TRANSPORTATION RESEARCH SYNTHESIS

Minnesota Department of Transportation
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Decision Tree for Unpaving Roads

Introduction

The Minnesota Department of Transportation and the Local Road Research Board initiated a preliminary investigation into the issues surrounding the maintenance, preservation and possible conversion of low-volume paved roads to gravel. Rising costs of pavement materials and stagnant or declining funds for road construction and maintenance prompted the agencies to begin looking into issues surrounding the decision to unpave low-volume roads. To assist in the process and to provide Mn/DOT and the LRRB with the best, most up-to-date information, CTC & Associates was asked to review the issues associated with the decision to convert paved low-volume roads to gravel roads. This research synthesis highlights relevant research and information related to road surfacing decisions, pavement preservation techniques, cost analysis and current road agency experiences.

Summary

This report is organized into three sections: **Local Road Agency Experiences**, **Road Surfacing Decisions and Criteria**, and **Pavement Preservation Techniques and Strategies**.

Local Road Agency Experiences
This section highlights interviews with the County Road Association of Michigan and with six county engineers and managers from Indiana, Michigan and North Dakota who have experience converting paved roads back to gravel. This section also includes a road plan from Lyon County, Minnesota, that addresses road surfacing choices and costs. The information provided by the County Road Association of Michigan gives an excellent overview of the scope of road challenges that Michigan faces. Interviews with county engineers and managers made it clear that the primary motivating factor for returning paved roads back to gravel is the lack of funding for construction and preventive maintenance. Each county road agency was asked three questions:

- What criteria are used to determine which roads are eligible for conversion?
- Have you done cost/benefit calculations comparing maintenance of paved roads versus gravel roads to determine what cost savings, if any, unpaving roads have or will provide?
- What type of techniques do you use to preserve pavement and avoid returning the road to gravel?

The decision-making process varied among agencies. Stutsman County, North Dakota, was the only agency with a formal documented road prioritization system. Sample prioritization sheets provided by Stutsman County can be found in Appendix A of this report. All agencies indicated that only the worst of the worst roads are being converted or considered for conversion from pavement to gravel. Faced with paved roads that are no longer safe and the increasing cost to simply maintain them in poor condition, agencies balance a series of factors to determine if returning the road or a section of the road to gravel makes sense. Those factors include:

- Cost to maintain or reconstruct the road as paved vs. the cost of graveling and maintenance
- Safety
- Average daily traffic
- Percentage of trucks
- Distance to other paved roads
- Number of homes on the road

Stutsman County, North Dakota, and Calhoun County, Michigan, provided documentation (Appendix B and Appendix C, respectively) to support recent cost calculations. Techniques used to preserve pavement included seal coating and patching, with several counties referencing the frequent and successful use of a DuraPatcher. All agencies indicated they currently use only traditional preventive maintenance techniques.

Road Surfacing Decisions and Criteria
In this section we reference six reports from the Kansas Local Technical Assistance Program, Mn/DOT/LRRB, Federal Highway Administration/Central Federal Lands Highway Division, South Dakota LTAP, Vermont LTAP and the *Transportation Research Record*. The most up-to-date study on the economics of road surfacing criteria is the 2005 study produced by Mn/DOT and the LRRB. This particular study—along with Minnesota's leadership in research on low-volume roads in general—was referenced by the Kansas LTAP and South Dakota's LTAP program manager, Ken Skorseth, as the best reference on the subject.

We were unable to identify any reliable and recent research focused on the conversion of paved roads back to gravel. All of the research to date focuses on the decision to upgrade from gravel to pavement. The exception is the *Transportation Research Record* paper regarding the experience of Finnish road agencies, published in 2003 and attached as Appendix D.

Pavement Preservation Techniques and Strategies
This section includes information provided by Ken Skorseth, program manager of SDSU/SDLTAP, and reports from FHWA and the Transportation Research Board.

Mr. Skorseth provided information regarding a potential low-cost road surfacing technique currently being used in one South Dakota county. The technique—using high-grade gravel stabilized with liquid magnesium chloride—falls between full bituminous asphalt reconstruction and traditional regraveling. Performance Evaluation of Various Rehabilitation and Preservation Treatments (see page 6 of this report), produced in January 2010, presents the results of an evaluation of 20 pavement preservation techniques used across the country.

Local Road Agencies Experience

Local road agencies are on the front lines dealing with this issue. Counties are responsible for maintenance and preservation of most low-volume roads and are often left to make decisions about preservation, reconstruction or deconstruction. Results of interviews with local road agency engineers in Indiana, Michigan, North Dakota and South Dakota are found below. Also included is information provided by the County Road Association of Michigan and a road improvement plan from Lyon County, Minnesota, that addresses pavement preservation and gravel conversion.

Interviews with Local Road Agency Engineers
Results of interviews with county engineers and managers from Indiana, Michigan and North Dakota are detailed below.

Indiana
Contact: Joe Copeland, County Engineer and Superintendent, Hancock County, (317) 477-1130, ext. 225
Hancock County has converted paved roads to gravel in the past few years. Mr. Copeland indicated the decision is made based on which roads are in the worst condition, which in most cases are old double seal roads. Every road is rated each year. The worst roads are evaluated and other factors, including how much traffic and how many homes are on the road, are taken into consideration. All of the roads converted to gravel have been rural roads generally with an ADT of less than 200.

Mr. Copeland believes that this process will be a cost savings in the long run. He indicated that the double seals he has been putting down have only been lasting five or six years with lots of patching in between. He estimates that over the next five years, the county will spend approximately $22,000 per mile for gravel road construction and maintenance. That figure is compared to spending $25,000 for a mile of double seal coat and then five years of patching costs.

Michigan

Calhoun County
Contact: Kevin Henning, Managing Director, Calhoun County Road Commission, (269) 781-9841, ext. 223
Calhoun County returned 2.5 miles of paved road to gravel in 2008-2009. The county anticipates returning 15 to 40 miles of road in 2010. Calhoun County uses PACER ratings to measure the condition of its roads. A PACER rating of 1 or 2 indicates a failed road that needs immediate attention. A map showing the county's worst roads can be found at http://www.calhouncrc.net/reference/Worst_Roads_Map.html.

In a December 2009 presentation, Mr. Henning outlined the challenges that the county faces in maintaining the road system. He included detailed estimates of the costs associated with seal coating, hot-mix asphalt, gravel and brine application. These figures are found on page 9 of the Calhoun Twp presentation, included as Appendix C of this report.

Page 2 of the presentation shows the county spent more than $2.5 million on patching in 2009. To do this, it cancelled all of the capital preventive maintenance for that year.

Benzie County
Contact: Nancy Roseman, Engineer Manager, (231) 325-3051, ext. 202
Deteriorating road conditions and lack of funding sources to rehabilitate those roads led Benzie County to convert several road segments to gravel in the past few years. Only roads that were considered failed and unsafe to drive on were candidates for conversion. (Benzie County also uses the PACER system to evaluate roads.) Other factors included cost savings as a result of the conversion and the very low vehicle per day counts on sections of the roads.

To return the previously paved road to gravel, the road agency spread 3 inches of gravel on the road, crushed and compacted it. The agency continues to brine the road once per year. Ms. Roseman indicated that this has saved a "ton" of money in maintenance costs. According to Ms. Roseman, "Two-man patch crews sitting out for a day or two every month for six months out of the year is a lot more than sending a float truck in spring ahead of a brine truck for a half-hour—basically good for the year." Benzie County did not provide any cost analysis documentation.

Iron County
Contact: Doug Tomasoski, Engineer Manager and Superintendent, (906) 265-6686
Iron County has converted some roads to gravel in the past few years. While Mr. Tomasoski indicated that he had not done a formal cost evaluation, the decision to convert road segments is made primarily because the cost of continually patching the roads or potentially reconstructing the roads is prohibitively high. The cost of laying gravel and grading it once or twice a year is manageable. He indicated that the county works with the townships to decide which roads are eligible for such conversion. They try to avoid roads with houses and also avoid hills. They do not have a formal process for selecting roads to be converted and did not provide any cost analysis documentation.

Montcalm County
Contact: Randy Stearns, Managing Director, (989) 831-5285
Montcalm County converted nearly 10 miles of paved road to gravel in 2009. Mr. Stearns focused on the cost analysis when describing the criteria for converting the roads: "We can crush it up and blade it for less money." He referenced spending $24,000 to patch and still ending up with a terrible road. The county hopes to avoid converting any more paved roads to gravel in 2010, but decisions are made on an as-needed basis. Road condition and maintenance costs are the fundamental criteria used to determine which roads are eligible for conversion.

Alpena County
Contact: Ryan Brege, Engineering Technician, (989) 354-3252
Alpena County has also returned some paved roads to gravel in recent years. Mr. Brege indicated that while cost was a big factor, sometimes it came down to simply not being able to maintain a safe road by patching in addition to the ease of maintaining the road in gravel condition by grading. Alpena County does not have a formal process or criteria to determine which roads it will convert and did not provide any cost analysis documentation.

North Dakota

Contact: Mike Zimmerman, Highway Supervisor, Stutsman County, (701) 252-9040
Stutsman County has developed a system to determine which paved roads should be converted to gravel. The county worked with Interstate Engineering, Inc. to develop a road prioritization system. The goal of the system is to use a variety of factors

that are scored and weighted for each road segment to come up with a ranking for each segment. The inputs can be adjusted based on the priority of the agency making the calculation. Factors that can be weighed include:

- Construction or rehabilitation costs
- Safety
- ADT
- Distance to parallel paved road
- Percentage of trucks using the road

Decision makers can also adjust the weights given to each factor based on the importance of the road segment to the overall network of roads. Sample prioritization sheets from Stutsman County are included as Appendix A.

Mr. Zimmerman also prepared a detailed cost analysis comparing the cost of maintaining a paved road in safe condition, the cost of reconstructing the road, and the cost of converting and maintaining the road as gravel. His cost analysis is based on a 20-year life span of the road. This analysis can be found on pages 12-15 of the document 2010: Work Plan for the Road Department, included as Appendix B. Important highlights include:

- Cost per mile per year to rehabilitate a paved road = $31,293.75
- Cost per mile per year to reclaim a paved road (recycling and maintaining a deteriorated paved road in a condition somewhere between fully paved and gravel) = $2,631.30
- Cost per mile per year of converting a paved road to gravel and then maintaining that road = $1,683.70

County Road Association of Michigan
Contact: Monica Ackerson Ware, Public Relations Specialist, mware@localroads.net, (989) 482-1189, ext. 17
Michigan is experiencing severe funding issues associated with the maintenance and preservation of its roads. The County Road Association of Michigan recently documented the extent of those challenges and their effect on pavement decisions through a comprehensive survey of Michigan counties. Data from the survey shows the number of counties that have returned previously paved roads to gravel and the continued funding issues that local road agencies are facing. The full report can be found at http://www.micountyroads.org/PDF/2010_Survey_Compare.pdf.

Important highlights include:

- At least 100 miles of paved road have been returned to gravel, 35 miles in 2009 alone.
- At the end of 2009, 38 counties had returned paved roads to gravel.
- Estimates show that an additional 100 miles could be converted in 2010.
- Over the past three years, 79 of 83 counties have reduced or eliminated maintenance or replacement activities on hard-surface roads.

Lyon County Highway Department: Local Road Improvement Plan, 2004
http://www.lyonco.org/depts/publicworks/rb/lrip/LRIP.pdf
This report details Lyon County's preparation of a local road improvement plan. It describes two proposals from the Road and Bridge Department to assist in the development of a final plan. Plan A would maintain pavement on all currently paved roads at a cost of $5 million over 14 years. Plan B would maintain paved roads based on criteria such as traffic, cost, distance to closest paved parallel route, existing condition, etc., at a total estimated cost of $3 million.

Page 7 and page 13 of the report contain spreadsheets detailing the various factors and costs associated with maintaining paved roads and converting roads to gravel, respectively.

County Engineer comments from page 4 of the report: "Typically roads with less than 200 vehicles a day cost less to maintain with a gravel surface than a paved surface. I have evaluated roadways for Plan C based on criteria such as distance to closest paved parallel route, average daily traffic, maintaining route continuity, location within City limits and cost. Consideration of the number of homes and businesses located on a route is not an engineering or maintenance factor for traffic under 200 cars a day.

"For 2001 and 2002, paved roads cost an average of $1,084 per mile per year more in routine maintenance (crack filling, seal coating, striping, re-graveling shoulders) than gravel roads. Paved roads also require an additional significant capital investment somewhere between 16 and 20 years of age."

Road Surfacing Decisions and Criteria

To Pave or Not to Pave: Making Informed Decisions on When to Upgrade a Gravel Road, Kansas Local Technical Assistance Program, 2006.
http://www.kutc.ku.edu/pdffiles/2006_Paving_Guide.pdf
This document presents the factors involved in determining when to pave a gravel road. It highlights two reports and tools to assist road agencies in making the decision. The first is a Minnesota report, Economics of Upgrading an Aggregate Road. The second is South Dakota's report, Local Road Surfacing Criteria. The document suggests using both tools to assist road agencies in determining what type of road surface is best.

Economics of Upgrading an Aggregate Road, Charles T. Jahren, Duane Smith, Jacob Thorius, Mary Rukashaza-Mukome, David White, Greg Johnson, Minnesota Department of Transportation/Local Road Research Board, 2005.
http://www.lrrb.org/pdf/200509.pdf
This report provides information and procedures to make decisions about when to upgrade gravel roads. The report contains an analysis that compares the cost of maintaining a gravel road with the cost of upgrading to a paved surface. This analysis can be modified to address local conditions. Such an analysis may be used as a tool to assist in making decisions about upgrading a gravel road to a paved surface.

The report is organized into three main sections:

- Historical cost analysis based on the spending history for low-volume roads found in the annual reports of selected Minnesota counties. The effects of traffic volume and type of road surface on cost were included in the analysis.
- Development of a method for estimating the cost of maintaining gravel roads, which is useful when requirements for labor, equipment and materials can be predicted.
- Development of an economic analysis example that can serve as a starting point for analyses to aid in making specific decisions.

This report has not been updated and therefore does not take into consideration the changing prices of asphalt, gravel and maintenance supplies.

Context Sensitive Roadway Surfacing Selection Guide, Michael Maher, Chris Marshall, Frank Harrison, Kathy Baumgaertner, U.S. Department of Transportation, Federal Highway Administration, Central Federal Lands Highway Division, August 2005.
http://www.pavementpreservation.org/toolbox/links/context-sensitive-roadways.pdf
From the report: "The purpose of this Guide is to provide consistent, objective and comprehensive information regarding all roadway surfacing types and to present a rational, transparent, systematic process for selecting surfacing types for a particular project or site application."

Chapter 3, beginning on page 21 of the guide, contains a comprehensive surface selection methodology. Pages 26-28 present a table containing suitability suggestions for types of road surfaces based on the traffic volume of the roadway. Beginning on page 29, the report details 11 scoring factors separated into three categories: performance and durability attributes; constructability and costs attributes; and context-sensitive and environmental attributes. Pages 32-34 detail the method for weighting and scoring the factors to determine the appropriate selection.

Appendix A of the guide, beginning on page 37, includes a comprehensive list of surfacing products and descriptions of their attributes.

Local Road Surfacing Criteria, K.A. Zimmerman, A.S. Wolters, South Dakota Department of Transportation, U.S. Department of Transportation, Federal Highway Administration, June 2004.
http://www.state.sd.us/Applications/HR19ResearchProjects/Projects%5CSD200210_Technical_Brief.pdf
This brief is the result of research initiated by South Dakota DOT regarding surfacing criteria for low-volume roads. It contains a step-by-step process for local road agencies to determine the costs associated with decisions to pave, not pave or maintain roadways. The process developed can be done manually, as described in the brief, or by using a computerized tool available through SDLTAP.

From page 1 of the report: "The methodology presented in this *Technical Brief* provides a practical tool to assist agencies with decisions about the most cost-effective road surface type to be used in various situations."

Factors used to determine appropriate road surfaces include construction costs, maintenance costs, user costs and non-economic factors. Page 17 of the report includes an example scoring table for economic and non-economic factors. The full report can be found at http://www.state.sd.us/Applications/HR19ResearchProjects/Projects%5Csd200210_Final_Report.pdf.

Vermont Local Roads Fact Sheet: When to Pave a Gravel Road, Vermont Local Technical Assistance Program, undated.
http://personalweb.smcvt.edu/vermontlocalroads/OLD/FactSheet%20files/OLD%20When%20to%20Pave%20a%20Gravel%20Road.pdf
This fact sheet discusses 10 questions to consider when deciding whether to pave a gravel road. The questions could also be viewed in terms of when to return a paved road to gravel. Design and safety questions in addition to construction, maintenance and road user costs are detailed. Pages 5-7 discuss construction and maintenance costs associated with both paved and gravel roads, and give a sample cost/benefit calculation used to determine which surface is more cost-effective.

Turning Deteriorated Paved Roads Back into Gravel Roads: Sheer Lunacy or Sustainable Maintenance Policy?, Jyri Mustonen, Janne Lintilä, Tauno Mäkiö, *Transportation Research Record*, Vol. 1, Issue 1819, 2003: 96-103.
Attached as Appendix D
This report discusses the decision by Finnish road agencies to begin converting some of their paved roads to gravel. It details how, from the local road agency perspective, the upkeep of gravel roads is economically feasible compared with maintaining paved roads in poor condition. Factors taken into account when deciding whether to return a paved road to gravel include road condition, number of people living on the road, traffic volume and fleet distribution, costs of alternatives and network significance of the road.

The report describes standards that Finnish road agencies use. For example: "Before a pavement is removed, it has to be in such a poor condition that motorists are experiencing obvious disturbance or even danger while driving on that road." (page 3) "In ordinary cases, the annual average daily traffic (AADT) should not exceed 250 vehicles per day when this kind of action is considered." (page 4)

The report also describes the economic, land use and network analysis that should be done when making the decision. A cost comparison on page 6 lists the factors that should be analyzed with example values comparing light maintenance, reconstruction as a paved road and reconstruction as a gravel road.

Pavement Preservation Techniques and Strategies

Contact: Ken Skorseth, Program Manager, SDSU/SDLTAP, ken.skorseth@sdstate.edu, (800) 422-0129
Mr. Skorseth has experience with converting paved roads to gravel and using stabilized gravel to maintain roadways. He pointed to the South Dakota DOT Local Road Surfacing Criteria research project (see page 5 of this report) as an "invaluable" resource. This report, published in 2004, does have some limitations. First, it has not been updated since 2004 and therefore does not reflect the changes in costs associated with asphalt, gravel and maintenance. The other limitation is that it does not evaluate the use of treated or stabilized gravel as an alternative road surface. He cited total traffic and the percentage of truck traffic as the two most important factors to determine whether it is appropriate to convert a paved road to gravel. Mr. Skorseth said that in general, roads that see ADT of more than 200 are not good candidates for conversion.

One exception to this rule appears to be Maitland Road in Lawrence County, South Dakota. Maitland Road has been maintained as a stabilized gravel road for 20 years and has an ADT of more than 1,000 in the summer. The SDLTAP is initiating a project to perform a cost analysis and gather information on construction/maintenance operational guidelines that have made this project perform so well, and possibly obtain information on the environmental impact on roadside vegetation after such a long period of chloride treatment. Mr. Skorseth highlighted this road in a presentation he gave at the national Road Dust Management Conference in 2008. A copy of his presentation, including photos of Maitland Road, is available at http://www.meetingsnorthwest.com/Event%20Archive/dustconf/Proceedings/Skorseth_C2presentation.pdf.

Performance Evaluation of Various Rehabilitation and Preservation Treatments, Zheng Wu, Jonathan L. Groeger, Amy L. Simpson, R. Gary Hicks, U.S. Department of Transportation, Federal Highway Administration, 2010.
http://www.fhwa.dot.gov/pavement/preservation/pubs/perfeval/perfeval.pdf
This report presents the results of a research study designed to highlight the degree to which pavement preservation strategies (including minor rehabilitation treatments) extend the service life of pavements. Researchers collected and analyzed 256

projects from six target states covering 20 treatment types. The report focuses on low-cost techniques used to extend the life of pavement that is still in relatively good condition instead of the wholesale reconstruction of roads in poor condition.

Data was summarized to yield the most common values for the following items:

- Timing of application: the stage of life (in years) the preventive and/or rehabilitative action was taken
- AADT and percentage of trucks on the pavement section associated with each treatment
- Distress types and values used to trigger each treatment
- Extended pavement service life or structural life associated with each treatment
- Cost per lane mile associated with each treatment

Page 2 of the report lists the extended service life ranges for each of the treatments analyzed in the study. Pages 19-38 contain tables evaluating each specific treatment type according to the factors listed above.

9th International Conference on Low-Volume Roads: Current Issues Facing Low-Volume Road Managers, Ann M. Johnson, Professional Engineering Services, Standing Committee on Low-Volume Roads, Transportation Research Board, November 2008.
http://www.dot.state.mn.us/materials/researchdocs/LVRHotTopics.pdf
This paper presents notes from the 9th International Conference on Low-Volume Roads. Pertinent discussions include:

- Full depth reclamation (pages 6-7 of the report): "Full Depth Reclamation (FDR) is an effective recycling method for low-volume roads. Aged, worn-out roads can be rebuilt using the existing materials from the roadway."

- Use of recycled aggregates from construction waste (pages 9-10): "Texas [DOT's] experience with projects on use of recycled aggregates shows increased durability of the roads from using rubber in the aggregate. Also, there was money savings due to the use of local recycled materials."

- To pave or not to pave – Information provided to support decision making of when to upgrade gravel road (pages 10-11): This discussion presents tools from Minnesota's research on the cost of upgrading aggregate roads and South Dakota's report on local road-surfacing criteria.

- Best practices and resources in pavement design methods for LVR (pages 16-17): This section lists a variety of manuals and guidelines referenced as resources in pavement design.

Gravel Roads: Maintenance and Design Manual, Ken Skorseth, Ali A. Selim, U.S. Department of Transportation, Federal Highway Administration, South Dakota Local Technical Assistance Program, November 2000.
http://www.t2.unh.edu/nltapa/Pubs/south_dakota_gravel_manual.pdf
This manual provides comprehensive information regarding the maintenance, design and preservation of gravel roads. Appendix D of the report, When to Pave a Gravel Road (pages 93-100 of the PDF), was prepared by the Kansas Transportation Center. It includes 10 questions that should be answered before making the determination to pave a gravel road. Pages 97-99 of the PDF include a cost comparison analysis between different paving and graveling options.

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Addendum to TRS 1007

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Addendum: AASHTO Research Advisory Committee Survey Results

Background

This document is an addendum to the Mn/DOT Transportation Research Synthesis report *Decision Tree for Unpaving Roads*. It includes the results of a short AASHTO Research Advisory Committee survey of state transportation research agencies.

Summary

We received responses from 15 states, one Canadian province, a consultant in Australia and a member of the German Federal Highway Research Institute. Seventy-two percent of respondents (13 of 18) are not actively considering the conversion of paved low-volume roads to gravel. Several states indicated that they either had no gravel roads in the state system (Mississippi) or that decisions on low-volume roads are generally made by local road agencies (Iowa, New York, North Dakota, Wisconsin). Four states (Missouri, Montana, New York, North Dakota) said they use chip seals to repair and maintain paved roads. The Utah Department of Transportation provided information on a new patching method, which has been used with some recent success utilizing an infrared heating system to heat, remix and recompact pavement. (See http://heatwurx.com/.) Additional methods mentioned in the responses include microsurfacing (Delaware, North Dakota), hot-mix overlays (Florida) and hot-in-place recycling (Missouri).

Survey questions and the results of interviews with representatives of state agencies are detailed below. Contact information for each responding agency is also included.

Survey Question 1

Are any local road agencies in your state considering conversion of paved low-volume roads to gravel roads?

No

Arizona, Delaware, Florida, Georgia, Louisiana, Mississippi, Missouri, North Dakota, Virginia, Wisconsin and Wyoming; Alberta, Canada; and Germany.

Yes

Iowa

The Iowa Department of Transportation distributed the survey to its counties and received 37 responses, which are included in Appendix A. Most counties had limited experience converting paved roads to gravel.

Montana
"Yes, it has been considered in some specific instances, but to date it has rarely been done so we really don't have any information on the effects of doing so."

New York
"Conversion is not typically done formally, but is an ad hoc response to the road failing. Agencies (mostly towns) in New York State have just let the roads revert to gravel. This has led to some problems as the gravel bases under the failing surfaces do not have enough fines. These roads then ravel more than a gravel road with the proper material. The Cornell Local Roads Program has had a few calls on this subject and it thinks there may be as many as 50 towns that have done this in the last few years (out of 932 towns). When asked, Cornell refers the agency to information on good gravel on its Web site: http://www.clrp.cornell.edu/techassistance/Gravel%20pdfs/Introduction.pdf. They typically discuss the issues involved including cost-benefit, but typically this is not done directly as some of the costs and benefits are not quantifiable (such as aesthetics). Cornell does not have any outcomes available at this time."

Survey Question 2
Has your department encouraged use of any nontraditional surface alternatives short of full conversion to gravel such as chip seals, oil-gravel, Otta seal or other options to maintain or reclaim paved low-volume roads without repaving?

The Utah Department of Transportation has used a new method of patching existing pavement, which uses an infrared heating system to reheat the pavement to a temperature that allows it to be remixed and recompacted. The Utah Department of Transportation has provided two articles about the process, which are included in Appendix B and Appendix C of this addendum.

Other states reported using the following methods:

- **Chip seals:** Missouri, Montana, New York, North Dakota
- **Microsurfacing:** Delaware, North Dakota
- **Various hot-mix overlays:** Florida
- **Hot-in-place recycling:** Missouri

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