



**Documentation and Assessment
of
Mn/DOT Gate Operations**

**Prepared for
Office of Advanced Transportation Systems
Minnesota Department of Transportation**

October, 1999

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By

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EXECUTIVE SUMMARY

Introduction

This report documents and assesses a relatively new operational procedure undertaken by the Minnesota Department of Transportation (Mn/DOT) for directing traffic off Interstates and prohibiting access during unsafe driving conditions such as severe snowstorms and major incidents. This procedure involves using gates on the mainline to direct traffic off an Interstate and at entrance ramps to prohibit traffic from gaining access to an Interstate. While using gates is a relatively new technique for closing roadways to travel in Minnesota, neighboring States such as North and South Dakota have used gates for a number of years.

Gates were first used in Minnesota on Interstate 94 during the winter of 1996/97 and today 65 gates are used in three of Mn/DOT's eight Districts. In Mn/DOT District 4, twenty-two (22) gates are used on portions of Interstate 94 and Highways 10 & 210 and in Districts 6 & 7, forty-three (43) gates are used on portions of Interstate I-90.



As the use of gates has spread in Minnesota, Mn/DOT has become increasingly interested in documenting the experience to date with the gates and identifying any opportunities to enhance gate operations, particularly through the utilization of Intelligent Transportation Systems (ITS).

As a result, Mn/DOT's Office of Advance Transportation Systems (OATS) undertook this study to document past experience, identify issues and to recommend enhancements to the current operations. Mn/DOT hired the consulting firm of BRW, Inc. to assist with the study that was conducted between March and August 1999.

Perspectives on Gate Use

A central part of the study was in-person interviews that were conducted during the Spring of 1999 with individuals in Mn/DOT Districts 4, 6 & 7. The purpose of these interviews was to gather first-hand information on gate operations and to document the use of gates. Representatives from Mn/DOT field operations and administration, the Minnesota State Patrol and County Sheriff's departments participated in the interviews.

The overall and overwhelming opinion of Mn/DOT and law enforcement personnel is that the gates offer a much better way to close and reopen roadways. After using the gates, there is unanimous support for keeping the gates and enhancing how they are used.

In addition to personnel directly involved in the gate operations and administration, interviews were conducted with employers and trucking companies located in District 7 in the vicinity of I - 90. Use of the gates also appears to be well received by the trucking industry and employers.

Key findings from the "public perspective" include the following:

- The gates provide a clear and indisputable notice that the road is closed and travel is prohibited. This view was the most predominant comment made among the four companies contacted.
- There is some frustration over roadways being closed when it appears the roadway is clear enough for traffic to make short trips between exits. This is related to Mn/DOT's practice of:
 - Closing the Interstate to all traffic.
 - Prohibiting access to the Interstate when towns ahead cannot accommodate additional stranded vehicles.

Benefits and Cost

The report documents potential savings attributed to a reduction in delays experienced by both passenger vehicles and heavy trucks. Based on Average Annual Daily Traffic (AADT) recorded by Mn/DOT in District 7, a delay of three hours on I-90 can range from \$36,400 during a low volume period up to \$78,000 during a high volume period.

In addition to a reduction in delays, cost estimates for a reduction in the number of accidents are also presented. Potential savings for accident reduction uses an estimated average cost per accident calculated to be \$7,900 and is based on values currently used by Mn/DOT to estimate accident costs. There is approximately 80 snow and ice related crashes per year on the segment of I-90 controlled by gates. A 5% reduction (4 accidents) in accidents annually will lead to an estimated annual savings of \$31,600.

These potential savings were compared with the estimated costs of gates. Based on information from District 7B, the cost for materials and installation of 43 gates averaged approximately \$3,700 per gate.

A severe snowstorm that struck District 7 in November, 1998 provided a good case study to compare costs for clearing a section of I-90 (with gates) and US Highway 75 (without gates). Based on Mn/DOT's Operations Management System Reports from the day that both roadways were cleared to bare pavement (95% clear), a number of comparisons can be made as follows:

- Plows made 4 passes before I-90 was 95% clear and opened, while 10 passes were made on Highway 75 before it was 95% clear.
- For I-90, approximately \$20 in labor and materials was expended per lane mile, while approximately \$24 was expended per lane mile for Highway 75.
- I-90 was cleared to bare pavement (95% clear) approximately 4 hours sooner than Highway 75 was cleared to bare pavement (95% clear).

This case study also demonstrated that with I-90 closed to travel there was less compaction due to travel, resulting in faster clearing times. Additionally, there were little or no stranded vehicles that interfered with Mn/DOT's plowing operations on I-90.

Recommended Next Steps

It is recommended that Mn/DOT focus on two main areas as it looks to the future; Project Deployment and Statewide Coordination. The Project Deployment area includes deployment of specific initiatives in the next 1 – 2 years and development of new initiatives related to gate operations. The Statewide Coordination area will focus on deployment of gates in other Mn/DOT Districts and coordination with related statewide initiatives.

To coordinate and oversee Mn/DOT's future development and enhancement of gate operations, it is recommended that a core group within Mn/DOT be established. It is recommended that the core group to oversee the future development and enhancements of gates include representatives from the following:

- Mn/DOT Office of Advance Transportation Systems
- Mn/DOT Office of Maintenance
- Mn/DOT Office of Finance and Administration
- Districts 7B and 4

The following projects are recommended for deployment within the next 1 – 2 years:

- *Additional Changeable Message Signs* – From the interviews with employers, trucking companies along with Mn/DOT personnel and others involved in gate operations, providing up-to-the minute information to motorists is very important. Throughout the State, changeable message signs have proven to be an effective tool for providing up-to-the minute information to motorists
- *Develop Sites for Portable Changeable Message Signs* – This initiative is intended as a low-cost and relatively quick way to provide information to motorists. This initiative would identify strategic sites along the Interstate system to “permanently“ place portable message signs during the winter months.

- *Deploy CCTV System* - Using cameras to monitor conditions on roadways along with activities at and around key gate locations will provide valuable information to Mn/DOT personnel.
- *Additional Gates* – The interviews revealed that there are a number of sections and interchanges that are not controlled by gates. This has resulted in instances where vehicles have entered the Interstate while crews were clearing the roadways.
- *Establish Performance Measures* – As Mn/DOT considers its on-going evaluation of gate operations, it is recommended that specific performance measures be established. The report recommends a number of performance measures for Mn/DOT to consider.

In addition to near-term deployment, other initiatives are recommended that require additional time for research, planning, development and deployment. These recommendations are:

- *Develop an Electronic Map to Track Gate Status* - This initiative results in the development of an electronic base map of an area covered by gates that will be configured to show the current status of gates. Initially, this could be used as a management tool by Mn/DOT and others, with future applications directed at providing real-time information to the public.
- *Remote Activation of Gates* – Under this initiative, a system for opening and closing gates from a remote location will be fully assessed, followed by development and deployment of a pilot project, if so determined by Mn/DOT.

In addition to deployment activities, considerations should be made for deployment in other districts along with coordination with related statewide initiatives. These initiatives are:

- *Establish Statewide Standards* – As Mn/DOT considers the future of gates in the State, best practices from existing gate operations should be agreed upon within Mn/DOT and serve as guidance for future gate deployments.
- *Prioritize Gate Deployment* – If Mn/DOT determines to move forward with additional gate operations, it is recommended that a deployment plan be developed that prioritizes the installation of gates in Mn/DOT Districts – both those with and without gates.
- *Integrate RWIS and PCRS Information* – As Mn/DOT's Road Weather Information System (RWIS) and Pavement Condition Reporting System, (PCRS), become operational, opportunities for incorporating information on Interstate closings/openings should be fully explored.
- *Utilize Connect Minnesota* – The fiber optic network developed under the Connect Minnesota project should be used to the greatest extent for gate related projects, (e.g. CCTV).

INTRODUCTION

Study Overview

This report documents and assesses a relatively new operational procedure undertaken by the Minnesota Department of Transportation (Mn/DOT) for directing traffic off Interstates and prohibiting access during unsafe driving conditions such as severe snowstorms and major incidents. This procedure involves using gates on the mainline to direct traffic off an Interstate and at entrance ramps to prohibit traffic from gaining access to an Interstate. While using gates is a relatively new technique for closing roadways to travel in Minnesota, neighboring States such as North and South Dakota have used gates for a number of years.

Gates were first used in Minnesota on Interstate 94 during the winter of 1996/97 and today 65 gates are used in three of Mn/DOT's eight Districts. In Mn/DOT District 4, twenty-two (22) gates are used on portions of Interstate 94 and Highways 10 & 210 and in Districts 6 & 7, forty-three (43) gates are used on portions of Interstate I-90.

As the use of gates has spread in Minnesota, Mn/DOT has become increasingly interested in documenting the experience to date with the gates and identifying any opportunities to enhance gate operations, particularly through the utilization of Intelligent Transportation Systems (ITS).



As a result, Mn/DOT's Office of Advance Transportation Systems (OATS) undertook this study to document past experience, identify issues and to recommend enhancements to the current operations. Mn/DOT hired the consulting firm of BRW, Inc. to assist with the study that was conducted between March and August 1999.

A central part of the study was in-person interviews that were conducted during the Spring of 1999 with individuals in Mn/DOT Districts 4, 6 & 7. The purpose of these interviews was to gather first-hand information on gate operations and to document the use of gates. Representatives from Mn/DOT field operations and administration, the Minnesota State Patrol and County Sheriff's departments participated in the interviews. A listing of participants in the interviews is found at the end of this document in Appendix A. Information from the interviews will be used to help guide the future deployment of gates throughout the State and to develop a framework for evaluating the effectiveness of gate operations. Additionally, future enhancements to gate operations are based in large part on the in-person interviews.

In addition to the in-person interviews, trucking companies and employers along Interstate 90 who are affected by the gate operations were contacted and interviewed about their perspective on the gates.

Cost/benefit information was also researched for the gates and included a cost/benefit analysis conducted by BRW, Inc. in a related study. Additionally, documented costs & hours were evaluated for a severe snowstorm on November 11, 1998 that prompted the closing of I-90 and Highway 75 in District 7. The report concludes with potential enhancements to Mn/DOT's existing gate operations and recommended next steps.

Background

Interstate highways in Minnesota have been closed in the past using a number of different techniques including, placement of barricades, piling of snow at entrance ramps and use of uniformed law enforcement. The introduction of gates during the winter of 1996/97 presented Mn/DOT with another technique for directing traffic off Interstates and prohibiting access during unsafe driving conditions such as severe snowstorms and major incidents. Following is general information on gate use in Minnesota:

- There are two types of gates in use. District 4 uses a gate arm that is placed to the side of the Interstate when not in use and is swung into position when placed in use. This style of gate is modeled after those used in North and South Dakota. Drawbacks to this style of gate are that snow often builds up along the gate requiring workers to shovel the snow away before it can be used and in the summer months, gate arms often become overgrown by grass that must be cut away before the gate can be used.
- Districts 6 & 7 use a gate arm that is placed in an upright position when not in use and needs to be lowered when placed in use. While this style gate does not have the snow build-up and grass problems associated with the swing-arm style gates, Mn/DOT personnel have experienced failures in the mechanism that lowers the gate arm, causing the arm to come down unexpectedly quick. This style gate is pictured to the right.
- District 4 uses amber lights on their gate arms, while Districts 6 & 7 use red lights on their gate arms.



- The gates have been used for a number of situations including:
 - Poor visibility – whiteout conditions.
 - Excessive snow accumulation.
 - Major accident clean-ups.
 - Gas line rupture.
- Generally, visibility and road surface conditions are the key factors for determining when to close and the ability/capacity of cities along the Interstate to accommodate motorists is a key factor for determining where to close.
- There are a number of variables that make it difficult to make an “apples-to-apples” comparison of gates and other techniques for closing an Interstate. These variables include:
 - Time of closure – (e.g. AM motorists will stay at home and not go to work, PM motorists will be trying to get home)
 - Weekday vs. weekend traffic volumes.
 - Seasonal travel.
 - Extent of advance warning for a winter storm.
 - Duration and nature of storms.

PESPECTIVES ON GATE USE

Operations and Administration

As noted earlier, a central part of this study was in-person interviews conducted in Mn/DOT Districts 4, 6 & 7 to gather first-hand information on gate operations and to document use of gates. Representatives from Mn/DOT field operations and administration, the Minnesota State Patrol and County Sheriff's departments participated in the interviews. A listing of participants in the interviews is found at the end of this document in Appendix A. Information from the interviews is summarized below and on the following pages.

Experience Before Gates

Prior to using gates, Mn/DOT personnel in Districts 4, 6 & 7 used a number of techniques to close Interstates and highways. These approaches and the advantages/disadvantages are summarized here.

Operations

- Barricades were the most common way to close Interstates and highways before the use of gates. Barricades were taken from storage areas throughout the district, along with sandbags and placed at entrance ramps by 2 – 3 person crews.
- Cones (mostly by the State Patrol) were also used on the mainline and at entrance ramps to indicate that an Interstate or highway was closed.
- Another technique is for Troopers from the State Patrol to use their vehicles to direct traffic off the mainline.
- Snow was piled up by Mn/DOT personnel at ramp entrances that acted as a barrier for vehicles entering the Interstate.

Advantages

- Mn/DOT and State Patrol personnel used existing resources for closures (e.g. barricades, cones).
- Snow piles were very effective at keeping motorists from gaining access Interstate.

Areas for Improvements

- Barricades are difficult to put in place, especially during strong winds. Districts 4, 6 & 7 all reported injuries from putting barricades in place.
- Once in place, barricades often blew over.

- Cones generally do not stay in place.
- At times, sandbags are not made up in advance. Often the first step for closing an Interstate was to make up sandbags to help hold barricades in place.
- When using patrol vehicles to direct traffic off the Interstate, occasionally the vehicles become frozen in place.
- At least 2 – 3 people are needed to erect barricades who could otherwise be used to plow snow.
- Decisions on closures & barricade placement are complex and involve a significant amount of time and staff.
- Motorists would go around barricades, especially after they blew down.
- While an Interstate or highway may be declared closed, in reality vehicles were still driving on it leading to confusion among drivers.
- Wrecker crews and law enforcement personnel would feel in danger when removing stranded motorists/abandoned vehicles due to the uncertainty of unauthorized vehicles being on the road.

Experience With Gates

As noted earlier, Mn/DOT has used gates for a relatively short period of time. While there has been limited experience, Mn/DOT and law enforcement personnel have developed initial thoughts on the use of gates. These initial thoughts are summarized here beginning with an overview of gate operations and the associated advantages and disadvantages.

Operations

- Districts 6 & 7 have developed an operations manual that outlines the steps to be taken for closures and identifies specific responsibilities. District 4 has developed a draft operations manual for use in the winter of '99/00.
- Generally, Mn/DOT personnel report to a gate location and activate a warning sign located in advance of the gate. This generally requires the sign to be fully opened up and an amber light to be activated.
- Once the sign is open and light activated, Mn/DOT personnel proceed to the gate and either swing out the gate arm (District 4) or lower the gate arm (Districts 6 & 7). Lights (red in Districts 6 & 7 and amber in District 4) on the gate arm are activated.

- Law enforcement personnel (State Patrol on mainline and Sheriff's at ramps) are positioned at the gate arm after it is deployed. Law enforcement personnel remain at the gate for 1 – 2 hours.

Advantages

- Deploying gates has led to a systematic and well-coordinated plan for closing and reopening the Interstates and highways.

- Gates provide a consistent and clear message that the road is closed.



- The presence of law enforcement personnel at the gates provides an “authoritative” presence and lends credibility to the road closures.

- Truckers are under a great deal of pressure to deliver their loads. The gate system provides the truckers with a clear and well-documented explanation for their delay in travel. Representatives from trucking companies and the U.S. Postal Services frequently call the Mn/DOT Districts to verify closures.

- Mn/DOT and law enforcement personnel feel they are less at risk with the gate system in place. This applies to closing and reopening the roads as well as working on the roads when they are closed.

- Significant time savings can occur due to the following:
 - It takes fewer people to close a road and it is quicker to close/reopen a road. This results in personnel getting out and plowing quicker and less overtime pay.
 - Closing the road quicker results in less compaction and quicker clearing.

- During the one deployment of gates in the Winter of '98/99 Districts 6 & 7 experienced half as many calls, (than a typical blizzard) from the public re: status of the Interstate and inquires about missing relatives.

Areas for Improvements

While the gate operations have been well received, there are areas to consider for improvements. Summarized below are potential opportunities that were raised during the interviews.

- Not all entrances to the Interstate are covered by gates as a result; motorists have a way to get on to the mainline when it is closed. *This was noted as a problem on I-94 only.*
- If a town or city can no longer handle delayed motorists, the Interstate will be closed back to the next town (with capacity) even if good road conditions exist. This can result in complaints from “local” motorists and businesses.
- Motorists can drive around the gates as they extend only to the centerline.
- Sheriff’s do not have direct radio contact with Mn/DOT field vehicles - State Patrol dispatchers often are contacted to serve as communications link.
- The feeling among some plow drivers is that occasionally they feel rushed to get the roadway cleared and opened.
- The fold-down signs (advance warning signs) sometimes ice up and they are difficult to open/close. There are occasions where you need a ladder to get to a sign. Wind can also hinder opening/closing of signs.
- Mn/DOT communications are not secure and are monitored by truckers and others. If word gets out that entrance will be opened soon, vehicles will proceed to ramp and end up blocking path of snowplows.
- As individual segments of the Interstate were opened, broadcast faxes were sent out to media outlets and others. This resulted in a constant stream of broadcast faxes that some found to be too much information.
- There is a capital investment required for the installation of gates.
- Swing-arm style gates require maintenance during the summer (trimming of overgrown grass) and the winter (clearing snow from the gate arms).
- The pulley mechanism on the drop-arm gates has failed on occasion, causing the gate arm to drop down unexpectedly.
- Animals (mice) have chewed on the wiring of the lights resulting in a need to repair/replace wiring.

Public Perspective

In addition to personnel directly involved in the gate operations and administration, interviews were conducted with employers and trucking companies located in District 7 in the vicinity of I - 90. Representatives from the following firms were contact about their perspective on the use of gates along I-90:

- Draper Foods – *Fairmont*
Trucking Firm that Supplies Grocers
- Fortune Transportation – *Windom*
Trucking Firm that Covers Several States
- The Toro Company – *Windom*
Large Employer Near I-90
- Ag-Chem Equipment Company – *Jackson*
Large Employer Near I-90

As noted earlier, gate operations along I-90 were first introduced during the Winter of 98/99 resulting in limited experience to report on gate operations. Representatives from these firms were aware of the gates and offered the following comments:

- The gates provide a clear and indisputable notice that the road is closed and travel is prohibited. This view was the most predominant comment made among the four companies contact.
- The gates were seen by some as an “excellent” idea and very useful. Motorists and others seemed to understand the need to use the gates to close the Interstate.
- Both trucking companies and employers expressed frustration over I-90 being closed when it appeared the Interstate was clear enough for traffic to make short trips between exits. This situation is related to Mn/DOT’s practice of:
 - a) Closing the Interstate to all traffic.
 - b) Prohibiting access to the Interstate when towns ahead cannot accommodate additional stranded vehicles.
- There was a fear expressed that Mn/DOT would “abuse” the gates by frequent closings of the Interstate. This was not a comment on actual gate operations, rather a concern with how the gates could be used in the future.
- Communications between Mn/DOT and the business could be “better”. As noted earlier, many businesses wish to speak with a “live” person to be assured they are receiving the latest information.

- Employers requested at least ½ hour prior notice of closings to allow employees to get home. If the Interstate is not an option for travel, many motorists may attempt to use back roads to get home, which is not a good option during poor driving conditions.

BENEFITS AND COSTS

Cost/Benefit Analysis of Gates

In the Fall of 1998, BRW, Inc. prepared a plan for deploying Intelligent Transportation Systems (ITS) in Mn/DOT's District 7. This plan included an analysis of proposed gate use on I-90 that focused on the cost of deployment along with the associated benefits due to savings in delays and reductions in accidents. Information on the cost/benefit analysis of gates is from that study.

Table 1 below, presents the average delay per year and associated costs due to the closure of I-90 in Mn/DOT District 7. The analysis assumes one closure per year for a period of 3 hours affecting a percentage of Average Annual Daily Traffic (AADT). The AADT was calculated to be 8,000 (6,900 for passenger vehicles and 1,100 for heavy trucks) using values along I-90 from the 1994 Mn/DOT District 7 Trunk Highway Traffic Volume Map.

Table 1

Average Annual Delay and Associated Costs due to Closure of I-90

Average Delay per Year	High Volume Scenario	Low Volume Scenario
Passenger Vehicles		
Average Number Delayed per Closure ¹	1,258	557
Average Value of Time per Hour ²	\$ 11.90	\$ 11.90
Average Annual Cost ³	\$ 44,911.00	\$ 19,885.00
Heavy Trucks		
Average Number Delayed per Closure ¹	550	275
Average Value of Time per Hour ²	\$ 20.00	\$ 20.00
Average Annual Cost ³	\$ 33,000.00	\$ 16,500.00
Average Annual Cost of Delay	\$ 77,911.00	\$ 36,385.00

Notes:

¹ Assumes one closure per year affecting a percentage of Average Annual Daily Traffic (AADT).

² The values of time per hour were derived from the default values of MicroBENCOST, microcomputer based model developed by the Texas Transportation Institute at Texas A & M University. The default values were updated to 1997 values using the CPI. The value of time for heavy trucks is an average of values for different truck types.

³ The average annual cost is calculated assuming a 3-hour delay.

Hourly distributions were obtained from Automatic Traffic Recorder (ATR) Data for 1994, Station 227 E&W, located east of Alden in Freeborn County. The High Volume Scenario assumes the closure occurs during the highest volume three hours of the day, from 3 p.m. to 6 p.m. with 22.6 % of AADT. This calculates to 1,808 total vehicles delayed, with 550 assumed to be trucks.

Assuming a certain minimum volume of traffic is required to justify closing the interstate, the hours of 6 a.m. to 9 a.m. with a volume of 10.4% AADT were used for the Low Volume Scenario. This calculates to 832 total vehicles delayed, 275 assumed to be trucks.

The potential annual delay and accident cost savings as a result of deploying gates on I-90 are found in Tables 2 and 3 below and on the following page. Once again, a range is presented because it is not possible to pinpoint the actual reductions in delay and accidents that will occur due to the deployment of gates on I-90.

Table 2

Potential Annual Delay Savings due to I-90 Gates

	High Volume Scenario	Low Volume Scenario
Average Annual Cost of Delay	\$77,911	\$36,385
Estimated Savings from		
10% Reduction in Delay (18 minutes)	\$7,791	\$3,639
20% Reduction in Delay (36 minutes)	\$15,582	\$7,277
30% Reduction in Delay (54 minutes)	\$23,373	\$10,916
40% Reduction in Delay (72 minutes)	\$31,164	\$14,554
50% Reduction in Delay (90 minutes)	\$38,956	\$18,193
60% Reduction in Delay (108 minutes)	\$46,747	\$21,831
70% Reduction in Delay (126 minutes)	\$54,538	\$25,470

Table 3
Potential Annual Accident Cost Savings due to I-90 Gates

Average Annual Cost of Accidents¹	\$ 630,080
Estimated Savings from	
1% Reduction in Accidents (Eliminate 0.8 accidents)	\$ 6,301
2% Reduction in Accidents (Eliminate 1.6 accidents)	\$ 12,602
3% Reduction in Accidents (Eliminate 2.4 accidents)	\$ 18,902
4% Reduction in Accidents (Eliminate 3.2 accidents)	\$ 25,203
5% Reduction in Accidents (Eliminate 4 accidents)	\$ 31,504

Notes:

¹ *There are approximately 80 snow and ice related crashes per year on this segment of I-90. The average cost per accident is calculated to be \$7,876. This assumes 81.38% of the accidents are Property Damage Only with a total cost of \$2,700 each, and 18.62% are Personal Injury with a total cost of \$30,500 each. These accident costs are the values currently being used by Mn/DOT. The values are based on the average cost of accidents obtained from the four largest insurance carriers in Minnesota.*

The potential 10-year benefits of delay savings and accident reduction are presented in Table 4 on the following page. The potential range of benefits vs. costs follows in Table 5. The analysis period is 10 years and the discount rate is 5%. The total cost assumes deployment costs of \$159,700 plus 5 percent Operations & Maintenance costs over 10 years, (*material for each gate is estimated at \$2,000 with installation costs for each gate estimated at \$1,350*).

Table 4
Potential Ten Year Delay Savings and Accident Reduction Benefits

		Estimated Annual Savings from Reduction in Delay		Estimated 10 Year Savings from Reduction in Delay	
		High Volume Scenario	Low Volume Scenario	High Volume Scenario	Low Volume Scenario
10%	Reduction in Delay	\$7,791	\$3,639	\$60,163	\$28,096
20%	Reduction in Delay	\$15,582	\$7,277	\$120,326	\$56,193
30%	Reduction in Delay	\$23,373	\$10,916	\$180,489	\$84,289
40%	Reduction in Delay	\$31,164	\$14,554	\$240,651	\$112,386
50%	Reduction in Delay	\$38,956	\$18,193	\$300,814	\$140,482
60%	Reduction in Delay	\$46,747	\$21,831	\$360,977	\$168,579
70%	Reduction in Delay	\$54,538	\$25,470	\$421,140	\$196,675
		Estimated Annual Savings from Accident Reduction		Estimated 10 Year Savings from Accident Reduction	
1%	Reduction in Accidents	\$ 6,301		\$ 48,655	
2%	Reduction in Accidents	\$12,602		\$ 97,310	
3%	Reduction in Accidents	\$18,902		\$145,964	
4%	Reduction in Accidents	\$25,203		\$194,619	
5%	Reduction in Accidents	\$31,504		\$243,274	
<i>Note: Discount Rate = 5%</i>					

Table 5

**Delay Savings and Accident Reduction Benefit - Cost Analysis
Potential Range of Benefits vs. Costs due to I-90 Gates**

Potential Range of Benefits over 10 Years ¹		Deployment and Annual O&M Costs over 10 Years	10 Year Delay Savings and Accident Reduction Benefit/Cost Ratio ²
10% Reduction in Delay (Low Volume Scenario) + 0% Accident Reduction	\$28,096	\$221,360	0.13
20% Reduction in Delay (High Volume Scenario) + 1% Accident Reduction	\$168,981	\$221,360	0.76
20% Reduction in Delay (High Volume Scenario) + 2% Accident Reduction	\$217,636	\$221,360	0.98
30% Reduction in Delay (Low Volume Scenario) + 3% Accident Reduction	\$230,253	\$221,360	1.04
40% Reduction in Delay (High Volume Scenario) + 0% Accident Reduction	\$240,651	\$221,360	1.09
40% Reduction in Delay (Low Volume Scenario) + 3% Accident Reduction	\$258,350	\$221,360	1.17
20% Reduction in Delay (High Volume Scenario) + 3% Accident Reduction	\$266,290	\$221,360	1.20
50% Reduction in Delay (Low Volume Scenario) + 4% Accident Reduction	\$335,101	\$221,360	1.51
40% Reduction in Delay (High Volume Scenario) + 4% Accident Reduction	\$435,270	\$221,360	1.97
70% Reduction in Delay (High Volume Scenario) + 5% Accident Reduction	\$664,414	\$221,360	3.00

Notes: Discount Rate = 5%

¹ The Range of Benefits goes from a low of \$28,096 with a 10% reduction in delay in the Low Volume Scenario and no reduction in accidents to \$664,414 with a 70% reduction in delay in the High Volume Scenario and a 5% reduction in accidents.

² Assuming Deployment Costs of \$159,700 + 5% Operations & Maintenance costs over 10 years for 39 manually operated gates.

Case Study of Cost Savings

The interviews that were conducted as part of this study revealed a significant amount of qualitative information on Mn/DOT's experience with gates while quantitative information was harder to come by.

The best example of quantitative data on savings associated with gate use is from a severe snowstorm that struck southern Minnesota in November 1998. This snowstorm hit the western portion of Mn/DOT's District 7B on November 10 and prompted the closing of Interstate 90 while nearby US Highway 75 (between the Iowa State Line and Trunk Highway 268) remained opened.

When dawn broke on November 11, I-90 was closed while Highway 75 remained opened with Mn/DOT crews out in full force clearing both roadways. Mn/DOT records detailed information on labor hours, cost of equipment and materials through their Operations Management System Reports. A map showing the area covered by these reports is found on the following page. The Mn/DOT reports for November 11, 1998 were reviewed with George Welk, Mn/DOT's Area Maintenance Engineer for District 7B.

Reports from the field for this storm indicated that I-90 experienced very little compaction attributed to vehicles on the roadway while Highway 75 experienced greater compaction because it was open to travel. This anecdotal information from the field is supported through a review of District 7B's Operations Management System Report for November 11, - the day plowing was completed and both roads were cleared to bare pavement (95% clear).

One of the most telling statistics from the reports is the number of passes that Mn/DOT plows had to make before each roadway was cleared to bare pavement (95% clear). For the 50 lane miles of I-90 that were closed, 200 total miles were plowed resulting in 4 complete passes that plows had to make along that stretch. By contrast, for the 59 lane miles of Highway 75 that were open, 590 miles were plowed resulting in 10 complete passes that plows had to make before it was cleared to bare pavement (95% clear). As a result, I-90 bare pavement was recovered at 11:00 AM and Highway 75 bare pavement was recovered at 3:00 PM – a difference of 4 hours.

Another informative statistic is the total direct costs (labor, material and equipment) expended when compared to the number of lane miles serviced. For I-90, approximately \$20 was expended per lane mile while for Highway 75; approximately \$24 was expended per lane mile – a savings of \$4 per lane mile for I-90. A summary of the reported miles, hours and costs along with comparative unit measures for November 11, 1998 can be found in Table 6 on page 17.

Given a similar region-wide storm that would result in the closure of I-90, and a potential saving of \$4 per lane mile, using gates to close the first 130 miles of I-90 from South Dakota to Blue Earth would result in a potential savings of \$2,080 (4 lane miles @ 130 miles @ \$4 savings per lane mile).

November 11, 1998 Snow Storm

Selected Roadways Closed with and without Gates

-  I-90 (closed with gates)
-  US Highway 75 (closed without gates)
-  Railroad
-  Roads
-  CSAH
-  Highway
-  Water
-  Municipal



0 0.5 1 1.5 Miles



August 1999

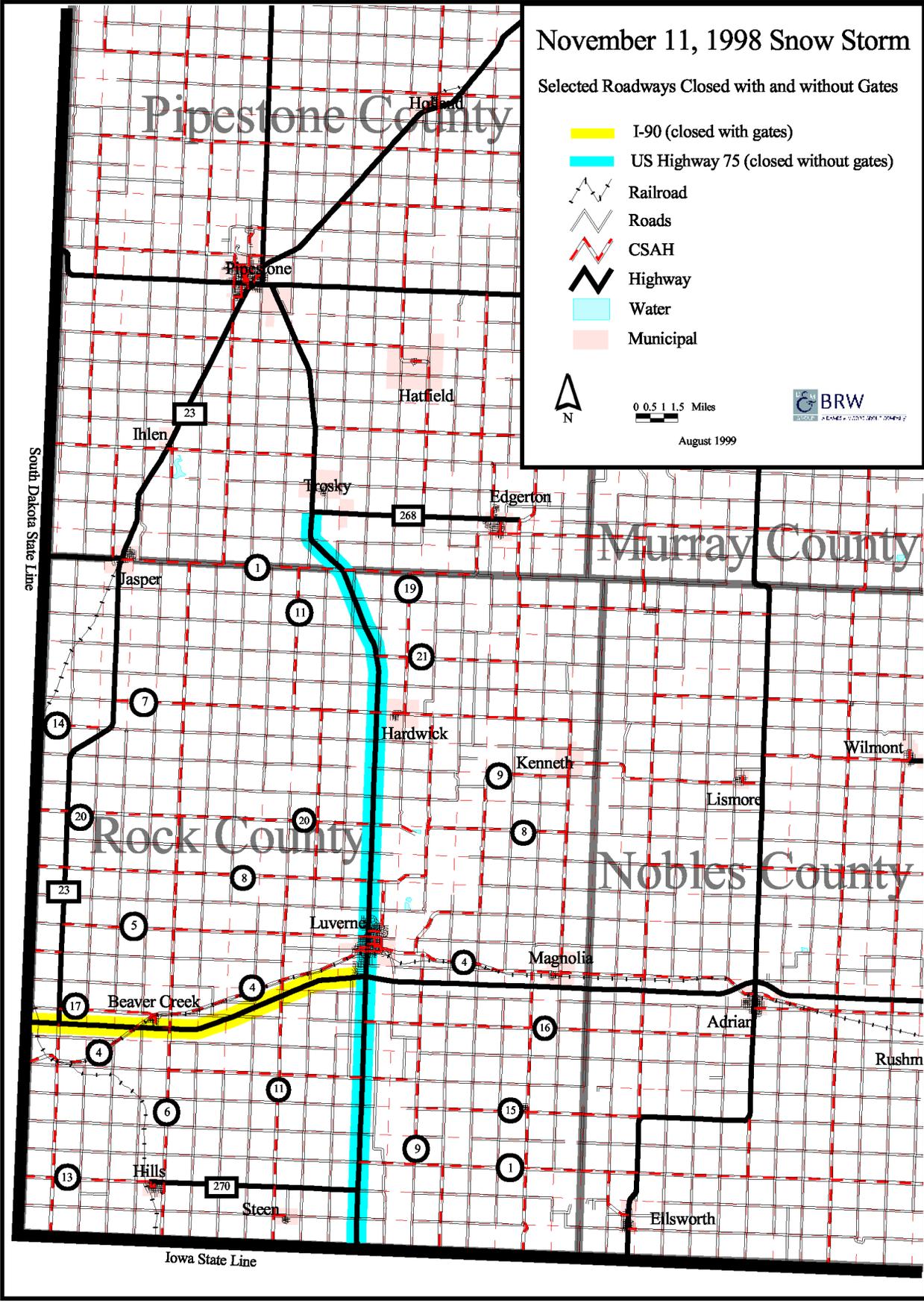


Table 6

Mn/DOT District 7B Plowing Hours and Direct Costs*

Snowstorm of November 11, 1998

<i>Reported Miles, Hours and Costs</i>									
Plow Route	Miles Serviced	Lane Miles	Labor Hours			Costs			
			Regular	Overtime	Total	Labor	Equipment	Material	Total
I-90 - SD Line to US 75	200	50	-	19	19	\$ 454	\$ 307	\$ 225	\$ 986
US 75 - IA Line to TH 268	590	59	-	24	24	\$ 589	\$ 563	\$ 271	\$ 1,423
<i>Comparative Unit Measures</i>									
Plow Route	Number of Passes	Labor Hours/ Miles Serviced	Labor Hours/ Lane Miles	Costs					
				Labor/ Lane Miles	Equipment/ Lane Miles	Material/ Lane Miles	Total/ Lane Miles		
I-90 - SD Line to US 75	4.00	0.10	0.38	\$ 9.08	\$ 6.14	\$ 4.50	\$ 19.72		
US 75 - IA Line to TH 268	10.00	0.04	0.41	\$ 9.98	\$ 9.54	\$ 4.59	\$ 24.12		

** From Mn/DOT District 7B Operations Management System Report for November 11, 1998 - Does NOT Include Overhead*

POTENTIAL ENHANCEMENTS

The overall and overwhelming opinion of Mn/DOT and law enforcement personnel is that the gates offer a much better way to close and reopen roadways. After using the gates, there is unanimous support for keeping the gates and enhancing how they are used. Use of the gates also appears to be well received by the trucking industry and employers.

The in-person interviews and comments from the public also found the following:

- Personnel in Districts 4, 6 & 7 have developed an excellent working relationship with the Minnesota State Patrol regarding closures.
- Regardless of how the roadways are closed, one of the most important elements is educating the public and getting current and accurate information out to motorists. While Districts broadcast faxes and automated telephone service provides up-to-the minute information, many callers don't feel they are getting the "latest" information and wish to speak to a "live" person.
- Motorists traveling a relative short distance have been more inconvenienced due to Interstate closings. When the Interstate is closed, it is closed to all motorists, even those who may be driving to their home or place of work in the next town. While the Interstate may be passable to the next town, the Interstate will remain closed if the town cannot handle any more motorists.

A number of enhancements to the gate operations were suggested during the interviews and are summarized below.

Traveler Information

- Install additional permanent changeable message signs. Also consider building up areas of the shoulder and placing portable changeable message signs at those locations throughout the winter.
- Acquire RWIS and PCRS information, reformat it and send it out to the public via cable television.
- Provide up-to-the minute information to the public via kiosks, the Internet, monitors at truck stops, etc.
- Develop an electronic map that shows the location and status of all gates...
 - Red – closed.
 - Yellow – about to open/close.
 - Green – open.

Communications

- Establish a secure radio communication that can be used jointly by the local Sheriffs, State Patrol and Mn/DOT.
- Develop a communications system that allows emergency messages to preempt radio, television and cable broadcasts.

Monitoring & Detection

- Use a device (e.g. laser beam) to detect and record vehicles that go around the closed gates.
- Install cameras in the vicinity of the gates to monitor and verify conditions and gate operations.

Gate Mechanisms/Operations

- Install overhead lights at gates (in District 4).
- Use solar panel for lights on advanced warning signs.
- Provide power at the gates for lights and to raise/lower arms.
- Establish a system that permits the gates to be operated from a remote location.
- Consider a crossing arm and warning system similar to those used at railroad crossings.
- Install additional gates (consider the drop-arm style over the swing-arm style).
- Provide clear markings on each gate that permits personnel to easily determine exactly which gate they are at.
- When gates are opened, consider using a State Patrol vehicle to “pace” traffic – especially when the road ahead is not yet opened.

RECOMMENDED NEXT STEPS

As noted earlier, the overall and overwhelming opinion of Mn/DOT and law enforcement personnel is that the gates offer a much better way to close and reopen roadways. After using the gates, there is unanimous support for keeping the gates and enhancing how they are used. Use of the gates also appears to be well received by the trucking industry and employers.

In reviewing the existing gate operations, it is recommended that Mn/DOT focus on two main areas as it looks to the future; Project Deployment and Statewide Coordination. The Project Deployment area includes deployment of specific initiatives in the next 1 – 2 years and development of new initiatives related to gate operations. The Statewide Coordination area will focus on deployment of gates in other Mn/DOT Districts and coordination with related statewide initiatives. To coordinate and oversee Mn/DOT's future development and enhancement of gate operations, it is recommended that a core group within Mn/DOT be established.

The recommended organizational structure along with proposed activities in the Project Deployment and Statewide Coordination areas are described in greater detail below and on the following pages.

Organizational Structure

To coordinate Mn/DOT's future gate activities, it is recommended that a core group be established with representatives from the following:

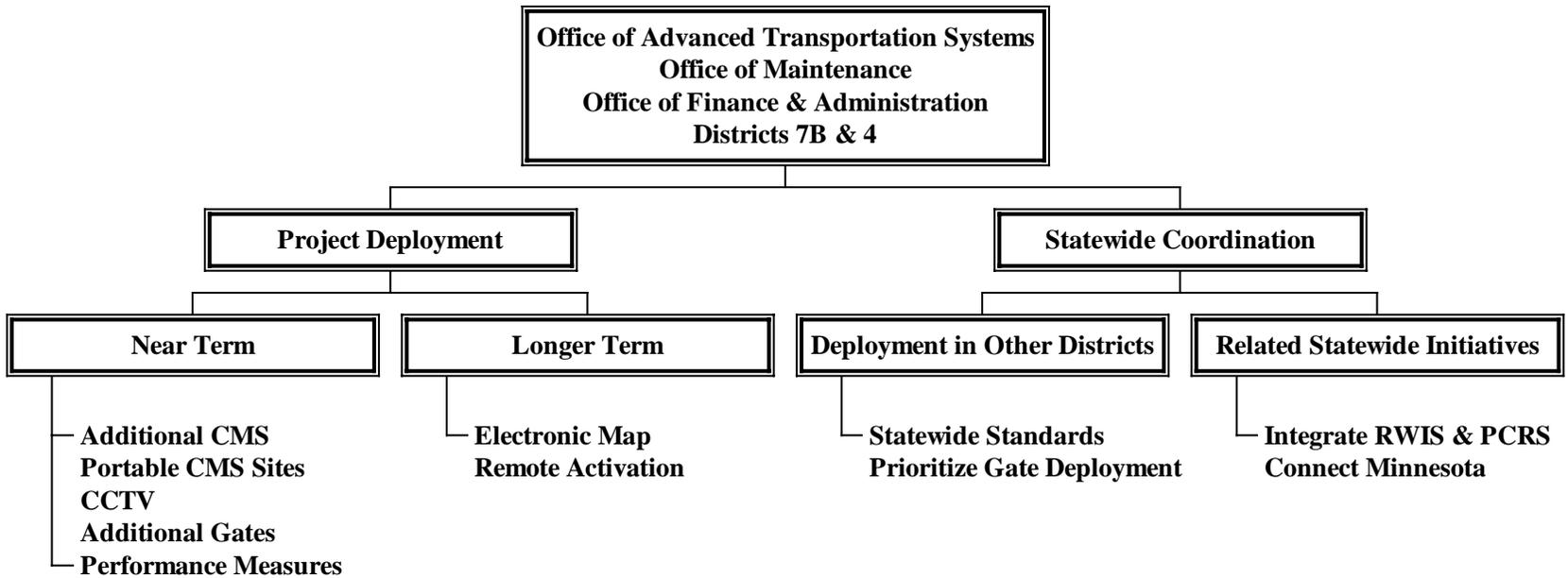
- Mn/DOT Office of Advance Transportation Systems
- Mn/DOT Office of Maintenance
- Mn/DOT Office of Finance and Administration
- Districts 7B and 4

It is recommended that this core group serve as a coordinating committee to direct Mn/DOT's future gate activities. These Mn/DOT offices and Districts have been most closely involved in the use of gates to date and will provide valuable direction as gate use is enhanced and considered for other districts.

In addition to this core group, it is expected that others will participate in various activities as conditions warrant. For example, if gates are considered for installation in District 6, representatives from that District would participate in the planning along with local law enforcement agencies.

A chart showing the proposed organizational structure for future Mn/DOT gate activities is presented on the following page.

**Proposed Organizational Structure
for
Gate Enhancements**



Project Deployment

This area will focus on deploying projects that enhance gate. Projects are categorized as either Near Term – initiatives that exist today and can be implemented within 1 – 2 years or Longer Term – initiatives that do not exist today and require additional planning and development.

Near Term

- *Additional Changeable Message Signs*

From the interviews with Mn/DOT and others involved in gate operations, along with the trucking companies and employers, it is clear that providing up-to the minute, accurate information to motorists is very important. An effective way to provide information is through the strategic placement of changeable message signs (CMS) on the Interstate system. Additional CMS are recommended for both the I-90 and I-94 corridors.

- *Develop Sites for Portable Changeable Message Signs*

One technique that has been undertaken in other States is to identify strategic sites along the Interstate system to place portable changeable message signs. When sites are identified, cement slabs are installed and used by portable message signs. By placing portable message signs in the field, the amount of time for retrieving signs and placing them in the field can be reduced.

- *Deploy CCTV System*

A CCTV system is a valuable tool for observing real-time conditions. Using cameras to monitor conditions on roadways along with the activities at and around key gate locations would provide valuable information to Mn/DOT personnel. Costs for the CCTV system can be greatly reduced by using the fiber-optic communications network developed through the Connect Minnesota program.

The cameras may also be part of a future ITS system underwhich gates are controlled from remote locations.

- *Additional Gates*

While over 68 gates are in place in Districts 7 and 4, there are a number of sections and interchanges within those areas that are not controlled by gates. As a result, both areas have experienced instances where vehicles have entered the Interstates while they are closed. This creates unsafe conditions and presents challenges to law enforcement as it can be difficult to prove a motorist has bypassed a gate.

- *Performance Measures*

During the in-person interviews, Mn/DOT and law enforcement personnel were asked to identify specific ways to measure the effectiveness of the gate operations. Following is a summary of potential performance measures for Mn/DOT to consider in its on-going evaluation of gate operations.

- Review of incident complaint reports (ICR) during Interstate and highway closures. ICR's are available from law enforcement agencies.
- Duration of closures.
- Amount of time required to open/close road segments.
- Number of telephone calls from the public during a closure.
- Number of rescues.
- Number of abandoned vehicles.
- Injuries to personnel attributed to road openings/closings.
- Amount of compaction & cost of materials used for clearing.
- Responses on Mn/DOT's survey of the public.
- Bare pavement recovery time, (the period of time to get to bare pavement following a snow and ice storm). This information has been collected by Mn/DOT for the past two years.
- Hours and cost information from Mn/DOT's Operations Management System Reports.
- Delays in opening roadways attributable to abandoned/stranded vehicles

Longer Term

There are two recommended initiatives that are not currently in place in Minnesota and require additional time for research, planning, development and deployment.

- *Develop an Electronic Map to Track Gate Status*

Under this initiative, an electronic base map of the area covered by the gates will be developed. The map will be configured to show the current status of gates, e.g. *Red* – closed, *Yellow* – about to open/close and *Green* – open. Initially the map could be used by Mn/DOT, County Sheriff and State Patrol personnel to instantly review the gate/Interstate status for a specific area.

Future applications could include providing the information to the public through the Internet, interactive kiosks and/or cable television.

- *Remote Activation of Gates*

One advantage that gates hold over barricades is that fewer personnel are needed for closing the Interstate resulting in more personnel being able to focus on clearing the roadway. To further reduce the number of people involved in closing an Interstate, the possibility of controlling gates from a remote location should be assessed. It is envisioned under this scenario that personnel at a control center would monitor (e.g. CCTV) the conditions on the interstate and have the capability of closing and opening the gates similar to how a railroad-crossing arm operates.

This recommendation is to first assess the feasibility of such a system, then if Mn/DOT decides to move forward, to develop and deploy a pilot project.

Statewide Coordination

As Mn/DOT considers the future of gates in the State, considerations should be made for deployment in other districts along with coordination with related statewide initiatives.

Deployment in Other Districts

- *Statewide Standards*

As noted earlier, there are differences in gates throughout the State including drop arm vs. swing arm gates; amber vs. red lights; amount of overhead lighting at gates; and, style of advance warning signs. As additional gate use is considered, “best practices” from existing gate operations should be agreed upon within Mn/DOT and serve as guidance for future gate deployments.

- *Prioritize Gate Deployment*

As the benefits of gate use become more widely known, other Mn/DOT Districts may identify areas where gate operations are feasible. Additionally, Administrators in both Districts 7B and 4 have indicated a need for additional gates.

Under this initiative, it is recommended that a deployment plan be developed that prioritizes the installation of gates in Mn/DOT Districts – both those with and without gates.

Related Statewide Initiatives

- *Integrate RWIS and PCRS Information*

Both Mn/DOT's Road Weather Information System (RWIS) and Pavement Condition Reporting System (PCRS) projects represent valuable sources of information for motorists that can be combined with information on Interstate closings/openings.

As these projects become operational, opportunities for incorporating information on Interstate closings/openings should be evaluated.

- *Connect Minnesota*

Under this project, a statewide fiber optic network is being developed that links all Mn/DOT District A and B offices. Individual Mn/DOT Districts will also have the option of adding to this Statewide network as necessary to meet specific needs within a District. This fiber optic network will serve as a communications backbone throughout the State and could be used for gate related projects.