MINNESOTA DEPARTMENT OF TRANSPORTATION

We all have a stake in A TO B

Transportation Asset Management Plan

July 2014

Draft

MinnesotaGO

A Collaborative Vision for Transportation

Executive Summary

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EXECUTIVE SUMMARY

Overview

In accordance with the Moving Ahead for Progress in the 21st Century Act ("MAP-21" – the federal transportation authorization signed into law on July 6, 2012), the Minnesota Department of Transportation (MnDOT) has developed its first ever Transportation Asset Management Plan (TAMP). It was a collaborative effort, guided by a TAMP Steering Committee with representation from a wide range of MnDOT offices and districts, as well as from the agency senior leadership. MnDOT also worked closely with the Federal Highway Administration (FHWA), the FHWA Minnesota Division, and regional partners (e.g. Metropolitan Planning Organizations, Regional Development Commissions) to create this plan. As a national pilot project, MnDOT's TAMP, along with those produced by Louisiana Department of Transportation and Development and New York State Department of Transportation will serve as an example and guide for other states as they develop TAMPs of their own.

The TAMP will continue to, and in fact already has improved infrastructure management at the agency. Using the TAMP as a guide, MnDOT will more thoroughly analyze life-cycle costs, evaluate risks and develop mitigation strategies, establish asset condition performance measures and targets, and develop investment strategies. The TAMP will also serve as an accountability and communication tool and will inform established capital and operations planning efforts.

This TAMP document is accompanied by a *TAMP Technical Guide*, which provides further detail about the process, methodology analyses, and procedures used during its development. The TAMP Technical Guide has been designed to roughly parallel the main TAMP with nine sections, each of which corresponds to a specific TAMP chapter. Specific elements in the guide are referenced and hyperlinked throughout the TAMP.

Figure ES-1: Minnesota's State Highway System

Pavements*

NHS Pavements: 7,595 roadway miles

Non-NHS Pavements: 6,736 roadway miles

Bridges*

NHS Bridges: 1,951 (count)

Non-NHS Bridges: 2,592 (count)

Hydraulic Infrastructure

Highway Culverts: 47,157 (count)

Deep Stormwater Tunnels: 7 tunnels

(50 segments; 69,272 linear feet)

Other Traffic Structures

Overhead Sign Structures: 2,359 (count)

High-Mast Light Tower Structures: 476 (count)

*Locally-owned inventory not included

Background

Minnesota's 14,000-mile state highway system – constructed, operated, managed, and maintained by MnDOT – is critical to the state's economic competitiveness and quality of life. Successful administration of such an extensive and complex system relies on sound investment strategies and management practices. To this end, MnDOT has used performance measures to inform management and investment decisions since the mid-1990s; these were made a formal part of MnDOT's statewide planning processes in 2003.

With the passage of MAP-21 each state transportation department is required to develop a risk-based TAMP for all pavements and bridges on the National Highway System (NHS). Because MnDOT had already begun to implement asset management principles prior to the MAP-21 legislation, it was in a good position to expand beyond MAP-21 requirements. This TAMP includes pavements and bridges on the entire state highway system as well as several smaller asset categories: highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures (see **Figure ES-1**). Additional asset categories will be included in future MnDOT asset management planning initiatives.

MnDOT expanded beyond the MAP-21 required assets.

ASSETS	MnDOT TAMP	MAP-21 REQUIRED
Pavement	✓	✓
Bridges	✓	✓
Highway Culverts	✓	
Deep Storm Tunnels	✓	
Overhead Signs	✓	
High-mast Lights	✓	

Performance Measures and Targets

MnDOT's performance-based approach to asset management relies on measures to assess system performance, identify needs, and develop investment priorities. Historically, these measures have included pavement ride quality and bridge condition and are used, along with targets for each measure, to develop the 20-year State Highway Investment Plan (MnSHIP). Additional performance measures, tracking things like culvert and stormwater tunnel condition, have been monitored and used internally for managing asset-specific programs, but not for establishing investment priorities.

As part of the TAMP process, MnDOT experts further developed performance measures and targets for several of these ancillary asset categories and recommended them for formal inclusion in future iterations of MnSHIP. **Figure ES-2** explains the performance measures for each asset category included in the TAMP, along with MnSHIP targets where they exist.

Figure ES-2: Performance Measures By Asset Type

ASSET TYPE	PERFORMANCE MEASURE	MNSHIP (2013) TARGET
Pavements	Share of system with lane miles with Poor ride quality	≤ 2% (NHS) ≤ 3% (Non-NHS)
Bridges	NHS bridges in Poor condition as a percent of total NHS bridge deck area	≤ 2% (NHS) ≤ 8% (Non-NHS)
Highway Culverts	Share of culverts in Poor or Very Poor condition	NA
Deep Stormwater Tunnels	Tunnels in Poor and Very Poor condition, measured as a percent of total tunnel system length	NA
Overhead Sign Structures	Share of overhead sign structures in Poor or Very Poor condition	NA
High-Mast Light Tower Structures	Share of High-Mast Light Tower Structures in Poor or Very Poor condition	NA

Notes: MnDOT uses multiple measures to evaluate the effectiveness of its pavement and bridge management activities. The measures listed here are those used to calculate MnDOT's performance-based investment needs. For a more comprehensive listing of MnDOT's pavement performance measures, see the 2013 Pavement Condition Annual Report. Additional bridge measures can be found in MnDOT's Annual Transportation Performance Report.

Asset Inventory and Condition

A considerable amount of information is needed to develop a robust TAMP. For the pavements and bridges, this information was, for the most part, readily available in MnDOT's pavement and bridge management systems. For other asset categories, data were less complete or accessible. Condition inspections are performed less consistently on deep stormwater tunnels, overhead sign structures, and high-mast light tower structures, resulting in limited maintenance histories and asset condition deterioration rates for these asset categories.

MnDOT is using the TAMP process to assess the maturity level of the maintenance and management of many of its assets, to identify process improvements that will help manage them more effectively, and to apply these principles to other MnDOT asset groups. Folios were created for each asset category to summarize inventory, estimate replacement value, and report on data collection, management technique, reporting practices, current condition, recommended targets, and planned investment levels over the next 10 years. **Figure ES-3** summarizes the system-wide replacement values for the asset categories included in the TAMP.

Figure ES-3: Replacement Cost by Asset Category

ASSET CLASS	REPLACEMENT COST
Pavements	$29.5 billion
Bridges (includes large bridges and culverts greater than 10 feet)	$6.6 billion
Hydraulic Infrastructure: Highway Culverts	$1.7 billion
Hydraulic Infrastructure: Deep Stormwater Tunnels	$300 million
Other Traffic Structures: Overhead Sign Structures	$200 million
Other Traffic Structures: High-Mast Light Tower Structures	$19 million

Risk Management

Risk – or the effect of uncertainty on objectives – can help a transportation agency more successfully plan for possible system and program disruptions and complications, mitigate potential consequences, and improve agency and infrastructure resiliency.

Even before MAP-21, risk management had been a focus area for MnDOT, implemented throughout the agency from high level investment, management, and operations plans to individual asset management programming processes. MnDOT began developing the risk section of the TAMP with an exercise designed to focus on "global" risks (e.g. natural events, operational hazards) and their effects on the assets, the public, and the agency. Discussions were held with in-house technical experts to assess the major risks related to each asset category.

Upon further deliberation, the technical experts and the project management team concluded that MnDOT's current practices were already mindful of many global risks and that the agency (and the public it serves) would benefit more if the TAMP emphasized "undermanaged risks" – areas in which there were clear opportunities for improvement at MnDOT. After pivoting to this concept and removing from the list those risks that were already well-managed by the agency, a final list of undermanaged risks and associated risk mitigation strategies was presented to the TAMP Steering Committee for prioritization. **Figure ES-4** displays the prioritized mitigation strategies, which were used to establish investment priorities and to amend existing business processes to improve the management of assets at MnDOT. **Chapter 9** of the TAMP includes a similar table (**Figure 9-2)** which also includes estimated costs, expected implementation timeframes, and individual MnDOT office responsibilities for each strategy.

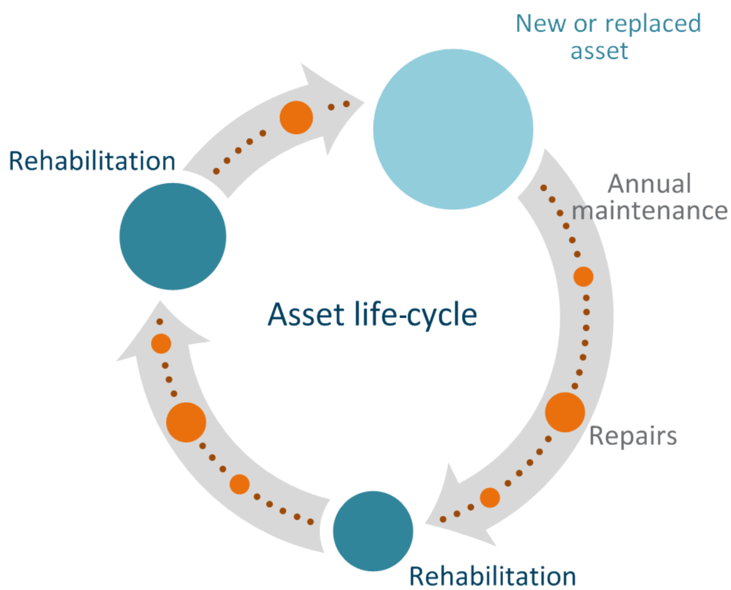
Figure ES-4: Prioritized Strategies for Mitigating Undermanaged Risks

PRIORITY LEVEL 1 STRATEGY	PURPOSE(S)
Annually track, monitor, and identify **road segments** that have been in Poor condition for more than five years and consistently consider them when programming.	To provide additional information when prioritizing projects; to highlight roads that have been in Poor condition for an extended period of time; to help MnDOT improve level of service for customers statewide
Address the repairs needed on the existing South I-35W **deep stormwater tunnel** system.	To improve condition of South I-35W deep stormwater tunnel; to alleviate safety concerns and reduce overall percentage of deep stormwater tunnel system in Poor and Very Poor condition (thereby helping MnDOT meet targets)
Investigate the likelihood and impact of **deep stormwater tunnel** system failure.	To improve understanding of the likelihood for failure of the deep stormwater tunnel system (located entirely in MnDOT's Metro District) and the likely impacts of such an event; to aid planning and management of the system
Develop a thorough methodology for monitoring **highway culvert** performance.	To increase availability of information; to develop a systematic and objective methodology to monitor culverts; to manage culverts more effectively
Develop and adequately communicate construction specifications for **overhead sign structures** and **high-mast light tower structures**.	To prevent installation problems that lead to premature deterioration and reduced asset life; to ensure that MnDOT inspectors and vendors understand and adhere to requirements (e.g. torque thresholds)
Track **overhead sign structures** and **high-mast light tower structures** in a Transportation Asset Management System (TAMS).	To more deliberately and effectively manage these asset categories; to include more assets in TAMS, thereby improving cross-asset tradeoff decision-making
PRIORITY LEVEL 2 STRATEGY	**PURPOSE(S)**
Collect and evaluate performance data on ramps, auxiliary lanes, and frontage **road pavements** for the highway system in the Twin Cities Metro Area.	To determine current inspection procedure is sufficiently capturing needs; to more effectively manage non-mainline highway pavements
Augment investment in **bridge** maintenance modules and develop related measures and tools for reporting and analysis.	To develop performance models to predict changes in bridge performance over time; to more effectively manage bridges
Include **highway culverts** in TAMS.	To more deliberately and effectively manage highway culverts; to include more assets in TAMS, thereby improving cross-asset tradeoff decision-making
Place pressure transducers in **deep stormwater tunnels** with capacity issues.	To place pressure transducers in deep stormwater tunnels that will collect better capacity-specific data such as pressure impact by water volume
Incorporate the **deep stormwater tunnel** system into the bridge inventory.	To improve regularity of deep stormwater tunnel inspections by adding the tunnel system to the bridge inventory, with inspection frequency tied to reported condition
Develop a policy requiring a five-year inspection frequency for **overhead sign structures**, as well as related inspection training programs and forms.	To establish a formal inspection program for overhead sign structures, based on MnDOT's best knowledge of structure condition, deterioration rates, and inspection needs
PRIORITY LEVEL 3 STRATEGY	**PURPOSE(S)**
Repair or replace **highway culverts** in accordance with recommendations from the TAMS (once it is implemented).	To improve overall system quality and management; to meet newly established and vetted asset targets

Life-Cycle Cost Analysis

Asset management helps to minimize the total cost of managing transportation assets in part by focusing on all phases of an asset's life-cycle (see in **Figure ES-5**). When a new road is built, the state is committing not only to the initial construction costs, but also to the future costs of maintaining and operating that road. Over a long time period, future costs can be much greater than the initial cost. Therefore, it is important to manage facilities as cost-effectively as possible over their entire lives, and to be mindful of life-cycle costs when making decisions about an asset.

Figure ES-5: Phases in a Typical Asset Life-Cycle



The life-cycle analyses conducted as part of this TAMP involved comparing several different improvement strategies for each asset type in order to determine which of the strategies was most cost-effective over an extended period. Analysis periods of various lengths were used for different asset categories based on the desire to include one full reconstruct (replacement) cycle for each asset.

At least two improvement strategies were analyzed for each asset – a "typical" strategy, which considered the types of treatments normally performed by MnDOT, and a "worst-first" strategy, which assumed limited improvements and that each asset would be allowed to deteriorate to the point that it needed to be replaced. A third strategy, referred to as the "desired" strategy, was considered for pavements only (due to a lack of data for other assets) and followed the treatment intervals suggested as ideal in MnDOT's Pavement Design Manual.

The results of the analyses are presented in **Chapter 6** of this document; **Figure ES-6** displays the results for the pavement asset category. The first chart represents the total costs of each investment strategy over the analysis period (excluding the initial capital investment). As illustrated, the worst-first strategy is significantly more expensive than the typical or desired strategy, indicating that MnDOT's typical improvement strategies are relatively cost-effective. The second chart shows future MnDOT capital and maintenance commitments for each new asset constructed (again, excluding the initial investment). Thus, for every $1.00 initially invested in a new lane-mile of pavement, MnDOT will need to plan for between $1.11 and $2.87 in additional capital and maintenance costs over the remainder of the analysis period. The total life-cycle costs vary by the investment strategy (typical, desired, worst-first).

Figure ES-6: Pavement Life-Cycle Cost Results

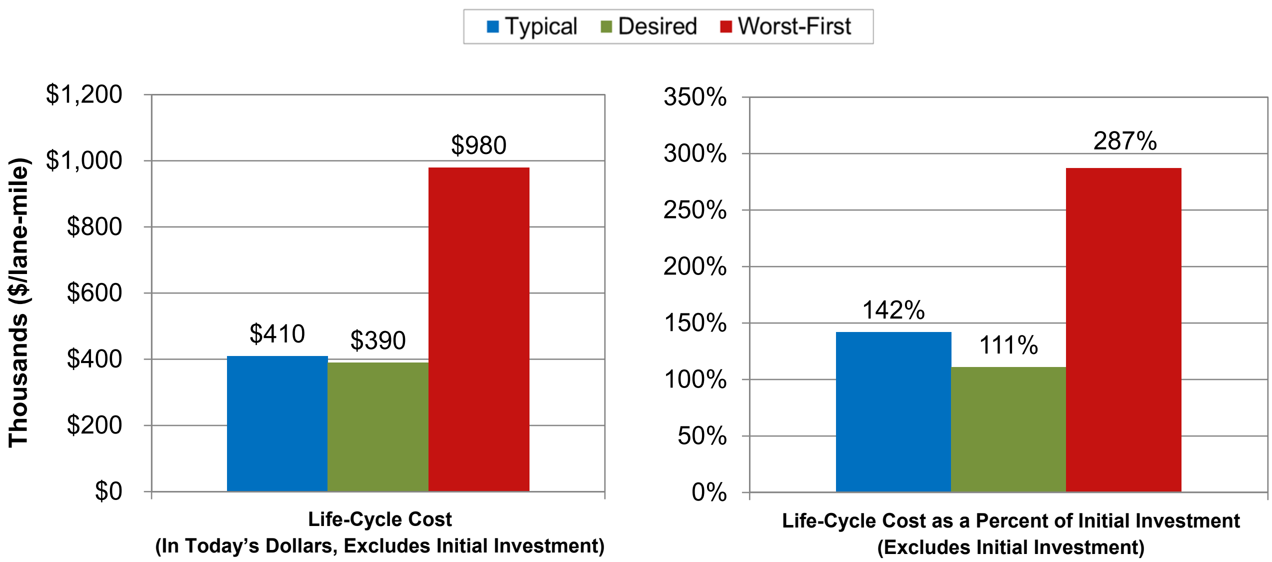


Figure ES-7 summarizes the annualized life-cycle costs for each of the asset categories included in the TAMP.

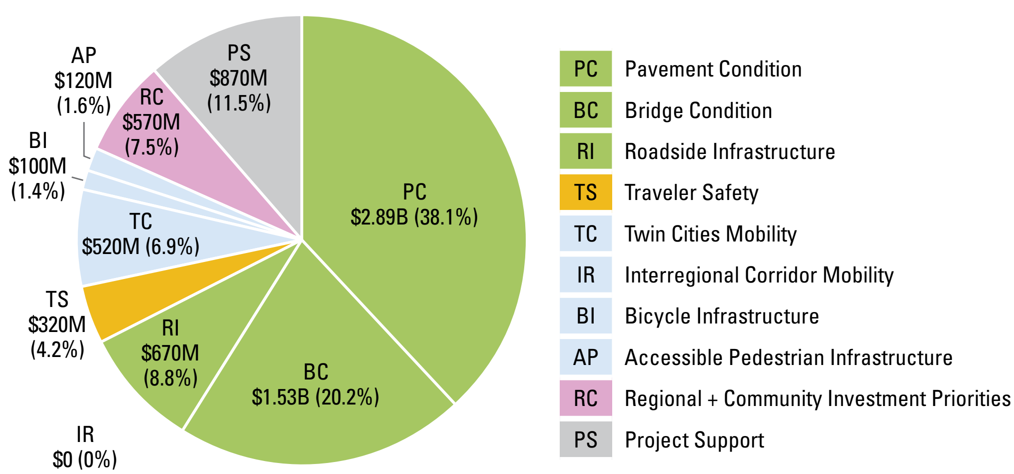
Figure ES-7: Asset Annualized Life-Cycle Costs

ASSET CLASS	ANNUALIZED COST
Pavements	$12,000 per lane-mile
Bridges: Large Bridges	$16,000 per bridge
Bridges: Culverts 10 feet or greater	$1,300 per large culvert
Hydraulic Infrastructure: Highway Culverts	$150 per small culvert
Hydraulic Infrastructure: Deep Stormwater Tunnels	$30,000 per mile of tunnel
Other Traffic Structures: Overhead Sign Structures	$900 per structure
Other Traffic Structures: High-Mast Light Tower Structures	$400 per structure

Financial Plan and Investment Strategies

When developing investment priorities, MnDOT accounts for various factors, including revenue trends, federal and state law, level-of-service provided by the system, and public input. Over the next 10 years, MnDOT's priorities – as described in it's 20-year State Highway Investment Plan (MnSHIP) and illustrated in **Figure ES-8** – will aim to balance investments that preserve existing infrastructure with investments in safety, multimodal transportation, and other projects that improve economic competitiveness and quality of life in Minnesota.

Figure ES-8: Capital Investments



Rather than replace the sound, publicly-vetted investment direction provided in MnSHIP, **Chapter 8** of the TAMP seeks to build upon and further refine the financial direction of that document. For instance, while MnSHIP groups many non-pavement and non-bridge assets together in a "Roadside Infrastructure" category (see **Figure ES-8**), the TAMP individually addresses and recommends targets for several of the constituent asset categories – highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures. These targets, and the investment levels needed to reach them, are included in **Figure ES-9**, along with the pavement and bridge targets and planned investments from MnSHIP.

Figure ES-9: Targets and Planned or Needed Investment to Achieve Targets

ASSET	CURRENT CONDITION	TARGET RECOMMENDATION	INVESTMENT*
Pavement: Interstate	2.4% Poor	≤ 2% Poor	$392 million
Pavement: Non-Interstate NHS	4.3% Poor	≤ 4% Poor	$1.13 billion
Pavement: Non-NHS	7.5% Poor	≤ 10% Poor	$1.38 billion
Pavement: Total	**NA**	**NA**	**$2.9 billion**
Bridge: NHS	4.7% Poor	≤ 2% Poor	$1.10 billion
Bridge: Non-NHS	2.1% Poor	≤ 8% Poor	$430 million
Bridge: Total	**NA**	**NA**	**$1.53 billion**
Hydraulic Infrastructure: Highway Culverts	10% Poor; 6% Very Poor	≤ 8% Poor; ≤ 3% Very Poor	$ 400 million
Hydraulic Infrastructure: Deep Stormwater Tunnels	39% Poor; 14% Very Poor	≤ 8% Poor; ≤ 3% Very Poor	$ 35 million (condition) + $1.6 million (inspection)
Other Traffic Structures: Overhead Sign Structures	6% Poor; 8% Very Poor	≤ 4% Poor; ≤ 2% Very Poor	$8 million
Other Traffic Structures: High-Mast Light Tower Structures	6% Poor; 15% Very Poor	TBD	TBD

*Pavement and bridge figures represent 10 year planned investment to meet targets; hydraulic Infrastructure and other traffic structures figures represent 10 year needed investment to meet targets.

Implementation and Future Developments

While meeting federal requirements is an important objective, MnDOT's primary reason for developing this TAMP is to improve the management of Minnesota's transportation assets, with special focus on risk and life-cycle costs. Success will be largely determined by the extent to which the principles and initiatives outlined in this document are incorporated, along with existing plans, into MnDOT's business practices.

To support this, MnDOT has established an Asset Management (governance) Steering Committee that is responsible for developing, updating, and monitoring the enhancements described in **Chapter 9** of the TAMP as well as other asset management planning initiatives. As a result of the TAMP process and other parallel asset management initiatives, several enhancements are currently underway. This includes collection of better maintenance data to improve life-cycle costs for assets included in this TAMP, initiation of a Transportation Asset Management System, programming of funds for rehabilitation of the I-35 south deep stormwater tunnel, and development of an Overhead Sign Structure inspection policy.

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Contents

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Chapter 1

INTRODUCTION

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INTRODUCTION

Overview

The 14,000-mile state highway system[1] constructed, operated, managed, and maintained by the Minnesota Department of Transportation (MnDOT) represents 74 percent of the State-owned capital assets. This transportation network is critical to Minnesota's economic competitiveness and quality of life, providing transportation connections that are necessary for thriving communities and successful businesses. It is imperative to maintain the performance and value of the state transportation assets to enable Minnesota to continue to provide safe and high-level service to its citizens.

Successful management of the state highway system relies on sound investment strategies that consider constituent input, legislative requirements, engineering needs, and fiscal constraints. Since the 1990s, MnDOT has used performance management tools to evaluate its services and to guide its plans, projects, and investment strategies.

Purpose

On July 6, 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law. It is the first long-term highway authorization enacted since 2005 to fund surface transportation programs. MAP-21 creates a streamlined, performance-based, and multimodal program to address the many challenges facing the nation's transportation system. These challenges include improving safety, maintaining infrastructure condition, reducing traffic congestion, improving efficiency of the system and freight movement, protecting the environment, and reducing delays in project delivery[2].

Under MAP-21, performance management transforms federal highway programs and provides a means to more efficient investment of federal transportation funds. It focuses on national transportation goals, increasing the accountability and transparency of the federal highway programs, and improving transportation investment decision making through performance-based planning and programming.

MAP-21 requires states to develop a risk-based asset management plan (i.e. TAMP) for the National Highway System (NHS) to improve or preserve the condition of the assets and the performance of the system. **Figure 1-1** summarizes the characteristics and benefits of a transportation asset management program[3]. The legislation focuses on the development

1 MnDOT's Office of Materials and Roads Research collects pavement condition data annually on 14,000 state highway system roadway miles. "Roadway miles" is equal to the total of undivided centerline miles of road in addition to two times the number of divided centerline roads.

2 http://www.fhwa.dot.gov/map21

3 Adapted from FHWA 2006, available online at: http://www.fhwa.dot.gov/infrastructure/asstmgmt/tpamb.cfm

of a TAMP for bridges and pavements on the NHS, but encourages states to include other infrastructure assets within the right-of-way corridor.

MnDOT elected to expand the TAMP beyond the MAP-21 requirements and include pavements and bridges on the entire state highway system as well as highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures (see **Figure 1-2**). Because MnDOT had already begun the implementation of asset management principles prior to MAP-21 legislation, it was in a better position to expand beyond the requirements of MAP-21.

Chapter 4: Asset Inventory and Condition includes folios that describe each asset category in greater detail.

The TAMP will serve as an accountability and communication tool and will inform established capital and operations planning efforts from this point forward. In addition to being a Federal requirement, the TAMP is a planning tool by which MnDOT can more thoroughly evaluate risks and develop mitigation strategies, analyze life-cycle costs, establish asset condition performance measures and targets, and develop investment strategies. It formalizes and documents the following key information, to meet MAP-21 federal requirements, into a single document:

- Description and condition of pavements and bridges on the NHS
- Asset management objectives and measures
- Summary of gaps between targeted and actual performance
- Life-cycle cost and risk management analysis
- Financial plan that addresses performance gaps
- Investment strategies and anticipated performance

Figure 1-1: Characteristics and Benefits of a Transportation Asset Management Program

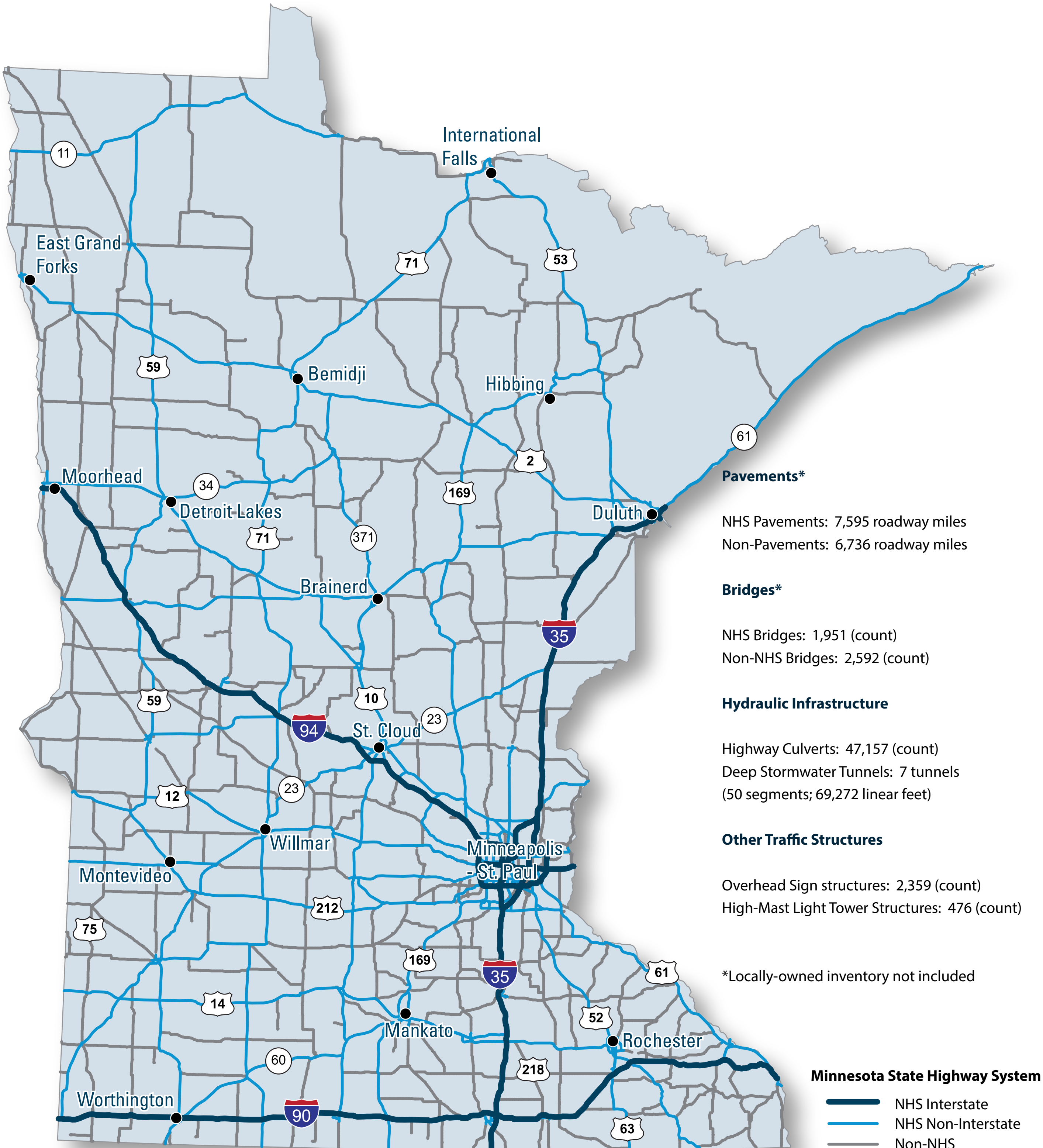
Characteristics of an Asset Management Program

- Track system condition, needs, and performance.
- Consider public expectations and desires when setting strategic objectives.
- Align agency investment decisions to achieve strategic goals.
- Use an objective process to maintain and manage assets; should consider needs, available funding, risks, operational constraints, and maintenance costs over the life of the assets.
- Determine the optimal time to improve assets based on performance data.

Benefits of Applying Transportation Asset Management Principles

- Optimize and improve transportation system performance.
- Improve customer satisfaction.
- Minimize life-cycle costs.
- Match level of service provided to public expectations.
- Make more informed, cost-effective program decisions and better utilize existing assets.
- Develop an unbiased methodology to balance trade-offs between competing objectives.

Figure 1-2: Minnesota's State Highway System



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Overhead Sign structures: 2,359 (count)
High-Mast Light Tower Structures: 476 (count)

*Locally-owned inventory not included

The Statewide Multimodal Transportation Plan objectives shape subsequent MnDOT plans and investments.

MnSHIP directs $5.1 billion to be spent on Asset Management over the next ten years.

Asset Management Planning at MnDOT

MnDOT's asset management policy is established and continually updated through statewide performance based planning initiatives. The Minnesota GO Vision, Statewide Multimodal Transportation Plan, State Highway Investment Plan (MnSHIP), and Highway System Operations Plan (HSOP) set policy objectives and performance based targets. The Annual Minnesota Transportation Performance Report documents system performance and informs future policy and investment planning.

MINNESOTA GO VISION AND STATEWIDE MULTIMODAL TRANSPORTATION PLAN

The Minnesota GO Vision and Statewide Multimodal Transportation Plan provide the policy framework used to shape subsequent MnDOT plans and investment decisions. Both documents stress the importance of asset management –strategically maintaining and operating transportation assets.

STATE HIGHWAY INVESTMENT PLAN

The State Highway Investment Plan (MnSHIP) is MnDOT's vehicle for determining and communicating capital investment priorities for the state highway system over a 20 year planning horizon. MnSHIP establishes asset condition targets for state highway pavement and bridge assets and sets funding levels for asset management at $5.1 billion (representing 68 percent of planned capital expenditures) over the first 10 years (2014-2023).

HIGHWAY SYSTEMS OPERATION PLAN

The Highway Systems Operation Plan (HSOP) provides a framework for managing key operations and maintenance activities throughout Minnesota. A key focus of HSOP is infrastructure asset management and being able to make decisions using total life-cycle costs by considering trade-offs in maintenance activities.

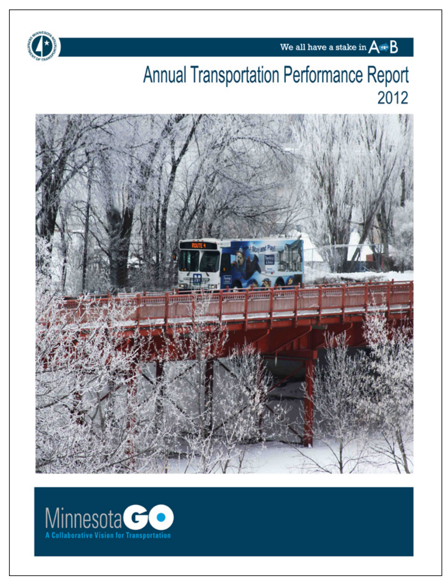
ANNUAL TRANSPORTATION PERFORMANCE REPORT

The (2012) Annual Transportation Performance Report describes trends in the condition and service levels for Minnesota's transportation systems. It summarizes the plans, investments, strategies and innovations MnDOT and its partners use to optimize performance, and tracks progress in 10 performance areas, asset management being one.

The report indicates:

"MnDOT expects pavement preservation needs to grow faster than available resources. Anticipating this scenario, MnSHIP directs MnDOT to focus pavement investment on the NHS with the objective of maintaining existing ride quality through 2023. Doing this also means the percentage of non-NHS highways with Poor ride quality will grow from 7.5 percent in 2012 to 12 percent in 2023. Minnesota's bridges will remain safe. Under current projections, by 2033 the share of NHS deck area in Poor condition will rise to between six and eight percent."

HSOP documents the management of non-capital highway investments for the next four years.



The Annual Performance Report indicates the percentage of non-NHS highways with Poor ride quality will grow from 7.5 percent in 2012 to 12 percent in 2023.

Process

This Transportation Asset Management Plan is the product of a 12 month process that involved a Steering Committee, Project Management Team, and four technical Work Groups.

The **Steering Committee** provided direction and oversight during TAMP development, and included broad representation across the agency and from Minnesota's Federal Highway Administration (FHWA) Division office. Steering Committee representation included:

- FHWA Division Office

- Minnesota Department of Transportation
- Bridge
- Data & Analysis
- Districts
- Executive Management
- Finance
- Investment Planning
- Maintenance & Operations
- Materials (Pavement)
- Performance Measures
- Policy Planning
- Risk
- Traffic, Safety, and Technology
- Transportation Systems Management

The **Project Management Team (PMT)**, a sub-set of the Steering Committee, was responsible for day-to-day work activities.

Work Groups were developed for each broad asset category: pavement, bridge, hydraulics, and other traffic structures. Each was comprised of subject matter technical experts and had a group lead or main contact. Highway culverts and deep stormwater tunnels were discussed together with the Hydraulic Work Group, while overhead sign structures and high-mast light tower structures were discussed together by the Other Traffic Structures Work Group. Work Groups were invaluable with efforts to document current practices, determine data availability, assess risks and propose mitigation strategies, and identify targets and investment strategies.

TAMP Themes

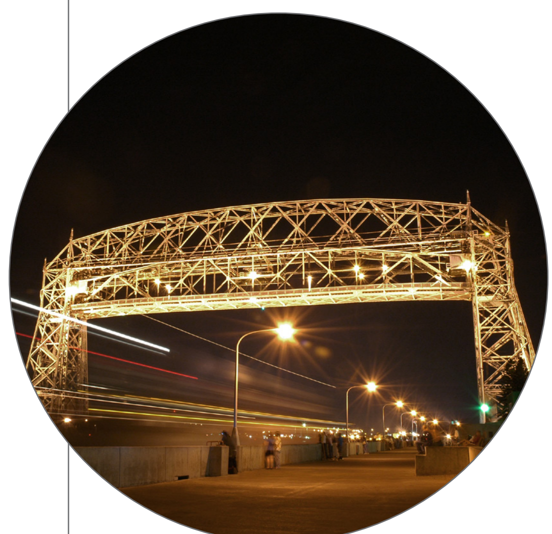
Four themes emerged during development of the TAMP that influenced recommendations, refined investment strategies, and identified enhancements.

- **Improve the consideration of maintenance costs in capital investment decisions.** In most transportation agencies, long-term maintenance costs associated with capital improvements are not fully considered when making investment decisions. While developing the TAMP, steps were taken to improve the consideration of maintenance costs when evaluating capital investments.

- **Reduce business and asset-specific risks.** A number of business process changes were identified to reduce agency risk. Several of these changes have already been implemented are currently being implemented. For example, MnDOT is in the process of developing a Transportation Asset Management System (TAMS) that will allow MnDOT to better manage roadside infrastructure data: location; work activity history; equipment; materials; and staffing needs. Asset-specific undermanaged risks and mitigation strategies were also identified and incorporated in the TAMP.

- **Build on existing plans, information, and processes.** MnDOT has a history with and commitment to risk based and performance based planning. (e.g., MnSHIP, HSOP, etc.). The intent of the TAMP is to build upon and enhance but not supplant established planning processes.

- **Identify and address gaps in data and business processes.** MnDOT elected to expand the use of asset management principles to a broader collection of assets beyond pavements and bridges, even though limited information was available for these assets. As a result, MnDOT has a better understanding of the information needed to more effectively manage these assets and has taken steps to obtain this information in support of both ongoing asset management and future capital and operational planning efforts.



TAMP Content

The TAMP is presented in nine chapters.

- **Chapter 1: Introduction** – This chapter provides an overview of current asset management policy and investment plans, purpose for developing a TAMP, general process during development, and information contained in each chapter.

- **Chapter 2: Asset Management Planning and Programming Framework** – This chapter summarizes the connection of existing asset management direction, policy, and programming at MnDOT to the TAMP.

- **Chapter 3: Asset Management Performance Measures and Targets** – This chapter summarizes MnDOT's existing (pre-TAMP) performance measures and MnSHIP targets for pavement and bridge, and the new (TAMP) target terminology that will replaced existing MnSHIP target definitions.
- **Chapter 4: Asset Inventory and Condition** – This chapter summarizes information about all six asset categories analyzed in this TAMP, and includes data on inventory, condition, and replacement value.
- **Chapter 5: Risk Management Analysis** – This chapter provides an overview of risk and why it's important, a summary of MnDOT's current risk structure, and risks associated with undermanaging transportation assets and strategies to mitigate these risks.
- **Chapter 6: Life-Cycle Cost Considerations** – This chapter describes life-cycle cost analysis and highlights strategies for managing assets. It includes a cost-effectiveness comparison of MnDOT's current (or typical) approach vs. other approaches (i.e. desired or worst-first) to managing each asset.
- **Chapter 7: Performance Gaps** – This chapter highlights existing performance measures and targets identified in MnSHIP, MnDOT's new direction for targets and agency commitments, and new TAMP target recommendations for consideration during development of the next MnSHIP.
- **Chapter 8: Financial Plan and Investment Strategies** – This chapter presents a financial outlook based on recent trends and assumptions, summarizes capital and maintenance investments for the next 10 years, and describes how different capital investment scenarios considered risk. It also outlines the committed revenue and revenue needs to meet expected performance outcomes over the next 10 years.
- **Chapter 9: Implementation and Future Developments** – This chapter summarizes the important actions or desired takeaways identified during the development of this TAMP. Governance of the TAMP is also important, and this chapter identifies implementation steps to continually make progress toward better asset management. It also presents recommendations for future updates to the TAMP.

In addition to the TAMP, a **Technical Guide** was prepared and published separately. The **Technical Guide** includes additional information on each chapter of the TAMP. It frames information around "process" and "supporting data and documentation," and includes additional technical information to supplement the TAMP.

Chapter 2

ASSET MANAGEMENT PLANNING AND PROGRAMMING FRAMEWORK

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ASSET MANAGEMENT OBJECTIVES

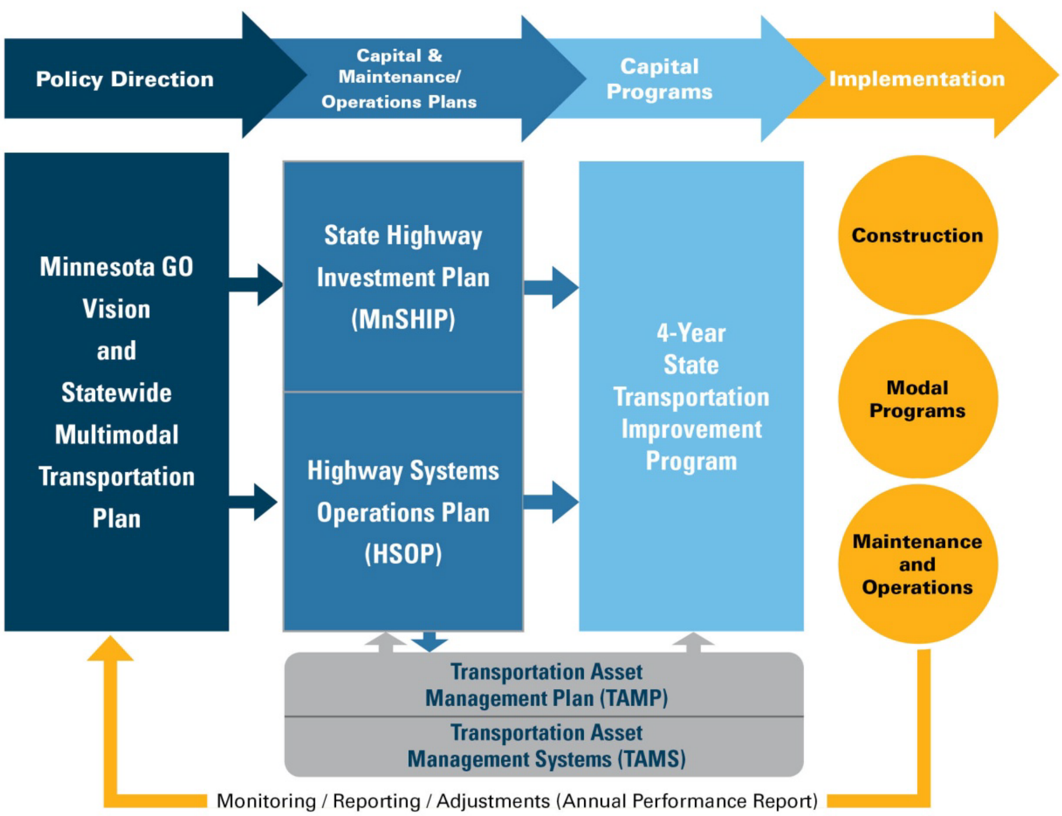
Overview

MnDOT has strong business processes currently in place to prioritize asset management investments in Minnesota's transportation infrastructure. Asset management is understood at MnDOT as the effective use of available resources to make the right investment decisions and minimize asset life-cycle costs, while considering the various tradeoffs involved in decision-making processes. This is in line with the definition of asset management outlined in MAP-21:

Asset management is a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life-cycle of the assets at minimum practicable cost.

A simplified schematic of the investment process, showing the link between the existing agency plans and the TAMP, is represented in **Figure 2-1**.

Figure 2-1: MnDOT Asset Management Planning Process



MnDOT's priorities and objectives are reflected in its investment plans, which include the 20-year State Highway Investment Plan (MnSHIP) for capital improvements and the 4-year Highway System Operations Plan (HSOP) for maintenance and operations investments. MnSHIP and HSOP are a part of the coordinated, ongoing planning and outreach process that connects policy direction – laid out in Minnesota's 50-year Statewide Vision (the "Minnesota GO Vision") and 20-year Statewide Multimodal Transportation Plan (SMTP) – to improvements made on the state highway system.

These plans document the investment strategies and expected outcomes for pavements and bridges that have been incorporated into this TAMP, as well as for other investments beyond the TAMP's scope. Future MnDOT TAMPs (see gray box in **Figure 2-1**) will serve as supporting documents that influence updates of MnSHIP and HSOP, objectives related to asset preservation, and system safety and reliability measures. The TAMP does not replace any existing MnDOT plan; rather, it provides critical input to existing plans, linking capital and maintenance expenditures related to asset preservation.

Existing Asset Management Policy

MINNESOTA GO VISION

MnDOT's long-term (50-year) vision is to provide a sustainable multimodal transportation system that improves the quality of life, environmental health, and overall economic competitiveness of Minnesota. As outlined in the Minnesota GO Vision, the role of the transportation system is to:

- Connect 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 the country.
- Provide a safe, convenient, efficient, and effective movement of people and goods.
- Provide a flexible system to adapt to changes in society, technology, environment, and the economy.

The Minnesota GO Vision guiding principles, which direct MnDOT's policy and investment decisions related to transportation assets, are summarized in **Figure 2-2**.

Figure 2-2: Guiding Principles for MnDOT's Policy and Investment Decisions

LEVERAGE PUBLIC INVESTMENTS TO ACHIEVE MULTIPLE PURPOSES	• Provide a transportation system to support other public purposes such as environmental stewardship, economic competitiveness, public health, and energy.
ENSURE ACCESSIBILITY	• Provide a safe system for user of all abilities and incomes. • Provide access to key resources and amenities.
BUILD TO A MAINTAINABLE SCALE	• Consider and minimize long-term obligations. • Affordably contribute to overall quality of life and prosperity of the state.
ENSURE REGIONAL CONNECTIONS	• Connect key regional centers through multiple modes of transportation.
INTEGRATE SAFETY	• Improve safety through systematic and holistic methods that take into account proactive, innovative and strategic considerations.
EMPHASIZE RELIABLE AND PREDICTABLE OPTIONS	• Prioritize multimodal options over reliance on a single option.
STRATEGICALLY FIX THE SYSTEM	• Strategically maintain and upgrade critical existing infrastructure.
USE PARTNERSHIPS	• Coordinate across sectors and jurisdictions to improve efficiency of transportation projects and services.

STATEWIDE MULTIMODAL TRANSPORTATION PLAN

MnDOT's Statewide Multimodal Transportation Plan (SMTP), adopted in 2012, identifies objectives and strategies to help achieve the Minnesota GO Vision. The plan emphasizes multimodal solutions that ensure high return-on-investment. The SMTP objectives, summarized in **Figure 2-3**, include Asset Management as one of six key focus areas, stressing the importance of data in strategically operating and maintaining the transportation system.

Figure 2-3: MnDOT's Statewide Multimodal Transportation Plan Objectives

ACCOUNTABILITY, TRANSPARENCY, AND COMMUNICATION
• Have a data-driven decision process. • Support coordination, collaboration, and innovation. • Ensure efficient and effective use of resources.
TRAVELLER SAFETY
• Safeguard travelers, transportation facilities, and services. • Use proven strategies to reduce fatalities and serious injuries in all modes of travel.
TRANSPORTATION IN CONTEXT
• Make fiscally responsible decisions that respect the context of place. • Integrate land use and transportation systems.

CRITICAL CONNECTIONS
• Identify, maintain, and improve essential transportation connections while considering new connections.
ASSET MANAGEMENT
• Maintain and operate transportation assets strategically.
• Use system data and consider needs of MnDOT's partners and public expectations to inform decisions.
SYSTEM SECURITY
• Reduce vulnerability and ensure redundancy to meet travel needs during emergencies.

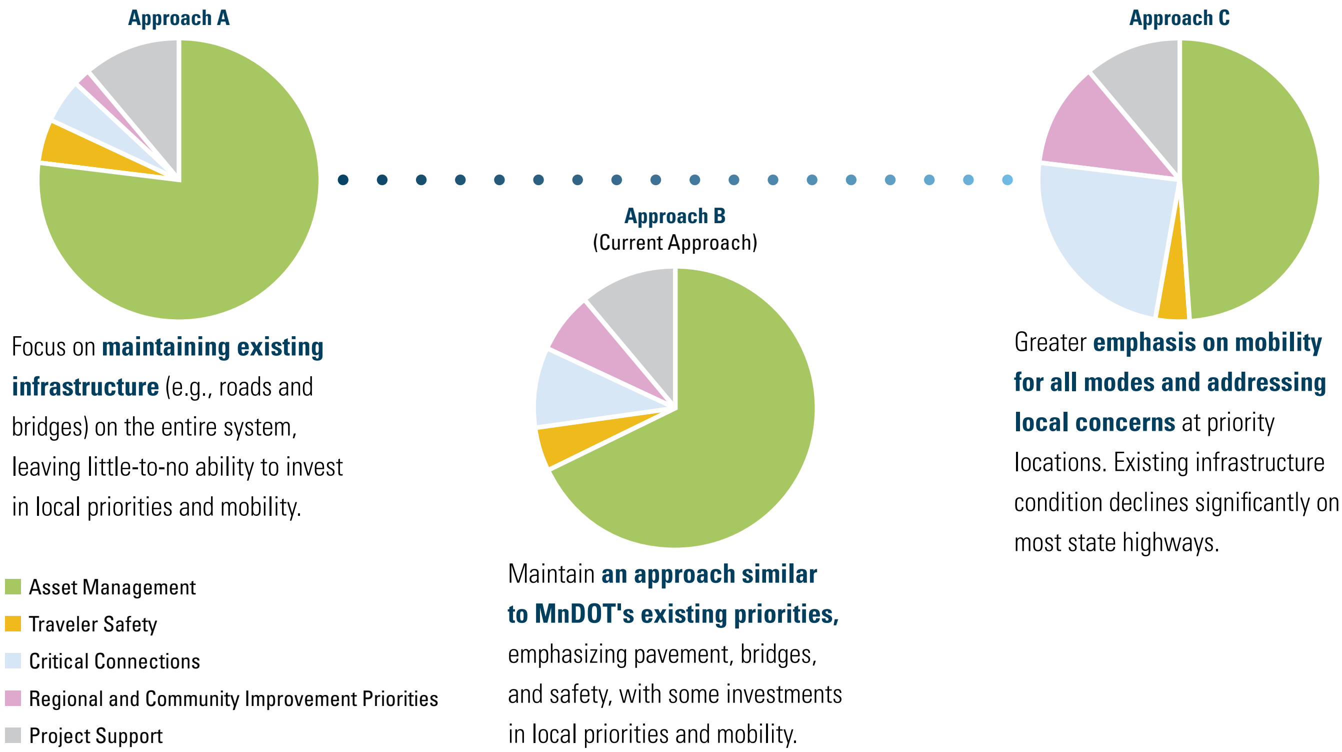
STATE HIGHWAY INVESTMENT PLAN

MnDOT documents its capital investment strategies to address all six of the above SMTP objectives in the State Highway Investment Plan (MnSHIP), which is a 20-year fiscally constrained plan. MnSHIP analyzes and tracks the impact of recent capital investments, identifies capital needs, establishes statewide priorities for projected revenue, and identifies strategies that ensure that MnDOT resources are used efficiently and effectively. The 2013 plan predicts revenues for the next 20 years to total $18 billion, although the projected needs on the transportation system total $30 billion. This $12 billion funding gap is projected to result in an increase in both the number of roads and bridges in Poor condition and the number of unfunded priorities over the 20-year planning horizon.

The growing disparity between available resources and the investments needed to maintain the transportation infrastructure system at a desired level of service has been the guiding focus for the major themes identified during the development of the TAMP (discussed in **Chapter 1**). These themes include emphasis on maintenance and preservation of existing transportation assets and enhancing current business processes to improve management of transportation assets.

The use of a risk-based approach to inform investment and project decisions is not a new concept for MnDOT. During the MnSHIP development process, tradeoffs between investment levels, performance levels, and risks were evaluated to improve understanding of the impact of investment decisions through a more holistic approach. **Figure 2-4** summarizes three approaches developed during the MnSHIP scenario planning process.

Figure 2-4: Investment Approaches Developed for Scenario Planning



The primary intent of comparing the three approaches discussed above was to demonstrate a range of possible objectives that MnDOT could pursue over the next two decades, as well as to evaluate the tradeoffs in performance and risk management within each approach. External and internal outreach efforts were conducted to gather input on the investment approaches. Two primary risks were identified through the outreach process:

- Failure to implement federal policy set in MAP-21
- Failure to preserve the state's bond rating by falling below the thresholds set in Government Accounting Standards Board Statement 34 (GASB 34)

These risks were used as the guiding focus in the development of the final MnSHIP investment strategies discussed in **Chapter 8: Financial Plan and Investment Strategies**. For the first 10 years, the adopted investment strategy emphasizes maintaining a diverse mix of improvements to reduce overall life-cycle costs, as well as enhancing mobility and MnDOT's ability to respond to evolving needs.

MNSHIP CAPITAL INVESTMENT PRIORITIES

For the 10-year period addressed in this TAMP, MnDOT will balance its investments in infrastructure preservation with new multimodal transportation connections and other projects that advance economic development and quality of life in Minnesota. These latter projects, which are funded via non-preservation investment categories (e.g. regional and community improvement priorities, accessible pedestrian infrastructure, bicycle infrastructure, traveler safety), reflect stakeholder input. They adequately manage key capital investment risks and honor current programming commitments.

The infrastructure preservation investments documented in this TAMP are targeted to optimize investments in asset management (considering fiscal constraints) while making progress toward established goals and objectives. **Figure 2-5** summarizes the specific strategies that MnDOT adopted as a part of the MnSHIP development process to better manage performance in various capital program areas over the next 10 years. The TAMP focuses specifically on the strategies within the Asset Management category.

Figure 2.5: Capital Strategies for More Efficient Asset Investments

INVESTMENT CATEGORY	10-YEAR STRATEGY
Asset Management - Pavements	• Maintain conditions on NHS pavements. • Allow non-NHS pavements to deteriorate to a slightly lower condition, while maintaining safe conditions for the traveling public. • Use low-cost maintenance and preservation strategies. • Use performance-based design to select projects that address pavement and safety needs. • Alternate bidding and contracting mechanisms to determine the most cost-effective solutions. • Research/evaluate innovative materials and construction techniques.
Asset Management - Bridges	• Maintain condition of NHS bridges. • Allow non-NHS bridges to deteriorate to a slightly lower condition, while keeping them safe and operable to the traveling public. • Invest in state highway bridges at optimum points in their life- cycles to ensure safety and structural health. • Conduct bridge inspections to ensure timely application of maintenance and capital improvements. • Apply appropriate measures to ensure bridges achieve or exceed their intended service lives.

INVESTMENT CATEGORY	10-YEAR STRATEGY
Asset Management - Roadside Infrastructure	• Maintain culverts, signals, sign structures, sign panels, lighting structures, rest areas, barriers, and retaining walls in safe operable conditions with the understanding that their general conditions are expected to deteriorate with current expected funding levels.
Traveler Safety	• Lower annual fatalities and continue to partner in the Toward Zero Deaths (TZD) initiative. • Invest in low-cost high-benefit treatments (for example, using guardrails along sharp curves). • Track and address locations with a history of crashes.
Critical Connections - Twin Cities Mobility	• Focus on active traffic management, strategic capacity improvements, and high-occupancy vehicle (MnPASS) lanes.
Critical Connections - Interregional Corridor Mobility	• Maintain the interregional corridor system mobility performance target.
Critical Connections - Bicycle Infrastructure	• Use bridge and pavement projects to accommodate bicyclists as appropriate. • Focus on stand-alone projects at high priority locations.
Critical Connections - Accessible Pedestrian Infrastructure	• Accommodate pedestrian accessibility concurrent with pavement and bridge projects. • Ensure that a majority of curb ramps and signalized intersections are maintained to ADA standards.
Regional and Community Improvement Priorities	• Address economic vitality and quality of life through partnerships, design add-ons, and a few stand-alone projects each year.
Project Support	• Make investments to support the delivery of projects in other categories.
Small Programs	• Ensure system resiliency to respond to unforeseen issues, one-time needs, or changes in policy/funding.

HIGHWAY SYSTEM OPERATIONS PLAN

HSOP provides a framework for managing key operations and maintenance activities throughout Minnesota and complements other strategic planning efforts, such as MnDOT's District Highway Investment Plans, which focus on capital infrastructure needs. In addition, HSOP builds on prior efforts for performance-based planning and data-driven decision making. The primary objective of the plan is to document the management of non-capital highway investments over the next four years.

HSOP themes that serve as a framework for operations and maintenance activities include:

- **Safety** – Systematically and holistically improve safety.
- **Good Stewards of the Environment** – The transportation system should support other public purposes, such as environmental stewardship, sustainable solutions, economic competitiveness, public health, and energy independence.

- **Seek Innovation** – Be proactive, innovative, strategic, and more efficient in operations and maintenance activities.
- **Infrastructure Asset Management** – Strategically maintain and upgrade critical existing infrastructure. Create a knowledge base to make decisions using life-cycle costs in the future. Identify inventory degradation and tradeoffs for maintenance activities.
- **Understanding System and Cost Trends** – Consider and minimize long-term obligations; do not overbuild. Use a life-cycle approach to focus on building only what MnDOT can sustain with regard to operations and maintenance. The scale of the system should reflect and respect the surrounding physical and social context.

The plan provides background information on factors influencing overall operations and maintenance activities, summarizes each work activity area, and identifies key implementation strategies to improve performance. It also identifies risk and investment strategies as part of a budget summary and gap analysis and provides findings and recommendations.

As part of this HSOP, a more formal Enterprise Risk Management (ERM) approach was used to help determine funding gaps and areas where additional funding could be directed if it became available. ERM involves identifying particular events or circumstances relevant to MnDOT's objectives (risks and opportunities), assessing them in terms of likelihood and magnitude of impact, determining a response strategy, and assessing the effectiveness of the response strategy in reducing overall risks.

HSOP OPERATIONS AND MAINTENANCE INVESTMENT PRIORITIES

HSOP identifies current operations and maintenance revenues for the next four years (2012-2015) of approximately $860 million, with a need of approximately $1.25 billion over this same timeframe. This results in a gap of approximately $390 million (or almost $410 million if inflation is included). As part of the ERM process, a flat budget was assumed for the next four years. Given this assumption and the impacts of inflation, business-as-usual will not manage operational risks to the extent needed. **Figure 2-6** summarizes specific findings and recommendations (i.e. strategies) adopted by MnDOT (as part of the HSOP development process) to better manage operations and maintenance performance.

Figure 2-6: Maintenance/Operations Findings and Recommendations for More Efficient Asset Management

FINDING	RECOMMENDATION (STRATEGY)
Aging Assets: As the state's infrastructure continues to age, much of it is either nearing or is beyond its useful life, thus creating significant operations and maintenance challenges.	Continue to place emphasis on preserving assets that are critical to the safety, mobility, and functionality of the transportation system.
Increasing Costs: Maintaining the current system is a very labor- and equipment-intensive task.	Research and develop new techniques, strategies, and processes to minimize costs and remain current with industry standards.
Growing Number of Assets: Increases in transportation system assets (e.g. complex interchange designs, traffic control devices) result in greater needs for operations and maintenance funds.	Continue to explore opportunities to provide low-cost, high-benefit improvements, but recognize that many of these elements place additional burdens on operations and maintenance forces, and consider the total project cost, not just the initial capital cost for construction.
Impacts of Capital Budget / Total Project Cost: Greater investment in the capital budget typically results in a reduced need for operations and maintenance, whereas reduced capital investment typically results in greater need for operations and maintenance.	Approach cost estimation on a "total project cost" basis in order to address cost management from conception to completion. This would consider the operating and maintenance costs associated with the project.
Mandates: Increased responsibilities and additional costs often accompany mandates, which require MnDOT to provide additional or new services that typically have not been accounted for in the past.	Actively communicate the costs and impacts associated with new mandates in order to try to avoid resource redirection or shortfalls in other areas.
Decreasing Staff Levels: A number of work activity areas are not able to address all of their required tasks with their current staff levels. Alternately, there are inefficiencies created due to a lack of staffing.	Continually evaluate staffing needs and identify opportunities to train staff in various work activities for organizational efficiency.
Use of Technology / Innovation: MnDOT work activities regularly use technology and innovative strategies to increase efficiencies and are involved with a number of research partnerships and activities.	Continue to seek and support technological enhancements that help the agency better track inventories and asset condition (e.g., traffic signals, fleet, sign management).
Preventive Maintenance: A preventive maintenance program can reduce overall operations and maintenance costs by regularly providing service and avoiding larger maintenance or capital costs.	Focus on preventive maintenance activities that will prolong service life and help avoid significant capital investments until the product has fulfilled its useful service life. Continue to evaluate preventive maintenance activities with less clear benefits.

Collectively, the Minnesota GO Vision, SMTP, MnSHIP, and HSOP documents establish MnDOT's direction and identify the strategic priorities that are considered in planning Minnesota's transportation future.

Existing Asset Management Programming Framework

Once investment levels are established, projects are selected to help achieve the targeted performance expectations established by MnDOT. The agency has several tools available to help determine the best use of available funding for asset management activities. For instance, MnDOT manages pavement condition data through its Highway Pavement Management Application (HPMA) software. MnDOT uses HPMA to develop funding scenarios based on pavement treatment decision trees and performance prediction models to optimize the combination of preservation and rehabilitation activities and achieve the best conditions possible.

For bridges, MnDOT has chosen to integrate commercial bridge management software (Pontis) with the agency's home-grown Bridge Replacement and Improvement Management (BRIM) system. Pontis is currently being upgraded to include models that will allow MnDOT to predict future bridge conditions. The BRIM system allows MnDOT to prioritize bridge investments based on risk and importance factors. It generates a bridge planning index score for each bridge in the state. Each bridge's score is based on risk factors (e.g. fracture criticality, substandard vertical clearance) and importance factors (e.g. bridge length, traffic volume).

Finally, MnDOT has a maintenance management program for tracking maintenance and operations activities. This system is also scheduled for enhancements in the next several years.

Programmed projects are based on recommendations from the management systems and input from MnDOT district personnel. The projects are part of the Statewide Transportation Improvement Program (STIP), which details federal and state funding allocations to state and local projects. Annual work plans for needed maintenance and operations activities are then derived from the STIP.

MnDOT is also in the process of implementing management systems for asset categories beyond pavements and bridges. These systems, collectively referred to as Transportation Asset Management Systems (TAMS), will allow MnDOT to better manage roadside infrastructure through a more objective, data-driven approach. The first TAMS implementation will focus on traffic signals and lighting.

Chapter 3

ASSET MANAGEMENT PERFORMANCE MEASURES AND TARGETS

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ASSET MANAGEMENT PERFORMANCE MEASURES AND TARGETS

Overview

MnDOT has used a performance-based approach to managing its transportation assets since the mid-1990s and made it a formal part of its business process in 2003. The ongoing measurement and review process allows MnDOT to evaluate the efficiency of service delivery and to assess the effectiveness of program activities. This objective-based approach increases transparency and encourages innovation by keeping the focus on outcomes.

Existing Performance Measures and Targets

MnDOT's performance-based approach to asset management relies on **performance measures** to assess system performance, identify needs, and develop investment priorities. Historically, these measures have included state highway ride quality and bridge condition. Additional performance measures, tracking things like culvert and stormwater tunnel condition, have been monitored and used internally for managing asset-specific programs; however, they have not been used at the system level for establishing budget requirements. **Figure 3-1** lists MnDOT's performance measures as of the 2013 adoption of the State Highway Investment Plan (MnSHIP), by asset category. Short descriptions of each measure's rating scale and criteria are also included, along with MnSHIP targets, where applicable. Targets are the subject of the final two sections of this chapter. Visual representations of the performance rating scales can be found in **Figure 4-5**, **Figure 4-6**, **Figure 4-7**, and **Figure 4-8** in the next chapter.

As part of its pavement and bridge management activities, MnDOT regularly conducts condition surveys in order to identify deficiencies in need of addressing. For pavements, MnDOT uses a specialized van that collects data regarding the amount of cracking present and the smoothness of the ride. This information is used to determine a Surface Condition Rating and a Ride Quality Index, the latter of which defines whether a road is in Good, Fair, or Poor condition. A Pavement Quality Index, which combines surface condition and ride quality ratings, is also calculated for reporting statewide conditions and to determine if other agency performance requirements are met (see discussion of GASB 34, below). Information regarding pavement condition on the National Highway System (NHS) is reported to the Federal Highway Administration (FHWA) each year.

Most bridges are inspected on two-year intervals; results are reported to the FHWA. Bridge inspections assess the condition of the decks, superstructures, substructures, and culverts using a standardized, national survey procedure. Inspection results are used to determine which bridges are in Good, Satisfactory, Fair, or Poor structural condition. Bridges in Good, Satisfactory or Fair condition generally require only maintenance or preservation activities, while bridges in Poor condition may require major capital investments.

Inspections of other assets are typically performed less frequently. For highway culverts, a MnDOT-developed statewide geographic information application – known as HydInfra – is used to manage the inventory, as well as inspections and maintenance activities. During inspections, a condition rating is assigned to each culvert. The ratings range from 1 to 4, with 1 representing a feature in Like New condition and 4 representing a feature in Very Poor condition with serious deterioration. In addition to reporting the feature condition, the HydInfra rating is used to set the inspection frequency. For instance, pipes with an overall rating of 4 (Very Poor) may be inspected annually or every two years, while a pipe with a rating of 1 or 2 (Like New or Fair) may be inspected as infrequently as once every six years. Deep stormwater tunnel inspection and reporting protocols are currently being updated to align with those of highway culverts.

Overhead sign structures were recently inspected by an independent consultant hired by MnDOT. Efforts are underway to develop a standardized inspection procedure for overhead sign structures. An inspection process for high-mast light tower structures was developed in 2001 and recently updated.

Figure 3-1: Performance Measures by Asset Type

ASSET TYPE	PERFORMANCE MEASURE	EXPLANATION	TARGET
Pavements	Share of system lane miles with Poor ride quality	Ride quality is assessed using MnDOT's Ride Quality Index, which is a measure of pavement smoothness as perceived by the typical driver. Pavement rated Poor can still be driven on, but the ride is sufficiently rough that most people would find it uncomfortable and may decrease their speed.	≤ 2% (NHS) ≤ 3% (Non-NHS)
Bridges	NHS bridges in Poor condition as a percent of total NHS bridge deck area	Bridge condition is calculated from the results of inspections on all state highway bridges. The ratings combine deck, superstructure, and substructure evaluations. Bridges rated Poor are safe to drive on but are reaching a point where it is necessary to either replace the bridge or extend its service life through significant investment.	≤ 2% (NHS) ≤ 8% (Non-NHS)
Highway Culverts	Share of culverts in Poor or Very Poor condition	Highway culvert condition is assigned during inspections. Culverts in Poor condition display cracks or joint separation, while those in Very Poor condition exhibit holes and more significant joint separation resulting in a loss of surrounding (road bed) material.	NA

ASSET TYPE	PERFORMANCE MEASURE	EXPLANATION	TARGET
Deep Stormwater Tunnels	Tunnels in Poor and Very Poor condition, measured as a percent of total tunnel system length	Deep stormwater tunnel condition is assigned during inspections. Inspections identify and measure cracks, fractures, and voids behind the tunnel liners. Tunnels in Poor condition have significant cracks and voids behind the unreinforced tunnel liner. Tunnels in Very Poor condition display defects that require timely corrective action.	NA
Overhead Sign Structures	Share of overhead sign structures in Poor or Very Poor condition	Overhead sign structure condition is assigned during inspections. Poor and Very Poor condition is dependent on a number of criteria, including the number of untightened nuts per structure or the need to remove grout, re-grade footing, replace welds, or replace the foundation.	NA
High-Mast Light Tower Structures	Share of High-Mast Light Tower Structures in Poor or Very Poor condition	High-mast light tower structures are not currently assigned an overall condition rating; rather each individual element (e.g. foundation, anchor rods, base plate, towers, power/luminaires, winch/cables) is given a condition rating. As a result, MnDOT is in the process of redefining the criteria and rating protocols to be able to assign an overall structure condition rating. For the purposes of this TAMP, asset experts used engineering judgment to assign overall condition ratings based on individual element conditions (identified in **Chapter 4**).	NA

Notes: MnDOT uses multiple measures to evaluate the effectiveness of its pavement and bridge management activities. The measures listed here are those used to calculate MnDOT's performance-based investment needs. For a more comprehensive listing of MnDOT's pavement performance measures, see the *2013 Pavement Condition Annual Report*. Additional bridge measures can be found in MnDOT's *Annual Transportation Performance Report*.

The targets in the figure above represent desired outcomes. MnDOT sets targets based on assessments of traveler expectations and the agency's stewardship responsibilities. As a communication tool, targets allow MnDOT to contrast current and anticipated performance with outcomes representing the achievement of strategic goals. These targets, which MnSHIP refers to as "aspirational", also serve as the basis for MnDOT's unconstrained investment need. Of the $30 billion 20-year need reported in MnSHIP, $16 billion (53 percent) reflects the cost to meet MnDOT's ride quality and bridge condition targets.

TARGETS REPORTED IN MNSHIP

In 2012 MnDOT began to develop the concept of constrained targets to help manage system performance within the confines of available resources. The first constrained target MnDOT established directed the agency to maintain the share of all state highways with Poor ride quality between five and nine percent. While less than desirable, this range represents an achievable level of service that MnDOT believes is acceptable to the public and sufficient to mitigate risks associated with asset deterioration. The concept of constrained targets was carried forward into MnSHIP, where it was used to respond to federal and state performance requirements.

When MAP-21 was signed into law in 2012, it streamlined the federal highway program through a restructuring that directs the majority of funding to the NHS. It also required states to demonstrate progress toward seven national goal areas using a limited number of national performance measures. The US Department of Transportation is developing performance measures relating to fatalities, serious injuries, asset condition, system reliability, congestion reduction, on-road mobile source emissions, and freight movement. In terms of asset condition, MAP-21 specifies that national performance measures cover pavement condition on the Interstate System, pavement condition on the NHS (excluding Interstate highways), and NHS bridge condition.

At the state level, Minnesota has adopted the Government Accounting Standards Board Statement Number 34 (GASB 34) financial reporting requirements for establishing the value of its major infrastructure assets. As part of this process, MnDOT set minimum performance thresholds for the condition of state highway pavement and bridges. MnDOT must maintain pavement and bridge assets at or above GASB 34 thresholds to avoid a potential downgrade of the state's bond rating. The thresholds are presented below.

- Pavements
- Average PQI of 3.0 or higher on NHS routes (MnDOT estimates that an NHS with an average PQI of 3.0 or higher is likely to have Poor ride quality on no more than 10 percent of its roadways miles.)
- Average PQI of 2.8 or higher on non-NHS routes (MnDOT estimates that a non-NHS with an average PQI of 2.8 or higher is likely to have Poor ride quality on no more than 13 percent of its roadways miles.)

- Bridges
- At least 92 percent of NHS bridges in Fair to Good condition (i.e. no more than 8 percent in Poor condition)
- At least 80 percent of the Non-NHS bridges in Fair to Good condition (i.e. no more than 20 percent in Poor condition)

MnSHIP responded to MAP-21 and GASB 34 requirements by establishing two sets of constrained targets for ride quality and bridge condition—one set of targets for the first 10 years of the planning horizon and one set of less official targets for the second 10 years. Constrained targets in the first 10 years are referred to in MnSHIP as either "MAP-21 targets" or "10-year anticipated outcomes" (see **Figure 3-2**). These targets/outcomes represent levels of service that MnDOT is committed to providing over the first 10 years of MnSHIP's planning horizon in order to meet MAP-21 requirements.

Figure 3-2: MnSHIP Targets, Performance Thresholds, and Anticipated Outcomes

ASSET TYPE	PERFORMANCE MEASURE	TARGET	GASB 34 THRESHOLDS	CONSTRAINED TARGETS 10-YEAR ANTICIPATED OUTCOMES
Pavements	Share of system with Poor ride quality in travel lane	≤ 2% (NHS) ≤ 3% (Non-NHS)	≤ 10% (NHS) ≤ 13% (Non-NHS)	2% (NHS Interstate) 4% (Other NHS) 12% (Non-NHS)
Bridges	NHS bridges in Poor condition as a percent of total NHS bridge deck area	≤ 2% (NHS) ≤ 8% (Non-NHS)	≤ 8% (NHS) ≤ 20% (Non-NHS)	2% (NHS) 6% (Non-NHS)

TARGET TERMINOLOGY IN THE TAMP

Constrained targets are a useful tool for communicating and managing system performance in the face of severe resource limitations. Constrained targets have also helped to advance the use of risk assessments and risk management principles in MnDOT's investment decision-making. This TAMP supports the practice of identifying achievable, fiscally constrained outcomes as part of MnDOT's planning processes. However, it also clarifies MnDOT's terminology around targets and other types of performance outcomes in order to avoid confusion about what MnDOT is ultimately trying to accomplish.

The following terms differentiate between desired outcomes, outcomes associated with a fiscally constrained plan or budget, and forecasted outcomes based on predictive modeling.

- **Targets** reflect desired outcomes. Meeting a target constitutes the achievement of a performance goal. The purpose of targets is to evaluate system performance, identify performance-based needs, and guide strategic planning decisions. MnDOT may plan to meet or not meet targets based on funding levels and tradeoff decisions.

  Targets can be stated as fixed benchmarks against which MnDOT evaluates past, present and future performance. Fixed benchmarks are typically used to describe desired outcomes in performance areas where MnDOT has a high degree of control, such as ride quality or pavement condition. Targets can also be year specific. Year specific targets are trend-based and may change over time. They are typically used to evaluate the anticipated contribution of a program or set of planned investments.

- **Plan outcomes** describe future performance outcomes consistent with MnDOT's financially constrained spending priorities. These outcomes, which are established in conjunction with plan updates, are used to allocate resources, develop programs, and plan specific investments. Plan outcomes are stated in terms of the year in which MnDOT plans to achieve them, typically at the completion of a plan's time horizon.

  The terms target and plan outcome are not mutually exclusive. MnDOT may choose to fully fund a target, in which case the target and plan outcome are the same. In performance areas where targets and plan outcomes diverge due to insufficient resources, MnDOT uses the target to communicate need, while managing its program and maintenance activities to the plan outcome.

- **Expected outcomes** reflect predictive modeling of future performance. All plan outcomes begin as expected outcomes. However, expected outcomes often diverge from plan outcomes as plans age and as new information becomes available. MnDOT contrasts expected outcomes with plan outcomes at regular intervals to evaluate how successfully it is executing its plans/budgets. These evaluations promote accountability. Evaluations that show a significant discrepancy between a planned and an expected outcome can trigger a course correction in the form of new spending priorities or a revised strategy.

This terminology replaces the language used in MnSHIP to describe performance outcomes. Going forward, MnDOT will use **target** to denote desired outcomes. The term **plan outcome** will be used to identify outcomes to which MnDOT is managing. As long as MnDOT is on pace to achieve plan outcomes, the gap between a target and an **expected outcome** will be used to demonstrate need; however, it will not be used as a justification for reallocating resources within existing constraints. **Figure 3-3** summarizes the key characteristics of targets, plan outcomes and expected outcomes, as explained above.

Figure 3-3: Types of Performance Outcomes – Key Characteristics

TERM	MEANING	USE	HOW IS IT ESTABLISHED?	HOW OFTEN IS IT USED?
Target	Outcome consistent with agency goals and traveler expectations	• Communicate desired outcome • Evaluate performance • Identify investment needs	Approved by senior leadership; guided by agency policies and public planning process	Less than once per planning cycle
Plan Outcome	Outcome consistent with fiscal constraint / spending priorities	• Communicate spending priorities • Develop / manage programs • Select investments	Established concurrently with the adoption of investment plans	Once per planning cycle
Expected Outcome	Forecasted outcome based on predictive modeling	• Monitor plan implementation • Promote accountability / initiate corrective action	Generated by expert offices based updated performance information and planned improvements	Annually

Chapter 7 and **Chapter 8** provide an expanded narrative on targets, plan outcomes and expected outcomes for each of the asset categories covered in this TAMP.

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Chapter 4

ASSET INVENTORY AND CONDITION

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ASSET INVENTORY AND CONDITION

Overview

Minnesota's state highway system includes the National Highway System and other important roads. The importance of the state highway system is demonstrated by its use. Although it comprises just 8.5 percent of Minnesota's total roadway system mileage, it carries almost 60 percent of the miles traveled statewide, including the majority of freight being moved by road within the state.

Minnesota's state highway system is comprised of approximately 14,000 roadway miles and 4,500 bridges. Collectively, the replacement value of these assets is roughly $40 billion. In addition to roadways and bridges, MnDOT is responsible for maintaining many other transportation assets as shown in **Figure 4-1**. MnDOT has a direct ownership role in hydraulic infrastructure, roadside asset and traffic infrastructure within the right of way. For the majority of the multimodal assets, MnDOT manages grants monies or conveys or transfers ownership of property. Given significant investment in these assets, continuing demands on the system, and increased fiscal constraints on available funding for managing the system, it is imperative that MnDOT continues to identify ways to improve its transportation asset management practices, which ensure a strategic and systematic process for managing asset performance.

Figure 4-1: Examples of Assets Managed by MnDOT

HYDRAULIC INFRASTRUCTURE
• Culverts
• Stormwater Systems
• Tunnels
TRAFFIC INFRASTRUCTURE
• Intelligent Transportation System (ITS) Assets
• Sensor Systems
• Traffic Signals
• Sign Structures
• Sign Panels

ROADSIDE ASSETS
• Pavement Marking, Striping
• Curb and Gutter
• Guardrails
• Fence, Barriers, Impact Attenuators
• Noise Walls
• Slopes, Embankments, Retaining Walls
• Rest Areas
• Weigh Stations
• Lighting Structures
MULTIMODAL ASSETS
• Americans with Disabilities Act (ADA) Features
• Bicycle & Pedestrian Facilities
• Transit (Bus and Rail)
• Freight
• Airports
• Ports and Waterways

Factors Influencing Asset Condition and Performance

The advanced age of Minnesota's state highway assets is one of the primary challenges facing MnDOT today. **Figure 4-2** illustrates the age profile of state highway pavements. It shows that approximately half of the network is more than 50 years old. The major spike of activity in the late 1940s through the 1950s is the advent of the Interstate System, which also included the structural enhancement of much of the non-Interstate highway system. This activity began to taper off in the 1960s as much of the rural interstate was completed. Several gaps in the interstate system were completed through the mid-1980s. **Figure 4-3** shows a similar age profile and spikes for state highway bridges, with approximately 40 percent of MnDOT's bridges built before the early 1970's. The application of a variety of maintenance and rehabilitation treatments has helped MnDOT considerably extend the service life of pavements and bridges although not always at the lowest life-cycle cost. The ability to predict and monitor deterioration is a key factor in effectively managing these assets over their life-cycles.

Life-cycle cost considerations (the subject of **Chapter 6**) recognize that the cost of maintaining pavements and bridges in serviceable condition increases as they age. This dynamic, in conjunction with limited resources, makes it more difficult to meet pavement and bridge condition targets while also limiting MnDOT's ability to invest in other performance areas.

Figure 4-2: Age Profile of State Highway Pavements

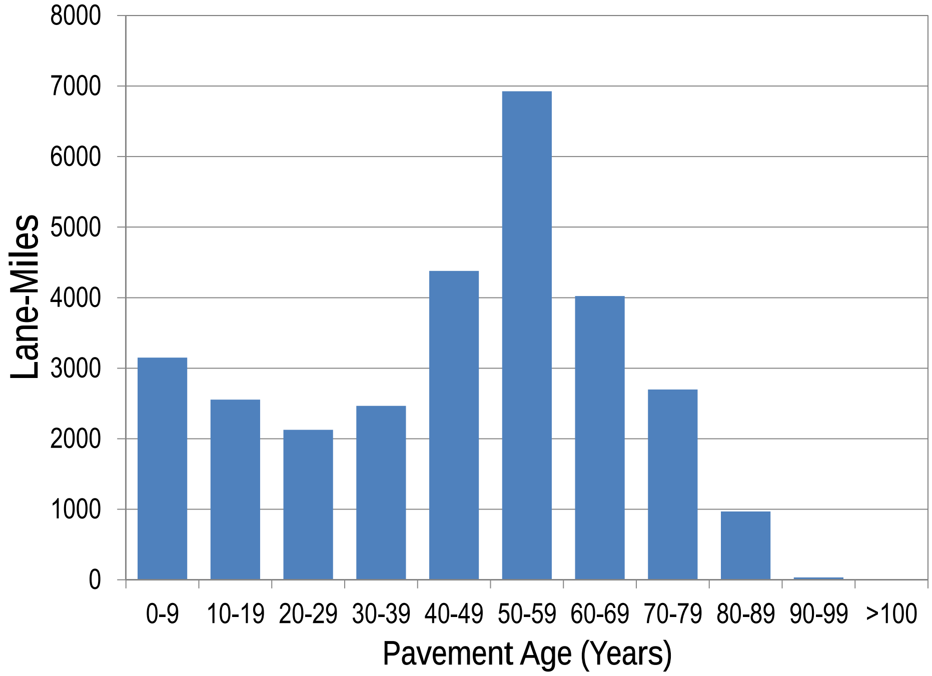
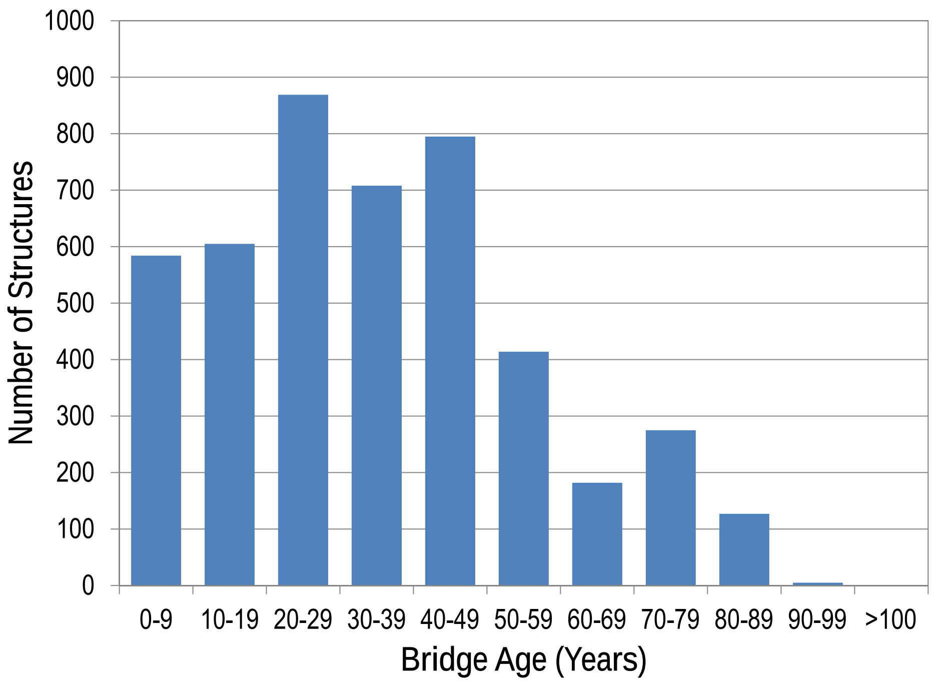


Figure 4-3: Age Profile of State Highway Bridges



In addition to age, the condition of state highway assets is influenced by type of construction, climate conditions and traffic usage. Significant flood events in 2010 and 2012 in Southeast and Northeast Minnesota caused widespread damage and highlighted the need to better understand flooding impacts on asset condition. MnDOT is currently participating in an FHWA Flash Flood Vulnerability and Adaptation Assessment Pilot Project that will help MnDOT and other state DOTs better understand the process for incorporating climate change in asset management planning. Some of the main factors influencing the condition of the assets included in the TAMP are highlighted in **Figure 4-4**.

Figure 4-4: Significant Factors Influencing Asset Conditions

PAVEMENTS	BRIDGES	HIGHWAY CULVERTS & STORMWATER TUNNELS	OVERHEAD SIGN STRUCTURES AND HIGH-MAST LIGHT TOWER STRUCTURES
• Pavement type • Traffic volumes • Traffic weight • Environmental factors • Material properties • Type of underlying material • Maintenance frequency • Construction quality	• Bridge type • Usage of deicing chemicals • Presence of water • Traffic volumes • Traffic weight • Environmental factors • Material properties • Maintenance frequency • Construction quality	• Material type • Support of underlying foundation • Shape and geometry of culvert • Culvert thickness and condition • Installation quality • Pressurization and maintenance frequency	• Fabrication quality • Installation quality • Material type • Traffic hits • Strong winds • Fatigue

A key to managing assets effectively is the ability to forecast changes in condition over time for each type of asset. MnDOT has developed sophisticated deterioration models for pavements. These models are used in the pavement management system to predict future conditions under different treatment scenarios. Although deterioration models are not currently available for the other asset categories included in the TAMP, planned enhancements to MnDOT's bridge management program include adding modeling capabilities. For bridges, highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures, MnDOT experts provided input to develop the projections that inform the life-cycle costing discussed in **Chapter 6: Life-Cycle Costs Considerations**.

Asset Inventory and Condition Summary

The fundamental philosophy and principles of asset management apply to all infrastructure assets maintained by MnDOT. This first edition of the TAMP addresses the following selected asset categories: pavements, bridges, highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures. Additional asset categories will be added in future TAMPs. The Moving Ahead for Progress in the 21st Century Act (MAP-21) transportation authorization bill requires a TAMP for all pavement and bridges on the National Highway System. MnDOT's TAMP exceeds these requirements.

The information needed to develop the TAMP for pavements and bridges was, for the most part, readily available in MnDOT's pavement and bridge management systems. For other asset categories, data were less complete or accessible. For instance, condition inspections were performed less consistently on deep stormwater tunnels, overhead sign structures, and high-mast light tower structures. As a result, data on maintenance history, asset condition, and deterioration rates were less than optimal for these assets. MnDOT is using this opportunity to assess the maturity level of the maintenance and management of these assets, to identify process improvements that will help manage them more effectively, and to apply these principles to other MnDOT asset groups.

Figure 4-5, **Figure 4-6**, **Figure 4-7**, and **Figure 4-8** comprise "folios" summarizing much of the available information on the **inventory and estimated replacement value** of each asset category, along with **data collection, management, and reporting practices** and **current condition, recommended targets, and investment levels** (recommended targets reflect changes discussed in **Chapter 2** and **Chapter 7**; investment levels are discussed in **Chapter 8**). This information was provided by Work Groups of MnDOT technical experts specially convened around each of the asset categories considered in this TAMP. It was then vetted by the larger TAMP project Steering Committee before inclusion in this plan.

A roadway mile is an entire segment of highway (all lanes), one mile in length.

A lane mile is a section of pavement with an area one lane-width wide by one mile long.

Both measures are used to calculate various pavement needs and costs.

Pavement replacement value is estimated at $1 million per lane mile. This is based on an average for Minnesota's entire trunk highway network.

Figure 4-5: Pavement Folio

PAVEMENTS

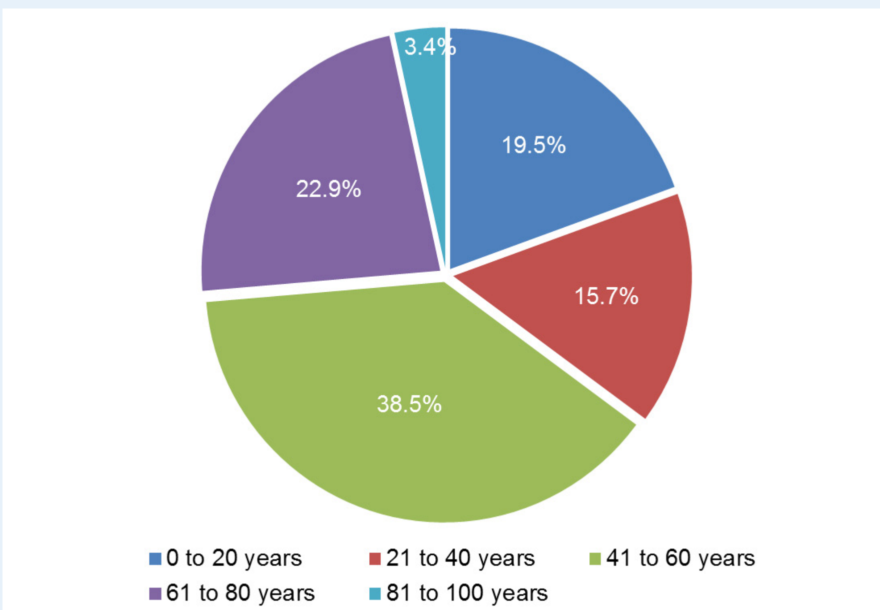
Pavements are a critical part of MnDOT's transportation network, providing mobility and access to a wide range of users. MnDOT's system consists of two types of pavements: flexible and rigid. Flexible pavements are often referred to as bituminous or black top, while rigid is commonly referred to as concrete. The state system consists of Interstates (e.g. I-94, I-35), non-Interstate NHS (e.g. Hwy 14, Hwy 169), and non-NHS highways (e.g. Hwy 75, Hwy 218). The entire state highway system is considered in all of the analyses (life-cycle cost analysis, risk management, financial plan and investment strategies) performed as a part of this TAMP.

INVENTORY AND REPLACEMENT VALUE

SYSTEM / FUNCTIONAL CLASSIFICATION	FLEXIBLE ROADWAY MILES	RIGID ROADWAY MILES	TOTAL ROADWAY MILES	TOTAL LANE-MILES	CURRENT REPLACEMENT VALUE
Interstate	925	896	1,821	4,036	$4.04 billion
Non-Interstate NHS	4,660	1,114	5,774	11,759	$11.76 billion
Non-NHS	6,569	167	6,736	13,567	$13.57 billion
TOTAL	**12,154**	**2,177**	**14,331**	**29,362**	**$29.36 billion**

Notes: Interstate and Non-Interstate NHS do not include locally-owned NHS roadways (232 roadway miles); current replacement value based on $1 million per lane-mile

PAVEMENT AGE PROFILE (BY LANE-MILE)



DATA COLLECTION, MANAGEMENT, AND REPORTING PRACTICES

Data Collection:

- Automated data collection performed annually on all state highways
- Ride condition and surface distresses collected
- Shoulders and ramps not surveyed
- Office of Road Research responsible for data collection

Data Management:

- Highway Pavement Management Application (HPMA) used to managed inventory and condition data
- Pavement condition deterioration models, project selection handled through HPMA

Data Reporting:

- Pavement condition report published annually by MnDOT Pavement Management Unit
- Data available on MnDOT's website

CONDITION RATING SCALE BASED ON RIDE QUALITY INDEX (RQI)

Good: 3.0 < RQI ≤ 5.0	**Fair: 2.0 < RQI ≤ 3.0**	**Poor: RQI ≤ 2.0**

CONDITION, TARGETS, AND 10-YEAR INVESTMENT LEVELS

SYSTEM	2012 CONDITION (% POOR)	TARGETS (% POOR)	INVESTMENT REQUIRED TO ACHIEVE TARGETS IN 2023
Interstate	2.4%	≤ 2%	$392 million
Non-Interstate NHS	4.3%	≤ 4%	$1.1 billion
Non-NHS	7.5%	≤ 10%	$1.4 billion
TOTAL	**NA**	**NA**	**$2.9 billion**

Note: Interstate and non-interstate NHS do not include locally-owned NHS roadways (232 roadway miles)

Figure 4-6: Bridge Folio

BRIDGES (INCLUDES LARGE CULVERTS)

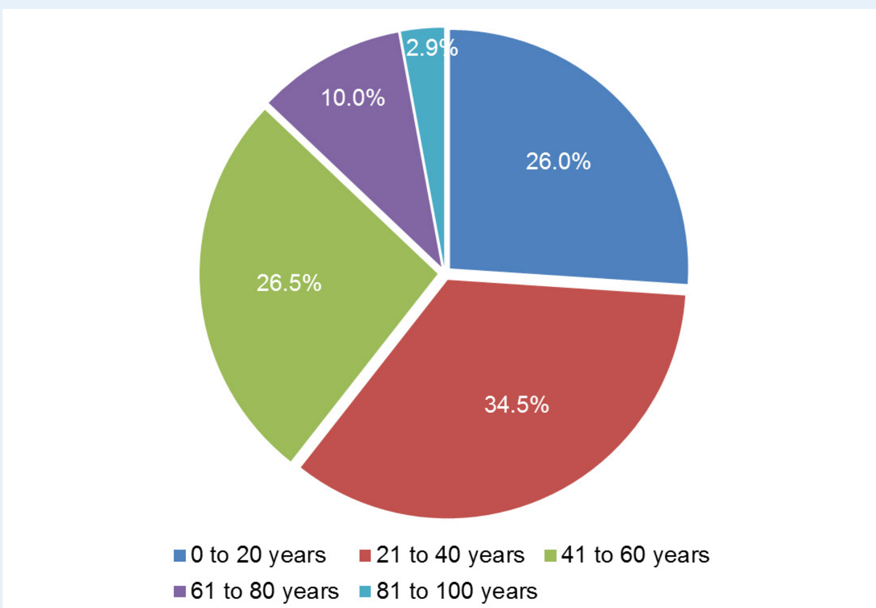
Bridges are large, complex, and expensive assets that are custom-designed and built to satisfy a wide variety of requirements. Large culverts (typically greater than 10 ft.) are also included in the bridge inventory. Analysis results related to bridges and large culverts presented in this TAMP (life-cycle cost analysis, risk management, financial plans and investment strategies) are limited to the National Highway System (NHS) inventory.

INVENTORY AND REPLACEMENT VALUE

SYSTEM / FUNCTIONAL CLASSIFICATION	COUNT	BRIDGE AREA (SQ. FT.)	CURRENT REPLACEMENT VALUE
Interstate	755	13,161,229	$1.9 billion
Non-Interstate NHS	1,196	13,483,129	$2.0 billion
Non-NHS	2,592	18,881,065	$2.7 billion
TOTAL (State Highway)	**4,543**	**45,525,423**	**$6.6 billion**

Notes: Interstate and Non-Interstate NHS do not include locally-owned NHS bridges (23); replacement values range from $145/sq. ft. to $225/sq. ft. depending on bridge type

BRIDGE AGE PROFILE (BY NUMBER OF BRIDGES)



DATA COLLECTION, MANAGEMENT, AND REPORTING PRACTICES

Data Collection:

- Data collection based on National Bridge Inspection Standards (NBIS), AASHTO, and MnDOT requirements
- Most bridges inspected annually in Minnesota (some more or less frequently based on inspection results)
- Districts perform/supervise inspections with some centralized management and Quality Assurance / Quality Control of data collected

Data Management:

- Pontis / Bridge Replacement and Improvement Management (BRIM) tools used to store and analyze data
- Structure Information Management System (SIMS) used to enter, submit, and manage inspection data

Data Reporting:

- Bridge inspection and inventory reports available through MnDOT's website

CONDITION RATING SCALE (BASED ON NBIS RATING SCALE)

9	8	7	6	5	4	3	2	1	0
Good: 7-9			**Satisfactory: 6**	**Fair: 5**	**Poor: 0-4**				

CONDITION, TARGETS, AND 10-YEAR INVESTMENT LEVELS

SYSTEM	2012 CONDITION (% POOR)	TARGETS (% POOR)	INVESTMENT REQUIRED TO ACHIEVE TARGETS IN 2023
Interstate and Non-Interstate NHS	4.7%	≤ 2%	$1.10 billion
Non-NHS	2.1%	≤ 8%	$430 million
TOTAL	**4.3%**	**NA**	**$1.53 billion**

Note: Interstate and Non-Interstate NHS do not include locally-owned NHS bridges (23)

Figure 4-7: Hydraulic Infrastructure Folio

HYDRAULIC INFRASTRUCTURE (HIGHWAY CULVERTS AND DEEP STORMWATER TUNNELS)

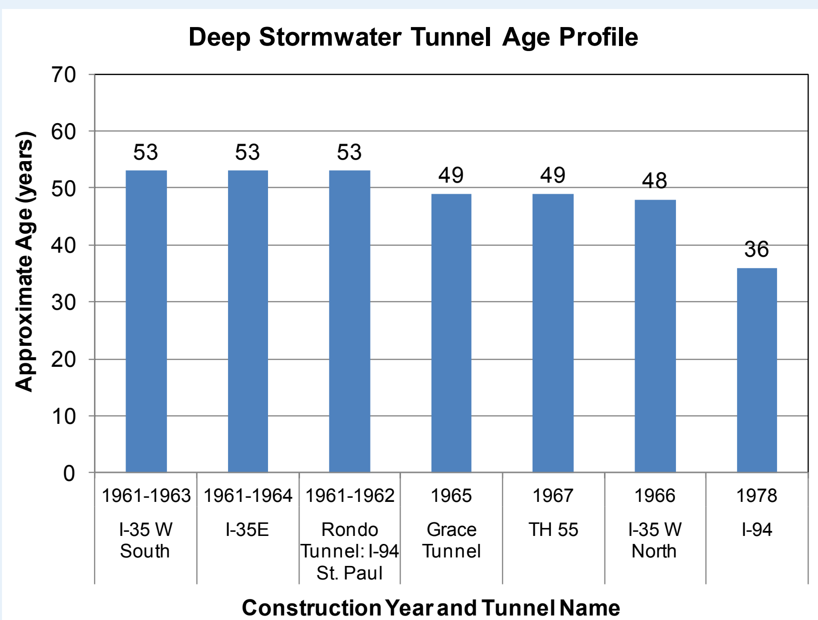
Hydraulic infrastructure, including highway culverts (diameter greater than 10 feet) and deep storm water tunnels, helps MnDOT effectively manage water flows throughout the state. Highway culverts convey surface water runoff under and adjacent to the state highway system. Deep stormwater tunnels are located in the Twin Cities Metropolitan Area, collect stormwater runoff (e.g. runoff from major highways and surrounding community), and are approximately 50-100 feet below the surface. All state highway system culverts and deep stormwater tunnels are considered in all of the analyses (life-cycle cost analysis, risk management, financial plans and investment strategies) performed as a part of this TAMP.

INVENTORY AND REPLACEMENT VALUE

ASSET TYPE	COUNT / UNIT	CURRENT REPLACEMENT VALUE
Highway Culverts	47,157 (number)	$1.7 billion
Deep Stormwater Tunnels	69,272 linear feet (7 tunnels, 50 segments)	Approximately $300 million

Note: Replacement value for centerline highway culverts based on $798 per foot., assuming average culvert length of 45 feet; replacement value for tunnels based on approximate estimate provided by hydraulic infrastructure Work Group

HYDRAULIC INFRASTRUCTURE AGE PROFILES



Insufficient Data for Highway Culvert Age Profile

DATA COLLECTION, MANAGEMENT, AND REPORTING PRACTICES
Data Collection: • Condition inspections performed in-house or through contract • Data collection frequency varies: 1 to 6 years for culverts; 2 to 5 years for deep stormwater tunnels • Culverts managed by MnDOT districts: Maintenance or Hydraulics / Water Resources Engineering (WRE) Division • Tunnels managed by Metro District WRE
Data Management: • HydInfra information application used to manage inventory, inspection, and maintenance activities
Data Reporting: • Condition ratings extracted from HydInfra system for internal reporting purposes

CONDITION RATING SCALE (BASED ON HYDINFRA RATING SCALE)				
Not Rated: 0	**Like New: 1**	**Fair: 2**	**Poor: 3**	**Very Poor: 4**

CONDITION, TARGETS, AND 10-YEAR INVESTMENT LEVELS			
SYSTEM	2012 CONDITION	TARGETS	INVESTMENT REQUIRED TO ACHIEVE TARGETS IN 2023
Centerline Highway Culverts	10% Poor; 6% Very Poor	≤ 8% Poor; ≤ 3% Very Poor	$400 million
Deep Stormwater Tunnel	39% Poor; 14% Very Poor	≤ 8% Poor; ≤ 3% Very Poor	$35 million (condition) + $1.6 million (inspection)

Figure 4-8: Other Traffic Structures Folio

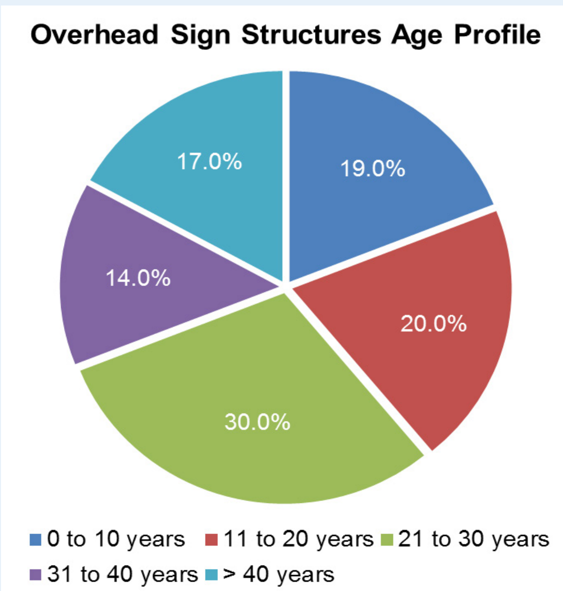
OTHER TRAFFIC STRUCTURES: OVERHEAD SIGN STRUCTURES AND HIGH-MAST LIGHT TOWER STRUCTURES

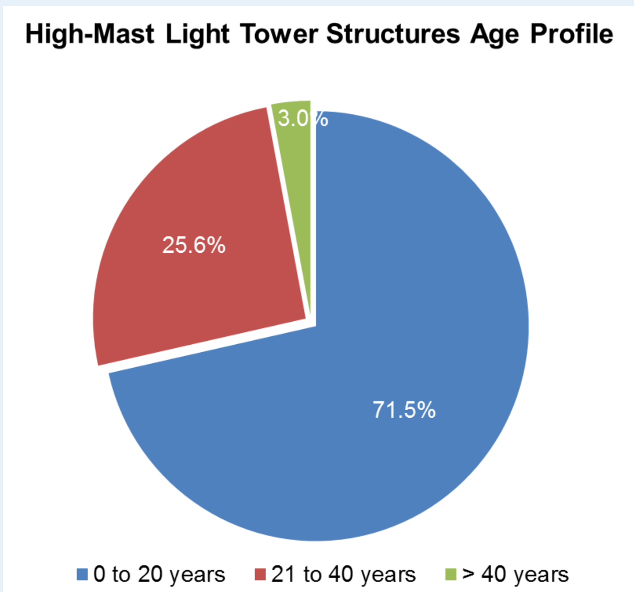
Other traffic structures included in this TAMP are overhead sign structures and high-mast light tower structures. Overhead sign structures include various types of span and cantilever structures, designed to support signs requiring vertical clearance for vehicles to pass underneath. High-mast light tower structures are tall poles, approximately 100 feet in height, which support 3-5 large lamps. The analysis performed in this TAMP accounts only for structural condition; other functional and operational requirements (e.g. sign retroreflectivity, bulb replacement) are not considered.

INVENTORY AND REPLACEMENT VALUE		
SYSTEM / FUNCTIONAL CLASSIFICATION	COUNT	CURRENT REPLACEMENT VALUE
Overhead Sign Structures	2,359	$200 million
High-Mast Light Tower Structures	476	$19 million

Note: Current Replacement Value is based on $85,000 per overhead sign structure and $40,000 per high-mast light tower structure

OTHER TRAFFIC STRUCTURES AGE PROFILES (BY NUMBER OF STRUCTURES)





DATA COLLECTION, MANAGEMENT, AND REPORTING PRACTICES
Data Collection: • Condition inspections performed in-house or via contract • Data collection typically on a five-year cycle • Data collection managed by the Maintenance / Traffic Division
Data Management: • Overhead sign structure data stored in a spreadsheet or on paper • High-mast light tower structure data stored in AFMS and in an Access database
Data Reporting: • Condition ratings extracted from rating spreadsheet for internal reporting purposes

CONDITION RATING SCALE (BASED ON NBI RATING SCALE)

9	8	7	6	5	4	3	2	1	0
Good: 7-9			Satisfactory: 6	Fair: 5	Poor: 4	Very Poor: 0-3			

CONDITION, TARGETS, AND 10-YEAR INVESTMENT LEVELS

SYSTEM	2012 CONDITION	TARGETS	INVESTMENT REQUIRED TO ACHIEVE TARGETS IN 2023
Overhead Sign Structures	6% Poor; 8% Very Poor	≤ 4% Poor; ≤ 2% Very Poor	$8 million
High-Mast Light Tower Structures	6% Poor; 15% Very Poor	TBD	TBD

Note: MnDOT is in the process of developing a new rating system for high-mast light tower structures

Asset Value

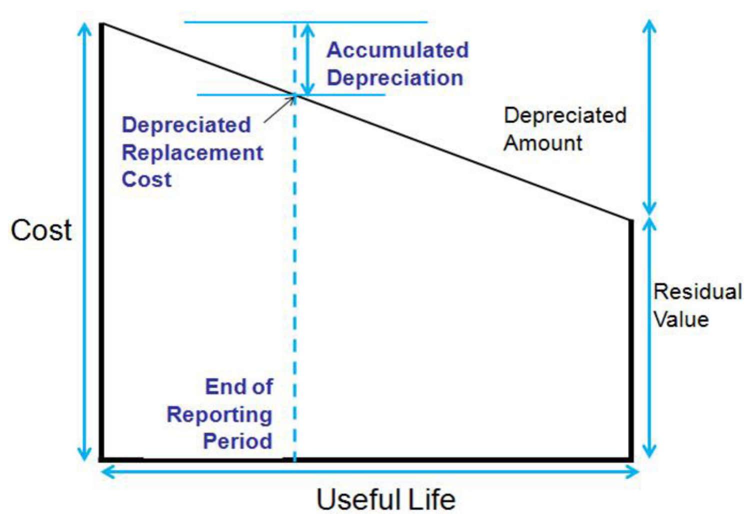
Transportation assets represent a significant investment - one that is crucial to the economic viability of the state. It is therefore important to preserve the value of transportation assets through a series of planned activities that extend their service lives for as long as possible. A summary of approximate current replacement values of the asset categories included in the TAMP is shown in **Figure 4-9**.

Figure 4-9: Summary of Current Replacement Value of Assets

STATE HIGHWAY SYSTEM ASSETS	CURRENT REPLACEMENT VALUE
Pavements	$29.4 billion
Bridges	$6.6 billion
Hydraulic Infrastructure (Highway Culverts and Deep Stormwater Tunnels)	$2.0 billion
Other Traffic Structures (Overhead Sign Structures and High-Mast Light Tower Structures)	$220 million
Total	**$38.2 billion**

As an asset ages, its value and functionality gradually declines. In accounting terms, this decrease in value is referred to as depreciation. Monitoring the change in asset value over time (illustrated in **Figure 4-10**) is one way of determining whether investment levels in transportation assets are financially sustainable. Stated simply, if an agency is not investing at least as much as its assets are depreciating each year, the assets are losing value and the program is not financially sustainable. The use of value to monitor financial sustainability is gaining momentum nationally. Therefore future MnDOT TAMPs may include a comparison between estimated asset depreciation and anticipated investment.

Figure 4-10: Illustration of the Concept of Asset Value Deterioration



Chapter 5

RISK MANAGEMENT ANALYSIS

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RISK MANAGEMENT ANALYSIS

Overview

Risk is frequently defined as the effect of uncertainty on objectives. When applied to the management of transportation assets, acknowledging and understanding risk can help a transportation agency more effectively plan for possible system and program disruptions and complications, mitigate potential consequences, and improve agency and infrastructure resiliency.

MnDOT understands the value of accounting for and managing risk and has been incorporating risk into both capital and highway operations planning, as well as into business planning for each of the agency's functional areas. Most recently, risk assessment has been formally incorporated into the Minnesota 20-year State Highway Investment Plan (MnSHIP), published in 2013, and played a prominent role during its development. MnDOT also produced an Enterprise Risk Management Framework and Guidance document in 2013, which "establishes the standards, processes and accountability structure used to identify, assess, prioritize and manage key risk exposures across the agency." Risk also factors into the most recent Statewide Highway Systems Operation Plan (HSOP), where it influences tradeoff discussions and funding prioritization.

This strong history with risk prompted MnDOT to take a somewhat unique approach to the Risk Management Analysis section of the TAMP. Because risk management is already integrated into most agency planning and management practices, it was recognized that focusing on "global" risks (e.g. natural events, operational hazards, aging assets) would be less beneficial than assessing and developing mitigation strategies for "undermanaged" risks – opportunities that exist for MnDOT to further improve its asset management processes.

Risk and Transportation

Like many transportation departments, MnDOT endeavors to provide the level of service demanded by the public at minimum cost. Unexpected events – including external hazards, economic disruptions, or insufficient understanding – can reduce the effectiveness of an agency in achieving its goals, however. **Figure 5-1** shows several examples of risks that are of particular concern to transportation agencies.

Figure 5-1: Key Transportation-Related Risk Factors

RISK FACTOR
Natural events (e.g. floods, storms, earth movement)
Operational hazards (e.g. vehicle and vessel collisions, failure or inadequacy of safety features, and construction incidents)
Asset ageing effects (e.g. steel fatigue or corrosion, advanced deterioration due to insufficient preservation or maintenance)
Adverse conditions in the economy (e.g. shortage of labor or materials, recession)
Staff errors or omissions in facility design, operations, or provision of services; or defective materials or equipment
Lack of up-to-date information about defects or deterioration, or insufficient understanding of deterioration processes and cost drivers

Consequences of such risks can include:

- Personal injury
- Loss of life
- Private property damage
- Infrastructure damage
- Traffic congestion
- Loss of access
- Loss of economic activity
- Harm to the environment
- Harm to public health
- Litigation and liability losses
- Resource waste
- Harm to agency reputation

Each of these can adversely affect the achievement of program goals and performance targets.

Some of these risk factors can be partially quantified by studying historical records, via active monitoring, or through quality assurance processes. Many significant risk factors, however, are prohibitively expensive or technologically impossible to measure. Even for factors that are difficult to measure, though, it is possible to adopt general risk management strategies, such as:

- Raising awareness of risks among staff and the public
- Adopting management strategies and techniques to avoid risks
- Prioritizing risk-prone assets for replacement
- Mitigating asset risks based on measurable characteristics that affect their resilience and exposure
- Working with partners and stakeholders on ways to reduce or to jointly manage risks

Risk at MnDOT

The principles of risk management have been adopted throughout the agency in recent years, from high level investment, management, or operations plans (MnSHIP, TAMP, HSOP) to individual asset management and programming systems and even research projects.

ENTERPRISE RISK MANAGEMENT (ERM)

To help guide the transition to formal and universal consideration of risk, MnDOT has implemented an ERM framework. The framework – illustrated in **Figure 5-2** – is an integral part of MnDOT's business processes, linking **strategic** risk assessments by senior executives to risks at the **business line** (program) level that affect products and services and at the **project** level that affect project objectives like scope, schedule, and cost. MnDOT created and now maintains a risk register to support the risk assessment processes, which reflects at any given time the current status of strategic and business line risks, including relevant performance objectives.

Figure 5-2: Levels of Risk Management MnDOT

MINNESOTA 20-YEAR STATE HIGHWAY INVESTMENT PLAN (MNSHIP)

Risk was a key factor considered during the 2013 MnSHIP process. Risk-based planning was central to its development, as MnDOT systematically identified the likelihood and impact of different risks to assess the tradeoffs associated with various investment mixes. The resulting comprehensive and dynamic document guides MnDOT's future investment planning.

As a result of changes in performance requirements, targets, and prioritization established by MAP-21, MnDOT also developed two programs – the Statewide Performance Program (SPP) and the District Risk Management Program (DRMP). By enhancing flexibility and collaboration with regional and local MnDOT staff, these programs help the agency effectively reallocate funding and address these changes. Further discussion of MnSHIP, the SPP, and the DRMP is found in **Chapter 8: Financial Plan and Investment Strategies**.

Figure 5-3 displays the capital investment risks categories considered in MnSHIP and the degree to which each is mitigated via the strategies outlined in the plan. Risks were not mitigated as well in years 11-20 (not relevant to the TAMP planning horizon and therefore not shown).

Figure 5-3: Investment Risk Mitigation in MnSHIP

KEY CAPITAL INVESTMENT RISKS	MITIGATED RISK THROUGH YEAR 10
GASB 34: pavement and bridge conditions deteriorate, jeopardizing state bond rating	*Partially mitigated.* MnDOT mitigates most of the risk through its investment priorities
Federal policy: failure to achieve MAP-21 performance targets on NHS reduces funding flexibility	*Adequately mitigated.* MnDOT mitigates most or all of the risk through its investment priorities
MnDOT Policy: misalignment with Vision and Statewide Multimodal Transportation Plan results in loss of public trust	*Partially mitigated.* MnDOT mitigates most of the risk through its investment priorities
Bridges: deferring bridge investments viewed as an unwise / unsafe strategy	*Adequately mitigated.* MnDOT mitigates most or all of the risk through its investment priorities
Responsiveness: rigid investment priorities limits ability to support local economic development and quality of life opportunities	*Partially mitigated.* MnDOT mitigates most of the risk through its investment priorities
Operations budget: untimely or reduced capital investment leads to unsustainable maintenance costs	*Partially mitigated.* MnDOT mitigates most of the risk through its investment priorities
Public outreach: investment inconsistent with MnSHIP public outreach results in loss of public trust	*Partially mitigated.* MnDOT mitigates most of the risk through its investment priorities

STATEWIDE HIGHWAY SYSTEMS OPERATION PLAN (HSOP)

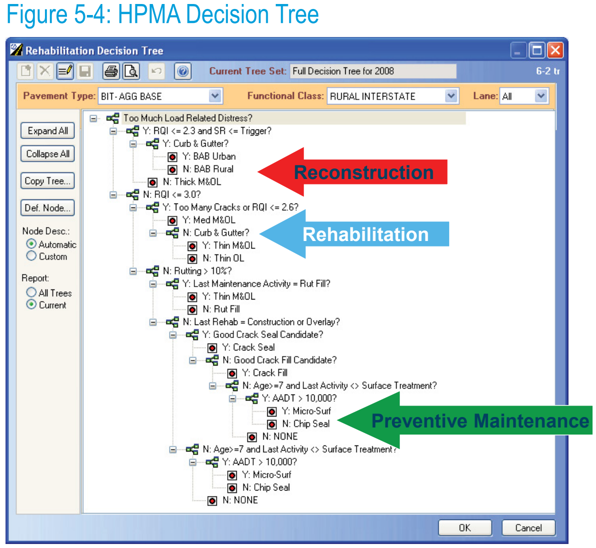
MnDOT's Statewide Highway Systems Operation Plan provides a framework for managing key operations and maintenance activities throughout the state, supports the agency's vision, and complements other planning efforts. It advocates performance-based planning and data-driven decision making for operations and maintenance. An Enterprise Risk Management assessment was completed as part of the HSOP and helped to identify, assess, manage, and communicate operations- and maintenance-related opportunities and threats. Assessments of risk are also driving factors for many operations and maintenance treatment decisions. With such a structure in place, MnDOT operations decision-makers and managers have a good baseline understanding of the current risk environment, a common language in operations, a risk inventory, and a risk-ranking methodology to prioritize risks within and across functions.

HIGHWAY PAVEMENT MANAGEMENT APPLICATION (HPMA)

Decisions about pavement management at MnDOT are made with the help of HPMA, which uses pavement condition data to forecast needs and optimize the combination of preservation and rehabilitation activities, in order to most effectively mitigate risk and achieve the best conditions possible, given funding constraints. The dynamic application allows for comparisons between a range of treatment option scenarios, from "Do Nothing" to "Full Reconstruction". This process is explained further in **Chapter 8: Financial Plan and Investment Strategies**.

The HPMA also helps MnDOT meet its GASB 34 minimum condition thresholds (see **Chapter 3**), thereby avoiding the risk of not doing so. Risks associated with the application were evaluated and addressed as part of risk exercises conducted in 2011, 2012, and 2013 and are identified in MnDOT's ERM risk register. A conceptual model of HPMA is shown in **Figure 5-4**.

Figure 5-4: HPMA Decision Tree



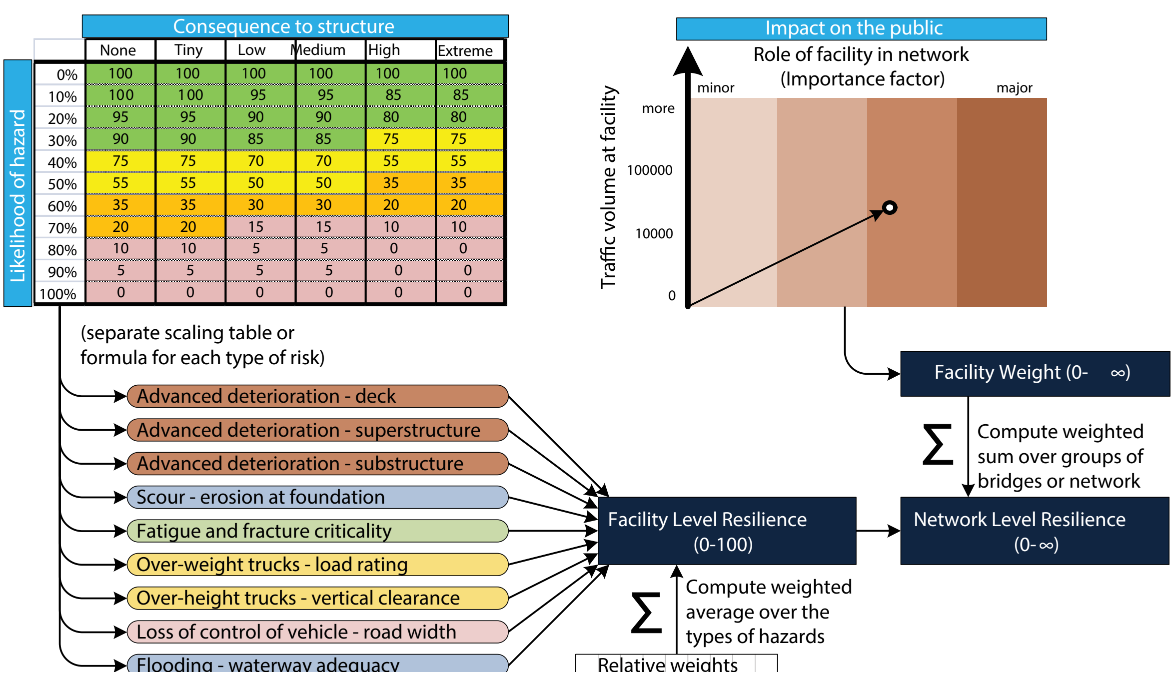
BRIDGE REPLACEMENT AND IMPROVEMENT MANAGEMENT (BRIM)

Many of MnDOT's asset-related risks are managed in whole or in part by established asset management processes, such as the BRIM program and the Highway Pavement Management Application (HPMA). BRIM is used by MnDOT to identify, classify, evaluate, and plan for a variety of quantifiable risks that apply to highway bridges. Hazards analyzed in BRIM include:

- Advanced deterioration of bridge decks, superstructures, and substructures
- Scour of riverbeds around bridge foundations
- Fracture criticality (possibility of bridge instability due to failure of only one element)
- Fatigue cracking
- Overload
- Collisions with over-height vehicles

Bridge characteristics related to each of these hazards are routinely updated in the MnDOT inventory. The information is used to prioritize necessary mitigation or replacement projects (illustrated in **Figure 5-5**). So far, MnDOT has not developed any network-level performance measures that can be used to track improvements in bridge resilience over time as a result of the BRIM analysis. This would be a logical next step to ensure effective implementation.

Figure 5-5: MnDOT Bridge Programming Risk Assessment



Likelihood of hazard \ Consequence to structure	None	Tiny	Low	Medium	High	Extreme
0%	100	100	100	100	100	100
10%	100	100	95	95	85	85
20%	95	95	90	90	80	80
30%	90	90	85	85	75	75
40%	75	75	70	70	55	55
50%	55	55	50	50	35	35
60%	35	35	30	30	20	20
70%	20	20	15	15	10	10
80%	10	10	5	5	0	0
90%	5	5	5	5	0	0
100%	0	0	0	0	0	0

Source: NCHRP Report 706, Uses of Risk Management and Data Management to Support Target-Setting for Performance-Based Resource Allocation by Transportation Agencies (2011).

RESEARCH PROJECTS

Finally, the concept of risk also factors heavily into several past and current research projects at MnDOT. For instance, the agency was selected to participate in an FHWA Flash Flood Vulnerability and Adaptation Assessment Pilot Project that will help MnDOT (and other state DOTs) better understand the process for incorporating climate change in asset management planning. This project is currently underway and results, when ready, will help inform future asset management initiatives.

TAMP Risk Assessment

As detailed above, risk is an important part of MnDOT's practices. Nevertheless, the agency's approach to the risk section of the TAMP process began with a focus on "global" risks (e.g. natural events, operational hazards) and their effects on the asset, the public, and the agency. MnDOT engaged in an exercise to identify and prioritize strategic and business risks that could impact its ability to deliver the level of service expected by the public. Discussions were held with Work Groups of technical experts to describe and rate the major risks related to each asset category. **Figure 5-6** illustrates MnDOT's risk rating scale. In consultation with agency risk experts, each Work Group developed a series of risk statements and risk ratings, described potential mitigation strategies for each risk, and developed methods for estimating mitigation costs. This process was iterative, extending over three formal workshops, with opportunities between workshops to modify aspects of the product. Participants took advantage of the process to learn about the risks, assess the ability of existing information systems to quantify risks and costs, and reach consensus on priorities and approaches for future improvements.

Figure 5-6: Risk Rating Matrix

CONSEQUENCE RATINGS	LIKELIHOOD RATINGS AND RISK LEVELS				
	RATE	UNLIKELY	POSSIBLE	LIKELY	ALMOST CERTAIN
CATASTROPHIC	Medium	Medium	High	Extreme	Extreme
MAJOR	Low	Medium	Medium	High	High
MODERATE	Low	Medium	Medium	Medium	High
MINOR	Low	Low	Low	Medium	Medium
INSIGNIFICANT	Low	Low	Low	Low	Medium

Given MnDOT's previous efforts at incorporating risk throughout its planning and management, the risk identification and mitigation process also sparked a debate as to the merits of a more conventional risk approach. It was concluded that MnDOT's current practices were already mindful of many global risks, and that the agency (and the public it serves) would therefore benefit most if the risks addressed in the TAMP emphasized "undermanaged risks" – areas in which there were clear opportunities for improvement at MnDOT. After pivoting to this concept and eliminating well-managed risks, a final list of undermanaged risks – relating to data, maintenance, or inspections – and associated **risk mitigation strategies** was presented to the Steering Committee for prioritization. The steps taken during the risk and mitigation strategy identification, prioritization, and costing exercises are described in detail in the accompanying Technical Guide.

Figure 5-7 identifies the risk mitigation strategies, separated into three priority levels based on factors like need, ease of implementation, and ability to reduce the perceived risk. **Chapter 9: Implementation and Future Developments** provides more detail for these priorities, including purposes, responsible parties, expected timeframes, and estimated implementation costs.

Figure 5-7: Undermanaged Risk Mitigation Strategy Prioritization

PRIORITY LEVEL 1: HIGH PRIORITY, ADDRESS IMMEDIATELY
• Pavements: Annually track, monitor, and identify road segments that have been in Poor condition for more than five years, and consistently consider them when programming.
• Deep Stormwater Tunnels: Address the repairs needed on the existing South I-35W tunnel system.
• Deep Stormwater Tunnels: Investigate the likelihood and impact of deep stormwater tunnel system failure.
• Highway Culverts: Develop a thorough methodology for monitoring highway culvert performance.
• Overhead Sign Structures and High-Mast Light Tower Structures: Develop and adequately communicate construction specifications for overhead sign structures and high-mast light tower structures.
• Overhead Sign Structures and High-Mast Light Tower Structures: Track overhead sign structures and high-mast light tower structures in a Transportation Asset Management System (TAMS).

PRIORITY LEVEL 2: ADDRESS BASED ON ESTABLISHED PRIORITIES

- Pavements: Collect and evaluate performance data on ramps, auxiliary lanes, and frontage road pavements for the highway system in the Twin Cities Metro Area.
- Bridges: Augment investment in bridge maintenance modules and develop related measures and tools for reporting and analysis.
- Highway Culverts: Include highway culverts in MnDOT's TAMS.
- Deep Stormwater Tunnels: Place pressure transducers in deep stormwater tunnels with capacity issues.
- Deep Stormwater Tunnels: Incorporate the deep stormwater tunnel system into the bridge inventory.
- Overhead Sign Structures: Develop a policy requiring a five-year inspection frequency for overhead sign structures, as well as related inspection training programs and forms.

PRIORITY LEVEL 3: REVISIT WHEN ADDITIONAL FUNDING BECOMES AVAILABLE (AFTER ITEMS IN PRIORITY LEVELS 1 AND 2 HAVE BEEN ADDRESSED)

- Highway Culverts: Repair or replace highway culverts in accordance with recommendations from the TAMS.

Chapter 6

LIFE-CYCLE COST CONSIDERATIONS

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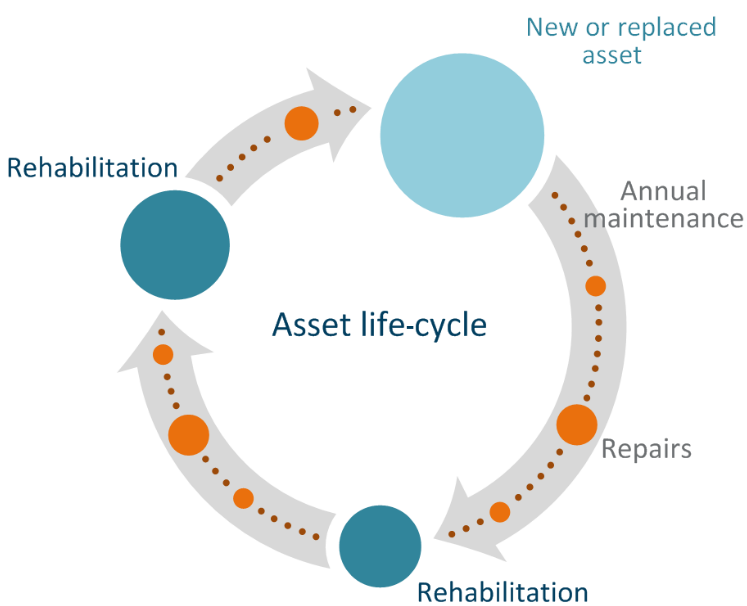
LIFE-CYCLE COST CONSIDERATIONS

Overview

Minnesota's transportation infrastructure is constantly under attack from the physical and chemical processes of deterioration, the damaging impact of floods and other hazards, and the normal wear-and-tear from use by thousands of cars and trucks. MnDOT and its partners work tirelessly to offset these effects and keep the state's valuable assets in service for as long as possible at minimum cost. Strong asset management practices help to minimize the total cost of managing transportation assets by focusing on all phases of an asset's life-cycle, each of which is shown in **Figure 6-1**.

Figure 6-1: Typical Asset Life-Cycle Phases



Because the service life of an asset can be lengthened through the timely application of maintenance and rehabilitation activities, MnDOT attempts to manage its transportation assets in a strategic and proactive way. This includes:

- Designing new facilities for durability and long life using state-of-the-art materials and methods
- Deploying well-trained maintenance personnel and advanced technology to apply needed maintenance actions at just the right times in the right places
- Anticipating future maintenance and rehabilitation costs that help defer the need for larger repair costs
- Taking advantage of preventive maintenance opportunities
- Minimizing the impact of work zones on the traveling public

The **life-cycle cost** of an asset includes costs associated with construction, inspection, maintenance, and disposal.

The **total cost of ownership** of an asset includes costs associated with life-cycle costs plus operations and other indirect costs.

MnDOT has been developing procedures and tools to forecast asset deterioration rates, determine the effectiveness of its maintenance and rehabilitation actions, and estimate the magnitude of future costs in an attempt to improve its ability to manage assets over their life-cycle. With performance-based procedures and tools in place, MnDOT can continue to improve its strategic decision processes to help further reduce agency costs over the long term.

Life-Cycle Cost Analysis

Life-cycle cost analysis (LCCA) is an analytical technique used to assess the total cost of an asset. It takes into account all costs associated with construction, inspection, maintenance, and disposal. LCCA is especially useful when comparing alternate strategies that fulfill the same performance requirements but differ with respect to construction, maintenance and operational costs. These can be compared in terms of the total costs over the entire life-cycle of the asset.

Because they do not directly extend the life of an asset, annual operational investments (such as snow and ice removal, de-icing roads, and debris removal) have not been included in the LCCA. It should be noted, however, that operational expenses and other indirect costs form a large part of the overall cost of asset ownership. Collectively, construction, inspection, maintenance, operations, disposal, and other indirect costs associated with transportation assets comprise **total cost of ownership**. As an example, MnDOT spends between $50 and $85 million annually on snow and ice removal on roadways, depending on the severity of the winter. These operational requirements significantly impact the amount of funding available for asset maintenance and rehabilitation activities.

When a new road is built, the state commits not only to the initial construction costs, but also to the future costs of maintaining and operating that road. Over a long time period, future costs can be much greater than the initial cost. Therefore, it is important to manage the facilities as cost-effectively as possible over their entire service life.

Naturally, the owner of a facility would like to postpone future costs as much as possible. If costs can be postponed, the money saved can be redirected to other priorities. In life-cycle cost analysis, this preference is quantified as a discount rate. MnDOT's policy is to analyze all investments using a real annual discount rate which is currently 2.2 percent. The term "real" means that the effects of inflation are removed from the computation in order to make the cost tradeoffs easier to understand.

Although it is attractive to delay costs as much as possible and take advantage of the discount rate, there are limits. When maintenance is delayed, the condition of each asset worsens, eventually affecting the serviceability or even the safety of the infrastructure. Also, certain kinds of preventive maintenance actions are highly cost-effective, but only if performed at the optimal time. For example, painting a steel bridge at the right time is highly effective in prolonging its life. However, if painting is delayed, too much of the steel may already be rusted and painting is no longer as effective (or even possible). A much more expensive rehabilitation or replacement action is then required.

Additional terms used in LCCA are:

- **Analysis Period:** the time-frame over which the LCCA is performed
- **Life-Cycle Cost (in today's dollars):** the total cost to build, inspect, maintain, and dispose of an asset over the analysis period when the costs incurred in future years are converted to current dollars
- **Future Maintenance Costs as a Percent of Initial Investment:** the total future agency costs (including maintenance, rehabilitation, and inspection, but not operations costs) as a fraction of the initial construction cost of the asset (This value represents the future cost commitment that MnDOT makes for every dollar spent on a capital project.)

Theoretically, once a section of state highway is built, the agency is responsible for all future costs to keep that road in service, including the costs to reconstruct components of the road when they reach the end of their physical lives. However, because of discounting, costs in the far future have very little effect on any decisions made during the 10-year period covered by the TAMP. Forecasts of future deterioration and future needs become very unreliable if these predictions are extended too far into the future. In best practice, the analysis period of a life-cycle cost analysis should be as short as possible while still satisfying the following criteria:

- Long enough that further costs make no significant difference in the results.
- Long enough that at least the first complete asset replacement cycle is included.

The reason for the second criterion is that replacement costs are typically much larger than any other costs during an asset's life, so these costs can remain significant even if discounted over a relatively long period. A fair comparison of alternatives should therefore include at least the first replacement cycle for each of the alternatives being compared. The following analysis periods have been used in the LCCA:

- **Pavements:** A 70-year analysis period has been chosen to account for at least one complete reconstruction activity (which is estimated to occur 50 years after initial construction, on average) and compare that to a strategy in which reconstruction activity is delayed by a few years (due to short-term funding constraints) and less optimal treatments are selected.
- **Bridges, culverts, and deep stormwater tunnels:** These assets have lifespans that potentially extend for much longer than the 70-year scenarios analyzed for pavements. As a result, based on the second criterion, a 200-year life is used for this longer-lasting asset category.
- **Overhead sign structures and high-mast light tower structures:** An analysis period of 100 years was chosen based on a review of existing literature that suggests that the life of these structures, with routine maintenance and inspection, is expected to be at least 100 years.

The LCCA modeling strategies presented in the TAMP are summarized in **Figure 6-2**. The "Typical Strategy" reflects MnDOT's current practices for managing the assets and the "Worst-First" strategy involves complete replacement of the asset when it deteriorates to a Poor condition in the absence of preventive maintenance activities. The "Desired Strategy" (established only for pavements) corresponds to the strategy that MnDOT aspires to adopt in order to further reduce total life-cycle costs.

Figure 6-2: Life-Cycle Cost Analysis Modeling Strategies

ASSET	TYPICAL STRATEGY	WORST-FIRST STRATEGY	DESIRED STRATEGY
Pavements	• Delay need for reconstruction by applying a combination of surface treatments, crack sealing, and mill and overlays, depending on condition of pavement and available budget.	• Reconstruct a pavement as it deteriorates to Poor condition without routine preservation activities.	• Apply a major rehabilitation/ reconstruction activity at year 50, once the pavement has gone through a few preservation cycles and minor rehabilitation events.
Bridges and Large Culverts	• Perform repair and preventive maintenance on approximately two percent of bridges and large culverts; wash about 75 percent of bridges annually. • Perform limited repair actions, based on funding availability and judgment of inspectors and district bridge engineers.	• Replace entire bridge or large culvert structure as it deteriorates to a Poor condition without any preventive maintenance or repairs.	• Insufficient data
Highway Culverts	• Perform various maintenance actions on approximately two percent of culverts annually; flush each culvert once every 10 years. • Maintenance work performed based on judgment of inspectors.	• Replace culvert as it deteriorates to a Poor condition without any preventive maintenance or repairs.	• Insufficient data
Overhead Sign Structures and High-Mast Tower Lights	• Perform routine inspections after initial construction to determine maintenance needs. • Perform routine maintenance and major structural rehabilitation on an as-needed basis, as identified through inspections.	• Perform routine inspections after initial construction, but perform no maintenance. • Replace structure in a 40-year cycle (assuming deterioration to a condition when maintenance and rehabilitation are not expected to be effective).	• Insufficient data

Notes: Typical Strategy reflects current MnDOT practices; Desired Strategy reflects optimal life-cycle strategy as described in MnDOT's Pavement Design Manual, there is not sufficient data currently available for other asset categories.

A key goal of a LCCA is to find the optimal level of maintenance where life-cycle costs are kept to an absolute minimum. This point may be known as the "happy medium," where maintenance expenditures are neither too frequent nor delayed too long. Typically, a well-maintained pavement or bridge, when maintained at a level that minimizes costs in the long-term, is kept in relatively good condition. **Over the life of a facility, well-timed maintenance is estimated to cut life-cycle costs roughly in half, compared to a policy where no maintenance is performed at all.**

PAVEMENTS

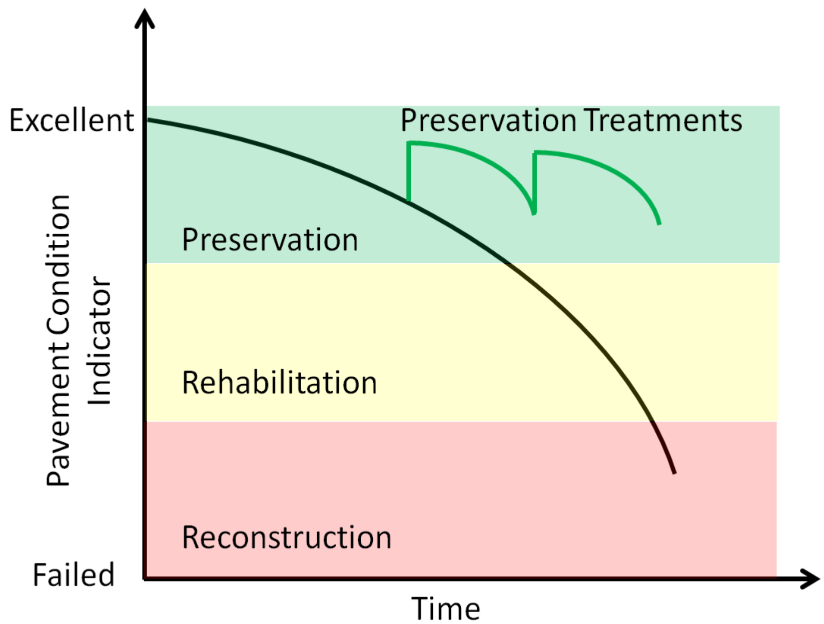
Roadways (see **Figure 6-3**) are a critical part of MnDOT's transportation network, providing mobility and access to a wide range of users. The roadway network not only contributes to the economy of the state, but also connects communities and provides access to schools, services, work, and places that matter most to Minnesotans. Pavements are a major part of this roadway network, providing a durable and safe traveling surface.

Figure 6-3: Typical Interstate Roadway in the Twin Cities Metro Area

As discussed in **Chapter 1** and **Chapter 4**, MnDOT maintains an inventory of more than 14,000 roadway-miles of pavements statewide, where the NHS pavements (Interstates, non-Interstate NHS, and locally-owned NHS) comprise over 7,800 roadway miles and the non-NHS pavements comprise almost 6,800 roadway miles of the total inventory. The current replacement values of NHS and non-NHS pavements are approximately $16 billion and $14 billion, respectively. These staggering costs demonstrate the need for a sound framework and methodological approach to manage these assets to the lowest life-cycle cost.

Pavements deteriorate over time due to environmental factors and traffic loading. As pavements age and start losing structural and/or functional capacity, they need to undergo maintenance and rehabilitation to restore them to the appropriate condition and provide a safe riding surface for the users. A typical pavement deterioration model demonstrating the impact of preservation is illustrated in **Figure 6-4**.

Figure 6-4: Typical Pavement Deterioration Model Illustrating Impact of Preservation

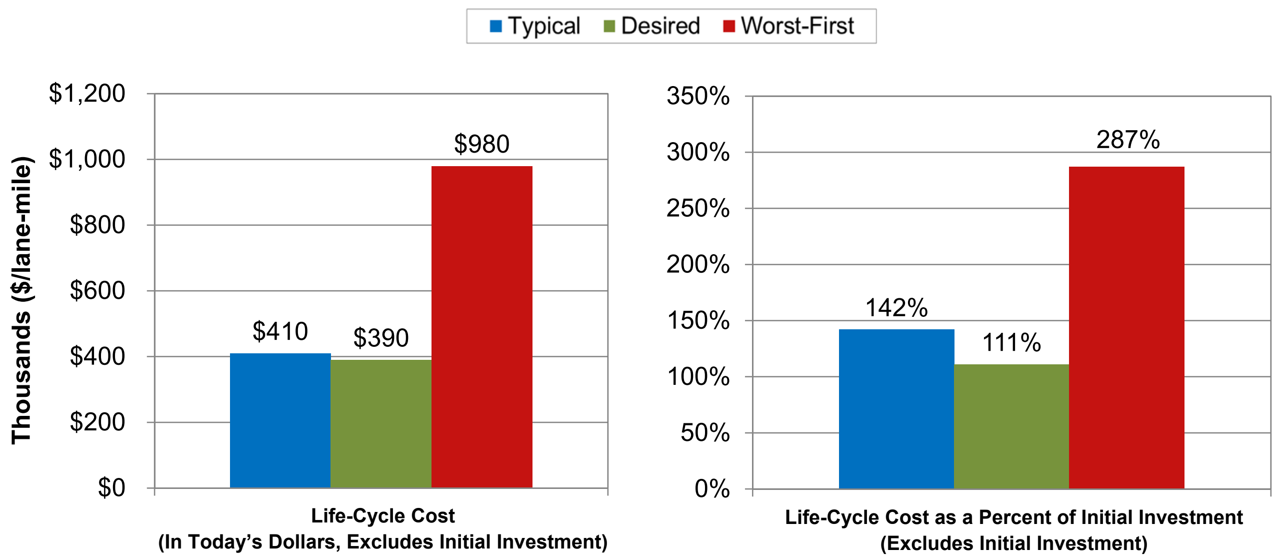


MnDOT has been actively involved in pavement preservation over the last decade to help sustain and improve the conditions of the existing pavement and delay the investments needed in major rehabilitation or reconstruction activities.

The typical preservation and rehabilitation treatments used by MnDOT on its asphalt-surfaced pavements include crack sealing, surface treatments (e.g. slurry seals, chip seals, and microsurfacing), full-depth reclamation, and asphalt mill and overlays. Typical preservation and rehabilitation treatments on concrete-surfaced pavements include joint resealing, partial depth repairs, minor/major concrete pavement repairs (e.g. dowel bar retrofit, diamond grinding, full-depth repairs), and unbonded overlays. While some treatments discussed above are applied primarily to extend the service life of the pavement and delay major rehabilitation/reconstruction activities, certain treatments are applied primarily to address safety issues (like friction loss or hydroplaning due to rutting in the wheel paths). The objective is to slow down the rate of deterioration and provide a smooth, durable, and safe roadway for the users at the lowest life-cycle cost.

The results of the life-cycle cost analysis highlighting the magnitude of differences in costs for each strategy are shown in **Figure 6-5**.

Figure 6-5: Summary of Life-Cycle Cost Analysis Results (Pavements)



MnDOT's current policy results in a savings of approximately 58 percent of future life-cycle costs when compared to the worst-first strategy. This is a savings of about $570,000 per lane-mile of pavement or approximately $17 billion over the entire inventory over the 70 year analysis period. Future costs (maintenance and capital) range from 1.1 (desired) to 2.9 (worst-first) times the initial cost of a capital project, depending on the treatment strategy used.

The results of the LCCA show the cost-effectiveness of the preservation strategy used by MnDOT to manage the pavements on the state highway system. The slightly higher life-cycle costs that MnDOT is incurring through its "typical" management strategy when compared to the "desired" strategy is the result of the need to balance investments between competing priorities (e.g., meeting state/federal targets, higher level of investment needed on some critical pavement sections in Poor condition).

BRIDGES AND LARGE CULVERTS

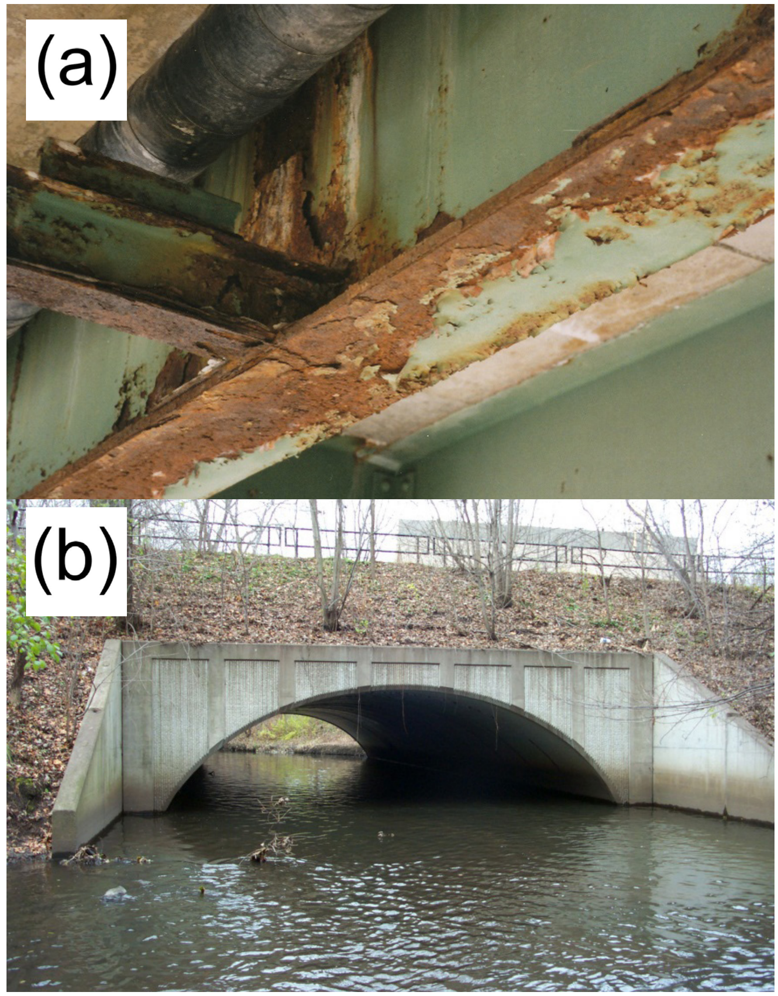
Bridges are large, complex, and expensive assets that are custom-designed and built to satisfy a wide variety of requirements. All culverts of at least 10 feet in diameter (and some important smaller culverts) are inspected and managed as bridges. The bridges addressed in this TAMP (NHS, non-NHS, large culverts) have a replacement value of approximately $4 billion. Although bridges and large culverts are managed using the same system, the LCCA was performed separately because deterioration rates, treatment costs and types are different.

Consistent with Federal and industry specifications, MnDOT performs a detailed inspection on all of its bridges on a periodic basis, usually at two year intervals as outlined in the MnDOT Bridge Inspection Best Practices Manual. Preventive maintenance actions – flushing, crack sealing, painting, etc. – are typically performed according to an assigned frequency, which is determined using criteria such as the activity performed, bridge age and type, condition, and traffic volume and control. Most bridges are flushed annually to remove corrosive salts from the bridge deck and other elements like joints, drains, bearing seats, and superstructure elements (e.g. beam ends, lower chord members). Staffing, funding, work zone traffic control limitations on high-volume bridges (typically on Interstate Highways), and other system priorities constrain MnDOT from being able to flush all bridges annually. Reactive maintenance actions, like patching, are performed based on conditions noted in the inspections.

Most bridges in the inventory are designed to last 50 years, but MnDOT experience has shown that many of them can last much longer if well-maintained. Newer bridges are designed for a 75 year life using more advanced materials and construction methods.

Bridges and culverts deteriorate over time. In particular, steel is strong, light, and inexpensive, but is prone to corrosion. Paint and concrete cover the steel and protect it from corrosion [see **Figure 6-6 (a)**]. But paint and concrete are often exposed to weather, traffic, erosion, animals, chemicals, and collisions, and therefore require regular care. These materials can also crack as they age, thus weakening their structural strength and allowing corrosive water and chemicals to penetrate the materials, worsening deterioration. Certain bridge materials, especially timber may also be subject to attack by insects and micro-organisms.

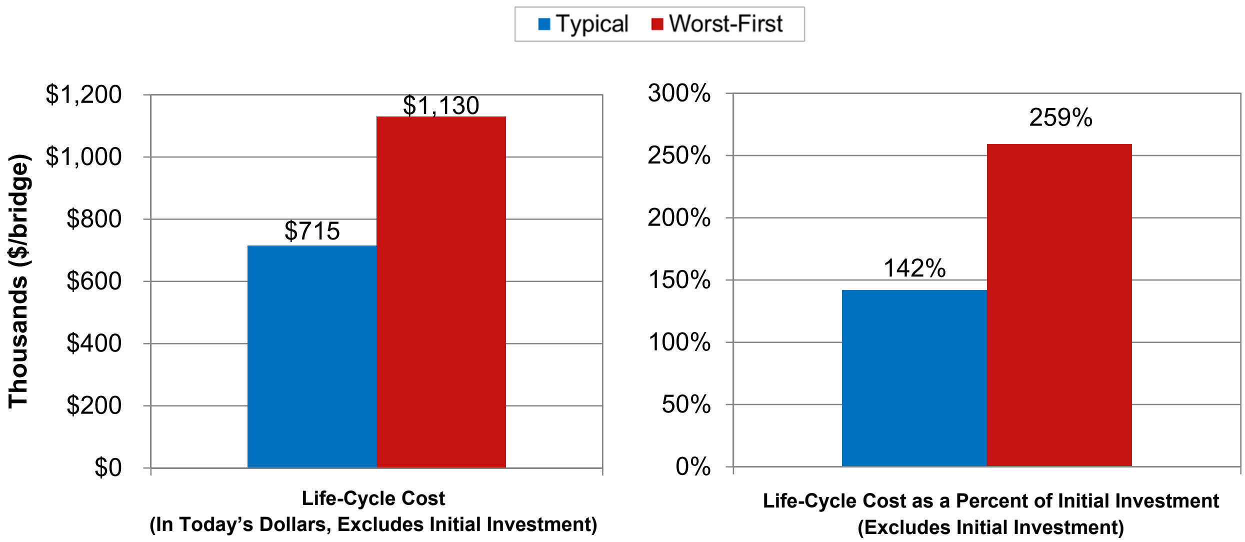
Figure 6-6: (a) Corrosion on a Bridge Structure Element (b) Large Culvert



Culverts [see **Figure 6-6 (b)**] tend to be more durable due to the fact that they are generally protected underground and are manufactured under more controlled conditions. They also deteriorate, but at a slower rate than bridges.

Bridges and large culverts in water are vulnerable to scour of their foundations, vessel collisions, and flood damage. Most bridges have expansion joints and bearings to prevent damage due to temperature changes and motion. These features can sometimes be damaged by the constant pounding of trucks passing over them, corrosion, excessive movement, or intrusion by rocks and other foreign materials. The results of the life-cycle cost analysis for bridge structures highlighting the magnitude of differences in costs for each strategy are shown in **Figure 6-7**.

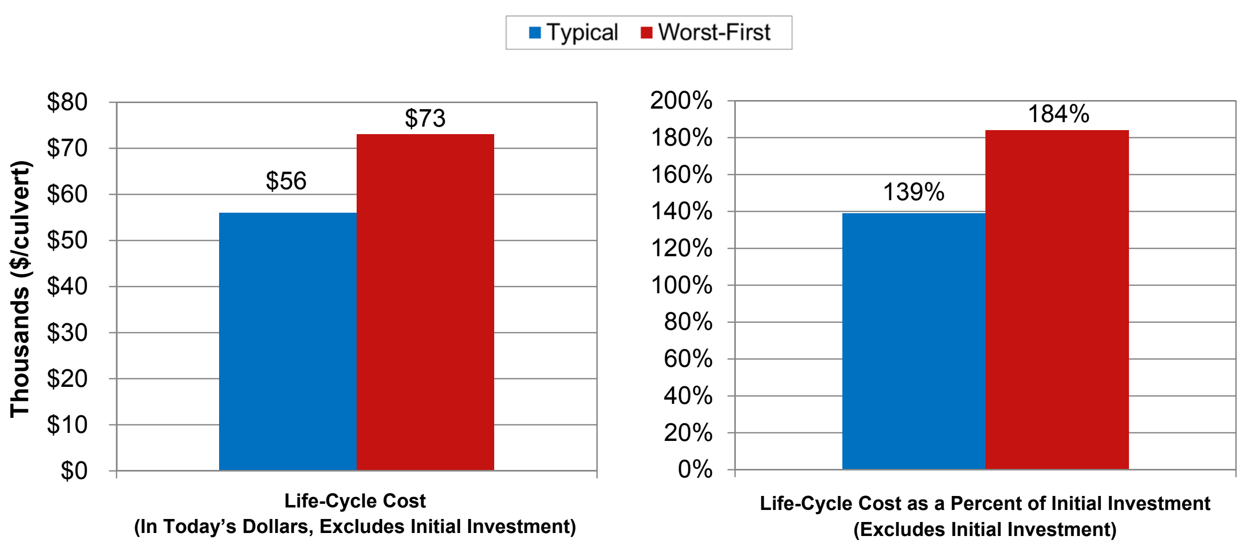
Figure 6-7: Summary of Life-Cycle Cost Analysis Results (Bridges)



MnDOT's typical preventative maintenance strategies extend the average service life of each structure from about 50 years to about 80 years. MnDOT's current policy saves about 37 percent of future life-cycle costs, a savings of $415,000 per bridge or $581 million for the entire NHS inventory over the 200 year analysis period. Small investments in improved asset management can have a very significant return when considering the large bridge inventory. The results illustrate that future costs (maintenance and capital) are approximately 1.42 (typical) to 2.59 (worst-first) times the initial cost of a capital project.

The results of the LCCA for large culverts highlighting the magnitude of differences in costs for each strategy are shown in **Figure 6-8**.

Figure 6-8: Summary of Life-Cycle Cost Analysis Results (Large Culverts)



MnDOT's typical strategy results in a savings of approximately 23 percent of future life-cycle costs, a savings of about $17,000 per large culvert, or $10 million over the inventory. The results further illustrate that future costs (maintenance and capital) are approximately 1.4 (typical) to 1.8 (worst-first) times the initial cost of a capital project.

HIGHWAY CULVERTS AND DEEP STORMWATER TUNNELS

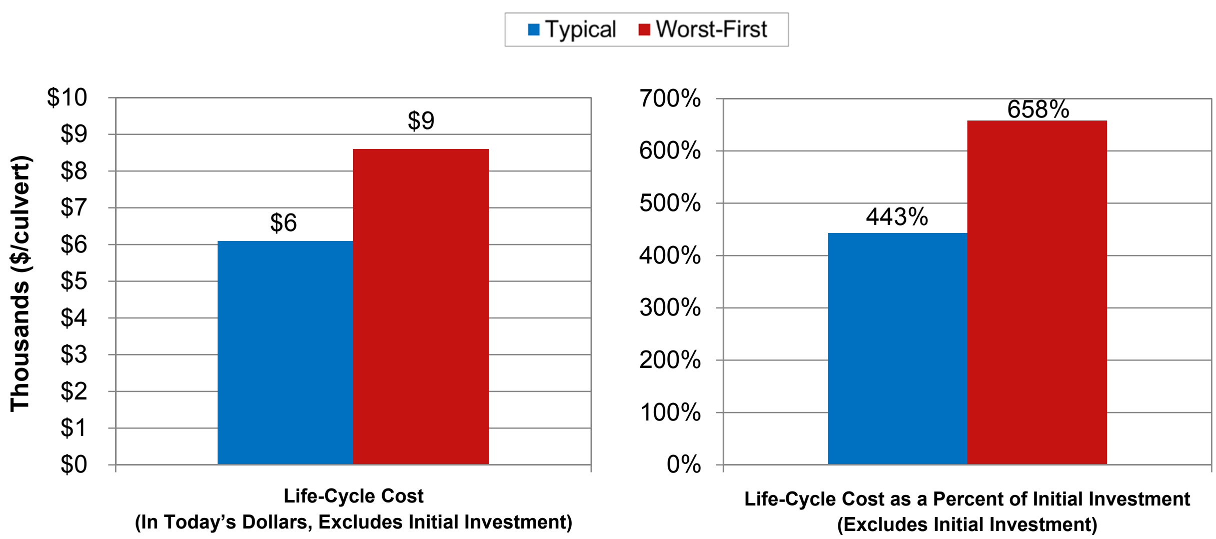
MnDOT maintains an inventory of more than 47,000 highway culverts on the state highway system, which includes NHS and non-NHS highways. These have a replacement value of approximately $1.7 billion. Culverts are inspected on an interval that is based on condition and risk: new assets are inspected every six years, while those in Poor condition may be inspected every year or every other year.

Culverts are flushed about once every 10 years to remove accumulated debris and a small fraction of them receive condition-based repairs as warranted. These assets are manufactured under relatively controlled conditions (compared to bridges) and, in most cases, have a very long life.

Drainage culverts do gradually deteriorate, exhibiting corrosion, settlement, deformation, scour from floods, impact damage, and buildup of debris. One relatively common problem is leakage where water intrudes into surrounding soil and washes it away, creating air pockets. The presence of these pockets tends to accelerate deterioration and can potentially cause a local collapse of the roadway above.

Figure 6-9 shows the results of the life-cycle cost analysis for highway culverts, highlighting the magnitude of differences in costs for each strategy.

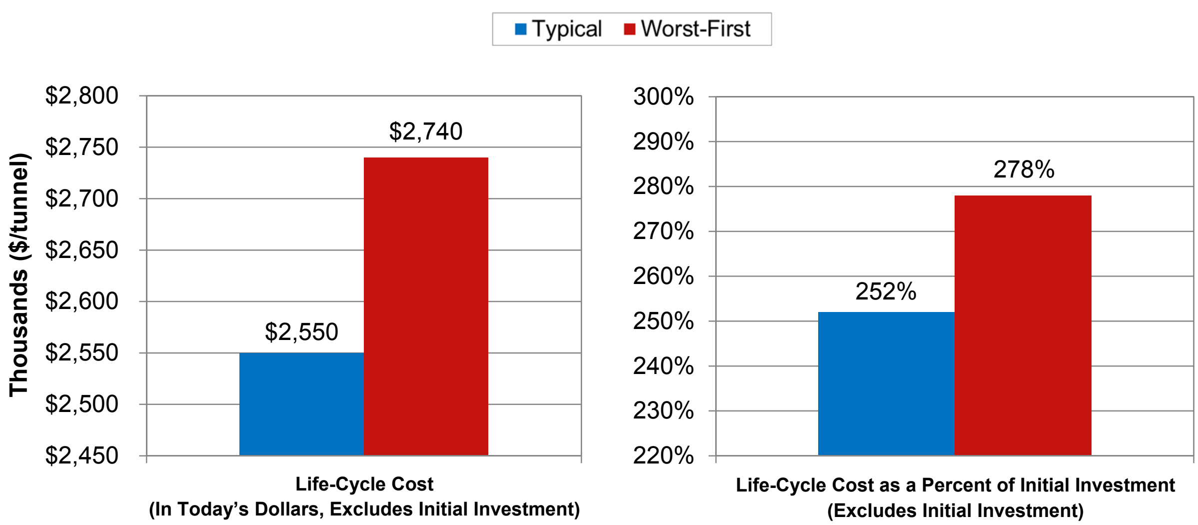
Figure 6-9: Summary of Life-Cycle Cost Analysis Results (Highway Culverts)



MnDOT performs maintenance activities on approximately two percent of the highway culverts per year, including resetting culvert ends, repairing joints, culvert lining, culvert replacement, and paving the lower interior of the culvert. MnDOT's current policy saves about 29 percent of future life-cycle costs, a savings of $2,500 per culvert, or $119 million for the whole inventory over the 200 year analysis period, compared to taking no maintenance action at all. Under these scenarios, the typical service life of both types of culverts is projected to be about 140 years. The future costs (maintenance and capital) for culverts are significant, ranging from 4.4 (typical) to 6.6 (worst-first) times the original cost of the culvert.

The results of the life-cycle cost analysis for deep stormwater tunnels highlighting the magnitude of differences in costs for each strategy are shown in **Figure 6-10**.

Figure 6-10: Summary of Life-Cycle Cost Analysis Results (Deep Stormwater Tunnels)



MnDOT maintains an inventory of 7 deep stormwater tunnels that are comprised of a total of 50 individual segments of varying lengths, covering a total length of approximately 70,000 linear feet. All seven tunnels have had detailed inspection studies completed, which identify specific conditions and repairs. The City of Minneapolis also performs a visual walk-through inspection of tunnels every two years. Tunnel conditions range from Good to Very Poor, with a majority of the segments in Poor or Very Poor condition. It should be noted that data for the LCCA are based on MnDOT's expert opinion and considered to be rough estimates. The best available estimate is that the total replacement value of these assets is approximately $240 million. A reliable maintenance schedule would have benefits similar in relative scale to culverts, but deep stormwater tunnels currently receive little maintenance. The future maintenance costs associated with deep stormwater tunnels range from 2.5 (typical) to 2.8 (worst-first) times the initial cost of the tunnel.

OVERHEAD SIGN STRUCTURES AND HIGH-MAST LIGHT TOWER STRUCTURES

MnDOT maintains an inventory of almost 2,400 overhead sign structures and 476 high-mast light tower structures statewide. Current replacement values of all overhead sign structures and all high-mast light tower structures are approximately $200 million and $19 million, respectively. High-mast light tower structures are inspected on a five-year cycle due to MnDOT's formalized inspection program; a similar program does not currently exist for overhead sign structures. Instead, a less-formalized element-level inspection process and rating system is used for overhead sign structures. As a result of this TAMP process, MnDOT has developed a uniform statewide overhead sign structure inspection form and is working on creating a corresponding statewide inventory and inspection spreadsheet.

Figure 6-11 shows a typical overhead sign structure in the Twin Cities metro area. Unlike pavements and bridges, which are managed through a fairly mature process, protocols for inspection and management of overhead sign structures and high-mast light tower structures are relatively new. Over the last couple of years, MnDOT has invested significant resources to improve the way these assets are managed.

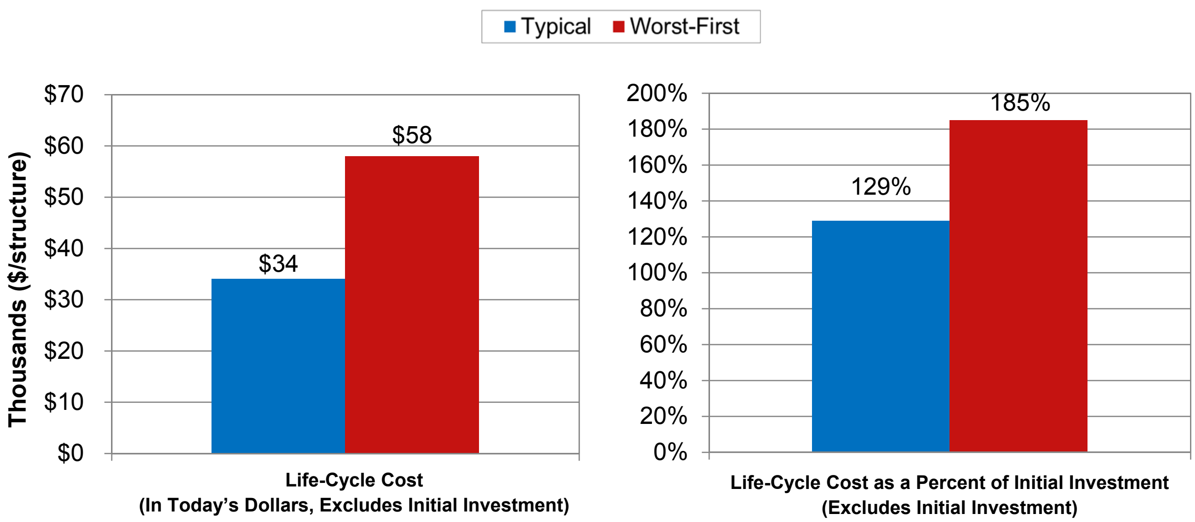
Figure 6-11: Overhead Sign Structure

Typical reactive maintenance activities performed on overhead sign structures include tightening nuts and removing grout. Minor rehabilitation activities performed include re-grading footing, replacing welds, removing catwalks/lighting, and replacing individual elements. Typical maintenance actions perfomed on high-mast light tower structures include tightening and levelling of nuts, removing debris, and replacing components that are not functioning adequately.

Deterioration of these assets results from environmental loading (e.g. winds and other climatic effects like rain, snow, heat) and past improper installation of select components (e.g. nuts not tightened adequately during initial installation).

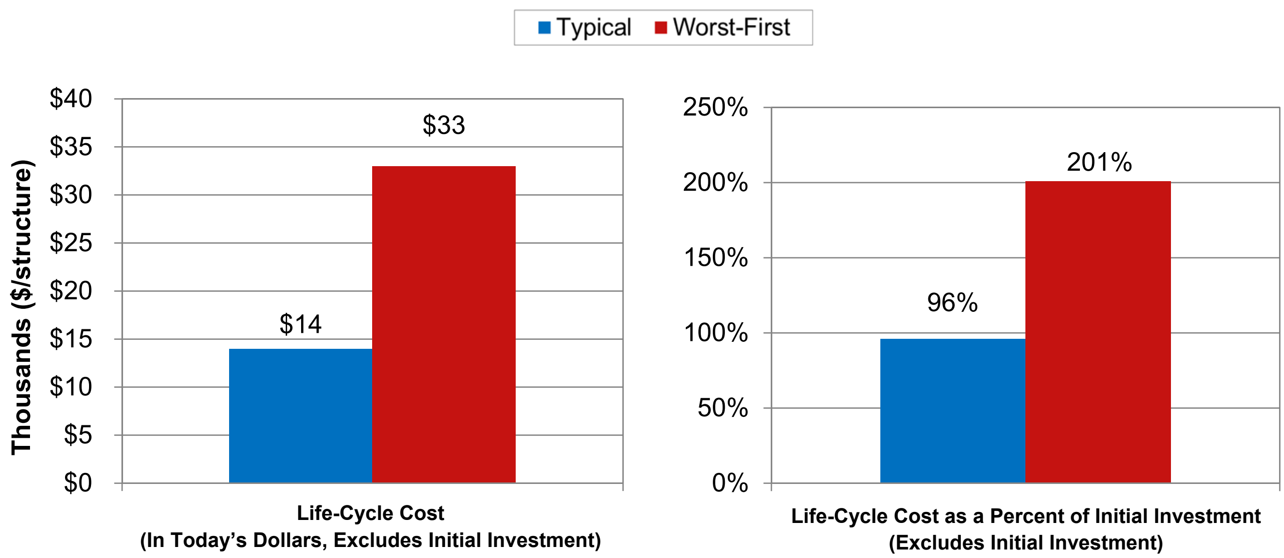
The results of the life-cycle cost analysis for overhead sign structures highlighting the magnitude of differences in costs for each strategy are shown in **Figure 6-12**. Future costs (maintenance and capital) associated with overhead sign structures range from 1.3 (typical) to 1.9 (worst-first) times the initial cost. The condition of the majority of the overhead sign structures is generally Fair to Good. Data for life-cycle cost analysis are based primarily on expert opinion and the best data available.

Figure 6-12: Summary of Life-Cycle Cost Analysis Results (Overhead Sign Structures)



The results of the life-cycle cost analysis for high-mast light tower structures highlighting the magnitude of differences in costs for each strategy are shown in **Figure 6-13**.

Figure 6-13: Summary of Life-Cycle Cost Analysis Results (High-Mast Light Tower Structures)



As with overhead sign structures, expert opinion was used to develop estimates for the maintenance costs associated with high-mast light tower structures. Future inspections and a consistent format for documenting the maintenance work performed on these structures and associated costs will help improve the life-cycle cost estimates. As demonstrated through the analysis, future costs (maintenance and capital) associated with high-mast light tower structures are estimated to range from 0.96 (typical) to 2.0 (worst-first) times the cost of the original structure.

Summary of Life-Cycle Cost Estimates

Figure 6-14 summarizes annualized life-cycle costs for each asset while **Figure 6-15** summarizes system-level, life-cycle cost analysis results by asset.

Figure 6-14: Annualized Life-Cycle Cost Estimates by Asset

ASSET CLASS	ANNUALIZED COST
Pavements	$12,000 per lane-mile
Bridges: Large Bridges	$16,000 per bridge
Bridges: Culverts 10 feet or greater	$1,300 per large culvert
Hydraulic Infrastructure: Highway Culverts	$150 per small culvert
Hydraulic Infrastructure: Deep Stormwater Tunnels	$30,000 per mile of tunnel
Other Traffic Structures: Overhead Sign Structures	$900 per structure
Other Traffic Structures: High-Mast Light Tower Structures	$400 per structure

The information in **Figure 6-14** shows how much it costs per year to maintain an asset when construction, inspection, maintenance, and disposal costs are totalled and divided by the LCCA period (number of years).

Figure 6-15: System-Level Life-Cycle Cost Estimates

ASSET CLASS	REPLACEMENT COST	FUTURE COST: WORST-FIRST	FUTURE COST: CURRENT POLICY
Pavements (NHS)	16,000	15,700	6,600
Pavements (non-NHS)	13,600	13,400	5,600
Bridges	4,000	1,600	1,000
Highway Culverts	1,700	400	285
Deep Stormwater Tunnels	240	140	130
Overhead Sign Structures	200	140	80
High-Mast Light Tower Structures	20	20	10

Note: All amounts are million dollars, in today's dollars

The information in **Figure 6-15** shows that timely preservation work is very effective in reducing life-cycle costs for pavements and bridges, primarily by extending the lifespans of these assets. Currently, MnDOT does not have fully-implemented tools to optimize preservation policies. As a result, it is believed that greater cost savings could be achieved through fine-tuning the timing and application of preservation actions. For assets like overhead sign structures and high-mast light tower structures, routine inspection of the structures to ensure that they are operating as intended is expected to reduce life-cycle costs.

Improving Life-Cycle Management

The primary purpose of life-cycle cost analysis is to answer the question: Which investments, made today, are most cost-effective in the long-term to keep the infrastructure in service? Often, the answer to this question is preventive maintenance or preservation work on assets that are in relatively good condition. Life-cycle cost analysis is used to identify and prioritize the best opportunities and timing for this strategic activity. In transportation asset management, state-of-the art life-cycle management is quantitative and scientific, based on research and analysis of historical condition and performance data. Predictive models for deterioration, cost, action effectiveness, and risk allow an agency to reliably forecast the outcomes of policies and program development decisions. Combined with the ability to generate policy and program alternatives, this approach enables better-informed decision-making.

MnDOT has tools in place for pavements and bridges to help optimize life-cycle management. However, these tools are not fully implemented because either the necessary research for predictive models has not been performed or maintenance costs could not easily be merged with performance data to document the increased costs of maintenance if capital improvements are not performed. However, the agency does have sufficient data to support such research for several of the major asset classes.

During the development of this TAMP, MnDOT developed a set of spreadsheet models to approximate a life-cycle cost analysis. Such models could be extended to make use of research results for any asset class, provided that a complete inventory and routine inspection process is in place. Examples of LCCA spreadsheet models are included in the life-cycle cost section of the **Technical Guide**.

Key conclusions from the LCCA that serve as drivers for improving existing management practices and investment strategies are summarized below:

- Investments in pavement preservation have significantly reduced life-cycle maintenance costs. MnDOT should continue to proactively maintain its pavements and should closely manage preventive maintenance activities for the entire state highway system.

- Strive to lower network life-cycle costs by considering major rehabilitation or reconstruction activities for pavements that are over 50 years old (in lieu of treatments like mill and overlays that become less effective as the pavement structure ages). When funding allows, MnDOT should invest in long-term fixes at the end of a pavement's life. Quantifying the benefits of performing the right fix for roads over 50 years old will allow MnDOT to have considerable life-cycle cost savings. For example, MnDOT's Materials Office works closely with the districts to recommend the most appropriate pavement life-cycle cost fixes at the project level – based on targets, financial commitments, investment strategies, age, and history.

- Invest in research studies to better understand deterioration of bridges, culverts, deep stormwater tunnels, overhead sign structures and high-mast light tower structures, thereby improving the accuracy of long-term investment decisions. For example, the effectiveness of slipliners to extend culvert life is understood only anecdotally, as is the phenomenon of void formation around the culvert joints. Such understanding would help MnDOT select more appropriate maintenance actions and develop new and more effective treatments.

- Make a conscious effort to move from a reactive to a more proactive approach for culverts, deep stormwater tunnels, overhead sign structures and high-mast light tower structures. Overhead sign structures and high-mast light tower structures must be inspected more consistently in order to anticipate problems that other agencies have found to be common, especially fatigue cracking.

- The LCCA demonstrated the ongoing maintenance and capital commitments associated with adding assets to the state's inventory. These costs represent significant future liabilities that are not always accounted for in traditional planning and programming processes. Therefore, MnDOT should develop a process for considering them when contemplating capital improvements.

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Chapter 7

PERFORMANCE GAPS

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PERFORMANCE GAPS

Overview

Asset condition is a critically important component of the highway system's overall performance. Assets that are maintained in a state of good repair support safe and efficient travel and are less costly to operate over an entire life-cycle. MnDOT continuously monitors and reports asset condition using the business practices and performance measures described in **Chapter 3**. This information serves as the basis for MnDOT's preservation driven investment programs and maintenance activities. For pavements and bridges, asset condition is also used to identify performance gaps, defined here as the difference between existing and desired performance.

This chapter presents 2012 condition results alongside target recommendations for state highway pavements, bridges, highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures. These target recommendations provide points of reference for evaluating condition and the adequacy of MnDOT's planned investment. New targets for highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures also have the potential to elevate the importance of these asset categories and provide a basis for developing and evaluating investment strategy alternatives.

STATUS OF TARGETS APPEARING IN THE TAMP

TAMP target recommendations reflect the expert judgment of MnDOT staff and were identified having considered a combination of current policy and investment direction (e.g. MnSHIP), federal and state requirements (e.g. MAP-21, GASB 34), risk, expected or anticipated deterioration, principles of life-cycle costs, and public expectation (as solicited through past planning efforts).

Chapter 2 further described the MnSHIP development process looking at tradeoffs between investment levels, performance levels, and risks to evaluate and select investment priorities. **Chapter 3** described the process outcomes and how they were used to help identify targets and outcomes for pavement and bridge condition.

For non-pavement and non-bridge assets, Work Groups developed asset-specific target methodologies, having considered existing and anticipated future conditions, current information on capital and maintenance investments, anticipated deterioration, and risk. For example, the Hydraulic Work Group identified the number of culverts in Poor and Very Poor condition, determined how many of them deteriorate to a worse condition annually, made judgments on the length of time that a culvert should remain in Poor or Very Poor condition given risk, and determined how many culverts could feasibly be repaired annually. The Technical Guide includes several tables that illustrate how these data were used to calculate targets. A similar methodological approach was followed for recommending targets for overhead sign structures.

Specific targets may be approved, modified or rejected through MnDOT's public planning process and senior leadership review. Approved or modified targets for the asset categories covered below will be used to calculate investment need and guide resource allocation decisions in the next iteration of MnSHIP. These targets will also be used to further develop and refine MnDOT's asset management strategies.

Target Recommendations

As discussed previously, the TAMP uses the terms target and plan outcomes to differentiate between desired outcomes and the outcomes MnDOT plans to achieve within the constraints of available resources. A single number can represent both ideas if MnDOT plans to achieve its desired outcome. In situations where a target and a plan outcome diverge due to insufficient resources, MnDOT uses the target to communicate need, while managing its program and maintenance activities to the plan outcome. This terminology eliminates the need for aspirational and constrained targets, as described in MnSHIP. For further detail on these terms, please see **Chapter 3**.

RECOMMENDED PAVEMENT TARGETS

Figure 7-1 presents MnDOT's existing pavement condition targets, plan outcomes (as reported in MnSHIP), and the new targets recommended in this TAMP.

This TAMP recommends that MnDOT recognize its plan outcomes on the Interstate and non-Interstate NHS as targets for the purpose of defining its desired outcomes and calculating investment needs. While slightly less aggressive than the target used to calculate need in MnSHIP, maintaining Poor pavement condition on no more than two percent of the Interstate System and four percent of the non-Interstate NHS represents a performance standard that is consistent with traveler expectations and MnDOT's strategic goals and objectives.

Off the NHS, this TAMP recommends MnDOT adopt a pavement condition target of no more than ten percent Poor. This target, which is a slightly higher than existing conditions, is less aggressive than the no more than three percent Poor target MnDOT has historically used to calculate needed investment in non-NHS pavement. Adopting a less aggressive pavement condition target on the non-NHS reflects emerging federal and state policy directing MnDOT to focus its resources on priority networks (e.g. NHS). Outreach conducted as part of MnSHIP also found that a majority of MnDOT's external stakeholders are willing to trade pavement condition on low volume roads for continued investment in other performance areas, such as safety, mobility and non-motorized transportation.

Unlike this TAMP's target recommendations for Interstate and non-Interstate NHS pavement condition, a no more than 10 percent Poor target on the non-NHS is not likely to be met under existing revenue projections. MnDOT expects the share of non-NHS roadway miles with Poor pavement condition to increase from 7.5 percent in 2012 to 12 percent in 2023 – a difference of 303 miles. While consistent with MnSHIP investment priorities, this outcome poses significant user costs, risks damage to MnDOT's reputation, and limits the agency's opportunities to manage assets in a cost-effective manner. Adopting this target on the non-NHS supports strategic prioritization while still conveying the idea that there is a gap between MnDOT's desired and planned outcome in this performance area.

This TAMP recommends retiring MnDOT's pavement condition target of 5-9 percent across all state highways. A single statewide pavement condition result is a useful summary reporting tool, but the 5-9 percent target is made redundant by MnDOT's measures of pavement condition on Interstates, the non-Interstate NHS and the non-NHS. These sub-system measures provide a better, more accurate indication of performance because they track more closely with how MnDOT manages and invests in its assets.

Figure 7-1: Existing and Recommended Pavement Condition Targets

		MNSHIP		TAMP	
System	**2012 Condition (% Poor)**	Aspirational Target (% Poor)	Constrained Target/10-year Anticipated Outcome (% Poor)	Target Recommendation (% Poor)	Plan Outcome (% Poor)
Interstate	2.4 %	≤ 2%	2 %	≤ 2 %	2 %
Non-Interstate NHS	4.3 %	≤ 4%	4 %	≤ 4 %	4 %
Non-NHS	7.5 %	NA	12 %	≤ 10 %	12 %

RECOMMENDED BRIDGE TARGETS

As identified in **Figure 7-2**, the TAMP recommends no changes to MnDOT's bridge condition targets. Consistent with MnSHIP investment priorities, MnDOT expects to meet condition targets for both NHS and non-NHS bridges. Compared to current condition, MnDOT expects the share of NHS deck area on Poor condition bridges to drop slightly from 4.7 percent in 2012 to 2 percent in 2023. The share of non-NHS deck area on Poor condition bridges is expected to increase from 2.1 percent to 6 percent, but this remains below MnDOT's target of 8 percent.

Figure 7-2: Existing and Recommended Bridge Condition Targets

		MNSHIP		TAMP	
System	**2012 Condition (% Poor)**	Aspirational Target (% Poor)	Constrained Target/10-year Anticipated Outcome (% Poor)	Target Recommendation (% Poor)	Plan Outcome (% Poor)
NHS	4.7 %	≤ 2%	2 %	≤ 2 %	2 %
Non-NHS	2.1 %	≤ 8 %	6 %	≤ 8 %	6 %

RECOMMENDED HIGHWAY CULVERT AND DEEP STORMWATER TUNNEL TARGETS

Figure 7-3 presents the current condition of MnDOT's highway culverts and deep stormwater tunnels. Performance targets for the condition of these assets were not available during the development of MnSHIP. This TAMP, reflecting the expert judgment of the Hydraulics Work Group, recommends that MnDOT establish targets that no more than eight percent of highway culverts be in Poor condition and no more than three percent be in Very Poor condition. These targets represent a slight improvement over 2012 condition levels. For deep stormwater tunnels, this TAMP recommends that MnDOT establish targets in line with those for highway culverts. This target represents a substantial improvement over current condition; however, a plan is in place to systematically address deep stormwater tunnel needs over the next several years, including within a very large tunnel under I-35W in Minneapolis. Deep stormwater tunnel condition will improve to 23 percent Poor and 11 percent Very Poor as a result of rehabilitating the I-35W (south) tunnel.

Figure 7-3: Existing Conditions and Recommended Highway Culvert and Deep Stormwater Tunnel Condition Targets

		MNSHIP	TAMP	
Asset	2012 Condition	Aspirational and Constrained Target / 10-year Anticipated Outcome	Target Recommendation	Plan Outcome
Highway Culverts	10 % Poor; 6 % Very Poor	NA	≤ 8 % Poor; ≤ 3 % Very Poor	TBD
Deep Stormwater Tunnels	39 % Poor; 14 % Very Poor	NA	≤ 8 % Poor; ≤ 3 % Very Poor	TBD

Note: Investment need identified to meet target; commitment will be determined in MnSHIP

RECOMMENDED OVERHEAD SIGN STRUCTURES AND HIGH-MAST LIGHT TOWER STRUCTURES TARGETS

Figure 7-4 presents the current condition of MnDOT's overhead sign structures and high-mast light tower structures. Performance targets for the condition of these assets were not available during the development of MnSHIP. This TAMP, reflecting the expert judgment of the other traffic structures Work Group, recommends that MnDOT establish a target of no more than four percent of its overhead sign structures in Poor condition and no more than two percent be in Very Poor condition. MnDOT expects the share of overhead sign structures in Poor condition to decline in the future as installation specifications and protocols are put in place.

At the time of the development of this TAMP, MnDOT was in the process of redefining condition rating criteria for high-mast light tower structures and there was insufficient data to appropriately recommend a condition target. A target for this asset category will be revisited during the next update of MnSHIP.

Figure 7-4: Recommended Existing Conditions and Recommended Overhead Sign Structures and High-Mast Light Tower Structures Condition Targets

		MNSHIP	TAMP	
Asset	2012 Condition	Aspirational and Constrained Target / 10-year Anticipated Outcome	Target Recommendation	Plan Outcome
Overhead Sign Structures	6 % Poor; 8 % Very Poor	NA	≤ 4 % Poor; ≤ 2 % Very Poor	TBD
High-Mast Light Tower Structures	6 % Poor; 15 % Very Poor	NA	TBD	TBD

Note: Investment need identified to meet target; commitment will be determined in MnSHIP

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Chapter 8

FINANCIAL PLAN AND INVESTMENT STRATEGIES

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FINANCIAL PLAN AND INVESTMENT STRATEGIES

Overview

When developing investment priorities, MnDOT accounts for various factors that include revenue trends, federal and state law, level-of-service provided by the system, and public input. Over the next 10 years, MnDOT's priorities will aim to balance investments in preservation of the existing infrastructure system with investments in safety, multi-modal transportation, and other projects that improve the economic competitiveness of Minnesota and the overall quality of life for Minnesotans.

Financial trends indicate that revenues have slowed compared to previous decades. As a result, it is imperative that MnDOT look for investment opportunities that provide the best "bang for the buck" in the long term, with the objective of minimizing life-cycle costs. Timely investments in both capital and preventive maintenance treatments help extend the service life of assets while reducing life-cycle costs (discussed in **Chapter 6**). Optimal life-cycle investment strategies are actively pursued when identifying investment priorities. Tradeoffs between investment areas, performance levels, public expectations, and risks play a significant role in MnDOT's ability to achieve lowest life-cycle costs.

This chapter summarizes funding sources, trends, and current revenues, and highlights investment levels and strategies for the asset categories included in this TAMP. It also includes estimates of the investment levels necessary to achieve asset condition performance targets by the end of the TAMP's time horizon (2023).

Revenue Sources

Transportation improvements on Minnesota's state highways are funded by taxes and fees from four main revenue sources:

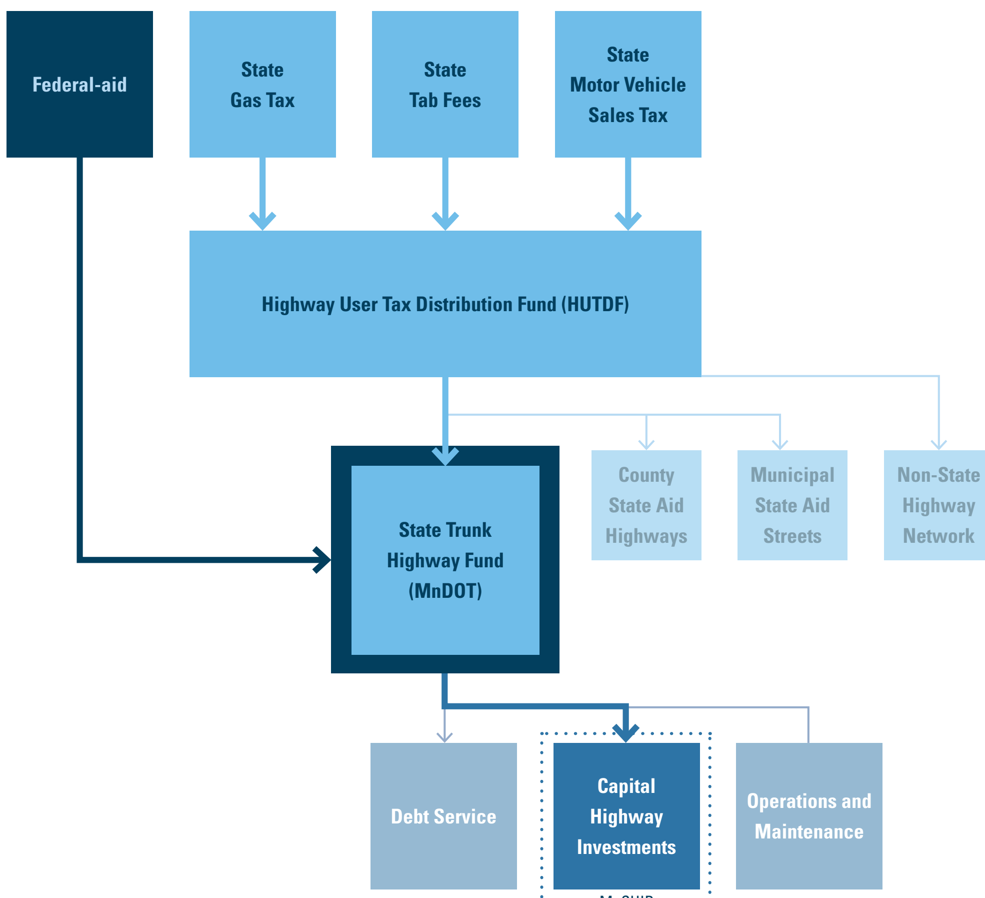
- Federal-aid (gas tax and General Funds)
- State gas tax (motor fuel excise tax)
- State tab fees (motor vehicle registration tax)
- State motor vehicle sales tax

The revenues from Federal-aid go directly to the State Trunk Highway Fund (see **Figure 8-1**), which funds capital improvements on the state highway system. Revenues from the main state sources, as well as various smaller revenues, are pooled into the Highway User Tax Distribution Fund (HUTDF) and divided between state highways, county roads, and city streets based on a constitutional formula.

Approximately five percent of these funds are set aside for the Non-State Highway Network (which includes the Flexible Highway Account, Township Roads Account, and Township Bridges Account). The remaining 95 percent is split among the State Trunk Highway Fund, County State Aid Highways, and Municipal State Aid Streets. The portion allocated from the HUTDF to the State Trunk Highway Fund (62 percent) must first go toward any existing debt repayment and is then divided among operations and maintenance activities and capital improvements on state highways.

In addition to the four main sources of funding, Minnesota also sells transportation bonds to support highway improvements. However, unlike the other revenue sources, bonds must be repaid with interest. The primary purpose of transportation bonds is to enable MnDOT to accelerate the delivery of projects and avoid construction cost increases due to inflation.

Figure 8-1: Revenue Sources and Uses for the Minnesota State Highway Network

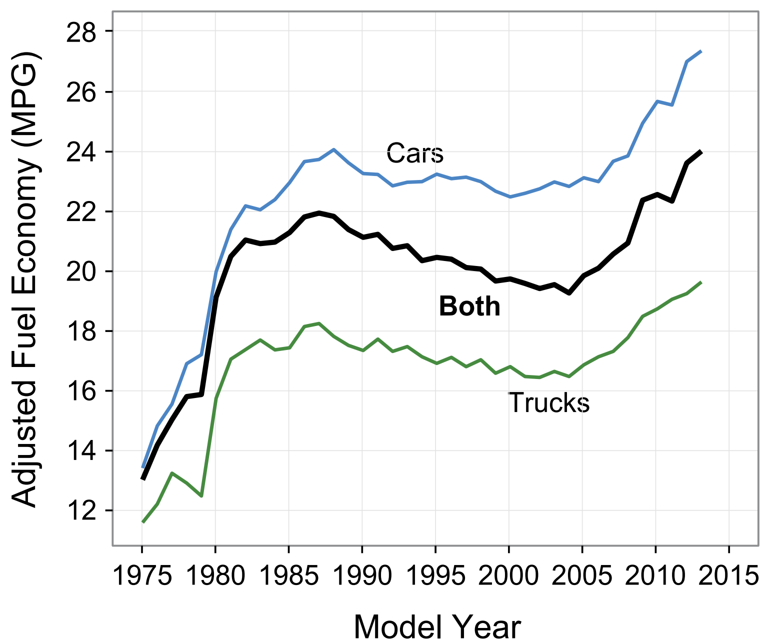


REVENUE TRENDS

Revenue growth has slowed relative to previous decades. There are several explanations as to why MnDOT expects revenues to grow more slowly between 2014 and 2033 as compared to previous years. These include:

- Vehicle fuel efficiency is improving (see **Figure 8-2**). Minnesotans, as well as Americans in general, are driving more fuel-efficient vehicles and consuming less gasoline. Increased fuel efficiency has been required by the federal government through the Corporate Average Fuel Economy (CAFE) program. While lowered emissions have a positive impact on the environment, the increased efficiency results in less funding because the gas tax is one of the major sources of both federal and state revenue.

Figure 8-2: Average Fuel Economy (Miles Per Gallon) by Model Year, 1975-2013[1]

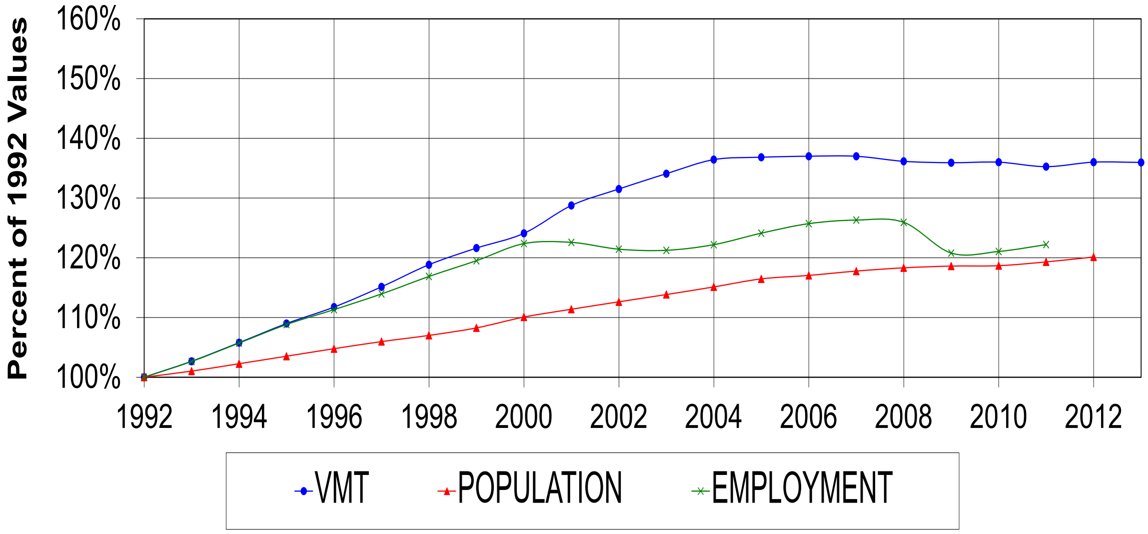


- Due to advances in engine and battery technologies, more conversions are occurring from gasoline to non-taxable energy sources. These conversions ultimately result in a loss of transportation revenue; electric and hybrid vehicles consume less or no fuel and thus contribute less revenue to the State Trunk Highway Fund.

1 US Environmental Protection Agency (EPA): http://epa.gov/fueleconomy/fetrends/1975-2013/420s13002.pdf

- People are driving less (see **Figure 8-3**). While there was significant growth in the number of miles traveled on the highway system in the 1990s and early 2000s, this growth leveled off in 2004 and vehicle miles traveled (VMT) has slightly declined over the last seven to eight years. Total VMT is still expected to increase along with economic and population growth, but per capita VMT is projected to remain relatively flat over the next 20 years due to demographic, technological, and behavioral changes. As a result, it is not likely that state motor fuel excise taxes will grow appreciably. Federal-aid revenues, based on motor fuel excise taxes and transfers from the US General Fund, are also expected to grow slowly over the next 20 years; increases in recent years are far less than in decades past.

Figure 8-3: Trends in Vehicle-Miles Traveled, Population, and Employment in Minnesota



- New vehicle sales have slowed. Consumers are keeping their cars longer, decreasing the amount of revenue generated by the number and price of vehicles sold. This also means lower vehicle registration tax (tab fee) revenues, as these taxes are based on the underlying value of registered vehicles. As the fleet of registered vehicles ages, the state is able to generate less revenue from these sources. MnDOT expects modest annual growth in motor vehicle sales tax and tab fee revenues.

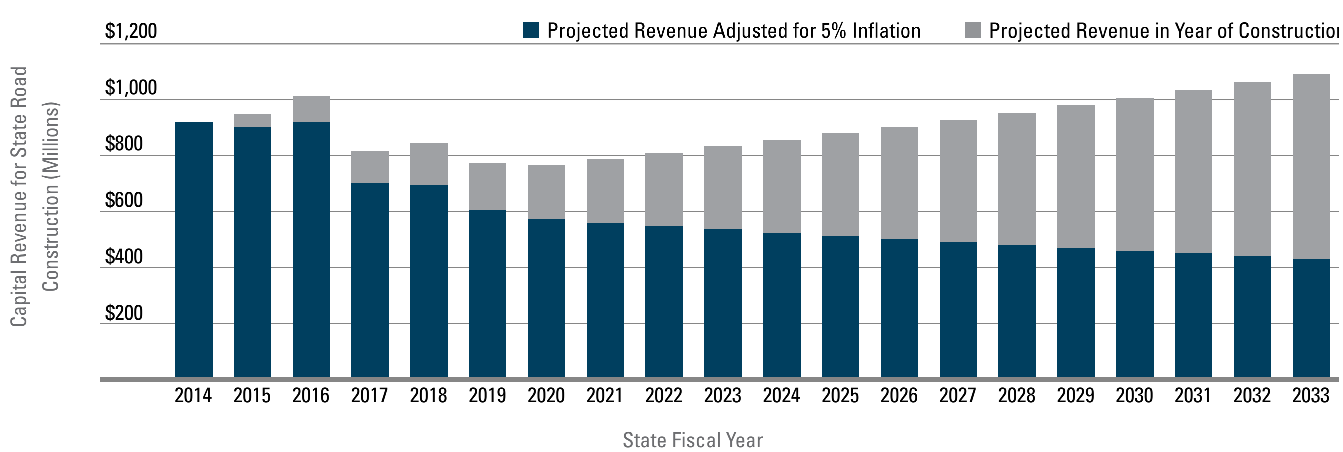
Revenue and Inflation

CAPITAL

Over the next 10 years, MnDOT estimates that $8 billion in revenue will be available for capital investment on the state highway system – approximately $800 million per year. This estimate is based on the assumption that no new major sources of revenue will be introduced and that the majority of MnDOT's future revenues will originate from the four main revenue sources shown at the top of **Figure 8-1**. Furthermore, the estimate assumes that temporary funding sources available over the past five years will have been drawn down or expired completely by the end of the decade. For example, the four-year, $357 million Better Roads for a Better Minnesota program will have mostly concluded by 2015, and the Chapter 152 bond authorization will expire in 2018.

MnDOT does anticipate that the actual amount of funding it receives from the State Trunk Highway Fund will increase on an annual basis over the next 10 years by approximately two percent per year. Unfortunately, however, construction costs are growing more quickly than revenues. Expected revenues will lose buying power over time as construction costs (e.g. fuel, raw materials, equipment, labor) continue to grow at an annual rate of approximately five percent, exceeding the annual revenue growth rate of approximately two percent. This imbalance is expected to persist as a long-term planning challenge for the state. **Figure 8-4** illustrates the impact of five percent inflation on annual buying power (blue) versus nominal revenues (grey) in future years of construction. The net effect is that inflation will erode the buying power of revenues by nearly 60 percent by 2033, given the assumptions stated above.

Figure 8-4: Anticipated Construction Revenue by Year Including Adjustments for Inflation



Operations and Maintenance

MnDOT's current operations and maintenance (HSOP) four-year budget (2012-2015) is approximately $860 million, with an operations and maintenance need of approximately $1.25 billion over this same timeframe. The result is an existing four-year budget gap without inflation of approximately $390 million and $410 million with inflation. Specific to TAMP assets, the current operations and maintenance budget includes $43.9 million for drainage, $19 million for lighting, $107.7 million for smooth roads and shoulders, and $36.5 million for bridge preventive and reactive maintenance, which does not include $21.2 million for bridge inspection and inventory (see **Figure 8-5**). In addition to the HSOP budget, MnDOT's capital program also includes two setasides to complement operations and maintenance activities. The average annual preventative maintenance setaside is approximately $20 million statewide. Each of MnDOT's eight districts also programs an annual Bridge and Road Construction (BARC) setaside, which is typically $2-5 million per district.

Figure 8-5: HSOP Budget Summary and Funding Gap, Specific to TAMP Assets: 2012-20151 (Dollar amounts shown in millions)

INVESTMENT AREA	CURRENT BUDGET	NEED BEYOND CURRENT BUDGET	CURRENT GAP	GAP INCLUDING INFLATION
Drainage	$43.9	$68.0	$24.1	$25.3
Safety and Guidance: Lighting	$19.0	$39.8	$20.8	$21.8
Smooth Roads: Roads	$77.8	$86.0	$8.2	$8.8
Smooth Roads: Shoulders	$29.9	$40.0	$10.1	$10.6
Structures: Bridge Preventative	$16.1	$27.4	$13.0	$13.6
Structures: Bridge Reactive	$20.4	$33.6	$8.6	$9.0
Structures: Other Infrastructure -Inspection/Inventory	$21.2	$26.0	$4.8	$94.1
TOTAL	**$228.3**	**$320.8**	**$89.6**	**$94.1**

Notes: Budget dollars shown in millions over the next two (2) bienniums (2012-2015); Current budget listed as zero (0); item is listed for the purpose of accounting for inflation

As part of the HSOP development process, a more formal Enterprise Risk Management (ERM) approach was used to help determine funding gaps – where additional funding could be directed if money became available. **Chapter 5: Risk Management Analysis** and the **TAMP Technical Guide** provide additional information on ERM. Operations and maintenance funding gaps by investment areas were determined by identifying and ranking investments based on existing budget levels, anticipated risk levels, and current organizational strengths. While this process helped to establish some acceptable risks, it did not compare and prioritize work activities ("tradeoffs") or include life-cycle cost considerations (identified in **Chapter 6**).

Funding Allocation

State and federal laws impose few restrictions on the allocation of funding between system expansion and preservation, or on preservation between various asset categories. At the federal level, the new surface transportation bill, Moving Ahead for Progress in the 21st Century (MAP-21), established new requirements for federal highway programs. MAP-21 expanded the number of highways in the National Highway System (NHS) to include Interstates, most US Highways, and other principal arterials, totaling about 45 percent of Minnesota's state highway system. The bill establishes national goals and requires USDOT to establish performance measures for the NHS in several categories.

For many years, MnDOT has allocated most revenue to its eight districts to make progress toward performance targets and key objectives and to address district-specific risks. With the passage of MAP-21, federal policy and performance requirements direct the majority of federal funds to the NHS. Continuing to allocate all revenue to the districts may not meet statewide NHS targets in an optimal way. In addition, MnDOT must manage the risk that deteriorating state highway assets could negatively affect Minnesota's bond rating. MnDOT developed the Statewide Performance Program (SPP) and District Risk Management Program (DRMP) to respond to these changes.

- The SPP focuses on federal performance requirements identified in MAP-21, which require MnDOT to make progress toward pavement, bridge, safety, and congestion performance targets. Failure to do so results in the loss of some federal funding flexibility. MnDOT's functional and district offices work collaboratively to select SPP projects, which primarily include rehabilitation and replacement fixes for existing pavement, bridges, and roadside infrastructure on NHS roads. The SPP also funds select projects that improve safety and mobility.

- The DRMP focuses on non-NHS highways and addresses unique conditions at the district level. It allocates funding to MnDOT districts, which identify and prioritize projects under this program. However, project selections are evaluated statewide through a collaborative process to ensure that each district is addressing district-level risks while making progress toward statewide goals. DRMP projects focus on pavement, bridge, and roadside infrastructure on low-volume roads, and the DRMP funds the majority of safety and mobility improvements.

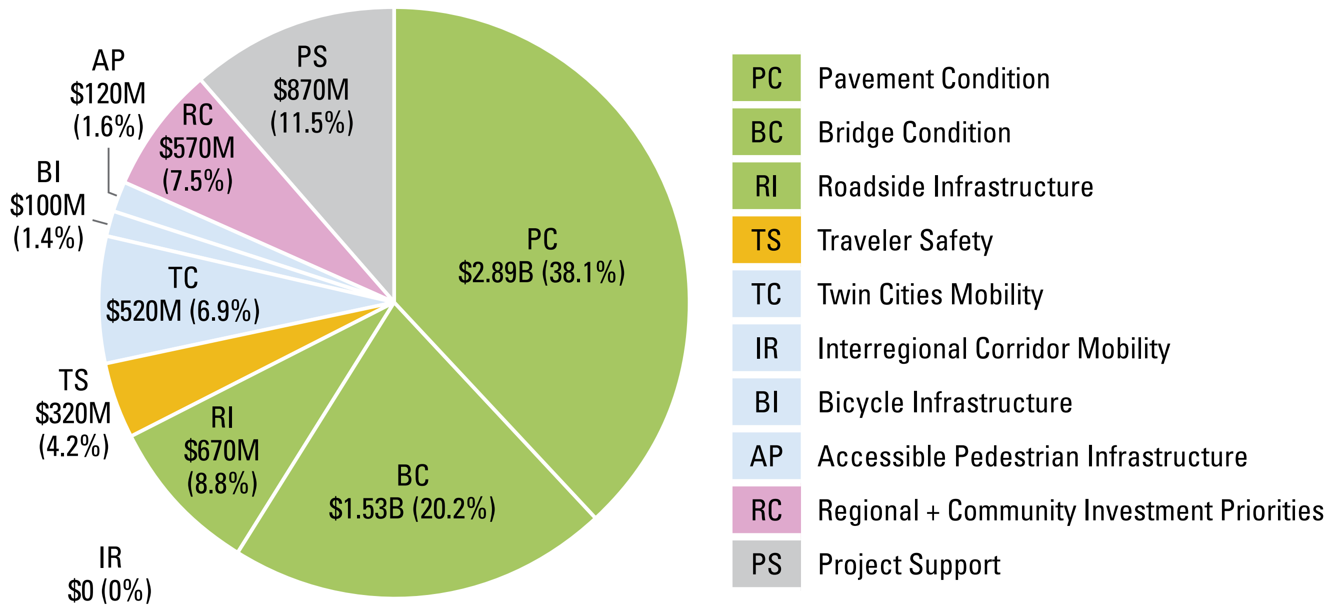
Investment Priorities and Direction

As shown on **Figure 8-6**, MnDOT's primary emphasis for the next 10 years is preservation in all asset management categories – Pavement Condition, Bridge Condition, and Roadside Infrastructure Condition. This will allow MnDOT to achieve multiple objectives through coordinated investments. For example, improving drainage infrastructure, which is part of Roadside Infrastructure Condition, helps pavements last longer. Funding Bridge Condition at a high level of performance supports traveler safety. Investing in Pavement Condition can enhance the bicycle network through shoulder repairs. The MnSHIP development process – including stakeholder involvement, scenario planning, and financial direction – is explained in greater detail in **Chapter 2: Asset Management Planning and Programming Framework** and the **TAMP Technical Guide**.

The Roadside Infrastructure category includes highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures, as well as a number of other asset categories not included in this TAMP. For pavements and bridges, MnDOT anticipates that this investment level is enough to keep conditions stable on the NHS, but not on non-NHS routes.

In 2014-2023, MnDOT is taking an investment direction similar to the approach taken in recent years, which addresses high-priority improvements in all investment categories.

Figure 8-6: 2014-2023 Capital Investments



Asset Investment Strategies

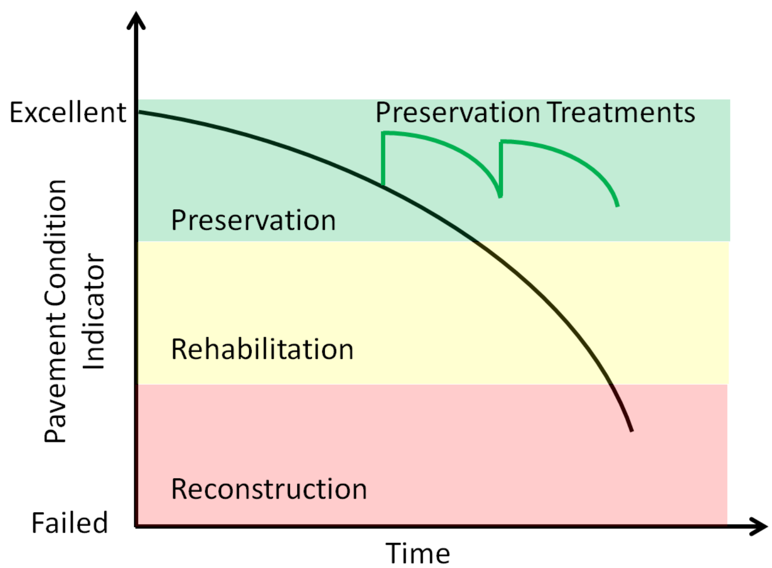
Pavement and bridge conditions in Minnesota are relatively well-understood and -documented according to longstanding condition surveys and databases. Programmed preventive maintenance capital investments are included in model assumptions. Information from the pavement management system is used by the districts to determine the appropriate type and level of repair for each pavement section. Since 2010, MnDOT has been developing, refining, and implementing its Bridge Replacement and Improvement Management (BRIM) system to quantify various risk factors that are appropriate for setting priorities among bridge projects. Each district uses BRIM to help prioritize work. Recently completed inventories and condition surveys are also included in **Chapter 4** of this plan.

Even with these data sources in place, MnDOT cannot fully realize life-cycle costs for its assets. Capital investment decisions identified in **Figure 8-6** do not consider non-capital funded maintenance activities. The life-cycle analysis results in Chapter 6 give MnDOT a great starting point moving forward, but additional work is needed to collect better data on maintenance investments and results. The inability to forecast future conditions that consider all maintenance activities, capital and non-capital, can lead to a less-than-optimal life-cycle investment approach, as illustrated in **Chapter 6**. As a result, MnDOT has an effort underway to better track maintenance investments associated with TAMP assets, which will in turn help the agency work toward achieving optimal life-cycle costs. Other asset-management-enhancing commitments and recommendations identified during the TAMP development process are included in **Chapter 9: Implementation and Future Developments**. When planning for future state highway capital investment needs, MnDOT envisions a more strategic program based on the asset management principles and techniques promoted in this TAMP.

PAVEMENTS

MnDOT's Highway Pavement Management Application (HPMA – discussed in **Chapter 5**) was used to determine the investment needs and outcomes developed for MnSHIP. A conceptual model of typical pavement deterioration is shown in **Figure 8-7**.

Figure 8-7: Conceptual Model of Pavement Deterioration



Though it is well understood that investments in preservation early in a pavement's life-cycle will provide a good return on investment, there are other tradeoffs to be considered when developing a balanced investment plan:

- **Constrained Budget:** Because MnDOT is working with a constrained budget and the fact that maintaining a road in Good condition is most cost-effective (see **Chapter 6**), investments are made to keep as many of the roads in Good condition as possible. This is done through the application of maintenance and preservation treatments for roads in Good and Fair condition and through major rehabilitation and reconstruction activities for pavements in Poor condition. Selection of individual project is based on several factors: average daily traffic (ADT), safety, the economic importance of the highway corridor, public perception, and customer satisfaction.

- **Pavement Age and Condition:** Approximately 50 percent of Minnesota's state highways are over 50 years old, which means that a high percentage of the pavement network will not benefit from preservation treatments; these roads are in need of more substantial rehabilitation or reconstruction. Care should be taken to apply the right type of treatment to the right asset. Pavements are rated based on their vehicle ride quality (see **Chapter 3**). Those with an RQI below 2.0 are typically candidates for major rehabilitation and reconstruction. Routine patching has been identified as a suitable maintenance operation for pavements that have an RQI of 3.2 or higher.

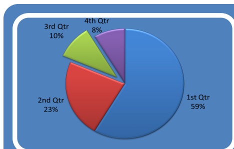
- **Length of Pavement Segment:** When selecting pavement projects, standard MnDOT practice is to combine several adjacent segments and construct one large project rather than doing short stretches; mobilization and logistical costs become expensive for small-scale projects.

- **Performance Targets:** To meet established performance targets, a good portion of the investment has to be made in major rehabilitation and reconstruction activities, which tend to have a greater effect on overall network condition when compared to maintenance and preservation activities.

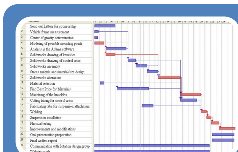
- **Pavement Preventive Maintenance:** MnDOT districts use this capital setaside to fund maintenance activities between major pavement rehabilitation projects in order to help manage pavements at the district level. MnDOT's pavement model assumes that preventive maintenance activities are being addressed.

Between 2014 and 2023, MnDOT identifies capital pavement expenditures of $392 million on Interstate pavements, $1.13 billion on the non-Interstate NHS and $1.38 billion on the non-NHS system, for a total of $2.90 billion. Investments in pavement preservation and operational/routine maintenance will total approximately $35-40 million annually (based on data from 2003 to 2012, provided by the Pavement Work Group). Conditions on NHS pavements will remain stable through 2023. In particular, fewer Interstate pavements will be in Poor condition relative to today. However, the condition of pavements on non-NHS roads will see a drop in performance, in large part to accommodate the federal emphasis on higher-volume NHS roads. The typical strategy used by MnDOT to develop investment levels for pavements is summarized in **Figure 8-8**.

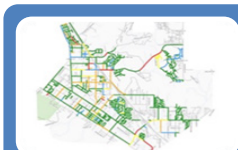
Figure 8-8: MnDOT Typical Preventive/Corrective Actions Investment Strategy for Pavements



Determine initial fraction of statewide system in Good, Fair and Poor conditions

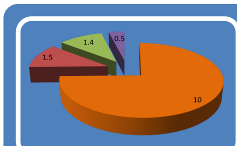


Using a constrained funding level, determine the amount of major rehabilitation and preventive maintenance work required of meet targets



Develop a candidate list of sections for rehabilitation and preventive maintenance to meet targets

- NHS projects are managed through the centrally (at a statewide level)
- Non-NHS projects are managed at the district level



Determine a revised fraction of sections in Good, Fair, and Poor conditions if the candidate sections in step 2 have been addressed

Overall, MnDOT expects projected pavement condition levels to meet assumed MAP-21 requirements and GASB 34 thresholds through 2023. Planned conditions for 2023 are: 2 percent of Interstate pavements in Poor condition, 4 percent of non-Interstate NHS pavements in Poor condition, and 12 percent of non-NHS pavement in Poor condition.

PAVEMENT OPTIMIZATION STRATEGIES

MnDOT will continue applying the following strategies to make the best use of resources when undertaking pavement projects:

- Design and schedule pavement projects to align with a roadway's life-cycle needs whenever possible.
- Use performance-based design to focus on projects that cost-effectively meet both pavement and safety performance needs.
- Continue preventive maintenance strategies, such as seal coats, joint seals, micro-surfacing, and thin overlays.
- Employ lower-cost long-term strategies, such as full depth reclamation or unbonded concrete overlays, to further stretch available dollars.
- Evaluate innovative contracting methods and assess potential advantages of bundling projects in order to lower costs.

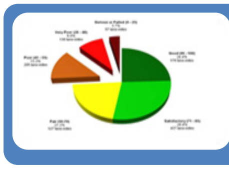
BRIDGES

Investment needs and outcomes for bridges were established using MnDOT's Pontis bridge management system for bridge inventory and condition data, and MnDOT's Bridge Replacement and Improvement Management System (BRIM) for prioritization and cost estimates. BRIM currently places an emphasis on rehabilitation and replacement, but there is an upgrade underway that will better link preventive activities to capital improvements.

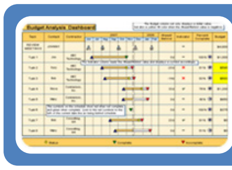
The life-cycle of a bridge offers multiple opportunities for maintenance and life extension. Deterioration from age, traffic, and chemicals is constantly at work to reduce the condition of bridges. Routine maintenance work tends to slow the rate of deterioration, but does not prevent damage from eventually taking place. If timely mid-life repairs are made, conditions can be improved, thus extending the lifespan. Eventually, age and deferred maintenance cause a bridge to slip into a structurally deficient state where only expensive rehabilitation and replacement can restore the needed level of performance.

Approximately $10-15 million is spent each year on routine bridge maintenance and bridge preservation using funds from the operations and maintenance budget. The size of this budget is based on management experience rather than objective analysis. Mid-asset-life preservation actions can be funded from either the operations or the capital budget, depending on the magnitude of the work. This category of work is under-funded and would benefit from improved planning tools to correctly size the budget, select the best candidates for this activity, and produce a more balanced investment plan. The typical strategy used by MnDOT to develop investment levels for bridges is summarized in **Figure 8-9**.

Figure 8-9: MnDOT Typical Preventive/Corrective Actions Investment Strategy for Bridges



Determine initial fraction of bridges in Good, Fair and Poor conditions



Plan and prioritize investments with a risk-based approach.

The primary goal is to meet bridge performance targets (through major rehabilitation) while making appropriate investments on the right type of treatment for the right candidates.

Proactively schedule preventive maintenance and minor repairs to maximize the useful life of bridges and slow rates of deterioration

Invest in larger rehabilitation efforts to improve condition and restore bridge function to acceptable levels

For years 2014-2023, MnDOT envisions capital bridge expenditures of $1.10 billion on the NHS and $48 million on non-NHS bridges, for a total of $1.58 billion. Condition of bridges on the NHS will improve overall, while condition on non-NHS bridges will worsen, but the overall condition of MnDOT bridges is expected to meet or nearly meet performance targets through 2023. As noted previously (and below), MnDOT's bridge condition targets state that no more than two percent of NHS bridge deck area and eight percent of non-NHS bridge deck area should be in Poor condition.

BRIDGE OPTIMIZATION STRATEGIES

MnDOT will apply the following strategies to ensure that its bridges are structurally sound and safe for the traveling public:

- Conduct frequent and regular inspections.
- Invest in preventive maintenance.
- Invest in rehabilitation at appropriate times in a bridge's life-cycle.
- Refine BRIM to help identify improvements that minimize life-cycle costs, meet performance targets, and address the highest-risk bridges.
- Defer some long-term fixes and impose occasional weight restrictions to avoid hazardous conditions, as needed.

HIGHWAY CULVERTS AND DEEP STORMWATER TUNNELS

MnSHIP does not break out the asset categories within the Roadside Infrastructure investment category, but culverts make up the largest portion of this cost. Approximately $300 million is included for capital funding of culvert work through 2023. HSOP also includes approximately $10 million annually for all drainage maintenance, which includes money spent on both highway culverts and deep stormwater tunnels.

Improved programs for flushing, inspection, and repair of culverts would increase the necessary amount of capital and maintenance funding to a total of $400 million over the 10 year period, with an additional $37 million needed for deep stormwater tunnels, given the targets recommended in **Chapter 7** (and below).

OVERHEAD SIGN STRUCTURES AND HIGH-MAST LIGHT TOWER STRUCTURES

In recent years, MnDOT has spent approximately $500,000 annually to maintain overhead sign structures and high-mast light tower structures. These structures exhibit long service lives with minimal maintenance. Their primary modes of failure include wind-induced vibration, fatigue cracking of structural components, corrosion, and collapse of structural support systems. MnDOT has not observed any catastrophic failures of these assets; if the structure was initially installed according to specifications, it seldom exhibits premature component failure. This has been the primary driver for instituting a change in the structure installation specifications (discussed in **Chapter 6** and **Chapter 7**).

The investment strategy for overhead sign structures and high-mast light tower structures has been developed using an approach that considers the fraction of structures with various condition levels and makes a balanced investment according to expert input. For the 10 years from 2014 to 2023, MnDOT envisions capital and maintenance expenditures of $8 million for overhead sign structures. An investment need could not be determined for high-mast light tower structures due to insufficient condition data; this will be revisited in the near future.

MnSHIP also outlines several strategies to maximize future Roadside Infrastructure Condition investment:

- Continue to perform preventive maintenance to extend infrastructure life.
- Coordinate investments with other projects where economies of scale exist to reduce unit costs.
- Manage culverts that have failed or are in the poorest conditions.
- Maintain the most critical supporting infrastructure for pavement and bridge projects.

Summary

Figure 8-10 summarizes planned 10-year capital investments (from MnSHIP) to achieve pavement and bridge targets, as well as investments needed to achieve highway culvert, deep stormwater tunnel, overhead sign structure, and high-mast light tower structure targets.

Figure 8-10: Targets and Planned or Needed Investment to Achieve Targets

ASSET	CURRENT CONDITION	TARGET RECOMMENDATION	INVESTMENT*
Pavement: Interstate	2.4% Poor	≤ 2% Poor	$392 million
Pavement: Non-Interstate NHS	4.3% Poor	≤ 4% Poor	$1.13 billion
Pavement: Non-NHS	7.5% Poor	≤ 10% Poor	$1.38 billion
Pavement: Total	**NA**	**NA**	**$2.9 billion**
Bridge: NHS	4.7% Poor	≤ 2% Poor	$1.10 billion
Bridge: Non-NHS	2.1% Poor	≤ 8% Poor	$430 million
Bridge: Total	**NA**	**NA**	**$1.53 billion**
Hydraulic Infrastructure: Highway Culverts	10% Poor; 6% Very Poor	≤ 8% Poor; ≤ 3% Very Poor	$ 400 million
Hydraulic Infrastructure: Deep Stormwater Tunnels	39% Poor; 14% Very Poor	≤ 8% Poor; ≤ 3% Very Poor	$ 35 million (condition) + $1.6 million (inspection)
Other Traffic Structures: Overhead Sign Structures	6% Poor; 8% Very Poor	≤ 4% Poor; ≤ 2% Very Poor	$8 million
Other Traffic Structures: High-Mast Light Tower Structures	6% Poor; 15% Very Poor	TBD	TBD

*Pavement and bridge figures represent 10 year planned investment to meet targets; hydraulic Infrastructure and other traffic structures figures represent 10 year needed investment to meet targets.

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Chapter 9

IMPLEMENTATION AND FUTURE DEVELOPMENTS

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IMPLEMENTATION AND FUTURE DEVELOPMENTS

Overview

An effective Transportation Asset Management Plan will require regular updates to reflect the dynamic nature of managing a transportation network. For MnDOT, efficient asset management is an established objective within existing policy, investment, and operations plans. Therefore, success will be largely determined by the extent to which the principles and initiatives outlined in this document are incorporated, along with existing plans, into MnDOT's business practices. This final chapter outlines MnDOT's governance approach moving forward, summarizes implementation priorities, and concludes with a set of "lessons learned" during the development of the plan.

TAMP Governance

In accordance with MAP-21, the TAMP development process must be reviewed by the FHWA and certified as meeting the requirements established by the Secretary of Transportation. The process used to develop and maintain the TAMP must be reviewed and recertified at least once every four years; FHWA will identify specific actions that are necessary to correct any deficiencies. Additionally, MAP-21 requires that states make significant progress toward achieving their targets for the National Highway System.

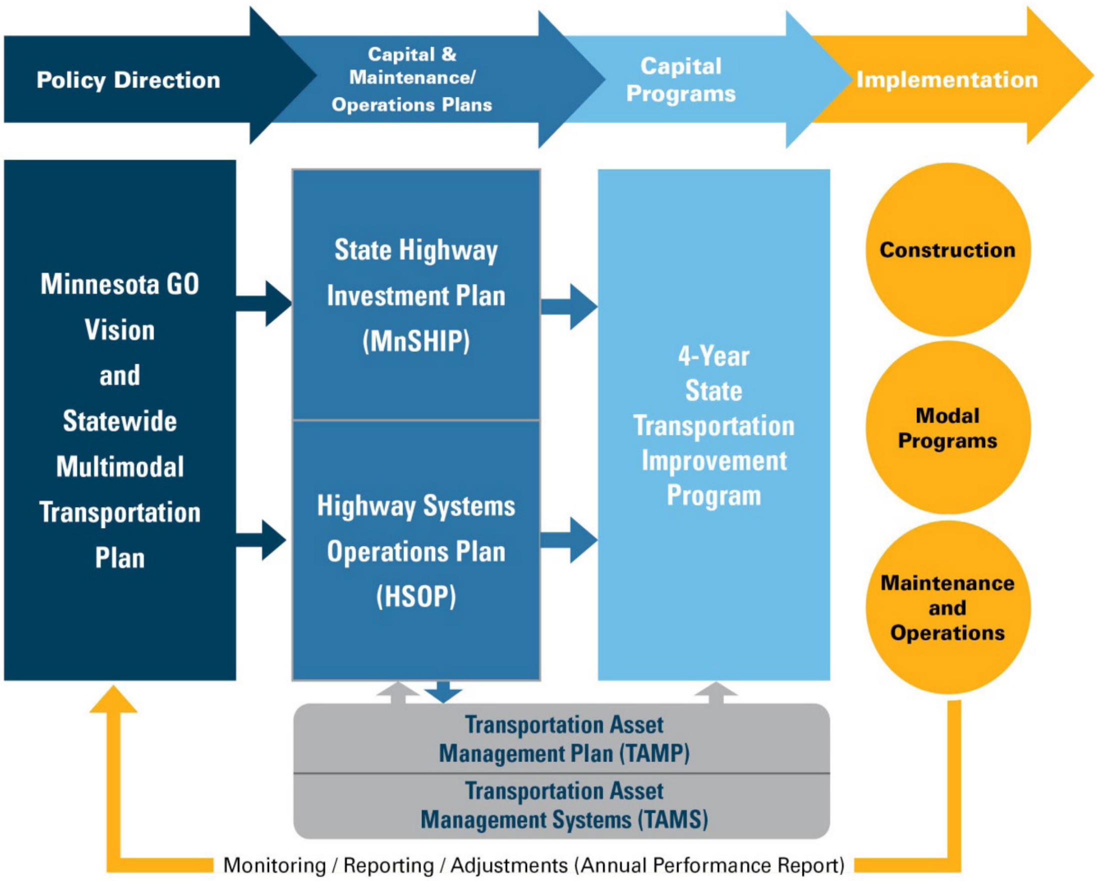
While meeting federal requirements was certainly an objective, MnDOT's primary focus in developing this plan has been to improve the life-cycle management of its transportation assets. Therefore, governance responsibilities must be extended beyond those required under the legislation. They must include plans for expanding the assets that are covered in future TAMPs and for monitoring the agency's success. It was recommended that an Asset Management Steering Committee be established and assigned responsibility for the development, update, and monitoring of the enhancements outlined in the TAMP, and oversight of Transportation Asset Management System (TAMS) development and other asset management initiatives. The Steering Committee will be championed by MnDOT's Modal Planning and Program Management, Engineering Services, and Operations Division Directors, and include representatives from Engineering Services, Transportation System Management, and Operations and Maintenance. Direct communication with Finance; Districts; Traffic, Safety, and Technology; Materials; Bridge; and other asset categories will be important. The Steering Committee will report directly to the Division Director champions and MnDOT's Senior Leadership Team, and meet on a regular basis to address the following:

- Modifying the draft TAMP to address any requirements outlined in the final rules issued by the Secretary of Transportation
- Establishing a regular cycle for updating the TAMP in conjunction with updates to MnSHIP and other relevant documents
- Developing and implementing guidance for expanding the TAMP to include other transportation assets; this guidance should include factors such as:
- Availability of data
- Overall maturity of business processes to support management of the asset
- Importance of preservation actions to maintain the asset
- Funds spent on the asset
- Level of risk associated with asset failure
- Monitoring progress toward performance targets and recommending adjustments

In addition to having responsibility for governance of the TAMP, the Steering Committee would also be assigned responsibility for ensuring that the asset management principles promoted in the TAMP are fully embraced at all levels of the agency to help ensure that the anticipated performance outcomes are met. This will require clear lines of responsibility and accountability for each of the assets included in the TAMP and an agency-wide commitment to completing scheduled inspections for highway culverts, overhead sign structures, and high-mast light tower structures. It will also necessitate timely application of preservation treatments by each district and other strategies to reduce the overall life-cycle cost of managing MnDOT's transportation assets.

The Steering Commitee would also work with several units of the Office of Transportation System Management and the larger Modal Planning and Program Management Division to coordinate the next update to MnSHIP, ensuring that the TAMP recommendations are used to drive future investment plans. The interrelationship between the TAMP and other MnSHIP planning and programming products is shown in **Figure 9-1**. As shown in the graphic (and discussed in **Chapter 2**), the TAMP serves as a link between the long-term statewide plans (such as MnSHIP) and the projects programmed into the STIP and Annual Work Plans.

Figure 9-1: Links between MnDOT Planning and Programming Processes



Implementation Priorities

PRIORITIES IDENTIFIED THROUGH RISK PROCESS

Chapter 5 of this plan explored the concept of risk as it relates to transportation, as it influences planning and management at MnDOT, and as it was incorporated into the TAMP. It also presented a series of prioritized strategies intended to help mitigate identified undermanaged risks – areas in which there are clear opportunities for improvement at MnDOT (see **Technical Guide** for more on the prioritization process). **Figure 9-2** offers more detail on these strategies, including responsible offices, expected timeframes, and estimated implementation costs.

Timeframes and costs were estimated by the TAMP Work Groups but could not be determined with certainty for several of the strategies.

Figure 9-2: Prioritized Strategies for Mitigating Undermanaged Risks

PRIORITY LEVEL 1 STRATEGY	PURPOSE(S)	RESPONSIBLE OFFICE	EXPECTED TIMEFRAME	ESTIMATED COST
Annually track, monitor, and identify **road segments** that have been in Poor condition for more than five years and consistently consider them when programming.	To provide additional information when prioritizing projects; to highlight roads that have been in Poor condition for an extended period of time; to help MnDOT improve level of service for customers statewide	MnDOT Materials Office	1-2 years (to develop)	Approximately $5 thousand (staff time)
Address the repairs needed on the existing South I-35W **deep stormwater tunnel** system.	To improve condition of South I-35W deep stormwater tunnel; to alleviate safety concerns and reduce overall percentage of deep stormwater tunnel system in Poor and Very Poor condition (thereby helping MnDOT meet targets)	MnDOT Metro District; City of Minneapolis	1-2 years (currently programmed)	Approximately $14.5 million (for repairs; funded)
Investigate the likelihood and impact of **deep stormwater tunnel** system failure.	To improve understanding of the likelihood for failure of the deep stormwater tunnel system (located entirely in MnDOT's Metro District) and the likely impacts of such an event; to aid planning and management of the system	MnDOT Bridge Office; MnDOT Metro District	1-3 years	Approximately $150 thousand (for study)
Develop a thorough methodology for monitoring **highway culvert** performance.	To increase availability of information; to develop a systematic and objective methodology to monitor culverts; to manage culverts more effectively	MnDOT Operations	1-2 years (currently underway)	$5-10 thousand (to develop procedures)

Develop and adequately communicate construction specifications for **overhead sign structures** and **high-mast light tower structures**.	To prevent installation problems that lead to premature deterioration and reduced asset life; to ensure that MnDOT inspectors and vendors understand and adhere to requirements (e.g. torque thresholds)	MnDOT Maintenance – Metro District; MnDOT Maintenance – Other Districts	1 year	Approximately $50 thousand (to develop and implement)
Track **overhead sign structures** and **high-mast light tower structures** in a Transportation Asset Management System (TAMS).	To more deliberately and effectively manage these asset categories; to include more assets in TAMS, thereby improving cross-asset tradeoff decision-making	MnDOT Office of Transp. System Management; MnDOT Metro District	2-4 years	TBD
PRIORITY LEVEL 2 STRATEGY	**PURPOSE(S)**	**RESPONSIBLE OFFICE**	**EXPECTED TIMEFRAME**	**ESTIMATED COST**
Collect and evaluate performance data on ramps, auxiliary lanes, and frontage **road pavements** for the highway system in the Twin Cities Metro Area.	To determine current inspection procedure is sufficiently capturing needs; to more effectively manage non-mainline highway pavements	MnDOT Metro District; MnDOT Materials Office	1-3 years	Approximately $200 thousand (for data collection/ analysis)
Augment investment in **bridge** maintenance modules and develop related measures and tools for reporting and analysis.	To develop performance models to predict changes in bridge performance over time; to more effectively manage bridges	MnDOT Bridge Office	1-3 years (currently underway)	Approximately $2 million (software upgrades; funded)
Include **highway culverts** in MnDOT's TAMS.	To more deliberately and effectively manage highway culverts; to include more assets in TAMS, thereby improving cross-asset tradeoff decision-making	MnDOT Bridge Office	2-4 years	TBD
Place pressure transducers in **deep stormwater tunnels** with capacity issues.	To place pressure transducers in deep stormwater tunnels that will collect better capacity-specific data such as pressure impact by water volume	MnDOT Metro District	1-2 years	Approximately $50 thousand

Incorporate the **deep stormwater tunnel** system into the bridge inventory.	To improve regularity of deep stormwater tunnel inspections by adding the tunnel system to the bridge inventory, with inspection frequency tied to reported condition	MnDOT Metro District; MnDOT Bridge Office	1-2 years	TBD
Develop a policy requiring a five-year inspection frequency for **overhead sign structures**, as well as related inspection training programs and forms.	To establish a formal inspection program for overhead sign structures, based on MnDOT's best knowledge of structure condition, deterioration rates, and inspection needs	MnDOT Maintenance – Metro District; MnDOT Maintenance – Other Districts	1 year (currently underway)	$150 thousand (staff time)
PRIORITY LEVEL 3 STRATEGY	**PURPOSE(S)**	**RESPONSIBLE OFFICE**	**EXPECTED TIMEFRAME**	**ESTIMATED COST**
Repair or replace **highway culverts** in accordance with recommendations from the TAMS (once it is implemented).	To improve overall system quality and management; to meet newly established and vetted asset targets	MnDOT Maintenance – Various Districts; MnDOT Bridge Office	10 years	$100 million ($10 million per year)

OTHER PRIORITIES IDENTIFIED DURING TAMP DEVELOPMENT

To further improve its overall asset management practices and achieve lowest life-cycle cost, MnDOT considered factors beyond risk during development of the TAMP. As a result, several overarching business process enhancements have been proposed and are summarized in **Figure 9-3**. Timeframes and costs for these broad improvements have not been estimated.

Figure 9-3: Planned Changes to MnDOT Business Processes

PRIORITY	PURPOSE(S)	RESPONSIBLE PARTY
Establish a single process governing the development of all MnDOT performance measures and targets. Incorporate process into MnDOT's performance-based planning framework.	To promote a consistent approach to performance measurement that is in line with traveler expectations and MnDOT's strategic direction; to provide a mechanism for acting on target recommendations provided in this TAMP	Performance, Risk and Investment Analysis Unit (MnDOT Office of Transportation System Management)
Implement strategies that reduce life-cycle costs for managing assets.	To improve consideration of total cost of ownership in capital investment decisions, including tracking preventive maintenance activities; to re-scope projects to realize life-cycle cost savings (candidate for Investment Opportunity Plan)	MnDOT Office of Transportation System Management
Identify new operational performance targets and reporting protocols covering preventive maintenance.	To ensure that asset-specific preservation activities are being completed on a timely basis; to regularly monitor progress and assess achievement	Asset Management Steering Committee; Operations Division; Materials Office
Evaluate investment impacts across asset categories.	To improve cross-asset decision-making processes by integrating tradeoff analyses (more comprehensive tradeoff analyses will be possible as asset registers and risk assessments are completed for additional asset categories)	MnDOT Office of Transportation System Management
Shift to a corridor management approach.	To more comprehensively consider safety, mobility, and preservation needs when making investment decisions; to select projects based on more than just pavement and bridge conditions	MnDOT (agency-wide)

RESEARCH PRIORITIES

Along with risk-based strategies and overall business process enhancement recommendations, the development of this TAMP illuminated a number of research needs. Such applied research would help MnDOT better understand asset performance and would lead to more informed investment decision-making. These research opportunities could be addressed via formal research studies or by program offices using data available to them. Identified research needs include:

- Overall
- Development of robust asset-specific or network-level deterioration models (for each material type used, if possible)
- Investigation of return-on-investment associated with capital and maintenance expenditures (the probabilities and impacts of not investing in assets are poorly understood)
- Pavements
- Better understanding of performance and benefit-costs of pavement preservation treatments applied in Minnesota
- Improved analysis of maintenance cost data for use in life-cycle costing
- Better understanding of performance of pavement rehabilitation activities (structural overlays, full depth reclamation, etc.) in relation to pavement age and condition
- Bridges
- More complete understanding of bridge performance by type of material (steel, concrete, timber, etc.)
- Better understanding of impact of routine maintenance activities on bridge performance and life-cycle costs
- Hydraulic Infrastructure
- Development of deterioration models for various types of culverts and tunnels
- Better understanding of impacts of various maintenance treatments
- Overhead Sign Structures and High-Mast Light Tower Structures

- Development of deterioration models and more accurate average service life
- Better understanding of impacts of various treatments performed on these structures in varying ages and conditions

Recommended Targets

Another important result of this TAMP development is the establishment of condition targets for asset categories or sub-categories not explicitly addressed in MnSHIP. A summary of these Work Group-developed and Steering Committee-vetted targets is included at the end of the previous chapter (**Figure 8-10**). Many of the implementation priorities discussed in **Figure 9-2** and **Figure 9-3** will directly or indirectly contribute to MnDOT achieving these targets within 10 years (and sustaining them thereafter). For a more detailed discussion the recommended condition targets, see **Chapter 8: Financial Plan and Investment Strategies**.

Lessons Learned

The TAMP development process was beneficial in that it helped formally document the asset management procedures currently being used at MnDOT for managing pavements and bridges. These existing procedures provided a framework for managing additional roadside assets now and in the future. As a result of the TAMP process, MnDOT also has a better understanding of the risks associated with undermanaged assets and is poised to improve many of its business processes.

As other states begin development of their own asset management plans, they may benefit from the following lessons learned during MnDOT's TAMP development process.

1. MnDOT has strong pavement and bridge management programs in place that have been used for years to support agency planning and programming activities. However, even with strong programs in place, several business process improvements were identified that will further strengthen the programs. The development of the TAMP also helped justify improvements that were already underway, such as completing bridge management tools to improve predictions of future conditions and formalizing the inspection of overhead sign structures and high-mast light tower structures to help reduce the risk of failure. For assets without formal management processes in place, such as overhead sign structures, high-mast light tower structures, highway culverts, and stormwater tunnels, the TAMP framework served as a proof-of-concept for expanding the scope of future TAMPs.

2. The process of using existing data to develop the TAMP provided insight into the completeness and reliability of the data and a better understanding of the risks associated with undermanaging the assets. For example, the potential risk of failure associated with the I-35W South deep stormwater tunnel contributed to MnDOT programming $12 million to address needed repairs. Similarly, the plan led to the observation that there are many miles of access roads, ramps, frontage roads, and auxiliary lanes that are not currently being monitored and tracked.

3. Evaluating the life-cycle cost of overhead sign structures led to the observation that most performance issues were related to inadequate construction practices (loose nuts). As a result, new design standards were initiated to eliminate this issue from occurring in the future.

4. MnDOT has a risk management framework for managing agency risks effectively at the enterprise level. By focusing on risks associated with achieving the performance outcomes documented in the TAMP, MnDOT was able to uncover risks associated with undermanaging assets that had not previously been at the forefront, such as the need for prediction models to better manage bridges and the need for a formal inspection process for overhead sign structures and high-mast light tower structures.

5. The multi-disciplinary nature of the Steering Committee and the Project Management Team served MnDOT well because of the different perspectives it provided. Similarly, the formation of the technical Work Groups was instrumental in providing the content required to complete the TAMP. Therefore, the breadth of the team is important to provide guidance, but the technical nature of the TAMP content requires input from in-house technical specialists.

6. The TAMP is intended to provide upper management, elected officials, and the public with a summary of the plans for managing existing transportation assets over a 10 year period. Therefore, the TAMP needs to be written at a fairly high level. However, there is a lot of documentation that should be captured as part of the development process and MnDOT elected to capture that documentation in a separate Technical Guide document that can serve as a reference during future TAMP updates.

Moving Forward

The development of MnDOT's first TAMP has already begun to improve and refine many aspects of the agency's policies and methods related to asset management. By demonstrating the value of life-cycle costing, the TAMP will have a positive effect on future investment decision-making. In addition, the TAMP development process focused attention on data gaps that exist at the agency and led to initiatives aimed at improving the sophistication of data collection and analysis methods. MnDOT plans to continue moving forward with asset management planning in the coming years, with each new task building on previous work and adding additional asset categories, increasing the breadth and precision of data available to decision makers. These and similar actions will help MnDOT achieve its overarching goal of enhancing financial effectiveness. When combined with the forthcoming Transportation Asset Management System (TAMS, see **Chapter 2**), the TAMPs will help guide and improve policy and programming decisions at MnDOT, leading to more efficient and effective management of infrastructure assets and helping the agency meet the high standard of service expected by all Minnesotans.