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Aggregate roads maintenance and cost: case study of state of Minnesota

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Aggregate roads maintenance and cost:
Case study of state of Minnesota

by

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Signatures have been redacted for privacy

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INTRODUCTION

With the reduction in available funds for maintenance and construction of existing and new infrastructure, local governments and cities are required to find cost-effective ways to maintain and rehabilitate any deteriorating infrastructure. The United States alone has 3,958,154 miles from which 10% (395,815 miles) are aggregate roads[1]. Municipalities, private organizations, but most particularly counties maintain the majority of these roads. During the process of trying to be cost effective, local governments are faced with a lack of information on the maintenance and upgrading of aggregate roads. The concept of applying the most cost effective treatment at the best time can be explained based on the physical characteristics of a road and by the maintenance cost.

This thesis is composed of two parts:

- Part I is a literature review of different designs, maintenance processes, and the time to apply these processes.
- Part II is a review of aggregate road maintenance costs in comparison to other types of treatment based on future maintenance cost.

Part I: Review of Design, Maintenance and Upgrade Alternatives for Aggregate Roads

To review when it is most cost effective to apply a specific treatment to a road, the life cycle of a road must be reviewed. An example is shown in Figure 1, a graph representing the process of deterioration of a road surface with respect to time. Assume the road was just built and its condition is at the highest possible point. With time, the road will deteriorate, reducing its condition. As the graph shows, there is a point in the deterioration process when it is cost effective to maintain a road. If this point is passed, it is then most cost effective to rehabilitate the road with a method such as re-graveling. The rehabilitation will improve the road condition as shown by the dotted graph line. If no action is taken at the condition lower limit line, the road will continue to deteriorate and require reconstruction, which will be the least cost effective action.

[1] CIA website information on USA at
http://www.theodora.com/wfb2003/united_states/united_states_transportation.html

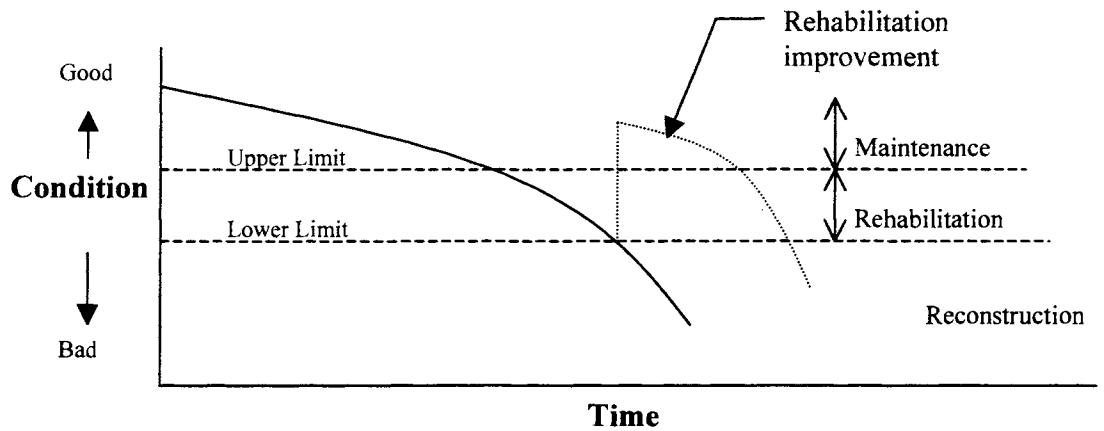


Figure 1: Time vs. road condition

Aggregate road deterioration is caused by conditions that cannot always be controlled. The most important element in managing roads is being able to predict how roads deteriorate so that cost-effective decisions can be made. In this graph, we can see that the most important thing is to develop optimal treatments and know when to apply the chosen treatment to have the most benefits. To help better understand all that can affect the maintenance cost, a literature review was conducted on the maintenance and treatment processes of aggregate roads used by different organizations.

The basic idea of getting the most "bang for your buck" in aggregate road maintenance starts with a good initial road design followed by taking all the necessary steps to preserve the road. The preservation of roads is composed of maintenance and improvement work. This thesis will summarize information on different design, maintenance, and upgrade options for aggregate roads to assist engineers in making informed decisions on what action to take and when.

Part II: Review of the Maintenance Cost of Aggregate Roads

The other way to determine when to apply the best treatment at the best time is by reviewing maintenance costs. Review of maintenance costs provides threshold values for points when a different technique, material, or upgrade is beneficial. As an example, initially a road has an aggregate surface with a low traffic volume. At some point, it may be advantageous to improve the road by stabilizing the surface, which would reduce the routine maintenance costs.

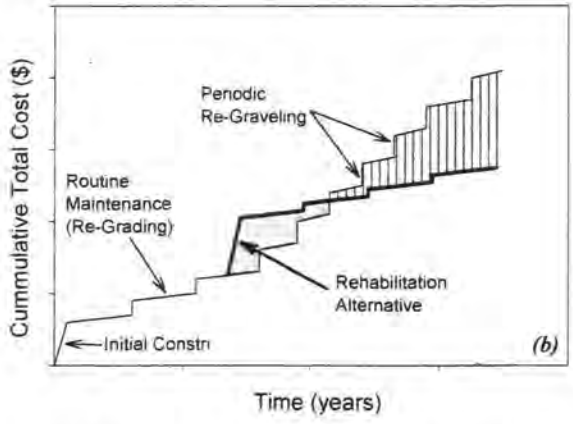


Figure 2: Cumulative maintenance cost vs. time

Figure 2 illustrates a case where an aggregate road is maintained regularly by retrieving (shown as the steps in the graph). If the traffic on this road increases with time, the maintenance costs will also increase with time. To view the effect of upgrading the road to a hard surface, a rehabilitation option is shown with the initial associated expense shown as the nearly vertical part of the solid line. Additional investments required by the rehabilitation alternative compared to the routine maintenance of an aggregate road are shown by the difference between the two lines. In this case, the rehabilitation reduces the annual routine maintenance costs, shown by the solid bold line. The hatched area shows savings in maintenance due to rehabilitation.

The low volume road research project has the objective of identifying the methods and costs of maintaining and upgrading an aggregate road. The research goal is to predict expected maintenance cost, the cost of retrieving, and the threshold required to justify an upgrade. With a review of county maintenance costs, we can estimate future maintenance costs, their effect, and the criteria that influence the costs. With this knowledge we can more effectively predict aggregate road maintenance costs.

Another way to compare maintenance costs versus time is shown in Figure 3. The maintenance costs for two roads with matching conditions are plotted against time. The difference in the two lines represents the difference in maintenance costs. Graphs like this will help identify the best practices in road maintenance.

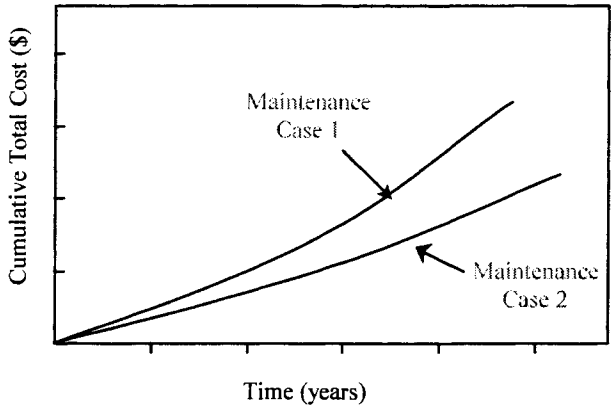


Figure 3: Cumulative maintenance cost vs. Time for two different maintenance cases

The goal of all organizations is to be cost effective. Figure 3 gives us an example where Case 2 is more cost effective then Case 1 if all road conditions match.

PART I: REVIEW OF DESIGN, MAINTENANCE AND UPGRADE ALTERNATIVES

1. BACKGROUND

This section is a literature review concerning maintenance of aggregate roads provided by various organizations. The following organizations were reviewed and summarized in this section:

- The Army Corp of Engineers (8) (9) (11)
- FHWA and South Dakota (2)
- State of Maine (4)
- Washington State (3)
- USDA Forest Services (7) (10) (12)
- Australia Road Research Board (1)
- Minnesota's Design Guide for Low Volume Aggregate Surface Roads (13)

This chapter will discuss aggregate roads in detail, including design requirements, maintenance guidelines, and activities. The review of these documents is organized as follows:

- Design of aggregate roads
- Material used on aggregate roads
- Maintenance practices

2. INTRODUCTION

The design and maintenance procedures of aggregate roads are generally similar. Each organization has its own specific details that will be shown in this chapter. The most important guidelines in aggregate roads design, maintenance and preservation are:

- Roads must be designed appropriately
    - Drainage consideration is of prime importance: it is vital that water is drained away.
    - The roads must have a firm foundation.
- High quality materials should be specified
- The road must be designed for the traffic and appropriate loads common to that road.
- During the design phase the appropriate projection of future traffic and developments must be considered.
- The owners of the road must maintain the road appropriately.

3. DESIGN STANDARDS

Road designers base the road layout, the thickness of the surface aggregate road, and the material on the following criteria:

- Location of the road: environmental limitation in the design of the road.
- Geometric consideration in the design and drainage.
- Design speed: a review of the travel speed is determined based on the quality of the ride, the radius of horizontal curves, road environment, and visibility.
- Traffic volume and the types of vehicles using the road, helping project future traffic needs.

To explain the use of these criteria in road design let us review a few examples:

- The road slope (grade) used in designing the road depends on the type of vehicle that will travel the road. The decision is based on the ability of the largest vehicle to drive the road at the design speed posted. The grade will also depend on the climate. Can the vehicle drive the road in winter with snow or when the surface is wet?
- In designing, one of the most important criteria to consider is the ability of a driver to see an obstruction on the road and have time to react. This is called the sight distance.
- Driving characteristics are based on the sight distance, which is based on the driver reaction time, vehicle type and driving direction.

In this section, we will review the geometry required to build a safe road and the drainage needed to keep the road in good condition. A design example of the thickness of the aggregate surface material is provided in Appendix 1 based on the design requirements from the Army Corp of Engineers.

3.1 Geometric criteria of aggregate roads

There are two parts to the geometric review of a road. The first is the layout of the road on the topography of the land, which is defined by the vertical and horizontal alignments of the road and drainage requirements. The second portion is the road's cross-section itself.

3.1.1. Road Alignments

Horizontal alignment standards partially determine the safe driving speed for a given road. For safety, a consistent alignment, which provides no surprises for the driver, is more important than achieving the desired design speed standard.
When a vehicle travels around a circular arc, it tends to move towards the outer side of the curve. The most comfortable circular path at which the radial force required to hold the vehicle on the path at the maximum allowed speed determines the super-elevation. The super-elevation is the cross-slope on the roadway that matches the comfortable circular path on a curve. Examples of maximum super-elevation standards are shown in Table 1.

A comparison of grade and super-elevation of different organizations is shown in Table 1. We can see that the range of maximum vertical grade allowed on the road ranges from 8-10%. The super-elevation used is between 4 and 6 %.

TABLE 1: Aggregate road grade and super-elevation

	Max Grade Vertical	Max super-elevation
Australia	8%	4-6%
Washington DOT	8%	5%
Division of Forest Resources	10%	

In the design of roads, **vertical alignment** is based on the driver reaction time, the vehicle type and the driving conditions on the road.

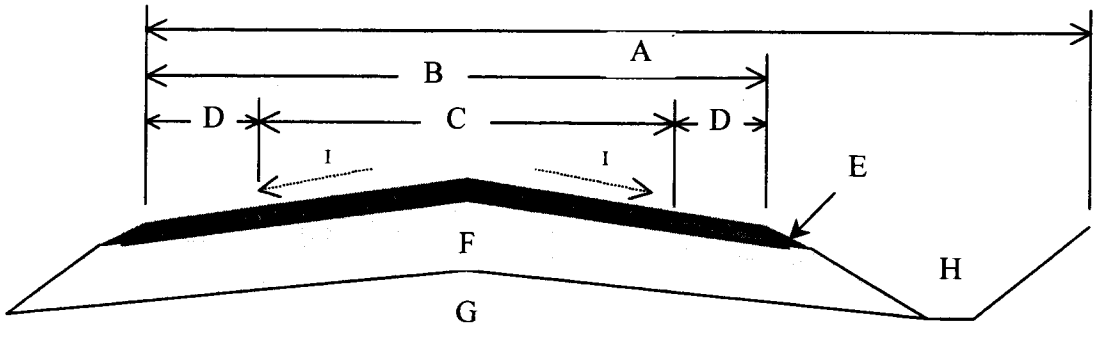
Sight distance: The aim of a designer is to ensure that the driver is able to see an obstacle on the road and have sufficient time to stop. The calculation of this distance is based on the driver's eye height and the object cut-off height above the road:

- The driver's eye height is taken as 3.8' (1.15 m) for passenger cars and 5.9' (1.8 m) for commercial vehicles.
- Object cut-off height above the road is 3.8' (1.15 m) for approaching vehicles and 8" (200 mm) for objects on the road.

Driver reaction time: This is the time that elapses between the first sighting of a hazard on the road and the time the vehicle begins to slow down. This time is estimated to be 2 – 2.5 seconds.

3.1.2. Road Cross-Section

All roads have a similar structure. The major components of roads are shown in Figure 4.



A: Right-of Way
B. Total pavement
C. Traffic paving
D. Shoulder
E. Surface course
F: Base course
G. Sub-grade
H. Ditch
I. Cross-slope

Figure 4: Aggregate road cross-section components

Figure 4, page 8, is a cross-section of an aggregate road. A road is composed of a driving surface (labeled C), and the sub-grade and sub-base (labeled F and G respectively) that support the surface. The shoulders (labeled D) play multiple roles of supporting the sub-grade and sub-base, permitting vehicles to stop if needed, and allowing drainage. Ditches (labeled H) are for drainage purposes. Table 2 is a summery of the cross-section dimensions from different transportation entities. A review of Table 2 shows that in most cases, the travel way width is greater then 10' with a minimum shoulder width of 2'. The crown slope varies depending on the sub-base type.

TABLE 2: Roadway cross-section dimension and slope comparisons

Code	Surface	Cross - slope min.	Width of Travel way	Shoulder	
				Slope %	Width
Australia	Earth, Loam Roads	5%	10 – 13'		6'
	Aggregate Roads	4-6%			
Army Corp of Engineer	Paved low volume roads	1.5-3%			
	Unpaved roads	2-4%			
Washington DOT[2]	Aggregate roads	2.7 – 4%	10' – 12'		4' min.
	Aggregate roads in heavy rain	6.3%			
PEA[3]	Aggregate roads (general)	6.3 – 8%			
	Aggregate roads in loose sands	2%			
Main DOT	Aggregate Road	4 – 6%	18' min	1.5 – 2	2' min
Division of Forest Resources	Aggregate road		15' min		2' min

[2] Washington State Department of Transportation, Maintenance of Aggregate and Earth Roads, FHWA, June 1987

[3] Choctawhatchee, PEA and Yellow River Watershed Management Authority, A Guideline for Maintenance and Service of Unpaved Roads, February 2000

3.2. Speed

The speed limit on a road is determined by the kind of traffic that will be on the road, the geometric design used for the road, and safety requirements for the driver.

3.3. Material

The other road component that affects the life of a road is the material used. Most states and counties have a standard of material to be used in construction. Considerable research has been performed to assist in the selection of appropriate materials for various situations. A generally accepted view is that crushed aggregate is the best material for roads because the material consists of sharp angles that permit better transfer of loads and better compaction. Adding aggregate to an earth road improves the strength and traction of the road and reduces erosion.

For aggregate roads to have a good surface, it is important to have surface material that is composed of stone, sand sized particles, and fines to act as a binding agent.

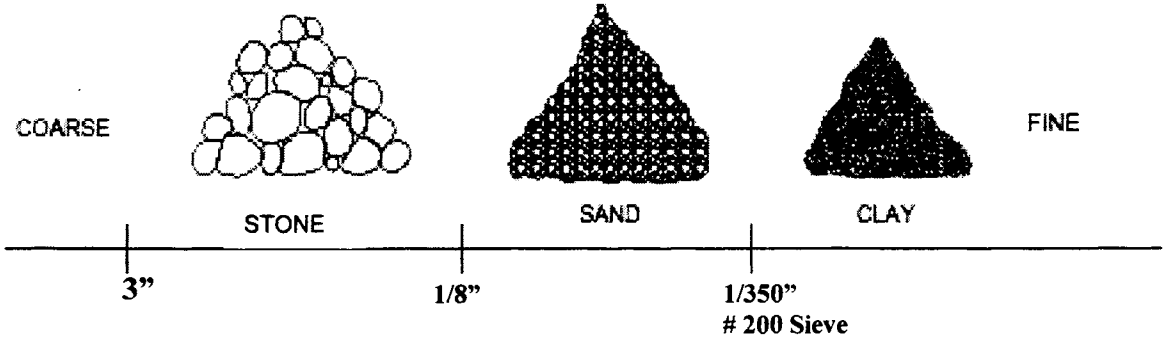


Figure 5: Road surface material
(A Guideline for Maintenance and Service of Unpaved Roads, PEA, Feb. 2000)

As shown in Figure 4, page 8, there are three main layers of material on an aggregate road: the sub-grade, the base course and the surface material.

The sub-grade (labeled G on Figure 4, page 8) is the existing soil in the area. The quality of the sub-grade will influence the thickness of the base course on a road. There are two types of sub-grade that can cause problems:

- Silty soils: silt easily displaces when dry, is strong when damp and flows when wet. It is good practice to use a sand blanket or geotextile to separate the sub-grade and base course material.
- Clay: is hard when dry and can crack if desiccated. The material loses strength as the moisture increases and deforms under load pressure.
- Sand: Sandy soils are good for drainage
- Mixture: In areas where there is a mixture of soils, it is hard to determine the proper design that will be cost effective for the road so most places use a conservative approach and design for the worst case scenario.

Sub-grade strength can vary from one end of the project to the other. It is important to investigate sub-grade strength on an entire project, and from there, determine the proper base course thickness to use on the road. The following table shows samples of sub-grade strength used in design in cases where the appropriate soil information is not available.

TABLE 3: Typical sub-base design CBR values used for existing soil material

Material	Well Drained	Poor Drainage
High Plasticity Clay	5	2-3
Silt		
Silty Clay	6-7	4-5
Sandy Clay		
Sand	15-20	

The base course (labeled F on Figure 4, page 8) is relatively stable material that is usually imported and designed to support the load from the traffic and prevent the surface from deteriorating. It also provides for drainage and evaporation of the sub-grade surface moisture. The standard required gradation of material used on the base course can be seen in Table 4.

TABLE 4: Gradation of base course material

Sieve Size No. (mm)	% Passing
2" (50)	100
1" (25.0)	100
¾" (19.0)	90-100
No. 10 (2.00)	20-65
No. 40 (.425)	10-35
No. 200 (.075)	3-10

In addition, comparison of materials used by various road authority organizations is provided in Table 6.

The surface course (labeled E on Figure 4, page 8) is the surface that traffic drives on. The material must be fairly hard and the particle should have rough rectangular surfaces. Brittle rock should be avoided. The minimum CRB for surface recommended by the Australian authorities is 11.

TABLE 5: Gradation of surface course material

Sieve Size No. (mm)	% Passing
2" (50)	100
1" (25.0)	100
¾" (19.0)	100
No. 10 (2.00)	20-70
No. 40 (.425)	10-45
No. 200 (.075)	8-15

Table 6 is a comparison of materials used in aggregate roads by five different transportation entities. The requirement varies and further review of the performance of roads in each of the jurisdictions maintained by these organizations would be needed in order to determine the best criteria to use.

TABLE 6: COMPARISON OF MATERIAL USED IN GRAVEL ROADS

		Sub-base				Base Course			Surface course				
		Gradation				Gradation			Gradation				
		Max. Particle size	% Passing # 200 sieve	PI	Thick ness	Max. Particle size	% Passing # 200 sieve	PI	Max. Particle size	% Passing # 200 sieve	PI	Thick ness	LL
Australian	Dry climate	2"	4-17	18		-	-	-	1"	6-20	4-15		35
	Wet Climate	2"	4-10	12		-	-	-	1"	3-11	4-9		35
	Note: For resistance to reveling, the percent of material retained on a 2.36mm sieve, should be between 20% and 60%.												
Army Corp Of Engineers	No Frost	3"	15	12		1"	3-12	0-6	1"	8-15	4-9		35
	Frost Areas		-	5		-	-	-	Minimal Fines			4"	25
	Notes: - In all cases fines smaller then .02mm should not exceed 3%. - Frost areas the % of fines should be restricted in all the layers to facilitate drainage and reduce the loss of stability and strength during thaw period												
South Dakota LTAP		1"	3-12	0 - 6		-	-	-	¾"	4-5	4-12		
Washington DOT	Non Frost		6-8			-	-	-	1" -¾"	6-10	2-9		35
	Frost Areas		5			-	-	-		4			
Maine Local Road Center		6"	0-7	-	18" min.	4"	0 - 5	-	2"	7-12		4"	

Abbreviations: PI: Plasticity Index LL: Liquid Limit CBR: California Baring Ratio

3.4. Drainage

It is estimated that at least 90%[4] of a road's deterioration is caused by excess water and/or poor drainage. To prevent drainage problems a few steps must be taken:

- All roads have a cross slope (See table 2 for examples of differences in the cross slope). The cross slope helps the water drain off the road on to the shoulder.
- The shoulders are designed to drain the water away from the driving surface to the ditches and culverts. In turn, the ditches and culverts should be designed to take the water away from the road system and into the streams.
- Ditches are placed at least a foot lower then the base course to prevent the water from seeping back in the road. The ditches and drainage systems of aggregate roads differ depending on the standard used by each organization.

To have good roads, it is important to design and construct the drainage system properly. The drainage system includes ditches, bridges, culverts, and other structures that help transport water to its destination. In this section, we are going to focus on ditches since they have the most influence on the condition of the road surface. Well-designed ditches serve a number of purposes:

- They collect road surface run-off and drain it away from the road.
- They store large amounts of rainfall.
- With proper turnouts and buffers, they keep pollution from reaching sensitive water resources.
- They collect and drain subsurface water away from the road's base and sub-grade soil materials.

During the design of the ditches it is important to review the watershed size, degree of slope, width of the right-of-way, ditch size and shape, and native soil type. Ditches should be constructed in late fall and mid- to late summer because it is the time of the year when there will be sufficient time and moisture for a new vegetative cover to take hold.

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[4] Basics of a good road, Wisconsin DOT bulletin No. 19

4. MAINTENANCE

The goal of road maintenance is to ensure that the existing road is maintained in its original condition. It is expected that over the life of the road, it will deteriorate due to factors with which maintenance activities cannot deal. Regular and timely maintenance is done to increase the life of the road by putting off the date at which it needs to be reconstructed.

There are two types of maintenance for aggregate roads:

- Routine maintenance is maintenance that is required continuously. This type of maintenance includes non-surface related and pavement related maintenance.
    - Non-surface related maintenance includes for example brush and weed control, traffic services, culvert and ditch clearing.
    - Surface related maintenance includes surface smoothing and minor surface repair.
- Periodic maintenance is maintenance that is required at intervals of several years. This maintenance includes activities such as re-gravelling, surface reshaping of the cross-section and restoring the drainage system.

In road maintenance, it is important to recognize road defects and establish the cause in order to determine the best action to be taken.

Road defects are either due to the surface or to the road components (structural problems).

Surface problems are usually related to user safety and comfort when using the road. These problems are caused by climate, maintenance practices, material used, or a combination of these factors. Grading and blading the surface can remove these defects.

Structural defects are due to the over-stressing of the surface and/or sub-grade, causing failure of the surface. The causes can be a lack of drainage, poor compaction and/or the use of inappropriate or insufficient material to carry the axle loads.

Aggregate road surface defects can be a sign of structural problems, which can be difficult to resolve, or simply a surface problem that can be easily remedied. If surface problems are not addressed quickly, they can turn into structural problems that will be costly to remedy. The best policy in aggregate road maintenance is to first review the defects, determine their cause, determine options of maintenance, and then schedule the needed maintenance.

There are many factors influencing when a road is maintained and the type of maintenance to be applied:

- Traffic type and ADT – farm to market roads
- Climate condition and the season
- Road cross-sectional material (sub-base, base course and surface material)
- Drainage requirements
- Community demands on service level

4.1. Defects and Remedies

This section will review the defects that occur on aggregate roads and provide a way to determine the severity of the problem and suggest remedies. The assessment of the severity provided in this section will be used in the condition assessment process described.

4.1.1. Corrugation:

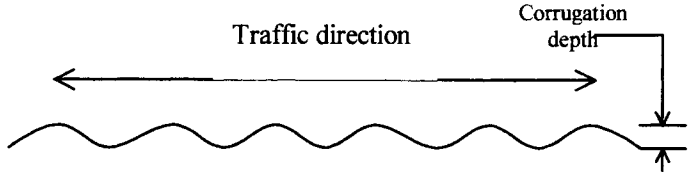


Figure 6: Corrugation

Corrugations, also known as "washboarding," are closely spaced ripples at regular intervals. Corrugations form perpendicular to the traffic direction. Corrugations are due to a combination of loose surface material and traffic moving the material. In wet climates or wet weather, corrugations are caused by structural defects in the base of the road. Most corrugations are found in areas of acceleration and deceleration such as intersections, bridge approaches, railroad crossings, super-elevations, hills, curves and driveways.

If this problem exists, check for:

- Particle size distribution and amount of binding material in the surface material.
- Compaction of surface material with sufficient moisture
- Grader operation speed
- Correct depth of cut to remove corrugation with grader blade.

The remedy for corrugations will depend on the severity of the problem. Table 7 provides severity assessment guidelines and remedies based on severity as described by reviewed manuals.

TABLE 7: Corrugation severity criteria and the remedies based on the severity.

Severity	Depth	Treatment
Low	1"	Grade only
Medium	1-3"	Grade and add material (water or aggregate or both and compact
High	> 3"	Cut to base, add aggregate, shape and add water and then compact.

4.1.2. Potholes

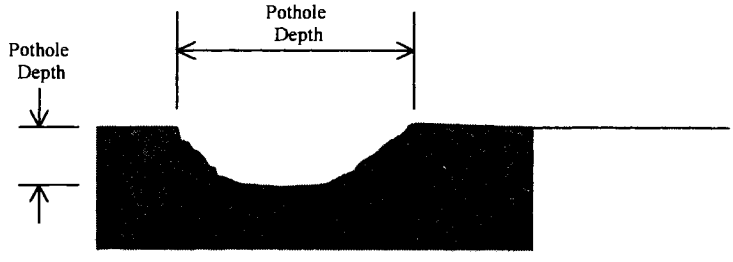


Figure 7: Pothole

Potholes are depressions in the road surface that are caused by traffic wearing away small pieces of the road surface. The holes grow when water collects inside them and from there the road continues to disintegrate. Roads particularly susceptible to potholing are those with flatter grades and cross-slope, such as bridge approaches, for example.

If this problem exists, check for:

- Driving surface cross-slope
- Compactness of surface material
- Shading of the road that prevents drying of the driving surface.

Remedies:

Restore surface shape and cross fall to prevent water retention in flat spots.

TABLE 8: Pothole severity criteria and the remedies based on the severity.

Severity	Width	Depth	Treatment
Low	1'-2'	0.5"- 4"	Grade only
Medium	2-3'	>4"	Grade and add material (water or aggregate or both and compact
High	>3'	> 4"	Cut to base, add aggregate, shape and add water and then compact.

4.1.3. Rutting

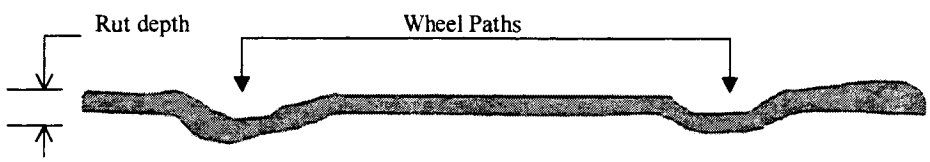


Figure 8: Rutting

A rut is a longitudinal deformation in the wheel path that is parallel to the road centerline and caused by a deformation in the road layers from tire wear during the passage of vehicles. Ruts pose potential problems, as they tend to retain rainwater that softens the wearing course.

If this problem exists, check for:

- Grading of the surface material, particle size distribution
- Cross-fall on pavement
- Compaction of the surface material
- The road wheel (this can cause the three wheel effect if the road is too narrow)

TABLE 9: Rutting Severity criteria and the remedies based on the severity.

Severity	Depth	Treatment
Low	1"	Grade only
Medium	1-3"	Grade , add material and compact
High	> 3"	Cut to base, add aggregate, shape, water and compact.

4.1.4. Loss of Aggregate

Figure 9: Loss of aggregate

Traffic usually loosens the larger aggregate particles from the soil binder leading to loose aggregate on the road surface or shoulder. The traffic moves the loose aggregate from the road to the center or shoulder forming the wheel path.

TABLE 10: Loss of aggregate severity criteria and the remedies based on the severity.

Severity	Aggregate berm height	Treatment
Low	2"	Grade only
Medium	2-4"	Grade, add material and compact
High	> 4"	Cut to base, add aggregate, shape, water and compact

4.1.5. Dust

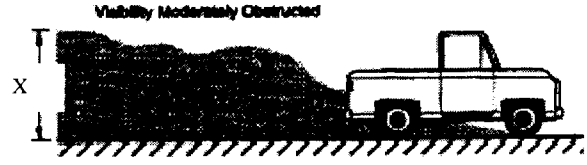


Figure 10: Dust problem

Dust is usually caused by the wear and tear of traffic on unpaved roads. This loosens the large particles from the soil binder and the small particles in the road are blown in the air by traffic. Driving a vehicle at 25 miles/hr and watching the dust cloud determine the dust problem severity.

TABLE 11: Dust severity criteria and the remedies based on the severity.

Severity	Characteristics	Treatment
Low	See –through	Add water
Medium	Visibility moderately obstructed causing traffic to slow down	Add stabilizer
High	Severe visibility problem that causes traffic to slow down significantly	▪ Increase stabilizer use. ▪ Cut to base, add stabilizer, water and compact ▪ Cut base, add aggregate and stabilizer, shape, water, and compact

Dust Control: A variety of dust suppressants are available today and more will continue to be developed in the future. They can be divided into seven basic categories and typical suppressants in each category are as follow:

- Water
- Water absorbing products such as calcium chloride brine, flakes, and magnesium chloride brine
- Petroleum based products such as asphalt emulsions, cutback asphalt (liquid asphalt), dust oils and modified asphalt emulsions

- Organic non-petroleum based products such as animal fats, tall oil emulsions and vegetable oils
- Electrochemical products such as enzymes, ionic products, vinyl acrylic
- Polymer products such as polyvinyl acetate and vinyl acrylic
- Clay additive products such as bentonite and montmorillonite

Appendix 2 gives an overview of these seven categories listing their attributes, limitations, typical application rate, and selection process tips as found in Peter Bolander and Alan Yamada's 1999 manual "Dust Palliative Selection and Application Guide" written for the USDA Forest service

Most dust control in the US is done using calcium chloride, which is a commercial chemical product used to control dust on roads. Calcium chloride helps to control dust conditions by preserving the moisture level in the road surface materials. Calcium chloride is found in liquid and dry (flake) forms. The application rate may vary, depending on the relative quality of materials in a given road surface. Some calcium chloride suppliers may require a road sample before recommending an application rate. Generally, 30% calcium chloride is recommended for most aggregate roads.

Suggestions for using calcium chloride:

- It is best to apply calcium chloride when the road surface is somewhat moist.
- Scarify the road surface with a rake or grader before applying the calcium chloride, assuring a better bond.
- Re-grade or rake the road surface after applying the calcium chloride to mix it uniformly with the surface material.
- Compact the road surface with a roller or a vehicle.
- Reapply calcium chloride as necessary. Successful applications can remain effective for 2 to 3 years.

4.1.6. Slippery surface

Slipperiness on roads is a serious safety problem. Slipperiness is encountered in wet weather conditions. The problem can be caused by three things: excessive fines in the road surface material, plastic material in the wearing surface and lack of adequate cross fall to shed water off the pavement.

Slipperiness can be reduced by:

- Use of clean aggregate or crushed aggregate placed over a surface that provides adequate cross-fall
- Removal of excessive water,
- Grading and reshaping of the surface,
- Removal and replacing the affected area, adding new and clean material

4.2. Equipment

For maintenance of aggregate roads, the following basic equipment is used but not required:

- Motor-grader used for blading, smoothing, reshaping of surface etc. There are many attachments available for ditch cleaning, compacting, racking, etc.
- Pump trucks to transport needed material
- Water truck to add moisture to the road when needed
- Ditch cleaning equipment to improve drainage and recover material
- Mower to improve sight distance
- Shouldering disk
- Grader mounted roller
- Windrow pulverizer
- Rock rake to smooth the surface by rearranging loose surfacing material

In this section we are going to focus on the motor grader as the most used equipment in maintenance and preservation of aggregate roads.

Motor grader:

The motor grader is the most common equipment used in the maintenance of aggregate roads. It has the ability to smooth the surface, cut the surface, mix the material and reshape the surface of the road as needed. There are many types of graders such as rigid-frame motor graders, articulated frame motor graders, single rear-axle motor graders and more, but the general use for maintenance of aggregate roads is the same.

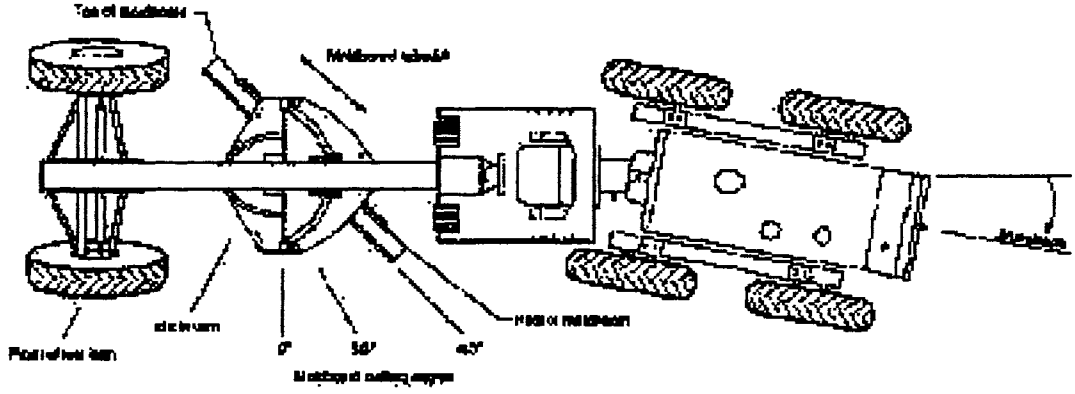


Figure 11: Motor Grader Components

When using a motor grader in the maintenance of aggregate roads, there are three important things to consider:

- Moldboard: the blade at the bottom of the motor grader that does the smoothing and the cutting of the surface. The moldboard has a pitch and an angle that is set depending on the maintenance activities to be done. These features are discussed more in the following section.
- Speed of the motor grader during maintenance activities. The ideal blading speed is < 3-5 mph. When the speed is too high, the motor grader will start bouncing and can cause wash boarding in the road surface.
- Articulation: Motor graders that have an articulated frame have an extra feature to help stabilize the motor grader by grabbing slightly.
- Front wheel tilt: This can help keep the grader's front end in place and makes steering easier. The recommended tilt for front wheels is 15 degrees in the direction of the moldboard material.

Moldboard angle and pitch: With proper pitch and angle the material will roll and have a packing action; the wrong pitch can cause the material to ball up, resulting in both the machine and operator having to work harder then necessary.

Moldboard angle can be set to assist the operator with the movement of the material. It is recommended to keep the angle of the moldboard at about 30 to 45 degrees.

Moldboard pitch is also important to determine what kind of maintenance activity the operator is doing. Figure 12 shows 3 different Moldboard pitches for 3 different maintenance activities.

Figure 12: Moldboard pitch

- Case 1: is used for spreading the material;
- Case 2 is used for light blading and dragging action; and
- Case 3 is used for cutting action.

When a material mixing action is needed, the moldboard is moved up and down as the motor grader moves forward.

4.3. Maintenance Activities

4.3.1. Smoothing

Smoothing is also called dragging. It is used to repair small defects. The intent is to smooth the surface without disturbing the existing crust.

Smoothing is done multiple times in a season due to the fact that the surface material moves with the passage of traffic. It is recommended that every third or fourth smoothing should be done in the direction opposite of traffic.

4.3.2. Reshaping

Reshaping is done to restore the shape of the road surface and shoulder and to restore the cross-section of the road. Reshaping the surface and shoulder is done by cutting material and reshaping the road. Reshaping should be done in the spring when there is moisture and no vegetation. Reshaping of the cross-section is appropriate when severe rutting, loss of crown, gravel loss, and deep secondary ditches are present.

The following steps are necessary for reshaping:

- Scarify the road surface
- Cut as deep as the deepest defect
- Add more material if needed to have a good gradation of surface material
- Mix aggregate to obtain a proper blend
- Add moisture
- Restore crown
- Spread and compact material

5. DECISION PROCESS BASED ON CONDITION

This section describes the evaluation and decision process presented in the Department of the Army's Technical Manual 5-626 "Unsurfaced Road Maintenance Management" written in 1995. In addition, a description will be provided of other processes used by specific counties in Minnesota that were identified during county visits.

There are five important steps in establishing a comprehensive maintenance program for aggregate roads.

Step 1: Surveying the road network

Step 2: Establishing a road condition index

Step 3: Setting maintenance priorities

Step 4: Determining maintenance alternatives

Step 5: Calculating actual maintenance costs

STEP 1: Surveying the road network

Survey all roads within the network and divide them into sections. They can be divided by mileposts or by some other logical denominator (possibly sections of a few miles between major intersections). Each road section has to be identified precisely so that it can be located for re-inspections in the future. If needed, sections can be marked with a stake, pin, or other permanent marker behind the ditch line. A sketch of each section should also be made to show sample unit locations.

STEP 2: Condition assessment

Rank the condition of each road segment using the Army Corp of Engineers "Unsurfaced Road Condition Index" (URCI). The URCI indicates the road condition using a scale of 0-100 shown in Figure 13. A hundred denotes that the distress has no impact on the road condition while zero signifies that the road has completely failed.

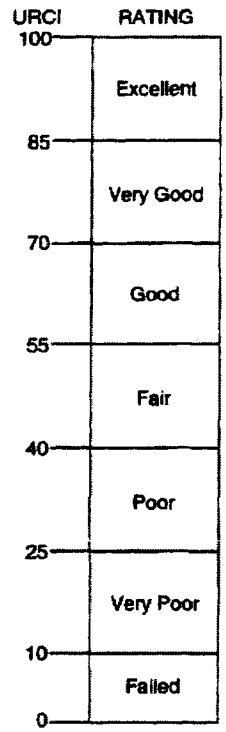


Figure 13: URCI scale and Condition rating

During the assessment process, it is important to be consistent. The structural integrity, capacity, roughness, and rate of deterioration are all reviewed and rated. The Army Corp of Engineers suggests using the DA Form 7348-R, (Unsurfaced Road Inspection Sheet) to record inspection data for each sample unit (see Appendix 3).

During the rating process, the road is inspected for seven defects numbered 81 to 87: improper cross section (81), inadequate roadside drainage (82), corrugations (83), dust (84), potholes (85), ruts (86) and loose aggregate (87). During the inspection, it is also important to note anything unusual at the site such as the existence of standing water in a ditch line. If two or more distresses occur together, measure each one separately. If it is difficult to determine which distress is being observed, make a reasonable guess. The system is robust enough to calculate a reasonable rating, despite the existence of some uncertainty.

There are two methods of inspections. The first is a quick survey done from a moving vehicle. The second involves detailed measurements of distresses in the sample units.

- To perform the first method, called "windshield inspection," drive the full length of the section at 25 miles per hour. Note any surface or drainage problems along the road. If the local area has times of the year when unsurfaced roads need regular maintenance to keep them usable, keep track of where the maintenance was done so that those areas can be inspected during the windshield survey. These inspections should be made four times a year (once each season.) The results can be used for estimating maintenance needs and priorities.
- The detailed sample unit measurements necessary to compute the ratings should be collected annually. Always make these measurements at the same time of year when the roads are in their best and most consistent condition. To make the measurements, the inspector will need to recognize certain kinds of problems described in the previous section, called the defects. To perform a survey, the following equipment is required: a measuring wheel (used to measure distress lengths and areas), a straight edge, and a ruler to measure the depths of the distress.

Calculating the URCI from inspection results is made in four steps. An example can be found in Appendix 3.

Step 1. Calculate the density for each distress type (except dust).

Density = (Amount of Distress/Area of Sample unite) * 100% ----- (eq. 3-1)

Step 2. Using the deduct value curves, find the deduct values for each distress type and severity level. The deduct value curves are in Appendix C.

Step 3. Find the Total Deduct Value (TDV) and the q value. Calculate the TDV by adding up all the deduct values. The q value is the number of individual deducts values greater than 5.0.

Step 4. Find the Unsurfaced Road Condition Index (URCI) from the URCI curve.

STEP 3: Setting maintenance priorities

This step identifies the roads that need routine maintenance, that need periodic maintenance, and the ones that need reconstruction or upgrade. The data required for the identification are the URCI, road rank, traffic, and management policy. Customarily, the lower the URCl and the higher the traffic volume, the greater is the priority. (See Figure 14)

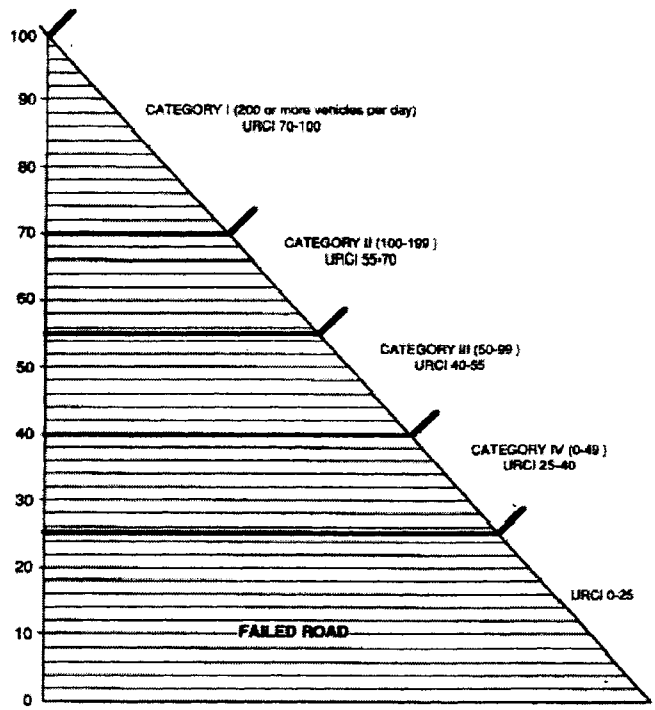


Figure 14: Maintenance priority graph

If the URCI rating is below the solid line for that traffic category, the priority is highest.

STEP 4: Determining maintenance alternatives

To determine the maintenance alternatives it is important to look at the defects of the road and the maintenance options that will improve the road as previously discussed in section 3.1. During the determination of the alternatives, it is important to review:

- Road user cost in terms of travel time, accident cost and vehicle operating cost
- Cost to maintain the road over the pavement life cycle – 20 years = 0
- Salvage value at the end of the analysis period, and

- Cost of the proposal which may be staged over a construction period

  It is beneficial to:
- Estimate the saving in travel time, the reduced probability of accident and the reduced vehicle operating cost if possible
- Project the road user benefits over the next twenty years, allowing for traffic to grow
- Estimate the cost of upgrading the road resulting in changed maintenance costs

STEP 5: Calculating actual maintenance costs

1. Estimate the cost of each alternative of maintenance
2. Select the alternative that provides the most benefits for a lower cost when applied to the road.
3. Prepare a benefit/cost analysis for the road proposal. This step involves four defined steps:
   a. Establish the objective of the proposal and the constraints of implementing it
   b. Determine the alternatives
   c. Estimate the benefits and cost of each alternative over an analysis period and calculate the net present value of each, relative to a base case, which is usually the do-nothing option
4. Rank all roads by priority with the highest priority first and the lowest last.
5. Show the estimated cost to upgrade that road.
6. Calculate the remaining funds and use that amount to maintain the next project until all funds are used up. This enables allocation of money more effectively and, if necessary, justification of requests for additional funds.

TABLE 12: Example of Funding allocation process

Road name	Available funds	Cost to maintain the road	Remaining balance
Co. 1	50,000	25,000	25,000
Co. 2	25,000	20,000	5,000
Co. 3	5,000	10,000	-5,000
Co. 6	0	10,000	Un-funded

PART II: REVIEW OF THE MAINTENANCE COST OF AGGREGATE ROADS

1. BACKGROUND

1.1. Research Project Introduction

This research project has the objective of identifying the methods and costs of maintaining and upgrading an aggregate road. The research goal is to estimate the cost of routine maintenance re-graveling and resurfacing and develop a process to justify upgrading the road to a paved surface when appropriate. By reviewing maintenance activities in different counties it may be possible to identify which factors affect maintenance costs. With this knowledge, we can more effectively predict aggregate road maintenance costs.

County maintenance cost data and interviews of county personnel provided input data and information for this effort. Statistics for Minnesota's highway system are provided in Table 13. As we see, 51% (68,790 miles) of total roads in the state of Minnesota are aggregate roads and 37% (50,410 miles) of all roads are bituminous.

TABLE 13: Minnesota Roads by Surface type[5]

Surface Type	Miles	% of Total Roads System
Brick/aggregate	57	0%
Bituminous	50,410	37%
Concrete	2,248	2%
Dirt/Soil	7,517	6%
Aggregate	68,790	51%
Unknown	6,468	4%
Total	**135,489**	

A review of road ownership shows that 33.5 % of total roads in Minnesota are built and maintained by counties (in Table 14).

[5] http://www.dot.state.mn.us/tda/products/reports/mileagereports.html, Report 4, OFFICE OF TRANSPORTATION DATA AND ANALYSIS, Statewide Mileage and Lane Miles, 7/6/2003

TABLE 14: Minnesota statewide total mileage – by route system[6]

RLG.ROUTE-SYSTEM	MILES	% of Total Road System
INTERSTATE TRUNK	913.9	0.7%
U.S. TRUNK	3,225.4	2.4%
MINNESOTA TRUNK	7,793.2	5.8%
COUNTY STATE AID	30,385.0	22.4%
MUNIC. STATE AID	2,817.7	2.1%
COUNTY	15,016.2	11.1%
TOWNSHIP	55,210.2	40.8%
UNORG. TOWNSHIP	1,234.4	0.9%
MUNICIPAL STREETS	15,774.5	11.6%
NAT. FOREST DEVEL.	1,166.3	0.9%
INDIAN RESERVATION	381.7	0.3%
STATE FOREST	1,187.6	0.9%
STATE PARK	166.4	0.0%
MILITARY	186.5	0.1%
TOTAL	**135,459.0**	

The state of Minnesota has 87 counties; counties maintain county roads and county state aid highway (CSAH) only, unless there is a special agreement with other entities. Each county is divided into townships and these townships are responsible for the roads. The counties assist the townships to varying degrees, depending on local agreements. As discovered during county visits, these agreements vary widely from county to county and from township to township.

[6] http://www.dot.state.mn.us/tda/products/reports/mileagereports.html, Report 1, OFFICE OF TRANSPORTATION DATA AND ANALYSIS, Statewide Mileage and Lane Miles, 7/6/2003

1.2. Methodology

The following steps were taken in this research:

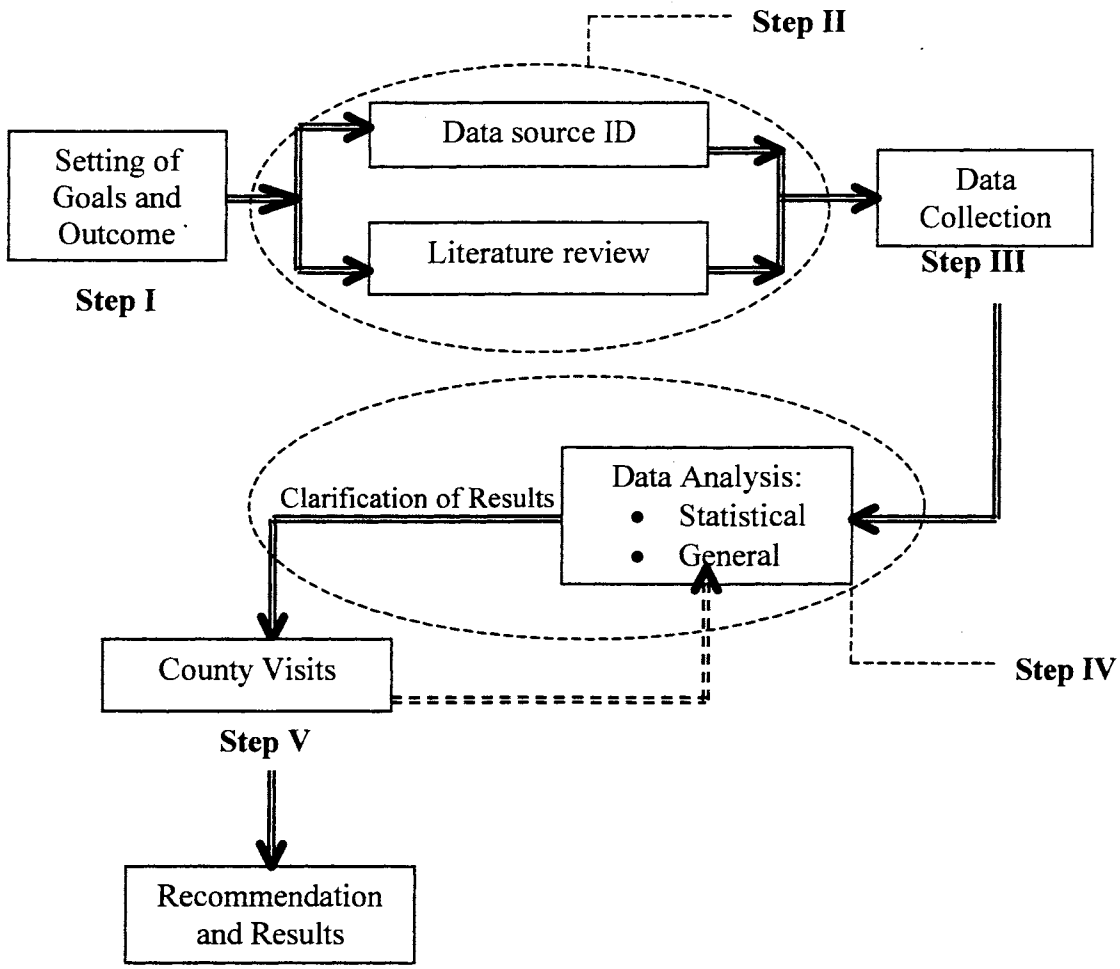


Figure 15: Research Approach.

STEP I: Setting of Goals and Expected Outcomes

This step was accomplished during a meeting with the research project steering committee, which includes representatives from Minnesota Local Roads Research Board (LRRB), MN/DOT and Iowa State University. A list of the members is found in Appendix 5. The main goal that was set at this meeting was to develop a set of relationships that can be modified to address local conditions and be used to aid in the decision process of maintaining aggregate roads, including whether or not to upgrade the aggregate road to a paved surface. The relationship will estimate the cumulative maintenance cost per mile for various types of roads under various conditions. These relationships are expected to show how the maintenance cost of aggregate roads, lightly surfaced roads, and HMA roads may vary with traffic, age, and type of surface.

STEP II. Identify a source of data to be used in the research project and conduct an extensive literature review (summarized in part I of this report)

A visit to Waseca County and Olmsted helped identify data to be used in the project. These counties were chosen as a consequence of their history of good record keeping. After the first meeting a second visit was scheduled to review county reports. During the second visit to Waseca County, the county engineer provided an annual report sent to the MN/DOT State Aid Office (SA) in Saint Paul, MN. This report provided a detailed summary of maintenance costs by route. An example of such a report can be found in Appendix 6; more information on the data used is described in part II.2.2. of this thesis.

STEP III. Data collection

The collection of data included a review of the reports found in the MN/DOT SA office in St. Paul and identifying the counties that provided consistent reports containing the level of detail determined in Step II. This permitted the team to narrow down the number of counties that had a potential to be used in the research project and from there, narrow down the counties further to the ones to be used in the research project. This selection process is further discussed in section 3 of this chapter.

STEP IV. Analysis

This step included two different analyses; a statistical analysis of the data and a general review of the data to identify trends and find ranges in cost.

STEP V. County Visits

After the data analysis phase, it was decided that other visits to the counties were needed to further clarify how the data was collected and to ascertain the extent to which the results can be generalized. In some cases, further analysis was required after the county visits.

STEP VI. Results and Recommendations

This step involved drawing conclusions and recommendations as a result of the analysis.

2. DATA COLLECTION

Step II of the research project identified the annual reports submitted by counties to the SA office as data to be used for our analysis. A visit to the MN/DOT SA office revealed that reports from 1997 – 2001 were available with 40% of the counties providing information at a level of detail similar to or better than that of Waseca County (see Appendix 6).

In each report, roads are grouped based on classes. There are four classes that denote four sources of funding:

1. County State Aid Highways Regular (CSAH): the roads in this class are owned by the counties but funded by the state.
2. County Roads: the roads in this class are owned by the counties and funded by the counties.
3. County State Aid Highways Municipal (CSAH Mun.): the roads in this class are owned by municipalities but funded by the state.

4. Townships: The roads in this class are owned by the townships and funded by the townships.

The report is prepared as an expense report detailing how the SA funding was used during the period of January 1st through December 31st of each year.

To explain the data in more detail, the reader is referred to the 2000 - Blue Earth County report, County State Aid Highway (CSAH) cost (Appendix 6). The cover sheet of the report contains a summary of all the costs in the report by class and account number; the costs provided are total cost and cost/mile. For example, if we look at routine maintenance of CSAH roads: the total amount spent for 406.46 miles of roads (found at the bottom of the class) was $767,063.75 and the cost/mile was $1,887.18.
The next part of the report is a summary of the maintenance cost of the specific class of roads – (shown on pages 2 and 3 of the report). The summary costs are divided into five major categories: routine maintenance; repair and replacement; betterment; special work; and special agreements. All but special agreements will be discussed. The report also contains the costs per road and surface type. For example, referring to the report for Blue Earth (Appendix 6), County Road (CR) 3 consists of 2.91 miles of aggregate road and 2.3 miles of bituminous road. The costs for each of the five categories are provided for each surface type.

The next pages of the report have each of the 5 categories subdivided into more factors. The division of the five main categories are shown in Table 15 and explained in more detail in Appendix 7.

TABLE 15: Categories of Maintenance Activities

Routine Maintenance Smoothing Surface* Minor Surface Repair* Cleaning Culverts & Ditches Brush & Weed Control Snow & Ice Removal Traffic Services & Signs	**Repairs and Replacements** Reshaping* Resurfacing** Culverts, Bridges, Guardrails Washouts
Betterments New Culverts, Rails or Tiling Cuts & Fills Seeding & Sodding Bituminous Treatments	**Special Work** Dust Treatments* Mud Jacking & Frost Boils* **Special Agreements**

* Costs related to routine maintenance of road surface
** Costs related to periodic maintenance of road surface

Some of the cost categories are affected by the choice of road surface and some are not. In the research we were only interested in costs affected by choice of surface. Some costs (like snow and ice removal) may be partly affected by the surface. For simplicity, it is assumed that the surface type does not influence costs such as snow and ice removal.

3. SELECTION OF COUNTIES

The selection of the counties to be used in the study was first based on the type of report submitted to the SA office. There were no guidelines set by the SA office on the required level of detail for the cost information submitted. Therefore the level of detail varied considerably. In some case, the level of detail varied from year to year for the same county.

Table 16 shows three counties and the detail of the report provided. There are cases where detailed reports are provided in both 1998 and 2000 (County A for example). There are other cases where counties provided details in 1998 but not in 2000 (County B for example), there are cases where counties provided little detail in either years reviewed (County C for example).

TABLE 16: Example of details provided by counties to the SA office.

County	Year	Report broken down by road	Report broken down by surface type	Sub-detail broken down
A	1998	Yes	Yes	Yes
	2000	Yes	Yes	Yes
B	1998	Yes	Yes	Yes
	2000	Yes	Yes	No
C	1998	No	No	No
	2000	No	No	No

Out of the 87 counties in Minnesota, 22 counties provided a report with a level of detail that was adequate for our purpose (similar or better than the Waseca county data). Thirteen (13) counties were initially selected as a sample, as shown in Table 17. The criteria considered for selecting counties were as follows:

- Soils: The states of Minnesota's sub-base soils were identified as clay soils and sandy soils.
- Geographic location that also determines predominant sub-base type: These areas were identified based on the land use:
    - Marsh areas – not used; have drainage problems,
    - Lake regions – mostly sandy soils, but can have problems due to the lakes, and
    - Agricultural lands where the soil has been drained but is mostly clay.
- Traffic characteristics: This classification identified counties that have agricultural traffic and tourist areas where the traffic is high during certain periods of the year.
- Trends in the population growth (growth and increase of traffic): this classification identified counties with a growth in population in urban areas and counties losing population in rural areas

TABLE 17: Selection of counties used in the study

County	Soil		Geographic			Traffic type		Population	
	Clay	Sand	Marsh	Lake	Agr.	Agr.	Tourist	Urban	Rural
Aitkin			x				x		
Becker	x								
Benton		x							
Blue Earth					x	x			
Chicago		x							x
Crow Wing			x				x		
Kandiyohi		x							
Lake				x			x		
Mahnomen	x								
Martin					x	x			
Meeker		x							
Norman	x								
Rice					x	x			x
Waseca					x	x			
Winona						x			

Another source of data used was traffic maps. These maps are prepared and provided by the state of Minnesota every two years. The Average Annual Daily Traffic (AADT) is given for road segments that have similar traffic levels. The segmentation based on AADT does not necessarily coincide with a pavement type; this results in challenges when researchers try to analyze this information. The maps served as a source of data for an investigation of possible correlations between AADT and the maintenance cost of roads.

4. DATA ANALYSIS AND RESULTS

As reported previously, thirteen counties were selected to be used in this investigation and interviews were conducted in seven locations. Personnel at two of the counties (Waseca and Olmsted) were interviewed at the beginning of the project to help guide the research and identify a data source that could be used in the research. Personnel at five other counties (Meeker, Blue Earth, Benton, Aitkin and Kandiyohi) were selected for interviewing to clarify the anomalies in the data found in the cost reports to the SA office. The interviews were also conducted to identify similarities and differences in classification of cost between cost categories.

During the interviews, the most important finding was that even though the annual reports were similar, the classifications of the activities and their cost were not consistent. For this reason, the results of this thesis will provide an overall cost breakdown statewide based on the seven counties visited and then a summary of the maintenance practices and costs of each of the counties visited.

4.1. Summary of Maintenance Practices and Cost in Visited Counties

4.1.1. Maintenance Practices

Routine Maintenance

Most visited counties' routine maintenance activities include blading, mowing, stabilization/dust control when needed and winter maintenance.

1. Blading: the majority of counties visited have a similar maintenance plan:
   Blade the roads once every 2 weeks on the average and spot treat with aggregate as needed throughout the year.
2. Mowing: The policy for mowing in all counties is, to mow the edge of the shoulder all summer and after Aug. 1 mow the ditches.
3. Stabilization/Dust control policy: This activity varies by county. Some counties pay for the full treatment of all roads; other counties and residents share the costs of the treatments; and some of the counties do not provide any treatment but recommend a

product. All counties visited use or recommend Calcium Chloride ($CaCl_2$) for dust control.

4. Winter maintenance strategy/policy: This policy also varies by county. Some counties clear aggregate roads after the accumulation of 2" of snow and others at 4". Some counties have one shift for clearing roads and others have two shifts. Most counties agree it is a good policy to leave a snow pack on the road to reduce the loss of aggregate.

Periodic Maintenance

Periodic maintenance includes re-graveling roads and repairing drainage as needed. Most counties re-gravel on a 2-5 year cycle. The amount of gravel used to re-gravel depends on the cycle length. All counties use a class 5 modified aggregate. The modification relates to adding fines to the aggregate mix as needed or reducing the size of the largest material to prevent car damage.

4.1.2 Equipment

The most used equipment in maintenance of aggregate roads is the tandem truck (for re-graveling and winter maintenance) and motor graders. Some counties such as Blue Earth County own equipment to be used for dust control, but most counties contract out the work.

Six visited counties' equipment purchases were based on winter maintenance needs with one exception. In Waseca County, the administration is faced with a lack of gravel source and the purchase is based on summer maintenance.

TABLE 18: Equipment replacement cost and life cycle

Equipment	Replacement		Salvage value ($)	Cost of new ($1,000)
	Miles or Hours	Age/ Cycle		
Trucks	225,000 miles	6-12	27,000	100 - 200
Motor Grader	12,000 hours	6-15	40,000	100 - 220

4.1.3. Cost Comparisons

Overall Cost Breakdown State Wide Based on the Seven Counties Visited

During the analysis phase of the research, anomalies were discovered that led to a close review of the data used in the study. The total average maintenance cost/mile for all seven counties (shown in Table 18 and Figure 16) revealed large differences in the maintenance costs for aggregate roads.

TABLE 19: Average Total County Maintenance cost/mile

Counties	Miles of roads	Total Average Maintenance cost/mile
Waseca County	132.0	4,639.0
Olmsted County	158.0	5,847.1
Aitkin County	312.0	3,283.4
Meeker Count	63.8	898.5
Blue Earth County	294.0	3,412.8
Benton County	115.0	2,239.0
Kandiyohi County	235.0	2,870.1

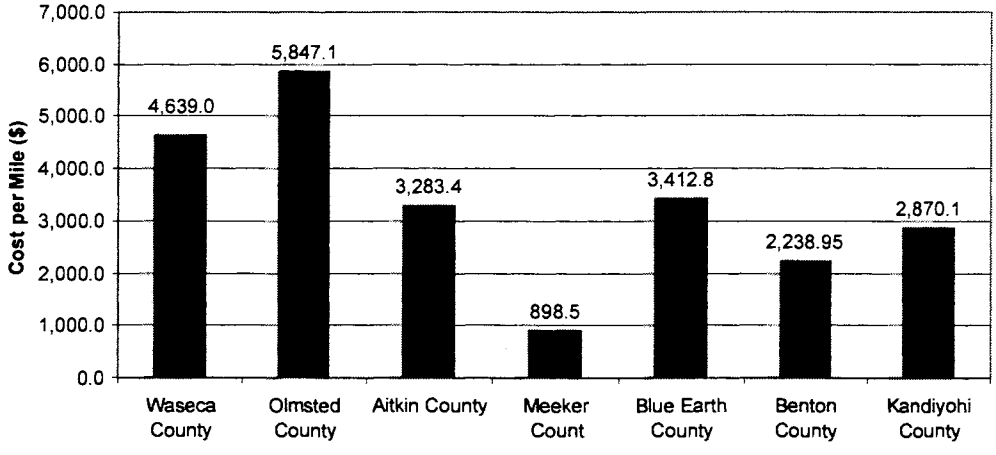


Figure 16: Comparison of the Total Average Maintenance Cost For all the 7 counties Visited.

For example, in Figure 16, the maintenance cost/mile for Meeker County is half to one third that of other counties. The reason the cost of maintenance in Meeker County is much lower than any other county is explained in the section on Meeker County report. Meeker County data was therefore not included in calculation of the total average maintenance cost/mile.

The maximum maintenance cost in the 7 counties visited was $5,850 and the minimum is $2,239. The average cost for the six (6) remaining counties is $ 3,715/mile. As we will find, in each county report these costs vary from year to year and this variation can be caused by variables including weather, soil type as well as other factors.

Waseca and Olmsted counties were also eliminated from the rest of the state summaries due to a lack of detail in the reports. A review of the annual reports for the four remaining counties was performed by graphing the major categories as described in Table 15 and then reviewing of all the categories together. Conclusions were subsequently made.

Comparisons of Average Maintenance Costs by Category

A breakdown of total maintenance cost/mile for aggregate roads by major categories (Figure 17) shows that routine maintenance (46%) and repair and replacement (38%) account for the largest portion of the cost.

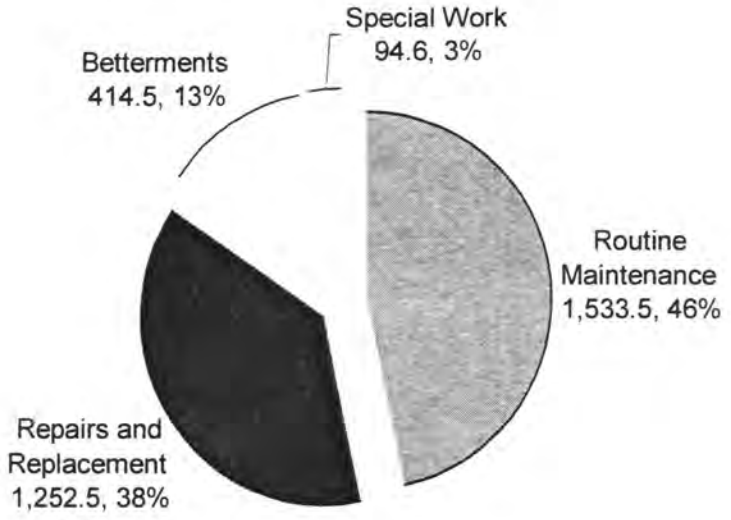


Figure 17: Four County Total Maintenance Costs by Major Categories

A review of routine maintenance categories (Figure 18) shows that Smoothing Surface is 44% of the cost and Snow and Ice Removal is 24 % of the cost in that category.

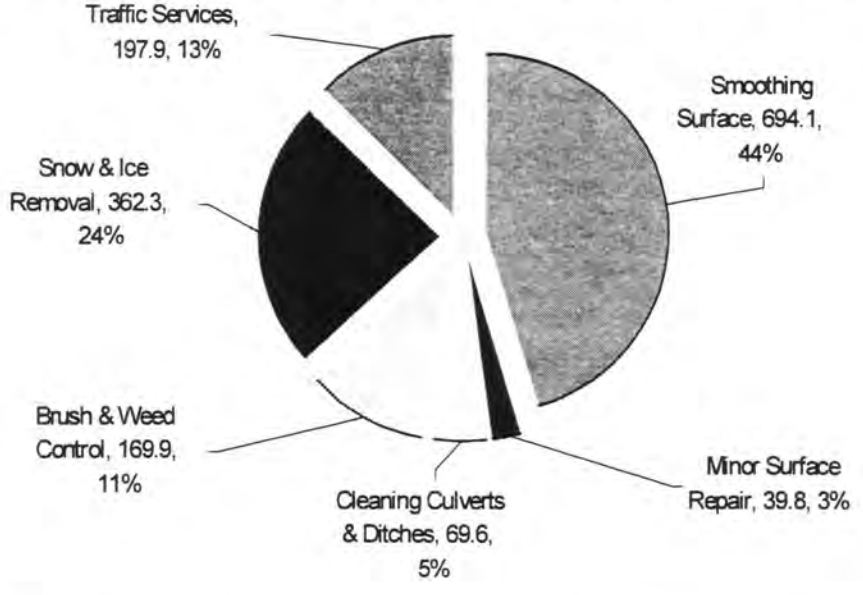


Figure 18: Four County Average Routine Maintenance Cost/Mile

A review of the repair and replacement category (Figure 19) shows that resurfacing represents 83% of the costs in this category. Also note that repair and replacement can be classified as a periodic maintenance category.

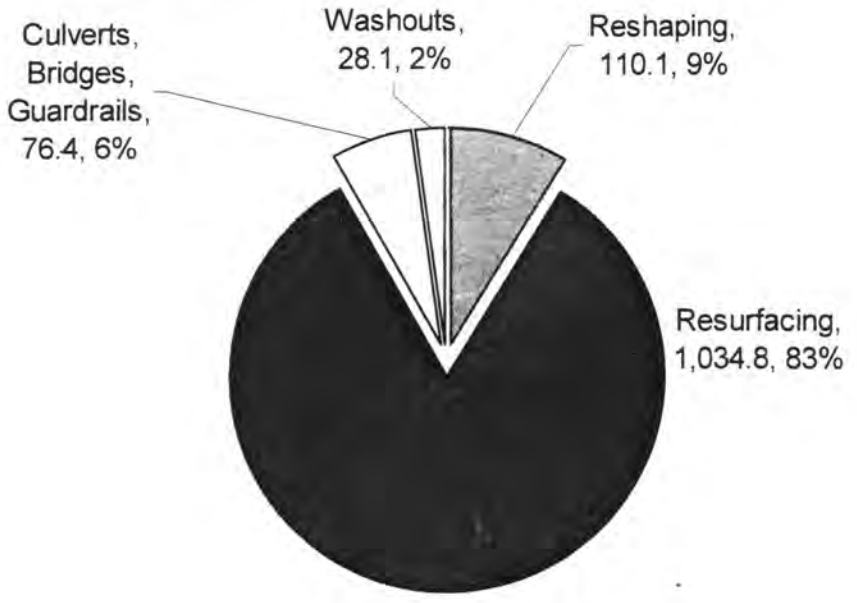


Figure 19: Four County Average Repair and Replacement Cost/Mile

If all sub-categories are combined (Figure 20), we find that resurfacing is 31% of the total maintenance cost, followed by smoothing surface at 21% and snow and ice removal at 11% of the total maintenance cost.

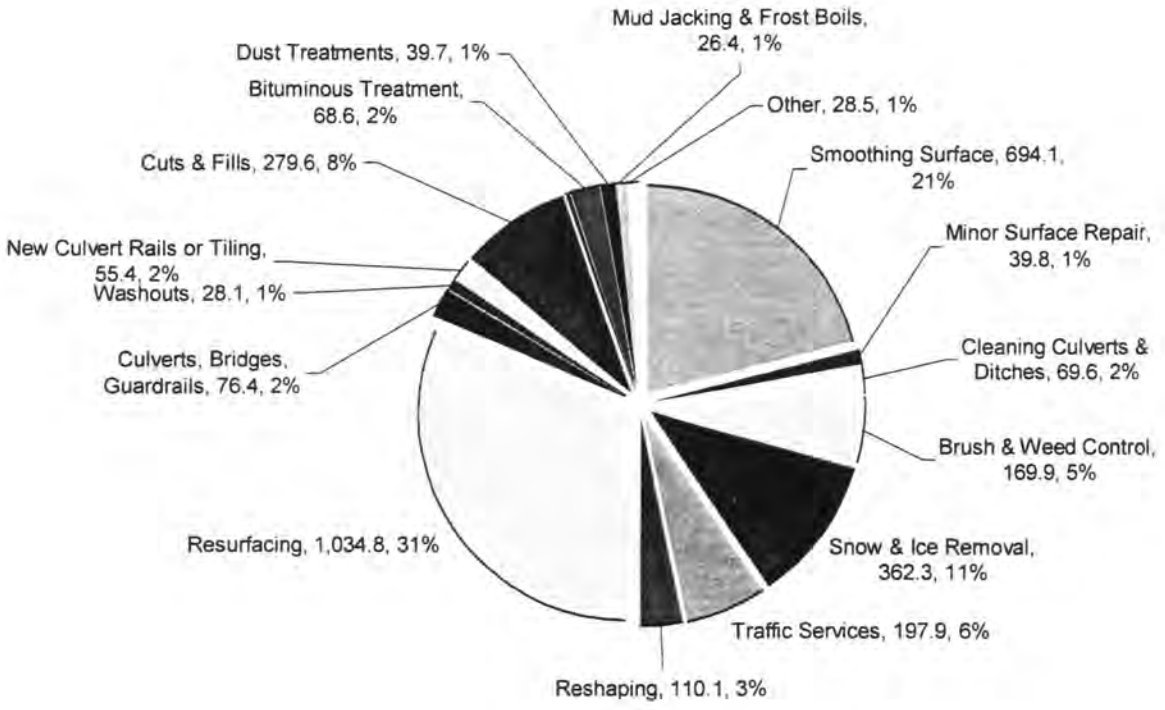


Figure 20: Four County Average Maintenance Cost by Sub-categories

TABLE 20: Maintenance Activities vs. Its Influence to the Total Cost

Maintenance Activity	% of Total Cost
Resurfacing	31%
Smoothing Surface	21%
Snow and Ice Removal	11%
Cut and Fill	8%
Traffic Services	6%
Brush and Weed Control	5&
Dust Treatment	1%

Table 20 shows how maintenance activities rank. If we combine activities that are influenced by the surface type as shown in Table 15, we find that these activities account for 57% of the total cost.

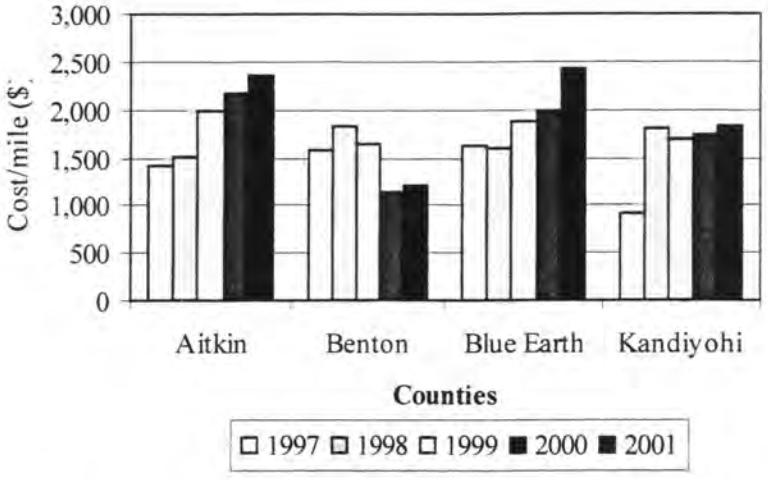


Figure 21: Four Counties Maintenance Cost/Mile by Year

Figure 21 provides an overview of total maintenance cost/mile for each county by year.

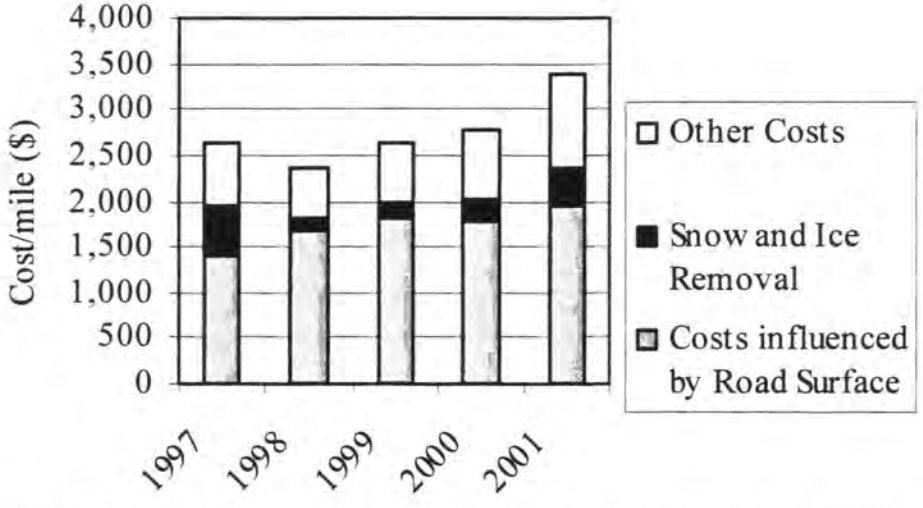


Figure 22: Four Counties Maintenance Cost/Mile by Year by Category

Figure 22 shows both the average maintenance cost/mile by year and the costs influenced by the road surface. Figure 23, 24 and 25 and Tables 21 and 22 shows the costs influenced by the road surface/mile and total costs with maximum, minimum, medians, 25 and 95 percentile costs. From these figures and tables we can see how much these costs are variable and how, without a detailed review of the influence of the cost, it is hard to generalize the results.

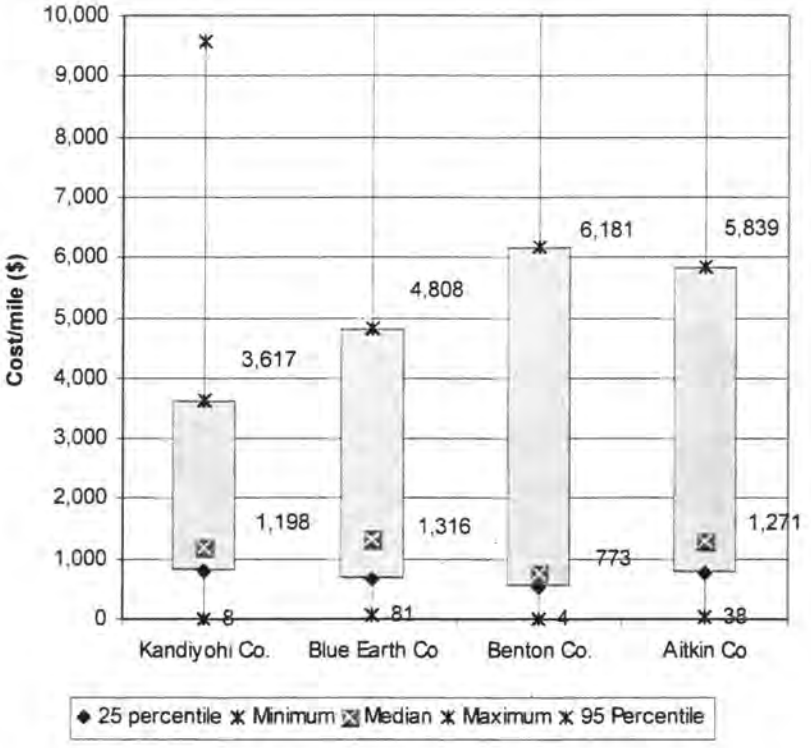


Figure 23: Four Counties Maintenance Cost/Mile influenced by Surface type Max, Min, Median and Percentile

TABLE 21: Four Counties Cost/mile influenced by the surface of the road 's Maximum, Minimum Medians and Percentiles

	Kandiyohi Co.	Blue Earth Co	Benton Co.	Aitkin Co
25 percentile	804	659	517	750
Minimum	8	81	4	38
Median	1,198	1,316	773	1,271
Maximum	9,572	13,195	13,147	13,360
95 Percentile	3,617	4,808	6,181	5,839

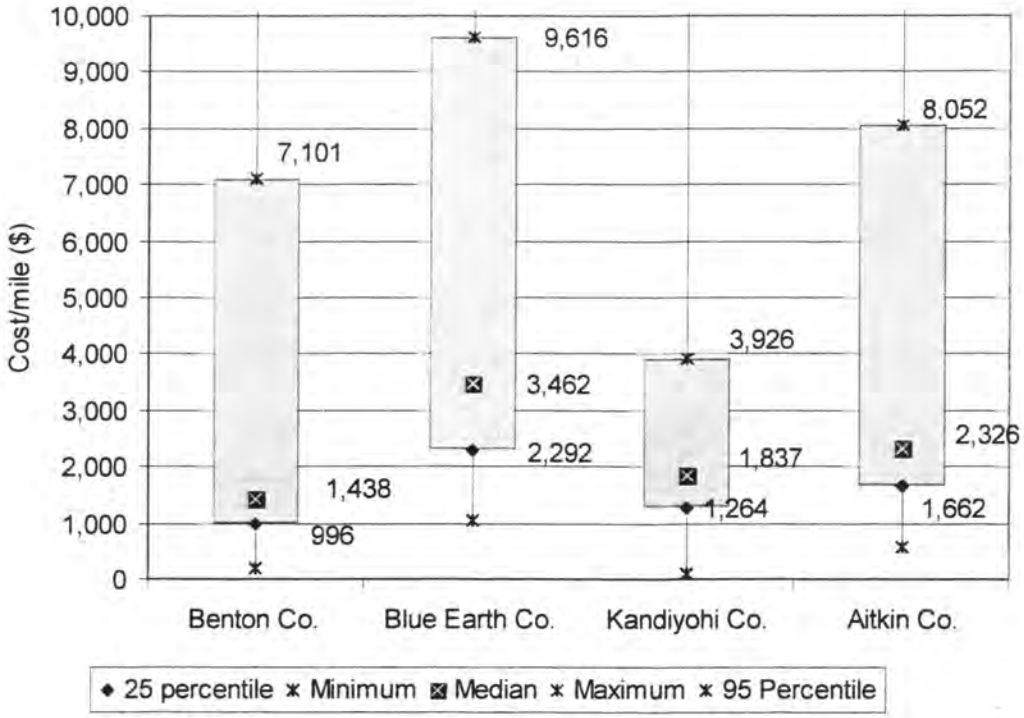
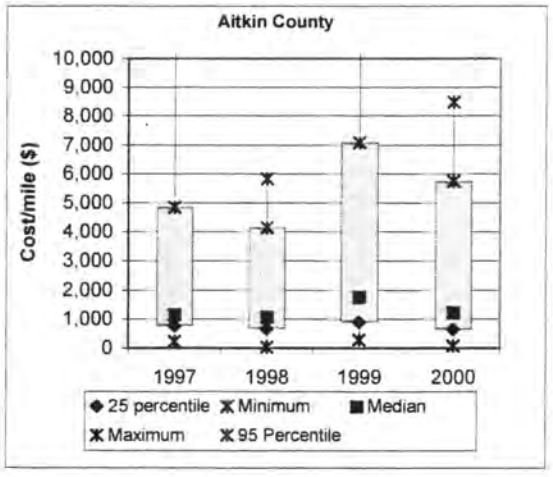
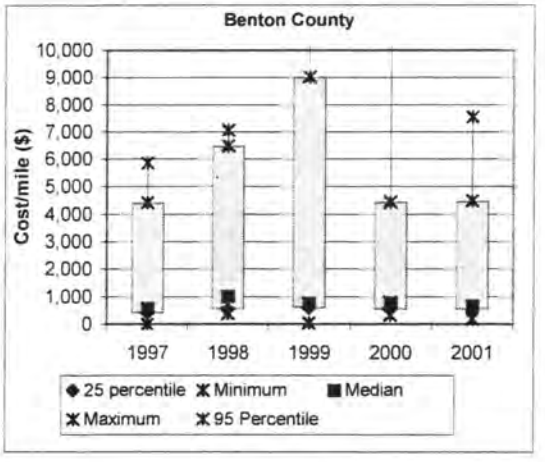


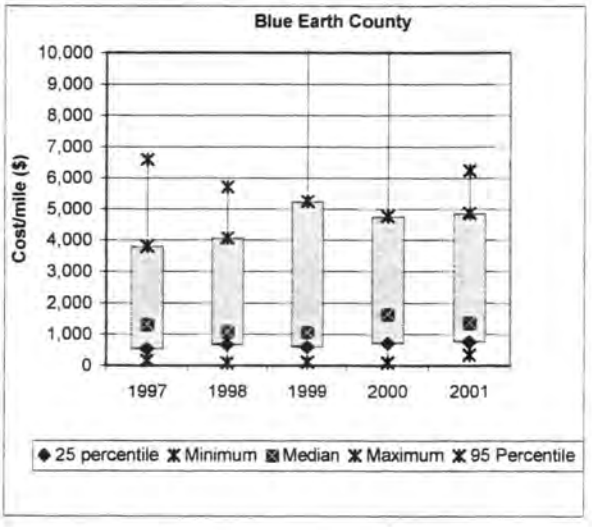
Figure 24: Four Counties Total Maintenance Cost/Mile Max, Min, Median and Percentile

TABLE 22: Four Counties Total Cost/mile's Maximum, Minimum Medians and Percentiles

	Benton Co.	Blue Earth Co.	Kandiyohi Co.	Aitkin Co.
25 percentile	996	2,292	1,264	1,662
Minimum	182	1,050	91	574
Median	1,438	3,462	1,837	2,326
Maximum	51,201	55,232	10,241	26,765
95 Percentile	7,101	9,616	3,926	8,052







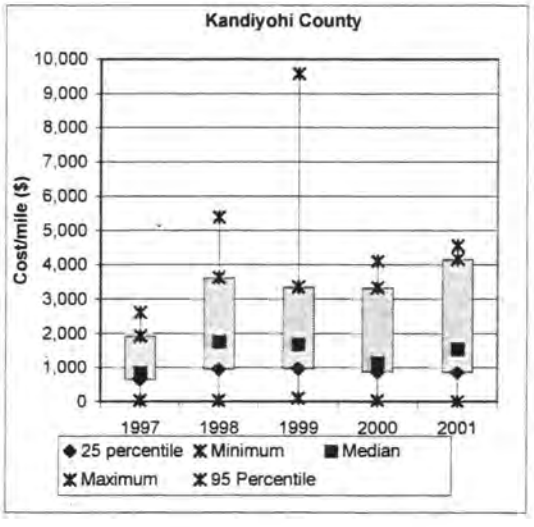


Figure 25: Counties Maintenance Cost/Mile influenced by the surface Max, Min, Median and Percentile by County

Average Maintenance Costs vs. AADT

Using AADT data from traffic maps provided to the research project by the counties allowed for this portion of the research data analysis. In most counties the AADT data is updated every two years by the state of Minnesota. From this information and the annual reports, the researchers were able to make a comparison of maintenance costs based on AADT. Roads were grouped based on the AADT as shown in Table 23 and then a comparison was made.

TABLE 23: Traffic Volume Categories

Traffic Volume Categories
0-49
50-74
75-99
100-124
125-149
150-199
200-249
250-299
300-up

A summary of the four counties reviewed is shown in Table 24 and in Figure 26. The maintenance cost/mile for aggregate roads increases at a range of 100 AADT and then again at 200 and above. From this graph we prove that aggregate roads are not cost effective when the AADT is above 200.

TABLE 24: Maintenance Cost/Mile by Traffic Range and Category

AADT	Miles / Categories	Costs Influenced by Road Surface	Percent of Total Cost	Other Costs	Snow & Ice Removal	Total Cost/Mile
0-49	1,221	1,837	**60%**	776	457	3,070
50-74	1,672	1,780	**55%**	952	509	3,241
75-99	686	1,842	**48%**	1,478	544	3,864
100-124	264	2,968	**64%**	1,053	588	4,608
125-149	255	2,311	**64%**	623	703	3,637
150-199	175	1,532	**51%**	844	620	2,996
200-249	46	3,073	**73%**	680	458	4,211
250-300	7	2,747	**53%**	1,617	804	5,168
301-999	52	1,847	**41%**	2,036	579	4,462

The mileage by category (shown in Table 24) is a total of all the roads in the 4 counties used in this portion of the study for the 5 years studied. The total maintenance cost/mile is based on the average maintenance cost of the miles shown in the table.

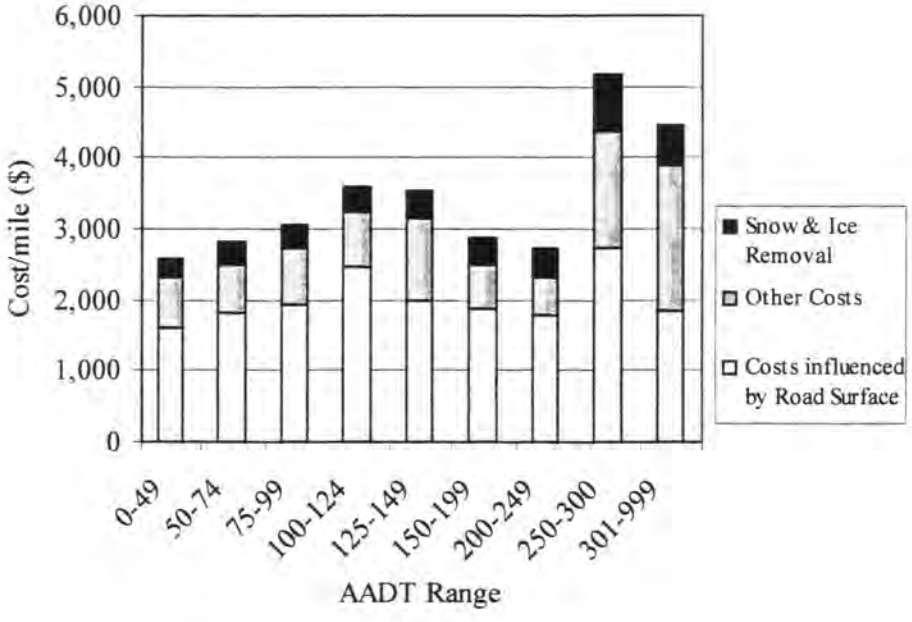


Figure 26: Four Counties Average Maintenance Cost/Mile vs. AADT

4.2 County Visit Reports

County visit minutes can be found in Appendix 8

4.2.1. Waseca County

Waseca County is located in south central Minnesota as shown on the map. Most of the soil in Waseca is clay and drains fairly well. The county contains 415 square miles, 12 townships, 5 municipalities and a total population of 19,526 citizens. The Waseca County Highway Department is responsible for the maintenance and construction of 383 miles of county and CSAH roads (shown in Table 25) and does not maintain any roads for townships or cities.

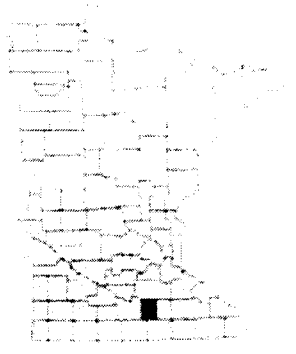


Figure 27: Waseca County Location

TABLE 25: Waseca County Road Miles by Source of Funding and by Surface Type

Funding	Miles of Road by Surface Type in 2002[7]		Total Miles/ Funding	% of Total Roads
	Aggregate	Bituminous or Concrete		
CSAH Regular	0	191	191	50%
County Roads	132	60	192	50%
Total Miles/Surface Type	132	251	383	

Waseca County has 3 to 4 gravel sources outside the county with a haul distance of 15-20 miles on the average. For this reason the purchase of equipment is based on summer maintenance. Waseca County equipment, cycle and replacement values can be found in Table 26.

[7] Waseca County Website - http://www.co.waseca.mn.us

TABLE 26: Waseca County Equipment, Cycle and Replacement Value

Equipment	No. Owned	Age/Cycle	Replacement Value
Trucks	6	8	$125,000
Motor Grader	4	8	$150,000

Routine Maintenance

Waseca County routine maintenance of aggregate roads includes blading, mowing, stabilization/dust control when needed, and winter maintenance. The county's policies and practices are as follow:

5. Blading: The blading schedule is as follow:
    i. Spring: Once every 2 weeks
    ii. Summer: Once a month or dependant on operator time availability and complaints.
    iii. Fall: Once every 2 weeks after re-graveling is completed.

    Roads are also spot treated with gravel as needed throughout the year.
6. Mowing: The policy for mowing is to mow the edge of the shoulder during summer. After August 1 the top of the ditches, the in-slope, and some ditch bottoms are mowed. Waseca County also sprays all the ditches for weeds each year.
7. Stabilization/Dust Control Policy: The County recommends the use of calcium chloride ($CaCl_2$) for dust control. The county does not pay for any treatment unless the road is a designated detour route. However, homeowners and businesses can contract with independent contractors directly if desired.
8. Winter Maintenance Strategy/Policy: The County only has one shift that goes from 4AM to 4PM in the winter. The strategy is to clear the roads with high volume first and clear the other major roads before the school buses go out.

Periodic Maintenance

Periodic maintenance is primarily composed of re-graveling roads and drainage repairs as needed. The county re-gravels a third (1/3) of the road system each year in late

summer or early fall. Approximately 400 yd^3/mile is placed for a total of 20,000 yd^3 a year, using a modified class 5 gradation of gravel for re-graveling. They pay \$2.65/yd^3 for crushed gravel in a stock pile at the source and load and haul it themselves. With a 15 to 20 mile haul for the gravel, this activity utilizes considerable county equipment and employee time.

Maintenance Cost

The reports used in this study from Waseca County did not have all cost categories broken down. The cost influenced by the road surface could not be calculated. Therefore routine maintenance is shown as a separate cost for comparison.

The average maintenance cost for Waseca County shown in Table 27 and Figure 28 show that the actual maintenance cost does not vary greatly from year to year. The average routine maintenance cost is \$1,136/mile and the average total maintenance cost is \$4,639/mile.

TABLE 27: Waseca County Maintenance Cost/Mile (\$)

Year	Routine Maintenance	Total Maintenance
1997	1,570.5	4,703.5
1998	1,060.1	5,345.2
1999	1,008.8	4,464.2
2000	881.5	4,648.8
2001	1,157.7	4,033.3

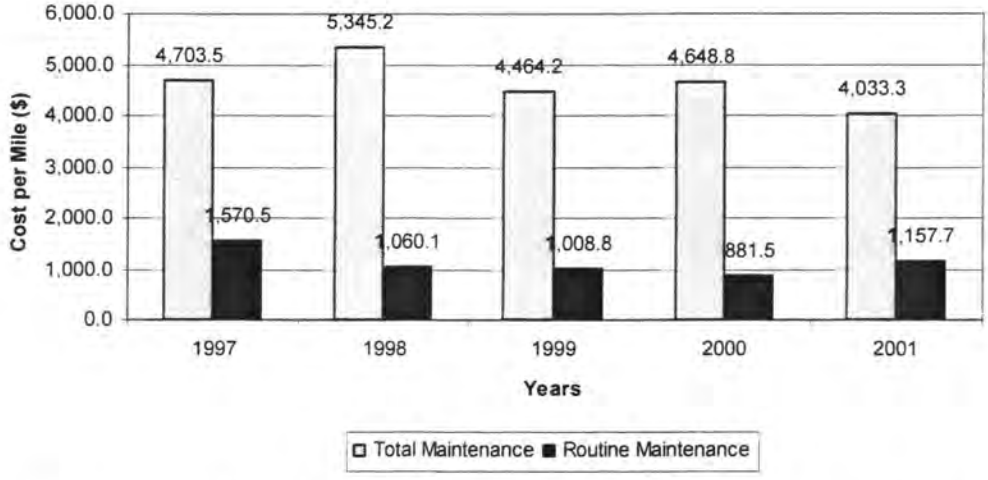


Figure 28: Waseca County Routine and Total Maintenance Cost/Mile per Year

A review of Figure 28 also shows that the average maintenance cost/mile ranges from $4,033/mile to $5,345/mile.

4.2.2. Olmsted County

Olmsted County is located in the Southeastern part of Minnesota and is an area with a sub-grade of sandy soils that drain well, with pockets of clay. The county contains 653 square miles, 18 townships, 8 municipalities, and a total population of 124,277.[8] The county has 4 to 5 sources of gravel. Olmsted County road classifications are shown in Table 28.

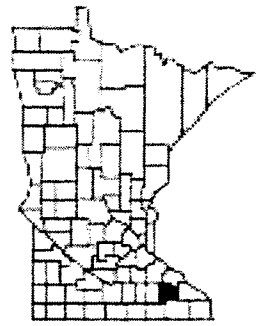


Figure 29: Olmsted County Location

The county also contracts maintenance of roads with 7 townships: Rock Dell, High Forest, Pleasant Grove, Elmira, Haverhill, Viola, and Eyota.

TABLE 28: Olmsted County Miles by Source of Funding and by Surface Type

Funding	Miles of Roads by Surface Type in 2002		Total Miles/ Funding	% of Total Roads
	Aggregate	Bituminous or Concrete		
CSAH Regular	10	310	320	28.0
CSAH Mun.	518	100	618	54.0
County Roads	148	58	206	18.0
Total Miles/Surface Type	676	468	1,144	

Equipment

Olmsted County equipment purchase is based on winter maintenance. The county spends $500,000 to $600,000/year on new equipment (the list of equipment, life cycle and replacement cost are shown in Table 29. Olmsted County also rents their motor graders to private parties at a rate of $70/hr.

[8] Olmsted County Website at http://www.olmstedcounty.com/

TABLE 29: Olmsted County Equipment Schedule Life Cycle and Replacement Value

Equipment	No. Owned	Replacement Age/Cycle	Replacement Value
Motor Grader	9	15 year	$220,000
Tandems	17	8 year	$150,000
Mowers	9		

Routine Maintenance

1. Blading: Blading is done on arterial roads on an average of every 3 to 4 weeks and on minor arterials every 6 to 8 weeks. During this process crown correction is done and additional aggregate is added as needed.

2. Mowing: The county mows the edge of the shoulder before August 1. After August 1, it mows the in-slope and ditch bottom of all roads.

3. Stabilization/Dust Control Policy: All intersections and fronts of residences are treated with $CaCl_2$ once a year in June. The county bids out 400,000 gallons of $CaCl_2$ at a cost of $1700/mile placed on the road.

   The county has also used other stabilization techniques such as geotextile fabrics to separate layers on Co. Rd. 9 and breaker runs on Co. Rd. 7.

4. Winter Maintenance Strategy/Policy: All county roads are plowed first before any township roads are done. The county begins plowing after an accumulation of 2 inches or more and uses two shifts for snow plowing. The first shift starts at 4 AM, working a 12-14 hour shift. The second shift works from 4 PM to midnight. A motor grader clears aggregate roads and sometime class 2 aggregate is spread on the road to improve traction.

Periodic Maintenance

Periodic maintenance in Olmsted County is mainly composed of re-graveling roads. Re-graveling is done each spring with 27 miles done every year resulting in a 5-year cycle. The county places 790 to 950 yd^3/mile which is equivalent to 2 inches of compacted aggregate, and spends $128,000 total or $4,700/mile. The re-graveling process used by the county involves spreading gravel on the road surface, watering the surface and rolling. This process only allows 2-3 miles to be maintained a day.

Maintenance Cost

Reports used in this study from Olmsted County did not have all cost categories broken down. The cost influenced by the road surface could not be calculated so routine maintenance is shown as a separate cost for comparison.

TABLE 30: Olmsted County Maintenance Cost/Mile ($)

Year	Routine Maintenance	Total Maintenance
1997	2,011.51	4,388.56
1998	1,544.10	4,993.61
1999	1,700.49	6,059.06
2000	2,094.27	7,947.16

The average maintenance cost for Olmsted County shown in Table 30 and Figure 30 show that the actual maintenance cost has increased in 1999 and 2000. A review of Figure 30 also shows that the average maintenance cost/mile ranges from $7,947/mile to $4,388/mile. The average routine maintenance cost is $1,836/mile and the average total maintenance cost is $5,847/mile.

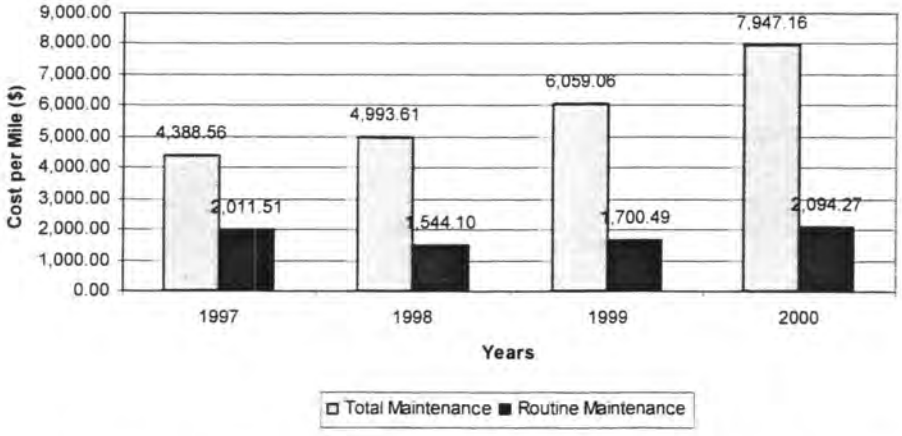


Figure 30: Olmsted County Routine and Total Maintenance Cost/Mile per Year

4.2.3. Blue Earth County

Blue Earth County is located in south central Minnesota contains 764 square miles (488,960 acres), 23 townships and 11 municipalities, with a population of 55,941 in 2003.

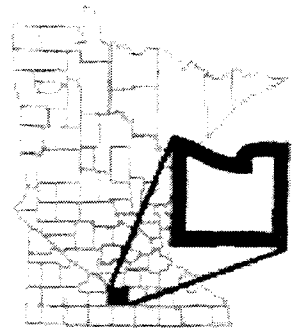


Figure 31: Blue Earth County Location

The political climate in Blue Earth County is pro-growth. As in many other counties the people would like to have paved roads but do not want to give up land for right-of-way.

Blue Earth County is not responsible for township roads, but they provide technical support, replace bridges, and sell supplies to townships.

TABLE 31: Blue Earth County Road Miles by Source of Funding and by Surface Type

Funding	**Miles of Roads by Surface Type in 2002**[9]		**Total Miles/ Funding**	**% of Total Roads**
	Aggregate	Bituminous or Concrete		
CSAH Regular	19	387	406	55.6
CSAH Mun.	19	0	19	2.6
County Roads	264	42	306	41.8
Total Miles/Surface Type	302	429	731	

The sub-grade in Blue Earth County is mostly fine clays soil that does not drain well. For this reason the county uses edge drains under pavement, and a thick base course to allow for drainage. There are gravel sources in the county that are mostly private; the county also owns a few pits just for stock piling.

[9] Blue Earth County Website at http://www.co.blue-earth.mn.us/

Equipment

The equipment purchased in Blue Earth County in based on snow removal. According to the County Engineer it is wise to invest 6-8% of the value of a fleet in the fleet itself every year. With such a policy the county can avoid serious equipment breakdowns, which in turn insures high productivity. The county's policy is that without good equipment the maintenance work cannot be done and the county is losing money.

TABLE 32: Equipment Owned by Blue Earth County and Replacement Cost and Policy.

Equipment	No. Owned	Time of Replacement		Salvage Value	Cost of new with Trade-in
		Miles	Age/ Cycle		
Trucks	13	225,000	6-8	27,000	80,000
Motor Grader	11		6-7	40,000	100,000

In addition to the equipment shown above the county rents one motor grader in one section of the county.

Routine Maintenance

1. Blading: Blading depends on the traffic on the road; some roads are bladed every week and some are bladed every two weeks. All summer the county spot treats roads when needed.

2. Mowing: The entire ROW is mowed every 3 years; shoulders are mowed where sight problems occur and once a year the county sprays for noxious weeds.

3. Stabilization/Dust Control: The county uses calcium chloride and private contractors use magnesium chloride. The cost for applying calcium chloride is covered by the county for stabilization purposes on hills and curves and construction detour routes; otherwise the residents can request treatment and pay the cost of material. The county will cover the placement cost. The cost of the $CaCl_2$ is about 70$/100 ft x 20ft wide for two (2) applications.

4. Snow and Ice Removal: The winter maintenance strategy is to remove snow based on priority, which includes ADT on the road and the function class of the road. The county works a maximum of 16 hours per day during this time.

Periodic Maintenance

Periodic maintenance is mostly composed of re-graveling, for which $250,000 is spent every year. The gravel costs the county $5/ton and the county covers 130 miles every season. Blue Earth County also does major reshaping every year of a few miles to build the road back up and improve the life cycle to about 10-20 years.

Maintenance Cost

A summery of maintenance cost and miles of roads per year in Blue Earth County is shown in Table 33. The miles of aggregate roads are reducing, from 297 mile to 283 miles. The average maintenance cost in Table 33 and Figure 32 show that the average maintenance cost/mile ranges from $4,269/mile to $2,560/mile. The average maintenance cost is $3,413 with the surface influenced costs accounting for 56% ($1,903) of the cost.

TABLE 33: Blue Earth County Maintenance Cost/Mile ($)

Year	Miles of Roads	Costs influenced by Road Surface	Percent of Total Cost	Snow and Ice Removal	Other Costs	Total Cost/mile
1997	297	1,633	45%	944	1,090	**3,667**
1998	297	1,604	63%	197	760	**2,561**
1999	296	1,867	63%	348	733	**2,947**
2000	296	1,986	55%	384	1,250	**3,620**
2001	283	2,424	57%	712	1,133	**4,269**

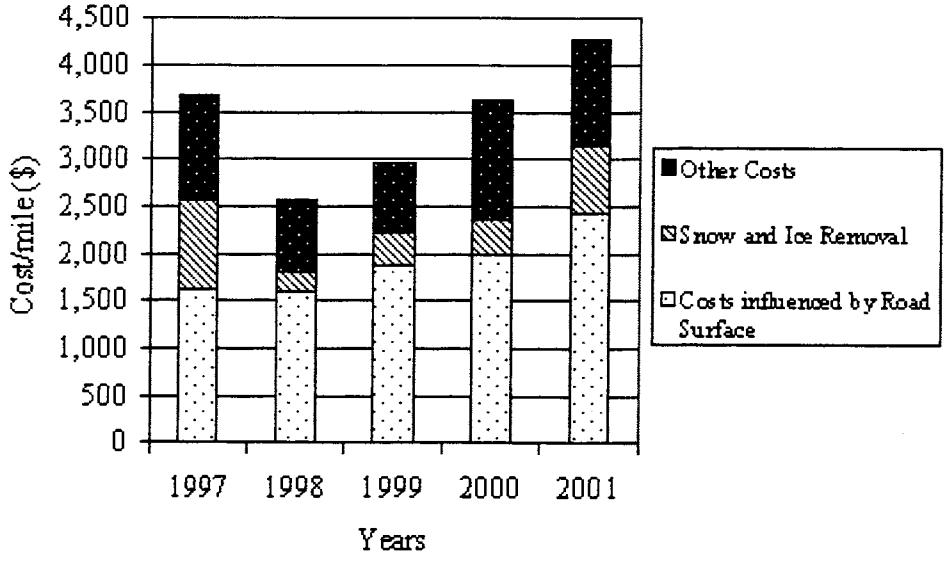


Figure 32: Blue Earth County Maintenance Cost/Mile per Year

A review of the maintenance cost/mile compared to the traffic volume (Figure 33) shows that the maintenance costs are high between 100-124 AADT and then again at 250 – 299 AADT. This increase in costs at the 100-124 AADT range appears to be caused by the increase in costs influenced by the type of road surface; these costs increased from 48% of the total cost in the previous range to 63% of the total cost.

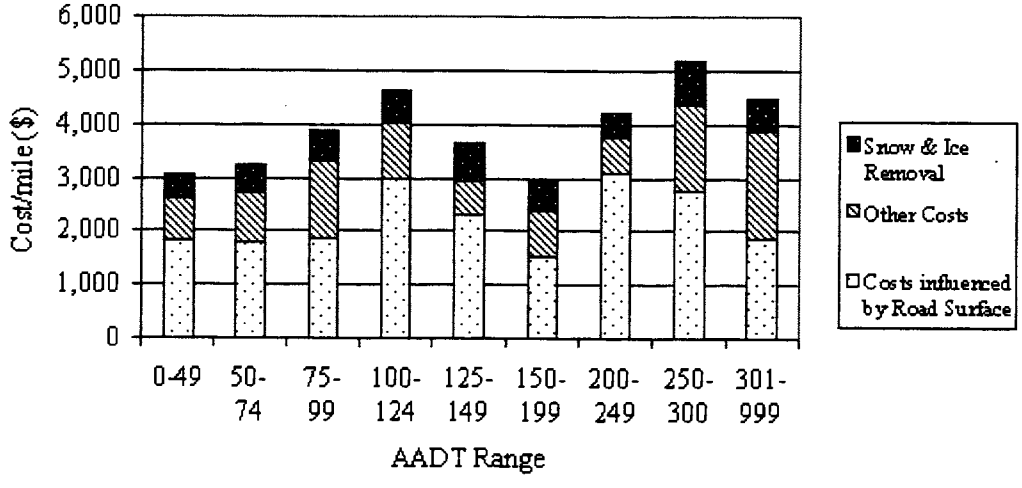


Figure 33: Blue Earth County Routine and Total Maintenance Cost/Mile vs. AADT

4.2.4. Aitkin County

Aitkin County has 1819 square miles, of which 2/3 of land is publicly owned. The county has 55 townships and a population of 15,000 year around and a population of 60,000 to 80,000 in the summer. Due to this seasonal increase in population, the County Engineer pointed out the misleading effect of AADT. The Annual Average Daily Traffic is not a good representation of the actual traffic the roads in the county get. Many of the roads may be at 500 ADT easily on the weekends during the summer and 50 during the week and in winter. The County Engineer thinks there needs to be some other way to represent the different traffic volumes in resort and lake region counties.

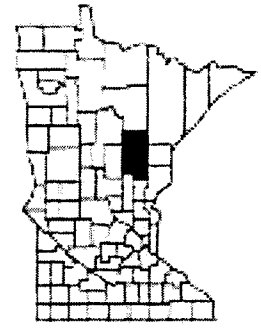


Figure 34: Aitkin County Location

TABLE 34: Aitkin County Road Miles by Source of Funding and by Surface Type

Funding	Miles of Roads by Surface Type in 2002[10]		Total Miles/ Funding	% of Total Roads
	Aggregate	Bituminous or Concrete		
CSAH Regular	177	197	374	73.2
County Roads	120	17	137	26.8

Aitkin County is said to be an "Aggregate Rich County," but the county has depleted three sources in the last four years. Even with a rich stockpile of aggregate the county has found it hard to develop new pits, due to the fact that most locations are near lakes or residences.

[10] Aitkin County Website http://www.co.aitkin.mn.us/

Equipment

The purchase of equipment in Aitkin County is based on winter maintenance activities. The equipment owned by the county, the life cycle, and the replacement costs are shown in Table 35.

TABLE 35: Equipment Owned by Aitkin County and Replacement Cost and Policy.

Equipment	No. Owned	Replacement Cycle	Salvage value	Cost of new with Trade in
Trucks	13	12	110,000	
Motor Grader	8	4 from '87 & 4 from '89 20-25 year service life	Completely rebuild at 10,000 hours	$10,000

Maintenance

Aitkin County maintains about 50 miles of road for 12 unorganized townships. These are townships that do not have large enough populations to have a government, so by default the county provides all governmental functions. Aitkin County spends about $200,000 annually on township roads alone. The county also offers blading and plowing services to the organized townships.

Routine Maintenance

1. Blading: The county blades roads as needed, usually about once a week, but required amount of blading dependent on traffic and weather conditions. Due to the high traffic on weekends the county blades some roads on Monday and Thursday.

2. Mowing: Aitkin County mows the top 8 feet of the road, two to three times a year and also mows the entire ROW every 3 years to control brush and weeds. Chemical weed control is no longer used because of environmental issues.

3. Stabilization/Dust Control Policy: The County treats the entire road on about 30-40 miles of higher volume aggregate roads to help reduce maintenance time and costs. This allows the county to only blade the road once a week instead of twice a week on those roads. The treatment is done once a year in June (by June 15th). The County Engineer has noticed that the cost of this treatment is about equivalent to placing 1/2" – 3/4" of gravel. The county offers dust control in front of residences but splits the cost 50/50 with the residents who want the treatment. The resident benefits from the treatment because dust is controlled and the county benefits from the stabilization effect. This treatment involves placing the treatment on a 400' strip for a cost of $150/treatment. On the average 150 residents request the treatment. The county uses $CaCl_2$, and it is placed at a rate of 0.21 gal/sy

4. Winter Maintenance Strategy/Policy: The county starts plowing roads after there is 3" of snow. Aggregate road clearing is done by keeping a snow pack on aggregate roads. This practice keeps the rock on the roads and helps save money on re-graveling in the spring.

Periodic Maintenance

- Re-graveling: The county uses a 4-man crew, 3 belly dumps and one water truck/blade/tractor and rubber tire roller all summer to re-gravel roads. The rock gets dumped, spread, watered and then rolled. The county hauls about 40-50,000 tons of gravel/year.

  The material used is Class 5 aggregate with a max size of 3/4" to reduce flat tire complaints and windshield damage, and 8-15% on the 200 sieves. When re-graveling they try to place about 1.5" of gravel on the road every 3-4 years depending on the traffic, at a cost of $3-3.50/yd for stockpiled gravel and typically placed at $7/yd.

- Drainage Correction: This is done as needed, but the county has a maintenance-grading program to build up aggregate roads and put ditches in.

Maintenance Cost

A summery of maintenance costs and miles of roads per year in Aitkin County is shown in Table 36. The miles of aggregate roads in the county went from 331 to 300 and then increased again in 2001 to 306 when a new road was constructed.

The average maintenance cost for Aitkin County shown in Table 36 and Figure 35 show the actual maintenance cost ranging from $4,183/mile to $2,485/mile. The average maintenance cost/mile for all 5 years is $3,182, with 57% ($1,887) of cost being influenced by the surface.

TABLE 36: Aitkin County Maintenance Cost/Mile ($)

Road	Length	Costs influenced by Road Surface	Percent of Total Cost	Snow & Ice Removal	Other Activities	Total Cost/mile
1997	**331**	1,413	**55%**	215	948	**2,576**
1998	**313**	1,507	**61%**	147	831	**2,485**
1999	**313**	1,983	**58%**	222	1,212	**3,417**
2000	**300**	2,177	**58%**	195	1,383	**3,756**
2001	**307**	2,353	**56%**	307	1,522	**4,183**

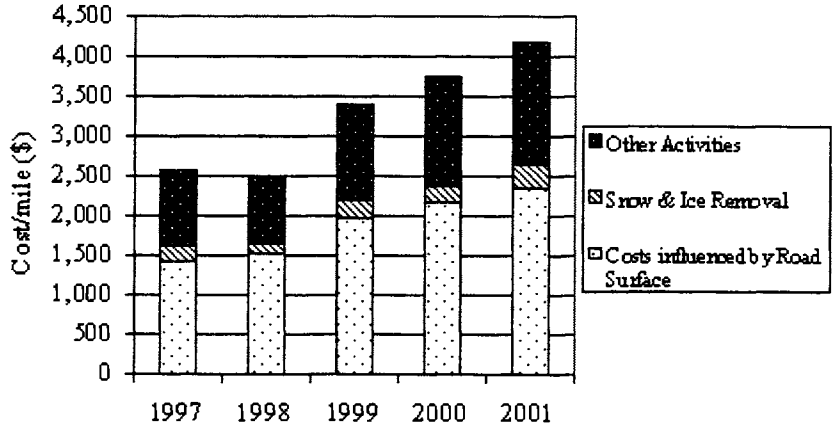


Figure 35: Aitkin County Maintenance Cost/Mile per Year

A review of the maintenance cost/mile compared to the traffic volume (Figure 36) shows that the maintenance cost is highest when traffic is between 75-99 AADT. Again we find that the costs influenced by the surface jumped from 57% of the total cost to 67% of the cost.

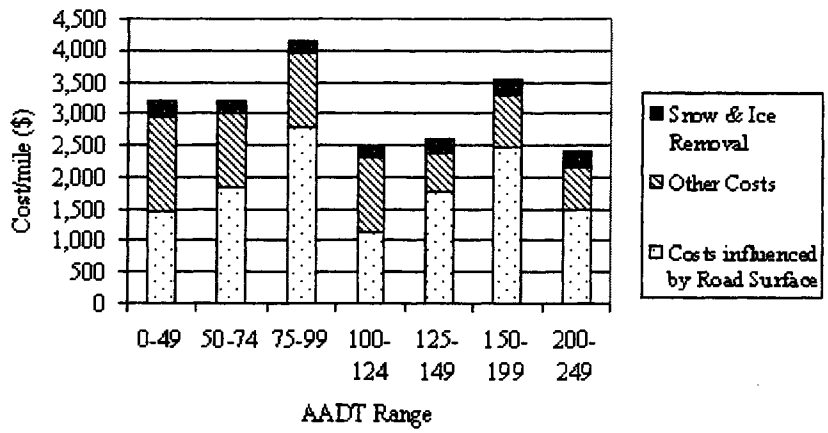


Figure 36: Aitkin County Routine and Total Maintenance Cost/Mile vs. AADT

4.2.5. Meeker County

Meeker County contains 610 square miles, 17 townships. The political climate in the county is very conservative. Meeker County road classification and funding sources is shown in Table 37. As we can see, the county has not owned any roads since 1969 but provides technical assistance and maintains township roads by contract (sample of the contract is found in Appendix 9). The county maintains the roads for townships after they pay to construct and upgrade them. The county also does all engineering for townships.

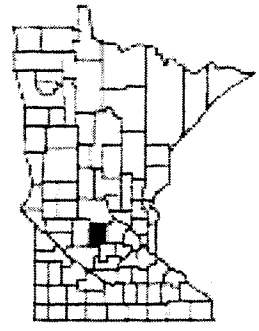


Figure 37: Meeker County Location

TABLE 37: Meeker County Road Miles by Source of Funding and by Surface Type

Funding	Miles of Roads by Surface Type in 2002[11]		Total Miles/ Funding
	Aggregate	Bituminous or Concrete	
CSAH Regular	25	250	275
CSAH Mun.	680	10	780
County Roads	No county roads under an agreement from 1969		

Equipment

The county equipment purchase is based on winter maintenance. The equipment owned by the county and the replacement cost is shown in Table 38.

TABLE 38: Equipment Owned by Meeker County and Replacement Cost and Policy.

Equipment	No. Owned	Time of Replacement		Replacement Cost
		Miles	Age/ Cycle	
Trucks	8		8	$135,000
Motor Grader	17			$165,000

[11] Meeker County Website http://www.co.meeker.mn.us/

The soils in Meeker County are very mixed. There is a heavy soil in the southwest part of the county where it is primarily farmland, and blown sand in the southeast part of the county. Meeker County has 25 active pits within the county, which brings down the gravel cost to $5/cy or less to place on road. Class 1 aggregate is used for re-graveling with 10% fines passing No. 200 sieve.

Routine Maintenance

1. Blading: The county blading schedule is as follow:
   Roads under 50 ADT – every 10 days to 2 weeks
   Roads with 50 – 100 ADT – 1/week
   Roads with 200 + ADT – more than once per week
2. Mowing: The county mows one swath along shoulders between June and July 4th. Then they mow two swaths before the snow falls.

Periodic Maintenance

1. Re-graveling: Meeker County uses about 11,000cy for re-graveling 25 miles of CSAH road. This is equivalent to a 1.5-inch lift. The county also uses a reclaimer to pull the fines and some lost material back up onto the road, a substantial savings in gravel. This allows them to re-gravel every 3 years or so. This has been really successful with shoulders on paved roads and is becoming useful on aggregate roads.
2. Crown correction: County personnel must rebuild the crowns every spring because they flatten them out in the winter to ease in snow removal

Maintenance Cost

Meeker County maintenance costs are not shown since it only incurs road maintenance costs for CSAH roads and cannot be used in the study.

4.2.6. Benton County

Benton County contains 408 square mile, 12 townships, and a population of 34,226.

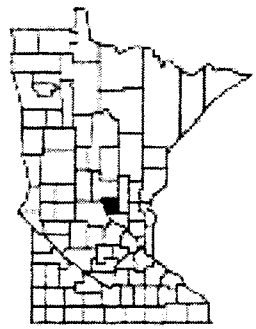


Figure 38: Benton County Location

Benton County road miles and funding source are shown in Table 39. The sub-grades are silty clays that are plastic and cause many significant number of frost boils. The process of using geo-textiles is becoming standard in the county. Geo-textiles are used by undercutting 12"- 18", placing the geo-textile and rebuilding the road with sand and gravel.

TABLE 39: Benton County Road Miles by Source of Funding and by Surface Type

Funding	**Miles of Roads by Surface Type in 2002**[12]		**Total Miles/ Funding**
	Aggregate	Bituminous or Concrete	
CSAH Regular	0	209	209
CSAH Mun.	0	17	17
County Roads	111	117	228
Total Miles/Surface Type			454

There are multiple gravel sources in the county with the county owning some pits that are used for stockpiling. The cost of gravel is $0.5 / CY to $0.75 / CY excavated and another $1.00/CY to crush it.

Equipment

The purchase of equipment in Benton County is based on winter maintenance and a list of the equipment and life cycle and replacement cost can be found in Table 40. The

[12] Benton County Website - http://www.co.benton.mn.us/

county is not responsible for the maintenance of township roads but townships purchase material and rent equipment from the county. The cost can be found in Table 41.

TABLE 40: Equipment Owned by Benton County and Replacement Cost and Policy.

Equipment	No. Owned	Time of Replacement		Replacement Cost
			Age/ Cycle	
Trucks	9	250,000 miles	10-12	$155,000
Motor Grader	3	12,000 hours	8-12 years	$180,000

TABLE 41: Equipment Rental Costs in Benton County

	Without Operator	With Operator
Motor Grader		$65/hr
Backhoe		$50/hr
Tractor & Mower		$50/hr
Pneumatic Tire Roller	$10/hr	
Truck		$50/hr

Routine Maintenance

The last 2 to 3 years the county has been experiencing flooding and culvert failure. The maintenance costs might reflect that.

1. Blading: The blading of aggregate roads depends on the traffic. In Benton County roads with ADT < 50 are bladed once a week and roads with ADT> 100 about twice a week.
2. Mowing: The ditches are mowed once before July 4 and then a second time around the third week of July. Occasionally on higher volume roads they are mowed later in the season.
3. Stabilization/Dust Control Policy: Magnesium chloride is used in the county but the county itself sells it and calcium chloride palliatives to citizens and also applies it to

the road for safety reasons. The pellets cost $60 a bag. The County Engineer has witnessed that the palliatives seem to have a longer life than liquid, but they do not work as fast; palliatives need water to be activated.

4. Winter Maintenance Strategy/Policy: The county's policy does not require a bare pavement. When there is 1" of snow the fleet goes out. The policy is to start with the high volume roads and then start clearing aggregate roads after they have about 3-4" of snow. Very low volume roads may not be cleared until the following day.

Periodic Maintenance

Benton County re-gravels roads by putting 1-3" of gravel on roads every 5 years. The material used is Class 5 gravel and fines are about 10-12%. The county also does reclaiming of shoulders during the year. The County Engineer's experience has provided proof that reclaiming shoulder material from the ditches can save the county about 18,000 cubic yards of gravel in a season.

Asset Management

Benton County has a Road Condition Assessment Program/Road Management Program that started 2 years ago. Two or three employees go out every year to examine the roads, one mile at a time. The following actions are taken:

- Conditions assessed: Ride, alligator cracking, rutting, transverse cracking, longitudinal cracking, shoulder width and condition, in-slopes, horizontal alignments, vertical alignments, ditches and drainage condition are noted. (See Appendix 10 for sample work sheet).
- The roads are ranked based on condition and ADT. Benton County has an Aggregate Road-Paving Plan that is based on economic development and cost to do the work, accident rate and the County Engineer's judgment.
- The County Engineer selects the top 10 listed as most in need of maintenance and inspects them, ranking them based on functional classification of the road, accident frequency and traffic count.

- The County Board is provided with a 5-year program.

The County Engineer realized that aggregate roads are always ranked lower and came up with an aggregate road-paving program. There is also a fund of $250,000 to be used to upgrade aggregate roads.

Maintenance Cost

A summery of maintenance costs and miles of road per year in Benton County is shown in Table 42. The miles of aggregate roads in the county has not changed in the 5 years that were reviewed. The average maintenance costs for Benton County shown in Table 42 and Figure 39 shows that the average maintenance cost/mile ranges from $2733/mile to $1576/mile. The average routine maintenance cost for all 5 years is $1,067/mile and the average total maintenance cost/mile for all 5 years is $2,239. Costs influenced by the surface account for 66% ($1,489) of the total cost.

TABLE 42: Benton County Maintenance Cost/Mile ($)

Year	Length	Costs influenced by Road Surface	Percent of Total Cost	Snow & Ice Removal	Other Activities	Total Cost/mile
1997	116	1,585	**65%**	311	533	**2,429**
1998	116	1,837	**81%**	57	377	**2,272**
1999	116	1,648	**75%**	66	470	**2,185**
2000	116	1,153	**73%**	151	273	**1,576**
2001	111	1,221	**45%**	217	1,295	**2,733**

A review of Figure 39 also shows that in 2001 other maintenance costs increased. This may be caused by the flooding problems the county has been facing.

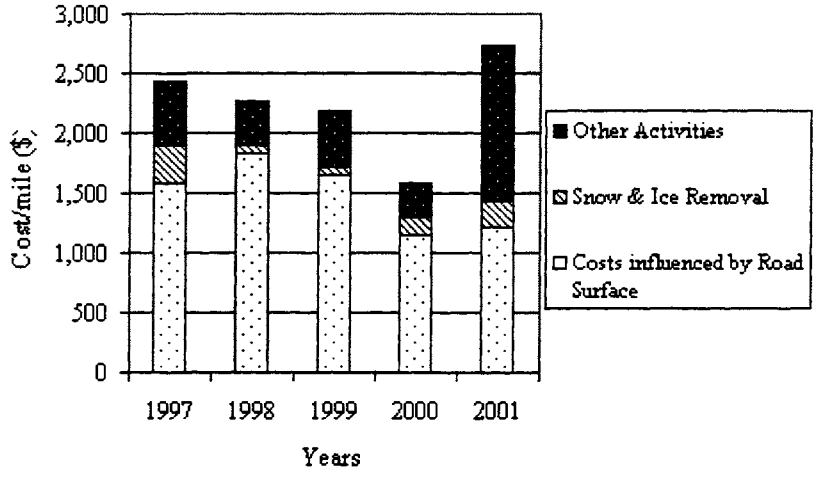


Figure 39: Benton County Routine and Total Maintenance Cost/Mile per Year

A review of the maintenance cost/mile compared to the traffic volume (Figure 40) shows that the maintenance cost doubles when AADT is above 100. The increase in the cost appears to be influenced by the road surface costs that increases from $ 1,564/mile to $3,991/mile.

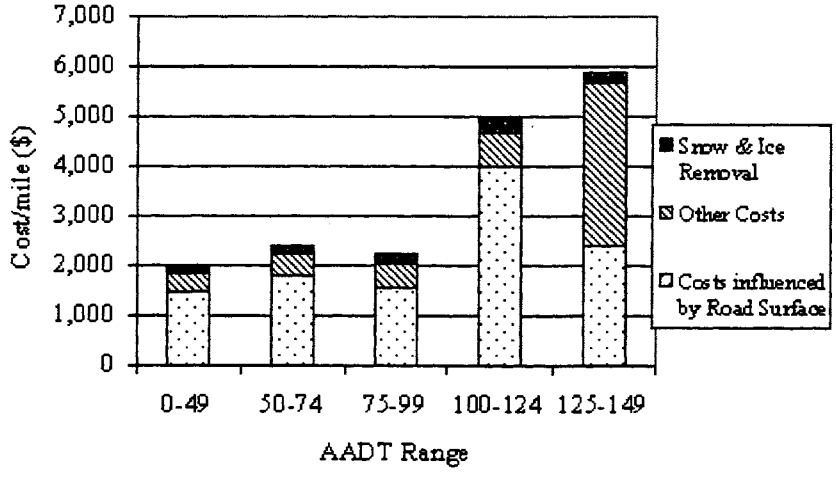


Figure 40: Benton County Total Maintenance Cost/Mile vs. AADT

4.2.7. Kandiyohi County

Kandiyohi County is located in the lake regions of Minnesota. It contains 864 square miles and 24 townships. The mileage of roads in the county and their funding sources are shown in Table 43.

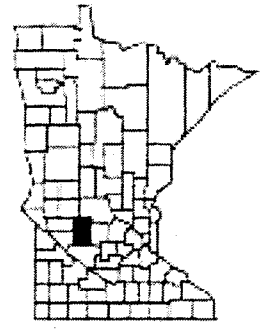


Figure 41 Kandiyohi County Location

The sub-grade in the county is a mixture of soils. On a 50' stretch it is possible to find all types of soils. For example, in the northeast portion of the county it is mostly sandy, while the southern part of the county is mostly clay. Kandiyohi County is responsible for the maintenance of six township roads in the summer and plows for 18 townships in the winter.

TABLE 43: Kandiyohi County Road Miles by Source of Funding and by Surface Type

Funding	Miles of Roads by Surface Type in 2002		Total Miles/ Funding	% of Total Roads
	Aggregate	Bituminous or Concrete		
CSAH Regular	27	381	408	62%
CSAH Mun.		14	14	3%
County Roads	198	21	219	35%
Total Miles/Surface Type	225	416	641	

The sources of the gravel in the county are in the northern and western parts of the county. The county does its own hauling to make greater use of its equipment. When hauling of the aggregate is contracted out it costs $6.50-7/ton. For this reason the county has five employees dedicated to hauling, using four tandems with pups and one belly dump owned by the county.

Equipment

The equipment purchased in Kandiyohi is based on winter maintenance. Equipment replacement schedule and the costs for Kandiyohi County are shown in Table 44.

TABLE 44: Equipment Owned by Kandiyohi County and Replacement Cost and Policy.

Equipment	No. Owned	Time of Replacement	Salvage value
		Age/ Cycle	
Trucks	15	10	$175 – 200,000
Motor Grader are owned by operators			

Kandiyohi County has a unique situation, as the operators themselves own the motor graders. The operators buy used equipment that has about 2000 hours on them and then replaces the old ones at about 12,000 hours. Due to the equal opportunity employment policy the county sees this arrangement phasing out as the current operators retire.

The county has an additional six contractors hired to help with snow removal.

Routine Maintenance

1. Three operators who own the equipment do the grading. These operators blade a road about every 7-14 days depending on road and weather conditions.

2. Mowing: The county tries to mow three times a year.

3. Winter Maintenance Strategy/Policy: The policy is to keep snow pack on the road, which saves money on re-graveling in the spring the county has many rural commuters and paved roads are cleared first. The county also plows roads for 18 townships in addition to their own, about 1000 miles of road plowed in total.

4. Stabilization/Dust Control Policy: The county pays for all stabilization and dust control in the county, and the application effort is contracted out every year. The

county uses $CaCl_2$ at a cost of about $0.45 per gal, but this year the cost almost doubled to $0.80 per gal. The application rate is 0.3 gal/yd^2 and placed once a year. The $CaCl_2$ is placed automatically in front of residences if they are within 200 ft of the road. They might not spray if there is a big wind block in front of the residence. The county also has three areas where the entire lengths treated (Co. Rd. 86, 121 and 107) for stabilization, to help reduce maintenance costs, and because of high traffic volumes.

Periodic Maintenance

Kandiyohi County re-gravels roads every other year by spreading and rolling the gravel on the surface. The county places about 300 tons/mile at a cost of $1.64 per ton for just the gravel – about 40,000 tons of gravel is placed/year.

The material used is Class 1 aggregate for re-graveling in the northeast part of the county and Class 5 on the remainder of the roads in the county.

The county also does some reclaiming of the fines from the ditches but tries not to be too aggressive with the reclaimer to limit the amount of fines on the road. The reclaiming practice is done more as a maintenance practice to knock down the secondary ditches than trying to save gravel/money.

Maintenance Cost

A summery of maintenance costs and miles of roads per year in Kandiyohi County is shown in Table 45. The miles of aggregate roads have been reduced from 249 to 225 miles. A review of Table 45 and Figure 42, show maintenance cost/mile ranging from $2,328/mile to $1,879/mile. The average maintenance cost/mile for all five years is $2,076 with costs influenced by the surface accounting for 77% ($1,597) of the total cost.

TABLE 45: Kandiyohi County Maintenance Cost/Mile ($)

Year	Miles	Costs influenced by Road Surface	Percent of Total Cost	Other activities	Snow & Ice Removal	Total Cost/mile
1997	249	916	49%	132	831	1,879
1998	249	1,804	87%	144	123	2,071
1999	226	1,698	85%	141	152	1,990
2000	226	1,744	83%	146	219	2,110
2001	226	1,825	78%	123	380	2,328

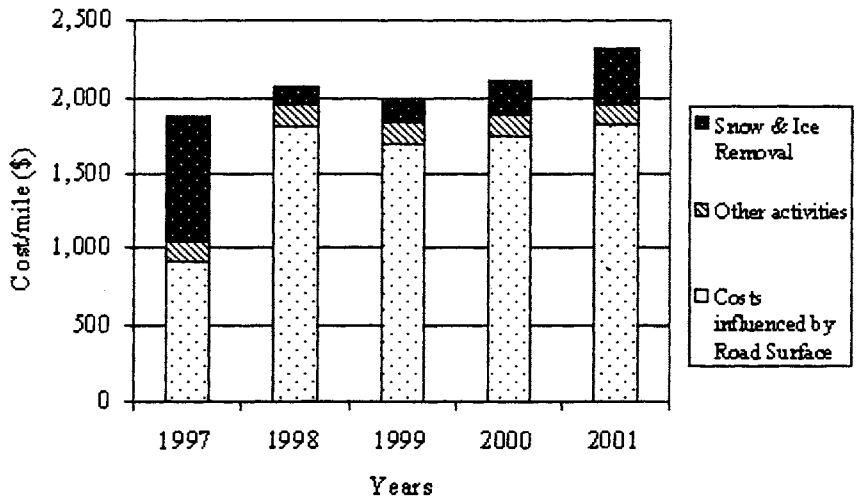


Figure 42: Kandiyohi County Maintenance Cost/Mile per Year

A review of the maintenance cost/mile compared to the traffic volume (Figure 43) shows that the maintenance cost is highest when the traffic is between 75 and 99 AADT.

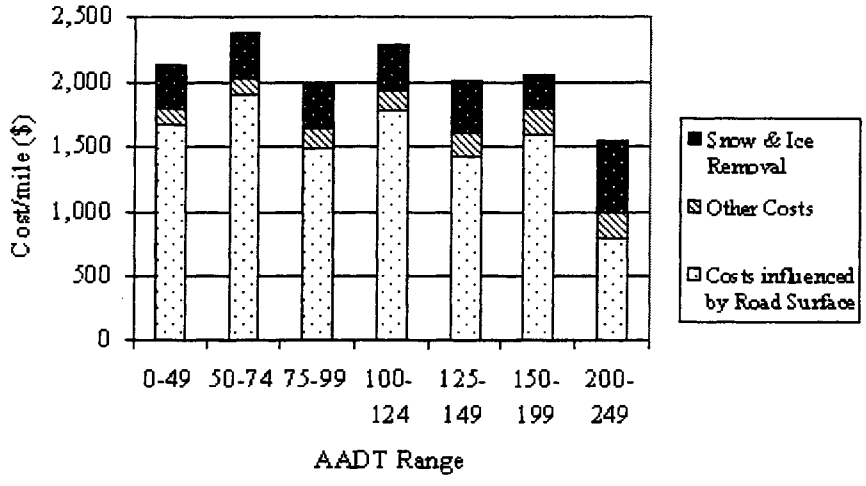


Figure 43: Kandiyohi County Maintenance Cost/Mile

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This research revealed several conclusions that were expected and others that were not expected:

- Anomalies in the data used were found and can be explained by geographic, political differences in counties, or even by the difference in classifying cost in the reports. The average maintenance costs estimated by this Research (section 4.1) cannot be used as an exact average cost.
- The weighted average aggregate road maintenance cost is $3,890/mile
- It was shown that when AADT is above 250, aggregate roads are no longer cost effective.
- Routine Maintenance costs and Resurfacing costs are the largest categories incurred cost accounting for more then 68% of the total cost.

5.2. Recommendation

It is recommended that all counties track all maintenance costs in the correct categories, as this can be a good source of data for further and better cost analysis of aggregate road maintenance.

In order for future research to be effective, it is important to take the following steps:

- Identify all counties' practices and organization
- Identify a source of electronic files for county annual report costs and AADT organized by route number and surface type.
- Make sure all data is recorded consistently.

5.3. Further research

- Further research is recommended to determine a more effective way of keeping track of maintenance costs to be used for projections and future research.
- Further research is recommended to determine a way to predict future maintenance costs for aggregate roads, taking into account all influences on this cost

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APPENDIX 1: MINNESOTA'S DESIGN GUIDE FOR LOW VOLUME AGGREGATE SURFACE ROAD

MINNESOTA'S DESIGN GUIDE FOR LOW VOLUME AGGREGATE SURFACED ROADS

INVESTIGATION NO. 667

By
Terrance M. Beaudry

Minnesota Department of Transportation

July, 1992

Prepared for the

MINNESOTA LOCAL ROAD RESEARCH BOARD
OFFICE OF RESEARCH ADMINISTRATION
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Executive Summary

The following Soil Factor Design Method was written for counties, townships, and municipalities for use in designing aggregate roads. Although many design methods for aggregate roads exist, most require thorough soil identification and soil strength testing. Since most local agencies do not have the means to perform elaborate testing of soils, and because they are familiar with soil factors, this design method should be helpful. This procedure requires soil identification, traffic counts, and rational judgement.

At present MN/DOT does not have a design method for aggregate roads. It is not the intention of this manual to change the present legal load limits of aggregate roads.

For those who would like a more thorough design method, or more background information on aggregate roads, this manual includes information on the use of the U.S. Forest Service Aggregate Surface Design Guide (ref. 1).

Also included is information regarding compaction, drainage, frost action, geosynthetic use, lime stabilization, and an appendix with sample problems based on the Soil Factor and Forest Service design methods.

Abstract

This Soil Factor Design Method was developed to assist counties, municipalities, and townships in designing aggregate roads. It was written for those who do not have the resources to use other more costly design methods. For those who would wish to use a more elaborate method, or would like more background information on aggregate roads, information on the use of the U.S. Forest Service design method has been included.

Table 1

Soil Factors For Different Soil Classification Systems

Mn/DOT Soil Class	Soil Factor
Gravel (G)	50
Fine Gravel (FG)	50
Sand (S)	50
Coarse Sand (CS)	50
Loamy Sand (LS)	50–75
Fine Sand (FS)	50
Sandy Loam (SL) With 0–10% clay	50–75
Sandy Loam (SL) With 10–20% clay	100–130
Loam (L)	100–130
Silty Loam (SiL)	100–130
Clay Loam (CL)	100
Silty Clay Loam (SiCL)	100–130
Sandy Clay Loam (SCL)	100–130
Clay (C)	120–130
Silty Clay (SiC)	120–130
Sandy Clay (SC)	120–130

AASHTO Soil Class	Soil Factor
A–1–a	50
A–1–b	50–75
A–2–4	50–115*
A–2–5	50–115*
A–2–6	75–115*
A–2–7	75–115*
A–3	50
A–4	100–130
A–5	130+
A–6	100
A–7–5	120
A–7–6	130

*They are commonly mixed with A–4's in the field, and are difficult to isolate.

Unified Soil Class	Soil Factor
GW	50
GP	50
GM	50–75
GC	50–75
SW	50–75
SP	50–100
SM	75–100
SC	75–110
ML	100–130
CL	100–130
OL	130+
MH	110–130
CH	130
OH	130+

Notes: Soil strength tests should be performed and sampling should be done in accordance with Appendix B. Soil factors may be modified based on local experience.

To calculate the aggregate thickness, one first determines the soil type. The preferred method is to sample the soil. The sampling frequency should be as shown on Appendix B (ref. 5). If sampling is not practical, USGS maps or information from the SCS may be used to determine soil types. Local Mn/DOT materials units often have data on local Soil Factors and R-values.

Appendices C-G (ref. 5-8) are charts that will help define the soil type and relate strength parameters, for the Mn/DOT, AASHTO, and Unified soil classification systems.

Note: The USDA soil classification system is similar but different from the Mn/DOT soil system.

The next step is to determine the soil factor for the soil type under consideration. Table 1 lists soil factors for each soil classification system and soil type.

Once the soil factor and two way traffic data (ADT or HCADT) have been determined, use Table 2 to determine the thickness requirement. Thicknesses for a specific soil may vary because of the range in subsoil strength within a specific soil class. This variance is accounted for by the soil factors within this soil class. If one cannot obtain the strength of the subsoil and only has a thickness range given by soil factors, use the average thickness, as a minimum, from these soil factors for the design of the aggregate road.

This design recommends that the top layer should be Surface Class 1 material. For thicknesses of five inches or less, the entire lift should be Class 1 material. For thicknesses greater than five inches, use Class 5 or 6 material as a base for the Class 1 material. If Class 3 or 4 material is used as a base, the base thickness requirement should be increased by 33% over the Class 5 or 6 thickness. If Select Granular is used, the base thickness should be increased by 100% over the Class 5 or 6 thickness.

Note: Surface Class 1 requires 10-15% passing the No. 200 sieve.

If both ADT and HCADT are known, design the roadway by using the traffic parameter that gives the greater thickness.

Care should be taken when designing roadways with subsoil strengths that are highly variable. For example, from Table 1, the soil factor range of a Mn/DOT silty loam (SiL) subsoil is 100-130. From Table 2, for a two way ADT of 150, the total thickness requirements using Class 5 and Class 1 aggregate are: 8, 9, 10, and 12 inches for soil factors of 100, 110, 120, and 130 respectively. If feasible, the soil strength should be determined and a more thorough design procedure used. If soil strength data are not available, the thickness should be at least the average thickness within this range, 10 inches.

and equations relating CBR to pavement DCP (ref. 3 and 9-11).

A soil's CBR value is defined as the force required to cause a standard cylindrical piston to penetrate at a given rate into the soil. The CBR is the ratio between this measured force and a standard force. Standardized procedures for conducting the CBR test are described in ASTM Standard D 1883 or AASHTO Standard T 193.

The pavement DCP is a simple to use soil strength testing instrument. The initial cost of the pavement DCP is reasonable, and one can quickly evaluate a section of roadway. Because the DCP is an economical test to perform and its data correlates well with other soil strength tests, its use should increase.

The other two parameters to set are the aggregate loss and the rut depth. According to the Forest Service report, the aggregate loss is usually set at one inch and the rut depth at two inches.

Appendix J contains sample problems using the Forest Service and Soil Factor Design methods. The first two examples compare the required thicknesses using the Soil Factor and Forest Service methods with the same input.

Note: The confidence level of using the equations in Appendix I to obtain CBR values for use in the Forest Service design is unknown.

Note: When performing field soil strength tests, it is critical that they are analyzed at times when the soil is at its lowest strength. This will usually occur in the spring, when the subgrade is saturated. If tests are run at other times of the year, one must compensate for the higher values.

Compaction

Good compaction is the most important requirement when building an aggregate road. The aggregate should be placed and compacted in accordance with Mn/DOT spec. 2211. This guide assumes that the subsoil and aggregate are well compacted. The CBR will decrease from 25 to 50 percent for each 5 percent decrease in T-99 compaction below 95% (ref. 12). The decrease is greatest for cohesive soils and least for granular soils.

The following example was obtained by imputing the following parameters into the Forest Service design program, and is an illustration of the benefits of compacting subsoils. It shows a three inch increase in the required aggregate for compaction decreasing from T-99 = 95% to T-99 = 85%.

Example:

A subsoil is cohesive and has a CBR of 10 at 95% T-99. Design lane traffic is 500 ADT or 4410 yearly design lane ESAL's. Five years of

references 17 and 18.

Using lime stabilization to enhance a soil's strength should be approached with some caution. One Minnesota study on clay soils found that the R-Value rose sharply after an initial treatment with lime, but after being subjected to freeze-thaw cycles, the soil's strength decreased (ref. 19 and 20). Consequently, the pavement cracked severely, which increased maintenance costs. Another unpublished study seems to indicate an accelerated ride deterioration with lime treated subgrade on a bituminous road (ref. 21).

Conclusions

The Soil Factor design method included in this report was written for counties, townships, and municipalities for use in designing aggregate roads. Although this Soil Factor Design Method will be helpful to these agencies, rational judgement and experience in identifying soil types, determining soil strengths, and thickness requirements should not be discounted. The required thicknesses assume that the soil is uniform and constructed at a moisture content in accordance with Mn/DOT spec. 2105. In subgrades that have variable soils, or where soil strengths of the same soil type vary, one should use particular design judgement.

For those who would like a more thorough design method, or more background information on aggregate roads, it is recommended that one obtain a copy of the U.S. Forest Service Aggregate Surface Design Guide.

By designing for drainage and against the effects of frost action, the performance of aggregate roads will be enhanced.

References

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5) Minnesota Department of Transportation, Road Design Manual, January 31, 1982.

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7) Minnesota Department of Transportation, Grading and Base Manual, May 1, 1959.

8) U.S. Department of Agriculture Soil Conservation Service, Basic Soil Mechanics Workbook, January 1981.

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10) Asphalt Institute, Research and Development of the Asphalt Institute's Thickness Design Manual, Ninth Edition, Research Report No. 82-2, pp. 60-, 1982.

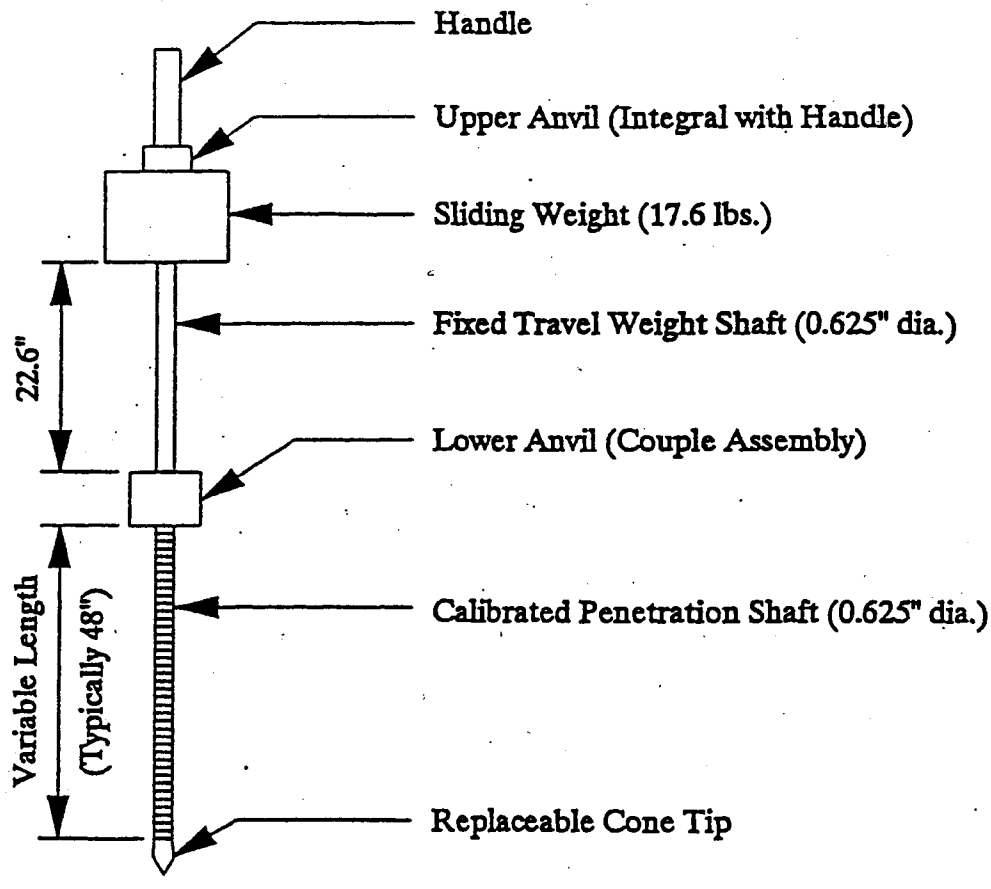
11) Harison, J.A., Correlation of CBR and Dynamic Cone Penetrometer Strength Measurement of Soils. Australian Road Research 16 (2), June 1986.

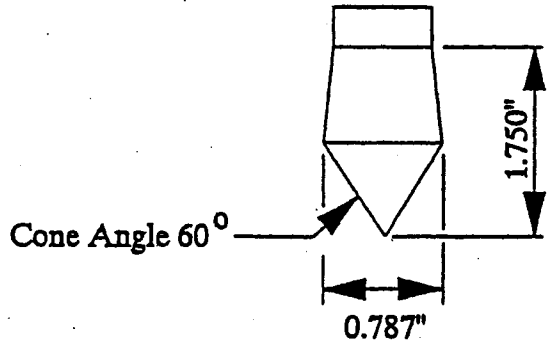
12) U.S.D.A. Forest Service, Interim Guide for Thickness Design of Flexible Pavement Structures, FSH 7709.11 Chapter 50, Region 6 Supplement No. 20, Portland, Oregon, January 1974.

13) Geotextile Engineering Manual, FHWA, Pub. # FHWA-HI-89-050, July 1989.

Appendix A

"Pavement" Dynamic Cone Penetrometer





Cone

Appendix B*

Stabilometer R–Value Sampling Frequency Guidelines for Mn/DOT Soil Types

For cases where R–value samples will be obtained,
the following table may be used as a guide in sample frequency.

Major Soil Texture**	Recommended Minimum Sampling Rate	Minimum Number of Samples
Sands	0 (assume a value of 70 or 75)***	0***
Clays, Clay Loams	1 every two miles	3****
Sandy Loams (nonplastic to slightly plastic)	3 per mile	5
Silt Loams	3 per mile	5
Silty Clay Loams	3 per mile	5
Plastic Sandy Loams	3 per mile	5
Sandy Clay Loams	3 per mile	5

*Table 7–5.03G from Mn/DOT Road Design Manual, January 31, 1982.

**Major soil texture refers to a soil texture significant enough in areal extent to economically justify a change in pavement design.

*** If % passing #200 exceeds 15%, then sample and select a design R–value in the same manner as for clay, clay loams. This means that a sufficient number of gradation checks of the sand areas will have to be made to determine if Stabilometer tests are required.

**** Given significant local experience, this may be reduced to 1 or 2 samples.

NOTE: Samples should be representative of the upper 4 feet of the proposed road grade as much as possible. In other words, in unbalanced jobs concentrate on the borrow sources; in balanced jobs concentate on the cuts. If practical, resample the embankment after construction.

Appendix D*

Mn/DOT Soil Classification System

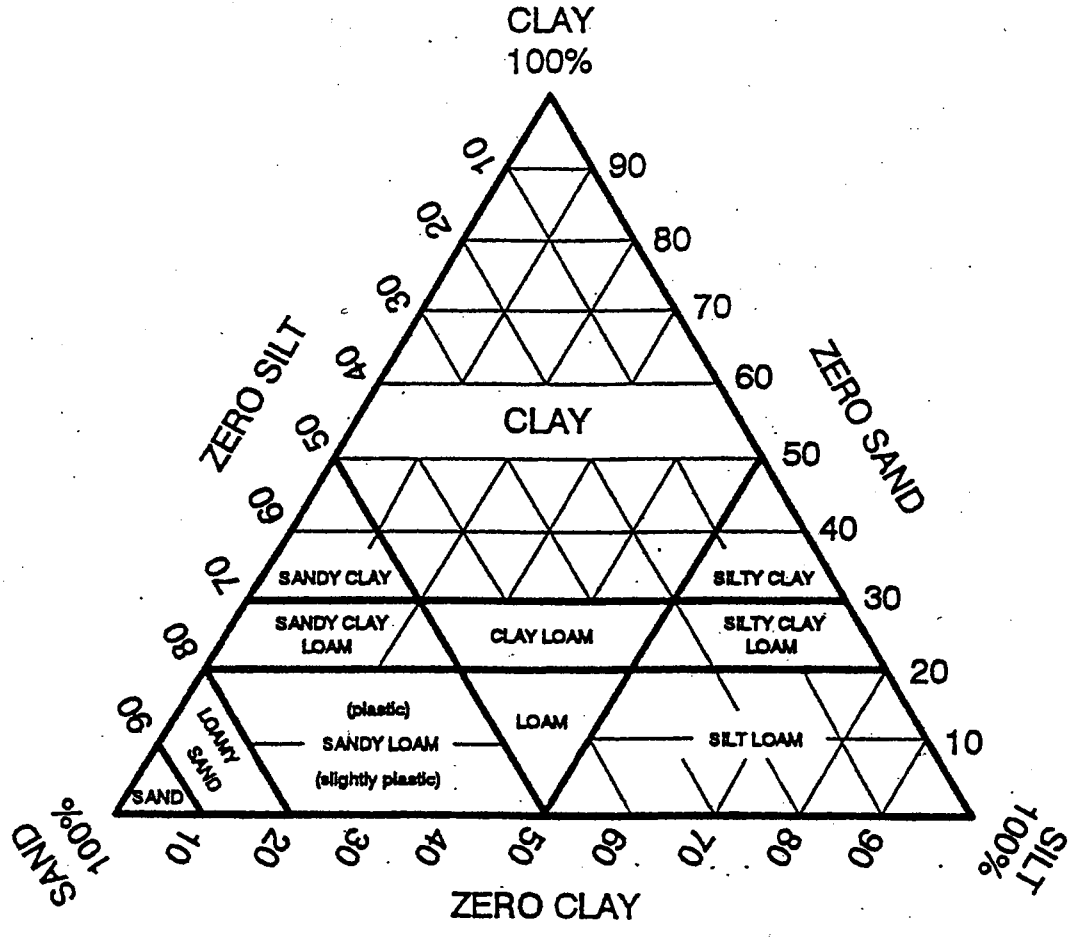


*Figure A 5-692.611 from Mn/DOT Grading & Base Manual. May 1, 1959.

Appendix F*

Stabilometer R–Values for AASHTO Soil Types

AASHTO Soil Type	Textural	Assumed R–Value	Comments
A–1–a	Sands Gravels	75	Excellent confidence in using assumed value.
A–1–b	Sands Sandy Loams (non–plastic	70	If percent passing number 200 sieve is 15 to 25 percent, R–value may be as low as 25. In such cases, it is highly desirable to obtain laboratory R–values.
A–2–4 & A–2–6	Sandy Loams (non–plastic, slightly plastic, or plastic)	30 (70 for LS and LFS)	Loamy Sands and Loamy Fine Sands commonly have R–values of 70. Laboratory R–values range from 10–80 for the entire A–2 classification. It is highly desirable to obtain laboratory R–values, for the Sandy Loams.
A–3	Fine Sands	70	Excellent confidence in using assumed value.
A–4	Sandy Loams (plastic) Silt Loams Silty Clay Loams Loams Clay Loams Sandy Clay Loams	20	Laboratory R–values range from 10 to 75. It is highly desirable to obtain laboratory R–values.
A–6	Clay Loams Clays Silty Clay Loams	12	Laboratory R–values commonly occur between 8 and 20.
A–7–5	Clays Silty Clays	12	Data available is limited.
A–7–6	Clays	10	Laboratory R–values commonly occur between 6 and 18.

Note: In using the above assumed R–value for bituminous pavement design, it is essential that the subgrade be constructed of uniform soil, and at a moisture content and density in accordance with Mn/DOT Spec. 2105, and be capable of passing test rolling, Mn/DOT Spec. 2111. To minimize frost heaving and thaw weakening, it is also essential that finished grade elevation be placed an adequate distance above the water table. This distance should be at least equal to the depth of frost penetration. For silty soils, this distance should be significantly greater.

*Table 7–5.03H from Mn/DOT Road Design Manual, January 31, 1982.

Appendix H.1

Assumed Distribution Factors By Vehicle Type (Table 7–5.03B)

Vehicle Type	Description	Rural Truck Highway % of AADT	Metro % of AADT	Local Rural and CSAH % of AADT**
1	Passenger Cars	78.1	83.5	75.7
2	Panels and Pickups (under 1 ton)	10.0	9.0	16.0
3	Single Unit – 2 axle, 4 tire	1.4	1.6	2.4
4	Single Unit – 2 axle, 6 tire	3.9	1.8	2.6
5	Single Unit – 3 axle & 4 axle	1.3	0.5	1.7
6	Tractor Semitrailer Combination – 3 axle	0.3	0.3	--
7	Tractor Semitrailer Combination – 4 axle	0.5	0.4	0.1
8	Tractor Semitrailer Combination – 5 axle	3.0	2.4	0.5
9	Tractor Semitrailer Combination – 6 axle	*	*	*
10	Trucks with Trailers and Buses	1.5	0.5	1.0

* Too few to establish a value at this time.
** Data for local roads is from 1975 and 1977 County Roads Pilot Project, and these should not be used in preference to current seasonally adjusted classification counts.

This is Table 7–5.03B From Mn/DOT Road Design Manual January 31, 1982, reference 5.

Appendix I

Note: The confidence level of using these equations to obtain CBR values for use in the Forest Service design is unknown to the author.

Equations Relating Resilient Modulus to R-value and CBR

1) M_R (psi) = 1500 x CBR.

2) M_R (psi) = A + (B x R-value).

3) M_R (psi) = 1000 + (555 x R-value).

Equation 1 is from Heukelom and Klomp. This correlation was made using dynamic compaction for CBR, and the insitu modulus of the soil. The data from which this correlation was developed ranged from 750 to 3000 times CBR.

Equation 2 is from the Asphalt Institute, where A = 772 to 1155 and B = 369 to 555.

Equation 3 is from AASHTO, and they state that this equation can be used for fine grained soils (R-values less than or equal to 20).

Equations Relating DCP to CBR*

1) Log CBR = 2.56 - 1.16 Log DCP, for cohesive soils and DCP > 10mm/blow.

2) Log CBR = 2.70 - 1.12 Log DCP, for granular soils and DCP < 10mm/blow.

3) Log CBR = 2.81 - 1.32 Log DCP, for combined data.

* From Harison, J.A., Correlation of CBR and Dynamic Cone Penetrometer Strength Measurement of Soils. Australian Road Research 16 (2), June 1986.

Appendix J-2

Using Table 2:

Thickness (Inches)		
Surface Class 1		Base Type
4.0"	+	2.0" Class 5 or 6 = 6.0" Total Aggregate, or
4.0"	+	3.0" Class 3 or 4 = 7.0" Total Aggregate.

In both cases a surface of 4 inches of Surface Class 1 should be used. If Class 5 or 6 is used, the base should be 2 inches. If Class 3 or 4 is used, the base should be 3 inches.

Example 2: Using Forest Service Design

Subsoil is granular R = 60, CBR = 25, Soil Factor = 50.
Two way traffic is 150 ADT, therefore one way traffic is 75 ADT = 662 yearly ESAL's. Use 10 Year design = 6,620 ESAL's.
Base = Class 5 or 6 (CBR = 80), or Class 3 or 4 (CBR = 45).
Aggregate loss = 1 inch.

Thickness (Inches)		
Surface Class 1		Base Type
4.0"	+	0.0" Class 5 or 6 = 4.0" Total Aggregate, or
4.7"	+	0.0" Class 3 or 4 = 4.7" Total Aggregate.

Example 3: Using Soil Factor Design

Subsoil is AASHTO Class A-4.
Measured two way traffic is 75 ADT and 12 HCADT. Since 12 HCADT gives a greater thickness, the HCADT should be the traffic parameter used. From Table 1, the soil factor varies from 100-130, therefore, if one does not have any soil strength information, use the average thickness for soil factors 100, 110, 120, and 130.

Using Table 2:

	Thickness (Inches)			
	Surface	Base Type		
Soil Factor	Class 1 +	Class 5 or 6	or Class 3 or 4	or Sel Gran.
100	4	4	5	8
110	4	5	7	10
120	4	6	8	12
130	4	8	11	16
Average	4	6	8	12

In all cases a surface of 4 inches of Surface Class 1 should be used. If Class 5 or 6 is used, the base should be 6 inches. If Class 3 or 4 is used, the base should be 8 inches. If Select Granular is used, the base should be 12 inches.

APPENDIX 2: DUST SUPPRESSANT EXPLANATIONS AND SELECTION GUIDE

(Peter Bolander, Alan Yamada, 1999, *Dust Palliative selection and application guide*, USDA- Forest service, November 1999)

Table 1—Road dust suppressants.

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Water	• agglomerates the surface particles • normally, readily available	• evaporates readily • controls dust generally for less than a day • generally the most expensive and labor intensive of the inorganic suppressants	• frequency depends on temperature and humidity; typically only effective from 1/2 to 12 hours	• any potable water source	• none
Water Absorbing: Calcium Chloride (deliquescent)	• ability to absorb water from the air is a function of temperature and relative humidity; for example, at 25°C (77°F) it starts to absorb water at 29% relative humidity, and at 38°C (100°F) it starts to absorb water at 20% relative humidity • significantly increases surface tension of water film between particles, helping to slow evaporation and further tighten compacted soil as drying progresses • treated road can be regraded and recompacted with less concern for losing moisture and density	• requires minimum humidity level to absorb moisture from the air • doesn't perform as well as MgCl in long dry spells • performs better than MgCl when high humidity is present • slightly corrosive to metal, highly to aluminum and its alloys, attracts moisture, thereby prolonging active period for corrosion • rainwater tends to leach out highly soluble chlorides • if high fines content in treated material, the surface may become slippery when wet • effectiveness when less than 20% solution has performance similar to water	• generally 1 to 2 treatments per season • initial application: flake: @ 0.5 to 1.1 kg/m² (1.0 to 2.0 lb/y²), typical application 0.9 kg/m² (1.7 lb/y²) @ 77% purity liquid: 35 to 38% residual @ 0.9 to 1.6 L/m² (0.2 to 0.35 g/y²), typical application is 38% residual concentrate applied undiluted @ 1.6 L/m² (0.35 g/y²) • follow-up: apply @ 1/2 to 1/3 initial dosage	• by-product in the form of brine from manufacture of sodium carbonate by ammonia-soda process and of bromine from natural brines • three forms: flake, or Type I, @ 77 to 80% purity pellet, or Type II, @ 94 to 97% purity clear liquid @ 35 to 38% solids	• water quality impact: generally negligible if the proper buffer zone exists between treated area and water • fresh water aquatic impact: may develop at chloride concentrations as low as 400 ppm for trout, up to 10,000 ppm for other fish species • plant impact: some species susceptible, such as pine, hemlock, poplar, ash, spruce, and maple • potential concerns with spills of liquid concentrate

Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Water Absorbing: Magnesium Chloride (deliquescent)	• starts to absorb water from the air at 32% relative humidity independent of temperature • more effective than calcium chloride solutions for increasing surface tension, resulting in a very hard road surface when dry • treated road can be regraded and recompacted with less concern for losing moisture and density	• requires minimum humidity level to absorb moisture from the air • more suitable in drier climates • in concentrated solutions, very corrosive to steel (note: some products may contain a corrosive-inhibiting additive); attracts moisture, thereby prolonging active period for corrosion • rainwater tends to leach out highly soluble chlorides • if high fines content in treated material, the surface may become slippery when wet • effectiveness when less than 20% solution has performance similar to water	• generally 1 - 2 treatments per season • initial application: 28 to 35% residual @ 1.4 to 2.3 L/m² (0.30 to 0.5 g/y²), typical application is 30% residual concentrate applied undiluted @ 2.3 L/m² (0.50 g/y²) • follow-up: apply @ 1/2 initial dosage	• occurs naturally as brine (evaporated)	• water quality impact: generally negligible if the proper buffer zone exists between treated area and water • fresh water aquatic impact: may develop at chloride concentrations as low as 400 ppm for trout, up to 10,000 ppm for other fish species • plant impact: some species susceptible such as pine, hemlock, poplar, ash, spruce, and maple • potential concerns with spills
Water Absorbing: Sodium Chloride (hygroscopic)	• starts to absorb water from the air at 79% relative humidity independent of temperature • increases surface tension slightly less than calcium chloride	• requires minimum humidity level to absorb moisture from the air • moderately corrosive to steel in dilute solutions • tends not to hold up well as a surface application	• generally 1 - 2 treatments per season • higher dosages than calcium treatment	• occurs naturally as rock salt and brines	• same as calcium chloride

Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Organic Petroleum Products	• binds and/or agglomerates surface particles because of asphalt adhesive properties • serves to waterproof the road	• under dry conditions some products may not maintain resilience • if too many fines in surface and high in asphaltenes, it can form a crust and fragment under traffic and in wet weather • some products are difficult to maintain	• generally 1 to 2 treatments per season • 0.5 to 4.5 L/m² (0.1 to 1 g/y²) depending on road surface condition, dilution, and product • the higher viscosity emulsions are used for the more open-graded surface materials • follow-up: apply at reduced initial dosages	• cutback asphalt: SC-70 • Asphalt emulsion: SS-1, SS-1h, CSS-1, or CSS-1h mixed with 5+ parts water by volume • modified asphalt emulsions • emulsified oils • mineral oils	• wide variety of ingredients in these products • "used" products are toxic • oil in products might be toxic • need product specific analysis • potential concerns with spills and leaching prior to the product "curing"
Organic Nonpetroleum: Lignin Derivatives	• binds surface particles together • greatly increases dry strength of material under dry conditions • retains effectiveness during long dry periods with low humidity • with high amounts of clay, it tends to remain slightly plastic permitting reshaping and additional traffic compaction	• may cause corrosion of aluminum and its alloys • surface binding action may be reduced or completely destroyed by heavy rain, due to solubility of solids in water • becomes slippery when wet, brittle when dry • difficult to maintain as a hard surface, but can be done under adequate moisture conditions	• generally 1 to 2 treatments per season • 10 to 25% residual @ 2.3 to 4.5 L/m² (0.5 to 1.0 g/y²), typical application is 50% residual concentrate applied undiluted @ 2.3 L/m² (0.50 g/y²) or 50% residual concentrate applied diluted 1:1 w/water @ 4.5 L/m² (1.0 g/y²) • may be advantageous to apply in two applications • also comes in powdered form that is mixed 1 kg to 840 liters (1 lb to 100 gallons) of water and then sprayed	• water liquor product of sulfite paper making process, contains lignin in solution • composition depends on raw materials (mainly wood pulp) and chemicals used to extract cellulose; active constituent is neutralized lignin sulfuric acid containing sugar	• water quality impacts: none • fresh water aquatic impacts: BOD may be high upon leaching into a small stream • plant impacts: none • potential concern with spills

Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Organic Nonpetroleum: Molasses/Sugar Beet Extract	• provides temporary binding of the surface particles	• limited availability	• not researched	• by-product of the sugar beet processing industry	• water quality impact: unknown • fresh water aquatic impact: unknown • plant impact: unknown, none expected
Organic Nonpetroleum: Tall-Oil Derivatives	• adheres surface particles together • greatly increases dry strength of material under dry conditions	• surface binding action may be reduced or completely destroyed by long-term exposure to heavy rain, due to solubility of solids in water • difficult to maintain as a hard surface	• generally 1 treatment every few years • 10 to 20% residual solution @ 1.4 to 4.5 L/m² (0.3 to 1.0 g/y²); typical application is 40 to 50% residual concentrate applied diluted 1:4 w/water @ 2.3 L/m² (0.5 gal/y²)	• distilled product of the kraft (sulfate) paper making process	• water quality impact: unknown • fresh water aquatic impact: unknown • plant impact: unknown
Organic Nonpetroleum: Vegetable oils	• agglomerates the surface particles	• limited availability • oxidizes rapidly, then becomes brittle	• generally 1 treatment per season • application rate varies by product, typically 1.1 to 2.3 L/m² (0.25 to 0.50 g/y²) • the warmer the product, the faster the penetration • follow-up: apply at reduced initial dosages	• some products: canola oil, soybean oil, cotton seed oil, and linseed oil	• water quality impact: unknown • fresh water aquatic impact: some products have been tested and have a low impact • plant impact: unknown, none expected

Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Electrochemical Derivatives	• changes characteristics of clay-sized particles • generally effective regardless of climatic conditions	• performance dependent on fine-clay mineralogy • needs time to "set-up," i.e. react with the clay fraction • difficult to maintain if full strengthening reaction occurs • limited life span	• generally diluted 1 part product to anywhere from 100 to 600 parts water • diluted product also used to compact the scarified surface	• typical products: sulfonated oils, ammonium chloride enzymes, ionic products	• need product specific analysis • some products are highly acidic in their undiluted form
Synthetic Polymer Derivatives	• binds surface particles because of polymer's adhesive properties	• difficult to maintain as a hard surface	• generally 1 treatment every few years • 5 to 15% residual solution @ 1.4 to 4.5 L/m² (0.3 to 1.0 g/y²); typical application is 40 to 50% residual concentrate applied, diluted 1:9 w/water @ 2.3 L/m² (0.50 gal/y²)	• by-product of the adhesive manufacturing process • typically 40 to 60% solids	• water quality impact: none • fresh water aquatic impact: generally low • plant impact: none • need product specific analysis
Clay Additives	• agglomerates with fine dust particles • generally increases dry strength of material under dry conditions	• if high fines content in treated material, the surface may become slippery when wet	• generally 1 treatment every 5 years • typical application rate is at 1 to 3% by dry weight	• mined natural clay deposits	• water quality impact: unknown • fresh water aquatic impact: none • plant impact: none

Table 2—Suppressant manufacturers.

Suppressant Category		Product Name	Manufacturer or Primary Distributor	Phone Number	Web Site
Water Absorbing	Calcium Chloride	Calcium Chloride Liquid	General Chemical	800-668-0433	www.genchem.com
		Calcium Chloride Flakes	General Chemical	800-668-0433	www.genchem.com
		Dowflake	Dow Chemical	800-447-4369	www.dowcalciumchloride.com
		Liquidow	Dow Chemical	800-447-4369	www.dowcalciumchloride.com
	Magnesium Chloride	DustGard	IMC Salt	913-344-9334	
		Dust-Off	Cargill Salt Division	800-553-7879	
		Chlor-tex	Soil-Tech	702-873-2023	www.soil-tech.com
	Blend of Calcium and Magnesium Chloride	Dust Fyghter	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com
	Sodium Chloride	Morton Salt	Morton International	312-807-2000	
		IMC Salt	IMC Salt	800-323-1641	
Organic Petroleum	Asphalt Emulsion	CSS-1	Any major asphalt supplier		
	Cutback	MC-70	Any major asphalt supplier		
	Dust Oil/Dust Fluids	Fuel Oil	Pacific Northern Industrial Fuels	206-282-4421	
		Duo Prime Oil	Lyondell Petrochemical Co.	800-423-8434	(white mineral oil)
		EnviroKleen	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com (synthetic iso-alkane)
	Modified Asphalt Emulsion	Asphotac	Actin	219-397-5020	
		Coherex	Witco Corp.	800-494-8287	www.witco.com
		DOPE-30	Morgan Emultech, Inc.	530-241-1364	
		PennzSuppress-D	Pennzoil-Quaker State Co.	713-546-4000	www.pennzsuppress.com
		Penetrating Emulsion Primer (PEP)	Koch Asphalt Co.	909-829-0505	www.kochmaterials.com
		Petro Tac	Syntech Products, Inc.	800-537-0288	www.syntechproducts.com
		Road Pro	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com
		Sandstill	Energy Systems Associates, Inc.	703-503-7873	
Organic Nonpetroleum	Lignosulfonate	DC-22	Dallas Roadway Products, Inc.	800-317-1968	www.dallasroadway.com
		Dustac	Georgia Pacific West, Inc.	360-733-4410	(was Lignosite)
		Dustac-100	Georgia Pacific West, Inc.	360-733-4410	www.gp.com/chemical/lignosulfonate
		CalBinder	California-Fresno Oil Co.	209-486-0220	www.calfresno.com
		Polybinder	Jim Good Marketing	805-746-3783	
		RB Ultra Plus	Roadbind America Inc.	888-488-4273	www.roadbind.com

Table 2—Suppressant manufacturers (continued).

Suppressant Category		Product Name	Manufacturer or Primary Distributor	Phone Number	Web Site
	Molassas/Sugar Beet	Dust Down	Amalgamated Sugar Co.	208-733-4104	
	Tall Oil Emulsion	Dust Control E	Pacific Chemicals, Inc./ Lyman Dust Control	604-828-0218 or 800-952-6457	
		Dustrol EX	Pacific Chemicals, Inc / Lyman Dust Control	604-828-0218 or 800-952-6457	
		Road Oyl	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org
	Vegetable Oils	Soapstock	Kansas Soybean Association Indiana Soybean Association	800-328-7390 800-735-0195	
		Dust Control Agent SS	Greenland Corp.	888-682-6040	
Electro-chemical	Enzymes	Bio Cat 300-1	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org
		EMCSQUARED	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org
		Perma-Zyme 11X	The Charbon Group, Inc.	714-593-1034	www.natural-industrial.com
		UBIX No. 0010	Enzymes Plus, Div of Anderson Affiliates	800-444-7741	
	Ionic	Road Bond EN-1	C.S.S. Technology, Inc.	800-541-3348	www.csstech.com
		Terrastone	Moorhead Group	831-685-1148	www.terrastone.com
	Sulfonated Oils	CBR Plus	CBR Plus, Inc. (Canada)	604-684-8072	www.cbrplus.com
		Condor SS	Earth Sciences Products Corp.	503-678-1216	www.earthscienceproducts.com
		SA-44 System	Dallas Roadway Products, Inc.	800-317-1968	www.dallasroadway.com
		Settler	Mantex	800-527-9919	
		TerraBond Clay Stabilizer	Fluid Sciences, LLC	888-356-7847 or 318-264-9448	www.fluidsciences.com
Synthetic Polymer Emulsions	Polyvinyl Acetate	Aerospray 70A	Cytec Industries	800-835-9844	www.cytec.com
		Soil Master WR	Enviromental Soil Systems, Inc.	800-368-4115	
	Vinyl Acrylic	Earthbound L	Earth Chem Inc.	970-223-4998	www.earthchem.com
		ECO-110	Chem-crete	972-234-8565	www.chem-crete.com/ soilstabilizer.htm
		PolyPavement	PolyPavement Company	323-954-2240	www.polypavement.com
		Liquid Dust Control	Enviroseal Corp.	561-969-0400	www.enviroseal.com
		Marloc	Reclamare Co.	206-824-2385	
		Soiloc-D	Hercules Soiloc	800-815-7668	
		Soil Seal	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org
		Soil Sement	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com
		TerraBond PolySeal	Fluid Sciences, LLC	888-356-7847	www.fluidsciences.com
	Combination of Polymers	Top Shield	Base Seal International, Inc.	800-729-6985	www.baseseal.com

Table 2—Suppressant manufacturers (continued).

Suppressant Category		Product Name	Manufacturer or Primary Distributor	Phone Number	Web Site
Clay Additives	Bentonite	Central Oregon Bentonite	Central Oregon Bentonite	541-477-3351	
		Pelbon	American Colloid Co.	800-426-5564 or 847-392-4600	www.colloid.com
		Volclay	American Colloid Co.	708-392-4600	www.colloid.com
	Montmorillonite	Stabilite	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org

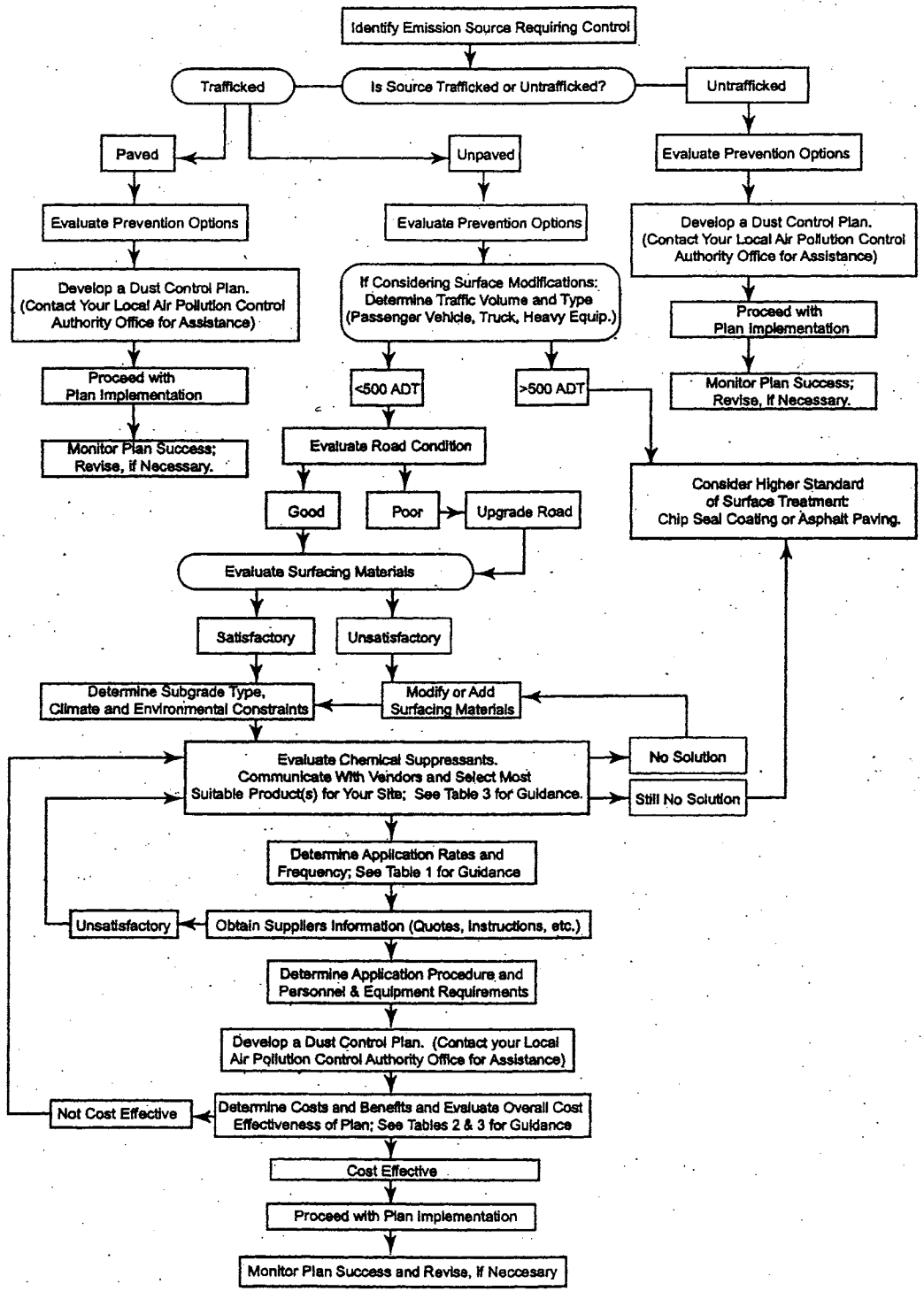


Figure 1—Guidelines for cost-effective selection and use of dust palliatives.

Table 3—Product selection chart.

Dust Palliative	Traffic Volumes, Average Daily Traffic			Surface Material								Climate During Traffic		
				Plasticity Index			Fines (Passing 75μm, No. 200, Sieve)							
	Light <100	Medium 100 to 250	Heavy >250 (1)	<3	3–8	>8	<5	5–10	10–20	20–30	>30	Wet &/or Rainy	Damp to Dry	Dry (2)
Calcium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓	✗ (3)	✗ (3,4)	✓✓	✗
Magnesium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓	✗ (3)	✗ (3,4)	✓✓	✓
Petroleum	✓	✓	✓	✓✓	✓	✗	✓ (5)	✓	✓ (6)	✗	✗	✓ (3)	✓✓	✓
Lignin	✓✓	✓✓	✓	✗	✓	✓✓ (6)	✗	✓	✓✓	✓✓	✓ (3,6)	✗ (4)	✓✓	✓✓
Tall Oil	✓✓	✓	✗	✓✓	✓	✗	✗	✓	✓✓ (6)	✓ (6)	✗	✓	✓✓	✓✓
Vegetable Oils	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✓
Electro-chemical	✓✓	✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓✓	✓✓	✓ (3,4)	✓	✓
Synthetic Polymers	✓✓	✓	✗	✓✓	✓	✗	✗	✓✓	✓✓ (6)	✗	✗	✓	✓✓	✓✓
Clay Additives (6)	✓✓	✓	✗	✓✓	✓✓	✓	✓✓	✓	✓	✗	✗	✗ (3)	✓	✓✓

Legend

✓✓ = Good ✓ = Fair ✗ = Poor

Notes:

(1) May require higher or more frequent application rates, especially with high truck volumes
(2) Greater than 20 days with less than 40% relative humidity
(3) May become slippery in wet weather
(4) SS-1 or CSS-1 with only clean, open-graded aggregate
(6) Road mix for best results

APPENDIX 3: CONDITION ASSESSMENT EXAMPLE BASED ON ARMY CORP OF ENGINEERS GUIDELINES (Department of the Army, TM 5-626, *Unsur-faced Road Maintenance Management*, 16 January 1995.)

URCI calculation Example

The sample unit shown in figure 3-2 has:

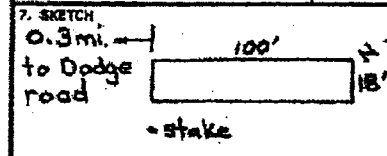
- 100 feet of medium severity improper cross section (distress 81),
- 200 feet (both ditches) of high severity inadequate roadside drainage (distress 82),
- Low severity dust (distress 84),
- 490 square feet of medium severity rutting (distress 86), and
- 910 square feet of high severity rutting (distress 86).

UNSURFACED ROAD INSPECTION SHEET

For use of this form, see TM 5-626; the proponent agency is USACE

1. BRANCH	2. SECTION	3. DATE
FS 101	1	7 Nov 94
4. SAMPLE UNIT	**5. AREA OF SAMPLE**	**6. INSPECTOR**
2	1800 ft²	R. Beaucham

7. SKETCH



DISTRESS TYPES

81. Improper Cross Section (linear feet)
82. Inadequate Roadside Drainage (linear feet)
83. Corrugations (square feet)
84. Dust
85. Potholes (number)
86. Ruts (square feet)
87. Loose Aggregate (linear feet)

8. DISTRESS QUANTITY AND SEVERITY

TYPE		81	82	83	84	85	86	87
QUANTITY AND SEVERITY	L	100						
	M			900	✓			160
	H							

9. UNSI CALCULATION

DISTRESS TYPE a	DENSITY b	SEVERITY c	DEDUCT VALUE d
81	5.6	L	13
83	50.0	M	29
84	–	M	4
87	8.8	M	18

10. REMARKS

e. TOTAL DEDUCT VALUE	f. q =	g. UNSI	h. RATING =
64	3	59	Good

DA FORM 7468-R NOV 94

In this example the density of each distress and severity level is based on a sample unit of 1,800 square feet

- For 100 linear feet of improper cross section (distress type 81), the density is

  = (100/ 1800) * 100 = 5.6

- For 900 square feet of corrugations (dis-tress type 83), the density is

= (900/ 1800) * 100 = 50

- No density calculation is needed for dust (distress type 84).
- For 160 linear feet of loose aggregate (distress type 87), the density is

  = (160/ 1800) *100 = 8.8

Using the deduct value curves, find the deduct values for each distress type and severity level. The deduct value curves are in appendix C .

- For improper cross section at low severity, locate on figure 3-4 the density of 5.6 on the horizontal axis, go vertically upward to the low severity curve, and then go left horizontally to the y-axis intersection, which gives a value of 13
- For corrugations at medium severity, the deduct value is 29 (fig C-3).
- For dust at medium severity, the deduct value is 4 (fig C-4).
- For loose aggregate at medium severity, the deduct value is 18 (fig C-7).

Find the Total Deduct Value (TDV) and the q value. Calculate the TDV by adding up all the deduct values. The q value is the number of individual deduct values greater than 5.0.

TDV = 13 + 29 + 4 + 18 = 64

The q value is 3 because three deduct values are greater than 5.0.

Find the Unsurfaced Road Condition Index (URCI) from the URCI curve. (NOTE: Slightly higher URCIs may result from manual computations.)

From figure 3-5, the TDV is 64 and q is 3, so the URCI curve shows that the URCI is 59. From figure 3-1, the rating is "good."

This is the rating for this sample unit. The rating for the section is the average of the ratings from all the sample units in the section. For example, URCIs of 63, 59, and 67 in a section would give an average URCI of 63 for the whole section.

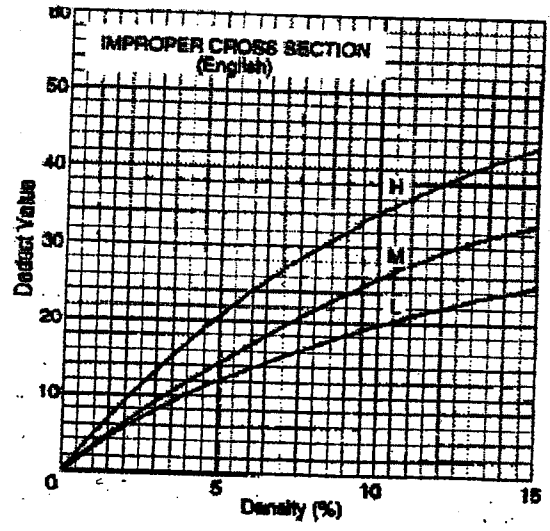


Figure 3-4. Improper cross section deduct values curves

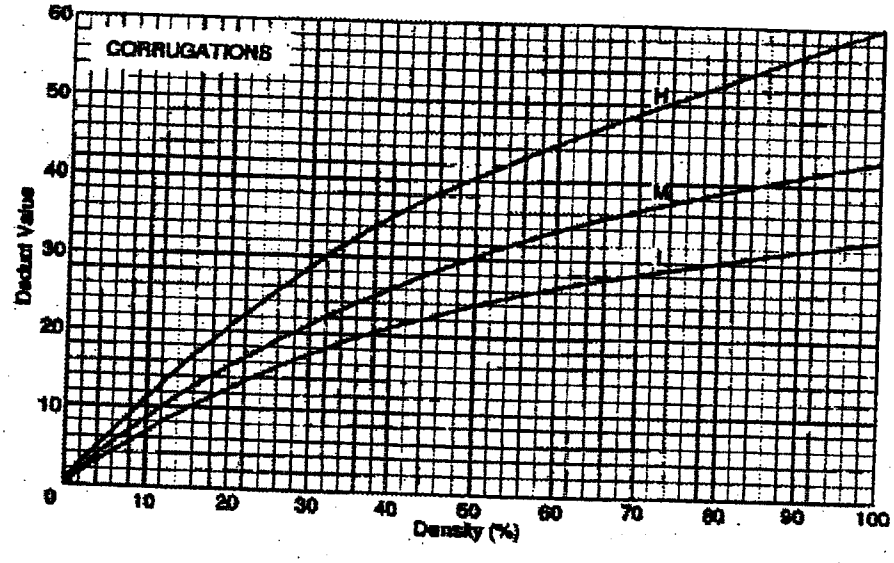


Figure X – 3 : Corrugation deduct value

DUST

Dust is not rated by density. The deduct values for the levels of severity are:

Low ——— 2 Points
Medium —— 4 Points
High ———15 Points

Figure X- 3: Dust Deduct Values

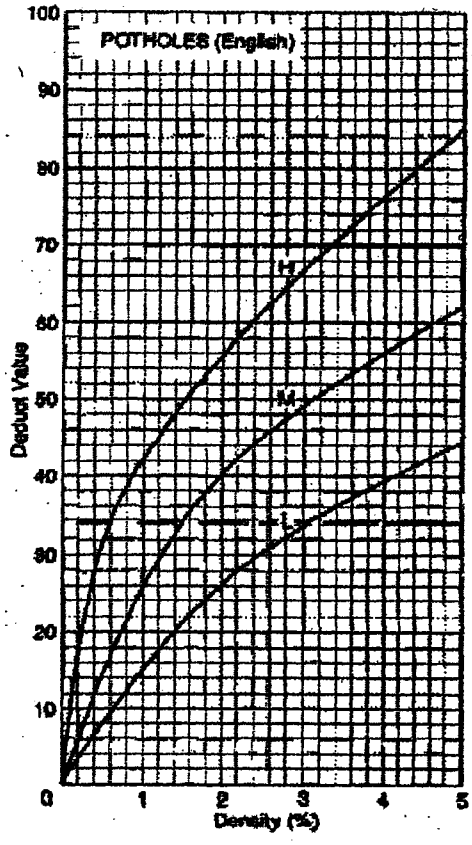


Figure x – 2 : Pothole deduct value

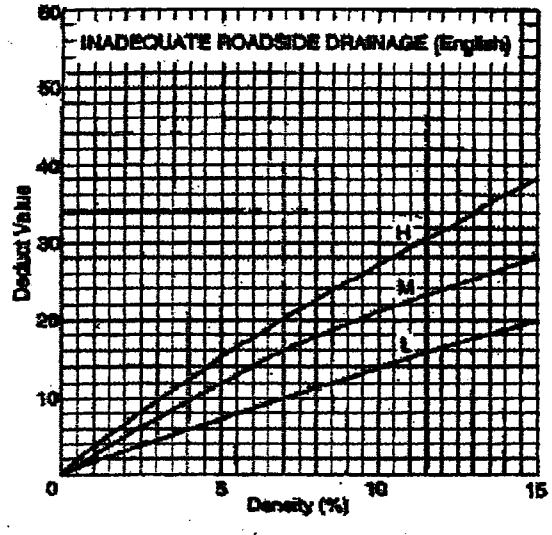


Figure x – 3 : Inadequate road side drainage deduct value

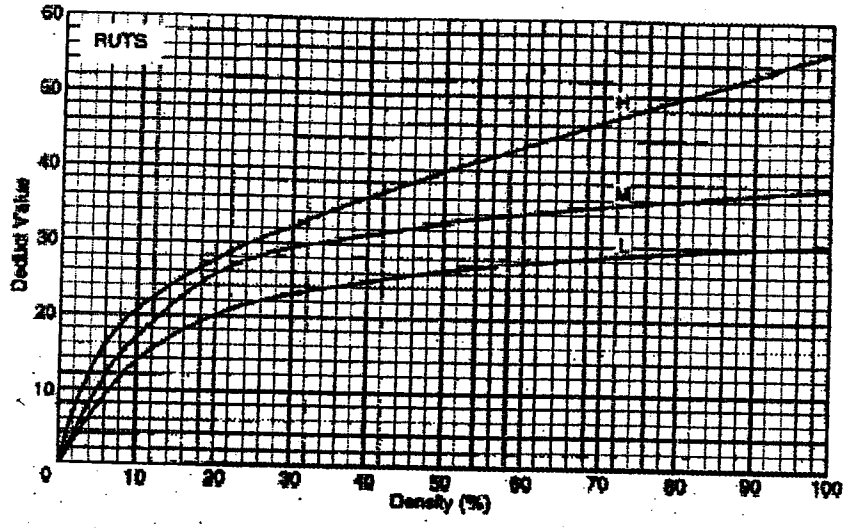


Figure x 1: Ruts Deduct Value

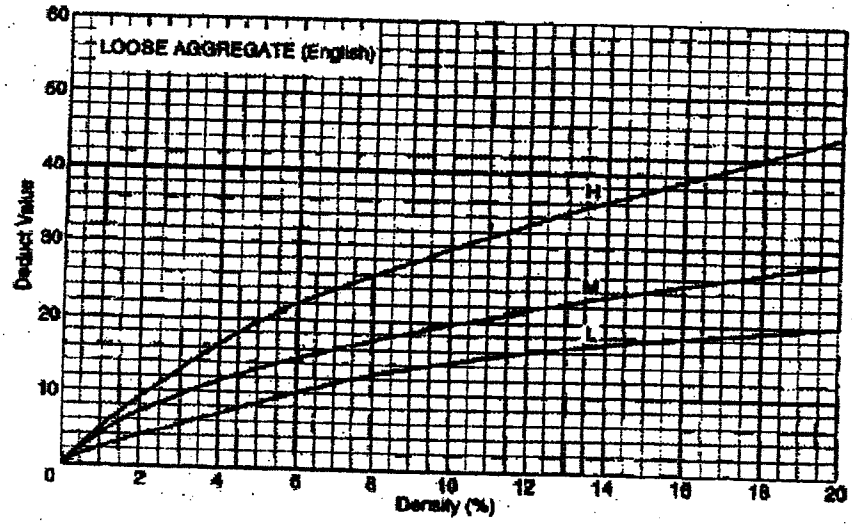


Figure X –2: Loose Aggregate Deduct Value

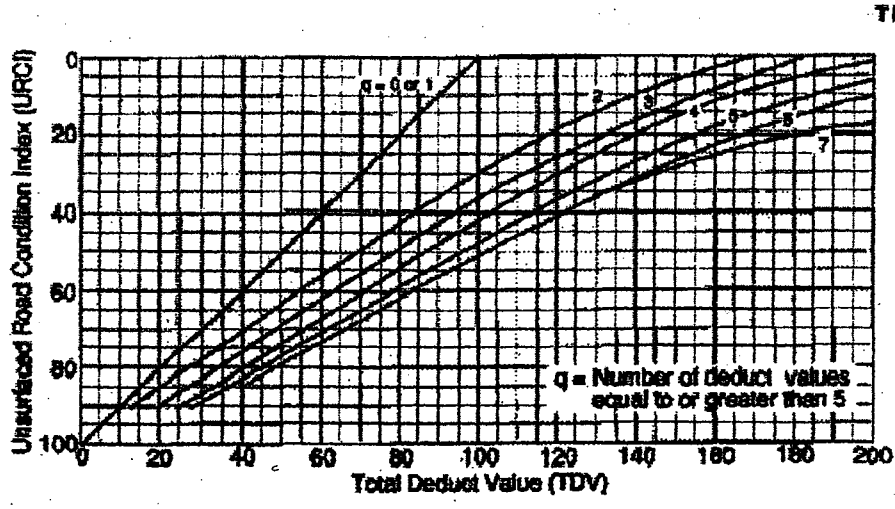


Figure X – 3: URCI curves

UNSURFACED ROAD INSPECTION SHEET

For use of this form, see TM 5-626; the proponent agency is USACE

1. BRANCH	2. SECTION	3. DATE
4. SAMPLE UNIT	5. AREA OF SAMPLE	6. INSPECTOR

7. SKETCH

DISTRESS TYPES

81. Improper Cross Section *(linear feet)*
82. Inadequate Roadside Drainage *(linear feet)*
83. Corrugations *(square feet)*
84. Dust
85. Potholes *(number)*
86. Ruts *(square feet)*
87. Loose Aggregate *(linear feet)*

8. DISTRESS QUANTITY AND SEVERITY

TYPE		81	82	83	84	85	86	87
QUANTITY AND SEVERITY	L							
	M							
	H							

9. URCI CALCULATION

DISTRESS TYPE a	DENSITY b	SEVERITY c	DEDUCT VALUE d

10. REMARKS

e. TOTAL DEDUCT VALUE	f. q =	g. URCI	h. RATING =

DA FORM 7348-R, NOV 94

*U.S. G.P.O.:1995-386-731:158

APPENDIX 4: BENTON COUNTY BORD OF COMMISSIONERS COUNTY PUBLIC WORKS DEPARTMENT ADMINISTRATIVE POLICY

ADMIN POL.2001

BENTON COUNTY BOARD OF COMMISSIONERS

COUNTY PUBLIC WORKS DEPARTMENT ADMINISTRATIVE POLICY

BE IT ADOPTED, That the County Highway Engineer is hereby authorized to expend from the County Road and Bridge fund a sum not to exceed $350.00 for furnishing of Engineering and Supervisory Assistance to the Townships of the County in their road work, as requested, and

BE IT FURTHER ADOPTED, That the County Highway Engineer is authorized to utilize County equipment, operators and supplies as necessary to assist Townships in maintaining roads and plowing snow on Township roads and City streets in emergencies but only if benefited Town or City reimburses the County for such work, and

BE IT FURTHER ADOPTED, That the County Highway Engineer shall have general supervision of all roads under County control and authority to restrict size and weight of loads and to erect and maintain special restriction signs, to issue permits for moving over-size and over-weight loads, to erect and maintain Regulatory, Warning and Guide Signs, have Speed Zones established in conformity to the rules and regulations of the Uniform Traffic Control manual as adopted by the Commissioner of Transportation, and if necessary assist essential personnel (Highway Maintenance and Sheriff's Deputies) in getting to their respective offices during heavy snowfalls and severe weather conditions, and

BE IT FURTHER ADOPTED, That the County Highway Engineer is authorized to cause suitable approaches to newly established highways to be constructed when necessary and reasonably practical; also to issue at least one permit per property owner along existing highways when necessary for a suitable approach after a written permit application is approved, and

BE IT FURTHER ADOPTED, That the County Highway Engineer is authorized to provide one approved standard mail box support per permitted new approach, and

BE IT FURTHER ADOPTED, That the County Highway Engineer is authorized to issue written permits for utility encroachments and the connecting of any drain or ditch with any drain or ditch constructed on or across highway rights-of-way, and

BE IT FURTHER ADOPTED, That the County Highway Engineer be authorized to hire such other miscellaneous skilled or semi-skilled labor and such machinery and equipment from time to time for emergency work or summer help required and at the going rate generally paid by other employers in the community, and

BE IT FURTHER ADOPTED, That the County Highway Engineer is hereby authorized to furnish County equipment and labor to remove snow from driveways for individuals in an emergency such as sickness and funerals.

BE IT FURTHER ADOPTED, That the County Highway Engineer is authorized to sell any surplus property estimated to be worth less than $500.00, either on competitive bids or on the open market. Receipts from said sales are to be deposited in the Road and Bridge Fund.

BE IT FURTHER ADOPTED, That pursuant to statutory authority, the County Highway Engineer, as per the Technical Assistance Agreement with MN/DOT, for and on behalf of Benton County is hereby authorized to request and obtain needed engineering and technical assistance from MN/DOT during the calendar year of 2001. Payments will be made by Benton County upon receipt of verified claims from the Commissioner of Transportation, and

BE IT FURTHER ADOPTED, That all authorized mileage will be compensated at $0.345 (Thirty four and one half cents) per mile by Benton County for the public use of privately owned vehicles, and

BE IT FURTHER ADOPTED, That the County Equipment Rental Rates for emergency work for Townships and Cities be established for the year 2001 as follows: All summer blading, $65.00 per hour, snowplowing and de-icing, $65.00 per hour.

BE IT FURTHER ADOPTED, That Equipment Rental Rates for other functions are as follows:

Motor Graders	150 H.P. or less $65.00/hr. (with operator)
Backhoe U#89	$50.00/hr. (with operator)
Pickup Truck	Not less than $ 0.32/mi. (without operator)
Trucks (5 cu. yd.)	$45.00/hr. (with operator)
Tractor & Mower	$50.00/hr. (with operator)
Asphalt Kettle U#43	$45.00/hr (with operator and LP Gas)
Front End Loader U#64	$70.00/hr. (with operator)
U#930	$65.00/hr. (with operator)
U#64	$145.00/hr. (w/operator & snowblower)
Pneumatic Tired Roller	$10.00/hr. (without operator)
Stepp Bituminous Trailer	$55.00/hr. (without operator & Mix)

D-4 Dozer	$95.00/hr.	(with operator)
Truck (12 cu. yd.)	$55.00/hr.	(with operator)
Power Broom (Mounted on U#930)	$15.00/hr.,	**(WITH U#930 @ $65.00/hr.)**
Self-Propelled Sweeper	$65.00/hr.	(with operator)
Tractor & Lowboy U#94 & 91	$50.00/hr.	(with operator)
Chipper	$45.00/hr.	(with operator)
Striper (Road Marking Machine)	$55.00/hr.	(with operator & pickup), **(PLUS PAINT & BEADS EXTRA)**
[illegible]	$45.00/hr	(with operator) ([illegible]

BE IT FURTHER ADOPTED, That the County Highway Engineer be directed to use the County Highway buildings, property, gravel pits, equipment, tools and supplies for the highway related work in the county and to secure and maintain a sufficient stock of supplies and repair parts to keep all properties and equipment in good repair and condition.

Adopted ______________________ ______________________________
Date Chairperson, Benton County Board of Commissioners

STATE OF MINNESOTA)
COUNTY OF BENTON)

I, Joan Neyssen ,County Auditor/Treasurer of the County of Benton, State of Minnesota so hereby certify that the foregoing policy is a true and correct copy of a policy duly adopted at a meeting of the Benton County Board of Commissioners held on the

________________day of __________________________, 2001.

____
Joan Neyssen, County Auditor/Treasurer

(SEAL)

APPENDIX 5: ECONOMICS OF UPGRADING AGGREGATE ROAD TEAM

LRRB 769: Economics of Upgrading an Aggregate Road Team

Principal Investigator: Greg Johnson, MnDOT – Road Research

Support Team:

Roger Olson (MnDOT)

Dr. Chuck Jahren (Iowa State University) – Consultant Investigator

Dwayne Smith (Iowa LTAP) – Consultant Investigator

David White, Assistant Professor, IA State University

Jacob Thorius, Graduate Student, IA State University

Mary Rukashaza-Mukome, Graduate Student, IA State University

LRRB 769, Technical Advisory Panel (TAP)

Dave Christy (Itasca County) – Technical Liaison

Dan Warzala (MnDOT – ORS) – Administrative Liaison

Mic Dahlberg (Chisago county)

David Fricke (Minnesota Association of Townships)

Keith Kile (Township Supervisor)

Joel Ulring (St. Louis county)

Richard West (Otter Tail county)

APPENDIX 6: BLUE EARTH COUNTY 2002 SUMMARY OF ROAD PROGRAM MAINTENANCE REPORT

TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD PROGRAM MAINTENANCE COSTS
FOR THE PERIOD JAN TO DEC

WT- CAG10R V08.00 PAGE 1
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ACCOUNT NUMBER	ACCOUNT DESCRIPTION	ACCOUNT CODE	CSAH REG	COST/ MILE	CSAH MUN	COST/ MILE	COUNTY ROADS	COST/ MILE
11-0000	ROUTINE MAINTENANCE							
11-0100	SMOOTHING SURFACE		21,556.36	53.03	528.07	31.25	132,243.83	432.20
11-0200	MINOR SURFACE REPAIR		221,369.60	544.63	31,943.08	1,890.12	28,844.09	94.27
11-0300	CLEANING CULVERTS & DITCHES		19,656.68	48.38	1,041.97	61.66	7,607.71	24.86
11-0400	BRUSH & WEED CONTROL		131,439.18	323.38	5,104.40	302.04	73,615.59	240.59
11-0500	SNOW AND ICE REMOVAL		261,263.07	642.78	19,597.93	1,159.64	122,510.21	400.39
11-0600	TRAFFIC SERVICES (INCL. SIGNS)		111,778.88	275.01	4,525.25	267.77	31,437.20	102.74
TOTAL	11-0000		767,063.75	1,887.18	62,740.70	3,712.47	396,258.63	1,295.05
12-0000	REPAIRS AND REPLACEMENT							
12-0100	RESHAPING		49,785.90	122.49	989.88	58.57	9,369.78	30.62
12-0200	RESURFACING		202,224.70	497.53	7,467.62	441.87	370,261.36	1,210.15
12-0300	CULVERTS, BRIDGES, GUARDRAILS		28,199.78	64.46	1,383.20	81.85	59,433.47	194.24
12-0400	WASHOUTS		6,977.39	17.17	31.91	1.89	3,538.38	11.56
TOTAL	12-0000		285,187.77	701.64	9,872.61	584.18	442,622.99	1,446.57
13-0000	BETTERMENTS							
13-0100	CULVERTS, RAILS OR TILING		57,709.12	141.98	35,387.61	2,092.76	32,622.31	106.62
13-0200	CUTS AND FILLS		75,327.50	185.33	3,358.99	198.76	118,978.60	388.84
13-0300	SEEDING AND SODDING		5,471.54	13.46	851.39	50.38	5,186.69	16.95
13-0400	BITUMINOUS TREATMENT		423,284.76	1,041.39	19,957.79	1,180.93	13,911.08	45.46
13-0500	ENGINEERING ASSISTANCE		3,625.26	8.92	142.56	8.44	4,033.58	13.18
TOTAL	13-0000		565,418.18	1,391.08	59,678.34	3,531.28	174,732.26	571.06
14-0000	SPECIAL WORK							
14-0100	DUST TREATMENT		1,159.48	2.85	1.96	.12	3,743.06	12.23
14-0200	PROSPECTING FOR GRAVEL		0.00		0.00		74.41	.24
14-0400	FLOOD DAMAGE REPAIR		80.83	.20	0.00		258.40	.84
14-0500	EROSION CONTROL		4,650.55	11.44	8,682.45	513.75	0.00	
14-0700	FIRE CALLS		576.45	1.42	38.61	2.28	0.00	
TOTAL	14-0000		6,467.31	15.91	8,723.02	516.16	4,075.87	13.32
15-0000	SPECIAL AGREEMENTS							
19-9900	ADJUSTING ENTRIES		155,611.03	382.84	8,452.51	381.81	116,810.55	381.76
TOTAL	15-0000		155,611.03	382.84	8,452.51	381.81	116,810.55	381.76
TOTAL EXPENSE			1,779,748.04	4,378.65	147,467.18	8,725.87	1,134,500.30	3,707.76
TOTAL NO. OF MILES			406.46		16.90		305.98	

CSAH REG
ROUTINE MAINTENANCE
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ROAD	LENGTH	SURFACE	SMOOTHING SURFACE	MINOR SURFACE REPAIR	CLEANING CULVERTS & DITCHES	BRUSH AND WEED CONTROL	SNOW AND ICE REMOVAL	TRAFFICE SERVICES (& SIGNS)	TOTAL COSTS	COST/ MILE
1	11.50	BITUM	37.41	3,331.88	327.79	3,006.73	4,676.40	1,334.13	11,714.34	1,018.64
2	4.80	BITUM	375.28	18,277.85	34.76	1,723.62	3,577.66	4,217.74	28,206.91	5,876.44
3	2.03	BITUM	9.14	121.95	152.67	279.57	1,663.01	664.38	2,890.72	1,424.00
3	2.91	GRAVEL	13.11	174.85	218.88	400.81	2,384.24	952.46	4,144.35	1,424.18
4	7.00	BITUM	36.86	5,022.64	110.98	1,584.73	2,245.09	3,680.44	12,660.74	1,808.68
5	4.37	BITUM	41.56	5,667.54	114.50	629.58	5,694.63	2,891.49	15,039.30	3,441.49
5	0.40	CONCTE	3.80	519.05	10.49	57.66	521.54	264.81	1,377.35	3,443.38
6	11.70	BITUM	54.03	27.22	62.49	3,537.99	5,058.38	5,837.61	14,577.70	1,245.96
7	4.60	BITUM	71.83	600.95	302.88	1,227.01	3,851.78	228.41	6,282.86	1,365.84
8	8.24	BITUM	100.80	14,677.01	176.55	1,118.70	7,887.41	4,021.28	28,181.75	3,420.12
9	8.20	BITUM	7.61	14,986.28	48.12	983.54	7,737.58	3,254.09	27,017.22	3,294.78
10	33.70	BITUM	192.41	7,084.53	1,690.03	9,142.23	12,597.30	4,651.09	35,357.59	1,049.19
11	13.80	BITUM	56.68	155.34	17.38	2,267.72	7,087.68	2,633.43	12,218.21	885.36
12	8.72	BITUM	26.28	2,484.94	527.35	1,876.30	6,933.43	2,189.97	14,038.25	2,089.03
13	15.10	BITUM	76.16	434.42	225.81	3,800.87	7,309.94	2,110.89	13,957.89	924.36
14	14.30	BITUM	124.95	84.38	1,196.39	2,772.41	5,734.78	7,233.86	17,146.77	1,199.07
15	8.50	BITUM	26.58	810.32	482.25	1,236.52	5,647.02	806.13	9,008.82	1,059.86
16	17.27	BITUM	798.89	913.24	972.74	2,165.89	9,643.25	4,127.19	18,621.20	1,078.24
16	1.00	GRAVEL	46.23	52.85	56.27	125.32	558.01	238.81	1,077.49	1,077.49
17	5.20	BITUM	14.54	6,361.72	753.54	2,754.76	7,279.05	1,714.39	18,878.00	3,630.38
18	5.30	BITUM	24.07	14.18	741.18	3,091.25	2,479.58	1,653.73	8,003.95	1,510.18
19	1.50	BITUM	832.70	0.00	126.96	425.70	1,133.20	79.03	2,397.59	1,598.39
19	3.30	GRAVEL	1,391.95	0.00	279.31	936.53	2,493.07	173.87	5,274.73	1,598.40
20	19.80	BITUM	62.00	2,807.40	312.31	3,097.42	13,964.03	4,385.79	24,628.95	1,243.89
21	8.00	BITUM	622.83	206.96	3,068.05	1,938.35	4,053.88	1,555.68	11,444.75	1,430.59
21	1.00	GRAVEL	77.84	25.73	383.39	242.22	506.57	194.38	1,430.13	1,430.13
22	3.50	BITUM	21.16	247.14	0.00	351.09	2,354.32	736.88	3,710.59	1,060.17
23	4.50	BITUM	96.07	1,423.15	0.00	2,219.45	1,861.92	1,926.03	7,526.62	1,672.58
24	3.00	BITUM	1,450.10	1,573.95	56.98	864.65	1,997.81	635.63	6,579.12	2,193.04
24	3.00	GRAVEL	1,450.08	1,573.94	56.97	864.60	1,997.75	835.60	6,578.94	2,192.98
25	4.00	BITUM	24.16	28.31	216.46	2,923.07	2,713.36	287.40	6,172.78	1,543.20
26	8.20	BITUM	13.36	1,392.05	43.32	3,795.18	6,226.29	2,337.26	13,807.46	1,683.84
27	6.70	BITUM	34.44	15,007.93	0.00	1,085.30	6,500.43	2,873.00	25,501.10	3,806.13
28	8.90	BITUM	54.73	420.47	81.54	2,227.35	3,318.71	1,701.18	7,803.98	876.85
29	7.40	BITUM	54.74	14.18	206.46	1,988.87	2,577.83	874.98	5,717.04	772.57
30	9.70	BITUM	0.00	110.46	8.60	1,791.51	3,003.88	2,242.88	7,157.22	737.86
31	3.40	BITUM	0.00	14.16	0.00	524.30	1,518.03	322.09	2,378.58	699.58
32	14.10	BITUM	1,706.39	391.58	761.91	3,509.79	7,211.93	744.94	14,326.54	1,016.07
32	3.00	GRAVEL	362.96	83.29	162.06	746.58	1,534.04	158.45	3,047.38	1,015.79
33	5.10	BITUM	6.77	16,103.44	432.87	2,198.75	4,400.00	2,754.07	25,895.90	5,077.63
34	10.10	BITUM	12.45	6,278.63	197.36	2,118.60	6,582.28	5,047.17	20,236.49	2,003.61
35	2.00	BITUM	1,245.48	8.31	452.41	494.37	1,233.77	229.90	3,664.24	1,832.12
35	4.70	GRAVEL	2,927.34	19.51	1,063.33	1,161.95	2,899.84	540.35	8,612.32	1,832.41
36	5.80	BITUM	15.05	22,288.30	231.94	1,634.28	2,646.19	2,003.25	28,819.01	4,968.79
37	4.70	BITUM	14.73	1,104.31	0.00	1,967.98	2,766.66	1,317.89	7,171.57	1,525.87
38	3.70	BITUM	34.70	271.70	49.13	965.29	4,682.03	919.59	6,922.44	1,870.93
39	5.10	GRAVEL	8.36	28.31	156.70	1,172.22	2,086.33	186.17	3,638.09	713.35
40	6.40	BITUM	41.03	28.31	0.00	3,675.49	3,259.46	341.47	7,345.76	874.50

BLUE EARTH COUNTY HIGHWAY DEPARTMENT — WT- CA620R V08.00 — PAGE

CSAH REG
MAINTENANCE
TOTAL CLASS

SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

HIGHWAY COSTING SYSTE
COST ACCOUNTIN

ROAD	LENGTH	SURFACE	ROUTINE MAINTENANCE	REPAIRS AND BETTERMENTS REPLACEMENT		SPECIAL WORK	SPECIAL AGREEMENTS	SUB-TOTAL COSTS	PRORATED COSTS	TOTAL COSTS	COST/ MILE
41	5.50	BITUM	8,762.10	3,356.95	5,999.13	0.00	2,100.02	20,218.20	3,307.19	23,525.39	4,277.34
42	2.90	BITUM	8,343.21	5,091.85	34,402.48	0.00	1,107.28	48,944.82	8,006.14	56,950.96	19,638.26
43	0.30	BITUM	427.42	15.60	0.00	4,650.55	114.54	5,208.11	851.92	6,060.03	20,200.10
44	0.50	BITUM	2,881.97	54.59	100.00	0.00	190.93	3,027.49	495.22	3,522.71	7,045.42
45	0.50	BITUM	900.13	0.00	0.00	0.00	190.91	1,091.04	178.47	1,269.51	2,539.02
46	5.60	BITUM	12,614.24	3,053.67	0.00	0.00	2,138.19	17,806.10	2,912.63	20,718.73	3,699.77
47	3.00	BITUM	4,657.17	126.09	0.00	0.00	1,145.46	5,928.72	969.79	6,898.51	2,299.50
48	3.30	BITUM	18,753.61	466.86	0.00	0.00	1,259.94	20,480.61	3,350.11	23,830.72	7,221.43
48	1.00	GRAVEL	5,684.31	141.53	0.00	0.00	381.89	6,207.73	1,015.43	7,223.16	7,223.16
49	3.00	GRAVEL	4,884.07	11,841.19	0.00	140.11	1,145.46	17,990.83	2,942.85	20,933.68	6,977.89
50	2.19	BITUM	15,782.58	2,792.25	22,180.20	0.00	840.01	41,575.04	6,800.63	48,375.67	22,089.35
52	2.50	BITUM	4,080.88	3,108.20	30,889.38	0.00	954.55	39,032.81	6,384.79	45,417.60	18,167.04
53	6.70	BITUM	24,906.78	11,510.11	53,529.48	0.00	2,568.18	92,504.49	15,131.41	107,635.90	16,065.06
54	1.14	BITUM	1,522.05	259.87	0.00	0.00	435.28	2,217.20	362.68	2,579.88	2,263.05
55	1.00	BITUM	3,392.63	4,388.29	1,118.92	0.00	381.82	9,281.66	1,514.97	10,776.63	10,776.63
56	0.25	BITUM	2,509.94	0.00	732.32	0.00	95.45	3,337.71	545.97	3,883.68	15,534.72
57	2.50	BITUM	4,368.26	84.31	0.00	0.00	954.55	5,407.12	884.47	6,291.59	2,516.64
60	0.71	BITUM	1,847.69	13.78	298.97	0.00	274.91	2,435.56	398.40	2,833.96	3,991.49
69	3.40	BITUM	29,162.07	717.89	0.00	0.00	1,298.20	31,177.96	5,099.93	36,277.89	10,669.97
82	1.30	BITUM	4,457.97	41.77	0.00	0.00	496.37	4,996.11	817.24	5,813.35	4,471.81
83	0.50	BITUM	3,541.61	0.00	0.00	0.00	190.91	3,732.52	610.55	4,343.07	8,686.14
90	7.73	BITUM	29,191.31	33,718.01	3,595.67	47.53	3,283.51	69,836.03	11,423.42	81,259.45	10,512.22
90	1.70	GRAVEL	6,420.84	7,418.58	790.90	10.46	722.24	15,361.02	2,512.68	17,873.70	10,513.94
TOTAL	406.46		767,063.75	285,187.77	565,416.18	6,467.31	155,611.03	1,779,748.04	291,122.01	2,070,870.05	5,094.89

PRORATION PERCENT 58.000
PRORATED COSTS USING PRORATION PERCENT 291,121.98
DIFFERENCE DUE TO ROUNDING 0.03

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MAINTENANCE
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT-- CA620R V00.00 PAGE 1
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ROAD	LENGTH	SURFACE	ROUTINE MAINTENANCE	REPAIRS AND REPLACEMENT	BETTERMENTS	SPECIAL WORK	SPECIAL AGREEMENTS	SUB-TOTAL COSTS	PRORATED COSTS	TOTAL COSTS	COST/ MILE
1	11.50	BITUM	11,714.34	104.52	404.33	0.00	4,390.84	16,614.13	2,717.65	19,331.78	1,681.02
2	4.80	BITUM	28,206.91	6,277.21	38,435.32	0.00	1,832.74	74,752.18	12,227.58	86,979.76	18,120.78
3	2.03	BITUM	2,890.72	78.45	11.24	0.00	775.04	3,753.45	613.97	4,367.42	2,151.44
3	2.91	GRAVEL	4,144.35	109.62	16.12	0.00	1,111.15	5,381.24	880.24	6,261.48	2,151.71
4	7.00	BITUM	12,660.74	433.24	261.56	0.00	2,872.75	16,028.29	2,621.82	18,650.11	2,664.30
5	4.37	BITUM	15,039.30	299.50	1,149.76	0.00	1,668.47	18,157.03	2,970.03	21,127.06	4,834.57
5	0.40	CONCTE	1,377.35	27.43	105.30	0.00	152.81	1,662.89	272.01	1,934.90	4,837.25
6	11.70	BITUM	14,577.70	9,188.60	54,556.53	0.00	4,467.39	82,790.22	13,542.40	96,332.62	8,233.56
7	4.80	BITUM	8,282.86	188.72	136.72	0.00	1,756.38	8,366.68	1,368.58	9,735.26	2,116.36
8	8.24	BITUM	28,181.75	244.58	5,477.62	0.00	3,146.20	37,050.15	6,060.47	43,110.62	5,231.87
9	8.20	BITUM	27,017.22	5,738.47	50,819.13	274.56	3,131.00	86,980.38	14,227.80	101,208.18	12,342.46
10	33.70	BITUM	35,357.69	5,082.47	18,775.13	0.00	12,887.08	72,082.27	11,787.57	83,869.84	2,488.13
11	13.80	BITUM	12,218.21	53.16	626.07	0.00	5,269.13	18,166.57	2,971.59	21,138.16	1,531.75
12	6.72	BITUM	14,038.25	1,088.64	3,172.51	0.00	2,568.98	20,868.38	3,413.54	24,281.92	3,613.38
13	15.10	BITUM	13,957.89	9,305.49	3,158.61	0.00	5,765.49	32,187.48	5,265.06	37,452.54	2,480.30
14	14.30	BITUM	17,146.77	0.00	0.00	0.00	5,460.05	22,606.82	3,697.91	26,304.73	1,839.49
15	8.50	BITUM	9,008.82	4,441.59	912.22	0.00	3,245.63	17,608.26	2,880.27	20,488.53	2,410.42
16	17.27	BITUM	18,621.20	8,623.86	6,498.94	76.41	6,594.29	40,412.70	6,610.50	47,023.20	2,722.83
16	1.00	GRAVEL	1,077.49	2,030.12	375.94	4.42	381.58	3,869.55	632.96	4,502.51	4,502.51
17	5.20	BITUM	18,878.00	13,373.55	2,187.84	0.00	1,985.54	36,424.93	5,958.20	42,383.13	8,150.60
18	5.30	BITUM	8,003.95	125.81	0.00	0.00	2,023.66	10,153.42	1,660.84	11,814.26	2,229.11
19	1.50	BITUM	2,397.59	415.55	0.00	0.00	572.73	3,385.87	553.84	3,939.71	2,626.47
19	3.30	GRAVEL	5,274.73	914.20	0.00	0.00	1,260.01	7,448.94	1,218.46	8,667.40	2,626.48
20	19.80	BITUM	24,628.95	788.99	7,949.45	286.83	7,560.37	41,214.59	6,741.67	47,956.26	2,422.03
21	8.00	BITUM	11,444.75	33,852.56	64,885.82	0.00	3,054.73	113,037.66	18,490.12	131,527.78	16,440.97
21	1.00	GRAVEL	1,430.13	4,205.06	8,107.83	0.00	381.70	14,124.72	2,310.45	16,435.17	16,435.17
22	3.50	BITUM	3,710.59	175.82	0.00	0.00	1,336.37	5,222.58	854.28	6,076.86	1,736.25
23	4.50	BITUM	7,526.82	10,581.52	25,936.89	0.00	1,718.19	45,713.02	7,477.50	53,190.52	11,820.12
24	3.00	BITUM	6,579.12	6,154.15	16,303.88	0.00	1,145.47	30,182.62	4,937.12	35,119.74	11,706.58
24	3.00	GRAVEL	6,578.94	10,924.20	14,660.46	93.41	1,145.46	33,402.47	5,463.80	38,866.27	12,955.42
25	4.00	BITUM	6,172.78	0.00	0.00	0.00	1,527.28	7,700.06	1,259.54	8,959.60	2,239.90
26	8.20	BITUM	13,807.46	860.93	114.95	0.00	3,130.91	17,914.25	2,930.32	20,844.57	2,542.02
27	6.70	BITUM	25,501.10	8,967.73	43,433.95	0.00	2,558.20	80,460.98	13,161.39	93,622.37	13,973.49
28	8.90	BITUM	7,803.98	6,273.12	242.73	0.00	3,398.06	17,717.89	2,898.20	20,616.09	2,316.41
29	7.40	BITUM	5,717.04	163.78	786.86	0.00	2,825.48	9,493.16	1,552.84	11,046.00	1,492.70
30	9.70	BITUM	7,157.22	0.00	0.00	0.00	3,703.66	10,860.88	1,776.57	12,637.45	1,302.83
31	3.40	BITUM	2,378.58	355.33	0.00	0.00	1,298.20	4,032.11	659.55	4,691.66	1,379.90
32	14.10	BITUM	14,326.54	4,925.25	3,459.68	0.00	5,383.93	28,095.40	4,595.70	32,691.10	2,318.52
32	3.00	GRAVEL	3,047.38	5,817.73	735.90	280.22	1,145.21	11,026.44	1,803.65	12,830.09	4,276.70
33	5.10	BITUM	25,895.90	4,098.55	0.00	0.00	1,947.29	31,941.74	5,224.86	37,166.60	7,287.57
34	10.10	BITUM	20,236.49	1,570.86	494.88	0.00	3,856.39	26,158.60	4,278.89	30,437.49	3,013.61
35	2.00	BITUM	3,664.24	2,804.75	90.25	5.67	763.53	7,328.44	1,198.75	8,527.19	4,263.60
35	4.70	GRAVEL	8,612.32	10,729.80	212.09	597.14	1,794.58	21,945.73	3,589.77	25,535.50	5,433.09
36	5.80	BITUM	28,819.01	7,765.47	36,715.13	0.00	2,214.52	75,534.13	12,355.48	87,889.61	15,153.38
37	4.70	BITUM	7,171.57	6,661.24	95.18	0.00	1,794.56	15,722.53	2,571.81	18,294.34	3,892.41
38	3.70	BITUM	6,922.44	97.17	0.00	0.00	1,412.73	8,432.34	1,379.32	9,811.66	2,651.80
39	5.10	GRAVEL	3,638.09	1,169.99	59.51	0.00	1,947.29	6,814.88	1,114.74	7,929.62	1,554.83
40	8.40	BITUM	7,345.76	172.19	434.88	0.00	3,207.30	11,160.11	1,825.51	12,985.62	1,545.91

BLUE EARTH COUNTY HIGHWAY DEPARTMENT — WT- — CAG20R V08.00
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD — HIGHWAY COSTING SYSTEM
FOR THE PERIOD JAN TO DEC — COST ACCOUNTING

CSAH REG
ROUTINE MAINTENANCE
TOTAL CLASS

ROAD	LENGTH	SURFACE	SMOOTHING SURFACE	MINOR SURFACE REPAIR	CLEANING CULVERTS & DITCHES	BRUSH AND WEED CONTROL	SNOW AND ICE REMOVAL	TRAFFICE SERVICES (& SIGNS)	TOTAL COSTS	COST/ MILE
41	5.50	BITUM	12.67	3,344.88	14.41	712.98	3,168.59	1,508.57	8,762.10	1,593.11
42	2.90	BITUM	29.67	1,928.33	261.35	1,217.82	2,479.42	2,426.62	8,343.21	2,876.97
43	0.30	BITUM	0.00	0.69	0.00	92.53	207.61	126.59	427.42	1,424.73
44	0.50	BITUM	0.00	959.32	0.00	839.03	650.05	233.57	2,681.97	5,363.94
45	0.50	BITUM	0.00	0.00	0.00	152.17	175.68	572.28	900.13	1,800.26
46	5.60	BITUM	629.51	7,394.44	273.04	944.11	2,322.78	1,050.38	12,614.24	2,252.54
47	3.00	BITUM	0.00	99.84	0.00	1,163.96	3,053.71	339.66	4,657.17	1,552.39
48	3.30	BITUM	745.98	14,750.54	0.00	382.00	1,772.67	1,102.62	18,753.81	5,682.97
48	1.00	GRAVEL	226.10	4,470.90	0.00	115.79	537.31	334.21	5,684.31	5,684.31
49	3.00	GRAVEL	2,385.59	271.89	309.83	660.67	1,138.65	117.44	4,864.07	1,621.36
50	2.19	BITUM	47.25	10,845.36	0.00	1,014.18	2,475.07	1,400.72	15,782.58	7,206.66
52	2.50	BITUM	0.00	110.59	0.00	1,102.03	2,026.72	841.34	4,080.68	1,632.27
53	6.70	BITUM	38.85	18,372.25	0.00	1,545.14	2,761.99	2,188.73	24,906.76	3,717.43
54	1.14	BITUM	0.00	0.00	0.00	106.59	1,380.80	34.66	1,522.05	1,335.13
55	1.00	BITUM	8.36	0.00	0.00	53.62	2,311.28	1,019.37	3,392.63	3,392.63
56	0.25	BITUM	0.00	0.00	0.00	129.42	2,186.25	194.27	2,509.94	10,039.76
57	2.50	BITUM	0.00	347.67	13.38	4.39	3,691.45	311.39	4,368.26	1,747.30
60	0.71	BITUM	0.00	0.00	0.00	95.70	1,194.91	557.28	1,847.89	2,602.66
69	3.40	BITUM	29.25	5,405.31	0.00	19,391.04	3,680.54	655.93	29,162.07	8,577.08
82	1.30	BITUM	0.00	85.51	328.14	296.41	2,783.48	964.45	4,457.97	3,429.21
83	0.50	BITUM	0.00	127.50	0.00	453.88	2,577.51	382.72	3,541.61	7,083.22
90	7.73	BITUM	2,396.57	328.67	1,545.43	10,050.84	10,324.35	4,545.45	29,191.31	3,776.37
90	1.70	GRAVEL	527.14	72.29	339.92	2,210.78	2,270.92	999.79	6,420.84	3,776.96
TOTAL	406.46		21,556.36	221,369.60	19,656.66	131,439.18	261,263.07	111,778.88	767,063.75	1,887.18

CSAH REG
REPAIRS AND REPLACEMENT
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ROAD	LENGTH	SURFACE	RESHAPING	RESURFACING	CULVERTS, BRIDGES, GUARDRAILS	WASHOUTS	TOTAL COSTS	COST/ MILE
1	11.50	BITUM	57.99	44.25	2.28	0.00	104.52	9.09
2	4.80	BITUM	1,298.18	4,969.33	11.70	0.00	6,277.21	1,307.75
3	2.03	BITUM	44.85	0.00	19.28	12.32	76.45	37.66
3	2.91	GRAVEL	84.31	0.00	27.65	17.66	109.62	37.67
4	7.00	BITUM	308.83	0.00	124.41	0.00	433.24	61.89
5	4.37	BITUM	40.44	238.47	0.00	20.59	299.50	68.54
5	0.40	CONCTE	3.70	21.84	0.00	1.89	27.43	68.58
6	11.70	BITUM	569.14	8,619.46	0.00	0.00	9,188.60	785.35
7	4.60	BITUM	0.00	0.00	188.72	0.00	188.72	41.03
8	8.24	BITUM	0.00	74.44	0.00	170.14	244.58	29.68
9	8.20	BITUM	134.05	5,604.42	0.00	0.00	5,738.47	699.81
10	33.70	BITUM	1,212.77	3,205.20	644.50	0.00	5,062.47	150.22
11	13.80	BITUM	0.00	53.16	0.00	0.00	53.16	3.85
12	6.72	BITUM	489.25	562.69	0.00	36.70	1,088.64	162.00
13	15.10	BITUM	598.51	7,305.08	27.59	1,374.31	9,305.49	616.26
14	14.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00
15	8.50	BITUM	533.66	2,404.85	1,503.08	0.00	4,441.59	522.54
16	17.27	BITUM	1,421.66	5,427.83	1,562.39	211.98	8,623.86	499.35
16	1.00	GRAVEL	82.28	1,845.16	90.41	12.27	2,030.12	2,030.12
17	5.20	BITUM	2,173.69	9,112.56	2,087.30	0.00	13,373.55	2,571.84
18	5.30	BITUM	0.00	0.00	125.81	0.00	125.81	23.74
19	1.50	BITUM	0.00	407.60	7.95	0.00	415.55	277.03
19	3.30	GRAVEL	0.00	896.73	17.47	0.00	914.20	277.03
20	19.80	BITUM	134.52	601.79	52.68	0.00	788.99	39.85
21	8.00	BITUM	5,317.32	17,472.64	10,862.60	0.00	33,652.56	4,206.57
21	1.00	GRAVEL	664.42	2,183.30	1,357.34	0.00	4,205.06	4,205.06
22	3.50	BITUM	17.23	0.00	158.39	0.00	175.62	50.18
23	4.50	BITUM	1,763.76	7,914.30	503.33	350.13	10,531.52	2,340.34
24	3.00	BITUM	31.37	6,122.78	0.00	0.00	8,154.15	2,051.38
24	3.00	GRAVEL	31.38	10,892.84	0.00	0.00	10,924.20	3,641.40
25	4.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00
26	8.20	BITUM	589.86	271.07	0.00	0.00	860.93	104.99
27	6.70	BITUM	114.57	8,061.07	663.02	129.07	8,967.73	1,338.47
28	8.90	BITUM	197.17	5,874.21	66.66	135.08	6,273.12	704.84
29	7.40	BITUM	163.78	0.00	0.00	0.00	163.78	22.13
30	9.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00
31	3.40	BITUM	315.73	0.00	0.00	39.60	355.33	104.51
32	14.10	BITUM	368.56	3,982.67	554.02	0.00	4,925.25	349.31
32	3.00	GRAVEL	82.65	5,617.25	117.83	0.00	5,817.73	1,939.24
33	5.10	BITUM	369.64	3,639.44	0.00	89.47	4,098.55	803.64
34	10.10	BITUM	303.60	803.42	363.84	0.00	1,570.86	155.53
35	2.00	BITUM	32.74	2,610.82	161.19	0.00	2,804.75	1,402.38
35	4.70	GRAVEL	76.97	10,273.79	378.84	0.00	10,729.60	2,282.89
36	5.80	BITUM	0.00	7,785.47	0.00	0.00	7,785.47	1,342.32
37	4.70	BITUM	0.00	6,661.24	0.00	0.00	6,661.24	1,417.29
38	3.70	BITUM	0.00	77.72	19.45	0.00	97.17	26.26
39	5.10	GRAVEL	1,083.87	0.00	86.12	0.00	1,169.99	229.41
40	8.40	BITUM	172.19	0.00	0.00	0.00	172.19	20.50

CSAH REG
REPAIRS AND REPLACEMENT
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ROAD	LENGTH	SURFACE	RESHAPING	RESURFACING	CULVERTS, BRIDGES, GUARDRAILS	WASHOUTS	TOTAL COSTS	COST/ MILE
41	5.50	BITUM	494.21	58.79	0.00	2,803.95	3,356.95	610.35
42	2.90	BITUM	1,791.08	2,540.99	759.80	0.00	5,091.85	1,755.81
43	0.30	BITUM	15.60	0.00	0.00	0.00	15.60	52.00
44	0.50	BITUM	26.83	0.00	27.76	0.00	54.59	109.18
45	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00
46	5.60	BITUM	1,875.71	708.10	149.82	320.04	3,053.67	545.30
47	3.00	BITUM	0.00	126.09	0.00	0.00	126.09	42.03
48	3.30	BITUM	86.27	380.59	0.00	0.00	466.86	141.47
48	1.00	GRAVEL	26.16	115.37	0.00	0.00	141.53	141.53
49	3.00	GRAVEL	683.73	11,157.46	0.00	0.00	11,841.19	3,947.06
50	2.19	BITUM	0.00	2,792.25	0.00	0.00	2,792.25	1,275.00
52	2.50	BITUM	0.00	3,108.20	0.00	0.00	3,108.20	1,243.28
53	6.70	BITUM	0.00	11,503.14	6.97	0.00	11,510.11	1,717.93
54	1.14	BITUM	0.00	259.87	0.00	0.00	259.87	227.96
55	1.00	BITUM	83.45	0.00	3,469.58	815.26	4,368.29	4,368.29
56	0.25	BITUM	0.00	0.00	0.00	0.00	0.00	0.00
57	2.50	BITUM	0.00	84.31	0.00	0.00	84.31	33.72
60	0.71	BITUM	0.00	0.00	0.00	13.79	13.79	19.42
69	3.40	BITUM	335.57	293.24	0.00	88.88	717.69	211.09
82	1.30	BITUM	41.77	0.00	0.00	0.00	41.77	32.13
83	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00
90	7.73	BITUM	19,216.16	14,227.86	0.00	273.99	33,718.01	4,361.97
90	1.70	GRAVEL	4,226.76	3,129.55	0.00	60.27	7,416.58	4,362.69
TOTAL	406.46		49,785.90	202,224.70	26,199.78	6,977.39	285,187.77	701.64

CSAH REG
BETTERMENTS
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTE
COST ACCOUNTIN

ROAD	LENGTH	SURFACE	CULVERTS RAILS OR TILING	CUT AND FILLS	SEEDING AND SODDING	BITUMINOUS TREATMENT	ENGINEERING ASSISTANCE	TOTAL COSTS	COST/ MILE
1	11.50	BITUM	155.91	152.88	84.52	11.02	0.00	404.33	35.16
2	4.80	BITUM	86.16	1,828.35	34.21	36,336.60	150.00	38,435.32	8,007.36
3	2.03	BITUM	11.24	0.00	0.00	0.00	0.00	11.24	5.54
3	2.91	GRAVEL	16.12	0.00	0.00	0.00	0.00	16.12	5.54
4	7.00	BITUM	223.74	37.82	0.00	0.00	0.00	261.56	37.37
5	4.37	BITUM	894.17	0.00	0.00	255.59	0.00	1,149.76	263.10
5	0.40	CONCTE	81.89	0.00	0.00	23.41	0.00	105.30	263.25
6	11.70	BITUM	258.24	0.00	0.00	54,298.29	0.00	54,556.53	4,662.95
7	4.60	BITUM	138.72	0.00	0.00	0.00	0.00	138.72	30.16
8	8.24	BITUM	64.19	0.00	0.00	5,387.41	26.02	5,477.62	664.76
9	8.20	BITUM	916.27	0.00	0.00	49,010.69	892.17	50,819.13	6,197.45
10	33.70	BITUM	982.83	0.00	597.77	15,571.17	1,623.36	18,775.13	557.13
11	13.80	BITUM	0.00	0.00	0.00	626.07	0.00	626.07	45.37
12	6.72	BITUM	874.57	0.00	2,224.67	0.00	73.27	3,172.51	472.10
13	15.10	BITUM	3,158.61	0.00	0.00	0.00	0.00	3,158.61	209.18
14	14.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	8.50	BITUM	797.95	0.00	0.00	114.27	0.00	912.22	107.32
16	17.27	BITUM	1,033.61	0.00	0.00	5,092.72	370.61	6,496.94	376.20
16	1.00	GRAVEL	59.81	0.00	0.00	294.69	21.44	375.94	375.94
17	5.20	BITUM	2,129.54	0.00	58.30	0.00	0.00	2,187.84	420.74
18	5.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	1.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	3.30	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	19.80	BITUM	228.64	654.88	457.38	6,607.13	1.42	7,949.45	401.49
21	8.00	BITUM	4,184.95	59,550.87	1,053.46	21.75	74.59	64,885.62	8,110.70
21	1.00	GRAVEL	522.95	7,441.22	131.64	2.71	9.31	8,107.83	8,107.83
22	3.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	4.50	BITUM	489.02	0.00	111.68	25,335.99	0.00	25,936.69	5,763.71
24	3.00	BITUM	0.00	0.00	0.00	16,303.88	0.00	16,303.88	5,434.63
24	3.00	GRAVEL	0.00	0.00	0.00	14,660.46	0.00	14,660.46	4,886.82
25	4.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	8.20	BITUM	0.00	0.00	0.00	114.95	0.00	114.95	14.02
27	8.70	BITUM	203.87	0.00	0.00	43,230.08	0.00	43,433.95	6,482.68
28	8.90	BITUM	242.73	0.00	0.00	0.00	0.00	242.73	27.27
29	7.40	BITUM	786.86	0.00	0.00	0.00	0.00	786.86	106.33
30	9.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	3.40	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	14.10	BITUM	1,599.53	1,289.32	570.83	0.00	0.00	3,459.68	245.37
32	3.00	GRAVEL	340.24	274.24	121.42	0.00	0.00	735.90	245.30
33	5.10	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	10.10	BITUM	494.86	0.00	0.00	0.00	0.00	494.86	49.00
35	2.00	BITUM	90.25	0.00	0.00	0.00	0.00	90.25	45.13
35	4.70	GRAVEL	212.09	0.00	0.00	0.00	0.00	212.09	45.13
36	5.80	BITUM	182.43	0.00	0.00	36,532.70	0.00	36,715.13	6,330.19
37	4.70	BITUM	0.00	0.00	0.00	95.16	0.00	95.16	20.25
38	3.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	5.10	GRAVEL	59.51	0.00	0.00	0.00	0.00	59.51	11.67
40	8.40	BITUM	434.86	0.00	0.00	0.00	0.00	434.86	51.77

CSAH REG
BETTERMENTS
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ROAD	LENGTH	SURFACE	CULVERTS RAILS OR TILING	CUT AND FILLS	SEEDING AND SODDING	BITUMINOUS TREATMENT	ENGINEERING ASSISTANCE	TOTAL COSTS	COST/ MILE
41	5.50	BITUM	412.25	0.00	0.00	5,586.88	0.00	5,999.13	1,090.75
42	2.90	BITUM	39,189.58	0.00	0.00	1,212.92	0.00	34,402.48	11,862.92
43	0.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	0.50	BITUM	100.00	0.00	0.00	0.00	0.00	100.00	200.00
45	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	5.60	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	8.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	3.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	1.00	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	3.00	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	2.19	BITUM	0.00	0.00	0.00	22,160.20	0.00	22,160.20	10,118.81
52	2.50	BITUM	0.00	0.00	0.00	30,889.38	0.00	30,889.38	12,355.75
53	6.70	BITUM	0.00	0.00	0.00	53,209.67	319.79	53,529.46	7,989.47
54	1.14	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	1.00	BITUM	1,118.92	0.00	0.00	0.00	0.00	1,118.92	1,118.92
56	0.25	BITUM	732.32	0.00	0.00	0.00	0.00	732.32	2,929.28
57	2.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.71	BITUM	0.00	0.00	0.00	298.97	0.00	298.97	421.08
69	3.40	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82	1.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
83	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	7.73	BITUM	163.70	3,359.07	21.03	0.00	51.87	3,595.67	465.16
90	1.70	GRAVEL	36.01	738.85	4.63	0.00	11.41	790.90	465.24
TOTAL	406.46		57,709.12	75,327.50	5,471.54	423,284.78	3,625.26	565,418.18	1,391.08

CSAH REG
SPECIAL WORK
TOTAL CLASS

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

ROAD	LENGTH	SURFACE	DUST TREATMENT	PROSPECTING FOR GRAVEL	FLOOD DAMAGE REPAIR	EROSION CONTROL	FIRE CALLS	TOTAL COSTS	COST/ MILE
1	11.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4.80	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2.03	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2.91	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4.37	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.40	CONCTE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	11.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4.60	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8.24	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	8.20	BITUM	0.00	0.00	0.00	0.00	274.56	274.56	33.48
10	33.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	13.80	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	6.72	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	15.10	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	14.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	8.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	17.27	BITUM	0.00	0.00	76.41	0.00	0.00	76.41	4.42
16	1.00	GRAVEL	0.00	0.00	4.42	0.00	0.00	4.42	4.42
17	5.20	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	5.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	1.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	3.30	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	19.80	BITUM	0.00	0.00	0.00	0.00	286.83	286.83	14.49
21	8.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	1.00	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	4.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	3.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	3.00	GRAVEL	93.41	0.00	0.00	0.00	0.00	93.41	31.14
25	4.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	8.20	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	6.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	8.90	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	7.40	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	9.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	3.40	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	14.10	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	3.00	GRAVEL	280.22	0.00	0.00	0.00	0.00	280.22	93.41
33	5.10	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	10.10	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	2.00	BITUM	5.67	0.00	0.00	0.00	0.00	5.67	2.84
35	4.70	GRAVEL	597.14	0.00	0.00	0.00	0.00	597.14	127.05
36	5.80	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	4.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	3.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	5.10	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	8.40	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00

BLUE EARTH COUNTY HIGHWAY DEPARTMENT
SUMMARY OF ROAD MAINTENANCE COSTS BY ROAD
FOR THE PERIOD JAN TO DEC

WT- CA620R V08.00
HIGHWAY COSTING SYSTEM
COST ACCOUNTING

CSAH REG
SPECIAL WORK
TOTAL CLASS

ROAD	LENGTH	SURFACE	DUST TREATMENT	PROSPECTING FOR GRAVEL	FLOOD DAMAGE REPAIR	EROSION CONTROL	FIRE CALLS	TOTAL COSTS	COST/ MILE
41	5.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	2.90	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	0.30	BITUM	0.00	0.00	0.00	4,650.55	0.00	4,650.55	15,501.83
44	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	5.60	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	3.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	3.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	1.00	GRAVEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	3.00	GRAVEL	140.11	0.00	0.00	0.00	0.00	140.11	46.70
50	2.19	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	2.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	6.70	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	1.14	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	1.00	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.25	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	2.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.71	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	3.40	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82	1.30	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
83	0.50	BITUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	7.73	BITUM	35.19	0.00	0.00	0.00	12.34	47.53	6.15
90	1.70	GRAVEL	7.74	0.00	0.00	0.00	2.72	10.46	6.15
TOTAL	406.46		1,159.48	0.00	80.83	4,650.55	576.45	6,467.31	15.91

APPENDIX 7: EXPLANATION OF REPORT CATEGORIES

Explanation of Spreadsheet Columns
By Jacob Thorius

Routine Maintenance is broken down in to six subcategories that included: smoothing surface, minor surface repair, cleaning culverts and ditches, brush and weed control, snow and ice removal, and traffic services (including signs). Each one of those categories then includes a list of different items that relate to the category title.

Smoothing Surface includes blading gravel roads and scarifying/mixing the gravel surface. This category seems to include anything that would be specific to smoothing the surface with the material already in place.

Minor Surface Repair relates to all smoothing type activities that occur on either a bituminous or concrete road. The specific tasks include: patching and crack-sealing bituminous roads, repairing and crack-filling concrete roads, repairing frost boils and blow outs, cleaning/sweeping bridge decks and pavements, and shoulder repair (no new material).

Cleaning Culverts and Ditches primarily includes all items of work related to culverts and ditches already in place. Particularly checking, cleaning, and thawing of culverts, checking and minor cleaning of ditches, repairing tile lines, lowering and raising culverts, and marking their ends. Also included in this category is the picking of debris/trash, particularly road kill.

Brush and Weed Control relates to all items concerned with maintaining the vegetation along the roadsides and in the ditches. Included are mowing grass and weeds, spraying weeds and brush, clearing and cutting brush and trees.

Snow and Ice Removal deals with what it implies, clearing roads of snow and ice. This includes cutting ice, plowing and winging snow from roads, sanding and salting roads, and clearing snow from bridges and guard rails.

Traffic Services (Including Signs) deals with road signs and pavement markings. Specific items include maintaining posted and emergency 911 signs, striping the pavement, lighting of road intersections, and placing barricades as needed. Also included would be inspecting roads (examining their general condition), patrolling roads based on load restrictions, any emergency assistance that may be needed, and operation of a tourist station.

Repairs and Replacements can be further divided in to five subcategories that included: reshaping, resurfacing, culverts, bridges, and guard rails, washouts, and subgrade repair. Each one is then further divided into tasks that are of similar nature to the category description.

Reshaping includes items related to the reshaping of the road surface and surrounding area. Particularly it would entail minor reshaping of the roadbed,

ditch, and backslope. It also includes reshaping the existing shoulders (no new material is used).

Resurfacing deals with applying any new gravel material to a gravel road or shoulder and stabilizing the surface. Specifically resurfacing includes spot and continuous gravelling of the road surface, adding to material to the shoulders (edge rutting), adding more binder to the road surface, and stabilizing a gravel surface.

Culverts, Bridges, and Guard Rails includes tasks related to those specific structures. Particularly it entails replacing an existing culvert (one that may have rusted through) with one of similar size, relaying culvert ends (so water will enter and exit pipe easier or flow through better), checking, repairing, and painting of the bridge, and assessing the counties ditches.

Washouts deals with repairing any washouts that might occur in the roadbed, shoulder, ditch, backslope, and culverts.

Subgrade Repair includes mud jacking and repairing any frost boils that occur in the subgrade, and any work dealing with frost boil tile lines.

Betterments can be further divided in to four subcategories including: new culverts, rails, or tiling, cuts and fills, seeding and sodding, and bituminous treatment. Specifically this relates to any new items that the county installs or major work undertaken by the county.

New Culverts, Rails, or Tiling would be the placement of new and larger culverts, any new guard rails and tile lines that might be installed, the addition to the road area of any erosion control devices and the placement of rip rap along culvert ends, bridges, and edges of waterways. Also included in this category are the placement of new approaches or drives and the addition of aprons and extensions along the road surface.

Cuts and Fills includes any major reshaping of the shoulders, roadbed, ditch, and backslope performed by the county. Also includes is the filling in of swamps.

Seeding and Sodding deals with the establishment of new turf (seed or sod) and planting new trees and shrubs.

Bituminous Treatment deals with treatment for bituminous road surfaces. Particularly it includes spot retreating road surface, applying an overlay, seal coating and sweeping a bituminous surface, maintenance money from a bituminous construction project, and repairing railroad crossings.

Special Work is further divided in to four subcategories including: dust treatments, railroad betterments, mud jacking and frost boils, and engineering studies. The main work done under this category deals with dust control.

Dust Treatments included the application of calcium or magnesium chloride and any other treatments that may be used to control dust.

Railroad Betterments deals with improving or upgrading crossing signals.

Mud Jacking and Frost Boils includes mud jacking any pavement surfaces, repairing any frost boils and frost boil tile lines. Also included in this category are any repairs from flood damage and maintenance money from unallocated accounts.

APPENDIX 8: COUNTY VISIT REPORTS

Olmsted County
Economics of Upgrading an Aggregate Road

Place: Olmsted Co. Public Works (Rochester, MN)

Attendees:

Kaye Bieniek	(Olmsted Co.)	*(Olmsted Co. interview only)*
Kevin Harms	(Olmsted Co.)	*(Olmsted Co. interview only)*
Chuck Jahren	(IA State)	
Greg Johnson	(MnDOT)	
Roger Olson	(MnDOT)	
Mary Rukashaza	(IA State)	
Jacob Thorius	(IA State)	
David White	(IA State)	

a. General Information
  1. County characteristics
    a. Size (area) **653 square miles (web site) or 660 (map)**
      124,277 citizens
      18 townships
      8 cities
    b. Miles of roads **County - 320 Hard surfaced**
      250 HMA
      70 Concrete
      1647 miles of road in county
      1. **Federal/State=163 miles (9.9%)**
      2. **County State Aid=320 miles (19.3%)**
        310 miles paved
        10 miles unpaved
      3. **County Roads=206 miles (12.3%)**
        58 miles paved
        148 miles unpaved
      4. **Municipal State Aid=46 miles (2.8%)**
      5. **Municipal Streeets=294 miles (17.9%)**
      6. **Township=618 miles (37.1%)**
        100 miles paved
        518 miles unpaved

      Percentages of different types of roads (i.e. CSAH, Co., surface types, etc.) **80% County, 20%CSAH**
    c. % of time spent maintaining aggregate roads **Will determine**
    d. Traffic volumes (maps, or tables) **Copies were made of county roads, township typically have < 50 vpd**
    e. Workforce
      i. Size **Maintenance - 25 Rochester**
        9 Eyota
        5 mechanics
        Engineering - 12 Rochester
        Sign Shop - 3 Rochester
      ii. Is it based on winter maintenance activities? **Yes**
    f. Equipment
      i. Is equipment purchased based on snow removal policy?
      ii. # of trucks and approx. cost for replacement
        17 Tandems, $150,000 (8 year replacement cycle)
      iii. # of graders and approx. cost for replacement
        9 Motorgraders, $220,000 (15 year replacement cycle)
    h. Political climate

i. Winter maintenance strategy/policy **Described in policy, given to IA state personnel**
   1. **All county roads will be done first before any township roads are done.**
   2. **Begin plowing after an accumulation of 2 inches or more.**
   3. **Gravel roads are cleared by motorgrader**
   4. **Sometime spread class 2 aggregate**
   5. **First crew starts at 4 AM, works 12-14 hour shift, second crew works from 4 PM to midnight.**

j. Views of citizens (type of construction and maintenance they expect) **An increasing number of people are moving out of the city to 1-3 acre lots. County treats all residents the same.**

k. Subgrade type(s) **Sandy, drains well, pockets of clay**

l. Stabilization/Dust control policy **Township buy from county contract**
   i. Entire road treated or just in front of residences **Intersections and in front of residences**
   ii. If used, application rate
   iii. Type of products used **CaCl2**
   iv. Frequency **Once per year (June 1)**

m. What is your policy about when to pave a gravel road? **Look at combination of traffic, money spent, and location (500-1000 ADT)**

n. Are you responsible for township roads?
   Do contract maintenance for 7 townships.
   1. **Rock Dell**
   2. **High Forest**
   3. **Pleasant Grove**
   4. **Elmira**
   5. **Haverhill**
   6. **Viola**
   7. **Eyota**

2. Maintenance

a. How often roads are bladed? (*I know this will vary.*)
   Arterials – Every 3 to 4 weeks
   Minor Arterials – 6 to 8 week interval
   4% crown

b. Then how much time does it take to blade each road? **Mike Harms (Olmsted Co. will check)**

c. Do you spot treat with additional gravel in spring or throughout the year?
   Regravel each spring (27 miles), placing 790 to 950 yd^3/mile (about 2 inches compacted), spent $128,000 total or $4700/mile.
   Spot treat with additional gravel as needed throughout the year

d. Where are your gravel sources? **4 to 5 sources (pits and quarries), Mathy owns most of the quarries**

e. Mowing (how often) **9 mowers; mow edge of shoulder before Aug. 1; After Aug. 1, mow in slope and ditch bottom of all roads.**

f. Costs of maintaining roads (If you have every totaled the costs)
   Aggregate Surfaced (Average of system) = $10,600
   Paved Surface (Average of system) = $10,864

g. Any thin surfaced roads (chip sealed surface, etc.) **Yes, Mike Sheehan would know where the road is located.**

h. If HMA surfaced
   i. Frequency of crack sealing **Every 5-7 years (before seal coating). 20 miles/yr. This is done during the winter months of January, February, and March. Use blow and go technique. Specification 3723.**

ii. Frequency of overlay
iii. Seal coat HMA roads on a 5 year cycle
County costs $0.03/ft^2, if contracted out it would be $0.06/ft^2. Use a CRS-2 with an emulsion application of 0.31 gal./yd^2 and 17 lb/yd^2 of aggregate.
iv. Have been using Cold in Place Recycling (CIR) on a 15 year cycle. Depth is at least 4 inches. Then 2 (1 ½ inch) HMA layers are applied.

3. Other Information
A. Typically purchase washed sand and Class 2 winter
B. Class 2 is used for surfacing and shoulder aggregate (Will waive maximum fines restriction, to get more fines)
C. Use class 5 as base aggregate
D. Maintenance on
1. Co. Rd. 150 (2001) = $25,500/mile
2. Co. Rd. 31 (2001) = $25,000/mile
E. Most common right of way width on aggregate roads is 66 feet.
F. Roads are designed to a 9 or 10 ton design.
1. one foot subcut, blend material, and replace
2. one foot of base (class 5)
3. 6 inches of HMA
G. The following stabilization techniques have been used
1. Fabric (separator layer) – Co. Rd. 9
2. Breaker run – Co. Rd. 7
H. Typical thickness of aggregate layer on aggregate surfaced roads is 4 to 6 inches.
I. Regraveling is based on traffic count and type of gravel
J. They do see some variation in aggregate mainly due to segregation at the pile (bad stockpile management)
K. The procedure involved with regraveling involves watering and rolling. (2-3 miles/day)
L. Looking at using scarifier blades for motorgraders (carbine teeth, "Sandvig blades"
M. Spend a lot on shouldering aggregate
N. Spend $500,000 to $600,000/year on new equipment
O. Motorgrader charge rate ($70/hr)
P. Bid out 400,000 gallons of CaCl2 at a cost of $1700/mile as contract work.
Q. Use many motorgraders for winter maintenance
R. Rebuild crowns in gravel roads as needed in the spring
S. Regraveling is done on about a 5 year cycle
T. Construction Costs, Capital Improvement Program (CIP) program
1. Concrete pavements- $400,000/mile
(Service life of 35 years)
2. Bituminous pavements - $350,000/mile
i. Seal coats- $5,500/mile
(Service life of 3-5 years)
ii. Overlays- $110,000/mile
(Service life of 12-15 years)
iii. In 2001, recycled 14.6 miles of HMA roads at a cost of $132,867/mile
4. Aggregate Surfaces- $150,000/mile

Waseca County

Economics of Upgrading an Aggregate Road

Place: Waseca Co. Public Works (Waseca, MN)

Attendees:

Jeff Blue	(Waseca Co.)	*(Waseca Co. interview only)*
Chuck Jahren	(IA State)	
Greg Johnson	(MnDOT)	
Roger Olson	(MnDOT)	
Mary Rukashaza	(IA State)	
Jacob Thorius	(IA State)	
David White	(IA State)	

General Information

1. County characteristics
   - a. Size (area) **276,480 acres (432 square miles)-map**
     (415 square miles)-web site
     18,744 citizens
     12 townships
     5 cities
   - b. Miles of roads **County - 375 total**
     120 gravel (50-60 miles are CSAH)
     195 HMA
     60 concrete
     ? Township miles
   - c. Percentages of different types of roads (i.e. CSAH, Co., surface types, etc.) **50% County, 50%CSAH**
   - d. % of time spent maintaining aggregate roads **25%**
   - e. Traffic volumes (maps, or tables) **Copies were made of county traffic volume map**
   - f. Workforce
     - i. Size **10 Highway maintenance workers**
       1 Road Foreman
       1 Shop Mechanic
       1 Sign Man
       1 County Engineer
       1 Assistant County Engineer
       2 Engineering Technicians
     - ii. Is it based on winter maintenance activities? **No**
   - g. Equipment
     - i. Is equipment purchased based on snow removal policy? **No**
     - ii. # of trucks and approx. cost for replacement
       6 Tandems and pups, $125,000 (8 year replacement cycle)
     - iii. # of graders and approx. cost for replacement
       4 Motorgraders, $150,000 (8 year replacement cycle)
       Note: $250,000/yr equipment budget + trade in value
   - h. Political climate
2. Winter maintenance strategy/policy **Out before buses (4AM-4PM) [1 shift], No clear pavement policy, drivers of trucks and blades are sent out on high volume roads first.**
   - i. Views of citizens (type of construction and maintenance they expect) **An increasing number of people are moving small acreage lots.**
   - j. Subgrade type(s) **Mostly clay, no sand, does drain**
   - k. Stabilization/Dust control policy **No treatment unless a designated detour route. Homeowner/businesses can contract with**

independent contractor directly if desired. County recommends CaCl2.

i. Entire road treated or just in front of residences **N/A**
ii. If used, application rate **N/A**
iii. Type of products used **N/A**
iv. Frequency **N/A**

l. What is your policy about when to pave a gravel road?
m. Are you responsible for township roads? **No**

2. Maintenance
   a. How often roads are bladed? (*I know this will vary.*)
      Spring: **Once every 2 weeks**
      Summer: **Once a month or dependant on operator time availability and complaints.**
      Fall: **Once every 2 weeks after regraveling is completed.**
      %crown depends on operator, individual operator correction
   b. Then how much time does it take to blade each road. **Depends on operator**
   c. Do you spot treat with additional gravel in spring or throughout the year?
      Regravel late summer/fall, 1/3 of system each year, placing ~400 yd^3/mile for a total of 20,000 yd^3
      Spot treat with gravel as needed throughout the year.
   d. Where are your gravel sources? **All are outside the county. 3 to 4 sources (pits), 15-20 mile average haul distance. Use a modified class 5 gradation. Load gravel themselves, with own loader.**
   e. Mowing (how often) **mow edge of shoulder during summer; After Aug. 1, mow top, in slope, and some ditch bottoms**
      Spray all ditches for weeds each year.
   f. Costs of maintaining roads (If you have every totaled the costs)
      Any thin surfaced roads (chip sealed surface, etc.) **No**
      If HMA surfaced
         i. Frequency of crack sealing
         ii. Frequency of overlay

3. **Other Information**
   A. Culverts are replaced under by hiring a contractor
   B. Class 5 costs (at source) [crushed at pile]= $2.65/yd^3
   C. Most reconstruction is reconstruction of old HMA roads. These are generally not to State Aid standards any more.
   D. One of problems they are dealing with is traffic related to large feedlots.
   E. State Aid standards are used for road improvements.
   F. Most of the reconstruction/construction recently has been improving old HMA roads using cold in place recycling (CIR).
   G. After the CIR, a 3 inch 2350 overlay is applied.
   H. The county does maintenance of some of the township paved roads during the summer.
   I. A 7 inch unbounded concrete overlay costs ~$300,000/mile
   J. Would like all roads over 250 vpd concrete is money was not an issue.
   K. New HMA (58-34) are sawed and sealed.
   L. Existing roads are routed and sealed.
   M. The first chip seal is applied 3-4 years after new HMA surface, then on a 7-8 year cycle
   N. An overlay lasts ~ 20 years
   O. Specify no RAP in the wear course
   P. The future work in the county will involve more overlays and less CIR.
   Q. Have placed a 1 to 1 ½ inch overlay over alligatored sections of HMA.

R. Have used scarifier teeth on a motorgrader. They tend to bring up dust, so the surface needs to be watered and rolled.
S. Most common right of way width is 66 feet
T. If rebuilding a road the following procedure would be done:
   i. 2 foot subcut
   ii. 40 foot gravel top
   iii. 4-5 inches of aggregate base
   iv. 7-8 inches of HMA
   v. 9 ton design
   vi. Cost: $100,000/mile – grading
   $225,000/mile – shoulder/HMA
   $300-325,000/mile overall
U. Use shoes or wheels on plow blades for gravel roads
V. If motorgraders were not needed, would buy more tandem axle trucks
W. During the winter, the maintenance staff cuts brush when not plowing.
X. The results of this project should be simple. Tables or spreadsheets would be desirable.

Meeker County

July 14, 2003

Ronald Mortensen – County Engineer

General Information

1. County characteristics
   - a. Size (area) **610 square miles**
     22,000 citizens
     17.5 townships
   - b. Miles of roads **275 Miles of CSAH**
     25 Gravel
     250 Paved
     780 Township
     680 Gravel
     100 Paved
     No County Roads under an agreement from 1969
   - c. % of time spent maintaining aggregate roads **Almost split equally amongst gravel and paved roads**
   - d. Traffic volumes (maps, or tables) **Tables possibly available from Needs State Aid Office, already have maps**
   - e. Workforce
     - i. Size **25 Full-time**
       - 4 technicians/construction force
       - 19 maintenance
       7 Part-time in summer – mainly retired farmers
       10 Part-time in winter – laid off construction workers
     - ii. Is it based on winter maintenance activities? **Yes**
   - f. Equipment
     - i. Is equipment purchased based on snow removal policy? **Yes**
     - ii. # of trucks and approx. cost for replacement
       8 $135,000 (1 per year)
     - iii. # of graders and approx. cost for replacement
       17 Motorgraders, $165,000 (1 per year)
   - h. Political climate **Very conservative**
   - i. Winter maintenance strategy/policy **4 inches or less try to get roads open in 12 hrs**
   - j. Views of citizens (type of construction and maintenance they expect) **The citizens expect money to be spent wisely and want the job done as soon as possible.**
   - k. Subgrade type(s) **Soils are very mixed, heavy soils in the southwest – primarily farmland, blow sand in the southeast.**
   - l. Stabilization/Dust control policy **Done by private contractor at owners expense**
     - i. Entire road treated or just in front of residences **about 300' in front of residences**
     - ii. If used, application rate
     - iii. Type of products used **CaCl2 at $0.30 – 0.40 per linear foot of road. Some Soy Oil is used at $1 per linear foot of road – seems to last longer with one treatment**
     - iv. Frequency **Most once per year, about 25% 2 times/year, and 5% 3 times per year**
   - m. What is your policy about when to pave a gravel road? **Pave gravel road according to State Aid Manual – need 150 ADT for state aid. 15 townships assess the cost of paving the road to those who live on the road, 1 township assess to everyone. Big battles around lakes with lake associations, 1700 active lake association people in county compared to 1000 active farmers**
   - n. Are you responsible for township roads? **County maintains the road for townships after they pay to construct/upgrade them. County does all engineering for townships.**

Routine Maintenance (weekly to once a year)

a. How often roads are bladed? (*I know this will vary.*)
Roads under 50 ADT – every 10 days to 2 weeks
Roads with 50 – 100 ADT – 1/week
Roads with 200 + ADT – more than once per week

b. Then how much time does it take to blade each road? **Depends on road width and operator. Most CSAH roads require 3 passes and township roads 2 passes. Use 14' blades with 2' extensions. 10 blade operators have 15-30 years experience with average experience 24-26 years. Do in house training and thinking about sending someone to LTAP course to be an in house trainer.**

c. Do you spot treat with additional gravel in spring or throughout the year? **Spot treat roads as needed throughout spring, summer, and fall.**

d. Where are your gravel sources? **All over the county, 25 active pits within the county. $5/cy or less to place gravel on road from pits with private contractor hauling.**

e. Mowing (how often) **Mow 1 swath along shoulders between June and July 4th. Then go back and mow 2 swaths before the snow falls.**

f. Costs of maintaining roads (If you have every totaled the costs)

g. Any thin surfaced roads (chip sealed surface, etc.) **None**
Some roads with a 3" overlay posted at 3 tons. Would consider thin surfaced roads for township roads, but not for CSAH roads. However, it is up to each particular township board, some are thinking about it.

Periodic Maintenance (1-8 years)

a. For roads surfaced with HMA/bituminous treatments
1. Frequency of crack sealing **When cracks get to 1/2" then do it themselves – blow and go seal technique (minor surface repair)**
2. Frequency of overlay **Very few overlays, believes it is a result of low ADT on roads, since '85 a push to pave roads – getting 35 year service life out of a 25 year design**
3. Frequency of other maintenance activities **Use bituminous treatment to fill potholes – cold mix; for bigger patches hire local contractor since they can do it cheaper. 15 miles of CSAH and township roads are seal coated a year, typically try to get first seal coat on 3 years after paving then another one a few years later. New mixes are performing well and getting longer life out of them and better seals**

b. Frequency and quantities of gravel for regraveling **Use Class 1 aggregate for regraveling – has more fines, greater than 10% on 200 sieve, good for tying the road surface together. If building road use Class 5 – clean aggregate. Use about 11,000 cy for regraveling 25 miles of CSAH road, about $5 cy to process from pit and delivered to road. Then use own crews to count loads, spread, and roll – need a good 1.5 inch lift for rolling to be effective – with pneumatic roller. A reclaimer is used along the shoulders to pull the fines and some lost material back up onto the road, a big savings in gravel – no need to gravel every year, down to about every 3 years or so. Real successful with shoulders on paved roads and becoming useful on gravel roads.**

c. Frequency of crown correction **Rebuild them every spring because they flatten them out in the winter to ease in snow removal**

d. Drainage correction **Done as needed. Have lots of frost boils with the different soil types in the county – mainly occur at soil type changes from rebuilding of road.**

Rebuilding/Construction Projects

1. Standards roads are brought to when improved **Roads are brought to CSAH standards when improved, try to regrade at 50 years old**

2. What is your estimated cost/mile or other cost/unit of measure for the

following construction projects/activities

√ if used		(Cost/Unit of measure) (expected service life)
☐	Concrete Pavement	no concrete roads
☐	HMA Pavement	use a 2360 mix at about $100,000 per mile – use a 9 ton design for 55 mph roads and a 5 ton design for 30 mph or better roads
☐	HMA overlay	not doing that many overlays
☐	Seal coat (type and cost)	same as Seal Coat, use FA2 – 3/8 inch for rock and CRS2 emulsion
☐	Regrading	shoulder widening and flattening of horizontal and vertical curves to get 55 mph design at $250,000 per mile, major realignment at $350,000 per mile
☐	Surface treatments*	
	o Otta Seal	
	o Chip Seal	
	o Emulsion Oil Gravel	
	o Other	have been designing roads to 30 mph or better and placing a 3 ton design by the lakes – consists of 3 inches mix on top of 2 inches of Class 5 rock

* Defined as "lightly surfaced roads", an alternative to conventional HMA or PCC pavements.

Do have a table or map of the structural capacity of your county roads that you could send to us?

We have broken the traffic volumes into the following ranges to describe the level of service. Do they seem appropriate or should they be changed? Please categorize some of your roads into the traffic volume ranges listed below or into the ranges that you feel are appropriate.

Level of Service	ADT	County Road Number
	0-49	maintain as is
	50-74	maintain as is
	75-99	look at regrading for paving
	100-124	look at regrading for paving
Increasing	125-149	begin to pave it
	150-199	begin to pave it
	200-249	
	250-299	
	300-up	maintain at higher level of service

What would you as a user like to see as a result of this project?
Would like to know when to do a thin overlay/surface – 5 ton design – for a township road. What type of drainable base should be used and specifications/recommendations on the use of geotech fabric.

Attached are copies of handouts from meeting

[MEE]R COUNTY HIGHWAY DEPARTMENT

CONSTRUCTION PROGRAM 2003 TO 2008

	TERMINI	DIST	TRAFFIC 1999	TRAFFIC 2019	YEAR CONST Last	YEAR CONST Proposed	COST
[MEE]DING & BITUMINOUS SURFACING							
14	TH 12 to N. Darwin	0.4	710	994	1955		500,000
14	N. Darwin to CSAH 11	2.7	710	994	1955		750,000
14	CSAH 11 to TH 24	4.3	710	994	1955		1,150,000
27	TH 24 to TH 15	3.6	810	1134	1954		1,000,000
14	N. Kingston to E. Co L	4.8	385	539	1959		1,450,000
17	TH 24 to TH 55	5.5	390	546	1978		1,500,000
15	S Co Line to CSAH 6	7.0	710	994	1954		1,900,000
30	CSAH 3 - T H 55	5.2	310	434	1957		1,500,000
					Subtotal		9,750,000
GRADING							
30	CSAH 16 TO 340th	2.3	95	133	1900		175,000
					Subtotal		175,000
BITUMINOUS SURFACING							
1	CSAH 28 (E) - CSAH 23	4.0	720	1008	1955	2003	650,000
35	T.H. 7 - CSAH 28	6.0	90	126	1983		750,000
37	W. Co Line to TH 4	3.0	130	182	1959		550,000
18	T H 22 - CSAH 35	3.1	120	168	1959		400,000
					Subtotal		1,700,000
MUNICIPAL							
2	TH 55 to County Line	1.5	2350	3290			400,000
14	T H 12 - 250 ST	0.4	710	994		2004	120,000
					Subtotal		520,000
Bituminous Overlays							
1	CSAH 23 to CSAH 11	4.4	1950	2730	1983		220,000
23	TH 4 to CSAH 1	8.8	660	924	1985		440,000
26	CSAH 12 to TH 7	3.5	680	952	1984		175,000
					Subtotal		835,000
BRIDGE REPLACEMENT			BRIDGE NO.				
14	Multi Plate		90979				80000
16	Multi Plate		90936				85000
34			90945				48000
Litchfield Twp			L-8370				50000
Cosmos Twp	Arch Culv		90959				48000
Cosmos Twp	Arch Culv		90964				48000
Dassel Twp			90990				65000
					Subtotal		424,000
	TOTAL CONSTRUCTION COSTS				Subtotal		13,404,000

FLEXIBLE PAVEMENT DESIGN USING SOIL FACTORS

Required Gravel Equivalency (G.E.) for various Soil Factors (S.F.)

For new construction or reconstruction use projected ADT. For resurfacing or reconditioning use present ADT.

All units of G.E. are in inches with millimeters (mm) in parenthesis.

7 TON @ LESS THAN 400 ADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	3.0 (75)	7.25 (180)
75	3.0 (75)	9.38 (235)
100	3.0 (75)	11.50 (290)
110	3.0 (75)	12.40 (310)
120	3.0 (75)	13.20 (330)
130	3.0 (75)	14.00 (350)

7 TON @ 400 - 1000 ADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	3.0 (75)	9.00 (225)
75	3.0 (75)	12.00 (300)
100	3.0 (75)	15.00 (375)
110	3.0 (75)	16.20 (405)
120	3.0 (75)	17.40 (435)
130	3.0 (75)	18.60 (465)

9 TON @ LESS THAN 150 HCADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	7.0 (175)	10.25 (255)
75	7.0 (175)	13.00 (350)
100	7.0 (175)	17.50 (440)
110	7.0 (175)	19.00 (475)
120	7.0 (175)	20.50 (515)
130	7.0 (175)	22.00 (550)

9 TON -150-300 HCADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	7.0 (175)	14.00 (350)
75	7.0 (175)	17.50 (440)
100	7.0 (175)	21.00 (525)
110	7.0 (175)	22.40 (560)
120	7.0 (175)	23.80 (595)
130	7.0 (175)	25.20 (630)

9 TON - 300-600 HCADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	7.0 (175)	16.00 (400)
75	7.0 (175)	20.50 (515)
100	7.0 (175)	25.00 (625)
110	7.0 (175)	26.80 (670)
120	7.0 (175)	28.60 (715)
130	7.0 (175)	30.40 (760)

9 TON - 600 @ 1100 HCADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	8.0 (200)	18.50 (465)
75	8.0 (200)	23.70 (595)
100	8.0 (200)	29.00 (725)
110	8.0 (200)	31.10 (780)
120	8.0 (200)	33.20 (830)
130	8.0 (200)	35.30 (885)

9 TON - MORE THAN 1100 HCADT

S.F.	Minimum Bit. G. E.	Total G. E.
50	8.0 (200)	20.30 (510)
75	8.0 (200)	26.40 (660)
100	8.0 (200)	32.50 (815)
110	8.0 (200)	35.00 (875)
120	8.0 (200)	37.40 (935)
130	8.0 (200)	39.80 (995)

MATERIAL	TYPE OF MATERIAL	G.E. FACTOR*
Superpave Hot Mix	Spec. 2360	2.25
Plant Mix Asp Pave	Spec 2350	2.25/ 2.25/ 2.00
Plant-Mix Bit.	Type 41, 61	2.25
Plant-Mix Bit.		
Aggregate Base	(	
Aggregate Base	(	
Select Granular		

AASHTO SOIL CLASS
A - 1
A - 2
A - 3
A - 4
A - 5
A - 6
A - 7 - 5
A - 7 - 6

5 Ton
2" Cl 5
2½ Bit Base
1½ Bit Wear
10" GE

7 Ton
4" Cl 5
2½" Bit Base
1½" Bit Wear
12" G.E.

9 Ton
5½" Cl 5
3" Bit Base
1½" Bit Binder
1½" Bit Wear
12.5" GE

NOTE: If 10 ton (9.1 t) design is to be used, see Road Design Manual 7-3.

For full depth bituminous pavements, see Road Design Manual 7-3.

* Granular Equivalent Factor per MnDOT Technical Memorandum 98-02-MRR-01

Meeker Co.

325 North Sibley Avenue
Litchfield Minnesota 55355-2155
Ph. (320) 693-5360
Fax (320) 693-5369

Ronald Mortensen
County Engineer

Marland R. Meyer
Assistant Engineer

Exhibit 2

Meeker County Highway Department Rates: January 1, 2002

Personnel:	
County Engineer	$75.00 hr.
Assistant County Engineer/Senior Design Technician	$60.00 hr.
Senior Construction Technician	$55.00 hr.
Senior Survey Technician	$50.00 hr.
Survey Crew	$110.00 hr.
Sign Technician	$50.00 hr.
Maintenance Personal	$25.00 hr.
Equipment: (Rate only, does not include the operator rate.)	
Motor Grader	$35.00 hr.
Tandem-Axle Truck	$45.00 hr.
Single-Axle Truck	$40.00 hr.
Trailer	$30.00 hr.
Tractor/Loader/Backhoe	$28.00 hr.
Skid Steer Loader	$39.00 hr.
Loader (2-3 Yard)	$35.00 hr.
Sweeper (Self-propelled)	$71.00 hr.
Shouldering Machine	$33.00 hr.
Tractor Loader	$35.00 hr.
Tractor Brush Mower	$35.00 hr.
Tractor Pneumatic roller	$40.00 hr.
Misc. Small Equipment (Wacker, Chain Saw, Auger, Etc.)	$10.00 hr.

Blue Earth County

Economics of Upgrading an Aggregate Road

Place: Blue Earth Co. Public Works (Mankato, MN)

Attendees:

Mr. Alan Forsberg	Blue Earth County Engineer
Chuck Jahren	(IA State)
Mary Rukashaza	(IA State)
Jacob Thorius	(IA State)

General Information

1. County characteristics
   - Size (area)
     - ***23 Townships***
     - ***723 sq. miles***
   - Miles of roads – **720 miles of roads**
     - ***420 CSAH***
     - ***12 CSAH future***
   - Percentages of different types of roads (i.e. CSAH, Co., surface types, etc.)
   - % of time spent maintaining aggregate roads
   - Traffic volumes (maps, or tables)
2. Workforce
   - Size ***(Hwy and Park services)***
     - ***42 full time HWY***
     - ***6 part time summer***
     - ***Normally: 43 full time and 12 part time***

   b. Is it based on winter maintenance activities? YES
   Equipment

   His policy is that without good equipment the maintenance work can not be done and the county is loosing money. Keep all equipment new or in good shape.
   Invest 6-8% of the value of your fleet in the fleet it's self every year.

3.
   - Is equipment purchased based on snow removal policy? **YES**
   - # of trucks and approx. cost for replacement
     - ***13 trucks***
     - ***Tandem Truck: 80K with trade in about***

225,000 miles
- ***Trade in = 27K***
- ***Equipment are on a 6-8 year cycle***

- # of graders and approx. cost for replacement
  - ***11 graders***
  - ***Motor Grader: 100K with trade in***
  - ***a trade in is 40K***
  - ***6-7 year cycle***
  - ***rent 1 motor grader in one section of the county***

4. Political climate:
   - ***The county is prow growth and does not have any problem paving or upgrading roads.***
   - ***People want paved roads but do not want to give up ROW***
5. Winter maintenance strategy/policy
   - ***Snow and Ice removal is removed by Priority based on ADT and function class of road***
   - ***Work days are 16 hours max during this time***
6. Views of citizens (type of construction and maintenance they expect)
   - ***People call in and complain and complain to their elected officials***
   - ***"The people who live in the county are just like city people but there houses are just a part" Dr. John Adams (Geography professor @ U of MN)***
7. Subgrade type(s)
   - ***The county has a lot of fine clays soil that does not drain well.***
   - ***The county uses:***
     - ***Edge drains under pavement***
     - ***Ditch drains and***
     - ***A thick of base course to allow for drainage.***
8. Stabilization/Dust control policy
   - Entire road treated or just in front of residences: ***Front of residents are treated IF the residents pay for the material.***
   - If used application rate
   - Type of products used: ***Calcium Chloride used by the county and Magnesium Chloride used by private contractor***
   - Frequency: ***depends on the owner also***

Other information:

Cost: 70$/ 100'x 20ft w – 2 applications

- ***Used for hills and curves and construction if it is a detour.***
- ***The county has the equipment and the material: (water truck)***
- ***Calcium Chloride also used for winter maintenance: lowers freezing point of water.***

9. What is your policy about when to pave a gravel road?
   - ***Traffic volume,***
   - ***Political decision***
   - ***Functional class of the road***
   - ***Other economical factors***
   - ***When traffic is above 200ADT the county can not keep the road smooth and it is very dust (Safety)***
   - ***Other info: Lose 1" of gravel for each 100ADT/year***
   - ***The new AASTO requirements on when to pave are very lose.***

10. Are you responsible for township roads?
    - ***No, but the county provides technical support, replace bridges, and sell supplies to townships. A few townships (5 – 6) have their own staff and equipment and the rest contract the work out to private organizations.***

Routine Maintenance (weekly to once a year)

1. How often roads are bladed? (*I know this will vary.*)
   - We could get an approximate frequency for 5 or 6 roads
     - ***Every week on some roads and once every 2 weeks depending on traffic and weather.***
   - Then how much time does it take to blade each road.
2. Do you spot treat with additional gravel in spring or throughout the year? ***Spot treat roads where needed all summer***
3. Where are your gravel sources? ***In the county***
   - ***Most are private owned sources but the county owns a few pits for stock piling***

4. Mowing (how often) :
   - ***Mow entire ROW every 3 years***
   - ***Mow shoulders where there is sight problem***
   - ***once a year they spray for noxious weeds***
5. Costs of maintaining roads (If you have every totaled the costs)
6. Any thin surfaced roads (chip sealed surface, etc.) ***No, because of bad sub-base material BUT:***
   - ***Trial surface: 12" base materials with 5" emulsified asphalt then***

place a double seal coat. Test area on two roads, The county kept the road as a 7 ton road

- ***The cost is ½ the cost of hot mix surface and regraveling.***
- ***Will test and report on condition later.***

7. If HMA surfaced
   - Frequency of crack sealing: **5 years**
     i. **$250K spent on regraveling => $ 5/ ton => 40 tons => 130 miles => 5 loads/mile reclaim shoulders and reshape as needed**
     ii. **the county does major reshaping every year of a few miles – to build the road back up and improve the life cycle to about 10-20 year**
   - Frequency of overlay: **15 years**
   - Other maintenance

Periodic Maintenance (1-8 years)

1. Frequency and quantities of gravel for regraveling
2. Is crown correction
3. Drainage

- ***Other info:***
  i. ***County put out bides for regraveling of $250,000 a year***
  ii. ***The gravel cost about $5-$6/Ton***

Type of gravel: Crushed limestone, mainly natural crushed gravel (dust)

Rebuilding

1. Costs (If you have any baselines that you use for budgeting)
   - Grading
   - HMA
2. Standards that roads are brought to
   Built to CSAH standards or better

When you do budget estimates for construction projects, what costs do you use for the following and what do they include:

√ if used (expected service life)		(Cost/Unit of measure)
☐	Concrete Pavement	***less then .5 of a mile***
☐	HMA Pavement **superpave**	**150k/mile for a 9Ton road: 12" gravel 4" no grading included**
☐	Seal coat (type and cost)	**$6,000/mile - pea rock natural gravel**

- Every 5 years

- Regrading — $100, 000/mile in flat open county where there is light grading
- Surface treatments* — $ 60-80K/mile (emulsion oil gravel)
- HMA Overlay — every 15 years, they do 2 overlays then CIPR and HMA => essentially it becomes a new road

Level of Service	ADT	County Road Number
↓	0-49	very few
	50-74	very few
	75-99	very few
	100-200	trying the new base stabilization and seal cost method
	200-above	Pave

Other information:

1. *The county Engineer does not think it is a good idea to pave trouble spots (example: bridge approaches..) because the drivers might expect the whole road to be the same.*
   - ⇨ *Pave the road from destination to destination and do not alternate surfaces.*
2. *Interested in what other counties are doing and what seems to be working for them. => a best practices*

ROAD NUMBER _____ DATE _____

FROM _____ TO _____

Types of Distress	Degree of Distress	Points			Totals
Ride	Slight (Roughness)	0	3	6	
	Moderate "	9	12	15	
	Severe "	18	22	25	
Alligator Cracking	Slight	0	3	6	
	Moderate	9	12	15	
	Severe	18	22	25	
Rutting	Slight	0	3	6	
	Moderate	8	10	12	
	Severe	15	18	20	
Transverse Cracking	Slight	1	3	5	
	Moderate	6	8	10	
	Severe	11	13	15	
Longitudinal Cracking	Slight	1	3	5	
	Moderate	6	8	10	
	Severe	11	13	15	
Shoulder Width & Condition	Slight (0-1' Def.)	0	3	6	
	Moderate (2'-3' Def.)	8	10	12	
	Severe (4'-> Def.)	14	17	20	
Inslopes	Safe - Flatter than 4:1	0	3	6	
	Moderate - 4:1 to 3:1	8	10	12	
	Unsafe - Steeper than 3:1	15	18	20	
Horiz. Alignment	Straight			0	
	Curves < 5°			5	
	Curves > 5°			20	
Vert. Alignment	Safe Passing Dist.			0	
	Intermittent Passing Zone			5	
	Minimum Passing Allowed			20	
Ditch and Drainage Condition	Slight	0	1	6	
	Moderate	8	10	12	
	Severe	15	18	20	
A D T					

Aitkin County

July 23, 2003

John Welle – County Engineer

General Information

1. County characteristics
   - a. Size (area) **1819 square miles (2000 U.S. Census figures)**
     55 townships (Aitkin Co. web site)
     2/3 of land in county publicly owned
     county is growing slowly, more into a year round retirement community about 15,000 people year round and as many as 60-80,000 in the summer
   - b. Miles of roads **511 Miles of Roads**
     374 CSAH ≈ 197 paved & 177 gravel
     137 County ≈ 17 paved & 120 gravel
   - c. % of time spent maintaining aggregate roads **spend most of time in the summer on this activity**
   - d. Traffic volumes (maps, or tables) **Provided a sheet with some breakdowns of traffic volumes (attached). Says the traffic volumes are very misleading – the average daily traffic is not a good representation of the actual traffic roads in the county get. Many of the roads may be at 500 ADT easily on the weekends during the summer, then be down around 100 or so in the week and during the winter could be down to 20 cars a day. Thinks their needs to be some other way to represent the different traffic volumes he sees – most of this is a result of everyone coming up to their lake cabin.**
   - e. Workforce
     - i. Size **5 technicians**
       1 project manager
       1 assistant engineer
       1 mechanic
       15 Full-time equipment operators (6 maintenance shops)
       - during summer - 7 full-time blades
       - 4 man graveling crew
       - 3 driving belly dumps
       - 1 running grader, water truck and roller
       3 Part-time in summer to mow
     - ii. Is it based on winter maintenance activities? **Yes**
   - f. Equipment
     - i. Is equipment purchased based on snow removal policy? **Yes**
     - ii. # of trucks and approx. cost for replacement
       13 plow trucks – most are about a 12 year cycle, at that point decide whether or not to overhaul – usually don't replace at about $110,000
     - iii. # of graders and approx. cost for replacement
       8 Blades – 4 from '87 & 4 from '89 – try to get 20-25 year service life, completely rebuild at about 10,000 hours for $10,000
       1 dozer and 1 backhoe
   - h. Political climate **Excellent, very supportive of the work county does/wants to do**
   - i. Winter maintenance strategy/policy **keep snowpack on gravel roads to keep rock their – saves money on regraveling in the spring. Generally won't plow unless more than 3". Try to have all paved roads cleared in about 10 hrs. Spend most of time in winter maintaining paved roads.**
   - j. Views of citizens (type of construction and maintenance they expect)
   - k. Subgrade type(s) **All types of soil – generally poor soils with areas of good**

l. Stabilization/Dust control policy
   i. Entire road treated or just in front of residences **On about 30-40 miles of high volume roads they treat the entire road to help reduce maintenance time and costs – blade once a week instead of twice a week on those roads. Cost of this treatment is about equivalent to placing 1/2" – 3/4" of gravel down. Do offer dust control in front of residences, split cost 50/50 with them if they want because residents want it for dust control and county benefits from the stabilization effect. Place a 400' strip $150/treatment (50:50 split) Average 150 residential treatments a year**
   ii. If used, application rate **Place at rate of 0.21 gal/sy ≈ 2500 gal/mile ≈ 67.9 ¢/gal applied – contracted out**
   iii. Type of products used **$CaCl_2$**
   iv. Frequency **Placed once per year in June (by June 15th)**

m. What is your policy about when to pave a gravel road? **Pave at about 200 ADT, but driven by funding. Along with ADT, look at # of residences on road, functional classification, safety issues, a part of an improved county route, and % of public land ownership. With funding they spend first on maintaining existing paved surfaces and bridges and then work off priority/rating sheet (attached). Right now road has to be up to standards**

n. Are you responsible for township roads? **County maintains about 50 miles of road from 12 unorganized townships – not large enough population for township government – by default, they do everything for those roads. Spend about $200,000 annually on township roads. County also offers blading and plowing services to the organized townships – blade about 65 miles in the summer and plow about 110 miles in the winter. Likes the winter work because it is added income to the county and keeps workers busy, plowing is usually done the next day. County tries not to take on additional miles in the summer because they have too much work to do as it is. County also maintains all the drainage ditches in the county (500 miles) – main problem there is beavers!**

Routine Maintenance (weekly to once a year)

a. How often roads are bladed? (*I know this will vary.*) **Blade as needed, usually about once a week – depends on traffic and weather conditions. Sometimes blade on Monday and Thursday because of heavy weekend traffic.**

b. Then how much time does it take to blade each road? **Depends on the operator.**

c. Do you spot treat with additional gravel in spring or throughout the year? **Spot treat roads as needed throughout spring, summer, and fall.**

d. Where are your gravel sources? **Several pits throughout the county. County is said to be "Aggregate Rich", but have depleted three sources in the last four years. It is hard to develop new pits, most locations are near lakes or residences and they put up a fight.**

e. Mowing (how often) **Mow entire ROW every 3 years to control brush and weeds – no chemical control anymore, to not worry about environmental issues. Mow the top 8' 2-3 times a year. Not to worried about protecting nesting habitat for birds – plenty of cover beyond the ditches.**

f. Costs of maintaining roads (If you have every totaled the costs)
   Their figures about $2385/mile – CSAH paved
   $2988/mile – Co paved
   $1522/mile – CSAH gravel
   $1724/mile – Co gravel

g. Any thin surfaced roads (chip sealed surface, etc.) **No thin surfaces poor soils don't work well with them – no base structure. However, thinking of maybe doing something since some roads**

don't warrant a full paved surface, but do need an upgrade from the gravel

Periodic Maintenance (1-8 years)

a. For roads surfaced with HMA/bituminous treatments
   1. Frequency of crack sealing **Do what they can in May, start on newer pavements and work backwards – trying to protect recent investments.**
   2. Frequency of overlay **1.5" about 8-10 years, 3" about 15-20 years**
   3. Frequency of other maintenance activities

b. Frequency and quantities of gravel for regraveling **Use Class 5 aggregate – max out the 3/4" (to reduce flat tire complaints and windshield damage) and 8-15% on the 200 sieve. Try to place about 1.5" on every 3-4 years, but depends on road – ADT and functional classification. Stockpile the gravel for about $3-3.50/yd, typically placed at $7/yd – thinks these costs will begin to skyrocket as pits are depleted. Use a 4 man crew all summer to regravel roads. 3 belly dumps (own – take box off tandem and put on 5th wheel) and one water truck/blade/ag tractor and rubber tire roller. Rock gets dumped, spread, watered and then rolled. Haul about 40-50,000 tons of gravel/year.**

c. Frequency of crown correction **Done as needed. Gravel Road system is in pretty good shape**

d. Drainage correction **Done as needed, but do have a maintenance grading program to build up gravel roads and put ditches in. Spend about $40,000/mile and try to do 4-5 miles/year (target – usually less than that)**

Rebuilding/Construction Projects

1. Standards roads are brought to when improved **Roads are brought to State Aid Standards – shoot for 50 mile per hour curves**
2. What is your estimated cost/mile or other cost/unit of measure for the following construction projects/activities

√ if used		(Cost/Unit of measure) (expected service life)
☐	Concrete Pavement	no concrete roads
☐	HMA Pavement	$115,000/mile – includes 4.5" HMA and 2" gravel also place a 4' shoulder – to reduce ongoing maintenance, eliminate summer activity (32' overall width)
☐	HMA overlay	$20,000/mile
☐	Seal coat (type and cost)	
☐	Regrading	$175,000/mile about average, $129,000 from State Aid office, up to $250,000 for more work – depends on terrain and soils
☐	Surface treatments*	
	o Otta Seal	thinking about it
	o Chip Seal	
	o Emulsion Oil Gravel	
	o Other	

* Defined as "lightly surfaced roads", an alternative to conventional HMA or PCC pavements.

Will probably have to start doing cold-in-place-recycling in the next 5-10 years on several roads

Roads tend to wear out due to environmental factors, not traffic loading

Do have a table or map of the structural capacity of your county roads that you could send to us?

We have broken the traffic volumes into the following ranges to describe the level of service. Do they seem appropriate or should they be changed? Please categorize some of your roads into the traffic volume ranges listed below or into the ranges that you feel are appropriate.

Level of Service	ADT	County Road Number
	0-49	
	50-74	
	75-99	
	100-124	
Increasing	125-149	
	150-199	
	200-249	**when they start to pave**
	250-299	
	300-up	

What would you as a user like to see as a result of this project?

Would like to know what others are doing and having luck with for different surface types and maintenance practices.

How do you put future costs on maintaining aggregate roads -- especially aggregate resources?

Says "Gravel roads waste more aggregate than paved roads." With gravel roads the material flies of the road into the ditch and maybe hard to recover or is worn down to finer particles and the fines are washed/blown away. With paved roads, the material is all right there and can be recycled/recovered later on.

Also thinks the EPA or other agencies responsible for health issues will probably start to put restrictions on dust from gravel roads and all that run-off.

Attached are copies of handouts from meeting

Priority Rating Worksheet
Major Reconstruction Program

Road Number	Segment Description	Length	Projected ADT (20 points)	Number of Seasonal and FT Residences (20 points)	Number of Seasonal and FT Residences Per Mile	Functional Classification (10 points)	Sight Distance Safety Rating (10 points)	Part of Larger Improved Route (10 points)	Percentage of Private land Adjacent to Segment (10 points)	Priority Rating (80 points)
29	CSAH 3 to 2.3 miles North	2.3	225	17	7.39	7	84.44	0	100	48.15
54	Between blacktop	0.5	360	2	4.00	4	0	10	100	48.05
62	TH 210 to 2 miles North	2	405	16	8.00	4	0	0	90	45.55
32	CSAH 8 to Carlton County Line	6.3	180	32	5.08	7	15.38	10	90	44.39
23	TH 18 to Beginning of Pavement	4.5	210	18	4.00	10	83.47	0	95	42.49
10	Between blacktop	6.8	165	4	0.59	10	59.94	10	70	42.06
10	TH 169 to TH 232	7.12	300	17	2.39	10	38.91	0	95	41.95
25	CSAH 23 to Kanabec County Line	3.3	90	10	3.03	7	35.01	10	100	39.70
62	2 miles N of TH 210 to CR 71	2	405	6	3.00	4	0	0	100	38.75
5	TH 47 to CR 56	8	210	28	3.50	10	32.24	0	95	38.56
2	CSAH 26 to Pine County Line	4.4	165	10	2.27	10	14.88	10	50	38.20
71		1	315	5	5.00	4	0	0	100	37.40
53	CSAH 4 to CSAH 5	3.08	203	21	6.82	4	17.87	0	100	36.51
88		1.02	120	13	12.75	0	0	0	75	33.42
5	CR 56 to TH 210	3.6	210	3	0.83	10	44.81	0	65	32.84
13	CSAH 18 to Carlton County Line	5.6	120	5	0.89	7	22.01	10	60	32.53
21	CSAH 1 to TH 169	6.9	83	10	1.45	10	30.59	0	95	28.93
85		0.5	40	4	8.00	0	41.84	0	100	28.71
61	TH 18 to CSAH 23	7	90	22	3.14	7	31.44	0	90	28.52
87		0.6	40	3	5.00	4	43.96	0	100	28.22
72		1.2	150	3	2.50	4	26.43	0	100	28.17
36	CR 65 to 1.5 miles N of CSAH 14	5.2	135	12	2.31	7	46.45	0	60	27.93
57	TH 65 to 5 miles east	5	120	16	3.20	4	30.46	0	95	27.48
30	TH 65 to CSAH 16	7	128	16	2.29	4	39.77	0	65	27.38
83		2.69	68	6	2.23	4	61.36	0	100	26.99
19	Cass County Line to CSAH 20	4.8	98	11	2.29	10	44.35	0	40	26.87
57	TH 27 to 4 miles North	4	120	8	2.00	4	42.08	0	95	26.77
36	TH 65 to CR 65	4.1	135	5	1.22	7	61.57	0	50	26.74
27	CSAH 13 to TH 27	6.6	68	20	3.03	7	28.19	0	90	26.73
60		5.06	113	19	3.74	4	11.37	0	100	26.58
19	CSAH 20 to CSAH 29	2	98	5	2.50	10	28.15	0	50	26.38
29	2.3 miles N of CSAH 3 to CR 68	3.3	225	5	1.52	7	6.34	0	45	25.62
26	CSAH 38 to CR 59	5	83	9	1.80	7	14.64	0	100	25.39
61	TH 65 to TH 18	4.23	60	15	3.55	4	33.44	0	95	25.37
51	TH 18 to CSAH 28	4.77	105	17	3.56	4	14.88	0	85	24.76
59		4.28	135	9	2.10	4	12.22	0	95	24.69
26	CR 59 to TH 65	8	83	18	3.00	7	8.72	0	75	24.18
18	CSAH 5 to CSAH 10	6.2	113	4	0.65	7	10.64	0	95	24.16
29	CR 68 to CSAH 7	6.3	225	7	1.11	7	12.92	0	30	24.15
62	CR 71 to TH 232	4	90	11	2.75	4	12.51	0	100	24.01
1	3.6 miles N of CSAH 22 to CSAH 3	7.4	135	12	1.62	7	7.81	0	70	23.99
74		2	75	4	2.00	4	27.52	0	100	23.59
65		8.96	90	14	1.56	4	78.91	0	50	23.59
29	CSAH 7 to CR 67	4.8	83	10	2.08	7	20.75	0	70	23.44
64		1.4	53	6	4.29	0	37.69	0	100	23.11
75	TH 27 to CSAH 34	6.9	90	7	1.01	7	30.36	0	70	23.07
86		0.6	40	2	3.33	0	56.86	0	100	22.89
20	Cass County Line to CSAH 19	6.9	45	17	2.46	7	26.84	0	70	22.75
5	TH 232 to CSAH 18	7.81	120	15	1.92	7	4.37	0	60	22.38
55		1.47	40	5	3.40	0	44.87	0	100	21.80
64	CSAH 32 to 5 miles North	5	173	6	1.20	4	21.56	0	50	21.58
67		5.17	60	9	1.74	4	36.51	0	80	21.34
34	CSAH 2 to CR 75	6.3	45	13	2.06	7	15.81	0	70	21.04
54	End of Blacktop to TH 210	4.77	75	6	1.26	4	16.59	0	95	20.84
58		2.87	30	8	3.00	4	23.51	0	80	20.53
73		5.1	120	10	1.96	4	7.76	0	85	20.28
54	CR 54 to TH 210	1.75	75	2	1.14	4	22.62	0	85	20.28
80		1.7	83	1	0.59	4	12.31	0	100	20.25
28	TH 65 to CSAH 2	9.1	75	10	1.10	7	27.09	0	50	20.14
64	5 miles N of CSAH 32 to CSAH 14	4.49	60	6	1.34	4	38.31	0	70	19.99
56	Rice River to CSAH 5	3.9	30	3	0.77	4	48.66	0	80	19.35
18	TH 169 to CSAH 5	6	113	1	0.17	7	6.6	0	50	18.50
29	CR 67 to TH 200	2	83	2	1.00	7	10.46	0	40	17.71
69		1	40	1	1.00	4	0	0	100	17.54
35	TH 65 to Itasca County Line	0.4	68	0	0.00	4	0	0	100	17.36
68	CSAH 29 to dead end west	2	60	4	2.00	0	31.36	0	80	17.24
56	TH 210 to Rice River	4.5	90	0	0.00	4	8.8	0	65	15.82
66	TH 169 to dead end east	1.2	60	2	1.67	0	10.99	0	80	14.68
66	CSAH 29 to TH 169	3.2	60	2	0.63	4	14.78	0	40	13.42

CERTIFIED COPY OF RESOLUTION OF COUNTY BOARD OF AITKIN COUNTY, MINNESOTA

Adopted_____, 20_____

Commissioner:

Rates Charged for County Equipment

Effective Date: _____May 1, 2002_____

owplowing Roads -	Per Hour
Motor Grader – w/Operator	$60.00
Tandem Trucks – w/Operator	65.00
Single Axle Trucks – w/Operator #125, #126, #127	60.00

aintaining Roads –	
Motor Grader – w/Operator	60.00
Tandem Trucks – w/Operator	65.00
Single Axle Trucks – w/Operator #125, #126, #127	50.00
2 Cubic Yard Loaders – w/Operator Unit #385	40.00
3 Cubic Yard Loaders – w/Operator Unit #391 & #387	65.00
Dozer – w/Operator Unit #388	60.00
Tractor Backhoe – w/Operator Unit #395 & #389	55.00
Hydraulic Excavator – w/Operator Unit #392	65.00
ASV Posi Track – w/Brushhead & Operator Unit #393	60.00
ASVPosi Track – w/Loader & Operator Unit #393	45.00
Mowing – w/Operator Units #390, #394, #395, #396	50.00
Sioux Steamer – w/Truck & Operator Unit #47	40.00
Unit 366	53.00

ommissioner _____moved the adoption of the resolution and it was declared adopted upon e following vote:

TATE OF MINNESOTA }
ounty of Aitkin } ss.
ffice of County Auditor, }

Kirk Peysar, Auditor, of the County of Aitkin, do hereby certify that I have compared the foregoing with the original resolution filed in y office on the _____A.D., 20_____, and that the same is a true and correct copy of the whole thereof.

ITNESS MY HAND AND SEAL OF OFFICE at Aitkin, Minnesota, this _____day of _____A.D., 20 _____

KIRK PEYSAR, County Auditor

By _____, Deputy

Unpaved County State-Aid Highways and County Roads

Segments	Length	2000 ADT
CSAH 1 from 3 6 miles north of CSAH 22 to CSAH 3	7.4	100
CSAH 2 from TH 65 to CSAH 26	6	105
CSAH 2 from CSAH 26 to Pine CSAH 41	4 4	105
CSAH 3 from Crow Wing County Line to CSAH 29	6	210
CSAH 5 from TH 47 to CR 56	7.6	140
CSAH 5 from CR 56 to TH 210	4	80
CSAH 5 from TH 232 to CSAH 18	7.81	70
CSAH 10 from CSAH 18 to 6.8 miles north of CSAH 18	6.8	160
CSAH 10 from TH 169 to TH 232	6.97	185
CSAH 13 from CSAH 16 to Carlton County Line	5 6	70
CSAH 18 from TH 169 to CSAH 5	6 1	50
CSAH 18 from CSAH 5 to CSAH 10	6 1	20
CSAH 19	6 8	70
CSAH 20	5 9	30
CSAH 21	6 9	55
CSAH 23 from TH 18 to end of blacktop	4 5	95
CSAH 25	3.3	140
CSAH 26 from CSAH 38 to CR 59	5	145
CSAH 26 from CR 59 to TH 65	8	40
CSAH 26 from TH 65 to CSAH 2	9.1	40
CSAH 27	6.6	65
CSAH 29 from CSAH 3 to 2.3 miles north of CSAH 3	2 3	165
CSAH 29 from 2.3 miles north of CSAH 3 to CR 66	3.3	165
CSAH 29 from CR 66 to CSAH 19	6.3	25
CSAH 29 from CSAH 19 to CR 67	4 8	55
CSAH 29 from CR 67 to TH 200	2	55
CSAH 30	7	50
CSAH 32	6.3	140
CSAH 34	6.3	40
CSAH 35	0.4	45
CSAH 36 from TH 65 to CR 65	4.2	85
CSAH 36 from CSAH 65 to 1.8 miles north of CSAH 14	5.2	85
Total CSAH:	**176.98**	
CR 51	4.77	60
CR 52	1	
CR 53	3.08	150
CR 54 west of CR 83	0 5	390
CR 54 form end of pavement to TH 169	4.77	50
CR 54N	1 75	50
CR 55	1.47	15
CR 56 from TH 169 to Rice River	4.5	60
CR 56 from Rice River to CSAH 5	3 9	20
CR 57 from TH 65 to 5 miles east	5	70
CR 57 from 5 miles east of TH 65 to TH 27	4 04	20
CR 58	2.67	30
CR 59	4 28	105
CR 60 and 60W	5 08	140
CR 61 from TH 65 to TH 18	4 23	30
CR 61 from TH 18 to CSAH 23	7	45
CR 62 from 2.5 miles north of TH 210 to CR 71	1 5	250
CR 62 from CR 71 to TH 232	4	60
CR 63	2.69	45
CR 64 from CSAH 32 to 5 miles north	5	125
CR 64 from 5 miles north of CSAH 32 to CSAH 14	4 49	40
CR 65	8 96	60
CR 67	5 17	40
CR 68	6 5	40
CR 71	1	140
CR 72	1 2	95
CR 73	5 1	85
CR 74	2.7	50
CR 75	6 9	45
CR 80	1 7	30
CR 86	0 6	85
CR 88	1 02	45
Total CR:	**116.57**	
GRAND TOTAL:	**293.55**	

APPENDIX 9: MEEKER COUNTY TOWNSHIP ROAD MAINTNENANCE AGREEMENTS

MEEKER COUNTY HIGHWAY DEPARTMENT
325 North Sibley Avenue
Litchfield Minnesota 55355-2155
Phone (320) 693-5360
Fax (320) 693-5369

Ronald Mortensen
County Engineer

Marland R. Meyer
Assistant Engineer

February 5, 2002

Meeker County Board of Commissioners

Dear County Board Members:

The County Highway Department would like to have a formal agreement for all the maintenance work that is being done for the townships. The County has new personnel and a number of the township's have new personnel since the concept of this agreement had been established.

Michael Thompson and I have worked out a Township Road Maintenance Agreement, which is attached. The agreement will explain in writing what is expected from each party. The agreement will also have a map showing each road and length that will be maintained be the County.

The following items must be addressed:

1.) County resolution authorizing the execution of this agreement.
2.) Basic Services rate (dollars per mile per year). *Presently $400.00*
3.) Credits for ditch mowing (dollars per mile per year). *Presently $30.00*
4.) Cost of Services rates. *(Exhibit 2)*

Respectfully submitted,

Ronald Mortensen
County Engineer
Meeker County Highway Department

TOWNSHIP ROAD MAINTENANCE AGREEMENT _____ TOWNSHIP

This Agreement is entered into this ____ day of _____, 20__, between the Township of _____, located within Meeker County (hereinafter referred to as Township), and Meeker County, a political subdivision of the State of Minnesota (hereinafter referred to as County).

It is hereby agreed that:

1. **Basic Services.** County shall provide the following described maintenance and engineering services for Township's roads (excluding minimum maintenance classified roads) as identified on the map attached hereto as Exhibit 1, which services are classified as Basic Services:

   A. Blading of gravel roads.
   B. Snow removal from gravel and hard surface roads.
   C. Signing, including identification, traffic and hazards.
   D. Mowing of ditch right of way with one swath in the Summer and two swaths in the fall.
   E. Such other special work projects as mutually agreed in writing between the parties.
   F. Conceptual designs for improving existing roadways including an original and one alternate.
   G. Roadway Construction inspection engineering for bituminous paving.
   H. Preparation of roadway construction plans consisting of:
      (1) an original plan
      (2) one alternate plan

   All services performed herein, including both basic and additional, shall be performed in accordance with the normal and customary operations of the County's highway department. All scheduling of services shall be performed by the County Highway Engineer or his/her designee.

2. **Additional Services.** County may, at the request of Township, perform the following additional services:

   A. Preparation of additional alternates, or amendments to, roadway construction plans and conceptual designs.
   B. Blading or snow removal services on minimum maintenance township roads.
   C. Installation of additional guide signs, providing the signs conform to Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD).

3. **Payment.** For the services provided hereunder, Township shall pay County the following:

   A. Basic Services. For the basic services provided herein at the rate of _____ dollars per mile per year for _____ miles for a total of _____. Payment shall be made in one annual installment and is due no later than December 1st of the year the services are provided.
   B. Additional Services. For additional services provided herein Township shall pay County the cost of materials and the cost of the service in accordance with the hourly rates attached hereto as Exhibit 2. Payment shall be made by Township within 30 days of receipt of billing from County.

4. **Seasonal Contracts.** Township shall be allowed to acquire road materials by including its requirements with the County's requests for bids or proposals for seasonal requirements for the following items:

   - Culverts
   - Gravel
   - Seal Coating
   - Road striping

   Township shall be responsible for payment of items it purchases under this arrangement, subject to the following exception for culverts.

5. **Culverts.** For culverts up to and including forty eight (48) inches in diameter, Township shall be responsible for the full cost. For culverts exceeding forty eight (48) inches in diameter, County shall pay one half the excess cost over and above the cost of a 48 inch diameter culvert as reflected in that year's seasonal contract.

6. **Credits.** If Township elects to perform its own right of way ditch mowing, Township shall receive a credit of ____ dollars per mile from the Basic Services payment due hereunder. Said election must be made by Township and communicated to County no later than March 30th of each calendar year, or this credit will not apply.

7. **Township Responsibilities.**

   A. Township retains final responsibility and authority for all design engineering, construction engineering, construction and maintenance for its roadways.
   B. Township shall not approve construction of a new road, nor alteration of an existing road, that does not meet the following minimum requirements without specific consent from County:

      (1) minimum grading grade width of 32 feet;

(2) minimum side ditch depth of 2 feet and bottom width of four feet;
(3) township (as opposed to private landowner) construction and maintenance of all culverts and crossings;
(4) County Highway Engineer approval of design.

In the event this provision is not adhered to, said road shall not be provided the basic services described herein.

C. Township shall promptly inform County of any known conditions requiring maintenance, repair, or warnings.

D. Township shall be responsible for making decisions regarding road closure due to hazardous conditions. In the event County becomes aware of hazardous conditions that it deems serious enough to warrant warnings or closure, it shall first attempt to receive approval from the Town Board chairman or his designee prior to taking action. If contact cannot be made within a reasonable period of time, the County is authorized to take protective measures.

E. Township shall at all times maintain liability insurance in the minimum amounts established by Minn. Stat. 466, as amended.

8. **Indemnification.** Each party shall be liable for its own acts and the results thereof to the extent authorized by law and shall not be responsible for the acts of the other party, its officers, employees or agents. Each party agrees to indemnify, hold harmless and defend the other, its officers and employees against any and all liability, loss, costs, damages, expenses, claims or actions, including attorneys fees which the other, its officers and employees may hereafter sustain, incur or be required to pay, arising out of or by reason of any act or omission of the party, its agents, servants or employees, in the execution, performance or failure to adequately perform its obligations pursuant to this Contract. Liability limits shall be accord with the minimums specified in Minn. Stat. Ch. 466 or its successors and nothing herein shall constitute a waiver by either party of said limitations or exceptions to liability.

9. Term of Agreement. This agreement shall commence on the effective date above written and shall be effective for one year. Thereafter, this agreement shall automatically renew for successive one year periods on the same terms and conditions unless, at least 60 days prior to expiration, either party provides written notice to the other of intent to terminate or amend its provisions.

325 North Sibley Avenue
Litchfield Minnesota 55355-2155
Ph. (320) 693-5360
Fax (320) 693-5369

Ronald Mortensen
County Engineer

Marland R. Meyer
Assistant Engineer

Exhibit 2

Meeker County Highway Department Rates: January 1, 2002

Personnel:	
County Engineer	$75.00/hr.
Assistant County Engineer/Senior Design Technician	$60.00/hr.
Senior Construction Technician	$55.00/hr.
Senior Survey Technician	$50.00/hr.
Survey Crew	$110.00/hr.
Sign Technician	$50.00/hr.
Maintenance Personal	$25.00/hr.
Equipment: (Rate only, does not include the operator rate.)	
Motor Grader	$35.00/hr.
Tandem-Axle Truck	$45.00/hr.
Single-Axle Truck	$40.00/hr.
Trailer	$30.00/hr.
Tractor/Loader/Backhoe	$28.00/hr.
Skid Steer Loader	$39.00/hr.
Loader (2-3 Yard)	$35.00/hr.
Sweeper (Self-propelled)	$71.00/hr.
Shouldering Machine	$33.00/hr.
Tractor/Loader	$35.00/hr.
Tractor/Brush Mower	$35.00/hr.
Tractor/Pneumatic roller	$40.00/hr.
Misc. Small Equipment (Wacker, Chain Saw, Auger. Etc.)	$10.00/hr.

APPENDIX 10: BENTON COUNTY ASSET MANAGEMENT WORK SHEET

ROAD NUMBER _____ DATE _____

FROM _____ TO _____

Types of Distress	Degree of Distress	Points			Totals
Ride	Slight (Roughness)	0	3	6	
	Moderate "	9	12	15	
	Severe "	18	22	25	
Alligator Cracking	Slight	0	3	6	
	Moderate	9	12	15	
	Severe	18	22	25	
Rutting	Slight	0	3	6	
	Moderate	8	10	12	
	Severe	15	18	20	
Transverse Cracking	Slight	1	3	5	
	Moderate	6	8	10	
	Severe	11	13	15	
Longitudinal Cracking	Slight	1	3	5	
	Moderate	6	8	10	
	Severe	11	13	15	
Shoulder Width & Condition	Slight (0-1' Def.)	0	3	6	
	Moderate (2'-3' Def.)	8	10	12	
	Severe (4'-> Def.)	14	17	20	
Inslopes	Safe - Flatter than 4:1	0	3	6	
	Moderate - 4:1 to 3:1	8	10	12	
	Unsafe - Steeper than 3:1	15	18	20	
Horiz. Alignment	Straight			0	
	Curves < 5°			5	
	Curves > 5°			20	
Vert. Alignment	Safe Passing Dist.			0	
	Intermittent Passing Zone			5	
	Minimum Passing Allowed			20	
Ditch and Drainage Condition	Slight	0	3	6	
	Moderate	8	10	12	
	Severe	15	18	20	
A D T					