# ROAD BARRIER CONDITION ASSESSMENT IN WIND RIVER INDIAN RESERVATION, WYOMING

By

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## EXECUTIVE SUMMARY

The condition of six different barrier systems located in Wind River Indian Reservation, Wyoming, were evaluated in this study. The study team collected the required data regarding the dimensions (length, offset, height), as well as the hardware condition (any damages on the barrier system) of barriers conducting a filed survey on Oct 31, 2017. Then, the information was used in a developed rating system called "Barrier Condition Index (BCI)" to rank the barrier segments from 1 to 4 based on the condition. The score 4 means the barrier condition is evaluated as very well with almost no serious damage or error, while the condition is evaluating as high-severity damage in the score of 1. The scores 2, and 3 are also the representative of a medium, and low-severity conditions, respectively. After the condition assessment procedure, the recommended improvement was proposed for each site considering the most recent cost estimation published by Wyoming Department of Transportation. Based on the evaluation, three of the locations were categorized as high-severity condition (with a BCI less than 2), and these sites should be considered in the propriety list of the improvement. The other sites studied had a medium-severity condition (the BCI was between 2 and 3). None of the sites had an appropriate end-treatment according to the data collected. Moreover, the end-treatments were found even as a dangerous fixed-object which would increase the severity of crashes (instead of reducing) in a few cases. Therefore, the end-treatments included the majority part of the improvement phase. A budget about $121,200 was estimated for the recommended improvements in the study (ignoring the costs of the instillation, and the mobilization).

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## 1. INTRODUCTION

Roadside safety has always been known as an important component of highway systems. Based on the statistics, only 16% of crashes in the US occurs on the roadside; however, these crashes mostly conclude in fatalities and high-severity injuries (NHTSA 2009). For instance, run-off-the-road (ROTR) crashes included 23% of the fatal crashes in 2008 (AASHTO 2011). Using road barriers is known as one of the popular and traditional strategies in roadside designs. An appropriate road barrier system reduces the severity of crashes as well as providing a second chance for the ROTR drivers to get the control of their vehicles back (in low-speed collisions). On the other hand, a poor performance would even cause a safety threat by switching its role to a dangerous fixed-object. In fact, barriers were introduced as the third most common object (after trees, and the utility poles) among all the fixed-object fatalities by object struck in 2008 (AASHTO 2011). Therefore, it is an essential fact for any highway agency to have a considerable attention to the maintenance and improvement of barriers for keeping their performance in an acceptable condition. According to Cafiso et al. (2014), a crash modification factor (CMF) about 0.78 (22% reduction in crashes) was examined for improving the old guardrails with barriers meeting the new standards while the influence could be even more significant in the ROTR crashes by a 0.67 CMF.

The primary objective of this report is to evaluate the condition of barriers in six sites located in Wind River Indian Reservation (WRIR), Wyoming. Afterward, the improvement recommendations and will be provided in each site to upgrade the performance of the barriers against any probable collision. For this purpose, a “barrier condition assessment (BCA)” worksheet was prepared by reviewing the previous studies (AASHTO 2011; NCHRP 2010; PennDOT 2017). Figure 1 shows a screen of the worksheet.

2017

## ROAD BARRIER CONDITION ASSESSMENT
WYOMING-WASHAKIE

Revised. 10/30/2017
By Wyoming Technology Transfer Center (T2)

| | | | |
|---|---|---|---|
| STATE ROUTE: | X COORDINATE: | BARRIER TYPE: | SIZE (W*L): |
| SEGMENT #: | Y COORDINATE: | POSTS TYPE: | BRIDGE? |
| SURVEY DATE: | SEGMENT LENGTH: | OFFSET FROM THE LANE: | H CURVE? |
| OBSERVER: | SPEED LIMIT: | END TREATMENT TYPES: | RADIUS: |
| DIRECTION: | ADT: | TANGENT OR FLARED? | SIDE THREAT: |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | - | Inches | N/A | N/A | |
| | Rigid Barrier | N/A | - | Inches | N/A | N/A | |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | | - | Inches | | | |
| | Cable System | | - | Inches | | | |
| | Cable System | | - | Inches | | | |
| | Cable System | | - | Inches | | | |
| **Panels Condtion** | | | | | | | |
| Vertical Tear | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | YES/NO | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | YES/NO | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | YES/NO | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | | - | Inches | | | |
| | Cable & W-Beam | | - | Inches | | | |
| Stub Height | Cable & W-Beam | | - | Inches | | | |
| | Cable & W-Beam | | - | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES/NO | Eng Judgement | | | |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES/NO | Eng Judgement | | | |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | YES/NO | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | | YES/NO | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |

**Figure 1. Barrier condition assessment worksheet in the project.**

Height (from the ground to the top, rail cross-section), deflection (vertical, lateral, cable sag), panels' condition (vertical tear, horizontal tear, deterioration, hardware condition), posts condition (separated from guardrail, posts condition), soil erosion, and the end-treatment condition (loosing cable, sub height, end-post condition) were selected as the main categories in the worksheet.

In the next step, barrier segments (six sites) were rated on a scale 1 to 4 to prioritize the sites with severe damage in the improvement process. The score 4 means an ideal condition with no damage, while a 1-rated site shows a high-severity damage that makes a critical condition in terms of safety. The rates 2, and 3 also belong to the medium, and low severity conditions, respectively. An example of the rating scale in BCI is presented in Figure 2.


**Figure 2. An example of the proposed BCI rating system.**

Finally, a cost estimation was presented for the recommended improvements based on the most recent updates from manufactures.

### 1.1 Site Description

As it was mentioned earlier, six different sites were selected for this project. Figure 3 illustrates the position of the six sites in WRR, while a comprehensive information regarding the GPS (Global Positioning System) coordinates, segment length, annual average daily traffic (AADT), and the speed limit has provided by Table 1.


**Figure 3. A general view of the sites in Wind River, Reservation.**

**Table 1. Geographic and traffic information of sites studied in the project.**

| Site | | GPS Coordinate | | Length (ft) | Speed Limit (mph) | | ADT (veh/day) |
|---|---|---|---|---|---|---|---|
| No. | Name | Latitude | Longitudinal | | NB/EB | SB/WB | |
| 1 | Little Wind & Blue Cloud | 42.96695 | -108.49938 | 205 | 55 | - | < 400 |
| 2 | Northern Arapahoe Rd | 42.98244 | -108.51877 | 130 | 55 | 55 | < 400 |
| 3 | Little Wind Bottom Rd | 42.97877 | -108.55819 | 150 | 55 | 55 | < 400 |
| 4 | South Fork Rd | 42.99903 | -108.93186 | 50 | 55 | 55 | < 400 |
| 5 | Shoyo Bridge | 43.00029 | -108.93799 | 60 | 55 | 55 | < 400 |
| 6 | Ft Washakie Bridge | 43.00464 | -108.89305 | 60 | 45 | 30 | < 400 |

As it is indicated in Figure 3, the sites were located by half in the northwest of Arapahoe and the west side of Fort Washakie. US-287, WY-137, and WY-132 were also the main highways in the area. Totally, 655 ft barrier segments were analyzed in this study as shown in Table 1. Site #6 was the only location with a speed limit sign. No speed limit signs were observed for the rest of the sites even in the distances of 2-3 miles away from the barrier segments. For locations without speed limit signs, the speed limit was chosen as much as 55 mph based on the recommendation of engineers in the WRIR Department of Transportation. It must be mentioned that the speed regulations for public roadways in Wyoming (WYDOT 2011) suggest a speed limit of 65 mph; however, this speed seemed high and unsafe for the sites studied in this report. Regarding the last column of Table 1, all the ADTs were assumed less than 400 veh/day.

## 2. EVALUATION OF EXISTING CONDITION

A field study was conducted on October 31, 2017, to observe and record the current condition of barriers. The following paragraphs describe the key points of the condition evaluation in each site. For more information, it is recommended to review the worksheets in Appendix A.

### 2.1 Site No. 1

Site No. 1 has a semi-rigid W-Beam guardrail with wood posts (without blockout). The poor condition of end-treatments was investigated as the main problem in this segment. As it is shown in Figure 4, one of the end-treatment seems to be a “trailing end W-Beam guardrail anchorage” type while a part of the end-post is missed. The existing end-post can apply a serious damage to

vehicles involved in a crash. In other words, it would perform the same as a sharp blade in the collisions. The first end-treatment was also missing the end terminal portion. Moreover, the offset from the edge of pavement was measured as 1 ft which is not acceptable based on the recommended offset of 4 ft in the roadside design guide (RDG) (AASHTO 2011).

**a. End-treatment No. 1** **b. End-treatment No. 2**

**Figure 4. Condition of end-treatments in site No. 1.**

The height of barrier was the second significant problem in this segment. The low-height barriers raise the propensity of vehicle rollover and override, while very tall-barriers are also promoting the vehicle underride (Julin et al. 2017). According to Wiebelhaus et al. (2013), the low-height of 24, and 26 inches will increase the potential of vehicle override in guardrails. However, the 27, 29, and 30 inches height will lead a redirection of the vehicle. According to the RDG (AASHTO 2011), a height of 30 to 32 inches (27 inches in the old types) was suggested for semi-rigid W-Beam guardrails while the existing segment had a height equal to 21 inches. Based on FHWA's W-Beam Guardrail repair (FHWA 2008), the guardrails with a lower height of 24 inches were categorized as "no longer reasonably functional." One of the reasons for this difference in the height was seen due to the shoulder drop-off and the soil erosion (5 inches) in the location of posts. Almost all the posts did not have an appropriate condition because of their longtime of service. Figure 5 shows one of the posts' condition.

**Figure 5. Condition of posts in site No. 1.**

25 ft of the guardrail segment had severe lateral deflection, high-severity deterioration was observed on the panels, and there was a missing bolt in the connection of two panels. As shown in Figure 6, the traffic signs were not placed behind the guardrail, and this can impact the performance of the barrier in crashes. Worksheets and pictures in Appendices A and B also refer the GPS coordinates and the condition of these damages more precisely.

**Figure 6. Wrong placement of traffic signs in site No. 1.**

As a summary of the assessment, Figure 7 shows the score of site No. 1 based on the established rating system in this project. Note that the significance coefficients (weights) were given to damages after reviewing NCHRP 2010 and PennDOT 2017 to consider the various level of significances for different types of damages. The score was estimated equal to 1.83 in site No. 1 which reflects high-severity condition.

| | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | * | | | | 3.0 | 1 | 3 | **1.83** |
| **Rail Flattening & Crush** | | | | * | 0.5 | 4 | 2 | |
| **Deflection** | | | | | | | | |
| Vertical | | | * | | 1.0 | 3 | 3 | |
| Lateral | * | | | | 1.0 | 1 | 1 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | | | | * | 1.0 | 4 | 4 | |
| Hardware | | | * | | 0.5 | 3 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Posts Condition | | * | | | 2.0 | 2 | 4 | |
| **Soil Erosion** | | * | | | 2.0 | 2 | 4 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | | | * | | | | |

**Figure 7. Summary of assessment and the estimated score on site No. 1.**

### 2.2 Site No. 2

The barrier system at site No. 2 has a Wyoming Two-Tube Bridge Railing" on the bridge and W-Beam guardrails as the end-treatments. No serious problems were observed for the barrier segment on the bridge but a low-severity deterioration due to the weather is shown in Figure 8.

**Figure 8. Low-severity deterioration observed in site No. 2.**

End-treatments seemed to be in good condition. Despite the good shape of the guardrails, there was a serious problem regarding the height of the end-treatments due to improper installation. In fact, the existing end-treatments has a turned-down terminal which was popular in the early 1960; however, this type of the terminal failed based on tests done by Federal Highway Administration (FHWA) and it is not acceptable to use turned-down terminals since 1994 (Wiebelhaus et al. 2013). The existing end-treatment can be called as a "W-Beam Guardrail Anchored (Buried) in Backslope" with wrong installation. An ideal backslope of 1V:2H is suggested (AASHTO 2011) for this type of end-treatment, while the topography of the location has no backslope. In this situation, a different type of end-treatment is more appropriate. Figure 9 shows a comparison between the existing end-treatments and the acceptable type based on RDG (AASHTO 2011).

**a. End-treatment in site No. 2** **b. End-treatment based on AASHTO 2011**

**Figure 9. The comparison between the end-treatment in site No. 2 and the recommended design in AASHTO 2011.**

As another concern regarding the existing end-treatments, the bridge transition is not designed well. Bridge transitions are very important because they are mostly joined of two different type of barriers (usually a rigid barrier on the bridge and a guardrail system as the end-treatments) with different stiffness, strengths, and geometric features. In such cases, it is required to use adequate blockouts and additional posts or rail elements to provide a proper stiffness transition to remove the potential vehicles snag or pocketing near the bridge end (Wiebelhaus et al. 2013). The existing end-treatment due to its weak wooden posts will perform poorly in the transition in crashes.

As a side note on site No. 2, approximately, 30 ft on Southbound (SB) and 20 ft on Northbound (NB) sections had around 5 inches of accumulated dirt at the bottom of the end-treatments' posts. For this reason, the height of end-treatment guardrail was measured as 26 inches at its highest level (at the start point and the end point of the bridge's barrier). This point is shown clearly in Figure 10.

**Figure 10. The elevation of accumulated dirt at the bottom of posts in site No. 2.**

Finally, the summary of barrier assessment in site No. 2 is presented in Figure 11. Both the SB and NB sections had similar conditions and received similar score of 2.55. This means that the whole barrier system on site No. 2 has medium-severity condition.

| Percentage of Severity | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | | * | | | 3.0 | 2 | 6 | **2.55** |
| **Rail Flattening & Crush** | | | | * | 0.5 | 4 | 2 | |
| **Deflection** | | | | | | | | |
| Vertical | | | | * | 1.0 | 4 | 4 | |
| Lateral | | | | * | 1.0 | 4 | 4 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | | | * | | 1.0 | 3 | 3 | |
| Hardware | | | | * | 0.5 | 4 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Post Failure | | | | * | 2.0 | 4 | 8 | |
| **Soil Erosion** | | | | * | 2.0 | 4 | 8 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | * | | | | | | |

**Figure 11. Summary of assessment and the estimated score on site No. 2.**

### 2.3 Site No. 3

Site No 3 has a Wyoming Two-Tube Bridge Railing with W-Beam guardrail end-treatments. The height was found to be 31”, and 27” for the barrier system on the bridge, and in the highest level of end-treatments (in their joint point with the bridge barrier), respectively. The reason for the lower elevation for the end-treatment was the accumulated dirt and plants (about 4-5 inches) at the bottom of W-Beam guardrail. Also, the posts were placed on a slope which reduced the height in comparison to the road surface.

The first end-treatment on the SB of the road seemed to be hit by a vehicle. The rail cross-section height of the rail was measured as 7 inches, while the typical W-Beam rails have a width equal to 12 inches. Based on NCHRP report 656 (2010), the end treatment has medium-severity damage. Figure 12 shows the damage.


**Figure 12. The lower rail cross-section height observed on site No. 3.**

There are issues related to the installation of the end-treatments including the height, turned-down terminal, and the bridge transition. These issues are visible in Figure 12 and they were explained in site No. 2.

The summary of condition evaluations on site No. 3 were provided separately for each bound as shown in Figure 13.

| Percentage of Severity | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | | * | | | 3.0 | 2 | 6 | **2.58** |
| **Rail Flattening & Crush** | | | * | | 0.5 | 3 | 2 | |
| **Deflection** | | | | | | | | |
| Vertical | | | | * | 1.0 | 4 | 4 | |
| Lateral | | | | * | 1.0 | 4 | 4 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | | | | * | 1.0 | 4 | 4 | |
| Hardware | | | | * | 0.5 | 4 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Post Failure | | | | * | 2.0 | 4 | 8 | |
| **Soil Erosion** | | | | * | 2.0 | 4 | 8 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | | | * | | | | |

**a. South Bound**

| Percentage of Severity | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | | * | | | 3.0 | 2 | 6 | **2.60** |
| **Rail Flattening & Crush** | | | | * | 0.5 | 4 | 2 | |
| **Deflection** | | | | | | | | |
| Vertical | | | | * | 1.0 | 4 | 4 | |
| Lateral | | | | * | 1.0 | 4 | 4 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | | | | * | 1.0 | 4 | 4 | |
| Hardware | | | | * | 0.5 | 4 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Post Failure | | | | * | 2.0 | 4 | 8 | |
| **Soil Erosion** | | | | * | 2.0 | 4 | 8 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | | | * | | | | |

**b. North Bound**

**Figure 13. Summary of assessment and the estimated score on site No. 3.**

Both directions at site No. 3 had similar score of 2.6 (medium-severity category). The minor difference was due to the lower height cross-section seen on the end-treatment of the south bound.

### 2.4 Site No. 4

Site No. 4 was the only site with no barrier system. Figure 14 shows a general view of the site.


**Figure 14. A general view of site No. 4.**

Based on the recommendations of RDG (AASHTO 2011), fill section height, and the sideslope rate are two main parameters to determine whether a barrier system is needed. The method is also shown in Figure 15. Site No. 4 is by a river with a fill section height of 10 ft and the sideslopes about 2H:1V on each side. Therefore, according to Figure 15, a barrier system is warranted for both directions. Therefore, the assigned site score is 1.0 which means the highest priority for installing a barrier system.

Some important observations were also recognized that should be noted in the design phase. These cobservations are listed as below:

- The existing road had a pavement width of 24 ft. This width is adequate for having two proper traffic lanes; however, a minimum width of 2 ft on each side is required for establishing the new barrier system.
- Soil erosion (or shoulder drop-off) with a height of 5 inches was observed all along the bridge on each side. This point should be considered regarding providing proper height for the barrier.
- As a restriction in the design phase, there were four adjacent entrances (to private properties) which could limit the length of the barrier system.

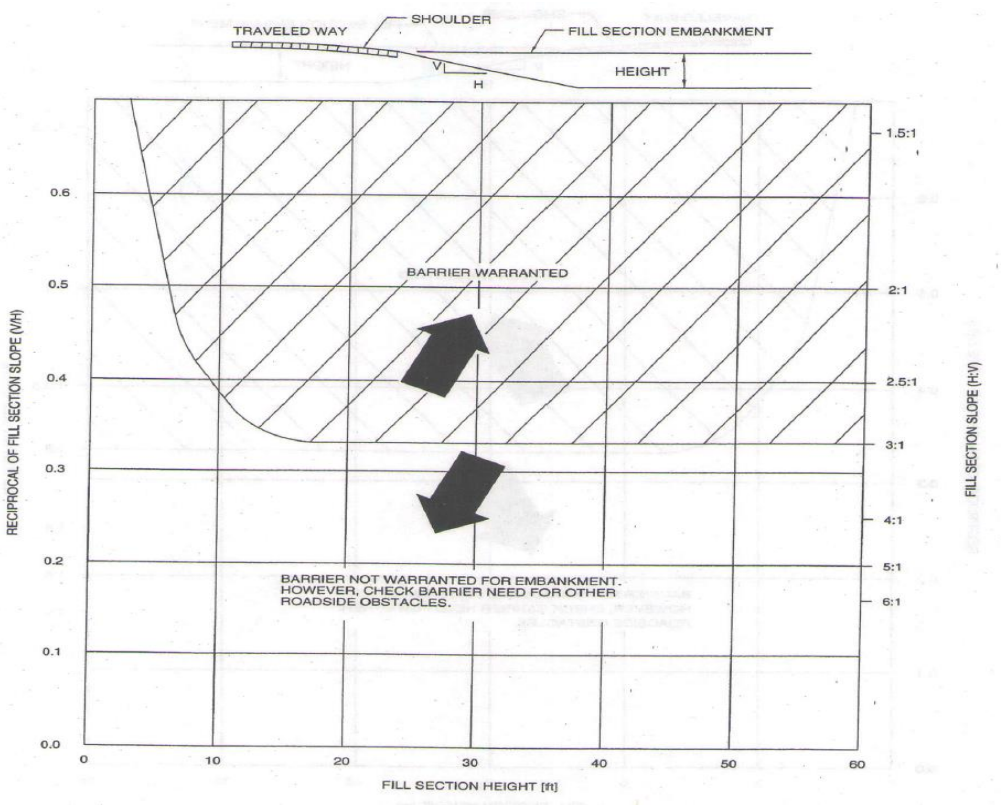


**Figure 15. Barrier warrant analysis based on AASHTO 2011.**

The last two observations are illustrated in Figure 16. Chapter 3 of the report (Improvement Recommendations) will focuses on the barrier design on this site.

**a. Shoulder drop-off** **b. Adjacent Entrances**

**Figure 16. Two important consideration of barrier design in site No. 4.**

### 2.5 Site No. 5

Site No. 5 also has a "Wyoming Two-Tube Bridge Railing" on the bridge. As it is shown in Figure 17, the barrier has no serious damages on the hardware; however, there were no end-treatments at the beginning and the end point of the bridge. This fact poses a dangerous situation due to the presence of a wide river.


**Figure 17. Good condition of bridge barrier on site No. 5.**

Side dozing also seemed required before installing any new end-treatment. No serious damage could be found during the field survey.

Figure 18 presents the summary of assessment on site No. 5. The score was estimated equal to 2.87 for both the directions (SB and NB) indicating a medium-severity damage (but very close to a low-severity) for the location.

| Percentage of Severity | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | | | | * | 3.0 | 4 | 12 | **2.87** |
| **Rail Flattening & Crush** | N/A | N/A | N/A | N/A | | | 0 | |
| **Deflection** | | | | | | | | |
| Vertical | | | | | 1.0 | 4 | 4 | |
| Lateral | | | | | 1.0 | 4 | 4 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | | | | * | 1.0 | 4 | 4 | |
| Hardware | | | | * | 0.5 | 4 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Post Failure | | | | * | 2.0 | 4 | 8 | |
| **Soil Erosion** | | | | * | 2.0 | 4 | 8 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | | | * | | | | |

**Figure 18. The summary of assessment and the estimated score on site No. 5.**

### 2.6 Site No. 6

The barrier system on site No. 6 consists of an old steel barrier with steel posts (no blockout) on the bridge. As shown in Figure 19, there were some wood-posts (without any rail) before and after the bridge. However, they could not be considered as end-treatments due to the lack of stability. It is predicted that the wood-posts will act as hazardous fixed-objects in case of crashes. Figure 19 shows the threat of fixed-objects (utility poles and the traffic signs) behind the weak wood-posts.


**Figure 19. The poor condition of wood-posts at site No. 6**

The barrier system considered on the bridge had substantial damages as listed below:

- The height of the bridge steel barrier is 21 inches which is well below the acceptable level (typically 30-32 inches).
- Figure 20 shows the significant aging of the bridge barrier.


**Figure 20. The deterioration observed in site No. 6.**

- As it is clear in Figure 21, one of the posts was separated about 2 inches from barrier. However, the damage is not significant since a separated distance less than 3 inches would be acceptable with no need to repair according to NCHRP report 656 (2010).


**Figure 21. The separated post from guardrail in site No. 6**

- The soil erosion on the sides was estimated about 8 inches which would increase the severity of ROTR crashes. This point is shown clearly in Figure 22.

**Figure 22. Soil erosion of shoulder site No. 6.**

- There were vertical and lateral deflections on 3 ft of the barrier segment in the north bound direction. The values of vertical and lateral deflections were examined as 10 degrees and 3 inches, respectively. The deflections were placed in the low-severity damages based on NCHRP report 656 (2010). Figure 23 shows the deflections observed during the field study.

**Figure 23. The deflections on the NB of site No. 6.**

As an important observation (but irrelevant to the barriers assessment) during the field evaluation, it was found that the concrete at the bottom of the bridge (near to the columns) was washed out.

Figure 24 shows a summary of barrier assessment in each direction of site No. 6. A score of 1.64 was estimated for the south bound while the condition of the north bound reflected a score of 1.54 due to the deflection damage. Therefore, both the directions have high-severity damages.

| Percentage of Severity | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | * | | | | 3.0 | 1 | 3 | **1.64** |
| **Rail Flattening & Crush** | N/A | N/A | N/A | N/A | | | 0 | |
| **Deflection** | | | | | | | | |
| Vertical | | | | * | 1.0 | 4 | 4 | |
| Lateral | | | | * | 1.0 | 4 | 4 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | * | | | | 1.0 | 1 | 1 | |
| Hardware | | | | * | 0.5 | 4 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Post Failure | * | | | | 2.0 | 1 | 2 | |
| **Soil Erosion** | * | | | | 2.0 | 1 | 2 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | | | * | | | | |

**a. South Bound**

| Percentage of Severity | High | Med | Low | None | Sig Coefficient | SCORE (1-4) | Weighted SCORE | AVE SCORE |
|---|---|---|---|---|---|---|---|---|
| **Height** | * | | | | 3.0 | 1 | 3 | **1.54** |
| **Rail Flattening & Crush** | N/A | N/A | N/A | N/A | | | 0 | |
| **Deflection** | | | | | | | | |
| Vertical | | | * | | 1.0 | 3 | 3 | |
| Lateral | | | * | | 1.0 | 3 | 3 | |
| **Cable Sag** | N/A | N/A | N/A | N/A | | | | |
| **Panels Condition** | | | | | | | | |
| Vertical Tear | | | | * | 1.0 | 4 | 4 | |
| Horizontal Tear | | | | * | 0.5 | 4 | 2 | |
| Deterioraton | * | | | | 1.0 | 1 | 1 | |
| Hardware | | | | * | 0.5 | 4 | 2 | |
| **Posts Condition** | | | | | | | | |
| Separated From Guardrail | | | | * | 0.5 | 4 | 2 | |
| Post Failure | * | | | | 2.0 | 1 | 2 | |
| **Soil Erosion** | * | | | | 2.0 | 1 | 2 | |
| **End-Terminal Condition** | | | | | | | | |
| End-Post #1 Condiiton | * | | | | 3.0 | 1 | 3 | |
| End-Post #2 Condiiton | * | | | | 3.0 | 1 | 3 | |
| **Extra Points** | | | | | | | | |
| Removal Section | | | | * | | | | |
| Side Dozing | | | | * | | | | |

**b. North Bound**

**Figure. 24 Summary of assessment and the estimated score on site No. 6.**

# 3. IMPROVEMENT RECOMMENDATIONS

This chapter summarizes the recommendations and the proposed improvements for upgrading the performance of barriers at each site.

## 3.1 Site No. 1

Since site No. 1 was ranked in a high-severity level of damages, the whole barrier should be replaced. The semi-rigid W-Beam guardrail seems to be the most appropriate type at this site. In fact, cable systems could be an expensive choice because it needs a wide width (about 10-12 ft) for the lateral deflection on crashes, and the rigid barrier is not a typical alternative for the low-volume roads like site No. 1. Therefore, three different semi-rigid guardrails are recommended at this location as shown in Table 2. The main reason for choosing these types is their low rate of the maximum deflection. So, a width as much as 4 ft (considering 1 ft offset from pavement and 3 ft behind the barrier for the deflection in crashes) would seem enough for these types of guardrails. Note that the 4-ft width is the minimum recommendation while a wider shoulder would provide a safer condition as the offset will be increased. All the traffic signs must also be shifted behind the barrier system.

**Table 2. Recommended barriers in site No. 1.**

| Type | Max Lateral Deflection (ft) |
|---|---|
| Blocked-Out W-Beam (Strong Post) | 2.6 |
| Midwest Guardrail System (MGS) | 3 |
| Blocked-Out Thrie-Beam | 1.9 |

Regarding the end-treatments, a tangent end-treatment would be more practical than the flared due to the limited flat area at the roadside (the flared would increase the offset from the pavement, while there is not enough width). For this reason, an "Extruder Terminal (ET-Plus)," or a "Sequential Kinking Terminal (SKT-350)" is recommended. As a cheaper alternative, the Slotted Rail Terminal (SRT-350) can be selected.

More information regarding the type of barriers and end-treatments is provided in Appendix C.

### *3.1.1 Length-of-Need*

Based on the RDG (AASHTO 2011), the important variables for calculating the length of barriers are shown in Figure 25. Among the variables of Figure 25, $L_A$, and $L_R$, have the key role in the method. $L_A$ (the lateral extent of the area of concern) is the distance from the edge of the pavement to the far side of the fixed object or to the outside edge of the clear zone (when the fixed object extends beyond the clear zone).

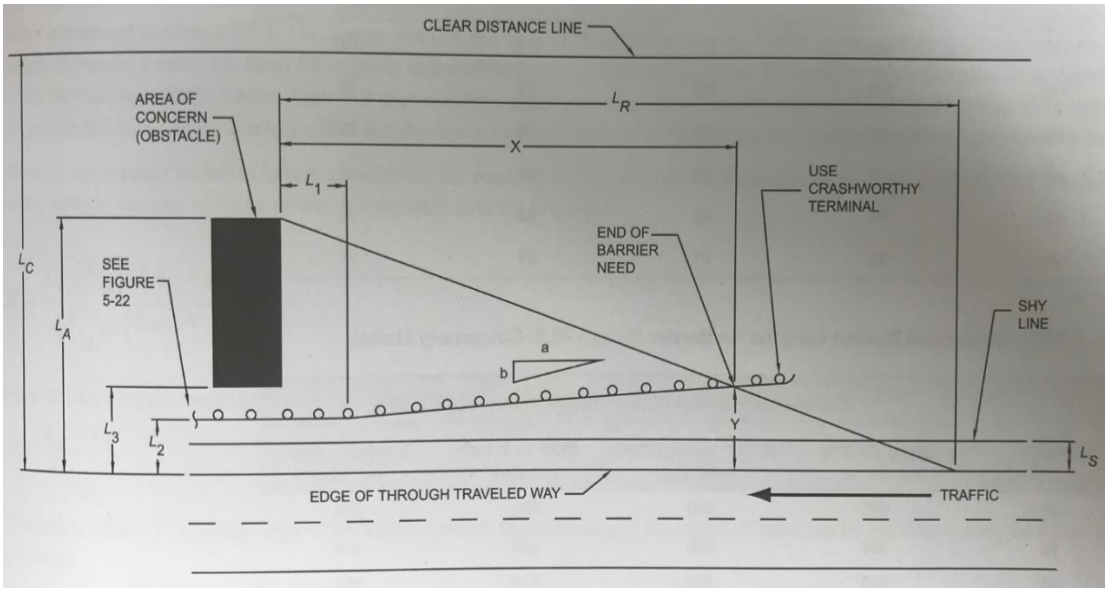


**Figure 25. Variables involved in barrier design (AASHTO 2011).**

$L_R$ (the runout length) is the distance from the fixed-object being shielded to the point where the vehicles depart from the road. The RDG (AASHTO 2011) estimates the required $L_R$ based on the ADT and speed limit as presented in Table 3. As the last step, these variables will be used in equations 1 and 2 to calculate the length-of-need when there is a flared installation or a parallel (tangent) installation, respectively.

**Table 3. Recommended runout lengths for barrier design (AASHTO 2011).**

| Design Speed (mph) | Runout Length Given Traffic Volume (ADT) (ft) | | | |
|---|---|---|---|---|
| | Over 10,000 veh/day | 5,000 to 10,000 veh/day | 1,000 to 5,000 veh/day | Under 1,000 veh/day |
| **80** | 470 | 430 | 380 | 330 |
| **70** | 360 | 330 | 290 | 250 |
| **60** | 300 | 250 | 210 | 200 |
| **50** | 230 | 190 | 160 | 150 |
| **40** | 160 | 130 | 110 | 100 |
| **30** | 110 | 90 | 80 | 70 |

Table 4 also shows the recommended flare rates by RDG (AASHTO 2011). In Table 4 and Figure 25, shy-line is "the distance from the edge of the roadway beyond that a roadside object will not be perceived as an obstacle by the typical driver to the extent that the driver will change the vehicle's placement or speed."

**Table 4. Recommended flare rates for barrier design (AASHTO 2011).**

| Design Speed (mph) | Flare Rate for Barrier Inside Shy Line | Flare Rate for Barrier at or Beyond Shy Line | |
|---|---|---|---|
| | | Rigid Barrier System | Semi-Rigid Barrier System |
| **70** | 30:1 | 20:1 | 15:1 |
| **60** | 26:1 | 18:1 | 14:1 |
| **55** | 24:1 | 16:1 | 12:1 |
| **50** | 21:1 | 14:1 | 11:1 |
| **45** | 18:1 | 12:1 | 10:1 |
| **40** | 16:1 | 10:1 | 8:1 |
| **30** | 13:1 | 8:1 | 7:1 |

$$X = \frac{\mathrm{LA} + \left(\frac{\mathrm{b}}{\mathrm{a}}\right)(L1) - L2}{\left(\frac{\mathrm{b}}{\mathrm{a}}\right) + (\frac{LA}{LR})} \quad Equation\ 1$$

$$X = \frac{\mathrm{LA} - L2}{(\frac{LA}{LR})} \quad Equation\ 2$$

The speed limit at site No. 1 is 55 mph according to Table 1. Therefore, a 60-mph design speed should be considered to calculate the required length (design speed is typically 5-7 mph higher than the speed limit). Therefore, the runout length was selected as 200 ft. $L_A$ was measured equal to 25 ft using Google Earth. According to Equation 2 (considering tangent end-treatment), the required length on one side (X) was estimated 192 ft. So, a 400-ft barrier segment is recommended at site No. 1. Note that the 192-ft length is the minimum required lengths based

on RDG (AASHTO 2011) while it should be rounded to a multiple of 12.5 ft (as the typical length of each guardrail panel).

### *3.1.2 Cost*

This study aims to provide an initial cost estimate for the improvements based on provided prices by WYDOT website (WYDOT 2016). It should be noted that the costs of mobilization and installation are not included in the cost estimations.

According to WYDOT website (WYDOT 2016), an average rate of $1.61 per ft is estimated for removal of guardrails. Therefore, the removal cost at site No. 1 is about $330. A $22.23 per foot is estimated for MGS guardrail. Therefore, a total budget of $8,900 is required for the installation of the new barrier system. The WYDOT data does not show the different types of barriers and end-treatments, so, the study assumed the same estimation for the rest of the recommended types by Table 3. Each end-terminal is estimated to cost about $2,575 ($5,150 for both sides); however, it should be emphasized again that the estimation is not based on the various type of the end-terminal and the unit price is just an average prediction of the end-terminal cost in Wyoming. Materials cost estimation equal to $14,400 is required for applying the recommended improvements at site No. 1.

## 3.2 Site No. 2

At this point, no improvement is required for the bridge barrier and it is anticipated that the barrier would not face any serious issues at least in the next five years. However, it is required to improve the condition of the end-treatments. The post spacing near the bridge should be only 3’ instead of the typical 6’ spacing to provide a good transition between the rail and the bridge barrier. A Thrie-Beam is recommended to provide a smoother transition (from the semi-rigid

guardrail to the rigid barrier on the bridge). Figure 26 shows an example of a proper bridge transition installation.

**Figure 26. An appropriate design of the bridge transition section.**

Blocked-Out W-Beam (Strong Post) and Midwest Guardrail System (MGS) would be the recommended alternatives if the decision-makers prefer to use new guardrails instead of the current rail system. Side dozing is another task that must be done before the installation of end-treatments. For the terminal section, the "Extruder Terminal (ET-Plus)," "Sequential Kinking Terminal (SKT-350)," or the "Eccentric Loader Terminal (ELT)" are recommended. Also, it is recommended to use flare on the end-treatments for three reasons: (1) the flare gives a chance to place the barrier with a wider offset to the road (it is always recommended to locate the barriers as far as possible from the roadway), (2) the required length would be shorter which is an advantage either in terms of costs or due to the adjacent entrances to the farms (at this specific site), and (3) it minimize the drivers' reaction to an object (barrier) near to the roadway since it is gradually introducing a parallel barrier installation.

The height of the whole barrier system must be considered as a minimum of 31 inches. Note that the maximum height on the guardrail (end-treatments) segments should also be limited to 36 inches to prevent the underride crashes for the vehicles in collisions based on Albuquerque et al. (2015).

### *3.2.1 Length-of-Need*

$L_A$ and $L_R$ are 15’ and 200’ at site No. 2. Based on these measurements, the length-of-need would be 60 ft on each side (from the edge of the river to the end-terminal). Considering the bridge length, the segment needs a 140 ft barrier system. However, there is only 130’ available between property entrances at both ends of the bridge. The variables a, b, and $L_1$ were considered as 5, 1, and 12 ft, respectively to minimize the length-of-need. The flare rate (5:1) considered is not based on the suggested rate in Table 5 (which is 14:1) since the design needed to be much longer. $L_2$ was also considered equal to 1 ft based on the existing offset at the site. Since removing the adjacent entrances would probably create problems for the residents, it is suggested to ignore the 10 ft-shortage of barrier length since the roadside is located on a flat terrain. A previous study by Albuquerque et al. (2015) suggested that shorter length can be considered for barriers when the sideslops are flat. This fact is missed in the existing method presented by RDG (AASHTO 2011) since the effect of the sideslope rate is ignored in the calculation of the length-of-need.

### *3.2.2 Costs*

The majority part of improvement cost at site No. 2 is related to the new end-terminals. The materials cost is estimated at $2,575 for each terminal ($10,300 for all the four terminals). New rails cost about $4,450 while about $640 is required for the removal guardrail cost. The total

material price is estimated about $15,400 (end-terminals = $10,300, new rails = $4450, removal = $640).

## 3.3 Site No. 3

The same as site No. 2, site No. 3 does not need any improvement regarding its barrier on the bridge while the end-treatments should be replaced. Regarding the terminal section, a flared type of “ET-Plus,” “SKT-350,” or the “ELT” are recommended. All these end-terminals can be practical at the location.

The bridge transition is recommended to be considered as elaborated in section 3.2. Blocked-Out W-Beam (Strong Post), and MGS are also recommended for the new guardrail system.

### *3.3.1 Length-of-Need*

$L_A$ and $L_R$ were extracted equal to 30, and 200 ft at site No. 3. Therefore, the length-of-need was calculated as 68 ft for each end-treatment considering a=3, b=1, $L_1$=12, and $L_2$=1 ft. However, the length is recommended to be considered as much as 50 ft due to the limited available length between the bridge and the adjacent entrances. Note that the existing guardrail system has not covered the current utility pole on the southeast of the site, while the new design will also cover it to avoid any high-severe collisions with the utility pole.

### *3.3.2 Costs*

The cost is estimated to be the same as the evaluated rate for site No. 2. Therefore, the material cost would be about $15,400 at site No. 3.

### 3.4 Site No. 4

A “Wyoming Two-Tube Bridge Railing” on the bridge with four W-Beam guardrail end-treatments (as end-treatments) are recommended at site No. 4. The Blocked-Out W-Beam (Strong Post), and MGS are suggested as the guardrail system at site No. 4 due to their lower lateral deflection (as shown in Table 2). The “ET-Plus,” “SKT-350,” or the “ELT” are recommended as the end-terminal as well. The height of the whole barrier system must be considered as a minimum of 31 inches.

The bridge transition is recommended to be considered as elaborated in section 3.2.

#### *3.4.1 Length-of-Need*

A 25 ft-$L_A$, and 200 ft-$L_R$ were measured at site No. 4. The short distance between the adjacent entrances does not provide enough space to meet all the design requirements provided in RDG (AASHTO 2011). For this reason, it is highly recommended to review the possibilities for removing the adjacent property entrances. In this way, the same design as presented on site No. 3 would be suggested at site No. 4. However, as the second alternative, the following information shows the recommended geometric features when removing the entrances is not possible:

- Length of the rigid barrier on the bridge = 30 ft on each bound,
- Length of each end-treatment rail = 25 ft (2 steel panels) with a flare rate of 1:1 (a=25, b=25 ft),
- Offset between the bridge barrier and the roadway = 1 ft.

It should be mentioned that the second alternative is not able to provide a good transition section between the bridge barrier and the guardrail.

### *3.4.2 Costs*

The unit cost for the bridge barrier is predicted as $124.57 per ft based on WYDOT. Therefore, a $7,500 ($124.57 * 60 ft) cost will be added to the price of the four terminals ($10,300), and the four guardrail end-treatments ($2250). The total material cost for the improvements will be approximately $20,100.

## 3.5 Site No. 5

No improvement is required for the bridge barrier at site No. 5. The only required improvement is regarding adding new guardrail end-treatments. The same end-terminals as site No. 2, 3, or 4 (ET-Plus, SKT-350, and ELT) are recommended here as well. One of the advantages at site No. 5 is the available space for providing an appropriate length. Then, the design procedure at site No. 5 will follow all the requirements provided by RDG (AASHTO 2011).

The bridge transition is recommended to be considered as elaborated in section 3.2.

### *3.5.1 Length-of-Need*

$L_A$ and $L_R$ are 25, and 200 ft at site No. 5. The suggested flare rate was also found equal to 14:1 in Table 5. Therefore, the length-of-need for each end-treatment is estimated as 132.5 ft (considering $L_1$ = 25 ft and $L_2$ = 1 ft).

### *3.5.2 Costs*

The improvement costs at site No. 5 only include the items related to the materials of the new end-treatments. The estimations show a range of $11,800, and $10,300, for the guardrails, and the terminals, respectively. A material cost of $22,100 would be required for the suggested improvements.

### 3.6 Site No. 6

Due to the poor condition of the existing barrier at site No. 6, the whole barrier system is recommended to be replaced with a new system. The "Wyoming Two-Tube Bridge Railing" on the bridge with W-Beam guardrail end-treatments (Blocked-Out W-Beam, or the MGS) is the recommended barrier system for site No. 6. All the existing wood posts on the roadside must be removed as well. Regarding the end-terminals, any of "Extruder Terminal (ET-Plus)," "Sequential Kinking Terminal (SKT-350)," or the "Eccentric Loader Terminal (ELT)" can be considered. The height of the bridge barrier in the whole barrier system must be considered as a minimum of 31 inches (as well as a maximum of 36 ft for the whole system).

The bridge transition is recommended to be considered as elaborated in section 3.2.

#### *3.6.1 Length-of-Need*

$L_A$ is equal to 20 ft in Site No. 6; however, $L_R$ would be different on each bound due to the various speed limits (45 mph on NB, 30 mph on SB). Therefore, $L_R$ was selected as 150, and 100 ft, while the flare rate was also considered equal to 11:1 and 8:1, on NB (with a speed limit of 45 mph) and SB (with a speed limit of 30 mph), respectively. Based on these measurements, a length-of-need about 100 ft, and 75 ft should be considered for the end-treatment sections on NB and SB. Considering the possibility that a vehicle leaves the road from NB toward the hazard on SB, it is recommended to consider the 100-ft length for both the directions. Also, a minimum length of 125 ft (instead of 100 ft) is highly suggested on the south of the NB (before the bridge) to cover the existing utility pole on the southeast of the site. The bridge barrier also needs a length of 55 ft on each side.

### *3.6.2 Costs*

A total material cost of $33,800 (guardrail end-treatments = $9500, bridge barrier = $13,700, end-terminals = $10,300, barrier removal = $300) is estimated for the improvement phase at site No. 6.

## 4. CONCLUSIONS

Table 5 shows the condition assessment conducted for the sites in this study, while the summary of improvement costs, crash statistics, and the BCI is each site is provided by Table 6 to present a prioritized ranking for the improvement phase.

**Table 5. Summary of the condition assessment**

| Site | BCI | | Severity Category | Main Problems |
|---|---|---|---|---|
| | NB/EB | SB/WB | | |
| **1** | 1.83 | - | High | Short height, Deflection, Poor end-treatment |
| **2** | 2.55 | 2.55 | Medium | Poor end-treatment |
| **3** | 2.60 | 2.58 | Medium | Poor end-treatment |
| **4** | 1.0 | 1.0 | High | There is no barrier, while it is warranted |
| **5** | 2.87 | 2.87 | Medium | There is no end-treatment |
| **6** | 1.54 | 1.64 | High | Short height, Deterioration, Posts failure, Poor end-treatment |

According to Table 5, site No. 4 with no existing barrier received the lowest BCI and would be listed as the first priority for the improvement among all the sites. Then, sites No. 6, and No. 1, with an average BCI of 1.59, and 1.83, respectively, were categorized as the sites with

high-severity damages. The rest of the sites had almost the same condition (good condition for the bridge barrier but a poor condition regarding their end-treatments). These sites were rated as medium-severity damage category. As another finding of the condition assessment, end-treatment was listed as the main problem in all the sites evaluated in this study.

**Table 6. Summary of the estimated improvement costs**

| Site | BCI | | Number of Crashes | Estimated Improvement Costs ($) [a] | Prioritized Ranking for the Improvement |
|---|---|---|---|---|---|
| | NB/EB | SB/WB | | | |
| **1** | 1.83 | - | 0 | 14,400 | 2 |
| **2** | 2.55 | 2.55 | 0 | 15,400 | 4 |
| **3** | 2.60 | 2.58 | 0 | 15,400 | 5 |
| **4** | 1.0 | 1.0 | 3 | 20,100 | 1 |
| **5** | 2.87 | 2.87 | 0 | 22,100 | 6 |
| **6** | 1.54 | 1.64 | - [b] | 33,800 | 3 |
| **TOTAL COSTS** | | | | **121,200** | |

a. Based on WYDOT website. Installation and mobilization costs are excluded.

b. No crash statistic was available at site No. 6

Based on Table 6, none of the sites studied in this project have had any crashes, but site No. 4 with three recorded crashes. These crashes were occurred at a distance of 700, 800, and 1200 ft away from site No. 4. Therefore, site No. 4 seems to be the highest priority for an improvement because of its crash history. Moreover, there is no barrier system at the site. Since the rest of the sites did not have any crash recorded, the benefits after the improvement phase were assumed to be the same in each damage-severity category (for example, the same benefits

will be received for improving any of the high-severity sites). Then, the prioritized ranking was provided comparing the improvement costs in each damage-severity level.

Regarding the cost estimation, a total budget of $121,200 is predicted for the materials to meet all the recommended improvements in the study. The cost of the installation and the mobilization should be investigated and added to this rate to predict an estimation regarding the whole improvement budget.

Note that no crash information was available for site No. 6 based on the data provided by Department of Transportation of WRIR for the study team in this report.

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# APPENDIX

# Part A- Barrier Condition Assessment Worksheets

2017

**ROAD BARRIER CONDITION ASSESSMENT**
WYOMING-WASHAKIE

Revised. 10/30/2017
By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Little Wind & Blue Cloud | X COORDINATE: | 42.96695 | BARRIER TYPE: | W-Beam | END SIZE (W*L): | 1*5 FT |
| SEGMENT #: | 1 | Y COORDINATE: | -108.49938 | POSTS TYPE: | Wood (No Blockout) | BRIDGE? | NO |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 205 FT | OFFSET FROM THE LANE: | 2 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | Wrong Treatment | RADIUS: | N/A |
| DIRECTION: | EB | ADT: | VEH/DAY | TANGENT OR FLARED? | Flared | SIDE THREAT: | Culvert-Sharp Slope |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | 21.0 | Inches | N/A | N/A | High |
| | Rigid Barrier | N/A | - | Inches | N/A | N/A | |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | 12.0 | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | 12.5 FT | 5.0 | Degree | 42.966870 | -108.499144 | Low |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | 25 FT | 11.0 | Inches | 42.966870 | -108.499144 | High |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condtion** | | | | | | | |
| Vertical Tear | W-Beam System | - | - | No. In a Panel | | | None |
| | W-Beam System | - | - | No. In a Panel | | | |
| | W-Beam System | - | - | No. In a Panel | | | |
| | W-Beam System | - | - | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | - | - | No. In a Panel | | | None |
| | W-Beam System | - | - | No. In a Panel | | | |
| | W-Beam System | - | - | No. In a Panel | | | |
| | W-Beam System | - | - | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | YES | Eng Judgement | 42.966930 | -108.499310 | High |
| | Any Type | | | Eng Judgement | | | |
| | Any Type | | | Eng Judgement | | | |
| | Any Type | | | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | YES | Eng Judgement | 42.966880 | -108.488170 | Low |
| | Any Type | | | Eng Judgement | | | |
| | Any Type | | | Eng Judgement | | | |
| | Any Type | | | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | YES | Eng Judgement | ALL | ALL | Med |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | 50.0 | 5.0 | Inches | 42.966870 | -108.499144 | Med |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.966950 | -108.499380 | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.966670 | -108.498650 | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |

2017

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised. 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Nothern Arapahoe Rd | X COORDINATE: | 42.98244 | BARRIER TYPE: | WY Two-Tube | SIZE (W*L): | 2*50 FT |
| SEGMENT #: | 2 | Y COORDINATE: | -108.51877 | POSTS TYPE: | Wood (No Blockout) | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 130 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | W-Beam Buried | RADIUS: | N/A |
| DIRECTION: | SB | ADT: | VEH/DAY | TANGENT OR FLARED? | Flared | SIDE THREAT: | River-Fixed Objects |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | 24.0 | Inches | N/A | N/A | High |
| | Rigid Barrier | N/A | 31.0 | Inches | N/A | N/A | None |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | 12.0 | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | - | Degree | | | None |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | | - | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condtion** | | | | | | | |
| Vertical Tear | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | 30.0 | YES | Eng Judgement | On the Bridge | On the Bridge | Low |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Failure (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | NO | Eng Judgement | | | None |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | None |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.981980 | -108.518870 | Med |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.98244 | -108.51877 | Med |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | 10 FT | YES | Eng Judgement | 42.982318 | -108.518769 | High |
| | | 20 FT | YES | Eng Judgement | 42.982214 | -108.518771 | High |

2017

## ROAD BARRIER CONDITION ASSESSMENT

WYOMING-WASHAKIE

Revised. 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Nothern Arapahoe Rd | X COORDINATE: | 42.98244 | BARRIER TYPE: | WY Two-Tube | SIZE (W*L): | 2*50 FT |
| SEGMENT #: | 2 | Y COORDINATE: | -108.51877 | POSTS TYPE: | Wood (No Blockout) | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 130 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | W-Beam Buried | RADIUS: | N/A |
| DIRECTION: | NB | ADT: | VEH/DAY | TANGENT OR FLARED? | Flared | SIDE THREAT: | River-Fixed Objects |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | 26.0 | Inches | N/A | N/A | High |
| | Rigid Barrier | N/A | 31.0 | Inches | N/A | N/A | None |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | 12.0 | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | - | Degree | | | None |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | | - | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condition** | | | | | | | |
| Vertical Tear | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | 30.0 | YES | Eng Judgement | On the Bridge | On the Bridge | Low |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Failure (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | NO | Eng Judgement | | | None |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | None |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.981980 | -108.518870 | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.98244 | -108.51877 | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | 20 FT | YES | Eng Judgement | 42.982220 | -108.518660 | Med |
| | | | | | | | |
| | | | | | | | |
| | | | | Eng Judgement | | | |

2017

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised. 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Little Wind Bottom Rd | X COORDINATE: | 42.97877 | BARRIER TYPE: | WY Two-Tube | SIZE (W*L): | 2*50 FT |
| SEGMENT #: | 3 | Y COORDINATE: | -108.55819 | POSTS TYPE: | Wood (No Blockout) | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 150 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | W-Beam Buried | RADIUS: | N/A |
| DIRECTION: | SB | ADT: | VEH/DAY | TANGENT OR FLARED? | Flared | SIDE THREAT: | River-Fixed Objects |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | 27.0 | Inches | N/A | N/A | High |
| | Rigid Barrier | N/A | 31.0 | Inches | N/A | N/A | None |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | 12.0 | Inches | N/A | N/A | None |
| | W-Beam System | 3 FT | 7.0 | Inches | 42.97876 | -108.55816 | Med |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | - | Degree | | | None |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | | - | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condtion** | | | | | | | |
| Vertical Tear | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | NO | Eng Judgement | | | None |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | None |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.978763 | -108.558165 | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.97845 | -108.55817 | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |

**2017**

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised. 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Little Wind Bottom Rd | X COORDINATE: | 42.97877 | BARRIER TYPE: | WY Two-Tube | SIZE (W"L): | 2"50 FT |
| SEGMENT #: | 3 | Y COORDINATE: | -108.55819 | POSTS TYPE: | Wood (No Blockout) | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 150 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | W-Beam Buried | RADIUS: | N/A |
| DIRECTION: | SB | ADT: | VEH/DAY | TANGENT OR FLARED? | Flared | SIDE THREAT: | River-Fixed Objects |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | 27.0 | Inches | N/A | N/A | High |
| | Rigid Barrier | N/A | 31.0 | Inches | N/A | N/A | None |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | 12.0 | Inches | N/A | N/A | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | - | Degree | | | None |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | | - | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condition** | | | | | | | |
| Vertical Tear | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | - | No. In a Panel | | | None |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| | W-Beam System | | - | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | NO | Eng Judgement | | | None |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | None |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.978763 | -108.558105 | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | 42.97845 | -108.55810 | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |

**2017**

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised. 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Shoyo Bridge | X COORDINATE: | 43.00029 | BARRIER TYPE: | WY Two-Tube | SIZE (W*L): | - |
| SEGMENT #: | 5 | Y COORDINATE: | -108.93799 | POSTS TYPE: | | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 60 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | - | RADIUS: | N/A |
| DIRECTION: | NB | ADT: | VEH/DAY | TANGENT OR FLARED? | - | SIDE THREAT: | River |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | - | Inches | N/A | N/A | |
| | Rigid Barrier | N/A | 40.0 | Inches | N/A | N/A | None |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | N/A | Degree | | | |
| | Cable & W-Beam | | N/A | Degree | | | |
| | Cable & W-Beam | | N/A | Degree | | | |
| | Cable & W-Beam | | N/A | Degree | | | |
| Lateral | W-Beam System | | N/A | Inches | | | |
| | W-Beam System | | N/A | Inches | | | |
| | W-Beam System | | N/A | Inches | | | |
| | W-Beam System | | N/A | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condition** | | | | | | | |
| Vertical Tear | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | - | Eng Judgement | | | None |
| | Cable & W-Beam | N/A | - | Eng Judgement | | | |
| | Cable & W-Beam | N/A | - | Eng Judgement | | | |
| | Cable & W-Beam | N/A | - | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | None |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | H=5" | YES | Eng Judgement | | | Low |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |

2017

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised: 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Shoyo Bridge | X COORDINATE: | 43.00029 | BARRIER TYPE: | WY Two-Tube | SIZE (W*L): | - |
| SEGMENT #: | 5 | Y COORDINATE: | -108.93799 | POSTS TYPE: | | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 60 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 65 MPH (No Sign) | END TREATMENT TYPES: | - | RADIUS: | N/A |
| DIRECTION: | SB | ADT: | VEH/DAY | TANGENT OR FLARED? | - | SIDE THREAT: | River |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | - | Inches | N/A | N/A | |
| | Rigid Barrier | N/A | 40.0 | Inches | N/A | N/A | None |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | N/A | N/A | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | N/A | Degree | | | None |
| | Cable & W-Beam | | N/A | Degree | | | |
| | Cable & W-Beam | | N/A | Degree | | | |
| | Cable & W-Beam | | N/A | Degree | | | |
| Lateral | W-Beam System | | N/A | Inches | | | None |
| | W-Beam System | | N/A | Inches | | | |
| | W-Beam System | | N/A | Inches | | | |
| | W-Beam System | | N/A | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condtion** | | | | | | | |
| Vertical Tear | W-Beam System | | N/A | No. In a Panel | | | None |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | N/A | No. In a Panel | | | None |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | - | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | - | Eng Judgement | | | None |
| | Cable & W-Beam | N/A | - | Eng Judgement | | | |
| | Cable & W-Beam | N/A | - | Eng Judgement | | | |
| | Cable & W-Beam | N/A | - | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | - | Inches | | | None |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | H=5" | YES | Eng Judgement | | | Low |
| | | | | Eng Judgement | | | |

2017

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised. 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Ft Washakie Bridge | X COORDINATE: | 43.00464 | BARRIER TYPE: | Steel Guardrail | SIZE (W*L): | - |
| SEGMENT #: | 6 | Y COORDINATE: | -108.89305 | POSTS TYPE: | Steel (No Blockout) | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 60 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 30 MPH | END TREATMENT TYPES: | - | RADIUS: | N/A |
| DIRECTION: | SB | ADT: | VEH/DAY | TANGENT OR FLARED? | - | SIDE THREAT: | River-Fixed Objects |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | - | Inches | N/A | N/A | |
| | Rigid Barrier | N/A | 21.0 | Inches | N/A | N/A | High |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | N/A | N/A | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | | - | Degree | | | None |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | | Degree | | | |
| Lateral | W-Beam System | | | Inches | | | None |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condtion** | | | | | | | |
| Vertical Tear | W-Beam System | | N/A | No. In a Panel | | | None |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | N/A | No. In a Panel | | | None |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | YES | Eng Judgement | | | High |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | NO | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | 2" | 1.0 | No. In a Panel | 43.004980 | -108.893360 | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | YES | Eng Judgement | | | High |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | 8.0 | Inches | | | High |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |

2017

# ROAD BARRIER CONDITION ASSESSMENT

## WYOMING-WASHAKIE

Revised: 10/30/2017

By Wyoming Technology Transfer Center (T2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATE ROUTE: | Ft Washakie Bridge | X COORDINATE: | 43.00464 | BARRIER TYPE: | Steel Guardrail | SIZE (W"L): | - |
| SEGMENT #: | 6 | Y COORDINATE: | -108.89305 | POSTS TYPE: | Steel (No Blockout) | BRIDGE? | Yes |
| SURVEY DATE: | 31/10/2017 | SEGMENT LENGTH: | 60 FT | OFFSET FROM THE LANE: | 1 FT | H CURVE? | NO |
| OBSERVER: | Bart & Amir | SPEED LIMIT: | 45 MPH | END TREATMENT TYPES: | - | RADIUS: | N/A |
| DIRECTION: | NB | ADT: | VEH/DAY | TANGENT OR FLARED? | - | SIDE THREAT: | River-Fixed Objects |

| | CATEGORY | LENGTH | VALUE | UNIT | GPS COORDINATE (X,Y) | | SEVERITY |
|---|---|---|---|---|---|---|---|
| **HEIGHT** | | | | | | | |
| From the Ground Level to the Top | Cable System | N/A | - | Inches | N/A | N/A | |
| | W-Beam System | N/A | - | Inches | N/A | N/A | |
| | Rigid Barrier | N/A | 21.0 | Inches | N/A | N/A | High |
| Height of Rail Cross-Section (Flattening & Crush) | W-Beam System | N/A | N/A | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | | | - | Inches | | | |
| **DEFLECTION** | | | | | | | |
| Vertical | Cable & W-Beam | 3 FT | 10.0 | Degree | 43.005010 | -108.893230 | Low |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| | Cable & W-Beam | | - | Degree | | | |
| Lateral | W-Beam System | 3 FT | 3.0 | Inches | 43.005010 | -108.893230 | Low |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| | W-Beam System | | - | Inches | | | |
| **Cable Sag** | | | | | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| | Cable System | N/A | N/A | Inches | | | |
| **Panels Condition** | | | | | | | |
| Vertical Tear | W-Beam System | | N/A | No. In a Panel | | | None |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Horizontal Tear (Add the height instead of length) | W-Beam System | | N/A | No. In a Panel | | | None |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| | W-Beam System | | N/A | No. In a Panel | | | |
| Deterioration (Any Rotted, Rusted, Damage?) | Any Type | | YES | Eng Judgement | | | High |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| Hardware (Any Missing Panel, Nuts, Bolts?) | Any Type | | NO | Eng Judgement | | | None |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| | Any Type | | - | Eng Judgement | | | |
| **Posts Condition** | | | | | | | |
| Separated From Guardrail | Cable & W-Beam | | - | No. In a Panel | | | None |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| | Cable & W-Beam | | - | No. In a Panel | | | |
| Post Condition (Any Missing/Broken, Damage?) | Cable & W-Beam | N/A | YES | Eng Judgement | | | High |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| | Cable & W-Beam | N/A | | Eng Judgement | | | |
| **Soil Erosion (Depth)** | | | | | | | |
| | Any Type | | 8.0 | Inches | | | High |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| | Any Type | | - | Inches | | | |
| **End-Terminal Condition** | | | | | | | |
| Loosing Cable (Slack) | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| Stub Height | Cable & W-Beam | N/A | N/A | Inches | | | |
| | Cable & W-Beam | N/A | N/A | Inches | | | |
| End-Post #1 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| End-Post #2 Condiiton (Any Damaged, Severly Cracked, Rotted?) | | N/A | YES | Eng Judgement | | | High |
| **Extra Points** | | | | | | | |
| Any Section is Candidate for Removal? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| Any Side Dozing is Required? | | | NO | Eng Judgement | | | None |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |
| | | | | Eng Judgement | | | |

# Part B- Photographs Taken During the Field Survey

## Site No. 1



GARMIN 10-31-2017 12:49:44 42.96688 -108.49920 0 MPH


GARMIN 10-31-2017 12:50:35 42.96567 -108.49865 0 MPH


GARMIN 10-31-2017 12:50:56 42.96665 -108.49866 0 MPH


GARMIN 10-31-2017 12:58:17 42.96686 -108.49913 0 MPH

# Site No. 2


GARMIN 10-31-2017 12:29:09 42.98207 -103.51875 0 MPH


GARMIN 10-31-2017 12:37:06 42.98217 -103.51366 0 MPH


GARMIN 10-31-2017 12:30:18 42.98237 -108.51865 0 MPH


GARMIN


GARMIN 10-31-2017 12:31:31 42.98223 -108.51875 0 MPH


GARMIN 10-31-2017 12:36:50 42.98223 -108.51867 0 MPH

# Site No. 3



GARMIN 10-31-2017 1:16:25 42.97876 -108.55807 0 MPH


GARMIN 10-31-2017 1:23:50 42.97855 -108.55303 0 MPH

# Site No. 4



GARMIN 10-31-2017 2:35:10 42.99910 -108.93216 0 MPH


GARMIN 10-31-2017 2:33:27 42.99903 -108.93215 0 MPH

# Site No. 5


GARMIN 10-31-2017 2:47:55 43.00029 -108.93799 0 MPH


GARMIN 10-31-2017 2:48:14 43.00036 -108.93798 0 MPH


GARMIN 10-31-2017 2:47:28 43.00028 -108.93799 0 MPH


GARMIN 10-31-2017 2:46:45
43.00054 -108.93802 0 MPH


GARMIN 10-31-2017 2:43:07 43.00045 -108.93794 0 MPH


GARMIN 10-31-2017 2:41:26 43.00048 -108.93793 0 MPH

# Site No. 6


SPEED LIMIT 45
GARMIN 10-31-2017 2:02:21 43.00464 -103.89305 0 MPH


GARMIN 10-31-2017 2:04:53 43.00494 -103.89331 0 MPH


GARMIN 10-31-2017 2:05:11 43.00501 -108.89335 1 MPH


GARMIN 10-31-2017 2:13:16 43.00518 -108.89338 0 MPH


GARMIN 10-31-2017 2:16:09 43.00502 -108.89308 0 MPH


GARMIN 10-31-2017 2:18:11 43.00502 -108.89333 0 MPH

# Part C- Barrier and End-Treatment Guidelines

## ROADSIDE BARRIERS GUIDELINE

### Flexible Systems

1- Three-Strand Cable Barrier

2- Weak-Post W-Beam Guardrail

3- Ironwood Aesthetic Guardrail

## Semi-Rigid Systems

1- Weak-Post Box Beam Guardrail

2- Steel-Post W-Beam Guardrail with Wood Blockouts

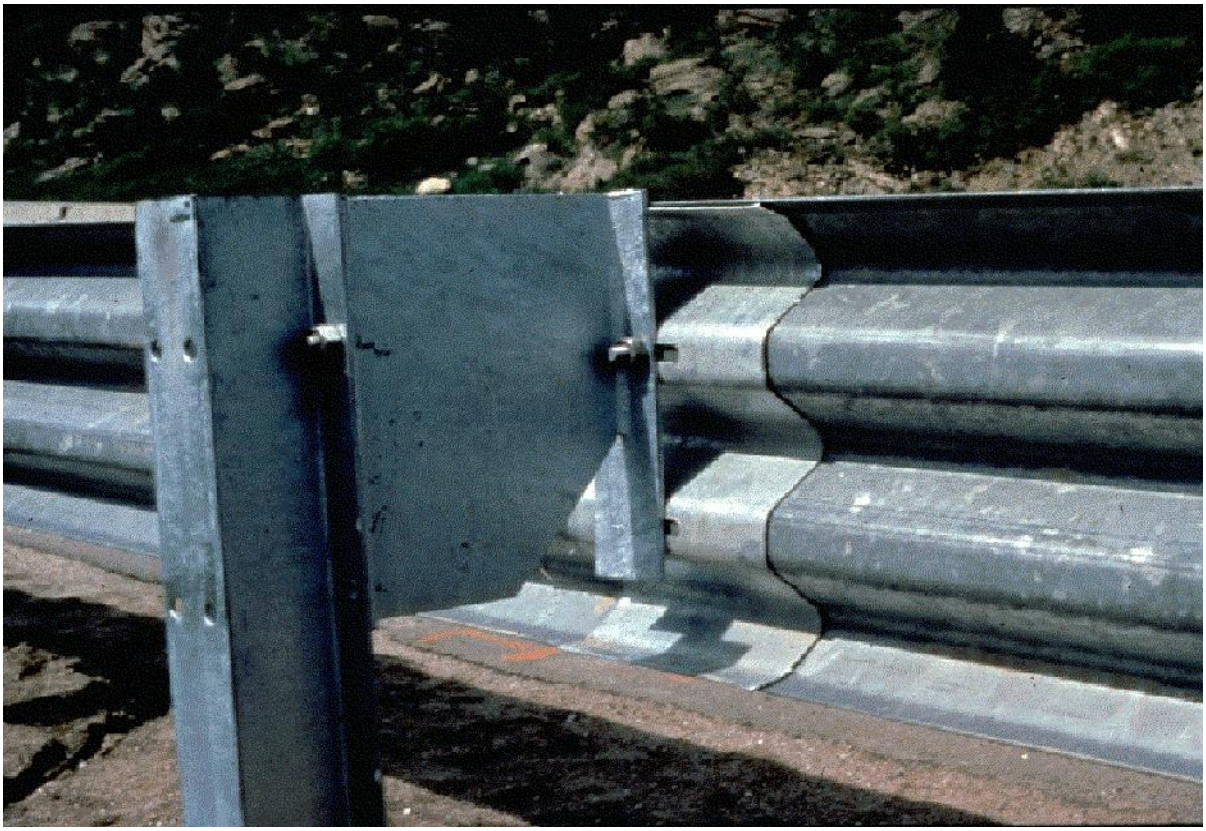
3- Midwest Guardrail System (MGS)

4- Gregory Mini Spacer

5- NU-GUARD-31 Guardrail System

6- Wood-Post Thrie-Beam Guardrail

7- Modified Thrie-Beam Guardrail



8- Trinity T-39 Guardrail System

9- Backed Timber Guardrail

# Rigid Systems

1- Low Profile Barrier

2- Constant Slope Barrier

# Other

1- CushionWall System

2- Stone Mansonry Wall

# END TREATMENT GUIDELINE

## Anchorages

1- Trailing End W-Beam Guardrail Anchorage

## Terminals

1- Three-Strand Cable Terminal

2- CASS Cable Terminal (CCT)

3- W-Beam Guardrail Anchored (Buried) in Backslope

4- Eccentric Loader Terminal (ELT)

5- Flared Energy-Absorbing Terminal (FLEAT)

6- Slotted Rail Terminal (SRT-350)


7- X-Tension Guardrail End Terminal

8- Extruder Terminal (ET-Plus)


9- Sequential Kinking Terminal (SKT-350)

10- Brakemaster 350

11- Crash Cushion Attenuating Terminal (CAT-350)

12- FLEAT Median Terminal (FLEAT-MT)


13- Wyoming Box-Beam End Terminal (WY-BET)

14- Bursting Energy Absorbing Terminal (BEAT)

## Crash Cushion

1- Bullnose Guardrail System

2- ABSORB 350 Crash Cushion

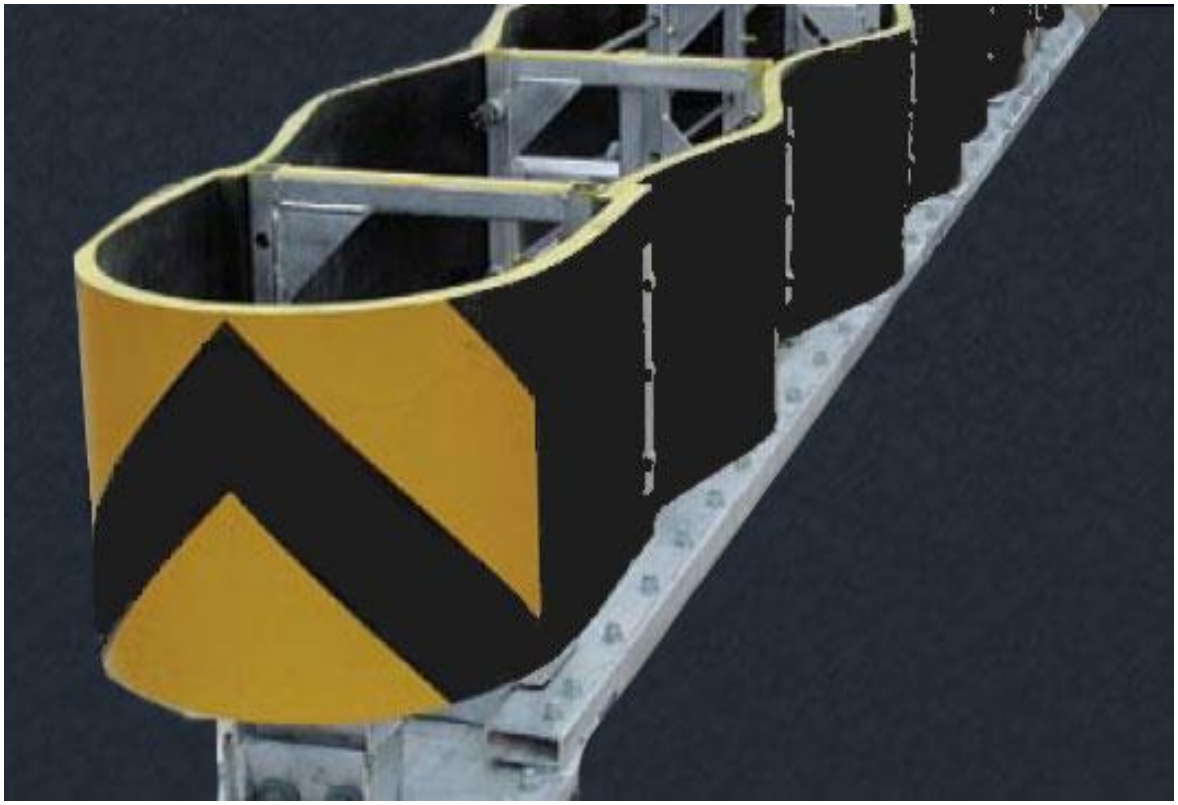

3- Advanced Dynamic Impact Extension Module (ADIEM)

4- Bursting Energy Absorbing Terminal-Single Sided Crash Cushion (BEAT-SSCC) System

5- QuadGuard Crash Cushion

6- TAU-2 Crash Cushion

7- Hybrid Energy Absorbing Reusable Terminal (HEART)



8- Smart Cushion Innovations (SCI-100GM) Crash Cushion


9- The Fitch Universal Barrel

10- Sloped Concrete End Treatment