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A REVIEW OF DENALI HIGHWAY LIFECYCLE COSTS

PREPARED FOR

Alaska Center for the Environment

PREPARED BY

Eric Larson

Institute of Social and Economic Research
University of Alaska Anchorage
3211 Providence Drive
Anchorage, AK 99508
http://www.iser.uaa.alaska.edu

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I. Introduction

The Alaska Department of Transportation and Public Facilities (DOT/PF) has considered several alternatives for maintaining the Denali Highway. The Alaska Center for the Environment asked the Institute of Social and Economic Research (ISER) to review published estimates of the cost of maintaining the road to see if they are consistent with standard economic methodology.

To conduct this review we relied primarily on two DOT/PF memorandums and a spreadsheet. DOT/PF confirmed that these documents are the most recent estimates of maintenance costs for the Denali Highway.[1] We supplemented this information with several relevant publications listed at the end of this report.

The remainder of this report summarizes our review of maintenance and construction costs of the Denali Highway. We describe the data used in the study, present the primary findings, describe the sensitivity of results to changes in assumptions, suggest future areas of research, and make final recommendations.

II. Maintenance and Construction Cost Data

Maintenance Cost estimates for this review come from printouts of special DOT/PF spreadsheets.[2] ISER scanned the printed spreadsheet into electronic format and re-derived the formulas. Since the original spreadsheet was not available in electronic form, we cannot confirm that the formulas exactly match the originals.

These DOT/PF spreadsheets present an engineering cost analysis of maintaining the road for several surfacing alternatives. This engineering cost analysis calculates costs by totaling the costs of all materials, equipment, and labor required to perform particular tasks. The spreadsheet analysis then projects the number of times these tasks are performed each year and how many times they must be repeated during the life of the road. Using this methodology, the spreadsheet calculates maintenance costs for three scenarios: Scenario A: Unsalted Gravel, Scenario B: Salted Gravel, and Scenario C: High Float Surface Treatment.

According to the calculations in the spreadsheets, the unsalted gravel scenario includes adding aggregate and grading the road about twice a year. The salted gravel scenario includes adding aggregate and grading the road about once a year and adding salt about once a year. The high float surface treatment scenario provides for purchase of the materials for the high float surface and applying and brooming the surface once during the life of the roadway. After the surface is applied, the high float surface scenario calls for paint stripping about every four years as well as "normal maintenance" and special grading of the shoulders about every three years.

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[1] Email correspondence with Dave McCaleb, Jan 22, 2001 and Janet Brown, Feb 5, 2001

[2] See spreadsheet (McHattie 1996) and memorandums (McCaleb March 1996 and April 1996) listed in the references at the end of this report.

Notably, while the spreadsheets do list the detailed labor, materials, and equipment required for each maintenance option, the spreadsheets do not provide further documentation of the source of these cost estimates or how they were derived. Based on the information in the spreadsheet and the memorandums, it is not clear whether the estimates for particular cost items (like grading, paint stripping, or laying surfacing) were based on observations of actual incurred costs, comparisons to the costs of maintenance of similar roadways, or other sources. Although the *source* of data used in the analysis is unclear, the engineering cost analysis methodology applied to the data is thorough and complete.

Construction Costs estimates for this review come from the *2001-2003 Statewide Transportation Improvement Program*. Based on the description in the STIP, these construction costs cover grading, drainage, surfacing improvements, and enhancements for several sections of the road.

III. Major Findings

Using the information in the spreadsheet and the STIP, we have estimated the lifecycle costs of the Denali Highway under different scenarios. Lifecycle costs include both the costs of constructing and maintaining the road. Lifecycle costs are equal to the total present discounted value of all construction and maintenance costs incurred each year over the entire lifetime of the road. The total present discounted value can be interpreted as the amount of money you would need in the bank today to cover the costs of the road for its ten-year life.

Table 1 lists the total present discounted value of construction and maintenance costs over a ten-year lifecycle. The rows in the table show the separate costs for construction, maintenance, and construction and maintenance combined for alternative surfacing scenarios. The columns in table show the distribution of costs borne by the Alaska state government, the federal government, and both governments combined.

One way to compare the surfacing alternatives is to look at the right-most column that shows the present discounted value of costs borne by the state and federal governments combined. This comparison is meaningful from the perspective of the U.S. taxpayers who have the financial interest to select the least costly alternative to both the federal and state government combined. From this perspective, the least costly alternative is the salted gravel surface. The total present discounted lifecycle costs of the salted gravel surface is $4 million -- compared to $5 million for the non-salted gravel surface and over $50 million for the high float surface.

The high float surface is substantially more expensive because it includes construction costs of preparing the bed and laying the high float surface. Many of these costs would be likely borne by the federal government. Another meaningful comparison is to look at the costs borne *only* by the state government of Alaska (shown in the left column of Table 1). From this perspective, the high float surface is the least costly alternative. The present discounted value of lifecycle costs borne by the state would be about $2 million for the high float surface, about $4 million for the salted gravel surface, and $5 million for the unsalted gravel surface.

IV. Effects of Changing Assumptions

A. Who pays for application of the high float surface?

Notably, this result is *not* sensitive to whether or not the federal government pays for the initial application of the high float surface. If some (or all) of the initial high float surfacing costs were incorporated into the initial construction and the initial high float application costs were paid mostly with federal dollars, then high float looks even more attractive. Under these circumstances, the present discounted value of costs borne by the state would decline from $2 million to $237,000 for the high float surface while the costs of the gravel alternatives would remain at $4 million or more.

B. Duration of the high float surface

These calculations implicitly assume that the high float surface would last ten years or more. We investigated how the present discounted value of state costs would be affected if the high float surface needed to be reapplied more frequently. Not surprisingly, if the high float surface is applied more than once in the ten-year lifetime, the present discounted value of lifecycle costs of high float treatment increase. The turning point comes if the high float surface is reapplied every three years (and assuming these costs are borne by the state). At this critical point, the present discounted value of the cost to the state increases to about $5.4 million for the high float surface. It becomes more expensive than both the salted gravel and non-salted gravel alternatives. However, if the high float surface lasts longer than three years or if the reapplication costs are borne by the federal government, then the high float surface remains less expensive than the gravel alternatives.

C. Should construction costs be included for the gravel alternatives?

For the comparisons we have made so far, we have assumed that the gravel alternatives do not require any initial construction and would not require any reconstruction during their ten-year life. The STIP does not explicitly specify whether the initial construction is required for either the salted or unsalted gravel alternative.[3]

It is beyond the scope of this essay and our expertise to evaluate whether or not the gravel road would require initial construction costs to prepare the bed or whether additional construction costs would be required to reconstruct the bed during its ten-year life. We have included estimate of the gravel options both with and without initial construction of the roadway for comparison. If the bed needs to be rebuilt during the ten year life, then the cost of a gravel road is much more expensive. However, regardless of whether construction costs are included for the gravel alternatives, the relative costs of

[3] The April 3, 1996 DOT/PF memo states that there is no initial "treatment" required for the gravel road: "We assumed the maintenance activities for all three options are initiated on existing roads which have already received the described surface treatment (no treatment at all in the case of the normal gravel surfacing)." McCaleb Mar 1996 and April 1996.

alternatives from the perspective of the State of Alaska do not change. This is solely because the construction costs would be largely born by the federal government.

D. Are High Float Surface application costs included in construction costs?

For the calculations in Table 1, we have assumed that the costs of laying the high float surface are included in the construction costs reported in the STIP. The DOT/PF memos do clearly state that the application of the high float surface would be included in a construction project and the 2001 STIP does include *"resurfacing"* as part of the construction project for the Denali Highway.[4] However, there is some ambiguous information from other published sources about whether the STIP construction costs actually include the cost of laying a high float surface.[5] If the initial cost of laying the high float surface are *not* actually included in the STIP construction costs, then the lifecycle costs of the high float surface would be slightly more than reported in Table 1. The lifecycle costs of the high float surface would be about $50.3 million. Even after this revision, the salted gravel alternative would still be the least costly alternative from the perspective o the U.S. taxpayer and the high float surface alternative would remain the least costly alternative from the perspective of the State of Alaska.

E. A Longer Lifecycle

The original DOT/PF memos report costs over a ten-year lifecycle. We investigated the sensitivity of the results to extending the life of the road beyond ten years. We included the costs of completely rebuilding the road after ten years and reapplying the high float surface again at the same time. After totaling the present discounted costs over twenty years, the results reported above remain the same. The total cost to the U.S. Taxpayer for the gravel surface scenarios is less than the high float alternative. The high float surface option is the least expensive for the State of Alaska.

F. Lower Discount Rate

The discount rate used for this analysis and the original spreadsheets is seven percent. This is an unusually high discount rate. A three percent discount rate is more typically used since this is a more accurate measure of the real rate of return in the national economy. We investigated the effect on results using a lower discount rate. The total present discounted value of all alternatives is slightly higher when using a lower discount rate, but the ranking of relative costs among alternatives does not change.

G. Effects of Inflation

Technically, the maintenance cost estimates for 1996 should be adjusted to account for the effects of inflation since 1996. However, as long as the costs all alternatives inflate at about the same rate, there will be no change in the relative costs of the different

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[4] "The [high float] applications would be done as part of a construction project…." McCaleb April 1996 memorandum. Based on this statement, we have included the initial construction costs in the calculation of lifecycle costs for high float surface treatment alternative.

[5] The April 3, 1996 memo includes the high float surface as a maintenance cost. The March 1996 memo does not.

scenarios. Since each alternative involves comparable purchase of labor, equipment, and materials, it is unlikely that adjusting for inflation from 1996 to 2001 would affect the relative costs of scenarios.

H. Variation in Maintenance Costs

As mentioned before, the methods used in the DOT/PF spreadsheet and memorandums rely on detailed estimates of the cost of materials, equipment, and labor required to maintain the road. The calculations use a single average cost per mile to represent the cost per mile for the entire roadway. However, due to substantial variations in road conditions, the actual cost of maintaining the road may vary substantially from one section to the next.

Notably, a study of the Alaska Highway in The Yukon Territory revealed the difficulty in finding a single average maintenance cost per mile.[6] . The report analyzed different sections of the Alaska Highway treated with a high float (BLT) surface and evaluated the maintenance costs per mile. The report found substantial variations in maintenance costs across sections, depending on the age and condition of the road. They found maintenance costs per mile as much as two to three times higher from one section to the next[7]

Not only are high float maintenance costs variable, the costs of gravel road maintenance also vary across sections. The Alaska DOT/PF report titled *Multi-year Maintenance Costs of Selected Alaskan Highways* confirms substantial variation in maintenance cost per mile of the gravel surface on the Denali Highway during the late 1970's.[8] As shown in Figure 1 at the end of this report, maintenance costs per mile were as much as two to three times higher along particular gravel sections of the highway (notably MP 25 to 30 and mp 110-130) compared to the average for the entire roadway. Notably, maintenance costs also varied considerably over mileposts 0 to 21 as well, which was paved during the entire period of the analysis. There may be similar variations in maintenance costs per mile along both gravel and paved sections of the Denali Highway today.[9]

These variations in maintenance costs of gravel, paved, and high float surfaces raise a few questions about the estimates of maintenance costs per mile for the Denali Highway. First, the variation across sections suggests that no single average maintenance cost estimate is appropriate for the entire length. A more accurate lifecycle cost analysis would estimate separate maintenance costs for different sections of the roadway. By comparing different sections, the analysis could compare the costs of gravel and high float surfaces more precisely. The important comparison is whether the gravel maintenance costs vary in the same way as high float costs across different sections. If both high float costs and

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[6] MacLeod (1989).
[7] MacLeod (1989), page 36, Figure 45.
[8] Reckard, 1983.
[9] Reported costs for maintaining different sections of the Denali Parks Road and the paved section of the Denali Highway also suggest (but do not confirm) variation in maintenance costs depending on the condition of the road and the type of surface (see Table 3 at the end of this report). Without more information about the condition of these different roads, their maintenance costs cannot be meaningfully compared.

gravel costs were proportionally higher or lower along different sections, then the relative costs of these alternatives would not change.

The substantial variation in maintenance costs along different sections also raises the concern that the estimates of high float surface maintenance costs are not as precise as the spreadsheets and memorandums suggest. Because of the observed variability of maintenance costs on other roads, the maintenance costs for the Denali Highway may actually be more uncertain than the costs presented. A more meaningful presentation of the costs of the high float surface would allow for the possibility of both higher (or lower) maintenance costs.

Even if this wider range of possible costs were included, the high float option may still be the preferred option. This is because the cost of the high float surface application would need to be nearly three times more expensive than anticipated to make it more costly than either gravel option. The regular maintenance of the high float option would need to be nearly twelve times more expensive to make it more costly than the gravel options from the perspective of the state.

The variation in maintenance costs across sections raises a final concern. An engineering cost model such as the one used in the DOT/PF spreadsheet analysis cannot always capture the variations in actual costs incurred. A more accurate portrayal of costs would be based on observations of actual, incurred costs for different sections of the road. The cost of actually acquiring, tabulating, and analyzing this primary data is certainly more expensive and time consuming than an engineering cost model approach, but would provide more precise maintenance cost estimates. More precise cost estimates would not necessarily change the relative ranking of the surfacing alternatives, but would make the analysis more reliable.

V. Full Cost Accounting Considerations

In this *lifecycle* cost analysis, we have included only the maintenance and construction costs of the roadway. In a *full cost accounting* of the roadway, the full range of likely costs and benefits are included. This broader accounting would include user costs, generated traffic cost, scenic value, facility costs, and environmental costs. Measuring and documenting all of these costs is well beyond the scope of this review. We identify and describe these costs and recommend they be explored in more detail in future research.

A. Travel Costs

One of the primary arguments for the high float surface treatment is that it would benefit users of the road by reducing their travel costs. [10] A high float emulsion surface would likely allow drivers to drive at higher travel and reduced travel times. The smoother surface with fewer potholes and less gravel may result in fewer breakdowns, vehicle damage, and lower repair costs. The smoother high float surface may provide a more comfortable ride with less dust and bumps. A more comfortable ride, as well as savings in

[10] McCaleb, April 1996.

travel time, and repair costs are all reductions in travel costs and would likely benefit those who use the road. For this review, we do not have the data needed to quantify these user benefits. A *full cost* accounting would document and quantify these benefits to the road users.

B. Induced / Generated Traffic

One of the effects of improving the level of service with a high float emulsion surface would be increased traffic. With lower travel costs and a smoother ride, more drivers and additional vehicles would have the incentive to use the roadway more. In particular, larger recreational vehicles, tourist busses, and rental cars would be able to use the roadway if the high float surface were applied.

This induced (or generated) traffic is not included in the lifecycle cost estimates of the roadway. If the generated traffic were significant, it could increase wear on the roadway and increase maintenance costs. In addition, generated traffic brings additional users who require additional facilities, such as turnoffs, trash disposal, restrooms, and camping areas. The costs of these additional facilities are not included in the lifecycle costs but would be included in a *full cost* accounting of the roadway.

C. Scenic Value

Another ramification of generated traffic is changes in the scenic value of the road. Some users of the current gravel road value it for its scenic, remote, and "less-developed" characteristics. Their perceived value of the roadway may *decrease* if the high float surface treatment attracted larger recreational vehicles, tourist busses, and other traffic traveling at higher speeds.[11] As a result, some users of the road may value the travel experience *less* if the road were treated with the high float emulsion. A *full cost* accounting of the roadway would include quantitative estimates of these losses to some users of the roadway due to the change in its scenic, remote, and "less-developed" characteristics.

D. Redistribution Effects

As described above, some users of the roadway may benefit directly from reduced travel costs while othe users may lose due to changes in the scenic value of the roadway. This is one example of how the roadway could redistribute benefits from one group to another. The other likely redistribution of costs and benefits would be revenues received from tour bus companies. The improved surface on the Denali Highway may provide an attractive alternative route for the tour companies. If tour companies redirect their bus routes to take advantage of the high float surface, they may divert busses from other routes.[12] A *full cost* accounting would include an assessment of which highway routes in

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[11] In 1998, 85% of the 500 people answering a DOT/PF survey did not want the Denali Highway paved. See Nickles (1999), Campbell (1998), Fairbanks Daily News Miner (April 26, 1998), and Anchorage Daily News, (April 28, 1998).

[12] See Allington (1994) for a discussion of the effects on tourism in Fairbanks. Allington argues that resurfacing the Denali Highway would not have significant effects on tourist traffic through Fairbanks.

the state would likely gain and which would lose from increased bus traffic along the Denali Highway generated by an improved high float surface.

E. Environmental costs

A full cost accounting of the roadway would include estimates of the economic costs of environmental impacts of the roadway. It is beyond the scope of this report to assess the environmental impacts of alternative surface treatments. Once they are identified, it may be possible to place an economic dollar value on some of the environmental impacts.[13]

VI. Conclusions and Recommendations

- From the perspective of the U.S. Taxpayer, the total present discounted value of the lifecycle costs of the salted gravel surface is the least costly alternative.

- From the perspective of the State of Alaska, the high float surface is the least costly alternative.

- The high float surface is less expensive as long as it lasts longer than three years. If the high float surface needs to be reapplied more frequently (and those costs are borne by the state) then the high float scenario would be more expensive than either gravel surface alternative.

- These conclusions are based on the assumption that the roadway does not need to be rebuilt during its ten-year life. If the roadway needs to be rebuilt or realigned during its ten-year life, it would substantially change the cost comparisons.

- A broader full cost accounting of the roadway would include the costs to different users, generated traffic costs, changes in scenic value, redistribution of costs, and environmental costs.

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[13] The most recent and comprehensive description of these methods applied to Alaska is available in Colt (2000).

Table 1: Present Discounted Value of the Ten-Year Lifecycle Costs

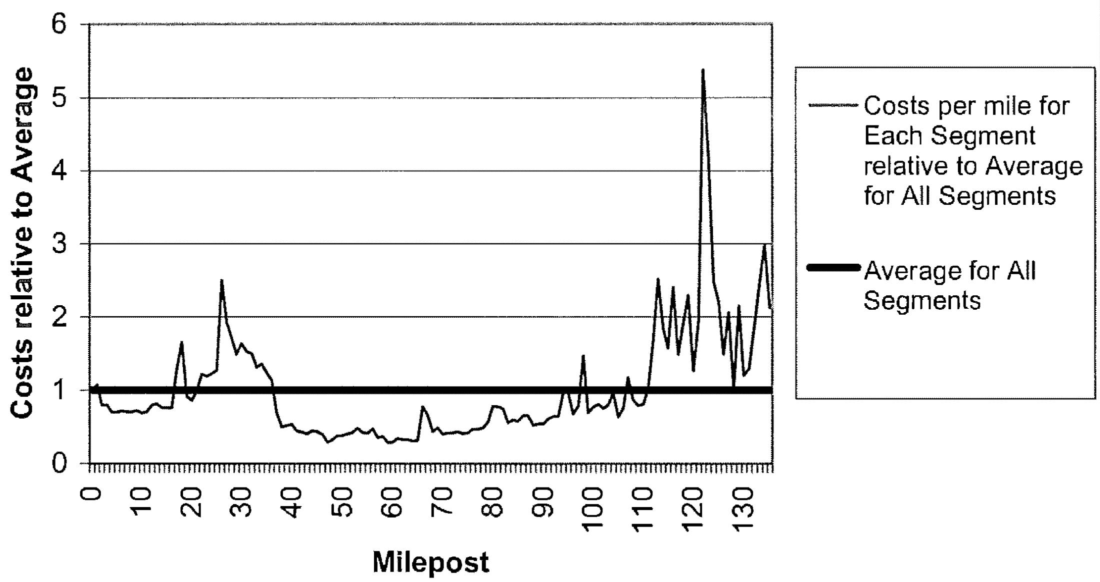
of Constructing and Maintaining the Denali Highway from MP 21 to 135
in thousands of current dollars for alternative maintenance scenarios

Cost Item and Surfacing Alternative	Costs borne by State	Costs borne by Federal Government	Costs borne by Federal and State Government Combined
Construction Costs			
	$182	$48,246	$48,428
Maintenance Costs			
Unsalted Gravel	$4,952	$0	$4,952
Salted Gravel	$3,943	$0	$3,943
High Float			
Cost of Laying Surface Only			
Every ten years	Unknown	Unknown	$1,638
Every three years	Unknown	Unknown	$4,957
Regular Annual Maintenance of High Float	$237	$0	$237
Construction and Maintenance Costs under Alternative Scenarios			
Scenario A: Unsalted Gravel			
Without construction	$4,952	$0	$4,952
With construction	$5,134	$48,246	$53,380
Scenario B: Salted Gravel			
Without construction	$3,943	$0	$3,943
With construction	$4,125	$48,246	$52,371
Scenario C: High Float Surface with construction			
Lay high float surface every ten years			
State bears cost of laying surface	$2,057	$48,246	$50,303
Federal government bears cost of laying surface	$237	$49,884	$50,303
Lay high float surface every three years.			
State bears cost of laying surface	$5,376	$48,246	$53,622
Federal government bears cost of laying surface	$237	$53,203	$53,622

Sources: Alaska Department of Transportation and Public Facilities, 2001-2003 Statewide Transportation Improvement Program, October 2000, and Alaska Department of Transportation and Public Facilities Memorandums dated March 14, 1996 and April 3, 1996 from Dave McCaleb to Rodney Platzke.

Note: the 2001 STIP (dated October 2000) describes construction *and surface treatment* for *114* miles of roadway from MP 21 to MP 135. The March 14, 1996 and April 3, 1996 memos describe surface treatment for *112* miles of roadway, but the memos do not specify the mileposts. To ensure consistency, the calculations in this table present the costs of constructing and maintaining 114 miles of roadway.

Figure 1: Average Maintenance Costs per Mile Along the Denali Highway from 1974 to 1982: Costs for each Segment Relative to Average for All Segments



Source: Reckard, Matthew, *Multiyear Maintenance Costs of Selected Alaskan Highways*, Alaska Department of Transportation and Public Facilities, April 1983, p 28-29.

Note: The highway was paved from MP 0 to 21 in 1972. MP 131 to 134 was paved during the 1980's. The remainder of the highway had a gravel surface during the period of analysis presented in this figure.

Table 3: Present Discounted Value of Lifecycle Maintenance Costs Per Mile of Different Highway Sections in thousands of dollars		
Highway Segment	**Scenario**	**Total Costs per Mile over Ten Years**
Denali Highway 21 to 135		
	Scenario A: Unsalted Gravel	$43.4
	Scenario B: Salted Gravel	$34.6
	Scenario C: High Float	
	Cost of Laying Surface Only	
	Every Ten years	$14.4
	Every Three Years	$43.5
	Regular Maintenance	$2.1
Denali Highway 0 to 21		
	Paved	$20.3
Denali Park Road		
	Gravel	$48.7
	Paved	$10.5
Sources: Denali Highway costs from McHattie, R.I., "Denali Highway Maintenance Cost Study," printed copy of spreadsheet, March 14, 1996. Denali Park Highway costs from United States Department of the Interior, "Denali National Park North Access Route Feasibility Study," report to US Congress, April 1997. Denali Highway paved section maintenance costs from Swarthout, Ralph, Letter dated Sept 17, 1999 to Ruth McHenry regarding cost of repair work on the Denali Highway from mile 0 to 21.		

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