Cost Comparison of Treatments Used to Maintain or Upgrade Aggregate Roads

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ABSTRACT

This paper describes an investigation that will give Minnesota counties, cities, and townships information to make informed decisions on when it may be economically advantageous to upgrade and pave aggregate roads. The investigation will also provide resources for local governments to explain to the public why certain maintenance or construction techniques and policy decisions are made.

The research effort is based on the spending used to maintain low-volume roads found in the annual reports of certain counties in Minnesota. The reviewed activities include maintenance grading, regraveling, dust control/stabilization, reconstruction/regrading, paving, and associated maintenance activities.

The expected end product is a set of relationships that can be modified to address local conditions, which will include a cumulative maintenance cost per mile. These relationships are expected to show how the maintenance costs of aggregate roads, lightly surfaced roads, and hot-mix asphalt roads vary with the traffic, age, and type of surface. This relationship will also be used as a tool to assist in decisions about whether or not to upgrade an aggregate road to a bound surface.

Key words: gravel roads—low-volume roads

INTRODUCTION

Counties, cities, and townships are often faced with the decision on how to best approach the maintenance of aggregate roads and when to upgrade them. Currently most of the information available for decision making on the costs, standards, and performance of different options is not specific to the upper Midwest. For example, Australian road agencies use economic evaluation of gravel roads to assist in their decision to upgrade a low-volume road (*1*). This study examines maintenance costs for various types of road surfaces found in Minnesota and identifies possible threshold values for upgrading low-volume roads.

This paper is a progress report of the research on the cost of maintaining low-volume roads in Minnesota. The goals of the research are to provide the tools needed to make decisions about upgrading low-volume roads. The research will use information from certain counties in Minnesota to estimate the costs to construct, maintain, and rehabilitate low-volume roads within the state of Minnesota.

OBJECTIVE

This project has the objective of identifying the methods and costs of maintaining and upgrading an aggregate road. The costs are from the viewpoint of a public maintenance entity using its own forces.

As an example, initially a road has an aggregate surface with a low-traffic volume. As traffic increases, so do the routine maintenance costs (*2*). At some point, it may be advantageous to improve the road by paving it, which would reduce the routine maintenance costs. Figure1 shows a case where a gravel road is maintained regularly by regraveling (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 surfaced road, a rehabilitation option is shown with the initial rehabilitation expense in gray. In this case the rehabilitation reduces the annual routine maintenance costs, shown by the solid bold line. The research goal is to determine at what point it is cost effective to upgrade the road so the initial rehabilitation cost, shown in gray, is less than the savings, shown in the hatched area, which then justifies an upgrade in the road surface. It is understood that the time value of money will be considered in this analysis. A review of current maintenance costs will provide a method to identify the threshold where a change in the surface would be beneficial, as in Figure 1.

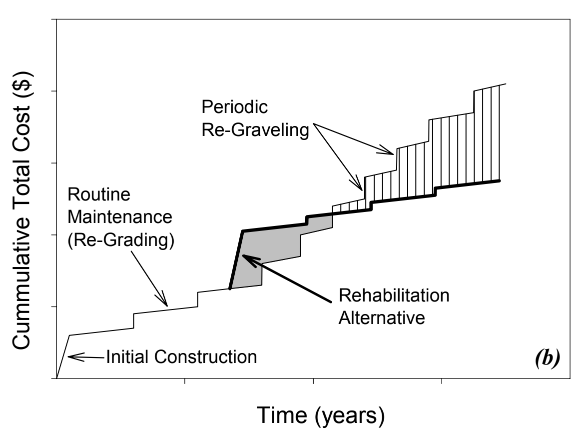

FIGURE 1. Cumulative Maintenance Cost vs. Time for a Specific Road

Cost comparisons will include the following types of roads found in Minnesota: hot mix asphalt (HMA), lightly surfaced roads, portland cement concrete (PCC), stabilizers/dust control products, and natural surfacing aggregate. Research team members' experiences with national/international practices in maintaining and upgrading low-volume roads will be recommended, if applicable. The authors intend to develop a process that will give counties, cities, and townships information to make informed decisions on the type of upgrade and time it may be economically advantageous to upgrade an aggregate road. Included will be methods used to upgrade a road with information on when each treatment would be appropriate.

DATA COLLECTION

The initial data review phase was done by a visit to Waseca and Olmsted Counties. During the initial visit, Waseca County provided an annual report that included a detailed summary their of maintenance costs by route.

The Minnesota Department of Transportation (MnDOT) State Aid Office had paper reports from 1997 to 2001 for some of the Minnesota counties. Of those reports, 40 percent provided information similar to the information found in Waseca County. Some reports had even more detail. The maintenance costs in the annual reports are grouped by funding source:

- County State Aid Highways (CSAH)
- County Roads (funded entirely by county funds)
- Municipal Roads

This study used CSAH and County Road information because most aggregate roads in the county system would fit one of these categories. For each road the maintenance costs were split into five main categories (see Table 1).

TABLE 1. Categories of Maintenance Activities

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

* Costs related to routine maintenance of road surface.
** Costs related to periodic maintenance of road surface.
*** Cost can be for routine or periodic maintenance of the road surface.

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

The other source of data was a set of county traffic maps that are used to determine the individual road cost (cost/mile/vehicle/day). The maps are prepared and provided to the counties once every four years by the state of Minnesota. The average daily traffic (ADT) on the maps is based on segments that have uniform traffic volumes. This does not necessarily coincide with changes in pavement type, thus making analysis difficult.

DATA REVIEW AND FINDINGS

Waseca County Data Analysis

The initial review of Waseca County data provided us with a snapshot of the kind of information that could be expected to be used in this study. The initial analysis was performed based on specific roads that did not change surface type within the reviewed time. The roads selected for review are shown in Table 2, and their cumulative maintenance costs are shown in Figure 2.

As seen in Figure 2, the conventional wisdom is that the maintenance cost of gravel roads increases with traffic was correct in this case. County Road 26, a high-volume gravel road, has the greatest total maintenance cost compared to the other roads over the same time.

Results of Initial Data Analysis of Other Counties

The initial review of four other counties provided an average total maintenance cost/mile as shown in Table 3 and Figures 3 and 4. The rest of this paper reviews the results of the analysis of the four counties. The final report for this project will include a more extensive review of more counties.

A review of Figures 3 and 4 shows the maintenance costs/mile for County D are much lower than the three other counties. Based on the data available at this time in the research, there is no explanation why the maintenance costs/mile are much less than the other counties. There possibly may have been recording errors when the cost reports were done. The cause of the low maintenance cost will be investigated in the next phase of the research when the counties are interviewed.

TABLE 2. Waseca County Roads Reviewed

Road	Length of Road	Surface	ADT	Classification
County Road 16	2.6 miles	Bituminous	225	Low-volume bituminous
County Road 7	4.1 miles	Bituminous	1200	High-volume bituminous
County Road 71	2.0 miles	Gravel	60	Low-volume gravel
County Road 26	5.6 miles	Gravel	130	High-volume gravel
County Road 27	2.4 miles	Concrete	800	Low-volume concrete

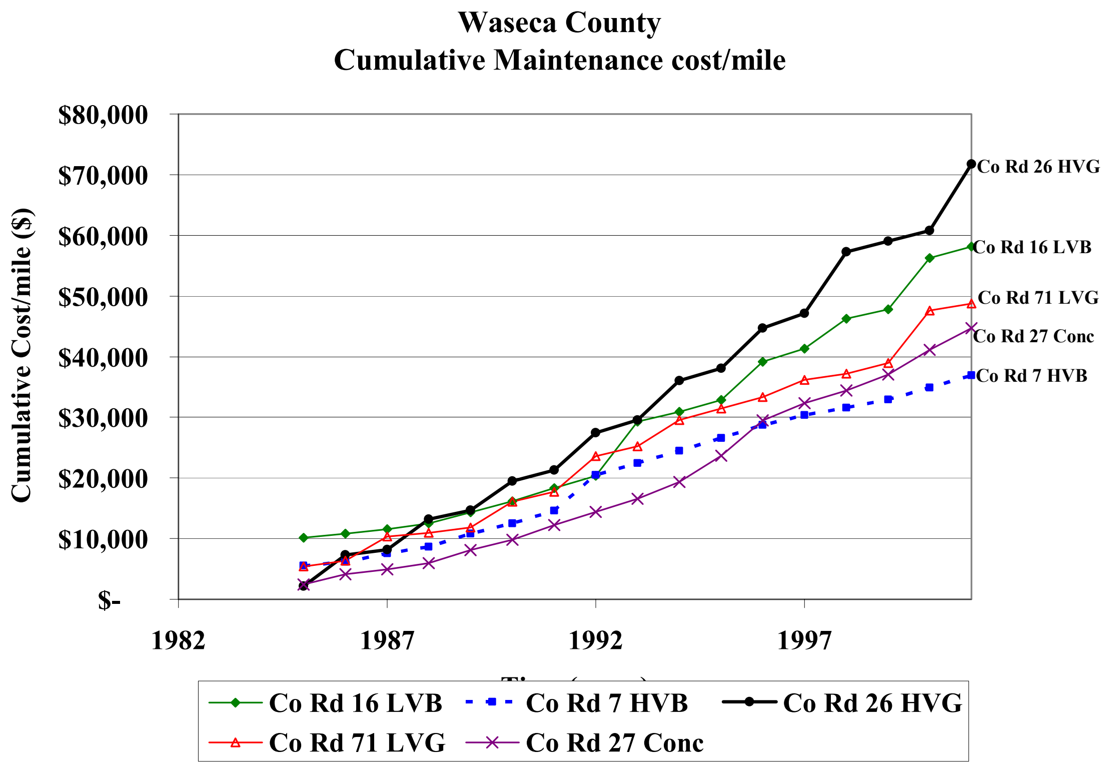

FIGURE 2. Waseca County Cumulative Total Costs/Mile vs. Years, Based on ADT

TABLE 3. Maintenance Cost/Mile by Road Type in the Reviewed Counties

County	Road Type	Miles	Total Maintenance Cost/Mile	Total Cost/Mile of Activities Influenced by Surface Type
A	Gravel	313	$3,250	$1,863
	Bituminous	189	$2,437	$638
B	Gravel	228	$2,526	$1,456
	Bituminous	442	$2,853	$1,320
C	Gravel	297	$3,413	$2,004
	Bituminous	426	$3,699	$2,105
D	Gravel	64	$395	$273
	Bituminous	198	$540	$210

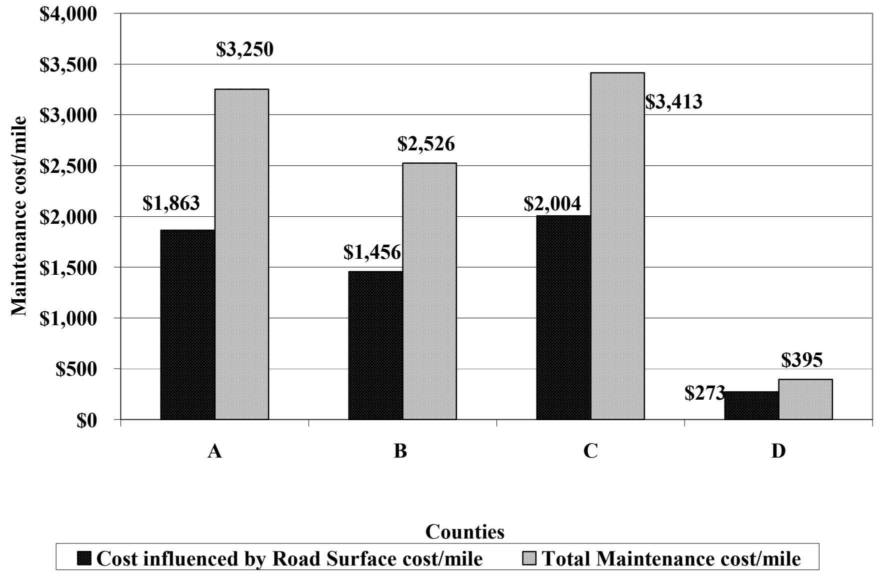

FIGURE 3. Average Maintenance Cost/Mile for Gravel Roads in Reviewed Counties

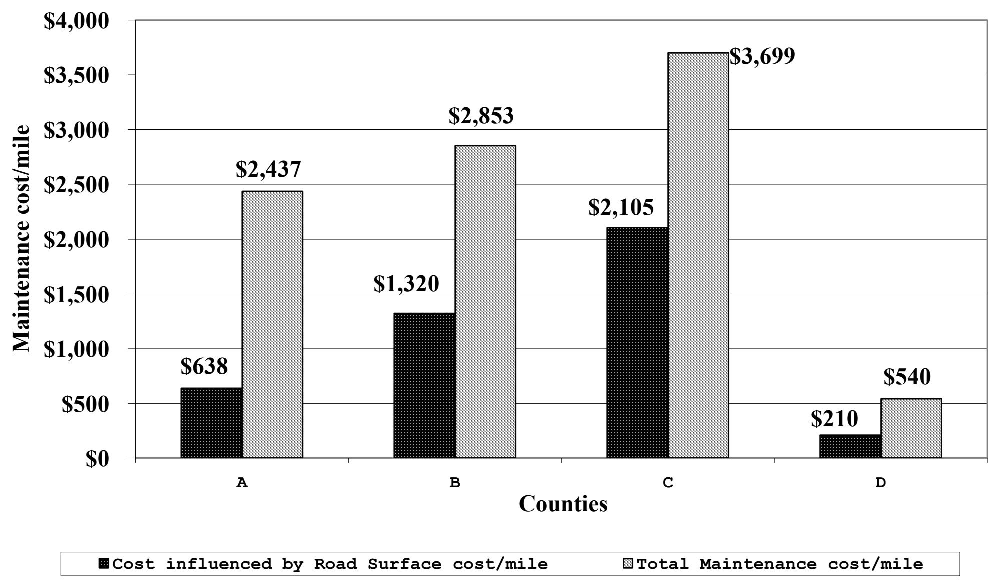

FIGURE 4. Average Maintenance Cost/Mile for Bituminous Roads in Reviewed Counties

Figure 5 shows the total maintenance cost/mile for gravel roads ranges from $1,380 to $5,452 per mile and from $1,785 to $6,055 per mile for bituminous roads, depending on the year. This cost variation could be caused by other maintenance activities not directly influenced by the road surface, such as brush and weed control; this variation is being investigated further. A review of the maintenance activities that influence the annual cost the most was performed and is shown in Figures 6 and 7.

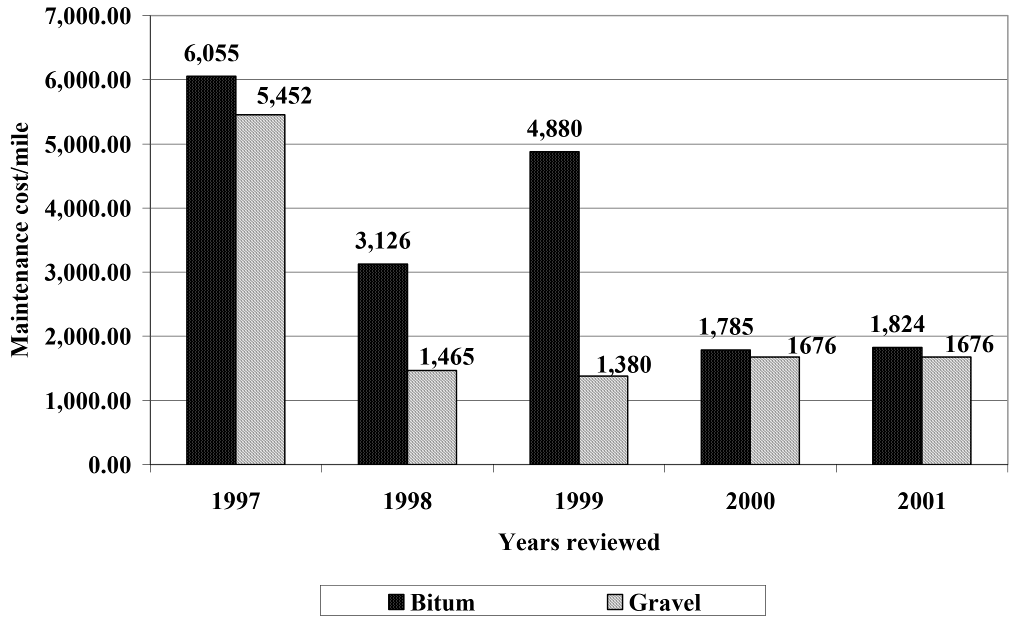

FIGURE 5. Total Average Maintenance Cost/Mile for Years from 1997 to 2001

Figure 6 shows, for gravel roads, resurfacing is the greatest portion of the total maintenance cost/mile at 43 percent, followed by smoothing surface at 17 percent and snow and ice removal at 11 percent. A combination of several other maintenance activities accounts for 24 percent of the total maintenance cost/mile.

Figure 7 shows there are five maintenance categories instead of four that represent more than 10 percent of the total maintenance cost/mile. The most influential costs/mile are snow and ice removal at 21 percent, minor surface repair at 17 percent, resurfacing at 15 percent, bituminous treatment at 12 percent, and other maintenance activities at 33 percent.

Notice the costs not related to the type of pavement surface (labeled other maintenance activities) exceed 20 percent of the total maintenance cost/mile. Another observation made from these two pie charts is that snow and ice removal is a greater cost/mile for hard surface roads than for gravel roads. This higher cost might be explained by the greater amount of time spent clearing snow and ice from bituminous roads compared to gravel roads and the use of sand and salt on bituminous roads compared to not using those materials on gravel roads. This finding brings up the point that when a road is upgraded to a hard surfaced road the cost of snow and ice removal increases and should be considered in the decision making process.

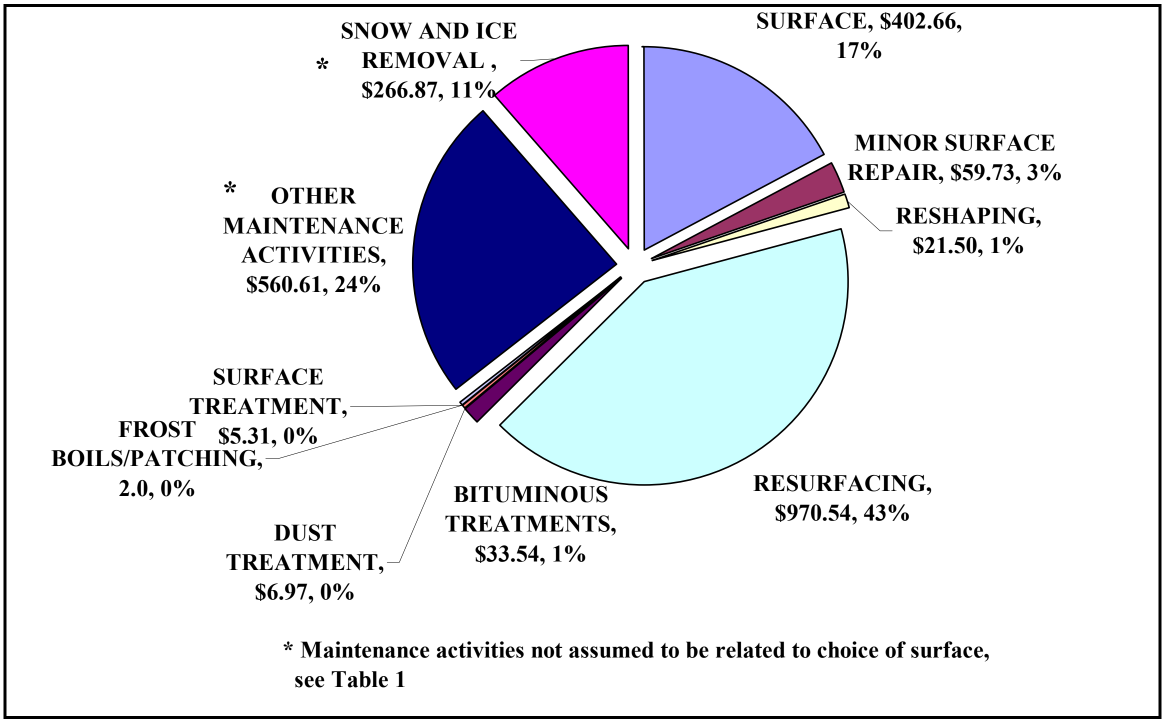

FIGURE 6. Average Cost/Mile for Gravel Road Maintenance Activities

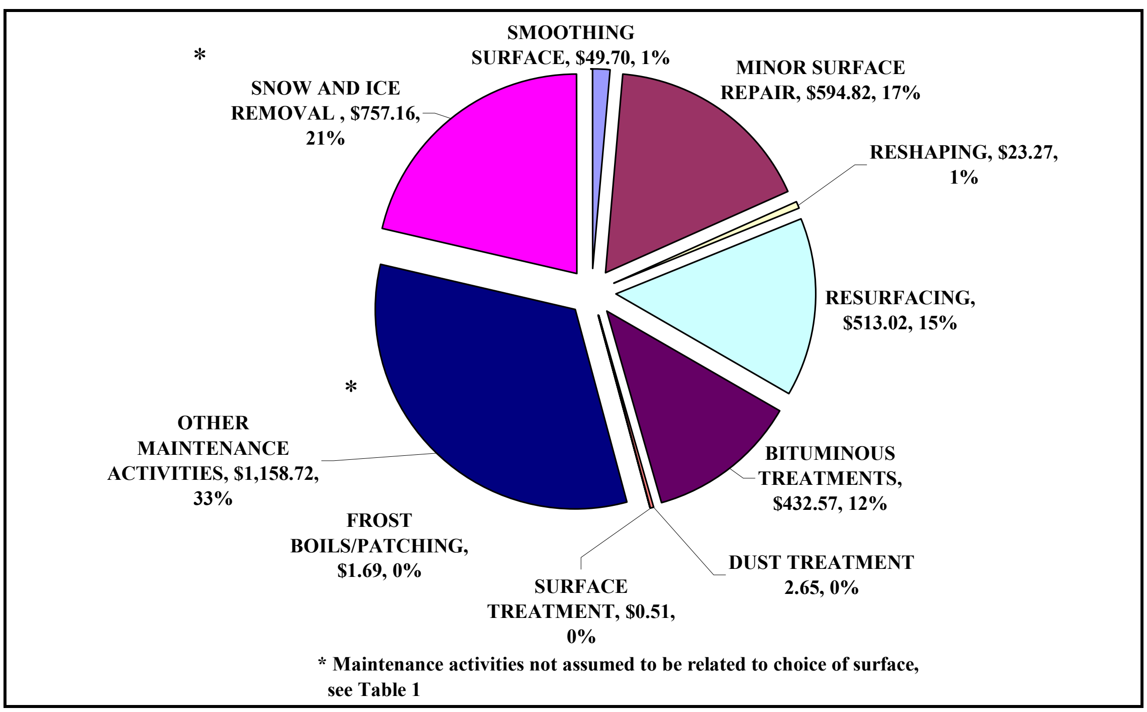

FIGURE 7. Average Cost/Mile for Bituminous Road Maintenance Activities

Results with Traffic

With the use of traffic maps, the variable of the ADT on each segment of road was added to the data set. The ADTs were grouped in the categories show in Table 4 to identify the relationship between traffic level and maintenance costs.

TABLE 4. Average Daily Traffic Range Groups

0–49	125–149	301–999
50–74	150–199	1,000 and up
75–99	200–249	
100–124	250–300	

From Figure 8 it is evident the maintenance cost/mile of gravel roads is greater than the maintenance cost/mile of bituminous roads when the ADT is above 100. Also, the maintenance cost/mile of gravel roads increases considerably when the ADT is greater than 200. The bar chart in Figure 8 provides valuable information on when to upgrade a gravel road to a hard surfaced road based on traffic range and total maintenance cost/mile.

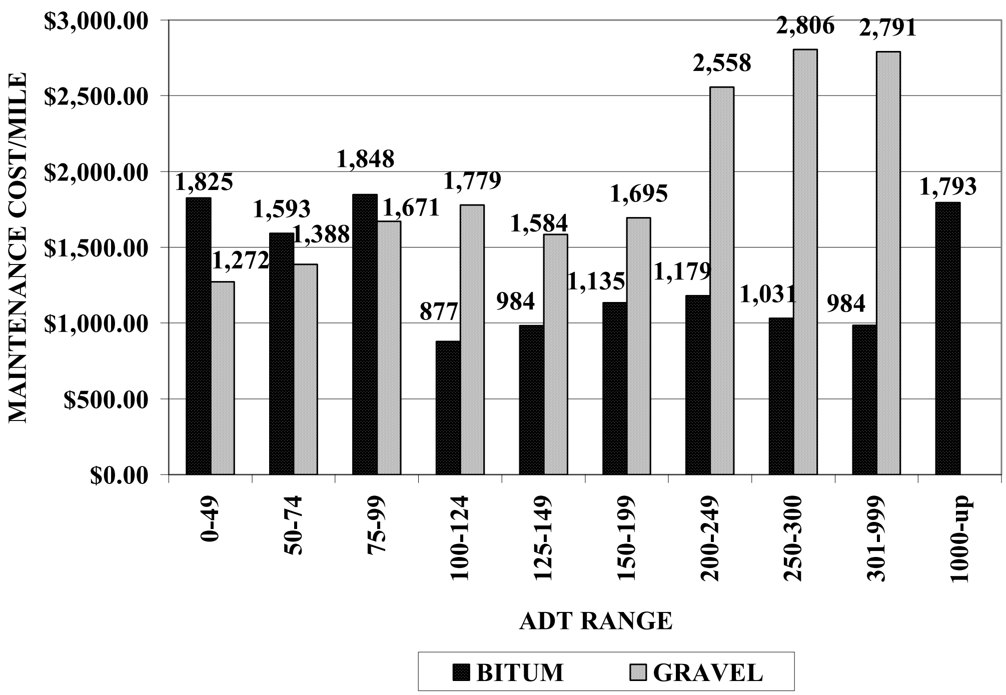

FIGURE 8. Average Maintenance Cost/Mile vs. ADT Range (surface type relevant costs only)

CONCLUSIONS

The study at this point has provided information to give rough averages and ranges for the total maintenance cost/mile of low-volume roads. During the research it was found that the data collected might not be comparable unless it is known how the counties classify their costs. The main questions to be asked now are follows:

- Do counties have a standard practice in classifying cost?
- Can the results be generalized and a database created?

In order to obtain answers to these questions, the researchers will conduct interviews with county engineers and continue the investigation about whether or not to upgrade a gravel road. The final result of the study will be a decision aid for those making decisions about upgrading gravel roads.

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The research project advisory committee includes the following members:

David Fricke, Minnesota Association of Townships
Dave Christy, Itasca County Engineer
Mic Dahlberg, Chisago County Engineer
Keith Kile, Birch Lake Township Supervisor
Joel Ulring, St. Louis County Engineer
Richard West, Otter Tail County Engineer
Roger Olson, MnDOT Road Research
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Duane Smith, Center for Transportation Research and Education, Iowa State University
Glenn Engstrom, MnDOT Road Research

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2. Skorseth, K., and A.A. Selim. *Gravel Roads: Maintenance and Design Manual.* South Dakota Local Transportation Assistance Program, Brookings, South Dakota; Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.