QUARTERLY PROGRESS REPORT

to the

CLEAR ROADS PANEL
STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

on

State Project ID #0092-06-23
Pooled Fund Project #TPF-5(092)
Contract #406028
Purchase Order #TRG3403142

DETERMINING EFFECTIVENESS OF DEICING MATERIALS AND PROCEDURES

for period

October 1, 2006 to December 31, 2006

SUBMITTED BY

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December 31, 2006

Preface

This quarterly progress report summarizes the progress of the research team during the fourth calendar quarter of 2006 to accomplish the research objectives of Wisconsin State Project ID #0092-06-23, "Determining Effectiveness of Deicing Materials and Procedures". The project team started to work on the study on August 1, 2006 the contract starting date. This report covers the project effort from October 1 through the end of the quarter on December 31, 2006.

Edward J. Fleege
Principal Investigator, and
Overall Project Manager

Section 1
Introduction

Research Problem Statement

Snow and ice control on the U.S. highway system consumes over $2 billion in direct costs each year. Indirect costs associated with corrosion and environmental impacts add at least $5 billion. State and local agencies are employing solid and liquid chemicals, abrasives, and mechanical methods - individually or in combination- in their snow and ice control operations. However, the process of selecting the ideal snow and ice control treatments that meet highway agency objectives can be difficult and costly. Research by the Strategic Highway Research Program (SHRP), the Federal Highway Administration (FHWA), the American Association of State Highway Officials (AASHTO), the National Cooperative Highway Research Program (NCHRP), and other organizations in the United States and other countries has tried to address many of the issues associated with snow and ice control treatments. However, both the expenditure level and the potential environmental impact of winter chemicals have also lead highway agencies to search for and implement more effective methods of winter maintenance; such as electronic ground-speed-oriented spreader controls, thermal mapping, pre-wetting, and anti-icing. These technologies have the potential of providing more effective and timely removal of snow and ice while requiring significantly less amount of chemicals.

Most of these alternative maintenance techniques require installation of advance information technologies such as road weather information systems (RWIS), automatic vehicle location (AVL) and fleet management systems and wireless communication to obtain real-time information on weather and road conditions. As a result these new solutions incur greater capital and operating costs than conventional operations. This difference in cost structure has lead to a wide spread interest and debate on the cost-effectiveness of these new methods and technologies.

Highway agencies are under increasing budget and environmental constraints to meet the expected level of service. Salt and fuel prices are increasing and agencies have fewer workers for operations. Chemicals that are being used on the roadways are affecting ground water, lakes and rivers. Highway agencies are now asking if the developed guidelines and/or their current practices are the “best value” for chemical application during snow and ice control operations. Field-testing procedures are needed to evaluate the effectiveness of the various winter chemical application rates.

The aim of this study is to develop testing guidelines for evaluation the performance of various winter road chemicals and to produce a portable test method that can be used by any interested highway agency in a variety of locations under a variety of winter conditions. The outcome of the study will provide state and local highway winter maintenance agencies with the ability to refine their current best practices to provide the traveling public with good service at an acceptable cost while protecting the environment.

Research Objective and Scope

The overall objective of the research is to develop field testing procedures and guidelines for determining the effectiveness of various winter chemicals at various application rates.

The scope of the research is divided into three parts. Part 1 will be the development of an evaluation plan. This evaluation plan will be designed to test the effectiveness of any winter chemical in any winter weather condition. The plan will specify the minimum equipment and data needed to conduct such evaluations.

Part 2 will be the small pilot test on proposed I-94 segment near Alexandria, MN during the 2006 - 2007 winter in an effort to validate the evaluation plan that was developed in Part 1. A Mn/DOT snowplow truck with ground-speed controller will be available for this pilot test. Data collection forms will be developed and provided to record the necessary data from the snowplow truck operations.

Part 3 will be the final report that documents the findings and conclusions of this study. This report will include the testing guidelines and procedures that were developed along with the minimum equipment and data requirements, results of the pilot test, and recommendations for modifications to the testing procedures.

Research Approach

The research approach described below is designed to develop guidelines for testing the effectiveness of any winter chemical in any winter weather condition and to produce a portable test method that can be used by any interested highway agency in a variety of locations under a variety of winter conditions. In addition, a small pilot test will be conducted at the test section on the by-pass around Alexandria.

The research plan consists of three parts. A brief paragraph summarizing each part is presented below.

Part 1, Evaluation Plan

The evaluation plan will be developed following the gathering of related research and guidelines from around the country to understand the state of practice in testing the performance of winter chemicals and the use of sensor data in that evaluation. This information will be obtained by conducting an extensive literature search along with research on evaluating various sensors that are used for decision-making on maintenance operations. In addition to a review of the pertinent reports, domestic and international sources of information will be contacted.

Access will be obtained to the various archived databases. A through review will be made to acquire an understanding of the data being reported from the various systems, e.g. RWIS, MDSS, SAIL II, camera and Geonor T-200B series all weather precipitation gauge.

Using the gathered information and data, an evaluation plan will be developed that will identify the procedures to be used in evaluating the performance and optimum application rates of chemical treatments. In addition to the evaluation plan, a proposal will be developed detailing how the pilot test will be conducted.

Part 2, Pilot Test

The Pilot Test will be conducted to validate the Evaluation Plan developed in Part 1 of this project. The small pilot test will be conducted on I-94 between mile points 97 and 106 during the winter season of year 2006 –2007. During the pilot test, an attempt will be made to gather data across a representation sampling of winter events (freezing rain, snow, etc.). A minimum of 5 and a maximum of 10 events will be recorded and analyzed.

Within Part 2, there will be four activities involved in carrying out the pilot test. First activity will be the development of forms that will be used to collect data and information. The second action will be to train the operators of the two snowplow trucks on the procedures to be used in completing the forms that are relative to their operations. The third action will be the data collection, assembling the data, and monitoring the integrity and accuracy of the data. The final activity will be analyzing the data from the pilot test.

Part 3, Reports

A Final Report will be issued in Part 3 to provide documentations of the findings and recommendations of this project. The Final Report will include an executive summary of the study plus provide the results of the literature search. This report will also include the testing guidelines and procedures that were developed including the minimum amount of equipment and data requirements needed to conduct a successful evaluation of the performance of various winter road chemicals. The documentation will provide the results of the pilot test, and recommendation for modification to the testing procedures as result of the findings from the pilot test. A draft of the Final Report will be submitted to Clear Roads TAC members approximately two months prior to the end of the project for their review and request for any modifications. A face-to-face meeting with the Clear Roads TAC members will take place one month prior to the end of the project to discuss the study findings and recommended revisions to the Final Report.

Section 2
Progress Schedule

The research on the project began on August 1, 2006, the date of the contract starting date. The project is to be conducted over a 12-month period of performance and be completed by July 31, 2007. The planned schedule of activities by parts is presented in Figure 1. This schedule reflects the start date of August 1, 2006 and a 12-month period of performance.

The planned progress schedule is presented in Figure 2. Figure 2A of the progress schedule illustrates the overall planned project schedule by part on a monthly basis. Figure 2B shows the planned schedule of expenditures over the project period. Figure 2C shows the planned schedule of percent completion over the project period. The progress schedule will be updated each month during the project period for internal review. The updated schedule will be presented in each quarterly report.

The research team realizes that progress on this project has fallen behind schedule. This is due in part to issues that have been identified in Sections 3 and 4 of this report. The development of the guidelines is tied with the development of the implement plan of the Pilot Test.

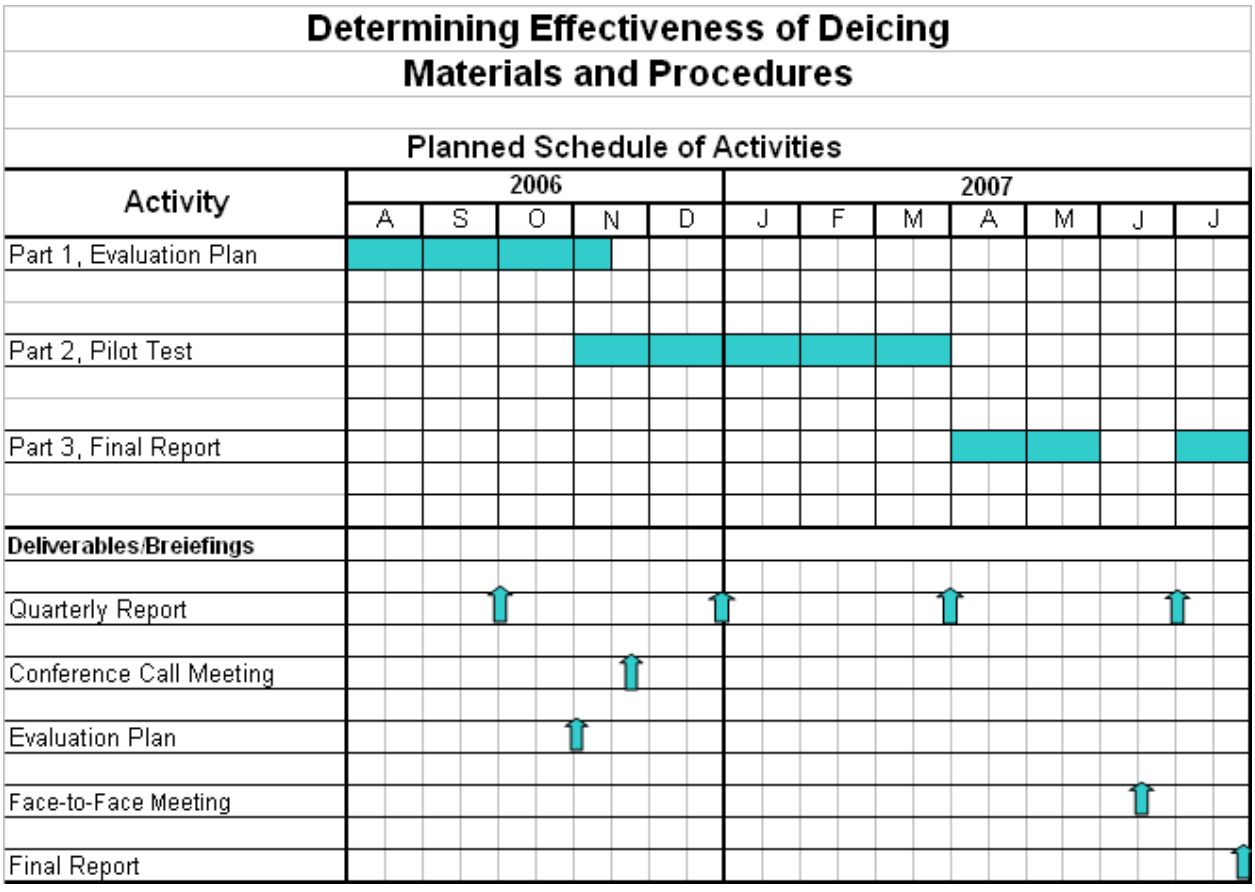


Figure 1 – Planned Schedule of Activities

CLEAR ROADS RESEARCH PROGRAM

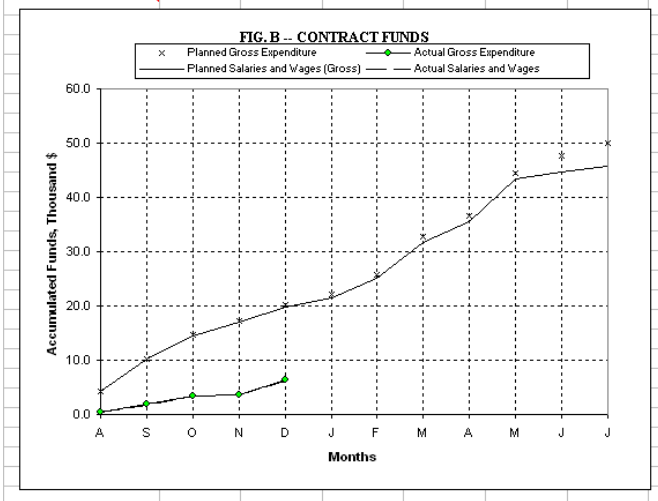
WISCONSIN DEPARTMENT OF TRANSPORTATION

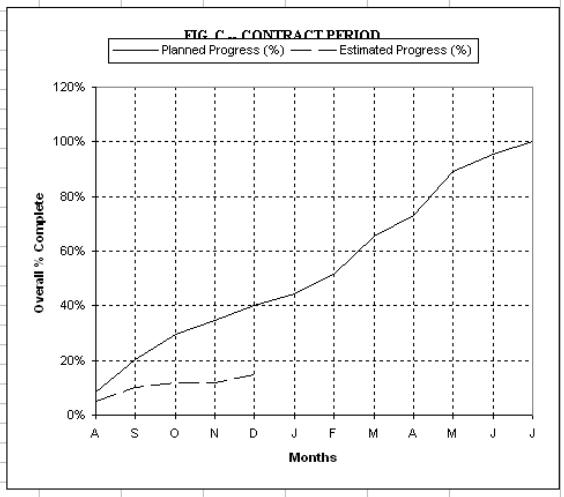
PROGRESS SCHEDULE

Project No.	TPF - 5(092), Determining Effectivenes of Deicing Materials and Procedures	Year: 2006	Quarter: Fourth
Research Agency	Edward J. Fleege		
Principal Investigator	Edward J. Fleege		

RESEARCH	2006					2007							ESTIMATED %
ACTIVITY	A	S	O	N	D	J	F	M	A	M	J	J	COMPLETION
PART 1	27	66	95	100									55
PART 2				12	30	44	68	100					
PART 3								10	30	72	88	100	
OVERALL % COMPLETED	8%	20%	29%	35%	40%	44%	52%	65%	73%	89%	95%	100%	15

FIG. A -- OVERALL PROJECT SCHEDULE





Funds Expended	13%	Time Expended:	41.92%
Contract Amount	49,980	Starting Date:	August 1, 2006
Expended This Quarter	4,458	Completion Date:	July 31, 2007
Total Exp. to Date	6,301		
Balance	48,137		

Salaries and Wages Estimated This Quarter:	$9,700
Salaries and Wages Spent This Quarter:	$4,313
Accumulated Salaries and Wages To Date:	$6,113

Figure 2 – Project Progress Schedule

Section 3
Accomplishments During the Reporting Period

Overview of Current Quarterly Activities

The project team worked on Part 1 of the project during the fourth quarter of 2006. This report covers the project effort through the end of the quarter on December 31, 2006. All of the work effort during the three months in this quarter was devoted to Part 1, Evaluation Plan. A minor effort was devoted to the administrative details of the project. The results of these activities are described below.

Part 1, Evaluation Plan

The research team worked on five tasks of Part 1 during the three months of the fourth quarter of 2006. These activities were Task 1- Literature Search; Task 2 - Review Electronic Data; Task 4 – Review MDSS Information; Task 6 – Quarterly Report; and Task 7 – Conference Call.

Task 1 – Literature Search

An extensive literature search was completed this quarter using the Transportation Research Board- Transportation Research Information Services (TRB-TRIS) to identify relevant information on performance measurements for snow and ice control operations and the performance measurements of RWIS data. The number of potentially useful papers/reports was reduced to 28 by a review of the abstracts. Nearly all the papers/reports were given at either one of 4 conferences: Sixth International Symposium on Snow Removal and Ice Control Technology that was held at Spokane, Washington on June 7-9, 2004; 85th Annual Meeting of Transportation Research Board at Washington D. C. on January 22-26, 2006; 11th AASHTO-TRB Maintenance Management Conference at Charleston, South Carolina on July 16-20, 2006; and XIth International Winter Road Congress (PIARC) meeting at Sapporo, Japan on January 28-31, 2002. Copies of the 28 papers have been gathered. Five of the entries were either authored or co-authored by one of the members of the research team. A bibliography was developed that contains the listing of the 28 papers. This bibliography is presented in Appendix A of this report.

Posting of an inquiry on the Snow-Ice List resulted in eight responses which did not contribute to the findings of the project. A review of the Transportation Research Laboratory of England's Electronic Catalogue of Published Reports did not provide any useful information. Review of the responses of the Survey of Snow Belt States from the other the Clear Roads Project indicated that the application rates of prewetted salt is generally 100 to 400 lbs/lane-mile. There are exceptions to this generality. There are some highway agencies that apply prewetted salt at the low rate of 50 lbs/lane mile and as high as 1000 lbs/lane-mile. The complete results of the survey can be seen in Appendix B to this report entitled "Material Types and Application Rate Range."

Task 2 – Review Electronic Data

An extensive review was conducted of three sources of RWIS data for the Alexandria ESS site. These three sources are: Mn/DOT's FRP site: ftp://rwis.dot.state.mn.us; Mn/DOT's RWIS site: http://rwis.dot.state.mn.us; and Dr. Kwon's site: ftp://tdrl.d.umn.edu/pub/rwis. Dr Kwon's FTP site is at Northland Advance Transportation Systems Research Laboratories on the University of Minnesota Duluth campus. Mn/DOT's FTP site (ftp://ftp.rwis.dot.state.mn.us) has archived data on RWIS, camera images, and SAIL II (The SAIL II system is no longer in place). The archived RWIS data from Mn/DOT's FTP site is in comma-delimited format. The various databases are archived for only 5 days.. The data from each site will be used during the pilot study. The video images from the camera at the ESS site are not being transmitted from the site. And the precipitation sensor is not reporting precipitation when it is occurring.

Mn/DOT has purchased and installed the traffic detector sensors at the ESS site. However, Mn/DOT has indicated that at this time the sensors are not able to communicate with ESS's RPU.

The Geonor T-200B series all weather precipitation gauge is located at a nearby truck station. This sensor monitors the liquid equivalent of precipitation and measures snow depth. The data is collected with a Campbell Scientific data logger and all the data are archived on the logger. Access to the database is by telnetting through Mn/DOT web portal web site. Address for the web portal is: hppt://webportal.dot.state.mn.us. The data from the Geonor T-200B series precipitation sensor are not available presently on Mn/DOT web portal site. It has been reported that Campbell data logger is logging the data but the communication port on the data logger is not functioning. Thus the data are not available for review.

Mn/DOT indicated that the Goodrich Ice Detection Camera may not be available for this winter season.

Mn/DOT has switched vendors for their Automated Vehicle Location (AVL) system and plans to increase the number of vehicles that will be using the system at their Alexandria Truck Station. They have purchased the GPS equipment but still have to locate an installer and negotiate a contract for the installation of the equipment. They hope to have the equipment installed sometime in January. They are going to use IWAPI as their new vendor. Reportedly the vendor will have an archive web site where the data collected from AVL can be retrieved. There is some question if the system will be able to monitor the spreader/controller. Mn/DOT has indicated that they are planning to develop the interface with the Dickey-John's Control Point spreader/controller.

Task 4 – Review MDSS

To fully understand the workings of the MDSS system, a member of the research team sat through a training session that was held at the Alexandria Truck Station on December 6, 2006. The training was led by John Mewes of Meridian (the company that produces the "Maintenance Action Recommendations"). Meridian has established a web site where the maintenance action recommendations and the action taken by maintenance operations are to be archived. This information will be archived for approximately one week and can be exported into an Excel

spread sheet. The weather conditions and road conditions used in reporting visible observations appears to be similar to the conditions that Mn/DOT is using in reporting their snow and ice control operations reporting. However, Mn/DOT is requesting that the roadway condition of "Black Ice" be added to the list of observed conditions. In addition, it was determined that Meridian uses only the pavement surface temperature data from the ESS site for maintenance action recommendations. It is not known which of the two roadways is used in the maintenance action recommendations.

When blowing snow is listed as a weather condition, MDSS has a challenge in making accurate "maintenance action recommendations." It is expected that this will improve during the winter. The Alexandria area contains slightly rolling terrain with a lot of blowing conditions. The range of application rates that are used by the MDSS model for the Alexandria highway segment is set for 200 to 500 lbs/lane-mile for prewetted salt and 200 to 700 lbs/lane-mile for a 50/50 mixture of sand and salt. The MDSS system uses an empirical formula with the ADT to estimate hourly traffic flow on the segment of highway. Finally, Meridian uses a fixed 1 hour and 20 minutes for the cycle time in their "maintenance action recommendations."

Mr. John Mewes has recommended that the evaluation phase of the Clear Roads Project begin in late winter (March) so that operators at Alexandria Truck Station become comfort with reporting their activities to MDSS and also using the system. This recommendation comes from his experience with working with maintenance operations people.

An issue was raised concerning the need for a separate "recommended maintenance action" for the east bound highway and one for the west bound highway at the Alexandria test site. The test site at Alexandria has a bituminous surface on the west bound roadway and a concrete surface on the east bound roadway. Both roadways have a concrete pavement sub-structure but the west bound roadway has a bituminous overlay. It is a known fact that bituminous roadway surfaces are normally considered warmer than concrete roadway surfaces when the sun shines on them. Since pavement temperatures are an important factor in the performance of chemicals on the roadway, it was thought that the MDSS maintenance action recommendations would need to be different for the two roadways. Therefore a pavement surface temperature comparison analysis was conducted between each of the two roadways.

A comparison analysis was carried out over a three day period where the various environmental conditions were fairly constant. The pavement surface temperatures for the west bound roadway and the east bound roadway, subsurface temperatures, and air temperatures were collected and tabulated. These data are displayed in Appendix C of this report. The subsurface temperature of the roadway varied between only 31 and 32 degrees F. so that this element would not have a strong influence on the surface temperature. The first day and half of the study there was heavy cloud cover and the air temperature only varied from 26 to 32 degrees F. During this period, the difference in surface temperature between the two roadways was less than 0.5 degrees F. except at high noon on the first day when the temperature difference got to 1.1 degrees F. On the second day in the early afternoon when the sun shone, the difference in temperature got as high 1.5 degrees F. Another interesting thing to note is the evening of the third day. Although the air temperature stayed above the pavement temperature in the evening, the bituminous surface cooled faster than the concrete surface and had a temperature difference of almost one degree F. due to the clear skies and reverse solar radiation,

The endothermic property of salt can be seen on December 22 at 4:00 am where the pavement temperature was lowered 1.5 degrees F. with salt going into solution.

Using the findings from this analysis along with the fact that MDSS is not making different maintenance recommendation for each of the roadway; the research team is recommended that during the Pilot Test, there will not be a separate analysis or comparison of chemical action on concrete surface and bituminous surface. We are asking the concurrence and approval of the panel on this recommendation.

Task 6 – Quarterly Report

This quarterly report constitutes the second of four reports to be issued for this project.

Task 7 – Conference Call

On December 18, a conference call was held with the Clear Roads Panel. The following people participated in the telephone conference call: Linda Taylor, Minnesota DOT; Curt Pape, Minnesota DOT; Dennis Burkheimer, Iowa DOT; Shane Larson, Illinois DOT; Thomas Martinelli, Wisconsin DOT; Kimberty Linsenmayer, CTC & Associates; and Edward J. Fleege, Consultant. The objectives and expectations of the project were reviewed and a report was made on the progress for Part 1, Evaluation Plan. Outstanding issues encountered on the project were discussed along with extending the time schedule for the project.

The progress of the project is enumerated in this quarterly report. The following outstanding issues encountered during this quarter were discussed during the conference call:

1. The video camera at the Alexandria ESS site is not reporting the images from the site.
2. The precipitation sensor at the ESS site is not reporting precipitation.
3. The Geonor T-200B Series Precipitation Sensor is collecting data but it is not able to communicate with the outside world.
4. Mn/DOT is replacing their Automated Vehicle Location (AVL) equipment with new equipment from the vendor, IWAPI. They have purchase the equipment but still have to develop a contract for the installation of the equipment into the snowplow trucks at Alexandria.
5. The traffic detector sensors have been installed but are not able to communicate with the ESS's RPU.
6. The range of application rate for prewetted salt and cycle time used in MDSS's maintenance action recommendations was questioned.

The plan of action that was agreed to by the participants of the conference call is:

1. Mn/DOT is to meet with Meridian to review the parameters that are used in the MDSS's maintenance action recommendations for the Alexandria Test Site, e.g., range of application rate for winter chemicals, cycle time, time from the end of a storm to the time of bare pavement,
2. A number of issues has prevented the research team from acquiring a though understanding of what data will be reported from various systems and not having access to all data from Alexandria Test Site, thereby, Part 2 – Pilot Test, can not be developed within the scheduled time frame of the project. Therefore, it was agreed to extend the completion date of the project to August 2008 in order to provide another winter to

conduct Part 2 – Pilot Test. It is expected that one or two events will be documented in March of 2007. This will provide an opportunity to de-bug the data collection process. Also it was determined that liability insurance will need to be carried by the Consultant not only through the original time schedule but also during the time extension. The liability insurance for the original time schedule is being funded from other project but there are no provisions to fund the insurance coverage during the time extension. As a result, the consultant will be compensated for the additional cost for the insurance during the time extension. Quarterly Reports will still be expected during periods of no activities. However, these quarterly reports can be one page report. The "Planned Schedule of Activities" and "Progress Schedule" will be revised to reflect the time extension after the contract has been extended.

3. On January 9, representatives from Mn/DOT, Meridian, and a member of the research team will be available to participate in telephone conference call with the Clear Roads Panel to discuss MDSS' maintenance action recommendations and its parameters and philosophy.

Section 4
Problems Encountered

The research team encountered a number of issues that has prevented the team from acquiring a though understanding of what data will be reported from various systems. Without this information it is not possible to develop an evaluation plan to test the proposed guidelines during the Pilot Test. The issues that have been identified are:

1. The video camera at the Alexandria ESS site is not reporting the images from the site.
2. The precipitation sensor at the ESS site is not reporting precipitation.
3. The Geonor T-200B Series Precipitation Sensor is collecting data but it is not able to communicate with the outside world.
4. Mn/DOT is replacing their Automated Vehicle Location (AVL) equipment with equipment from a new vendor, IWAPI. The new equipment has been purchased but a contract needs to be developed for the installation of the equipment into the snowplow trucks at Alexandria. We need to know what information and in what format will the data be archived by IWAPI.
5. The traffic detector sensors have been installed but are not able to communicate with the ESS's RPU.
6. The range of application rate for prewetted salt and cycle time used in MDSS's maintenance action recommendations was questioned and needs to be resolved.

As a result, it has been agreed that the project will be extended to include another winter in order to conduct Part 2 of the project.

Section 5
Activities Planned for the Next Quarter

During the next quarter, work on Part 1 will be completed. The main activities will be: follow-up on the progress being made on the installation and/or repair of the various systems by Mn/DOT; development of Evaluation Plan. Activities for Part 2 will begin with the development of the various collection forms and training the operators to use the forms and plan to captive data from one or two events in March.

The “Planned Schedule of Activities” and “Progress Schedule” will be revised to shown the new ending date of August 2008 after receiving a contract extension from WisDOT.

Appendix A

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Appendix B

State DOT	Material Types and Application Rate Range				
	Straight salt (lbs/lane-mile)	Other straight chemical (lbs/land-mile)	Straight sand/abrasive (lbs/lane mile)	Salt/sand or abrasive mix (lbs/lane-mile)	Amount of liquid chemical used for prewetting (gal/ton)
Alaska					
Arizona	50-300	50-300	500-3000	500-3000	5 to 7
California					
Colorado					
Connecticut	215			150	
Delaware	300-400				8 to 10
Idaho			500-550		5 to 7.5
Illinois					
Indiana	250				10
Iowa	80-400				17-24
Kansas	200-500			200-500	8 to 10
Kentucky	250-400				8
Maine	110-400			400-800	6 to 10
Maryland	300-1000				10
Massachusetts	240			300	8 to 10
Michigan	200-450				6 TO7
Minnesota	100-400			Variable	6 TO 10
Missouri	100-400			200-800	10 TO 15
Montana	≤200			850-2000	6
Nebraska	100-1000				10
Nevada	50-200			70-300	What looks good
New Hampshire	150-750			750	
New Jersey	350±				10
New Mexico					
New York	90-450			600-900	8 to 10
North Carolina	150-500	VARIES	200	50/50 500	
North Dakota	0-2000			10/90 TO 50/50	8 to 10
Ohio	50-600				8 to 10
Oklahoma					
Oregon	?		3/8*		5
Pennsylvania	250			250-1000	6 to 8
Rhode Island	200-500				20 to 30
South Dakota	Not known				
Tennessee	200-350	CMA***			10
Texas	None				
Utah					
Vermont	100-300				
Virginia	250-500			250	
Washington	50-250		60-800		15
West Virginia	100-450		750	50/50 450	
Wisconsin	100-400			200-600	4 to 10
Wyoming	100-200			500-1000	12 to 15
Washington DC	100-400				30 to 50**

Note: * = 3/8 cubic-yard/lane-mile

** = liquid brine application

*** = Unknown rate

Appendix C

Pavement Temperature Comparison Between Bituminous Surface and Concrete Surface

Date	Time	Pavement Temperature		Difference In Pavement Surface Temperature Between West and East Roadway (°F)	Subsurface Temperature (°F)	Air Temperature (°F)
		West Bound (Bituminous) (°F)	East Bound (Concrete) (°F)			
12/21/2006	16:00	29.8	29.1	0.7	31	28
	17:00	29.3	27.5	1.8	31	27
	18:00	29.1	28.4	0.7	31	27
	19:00	28.2	28.4	-0.2	31	28
	20:00	29.5	29.3	0.2	31	29
	21:00	30.0	29.8	0.2	31	29
	22:00	30.2	29.8	0.4	31	30
	23:00	30.4	30.0	0.4	31	29
12/22/2006	0:00	30.2	30.0	0.2	31	29
	1:00	30.2	30.0	0.2	31	29
	2:00	30.4	30.4	0.0	31	29
	3:00	30.4	30.2	0.2	31	29
	4:00	30.2	28.6	1.6	31	29
	5:00	29.8	30.0	-0.2	31	29
	6:00	30.0	30.2	-0.2	31	29
	7:00	30.2	30.4	-0.2	31	29
	8:00	30.4	30.4	0.0	31	29
	9:00	31.6	31.3	0.3	31	30
	10:00	33.3	32.9	0.4	31	30
	11:00	34.9	34.3	0.6	31	31
	12:00	35.8	34.9	0.9	31	31
	13:00	37.2	36.1	1.1	31	31
	14:00	36.1	35.4	0.7	31	31
	15:00	36.1	35.4	0.7	32	32
	16:00	34.7	34.3	0.4	32	31
	17:00	33.3	32.7	0.6	32	31
	18:00	32.9	32.2	0.7	32	31
	19:00	32.4	32.0	0.4	32	30
	20:00	32.4	31.8	0.6	32	30
	21:00	30.7	30.6	0.1	32	29
	22:00	30.6	30.4	0.2	32	29
	23:00	30.6	30.4	0.2	32	30
12/23/2006	0:00	29.3	29.3	0.0	32	29
	1:00	29.3	29.3	0.0	32	28
	2:00	28.9	28.9	0.0	32	27
	3:00	27.7	27.5	0.2	32	24
	4:00	27.1	27.1	0.0	32	24
	5:00	24.6	24.8	-0.2	32	24

Date	Time	Pavement Temperature		Difference In Pavement Surface Temperature Between West and East Roadway (°F)	Subsurface Temperature (°F)	Air Temperature (°F)
		West Bound (Bituminous) (°F)	East Bound (Concrete) (°F)			
12/23/2006	6:00	25.2	25.2	0.0	32	24
	7:00	25.9	25.9	0.0	32	25
	8:00	26.2	26.1	0.1	32	26
	9:00	27.5	27.3	0.2	32	26
	10:00	31.6	31.1	0.5	32	29
	11:00	34.2	33.4	0.8	32	29
	12:00	37.4	36.1	1.3	32	30
	13:00	42.1	40.6	1.5	32	33
	14:00	43.2	41.9	1.3	32	35
	15:00	40.5	40.8	-0.3	32	36
	16:00	35.8	36.0	-0.2	32	34
	17:00	31.6	32.0	-0.4	32	32
	18:00	30.0	29.8	0.2	32	31
	19:00	28.4	28.2	0.2	32	30
	20:00	27.5	27.1	0.4	32	29
	21:00	26.2	25.9	0.3	32	28
	22:00	25.5	25.7	-0.2	32	27
	23:00	24.6	24.6	0.0	32	26
12/24/2006	0:00	24.4	24.4	0.0	32	24
	1:00	23.4	23.4	0.0	32	24
	2:00	24.4	24.4	0.0	32	25
	3:00	22.6	22.6	0.0	32	24
	4:00	22.1	22.3	-0.2	32	24
	5:00	22.3	22.3	0.0	32	23
	6:00	22.8	22.6	0.2	32	24
	7:00	24.3	23.7	0.6	32	26
	8:00	25.0	24.8	0.2	31	27
	9:00	27.3	26.8	0.5	31	29
	10:00	30.7	30.4	0.3	31	30
	11:00	32.0	31.6	0.4	31	30
	12:00	37.4	36.5	0.9	31	32
	13:00	41.2	39.9	1.3	31	34
	14:00	40.3	39.4	0.9	31	35
	15:00	38.7	38.3	0.4	31	36
	16:00	35.1	35.2	-0.1	31	36
	17:00	32.0	32.5	-0.5	31	35
	18:00	30.6	31.5	-0.9	31	33
	19:00	28.4	29.3	-0.9	32	31
	20:00	27.5	28.2	-0.7	32	30