Highway Spending

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A Program Evaluation Report

Photo courtesy of the Minnesota Department of Transportation

Office of the Legislative Auditor
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Centennial Office Building, 658 Cedar Street, St. Paul, MN 55155 • 612/296-4708

STATE OF MINNESOTA
OFFICE OF THE LEGISLATIVE AUDITOR
CENTENNIAL BUILDING, 658 CEDAR STREET • ST. PAUL, MN 55155 • 612/296-4708 • TDD RELAY 612/297-553

JAMES R. NOBLES, LEGISLATIVE AUDITOR

March 31, 1997

Members
Legislative Audit Commission

For the past several years, policy makers have debated the need for additional highway funding. In May 1996, the Legislative Audit Commission asked us to evaluate the condition of and funding for the State Trunk Highway System.

We found that the Minnesota Department of Transportation (Mn/DOT) has generally been able to keep trunk highway roads and bridges in good condition. Relatively stable highway construction prices in the 1980s and 1990s have helped maintain the purchasing power of the Trunk Highway Fund.

However, some trunk highway needs have not been fully addressed and will be difficult to address in the future under current funding projections. The system faces a backlog of bridges with structural deficiencies and is likely to experience further growth in traffic congestion. In addition, with a tight budget and many pressing problems, Mn/DOT probably does not perform enough preventive maintenance on some highways and bridges.

We think that public policy debates would benefit from more systematic information than has been presented in the past. We recommend that Mn/DOT should periodically prepare a report on the funding needs of the trunk highway system. Unlike previous efforts, the report should define needs in terms of what funding is necessary to achieve specific performance targets and should incorporate benefit-cost criteria where appropriate.

Our report was researched and written by John Yunker (project manager) and Carrie Meyerhoff, with the assistance of Amy Zimmer. We received the full cooperation of the Minnesota Department of Transportation and all of its division and district offices.

Sincerely,

James Nobles
Legislative Auditor

Roger Brooks
Deputy Legislative Auditor

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MINNESOTA OFFICE OF THE LEGISLATIVE AUDITOR

Highway Spending

SUMMARY

By some accounts, highway infrastructure in Minnesota is in tough shape. Transportation spending has been the slowest growing category of state and local government spending over the last 20 or so years. Since 1972, transportation spending in Minnesota has shrunk from 13 to 8 percent of state and local government spending. Meanwhile, traffic on Minnesota's roads has increased about 80 percent. Some concerned groups also point to national data showing Minnesota's trunk highways to be in much worse condition than the national average. However, data also indicate that state and local governments in Minnesota generally spend about 40 to 60 percent more per capita on highways than the national average.

In this report, we attempt to resolve some of these apparently conflicting facts. We focus primarily on the State Trunk Highway (STH) system in Minnesota. While trunk highways account for only 9 percent of the miles of roads in Minnesota, they are the ''backbone'' of the state's road system and carry nearly 60 percent of the state's traffic. The Minnesota Department of Transportation (Mn/DOT) is responsible for the construction, repair, and maintenance of trunk highways and, over the last 10 years, has spent an average of about $775 million annually (in 1996 dollars) on the trunk highway system. In particular, we address the following issues:

- **How does Minnesota's road system and level of road spending compare with those in other states, and how does our trunk highway system compare with other state-administered systems?**

- **How have trunk highway revenues and expenditures changed over time?**

- **In what condition are state trunk highway pavements and bridges?**

- **How has the condition of trunk highway pavements and bridges changed since the mid-1980s?**

- **Given funding projections, how well will Mn/DOT be able to respond in the future to pavement and bridge deterioration, growing traffic, and other needs?**

- **To what extent does Mn/DOT perform adequate preventive maintenance on trunk highway pavements and bridges?**

- **Is Mn/DOT appropriately reassessing its lane and shoulder width standards for low volume rural trunk highways and state-aid roads?**

In carrying out this study, we interviewed Mn/DOT employees, as well as transportation planning officials at the Metropolitan Council. In addition to numerous contacts with staff in Mn/DOT's central office, we visited with employees at each Mn/DOT district office and the Metropolitan Division. We analyzed a variety of data from Mn/DOT data systems, particularly the pavement and bridge management systems and, in evaluating preventive maintenance practices, collected data from each district through several questionnaires and follow-up interviews. Our research also included a review of relevant literature on a variety of transportation topics.

TRUNK HIGHWAY SYSTEM

Minnesota has a large system of local roads but an average sized system of state roads.

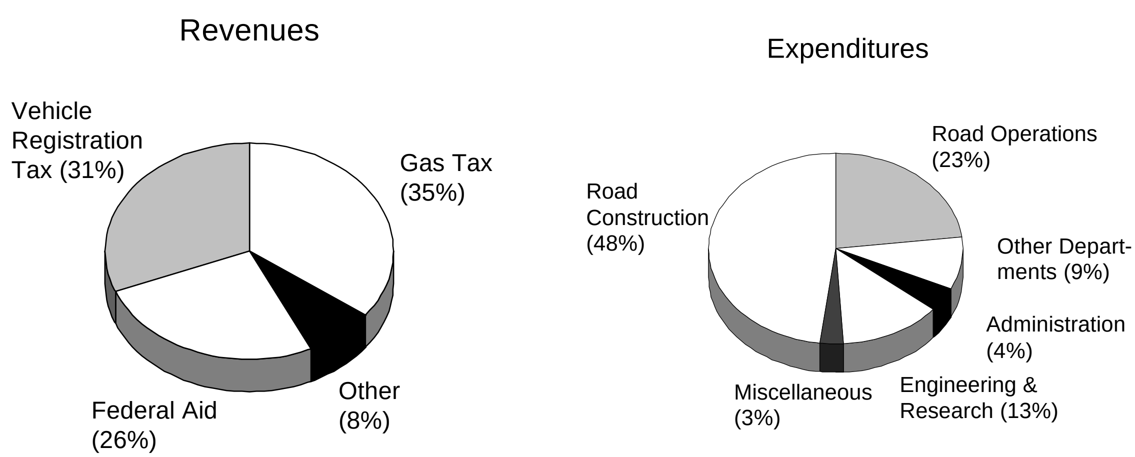
Minnesota has about 130,000 miles of roads--the fifth largest system in the nation--and in 1993 spent 52 percent more per capita on roads than the national average. Two factors contribute to Minnesota's higher than average spending. First, the state has a large rural road system due to its low population density and large number of smaller than average sized farms. Second, Minnesota has generally spent more per mile of road than the national averages for roads under the jurisdiction of state and municipal governments.

Minnesota's trunk highway system consists of about 12,000 miles of highways. Unlike Minnesota's overall road network, the trunk highway system is not large by national standards. While Minnesota's spending per mile for state-administered roads has generally been above the national average, it appears to be lower than spending per mile for a comparison group of midwestern states. The national average for state-level spending per mile may be biased downward because several eastern states have unusually large state systems including many low-cost local roads.

TRUNK HIGHWAY REVENUES

The Trunk Highway Fund is the principal source of support for the trunk highway system. There are three major sources of revenues for the fund: the state gasoline tax, motor vehicle registration taxes, and federal aid. Figure 1 shows the share of fund revenues from each of these sources in 1996. The Trunk Highway Fund receives about 60 percent of the proceeds of these two state-imposed taxes, while counties, cities, and townships receive the rest by virtue of the state constitution and other laws.

Figure 1: State Trunk Highway Revenues and Expenditures, 1996



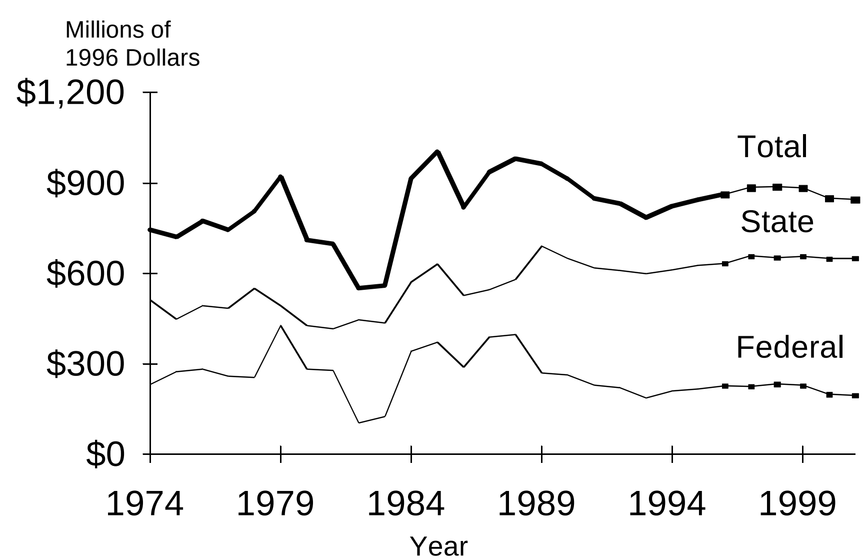
Source: Minnesota Department of Transportation.

Inflation-adjusted revenues for the Trunk Highway Fund increased 16 percent between 1974 and 1996. However, as Figure 2 shows, revenues have varied significantly in the past largely due to fluctuations in the amount of federal aid received. Revenues in 1996 were about 14 percent lower than the peak reached in 1985.

Revenues over the next 5 years are expected to be close to the average for the last 10 years.

In the 1990s, overall revenues have been relatively stable even though the gasoline tax was last increased in 1988. Growth in gasoline consumption has prevented gas tax revenues from losing significant ground due to inflation as occurred during the 1980s. Over the next 5 years (1997-2001), we estimate

Figure 2: Trunk Highway Fund Revenues, Actual and Projected, 1974-2001



Source: Program Evaluation Division analysis of Mn/DOT data.

average annual revenues (in 1996 dollars) to be within 1 percent of the annual average for the last 10 years.

TRUNK HIGHWAY EXPENDITURES

In 1996, expenditures from the Trunk Highway Fund totaled $808 million. About 91 percent of the spending was done by Mn/DOT, while other agencies--primarily the Department of Public Safety--made about 9 percent of the expenditures. As Figure 1 shows, nearly half of the spending out of the Trunk Highway Fund in 1996 was for Mn/DOT's road construction projects. Close to one-fourth was for Mn/DOT's road operations, including snow and ice control and routine maintenance.

The Trunk Highway Fund has benefited from relatively stable construction prices during the 1980s and 1990s.

Although Trunk Highway Fund revenues have only increased 16 percent since 1974, Mn/DOT's road construction budget has benefited tremendously from relatively stable highway construction prices during the 1980s and 1990s. Since 1974, the average annual inflation rate for highway construction in Minnesota has been almost 2 percentage points less than the rate experienced by state and local governments. As a result, we estimate that:

- **Inflation-adjusted spending on highway and bridge construction increased 52 percent from 1974 to 1996.**

Other trunk highway spending increased 11 percent. Much of the growth in other spending was due to spending on Mn/DOT's road operations, which increased 24 percent. Spending by Mn/DOT on general support and administration more than doubled but accounts for less than 4 percent of total spending. Mn/DOT's engineering and research spending declined 6 percent.

As Figure 3 indicates, trunk highway expenditures have fluctuated from year to year. Construction spending, which is more dependent on federal aid, has varied the most. In 1996, construction spending was about 20 percent below the peak reached in 1988. Total spending in 1996 was about 12 percent below its 1988 peak.

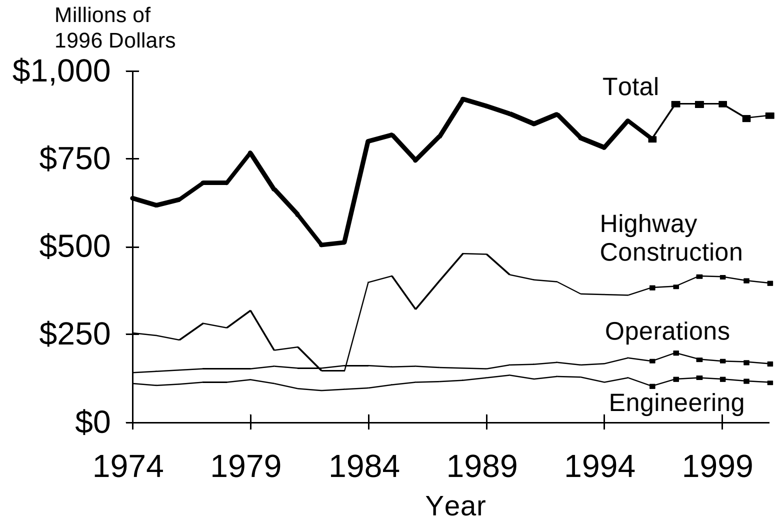
Based on the Governor's 1998-99 budget proposal and Mn/DOT's projections for the 2000-01 biennium:

- **Average annual trunk highway construction spending (in 1996 dollars) over the next 5 years is expected to be about 1 percent less than the annual average over the last 10 years.**

Other categories of Trunk Highway Fund expenditures would increase more relative to the 10-year average (1987-96). Other Mn/DOT spending is expected to be about 6 percent higher than the historical average. Spending by other departments is estimated to be about 10 percent higher under the Governor's proposal, which includes funding to hire more state patrol officers.

Construction spending over the next 5 years is expected to be comparable to historical averages.

Figure 3: Trunk Highway Fund Expenditures, Actual and Projected, 1974-2001



Source: Program Evaluation Division analysis of Mn/DOT data.

Beyond 2001, spending might not compare so favorably with historical averages. Under the Governor's proposal, the amount of spending for construction and other purposes is expected to receive a boost during the 1997-99 period by the use of the available fund balance, which totaled $147 million at the end of 1996. However, by the end of 1999, the fund balance is estimated to be only $3 million. As a result, the Trunk Highway Fund may not be able to sustain the spending levels anticipated during the 1997-99 period.

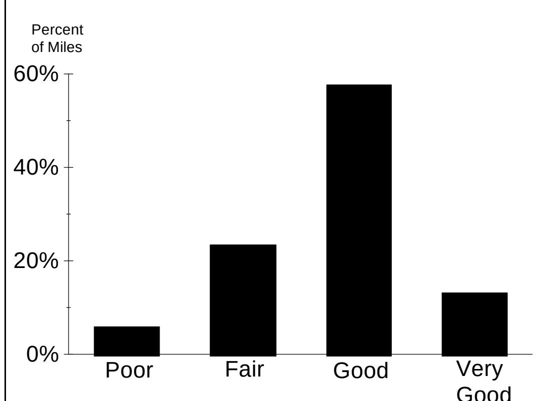
PAVEMENTS

Most trunk highway pavements are in good condition.

Based on our analysis of Mn/DOT's pavement quality data, we think that:

- **The typical trunk highway was in good condition in 1996, and only a small percentage of pavements were in poor or very poor condition.**

Figure 4: Pavement Quality for State Trunk Highways, 1996



Source: Program Evaluation Division analysis of Mn/DOT data.

We estimate that about 70 percent of trunk highway miles were in good to very good condition as measured by Mn/DOT's pavement quality index (Figure 4). About 24 percent were in fair condition in 1996, while only about 6 percent were in poor or very poor condition. These measurements came prior to the winter of 1996-97 which may have taken an unusually harsh toll on Minnesota's roads, including its trunk highways.

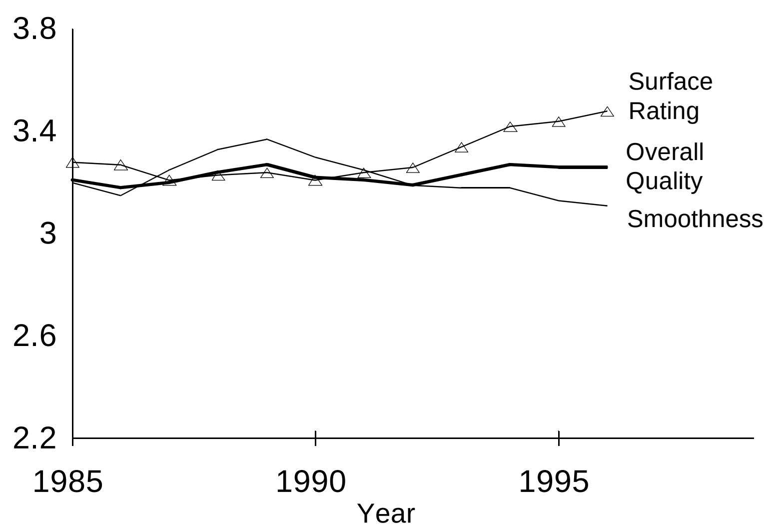
Our conclusions conflict with characterizations of Minnesota highway conditions made by Mn/DOT and the Federal Highway Administration. As Mn/DOT agrees, the federal data are invalid for comparison purposes across states because the data do not take into account the differences in equipment used to measure pavement smoothness. But, we also disagree with the labels Mn/DOT has used to characterize pavement quality index numbers. The labels (such as ''poor'' or ''good'') Mn/DOT has attached to various numbers are inconsistent with how Mn/DOT's Pavement Management Unit has calibrated the smoothness component of the index. It is possible for a pavement to have a ''fair'' rating on smoothness and the best possible rating on surface defects and yet be labeled as being in ''poor'' condition by Mn/DOT.

Mn/DOT has been able to maintain relatively constant pavement quality on the trunk highway system since at least the mid-1980s (Figure 5). Between 1985 and 1996, the pavement quality index has increased about 2 percent. The average is toward the lower end of what we consider the ''good'' range for pavement quality. The pavement quality index consists of both a smoothness rating and a rating for surface defects. Since 1985, the surface rating improved by about 6 percent, while the smoothness rating declined by about 3 percent.

Pavement quality has increased slightly since 1985.

Based on our assessment of the data on pavement quality, we do not think Mn/DOT has a backlog of pavements in poor condition. However, a backlog would develop if Mn/DOT reduced the average amount of resurfacing work it does annually. In fact, we think that:

Figure 5: Pavement Quality Ratings for State Trunk Highways, 1985-96



Source: Minnesota Department of Transportation.

- **Mn/DOT may have to increase the rate at which it resurfaces highways.**

We used Mn/DOT's Pavement Management System (PMS) to estimate the number of miles of resurfacing (including concrete pavement repair) necessary over the 10-year period from 1996 through 2005 to maintain a constant systemwide average pavement quality. The PMS predicts that between 13 and 28 percent more miles of resurfacing activity annually will be necessary than were actually done from 1986 to 1995.

The aging of the trunk highway system may require Mn/DOT to resurface highways more frequently in the future.

This increased need may be the result of the aging of Minnesota's trunk highways. The average pavement age on trunk highways increased from 32 to 40 years from 1985 to 1995. Mn/DOT has been able to maintain its highways in relatively good condition by resurfacing them. In fact, the average age of trunk highway surfaces declined from 11.5 years in 1985 to 10.9 years in 1995. However, the composition of trunk highway pavements and surfaces has changed, and some engineers think that each successive resurfacing may not last as long as the previous surface or the original surface. From 1985 to 1995, the percentage of trunk highway miles with their original surfaces declined from 38 percent to 27 percent.

It is also possible that the PMS is overstating the rate at which surface quality is deteriorating. Mn/DOT needs to examine the PMS to see if it is accurately predicting the deterioration rate. In addition, Mn/DOT needs to consider whether greater use of preventive maintenance might affect the need for resurfacing in the future and might reduce the estimated future costs of maintaining a constant pavement quality index.

BRIDGES

Trends show very slight changes in the condition of trunk highway bridges since the mid-1980s. The systemwide average bridge sufficiency rating improved less than 1 percent between 1986 and 1995. A sufficiency rating is an all-purpose indicator that measures structural adequacy, functional obsolescence, and essentiality for public use. Bridge condition ratings, which focus on structural condition, have declined slightly. The average systemwide condition ratings for bridge decks, superstructures, and substructures all decreased between 1 and 3 percent. The percentage of bridges which are deficient by federal standards for either structural or functional reasons has declined from 12.8 percent in 1990 to 11.7 percent in 1995. The estimated costs of improving deficient bridges also declined between 1990 and 1995. Longer trends are difficult to interpret because the federal criteria for identifying deficient bridges were changed several times in the late 1980s.

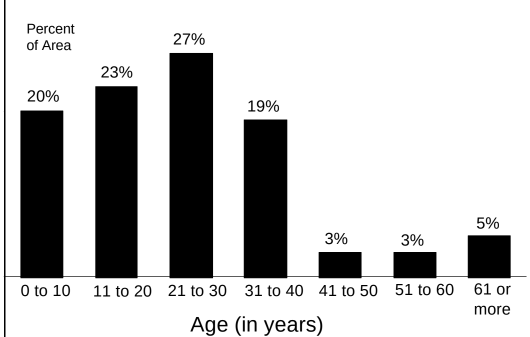
Overall, we found that:

- **The typical trunk highway bridge is in good to fair condition, but there is a backlog of bridges that are classified as having structural deficiencies.**

Most trunk highway bridges are in good condition, but there is a backlog of bridges with structural deficiencies.

Mn/DOT data indicate that 240 of the 4,614 trunk highway bridges had structural deficiencies which would cost an estimated $100 million to correct. This figure is more than twice the average annual amount Mn/DOT spent on bridge replacement, preservation, and safety improvements between 1991 and 1995. Mn/DOT also estimates that there are an additional 116 bridges for which both condition and functional problems exist. The functional problems include inadequate width or clearance, as well as load restrictions. It would cost an estimated $95 million to correct deficiencies on these bridges, but Mn/DOT does not itemize the costs of correcting condition problems from width or other functional deficiencies. Finally, another 185 bridges have functional deficiencies which would cost $127 million to correct. Clearly, there is a significant cost to repairing the trunk highway bridges identified as being structurally deficient. We are less convinced of the need to improve or replace bridges simply because of functional deficiencies. Such a project, generally designed to reduce accidents or congestion, should only be undertaken if the benefits to highway users exceed the costs of the project.

Figure 6: Age of Bridges and Culverts, 1995



Source: Minnesota Department of Transportation.

If additional funding were available, it might be a good time to address the backlog of bridges needing repair or replacement due to deficient structural conditions. In at least 15 to 20 years, Mn/DOT will be facing even more significant bridge replacement needs, since a significant percentage of trunk highway bridges will begin to meet or exceed their expected life of 60 years. As Figure 6 shows, only 11 percent of the total bridge deck area was on bridges which were 41 years old or more in 1995. However, that percentage is expected to grow significantly in the future.

CONGESTION

While trunk highway spending has been able to outpace inflation and even population growth since 1974, spending has not been able to keep pace with the significant growth in traffic on Minnesota's highways. Between 1974 and 1996, the amount of traffic on all of Minnesota's roads increased an estimated 80 percent, and traffic probably increased even more on the trunk highway system. This increase in traffic was well in excess of the 52 percent increase in the trunk highway construction budget and the 11 percent increase in other spending out of the Trunk Highway Fund.

Highway spending does not necessarily need to grow as fast as the growth in traffic, particularly when there is excess capacity in the highway system. However, at some point, the capacity is exceeded on some highways and the amount of resources needed to manage or reduce congestion needs to be increased. Also, as traffic has grown, so have the loads borne by trunk highways largely from truck traffic. This increase in pavement stress may cause problems for some highways not built to handle the loads they now carry.

The increase in travel has caused a significant increase in congestion on some interstate highways, other freeways, and some principal arterials. The worst congestion is in the 7-county Twin Cities metropolitan area, but there are trunk highways in other parts of the state that are also congested. There is congestion at times on some interstate highways outside the Twin Cities area, as well as other trunk highways such as those in major tourism centers. The Metropolitan Council is projecting that the number of congested miles on major highways in the metropolitan area will more than double between 1995 and 2020, even though the Council's long-range plan for the area includes a number of important highway capacity improvements.

PREVENTIVE MAINTENANCE

Many studies have found preventive maintenance to be effective in extending pavement life or improving pavement quality over what it would have been in the absence of preventive maintenance. Preventive maintenance is generally done on pavements to keep moisture out of the pavement subbase or to maintain the ability of the pavement to move due to temperature changes. Some of the benefits of preventive maintenance on pavements include less cracking and fewer potholes and pavement blowups. Bridge preventive maintenance can reduce the exposure of bridge components to corrosive de-icing chemicals and maintain the ability of bridge components to expand and contract in response to temperature changes.

Mn/DOT probably should be doing more preventive maintenance.

We asked key Mn/DOT managers around the state whether they felt that their district or maintenance area was doing the right amount of certain types of preventive maintenance. We also examined records indicating the amount of preventive maintenance which has been done in the past and used the recently revised Pavement Management System to estimate how much of the trunk highway system might benefit from preventive maintenance. In general, we found that:

- **Mn/DOT is probably not doing enough preventive maintenance.**

The vast majority of Mn/DOT managers generally felt that the preventive maintenance activities we asked about are cost-effective or would be if they were used. For some activities, particularly newer technologies, a majority was not sure. Roughly half of the Mn/DOT managers felt that their district or maintenance area did not do enough of the preventive maintenance activities we identified, although the answers varied depending on activity.

For bituminous pavements, managers were more concerned about the amount of crack filling, thin asphalt overlays, crack sealing, slurry sealing, and micro-surfacing and somewhat less concerned about the amount of chip sealing that is currently done. For concrete pavements, managers were more concerned about joint sealing and repair and less concerned about retrofit load transfer which is a new technique in the experimental phase. Some managers were particularly concerned that Mn/DOT does not address concrete joint problems in a timely way and, as a result, more costly repairs are ultimately necessary.

For bridges, most Mn/DOT managers said not enough of the following types of preventive maintenance were being done: spot painting, cleaning and resealing of deck joints, lubrication of expansion bearings, and correction of approach panel settlement. Sealing of cracks in concrete decks and reinstallation of strip neoprene glands in expansion joints were also a concern of some managers. Most managers were satisfied with the amount of bridge flushing their districts or maintenance areas performed. However, using the Bridge Management System, we found that bridge flushing is inadequate in several areas of state. While bridge experts recommend an annual bridge flushing to prevent concrete from cracking and scaling and steel components from corroding, the 1994-95 statewide average was about once every 3 years. The frequency was once every 6 years in the Twin Cities metropolitan area and once every 10 years in District 1 (Duluth).

Based on responses from managers as well as our own assessment of Mn/DOT's finances, we think that:

- **The principal reason Mn/DOT does not do more preventive maintenance is that it has more pressing needs.**

Preventive maintenance is important in controlling long-run costs but is hard to fund given more pressing problems.

Mn/DOT managers find it hard to justify allocating more money to preventive maintenance when they have other significant needs such as roads in bad shape, deficient bridges, and safety and congestion concerns. For example, a number of Mn/DOT managers told us that they find it difficult to justify doing preventive maintenance on highways in fairly good condition when other highways are in worse condition. Even in those instances when Mn/DOT managers said they thought their district was doing enough of a certain preventive maintenance activity, half of them said they would spend more on the activity if additional funds were available. They felt they were doing the best they could given funding constraints.

Unfortunately, however, the effect of these funding constraints may be to increase the long-run costs of maintaining the trunk highway system in good condition. If Mn/DOT were able to fund more preventive maintenance, it would likely incur some additional initial costs but would hopefully be able to reduce the number of highway miles and bridges needing more significant work in the long run and may be able to reduce the amount of necessary maintenance work such as pothole patching.

We think that:

- **Mn/DOT is moving in the right direction but needs to take a more strategic approach to preventive maintenance on the state's trunk highways.**

In recent years, Mn/DOT has shown more interest in preventive maintenance. A department team wrote a report on the advantages of preventive maintenance for pavements. The team recognized the possibility of using the Pavement Management System to suggest and evaluate preventive maintenance activities. Prior to that time the system had been only used to suggest more costly rehabilitation options for pavements in relatively poor condition. Mn/DOT has now developed decision criteria which will help districts select preventive maintenance activities for pavements in better condition. Also, the department, in cooperation with local governments, is conducting research on preventive maintenance for pavements. We are concerned that current practices will not change, however, unless Mn/DOT establishes a separate category of preventive maintenance funding which cannot be used for other activities.

ADEQUACY OF FUNDING

In recent years, policy makers have been deadlocked over the issue of providing additional revenues for highways in Minnesota. Funding for transit has also been a key issue. Our study was limited to an examination of the trunk highway system and did not include an assessment of highway funding adequacy for counties and cities, which would also benefit from an increase in highway user taxes. In addition, we were not able to study Minnesota's transit needs.

Mn/DOT needs to develop better estimates of its pavement and bridge preservation and replacement needs.

In general, we found that:

- **Mn/DOT does not have adequate estimates of the funding needed to maintain current pavement quality and bridge condition ratings on the trunk highway system.**

Mn/DOT has not developed an estimate of the funding needed for highway preservation and replacement in order to maintain a constant systemwide average pavement quality. In addition, the estimate developed by Mn/DOT for bridge preservation and replacement needs should be revised because it overstates bridge replacement needs in some respects but also does not fully account for the emerging problems Mn/DOT is likely to face with steel fatigue on some bridges. The revised estimate should also be linked to a performance target such as a constant systemwide average for bridge condition ratings. Furthermore:

- **Because the use of benefit-cost analysis in Mn/DOT is still in a developmental stage, there is little systematic information on whether expansion and improvement projects planned for future years are worthwhile from a benefit-cost standpoint.**

The adequacy of funding should not be measured by simply comparing available funds to a list of potential projects. Such comparisons invariably have shown that infrastructure needs exceed available funding. Expansion or improvement projects that cost more than their estimated benefits, such as those measured by reduced highway user costs or the value of reduced accidents, should not be considered a system need.

Mn/DOT should better define its funding needs and periodically report on them.

We recommend that:

- **Mn/DOT should periodically prepare a report on the funding needs of the trunk highway system. Needs should be defined in terms of what funding is necessary to achieve specific performance targets and should incorporate benefit-cost criteria where appropriate and feasible.**

Despite the difficulties we had in arriving at any precise estimate of trunk highway funding needs, we think that:

- **Projected funding is probably not adequate to address all of Minnesota's trunk highway needs.**

Mn/DOT's funding has not been sufficient for it to fully fund mega-projects on Twin Cities area freeways. These projects have had to be delayed. Parts of the projects are scheduled to be implemented in piecemeal fashion over a period of many years. In addition, funding is not sufficient to fully address the backlog of structurally deficient bridges, perform adequate preventive maintenance on trunk highways and bridges, and reconstruct those heavily used highways which may be more cost-effective to reconstruct than to overlay frequently.

Projected funding is probably insufficient to meet trunk highway needs.

We think the executive and legislative branches need to cooperate to ensure that Minnesota is not "penny wise and pound foolish." It may take an increase in taxes in order for Mn/DOT to implement practices and projects which more than pay for themselves by generating benefits in excess of their costs. In order for that cooperation to occur, Mn/DOT needs to thoroughly assess its trunk highway needs. Needs should be linked to performance targets and tied to benefit-cost analysis as much as possible so that the assessment of needs is not simply the compilation of a "wish list."

LANE AND SHOULDER WIDTH STANDARDS

In its 1995 report entitled *Within Our Means: Tough Choices for Government Spending*, Minnesota Planning recommended a variety of ways in which state and local governments could make more effective use of their resources. One recommendation was to reduce right-of-way, lane width, and other standards for highways, particularly low volume rural roads. In response, Mn/DOT established a Geometric Design Standards Task Force to review lane and shoulder width standards for rural trunk highways and state-aid highways which serve fewer than 2,000 vehicles per day. In December 1996, the Task Force finalized its recommendations and passed them on to the Commissioner of Mn/DOT and the County Highway Engineers Association. As part of our study, we examined the work of the Task Force. We found that:

Mn/DOT's Task Force has made useful recommenda-tions for resurfacing projects.

- **While the Task Force has made a number of useful recommendations, particularly new lane and shoulder width standards for reconditioning (or resurfacing) projects, the Task Force's recommended construction or reconstruction standards are inconsistent with Mn/DOT's own benefit-cost analysis and reputable national studies.**

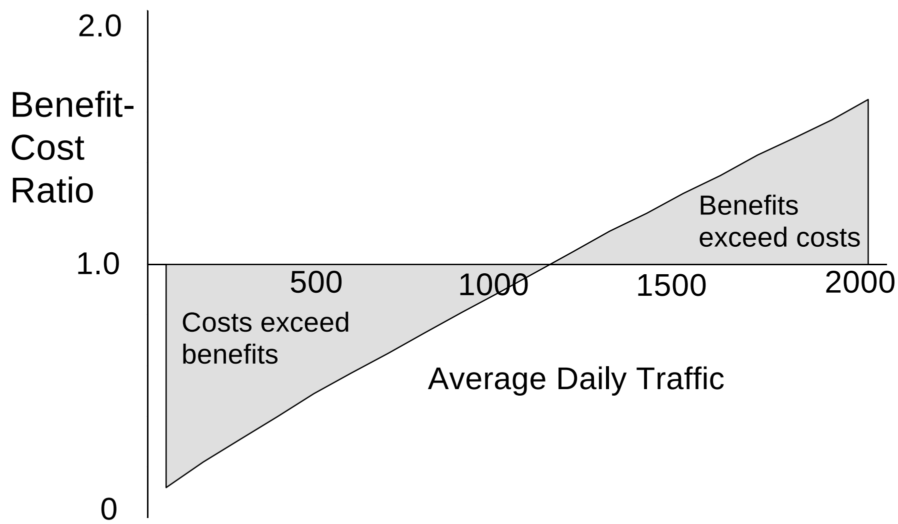
The Task Force's recommended reconditioning standards seem practical and may help to reduce the number of highways which are required to be reconstructed because of their current lane or shoulder width. For many low volume rural highways, it makes more sense to permit Mn/DOT districts and counties to preserve their existing roads with a less costly resurfacing project than to require total reconstruction.

However, the Task Force's recommended construction and reconstruction standards are relatively unchanged from existing standards for both trunk highways and county state-aid highways. In particular, the Task Force retained the requirement that all paved roads have at least 12-foot lanes and 4-foot shoulders regardless of traffic volumes. Like reputable national studies, Mn/DOT's own benefit-cost analysis shows that the costs of constructing 12-foot lanes outweigh the potential accident reduction benefits for lesser-traveled rural highways. For example, using Mn/DOT's data and assumptions, Figure 7 shows that the costs of constructing a highway with 12-foot lanes and 4-foot shoulders (rather than 11-foot lanes and 4-foot shoulders) exceed the benefits for highways with traffic volumes below about 1,100 to 1,200 vehicles per day. Judging from better cost data on county state-aid highways, we think that 11-foot lanes might be cost-effective at traffic volumes up to 1,500 or possibly 2,000 vehicles per day.

The Task Force cited a number of reasons for recommending standards not supported by Mn/DOT's benefit-cost analysis. However, we do not think that the Task Force thoroughly evaluated these additional factors. For example, the Task Force report cited some shoulder maintenance concerns for highways with 11-foot lanes but did not mention the additional pavement maintenance and rehabilitation costs which would be incurred with 12-foot lanes.

The recommended construction and reconstruction standards for lane width are not supported by national studies or Mn/DOT's own benefit-cost analysis.

Figure 7: Benefit-Cost Ratio for Constructing 12-Foot Lanes Instead of 11-Foot Lanes by Average Daily Traffic



Source: Minnesota Department of Transportation.

Minnesota already has more rural roads with 12-foot lanes than the national average. In addition, the Task Force's recommendation maintains a lane width standard in excess of nationally recommended standards such as those recommended in a 1994 report prepared for the National Highway Cooperative Research Program (NCHRP) by the Transportation Research Board and National Research Council. The adoption of the NCHRP recommendations instead of the Task Force's recommendation could potentially affect about 600 miles of trunk highways and more than 8,500 miles of county state-aid highways, which would no longer be considered substandard. It would also mean that more of the state aid for county state-aid highways could be directed toward preservation of existing highways or other important needs.

We urge Mn/DOT and the Task Force to reconsider the recommendation for construction and reconstruction projects. Given the fiscal realities facing state and local governments in Minnesota, it is important that every reasonable effort be made to maximize the cost-effectiveness of government spending. Mn/DOT and local governments need to focus on preserving existing infrastructure and should improve or expand infrastructure only when it makes sense from a benefit-cost standpoint. Governments cannot afford to focus on building the best possible transportation system.

Introduction

The maintenance and construction of highways and bridges are essential government functions. In today's increasingly mobile society, highways carry over 90 percent of personal travel. Per capita highway travel in the United States exceeds that in other major countries and is growing. In Minnesota, highway travel increased 35 percent from 1985 to 1995, while population increased only about 10 percent.

Concerns have been raised, however, about whether highway funding has kept pace with infrastructure needs. In 1995, the United States Department of Transportation estimated that the annual capital cost to maintain current highway and bridge conditions and performance over the 20-year period from 1994 through 2013 would significantly exceed current annual capital expenditures. While an estimated $55 billion would be required annually to maintain the current condition and performance of the nation's highways and bridges, only $39 billion per year was spent in 1993. The department estimated that an additional $15 billion in annual spending would be desirable from an economic perspective, considering the benefits and costs of highway improvements, and another $4 billion per year would be required to eliminate all current bridge deficiencies.[1]

In Minnesota, highway spending has generally kept pace with inflation and population growth but not with the growth in traffic. Highway spending has also not kept pace with the growth in personal income or other government spending. Minnesota's state and local government spending on transportation declined from about 3.0 to 2.2 percent of personal income from 1972 to 1992. The share of state and local government spending devoted to highway spending has fallen from 13 to 8 percent.

It remains to be seen whether highway spending in Minnesota has been sufficient to maintain the current highway system in good condition and respond adequately to increased traffic levels. Highway spending does not necessarily have to grow as fast as other government spending or personal income in order to be adequate. Furthermore, highway spending has not always needed to grow as fast as traffic, especially when there was excess capacity in the highway system.

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1 United States Department of Transportation, *1995 Status of the Nation's Surface Transportation System: Conditions and Performance, Report to Congress* (October 27, 1995), 190. The department's estimates of future needs are in 1994 dollars.

In this report, we focus on the State Trunk Highway (STH) System, which is the responsibility of the Minnesota Department of Transportation (Mn/DOT). The trunk highway system carries about 59 percent of Minnesota's traffic and accounts for roughly 40 percent of all highway spending but includes only about 9 percent of the street and highway miles in Minnesota.

The report addresses the following questions:

- **How does Minnesota's road system and level of road spending compare with those in other states, and how does our trunk highway system compare with other state-administered systems?**
- **How have trunk highway revenues and expenditures changed over time?**
- **In what condition are state trunk highway pavements and bridges?**
- **How has the condition of trunk highway pavements and bridges changed since the mid-1980s?**
- **Given funding projections, how well will Mn/DOT be able to respond in the future to pavement and bridge deterioration, growing traffic, and other needs?**
- **To what extent does Mn/DOT perform adequate preventive maintenance on trunk highway pavements and bridges?**
- **Is Mn/DOT appropriately reassessing its lane and shoulder width standards for low volume rural trunk highways and state-aid roads?**

During our research, we interviewed numerous Mn/DOT employees throughout the organization. In addition to contacts with various central office staff, we visited each of the seven outstate Mn/DOT districts, as well as the Metropolitan Division. We discussed the challenges faced by and the resources available to each organization with the district (or division) management teams. We also interviewed transportation planning officials at the Metropolitan Council.

We analyzed a variety of data from Mn/DOT information systems, particularly the pavement and bridge management systems, and collected data from district personnel about preventive maintenance practices. Our research also included a review of relevant literature on a variety of transportation topics.

Chapter 1 of this report provides background information on Minnesota's highways and the Minnesota Department of Transportation and compares Minnesota's highways, and the trunk highway system, with those in other states. Chapter 2 reviews the condition of Minnesota's trunk highways and bridges and analyzes the trends affecting the trunk highway system. In Chapter 3, we examine Mn/DOT's ability to address pavement and bridge needs, given revenue projections based on current law. Chapter 4 evaluates Mn/DOT's preventive maintenance practices in light of studies of preventive maintenance and comments from Mn/DOT managers located throughout the state. Finally, Chapter 5 reviews Mn/DOT's recent efforts to reexamine highway standards for rural trunk highways and state-aid highways. We evaluate the work of the Mn/DOT-sponsored task force, which reviewed existing lane and shoulder width standards for rural highways with low traffic volumes.

Background

CHAPTER 1

Minnesota has an extensive system of streets and highways. The Minnesota Department of Transportation (Mn/DOT) is responsible for maintenance and construction work on the State Trunk Highway System, which includes many of the most heavily traveled highways in the state. Most of the other roads are under the jurisdiction of counties, cities, or townships.

In this chapter, we provide general information on Minnesota's highways and compare Minnesota with other states. In particular, we address the following questions:

- **How does Minnesota's overall highway spending and network of roads compare with other states?**
- **What portions of Minnesota's highway system and spending are on the State Trunk Highway System?**
- **How does Minnesota's State Trunk Highway System compare with state-administered systems elsewhere?**
- **How are highway construction and maintenance funded in Minnesota?**
- **How is the Minnesota Department of Transportation organized and how does the department make decisions about highway projects?**

SYSTEM SIZE

All Streets and Highways

Minnesota has about 130,000 miles of streets and highways--the fifth largest system in the nation after Texas, California, Illinois, and Kansas. Minnesota's large network of roads is largely due to the size of its rural road system. Minnesota has the third largest system of rural roads but ranks only 21st in the number of urban miles of road.

As Table 1.1 shows:

Table 1.1: Miles of Roads and Traffic by Type of Road, Minnesota, 1994

	Miles of Roads	Percentage of Miles	Annual Vehicle Miles of Travel (in millions)	Percentage of Traffic	Vehicle Miles per Road Mile (in 1,000s)
Interstate	233	0.2%	6,116	14.1%	26,249
Other Freeways and Expressways	127	0.1	2,322	5.4	18,283
Other Principal Arterials	577	0.4	3,234	7.5	5,605
Minor Arterials	1,944	1.5	6,130	14.2	3,153
Collectors	1,624	1.2	2,043	4.7	1,258
Local	10,511	8.1	2,776	6.4	264
URBAN	15,016	11.5%	22,621	52.2%	1,506
Interstate	681	0.5%	3,454	8.0%	5,072
Other Principal Arterials	3,571	2.7	5,853	13.5	1,639
Minor Arterials	6,485	5.0	4,352	10.0	671
Major Collectors	15,786	12.1	3,312	7.6	210
Minor Collectors	11,657	9.0	1,106	2.6	95
Local	77,002	59.1	2,619	6.0	34
RURAL	115,182	88.5%	20,696	47.8%	180
TOTAL	130,198	100.0%	43,317	100.0%	333

Source: Federal Highway Administration.

- **Minnesota has a particularly large network of rural roads that serve local needs and carry relatively small amounts of traffic.**

Minnesota has a large network of local roads in rural areas.

Over 59 percent of all the road miles in the state are accounted for by rural roads serving local needs. Only 6 percent of the state's traffic occurs on these roads, many of which are unpaved. In terms of traffic levels, rural local roads carry about one-tenth as much traffic per mile of road as the average road in Minnesota. Urban interstate highways, the busiest category of roads, carry almost 80 times the average traffic level. Figure 1.1 provides definitions for the types of roads listed in Table 1.1.

Overall, Minnesota had about 89 percent more miles of roads per capita than the national average in 1994. Minnesota also had more bridges per capita than the national average, although the state was closer to the national average for bridges than it was for miles of roads. In 1994, Minnesota had 28 percent more bridges per capita than the national average for bridges 20 feet in length or longer.

Two factors contributing to Minnesota's large network of rural roads are Minnesota's low population density and its large number of farms. Compared with other states, Minnesota's population density is 22 percent lower. Minnesota is a relatively large state and is ranked 14th highest in land area, while it is only 20th largest in population. To connect all parts of the state with roads requires a larger network of roads per capita than in more densely populated states.

Figure 1.1: Functional Classifications of Highways

Interstate highways are divided expressways for through traffic, which are part of the federally designated interstate system. Interstates generally have full control of access.

Other freeways and expressways are divided highways for through traffic with full or partial control of access. They generally have grade separation at intersections with other highways.

Principal arterials include interstate highways and freeways, as well as other major roadways serving high-speed, long distance travel. They serve virtually all urban areas with a population of 25,000 or more and a majority of those with a population of 5,000 or more. They provide little or no access to adjacent property.

Minor arterials are intermediate roadways which emphasize mobility but provide more property access than principal arterials. They handle medium length trips and, when combined with the principal arterial system, connect most cities, larger towns, and other traffic generators with one another.

Collectors have an equal emphasis on mobility and land access and provide for trips within neighborhoods and between small cities. Collectors provide the intermediate connection between local streets and the arterial system. In rural areas, **minor collectors** collect traffic from local roads and small communities and link them with more heavily traveled roads. **Major collectors** provide service to moderately sized communities within a county and link those communities with larger population centers nearby.

Local streets and roads facilitate travel over relatively short distances and primarily provide access to property.

Source: Various publications of the Minnesota Department of Transportation and the Transportation Study Board.

Minnesota also has an above average number of farms and smaller than average farms. Minnesota has about 88,000 farms, or about 138 percent more farms per capita than the national average. Minnesota's farms are also 27 percent below the national average in acreage. Connecting a larger number of smaller farms may require more roads per square mile of land in rural areas. Overall, Minnesota has 53 percent more miles of road per square mile of land than the national average.

State Trunk Highway System

The State Trunk Highway (STH) System includes approximately 12,000 miles of highways, designated in part by the Minnesota Constitution and in part by legislative act. The system includes all interstate highways and urban freeways, as well as the vast majority of principal arterials and rural minor arterials in the state. The size of the system has not changed much since the mid-1980s. As Table 1.2 shows, the STH system is slightly smaller today than in 1984. The STH system has fewer miles of collectors, minor arterials, and local roads and more miles of interstate highways and principal arterials. These changes have come about as a result of some interstate and other construction, turnbacks of lesser traveled roads to counties, and some reclassification of roads.

Minnesota's trunk highway system includes many of the most heavily traveled roads in the state. Table 1.3 shows that:

Table 1.2: Miles of State Trunk Highways, 1984 and 1996

	1984	1996
Interstate	885	914
Other Freeways and Principal Arterials	3,924	4,205
Minor Arterials	5,685	5,639
Major Collectors	1,573	1,193
Minor Collectors and Local	54	23
Total	12,121	11,974

Source: Minnesota Department of Transportation.

Table 1.3: Miles of Roads and Traffic by Jurisdiction, Minnesota, 1993

	Percentage of Road Miles	Percent of Traffic
State Trunk Highways	9%	59%
County State-Aid Highways	23	21
Municipal State-Aid Streets	2	8
City Streets	10	7
County Roads	12	3
Township Roads	42	2
Other	2	0
Total	100%	100%

Source: Minnesota Department of Transportation.

- **The State Trunk Highway System includes less than 10 percent of the state's roads, but carries almost 60 percent of the state's traffic.**

The interstate highways and other freeways alone carry more than one-fourth of the state's traffic but represent less than 1 percent of the state's miles of road. County and city roads not on the STH system but receiving state aid account for 25 percent of the miles and 29 percent of the traffic. Other county and city roads represent 22 percent of the miles and 10 percent of the traffic. Township roads, many of which are unpaved, account for 42 percent of the state's roads but only 2 percent of the traffic. Federal roads and other state-administered roads such as state park roads account for 2 percent of Minnesota's roads but an insignificant amount of the overall traffic.

The size of Minnesota's trunk highway system is typical of Midwestern states.

In 1994, Minnesota's trunk highway system was the 18th largest state-administered highway system in the nation. On a per capita basis, Minnesota's system had about 11 percent fewer miles than the average state system. While the size of Minnesota's state system is fairly typical of most Midwestern states, some mid-Atlantic states (North Carolina, South Carolina, Virginia, West Virginia, and Delaware) have unusually large state systems. In these states, more than half of the total miles of road are under the control of state highway agencies. Unlike Minnesota, state agencies in these five states are responsible for many roads serving only local needs.

FUNDING SOURCES

All Jurisdictions

The two largest sources of funds for highway and street expenditures in Minnesota are state highway user taxes and property taxes and assessments. Table 1.4 shows that almost 40 percent of highway and street spending is financed by highway user taxes, including state taxes on motor fuel and motor vehicle registrations. These state taxes are a major source of revenues for state and county governments. About two-thirds of the funding for state trunk highways and close to half of county highway funding comes from these state taxes.

Table 1.4: Share of Highway and Street Expenditures by Revenue Source, 1993

	Source of Each Jurisdiction's Expenditures[a]				
Revenue Source	State	Counties	Cities	Townships	All Jurisdictions
State Highway User Taxes	68%	46%	13%	8%	39%
Property Taxes and Assessments	0	31	53	63	31
State General Fund	0	5	12	17	6
Federal Aid	24	9	0	0	10
Bonds and Notes	0	2	15	6	7
Other	8	7	8	6	7
Total	100%	100%	100%	100%	100%
Total Expenditures (in millions)	$735	$562	$868	$78	$2,243
Share of Total	33%	25%	39%	3%	100%

Source: Office of the State Auditor and Minnesota Department of Transportation.

[a]Data for state government are for fiscal year 1993. Other data are for calendar year 1993.

Some cities and townships also receive revenue from highway user taxes, but spending in these jurisdictions is more dependent on local property taxes and assessments. More than half of city and township spending on roads is financed by local taxes and assessments. About 30 percent of funding for county roads also comes from these local sources. Overall, local property taxes and assessments account for roughly 30 percent of highway and street funding.

Other sources of funding each provide 10 percent or less of total highway and street funding statewide. They include federal aid, the state's General Fund, bonds, and other sources such as investment income and various fees. Federal aid is particularly significant at the state level, accounting for about one-fourth of the funding for the state Trunk Highway Fund. General purpose aid from the state is also used by cities, counties, and townships to support highways as well as other local government functions.

Highway User Taxes

The State Constitution mandates how 95 percent of the highway user taxes are distributed.

The distribution of highway user taxes is, in large part, governed by provisions in Minnesota's State Constitution. Taxes on motor fuel and motor vehicle registrations must be deposited into the Highway User Tax Distribution Fund.[1] The Constitution requires that 95 percent of the net proceeds of the fund be allocated in the following proportions: 62 percent to the state Trunk Highway Fund, 29 percent to the County State-Aid Highway Fund, and 9 percent to the Municipal State-Aid Street Fund. The remaining 5 percent may be distributed by law to the three funds, but the apportionment of these funds may not be changed more frequently than every 6 years.

Figure 1.2 shows how the $974 million in highway user taxes were distributed in 1996.[2] The Trunk Highway Fund received $572 million, or a little more than 60 percent of the net proceeds of the Highway User Tax Distribution Fund. The County State-Aid Highway Fund received $262 million for distribution to counties according to statutory formulas and needs studies and another $8 million to repair or restore roads being turned back to counties by the state. The Municipal State-Aid Street Fund received $81 million to be distributed according to law to cities with populations of 5,000 or more, as well as $4 million to reconstruct or improve highways turned back to cities by the state. In addition, $22 million was distributed through the County State-Aid Highway Fund for town roads and bridges.

National Comparisons

In general:

- **Mn/DOT is more reliant than other state highway agencies on motor vehicle registration taxes and less reliant on federal aid, state bonding, and tolls.**

Figure 1.3 shows that 34 percent of revenues for state-administered highways in Minnesota came from motor vehicle registration taxes in 1994, compared with only 15 percent for all such highways in the United States. On either a per capita or per mile basis, vehicle taxes used for state highways in Minnesota were 80 to

1 Taxes on the sale of motor vehicles do not need to be deposited in the Highway User Tax Distribution Fund.

2 About $13 million of the $974 million total went for tax collection costs. About $11 million was transferred to the Department of Natural Resources (DNR) for recreational programs serving users of vehicles such as watercraft and snowmobiles. These vehicle owners pay the gasoline tax, but their vehicles do not use highways. Consequently, a portion of gasoline tax receipts is transferred to pay for DNR programs serving their needs.

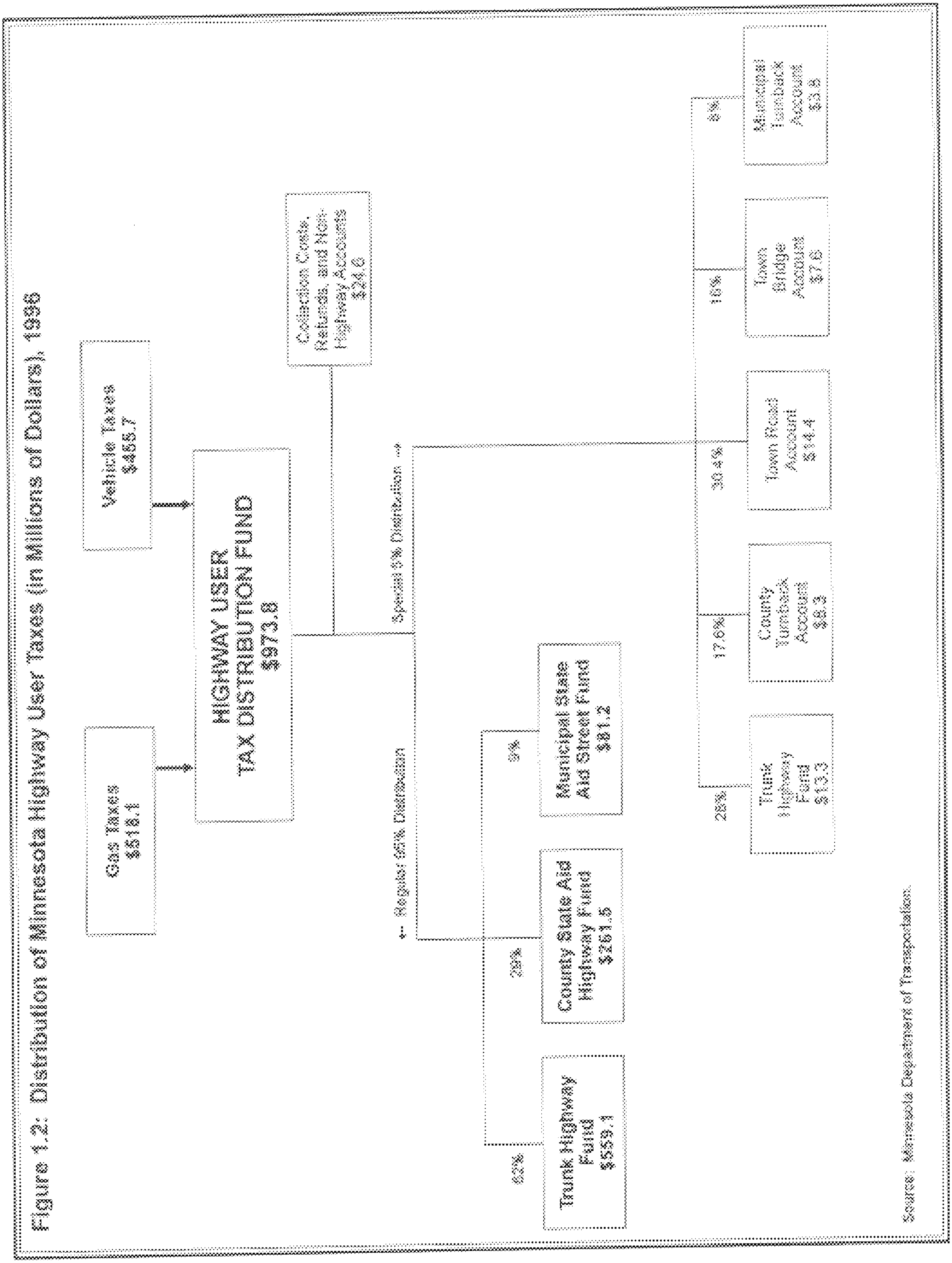
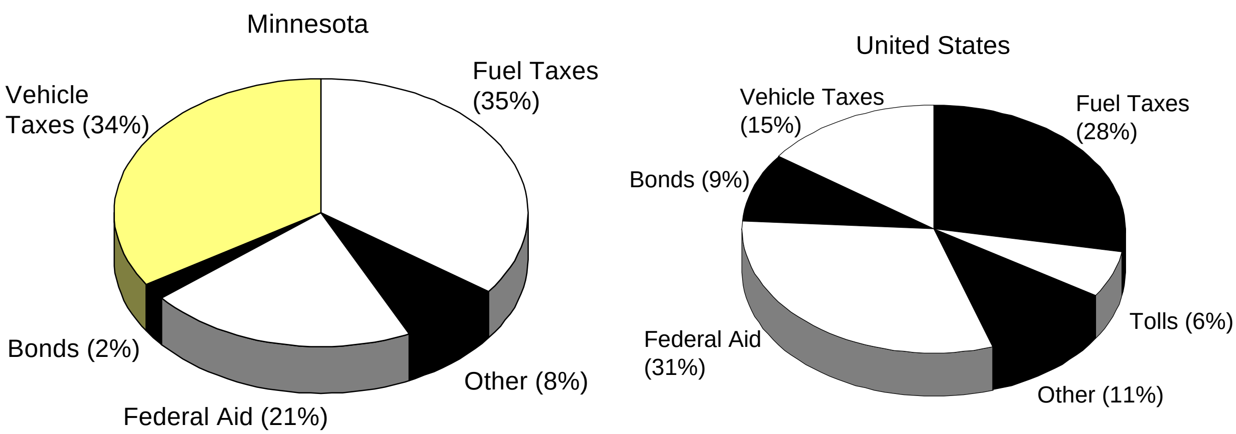


Figure 1.2: Distribution of Minnesota Highway User Taxes (in Millions of Dollars), 1996

Source: Minnesota Department of Transportation.

Figure 1.3: Sources of Revenues for State-Administered Highways, 1994



Source: Federal Highway Administration.

Minnesota's trunk highway system relies more on highway user taxes and less on federal aid than most other state systems.

90 percent above the national average. A larger share of Minnesota's revenues (35 percent) were also derived from motor fuel taxes than nationwide (28 percent). However, when measured on a per capita or per mile basis, Minnesota's revenues from fuel taxes are fairly close to the national average.

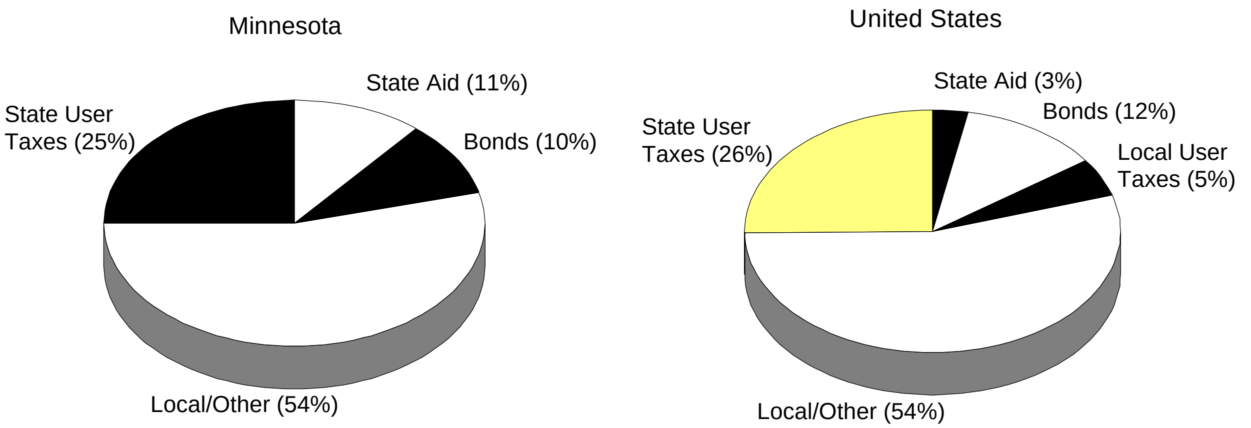
The share of Minnesota's revenues from federal aid was lower than the national average in 1994. Only 21 percent of funds used for Minnesota's state highways came from the federal government, compared with 31 percent for all states. In addition, Minnesota made less use of bonds than other states and no use of tolls to finance state highways.

Some have suggested that Minnesota's constitutional requirements for sharing state highway user taxes with local government are somewhat unique among the 50 states. While a constitutional requirement may not be typical among states, Figure 1.4 shows that state highway user taxes accounted for approximately the same share of revenues for local government highways in Minnesota during 1993 as throughout the nation. The main difference between Minnesota and other states was that:

- **Local governments in Minnesota were more reliant on general purpose state aid and less reliant on local user taxes and tolls to finance local highway spending than the national average.**

About 11 percent of local government revenues in Minnesota were from state aid other than state levied user taxes compared with only 3 percent nationwide. In contrast, local governments in Minnesota received no revenues from locally imposed highway user taxes or tolls, while 5 percent of nationwide revenues came from these sources. Minnesota's local governments were also slightly less reliant than their counterparts in other states on bonds to finance highway spending.

Figure 1.4: Sources of Revenues for Locally-Administered Highways, 1993



Source: Federal Highway Administration.

SPENDING

State and local governments in Minnesota spend more than $2 billion per year on highways. In this section, we examine how Minnesota's overall spending, as well as expenditures on state-administered highways, compare with the national averages. We also review the growth in Minnesota's highway spending and examine the components of Trunk Highway Fund spending in greater detail.

National Comparisons

Minnesota has consistently spent more per capita on highways than the national average. From 1977 to 1993, state and local governments in Minnesota spent between 43 and 57 percent more per capita than the national average. In 1993, highway spending per capita was 52 percent higher in Minnesota.

There are two factors responsible for Minnesota's higher than average spending:

1. **Minnesota's large rural road system, and**

2. **Higher than average spending per mile on both state and local roads.**

Table 1.5 shows that Minnesota spent about 10 percent more per mile on state-administered roads and about 2 percent more per mile on locally-

Table 1.5: Spending on State and Local Roads, Minnesota and the United States, 1993

	Expenditures per Capita			Expenditures per Mile		
	Minnesota	National Average	Percentage Difference	Minnesota	United States	Percentage Difference
State Roads	$170	$163	4%	$57,749	$52,657	10%
Local Roads	232	101	129	9,129	8,918	2
Total	$402	$264	52%	$14,187	$18,302	(-22)%

Source: United States Census Bureau.

administered roads than the respective national averages for 1993. [3] This table, based on data from the United States Census Bureau, is roughly consistent with data from the Federal Highway Administration (FHWA). From 1990 to 1994, FHWA data show that Minnesota's spending on state-administered roads has averaged about 9 percent more per mile than the national average. [4]

As we discussed earlier in this chapter, the size of Minnesota's rural road system has much to do with the state's population density and agricultural geography. It is less clear what factors account for Minnesota's higher than average spending per mile. It has been suggested that differences in snow and ice control expenditures and higher road standards in Minnesota, including generally wider lanes and shoulders, may account for part of the difference between Minnesota's spending and the national average.

We think that Minnesota's higher than average *spending per mile* at the state level may simply be a statistical aberration and may be misleading. In 1993, FHWA data show that Minnesota spent 5 percent more per mile than the 50 states combined. However, as we pointed out earlier, several states are unusual in that their state highway agencies operate more than half of their states' roads, including many rural roads serving local needs and requiring less costly maintenance and construction on a per mile basis than urban roads. When these

3 Overall, Minnesota's spending per mile has been less than the national average because Minnesota has substantially more miles per capita of relatively low cost rural roads. Despite havin g more unpaved roads per capita, Minnesota still spends more per mile on its locally administered roads. Available data from 1990 suggest that Minnesota spends substantially more per mile on its municipal roads than the national average. See Office of the Legislative Auditor, *Trends in State and Local Government Spending* (St. Paul, February 1996), 125.

4 Minnesota's relative position has varied considerably during this period. In 4 of the 5 years Minnesota spent more than the national average. The difference ranged from 5 percent to 20 percent above average. In 1994, however, Minnesota spent 16 percent less per mile than the national average. Data from Mn/DOT suggest that Minnesota's spending from the Trunk Highway Fund was unusually low that year.

Minnesota's spending per trunk highway mile appears lower than that in similar states.

states were excluded, we found that Minnesota's 1993 spending per mile on state roads was 13 percent less than the average for the remaining states.[5]

We also constructed a comparison group of 9 states similar to Minnesota, including Illinois, Indiana, Iowa, Kansas, Michigan, Nebraska, North Dakota, South Dakota, and Wisconsin. Together, these states have approximately the same percentage of their roads under state control as Minnesota, and the distribution of their state-controlled roads by functional class is also similar to that in Minnesota. When compared to this group of 9 midwestern states, Minnesota's spending per mile on state roads was about 10 percent below the average. This result suggests that one should not draw any substantive conclusions about the level of Minnesota's spending on state roads from a comparison to spending in all 50 states.

Spending Trends

Generally, Minnesota's overall trends in highway spending have been similar to national trends. Both in Minnesota and nationally, highway spending between 1977 and 1993 kept pace with population growth and inflation, but not with the growth in traffic.

From 1977 to 1993, highway spending by state and local governments in Minnesota tripled. After adjusting for inflation, spending growth was 33 percent, which was greater than the 13 percent growth in population but less than the 50 percent increase in traffic volumes statewide. Spending per capita grew 17 percent.[6] As Table 1.6 shows, the growth in Minnesota's highway spending was slightly larger than that in other states.

Over this same period of time (1977-93), spending by Mn/DOT from the Trunk Highway Fund grew slower than highway spending at all government levels in Minnesota. Spending out of the Trunk Highway Fund increased almost 150 percent over this period but inflation-adjusted spending per capita declined 3 percent.

However, the results depend on which inflation index is used. In Table 1.6 we used the deflator for all government purchases of goods and services (also known as the PGSL), which increased 127 percent from 1977 to 1993. In contrast, the construction cost indices computed by Mn/DOT and the FHWA show an increase in highway construction costs of 79 percent and 84 percent respectively. In other words, highway construction prices have not increased as fast over this period as the prices of other goods and services purchased by state and local governments.

5 We excluded North Carolina, South Carolina, Virginia, West Virginia, and Delaware because their state highway systems included more than half of their states' roads, including a significant number of roads serving only local needs. We also excluded Alaska and Hawaii because of the unusual geography of those two states.

6 It should also be noted that spending on highways has grown slower than spending on most other state and local government functions. Driven largely by increased health and welfare expenditures, spending per capita on non-highway functions grew 48 percent in Minnesota between 1977 and 1993. As a result, the share of state and local government spending going to highways declined from 10.4 percent to 8.4 percent.

Table 1.6: Trends in State and Local Highway Spending, Minnesota and the United States, 1977-93

	Percentage Change	
	Minnesota	United States
Highway Spending	201%	195%
Highway Spending (inflation-adjusted)[a]	33	30
Population	13	17
Vehicle Miles of Travel	50	56
Spending per Capita (inflation-adjusted)	17	11
Spending per Vehicle Mile (inflation-adjusted)	(11)	(17)

Source: United States Census Bureau and Federal Highway Administration.

[a]Spending was adjusted for inflation using the deflator for state and local government consumption expenditures and gross investment.

Consequently, in Table 1.7, we present data on the Trunk Highway Fund by applying the Minnesota Construction Cost Index to construction spending from the fund and the PGSL to other spending from the fund. The data show that:

- **Expenditures by Mn/DOT out of the Trunk Highway Fund kept pace with inflation and population growth but not with traffic growth.**

Trunk highway spending grew 23 percent in constant dollars from 1977 to 1993. This growth exceeded the 13 percent population growth experienced in Minnesota but not the 50 percent growth in traffic volumes. The trunk highway system was able to accommodate some of the growth in traffic volumes over this period since there was excess capacity in the system. As we will see in Chapter 2, however, the growth in spending has not been sufficient to prevent growing congestion in Minnesota, particularly on the freeways of the Twin Cities metropolitan area.

Trunk highway spending has outpaced inflation but not the growth in traffic.

Table 1.7: Trends in Trunk Highway Spending by the Minnesota Department of Transportation, 1977-93

	Percentage Change
Spending	149%
Spending (inflation-adjusted)[a]	23
Spending per Capita (inflation-adjusted)	9

Source: Minnesota Department of Transportation and analysis by the Office of the Legislative Auditor.

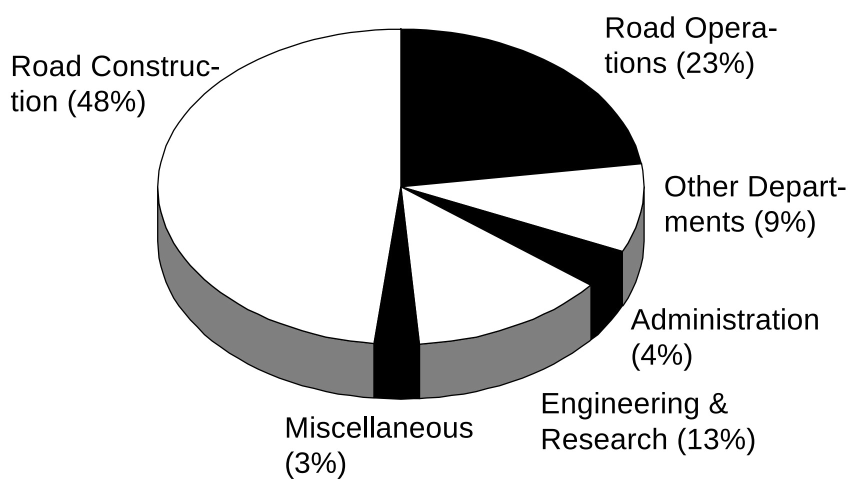
[a]The Minnesota Construction Cost Index was used to adjust construction spending for inflation. The deflator for state and local government consumption expenditures and gross investment was used to adjust other types of spending.

Trunk Highway Spending

During 1996, approximately $808 million in expenditures were made from the State Trunk Highway Fund. Figure 1.5 shows that in 1996 about 48 percent of the expenditures out of the fund were for road construction projects, including the acquisition of right-of-way. Road construction expenditures include road construction, reconstruction, resurfacing, and reconditioning projects, as well as bridge replacement, repair, and improvement projects. All of the items in the state road construction program are generally done by private contractors hired by Mn/DOT. Close to one-fourth of the spending went for state road operations, such as snowplowing and minor road repairs. Road operations are generally conducted by Mn/DOT personnel stationed around the state. Engineering and research accounted for 13 percent of trunk highway spending. This category primarily includes expenditures on engineering during both the design and construction phases of projects. It also includes Mn/DOT's research and investment management functions. Mn/DOT's administrative functions accounted for 4 percent of trunk highway spending, while other miscellaneous Mn/DOT costs, including building projects and debt service, were responsible for 3 percent of spending. Approximately 9 percent of spending out of the Trunk Highway Fund was done by departments other than Mn/DOT. The vast majority of spending in this category was done by the Minnesota Department of Public Safety, which primarily uses trunk highway monies for highway law enforcement and driver licensing.

Nearly half of the spending out of the Trunk Highway Fund is for the road construction program.

Figure 1.5: State Trunk Highway Expenditures, FY 1996

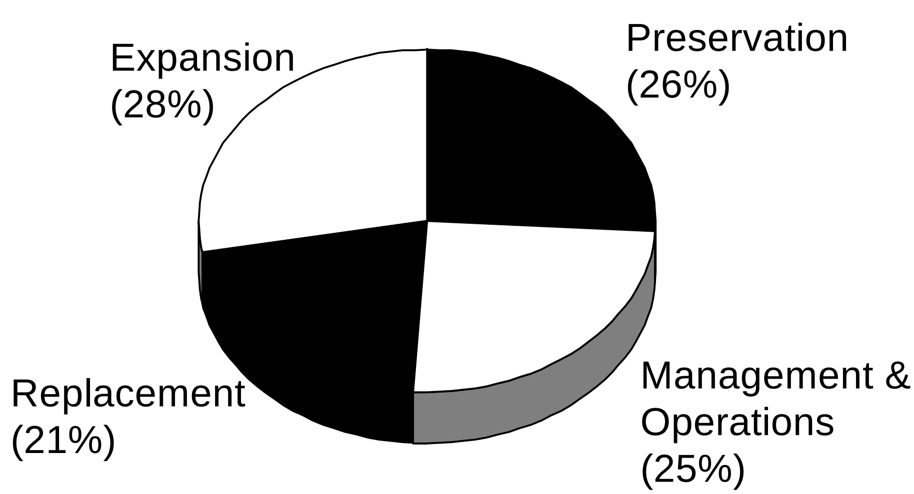


Source: Minnesota Department of Transportation.

Figure 1.6 provides greater detail on the $385 million of expenditures in the state road construction budget. Roughly equal shares were spent in 1996 on expansion (28 percent), preservation (26 percent), management and operations (25 percent), and replacement (21 percent).[7] Expansion projects generally attempt to reduce travel times and improve mobility over projected conditions. The goal of preservation projects is to maintain existing roads and bridges in acceptable condition. Preservation activities include road repair, resurfacing, and reconditioning, as well as bridge repair. Timely attention to preservation activities helps to maximize the life of roads and bridges.

The road construction budget funds expansion, preservation, replacement, and system management projects.

Figure 1.6: Expenditures in the State Road Construction Program, 1996



Source: Minnesota Department of Transportation.

The purpose of management and operation activities is to operate the existing highway system in a safe and efficient manner. This category includes the acquisition of right-of-way, safety improvements, traffic management, intelligent transportation systems, cooperative agreements, and miscellaneous improvements and enhancements.

The purposes of replacement projects are two-fold. Reconstruction of a road or replacement of a bridge may be done simply to replace a deteriorated piece of the system for which repair is no longer a cost-effective option. Alternatively, reconstruction or replacement may occur primarily to improve a part of the highway system for economic development reasons. In that case, the project may address safety, congestion, or weight restriction problems. Some replacement projects may serve both purposes.

7 These Mn/DOT estimates are based on the assumption that the $53.4 million spent on interstate preservation was divided among the four categories according to actual project histories studied in 1991. They may understate the amount of preservation activity and overstate the amount of expansion activity.

Mn/DOT

The Minnesota Department of Transportation is the principal state agency responsible for the "development, implementation, administration, consolidation, and coordination of state transportation policies, plans, and programs." Mn/DOT was established to create a "balanced transportation system, including aeronautics, highways, motor carriers, ports, public transit, railroads, and pipelines."[8]

The Commissioner of Mn/DOT is responsible for managing a department which had over 5,000 employees and spent or distributed funds totaling about $1.4 billion per year in 1996. As the organization chart in Figure 1.7 shows, the department has two deputy commissioners. One deputy commissioner oversees engineering and operations and serves as the chief engineer. Three divisions--Engineering Services, Operations (outstate), and Metropolitan--report to the chief engineer. The other deputy commissioner serves as chief financial officer and oversees the work of Mn/DOT's other three divisions: Finance and Administration, Transportation Research and Investment Management, and State Aid for Local Transportation.

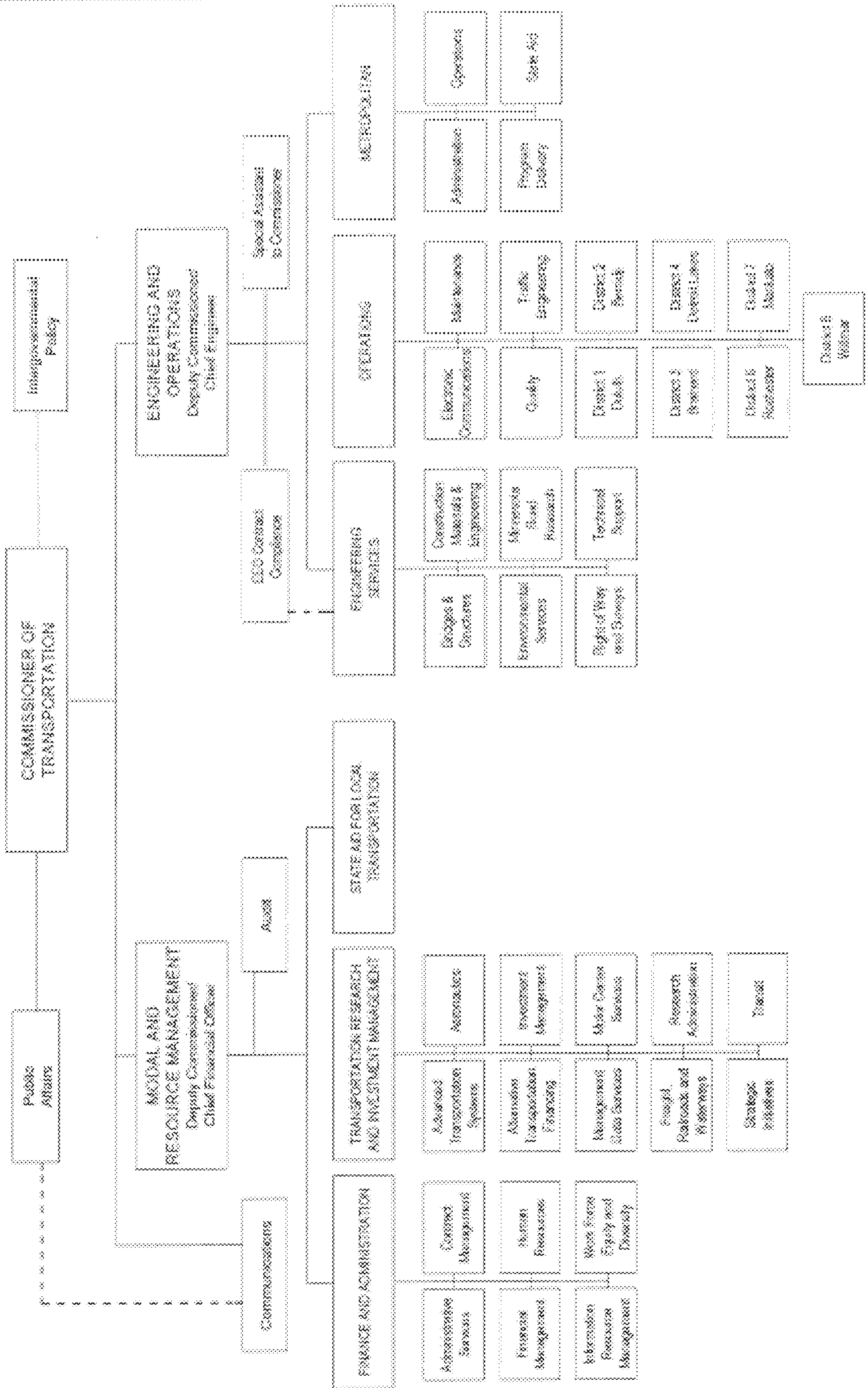
In terms of spending and staff, the State Trunk Highway System is Mn/DOT's largest responsibility. State and local roads together account for about 90 percent of the department's spending. Because Mn/DOT's role with local roads is mainly in setting standards and distributing state aid, local roads account for 40 percent of spending but only 1 percent of staff. About half of Mn/DOT's spending and 90 percent of its staff are involved with the maintenance and construction of the State Trunk Highway System. In addition, as Table 1.8 shows, 71 percent of Mn/DOT's full-time employees are involved in trunk highway operations and are located in Mn/DOT district offices or Metropolitan Division offices, maintenance area offices, and truck stations throughout the state. Another 5 percent of staff provide operations centrally or support the operations in the field. Centrally provided engineering services account for about 12 percent of Mn/DOT's total staff. Other centrally provided functions account for another 12 percent.

Decision-making within Mn/DOT was significantly decentralized in 1992.

Since about 1992, decision-making within Mn/DOT about highway construction and maintenance has been significantly decentralized. Mn/DOT's seven outstate district offices and the Metropolitan Division (see Figure 1.8) have the primary responsibility for delivering maintenance services and planning and overseeing construction work by contractors. District offices and the Metropolitan Division make maintenance and construction decisions with input from the central office at Mn/DOT and in coordination with Area Transportation Partnerships (ATPs). These ATPs are principally responsible for making decisions about how to spend federal funds allocated under the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). In the seven-county Twin Cities metropolitan area, the Metropolitan Council is the federally designated Metropolitan Planning Organization and is responsible for developing, in cooperation with Mn/DOT and

8 *Minn. Stat.* §174.01, Subd. 1.

Figure 1.7: Minnesota Department of Transportation Organization Chart, September 1996



Source: Minnesota Department of Transportation.

Figure 1.8: Minnesota Department of Transportation Districts

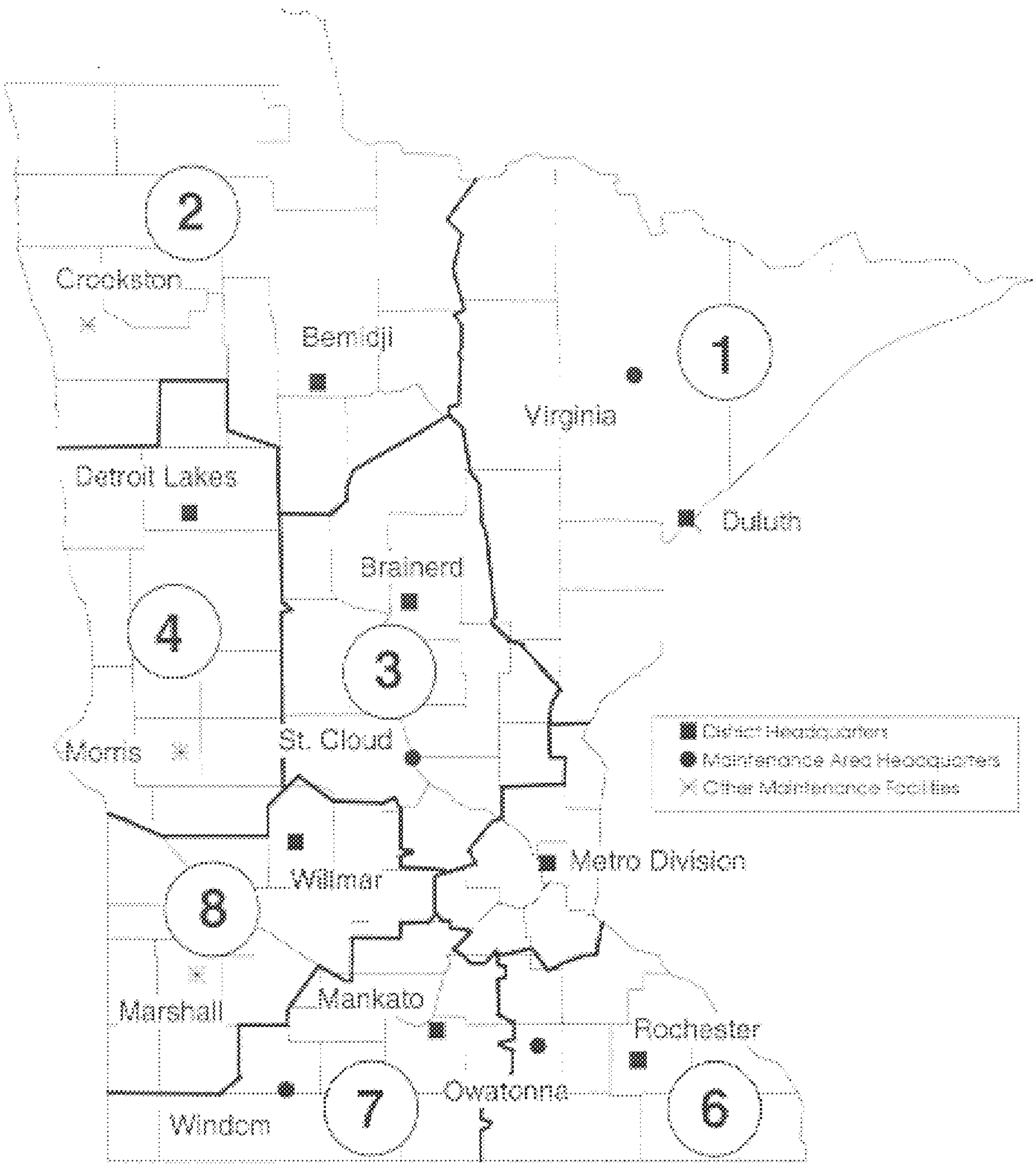


Table 1.8: Full-Time Mn/DOT Employees, June 1996

	Number	Percentage
Outstate Operations	2,182	43.7%
Metropolitan Operations	1,381	27.7
Central Operations	243	4.9
Subtotal: Operations	3,806	76.3%
Engineering Services	597	12.0%
General and Administration	288	5.8
Transportation Research and Investment Management	276	5.5
State Aid	24	0.5
Subtotal: Non-Operations	1,185	23.7%
Total	4,991	100.0%

Source: Minnesota Department of Transportation.

affected transit operators, a long-range transportation plan and a transportation improvement program for the area.

SUMMARY

Minnesota's state and local governments spend significantly more than the national average on highways. This is due in part to Minnesota's large network of rural roads, which are largely under the jurisdiction of local governments. Minnesota also spends more per mile than the national average for both state-administered roads and locally-administered roads. However, it is difficult to conclude much from this about Minnesota's State Trunk Highway System, because the national average is distorted by a handful of state highway agencies which have responsibility for more than half of the roads in their states.

Minnesota's trunk highways account for less than 10 percent of the roads in the state, but almost 60 percent of the traffic and about one-third of the highway spending. Trunk highway spending by Mn/DOT has generally kept up with inflation and population growth but not with increases in traffic volumes.

Trunk Highway Trends

CHAPTER 2

In Chapter 1, we reviewed how the size of and spending on Minnesota's road system, including both the State Trunk Highway (STH) System and locally administered streets and highways, compare with other systems across the nation. This chapter focuses on the condition of Minnesota's state trunk highways and bridges, as well as the resources the Minnesota Department of Transportation (Mn/DOT) has had available to construct, preserve, and maintain them. In particular, this chapter addresses the following questions:

- **How have trunk highway revenues and expenditures, as well as Mn/DOT staffing levels, changed over time?**
- **In what condition are Minnesota's trunk highway pavements and bridges and how has this changed over the last 10 years?**
- **How have Minnesota's trunk highways been affected by growing levels of traffic?**
- **How safe are Minnesota's roads and how has this changed over time?**

RESOURCES

In this section, we examine the trends in trunk highway resources since the mid-1970s. Detailed data on revenues and expenditures are available going back to 1974. Information on Mn/DOT staffing is available back to 1970 but is only adequate for trend analysis from 1985 to the present.

Revenues

From 1974 to 1996, revenues of the Trunk Highway Fund increased from $240 million to $864 million--a growth of 260 percent. However, as Table 2.1 shows, revenue growth in inflation-adjusted dollars was only 16 percent. Revenues per capita, when adjusted for inflation, declined 3 percent.

Vehicle registration taxes, which accounted for 31 percent of Trunk Highway Fund revenues in 1996, grew the fastest. In inflation-adjusted dollars, revenues

Table 2.1: Percentage Change in Trunk Highway Fund Revenues by Source, 1974-96

	Revenues[a]	Revenues per Capita[a]
Gas Taxes	11%	(7)%
Vehicle Registration Taxes	65	39
Federal Aid	(2)	(18)
Other	(18)	(31)
Total Revenues	16%	(3)%

Source: Minnesota Department of Transportation.

[a]Adjusted for inflation using the deflator for state and local government consumption exp enditures and gross investment.

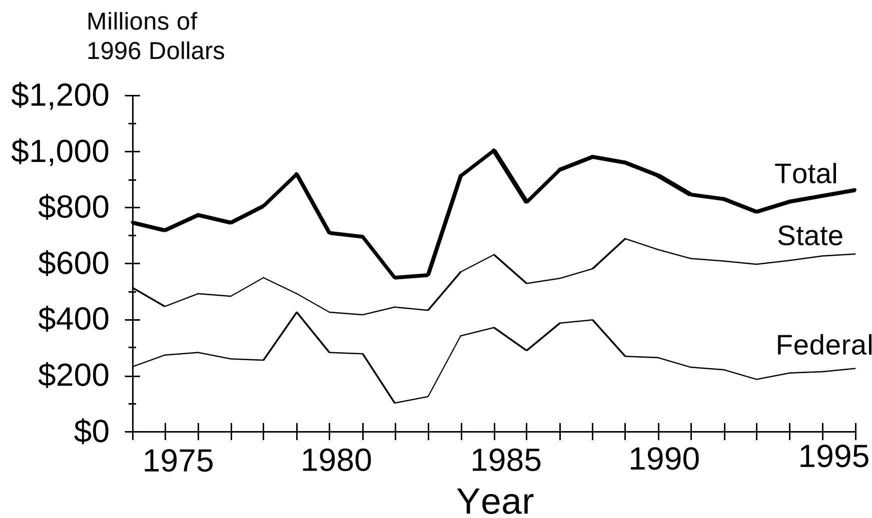
from vehicle registrations increased 65 percent. Even revenues per capita from vehicle registrations rose 39 percent. Gas tax revenues, which accounted for 35 percent of revenues, grew 11 percent between 1974 and 1996 but declined 7 percent in per capita terms. The other large source of revenues is federal aid, which accounted for 26 percent of revenues in 1996. Federal aid declined 2 percent in inflation-adjusted dollars and 18 percent relative to population.

Figure 2.1 shows that:

- **Trunk highway revenues, though relatively stable in the 1990s, have varied significantly in the past.**

Trunk highway revenues have generally kept pace with inflation but are below the peak reached in 1985.

Figure 2.1: Trunk Highway Fund Revenues by Source, 1974-96



Source: Program Evaluation Division analysis of Mn/DOT data.

Inflation-adjusted revenues grew 23 percent from 1974 to 1979 but plunged 40 percent between 1979 and 1982. By 1985, however, trunk highway revenues grew 83 percent from their 1982 low point. Revenues in 1996 were about 14 percent lower than the peak reached in 1985.

Much of the variation in revenues was due to changes in federal aid, which declined 76 percent between 1979 and 1982 and then rose 258 percent by 1985. Fluctuations in state revenue sources played a lesser role. To some extent, revenue peaks were accentuated by state revenues from bonds or motor vehicle excise taxes. The Trunk Highway Fund received revenues from these sources during only a few years, but some of those years also happened to be peak years for the receipt of federal aid. By comparison, the major state revenue sources--gas taxes and motor vehicle registration taxes--have not fluctuated much.

Spending

Highway construction prices have increased less than the general rate of inflation.

Like Trunk Highway Fund revenues, expenditures from the fund have increased since 1974. Just how much expenditures have increased since 1974 depends, however, on the index one uses to measure inflation. In analyzing revenue trends, we used an index--the national price deflator for state and local government consumption expenditures and gross investment (PGSL)--which reflects the general rate of inflation faced by state and local governments. This index shows that prices faced by state and local governments increased 209 percent between 1974 and 1996. Over the same period, according to Mn/DOT, prices for highway construction increased only 109 percent. This latter figure is based on the Minnesota Construction Cost Index, which reflects changes in highway and bridge construction prices faced by Mn/DOT.

We analyzed the trends in trunk highway expenditures in two ways. First, we used the PGSL to convert all expenditures to 1996 dollars. Table 2.2 shows that inflation-adjusted expenditures increased 6 percent from 1974 to 1996. The fastest growth was for general support and administration within Mn/DOT, which has doubled since 1974. Spending on equipment and buildings also increased significantly but, like general support and administration, accounts for a small portion of trunk highway expenditures. Also increasing faster than average were highway maintenance operations and spending by other state agencies. Expenditures on engineering services provided during the design and construction phases of projects declined 6 percent, while highway and bridge construction spending grew only 2 percent.

The second method we used to analyze spending trends was different in one respect. We used the Minnesota Construction Cost Index to convert highway construction spending to 1996 dollars. For all other types of spending, we continued to use the PGSL to make this conversion. Table 2.3 shows the impact of using this method. Instead of increasing 2 percent:

- **Inflation-adjusted spending on highway and bridge construction increased 52 percent between 1974 and 1996.**

Table 2.2: Percentage Change in Trunk Highway Fund Expenditures by Type, 1974-96

	Expenditures[a] (in Millions of 1996 Dollars)		
	1974	1996	Percentage Change
Highway Construction	$378	$385	2%
Operations[b]	141	176	24
Engineering, Research, and Investment Management	112	105	(6)
General Support and Administration[b]	13	27	110
Highway Bonds and Debt Service	39	19	(52)
Equipment and Buildings	17	18	7
Other[c]	60	78	30
Total	$761	$808	6%

Source: Minnesota Department of Transportation.

[a]Adjusted for inflation using the deflator for state and local government consumption expenditures and gross investment.

[b]Excludes equipment.

[c]Primarily includes spending by other state agencies.

In 1996 dollars, trunk highway spending has increased 27 percent since 1974.

Table 2.3: Percentage Change in Trunk Highway Fund Expenditures on Highway Construction, 1974-96

	Expenditures (in Millions of 1996 Dollars)		
	1974	1996	Percentage Change
Highway Construction[a]	$254	$385	52%
All Other[b]	383	423	11
Total	$637	$808	27%

Source: Minnesota Department of Transportation.

[a]Adjusted for inflation using the Minnesota Construction Cost Index.

[b]Adjusted for inflation using the deflator for state and local government consumption expenditures and gross investment.

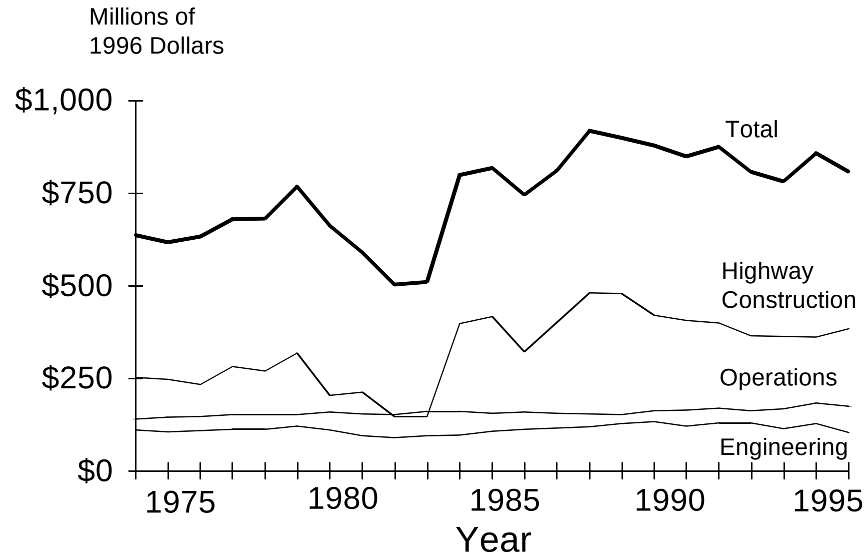
Combined with an average increase of 11 percent for other trunk highway expenditures, this substantial increase in construction spending resulted in an increase of 27 percent in overall trunk highway expenditures.

On balance, we think that this second method provides a better indication of trunk highway spending trends than the first method. It is more appropriate to apply the Minnesota Construction Cost Index to highway construction expenditures, since this cost index directly measures the changes in construction prices affecting Mn/DOT.[1]

Figure 2.2 shows the trends in Trunk Highway Fund expenditures based on the second method. As we saw earlier with revenue trends, expenditures have grown since 1974 but have fluctuated from year to year. Spending in 1996 is 27 percent greater than 1974 spending but about 12 percent below the spending peak reached in 1988. The principal source of revenue fluctuations was federal aid. Because federal aid is primarily used for highway construction, it makes sense that highway construction spending has also fluctuated over this time period.

Highway construction spending has fluctuated a lot due to changes in the level of federal aid.

Figure 2.2: Trunk Highway Fund Expenditures by Type, 1974-96



Source: Program Evaluation Division analysis of Mn/DOT data.

It is important to place the increase in trunk highway spending into perspective. The 27 percent increase in trunk highway spending exceeds the growth in the size of the trunk highway system. The number of centerline miles on the system has declined about 1 percent since 1974, while the number of lane miles has increased about 1 percent. The increase in spending is also greater than the 19 percent increase in Minnesota's population, but less than the increase in vehicle miles traveled in Minnesota, which exceeded 75 percent.

Staffing

Available data indicate that the number of staff in Mn/DOT declined significantly from 1970 until 1982. Staffing then rose until about 1990 and has declined

1 One potential drawback to the second method is that the Minnesota Construction Cost Index does not reflect changes in land prices. The highway construction category includes right-of-way purchases, as well as construction spending.

slightly since then. Due to data problems, it is not exactly clear how current staffing levels compare with levels prior to 1985. It appears, however, that the number of full-time equivalent employees has decreased since 1970.

The best available data are presented in Table 2.4. They show that the number of full-time employees in Mn/DOT increased about 16 percent between 1985 and 1990, but has declined 3 percent since then. The overall increase in full-time employees since 1985 was 12 percent. The number of part-time employees has declined during both of these periods and is down 70 percent since 1985. Although data on the number of full-time equivalent employees are not available, we can roughly estimate the number by assuming that part-time employees worked an average of 20 hours per week. Under that assumption, the number of full-time equivalent employees increased 9 percent between 1985 and 1990 but then decreased 3 percent by 1996. The overall increase in the estimated number of full-time equivalent employees between 1985 and 1996 was 6 percent.

Table 2.4: Number of Full-Time and Part-Time Employees of the Minnesota Department of Transportation, 1985-96

	June 1985	June 1990	June 1996	Percentage Change (1985-96)
FULL-TIME EMPLOYEES				
Districts and Metropolitan Division	3,245	3,765	3,563	10%
Other	1,219	1,402	1,428	17
Total	4,464	5,167	4,991	12%
PART-TIME EMPLOYEES				
Districts and Metropolitan Division	531	217	117	(78)%
Other	123	116	81	(34)
Total	654	333	198	(70)%

Source: Minnesota Department of Transportation.

The table also shows that the number of full-time employees in the field--namely, working for the outstate district offices or the Metropolitan Division--has increased slower than the number of central office employees. Also, the number of part-time employees in the field has declined more than the number of part-time staff assisting in central office functions. A rough estimate suggests that the number of full-time equivalent employees in the field increased 3 percent from 1985 to 1996, compared with a 15 percent increase for the central office.

This shift in staff resources has come during a period in which the field offices have been asked to take on greater responsibilities. Since about 1992, Mn/DOT has decentralized some of its decision-making and let the districts and the Metropolitan Division make more decisions on how to spend money allocated to them.

PAVEMENTS

In this section, we examine changes in the condition and age of Minnesota's trunk highways since 1985. We also consider whether Minnesota faces a backlog of rehabilitation work.

Background

The vast majority of Minnesota's trunk highways are in rural parts of Minnesota. As Table 2.5 shows, 87 percent of trunk highway miles are outside the 7-county Twin Cities metropolitan area, and 86 percent are in rural areas. Traffic, however, is more evenly distributed. Trunk highways in the Twin Cities metropolitan area carry about 48 percent of the traffic on the State Trunk Highway System. Urban areas throughout the state account for 49 percent of the traffic.

About 86 percent of the trunk highway mileage and half of the system's traffic are in rural areas of the state.

Table 2.5: Percentage of State Trunk Highway Miles and Traffic, 1995

	Share of Roadway Miles	Share of Vehicle Miles of Travel
Twin Cities Metro Area	13%	48%
Outstate	87	52
Urban Areas	14	49
Rural Areas	86	51
Interstate Highways	13	37
Principal Arterials	38	42
Minor Arterials	40	20
Collector and Local Highways	9	2

Source: Minnesota Department of Transportation.

Interstate highways account for a disproportionate share of the traffic. While 13 percent of the trunk highways are on the federal interstate system, Minnesota's interstate highways carry 37 percent of the trunk highway traffic. Principal arterials account for 38 percent of the miles and 42 percent of the traffic. Other highways represent nearly half of the trunk highway miles but only 22 percent of the traffic.[2]

Overall, Minnesota's trunk highways consist primarily of bituminous materials, but interstate highways are generally concrete. As Table 2.6 shows, about 62 percent of all trunk highways are bituminous, while 18 percent are concrete and 20 percent have a concrete base overlaid with bituminous. The choice between

2 In discussing pavements, we are using *roadway miles*, rather than *centerline miles* or *lane-miles*. The State Trunk Highway System currently has about 12,000 centerline miles, 14,200 roadway miles, and 28,800 lane-miles of highways. Each mile of highway is counted only once to measure centerline miles, while each lane is counted separately to obtain lane-miles. In measuring the number of roadway miles, each centerline mile is counted twice if the highway has four or more lanes for traffic.

Table 2.6: State Trunk Highway Miles by Type of Pavement and Surface, 1996

	Interstate	Non-Interstate	All Trunk Highways
Bituminous	15%	69%	62%
Concrete	66	11	18
Bituminous over Concrete	20	20	20
Total[a]	100%	100%	100%

Source: Minnesota Department of Transportation.

[a]Some totals do not sum due to rounding.

bituminous and concrete generally depends on traffic volumes and soil conditions. Concrete tends to last longer but costs more initially. Concrete is more likely to be used on roads with high traffic volumes. As a result, two-thirds of Minnesota's interstate highways are concrete, while only 15 percent are bituminous. Concrete highways are generally overlaid with bituminous when they get older and can no longer be effectively repaired with concrete materials. About 20 percent of the interstate highways and other trunk highways consist of a bituminous surface over a concrete pavement.

Condition

Mn/DOT uses the Pavement Quality Index (PQI) to measure the overall quality of trunk highway surfaces. The PQI is a composite measure of the present serviceability rating (PSR) and the surface rating (SR). [3] The PSR measures the rideability or smoothness of the pavement, while the SR measures the degree of pavement surface defects or distresses.

In theory, the PQI can range from zero to almost 4.5. The PSR can range between zero and 5.0, while the SR ranges from zero to 4.0. Higher numbers on any of these indices represent better pavement quality.

Pavement quality has increased slightly since the mid-1980s.

Trends

Figure 2.3 shows that:

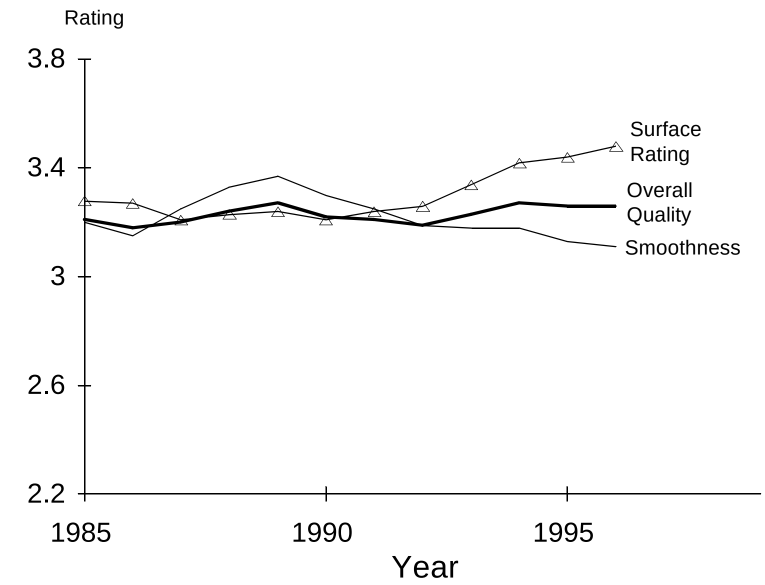
- **Overall pavement quality has increased slightly since 1985.**

Between 1985 and 1996, the PQI has varied within a narrow range from 3.18 to 3.27. The PQI increased less than 2 percent from 3.21 in 1985 to 3.26 in 1996. The figure also shows that:

- **Surface defect ratings have improved since 1985, while the smoothness of pavements has declined.**

3 Mathematically, the PQI is the square root of the product of the PSR and the SR.

Figure 2.3: Pavement Quality Ratings for State Trunk Highways, 1985-96



Source: Minnesota Department of Transportation.

The surface rating or SR has increased 6 percent from 3.28 in 1985 to 3.48 in 1996. The PSR increased from 3.20 in 1985 to 3.37 in 1989 but has declined almost every year since then. The current PSR of 3.11 is about 3 percent lower than it was in 1985.

It is not entirely clear why the rideability or smoothness of pavements has declined since 1989. In part, it may be related to the relatively small amount of grinding done on concrete pavements following a concrete pavement repair. The purpose of grinding is to improve the smoothness of the ride by leveling off the difference in height between adjacent concrete sections of the highway. This reduces the thumping noise heard by motorists and improves the ride. One of the biggest drops in the PSR rating is on concrete pavements on interstate highways.

Current Condition

Pavement quality is generally higher on more heavily traveled highways.

Table 2.7 indicates that:

- **The PQI is generally higher on interstate highways and principal arterials than on other trunk highways.**

Table 2.7 indicates that the average PQI in 1996 was 3.37 on interstate highways and 3.28 on principal arterials. Minor arterials had an average rating of 3.23, while collector and local highways had a rating of 3.15. There is also a smaller share of interstate highway miles with lower PQI ratings. Only 11 percent of interstate highway miles are rated at 2.8 or lower, while 20 percent or more of other types of trunk highways are similarly rated.

Table 2.7: Pavement Quality Index for State Trunk Highways by Type of Highway, 1996

	Average Pavement Quality Index	Percentage Rated at 2.8 or Lower
Interstate Highways	3.37	11%
Principal Arterials	3.28	20
Minor Arterials	3.23	22
Collector and Local Highways	3.15	26
All Trunk Highways	3.26	20%

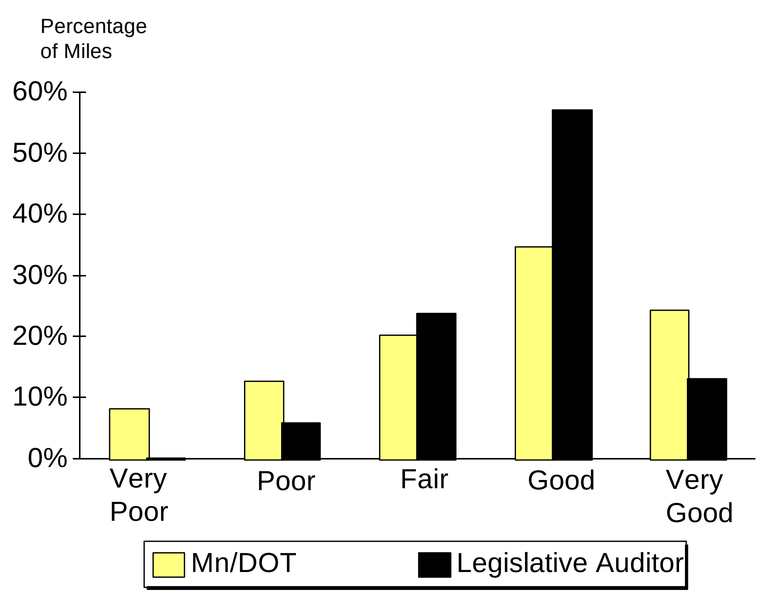
Source: Minnesota Department of Transportation.

Mn/DOT has assigned labels to the values of the PQI. Ratings of 3.7 or higher are considered to be "very good" or "excellent," and ratings of 3.3 to 3.6 are considered to be "good." A PQI of 2.9 to 3.2 is said to be "fair," while a rating of 2.5 to 2.8 is considered "poor" pavement quality. Pavements with a PQI of 2.4 or less are said to be in "very poor" condition.

About 70 percent of trunk highway pavements are in good or very good condition.

According to Mn/DOT's rating system, the average trunk highway has an overall pavement quality rating between "fair" and "good." Figure 2.4 indicates that, according to Mn/DOT, 24 percent of the trunk highways have a "very good" rating and 35 percent are rated "good." About 20 percent are rated "fair," while 12 percent are rated "poor" and 8 percent are considered to be in "very poor" condition.

Figure 2.4: Distribution of Overall Pavement Quality for State Trunk Highways, 1996



Source: Program Evaluation Division analysis of Mn/DOT data.

Although we have no disagreement with Mn/DOT over how ratings are calculated, we do not believe that the labels Mn/DOT has assigned to PQI ratings are appropriate. In fact, the labels are inconsistent with how Mn/DOT has calibrated the PSR portion of the PQI. The Pavement Management Unit in Mn/DOT constructed the PSR so that roads with a PSR of 4.0 or more were considered to be in ''very good'' condition and roads with a PSR of 3.0 to 3.9 were in ''good'' condition. Similarly, roads in ''fair'' condition from a smoothness standpoint were given a PSR of 2.0 to 2.9, while roads in ''poor'' condition were assigned PSR values between 1.0 and 1.9. Only roads with a PSR between 0.0 and 0.9 were considered to be in ''very poor'' condition.

An example illustrates how Mn/DOT's PQI labels are inconsistent with how the PSR was constructed. A road with a PSR of 2.0 and an SR of 4.0 would have a PQI of 2.8 and thus, according to Mn/DOT, would be in ''poor'' condition. However, a road with a PSR of 2.0 is considered to be ''fair'' from a smoothness perspective, and a road with an SR of 4.0 is in ''excellent'' shape, since 4.0 is the maximum surface rating. It is unclear why a road with an excellent surface rating and a fair rideability or smoothness rating should be categorized as being in poor condition.

Working with Mn/DOT's Pavement Management Unit, we derived more reasonable labels to apply to PQI ratings.[4] We think that Mn/DOT's labels underidentify the number of miles of ''good'' pavements while overidentifying the number of miles of ''poor'' and ''very poor'' pavements. Mn/DOT's labels also may overidentify the number of miles of ''very good'' pavements, although they underidentify the combined number of miles which are either in ''good'' or ''very good'' condition. Figure 2.4 shows that, in our view:

Only 6 percent of trunk highway pavements are in poor or very poor condition.

- **The typical trunk highway was in "good" condition, and only 6 percent of all pavements were in "poor" or "very poor" condition in 1996.**

We think that 13 percent of trunk highway miles were in ''very good'' condition in 1996, and 57 percent were in ''good'' condition. About 24 percent were in ''fair'' condition, while slightly fewer than 6 percent were in ''poor'' condition. Only 13 miles of the trunk highway system, or about 0.1 percent, were in ''very poor'' condition.[5]

As a result, we think that:

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4 To get more accurate PQI labels, we had to make assumptions about how to label various surface ratings. For the purposes of this report, we called surface ratings of 3.6 to 4.0 very good , 3.2 to 3.5 good, 2.8 to 3.1 fair, 2.4 to 2.7 poor, and 2.3 or less very poor. Although different cutoff s could be used, they would probably not change the basic conclusion that Mn/DOT's current PQI labels overidentify the number of miles in poor or very poor condition and understate the combined number in good or very good condition.

5 Based on Mn/DOT's calibration of the PSR and the assumptions we used for the SR, we assigned the following labels to PQI ratings: 3.8 to 4.5 (very good), 3.1 to 3.7 (good), 2.4 to 3.0 (fair), 1.5 to 2.3 (poor), and 0.0 to 1.4 (very poor).

- **Mn/DOT does not have a backlog of pavements in "poor" condition but would have a backlog if it reduced the average amount of surface rehabilitation work done each year.**

Mn/DOT does not have a backlog of pavements in poor condition.

From 1986 to 1995, Mn/DOT did about 938 miles of resurfacing, concrete pavement repair, and reconstruction work annually. This annual amount of work represented about 6.7 percent of the roadway miles on the trunk highway system during this 10-year period. Based on information from Mn/DOT engineers, we estimate that the average expected life of surfaces on trunk highways has been about 15 years.[6] On average, Mn/DOT would have to resurface about 6.7 percent of its highways annually in order to maintain a constant average surface age and probably a constant PQI. Over the last 10 years, Mn/DOT has been able to maintain that pace of activity. In fact, the PQI has increased slightly and, as we will see, the average surface age has declined a bit. However, if Mn/DOT was unable to maintain this amount of activity, we would expect to see a decline in PQI and an increase in average surface age. While Mn/DOT has very few roads in poor condition now, the number of roads in poor condition would grow and a backlog of needed work would develop if Mn/DOT did not continue to rehabilitate at least an average of about 6.7 percent of the roads annually.

In Chapters 3 and 4, we will see that the above conclusion may need to be modified in two ways. First, we think that the amount of rehabilitation work done annually may need to be increased over time in order for Mn/DOT to maintain a constant PQI. This is due to increasing traffic loads and the declining percentage of trunk highways which consist only of their original surfaces. Second, we think that, if Mn/DOT did more preventive maintenance, it might reduce the number of miles of resurfacing work needed over the long run. Mn/DOT, however, finds it difficult to spend more on preventive maintenance because each spring it has plenty of roads which need resurfacing, and Mn/DOT does not want to develop a backlog of roads in poor condition.

Comments

By assigning more appropriate labels to the PQI, we have been able to more fairly assess the current condition of pavements on the trunk highway system. However, we have not been able to address certain issues due to a lack of adequate data.

First, it is not possible at this time to compare the condition of Minnesota's trunk highway pavements with other states. Although the Federal Highway Administration (FHWA) publishes state-by-state comparisons of pavement roughness, these comparisons are not valid. States use different equipment to measure pavement roughness. Without proper calibration of equipment, valid comparisons cannot be made. The existing FHWA data should not be used to draw any conclusions about the relative condition of Minnesota's highways.

6 This figure is the average expected time between surface rehabilitations. Underlying pavements are expected to last considerably longer. The systemwide average of 15 years is based on an average of 15 years for bituminous surfaces, 17.5 years for concrete surfaces, and 12 years for bituminous surfaces over concrete pavements. In Chapter 3, we discuss why the average expected surface life of trunk highways may decrease in the future.

Second, the PQI does not measure the adequacy of the underlying pavement relative to the traffic and loads it carries. The PQI measures smoothness and surface defects but does not directly indicate a pavement's structural adequacy. A pavement can have a shorter life if the loads it carries exceed its design capacity or are too high during the crucial thawing period in spring. Mn/DOT does not have a statewide system of collecting data on the structural condition of all trunk highways. Some districts, however, collect these data on all or a portion of their highways. District 2 in Bemidji reported to us that the number of miles at risk due to loads has increased from 218 miles in 1989 to 362 miles in 1995. This increase is due in part to increasing truck traffic. In addition, Minnesota increased the general weight limit on trunk highways in 1986 and reduced the load restrictions on principal arterials and key market routes during spring. The lessening of load restrictions may have placed more roads at risk of premature failure.

Finally, the pavement quality trends we examined do not include any possible worsening of pavement conditions during recent winter months. PQI data reflect conditions during 1996 prior to the winter of 1996-97. [7] According to some accounts, this winter has taken an unusually harsh toll on Minnesota's roads, including its trunk highways. Not only have state and local governments incurred larger than average snow removal costs, but roads have also experienced more potholes than usual. Any effect of the 1996-97 winter on the pavement quality of Minnesota's trunk highways will not begin to show up in PQI measurements until data are collected later this year. In addition, the magnitude of the effect is unclear at this point because Mn/DOT will probably repair most of the potholes before PQI measurements are taken.

Age

The average age of trunk highway surfaces has declined, although pavement age has continued to increase.

An examination of pavement and surface ages provides both encouraging and discouraging signs for Minnesota's trunk highways. On the one hand, as Table 2.8 indicates:

- **The average age of the surfaces on Minnesota's trunk highways declined from 11.5 years in 1985 to 10.9 years in 1995.**

Table 2.8: Average Surface and Pavement Ages, 1985 and 1995

	Average Age in Years	
	Surface	Pavement
1985	11.5	32.5
1995	10.9	39.8

Source: Minnesota Department of Transportation.

7 More precisely, the 1996 PQI data reflect conditions in both 1995 and 1996. Data needed to calculate the PQI are collected on about half of the trunk highways each year. As a result, the 199 6 PQI data consist of 1996 measurements for half of the trunk highways and 1995 measurements for the other half.

This is encouraging news, because it indicates that construction and rehabilitation work on the State Trunk Highway System have been sufficient over the last decade to reduce the average age of the surfaces on trunk highways. A highway is considered to have a new surface if it has just been constructed, reconstructed, resurfaced, or had a concrete pavement repair. [8]

On the other hand, the average pavement age on trunk highways has increased steadily from 32.5 years in 1985 to 39.8 years in 1995. Pavement age indicates the age of the underlying pavement, which may have been resurfaced one or more times since the road was initially built. Although this is not a favorable trend, the significance of this trend is unclear. It is not known how long pavements can last if properly maintained. One point of view suggests that pavements may last indefinitely as long as they are properly maintained and are resurfaced before they deteriorate too much. Another point of view suggests that, while pavements may be able to have indefinite lives, each successive overlay or new surface applied to a pavement may last a shorter time than the previous surface.

One way of illustrating the aging of Minnesota's trunk highway pavements is provided by Table 2.9. Between 1985 and 1995, the share of trunk highway miles which have their original bituminous surface has declined from 14 percent to 8 percent. In contrast, the share which have been resurfaced at least once has increased from 47 percent to 53 percent of all trunk highway miles. Also, the share of concrete pavements declined from 24 percent to 19 percent, while the share of bituminous-over-concrete pavements increased accordingly. Based only on the changes in the shares of concrete and bituminous-over-concrete pavements, we estimate that the average expected life of trunk highway surfaces may have

Fewer trunk highways have their original surface.

Table 2.9: Change in Pavement and Surface Composition of State Trunk Highways, 1985-95

	1985	1995
Original Bituminous	14%	8%
Bituminous over Bituminous	47	53
Concrete	24	19
Bituminous over Concrete	15	19
Total[a]	100%	100%

Source: Minnesota Department of Transportation.

[a]Some totals do not sum due to rounding.

8 The average surface age of 10.9 years is high relative to an average expected life of 15 years and might indicate that Mn/DOT has a backlog of old pavements needing work. One would generally expect the average age to be about 8 years, given a 15-year life. However, we do not think that average surface life indicates a backlog problem for two reasons. First, the median surface age is 9 years and might be closer to 8 years if Mn/DOT had more accurate data on the last time some roads were resurfaced. According to Mn/DOT's Pavement Management Unit, some roads may have been resurfaced but the resurfacing was not reported to the Unit. Second, some old trunk highways have performed well despite their age. Good original materials and low levels of truck traffic may explain why some roads still have a good PQI even though they have not been resurfaced in 20 or more years.

declined by as much as 0.25 years between 1985 and 1995. This estimate does not reflect any deterioration in the average expected surface life due to the shift from original bituminous to bituminous-over-bituminous highways.

BRIDGES

In this section, we review the condition and age of trunk highway bridges. Trend data are available for at least the last 8 years and, in some cases, for the last 10 years. We also consider whether Mn/DOT has a backlog of bridges needing work.

Background

In 1995, there were 2,911 bridges and 1,703 culverts on Minnesota's trunk highway system.[9] The total number of trunk highway structures has increased 2 percent from 4,530 in 1988 to 4,614 in 1995. The total area of these structures, as measured by the sum of the total deck area of bridges and the roadway area of culverts, is perhaps a better indicator of the size of the system and its funding needs over the long run. The total area of trunk highway structures has increased 9 percent since 1988, growing from 40.5 million square feet to 44.1 million square feet. In 1995, bridges accounted for 92 percent of the total area. Culverts accounted for only 8 percent of the area, while accounting for 37 percent of the total number of trunk highway structures.

About 60 percent of the deck area on Minnesota's bridges is on the trunk highway system.

The State Trunk Highway System has a majority of the structure area in the state, although it only has about one-fourth of the bridges and culverts in the state. In 1995, the trunk highway system accounted for 23 percent of Minnesota's bridges and culverts and 60 percent of the total structure area. Most of the long bridges in the state are on the trunk highway system.

Condition

There are several indicators which can be used to assess the current condition of trunk highway bridges and culverts and track changes in condition over time. Below, we examine sufficiency ratings, condition ratings, and various measures of the extent of bridge deficiencies.

Sufficiency Ratings

Sufficiency ratings are used for federal funding purposes and are calculated using a complicated formula. In general, the sufficiency rating considers three factors: structural adequacy and safety, serviceability and functional obsolescence, and

9 A culvert is a drainage opening beneath an embankment.

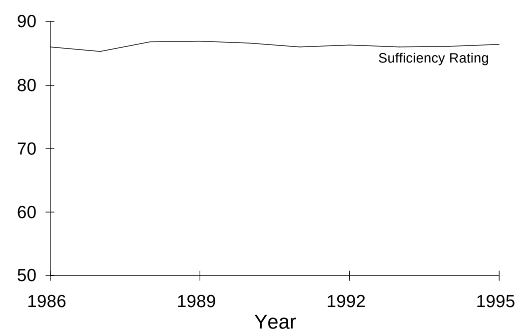
essentiality for public use.[10] These three factors account for 55 percent, 30 percent, and 15 percent respectively of the sufficiency rating. The maximum sufficiency rating is 100. A sufficiency rating less than 80 is used by the federal government to indicate that a bridge qualifies for rehabilitation funding. A sufficiency rating less than 50 qualifies a bridge for replacement funding.

Figure 2.5 shows that:

- **The average sufficiency rating on trunk highway bridges has been relatively constant between 1986 and 1995.**

During this period, the average rating has varied within a narrow range from 85.3 to 86.9. Between 1986 and 1995, the average rating has increased less than 1 percent.

Figure 2.5: Average Sufficiency Rating for Trunk Highway Bridges, 1986-95



Source: Minnesota Department of Transportation.

Condition Ratings

The typical trunk highway bridge is in good to fair condition.

Condition ratings focus exclusively on the structural adequacy of bridges. Unlike sufficiency ratings, condition ratings do not consider the serviceability of bridges and whether they meet various width and other geometric criteria. Condition ratings also do not explicitly measure the relative importance of bridges like sufficiency ratings do, but condition ratings can be compared for bridges on different types of trunk highways.

A condition rating can range from zero to 9, with a 9 indicating a new bridge and a zero indicating a bridge that is unusable. Generally, bridges with ratings of 7 to 9 are considered to be in good to excellent condition. Ratings of 5 or 6 indicate that a bridge has some deficiencies but is in fair or satisfactory condition. Ratings of 4 or less indicate that a bridge is in poor to critical condition.[11]

Table 2.10 shows that:

- **The typical trunk highway bridge is in good to fair condition.**

10 Serviceability primarily measures the extent to which a bridge meets various geometric criteria including such factors as the bridge's roadway width and alignment, vertical and horizontal clearances, and underclearances. Essentiality for public use refers to the importance of the bridge in terms of the type of highway it serves, the traffic it carries, and the length of the detour which would be necessary if the bridge could not be used.

11 United States Department of Transportation, *The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* (Washington, D.C., 1993), 123.

Table 2.10: Average Condition Ratings for Trunk Highway Bridges and Culverts, 1995

	Superstructure	Deck	Substructure	Culverts
Interstate Highways	7.25	6.99	7.05	6.87
Other Federal Aid Highways	7.11	6.93	7.01	6.75
Other Trunk Highways	6.89	6.64	6.74	6.59
All Trunk Highways	7.09	6.84	6.92	6.64

Source: Minnesota Department of Transportation.

Bridge sufficiency ratings have increased slightly since the mid-1980s, while condition ratings have declined a bit.

The table provides average condition ratings for bridge superstructures, decks, and substructures, as well as for culverts. [12] In 1995, the typical bridge had ratings in the low 7s or high 6s, indicating that the average bridge was in good to fair condition. Culverts had a slightly lower rating but still a satisfactory one.

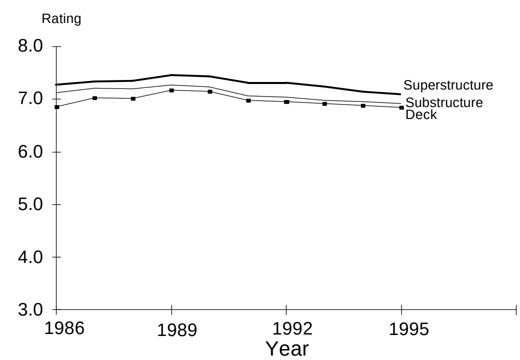
Condition ratings are generally somewhat higher for bridges on interstate and other federal aid highways than for bridges on other trunk highways. For example, the average condition rating for superstructures was 7.25 on interstate highway bridges in 1995 and 7.11 on other federal aid highway bridges. In contrast, bridge superstructures on other trunk highways had an average rating of 6.89.

Figure 2.6 displays the trends in condition ratings from 1986 to 1995. Condition ratings of all components increased between 1986 and 1989 and have declined since 1989. In general:

- **Bridge and culvert condition ratings in 1995 were slightly lower than ratings in 1986.**

The average superstructure rating decreased 2 percent, while the average substructure rating decreased 3 percent and the average culvert rating declined 6 percent. The average deck condition rating decreased less than 1 percent.

Figure 2.6: Average Condition Ratings for Trunk Highway Bridges, 1986-95



Source: Minnesota Department of Transportation.

12 The superstructure of a bridge includes the entire portion of a bridge structure which receives and supports traffic loads and in turn transfers the resulting reactions to the bridge substructure. The superstructure includes the deck, which comes in direct contact with vehicle loads, as well as the floor system, supporting members, and bracing. The substructure includes the abutments, piers, grillage, or other construction built to support the superstructure and transfer loads from the superstructure to the ground. Culverts do not have a definite distinction between superstructure an d substructure and have no deck.

Slight declines in condition ratings were generally experienced on each of the three types of trunk highways we discussed above. For example, average superstructure condition ratings declined from 7.44 to 7.25 on interstate bridges from 1986 to 1995. On other federal aid highways, the average bridge superstructure rating decreased from 7.26 to 7.11. Bridges on other trunk highways experienced a decrease from 7.13 to 6.89.

Deficient Structures

Mn/DOT routinely tracks the number of structures that are deficient. There are two types of deficient bridges and culverts--structurally deficient and functionally obsolete. A structurally deficient bridge or culvert generally has one or more of its major components in poor structural condition. A functionally obsolete bridge does not meet the criteria established for width, clearance, roadway alignment, or load carrying capacity. [13] Any structure classified as structurally deficient is excluded from the functionally obsolete category so that it is not double counted.

There are three different categories that Mn/DOT uses to track deficient bridges. One category includes only those deficient bridges which have a sufficiency rating below 50. These bridges are eligible for federal replacement or rehabilitation funding. A second category includes deficient bridges with a sufficiency rating below 80. Bridges with sufficiency ratings between 50 and 80 are eligible for federal rehabilitation funding. The third category includes all deficient bridges including those with sufficiency ratings of 80 or more.

Data on deficient bridges are presented in Table 2.11. The extent of the deficiencies can be measured in three ways: 1) the number and percentage of bridges which are deficient, 2) the deck area on deficient bridges and the percentage of all deck area which is on deficient bridges, and 3) the estimated cost to eliminate bridge deficiencies through replacement or remodeling.

Table 2.11: Deficient Trunk Highway Bridges, 1990 and 1995

	Year	Number of Deficient Bridges	Percentage of Bridges	Deck Area (in Millions of Square Feet)	Percentage of Area	Estimated Improvement Cost (in Millions)
Sufficiency Ratings Less than 50	1990	269	5.8%	2.01	4.8%	$285.1
	1995	234	5.1	1.65	3.7	184.7
Sufficiency Ratings Less than 80	1990	592	12.8	4.07	9.8	463.5
	1995	541	11.7	4.15	9.2	321.8
All Sufficiency Ratings	1990	699	15.1	4.91	11.8	529.8
	1995	626	13.6	5.32	11.8	386.3

Source: Minnesota Department of Transportation.

13 Technically speaking, a bridge or culvert is structurally deficient if it has a condition rating of 4 or less for deck condition, superstructure, substructure, or culverts, or an appraisal rating of 2 or less for structure evaluation or waterway adequacy. A structure is functionally obsolete if it has an appraisal rating of 3 or less for deck geometry, underclearance, or approach roadway, or an appraisal rating of 3 for structure evaluation or waterway adequacy.

The share of trunk highway bridges which are deficient depends on which sufficiency rating categories we examine. In 1995, about 5 percent of trunk highway bridges had sufficiency ratings below 50. These bridges represented less than 4 percent of the total area on trunk highway bridges and culverts. Mn/DOT estimates that it would take about $185 million to correct the deficiencies on these bridges.

The estimates of deficient bridges, areas, and improvement costs are greater if bridges with higher sufficiency ratings are included. For example, about 541 or 12 percent of trunk highway bridges and culverts had sufficiency ratings less than 80 in 1995. These bridges represented 9 percent of the total area and would cost an estimated $322 million to improve.

The trunk highway system has a backlog of structurally deficient bridges.

Table 2.12 shows that most of these 541 bridges had a deficiency related to their condition or structural adequacy. [14] Deficient bridge conditions accounted for 356 of these bridges, and it would require $195 million to correct the deficient conditions. Structural conditions are the only deficient factor for 240 bridges and would require an estimated $100 million in improvement projects. This latter figure is more than twice the average annual amount Mn/DOT spent on bridge replacement, preservation, and safety between 1991 and 1995. [15] These data suggest that:

- **There is a backlog of bridges which are structurally deficient and need to be improved or replaced.**

We are less convinced of the need to improve or replace those bridges which are labeled deficient only because of their failure to meet width, clearance, or other

Table 2.12: Type of Deficiency for Trunk Highway Bridges, 1995

	Number of Deficient Bridges[a]	Deck Area of Deficient Bridges (in Millions of Square Feet)	Estimated Improvement Cost (in Millions)
Condition Only	240	1.71	$100.2
Condition and Other Factors	116	0.87	95.3
Load But Not Condition	2	0.03	24.2
Other Factors	183	1.54	102.1
Total	541	4.15	$321.8

Source: Minnesota Department of Transportation.

[a]Based on sufficiency ratings less than 80.

14 Of the 541 bridges, Mn/DOT considers 333 to be structurally deficient. Another 147 bridges are considered to be functionally obsolete based on substandard width, clearance, or other geometric factors. The remaining 61 bridges are deficient railroad bridges over trunk highways.

15 In the 5-year period (1991-95), Mn/DOT spent an annual average of $45.8 million for bridge replacement, preservation, and safety work. Mn/DOT also spent an annual average of $16.9 million for expansion purposes--namely, new bridges which did not previously exist.

geometric criteria. The decision on whether to improve those bridges should be based primarily on an assessment of the benefits and costs. Widening or replacing a bridge may or may not make sense depending on the cost of the improvement and the extent to which the project is expected to reduce accidents and congestion.

It is somewhat difficult to interpret the long run trends in the number of deficient bridges and the estimated cost to improve them. On several occasions, the criteria used to determine whether a bridge is deficient have changed and caused more bridges to be labeled deficient. In particular, there were some major changes in 1988 and 1990 as new federal criteria were implemented. As a result, it is probably best to examine the trends which have occurred since the last significant change in 1990.[16]

Even the trends since 1990 are not easy to interpret. Some of the data in Table 2.11 show that Mn/DOT has been able to reduce the backlog of deficient bridges since 1990. The number of deficient bridges has declined 9 to 13 percent, depending on what sufficiency ratings are included. In addition, the estimated cost to improve bridges declined roughly 30 to 35 percent. However, while the deck surface area of deficient bridges declined 18 percent for deficient bridges with sufficiency ratings less than 50, it increased for the other categories. Mn/DOT also believes that its data may understate estimated improvement costs, particularly for bridge deck rehabilitations. This would affect 1995 more than 1990, since there is a higher percentage of deck rehabilitations in the 1995 data, and would suggest that estimated improvement costs for deficient bridges did not decline as much as shown in Table 2.11.

Mn/DOT has reduced the backlog of deficient bridges since 1990 but a significant backlog remains.

We estimate, however, that the cost of improving deficient bridges decreased between 1990 and 1995 even allowing for the potential understatement of deck rehabilitation costs.[17] As a result, we think that:

- **Spending over the 1990-95 period was sufficient to modestly reduce, but not eliminate, the magnitude of the deficient bridge backlog.**

Although Mn/DOT has a backlog of deficient bridges, other states may face bigger backlogs. Available data suggest that a substantially smaller percentage of Minnesota's bridges are deficient than the national average. Minnesota has a smaller percentage of structurally deficient bridges and a much lower percentage of functionally obsolete bridges than the national average.[18]

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16 Effective in 1990, states were required to apply a uniform set of federal criteria for determining whether a bridge's width was adequate. As a result, more bridges in Minnesota were identified as having deficient widths.

17 Even if the understatement of deck rehabilitation costs would have applied only to 1995 and to all deficient bridges, which it does not, it would not account for the entire decrease in estimated improvement costs between 1990 and 1995.

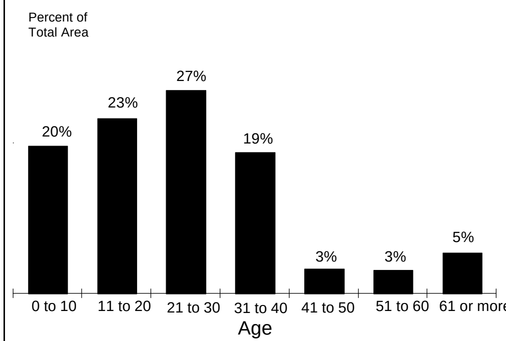
18 Minnesota has a smaller than average percentage of deficient bridges on both its state and local highway systems.

Age

Data presented in Table 2.13 and Figure 2.7 show that:

- **Trunk highway bridges are aging, but Minnesota will benefit from a favorable age distribution for the next 15 to 20 years.**

Figure 2.7: Age of Bridges and Culverts by Year Built, 1995



Source: Minnesota Department of Transportation.

While trunk highway bridges are aging, only a small share of them are nearing the end of their expected lives.

The average age of trunk highway bridges and culverts has increased modestly over the last 10 years. From 1986 to 1995, the average age of trunk highway structures increased from 31 to 34 years. In 1995, it had been about 28 years since the average structure had been either built or remodeled.

Table 2.13: Average Age of Trunk Highway Bridges

	Based on Year Built	Based on Year Last Remodeled
1986	31.3	NA
1988	NA	26.8
1995	34.2	28.4

NA = Not available.

Source: Minnesota Department of Transportation.

Despite the aging of trunk highway bridges and culverts, Minnesota is currently benefiting from the fact that most of its structures are relatively new and are not expected to need replacement for some time. Figure 2.7 shows that 70 percent of the structures were 30 years old or less in 1995 and almost 89 percent were 40 years old or less.[19]

Given an average expected life of 60 years, this age distribution suggests that Minnesota may benefit for the next 15 to 20 years by being able to replace a relatively small share of its bridges. However, starting in about the year 2015, Mn/DOT will likely face an increasing need to replace bridges.

19 The data in Figure 2.7 are based on the year that a structure was built. Based on year last remodeled, 83 percent of Minnesota's structures are 30 years old or less and 94 percent are 40 years old or less.

This expected trend is somewhat complicated by the recent discovery by Mn/DOT that some of its bridges may not last as long as previously expected. Mn/DOT has found problems with some of the steel bridges built between 1950 and 1980. Steel bridges that are subject to high volumes of heavy truck traffic are thought to have fatigue-prone steel elements and may need major rehabilitation or replacement earlier than would otherwise be expected. Mn/DOT has estimated that 87 bridges carry traffic loads which may put them at risk. The costs of repairing or replacing these bridges may be as high as $270 million, with about 85 percent of the estimated costs applying to bridges in the Twin Cities metropolitan area.

CONGESTION

The total amount of travel on Minnesota's streets and highways increased 76 percent between 1974 and 1994, including a 36 percent increase over the last 10 years. Travel on the State Trunk Highway System increased more, because most of the largest increases have occurred on interstate highways and principal arterials which are part of the system. For example, from 1985 to 1995, travel on trunk highways increased 46 percent. The largest increase was on urban interstate highways (87 percent) and rural interstate highways (62 percent). Travel also increased 55 percent on other urban principal arterials. Travel on collector and local highways on the system actually declined 24 percent.

Congestion has grown on Minnesota's highways.

This increase in travel has resulted in a significant increase in congestion on some interstate highways and principal arterials. One way to measure congestion is to compare the traffic volume on a highway to its capacity or peak service flow. In Table 2.14, we examine how the percentage of Minnesota highways which had significant congestion changed over a recent 10-year period. A highway is

Table 2.14: Percentage of Streets and Highways with Significant Congestion, 1984 and 1994

	Percentage of Miles with Volume-to-Service Flow Ratios Exceeding 0.95	
	1984	1994
URBAN		
Interstate	36.3%	45.5%
Other Freeways	13.3	39.4
Other Principal Arterials	19.1	18.4
Minor Arterials	13.6	8.4
Collectors	0.6	1.5
RURAL		
Interstate	0.0%	11.7%
Other Principal Arterials	0.6	2.9
Minor Arterials	0.7	0.9
Major Collectors	0.1	0.0

Source: Federal Highway Administration.

considered to be congested if its traffic volume exceeds 95 percent of its capacity. According to this definition:

- **The miles of congested highways in Minnesota increased from 449 miles in 1984 to 694 miles in 1994, with urban interstate highways and freeways being the most congested.**

Nearly 46 percent of urban interstate highways and 39 percent of other urban freeways were congested in 1994. In addition, 18 percent of other urban principal arterials and 12 percent of rural interstate highways experienced congestion.

Most, but not all, of the congestion is in the Twin Cities metropolitan area. In the last several years, Mn/DOT has addressed congestion in the metropolitan area by focusing on installing meters on freeway ramps, building some high-occupancy vehicle lanes, and permitting buses to use highway shoulders. Data from Mn/DOT indicate that the percentage of metropolitan area freeway miles which are congested has declined slightly in recent years. Mn/DOT, however, believes that the biggest gains from the ramp metering system have already been realized and that freeway congestion will probably grow in the future.[20]

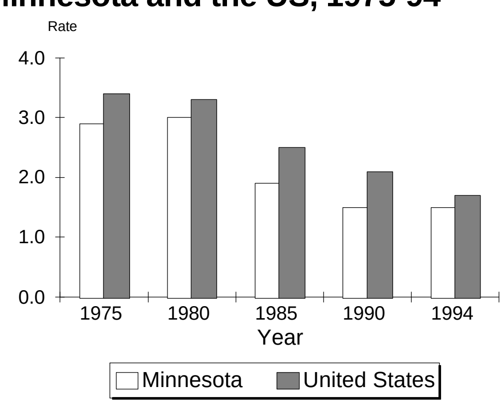
SAFETY

The fatality rate on all of Minnesota's roads has declined by nearly 50 percent since the mid-1970s. In 1994, there were 644 fatalities on Minnesota's roads, or 1.5 fatalities for each 100 million vehicle miles driven. This rate was significantly lower than the rate of 2.9 experienced in 1975, when there were 754 fatalities on Minnesota's roads.

Highway fatality rates have been declining in Minnesota and many other states.

As Figure 2.8 shows, much of the decrease came during the 1980s. In addition, the trend in Minnesota reflected the national trend. The fatality rate on roads throughout the nation also declined by about 50 percent between 1975 and 1994. The reasons for this trend are not entirely clear. The aging of the baby boom generation, greater seat belt usage, and more severe penalties for driving while intoxicated each may have played a role in reducing fatality rates.

Figure 2.8: Fatality Rate per 100 Million Vehicle Miles Traveled, Minnesota and the US, 1975-94



Source: National Highway Traffic Safety Administration.

20 Minnesota Department of Transportation, *Performance Report* (St. Paul, 1996), 88-90.

Minnesota's fatality rate per 100 million vehicle miles of travel has generally been below the national average. In 1994, Minnesota's rate was about 14 percent lower than the national rate. In addition, data from the Federal Highway Administration suggest the injury rate in Minnesota is also lower than the national average. While Minnesota's road standards may play a role in our lower fatality and injury rates, it is unclear how significant road standards are in reducing fatality and accident rates. It is possible that the driving habits of Minnesotans relative to drivers elsewhere may explain a significant portion of the difference in rates.[21]

Minnesota's trunk highways are generally safer than other roads in the state. Trunk highways carry about 60 percent of the state's traffic but account for a lower share of the state's crashes. In 1995, 47 percent of the fatalities and 40 percent of the injuries on Minnesota's roads occurred on trunk highways. In addition, 40 percent of the property damage crashes were on trunk highways.

SUMMARY

Funding for the State Trunk Highway System is higher today than it was during the mid-1970s. However, funding has declined from the peaks reached during the mid- to late 1980s. The decline is mostly due to lower levels of federal aid. State funding has also declined since the late 1980s, when the state gasoline tax was last increased and vehicle excise taxes were last transferred to the Trunk Highway Fund.

Stable construction prices have helped maintain the purchasing power of the Trunk Highway Fund.

The purchasing power of the Trunk Highway Fund has been helped, however, by stable construction prices. Prices for highway construction in Minnesota have increased significantly less than the general rate of inflation. As a result, overall spending from the Trunk Highway Fund in 1996 was only 12 percent below the peak reached in 1988.

There is a backlog of trunk highway bridges needing repairs or replacement, although some modest improvement appears to have been made in recent years in reducing the backlog. There does not appear to be a similar backlog for trunk highway pavements, although Mn/DOT would develop a backlog if it reduced the amount of pavement rehabilitation work done each year.

Trunk highway pavement and bridge conditions have been relatively unchanged over the last decade. Pavement conditions have improved slightly, while bridge conditions have declined slightly. Both pavements and bridges on the State Trunk Highway System are aging. However, Mn/DOT has been able to keep pavements in good condition by resurfacing them. Over the last decade, the average age of the surfaces covering trunk highway pavements has declined modestly. Based on age alone, a relatively small percentage of the bridges may need replacement over the next 15 years. About 89 percent of bridges and culverts are 40 years old or less, and they are generally expected to last 60 years. Problems with steel fatigue

21 Minnesota also has a lower fatality rate on interstate highways, where differences in road standards are less likely to be a factor.

on certain bridges subject to high volumes of heavy truck traffic may require the replacement of some bridges earlier than would otherwise be expected.

Congestion has been growing on trunk highways over the last several decades. Mn/DOT has been able to constrain the growth in congestion somewhat through the installation of freeway ramps and other projects. However, future growth in congestion is expected.

Projections

CHAPTER 3

In the previous chapter, we saw that the general trend in trunk highway spending has been upward since the mid-1970s, although spending has declined from the peak reached in 1988. Spending has also not kept up with the growth in traffic on Minnesota's trunk highways since the mid-1970s.

In this chapter, we examine the projected revenues for the Trunk Highway Fund and Mn/DOT's spending plans through fiscal year 2001. We consider the implications of financial projections and spending plans for the condition of trunk highway pavements and bridges. In particular, we address the following questions:

- **How does projected revenue growth for the Trunk Highway Fund compare with expected inflation?**
- **How does Mn/DOT propose to spend trunk highway revenues over the next two to four years?**
- **What are the implications of these financial projections for the condition of trunk highway pavements and bridges?**
- **Does Mn/DOT have adequate methods for projecting trunk highway needs?**

To analyze Trunk Highway Fund revenues and expenditures, we used projections recently prepared by Mn/DOT. Mn/DOT estimated revenues and expenditures for fiscal year 1997, as well as for the next four years. Revenue projections were based on current law. Expenditure projections incorporated the Governor's recommendations for the 1998-99 Biennial Budget.

We compared estimated revenues and expenditures for the 5-year period 1997-2001 with actual revenues and expenditures for the last 10 years, 1987-96. All revenues and expenditures were converted to 1996 dollars using estimates of past and future inflation rates obtained from the Department of Finance and prepared by Data Resources, Inc.[1] The comparison period includes a period (1988-90) of historically high revenues and expenditures, as well as a period (1991-94) of generally declining revenues and expenditures.

These projections of revenues and expenditures are reasonable estimates. However, future economic conditions, the public's desire to travel on highways, and Congressional decisions about federal aid are all difficult to forecast and will play a key role in determining the actual level of future revenues and, indirectly, expenditures.

REVENUES

Projections indicate that:

- **Average annual revenues for the Trunk Highway Fund over the next 5 years will probably be close to the average experienced over the last 10 years.**

Table 3.1 shows that average annual revenues for 1997-2001 are estimated to be $871 million in 1996 dollars. This estimate is within 1 percent of the 1987-96 average of $879 million. Despite no increase in the tax rate, state gasoline taxes are expected to keep up with inflation, as measured by the deflator for state and

Table 3.1: Comparison of Projected 1997-2001 Trunk Highway Fund Revenues with the 10-Year Average for 1987-96

	Average Annual Revenue (in millions of 1996 dollars)			Average Annual Revenue per Capita (in 1996 dollars)		
	1997-2001 (Projected)	1987-96 (Actual)	Percentage Difference from 10-Year Average	1997-2001 (Projected)	1987-96 (Actual)	Percentage Difference from 10-Year Average
REVENUES						
Gas Tax	$311	$298	4%	$65	$67	(3)%
Vehicle Registration Tax	267	225	18	56	50	10
Other State Sources	76	94	(19)	16	21	(25)
Federal Aid	217	262	(17)	45	59	(23)
Total Revenues	$871	$879	(1)%	$182	$198	(8)%

Source: Legislative Auditor's analysis of data from Mn/DOT, the Department of Finance, and Minnesota Planning.

1 We used the state and local government deflator for consumption expenditures and gross investment to convert historical and projected revenues and non-construction expenditures to 1996 dollars. As in Chapter 2, we used the Minnesota Highway Construction Cost Index to convert highway construction expenditures to 1996 dollars. Because projected values of the index are not available, we constructed a proxy from indices for which forecasts are available. The proxy consist s of 60 percent of the state and local government deflator for expenditures on structures and 40 percent of the deflator for residual fuels in the oil refining process. The 60 percent weight refle cts the significance of concrete and steel in highway construction work, while the 40 percent weight reflects the importance of bituminous products, which are a by-product of the oil refining process. Our results would not have been significantly different if we had used the same deflator for future highway construction spending as we used for future revenues and other expenditures.

local government purchases.[2] Average annual revenues from vehicle registration taxes are projected to be 18 percent higher during the next 5 years than during the last 10 years. The growth in vehicle registration taxes is primarily due to the projected increase in vehicle prices. Registration taxes are based on the value of vehicles sold and are thus more responsive to general inflation in the economy than the current fixed-rate gasoline tax. Other state sources of revenues and federal aid are, however, expected to be lower over the 1997-2001 period.

On a per capita basis, average annual revenues are projected to be 8 percent lower over the next 5 years than the last 10 years. Only revenues from vehicle registration taxes are expected to exceed the level experienced from 1987 to 1996. If traffic levels continue to increase faster than population, then revenues per vehicle mile traveled over the period 1997-2001 will be more than 8 percent lower than they were over the last 10 years.

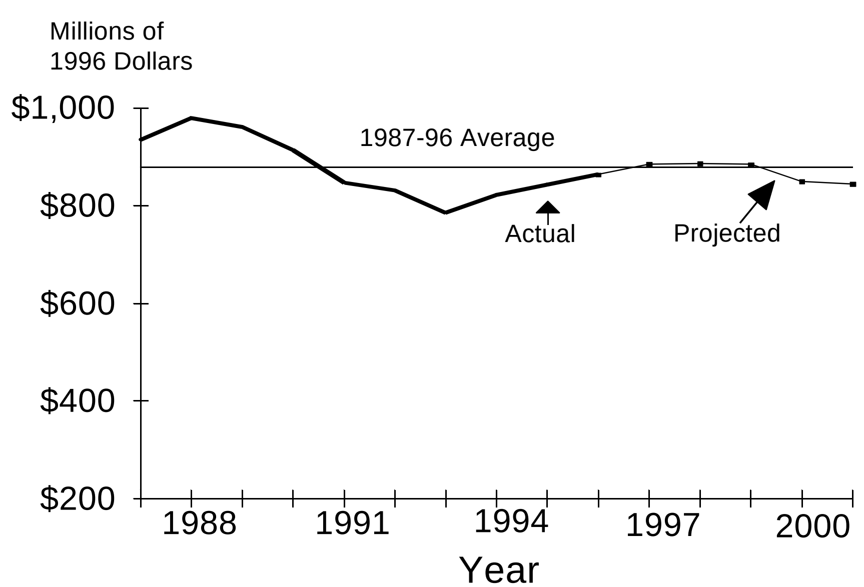
Figure 3.1 shows that:

- **Trunk Highway Fund revenues are expected to increase through fiscal year 1999 and then decline slightly.**

Overall, the estimated decline in revenues is about 5 percent from 1999 to 2001. Most of this decline is due to lower levels of expected federal aid in the years 2000 and 2001. Mn/DOT expects the levels in 1998 and 1999 to be higher due to

Trunk highway revenues are expected to be close to the 10-year historical average.

Figure 3.1: Trunk Highway Fund Revenues, Actual and Projected, 1987-2001



Source: Program Evaluation Division analysis of Mn/DOT data.

2 By the year 2000, the growth in gasoline tax revenues is projected to slow down and be slightly less than the inflation rate. This modest slowdown in the expected rate of revenue growth is becaus e the phase-out of the blender's credit for ethanol will have been completed by 1999.

demonstration grants from the federal government. However, projections of federal aid are subject to some uncertainty, particularly at this time.[3] Congress will be considering the reauthorization of the Intermodal Surface Transportation Efficiency Act later this year. Better information on future levels of federal aid will be available after Congress acts on this legislation.

SPENDING

Table 3.2 indicates that:

- **Average annual trunk highway expenditures from 1997 through 2001 are expected to be about 5 percent above the average for the last 10 years.**

Spending is also expected to be close to the historical average.

Table 3.2: Comparison of Projected 1997-2001 Trunk Highway Expenditures with the 10-Year Average for 1987-96

	Annual Averages (in millions of 1996 dollars)		
	1997-2001 (Projected)	1987-96 (Actual)	Percentage Difference from 10-Year Average
Trunk Highway Construction	$405	$407	(1)%
Other Mn/DOT	376	355	6
Other Departments	82	75	10
Miscellaneous[a]	30	12	139
Total	$892	$849	5%

Source: Legislative Auditor's analysis of data from Mn/DOT and the Department of Finance.

[a]Includes buildings, shared construction, and Mn/DOT spending in non-trunk highway program are as.

In 1996 dollars, average annual spending on trunk highway construction projects over the next 5 years is estimated to be about one percent less than the average experienced over the last 10 years. Expenditures by Mn/DOT for operations, engineering, general support, administration, equipment, and debt service are expected to be about 6 percent higher on average over the next 5 years than they were over the last 10 years.[4] Average annual spending by the Department of Public Safety and other departments out of the Trunk Highway Fund is estimated to increase by 10 percent. Spending on other miscellaneous activities is expected to more than double. About two-thirds of the increase in this relatively small

3 Due to uncertainty about federal aid, Mn/DOT included a $20 million reserve in its budget plan for the Trunk Highway Fund. This reserve would be needed in case expected federal aid during 1998 and 1999 falls short of projections.

4 We amended Mn/DOT's projections to reflect its recent request to add $16 million in 1997 to its operations budget for the additional costs of snow and ice control this winter. That change also reduced projected highway construction expenditures in 1997 by $16 million.

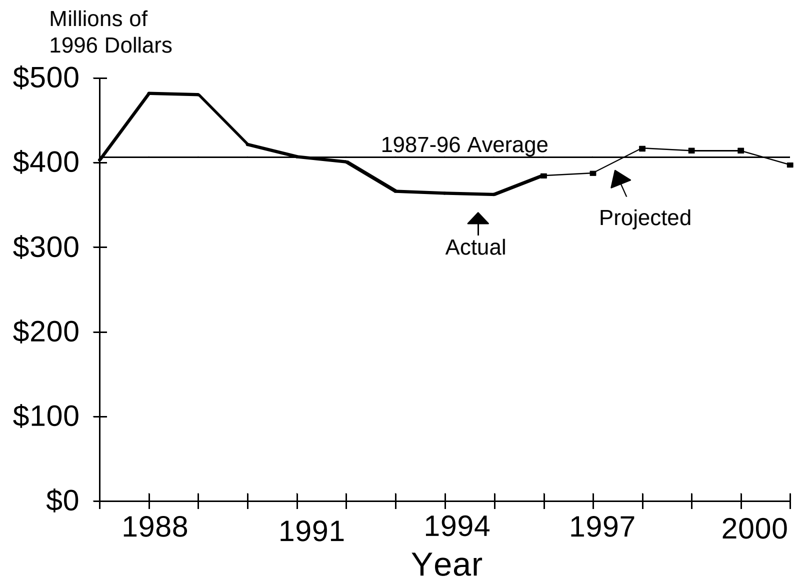
category is due to the new shared construction program.[5] The remainder is due to increased spending on capital building projects.

Figure 3.2 shows how trunk highway construction spending has varied over the last 10 years and how it is projected to change over the next 5 years. Similar to the trend we saw in overall revenues:

- **Highway construction spending is expected to increase through 1998 and then decline by about 5 percent by 2001.**

Construction spending is expected to increase during the 1998-99 biennium but decrease during the following biennium.

Figure 3.2: Trunk Highway Construction Expenditures, Actual and Projected, 1987-2001



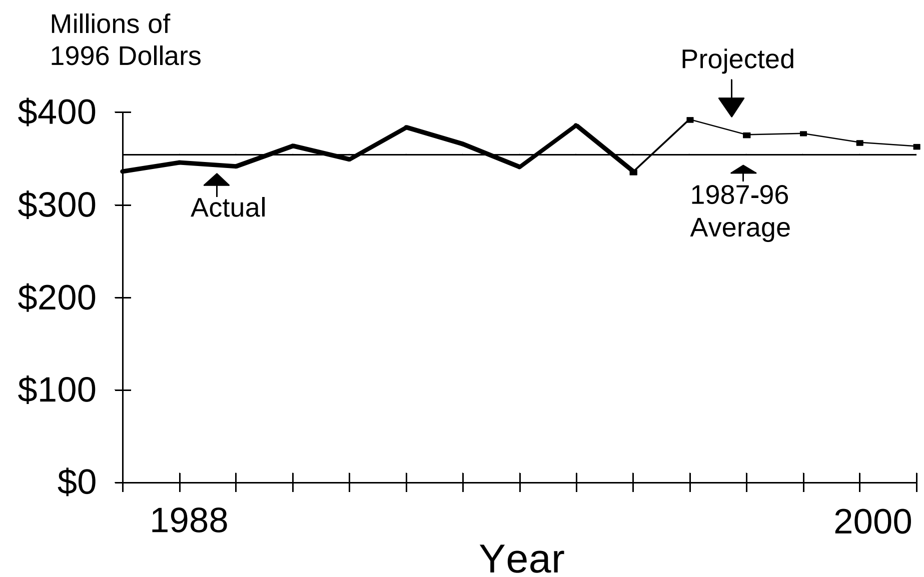
Source: Program Evaluation Division analysis of Mn/DOT data.

Projections for other trunk highway expenditures by Mn/DOT are shown in Figure 3.3. These projections also show spending declining in 2000 and 2001. Other trunk highway spending by Mn/DOT is expected to increase in 1997 and then decline by 9 percent by the year 2001. The decline is a little larger than for construction spending because Mn/DOT carried over part of its non-construction appropriations for 1996 to 1997. As a result, spending in 1996 was lower than previously anticipated and spending in 1997 will be higher than it otherwise would have been.

Overall spending and revenue trends for the Trunk Highway Fund seem somewhat inconsistent. We saw in Table 3.1 that revenues over the next 5 years are expected to average about 1 percent less than the annual average over the last 10 years.

5 Under the shared construction program, Mn/DOT does construction work at the request of various political subdivisions, and the Trunk Highway Fund is ultimately reimbursed for these expenditures. As a result, the cost of the shared construction program to the Trunk Highway Fund is a relatively minor reduction in investment earnings. The increase reflected in Table 3.2 greatly overstates the ultimate net cost to the fund.

Figure 3.3: Other Trunk Highway Expenditures by Mn/DOT, Actual and Projected, 1987-2001



Source: Program Evaluation Division analysis of Mn/DOT data.

However, average expenditures from 1997 through 2001 are estimated to be 5 percent higher than the 10-year historical average.

There are two reasons for this apparent inconsistency. First, we used a different inflation index to deflate construction expenditures than we used for other expenditures and for revenues. As we explained in Chapter 2, prices paid by Mn/DOT for highway construction have been relatively stable over the last 10 years. While prices faced by state and local governments rose 30 percent between 1987 and 1996, construction prices paid by Mn/DOT increased less than 10 percent. Our use of the Minnesota Highway Construction Cost Index to deflate past construction spending is responsible for about half of the overall difference between revenue and expenditure trends.

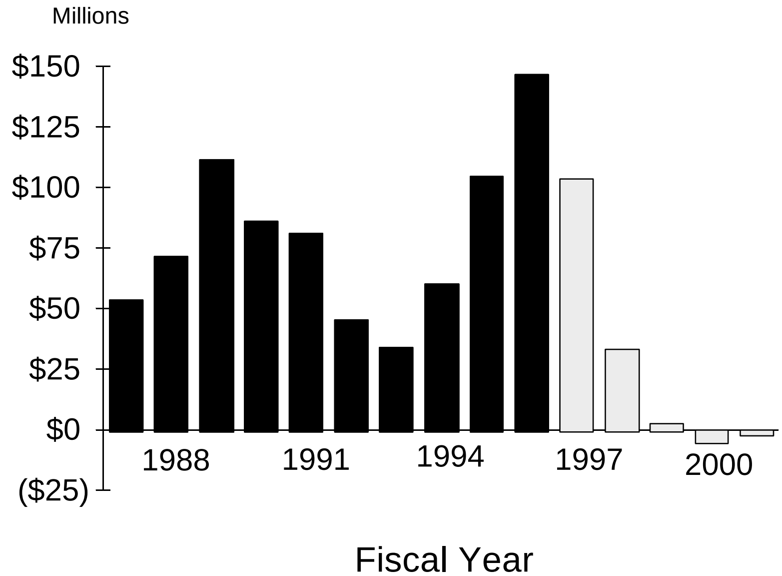
Second, most of the remaining difference results from the spending down of Trunk Highway Fund balances. As Figure 3.4 shows, the fund balance was about $147 million at the end of 1996 and will be less than $3 million by the end of 1999 if the Governor's proposed budget is adopted. Mn/DOT has forecast small year-end deficits for 2000 and 2001. [6] Mn/DOT's spending plans essentially anticipate the spending down of fund balances during the 1997-99 period. As a result:

- **Trunk highway spending during the 2000-01 biennium is expected to be about 4 percent lower than during the 1998-99 biennium.**

6 Mn/DOT's projections include some contingency funds for 1997-99, which, if not needed, may preclude the fund from running a deficit after 1999. The projection for 1997 includes a $6.75 million contingency, while the projections for 1998 and 1999 each include a $10 million contingency.

The boost in spending during the 1998-99 biennium is possible because of the large fund balance in the Trunk Highway Fund.

Figure 3.4: Year-End Balances in the Trunk Highway Fund, Actual and Projected, 1987-2001



Source: Minnesota Department of Transportation.

The availability of sizeable fund balances make it possible to increase spending in 1997 and during the 1998-99 biennium more than revenues alone would allow. However, these spending levels are not sustainable, and spending is expected to decrease the following biennium. Spending trends beyond 2001 will depend on revenues, which are not likely to grow faster than inflation unless state tax rates are increased or the federal government increases federal aid to Minnesota.

IMPLICATIONS

In the 1998-99 Biennial Budget, Mn/DOT presented information on the expected impact of funding levels on the condition of state trunk highways. [7] Table 3.3 shows how Mn/DOT expects trunk highways to be affected under either the base level of funding or the change level of funding. The revenue and expenditure projections we examined earlier in this chapter reflect the change level of funding.

According to Mn/DOT, recent trends in pavement quality, bridge conditions, Twin Cities metropolitan area freeway congestion, and spring road restrictions are expected to continue if the Legislature adopts the change level of funding. Pavement quality is expected to improve, bridge condition ratings are expected to decline, the share of metropolitan area freeways with peak-hour congestion will remain the same, and fewer roads will be subject to spring road restrictions. Mn/DOT also expects crash and fatality rates to decline and engineering costs as a percentage of construction expenditures to decline. Although not shown in Table

7 *1998-99 Minnesota Biennial Budget: Transportation and Other Agencies*, G-70.

Table 3.3: Expected Impact of Funding on the State Trunk Highway System

	Level of Funding	
	Base Level	Change Level[a]
Pavement Quality Index	No Change	Increase
Bridge Condition Ratings	Decrease	Decrease
Percentage of Metro Area Freeway Miles Congested During Peak Hours	Increase	Same
Percentage of Miles with Spring Road Restrictions	Minor Decrease	Decrease
Crash and Fatality Rates	Increase	Decrease
Ratio of Program Delivery Costs to Construction Expenditures	No Change	Decrease

Source: Minnesota Department of Transportation.

[a]The revenue and expenditure projections in this chapter are based on the change level of fund ing.

3.3, Mn/DOT also expects highway user satisfaction with travel time, safety, and winter road condition information to increase.

While Mn/DOT is to be commended for attempting to link funding with performance, we do not think Mn/DOT has sufficiently analyzed its construction program or budget in preparing these forecasts of highway and bridge conditions over the 1998-99 biennium. Mn/DOT's forecasts are rough estimates at best and are not based on an analysis of the construction work programmed for this year and the 1998-99 biennium. In addition, Mn/DOT has not used its pavement and bridge management systems to analyze the implications of the construction program.

We estimate that Mn/DOT's proposed highway construction budget for the 1998-99 biennium will be about 8 percent higher in inflation-adjusted dollars than it was during the previous two years. This suggests that there is room for a small amount of improvement in trunk highway conditions during the next biennium.[8] However, it is unclear what implications the overall increase would have for particular performance measures.

For the most part, Mn/DOT's forecasts of highway conditions in the next biennium are based on this overall increase planned for the construction budget (or other budgets when relevant) without any detailed information on how much certain programs within the construction budget would receive. So, for example, the effect on bridge condition ratings was forecast without knowing how much additional money, if any, would be allocated to the bridge replacement program or the bridge improvement and repair program. Similarly, trends in pavement quality would be difficult to project without knowing how much of the construction

8 We estimate that inflation-adjusted construction expenditures in the 2000-01 biennium would be about 3 percent lower than in the 1998-99 biennium.

budget would be allocated to resurfacing, reconditioning, road repair, and reconstruction.

More important, these forecasts cover a short period of time. Changes in highway or bridge conditions over a two-year period are likely to be relatively small. Even as funding changed over the last 10 years, any changes in highway and bridge conditions were small and slow to occur. It is more essential to know what performance Mn/DOT can sustain over a longer period of time given projected funding levels based on current state tax rates. In the remainder of this chapter, we consider what long run changes might be expected and how Mn/DOT could better forecast these and provide policy makers and the public with clearer and more accurate information on the implications of funding levels for trunk highways. In addition, we will assess the adequacy of funding for trunk highways.

Pavements

In the past, Mn/DOT has attempted to forecast future pavement needs. One method Mn/DOT has used involves making assumptions about how frequently trunk highways need to be resurfaced and reconstructed. This method is somewhat unsatisfactory because it is not clear that a highway needs to be reconstructed unless it was poorly built in the first place or has not been adequately maintained and resurfaced over time. [9] In fact, many of the highway reconstructions done by Mn/DOT are done for reasons other than pavement condition.[10] Mn/DOT is much more likely to reconstruct a road as part of an expansion or safety project. As a result, it is difficult to project the reconstruction costs that will be necessary due to pavement conditions.

We estimate that Mn/DOT's annual pavement rehabilitation needs are $160 million.

We used a different method to estimate the amount of resurfacing and reconstruction work necessary to maintain a constant pavement quality index on Minnesota's trunk highways in the future. We asked staff in Mn/DOT's Pavement Management Unit to use the Pavement Management System (PMS) to estimate the number of miles of resurfacing and other work necessary to maintain a constant PQI from 1995 through 2005. In addition, we requested that Mn/DOT staff use the PMS to estimate the cost of the work over the 10-year period running from 1996 through 2005. [11] The results were as follows:

- **Maintaining a constant systemwide average pavement quality index on Minnesota's trunk highways would require an estimated $160**

9 In addition, a road might not have been built to handle the heavy truck loads it is carrying.

10 Erland O. Lukanen and Chunhua Han, Braun Intertec Corporation, "Performance History and Prediction Modeling for Minnesota Pavements," Conference Proceedings*: Third International Conference on Managing Pavements, Volume 1* (Washington, D.C.: National Academy Press, 1994), 68.

11 At the time Mn/DOT made these estimates, actual data on the PQI was available through 1995. As a result, the estimates were made for 1996 through 2005. The optimization procedure used by Mn/DOT selects resurfacing and other projects which have the greatest cost-effectiveness given the constraint of a fixed annual budget. We had Mn/DOT staff run several optimizations at different annual budget levels until we could estimate the annual expenditure level necessary to maintain a relatively constant PQI over the 10-year period.

million per year (in 1996 dollars) to be spent on resurfacing and other pavement rehabilitation projects.

- **An estimated 1,200 miles of resurfacing and other pavement rehabilitation work would need to be done annually on the State Trunk Highway System in order to maintain a constant pavement quality index.**

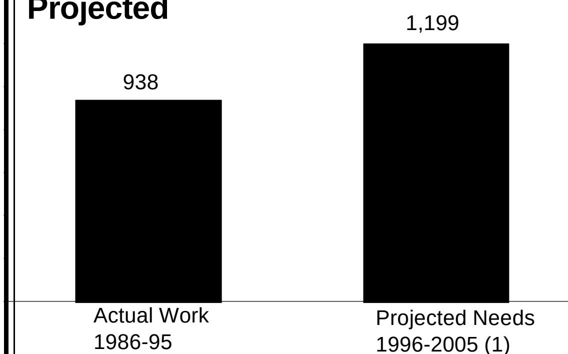
We also compared the annual amount of work necessary to maintain a constant PQI through 2005 with the actual amount of work done from 1986 through 1995. That comparison indicates that:

- **In the future, Mn/DOT may need to increase the average annual number of miles of pavement rehabilitation work in order to maintain the pavement quality index at its current level.**

Mn/DOT may need to resurface highways more frequently in the future.

As Figure 3.5 shows, Mn/DOT averaged 938 miles of resurfacing, concrete pavement repair, and reconstruction work per year on trunk highways from 1986 through 1995. The Pavement Management System predicts that 1,199 miles of annual work, or 28 percent more than the historical average, will need to be done from 1996 through 2005 in order for the pavement quality index to remain constant. If chip and sand seals are included along with these other types of work, then the total projected annual needs are 1,200 miles, which is 13 percent higher than the historical average of 1,066. [12]

Figure 3.5: Average Annual Miles of Resurfacing, Reconditioning, and Reconstruction Work on Trunk Highways, Actual and Projected



Source: Program Evaluation Division analysis of Mn/DOT data.

[1]Amount necessary to maintain a constant pavement quality index.

The estimates generated by the Pavement Management System may indicate that the expected life of a trunk highway surface is changing due to changes in pavement and surface composition, as well as increasing traffic levels and loads. Fewer highways are composed of only their original bituminous or concrete pavements. More highways consist of bituminous surfaces over the original bituminous or concrete pavements, and these overlays may not last as long as the original pavement did before it needed to be resurfaced. In addition, the loads carried by trunk highways have increased along with traffic levels, which have been growing 2 to 3 percent annually.

12 It should be noted that the volume of activity from 1986 to 1995 was sufficient to raise the pavement quality index slightly. This forecast suggests that even more miles of work will need to b e done over the next 10 years just to keep the PQI constant.

The above estimate of future pavement needs is not definitive but raises a significant issue which Mn/DOT needs to investigate more thoroughly. We recommend that:

- **Mn/DOT should examine the Pavement Management System to see if it is accurately predicting the rate at which roads deteriorate. If the system is found to be accurate, then Mn/DOT should reexamine how much money it is planning to spend on the preservation of trunk highway surfaces and pavements.**

Mn/DOT is in the process of modifying its Pavement Management System to include more systematic consideration of preventive maintenance activities. After this revision, Mn/DOT should reexamine the optimization procedure we used to estimate the average annual amount of work and expenditures necessary to maintain a constant pavement quality index. It is possible that including preventive maintenance may alter these work and expenditure requirements. As we will discuss in Chapter 4, advocates of preventive maintenance say that preventive maintenance is cost-effective and can reduce the frequency with which pavements need resurfacing.

Bridges

In 1995, Mn/DOT's Office of Bridges and Structures developed an estimate of annual bridge funding needs for the next 10 years. Mn/DOT has used this estimate internally and has presented it to legislative committees. The estimate, including $24 million for bridge preservation and $47 million for bridge replacement, totals $71 million per year in 1996 dollars.

Mn/DOT needs to reestimate its bridge preservation and replacement needs.

The amount of money Mn/DOT spends annually on bridge preservation and replacement has been and is expected to be substantially less than the estimated $71 million in annual needs. From 1988 through 1995, Mn/DOT spent an annual average of $48 million on bridge preservation and replacement. The Office of Bridges and Structures projected that an average of about $41 million would be spent annually from 1996 through 1998. [13]

For several reasons, however, we think that:

- **Mn/DOT should reexamine its estimate of annual bridge preservation and replacement needs.**

We have several concerns about the estimate. First, the estimate includes bridges which have width or other geometric problems but do not have structural problems. We think that the cost of replacing those bridges should be categorized separately. Mn/DOT generally will not replace a bridge only because it does not meet geometric standards. In part, Mn/DOT's practices probably reflect a cost-effective use of resources. Bridges with only geometric deficiencies should

13 Expenditure data are based on the bridge projects let or programmed during each year. These expenditures do not include new bridges built under the expansion program.

only be replaced if the benefits in terms of reduced accidents, travel time, and vehicle operating costs outweigh the cost of replacement. Many geometric problems, particularly on lesser traveled or non-congested bridges, may not justify bridge replacement on a benefit-cost basis.

Second, Mn/DOT's estimate may count some bridges twice: once for preservation work and a second time for replacement. It is not possible to tell how much double counting occurs in the estimate, if any. Mn/DOT should attempt to eliminate any double counting in the estimate.

Third, the replacement cost estimate may include some bridges for which repair work may be more appropriate. One of the criteria used by the Office of Bridges and Structures to identify bridges needing replacement was to include bridges for which any major superstructure or substructure element had more than 5 percent of its area in the least favorable condition or more than 20 percent of its area in the two lowest conditions.[14] It is not entirely clear that a limited amount of structurally deficient area requires replacement rather than repair work. This criterion should be examined by Mn/DOT.

Fourth, Mn/DOT needs to make sure that the recently discovered problems with fatigue-prone steel bridges are incorporated in its estimate of bridge replacement and repair needs. Some of these bridges are already in its $71 million estimate, but others are not included in the estimate and should be added.

Finally, it is unclear how spending $71 million per year on the bridges identified by the Office of Bridges and Structures would affect overall bridge performance measures. For example, the office has not attempted to determine how statewide average bridge condition ratings would change if the preservation and replacement work recommended by the office were done. It is not known whether the $71 million would be adequate to maintain constant condition ratings or would increase the statewide average ratings for decks, superstructures, substructures, and culverts. Similarly, it is not known how implementing the office's recommended spending level would affect the backlog of deficient bridges.

The estimate of bridge needs should be linked to performance and benefit-cost criteria.

We think it is important to link any estimate of needs to some performance measure. For example, in considering pavement needs, we estimated the cost of maintaining a constant PQI on trunk highway pavements. Similarly, for bridges, we recommend that:

- **Mn/DOT should attempt to provide an overall estimate of bridge needs based on an easily understood performance criterion such as maintaining constant systemwide bridge condition ratings.**

In addition to this estimate, Mn/DOT could also provide estimates of the cost of eliminating all geometric deficiencies, although we would prefer that the estimate be limited to those deficiencies which should be addressed because the societal benefits of eliminating the deficiency exceed the costs.

14 Generally, the condition of a major element can be characterized as being in one of four or five categories.

Congestion

According to the Metropolitan Council:

- **Congestion in the Twin Cities metropolitan area is expected to grow by the year 2020 even though current funding levels will probably permit some expansion of and significant improvements to the metropolitan area highway system.**

Congestion is expected to grow.

In its recently adopted 20-year transportation plan, the Metropolitan Council projects that the number of congested miles will increase from 100 miles in 1995 to 220 in the year 2020. [15] While it is currently possible to access almost any point within the 7-county metropolitan area within 60 minutes during the peak hour of traffic, the Council projects that only 60 to 70 percent of the area will have the same accessibility by 2020. Unpublished data from the Council also show that the average speed during the afternoon peak hour will decrease from 36 miles per hour in 1995 to 28 miles per hour in 2020. These average speeds apply to all roads in the metro area which are principal arterials, minor arterials, or collectors and thus include roads other than those on the trunk highway system. The average off-peak speed is not expected to change much from the 1995 estimate of 41 miles per hour.

According to the Metropolitan Council, the metropolitan area could not possibly build enough multi-purpose lanes to significantly reduce congestion--it would cost much more than is available. In addition, the Council feels that the environmental, social, and political impacts would be too severe if the area attempted to build its way out of congestion.

The Metropolitan Council believes it should focus on the most cost-effective improvements first. As a result, Mn/DOT and the Council have focused first on ramp meters, ramp by-passes, and HOV lanes. In the future, they will pursue additional ramp improvements and HOV lanes, and will also be able to fund some highway expansion and improvement projects designed to address current bottlenecks. However, a number of large projects such as those involving LRT and major highway reconstruction cannot be completely funded within the 20-year transportation plan. Limited funding, as well as other constraints, mean that congestion in the metropolitan area will probably grow, but its growth will be lessened by the projects Mn/DOT and the Council have placed in the 20-year plan.

Mn/DOT publicly reports only a limited measure of congestion on metropolitan area freeways and does not routinely report long-term projections for congestion. The measure used by Mn/DOT in its biennial performance report counts the number of freeway miles on which average speeds fall below 45 miles per hour for at least one hour during the morning and afternoon peak periods. We think it would be useful if Mn/DOT regularly reported additional congestion measures.

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15 For this plan, the Metropolitan Council defined a congested highway mile as one for which traffic volume exceeds highway capacity during the peak hour of the day. Most of these congested miles are on the trunk highway system. See Metropolitan Council, *Transportation Development Guide/Policy Plan* (St. Paul, December 1996 Draft).

Mn/DOT should report additional congestion measures and make projections.

Elsewhere, we have suggested that Mn/DOT consider some additional congestion measures.[16] The current measure does not capture the increased amount of time vehicles spend waiting on freeway ramps before entering freeways. In addition, it does not reflect any growth in the average number of hours that a highway is congested during a typical day.

We also think it would be useful if Mn/DOT used the Metropolitan Council's models to project how congestion on metro area trunk highways is expected to change. The council does not publish estimates that focus exclusively on trunk highways.

Furthermore, we suggest that Mn/DOT publicly report data on congestion outside the Twin Cities metropolitan area. A simple measure such as the volume-to-capacity ratio or the average daily traffic per lane may be appropriate for this purpose. Such a measure would help to inform policy makers about statewide needs for additional lane capacity.

Engineering Expenditures

Mn/DOT forecasts that its spending on design and construction engineering, while increasing over the 1998-99 biennium, will decline as a percentage of construction spending. We agree with Mn/DOT about this trend, although the change is likely to be slight and occurs only because Mn/DOT uses a 3-year moving average to calculate spending. On a current year basis, engineering spending as a percentage of construction declined in 1996 and is expected to increase in 1998. Mn/DOT estimates a decrease during the 1998-99 biennium because its 3-year moving average in 1998 will include the 1996-97 biennium when the percentage was lower than during the 1994-95 biennium.

Engineering spending is expected to be close to long-run averages.

We calculated engineering spending as a percentage of construction expenditures over the 23-year period from 1974 to 1996 and projected this percentage for the years 1997 through 2001 based on Mn/DOT's spending plans.[17] While engineering expenditures as a percentage of construction spending has varied considerably from year to year--ranging from 19 percent to 48 percent--we found that:

- **Engineering spending from 1997 to 2001 as a percentage of either construction spending or all Trunk Highway Fund spending is expected to be close to the long-run average.**

Using Mn/DOT's spending projections, we estimate that engineering spending as a percentage of construction spending will be about 30.1 percent of highway construction spending during the 1997-2001 period, which is exactly the same as

16 Office of the Legislative Auditor, *Comments on the Department of Transportation's 1996 Biennial Performance Report* (St. Paul, January 1997), 2.

17 The percentage was calculated on a current year basis. We included all engineering and research spending, as well as spending on investment management.

the 23-year average from 1974 to 1996.[18] We also calculated engineering spending as a percentage of all Trunk Highway Fund spending. That percentage is expected to be lower (13.7 percent) over the next 5 years than the 23-year average (14.1 percent).

ADEQUACY OF FUNDING

Construction Funding

Policy makers have been deadlocked in recent years over highway and transit funding. Part of this deadlock involves rural-urban policy differences over the relative merits of highways and transit. In addition, there have been questions raised about whether highway funding is adequate. Furthermore, some policy makers have been reluctant to support a tax increase.

It is apparent to us that Mn/DOT does not have enough funding to meet all potential highway needs. We previously estimated pavement preservation and replacement needs to be about $160 million per year in 1996 dollars. Mn/DOT estimated bridge preservation and replacement needs to be about $71 million per year in 1996 dollars. Although we think this bridge estimate needs to be revised, we will use it below for purposes of illustration.

Mn/DOT's funding is not likely to be adequate to address all trunk highway needs.

Over the 5-year period 1997-2001, Mn/DOT's construction budget will average about $405 million in 1996 dollars. Bridge and pavement preservation and replacement needs account for an estimated 57 percent of the construction budget.[19] About $174 million per year (in 1996 dollars) would be left for expansion projects and management and operations projects. The latter category includes safety projects, right-of-way costs, traffic management, cooperative agreements, and miscellaneous types of projects such as enhancements, junkyard screening, planning, rest areas and beautification, and rail safety.

As we saw above, funding is not adequate to address all of Minnesota's highway congestion problems or even to prevent congestion from growing in the Twin Cities metropolitan area. Mn/DOT's funding is also insufficient to fully fund mega-projects such as those on Interstate 35W south of Minneapolis and on Interstate 94 between St. Paul and Minneapolis, which include multiple objectives such as construction of light rail transit, safety improvements, and reconstruction of aging pavements. Funding is sufficient to fund parts of those mega-projects in a piecemeal fashion. In addition, funding is not sufficient to fully address the backlog of structurally deficient bridges, perform adequate preventive maintenance on trunk highways and bridges, and reconstruct those heavily used

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18 Spending was calculated in 1996 dollars.

19 When comparing pavement needs with the construction budget, the $160 million figure could be reduced somewhat since Mn/DOT crews, not contractors, do a small share of the total bituminous overlays.

highways which may be more cost-effective to reconstruct than to overlay frequently.[20]

But Mn/DOT should develop the capability to provide better information on its funding needs.

Despite years of discussion about whether trunk highway funding is adequate:

- **Mn/DOT does not have some of the basic information and has not done some of the analysis necessary to draw precise conclusions about the adequacy of funding for Minnesota's trunk highways.**

The adequacy of funding should not be measured by simply comparing available funds to a list of potential projects.[21] Comparisons such as this invariably result in a conclusion that infrastructure needs exceed available funding. Instead, it is better to link the amount of funding to performance objectives, such as maintaining a constant PQI, and to know how different levels of funding would affect performance. Furthermore, highway projects involving expansion or safety need to be evaluated on a benefit-cost basis. Projects which cannot be justified on that basis should not be considered to be part of highway needs. While it might be nice to improve safety or relieve congestion on a highway, it should not be considered a need if the costs of doing so exceed the benefits to highway users.

There have been several previous studies of transportation funding adequacy in Minnesota. In 1991 the Transportation Study Board issued its final report and found substantial needs in all areas of Minnesota's transportation system over the next 20 years.[22] The report compared existing funding levels to inflation-adjusted estimates of ''full-service'' needs and needs under ''acceptable levels of service.'' Also, a 1992 Mn/DOT study looked at transportation needs through the year 2000 and identified the funding necessary to achieve various scenarios labeled as the deteriorating infrastructure, investment preservation plus transit, economic development, and competitive advantage scenarios.

While these studies were helpful in understanding transportation needs, neither study considered specific performance targets and the funding needed to achieve them. The studies also did not consider how the benefits of projects included in various scenarios compared with their costs.

Mn/DOT does not currently have the information which would have enabled us to reach a more specific conclusion about the adequacy of funding for trunk highways. Mn/DOT has not developed an estimate of the funding needed for highway preservation and replacement in order to achieve certain pavement quality targets. Its estimate of bridge preservation and replacement needs is

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20 Chapter 4 discusses the reasons for performing more preventive maintenance. We think that performing more preventive maintenance may lower the long term costs of pavement preservation and replacement. However, Mn/DOT finds it difficult to allocate more funds to preventive maintenance because the immediate pavement, bridge, and expansion needs of the trunk highway system would have to be compromised.

21 For example, see Peggy L. Cuciti and E. Sam Overman, *The Assessment of Investment Needs: A Review of Current Estimates and Approaches,* prepared for the National Council on Public Works Improvement (Denver, 1986).

22 Transportation Study Board, *Study of Minnesota's Surface Transportation Needs* (St. Paul, January 1991).

flawed in some respects and needs to be developed with specific performance targets. Furthermore, Mn/DOT is in the early stages of using benefit-cost analysis to assess the pros and cons of major transportation investments, including those which reduce projected congestion or improve safety. Mn/DOT expects to have analyzed 10 percent of the major investments made in the year 2000, but will have analyzed all major investments made in 2004. [23]

Mn/DOT should periodically report on its funding needs.

However, we think it would be useful for policy makers to get a regular report from Mn/DOT regarding the adequacy of funding for trunk highways. Such a report might be helpful in resolving the debate about highway and transit and certainly could provide better information for policy makers about the amount of funding necessary for the trunk highway system to maintain current conditions. We recommend that:

- **Mn/DOT should periodically prepare a report on the funding needs of the trunk highway system. Needs should be defined in terms of what funding is necessary to obtain specific performance targets and should attempt to use benefit-cost criteria where appropriate.**

It would be useful for policy makers to receive a report from Mn/DOT on its funding needs every two years to coincide with consideration of the biennial budget. Mn/DOT believes, however, that it would be more valuable to prepare such a report on a four-year cycle as it is currently proposing for its statewide transportation plan. Mn/DOT does not think that the needs would change significantly in two years time but would change more over a longer time period. We would support the concept of a four-year cycle but would like to see Mn/DOT prepare a needs report by 1999. Mn/DOT is proposing that the next statewide transportation plan should be published in the year 2000.

Needs should be defined relative to performance and benefit-cost criteria.

This type of report would not be unique. The United States Department of Transportation reports to Congress every two years on the status of the nation's surface transportation system, including highways, bridges, transit, and waterborne transportation. [24] The department's report includes estimates of the funding needed over the next 20 years to maintain current conditions on the nation's highways and bridges, as well as additional funding for congestion relief or safety which can be justified on a benefit-cost basis. Mn/DOT should not necessarily use the national report as a model, but it serves to show that such estimates can be made and that funding can be linked with performance targets and benefit-cost analysis.

In addition, Mn/DOT has some recent experience in preparing a needs study which is somewhat linked to performance criteria. In November 1996, Mn/DOT's Metropolitan Division prepared a draft transportation system plan covering the

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23 Mn/DOT believes that benefit-cost analysis is best conducted early in the planning stage of a project. Because major transportation investments take 6 or more years to develop, benefit-cost results will not be provided on a regular basis until about 2004. Mn/DOT's Economic Analysis and Special Studies Unit is currently conducting analyses on a number of projects on a demonstration basis.

24 United States Department of Transportation, *1995 Status of the Nation's Surface Transportation System: Conditions and Performance, Report to Congress* (Washington, D.C., October 1995).

years 2001 through 2020. The report is very useful and provides a great deal of information on the division's planning efforts and attempts to estimate trunk highway needs in the metropolitan Twin Cities area. We think the draft report is a good starting point for Mn/DOT in preparing a statewide needs estimate. However, the draft report was not completely explicit about the impact of its plan or its unconstrained needs estimate on pavement quality, bridge conditions, and congestion. In addition, there was limited use of benefit-cost analysis in developing estimates of need for the metropolitan area.

Maintenance Funding

For the most part, this chapter has focused on Mn/DOT's construction budget, which accounts for nearly half of all Trunk Highway Fund expenditures. This choice was appropriate since much of Mn/DOT's impact on the physical condition and capacity of trunk highways comes through construction funding. However, almost one-fourth of Trunk Highway Fund spending is for highway operations, including snow and ice control and various types of routine maintenance. Here, too, Mn/DOT lacks good information on the unit costs, results, and perhaps the adequacy of its current spending level.

Overall, we think Mn/DOT has been pursuing some important issues regarding its operations budget. Mn/DOT has a pilot project operating in District 8 in Willmar to assess how it can better utilize existing staff through the use of a ''transportation worker '' job classification. The more generic classification might help Mn/DOT improve its performance or control costs by enabling districts to use workers for a greater variety of functions.

In addition, Mn/DOT has had several pilot efforts underway to assess the usefulness of activity-based cost accounting. Previous efforts to develop statewide maintenance management systems have not been successful in producing useful information on the costs of various maintenance activities. As a result, Mn/DOT has encouraged district participation in pilot projects to try to build a useful system from the ground up rather than from the top down.

We encourage Mn/DOT to develop a statewide activity cost system.

We think that activity-based costing would be useful for both Mn/DOT and policy makers. We first cited the need for good maintenance activity cost information in a 1985 report on highway maintenance.[25] Mn/DOT and its districts need such information in order to make cost-effective decisions about maintenance operations. Activity-based cost accounting provides information on the unit cost of performing various maintenance activities and can help districts better manage their resources. Oversight from policy makers would also benefit from good information on the cost of various maintenance activities. We encourage Mn/DOT's development of a statewide activity cost system.

25 Office of the Legislative Auditor, *Highway Maintenance* (St. Paul, January 1985).

SUMMARY

In the short term, trunk highway spending is projected to increase under the Governor's proposed budget. In inflation-adjusted dollars, Mn/DOT's construction spending is expected to be 8 percent higher during the 1998-99 biennium than during the 1996-97 biennium. Because part of the increase in spending would occur due to a spending down of the balance in the Trunk Highway Fund, construction spending is expected to drop about 3 percent during the 2000-01 biennium. Overall, we estimate that average annual construction spending from 1997 through 2001 would be almost equal to the 10-year average experienced from 1987 through 1996. Other spending by Mn/DOT out of the Trunk Highway Fund is expected to be about 5 percent above the average for the last 10 years.

Mn/DOT has not prepared any long-range estimates of the implications of current funding levels for highway and bridge conditions. Its short-range estimates for the 1998-99 biennium are questionable, since they were based on incomplete funding information and did not make use of Mn/DOT's pavement and bridge management systems.

In general, we think that projected funding for trunk highways will not be sufficient to address a number of problems. However, Mn/DOT's data were not adequate for us to develop a more precise conclusion. We recommend that Mn/DOT should periodically prepare a report which analyzes trunk highway funding needs. Unlike previous reports, this report should show what funding levels are needed to achieve certain targets such as maintaining a constant systemwide average pavement quality. The report should also attempt to distinguish between expansion and safety projects which have benefits in excess of costs and those which do not. The latter projects should not generally be considered highway needs, since they would cost more to implement than they are valued by highway users.

Preventive Maintenance

CHAPTER 4

The word "maintenance," when used in relation to highways and bridges, refers to a wide assortment of activities that range from routine pothole filling to fairly substantial overlays. Our emphasis in this chapter is on maintenance activities that are preventive in nature, that is, activities that are performed to prevent or delay the occurrence of urgent and/or extensive maintenance problems. In this chapter, we asked:

- **What does research show about the effectiveness and cost-effectiveness of preventive maintenance?**

- **To what extent does the Minnesota Department of Transportation (Mn/DOT) perform adequate preventive maintenance on state trunk highways and trunk highway bridges?**

To answer these questions, we reviewed studies on preventive maintenance; surveyed individuals in the seven outstate Mn/DOT district offices and the Metropolitan Division who are familiar with the maintenance of Minnesota's state trunk highway system; spoke to managers at the district offices, Metropolitan Division, and central office; and obtained data from Mn/DOT's bridge and pavement management systems on preventive maintenance activities performed on the trunk highway system.

DEFINITION

Preventive maintenance of highways and bridges includes activities that are performed while a structure is still in fairly good condition. For our study, we adopted a definition of "preventive maintenance" from a study by the Transportation Research Board and used by a Mn/DOT "pathbuilding team" that looked at the issues of preventive maintenance and preservation in 1994.[1] Preventive maintenance is:

1 Mn/DOT created three pathbuilding teams to further the department's understanding of how "business practices could be applied to the public sector to further its strategic management process." Minnesota Department of Transportation, *Pathbuilding Projects: Final Report* (St. Paul, December 1994), 6. The three team topics were: finance, preventive maintenance/preservation, and marketing.

> a program strategy intended to arrest light deterioration, retard progressive failures, and reduce the need for routine maintenance and service activities. Preventive maintenance is generally cyclic in nature. It is planned maintenance. Preventive maintenance activities do not significantly improve the load-carrying capacity of pavements, shoulders, or structures but extend the useful life and improve the level of service.[2]

Much pavement preventive maintenance is performed to keep moisture out of the pavement subbase. Moisture in the subbase can weaken the support the subbase provides to the pavement, leading to cracking and, during freeze-thaw cycles, potholes. Water under concrete slabs can contribute to faulting at the joints between the slabs.[3] Pavement preventive maintenance can also reduce the quantity of incompressible objects in pavement joints and cracks, which can obstruct the natural movement of the pavement in response to temperature changes. We describe the pavement preventive maintenance activities on which we focused in Figures 4.1 and 4.2. Some of the bituminous and bituminous-over-concrete activities, and all of the concrete activities, on which we focused are usually performed by contractors, as opposed to Mn/DOT maintenance crews.

Figure 4.1: Preventive Maintenance Activities for Bituminous and Bituminous-over-concrete Pavement

crack fill--Crack filling consists of placing a material such as an asphalt emulsion[1] into a crack. The material reduces water infiltration and reinforces the adjacent pavement. This procedure is generally used to maintain older cracks.

crack seal--Crack sealing (or rout and seal) involves routing a crack into a special configuration and filling it with a material such as rubberized asphalt. The material prevents incompressible objects and moisture from entering the crack.

fog seal--Fog sealing is the application of an asphalt emulsion. Fog seals coat the road surface and may fill small cracks. These seals are more commonly used on low-volume roads and shoulders because surface friction might be reduced after application.

sand seal--Sand sealing involves applying asphalt emulsion to a road surface, followed by a sand cover. The sand provides some friction and the seal may provide some protection from moisture.

slurry seal--Slurry sealing consists of applying a mixture of fine aggregate,[2] emulsion, water, and mineral filler to the road surface. A slurry seal may be applied to the full width of the road, or used to repair cracks and other minor defects. When applied full-width, slurry seals seal the pavement surface and may improve minor defects and friction.

micro-surface--Micro-surfacing is basically a special type of slurry seal that uses higher quality materials and a special binder. Micro-surfacing has been used to fill wheel ruts and improve friction, among other things. This treatment can be used on high-volume roads.

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2 Louis G. O'Brien for the Transportation Research Board, *National Cooperative Highway Research Program, Synthesis of Highway Practice Report 153: Evolution and Benefits of Preventive Maintenance Strategies* (Washington, D.C.: National Research Council, December 1989), 7.

3 Two adjacent concrete slabs form a joint. Ideally, the slabs are level. A fault occurs when one of the slabs of concrete is elevated so that the adjacent slabs are no longer level.

Figure 4.1: Preventive Maintenance Activities for Bituminous and Bituminous-over-concrete Pavement, continued

single- and multiple-application chip seal--Chip sealing involves applying an asphalt emulsion followed by an aggregate cover. Chip seals may waterproof the road surface, seal low-severity cracks, and improve surface friction. Use of chip seals is usually restricted to low-volume roads.

asphalt overlay (2.0" or less)--Asphalt overlaying consists of applying a surface of hot-mix asphalt. Asphalt overlays improve the smoothness of a road and the friction of the pavement surface. Thin overlays typically do not add to the load carrying capacity of the pavement.

[1]An asphalt emulsion is a mixture of asphalt cement, water, and an emulsifying agent.

[2]Aggregate is a mixture of mineral particles such as sand, gravel, or rocks.

Figure 4.2: Preventive Maintenance Activities for Concrete Pavement

reseal joints--Joints in concrete pavements are resealed to prevent moisture and incompressible objects such as sand from entering the joint. Water penetrating the cracks may cause fine material below the concrete slab to wash out, reducing the pavement support, and incompressibles may increase the likelihood of pavement blowups during freeze-thaw cycles.

repair spalled[1] joints--Repairing spalled joints before the spalling becomes too severe improves the smoothness of the ride of the road and may prevent further deterioration, which would require more extensive and expensive repairs.

install edge drains--Edge drains provide a system for water that reaches a pavement's base layer to drain out of the base materials. Edge drains are important when the pavement has a poorly draining subgrade, such as clay or silt.

retrofit load transfer--Retrofit load transfer involves doweling (or fastening) concrete slabs together with a metal bar to help reduce the impact of traffic on the concrete slabs. Retrofit load transfer may help reduce faulting[2] and the ejecting of fine materials under the concrete slabs up through joints and cracks. The latter weakens the pavement support.

grind concrete--Grinding improves the smoothness of the ride on concrete pavements that have experienced faulting at cracks or joints. It may also slow down or prevent the ride from becoming rough again and reduce the impact of traffic.

[1]Ideally, the edge of a concrete panel is a relatively sharp 90-degree angle. Two adjacent panels form a joint. A spalled joint is one in which the sharp edges of the concrete panels forming the joint have worn away, leaving a rougher and wider opening to the joint.

[2]Two adjacent concrete panels form a joint. Ideally, the panels are level and traveling from one to the other is barely noticeable. A fault occurs when one of the panels of concrete is elevated due to water problems and traffic, so that the adjacent panels are no longer level.

On bridges, most of the preventive maintenance activities on which we focused are designed to reduce the exposure of bridge components to water and corrosive agents, such as de-icing chemicals, or to reduce the effects of stress on the bridge, such as that caused by the expansion and contraction of components in response to temperature changes. We describe the bridge preventive maintenance activities on which we focused in Figure 4.3. Most of the bridge preventive maintenance activities on which we focused are usually performed by Mn/DOT bridge maintenance crews.

Figure 4.3: Preventive Maintenance Activities for Bridges

crack seal on concrete decks--Crack sealing of bridge decks prevents water and corrosive materials from reaching the reinforcing steel in the deck.

lubricate expansion bearings--Expansion bearings are lubricated to maintain their ability to move. Bearings that cannot move in response to expansion of bridge components may cause stress on other components of the bridge.

flush winter residue--Salt, sand, debris, and corrosive materials are flushed from bridge decks and other surfaces (such as bridge seats) to prevent the concrete from cracking and scaling and steel components from corroding.

reinstall strip neoprene glands--A strip neoprene gland is a flexible material placed in expansion joints to prevent water and debris from reaching components below the bridge deck. The glands can pull out of the joints or tear.

clean and reseal joints--Joints that are not sealed with neoprene glands are filled with some other material, such as cork or felt, that is covered with a sealer. These joints are hard to maintain, and the seal does not last long. The joints need to be cleaned and resealed to prevent corrosive materials from leaking onto components below the deck.

spot paint--A protective coat of paint prevents corrosion of steel elements. Spot painting may extend the life of the paint coat.

install relief joints in concrete approaches--Relief joints in concrete approaches to bridges relieve the pressure on bridge components caused by expanding concrete. The pressure may cause damage to bridge components.

correct approach panel settlement[1]--Correcting approach panel settlement improves the smoothness of the ride and safety and reduces the impact of traffic on the bridge.

place drain extensions on floor drains--Drain extensions carry water away from the supporting structures below the bridge deck.

Note: These activities were taken from the list of preventive maintenance activities in Mn/DOT's Bridge Maintenance Manual. The manual includes activities not included above.

[1]Approach panel settlement occurs when the approach panel to the bridge settles so that it is on a lower level than the bridge.

RESEARCH

Most of the studies we reviewed found pavement preventive maintenance activities to be effective if they were applied to pavements at the right time using proper materials and application procedures. Preventive maintenance cannot be expected to extend the life or improve the service of a pavement or bridge that was poorly constructed or that has already deteriorated. The appropriateness of an activity for a specific highway or bridge may depend on traffic volume and climate, among other things.

An Indiana study looked at the trade off between two maintenance activities: sealing cracks and joints (preventive maintenance) and patching (demand maintenance). The authors found that "if more cracks are sealed before winter, less patching is required after winter, primarily because of fewer potholes."[4]

In 1994, the Transportation Research Board surveyed state, local, and Canadian transportation agencies about their experiences with pavement preventive maintenance.[5] Table 4.1 shows that state transportation agencies generally observed increases in pavement life that they attributed to preventive maintenance activities.[6] Some of the variation in experience may be due to differences in design, materials, or work quality, and it is possible that some of the roads were not good candidates for preventive maintenance.

Table 4.1: States' Reported Increase in Pavement Life Attributed to Preventive Maintenance Activities

Surface and Activity	Most Common Response	Range of Responses	States Responding[1]
BITUMINOUS			
Crack filling[2]	2-4 years	Less than 2 to 7-8 years	29
Single-application chip seal	5-6 years	2-4 to 7-8 years	26
Multiple-application chip seal	5-6 years	2-4 to 9-10 years	12
Slurry seal	2-4 years	2-4 to 5-6 years	7
Micro-surface	5-6 years	2-4 to 7-8 years	11
Thin hot-mix asphalt overlay (1.25 inches or less)	7-8 years	2-4 to 9-10 years	23
CONCRETE			
Joint spall repair	5-6 years	2-4 to 15 years	21
Joint sealer replacement	5-6 years	2-4 to 9-10 years	18

Source: Donald N. Geoffroy, for the Transportation Research Board, *National Cooperative Highway Research Program Synthesis of Highway Practice 223: Cost-Effective Preventive Pavement Maintenance* (Washington, D.C.: National Academy Press, 1996), 54-60.

[1]This is the number of states responding for each activity. It does not include states that responded "unknown" or N/A.

[2]The survey asked about crack filling with or without routing.

The Federal Highway Administration (FHWA) is studying the effectiveness of pavement preventive maintenance on "test sections" of highways. The test sections are located throughout the United States and Canada and were constructed using the same crew, materials, and design to control some of the variables that can affect preventive maintenance performance. In the early 1990s, the FHWA completed subjective visual field evaluations of 87 sections. The evaluators concluded that the sections that received preventive maintenance were generally performing better than those that had not, and the preventive

4 Essam A. Sharaf and Kumares C. Sinha, "Energy Savings from Increased Preventive Maintenance on Indiana Highways," *Transportation Research Record 1102: Highway Maintenance Planning* (Washington, D.C.: National Research Council, 1986), 28.

5 Donald N. Geoffroy, for the Transportation Research Board, *National Cooperative Highway Research Program Synthesis of Highway Practice 223: Cost-Effective Preventive Pavement Maintenance* (Washington, D.C.: National Academy Press, 1996). Forty-five states, four Canadian provinces, and eleven local agencies responded.

6 The increases in pavement life were primarily estimates based on observational experience of agency staff.

maintenance was more effective when performed on pavements that were in better condition.[7]

Many studies have found preventive maintenance to be effective.

The American Association of State Highway and Transportation Officials, in its 1987 Manual for Bridge Maintenance, states, ‘‘Most problems can be prevented or minimized by timely preventive maintenance for bridges.’’[8] Some activities mentioned in this manual include cleaning the deck, joints, substructure caps, and bearings; spot painting; and maintaining joint seals. In the mid-1980s, several researchers interviewed bridge maintenance engineers who identified the following effective practices: flushing bridge seats; cleaning, painting, and lubricating bearings; and flushing and providing good drainage for the deck.[9] Neither of these publications evaluated the activities.

Several studies have concluded that the benefits of pavement preventive maintenance exceed the costs.[10] However, the measures of costs and benefits have varied across studies. Benefits may include lower repair and rehabilitation costs over the life of the pavement or structure and improved ride quality and safety. Costs generally include the cost of labor and materials and may include user delay costs.

A study on sand sealing and chip sealing in Indiana estimated that agency and vehicle operating costs would be lower over the life of a pavement if sealing were performed at the appropriate times.[11] Researchers from the Ministry of Transportation in Ontario concluded that crack sealing in bituminous pavements, when done at the right time, was cost-effective when total agency and some user costs were considered.[12] A third study concluded that ‘‘undertaking [maintenance and rehabilitation] actions on pavement in ‘good’ condition may cost only $1.00 for every $4.00 that would be necessary for appropriate [maintenance and rehabilitation] if the pavement were left to deteriorate into poor condition.’’[13]

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7 Raza Hassan, *Summary Report: 1993 Field Evaluations of SPS-3 and SPS-4 Test Sites*, Publication No. FHWA-SA-94-078 (Washington, D.C.: Federal Highway Administration, October 1994). Additional studies supporting the effectiveness of pavement preventive maintenance are cited below because they also support the cost-effectiveness of these treatments.

8 American Association of State Highway and Transportation Officials, *AASHTO Manual for Bridge Maintenance* (Washington, D.C., 1987), 3.

9 J.M. Kruegler, G.M. Briggs, C.C. McMullen, and G.A. Earnhart, *Cost-Effective Bridge Maintenance Strategies, Volume II: Guidelines and Recommendations*, Report No. FHWA/RD-86/110 (McLean, Virginia: Federal Highway Administration, June 1986).

10 The distinction between effectiveness and cost-effectiveness is important. The effectiveness of a treatment refers to its ability to achieve a desired result. Cost-effectiveness also considers whether the benefits of a treatment exceed the cost. It is possible that a treatment could be effective in extending pavement life (i.e., be effective), but cost more than the additional years of life are worth.

11 Abdullah I. Al-Mansour and Kumares C. Sinha, ‘‘Economic Analysis of Effectiveness of Pavement Preventive Maintenance,’’ *Transportation Research Record 1442: Maintenance of the Highway Infrastructure* (Washington, D.C.: National Academy Press, 1994), 31-37.

12 Joseph Ponniah and Gerhard Kennepohl, ‘‘Crack Sealing in Flexible Pavements: A Life-Cycle Cost Analysis,’’ Transportation Research Board 74th Annual Meeting, Paper #950763 (January 22-28, 1995).

13 Essam A. Sharaf, Mohamed Y. Shahin, and Kumares C. Sinha, ‘‘Analysis of the Effect of Deferring Pavement Maintenance,’’ *Transportation Research Record 1205: Pavement Maintenance 1988* (Washington, D.C.: National Research Council, 1988), 29-35.

However, not all studies support the effectiveness (and therefore the cost-effectiveness) of preventive maintenance of pavements. For example, researchers at the Wisconsin Department of Transportation are studying sealing joints in concrete pavements and have questioned its effectiveness. [14] Some studies showed mixed results on the effectiveness of micro-surfacing. With four years of data, one study showed micro-surfacing to be more resistant to re-rutting than a 1.5 inch asphalt overlay, but less resistant to cracking. [15] In another study, poorly performing test sections were usually attributable to problems during application of the micro-surfacing materials or inadequate treatment design. The researcher concluded that the experience of the contractors and quality control throughout the micro-surfacing process were very important to successful use of micro-surfacing. [16]

Mn/DOT is currently participating in a study of the cost-effectiveness of pavement preventive maintenance. A description of the study says the study will look at existing data on maintenance obtained from state and local agencies and supplement it with new data obtained from test sections constructed primarily on the state trunk highway system. The study will focus on preventive maintenance treatments for bituminous pavements, such as slurry sealing, crack filling, and micro-surfacing. Both agency and user costs will be considered in the calculation of cost-effectiveness.

Mn/DOT is responsible for preventive maintenance on the State Trunk Highway System.

Mn/DOT PRACTICES

Mn/DOT performs preventive maintenance on state trunk highways and bridges, or arranges for the preventive maintenance to be performed by contractors. The decisions about which activities to use on which highways and bridges, and how much money to spend on preventive maintenance versus other activities, are made by the Mn/DOT districts and the Metropolitan Division.

Mn/DOT provided us with data on the amount of preventive maintenance performed on bituminous, bituminous-over-concrete, and concrete pavements between 1986 and 1995, as recorded in its pavement management system. [17] As Table 4.2 shows, contractors sealed cracks on about 1,700 miles of bituminous

14 Stephen F. Shober, ''The Great Unsealing: A Perspective on PCC Joint Sealing,'' Wisconsin Department of Transportation, (unpublished). We discussed this study with an engineer at Mn/DOT who suggested the current findings of the study are applicable to pavements on certain types of bases for which drainage is not much of a problem. Other test sections were too new to draw a conclusion.

15 C.M. ''Swede'' Pederson and William J. Schuller, ''Micro Surfacing with Natural Latex Modified Asphalt Emulsion: A Field Evaluation'' (Oklahoma Department of Transportation, August 1987).

16 Dean A. Maurer, ''Ralumac Latex-Modified Bituminous Emulsion Mixtures: A Summary of Experience in Pennsylvania,'' Research Project 82-22 (Pennsylvania Department of Transportation, April 1987).

17 According to Mn/DOT, the pavement management system records all contract work and some asphalt overlays performed by Mn/DOT crews. Overlays that are at least a half-mile long and are performed by Mn/DOT crews are included. Other work performed by Mn/DOT crews is not reflected in these figures.

Table 4.2: Miles of Selected Activities on the State Trunk Highway System, 1986-95

	Miles of Activity[1]			
Activity	1986-90	1991-95	Total	Annual Average
BITUMINOUS/BITUMINOUS-OVER-CONCRETE				
Crack Seal	273	1,392	1,665	167
Chip Seal	547	668	1,215	122
Asphalt Overlay (2" or less)	1,320	1,383	2,703	270
CONCRETE				
Reseal Joints	441	33	474	47
Repair Spalled Joints[2]	651	527	1,178	118

Source: Minnesota Department of Transportation.

[1]Miles of work include all contract work and some asphalt overlays performed by Mn/DOT mainten ance crews. Overlays that are at least a half-mile long and performed by Mn/DOT crews are included.

[2]Includes partial-depth repair and more extensive full-depth repair.

and bituminous-over-concrete highways and chip sealed just over 1,200 miles in this ten-year period. Contractors or Mn/DOT crews also applied thin asphalt overlays (less than or equal to two inches) on almost 2,700 miles of bituminous and bituminous-over-concrete highways. According to Mn/DOT records, about 22 percent more miles were chip sealed and 3 percent more miles were overlaid with a thin asphalt layer in the second five-year period (1991-95) than in the first five years. The records also showed that cracks were sealed in five times as many miles in 1991-95 than in 1986-90.

On concrete pavement, contractors resealed joints in over 450 miles of highway and repaired spalled joints in over 1,100 miles of highway. Mn/DOT records show that spalled joints were repaired on about 20 percent fewer miles in the second five-year period (1991-95) than in the previous five-year period. Records also showed that joints were resealed on about 92 percent fewer miles in the second five-year period, relative to the period 1986-90. Over the ten-year period, the number of concrete roadway miles on the state trunk highway system declined about 16 percent.

We asked Mn/DOT to use its pavement management system to see if there were pavements that were in a condition such that preventive maintenance might be appropriate. The pavement management system analyzes information on condition ratings, levels of surface defects, age, and average daily traffic on the state trunk highways. The pavement management system recommends one or more possible actions based on the pavement information. The recommendations range from "do nothing" to "reconstruct."[18] The results of the analysis show that about 65 percent of state trunk highway miles *might* benefit from preventive maintenance. This does not mean that two-thirds of the highway miles need immediate preventive maintenance. However, these miles are in good enough condition for preventive maintenance to be considered.

Though the pavement management system can supply information on the level of activity taking place and the number of miles that might benefit from preventive maintenance, it does not give an indication of whether this level of activity is appropriate. To help us evaluate whether Mn/DOT is doing enough preventive maintenance, we sent questionnaires to the District Engineers and the Metropolitan Division Engineer. One questionnaire asked about preventive maintenance of bituminous and bituminous-over-concrete pavement, one asked about preventive maintenance of concrete pavement, and one asked about preventive maintenance of bridges. The specific activities we asked about are described in Figures 4.1, 4.2, and 4.3.

We asked Mn/DOT managers around the state about their use of preventive maintenance.

We asked the engineers to distribute the surveys to those individuals who could best respond for the districts' maintenance areas. [19] For each questionnaire, we received 12 responses from individuals in supervisory and management positions representing all parts of the state. In most cases, we also spoke with the people who returned the questionnaires for clarification and further explanation of answers.

Some responses we received represent an entire district, while others represent a maintenance area within a district. Figure 4.4 shows the organizational units that responded. Maintenance areas and districts do not represent equal miles of bituminous pavement or concrete pavement, or equal numbers of bridges, so we did not weight responses in any way. [20] We think the responses we received convey what the people familiar with preventive maintenance think about its use in the areas where they work.

18 At our request, the decision criteria used by the pavement management system to assess the pavements that might benefit from preventive maintenance are different from the criteria used in the current system. The criteria used were developed by a Mn/DOT pathbuilding team on preventive maintenance based on the members' years of experience and engineering expertise. These criteria, which will be incorporated into the pavement management system, contain more options for pavements in relatively good condition, for which preventive maintenance might be appropriate. The current criteria focus more on pavements in relatively worse condition.

19 Four of the outstate Mn/DOT districts (Districts 1, 3, 6, and 7) are divided into two maintenance areas. Districts 2 and 4 formerly had separate maintenance areas, but no longer do. District 8 has a maintenance sub-area, but not separate maintenance areas. We asked for responses for the separate maintenance areas because we thought practices might differ among them. However, for each of the three questionnaires, three districts responded with only one questionnaire for the whole district. The Metropolitan Division Engineer was asked to forward the questionnaires to the people who could respond for the entire metropolitan area.

20 In analysis not reflected in this report, we counted each single district response and the Metropolitan Division response twice, as if each maintenance area or sub-area had responded. The results did not change the general conclusions we draw in this chapter, though specific relationship s sometimes changed.

Managers from all regions of the state responded to our questionnaire.

Figure 4.4: Responses to the Preventive Maintenance Questionnaires

Pavement Questionnaires	Bridge Questionnaire
District 1	District 1
District 2	Maintenance Area 2A
Maintenance Area 3A	Maintenance Area 2B
Maintenance Area 3B	Maintenance Area 3A
Maintenance Area 4A	Maintenance Area 3B
Maintenance Area 4B	District 4
Maintenance Area 6A	Maintenance Area 6A
Maintenance Area 6B	Maintenance Area 6B
Maintenance Area 7A	Maintenance Area 7A
Maintenance Area 7B	Maintenance Area 7B
District 8	District 8
Metropolitan Division	Metropolitan Division

Bituminous and Bituminous-over-concrete Pavement

Bituminous and bituminous-over-concrete pavements together comprise about 80 percent of Minnesota's state trunk highway roadway miles. Bituminous pavements include both originally constructed bituminous highways and bituminous highways that have been overlaid with a bituminous layer. Bituminous-over-concrete highways, as their label would suggest, are highways that were originally constructed as concrete but have since been overlaid with a bituminous layer. The preventive maintenance activities on which we focused for these two types of pavements are the same and, in the remainder of this section, we use "bituminous" to refer to both.

The questionnaire we sent the district offices and the Metropolitan Division asking about preventive maintenance activities for bituminous pavement focused on the nine activities described in Figure 4.1. Of the nine activities we asked about, five had been used in most respondents' areas since January 1990. The five activities that had been performed in most areas include crack filling, crack sealing, fog sealing, single-application chip sealing, and asphalt overlaying. [21]

Managers gave various reasons for why sand sealing, slurry sealing, multiple-application chip sealing, and micro-surfacing had not been used. For example, lack of pavements requiring the treatment, ineffectiveness of the treatment, and lack of cost-effectiveness in the respondent's area were cited as reasons why sand sealing and multiple-application chip sealing were not used. For slurry sealing, managers cited the newness of the procedure and either a lack of opportunity to try it or a desire to see performance in other areas before using it. A lack of Mn/DOT equipment or private contractors who perform micro-surfacing and the

21 The question read: "Since January 1990, have Mn/DOT crews or contractors performed this activity on any of your maintenance area's bituminous or BOC pavements? 1.) Yes 2.) No 3.) Don't know."

newness of the procedure were cited by respondents as reasons why more of this activity does not occur. [22]

Table 4.3 shows that:

- **Mn/DOT managers responding to our questionnaire said their areas performed the right amount of some preventive maintenance activities, but too little of other activities.**

Mn/DOT managers thought they did the right amount of some activities, but too little of others.

For example, almost all managers said that too little crack filling was performed in their areas, and half thought too little crack sealing was performed. Some people thought the right amount of almost all activities was performed in their areas, while others thought they did not perform the right amount of any

Table 4.3: Questionnaire Responses on Adequacy of Pavement Preventive Maintenance

Activity	We do "too little"	We do the "right amount"	No Response
BITUMINOUS/BITUMINOUS-OVER-CONCRETE PAVEMENT			
Crack fill	11	1	0
Asphalt overlay (2" or less)	7	5	0
Crack seal	6	5	1
Fog seal	6	6	0
Slurry seal	6	3	3
Micro-surface	6	1	5
Sand seal	4	6	2
Single-application chip seal	4	7	1
Multiple-application chip seal	4	6	2
CONCRETE PAVEMENT			
Repair spalled joints	6	5	1
Reseal joints	5	7	0
Grind concrete	4	8	0
Install edge drains	2	10	0
Retrofit load transfer	1	4	7

Note: The question read: "In your professional opinion, how adequate is your maintenance are a's use of this treatment? (Please consider only the need for the activity, not budget or other contra ints.)"

Source: Program Evaluation Division questionnaire sent to Minnesota Department of Transpo rtation district offices and the Metropolitan Division, 1996.

22 The question read: ‘‘For each activity that has not been performed in your maintenance area since January 1990, which reason best explains why? 1.) It is not effective in our maintenance area . 2.) It is not cost-effective in our maintenance area. 3.) We have not had any pavements in the condition for which this treatment should be used. 4.) Other 5.) Don't know. ’’

activity.[23] However, most managers' responses were somewhere between these two extremes. The wide range of opinion may in part be explained by different levels of preventive maintenance that respondents feel are ''adequate'' and by different interpretations of what ''adequate'' means.

Resource constraints limit the amount of preventive maintenance performed.

About half the time, Mn/DOT managers indicated that resource constraints, either financial or personnel, at least partly explained why some preventive maintenance activities are used too little. However, for some individual activities, other reasons were cited more frequently. For example, traffic volumes were cited most often as the reason more chip sealing is not done.[24]

Concrete Pavement

We also asked the Mn/DOT district offices and the Metropolitan Division about their use of and experience with preventive maintenance activities for concrete pavement. The activities are described in Figure 4.2. Resealing joints, repairing spalled joints, installing edge drains, and grinding concrete had been performed in most of the respondents' areas since January 1990. Retrofit load transfer had been used in five areas.[25]

Table 4.3 shows how managers felt about the adequacy of their use of concrete preventive maintenance activities.[26] Compared to their use of bituminous preventive maintenance,

- **Mn/DOT managers generally were more satisfied with their use of concrete pavement preventive maintenance, but some were concerned that Mn/DOT may not be attending to concrete joints early enough to prevent more costly problems from developing.**

23 The number of activities respondents thought were being performed too little in their areas ranged from one to nine. The question read: ''In your professional opinion, how adequate is your maintenance area's use of this treatment? (Please consider only the need for the activity, not budg et or other constraints.) 1.) We perform too little of this. 2.) We perform the right amount of this. 3.) We perform too much of this.'' Some respondents did not provide an opinion on the adequacy of use for all activities. In these cases, the individuals indicated the activity had not been used in their area since January 1990 and they felt they did not have enough experience with the activity to form an opinion. Originally, 25 items were unanswered. Based on follow-up calls we recoded twelve of the missing responses. Two were recoded as ''too little.'' Ten were recoded as ''the right amount.''

24 The question read: ''For each activity for which you indicated your maintenance area ''performs too little,'' why doesn't your maintenance area use this treatment more? (Indicate all that apply.) 1.) We do not have adequate funds to perform this activity on all applicable roads. 2.) It is hard to justify performing this activity on roads in relatively good condition when other roads are in worse condition. 3.) Maintenance workers are performing other maintenance activities. 4.) Maintenance workers are working in other areas (e.g., performing constructions inspections). 5.) This activity is not a maintenance area, district, and/or agency priority. 6.) Traffic volumes prevent more use of t his treatment. 7.) Other 8.) Don't know.''

25 The question read: ''Since January 1990, have Mn/DOT crews or contractors performed this activity on any of your maintenance area's concrete pavements? 1.) Yes 2.) No 3.) Don't know. ''

26 The question read: ''In your professional opinion, how adequate is your maintenance area's use of this treatment? (Please consider only the need for the activity, not budget or other constraints .) 1.) We perform too little of this. 2.) We perform the right amount of this. 3.) We perform too muc h of this.''

Trunk highways might benefit from earlier and more frequent concrete joint work.

Five managers said they performed too little joint resealing and six said they performed too little repairing of spalled joints. According to activity data maintained in Mn/DOT's pavement management system, contractors repaired spalled joints on about 80 percent as many miles and resealed joints on about 8 percent as many miles in the five years 1991-95 as in the previous five-year period.[27] In a national study, most of the states that provided information reported first replacing joint sealer and first repairing spalled joints in the first ten years of pavement life, while Minnesota reported a pavement age of 12 years at first treatment.[28] Responses to our questionnaire suggest the pavement might even be older than 12 years, on average, when this work is first done. This is not necessarily evidence that too little of these activities is being performed; other factors can affect the use of these treatments. For example, one respondent told us that his area has a large quantity of failed concrete pavements because of the quality of aggregate used during construction, and resealing joints would not help. Another told us, ''Our concrete roads are getting old enough that we have done repairs once or twice already. The next fix would be bigger. ''

We asked why too little of some preventive maintenance activities is performed. The most common reason given by Mn/DOT managers was inadequate funds. The second most frequently cited reason for too little work being performed was the difficulty in justifying work on roads in relatively good condition when other roads are in worse condition.[29]

Bridges

In the bridge questionnaire, we asked Mn/DOT about the preventive maintenance activities described in Figure 4.3. It is not surprising that all but one of the activities (extending floor drains) had been performed in most respondents' areas since January 1990 because all of the activities we asked about are recommended in Mn/DOT's Bridge Maintenance Manual.[30]

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27 According to Mn/DOT, its pavement management system records work done under contract and some asphalt overlays performed by Mn/DOT's maintenance crews. If any joint spall repair or resealing of joints was performed by Mn/DOT crews, it would not be captured in these figures. According to questionnaire respondents, both types of activities are usually performed under contract, though one respondent indicated joint resealing is performed by Mn/DOT crews and under contract.

28 Geoffroy, *Cost-Effective Preventive Pavement Maintenance* , 54-55 (Appendix D). Fifteen of 21 states repaired spalled joints in the first ten years and 17 of 22 states replaced joint sealer in t he first ten years.

29 The question read: ''For each activity for which you indicated your maintenance area ''performs too little,'' why doesn't your maintenance area use this treatment more? (Indicate all that apply.) 1.) We do not have adequate funds to perform this activity on all applicable roads. 2.) It is hard to justify performing this activity on roads in relatively good condition when other roads are in worse condition. 3.) Maintenance workers are performing other maintenance activities. 4.) Maintenance workers are working in other areas (e.g., performing constructions inspections). 5.) This activity is not a maintenance area, district, and/or agency priority. 6.) Traffic volumes prevent more use of t his treatment. 7.) Other 8.) Don't know.''

30 Minnesota Department of Transportation, Office of Bridges and Structures, *Bridge Maintenance Manual* (St. Paul, February 27, 1996), Section 5-399.100. Half of the respondents reported that none of their bridges needed floor drain extensions since January 1990.

Table 4.4 shows that:

- **Mn/DOT managers responding to our questionnaire said their areas performed the right amount of some bridge preventive maintenance activities, but too little of other activities.**

Table 4.4: Questionnaire Responses on Adequacy of Bridge Preventive Maintenance

Activity	We do "too little"	We do the "right amount"	No Response
Spot paint	11	1	0
Clean/reseal deck joints	9	3	0
Lubricate expansion bearings	8	4	0
Correct approach panel settlement	7	5	0
Crack seal concrete decks	5	7	0
Reinstall strip neoprene glands	5	7	0
Install relief joints in concrete approaches	5	7	0
Flush winter residue	3	9	0
Place drain extensions on floor drains	1	10	1

Note: The question read: "In your professional opinion, how adequate is your maintenance are a's use of this treatment? (Please consider only the need for the activity, not budget or other contra ints.)"

Source: Program Evaluation Division questionnaire sent to Minnesota Department of Transpo rtaion district offices and the Metropolitan Division, 1996.

For example, most managers felt their areas were doing too little spot painting of bridges.[31] Bridge maintenance people mentioned the difficulty of doing spot painting cost-effectively because of the environmental and safety regulations involved with removing lead-based paint.

Nine of the twelve respondents felt their areas were doing too little cleaning and resealing of bridge deck joints. According to one Mn/DOT publication, "One of the most serious bridge maintenance problems is leaky expansion joints."[32] Ideally, joints should not leak. If joints with poured joint sealer are leaking, the joints should be cleaned and resealed. If joints with strip neoprene glands are leaking, the glands should be repaired or replaced. Table 4.5 shows the percent of bridges with leaking joints recorded in the bridge maintenance management system as of September 1996.[33] About 70 percent of bridges with poured joint sealer had at least one leaking joint. Only 9 percent of bridges with neoprene

31 The question read: "In your professional opinion, how adequate is your maintenance area's use of this treatment? (Please consider only the need for the activity, not budget or other constraints .) 1.) We perform too little of this. 2.) We perform the right amount of this. 3.) We perform too mu ch of this."

32 Minnesota Department of Transportation, *Transportation Research 1995 Annual Report* (St. Paul), 49.

33 The condition information we received contains the most recent inspection information as of September 1996. The actual inspection dates for the bridges vary.

Table 4.5: Bridge Expansion Joint Condition

Type of Expansion Joint	Number of Bridges	Bridges with Leaking Joints	Percent of Bridges with Leaking Joints
Poured joint sealer	258	186	72%
Neoprene gland	1,982	176	9
Other[1]	167	142	85
Total with joints	2,407	504	21

Note: Only the condition of the expansion joint in the worst condition is noted. Not every joint in a bridge with one leaking joint is necessarily leaking.

Source: Program Evaluation Division analysis of data from the Minnesota Department of Transportation's Bridge Maintenance Management System, September 1996.

[1]Includes three bridges that did not have "type of device" information but did have condition information.

glands had leaking joints; most of the state trunk highway bridges have this type of expansion joint.[34]

Most of the managers answering our questionnaire thought they were doing the right amount of bridge flushing. Flushing winter residue from bridges is one preventive maintenance activity for which Mn/DOT has a recommended frequency against which we could compare actual performance. It is important to flush bridges to prevent concrete from cracking and scaling and steel components from corroding. By analyzing data maintained in Mn/DOT's bridge maintenance management system, we found that:

Mn/DOT needs to flush debris from bridges more frequently.

- **Mn/DOT flushes bridges less frequently than the once-a-year frequency recommended in the Mn/DOT Bridge Maintenance Manual.**

Table 4.6 shows that, based on two years of data from the bridge maintenance management system, bridges are being flushed, on average, once every three years. Some bridges were flushed more than once during the two years, so some bridges probably have a once-a-year cycle, while others are flushed even less frequently than the once-every-three-years average we calculated.

We called a few of the managers who responded to our questionnaire for possible explanations of why the bridge flushing activity was below recommended levels. We learned that the bridge maintenance management system does not contain information about all of the bridge flushing activity that occurs. For example, Duluth has the longest cycle between flushing in Table 4.6, but this may partly reflect the fact that highway maintenance workers do some of that district's bridge flushing, and the flushing done by these workers is not recorded in the bridge maintenance management system. Managers also told us that it is less important to flush certain bridges each year, such as bridges that are not treated with a lot of

34 One respondent who initially indicated that his area does the right amount of reinstallation of strip neoprene glands said the latest inspections revealed a lot of the glands in his area were pulling out of the joints and needed to be replaced. Two respondents who said their replacement of neoprene glands is adequate indicated that they patch the glands a lot and if they had more money, they would do more replacement of the glands.

Table 4.6: Flushing Activity on State Trunk Highway Bridges, Calendar Years 1994-95

District	Bridges[1]	Number of Flushes[2]	Cycle in Years[3]
1 - Duluth	333	62	10.7
2 - Bemidji	129	74	3.5
3 - Brainerd	221	324	1.4
4 - Detroit Lakes	147	102	2.9
6 - Rochester	392	329	2.4
7 - Mankato	221	200	2.2
8 - Willmar	137	222	1.2
Metropolitan Division	944	318	5.9
Total	2,524	1,631	3.1

Source: Program Evaluation Division analysis of data from the Minnesota Department of Transportation's Bridge Maintenance Management System.

[1]The number of bridges is the number we estimate were open in both 1994 and 1995.

[2]The number of flushes includes flushing of the entire bridge or any component of the bridge, as recorded in the Minnesota Department of Transportation's Bridge Maintenance Management System. Deck flushing by non-bridge crews is not reflected. Some bridges were flushed more than once in the two-year period.

[3]The "cycle" refers to the years between flushes based on the activity for the two years 1994-1995.

de-icing chemicals. This may explain why most managers felt their bridge flushing activity was adequate even though it does not meet the once-a-year standard.[35]

Bridges are seldom flushed in the East Metro area and Northeastern Minnesota.

We explored bridge flushing in the metropolitan area more closely because over a third of the bridges for which we had information are in the metropolitan area and the use of de-icing chemicals might be more intense because of traffic volumes. In the Metropolitan Division, the Metro West bridge maintenance superintendent said he emphasizes flushing bridges inside the Interstate 494-694 loop because the high volume of traffic leads to more chemicals being used during the winter. The Metro East superintendent said he thought his crews probably flushed more bridges outside the loop, except for a few structures inside the loop over the Mississippi River that have a lot of exposed steel. As Table 4.7 shows, Metro West does do more flushing of bridges inside the loop, though the frequency still does not meet the recommended standard. Metro East did little bridge flushing, especially inside the loop. The six recorded flushings inside the Interstate 494-694 loop on the east side occurred on three bridges, two over the Mississippi River and one over Interstate 35E.

We asked Mn/DOT managers why some preventive maintenance activities on bridges were not performed enough, and their most common response was that maintenance workers were performing other maintenance activities. Since most bridge preventive maintenance work is performed by Mn/DOT crews, it is not surprising that this explanation would be more common for bridges than for

35 Two people said that, in their opinions, some bridges with strip neoprene glands should be flushed more than once a year.

Table 4.7: Bridge Flushing Inside the Twin Cities Interstate 494-694 Loop, Calendar Years 1994-95

	Metro West	Metro East	Total Metro
Bridges within the 494-694 loop[1]	409	267	676
Flushes within the 494-694 loop[2]	250	6	256
Cycle within the loop[3]	3.3	89.0	5.3
Bridges outside the 494-694 loop	125	143	268
Flushes outside the 494-694 loop	48	14	62
Cycle outside the loop	5.2	20.4	8.6
Total bridges in area	534	410	944
Total flushes in area	298	20	318
Overall cycle	3.6	41.0	5.9

Source: Program Evaluation Division analysis of data from the Minnesota Department of Transportation's Bridge Maintenance Management System.

[1]The number of bridges is the number we estimate were open in both 1994 and 1995.

[2]The number of flushes includes flushing of the entire bridge or any component of the bridge as recorded in the Minnesota Department of Transportation's Bridge Maintenance Management System. Deck flushing by non-bridge crews is not reflected. Some bridges were flushed more than once in the two-year period.

[3]The "cycle" refers to the years between flushes based on the activity for the two years 1994-1995.

In almost half the cases, Mn/DOT managers thought they performed too little preventive maintenance.

pavements. This reason was followed by inadequacy of funds and difficulty in justifying work on bridges in relatively good condition when others are in worse condition.[36]

Additional Analysis

Mn/DOT managers responding to our questionnaire gave a mixed report on the adequacy of preventive maintenance of Minnesota's state trunk highway system. In our questionnaire, there were 127 instances in which managers indicated they were doing the right amount of a particular preventive maintenance activity, compared with 126 instances in which they said they did too little. But we were surprised to find that:

- **In about half the cases where Mn/DOT managers reported performing the right amount of a preventive maintenance activity, they also indicated they would spend additional money on the activity if funds were available.**

36 The question read: ''For each activity for which you indicated your maintenance area ''performs too little,'' why doesn't your maintenance area use this treatment more? (Indicate all that apply.) 1.) We do not have adequate funds to perform this activity on all applicable bridges. 2.) It is hard to justify performing this activity on bridges in relatively good condition when other bridges are in worse condition. 3.) Maintenance workers are performing other maintenance activities. 4.) Maintenance workers are working in other areas (e.g., performing constructions inspections). 5.) This activity is not a maintenance area, district, and/or agency priority. 6.) Traffic volumes prevent more use of this treatment. 7.) Other 8.) Don't know.''

Respondents frequently explained that they were maintaining the system at a certain level and were doing a reasonable amount of preventive maintenance given their resource constraints, but they thought there were additional opportunities to use preventive maintenance if funds were available.[37]

Table 4.8 shows that most Mn/DOT managers responding to our questionnaire thought that most of the activities we asked about are cost-effective. In addition, Mn/DOT's 1996 performance report says that not performing preventive maintenance causes increased costs in later years, which increases the cost of state

Generally, Mn/DOT managers believe preventive maintenance is cost-effective.

Table 4.8: Mn/DOT Managers' Opinions on Cost-Effectiveness of Preventive Maintenance

	In your professional opinion, is this activity cost-effective in your maintenance area, or would it be if it were used? (n=12)		
Activity	Yes	No	Don't know
BITUMINOUS/BOC			
Crack fill	83%	0%	17%
Crack seal	83	0	17
Asphalt overlay (2" or less)[1]	92	0	0
Fog seal	75	0	25
Sand seal[1]	42	0	50
Slurry seal	25	8	67
Micro-surface	33	0	67
Single-application chip seal[1]	67	0	25
Multiple-application chip seal[1]	17	0	75
CONCRETE			
Reseal joints	100%	0%	0%
Retrofit load transfer	25	0	75
Repair spalled joints	83	17	0
Grind concrete[2]	67	17	17
Install edge drains	92	0	8
BRIDGES			
Crack seal	92%	0%	8%
Lubricate expansion bearings	92	0	8
Flush winter residue	100	0	0
Reinstall strip neoprene glands	100	0	0
Spot paint[2]	83	8	8
Clean/reseal bridge deck joints	100	0	0
Install relief joints in concrete approaches	75	0	25
Correct approach panel settlement	92	0	8
Place drain extensions on floor drains	83	0	17

Source: Program Evaluation Division questionnaire sent to Minnesota Department of Transportation district offices and the Metropolitan Division, 1996.

[1]Percents do not total 100 percent because one respondent did not answer.

[2]Percents do not total 100 percent because of rounding.

37 The question read: "If you had additional funds at your disposal, would you spend any on this particular activity? 1.) Yes 2.) No 3.) Don't know."

road operations per lane mile.[38] However, when determining how to use their budgets, Mn/DOT districts and the Metropolitan Division try to address safety and congestion problems, in addition to considering ways to prevent later maintenance problems. Also, sometimes work needs to be done on highways and bridges in poor shape to maintain them until they can be programmed for reconstruction. Finally, the amount of preventive maintenance work performed sometimes depends on the amount of money districts spend on other maintenance activities. For example, a harsh winter might deplete maintenance budgets because of Mn/DOT's snow and ice removal responsibilities.

Preventive maintenance tends to be a lower priority than more immediate problems.

In sum, Mn/DOT managers generally believe that preventive maintenance is cost-effective and would do more of it, but preventive maintenance tends to be a lower priority than more pressing problems. Perhaps this reflects the fact that the negative impacts of deferring preventive maintenance are not noticeable in the short-term. Managers often feel compelled to respond to more immediate public concerns, such as a pothole-filled or bumpy highway, before they invest in strategies that might prevent some of these problems from developing.

RECOMMENDATIONS

Data provided in Chapter 2 show that bridge and pavement quality have stayed relatively constant over the past 10 years, indicating that Mn/DOT is keeping Minnesota's state trunk highway system in the shape to which Minnesotans have become accustomed. However, we question whether Mn/DOT is maintaining highways and bridges in the most cost-effective manner.

- **In our opinion, Mn/DOT should take a more strategic approach to preventive maintenance on the state's trunk highway system.**

A more strategic approach to preventive maintenance might include:

Mn/DOT should take a more strategic approach to preventive maintenance.

(1) developing maintenance strategies that suggest when specific activities should be performed in the life of a pavement or structure;

(2) continuously evaluating the cost-effectiveness of preventive maintenance techniques, treatments, and strategies;

(3) setting aside funds for specific types of preventive maintenance; and

(4) at least initially, making centralized decisions about the most cost-effective preventive maintenance projects to pursue.

We think Mn/DOT should consider developing formal preventive maintenance strategies. A 1994 survey of state, local, and Canadian transportation agencies asked the agencies about their pavement preventive maintenance strategies. A

38 Minnesota Department of Transportation, *1996 Performance Report* (St. Paul, December 1996), 110.

preventive maintenance strategy was defined as, "A plan for applying a series of preventive maintenance treatments over the life of the pavement. It is an organized, systematic process to select and budget preventive maintenance activities over the life of the pavement so as to minimize life cycle costs."[39] Twenty-two states (including Minnesota) of 45 states responding to the survey said they did not have formal preventive maintenance strategies for pavements. States with strategies generally reported observing an increase in time before pavement rehabilitation was required, a decrease in time and money spent on demand maintenance activities, and an improvement in pavement smoothness.

Mn/DOT should evaluate any new strategies it develops.

According to a report published by the Federal Highway Administration, "A single preventive maintenance treatment will improve the quality of the pavement surface and extend the pavement life. However, the true benefits of pavement preventive maintenance are realized when there is a consistent schedule for performing the preventive maintenance."[40] The report also said that preventive maintenance is defined less by the activities that are used than by *when* those activities are employed. "To be cost-effective," the authors wrote, "pavement preventive maintenance treatments should be applied before most engineers, or project decision makers would normally consider their use."[41] If Mn/DOT developed strategies and made a long-term commitment to evaluate them, it could confirm that its strategies are cost-effective, or learn that it needs to modify them.

Mn/DOT already has invested in pavement and bridge management systems that could help develop and evaluate preventive maintenance strategies. Mn/DOT developed its pavement management system (PMS) in the 1980s. In 1994, a Mn/DOT "pathbuilding team" on preventive maintenance recognized the possibility of using the PMS to suggest and evaluate preventive maintenance activities.[42] Prior to that time, the system had been used to suggest activities for highways in relatively poor condition. The pathbuilding team developed decision criteria that suggest activities for pavements in relatively good condition. Those criteria are being included in a new version of the PMS. Mn/DOT's bridge management system (PONTIS) already has the ability to identify preventive maintenance activities that would be appropriate at particular times.[43]

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39 Geoffroy, *Cost-Effective Preventive Pavement Maintenance*, 42 (Appendix B).

40 John P. Zaniewksi and Michael S. Mamlouk, *Preventive Maintenance Effectiveness-Preventive Maintenance Treatments: Participant's Handbook* (Washington, D.C.: Federal Highway Administration, February 1996), 39.

41 Zaniewksi and Mamlouk, *Preventive Maintenance Effectiveness-Preventive Maintenance Treatments*, 5.

42 Minnesota Department of Transportation, *Pathbuilding Projects: Final Report* (St. Paul, December 1994), 23-30.

43 Two issues affecting the usefulness of both the bridge and pavement management systems for evaluating preventive maintenance are (1) the thoroughness and reliability of data and (2) calculation of costs and benefits. As mentioned previously, we found some bridge flushing was not recorded in the bridge maintenance management system, and the pavement management system includes only contract work and some asphalt overlays done by Mn/DOT crews. Overlays that are at least a half-mile long and are performed by Mn/DOT crews are included. Regarding calculation of costs and benefits, the benefits of preventive maintenance would probably be reflected by a change in highways' and bridges' rates of deterioration. For bridges, the benefits might extend beyond the component directly being maintained. Also, neither system measures costs beyond agency costs of materials and labor.

Preventive maintenance is too important to handle inconsistently.

We suggest the department consider setting aside funds for preventive maintenance and, at least initially, exercise some central control over selecting the projects. We concluded in the previous section that the amount of preventive maintenance that Mn/DOT performs may depend on how much Mn/DOT spends on more obvious and immediate demands. If Mn/DOT set aside funds for preventive maintenance, which is currently funded by both the construction and operations budgets, perhaps the districts and the Metropolitan Division would be less likely to defer preventive maintenance when other transportation concerns arise. As investment in preventive maintenance is increased, over time it would be expected that the amount of rehabilitation work and demand maintenance activities, such as patching potholes, would decrease somewhat. Initial central office oversight in selecting projects might make Mn/DOT better able to evaluate the cost-effectiveness of preventive maintenance treatments and strategies by establishing and using uniform criteria to determine the types and timing of preventive maintenance to be used.

For example, comments from Mn/DOT managers suggest that a more systematic approach to maintaining concrete joints that are new and/or in good condition might be beneficial. If earlier and more frequent attention to concrete joints were part of a formal maintenance strategy for concrete pavements, and if funds were set aside to perform the scheduled activities, the result might be a reduction in overall spending by catching problems before major concrete repairs are required. Using the pavement management system to evaluate the strategy for concrete preventive maintenance would inform the department if the strategy it adopted was having the anticipated effects.

If preventive maintenance is as cost-effective as Mn/DOT managers and the research literature suggest, it is too important for Mn/DOT to deal with inconsistently. We think Mn/DOT should develop a statewide strategy and carefully evaluate its results over time.

Lane and Shoulder Width Standards

CHAPTER 5

Recent reports have concluded that Minnesota is likely to face tough fiscal decisions in the future as projected revenues fall short of estimated spending.[1] In its 1994 report, Minnesota Planning recommended a number of ways in which future state and local government budget gaps could be addressed. One recommendation was to reduce right-of-way, lane width, and other standards for highways, particularly lower volume roads. Minnesota Planning estimated that reducing standards for newly constructed or reconstructed roads could save between $26 million and $265 million on county state-aid highways alone.

In 1995, the Minnesota Department of Transportation (Mn/DOT) created a Geometric Design Standards Task Force to review department standards for low volume rural state trunk highways and state-aid highways in Minnesota. The Task Force focused on lane and shoulder width standards for rural highways serving fewer than 2,000 vehicles per day. In December 1996, the Task Force finalized its recommendations, but its report has not yet been adopted by the Commissioner of Mn/DOT. Changes in administrative rules would be needed in order to adopt the recommendations affecting state-aid highways.

This chapter examines the work of Mn/DOT's Task Force and, like the Task Force, focuses primarily on lane and shoulder width standards for low volume, two-lane rural roads on the State Trunk Highway (STH) System and the County State-Aid Highway (CSAH) System. In this chapter, we address the following questions:

- **How do Minnesota's current and proposed lane and shoulder width standards compare with nationally recommended standards, as well as standards in other midwestern states?**

- **How does the lane width of Minnesota's roads compare with lane widths in other states?**

1 Minnesota Planning, *Within Our Means: Tough Choices for Government Spending* (St. Paul, January 1995); John Brandl and Vin Weber, *An Agenda for Reform: Competition, Community, Concentration--A Report to Governor Arne H. Carlson* (St. Paul, November 1995); and Office of the Legislative Auditor, *Trends in State and Local Government Spending* (St. Paul, February 1996).

- **What impact would the recommendations made by Mn/DOT's Geometric Design Standards Task Force have on the State Trunk Highway and County State-Aid Highway systems?**

- **Has the Task Force adequately considered the benefits and costs of alternative standards, as well as other important factors?**

RURAL HIGHWAYS

Minnesota has approximately 10,800 miles of rural trunk highways and about 28,800 miles of rural county state-aid highways. Roughly half of the rural trunk highways and more than 90 percent of the rural county state-aid highways were the subject of the Task Force's study. Specifically, 5,600 miles of trunk highways and 27,700 miles of county state-aid highways carry fewer than 2,000 vehicles per day.

Most of these low volume rural highways are paved. Only about 25 miles, or less than 1 percent, of the rural trunk highways are unpaved, while about 6,200 miles, or 22 percent, of the rural county state-aid highways are gravel roads. These unpaved county roads are very lightly traveled. Two-thirds of them carry fewer than 150 vehicles per day, and less than 3 percent serve 400 or more vehicles per day.

Most rural trunk highways have 12-foot lanes.

Table 5.1 shows that the vast majority of rural trunk highways have 12-foot lanes. Only about 5 percent have 11-foot lanes and 1 percent have 10-foot lanes. In contrast, about one-fourth of the paved rural county state-aid highways have lanes which are less than 12 feet wide. As Table 5.2 shows, most of these have 11-foot lanes.

Table 5.1: Miles of Rural State Trunk Highways by Lane Width and Average Daily Traffic, 1996

Average Daily Traffic	Lane Width: 10 Feet	11 Feet	12 Feet	Percentage Less Than 12 Feet
0-749	52[a]	162	1,599[b]	12%
750-1,499	28	124	2,535	6
1,500-1,999	6	26	1,100	3
2,000 or More	50	221	4,928	5
Totals[c]	137	532	10,162	6%
Percentage	1%	5%	94%	

Source: Minnesota Department of Transportation.

[a]Includes 14 miles of gravel roads.

[b]Includes 11 miles of gravel roads.

[c]Some totals do not add due to rounding.

Three-fourths of the rural county state-aid highways have 12-foot lanes.

Table 5.2: Miles of Rural Paved County State-Aid Highways by Lane Width and Projected Average Daily Traffic, 1996

	Lane Width			
Projected Average Daily Traffic[a]	10 Feet or Less	11 Feet	12 Feet	Percentage Less Than 12 Feet
0-399	54	1,714	5,731	23%
400-749	89	1,793	4,584	29
750-999	18	640	1,697	28
1,000-1,499	23	526	1,719	24
1,500-1,999	22	220	911	27
2,000 or More	74	256	2,498	12
Totals[b]	280	5,148	17,140	24%
Percentage	1%	23%	76%	

Source: Minnesota Department of Transportation.

[a]Based on projected traffic levels in 20 years.

[b]Some totals do not add due to rounding.

CURRENT AND PROPOSED STANDARDS

Currently, Mn/DOT has separate standards for trunk highways and state-aid highways. For the State Trunk Highway System, Mn/DOT has one set of design standards which applies to the construction or reconstruction of roads and another which applies to reconditioning or resurfacing projects. Similarly, for the County State-Aid Highway System, Mn/DOT has two different sets of standards.

Construction and Reconstruction Standards

Table 5.3 shows the current construction and reconstruction standards for lane and shoulder widths on the STH and CSAH systems. [2] Since the Task Force focused on highways carrying fewer than 2,000 vehicles per day, the table only shows the lane and shoulder width standards for those roads.

Generally, Mn/DOT's current standards call for newly constructed or reconstructed roads to have paved lane widths of 12 feet. The required width of each shoulder varies by average daily traffic and, for trunk highways, by the functional classification of roads. On paved roads, the minimum shoulder width currently required is 4 feet. Thus, Mn/DOT's current standards require that paved trunk highways and state-aid highways have at least a 32-foot top--namely, 2 lanes

2 Mn/DOT has other construction and reconstruction standards besides lane and shoulder widths. Both the Task Force and this report focus on lane and shoulder widths because they are very important and have been studied extensively in the national literature. More information is availab le on the safety implications of lane and shoulder width configurations than is available on the implications of other types of construction standards.

Table 5.3: Current and Proposed Construction/Reconstruction Standards for Low Volume Rural State Trunk Highways and County State-Aid Highways, 1996

	Lane Width (in feet)					Shoulder Width (in feet)				
	State Trunk Highways (Current)			County State-Aid		State Trunk Highways (Current)[b]			County State-Aid	
Projected Daily Traffic	Principal Arterials	Minor Arterials	Collectors	Highways (Current)	Proposed Standards	Principal Arterials	Minor Arterials	Collectors	Highways (Current)	Proposed Standards
0-49	12	12	12	11[a]	11[a]	8	6	4	1[a]	1[a]
50-149	12	12	12	11[a]	11[a]	8	6	4	3[a]	3[a]
150-749	12	12	12	12	12	8	6	4	4	4
750-1,499	12	12	12	12	12	8	6	6	6	4
1,500-2,000	12	12	12	12	12	10	8	6	8	6

Source: Minnesota Department of Transportation.

[a]Unpaved roads.

[b]On trunk highways, Mn/DOT generally requires at least 2 feet of the shoulder width to be paved, except on collector roads with projected daily traffic less than 750.

A task force is proposing changes in lane and shoulder width standards for low volume rural highways.

of at least 12 feet each and 2 shoulders of at least 4 feet each. [3] The only exception to this general rule is CSAH roads carrying fewer than 150 vehicles per day. This latter group of roads are gravel roads and are only required to have lane widths of 11 feet. Shoulders narrower than 4 feet are also permitted on these gravel roads.

Also included in Table 5.3 are the Task Force's proposed new construction and reconstruction standards. The Task Force has recommended reductions in minimum shoulder widths for some types of roads at certain traffic levels but has recommended no changes in minimum lane widths. Except for gravel roads, the proposed standards would still require roads to have at least 12-foot lanes and 4-foot shoulders or, in other words, a 32-foot top.

Table 5.4 shows that:

- **The proposed changes in construction and reconstruction standards would ultimately affect 12 percent of rural trunk highways and 5 percent of rural county state-aid highways.**

Currently, 3,460 miles of trunk highways and about 12,250 miles of paved county state-aid highways do not meet construction and reconstruction standards for lane and shoulder widths. [4] The proposed standards would reduce the number of substandard miles to 2,215 miles of trunk highways and 10,800 miles of paved county state-aid highways. In other words, 12 percent of the STH system and 5 percent of the CSAH system are affected by the proposed change in standards. The impact of the proposal is primarily on roads which have substandard shoulder

3 Current standards for state trunk highways also require that 2 or more feet of each shoulder be paved, except on collector or local roads carrying fewer than 750 vehicles per day. CSAH standards do not require paving of any portion of the shoulders.

4 These estimates are based on combined lane and shoulder widths and use current, rather than projected, traffic levels.

Table 5.4: Impact of Proposed Construction/Reconstruction Standards for Rural State Trunk Highways and County State-Aid Highways With Average Daily Traffic Less Than 2,000 Vehicles

	State Trunk Highways		County State-Aid Highways[a]	
	Miles	Percent	Miles	Percent
Current Standards Not Met	3,460	32%	12,253	43%
Proposed Standards Not Met	2,215	20	10,802	38
Miles Affected by Change in Standards	1,245	12%	1,451	5%
Total Rural Miles	10,831		28,764[b]	

Source: Minnesota Department of Transportation.

[a]Based on projected traffic levels in 20 years. Includes only paved roads not meeting standard s.

[b]Includes both paved and unpaved roads.

widths, since the proposal does not affect lane widths on construction and reconstruction projects.

Reconditioning and Resurfacing Standards

Table 5.5 shows Mn/DOT's current reconditioning and resurfacing standards for trunk highways and the CSAH system. These standards specify the minimum lane and shoulder widths required for reconditioning or resurfacing projects to proceed. The specified widths are lower than those contained in Mn/DOT's construction/reconstruction standards. If the lower set of standards is not met, then a road cannot be reconditioned or resurfaced and must instead be reconstructed at a much higher cost to meet the more demanding standards.[5] Reconditioning or resurfacing standards permit a highway agency to preserve existing roads at a reasonable cost, unless the roads are considerably below standard.

The current standards for the STH system distinguish between reconditioning projects and resurfacing projects, while the current standards for the CSAH system do not make this distinction and are simply called resurfacing standards. For state trunk highways, resurfacing projects are considered to be less costly than reconditioning projects and generally only provide a new surface for the existing pavement in order to improve the ride and prolong the life of the roadway. In addition to a new surface, reconditioning projects may involve modest safety or other improvements, although they generally stay within the existing right-of-way.

Mn/DOT's current standards for the STH system call for a minimum lane width of 11 feet before a resurfacing project can be undertaken. No minimum shoulder width is required prior to resurfacing a state trunk highway. The current standards

5 On the STH system, Mn/DOT has sometimes found it feasible to widen a road as part of a reconditioning project.

Table 5.5: Current and Proposed Reconditioning Standards for Low Volume Rural State Trunk Highways and County State-Aid Highways, 1996

	Minimum Acceptable Width for Reconditioning[a]											
	Lane Width (Paved)						Combined Lane and Shoulder Width					
	State Trunk Highways (Current)				Proposed Standards		State Trunk Highways (Current)				Proposed Standards	
Projected Daily Traffic	Principal Arterials	Minor Arterials	Collectors	County State Aid Highways (Current)	Speed Limit Under 50	Speed Limit of 50 or More	Principal Arterials	Minor Arterials	Collectors	County State-Aid Highways (Current)	Speed Limit Under 50	Speed Limit of 50 or More
0-749	11	11	11	11	10	10	3	2	2	2	1	2
750-999	11	11	11	11	10	11	3	2	2	4	2	4
1,000-1,499	11	11	11	12	10	11	3	2	2	4	2	4
1,500-2,000	11	11	11	12	10	11	6	6	2	4	2	4

Source: Minnesota Department of Transportation.

[a]At lower widths, the road must instead be reconstructed.

[b]The existing CSAH standards are called resurfacing standards and are based on the current level of average daily traffic.

for reconditioning work on the STH system are greater. Reconditioning a trunk highway can only be done if a road's lanes already are 12 feet wide or will be widened to 12 feet during the project. In addition, the combined lane and shoulder width of a rural low volume trunk highway must be between 14 and 18 feet, depending on projected daily traffic and the road's functional class.

The current CSAH resurfacing standards are more similar to STH reconditioning standards than to STH resurfacing standards. [6] Current CSAH standards for resurfacing projects call for 11-foot lanes for existing traffic volumes below 1,000 vehicles per day and 12-foot lanes for higher traffic volumes. Combined lane and shoulder widths must be 13 feet or more at daily traffic volumes under 750 and 15 feet or more at higher traffic volumes.

The proposed ''reconditioning'' standards for both the STH and the CSAH systems do not distinguish between reconditioning and resurfacing like the old STH standards. The proposal lumps both types of work together and defines reconditioning as work which extends the life of the roadway by overlaying the existing pavement or structure and may include modest safety or operational improvements but little or no additional right-of-way.

As Table 5.5 shows, the proposed standards would generally reduce the minimum lane width required for reconditioning or resurfacing work, but may lower or raise the combined lane and shoulder width required. The proposed standards raise the combined lane and shoulder width required on most STH resurfacing projects and lower the combined width required on most STH reconditioning projects and all CSAH resurfacing projects.

Table 5.6 shows that the proposed standards will loosen standards for about 1,200 miles, or 4 percent of the rural county state-aid highways. For resurfacing projects, the proposed standards will have virtually no impact on rural trunk highways.[7] For more extensive reconditioning projects, the proposed standards would be less restrictive for about 1,500 miles of trunk highways, or 14 percent of all rural trunk highways.

COMPARISON WITH OTHER STATES

In this section, we compare Minnesota's proposed standards with nationally recommended standards and those of other states. In addition, we compare lane widths in Minnesota with those in other states. In general, we find that Minnesota's proposed construction and reconstruction standards are more

6 Current STH reconditioning and CSAH resurfacing standards for shoulder widths are hard to compare because the trunk highway reconditioning standards vary by a road's functional class. However, since 94 percent of the county state-aid highways are collectors or local roads, it is reasonable to compare the CSAH standards to the trunk highway reconditioning standards for collectors.

7 For resurfacing projects, the proposal would loosen lane width standards for a small number of rural trunk highways with 10-foot lanes but raise combined lane and shoulder width standards for other trunk highways.

Table 5.6: Impact of Proposed Reconditioning Standards for Rural State Trunk Highways and County State-Aid Highways

	State Trunk Highways[a]				County State-Aid Highways	
	Reconditioning		Resurfacing			
	Miles	Percentage	Miles	Percentage	Miles	Percentage
Current Standards Not Met	1,653	15%	137	1%	1,713	6%
Proposed Standards Not Met	105 to 146	1	105 to 146	1	502	2
Affected Miles	1,507 to 1,548	14%	-9 to 32	0%	1,211	4%
Total Rural Miles	10,831				28,764	

Source: Minnesota Department of Transportation and analysis by the Office of the Legislative Auditor.

[a]Includes all rural trunk highways, including those with average daily traffic of 2,000 or more vehicles per day.

demanding than nationally recommended standards and those of most of the midwestern states which Mn/DOT recently contacted. In addition, data from the Federal Highway Administration show that Minnesota has a higher percentage of roads with 12-foot lanes than the national average and most midwestern states.

Nationally Recommended Standards

At the national level, there are two sets of standards which have been recommended for construction and reconstruction projects on paved rural highways carrying fewer than 2,000 vehicles per day.[8] One set of standards is recommended by the American Association of State Highway and Transportation Officials (AASHTO). The other set was recommended in a recent research report prepared for the National Cooperative Highway Research Program (NCHRP) by the Transportation Research Board and the National Research Council.[9] The recommendations in the latter report were based on the results of extensive research which had previously been conducted on rural low volume highways across the United States. Accident data from a number of states including Minnesota were examined in this report.

The proposed standards generally require wider lanes than nationally recommended standards.

As shown in Table 5.7:

- **Minnesota's proposed construction and reconstruction standards generally require wider lanes than nationally recommended standards.**

Both the current and proposed Mn/DOT standards for construction and reconstruction projects require that paved roads have lanes at least 12 feet wide. The NCHRP report recommends 11-foot lanes for paved roads carrying fewer

8 We are not aware of any nationally recommended standards for reconditioning or resurfacing projects.

9 Zegeer C., Stewart R., Council F., and Neumann T. for the Transportation Research Board and the National Research Council, *National Cooperative Highway Research Program Report 362* (Washington, D.C., 1994).

Table 5.7: Proposed Minnesota and Nationally Recommended Construction/Reconstruction Standards for Low Volume Rural Highways, 1996

	Lane Width (in Feet)			Shoulder Width (in Feet)		
Projected Daily Traffic	Minnesota (Proposed)	AASHTO[a]	NCHRP[b]	Minnesota (Proposed)	AASHTO	NCHRP
0-49	11[c]	11	11	1[c]	2	2
50-149	11[c]	11	11	3[c]	2	2
150-399	12	11	11	4	2	2
400-1,499	12	11	11	4	4	4
1,500-2,000	12	12	11	6	6	6

Source: Minnesota Department of Transportation.

[a]American Association of State Highway and Transportation Officials.

[b]National Cooperative Highway Research Program.

[c]Unpaved Roads.

than 2,000 vehicles per day. AASHTO standards call for lanes at least 11 feet wide for traffic levels under 1,500 vehicles per day and at least 12 feet wide for traffic levels between 1,500 and 2,000 vehicles per day.

Minnesota's proposed standards for shoulder widths on construction and reconstruction projects are slightly more demanding than the AASHTO and NCHRP standards. For the most part, the proposed standards for paved roads are the same as the nationally recommended standards. For traffic levels between 150 and 399 vehicles per day, however, the proposed Minnesota standards would require 4-foot shoulders, while the nationally recommended standards call for 2-foot shoulders.

Table 5.8 shows that:

- **Implementing the NCHRP standards, particularly for county state-aid highways, could potentially lower future construction and reconstruction costs much more than the Task Force's proposed standards.**

The NCHRP standards would generally require 11-foot lanes to be built, while the proposed standards would require 12-foot lanes. The Task Force's proposed standards would affect only 5 percent of the CSAH system. In contrast, implementing the NCHRP standards would bring 28 percent of the CSAH system into compliance with standards. In addition, the NCHRP standards would reduce the costs needed to reconstruct and pave the more than 2,000 miles of gravel roads which have projected traffic volumes of 150 or more vehicles per day and thus require paving according to Mn/DOT standards. [10] The difference between the

10 A county may elect to reconstruct a road projected to carry 150 or more vehicles per day as a gravel road. However, the road must be built wide enough to meet the width standards applicable to its projected traffic level.

Table 5.8: Impact of Nationally Recommended Construction/ Reconstruction Standards for Paved Low Volume Rural Highways on Minnesota's Trunk Highways and County State-Aid Highways

	State Trunk Highways		County State-Aid Highways[a]	
	Miles	Percent	Miles	Percent
Current Minnesota Standards Not Met	3,460	32%	11,814	41%
Nationally Recommended (NCHRP) Standards Not Met	1,628	15	3,645	13
Difference Between NCHRP Recommended Standards and Current Minnesota Standards	1,832	17%	8,169	28%
Total Rural Miles	10,831		28,764[b]	

Source: Minnesota Department of Transportation.

[a]Based on current traffic levels. Includes only paved roads not meeting standards.

[b]Includes both paved and unpaved roads.

proposed standards and NCHRP standards potentially affects more than 8,500 miles on the CSAH system.

Nationally recommended standards would impose less stringent standards on 8,500 miles of county state-aid highways.

Under the current formula for allocating state aid to counties, half of the state aid paid to counties is for construction needs. If a road has not been reconstructed in the last 25 years, it is eligible for construction needs aid. The amount of aid a road receives depends on the estimated reconstruction costs, which in turn depend on the standards set for the CSAH system. Implementing the NCHRP standards would redirect a portion of the funds away from certain low volume rural roads and permit counties to use state aid to more frequently reconstruct or resurface CSAH highways.[11] The state aid formula could also be modified to permit more funds to be used for maintenance purposes.

The impact on trunk highways would be less significant. The proposed standards would reduce the miles of state trunk highways below lane and shoulder width standards from 3,460 to 2,215 miles. In contrast, implementing the NCHRP standards would reduce the miles of substandard trunk highways to 1,628 miles. The difference in miles affected by the proposed standards and the NCHRP standards is less than 600 miles of trunk highways. It is not known how many of these miles of trunk highways, if any, are likely to be reconstructed or widened in future years.

11 We estimate that it takes about 60 to 70 years from the time of the last reconstruction for counties to receive sufficient funds to reconstruct a road again. This estimate does not include an allowance for the resurfacing needs between reconstructions.

Standards of Other Midwestern States

At our request, Mn/DOT gathered information on lane and shoulder width standards for several midwestern states, including Iowa, Michigan, South Dakota, and Wisconsin. Three of these four states permit certain low volume rural roads to have 11-foot lanes. Wisconsin permits 11-foot lanes on state and county trunk highways which are collector or local roads and have a projected traffic volume under 1,500 vehicles per day. Iowa's standards call for 11-foot lanes on rural local roads, collector highways, and some minor arterials. The cutoff point between 11-foot lanes and 12-foot lanes varies from a projected traffic level of 1,000 vehicles per day for certain minor arterials and major collectors to 3,000 for local roads. Michigan's standards say that 12-foot lanes are desirable but that 11-foot lanes are acceptable for 2-lane rural highways with projected traffic volumes under 750 vehicles per day. Only the South Dakota Department of Transportation reported to Mn/DOT that its standards call for a minimum lane width of 12 feet on all state highways. South Dakota's standards were, however, ''very preliminary'' and had not yet been adopted by the department.

Comparison of Lane Widths

Having higher standards than other states or than nationally recommended standards might make sense if Minnesota's roads were narrower than other states and the higher standards served to help Minnesota catch up with other states.[12] According to data from the Federal Highway Administration, however:

- **Minnesota already has a higher percentage of highways with 12-foot lanes than the national average and surrounding states.**

Minnesota's rural roads have wider lanes than the average for many midwestern states and the nation as a whole.

Table 5.9 shows that about 74 percent of the rural roads in Minnesota have lane widths of 12 feet or more.[13] This compares with a national average of 43 percent and figures ranging from 31 percent to 64 percent for other midwestern states. South Dakota and North Dakota are the only other midwestern states which have lane widths of 12 feet or greater on more than 50 percent of their rural roads. However, many of the rural roads with 12-foot lanes in these two states may be gravel roads. While only 17 percent of Minnesota's rural roads (excluding local roads) are gravel, the share of unpaved roads is 42 percent in South Dakota and 47 percent in North Dakota.[14]

Table 5.10 shows that:

- **The difference in lane widths between Minnesota and other states is most significant for rural collector roads.**

12 Having higher standards might also make sense if those standards were based on factors unique to Minnesota. However, under any of these circumstances having higher standards only makes sense if they are justified based on an analysis of benefits and costs.

13 Available data include roads of all functional classes except local roads. It is not possible to compare lane widths across states for just state or county roads.

14 Excluding local roads, 16 percent of rural roads across the nation are gravel.

Table 5.9: Lane Width of Existing Rural Roads, Minnesota and Other States, 1994

	Percentage of Roads with Various Lane Widths[a]					
	Less Than 9 Feet	9 Feet	10 Feet	11 Feet	12 Feet	Over 12 Feet
Minnesota	0%	1%	4%	20%	71%	3%
Wisconsin	0	0	17	49	34	0
Michigan	0	5	29	35	31	0
Iowa	1	1	5	43	35	14
Illinois	5	11	21	26	34	4
North Dakota	4	5	12	15	63	1
South Dakota	5	8	10	15	60	2
National Average	5%	10%	24%	19%	40%	3%

Source: Federal Highway Administration.

[a]Excludes local roads.

Table 5.10: Lane Width of Existing Rural Roads by Functional Class, Minnesota and the United States, 1994

		Percentage of Roads with Various Lane Widths[a]					
		Less than 9 Feet	9 Feet	10 Feet	11 Feet	12 Feet	Over 12 Feet
Interstate	MN	0%	0%	0%	0%	100%	0%
	US	0	0	0	0	97	3
Other Principal Arterials	MN	0	0	4	7	84	5
	US	0	0	2	10	83	4
Minor Arterials	MN	0	0	2	8	86	3
	US	0	2	12	19	63	5
Major Collector	MN	0	1	5	26	68	1
	US	3	9	29	24	33	3
Minor Collector	MN	1	2	5	23	62	7
	US	12	21	31	16	17	3

Source: Federal Highway Administration.

[a]Data on minor collectors are from 1992.

In Minnesota, 69 percent of rural collector roads have lane widths of 12 feet or more. Nationally, only 36 percent of rural major collectors and 20 percent of minor collectors have lane widths of 12 feet or more. There are also some differences in lane widths on minor arterials. About 89 percent of Minnesota's rural minor arterials have lane widths of 12 feet or more compared with 68 percent nationally. There is very little difference between Minnesota and other states, however, in lane widths on rural interstates or principal arterials.

DISCUSSION OF TASK FORCE'S RECOMMENDATIONS

The Geometric Design Standards Task Force has recommended new lane and shoulder width standards for both construction and reconstruction projects and reconditioning or resurfacing work on trunk highways and state-aid highways. These standards would apply to rural two-lane highways serving fewer than 2,000 vehicles per day. In addition, the Task Force has recommended the state-aid variance process be improved by increasing the use of administrative variances for exceptions to standards and reducing the time required to process variance requests.

Strengths

We think that:

- **The Task Force has made reasonable recommendations for changing the current reconditioning and resurfacing standards and has correctly recognized the need for greater flexibility and timeliness in the state-aid variance process.**

Some of the Task Force's recommenda-tions deserve support.

The proposed reconditioning standards provide needed flexibility for highway authorities at a time when fiscal realities place a greater emphasis on preserving existing roads than on expanding existing roads. The proposed standards particularly provide additional flexibility for county state-aid highways. These roads have been subject to a much more stringent standard than trunk highways for resurfacing projects. [15]

Changes in the variance process are also needed since standards cannot fully anticipate all possible circumstances. Ideally, decisions about a particular project should take into account the project's unique circumstances and involve a careful analysis of advantages and disadvantages of various options. Standards which are well suited for one set of circumstances may be ill suited for another. A speedy but fair process is needed so that variances can be granted in a timely manner in those circumstances in which they are warranted. It remains to be seen exactly what specific changes in the variance process Mn/DOT will choose to implement.

In addition, we feel that the Task Force has suggested some reasonable improvements to the existing construction and reconstruction standards for shoulder width. The proposal sets the cutoff point between 4-foot shoulders and 6-foot shoulders at 1,500 vehicles per day and thus reduces minimum shoulder widths for certain highways. This cutoff point was established using benefit-cost analysis with actual cost data from county state-aid highways. The proposal, however, still deviates from nationally recommended standards. For roads carrying 150 to 399 vehicles per day, the proposal calls for shoulders to be at least

15 Current state-aid practices, however, partially penalize counties for resurfacing highways with state-aid funds received because of construction needs.

4 feet wide, while AASHTO and NCHRP standards call for shoulders to be 2 feet wide. The Task Force and Mn/DOT need to examine more carefully the rationale for this difference, including whether the accident reduction benefits of 4-foot shoulders outweigh the additional costs.

Weaknesses

We do not believe, however, that the Task Force has adequately considered the need for 12-foot lanes, rather than 11-foot lanes, on low-volume rural roads. The proposed standards still call for wider lanes than recommended by national organizations or studies. In particular, we note that:

- **The proposed construction and reconstruction standards for lane width are not justified by Mn/DOT's own benefit-cost analysis.**

But the recommended lane widths for construction projects are not supported by national studies or Mn/DOT's own benefit-cost analysis.

As part of the Task Force's study, Mn/DOT staff from the Office of Investment Management prepared an analysis which examined the benefits and costs of five different lane and shoulder width options at various traffic levels. [16] The analysis measured the benefits of wider lanes or shoulders in terms of the value of reduced fatality, injury, and property-damage-only accidents. It used cost estimates for various lane and shoulder width options, which had been prepared by Mn/DOT's Engineering Cost Data and Estimating Unit. Estimates, rather than actual cost data, were used, because actual data were not available for several of the options. The only paved trunk highways or county state-aid highways which have been built in recent years have 12-foot lanes and at least 4-foot shoulders.

Mn/DOT's analysis showed that:

- **The 11-foot lane, 2-foot shoulder option was the most cost-effective option at traffic volumes less than about 950 vehicles per day.**[17]

For some of the options examined, the 11-foot lane, 2-foot shoulder option was cost-effective at traffic volumes up to 1,300 vehicles per day. In addition, if a 7 percent discount rate was used instead of 4.5 percent, the 11-foot lane, 2-foot shoulder option was judged to be more cost-effective than all the other options at traffic volumes less than 1,200 and than some of the options at traffic volumes up to 1,600 vehicles per day. [18]

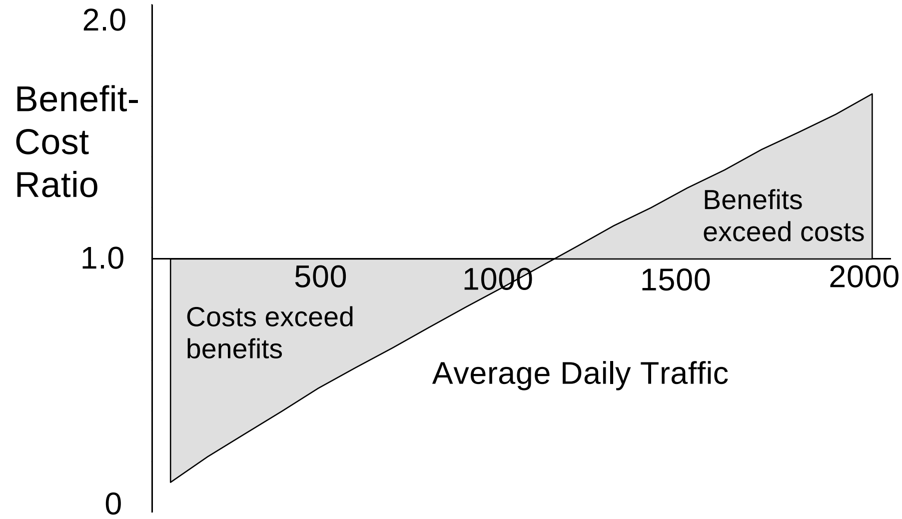
Figure 5.1 illustrates the relationship between traffic volumes and benefit-cost ratios for two of the options: 11-foot lanes, 4-foot shoulders and 12-foot lanes,

16 Five options were included in the analysis: 11-foot lanes and 2-foot shoulders, 11-foot lanes and 4-foot shoulders, 12-foot lanes and 3-foot shoulders, 12-foot lanes and 4-foot shoulders, and 12-foo t lanes and 6-foot shoulders.

17 By ''cost-effective'' we mean that the additional costs of any other option relative to the costs of the 11-foot lane, 2-foot shoulder option exceeded the difference in benefits, as measured by the estimated reduction in accidents.

18 The discount rate is the interest rate which is used to convert future benefits or costs to a presen t value. A discount rate is used because it is generally assumed that people value $1 in benefits received today more than $1 in benefits received at some future date. Mn/DOT generally uses a 4.5 percent discount rate, while the Federal Highway Administration uses a 7 percent discount rate.

Figure 5.1: Benefit-Cost Ratio for Constructing 12-Foot Lanes Instead of 11-Foot Lanes by Average Daily Traffic



Source: Minnesota Department of Transportation.

4-foot shoulders. At 100 vehicles per day, the benefit-cost ratio is 0.12. In other words, the costs of building 12-foot lanes instead of 11-foot lanes are about 8 or 9 times the benefits. At 500 vehicles per day, the benefit-cost ratio is 0.49, and the costs of 12-foot lanes are about twice the benefits. At traffic levels between 1,100 and 1,200 vehicles per day, the benefits of 12-foot lanes begin to equal the costs, and they exceed the costs at higher traffic levels.

There is reason to believe, however, that the cost estimates used in Mn/DOT's analysis understate the real difference in costs per mile between the various options. Table 5.11 shows the costs per mile of reconstructing a highway to various lane and shoulder width combinations, as estimated by Mn/DOT in the

Table 5.11: Costs Per Mile for Reconstruction of a Rural Two-Lane Highway

Options		Cost Per Mile[a]	
Lane Width	Shoulder Width	Mn/DOT Estimates	Actual Costs for County State-Aid Highways
11	2	$86,606	NA
11	4	101,323	NA
12	3	103,924	NA
12	4	109,601	$192,775
12	6	112,998	204,731

NA = Not available.

Source: Minnesota Department of Transportation.

[a]Mn/DOT's estimates include the paving of at least two feet of each shoulder, while the actual costs for county state-aid highways do not include paved shoulders.

analysis mentioned above as well as in another analysis. In the second analysis, Mn/DOT used actual construction cost data for county state-aid highways constructed with 12-foot lanes and either 4-foot or 6-foot shoulders. The actual cost per mile for county state-aid highways was significantly higher than the estimates per mile prepared by Mn/DOT's estimators. In addition, the difference in actual cost per mile between the 12-foot lane, 4-foot shoulder option and the 12-foot lane, 6-foot shoulder option was much higher ($11,956) than the difference when the cost estimates are used ($3,397).

Assuming Mn/DOT's cost estimates understated the cost differences among the various options, then 11-foot lanes would be cost-effective at average daily traffic levels higher than Mn/DOT staff originally concluded. In fact:

- **Judging from the actual cost data for county state-aid highways, 11-foot lanes would probably be cost-effective at traffic volumes up to 1,500 or possibly 2,000 vehicles per day.**

The Task Force cited factors for deviating from the benefit-cost analysis but did not fairly evaluate those factors.

This result is not surprising, since nationally recommended standards call for 11-foot lanes at traffic volumes in that range and for 12-foot lanes at traffic volumes exceeding 1,500 or 2,000 vehicles per day.

The Task Force indicated that there may be situations in which 11-foot lanes are acceptable but recommended standards calling for 12-foot lanes on all paved roads. As support for its recommendation, the Task Force cited Minnesota's past safety record, past road construction practices, public expectations, climate, the size of trucks and other large vehicles, and shoulder drop-off problems. However, there are no data which support the Task Force's conclusion that the public expects 12-foot lanes and certainly no data which suggest that the public is willing to pay the additional costs of wider lanes on lightly traveled roads. [19] Climate, the size of vehicles, and shoulder drop-off problems are potential problems which are faced by other states besides Minnesota. [20] Most other states find 11-foot lanes adequate in certain situations, and three of the four nearby states which sent their standards to Mn/DOT permit 11-foot lanes for low volume roads.

Minnesota's accident and fatality rates have generally been below the national average, but it is unlikely that Minnesota's wider lanes explain much of the difference between state and national rates. Driving under the influence of alcohol or drugs, speeding, and inattentive or reckless driving are among the most significant factors causing accidents. The failure to use selt belts also increases the severity of injuries in accidents. The benefit-cost analysis done by Mn/DOT was based on nationally respected research which estimated the relationship

19 The Task Force cited a national survey in which highway users rated their satisfaction with lane widths higher than their satisfaction with other safety items. As we have seen, the share of lanes which are less than 12-feet wide is much larger nationally (57 percent) than in Minnesota (26 percent). Perhaps the Task Force should have concluded that national highway users are satisfied with having more than half of their roads narrower than 12 feet and that higher standards, particularly for low volume roads, are an unnecessary cost.

20 Mn/DOT needs to do a more comprehensive analysis of future maintenance and rehabilitation costs under various lane and shoulder width options. The Task Force cited the shoulder drop-off problem for 11-foot lanes but did not mention the additional pavement maintenance costs which would be incurred with 12-foot lanes.

between the number of accidents and lane and shoulder width. At a traffic level of 500 vehicles per day, research indicates that a highway with 12-foot lanes and 4-foot shoulders would have only one fewer accident per year than a highway with 11-foot lanes and 4-foot shoulders for every 78 miles of road.[21]

Considering Mn/DOT's own benefit-cost analysis, national standards and research, data showing the share of roads which are less than 12 feet wide nationally, and the Task Force's rationale, we recommend that:

- **Mn/DOT should reject the Task Force's lane width recommendations, and**

- **Mn/DOT should permit 11-foot lanes on certain low volume rural highways and determine the projected traffic level at which the standard should be 12 feet.**

Mn/DOT should reexamine the Task Force's recommenda-tions for construction and reconstruction projects.

The CSAH system would be more affected by a change in the status quo regarding lane width standards. Only 6 percent of trunk highway miles have lane widths below 12 feet, and Mn/DOT is unlikely to reconstruct these roads in the near future. It makes sense to lower the lane width standard on certain low volume roads, but some counties may resist this change because it reduces the amount of state aid they receive. Counties should be permitted to build a road wider than 11 feet if they want, but they should pay the extra costs. State aid does not need to be provided at a level which permits the highest construction standards to be met. State aid should be sufficient to build or rebuild roads to a reasonable standard, which is supported by an analysis of benefits and costs. The Task Force's recommendations on lane width are not supported by national research or the benefit-cost analysis conducted by Mn/DOT staff.

We also think the Task Force's recommendation on lane width for construction and reconstruction projects fails to consider the fiscal realities faced by state and local highway agencies in Minnesota. Given the current level of funding, highway agencies must emphasize preservation of the existing infrastructure over improvements, particularly improvements which do not deliver benefits in excess of their costs. State government, including Mn/DOT, should not set standards for local governments which are excessive and not cost-effective. Just as Mn/DOT finds it beneficial to have increased flexibility from the federal government in decisions about federally-funded projects, Mn/DOT should permit local governments greater flexibility in designing state-funded projects at the local level and in meeting local needs.

SUMMARY

The Geometric Design Standards Task Force sponsored by Mn/DOT has developed some reasonable recommendations for new highway standards. In

21 Data on crashes on rural county state-aid highways in Minnesota indicate that only 1 percent of crashes involve fatalities, while 36 percent involve injuries, and 63 percent are property-damage-only incidents.

particular, its recommended reconditioning standards seem practical and may help to reduce unnecessary highway expenditures on a limited number of highway miles.

The Task Force's recommended standards for lane widths on construction and reconstruction projects are somewhat arbitrary and deviate from the results of Mn/DOT's own benefit-cost analysis. That analysis suggests, like reputable national studies, that the costs of constructing 12-foot lanes outweigh accident reduction benefits for lesser-traveled rural highways. Minnesota has significantly more rural roads with 12-foot lanes than the national average, and the Task Force's proposal maintains a lane width standard in excess of nationally recommended standards.

We urge Mn/DOT and the Task Force to reconsider the Task Force's recommendations for construction and reconstruction projects. Given the fiscal realities facing state and local governments in Minnesota, it is important that every reasonable effort be made to maximize the cost-effectiveness of government spending. Mn/DOT and local governments need to focus on building a transportation system that is affordable and practical from a benefit-cost standpoint, not on building the best possible system. Adopting lane and shoulder width standards more like nationally recommended standards could free up funds which are needed to preserve the existing infrastructure and to respond to congestion, economic development, and other safety needs.

Minnesota Department of Transportation

Transportation Building
395 John Ireland Boulevard
Saint Paul, Minnesota 55155-1899

March 26, 1997

James R. Nobles
Legislative Auditor
Centennial Building
658 Cedar Street
St. Paul, MN 55155

Dear Mr. Nobles:

Thank you for the opportunity to comment on the evaluation report "Highway Spending." The report is helpful in highlighting our strengths, reconfirming the system's needs, and facilitating a discussion about the transportation issues that confront Minnesota. On behalf of the managers and staff of Mn/DOT, I wish to extend our appreciation for the constructive manner in which you have expressed the issues concerning highway spending in Minnesota.

The report confirms that beyond 2001 the Trunk Highway Fund may not be able to sustain the spending levels anticipated during the 1997-99 period. We share your concern that there is a backlog of bridges needing repair or replacement due to deficient structural conditions. The report also finds that, due to an aging roadway infrastructure, Mn/DOT may need to increase pavement preservation investments in order to maintain the quality of our highway system. Additionally, capacity is being exceeded on some highways, resulting in a significant projected increase in congestion. While we agree with your conclusion that more preventive maintenance may be desirable, it is difficult to justify performing preventive maintenance on roads in relatively good condition when other roads and bridges are in worse condition. Your overall conclusion that projected funding is not adequate to address all of Minnesota's trunk highway needs is an important message for citizens and policy makers.

The report recommends using performance-based criteria to estimate funding needs of the trunk highway system and incorporating benefit-cost analysis wherever feasible. Performance measures have been developed throughout the Department, and we are beginning to link specific targets with the measures. During the last two years we have made substantial progress in incorporating benefit-cost into our discussions of expansion projects. We will continue with our management efforts to better define needs in terms of benefit-cost and performance-based criteria.

We respect your suggestions to refine our Pavement Quality Index and develop a simplified bridge condition measure. However, we think it is unlikely that these refinements would significantly affect the needs identified in your report. For example, we feel that the $71 million estimate represents the best projection we can currently provide, using the Pontis Bridge Management System and based on our engineering judgment.

Similarly, it is important to note that standards for low volume roads also will have negligible impact on highway spending. Geometric design standards do not force highway reconstruction; rather, deteriorating pavement condition forces reconstruction. As a result, your general conclusion that Mn/DOT revenues are probably not adequate to maintain the highway system and mobility of our citizens would not be changed even if we accepted your recommendation to adopt lower standards for low volume roads.

However, we do not agree with the report's suggestion to reject the Geometric Design Standards Task Force's recommendations in regard to lane width. Based on decades of experience in designing, constructing, and maintaining rural two lane highways, the Task Force concluded that a 32 foot road width, including shoulders, should be the minimum width when a rural road must be constructed or reconstructed. These standards are the most appropriate combination to adequately meet both user needs and cost effective operation and maintenance of the road.

The Department is committed to improving Minnesota's transportation system and continued discussion about how this might be accomplished.

Sincerely,

James N. Denn
Commissioner

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