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UTILIZING AUTOMATED DATA COLLECTION VEHICLES IN DETERMINING THE FORE SLOPES OF SHOULDERS

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Abstract: The Wyoming DOT has an interest in collecting automated data on pavement shoulders. Such data would include shoulder width, type, as well as slope. Pathway Services Inc. has been collecting Pavement Management Systems (PMS) data on roadways in Wyoming, and indicated they had the ability to measure the transverse profile of 10 to 20 feet from the white strip shoulder marking. Pathway Services has offered to provide measurements on test sections in Wyoming since they had not collected such data for any other states, so it was important to them to determine the limitations or potential of the system. The test sections included seventy miles of Wyoming highways with shoulder widths varying from zero to ten feet in two foot increments. Vegetation observations were made by researchers from the Wyoming T2-LTAP Center on the same day when Pathway's data was collected to ensure identical conditions. It was found that the section with no shoulder had the most vegetation and the most varied slope measurements. It was concluded that vegetation does affect the accuracy of the sensor and that the sensor could not read past the pavement taper. In addition, the manually collected slope measurements and the automated slope measurements were statistically different on most of the sections included in the experiment.			
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SI* (Modern Metric) Conversion Factors

Approximate Conversions from SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
Length				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
Area				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
Volume				
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m ³	cubic meters	35.71	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
Mass				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lbs)	T
Temperature (exact)				
°C	Centigrade temperature	1.8 C + 32	Fahrenheit temperature	°F
Illumination				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
Force and Pressure or Stress				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

Approximate Conversions to SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
Length				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
Area				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yards	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
Volume				
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
Mass				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lbs)	0.907	megagrams	Mg
Temperature (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
Illumination				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
Force and Pressure or Stress				
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

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CHAPTER 1

INTRODUCTION

1.1 Background

There is very little recorded information on pavement shoulders in Wyoming. In some cases shoulder width, slope, pavement taper, drop-off, and even type are unknown or go unrecorded. All of this information is important for many reasons. Pavement shoulder slope and drop-off can have a significant effect on recoverability of single vehicle rollover crashes. Being the largest form of crashes in Wyoming, it has been proven that single vehicle crashes can be reduced with wider shoulders and flatter slopes. If Pathway Services is able to collect shoulder data automatically at the same time that they are collecting Pavement Management Systems data, WYDOT could add that information to the roadway characteristics database. With this new shoulder information on record, it could be used in roadway safety studies. This kind of information is also helpful when determining whether or not a pavement can be overlaid, sealed, or maintained without requiring additional shoulder or grading work to maintain an acceptable level of safety.

This study addresses the validity of an automated data collection method used for determining the shoulder slope and drop-off. Pathway Services' shoulder drop-off sensor technology is on the cutting edge of automated data collection methods. It was developed in house by the companies' own designers and has not been extensively studied by outside entities in order to maintain research confidentiality. The Wyoming Technology Transfer Center will serve as an outside source to evaluate this product.

Network level testing of this sensor will help to determine the validity of the data collected. The sensor will be tested on five different sections of highway in Wyoming having shoulder widths from 0 to 10 feet at 2-foot increments. This kind of testing of the sensor is critical in determining the usefulness of the data to WYDOT. Pathway has not tested the new technology at such a scale and is interested in the accuracy and effectiveness of the drop-off sensor. This study will provide both WYDOT and Pathway with vital information on which kind of roads the sensor is most and least effective.

1.2 Objectives

The main objectives of this study are to 1) address the lack of proven automated data collection systems of the slopes off the edge of pavements; 2) compare the data collected by Pathway's profiler with manually collected data; 3) investigate the effects of vegetation height and density on Pathway's profiler measurements; and 4) provide recommendations on the effect of shoulder type and width on measurements as well as the need for additional data collection/analysis.

1.3 Report Organization

This report is organized into five chapters. Chapter one is the background information and objectives. Chapter two summarizes the comprehensive literature review, which examines all

other research and work done on this topic. Chapter three lays out all data collection processes for both the manual and automated data methods. Following data collection, chapter four is the data analysis which examines and processes the data for both collection methods as well as the comparison of both data sets. Chapter five provides the conclusions to the research and the recommendations produced from the findings.

CHAPTER 2

LITERATURE REVIEW

2.1 Effects of Shoulder Width on Road Safety

Shoulders are the portion of a roadway that are on the outside of the travel lanes. These sections of roadway are adjacent to the travel lanes and are designed to accommodate stopped vehicles and emergency vehicles, allow for vehicle wander and recovery, but not continual travel.

The width of shoulders can vary depending on the type of road. They vary from only 2 feet wide on minor roads, to approximately 12 feet on major roads where the entire shoulder may be stabilized or paved [AASHTO 2004]. There are two different types of shoulder widths: the “graded” width and the “usable” width. The “graded” width of a shoulder is measured from the edge of the travel lane to where the shoulder slope meets the foreslope. The “usable” width is the total width that can be used when a driver has to make an emergency stop. The usable width is the same as the graded width where the foreslope is 1V:4H or flatter [AASHTO 2004].

AASHTO suggests that a vehicle stopped on the shoulder should clear the edge of the travel lane by 1 foot, and preferably 2 feet. High-speed, high volume highways and highways that carry a large numbers of trucks should have a usable shoulder of at least 10 feet and preferably 12 feet [AASHTO 2004].

The 1987 FHWA study by Zegeer and Deacon investigated the effects of shoulder type and width on crashes on rural two-lane highways. The study estimated the percent reduction in crash frequency as a result of widening the road shoulder, shown in Table 2.1. The data shows that the greater the amount of shoulder widening, the greater the percent reduction in crashes. For example, if a rural two-lane highway with a 2 foot wide paved shoulder is widened to 8 feet, the amount of “related” crashes would be reduced by 40%.

TABLE 2.1 Effectiveness of Shoulder Type and Widening with Respect to “Related” Crashes [Zegeer and Deacon 1987].

Amount of Shoulder Widening (feet)	% Reduction in Crashes	
	Paved	Unpaved
2	16	13
4	29	25
6	40	35
8	49	43

Figure 2.1 illustrates the recommended Accident Modification Factor (AMF) for different shoulder widths. A six foot wide shoulder is the nominal shoulder width, which is assigned an AMF value of 1.00 [Harwood et al. 1998]. It is apparent from Figure 2.1 that roads with wider shoulders have lower AMF values. There are two AMF values for a given shoulder width, one at an average daily traffic (ADT) volume of 500 or less, and the other for ADT volumes of 2,000 or greater. A linear transition between these ADT values and AMF values can be interpolated between the lines in Figure 2.1 [Harwood et al. 1998].

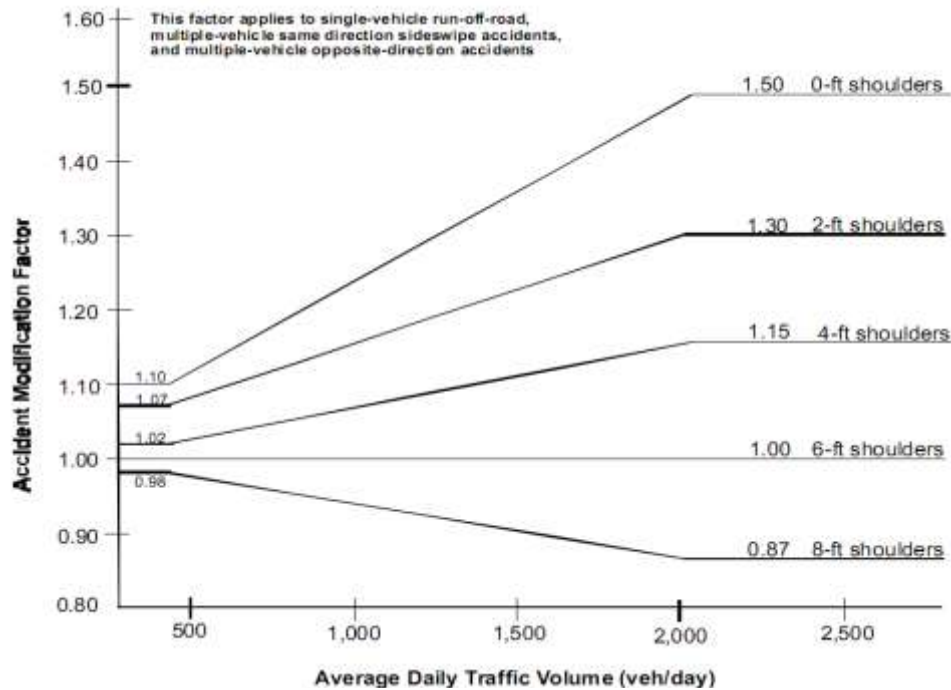


FIGURE 2.1 Accident Modification Factor for Shoulder Width [Harwood et al. 1998].

2.2 Effects of Pavement Edge Drop-Off on Safety

Pavement edge drop-off (PEDO) is the vertical difference between two adjacent road surfaces. Drop-offs can occur between two travel lanes, a travel lane and a paved or unpaved shoulder, or between a paved shoulder and an adjacent surface such as the sideslope. Drop-offs are typically caused by improper design, settling between the pavement surfaces, or roadway resurfacing. Shoulder material may also break off from the pavement edge from excessive wear or erosion [Hallmark et al. 2006]. See Figure 2.2.



FIGURE 2.2 Common Causes of Pavement Edge Drop-off [Hallmark et al. 2006].

2.2.1 PEDO Crash Analysis

Vehicles may leave the travel lane for a number of reasons. The road may have poor surface conditions, the driver may be distracted or fall asleep at the wheel, or the driver may veer off the road to avoid colliding with an animal or another vehicle. Drop-offs can be safety hazards when vehicles leave the travel lane because they can cause the vehicle to handle differently. Studies show that when drivers encounter a steep pavement edge, they attempt to return to the travel lane immediately without slowing down. When this happens, the driver tends to oversteer causing the vehicle's tires to rub against the pavement edge. This oversteering can cause the driver to lose control of the vehicle when the rear tire climbs back onto the pavement [Moler 2007].

Although PEDO crashes are relatively rare compared to other crash types, they are typically more severe, because the vehicle is subject to rolling over, hitting a roadside object, or oncoming vehicle [Moler 2007; FHWA 2004]. In fact, they are two to three times more likely to be fatal than other crash types on similar roadways [Moler 2007]. According to the FHWA,

approximately 11,000 Americans suffer injuries and 160 die each year in crashes related to unsafe pavement edges [FHWA 2004].

The United States Department of Transportation (USDOT) suggests that a vertical drop-off of three inches or more is considered unsafe, and drop-off depths should be maintained at two inches or less on high-speed highways [USDOT 2010]. There are numerous studies that determine the relationship between drop-off heights and a driver's ability to recover. One study by Graham and Glennon [Graham and Glennon 1984] evaluated the safety of drop-offs. After reviewing existing studies and conducting simulation tests, they developed relationships between different characteristics. They developed windows of safety that described the conditions that allowed a vehicle to safely recover from an edge drop-off. Table 2.2 shows the drop-off heights where traffic control is suggested for a five degree window of safety. The table shows that as speeds increase, the safe drop-off height decreases. For example, a 4 inch vertical drop-off can only be safely negotiated at a maximum of 35 mph. For speeds above 35 mph, it is suggested that traffic control devices be used [Hallmark 2006; Graham and Glennon 1984]. The table also shows that at speeds above 50 mph, only small drop-offs can be safely negotiated.

TABLE 2.2 Relationship Between Drop-off Height, Lane Width, and Speed to maintain a 5-degree window of safety [Hallmark 2006; Graham and Glennon 1984].

Speed (mph)	Drop-off height (in) warranting traffic control for various lane widths (feet)			
	12	11	10	9
30	4	4	3	2
35	4	3	2	1
40	3	2	1	1
45	2	1	1	1
≥ 50	1	1	1	1

Pavement edge drop-offs are a driving hazard because they can easily prevent the driver from maintaining control of their vehicle when returning to the travel lane. PEDO crashes are less common than other types of crashes, but they are often more severe [Moler 2007; FHWA 2004]. The pavement edge is subject to corrosion and wear, and must be properly designed and maintained to ensure road safety. In order to minimize pavement drop-off risk, USDOT has suggested installing a “safety edge”, a 30-35 degree wedge, at the graded material interface in asphalt resurfacing projects [USDOT 2010]. The safety edge is an inexpensive solution to pavement drop-offs, and provides a safe roadway edge.

2.3 Effects of Side Slope on Road Safety

The side slope is the roadway feature that makes up a portion of the clear zone. This feature influences the ability of an errant vehicle to recover and the likelihood of a vehicle roll over [Labi 2006]. In the 2004 Policy on Geometric Design of Highways and Streets [AASHTO 2004], AASHTO identifies three specific regions that are important to roadside safety: the top of the slope (hinge point), the foreslope, and the toe of the slope (intersection of the foreslope with level ground or with a backslope, forming a ditch). The hinge point, which is the point where the

shoulder meets the foreslope, contributes to loss of steering because vehicles tend to become airborne at this point [AASHTO 2004].

Side slopes (or foreslopes) should be designed to provide sufficient space for an out-of-control vehicle to recover, or stop safely. AASHTO [AASHTO 2004] recommends that a slope of 1V:6H or flatter should be provided, where practical, because it can be negotiated by a vehicle with a good chance of recovery. Side slopes between 1V:6H and 1V:3H are typically not recoverable, but can be traversed safely. If slopes steeper than 1V:3H are used, the use of roadside barriers should be considered [AASHTO 2004].

An FHWA study performed by Zegeer et al. [Zegeer et al. 1987] investigated the relationship between side slopes and the relative frequency of single vehicle crashes. Figure 2.3 shows the results of their study, and it can be seen that steeper side slopes contribute to higher frequencies of single vehicle crashes. Additionally, Table 2.3 shows the percent reductions in single-vehicle and total crashes after flattening the side slopes on two-lane rural roads. For example, if a side slope of 1:2 was flattened to a slope of 1:6, the number of single-vehicle and total crashes would be reduced by 21 percent and 12 percent, respectively [Zegeer et al. 1987].

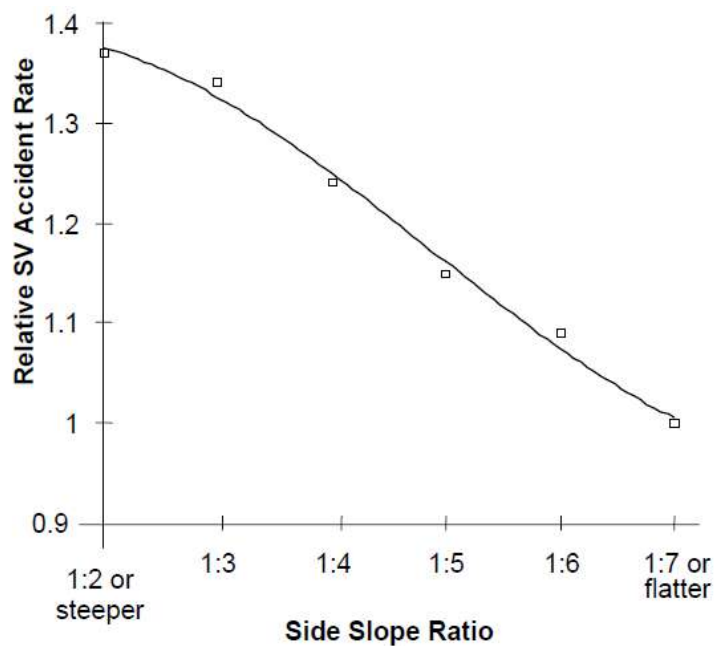


FIGURE 2.3 Relationship between Side-slopes and Single-vehicle Crash Rate [Zegeer et al. 1987].

TABLE 2.3 Effect of Side Slope Flattening on Single-Vehicle and Total Crash [Zegeer at al. 1987].

Side Slope Before Condition	Side Slope in After Condition							
	1:4		1:5		1:6		1:7 or Flatter	
	Single-Vehicle	Total	Single-Vehicle	Total	Single-Vehicle	Total	Single-Vehicle	Total
1:2	10%	6	15	9	21	12	27	15
1:3	8	5	14	8	19	11	26	15
1:4	0	-	6	3	12	7	19	11
1:5	-	-	0	-	6	3	14	8
1:6	-	-	-	-	0	-	8	5

Note: These Values are only for two-lane rural roads

Although it is assumed that a side slope of 1:4 is considered safe, the FHWA study found that side slopes of 1:5 or flatter are needed to significantly reduce rollover crashes [Zegeer at al. 1987]. In addition to reducing single-vehicle crash rates, the use of flatter side slopes may also reduce rollover crashes, as shown by the FHWA study.

2.4 Automated Data Collection

Automated Data Collection of roadway characteristics has become more utilized in recent years due to increased demand to gain accurate inventories through pavement condition surveys. In the past two decades, an effort has been made to fully automate the data collection process. Through extensive research and technological advancements, the concept of a fully automated pavement condition survey has become a reality [McQueen and Timm 2005]. As technology has become less expensive and more attainable, a diverse group of options have become available and are being used in practice.

2.4.1 Background

Road Profilers are used by many highway departments to measure the characteristics and profile of the roadway. The observations taken when doing so, help to obtain the International Roughness Index (IRI). The IRI is used to measure comfort of the pavement surface because road smoothness can affect ride quality, operating cost, and vehicle dynamic load [Wang and Flintsch 2007]. There has been much question about the accuracy of profilers when compared to the use of rod-and-level techniques to obtain the same information. Recent studies conducted at the Virginia Tech Transportation Institute have shown that there are profilers available that can produce the level of accuracy (repeatability and bias) required for quality control and assurance of smooth pavements [Wang and Flintsch 2007].

Before the time of automated data collection, road profilers were simply a rod-and-level survey system. This is widely accepted as the most accurate way of establishing surface profiles. The problem is that this process is very time consuming and labor intensive. The equipment consists of an eye level set up on a tripod, a measuring tape and a rod marked with elevations.

The survey crew that uses this equipment requires at least three people: a rod holder, a level reader, and someone to take notes. The crew traverses the wheel track and takes measurements at predetermined intervals. The vertical distance from the level to the road profile is then recorded. This makes the whole process take a very long time and one can see why this prompted the development of automated data collection [Sayers et al. 1986].

2.4.2 Systems

Profilers Systems are attached to a vehicle and driven at high speeds down the roadway, collecting the data automatically as the vehicle moves down the road. There are many ways to collect this data from personal transportation devices to vans. Technology can range from basic photograph technology, to laser measurements, and high speed inertial profilers.

2.4.3 Photogrammetry

Modern collection vans use a system of photogrammetry to evaluate the distress of pavements at high speeds. This surface data is collected using digital pavement images and then is transferred into software so that evaluations can be made [McQueen and Timm 2005]. These types of images can be analyzed for cracking and alligating; visual evaluations of the surface can also be made from the images taken using these techniques. Roadway distress is a very important part of pavement management systems and evaluating the current state of the road surface.

2.4.4 Fault Meters

A fault meter is a handheld device used to measure the difference in elevation between one side of a crack to the other. Faulting is caused by the rocking of rigid pavements due to loading and therefore creating a discontinuity between slabs. It can also be caused by unstable base conditions and cracking of the roadway. Fault meters were the first automated method of creating road profiles and evaluating roadways for comfort. Although, fault meters were considered to be an improvement over previous methods such as rulers and survey equipment, operating fault meters close to traffic is labor intensive and is very unsafe. High speed profilers are safer, faster and offer many more capabilities [Nazef et al. 2009].

2.4.5 High Speed Pavement Condition Vehicles

High speed profilers are the most common form of collection today. They are often one vehicle that collects several types of information at one time. These types of equipment usually include forward view cameras, laser measurement systems, global positioning systems, and accelerometers to account for vertical motion of the vehicle body. The profile is actually calculated by the lasers measuring the distance from the vehicle to the road surface [Nazef et al. 2009]. These lasers are able to take measurements at certain intervals as the vehicle drives down the roadway at very high speeds. For the Pathway sensor, the shoulder profiler collects data on the roadway ten feet from the vehicle edge at 2-foot intervals. This collects information on shoulder drop-off.

2.5 Chapter Summary

Automated Data Collection of roadway characteristics has been utilized more in recent years due to the large demand by highway departments to gain accurate inventories through pavement condition surveys. It has been used to determine pavement characteristics such as IRI, pavement serviceability index, and pavement distress. The vehicle can also collect data on roadway rutting, which is a safety concern on most roadways. Rutting was not explored because it was outside the scope of this study. It has also been found that there are many design requirements for shoulder slopes and that if those requirements are not met, shoulders become significantly less safe. The safety change from a critical to a traversable to a recoverable slope is significant. An automated method to measure shoulder profiles has not yet been developed outside of Pathway's creation of this device. A thorough literary review has revealed the informational gap and lack of research in the area of either slope or drop-off sensors. This study will provide information on the validity of drop-off sensor equipment.

CHAPTER 3 DATA COLLECTION

3.1 Road Selection

It was determined that in order to thoroughly test the sensor for the shoulder application that several variables must be identified. Certain factors such as road alignment, shoulder width, roadway classification, shoulder material, and even crash characteristics were identified and suggested as possible test section criteria. For this study, five different roads were selected by WYDOT to be tested. These road sections were Interstate and State Highways with shoulder widths varying from 0 to 10 feet wide at 2 foot increments. Table 3.1 summarizes the road sections included in this experiment.

TABLE 3.1 Summary of Test Sections.

Route	Beginning MP	Ending MP	MP Direction	Length (miles)	Shoulder Width (ft)
WY 319	101	110	Decreasing	9	0
WY 225	350	356	Both	12	2
WY 313	101	109	Both	16	4
WY 316	2	11	Both	18	6
WY 259	12	20	Decreasing	8	8
I-25	18	25	Decreasing	7	10
Total				70	

3.2 Automated Data Collection Process

Shoulder slope and drop-off data were collected by Pathway Services, Inc. using a high-speed automated data collection vehicle. This road profiler is a full-size van equipped with various cameras, lasers, and sensors. High-resolution cameras mounted on the front and back of the vehicle capture an image every 50 feet. Motion sensors are located inside the vehicle to measure the vertical movement of the vehicle. Scanning lasers are mounted on the front and rear bumpers to measure the rut depth and to detect and measure distress in the road surface. The sensor that was evaluated in this study was the drop-off sensor. This is a class 2 scanning laser that collects up to 300 points using time-of-flight technology. It is mounted on the front bumper about 3 feet above the ground and about 45 degrees from horizontal, as shown in Figure 3.1. This laser is a relatively new technology that has not been used by any state transportation department on a network level. This laser collects the transverse profile of a road shoulder and measures the maximum drop-off for each reading. According to Pathway Services, this laser may be able to take measurements at every 2 feet at highway speeds and capture a detailed edge drop-off as far as 10 feet from the vehicle's wheel path. Once Pathway collects this data, the information is tabulated using a program developed by Pathway. The program and collected data are then stored on an external hard drive and sent to the respective client.



FIGURE 3.1 Pathway Collection Van and Drop-off Sensor.

3.3 Vegetation Observations

Because there has been concern whether roadside vegetation would affect the readings of the new drop-off sensor, a vegetation observation was conducted on all test sections. In this observation, the vegetation height and density was recorded for each section at every milepost, +0.3 milepost, and +0.6 milepost. Figure 3.2 below illustrates examples of light, medium, and dense vegetation patterns and shows the roadside vegetation was classified. In addition, three photographs were taken at each observation to document visual observations and allow for further investigation if the need arose. Photograph numbers were documented in the vegetation observation logs to keep all of the information in order. Vegetation observations were conducted the same day as Pathway Services' data was collected to ensure relevant vegetation height and density.



FIGURE 3.2 Vegetation Density Scale.

3.4 Sensitivity Analysis

Pathway Services' data vehicle collects drop-off profile data every two feet. It would not be efficient to manually collect slope measurements every two feet, therefore a sensitivity analysis was conducted on a random test section to determine how many measurements needed to be taken for each tenth-mile section tested. Table 3.2 is a summary of this sensitivity analysis. The shoulder is divided into three sections, Sections A, B, and C. To perform the sensitivity

analysis, horizontal and vertical measurements for each section were taken every 52.8 feet for one-tenth of a mile. The slopes were calculated for every set of horizontal and vertical measurements. Next, the average slope for each section, and the overall slope was calculated for the entire one-tenth mile measured. These values are shown in the 'Average' row in Table 3.2. The slope values shown in the table represents the ratio of the horizontal to the vertical component of the slope. For example, a slope value of 20.7 represents a slope of 1V:20.7H.

Next, average slopes were calculated for four criteria: 1) every other measurement; 2) every third measurement; 3) every fourth measurement, and 4) the beginning, middle and end measurements of the tenth-mile section. Additionally, the percent difference from the average slope of all measurements was calculated for all four criteria previously mentioned. These values were calculated separately for each section and are represented in the 'Percent Different' column of each respective section. It was found that overall slope at the beginning, middle, and end of each tenth-mile section differed by 2% from data collected every 52.8 feet of the section. This means that nine measurements were taken for each mile of road tested.

TABLE 3.2 Sensitivity Analysis Summary.

	Section A		Section B		Section C		Overall Slope	
	Slope	Percent Different	Slope	Percent Different	Slope	Percent Different	Slope	Percent Different
Average	-52.15		20.70		10.54		25.32	
Every Other	-50.11	4%	20.40	1%	10.42	1%	25.53	1%
Every Third	-53.25	2%	20.00	3%	10.35	2%	24.87	2%
Every Fourth	-54.22	4%	21.13	2%	10.11	4%	24.75	2%
Beginning, Middle, End	-56.00	7%	21.13	2%	10.50	0%	25.75	2%

3.5 Manual Data Collection

Shoulder slope and drop-offs were measured manually for three one-tenth of a mile sections per mile. Slopes were measured at the first, third and sixth tenth of every mile. Road shoulder measurements were split into three sections, as shown in Figure 3.3, determined by a noticeable break in slope. Section A is the paved shoulder, section B represents pavement taper, and section C is the unpaved, vegetated foreslope. Section A was always taken as the shoulder width; on sections with no shoulder, the width of Section A was zero. The line separating section A and B is where the break in slope occurs and the pavement begins to taper. The change in color of the pavement in section B is due to overlays.

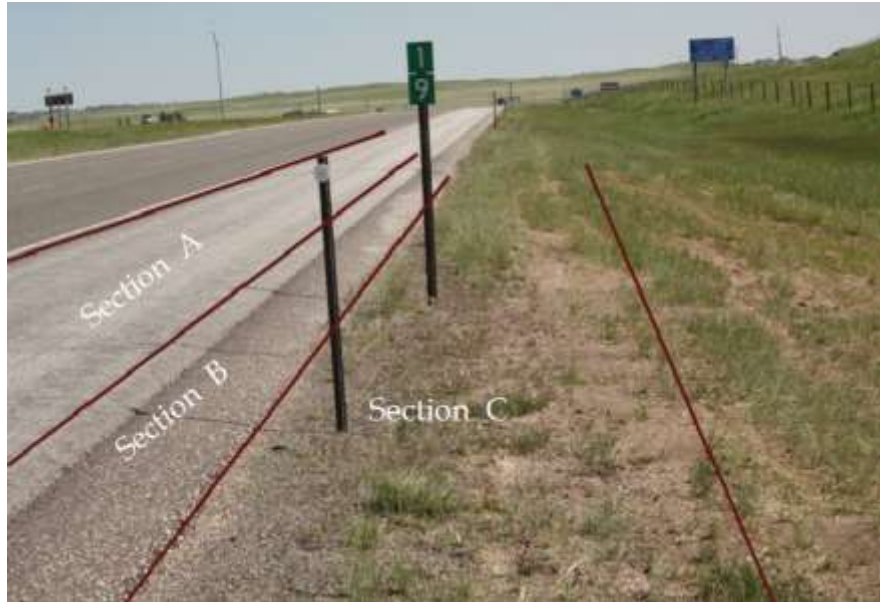


FIGURE 3.3 Shoulder Section Subdivisions.

The slopes were determined by measuring the horizontal and vertical components of each section using a 12 foot level and measuring tape. The level was marked in feet and inches and in feet so that the horizontal component could be determined quickly. The vertical component was measured with a tape measure to the nearest $\frac{1}{4}$ inch. Measurements were recorded in the field and slopes were calculated from those measurements once entered into database software. Figure 3.4 shows how these sections were measured using a 12 foot extendable level and measuring tape.



FIGURE 3.4 Manual Data Collection Method.

3.6 Chapter Summary

Data collection for both methods was completed at the same time to ensure that conditions remained constant throughout the survey. The automated data was collected in one day, which was the same day that the vegetation observations were collected. The manual slope measurements were collected in the days following the automated collection. A sensitivity analysis was completed to determine the measurement interval. All data was collected as described above, and remained the same for all test sections.

CHAPTER 4 DATA ANALYSIS

4.1 Manual Observations

Vegetation density was evaluated every three tenths of a mile for each section of roadway described in Table 3.1. Table 4.1 summarizes those observations for every mile progressed in the test sections. The offset is the average perpendicular distance from the white shoulder marking to the first observed vegetation on the shoulder for the entire mile. The density shown is the average density observed according to the scale shown in Figure 3.2. The density cannot be averaged over the entire section because those observations were qualitative. The vegetated state of the shoulder also changed greatly due to the changes in terrain and diversity of Wyoming landscapes. The height shown is the average height of the vegetation found closest to the pavement. Some test sections were shorter than others and therefore have fewer miles for comparison.

TABLE 4.1 Vegetation Summary By Mile.

Mile	Wy 319 DEC (0')			Wy 225 INC (2')			Wy 225 DEC (2')		
	Offset	Den.	Ht.	Offset	Den.	Ht.	Offset	Den.	Ht.
1	0.7 ft	D	22 in	4.8 ft	M	11 in	4.0 ft	M	9 in
2	0.8 ft	D	28 in	6.5 ft	M	11 in	4.5 ft	D	9 in
3	0.0 ft	D	20 in	5.3 ft	D	11 in	4.2 ft	M	9 in
4	0.2 ft	D	23 in	5.0 ft	D	10 in	4.3 ft	M	8 in
5	0.5 ft	D	28 in	6.5 ft	D	10 in	4.5 ft	D	9 in
6	0.0 ft	D	26 in	4.5 ft	D	11 in	3.6 ft	D	9 in
7	0.2 ft	D	29 in						
8	0.3 ft	D	24 in						
9	0.0 ft	D	30 in						
Average	0.3 ft		26 in	5.4 ft		11 in	4.2 ft		15 in

TABLE 4.1 Vegetation Summary By Mile (Con't).

Mile	Wy 313 INC (4')			Wy 313 DEC (4')			Wy 316 INC (6')		
	Offset	Den.	Ht.	Offset	Den.	Ht.	Offset	Den.	Ht.
1	5.0 ft	M	15 in	4.2 ft	D	23 in	6.0 ft	L	7 in
2	5.2 ft	M	13 in	4.5 ft	D	21 in	6.5 ft	L	9 in
3	4.8 ft	D	16 in	4.8 ft	D	21 in	7.0 ft	M	9 in
4	4.7 ft	D	16 in	5.0 ft	D	21 in	7.2 ft	L	8 in
5	3.7 ft	D	22 in	5.2 ft	M	18 in	7.0 ft	L	10 in
6	5.0 ft	D	25 in	5.0 ft	D	21 in	6.7 ft	M	10 in
7	4.8 ft	D	25 in	5.2 ft	D	23 in	6.7 ft	M	11 in
8	5.4 ft	D	25 in	4.9 ft	M	17 in	6.7 ft	D	13 in
9							6.5 ft	D	17 in
Average	4.8 ft		20 in	4.9 ft		21 in	6.7 ft		10 in

TABLE 4.1 Vegetation Summary By Mile (Con't).

Mile	Wy 316 DEC (6')			Wy 259 DEC (8')			I- 25 DEC (10')		
	Offset	Den.	Ht.	Offset	Den.	Ht.	Offset	Den.	Ht.
1	5.7 ft	M	11 in	12.8 ft	L	9 in	15.0 ft	M	8 in
2	6.5 ft	M	13 in	11.7 ft	L	7 in	16.0 ft	L	7 in
3	7.0 ft	M	11 in	11.0 ft	L	7 in	14.0 ft	M	9 in
4	6.7 ft	M	10 in	10.7 ft	M	7 in	13.0 ft	M	7 in
5	6.7 ft	M	11 in	11.0 ft	L	7 in	12.7 ft	M	7 in
6	6.7 ft	M	11 in	11.7 ft	M	9 in	15.7 ft	M	9 in
7	6.7 ft	L	11 in	11.3 ft	L	8 in	13.8 ft	D	9 in
8	6.3 ft	L	11 in	11.3 ft	L	8 in			
9	6.3 ft	M	13 in						
Average	6.5 ft		11 in	11.4 ft		8 in	14.3 ft		8 in

The manually collected slope measurements were summarized in a technique very similar to the vegetation observations. Table 4.2 shows the average slope for every mile of test section. The slope is expressed as that many units of horizontal distance to every unit of vertical drop (i.e. 3:1). The larger the slope indicator, the more nearly level the slope and likewise, the closer the indicator gets to zero, the steeper the slope. The offset indicates the distance from the white shoulder marking to the natural break in slope. The standard deviation was large on some sections due to the high amount of super elevation in those sections. When a section is super elevated the slope would either be zero or a negative value, while when a slope is flat, it would have a higher number. This makes the standard deviation very large in some sections.

TABLE 4.2 Manual Shoulder Slopes.

Mile	Wy 319 DEC (0')		Wy 225 INC (2')		Wy 225 DEC (2')		Wy 313 INC (4')		Wy 313 DEC (4')	
	Offset	Slope	Offset	Slope	Offset	Slope	Offset	Slope	Offset	Slope
1	12.0 ft	8	4.4 ft	11.8	4.1 ft	11	5.1 ft	24.2	4.7 ft	17.8
2	12.0 ft	7.5	4.8 ft	19.8	2.6 ft	11.6	4.6 ft	13.9	4.7 ft	18.1
3	12.0 ft	6.7	4.8 ft	14.7	3.1 ft	13.6	4.6 ft	15.9	4.9 ft	20
4	12.0 ft	7.7	4.2 ft	12.1	2.8 ft	12.3	4.7 ft	19.6	5.3 ft	19.5
5	12.0 ft	5.6	5.0 ft	28.7	3.2 ft	14.8	4.8 ft	20.6	4.9 ft	13.5
6	12.0 ft	9.6	4.4 ft	16.7	2.6 ft	12.8	4.7 ft	23.1	5.1 ft	16
7	12.0 ft	5.9					5.1 ft	23.1	4.6 ft	-14.7
8	12.0 ft	5.2								
9	12.0 ft	5.9								
Average	12.0 ft	6.9	4.6 ft	17.29	3.1 ft	12.75	4.8 ft	19.1	4.9 ft	13.5
St. Dev	0.0 ft	3.32	1.1 ft	9.69	0.9 ft	5.74	0.4 ft	7.5	0.4 ft	14.65

TABLE 4.2 Manual Shoulder Slopes (Con't).

	Wy 316 INC (6')		Wy 316 DEC (6')		Wy 259 DEC (8')		I- 25 DEC (10')	
Mile	Offset	Slope	Offset	Slope	Offset	Slope	Offset	Slope
1	7.1 ft	12	6.8 ft	16.3	7.4 ft	31.18	10.4 ft	43.1
2	6.7 ft	10.8	6.8 ft	12.2	7.9 ft	45.55	10.7 ft	42.1
3	6.9 ft	12.1	6.9 ft	15.2	7.8 ft	25.02	10.6 ft	41.4
4	7.3 ft	12.8	6.7 ft	13	7.4 ft	40.93	10.3 ft	39.7
5	7.0 ft	10.5	6.7 ft	13.9	7.7 ft	41.63	8.1 ft	39.9
6	6.9 ft	12.4	6.7 ft	10.2	7.4 ft	53.04	10.6 ft	47.9
7	6.9 ft	17.3	6.6 ft	10.3	7.8 ft	26.9	10.3 ft	46.7
8	7.0 ft	11.2	6.8 ft	11.9	7.6 ft	45.63		
9	6.8 ft	15.6	6.8 ft	13.4				
Average	7.0 ft	12.73	6.8 ft	12.94	7.6 ft	37.67	10.1 ft	42.95
St. Dev	0.3 ft	5.57	0.3 ft	3.23	0.4 ft	30.86	1.4 ft	7.6

Interstate 25 has an average slope of 43.0. This means that it runs 43 inches horizontally for every inch in drop. It was difficult to achieve consistent readings of fore slope because at a horizontal distance of ten feet the difference between one inch and one and a half inches of drop had a drastic effect on the slope indicator. This contributes to the very high standard deviations for the slopes. The steepest section measured was the section with a shoulder width of zero feet. This was also the section with the densest and the tallest vegetation.

4.2 Automated Data Observations

When the data were received from Pathway Services, it came in the form of a drop-off profile graph. These graphs showed the distance from the wheel path in inches and the drop-off for every time the sensor took a measurement. A detailed preliminary inspection was performed on the data to see if there were any trends or if there might be some discrepancies in the data. The data and observations are summarized by road section so that trends and differences can be determined.

One discrepancy between the manually collected data and the data collected by Pathway Services is that the sensor reads from the wheel path out while the manually collected data was obtained starting from the shoulder marking (white line) and continued outward from there. This was done because the wheel path is very subjective and could be different for every vehicle that passes on that roadway. Measuring from the white line was the only way to stay consistent. This made it difficult to correlate manual and automated data.

4.2.1 WY 319 (0 ft Shoulder)

Wyoming 319 is the section of the road with zero shoulder width. The vegetation on the foreslope was higher on this road than any other section, as can be seen in Table 4.1. The graphs show no drop-off and the picture and Table 4.2 are very clear that there is a steeper foreslope at this location. Most likely dense and very tall vegetation is having some effect on the shoulder profile graph. Graphs revert to the horizontal after 45 inches and that should show a slope or more noise due to the vegetation on the side of the road. There are also some points in the data where the drop-off will spike and stay there. This spike occurs typically right before the profile levels off. Figure 4.1 shows a very typical profile from this test section.

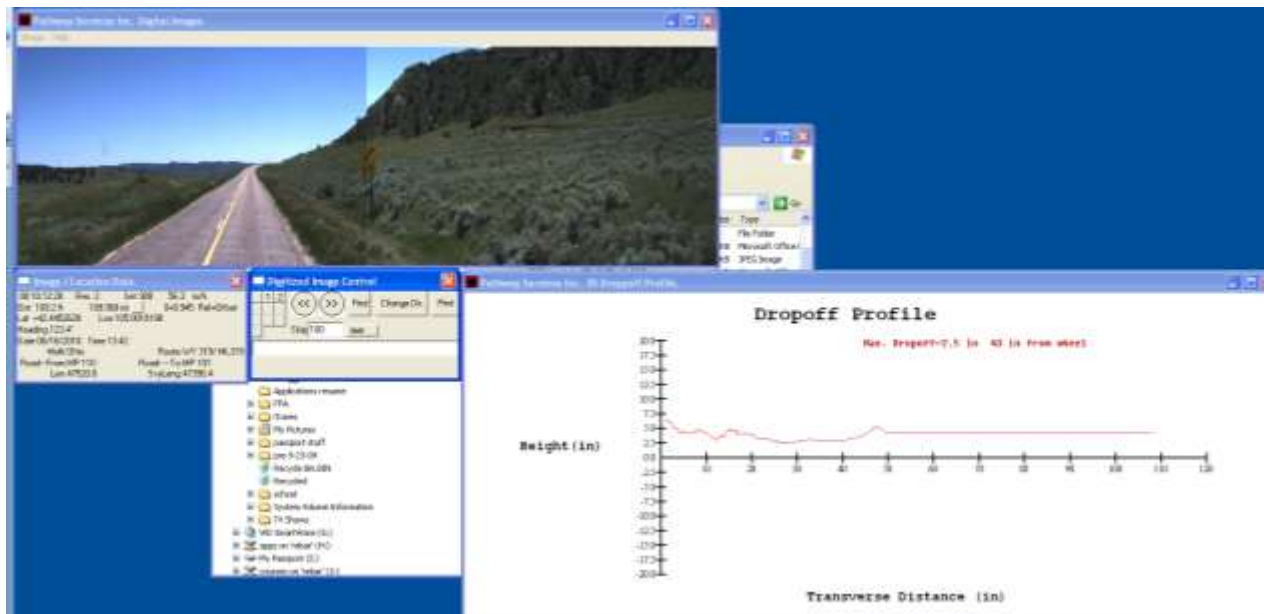


FIGURE 4.1 Typical Profile of WY 319.

4.2.2 WY 225 (2 ft Shoulder)

Pathway Services took measurements on Interstate 80 which parallels WY 225 instead of WY 225. Because I-80 was not identified as one of the sections in this study, no manual observations were made concerning that section and the two foot shoulder section was not included in this study.

4.2.3 WY 313 Increasing (4 ft Shoulder)

On WY 313 increasing, from the time 47:06 through 47:29 on the recoding clock, the drop-off profile maintains an extremely level end behavior and the graph never goes below the x axis, which is peculiar as typical profiles decrease beyond the transverse axis. Figure 4.2 demonstrates this observation.

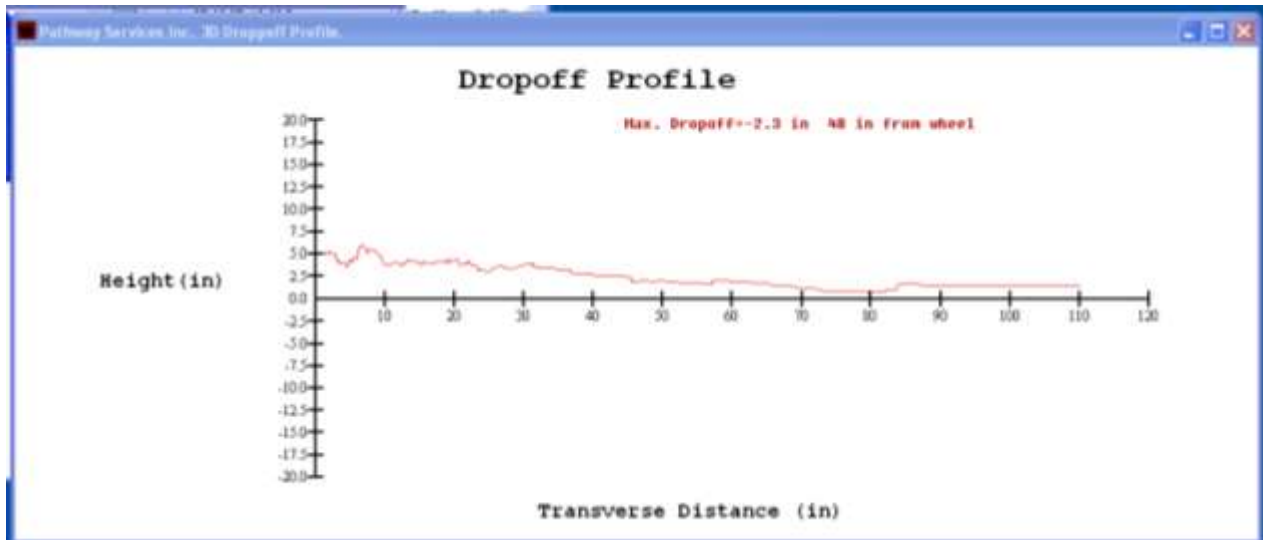


FIGURE 4.2 Profile That Does Not Cross The Transverse Axis.

The graph reaches an approximate minimum at 75" on the transverse axis and often the graph will increase from this point or plateau to remain horizontal. If it is assumed that the wheel path of the collection vehicle is 18 inches inside the driving lane, and using the average transverse distance to the roadside vegetation from Table 4.1 of 4.8 feet or 57.6 inches, the sum equals roughly 80 inches. The minimum consistently occurs between seventy and eighty inches from the vehicle. The vegetation interference could be the cause of this dip and then increase in the profile. Figure 4.3 illustrates this minimum.

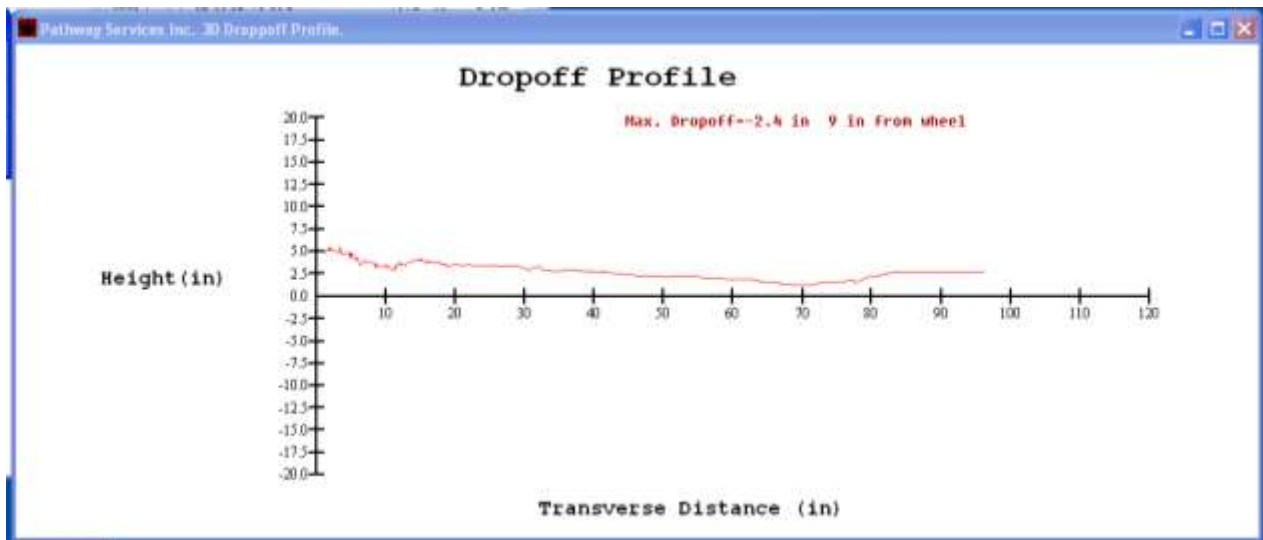


FIGURE 4.3 Minimum In The Drop-off Profile Graph.

4.2.4 WY 313 Decreasing (4 ft Shoulder)

As with other sections, super elevation of the curve is not shown on the drop-off profile. Turnouts in this case actually caused the shoulder profile to come back down to level as opposed to increasing. On the transverse profile there is a minimum at 70" where the shoulder appears to decrease before sharply increasing again. This is possibly where the pavement ends. Figure 4.4 shows a characteristic profile where this occurs.

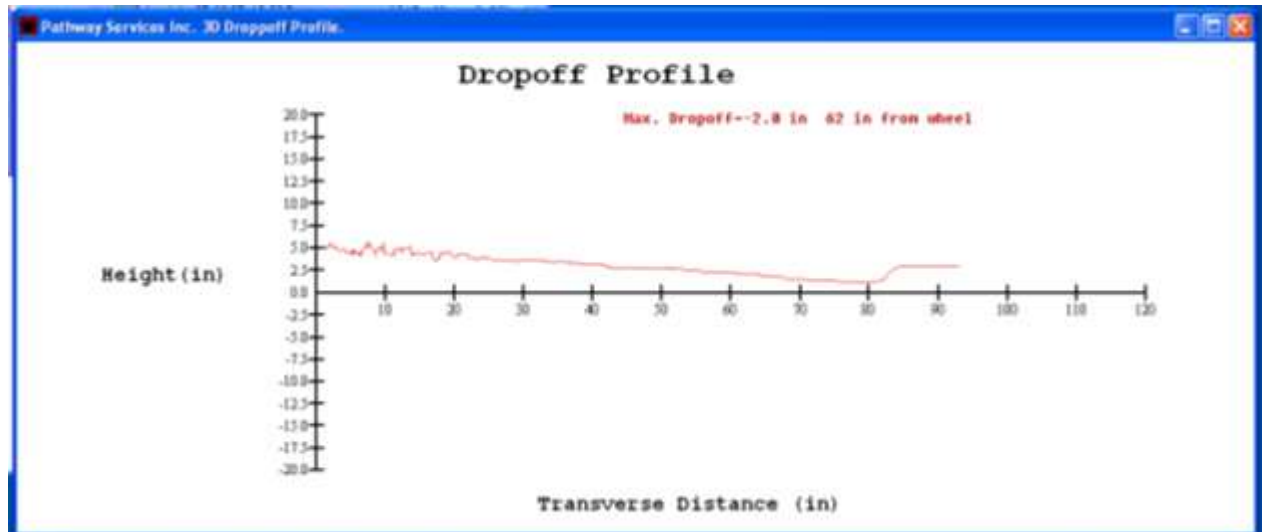


FIGURE 4.4 Sharp Increase At The Far End Of The Profile.

4.2.5 WY 316 Decreasing (6 ft Shoulder)

The data collected on WY 316 Decreasing revealed an extreme vertical spike at 0 inches in the transverse direction. This occurs intermittently throughout the test section. This causes a very large drop-off to occur very close to the wheel. The maximum drop-off reading provided in the Pathway output was intended to be used for the correlation analysis. Irregularities such as these cause anomalies in the drop off data and have an adverse effect on making positive correlations; therefore, other systems of comparison had to be established. Figure 4.5 shows the vertical spike.

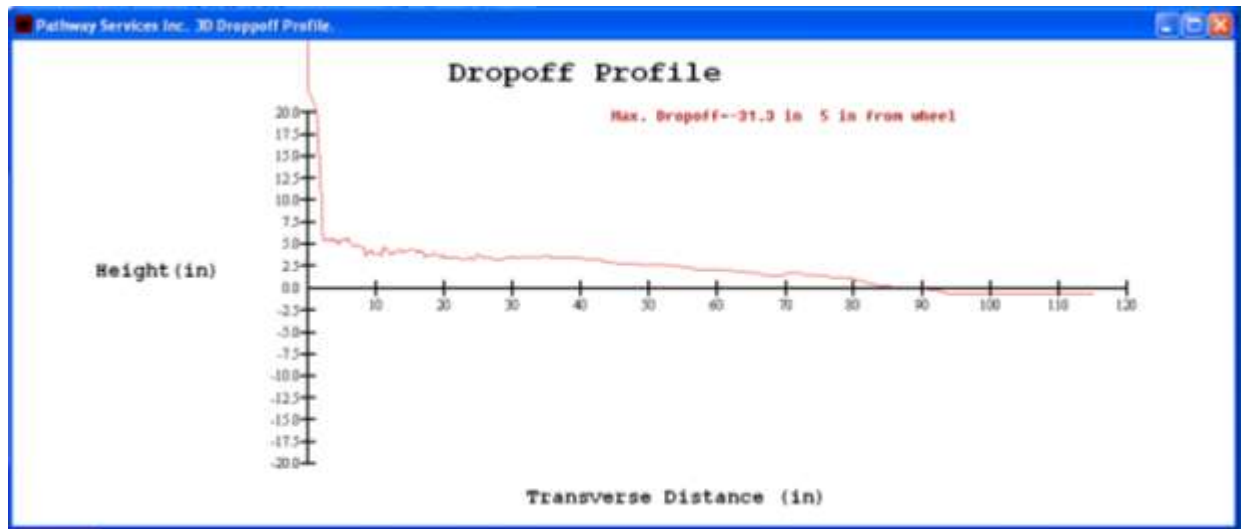


FIGURE 4.5 Vertical Spike Near the Wheel Path.

Several intermittent, unexpected drops were initially considered rumble strips. But this theory was ruled out when they occurred in transverse locations including sections of road without rumble strips; also they are not the correct transverse distance from the right wheel path. Super elevated shoulders are still shown with decreasing profiles when the profiles should produce increasing slopes. Figure 4.6 shows a super elevated curve and the profile it produced.

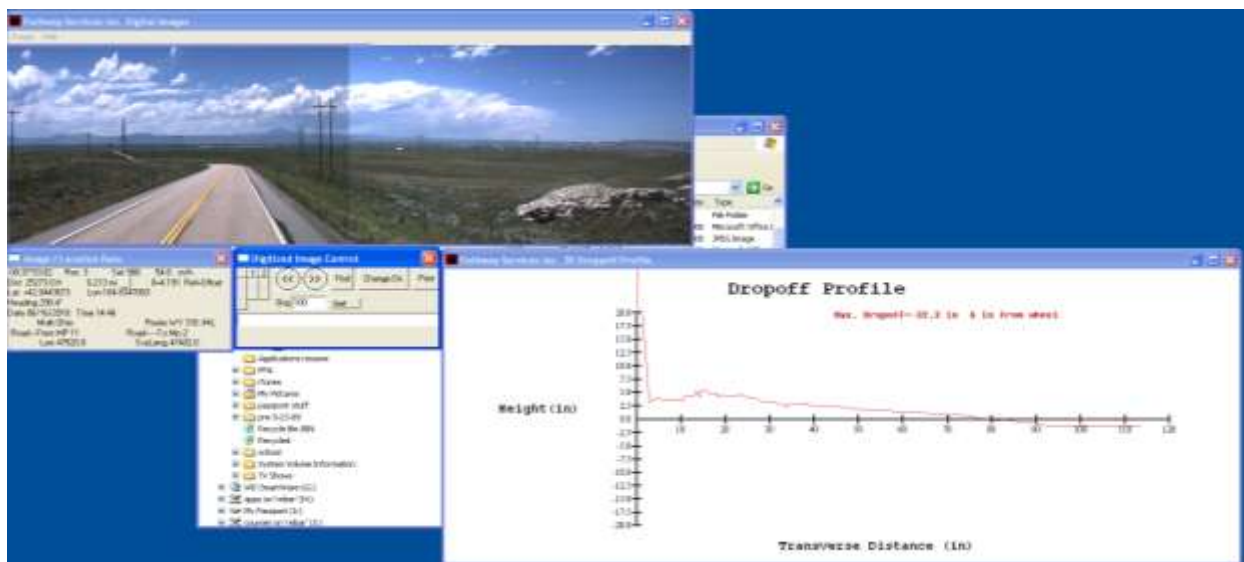


FIGURE 4.6 Profile of a Super Elevated Curve.

Access points or turnouts should show an increasing profile at the beginning of this section. They actually show no change from a typical shoulder and decrease to the transverse axis. The guard rail does seem to cause a spike in the profile graph indicative of the curb on the shoulder of the bridge. The vertical rise is approximately the same as is to be expected for this

The screenshot displays a Windows XP desktop environment with a blue background. Several application windows are open, illustrating a virtual simulation of a vehicle's dropoff profile.

- Image / Camera View:** Shows a first-person perspective of a road with a guardrail on the left and trees on the right. The sky is blue with white clouds.
- Image / Camera Control:** Contains various controls for the camera view, including a 'Drop' button and a 'Dropoff' button.
- Dropoff Profile:** A graph titled 'Dropoff Profile' showing 'Height (in)' on the Y-axis (ranging from 0 to 200) and 'Transverse Distance (in)' on the X-axis (ranging from 0 to 120). The graph displays a red line representing the dropoff profile, which rises sharply from a low height to a higher, constant height around 65 inches transverse distance.
- Dropoff Profile Data:** A table titled 'Dropoff Profile Data' showing the data points for the dropoff profile. The table has columns for 'Transverse Distance (in)' and 'Height (in)'. The data points show a sharp increase in height around 65 inches transverse distance.

4.2.6 WY 316 Increasing (6 ft Shoulder)

23

4.2.7 WY 259 (8 ft Shoulder)

For WY 259 drop-off profile graphs and the roadway picture of the cross section do not advance in unison when the program operator navigates through the roadway file. Therefore, it is impossible to determine the location of the drop-off graphs. The profile graphs could not be matched to a specific mile post because the graphs and location information were not linked. The data from this section was not compared to the manual data because there was no way to link the data sets.

4.2.8 Interstate 25 Decreasing (10 ft Shoulder)

In the first ten profiles provided for Interstate 25, the profile has an irregularity which is shown below. The profile does not start until 10 inches from the wheel path and begins 10 inches in the vertical direction. Figure 4.9 shows how it decreases very sharply and flattens out. The photograph obviously does not agree with the profile graph provided.

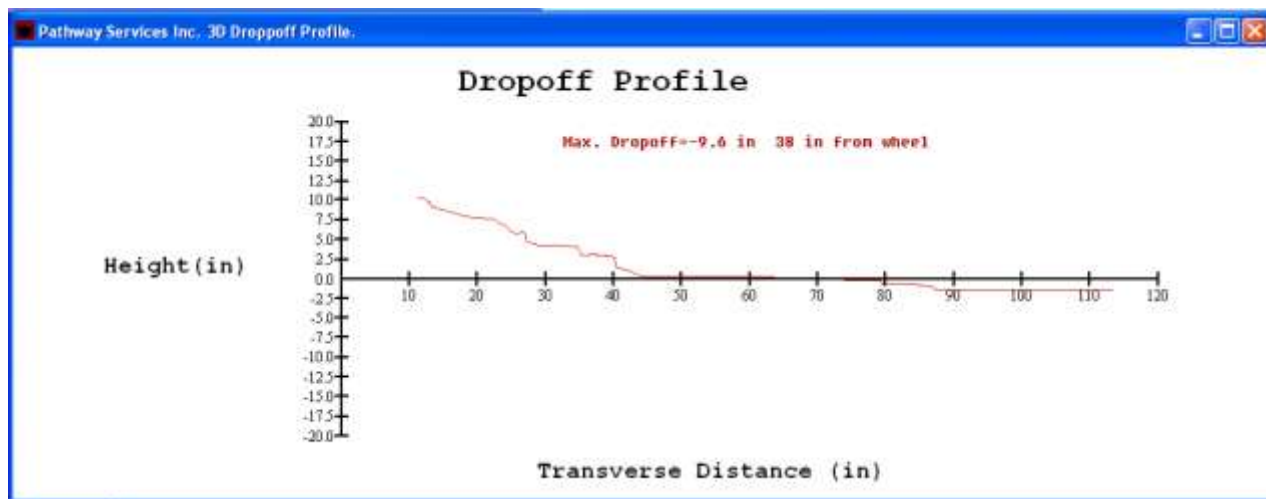


FIGURE 4.9 Corrupted Profile Data.

Figure 4.10, shows the sensor's sporadic behavior with a nearly fourteen-inch drop which does not actually occur on the shoulder of the roadway. There are numerous occurrences of this phenomenon throughout the duration of this section.

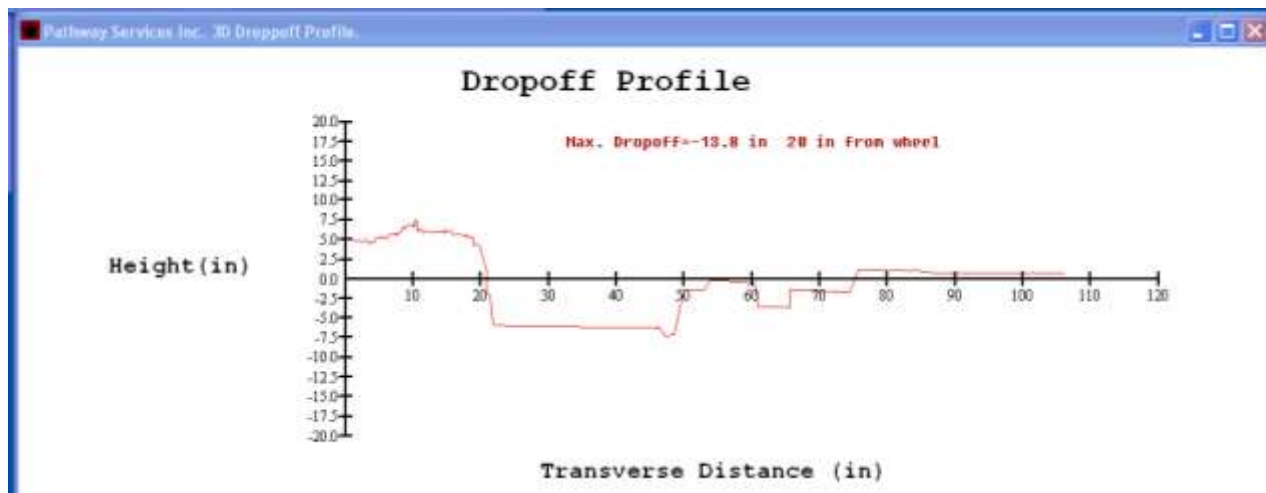


FIGURE 4.10 Sporadic Profile Behavior.

The most common profile for this section, which best fits the shoulder slopes measured manually and outlined in Table 4.1, is shown by the profile in Figure 4.11. The manually collected data show the drop in this section was between one and two inches over a 12-foot distance (shown in Table 4.2). The graphs show a five-inch drop over a nine foot section of roadway shoulder, which stands out as a major difference between the two data sets. Also the profiles almost always go from the positive five and terminate at zero in the vertical. Notice in Figure 4.11, at 95 inches the profile becomes horizontal. This is common in this section as well.

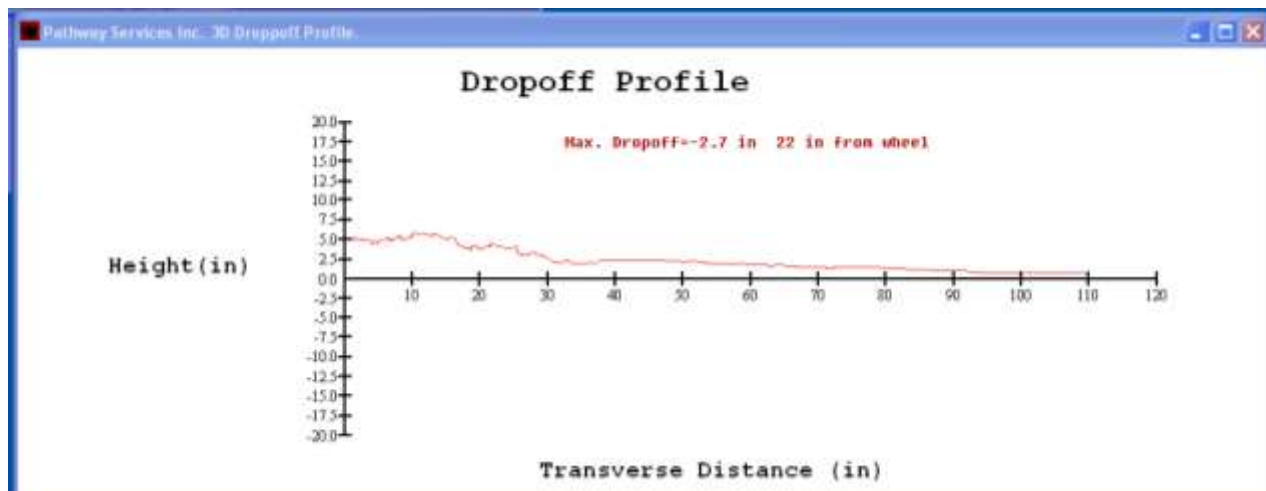


FIGURE 4.11 Common Profile for Interstate 25.

Bridges featuring concrete produced more consistent readings, which suggests the sensor may be better suited for taking readings on concrete. There is also less noise closer to the wheel path. Figure 4.12 shows the profile of the concrete bridge.

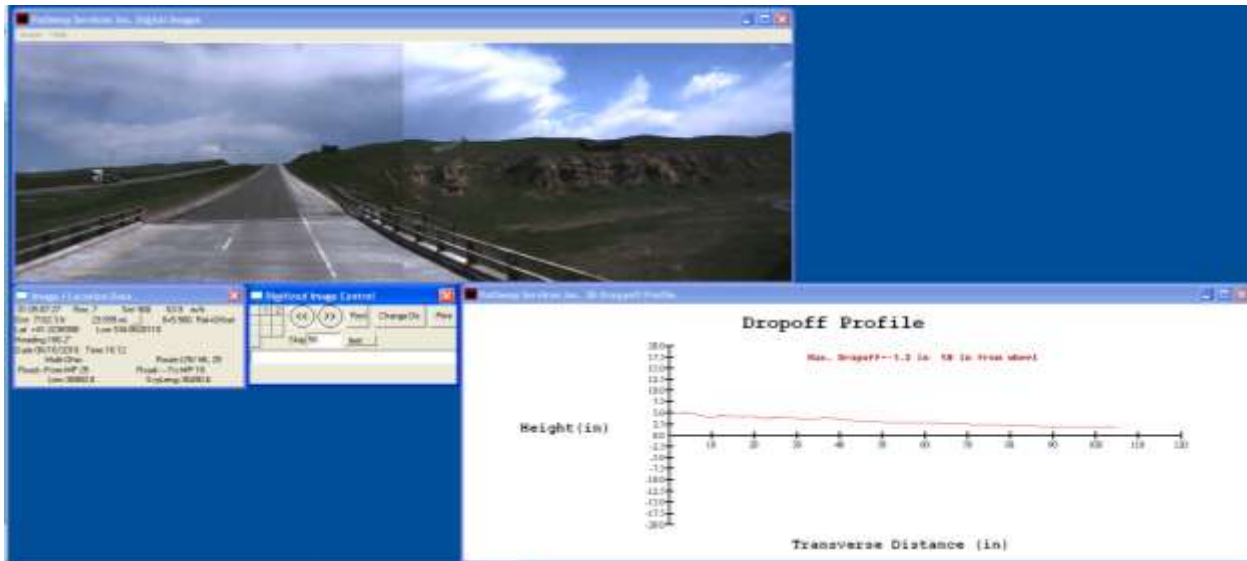


FIGURE 4.12 Profile on Concrete.

There was no change in the profile graph when analyzing off ramps from the interstate. Nor did the shadow of the overpass have a visual effect on the profile graph.

4.3 Gyroscope and IRI Data

International Roughness Index (IRI) was also recorded for each of the test sections. The data were summarized for every tenth of a mile, and then averaged over the entire length of the section. IRI is the measurement of inches of vertical change per mile or roadway. The IRI for the left and the right wheel paths are measured by Pathway Services and the average of both was calculated from those values. Table 4.3 is a summarization of that information for the six sections of roadways which produced usable slope data.

TABLE 4.3 International Roughness Index.

Route	IRI Left (in/mile)		IRI Right E (in/mile)		IRI AVERAGE	
	Average	ST. DEV	Average	ST. DEV	Average	ST. DEV
WY 319 DEC	155	70	186	84	171	50
WY 316 DEC	51	9	55	13	53	26
WY 316 INC	59	8	61	10	60	35
WY 313 INC	91	21	100	24	95	48
WY 313 DEC	90	15	103	21	97	49
I-25 DEC	69	30	70	27	70	30

The gyroscope information was also collected on the cross section of each of the sections tested. This information shows the longitudinal grade of the travel lane and the cross slope of the roadway. This information could be used to compare gyroscope to manually collected data, but the manually collected slopes include the slope of the fore slope. Therefore, it would be

inappropriate to compare the gyroscope information to the slope of the foreslope. The information shown in Table 4.4 represents the average cross grade and cross slope for each section collected by Pathway.

TABLE 4.4 Gyroscope Information.

Route	%Grade		Cross Slope	
	Average	ST. DEV.	Average	ST. DEV.
WY 319 DEC	1.8	2.3	0.4	1.4
WY 316 DEC	0.7	2.3	0.6	0.6
WY 316 INC	1.3	2.2	0.1	0.9
WY 313 INC	0.6	1.9	0.8	0.7
WY 313 DEC	1.3	1.8	1.0	1.2
I-25 DEC	0.2	2.0	0.3	1.0

4.4 Automated – Manual Data Correlations

The pathveiw program, for reading and organizing the data, provides a maximum drop-off at a certain distance from the wheel. The program allows this information to be exported to a spreadsheet for user designated milepost distances. When the report was generated it showed the maximum drop-off at distances very close to the wheel path, sometimes so close that it could not be assumed that the measurements would extend past the driving lane. Because the manual measurements were taken from the white shoulder marking, an alternative method for determining the slopes of the automated data was developed.

This system involved selecting the shoulder drop-off profile graph for every mile post from which a manual slope measurement was taken. From there a slope was fitted to the profile graph 10 inches in the transverse direction from the wheel to the point of termination or where the profile graph leveled out. The points were observed from the graph and then used to find the slope of the shoulder and the offset at which that slope was valid. Figure 4.13 is an example of where the points were taken to determine the slope of a non-linear shoulder profile.

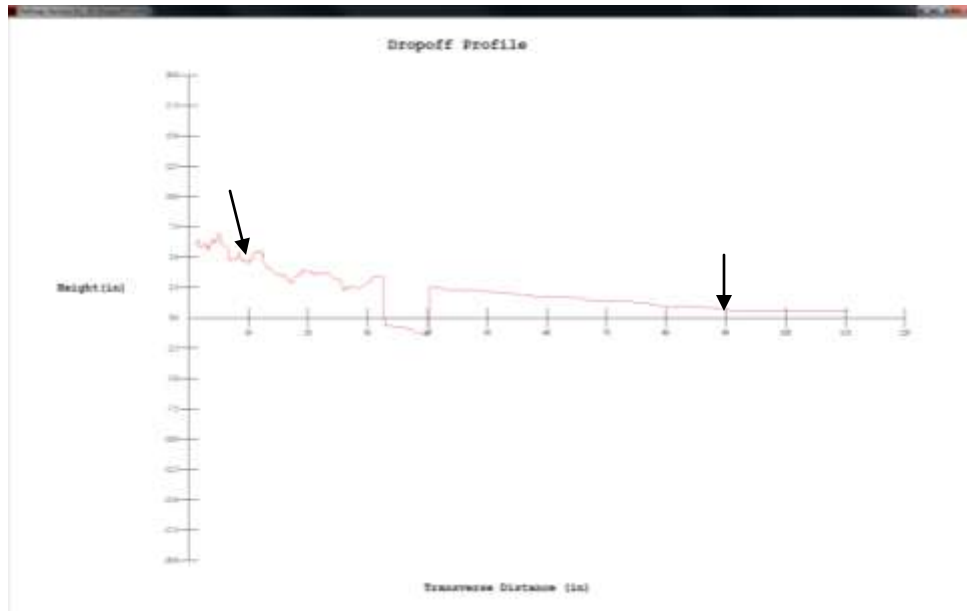


FIGURE 4.13 Slope Interpretations.

These profile graphs were obtained for every location where manual data was collected. They were then used to compute shoulder slopes for comparison with the manual data set. Graphs were generated to show the slope of the automated data (black) graphed along with the manually collected slopes (grey). The graphs show the mile post and the slopes of both collection procedures. A higher slope on the graph designates where the shoulder is flatter and a low number would be indicative of steeper slopes. Negative or zero slope indicators designate super elevation in the case of manually collected data.

Wyoming 319 Decreasing has no shoulders and it also has the highest and densest vegetation. When the slopes are plotted against each other, as shown in Figure 4.14, there are significant variations in the automated data and the slopes are consistently different.

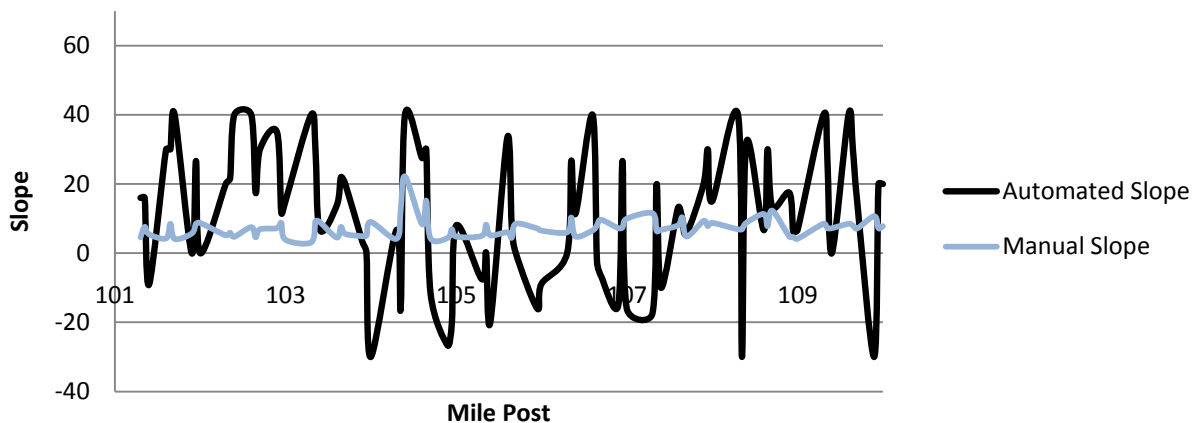


FIGURE 4.14 WY 319 Decreasing (0 ft Shoulder).

In the 4-foot wide shoulder test sections, the two data sets more closely matched each other in terms of the measured slopes. As shown in Figures 4.15 and 4.16, the variation in the slope's data determined by Pathway Services was much less than the section with no shoulder. It is important to point out that the first mile of the decreasing section is super elevated and therefore shows a negative slope for the manually collected data. The data collected by Pathway Services does not show this super elevation.

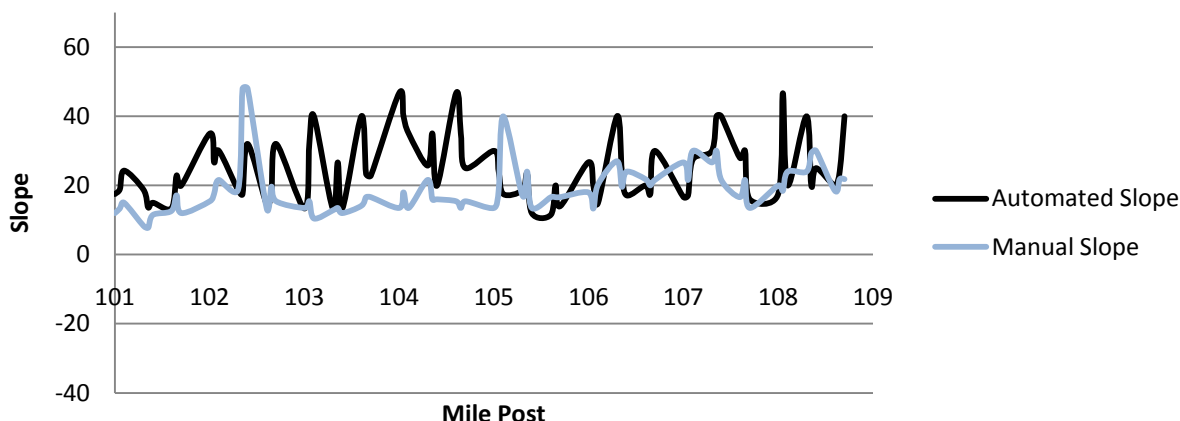


FIGURE 4.15 WY 313 Increasing (4 ft Shoulder).

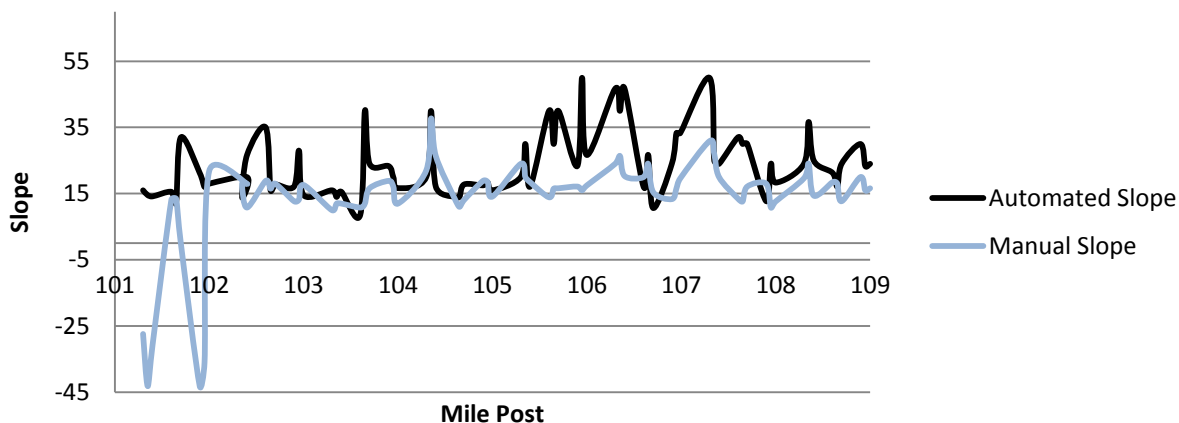


FIGURE 4.16 WY 313 Decreasing (4 ft Shoulder).

The section with six-foot shoulders shows the most similarities between the two data sets. The average slopes for the increasing section are 13.7:1 for the automated method of collection and 12.5:1 for the manual method of collection. The average for the decreasing sections was equally similar with 13.7:1 being the automated average and 13.0:1 being the average for the manually collected method. It is evident from Figures 4.17 and 4.18 that the slopes are similar as they overlap in the graph. The only difference in the two sets is that at mile posts 3 and 8.3 there is super elevation in the increasing section that is not detected using the automated method.

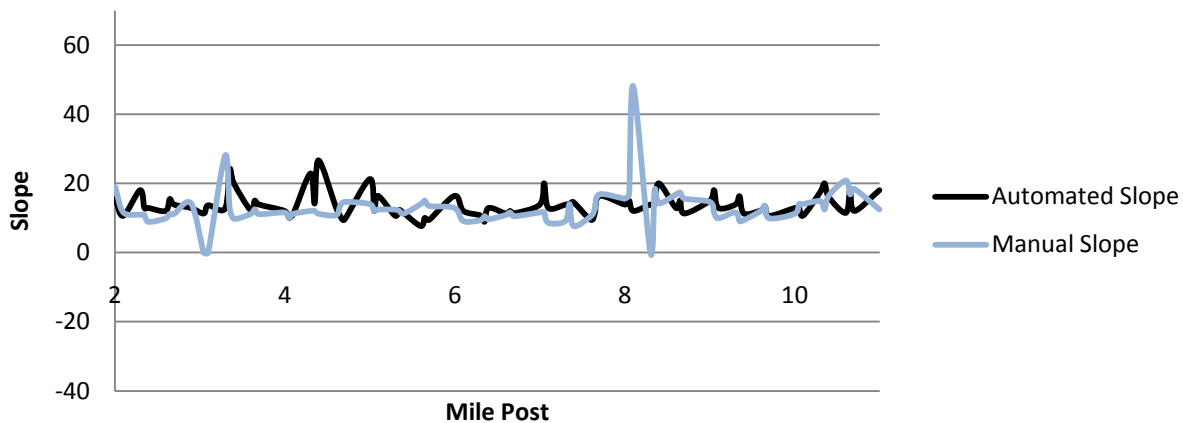


FIGURE 4.17 WY 316 Increasing (6 ft Shoulder).

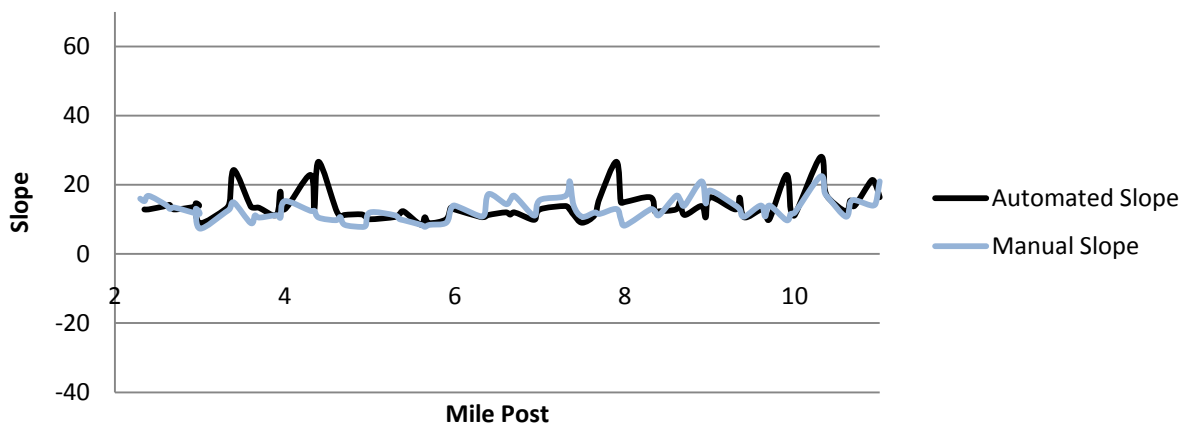


FIGURE 4.18 WY 316 Decreasing (6 ft Shoulder).

The section with the ten-foot shoulder should have produced the data sets that are the most similar because there was no vegetation for over 14 feet from the white shoulder marking. The average slope of the shoulder in this section for the manually collected data is 42.9:1, indicating that the slope of the shoulder is very flat. The slope of the paved shoulder is most nearly level and in fact at the beginning of the section, there is a third of a mile of super elevation. As shown in Figure 4.19, the profile graphs collected by Pathway Services do not show this super elevation. On average, the slope characteristics of the shoulder collected by Pathway Services were also steeper than that of the manually collected data. The automatically collected data was on average about twice as steep as the data collected manually. Another observation about this section is that the paved shoulder was an average of 10.1 feet wide and the Pathway sensor only returns data to 7.3 feet; less than the distance it could measure in the 6-foot sections.

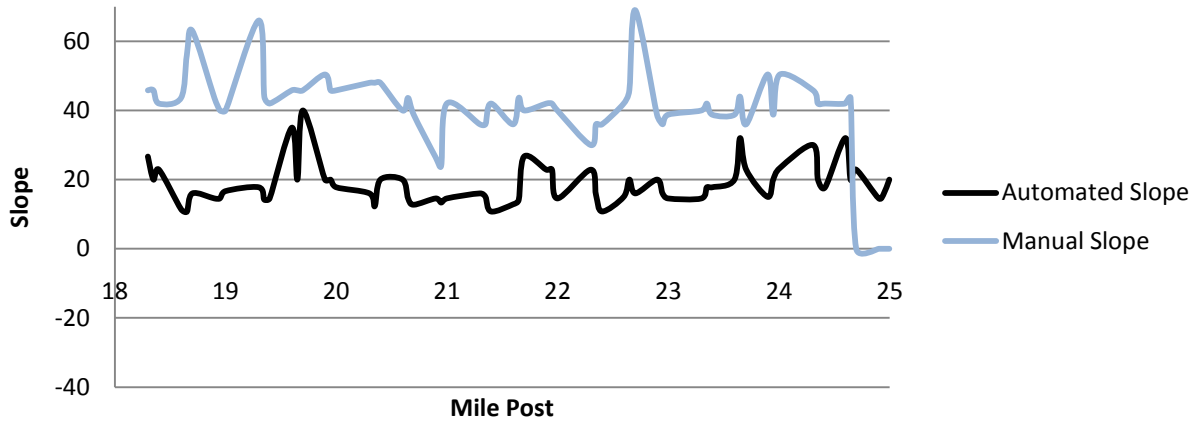


FIGURE 4.19 Interstate 25 Decreasing (10 ft Shoulder) .

4.5 Statistical Analysis

Table 4.5 summarizes the results from the statistical analysis conducted on the six sections that produced viable data. The eight-foot shoulder section was eliminated because of an operational defect in the program. It was impossible to determine a mile post for the shoulder profile drop-off graph and therefore was excluded. It was mentioned previously that Pathway Services collected data for the two-foot section on the wrong road and so the data sets could not be compared.

The slope for both methods of collection as well as the transverse distance from either the white shoulder marking (for manually collected data) or the wheel path (for the Pathway data) is presented for each section in Table 4.5. A paired t-test was conducted on the slopes found in each method. The table shows that the number of pairs and the t-value as well as the populations were significantly different. That table also provides the average distance to first vegetation for each section which may help explain the difference in average slopes.

TABLE 4.5 Statistical Analyses.

Section	Shoulder Width	Distance to Vegetation	Average Automated		Average Manual		Number of Pairs	T - Value	Significantly Different
			Offset	Slope	Offset	Slope			
Wy 319 Dec	0 ft	0.3 ft	4.5 ft	11.9	12.0 ft	7.3	80	0.03976	YES
Wy 313 INC	4 ft	4.8 ft	6.5 ft	25.0	4.8 ft	19.1	72	0.00005	YES
Wy 313 DEC	4 ft	4.9 ft	6.2 ft	24.0	4.9 ft	13.5	72	0.00000	YES
Wy 316 INC	6 ft	6.7 ft	8.0 ft	13.8	7.0 ft	12.5	80	0.11993	NO
Wy 316 DEC	6 ft	6.5 ft	7.9 ft	13.7	6.8 ft	13.0	81	0.12059	NO
I - 25 DEC	10 ft	14.3 ft	7.3 ft	18.6	10.1 ft	42.9	63	0.00000	YES

It is clear from Table 4.5 that there is statistically a significant difference between the manually and automated data sets. Three of the test sections were significantly different at the 0.05 level. Each of these sections produced t-values less than 0.05. The t-values for WY 316

were greater than 0.05 meaning that section's data sets are statistically equal. The automated sensor also read the farthest from the wheel path on WY 316.

4.6 Chapter Summary

Four test sections produced data that was usable in the statistical analysis. Of those sections, only one, the six-foot shoulder section, showed slopes from the two data sets that could not be proven different. Observations of the data also showed that the drop-off sensor does not show super elevation. It does seem to work better on concrete and shows curbs well. This exhibits how the data was processed and how the two different sets were correlated to one another. It was also found that the Pathway sensor did not reach past the paved shoulder and onto the foreslope.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The objective of this study is to address the lack of proven technology for measuring the drop off and slopes of shoulders. This was addressed by comparing the data collected by Pathway's drop off sensor to manually collected data. A comprehensive literature review was conducted to determine whether or not a similar study had been done in the past. The findings of that literature review showed that there was extensive work in the area of automated data collection but no previous studies in validating shoulder drop off sensors.

Vegetation observations were made on all of the sections so that the height and density could be correlated to the slopes and the accuracy of the sensor. The slopes of the shoulders were measured manually and with the automated equipment. The two data sets were then compared.

5. Conclusions

The following conclusions can be drawn based on the data collection and analysis described in this report:

- By comparing the slopes, the results of the t-tests, and the vegetation in the sections it becomes very evident that the automated readings are not accurate in determining the slopes of shoulders and foreslopes. In most sections the vegetation appears to be a significant factor causing inaccuracy. It is most apparent in the section with no shoulder where the height of the vegetation averaged 26 inches tall and was the densest of all the sections. The profile graphs in this section had the most variance and the least amount of consistency.
- For other sections, the average distance from the wheel path to the site of the automated readings, was consistently 1.5 feet longer than the distance from the white shoulder marking to the first vegetation. Assuming a vehicle travels approximately 18 inches inside the driving lane this means that the sensor readings are affected by the first vegetation on any road section, and may need to be corrected for this.
- In the automated and manual data the sections with no shoulders, 4 foot, and 10 foot shoulders were statistically at the $\alpha = .05$ level.

- The two forms of data collection yielded slope populations that were not significantly different in the six-foot section. In this section, the slopes of both directions had very similar averages and the correlation graphs were closer than any of the rest. Unfortunately, the fact that all of the other sections were significantly different implies that the slopes were similar due to some other circumstance. This could be anything from the reflectivity of the aggregate, recent resurfacing, or the roughness of the roadway.
- The data collected by Pathway Services shows the bridge curbs in the profile drop-off graphs fairly accurately. The increase in height at the bridge curb was nearly six inches and the distance from the wheel path was accurate. The use of the sensor for this purpose could be very useful in determining curb height and distance from the travel lane. The purpose of this study was not to test it for this use.
- In the wide shoulders where the bridge curb was too far out for the sensor to pick up, the drop-off profiles were uncharacteristically level and displayed less noise near the wheel path. It is believed that this accuracy is due to the surface materials on the bridge. On every section where concrete was the surface material, the drop-off sensor makes more accurate readings and profile graphs.
- The Pathway program does not identify the shoulder marking in any reports and therefore it is vastly difficult to match any data. It also does not provide the reader with a basis of measurement from the vehicle and therefore there is no standard for measurement.
- The sensor did not measure the foreslope; it only measured the slope and distance to the nearest vegetation.

5.2 Recommendations

Because of the potential effect that different materials could have on the results of the sensory reading, it would be beneficial to look at the types of surfacing and correlate it to the accuracy of the sensor. It is speculated that the type of surfacing could have an effect on the accuracy of the sensor readings. Different aspects, such as reflectivity, texture and roughness of the pavement could have a significant effect on the readings.

The position of the sensor could also be causing problems with the readings. It would seem more logical to place the sensor at a higher position on the vehicle to ensure that it could take a more extensive reading and take more accurate measurements with a larger angle. At this point, the sensor is not capable of identifying guardrail height or fore slopes; two of the

measurements identified as being of concern initially. Changing the position of the sensor will most likely improve the accuracy and effectiveness of its readings.

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APPENDIX A: Vegetation Observation Sheets

Manual Roadside Vegetation Observations

Date: 6/15/2010

Width: 10ft

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: Interstate 25 ML25 12-20 DEC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
3:17 PM	25		118 - 120	Grass	10.0 ft		-	-	5.0 ft		-	-	5.0 ft		M	8 in
3:22 PM	24.7		121 - 125	Grass	11.0 ft		-	-	6.0 ft		L	3 in	3.0 ft		M	8 in
3:27 PM	24.4		126 - 128	Grass	10.0 ft		-	-	5.0 ft		-	-	5.0 ft		M	7 in
3:29 PM	24		129 - 131	Grass	11.0 ft		-	-	3.0 ft		-	-	6.0 ft		M	6 in
3:32 PM	23.7	Bridge w/ GR	132 - 134	Grass	12.0 ft		-	-	6.0 ft		-	-	2.0 ft		L	8 in
3:35 PM	23.4		135 - 137	Grass	10.0 ft		-	-	4.0 ft		-	-	6.0 ft		L	8 in
3:37 PM	23		138 - 140	Grass	10.0 ft		-	-	3.0 ft		-	-	7.0 ft		M	7 in
3:39 PM	22.7		141 - 143	Grass	11.0 ft		-	-	4.0 ft		-	-	5.0 ft		M	12 in
3:41 PM	22.4		144 - 146	Grass	10.0 ft		-	-	4.0 ft		-	-	6.0 ft		L	8 in
3:43 PM	22	Exit Ramp	147 - 149	Grass	10.0 ft		-	-	4.0 ft		-	-	6.0 ft		L	7 in
3:46 PM	21.7		150 - 151	Grass	10.0 ft		-	-	3.0 ft		-	-	7.0 ft		M	7 in
3:48 PM	21.4	Entry Ramp Lane	152 - 154	Grass	10.0 ft		-	-	2.0 ft		-	-	8.0 ft		M	8 in
3:50 PM	21		155 - 157	Grass	10.0 ft		-	-	2.0 ft		-	-	8.0 ft		M	8 in
3:53 PM	20.7		158 - 160	Grass	10.0 ft		-	-	3.0 ft		-	-	7.0 ft		M	7 in
3:54 PM	20.4		161 - 163	Grass	10.0 ft		-	-	3.0 ft		-	-	7.0 ft		L	7 in
3:56 PM	20		164 - 166	Grass	11.0 ft		-	-	4.0 ft		-	-	5.0 ft		M	10 in
3:58 PM	19.7		167 - 169	Grass	10.0 ft		-	-	5.0 ft		-	-	5.0 ft		M	8 in
4:02 PM	19.4		170 - 172	Grass	11.0 ft		-	-	6.0 ft		-	-	3.0 ft		M	8 in
4:05 PM	19		173 - 175	Grass	11.0 ft		-	-	3.0 ft		-	-	6.0 ft		M	7 in
4:06 PM	18.7		176 - 178	Grass	11.0 ft		-	-	3.0 ft		-	-	6.0 ft		D	12 in
4:09 PM	18.4		179 - 181	Grass	10.5 ft		-	-	2.5 ft		-	-	7.0 ft		D	8 in
4:11 PM	18		182 - 184	Grass	10.5 ft		-	-	3.5 ft		-	-	6.0 ft		D	10 in

Manual Roadside Vegetation Observations

Date: 6/16/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 INC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
1:33 PM	2		364 - 366	Grass	6.0 ft		-	-	1.0 ft		-	-	13.0 ft		M	8 in
1:36 PM	2.3		367 - 369	Grass	3.5 ft		-	-	3.5 ft		L	3 in	13.0 ft		L	6 in
1:39 PM	2.6		370 - 372	Grass	3.0 ft		-	-	3.5 ft		-	-	13.5 ft		L	6 in
1:41 PM	3	Super-Elev.	373 - 374	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	8 in
1:43 PM	3.3		375 - 377	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		L	10 in
1:45 PM	3.6		378 - 380	Grass	3.0 ft		-	-	3.5 ft		-	-	13.5 ft		M	10 in
1:47 PM	4		381 - 383	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		M	10 in
1:49 PM	4.3		384 - 386	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	10 in
1:50 PM	4.6		387 - 389	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		M	7 in
1:52 PM	5		390 - 392	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	8 in
1:54 PM	5.3		393 - 395	Grass	4.0 ft		-	-	4.0 ft		-	-	12.0 ft		L	8 in
1:55 PM	5.6		396 - 398	Grass	3.0 ft		-	-	3.5 ft		-	-	13.5 ft		L	9 in
1:57 PM	6	Curve	399 - 401	Grass	4.0 ft		-	-	3.0 ft		-	-	13.0 ft		M	10 in
1:59 PM	6.3		402 - 404	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	8 in
2:01 PM	6.6		405 - 407	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	12 in
2:02 PM	7		408 - 410	Grass	4.0 ft		-	-	3.0 ft		-	-	13.0 ft		L	8 in
2:04 PM	7.3		411 - 413	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	10 in
2:06 PM	7.6		414 - 416	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	12 in
2:08 PM	8	Super-Elev.	417 - 419	Grass	3.0 ft		-	-	4.0 ft		-	-	13.0 ft		M	8 in
2:10 PM	8.3		420 - 422	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	12 in
2:12 PM	8.6		423 - 425	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	12 in
2:13 PM	9		426 - 428	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	12 in
2:15 PM	9.3		429 - 431	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		D	10 in
2:17 PM	9.6		432 - 434	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		D	18 in
2:19 PM	10		435 - 437	Grass	3.0 ft		-	-	3.5 ft		-	-	13.5 ft		D	12 in
2:21 PM	10.3		438 - 440	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	12 in
2:22 PM	10.6		441 - 443	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		D	18 in
2:24 PM	11		444 - 446	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		D	24 in

Manual Roadside Vegetation Observations

Date: 6/16/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 DEC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
2:26 PM	11		447 - 449	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		M	8 in
2:28 PM	10.7		450 - 452	Grass	3.0 ft		-	-	3.0 ft		L	3 in	14.0 ft		D	12 in
2:30 PM	10.4		453 - 455	Grass	3.0 ft		-	-	4.0 ft		-	-	13.0 ft		M	12 in
2:32 PM	10		456 - 458	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		M	12 in
2:34 PM	9.7		459 - 461	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	18 in
2:36 PM	9.4		462 - 464	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		M	8 in
2:37 PM	9		465 - 467	Grass	4.0 ft		-	-	3.0 ft		-	-	13.0 ft		M	8 in
2:39 PM	8.7		468 - 470	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		D	14 in
2:41 PM	8.4		471 - 473	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		M	12 in
2:43 PM	8	Super-Elev.	474 - 476	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		M	10 in
2:45 PM	7.7		477 - 479	Grass	3.0 ft		-	-	4.0 ft		-	-	13.0 ft		M	8 in
2:47 PM	7.4		480 - 482	Grass	4.0 ft		-	-	3.0 ft		-	-	13.0 ft		D	12 in
2:49 PM	7		483 - 485	Grass	4.0 ft		-	-	3.0 ft		-	-	13.0 ft		M	14 in
2:51 PM	6.7		486 - 488	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		M	8 in
2:53 PM	6.4		489 - 491	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	12 in
2:55 PM	6		492 - 494	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	12 in
2:58 PM	5.7		495 - 497	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		M	12 in
3:00 PM	5.4		498 - 500	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		M	8 in
3:01 PM	5		501 - 503	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	8 in
3:03 PM	4.7		504 - 506	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		L	12 in
3:05 PM	4.4		507 - 509	Grass	3.5 ft		-	-	3.5 ft		-	-	13.0 ft		L	12 in
3:07 PM	4		510 - 512	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		L	10 in
3:09 PM	3.7		513 - 515	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		L	10 in
3:11 PM	3.4		516 - 518	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		M	12 in
3:13 PM	3		519 - 521	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		M	18 in
3:15 PM	2.7		522 - 523	Grass	3.0 ft		-	-	3.5 ft		-	-	13.5 ft		M	12 in
3:26 PM	2.4		524 - 527	Grass	3.5 ft		-	-	3.0 ft		-	-	13.5 ft		M	10 in
3:28 PM	2		528 - 529	Grass	3.0 ft		-	-	3.0 ft		-	-	14.0 ft		D	12 in

Manual Roadside Vegetation Observations

Date: 6/16/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 INC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
4:05 PM	101		530 - 532	Grass	4.0 ft		-	-	1.0 ft			-	15.0 ft		M	8 in
4:07 PM	101.3	Super-Elevated	533 - 535	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	24 in
4:09 PM	101.6		536 - 538	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	12 in
4:12 PM	102		539 - 541	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	10 in
4:14 PM	102.3		542 - 544	Grass	4.0 ft		-	-	2.0 ft		-	-	14.0 ft		M	12 in
4:15 PM	102.6		545 - 547	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		M	18 in
4:17 PM	103		548 - 550	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		M	12 in
4:19 PM	103.3		551 - 553	Grass	3.5 ft		-	-	1.5 ft		-	-	15.0 ft		D	12 in
4:21 PM	103.6		554 - 556	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	24 in
4:23 PM	104		557 - 559	Grass	2.5 ft		-	-	1.5 ft		-	-	16.0 ft		D	12 in
4:25 PM	104.3		560 - 562	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	18 in
4:27 PM	104.6		563 - 565	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	18 in
4:29 PM	105		566 - 568	Grass	3.5 ft		-	-	1.5 ft		-	-	15.0 ft		D	18 in
4:31 PM	105.3		569 - 571	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	24 in
4:33 PM	105.6		572 - 573	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		D	24 in
4:34 PM	106		574 - 576	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	28 in
4:36 PM	106.3		577 - 579	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	24 in
4:37 PM	106.6		580 - 582	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	24 in
4:39 PM	107		583 - 585	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	24 in
4:40 PM	107.3		586 - 588	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	24 in
4:42 PM	107.6		589 - 591	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		D	28 in
4:44 PM	108		592 - 594	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	24 in
4:45 PM	108.3		595 - 597	Grass	4.5 ft		-	-	1.0 ft		-	-	14.5 ft		D	24 in
4:47 PM	108.6		598 - 600	Grass	4.5 ft		-	-	1.0 ft		-	-	14.5 ft		D	24 in
4:49 PM	109		601 - 603	Grass	4.5 ft		-	-	1.0 ft		-	-	14.5 ft		D	28 in

Manual Roadside Vegetation Observations

Date: 6/16/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 DEC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
4:49 PM	109		604 - 606	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		D	24 in
4:51 PM	108.7		607 - 609	Grass	3.0 ft		-	-	1.0 ft		-	-	16.0 ft		D	24 in
4:53 PM	108.4		610 - 612	Grass	3.0 ft		-	-	1.0 ft		-	-	16.0 ft		D	20 in
4:54 PM	108		613 - 615	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		M	18 in
4:56 PM	107.7		616 - 618	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		D	24 in
4:57 PM	107.4		619 - 621	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		D	22 in
4:59 PM	107		622 - 624	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		D	22 in
5:01 PM	106.7		625 - 627	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	20 in
5:03 PM	106.4		628 - 630	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	20 in
5:04 PM	106		631 - 633	Grass	3.0 ft		-	-	1.5 ft		-	-	15.5 ft		D	18 in
5:05 PM	105.7		634 - 636	Grass	4.0 ft		-	-	1.5 ft		-	-	14.5 ft		D	24 in
5:06 PM	105.4		637 - 639	Grass	3.5 ft		-	-	1.5 ft		-	-	15.0 ft		D	20 in
5:08 PM	105		640 - 642	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	20 in
5:09 PM	104.7		643 - 645	Grass	4.0 ft		-	-	1.5 ft		-	-	14.5 ft		M	16 in
5:11 PM	104.4		646 - 648	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	18 in
5:12 PM	104		649 - 651	Grass	3.0 ft		-	-	2.0 ft		-	-	15.0 ft		D	22 in
5:13 PM	103.7		652 - 654	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	18 in
5:15 PM	103.4		655 - 657	Grass	3.5 ft		-	-	1.5 ft		-	-	15.0 ft		D	24 in
5:16 PM	103		658 - 660	Grass	4.0 ft		-	-	1.5 ft		-	-	14.5 ft		D	16 in
5:18 PM	102.7		661 - 663	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	26 in
5:19 PM	102.4		664 - 666	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		D	28 in
5:20 PM	102		667 - 669	Grass	4.0 ft		-	-	1.0 ft		-	-	15.0 ft		M	22 in
5:22 PM	101.7		670 - 672	Grass	3.0 ft		-	-	1.5 ft		-	-	15.5 ft		M	8 in
5:23 PM	101.4		673 - 675	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		M	14 in
5:25 PM	101		676 - 678	Grass	3.5 ft		-	-	1.0 ft		-	-	15.5 ft		M	22 in

Manual Roadside Vegetation Observations

Date: 6/16/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 259 ML41 12-20 DEC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
8:28 AM	20		185 - 187	Grass	7.5 ft		-	-	8.5 ft		-	-	4.0 ft		L	8 in
8:32 AM	19.7		188 - 190	Grass	8.0 ft		-	-	3.5 ft		L	3 in	8.5 ft		L	9 in
8:34 AM	19.4		191 - 193	Grass	7.0 ft		-	-	4.0 ft		-	-	9.0 ft		L	10 in
8:35 AM	19		194 - 196	Grass	8.0 ft		-	-	4.0 ft		-	-	8.0 ft		L	6 in
8:37 AM	18.7		197 - 199	Grass	8.0 ft		-	-	4.0 ft		-	-	8.0 ft		L	8 in
8:39 AM	18.4		200 - 202	Grass	8.0 ft		-	-	3.0 ft		-	-	9.0 ft		L	8 in
8:41 AM	18		203 - 205	Grass	8.0 ft		-	-	3.5 ft		-	-	8.5 ft		L	6 in
8:43 AM	17.7		206 - 208	Grass	7.5 ft		-	-	3.5 ft		-	-	9.0 ft		L	7 in
8:44 AM	17.4		209 - 211	Grass	7.5 ft		-	-	4.0 ft		-	-	8.5 ft		M	8 in
8:46 AM	17		212 - 214	Grass	7.5 ft		-	-	3.5 ft		-	-	9.0 ft		M	8 in
8:48 AM	16.7		215 - 217	Grass	7.0 ft		-	-	4.0 ft		-	-	9.0 ft		L	9 in
8:50 AM	16.4		218 - 221	Grass	8.0 ft		-	-	3.0 ft		-	-	9.0 ft		M	9 in
8:52 AM	16		222 - 224	Grass	7.5 ft		-	-	3.5 ft		-	-	9.0 ft		L	6 in
8:53 AM	15.7	CURVE/SUPER-ELEV.	225 - 227	Grass	8.0 ft		-	-	4.0 ft		-	-	8.0 ft		L	7 in
8:55 AM	15.4		228 - 230	Grass	8.0 ft		-	-	3.0 ft		-	-	9.0 ft		M	8 in
8:57 AM	15		231 - 233	Grass	8.0 ft		-	-	4.0 ft		-	-	8.0 ft		D	10 in
8:59 AM	14.7		234 - 236	Grass	7.0 ft		-	-	5.0 ft		-	-	8.0 ft		L	8 in
9:01 AM	14.4		237 - 239	Grass	7.0 ft		-	-	4.0 ft		-	-	9.0 ft		M	10 in
9:03 AM	14		240 - 242	Grass	8.0 ft		-	-	3.0 ft		-	-	9.0 ft		M	10 in
9:07 AM	13.7		243 - 245	Grass	7.5 ft		-	-	4.5 ft		-	-	8.0 ft		L	7 in
9:09 AM	13.4		246 - 248	Grass	7.0 ft		-	-	4.0 ft		-	-	9.0 ft		L	7 in
9:12 AM	13		249 - 251	Grass	8.0 ft		-	-	3.5 ft		-	-	8.5 ft		M	8 in
9:14 AM	12.7		252 - 254	Grass	7.0 ft		-	-	5.5 ft		-	-	7.5 ft		L	7 in
9:16 AM	12.4		255 - 257	Grass	7.0 ft		-	-	4.0 ft		-	-	9.0 ft		M	10 in
9:18 AM	12		258 - 260	Grass	7.5 ft		-	-	3.5 ft		-	-	9.0 ft		L	8 in

Manual Roadside Vegetation Observations

Date: 6/15/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: US 30 ML56 350-356 INC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
1:00 PM	350		2 - 6	Grass	2.0 ft		-	-	2.0 ft		-	-	16.0 ft		M	12 in
1:07 PM	350.3		6 - 9	Grass	1.5 ft		-	-	3.0 ft		-	-	15.5 ft		L-M	9 in
1:14 PM	350.6		10 - 14	Grass	2.0 ft		-	-	4.0 ft		-	-	14.0 ft		M	12 in
1:21 PM	351		15 - 17	Grass	2.0 ft		-	-	6.0 ft		-	-	12.0 ft		M	10 in
1:27 PM	351.3		18 - 20	Grass	2.0 ft		-	-	3.0 ft		-	-	15.0 ft		D	12 in
1:32 PM	351.6		21 - 23	Grass	1.5 ft		-	-	5.0 ft		-	-	13.5 ft		M	10 in
1:36 PM	352		24 - 26	Grass	1.0 ft		-	-	2.0 ft		-	-	17.0 ft		D	9 in
1:39 PM	352.3		27 - 29	Grass	1.0 ft		-	-	7.0 ft		-	-	12.0 ft		D	12 in
1:41 PM	352.6		30 - 32	Grass	2.0 ft		-	-	3.0 ft		-	-	15.0 ft		D	12 in
1:44 PM	353		33 - 35	Grass	2.0 ft		-	-	2.0 ft		-	-	16.0 ft		D	10 in
1:46 PM	353.3		36 - 37	Grass	1.0 ft		-	-	5.0 ft		-	-	14.0 ft		D	10 in
1:48 PM	353.6		38 - 40	Grass	2.0 ft		-	-	3.0 ft		-	-	15.0 ft		D	10 in
1:50 PM	354		41 - 43	Grass	1.0 ft		-	-	7.0 ft		-	-	12.0 ft		M	7 in
1:52 PM	354.3		44 - 46	Grass	1.0 ft		-	-	5.5 ft		-	-	13.5 ft		D	10 in
1:55 PM	354.6		47 - 49	Grass	1.5 ft		-	-	3.5 ft		-	-	15.0 ft		D	12 in
1:59 PM	355		50 - 52	Grass	2.0 ft		-	-	4.0 ft		-	-	14.0 ft		D	14 in
2:00 PM	355.3		53 - 55	Grass	1.3 ft		-	-	2.2 ft		-	-	16.5 ft		M	7 in
2:02 PM	355.6		56 - 58	Grass	2.0 ft		-	-	2.0 ft		-	-	16.0 ft		D	10 in
2:04 PM	356		59 - 61	Grass	2.0 ft		-	-	2.0 ft		-	-	16.0 ft		D	12 in

Manual Roadside Vegetation Observations

Date: 6/15/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: US 30 ML56 350-356 DEC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
2:06 PM	356		61 - 63	Grass	1.0 ft		-	-	1.0 ft		-	-	18.0 ft		M	10 in
2:10 PM	355.7		64 - 65	Grass	2.0 ft		-	-	2.0 ft		-	-	16.0 ft		M	8 in
2:13 PM	355.4		66 - 68	Grass	2.0 ft		-	-	4.0 ft		-	-	14.0 ft		M	8 in
2:16 PM	355		69 - 72	Grass	1.0 ft		-	-	5.0 ft		-	-	14.0 ft		D	14 in
2:18 PM	354.7		73 - 75	Grass	0.5 ft		-	-	2.0 ft		-	-	17.5 ft		D	14 in
2:20 PM	354.4		76 - 78	Grass	1.0 ft		-	-	4.0 ft		-	-	15.0 ft		D	18 in
2:22 PM	354		79 - 81	Grass	0.5 ft		-	-	3.0 ft		-	-	16.5 ft		M	6 in
2:25 PM	353.7		82 - 84	Grass	2.0 ft		-	-	3.0 ft		L	6 in	15.0 ft		M	10 in
2:27 PM	353.4		85 - 87	Grass	1.0 ft		-	-	3.0 ft		L	8 in	16.0 ft		D	12 in
2:30 PM	353		88 - 90	Grass	1.0 ft		-	-	5.0 ft		L	8 in	14.0 ft		M	8 in
2:32 PM	352.7		91 - 93	Grass	0.0 ft		-	-	4.0 ft		-	-	16.0 ft		M	7 in
2:34 PM	352.4		94 - 96	Grass	1.0 ft		-	-	2.0 ft		-	-	17.0 ft		D	8 in
2:36 PM	352		97 - 99	Grass	1.5 ft		-	-	3.0 ft		-	-	15.5 ft		D	12 in
2:39 PM	351.7		100 - 102	Grass	2.0 ft		-	-	3.0 ft		-	-	15.0 ft		D	8 in
2:41 PM	351.4		103 - 105	Grass	0.0 ft		-	-	4.0 ft		L	6 in	16.0 ft		M	8 in
2:44 PM	351		106 - 108	Grass	0.5 ft		-	-	3.0 ft		-	-	16.5 ft		M	7 in
2:46 PM	350.7		109 - 111	Grass	0.0 ft		-	-	3.0 ft		-	-	17.0 ft		D	9 in
2:48 PM	350.4		112 - 114	Grass	0.0 ft		-	-	3.0 ft		-	-	17.0 ft		D	10 in
2:50 PM	350		115 - 117	Grass	1.0 ft		-	-	4.0 ft		-	-	15.0 ft		D	10 in

Manual Roadside Vegetation Observations

Date: 6/16/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 319 ML319 101-110 DEC

Time	Mile Post	Notes	Photo Number	Vegetation Type	Section A				Section B				Section C			
					Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.	Horiz.	Vert.	Veg.	Ht.
12:07 PM	110		280 - 282	Grass	0.5 ft		-	-	19.5 ft		D	24 in				
12:12 PM	109.7		283 - 285	Grass	0.7 ft		-	-	19.3 ft		D	24 in				
12:12 PM	109.4		286 - 288	Grass	1.0 ft		-	-	19.0 ft		D	18 in				
12:15 PM	109		289 - 291	Grass	2.0 ft		-	-	18.0 ft		D	24 in				
12:17 PM	108.7		292 - 294	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:19 PM	108.4		295 - 297	Grass	0.5 ft		-	-	19.5 ft		D	30 in				
12:21 PM	108		298 - 300	Grass	0.0 ft		-	-	20.0 ft		D	28 in				
12:23 PM	107.7		301 - 303	Grass	0.0 ft		-	-	20.0 ft		D	14 in				
12:24 PM	107.4		304 - 306	Grass	0.0 ft		-	-	20.0 ft		D	18 in				
12:24 PM	107		307 - 308	Grass	0.0 ft		-	-	20.0 ft		D	24 in				
12:27 PM	106.7		309 - 311	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:28 PM	106.4		312 - 314	Grass	0.5 ft		-	-	19.5 ft		D	16 in				
12:29 PM	106		315 - 317	Grass	0.5 ft		-	-	19.5 ft		D	30 in				
12:30 PM	105.7	Curve	318 - 320	Grass	1.0 ft		-	-	19.0 ft		D	24 in				
12:31 PM	105.4		321 - 323	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:32 PM	105		324 - 326	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:34 PM	104.7	Curve	327 - 329	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:35 PM	104.4		330 - 332	Grass	0.0 ft		-	-	20.0 ft		D	18 in				
12:36 PM	104		333 - 335	Grass	0.5 ft		-	-	19.5 ft		D	30 in				
12:38 PM	103.7	Lane Widens	336 - 338	Grass	0.0 ft		-	-	20.0 ft		D	28 in				
12:39 PM	103.4		339 - 341	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:40 PM	103		342 - 344	Grass	0.5 ft		-	-	19.5 ft		D	24 in				
12:42 PM	102.7		345 - 347	Grass	0.0 ft		-	-	20.0 ft		D	30 in				
12:43 PM	102.4		348 - 350	Grass	0.5 ft		-	-	19.5 ft		D	18 in				
12:45 PM	102		351 - 353	Grass	0.0 ft		-	-	20.0 ft		D	36 in				
12:46 PM	101.7		354 - 356	Grass	0.00		-	-	20.0 ft		D	30 in				
12:48 PM	101.4		357 - 359	Grass	0.00		-	-	20.0 ft		D	24 in				
12:50 PM	101		360 - 362	Grass	0.00		-	-	20.0 ft		D	30 in				

APPENDIX B: Manual Slope Measurements

Manual Slope Measurements

Date: 7/8/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: I-25 ML25 25-18 DEC

1 of 3

Time	Station	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
11:06 AM	25		10.5 ft	0.00 in	0.00		5.0 ft	7.00 in	8.57		12.0 ft	17.00 in	8.47	
	24.95		10.5 ft	0.00 in	0.00		5.0 ft	6.75 in	8.89		12.0 ft	18.00 in	8.00	
	24.9		10.5 ft	0.00 in	0.00	0.00	4.0 ft	5.00 in	9.60	9.02	12.0 ft	14.00 in	10.29	8.92
11:13 AM	24.7		10.5 ft	0.00 in	0.00		4.5 ft	5.75 in	9.39		12.0 ft	14.00 in	10.29	
	24.65		10.0 ft	2.75 in	43.64		4.0 ft	6.75 in	7.11		12.0 ft	13.75 in	10.47	
	24.6		10.5 ft	3.00 in	42.00	28.55	4.0 ft	8.00 in	6.00	7.50	12.0 ft	17.00 in	8.47	9.74
11:20 AM	24.4		10.5 ft	3.00 in	42.00		3.5 ft	6.50 in	6.46		12.0 ft	24.50 in	5.88	
	24.35		10.5 ft	3.00 in	42.00		3.5 ft	4.75 in	8.84		12.0 ft	19.00 in	7.58	
	24.3		10.5 ft	2.75 in	45.82	43.27	3.5 ft	4.75 in	8.84	8.05	12.0 ft	19.00 in	7.58	7.01
11:26 AM	24		10.5 ft	2.50 in	50.40		3.0 ft	5.50 in	6.55		12.0 ft	21.00 in	6.86	
	23.95		10.5 ft	3.25 in	38.77		3.0 ft	6.00 in	6.00		12.0 ft	17.00 in	8.47	
	23.9		10.5 ft	2.50 in	50.40	46.52	3.0 ft	6.00 in	6.00	6.18	12.0 ft	22.00 in	6.55	7.29
11:32 AM	23.7	Near bridge	12.0 ft	4.00 in	36.00		5.0 ft	7.00 in	8.57		12.0 ft	16.50 in	8.73	
	23.65		11.0 ft	3.00 in	44.00		4.0 ft	5.00 in	9.60		12.0 ft	12.00 in	12.00	
	23.6		10.5 ft	3.25 in	38.77	39.59	3.0 ft	4.25 in	8.47	8.88	12.0 ft	15.50 in	9.29	10.01
11:37 AM	23.4		10.5 ft	3.25 in	38.77		3.0 ft	4.75 in	7.58		12.0 ft	16.00 in	9.00	
	23.35		10.5 ft	3.00 in	42.00		3.0 ft	5.50 in	6.55		12.0 ft	19.50 in	7.38	
	23.3		10.0 ft	3.00 in	40.00	40.26	3.5 ft	6.50 in	6.46	6.86	12.0 ft	20.00 in	7.20	7.86
11:42 AM	23		10.5 ft	3.25 in	38.77		3.0 ft	5.50 in	6.55		12.0 ft	20.00 in	7.20	
	22.95		10.5 ft	3.50 in	36.00		3.0 ft	6.00 in	6.00		12.0 ft	17.50 in	8.23	
	22.9		10.5 ft	3.25 in	38.77	37.85	3.0 ft	6.00 in	6.00	6.18	12.0 ft	18.00 in	8.00	7.81
11:48 AM	22.7		11.5 ft	2.00 in	69.00		3.0 ft	4.00 in	9.00		12.0 ft	12.00 in	12.00	
	22.65		10.5 ft	2.75 in	45.82		3.0 ft	4.00 in	9.00		12.0 ft	15.00 in	9.60	
	22.6		10.5 ft	3.00 in	42.00	52.27	3.0 ft	5.50 in	6.55	8.18	12.0 ft	13.50 in	10.67	10.76
11:53 AM	22.4		10.5 ft	3.50 in	36.00		3.0 ft	5.00 in	7.20		12.0 ft	14.00 in	10.29	
	22.35		10.5 ft	3.50 in	36.00		3.0 ft	5.00 in	7.20		12.0 ft	17.00 in	8.47	

Manual Slope Measurements

Date: 7/8/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: I-25 ML25 25-18 DEC

2 of 3

Time	Station	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	22.3		10.0 ft	4.00 in	30.00	34.00	4.0 ft	7.00 in	6.86	7.09	12.0 ft	16.00 in	9.00	9.25
11:58 AM	22		10.0 ft	3.00 in	40.00		3.5 ft	7.00 in	6.00		12.0 ft	13.00 in	11.08	
	21.95		10.5 ft	3.00 in	42.00		3.0 ft	6.00 in	6.00		12.0 ft	12.00 in	12.00	
	21.9		10.5 ft	3.00 in	42.00	41.33	3.5 ft	7.50 in	5.60	5.87	12.0 ft	15.00 in	9.60	10.89
12:04 AM	21.7	past exit ramp	10.0 ft	3.00 in	40.00		3.0 ft	4.50 in	8.00		12.0 ft	14.50 in	9.93	
	21.65		10.0 ft	2.75 in	43.64		3.0 ft	5.50 in	6.55		12.0 ft	14.50 in	9.93	
	21.6		10.5 ft	3.50 in	36.00	39.88	3.0 ft	5.00 in	7.20	7.25	12.0 ft	16.00 in	9.00	9.62
12:10 AM	21.4		10.5 ft	3.00 in	42.00		3.0 ft	4.00 in	9.00		12.0 ft	14.50 in	9.93	
	21.35		10.5 ft	3.50 in	36.00		3.0 ft	4.50 in	8.00		12.0 ft	14.00 in	10.29	
	21.3		10.5 ft	3.50 in	36.00	38.00	3.0 ft	6.00 in	6.00	7.67	12.0 ft	20.00 in	7.20	9.14
12:15 PM	21	Entrance ramp lane	3.5 ft	1.00 in	42.00		3.0 ft	7.00 in	5.14		12.0 ft	16.50 in	8.73	
	20.95	Entrance ramp lane	3.5 ft	1.75 in	24.00		2.5 ft	3.75 in	8.00		12.0 ft	20.00 in	7.20	
	20.9	Entrance ramp lane	5.5 ft	2.50 in	26.40	30.80	3.0 ft	6.00 in	6.00	6.38	12.0 ft	13.00 in	11.08	9.00
12:20 PM	20.7		10.5 ft	3.25 in	38.77		3.0 ft	5.00 in	7.20		12.0 ft	13.00 in	11.08	
	20.65		10.0 ft	2.75 in	43.64		3.0 ft	4.25 in	8.47		12.0 ft	15.50 in	9.29	
	20.6		10.0 ft	3.00 in	40.00	40.80	3.5 ft	3.50 in	12.00	9.22	12.0 ft	16.00 in	9.00	9.79
12:26 PM	20.4		10.0 ft	2.50 in	48.00		3.0 ft	5.75 in	6.26		12.0 ft	14.00 in	10.29	
	20.35		10.0 ft	2.50 in	48.00		3.0 ft	6.50 in	0.00		12.0 ft	17.00 in	8.47	
	20.3		10.0 ft	2.50 in	48.00	48.00	3.0 ft	5.50 in	6.55	4.27	12.0 ft	17.00 in	8.47	9.08
12:31 PM	20		10.5 ft	2.75 in	45.82		3.0 ft	6.00 in	6.00		12.0 ft	19.00 in	7.58	
	19.95		10.5 ft	2.75 in	45.82		3.0 ft	5.50 in	6.55		12.0 ft	17.00 in	8.47	
	19.9		10.5 ft	2.50 in	50.40	47.35	3.0 ft	5.50 in	6.55	6.36	12.0 ft	16.00 in	9.00	8.35
12:36 PM	19.7		10.5 ft	2.75 in	45.82		3.0 ft	6.50 in	5.54		12.0 ft	17.00 in	8.47	
	19.65		10.5 ft	2.75 in	45.82		3.0 ft	7.50 in	4.80		12.0 ft	15.00 in	9.60	
	19.6		10.5 ft	2.75 in	45.82	45.82	3.0 ft	6.25 in	5.76	5.37	12.0 ft	15.00 in	9.60	9.22
12:41 PM	19.4		10.5 ft	3.00 in	42.00		3.0 ft	4.00 in	9.00		12.0 ft	11.50 in	12.52	

Manual Slope Measurements

Date: 7/8/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: I-25 ML25 25-18 DEC

3 of 3

Time	Station	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	19.35		11.0 ft	3.00 in	44.00		4.0 ft	5.00 in	9.60		12.0 ft	14.00 in	10.29	
	19.3	Guard rail at 12'	11.0 ft	2.00 in	66.00	50.67	3.0 ft	4.25 in	8.47	9.02	12.0 ft	11.00 in	13.09	11.97
12:46 PM	19		10.0 ft	3.00 in	40.00		3.0 ft	7.00 in	5.14		12.0 ft	14.00 in	10.29	
	18.95		10.0 ft	3.00 in	40.00		3.0 ft	7.00 in	5.14		12.0 ft	14.50 in	9.93	
	18.9		10.0 ft	2.75 in	43.64	41.21	3.0 ft	6.50 in	5.54	5.27	12.0 ft	14.00 in	10.29	10.17
12:52 PM	18.7		10.5 ft	2.00 in	63.00		3.0 ft	8.00 in	4.50		12.0 ft	15.00 in	9.60	
	18.65		10.5 ft	2.25 in	56.00		3.0 ft	7.00 in	5.14		12.0 ft	14.00 in	10.29	
	18.6		10.0 ft	2.75 in	43.64	54.21	3.0 ft	7.50 in	4.80	4.81	12.0 ft	16.00 in	9.00	9.63
12:57 PM	18.4		10.5 ft	3.00 in	42.00		2.5 ft	6.50 in	4.62		12.0 ft	13.00 in	11.08	
	18.35		10.5 ft	2.75 in	45.82		3.0 ft	5.50 in	6.55		12.0 ft	11.50 in	12.52	
	18.3		10.5 ft	2.75 in	45.82	44.55	3.0 ft	5.00 in	7.20	6.12	12.0 ft	13.50 in	10.67	11.42
1:02 PM	18		10.5 ft	3.00 in	42.00		3.0 ft	7.00 in	5.14		12.0 ft	17.00 in	8.47	
Average			10.1 ft	2.7 in	42.95		3.3 ft	5.8 in	6.90		12.0 ft	15.8 in	9.36	
Standard Deviation			1.4 ft	0.9 in	7.60		0.5 ft	1.1 in	1.78		0.0 ft	2.7 in	1.56	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 259 ML41 12-20 DEC 1 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	20	Superelevated	7.5 ft	-1.50 in	-60.00		5.5 ft	3.00 in	22.00		7.0 ft	8.00 in	10.50	
	19.95	Superelevated	7.5 ft	-1.50 in	-60.00		5.5 ft	2.50 in	26.40		7.0 ft	8.00 in	10.50	
	19.9	Superelevated	8.0 ft	1.50 in	64.00	61.33	5.0 ft	4.00 in	15.00	21.13	7.0 ft	8.00 in	10.50	10.50
	19.7		7.5 ft	1.75 in	51.43		4.0 ft	6.00 in	8.00		9.5 ft	12.00 in	9.50	
	19.65		8.0 ft	2.75 in	34.91		4.0 ft	6.00 in	8.00		8.0 ft	13.00 in	7.38	
	19.6		7.5 ft	2.00 in	45.00	43.78	3.5 ft	4.50 in	9.33	8.44	9.0 ft	15.00 in	7.20	8.03
	19.4		7.5 ft	3.50 in	25.71		5.0 ft	7.00 in	8.57		8.5 ft	14.00 in	7.29	
	19.35		6.5 ft	3.50 in	22.29		4.0 ft	7.50 in	6.40		9.5 ft	16.00 in	7.13	
	19.3		7.0 ft	3.00 in	28.00	25.33	4.0 ft	8.00 in	6.00	6.99	9.0 ft	15.00 in	7.20	7.20
	19		8.0 ft	2.50 in	38.40		4.0 ft	5.50 in	8.73		8.0 ft	10.50 in	9.14	
	18.95		8.0 ft	2.25 in	42.67		4.0 ft	6.00 in	8.00		8.0 ft	11.00 in	8.73	
	18.9		8.0 ft	2.50 in	38.40	39.82	4.0 ft	5.75 in	8.35	8.36	8.0 ft	12.00 in	8.00	8.62
	18.7		8.0 ft	2.25 in	42.67		4.0 ft	3.50 in	13.71		8.0 ft	10.00 in	9.60	
	18.65		8.0 ft	1.50 in	64.00		4.0 ft	4.00 in	12.00		8.0 ft	10.50 in	9.14	
	18.6		8.0 ft	1.75 in	54.86	53.84	4.0 ft	5.00 in	9.60	11.77	8.0 ft	12.00 in	8.00	8.91
	18.4		7.5 ft	2.00 in	45.00		4.0 ft	5.75 in	8.35		8.5 ft	12.00 in	8.50	
	18.35		7.5 ft	2.50 in	36.00		4.0 ft	5.50 in	8.73		8.5 ft	11.50 in	8.87	
	18.3		8.0 ft	2.00 in	48.00	43.00	4.0 ft	5.00 in	9.60	8.89	8.0 ft	10.00 in	9.60	8.99
	18		8.0 ft	2.75 in	34.91		4.0 ft	4.50 in	10.67		8.0 ft	11.75 in	8.17	
	17.95		8.0 ft	2.00 in	48.00		4.0 ft	4.50 in	10.67		8.0 ft	10.50 in	9.14	
	17.9		8.0 ft	1.75 in	54.86	45.92	4.0 ft	5.00 in	9.60	10.31	8.0 ft	9.00 in	10.67	9.33
	17.7		8.0 ft	2.00 in	48.00		4.0 ft	5.00 in	9.60		8.0 ft	8.00 in	12.00	
	17.65		7.5 ft	1.75 in	51.43		3.5 ft	4.00 in	10.50		9.0 ft	11.50 in	9.39	
	17.6		7.5 ft	1.50 in	60.00	53.14	5.0 ft	4.50 in	13.33	11.14	7.5 ft	12.00 in	7.50	9.63
	17.4		8.0 ft	0.00 in	0.00		3.5 ft	4.00 in	10.50		8.5 ft	9.00 in	11.33	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 259 ML41 12-20 DEC 2 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	17.35		7.50	0.00 in	0.00		4.00	5.00 in	9.60		8.50	9.00 in	11.33	
	17.3		7.50	-1.25 in	-72.00	24.00	4.00	4.00 in	12.00	10.70	8.50	8.50 in	12.00	11.56
	17		7.50	2.00 in	45.00		4.00	4.75 in	10.11		8.50	14.50 in	7.03	
	16.95		7.50	3.00 in	30.00		3.50	5.00 in	8.40		9.00	11.50 in	9.39	
	16.9		7.50	2.25 in	40.00	38.33	4.00	5.00 in	9.60	9.37	8.50	12.50 in	8.16	8.20
	16.7		7.00	2.00 in	42.00		3.50	4.75 in	8.84		9.50	10.50 in	10.86	
	16.65		7.50	1.50 in	60.00		3.50	4.50 in	9.33		9.00	10.25 in	10.54	
	16.6		7.50	1.50 in	60.00	54.00	4.00	4.00 in	12.00	10.06	8.50	10.50 in	9.71	10.37
	16.4	Superelevated	8.00	4.00 in	24.00		3.50	3.50 in	12.00		8.50	13.00 in	7.85	
	16.35		7.50	3.00 in	30.00		3.50	4.00 in	10.50		9.00	12.00 in	9.00	
	16.3		7.00	2.25 in	37.33	30.44	3.50	2.75 in	15.27	12.59	9.50	12.00 in	9.50	8.78
	16		7.50	2.25 in	40.00		4.00	2.50 in	19.20		8.50	12.00 in	8.50	
	15.95		7.50	1.50 in	60.00		4.00	7.00 in	6.86		8.50	12.00 in	8.50	
	15.9		7.50	0.75 in	120.00	73.33	4.00	4.75 in	10.11	12.05	8.50	14.50 in	7.03	8.01
	15.7	Superelevated	8.00	6.50 in	14.77		4.50	3.50 in	15.43		7.50	5.00 in	18.00	
	15.65	Superelevated	8.00	6.50 in	14.77		4.50	1.50 in	36.00		7.50	4.00 in	22.50	
	15.6	Superelevated	8.00	7.00 in	13.71	14.42	4.00	2.00 in	24.00	25.14	8.00	4.00 in	24.00	21.50
	15.4		7.50	1.75 in	51.43		4.00	6.00 in	8.00		8.50	11.50 in	8.87	
	15.35		7.50	0.00 in	0.00		4.00	6.00 in	8.00		8.50	14.75 in	6.92	
	15.3		7.50	1.50 in	60.00	37.14	4.00	5.25 in	9.14	8.38	8.50	13.00 in	7.85	7.88
	15		8.00	3.00 in	32.00		4.00	3.75 in	12.80		8.00	12.00 in	8.00	
	14.95		8.00	2.50 in	38.40		4.00	4.50 in	10.67		8.00	14.50 in	6.62	
	14.9		8.00	2.00 in	48.00	39.47	4.00	5.00 in	9.60	11.02	8.00	15.50 in	6.19	6.94
5:40 PM	14.7		7.00	2.00 in	42.00		4.00	4.00 in	12.00		9.00	12.00 in	9.00	
	14.65		7.50	1.00 in	90.00		4.00	6.00 in	8.00		8.50	13.00 in	7.85	

Manual Slope Measurements

Date: 6/29/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 259 ML41 12-20 DEC 3 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	14.6		7.50	2.00 in	45.00	59.00	4.00	5.50 in	8.73	9.58	8.50	14.50 in	7.03	7.96
	14.4		7.00	1.00 in	84.00		3.50	4.50 in	9.33		9.50	13.50 in	8.44	
	14.35		7.00	2.00 in	42.00		4.00	5.00 in	9.60		9.00	13.00 in	8.31	
	14.3		7.00	1.50 in	56.00	60.67	4.00	4.50 in	10.67	9.87	9.00	12.50 in	8.64	8.46
	14		7.50	4.50 in	20.00		4.00	6.00 in	8.00		8.50	15.50 in	6.58	
	13.95		8.50	7.25 in	14.07		3.00	6.75 in	5.33		8.50	15.50 in	6.58	
	13.9		8.00	6.00 in	16.00	16.69	3.50	6.50 in	6.46	6.60	8.50	16.25 in	6.28	6.48
5:59 PM	13.7		7.50	2.75 in	32.73		3.50	6.00 in	7.00		9.00	16.00 in	6.75	
	13.65		8.00	2.50 in	38.40		4.00	6.25 in	7.68		8.00	12.50 in	7.68	
	13.6		7.50	3.25 in	27.69	32.94	4.00	6.00 in	8.00	7.56	8.50	13.00 in	7.85	7.43
6:06 PM	13.4		7.50	2.50 in	36.00		4.00	5.25 in	9.14		8.50	10.00 in	10.20	
	13.35		7.50	3.25 in	27.69		4.00	5.00 in	9.60		8.50	9.50 in	10.74	
	13.3		8.00	3.25 in	29.54	31.08	4.00	6.00 in	8.00	8.91	8.00	14.00 in	6.86	9.26
6:14 PM	13		7.50	1.75 in	51.43		3.50	5.75 in	7.30		9.00	10.75 in	10.05	
	12.95		8.00	2.00 in	48.00		4.00	5.00 in	9.60		8.00	14.00 in	6.86	
	12.9		7.50	2.50 in	36.00	45.14	4.00	5.25 in	9.14	8.68	8.50	6.50 in	15.69	10.87
6:20 PM	12.7		7.00	1.25 in	67.20		4.00	6.00 in	8.00		9.00	12.00 in	9.00	
	12.65		7.00	0.00 in	0.00		4.00	5.00 in	9.60		9.00	10.00 in	10.80	
	12.6		8.00	0.00 in	0.00	22.40	4.00	3.00 in	16.00	11.20	8.00	8.25 in	11.64	10.48
6:31 PM	12.4		7.50	2.25 in	40.00		4.00	6.00 in	8.00		8.50	7.00 in	14.57	
	12.35		7.50	1.25 in	72.00		4.00	4.50 in	10.67		8.50	13.00 in	7.85	
	12.3		8.00	1.00 in	96.00	69.33	4.00	5.00 in	9.60	9.42	8.00	12.00 in	8.00	10.14
	12		7.50	1.00 in	90.00		3.50	6.50 in	6.46		9.00	15.00 in	7.20	
Average			7.6 ft	2.2 in	37.67		4.0 ft	4.9 in	10.70		8.4 ft	11.6 in	9.37	
Standard Deviation			0.4 ft	1.7 in	30.86		0.4 ft	1.2 in	4.83		0.6 ft	2.8 in	3.15	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 INC 1 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
12:08 PM	2		4.5 ft	1.25 in	43.20		3.0 ft	3.50 in	10.29		12.0 ft	15.00 in	9.60	
	2.05		4.0 ft	1.25 in	38.40		4.0 ft	7.00 in	6.86		12.0 ft	23.50 in	6.13	
	2.1		3.5 ft	1.50 in	28.00	36.53	4.0 ft	6.75 in	7.11	8.08	12.0 ft	21.50 in	6.70	7.48
12:14 PM	2.3		3.0 ft	1.00 in	36.00		4.0 ft	6.75 in	7.11		12.0 ft	12.00 in	12.00	
	2.35		3.0 ft	1.00 in	36.00		4.0 ft	8.50 in	5.65		12.0 ft	16.00 in	9.00	
	2.4		3.5 ft	1.75 in	24.00	32.00	3.5 ft	6.75 in	6.22	6.33	12.0 ft	23.50 in	6.13	9.04
12:20 PM	2.6		3.5 ft	1.50 in	28.00		3.5 ft	6.00 in	7.00		12.0 ft	18.50 in	7.78	
	2.65		3.0 ft	0.75 in	48.00		3.5 ft	6.25 in	6.72		12.0 ft	19.00 in	7.58	
	2.7		3.0 ft	1.00 in	36.00	37.33	3.5 ft	4.50 in	9.33	7.68	12.0 ft	17.75 in	8.11	7.83
12:35 PM	3		3.5 ft	-3.50 in	-12.00		4.0 ft	3.50 in	13.71		12.0 ft	11.00 in	13.09	
	3.05		3.5 ft	-3.00 in	-14.00		3.5 ft	2.25 in	18.67		12.0 ft	13.50 in	10.67	
	3.1		3.5 ft	-1.00 in	-42.00	22.67	3.5 ft	4.00 in	10.50	14.29	12.0 ft	16.00 in	9.00	10.92
12:40 PM	3.3		3.5 ft	1.25 in	33.60		3.5 ft	5.25 in	8.00		12.0 ft	15.50 in	9.29	
	3.35		3.0 ft	1.00 in	36.00		3.5 ft	7.00 in	6.00		12.0 ft	15.75 in	9.14	
	3.4		3.5 ft	1.50 in	28.00	32.53	3.0 ft	5.50 in	6.55	6.85	12.0 ft	18.50 in	7.78	8.74
12:45 PM	3.6		3.0 ft	1.50 in	24.00		3.5 ft	4.75 in	8.84		12.0 ft	20.00 in	7.20	
	3.65		3.0 ft	0.75 in	48.00		3.0 ft	5.75 in	6.26		12.0 ft	20.50 in	7.02	
	3.7		3.0 ft	1.00 in	36.00	36.00	3.5 ft	5.75 in	7.30	7.47	12.0 ft	24.00 in	6.00	6.74
12:52 PM	4		3.5 ft	1.75 in	24.00		3.0 ft	6.00 in	6.00		12.0 ft	21.75 in	6.62	
	4.05		3.5 ft	1.50 in	28.00		3.5 ft	6.00 in	7.00		12.0 ft	17.00 in	8.47	
	4.1		3.5 ft	1.25 in	33.60	28.53	3.5 ft	5.75 in	7.30	6.77	12.0 ft	20.75 in	6.94	7.34
12:58 PM	4.3		3.5 ft	1.50 in	28.00		3.5 ft	5.50 in	7.64		12.0 ft	22.00 in	6.55	
	4.35		3.5 ft	1.50 in	28.00		3.5 ft	6.00 in	7.00		12.0 ft	19.50 in	7.38	
	4.4		3.0 ft	1.00 in	36.00	30.67	3.5 ft	6.25 in	6.72	7.12	12.0 ft	20.25 in	7.11	7.01
	4.6		3.5 ft	1.50 in	0.00		3.5 ft	4.75 in	8.84		12.0 ft	18.00 in	8.00	
	4.65		3.5 ft	1.25 in	0.00		3.5 ft	4.50 in	9.33		12.0 ft	15.00 in	9.60	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 INC 2 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	4.7		3.5 ft	1.00 in	42.00	14.00	3.5 ft	5.00 in	8.40	8.86	12.0 ft	14.50 in	9.93	9.18
	5		3.5 ft	1.50 in	28.00		3.5 ft	5.50 in	7.64		12.0 ft	13.00 in	11.08	
	5.05		3.50	1.00 in	42.00		4.0 ft	6.25 in	7.68		12.0 ft	19.50 in	7.38	
	5.1		4.00	1.50 in	32.00	34.00	3.5 ft	5.75 in	7.30	7.54	12.0 ft	28.00 in	5.14	7.87
1:08 PM	5.3		4.00	1.00 in	48.00		3.5 ft	6.50 in	6.46		12.0 ft	23.00 in	6.26	
	5.35		4.00	1.50 in	32.00		3.0 ft	6.00 in	6.00		12.0 ft	21.00 in	6.86	
	5.4		4.00	1.00 in	48.00	42.67	3.0 ft	5.00 in	7.20	6.55	12.0 ft	23.00 in	6.26	6.46
1:18 PM	5.6		4.00	1.25 in	38.40		3.5 ft	4.75 in	8.84		12.0 ft	14.50 in	9.93	
	5.65		3.50	1.25 in	33.60		3.5 ft	5.00 in	8.40		12.0 ft	18.00 in	8.00	
	5.7		4.00	1.00 in	48.00	40.00	3.5 ft	6.00 in	7.00	8.08	12.0 ft	19.00 in	7.58	8.50
1:20 PM	6	slight R curve	3.50	2.75 in	15.27		3.5 ft	6.50 in	6.46		12.0 ft	21.25 in	6.78	
	6.05		3.50	2.50 in	16.80		3.5 ft	6.50 in	6.46		12.0 ft	23.00 in	6.26	
	6.1		3.50	2.50 in	16.80	16.29	3.5 ft	5.50 in	7.64	6.85	12.0 ft	22.75 in	6.33	6.46
1:26 PM	6.3		3.50	2.00 in	21.00		3.5 ft	6.75 in	6.22		12.0 ft	21.50 in	6.70	
	6.35		3.50	1.50 in	28.00		3.5 ft	6.25 in	6.72		12.0 ft	18.00 in	8.00	
	6.4		3.50	1.00 in	42.00	30.33	3.5 ft	6.25 in	6.72	6.55	12.0 ft	20.00 in	7.20	7.30
1:30 PM	6.6		3.50	1.75 in	24.00		3.5 ft	6.25 in	6.72		12.0 ft	19.00 in	7.58	
	6.65		3.50	1.00 in	0.00		3.5 ft	6.25 in	6.72		12.0 ft	20.00 in	7.20	
	6.7		3.50	1.50 in	28.00	17.33	3.5 ft	5.75 in	7.30	6.91	12.0 ft	21.00 in	6.86	7.21
1:38 PM	7		4.00	1.50 in	32.00		3.5 ft	9.00 in	4.67		12.0 ft	20.00 in	7.20	
	7.05		3.50	1.00 in	42.00		3.5 ft	8.25 in	5.09		12.0 ft	16.00 in	9.00	
	7.1		3.50	1.00 in	42.00	38.67	3.5 ft	5.00 in	8.40	6.05	12.0 ft	23.00 in	6.26	7.49
1:45 PM	7.3		3.50	2.00 in	21.00		3.5 ft	9.00 in	4.67		12.0 ft	20.00 in	7.20	
	7.35		3.00	1.25 in	28.80		3.5 ft	6.25 in	6.72		12.0 ft	17.50 in	8.23	
	7.4		3.50	1.25 in	33.60	27.80	3.5 ft	5.50 in	7.64	6.34	12.0 ft	16.50 in	8.73	8.05

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 INC 3 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
1:53 AM	7.6		3.50	1.00 in	42.00		3.5 ft	4.00 in	10.50		12.0 ft	18.50 in	7.78	
	7.65		3.50	1.00 in	42.00		3.0 ft	4.00 in	9.00		12.0 ft	10.50 in	13.71	
	7.7		3.50	1.00 in	42.00	42.00	3.5 ft	4.00 in	10.50	10.00	12.0 ft	18.00 in	8.00	9.83
1:59 PM	8	L curve	3.50	-1.50 in	-28.00		3.5 ft	3.25 in	12.92		12.0 ft	23.50 in	6.13	
	8.05	L curve	3.50	-1.50 in	-28.00		3.5 ft	1.25 in	33.60		12.0 ft	16.25 in	8.86	
	8.1		3.50	1.50 in	28.00	28.00	4.0 ft	3.50 in	13.71	20.08	12.0 ft	21.50 in	6.70	7.23
2:06 PM	8.3		3.00	1.25 in	28.80		3.5 ft	4.25 in	9.88		12.0 ft	21.00 in	6.86	
	8.35		3.50	1.00 in	42.00		3.5 ft	4.00 in	10.50		12.0 ft	20.75 in	6.94	
	8.4	L curve	3.00	-0.50 in	-72.00	47.60	3.5 ft	5.00 in	8.40	9.59	12.0 ft	20.00 in	7.20	7.00
2:11 PM	8.6		3.50	1.25 in	33.60		3.0 ft	3.75 in	9.60		12.0 ft	23.00 in	6.26	
	8.65		3.50	1.00 in	42.00		3.5 ft	4.75 in	8.84		12.0 ft	17.25 in	8.35	
	8.7		3.50	1.25 in	33.60	36.40	3.5 ft	6.00 in	7.00	8.48	12.0 ft	24.50 in	5.88	6.83
2:17 PM	9		3.50	1.25 in	33.60		3.5 ft	7.25 in	5.79		12.0 ft	18.00 in	8.00	
	9.05		3.50	1.00 in	42.00		3.5 ft	6.25 in	6.72		12.0 ft	25.00 in	5.76	
	9.1		3.50	1.25 in	33.60	36.40	3.5 ft	8.00 in	5.25	5.92	12.0 ft	21.00 in	6.86	6.87
2:23 PM	9.3		3.50	2.00 in	21.00		3.5 ft	7.00 in	6.00		12.0 ft	27.50 in	5.24	
	9.35		3.50	1.50 in	0.00		3.5 ft	5.50 in	7.64		12.0 ft	23.00 in	6.26	
	9.4		3.50	1.75 in	0.00	7.00	3.5 ft	4.50 in	9.33	7.66	12.0 ft	22.50 in	6.40	5.97
2:30 PM	9.6		3.50	1.50 in	28.00		3.5 ft	7.00 in	6.00		12.0 ft	18.00 in	8.00	
	9.65		3.50	1.50 in	28.00		3.5 ft	6.00 in	7.00		12.0 ft	22.50 in	6.40	
	9.7		3.50	1.00 in	42.00	32.67	3.5 ft	5.00 in	8.40	7.13	12.0 ft	22.75 in	6.33	6.91
2:36 PM	10		3.50	1.00 in	42.00		3.5 ft	5.00 in	8.40		12.0 ft	26.00 in	5.54	
	10.05		3.00	0.75 in	48.00		3.5 ft	4.50 in	9.33		12.0 ft	19.50 in	7.38	
	10.1		3.50	1.00 in	42.00	44.00	3.5 ft	5.75 in	7.30	8.35	12.0 ft	21.00 in	6.86	6.59
2:42 PM	10.3		3.50	1.25 in	33.60		3.0 ft	3.50 in	10.29		12.0 ft	22.50 in	6.40	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 INC 4 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	10.35		3.50	1.00 in	42.00		3.0 ft	2.75 in	13.09		12.0 ft	19.00 in	7.58	
	10.4		3.50	0.75 in	56.00	43.87	3.5 ft	4.25 in	9.88	11.09	12.0 ft	18.50 in	7.78	7.25
2:48 PM	10.6		3.00	1.25 in	28.80		3.5 ft	3.00 in	14.00		12.0 ft	18.00 in	8.00	
	10.65		3.50	1.00 in	42.00		3.5 ft	5.75 in	7.30		12.0 ft	18.50 in	7.78	
	10.7		3.50	1.00 in	42.00	37.60	3.5 ft	5.00 in	8.40	9.90	12.0 ft	20.00 in	7.20	7.66
2:53 PM	11		3.50	1.00 in	42.00		3.5 ft	6.00 in	7.00		12.0 ft	20.00 in	7.20	
Average			3.5 ft	1.1 in	27.67		3.5 ft	5.5 in	8.37		12.0 ft	19.6 in	7.62	
Standard Deviation			0.3 ft	1.0 in	21.36		0.2 ft	1.4 in	3.65		0.0 ft	3.5 in	1.59	

Manual Slope Measurements

Date: 6/29/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 DEC 1 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
2:55 PM	11		3.5 ft	1.00 in	42.00		3.5 ft	3.00 in	14.00		12.0 ft	18.50 in	7.78	
	10.95		3.5 ft	1.25 in	33.60		3.5 ft	4.50 in	9.33		12.0 ft	17.00 in	8.47	
	10.9		3.5 ft	1.25 in	33.60	36.40	3.5 ft	4.75 in	8.84	10.73	12.0 ft	18.00 in	8.00	8.08
3:02 PM	10.7		3.5 ft	1.50 in	28.00		3.0 ft	3.50 in	10.29		12.0 ft	18.00 in	8.00	
	10.65		3.5 ft	1.75 in	24.00		3.0 ft	3.50 in	10.29		12.0 ft	15.00 in	9.60	
	10.6		3.0 ft	1.25 in	28.80	26.93	3.5 ft	6.00 in	7.00	9.19	12.0 ft	17.00 in	8.47	8.69
3:09 PM	10.4		3.5 ft	1.25 in	33.60		3.5 ft	4.00 in	10.50		12.0 ft	13.00 in	11.08	
	10.35		3.5 ft	1.25 in	33.60		3.5 ft	3.50 in	12.00		12.0 ft	17.50 in	8.23	
	10.3		3.5 ft	1.25 in	33.60	33.60	3.5 ft	2.50 in	16.80	13.10	12.0 ft	14.50 in	9.93	9.75
3:23 PM	10		3.5 ft	1.50 in	28.00		3.0 ft	5.00 in	7.20		12.0 ft	12.00 in	12.00	
	9.95		3.5 ft	1.25 in	33.60		3.5 ft	6.00 in	7.00		12.0 ft	21.00 in	6.86	
	9.9		3.0 ft	1.25 in	28.80	30.13	3.5 ft	6.75 in	6.22	6.81	12.0 ft	15.00 in	9.60	9.49
3:30 PM	9.7		3.5 ft	1.50 in	28.00		3.5 ft	4.50 in	9.33		12.0 ft	21.00 in	6.86	
	9.65		3.5 ft	1.50 in	28.00		3.5 ft	6.25 in	6.72		12.0 ft	20.00 in	7.20	
	9.6		3.5 ft	1.50 in	28.00	28.00	3.5 ft	4.50 in	9.33	8.46	12.0 ft	21.50 in	6.70	6.92
3:35 PM	9.4		3.0 ft	2.00 in	18.00		3.5 ft	5.25 in	8.00		12.0 ft	19.50 in	7.38	
	9.35		3.5 ft	1.75 in	24.00		3.5 ft	4.75 in	8.84		12.0 ft	15.00 in	9.60	
	9.3		3.5 ft	1.25 in	33.60	25.20	3.5 ft	4.75 in	8.84	8.56	12.0 ft	18.00 in	8.00	8.33
3:42 PM	9		3.5 ft	1.25 in	33.60		3.0 ft	3.00 in	12.00		12.0 ft	19.75 in	7.29	
	8.95		3.5 ft	1.25 in	33.60		3.5 ft	4.50 in	9.33		12.0 ft	16.50 in	8.73	
	8.9		3.5 ft	0.00 in	0.00	22.40	3.5 ft	4.00 in	10.50	10.61	12.0 ft	19.75 in	7.29	7.77
3:48 PM	8.7		3.5 ft	1.50 in	28.00		3.5 ft	4.50 in	9.33		12.0 ft	17.00 in	8.47	
	8.65		3.0 ft	0.75 in	48.00		3.5 ft	4.25 in	9.88		12.0 ft	20.00 in	7.20	
	8.6		3.5 ft	1.00 in	42.00	39.33	3.5 ft	4.00 in	10.50	9.91	12.0 ft	14.50 in	9.93	8.53
3:54 PM	8.4		3.5 ft	2.00 in	0.00		3.5 ft	5.50 in	7.64		12.0 ft	17.50 in	8.23	

Manual Slope Measurements

Date: 6/29/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 DEC 2 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	8.35		3.5 ft	1.50 in	0.00		3.5 ft	5.25 in	8.00		12.0 ft	16.00 in	9.00	
	8.3		3.5 ft	1.50 in	28.00	9.33	3.5 ft	5.00 in	8.40	8.01	12.0 ft	19.50 in	7.38	8.20
3:59 PM	8		3.0 ft	2.50 in	14.40		3.5 ft	7.00 in	6.00		12.0 ft	18.50 in	7.78	
	7.95		3.5 ft	2.00 in	21.00		3.0 ft	5.75 in	6.26		12.0 ft	15.25 in	9.44	
	7.9		3.5 ft	1.50 in	28.00	21.13	3.0 ft	4.50 in	8.00	6.75	12.0 ft	11.00 in	13.09	10.11
4:05 PM	7.7		3.0 ft	1.25 in	28.80		3.5 ft	5.50 in	7.64		12.0 ft	24.50 in	5.88	
	7.65		3.5 ft	1.50 in	28.00		3.5 ft	5.50 in	7.64		12.0 ft	22.00 in	6.55	
	7.6		3.0 ft	1.25 in	28.80	28.53	3.5 ft	6.00 in	7.00	7.42	12.0 ft	25.00 in	5.76	6.06
4:10 PM	7.4		3.5 ft	1.00 in	42.00		3.5 ft	5.00 in	8.40		12.0 ft	19.00 in	7.58	
	7.35		3.5 ft	0.00 in	0.00		3.5 ft	4.00 in	10.50		12.0 ft	20.50 in	7.02	
	7.3		3.5 ft	0.00 in	0.00	14.00	3.5 ft	5.00 in	8.40	9.10	12.0 ft	16.75 in	8.60	7.73
4:16 PM	7		3.5 ft	1.25 in	33.60		3.0 ft	3.75 in	9.60		12.0 ft	20.50 in	7.02	
	6.95		3.5 ft	1.50 in	28.00		3.5 ft	6.00 in	7.00		12.0 ft	17.50 in	8.23	
	6.9		3.5 ft	1.75 in	24.00	28.53	3.5 ft	5.50 in	7.64	8.08	12.0 ft	18.00 in	8.00	7.75
4:21 PM	6.7		3.5 ft	1.00 in	42.00		3.5 ft	4.00 in	10.50		12.0 ft	18.00 in	8.00	
	6.65		3.0 ft	0.50 in	72.00		3.5 ft	4.50 in	9.33		12.0 ft	16.00 in	9.00	
	6.6		3.0 ft	0.00 in	0.00	38.00	3.0 ft	5.00 in	7.20	9.01	12.0 ft	17.00 in	8.47	8.49
4:28 PM	6.4		3.5 ft	1.25 in	33.60		3.0 ft	3.25 in	11.08		12.0 ft	20.50 in	7.02	
	6.35		3.5 ft	1.25 in	0.00		3.5 ft	6.00 in	7.00		12.0 ft	19.00 in	7.58	
	6.3		3.5 ft	1.25 in	33.60	22.40	3.5 ft	6.50 in	6.46	8.18	12.0 ft	18.50 in	7.78	7.46
4:33 PM	6		3.5 ft	0.00 in	0.00		3.5 ft	6.00 in	7.00		12.0 ft	17.00 in	8.47	
	5.95		3.0 ft	0.00 in	0.00		3.5 ft	6.00 in	7.00		12.0 ft	16.50 in	8.73	
	5.9		3.0 ft	1.50 in	24.00	8.00	3.0 ft	6.50 in	5.54	6.51	12.0 ft	16.00 in	9.00	8.73
4:39 PM	5.7		3.5 ft	1.50 in	28.00		3.5 ft	8.50 in	4.94		12.0 ft	20.50 in	7.02	
	5.65		3.5 ft	1.75 in	24.00		3.5 ft	9.00 in	4.67		12.0 ft	20.00 in	7.20	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 DEC

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Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	5.6		3.5 ft	1.75 in	24.00	25.33	3.5 ft	8.25 in	5.09	4.90	12.0 ft	21.50 in	6.70	6.97
4:44 PM	5.4		3.0 ft	1.50 in	24.00		3.5 ft	6.50 in	6.46		12.0 ft	16.50 in	8.73	
	5.35		3.0 ft	1.75 in	20.57		3.5 ft	6.00 in	7.00		12.0 ft	22.50 in	6.40	
	5.3		3.0 ft	2.00 in	18.00	20.86	3.5 ft	5.00 in	8.40	7.29	12.0 ft	20.00 in	7.20	7.44
4:50 PM	5		3.5 ft	1.50 in	28.00		3.5 ft	5.50 in	7.64		12.0 ft	19.50 in	7.38	
	4.95		3.0 ft	1.00 in	36.00		3.5 ft	8.50 in	4.94		12.0 ft	16.50 in	8.73	
	4.9		3.0 ft	1.50 in	24.00	29.33	3.5 ft	8.50 in	4.94	5.84	12.0 ft	17.50 in	8.23	8.11
4:55 PM	4.7		3.0 ft	1.25 in	28.80		3.5 ft	8.00 in	5.25		12.0 ft	17.50 in	8.23	
	4.65		3.0 ft	1.00 in	36.00		3.0 ft	5.75 in	6.26		12.0 ft	19.00 in	7.58	
	4.6		3.0 ft	1.00 in	36.00	33.60	3.5 ft	7.00 in	6.00	5.84	12.0 ft	21.00 in	6.86	7.55
5:01 PM	4.4		3.5 ft	1.50 in	28.00		3.5 ft	6.50 in	6.46		12.0 ft	16.50 in	8.73	
	4.35		3.5 ft	2.00 in	21.00		3.0 ft	4.25 in	8.47		12.0 ft	15.50 in	9.29	
	4.3		3.5 ft	1.25 in	33.60	27.53	3.5 ft	5.50 in	7.64	7.52	12.0 ft	21.50 in	6.70	8.24
5:07 PM	4		3.5 ft	1.25 in	33.60		3.5 ft	4.25 in	9.88		12.0 ft	20.50 in	7.02	
	3.95		3.5 ft	1.50 in	28.00		3.5 ft	6.50 in	6.46		12.0 ft	17.50 in	8.23	
	3.9		3.5 ft	2.00 in	21.00	27.53	3.5 ft	5.50 in	7.64	7.99	12.0 ft	15.50 in	9.29	8.18
5:12 PM	3.7		3.5 ft	1.50 in	28.00		3.5 ft	6.50 in	6.46		12.0 ft	22.00 in	6.55	
	3.65		3.5 ft	1.50 in	0.00		3.0 ft	5.50 in	6.55		12.0 ft	24.00 in	6.00	
	3.6		3.5 ft	1.75 in	0.00	9.33	3.0 ft	7.00 in	5.14	6.05	12.0 ft	24.50 in	5.88	6.14
5:17 PM	3.4		3.5 ft	1.25 in	33.60		3.0 ft	4.00 in	9.00		12.0 ft	21.50 in	6.70	
	3.35		3.5 ft	1.50 in	28.00		3.0 ft	4.50 in	8.00		12.0 ft	5.00 in	28.80	
	3.3		3.5 ft	1.00 in	42.00	34.53	3.5 ft	6.00 in	7.00	8.00	12.0 ft	16.00 in	9.00	14.83
5:23 PM	3		3.0 ft	3.00 in	12.00		4.0 ft	8.50 in	5.65		12.0 ft	22.00 in	6.55	
	2.95		3.0 ft	2.00 in	18.00		3.5 ft	4.00 in	10.50		12.0 ft	19.50 in	7.38	
	2.9		3.0 ft	1.25 in	28.80	19.60	3.5 ft	5.50 in	7.64	7.93	12.0 ft	17.50 in	8.23	7.39
5:28 PM	2.7		3.5 ft	2.25 in	18.67		3.5 ft	4.00 in	10.50		12.0 ft	21.00 in	6.86	

Manual Slope Measurements

Date: 6/29/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 316 ML1604 2-11 DEC

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Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	2.65		3.0 ft	1.00 in	36.00		3.5 ft	5.00 in	8.40		12.0 ft	16.00 in	9.00	
	2.6		3.5 ft	1.50 in	28.00	27.56	3.0 ft	4.00 in	9.00	9.30	12.0 ft	19.50 in	7.38	7.75
5:35 PM	2.4		3.5 ft	1.50 in	28.00		3.5 ft	3.50 in	12.00		12.0 ft	26.00 in	5.54	
	2.35		3.5 ft	1.50 in	28.00		3.5 ft	4.00 in	10.50		12.0 ft	30.00 in	4.80	
	2.3		3.5 ft	1.25 in	33.60	29.87	3.5 ft	4.00 in	10.50	11.00	12.0 ft	18.00 in	8.00	6.11
5:40 PM	2		3.0 ft	1.25 in	28.80		3.5 ft	4.50 in	9.33		12.0 ft	20.00 in	7.20	
Average			3.4 ft	1.3 in	25.85		3.4 ft	5.3 in	8.24		12.0 ft	18.5 in	8.17	
Standard Deviation			0.2 ft	0.5 in	12.90		0.2 ft	1.4 in	2.16		0.0 ft	3.5 in	2.67	

Manual Slope Measurements

Date: 6/30/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 INC 1 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
1:32 PM	101		3.5 ft	1.50 in	28.00		1.5 ft	3.50 in	5.14		12.0 ft	39.00 in	3.69	
	101.05		4.0 ft	1.00 in	48.00		1.0 ft	3.50 in	3.43		12.0 ft	25.00 in	5.76	
	101.1		3.5 ft	1.50 in	28.00	34.67	1.5 ft	2.50 in	7.20	5.26	12.0 ft	28.50 in	5.05	4.83
1:38 PM	101.3	R curve	3.5 ft	3.50 in	12.00		1.0 ft	3.00 in	4.00		12.0 ft	22.00 in	6.55	
	101.35	R curve	4.0 ft	3.25 in	14.77		1.5 ft	5.25 in	3.43		12.0 ft	23.00 in	6.26	
	101.4	R curve	3.5 ft	1.50 in	28.00	18.26	2.0 ft	4.25 in	5.65	4.36	12.0 ft	22.00 in	6.55	6.45
1:43 PM	101.6		3.5 ft	1.25 in	33.60		1.5 ft	3.50 in	5.14		12.0 ft	20.00 in	7.20	
	101.65		3.5 ft	1.50 in	28.00		1.5 ft	2.00 in	9.00		12.0 ft	21.50 in	6.70	
	101.7		3.0 ft	3.00 in	12.00	24.53	1.5 ft	1.50 in	12.00	8.71	12.0 ft	22.50 in	6.40	6.77
1:49 PM	102		3.5 ft	1.75 in	24.00		1.0 ft	1.75 in	6.86		12.0 ft	18.00 in	8.00	
	102.05		3.5 ft	1.25 in	33.60		2.0 ft	2.50 in	9.60		12.0 ft	16.50 in	8.73	
	102.1		3.0 ft	0.50 in	72.00	43.20	1.5 ft	2.00 in	9.00	8.49	12.0 ft	21.00 in	6.86	7.86
1:54 PM	102.3	L curve	4.0 ft	1.50 in	32.00		1.5 ft	2.00 in	9.00		12.0 ft	17.00 in	8.47	
	102.35	L curve	4.0 ft	0.25 in	192.00		2.0 ft	1.25 in	19.20		12.0 ft	24.50 in	5.88	
	102.4		4.0 ft	0.00 in	0.00	74.67	2.0 ft	1.50 in	16.00	14.73	12.0 ft	22.50 in	6.40	6.92
1:59 PM	102.6		3.5 ft	1.00 in	42.00		1.5 ft	3.50 in	5.14		12.0 ft	18.50 in	7.78	
	102.65		3.5 ft	1.25 in	33.60		1.0 ft	1.50 in	8.00		12.0 ft	14.00 in	10.29	
	102.7		3.5 ft	1.00 in	42.00	39.20	1.0 ft	2.50 in	4.80	5.98	12.0 ft	13.00 in	11.08	9.72
2:04 PM	103		3.5 ft	1.50 in	28.00		1.0 ft	2.50 in	4.80		12.0 ft	18.50 in	7.78	
	103.05		3.5 ft	1.50 in	28.00		1.0 ft	2.00 in	6.00		12.0 ft	20.00 in	7.20	
	103.1		4.0 ft	1.75 in	27.43	27.81	1.0 ft	4.00 in	3.00	4.60	12.0 ft	22.00 in	6.55	7.18
2:09 PM	103.3		3.0 ft	1.25 in	28.80		1.0 ft	2.50 in	4.80		12.0 ft	21.00 in	6.86	
	103.35		3.0 ft	1.00 in	36.00		1.5 ft	3.00 in	6.00		12.0 ft	17.00 in	8.47	
	103.4		3.5 ft	1.25 in	33.60	32.80	1.5 ft	3.75 in	4.80	5.20	12.0 ft	17.00 in	8.47	7.93
2:14 PM	103.6		3.5 ft	1.25 in	33.60		1.5 ft	3.00 in	6.00		12.0 ft	18.50 in	7.78	

Manual Slope Measurements

Date: 6/30/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 INC 2 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	103.65		3.5 ft	1.00 in	42.00		1.0 ft	2.25 in	5.33		12.0 ft	19.50 in	7.38	
	103.7		3.5 ft	1.50 in	28.00	34.53	1.0 ft	1.75 in	6.86	6.06	12.0 ft	17.00 in	8.47	7.88
2:19 PM	104		3.0 ft	1.00 in	36.00		1.5 ft	3.00 in	6.00		12.0 ft	18.00 in	8.00	
	104.05		3.5 ft	1.00 in	42.00		1.0 ft	2.00 in	6.00		12.0 ft	12.00 in	12.00	
	104.1		3.0 ft	1.00 in	36.00	38.00	1.5 ft	3.00 in	6.00	6.00	12.0 ft	15.00 in	9.60	9.87
2:24 PM	104.3		3.5 ft	1.50 in	28.00		1.0 ft	1.00 in	12.00		12.0 ft	14.00 in	10.29	
	104.35		4.0 ft	1.50 in	32.00		1.0 ft	2.25 in	5.33		12.0 ft	19.00 in	7.58	
	104.4		4.0 ft	1.75 in	27.43	29.14	1.0 ft	2.00 in	6.00	7.78	12.0 ft	18.50 in	7.78	8.55
2:29 PM	104.6		3.5 ft	1.50 in	28.00		1.0 ft	2.00 in	6.00		12.0 ft	18.50 in	7.78	
	104.65		3.5 ft	1.75 in	24.00		1.0 ft	2.25 in	5.33		12.0 ft	25.00 in	5.76	
	104.7		3.5 ft	1.50 in	28.00	26.67	1.0 ft	2.00 in	6.00	5.78	12.0 ft	15.00 in	9.60	7.71
2:34 PM	105		3.5 ft	1.50 in	28.00		1.0 ft	2.50 in	4.80		12.0 ft	20.00 in	7.20	
	105.05		4.0 ft	2.00 in	24.00		1.0 ft	1.20 in	10.00		12.0 ft	16.50 in	8.73	
	105.1		4.0 ft	1.50 in	32.00	28.00	1.0 ft	0.00 in	0.00	4.93	12.0 ft	14.50 in	9.93	8.62
2:42 PM	105.3		4.0 ft	2.00 in	24.00		1.0 ft	1.50 in	8.00		12.0 ft	22.00 in	6.55	
	105.35		3.5 ft	1.25 in	33.60		1.0 ft	1.00 in	12.00		12.0 ft	25.50 in	5.65	
	105.4		3.5 ft	2.00 in	21.00	26.20	1.0 ft	2.00 in	6.00	8.67	12.0 ft	24.25 in	5.94	6.04
2:47 PM	105.6		3.5 ft	1.75 in	24.00		1.0 ft	1.50 in	8.00		12.0 ft	21.50 in	6.70	
	105.65		3.5 ft	1.75 in	24.00		1.0 ft	1.50 in	0.00		12.0 ft	24.75 in	5.82	
	105.7		3.5 ft	1.50 in	28.00	25.33	1.0 ft	1.75 in	6.86	4.95	12.0 ft	26.00 in	5.54	6.02
3:07 PM	106		3.5 ft	1.50 in	28.00		1.0 ft	1.50 in	8.00		12.0 ft	13.50 in	10.67	
	106.05		4.0 ft	2.00 in	24.00		1.0 ft	2.50 in	4.80		12.0 ft	18.00 in	8.00	
	106.1		4.0 ft	1.50 in	32.00	28.00	1.5 ft	1.75 in	10.29	7.70	12.0 ft	20.50 in	7.02	8.56
3:11 PM	106.3		3.5 ft	1.00 in	42.00		1.0 ft	1.00 in	12.00		12.0 ft	18.00 in	8.00	
	106.35		3.5 ft	1.00 in	42.00		1.0 ft	1.75 in	6.86		12.0 ft	20.00 in	7.20	
	106.4		4.0 ft	1.50 in	32.00	38.67	1.0 ft	1.00 in	12.00	10.29	12.0 ft	18.00 in	8.00	7.73

Manual Slope Measurements

Date: 6/30/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 INC 3 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
3:16 PM	106.6		4.0 ft	1.50 in	32.00		1.0 ft	1.25 in	9.60		12.0 ft	19.50 in	7.38	
	106.65		4.0 ft	1.75 in	27.43		1.0 ft	1.25 in	9.60		12.0 ft	15.00 in	9.60	
	106.7		3.5 ft	1.00 in	42.00	33.81	1.0 ft	1.50 in	8.00	9.07	12.0 ft	19.00 in	7.58	8.19
3:23 PM	107		4.0 ft	1.00 in	48.00		1.0 ft	1.25 in	9.60		12.0 ft	19.50 in	7.38	
	107.05		3.5 ft	1.25 in	33.60		1.0 ft	1.25 in	9.60		12.0 ft	18.00 in	8.00	
	107.1		4.0 ft	1.00 in	48.00	43.20	1.0 ft	1.00 in	12.00	10.40	12.0 ft	17.00 in	8.47	7.95
3:27 PM	107.3		4.0 ft	1.50 in	32.00		1.0 ft	0.75 in	16.00		12.0 ft	20.00 in	7.20	
	107.35		4.0 ft	2.00 in	24.00		1.0 ft	0.00 in	0.00		12.0 ft	18.50 in	7.78	
	107.4		3.5 ft	1.50 in	28.00	28.00	1.0 ft	1.00 in	12.00	9.33	12.0 ft	16.50 in	8.73	7.90
3:32 PM	107.6		3.5 ft	1.50 in	28.00		1.0 ft	1.75 in	6.86		12.0 ft	18.50 in	7.78	
	107.65		3.5 ft	1.25 in	33.60		1.0 ft	1.25 in	9.60		12.0 ft	21.25 in	6.78	
	107.7		3.5 ft	1.50 in	28.00	29.87	1.0 ft	2.50 in	4.80	7.09	12.0 ft	24.00 in	6.00	6.85
3:37 PM	108		4.0 ft	2.00 in	24.00		1.0 ft	1.00 in	12.00		12.0 ft	18.50 in	7.78	
	108.05	L curve	4.0 ft	2.00 in	24.00		1.0 ft	1.25 in	9.60		12.0 ft	18.50 in	7.78	
	108.1	L curve	4.5 ft	2.00 in	27.00	25.00	1.0 ft	0.75 in	16.00	12.53	12.0 ft	22.00 in	6.55	7.37
3:43 PM	108.3		4.0 ft	1.50 in	0.00		1.0 ft	1.00 in	0.00		12.0 ft	23.50 in	6.13	
	108.35		4.5 ft	1.50 in	36.00		1.0 ft	0.75 in	16.00		12.0 ft	17.00 in	8.47	
	108.4		4.0 ft	1.00 in	48.00	28.00	1.0 ft	1.00 in	12.00	9.33	12.0 ft	20.00 in	7.20	7.27
3:48 PM	108.6	L curve	4.0 ft	1.25 in	38.40		1.0 ft	2.00 in	6.00		12.0 ft	21.50 in	6.70	
	108.65	L curve	4.0 ft	1.50 in	32.00		1.0 ft	1.25 in	0.00		12.0 ft	23.00 in	6.26	
	108.7	L curve	4.0 ft	1.25 in	38.40	36.27	1.0 ft	1.50 in	0.00	2.00	12.0 ft	22.50 in	6.40	6.45
3:53 PM	109		4.0 ft	1.50 in	32.00		1.0 ft	1.50 in	8.00		12.0 ft	19.50 in	7.38	
Average			3.7 ft	1.5 in	33.06		1.2 ft	1.9 in	7.48		12.0 ft	19.9 in	7.52	
Standard Deviation			0.3 ft	0.5 in	21.50		0.3 ft	1.0 in	4.04		0.0 ft	4.0 in	1.45	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 DEC 1 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
10:06 AM	109		3.5 ft	1.75 in	24.00		1.0 ft	1.50 in	8.00		12.0 ft	20.00 in	7.20	
	108.95		3.5 ft	1.75 in	24.00		1.5 ft	2.00 in	9.00		12.0 ft	22.00 in	6.55	
	108.9		3.5 ft	1.50 in	28.00	25.33	1.5 ft	1.50 in	12.00	9.67	12.0 ft	21.00 in	6.86	6.87
10:11 AM	108.7		3.5 ft	2.00 in	21.00		1.0 ft	2.25 in	5.33		12.0 ft	21.50 in	6.70	
	108.65		3.5 ft	2.00 in	21.00		1.0 ft	1.00 in	12.00		12.0 ft	13.00 in	11.08	
	108.6		3.0 ft	1.00 in	36.00	26.00	2.0 ft	2.25 in	10.67	9.33	12.0 ft	14.00 in	10.29	9.35
10:17 AM	108.4		3.0 ft	1.75 in	20.57		1.5 ft	2.00 in	9.00		12.0 ft	21.50 in	6.70	
	108.35		3.5 ft	1.50 in	28.00		1.0 ft	0.75 in	16.00		12.0 ft	24.50 in	5.88	
	108.3		3.5 ft	1.75 in	24.00	24.19	1.0 ft	1.00 in	12.00	12.33	12.0 ft	23.50 in	6.13	6.23
10:23 AM	108		3.5 ft	1.75 in	24.00		1.5 ft	3.00 in	6.00		12.0 ft	19.75 in	7.29	
	107.95		3.0 ft	1.50 in	24.00		1.5 ft	3.50 in	5.14		12.0 ft	15.00 in	9.60	
	107.9		3.5 ft	1.00 in	42.00	30.00	1.0 ft	2.00 in	6.00	5.71	12.0 ft	22.00 in	6.55	7.81
10:29 AM	107.7		3.5 ft	1.25 in	33.60		1.5 ft	2.25 in	8.00		12.0 ft	25.75 in	5.59	
	107.65		3.5 ft	2.25 in	18.67		1.5 ft	2.50 in	7.20		12.0 ft	23.50 in	6.13	
	107.6		3.5 ft	2.00 in	21.00	24.42	1.0 ft	2.00 in	6.00	7.07	12.0 ft	23.00 in	6.26	5.99
10:34 AM	107.4		3.5 ft	1.25 in	33.60		1.5 ft	1.75 in	10.29		12.0 ft	13.50 in	10.67	
	107.35		3.5 ft	1.00 in	42.00		1.0 ft	1.00 in	12.00		12.0 ft	#####	0.94	
	107.3		3.5 ft	1.00 in	42.00	39.20	1.0 ft	0.75 in	16.00	12.76	12.0 ft	12.00 in	12.00	7.87
10:40 AM	107		3.5 ft	1.50 in	28.00		1.0 ft	1.25 in	9.60		12.0 ft	16.00 in	9.00	
	106.95		3.5 ft	1.75 in	24.00		1.0 ft	1.50 in	8.00		12.0 ft	16.75 in	8.60	
	106.9		3.5 ft	1.50 in	28.00	26.67	1.5 ft	3.00 in	6.00	7.87	12.0 ft	19.00 in	7.58	8.39
10:45 AM	106.7		3.5 ft	1.25 in	33.60		1.0 ft	2.25 in	5.33		12.0 ft	19.25 in	7.48	
	106.65		3.5 ft	1.75 in	24.00		1.5 ft	0.75 in	24.00		12.0 ft	15.00 in	9.60	
	106.6		3.5 ft	1.00 in	42.00	33.20	1.5 ft	2.00 in	9.00	12.78	12.0 ft	18.50 in	7.78	8.29
10:51 AM	106.4		4.0 ft	2.00 in	24.00		1.5 ft	1.25 in	14.40		12.0 ft	14.00 in	10.29	

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 DEC 2 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	106.35		4.0 ft	1.25 in	38.40		1.5 ft	1.25 in	14.40		12.0 ft	12.50 in	11.52	
	106.3		4.0 ft	1.25 in	38.40	33.60	1.0 ft	1.25 in	9.60	12.80	12.0 ft	16.50 in	8.73	10.18
10:56 AM	106		3.0 ft	1.50 in	24.00		1.0 ft	1.25 in	9.60		12.0 ft	16.00 in	9.00	
	105.95		3.5 ft	1.25 in	33.60		1.5 ft	2.50 in	7.20		12.0 ft	12.00 in	12.00	
	105.9		3.5 ft	1.25 in	33.60	30.40	1.5 ft	2.25 in	8.00	8.27	12.0 ft	21.75 in	6.62	9.21
11:02 AM	105.7		3.5 ft	1.75 in	24.00		1.0 ft	1.50 in	8.00		12.0 ft	20.00 in	7.20	
	105.65		4.0 ft	2.00 in	24.00		1.5 ft	2.00 in	9.00		12.0 ft	19.25 in	7.48	
	105.6		3.5 ft	2.00 in	21.00	23.00	2.0 ft	2.75 in	8.73	8.58	12.0 ft	27.50 in	5.24	6.64
11:09 AM	105.4		3.5 ft	1.50 in	28.00		1.5 ft	1.75 in	10.29		12.0 ft	18.00 in	8.00	
	105.35		3.5 ft	1.00 in	42.00		1.5 ft	2.00 in	9.00		12.0 ft	20.00 in	7.20	
	105.3		3.5 ft	1.00 in	42.00	37.33	1.5 ft	1.50 in	12.00	10.43	12.0 ft	13.00 in	11.08	8.76
11:15 AM	105		4.0 ft	2.25 in	21.33		1.0 ft	2.00 in	6.00		12.0 ft	21.50 in	6.70	
	104.95		4.0 ft	2.00 in	24.00		1.0 ft	1.25 in	9.60		12.0 ft	23.00 in	6.26	
	104.9		4.0 ft	1.50 in	32.00	25.78	1.5 ft	2.00 in	9.00	8.20	12.0 ft	21.50 in	6.70	6.55
11:21 AM	104.7		4.0 ft	1.50 in	32.00		2.0 ft	4.00 in	6.00		12.0 ft	16.00 in	9.00	
	104.65		4.0 ft	2.00 in	24.00		1.5 ft	4.00 in	4.50		12.0 ft	16.00 in	9.00	
	104.6		3.5 ft	1.00 in	42.00	32.67	1.0 ft	3.00 in	4.00	4.83	12.0 ft	14.00 in	10.29	9.43
11:26 AM	104.4		3.5 ft	1.25 in	33.60		2.0 ft	1.25 in	19.20		12.0 ft	20.50 in	7.02	
	104.35		4.0 ft	1.75 in	27.43		1.5 ft	0.00 in	0.00		12.0 ft	19.00 in	7.58	
	104.3		4.0 ft	1.75 in	27.43	29.49	1.5 ft	1.25 in	14.40	11.20	12.0 ft	25.00 in	5.76	6.79
11:31 AM	104		3.5 ft	1.50 in	28.00		1.5 ft	3.50 in	5.14		12.0 ft	23.00 in	6.26	
	103.95		3.5 ft	1.50 in	28.00		1.5 ft	2.00 in	9.00		12.0 ft	24.00 in	6.00	
	103.9		4.0 ft	1.75 in	27.43	27.81	1.5 ft	1.75 in	10.29	8.14	12.0 ft	18.00 in	8.00	6.75
11:37 AM	103.7		3.5 ft	2.00 in	21.00		1.0 ft	1.25 in	9.60		12.0 ft	15.50 in	9.29	
	103.65		3.5 ft	1.50 in	28.00		1.5 ft	3.50 in	5.14		12.0 ft	17.50 in	8.23	
	103.6		3.0 ft	1.50 in	24.00	24.33	1.5 ft	3.50 in	5.14	6.63	12.0 ft	20.00 in	7.20	8.24

Manual Slope Measurements

Date: 6/29/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: WY 313 ML1602 101-109 DEC 3 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
11:42 AM	103.4		4.0 ft	2.00 in	24.00		1.0 ft	3.00 in	4.00		12.0 ft	13.00 in	11.08	
	103.35		3.5 ft	1.00 in	42.00		1.5 ft	4.00 in	4.50		12.0 ft	16.00 in	9.00	
	103.3		3.5 ft	1.25 in	33.60	33.20	1.5 ft	4.75 in	3.79	4.10	12.0 ft	18.50 in	7.78	9.29
11:47 AM	103		4.0 ft	1.75 in	27.43		1.5 ft	2.00 in	9.00		12.0 ft	14.75 in	9.76	
	102.95		4.0 ft	1.75 in	27.43		1.5 ft	3.25 in	5.54		12.0 ft	13.50 in	10.67	
	102.9		3.0 ft	1.75 in	20.57	25.14	1.5 ft	2.50 in	7.20	7.25	12.0 ft	12.75 in	11.29	10.57
11:52 AM	102.7		4.0 ft	1.75 in	27.43		2.0 ft	2.25 in	10.67		12.0 ft	25.00 in	5.76	
	102.65		4.0 ft	0.75 in	64.00		1.5 ft	3.25 in	5.54		12.0 ft	25.00 in	5.76	
	102.6		4.0 ft	1.00 in	48.00	46.48	1.5 ft	2.50 in	7.20	7.80	12.0 ft	19.00 in	7.58	6.37
11:57 AM	102.4		3.5 ft	4.00 in	10.50		1.0 ft	1.00 in	12.00		12.0 ft	20.00 in	7.20	
	102.35		3.5 ft	2.00 in	21.00		1.0 ft	1.00 in	12.00		12.0 ft	22.50 in	6.40	
	102.3		3.5 ft	1.75 in	24.00	18.50	1.0 ft	1.25 in	9.60	11.20	12.0 ft	24.00 in	6.00	6.53
12:03 PM	102		4.0 ft	0.75 in	64.00		1.0 ft	2.00 in	6.00		12.0 ft	25.50 in	5.65	
	101.95	L curve	3.5 ft	-2.50 in	-16.80		1.0 ft	1.00 in	12.00		12.0 ft	23.00 in	6.26	
	101.9	L curve	3.5 ft	-2.75 in	-15.27	32.02	1.0 ft	1.50 in	8.00	8.67	12.0 ft	20.00 in	7.20	6.37
12:08 PM	101.7		3.5 ft	0.00 in	0.00		1.0 ft	0.00 in	0.00		12.0 ft	19.00 in	7.58	
	101.65		3.5 ft	1.75 in	24.00		1.0 ft	2.25 in	5.33		12.0 ft	21.00 in	6.86	
	101.6		3.5 ft	1.50 in	28.00	17.33	2.0 ft	3.50 in	6.86	4.06	12.0 ft	26.00 in	5.54	6.66
12:13 PM	101.4	L curve	3.5 ft	-0.75 in	-56.00		1.0 ft	-1.00 in	-12.00		12.0 ft	13.00 in	11.08	
	101.35	L curve	3.5 ft	-1.25 in	-33.60		1.0 ft	0.00 in	0.00		12.0 ft	16.00 in	9.00	
	101.3	L curve	3.0 ft	-1.75 in	-20.57	36.72	1.0 ft	0.00 in	0.00	4.00	12.0 ft	17.00 in	8.47	9.52
12:19 PM	101		3.5 ft	1.00 in	42.00		1.0 ft	2.50 in	4.80		12.0 ft	18.00 in	8.00	
Average			3.6 ft	1.3 in	25.56		1.3 ft	2.0 in	8.11		12.0 ft	20.9 in	7.86	
Standard Deviation			0.3 ft	1.0 in	18.20		0.3 ft	1.1 in	4.79		0.0 ft	16.3 in	1.99	

Manual Slope Measurements

Date: 7/7/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: Wy 225 350-356 INC

1 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
2:52 PM	350		1.5 ft	0.75 in	24.00		5.5 ft	3.75 in	17.60		12.0 ft	22.50 in	6.40	
	350.05		1.5 ft	0.75 in	24.00		2.0 ft	3.25 in	7.38		12.0 ft	24.50 in	5.88	
	350.1		1.0 ft	0.75 in	16.00	21.33	1.0 ft	1.50 in	8.00	10.99	12.0 ft	28.50 in	5.05	5.78
2:57 PM	350.3		1.0 ft	1.00 in	12.00		4.0 ft	2.75 in	17.45		12.0 ft	18.50 in	7.78	
	350.35		1.0 ft	0.50 in	24.00		2.5 ft	2.50 in	12.00		12.0 ft	18.50 in	7.78	
	350.4		1.0 ft	0.50 in	24.00	20.00	3.0 ft	2.75 in	13.09	14.18	12.0 ft	17.25 in	8.35	7.97
3:03 PM	350.6		1.0 ft	0.75 in	16.00		4.0 ft	7.00 in	6.86		12.0 ft	19.00 in	7.58	
	350.65		1.5 ft	1.25 in	14.40		3.5 ft	7.50 in	5.60		12.0 ft	16.00 in	9.00	
	350.7		1.5 ft	1.25 in	14.40	14.93	3.0 ft	6.00 in	6.00	6.15	12.0 ft	16.00 in	9.00	8.53
3:09 PM	351		2.0 ft	1.00 in	24.00		4.0 ft	3.75 in	12.80		12.0 ft	17.00 in	8.47	
	351.05		1.5 ft	1.00 in	18.00		3.0 ft	2.75 in	13.09		12.0 ft	18.00 in	8.00	
	351.1		1.5 ft	0.75 in	24.00	22.00	3.0 ft	3.00 in	12.00	12.63	12.0 ft	19.00 in	7.58	8.02
3:15 PM	351.3		2.5 ft	0.50 in	60.00		3.5 ft	2.00 in	21.00		12.0 ft	8.00 in	18.00	
	351.35		2.5 ft	0.75 in	40.00		2.0 ft	1.50 in	16.00		12.0 ft	15.50 in	9.29	
	351.4		2.0 ft	1.00 in	24.00	41.33	2.0 ft	1.00 in	24.00	20.33	12.0 ft	16.50 in	8.73	12.01
3:21 PM	351.6		1.5 ft	1.00 in	18.00		3.0 ft	1.75 in	20.57		12.0 ft	31.00 in	4.65	
	351.65		1.5 ft	1.00 in	18.00		3.0 ft	3.00 in	12.00		12.0 ft	37.00 in	3.89	
	351.7		1.5 ft	1.25 in	14.40	16.80	3.0 ft	1.00 in	36.00	22.86	12.0 ft	39.00 in	3.69	4.08
3:27 PM	352		1.0 ft	1.00 in	12.00		2.0 ft	1.00 in	24.00		12.0 ft	13.00 in	11.08	
	352.05		1.0 ft	0.50 in	24.00		1.5 ft	1.00 in	18.00		12.0 ft	12.00 in	12.00	
	352.1		1.0 ft	1.00 in	12.00	16.00	2.0 ft	4.50 in	5.33	15.78	12.0 ft	19.50 in	7.38	10.15
3:33 PM	352.3		2.5 ft	1.00 in	30.00		5.0 ft	3.50 in	17.14		12.0 ft	21.00 in	6.86	
	352.35		2.5 ft	0.00 in	0.00		3.0 ft	5.50 in	6.55		12.0 ft	21.00 in	6.86	

Manual Slope Measurements

Date: 7/7/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: Wy 225 350-356 INC

2 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	352.4		1.0 ft	1.00 in	12.00	14.00	3.0 ft	3.00 in	12.00	11.90	12.0 ft	26.50 in	5.43	6.38
3:38 PM	352.6		2.0 ft	1.50 in	16.00		3.0 ft	2.75 in	13.09		12.0 ft	23.50 in	6.13	
	352.65		2.5 ft	1.50 in	20.00		4.0 ft	3.00 in	16.00		12.0 ft	21.50 in	6.70	
	352.7		3.0 ft	2.00 in	18.00	18.00	3.0 ft	3.75 in	9.60	12.90	12.0 ft	23.00 in	6.26	6.36
3:44 PM	353		1.5 ft	1.00 in	18.00		3.5 ft	5.50 in	7.64		12.0 ft	15.50 in	9.29	
	353.05		1.5 ft	1.00 in	18.00		2.0 ft	2.50 in	9.60		12.0 ft	15.00 in	9.60	
	353.1		1.0 ft	0.75 in	16.00	17.33	3.0 ft	1.50 in	24.00	13.75	12.0 ft	22.00 in	6.55	8.48
3:50 PM	353.3		1.5 ft	2.50 in	7.20		3.0 ft	1.75 in	20.57		12.0 ft	11.00 in	13.09	
	353.35		1.5 ft	1.00 in	18.00		2.5 ft	4.00 in	7.50		12.0 ft	11.50 in	12.52	
	353.4		1.0 ft	1.50 in	8.00	11.07	2.0 ft	4.50 in	5.33	11.13	12.0 ft	15.00 in	9.60	11.74
3:56 PM	353.6		2.0 ft	3.00 in	8.00		2.0 ft	1.50 in	16.00		12.0 ft	13.00 in	11.08	
	353.65		2.0 ft	2.00 in	12.00		3.0 ft	1.50 in	24.00		12.0 ft	9.00 in	16.00	
	353.7		2.0 ft	2.50 in	9.60	9.87	3.0 ft	3.50 in	10.29	16.76	12.0 ft	19.00 in	7.58	11.55
4:01 PM	354		1.5 ft	1.00 in	18.00		5.0 ft	1.00 in	60.00		12.0 ft	15.50 in	9.29	
	354.05		0.0 ft	0.00 in	0.00		5.0 ft	1.00 in	60.00		12.0 ft	14.00 in	10.29	
	354.1		0.0 ft	0.00 in	0.00	18.00	5.0 ft	1.25 in	48.00	56.00	12.0 ft	34.00 in	4.24	7.94
4:06 PM	354.3		1.0 ft	1.50 in	8.00		4.0 ft	5.00 in	9.60		12.0 ft	25.00 in	5.76	
	354.35		1.0 ft	0.00 in	0.00		4.0 ft	2.50 in	19.20		12.0 ft	20.50 in	7.02	
	354.4		1.0 ft	0.00 in	0.00	2.67	4.0 ft	4.00 in	12.00	13.60	12.0 ft	23.00 in	6.26	6.35
4:12 PM	354.6		1.0 ft	0.00 in	0.00		3.0 ft	1.75 in	20.57		12.0 ft	20.00 in	7.20	
	354.65		1.0 ft	0.00 in	0.00		3.0 ft	2.00 in	0.00		12.0 ft	18.00 in	8.00	
	354.7		1.5 ft	0.00 in	0.00	0.00	4.0 ft	5.50 in	8.73	9.77	12.0 ft	19.00 in	7.58	7.59
4:18 PM	355		2.0 ft	1.00 in	24.00		2.0 ft	2.25 in	10.67		12.0 ft	18.50 in	7.78	
	355.05		1.5 ft	1.75 in	10.29		4.0 ft	1.25 in	38.40		12.0 ft	27.00 in	5.33	
	355.1		1.5 ft	1.50 in	12.00	15.43	3.0 ft	2.00 in	18.00	22.36	12.0 ft	17.00 in	8.47	7.20

Manual Slope Measurements

Date: 7/7/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: Wy 225 350-356 INC 3 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
4:23 PM	355.3		1.5 ft	1.00 in	18.00		1.0 ft	4.50 in	2.67		12.0 ft	32.00 in	4.50	
	355.35		1.0 ft	1.00 in	12.00		3.0 ft	1.50 in	24.00		12.0 ft	12.00 in	12.00	
	355.4		1.0 ft	1.00 in	12.00	14.00	3.0 ft	2.00 in	18.00	14.89	12.0 ft	11.00 in	13.09	9.86
4:27 PM	355.6		1.5 ft	0.50 in	36.00		3.0 ft	2.50 in	14.40		12.0 ft	23.50 in	6.13	
	355.65		1.5 ft	0.75 in	24.00		4.0 ft	2.50 in	19.20		12.0 ft	26.00 in	5.54	
	355.7		2.0 ft	1.00 in	24.00	28.00	3.5 ft	2.50 in	16.80	16.80	12.0 ft	21.00 in	6.86	6.17
4:32 PM	356		2.0 ft	1.25 in	19.20		2.5 ft	2.00 in	15.00		12.0 ft	24.00 in	6.00	
Average			1.5 ft	1.0 in	16.10		3.1 ft	2.9 in	16.79		12.0 ft	19.9 in	8.08	
Standard Deviation			0.6 ft	0.6 in	10.89		1.0 ft	1.6 in	12.09		0.0 ft	6.7 in	2.88	

Manual Slope Measurements

Date: 7/8/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: US30 ML56 350-356 DEC

1 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
2:41 PM	356		1.0 ft	0.00 in	0.00		4.0 ft	3.75 in	12.80		12.0 ft	22.00 in	6.55	
	355.95		1.5 ft	0.50 in	36.00		4.0 ft	3.25 in	14.77		12.0 ft	19.50 in	7.38	
	355.9		1.0 ft	0.75 in	16.00	17.33	2.0 ft	1.50 in	16.00	14.52	12.0 ft	22.50 in	6.40	6.78
2:48 PM	355.7		2.0 ft	3.50 in	6.86		2.0 ft	2.75 in	8.73		12.0 ft	18.50 in	7.78	
	355.65		1.0 ft	1.00 in	12.00		1.5 ft	2.50 in	7.20		12.0 ft	27.00 in	5.33	
	355.6		1.0 ft	1.00 in	12.00	10.29	2.0 ft	2.75 in	8.73	8.22	12.0 ft	32.50 in	4.43	5.85
2:53 PM	355.4		1.0 ft	0.50 in	24.00		3.0 ft	7.00 in	5.14		12.0 ft	16.50 in	8.73	
	355.35		1.0 ft	0.00 in	0.00		4.0 ft	7.50 in	6.40		12.0 ft	14.00 in	10.29	
	355.3		1.0 ft	0.75 in	16.00	20.00	4.0 ft	6.00 in	8.00	6.51	12.0 ft	22.50 in	6.40	8.47
3:00 PM	355		1.0 ft	0.50 in	24.00		2.0 ft	3.75 in	6.40		12.0 ft	16.00 in	9.00	
	354.95		1.0 ft	0.50 in	24.00		2.0 ft	2.75 in	8.73		12.0 ft	16.00 in	9.00	
	354.9		0.0 ft	0.00 in	0.00	24.00	2.0 ft	3.00 in	8.00	7.71	12.0 ft	11.00 in	13.09	10.36
3:05 PM	354.7		0.5 ft	0.25 in	24.00		2.0 ft	2.00 in	12.00		12.0 ft	21.00 in	6.86	
	354.65		1.0 ft	1.00 in	12.00		1.5 ft	1.50 in	12.00		12.0 ft	22.00 in	6.55	
	354.6		0.5 ft	0.50 in	12.00	16.00	1.0 ft	1.00 in	12.00	12.00	12.0 ft	23.00 in	6.26	6.55
3:10 PM	354.4		1.0 ft	0.75 in	16.00		2.0 ft	1.75 in	13.71		12.0 ft	19.00 in	7.58	
	354.35		0.5 ft	1.00 in	6.00		2.0 ft	3.00 in	8.00		12.0 ft	26.50 in	5.43	
	354.3		1.0 ft	1.00 in	12.00	11.33	2.0 ft	1.00 in	24.00	15.24	12.0 ft	30.50 in	4.72	5.91
3:16 PM	354		0.0 ft	0.00 in	0.00		2.5 ft	1.00 in	30.00		12.0 ft	14.50 in	9.93	
	353.95		0.0 ft	0.00 in	0.00		2.5 ft	1.00 in	30.00		12.0 ft	10.00 in	14.40	
	353.9		0.5 ft	0.00 in	0.00	0.00	2.5 ft	4.50 in	6.67	22.22	12.0 ft	22.50 in	6.40	10.24
3:21 PM	353.7		1.0 ft	0.75 in	16.00		3.0 ft	3.50 in	10.29		12.0 ft	11.00 in	13.09	
	353.65		1.0 ft	1.75 in	6.86		3.0 ft	5.50 in	6.55		12.0 ft	16.00 in	9.00	

Manual Slope Measurements

Date: 7/8/2010

Evaluato Burt Andreen / Cody Kalivoda

Highway Section: US30 ML56 350-356 DEC

2 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	353.6		1.0 ft	0.75 in	16.00	12.95	2.5 ft	3.00 in	10.00	8.94	12.0 ft	17.00 in	8.47	10.19
3:27 PM	353.4		1.0 ft	0.75 in	16.00		2.0 ft	2.75 in	8.73		12.0 ft	19.00 in	7.58	
	353.35		1.0 ft	0.75 in	16.00		1.0 ft	3.00 in	4.00		12.0 ft	16.00 in	9.00	
	353.3		1.5 ft	1.25 in	14.40	15.47	2.0 ft	3.75 in	6.40	6.38	12.0 ft	18.50 in	7.78	8.12
3:32 PM	353		0.0 ft	0.00 in	0.00		4.0 ft	5.50 in	8.73		12.0 ft	21.50 in	6.70	
	352.95		0.0 ft	0.00 in	0.00		1.5 ft	2.50 in	7.20		12.0 ft	23.50 in	6.13	
	352.9		0.0 ft	0.00 in	0.00	0.00	2.0 ft	1.50 in	16.00	10.64	12.0 ft	26.00 in	5.54	6.12
3:37 PM	352.7		0.0 ft	0.00 in	0.00		3.0 ft	1.75 in	20.57		12.0 ft	23.50 in	6.13	
	352.65		0.0 ft	0.00 in	0.00		3.0 ft	4.00 in	9.00		12.0 ft	21.50 in	6.70	
	352.6		0.0 ft	0.00 in	0.00	0.00	3.0 ft	4.50 in	8.00	12.52	12.0 ft	24.00 in	6.00	6.28
3:42 PM	352.4		0.0 ft	0.00 in	0.00		2.0 ft	1.50 in	16.00		12.0 ft	14.00 in	10.29	
	352.35		1.0 ft	1.00 in	12.00		2.0 ft	1.50 in	16.00		12.0 ft	14.00 in	10.29	
	352.3		1.0 ft	1.00 in	12.00	12.00	3.0 ft	3.50 in	10.29	14.10	12.0 ft	19.00 in	7.58	9.38
3:47 PM	352		1.0 ft	0.50 in	24.00		1.5 ft	1.00 in	18.00		12.0 ft	12.50 in	11.52	
	351.95		1.0 ft	0.25 in	48.00		2.0 ft	1.00 in	24.00		12.0 ft	9.00 in	16.00	
	351.9		1.0 ft	0.25 in	48.00	40.00	2.0 ft	1.25 in	19.20	20.40	12.0 ft	16.00 in	9.00	12.17
3:54 PM	351.7		1.5 ft	0.50 in	36.00		3.0 ft	5.00 in	7.20		12.0 ft	28.00 in	5.14	
	351.65		1.5 ft	1.25 in	14.40		3.0 ft	2.50 in	14.40		12.0 ft	32.00 in	4.50	
	351.6		0.5 ft	1.00 in	6.00	18.80	3.0 ft	4.00 in	9.00	10.20	12.0 ft	41.00 in	3.51	4.39
4:00 PM	351.4		0.5 ft	0.75 in	8.00		1.0 ft	1.75 in	6.86		12.0 ft	17.00 in	8.47	
	351.35		0.0 ft	0.00 in	0.00		2.0 ft	2.00 in	0.00		12.0 ft	18.00 in	8.00	
	351.3		0.0 ft	0.00 in	0.00	8.00	4.0 ft	5.50 in	8.73	5.19	12.0 ft	26.00 in	5.54	7.34
4:05 PM	351		0.0 ft	0.00 in	0.00		2.5 ft	2.25 in	13.33		12.0 ft	29.00 in	4.97	
	350.95		1.0 ft	1.00 in	12.00		2.5 ft	1.25 in	24.00		12.0 ft	30.00 in	4.80	

Manual Slope Measurements

Date: 7/8/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: US30 ML56 350-356 DEC

3 of 3

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	350.9		0.5 ft	0.50 in	12.00	12.00	2.0 ft	2.00 in	12.00	16.44	12.0 ft	24.00 in	6.00	5.26
4:09 PM	350.7		0.0 ft	0.00 in	0.00		3.0 ft	4.50 in	8.00		12.0 ft	21.00 in	6.86	
	350.65		0.0 ft	0.00 in	0.00		2.0 ft	1.50 in	16.00		12.0 ft	18.00 in	8.00	
	350.6		0.0 ft	0.00 in	0.00	0.00	2.0 ft	2.00 in	12.00	12.00	12.0 ft	17.00 in	8.47	7.78
4:13 PM	350.4		0.5 ft	0.25 in	24.00		2.0 ft	2.50 in	9.60		12.0 ft	21.00 in	6.86	
	350.35		0.0 ft	0.00 in	0.00		2.5 ft	2.50 in	12.00		12.0 ft	22.00 in	6.55	
	350.3		0.0 ft	0.00 in	0.00	24.00	2.5 ft	2.50 in	12.00	11.20	12.0 ft	20.50 in	7.02	6.81
4:18 PM	350		1.0 ft	0.50 in	24.00		2.5 ft	2.00 in	15.00		12.0 ft	19.00 in	7.58	
Average			0.7 ft	0.5 in	11.25		2.4 ft	2.9 in	11.97		12.0 ft	20.6 in	7.66	
Standard Deviation			0.5 ft	0.6 in	12.18		0.8 ft	1.6 in	6.13		0.0 ft	6.2 in	2.51	

Manual Slope Measurements

Date: 6/29/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 319 ML319 101-110 DEC 1 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
8:32 AM	110		12.0 ft	18.50 in	7.78									
	109.95		12.0 ft	20.00 in	7.20									
	109.9		12.0 ft	13.50 in	10.67	8.55								
8:43 AM	109.7		12.0 ft	20.25 in	7.11									
	109.65		12.0 ft	18.00 in	8.00									
	109.6		12.0 ft	17.00 in	8.47	7.86								
8:49 AM	109.4		12.0 ft	20.00 in	7.20									
	109.35		12.0 ft	20.00 in	7.20									
	109.3		12.0 ft	17.00 in	8.47	7.62								
8:54 AM	109		12.0 ft	35.00 in	4.11									
	108.95		12.0 ft	31.00 in	4.65									
	108.9		12.0 ft	30.00 in	4.80	4.52								
9:00 AM	108.7		12.0 ft	11.75 in	12.26									
	108.65		12.0 ft	18.50 in	7.78									
	108.6		12.0 ft	12.75 in	11.29	10.44								
9:09 AM	108.4		12.0 ft	16.50 in	8.73									
	108.35		12.0 ft	21.00 in	6.86									
	108.3		12.0 ft	21.00 in	6.86	7.48								
9:12 AM	108		12.0 ft	16.50 in	8.73									
	107.95		12.0 ft	18.50 in	7.78									
	107.9		12.0 ft	15.50 in	9.29	8.60								
9:17 AM	107.7		12.0 ft	30.00 in	4.80									
	107.65		12.0 ft	14.00 in	10.29									

Manual Slope Measurements

Date: 6/29/2010

Evaluator: Burt Andreen / Cody Kalivoda

Highway Section: WY 319 ML319 101-110 DEC 2 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	107.6		12.0 ft	18.00 in	8.00	7.70								
9:22 AM	107.4		12.0 ft	21.50 in	6.70									
	107.35		12.0 ft	22.50 in	6.40									
	107.3		12.0 ft	12.50 in	11.52	8.21								
9:27	107		12.0 ft	14.50 in	9.93									
	106.95		12.0 ft	19.50 in	7.38									
	106.9		12.0 ft	20.00 in	7.20	8.17								
9:32	106.7		12.0 ft	15.00 in	9.60									
	106.65		12.0 ft	18.00 in	8.00									
	106.6		12.0 ft	22.00 in	6.55	8.05								
9:37	106.4	R curve	12.0 ft	30.00 in	4.80									
	106.35	Near bridge w/ GR	12.0 ft	14.00 in	10.29									
	106.3		12.0 ft	24.00 in	6.00	7.03								
9:42	106	R curve	12.0 ft	22.25 in	6.47									
	105.95		12.0 ft	20.25 in	7.11									
	105.9		12.0 ft	17.00 in	8.47	7.35								
9:47	105.7	R curve	12.0 ft	32.50 in	4.43									
	105.65	R curve	12.0 ft	24.00 in	6.00									
	105.6	R curve	12.0 ft	28.00 in	5.14	5.19								
9:53	105.4		12.0 ft	17.50 in	8.23									
	105.35		12.0 ft	29.00 in	4.97									
	105.3		12.0 ft	30.25 in	4.76	5.98								
9:57	105		12.0 ft	21.00 in	6.86									
	104.95		12.0 ft	33.00 in	4.36									

Manual Slope Measurements

Date: 6/29/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 319 ML319 101-110 DEC 3 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	104.9		12.0 ft	34.00 in	4.24	5.15								
10:02	104.7	L curve	12.0 ft	9.50 in	15.16									
	104.65	L curve	12.0 ft	17.25 in	8.35									
	104.6	L curve	12.0 ft	6.50 in	22.15	15.22								
10:07	104.4		12.0 ft	11.50 in	12.52									
	104.35		12.0 ft	35.00 in	4.11									
	104.3		12.0 ft	16.00 in	9.00	8.55								
10:12	104		12.0 ft	28.50 in	5.05									
	103.95		12.0 ft	29.50 in	4.88									
	103.9		12.0 ft	26.00 in	5.54	5.16								
10:16	103.7	R curve	12.0 ft	19.00 in	7.58									
	103.65		12.0 ft	32.00 in	4.50									
	103.6		12.0 ft	16.00 in	9.00	7.03								
10:21	103.4		12.0 ft	15.75 in	9.14									
	103.35		12.0 ft	46.50 in	3.10									
	103.3		12.0 ft	37.25 in	3.87	5.37								
10:25	103		12.0 ft	16.50 in	8.73									
	102.95		12.0 ft	20.00 in	7.20									
	102.9		12.0 ft	21.00 in	6.86	7.59								
10:30	102.7		12.0 ft	31.50 in	4.57									
	102.65		12.0 ft	19.25 in	7.48									
	102.6		12.0 ft	30.50 in	4.72	5.59								
10:34	102.4		12.0 ft	24.50 in	5.88									

Manual Slope Measurements

Date: 6/29/2010

Evaluator Burt Andreen / Cody Kalivoda

Highway Section: WY 319 ML319 101-110 DEC 4 of 4

Time	Mile Post	Notes	Section A				Section B				Section C			
			Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope	Horiz.	Vert.	Slope	Ave. Slope
	102.35		12.0 ft	28.00 in	5.14									
	102.3		12.0 ft	16.50 in	8.73	6.58								
10:38	102		12.0 ft	17.00 in	8.47									
	101.95		12.0 ft	25.50 in	5.65									
	101.9		12.0 ft	35.25 in	4.09	6.07								
10:45	101.7		12.0 ft	17.00 in	8.47									
	101.65		12.0 ft	34.00 in	4.24									
	101.6		12.0 ft	26.50 in	5.43	6.05								
10:50	101.4		12.0 ft	19.00 in	7.58									
	101.35		12.0 ft	31.50 in	4.57									
	101.3		12.0 ft	32.50 in	4.43	5.53								
10:54	101		12.0 ft	25.00 in	5.76									
Average			12.0 ft	22.4 in	7.26									
Standard Deviation			0.0 ft	7.6 in	2.84									

APPENDIX C: Automated Slope Tabulation
Automated Slope Tabulation

Road Section:

Wy 319 DEC

Width: 0ft

1 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
110	10	4.5	40	3	20	8
109.948	10	5.5	40	4	20	7
109.898	10	5	40	6	-30	11
109.698	10	5	85	0	15	7
109.648	10	4.5	40	3.5	30	8
109.597	10	5	50	4	40	8
109.402	10	5	50	5	0	7
109.348	10	5	80	2.5	28	7
109.303	10	4.5	70	3	40	8
108.999	10	5	60	-2.5	7	4
108.949	10	5	60	-3	6	5
108.903	10	5	45	3	18	5
108.703	10	5	30	3.5	13	12
108.648	10	5	40	4	30	8
108.604	10	7	30	4	7	11
108.399	10	5	90	2.5	32	9
108.348	10	3.5	40	4.5	-30	7
108.302	10	5	50	4	40	7
107.998	10	4.5	40	2.5	15	9
107.948	10	4.5	40	3.5	30	8
107.898	10	5	40	3.5	20	9
107.699	10	5	50	-2	6	5
107.649	10	5	85	-2.5	10	10
107.598	10	4.5	95	-2	13	8
107.398	10	4.5	40	7.5	-10	7
107.348	10	4.5	40	3	20	6
107.298	10	5	45	7	-18	12
106.998	10	4.5	50	7	-16	10
106.948	10	4.5	50	3	27	7
106.899	10	3	40	5	-15	7
106.698	10	5.5	40	10	-7	10
106.649	10	3.5	40	16.5	-2	8
106.598	10	5	90	3	40	7
106.398	10	5	90	-2	11	5
106.348	10	5	50	3.5	27	10

Automated Slope Tabulation

Road Section:

Wy 319 DEC

Width: 0ft

2 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
106.299	10	4.5	80	4.5	0	6
105.998	10	4.5	50	9	-9	6
105.949	10	5	50	7.5	-16	7
105.698	10	3	45	3	0	8
105.65	10	5	90	-5	8	4
105.598	10	4.5	60	3	33	6
105.399	10	5	50	7	-20	5
105.35	10	4	40	4	0	8
105.298	10	3	40	7	-8	5
104.999	10	5	90	-5	8	5
104.949	10	5.5	50	7.5	-20	7
104.899	10	3	50	4.5	-27	4
104.699	10	4.5	45	7.5	-12	4
104.648	10	4.5	55	3	30	15
104.599	10	4	65	2	28	8
104.399	10	4	50	3	40	22
104.349	10	4.5	50	7	-16	13
104.299	10	4	30	1	7	4
103.999	10	3.5	40	4.5	-30	9
103.948	10	4	40	4	0	5
103.899	10	5	20	2	3	5
103.7	10	3.5	40	2	20	6
103.649	10	4	65	1.5	22	8
103.599	10	4	65	0	14	5
103.399	10	4	85	-7	7	9
103.35	10	5	40	4	30	9
103.299	10	4	50	3	40	3
102.998	10	4	70	0	15	4
102.95	10	5	80	-1	12	9
102.899	10	4	45	3	35	7
102.699	10	3.5	40	2.5	30	7
102.649	10	4.5	45	2.5	18	5
102.598	10	4.5	50	3.5	40	7
102.399	10	3.5	50	2.5	40	5
102.35	10	3	75	0	22	6
102.299	10	4.5	50	2.5	20	5
101.999	10	5	50	5	0	9

Automated Slope Tabulation

Road Section:

Wy 319 DEC

Width: 0ft

3 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
101.95	10	4.5	50	3	27	8
101.9	10	5	40	5	0	6
101.7	10	4.5	90	2.5	40	4
101.65	10	3.5	40	2.5	30	8
101.599	10	5.5	40	4.5	30	4
101.4	10	4.5	60	10	-9	5
101.349	10	5	50	2.5	16	8
101.3	10	5	50	2.5	16	5
						4
Average	10.0	4.5	53.4	3.2	11.9	7.3
St. Dev	0.0	0.7	17.5	3.5	19.4	2.9

Automated Slope Tabulation

Road Section:

Wy 319 DEC

Width: 10ft

1 of 2

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
24.998	10	5	90	1	20	0
24.949	10	7.5	90	2.5	16	0
24.903	10	7	90	1.5	15	0
24.699	10	5	90	1.5	23	0
24.648	10	5	90	1	20	44
24.6	10	4	90	1.5	32	42
24.418	10	5	90	0.5	18	42
24.353	10	5	90	1	20	42
24.309	10	4.5	70	2.5	30	46
24.009	10	5	80	2	23	50
23.949	10	5	90	1	20	39
23.898	10	6	70	2	15	50
23.705	10	5.5	90	2	23	36
23.649	10	4.5	90	2	32	44
23.599	10	5	70	2	20	39
23.399	10	5.5	90	1	18	39
23.349	10	6.5	90	2	18	42
23.3	10	5.5	90	0	15	40
22.999	10	4.5	90	-1	15	39
22.949	10	5	90	0	16	36
22.899	10	5	90	1	20	39
22.703	10	5	90	0	16	69
22.649	10	5	90	1	20	46
22.598	10	5	100	-1	15	42
22.403	10	7.5	80	1	11	36
22.348	10	6	80	1.5	16	36
22.3	10	5	90	1.5	23	30
21.999	10	4.5	90	-1	15	40
21.95	10	5	90	1.5	23	42
21.899	10	5	90	1.5	23	42
21.698	10	5	90	2	27	40
21.65	10	7.5	95	1.5	14	44
21.6	10	7.5	100	0.5	13	36
21.399	10	7.5	80	1	11	42
21.349	10	5.5	70	1.5	15	36
21.299	10	5	90	0	16	36

Automated Slope Tabulation

Road Section:

Wy 319 DEC

Width: 10ft

2 of 2

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
21	10	6	90	0.5	15	42
20.949	10	6	90	0	13	24
20.9	10	6.5	90	1	15	26
20.701	10	7	80	1.5	13	39
20.65	10	6	90	0.5	15	44
20.6	10	5	90	1	20	40
20.4	10	5.5	90	1.5	20	48
20.349	10	7	90	0.5	12	48
20.301	10	6	90	1	16	48
20.001	10	6	90	1.5	18	46
19.95	10	5	90	1	20	46
19.899	10	5	90	1	20	50
19.7	10	5	90	3	40	46
19.65	10	6	90	2	20	46
19.599	10	4	80	2	35	46
19.399	10	7.5	90	2	15	42
19.351	10	6	95	0	14	44
19.3	10	6.5	90	2	18	66
19.001	10	5	85	0.5	17	40
18.95	10	6	90	0.5	15	40
18.9	10	6	90	0.5	15	44
18.701	10	6	90	1	16	63
18.651	10	7.5	90	0	11	56
18.599	10	7	90	0	11	44
18.399	10	5	90	1.5	23	42
18.349	10	4.5	90	0.5	20	46
18.299	10	5	90	2	27	46
Average	10	5.63	88	1.08	19	43
St. Dev	0	0.96	6.04	0.86	6	8

Automated Slope Tabulation

Road Section:

Wy 316 INC

Width: 6ft

1 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
2.006	10	4	95	-1.5	15	19
2.1	10	4.5	100	-4	11	12
2.298	10	3	100	-2	18	11
2.349	10	4.5	100	-2.5	13	11
2.399	10	4	100	-3	13	9
2.599	10	4.5	100	-3	12	10
2.648	10	4	95	-1.5	15	11
2.698	10	5	100	-1.5	14	11
2.898	10	4	100	-3	13	14
3.047	10	5	100	-3	11	0
3.099	10	4.5	85	-1	14	0
3.298	10	5	105	-2.5	13	28
3.352	10	2.5	70	0	24	13
3.402	10	5	100	0.5	20	10
3.599	10	4.5	65	0	12	11
3.648	10	5	100	-1	15	12
3.698	10	4.5	100	-2	14	11
3.998	10	5	100	-2.5	12	12
4.053	10	6.5	90	-1.5	10	10
4.103	10	4.5	100	-3.5	11	11
4.302	10	5	90	1.5	23	12
4.352	10	5	95	-1	14	12
4.398	10	4	90	1	27	11
4.602	10	4	95	-2.5	13	11
4.652	10	4.5	100	-4	11	13
4.703	10	4.5	100	-5	9	15
5.002	10	0	95	-4	21	14
5.052	10	4.5	100	-3	12	12
5.098	10	3	100	-2.5	16	12
5.298	10	4	95	-4	11	12
5.348	10	4	90	-2.5	12	12
5.398	10	5	90	-2	11	11
5.601	10	4.5	90	-6	8	14
5.648	10	2.5	100	-6.5	10	15
5.702	10	3	95	-6	9	13
5.998	10	3	100	-2.5	16	13

Automated Slope Tabulation

Road Section:

Wy 316 INC

Width: 6ft

2 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
6.102	10	5	100	-2.5	12	9
6.303	10	4.5	90	-3	11	9
6.352	10	5	90	-4	9	11
6.398	10	4.5	100	-2.5	13	10
6.602	10	4.5	100	-3.5	11	11
6.652	10	4.5	100	-3	12	12
6.701	10	4.5	95	-3	11	11
7.002	10	4	100	-2.5	14	12
7.052	10	4	90	0	20	12
7.102	10	3.5	100	-3.5	13	9
7.302	10	4.5	100	-2	14	9
7.352	10	5	80	0	14	14
7.398	10	4	90	-1.5	15	8
7.598	10	5	100	-4.5	9	10
7.648	10	5	100	-3	11	12
7.703	10	4	100	-1.5	16	17
8.002	10	3.5	100	-3	14	16
8.052	10	3	100	-3	15	17
8.102	10	3.5	100	-4	12	48
8.302	10	3	100	-3.5	14	0
8.352	10	5	100	-1.5	14	18
8.402	10	3	100	-1.5	20	14
8.603	10	5	100	-2	13	17
8.653	10	3	100	-3	15	17
8.702	10	4	100	-4	11	16
9.002	10	4	100	-2	15	15
9.052	10	3	100	-2	18	12
9.102	10	3	100	-4	13	10
9.302	10	4	100	-2.5	14	12
9.352	10	4	75	0	16	9
9.402	10	5	100	-3	11	9
9.601	10	5	95	-2	12	12
9.651	10	4	90	-2	13	13
9.701	10	5	100	-3.5	11	10
10.001	10	5	100	-2	13	11
10.051	10	5	100	-2	13	14
10.101	10	5.5	90	-2	11	14

Automated Slope Tabulation

Road Section: Wy 316 INC **Width:** 6ft 3 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
10.301	10	4	80	0	18	15
10.352	10	3	100	-1.5	20	12
10.402	10	5	90	0	16	16
10.602	10	5	90	-2	11	21
10.653	10	3	100	-2	18	17
10.702	10	5	100	-2.5	12	18
10.997	10	4	100	-1	18	12
Average	10.0	4.2	95.9	-2.4	13.9	12.7
St. Dev	0.0	0.9	7.2	1.5	3.5	5.6

Automated Slope Tabulation

Road Section:

Wy 316 DEC

Width: 6ft

1 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
10.999	10	4.5	100	-1	16	21
10.952	10	3	90	-1	20	15
10.902	10	3	95	-1	21	14
10.702	10	3.5	100	-3	14	16
10.653	10	3	95	-2.5	15	15
10.602	10	4	90	-2.5	12	11
10.402	10	5	90	0	16	16
10.352	10	3	95	-1.5	19	18
10.301	10	3	80	0.5	28	22
10.001	10	5	100	-3	11	12
9.951	10	4	100	-3	13	12
9.902	10	4	90	0.5	23	10
9.701	10	5	100	-4	10	14
9.651	10	4	100	-3	13	11
9.601	10	5	100	-2	13	14
9.402	10	5.5	100	-3	11	11
9.352	10	4	75	0	16	13
9.302	10	4	100	-3	13	14
9.002	10	3.5	100	-2	16	18
8.952	10	5	105	-4	11	15
8.902	10	4	100	-2.5	14	21
8.702	10	5	100	-3	11	14
8.653	10	3	100	-3	15	16
8.603	10	5	100	-2	13	17
8.402	10	5	90	-1.5	12	11
8.352	10	5	90	-1.5	12	12
8.302	10	2.5	100	-3	16	13
8.002	10	3	100	-3	15	8
7.953	10	3	100	-3	15	10
7.902	10	5	90	2	27	13
7.703	10	4	90	-1	16	12
7.648	10	4	100	-4	11	12
7.498	10	5	100	-5	9	11
7.398	10	5	95	-2.5	11	14
7.352	10	5	100	-2	13	21
7.302	10	4.5	100	-2	14	17

Automated Slope Tabulation

Road Section:

Wy 316 DEC

Width: 6ft

2 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
7.002	10	4.5	100	-2.5	13	16
6.948	10	4	100	-5	10	11
6.898	10	4	100	-5	10	12
6.701	10	4.5	100	-3	12	17
6.652	10	4.5	95	-3	11	16
6.602	10	4.5	100	-3	12	14
6.398	10	4.5	100	-3.5	11	17
6.352	10	5	90	-2.5	11	12
6.303	10	4.5	90	-3	11	11
5.998	10	3.5	100	-3.5	13	14
5.953	10	4.5	90	-1.5	13	13
5.898	10	4.5	90	-3.5	10	9
5.702	10	5	90	-4	9	8
5.648	10	2.5	100	-6	11	8
5.601	10	4.5	90	-5	8	8
5.398	10	4.5	90	-2	12	10
5.348	10	3.5	90	-3.5	11	10
5.298	10	5	90	-2.5	11	11
5.002	20	4	100	-4	10	12
4.952	10	4.5	85	-2.5	11	8
4.902	10	5	90	-2	11	8
4.703	10	4.5	100	-3.5	11	8
4.652	10	5	90	-2.5	11	11
4.602	10	5	100	-2	13	10
4.398	10	4	90	1	27	11
4.348	10	5	100	-2	13	12
4.302	10	5	90	1.5	23	12
3.998	10	4.5	100	-2.5	13	15
3.948	10	3	100	-2	18	11
3.902	10	4	100	-4	11	11
3.698	10	4	90	-2	13	11
3.648	10	5	90	-1	13	11
3.599	10	4	65	0	14	9
3.402	10	4.5	95	1	24	15
3.352	10	4	100	-2	15	13
3.298	10	5	100	-2	13	12

Automated Slope Tabulation

Road Section: Wy 316 DEC **Width:** 6ft 3 of 3

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
3.002	10	4.5	90	-4.5	9	7
2.952	10	4	90	-1.5	15	13
2.989	10	3.5	100	-3	14	12
2.698	10	5	100	-2	13	13
2.648	10	4	95	-2	14	13
2.599	10	4	100	-2.5	14	14
2.399	10	4	100	-3	13	17
2.349	10	4	100	-3	13	15
2.298	10	3	100	-2	18	16
Average	10.1	4.2	95.4	-2.4	13.8	12.9
St. Dev	1.1	0.7	6.6	1.5	4.1	3.2

Automated Slope Tabulation

Road Section:

Wy 313 INC

Width: 4ft

1 of 2

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
101.001	10	5	80	1	18	12
101.053	10	2.5	95	-2	19	13
101.098	10	2.5	95	-1	24	15
101.303	10	2.5	85	-1.5	19	8
101.352	10	3.5	85	-2	14	8
101.402	10	3	85	-2	15	11
101.598	10	4.5	90	-1.5	13	13
101.652	10	2.5	90	-1	23	17
101.702	10	4.5	90	0.5	20	12
102.003	10	4.5	80	2.5	35	15
102.048	10	5	90	2	27	18
102.098	10	5	70	3	30	22
102.302	10	4.5	75	1	19	19
102.348	10	5	80	1	18	48
102.402	10	5	90	2.5	32	48
102.603	10	4.5	90	-1	15	13
102.652	10	4	80	0	18	20
102.703	10	4	90	1.5	32	15
103.003	10	5	90	-1	13	14
103.053	10	4	90	1.5	32	15
103.102	10	4	90	2	40	10
103.301	10	4	90	-2	13	13
103.353	10	4	90	1	27	14
103.402	10	4	90	-2	13	12
103.602	10	4	90	2	40	14
103.652	10	4	80	1	23	17
103.703	10	3.5	90	0	23	17
104.001	10	4.5	80	3	47	14
104.047	10	4	70	2.5	40	18
104.102	10	4	80	2	35	14
104.302	10	3	100	-0.5	26	22
104.352	10	3.5	80	1.5	35	16
104.402	10	5	80	1.5	20	16
104.602	10	4.5	80	3	47	15
104.652	10	3.5	80	1.5	35	14
104.701	10	4	85	1	25	15
105.003	10	4	70	2	30	14

Automated Slope Tabulation

Road Section:

Wy 313 INC

Width: 4ft

2 of 2

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
105.052	10	3	70	0.5	24	19
105.101	10	4.5	80	0.5	18	40
105.302	10	4.5	75	1	19	17
105.352	10	5	45	3.5	23	24
105.401	10	4.5	100	-3	12	14
105.603	10	5	85	-1.5	12	17
105.652	10	4	90	0	20	17
105.701	10	5	80	0	14	17
105.997	10	4.5	90	1.5	27	18
106.051	10	4.5	40	3	20	13
106.101	10	5	40	3	15	20
106.301	10	3.5	70	2	40	27
106.352	10	4.5	70	2	24	20
106.401	10	4	70	0.5	17	24
106.601	10	4	90	0	20	22
106.652	10	4.5	80	0.5	18	20
106.701	10	4	70	2	30	22
107.001	10	5	60	2	17	27
107.051	10	5	70	1.5	17	22
107.101	10	4.5	65	2.5	28	30
107.302	10	4	70	2	30	27
107.351	10	3.5	70	2	40	30
107.401	10	3	70	1.5	40	22
107.597	10	2.5	80	0	28	17
107.652	10	3.5	40	2.5	30	22
107.701	10	4	50	1.5	16	14
108.002	10	5	80	1	18	20
108.051	10	3	80	1.5	47	18
108.101	10	5	70	2	20	24
108.301	10	3	70	1.5	40	24
108.351	10	4	90	0	20	29
108.402	10	4	60	2	25	30
108.601	10	4	70	1	20	18
108.651	10	3.5	70	1	24	22
108.702	10	3	70	1.5	40	22
Average	10.0	4.1	78.1	0.9	25.0	19.1
ST. Dev.	0.0	0.7	13.4	1.5	9.5	7.5

Automated Slope Tabulation

Road Section:

Wy 313 DEC

Width: 4ft

1 of 2

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
108.999	10	4.5	70	2	24	17
108.948	10	4	80	1	23	16
108.897	10	4	70	2	30	20
108.697	10	5	70	2.5	24	13
108.652	10	5	70	1.5	17	18
108.602	10	4	95	0	21	18
108.402	10	4.5	60	2.5	25	14
108.348	10	4.5	65	3	37	24
108.298	10	4.5	70	2	24	20
107.999	10	5	65	2	18	13
107.948	10	4.5	70	2	24	11
107.898	10	4.5	80	-1	13	18
107.698	10	4.5	40	3.5	30	17
107.648	10	5	40	4	30	13
107.599	10	5	90	2.5	32	14
107.399	10	5	70	2.5	24	20
107.348	10	4.5	60	2.5	25	27
107.298	10	5	60	4	50	31
106.989	10	4	60	2.5	33	20
106.948	10	4.5	60	3	33	17
106.899	10	4.5	70	2	24	13
106.702	10	5	95	-3	11	15
106.649	10	4.5	50	3	27	24
106.599	10	5	70	1.5	17	20
106.399	10	4	80	2.5	47	20
106.349	10	4	70	2.5	40	26
106.298	10	4	80	2.5	47	24
105.998	10	4	50	2.5	27	17
105.948	10	5	60	4	50	16
105.898	10	5	80	2	23	17
105.698	10	4	70	2.5	40	17
105.648	10	4	70	2	30	17
105.598	10	4.5	70	3	40	14
105.398	10	5	70	1.5	17	18
105.348	10	4	70	2	30	20
105.299	10	5	60	2.5	20	24
104.999	10	4	90	-1	16	14

Automated Slope Tabulation

Road Section:

Wy 313 DEC

Width: 4ft

2 of 2

	Point I		Point II		Automated	Manual
Station	Distance (in)	Height (in)	Distance (in)	Height (in)	Slope	Slope
104.949	10	4.5	65	1.5	18	18
104.899	10	4	80	0	18	19
104.699	10	5	90	0.5	18	13
104.649	10	5	80	0	14	11
104.599	10	5	80	0	14	14
104.399	10	5	70	1.5	17	26
104.349	10	3	70	1.5	40	38
104.298	10	5	60	2.5	20	22
103.999	10	5	60	2	17	12
103.949	10	4.5	70	1.5	20	17
103.899	10	3.5	80	0.5	23	19
103.698	10	4.5	70	2	24	17
103.648	10	5	70	3.5	40	12
103.599	10	5	40	1.5	9	11
103.399	10	5	80	0.5	16	12
103.348	10	5	80	0	14	12
103.299	10	4.5	90	-0.5	16	10
102.999	10	5	90	-0.5	15	18
102.95	10	4	80	1.5	28	13
102.898	10	4.5	70	1	17	13
102.699	10	4	90	-0.5	18	18
102.649	10	5	90	0	16	17
102.598	10	4	80	2	35	19
102.4	10	5	90	2	27	11
102.348	10	4.5	100	-2	14	18
102.399	10	3	90	-1	20	18
101.999	10	4	100	-1	18	22
101.95	10	5	95	0	17	-36
101.899	10	4	95	0	21	-43
101.699	10	4	90	1.5	32	0
101.649	10	4.5	90	-2	12	14
101.599	10	5	80	0.5	16	13
101.399	10	5	95	-1	14	-31
101.348	10	5	90	-0.5	15	-43
101.299	10	5	90	0	16	-27
Average	10.0	4.5	74.9	1.3	24.0	13.5
ST. Dev.	0.0	0.5	14.2	1.5	9.8	14.7

