Skunk Hollow Road Safety Analysis

Final Report

May, 2011

Chittenden County Metropolitan Planning Organization

Communities working together to meet Chittenden County's transportation needs

Skunk Hollow Road Safety Analysis

May, 2011

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Executive Summary

The Town of Jericho requested the Chittenden County Metropolitan Planning Organization's (CCMPO) assistance in addressing safety concerns on Skunk Hollow Road. The Town received complaints regarding the conditions and subsequent safety of the unpaved section of roadway. In support of the complaints, the majority of recorded crashes on the roadway coincided with the unpaved section. Therefore the analysis focused primarily on this section of roadway.

The gravel section has been rebuilt over the past few years and overall is in good shape. However, the traffic volumes are around the theoretical limit to which it no longer becomes cost effective to maintain a gravel road. Appendix B of this report contains a copy of "Appendix D: When to Pave a Gravel Road" from FHWA's publication conducted by the South Dakota Local Technical Assistance Program (LTAP) titled "Gravel Roads Maintenance and Design Manual". In addition, a subsequent life cycle analysis of comparing the costs associated with the routine maintenance on the gravel portion versus completing the paving of the road is being conducted by DuBois and King. This will serve to inform the debate as to whether or not the gravel portion should be paved.

The crash data indicates the majority of incidents involved single vehicles running off the road. Appendix A details several improvements to existing signage which would increase driver information in areas where loss of control is more likely due to tight curves and limited sight distance.

Background

Skunk Hollow Road (TH-6) is a 3.1 mile Class II Town Highway functionally classified as a local road, and as such it is not included in the Federal Aid System of highways. It provides access to local residents and in combination with Plains Road serves as a north/south route between VT 15 and VT 117. Because of its function as a connection between two minor arterials (VT 15 and VT 117) it may be better classified as a major or minor collector. It also functions as an alternative to the Sand Hill Road/Allen Martin Drive route between VT 15 and VT 117 roughly a mile and a half west of Skunk Hollow Road. This is important to note because of the possibility of traffic shifting to Skunk Hollow Road from Sand Hill Road and Allen Martin Drive due to congestion on those roadways. There is a 0.8 mile section of Skunk Hollow Road which remains unpaved. The decision not to pave this section was done as a compromise with Skunk Hollow Road residents at the time and to discourage through traffic. The roadway exhibits a 24,000 pound weight limit and 35 mph speed limit. The location of Skunk Hollow Road and its proximity to VT 15 and VT 117 can be seen in Figure 1 along with the unpaved section of roadway highlighted in brown.

Site Visit

A site visit to Skunk Hollow Road was conducted on July 29, 2010. The following items were recorded:

- An inventory of existing signage
- Roadside hazards (See Figure 2)
- Washboarding/rutting in the unpaved section (See Figure 3)
- A series of horizontal curves present in the unpaved section
- Varying roadway widths in the unpaved section[1]

[1] Roadway widths measured at a few spot locations varied between 23 and 26 feet.

Figure 1: Skunk Hollow Road & Surrounding Roadway Network

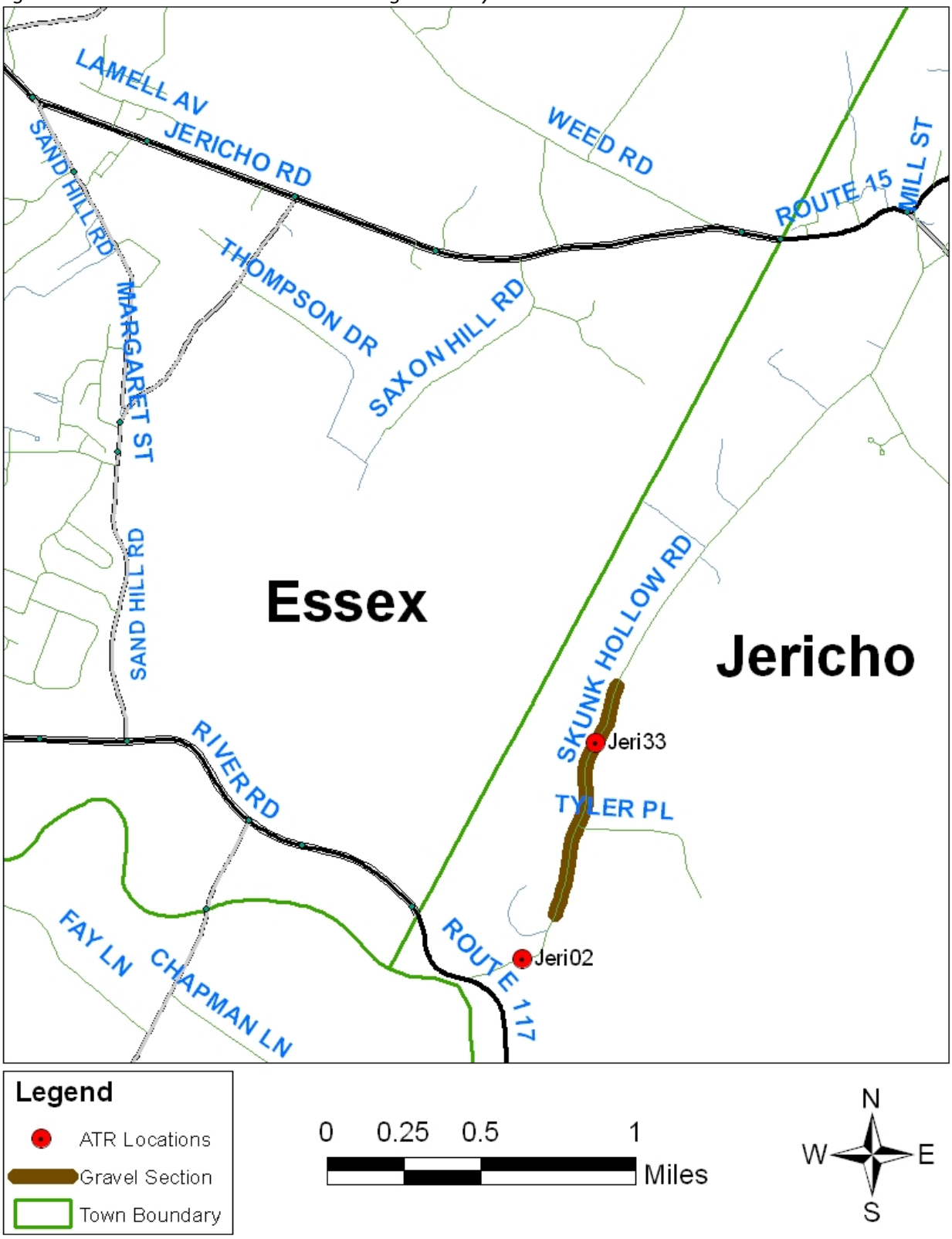


Figure 2: Large Tree Close to Roadway

Figure 3: Washboarding/Rutting & Loose Gravel on Roadway

Data Analysis

Traffic Data

Traffic counters were set during the site visit at two locations to determine speeds and Annual Average Daily Traffic (AADT). The first location was in the southern paved section of the roadway between VT 117 and White Oak Drive. The second location was in the unpaved section of roadway between 156 and 162 Skunk Hollow Road. The data from the two traffic counter locations can be seen in Table 1.

Table 1: 2010 Automatic Traffic Recorder Data

Automatic Traffic Recorder (ATR)		AADT (vehicles)	85th Percentile (mph)		Truck AADT (vehicles)
ID	Location		NB	SB	
Jeri 02	Skunk Hollow North of VT 117	1600	43	44	70
Jeri 33	Skunk Hollow South of 154/156	1500	40	38	50

As shown in Table 1 the speeds in the unpaved section are lower than the paved section. The slight differences in northbound and southbound speeds at the two locations can be attributed to their proximity to roadway curves and grades.

Crash Data

Crash data from 2005-2009 was analyzed. A total of 9 crashes were recorded on Skunk Hollow Road. However there is anecdotal input provided by property owners that a number of crashes go unrecorded. All but one of the recorded crashes was a single vehicle crash with the other being a rear end. Most drivers were going too fast and were unable to stay on the roadway. At least 6 of the 9 recorded crashes occurred on or in close proximity to the gravel section.

The Vermont Agency of Transportation (VTrans) prepares a listing of High Crash Locations (HCLs) on the Federal Aid System (FAS) to track statewide safety deficiencies. To qualify for inclusion on the HCL list a 0.3 mile section must have an actual crash rate that exceeds a calculated "critical" rate and have at least 5 crashes in as many years. Since Skunk Hollow Road is not on the FAS it is not included in the VTrans HCL calculations. However, it appears a piece of the unpaved portion of Skunk Hollow Road would qualify as a HCL if it was on the Federal Aid System and at least 5 of the recorded crashes occurred within a 0.3 mile section.[1] In this scenario the actual crash rate exceeded the critical crash rate yielding a value of 1.66. Crash data from the paved sections of Skunk Hollow Road indicate fewer crashes and would not contain any plausible HCLs despite exhibiting higher speeds.

[1] Some of the crash data lack specific locations as to where the crash took place, which is why it is unsure as to whether or not 5 crashes occurred within a 0.3 mile section of the gravel portion.

Discussion & Recommendations

Signage

During the site visit an inventory of the existing signage was recorded and can be seen in Appendix A. Recommendations of proposed new signage can be found here as well and generally involve curves in the roadway. Some specific curves include:

- North and south of Tyler Place
  - The Tyler Place intersection is in the middle of a right reverse curve. A modified right reverse curve sign showing the intersection in the tangent section is recommended along with a supplemental street name plaque to go beneath the curve sign.
- North of the driveway to 154/156 Skunk Hollow Road
  - This curve is short in terms of distance but has a tight radius coupled with the road being slightly narrower in this section. It also has limited sight distance due to the vertical curvature and knoll on the inside of the curve. Large arrows on the outside of the curve perpendicular to the tangent sections are recommended along with advanced curve warning signs. (See Figures 3 & 4) A longer term solution would be to remove the knoll to improve sight distance around the corner.
- South of White Oak Drive
  - The chevrons in this curve are too closely spaced together. An additional chevron is recommended with approximately 80 foot spacing between signs. (See Figures 5 & 6)

All signs should be compliant with the Manual on Uniform Traffic Control Devices (MUTCD).

Traffic

The traffic counts indicate anywhere from 50-70 trucks per day are using Skunk Hollow Road. These are mostly 2 axle, 6 tire trucks which are common local delivery trucks. These vehicles do more damage to the gravel section than passenger cars yet the Town cannot legally restrict through truck travel despite the existing "No Thru Trucks" signs at either end of the roadway.[1] They can restrict truck travel through the posted 24,000 pound weight limit provided it is included in the Town's Traffic Ordinance.

Vehicle speeds are slower in the unpaved section but are still above the posted 35 mph speed limit. Speed limits are typically set at or around the 85th percentile speed. This is the speed at which 85 percent of vehicles are traveling at or below. The Town may want to increase enforcement to mitigate speeding along the roadway. However, this would not likely be a permanent solution without consistent enforcement. Radar feedback signs are another tool which could be installed to increase driver awareness of speeding. These could be moved to different sections of the roadway at regular intervals in order to avoid complacency.

Anecdotal observations indicate pedestrian and bicycle usage of the roadway. Accommodations for these modes are minimal and in combinations with poor gravel conditions can present safety problems.

[1] Title 23 V.S.A. § 1042. Restricting the use of town highways

Figure 4: Southbound at Curve North of Driveway 154/156

Figure 5: Northbound at Curve North of Driveway 154/156

Figure 6: Southbound Existing Signage at Curve South of White Oak Drive

Figure 7: Effect of Wider Chevron Spacing at Southbound Curve South of White Oak Drive

Paving

Much discussion has occurred in the past as to whether or not the unpaved section of roadway should be paved. There are many aspects to this that should be considered – one of which is traffic volumes. General guidelines as to when a road should be considered for paving range anywhere from 50 to 500 AADT. The unpaved section currently experiences an AADT of 1,500 vehicles with 50 of those being trucks. It becomes increasingly difficult to maintain a sufficient gravel surface as traffic volumes increase. A conversation with the Town's Road Foreman yielded maintenance on the small 0.8 mile section of roadway is a substantial burden on staff resources. It was also noted that the roadway has been rebuilt over the last few years with improvements to drainage. However, other factors such as roadway standards, safety, and cost comparisons should be considered as well.

Paving a gravel road will not necessarily make the road safer. In this case it will likely help keep speeders on the roadway that would have otherwise lost control due to washboarding and loose gravel on the roadway surface. It will also serve to keep drivers on their proper side of the roadway. There have been anecdotal observations of drivers crossing over the center line to avoid potholes and washboarding causing an unsafe scenario if a vehicle were to be traveling in the opposite direction. This presents concerns for not only other motorists but pedestrians and bicyclists as well. Any future reconstructions could create the opportunity for expanded shoulders for bicyclists and pedestrians. An adverse effect to paving a gravel road is that it will likely encourage higher speeds and more traffic. It is difficult to say whether or not the speeds will be similar to that of the Jeri02 location. There are numerous horizontal curves present in the gravel section that motorists must slow down to navigate. Slight increases in speeds may be acceptable with a more consistent roadway surface. The sharp curves and varying roadway widths should be addressed through signage and/or geometric improvements before paving.

It is important not to simply pave over the existing roadway despite recent improvements to drainage. As the gravel roads maintenance manual suggests, "There is a substantial difference in the type of crushed stone or gravel used for a gravel road-riding surface versus that used as a base under a pavement. The gravel road surface needs to have more fines plus some plasticity to bind it together, make it drain quicker and create a hard riding surface. Such material is an inferior base for pavement. If pavement is laid over such material, it traps water in the base. The high fines and the plasticity of the material make the wet base soft. The result is premature pavement failure."[1] Appendix B of this report contains a copy of "Appendix D: When to Pave a Gravel Road" from FHWA's publication conducted by the South Dakota Local Technical Assistance Program (LTAP) titled "Gravel Roads Maintenance and Design Manual". This publication provides more detailed information pertaining to the many factors that should be taken into consideration when paving a gravel road.

Conclusions

For a roadway that is partially unpaved, Skunk Hollow Road handles a significant volume of traffic of about 1,500 to 1,600 vehicles per day. The unpaved segment is one of the most heavily traveled gravel roads in the county. Since it is surrounded by paved sections, motorists may feel they can drive the same speed on the gravel especially when the posted speed limit remains unchanged. The motorists may have a difficult time reacting to the different friction and ride quality properties on gravel roads and thus decreasing their overall safety. Motorists are on average traveling a bit slower in the unpaved section but still exceed the posted speed limit.

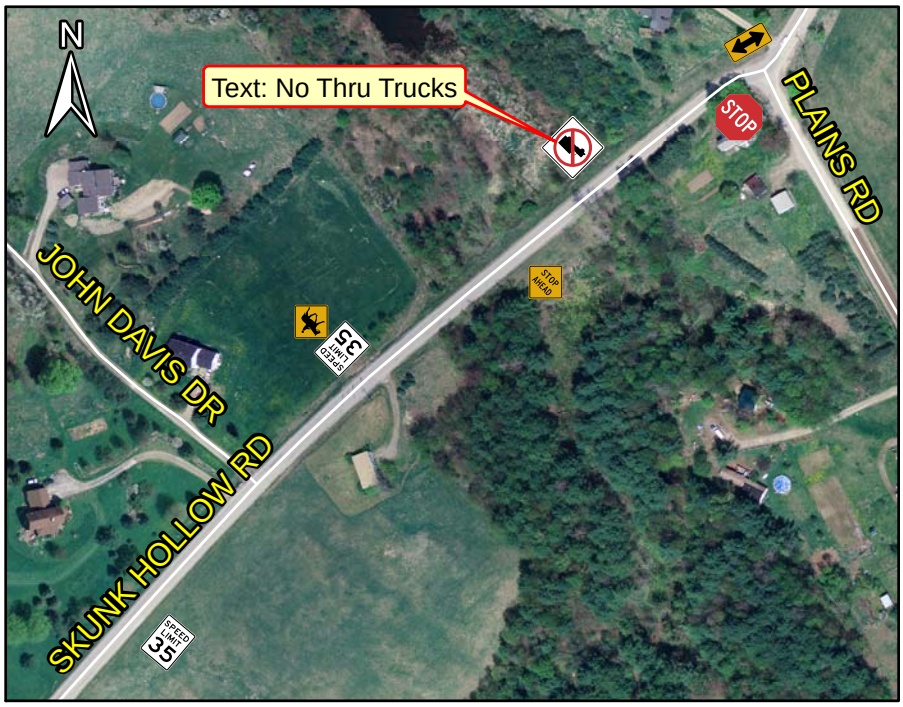
This report recommends improvements be made to alert drivers of changes in alignment with additional signage, but there is also point at which it becomes uneconomical to maintain a gravel road surface. Paving the road would likely increase speeds somewhat, but the presence of several curves and grades in this section should continue to have a moderating effect. A more regular driving surface would improve traction and increase the ability of vehicles to stay in designated travel lanes which would improve safety. The Town has initiated a separate study examining the lifecycle costs associated with maintaining the gravel surface on Skunk Hollow versus paving this section. The results of this CCMPO Safety Analysis and the separate lifecycle cost study will provide a good foundation for Town discussions moving forward.

[1] *Gravel Roads Maintenance and Design Manual – Appendix D: When to Pave a Gravel Road,* FHWA, South Dakota LTAP, Kentucky Transportation Center, 2000.

Appendix A: Existing & Proposed Signage Maps

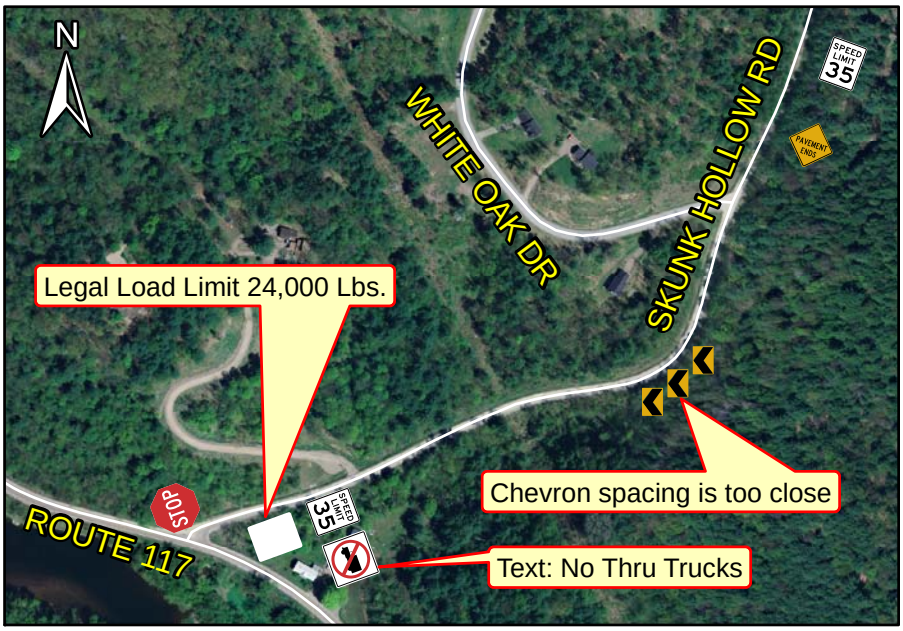
Skunk Hollow Road - Existing Signage

Plains Road Intersection

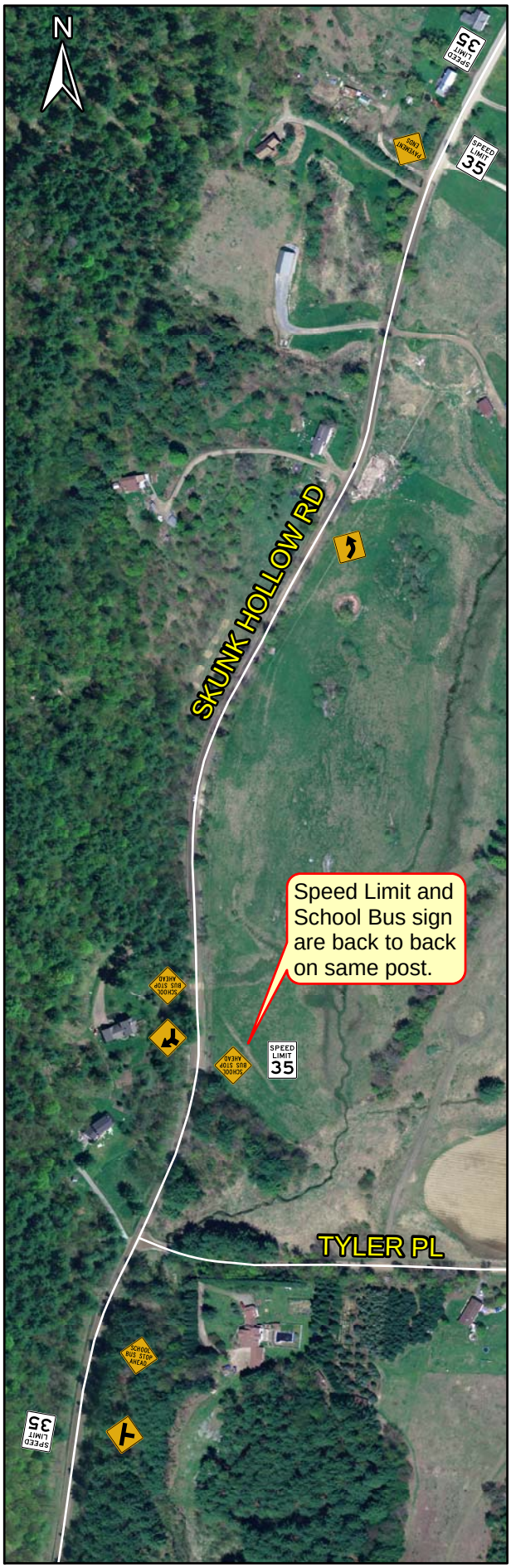


Saxon Lane Intersection

VT 117 Intersection

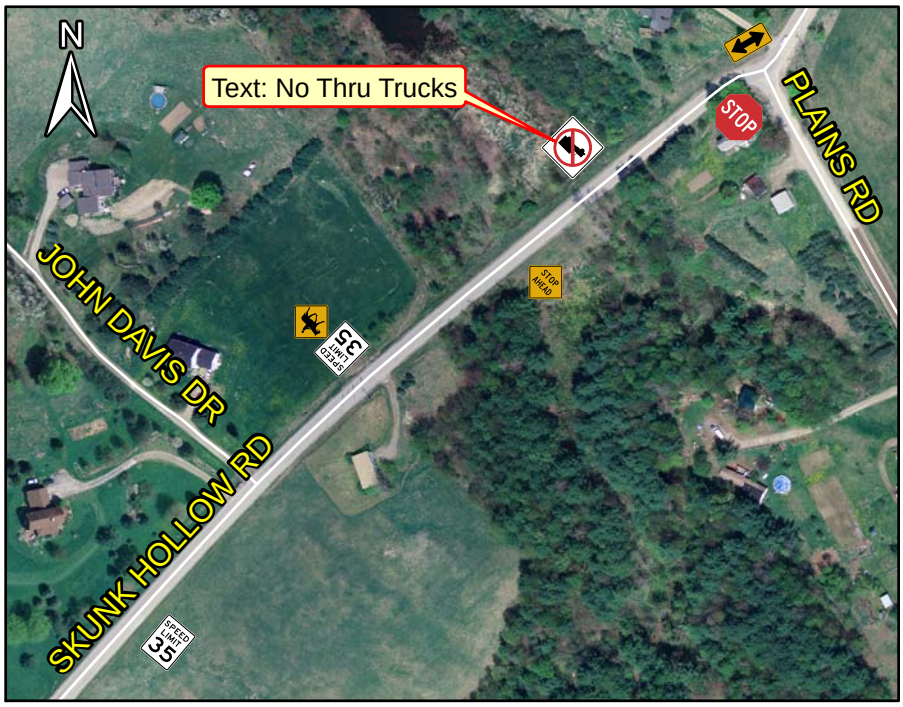


Unpaved Section



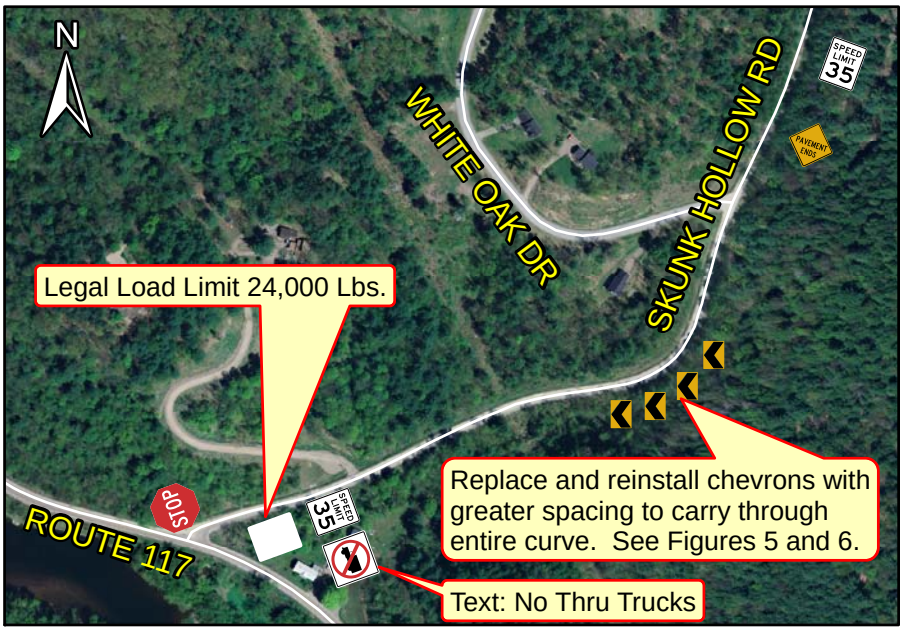
Skunk Hollow Road - Proposed Signage

Plains Road Intersection

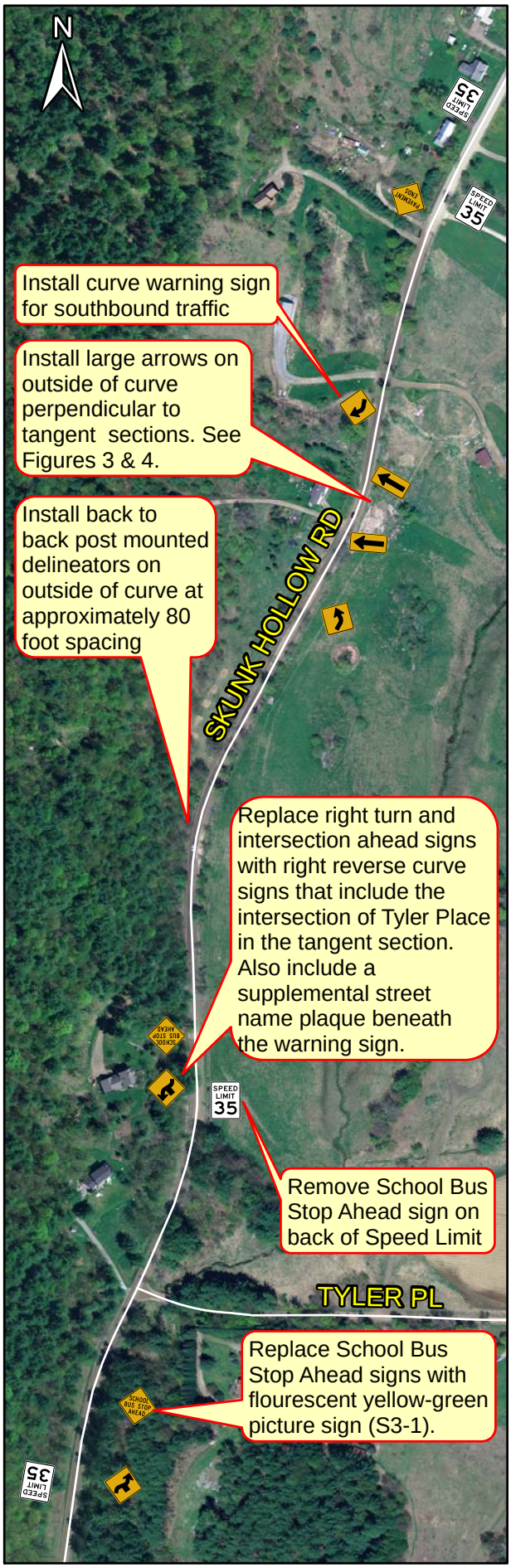


Saxon Lane Intersection

VT 117 Intersection



Unpaved Section



Appendix B: “Appendix D: When to Pave a Gravel Road”

Appendix D: When to Pave a Gravel* Road

by Kentucky Transportation Center, University of Kentucky at Lexington,KY

Contents

- A Word About the Term "Paved"
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*Gravel as used here may refer to sand and gravel,or to crushed stone.

A Word About the Term "Paved"

What is meant by a "paved" road? For some, a light chip seal coat is considered paving. For others, paving is four or more inches of bituminous asphalt or "hot mix." The primary purpose of a pavement is to protect the subgrade. As the loads get heavier, the pavement thickness must be increased.

Generally speaking, bituminous concrete (hot mix asphalt) has little real load-bearing capacity of its own until it reaches a thickness of two inches. In fact, the Asphalt Institute has a firm policy of recommending a minimum pavement thickness of 4 inches full depth asphalt or 3 inches asphaltic concrete plus a suitable granular base even for low volume roads. Their research shows that 4 inches of hot mix will carry about 10 times as much traffic as 2 inches of hot mix when constructed over thin granular bases.

A pavement less than two inches thick primarily protects the base materials by shedding water and providing a smooth riding surface. Such a road is more properly called a surface-treated road. Roads with thin pavements must have excellent drainage designed into them and be diligently maintained throughout their service life.

In this paper we will consider even a light surface treatment as paving,however. The assumption is that,when a town first applies a chip seal treatment,for example, it has taken a first step toward eventually achieving a load-bearing pavement.

Introduction

Two-thirds of the highway systems in the United States and more than 90 percent of all the roads in the world are unsurfaced or lightly surfaced low volume roads. In Kentucky, more than 19,000 miles of local roads have gravel surfaces.

Most local roads were not designed with the same considerations used in the design of state and interstate highways. Most have evolved from primitive trails. Paths of least resistance first created by wild animals were later used by settlers. As needs and traffic increased, these traveled ways became roads which were gradually improved with gravel or crushed rock. Little engineering went into these improvements. Using available materials and "keeping them out of the mud" were the extent of efforts to maintain a road.

As paving occurred, the tendency was to make minor modifications to the foundations of the evolved road and to seal or pave the surface. As a result,many low volume roads in Kentucky now have continual maintenance problems because of inadequate base support in addition to alignment and drainage problems.

To add to the problem, roads throughout Kentucky are experiencing ever-increasing weights and volumes of traffic. Population growth and tourism make traffic demands. Coal trucks and other commercial vehicles are carrying heavier loads than ever before. These higher volumes and greater weights are putting a steadily increasing strain on local road maintenance and reconstruction budgets.

Gravel or Paved: A Matter of Trade-Offs

The decision to pave is a matter of trade-offs. Paving helps to seal the surface from rainfall, and thus protects the base and subgrade material.It eliminates dust problems, has high user acceptance because of increased smoothness, and can accommodate many types of vehicles such as tractor-trailers that do not operate as effectively on unsurfaced roads.

In spite of the benefits of paved roads, well-maintained gravel roads are an effective alternative. In fact, some local agencies are reverting to gravel roads. Gravel roads have the advantage of lower construction and sometimes lower maintenance costs. They may be easier to maintain, requiring less equipment and possibly lower operator skill levels. Potholes can be patched more effectively. Gravel roads generate lower speeds than paved surfaces. Another advantage of the unpaved road is its forgiveness of external forces. For example, today vehicles with gross weights of 100,000 pounds or more operate on Kentucky's local roads. Such vehicles would damage a lightly paved road so as to require resealing, or even reconstruction. The damage on a gravel road would be much easier and less expensive to correct.

There is nothing wrong with a good gravel road. Properly maintained, a gravel road can serve general traffic adequately for many years.

Should We Pave This Gravel Road? A Ten Part Answer

When a local government considers paving a road,it is usually with a view toward reducing road maintenance costs and providing a smooth riding surface. But is paving always the right answer? After all, paving is expensive. How does a county or city know it is making the most cost-effective decision?

We will consider ten answers to the question,"Should we pave this gravel road?" In fact they are ten parts of one answer. If one of the ten is not considered, the final decision may not be complete. The ten answers taken together provide a framework for careful decision making.

Answer 1: After Developing a Road Management Program

If the road being considered for paving does not fit into a countywide road improvement program,it is quite possible that funds will not be used to the fullest advantage. The goal of a road management system is to improve all roads or streets by using good management practices. A particular road is only one of many in the road system.

A road management system is a common sense, step-by-step approach to scheduling and budgeting for road maintenance work. It consists of surveying the mileage and condition of all roads in the system,establishing short-term and long-term maintenance goals and prioritizing road projects according to budget constraints.

A road management system helps the agency develop its road budget and allows the use of dollars wisely because its priorities and needs are clearly defined.

Through roadway management, local governments can determine the most cost-effective, long-term treatments for their roads, control their road maintenance costs, and spend tax dollars more wisely. Local governments that stick with the program will be rewarded with roads that are easier and less costly to maintain on a yearly basis. Pertinent information about all roads will be readily available for years to come instead of scattered among files or tucked away in an employee's head.

Steps in a Road Management Program:

1. Inventory the roads. The amount of time available and the miles of road in a county or city will determine how much detail to go into.
2. Assess the condition of the roads. Develop simple and easy techniques to use each year. Maintain a continuing record of the assessed condition of each road so that changes in condition can be noted easily and quickly.
3. Select a road management plan. Select the most appropriate treatment to repair each road, bridge, or problem area.
4. Determine overall needs. Estimate the cost of each repair job using generalized average costs and tally up the total.Establish long-range goals and objectives that in turn will help the agency justify its budget requests.
5. Establish priorities. Keep good roads in good shape (preventive maintenance) and establish a separate budget, or request a temporary increase, to reconstruct really bad roads.

Answer 2: When the Local Agency Is Committed to Effective Management

A commitment to effective management is an attitude. It is a matter of making sure that taxpayers' money is well spent—as if it were one's own money. It does not mean paving streets with gold but it does mean using the best materials available. It does not mean taking short cuts resulting in a shoddy project but it does mean using correct construction techniques and quality control.A commitment to effective management means planning for 5 or even 10 years instead of putting a band-aid on today's problem. It means taking the time to do things right the first time and constructing projects to last.

Consider a child's tree house compared to a typical three-bedroom house in a Kentucky town. Because each protects people from the wind and rain each comes under the definition of a shelter. However, the tree house was built with available materials and little craftsmanship. The other was planned, has a foundation, sound walls and roof and, with care, can last hundreds of years. One is a shack and the other is a family dwelling. Only one was built with a commitment to excellence.

Many roads are like the tree house. They qualify under the definition but they are not built to last.

The horse and buggy days are over. We are in an age of travelers' demands, increasing traffic, declining revenues and taxpayer revolts. We are expected to do more with less. Building roads to last requires an attitude of excellence. Such an attitude helps to make better decisions, saves money in the long run, and results in a better overall road system.

Answer 3: When Traffic Demands It

The life of a road is affected by the number of vehicles and the weight of the vehicles using it.Generally speaking, the more vehicles using a road,the faster it will deteriorate.

The average daily traffic volumes (ADT) used to justify paving generally range from a low of 50 vehicles per day to 400 or 500.When traffic volumes reach this range, serious consideration should be given to some kind of paving.

Traffic volumes alone are merely guides. Types of traffic should also be considered. Different types of traffic (and drivers) make different demands on roads. Will the road be used primarily by standard passenger cars or will it be a connecting road with considerable truck traffic? Overloaded trucks are most damaging to paved roads.

The functional importance of the highway should also be considered.Generally speaking, if the road is a major road, it probably should be paved before residential or side roads are paved. On the other hand, a residential street may be economically sealed or paved while a road with heavy truck usage may best be surfaced with gravel and left unpaved until sufficient funds are available to place a thick load-bearing pavement on the road.

Answer 4: After Standards Have Been Adopted

Written standards in the areas of design,construction and maintenance define the level of service we hope to achieve. They are goals to aim for. Without written standards there is no common understanding about what a local government is striving for in road design, construction and maintenance. In deciding to pave a gravel road, is the local government confident it would be achieving the desired standards?

Design and construction standards do not have to be complex. It takes only a few pages to outline such things as right-of-way width, traveled way width, depth of base, drainage considerations (such as specifying minimum 18”culvert pipe),types of surfacing and the like.

Maintenance standards address the need for planned periodic maintenance. A good maintenance plan protects local roads, which for most counties represents many millions of dollars of investment. It also is an excellent aid when it comes time to create a budget.

Considerations include: How often shall new gravel be applied to a gravel road? (Some roads require it more than others do.) How many times per year are roads to be graded? How often and in what locations should calcium chloride or other road stabilizers be applied? What is our plan for checking road signs? (Because of legal liability, a missing sign can be very costly if not replaced.) What is our plan for ditching and shouldering?

Answer 5: After Considering Safety and Design

Paving a road tempts drivers to drive faster. As speed increases, the road must be straighter, wider, and as free as possible from obstructions for it to be safe. Paving low volume roads before correcting safety and design inadequacies encourages speeds which are unsafe, especially when the inadequacies “surprise” the driver. Because of the vast mileage of low volume roads, it is difficult to reduce speeds by enforcement.

Roads must be designed to provide safe travel for the expected volume at the design speed. To do this a number of physical features must be considered:

- Sight Distance
- Alignment and Curves
- Lane Width
- Design Speed
- Surface Friction
- Superelevation

It may be necessary to remove trees or other obstructions such as boulders from the road’s edge. Some engineers insist that no road should be paved that is less than 22 feet wide. If this standard is accepted, gravel roads must be widened before paving. Bridges may need widening. Considering these and other safety and design factors in the early stages of decision making can help to achieve the most economical road and one that will meet transportation needs. It makes no sense to pave a gravel road which is poorly designed and hazardous.

Answer 6: After the Base and Drainage Are Improved

"Build up the road base and improve drainage before paving." This cardinal rule cannot be stressed enough. If the foundation fails, the pavement fails. If water is not drained away from the road, the pavement fails. Paving a road with poor base or with inadequate drainage is a waste of money. It is far more important to ask,"Does this road need strengthening and drainage work?" than it is to ask,"Should we pave this gravel road?"

Soil is the foundation of the road and, as such, it is the most important part of the road structure. A basic knowledge of soil characteristics in the area is very helpful and can help avoid failures and unneeded expense. Soils vary throughout the country. For highway construction in general, the most important properties of a soil are its size grading, its plasticity, and its optimum moisture content.

There is a substantial difference in the type of crushed stone or gravel used for a gravel road-riding surface versus that used as a base under a pavement. The gravel road surface needs to have more fines plus some plasticity to bind it together, make it drain quicker and create a hard riding surface. Such material is an inferior base for pavement. If pavement is laid over such material, it traps water in the base. The high fines and the plasticity of the material make the wet base soft. The result is premature pavement failure.

Answer 7: After Determining the Costs of Road Preparation

The decision to pave a gravel road is ultimately an economic one. Policy makers want to know when it becomes economical to pave.

There are two categories of costs to consider:total road costs and maintenance costs.

Local government needs to determine what the costs are to prepare a road for paving. Road preparation costs are the costs of construction before paving actually takes place.

For example, if standards call for a traveling surface of 22 feet and shoulders of two feet for a paved road, the costs of new material must be calculated. Removing trees, brush or boulders, adding new culverts or other drainage improvements, straightening a dangerous curve, improving slopes and elevations, constructing new guardrails, upgrading signs and making other preparations – all must be estimated.

Costs will vary greatly from project to project depending on topography, types of soils, availability of good crushed stone or gravel, traffic demands and other factors. One important factor is the standards. That is one reason why we should carefully consider what is contained in the road policy (#4 above). For larger projects it may be desirable to hire an engineering consulting firm (another cost) to design the road and make cost estimations. For smaller projects construction costs can be fairly closely calculated by adding the estimated costs of materials, equipment and labor required to complete the job.

Answer 8: After Comparing Pavement Costs, Pavement Life and Maintenance Costs

A second financial consideration is to compare maintenance costs of a paved road to maintenance costs of a gravel road. To make a realistic comparison we must estimate the years of pavement life (how long the pavement will be of service before it requires treatment or overlay) and the actual cost of paving. It is at this point that we can begin to actually compare costs between the two types of roads.

Consider the following maintenance options:

A. For both paved and gravel roads, a local government must: maintain shoulders – keep ditches clean – clean culverts regularly – maintain roadsides (brush, grass, etc.) – replace signs and signposts.
B. PAVED roadways require: patching – resealing (chip, slurry, crack seal) and striping.
C. GRAVEL roadways require: regraveling – grading and stabilization of soils or dust control.

Since the maintenance options in "A" are common to both paved and gravel roads, they do not have to be considered when comparing maintenance costs. These costs for either type of road should be about the same. But the costs of the maintenance options in "B" and "C"are different and therefore should be compared.

Figure 16 shows costs for maintaining gravel roads over a six-year period in a hypothetical situation.If records of costs are not readily available, you may use a "best guess"allowing for annual inflation costs.

Three paving options are listed in Figure 17. Each includes estimated costs for paving and an estimated pavement life. You should obtain up-to-date cost estimates and expected pavement life figures for these and other paving options by talking to your state department of transportation,contractors, and neighboring towns and counties.

YEAR	1	2	3	4	5	6	TOTALS
GRADING							
Equipment	270	280	290	300	310	320	1,770
Labor	90	100	110	120	130	140	690
REGRAVEL							
Materials	–	–	4,000	–	–	–	4,000
Equipment	–	–	2,500	–	–	–	2,500
Labor	–	–	2,300	–	–	–	2,300
STABILIZATION/DUST CONTROL							
Materials	800	900	1,200	920	950	975	5,745
Equipment	30	35	70	40	50	60	285
Labor	100	110	150	125	140	150	775
Totals	1,290	1,425	10,620	1,505	1,580	1,645	$18,065

Figure 16: Gravel Road Maintenance Cost Per Mile

Let's consider the cost of a double surface treatment operation and the projected cost of maintaining it before anything major has to be done to the pavement (end of pavement life). We see in Figure 17 that the estimated cost to double surface treat one mile of road is $20,533. Estimated maintenance costs over a six-year period could be:

Patching	$1,800	Total maintenance	$4,300
Striping	$500	Construction	$20,533
Sealing	$2,000	Total cost over six years	$24,833
	$4,300		

When we compare this cost to the cost of maintaining an average mile of gravel road over the same period of six years ($18,065), we find a difference in dollar costs of $6,768.It is not cost beneficial to pave in this hypothetical example, even without considering the costs of road preparation (#7).

This is not a foolproof method, but it does give us a handle on relative maintenance costs in relation to paving costs and pavement life. The more accurate the information,the more accurate the comparisons will be. The same method can be used in helping to make the decision to turn paved roads back to gravel.

Option	Life	Cost Per Mile	Cost/Mile Per Year	Calculations	Maintenance Per Mile/Year
Chip Seal-Double Surface Treatment	6 yrs.	$20,533	$3,422	Based on price of $1.75 per sy; 20 ft. wide x 5,280 ft. = 105,600 sf 105,600 sf ÷ 9 = 11,733 sy 5 $1.75 = $20,533	?
Bituminous Concrete-Hot Mix	12 yrs.	$58,080	$4,840	Based on estimated price of $30 per ton; 1 sy of stone and hot mix/ cold mix 1" thick weighs about 110 lbs. Therefore 3" = 330 lbs. per sy. 11,733 sy (1 mile of pavement) 5 330 lbs. = 3,871,890 lbs. 3,871,890 lbs. = 1936T x $30 = $58,080	?
Cold Mix	8 yrs.	$48,390	$6,048	At $30 per ton, using same formula as hot mix, 2 1/2" of cold mix equals 1,613T x $30 = $48,390	?

*These costs must be determined before any conclusions can be reached regarding the most cost-effective pavement method. The thinner the pavement, the greater the maintenance cost. Traffic, weather conditions, proper preparation before paving and many other factors can affect maintenance costs. No Kentucky data exists upon which to base estimates of maintenance costs on low volume roads of these paving options; and, therefore, we offer no conclusion as to the "best" way to pave.

Figure 17: Paving Options (Costs and road life are estimates and may vary)

Answer 9: After Comparing User Costs

Not all road costs are reflected in a highway budget. There is a significant difference in the cost to the user between driving on a gravel surface and on a paved surface. User costs, therefore, are appropriate to consider in the pave/not pave decision. By including vehicle-operating costs with construction and maintenance costs, a more comprehensive total cost can be derived.

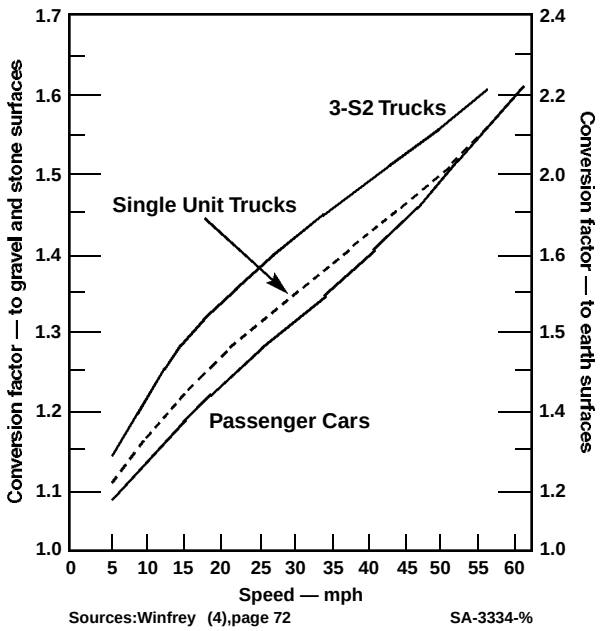
Vehicles cost more to operate on gravel surfaces than on paved surfaces, often 2 or 3 times greater than for bituminous concrete roads in the same locations. There is greater rolling resistance and less traction which increase fuel consumption. The roughness of the surface contributes to additional tire wear and influences maintenance and repair expenses. Dust causes extra engine wear, oil consumption and maintenance costs. Figure 18 from AASHTO'S "A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements" shows the impacts of gravel surfaces on user costs. For example, an average running speed of 40 MPH on a gravel surface will increase the user costs of passenger cars by 40% (1.4 conversion factor). The general public is not aware that their costs would actually be less if some of these roads were surface treated.

Add to the gravel road maintenance the user costs over a six-year period. Estimate an average daily traffic (ADT) of 100 cars and 50 single unit trucks, traveling at 40 mph. Estimate that it costs $.25 per mile to operate the vehicles on pavement. Using the chart in Figure 3, we see it costs 1.4 times as much (or $.35) to drive a car 40 mph one mile on gravel road and 1.43 times as much (or $.36) to drive a single unit (straight frame) truck 40 mph one mile on gravel road.

100 cars x 365 days x $.10 added cost x 1 mile = $3,650

50 trucks x 365 days x $.11 added cost x 1 mile = $2,008

User costs for the gravel road is $5,659 per year or $33,954 for a six-year period.Assuming we still do not consider road preparation costs, it now appears justified to pave the road.Such an approach can be used to establish a "rule of thumb"ADT. For example, some agencies give serious consideration to paving roads with an ADT above 125.



To use this chart, determine the type of vehicle, the speed and the type of road surface. Follow the speed line vertically to the vehicle type. Go horizontally to multiplier factor of road surface. Multiply the cost of travelling on a paved surface by this number to determine the cost of operating the same vehicle on gravel surface or dirt surface. Example: If it costs 28¢ per mile to operate a passenger car* at 40 mph on pavement, it will cost 39¢ per mile to operate it on a gravel road at the same speed and 50¢ per mile on a dirt road.

*1984 Federal Highway Administration Statistics quotes an operating cost of 28¢ per mile for an intermediate size passenger car traveling on average suburban pavement. You must determine your own vehicle operating costs on pavement in order to use these multiplicative factors to calculate

Figure 18: Impacts of Gravel Surfaces on User Costs

Answer 10: After Weighing Public Opinion

Public opinion as to whether to pave a road can be revealing, but it should not be relied upon to the exclusion of any one of points 1-9 already discussed.If a decision to pave is not based on facts, it can be very costly. Public opinion should not be ignored, of course, but there is an obligation by government leaders to inform the public about other important factors before making the decision to pave.

Stage Construction

Local government may consider using "stage construction design"as an approach to improving roads. This is how it works. A design is prepared for the completed road,from base and drainage to completed paving. Rather than accomplishing all the work in one season, the construction is spread out over three to five years. Paving occurs only after the base and drainage have been proven over approximately one year. Crushed gravel treated with calcium chloride serves as the wearing course for the interim period. Once all weak spots have been repaired,the road can be shaped for paving.

There are some advantages to keeping a road open to traffic for one or more seasons before paving:

1. Weak spots that show up in the sub-grade or base can be corrected before the hard surface is applied,eliminating later expensive repair;
2. Risky late season paving is eliminated;
3. More mileage is improved sooner;
4. The cost of construction is spread over several years.

Note:Advantages may disappear if timely maintenance is not performed. Surface may deteriorate more rapidly because it is thinner than a designed pavement.

Summary

Some local roads are not well engineered. Today, larger volumes of heavy trucks and other vehicles are weakening them at a fast rate. Paving roads as a sole means of improving them without considering other factors is almost always a costly mistake. Counties and cities should consider these ten points first. Carefully considering them will help to assure local government officials that they are making the right decision about paving a gravel road.