A Monitoring Program for Wyoming County Paved Roads

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BACKGROUND

Most asphalt county roads within the state of Wyoming were built several decades ago. They were not built to withstand the very heavy loads that often accompany modern industrial activities such as oil and gas drilling. When industrial activities are widely dispersed, roads built to carry lighter traffic are often subjected to more additional loads than they can handle. Assessing the condition of these roads before the additional traffic arrives provides baseline information on the county roads' conditions, allowing for realistic and defensible evaluations of the impacts of increased traffic. Such information can also be used to recommend maintenance and structural enhancements to improve a road's ability to carry heavy loads, potentially preventing the expenditure of many millions of dollars in unnecessary repair and rehabilitation work by properly applying preventive maintenance.

This proposal describes a way of providing information that will allow appropriate measures to be taken to prevent a large economic loss to Wyoming's counties in the form of irreversible damage to the state's paved county roads. The elements of county road networks which are affected by increases in heavy traffic are described, followed by descriptions of the objectives and benefits of the proposed monitoring system. A detailed work plan is presented which outlines the specifics of how paved county roads would be monitored and evaluated.

County Road Networks

A county road and bridge network has many elements. Many but not all of these may deteriorate more quickly as traffic increases. Those elements most likely to be damaged by increases in heavy truck traffic are described below, along with the prospects for managing them.

Paved Roads

Paved roads are vulnerable to complete destruction due to an influx of heavy trucks, particularly older ones with limited structural capacity, as so many paved county roads are. The cost of reconstructing a paved road largely destroyed by heavy traffic could approach $1 million per mile. The costs of preventing such losses are also high. Structural improvements allowing a road to carry more heavy loads generally consist of asphalt pavement overlays or more expensive rehabilitation, depending on a road's current condition and structure. If a paved road fails and it is concluded that it should be allowed to become an unpaved road, even this process is expensive since the pavement must be ground up and blended to return it to a state where it can be maintained like any other unpaved road. There are no inexpensive options when a paved road fails.

The narrow width of many paved county roads creates a rehabilitation problem. Roads narrower than about 26 feet are not recommended for an overlay since they should have two-lanes at least 24 feet wide. There are two basic reasons for this limitation. First, narrower roads are more dangerous, and, second, narrower roads are more prone to edge break-up. Therefore, when narrower roads are in need of structural improvement to withstand anticipated increases in heavy traffic, they should be widened. The cost of such an improvement will vary depending on an individual road's needs, geometry and drainage. Figure 1 illustrates how a lane might be narrowed by an overlay, making the road more dangerous and causing people to drive closer to the shoulder, leading to more pavement edge break-up. Therefore, for narrower paved roads, simple overlays are less desirable.

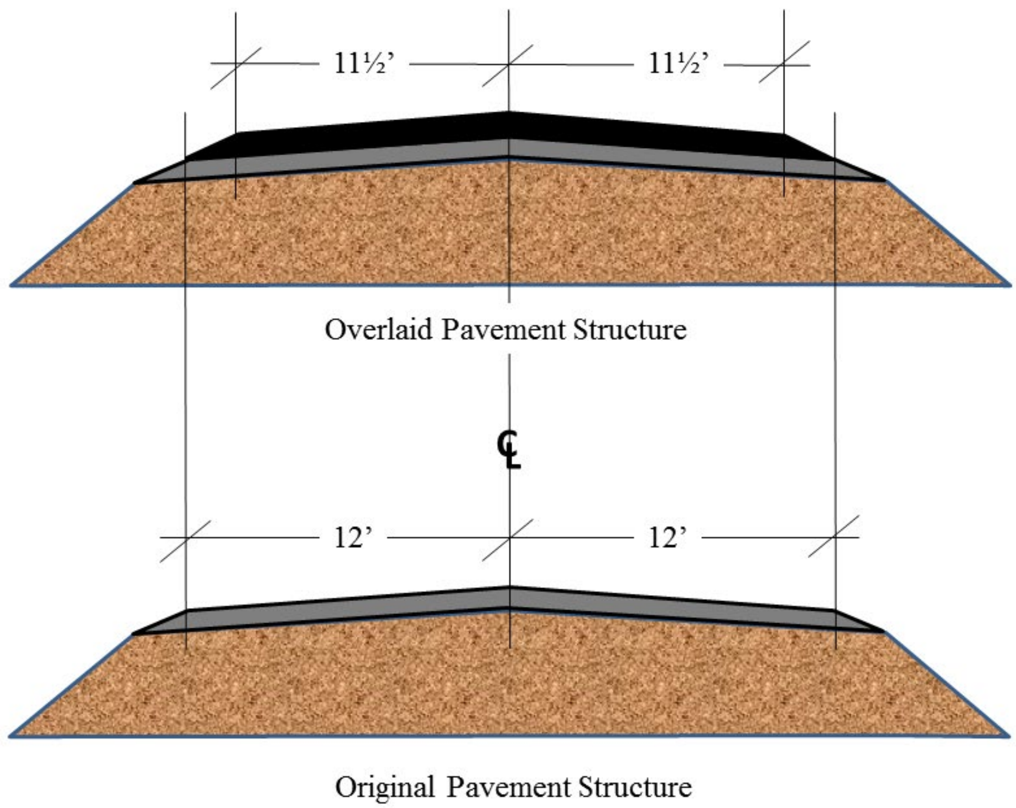

Figure 1. Lane narrowing brought about by a 3 inch overlay with a 2:1 edge slope (not to scale).

Unpaved Roads

Unpaved roads are fundamentally different from paved roads in several ways. They usually deliver a lower level of service to the traveling public. Travel speeds are generally slower and vehicle and user costs per mile traveled are generally higher. Balancing this, unpaved roads are much cheaper to construct. Road damage costs due to heavy trucks are relatively limited. Replacing gravel on an unpaved road costs in the neighborhood of $50,000 per mile. New gravel might need to be added every three years, perhaps as opposed to every few decades. Heavy traffic may greatly increase routine maintenance costs. It would not be particularly surprising if annual blade maintenance costs went from $1,500 per mile per year to $15,000 per mile per year due to increases in traffic, particularly heavy truck traffic, as routine maintenance frequencies go from several times per year to several times per month. Therefore, additional costs to an unpaved road could be as high as $30,000 per mile per year. Compared to the potential loss of investment on paved roads, this value is small.

Longer Bridges

Since WYDOT inspects bridges with over a 20 foot span, they are already adequately monitored. Thus, data is available to assess the risks to the majority of county bridges.

Short Span Bridges and Larger Culverts

County bridges with a span of less than 20 feet and larger culverts are not monitored by WYDOT. However, they may suffer considerable damage from influxes of heavy traffic. For this reason, performing some assessments of their conditions might be worthwhile. (Smaller culverts, perhaps those less than 36 inches in diameter, are so numerous and difficult to locate that a statewide assessment of their conditions would be impractical. Smaller culverts are also less vulnerable to damage from heavy trucks.)

The T^2 Center developed a method to evaluate these short span bridges and larger culverts and implement that methodology in Laramie County. The Center plans to present a proposal to monitor these intermediate-sized drainage structures in the future.

Cattle Guards

Cattle guards represent a far smaller financial investment than the roads themselves. Therefore, the cost of any damage caused by traffic increases is limited. Four southeastern Wyoming counties' remaining cattle guards' value was estimated to be 67% of their replacement value. The average current value of their cattle guards is about $1.46 million per county. This relatively small value, combined with the fairly durable nature of cattle guards, probably means that it would not make sense to spend effort on statewide cattle guard management at this time.

Risk Assessment

In terms of total investment costs, Wyoming county road networks are dominated by paved roads, unpaved roads, and bridges. As the discussions above indicate, unpaved roads, though they are easily damaged by heavy traffic, are relatively inexpensive to repair. Therefore, damage to unpaved roads poses a relatively small risk to Wyoming counties. Larger bridges are monitored by WYDOT, so no additional monitoring is needed. Short span bridges and larger culverts should be further evaluated in the future as a source of risk in the event of significant increases in heavy traffic. Paved roads are particularly vulnerable to damage by heavy traffic, and this damage is expensive to prevent and even more expensive to repair. It's even expensive to return a paved road to a gravel road. The greatest undocumented risk due to sudden increases in heavy truck traffic on Wyoming county road and bridge networks is to paved county roads.

There are several reasons for this. First of all, most paved county roads have historically served very low traffic volumes. They lack the structural strength to carry many heavy loads, particularly in spring when the base and subgrade materials are wet and soft. Many agricultural producers recognize that when road bases are wet, roads are vulnerable so they try not to use them at these times. They will rely on these same roads a decade from now, so they want them to last. For oil and gas drilling companies, seasonally restricting their activities is not likely to be successful, short of legal means. They must get the rig, the water, or the drill stems to the site now or lots of money will be lost. The combination of heavy loads at all times of the year, structurally weak pavement sections, and high repair and replacement costs makes paved county roads very vulnerable to sudden influxes of heavy traffic. The possibility of rapid, severe, and expensive damage to their paved county roads comprises a major risk to many Wyoming counties.

During 2011 and 2012 the T^2 Center performed a study documenting the condition of four southeastern Wyoming counties' road networks. The initial proposal defined the work to be performed *(Ksaibati 2011)*. The final report completed in February 2013 evaluated paved roads, unpaved roads, and cattle guards in Converse, Goshen, Laramie and Platte Counties *(Huntington et al 2013)*. Methods were developed to generate recommended improvement costs for the roads and current values of the cattle guards. Figure 2 shows recommended upgrade costs for the roads and the total values of each county's cattle guards.

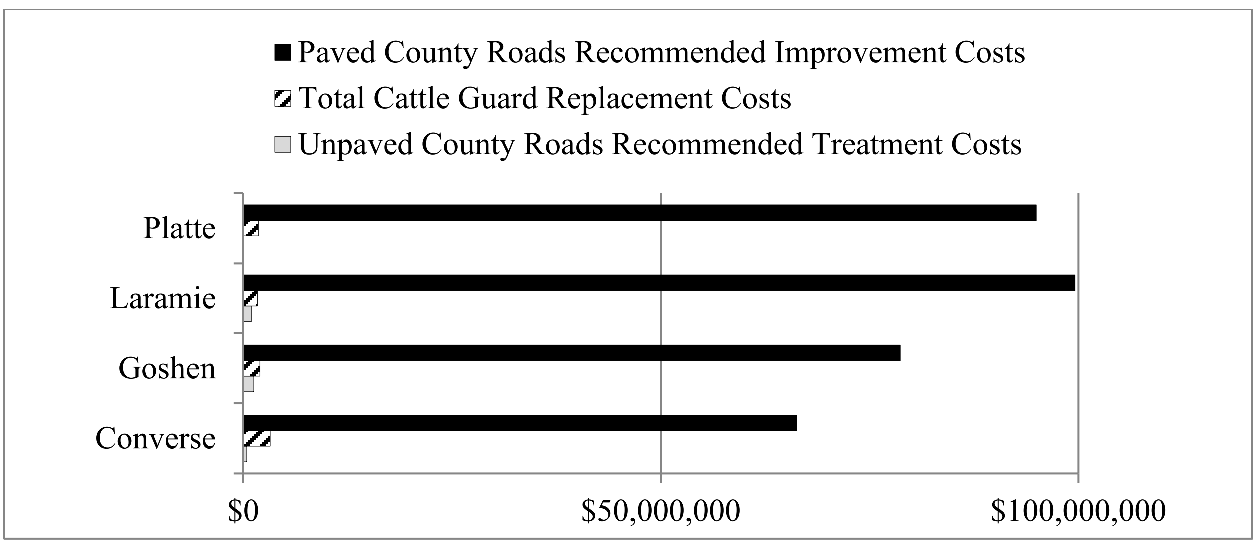

Figure 2. County roads upgrade costs and total cattle guards replacement values.

As is clear from Figure 2, upgrade costs associated with paved roads dwarf those for cattle guards and unpaved roads. This indicated that there is already a greater backlog of desirable improvements on the four counties' paved roads than for their cattle guards or unpaved roads. It also indicated that the financial impacts of additional truck traffic on paved county roads are far greater than the potential impacts on unpaved roads or cattle guards. This confirms that the greatest risk to county road networks is paved road damage.

Pavement Monitoring Objectives

Oil and gas development generally happens quickly. The wheels of government often turn slowly, but the drilling industry won't wait for roads to be upgraded sufficiently to carry the impending traffic loads. The following proposal outlines several options which will provide varying amounts of information about the conditions and possible treatment options available for Wyoming counties' paved roads. The data collection activities proposed below provide data that could be used to quantify damage done to paved county roads, to determine each road's vulnerability to damage from increased truck traffic, and to recommend appropriate maintenance and construction practices for individual roads under various traffic loads, depending on which data collection option is selected and how this data is analyzed.

The state legislature recognized threats to the county road networks of Converse, Goshen, Laramie and Platte Counties, and as a result they funded the recently completed study by the T^2 Center. This study documented and quantified the risks to cattle guards, unpaved and paved county roads. As shown in Figure 3, the results of this study have been presented to WCCA, WACERS and WYDOT. The proposed pavement monitoring would provide information that will allow the state and the counties to react appropriately as heavy traffic using paved county roads increases.

Consistency in data collection throughout the state is essential if any statewide efforts are to be made to quickly respond to imminent, rapid increases in heavy traffic on paved roads. Ideally, this consistency will apply to both paved county roads and to state highways. WYDOT contracts annually with Pathway Services® to survey the state highways. This contract could be expanded to include paved county roads. By using the same data collection procedures on the state and county roads, comparisons may be made between the networks.

Several options may be pursued. Figure 3 shows a composite of all options. Figures 4 through 8 show each option individually, while Table 1 shows the information that will be available with each option. For options I, II and III, sub-option A may be selected which only provides the raw data and unprocessed video logs, while sub-option B also provides summaries of each county's data. Options I through IV were developed by the T^2 Center and presented to WACERS on April 2, 2014. WACERS selected those components they felt were the most important at this time and called it option V, as shown in Table 1 and Figure 8, which they voted unanimously to support.

The Pathway Services® automated data collection van which operates at normal highway speeds is fundamental to all options. Three types of information are provided for each paved road segment the van analyzes: Automated roughness data expressed as the international roughness index (IRI); automated rutting data expressed in inches (RUT); and video logs of the pavement and roadside. All roads must be divided into segments so those who operate the van know when to begin and end their data collection. This segmentation will be performed by T^2 Center staff in consultation with county personnel. To provide useful information, this data must be analyzed.

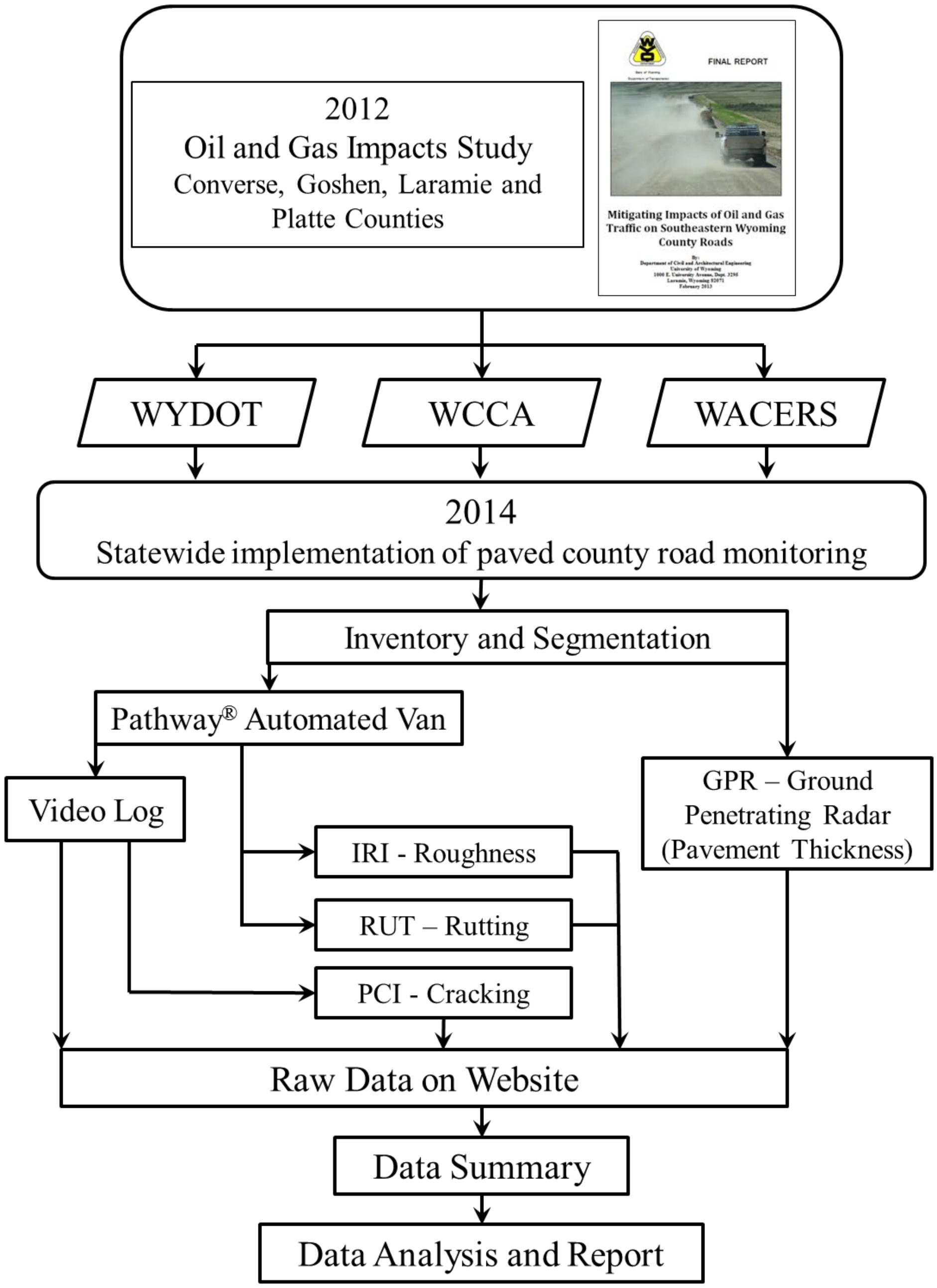

Figure 3. County road assessment processes.

A pavement condition index (PCI) may be generated by observing the video logs from the camera facing the pavement. For each segment, several sections are sampled and distresses are measured by an operator watching videos of the pavement on a computer with specialized software that facilitates distress evaluation. From these distress measurements, the PCI is calculated.

Pavement thicknesses may be established using ground penetrating radar (GPR). This data is collected by specialized vehicles traveling at normal highway speeds. Specialized software is used to convert the signals from the GPR into pavement thicknesses.

Table 1. Information Available with Several Proposed Options

	Options							
	IA	IB	IIA	IIB	IIIA	IIIB	IV	V
Inventory & Segmentation	√	√	√	√	√	√	√	√
IRI - Roughness for individual segments	√	√	√	√	√	√	√	√
RUT - Rutting for individual segments	√	√	√	√	√	√	√	√
Video log without processing	√	√	√	√	√	√	√	√
PCI - Pavement Condition Index			√	√			√	√
GPR - Pavement thickness					√	√	√	√
Raw data on website	√	√	√	√	√	√	√	√
Data Summary		√		√		√	√	
Data Analysis and Report							√	

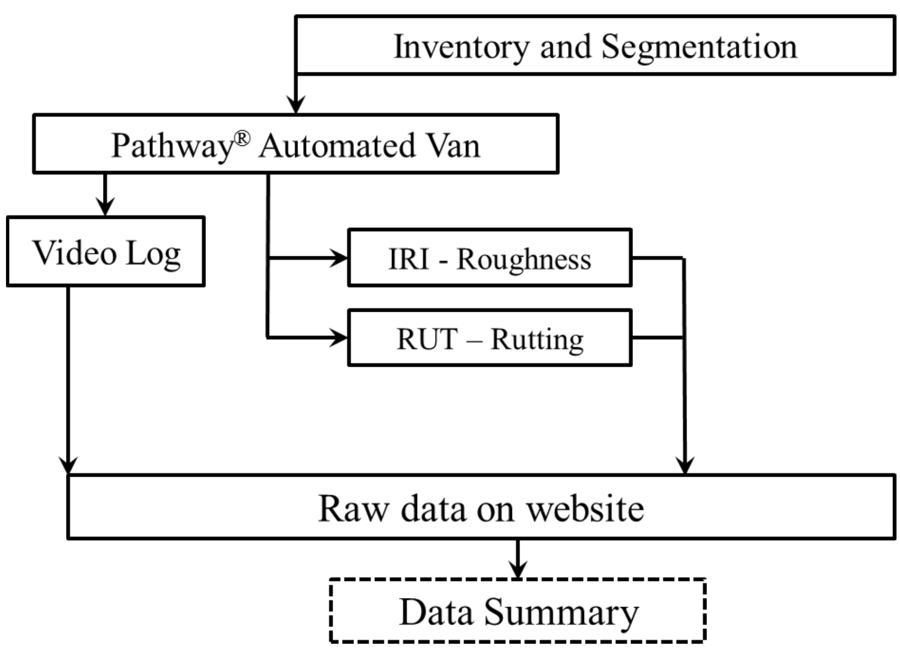

Figure 4. Option I (IB includes a data summary, IA does not).

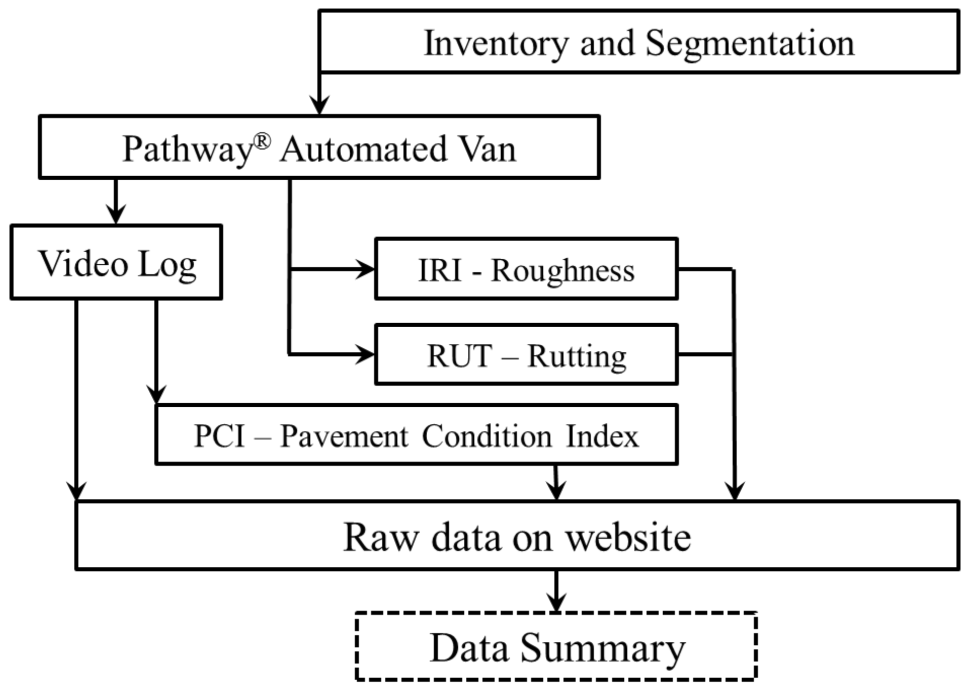

Figure 5. Option II (IIB includes a data summary, IIA does not).

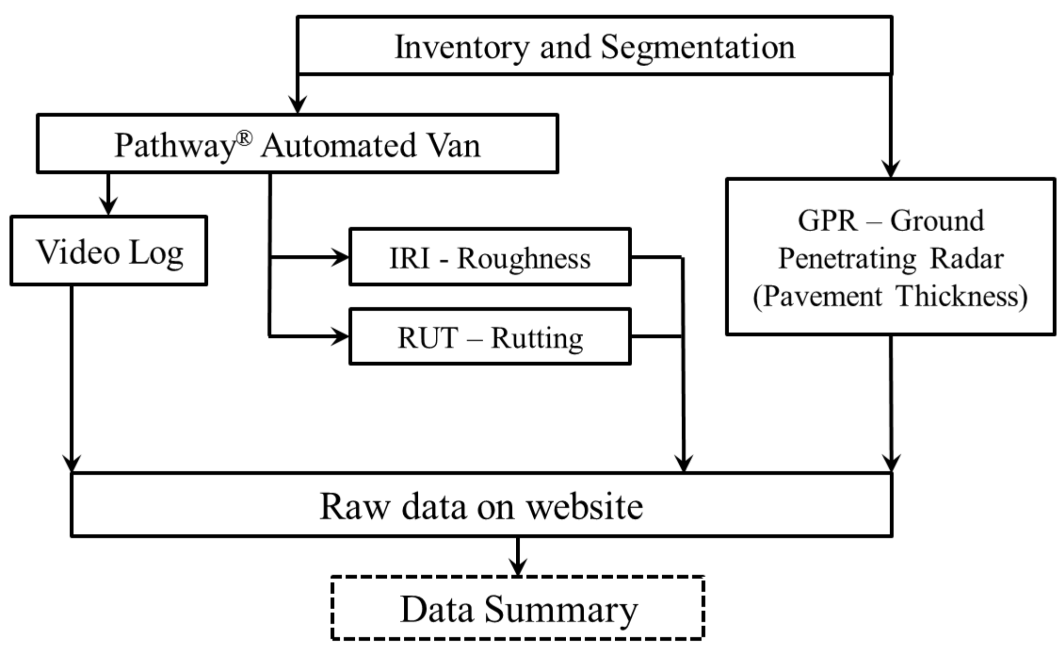

Figure 6. Option III (IIIB includes a data summary, IIIA does not).

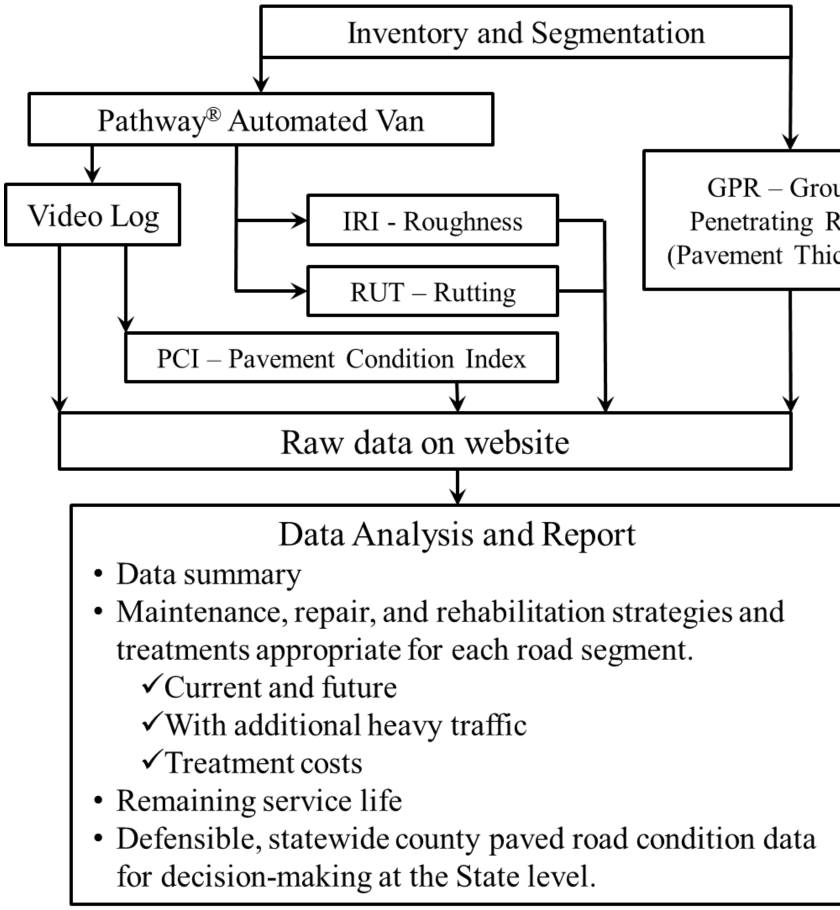

Figure 7. Option IV.

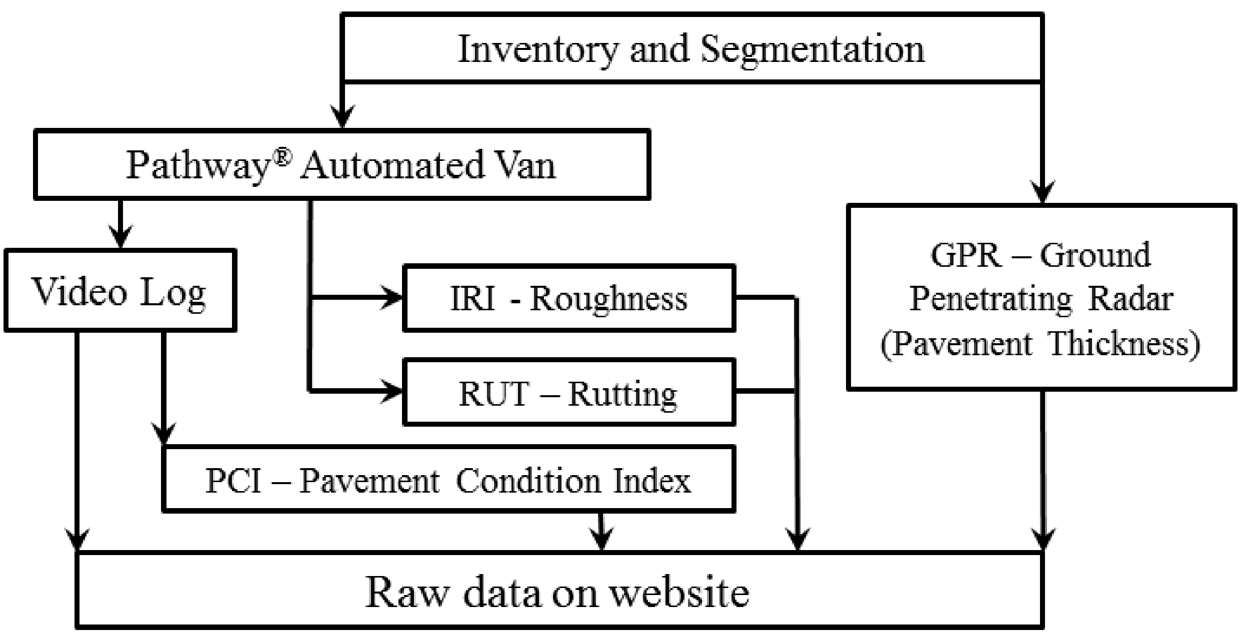

Figure 8. Option V selected by WACERS.

Pavement Monitoring Benefits

Several specific benefits may be realized from the proposed county paved road monitoring. The primary benefits would include:

1) Current county road surface conditions could be directly identified, allowing appropriate decisions to be made.
2) Impacts to paved county roads due to oil and gas drilling or other industrial activities could be assessed and evaluated.
3) The success of treatment methods used on various county roads could be evaluated and adopted by other counties who might learn from their neighbors.
4) WYDOT pavement management system data and decision processes could be used to provide insights into possible treatment methods on paved county roads.
5) Appropriate maintenance, repair and rehabilitation strategies could be developed for individual roads. These strategies could be based on both current conditions and on individual road segments' structural ability to carry anticipated traffic regardless of its source.
6) Future maintenance and rehabilitation needs could be projected using surface condition and layer thickness data.
7) Counties with limited resources would not need to develop their own methods for monitoring or analyzing their paved roads.
8) The state legislature could be provided with defensible data justifying funding for paved county roads.

Ultimately, the greatest single benefit from this monitoring will be to provide county road and bridge supervisors, county commissioners, state legislators, and other decision-makers with adequate information to act in the public's best interests.

WORK PLAN

Two basic properties of a road can be quantified – surface conditions and structural strength. Both these properties should be evaluated to provide an overall road assessment. In simplest terms, surface conditions indicate the current quality of a road, while structural strength indicates a road's ability to carry more heavy traffic. These two properties combined can be used to predict a road's performance under various circumstances.

In the first year, all 2,511 miles of paved county roads will be monitored. Biennial monitoring is proposed in subsequent years, with possible geographic splits as shown in Figures 4 and 5. Half of the state's paved county roads would be monitored each year, so each paved road would be monitored every other year as WYDOT does for its lower classification roads. Table 2 shows each county's paved road mileage.

Segmentation

When analyzing the state highway network, the roads are segmented based on construction histories. When WYDOT contracts for major work on their roads, they do so in discrete road segments with well-defined beginning and ending points, often referred to as projects. These segments provide convenient and consistent analytical units for the state highway system. Segmentation for this project will be performed by T^2 Center staff in consultation with county personnel. This segmentation is essential since those collecting data need to know where to begin and end their activities, and since any analysis must be performed on discrete, defined road segments.

Table 2. County Paved Road Mileages

County	Paved Mileage	County	Paved Mileage
Albany	40.3	Natrona	142.6
Big Horn	112.3	Niobrara	3.3
Campbell	187.7	Park	271.1
Carbon	68.7	Platte	157.3
Converse	102.4	Sheridan	25.6
Crook	52.6	Sublette	82.1
Fremont	230.3	Sweetwater	153.8
Goshen	127.6	Teton	65.7
Hot Springs	82.7	Uinta	43.0
Johnson	106.9	Washakie	44.4
Laramie	221.8	Weston	4.7
Lincoln	184.6	TOTAL	2,511.4

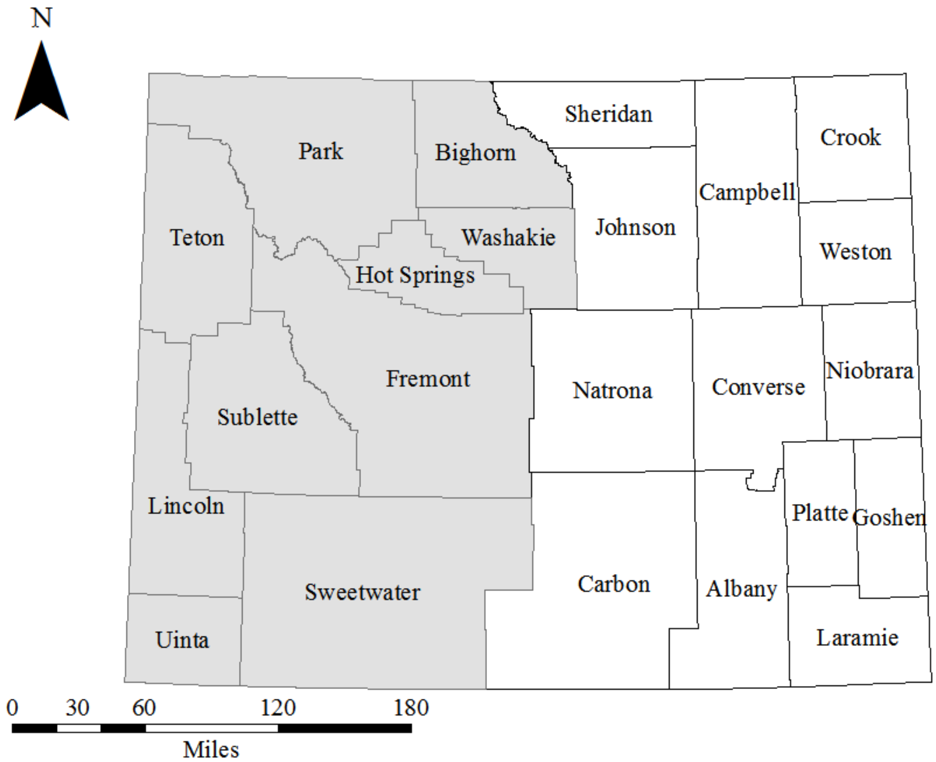

Figure 9. Option A: W-E split (W 1,270 miles; E 1,241 miles).

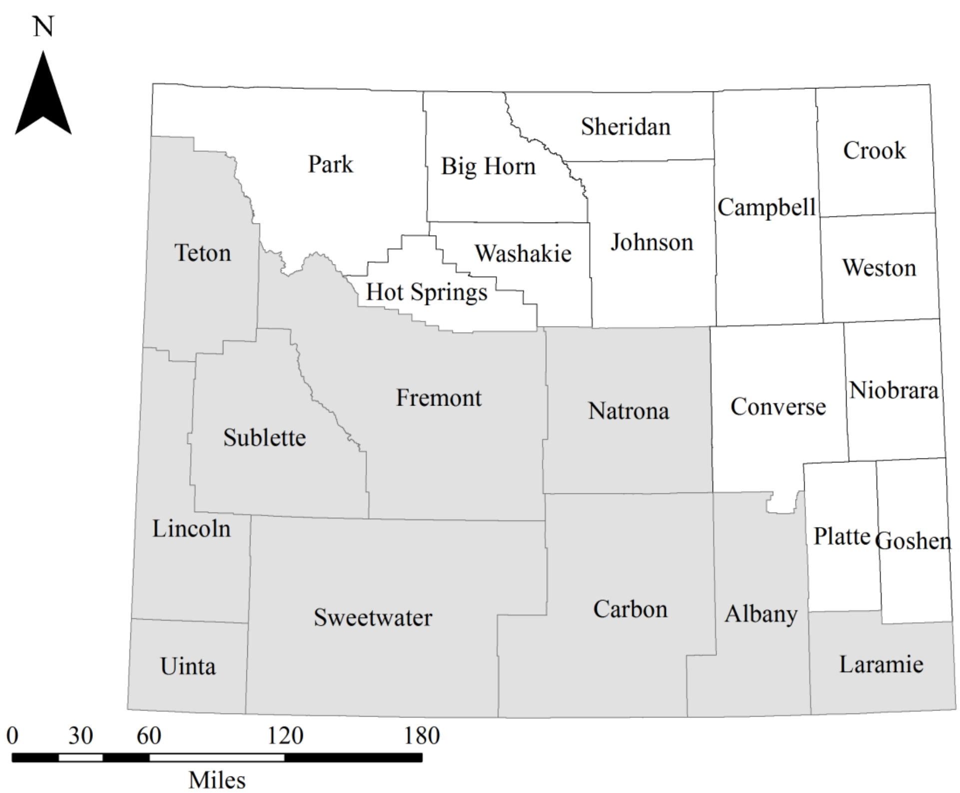

Figure 10. Option B: SW-NE split (SW 1,278 miles; NE 1,233 miles).

County roads should be divided into discrete segments for analytical purposes. Segment break points should be identified and established while driving the paved county roads with GPS location and GIS software. Several criteria should be used when identifying these break points, including:

- Major changes in traffic volume
    - Industrial activities
    - Subdivisions
    - Major intersections
- Major changes in surfacing
    - Surfacing type
    - Surfacing condition
    - Top width
- Major alignment changes
    - Design speed
    - Curve degree and frequency
    - Hills and grade

Segments are typically several miles long, ranging from a few tenths of a mile up to as long as perhaps fifteen miles.

Surface Condition Monitoring

WYDOT annually contracts with Pathway Services® to monitor the state highways with a van specially equipped for the purpose. As part of a prior T^2 Center study, Pathway monitored the paved county roads in Converse, Goshen, Laramie and Platte Counties in 2012 with their van which has sensors that measure rut depths and ride quality as quantified by the international roughness index (IRI). The van also has cameras mounted on it, some of which face downwards *(Pathway Services 2010)*. The videos made from these cameras may be evaluated to quantify cracking, generating a pavement condition index (PCI). Since considerable effort is needed to quantify the cracks from the videos, PCI data is somewhat more expensive. However, water infiltration is a leading cause of pavement failure, and cracks allow water into the pavement structure. The general consensus among the members of WACERS is that the extra effort to perform PCI analyses is worth it since cracking indicates both ride quality and pavement durability.

To arrive at a PCI for each segment, WYDOT samples 1,000 foot segments beginning at each milepost, alternating lanes. This should be modified to use only one lane, thereby reducing data collection costs. For the entirety of each sampled segment, the following distresses are measured and evaluated:

- Longitudinal cracking: sealed and unsealed
- Transverse cracking: sealed and unsealed

- Alligator/fatigue cracking
- Block cracking
- Bleeding
- Raveling
- Patching

These distresses are observed on the video for each 1,000 foot segment and entered using Pathway's PSINT software. The software then takes the distress entries and uses them to calculate a PCI. The T^2 Center will analyze all the condition data collected by Pathway.

Structural Strength Monitoring

Structural strength is largely a function of the asphalt layer(s) and base layer(s) thicknesses. Traditionally, thicknesses have been determined either by coring or from as-built construction plans. Unfortunately many county road and bridge departments do not have good historical records that indicate layer thicknesses. In addition, many asphalt county roads consist of chip seals on top of a base, often referred to as invert pen, blotter, chip seal, or bituminous surface treated roads. Still other long-forgotten construction methods were probably also used to build county asphalt roads. There are two methods for determining layer thicknesses, described below.

Layer Thickness Determination

Coring

Holes may be drilled in the pavement surface allowing for measurement of each pavement layer's thickness. This method is expensive and labor-intensive. It provides only point data, so a core may not be representative of the entire segment and it may miss large areas of weakness. When preparing to perform rehabilitation, it is very useful for assessing the current condition of existing pavement layers. However, it is not practical for network-wide assessments such as the one proposed.

Ground Penetrating Radar (GPR)

Recently, advances in ground penetrating radar (GPR) technology have made it possible to determine the thickness of pavement layers with a specially equipped van traveling at normal highway speeds. As described above, a large portion of paved county roads have unknown thicknesses. Several contractors conduct GPR surveys to evaluate pavement layer thicknesses. If one were hired, they could provide current layer thicknesses for all the paved county roads in the state.

Thickness Method Selection

Recent advances in GPR allow for pavement layer thicknesses to be generated with a van traveling at highway speeds. Coring is expensive and impractical for network-wide analysis. Like the Pathway data collection van, GPR data may be collected at typical highway speeds, making data collection both faster and safer. A GPR data collection event would allow for reasonably priced acquisition of pavement layer thicknesses on all the paved county roads throughout the state.

Ongoing Data Collection

Once GPR data has been collected, the counties could then be sure to keep good records so they could adopt the state's system of updating thicknesses based on construction records. This would mean counties would need to track all future construction and project-wide maintenance. With a computer as the primary tool in this record keeping effort, this task should be much easier than it once was. Still, it might be advisable to provide the counties with systematic support for this record-keeping task. If this data is not collected, with time the data collected with GPR would become less and less accurate. Also, as projects are worked on and coring or falling weight deflectometer (FWD) data is collected, this information could be used to corroborate, adjust, and update the GPR thickness data.

Falling Weight Deflectometer (FWD)

Use of the FWD may be proposed for future analysis of paved county roads. It consists of a heavy weight dropped several feet onto a one-foot diameter plate placed on the pavement, typically with from 6,000 to 12,000 pounds of force. Sensors measure the flexure of the road. The degree of flexure at the plate and at several points out to about five feet from the load plate provides an indication of a road's surface, base, and subgrade strengths. When combined with thickness data from the GPR, FWD provides additional information about a pavement's structural strength.

Data Analysis (Option IV Only)

There are many ways in which the data collected in Option IV could be used. Examples of these may be found in the final report from the prior study, *Mitigating Impacts of Oil and Gas Traffic on Southeastern Wyoming County Roads*, February 2013. In addition, with the layer thickness information obtained with the GPR, additional projections, primarily remaining service life (RSL), could be made.

Surface Conditions

Present Serviceability Index (PSI)

The present serviceability index (PSI) is a measure on a scale of 0-Failed to 5-Excellent of the quality of the road surface as perceived by the public. The original PSI was generated from the AASHO road tests conducted in the late 1950's. WYDOT developed an equation to generate PSI using the Pathway inputs – roughness, rutting and cracking – in 1996. Figure 6 maps the condition of Converse County's paved roads as expressed by the PSI using the following scale:

- PSI > 3.5: Excellent
- 3.5 > PSI > 3.0: Good
- 3.0 > PSI > 2.5: Fair

- 2.5 > PSI: Poor

Figure 7 shows the PSIs for Converse, Goshen, Laramie and Platte Counties' paved roads, while Figure 8 shows the PSI for the four counties' paved roads compared to the state secondary, primary and interstate roads.

Top Widths

As described earlier, top widths affect both safety and durability. Wider roads are both safer and less prone to edge breakup. Roads with top widths of 28 feet or more may receive a thick overlay and roads with top widths of 26 feet or more may receive a thin overlay, both without widening. For narrower roads, widening is needed if overlays are to be performed. Figure 9 shows the top widths for the four counties previously monitored.

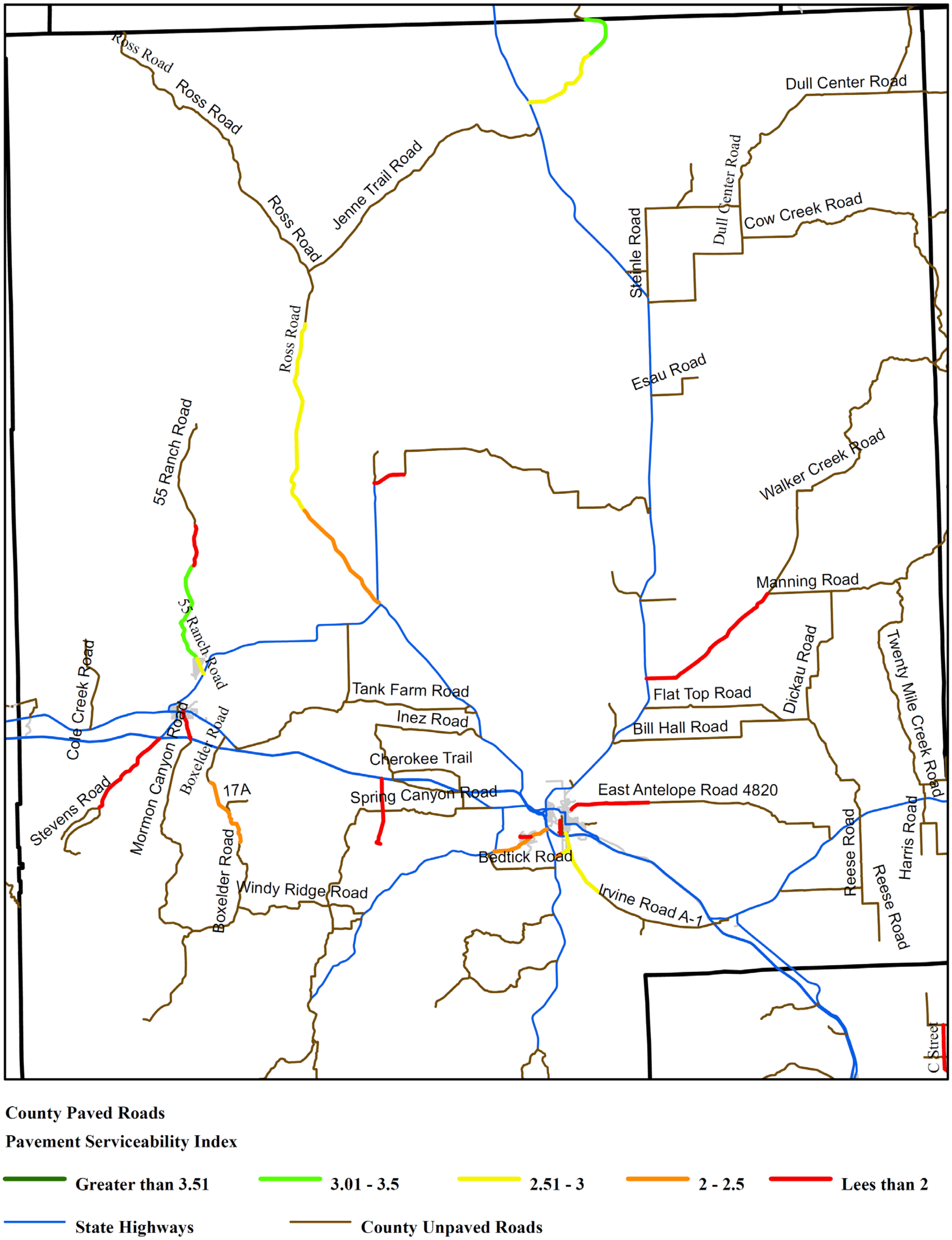

Figure 11. PSI of Converse County paved roads in 2012.

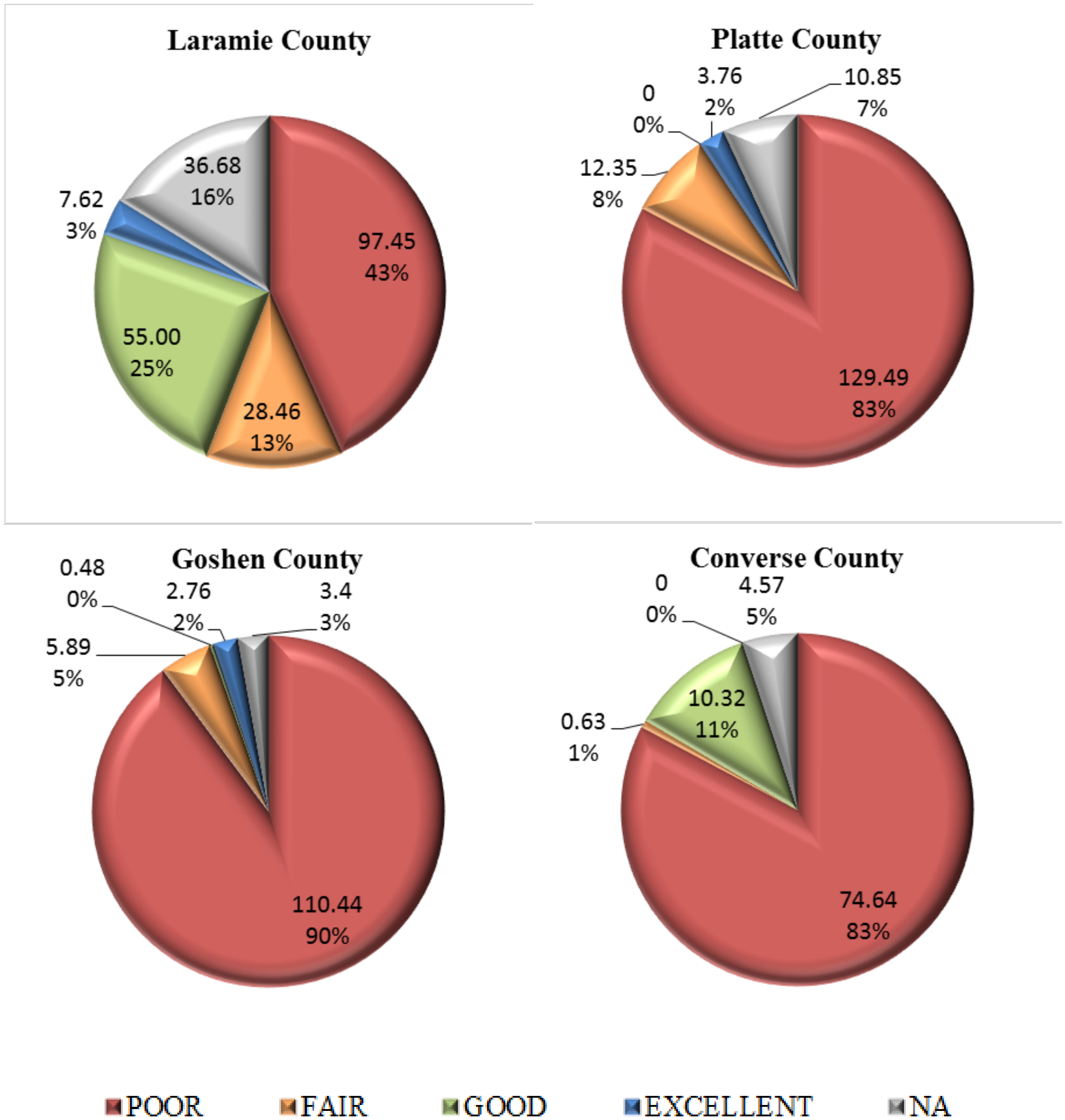

Figure 12. Paved county road conditions from the PSI.

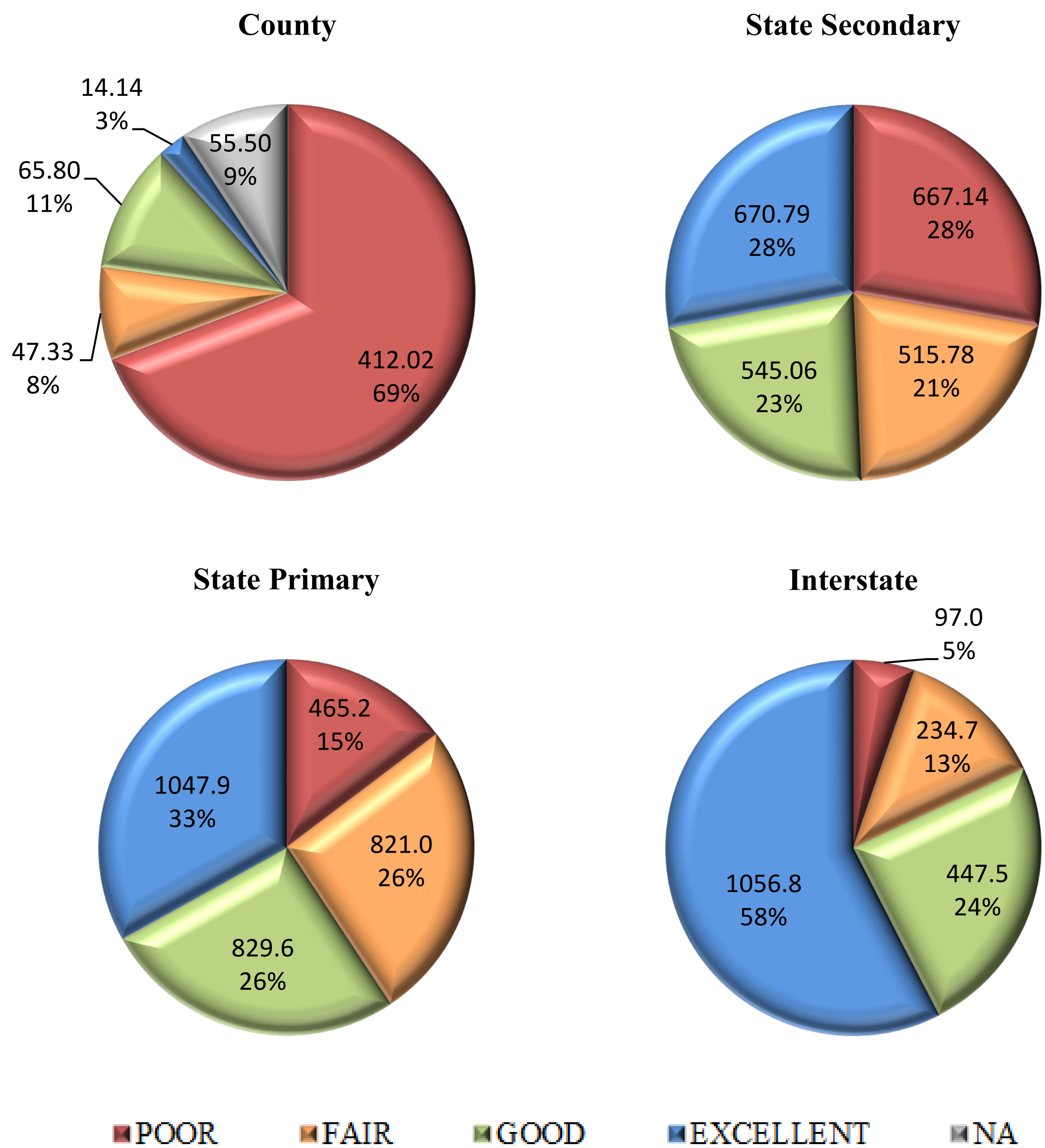

Figure 13. PSI mileages by road class.

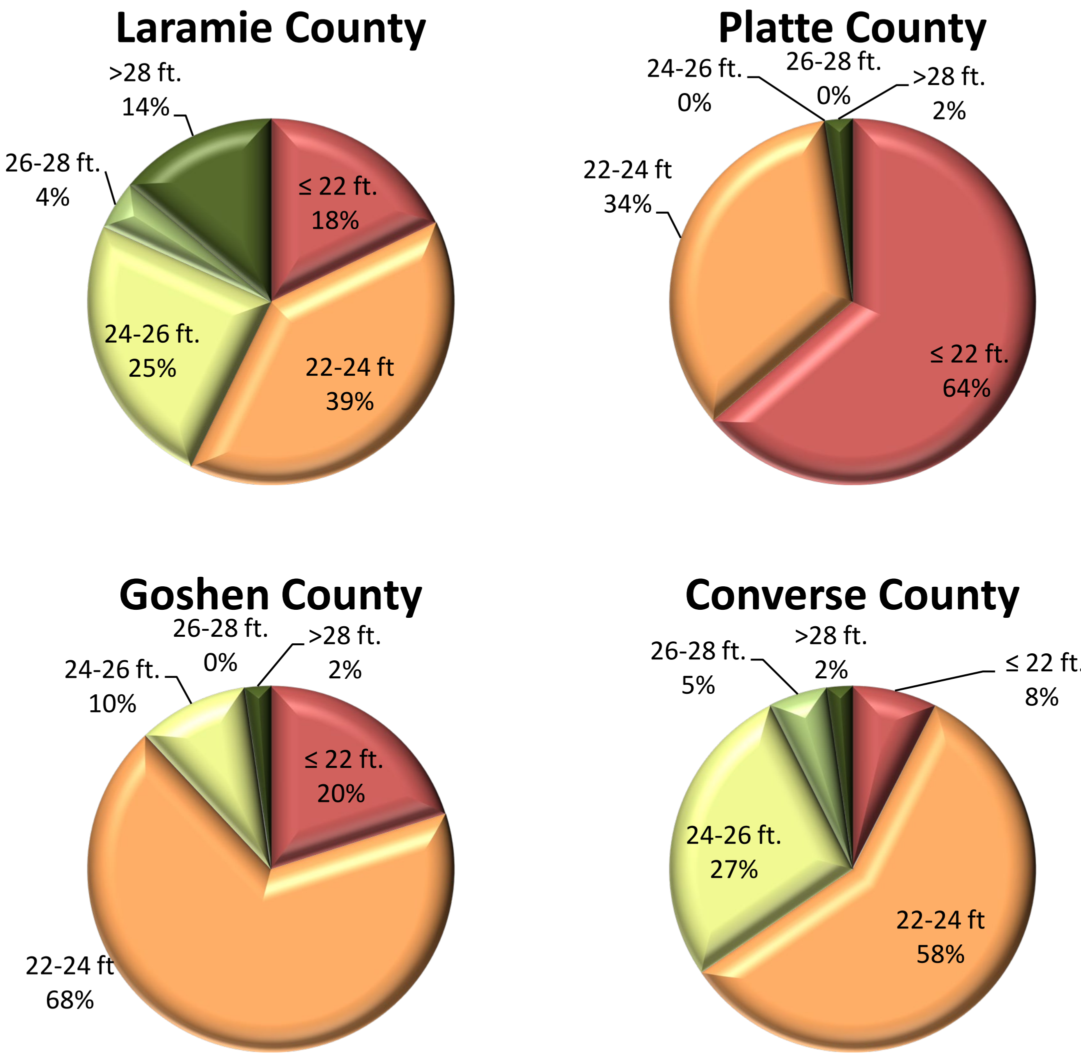

Figure 14. Paved county road widths.

Remaining Service Life (RSL)

A primary output of this monitoring would be a remaining service life (RSL) estimate for each road segment. The two primary inputs for a pavement RSL analysis are the structural capacity of the pavement and the traffic loads to which it will be exposed *(AASHTO 1993)*. The structural capacity is a function of the layer thicknesses and of the current strengths of the layers. The proposed monitoring should provide reliable structural inputs.

The GPR data provides thicknesses while PCI data provides layer coefficients. With these two inputs, the structural capacity of the road is computed, providing a result expressed as the number of typical trucks the road can carry. Then, one can estimate the number of trucks per day which the road is expected to carry to estimate the remaining service life in years.

A newer design method described in the *Mechanistic-Empirical Pavement Design Guide* (MEPDG) may be used to provide more accurate structural assessments. The T^2 Center is currently performing a study for WYDOT to calibrate the MEPDG for Wyoming roads.

The data analysis may project both the future condition of individual roads under different traffic loads and the overall durability of the counties paved road networks. Layer thickness information was not available for the previous study, other than overall estimates, so no examples from the earlier study are available. However, maps showing the RSL in years or trucks could be prepared, similar to the map in Figure 6. County-wide or statewide charts, similar to those in Figures 7, 8 and 9, could display the RSL for different counties and classes of roads.

Treatment Selection

An additional benefit from the data collected as part of the proposed monitoring program would be the compilation of preliminary maintenance, repair, and rehabilitation strategies for each individual road segment. Using the roughness, cracking, rutting, and layer thickness data combined with traffic estimates, recommended treatment strategies would be generated for each road segment. These estimates would be made based on various traffic levels, probably ranging from minimal agricultural traffic to very heavy industrial traffic. Thus, maintenance and construction treatments could be adjusted to match anticipated traffic levels.

As part of the previous study, treatment recommendations were prepared for those roads impacted by oil and gas activities. Table 2 describes the possible treatments, while Table 3 shows the recommended treatments for Goshen County. Since the previous study did not evaluate layer thicknesses, no projections could be made of future needs. However, with layer thicknesses as determined by GPR, projections could be made which could generate recommended future treatments with various traffic loads.

Table 3. Paved Road Treatment Options

	Treatment Type	Description	Est. Cost/ Mile
GM	General Maintenance	Patching, crack sealing, striping, etc.	$0
1-R	Preventative Maintenance	Chip seal, thin overlay, etc.	$60,000
2-R	Minor Rehabilitation	Mill & level, full depth reclamation, thick overlay, etc.	$250,000
3-R	Preventative Rehabilitation with Shoulder Needs	1-R plus shoulder widening	$350,000
4-R	Major Rehabilitation	2-R plus shoulder widening	$650,000
5-R	Full Reconstruction	Complete reconstruction	$1,200,000

Table 4. Goshen County Impacted Road Recommended Treatment List

Road Name	Begin MP	End MP	Length, miles	Top Width, feet	PSI	Treatment Type	Estimated Cost
Lingle-Veteran Rd	*0*	*8.6*	*8.6*	*24*	*2.5*	*3-R*	*$2,778,750*
CR 55A	0	5.1	5.1	26	2.0	3-R	$1,667,250
Deer Creek Rd	0	5.6	5.6	22	1.2	4-R	$3,620,500
Wyncote Rd	0	2.7	2.7	20	1.3	4-R	$1,768,000
Kaspiere Rd	0	17.7	17.7	24	1.1	4-R	$11,505,000
CR 31B	0	0.6	0.6	22	0.7	5-R	$768,000
AVERAGE	--	--	6.7	23	1.5	--	--
TOTAL	--	--	40.3	--	--	--	$22,107,500

Italic font: Road that has been rehabiiltated since data collection.

TIMELINE

This project will begin as soon as funding is available. Data collection and analysis will be performed on annual basis.

BUDGET

As shown in Table 4, the total cost of the first year of this project is $315,584. FHWA and WYDOT will provide resources to fund the first year with the understanding that the counties are willing to pick up the funding for the subsequent years. WYDOT has agreed to provide $215,584 and it is requested that the STIC would provide $100,000 to fully fund the first year of this effort. That cost will cover all data collection activities including $120,000 for Pathways to collect the surface condition data and $125,000 to collect the GPR data. The cost of preparing a segmented inventory and storing the raw data on a website will be $70, 584. This cost will cover all 2500 of paved county roads in the state. As shown in Table 5, the cost of data collection and analysis for subsequent years will be only $125,657 per year since there is no need to collect any additional GPR data and the condition data will be collected on only half of the network every year.

Table 4. Budget for County Paved Road Monitoring Program

County Paved Road Monitoring Program
Wyoming T²/LTAP Center

FIRST YEAR BUDGET

CATEGORY	Budgeted Amount	Explanatory Notes
Staff Salaries	$8,900	
Administrative Staff Salaries	$3,200	
Engineer Salaries	$0	
Student Salaries	$22,000	
Staff Benefits	$7,387	
Total Salaries and Benefits	**$41,487**	
Permanent Equipment	$2,000	Computer
Expendable Property, Supplies, and Services	$4,000	
Domestic Travel	$5,500	
Foreign Travel	$0	
Other Direct Costs (specify)	$7,000	Student tuition, no overhead
Total Other Direct Costs	**$18,500**	
F&A (Indirect) Costs	$10,597	
WY T²/LTAP Center Costs	**$70,584**	
Pathway Costs	**$120,000**	
GPR Costs	**$125,000**	
TOTAL COSTS	**$315,584**	
Amount Requested from STIC	**$100,000**	
WYDOT Contribution	**$215,584**	

Table 5. Budget for County Paved Road Monitoring Program

County Paved Road Monitoring Program
Wyoming T^2/LTAP Center
SECOND AND SUBSEQUENT YEARS

CATEGORY	Budgeted Amount	Explanatory Notes
Staff Salaries	$8,900	
Administrative Staff Salaries	$2,500	
Engineer Salaries	$0	
Student Salaries	$21,000	
Staff Benefits	$6,981	
Total Salaries and Benefits	**$39,381**	
Permanent Equipment	$0	
Expendable Property, Supplies, and Services	$4,000	
Domestic Travel	$5,500	
Foreign Travel	$0	
Other Direct Costs (specify)	$7,000	Students tuition, no overhead
Total Other Direct Costs	**$16,500**	
F&A (Indirect) Costs	$9,776	
WY T^2/LTAP Center Costs	**$65,657**	
Pathway Costs	**$60,000**	
GPR Costs	**$0**	
TOTAL COSTS	**$125,657**	

Beginning the second year, the annual cost of this program will be borne by each county, pro-rated by miles of county paved roads. Table 6 shows the costs for each county.

Table 6. Second and Subsequent Years County Costs

County	Paved Mileage	Total County Costs
Albany	40.3	$2,016
Big Horn	112.3	$5,617
Campbell	187.7	$9,390
Carbon	68.7	$3,435
Converse	102.4	$5,123
Crook	52.6	$2,633
Fremont	230.3	$11,522
Goshen	127.6	$6,384
Hot Springs	82.7	$4,137
Johnson	106.9	$5,350
Laramie	221.8	$11,100
Lincoln	184.6	$9,238
Natrona	142.6	$7,134
Niobrara	3.3	$165
Park	271.1	$13,563
Platte	157.3	$7,872
Sheridan	25.6	$1,282
Sublette	82.1	$4,105
Sweetwater	153.8	$7,697
Teton	65.7	$3,288
Uinta	43.0	$2,153
Washakie	44.4	$2,219
Weston	4.7	$234
TOTAL	**2,511.4**	**$125,657**

SUMMARY AND CONCLUSIONS

The option selected by WACERS, option V, provides for collection of all desired pavement condition data. Though no analysis is requested at this time, by collecting this data, analyses may be performed later as it becomes more apparent which analyses will be most useful. This provides considerable flexibility without any commitment of funds for analysis at this time. Thus, analyses may be performed on individual roads, on all roads within a county, or on all paved county roads statewide as needs for information arise. In addition, this data will allow for comparisons to be made between county paved roads and state highways. Overall, this plan provides the most information at the least possible cost while postponing any analysis, and the associated costs, until it becomes more apparent which analyses will be most useful.

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