenario, the share of system improved increases to 32 percent. Also notable is that while the Beyond Increased Revenue 1 scenario is relatively balanced across freeways and non-freeways, Beyond Increased Revenue 2 is heavily focused on freeways.

Table 18: Share of metro-area state highways improved under highway mobility investment scenarios

Improvement Scenario	Freeways	Non-freeway	Total
Beyond Increased Revenue 1	14.3%	9.8%	24.1%
Beyond Increased Revenue 2	25.7%	6.6%	32.3%

Figure 8 presents total miles of MnDOT owned freeways and non-freeways improved in highway mobility improvement scenarios compared to year 2040 baselines.

Figure 8: Miles of metro-area state highways improved under highway mobility investment scenarios



Identify highway mobility investment needed to meet target.

The fourth step in the development of year 2040 highway mobility investment scenarios was to identify the level of highway mobility investment needed to achieve target values. As with highway mobility performance outcomes, cost estimates help analysis stakeholders understand the scale, significance, and reasonableness of highway mobility target values.

Unit cost estimates

The capital cost of highway mobility investments needed to meet target values were calculated using unit cost estimates for spot mobility and strategic capacity improvements. These estimates were generated based on recent highway construction bid prices disaggregated by project location (urban, suburban, and rural) to account for differences in land value, availability of right of way, and project complexity. A low, medium, and high-cost range was generated for each location type to account for uncertainty and difference among projects. Table 18 provides these cost ranges in year 2020 dollars.

Table 19: Highway Mobility Improvement Unit Cost Estimates (in 2020 dollars)

Improvement Description ($million/mile)	Urban			Suburban			Rural		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
Freeway Improvement	$12	$15	$18	$8	$10	$12	$8	$10	$12
Expressway Improvement	$11	$14	$17	$7	$9	$11	$6	$8	$10
Freeway Conversion	$50	$65	$80	$38	$48	$58	$32	$40	$48
4-Lane Arterial Improvement	$6	$8	$10	$4	$6	$8	$4	$5	$6
2-Lane to 4-Lane Divided	$11	$13	$15	$6	$8	$10	$6	$8	$10
2-Lane to 4-Lane Undivided	$6	$9	$12	$3	$5	$7	$3	$5	$7
2-Lane Arterial Improvement	$4	$6	$8	$2	$4	$6	$2	$4	$6
Interchange (per location)	$30	$40	$50	$25	$30	$35	$20	$25	$30
Intersection Improvement (per location)	$1.0	$1.5	$2.0	$1.0	$1.5	$2.0	$1.0	$1.3	$1.5

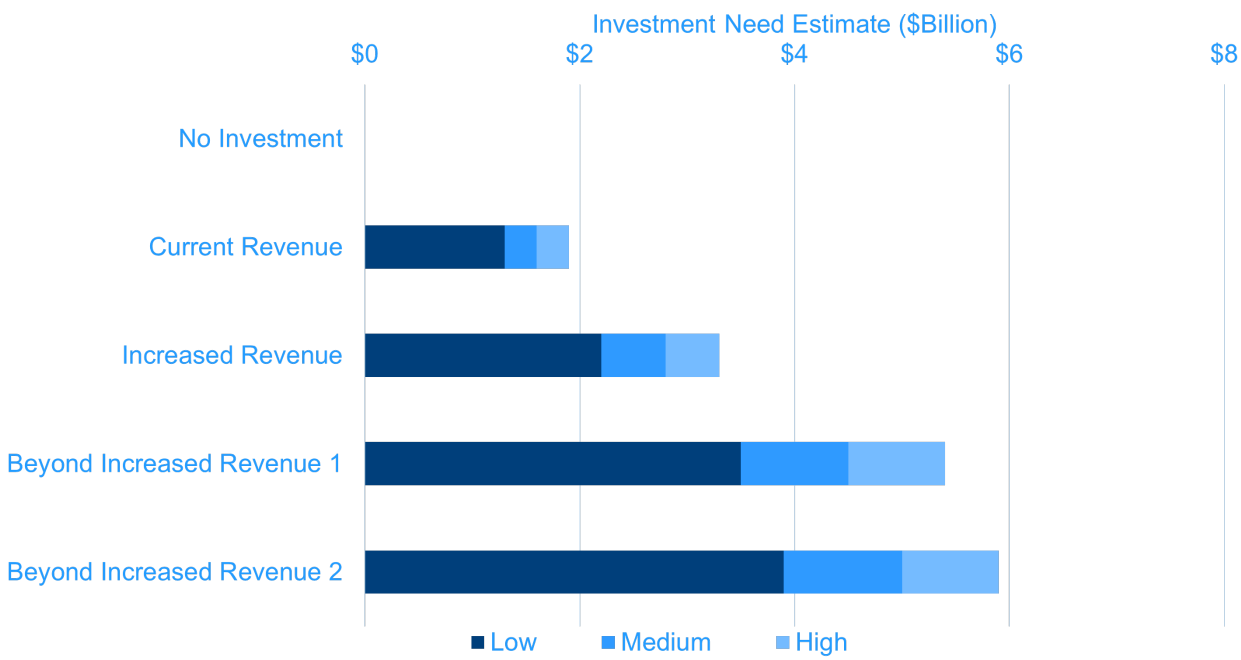
A key feature of these cost estimates is that they specifically reflect the marginal mobility improvement cost needed to modify a highway from its existing condition to the future condition assumed in the investment scenario. This means that if, for example, a modeled future condition involves a new E-ZPass lane, the highway mobility improvement cost estimate includes only the incremental cost of adding an E-ZPass lane, not the full cost to reconstruct the facility AND add the E-ZPass lane.

This is important for two reasons: 1.) Current MnDOT practice is to combine highway mobility improvements with needed preservation investments to minimize capital costs and construction traffic disruptions; and 2.) MnSHIP already accounts for asset management costs in the pavement, bridge, and roadside infrastructure condition investment categories. Separating the marginal mobility improvement cost from the cost of preserving existing facilities avoids double counting when calculating MnDOT's overall investment needs.

Cost estimates

Highway mobility unit cost estimates were multiplied by miles of improved highway in the urban, suburban, and rural categories under a given highway mobility investment scenario. This analysis generated low, medium, and high-cost ranges in each location category that were summed to create low, medium, and high estimates of scenario investment needs. Investment needs were then inflated over 10 years to represent the midpoint of the MnSHIP planning process using MnDOT's current adopted inflation rate of 3 percent annually. The results of the cost estimation process are depicted in Figure 9.

Figure 9: Cost Estimate Ranges by Investment Scenario



The cost estimate ranges depicted in Figure 9 for the Current and Increased Revenue investment scenario were compared to the cost estimates presented in the 2040 TPP. While significantly different cost estimation methodologies were used, this comparison found 2040 TPP cost estimates to fall within the low-to-high range, suggesting that the planning-level methodology used in this analysis can be relied upon to produce realistic capital costs at the regional scale.

Highway Mobility Investment Scenarios

The previous section described how the Twin Cities Highway Mobility Needs Analysis developed five 2040 highway mobility capital investment scenarios. This section summarizes the results of that process.

Scenario nomenclature

During the traffic modeling stage of analysis, these scenarios were referred to as 2040 no-build, current revenue, increased revenue, beyond increased revenue 1, and beyond increased revenue 2. As the project moved from modeling to analysis of performance outcomes and investment needs, new terminology was developed to describe the scenarios. As with terms applied to model runs, these new terms conveyed a continuum of investment from no additional investment beyond planned improvements to the investment necessary to improve on year 2018 conditions.

Table 20 provides summary information about year 2040 highway mobility investment scenarios. The left column identifies the travel delay per capita target values that provide the basis for each highway mobility investment scenario. The center column contains the names used to describe distinct year 2040 model runs. The right column contains the names used to present 2040 performance outcomes and investment needs.

Table 20: Year 2040 highway mobility investment scenario nomenclature

Target option	Scenario name during traffic modeling	Scenario name used when reporting performance outcomes and costs
56	2040 no-build	Implement planned investment
52	2040 current revenue	Extend current investment
48	2040 increased revenue	Manage decline in regional mobility
44	2040 beyond increased revenue 1	Sustain regional mobility
40	2040 beyond increased revenue 2	Improve regional mobility

Names used to report year 2040 highway mobility performance outcomes and costs were informed by the performance level concept developed in MnDOT's Minnesota State Highway Investment Plan (MnSHIP). MnSHIP performance levels refer to performance outcomes at a given level of highway investment. In general, as investment increases in a MnSHIP investment category, the performance outcomes associated with that investment category improve. MnDOT numbers performance levels and uses the numbers (e.g., performance level 1, performance level 2, etc.) to represent alternative investment approaches available in each investment category.

Scenario networks

As discussed above, the scenarios used to forecast year 2040 highway mobility performance outcomes and investment needs are a combination of baseline and improvement scenarios. Baseline scenarios forecast year 2040 performance outcomes and investment needs on the existing Twin Cities roadway network or a year 2040 highway network developed in the 2040 TPP. Improvement scenarios forecast performance outcomes and investment needs associated with modeled capacity adjustments to the year 2040 Increased Revenue network. Table 21 identifies each scenario's input network and any adjustment made to network capacity as part of the analysis.

Table 21: Year 2040 highway mobility investment scenario networks

Scenario	Input Network	Adjustments
Implement planned investment*	Existing (year 2018)	N/A
Extend current investment	2040 TPP current revenue network	N/A
Manage decline in regional mobility	2040 TPP increased revenue network	N/A
Sustain regional mobility	2040 TPP increased revenue network	Capacity adjustments made to state highway links with a TTI above 1.75
Improve regional mobility	2040 TPP increased revenue network	Capacity adjustments made to state highway links with a TTI above 1.35 (freeways) and 2.0 (non-freeways)

*The label "implement planned investment" was chosen to align the lowest cost scenario with the MnSHIP concept of performance level 0. The concept behind this scenario is that MnDOT could make no further improvements out of a particular investment category beyond existing commitments (e.g., projects under construction or programmed in the 4-year Statewide Transportation Improvement Program). As a practical matter, the project ream modeled the implement planned investment scenario using the existing Twin Cities roadway network. This network does not include $375 million in highway mobility improvements MnDOT plans to make over the next 20 years. Given the regional scale of the analysis and inherent uncertainty in estimating 20-year performance outcomes, the "no-build" approach was used to model the implement planned investment scenario.

Chapter 5: Model Highway Mobility Performance Outcomes

This chapter presents the results of the Twin Cities Highway Mobility Needs Analysis. The chapter is divided in three sections. Section one presents highway mobility performance outcomes modeled under the investment scenarios introduced in Chapter 4. As noted above, highway mobility outcomes such as travel times savings and job access were modeled to explain and assess the significance of changes in travel delay per capita and consider whether additional improvement in highway mobility warrants additional cost.

Section two assesses the sensitivity of highway mobility outcomes and cost estimates to assumptions about future telecommuting. The purpose of this analysis was to compare year 2040 outcomes and costs under traditional telecommuting conditions to year 2040 outcomes and costs under conditions in which significantly more people work from home. This is followed by a third section providing a short description of the rationale used to evaluate and select a Twin Cities highway mobility target.

Year 2040 Highway Mobility Performance Outcomes

Year 2040 highway mobility performance outcomes were modeled for the highway mobility capital investment scenarios introduced in Chapter 4. Table 22 identifies these scenarios, along with each scenario's 20-year capital investment need.

Table 22: 20-year highway mobility investment needs

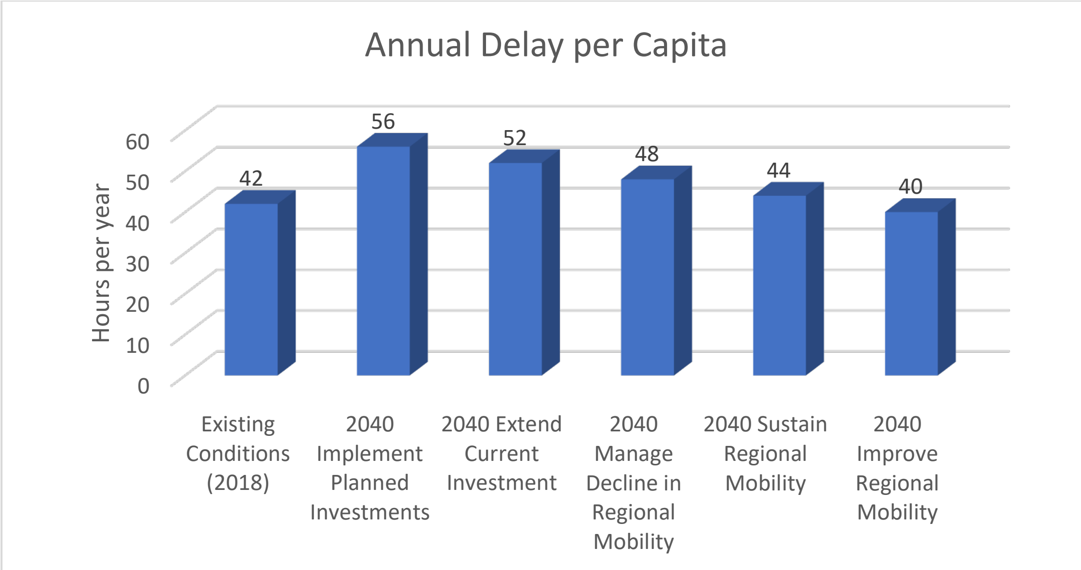
Highway Mobility Investment Scenario	20-year Investment Need
Implement planned investment	$0 - $375 million
Extend current investment	$1 - $2 billion
Manage decline in regional mobility	$2 - $3 billion
Sustain regional mobility	$3 - $5 billion
Improve regional mobility	$4 - $6 billion

Although many measures were modeled over the course of the analysis, a total of five measures were advanced as part of the process used to recommend a highway mobility target. These five measures were annual hours of travel delay per capita, jobs accessible to a typical Twin Cities resident within a 30-minute drive, 2040 benefit from travel time savings, freight bottlenecks improved, and GHG emissions.

Travel Delay per Capita

Annual hours of travel delay per capita provided the target value used to develop year 2040 highway mobility investment scenarios, as described in Chapter 4. Travel delay per capita is different than the other measures used in this analysis in that the measure result drove the modeling instead of the other way around. Figure 10 identifies travel delay per capita results for year 2018 and the analysis's five highway mobility investment scenarios. The chart shows that as additional investment is added, delay per person decreases. This is an important finding because it demonstrates that additional investment continues to improve highway mobility performance and does not encounter an asymptote or point of diminishing return.

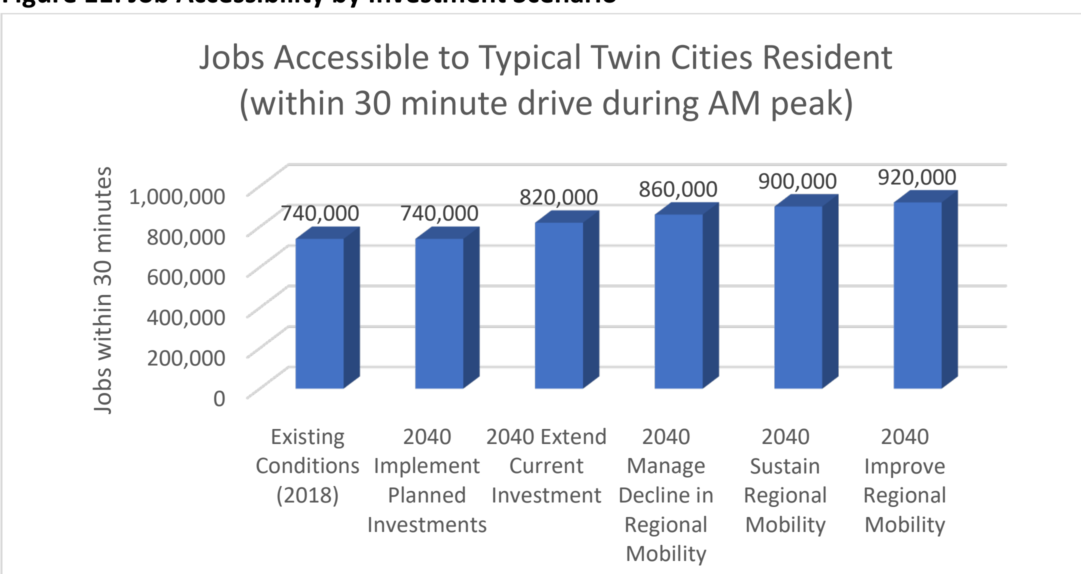
Figure 10: Annual Delay per Capita by Investment Scenario



Job Access

Figure 11 charts increases in the number of jobs accessible to the typical Twin Cities resident as investment in highway mobility increases. The chart shows that with no additional investment in highway mobility, job access is expected to remain flat between year 2018 and year 2040 at 735,000 jobs. As highway mobility investment increases, job access improves at a rate of approximately 40,000 additional jobs accessible during the AM peak for every 4-hour reduction in annual hours of delay per capita.

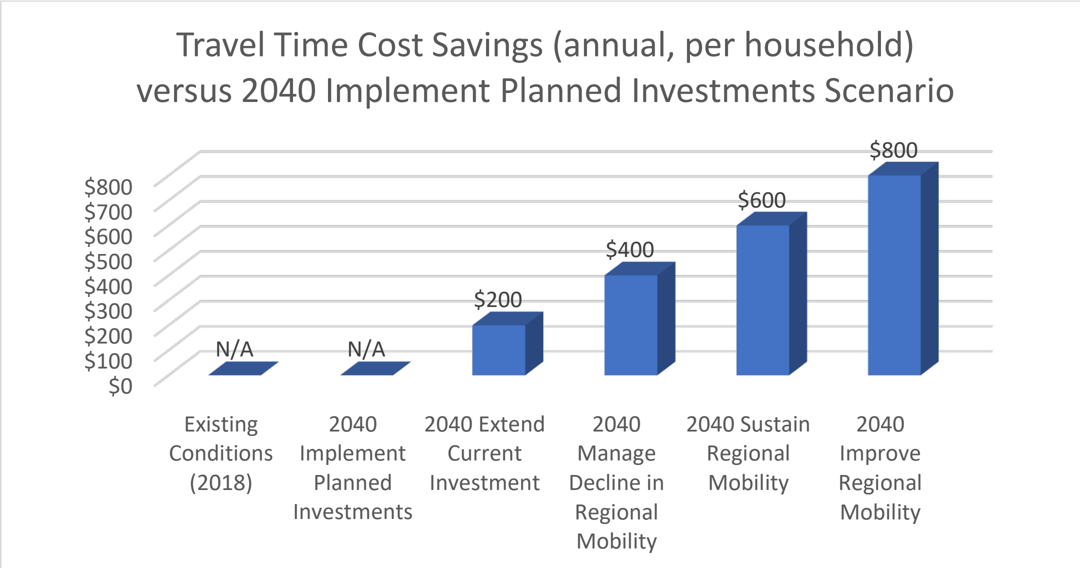
Figure 11: Job Accessibility by Investment Scenario



Travel Time Cost Savings

Figure 12 charts the monetary benefit of travel time cost savings to the typical Twin Cities household as investment in highway mobility increases. The chart shows that travel time cost savings in year 2040 are expected to increase at a rate of approximately $200 per household with every 4-hour reduction in annual hours of delay per capita.

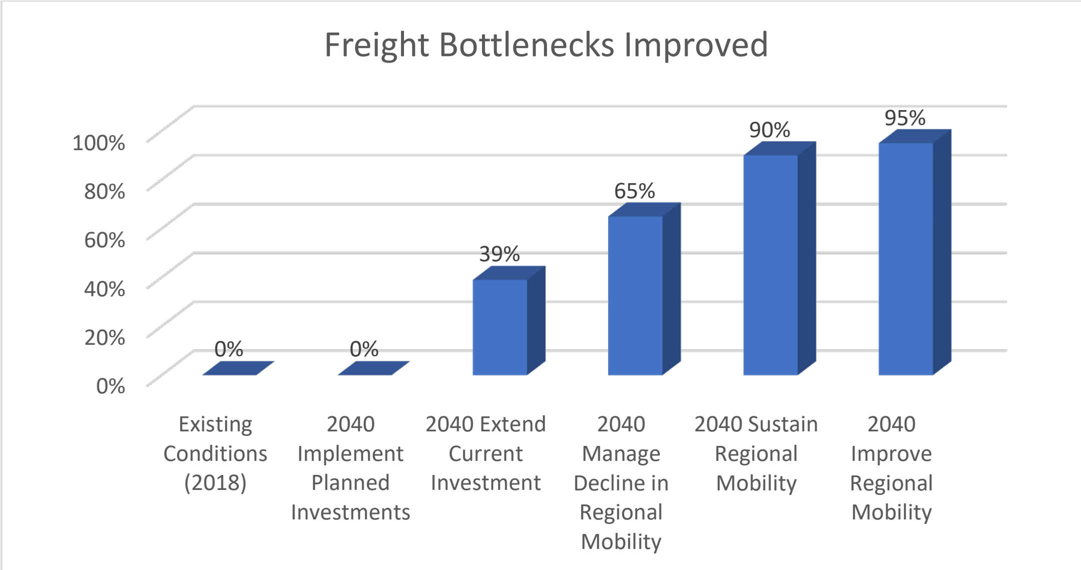
Figure 12: Travel Time Cost Savings by Investment Scenario



Freight Bottlenecks Improved

The analysis also considered the benefit of highway mobility investment to goods movement throughout the Twin Cities region. Figure 13 charts the share of freight bottlenecks improved under each highway mobility investment scenarios. The percentages shown in Figure 13 represent the number of freight bottleneck locations identified in the *Minnesota Statewide Freight Bottleneck Report* with increased capacity due to highway mobility investment divided by 220 (the total number of freight bottlenecks). While this analysis relies on the location of improvements, it is important to note that the highway mobility needs analysis was not conducted as a programming exercise. The results of this analysis are intended to be illustrative at the regional level and not recommendations of specific future improvements.

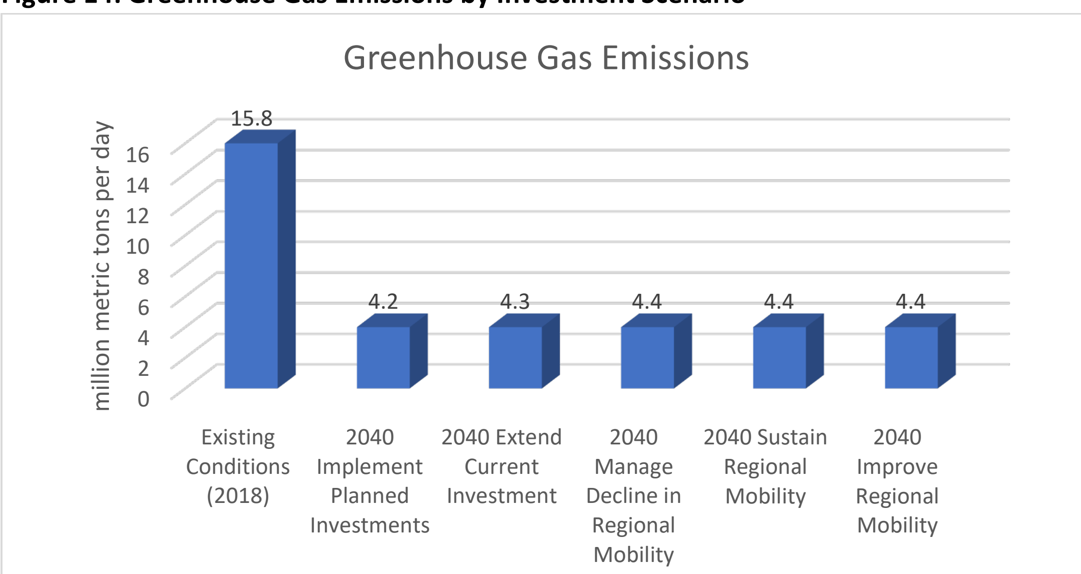
Figure 13: Freight Bottlenecks Improved by Investment Scenario



Greenhouse Gas (GHG) Emissions

GHG emissions were another highway mobility performance outcome considered in this analysis. Using the EPA MOVES model for estimating future emissions, this analysis estimated year 2040 GHG emissions from roadway travel in the Twin Cities to be between 4.2 and 4.4 million metric tons per day. Figure 14 shows these estimates in relation to each other and to year 2018, when GHG emissions from roadway travel in the Twin Cities were an estimated 15.8 million metric tons per day. This 70 to 75 percent decrease is the result of the EPA MOVES model's assumptions about fuel efficiency standards, electric vehicle adoption rates, fleet turnover to more fuel-efficient vehicles, VMT, and distribution of travel speeds.

Figure 14: Greenhouse Gas Emissions by Investment Scenario



The small difference in GHG emissions between year 2040 investment scenarios is because the analysis modeled negligible change in VMT due to highway mobility investment. A couple of factors were identified as being responsible for this. First, year 2040 land use is held constant across all investment scenarios, so no influence of accelerated outward expansion that might be associated with improved highway mobility is included. Second, while the reduction in delay shows improvement across the scenarios, the magnitude – approximately four hours per year per person at each increment of investment – is small relative to overall travel time, so there is minimal sensitivity to changes in travel behavior in terms of people making longer or additional trips.

Equity Analysis

Decision-making in transportation is increasingly taking equity into account to ask not just "how much" benefit or impact is produced by investments, but "who" is experiencing those benefits and impacts. In this analysis, different population profiles were evaluated with respect to job accessibility under each investment scenario. Specifically, the analysis looked at the job access of Areas of Concentrated Poverty (ACP), Areas of Concentrated Affluence (ACA), and areas with a non-white racial or ethnic plurality.

The RTDM was used to calculate the number of jobs accessible to Transportation Analysis Zones (TAZa) by auto in 30 minutes or less from 7-8 AM. Since TAZ data does not include information on race/ethnicity or income, 2019 estimates for census tracts were used to identify ACAs and ACPs. After identifying the locations of ACAs and ACPs, TAZs were binned into these categories and used calculate the number of jobs accessible to these areas. This TAZ-based approach does not account for workers, nor the types of jobs workers may be qualified for, and it is likely auto ownership limits the actual job accessibility of underserved communities relative to the results.

Overall, the relationships observed between different TAZ types remain consistent across all investment scenarios. That is to say, the relative job accessibility by ACA and ACP designation does not significantly change at different levels of highway mobility investment. The results show that areas designated as ACA have a slightly higher job access baseline and a comparable job access increase with additional highway mobility investment compared to areas without an ACA designation. Areas designated as ACP have a much higher job access baseline and a comparable job access increase with additional highway mobility investment compared to areas without an ACP designation. Analysis of the number of jobs accessible to areas with a non-white racial or ethnic plurality produced similar findings to the ACP analysis.

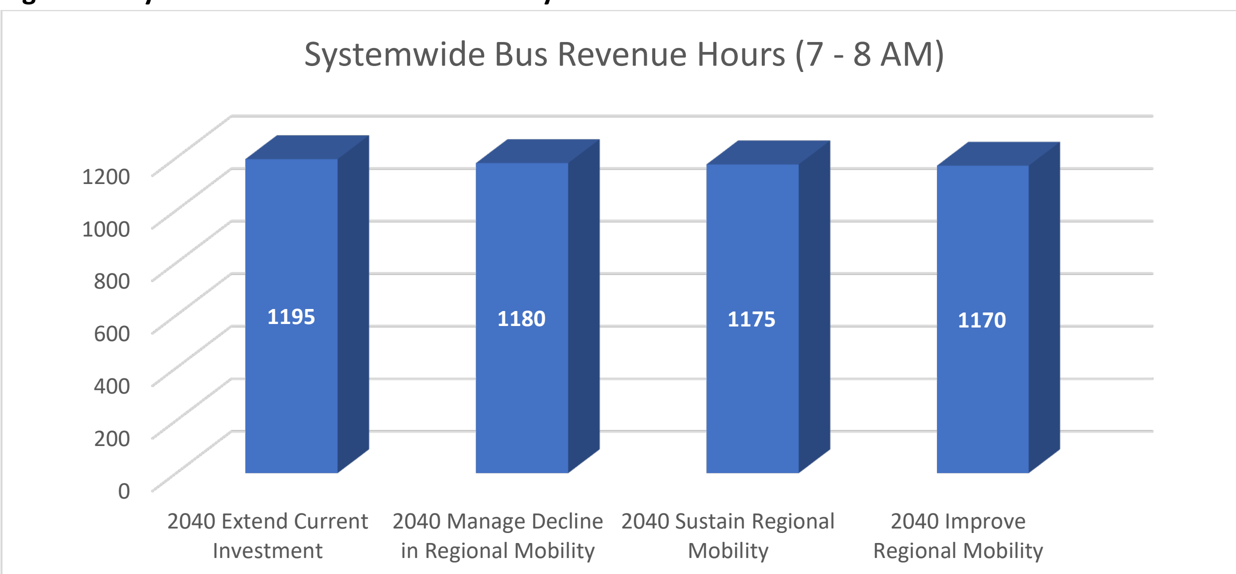
The equity analysis described above sheds light on how highway mobility investment impacts the job accessibility of different communities in the Twin Cities region, but these results are not conclusive. A much broader and more detailed evaluation is needed to better understand the equity implications of additional highway mobility investment. MnDOT and the Council will continue to refine their methodologies with respect to equity analysis and implement them as part of future efforts.

Transit Analysis

The investment scenarios were tested for impacts on the transit system using the RDTM transit assignment to measure and compare each scenario's results. Since the scenarios only include improvements on the highway network and not improvements or changes in transit service, bus revenue hours was selected as the most appropriate measurement for transit impacts. Bus revenue hours are defined as the number of hours buses are operating on transit routes, and as such, reductions in congested travel time resulting from capacity improvements on the highway network can result in an observable improvement in transit using this metric.

Figure 15 shows the change in bus revenue hours across the regional transit system during the AM peak hour under year 2040 investment scenarios. These results show a small decrease in bus travel times as highway mobility investment increases. There are two primary reasons for the limited improvement. One, these scenarios include mobility investments on state highways, so for transit routes that operate on city or county roadways, travel time benefits are based on impacts from diversion of regional trips back to state highways. Additional investment on these lower jurisdictional roadways could further improve transit outcomes. Two, the highway improvements implemented in this analysis were directed at highway mobility only. In practice, many of these improvements could provide greater transit benefits through E-ZPass lanes, signal enhancements that facilitate transit priority, and improved transit station design to improve efficiency of bus access and egress.

Figure 15: Systemwide Bus Revenue Hours by Investment Scenario



Sensitivity Analysis

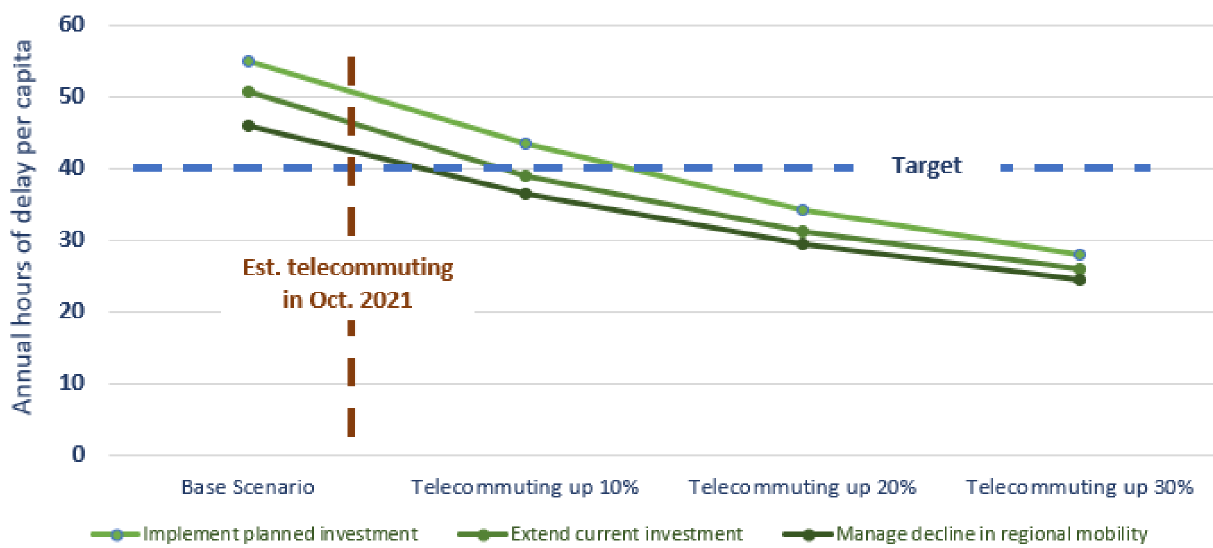
Perhaps the most profound change to the transportation landscape resulting from the COVID-19 pandemic was the seismic shift to remote work by workers able to perform their jobs from home. During the peak of the health crisis, a significant portion of the workforce was telecommuting, and the impacts on the highway system were equally dramatic, with near total elimination of recurring congestion. This section describes a telecommuting sensitivity analysis that explored the extent to which the investment needed to meet a highway mobility target would change if high rates of telecommuting were to persist through year 2040.

The sensitivity of highway mobility investment scenarios to increased telecommuting was tested by designating an additional 10, 20, and 30 percent of work trips as telecommute trips. A 30 – 35 percent telecommuting rate approximates the level of telecommuting observed at the height of the pandemic. Increased telecommuting rates were modeled by eliminating a desired percent of “work tours” in the activity-based RTDM. A work tour consists of multiple trip records associated with a work commute. For example, a work tour could include a trip to the coffee shop on the way to work or a trip to the grocery store on the way home. Eligible work tours were subjected to a randomized selection process and were removed from the model assignment input until the desired reduction in commuting work tours was achieved, emulating an increase in telecommuting.

This analysis resulted in time-of-day profiles that tracked VMT and VHT under different telecommuting assumptions. These profiles illustrated how telecommuting rates have a dramatic impact on VMT and VHT during the AM and PM peak, but a very small impact on VMT and VHT during non-peak hours – a pattern reflected in real-world observations during the pandemic. Furthermore, differences between telecommuting levels are proportionally higher for VHT compared to VMT, showing that as traffic volumes decrease the reduction in congestion accelerates.

The sensitivity analysis culminated in the chart depicted in Figure 16. This chart shows the impact of telecommuting assumptions on annual hours of delay per capita under the Implement Planned Investment, Extend Current Investment, and Manage Decline in Regional Mobility Investment Scenarios. These impacts suggest that if telecommuting rates were to increase by 10 percentage points, both the Extend Current Investment and Manage Decline in Regional Mobility Scenarios would achieve a target of 40 annual hours of delay per capita. If telecommuting rates increase by 20 percentage points or more, all the highway investment scenarios developed in the analysis would limit annual hours of delay per capita to less than 40 hours.

Figure 16: Sensitivity of Travel Delay to Telecommuting Rates



The results of this sensitivity analysis should be taken with caution, however, as the methods used in this analysis assume complete elimination of work-related trips at the 10, 20, or 30 percent telecommuting level. This can be misleading for two important reasons. First, many surveys of workers and employers conducted during the pandemic defined telecommuting as working from home "some of the time", and not "all of the time" as was assumed here. Second, the work tour reduction method described in this section removes all trips associated with the journey to work, many of which may still occur when working from home, such as shopping or driving children to childcare. In summary, these results likely represent far higher levels of travel reduction than would occur at the specified levels of telecommuting.

Table 23 relates sensitivity analysis findings to the cost estimate ranges provided for annual hours of delay per capita target options. The table shows that a 10-percentage point increase in assumed telecommuting rates (from 5 percent to 15 percent) would enable MnDOT to limit annual hours of delay per capita to 48 hours with no additional investment, an investment need savings of $2-3 billion over 20-years. The same 10-percentage point increase in assumed telecommuting rates would also reduce the 20-year cost of achieving a 40 hours of annual delay per capita target from $4-$6 billion to $1-$2 billion.

Table 23: Sensitivity of 20-year Highway Mobility Investment Needs to Telecommuting Assumptions

Telecommuting Scenario	48 hour target	44 hour target	40 hour target
5 percent of work trips telecommuting (baseline assumption)	$2-3 billion	$3-5 billion	$4-6 billion
15 percent of work trips telecommuting	No additional investment needed	$0-375 million	$1-2 billion

Target Recommendation

Summary results of the Twin Cities Highway Mobility Needs Analysis were shared with analysis stakeholders in early 2021 for the purpose of considering highway mobility performance target options and recommending a performance target to MnDOT and the Council. As noted in Chapter 4, the analysis produced three highway mobility target options using a measure of annual hours of delay per capita. These options ranged from 48 to 40 hours of annual delay per person. For each option, stakeholders were provided information about the performance-based need (estimated cost of state highway capital improvements needed to achieve the performance target) and associated highway mobility performance outcomes. This information is summarized in Table 24, with target options displayed in columns 4 through 6.

Table 24: Summary Results of the Twin Cities Highway Mobility Needs Analysis

Scenario	Implement Planned Investments	Extend Current Investment	Manage Decline in Regional Mobility	Sustain Regional Mobility	Improve Regional Mobility
20-Year Investment	$0-$375 million	$1-$2 billion	$2-$3 billion	$3-$5 billion	$4-$6 billion
Annual Delay per Capita (calendar icon = An 8 hour workday; -- = Delay per capita in 2018)	56 hours 14 hours more than 2018	52 hours 10 hours more than 2018	48 hours 6 hours more than 2018	44 hours 2 hours more than 2018	40 hours 2 hours less than 2018
Jobs Accessible to Typical Twin Cities Resident (within 30 minute drive during AM peak) (briefcase icon = 200,000 jobs accessible)	740k jobs Same as 2018	820k jobs 80k jobs more than 2018	860k jobs 120k jobs more than 2018	900k jobs 160k jobs more than 2018	920k jobs 180k jobs more than 2018
2040 Benefit from Travel Time Savings ($ icon = 100 dollars per household)	N/A	$200	$400	$600	$800
Freight Bottlenecks Improved	0%	39%	65%	90%	95%
Greenhouse Gas Emissions	4 million metric tons per day in 2040 (Substantial decreases in greenhouse gas emissions through year 2040 are projected based on vehicle efficiency improvements; the overall magnitude of regional emissions in 2040 are not greatly influenced by these highway mobility investment scenarios, but further study is needed.)				
Risk of Not Reaching Delay Target	HIGH	HIGH	MODERATE	MODERATE	LOW

As part of this review, analysis stakeholders were presented with a recommendation that the most aggressive target option – 40 hours of annual delay per capita – be advanced into MnDOT and Met Council planning processes for public review and comment. A target of 40 hours of annual delay per capita represents a slight (5 percent) improvement over year 2018 conditions. The primary rationale for recommending slight improvement over pre-pandemic conditions is that, within the highway mobility investment category, the highest level of possible investment should seek to keep pace with anticipated growth in regional population and demand for travel. Accepting this rationale, analysis stakeholders broadly endorsed the highway mobility performance target recommendation of 40 hours of annual delay per capita.

Chapter 6: Next Steps

The process, methods, and results presented in this report demonstrate that the Twin Cities Highway Mobility Needs Analysis accomplished the primary goals set out for the effort, namely to select a highway mobility performance measure and target, determine the financial need to meet the target, and measure the outcomes at different investment levels. Through the course of the analysis and upon its completion, MnDOT and the Council identified three next steps that would further improve the region's approach to highway mobility investment planning on the state highway system.

First, MnDOT should adopt the highway mobility measure and target in the forthcoming update of the Statewide Multimodal Transportation Plan and 20-year Minnesota State Highway Investment Plan (MnSHIP). Use of a highway mobility measure and target in MnSHIP will enable MnDOT to consider highway mobility performance outcomes when making comparisons and tradeoffs between highway mobility and other investment priorities. Study results should also be incorporated into the next update of the Metropolitan Council's Transportation Policy Plan.

Second, MnDOT and the Council should conduct additional study of the relationship between the type and location of highway mobility investment and greenhouse gas emissions. One limitation of the analysis was an inability to forecast the impact of increased highway mobility investment on future land use decisions. The Council will be leading the Regional Transportation and Climate Changes Measures Study in 2022/2023 to further analyze the issue.

Third, MnDOT and the Council should continue to investigate telecommuting trends in the Twin Cities as the COVID-19 pandemic subsides. The Council's Regional Travel Demand Study and Travel Behavior Inventory will further explore near and potential long-term telecommute rates. Another related area to be better understood by the Travel Behavior Inventory is the extent and timing of additional trips made by telecommuters who may now run their errands midday instead of on their way home from work.