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ENGINEERING STANDARDS

Minnesota Department Of Transportation

MAINTENANCE STANDARDS

SNOW AND ICE COMMITTEE

REPORT ON

SNOW AND ICE FORMULA

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MAINTENANCE STANDARDS SNOW AND ICE COMMITTEE REPORT

on

SNOW AND ICE FORMULA

October, 1983

Report prepared by

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Reviewed and approved by the Snow and Ice Committee

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EXECUTIVE SUMMARY

Mn/DOT's Snow and Ice Formula was initially developed in the early 1970's in recognition of a need to standardize snow and ice operations and to control rising maintenance cost. Snow and Ice operations is the most important job confronting maintenance personnel during the winter season and it is a major budget item. The significance of the formula is that it is used to establish complement needs for the 15 Maintenance Areas. Because there have been numerous changes in personnel and equipment since 1970 the Snow and Ice Committee was requested to review the adequacy of the formula and update if needed.

The Snow and Ice Committee's approach was two-fold. First the Committee requested the Office of Research and Development to conduct a survey of the public to determine if we were providing the right level of snow and ice removal. Results of this questionnaire indicated that the driving public feels that Mn/DOT maintenance personnel are doing a very creditable, yet not extravagant, job in ice and snow control.

The Committee then reviewed the findings of the survey with the Commissioner's staff to establish a policy on Mn/DOT's level of service. As a result of the survey and staff comments, the policy guideline set for the Committee was that the level of service for snow and ice removal should be held at the current level or slightly below. The second part of the study was directed at studying the current formula factors and considering new ones which would result in maintaining the policy established above. In section four of the report each of the existing formula factors are identified and evaluated. Briefly the study and recommendations of the Committee were:

Classifications: Two alternatives were studied. The one recommended by the Committee added a new classification for ADT > 30,000 called Super Commuter. It was added to fit more realistically the level of service the higher volume routes were getting. The other alternative revised the primary and secondary classifications but it did not work out for the rural areas.

Truck Speed: An extensive truck speed study was conducted because of the significant change in equipment that has taken place since 1971. Results showed that on a state-wide basis the average speed was 18.75 mph. In further review, Area by Area it was

obvious to the Committee that the truck speed should not be the same for all classifications. A metro weighed average came to 15.51 mph and a rural weighed average came to 19.1 mph. Therefore it was decided to use 15 mph for Super Commuter and Urban Commuter and 19 mph for the rest.

Cycle Times: The cycle times were evaluated against what was actually occurring in the field operation and significant reductions are recommended. This does not mean an increase in level of service but only addresses what we currently were doing, which was better than the current formula cycle times.

Interchange Factors: Significant study went into the development of this factor. An interchange plowing speed study conducted by the committee involved the evaluation of 38 interchange speed checks. An average speed of 13 mph for plowing all types of interchanges was established. The Committee also recommended that the cycle time for interchanges equal that of the mainline to realistically relate to what was the practice in the field. Therefore the factor changes were significant.

Coverage Time: This factor closely relates to the level of service so no changes were recommended. A coverage time of 24 hours was recommended for the super commuter.

Workers per Truck: A 12 hour shift was used to maintain the recommended coverage hours. As a result the only part of this factor not lowered was the rural commuter. The Super Commuter factor was set at 2.2 to address the need of a wing man in the truck on these very high volume routes.

Spare Truck Allotment: The Committee noted we are getting much better performance from the diesel fleet and therefore recommended a reduction to address this. The factor was 7% or a min. of 4. It is recommended that it be 5% or a min. of 3.

Intermittent Foreman: The formula provided for a certain number of intermittent foremen depending on the percent urban commuter within a subarea. However, in Areas other than the Metro Areas the intermittent drives a snow plow truck while acting as foreman. To more realistically address this field practice, the number allowed was reduced.

Level of Service: Based on the policy established to maintain the current level of service was not changed. For the new Super Commuter classification the level of service will be the same as the urban commuter.

Section Five of the report reviews the new factors considered for the formula. These included Absenteeism, Winter ADT, and Functional Classification. The concept of Absenteeism addressed a need in the formula. Staffing reductions have made it hard to cover the normal absenteeism rate of employees found to average about 9.4%. Some auxiliary help is available such as technicians from Construction and Design but they are not always where they are needed. The disadvantage of supplemental help is that they are not nearly as efficient as the trained maintenance worker. With these considerations in mind the Committee decided to use a factor of 4%.

The concept of using Winter ADT instead of the Traffic Flow Map proved to be difficult to get accurate information. The use of the functional classification system had the interest of the Committee but because of the significant amount of work completed in the classifications already the Committee decided to take this under consideration in the future.

Table 5 on page 22 provides a summary and comparison of all the proposed and current formula factors.

Table 7 on page 25 provides a comparision between the computer results of applying all the new factors into the Formula with the actual staffing of both Trucks and Workers for each Maintenance Area.

The Committee feels that the recommended formula best represents what is actually being done out in the field and therefore, recommends its adoption. Changes in staffing between Areas should be worked out by attrition and equipment moved on an as needed basis.

The report concludes with a look into the future. The Committee expresses two concerns. The first is a need to address efficiency improvements because of the impact this has on the formula. The second is the future staffing requirements based on the new roadway openings coming in the next several years. The tabulations provided in the future section of the report shows the dramatic changes in efficiency made over the last 12 years. These improvements created a disparity between the current formula and the complement level. This disparity is a real credit to Mn/DOT employees, but it points out the need to have a formula which can be continually adjusted to stay viable. The Snow and Ice Committee will study this problem in an effort to provide guidelines by July, 1984.

Future staffing needs were also determined based on data submitted by each Area. Tables 8, 9, and 10 provide the staffing needs for 1983 - 84, 84 - 85 and 85 - 86 winters. These totals are 1496, 1504, and 1532 respectively. This growth in staffing needs is significant.

In the long range outlook, the basic roadway system after the decade of the 80's will be significantly complete. Mn/DOT Snow and Ice needs should nearly stabilize except for fluctuations as a result of changes in traffic volume. The Committee therefore, will begin studying the future needs to 1990 based on the projected openings using the Highway Work Program as a guide.

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I. INTRODUCTION

Mn/DOT's Snow & Ice Formula was initially developed in the early 1970's in recognition of a need to standardize statewide snow and ice operations and to control rising maintenance costs. Since that time, the formula has not changed significantly. The various factors within the formula have been adjusted to address personnel cutbacks, but basically no indepth study of the formula factors has been made since its development in 1970.

In application, the formula was initially used more as a tool to standarize the level of service statewide and not to set staffing and equipment needs, however; in recent years this has changed. The formula is now accepted as a management tool for distributing both men and equipment to the fifteen maintenance areas to meet the snow and ice operational needs.

Snow and Ice operations is the most important job confronting maintenance personnel during the winter season and it is a significant budget item. It also determines our minimum acceptable staffing level. Additional staffing needs for summer projects is met by temporary help.

Because of the significant role the formula now has in establishing complement there was concern about its need to be updated. For that reason, the Snow & Ice Committee was requested to review and update the formula if needed.

The Snow & Ice Committee's approach to the study was two-fold. First, an initial position had to be established as to whether we were providing the right level of service (snow and ice removal) to the public.

The answer to this question was achieved by requesting the assistance of the Office of Research and Development to do a public opinion survey. Results of this survey were reviewed with Mn/DOT's top staff to establish the initial assumption of the accuracy of Mn/DOT's level of service. Once this relationship between the public's needs and what we should provide was established, our level of service was basically defined. The Committee then had a better understanding of how to approach the study in the individual formula factors which became the second part of the study.

The snow and ice formula has many different factors within it. Definitions of each of these factors are provided in Appendix A of this report. For those unfamiliar with the formula, it is recommended that you review the definitions before reading the rest of the report.

The Snow and Ice Committee studied each of the factors of the existing formula in depth to determine its appropriateness within the formula. This included an elaborate study to determine our current truck speeds. Every employee within Mn/DOT's Snow & Ice complement had an opportunity to provide data for the truck speed study, which lasted for about a four month period. In addition to the truck speed study, which applied to mainline plowing, the committee took on a study of interchange plowing. Each committee member selected several interchange types and collected plowing time data throughout the winter season. The Committee also considered several new factors currently not in the formula to assure that the formula does address exactly what is being done out in the field.

The rest of this report gives the results of this year long study. It provides documentation of all the formula variables and presents a new formula recommendation based on the committee's findings.

II. HISTORY OF SNOW AND ICE FORMULA

Mn/DOT has divided the State up into fifteen maintenance areas. A map that identifies this division is provided in Appendix B of this report.

The staffing for these fifteen areas is based primarily on staffing requirements for snow and ice removal. Winter is considered the lowest staffing time period. For summer activities, staffing needs are supplemented with part-time help.

Since 1971, Mn/DOT has been using a Snow and Ice Staffing Formula to assist in establishing the staffing levels. The general benefit from the formula is that it provides a way to equalize the level of service throughout the 15 maintenance areas. Initially, the formulas most significant contribution was the establishment of a set of guidelines to standardize the level of snow removal service given on State highways. Now the formula also plays a major role in the distribution of complement. The current formula guidelines are provided in Appendix C.

The graph on page 4 shows an overview of Snow & Ice compelment since 1971. As can be noted on the graph, complement has dropped significantly since it peaked in 1975. Modifications were made to the Formula to address these reductions but no indepth study was made at the time of the change.

Without changing the 1971 Formula the needs for 1983 would have been 894 trucks and 2014 workers. The last modification of the formula gave the 1983 needs as 815 trucks and 1674 workers. But currently today, Mn/DOT has only 794 trucks and 1497 workers available for Snow and Ice Operations.

As noted from above the complement level has dropped significantly below formula. At the same time, however, formula needs have gone up because of the additional freeway lane miles added to the system since 1971 and because of traffic volume increases requiring a better level of service. This disparity between the current complement and the formula is one of the reasons for this study. If we are able to operate so far below formula and still give an acceptable level of service then the formula must be no longer accurate.

The reason this disparity exists is a credit to Mn/DOT employees. Although cuts in workers has been generally mandated by the Legislature, Mn/DOT has been able to provide a better level of service because of the increased productivity of it's employees, and the use of more efficient equipment.

SNOW & ICE COMPLEMENT



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III. INITIAL POSITION

The objective of the Committee was to assure that the truck fleet and complement level is adequate to provide an appropriate level of service for the traveling public. Before work could be done on the formula, public opinion on the level of service we were currently providing had to be determined. In other words, the committee felt the formula ought to reflect the level of service desired by the public. Therefore, the Office of Research and Development was asked to do an independent survey to determine the driving public's opinion of the adequacy of Mn/DOT's snow and ice operations. Once the public opinion was established, it was also necessary to determine if the level of service requested by the public was achievable and acceptable to Mn/DOT. This was accomplished by reviewing the results with the Commissioner and his staff.

A. Public Opinion Poll

The Office of Research and Development assisted the Committee in surveying public opinion. It was felt this would minimize any prejudices involved if the committee did the survey.

The questionaire developed by that Office was similar to one used in a multi-state study done several years ago, known as the Utah Study. A copy of the questionaire is provided in Appendix D. The questionaires were distributed at driver license examining stations to licensed drivers accompanying examinees. A total of 1,730 questionaires were returned. The results indicated the following:

- Our current level of maintenance effort is quite satisfactory. Using a scale on which 3.0 equals satisfactory and 5.0 equals excellent, we were rated 3.73 on the freeways and 3.45 on trunk highways. More than 90 percent of the respondents felt we were doing a satisfactory job.
- The mean rating on the amount of plowing we do was 1.95 based on 2.0 equals satisfactory. Thus, in the opinion of the public, the amount of plowing we do should not be decreased.
- About 30 percent of the questionaires expressed the opinion that we are using too much salt. This is probably because of the reputation salt has gained in regard to its effect on the environment and causing corrosion.

- The public does not object to paying the \$6.00 per vehicle currently being spent on ice and snow control by Mn/DOT. In fact, slightly more people favor raising cost than favor decreasing costs.

Statewide data are shown in Table 1 and results for the Minneapolis-St. Paul Metro and Rural Minnesota are given in Tables 2 and 3. These results are both very similar to the state wide data. The maintenance effort on freeways and trunk highways in the metro area were rated slightly higher.

The mean ratings on a maintenance-area basis are given in Table 4, along with the rural, urban and statewide means. In general, there was good agreement between maintenance areas. Because of the small sample sizes in Maintenance Areas 2A and 2B we cannot be confident that the values accurately represent the opinion of the entire driving public in those two Areas. Also, the values in Table 4 may not have a relationship to the level of service in any particular Maintenance Area. They only reflect the overall views of the people who reside in the Area. In other words the people polled may have expressed an opinion on Interstate Highways, but some Areas do not have Interstate Highways within their boundaries.

An analysis was made to determine any relationship between driver's opinion and classification of license (A, B or C), age of driver, and miles driven annually; no significant relationships were found.

A smaller number of questionaires (169 respondents) were distributed at several rest areas. These results agreed very well with those of the larger survey.

In summary, the analysis indicates that the driving public feels that Mn/DOT maintenance personnel are doing a very creditable, yet not extravagant, job in ice and snow control.

B. Commissioners Staff Comments

The results of the public opinion survey were reviewed with the Commissioner's Staff to gather their input and direction in establishing a policy on Mn/DOT's level of service.

Based on the discussion with the Staff, the policy direction the Committee decided to follow in the study of the Snow & Ice Formula was that the level of service for snow and ice removal should be held at the current level or slightly below. Considering the high percent of satisfaction with the level of service currently provided there appears to be no justification to consider either increase or decrease the level of service to any extent.

Opinion of	Percent of Responses						
Maintenance	Freeways	Trunk Highways	County Roads	City Streets			
Excellent	26.1	13.9	9.4	7.3			
	26.8	27.0	13.1	12.7 second			
Satisfactory	42.7	51.3	42.4	42.7			
	2.8	5.5	21.6	18.8			
Poor	1.5	2.3	16.7	18.5			
Mean Rating*	3.73	3.45	2.86	2.72			

*5 = Excellent, 3 = Satisfactory, 1 = Poor

Opinion of	Percent of Responses					
Amount of	Too Little	Satisfactory	Too Much	Mean Rating**		
Plowing	9.5	86.2	4.3	1.95		
Sanding and Salting	9.7	61.0	29.3	2.20		

**3 = Too Much; 2 = Satisfactory; 1 = Too Little

Suggested Cost Per Registered Vehicle Per Year

Amount	\$0.00	\$3.00	\$6.00***	\$9.00	\$12.00
Percent of Responses	1.6	9.1	67.1	19.9	2.3
Mean Value	\$6.37				

***Current Amount Spent per vehicle

Table 2. Results of ice and snow control questionnaire - metro.

Opinion of	Percent of Responses						
Maintenance	Freeways	Trunk Highways	County Roads	City Streets			
Excellent	<mark>2</mark> 9.5	15.8	7.8	8.1			
	29.5	30.1	17.1	10.8			
Satisfactory	36.0	46.7	42.8	34.2			
	3.3	5.8	19.7	23.4			
Poor	1.7	1.5	12.7	23.4			
Mean Rating*	3.82	3.53	2.87	2.57			

*5 = Excellent; 3 = Satisfactory, 1 = Poor

Opinion of		Percent o	f Responses	
Amount of	Too Little	Satisfactory	Too Much	Mean Rating**
Plowing	11.1	86.0	2.9	1.92
Sanding and Salting	9.7	62.9	27.4	2.18

**3 = Too Much; 2 = Satisfactory; 1 = Too Little

Suggested Cost Per Registered Vehicle Per Year

Amount	\$0.00	\$3.00	\$6.00	\$9.00	\$12.00
Percent of Responses	2.2	7.5	67.9	20.3	2.2
Mean Value	\$6.38				

Table 3.	Results of ice an	nd snow control	questionnaire - rural.
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Oninion of		Percent of Responses					
Maintenance	Freeways	Trunk Highways	County Roads	City Streets			
Excellent	23.6	12.5	10.5	6.8			
	24.9	24.8	10.4	14.0			
Satisfactory	47.5	54.6	42.1	48.6			
	2.5	5.3	22.9	15.6			
Poor	1.4	2.8	19.5	15.0			
Mean Rating*	3.68	3.39	2.86	2.82			

*5 = Excellent; 3 = Satisfactory; 1 = Poor

Opinion of		Percent o	of Responses	and the second
Amount of	Too Little	Satisfactory	Too Much	Mean Rating**
Plowing	8.3	86.3	5.4	1.97
Sanding and Salting	9.7	59.6	30.6	2.21

**3 = Too Much; 2 = Satisfactory; 1 = Too Little

Suggested Cost Per Registered Vehicle Per Year

Amount	\$0.00	\$3.00	\$6.00	\$9.00	\$12.00	
Percent of Responses	1.2	-10.1	66.5	19.7	2.5	
Mean Value	\$6.37					

	Mean Rating, Winter Maintenance $\operatorname{Effort}^{(1)}$			Opinion on A	Amount of	Suggested Annual		
Maintenance	Sample	Interstate	State	County	City	Plowing(2)	Sanding &	Cost Per Vehicle,
Area	Size	Freeways	Highways	Roads	Streets		Salting(2)	Dollars(3)
1A	80	3.64	$\begin{array}{c} 3.16\\ 3.38\end{array}$	2.35	2.63	1.89	2.33	6.34
1B	72	3.85		2.81	2.77	2.01	2.30	5.95
2A	23	3.84	3.47	2.83	2.72	2.00	2.21	5.71
2B	9	4.11	3.66	3.11	2.33	1.77	2.55	5.66
3A	80	3.64	3.33	2.39	2.85	1.98	2.13	6.18
3B	154	3.70	3.40	2.29	2.72	1.92	2.09	6.31
4A	46	3.84	$\begin{array}{c} 3.34\\ 3.41\end{array}$	2.63	2.55	2.00	2.26	5.80
4B	60	3.79		2.70	3.04	2.01	2.30	6.25
5	395	3.81	3.56	2.91	2.62	1.93	2.19	6.36
6A 6B	67 152	3.52 3.66	$\begin{array}{c} 3.41\\ 3.40\end{array}$	2.68 2.70	2.75 2.72	2.00 1.97	$\begin{array}{c} 2.22\\ 2.15\end{array}$	6.17 6.50
7A	$100 \\ 42$	3.71	3.43	2.69	2.79	1.91	2.26	6.33
7B		3.71	3.23	2.64	2.73	1.95	2.12	6.85
8	194	3.62	3.33	2.58	2.93	1.87	2.17	6.48
9	256	3.80	3.46	2.82	2.47	1.88	2.15	6.42
Rural	1,079	3.82	3.39	2.86	2.82	1.97	2.21	6.37
Urban	651	3.82	3.53	2.87	2.57	1.92	2.18	6.38
Statewide	1,730	3.73	3.45	2.86	2.72	1.95	2.20	6.37

Table 4. Mean values from ice and snow control questionnaire.

(1) 5 = Excellent
 3 = Satisfactory
 1 = Poor

(3) Current Cost

(2) 3 = Too Much 2 = Satisfactory 1 = Too Little

is \$6.00

IV. STUDY OF FORMULA FACTORS

With the policy for the level of service established, the review of the formula factors was conducted with an emphasis on what actually was being done out in the field. If we are to hold the level of service at what it is or slightly below, the factors established at the current level would give appropriate guidelines to meet this policy. Since there has been a lot of changes in equipment and procedures since the first formula was developed, the Committee felt it desirable to look at each of the formula factors individually before addressing the combined effect they would have on each of the Maintenance Areas.

The Committee looked at the existing formula factors as well as some new ones which might better define what is actually done in Snow and Ice Operations.

A. Classification and Lane Miles

Presently the trunk highway system is divided into four classifications according to traffic volumes as shown in the table below:

Classification	ADT		
Urban Commuter	Over 10,000		
Rural Commuter	2,000 - 10,000		
Primary	800 - 2,000		
Secondary	0 - 800		

Each of these classifications has an assigned level of service, coverage time and cycle time. It was therefore, difficult to study this independently. Also, for each change in classification, the Maintenance Areas would have to provide the Committee with the number of lane miles within that classification. This would involve a significant amount of effort and was time consuming. Two alternates were selected for detail study:

Classification	Alternate 1	Alternate 2
Super Commuter	Over 30,000 ADT	30,000 ADT
Urban Commuter	10,000 - 30,000 ADT	10,000 - 30,000 ADT
Rural Commuter	2,000 - 10,000 ADT	2,000 - 10,000 ADT
Primary	800 - 2,000 ADT	1,000 - 2,000 ADT
Secondary	<800 ADT	<1,000 ADT

Each Maintenance Area was requested to turn in their lane mile totals for the two alternatives along with the number of interchanges. Lane miles are defined in Appendix A. Only roadway lane miles are included in the totals. Such items as plowing frontage roads, crossovers, rest areas, turn lanes and driver training centers, etc. are not included in the lane mile totals. These items are generally done during the plowing cycles and are reflected in the truck speeds.

The two alternatives were then evaluated with all other factors involved. Alternate 2 had too much of an impact on the rural districts because of significant number of lane miles dropped into the secondary classification. Such an impact would have reduced the level of service below the policy established. The addition of the super commuter classification was done to fit more realistically the level of service the higher volume routes were getting. The accident potential and traffic delays warranted this additional emphasis.

B. Truck Speed Study

The truck speed is a significant factor in the Snow and Ice Formula. The committee failed to find any past documentation on how the current 15 mph truck speed was originally determined. The truck fleet has also changed significantly since that speed was selected. Mn/DOT was a 100% gas engine fleet at that time and now it is a 100% diesel engine fleet. Therefore, it was decided to conduct a study to evaluate the speeds.

A truck speed evaluation form was developed. This form was designed so it could be handed out to each driver at the start of his day on snow and ice removal operations. See Appenix E. for an example of the card and instructions. Approximately 3,000 cards were printed.

Mn/DOT has 794 snow plow trucks. The goal was to get information from one shift operating in three different storms between Dec. 15, 1982 and April 1st, 1983, from as many of the truck drivers as possible.

Some of the areas found it difficult to come up with the cards for three separate storms because the weather did not cooperate. In addition, some cards were completed incorrectly and could not be used. A total of approximately 1135 valid cards were returned. The number of cards per Maintenance Area were as follows:

Maintenance Area	Cards Returned
1A	51
1B	41
2A	16
2B	18
3A	60
3B	81
4A	69
4B	53
5	202
6A	112
6 B	108
7A	74
7B	45
8	139
9	66

The results from the completed forms were entered into the computer and "Truck Speed" was determined. "Truck Speed" is defined in Appendix A. The speed is low because the computation includes time for other activities other than actual plowing.

On a statewide basis the average speed was 18.75 mph. In further review, Area by Area, it was obvious to the Committee that the truck speed should not be the same for all classifications. A metro weighed average came to 15.51 mph and a rural weighed average came to 19.1 mph. Therefore it was decided to use 15 mph for super commuter and urban commuter and 19 mph for rural commuter, primary, and secondary classifications.

C. Cycle Times

Cycle time is closely tied to the truck speed and length of route since it is the period of time it takes to make one complete pass of a snow plow route. The new truck speed data was applied to the route lengths of each classification to come up with cycle times actually being accomplished out in the field. Random routes were selected from each classification and the lengths were determined. A significant number of routes were found for each classification except that of super-commuter. Cycle times were computed by dividing the lengths by the appropriate truck speed. Results of these calculations were:

	Cycle Times (hrs.)		
Classification	Now	Prop.	
Super Commuter	N/A	1.2	
Urban Commuter	2.1	1.5	
Rural Commuter	3.2	2.1	
Primary	4.5	4.0	
Secondary	6.0	5.0	

The concern the Committee had when evaluating the results of these computations was the significant difference between the present and proposed cycle times. (A decrease in cycle time represents an increase in the level of service) the computed cycle times show that Mn/DOT is providing a better level of service than the current formula required. However, the proposed cycle times reflect the true level of service Mn/DOT currently provides and therefore, in accordance with the policy of not changing the current level of service the proposed cycle times are more appropriate.

D. Miles Per Truck

The truck speed times the cycle time provides the length of route for a truck. This is not a formula factor itself but a combination of two of them which gives information on the length of routes for each classification. By classification a truck can cover:

	Route Length (Miles)		
Classification	Now	Proposed	
Super Commuter	N/A	18	
Urban Commuter	31.5	22.5	
Rural Commuter	48.0	39.9	
Primary	67.5	76.0	
Secondary	90.0	95.0	

E. Interchange Factors

Current interchange factors were originally developed using cycle times equal to 1-1/2 times the cycle for the adjacent mainline. Through the years, the factors were slightly adjusted to meet personnel cut backs. Currently they are:

	Interchanges/Truck
Urban Commuter Simple:	2.1
Urban Commuter Complex:	1.6
Rural Commuter Simple:	4.2
Rural Commuter Complex:	2.6

The Committee felt strongly that the cycle time should equal the adjacent mainline to realistically relate to what was the practice in the field.

In order to come up with new factors using the appropriate mainline cycle time, an interchange plowing speed had to be determined. No data was readily available from any previous study so each committee member volunteered to collect as much data as possible on several different types of interchanges during the winter of 1982-83.

A total of 38 interchange runs were made through the course of the winter. The results were as follows:

Interchange Type	Average Length	Average Speed
Diamond	2.5	14.2
Folded diamond	2.5	11.3
Cloverleaf	5.0	13.6

Using a factor of down time (meals, coffee breaks, changing plow blades etc.) determined to be approximately one mph through data collected in the truck speed study, it was agreed to use 13 mph on the speed for plowing all types of interchanges. In addition it was agreed that mileage for all simple interchanges would be 2.5 lane miles and complex interchanges would all be considered 5.0 lane miles.

The following computations are for the interchange factors.

- The number of simple interchanges covered per hour:

$$\frac{13 \text{ mph}}{2.5 \text{ miles}} = 5.2$$

- The number of complex interchanges covered per hour is:

 $\frac{13 \text{ mph}}{5 \text{ miles}} = 2.6$

- The interchange factors are established by multiplying the above values by the established cycle time for each of the mainline classifications.

Super Commuter Complex:	$2.6 \times 1.2 = 3.1$	Interchanges
Super Commuter Simple:	$5.2 \ge 1.2 = 6.2$	Truck
Urban Commuter Complex:	$2.6 \ge 1.5 = 3.9$,,
Urban Commuter Simple:	$5.2 \ge 1.5 = 7.8$,,
Rural Commuter Complex:	2.6 x 2.1 = 5.5	,,
Rural Commuter Simple:	5.2 x 2.1 = 10.9	• • • •

F. Coverage Times

Coverage time is closely related to the level of service. It is not a factor in the formula itself but it does affect the relationship of workers needed. The coverage time is the suggested number of hours per day trucks should be on the road in an attempt to maintain the level of service. Because of the Department position not to increase the level of service; and the Committee's opinion that the hours are realistic to what is practiced in the field; the coverage hours remain the same. The coverage time for super commuter was set at 24 hours.

Coverage Tin	mes
Super Commuter	24 hours
Urban Commuter	24 hours
Rural Commuter	20 hours
Primary	18 hours
Secondary	12 hours

G. Workers Per Truck

In order to provide efficient service on the trunk highway system, most trucks used for snow plowing and winging, sanding, or spreading chemicals will be operated by one person except when conditions exist requiring the use of a second person in the cab. Using this policy and a two twelve hour shift operation the workers per truck factor can be worked out. The Committee revised the existing factors to more realistically relate to field operations. The factors are as follows:

ADT	Coverage Time	Factor	Existing Factor
Super Commuter	24 hrs.	2.2	N.A.
Urban Commuter	24 hrs.	2	2.5
Rural Commuter	20 hrs.	2	2.0
Primary	18 hrs.	1.5	2.0
Secondary	12 hrs.	1.0	1.5

The super commuter factor of 2.2 was set to address the need to have a wing man in the truck in the very high volume areas. This man is needed to insure safe plowing operations such as making sure the wing does not drop on top of a vehicle when being lowered or hit channelized islands when down. It was determined that a wing man was being used in only about 10 percent of the truck fleet operating in this classification.

H. Spare Trucks

The formula determines the number of trucks required to cover the lane miles within each area, however, it does not account for break-downs of these units. Therefore, a spare truck allotment was provided to be sure each Area has a sufficient number of snow plows. This allotment prior to the winter of 1979-80 was set at 10% of the total or a minimum of 4, which ever is greater. In the winter of 1979-80, this was reduced to 7% of total or a minimum of 4. Because we are getting better performance from the newer diesel engine trucks, the Committee felt that the spare allotment could be reduced to 5% of the total or a minimum of 3.

I. Foreman

Currently, one intermittent foreman is allowed for each sub area that has between 1% and 30% their lane miles in the urban commuter classification and two intermittent foreman are allowed each sub area that has 30% or more urban commuter lane miles. By this procedure, snow and ice complement required another 69 positions.

In reality, the Maintenance Areas were not operating this way. In subareas having less than 30% urban commuter when an intermittent foreman was used that individual usually drives a snow plow truck. In subareas having more than 30% urban commuter only one intermittent foreman was found to be necessary. Therefore, it was felt that the current method provided too many people. To better balance this, the Committee recommends using the following guideline: One intermittent foreman is allowed for each sub-area that has 30% or more urban commuter lane miles. With this, method 25 complement positions are added.

It should be noted that this method of counting intermittent foremen in no way limits the number of intermittent foremen an Area can use. The method is used only to determine the complement needed for Snow and Ice Operations.

J. Level of Service

Based on the policy established to maintain the current level of service the written description of the service levels were not changed.

The new Super Commuter classification is to be maintained at the same level of service that urban commuter receives. The following then is recommended to continue as is:

Classification	Level of Service
Super Commuter	All lanes will have substantially bare pavement before coverage time is reduced.
Urban Commuter	All lanes will have substantially bare pavement before coverage time is reduced.
Rural Commuter	The right lane on divided roadways and both lanes on two lane roads will have bare wheel paths with intermittent bare pavement before coverage time is reduced. The left lane on divided roadways will have intermittent bare wheel paths with sanded hills and curves.
Primary	Both lanes will have intermittent bare wheel paths with sanded hills and curves before coverage time is reduced.
Secondary	One wheel path in each lane will have intermittent bare pavement with sanded hills and curves before coverage time is reduced

V. OTHER FACTORS CONSIDERED FOR THE FORMULA

Several new items were discussed for inclusion in the formula to assure that the formula actually addressed what is being done out in the field. Considered was Absenteeism, Winter ADT, and Functional Classifications. In review of the three, Absenteeism addressed a need in the formula.

A. Absenteeism

Staffing reductions have made it hard to cover the normal absenteeism rate of employees. Generally auxiliary help is available in the Area Headquarters such as technicians from construction or design to supplement when help is needed but few are available at the truck stations. The disadvantage of supplemental help is that these individuals are not near as efficient as the trained maintenance worker in the snow and ice operations.

The Committee reviewed this issue by collecting data on two winter storms. Data was received from Districts 1A, 3B, 5, 6A, 6B, 7A, and 8. The average absenteeism rate was 9.4%.

Because some help is available the Committee felt that using the entire 9.4% was not realistic. A factor of 4% was agreed to. That is, 4% of the total workers computed by formula before the intermittent foreman numbers were added.

B. Winter ADT

Lane miles are divided up into each classification by use of the most current traffic flow map. Volumes on that map are "Average Annual Daily Traffic Volumes" which do not necessarily reflect the volumes during the winter time. Therefore, it is possible some roadways get a better level of service than needed because they carry a higher traffic volume in the summer. To correct this, the possibility of using Winter ADT was studied.

The problem found was that Winter ADT adjustment factors are not readily available. These factors are based on Automatic Traffic Recorder (ATR) reports and would only be an assumption on roadways that didn't have an ATR on them. The adjustment would more than likely have to be averaged over a six month period or perhaps be regional in nature.

After appraisal of the problems involved, the Committee decided to continue with the flow map procedure.

C. Functional Classification

The Snow and Ice Formula classifications is a system established only in Maintenance

for use within the formula based on traffic volume ranges. The system does not relate to Mn/DOT's TIS functional classification system. The TIS System takes into account the significance of the roadway as well as the volume on that roadway.

The TIS categories are Interstate, Principal Arterial, Minor Arterial, Major Collector, Minor Collector, and Local. The Committee met with staff involved with TIS for disucssion on the feasibility of changing to that system. The advantage of the TIS system is that everything is computerized.

The Committee recognized the potential of the system and several members are reviewing the feasibility of using it. It was decided not to include this in the scope of the formula study at the present time because of the amount of work already completed. The Committee will follow up on this issue.

VI. APPLICATION OF NEW FORMULA

The results of the individual studies on each factor are summarized below:

NEW FORMULA FACTORS

Spare Trucks = 5% with minimum of 3

Absenteesim = 4%

Intermittent Foremen = 1/sub-Area with 30% M.C. and S.C. Lane Miles

		Trucks/In	terchange		
Class	Cycle Time	Complex	Simple	Workers/Truck	Truck Speed (MPH)
Super Commuter	1.2	3.1	6.2	2.2	15
Urban Commuter	1.5	3.9	7.8	2.0	15
Rural Commuter	2.1	5.5	10.9	2.0	19
Primary	4.0		-	1.5	19
Secondary	5.0			1.0	19

Table 5 provides a comparison of the Committee recommendations to the currently used formula factors. As can be seen, there are some significant changes.

Each Maintenance Area provided their lane miles for the 1983-84 winter by the ADT Classifications and the number of interchanges within each of the classifications. This data is provided in Appendix F. Applying this data in both the current formula and the proposed formula, as demonstrated in Appendix C, provided the results presented in Table 6.

The difference in staffing needs illustrated in Table 6 must be clarified. The current formula was adjusted for complement needs in 1981 by arbitrarily reducing the complement results by a uniform percent but the formula was never adjusted. Since 1981, there have also been a number of cuts which were not directly addressed by the formula. Mn/DOT never did staff to the current formula level. However, the current formula was the reference point and all Maintenance Areas were "under formula".

The Committee's policy of maintaining the current level of service required that no significant change in man-power and trucks be made. The total compelment and number of trucks should remain similar in both the rural and metro area. This was accomplished by the new formula. Table 7 provides a comparison of the number of trucks proposed in the

SNOW AND ICE FORMULA FACTORS

COMPARISON OF CURRENT WITH PROPOSED

		-						INTER	RCHANG	ES/TRUC	к		
CLA	ss	SPEED	- MPH	CYCL	ETIME	MILES	TRUCK	COMP	LEX	SIMPL	E	WORKE	RS/TRUCK
Now	Prop.	Now	Prop.	Now	Prop.	Now	Prop.	Now	Prop.	Now	Prop.	Now	Prop.
	>30,000	N/A	15	N/A	1.2	N/A	18	N/A	3.1	N/A	6.2	N/A	2.2
>10,000	10,000 -30,000	15	15	2.1	<mark>1.5</mark>	31.5	22.5	1.6	3.9	2.1	7.8	2.5	2.0
2,000 - 10,000	2,000 - 10,000	15	19	3.2	2.1	48.0	39.9	2.6	5.5	4.2	10.9	2.0	2.0
800 - 2,000	800 - 2,000	15	19	4.5	4.0	67.5	76.0					2.0	1.5
0 - 800	0 - 800	15	19	6.0	5.0	90.0	95.0					1.5	1.0

SPARE TR	UCKS	ABSEN	NTEEISM		INTERMITTENT	FOREMEN
Now	Prop.	Now	Prop.	Now		Prop.
7% Min. = 4	5% Min. = 3	0%	4%	1/S.A 2/S.A	1% and 30% urban mileage	1/S.A 30% urban mileage

			Current	Formula	Propose	d Formula	
	Maintenance Area	Lane Miles	Trucks	Workers	Trucks	Workers	
	1A 1B	1,903.65 1,742.13	55 37	112 68	50 38	93 66	
A CONTRACT	2A 2B	1,741.46 2,184.00	31 37	50 64	20 36	42 53	
	3A 3B	1,745.55 1,963.62	36 56	63 117	36 56	61 106	
	4A 4B	2,016.32 1,684.50	.44 32	81 55	44 30	78 47	
	5	1,885.60	127	315	116	252	
	6A 6B	$1,\!956.84$ $1,\!676.24$	52 59	105 126	50 52	94 100	
	7A 7B	1,595.00 1,750.00	46 46	72 86	43 43	69 79	LANZ.
	8	2,939.70	56	102	58	104	
	9	1,944.50	135	333			
	Totals	28,729.11	842	1,749	792	1,496	

SUMMARY FOR WINTER OF 1983 - 84

Difference: 50 Trucks & 253 Positions

new formula as compared to the current number assigned each maintenance area. The same is provided for complement.

The Committee feels that the recommended formula best represents what is actually being done out in the field and therefore, recommends its adoption into practice.

Transition from the old to the new should be worked out on an as needed basis in reference to the equipment. The Committee recommends that Curt Christie as State Maintenance Engineer be delegated the responsibility of adjusting the trucks within the formula quotas as needs arise. Also, the Committee recommends that the complement figure be accomplished by however long attrition takes to work out the differences.

PROPOSED FORMULA VS CURRENT TRUCKS AND COMPLEMENT

ſ		TR	UCKS			PER	SONNEL COM	IPLEMENT	C	
	Area	Proposed	Currenț	Diff.	Workers	Absent	Intermittent Foremen	Proposed	Current	Diff.
	1A 1B	50 38	52 37	-2 +1	88 63	4 3	1	93 66	99 64	-6 +2
	2A 2B	29 36	31 35	-2 +1	40 51	2 2	atompic 2 mil	42 53	46 56	$-4 \\ -3$
	3A 3B	<mark>36</mark> 56	34 53	+2+3	59 101	2 4	1	61 106	56 104	+5 +2
	4A 4B	44 30	41 32	+3	75 45	3 2	an and an	78 47	75 51	+3 -4
	5	116	121	-5	233	9	10	252	268	-16
	6A 6B	50 52	50 52	2	89 96	4 4	1	94 100	90 94	+4 +6
	7A 7B	38 43	40 46	$-2 \\ -3$	66 76	3 3	erruphitierin 1	69 79	74 79	$-5 \\ 0$
	8	58	57	+1	100	4		104	96	+8
	9	116	113	+3	231	9	12	252	245	+7
	Total	792	794	-2	1,413	58	25	1,496	1,497	

VII. FUTURE

The Committee would like to express two concerns in addressing the future use of the formula. The first is the need to address efficiency improvements and second is the future staffing changes which will impact within the next several years.

A. Addressing Efficiency Improvements

A comparision of the proposed cycle times with those in the original 1971 formula is shown below. It indicates a significant increase in level of service in the past 12 years.

Classification	Cycle	Time
L.	1971	1983
Super Urban Commuter		1.2
Urban Commuter	2	1.5
Rural Commuter	3	2.1
Primary	4	4.0
Secondary	8	5.0

The tabulation below shows the changes that have occurred in complement, trucks, lane miles and interchanges between 1971 when the Formula was first developed and 1983.

Year	S & I Positions	Trucks	Lane Miles	Interchanges
1971	1725	772	27,074	206.5
1983	1497	794	28,729	476.5

The above shows a significant increase in efficiency has been accomplished since 1971. Mn/DOT is now maintaining 1,655 more lane miles and 270 more interchanges with 228 fewer snow and ice positions and only 22 more trucks. Considering the increase in the level of service as indicated by the decreased cycle times, the increase in efficiency has to be considered dramatic. Some of the reasons for this dramatic improvement are two-way radios in all trucks, diesel engines, better plows and sanders, improved roadway cross-sections, less vehicle breakdowns, more knowledgeable supervisors and operators, and one man winging.

The Committee anticipates that Mn/DOT Maintenance forces will continue to improve their efficiency in the coming years. It is difficult to predict what will happen to improve efficiency, but it is likely that we'll see additional improvements in equipment and road cross-sections, better weather forecasting and better use of those forecasts, more efficient scheduling, better use of contractor's equipment, etc. In addition, a higher percentage of tandems in the truck fleet would increase efficiency. If maintenance forces were permitted to use straight salt, a significant improvement in efficiency would be realized. At any rate, there seems little doubt that efficiency will improve.

If the mileage and interchanges were to stay at the current numbers, the result of this increase in efficiency would either be an increase in level of service or a decrease in trucks and complement. It is difficult to predict how big that improvement will be. However, the committee feels that efficiency improvements must be addressed to avoid what happened in the past to the formula. Therefore, by July of 1984, the Committee will develop a method, based on the Commissioner and staff policy of keeping the level of service at or slightly below the present level, to periodically adjust the formula to account for these efficiency improvements.

B. Future Staffing Changes

Future staffing requirements are going to be significantly affected by the construction program especially in the metro area. The following segments of the freeway system are scheduled for the near future.

I-35E	Dakota County	from T.H. 77 to T.H. 110
I-35	Duluth	from Mesabe to 10th Ave. E.
I-94	Washington County	from I694 to St. Croix River
I-494	Dakota County	from T.H. 55 to South St. Paul
I-394	Hennepin County	from Minneapolis to I494
I-35E	St. Paul	from West 7th Street to 194
T.H. 252	Hennepin and	
and 610	Anoka Counties	from I94-694 to T.H. 10

Recently each Maintenance Area was asked to project road openings for the 1984-85 and 1985-86 winters. By applying the proposed formula to the anticipated mileage identified in this request the impact of some of this construction can already be seen. The results for the 1983-84, 84-85 and 85-86 winter are provided in Tables 8, 9, and 10 for comparison. Note the increase in both trucks and workers that is necessary to maintain the current level of service.

In the long range outlook, the basic roadway system after the decade of the 80's will be significantly complete. Mn/DOT Snow and Ice needs should nearly stabilize except for fluctuation as a result of changes in traffic volumes. The Committee therefore, will begin studying the future needs to 1990 based on the projected openings using the Highway Work Program as a guide.

C. Summary

The Committee feels strongly that the proposed formula will result in the level of service that the public desires. Road openings and increases in traffic volumes during the next few years will necessitate an increase in both trucks and workers. However, by 1988-89, increases in efficiency will tend to offset these effects. The net effect will depend upon the actual increases in traffic volume and the lane miles and interchanges added to the system.

MAINTENANCE AREA	LANE MILES	TRUCKS	WORKERS
1A	1,903.65	50	88
1B	1,742,13	38	63
2A	1,741.46	29	40
2B	2,184.00	36	51
3A	1,745.55	36	59
3B	1,963.62	56	101
4A	2,016.32	44	75
4B	1,684.50	30	45
5	1,885.60	116	233
6A	1,956.84	50	89
6B	1,676.24	52	96
7A	1,595.00	38	66
7B	1,750.00	43	76
8	2,939.70	58	100
9	1,944.50	116	231
TOTALS	28,729.11	792	1,413

SUMMARY REPORT FOR WINTER OF 1983 - 84

ASSUMPTIONS: SPARE TRUCKS %5 NUMBER 3

Ln Mile	Interchan	iges	Workers	T Speed
Csc = 1.2 Cuc = 1.5 Crc = 2.1 Cp = 4 Cs = 5	Hscc = 3.1 Hcu = 3.9 Hcr = 5.5	Hscs = 6.2 Hsu = 7.8 Hsr = 10.9	Vsc = 2.2 Vuc = 2 Vrc = 2 Vp = 1.5 Vs = 1	Ssc = 15 Suc = 15 Src = 19 Sp = 19 Ss = 19

Workers	+	4% Absenteeism	+	Foreman	_	1496
1413		58		25		1150

MAINTENANCE AREA	LANE MILES	TRUCKS	WORKERS
1A	1,913.65	51	89
1B	1,742.13	38	63
2A	1,741.46	29	$\begin{array}{c} 40\\51\end{array}$
2B	2,184.00	36	
3A	1,745.55	36	59
3B	1,963.62	56	101
4A	2,016.32	44	75
4B	1,684.50	30	45
5	1,865.00	115	232
6A	1,956.84	50	89
6B	1,676.24	52	96
7A	1,595.00	38	66
7B	1,750.00	43	76
8	2,958.70	59	101
9	1,976.50	119	238
TOTALS	28,769.51	796	1,421

SUMMARY REPORT FOR WINTER OF 1984 - 85

MAINTENANCE AREA	LANE MILES	TRUCKS	WORKERS
1A	1,924.35	52	52
1B	1,761.73	39	64
2A	1,741.46	<mark>29</mark>	40
2B	2,184.00	36	51
3A	1,759.55	36	59
3B	1,982.42	56	102
4A	2,016.32	44	75
4B	1,684.50	30	45
5	1,869.10	116	234
6A	1,956.84	50	89
6B	1,676.24	52	96
7A	1,595.00	38	66
7B	1,750.00	43	76
8	2,958.70	59	101
9	2,094.60	129	258
TOTALS	28,954.81	809 .	1,448

SUMMARY REPORT FOR WINTER OF 1985 - 86

ASSUMPTIONS: SPARE TRUCKS % 5 NUMBER 3

Ln Mile	Interchan	ges	Workers	T Speed
Csc = 1.2 Cuc = 1.5 Crc = 2.1 Cp = 4 Cs = 5	Hscc = 3.1 Hcu = 3.9 Hcr = 5.5	Hscs = 6.2 Hsu = 7.8 Hsr = 10.9	Vsc = 2.2 Vuc = 2 Vrc = 2 Vp = 1.5 Vs = 1	Ssc = 15 Suc = 15 Src = 19 Sp = 19 Ss = 19
	$\frac{\text{Workers}}{1448} + \frac{4}{14}$	% Absenteeism 59	+ Foreman 25	= 1532







Appendix A DEFINITIONS

To be better able to understand the references to some of the Snow and Ice Formula Factors the following definitions apply:

Snow Removal Route Classifications:

Priorities are assigned to the trunk highway system according to traffic volumes. The most recent traffic flow map is used to establish the number of lane miles each maintenance area has per classification group.

Truck Speed:

For application within the formula, the truck speed is determined by dividing the number of miles traveled on the snow and ice route by the number of hours the driver spends on the snow and ice operations until a described level of service is achieved. Time spent on coffee breaks, changing cutting edges, loading, etc. is included. Mileage back and forth to the route is not included.

Trucks:

The formula value for trucks includes both single and tandem axle dump trucks (Class 33's and 35's). Not to be included in this total are auxiliary equipment such as motor graders, loaders, ten-ton trucks, and Sno-Go's.

Lane Miles:

For computations of the formula, only mainline lane miles are counted. Lane miles equals the number of driving lanes on the roadway times the length of section within the classification. Not to be included in the lane mile totals are turn-around time, turn lanes, shoulders, frontage roads, rest areas, etc.

Coverage Time:

The suggested number of hours per day snow plow trucks should work during and after winter storms to maintain the desired conditions of driving surface.

Cycle Time:

The period of time it takes to make one complete pass of a snow plow route.

Levels of Service:

A written description of the roadway surface appearance that must be reached before coverage time is reduced. Each classification has a described level. This level of service applies to mainline roadways and interchanges during the weekdays. Weekend level of service can be adjusted by the area maintenance engineer.

Maintenance Worker:

The winter personnel complements counted in the formula are:

Highway Maintenance Worker Highway Maintenance Worker Senior Heavy Equipment Operator Bridge Worker

APPENDIX B

STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION WORK MAP



DISTRICT & MAINTENANCE AREA MAP

APPENDIX C

MAINTENANCE MANUAL

J. SNOW AND ICE STAFFING GUIDELINES

Guidelines to be followed in filling out the snow and ice staffing requirements form are as follows:

1. <u>Tr</u>	uck Re	quireme	nts
Th	eoretic	al fleet s	size $(N_A) = Number of trucks^* required (N_t) + spare trucks^* (N_s)N_A = N_t + N_s$
Ns	=	7%	of N _t or 4 trucks per maintenance area whichever is greater
Nt	=	truck	ss required to maintain highways (TH)
			+
		truck	s required to maintain interchanges (TI)
	=	T _H +	TI
т _Н	[=	D 15C	= <u>lane miles to plowed for each road classification</u> 15 ^x cycle time for each road classification
	15	=	average plowing speed in miles per hour
	D	=	D_{UC} = lane miles of urban commuter
		=	DRC = lane miles of rural commuter
		=	Dp = lane miles of primary
		=	D_S = lane miles of secondary
	С	=	CUC = 2.1 for urban commuter
		· =	$C_{RC} = 3.2$ for rural commuter
		=	CP = 4.5 for primary
		=	$C_S = 6.0$ for secondary
	TH	=	$\frac{D_{UC}}{15^{x} C_{UC}} + \frac{D_{RC}}{15^{x} C_{RC}} + \frac{D_{P}}{15^{x} C_{P}} + \frac{D_{S}}{15^{x} C_{S}}$
		=	$\frac{D_{UC}}{31.5} + \frac{D_{RC}}{48.0} + \frac{D_P}{67.5} + \frac{D_S}{90.0}$
	Тт	=	number of interchanges to be maintained
	-1		number of interchanges one truck will maintain
		=	$\frac{I_{CU}}{1.6} + \frac{I_{SU}}{2.1} + \frac{I_{CR}}{2.6} + \frac{I_{SR}}{4.2}$
	I _{CU}	=	number of complex**urban interchanges (use where ADT is over 10.000)
	ISU	=	number of simple*** urban interchanges (use where ADT is over 10,000)
	ICR	=	number of complex rural interchanges (use where ADT is 10,000 or less)
	ISR	=	number of simple rural interchanges (use where ADT is 10,000 or less)

^{*} total of class 33 + class 35

^{**} cloverleafs, directional types, etc.

^{***} diamonds, folded diamonds, etc.

2. Personnel Requirements (maintenance workers)

For Urban Commuter	Use 21/2 workers per truck (provides for 24 hour coverage)
Rural Commuter	2 workers per truck (provides for 20 hour coverage)
Primary	2 workers per truck (provides for 18 hour coverage)
Secondary	1 ¹ / ₂ workers per truck (provides for 12 hour coverage)

- 3. Do not include right turn lanes, cross-overs, frontage roads, scales, rest areas, information centers, and inside shoulders adjacent to narrow medians.
- 4. Use the most recent traffic flow map prepared by the Transportation Planning and Programming Division except within corporate limits of cities use more detailed ADT maps.
- 5. Use current mileage plus mileage that is anticipated to be added by the winter season.
- 6. Carry out all computations at route classification level to hundredths. Round off all computations for sub area total to nearest whole number as follows: 0.50 = 1
 0.49 = 0
- 7. Do not allow extra trucks for the following:
 - (a) Grade Separations which do not have ramps and loops
 - (b) At grade intersections of trunk highways
- 8. Allow for parts of interchanges: an example would be 1/2 diamond = 1/2 interchange.
- 9. One intermittent foreman shall be allowed for each sub area that has between 1 and 30% of their lane miles in the urban commuter classification and they shall be allowed two intermittent foremen for each sub area that has 30% or more urban commuter lane miles in that sub area.

ASSUMPTIONS: SPARE TRUCKS % 5 NUMBER 3

Ln Mile	Interch	anges	Workers	T Speed
Csc = 1.2	Hscc = 3.1	Hscs = 6.2	Vsc = 2.2	Ssc = 15
Cuc = 1.5	Hcu = 3.9	Hsu = 7.8	Vuc = 2	Suc = 15
Crc = 2.1	Hcr = 5.5	Hsr = 10.9	Vrc = 2	Src = 19
Cp = 4			Vp = 1.5	Sp = 19
Cs = 5		· · · · · ·	Vs = 1	Ss = 19

MAINT. AREA: 1A SUB AREA: 1

FOR WINTER OF 83-84

DATE: 08/22/83

Route	Lane	Lane Mile	Numb Interch	er of anges	Interchange		
Class.	Miles	Trucks	Comp.	Simp.	Trucks	Trucks	Workers
Super Com	7.01	0.39	5.0	0.0	1.61	2.00	4.4 <mark>0</mark>
Urban Com	126.31	5.61	8.0	7.0	2.95	8.56	17.12
Rural Com	998.31	25.02	3.0	13.0	1.74	26.76	53.52
Primary	519.02	6.83	0.0	0.0	0.0	6.83	10.25
Secondary	253.00	2.66	0.0	0.0	0.0	2.66	2.66
					SUB TOTALS	46.81	87.95
Maint. Area							
1A Totals:	1,903.65			16.0	20.0	46.81	87.95
					+ Spare Trucks:	3.00	
					Rounded Totals:	50	88

Formula Computations for Super Com.:

 Lane Miles
 +
 Interchanges

 Truck Speed x Cycle Time
 +
 Interchange Factor

No. of trucks x worker factor = workers

 $\therefore \frac{7.01}{15 \times 1.2} + \frac{5}{3.1} = 0.39 + 1.61 = 2.00 \times 2.2 = 4.40$

APPENDIX D

	Minnesota Department of Transportation
	"Questionnaire" Winter Driving Conditions
	Winter Driving contents
1.	County
2.	License Applying For:
	A B C
3.	Age?
	21 or less 22 to 30 31 to 45 45 to 60 Over 60
4.	How many miles per year do you drive:
	Less than 5,000 5,000-10,000 10,000-20,000 20,000-30,000 Over 30,000
5	In your opinion, is the winter maintenance effort for snow and ice control
5.	on most:
	Poor Satisfactory Interitate
	Interstate Freeways
	State Highways
	County Roads
	City Streets
6.	Freeways and Highways receive (check all that apply):
	Plowing Sanding & Salting
4.5	The Little
7.	At the present time the Minnesota Department of Transportation spends approximately \$6.00 per registered vehicle a year for snow and ice removal on State maintained highways. What amount would you favor to be spent?
	\$0.00 \$3.00 \$6.00 \$9.00 \$12.00

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APPENDIX E

TRUCK SPI	SED EVALUATION	
MAINTENANCE AREA	DATE	-
SINGLE AXLE	· · INTERCHANGES ON J	ROUT
TANDEM AXLE	Yes No	
TIME 1	TIME 2	• • •
<u>M</u>	IILEAGE	
INITIA	\L	
START 1	START 5	
STOP 1	STOP 5	
START 2	START 6	
STOP 2	STOP 6	
START 3	START 7	
STOP 3	STOP 7	
START 4	START 8	
STOP 4	STOP 8	
	Signature	

(Frontside)

TIME

"Time 1", is the time you report to the truck station for snow and ice removal operations.

"Time 2", is the time you complete snow and ice operations on the travelled portion of the roadway.

MILEAGE

- "Initial", is the odometer reading at the truck station when you start.
- "Start 1," ... is the odometer reading when you start your route.
- "Stop 1", ... is the odometer reading whenever you leave your route such as to return to stockpile site for more sand.
- "Start 2, 3,"... is the odometer reading when you return to your route such as after reloading.
- "Stop 2, 3,"... is the odometer reading whenever you leave your route such as to return to stockpile site for more sand or when snow and ice operations are completed at "Time 2".

(Backside)

APPENDIX F

SNOW & ICE FORMULA DATA SHEET

Maintenance Area <u>1-A</u>

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	7.01
Urban Commuter	10,000 - 30,000	126.31
Rural Commuter	2,000 - 10,000	998.22
Primary	800 - 2,000	519.02
Secondary	< 800	253.00

INTERCHANGE DATA

DESCRIPTION	COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		6	13
Half Diamond		2	
Folded Diamond		2	1
Other Diamond			1
Trumpet		_	
Cloverleaf	1		
Partial Directional	1	5	1
Full Directional	4	1	
Complex			
Other			

SNOW & ICE FORMULA DATA SHEET

Maintenance Area <u>IB</u>

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	
Urban Commuter	10,000 - 30,000	86.20
Rural Commuter	2,000 - 10,000	846-91
Primary	800 - 2,000	341.12
Secondary	< 800	467.90

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		3	З
Half Diamond			
Folded Diamond			
Other Diamond			
Trumpet			
Cloverleaf			—
Partial Directional			
Full Directional			
Complex			
Other			

Maintenance Area 2-A

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	O
Urban Commuter	10,000 - 30,000	19.00
Rural Commuter	2,000 - 10,000	371.78
Primary	800 - 2,000	494.10
Secondary	<800	856.58

INTERCHANGE DATA

INTERCHANGE	SUPER	URBAN	RURAL
DESCRIPTION	COMMUTER	COMMUTER	COMMUTER
Diamond			3.0
Half Diamond			
Folded Diamond			
Other Diamond			
Trumpet	1.2021.31.016		
Cloverleaf			
Partial Directional			2.0
Full Directional			
Complex			
Other			

SNOW & ICE FORMULA DATA SHEET

Maintenance Area 28

LANE MILE DATA

CLASSIFICATION ADT		LANE MILES
Super Commuter	30,000>	
Urban Commuter	10,000 - 30,000	4
Rural Commuter	2,000 - 10,000	424
Primary	800 - 2,000	1150
Secondary	< 800	606

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		1	1
Half Diamond			
Folded Diamond			
Other Diamond			
Trumpet			
Cloverleaf			
Partial Directional			Arrend Same
Full Directional	and the second sec		All and a second second
Complex			and the second second
Other			

Maintenance Area _____

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	0
Irban Commuter	10,000 - 30,000	12.80
Rural Commuter	2,000 - 10,000	811.96
Primary	800 - 2,000	531.19
Secondary	< 800	389.60

INTERCHANGE DATA

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		· ·	1
Half Diamond			1
Folded Diamond			-
Other Diamond			
Trumpet			_
Cloverleaf			
Partial Directional			2
Full Directional			2
Complex			
Other			1

SNOW & ICE FORMULA DATA SHEET

Maintenance Area <u>38</u>

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	0
Urban Commuter	10,000 - 30,000	271.77
Rural Commuter	2,000 - 10,000	1189.99
Primary	800 - 2,000	379.08
Secondary	< 800	122.78

LANE MILE DATA

-	INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
	Diamond		8	13
	Half Diamond		1	
-	Folded Diamond			
	Other Diamond			
	Trumpet		3	2
	Cloverleaf		3	I
	Partial Directional		-	
	Full Directional			
	Complex			
	Other			

SNOW & ICE FORMULA DATA SHEET

Maintenance Area 4A

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	
Urban Commuter	10,000 - 30,000	30.72
Rural Commuter	2,000 - 10,000	1,059.22
Primary	800 - 2,000	605.86
Secondary	<800	320.52

INTERCHANGE DATA

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond	2-1 TTP	1	14
Half Diamond			
Folded Diamond		1	
Other Diamond			
Trumpet			
Cloverleaf		A COLUMN TO A COLUMN	
Partial Directional			1
Full Directional			
Complex			
Other			

SNOW & ICE FORMULA DATA SHEET

Manntenance Area 48 -

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	0
Urban Commuter	10,000 - 30,000	17.6
Rural Commuter	2,000 - 10,000	417.3
Primary	800 - 2,000	84.8
Secondary	< 800	384.8

SUPER	URBAN	RURAL
COMMUTER	COMMUTER	COMMUTER
		7
		SUPER URBAN COMMUTER COMMUTER

SNOW & ICE FORMULA DATA SHEET

Maintenance Area 5

Golden Valley Dist.

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	731.6
Urban Commuter	10,000 - 30,000	670.7
Rural Commuter	2,000 - 10,000	387.3
Primary	800 - 2,000	96.0
Secondary	<800	

TOTALS

1885.6

DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond	33.5	7	•
Half Diamond	16		
Folded Diamond	9.5	1.6	
Other Diamond	15	1	
Frumpet	3.5		
Cloverleaf	16	0.5	
Partial Directional	4.5	3	
Full Directional	1	2	
Complex	8		
Other	1.5		
TOTAL	108.5	15	

INTERCHANGE DATA

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SNOW & ICE FORMULA DATA SHEET

Maintenance Area 6A

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	
Urban Commuter	10,000 - 30,000	150.49
Rural Commuter	2,000 - 10,000	1109.02
Primary	800 - 2,000	503.21
Secondary	<800	194.12

INTERCHANGE DATA

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		4	10
Half Diamond			2
Folded Diamond			
Other Diamond		6	2
Trumpet			
Cloverleaf			
Partial Directional			2
Full Directional			
Complex			
Other			a serie and the
	INTERCHANGE DESCRIPTION Diamond Half Diamond Folded Diamond Other Diamond Trumpet Cloverleaf Partial Directional Full Directional Complex Other	INTERCHANGE DESCRIPTION COMMUTER Diamond . Half Diamond . Folded Diamond . Other Diamond . Trumpet . Cloverleaf . Partial Directional . Full Directional . Complex .	INTERCHANGE DESCRIPTIONSUPER COMMUTERURBAN COMMUTERDiamondHalf DiamondFolded DiamondOther DiamondCloverleafPartial DirectionalFull DirectionalComplexOther

SNOW & ICE FORMULA DATA SHEET

Maintenance Area 68 OWATONNA

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	
Urban Commuter	10,000 - 30,000	310.67
Rural Commuter	2,000 - 10,000	917.25
Primary	800 - 2,000	435.08
Secondary	<800	13.24

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		191/2	8 1/z
Half Diamond			
Folded Diamond		2	1 1/z
Other Diamond		2	1 1/2
Trumpet		2	The second second
Cloverleaf			
Partial Directional		the subscreen states	
Full Directional		1	· · · · · · · · · · · · · · · · · · ·
Complex		1	1/z
Other	1	3	1

Maintenance Area 7A

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	
Irban Commuter	10,000 - 30,000	54
Rural Commuter	2,000 - 10,000	962
'rimary	800 - 2,000	434
Secondary	< 800	145

INTERCHANGE DATA

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond		4	7
Half Diamond			2
Folded Diamond			1
Other Diamond			
Trumpet			
Cloverleaf			
Partial Directional			
Full Directional			
Complex		1	
Other			

SNOW & ICE FORMULA DATA SHEET

Maintenance Area 7-B Window

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	0
Urban Commuter	10,000 - 30,000	22
Rural Commuter	2,000 - 10,000	1052
Primary	800 - 2,000	636
Secondary	< 800	40

INTERCHANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond			21
Half Diamond			3
Folded Diamond			2
Other Diamond			
Trumpet		-	-
Cloverleaf			
Partial Directional			
Full Directional			2.
Complex			
Other			7

Maintenance Area 8

LANE MILE DATA

CLASSIFICATION	ADT	LANE MILES
Super Commuter	30,000>	
Urban Commuter	10,000 - 30,000	
Rural Commuter	2,000 - 10,000	1433.76
Primary	800 - 2,000	1826.70
Secondary	< 800	279.24

INTERCHANGE DATA

INTERCHANGE	SUPER	URBAN	RURAL
DESCRIPTION	COMMUTER	COMMUTER	COMMUTER
Diamond			
Half Diamond			2
Folded Diamond		in the second second	
Other Diamond			
Trumpet		A CONTRACTOR OF A CONTRACT	
Cloverleaf			
Partial Directional			and the second
Full Directional			
Complex			
Other			1

SNOW & ICE FORMULA DATA SHEET

Maintenance Area 9A

CLASSIFICATION	ADT	LANE
Super Commuter	\$0,000>	565.1
Urban Commuter	10,000 - 30,000	715.7
Rural Commuter	2,000 - 10,000	579.3
Primary	800 - 2,000	84.4
Secondary	<800	

LANE MILE DATA

INTERCIIANGE DESCRIPTION	SUPER COMMUTER	URBAN COMMUTER	RURAL COMMUTER
Diamond	30	15	2
Half Diamond	7	7	1
Folded Diamond	12	0	1.
Other Diamond	16	3.	0
Trumpet	1	0	0
Cloverleaf	10	2	0
Partial Directional	8	5.	0
Full Directional	5	3	0
Complex	6	1	0
Other	3	0	0

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