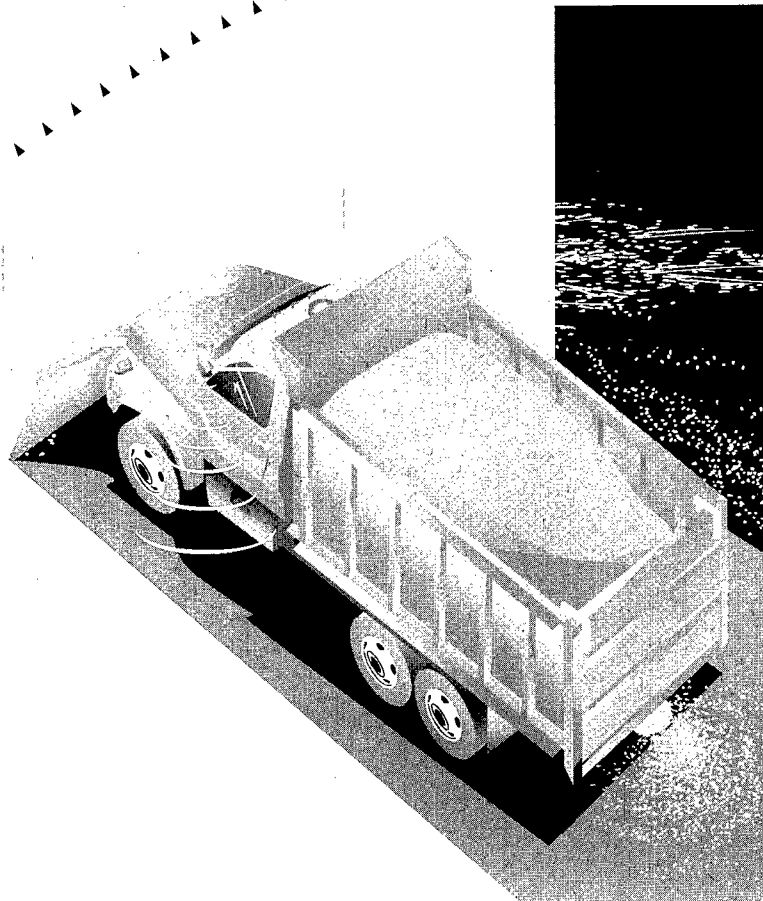




PB99-112021



SALT SOLUTIONS— Statewide Salt and Sand Reduction





Salt Solutions

Statewide Salt and Sand Reduction Initiative

FINAL REPORT

September 1998

Prepared for:

Minnesota Department of Transportation
Office of Research Services
First Floor
395 John Ireland Boulevard, MS 330
St. Paul, MN 55155

Prepared by:

SRF Consulting Group, Inc.
One Carlson Parkway, Suite 150
Minneapolis, MN 55447
(612) 475-0010
SRF No. 0972871.2

PROTECTED UNDER INTERNATIONAL COPYRIGHT
ALL RIGHTS RESERVED.
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE



ACKNOWLEDGMENT

The *Salt Solutions* program managers would like to acknowledge several individuals for making this project a success. The cost savings indicated in this report were not merely the result of a good idea. Pavement temperature sensors, program incentives and training offered good tools for this project, but the contribution of Mn/DOT employees and their willingness to try something different are what made this project a success.

The *Salt Solutions* program required a significant time commitment from many people. Acknowledgment is made to the managers, superintendents, and supervisors that allowed their employees to participate in the *Salt Solutions* program. Thanks go to the mechanics that mounted the infrared sensors and kept the equipment running. The *Salt Solutions* coordinators went beyond the call of duty in bringing this message to their districts. Their dedication made this project a success. Most of all, thank you to the Mn/DOT maintenance workers. It was the snow plow operators who were responsible for reducing salt and sand costs without reducing current levels of service. Without their efforts the rest of us would have had nothing to write about in this report.



TABLE OF CONTENTS

	page
EXECUTIVE SUMMARY	
I. INTRODUCTION	1
A. Project Overview	1
B. Purpose of Report	3
II. DISTRICT 1A PROGRAM.....	5
A. Background	5
B. Program Description	6
C. Cost / Benefit Analysis	6
D. Lessons Learned.....	9
III. STATEWIDE PROGRAM.....	13
A. Background	13
B. Program Description	13
C. Cost / Benefit Analysis	14
D. Accidents.....	16
E. Lessons Learned.....	17
IV. RECOMMENDATIONS.....	19

APPENDICES

- Appendix A Pavement Temperature Sensing Technology
- Appendix B Wisconsin Department of Transportation's Report
- Appendix C District 1A Program Details
- Appendix D Statewide Program Details
- Appendix E Salt and Sand Use Perception Survey Results
- Appendix F Salt Solutions Survey Results
- Appendix G Metro Division Infrared Sensor Survey Results

LIST OF TABLES

Table 1 - Costs of the District 1A program.....	7
Table 2 - Savings due to the District 1A program	9
Table 3 - Costs of the Statewide Program	15
Table 4 - Metro Division Costs.....	16

EXECUTIVE SUMMARY

Every winter, literally tons of salt and sand are placed on roadways throughout the State of Minnesota. While the application of salt and sand is critical to providing a safe driving environment, the amount used is often significantly more than is required. Visible evidence of over salting and sanding can be seen on highways and local streets throughout the state. Salt dust and residue remain on the shoulders, ramps, intersections and driving lanes for days after a snowfall event. The cost of salt and sand is significant in northern states like Minnesota, but in addition to these material costs, excessive salt applications impact the environment and causes untimely vehicle damage. Also, excess sand applications necessitate costs associated with cleaning roadways and water drainage systems.

Recognizing the potential to reduce the level of salt and sand use, the Maintenance Division of the Minnesota Department of Transportation (Mn/DOT) began a reduction initiative in District 1A (Duluth) during the 1996-97 snow and ice season. A key component of the *Salt Solutions* program was the use of truck-mounted infrared pavement temperature sensors. These sensors provided critical information that assisted truck operators in selecting salt and sand application rates. The program also included operator training, application guideline charts, and equipment calibration and repairs.

Building on the *Salt Solutions* program in Duluth, Mn/DOT decided to expand the program in the 1997-98 winter season to a statewide level. In this program, 150 trucks

were outfitted with infrared pavement sensors throughout the state. The program again included training for supervisors and operators as well as incentives to reduce the amount of salt and sand use.

This report evaluates the *Salt Solutions* program over the past two winter seasons. The evaluation documents the components of the program, describes the technology being used, and provides a detailed cost-benefit analysis. The results of a study on infrared temperature sensing technology that was recently conducted by the Wisconsin Department of Transportation are also included.

Results of this evaluation show that the *Salt Solutions* program is a cost-effective means of reducing the amount of salt and sand applied to Minnesota roadways while still maintaining a safe operating environment. For example, the number of accidents on Mn/DOT roads actually decreased by six percent from the 1996-97 to the 1997-98 snow and ice seasons, the first year the program was implemented on a state-wide basis. The findings for this evaluation are based on observations by program coordinators, surveys completed by supervisors and operators, and a cost-benefit analysis based on salt and sand usage in the study and control areas.

The following recommendations are critical to future *Salt Solutions* success:

- Require supervisors to be accountable for the economic use of salt and sand.
- Calibrate equipment prior to and during the snow and ice season.
- Demonstrate Mn/DOT's support for *Salt Solutions* through recognition programs.
- Employ a full-time project coordinator.

I. INTRODUCTION

A. PROJECT OVERVIEW

The Maintenance Division of the Minnesota Department of Transportation (Mn/DOT) began an initiative in District 1A (Duluth) to reduce salt and sand use during the 1996-97 snow and ice season. The program, known as *Salt Solutions*, utilized vehicle-mounted pavement temperature sensors to assist operators in determining the appropriate salt and sand application rates. The success of the District 1A program encouraged the development of a statewide program to reduce salt and sand use during the 1997-98 winter season.

Application rate charts correlate pavement temperature and weather conditions to provide a factual system that enables plow operators to make better application rate decisions. The application guidelines used in this program are provided in Appendix A. Using these application guidelines, however, requires reliable information on pavement temperature. Mn/DOT maintains some stationary temperature sensing equipment, but not enough to provide adequate coverage for all roadways in the state. As a result, the *Salt Solutions* program outfitted a portion of Mn/DOT's trucks with temperature sensing devices in order to provide continual temperature data over a wide area.

Two types of pavement sensors were procured: Control Products and Sprague Controls. Control Products sensors are mounted under the front bumper. Sprague Controls sensors are mounted on the driver's side rear view mirror. Each one used infrared technology to determine the temperature of the pavement. The Wisconsin Department of Transportation conducted a study on vehicle-mounted infrared pavement temperature

sensors that included both the Control Products and Sprague Controls sensors. With the permission of the Wisconsin Department of Transportation, a summary of this study is provided in Appendix B.

The State of Minnesota has a policy limiting the amount of salt and chemicals used on the state's roadways. Minnesota Statute 160.215 - Snow Removal; Salt and Chemicals restrictions, states the following:

Salt and Chemicals restricted in order to:

1. Minimize the harmful or corrosive effects of salt or other chemical upon vehicles, roadways, and vegetation.
2. Reduce the pollution of waters; and
3. Reduce the driving hazards resulting from chemicals on windshields;

Road authorities, including road authorities of cities, responsible for the maintenance of highways or streets during periods when snow and ice are prevalent, shall utilize such salt or other chemicals only at such places as upon hills, at intersections, or upon high speed or arterial roadways where vehicle traction is particularly critical, and only if, in the opinion of the road authorities, removal of snow and ice or reduction of hazardous conditions by blading, plowing, sanding, including chemicals needed for free flow of sand, or natural elements cannot be accomplished within a reasonable time.

History: 1971 c 622 s 1; 1973 c 123 art 5 s 7.

B. PURPOSE OF REPORT

Mn/DOT desires to continue the salt and sand reduction initiative because of its proven success in the first two years of deployment. To determine the project's future direction, a detailed analysis was performed on the information and data collected from the past two snow and ice seasons. This report provides a cost-benefit analysis to identify the most effective aspects of the previous initiatives. Also, recommendations are provided as to how the *Salt Solutions* project should be implemented for continued project success.

II. DISTRICT 1A PROGRAM

A. BACKGROUND

Before the District 1A program was implemented, the average snow plow operator used more salt and sand on the road than was needed to provide a safe driving environment. This was due in a large part to operators choosing their application rate according to the length of their route. No factual system, such as application rate charts, was available for operators to make better application rate decisions. Also, the majority of trucks were not calibrated properly and/or the application equipment was not functioning properly.

Before the *Salt Solutions* program was implemented, the application rates between operators commonly varied by as much as 700 pounds per lane mile. The following factors contributed to this variation:

- Maintenance workers wanting to “pull their own weight”;
- Varying amounts of pressure from outside sources;
- Supervisors not being involved in application rate decisions;
- Operator confusion on how equipment functioned;
- Snow plow operators not having to account for the application rates they chose.

In general, a significant need existed for a consistent method of applying salt and sand among snow plow operators.

B. PROGRAM DESCRIPTION

During the summer of 1996, Mn/DOT developed a program to reduce salt and sand use among snow plow operators. The main structural components of the program were the following:

- Operator training and awareness of application rates;
- Determine control sites against which District 1A's salt and sand usage could be compared;
- Procure pavement temperature sensing technologies;
- Identify costs of the program;
- Quantify salt and sand use;
- Perform a cost-benefit analysis.

C. COST-BENEFIT ANALYSIS

Analysis of the salt and sand use estimates from District 1A and the control sites shows a significant reduction in usage from the 1995-96 season to the 1996-97 season, when *Salt Solutions* was implemented. Comparison of salt and sand usage levels from one year to the next is difficult because of the variation in each winter's severity. To account for this, control sites were selected in order to provide a comparison between nearby roadways during the same snow and ice seasons. The City of Duluth and the St. Cloud District are the two control sites near District 1A that use salt. While District 1A's salt use remained constant from the first winter to the next, the City of Duluth's and St. Cloud District's salt

use increased. An equivalent effect can be seen when comparing the sand usage between these areas. Detailed results of this analysis can be seen in Appendix C.

Pine County, St. Louis County, and Lake County only use sand to control snow and ice on the roadways. As can be seen in Appendix C, a decrease between District 1A and these areas in sand use was experienced between the year previous to the *Salt Solutions* implementation and the year the program was in effect.

Note that the process of quantifying the salt and sand use at each of the shops was and still is cumbersome. Poor record keeping and the need to enact a consistent and relatively accurate method of salt and sand use measurement accounts for most of the problems.

The total cost of the District 1A program was \$37,000. This includes wages, overhead, incentives, marketing, travel, incidentals, and an equivalent uniform annual cost of the infrared pavement temperature sensors (see Table 1).

**Table 1
Costs of the District 1A Program**

Item	Unit Price	Annualized Cost*
wages and overhead	N/A	\$25,000
incentives and marketing	N/A	\$4,000
travel and incidentals	N/A	\$5,000
11 Sprague Controls pavement temperature sensors	\$350/unit	\$1,350
	Total Cost	\$35,300

*Note, the annualized cost of the sensors is determined by calculating the equivalent uniform annual cost assuming a 3 percent interest rate and a 3 year life.

The total sand savings from the District 1A program was calculated using \$12.50 per yard of sand. At the conclusion of the 1996-97 snow and ice season, 7,700 yards of sand remained in District 1A's storage yards. As can be seen in Appendix C, the sand use at each of the control sites essentially remained constant between the 1995-96 and 1996-97 snow and ice seasons. However, District 1A's sand use decreased 24 percent from 44,300 tons in the 1995-96 season to 33,600 tons in 1996-97 season. As a result, a conservative assumption was made that without the *Salt Solutions* program, District 1A would have applied 7,700 tons of excess sand to the roadways. Calculations using these numbers show a savings of \$96,000 (see Table 2).

In 1996-97, District 1A used 27,000 tons of salt, 260 tons less than was used in 1995-96. Given the severity of the 1996-97 winter as compared to the 1995-96 winter, this reduction is significant. It is difficult to quantify the actual salt savings because there was no foundation from which to base an accurate number. The City of Duluth used 24 percent and St. Cloud District 3B used 13 percent more salt in 1996-97 than in 1995-96. However, District 1A used the same amount of salt during the 1995-96 and the 1996-97 snow and ice seasons. As a result, a conservative 10 percent salt savings was assumed for District 1A during the 1996-97 season to reflect the impact of the *Salt Solutions* program. At \$30 per ton of salt, calculations show an \$81,000 savings (see Table 2).

Table 2
Savings Due to the District 1A Program

Item	Unit Price	Total
Sand Savings	\$12.50/ton	\$96,000
Salt Savings	\$30.00/ton	\$81,000
	Total Savings	\$177,000

The total cost of the program was \$35,300 and the total savings in salt and sand due to the program was \$177,000, which gives a 500 percent rate of return on investment.

D. LESSONS LEARNED

Maintenance personnel acceptance of the *Salt Solutions* program grew throughout the year as people became more comfortable with the program. Bi-weekly meetings provided an opportunity for plow operators to discuss their concerns and improve their ability to use the application rate charts as a guideline. While most of the operators accepted the established goals, the truck stations that accepted them and worked together toward achieving them as a team experienced the most success. The goals included:

- Saving money
- Reducing material usage
- Improving equipment efficiency
- Maintaining and/or improving the current level of service

The Maintenance Supervisor's primary role in the program was to become involved in the application rate decisions the plow operators were making. Supervisor's sense of responsibility for how much salt and sand their shop was using was essential in achieving a decrease in the shop's total salt and sand use. A vital part of a supervisor's role was to

interact with snow plow operators and facilitate group decisions about how the shop would respond to a storm. Discussing the results of application strategies was also important in lowering the shop's overall usage.

The following list details useful information gained from the District 1A program:

- Incentives were effective in demonstrating Mn/DOT's support as perceived by maintenance personnel.
- The District 1A program exposed the external pressures of snow and ice control that lead to the overuse of de-icing chemicals. Specifically, pressure to add more salt and sand came from the Highway Patrol, District Maintenance Supervisors, the public, and dispatch. More education of these groups is required.
- Fixed pavement temperature sensors were determined to be ineffective in giving direct real-time pavement temperature information because of placement and communication problems.
- Tom Broadbent, the program's administrator, attended shop meetings on a biweekly basis. During each of the meetings, questions and concerns were raised and basic application rate guideline charts were discussed. These questions and concerns were then brought before a steering committee and addressed. This gave plow operators timely responses to their questions and concerns and improved the overall quality of the program.

- A successful program needs a solid foundation. One of the most important initial steps was the training provided on equipment functions. Essential tools for program success included calibration charts, pavement temperature sensors, and application guidelines.
- The significant savings from the District 1A program caused Mn/DOT to look beyond “quick fix” technical solutions and address the underlying factors behind the overuse of salt and sand.
- Measuring salt and sand use was an essential component to the overall project success.

III. STATEWIDE PROGRAM

A. BACKGROUND

Based on the results of the District 1A program, the Maintenance Division decided to implement the *Salt Solutions* Program on a statewide basis. Although the program was implemented statewide, the analysis for this report was performed in the metro division using the county maintenance shops as controls and the Mn/DOT maintenance shops as test sites.

B. PROGRAM DESCRIPTION

Sixteen *Salt Solutions* coordinators were recruited for the 1997-98 snow and ice season and were assigned to various shops throughout the state. The coordinators attended shop meetings approximately once a month. The main purpose of the shop meetings was to train personnel and answer their questions. In addition, approximately 90 percent of the plow trucks statewide were calibrated to provide accurate application rates. Vehicle-mounted pavement temperature sensors were purchased for every Mn/DOT maintenance shop participating in the statewide program. Application rate charts were posted in each shop and mounted in every truck. The application rate charts correlate pavement temperature and weather conditions to application rates. The application guidelines used in this program are provided in Appendix A. In the Metro Division, 39 Control Products sensors and 20 Sprague Controls sensors were purchased, see the detailed distribution list in Appendix A. Note that 150 trucks were outfitted with infrared pavement temperature sensors statewide as a result of this program. Finally, incentives were given to every person participating in the *Salt Solutions* program. The cost of the incentives, which

included one pen, one water bottle, and a pocketknife, flashlight, or multi-tool, was \$16 per person. These incentives functioned primarily as marketing tools.

Unfortunately, the statewide program was not fully implemented until late in the 1997-98 winter season. The sensors were delivered to each truck station in late November. Full deployment of the sensors did not occur until mid December when each truck station had at least one Sprague Controls infrared sensor installed. Every other component of the program was in place at the beginning of the snow and ice season.

The following Mn/DOT-Metro Division counties were chosen as test sites for the statewide program: Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott, and Washington. The control sites chosen were County routes in the same counties. A two percent to four percent overlap of routes exists between Mn/DOT and the Counties. Thus, a small amount of error must be taken into consideration when considering salt and sand use totals.

C. COST-BENEFIT ANALYSIS

Close inspection of the data did not reveal a reliable source of control site data in the metropolitan region. However, the overall trend in the data clearly shows a reduction in both sand and salt use that is similar to District 1A's during the 1996-97 season. A conservative estimate of a 10 percent savings is realistic for the Metro division during the statewide program. The absence of reliable data can be attributed to various factors, such as problems with the control site data, inadequate biweekly shop meeting schedules, the temperature sensing and application equipment not working properly, and poor records of

salt and sand use. The total salt and sand use numbers for Mn/DOT and the counties are given in Appendix D.

Although numerical analysis from the statewide *Salt Solutions* program is not effective in determining program benefits, many qualitative benefits can be used to describe the positive and negative impacts of the program. *Salt Solutions* has provided the following qualitative benefits:

- Basic managerial tools have been incorporated within the shops that will remain in place for as long as managers and supervisors continue to use them.
- Operators have been trained to methodically choose an application rate from the guideline charts instead of by the length of their route.
- The program illustrated the need for improving salt and sand use record keeping.

**Table 3
Statewide Program Costs**

Item	Unit Price	Annualized Cost*
wages and overhead	N/A	\$41,700
incentives and marketing	N/A	\$15,200
travel and incidentals	N/A	\$11,600
Infrared pavement temperature sensors	50 Control Products at \$410/unit	\$7,200
Infrared pavement temperature sensors	100 Sprague Controls at \$350/unit	\$12,300
	Total Cost	\$88,000

*Note, the annualized cost of the sensors is determined by calculating the equivalent uniform annual cost assuming a 3 percent interest rate and a 3-year life.

**Table 4
Metro Division Costs**

Item	Unit Price	Annualized Cost*
wages and overhead	N/A	\$13,900
incentives and marketing	N/A	\$5,500
travel and incidentals	N/A	\$3,800
Infrared pavement temperature sensors	39 control Products at \$410/unit	\$5,600
Infrared pavement temperature sensors	20 Sprague Controls at \$350/unit	\$2,500
	Total Cost	\$31,300

*Note, the annualized cost of the sensors is determined by calculating the equivalent uniform annual cost assuming a 3 percent interest rate and a 3-year life.

D. ACCIDENTS

Evaluation of accident totals on Mn/DOT and County routes shows a reduction from the 1996-97 winter season to the 1997-98 winter season, when *Salt Solutions* was implemented. Between these years Mn/DOT's accident totals decreased by 1,800 accidents, while the County's accident totals decreased by 1,100 accidents. As a result, the number of accidents occurring on Mn/DOT's roads decreased by six percent more than the number of accidents occurring on the County's roads. When considering that Mn/DOT reduced its total salt and sand use by at least 10 percent from the 1996-97 to the 1997-98 seasons, this accident reduction is significant and suggests that the *Salt Solutions* program does not adversely affect road safety. The Mn/DOT's and the County's accident data is provided in Appendix D.

E. LESSONS LEARNED

In general the operators thought the sensors helped them make good application rate decisions and helped them reduce their salt and sand use. Operators thought the sensors worked very well and they would like to see more of them installed. The following list details useful information gained from the statewide program:

- Once the trucks were calibrated and training on the equipment was completed, most of the operators were very willing to support the program. By mid season, many of the operators were still demonstrating interest in the program and were supporting its continuation.
- Some Supervisors felt they could save money by using more sand and less salt. However, total sand costs encompass much more than the cost to buy sand. The combined purchasing costs, clean up costs, hauling costs, and screening costs result in a total cost of approximately \$72 per yard for sand applied to the roadways. Environmental effects must be considered as well. In general, using more sand to save salt is not the answer for a successful reduction of salt use.
- A salt and sand use perception survey was given to supervisors prior to the statewide program in the Metro area. The main purpose of this survey was to encourage supervisors to begin thinking about salt and sand use reduction and related safety issues. The complete survey form and results can be found in Appendix E.

- Immediately following the conclusion of the 1997-98 snow and ice season, plow operators in the Metro Division were given a *Salt Solutions* survey. This survey attempted to obtain information on the degree to which plow operators accepted the *Salt Solutions* program. The survey also asked if they would like the program to continue and if so what they would like included in the program during the 1998-99 snow and ice season. In this survey the operators indicated they would like to see the program continue, see Appendix F.

- Plow operators in the Metro Division were also given an Infrared Sensor Survey at the conclusion of the 1997-98 snow and ice season. The objective of the survey was to measure how satisfied the plow operators were with the operation of the sensors. The survey addressed the following questions:
 - Are the sensors easy to read?
 - Are the sensors reliable?
 - Do the drivers feel the sensors are accurate in all types of weather?
 - Is the information of use to the operators?
 - Did the sensor influence the plow operator's application rate decisions?

The complete survey form and results can be found in Appendix G.

- Supervisors need to be pro-active in helping their crews select the best materials for a given temperature range and weather conditions. Supervisors must also ensure repairs and calibrations are performed properly and that sanders are stored properly over the summer.

IV. RECOMMENDATIONS

1. Complete repairs and checks of all equipment during the summer months.
2. Purchase additional infrared sensors to equip every truck in the state.
3. Produce a video showing application rate comparisons.
4. Require Supervisors to be accountable for the economic use of salt and sand.
5. Require Supervisors to coordinate and support proper storage of sanders during the off season.
6. Require Supervisors to give performance reviews of plow operators at the conclusion of the snow and ice season.
7. Award incentives for outstanding performance at the end of the snow and ice season both to individuals and shops.
8. Program the salt and sand application controllers (Dickey John 2000's) prior to the start of the winter season.
9. Allow first salt application time to work before applying additional amounts.
10. Apply less salt to a glazed or frosty road than a snow covered road.
11. Include the number of events per month and number of lane miles for each truck station when performing the record keeping procedures.
12. Change salt and sand use record forms to require plow operators to document their application rates.
13. Mark salt bins along the contour of salt for easy measurement of use.
14. Hire a full-time coordinator whose duties, among others, will include:

- Ensure all trucks' snow and ice equipment is calibrated properly at the beginning of the snow and ice season and at least twice during the season.
- Determine better methods for measuring quantities of salt and sand in stockpile and developing strategies to record salt and sand usage in a computerized data base.
- Evaluate salt and sand use at the conclusion of the snow and ice season. Perform necessary calculations and draw relevant conclusions.
- Organize and lead meetings with plow operators to determine what is and what is not working. Lead discussions in the sub-areas every two weeks about snow and ice control.
- Coordinate regular steering committee meetings.
- Continue regular shop meetings.
- Plan, write, and edit a *Salt Solutions* newsletter.
- Procure technologies to enhance salt and sand operations.
- Promote *Salt Solutions* through marketing techniques such as designing and distributing posters communicating Mn/DOT's interest in the *Salt Solutions* program.
- Hold managers, supervisors, and operators accountable for their salt and sand use.

- Provide training, tools, and equipment that allow operators and supervisors to make good application rate decisions and meet organizational goals.
- Coordinate ordering and paying for the incentive items.
- Set up training for State Troopers and develop methods to educate the general public.



APPENDIX A

Pavement Temperature Sensing Technology



Pavement Temperature	Weather Conditions	Pounds Per Two Lane Mile	Operation
30°+	Snow	200-400	As Needed
	Freezing Rain	200	Re-apply as necessary
25°-30°	Wet Snow	400-500	Re-apply as necessary
	Freezing Rain	300 200	Re-apply as necessary
20°-25°	Wet Snow Sleet	1200 Sand/Salt	Repeat as necessary
	Freezing Rain	1200 Sand/Salt	Repeat as necessary
15°-20°	Dry Snow	1200 Sand/Salt	Sand Hazardous Areas 20:1 Sand/Salt Mixture (Stockpile)
	Wet Snow Sleet	1200 Sand	Repeat as necessary
Below 15°	Dry Snow	1200-1500	Sand Hazardous Areas 20:1 Sand/Salt Mixture (Stockpile)

Temperature, °F	One pound of salt will melt
30	46.3 pounds of ice
25	14.4 pounds of ice
20	8.6 pounds of ice
15	6.3 pounds of ice
10	4.9 pounds of ice
5	4.1 pounds of ice
0	3.7 pounds of ice
-6	3.2 pounds of ice

The following is a list of where the sensors were sent:

Sprague:

1. Cannon Falls #3
2. Zumbrota #3
3. Red Wing #1
4. Dodge Center #2
5. Albert Lea #7
6. Northfield #2
7. Faribault #3
8. Austin #2

Control Products:

1. Owatonna #2

By November 20, 1997 the sensors were delivered to each truck station. By December 18, 1997 each truck station should have one Sprague infrared sensor installed at this time. The stations were to put them on the vehicle in which it would be the most useful.

In the Metro Division 39 Control Products and 20 Sprague sensors were installed.

Control Products Sensor Distribution List:

Anoka	2
Arden Hills	2
Camden	2
Eden Prairie	2
Forest Lake	2
France Ave.	2
Golden Valley	1
Hastings	1
Jordan	1
Lakeville	2
Maple Grove	2
Mendota	2
Maryland	2
North Branch	1
Taylor's Falls	1
Oakdale	2
Plymouth	2
Shakopee	2
Snelling	2
Spring Lake Park	1

Four Sensors needed Repairs in the following locations:

Spring Lake Park	1
Jordan	1
Hastings	1
Golden Valley	1



APPENDIX B

Wisconsin Department of Transportation's

report on:

Vehicle Mounted Infrared Pavement Temperature Sensors



**Summary of Wisconsin Department of Transportation's
report on:
Vehicle Mounted Infrared Pavement Temperature Sensors**

Study Performed During the Winter Season of 1996-1997 and 1997-1998

OVERVIEW:

During the spring of 1996, the Wisconsin Department of Transportation (WisDOT) Bureau of Highway Operations (BHO) polled the districts to determine how many counties were interested in receiving Vehicle Mounted Infrared Pavement Temperature Sensors. As a result of the survey, WisDOT decided to purchase 85 units. After a competitive bidding process in which only Control Products, Inc. (CP) could enter, due to specification requirements, WisDOT purchased 85 CP Model 994A units. Eighty units were distributed to the counties, five units were kept at BHO as backup.

BHO performed an evaluation of the Infrared Pavement Temperature Sensors following the 1996-97 snow and ice season. The majority of plow operators felt they improved their service to the customers. Nearly half of the operators indicated they used less chemicals than they would have without the devices. Eighty seven percent of the plow operators interviewed said they would recommend the purchase of more of the sensors. The only complaint with the sensors is some of them had to be sent in twice for repairs. Also, some complaints were received about the inaccuracy of the units. As a result of positive feedback from the plow operators, WisDOT decided to purchase additional units for the 1997-98 snow and ice season. Two different units, in different price categories, were purchased to provide a more complete evaluation of this technology. CP won the bid for both price categories. The higher and lower priced units purchased were the CP Model 996D and CP Model 996D-A respectively. No Sprague models were purchased at this time. Unfortunately, due to the mild winter and delays in receiving the units, no evaluation could be performed on these units.

CALIBRATION:

The calibration process involves aiming the sensor at a container of ice water and adjusting it until it reads 33 degrees Fahrenheit. Between five and ten CP units purchased experienced calibration problems and were returned for repair. The following statement was included in the WisDOT evaluation report: "**WisDOT strongly recommends all infrared sensors be calibrated at least annually before the start of the winter. Calibration checks should be performed periodically throughout the winter because erroneous readings could negatively impact snow and ice control decisions.**"

RELIABILITY:

Numerous units purchased prior to the 1996-97 snow and ice season experienced reliability problems. Faulty thermistors received from a supplier caused some of the units to display unrealistic pavement temperatures such as 200 degrees Fahrenheit. Because of this problem 40% to 50% of the units were sent back to CP for repair. WisDOT had a warranty agreement with CP, but other states have noted the average cost of repair is approximately \$400.00. Dissatisfaction with the units stemmed from reliability problems, not with their usefulness, which was not questioned. As a result, the WisDOT BHO recommends using more information than just the sensors to make operational decisions.

RESULTS:

The following are results from a survey given to snow plow operators at the end of the 1996-97 snow and ice season:

- a. **Did use of the infrared vehicle mounted sensor result in you using (more/less/about the same amount of) chemical on the roads?**

More	4.1%
Same	49.0%
Less	46.9%

- b. **Did the use of these sensors result in improved service to your constituents?**

Yes	91.5%
No	8.5%

- c. **Would you recommend purchase of more of these sensors?**

Yes	87.2%
No	12.8%

Following the winter of 1997-1998, counties were asked to rate their satisfaction of the infrared sensors on a scale of 1-10. The average satisfaction of the respondents was 8.1.

Sprague, Inc. began marketing the Road Watch Sensor shortly after BHO purchased the CP sensors in 1996. The following problems with these sensors have been noted:

1. The Sprague Road Watch sensor was not as reliable as the CP sensor. Iowa purchased seven Sprague units and returned six of them for repairs. However, Indiana and Missouri used the Sprague sensors the past two winters and were satisfied.

2. The Sprague sensors took anywhere from 5 to 15 minutes to acclimate to the outside conditions. During that time they gave unreasonable temperature readings.
3. The Sprague sensor does not have protection from environmental effects which may cause accuracy problems.

BHO installed a Sprague Road Watch sensor and a CP Model 994A on an assigned pool car. The readings from each sensor were compared to each other and to in-pavement sensors connected to remote processing units (RPU's) that are part of the road weather information system (RWIS). A pan of ice water was placed beneath each of the sensors just after the vehicle was started and again after the vehicle had been driven for an hour in a variety of conditions. The following results were obtained:

Condition	Actual Temp (°F)	Sprague Temp (°F)	CP Temp (°F)	Sprague Diff. (°F)	CP Diff (°F)
Startup	33	30	33	-3	0
Warmed up	35	32*	35	-3	0

* Varied from 31-33 without stabilizing

Please note the consistent difference in the Sprague readings could be due to a calibration problem. Sprague offers no method of recalibrating the unit, the only way to check these units is to send them back to the factory.

The following results are a comparison between the two units and fixed pavement sensors. For the purposes of this comparison, it is assumed the readings generated by the fixed sensors are accurate because they were calibrated prior to the winter of 1997-98. As a result, the fixed sensors are used as a baseline reading. The vehicle readings were logged manually as the vehicle drove over the sensor.

Definitions:

Mean Difference (MD, or bias): The average of all the differences. This quantity is useful for determining the sign of the average difference, not the magnitude. For example, if one reading was five degrees too warm and the other five degrees too cold, the MD would be zero.

$$MD = \frac{\Sigma(\text{mobile sensor observations} - \text{fixed sensor observations})}{\text{Number of comparisons}}$$

Mean Absolute Difference (MAD): The average magnitude of the differences. This quantity is useful for determining the accuracy of a measurement. In the previous example, the MAD would be five, not zero.

$$MAD = \text{absolute value (MD)}$$

Root Mean Square Difference (RSMD): The RSMD is more sensitive to large differences than the MAD. For example, suppose a sensor shows 10 differences of one degree, while the other sensor shows nine differences of zero degrees and one with a 10 degree difference. The RMSD for the first sensor is one degree, while the RMSD for the second sensor is 3.16 degrees.

$$RSMD = \sqrt{(MD)}$$

ALL READINGS

	<u>Sprague</u>	<u>Control Products</u>
Mean Difference (MD)	-5.84	0.79
Mean Absolute Difference (MAD)	6.23	2.55
Root Mean Square Difference (RSMD)	7.44	3.4

FIXED SENSOR READINGS LESS THAN OR EQUAL TO 40°F

	<u>Sprague</u>	<u>Control Products</u>
Mean Difference (MD)	-6.63	2.21
Mean Absolute Difference (MAD)	6.76	2.27
Root Mean Square Difference (RSMD)	8.06	2.76

FIXED SENSOR READING GREATER THAN 40°F

	<u>Sprague</u>	<u>Control Products</u>
Mean Difference (MD)	-4.76	-1.15
Mean Absolute Difference (MAD)	5.50	2.93
Root Mean Square Difference (RSMD)	6.49	4.11

DIFFERENCES BETWEEN THE SPRAGUE UNIT AND THE CP UNIT

	<u>>40°F</u>	<u>≤40°F</u>	<u>All Readings</u>
Mean Difference (MD)	-3.49	-8.84	-6.50
Mean Absolute Difference (MAD)	4.18	8.84	6.80
Root Mean Square Difference (RSMD)	5.25	10.08	8.32

CONCLUSIONS:

- Most superintendents used the sensors daily. They were able to discern pavement temperature differences between asphalt and concrete surfaces and between sunny and shady areas. Superintendents were able to obtain a better understanding of the pavement temperature variations within their region.

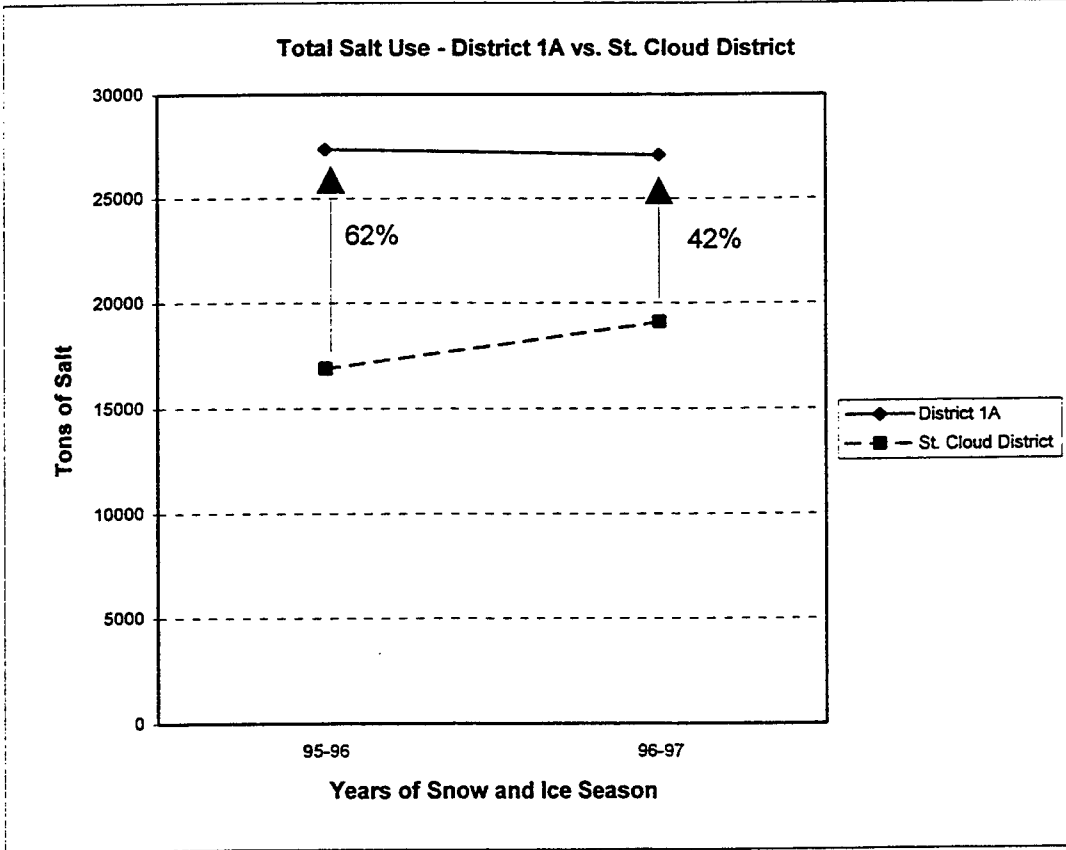
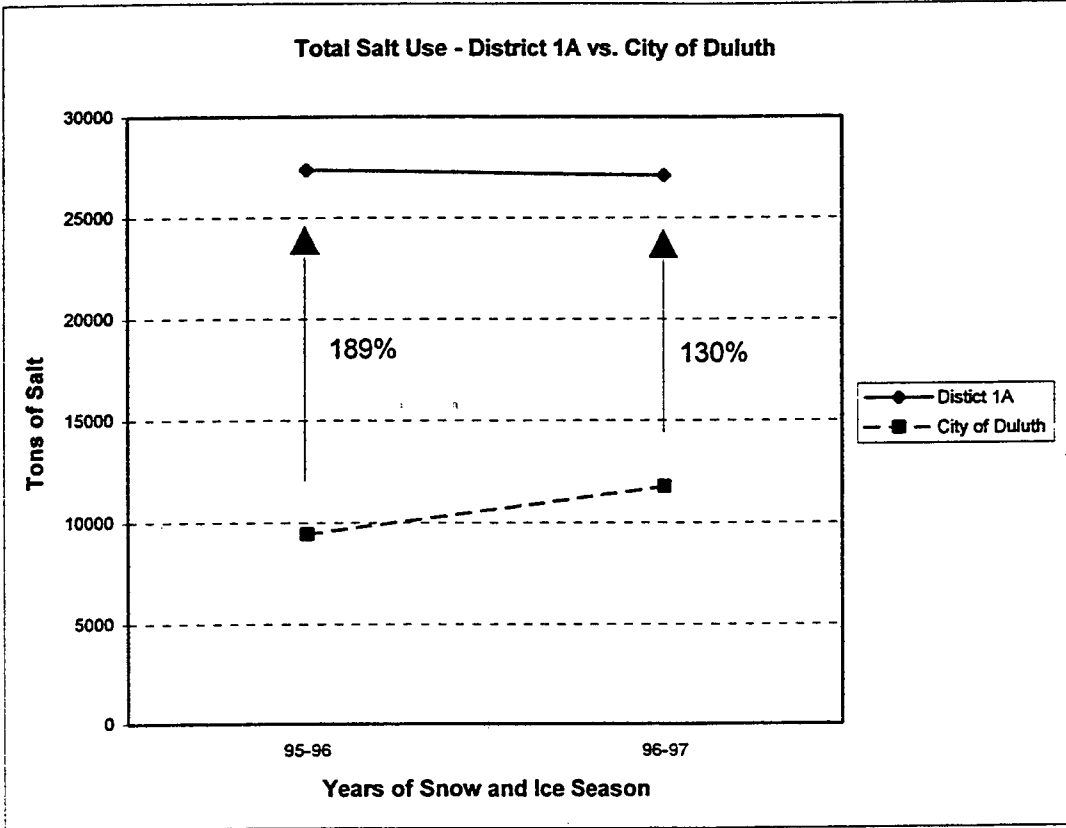
- Users indicated they were able to provide improved service to their customers while applying less chemicals.
- Two minor problems arose when dealing with CP. First, a misunderstanding of who was to pay shipping fees when a unit was sent back for repair. Second, CP did not have parts on hand for older sensors because they had discontinued production of those sensors.
- Milwaukee County designed a mount that allows the sensors to be transferred from one vehicle to another within five minutes.
- Some counties are going to test *SaltMiser*[™] during the 1998-99 snow and ice season. This system links outputs from an infrared pavement temperature sensor and a ground speed controller to an onboard computer that controls salt application rates.



APPENDIX C

District 1A Program Details



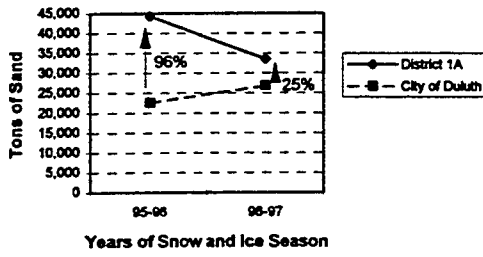


Comparison of the test and control sites for the 1996 - 1997 Snow and Ice Season

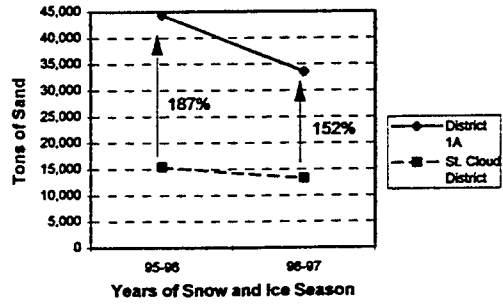
Total Salt Use		City of Duluth	
Year	District 1A (tons)	District 1A used (Tons)	Ratio
1995-96	27,359	9,469	2.9 times the amount of salt used by the City of Duluth
1995-96	27,359	9,469	
1996-97	27,095	11,772	District 1A used 189% more salt than the City of Duluth
1996-97	27,095	11,772	District 1A used 2.3 times the amount of salt used by the City of Duluth
			District 1A used 130% more salt than the City of Duluth

Total Salt Use		St. Cloud District	
Year	District 1A (tons)	District 1A used (Tons)	Ratio
1995-96	27,359	16,900	1.6 times the amount of salt used by St. Cloud District
1995-96	27,359	16,900	
1996-97	27,095	19,100	District 1A used 62% more salt than St. Cloud District
1996-97	27,095	19,100	District 1A used 1.4 times the amount of salt used by St. Cloud District
			District 1A used 42% more salt than St. Cloud District

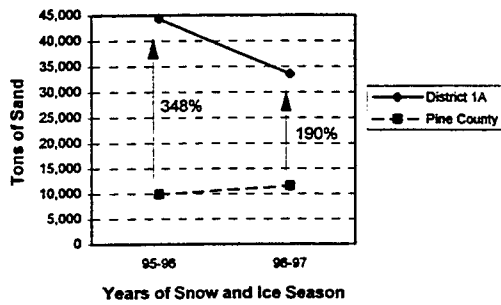
Total Sand Use - District 1A vs. City of Duluth



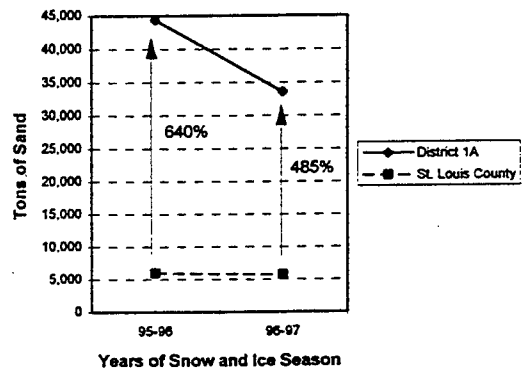
Total Sand Use - District 1A vs. St. Cloud District



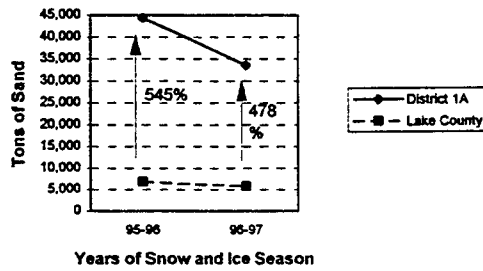
Total Sand Use - District 1A vs. pine County



Total Sand Use - District 1A vs. St. Louis County



Total Sand Use - District 1A vs. Lake County



Comparison of the test and control sites for the 1996 - 1997 Snow and Ice Season

Total Sand Use

Year	District 1A (tons)	City of Duluth (tons)		
1995-96	44,383	22,634	District 1A used	1.96 times the amount of sand used by the City of Duluth
1995-96	44,383	22,634	District 1A used	96% more sand than the City of Duluth
1996-97	33,600	26,800	District 1A used	1.25 times the amount of sand used by the City of Duluth
1996-97	33,600	26,800	District 1A used	25% more sand than the City of Duluth

Total Sand Use

Year	District 1A (tons)	St. Cloud District (tons)		
1995-96	44,383	15,455	District 1A used	2.87 times the amount of sand used by St. Cloud District
1995-96	44,383	15,455	District 1A used	187% more sand than St. Cloud District
1996-97	33,600	13,335	District 1A used	2.52 times the amount of sand used by St. Cloud District
1996-97	33,600	13,335	District 1A used	152% more sand than St. Cloud District

Total Sand Use

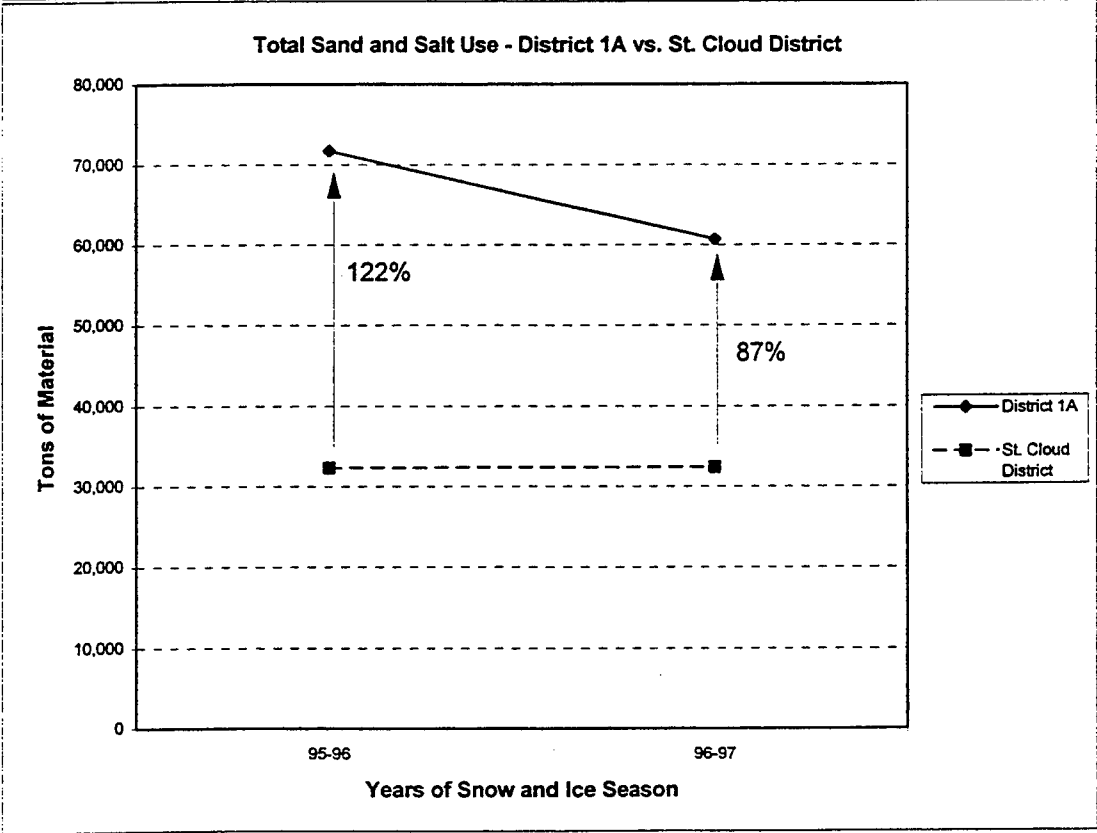
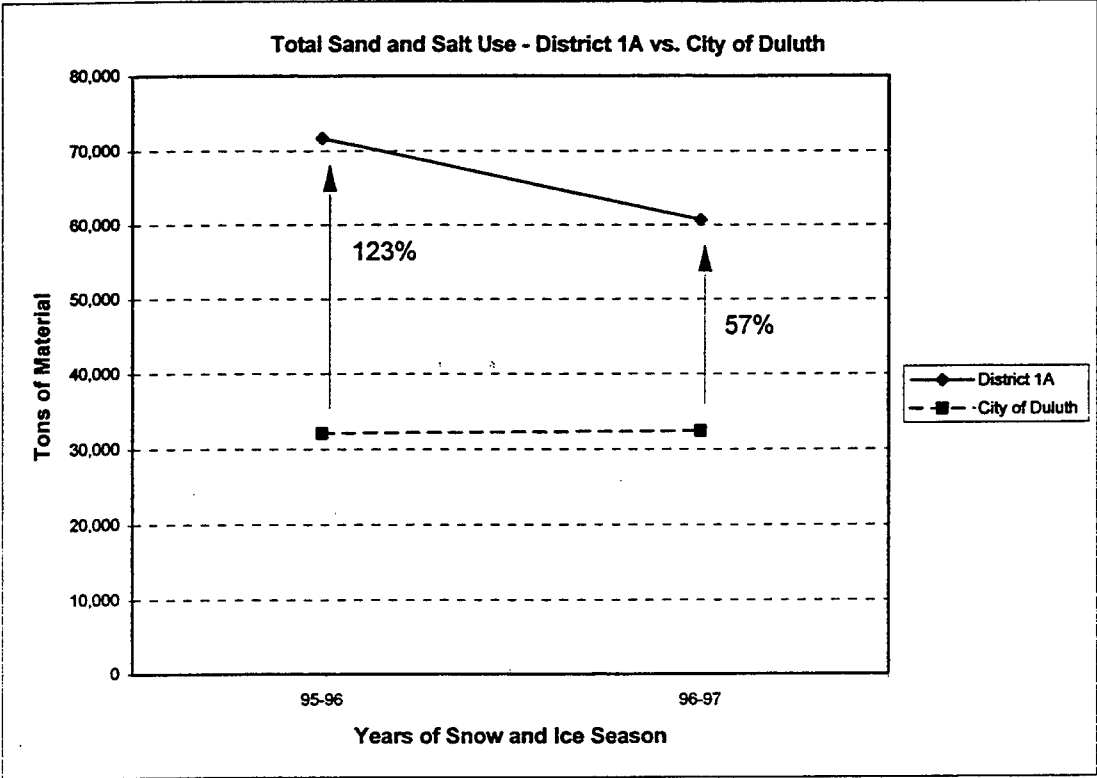
Year	District 1A (tons)	Pine County (tons)		
1995-96	44,383	9,910	District 1A used	4.48 times the amount of sand used by Pine County
1995-96	44,383	9,910	District 1A used	348% more sand than Pine County
1996-97	33,600	11,595	District 1A used	2.90 times the amount of sand used by Pine County
1996-97	33,600	11,595	District 1A used	190% more sand than Pine County

Total Sand Use

Year	District 1A (tons)	St. Louis County (tons)		
1995-96	44,383	6,000	District 1A used	7.40 times the amount of sand used by St. Louis County
1995-96	44,383	6,000	District 1A used	640% more sand than St. Louis County
1996-97	33,600	5,744	District 1A used	5.85 times the amount of sand used by St. Louis County
1996-97	33,600	5,744	District 1A used	485% more sand than St. Louis County

Total Sand Use

Year	District 1A (tons)	Lake County (tons)		
1995-96	44,383	6,878	District 1A used	6.45 times the amount of sand used by Lake County
1995-96	44,383	6,878	District 1A used	545% more sand than Lake County
1996-97	33,600	5,813	District 1A used	5.78 times the amount of sand used by Lake County
1996-97	33,600	5,813	District 1A used	478% more sand than Lake County



Comparison of the test and control sites for the 1996 - 1997 Snow and Ice Season

Total Sand and Salt Use		City of Duluth	
Year	District 1A (tons)	District 1A used (tons)	Ratio
1994-97	71742	32103	2.23 times the amount of sand and salt used by the City of Duluth
1994-97	71742	32103	123% more sand and salt than the City of Duluth
1997-98	60695	38572	1.57 times the amount of sand and salt used by the City of Duluth
1997-98	60695	38572	57% more sand and salt than the City of Duluth

Total Sand and Salt Use		St. Cloud District	
Year	District 1A (tons)	District 1A used (tons)	Ratio
1994-97	71742	32355	2.22 times the amount of sand and salt used by St. Cloud District
1994-97	71742	32355	122% more sand and salt than St. Cloud District
1997-98	60695	32435	1.87 times the amount of sand and salt used by St. Cloud District
1997-98	60695	32435	87% more sand and salt than St. Cloud District

APPENDIX D

Statewide Program Details

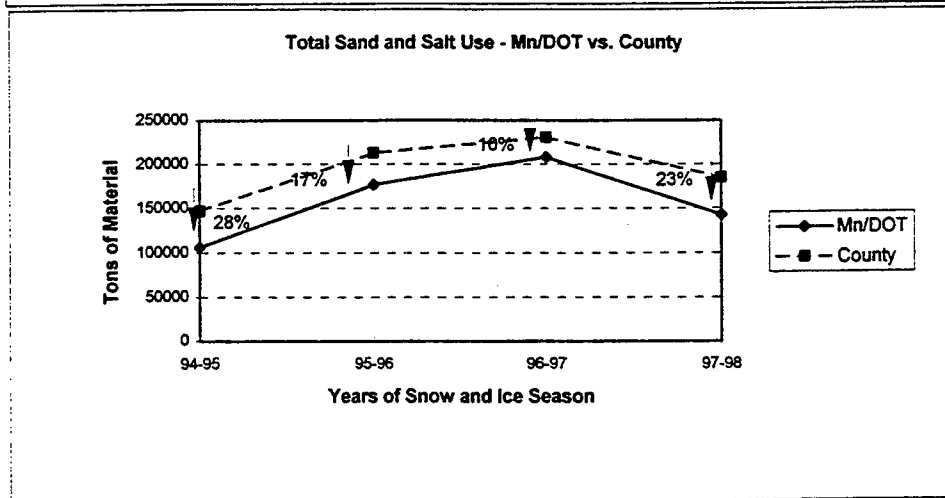
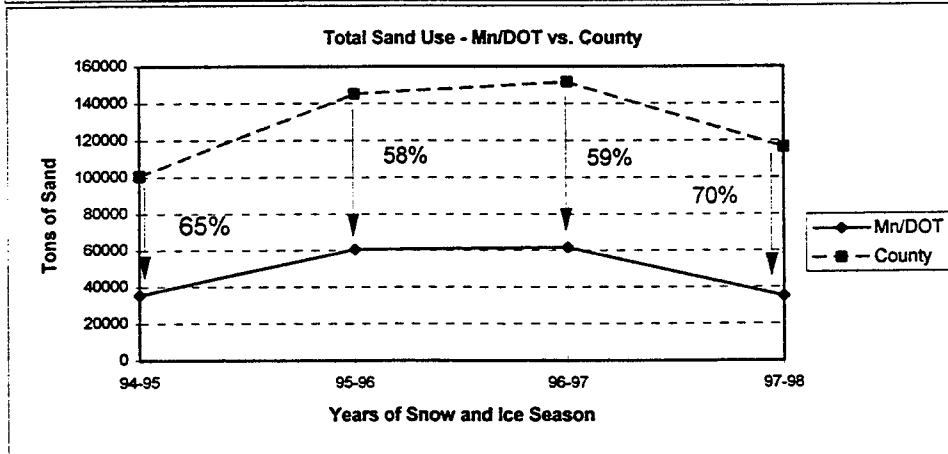
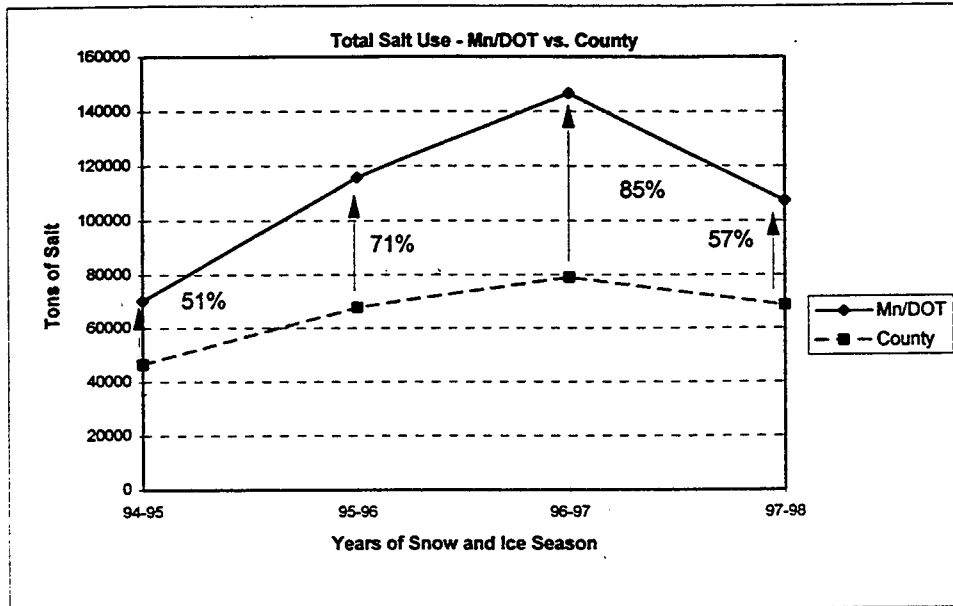


Sand and Salt Use By Maintenance Region and Agency

County	Highway	1994-95		1995-96		1996-97		1997-98		1998-99		1999-00		2000-01		2001-02		2002-03		2003-04		2004-05	
		Sand Use (tons)	Salt Use (tons)	Sand Use (tons)	Salt Use (tons)	Sand Use (tons)	Salt Use (tons)	Sand Use (tons)	Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand and Salt Use (tons)	Total Sand and Salt Use (tons)
Anoka County	Mn/DOT	3,410	5,373	6,065	14,848	7,825	10,919	14,942	35,186	11,035	16,292	20,707	16,285	28,927	48,034								
Carver County	Mn/DOT	1,919	2,259	2,223	6,401	2,872	3,053	3,859	9,884	4,891	5,312	6,082	6,285	16,285									
Chisago County	Mn/DOT	2,986	4,220	4,871	12,077	2,687	4,507	9,656	16,850	5,673	8,727	14,527	8,727	28,927									
Dakota County	Mn/DOT	7,882	15,719	11,736	35,337	9,599	14,679	17,965	42,243	17,481	30,398	29,701	30,398	77,580									
Hennepin County	Mn/DOT	5,849	12,832	13,687	32,368	24,432	48,925	54,476	127,833	30,281	61,757	68,163	61,757	160,201									
Ramsey County	Mn/DOT	6,488	10,042	10,502	27,032	10,315	18,780	25,488	54,583	16,803	28,822	35,990	28,822	81,615									
Scott County	Mn/DOT	1,865	2,163	4,595	8,623	2,764	4,017	4,997	11,778	4,629	6,180	9,592	6,180	20,401									
Washington County	Mn/DOT	5,267	8,240	8,139	21,646	9,927	11,087	15,492	36,506	15,194	19,327	23,631	19,327	58,152									
Total		35,666	60,848	61,818	158,332	70,321	115,967	146,575	332,863	105,987	176,815	208,393	176,815	491,195									

County	Highway	1994-95		1995-96		1996-97		1997-98		1998-99		1999-00		2000-01		2001-02		2002-03		2003-04		2004-05	
		Sand Use (tons)	Salt Use (tons)	Sand Use (tons)	Salt Use (tons)	Sand Use (tons)	Salt Use (tons)	Sand Use (tons)	Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand Use (tons)	Total Salt Use (tons)	Total Sand and Salt Use (tons)	Total Sand and Salt Use (tons)
Anoka County	Public Works	10,000	10,000	8,000	28,000	11,000	12,000	14,000	37,000	21,000	22,000	22,000	22,000	65,000									
Carver County	Hwy. Dept.	8,096	8,089	7,842	24,027	2,258	2,971	2,576	7,805	10,354	11,060	10,418	11,060	31,832									
Chisago County	Hwy. Dept.	8,400	10,200	12,000	30,600	1,800	2,200	3,200	7,200	10,200	12,400	15,200	12,400	37,800									
Dakota County	Hwy. Dept.	20,000	25,000	33,400	78,400	5,000	7,300	9,400	21,700	25,000	32,300	42,800	32,300	100,100									
Hennepin County	Public Works	14,810	25,382	18,767	59,939	12,670	21,827	25,872	60,369	27,480	47,189	45,639	47,189	120,308									
Ramsey County	Public Works	12,271	28,074	26,339	66,684	5,500	10,420	10,095	26,015	17,771	38,494	36,434	38,494	92,699									
Scott County	Hwy. Dept.	7,108	9,070	12,913	29,091	2,789	3,653	5,928	12,370	9,897	12,723	18,941	12,723	41,461									
Washington County	Hwy. Dept.	20,000	29,400	31,400	60,800	5,500	7,500	6,000	21,000	25,500	36,900	39,400	36,900	101,800									
Total		100,885	145,195	151,661	397,541	48,517	67,871	79,071	193,459	147,202	213,066	230,732	213,066	591,000									

*Note: All quantities are represented as estimated tons of material.



Comparison of the test and control sites for the 1997 - 1998 Snow and Ice Season

Total Salt Use

Year	Mn/DOT (tons)	County (Tons)	
1994-95	70321	46,517	Mn/DOT used 1.5 times the amount of salt used by the County
1994-95	70321	46,517	Mn/DOT used 51% more salt than the County
1995-96	115,967	67,871	Mn/DOT used 1.7 times the amount of salt used by the County
1995-96	115,967	67,871	Mn/DOT used 71% more salt than the County
1996-97	146,575	79,071	Mn/DOT used 1.9 times the amount of salt used by the County
1996-97	146,575	79,071	Mn/DOT used 85% more salt than the County
1997-98	107,481	68,630	Mn/DOT used 1.6 times the amount of salt used by the County
1997-98	107,481	68,630	Mn/DOT used 57% more salt than the County

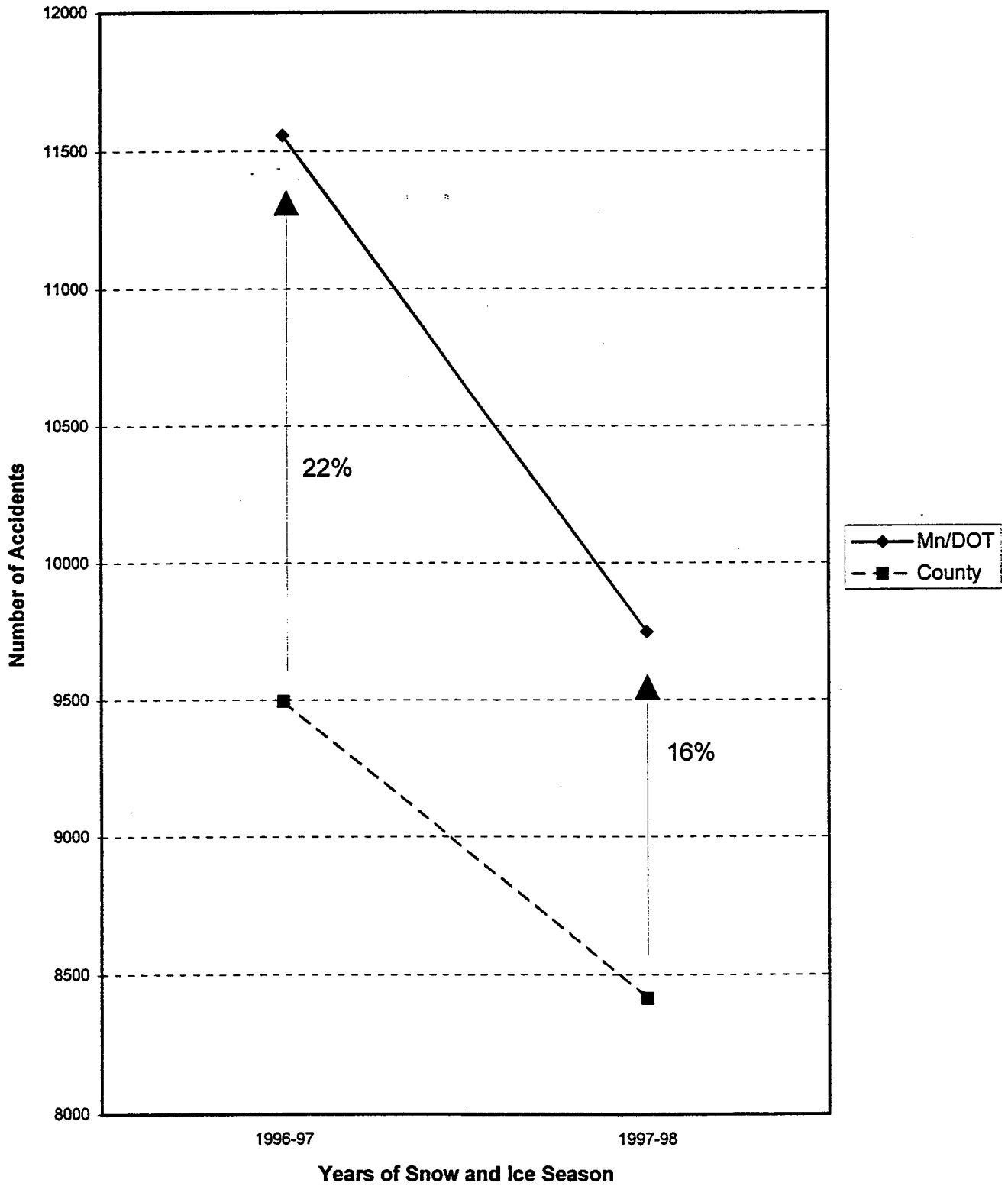
Total Sand Use

Year	Mn/DOT (tons)	County (Tons)	
1994-95	35,666	100,685	Mn/DOT used 0.35 times the amount of sand used by the County
1994-95	35,666	100,685	Mn/DOT used 65% less sand than the County
1995-96	60,848	145,195	Mn/DOT used 0.42 times the amount of sand used by the County
1995-96	60,848	145,195	Mn/DOT used 58% less sand than the County
1996-97	61,818	151,661	Mn/DOT used 0.41 times the amount of sand used by the County
1996-97	61,818	151,661	Mn/DOT used 59% less sand than the County
1997-98	35,214	116,306	Mn/DOT used 0.30 times the amount of sand used by the County
1997-98	35,214	116,306	Mn/DOT used 70% less sand than the County

Total Sand and Salt Use

Year	Mn/DOT (tons)	County (tons)	
1994-95	105,987	147,202	Mn/DOT used 0.72 times the amount of sand and salt used by the County
1994-95	105,987	147,202	Mn/DOT used 28% less sand and salt than the County
1995-96	176,815	213,066	Mn/DOT used 0.83 times the amount of sand and salt used by the County
1995-96	176,815	213,066	Mn/DOT used 17% less sand and salt than the County
1996-97	208,393	230,732	Mn/DOT used 0.90 times the amount of sand and salt used by the County
1996-97	208,393	230,732	Mn/DOT used 10% less sand and salt than the County
1997-98	142,695	184,936	Mn/DOT used 0.77 times the amount of sand and salt used by the County
1997-98	142,695	184,936	Mn/DOT used 23% less sand and salt than the County

Total Number of Accidents - Mn/DOT vs. County



Accidents comparison of the test and control sites for the 1997-98 Snow and Ice Season

Total Number of Accidents		
Year	Mn/DOT	County
1996-97	11,557	9,496
1996-97	11,557	9,496
1997-98	9,749	8,416
1997-98	9,749	8,416

Mn/DOT had 1.2 times more accidents than the County
Mn/DOT had 22% more accidents than the County
Mn/DOT had 1.2 times more accidents than the County
Mn/DOT had 16% more accidents than the County



APPENDIX E

Salt and Sand Use Perception Survey



SALT & SAND USE PERCEPTION SURVEY RESULTS

Enter your job level _____ Enter your work group _____ Work location _____
 (maint. Worker. technician. supervisor) (maintenance. bridge. construction. traffic)

	Yes	No	
1.	53	10	Do you feel you received adequate job training?
2.	28	33	Would a saving salt incentive program cause you to use salt more efficiently?
3.	51	11	Does your company actively encourage employees to use salt more efficiently?
4.	50	11	Is using salt and sand efficiently considered important by management?
5.	25	33	Do you think penalties should be assessed for blatant excessive use of salt & sand?
6.	38	19	Is the amount of snow and ice training given to the supervisor adequate?
7.	19	44	Have you been asked to perform any operations which you felt would waste salt and sand?
8.	36	24	Are employees influenced by your company's efforts to promote the efficient use of salt and sand?
9.	42	20	Are employees provided information on such things as cost of salt and sand?
10.	33	28	Are efficient sanding and salting procedures regularly reviewed with employees?
11.	34	28	Do your co-workers support Mn/DOT's effort to use sand and salt efficiently?
12.	36	24	Do supervisors pay adequate attention to salt and sand application rates?
13.	36	23	Is efficient salt and sanding recognized by supervisors?
14.	40	19	Are supervisors supported by management in their decisions affecting the efficient use of sand and salt?
15.	38	18	Do the people in your department understand the relationship between what they do and Mn/DOT's efforts to use sand and salt efficiently?
16.	35	20	Did you receive adequate training on the efficient use of sand and salt?
17.	42	20	Do you think your Mn/DOT has too many rules and regulations governing salt and sand application rates?
18.	16	47	Are regular contacts made to all employees by supervisors regarding salt and sand application rates?
19.	29	31	Do employees participate in setting goals for saving salt and sand?
20.	16	45	Do you think your supervisor seeks prompt correction of problems found with sanders during inspection?
21.	44	14	Are you interested in how you sub-areas salt and sand use compare with other sub-areas?
22.	44	18	Can first line supervisors reward employees for using sand and salt efficiently?
23.	22	46	Do employees caution other employees about wasteful sanding practices?
24.	31	31	Is discipline usually assessed when salt and sand is blatantly wasted?
25.	12	50	Do supervisors provide training on application rates for newly assigned employees?
26.	35	24	Is saving sand and salt recognized by your company?
27.	38	24	Are checks made to be sure that sanding controllers are used properly?
28.	30	31	Does Mn/DOT have established goals for saving sand and salt?
29.	26	29	Is the efficient use of sand and salt sometimes overlooked in order to get the job done?
30.	52	9	Does compliance with application rate guidelines slow down the operation?

31. 36 24 Are workers that use sand and salt sometimes overlooked in order to get the job done?
32. 27 33 Do supervisors discuss goals for reducing sand and salt with employees regularly?
33. 24 37 Has Mn/DOT's past efforts encouraged you to use sand and salt efficiently?
34. 38 23 Is information that is needed to use sand and salt efficiently made available to employees?
35. 40 21 Are new employees assigned to work with experienced employees for job instruction?
36. 42 18 Are employees checked on a routine basis to see whether they are using sand and salt efficiently?
37. 23 38 Is promotion to higher level jobs dependent upon using sand and salt efficiently?
38. 5 55 Do supervisors show a personal interest in using sand and salt efficiently?
39. 38 21 Do most supervisors have a good knowledge of application rates, and using sand and salt efficiently?
40. 43 14 Does the company have a uniform procedure for dealing with employees that blatantly waste sand and salt?

APPENDIX F

Salt Solutions Survey



Salt Solutions Survey 1997-1998

Please take a moment to fill out the following survey. The results will help direct the development of the Salt Solution program for next year's snow and ice season. Also, a summary of this survey will be included in the Salt Solution final report. It is not necessary to write your name of the survey.

1. **How useful did you find the Salt Solutions shop meetings?**

- 26 Very useful
- 61 Useful
- 60 Somewhat useful
- 16 Not useful / If not useful, why?
 - Sander doesn't work

2. **How useful did you find the topics discussed?**

- 20 Very useful
- 65 Useful
- 70 Somewhat useful
- 7 Not useful / If not useful, why?
 - Learn from co-workers

3. **As a result of Salt Solutions training. Do you feel that you used less salt than you normally would have used?**

- 44 Yes
- 55 Maybe
- 64 No

4. **As a result of Salt Solutions training, do you fell that you used less sand than you normally would have used?**

- 72 Yes
- 41 Maybe
- 50 No

5. How useful did you find the information in the newsletter?

8 Very useful

38 Useful

90 Somewhat useful

16 Not useful / If not useful, why?

- 11 operators did not know a newsletter was available

6. What information would you like to see included in the newsletter?

- Temperature sensors that work.
- Usage reports, expose abusers.
- What different shops are doing. Pre-wet, Chloride, or sand.
- Stress which shops continue to use increased amounts of salt.
- Information on pre-wetting, anti-icing, de-icing, new equipment being used at Mn/DOT, outstate, and metro.
- The price of salt.
- Salt and sand totals from each shop.
- Statistics on different shops.
- How much salt and sand each shop is using.
- Amount of snow each area received.
- How much money is saved each year due to the program.
- Test section information.

7. Would you like to see the Salt Solutions program continued next year?

73 Yes

72 No opinion

18 No / If no, why?

8. If you answered yes to question #7, what would you like to see included in the program next year?

- More shops that used more sand.
- Program had good intentions, but some shops will never change.
- Speed of trucks applying salt, maybe video of different speeds.
- More training on temperature conditions, pavement, etc.
- Promote less sand usage, cleanup would be a lot easier in the spring.
- Let's see program come up with real incentives to save salt.
- More pre-wetting pros and cons. Simpler sander controls.
- Get rid of complicated Dickey Johns and go back to the black box.
- More information of salt effectiveness at different temperatures.

- Want back up from mechanical side of Mn/DOT to get equipment working like designed to before it snows.
- Different chemicals being used.
- Would like to see program finish what it started to get sanders working all the time.
- At beginning of year should review procedures again. Nice that they gave prizes to everyone.
- Pictures.
- Spinner control.
- Accountability! People need to be accountable for the amount of salt and sand they use. There is still a lot of waste going on out there.
- Address issue of plowing vs. Dumping salt to melt snow.
- Comparison between salt/sand mix and straight salt.
- What shops had trouble with putting out too much chemical because of faulty equipment.
- Fix the Dickey Johns
- More shop meetings
- Different systems tested (i.e. D.J., Penguin, Greshm).
- Different systems (i.e. Gresham).
- Dickey John not always working properly.



APPENDIX G

Metro Division Infrared Sensor Survey Results



METRO DIVISION INFRARED SENSOR SURVEY RESULTS

1. Please identify which type of sensor you used.

- 23 Sprague Users
- 25 Control Products Users

2. Please check all that apply:

2a. I used the pavement temperature to determine the rate of application.

- 18 Sprague Users
- 14 Control Products Users

2b. I used the pavement temperature to determine the timing of chemical application.

- 17 Sprague Users
- 13 Control Products Users

2c. I did not use the sensor.

- 0 Sprague Users
- 5 Control Products Users

2d. I used the sensor for other purposes. Please describe

- Herbicide applications (3 daily recordings needed for spray reports)
- Shared the information with others (dispatch and co-workers)
- Air temperature
- Application rates and where to apply
- Don't believe the sensor works properly (Control Products)
- Road temperature for possible blow-ups

3. The sensor worked properly:

	Sprague	Control Products
Always	20	7
Sometimes	3	9
Occasionally	0	5
Never	0	4

4. In your opinion, did knowing the pavement temperature help you use less sand and salt?

	Sprague	Control Products
Yes	20	14
No	1	5
Don't Know	2	6

5. In your opinion, should Mn/DOT install these on more plow trucks?

	Sprague	Control Products
Yes	21	14
No	0	7
Don't Know	2	4

Additional Comments:

- Temperature of the air was a problem and never the same as billboard weather.
- Expensive versus buying from Radio Shack
- Problems with transmission when connected
- I put down materials based on condition of the road versus the pavement temperature.
- Temperature reading off by as much as 10 degrees.
- It takes 20 to 20 minutes to get good readings.
- Reading would change dramatically when sitting at idle - great piece of equipment.
- Problem with correct air temperature
- heat from engine seems to effect air temperature
- Install on supervisors/project supervisors truck.
- Installed to late to use during most of the season snowfall.
- I adjusted the material usage by the way the road looked.
- Sprague seems to be the most accurate of the two.
- I really felt this was useful as to when and when not to apply materials. It also helped me determine the application rates based on guidelines and temperature. This is also very helpful for those with little experience in snow removal (that 6th sense). Just a helpful tool that goes along with making better decisions and experience. I highly recommend the mirror mounted unit.
- At slow speeds the unit seemed to pick up the engine compartment temperature.
- Mirror mount works better of the two.
- Great device.
- Works good - very accurate.

- I thought it worked great.
- It did help me on the roads during night patrol.
- I helped determine rising and falling temperatures.
- Outside temperature always wrong on Control Products sensor.
- Sprague model much better.

