Minnesota GO
A Collaborative Vision for Transportation

Statewide Highway Systems Operation Plan

2012 - 2015

September 2012

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Chapter 1 Introduction

Welcome to the Minnesota Department of Transportation's (MnDOT) Statewide Highway Systems Operation Plan (HSOP) 2012 - 2015. The HSOP is part of MnDOT's family of plans. The family of plans includes the Statewide Multimodal Transportation Plan and modal system/investment plans (highway capital, highway operations, rail, transit, freight, bike/pedestrian, and aviation). Together, the family of plans establishes MnDOT's policies, objectives, strategies, performance targets, and investment priorities.

The plan provides a framework for managing key operations and maintenance activities throughout Minnesota, supports the Department's Strategic Direction, and complements other strategic planning efforts, such as the MnDOT District Highway Investment Plans, which focus on capital infrastructure needs. In addition, the plan builds on prior efforts for performance-based planning and data-driven decision making.

This plan is divided into five chapters. Chapter 1 introduces the plan. Chapter 2 provides background information on key trends and factors influencing overall operations and maintenance activities. Chapter 3 summarizes each work activity area and identifies key implementation strategies to increase performance. Chapter 4 identifies risk and investment strategies which includes a budget summary and gap analysis. Chapter 5 provides findings and recommendations based on common themes and issues for all work activity areas.

- MnDOT notes several accomplishments since developing the original HSOP in 2005, including increased emphasis on pavement patching. (Positive customer feedback indicates MnDOT is doing a better job in this area.)
- Developed better asset management information in the asset areas of noise walls, bridges, drainage, signing, buildings, and rest areas
- Continued vehicle fleet optimization. For example, the Department recently implemented new engine requirements as well as increased use of alternative fuels and increased fuel efficiencies.
- Implemented low-cost, high-benefit safety improvements (significant investments in signing, striping, rumble strips, and cable median barriers). This continues to reduce serious injuries and fatalities statewide.
- Addressed bridge needs with the bridge maintenance program and the Chapter 152 funding program that accelerated bridge replacement.
- Placed increased emphasis on efficiencies in overall operations. Examples include shared maintenance crews, shared equipment, salt solutions, and improved maintenance activities through innovation.

1.1 Plan Objectives

The Highway Systems Operation Plan (HSOP) 2012 - 2015 has three primary objectives:

1. Expand HSOP into MnDOT's family of investment plans and include it as a chapter in a larger Operations Division Plan.

2. Show maintenance/preservation connections to the Statewide Transportation Policy Plan (STPP), which is a 20-year plan, and tie to MnDOT Strategic Directions (Safety, Mobility, Innovation, Leadership, and Transparency).

3. Document the management of non-capital highway investments for the next two bienniums (short-term); these investments should work toward the long-term operations and maintenance vision, with the goal of being a world-class transportation agency. This Plan should address what MnDOT must prepare for and respond to in the next 10-15 years based on recent trends, the current condition of existing infrastructure, and the public's expectations for a transportation system. This includes:

   - Focusing on maintenance investments and allocating resources.

   - Explaining the complexities associated with maintaining the State's transportation system.

As the HSOP 2012 - 2015 was developed, a risk-based approach was being implemented throughout the Department. As such, an Enterprise Risk Management (ERM) assessment was completed for operations and maintenance activities as part of this plan. The next step in the process includes using the ERM strategy and process to help shape investment decisions and trade-offs in the future.

1.2 Major Themes

The following list identifies major themes for the HSOP 2012 - 2015. These themes tie into MnDOT's Strategic Direction and Guiding Principles, and they frame the vision for operations and maintenance activities over the next two bienniums and beyond.

1. Safety – Systematically and holistically improve safety

2. 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.

3. Seek Innovation – Be proactive, innovative, strategic, and more efficient in operations and maintenance activities.

4. Infrastructure Asset Management – Strategically maintain and upgrade critical existing infrastructure. Create a knowledge base to make decisions using lifecycle costs in the future. Identify inventory degradation and trade-offs for maintenance activities.

5. Understanding System and Cost Trends – Consider and minimize long-term obligations – do not over build. Focus on building only what the Department can sustain with regard to operations and maintenance with a lifecycle approach. The scale of the system should reflect and respect the facility's surrounding physical and social context, and overall quality of life.

1.3 Plan Development Process

The HSOP 2012 - 2015 was developed over a two-year process that included a significant amount of participation from MnDOT's District Operations staff, Office of Maintenance staff, and specialized groups. The plan development was led by a Steering Team and a Project Management Team[1] that included statewide participation and input from specialty offices. Eight Work Teams were formed to investigate and develop maintenance trends, recent mandates and regulatory requirements, performance measures, existing and future service levels, best management practices, benchmarks and/or performance standards.

Each Work Team met numerous times to review and discuss information that was then funneled through a consultant that was responsible for reviewing, organizing, and assisting plan development. The overall process, findings, and recommendations were reviewed and approved by the Steering Team and the Commissioner of Transportation.

The Work Teams were established based on the primary operations and maintenance activities that each performs. The Work Teams are described below.

I. Clear Roads

Ensuring state roadways are operational and levels of service are restored quickly after a snow or other event is important to business and commercial interests as well as other transportation users. Market research indicates snow and ice is one of the highest priority services. This activity involves the work associated with clearing snow and ice on more than 12,000 centerline miles of state highways throughout Minnesota as well as removing debris from roadways year-round.

II. Smooth Roads

Smooth pavements are important to road users because it not only increases safety, fuel efficiency and mobility for motorists, but it also reduces vehicle wear and tear as well as damage to goods moved by the freight industry. Typical activities in this area include pavement preventive maintenance activities, such as crack sealing, and seal coats, as well as reactive maintenance,

[1] See Appendix C for the complete HSOP management structure.

such as pothole repair and patching. Repair and replacement of culverts/drainage systems are also part of this area.

III. Structures

Inspecting and extending the life of structural elements are vital to the safety, mobility, and connectivity of the transportation system. This area has been broadened to include bridges as well as retaining walls, sound walls, sign bridges, cantilever sign structures, and the poles for tower lighting.

IV. Safety and Guidance Systems

Safety and guidance systems include activities and systems that help motorists stay on the roadway surface and within the driving lanes as well as help increase safety and provide for better outcomes should the vehicle leave the roadway. This includes several items: signing, striping, rumble stripes, guardrail and cable median barrier as well as pavement markings and lighting.

V. Arterial and Freeway Operations

Activities in this area focus on user safety, mobility, travel reliability, and signalized arterial systems. User mobility and travel reliability are enhanced by managing peak freeway traffic flows, responding to and clearing incidents quickly, and minimizing lane closures or other capacity restrictions. In addition, this area also includes the management and operations of approximately 630 signalized intersections within the Twin Cities Metropolitan Area.

VI. Roadsides

Roadside activities are an important safety component and include maintaining clear zones, sight lines and snow fences. One of the more visible areas, roadside activities also include mowing, litter control, sidewalk maintenance, and vegetation control.

VII. Fleet and Facility Management

This area focuses on vehicle and building operations and maintenance elements needed to support other core MnDOT work activities. This includes a variety of MnDOT vehicles, roadway equipment, buildings, and other general facilities necessary to perform statewide transportation services. Fleet and facility management also includes all public safety rest area facilities throughout the State.

VIII. Supporting Infrastructure

Communications systems play an important role in delivering transportation services across the 12,000-mile system comprising seven District offices as well as sub-offices and numerous trunk stations. This area focuses on the electronic communications and information technology systems that support these services. This communication system also supports other state agencies, including the state patrol and Department of Natural Resources (DNR).

Chapter 2 Trends

2.1 Major Trends and Influencing Factors

The Minnesota Statewide Transportation Policy Plan 2009-2028 identifies major trends and travel implications for the State of Minnesota. These include a growing, aging and more diversified population; increased global competition; aging infrastructure and declining physical conditions; concern with energy and the environment; and volatile revenues and costs. Operations and maintenance activities are influenced by numerous factors, from costs of raw materials, traffic levels and operations strategies, to weather, regulatory mandates and customer expectations and satisfaction. These are categorized into seven main areas:

- System use
- Economic and cost trends
- System condition
- Operational trends
- Customer expectations and satisfaction
- Regulations and mandates
- Technology, innovation, and research

2.2 System Use

According to data from the 2010 U.S. Census, Minnesota's population increased by 384,433 people, or 7.8 percent, from 2000 to 2010. Population growth is expected to increase with the Minnesota State Demographic Center projecting the State will add another one million people by 2035. Population growth correlates with increased use of the transportation system, resulting in congestion, crashes and infrastructure needs.

As Minnesota grows, it also continues to urbanize. As Table 2.1 shows, Minneapolis-St. Paul and other metropolitan areas have grown at a much faster rate than non-metropolitan areas.

Table 2.1: Minnesota Population Change by Metropolitan Area 2000-2010

Region	Population 2000	Population 2010	Absolute Change 2000-2010	% Change 2000-2010
Duluth-Superior*	232,199	235,612	3,413	1.5%
Fargo-Moorhead*	51,229	58,999	7,770	15.2%
Grand Forks*	31,369	31,600	231	0.7%
La Crosse*	19,718	19,027	-691	-3.5%
Mankato-North Mankato	85,712	96,740	11,028	12.9%
Minneapolis-St. Paul*	2,868,858	3,154,469	285,611	10.0%
Rochester	163,618	186,011	22,393	13.7%
St. Cloud	167,394	189,093	21,699	13.0%
All Metropolitan Areas	3,620,097	3,971,551	351,454	9.7%
Non-metropolitan Minnesota	1,299,395	1,332,374	32,979	2.5%

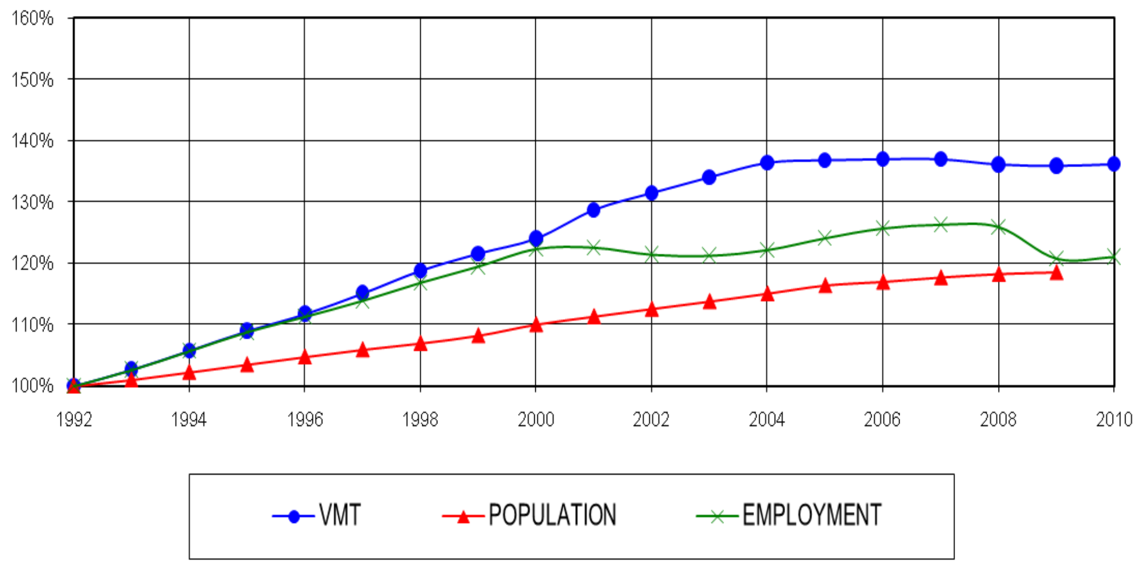
*Only the Minnesota portions of multi-state metropolitan areas are shown.

Source: Minnesota State Demographic Center

System use is represented by vehicle-miles traveled (VMT). Figure 2.1 shows trends in population, employment and VMT in Minnesota from 1992 to 2010. Before leveling off in 2004, VMT was growing at a much faster rate than population and employment. Though the overall VMT trend is flat, the share of travel on state and county roads has declined slightly since 2004, offset by an increase in travel on city streets. Interstates and other trunk highways carry about 58 percent of all travel in the state.

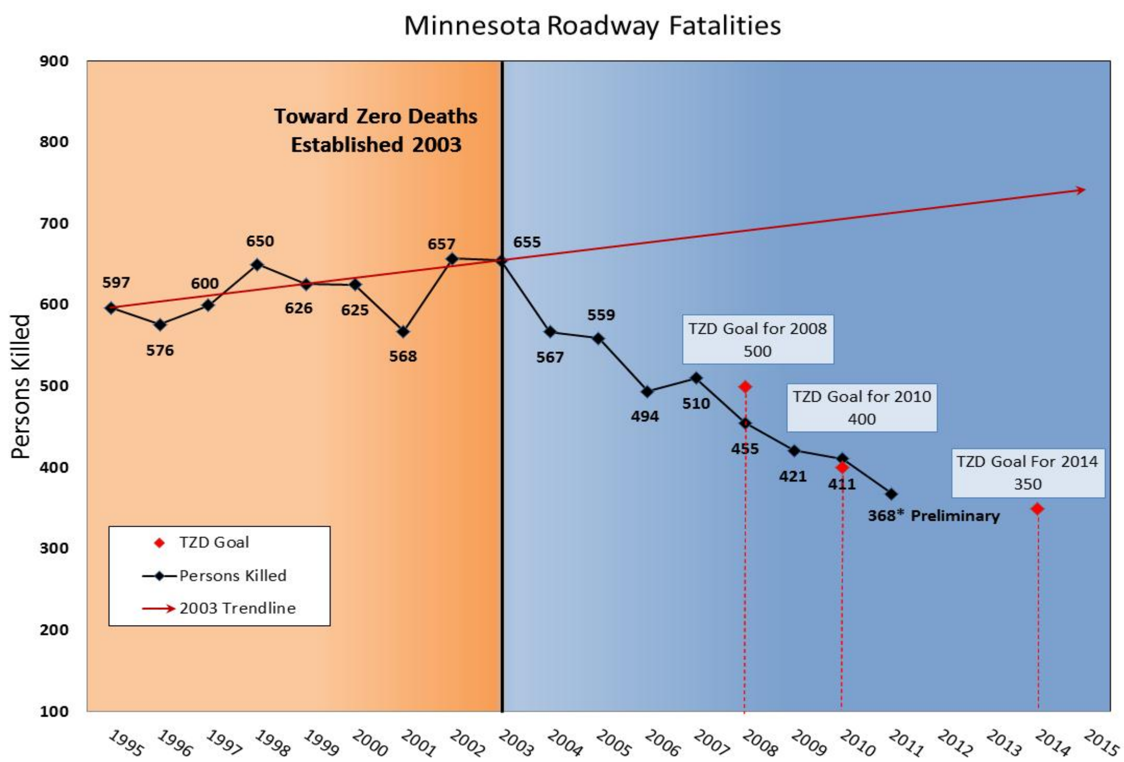
In addition to system use (VMT, population, and employment), roadway fatalities have significantly declined since 2003. Figure 2.2 depicts roadway fatalities since 1995 and associated trend lines. Since the "Toward Zero Deaths" effort began in 2003, the number of roadway fatalities in Minnesota has decreased while VMT has remained flat.

Figure 2.1: VMT, Employment and Population in Minnesota 1992-2010 (Index, 1992=100%)



Source: MnDOT Office of Transportation Data Analysis

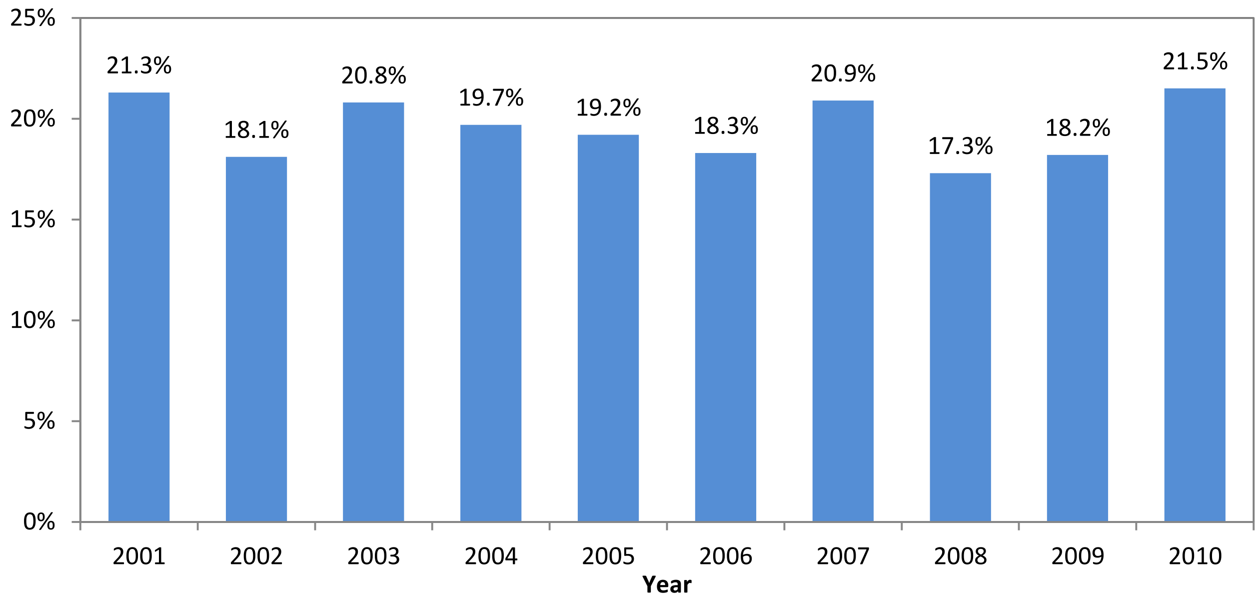
Figure 2.2: Minnesota Roadway Fatalities, Toward Zero Death Goals 1995-2015



Source: MnDOT Office of Transportation Data Analysis

Freeway congestion in the Twin Cities metropolitan area reached a record high in 2010. As Figure 2.3 shows, the duration and extent of congestion are increasing after dropping with the recession in 2008. As volumes increase and facilities are congested for more of the day, maintenance activities must be scheduled to limit traffic problems. This creates a need for more work in off-peak and nighttime hours to avoid significant traffic delays, crash risk, and customer dissatisfaction.

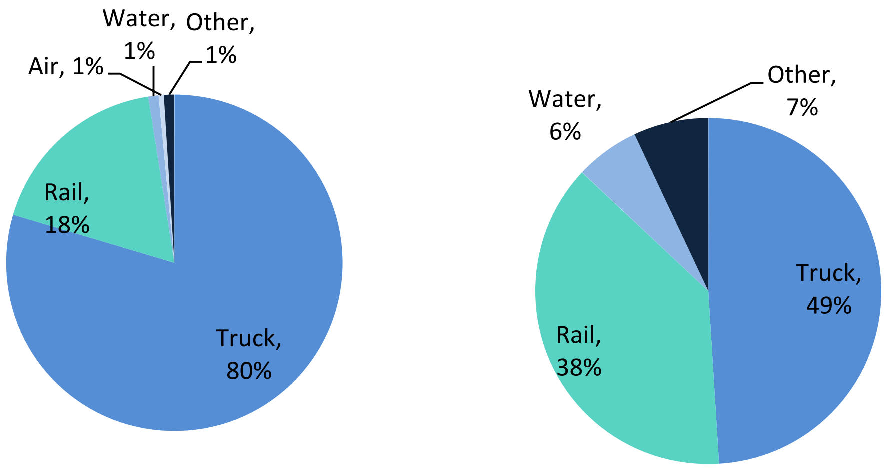
Figure 2.3: Percent of Congested Miles on the Twin Cities Urban Freeway System 2001-2010



Source: MnDOT Regional Transportation Management Center

Between 1980 and 2007, Minnesota's economy grew relative to other Midwest states. The Twin Cities is the third largest economy in the region, behind Detroit and Chicago. Of all national intercity freight shipments in 2007, nine percent by value and five percent by weight passed through Minnesota. As Figure 2.4 shows, trucks carried the largest share at 80 percent by value and 49 percent by weight. Because of geographic conditions and the nature of its industries, rail and waterways carry a higher share of freight by weight than trucks in the United States. However, the majority of the State's truck traffic uses the trunk highway system. Heavy truck use is a major cause of pavement deterioration, resulting in increased maintenance needs.

Figure 2.4: 2007 Minnesota Freight Mode Share by Value (left) and Weight (right)

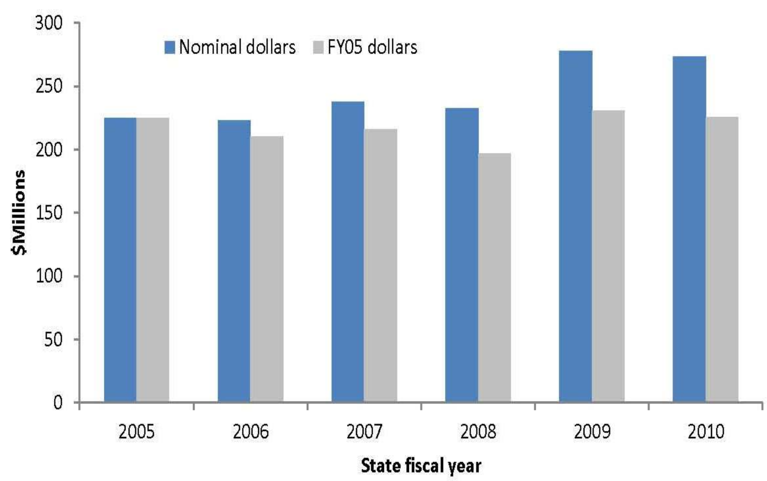


Source: Minnesota Comprehensive Statewide Freight and Passenger Rail Plan

2.3 Economic and Cost Trends

The most important economic trends affecting MnDOT's ability to operate and maintain its system are related to labor, equipment and material prices. Figure 2.5 shows that although spending on maintenance has nominally increased since 2005, in real terms it has remained relatively flat.

Figure 2.5: Operations and Maintenance Spending 2005–2010, including BARC[2]



Source: MnDOT Office of Capital Programs and Performance Measures

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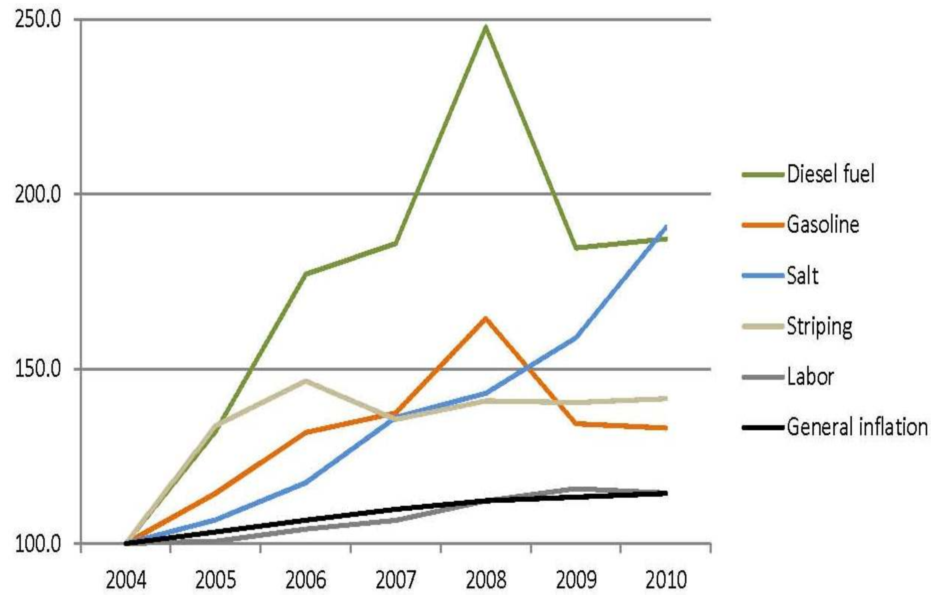
[2] BARC (Bridge and Road Construction) – Money from the Capital Budget that is used for road and bridge repair materials and contracts.

The prices of commodities such as salt, sand, paint, and fuel continue to rise at rates higher than general inflation. Figure 2.6 compares price indices of maintenance materials and labor with the general inflation rate represented by the gross domestic product (GDP) deflator from the U.S. Bureau of Economic Analysis.

Figure 2.6: Commodity Price Indices (2004 = 100.0)



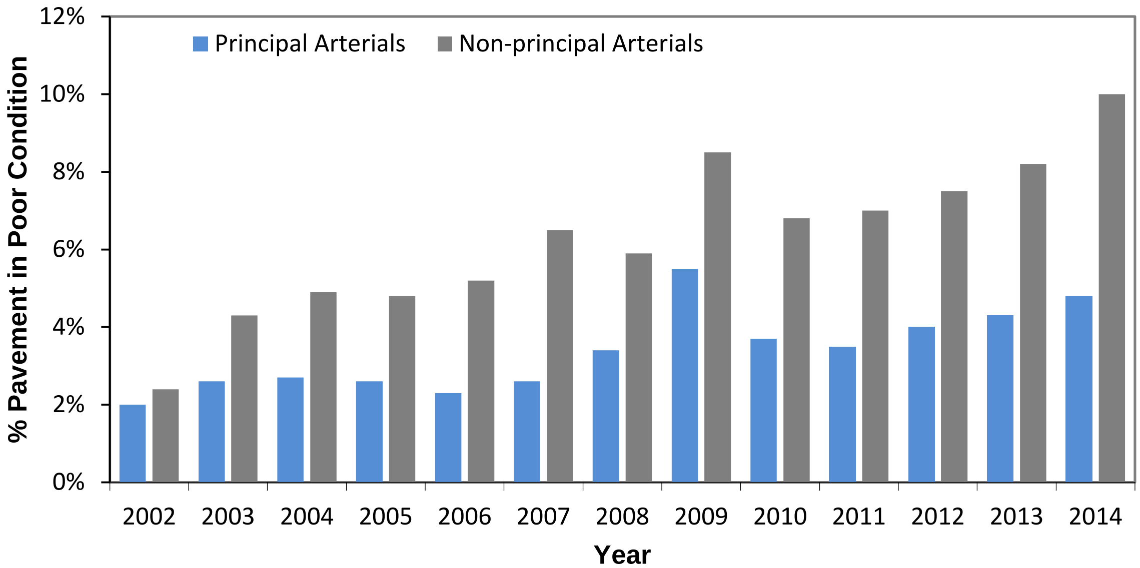
Source: MnDOT Office of Capital Programs and Performance Measures

2.4 System Condition

The share of the state highway pavement in good condition is fairly steady, but the share in poor condition is increasing, especially on non-principal arterials, as shown in Figure 2.7 (percent poor for Principal Arterials has doubled since 2002 and percent poor for Non-Principals is four-times greater than 2002 levels). In general, repairing pavement that has deteriorated to poor condition is more expensive than maintaining pavement in fair or good condition. Declining pavement condition creates an increased need for maintenance and patching.

The number of lane miles on the trunk highway system has increased by about one percent since 2002. The number of centerline miles has decreased slightly as a few routes have been transferred to counties or cities. However, maintenance needs will grow with the addition of interchanges, signals, lighting and other appurtenances to existing trunk highway segments.

Figure 2.7: Percent of Trunk Highway Pavement in Poor Condition (2011-14 projection based on 2011-14 STIP)



Source: MnDOT Office of Materials and Road Research

Note: Principal arterials account for roughly 7,570 miles of the state highway system (approximately 53 percent). Non-principal arterial roadways total 6,740 miles, or approximately 47 percent of the state highway system.

2.5 Operational Trends

The 2010 Metro District Highway Investment Plan and the updated Metropolitan Council Highway Investment Plan mark a shift away from the major capacity expansion projects in previous plans toward a more system-wide, fiscally constrained approach. Active traffic management strategies in these plans incorporate traveler information systems, incident response programs, dynamic signing, and variable speed limits. The infrastructure to support this strategy includes cameras, loop detectors, ramp meters, and changeable message signs.

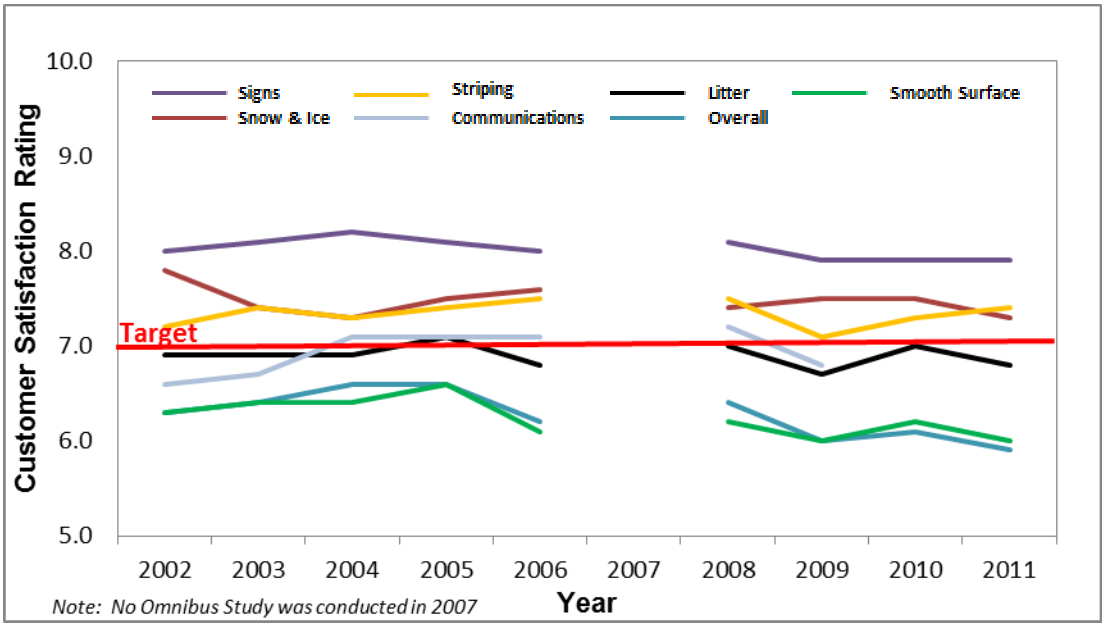
The goal of the traffic management strategies is to enable the movement of more people and vehicles through existing right-of-way. One method of doing this allows buses or general traffic to use the shoulders during peak periods. This reduces the space available along the route for snow storage and increases the importance of clearing incidents quickly.

2.6 Customer Expectations and Satisfaction

MnDOT regularly conducts market research to determine which products and services are most important to the public, and to evaluate how well those are being delivered. Based on recent Quality of Life studies, most maintenance services have positive and stable customer satisfaction ratings. Overall satisfaction with maintenance is heavily influenced by the smooth surface rating. This score rebounded slightly in 2010 after slipping in 2009 and continues to rate the lowest of all the individual services as shown in Figure 2.8.

In addition to the yearly market research outlined above, more in-depth customer market research is completed periodically using MnDOT's online customer community to better understand customer needs and expectations. This research has helped identify appropriate levels of snow plowing and road roughness, and assisted with funding trade-off decisions for non-safety services. Customers consistently rate mowing and eliminating roadside weeds as significantly less important than maintenance of the road itself. Accordingly, MnDOT has reduced efforts in those areas and redirected resources to areas with higher perceived value, such as snow and ice removal, pavement markings, and smooth road surfaces.

Figure 2.8: Customer Satisfaction with State Highway Maintenance (1-10 scale, 10 is best, no survey in 2007)



Source: MnDOT Market Research

In 2007, MnDOT conducted a study of core highway services. The results showed that Minnesota residents have a slight preference for maintenance activities over long-term rebuilding. Day-to-day maintenance ranked as the second priority in the Twin Cities Metropolitan Area and first in Greater Minnesota.

2.7 Regulations and Mandates

Regulations and mandates affect operations and maintenance priorities and processes and procedures within the department. These regulations are intended to increase efficiencies, increase user and worker safety, limit environmental impacts, address the spread of problem plants and pests, and provide reasonable transportation accommodations for people with disabilities. In most cases, these regulations result in increased costs.

Below are a few examples of regulations and mandates that affect MnDOT:

- Fleet type (e.g. flex-fuel vehicles)
- Chemical usage
- Roadside mowing
- Noxious weeds
- Pest control
- Endangered species
- Clean Water Act
  - Municipal Separate Storm Sewer System (MS4) – Pollution Control Act (PCA)
  - Total Maximum Daily Loads (TMDL) – Watershed Requirements
- Americans with Disabilities Act (ADA)
- Retro-reflectivity
- Bridge inspection certifications and maintenance
- Governors Initiatives
  - Achieving a 20 percent reduction in energy use for all state-owned buildings
  - Achieving a 25 percent reduction in workplace injuries over the next three years

2.8 Technology, Innovation, and Research

Maintenance performance is improved through MnDOT's maintenance research program and commitment to new technology. A recent example related to snow and ice is a chemical blending station that mixes liquid chemicals and salt, enabling de-icing material to work better in lower temperatures. One example of technology improving summer maintenance efficiency is the road groom, which saves fuel and can maintain three times as many lane miles per day than a conventional motor grader. Other best practices that have been replicated across multiple MnDOT districts include automatic pothole patchers, pre-wetting of winter materials, and underbody snowplows.

MnDOT's Research Services and the Office of Maintenance focus on various aspects to enhance and improve operations and maintenance. MnDOT is involved with several national, international, and multi-state research partnerships to identify new practices and procedures. A partial summary of MnDOT's recent research projects and information is located in the Research Services 2010 Annual Report (http://www.dot.state.mn.us/research/annual-reports/2010/mndot-research-services-2010-annual-report.pdf).

MnDOT also has a unique maintenance, operations, and research program that focuses on identifying and applying real-world solutions to highway maintenance operations. A summary of this effort can be found in the 2009 – 2011 Statewide Biennial Maintenance Operations Research Report (http://www.dot.state.mn.us/maintenance/research/files/mor_bull/ResearchReport%202009-2011.pdf).

In addition, MnDOT also has several innovative programs and committees that implement the best practices and techniques developed. Examples of these include:

1. Destination Innovation
2. Innovative snow management practices
3. Americans with Disabilities Act (ADA) compliance
4. Maintenance Decisions Support System (MDSS)
5. Automatic Vehicle Location (AVL) systems

Chapter 3 Operations and Maintenance Performance Areas

3.0 Introduction

MnDOT has made a significant effort to develop performance measures and track performance of key operations and maintenance activities. The HSOP 2012 - 2015 provides an opportunity to revisit and improve existing measures, identify new measures when needed, assess data and reporting issues, and evaluate the operations and maintenance financial picture.

3.0.1 HSOP Work Teams Overview

MnDOT performs a variety of operations and maintenance activities. These range from obvious tasks, such as snow and ice removal, to less commonly known activities, like providing electronic communications and building maintenance. As part of the HSOP 2012 - 2015, a holistic review of the primary operations and maintenance duties includes the following work areas:

Primary work activities:

A. Clear Roads

B. Smooth Roads

C. Structures

D. Safety and Guidance

E. Arterial and Freeway Operations

F. Roadsides

G. Fleet and Facility Management

H. Supporting Infrastructure

While this review includes a wide range of activities, it does not capture all work areas that fall under operations and maintenance. One area not included is Administration. MnDOT's Administration staff performs many of the daily tasks and activities that keep MnDOT operational. This includes addressing human resources needs and maintaining workforce compliance information. This involves processing paperwork for new, temporary, and retiring employees among others employed by the Department. While these services are fundamental to MnDOT's overall success, they are not specifically documented in this HSOP.

3.0.2 Performance Targets

One of the critical aspects of managing activities using a performance-based approach is the setting of performance targets. In setting performance targets, both trend-based and policy-based targets are used. Trend-based targets are used if good data is available to estimate levels of performance based on extrapolation of historic information. Policy-based targets may be set when good information is lacking or the objective is based more on a policy objective or user expectations. In addition, national benchmarks, accepted or standards of practice, and/or benefit-cost comparisons were used to evaluate current practices and effectiveness of activities.

Targets should be realistic. Setting targets too high can lead to over-investment and inefficient use of scarce resources, while setting targets too low can lead to under-investment and a failure to meet user expectations and provide for safety.

There are two important cautions with respect to target-setting. First, when only a limited number of historical baseline points are available (limited data); trend-based projections are used as more of a reference than a predictive tool. Over time, as more data is collected, and as more experience is gained with specific measures, better predictive tools should be developed. Second, there is a significant correlation between the level of capital investments for roadway and bridge reconstruction and rehabilitation, and the level of maintenance. If the system is allowed to age without capital investments for system replacement/rehabilitation, more maintenance will be needed to keep the system functioning. Finally, there are some capital investments that have higher ongoing operations and maintenance costs. The recent trend has been to limit ROW and costly capacity expansions (i.e., increase effectiveness of current system); oftentimes this has implications for operations and maintenance with additional guardrail, traffic signals and other operational costs.

MnDOT currently tracks and monitors several performance measures. Many of these are included in the 2011 State Road Operations and Maintenance Performance and Investment Snapshot, which provides people a quick reference on areas/activities performing well and conversely, those that are not. This information is shown on the following page in Table 3.1.

Table 3.1: 2011 State Road Operations and Maintenance Performance and Investment Snapshot

2006-2010 State-Wide Performance	2006	2007	2008	2009	2010 Current	Target	2006-2010 Trend	2010 Performance by District: 1	2	3	4	6	7	8	M	Investment: FY2006	FY2007	FY2008	FY2009	FY2010
Overall State Highway Maintenance																				
Public satisfaction with maintenance (scale of 1-10)	6.2	—	6.4	6.0	▲ 6.1	7.0														
Smooth Roads																				
Pavement patching - Total lane miles with surface rating of 3.2 or less	7,866	8,609	9,482	8,794	9,944	Indicator of system need		1,844	1,078	978	1,342	1,644	1,322	910	826	$9.7M includes $468k BARC	$9.6M includes $320k BARC	$10.4M includes $1.2M BARC	$12.0M includes $1.3M BARC	$11.9M includes $780k BARC
Pavement patching - Percent of need addressed	—	—	—	79%	● 98%	90%		89%	100%	100%	93%	100%	100%	100%	100%					
Pavement - Public satisfaction with smooth ride, scale of 1-10	6.1		6.2	6.0	▲ 6.2	7.0														
Drainage infrastructure inspection - Completion of annual culvert inspection cycle	—	—	—	65%	72%	100%		78%	86%	73%	53%	81%	54%	83%	68%	$7.7M includes $297k BARC	$8.2M includes $182k BARC	$8.8M includes $856k BARC	$12.7M includes $1.5M BARC	$11.9M includes $709k BARC
Drainage infrastructure maintenance - Percent of Condition 4 pipes repaired or replaced annually	—	—	—	20%	24%	NA		19%	39%	36%	12%	30%	9%	21%	14%					
Bridges																				
Routine bridge inspection - Percent completed on time (within 30-day grace period)	—	86%	89%	94%	▲ 99%	100%		● 100%	● 100%	● 100%	▲ 99%	● 100%	● 100%	● 100%	▲ 98%	$2.1M includes no BARC	$2.1M includes no BARC	$7.1M includes $4k BARC	$4.1M includes no BARC	$4.6M includes $1k BARC
Fracture critical bridge inspection - Percent completed on time (within 30-day grace period)	—	100%	100%	99%	▲ 99%	100%		Fracture critical inspections coordinated on statewide basis												
Bridge reactive maintenance - Percent of high priority items complete within 12 months	—	—	—	54%	▲ 89%	100%		▲ 98%	● 100%	● 100%	● 100%	● 100%	▲ 94%	● 100%	▲ 85%	$2.4M includes $114k BARC	$2.3M includes $65k BARC	$4.7M includes $471k BARC	$5.1M includes $511k BARC	$5.6M includes $283k BARC
Bridge preventive maintenance - Percent of strip seal joints in good condition	91%	91%	92%	92%	92%	95%		96%	88%	98%	97%	98%	91%	98%	88%	$2.9M includes $112k BARC	$6.0M includes $475k BARC	$2.6M includes $254k BARC	$2.5M includes $211k BARC	$2.8M includes $283k BARC
Bridge preventive maintenance - Percent of poured joints in good condition	77%	77%	77%	76%	74%	87%		67%	88%	92%	94%	91%	63%	82%	63%					
Bridge preventive maintenance - Percent of crack seals in good condition	54%	56%	59%	59%	51%	80%		61%	90%	67%	91%	72%	55%	79%	37%					
Clear Roads																				
Snow and ice removal - Frequency of meeting bare lane target (for season beginning in year shown)	79%	75%	68%	79%	● 79%	70%		● 79%	● 82%	● 84%	● 73%	● 81%	● 81%	● 72%	● 82%	$50.9M	$52.5M	$57.2M	$72.3M	$63.4M
Customer satisfaction with snow and ice removal, scale of 1-10	7.6		7.4	7.5	● 7.5	7.0														

Legend: ● At or above target ▲ Moderately below target ● Seriously below target

▭ Customer measure from omnibus survey (Not taken in 2007) — No measure/data not collected

BARC = Bridge and Road Construction

Table 3.1 (Continued): 2011 State Road Operations and Maintenance Performance and Investment Snapshot

2006-2010 State-Wide Performance

	2006	2007	2008	2009	2010 Current	Target	2006-2010 Trend
Traffic Management							
Incident clearance time - Metro freeways (in minutes, 3-year average)	38.8	37.3	37.2	37.7	NA	35	
FIRST coverage - Percent of metro freeway miles	77%	76%	63%	63%	63%	100%	
Metro signal retiming - Percent of signals on major corridors retimed within three years	31%	47%	60%	71%	△ 68%	80%	
Metro signal retiming - Percent of signals on minor corridors retimed within five years	5%	28%	34%	44%	△ 43%	80%	
Pavement marking - Percent tech memo compliance	99.4%	99.7%	99.6%	99.7%	🟢 98.5%	100.0%	
Pavement marking - Public satisfaction, scale of 1-10	7.5	—	7.5	7.1	🟢 7.3	7.0	
Signs - Percent of signs older than 12 yrs (future shift to 15 yrs)	12%	14%	16%	19%	🔴 23%	5%	
Signs - Public satisfaction, scale of 1-10	8.0	—	8.1	7.9	🟢 7.9	7.0	
Signal, lighting and ITS maintenance - No formal measure	—	—	—	—	—	NA	
Guardrail & cable median barrier - No formal measure	—	—	—	—	—	NA	
Roadsides							
Rest Areas - Mn/DOT Class I rest area facility condition index (FCI)	—	62% with FCI < 25	—	—	74% with FCI < 25 (Est.)	70% with FCI < 25	
Range is 0-100; lower is better. Replacement recommended at 60. FCI = Cost of Assessed Deficiencies / Replacement in Kind Value	—	88% with FCI < 45	—	—	90% with FCI < 45 (Est.)	96% with FCI < 45	
Rest Areas - Public satisfaction, scale of 1-10	7.8	—	8.0	—	—	7.0	
Litter removal - Public satisfaction, scale of 1-10	6.8	—	7.0	6.7	🟢 7.0	7.0	
Fleet Management							
Fleet - Units within life cycle (reported in April of following year)	68%	68%	66%	65%	64%	🔴 90%	
Fleet - Equipment achieving minimum utilization (reported in April of following year)	53%	57%	62%	63%	63%	🔴 95%	
Fleet - Percent of maintenance preventive vs. reactive (reported in April of following year)	46%	48%	50%	47%	40%	🔴 70%	

2010 Performance by District

	1	2	3	4	6	7	8	M
Traffic Management								
Incident clearance time - Metro freeways	Measure applies to Metro District only							
FIRST coverage - Percent of metro freeway miles	Measure applies to Metro District only							
Metro signal retiming - major corridors	Measure applies to Metro District only							△ 68%
Metro signal retiming - minor corridors	Measure applies to Metro District only							△ 43%
Pavement marking - Percent tech memo compliance	🟢 100.0%	🟢 98.2%	△ 94.0%	🟢 100.0%	🟢 99.2%	🟢 100.0%	🟢 96.5%	🟢 99.9%
Pavement marking - Public satisfaction								
Signs - Percent of signs older than 12 yrs	△ 10%	🔴 21%	🔴 27%	🔴 22%	△ 7%	🔴 44%	△ 19%	🔴 26%
Signs - Public satisfaction								
Signal, lighting and ITS maintenance								
Guardrail & cable median barrier								
Roadsides								
Rest Areas - Estimated number and percent of rest areas with FCI less than 25	7 71%	3 67%	7 85%	6 50%	12 92%	10 60%	No Rest Areas	5 80%
Rest Areas - Estimated percent of rest areas with FCI less than 45	100%	100%	85%	67%	100%	80%	No Rest Areas	100%
Rest Areas - Dollar totals of assessed deferred and routine maintenance (2008)	$1.4M	$1.1M	$2.4M	$2.1M	$5.7M	$4.8M	No Rest Areas	$1.7M
Rest Areas - Public satisfaction								
Litter removal - Public satisfaction								
Fleet Management								
Fleet - Units within life cycle	🔴 58%	🔴 64%	🔴 61%	△ 74%	△ 70%	🔴 58%	🔴 68%	🔴 66%
Fleet - Equipment achieving minimum utilization	🔴 61%	🔴 70%	🔴 69%	🔴 74%	🔴 71%	🔴 64%	🔴 74%	🔴 55%
Fleet - Percent of maintenance preventive vs. reactive	🔴 39%	△ 61%	🔴 40%	△ 52%	🔴 35%	🔴 33%	🔴 44%	🔴 28%

Investment

	FY2006	FY2007	FY2008	FY2009	FY2010
Traffic Management					
Incident clearance time					
FIRST coverage	$1.1M	$1.5M	$1.5M	$1.6M	$1.6M
Metro signal retiming (major and minor corridors)	$150k	$331k	$184k	$516k	$530k includes $205k BARC
Pavement marking (tech memo compliance and public satisfaction)	$12.9M includes $2.8M BARC	$9.6M includes $2.1M BARC	$11.2M includes $3.9M BARC	$11.6M includes $3.2M BARC	$12.5M includes $3.5M BARC
Signs (age and public satisfaction)	$7.8M includes $388k BARC	$10.6M includes $291k BARC	$8.6M includes $860k BARC	$10.4M includes $1.2M BARC	$11.9M includes $794k BARC
Signal, lighting and ITS maintenance	$2.9M signals; $3.8M lighting; $2.0M ITS	$3.4M signals $4.4M lighting $2.6M ITS	$3.2M signals $3.9M lighting $2.4M ITS	$3.3M signals $4.8M lighting $3.9M ITS	$3.9M signals $5.9M lighting $3.6M ITS
Guardrail & cable median barrier	$3.5M includes $327k BARC	$4.3M includes $455k BARC	$1.8M includes $41k BARC	$4.8M includes $21k BARC	$4.1M includes $20k BARC
Roadsides					
Rest Areas (FCI)	$4.7M	$5.1M	$5.2M	$5.5M	$5.3M
Rest Areas - Public satisfaction					
Litter removal - Public satisfaction					
Fleet Management					
Fleet (all measures)	$48.7M	$59.3M	$47.7M	$64.4M	$60.7M

Legend: 🟢 At or above target; △ Moderately below target; 🔴 Seriously below target

▭ Customer measure from omnibus survey (Not taken in 2007); — No measure/data not collected

BARC = Bridge and Road Construction

3.0.3 Work Team Summaries

The remainder of the information included in this chapter focuses on the primary maintenance activities performed by MnDOT. Each of the work activity areas are organized in a similar manner and include the following information:

Introduction and Background: This segment provides an overview of the primary work area and highlights the key details that affect operations and maintenance activities.

Factors Affecting Capability: This section discusses the legal mandates and regulations that affect operations and maintenance activities and identifies the cost trends and other changes that have occurred within the system (operational realities) over the past four years.

Performance Measures: This portion review new and existing measures and targets to evaluate operations and maintenance performance. Some areas have clearly defined measures with historical data; others have limited data and no data history.

Strategy Development/Policy Direction/Risk: This section identifies the key strategies that can perform the work activity more efficiently and effectively. In addition, these strategies should be consistent and comply with the following:

a. Statewide Transportation Policy Plan

b. Americans with Disabilities Act

c. Strategies and Impacts related to Innovation

d. Shared Services

e. Risk

f. Sustainability

Implementation Strategies: This area identifies implementation strategies to increase performance as high as possible. Consideration should be given to the financial scenario and risk analysis that was completed as part of this HSOP with the focus being on items that maximize lifecycle effectiveness.

3.1 Clear Roads

The Clear Roads service area is comprised of two key components. The first component – snow and ice control – is the most highly valued maintenance service MnDOT provides to users. The second component, clear obstructions, encompasses many types of debris-clearing activities that take place throughout the year and are critical to keeping the roadways safe for travel. The six-year average annual spending on these two components is $75 million ($63 million for snow and ice and $12 million for clearing debris).

Both components of the Clear Roads service are extremely important, primarily because both directly impact the mobility and safety of our customers as they travel the State's roads and bridges. The following sections address the two key components of Clear Roads.

3.1.1 Snow and Ice Control

Introduction and Background

Minnesotans expect to continue normal activities during most winter weather events and presume that transportation facilities can safely accommodate travel shortly after a snow event has ended. Clearing snow from the State's 12,000 miles of roadways is a labor and equipment-intensive task. Accordingly, MnDOT has allocated significant resources to these activities and has managed its performance for many years. In fact, customer surveys indicate that clearing snow and restoring roadways to bare lane[3] conditions is the highest priority service that MnDOT provides.

The level of activity for snow and ice removal (i.e., resources needed) is difficult to predict from year to year and district to district. Weather severity varies significantly from year to year, as well as from region to region. For example, in 2003-2004, the Twin Cities received approximately 66 inches of snow. The following year (2004-2005), the same area received only 25 inches of snow. However, snowfall is just one of the many factors that affect snow and ice removal cost. Other factors include event duration, moisture content of precipitation, air temperature, pavement temperature, timing of event (weekend or in rush hour), wind, and traffic levels. Generally, the northeastern portions of the State receive more snow and colder temperatures while the western portions contend with wind and drifting snow. The six-year average spending on snow and ice control is approximately $63 million.

In addition to removing snow and ice from the roadway, MnDOT provides winter maintenance service to certain Pedestrian Access Routes. This service occurs during the "clean up" operation. Listings of these locations are maintained in the District.

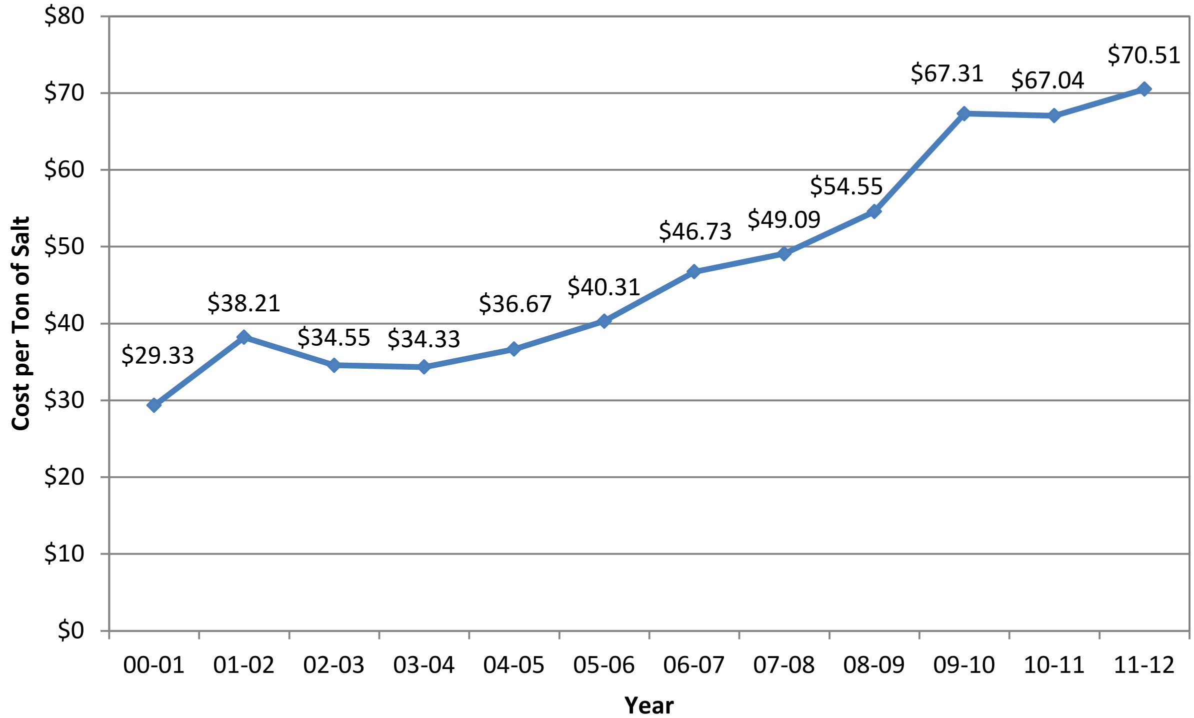
Factors Affecting Capability

Since the initial HSOP was prepared in 2005, the cost of doing business has increased significantly. Although there are other factors affecting MnDOT's ability to perform snow and ice service, operational costs (equipment, fuel and material costs) are by far the most significant factor. The increase in salt prices over the last several years is a prime example of cost increases. Figure 3.1 shows the increase in salt prices from 2001 to 2011. Note: The slight drop in price in

[3] Bare-lanes within "wheel-track" area.

Calendar Year 2010-11 is attributed to a modified contract approach in which MnDOT assumed more contractual risk by guaranteeing purchase quantities.

Figure 3.1: Average MnDOT Salt Cost per Ton



Material costs, such as salt, are not the only cost increases that have a major impact on snow and ice operations. The increased cost of equipment also impacts the cost of snow and ice removal activities. Examples of the cost increases related to snow plow trucks, as well as other types of equipment, is located in Section 3.6. While labor costs have increased, these have not increased nearly as much as materials and equipment. Also, technology costs have increased in the pursuit of efficiencies.

As with any successful business, MnDOT focuses its limited resources on its highest priority services, such as snow and ice control. As the cost of performing snow and ice control increases, MnDOT is forced to redirect money from other priority areas to address the cost gaps resulting from these inflationary increases. This has caused lower levels of service in other maintenance areas such as surface repair, drainage, roadside maintenance, etc.

In addition to redirecting money from other core areas, MnDOT developed and uses a flexible workforce. Nearly 15 percent of the State's regular plow drivers work in MnDOT functions unrelated to maintenance activities and are reassigned from their regular duties and brought in to plow during snow and ice events. While this strategy distributes limited workers across functional boundaries, it is believed additional full-time maintenance workers would provide more effective snow and ice operations and correspondingly, a larger summer workforce. Roadway and bridge maintenance workers were added as a result of the 2008 Minnesota Laws Chapter 152 funding, but a reduction of the Chapter 152 funds available to the Districts (under 2011 Minnesota Laws Chapter 36) and inflationary pressures have resulted in reductions to the increased maintenance staff.

Operators from program delivery sections have competing priorities, such as mandatory training and workload deadlines within their primary work areas. Often times, because temporary and/or program delivery employees are unavailable, route trucks have not been on the road due to not having an operator available to run the truck. Supervisors in technical areas, such as design and surveys, have raised concerns after missing letting dates and project deadlines as a result of members of their workforce plowing snow several times per week. This phenomenon is especially evident during difficult winters like the 2010-2011 winter. However, due to budget limitations, this practice will have to continue into the future. To illustrate the size and scope of this issue, during the winter of 2010-2011, temporary and program delivery employees made up 16.2 percent of the Priority 1 drivers operating the snow plow fleet. This equates to 240 operators across the state that are either temporary or program delivery employees. While it is difficult to calculate the ideal percent of temporary and cross-over employees, it is a common belief that reducing the current level would provide a more effective delivery of snow and ice services. It would cost approximately $7.4 million annually to add 120 full-time maintenance workers, reducing the current percentage of 16.2 percent by half.

MnDOT has recently increased the use of temporary employees. Similar to "flexible" staff, temporary employees have limitations and restrictions that constrain their availability to plow. Frequent utilization of temporary staff also places a demand on Human Resources staff to hire and train the temporary employees each year.

While increased costs are the most significant factor affecting snow and ice operations, many other factors also affect MnDOT's capabilities. Additional infrastructure added through construction projects has an immediate impact. Since 2005, MnDOT has added additional interchanges, ramps, and traffic lanes across our system. This extra infrastructure results in additional time and materials being expended to clear snow and ice. Many of the improvement projects or safety enhancement projects add miles and complexity to the plow route system. The following are examples:

- In the fall of 2010, the Metro District completed a major reconstruction of the I-35W and TH-62 (Crosstown) interchange. Reconstruction of this 2.5-mile roadway section resulted in an additional 5.5 lane miles, 16 bridges, sound walls, several areas of center median islands, barriers to divide segments of roadway, and a reduction in snow storage. The reconstruction of this segment of roadway has drastically changed the area's snow removal procedure. This route did not see an increase in additional plow trucks, so it requires more passes to be made to remove snow from the traveling lanes. With the increase of lanes and structures, snow storage has been reduced significantly, requiring more snow to be removed and hauled to remote storage sites. This greatly impacts the cost and time required for clean-up operations.

- In 2011, a roundabout was constructed on Highway 75, south of Moorhead in District 4. The addition of this roundabout will require the District to extend its gang plowing operation an additional four miles south of town, costing three plow trucks an additional half an hour each before they can head out on their individual routes. This is an example of how the total lane miles of this route have not changed, but the addition of the roundabout has had a significant impact on the operations of three separate plow trucks and their respective routes.
- In the Twin Cities Metro Area, many roadway shoulders have been converted into transit bus lanes. The conversion of the transit lanes has significantly reduced snow storage capacity. This decrease of storage capacity means that snow must be loaded and hauled away more often and in much greater volumes than in the past.
- Low-cost, high-benefit improvements have been very effective at increasing traffic capacity, they have resulted in higher maintenance costs for snow plowing and other activities. In the future, projects such as MnPASS could result in additional loss of snow storage capacity.

MnDOT must complete operational guidance for performing snow and ice operations on pedestrian facilities. Funding and staff will likely become a limiting factor since the greatest need to maintain accessibility of these features arises during snow events when resources are engaged clearing roads and bridges. In addition, a funding mechanism is needed to address snow and ice maintenance costs for pedestrian and bike facilities on MnDOT right-of-way. Currently, no funding source has been identified to support this.

MnDOT is also in the process of working with local partners to establish snow and ice removal responsibilities on pedestrian facilities within communities. For example, many communities have, or are in the process of passing local ordinances that place this responsibility on the adjacent property owner. In locations where MnDOT will be responsible for snow and ice control, work will be performed as part of Priority A and Priority B clean-up operations. An inventory and prioritized order of these locations will be developed and maintained in each District.

Environmental sensitivity continues to be an issue as it relates to snow and ice control. Road salt contains chloride and is the most commonly used deicer. The chloride in road salt enters the surface waters, groundwater, and soils after a snowmelt. Road salt interferes with the growth of plants by inhibiting water and nutrients, which results in the slow growth or killing of the plants. It is imperative that MnDOT be proactive in regard to salt use. The most effective strategies currently available to accomplish this goal are focused in three areas – training, new technology and alternative chemicals.

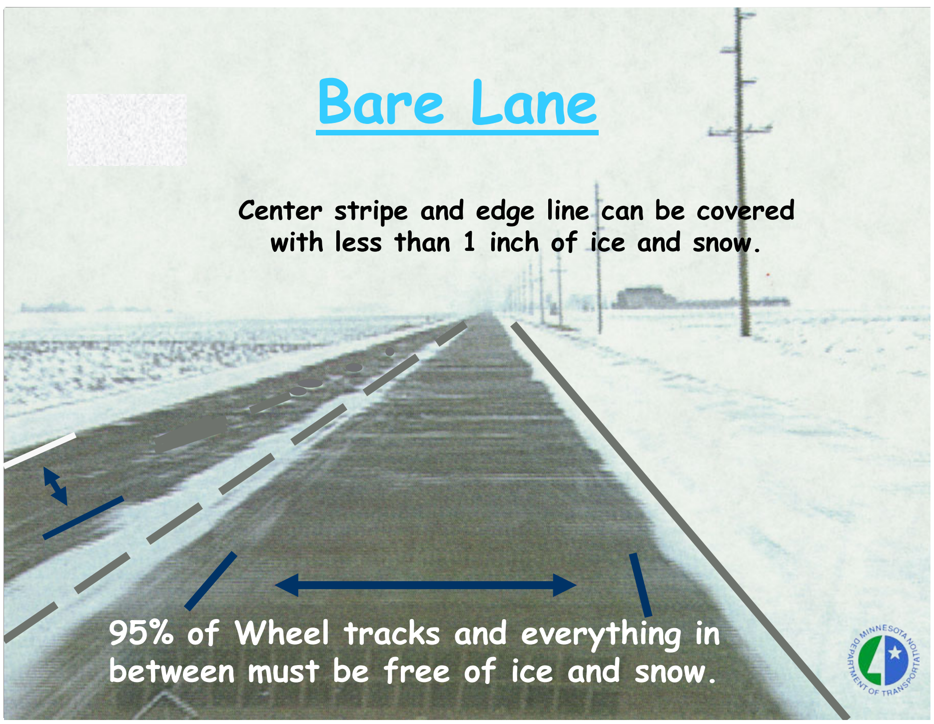
Performance Measures

The performance measures for snow and ice control are categorized as “mature measures.” They have been developed and adjusted through many years of experience and with considerable public involvement in the form of customer market research. The performance measure for snow and ice is based on the number of hours to achieve bare lane condition after a weather event ends. To achieve a bare lane condition, the roadway must meet the following state:

“All driving lanes are 95 percent free of snow and ice between the outer edges of the wheel paths and have less than one inch of accumulation on the center of the roadway.”

Figure 3.2 shows an example of a road that meets the bare lane condition.

Figure 3.2: Example of Bare Lane Roadway Condition



Target level of service is based on market research and varies by roadway traffic volume. State trunk highways have been classified by volume into five groups. The classifications addressed by this measure are: super commuter (SC), urban commuter (UC), rural commuter (RC), primary collector (PR), and secondary collector (SE) routes. The measure identifies a target for the number of hours after a weather event ends until a bare lane condition is provided (between the “wheel track” portion of the driving lanes). This time is referred to as the “regain time” or time to bare lane. The targets set for the overall system and five types of roadways are shown in Table 3.2.

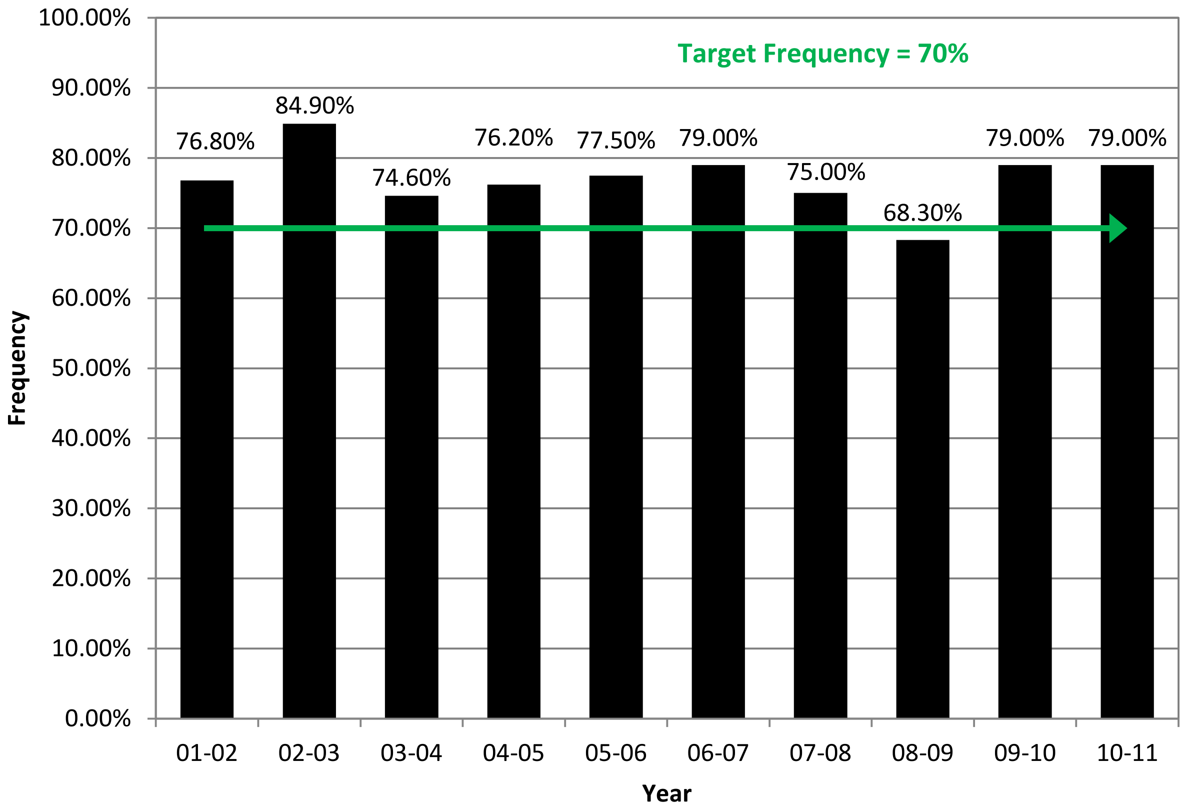
Table 3.2: Clearance Times for Snow and Ice Removal

Road Classification	Target Clearance Time (Hours)
Super Commuter (SC)	0 to 3
Urban Commuter (UC)	2 to 5
Rural Commuter (RC)	4 to 9
Primary Collector (PR)	6 to 12
Secondary Collector (SE)	9 to 36

Please note the regain times and performance measures for snow and ice control are based on an average for all events throughout the entire winter season. Although the bare lane measurement is the average number for all the events of the season, operators are very conscious of the regain times for each route during each event. Many times over the course of the winter, performance is exceeded and the regain clearance time is less than the target listed above. However, there are instances for individual storms when the regain target is not met and the regain clearance time is longer than the target listed in the table above.

For the past few years MnDOT has used the ”Frequency” measure as a roll-up measure of performance. The Frequency measure is a pass/fail calculation that considers all snow events on all plow routes. The chart below shows the frequency that MnDOT achieved bare lanes within the targeted number of hours (for all events and all routes) from the winter of 2001-2002 to the winter of 2010-2011. MnDOT has met its target of 70 percent in nine out of the last 10 seasons.

Figure 3.3: Frequency of Achieving Bare Lanes within Targeted Number of Hours



The average annual snow and ice removal costs for these different categories range from a high of $2,574 per lane mile per year for super commuter roads to a low of $787 per lane mile per year for a secondary collector (winter FY11 dollars).

Although the performance measure and targets for snow and ice control were developed with considerable involvement from the public, and while MnDOT has done a good job meeting the consumer based targets, this does not mean that all customers are satisfied with the level of snow and ice service that MnDOT is providing. Maintenance engineers across the State have reported receiving many calls this past winter from citizens requesting an increased level of service. Many of the callers are not simply looking for faster service after the end of the storm event, but are expressing the opinion that MnDOT should provide the capacity to keep the roadways clear "during" the storm event as well. This trend of customers asking for increased levels of service has risen over recent years. It appears that customer's expectations of snow and ice service are increasing from past years.

At this time, it is believed that the current performance measures and regain targets provide a good balance between customer expectations and budget limitations. As noted previously in this section, funding and staff are currently being taken from other priorities and work areas in order to meet the existing regain targets for snow and ice control. If an attempt were made to increase the level of service from the current levels, significant additional funding would be needed. Without additional funding, any increase in the level of service would result in a negative impact to the other priority areas of the Department.

Strategy Development/Policy Direction/Risk

MnDOT constantly searches for new technologies and strategies to help improve performance and lower the cost of providing services. Several examples of technological advances and operational strategies related to snow and ice control have been described earlier in this section and/or are listed below:

Maintenance Decision Support System (MDSS)

Winter maintenance staff and supervisors must often make quick decisions, preparing for forecasted conditions and adjusting their response as the weather changes. In the past, these decisions were based largely on the prior experience of supervisors and operators. However, MnDOT increasingly uses the Maintenance Decision Support System (MDSS), an automated software tool that integrates information about the weather, road conditions, maintenance practices and available resources. This helps winter maintenance personnel make proactive decisions about the best treatment to use before and during winter events.

MDSS incorporates the scientific framework and computational tools necessary to reliably recommend sound winter maintenance strategies (including materials, application rates, and timing) and predicts the resulting road conditions. By analyzing available alternatives, MDSS can recommend the most cost-effective treatments.

MnDOT participates in a pooled-fund research project on MDSS with 17 states and FHWA, which works to advance the software and provide training and support to users. About 30 percent of all MnDOT plow routes use MDSS technology to provide maintenance recommendations based on site-specific forecast and road condition data. These routes are distributed evenly across the state, except in the northwest, where all routes have been entered into MDSS to demonstrate the viability of statewide deployment.

Automated Vehicle Location (AVL)

MnDOT is also involved in an Automated Vehicle Location (AVL) system project integrated with the Department's MDSS initiative. An AVL system uses a computer to automatically record a plow truck's location and other information, and the plow driver uses a touch screen to update the road and weather conditions. This data is automatically forwarded to central servers at MnDOT, which gives maintenance supervisors more accurate information to correctly respond to changing conditions. Plow operators can use the in-cab computer to view weather radar, forecasts, and treatment recommendations for their location.

Anti-Icing

Research shows that when used at the right time and under the right conditions, anti-icing can be an effective means to reduce overall chemical use as well as reducing the ability for snow and ice to form a bond with the pavement surface. As a result, anti-icing can save time and money and help keep the roads safe for travel. Anti-icing is typically done with salt brine, alternative chemicals such as calcium or magnesium chloride, or in some cases, a combination of multiple chemicals. The initial cost of purchasing the brine-making systems, storage tanks and anti-icing placement equipment is cost-prohibitive for MnDOT to pursue on a large-scale basis with existing budgets. Therefore, anti-icing is currently used on a limited basis only, particularly in greater Minnesota. In some instances, the cost of alternative chemicals and performing anti-icing work would be offset by the cost savings realized by reduced salt use and anticipated labor and fuel savings resulting from a reduction in time and effort necessary to remove compacted ice from the roadways.

Pre-Wetting

Testing and experience indicate salt and mixed sand that are pre-treated with salt brine prior to application are more efficient and cost-effective than material that does not have moisture added. The addition of the salt brine prior to application allows the material to start working faster than dry salt alone. In addition, pre-wetting the material proves to help keep more of the product from bouncing and blowing off the roadway. MnDOT has made substantial investments in the addition of pre-wetting salt brine tanks to the majority of our plow truck fleet. The goal is to equip 100 percent of the fleet in the near future.

Underbody Plows

The addition of underbody plows to the fleet has greatly improved MnDOT's ability to remove snow and ice that has been compacted onto the roadway by traffic. The down pressure exerted by the underbody plow is significantly greater than normal front mounted plows and side wings. MnDOT has greatly increased the number of underbody plows on the fleet of plow trucks. MnDOT has identified the underbody plow as a maintenance best practice. All plows coming off the assembly line are equipped with an underbody plow unless otherwise requested.

Tow Plows

In the last couple of years, MnDOT has incorporated a limited number of tow plows into its fleet. As the name implies, a tow plow is a large plow that is towed behind the plow truck. The tow plow allows one truck to cover an additional traffic lane or shoulder as it travels down the roadway. Except in heavy snow conditions, when the added weight of the plow and additional snow can become too heavy for the truck to pull, the tow plow has proven to be an extremely cost-effective piece of equipment. At this time, deployments of the tow plows are limited due to the high initial purchase cost of approximately $87,000 per plow, plus any additional cost for modifications required on the plow truck itself. Additional funding is necessary to take full advantage of this new technology. It is anticipated that MnDOT will be adding additional tow plows to its fleet.

Snow and Ice Performance Measures

As discussed earlier in this section, the volume of calls from customers requesting, and in some cases demanding, increased levels of service for snow and ice control continues to climb at an alarming rate. Districts report this trend is consistent across the State rather than being isolated to any one particular geographical area. MnDOT's Operations Managers Group contends the existing performance targets represent a good balance between meeting customers' expectations and budget limitations. Based on this input, it is strongly recommended that MnDOT continues with the existing performance measures and targets. Without additional funding, any increase in level of service would result in considerable additional impact to the other priority areas of the Department.

Implementation Strategies

Keeping roadways clear of snow and ice is one of the highest priorities for MnDOT. This is documented in the customer surveys and other information that is passed along regarding what the public wants from MnDOT. Therefore, in an effort to keep up with the public's expectations, the following implementation strategies are recommended.

Training

MnDOT has made a strong commitment to winter maintenance training. These efforts include an annual refresher training that all snow plow operators must meet in order to operate a snow plow. MnDOT also conducts an annual boot camp for all new snow plow operators called SPOT (Snow Plow Operator Training). In the early fall of the year, new snow plow operators assemble at Camp Ripley in Central Minnesota for two weeks of onsite winter plowing fundamentals. SPOT training is recognized by MnDOT as a best practice. Significant District-level training is also conducted in the days leading up to winter operations. This training, known as "winter prep," allows all snow plow operators to assemble together and discuss various aspects of their winter responsibilities, including performance measure reporting, plow inspection, right to know, etc. These training efforts help MnDOT perform the necessary safety services needed throughout the winter season while not doing it in ways that unnecessarily harm the environment.

New Technology

MnDOT's commitment to new technology dates back many years. One example of this commitment is the ongoing NTREC program (New Technology, Research and Equipment Committee). This is an annual funding program that allows grass roots innovation and technology implementation to happen in all Districts.

Some of the proven and active technologies that are deployed or are in implementation include:

- Continue to pursue pre-wetting and anti-icing strategies to make existing chemical use more effective, thereby reducing the amount of materials needed to deliver the same level of service.

- Continue pursuing equipment innovations to make plowing more effective and efficient. This would include adding more underbody blades and pre-wetting equipment to the snowplow fleet to improve snow and ice removal capabilities.
- Increase the deployment and use of the Maintenance Decision Support System (MDSS).
- Expand in-cab, expert computer system to help operators make the most accurate application rate decisions based on real-time information.
- Implement Anti-Icing - While these strategies effectively reduce the salt needed to meet the performance measure target, they are not without cost. The Department struggles to find available funds to complete full implementation across the State since alternative chemicals tend to be more expensive than salt.

These technologies help MnDOT use the right amount of chemical, in the right location, at the right time.

Alternative Chemicals

MnDOT maintains various chemicals on the "alternative chemical" contract, including a number of chemicals in the testing mode. The purpose of having an alternative chemical list is to provide snow plow operators with a choice of chemicals that fit the varying weather conditions that are encountered throughout the winter. With differing performance-capable chemicals, snow plow operators are able to select the right chemical for the right situation.

Decrease Percentage of Temporary and Program Delivery Employees Assigned to Plow Snow

As stated earlier in this section, during the winter of 2010-2011, the percentage of temporary and program delivery employees assigned to Priority 1 (full-time routes) snow and ice control was approximately 16 percent. This percentage of temporary and program delivery employees has a negative impact on the productivity and efficiency of both maintenance operations and program delivery. While it is generally believed there needs to be a portion of the workforce that crosses over between work areas, the current percentage appears to be too high. An additional 120 full-time maintenance workers would allow the department to reduce the number of non-full-time snow plow operators by 50 percent.

3.1.2 Clear Obstructions

Introduction and Background

Clear obstructions, the second key component of the Clear Roads area, receives much less publicity than snow and ice removal, but is also a critical service that MnDOT provides. These activities involve keeping the traveled roadways clear of obstructions so traffic can travel safely. This wide ranging group of activities includes everything from responding to major traffic incidents (e.g., spills or truck over turns) to removing dead animals or debris from the road.

In 2010, MnDOT and the State Patrol entered into a joint agreement called the "Open Roads Policy." This agreement gives MnDOT the responsibility, through the authority of the State Patrol, to clear debris, such as wrecked vehicles from the roadway, so traffic can begin flowing in a timely fashion after a crash. The intent of the policy is to get traffic back to normal as soon as possible following an incident in order to reduce the likelihood of secondary crashes from occurring. The faster traffic is restored to normal, the faster the roadway is returned to a safe condition for the traveling public. The six-year average spending for clearing obstructions is approximately $12 million.

Factors Affecting Capability

Traffic crashes, animal carcasses, fallen trees, and other debris removal are an endless service for MnDOT maintenance forces. They are part of everyday reality and often prevent crews from being able to adhere to a comprehensive work plan. This reactionary workload is a daily consideration in the world of maintenance, and anyone working in this area learns to live with it. Although the reactionary maintenance activities listed above are likely the most well-known, other less noticeable areas in the clearing obstructions category also have a significant impact on budget and resources.

Street Sweeping

Street sweeping is one of many Best Management Practices (BMPs) that MnDOT incorporates into the required Municipal Separate Storm Sewer Systems (MS4) permitting requirements under the laws of the State of Minnesota and Federal Government. As with all BMPs that are used, they come with a cost. Each year MnDOT spends millions of dollars to meet the requirements of the MS4 permitting process. For example, annual costs for the sweeping operations are approximately $1.3 million in the Metro District alone.

The term "storm water" generally refers to precipitation, snow melt, and surface runoff as well as drainage (not industrial process wastewater). The U.S. Environmental Protection Agency delegated authority to the MPCA to carry out Federal industrial storm water permit requirements within Minnesota. The agency's industrial storm water program's goals are to better protect surface water and ground water quality through adaptive management of storm water control measures, which will reduce pollutants in industrial storm water discharges, and have an effective, workable permit that reflects key water resource values and provides a balance of environmental protection and site-based controls, which will help to protect Minnesota's 10,000 plus lakes and groundwater.

Many Watershed Districts within the Metro District require MnDOT to incorporate BMPs into the roadway permitting process. One example of the required BMP includes adding winter sweeping into MS4 permitting. A winter sweeping program requires the use of a special design broom that functions without the use of water (water would freeze) to keep the dust particles from polluting the air. A standard Elgin Pelican pick-up sweeper costs $190,000, and a Waterless Elgin Pelican pick-up sweeper costs $220,000, a difference of $30,000. Issues such as these often originate in the Metro Area and then migrate throughout the State over time.

Performance Measures

Because this service is primarily reactionary, MnDOT does not have a performance measure. At a District level, annual costs are typically tracked and used as a basis for budgeting resources for future years, usually at the expense of other activities. An example of this increase is from the Metro District where the miles of roadway swept have increased five percent from May 2002 to May 2010.

At this time, it is felt that there is no need for a formal performance measure for the Clear Obstructions Core Activity.

Strategy Development/Policy Direction/Risk

MnDOT generally responds as quickly as possible to reports of obstructions. While removal of some types of obstructions may be less urgent than others, there is little room to develop groundbreaking management strategies. Public safety risks will generally rise as full-time maintenance staff numbers diminish and obstruction response times increase. Also, as full-time maintenance staff numbers decrease, the responsiveness to obstructions will be impacted based on the amount of planned work and vice versa.

Implementation Strategies

In cooperation with the Minnesota State Patrol, MnDOT just finished implemented the Open Roads Policy addressed earlier in this section. By working together to clear vehicles from crash sites in a timely manner, the number of secondary incidents that occur will be reduced.

MnDOT will continue to implement a proactive roadway sweeping program to ensure compliance with the MS4 permitting requirements as well as other State and Federal environmental regulations. As these regulations become increasingly stringent, MnDOT will effectively use in-house staff and equipment as well as supplementing resources through outsourcing where and when appropriate.

In regard to the reactionary workload of the Clear Obstructions service area, MnDOT will continue to make safety the number one priority. Accordingly, MnDOT will continue its urgent response to safety concerns, such as crash sites and debris on the roadways, despite its negative impact to scheduled work plans. Operating in this manner makes it difficult to maintain competitiveness in other aspects of maintenance operations. However, in order to ensure tax payers are able to travel safely on State roadways, this will continue to be a daily reality for the employees of the operations section of MnDOT.

3.2 Smooth Roads (Pavements and Drainage)

The smooth roads section covers both pavement maintenance as well as the maintenance of drainage structures that are less than 10 feet wide (structures that are not considered a bridge). Roadway pavements are the most significant element in the transportation system and require a significant amount of maintenance to keep the 12,000 plus miles of the system in a state of good repair and operation.

3.2.1 Pavements

Introduction and Background

Preservation of pavement infrastructure is one cornerstone to soundly manage the State's transportation system as well as provide a safe and acceptable driving surface for users. In addition, MnDOT is committed to seeking solutions that are innovative, environmentally friendly, and fiscally responsible with a goal of extending pavement lifecycle.

Pavements are one of the most visible transportation elements to the public. As a result, they directly influence customer satisfaction. The public can easily observe the pavement's surface condition and feel the condition of the roadway through its ride. MnDOT evaluates all pavements statewide biannually, half each year, to identify problem areas and determine cost-effective solutions. Two main measures are evaluated: the Ride Quality Index (RQI), which measures the smoothness of the road, and the Surface Rating (SR), which is calculated from the type, amount, and severity of cracks, ruts, and faults.

From a maintenance operations standpoint, treatments generally fall into two categories; pavement preventive maintenance and pavement patching. Pavement preventive maintenance is generally performed on "good" pavements to prevent or slow further deterioration. Pavement patching is reactive maintenance to temporarily fix isolated pavement areas that may have a significant problem. These two maintenance activities are described in more detail below.

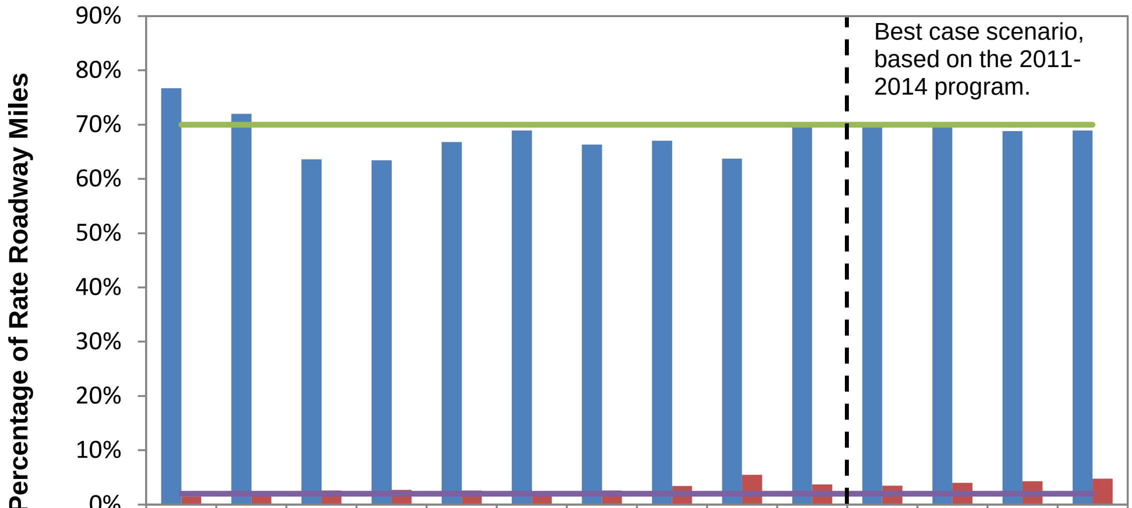
MnDOT uses its pavement management system to assess the best combination of preventive treatments, rehabilitation strategies and patching on a segment-by-segment basis. RQI targets by roadway class are shown in Table 3.3.

Table 3.3: Ride Quality Index (RQI) Targets by Functional Group

Roadway Class	Target (in percent)	
	Good (RQI > 3.0)	Poor (RQI <= 2.0)
Principal Arterial	70 or more	2 or less
Non-Principal Arterial	65 or more	3 or less

For principal arterials, the overall goal is to achieve 70 percent of the system in the "good" RQI category and only two percent in the "poor" RQI category (Table 3.3). A historical review of the RQI for principal arterials is shown below in Figure 3.4. There are two components to achieving the statewide pavement targets identified above. One is to effectively slow or prevent pavement deterioration through preventive maintenance, and the other is to fix and/or preserve pavements that are in poor condition through rehabilitation and/or reconstruction.

Figure 3.4: Principal Arterial Ride Quality Index (RQI)



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
RQI >= 3.1	76.7%	72.0%	63.6%	63.4%	66.8%	68.9%	66.3%	67.0%	63.7%	70.2%	69.8%	69.5%	68.8%	68.9%
RQI <= 2.0	1.5%	2.0%	2.6%	2.7%	2.6%	2.3%	2.6%	3.4%	5.5%	3.7%	3.5%	4.0%	4.3%	4.8%

Good/Very Good RQI Performance Target = 70 percent or more
Poor RQI Performance Target = 2 percent or less

Source: MnDOT Pavement Condition Executive Summary, 2010

Pavement Preventive Maintenance

Pavement Preventive Maintenance (PPM) activities (i.e., seal coats, joint seals, micro-surfacing, thin overlays) are performed to cost-effectively extend pavement life. Pavements are exposed to weather (i.e., rain, snow, cold, heat) and various traffic loads. These external forces can cause significant deterioration over time. Many of the preventive treatments focus on sealing the roadway surface to prevent water from seeping into pavement joints and subgrade materials. Water can cause loss of roadway strength, stripping and raveling of the pavement surface, and significant joint deterioration. Other preventive treatments focus on correcting rutting and/or isolated structural problems to improve ride and drivability.

Pavements throughout the State are rated to assess their vehicle ride quality. These "surface ratings" (SR values) correlate with public expectations. The smoothness of ride is based on a scale of 0 to 5. "Good" ratings are based on values between 3.1 and 5.0. "Fair" values are values between 3.0 and 2.1. "Poor" values are represented by ratings of 2.0 or less. Normally, only pavements with a RQI above 3.0 are considered for preventive maintenance activities because once pavements deteriorate beyond this point, they tend to have too many structural defects to cost-effectively be addressed by pavement preventive activities. These types of fixes are capital expenditures and will not be addressed further in this document. As stated in the following section, pavement patching has been identified as a suitable maintenance operations technique for pavements with a SR of 3.2 and below.

Pavement Reactive Maintenance

Pavement patching is a reactive maintenance treatment that is performed by MnDOT maintenance crews to hold pavements together until major rehabilitation and/or reconstruction activities can occur. Pavement patching is needed to address severe pavement distresses, such as severe transverse cracking, severe longitudinal cracking, alligator cracking and rutting. These distresses are most often associated with a poor ride and limited roadway strength. Roadways with severe distresses are most likely to be ones in "poor" condition. In theory, if roadway conditions worsen, then more of these severe distresses will be present and the need for patching will rise. If patching does not occur, potholes and more significant pavement ride issues usually develop and can impact safety.

It is MnDOT's policy to repair all potholes and severe distresses. However, the level of repairs or "fixes" depends on the amount of patching dollars available, weather conditions, and the timing for future rehabilitation and/or upgrades. There are different levels of patching fixes, from placing cold mix directly in potholes to cutting out bad areas, correcting the poor sub-soils and patching with hot mix. The level of fix affects the ride of the roadway and how long the fix will last. Pavement patching expenditures (type and longevity of fixes) have historically fluctuated with the type of winter (availability of funds due to snow and ice activities). For example, if there is a light winter, monies left in snow and ice would be used to do better and more permanent fixes to pavements so that ride is improved and potholes don't occur the following year. If it is a severe winter and more money is needed for snow and ice, there is typically less money available for patching and other maintenance activities; therefore less extensive fixes are made.

Factors Affecting Capability

Pavement patching has long been recognized as a necessary and important role of maintenance. As surface conditions deteriorate, patching is needed to maintain a safe and acceptable driving surface until more extensive rehabilitation efforts can be implemented. During the original HSOP, a gap existed to meet the patching needs identified by the public and internal experts. Roughly 50 percent of the then current effort was funded during the first HSOP, which brought the patching effort up to an adequate level. Since that time, the overall condition of pavements have continued to decline (increased percentage of pavements in poor condition – these are pavements that require patching type work), and inflationary costs have limited the ability to make resources go as far as they once did.

Source: MnDOT Office of Maintenance Pavement Patching

Pothole patching is a top priority. Once MnDOT is aware of a pothole, it is scheduled for repair based on the condition of the pothole. Failure to properly address potholes could expose MnDOT to potential liability.

As stated, inflationary costs can and do impact pavement patching. This is especially true with rising oil prices that affect not only the diesel needed for equipment that haul and place materials on the road network, but can drive up the cost of materials (the patch mix).

Performance Measures

Subsequent to the first HSOP effort, a patching indicator was developed to quantify the amount of patching that should be done annually. It was found that the miles of road with a SR of 3.2 or less is a good indicator of the number of miles that should be patched annually. The current performance measure is to patch 90 percent of the number of miles identified in the patching indicator annually.

Data shows all Districts have met or exceeded the patching indicator miles for CY 2010. Therefore, the CY 2010 data will be used as a baseline for this analysis.

The pavement data prediction model shows a slight decrease in patching needs for CY 2011 with an increase over the next three years (2012 – 2014). This is based on current SR readings and the current STIP (FY 2011-14). Increasing the spending by the same percentage leaves a total gap of $11.8 million. The largest portion of this is in 2014. Due to an ever changing program, it is assumed something in the program will change by 2014 and the gap that year would be reduced to the 2013 number of $8.2 million (see Table 3.4). If not, the percentage of patching performed would drop proportionately.

Table 3.4: Pavement Data Prediction Model Summary

Year	2010	2011	2012	2013	2014	Totals
Total Miles <=3.2	9,944	9,803	10,397	11,839	13,701	–
% Increase	Base year	-1%	5%	19%	38%	–
Actual/Predicted Expenditures (millions)	$19.4	$19.3	$20.4	$23.1	$26.7	–
Gap computed	Base year	-$0.2	$1.0	$3.7	$7.3	**$11.8**
Gap recommended	Base year	-$0.2	$1.0	$3.7	$3.7	**$8.2**

These numbers do not take inflation into account for materials, increases in labor due to benefits or wage increases, or changes to the program.

Strategy Development/Policy Direction/Risk

This is a difficult performance measure because it is reactive and subject to other capital investments in pavement preservation and reconstruction. In addition, it is somewhat dependent on weather conditions and historically, it has depended on the availability of funds left over from snow and ice removal.

There have been strides in technology through the years to assist in patching, such as the air injected pothole patcher and shared emulsion tank(s). MnDOT continues to search for new technology and techniques to assist these efforts.

There are various risks associated with the level of patching that MnDOT is able to complete each year. Patching is necessary to prolong the usefulness of the existing roadway surface, prolong expensive reconstruction projects, and provide a smooth ride for motorists.

Implementation Strategies

Pavement patching is generally reactive and subject to available resources (i.e., budgeted amounts for this activity can be transferred to other higher priorities such as snow and ice removal). MnDOT currently works with the Districts to identify the level of funding needed for patching with the focus on providing a safe and reliable surface until longer term rehabilitation or reconstruction efforts can be funded.

3.2.2 Drainage

Introduction and Background

While many components of the transportation system are visible, (pavements, bridges, signs, etc.) many are not (e.g., culverts and other drainage features). Infrastructure systems that convey drainage elements through or below the surface represent important elements of the transportation system. Management and maintenance of the drainage infrastructure is important because:

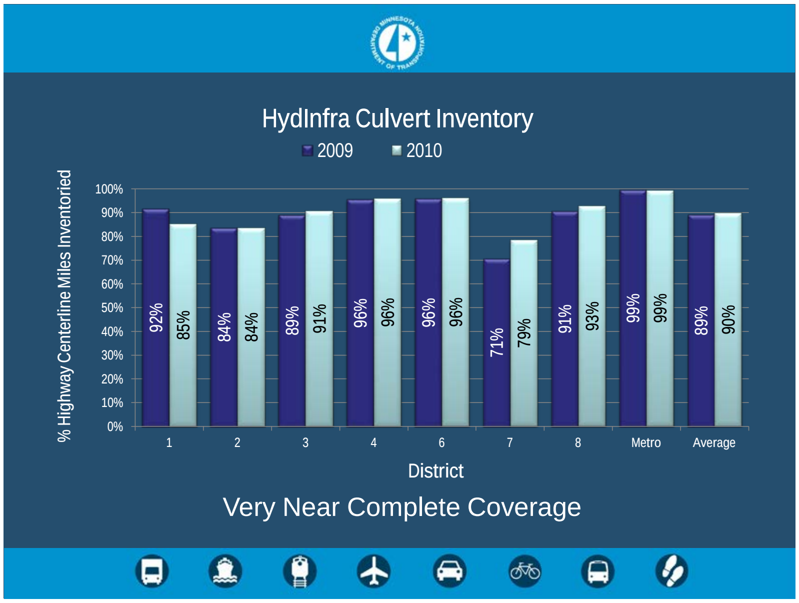
- Drainage infrastructure represents a large investment of public resources, and active management can minimize lifecycle costs.
- Preventive repairs can be made for fractions of the costs of reactive or emergency repairs.
- Active management reduces the risk of drainage system failures and associated costs, including:
  - Traffic safety/hazards resulting from failed infrastructure
  - Liability/impacts to adjacent properties resulting from failures
- The Department has legal obligations (SWPPP/MS4) to inspect the drainage infrastructure.

To help track and assess drainage infrastructure, MnDOT has developed a computerized inventory system called HydInfra (Hydraulic Infrastructure). Since 2008, MnDOT has conducted thousands of drainage system inspections (Figure 3.5) and is actively monitoring drainage performance. In addition, a performance measure for actual infrastructure repair is currently under development.

The inventorying, inspection, and inclusion of highway culverts in HydInfra represents a large portion of the actual highway drainage system statewide. Information on the location, condition, and overall status of the drainage feature is available in electronic form for a vast majority of highway culverts throughout the State's system. Though some data exists, other drainage features (aside from centerline culverts) are not inventoried as accurately or completely on a statewide level. These include items such as storm sewers, driveway/entrance culverts, roadway subsurface "tile" drainage systems, special drainage structures (e.g., grit chambers), ponds, and ditches.

The Department can also use HydInfra data to estimate system repair needs and plan for needed work. Algorithms have been developed to scan the data for seriously deteriorated culverts (Condition 4) and use relevant information, such as type of culvert material, size, type and location of defect, and numerous other parameters to yield recommendations regarding repair type/strategy and estimated costs. These recommendations are applicable at an individual culvert level, as well as a statewide level.

Figure 3.5: HydInfra Culvert Inventory



Estimates for MnDOT labor requirements are also produced based on the type of repair and assumptions about types of work performed by MnDOT forces, or outsourced specialty contracts (typically "Cured Inplace Liners" and jacking of replacement pipes).

MnDOT can also utilize HydInfra data to prepare capital plans. There are some types of culvert repair work for which the department is not equipped and which must therefore be outsourced as specialty work. These contracts may be small operating fund expenditures, or could be larger "stand alone" construction program contracts. The Department can also include any type of needed culvert work within highway construction contracts, also as standalone projects, or as work components in discrete highway improvement projects. Districts make choices regarding which blend of contracting versus outsourcing, and the specific methodologies based on numerous factors, including repair needs, logistics, required timing, staffing and equipment available, funding availability and possibly contracting economies of scale, to name just a few criteria. HydInfra information is useful in planning for the most efficient approach to meeting needs, and helps to set the project "scope" during the planning/programming activities performed within the districts.

Factors Affecting Capability

MnDOT must comply with the NPDES MS-4 permit within the urbanized areas of Minneapolis-St. Paul, Duluth, St. Cloud, Rochester, East Grand Forks, Moorhead, and La Crescent. The permit requires MnDOT to operate and maintain storm water facilities in order to minimize the discharge of pollutants.

In addition, MnDOT may be subject to claims and legal action when water in its system backs up or in other ways causes damage to adjacent properties.

Performance Measures

MnDOT measures its performance with regard to **performing culvert inspections** and is currently in the process of developing a culvert **repair** measure.

Drainage Infrastructure Inspection: The drainage infrastructure inspection measure assesses the MnDOT's success at meeting the inspection cycle established for highway culverts (based on last reported condition of each culvert). The following describes the inspection targets:

- Condition 4 Pipes ("Very Poor") - inspected once per year
- Condition 3 Pipes ("Poor") - inspected once every two years
- All other Pipes/infrastructure - once every five years (or per MS4)

Condition ratings are based on numerous inspection parameters. A Condition 4 pipe would be considered to be in "Very Poor" condition. It may exhibit holes or cracks through the culvert material, separation of joints, severe deformation or misalignment, and settlement or loss of roadway grade/voids under the roadway.

The performance target is to have all (100 percent of) inspections completed within the specified inspection period. This measure is reviewed on a calendar year basis.

Drainage Infrastructure Repair: The repair measure is currently under development (pending the completion of inspections for all highway pipes). Upon full development, the measure can be expected to be "percent of Condition 4 pipes repaired annually." This measure would imply a turnaround time in years, until any given pipe would be addressed. A target such as "Address 20 percent of Condition 4 pipes annually" would imply roughly a five-year turnaround in addressing these defect pipes. At of the end of Calendar Year 2010, there were 3,410 Condition 4 pipes. If MnDOT were to repair 20 percent of the pipes per year, that would be roughly 680 pipes. In addition, it was determined that number of Condition 4 pipes had grown by approximately 250 from the previous year and will continue to grow at about the same pace in future years. This means that MnDOT would have to repair over 900 pipes per year to catch up and address all Condition 4 pipes over a five-year period.

Strategy Development/Policy Direction/Risk

MnDOT's efforts in maintaining the drainage system fall into two broad categories: inspection of the system and making needed repairs.

Currently the Department is not meeting its targets for inspections, but given competing priorities, is nearing acceptable performance. It has been several years since the development of the inspection targets, and an effort will soon be made to re-evaluate the inspection cycle targets. The inspection process has become more efficient as Districts have moved into a "re-inspection" mode versus the initial populating of the inventory system. Each year, enhancements are made to the software, which also generally improve efficiency. It is also possible that through the performance of repeated inspections, the Department has learned that longer inspection intervals may be appropriate. If it is determined that it is practical to do so, the Department will be able to more fully meet its targets with similar levels of resources.

Districts currently operate primarily in a reactive mode in regard to making drainage repairs. Associated risks include:

- Increased frequency of traffic impacting road surface failures
- Hampered ability to minimize lifecycle costs of infrastructure
- Increased expense (fiscal and traffic impacts) of performing reactive repairs
- Increased property liability exposure
- Annually increasing backlog of repair needs as more infrastructure deteriorates than is repaired

Ideally, MnDOT would allocate funding as determined in the HSOP gap analysis ($24 million) sufficient to correct the Condition 4 culverts over a five-year period, and thereafter keep pace with the newly deteriorated pipes on an annual basis. In the absence of additional resources, the Districts should continue to maintain a high priority level of inspection cycles, as the resources required are comparatively low, to avoid loss of investment to date. In addition, the Districts should also continue to blend reactive work performed by staff with strategic approaches to reduce the backlog of Condition 4 culverts through the analytical use of HydInfra to prioritize staff resources, BARC (capital) and Construction project (capital) investments. In the absence of MnDOT's ability to direct specific resources to drainage, MnDOT should postpone the introduction of a repair measure which it would likely be unable to meet.

Implementation Strategies

In the past, drainage infrastructure has received limited attention with respect to understanding the conditions and level of effort required to maintain the current system. However, over the past number of years, through development of the HydInfra system and methodologies, and near completion of inspections over the system, MnDOT has for the first time been able to develop a relatively comprehensive assessment of drainage infrastructure elements. This information should be considered in its early stages and will likely mature over time. This will allow for further refinement of methods, inspection cycles, strategies for addressing problems, and estimates of resources needed to accomplish such.

Drainage Infrastructure Inspections

Over the course of the past two years (calendar year 2009-2010), MnDOT has inspected approximately 33,000 highway culverts. This includes many new inspections, re-inspections, areas with densely located pipes, and areas with sparsely located pipes where travel time between inspections is a significant factor. MnDOT has access to records of labor expended over the previous years, which was useful in estimating a "labor factor" with regard to the inspection program. While there is significant variation in the time required to inspect an individual pipe, for the whole system, an average inspection time of 1.0 hours per pipe can be estimated. The inspection program calls for annual inspections of approximately 16,000 pipes per year, yielding annual labor requirements of approximately 16,000 hours to maintain the cycle. To put this into perspective, one could consider that there are approximately 100,000 pipes in HydInfra. Using averages of size and length and bid prices for furnish and install culvert pipe, the replacement value of culverts in the system is on the order of $285 million. Labor costs to meet inspection cycles would be on the order of $500,000 per year; or about 0.18 percent of the system on a replacement cost basis.

Drainage Infrastructure Repairs

MnDOT has developed a decision tree, which yields a recommended repair strategy for each Condition 4 pipe inventoried in HydInfra. The recommended repair strategy considers items such as culvert material (metal/concrete), type of defect (joint separation, rusted invert, etc.), repair under road (traffic implications), pipe diameter (internal access implications) and many other criteria. While the accuracy of a given recommendation for a specific culvert may not be flawless, on average the results provide a good representation of the overall drainage system needs. Having the recommended system repairs in hand, the department is able to estimate, with relative confidence, the costs of the various repairs. The following table shows the estimated repair needs, and corresponding costs to address all Condition 4 pipes in the system (as of the end of CY 2010) by repair type:

Table 3.5: Condition 4 Pipe Repair Costs

Item	Cost (Millions)
Cured Inplace Liner	$ 4.31
Grout Joints	$ 0.18
Jack New Pipe	$ 8.15
Pave Invert	$ 0.28
Reset Section(S)	$ 1.59
Slipline	$ 7.65
Trench New Pipe	$17.18
Totals	**$39.34 million**

The total costs could be spread over a number of years, as implied in the discussion of repair measure/targets. For example, if a goal of a five-year timeframe were chosen, the costs would be on the order of $8 million per year for the catch-up component of annual costs.

An evaluation of the number of pipes deteriorating into Condition 4 on an annual basis was attempted. Based on a few recent years with accurate data, it is estimated that 250 pipes are added to the list of Condition 4's on an annual basis. If the same ratio of repairs and costs are assumed, then the ongoing annual repair costs could be estimated at $2.28 million per year.[4]

Other Drainage Infrastructure Considerations

The following drainage system components, though part of the overall drainage infrastructure, are not reliably included in the HydInfra data:[5]

- Entrance/Approach culverts
- Storm Sewer Systems
- Ditches
- MS4 Systems (ponds, grit chambers, etc.)

[4] This is based on a review of the best information available at the time and relatively high level assumptions. Care should be used when interpreting these results as there are many variables, assumptions, and averages built into them. It may be reasonable to assume that the actual value lies somewhere between 50 percent and 200 percent of the stated number.

[5] Reasons include: Work to be done at a later stage of HydInfra development, lack of established protocols, low benefit/cost for inspection resources.

Maintenance of these items tends to be on an “as needed” basis rather than a planned approach. For example, in the case of entrance culverts, MnDOT repairs are generally at the request of adjacent landowners/jurisdictions.

This is appropriate as it defers expenditures as long as possible, and the risks of failure and associated costs are much lower than that of failed centerline culverts. It would be a monumental task, with relatively low return, to attempt to inspect and inventory this component of the drainage system. For storm sewer systems, annual rates of change, and failure rates are comparatively lower than for culvert pipes, however, MnDOT is making efforts to complete these inspections. While it would be desirable to incorporate ditch conditions and maintenance needs into HydInfra, protocols do not exist in part because a high degree of subjectivity would be inherent in any rating system. MS4 systems are comparatively few in number and presumably account for a relatively small annual cost component of the overall infrastructure need/expense picture. These systems often have independent management plans, and may be subjects of agreements with local jurisdictions.

3.3 Structures

The Structures section of this report is divided into two groups: bridges and other structures. Other structures include items such as retaining walls, sound barriers, sign bridges, light tower poles and concrete barriers. Bridges have had a very well developed inventory system for assessing performance, completing reactionary and preventative maintenance, and developing projects for rehabilitation and replacement. All of these activities are supported by performance measures that either measure outcome or output of the activity. The other structure category has a more disjointed system for maintaining an inventory, assessing performance, completing reactionary and preventative maintenance and developing projects for rehabilitation and replacement. None of these activities for other structures is supported by performance measures that either measure outcome or output

of the activity. The average three-year spending on inventory, assessment, and maintenance of these components of the highway system is approximately $15.3 million.

Bridges and other structures are combined in this report because of their similar management needs. Bridges are a primary component of the highway system because they carry traffic while the other structures provide a more secondary function. The following sections address needs for these two sets of structures on the highway system.

3.3.1 Bridge Management

Introduction and Background

There are 4,840 bridges on MnDOT's trunk highway system. These transportation assets are managed with a focus on increasing public safety and minimizing lifecycle costs. Bridge asset management consists of three components: **Assessment**, **Preservation,** and **Improvement**.

Assessment is the collection and maintenance of bridge data. This program provides a complete bridge inventory and detailed condition information on every bridge that carries or crosses a public roadway.

Each bridge is inspected in accordance with Federal and State laws and analyzed for safe load-carrying capacity based on current condition. This assures public safety and provides current data that is used to support sound asset management decisions. Bridge maintenance needs are identified from inspection findings, and both Preventive and Reactive Maintenance activities are then prioritized and scheduled.

Preservation is a program of cyclical, condition-based maintenance activities that keep bridges in sound condition with the intent of slowing their deterioration rate. These activities are categorized as either preventive or reactive maintenance.

- *Preventive Maintenance* includes routine maintenance activities performed according to an assigned frequency, as well as periodic minor repairs.
- *Reactive Maintenance* includes those activities that are scheduled in response to an identified condition that may compromise public safety or bridge structural function.

Improvement includes major rehabilitation and replacement. When a bridge deteriorates to a condition in which preservation is not viable or cost-effective, a major capital improvement or complete bridge replacement must be performed.

Effective management of the bridge network requires that resources are allocated to the correct asset management component at the correct time. This ensures that service life is maximized, lifecycle costs are minimized and our bridges safely fulfill their transportation function.

MnDOT is organized to support bridge asset management with a central Bridge Office and eight transportation Districts. The Bridge Office provides overall guidance to the asset management program through technical support, training, policy direction and inspection resources. Each District is responsible for conducting bridge inspections, performing Preventive and Reactive Maintenance, and programming improvement projects.

Factors Affecting Capability

The primary factors affecting MnDOT's bridge management program are funding levels and bridge network condition.

Funding

Minnesota's 2008 Legislative session provided funding for bridge needs through the Chapter 152 program. Under this 10-year program (2009-2018) an estimated $2.1 billion will be invested in bridge improvements, allowing MnDOT to rehabilitate or replace 120 fracture critical and structurally deficient bridges. Despite this dedicated funding, which mainly targets bridges in poor condition; the 2009 Statewide Transportation Plan identified additional bridge improvement needs of $725 million for the years 2009-2018, and $2 billion in needs for the years 2019-2029.

The Chapter 152 program also provided a base operating budget increase that allowed the addition of 55 full-time positions to the statewide bridge maintenance and inspection workforce.

Aside from the capital improvement needs identified above, approximately $15 million is currently allocated annually for bridge assessment and preservation as shown in Table 3.6.

Table 3.6: Bridge Inspection and Maintenance Expenditures

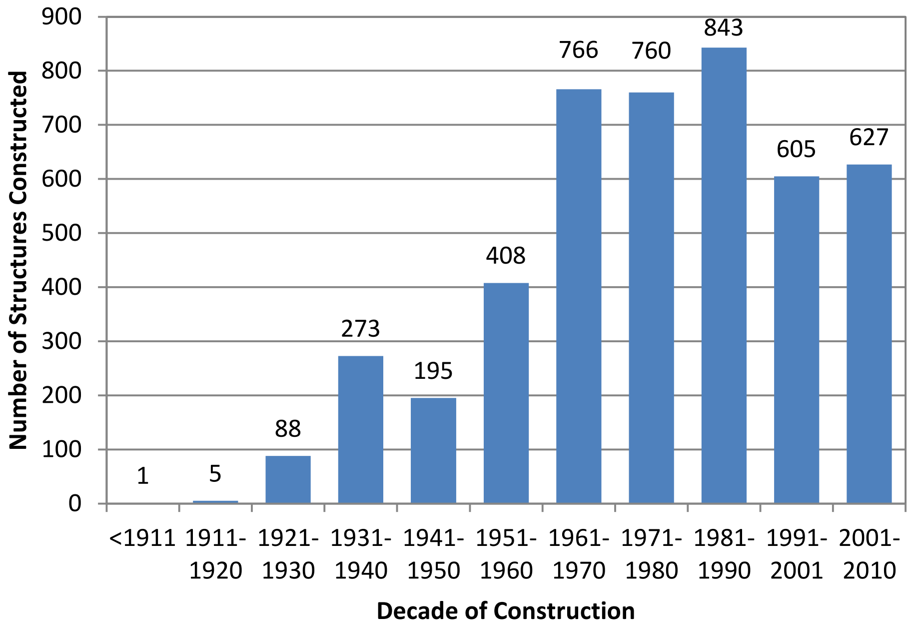
	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Bridge Preservation	$4,978,502	$8,036,230	$7,297,772	$7,738,328	$8,373,909	$10,296,272
Bridge Assessment	$1,765,245	$1,827,886	$6,691,501	$3,591,116	$4,145,485	$3,877,139

Bridge Age and Condition

Bridge condition is directly related to the age of the bridge and the resources applied toward maintaining it over its life. Proper attention to maintenance can slow deterioration, but eventually all bridges will reach a condition in which major rehabilitation or replacement is necessary.

The age distribution of Minnesota's trunk highway bridges (Figure 3.6) reveals substantial resources will be required in the next 20 years to maintain the bridge network. As these bridges deteriorate, more frequent safety inspections will be required and maintenance will become more extensive and costly. At some point, continued investment in maintaining these older bridges will become imprudent, and major capital investments will be required for rehabilitation or replacement.

Figure 3.6: Age Distribution of MnDOT's Trunk Highway Bridge Infrastructure



Other Factors

Even when adequate resources are available, efficient scheduling of preservation activities can be challenging. A significant amount of "non-bridge" work is assigned to district bridge personnel, which limits their availability to perform required bridge maintenance. Federal rules give very limited flexibility in scheduling bridge inspections, which becomes a major constraint when establishing a bridge maintenance work plan. Maintenance of traffic is routinely seen as a higher priority, especially in densely populated metropolitan areas, allowing important bridge preservation activities to sometimes be deferred or neglected. Most importantly, MnDOT cannot properly address these factors and enhance its ability to effectively manage bridge assets in the absence of a comprehensive resource management tool.

Although bridge operations staffing has increased, the aggregate experience level of the work force has decreased due to the extensive retirements of seasoned bridge workers over the past decade. The newer bridge workers and supervisors lack a formal training program to ensure that they have the knowledge and skills to perform their work proficiently. A formal training program is currently in the early stages of development, but will require continued investment going forward.

Performance Measures

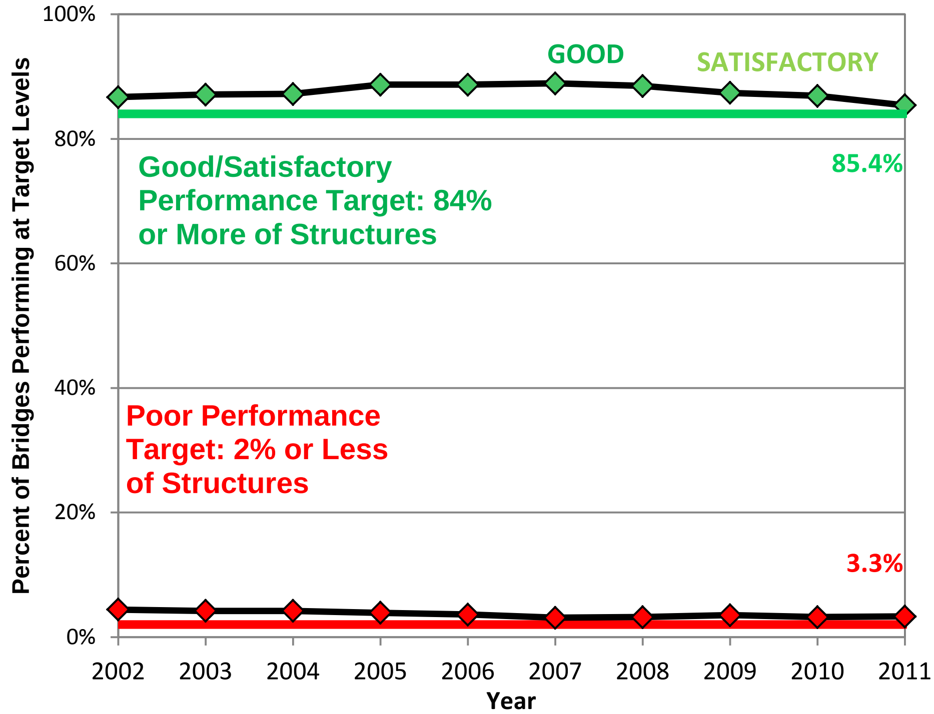
The bridge management program's effectiveness is tracked by several performance measures which focus on structural condition, inspection processes, and maintenance activities. In addition to monitoring actual results, the performance measures themselves are continually evaluated to confirm they are appropriate indicators of the success of the bridge asset management program.

Structural Condition

Performance targets were established to ensure that Minnesota's bridges are safe and maintained in a reasonable state of repair. The targets and historic performance is shown below in Figure 3.7.

- 84 percent of bridges in GOOD and SATISFACTORY condition
- Less than two percent of bridges in POOR condition

Figure 3.7: Structural Condition



Also, within the population of GOOD and SATISFACTORY bridges, a supplemental target of 55 percent of bridges in GOOD condition was established. This measure recognizes that SATISFACTORY bridges will eventually deteriorate into FAIR condition and require a major rehabilitation or replacement effort.

It is expected that the POOR condition target (two percent or less) will be achieved during the course of the 10-year Chapter 152 program. In order to maintain this target, significant investment in bridge improvement projects must be continued beyond the Chapter 152 program.

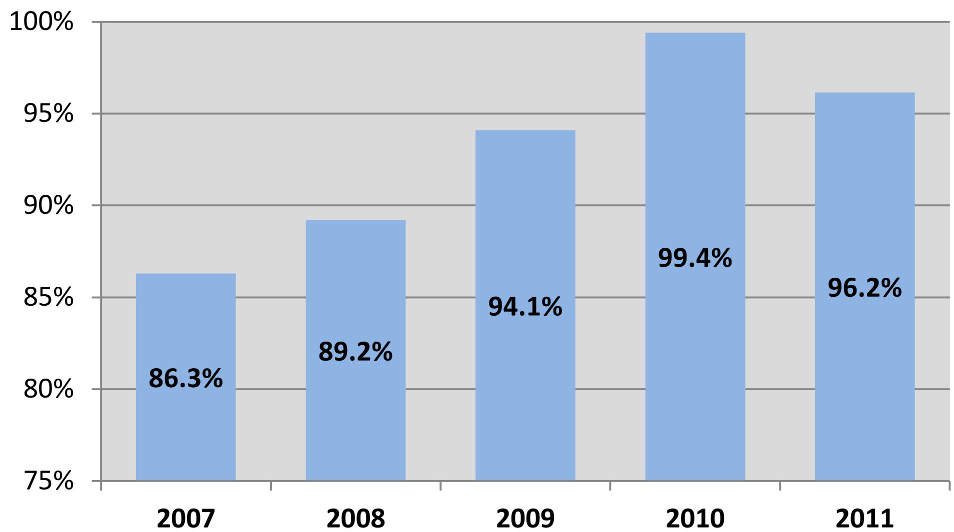
An appropriate investment in bridge preservation will also be required to continue to meet the GOOD and SATISFACTORY target (84 percent or more). The resources allocated toward preservation will not only assist in meeting this target, but will slow deterioration rates and can defer or reduce the magnitude of major capital investments.

Inspection

To ensure that inspection findings and maintenance needs are effectively documented, two inspection performance measures are in place: timeliness of bridge inspections and timeliness of data entry. Tracking these measures confirms whether adequate resources were effectively applied to the inspection and inventory effort. Aggressive targets have been set, with the goal of 100 percent of bridge inspections completed on time and 100 percent of bridge data reported within the required timeframe.

MnDOT has significantly improved its on-time inspection rate over the past five years (Figure 3.8). This success can be directly contributed to an increased focus on the inspection program and a commitment to maintaining quality bridge data. MnDOT expects to be consistently at or near the 100 percent target in future years.

Figure 3.8: Percentage of Routine Bridge Inspections Completed on Time



Maintenance

The measures to evaluate bridge **Preservation** accomplishments and outcomes include:

- On-time completion of High Priority Reactive Maintenance
- Backlog of Medium Priority Reactive Maintenance
- Completion of Preventive Maintenance

The **High Priority Reactive Maintenance** measure assesses if adequate resources have been applied toward addressing bridge conditions that may impact public safety or compromise bridge structural function. The target is 100 percent on-time completion of these tasks.

Monitoring the **Medium Priority Reactive Maintenance** backlog indicates whether adequate resources have been applied toward managing items that were initially identified as a lower priority. This backlog is defined as medium priority tasks that were not addressed at the time they were due. A due date is determined based on the anticipated time it will take for this condition to deteriorate to a higher level. Even though these conditions are classified as medium priority, they may have already escalated to a higher concern by the time they are officially due.

Figure 3.9: Bridge Maintenance Definitions

HIGH PRIORITY REACTIVE MAINTENANCE is in response to bridge conditions that may impair the safe function of the bridge or deteriorate to critical if not repaired within one year.

MEDIUM PRIORITY REACTIVE MAINTENANCE is in response to bridge conditions that are expected to deteriorate within three years to a High Priority condition.

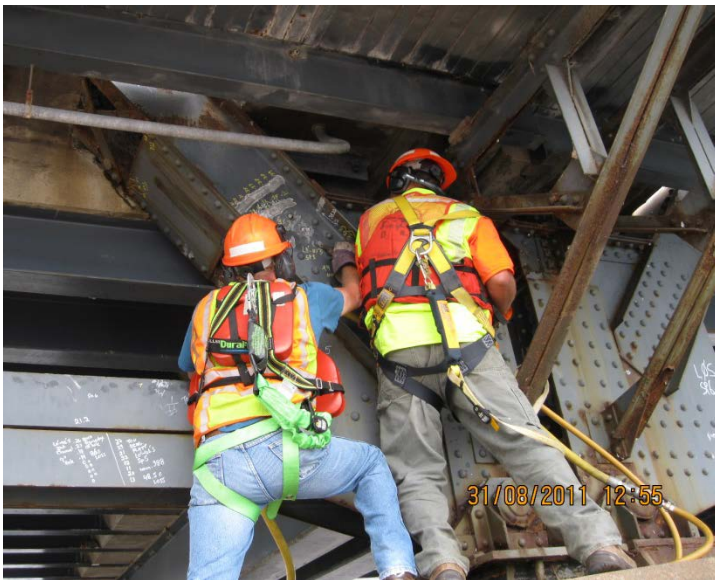
PREVENTIVE MAINTENANCE maintains bridge components in good condition.

Preventive Maintenance is a proven methodology that slows deterioration and extends the service life of bridges. To assess whether adequate resources are dedicated to bridge **Preservation**, MnDOT has traditionally measured work accomplished versus work planned and monitored the condition of targeted bridge elements (strip seals, poured joints, deck crack sealing, and beam end/connection spot painting).

Enhanced processes for prioritizing and scheduling bridge maintenance have allowed MnDOT to improve on-time completion of **High Priority Reactive Maintenance** from 54 percent to 98 percent over the last three years. Despite this success, the **Medium Priority Maintenance** performance measure shows an annual increase in the backlog of maintenance needs.

Results from the preventive maintenance performance measure imply that bridge maintenance forces accomplished 100 percent of the required Preventive Maintenance, when, in actuality, the extent of Preventive Maintenance requirements is not sufficiently defined. With further development, this measure should determine whether the recommended Preventive Maintenance Program is applied consistently across the State.

Bridge management decisions are not based on individual performance measures. The network is managed with the recognition that the resources applied toward meeting one target are unavailable for meeting other bridge needs. For example, time spent on high priority maintenance can cause a backlog of lower priority maintenance tasks to accumulate, allowing these lower priority items to eventually deteriorate into conditions that are more extensive and costly to repair. Collectively evaluating the results of these performance measures enables a balanced approach toward bridge management decisions.



Strategy Development/Policy Direction/Risk

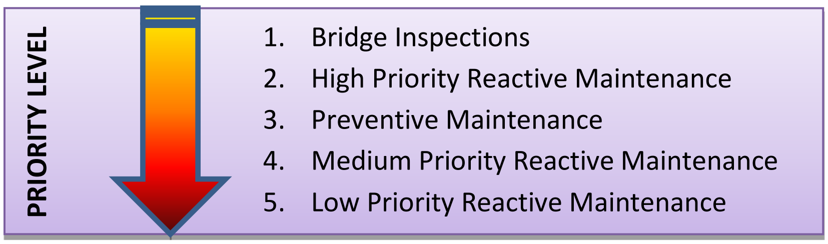
MnDOT has traditionally managed the bridge system through separate programs (inspection, maintenance, and capital improvement). Each program was developed and managed individually, with decisions generally made in isolation from the other efforts.

As the bridge network ages, limited resources and variable funding levels will continue to constrain MnDOT. A strategic approach to managing bridge infrastructure must be employed, including reasonable and timely investments into the correct management activity at the correct time. To accomplish MnDOT's strategic goals, bridge investments must be viewed in light of a comprehensive asset management concept. This not only requires that individual bridge **Assessment**, **Preservation** and **Improvement** programs be maintained, but also enhanced and linked to make coordinated decisions across the three asset management components.

These enhancements will position the bridge management program for eventual integration into an overall management framework for all transportation assets. Without this comprehensive framework, MnDOT cannot effectively respond to variable funding levels and will continue to be largely reactive in bridge management decisions rather than employing techniques to maximize bridge service life at lower lifecycle costs.

Variable funding levels greatly impact the ability to effectively manage the bridge network. Without stable and reasonable operating and capital budgets, **Preservation** and **Improvement** investments cannot be optimized. In recognition of this financial uncertainty, bridge inspection and maintenance tasks are assigned the following priority:

Figure 3.10: Bridge Assessment and Maintenance Priorities



In accordance with State and Federal law and MnDOT policy, all bridge inspections must be completed on time; therefore, bridge inspections are the top priority.

Bridge needs are primarily driven through the inspection process. From this, bridge maintenance tasks are identified. Each maintenance task is classified as either Preventive or Reactive and assigned a priority level of high, medium or low, based on the condition, safety and type of repair. These maintenance items are then scheduled based on the type of need and the assigned priority level.

Current funding levels provide resources to accomplish Inspections, High Priority Reactive Maintenance, and a portion of the Preventive Maintenance requirements. Lower priority maintenance activities may be coordinated with these high priority activities whenever possible to minimize traffic impacts, traffic control costs and mobilization costs. By deferring Preventive Maintenance and lower priority reactive maintenance tasks, bridge elements will deteriorate at a higher rate, bridge service life will be decreased, and MnDOT will eventually incur greater costs, more frequent service interruptions, and an increased risk to public safety.

Implementation Strategies

The implementation strategy should focus on enhancing and linking the current processes into a comprehensive Bridge Asset Management System. This system will allow MnDOT to make informed decisions ensuring that bridge service life is maximized, lifecycle costs are minimized, and the Minnesota's bridge network safely fulfills its transportation function. To realize the full potential of this Bridge Asset Management System, the following specific strategies should be adopted:

- Develop and implement a formal statewide **Preservation Program,** including guidelines, performance criteria, maintenance intervals, standardized best practices and reporting.
- Continue to enhance the integration of bridge inspection processes and bridge maintenance planning within the Structure Information Management System (SIMS).
- Continue to enhance the Bridge Replacement and Improvement Management (BRIM) system, a risk-based planning tool for programming bridge rehabilitation and replacement projects.
- Improve MnDOT's bridge management systems to include detailed system-level tools that adequately allow MnDOT to prioritize and manage bridge needs, link investment strategies to lifecycle costs, and allocate appropriate resources to the appropriate bridge asset management component.

3.3.2 Other Structures

Introduction and Background

In addition to bridges, several other roadside structures should be included in MnDOT's structures inventory. These structures include items such as retaining walls, sound barriers, sign bridges, light tower poles, and concrete barriers. In the past few years, MnDOT has become aware of the need to better manage these structures. Efforts have recently begun to develop an inventory and condition assessment on these structures; however, additional effort needs to be put forth to complete this information so that it can be used to effectively manage these system elements.

MnDOT is undergoing a process to develop criteria and framework for Enterprise Asset Management. This framework will allow for a process to implement a Department-wide inventory and assessment system for MnDOT's other structures.

Many of these structures were built since 1960 when the trunk highway system was significantly expanded. A portion of these facilities are now reaching their effective lifecycle and will require significant maintenance, rehabilitation, and/or replacement. None of these structures were addressed in the initial HSOP report.

Factors Affecting Capability

Since there is virtually no history on these additional structures, the initial direction is to develop an inventory, condition assessment, and then a plan for adequate repair/maintenance. It is anticipated that developing these programs will most likely require the four-year planning window to accomplish. Subsequent studies and updates to the HSOP will need to develop schedules for inspection, reporting, repair, and maintenance of these structures.

Performance Measures

Non-bridge structures currently do not have any measures or established maintenance programs. This study suggests developing measures for inspection frequency and timeliness, structure condition, and reactive and preventive maintenance schedules for the non-bridge structure programs.

Strategy Development/Policy Direction/Risk

MnDOT historically has not tracked the overall condition of these other structures. Maintenance activities were primarily based on visual inspection if something was reported or observed during another activity. The lack of information on the overall condition of these other structures poses some potential liability and risks to MnDOT.

Implementation Strategies

The following list identifies various strategies that should be pursued over the next several years to enhance the status of MnDOT's other structures.

1. Identify an inventory and assessment process and criteria through the MnDOT Enterprise Asset Management framework for other structures. In addition to the inventory and assessment process, the frequency of updates and performance thresholds should also be established.

2. Identify effective preventive and/or reactive maintenance strategies to extend lifecycle and/or plan for infrastructure replacement.

3. Identify key risk elements and how these risks should be addressed as they relate to maintenance and replacement strategies.

4. Assign responsibilities to MnDOT staff for maintaining records of these various elements.

3.4 Safety and Guidance

Transportation users expect safe travel. Accordingly, safety is a broad, constant, underlying goal for almost all MnDOT work activities, including operations and maintenance. Reducing the risk of crashes and decreasing the severity of crashes are ongoing challenges for MnDOT and all road authorities. Policy 1: Traveler Safety in MnDOT's STPP aims to reduce the number of fatalities and serious injuries for all travel modes. One component includes the state highway network and focuses on "Toward Zero Death" (TZD) and the Four E's, as well as cost-effective safety enhancements. For HSOP, the focus is on ensuring safety and guidance systems are in place and functioning as intended.

MnDOT has partnered with the Department of Public Safety (DPS), Department of Health, the MN State Patrol, the Federal Highway Administration (FHWA), MN County Engineers, and the Center for Transportation Studies in the TZD program. This program was developed to create a culture in which traffic fatalities and serious injuries are no longer acceptable. Cable median barrier virtually guarantees consistent success in saving lives every year on the interstate system. Cable median barrier will continue to be installed in order to meet TZD goals and MnDOT initiatives.

Providing users good guidance through roadway signing and pavement markings is part of ensuring the user has the information to make good decisions. Ensuring the presence and legibility of guidance systems helps make the system safer. MnDOT has significant activities directed toward the operations and maintenance of such systems. For example, MnDOT manages a large system of pavement marking and road signs, along with lighting systems, to reduce the risks for users as well as provide better outcomes should the vehicle leave the roadway in a hazardous location.

Reducing the frequency and severity of crashes, especially run-off-the-road crashes, is one safety goal MnDOT has established. Traditional guardrail and barrier systems, including plate beam and low-tension cable types have been utilized successfully for many years to prevent more serious crashes. The newer high-tension, cable barrier-type systems installed in many highway medians have saved lives and reduced serious injury crashes. However, these systems have also increased the need for maintenance as these barriers catch errant vehicles.

This “Safety and Guidance” section will provide information about MnDOT’s infrastructure assets that are directed toward the goals mentioned above. These systems include pavement striping, pavement messages and markings, highway signs and delineators, highway lighting, guardrails, impact attenuators, and cable barriers. Some major issues affecting this area include, but are not limited, to the following:

- Address retro-reflectivity requirements.
- Shift to increased lighting efficiency (carbon footprint).
- Increased use of cable barrier systems (more infrastructures to maintain).
- Shift to longer sign-face life (15 years).
- Older population – visibility issues (size of sign lettering).
- Shift to computerized sign inventory system.
- Need for night maintenance for many of these infrastructure elements in high volume, congested metropolitan areas.

3.4.1 Guardrail

Introduction and Background

Guardrail is an essential safety element on Minnesota roadways. Guardrail prevents vehicles from veering off roadways into oncoming traffic, crashing against solid objects, and running off the road in hazardous locations.

Properly located highway guardrail systems have a 94 percent success rate of preventing more serious crashes from occurring. MnDOT has added a substantial amount of cable median barrier on divided highways in order to prevent or reduce crossover crashes. A preliminary study indicates 13 lives have been saved with the installation of only 75 miles of cable median barrier. In addition to cable median barrier, the amount of plate beam guardrail installed on MnDOT roads has also increased. These increases are the result of several factors, including expanding roadways, limited right-of-way, and providing context-sensitive designs with limited encroachments into natural features.

Based on the above, it is expected that guardrail inventory will continue to grow slowly over time. Additional guardrail will likely be required to repair damages. Maintenance crews prioritize guardrail repairs based on functionality and plan repairs for when traffic volumes are low and snow and ice events do not compromise crew safety.

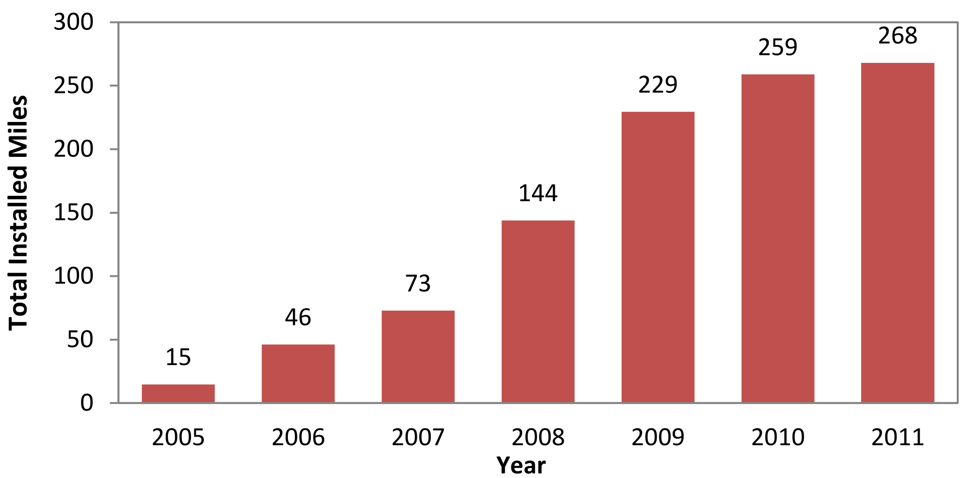
The cost to maintain the guardrail system will continue to increase as the number of damages to the system increases. Due to limited windows for repair, more crews will be needed to accomplish this work.

Factors Affecting Capability

The Federal Highway Administration (FHWA) implements standards and design changes that can alter MnDOT policy. Updating existing inventory components and systems, for example removing wood posts and installing steel posts, will affect material costs to repair the guardrail.

The amount of high-tension cable median barrier installed on MnDOT roadways rapidly increased from 2005 to 2010, as shown in Figure 3.11. The number of planned cable median barrier installations is approximately 78 miles this biennium, which would make the statewide in-place total 347 miles.

Figure 3.11: Statewide Cable Median Barrier Mileage (2005 – 2011)



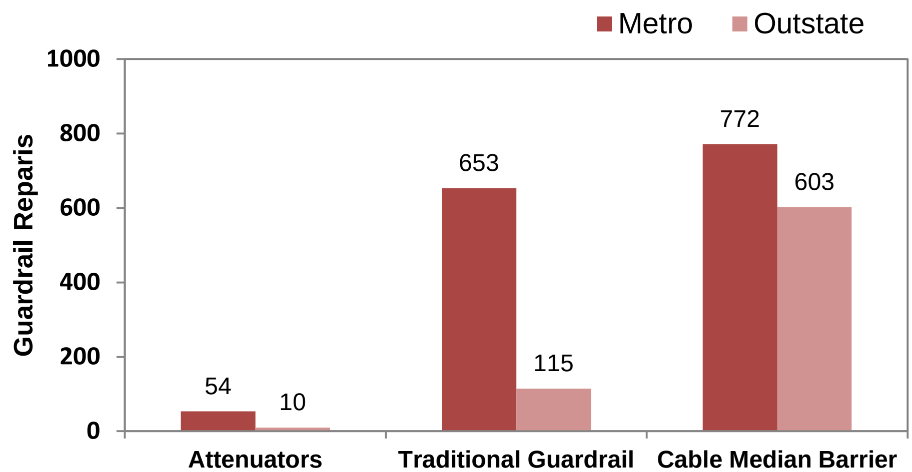
Traditional guardrail systems (i.e. plate beams) will increase roughly 10 percent in the next five years. Yearly inventory data on traditional guardrail systems is unavailable because a reliable inventory system that quantifies the length of guardrail, the number of crash attenuators, and/or the condition of the specific element does not exist. For the purposes of this report, estimates were made by gaining feedback from maintenance engineers throughout the state.

Performance Measures

Designing and maintaining a "forgivable roadside" is a preferred methodology to safe highway design. However, as previously described, forgivable is not always feasible, and so guardrail is installed to protect the traveling public. For each vehicle crash involving guardrail, an instance of protection has occurred. The protection minimizes the severity of injuries to vehicle occupants, danger to adjacent vehicles, and damage to the vehicle itself. Sustained protection is a systematic performance measure.

In 2010, Metro and outstate cable median barrier averaged approximately six hits/mile and 4.5 hits/mile, respectively. When guardrail is hit, maintenance crews repair the damage. Figure 3.12 illustrates the total number of guardrail repairs (hits) statewide. For purposes of this report, traditional guardrail systems include all components not included in cable median barrier or attenuators.

Figure 3.12: Number of Guardrail Repairs (Hits) in 2010 by Type



Guardrail that is not functioning properly does not adequately protect the traveling public. Maintenance crews must respond to non-functioning guardrail in an efficient and effective manner. As such, damaged or non-functioning areas are typically flagged and temporary barrier is provided until crews can schedule and make repairs. In 2010, the Metro District repaired non-functioning traditional guardrail in an average of 16 days and HT Cable Median Barrier in an average of 11 days. Continued record keeping will refine future performance in this area.

Strategy Development/Policy Direction/Risk

Several risk factors could contribute to a change in guardrail maintenance costs. Future legislative changes could affect budget and resource allotments. Federal mandates that include design changes or upgrades could cause substantial increase to the cost of guardrail maintenance. Market volatility and increases in material costs, especially those of metal and steel post price, could influence the cost of guardrail repairs.

MnDOT proactively uses innovative techniques and practices that improve public and employee safety. For example, MnDOT is purchasing a field swage machine. The machine is a safer and more efficient way to repair guard cables in the field.

MnDOT is a member of the Midwest States Pooled Fund Crash Test Program, in which highway roadside appurtenances are crash tested to assure they meet nationally established criteria. Participation in this Program keeps MnDOT in front of new technologies and other safety improvements.

Implementation Strategies

Gaps and Funding Needs

The average cost to repair guardrail is based on the total amount for labor, equipment, and materials. Guardrail costs differ from metro to outstate areas; maintenance costs are higher in the Metro due to increased traffic volumes, labor, and materials cost. Maintenance costs were computed on a per hit basis for cable median barrier, traditional guardrail, and attenuators, and are shown in Table 3.7 below.

Table 3.7: Cost to Repair Guardrail System per Hit

	Attenuator	Traditional Guardrail	Cable Median Barrier
Metro	$3500	$2500	$1200
Outstate	$3150	$2250	$1080

In the next five years, planned cable median barrier installations will increase the current inventory by 30 percent in the Metro and 16 percent outstate. Traditional guardrail systems will increase 10 percent. Maintenance expects the number of repairs on MnDOT roadways will increase at the same rate as inventory projections. Future maintenance repair costs were determined by multiplying the number of repairs times the cost to repair the guardrail system per hit. Table 3.8 describes future guardrail budget and needs.

Table 3.8: Guardrail System Budget Gaps FY12-FY15

	Budget	**Need**		**Gap**	
	FY12-FY15	**FY12-FY13**	**FY14-FY15**	**FY12- 13**	**FY14-15**
Metro	2,700,000	3,000,000	$3,200,000	300,000	$500,000
Outstate	1,000,000	$1,010,000	$1,080,000	$10,000	$80,000
Totals	**3,700,000**	**$4,010,000**	**$4,280,000**	**$310,000**	**$580,000**

3.4.2 Signing

Introduction and Background

The function of highway signs is to provide regulatory, warning, and guidance information to road users. Both words and symbols are used to convey messages to drivers to aid them in their trip. Regulatory signs give notice to traffic laws or regulations, such as speed limits and stops. Warning signs call attention to hazardous or unexpected conditions on or adjacent to the roadway that might not be readily apparent to road users, such as sharp curves and reductions in speed. Guide signs provide directions to road users and help them find their destination. Guide signs also give information such as: city locations, motorist services (including gas, food and lodging); and points of interest that are geographical, recreational, or cultural in nature.

The basic requirements for signs include high visibility in both day and night, and high legibility through adequate-sized letters and symbols for quick comprehension. Providing these basic requirements allows the motorist to comprehend the intended message, determine a course of action, and react to the situation in a timely, safe, and comfortable manner.

Over the past several years, MnDOT has made great progress in developing a sign inventory and management system. The sign inventory and management system will provide many benefits, which include:

- Improving the quality of signs
- Budgeting
- Tracking trends
- Developing best practices for cost-effective replacements

- Complying with Federal standards
- Reporting progress on performance measures

At this time, the system is approximately 85 percent complete.

Factors Affecting Capability

In December 2007, the Federal Highway Administration (FHWA) issued a new standard that requires agencies to maintain traffic signs to a minimum level of retroreflectivity in order to enhance the safety of the driving public. It was then adopted into the Minnesota Manual of Uniform Traffic Control Device (MMUTCD) in February 2008. The new MMUTCD language requires public agencies, or officials having jurisdiction, to use an assessment or management method that is designed to maintain sign retroreflectivity at or above the minimum levels. Three compliance dates were also set forth:

January 22, 2012 – Assessment or management method must be established.

January 22, 2015 – Regulatory, warning and ground-mounted guide signs must meet the minimum retroreflectivity levels.

January 22, 2018 – Street name signs and overhead guide signs must meet the minimum retroreflectivity levels.

One of the suggested management methods identified in the MMUTCD is a replacement cycle based on the expected sign life. MnDOT installs signs with a sticker on the back of the sign identifying the year of installation. The age of the sign is then compared to the expected sign life in order to determine if replacement is needed. The expected lifecycle of a sign in Minnesota is about 12-15 years, depending on the sheeting type. Signs deteriorate and fade over time due to weather conditions, and thus the ability of drivers to see them at night decreases each year. This standard is more critical for certain types of signs. For example, stop signs are a higher priority and require more attention to ensure they can be seen. If a stop sign is no longer reflective and cannot be seen at night, a very serious injury or fatal crash can result.

There are approximately 400,000 signs on the State highway system that require lifecycle replacements. Signs installed before the year 2000 are expected to have a sign life of 12 years. Due to advances in sign sheeting technology, signs installed after the year 2000 are expected to have a 15-year life. MnDOT has had this expected sign life method in place for several years. As a result, MnDOT meets the January 22, 2012 compliance date above.

MnDOT's sign inventory and management system mentioned in Section A will help meet the Federal compliance dates above and maintain compliance in the future.

Inventory Trends

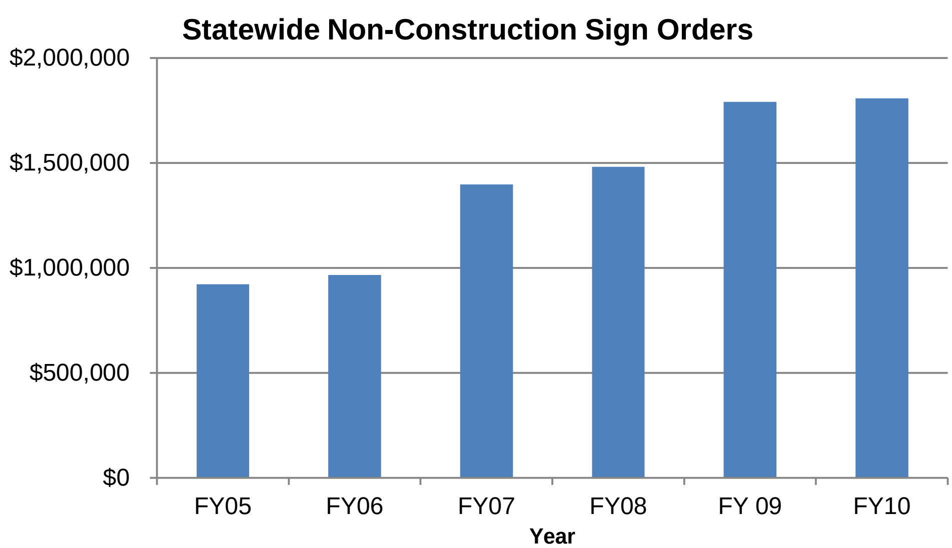
1. **Inventory –** MnDOT's sign inventory increases each year by about 4,000 signs (one percent). The yearly increase is expected to grow based on new Federal standards requiring more signs as described in the 2009 Federal MUTCD.

2. **Operations and Maintenance –** Districts are reporting an increase in wind, storm, vandalism and vehicle damage sign repairs, which is not included in the 12-year cycle replacement numbers.

3. **Cost –** The cost per sign has increased in the past five years.

Figure 3.13 shows that in the past five years, there has been an increase in the total dollar amount of sign orders placed with the sign shop. The increase in total dollar amount is due to an increase in the number of signs fabricated and an increase in the price per square foot of material.

Figure 3.13: Statewide Sign Orders for Signs not Replaced as Part of a Road Construction Project

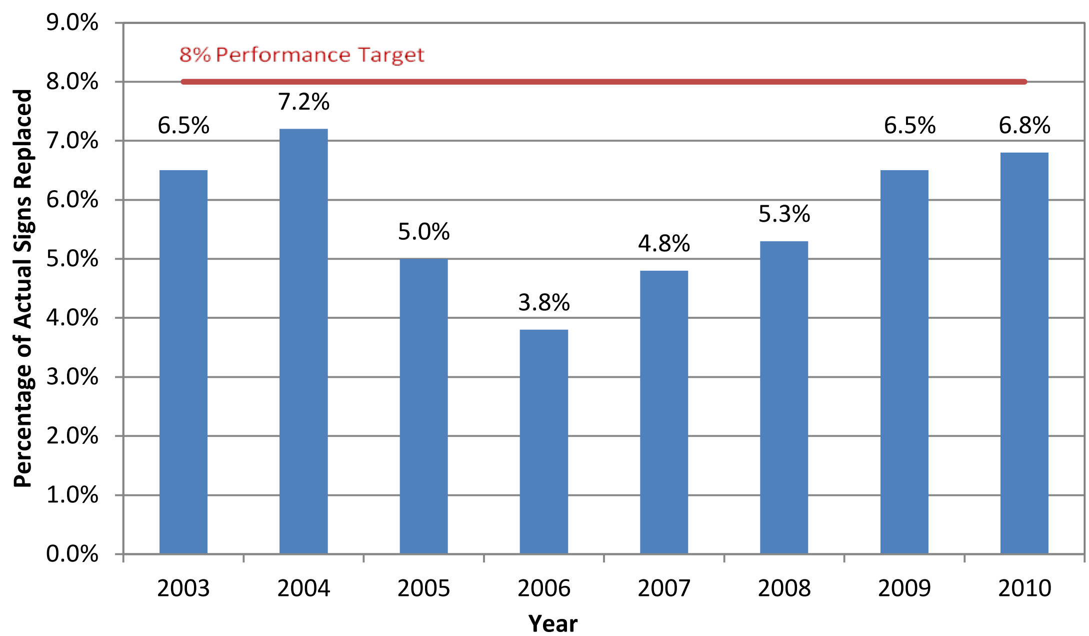


Performance Measures

Districts replace signs using a systematic corridor approach. Based on field longevity tests and the types of sign face materials being used, the high-intensity sheeting lasts an average of 12 years before retroreflectivity is lost and/or the sign legend becomes difficult to read. MnDOT continues to look for products that will improve sign service life and increase retroreflectivity. In 2000, MnDOT began installing a better performing sign sheeting called VIP (ASTM IX) and followed later in 2007 with DG3 (ASTM XI). These types of sheeting materials will allow MNDOT to increase our expected sign life management method to a 15-year replacement cycle.

MnDOT's current performance measures are based on a 12-year lifecycle. If sign replacement goals are met, by the year of 2015 MnDOT should have all signs replaced that were installed before the year 2000 and move to a 15-year lifecycle. With 400,000 signs and a 12-year lifecycle replacement, the performance target for this measure is to replace eight percent of the total signs annually. However, MnDOT is currently averaging only six percent replacement and therefore, the target is not being met. Based on this information, MnDOT is not on track to meet the January 2015 and 2018 compliance dates listed above. This information is shown below in Figure 3.14.

Figure 3.14: Statewide Sign Replacement as a Percentage of Total Road Sign Inventory



Source: MnDOT District Operations Performance Data Collection for 2003-2010

Strategy Development/Policy Direction/Risk

Based on an estimated 400,000 signs on the system and an eight percent performance measure, 32,000 signs per year should be replaced based on lifecycle. However, on a statewide basis, MnDOT has only been able to replace an average of six percent of the signs each year, creating a replacement gap of 8,000 signs per year. Over the past several years, this has grown into a significant amount of signs that are beyond their expected lifecycle. The data collected in the sign management system suggests there are more than 80,000 signs, or roughly 20 percent of the entire inventory, beyond expected life. This gap in the lifecycle replacement target is due to a number of factors including:

- Average cost per sign continues to increase.
- Sign maintenance staff is required to plow snow during winter events; this limits the ability to address sign maintenance issues and lifecycle replacements.
- Reduced maintenance budgets have significantly reduced staffing levels.
- Increasing numbers of signs are in need of immediate repair or replacement due to wind, storm, vandalism, and vehicle damage. For the safety of the road users, these signs are given first priority over lifecycle replacements.
- The traffic volumes and speeds on trunk highways have increased in the past several years. These factors require additional staff and equipment for traffic control during sign replacements.
- MnDOT's signing has ranked very high in customer satisfaction. The latest 2010 MnDOT Omnibus Study asked participants: "Overall, how well has MnDOT been doing at making highway signs clearly readable?" On a 10 point rating scale, signing performance has ranked between 7.9 and 8.2 since 2003.

Implementation Strategies

Based on the analysis, the following strategies are recommended:

1. Continue to replace older signs and signs lost to vandalism, weather, or other damage with ASTM XI sign sheeting in order to increase lifecycle by 25 percent (from 12 years to 15 years).
2. Continue implementing an automated sign inventory and management system to track the repair and maintenance of signing activities. When fully functional, this system will help MnDOT to:
    - Identify and replace critical signs that have the greatest impact on motorist safety
    - Optimize sign replacement schedules by providing a database of sign age and sheeting type
    - Improve the efficiency of the maintenance and traffic engineering staff responsible for signing.

3. Evaluate signing staffing levels necessary to meet MnDOT performance levels and Federal signing regulations. Signing duties must be made a priority to ensure an adequate number of staff is available to address signing needs and meet replacement goals.

4. Continue to look for improved signing materials to extend sign life, improve visibility, and meet motorists needs.

5. Consider developing a preservation program for larger interstate and freeway signs. These signs require large structures and should be treated similar to bridges.

3.4.3 Pavement Markings

Introduction and Background

Pavement markings perform an important function in managing, directing, and controlling traffic. In some cases, they are used to supplement the regulations or warnings of other devices, such as traffic signs or signals. In other instances, they are used alone and produce results that cannot be obtained by the use of any other device. Pavement markings provide the best vehicle guidance to the motorist, especially in low visibility conditions, thereby minimizing the risk of motorists leaving their travel lane. MnDOT has made, and continues to make, a significant investment toward maintaining year-round pavement markings. This effort is especially difficult in Minnesota due to the seasonal conditions that not only limit the time in which pavement markings can be installed and maintained, but also reduces the visibility or retroreflectivity of the markings. In addition, snow and ice control operations affect the life of the pavement markings through abrasive materials and snow plowing operations.

Pavement markings can be divided into two subcategories: longitudinal pavement markings and pavement messages. Longitudinal markings are defined as edge lines, lane lines (or "skips"), and centerlines. Pavement messages include word messages, as well as symbols, such as arrows and stop bars.

Factors Affecting Capability

MnDOT's pavement marking policy is covered in *MnDOT Technical Memorandum No. 08-10-T-02*. The Technical Memorandum states that MnDOT's goal is to "provide an appropriate pavement marking on all highways, 365 days per year." An appropriate pavement marking is defined as one that meets or exceeds the standards defined in the *Minnesota Manual on Uniform Traffic Control Devices,* providing presence and retroreflectivity.

The Technical Memorandum requires MnDOT to use a variety of pavement marking materials depending on roadway characteristics, observed traffic volumes, and remaining life expectancy. The materials used range from the less costly and less durable markings like latex, to the midrange product epoxy to polymer preformed tape for markings that will be exposed to a lot of traffic on roadways with long life service expectancy.

Generally, MnDOT practice has been that pavement marking installation done as part of a construction project is performed by a contractor, while the maintenance or replacement of a marking is done by State maintenance forces.

The FHWA was mandated in the 1993 Appropriations Act to develop Federal guidelines on retroreflectivity for both signing and pavement markings. Signing guidelines have already been passed; however, pavement markings have yet to be passed due to many operational and tort/liability concerns. If these were to pass, this would change the way MnDOT manages pavement markings greatly and would likely require an increase in funding.

Trends

MnDOT has an estimated total of 37,000 lineal miles of striping on the 12,000-mile State trunk highway system. This estimate was performed in 2005. It is unknown how much that figure has changed since then, but because trunk highways are expanded or added in some cases, and turned back in others, the estimated total above is still fairly accurate. There is no known inventory of pavement messages.

MnDOT has six internal striping crews. Four of the crews stripe latex, while two stripe epoxy. While the total mileage of maintenance striping performed each year has been relatively steady, the relative percentage of epoxy used compared to latex has increased. This information is shown below in the following Figure 3.15 and Figure 3.16 and Table 3.9 and Table 3.10.

Figure 3.15: Pavement Marking Mileage Striped by State Maintenance

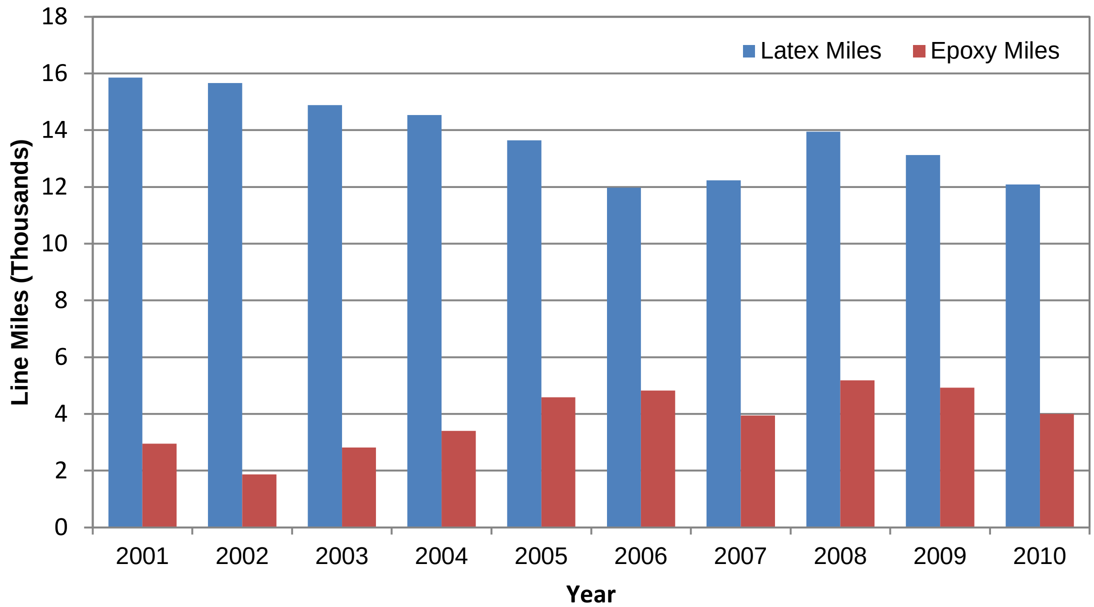


Table 3.9: Pavement Marking Mileage Striped by State Maintenance Forces

Year	Latex Miles	Epoxy Miles	Total Miles
2001	15,851	2,953	18,804
2002	15,662	1,875	17,537
2003	14,879	2,821	17,700
2004	14,535	3,400	17,935
2005	13,647	4,586	18,233
2006	11,977	4,820	16,798
2007	12,236	3,942	16,179
2008	13,951	5,188	19,139
2009	13,119	4,924	18,043
2010	12,087	4,004	16,091

Figure 3.16: Pavement Marking Expenditures for State Maintenance Forces

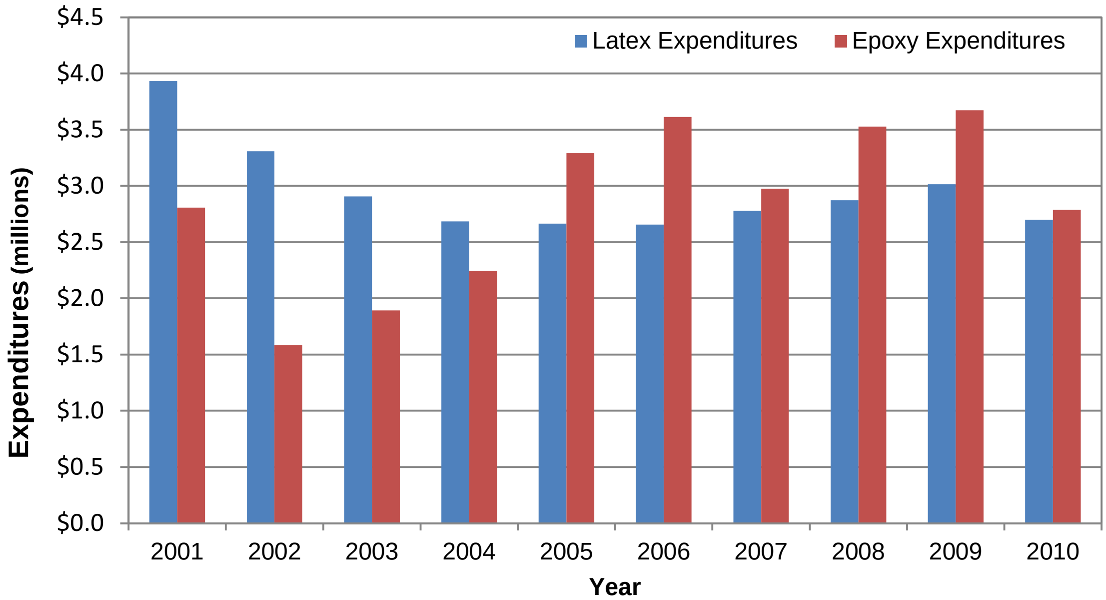


Table 3.10: Pavement Marking Expenditures for State Maintenance Forces

Year	Latex $	Epoxy $	Total $
2001	$3,933,584	$2,806,531	**$6,740,115**
2002	$3,307,814	$1,584,000	**$4,891,814**
2003	$2,906,761	$1,891,650	**$4,798,411**
2004	$2,686,068	$2,244,330	**$4,930,398**
2005	$2,666,117	$3,293,187	**$5,959,304**
2006	$2,656,108	$3,614,368	**$6,270,476**
2007	$2,778,220	$2,976,821	**$5,755,041**
2008	$2,872,388	$3,528,062	**$6,400,450**
2009	$3,016,352	$3,673,592	**$6,689,944**
2010	$2,699,020	$2,787,330	**$5,486,350**

Notice the quantities for both mileage striping and expenditures decreased in 2010, but that is an anomaly. This was due to funding becoming available for striping and signing safety projects that did not involve any pavement maintenance or reconstruction. Thus, a lot of markings that normally would have been re-striped by maintenance forces were instead shifted to construction projects.

Despite inflation and increases in fuel costs, unit costs have decreased for epoxy but held steady for latex. This information is shown below in Figure 3.17 and Table 3.11. Increases in efficiency have held these costs in check; however, due to concerns about shortages in raw materials and increasing fuel costs, these costs will likely increase in the future.

Figure 3.17: Unit Costs for Pavement Markings Installed by State Maintenance Forces

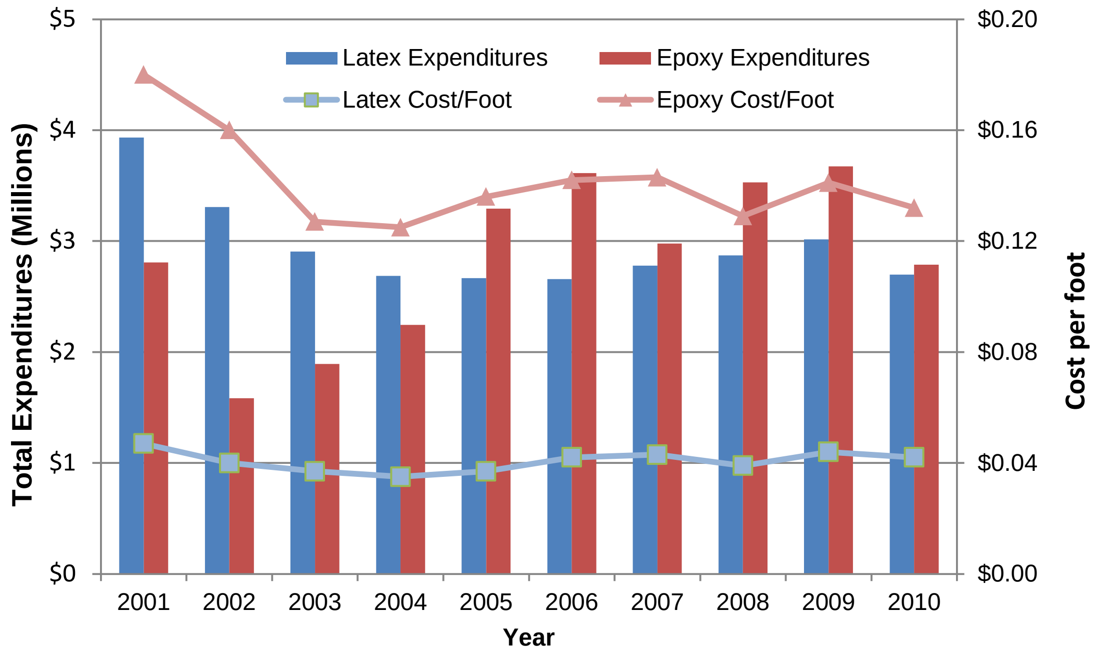


Table 3.11: Unit Costs for Pavement Markings Installed by State Maintenance Forces

Year	Latex	Epoxy
2001	$0.047	$0.180
2002	$0.040	$0.160
2003	$0.037	$0.127
2004	$0.035	$0.125
2005	$0.037	$0.136
2006	$0.042	$0.142
2007	$0.043	$0.143
2008	$0.039	$0.129
2009	$0.044	$0.141
2010	$0.042	$0.132

Performance Measures

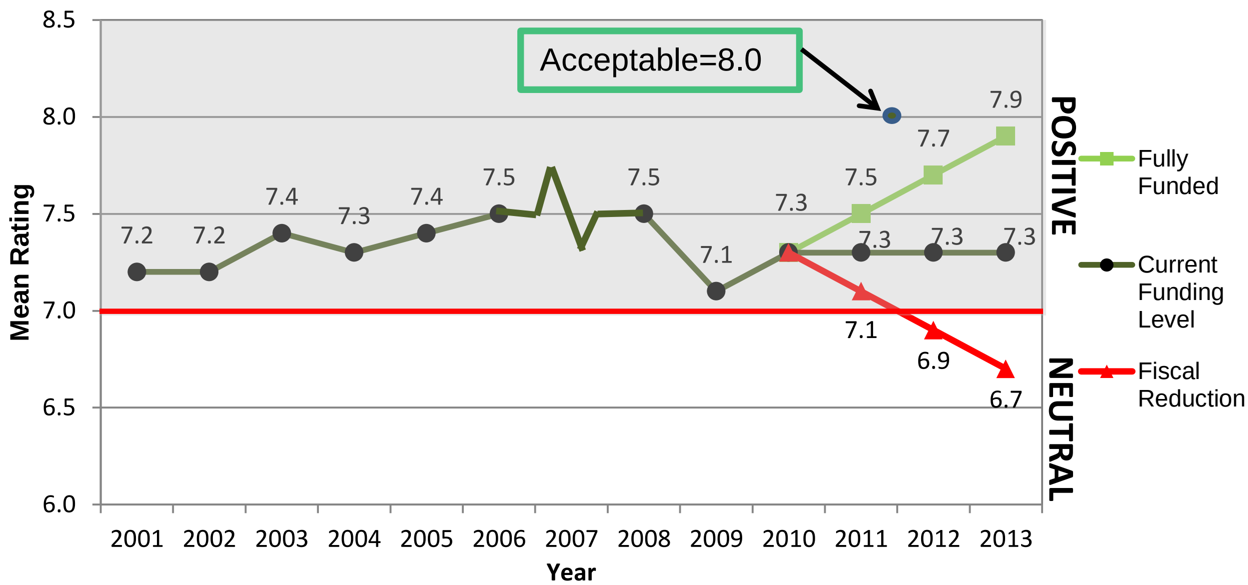
A couple of different performance measures have been used to gauge the effectiveness of MnDOT's pavement markings and are summarized below.

Percentage of system compliant with Technical Memorandum (in terms of material selection) - Percentage of system compliant with the Technical Memorandum is estimated by the Districts. MnDOT's compliance, in terms of appropriate material selection, is usually greater than 99 percent.

Minimum Retroreflectivity (80 or 100 mcd/m^2/lux) - MnDOT re-stripes all markings (it is aware of) that are at or below the minimum retroreflectivity threshold. However, as the mobile van unit only reads 30 percent of the State, many of these decisions are estimated based on the assumed lifecycle of the markings.

Customer Satisfaction - Customer satisfaction has remained relatively steady since 2001, averaging around 7.3. Please refer to Figure 3.18, which also includes a projection of customer satisfaction based on three different proposed budget scenarios. As shown in Figure 3.18, while customer satisfaction has not reached MnDOT's targeted level of approval (eight), this graphic indicates customers are mostly satisfied. It also suggests that while MnDOT may be close to a desirable service level, a funding decrease would negatively affect the public perception of pavement marking quality.

Figure 3.18: Customer Satisfaction Survey Results



Strategy Development/Policy Direction/Risk

Gaps in the area of pavement markings can be difficult to quantify. It is hard to tell how well MnDOT is doing with respect to performance measures due to the lack of data and the resources to manage it. This causes a missed opportunity of stretching the life of markings when there is still measurable life remaining (rather than using a set replacement cycle). MnDOT also lacks data to track the pavement marking life associated with challenging conditions due to snowier seasons or budget tightening pavement fixes such as microsurfacing or chip seals.

There are two major quantifiable gaps in the area of pavement markings. They include:

- Longitudinal pavement marking retroreflectivity readings
- Pavement messages

MnDOT is able to read only 15-30 percent of its system each year for retroreflectivity. MnDOT plans to implement initial retroreflectivity requirements that will be contracted out, either as part of the construction striping bid item, or as a separate additional bid item required for all construction striping. This will lessen, but not completely fill, the gap.

Pavement messages are one area experiencing a gap. Each District used to have at least one message crew to refresh markings, and the crew remained busy throughout the summer. However, these message crews were eliminated in most Districts for budgetary reasons.

This has forced a change in the Districts' striping practices. In construction, most of them have a policy in which they try to minimize the amount of markings that go down initially in order to minimize long-term maintenance needs. Problems also exist at intersections that have both State trunkline and local approaches. Cost-sharing can be an issue for local agencies, which are also short on cash.

Risks

A new Federal pavement marking retroreflectivity standard may be passed that would include minimum thresholds and could result in a major gap, as well as potential tort liability. This would require MnDOT to increase how it stripes markings and probably also increase how many retroreflectivity readings are taken to ensure that the markings are compliant with Federal standards.

As discussed above, price inflation and volatility of available materials are anticipated problems for the future. Also, the 2011 State government shutdown cut into the striping season during the prime months to perform re-striping. This might result in a backlog of striping during upcoming striping seasons.

Finally, preventive pavement maintenance indirectly affects pavement marking performance. Any budget cuts to pavement expenditures will likely cause an increased need for re-striping of markings. Pavement markings do not perform as well on either poor or treated pavement.

Longitudinal Pavement Marking Retroreflectivity Readings

It costs approximately $150,000 to staff and operate the Laserlux van each year. In 2010, the van read 11,100 line-miles of markings. This amount was higher than normal because the van and laser equipment did not break down. This represents about 30 percent of the State's markings.

That 30 percent likely represents the maximum amount that can be read by one van per year. The Office of Traffic, Safety and Technology (OTST) and Central Office Maintenance purchased a new van that will arrive in November 2011. Nonetheless, a decision will need to be made either to add staff to the new van and keep both of them, or sell the old van.

Adding at least one van is necessary to read the entire State every year. The van just purchased cost approximately $220,000. When considering the cost of purchasing another van and staffing three of these units, the costs to take all readings with State forces are prohibitive.

Contracting out the remaining readings is another possibility that might be more cost-effective. MnDOT contracted out readings for all of the Metro District and District 6 (headquartered in Rochester). The winning bid was $15/line-mile. If one assumes that the remainder of the State is 25,900 line-miles, the cost breakdown to read it out by contract would be *25,900 line-miles * $15/line-mile = $388,500.*

Operationally, it makes no sense to simply contract out all readings. Having at least one in-house van is more responsive and also helps manage disputes with contractors on construction projects. Also, the one in-house van is probably cheaper on a per mile basis to operate than contracting it out since the cost of the existing MnDOT van and laser is sunk. A mix of State forces and private contracting to take retroreflectivity readings is likely the most prudent approach.

Therefore, an additional $400,000 per year dedicated to read pavement marking retroreflectivity would offset the increasing costs that are lowering the amount of markings that can be installed.

Pavement Messages

The 2009 Federal Manual on Uniform Traffic Control Devices (MUTCD) prescribes the use message arrows at exclusive use turn bays as a Guidance or "should" condition (refer to Section 3B.20), meaning they should be installed unless there is an engineering reason to not do so. However, the reason they are currently not installed is entirely due to cost.

It is assumed that MnDOT could add at least one more epoxy striping message crew and two more latex striping message crews, and all crews would remain busy. Because the remaining Districts are outstate, the costs for the epoxy crew in District 6 (Rochester) and the latex crew in District 3A (Baxter) were used.

The District 6 epoxy message crew cost $152,859 to run in 2010. The 2010 cost for the District 3A latex crew was $80,468. The cost estimate for adding and operating one additional epoxy crew and two additional latex crews is as follows: $152,859 + 2*$80,468 = $313,795. Thus, the pavement message gap for MnDOT CO Maintenance is roughly $350,000 per year.

The total funding gap for longitudinal pavement marking retroreflectivity readings and pavement messages amounts to about $750,000 per year.

Innovations

MnDOT is currently implementing the Pavement Marking Management Tool (PMMT). The PMMT is an asset management program that will have many positive outcomes. Among other things, the PMMT will contain product, installation, and retroreflectivity history for longitudinal markings on trunk highways statewide in a web-based geospatial database. This will streamline management of pavement markings statewide and provide the Department great benefits.

In addition, the PMMT will help Districts develop their striping plans, help OTST evaluate new products, and help the Department as a whole meet anticipated upcoming Federal retroreflectivity standards for pavement markings.

Of course, the PMMT is only as useful as the data it contains. In order for it to reach its full potential, it must be filled with retroreflectivity data. MnDOT has a van that takes retroreflectivity readings during the construction season, roughly May through November. However, the van can only read about 15 percent of the longitudinal markings in the State. In order to read the entire State, MnDOT would need to contract out most of these readings, or add personnel and another van to take more readings.

Another big trend includes the proliferation of wet-reflective striping. Wet-reflective markings are more visible in dark and wet conditions than standard markings. There are specific, larger optical elements that can be included in liquid markings, like latex and epoxy. When these elements are applied in combination with standard beads, the marking can be much more noticeable to the driver in adverse visibility conditions.

MnDOT has conducted some studies on wet-reflective markings, installing many targeted segments in 2008. Many customer dissatisfaction calls pertain to not seeing the markings during/after rainfall. MnDOT will release a study sometime in 2012 that will include a full, three years of before and after data. However, District personnel have received much positive feedback from motorists about the visibility of these markings.

Another major trend indicates more markings are being recessed, or grooved in, when installed during construction. This helps lower the marking and protect it from both plowing operations and traffic wear. More Districts are grooving in epoxy on concrete pavement during construction projects, and Metro District has made it a standard practice. Ultimately, this helps the marking last longer before needing maintenance and shifts some of the cost burden to construction, where it can be more easily quantified and planned for.

Finally, MnDOT continues to sponsor research on items such as robotic message painters. This could potentially result in a less expensive and safer re-striping of messages that also requires less manpower.

Implementation Strategies

MnDOT has the current architecture to implement any funding increases. MnDOT recently purchased another mobile van reflectometer, which allows for the collection of some retroreflectivity information. If the data collection is contracted out, additional data can be collected and stored in the Pavement Marking Management Tool. Also, the Maintenance Striping Business is equipped to manage any additional striping crews or funding necessary to increase the amount of pavement messages installed by State forces.

MnDOT will continue using a mix of materials for pavement markings, including durable markings in the appropriate locations. The exact mix of pavement marking materials will be based on market prices, customer feedback, and the ability to address those needs based on the capabilities of MnDOT striping crews throughout all Districts.

3.4.4 Lighting Systems

Introduction and Background

Roadway lighting is employed mainly to promote increased visibility, which allows the driver extended time and distance to safely judge roadway orientation, delineate objects or obstructions in or near the travel path, recognize intersection or interchange type(s), indicate roadway changes, and improve visibility during inclement weather. Information in this section includes maintenance, operations, replacement lifecycle and cost of power.

Roadway lighting provides the following safety, capacity, and economic benefits:

1. Reduces nighttime crashes by up to 25 percent.
2. Facilitates traffic flow by adding to roadway capacity.
3. Improves safety at rural intersections.
4. Improves pedestrian safety.
5. Aids police protection, public safety and security.
6. Promotes business and industry during nighttime hours.
7. Diminishes glare from oncoming vehicles.
8. Reduces the number of crashes with deer.
9. Provides visibility beyond headlight sight distance.
10. A 1996 FHWA report indicates lighting has the highest benefit-cost ratio of all safety improvements. Specifically, for each dollar spent, $26.80 was saved in reducing fatalities and injuries in vehicle crashes from 1974 to 1995.

MnDOT owns, maintains, and operates more than 29,000 lighting units statewide for illuminating roadways, interchanges, underpasses, intersections, tunnels, bridges, rest areas, parking lots, aesthetic lighting, and other transportation related facilities. Approximately 2/3 of the lighting units are located within the Metro District (18,500). Please note that urban areas tend to have a higher number of lights since much of the lighting is continuous along the roadway. Rural areas typically have fewer lights since they tend to only illuminate conflict areas such as interchanges, intersections, and other safety related locations.

Due to a long-term lack of system replacement funding, lighting systems are aging disproportionately. As of 2007, more than 40 percent of the systems in the Metro Area were at least 30 years old. This exceeds the industry standard 25-year lifecycle for a lighting system. MnDOT currently spends approximately $3.3 million per year on electricity for lighting systems statewide.

There is recent statewide and national interest in establishing an ongoing structural inspection program for MnDOT Traffic assets such as signals, lighting, and overhead signs. Additional information on this system is provided in the Structures section of this report.

Factors Affecting Capability

Several factors affect MnDOT's capability to provide adequate lighting to the State's transportation system. Many of these trends relate to operations and maintenance responsibilities. The following list provides background information on many of these factors.

1. **Increasing Inventory –**The lighting inventory has increased by nearly 2,000 lights in the last five years. The number of lighting units is expected to continue increasing given the number of new interchanges and intersection types that require lighting (roundabouts, rural intersections, J-turns, 3/4 intersections, etc.) for safety.

2. **Operations and Maintenance Staffing and Budget Levels –** Materials Budget (8500 Fund) - From calendar year 2005 through 2010, the 8500 Materials Budget Account for electrical maintenance has increased 14 percent overall, but the costs of materials have increased 65 percent during this same time period. This has hindered maintenance activities by foregoing purchasing of electrical materials, such as cabinets, luminaries, and poles, when the funding runs short. This requires the maintenance staff to make temporary repairs, which increases the overall cost of the maintenance as personnel must return to make a permanent repair when material funds become available. Increased material funding is needed to handle knock-downs, emergencies, and short-term component replacements. (Note that preservation funding is currently used to fund full system replacements and re-lamping). Recommendations from the structural inspection contract have adversely affected the 8500 Fund (see below).

3. **Average Number of Work Orders –** While the number of work orders fluctuates from year to year, on average the Metro Electrical Services Unit (MESU) handles more than 1,500 highway lighting work orders per year. But the number of uncompleted work orders that are carried over to the next year has increased 111 percent since 2006, while the uncompleted work orders totaled just 213 and has steadily grown each year to 574 in 2010.

4. **Funding –** Preservation funding allocations have remained at levels far below recommended replacement cycles.

5. **Structural Inspection –** There is recent statewide and national interest in establishing an ongoing structural inspection program for MnDOT Traffic assets such as signals, lighting, and overhead signs. In 2009-10, Metro Traffic requested and completed a consultant contract for structural inspections of light poles. The inspection identified the following high-priority items (to be replaced within one year):

    - 470 Poles
    - 799 Bases
    - 1,388 Anchors
    - 82 Foundations

    Costs for these items have overwhelmed the materials 8500 Fund.

6. **Age of Drivers –** Lighting will be even more important as the number of aging drivers is expected to increase significantly due to the generation of baby boomers.

7. **Age of Lighting System –** Due to a lack of preservation funding over time, the system is aging disproportionately. This adversely affects maintenance costs since they more than double with the age of the system. Table 3.12 highlights the estimated annual maintenance cost for lighting by age.

Table 3.12: Annual Feed Point Maintenance Costs vs. Age of Lighting System

Lighting System Age	Estimated Annual Maintenance Cost
15 years	$1,300
20 years	$1,900
30 years	$2,600

Note: This assumes an urban lighting system (20 lights per feed point) at 2007 costs.

8. **Need for Expansion –** As the number of aging drivers increases, it is important to consider expanding the use of continuous lighting systems in large urban areas. Specifically in the metro area, MnDOT should consider adding lighting systems within the I-494/694 ring. MnDOT Traffic receives no funding for system expansion. Expansion can only occur with road projects and only when the project manager deems that funding available.

9. **Cost of Power –** The cost of electricity has increased by 31.8 percent since 1990, from $5.98 per kilowatt-hour in 1990 to $8.36 per kilowatt-hour in 2008.

10. **Reductions in Operating Budgets –** The electrical costs are funded out of different office's operating budgets. Over the years there have been across the board cuts to MnDOT's budget. These cuts have hit these offices disproportionally hard since they were unable to reduce utility demand.

11. **Cost of Steel, Copper and Aluminum –** These costs are variable and can affect project bids and the maintenance material budget.

Performance Measures

Currently, there are no performance measures or indicators related to lighting systems; however, the following are some potential measures/indicators that should be further explored and evaluated:

- Percentage of new work orders addressed within four weeks.
- Overall number of work orders written/completed (percentage of work orders completed within four weeks).
- Percentage of lighting systems and individual components within lifecycle (see Table 3.13 below).

Table 3.13: Replacement Frequency (Best Management Practice vs. Actual) and Component Costs

Lighting Component	Best Practice Replacement Frequency (Years)	Actual Replacement Frequency (Years)	Approximate Cost/Unit to Furnish & Install
Light Pole (Std. Type)	25	>30	$3,000 (including foundation)
Light Pole Tower	30	40	$60,000 (includes foundation)
Cabinet	10	15	$6,000 (includes foundation)
Light Fixture	10	15	$300
Re-lamp	4	5	$90-120

Strategy Development/Policy Direction/Risk

As documented above, lighting systems provide substantial benefits to highway users and help minimize crashes. Various manuals provide guidance on lighting systems to ensure the proper placement and design of these systems. These manuals include:

Federal Design Standards (Light Levels, Uniformity, Etc.):

- Roadway Lighting Guide by American Association of State Highway and Transportation Officials (AASHTO)
- Lighting Handbook by the Illuminating and Engineering Society (IES)

State Design Standards:

- Transportation Traffic Engineering Manual
- Roadway Lighting Design Manual

In addition to following the guidance in the various manuals, lighting policies are also consistent with MnDOT's over-arching safety policies. These include the Toward Zero Death (TZD) Safety Initiative and the rural intersection lighting policy that requires proactive lighting installations as part of the rural safety initiative.

While MnDOT policies are in place to enhance safety, these policies also have some limitations in regard to necessary funding and statewide direction for lighting. For example, there is a current lack of long-term preservation funding, particularly for lighting operations and maintenance activities (both routine maintenance and preventative maintenance). The rising cost of electricity is another factor hurting the lighting program and results in reduced services, taking money originally allocated for either maintenance or potential expansion of lighting systems. In addition to a lack of funding, there is a need for statewide direction for a structural inspection program. While Central Office currently conducts light tower inspections, this activity must be delegated to the Districts in the future.

Risks

Several potential risks affect the lighting program, including funding. As energy costs rise and the system ages, costs necessary to keep the current system operating are increasing. If additional revenues are unavailable, the amount of lighting may need to be decreased, which could have impacts on safety as well as operations.

Another potential risk in highway lighting is technology and the number of new products that are coming out each year. Standards must be modified to keep up with the evolution of technology and can result in additional costs to the Department. The costs of raw materials (steel, copper, aluminum, etc.) are also a significant factor in overall funding, which pose an additional risk. Various lighting components (lamps, fixtures, wiring, poles, etc.) are expected to increase in cost over time. Further, if there were a shortage of these products at any time, it would also increase costs and present an additional risk.

Innovations

A number of innovations have been identified to enhance lighting systems, including technological advancements, organizational efficiencies, and efforts to reduce utility costs. The following section summarizes these innovations.

Technological Advancements

Light Emitting Diodes (LED) are being considered a possible replacement to traditional High Pressure Sodium (HPS) lights as they could potentially reduce the amount of maintenance re-lamping and possibly reduce energy costs. Prior to acceptance, certain performance thresholds must be considered. These include:

- Light levels and uniformity
- Light level loss over time (LEDs tend to dim over time)
- Reliability
- Energy cost
- Maintenance cost
- Overall lifecycle cost

While LED's show great promise, the technology currently has not proven to be cost-effective for roadway lighting. However, the technology is improving rapidly and must continue to be monitored. MnDOT will continue to investigate product improvements that will lower the lifecycle cost. It is acceptable to pay somewhat more for better products as long as maintenance costs are reduced and they improve the overall lifecycle cost.

Organizational Efficiency

The number of trips and lane control required to maintain lighting systems account for a high portion of the overall lighting maintenance costs. In order to minimize the number of site visits, MnDOT must consider the cost implications of combining re-lamping, structural inspection, and preventative maintenance activities.

Change Lighting Usage to Reduce Utility Costs

One way to control utility costs is to reduce consumption. This could mean turning off some lighting systems or turning them off at times of reduced traffic flow. LEDs may also provide the opportunity for remote programming. This could allow MnDOT to remotely dim the lights at times of reduced traffic flow, which would reduce energy costs. Therefore, reduced utility consumption would need to be weighed against safety benefits, such as the rate and severity of nighttime crashes, especially with the expected large increase in the number of older drivers.

Gaps, Funding Needs and Scenario Analysis

This section was written using available Metro data. Metro needs were extrapolated to statewide values using a ratio of the number of lights statewide versus Metro. The multiplier = 29,000/18,500 = 1.57. Also reference the spreadsheet summarizing Metro and statewide gaps/needs in Table A.

Permanent System Replacement (Preservation) Funding for Lighting Systems

The industry standard service life for lighting systems is 25 years, however, due to a lack of system replacement funding, MnDOT has been forced to use a service life beyond 30 years. In 2007, approximately 7,600 lights (43 percent) older than 30 years were found within the Metro District.

To replace and re-lamp systems on a 30-year lifecycle, Metro needs $3.9 million per year (approximately 620 light poles per year at $5,500 each, plus $500,000 for re-lamping). Since some portions of lighting systems are replaced and funded via road projects, it is assumed that only $3 million is needed for preservation funding.

Through FY 2015, Metro Traffic is expected to continue to receive $1.5 million per year for lighting preservation.

Funding Request:

MnDOT needs a permanent funding increase to sustain projected lifecycles for lighting systems and perform re-lamping.

- Metro Traffic requests an additional $1.5 million annually (capital costs).
- Total statewide request is for an additional $2.4 million annually (capital costs).

Notes:

1. Full system replacement estimates were computed using an average cost of $5,500 per lighting unit, which includes all wiring, conduit, cabinet, foundation, and lighting unit. It does not include costs of upgrading structural elements to which the lights are mounted (such as median barrier, bridge railings, retaining walls, etc.).
2. The replacement of old lighting systems will result in maintenance savings.

Permanent Funding for a Structural Inspection Program for Light Poles

In order to provide ongoing structural inspections, Metro would need to average approximately $140,000 per year through FY 2015. Table 3.14 below indicates the proposed number of poles to be inspected each year. The number varies each year since poles in good condition remain on a default schedule while poles in worse condition require more frequent inspection.

Table 3.14: Proposed Poles to Be Inspected

Year	Poles	Cost ($90 each)
2010	1,008	$90,720
2011	887	$79,830
2012	2,241	$201,690
2013	866	$77,940
2014	2,798	$251,820
2015	1,408	$126,720

Implementation Strategies

Based on the previous scenario analysis summary, the following strategies are recommended:

- Use short-term funding shifts within the Traffic budget to allow existing lighting systems to continue to operate uninterrupted for an interim timeline.
- Deploy advanced concepts to manage power consumption, such as adjustments to lighting usage by time of day, traffic volumes and selected locations, in order to systematically reduce the utility budget. Note: There will be significant up-front conversion costs.
- Program an increase of capital expenditures to replace old lighting systems in order to “catch up” to a recommended lifecycle.
- Adopt an undesirable system lifecycle of 40 years (structural adequacy must be monitored). Note: This option will increase maintenance and structural inspection costs.
- Completely remove systems when they exceed the 40-year lifecycle and/or fail to meet structural requirements.
- Reduce support staff proportionally to match the overall downsized lighting system.
- Continue to evaluate new technologies/products that will increase lifecycle performance, improve operational efficiency (such as remote access), and reduce maintenance and energy consumption costs. Light Emitting Diodes (LED) are being considered a replacement to traditional High Pressure Sodium (HPS) lights as they have the potential to significantly reduce the amount of maintenance and potentially reduce energy costs. Conversion, however, will require significant upfront funding.
- Investigate alternative and creative funding scenarios in order to develop a sustainable funding source for the utility budget.

3.5 Arterial and Freeway Operations (Mobility)

Arterial and Freeway Operations addresses congestion and incident management on freeways and arterials, including signal operations and retiming, camera video infrastructure, ramp meters, changeable message signs (CMS), MnPASS, active traffic management, work zone traffic management, and incident management response (Maintenance Operations and FIRST). Effectively managing the State's arterial and freeway systems increases efficiency (reduces delays), improves safety, and provides traveler information for the motoring public.

MnDOT has invested substantial funding in arterial and freeway operational treatments, and more investments are anticipated as the Department continues to look for innovative approaches to increase the efficiency and safety of the State’s transportation network. These operational treatments can typically be done for a relatively modest cost compared to capital-intensive expansion projects.

The 2011 Urban Mobility Report published by the Texas Transportation Institute encourages the use of arterial and freeway operational treatments as part of “a balanced and diversified approach to reduce congestion.” According to the 2011 report, operational treatments, such as ramp metering, freeway management systems, and signal operations, saved the Twin Cities Metro Area $154.30 million in delay costs.

Increased demand for the expansion of arterial and freeway operational treatments has strained existing staff resources required to operate and maintain such systems. Additional resources have also been committed to address increased utility costs, replacement of aging equipment, and ADA requirements for signals.

As a result of the first Highway Systems Operation Plan (HSOP), the Freeway Incident Response Safety Team (FIRST) Program was expanded, a number of signals retimed, and a night maintenance crew added.

3.5.1 Freeway Operations

Introduction and Background

This area emphasizes the management of traffic flow and incidents on Minnesota’s statewide freeway system, including video surveillance systems, deploying CMS and lane control signals, providing traveler information, MnPASS Operations, ramp metering, and the response effort by MnDOT field personnel in removing incidents that affect traffic flow.

Regional Transportation Management Center (RTMC)

The RTMC Freeway Operations staff currently maintains and operates nearly 400 miles of freeway management system devices on the Twin Cities Metropolitan Area Urban Freeway System (MUFS). This system includes cameras, loop detection, CMS, and ramp meters that Freeway Operations staff uses to monitor operations and manage traffic. Freeway Operations provides staffing and monitoring during the peak travel hours of 5:00 a.m. to 9:00 p.m., Monday to Friday, with limited coverage on weekends. During all other hours, Metro District Maintenance Dispatch assumes the responsibilities of Freeway Operations staff.

The state-of-the-art RTMC and freeway management system performs the following functions;

1. Identifies traffic incidents, stalls or other operational problems.

2. Dispatches appropriate resources, including State Patrol, Maintenance units, and the Freeway Incident Response Safety Team (FIRST).

3. Monitors and adjusts ramp metering system, CMS, intelligent lane control signals (ILCS), and other devices to provide information to facility users and manage traffic.

4. Provides information to the motoring public and media through 511 and traffic radio.

Traffic Operations Communications Centers (TOCC)

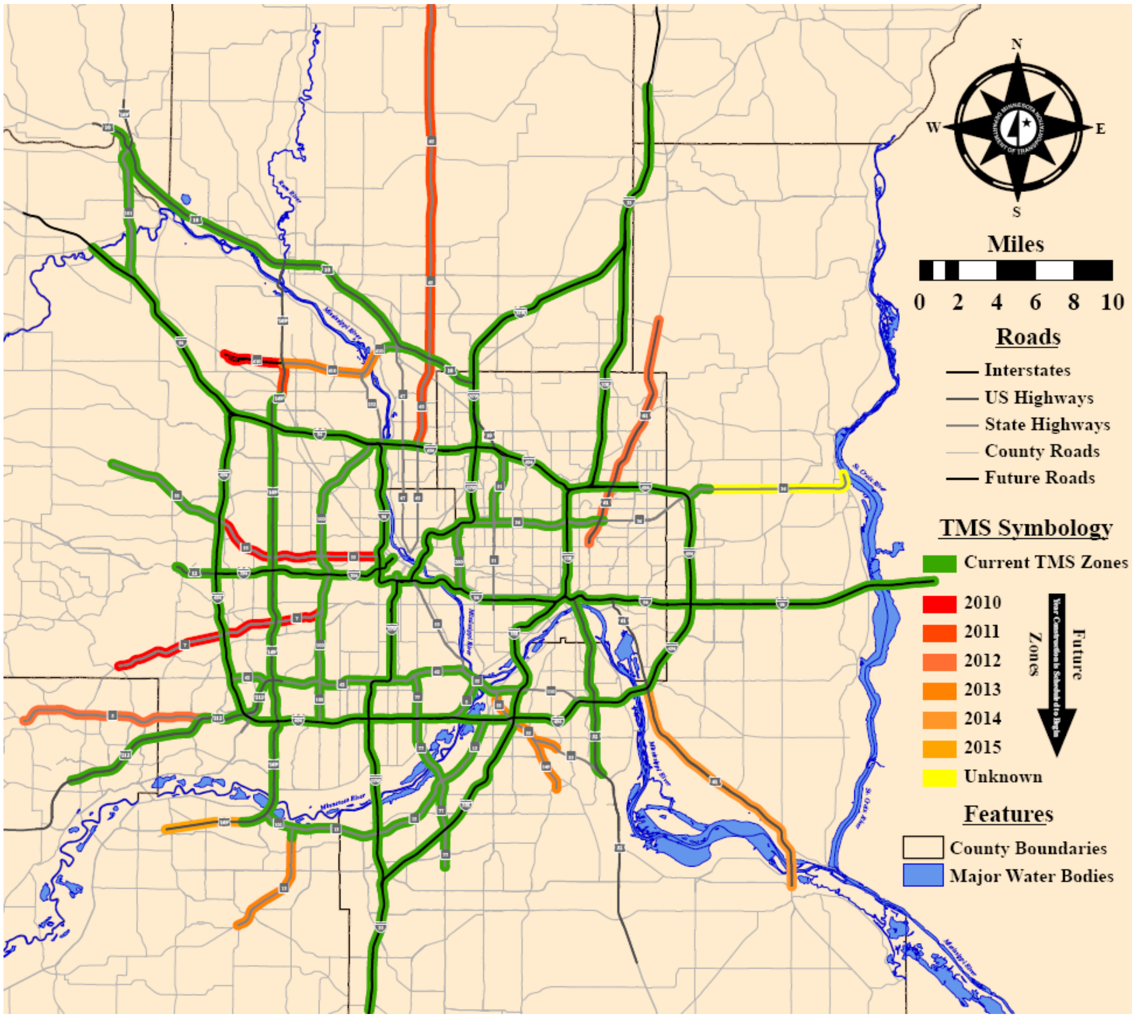
MnDOT and the Minnesota State Patrol currently operate nine TOCCs throughout the State. The individual TOCCs act as regional centers for 24-hour incident and emergency response, including cellular 911 calls, multi-agency dispatching and fleet management, interagency communications, collection and dissemination of road conditions and closures, and traffic management.

Within the next few years, the Minnesota State Patrol will consolidate the TOCCs to two centers located in Duluth and Rochester. With the TOCC consolidation and increasing growth in recreational trips and congestion leading out of the Twin Cities Metropolitan area, there is an increasing need for statewide coordination of traveler information and incident management between the RTMC and TOCCs. This is especially true for incidents that may occur near a district boundary, affect major interstate highway routes, or statewide weather events.

Metro Freeway Management System

Figure 3.19 shows the new expansion plan for both freeway and arterial traffic management systems. The types of devices in the traffic management system include vehicle detection, cameras, ramp metering, CMS, and FIRST coverage. With the majority of the MUFS completed, the focus of any further system expansion is on arterial routes.

Figure 3.19: Twin Cities Metropolitan Arterial and Freeway Management System Expansion



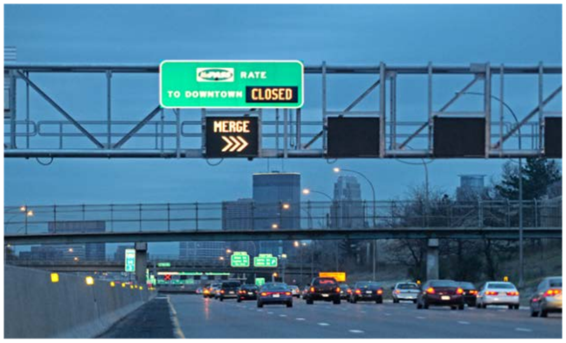
Outstate Freeway Management Systems

With increasing growth in recreational travel and commuter congestion leading out of the Metro area, there is a greater need to provide traveler information and traffic management for outstate freeway corridors. Surveillance cameras, CMS, and traffic detection have been deployed on corridors throughout the State in areas like Duluth, Rochester, and St. Cloud. Further deployments are planned as there is a growing need to coordinate statewide traffic management and traveler information.

MnPASS Operations

In 2005, MnDOT introduced the first high occupancy toll (HOT) lane in the Twin Cities on I-394. Branded as MnPASS, the system allows a single occupant vehicle to use the car pool lane if the owner is willing to pay a toll that changes based on real-time traffic conditions. The MnPASS system provides new choices for drivers to get around congestion while using pricing to limit the number of vehicles in the HOT lane to still allow a free-flow trip for transit and car pools. In fall 2009, this system was expanded to the I-35W corridor connecting the southern suburbs with downtown Minneapolis.

Active Traffic Management (ATM) Systems



Over the past few years, MnDOT has become a national leader in deploying ATM systems on a 15-mile stretch of I-35W. This system includes Intelligent Lane Control Signals (ILCS) over every lane of traffic spaced out every 1/2 mile along the corridor. RTMC staff use 174 **ILCSs** to direct motorists around incidents, inform drivers when the priced dynamic shoulder lane is open for traffic, and provide advisory variable speed limits to warn motorists of congestion ahead with the goal of reducing congestion and improving safety.

ATM systems added to I-35W allowed for a priced dynamic shoulder lane for approximately $35 million. This added lane was completed on this busy section of road years ahead of schedule and at a fraction of the $350-500 million estimate that was developed for a full corridor expansion project. Although ATM systems can save on overall capital costs, they require dedicated staff to design the technology, integrate new devices into the RTMC system, operate, and maintain these devices.

Freeway Incident Response Safety Team (FIRST)

To effectively manage congestion related to incidents, MnDOT uses the *Freeway Incident Response Safety Team (*FIRST) in the Twin Cities Metropolitan Area to assist with quickly clearing stalled vehicles, crashes, and debris. MnDOT developed the FIRST freeway service patrol program to assist the State Patrol with incident response and to respond to problems that do not require State Patrol involvement (i.e., stalls, flat tires).

The primary purpose of the **FIRST** program is to minimize congestion and prevent secondary crashes through quick response and removal of incidents. A secondary benefit to the program is aiding stranded motorists.

Prior to the original HSOP, there were eight FIRST routes covering 165 miles of the MUFS. Additional funding from the initial HSOP allowed MnDOT to expand the FIRST program by three routes. Currently, there are 11 FIRST routes that cover 220 miles of the MUFS. The program operates weekdays from 5:00 a.m. to 8:00 p.m. and limited coverage on weekends to switch the I-394 reversible lane gates.

Intelligent Transportation Systems (ITS)

MnDOT has embraced and actively helped develop Intelligent Transportation Systems (ITS) to improve safety and efficiency of the system for its users. As technology and communications systems have grown in their complexity, so has the need for the level of staffing required to service the various types of ITS devices. In addition to the freeway management systems mentioned above, ITS includes stand-alone systems including:

- Curve speed warning systems
- Dynamic speed display signs ("YOUR SPEED")
- Overhead warning systems
- Roadway closure warning systems
- Remotely operated gates arms
- Traffic detector systems, dynamic message signs, and video surveillance systems not part of a freeway or arterial management system

Factors Affecting Capability

Increased Demand for Freeway Management Systems

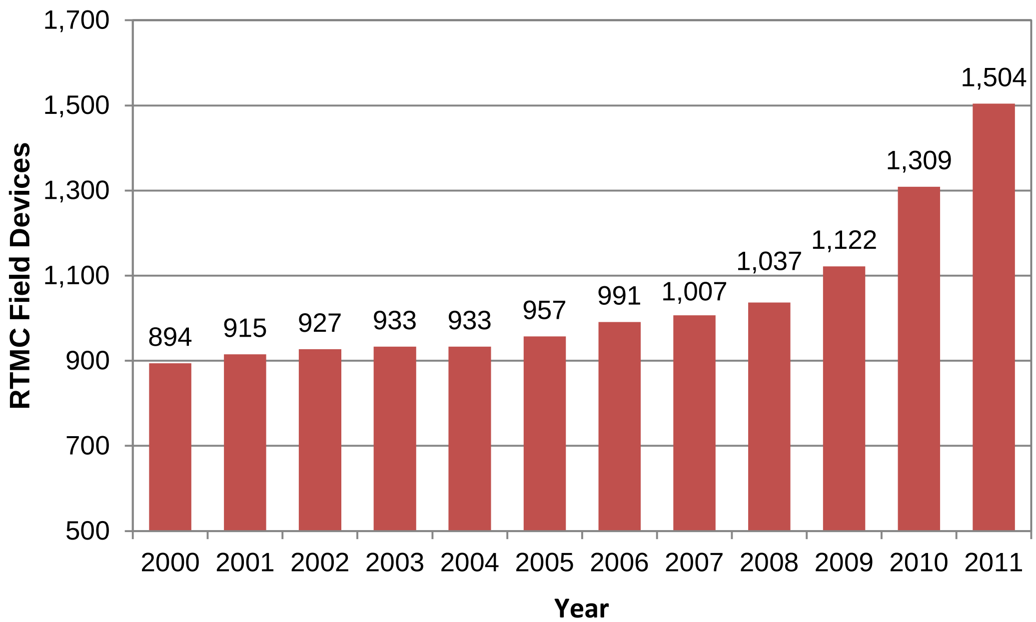
The expansion of freeway and arterial management systems has strained RTMC staff due to the increased amount of system to design, operate, and maintain. With increased congestion and incidents in the metro, the freeway management system now covers approximately 385 miles of the Twin Cities Metropolitan Area urban freeways. The number of system miles has more than doubled from 188 miles in 2000.

Continued growth of the RTMC system is expected as the Metro District's 20-Year Highway Investment Plan 2011-2030 and the Metropolitan Council's Transportation Policy Plan identify and emphasize new strategies for highway investments. A major part of these new strategies is the expansion of MnPASS and ATM. Work is underway on constructing ATM on I-94 between downtown

Minneapolis and downtown St. Paul, and plans are already being developed for expanding MnPASS to the I-35E corridor north of St. Paul.

To illustrate the growth in the RTMC system, Figure 3.20 shows the number of cameras, ramp meters, CMS, ILCS, and gate arm devices deployed since 2000 and the projection for 2011. It is worth noting that while the number of devices deployed has dramatically increased over this period, staffing levels in the RTMC have actually declined.

Figure 3.20: Number of RTMC Field Devices Added to the Metro Area Freeway Management System



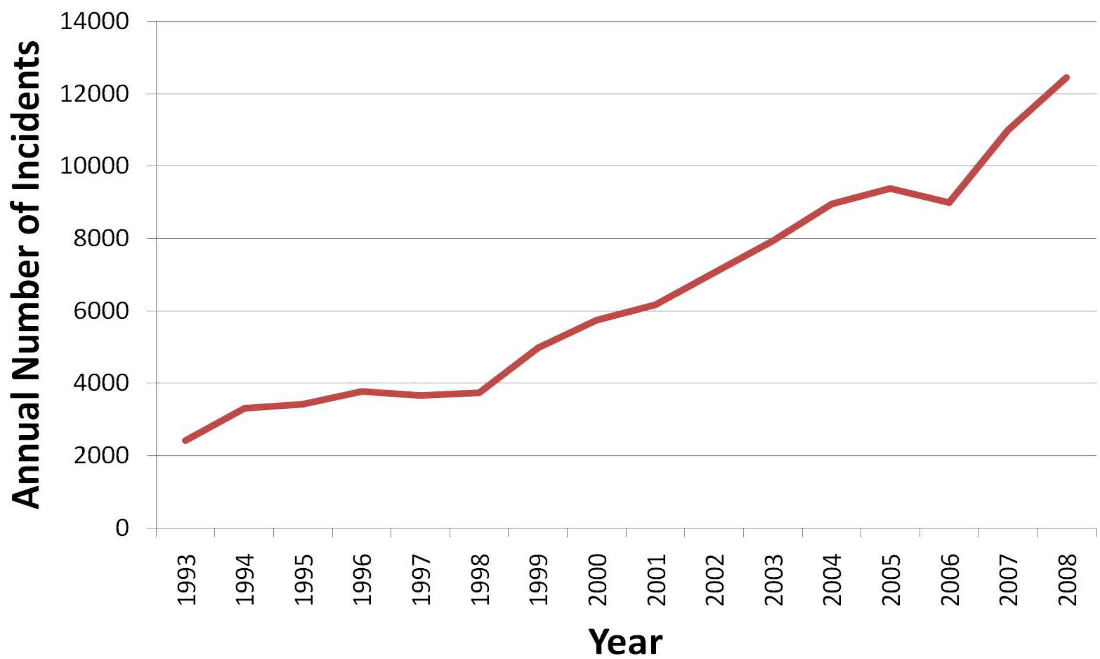
Field devices include cameras, ramp meters, CMS, ILCS, and gate arms. Note that 2010 includes 174 ILCS added to I-35W, and 2011 includes 120 ILCS planned on I-94.

As the system expands, RTMC operators must manage an increasing number of CMS and ILCS. It is critical to display accurate and timely information on these devices so the motoring public considers the messages to be credible. This becomes increasingly important for an ILCS located directly over an incident scene as it could affect the safety of those involved in the incident. The RTMC's ability to maintain accurate and timely messages begins to decline as the number of incidents requiring monitoring grows and the numerous devices to activate per incident increases.

In addition to deploying CMS and LCS devices, RTMC operator staff must also dispatch FIRST units, communicate with Media partners, and ensure the accuracy of the 511 traveler information system.

Figure 3.21 shows the growing magnitude of incidents that RTMC freeway operations staff responds to on an annual basis. As the managed system and traffic volumes have grown, the total number of incidents the RTMC responds to has increased by more than six times since the early 1990s, while the RTMC has maintained the same number of staff in the RTMC Operations Center.

Figure 3.21: Annual Number of Incidents Responded to by RTMC Freeway Operations Staff

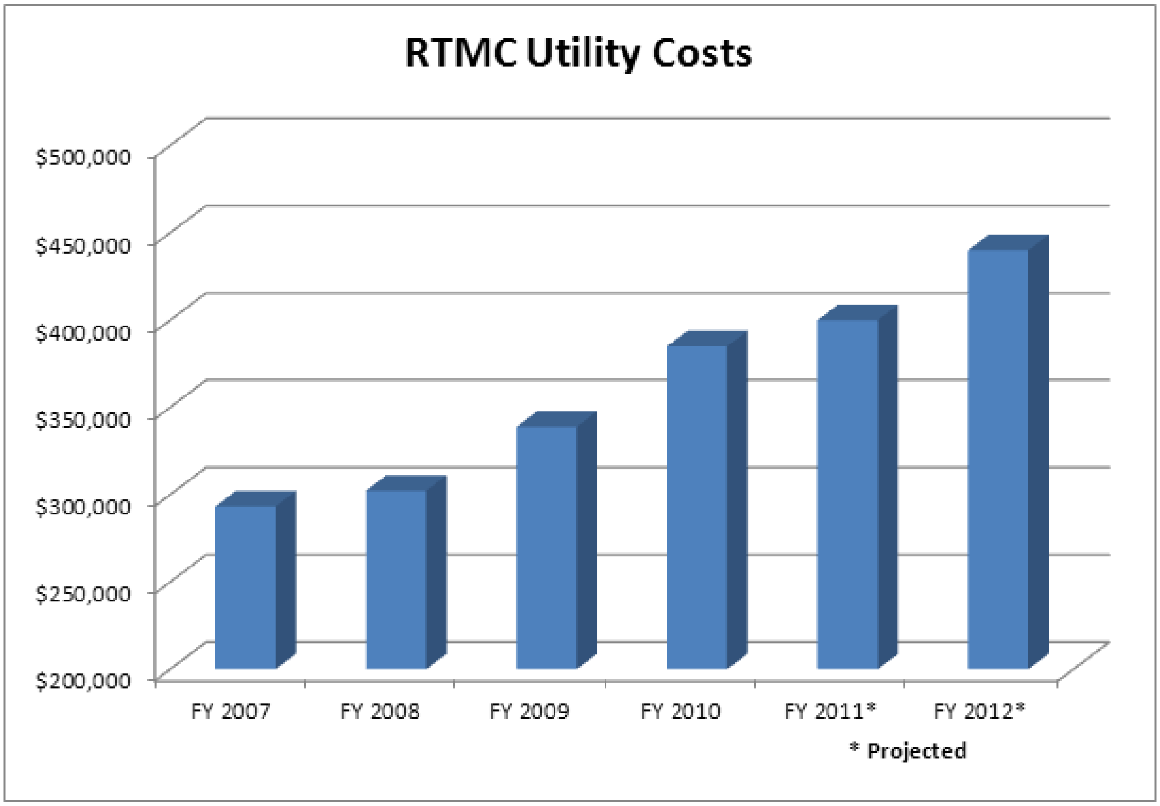


Includes deploying CMS or ILCS, dispatching FIRST, notifying media partners, inputs into 511, etc.

Increased Utility Costs

The growth of the freeway management system has resulted in higher utility costs. Utility costs for the ATM system on I-35W alone are expected to exceed $30,000 per year. Figure 3.22 reflects the increasing utility costs due to rate increases and system expansion since FY 2007. Projected costs per FY are based on annual trends and expected increases due to additional expansion (i.e., an additional $30,000 for the I-94 ATM system).

Figure 3.22: RTMC Utility Costs



Need for Additional FIRST Coverage

The use of shoulders and narrow lanes is an effective way to add capacity without requiring additional infrastructure and right-of-way. However, the lack of shoulders requires additional saturation of FIRST coverage due to the increasing potential of blocked lanes. FIRST coverage has also become an important part of work zone incident management plans to keep traffic moving during a construction project. Currently existing FIRST staff is shifted to provide coverage in these areas, but this spreads out FIRST resources, increasing response times on other high volume corridors.

Work Zone Traffic Management Systems

In the past, freeway management systems were disconnected during construction and one of the last things put back in place. With increasing traffic volumes, construction projects often increase delay and the number of crashes on the freeway system. Maintaining or providing temporary freeway management systems can help to reduce the impacts of construction projects on traffic.

The FHWA has also required MnDOT and other state DOTs to be more proactive in managing traffic during long-term lane closures. States are being asked to develop traffic management plans for road construction projects that will have a significant impact on traffic flow. These plans include using ITS and freeway management systems during the extent of the project.

Greater Minnesota Freeway Traffic Management and ITS

Throughout the State, there is an increased use of ITS to help manage traffic and improve safety. Traffic operations staff is deploying cameras and CMS throughout the State to monitor conditions and warn motorists of traffic hazards downstream. New ITS devices are being deployed at an increasing amount and require additional staff to ensure these devices are adequately maintained and operate as intended. Staff at the district level and at the RTMC is required to support the design and installation of these devices as they require expert staff familiar with the ever changing technology.

Performance Measures

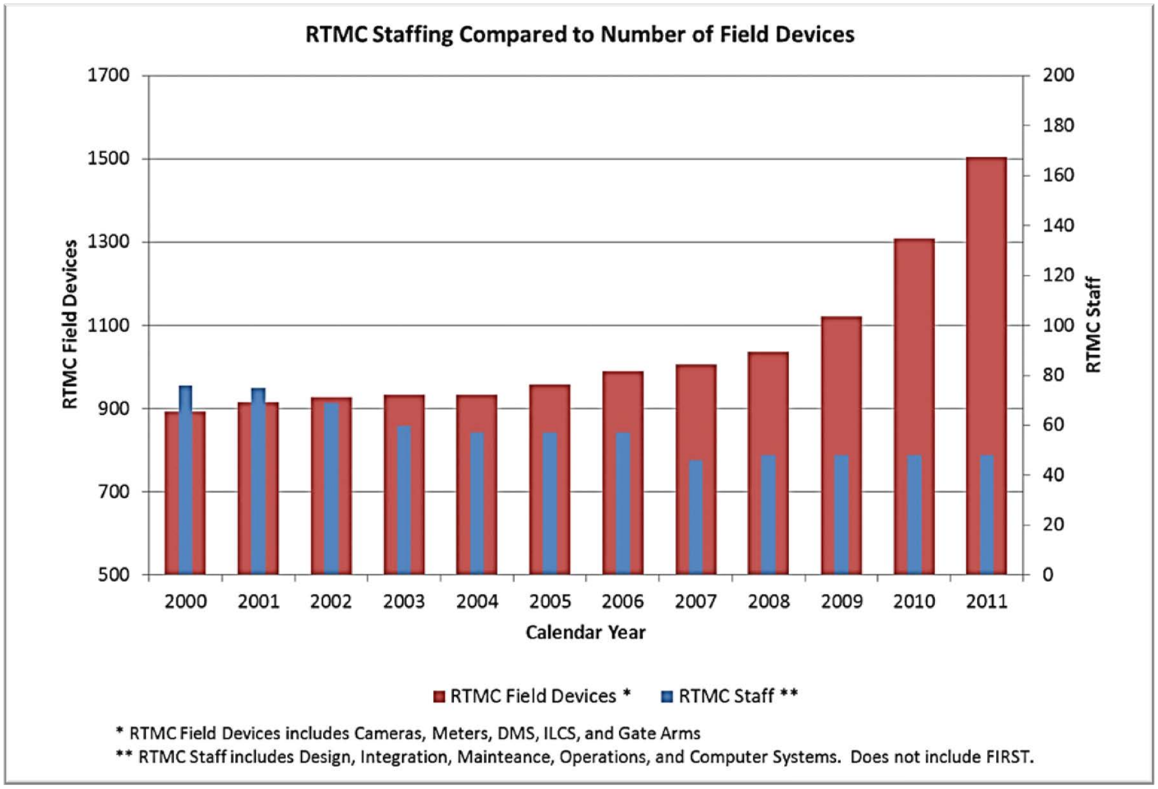
Freeway Operations Staffing Increase

Increased staffing levels would allow operators to display timely and accurate messages for incidents on the freeway system CMS and ILCS. Operators would also be able to provide more timely information in 511. Additional maintenance staff would make equipment more reliable, while additional staff for design and integration would allow for further expansion of the freeway management system plus support for arterial traffic management and the outstate districts.

The proposed performance measure is to compare the number of RTMC staff to the number of field devices the RTMC is responsible for. Using the number of devices is preferred to the number of miles as it reflects additional equipment added, such as the ILCS on I-35W and I-94. The list of equipment includes cameras, CMS, ILCS and gate arms; however, it does not include other support equipment, such as loops, cabinets, shelters, etc. RTMC staffing includes Design, Integration, Maintenance, Operations, and Computer Systems staff.

As illustrated in Figure 3.23, staffing levels have actually decreased in the last decade while the amount of field devices has increased significantly. The ratio of equipment to staffing in 2000 is 12 to 1, while in 2011 it is 31 to 1.

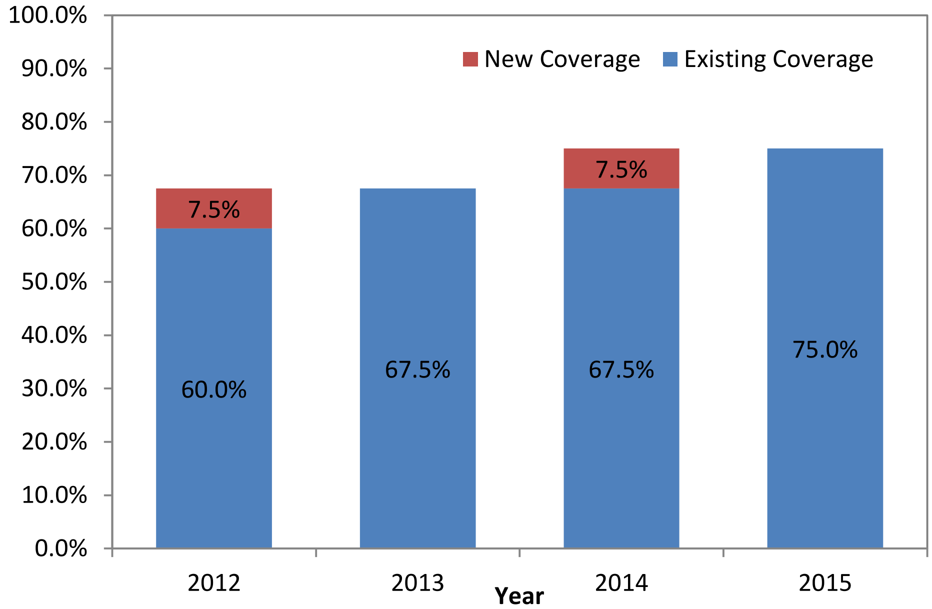
Figure 3.23: RTMC Staffing Compared to Number of Field Devices



FIRST Route Expansion

The proposed measure to track the FIRST program expansion is the percentage of the instrumented MUFS that is covered by a FIRST team. The proposed measure was used in the original HSOP report. The measure is an input measure; however, this measure directly affects the Statewide Plan measure of average incident clearance time. The goal of this measure is to have FIRST coverage on 75 percent of the instrumented MUFS. Figure 3.24 displays the projected percentage of instrumented MUFS covered by FIRST.

Figure 3.24: Instrumented MUFS Covered by FIRST



Strategy Development/Policy Direction/Risk

Technology enhancements have already been made to improve the efficiency of the RTMC freeway operations. The RTMC uses a software program known as IRIS to deploy messages on DMS and ILCS. With the addition of the ATM system on I-35W, IRIS was expanded to allow some automated deployment of the ILCS messages. This improvement allows operators to enter the incident location and the number of blocked lanes. Once general incident information is entered, IRIS then deploys the appropriate ILCS messages. This system is being expanded to auto-deploy DMS messages based on the same incident information. These software enhancements have greatly improved the efficiency of RTMC operations staff, however, it still requires an experienced operator to correctly identify the location of the incident and monitor the incident on camera for any changes that may occur as responders arrive or as the incident clears as these changes may require modifications to the messages being displayed.

RTMC Staffing Increase

Increasing the size of the freeway management system and expanding the use of ATM systems requires additional staff to design, operate, and manage these devices.

- Additional operations staff is needed to monitor incidents, deploy CMS and ILCS, and dispatch FIRST. Currently five FTE, three student workers, and six part-time operators from other areas staff the RTMC freeway operations section. With the increased workload, dedicated FTE staff is needed rather than part-time staff. Expanded hours of coverage are also needed for weekend coverage and extension into the evenings. To provide more dedicated staff while expanding hours of coverage requires four additional FTE operator staff.

- Additional design and integration staff is required to handle future expansion and enhancements of the freeway management system. This staff works with the electronic feeds connecting the pavement sensors, cameras, DMS, and ILCS data to the RTMC Operations Center. Four additional FTE design and integration staff is needed to handle the increased devices and equipment. Table 3.15 shows the RTMC additional staff needs and estimated costs over the next four years.

Table 3.15: RTMC Future Staff Needs

Year	Additional Staff Needed	Estimated Cost
2012	8	$600,000
2013	8	$600,000
2014	8	$600,000
2015	8	$600,000

RTMC Utilities

Additional funding is also needed to keep up with rising utility rates and system expansion. Efforts have been made to minimize utility costs through various methods, such as replacing ramp meter lights with LED lights. Estimated utility costs based on planned expansion and increased utility costs are shown on the following table:

Table 3.16: Future Estimated Utility Costs

Year	Estimated Utility Costs
2012	$450,000
2013	$500,000
2014	$550,000
2015	$600,000

RTMC Maintenance

With an aging system and continued expansion, additional funds are needed to provide replacement parts to keep equipment operational. In addition, two more maintenance technicians are needed for preventive and routine maintenance of the freeway management devices. The following table illustrates estimated costs for additional staff and replacement parts.

Table 3.17: Estimated Costs for Additional Staff and Replacement Parts

Year	Estimated Cost
2012	$400,000
2013	$400,000
2014	$400,000
2015	$400,000

Work Zone ITS

To reduce ongoing operations and setup costs, the RTMC is proposing to purchase field devices that can be easily relocated from project to project, but are already fully integrated with the RTMC systems and operations center. These devices include portable DMS, temporary detection, and other hardware to track the roadway's performance during construction or other long-term lane closures. The estimated costs for additional field devices are shown below.

Table 3.18: Estimated Costs for Additional Field Devices

Year	Estimated Cost
2012	$100,000
2013	$100,000
2014	$100,000
2015	$100,000

FIRST Expansion

The national policy direction includes developing more freeway service patrol teams, such as FIRST, that respond to and clear incidents. A 2005 study found the FIRST program had a benefit cost ratio of 15 to 1 by reducing congestion due to incidents and preventing secondary crashes. Many DOTs have been looking at sponsorship to help expand or maintain programs that are at risk of being cut or eliminated. RTMC staff has continued to explore sponsorship as an option for the FIRST program. Although it does appear that sponsorship would help fund the entire program, it could be used to supplement expansion efforts or equipment purchases. Each FIRST route includes two staff and a vehicle for a total cost of $150,000 per route. Meeting the goal of having 75 percent FIRST coverage for the instrumented MUFS system requires two additional routes at a cost of $300,000 per year. Table 3.19 shows the estimated costs for FIRST expansion over the next four years.

Table 3.19: Estimated Costs for FIRST Expansion

Year	Number of Routes	Estimated Cost
2012	1	$150,000
2013	1	$150,000
2014	2	$300,000
2015	2	$300,000

Implementation Strategies

MnDOT has made substantial investments in the arterial and freeway system throughout Minnesota. These devices and the staff that operate them help to minimize congestion and increase safety. Investments in staffing, ITS devices, FIRST route expansion, and other related areas highlighted above help improve the operational efficiency of the freeway system, which in turn results in less congestion and fewer crashes/incidents. These investments seek to maximize the return on investment and use the existing infrastructure to the fullest, rather than funding capital projects that are often significantly more expensive.

3.5.2 Signal System Operations and Maintenance

Introduction and Background

Traffic signals are highly visible to both the public and local government partners. Traffic signals directly influence safety and mobility on Minnesota roadways. Operations personnel are responsible for retiming the signal and monitoring its performance to ensure efficient operations. Maintenance crews are responsible for ensuring signals and other electrical devices are functioning and the infrastructure (i.e., connections, poles, hardware, and software) is in good working condition. When traffic signals malfunction, they have a direct impact on traffic flow and user safety. A properly designed, operated, and maintained traffic signal is expected to provide one or more of the following benefits:

1. Provide for the orderly and efficient movement of people.
2. Maximize the volume movements served at the intersection.
3. Reduce the frequency and severity of certain types of crashes.
4. Provide appropriate levels of accessibility for pedestrians and side street traffic.

The degree to which these benefits are realized is based partly on the design and partly on the need for a signal. A poorly designed signal timing plan, or an unnecessary signal, may make the intersection less efficient, less safe, or both.

Signals control mainline and cross-street traffic flow movements on key arterial routes. New technologies are being used in signal systems to enhance their ability to move traffic and improve safety. MnDOT currently owns, maintains, and operates approximately 1,300 signal systems statewide. About half of the traffic signals are located within the Metro District. A complete breakdown of the number of traffic signals by District is shown in Table 3.20.

Table 3.20: Number of Traffic Signals by District

MnDOT District	Traffic Signals
1	83
2	61
3	180
4	67
6	94
7	61
8	51
Metro	700
Total	**1,297**

Operations

MnDOT is responsible for operating traffic signal systems on the State trunk highway system. This includes a broad range of tasks (outlined below):

- Developing and implementing signal timing plans
- Monitoring daily logs (detectors and events)
- Responding to signal complaints
- Checking annual operations
- Developing and maintaining plans, agreements, and maintenance data
- Providing construction support
- Writing and tracking work orders
- Monitoring trends
- Maintaining an asset inventory
- Updating the inventory database system

Implementing up to date signal coordination timing plans is a cost-effective strategy to optimize throughput of the current system. This typically results in an overall reduction in vehicle delays and stops, and a savings in fuel and other operating costs. The national standard for signal retiming is every three years. Of the 1,300 signals that MnDOT operates, very few meet this standard.

Maintenance

In addition to ensuring the proper operation of the signal system, staff time is also dedicated to properly maintaining all signals. This includes electrical maintenance and preventative maintenance activities. Proper maintenance can extend the useful life of a traffic signal, and it can improve system capacity and safety as a whole.

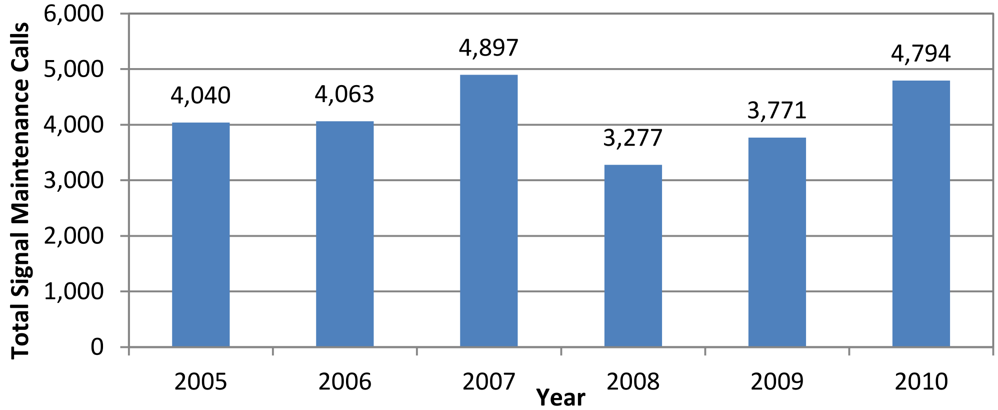
Due to a long-term lack of system replacement funding, the entire signal system is aging disproportionately. Approximately 25 percent of the signal systems are at least 30 years old. This exceeds the industry standard 30-year lifecycle for a signal system[6]. This is problematic because older signals have more maintenance problems, which incur additional costs.

Maintenance activities are divided into two categories: **reactive/emergency type maintenance,** in which technicians respond to reports of problems, and **preventative maintenance,** in which systems are inspected on a regular basis and updates/repairs are made before they lead to a future malfunction. Preventative maintenance is considered a more cost-effective operation and decreases the risk of the system.

In 2010, Metro electrical workers responded to approximately 4,500 reports of signal problems. This number is up from 4,000 in 2005 (a 12.5 percent increase over this period). This does not include signal calls responded to by electricians in greater Minnesota (by the Regional Electrical Services Unit or RESU). Due to a lack of available data, the data used to report signal maintenance is based on Metro's maintenance records (see Figure 3.25). It is assumed this is roughly half of all signal maintenance work performed since half of MnDOT's signals are located in the Metro District. Also, there has been a recent interest in establishing an ongoing structural signal inspection program, which has the potential to greatly increase the number of signal work orders in the near future.

[6] Many agencies have used a 20-year lifecycle for a signal system.

Figure 3.25: MnDOT Metro District Signal Maintenance Calls



Factors Affecting Capability

Several variables have influenced MnDOT's ability to properly operate and maintain its entire traffic signal system. Some of these relate to increasing material costs, while others result from changes in technology and innovative advancements. The overall growth in the number of traffic signals has triggered an additional need for more staffing and resources to operate and maintain the system. Despite the fluctuations in traffic volumes over the past several years, once a traffic signal is installed it must be regularly maintained and retimed to operate effectively. Some of the factors that affect the overall operation are:

- **Additions to the system.** In the past five years alone, an additional 100 signals have been added to the system (roughly an eight percent increase), and more signals are expected to be installed on the trunk highway system in the future.
- **Increased use of technology.** Various technologies have been implemented to increase efficiencies, reduce operational costs, and comply with standards. These technologies include:
  - LED signal indications have reduced electrical power use, which have greatly decreased annual maintenance costs and increased safety. On the negative side, LEDs are 50 times the cost for replacement.
  - The installation of fiber optic signal interconnect has greatly increased the efficiency and reliability of signal communications, reducing the monthly communications costs. Unfortunately, the cost to repair these newer systems is vastly more expensive.
  - ADA Accessible Pedestrian Signals (APS) are being installed on all new and existing signal systems throughout the State. Due to the requirements of the pushbutton location, the signals are more prone to being hit and damaged. The cost of reinstalling a pedestrian station with APS is approximately $1,000 each.

- **Aging infrastructure.** The existing systems are reaching the end of their 30-year anticipated lifecycle. Older signals have a higher likelihood of major failures and increase the cost of repair. Table 3.21 lists the estimated annual signal costs by age of the signal system.

Table 3.21: Estimated Annual Signal Costs by Age

Age of Signal system	Estimated Annual Maintenance Cost (per signal, as of 2007)
15 years	$1,250
20 years	$1,800
30 years	$2,500

In an effort to minimize the number of emergency response calls and increase the functionality and standardization of equipment, MnDOT's Metro District has initiated a lifecycle for signal control equipment. The following table (Table 3.22) includes the lifecycle of the equipment.

Table 3.22: Lifecycle of Signal System Components

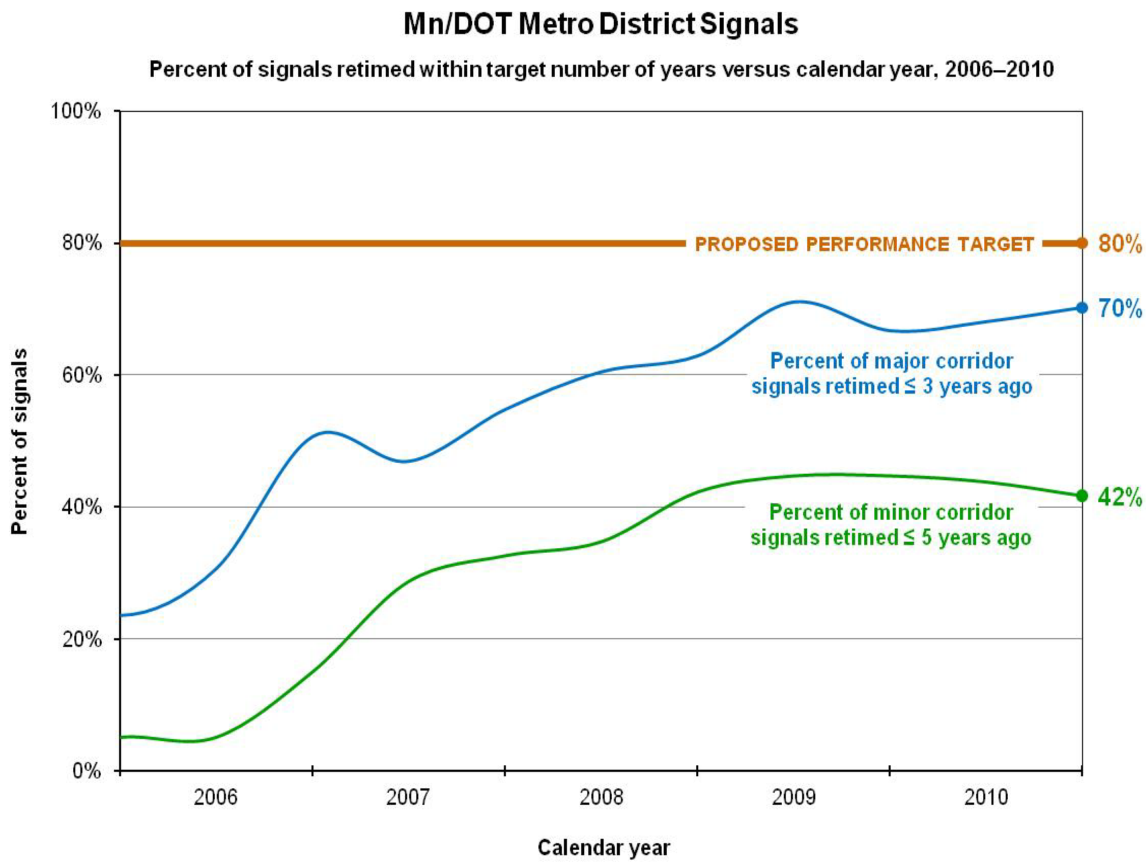
Components	Lifecycle	Components	Lifecycle
Poles, mast arms & foundations	30 years	Detector Amp	15 years
Signal indications (LED)	7 years	Detector Camera	10 years
Cabinet	15 years	Malfunction Management Unit	15 years
Controller	15 years	UPS Batteries	5 years
Controller – Master	15 years	Luminaries	10 years

Based on Table 3.23, one can assume that each year MnDOT should be replacing each of these components to account for depreciation and the aging of the infrastructure. For example, cabinets are expected to last approximately 15 years and therefore, based on this life expectancy, MnDOT should be replacing approximately 1/15 of its cabinets every year.

Staffing Levels – Staffing reductions due to retirements and transfers, and the increased demands of the staff, have resulted in a reduction of dedicated staff working on traffic signals. This affects both the operation and the maintenance duties, where less people are available to provide the required functions. When comparing present staffing levels for all the Districts to the recommended FHWA staffing levels, MnDOT is greatly understaffed in signal operations and maintenance.

Signal Retiming – According to national standards, to maximize efficient operations traffic signals should be retimed every three years. Metro District's goal is to retime all major corridors every three years and minor corridors every five years. However, at present staffing and funding levels, the number of signals being retimed does not keep up with the number of new signals being added (see Figure 3.26). Due to a lack of staffing and competing priorities, it is expected the results for the outstate districts are assumed to be lower than the Metro District.

Figure 3.26: MnDOT Metro District Signals



Performance Measures

Performance measures and/or indicators are used to track progress over a period of time. In regard to the operations and maintenance of traffic signals, various performance measures and/or indicators could be used. These include:

1. **Total Number of Signals –** Since the installation and type of signals vary, this should be further broken out by signal type (coordinated, isolated, dial-up, interconnect type, railroad interconnect, etc.) to more accurately determine the status of MnDOT's signal system. Signal complaints received and responded to, including requests for information from lawyers and consultants, and the response time to provide this information. However, this information is currently available for the Metro District only.

2. **Metro Work Orders** – Work orders and traffic engineering work requests written within the Metro District.

3. **Operational Checks and Annual Field Reviews of Traffic Signals –** Completing routine operational checks and field reviews would enable MnDOT to detect potential trends and better identify the condition of the equipment. For example, in 2011, MnDOT Metro District inspected 700 traffic signals.

4. **Preservation Funding Level –** Preservation funding is used for full system replacements since maintenance budgets only fund a portion of some of the individual component replacement needs, and the maintenance budgets have a finite amount. Therefore, any full-system replacement needs to be programmed as a Capital project instead of a maintenance/preservation project.

5. **Age of Individual Signal Components –** Certain signal components reach the end of their lifecycles before others. The major signal components, mainly those inside the signal cabinet, should be tracked so replacement parts can be installed prior to a signal failure.

6. **Signal Staffing –** Signal operations staff, including operations support staff, (i.e., design and maintenance staff) as it relates to the number of signals operated.

7. **Signal Budget –** Similar to tracking staffing levels, tracking the operations and maintenance budgets can also serve as an indicator to the amount of work being completed.

8. **Overtime –** Amount of overtime used for maintenance staff.

9. **Consultant Budget –** Dollars spent on consultant maintenance contracts (e.g., loop replacements, directional boring, lane control, etc.).

10. **Replacement Age –** Recommended replacement age of signal systems and individual components. MnDOT is currently unable to meet these recommendations included in the Lifecycle table provided above.

Strategy Development/Policy Direction/Risk

Technical specifications regarding traffic signal maintenance is provided through various statewide manuals. These manuals provide guidance on overall traffic engineering, traffic signal design, signal timing, and other useful information to ensure that State standards are followed regarding the location, operation, and maintenance of State-owned traffic signals.

While the technical specifications for traffic signal timing are well defined and documented, there is less clarity regarding future operations and maintenance funding for traffic signals. In general, there is a lack of preservation funding available, and this directly impacts MnDOT's abilities to maintain and operate all of the traffic signals on the State system. Additional statewide direction and funding is needed for a structural inspection program.

Overall, there is a current lack of maintenance funds necessary for routine and preventive maintenance activities. This poses a potential liability risk for MnDOT in the event that a traffic signal does not function properly, nor has other structural issues. Other risks related to the signal system include the need to retrofit ADA components to meet Federal requirements and keeping up with inflation related to the rising cost of materials (copper, aluminum, and steel prices).

Technological Advancements

Over the last five years, there have been many changes in signal design and operation. The TS2 cabinet was introduced into MnDOT signal systems. This opened the door to many other changes that have taken place. During that time, MnDOT has introduced the battery back-up systems, flashing yellow arrows, and enforcement lights. Fiber optic is becoming more common, along with wireless communication. Closed Circuit Television (CCTV) and dynamic message signs are used on signal systems. The effects of LED indications are seen. While they last longer and have a significantly lower energy cost, the replacement cost still needs to be addressed. A longer mast arm has been designed to be used as intersections continue to get larger. Accessible pedestrian buttons are now standard on our designs.

Implementation Strategies

Efficient traffic signal operations provide a variety of benefits and are closely aligned with some major themes associated with the HSOP 2012 - 2015, including enhanced safety, reduced emissions, and better environmental conditions. Several factors influence efficient traffic signal operations and need to be addressed. Based on this report, some of the specific recommendations that should be pursued to enhance signal operations include:

- Properly maintain the existing signal system. While the number of signals has increased, staffing levels have decreased. This trend is not sustainable and will need to be addressed to properly maintain the existing signal system. Efforts should be taken to retime all major corridors every three years and minor corridors every five years.

- Based on the cost to maintain aging traffic signals, approximately 1/15th of MnDOT signal cabinets should be replaced each year. This will require additional funding; however, over time it is expected the additional funding needed in the capital budget would be offset by the reduced funding needed in the operations/maintenance budget.

- Invest in new technology that offers long-term higher efficiency, if proven to be cost-effective. Many new advancements with LED technology offer greater operational efficiencies, but cost more than other alternatives.

3.6 Roadsides Management

Maintenance operations of highway roadsides and right-of-ways are a very visible part of the highway system operations work. With MnDOT's ownership and responsibility for more than 12,000 miles of roadway comes a responsibility to maintain nearly 175,000 acres of right-of-way/green space. The proper maintenance of these areas has implications for both the public perception of roadway quality and the tangible benefits of improved roadway safety and environmental quality. The roadside also functions as a buffer to road noise and roadside pollutants, improving the quality of life for those who live and work near the roadway. Roadsides Management is divided into three primary categories: Vegetative Maintenance and Control, Beautification, and Permitting.

- **Vegetative Maintenance and Control** describes the various methods and challenges of maintaining the natural and landscaped vegetative growth along the roadside right-of-way.

- The primary focus of the **Beautification** category is to manage levels of graffiti and litter on MnDOT roadways. It also describes the use of landscaping and community partnerships to improve the aesthetics of roadside areas.

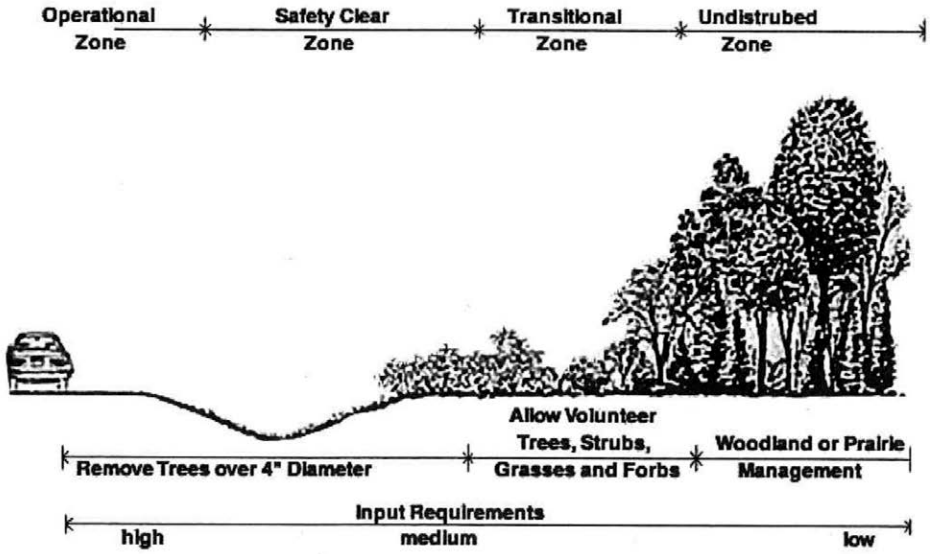
- **Permitting and Property Management** covers the management efforts of all permitted work by non-MnDOT entities, including advertising devices and signs as regulated by the Federal and State Highway Beautification Acts and Minnesota Statutes Chapter 173, "Signs and Billboards along Highways."

3.6.1 Vegetative Maintenance and Control

Introduction and Background

Vegetative maintenance and control account for the most cost-intensive component of roadside management. The scope of vegetative maintenance includes mowing, tree trimming, prescribed burning, erosion control, and the control of invasive species. Constrained budgets and the ecology of the surrounding roadside environment require a focused and integrated approach to cost-effectively manage roadside vegetation. Vegetative Management priorities are given to these activities, which will implement the safety of the traveling public and reduce impacts to ecosystems. Figure 3.27 depicts a typical roadside cross section.

Figure 3.27: Typical Roadside Cross Section



Mowing

Mowing is an important roadside maintenance activity and controls the height of vegetation along the shoulder of the road and within the driver sight lines. Mowing also helps control volunteer brush/trees from growing within the safety clear zone to provide an area for safe recovery for errant vehicles that leave the road. Techniques for limiting the impact of mowing on surrounding ecological systems include limiting mowing in areas outside of the safety clear zone to benefit grassland nesting birds and improve environmental regulatory compliance.

Tree Trimming/Removal – Brush Control

Tree trimming is another important Roadside Maintenance activity that improves road signage and site line visibility. Trimming the lower limbs of trees along highway medians and boulevards reduces damage to high-profile vehicles like semi-tractor trailers. Hazardous trees that could lead to tree failure, resulting in property damage or personal injury, were also removed when identified. Trees within the highway safety clear zones, which are greater than four inches in diameter, are removed to improve driver safety. Removal of trees growing near culvert ends and at the bottom of ditches helps maintain drainage capacity and ensure the integrity of the road surface, resulting in reduced flooding impacts and road closures.

Weed/Invasive Species Control

Noxious weeds are defined in Minnesota State Statute "Section 18.75-18.91." These plants have been determined to be injurious to public health, the environment, public roads, crops, livestock, and other property. Noxious weeds must be controlled or eradicated as required in Minnesota Statutes, "Section 18.78" and their reproducing parts are restricted from sale, importation, and transportation. Invasive and noxious weeds are more effectively controlled by treatment of small populations. Using the right treatment at the right time is also more cost-effective.

MnDOT is also held responsible for removing trees within the highway right-of-way that are infected with forest pests and disease that could spread into the surrounding urban and rural forests. Examples of pests that MnDOT has experienced with through the years include Dutch elm disease, oak wilt, and the pine bark beetle.

The greatest threat MnDOT is actively dealing with is the Emerald Ash Borer (EAB) Beetle. The EAB is capable of killing ash trees of every species in North America and has killed five percent of the total ash resource in Michigan, where EAB was originally found in 2002. Ash trees' ability to grow in poor soil conditions and its high tolerance to salt makes it a widely found species along MnDOT roadsides. In order to select effective management tactics to decrease the natural and artificial spread of EAB, an inventory of the resource at risk was needed. MnDOT Destination/Innovation Funding was allocated to the Metro District to inventory a portion of the ash trees growing along MnDOT highway right-of-way. Ash tree information, such as location, size, condition, function in the roadside landscape, and any observed signs of EAB infestation were collected. The ash tree data has been published to a web-based mapping tool allowing any others to view the data. EAB is projected to continue to affect all ash trees and will require significant resources from multiple agencies to manage.

Prescribed Fire

Prescribed fire is another vegetation management tool that is an important part of Integrated Roadside Vegetation Management (IRVM) in addition to those already discussed, such as mowing and herbicides. Fire has short-term benefits of enhancing weed control when used in combination with herbicides. It also stimulates dense growth of tall native grasses that can serve an important role in trapping blowing and drifting snow, keeping the roadways clear. Fire is also a cost-effective brush control technique. It is an ideal method for managing roadside prairie remnants to control weeds and protect threatened and endangered species. The most significant value of fire, however, is in reducing lifecycle maintenance costs by promoting healthy roadside vegetation that is better able to resist weed infestations, maintain proper drainage, and prevent erosion. In addition to roadside maintenance functions, fire is also important to the construction program because of its necessity in restoring native vegetation on wetland mitigation sites.

Prescribed fire is gradually being reintroduced at MnDOT as a tool for vegetation management after little activity in the first decade of the 2000s. Three districts have formed crews with members trained to the same standards as required by the Minnesota DNR fire personnel. An effort is currently underway to develop a department policy to guide the use of prescribed fire at MnDOT and implement training and safety standards.

Soil Stabilization/Erosion Control

Routine maintenance and authorized or unauthorized use of road corridors frequently require repairs to vegetative surfaces to preserve the road surface and prevent subsequent failure of the infrastructure. Disturbed surfaces and poor quality soil strength are susceptible to erosion, which can weaken the roadbed, obstruct drainage channels, and pollute rivers and streams.

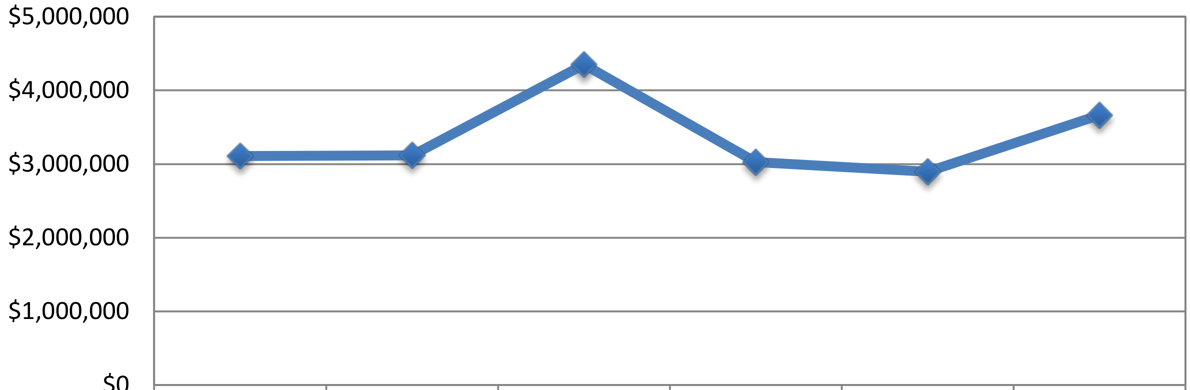
Factors Affecting Capability

Mowing

Minnesota State Statues 160.232 was adopted in 2008 and relates to mowing procedures. This law directs MnDOT and other road authorities not to mow specific roadside areas outside a city limit during the grassland nesting bird period of April through July, except for safety reasons or noxious weed control. This law also does not allow mowing beyond eight feet from the edge of pavement until after August 1 to provide an area for nesting birds and other wildlife. The first eight feet from the road surface or shoulder (if one exists) are exempt from this requirement and may be mowed at any time along any highway.

Overall costs for the Metro District labor, equipment, and materials between 2005 and 2010 are shown in Figure 3.28. As noted in the chart, costs have been relatively flat over this time. Over the past six years, the average cost of mowing operations has steadily increased from approximately $5.3 million in 2005 to $6.5 million in 2010. Mowing operations costs are shown in Figure 3.29.

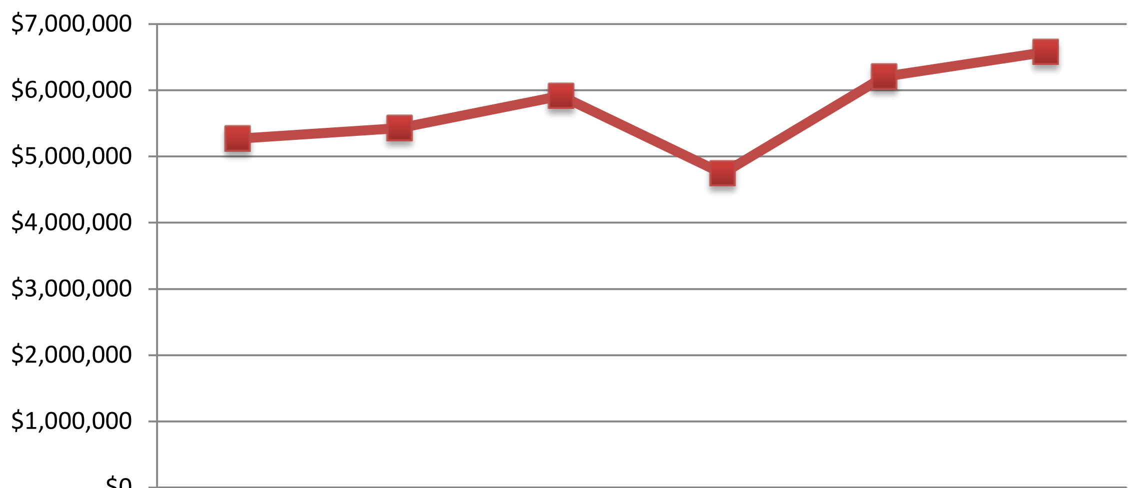
Figure 3.28: Tree Trimming/Removal – Brush Control Costs (Metro Division)



	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10
Brush Control Cost	$3,109,612	$3,115,947	$4,352,619	$3,028,228	$2,897,063	$3,665,367

Year

Figure 3.29: Mowing Operations Costs (Metro District)



	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10
Mowing Costs	5,267,189	5,430,101	5,917,839	4,741,794	6,203,500	6,577,294

Year

Tree Trimming/Removal – Brush Control

Trees are typically removed following complaints from the public, city tree inspectors, or state foresters. The majority of complaints is received from city tree inspectors and is related to Dutch elm disease or oak wilt. Per local city ordinance, MnDOT is required to remove a tree 14 days after notification from a city tree inspector. Currently MnDOT performs limited pruning due to the lack of aerial lift bucket equipment and trained International Society of Arboriculture certified arborists.

The State currently has more than 900 million ash trees, on public and private land, which will need to be removed due to the EAB. Currently three counties in the State are quarantined: Houston, Ramsey and Hennepin. All Metro Tree crews have been equipped and trained to use handheld Global Positioning System (GPS) units to track ash tree activities. Tree crew supervisors can efficiently assign work activities from office computers that sync with the handheld units. Removal of ash trees will have significant impacts on the current maintenance budget.

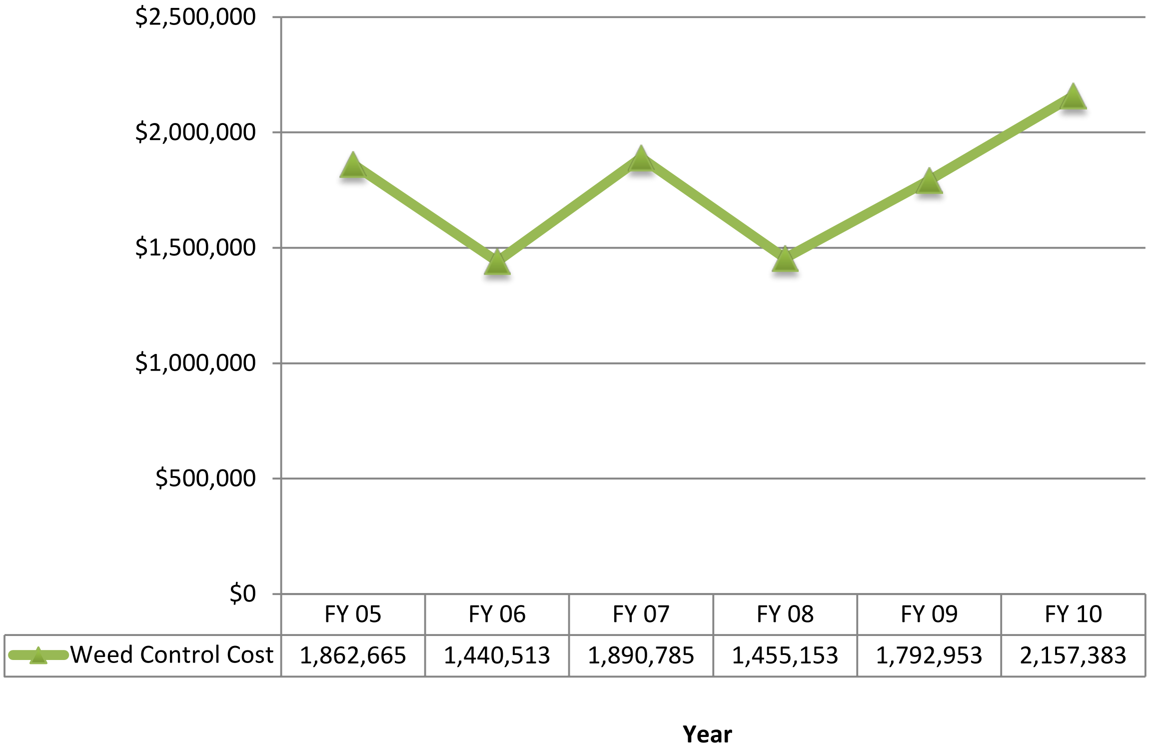
Weed/Invasive Species Control

The key approaches used in this area include:

- Mowing – Mowing improves sight lines and also controls weeds.
- Herbicide Application – A cost-effective and easy-to-use method of controlling weeds
- Native Plant Ecosystems (Prairie) – Planting native plants and using prescribed fire encourages the health of the planting or native remnant.
- Biological – Use of biological agents, which are natural enemies of the targeted noxious weed, should be used on large populations as a long-term solution and when a large population limits the effectiveness of alternative methods. Smaller populations are better controlled with other methods.

Weed control costs are somewhat variable from year to year, but are generally between $1.5 and $2.1 million. Complete cost information for the Metro District mowing and weed control operations is shown in Figure 3.30.

Figure 3.30: Weed Control Costs (Metro District)



Soil Stabilization/Erosion Control

Soil erosion typically occurs along roadside areas with a disturbed vegetative surface. These disturbed surfaces may be the result of weather events, roadway design issues, poor quality soils, terrain features, errant vehicle run-off-roads, ATV/Snowmobile trails, permitted utilities, or from normal maintenance activities. If left unchecked, soil erosion can lead to weakened roadbeds, obstructed drainage channels, and polluted waterways.

The most common source of disturbed vegetative surfaces is roadside construction activity. To limit the effect of these disturbances, a general Storm Water Permit is necessary for owners and operators of construction activities disturbing:

- One acre or more of soil
- Less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre
- Less than one acre of soil for which the Minnesota Pollution Control Agency (MPCA) determines the activity poses a risk to water resources

Performance Measures

Currently there are no performance measures in place for any of the Roadside activities. One of the first steps toward implementing potential targets is establishing an Integrated Roadside Vegetation Management Plan. By having a plan in place, mowing operations, tree trimming, erosion control, and the overall control of invasive and noxious weeds can be done in a cost-effective manner, at the correct time, and under uniform common goals and objectives. This plan will also help communicate goals, results, needs, and measures to the public.

Suggested performance measures for vegetative maintenance and control activities include:

Mowing	**Mowing Efficiency (Acres Mowed per Hundred Man-Hours)**
Tree Trimming/ Removal – Brush Removal	Percentage of complaints resolved within 14 days Percentage of safety clear zone that is free of trees and brush
Weed/Invasive Species Control	Total and proportional area of weed and invasive species infestation Acres of prairie remnant (including threatened/endangered species) maintained and protected Acres seeded to native vegetation during construction that are maintained as native vegetation
Prescribed Fire	Annual acres of prescribed fire area Performance should be linked to Weed/Invasive Species Control performance measures
Soil Stabilization/ Erosion Control	Annual acres of disturbed vegetative surface for construction or other purposes

Strategy Development/Policy Direction/Risks

For all roadside maintenance components, MnDOT should continually evaluate equipment needs and costs in an effort to reduce overall time and/or expenditures. MnDOT should also review reduced commitments or service levels where they are determined to be over the stated guidelines.

Mowing

A "Best Practices Handbook" and "Integrated Roadside Vegetation Management Plan" are used to establish goals and standards for mowing operations. Training on standards, practices, and expectations for field activities, documentation, and coordination with others, such as noxious weed eradication, occurs for all mower operators. All MnDOT Districts have some form of IRVM Plan in place.

Tree Trimming/Removal – Brush Control

Maintenance personnel or contracted private tree care companies may perform tree trimming/removal work on a statewide basis. Private companies are hired when tree work is performed within 10 feet of an energized overhead utility line or if specialized rigging equipment is needed for the tree removal. The Metro District has two specialized tree crews and District 1 has one crew that performs all of these removals or trimming. MnDOT also utilizes the Institutionalized Community Workforce Crew (ICWC) for removal of trees four inches or less in diameter. Young trees planted through landscape contracts or landscape partnerships are pruned every two years, and trees growing in intensively managed areas are pruned once every five to eight years.

Weed/Invasive Species Control

Weeds are most cost-effectively controlled in small populations. If small populations are allowed to spread, the cost of control will rise, and the potential for eradication diminishes greatly. As such, consistent and ongoing attention to this area is needed through primarily mechanical means (i.e., mowing).

MnDOT should also continue to work with private farming interests to permit haying of ROW, thereby limiting MnDOT's costs in mowing and weed control.

MnDOT should evaluate ways to better control noxious weeds through use of prairies and/or biological means where it is feasible and continue to find ways to reduce chemical usage.

Prescribed Fire

In keeping with the policy of reducing chemical usage for weed control, MnDOT should develop a department policy to set standards and guide implementation of prescribed fire methods at MnDOT. This policy should integrate prescribed fire within the overall vegetation management strategy through the coordination of district roadside vegetation managers. This policy is currently in its final draft version with final approval planned for June 2012.

Soil Stabilization/Erosion Control

MnDOT will continue to implement the general Storm Water Permit requirement for construction projects meeting the minimum criteria.

Risks

Some of the key risks associated with Roadside maintenance are:

- The Department of Agriculture and County Agricultural Inspectors have the enforcement authority to force the control of and administer fines for noxious weeds. They also have the authority to hire contractors to perform the control work and then bill the responsible landowner. This authority could at times be in direct conflict with MnDOT's preferred strategy and performance measures.

- MnDOT plays an important role in meeting environmental standards. Not being a steward of the environment and a partner in the control and eradication of organisms can have large economic impacts on natural resources.

MnDOT's strategy includes removing problem trees and brush from the roadside in the most economical way possible. The following are identified risks if the activities are not performed:

- If trees are not removed, disease could spread from tree to tree and to adjacent properties; this could result in higher removal costs and/or loss of value in the wood.

- The state forester can have the tree removed, and MnDOT could be billed for its removal by a private contractor.

- Trees four inches or greater in diameter remaining within the clear zone become hazards or fixed objects which can result in crashes to errant vehicles leaving the roadway. Trees must be trimmed regularly so they do not cover up signs and sight lines, which pose a safety concern.

- Brush needs to be removed or treated chemically when it is less than six feet tall so it will not continue to grow and become a potential hazard. Removal costs for trees and brush are directly proportional to their size; therefore it is less costly to remove them before they are allowed to grow for many years.

- Less successful wetland mitigations can result in high costs for right-of-way, engineering, and planting wetland restorations to compensate for construction related wetland impacts. When these are not properly maintained, MnDOT does not receive the wetland credits it needs to maintain compliance with wetland regulations. Greater emphasis to fully develop strategies to monitor wetland development to the point of final acceptance by the Minnesota Board of Soil and Water Resources is vital.

Strategies need to be developed to effectively implement prescribed fire as a tool to manage our vegetation statewide. Policy direction should be coordinated to mandates and environmental concerns. Identified risks include initial and on-going training, equipment and material purchases, and education outreach.

Implementation Strategies

Currently, there is insufficient data to determine the needs for vegetation maintenance and control. Additional information on specific performance measures is needed to determine if complaints are being addressed within the allotted timeframes or not. That being said, the following implementation strategies are provided:

- Trained chainsaw operators and all operators should have CPR and first aid training. In addition, there is a shortage of equipment to get the job done (e.g., tree trucks, chippers, clam trucks, skid steers). Each district should evaluate the need for a trained tree crew with specialized equipment.
- Employees should be trained by certified chainsaw operators and tree pruning as improper pruning damages the tree.
- Increased funding to expand prescribed fires will improve the overall health of vegetation which is better able to combat weed infestations.
- Increase funding to enable better monitoring of the right-of-way so that erosion problems can be detected.
- Increased education on required permits, rules, mandates, and best management practices.
- Each district to evaluate their need/resources for a vegetative manner.

3.6.2 Beautification

Introduction and Background

Maintaining the aesthetic appeal of roadsides is an important step in promoting the MnDOT highway network as a world-class transportation system. Every year MnDOT receives complaints from citizens about roadside aesthetics, including roadside litter and graffiti. Roadside beautification is accomplished by following four program areas: Graffiti, Litter, Landscaping, and Community Partnerships.

Graffiti

Removing graffiti improves the surrounding highway scenery, and it also improves public safety. Graffiti diminishes the scenery through inappropriate messages and graphics by being distracting, dangerous, and unsightly. Expedient graffiti removal is important to discourage additional graffiti, minimize attention for the perpetrator, and reduce safety concerns.

Litter

As with graffiti, removing roadside litter improves the surrounding highway scenery. Large quantities of litter may also encourage additional littering.

Landscaping

Roadside landscaping is an important component of roadside beautification. Roadway scenery is often improved through the use of ornamental plants, shrubs, and trees, or through the installation of physical features such as decorative retaining walls and planters.

Community Partnerships

The Community Roadside Landscape Partnership Program offers communities technical and financial assistance to install and maintain landscape plantings on eligible state highway rights-of-way. Through partnerships, MnDOT has fostered more than 350 roadside landscaping improvement projects in communities throughout the State. Landscape partnerships expand the network of responsibility, pride, and ownership of highway landscaping while stretching MnDOT's available funding. MnDOT benefits from an annual cost savings/avoidance for ongoing work necessary to maintain the landscape plantings.

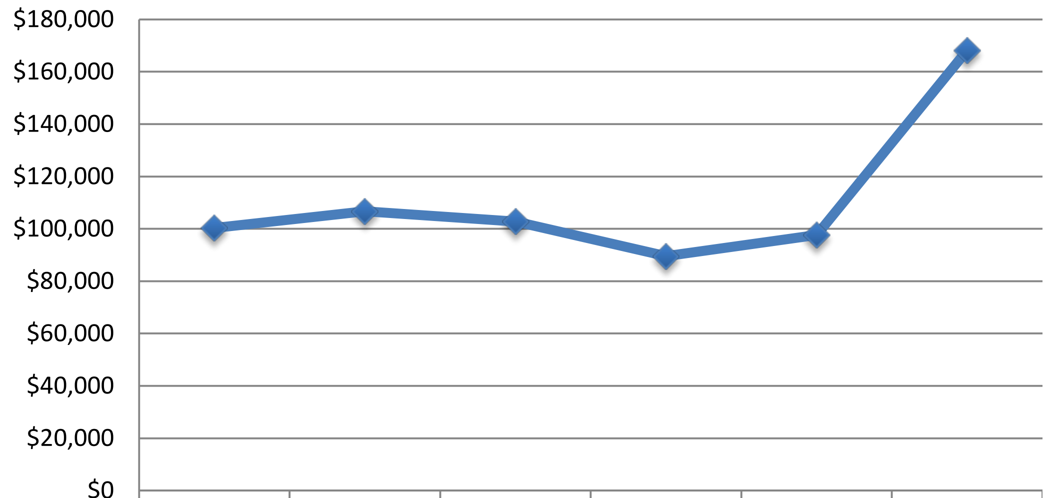
Factors Affecting Capability

Graffiti

Some of the challenges that are affecting the cost of the removal operation are unique aesthetics, environmental compliance, and historical restrictions. Traditional graffiti removal methods such as repainting do not work on many of the unique surface types used for aesthetic reasons. Other options such as the use of chemicals are limited in environmentally sensitive areas. Historical markers or plaques present a more difficult problem since the process to remove any graffiti can further damage the marker.

Instances of graffiti are primarily concentrated in the Twin Cities Metro Area and are much less frequent in other MnDOT Districts. For example, in 2010, MnDOT's Metro District addressed 550 graffiti "tags," resulting in more than $160,000 for labor, materials, and equipment. A summary of costs associated with graffiti removal are shown in Figure 3.31.

Figure 3.31: Graffiti Removal Costs (Metro District)



	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10
Graffiti Removal Costs	$100,329	$106,652	$102,805	$89,636	$97,625	$168,146

Year

Litter

Significant time and labor are needed for litter removal due to the large right-of-way areas under MnDOT's jurisdiction. To reduce part of the time and labor requirements MnDOT has initiated the Adopt-a-Highway program, which has been very successful in keeping roadsides clean.

Additional roadside cleanup is conducted through the Hennepin County Sentence-to-Serve (STS) program. This program costs roughly $80,000 per year for seven crews working four days a week, including weekends. MnDOT also contracts with the Department of Corrections for one Institutionalized Community Workforce Crew (ICWC) at $82,511 per year. To supplement the work performed by the ICWC, the Metro District established a labor crew in 2011 at a cost of $200,000 per year.

Landscaping

MnDOT Maintenance Crews perform landscaping on projects along trunk highway right-of-way. Most landscaping is installed by contractors following construction projects and includes a two-year warranty for maintenance and plant life. Once the two year warranty expires, MnDOT continues to struggle to assume the maintenance responsibility due to the lack of resources. The majority of MnDOT Districts does not have dedicated landscape crews, and therefore do not have the expertise and experience to perform this type of work. Competing priorities have resulted in the shortage of resources to handle landscaping in the Districts.

Community Partnerships

In the past few years, MnDOT's landscape partnership program and projects have received more than 60 national and State awards. Despite this, the overall cost for this program and the number of partnerships involved in this program has fluctuated over the past few years. If a community does not follow through with the maintenance stated in the agreement, MnDOT assumes ownership and maintenance, and in many cases simply removes the plantings.

Performance Measures

MnDOT currently has no performance measures in place for roadside beautification. Suggested performance measures for this area include:

Graffiti	Number of days between report and removal of graffiti. The total number and frequency of graffiti incidences on specific landmarks.
Litter	Tons of trash removed annually. Number and location of complaints annually. Percent of miles of Adopt-A-Highway.
Landscaping	Semi-annual inventory of plantings including plant health, type of care administered, resources consumed, etc. These observations could then be shared with MnDOT landscape designers/architects to improve future roadside landscape design treatments.
Community Partnerships	Community partnership retention rate. A measure of each community's fulfillment of the agreement requirements that labels each community as in good standing, in need of improvement, or not in compliance.

Strategy Development/Policy Direction/Risk

Graffiti

Increased use of anti-graffiti film on highway guide signs has helped reduce the frequency of sign replacement due to damage from paint or chemicals. In addition, MnDOT purchased a Soda Blaster to remove paint on delicate structures to minimize damages and still be environmentally compliant. Anti-graffiti cameras placed in high target locations are also being used as a preventative measure.

Litter

MnDOT has attempted to introduce legislation to pass a bottle bill (HF 1128 and SF 1549) that would place a deposit on bottles and cans, which in turn would decrease the amount of litter on highways. The states of Michigan, Iowa, and Pennsylvania currently have bottle bills that have successfully led to cleaner highways.

Landscape

Maintenance currently doesn’t have enough resources to perform landscape upkeep after the contractors have placed it along the roadsides; therefore, they’re not maintained, resulting in millions of dollars in wasted resources.

Community Partnerships

MnDOT benefits from an annual cost savings/avoidance for ongoing work necessary to maintain the landscape plantings. Continued investment in this program would result in additional savings.

Implementation Strategies

Graffiti

If additional funding is allocated to graffiti removal, it should be used for both preventative and reactive treatments. More signs could be fabricated with anti-graffiti film. A sign with this film could be easily washed a few times before the panel would need to be replaced, as opposed to being replaced each time. There may be a need for additional FTEs to be added to the graffiti removal crew, which would assure removal each day would occur. The present crew also provides temporary traffic control to other metro district units and is therefore not readily available to perform timely graffiti removal.

Litter

Ramsey County and Dakota County also have STS programs, which cost about $80,000 each, but the current budget does not allow this. Additional budget to contract with these two counties would help to reduce complaints. Hiring additional laborers to help pick litter and keep the roadsides clean would also be greatly beneficial.

Landscaping

Increased funding would add additional FTEs to help maintain some of the landscaping that are being installed after construction projects is completed.

Community Partnerships

If additional funding were available, it would be ideal to increase the amount of community partnerships to Cities, Counties, and Townships. MnDOT would also like to start an “Adopt-A-Landscape” project that would allow communities to maintain the landscape on the highway that is within their city.

3.6.3 Permitting and Property Management

Introduction and Background

Each District's MnDOT Permits Section is responsible for approving and regulating all permitted work within the right-of-way and all right-of-way encroachments, both legal and illegal by all entities. The number of permits issued between 2006 and 2009 remained relatively stable with 3,744 permits issued in 2006 and 3,584 permits in 2009. The numbers for 2010 dropped significantly to 2,648.

Advertising devices and signs on and near roadsides are subject to federal and state regulations, as well as local ordinances. In addition, the Highway Beautification Act and Minnesota State Chapter 173 also set regulations of roadside properties. These mandates have a significant impact on roadside maintenance activities in terms of staffing, budgets, and review timelines.

Factors Affecting Capabilities

The most significant factor affecting permitting is the significant amount of labor and time required to adequately enforce rules. The monitoring of unauthorized uses and remediation are often neglected due to the funding being directed to other priorities. Other obstacles include a lack of accurate right-of-way maps and missing right-of-way markers. The increase in newly permitted billboard installations has added additional workload to the already limited resources used to oversee outdoor advertising structures.

Performance Measures

There are currently no performance measures in place for permitting and property management. Given the limited resources currently available to these tasks, accurate performance measures will be difficult to obtain. However, if resources become available for the implementation of performance measures, the following measures should be considered:

- Violation rate for all permits
- Average time to attain compliance for violating properties

Strategy Development/Policy Direction/Risk

One step to improve compliance with advertising device management is to consider the need for an additional position for each District working closely with the permits personnel to help enforce compliance with mandates for advertising devices as well as other permitted uses of right-of-way. Another consideration could be to provide the necessary training and time needed to individuals in each subarea to monitor for compliance to the above criteria.

Each District's permit section will continue to monitor and correct all impacts to MnDOT right-of-way and will strive to ensure all activities within MnDOT right-of-way are performed to MnDOT standards. Consequences of not adequately funding the Permit Department could result in illegal installations of utilities, unsafe accesses, altered drainage, theft of property, and unsafe traffic control.

The safety of the traveling public would be compromised, and damage claims collections could increase.

The greatest percentage of permitting activity has been directed, performed, and evaluated from the Office of Environmental Stewardship at MnDOT's Central Office. Because of extensive workload and travel to all areas of the State, this sometimes results in considerable delays and lack of opportunity for follow-up review. Many of these tasks could be completed at the District level with adequate training and manpower availability. Increased cooperation with other agencies and interests would also reduce duplication of effort.

Implementation Strategies

Each District should evaluate which area of advertising device enforcement is most in need of attention. An annual inventory of advertising devices is required statewide, and often there are not enough resources to properly inventory all roadways and follow-up on violations. The task of managing advertising devices is administered by our Permits section, which is also responsible for all contractor activities within MnDOT properties. This results in many illegal advertising devices going undetected for years.

Additional resources can be distributed to have personnel, or identify equipment and/or technology to reduce workload and improve efficiency to process and monitor permitted and non-permitted activities.

3.7 Fleet and Facility Management

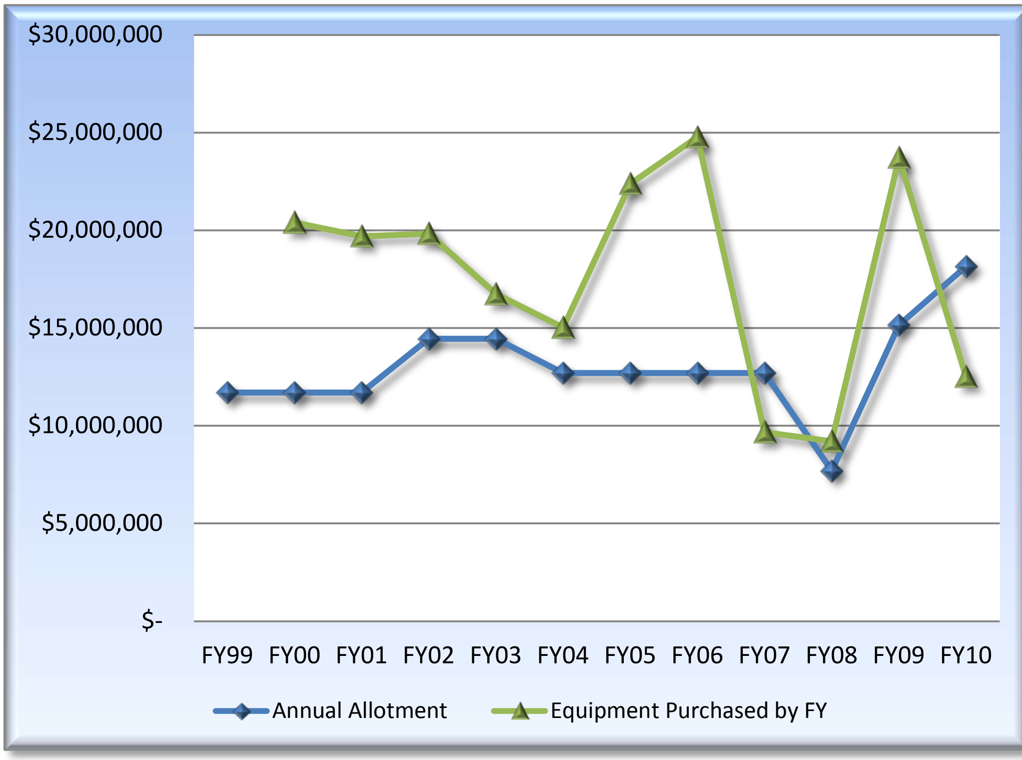
3.7.1 Fleet

Introduction and Background

MnDOT currently has an investment of roughly $255 million in approximately 11,000 pieces of equipment (units in the fleet). Of this number, roughly 3,100 are licensed on-road vehicles. In 1985, the fleet size was 11,700 units, indicating there has been a 700-unit reduction to the fleet since that time. Figure 3.32 displays the equipment budget and the total dollars spent on equipment since 1999. The current annual budget to purchase replacement equipment is $14.4 million. It has fluctuated between a low of $11.7 million prior to 2002 and a high of $15.1 million in 2009. Base budgets for FY12-13 will be increased to $14.6 million. In addition to the funds allotted for the purchase of equipment, revenue from the remarketing of surplus equipment is used to replace equipment as well. Districts/Central Office also uses restitution funds as well as remaining operation funds to help purchase needed equipment. During each biennium in the past 10 years, MnDOT has spent more on equipment purchases than the funding which was allotted. In some cases the expenditures have doubled the amount allotted for that purpose.

Analysis of MnDOT's current fleet indicates that in order to keep the fleet within established lifecycles, the equipment budget would need to be set at $22.7 million. In addition, due to the shortages during the past years, $108 million dollars would be needed to "catch-up" and bring the fleet into lifecycle standards.

Figure 3.32: Equipment Budget vs. Total Equipment Dollars Spent



While the equipment funding has remained relatively flat the past 10 years, the cost of equipment has not. Equipment pricing has been impacted by recent events, such as steel surcharges and costs related to engine manufacturers complying with 2007 and 2010 Federal emission standards. These costs have escalated the cost of equipment dramatically. The cost of cab/chassis used to fabricate MnDOT's tandem axle snow plow truck has seen an increase of close to 60 percent since FY00. In that year, a cab/chassis could be purchased for $67,000; in FY10 that cost increased to $107,000. The additional costs associated with the fabrication of a plow truck, including the dump box, hydraulic system and lighting package have risen as well. A truck that could be equipped in 2000 for $105,000 costs $159,000 in 2010. Table 3.23 lists the costs of plow trucks in Fiscal Year 2000, 2005, and 2010. In addition, Table 3.23 also lists the costs for fully equipped plow trucks with the latest snow and ice management devices.

Table 3.23 lists the costs of plow trucks in Fiscal Year 2000, 2005, and 2010. In addition, Table 3.23 lists the costs for fully equipped plow trucks with the latest snow and ice management devices.

Table 3.23: Plow Truck Costs

	Plow Truck Cab/Chassis Only	Plow Truck Costs
FY00	$ 67,000	$105,000
FY05	$ 90,602	$155,529
FY10	$107,000	$159,000
	Fully Equipped Single-Axle Truck	**Fully Equipped Tandem-Axle Truck**
FY12	$170,000	$210,000

Flat funding levels have resulted in equipment being held longer than their recommended lifecycle; this has resulted in additional resources to maintain and operate older pieces of equipment. MnDOT spent in excess of $30 million in the repair and maintenance of the fleet in FY10.

Factors Affecting Capability

Funding levels is only one of the factors that typically make managing governmental fleets challenging. Equipment needs vary from year to year and season to season. Weather and construction program levels are often unpredictable. Fleet managers scramble to find enough vehicles when the construction season is in full swing and then deal with excess vehicles when the program drops back down. The fleet has to be prepared for a heavy winter season, a bad-pothole spring and a summer when roadsides continuously grow; yet the fleet manager is scrutinized during light winters and dry summers when the equipment is sitting idle. At the same time, it is expected that MnDOT be equipped so it can quickly respond to floods, tornados, and other disasters and events.

Low utilization problems and keeping equipment beyond its economic life are common deficiencies in governmental fleets. In a U.S. General Accounting Office (GAO) report dated May 2004[7], it was cited that, "*Because of lack of attention to key vehicle fleet management practices, the agencies GAO reviewed cannot insure their fleets are the right size or composition to meet their missions.*" The GAO report examined the departments of Agriculture, Army, Homeland Security, Navy and Veterans Affairs, and focused their attention on agencies' justifications for acquiring and retaining vehicles. The report goes on to say, "*Industry practices of cost-efficient fleets include developing utilization criteria related to the mission of a vehicle and conducting periodic fleet assessments to determine whether fleets are the right size and composition.*"

Another key factor of fleet management is managing the fleet so that it continues to be reliable and perform the intended function. As equipment ages, more maintenance is typically required (equipment is less reliable) and parts become

[7] Federal Acquisition – Increased Attention to Vehicle Fleets Could Result in Savings, (United States General Accounting Office, GAO-04-664, 2004).

more difficult to obtain (end of lifecycle). Based on the "right-sized" fleet and standard equipment lifecycles, there is a need to replace a certain number of units each year. For MnDOT, this analysis showed that $8.1 million annually in additional funding is needed to stay within the target lifecycle.

Other factors also affect the cost of replacement funding and are not included in the $8.1 million figure. One factor deals with inflation due to high increases in steel that is having an unpredictable impact on the cost of equipment. Two recent State statues have other financial implications as well. For example, State statute 16C.135 calls for State agencies to purchase vehicles capable of burning "cleaner fuels". Secondly, statute 16C.137 orders agencies to *"reduce the use of gasoline by on-road vehicles owned by state departments by 25 percent by 2010 and by 50 percent by 2015, and the use of petroleum-based diesel fuel by those vehicles 10 percent by 2010 and 25 percent by 2015."* The goal is to move toward cleaner fuel, increase miles per gallon, and support hybrid electric cars and hydrogen-powered vehicles. The financial implications of these have not yet been quantified, but it is known that diesel powered pickups cost an additional $4,600.

MnDOT is also required by the Federal Energy Policy Act (EPAct) to purchase alternative fueled vehicles. This Act requires 75 percent of MnDOT's light-duty vehicle acquisitions in certain Metropolitan Statistical Areas (MSA) be alternative fueled vehicles. MnDOT has constantly exceeded this requirement. The Federal Government's Environmental Protection Agency (EPA) Highway Diesel Rule set forth emission requirements for diesel truck engine manufacturers to meet. Key dates of these requirements were January 1, 2007 and 2010. In order to meet these requirements, engines needed to be redesigned and the prices increased. Truck manufacturers passed these costs onto the buyer and, as a result, MnDOT has seen substantial increases in the costs of Medium and Heavy Duty diesel engine trucks. This increase can be seen in the snow plow truck pricing information listed above.

Federal Motor Carrier Safety Standards require all commercial motor vehicle operators to perform pre-and post-trip inspections along with annual Commercial Vehicle Inspections (CVI), resulting in increased operating costs.

Performance Measures

In July 2002 MnDOT formally initiated key performance measures to better manage its equipment fleet[8]. These performance measures included targets for equipment utilization, units out-of-lifecycle, fleet size, and scheduled vs. unscheduled maintenance. At the same time, MnDOT continued to pursue enhancement of fleet management and data collection systems, expansion of internal leasing programs and challenged Districts/Offices to implement changes in organizational structure. This was all aimed at enhancing the ability to manage its fleet.

The following focuses on two of the measures, namely equipment utilization and out-of-lifecycle. (Note that reduction in fleet size is a *result* of achieving targets of the other two and therefore does not have specific targets set for it.)

[8] Richard A. Stehr, Guidelines for Implementation of Fleet Management, (MnDOT Memorandum, July 30, 2002), p. 2.

Equipment Utilization Rate Goals (Targets)

Equipment is procured to produce work; equipment that is idle produces no work. There are two basic cost types associated with fleet management, typically referred to as “ownership costs” and “operating costs”. While idle equipment does not incur any operating costs, such as, fuel, oil, or maintenance and repair costs, it still incurs ownership costs. Ownership costs include depreciation, obsolescence, storage costs, insurance, and the cost of tied up money in asset and parts, etc. The cost per usage increases significantly if age alone is used to justify replacement and the much needed dedicated equipment funds are used to purchase new units to replace low usage equipment.

For these and other reasons, it is essential that MnDOT properly sizes its fleet for meeting its mission and it establishes performance measures to monitor and justify the number of units permitted in its fleet. To “right size” its fleet, MnDOT monitors equipment utilization on an ongoing basis for the purposes of making sure equipment is used enough to justify its presence. In July 2002, MnDOT developed a performance measure called *Equipment Utilization Rate Goals (targets)*. Equipment Utilization Rate Goals are established for selected categories of mobile equipment, including all light, medium, and heavy duty vehicles, snow plow trucks, loaders, mowers, tractors, motor graders, etc. They represent about 70 classes of mobile equipment that comprise over 75 percent of MnDOT’s total fleet investment. The targets are being implemented in a phased-in manner as follows:

- 80 percent of the fleet to be above minimum utilization level target by July 2003
- 95 percent of the fleet to be above minimum utilization level target by July 2005

Figure 3.33 depicts MnDOT’s equipment utilization since 2002. These goals are defined in terms of the minimum number of miles or hours that units in a given class are expected to be utilized over a 12-month basis. In early 2002, the consulting firm Kelly Walker Associates recommended Utilization Rate Target levels. Their recommendations were based on surveys of a variety of public and private agencies. These recommendations were modified to “challenging yet deemed achievable” levels and were approved by MnDOT’s upper management in July 2002.

The targets for minimum annual equipment utilization were set at:

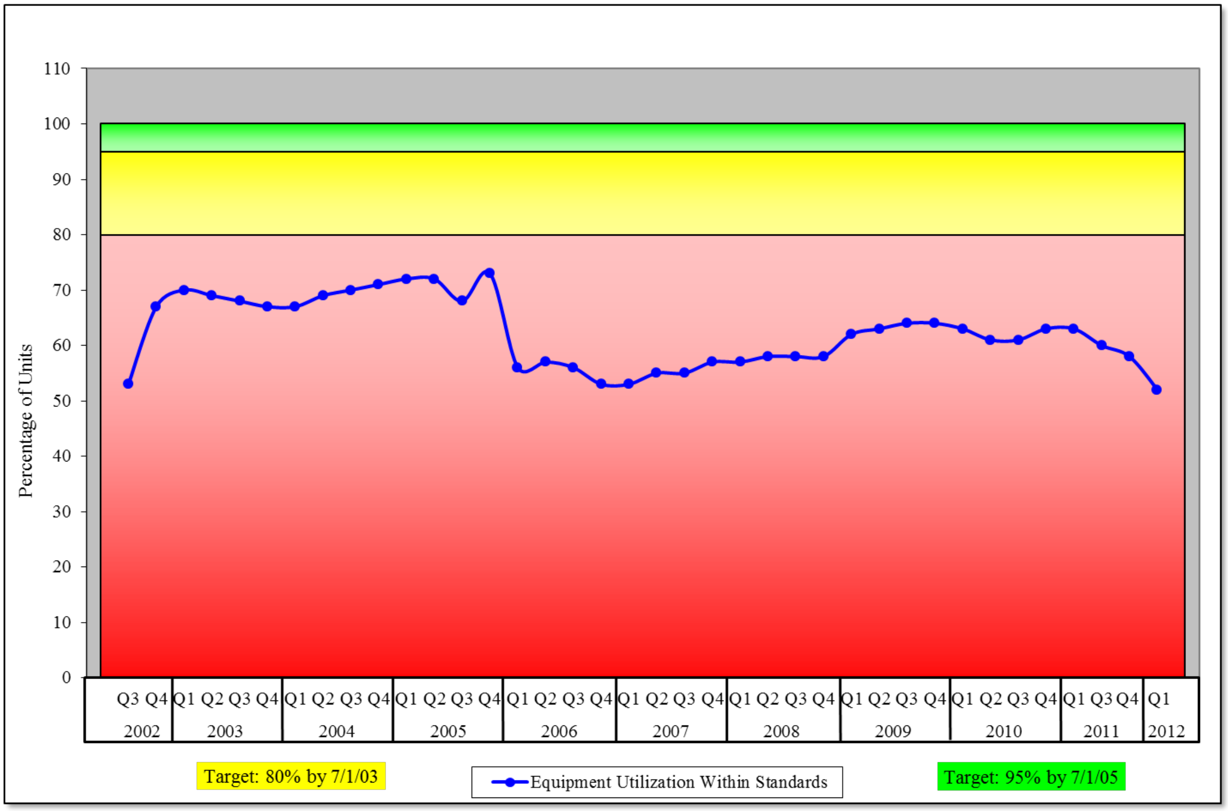
- 8,000 miles per year (3,500 miles for seasonal snow plow trucks)
- 500 hours per year (125 hours for seasonal snow and ice support equipment)

In 2006, a committee made up of a cross-section of staff within MnDOT met to re-evaluate the utilization standard for the various classes of equipment. The results of this effort saw some classes remaining at originally set targets and other classes increasing or decreasing their utilization standard.

- 12,000 miles per year most light duty automotive classes
- 8,000 miles per year most medium/heavy duty trucks
- 8,000 miles per year tandem axle snow plow trucks

- 6,000 miles per year single axle snow plow trucks
- 500, 350, 250, or 125 hours per year for off-road heavy equipment and tractors

Figure 3.33: Statewide Equipment Achieving Minimum Utilization Trend



The progress to date on attaining the utilization performance target is shown in Figure 3.33. In September 2002, the statewide utilization was 57 percent. This rose to a high of 73 percent by September 2005 and then fell back down again after the re-evaluation of the utilization standards to the current rate of 61 percent in 2010. This is well below the 80 percent target for July 2003 or the 95 percent target for July 2005. While this target has not yet been met, changes in fleet strategies are being developed in attempt to meet this goal.

Units Within Lifecycle

Determining the lifecycle of a class of equipment is based on a number of factors. Perhaps the biggest driver is economics. This includes the cost of maintenance and repair as equipment accumulates usage and age, resale value, and the simple principal of minimizing loss due to depreciation, downtime, (i.e., the degree of which the equipment is unavailable because of breakdowns), and the loss of value due to technological age of equipment.

Performance targets set in July 2002 were as follows:

- 70 percent of the fleet within lifecycle by July 2003
- 90 percent of the fleet within lifecycle by July 2005

MnDOT uses a state-of-the-art Equipment Management Information System (EMS) called FleetFocus – M5 to provide fleet managers with not only average lifecycle information, but also running repair costs of parts and labor, and downtime. The EMS plays an important role in defining the most economical lifecycle for different classes of equipment. Over the past 20 years, close monitoring of economic and technological life of equipment proved that some classes of equipment could be retained longer, some shorter. As a result, optimum lifecycles have and continue to be adjusted accordingly. Current lifecycles are:

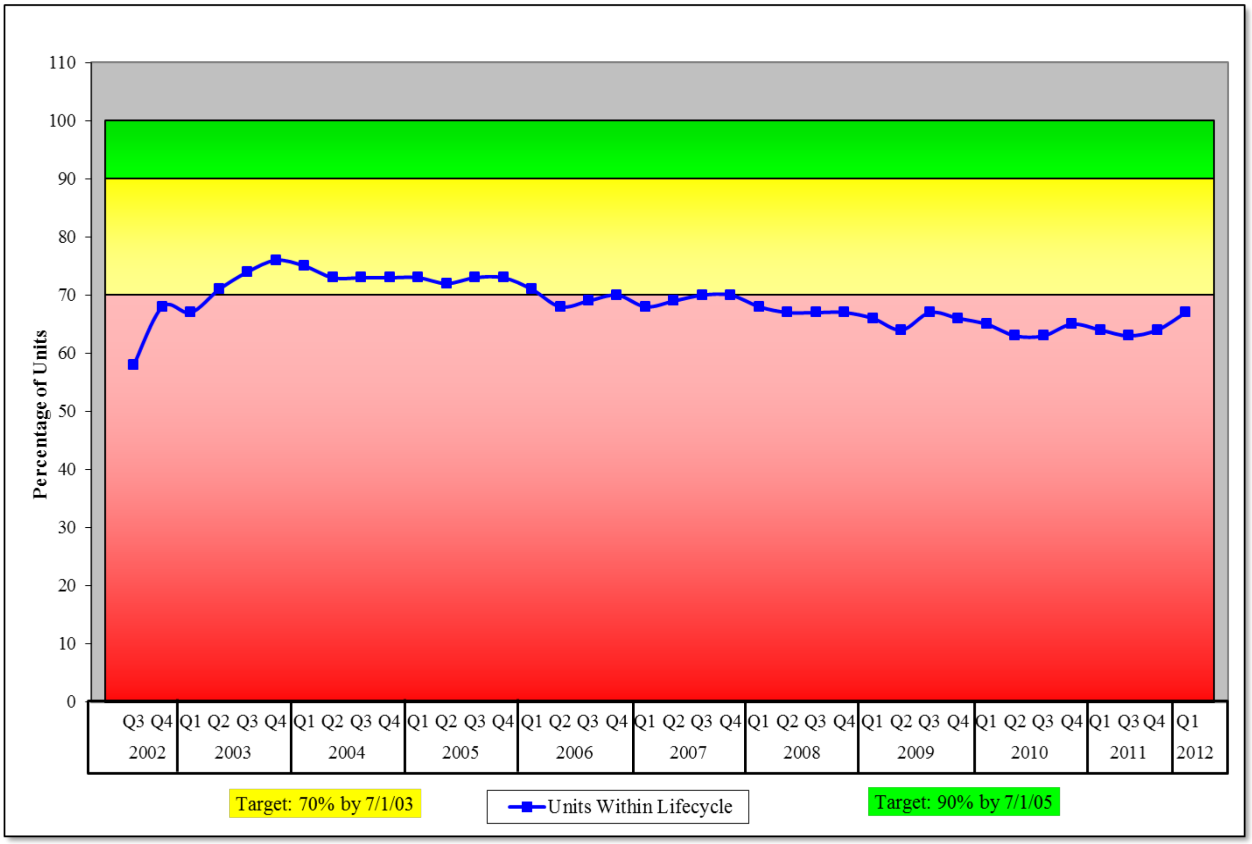
- 5 years for cars
- 7 years for pickups
- 12 years for snowplow trucks
- 15 years for 4WD loaders
- 20 years for mower and tractors
- 20 years for motor graders

As shown in Figure 3.34, September 2002 was used as a baseline. At that time, only 57 percent of the total fleet was within lifecycle. By July 2003, the statewide average had risen to 75 percent. However, since 2003, no significant progress has been made; in fact, this area is trending downward (September 2010 showed 63 percent of equipment within lifecycle). This lack of continued progress may be due to a combination of many factors, including:

- Equipment budget remaining flat up to FY09
- A $5 million onetime loss in the equipment fund to help address the I-35W bridge collapse
- Dramatic increases in equipment costs due to increased steel costs and engine emission requirements
- Fleet size increasing since 2009 as Districts are retaining older units

While the lifecycle goal has not been met, a statewide committee is evaluating changes in lifecycle strategies to meet this goal.

Figure 3.34: Statewide Units within Lifecycle Trend



Strategy Development/Policy Direction/Risk

MnDOT is a leader in many policy areas, both globally and locally. In regard to the fleet of equipment, MnDOT has made significant efforts to be more environmental friendly and resource-conscious. This is evident by State statues (16C.135 and 16C.137) related to fleet requiring agencies to purchase vehicles capable of burning "cleaner fuels" and/or hybrid vehicles. These efforts are consistent with MnDOT's Strategic Directions and Statewide Transportation Policy Plan, both of which encourage MnDOT to be environmentally sensitive and look to conserve natural resources; however, these efforts come with increased ownership and operating costs.

MnDOT is constantly aware of the safety concerns surrounding the fleet of equipment and the impacts this will have on employees and the motoring public. MnDOT is currently attempting to upgrade all mobile crash attenuator devices from the 45 mph rated Test Level 2 (TL2) to the higher 62 mph rated TL3 models. These higher rated devices offer greater protection to the occupants of any vehicle that could strike the back of a vehicle while on the roadway; however, these higher rated devices are more expensive than the lower rated TL2s. MnDOT has 162 such TL2s that need to be upgraded. MnDOT has also increased its use of early warning devices, such as arrow boards and changeable message sign trailers. In 2010, MnDOT approved the use of LED warning lights to be mounted on light/medium duty fleet vehicles. These lights have been tested by the Research Office and found to be more conspicuous than the standard halogen rotating lights.

MnDOT has also assumed leadership roles within fleet management by participating in efforts by “Project Green Fleet” to retrofit the existing diesel truck fleet with Diesel Oxidation Catalyst (DOC) to help capture additional exhaust partials and clean the exhaust emitted. MnDOT is also purchasing vehicles capable of burning cleaner fuels whenever possible.

If equipment replacement funding does not keep pace with the lifecycle performance needs, then operating costs will continue to increase. The aging fleet will lead to greater vehicle downtime and loss of production.

MnDOT’s field operations are dependent on a healthy equipment fleet to perform their tasks. Failure to provide equipment will result in diminished abilities to meet performance targets across the spectrum of operations (snow/ice control, pavement patching, signing, and vegetation management, etc.).

Implementation Strategies

MnDOT has a diverse equipment fleet needed to perform all of the different maintenance activities. These activities are constantly changing to better respond to public demands and a changing environment (i.e.., night maintenance work requires different equipment, public demand to minimize delays results in need to complete work faster and reduce time duration of lane closures). The following are ongoing strategies for achieving the fleet performance target:

1. In 2008 MnDOT formed a Statewide Fleet Management Group to help the Districts and Offices manage their fleet. This group has been tasked with several issues, such as addressing fleet utilization, determining whether current equipment lifecycles are in need of updating, and increasing the opportunities for MnDOT to share their equipment resources. This group is made up of a cross-section of personnel with each District having one position on the group.

2. A committee is currently in the process of re-evaluating current equipment lifecycles. The committee has contracted with a third party fleet benchmarking firm (Utilimarc) to analyze data from the EMS regarding equipment ownership and operation costs, compare this data to peers, and develop a model that forecasts the impact of reducing or extending existing lifecycles. Once this modeling is completed, the committee will review the current lifecycles and present any recommendations. The goals of working with Utilimarc include:

    - Refresh the existing equipment lifecycles
    - Withstand scrutiny both, internally and externally
    - Inform all fleet managers in the department of the elements and methodology that went into determining equipment lifecycles

3. MnDOT’s EMS system generates utilization reports and graphs by equipment class as well as by individual units. Districts who best utilize their equipment are currently being queried for “best practices,” and this information is used to assist other Districts in meeting the utilization targets. MnDOT will also set targets based primarily on averages achieved within MnDOT by class.

4. Encourage the use of the following to improve equipment utilization (spread usage over fewer units) and reduce usage needs:
   - Double-shifting of equipment
   - Encourage use of central motor pool
   - Reorganizing operations at a District level vs. area or sub-area level
   - Sharing equipment between operating units/Districts/other governmental units
   - Local renting/leasing for seasonal needs
   - Lowering need for business travel (less meetings, more video conferences)
   - Encouraging employee use of personal vehicles
   - Centralized purchase with lease to District/Office
5. Incorporate use of enterprise-wide Fleet Management database into overall agency fleet management decisions.

3.7.2 Building (Facility) Maintenance

Introduction and Background

MnDOT's Building Maintenance is one of the largest caretakers of buildings in State government with a total of 880 facilities spread across 380 locations throughout the State of Minnesota. Building Maintenance provides a custodial role in managing these resources with the Building Services Section providing support to the State's eight districts. Funding sources are allocated between districts to ultimately build, repair, and maintain the facilities used by MnDOT and the public. Facility types include utility buildings to office headquarters as well as the rest areas visited by the public. Total building footprint areas have been tabulated in excess of 5.4 million square feet with an estimated replacement value of more than $709 million.

The methodology of how the appropriated budget is used and divided between Districts is outlined below. Management and allocations of funds are adjusted as needed by each District's needs or as emergency conditions warrant. Needs are also generated from statewide comprehensive reviews of all facilities each year. These reviews use a detailed assessment of all functional areas of a facility ranging from condition and safety standards, energy conservation, barrier-free access, and environmental compliance[9]. Facility assessment "scores" are key indicators for the health and condition of our facilities. Refinements and

[9]Assessment follows standards developed by Minnesota Enterprise TIFM Team a workgroup under the Real Property Governance Team. This group represents 18 agencies that manage and maintain the State's capital assets using ARCHIBUS, an Enterprise web-enabled database. This program allows the Department of Administration to manage this data on an Enterprise basis.

adjustments are made each biennium as Building Maintenance struggles to manage resources with aging facilities and new challenges.

Building Construction and Maintenance Budgets are divided into four primary areas:

1. Capital Building Budget (CBB): Major Building Projects *over* $1.5 million

2. Capital construction of facilities (over $1.5 million dollars) range from total replacement, to additions or alterations of existing structures. Target funding for these large projects is approximately $20-30 million every two years (state bonding appropriation), with FY10 and FY11 totaling approximately $55[10] million.

3. Capital Operations Budgets (COB): Building Projects *under* $1.5 million. Capital Operations Budgets are similar to Capital Construction Projects; however, budgets are less than $1.5 million dollars per project. These projects are in the operating budget, which allocates approximately $4 million toward the replacement/ rehabilitation of smaller buildings.

4. Facility Maintenance Program (FMP): An annual appropriation to cover work that preserves/extends the facility's capital value, such as roof replacement, mechanical and electrical systems, and other building components. This program includes approximately $6.7 million annually.

Factors Affecting Capability

1. Historically, the Minnesota Legislature has acknowledged the need to maintain the State's buildings and in 1996, Minnesota State Statutes 16A.11 was amended to include [budgeted] two percent of overall building replacement value but was revised in 2002 and reduced building maintenance to one percent. This single budgetary reduction equates to approximately $8 million per year not currently available to maintain our State facilities. At this time, a value (percent of building costs) cannot be precisely calculated; however, this should inherently be above 1.5 percent to two percent. Years of deferred maintenance place a burden on the ability to calculate this value and establish optimum operating budgets. It is generally agreed a shortfall exists between budget and maintenance demands, however this value cannot be accurately defined by an accepted methodology at this time. Please refer to Part C: Performance Measures.

2. Minnesota Statutes 16A.633 mandates building conditions are assessed every year. This enforces the need for routine monitoring and building condition assessments. Updated assessments show a continuing degradation in the conditions of our facilities with almost half of MnDOT mission critical facilities with major deficiencies or functionally inadequate. Budgetary shortfalls put a large burden on available funds for deferred maintenance responsibilities.

[10] Department of Transportation State of Minnesota 2010 Capital Budget Requests

3. Beyond regular maintenance, Building Services has identified critical issues with many of the State's salt storage buildings and truck stations. Funding will be needed to address an aggressive program to effectively address repairs and renovations of these facilities.

    a. Twenty-six salt storage buildings have been identified as structurally deficient and unsafe; repairs or replacement is to be scheduled in the next two biennium (four years). Thirteen buildings per biennium, (with an estimated value of $307,000 each) is a budgeted shortfall of $4 million per biennium.

    b. Budgeted dollars allow for a programmatic updating of approximately two truck stations per year. This extends a replacement cycle (for 137 truck stations) to almost 70 years, which is over life expectancy for these critical-use facilities. At this slower cycle, new equipment sizes, energy conservation expectations, and deferred maintenance place more truck stations with the desperate need of upgrades. At $1.5 million (average) each, upgrading two additional stations per year will allow Building Maintenance to better manage this issue with facility life expediencies. Currently, 15 truck stations are assessed to be "functionally inadequate." In spite of an aggressive schedule of four stations per year, program delivery pushes this out 10 years before catching up to objectives.

    c. Current technologies are aiding our abilities to communicate and manipulate building information. This ability and automation through web-based systems allows controls for environmental efficiencies and energy cost savings. This provides benefits but also additional upfront costs, which had not existed previously. Current budgets must factor in these extra costs.

    d. Staffing trends have changed over the years, and facilities were often limited for accessibility and staffing accommodations. Uses such as bathrooms and showers need renovation to accommodate both men and women users. Heightened awareness to the needs of the disabled user or employee is being assessed and revised where budgets allow.

    e. ADA compliance is becoming to the forefront and recognized as part of the overall renovation scope for many primary use facilities. In 2011, discretionary funds were allocated to begin a formal analysis of existing conditions related to accessibility. Accessibility codes are integrated into local, State and Federal regulations; compliance is an added responsibility [cost] for new and renovated facilities.

Performance Measures

Significant emphasis has been placed on the requirements of tracking and prioritizing facility needs throughout all State agencies. These needs are compounded with demands on staff utilization, technological advancements, and systems. Newer tools are currently and literally coming "online" to help manage this complex pool of information.

1. As part of Minnesota's Drive to Excellence Initiative (DTE), a statewide facilities management tool ARCHIBUS is being used as a repository of property information. ARCHIBUS as Computer Aided Facilities Management (CAFM) software enables Building Maintenance to evaluate space, usage, costs, resources, etc. statewide. With the "building operations module," facility maintenance will issue and track time and money expenditures and allow operations to monitor and prioritize resources. Ultimately, real-time budgetary demands can be assessed. 2011 into 2012 will prove to be a pivotal period for utilizing this new tool.

2. Within Building Maintenance, a budgetary gap exists between needs and resources; however, new tools (inventory/scheduling/ management software) are being implemented to better define where deficiencies exist. This gap is expected to be initially higher, including current deferred maintenance, however, it is expected to be within a calculated value of 1.5 percent to two percent of building replacement costs (between $4.0 and $7.5 million yearly[11]). Building Maintenance currently spends 0.95 percent of the replacement value, or $6.7 million, on building maintenance each year.

Strategy Development/Policy Direction/Risk

State Facilities that include life safety issues, or are functionally inadequate, pose a high risk. These facilities are prioritized and draw a proportionally large amount of resource away from available budgets. Currently, 26 salt storage buildings and 15 truck stations fall into this category and are critical liabilities to the general capital operations budget.

Long-range plans are in place to maximize efficiency within routine building maintenance by tracking needs and resources via web-based tools, such as ARCHIBUS. The building operation module will be especially useful with its ability to define tasks, costs, and related resources. Administration and paperwork can be minimized by working through the process within the software interfaces.

A large percentage of MnDOT's facilities are currently evaluated with a large number of deficiencies and compounded with deferred maintenance issues. As budgets allow and facilities are renovated, upgrades related to building and energy codes, accessibility, and life safety are integrated into the work.

Beyond the functional and safety demands of facilities, upgrades are needed to complement and support staff environments, expectations, and newer technologies. A pleasant, comfortable environment supports daily tasks and fosters pride and productivity in the workplace.

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[11] Calculated budgetary maintenance values are figured by multiplying the existing replacement cost of facilities (2011 = $709 million) by 1.5 and 2.0 percentage multipliers respectively. Actual 2011/12 budgeted values are $6.7 million at 0.94 percent with an estimated shortfall of 4 and $7.5 million.

Implementation Strategies

MnDOT allocates the biennium funding stream to cover all aspects of maintenance and repairs to new and replaced facilities. Budget fluctuations require MnDOT to prioritize and manage the highest risks to safety and function as they relate to the immediate and assessed needs of the State's facilities. Due to gaps in the overall budget, there is an increase in deferred maintenance and deterioration of building assets.

This scenario establishes an escalation and back log of responsibilities for MnDOT staff. Budgets are expended on items of the highest or immediate priorities. Examples of "reactionary expenditures" include:

1. Outstanding issues related to salt storage structures
2. "Catch-up" to lifecycle replacement of truck stations
3. Systematic upgrades to facilities; avoid routine maintenance which turns into more costly deferred maintenance
4. Patching deteriorating parking/equipment yards in lieu of replacing them

Implementation strategies focus on allocation planning and resource tracking/management. With limited increased annual/biennium expenditures, strategies will include:

1. Increased use of tools like ARCHIBUS to monitor resources and more efficiently distribute work orders and staff.
2. Continued development of methodologies to better tie building assessment information protocols to reconcile deficiencies and access associated costs. Need to establish better models for building assessments as it relates to maintenance budgets.
3. Educate staff on best management practices and how to extend the useful life of buildings and exterior paved surfaces.
4. Continually review and refine the work being done. Use experience to maximize facility efficiencies; work better and longer.
5. Integrate energy conservation designs into new and renovated facilities. Look for best payback periods available.
6. In all new and/or renovated projects, there is a need to integrate accessible design regulations and related criteria to the best ability and budget. In addition, many facilities were limited to male-only restrooms and accommodations, like showers and locker rooms. Staffing is moving toward a mixed gender.

In general, costs for building maintenance, repair, and upgrades are rising. Compounding these rising costs is the acknowledgement of changing demographics (more women and physically impaired individuals being employed) and older facilities not fully accommodating everyone's needs. Also, State-issued Executive Orders, higher expectations for efficiencies, and technological advances in the workplace inherently raise the costs for future renovations and replacement. Unfortunately, the current budgetary "model" can fluctuate between biennia and requires allocations to be adaptive. With shortages, some things simply do not get done and are pushed further out in the future.

3.7.3 Safety Rest Areas

Introduction and Background

MnDOT's Safety Rest Area (SRAs) Program provides motorists, including commercial motor vehicle operators, a convenient and coordinated system of facilities at which they can stop, rest, and refresh. The majority of this system was developed during the Interstate construction era from the 1960s through the early 1980s on both Interstate and non-Interstate highways. While the system has undergone changes, it continues to contribute to improved highway safety and provides a valuable service to transportation users.

The primary purpose of safety rest areas is to reduce crashes caused by driver fatigue. However, rest areas also:

1. Support commercial freight movements.
2. Reduce motorist need for shoulder stops.
3. Reduce driving under hazardous weather and road conditions.
4. Offer customer services.
5. Promote the State.
6. Promote statewide tourism.

MnDOT designates four classes of SRAs: Class I through IV. The number and location of MnDOT SRAs are shown on the following map (Figure 3.35).

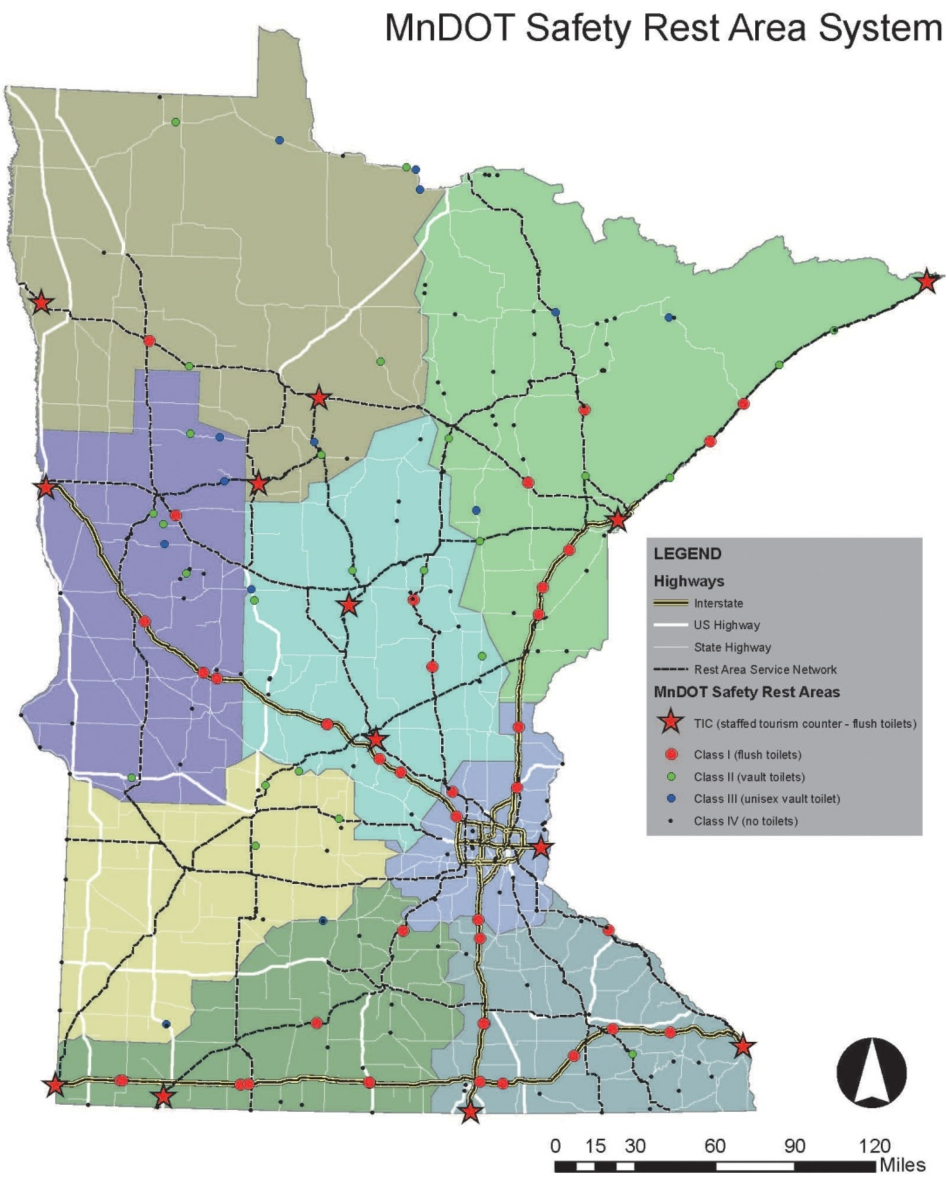
The 51 Class I SRAs are located on the highest volume routes. These SRAs feature a full-service heated building with flush toilets, picnic facilities, lighted walkways, and lighted car, recreational vehicle, and commercial truck parking lots. Class I facilities frequently include a children's play lot, pet exercise areas, artwork, regional, and cultural interpretive information, and scenic views.

The 36 Class II and III SRAs are located along other major corridors and include vault toilet buildings as well as picnic facilities and other amenities.

The 180 plus Class IV SRAs are located along State highways and typically mark historic areas, scenic overlooks, and/or areas of interest. These facilities are typically referred to as "Waysides" with minimal other services offered.

This chapter only addresses Class I SRAs. Refer to the Roadside Chapter for information regarding Class II-IV SRAs.

Figure 3.35: MnDOT Safety Rest Area System



Factors Affecting Capability

A significant number of changes have impacted SRAs over the past 10 years. These range from regulatory requirements for commercial vehicles to the size of vehicles and the level of funding, to the number of people using these facilities. Some of the key factors affecting the operations and maintenance of SRAs are summarized below:

Age of Facilities: Since the majority of the rest areas were constructed from 1960 to 1980, many of these facilities are 30 to 50 years old. Older facilities are less efficient, require more maintenance, and often do not meet current building code requirements. As a result, sometimes small changes to facilities cannot be made without triggering a requirement to meet current codes or standards.

In addition, though rare, MnDOT sometimes uses Minnesota State bonds for the construction of SRAs. In such cases, State law requires MnDOT to build such facilities to meet the State of Minnesota Sustainable Building Guidelines (MSBG). While these guidelines increase MnDOT's environmental stewardship, they can significantly increase the cost of the overall project.

Increased Usage: Rest areas have seen increased use due to more users on the system as well as regulatory changes that have required more rest time for commercial vehicles (i.e., 2005 Federal laws modifying hours of service for commercial vehicles). In addition, Minnesota enacted a 2008 law allowing commercial vehicle drivers to park in rest areas for up to 10 hours in SRAs.

ADA Requirements: Since initial construction of SRAs, many changes have occurred, including changes in accessibility requirements and Americans with Disabilities Act (ADA) compliance issues. Many SRAs built before the changes to accessibility requirements do not comply with the current ADA guidelines. Accessibility deficiencies were found at 46 of the Class 1 facilities. Furthermore, 33 percent of Class I SRAs lack an accessible toilet stall, which constitutes a violation of Federal regulations.

Larger Commercial Vehicles: Since initial construction of SRAs, many changes have occurred in the trucking industry, including an increase in commercial vehicle lengths. Current regulations allow a maximum length of any combination of trucks, trailers and tractor of 75 feet. Many older SRAs do not meet this standard. As such, they have difficulty accommodating these large vehicles in parking areas.

Remote Locations and Diversity of Issues: Maintaining and operating SRAs are difficult due to their remote locations (many are not close to urbanized areas), and as such, servicing these requires a fair amount of extra travel time. These facilities are unique in that they require diversity of maintenance staff and skills sets (i.e.., electricians, plumbers, grounds keepers, snow and ice, etc.).

Rising Labor Costs: One of the major contributors to budget pressures for the SRA system is labor costs. MnDOT outsources custodial services for SRAs, and in 2010 the custodial contract with Green View, Inc. accounted for approximately 80 percent of the total recorded SRA operations and maintenance budget expenditures. Over the past eight years, the Department absorbed cost increases for the custodial contract through a corresponding reduction in the hours of custodial service provided at SRAs. The reduction of custodial service hours began in 2002; however, MnDOT has determined that further cuts to the hours of custodial service at SRAs would compromise the mission of the SRA Program, undermine the viability of contracting for custodial services, and be inconsistent with the public's desired level of service and onsite presence during most hours. As a result, future custodial contract costs will likely rise commensurate with labor rate increases.

Performance Measures

MnDOT identified the following goals with respect to SRA performance measures.

1. Based on objective data
2. Relatively easy to use and maintain (i.e., not too labor intensive)
3. Tied to national experience or best management practices
4. Tracked over time to reveal trends
5. Related to financial needs and respond to customer expectations
6. Relatively easy to communicate to policy makers

The Department identified three performance measures for managing Class I SRAs and has developed one of them:

1. Condition Rating (developed)
2. Maintenance Rating (potential)
3. Functional Rating (potential)

Developed Measures

Condition Rating

The condition rating is an assessment of the physical condition of the SRA as it currently exists. MnDOT bases the condition rating on the evaluation of individual features of the SRA. A SRA feature is an individual characteristic or element, such as the building, parking lot, play equipment, or sidewalks. To evaluate the conditions, a tool was developed that rates conditions on numerous components and aggregates these to an overall rating called the Facility Condition Index (FCI). This rating allows for a statewide comparison of all SRA facilities.

The key objectives of the assessments were to identify the renewal and deferred maintenance requirements at each facility, including cost estimates; to correct observed deficiencies for the individual features; and restore them to a reliable operating condition. This information provided MnDOT with a snapshot of the current physical condition of each individual SRA, as well as an overall comprehensive assessment of the entire SRA system.

Information from facility questionnaires, a review of original construction documents and discussions with facility representatives and maintenance staff, provided a general understanding of the conditions of the SRA. During site visits, the assessors made a visual inspection of each SRA component and compiled a list of observed deficiencies.

The assessors prepared a cost estimate for each observed deficiency using RS Means[12] cost data adjusted for Minnesota. The information from these inspections was entered into a database that cataloged current deficiencies with a direct project cost. Assessors used a database to record all deficiencies.

FCI Calculations

MnDOT uses a Facility Condition Index (FCI) to measure the relative state or physical condition of the SRA against a cost model of a similar facility as if it were at the beginning of its useful life, fully "renewed" to today's standards.

The FCI is calculated using the following formula:

$$\text{FCI} = \frac{\text{Cost of Assessed Deficiencies (Cost to Repair)}}{\text{Replacement Value (Cost to Replace)}}$$

The FCI rating works well for the entire SRA system since each individual SRA has a wide range of systems and components. Using the FCI to measure the condition, allows MnDOT to assess all system and components using one rating system.

Because SRAs are composed of such a diverse array of elements (i.e., parking lots, picnic shelters, play equipment, acceleration/deceleration ramps, etc.), it was important to identify core SRA elements critical to the operation and mission of the SRA program. This was important so that non-core elements, such as picnic shelters, trails, and play equipment, although important in terms of overall SRA amenities, did not inflate the FCI, thereby driving the need to replace the SRA. MnDOT staff along with the study Technical Advisory Committee identified the building and pavement as core SRA elements critical to the operation and mission of the SRA program. Therefore, the FCIs for only the SRA building and/or pavement will drive the identification of SRAs in need of replacement.

Other SRA elements, such as sidewalks and trails, landscaping, signage, striping, and other site amenities, were not considered critical to the operation and mission of the SRA program, but were rated and wrapped up with the building and pavement FCIs into the overall SRA FCI. By doing this, the non-core elements are still able to be measured, because although it was important, these elements did not drive the need for total SRA replacement, they are still important to the SRA mission and overall customer satisfaction.

The overall SRA FCI gives a general indicator of the overall site condition and can be rolled up further to indicate the health of the entire SRA system. It is important to note that neither the core nor the non-core SRA elements include functional components such as correcting poor parking lot geometrics, building capacity, sewer/water capacity, etc. These components are discussed further under the functional rating framework.

[12] RS Means is a national standard, adjustable for local conditions, for cost estimating repairs or replacement of component features.

Assessment Frequency

The comprehensive facilities assessment that was conducted in 2007 is recommended to be conducted every three to five years. The assessment program provides for differing levels of assessment and in interim years, a more general planning-level assessment can be done. This planning-level assessment may be an efficient process of updating portions of the assessment without having to conduct site visits at all facilities.

Targets

Similar to pavements, MnDOT has set a combination of high and low targets for SRAs as shown below.

1. 70 percent or more of Minnesota's Class I Safety Rest Areas should have a composite FCI rating between 0 and 25.

2. 96 percent or more should have an FCI rating between 0 and 45.

Methodology

In 2007, MnDOT established a management system, developed assessment criteria, and conducted its first comprehensive condition rating of its Class I SRAs. The condition rating is an average of the Building FCI and the Parking FCI for the individual rest area. The closer the FCI composite score is to zero, the better the physical condition of the rest area is considered.

Trends

The comprehensive condition ratings were first completed in 2007. At that time, just 62 percent of the rest areas had FCI ratings between 0 and 25, while 88 percent had an FCI between 0 and 45. Looking forward, the rating system is intended to be used to periodically assess the condition of the entire SRA system and individual SRAs, begin to quantify and prioritize the needs within the system, and assist MnDOT in determining when safety rest areas require renovation or replacement.

SRA System Condition (Indicator)

This indicator identifies the overall FCI for the entire Class 1 SRA system, including all SRA components (not just the critical components). FCIs for individual SRAs are aggregated into a single FCI for the entire system.

Indicator Definition and Calculation

The performance indicator is the aggregated FCI for the entire Class 1 Safety Rest Area system. The FCI is an industry standard index derived by dividing the total cost of correcting all Class 1 Safety Rest Area deficiencies by the "cost of replacing the all of the Class 1 Rest Area facilities in-kind" (same building size, same materials, etc.). Higher FCIs mean the overall system is in worse condition and in need of greater repairs. Rest Area system inventory updates are proposed to be completed every three to five years.

This particular measure includes all SRA components and is shown below:

$$FCI^{System} = \frac{\text{Cost of Assessed Deficiencies System-wide (Cost to Repair)}}{\text{Replacement Value (Cost to Replace In-kind)}}$$

This indicator does not rate functional components, such as parking lot size, building capacity, sewer/water capacity, etc.

The aggregated FCI for the entire Class 1 Safety Rest Area system is 20.36 as measured during the first Facilities Assessment completed in 2007. MnDOT identified 15 as the SRA overall system target. MnDOT expects to track this aggregated FCI over time to review how the overall health of the SRA system is impacted by the corresponding levels of operations and maintenance.

Individual SRA FCI (Critical Components)

The individual SRA FCI identifies the condition (good, fair, or poor) of critical components for individual Class I Safety Rest Areas in Minnesota and tracks condition changes over time. The critical components included in the individual SRA FCI are pavement and building condition. The details of the measure are described below.

This particular measure focuses on the core SRA elements critical to the operation and mission of the SRA program (i.e., the building and pavement). Therefore, the performance measure for an individual SRA will measure both the Building FCI (FCI^{Bldg}) and the Pavement FCI (FCI^{Pvmt}). Rest area system inventory updates are to be completed at least once every three to five years. The definition of these two FCIs is shown below:

$$FCI^{Bldg} = \frac{\text{Cost of Assessed SRA Building Deficiencies (Cost to Repair)}}{\text{SRA Building Replacement Value (Cost to Replace In-kind)}}$$

$$FCI^{Pvmt} = \frac{\text{Cost of Assessed SRA Pavement Deficiencies (Cost to Repair)}}{\text{SRA Pavement Replacement Value (Cost to Replace In-kind)}}$$

FCI scores are grouped as follows:

1. Good = FCI^{Bldg} and FCI^{Pvmt} are both less than or equal to 25
2. Fair = FCI^{Bldg} or FCI^{Pvmt} is between 25 and 45
3. Poor = FCI^{Bldg} or FCI^{Pvmt} is greater than or equal to 45

This measure does not incorporate other non-critical SRA components (e.g., landscaping, trails, and play areas). These components are incorporated into the SRA System Condition (Indicator) discussed earlier. In addition, the functional components such as parking lot size, building capacity, sewer/water capacity, etc. need to be further developed and incorporated into future measures/indicators.

Proposed Performance Measures

The framework for two potential rating systems is as follows:

Maintenance Rating (Customer Satisfaction Survey)

SRAs serve as a key interface between the State and travelers/tourists. SRAs also represent a strategic opportunity to promote and provide a positive impression of the State of Minnesota. Custodians provide most of the day-to-day maintenance activities at SRAs. The custodial service provider is self-evaluated through periodic reviews to measure the performance of custodians at meeting maintenance and cleanliness standards. The visitor, however, ultimately determines the acceptability of these facilities. Unfortunately, MnDOT currently does not have a mechanism to regularly receive site specific and general visitor feedback. Presently, MnDOT only gauges the traveler's views from the level of complaints received or through information gained from the statewide Omnibus Survey measuring residents' satisfaction with MnDOT services. As a result, MnDOT will consider developing of a simple customer satisfaction survey to gauge specific public satisfaction of SRA services and experiences tied closely to daily conditions at the SRA sites. MnDOT would track these ratings over time to gauge trends in performance and/or customer expectations.

Functional Rating

One of the needs that transcend SRA maintenance and conditions is the ability of a SRA to meet the basic functional needs of users. Rest areas become functionally obsolete or ineffective if they no longer provide useful service or fail to meet user needs. For example, larger truck sizes force truck operators to drive outside pavement areas or to park across parking stall lines if geometric conditions at older SRAs have not been improved.

A functional rating may include the following:

1. Geometric design deficiencies
2. Parking capacity and demand
3. SRA location issues related to spacing between SRAs
4. Building and/or other site conditions limiting the delivery of necessary services

A functional rating could identify and quantify this type of deficiency and could serve as a useful programming tool to assist MnDOT in planning improvement projects.

Strategy Development/Policy Direction/Risk

The following section discusses the potential range of options for addressing ongoing SRA operations and infrastructure needs. MnDOT currently has difficulty funding maintenance, operations, and improvement activities for SRAs. Costs for these activities have significantly increased while revenues, in real terms, have decreased. Funding to maintain the current size of the system presents a challenge.

Potential strategies for addressing ongoing needs are as follows:

1. Continue to strive for improved efficiency and effectiveness in the operations and maintenance of SRAs, including bundling services to reduce cost/fees.

2. Maintain the Facility Site Assessment to rate the condition of SRAs. Strive to complete a comprehensive assessment of the entire SRA system every three to five years with planning-level assessments of individual components as necessary, in the interim.

3. Track historical FCI data trends and report performance measures over time. Build trend-line data set to forecast future performance and budgets based on historic data.

4. Explore Public Private Partnership (P3) opportunities to enhance services and restore infrastructure at a reduced cost to the public. This should be done in conjunction with a Comprehensive Safety Rest Area System Plan to identify the strategic spacing and reinvestment timing of the entire SRA system. A component of this Plan should also include a functional assessment of the SRA system to determine where functional upgrades and/or changes are necessary.

Continue to explore new initiatives that improve traveler services and/or generate a revenue stream from SRAs, including:

1. Wireless Internet access at SRAs

2. Advertising within SRAs

3. Enhanced and expanded vending

4. Leasing to tourism departments, chambers of commerce, and other leasing candidates

5. Continued development of Public/Public and Public/Private Partnerships

Implementation Strategies

To restore to and maintain safety rest areas at acceptable levels, MnDOT will need to implement the following strategies over the next four years:

1. Develop a System Plan for MnDOT Class I SRAs. Use the plan to guide capital reinvestment that responds to SRA Program objectives. Use the plan to prioritize and to program SRA capital reinvestment. The System Plan should consider the potential for partnership opportunities to develop SRAs or SRA-like facilities that could improve motorist services and that could reduce MnDOT costs.

2. Use performance-based project selection criteria, triggers and processes for identifying SRAs requiring capital investment. Continue to refine criteria, triggers and processes as necessary and develop a trigger for SRA functional deficiencies.

3. Update statewide SRA Investment recommendations to guide SRA capital investment and to assist MnDOT with making informed operations and maintenance decisions.

4. Work with the Office of Capital Programs and Performance Measures and Districts to secure timely funding and programming of SRA capital investment projects.

5. Coordinate SRA operations and maintenance activities with the programming of SRA capital investments in order to better scope and better time operations and maintenance work.

6. Complete Facility Condition Index (FCI) assessment every three to five years. Track historical FCI data trends and report performance measures over time. Build trend line data set to forecast future performance and budget based on historic data.

7. Continue to better track maintenance and capital costs for SRAs.

8. Continue to strive for improved efficiency and effectiveness in the operations and maintenance of SRAs.

9. Consider developing a customer satisfaction survey to determine public perception of the adequacy of operations and maintenance of SRAs. Use surveys to track the customer's view of the performance of both custodial services and routine maintenance. Track the survey results over time to gauge changes in performance and/or customer expectations.

3.8 Supporting Infrastructure

Supporting Infrastructure is the infrastructure that supports the activities and work that MnDOT does. These are the (a) Electronic Communication function- that provides radio communications to MnDOT vehicles and support to a multitude of state, county and city services; (b) Information and Technology (IT) services that support over 250 applications used by MnDOT, and (c) the Road Weather Information System (RWIS) that supports MnDOT by providing weather related information about the road system.

3.8.1 Electronic Communications

Introduction and Background

The Office of Electronic Communications (OEC) provides management, engineering, and technical expertise in electronic communication systems and technologies that address the specialized needs of transportation, public safety, and other State and local agencies' missions. OEC provides four products and services under the State Roads service line.

- Electronic Communication Investment & Planning (planning, design, and construction)
- Electronic Communication Management (operations and maintenance)
- External Transportation System Support - Electronic Communication (external agency services)
- Electronic Communication Administration (office and business management)

OEC's primary responsibility is to manage, construct, operate, and maintain the State's public safety communications radio network known as ARMER (Allied Radio Matrix for Emergency Response). ARMER provides radio communication service to MnDOT and State Patrol and will serve the day-to-day and emergency radio communication needs of other State agencies and a majority of local and regional public safety agencies, such as law enforcement, fire, emergency medical, and publics works services to name a few. The system currently serves over 40,000 mobile and portable radio users, and may grow to about 100,000 users over the next few years.

OEC also provides technical services and electronic equipment repair to MnDOT, the DPS, the DNR, and other State agencies. OEC provides services to Federal, regional, and local agencies upon request.

Since the 2005 HSOP was published, the legislature has provided funding to complete all phases of the ARMER backbone system, which is currently under construction and about 65 percent complete.

Approximately 325 towers are planned to make up the backbone of the ARMER system. This incorporates the transition to digital technology from the older analog technology. However, these additions to the system will create new financial needs over time in terms of additional operations and maintenance costs as well as periodic long term replacement costs. Upgrade (and update) costs will also be needed as technology provides better and updated functionality.

3.8.2 Electronic Communications Funding

Trunk highway funds are used to support the electronic communications needs of MnDOT and the DPS. Costs attributable to the DPS are reimbursed to the Trunk Highway Fund by the DPS. The cost of services provided to other State agencies or external entities are billed to the agencies requesting the services and the receipts reimburse the OEC operating budget.

The State Government Special Revenue Fund for 911 (administered by the Department of Public Safety) complements trunk highway funds for operation and maintenance of ARMER. The 911 funds allow MnDOT to provide local agencies access to ARMER without assessing user fees. Revenue from leasing space on state owned tower sites is used to defray the lease and utility costs of ARMER.

District Relationship

The ARMER system operated by OEC provides radio communication service to the Districts. There is no cost to the District for this service as OEC has its own appropriation from the Trunk Highway Fund to provide the service. Service also includes installation, programming, repair, and parts replacement. The District is responsible for the initial purchase of mobile and portable radio equipment and accessories.

OEC may also provide other services to the Districts upon request. Examples include designing in-building cell phone signal amplification systems, installing wireless gas pump controllers, and repairing electronic equipment. There is no cost to the District if OEC agrees to perform those services. One exception to this is the Office of Maintenance does provide funding for OEC to maintain the RWIS sites.

OEC receives support services back from the Districts. All OEC employees are housed in District facilities. Districts often provide maintenance services for the radio tower sites, including snow removal, weed control, and generator oil changes and maintenance. Districts may also assist with minor construction improvements at sites such as pouring concrete pads or adding gravel to a site access driveway. When Districts agree to provide these services, there is no cost to OEC.

Factors Affecting Capability

The following section summarizes some of the legal mandates and regulatory changes that are affecting OEC, cost implications, and overall operations.

Legal Mandates and Regulations

FCC 2013 Narrowbanding Deadline – The Federal Communications Commission has mandated that VHF frequencies used by most public safety agencies in Minnesota be narrowbanded by December 31, 2012. This mandate means that equipment either needs to be modified or replaced if it is not capable of being modified. A large portion of the equipment used in Minnesota, especially local agencies, is too old to modify. This has driven the decision of MnDOT and most other agencies to migrate to the ARMER system rather than replace their old equipment.

Cost Trends

Construction Materials Costs – Tower construction costs are influenced heavily by the cost of steel. The steel price index is highly volatile, but has remained generally lower today that it was two years ago. Higher prices could return at any time, adding pressure to bring as many sites to letting as quickly as possible to take advantage of lower steel costs.

- Energy Costs – One of the single largest expenses for the radio system is electrical power. Power costs are top priority for keeping the system on the air, and higher costs directly reduce the amount of money available for other kinds of maintenance.

- Shorter Lifecycles for Technology Products – In the past, agencies could count on their radio equipment lasting many years. Twenty years was not out of the question. With the rapid change of pace regarding technology today, equipment needs to be replaced or upgraded more frequently, which drives up the cost of operations.

- High Cyclical Replacement/Upgrade Costs – The overall rapid changes in technology have also resulted in higher replacement costs for new equipment and devices. The advancements in technology provide additional capabilities, but often with increased efficiencies. So while a replacement is desired, an upgrade often is associated with the replacement. Therefore, these equipment upgrades can impact the budget.

Operational Realities

The number of users on the ARMER system is increasing. Historically, OEC supported a system for less than 10,000 radios used by State agency employees. Today, there are over 40,000 active radios on the ARMER network. The number of users is expected to reach 100,000 or more in the next few years.

ARMER availability has become supercritical as all State and local agencies will eventually depend upon ARMER for day-to-day and emergency communications. There will be few parallel systems to fall back on. OEC will need to evolve into a 24/7/365 organization capable of providing immediate response to critical network problems.

Historically, the radio network consisted of less than 100 towers. By the end of 2012, ARMER will reach a size of over 300 tower sites, tripling the infrastructure that existed as little as two years ago. That added infrastructure must be maintained. Demands far exceed historical levels of effort by both OEC and the Districts. Some services may need to be outsourced or funded by other sources.

- As stated earlier, there are approximately 325 additional towers that will make up the backbone of the ARMER system. These additional towers will create a new financial commitment over time for both operations and maintenance costs, as well as periodic long-term replacement costs. Upgrade (and update) costs will also be needed once the current technology becomes outdated.

Performance Measure

In the past, the performance measure for the radio system was coverage. With the implementation of ARMER, coverage is no longer a meaningful measure as the system is being designed and constructed to provide 95 percent mobile coverage to all counties of the State, which is considered ultimately sufficient for State agency purposes.

In lieu of coverage, a measure of the number of sites complete was developed. This is a progress measure on completion of the system and is reported monthly to the Statewide Radio Board. The ultimate goal is 100 percent at which time the measure will no longer be relevant to system performance. At the present time, the system stands at just over 65 percent complete.

After implementation is sufficiently advanced, a measure that reflects system availability or reliability to users will be needed. OEC is researching proxies that can reflect that characteristic and be easily measured. “Five 9’s” (99.999 percent) is the industry gold standard for carrier grade telecommunications systems. ARMER leadership and users will need to define a meaningful target for the ARMER backbone.

Strategy Development/Policy Direction

MnDOT's Office of Electronic Communications coordinates with the Department of Public Safety and other agencies to address the State's radio and communication needs. A summary of the key policies and strategies are highlighted below.

Statewide Radio Board Plan

The ARMER systems is built, operated, and maintained according to the plan approved by the Statewide Radio Board. OEC services must be consistent with the adopted plan.

Strategies and Impacts (Innovations)

OEC has developed preliminary plans and budget requests to create a 24/7 operations center. Currently OEC relies upon on-call engineers to respond to system issues outside of the normal working hours. The number of pages and the critical nature of responses have driven OEC to develop this initiative. The risk of failure has become too great to rely upon on-call as a method of incident response.

Broadband data will be the next stage of development, eventually leading to a combined voice and data system. A separate data system may be developed in 5-10 years with a combined voice and data system likely more than 10 years out. A needs study is currently underway in the Department of Public Safety which will include the data needs of MnDOT. The goal of the study is to position the state to receive Federal grants to develop an interoperable public safety data system.

Shared Services

ARMER is by design a shared system. Economies have already been achieved by partnering with other agencies. This partnership brought in capital and operational funds from non-trunk highway sources. MnDOT is already enjoying the benefits of this statewide system in terms of better statewide coverage, statewide communications capability, and interoperable communications with other agencies.

Further opportunities to share resources may continue to present themselves as new users join the system. One example is sharing site maintenance responsibilities to reduce the number of independent service calls to a site. Another is sharing system monitoring services to spread the costs over more agencies.

Implementation Strategies

To establish and maintain a high performance level for Electronic Communications infrastructure support, OEC will need to implement the following strategies over the next four years.

As the user base of ARMER grows and diversifies, the OEC will need to respond with additional user support services such as system monitoring, performance measurement, technical assistance, and user application development. This will not require new positions beyond those planned for FY 2012-2013, but will require a shift of resources from design and construction to operations and user support.

As deployment reaches completion in FY 2013, additional effort will be focused on improving the reliability of the system through enhanced technologies and effective system monitoring and maintenance. Planning for end-of-lifecycle equipment replacement will soon become a necessity as the oldest electronic parts of the system are now over 10 years old.

Implementation of new technologies will be a requirement to keep up with the continually growing demands for wireless communication, not only voice, but data. As seen in the consumer market, integrated communication devices will eventually be the norm in public safety as well. The backbone will need to grow and adapt as new technologies are implemented.

3.8.3 Information and Technology Services

Introduction and Background

MnDOT has more than 250 business applications and technology tools. These applications and tools help MnDOT manage its transportation system and deliver services faster, better and more cost-effectively. Leveraging the use of future technologies is a key component in continuing to increase efficiency.

Most of the maintenance areas discussed in this report rely on technology and Information Technology (IT) infrastructures to collect, analyze, report, and communicate data. Examples of these include bridge management, pavement management, maintenance work management, facility management, traffic/safety management and financial management systems. These systems are used every day to manage the transportation system. Therefore, the IT infrastructure that supports these systems is critical to delivering and tracking the services it provides.

IT Infrastructure, within the Office of Information and Technology Services (OI&TS), provides the following services:

- **Data Security –** Various hardware and software solutions that protect MnDOT's IT investments
- **Server Hosting –** Physical and virtual solutions for server needs within MnDOT
- **Data Warehouse & Reporting –** The collection and holding of MnDOT data required by multiple parts of the Department ensuring that the data is considered an authoritative source
- **Storage & Backup –** Repository of MnDOT data for production and disaster recovery needs
- **Data Network Connectivity –** Various methods for all MnDOT staff to access the network for application, database, files, and/or Internet connectivity

IT Infrastructure's primary responsibilities are to plan, design, construct, implement, operate, manage, maintain, and support MnDOT's IT infrastructure, data and application servers, and network security used to support Department business applications.

Historically, IT infrastructure (servers, network infrastructure, software, licensing, etc.) has been acquired via project funding or one-time funds that were intended to improve business processes and delivery mechanisms. These funding opportunities, while delivering additional software and/or licenses, have often left gaps for funding the ongoing needs and maintenance. IT Infrastructure has been given the funds, from time to time, to acquire additional licenses and/or software, but no funding has been delivered to cover ongoing maintenance and support costs. Without covering the software maintenance and support costs, MnDOT would need to repurchase software and licenses to take advantage of upgrades.

There are many components that comprise MnDOT's IT Infrastructure. In the original HSOP, servers and routers were highlighted as components in desperate need for replacement funds. Since the HSOP was developed, MnDOT's routers have transitioned to the Office of Enterprise Technology (OET) and are no longer an asset the Department is responsible for maintaining. Servers are still a MnDOT responsibility, and the need for replacement funding still exists. As MnDOT's business needs expand and the business continues to use innovation for creating efficiencies, the number of IT Infrastructure components also increases. MnDOT's network connectivity has also grown, requiring increased network security.

Since the first HSOP was developed, OET has taken ownership of MnDOT's routers. OET invoices the maintenance work and support to MnDOT. Current needs are associated to hardware replacements (servers, switches, firewalls, wireless access points, etc.) and software maintenance growth.

IT Infrastructure Funding

Trunk highway funds are used to support MnDOT's IT Infrastructure needs. Costs for the services provided to the various MnDOT offices are handled primarily by office or project funds acquiring the required hardware and software. Ongoing maintenance costs become the responsibility of the IT Infrastructure section's budget. This process has become a concern as maintenance costs have now surpassed the IT Infrastructure section's base budget.

District Relationship

IT Infrastructure currently funds the WAN charges for connectivity to the District. IT Infrastructure supports District IT staff statewide with troubleshooting, network architecture guidance, and planning upon request. This support is provided at no cost to the Districts.

Factors Affecting Capability

MnDOT's operating budget for IT needs is often difficult to predict due to the rapid pace of changing technology and business needs. While software needs and licensing have been funded, other maintenance and IT support costs have not. Not to mention that new technologies may come online once a budget has already been established. Ideally the IT budget would be large enough and flexible enough that it could be adapted to accommodate these changes if and when they should occur; unfortunately, this is not always the case.

The following section summarizes the legal mandates and cost trends that are affecting OET and IT infrastructure.

Legal Mandates and Regulations

- State of Minnesota Office of Enterprise Technology has mandated that all State Agency Metro Area Data Centers be consolidated to a co-located data center provided and managed by OET. This consolidation is expected to improve the overall business continuity efforts and save money on electrical and cooling costs for each agency's existing data centers.
- Software licensing and maintenance legal requirements
- Multiple litigation holds currently exist at MnDOT that require servers, software licenses, and storage to ensure all data that is part of the hold is saved and protected.

Cost Trends

- Maintenance costs continue to increase (software, licensing, and staffing).
- Software license needs continue to grow.
  - A couple of examples of how licensing needs are continuing to expand are Primavera and Business Integrity (BI). Both rely on Oracle licensing and have required Oracle expertise to build these environments. Both are part of business improvement projects and require additional Oracle licenses that projects pay for initially, but do not cover the yearly maintenance fees that are required for the life of that application requiring specific software.
- Data Center consolidation costs largely unknown.
  - Data Center consolidation project is currently active and will soon be preparing equipment to move from MnDOT Data Centers to a State Data Center. The monthly costs for having equipment in the State Data Center are still not confirmed completely.
- Shorter lifecycles for technology products.
  - Lifecycles for various technologies are becoming seemingly shorter due to newer and faster technology being available in newer products or versions at an unprecedented pace.
- Fork-lift upgrades for hardware have excessive (OT required) staffing costs.
  - Replacing a complete product line all at once is what is referred to as a fork-lift upgrade. End of fiscal or biennium has produced opportunities where money has been available to invest in the IT infrastructure. Having

these large implementation needs requires staff to work overtime in larger amounts to provide installations as quickly as possible. Another cost factor in some cases is the contracting costs needed to fill in for day to day support when full-time staff is needed to plan and design a fork-lift implementation.

Operational Realities

- MnDOT IT Infrastructure replacement needs are being handled on a site by site, or district by district, need. MnDOT IT Infrastructure replacement needs should be handled at the department level. This would provide greater efficiency and effectiveness for identifying needs and researching possible solutions.
- MnDOT currently has more than 250 business applications that require IT Infrastructure.
- MnDOT IT Infrastructure (Network Authentication, Network Accessibility, Database Accessibility and Quality, Reliability) has become critical for MnDOT to provide services to the public.
- Added software, licenses, and infrastructure must be maintained. Current costs for maintaining software, licenses, and infrastructure exceed IT Infrastructure's base budget. Funding for this gap will need to come from other sources, or services requiring software, licenses and/or infrastructure will need to be reduced.

Performance Measures

IT Infrastructure has a goal to achieve 90 percent virtualization for the server infrastructure by FY15. Current manual measures indicate MnDOT has 48 percent of current servers virtualized.

Server and switch reliability performance measure is in development. After implementation, a measure that reflects system availability or reliability to users will be needed.

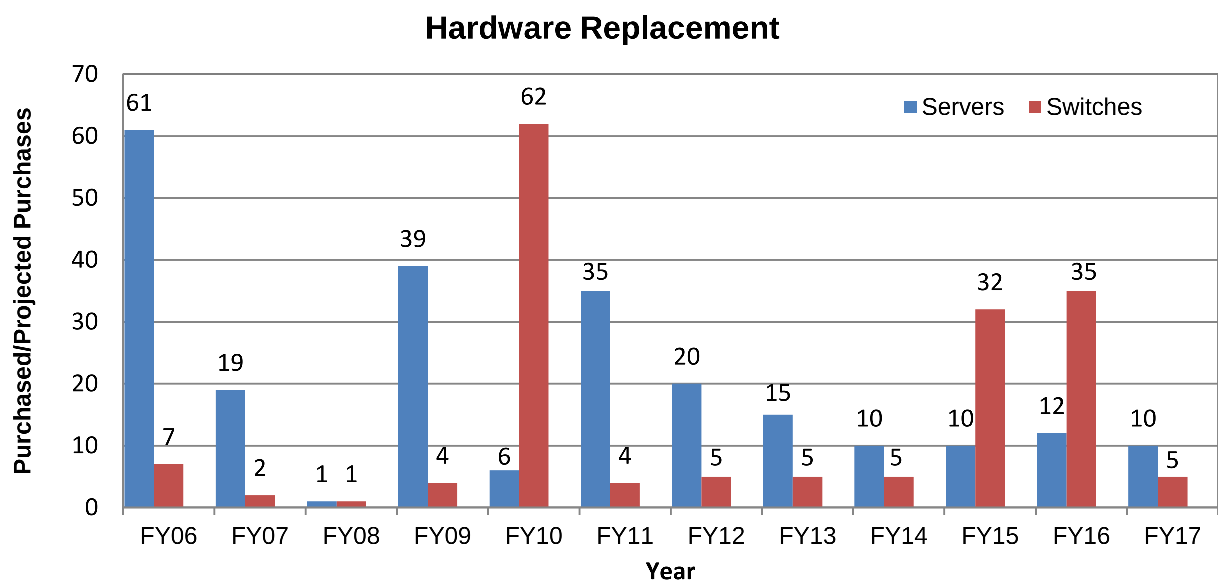
Current measures do not exist to identify how licenses and infrastructure are being utilized by MnDOT. IT Infrastructure hopes to have the ability to measure the use of licenses, server use, and disk space by the end of FY12.

In light of the lack of current performance measures for IT, the following proposed measures should be explored.

Hardware Replacement

The proposed measure is the *percentage of servers that are within recommended industry service lives*. The target for this measure is to have 90 percent of the 340 production servers within the recommended service lives (within 12 months off warranty or a four-year lifecycle). Figure 3.36 identifies the replacement of servers and switches by year.

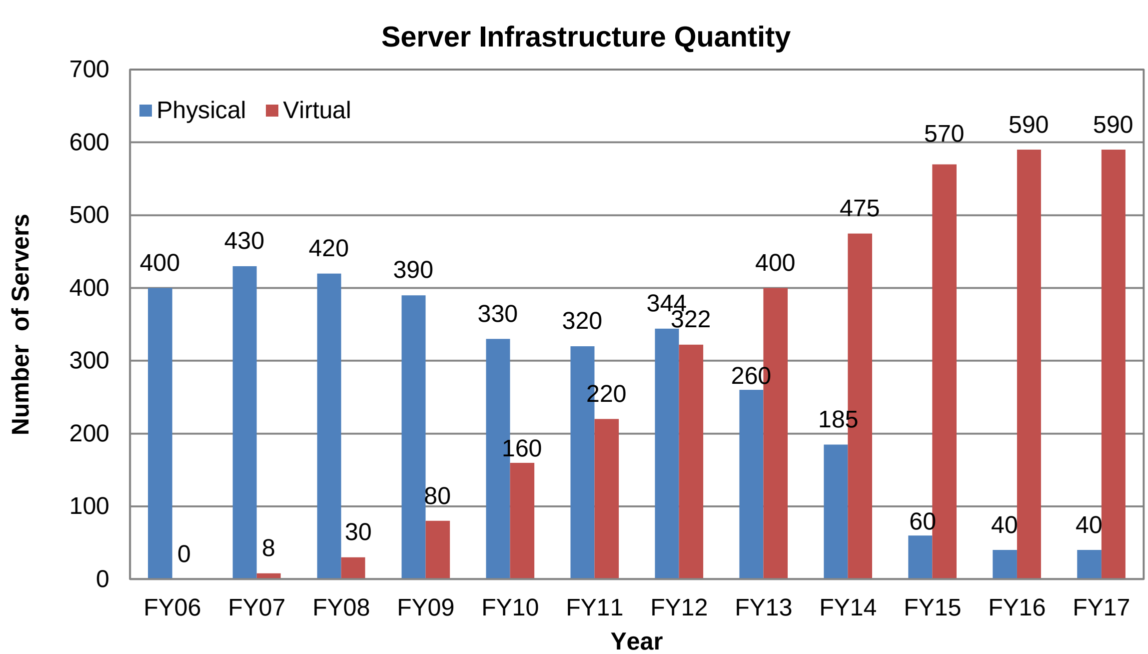
Figure 3.36: Hardware Replacement



Server Virtualization

The proposed measure is the *percentage of servers that are being virtualized each fiscal year*. The target for this measure is to have 90 percent of the total servers virtualized by 2015. The number of servers that are virtualized is depicted below in Figure 3.37.

Figure 3.37: Server Infrastructure Quantity



Strategy Development/Policy Direction

IT Infrastructure's current strategies include reducing the overall quantity of hardware wherever possible, complying with State data center collocation mandates, and taking advantage of shared services wherever possible.

Server Virtualization

- Aggressively moving physical servers to a virtual environment to reduce amount of hardware needed, thus reducing power, cooling, and management costs. "Going Green!"

Data Center Collocation (OET)

- The State is currently directing agencies with data centers in the Metro District to consolidate into a shared facility, EDC1.

Shared Services

- Sharing IT support responsibilities for software and/or management systems can improve support resiliency as well as share costs throughout the Department. One example of this is the SolarWinds core team. IT staff from D1, D3, D4, and IT Infrastructure (CO) currently share responsibilities in supporting SolarWinds network management solution for MnDOT. Staff spends a percentage of their time supporting the SolarWinds product and customers. A contractor or dedicated position has been avoided to this point due to the work each person is providing as part of their daily tasks.

Financial Implications

The IT Infrastructure budget does not currently allow for any hardware replacements to be made without special requests or unfunded needs being allocated by Division Management. Software maintenance and licensing costs have grown to the point that they require the entire amount of the IT Infrastructure budget.

Implementation Strategies

MnDOT has been investing in network and server infrastructure as monies become available (i.e., as unbudgeted and/or one time funding). Though this strategy has expanded the system to where it is today, it continues to defer the majority of replacements to one-time investments. These one-time investments are less efficient in allocating staff resources, and they put the overall system at more risk of downtime due to age. Implementation strategies to overcome these issues include:

- Work closely with the State Drive to Excellence efforts to investigate this infrastructure preservation as one of the business transformation areas and share infrastructure as a State Enterprise system.
- Continue to track historic and current annual performance levels (i.e., either percentage of downtime and/or percentage of uptime or total user hours lost) for system reliability.
- Continue to consolidate the system by reducing overall numbers of servers and the number of different application infrastructures.
- Work toward the goal of budgeting for annual replacement of portion of network and server infrastructure to meet performance targets.

3.8.4 Supporting Infrastructure RWIS

Introduction and Background

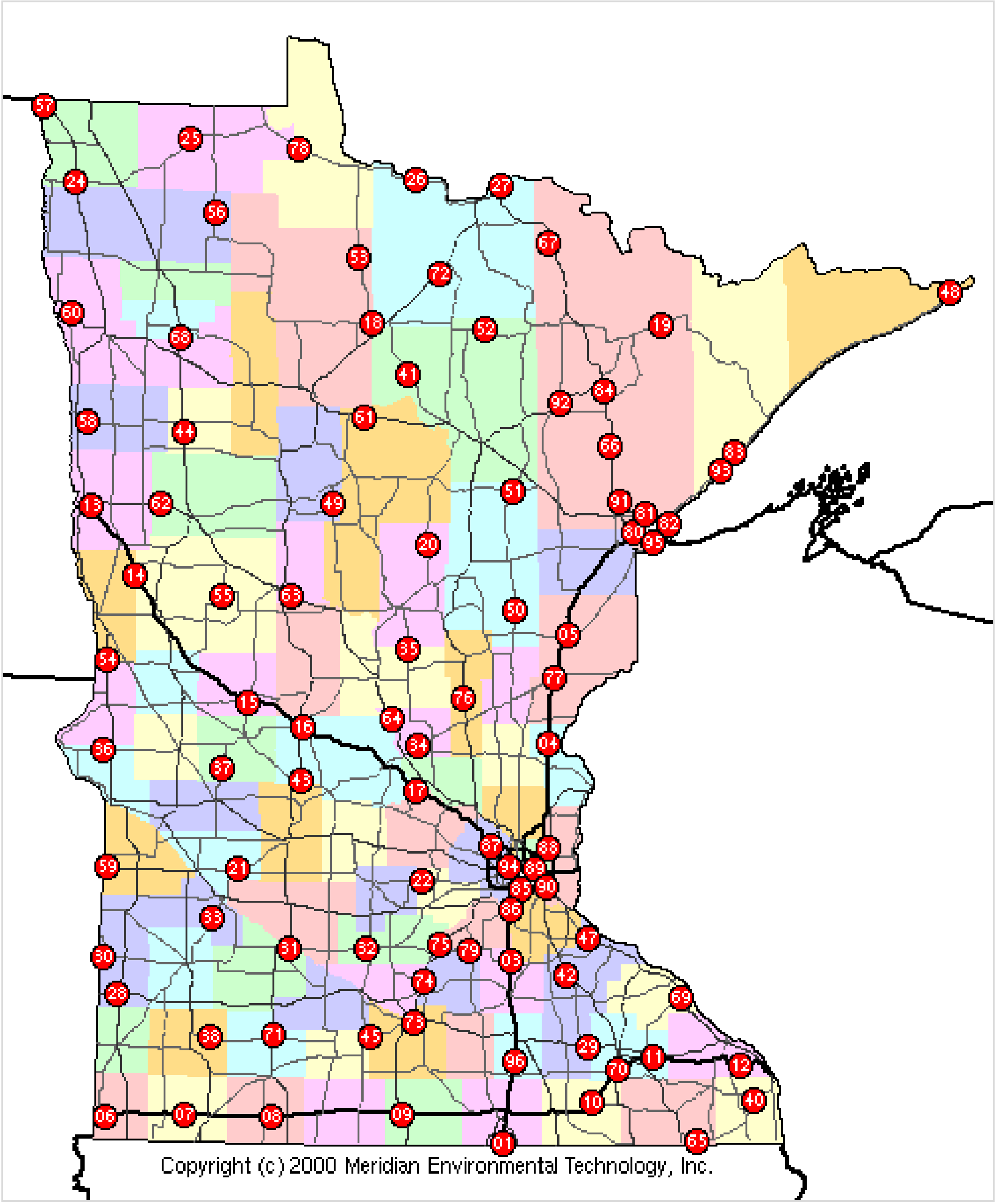
The Office of Maintenance's Road/Weather Information System section provides management and technical expertise in the operations and maintenance of the RWIS. Research and implementation of Decision Support and other emerging technologies in Road/Weather Management are also part of these services.

The RWIS section's primary responsibility is to manage, construct, operate, and maintain a network of Electronic Sensing Stations (ESS); a wide area communication system; and centralized data collection, storage and display equipment that comprise the RWIS. MnDOT's RWIS provides near real-time road and weather condition information to MnDOT, State Patrol, and other agencies. The system currently has over 1,500 users within MnDOT and is set up to provide access to any State or local agency as well as news media and the general public. Usage of this system continues to grow as equipment and communications technology are updated to provide more timely and reliable data.

RWIS data is used to increase the accuracy, cost-effectiveness and consistency of services that MnDOT provides to the public such as snow and ice control, road surface repair, noxious weed control, and roadside maintenance and repair. Data collected and stored by this system is also used in the measurement and performance management systems operated by the Department.

A map depicting the current locations of MnDOT's RWIS sites is shown in Figure 3.38.

Figure 3.38: RWIS Site Locations



RWIS Funding

Trunk Highway funds are used to support the RWIS. Rather than taking money directly from the Trunk Highway Fund, the RWIS budget is estimated before the start of a new fiscal year, and once the budgets are set, transfers are done from each District according to their percentage of the budget distribution. This is a somewhat unique way of funding an enterprise within MnDOT, but the Operations Division leadership felt the Districts needed to stay involved with RWIS and seeing the funds taken from each area would encourage them to continue to take an active role in system use and maintenance.

In addition to this annual budget, the Office of Maintenance frequently makes use of fiscal year-end funds and other opportunities to perform research on emerging technology, purchase equipment, and upgrade the RWIS system.

District Relationship

The RWIS system is operated by the Office of Maintenance specifically to provide road and weather information to the Districts. As stated above, this is a direct cost to the Districts and they play an active role in deciding future enhancements to the system. Initial purchase and installation of the system was done using State construction funds, and any damage to the system caused by road construction is restored by that project. Districts can add an RWIS station during a construction project if they see a specific need; all purchase and installation costs are included as part of the construction project. Once the new site is operational, the Office of Maintenance takes over maintenance and repair.

Office of Electronic Communications Relationship

The Office of Maintenance has a Memorandum of Understanding with the Office of Electronic Communications (OEC) for maintenance and repair of the remote weather sites (also called Electronic Sensing Stations or ESS). OEC technicians perform scheduled maintenance, calibration, and repair of the sites and in return, the Office of Maintenance contributes $100,000 per year to pay OEC salaries. The Office of Maintenance also periodically hires training consultants to ensure the technicians' skills stay up to date.

Factors Affecting Capability

Budget

- Current structure is great for accountability, but results in "feast or famine" situations that make planning for updates and/or expansion very difficult.
- Communication infrastructure needs to continually change to keep current with available technology and take advantage of potential cost savings.
- Shorter lifecycles for technology products mean hardware/software updates will be needed more frequently.

Operational Realities

- RWIS information is being used more by the public and should evolve into an important source of traveler information in the future.
- Availability of current and accurate RWIS information has become critical as this system is used by State and local agencies, Maintenance Decision Support Systems, and the general public. As more systems and users depend on RWIS for day-to-day and emergency road/weather information, system maintenance will need to be stepped up to ensure availability of timely/accurate data.

- As ARMER maintenance demands increase for OEC, the Office of Maintenance may need to explore alternate ways to repair and maintain the RWIS sites if OEC is unable to meet these needs.

Performance Measures

While no formal performance measures have been established for RWIS, customer satisfaction and the ability to keep data current and accessible have been good indicators of how the system is performing and any changes that are needed.

Strategy Development/Policy Direction/Risk

RWIS System Improvements

While the backbone of the RWIS has been in place since the statewide expansion project in 1999, MnDOT Districts have continued to identify unmet needs in their areas and address those needs in road construction projects when feasible. This has resulted in the addition of several sites, but lacks the consistency and planning that would occur if these improvements were centrally funded and done on a system-wide basis.

Shared Services

The Office of Maintenance has encouraged other offices to share facilities and communications available at its remote ESS sites. This has resulted in the co-location of many Continuously Operating Reporting Stations (CORS) operated by the Office of Land Management; soil moisture instrumentation used by the Maplewood Lab; traffic counting and classification equipment operated by the Office of Transportation Data, Policy and Analysis; and sharing of information from the RWIS database to run the algorithm responsible for Winter Load Increases and Spring Load Restrictions.

Implementation Strategies

Since the Statewide RWIS expansion in 1999, MnDOT has provided training on the use of RWIS information to the majority of its equipment operators, supervisors and managers. RWIS receives widespread use during Snow and Ice control operations as well as for weather and surface condition monitoring year around. Providing continued user training and performing regular system maintenance and upgrades will be key components in keeping and expanding this customer base. Careful planning is also required to ensure the RWIS is able to incorporate improvements in sensor and data display technology as they become available and/or cost-effective.

While funding reductions to the RWIS operating budget may result in short-term savings, they would affect maintenance and sensor replacement. This could lead to lower quality data and require major investments to return the system to good operating condition. Secondary impacts of this would be lower operator confidence in RWIS information which could increase costs and lower effectiveness of MnDOT operations.

Chapter 4 Risk and Investment Strategies

4.1 Introduction

MnDOT makes maintenance and operational trade-off decisions at the District level in an effort to meet legal mandates, provide priority services, such as snow and ice, and deal with operational realities and costs. MnDOT routinely evaluates changes in regulations, user expectations, and best practices. As part of this HSOP, a more formal Enterprise Risk Management (ERM) approach was used to help determine funding gaps and where additional funding could be directed if money became available. ERM involves identifying particular events or circumstances relevant to MnDOT's mission/objectives (risks and opportunities), assessing them in terms of likelihood and magnitude of impact, and determining a response strategy and the effectiveness of the response strategy in reducing overall risks.

4.2 Methodology and Process

The systematic risk management process provides structure to assessing this vision and resulted in mutual understanding of high-risk areas. Additionally, the formal structure supplements MnDOT experts' abilities to identify, assess, manage, and communicate opportunities and threats. Participants were asked to identify alternative strategies that have different costs or requirements for funding; these were used to identify different or manage risk to the group's risk tolerance level.

4.3 Major Assumptions

The risk management process used a common set of assumptions to ensure a uniform understanding of risks for different work activities. This was done in an open and transparent manner in a large group setting to ensure consistency. Participants must make assumptions to create a common vision about the future. Major assumptions used in this process include:

1. Stakeholder's shared vision of success is the following: Provide a safe, high quality and reliable transportation system through maintaining, operating, and preserving transportation assets and building trust with green sustainable solutions and collaborative innovations in a cost-effective manner.

2. A flat budget will be assumed for the next two bienniums. Given this assumption and the impacts of inflation, business as usual will not manage risk to the extent needed to realize stated objectives. However, by assuming common practice and flat budget levels, the participants were better able to gauge the importance of risks and develop "need" based budgets that are innovative and manage them effectively to risk tolerance levels.

3. Probability was evaluated over the next four years. This is important because risk is a function of time. The longer the time span, the more likely a risk will occur.

4. The impact of a risk event was gauged by judging the impact on participants' vision of success. This included public trust and confidence in MnDOT's operational services, the impact on public Quality of Life (QOL), and impact to MnDOT's operations vision.

Facilitated by MnDOT ERM staff, the risk management process helped experts use a consistent process while focusing on the importance of each of the maintenance activities in the context of statewide and user priorities. Further, the HSOP risk management plan will be dynamic and "living" as time passes. After risks were identified and prioritized, participants focused on challenging proposed funding gap strategies and developing risk-based strategies that accept a reasonable level of risk.

4.4 Enterprise Risk Management Results and Funding Summary

The ERM results for operations and maintenance were determined through a facilitated conversation with operations experts at MnDOT. The ERM process was aimed at identifying and ranking investments based on existing budget levels, anticipated risk levels, and current organizational strengths. Determining the funding gaps in these core risk areas, which are likely to underpin the future success of operations and ensure public trust and confidence, are important decisions. The prevailing risk environment needed to be examined in depth to determine the attractive risk areas for increased funding and, specifically, areas which may suit MnDOT best. Furthermore, consideration was given to the current business environment.

Once existing issues and anticipated risks are well understood, further consideration is given to the capacity of MnDOT, specifically the resources and capabilities and how these are combined to potentially form a competitive advantage for reaching the vision of success. Table 4.1 at the end of this Chapter provides a summary of the ERM results for operations and maintenance, as well as information regarding the current budget information and existing budget gap. As shown in Table 4.1, MnDOT's current operations and maintenance four-year budget (2012-2015) is approximately $860 million, with current the operations and maintenance need of approximately $1.25 billion over this same timeframe. This results in an existing gap (without inflation) of approximately $390 million and a gap with inflation of almost $410 million. Using the ERM process, the risk-based need over the next four year is reduced to $240 million, and the reduced-based need with inflation is $252 million. While this process helped to establish some acceptable risks, it did not compare and prioritize work activities amongst one another; this will be the next step in the budget process. In addition to Table 4.1, the detailed spreadsheets that were used throughout this risk process are included in Appendix B.

MnDOT's ability to create and deliver value to the traveling public is determined by the resources and capabilities of the Department, and how effectively MnDOT can develop competency in core risk areas to deliver inexpensive and effective strategic advantages. In the current constrained environment, it is particularly important to ensure that all investment gaps achieve a superior return on investments, sometimes allowing risk levels to increase above some risk thresholds.

Generally speaking, funding increases should begin with the top investment priorities, and likewise, funding reductions should be evaluated where risk areas are low. During these discussions, it was recommended that a risk committee within operations is formed to coordinate certain funding activities and scenario evaluations. This committee could be made up of the Work Teams Chairs and Area Maintenance Engineers (AMEs) to help establish ownership for particular risks and budget responses. The committee will also further evaluate the cost-benefit of the risk management effort and ensure action plans are developed and the risks are appropriately managed. It is also recommended that MnDOT develop consolidated performance reporting for various stakeholders, and the risk register is updated regularly to ensure efficient risk coverage by internal auditors, consulting teams, and other evaluating entities.

4.5 Summary

Based on the ERM process, MnDOT has a good baseline understanding of the current risk environment, established a common language in operations, described common risk understanding, identified and described a risk inventory, and implemented a risk-ranking methodology to prioritize risks within and across functions. The next steps will include using the ranking methodology to facilitate future discussions about funding scenarios and the various trade-offs associated with each of the risks.

Table 4.1: Enterprise Risk Management, Budget Summary and Gap Analysis: 2012-2015[1] (Dollar amounts shown in millions)

Risk Area	Current Budget	Need Beyond Current Budget	Current Gap	Gap Including Inflation	Risk Based Need	Risk Based Need Including Inflation[2]	Prioritized Budget[3]	Summary Notes
Arterial and Freeway Operations								
Signals	$1.0	$15.1	$14.1	$14.8	$7.5	$7.9		- It is likely that there will be increases in motorist delays and crashes due to a lack of signal retiming. - Proposed funding would result in minimal risk and manage the service life over the next four years.
Freeway operations	$7.2	$13.0	$5.8	$6.1	$4.0	$4.2		- Operational needs will exceed the capacity of staffing and resources. - Risk level is low; increased funding will meet needs while accepting only a small amount of risk.
Clear Roads								
Additional trucks and drivers	$0.0	$14.2	$14.2	$15.0	$10.5	$11.1		- Increased traffic volumes will lead to construction of additional lanes, ramps, and interchanges. - Bus-only shoulder lanes impacts the ability for snow storage and removal.
Additional snow/ice equipment	$0.0	$16.7	$16.7	$17.3	$12.0	$12.4		- Additional snow and ice equipment is needed to more efficiently provide service. - New technology/innovations exists that would provide greater efficiencies and environmentally friendly.
Drainage								
	$43.9	$68.0	$24.1	$25.3	$24.1	$25.3		- Drainage issues include plugged culverts, erosion control, saturated road embankments. - Funding will include maintenance of cross/centerline and entrance culverts.
Facilities								
Salt storage	$37.8	$45.8	$8.0	$8.4	$2.0	$2.1		- Cover-all salt shed facilities have design flaws throughout the state. - Impact of not meeting building code requirements and potential safety concerns is small.
Safety rest areas	$22.0	$51.5	$29.5	$31.1	$16.0	$16.8		- Maintenance needed for long-term building operations, ADA, building code requirements, etc. - Lack of funding could result in rest area closures which may have strong negative public reaction.
Truck stations	$56.6	$68.6	$12.0	$12.6	$11.0	$11.5		- Facilities expected to deteriorate beyond a level of acceptance, and possibly beyond a usable state. - Truck station replacement is a high priority.
Fleet								
Catch-up, equipment allotment, maintenance	$249.2	$322.0	$72.8	$76.3	$62.0	$65.0		- Fleet prices, maintenance lifecycle costs, fuel emission standards are likely to increase. - Proposed investment appears high relative to others, but manages a high level of risk.
Attenuators/TL3	$0.0	$2.8	$2.8	$2.9	$0.0	$0.0		- Unable to meet workzone safety (TL3) standards. - Potential work zone safety concerns exist.
Inflation[4]								
Electrical costs	$0.0	$4.0	$4.0	$4.2	$0.5	$0.5		- Likely that utility costs will increase, resulting in a less reliable system and potential safety concerns. - Proposed funding would mitigate the risk at a more acceptable level.
Salt	$0.0	$4.6	$4.6	$4.8	$4.6	$4.8		- Salt price inflation likely to continue. - Relatively inexpensive compared to other needs.
Fuel	$0.0	$2.0	$2.0	$2.1	$2.1	$2.2		- Fuel price inflation very likely to continue. - Proposed investment appears reasonable, but slightly low.

Table 4.1: (continued) Enterprise Risk Management and Budget Summary: 2012-2015[1]

Risk Area	Current Budget	Need Beyond Current Budget	Current Gap	Gap Including Inflation	Risk Based Need	Risk Based Need Including Inflation[2]	Prioritized Budget[3]	Summary Notes
Roadsides								
Vegetation management	$61.6	$109.7	$48.1	$50.1	$14.0	$14.6		- Likely unable to control weeds and brush; potential legal responsibilities and safety concerns. - Recommended funding would effectively manage the risk based on the lower risk level.
Litter control and snow fences	$6.4	$24.0	$17.6	$18.4	$0.0	$0.0		- It is unlikely that roadside maintenance services will keep pace with needs. - The relatively very expensive risk is managed at acceptable levels under the current funding levels.
Safety and Guidance								
Sign management	$42.8	$83.2	$40.4	$42.3	$25.0	$26.2		- The sign management program goals will not be met due to a lack of resources. - Proposed funding accepts some risk and would require a prioritization plan.
Pavement markings	$61.1	$62.7	$1.6	$1.7	$0.5	$0.5		- Unknown number of pavement markings do not meet retro-reflectivity requirements throughout the state. - Falling short of requirements will not significantly impact Operations Vision success.
Guardrail	$16.4	$18.2	$1.8	$1.9	$0.8	$0.8		- It is unknown whether guardrail repairs will keep pace with maintenance needs. - Failure to meet needs could result in an inability to meet public expectations and create safety concerns.
Lighting	$19.0	$39.8	$20.8	$21.8	$15.0	$15.7		- A growing inventory and aging drivers increase the need for additional funding. - Proposed funding would result in minimal risk and manage the service life over the next four years.
Smooth Roads								
Roads	$77.8	$86.0	$8.2	$8.8	$8.2	$8.8		- Better Roads Capital Program (BRCP) addressed some needs for pothole patching. - Relatively inexpensive compared to other needs.
Shoulders	$29.9	$40.0	$10.1	$10.6	$0.0	$0.0		- Unlikely shoulder failure will occur statewide. - Acceptable level of risk and should not be a barrier to preserving transportation assets.
Structures								
Bridge preventive	$16.1	$27.4	$13.0	$13.6	$9.5	$10.0		- Funding levels will not keep up with needs, resulting in reduction of service life for some structures. - Proposed funding increase would effectively manage the service life risk over the next four years.
Bridge reactive	$20.4	$33.6	$8.6	$9.0	$6.4	$6.7		- Unclear if MnDOT will have problems with reactive structure maintenance at current budget levels. - Proposed funding would manage some risk and limit unexpected service interruptions.
Other infrastructure - Inspection/Inventory	$21.2	$26.0	$4.8	$5.0	$1.6	$1.7		- Lack of inspections and inventory within ""other structures"" currently exists. - Any service interruptions are currently being managed at an acceptable level of risk.
Supporting Infrastructure								
Information Technology: Electronic Communication, RWIS, ARMER, etc.	$69.0	$73.0	$4.4	$4.6	$3.0	$3.1		- The impact of an IT breakdown is unknown, but likely not excessive. - Increased funding would manage some risk; still without some existing maintenance and innovation.
Agreements	$0.0	$1.0	$1.0	$1.0	$0.5	$0.5		- Developing maintenance agreements with local agencies requires staff time and resources. - Increased funding would manage some risk and maintain the level of service.
TOTAL	**$859.4**	**$1,252.9**	**$391.0**	**$409.7**	**$240.8**	**$252.4**		

[1] Budget dollars shown in millions over the next two (2) bienniums (2012 - 2015).
[2] Additional funding is needed to account for inflation over the next four years.
[3] This column intentionally left blank. The next step in this process is a comparison of each work activity which includes a trade-off analysis.
[4] Current budget listed as zero (0) since the item is listed account for inflation.

Chapter 5 Findings and Recommendations

MnDOT has a very large, complex transportation system to maintain and operate. For the most part, surveys of the public have indicated that MnDOT does a good job maintaining the system. However, an aging infrastructure system and increased costs often make it difficult to meet public expectations.

As part of the evaluation process, an Enterprise Risk Management (ERM) process was used as well as an objective exercise that included input from all Work Team Chairs. It is important to recognize that working conditions, risks and priorities can change over time. As a supplement to the ERM process, the Work Team Chairs and Area Maintenance Engineers (AMEs) were asked about funding allocations. The purpose of this exercise was to determine how the risk allocations using ERM process aligned with AME priorities. While future funding for fleet remained as a top priority, there were many variations of priorities between the ERM approach and the AMEs. As such, more discussion and vetting should be done to take the ERM process to the next level with the goal of comparing activities/work and prioritizing funding allocations based on risk.

The findings and recommendations listed below are based on common themes, trends, and issues that consistently appeared in a number of work activity areas. The findings and recommendations focus on the 2012-2015 timeframe, however, a number of the strategies identified provide direction beyond this timeframe. The recommendations and findings are listed below in Table 5.1 in no particular order of importance.

Table 5.1 Findings and Recommendations

1. Aging Infrastructure	
Finding	The majority of infrastructure assets continue to age. The age of these infrastructure assets presents operations and maintenance challenges. Similar to an aging automobile that has increasing automotive repair costs, as the system ages, maintenance costs typically increase. This is particularly the case in some work activity areas, including bridges/structures, pavements, and traffic signals. A significant percentage of these assets are either beyond or reaching the useful lifecycle and will need to be replaced or will experience increased maintenance costs with reduced service levels.
Recommendation	Continued emphasis needs to be placed on preserving infrastructure assets that are critical to safety, mobility, and functionality of the transportation system. Given inflation and the increasing number of assets to maintain, this most likely will require an increase in funding.

Table 5.1 (continued) Findings and Recommendations

2. Increasing Costs	
Finding	Maintaining the 12,000-plus mile system is a very labor and equipment intensive task. Many of the work activity areas reported that labor, equipment, fuel, and material costs are rising. Efforts to minimize costs and still provide a high level of service continue to be pursued.
Recommendation	New techniques, strategies, and processes are continuously being researched and developed to minimize costs and to stay current with industry standards. However, oftentimes the advancements and gains are not adequate to offset additional costs to maintain existing operations. Therefore, in many areas, increasing costs will result in either a decline in service levels or the need for additional funding in order to maintain the current service level.
3. Growing Number of Infrastructure Assets	
Finding	Overall increases in the transportation system and its assets have resulted in a greater need for operations and maintenance funds. While the overall mileage has not increased significantly, the system is now more complex with various interchange designs, traffic control devices, and other system improvements. Increases in other types of infrastructure, while more cost-efficient in terms of capital dollars, also incur ongoing operations and maintenance costs.
Recommendation	MnDOT should 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. Consideration should be given to the total project cost, not just the capital cost for construction. While the system will grow and change with population growth and development, operations and maintenance activities should continue to be included in the benefit-cost analysis for the entire project.
4. Impacts of the Capital Budget/Total Project Cost	
Finding	MnDOT's capital budget can greatly affect the operations and maintenance work that is required. Greater investment in the capital budget will typically result in a reduced need for operations and maintenance funding since the key assets, if invested in, will be in better condition. Conversely, a reduced investment in the capital budget would require a greater investment in the operations and maintenance budget since an older system will typically require more maintenance.

Table 5.1 (continued) Findings and Recommendations

Recommendation	MnDOT has historically approached project cost estimating based on the cost to deliver a project from conception through completion, with completion being defined as the end of construction. MnDOT has done considerable work over the last several years to strengthen this process. These efforts have been extremely effective, but have not yet taken the cost estimating process to the next level. The next level would be to approach cost estimating on a total project cost basis which would not only address cost management from conception to completion, but would also take into consideration the operating and maintenance costs associated with the project. In a total project cost approach, increases in operating and maintenance costs would be addressed and funded. For example, on the Crosstown project, additional equipment and operators would have been added to help address the increased maintenance demands that resulted from the reconstructed project. Under the current system in use today, no additional operating or maintenance funding is provided. Maintenance dollars have to be stretched across the system to cover the additional demands created by each reconstructed project.
5. Mandates	
Finding	Mandates often come with an increased responsibility and additional cost. While some mandates have been around for a number of years (e.g., noxious weed control and Americans with Disabilities (ADA)), others have just recently been introduced over the past few years. New mandates, such as Emerald Ash Borer removal compliance, require MnDOT to provide additional or new services that typically have not been accounted for in the past.
Recommendation	MnDOT needs to actively communicate the costs and impacts associated with new mandates. Some of the recent mandates have been unfunded, meaning that performing the required service is to be done with existing funding. This often leads to resources being redirected and shortfalls in other areas.
6. Decreasing Staff Levels	
Finding	A number of work activity areas stated they are not able to address all of the work tasks with the current number of staff available, or that there are inefficiencies created due to a lack of staffing. Examples of existing inefficiencies as a result of a lack of staff include the following: • Using temporary and program delivery employees for snow and ice control, which further delays other projects or results in increased human resources costs for processing new/temporary employees. • Not being able to fully manage the ITS infrastructure that is deployed throughout the Twin Cities Metropolitan Area and other parts of Minnesota because there are too many devices and not enough staff. • Various roadside activities (e.g., litter control, EAB removal, etc.) are often not completed or not completed within a reasonable period of time.

Table 5.1 (continued) Findings and Recommendations

Recommendation	Efforts to evaluate staffing needs are a continuous process. As noted in many work activities throughout this report, MnDOT's operations and maintenance responsibilities are constantly changing. Balancing the need to hire additional staff versus cross-training is often difficult. Identifying opportunities to train staff in various work activities should continue to maintain organizational efficiency. Further discussions on the need to hire staff to fully utilize all of the equipment and devices should continue.
7. Use of Technology and Innovation	
Finding	MnDOT work activities regularly use technology and innovative strategies to increase efficiencies. As noted in Chapter 2, MnDOT is involved with a number of research partnerships and activities. MnDOT is on the forefront of many research activities including areas such as environmental, technological, and sustainable solutions.
Recommendation	MnDOT should continue to seek and support technology enhancements that are also able to better track inventories and the condition of assets (e.g., traffic signals, fleet, sign management, etc.). This innovative mentality continues to propel MnDOT forward as a world-class transportation agency.
8. Performance Measures	
Finding	The use of performance measures and targets can be used to evaluate operations and maintenance decisions. Sound, reliable measures also enable MnDOT to track performance over time to establish historic patterns. This data can then be used to evaluate current practices as well as predict impacts of changing investment levels.
Recommendation	Further efforts to expand and enhance the use of performance measures should continue to be explored. The areas that have established performance measures should reevaluate them to ensure they remain a true indicator of performance. Other areas that lack measures should consider identifying and developing them assuming that the costs for maintaining the measures are valuable to managing performance.
9. Training	
Finding	An emphasis in technology and innovative techniques requires a focus on staff training to ensure that employees are educated and knowledgeable of new techniques and advancements that can provide efficiencies and increased effectiveness. One of the negative effects of MnDOT's early retirement program is that the benefits of an experienced staff have been lost.
Recommendation	MnDOT is highly regarded as an innovative Transportation Department throughout the country. There are various benefits to staff training and outreach. Continued efforts to train and educate staff should be pursued to provide increased efficiency and service delivery.

Table 5.1 (continued) Findings and Recommendations

10. Preventive Maintenance	
Finding	A preventive maintenance program can reduce overall operations and maintenance costs by regularly providing service and avoiding larger maintenance/capital costs. Many of the work activity areas reported a regular schedule or process for inspections, maintenance, and system review.
Recommendation	In most cases, increased effort and focus on preventive maintenance activities will lead to a prolonged service life and avoidance of significant capital investments until the product has fulfilled its useful service life. The Department should continue to evaluate preventive maintenance activities where benefits are not clear. Where there is direct evidence of benefits, MnDOT should prioritize these activities to maximize effectiveness.
11. Operations and Maintenance Funding Committee	
Finding	Additional review and further discussion is needed regarding operations and maintenance funding. Previous discussions did not fully encompass the funding impacts on staffing, inflation, technology/innovation, and regulations/mandates.
Recommendation	A risk committee, made up of Work Team Chairs and Area Maintenance Engineers, should be developed to prioritize and evaluate budget implications and risk management. In particular, this committee should also evaluate the cost-benefit of the risk management effort and ensure action plans are developed and the risks are appropriately managed.
12. HSOP Update	
Finding	The heightened awareness of the key issues and true costs associated with providing service was insightful to all of the Work Teams and staff. The development of this document provided an opportunity for each Work Team to identify key strategies and initiatives that should be pursued. This intangible benefit will continue to serve MnDOT for years to come.
Recommendation	Due to the changing nature associated with many, if not all, Work Team activities, it is important to continue to document the key policies, strategies, and work activities that are performed by the Department. The HSOP report provides a significant role in monitoring the true costs and impacts of operations and maintenance. Therefore, it is recommended this document be updated every four years to coincide with the biennial budget and maintain an accurate record of what it takes to deliver transportation services for the State of Minnesota.

Appendix A
Acronyms and Definitions

ADA:	Americans with Disabilities Act
AFMS:	Automated Facilities Management System
AME:	Area Maintenance Engineer
APS:	Accessible Pedestrian Signals
ARMER:	Allied Radio Matrix for Emergency Response
ATM:	Active Traffic Management
AVL:	Automated Vehicle Location
BARC:	Bridge and Road Construction
BI:	Business Integrity
BMP:	Best Management Practices
BRIM:	Bridge Replacement and Improvement Management
CAFM:	Computer Aided Facilities Management
CBB:	Capital Building Budget
CCTV:	Closed Circuit Television
CESU:	Central Electrical Services Unit
CMS:	Changeable Message Signs
COB:	Capital Operations Budgets
CORS:	Continuously Operating Reporting Stations
CVI:	Commercial Vehicle Inspection
DNR:	Department of Natural Resources
DPS:	Department of Public Safety
DTE:	Drive to Excellence Initiative
EAB:	Emerald Ash Borer Beetle
EER:	Electronic Equipment Repair
EMS:	Emergency Management System
EMS-M4:	Equipment Management Information System
EPAct:	Federal Energy Policy Act
ERM:	Enterprise Risk Management
ESS:	Electronic Sensing Stations
FCC:	Federal Communications Commission

FCI:	Facility Condition Index
FHWA:	Federal Highway Administration
FIRST:	Freeway Incident Response Safety Team
FMP:	Facilities Maintenance Program
FTE:	Full Time Equivalent
FY:	Fiscal Year
GAO:	General Accounting Office
GDP:	Gross Domestic Product
GPS:	Global Positioning System
HOT:	High Occupancy Traffic lane
HPS:	High Pressure Sodium
HSOP:	Highway Systems Operation Plan
HydInfra:	Hydraulic Infrastructure
ICWC:	Institutionalized Community Workforce Crew
ILCS:	Intelligent Lane Control Signals
IRC:	Interregional Corridor
IRVM:	Integrated Roadside Vegetation Management
IT:	Information Technology
ITE:	Institute of Transportation Engineers
ITS:	Intelligent Transportation System
LED:	Light Emitting Diodes
MS4:	Municipal Separate Storm Sewer Systems
MDSS:	Maintenance Decision Support System
MESU:	Metro Electrical Services Unit
MHz:	Mega Hertz
MMUTCD:	Minnesota Manual of Uniform Traffic Control Device
MnDOT:	Minnesota Department of Transportation
MPCA:	Minnesota Pollution Control Agency
MSBG:	Minnesota Sustainable Building Guidelines
MUFS:	Metropolitan Urban Freeway System
NPDES:	National Pollution Discharge Elimination System
NTREC:	New Technology, Research and Equipment Committee
OEC:	Office of Electronic Communications
OET:	Office of Enterprise Technology

OIT: Office of Information Technology

OMG: Operations Management Group

OTSO: Office of Traffic, Safety and Operations

OTST: Office of Traffic, Safety and Technology

PM: Preventive Maintenance

PPM: Pavement Preventive Maintenance

PSR: Present Serviceability Rating

QOL: Quality of Life

RESU: Regional Electrical Services Unit

RQI: Ride Quality Index

RTC: Regional Trade Center

RTMC: Regional Transportation Management Center

RWIS: Road Weather Information Systems

SFMG: State Facilities Management Group

SIMS: Structure Information Management Systems

SPOT: Snow Plow Operator Training

SR: Surface Rating

SRA: Safety Rest Areas

STIP: State Transportation Improvement Program

STPP: State Transportation Policy Plan

STS: Sentence-to-Serve program

TCMA: Twin Cities Metropolitan Area

TEO: Transportation Engineers Organization

TMDL: Total Maximum Daily Loads

TOCC: Traffic Operations Communications Center

TSP: Transportation System Plan

TTI: Texas Transportation Institute

TTR: Travel Time Reliability

TZD: Towards Zero Deaths

VHF: Very High Frequency

VMT: Vehicle Miles of Travel

WAN: Wide Area Network

Annual Vehicle Miles of Travel: Annual vehicle miles of travel is calculated by taking the length of each highway segment times the average annual daily traffic volume times the number of days in a year.

Average Clearance Time: The amount of time between incident (see definition below) detection and total clearance. Average clearance time is a metric used by FHWA and other state departments of transportation.

Bare Lanes: When the "tire track" portion of the driving lane is clear of snow and ice.

Developmental Measures: These are measures for which neither data nor targets were previously developed.

District Long-Range Plan: Fiscally con strained report of capital programs and improvements of MnDOT projects for the next five years by individual Districts.

Emerging Measures: These are measures for which data exists, but targets have not been set previously.

Flushing: Flushing is to remove chemicals and material build-up through a rapid flow of water.

Indicator: A set of consistent trend data reported over time that provides information on a changing condition of strategic importance.

Incidents: Include all crashes, rollovers, spinouts and stalled vehicles blocking traffic.

Input Level: Measurement that relates to how many resources are consumed to provide the product or service. Resources generally consist of labor, equipment, materials, and dollars. Input measurements alone are important for fiscal and budgetary accounting purposes and are often monitored internally within the organization and by elected officials. When coupled with outcomes, they provide the customer an indication of the cost/efficiency of an organization. When coupled with outcomes, it provides an indication of the cost/benefit to the customer.

Interregional Corridors (IRCs): There are approximately 3,000 miles of Interregional Corridors with in Minnesota. These are the important roadways linking regional trade centers levels 0 through 1 and 3 in the state.

Lifecycle Cost: The amortized annual cost of a product or service, including costs associated with capital, installation, operations, maintenance, and disposal, discounted over the lifetime of the product[13].

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[13] U.S. Department of Transportation

Mature Measures: These are measures for which baseline data exists and policy targets have been in use previously.

Mobility: Includes travel time and reliability. Reliability is also referred to as travel time variability or predictability.

Outcome Level: Measurement that relates to the *result* of the work done, i.e., how well the service is provided. Results are what the customer sees and/or measures. Results are what the customer believes or perceives as getting value from. Outcomes are quantitative as opposed to qualitative. Measurements that reflect smoothness of roads, bareness of pavement, brightness and legible of signs/markers, neatness of roadside s, reliability of signal lights, etc., are examples of outcome based performances in maintenance. Response time to repairing a defect is often an outcome measurement as well because it relates directly to a customer need.

Output Level: Measurement that relates to the *accomplishment* of the work done, i.e., how much of a product or service is provided. Outputs are important because they relate to productivity and efficiency. Measurements that reflect miles plowed, acres mowed, miles striped bags of litter picked, etc., are examples of output-based performances in maintenance.

PONTIS: A Federal bridge inventory/inspection program that tracks the conditions of individual bridge elements. It is also used to report the overall condition of bridges.

Present Serviceability Rating (PSR): The PSR rating is based both on a quantitative measure of highway ride quality (roughness) and a qualitative assessment or correlation of this ride roughness on a scale of 0 to 5.

Preservation: Maintain existing systems at a minimum level that will provide for the safe movement of people and freight. Focus is on activities that retain or restore the existing condition without necessarily extending the service life or adding capacity. “Preservation” includes traditional program categories of road repair, resurfacing, reconditioning and bridge repair. Transit projects considered under “Preservation” include operating assistance for existing transit service, bus rehabilitation/refurbishing, bus replacement with same size bus, bus replacement due to end of useful life and facility repair (garage, terminals, shelters)[14].

Primary Collector Route (PR): A roadway that carries between 800 and 2000 trips a day. Used for snow and ice removal purposes.

Principal Arterial Corridor: For purposes of defining levels of corridor management, a principal arterial corridor includes adjacent minor arterial(s) either side of the principal arterial facility, provided they function as alternate routes.

[14] 1999 STIP Guidance.

Replacement: Enhance economic development by replacing eligible system pieces or elements; reduce barriers such as weight restrictions, bottlenecks and system disruptions. “Replacement” includes traditional program categories of bridge replacement and reconstruction. Transit projects under “Replacement” include bus replacement with larger size bus.[15]

Right-of-Way: A strip of land acquired by purchase, reservation, dedication, prescription or condemnation and intended to be occupied by a roadway, trail, water line, sanitary sewer, and/or other public utilities or facilities.

Rural Commuter Route (RC): A roadway that carries between 2,000 and 10,000 trips a day. Used to define snow and ice removal routes and targets.

Secondary Collector Route (SE): A roadway that carries fewer than 800 trips a day. Used to define snow and ice removal routes and targets.

Structural Condition of Bridges: The structural condition is made up of three areas: deck condition, superstructure condition, and substructure condition.

Super Commuter Route (SC): A roadway that carries over 30,000 trips a day. Used to define snow and ice removal routes and targets.

Urban Commuter Route (UC): A roadway that carries between 10,000 and 30,000 trips a day. Used to define snow and ice removal routes and targets.

Weather Event: Time from the beginning of snowfall until three hours after snowfall has ended.

[15] 1999 STIP Guidance.

Appendix B
Enterprise Risk Management

The following spreadsheet was developed as part of the Enterprise Risk Management (ERM) process that was used to assess budgetary trade-offs between the different work activity areas. This information was not used to compare different work activities against one another, but rather assessing the greatest opportunity for future financial investment (e.g., what provided the “best bang for the buck”).

Appendix B
Enterprise Risk Management Worksheet

Risk Category (6/29/12)	Risk Event	PROBABILITY	IMPACT success, Mn/DOT Strategic Vision	Risk Score	Risk Response Strategy	Current Annual Expenditures in this area	Current 4-year Budget	Cost of Strategy over 4 years	Effectiveness	Residual Risk	Return on Risk with Strategy (Function)	Cost/Benefit (ROR)	Cost Per Risk Level	Acceptable Funding Scenario over 4 years	Percentage of Strategy Funded	Percentage of Strategy Effectiveness	Forecasted Risk After Actual Investment
Administration	Shifting of current and future Administrative funding to meet the increasing costs of the legally mandated accounts of Worker's Compensation and Unemployment Compensation, results in decreasing services in other essential Administrative functions which will lead to: lack of oversight on compliance leading to waste, abuse or fraud; reduced emphasis on protecting human, fiscal and physical resources and assets; inability to fully meet the Department's immediate and future workforce development needs; reactive responses rather than proactive planning; inefficient and incongruent businesses practices; and reduced tracking and reporting capabilities		1	0			$18.00	$2.00		0	0	0.00	0.00	$0.00	0.00%	0.00%	0
Arterial and Freeway Operations - Signals	Increased delays for motorists and more crashes, due to signals not being retimed or maintained as often as they should be results in an unreliable transportation system and trust issues.	75%	3	2.25	Increase resources in signal operations and maintenance to effectively manage traffic signal to national standards, timing them every 3 years.		$1.00	$14.00	95%	0.1125	2.1375	0.15	6.22	$7.50	53.57%	50.89%	1.104910714
Arterial and Freeway Operations - Freeway Operations	Increased traffic demand and more crashes requires additional freeway management systems exceeding the capacity of staffing and resources, which results in reduced performance of the system and public trust.	95%	3	2.85	More staff and resources are needed to meet the demands an public expectation.		$7.20	$5.90	95%	0.1425	2.7075	0.46	2.07	$4.00	67.80%	64.41%	1.01440678
Clear Roads - Additional trucks/drivers	Increases in traffic volumes have led to the construction of additional traffic lanes, ramps and interchanges all across the system and shoulders in metro areas have been converted into transit bus lanes reducing our ability to meet existing performance targets	95%	3	2.85	Politicians starting to re-evaluate expectations. We are meeting our expectations, but we are starting to think others may not. Snowplow trucks and drivers.		$0.00	$14.20	85%	0.4275	2.4225	0.17	4.98	$10.50	73.94%	62.85%	1.058714789
Clear Roads - Additional stationary and mobile snow and ice equipment	District budgets are not able to support snow and ice LEM needs necessary to meet existing performance targets, forcing districts to reduce service levels in other areas to meet the unfunded snow and ice equipment needs	95%	2.5	2.375	Additional snow and ice equipment, stationary and mobile (no snowplows or drivers).		$0.00	$16.70	85%	0.35625	2.01875	0.12	7.03	$12.00	71.86%	61.08%	0.924401198
Drainage	Drainage infrastructure failures cause roadway undermining and collapse potentially impacting safety and roadway availability. Reactive repairs impact roadway availability and cost effectiveness of repairs. Road grade and landowner impacts are possible.	95%	3.5	3.325	Just cross culverts and entrance culverts.		$43.90	$24.00	70%	0.9975	2.3275	0.10	7.22	$24.00	100.00%	70.00%	0.9975
Facilities - Salt storage	Salt sheds or coverall facilities have a design flaw and we now own them with the design flaw, that results in a inability to use when weather conditions exist and not meeting building code.	95%	1.5	1.425	Should reach all sheds with design flaw. Replacement of current structures and does not add capacity.		$37.80	$8.00	95%	0.07125	1.35375	0.17	5.61	$2.00	25.00%	23.75%	1.0865625
Facilities - Safety Rest Areas	Safety rest areas are not adequately maintained resulting in reactive more costly repairs compounded with public concerns for facility condition. Many onsite wastewater systems need immediate investment	95%	2	1.9	Negative impact to commercial freight movements (CMV hours of service regulations), long-distance travelers and tourist. Also, negative impacts to other state agency operations and funding including State Patrol, Explore Minnesota Tourism and State Services for the Blind.		$22.00	$29.50	85%	0.285	1.615	0.05	15.53	$16.00	54.24%	46.10%	1.024067797
Facilities - Truck Stations	Facilities and buildings deteriorate beyond a usable state that results in a significant loss of use and/or functionality.	95%	2	1.9	Truck Station replacements. 2 additional each year statewide. Currently funded for 2/year		$56.60	$12.00	50%	0.95	0.95	0.08	6.32	$11.00	91.67%	45.83%	1.029166667

Risk Category (6/29/12)	Risk Event	PROBABILITY	IMPACT success, Mn/DOT Strategic Vision	Risk Score	Risk Response Strategy	Current Annual Expenditures in this area	Current 4-year Budget	Cost of Strategy over 4 years	Effectiveness	Residual Risk	Return on Risk with Strategy (Function)	Cost/Benefit (ROR)	Cost Per Risk Level	Acceptable Funding Scenario over 4 years	Percentage of Strategy Funded	Percentage of Strategy Effectiveness	Forecasted Risk After Actual Investment
Fleet - Catch-up, Equipment Allotment, Maintenance	Fleet prices, maintenance lifecycle prices and fuel emission standard requirements cause increases in cost for operating and results in impacting other core services and reduces service levels and lesson the dependability of the transportation system.	95%	4	3.8	This includes Catch up for snow plows over 12 years, and maintenance and repair of the fleet. Cost has been spread over 12 years and the 4 year budget only brings forecasted risk after investment to 2.		$249.20	$72.80	85%	0.57	3.23	0.04	19.16	$62.00	85.16%	72.39%	1.049175824
Fleet - Attenuators	Unable to meet workzone safety (TL3) standards, which results in inability to keep benefits of workzone safety resulting in decreased safety.	50%	2	1			$0.00	$2.80	95%	0.05	0.95	0.34	2.80	$0.00	0.00%	0.00%	1
Inflation - Electrical costs	Electrical utility costs increases per year and power bills continue to increase, that results in a less reliable transportation system and safety concerns.	75%	1.5	1.125	Budget to anticipated increases in utility costs, which is 4% per year for four years.		$0.00	$4.10	95%	0.05625	1.06875	0.26	3.64	$0.50	12.20%	11.59%	0.994664634
Inflation - Salt	Average Statewide Salt Price increases to the point that results in impacting core services and lessons the dependability of the transportation system and impact the public awareness on use of sand	95%	4	3.8	Possible chance that inflation rates are off.		$0.00	$4.60	75%	0.95	2.85	0.62	1.21	$4.60	100.00%	75.00%	0.95
Inflation - Fuel	Fuel Prices increase to the point that results in impacting core services and lessons the dependability of the transportation system.	95%	3.5	3.325	Economic uncertainty makes the 2 million a little less effective in theory. Could see greater than expected.		$0.00	$2.00	65%	1.16375	2.16125	1.08	0.60	$2.10	105.00%	68.25%	1.0556875
Roadsides	Vegetation Management is unable to effectively control weed and brush that results in inability to meet legal responsibilities and safety concerns.	75%	2	1.5	Brush and erosion control.(5.7 for mowing, 16.1 for brush/tree, 14.6 for weeds, 1 for burns, 4.7 for erosion, 3.2 for plantings, 2.0 sidewalks/trails and 0.4 for waysides)		$61.60	$47.70	95%	0.075	1.425	0.03	31.80	$14.00	29.35%	27.88%	1.081761006
Roadsides	Roadside maintenance, snow fence repairs, litter control... does not keep pace with roadside maintenance needs, especially summer maintenance that results in inability to meet the expectations of our partners and the public and results in low quality transportation system.	25%	2	0.5	8.4 for litter, 9.2 for fences, 0.4 for Waysides		$6.40	$18.00	95%	0.025	0.475	0.03	36.00	$0.00	0.00%	0.00%	0.5
Safety and Guidance Systems - Signs	Sign Management Program is unable to work due to lack of resources and that results in an unreliable system for maintaining minimum standards.	95%	2.5	2.375	Cost according to central office data. 70 to 80 thousand signs. Could be funded by another source. **** Requires prioritization of signs with risk funding level.		$42.80	$40.40	95%	0.11875	2.25625	0.06	17.01	$25.00	61.88%	58.79%	0.978805693
Safety and Guidance Systems - Pavement Markings	Pavement Markings do not meet retro-reflectivity requirements throughout the state, that results in a lack of basic safety and traffic control strategy for TZD.	50%	3	1.5	4 year cost.		$61.10	$1.60	95%	0.075	1.425	0.89	1.07	$0.50	31.25%	29.69%	1.0546875
Safety and Guidance Systems - Guardrail	Guardrail repairs do not keep pace with maintenance needs, that results in inability to meet the needs and expectations of the public and safety impacts.	50%	3	1.5			$16.40	$1.80	75%	0.375	1.125	0.63	1.20	$0.80	44.44%	33.33%	1
Safety and Guidance Systems - Lighting	District budgets are not able to support lighting operational needs resulting in reduced system performance and loss of basic safety and public trust	95%	2.5	2.375	Assure ability to cover power costs, detect and make necessary repairs and replace obsolete systems. Does not include utility inflation costs.		$19.00	$20.80	80%	0.475	1.9	0.09	8.76	$15.00	72.12%	57.69%	1.004807692
Smooth Roads - Roads	Pavements deteriorate and move into the "poor" category that results in large increases in poor smoothness. Results in unreliable transportation system and requires more patching.	95%	4	3.8	Patching only and not overlays. 10 percent increase. Hitting the point of diminishing returns, because potholes are going to happen assuming likelihood in poor pavements.		$77.80	$8.20	33%	2.546	1.254	0.15	2.16	$8.20	100.00%	33.00%	2.546

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Smooth Roads - Shoulders	Shoulder failure occurs statewide that results in negatively affecting road surface and structure and the inability to preserve transportation assets.	25%	3	0.75			$81.50	$10.00	80%	0.15	0.6	0.06	13.33	$0.00	0.00%	0.00%	0.75
Structures - Medium Priority Preventive Bridge Maintenance	Medium priority bridge **preventative** maintenance does not keep up with needs that results in significant amounts of reduction in service life.	95%	3	2.85	Preventive maintenance involves recommended activities that have been shown to have a b/c greater than 2.(45% of expenditures is for preventive).		$16.10	$13.00	85%	0.4275	2.4225	0.19	4.56	$9.50	73.08%	62.12%	1.079711538
Structures - Medium Priority Reactive Bridge Maintenance	Medium priority bridge **reactive** maintenance does not keep up with needs resulting in significant amounts of identified items becoming high priority bridge maintenance items that result in service interruption prior to being addressed.	95%	3	2.85	Reactive maintenance is about 55% of the expenditures)		$20.40	$8.60	85%	0.4275	2.4225	0.28	3.02	$6.40	74.42%	63.26%	1.047209302
Structures - Other infrastructure (Inspection/Inventory)	Failure of other structures occurs because system inventory and inspection/assessment has not been completed and data does not exist to develop a planned maintenance, preservation or replacement program	95%	1.5	1.425	Develop inventory and assessment database in SIMS for retaining walls, sound walls, concrete barriers, sign bridges, cantilever signs and tunnel mechanical and electrical systems. (Tunnel structural data has been inventoried and assessed as part of the bridge inspection program).		$21.20	$4.80	85%	0.21375	1.21125	0.25	3.37	$1.60	33.33%	28.33%	1.02125
Supporting infrastructure - Agreements	Maintenance agreements with locals fall through that results in tensions with local relationships and results in increased work for MnDOT and decrease the level of service	95%	2	1.9	Needs further investigation, will accept until further research. Not in the onepagers.		$0.00	$1.00	95%	0.095	1.805	1.81	0.53	$0.50	50.00%	47.50%	0.9975
Supporting infrastructure - Communications	Electronic communication becomes underfunded, and we need to reduce staff in that area. That results in inability to run a system that supports multiple governmental agencies	5%	4	0.2			$55.80	$0.00		0.2	0	0.00	0.00	$0.00	0.00%	0.00%	0.2
Supporting infrastructure - IT	The growth of IT software, license maintenance and replacement needs has grown substantially which has caused delays in innovation increased risk and likelihood of failure. Failure could cause a decrease in safety for Mn/DOT and the public.	60%	3	1.8	IT Infrastructure, RWIS, Networking gear. Staying at the status quo with the system. We will be continuing to live without the maintenance dollars with the 5 million dollar figure.		$13.20	$5.00	75%	0.45	1.35	0.27	2.78	$3.00	60.00%	45.00%	0.99
Unfunded Needs	Sufficient funds don't exist for ADA, or Title II, mandates that lead to poor decisions, low morale, and unintended outcomes, that results in unreliable transportation system for the Disabled.	95%	2.5	2.375	Some covered under snow and ice. Gap is unknown. Accept strategy right now, due to not understanding the gap and best strategy to move forward. This is included in the 39.		$0.00	$0.00	0%	2.375	0	0.00	0.00	$0.00	0.00%	0.00%	2.375
Unfunded Needs	Lack of an asset management system causes us to be less capable of following through with maintenance activities, due to rapid increase in infrastructure.	95%	2.25	2.1375	The tool would encompass all the areas, and an information system. Unsure of cost, currently willing to accept. We would like to see what SWIFT will do, and Asset management training is coming up.		$0.00	$0.00	0%	2.1375	0	0.00	0.00	$0.00	0.00%	0.00%	2.1375

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															Difference		
	HSOP Risk Assessment. Current Budget. Goal from Strategic Vision: Provide a safe high quality, reliable transportation system through maintaining, operating, and preserving transportation assets, building trust with green sustainable solutions and collaborative innovations in a cost effective manner.				**All Needs Sum (does not include admin.)**			391.5					**Risk Based (no admin)**	**240.7**	**150.8**		
					Clear Roads			30.0					Clear Roads	22,5	12.5		
					Fleet and Facilities			125.1					Fleet and Facilities	91.0	34.1		
					Roadsides			65.7					Roadsides	14.0	51.7		
					Safety and Guidance Systems			64.6					Safety and Guidance Systems	41.3	23.3		
					Smooth Roads			42.2					Smooth Roads	32.2	10.0		
					Structures			26.4					Structures	17.5	8.9		
					Supporting Infrastructure			6.0					Supporting Infrastructure	3.5	2.5		
					Arterial and Freeway Operations			19.9					Arterial and Freeway Operations	11.5	8.4		
					Inflation			10.7					Inflation	7.2	3.5		

Appendix C
HSOP Management Structure

<table>
<tr><th>Team</th><th>Members</th><th>Role</th></tr>
<tr><td>Steering Committee</td><td>Mike Barnes
Greg Ous
Steve Lund
Lynn Eaton
Sue Lodahl</td><td>▪ Provide strategic direction
▪ Guide policy decisions</td></tr>
<tr><td>Project Management Team</td><td>Sue Lodahl – Project Manager
Gary Dirlam – Co-Chair
Beverly Farraher – Co-Chair
Jim Curran
Gordy Regenscheid
Jeff Perkins
John Bieniek
Jim Kranig
Jeff Vlaminck
Dewayne Jones
Mukhtar Thakur
Brenda Wrobel
Emma Corrie
Peggy Reichert
Mark Nelson
Phil Barnes
Judy Schmidt
Tracy Hatch
Deanna Belden
Duane Hill
Dan Anderson
Mark Panek
Dave Solsrud</td><td>▪ Design and lead process
▪ Manage consultant
▪ Synthesize results
▪ Identify policy issues for resolution</td></tr>
<tr><td>Work Teams
Clear Roads</td><td>Jeff Perkins - Lead
John Howard
Dave Solsrud
Steve Lund
Mark Fischbach
Tom Zimmerman</td><td rowspan="2">▪ Draft text for Work Team activity area
▪ Develop/Review performance measures and targets
▪ Estimate cost to maintain current service levels
▪ Identify strategies and estimate cost to achieve targets
▪ Identify strategies for implementation</td></tr>
<tr><td>Smooth Roads</td><td>Jim Curran - Lead
Dave Solsrud
Mark Panek
Jerry Geib</td></tr>
</table>

Team	Members	Role
Structures	Gordy Regenscheid/Duane Hill - Lead Duane Green Tom Styrbicki Dale Dombroske Jim Stoutland Perry Collins	▪ Draft text for Work Team activity area ▪ Develop/Review performance measures and targets ▪ Estimate cost to maintain current service levels ▪ Identify strategies and estimate cost to achieve targets ▪ Identify strategies for implementation
Safety and Guidance	John Bieniek – Lead Cassandra Isackson Steve Misgen Sue Zarling Tom Dumont Michael Gerbensky Trisha Nelson Heather Lott Mitch Bartelt	
Arterial and Freeway Operations	Jim Kranig - Lead Ray Starr Steve Misgen Bob Vasek Brian Kary Jim Miles Tom Dumont Ralph Adeer	
Roadsides Management	Michael Kamnikar/ John Howard – Lead Dewayne Jones Ken Graeve Tom Jacobson Dan Gullickson	
Fleet and Facility Management	Jeff Vlaminck – Lead Mike Bauer Bob Ellingsworth Bob Miller John Bieniek Rob Williams Mike Cirks	
Supporting Infrastructure	Mukhtar Thakur – Lead Curt Pape John Moreland Sue Zarling	
SRF Consulting Group, Inc.	Dave Montebello – Project Principal Andy Mielke – Project Manager	