BADLANDS NATIONAL PARK

SD PRA BADL 10(7) Dillon Pass

PAVEMENT REPORT
Report # 11-006

Pavements Report
September 2011

SIGNATURE SHEET

Report prepared by: ____________________
Steve Deppmeier, Pavements Engineer

Report reviewed by: ____________________
Joe Wilson, Materials Quality Assurance

Approved for distribution by: ____________________
Charles G Luedders, Division Pavements Engineer

September 8, 2011
Date

Distribution
Project Management
Project Development (3)
Construction (2)
CFLHD, Central Files
CFLHD, Report Room
Pavements (2)
Materials

TABLE OF CONTENTS

RECOMMENDED PAVEMENT TYPICAL STRUCTURAL SECTION

Route 10 (Dillon Pass) MP 23.0 to 26.5

Crack Seal
Pavement Patching (Type 1)
Double Chip Seal Designation 2C (first layer Grading C followed by D)
2 inches HACP placed in one lift

Route 204 Conata Road MP 0.0 to 1.6

Crack Seal
Pavement Patching (Type 2)
Double Chip Seal Designation 2C (first layer Grading C followed by D)
2 inches HACP placed in one lift

I. INTRODUCTION AND BACKGROUND

This report presents pavements recommendations for SD PRA BADL 10(7) Dillon Pass portion of the Badlands Loop Road in Badlands National Park. The report addresses recommendations, findings, analysis, and discussions regarding:

- Pavement alternatives
- Existing pavement and subgrade conditions
- Field investigations
- Laboratory analysis

The project covers a length of 3.48 miles of Badlands Loop Road, beginning just east of Conata Road at milepost 23.0 and extending northwest to milepost 26.4 just prior to the intersection with Sage Creek Rim Road. This report also includes a pavement recommendation for Conata Road, which is located off of Badlands Loop Road at milepost 23.76. Figure 1 on the next page provides a location map. The Dillon Pass portion of the project is shown as SD PRA BADL 10(7). The project portion for Conata Road is shown as Option X.

Badlands Loop Road is also known as SD State Route 240. Conata Road is also known as Pennington County Road 502, even though it is indicated as County Road 509 on the location map on the next page.

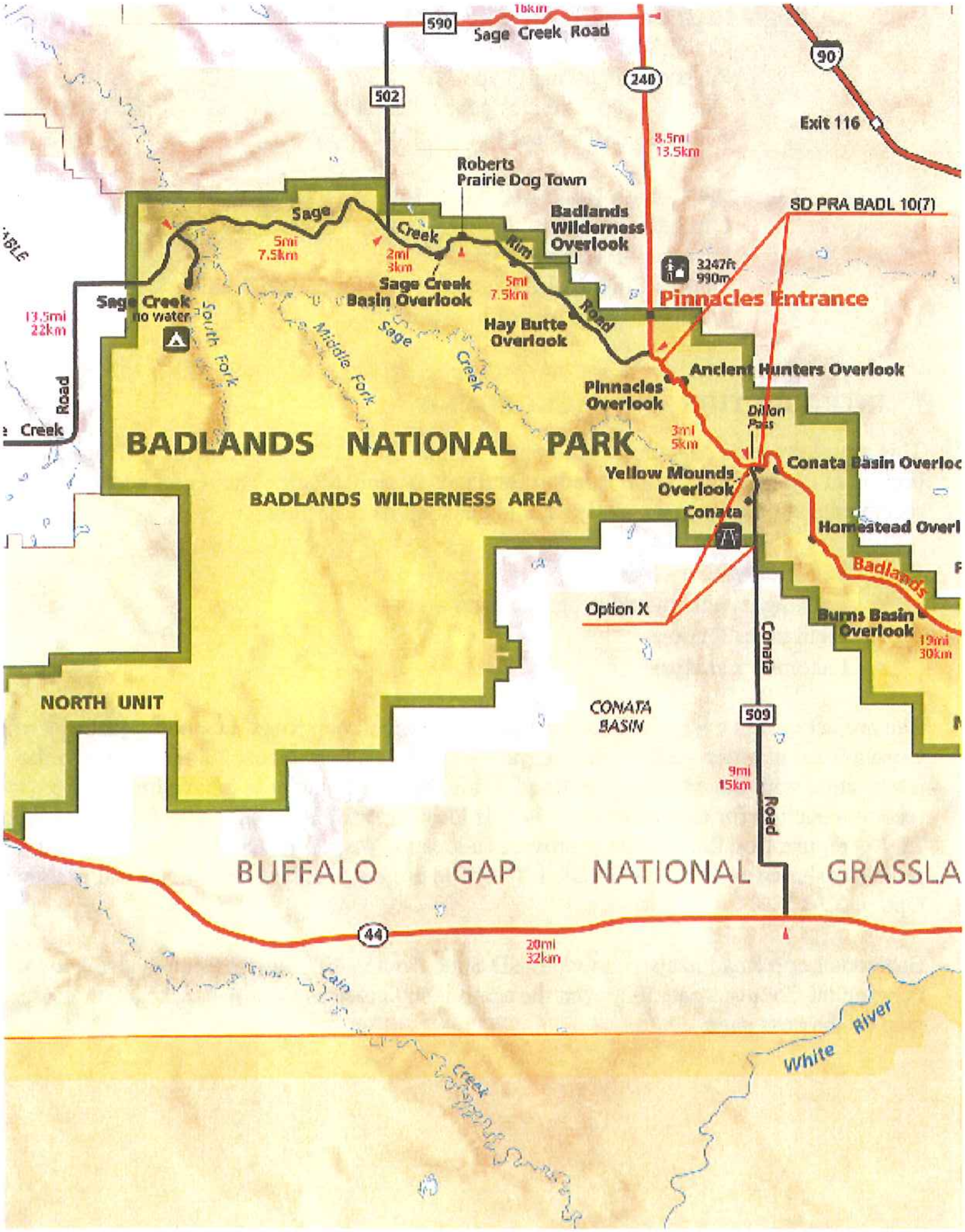


Figure 1: Location Map

Badlands Loop Road has been the subject of several investigations during the last 20 years by Central Federal Lands. The first is a 1993 Materials Investigation by Wayne Folkman, submitted as Report 93-12. It investigated three areas of Badlands Loop Road with Section 3 being the Dillon Pass area. This report contains pavement, base, subgrade classifications and R-Values for this section.

A follow-up report produced in 1999, again by Wayne Folkman, provided less detailed information, but covers the entire route including the Dillon Pass Area. It provides information on the pavement thickness, base depth and subgrade type. It also provides a pavement recommendation for the entire Badlands Loop Road.

The next report was produced in 2004 for the SD PRA BADL 10(5) project. It was prepared by Michelle Cline and K. N Gunalan of Parsons Brinckerhoff Quade and Douglas, Inc. This report covers the sections of Badlands Loop Road on both sides of Dillon Pass without investigating the Dillon Pass section. This report contains information on the pavement, base and subgrade to depths of six feet.

As indicated by the number of investigations on Badlands Loop Road, this roadway has continually been a concern for the Midwest Region of the National Park Service. The Plastic Indexes for the subgrade in the Dillon Pass Area from the 1993 report ranged from 26 to 56 with Liquid Limits ranging from 54 to 90. All of the R-values were less than 5.

II. EXISTING PAVEMENT AND SUBGRADE CONDITIONS

Badlands Loop Road

The existing roadway ranges from 26 to 28 feet in width with paved ditches and asphalt curbs at various locations. The existing asphalt pavement is highly distressed in areas of frost heave and roadway subsidence. These areas should be sub-excavated to restore the integrity of the roadway. The remainder of the roadway is in fair to good condition based on the latest results from the Route Inventory Program (RIP).

The RIP data provides information on the distresses that affect the pavement. The cracking distresses for all types of cracking are very low with transverse cracking being the predominant cracking type. The longitudinal and alligator cracking are localized and generally occur in the areas of frost heave and roadway subsidence. The rutting throughout this section falls in the fair range. The ride condition is in the fair to poor range with spikes in localized areas. Much of the detrimental ride is again caused by the frost heaves and the roadway subsidence.

The average pavement thickness in the Dillon Pass area is 6 ¼ inches with depths ranging from 6 inches to 7 inches. Underlying this pavement is a base material averaging 5 inches in depth

The 1993 and 1999 reports give the average thickness of the pavement as approximately 4 inches. Therefore, additional pavement of 2 inches and at least one chip seal have been placed in this area within the past 10 years.

Conata Road

Conata Road is generally 24 feet in width. It has a pavement approximately 1 ¼ inches in thickness, mostly made up of cold mixed material and chip seals. The base averages 4 inches in thickness.

Only the first half mile was investigated for this report, since that was thought to be the extent of the Project at the time of the boring. Badlands National Park has extended the pavement to the Park Boundary. This added mile of pavement has only been analyzed visually and with the RIP process. It consists of cold mixed material and is most likely approximately 2 inches in depth, similar to the first core location.

The RIP scoping report includes all of Conata Road. It indicates a pavement with little or no cracking. However, the rutting is in the fair to poor range with the ride in the poor range. Two pavement failures were noted, one in the first portion of Conata Road and one in the Yellow Mounds Overlook Pullout.

III. FIELD INVESTIGATIONS (2011)

Badlands Loop Road

On March 30, 2011, a drill crew from American Technical Services of Black Hawk, South Dakota was contracted to drill both the Badlands Loop Road and Conata Road. Drilling started on Conata Road and continued to Badlands Loop Road beginning at milepost 23 and continuing northwest to the end of the Project. Beau Williams of Central Federal Lands directed the sampling, took possession of the samples and logged the information from the borings. The weather was generally overcast and the ambient temperature at the start of the operation was 30 °F.

Pavement, base, and subgrade samples were collected for laboratory testing to determine R-Values, gradations, and soil classifications. Thirteen 1 foot deep cores were taken to determine the thicknesses of the pavement and base. Three of these locations were extended to 5 feet in depth to determine the quality of the subgrade. All boring hole locations were determined by FHWA and were chosen based off of visual areas of distress. The field investigation log for this site visit is in Table 2 in Appendix B at the back of this report.

Conata Road

Pavement, base, and subgrade samples were collected for laboratory testing to determine R-Values, gradations, and soil classifications. Three 1 foot deep cores were taken to determine the thicknesses of the pavement and base. The second location was extended to 5 feet in depth to determine the quality of the subgrade. All of these locations are within the first half mile of the Badlands Loop Road intersection since that was thought to be the project limits when the coring operation occurred. The field investigation log for Conata Road is in Table 2 in Appendix B at the back of this report. Additional photographs of the boring holes and soils found can also be found in Appendix E.

IV. TEST RESULTS

Badlands Loop Road

Samples were tested for soil classification and R-Values. Base course was collected from all of the core locations. Individual samples from core locations #2, #6 and #10 were analyzed for soil classification. The overall combined soil classification for the base is silty clay with a classification of A-2-4(0). The Plastic Index for this material is 9 with a Liquid Limit of 24. Material from all locations was combined for the R-value test. The R-value for the combined base material was 80. Another R-value test was performed using a combination of asphalt pavement and base material for full depth pulverization analysis. This combination consisted of 75% pavement and 25% base. The R-value for this combination was 79.

Three samples of the subgrade were collected and tested for soil classification and R-value. These samples represent the material found below the pavement from 1 to 5 feet in depth. These materials are all classified as A-7-6 soils or fat clay. The Plastic Index for these samples ranged from 50 to 119 with Liquid Limits ranging from 72 to 142. The R-values for all three samples were less than 5.

Conata Road

One sample of base and subgrade was taken from Conata Road at milepost 0.25. Both samples were tested for soil classification properties. There was not enough material collected to provide an R-value. The base material is a silty clay classified as an A-2-6 material. The Plastic Index for the material is 13 with a liquid limit of 37. This material is similar to the base material found on the Badlands Loop Road, so a similar R-value can be assumed for the base material.

The subgrade material sample represents the material found from 6 inches to 5 feet below the pavement. This material has a plastic index of 22 with a liquid limit of 36. It is lean clay with a soil classification of A-6. These properties are much better than the material found below the Badlands Loop Road, but not enough material was collected to run the R-value test.

V. PAVEMENT RECOMMENDATIONS & DISCUSSIONS

Badlands Loop Road

The average daily traffic for Badlands Loop Road was calculated by using park traffic data for the Pinnacles Entrance from 2006 through 2010. This provides an average daily traffic of 255 vehicles per day. This is actually below the 20 year average of 285 vehicles per day. Various values are available for the amount of heavy commercial traffic. These values range from 1% to 7% trucks. For the analysis for this project, we used 93% passenger cars, 0.5% buses, 4.5% recreational vehicles and 2.0% trucks. These values come from the Geotechnical Report for the previous Badlands Project SD PRA BADL 10(5) Project. A flat growth factor is being used as supported by the traffic counts from the National Park Service for the last twenty years.

The major concern with the pavement for this project is the quality of the subgrade. The subgrade soils consist of fat clays with high liquid limits and high plastic indexes. As shown above, the plastic index for this material is as high as 119. This material provides an unstable platform on which to build a roadway structure. The amount of this material makes it unreasonable to remove and replace all of the undesirable material. Therefore, the question is how best to build a pavement structure while using this unstable subgrade material. This becomes the overriding factor in selecting the most desirable option.

Option 1: Full Depth Recycle with Asphalt Pavement

HACP (3 inches) – Asphalt Pavement
FDR (8 inches) – Full Depth Recycle
Structural Number – 2.28 (2.23 required)
Grade Raise – 3 inches
Cost Estimate - $338,380 per mile

This is the least expensive option, but is also the option with the most risk. The advantages of this option are the simplicity of two main operations and the low cost. The disadvantages of this option are the grade raise of three inches and the risk inherent with the pulverizing option opening up the entire roadway and placing construction traffic onto the subgrade without a pavement structure. The risk of this option is further increased with the possibility of moisture getting into the subgrade. These scenarios could lead to a large overrun of subexcavation. The estimate above does not include any subexcavation.

Option 2: Pavement Repair and Overlay (Recommended)

HACP (2 inches) – Asphalt Pavement
Double Chip Seal – Stress Absorbing Membrane
Crack Sealing
Pavement Patching – Type 1 Pavement Patching
Structural Number – 3.28 (2.23 required)
Grade Raise – 2 inches
Cost Estimate – $542,180 per mile

This option makes the best use of the existing pavement structure. This option has the largest amount of patching, 9,536 square yards, to correct the heaving and subsidence areas. These areas are excavated for the placement of geogrid, base material and six inches of asphalt pavement. The use of the geogrid should reduce the heaving and subsidence by spreading the load across the base and subgrade. This option also has the highest structural number since all of the existing pavement remains in place. It has the lowest risk and should require the least amount of time to construct. The disadvantages of this option are the highest cost and the increase of two inches to the final roadway grade.

Option 3: Mill and Fill Overlay

HACP (2 inches) – Asphalt Pavement
Double Chip Seal – Stress Absorbing Membrane
Crack Sealing
Pavement Patching – Type 1 Pavement Patching
Milling (2 inches)
Structural Number – 2.48 (2.23 required)

Grade Raise – None
Cost Estimate – $522,120 per mile

This option requires the removal of two inches of the existing pavement. Since the milling will remove some of the roadway undulations, the patching for this option has been reduced to 1,000 square yards. These areas are excavated for the placement of geogrid, base material and six inches of asphalt pavement as in Option #2. The use of the geogrid should reduce the heaving and subsidence by spreading the load across the base and subgrade, but to a much lesser degree than Option #2, since the quantity is much smaller. Another advantage of this option has the roadway grade remaining the same. The disadvantages of this option are the high cost, removal and disposal of existing pavement and the possibility of overrunning the patching due to the reduction.

The recommended option is Option #2 with the pavement repair followed by the overlay. This option makes the highest use of the existing pavement, reduces the risk by the largest quantity of patching and geogrid placement and provides the highest structural number. It has nearly the same cost as Option #3, without the added risk due to the reduced patching. It also has much less risk than Option #1, which could end up being more expensive than either of the other two options, if major subexcavation comes into play, a very likely scenario with the poor quality of the subgrade.

Conata Road

No traffic counts for Conata Road are available, so the traffic loading was estimated for this roadway. It receives a small portion of the traffic that uses the Pinnacles Entrance on Badlands Loop Road. The traffic count for Badlands Loop Road is 255 ADT with a breakdown as follows: 93% passenger cars, 0.5% buses, 4.5% recreational vehicles and 2.0% trucks. We assumed that 20% of the cars and all of the trucks use Conata Road. This puts the estimated traffic for Conata Road at 50 ADT with 10% trucks. A flat growth factor will be used as supported by the traffic counts from the National Park Service for the last twenty years.

The major concern with the pavement for this project is the quality of the subgrade. Since no specific sample was tested from Conata Road, the same subgrade support factor as used for Badlands Loop Road will be used. Using this support factor for the design with the loading factor derived for the above traffic gives us a 1.95 structural number.

Option 1: Full Depth Recycle with Asphalt Pavement

HACP (3 inches) – Asphalt Pavement
FDR (6 inches) – Full Depth Recycle
Structural Number – 2.04 (1.95 required)
Grade Raise – 3 inches
Cost Estimate - $338,380 per mile

The advantages of this option are the simplicity of two main operations and the low cost. The disadvantages of this option are the grade raise of three inches and the risk inherent with the pulverizing option opening up the entire roadway and placing construction traffic onto the subgrade without a pavement structure. The risk of this option is further increased with the possibility of moisture getting into the subgrade. These scenarios could lead to a large overrun of subexcavation. The estimate above does not include any subexcavation.

Option 2: Pavement Repair and Overlay (Recommended)

HACP (2 inches) – Asphalt Overlay
Double Chip Seal – Stress Absorbing Membrane
Crack Sealing
Pavement Patching – Type 2 Pavement Patching
Structural Number – 1.98 (1.95 required)
Grade Raise – 2 inches
Cost Estimate – $268,180 per mile

This option makes the best use of the existing pavement structure. The roadway condition of Conata Road makes this a very viable option. There are two areas that will require minimal patching, most likely Type 2 patching. This option will raise the grade two inches, but with the current width and profile, this should be acceptable.

The recommended option is Option #2 with the pavement repair followed by the overlay. This option makes the highest use of the existing pavement and is the least expensive option. It also contains the least risk since the roadway won't be opened up for the possible intrusion of moisture. It also eliminates the risk of subexcavation quantities.

VII. MATERIALS RECOMMENDATIONS

Drainage, Subexcavation, and other Issues

The material in this area of the Badlands is very susceptible to erosion. This is evident with all of the erosion apparent where culverts have separated and ditches have degraded. The overlay strategy put forth in this report eliminates much of the risk associated with the infiltration of water. The use of geogrid and the stress absorbing membrane should reduce the reflective cracking of the surface and distribute the loading to reduce the heaving.

Selection of Asphalt Binder

LTTPBind software indicates use of PG 64-28 at 98% reliability.

Pavement Materials

- **30802-2000** - Roadway Aggregate, Method 2. Estimate at 139 lb/ ft^3.
- **40201-2300** - Hot Asphalt Concrete Pavement, Marshall Test, Class B, Grading C or E. The unit weight for can be estimated at 145.0 lb/ft^3. The asphalt cement should be a PG 64-28. Estimate at 6% by weight of mix. Straight edge roughness requirement.

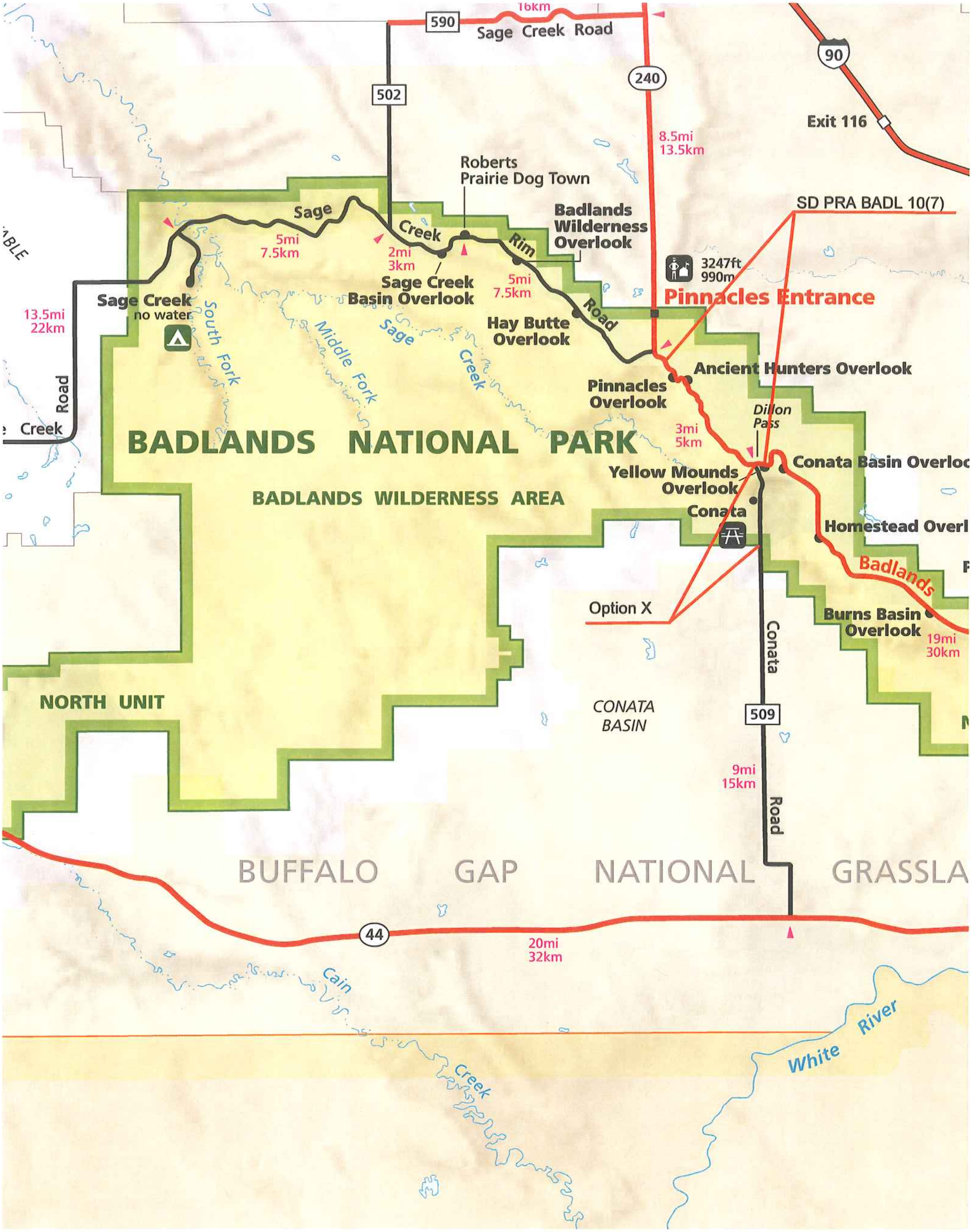
- **40205-3000** - Antistrip Additive, Type 3 (Hydrated Lime). Estimate at 1% by weight of mix.
- **40910-0800** - Surface Treatment, Designation 2C but include in the SCR to replace Aggregate Gradation B with C. Estimate Aggregate Gradation C at 35 lb/yd^2 and Grading D at 22 lb/yd^2.
- **40940-1300** - Emulsified Asphalt, Grade CRS-2P. Estimate the first application of emulsified asphalt at 0.44 gal/yd^2 and the second application at 0.52 gal/yd^2.
- **40920-1000** - Fog Seal, Emulsified Asphalt Grade CSS-1, CSS-1h, SS-1, SS-1h. Estimated at 0.10 gal/yd^2.
- **41201-1000** - Tack Coat Grade CSS-1, CSS-1h, SS-1, SS-1h is required between the chip seal and HACP. Estimated at 0.10 gal/yd^2.
- **41411-1000** - Crack, Cleaning and Sealing.
- **42801-0100** - Flexible Pavement, Full Depth Patch, Type 1. A separation fabric Type IV-F should be included with the geogrid as subsidiary to the pavement patching item.

APPENDIX A

LOCATION MAP

SD PRA BADL 10(7)

Badlands Loop Road



16km
590
Sage Creek Road
240
90
502
Exit 116
8.5mi
13.5km
Roberts
Prairie Dog Town
Badlands
Wilderness
Overlook
SD PRA BADL 10(7)
Sage
Creek
Rim
Road
5mi
7.5km
2mi
3km
Sage Creek
Basin Overlook
5mi
7.5km
3247ft
990m
Pinnacles Entrance
13.5mi
22km
Sage Creek
no water
South Fork
Middle Fork
Sage
Creek
Hay Butte
Overlook
Ancient Hunters Overlook
Pinnacles
Overlook
Dillon
Pass
Road
Creek
3mi
5km
BADLANDS NATIONAL PARK
Conata Basin Overloo
Yellow Mounds
Overlook
BADLANDS WILDERNESS AREA
Conata
Homestead Overl
Badlands
Option X
Burns Basin
Overlook
19mi
30km
Conata
NORTH UNIT
509
CONATA
BASIN
9mi
15km
Road
BUFFALO GAP NATIONAL GRASSLA
44
20mi
32km
Cain
Creek
White River

APPENDIX B

FIELD INVESTIGATION NOTES

SD PRA BADL 10(7)

Badlands Loop Road

SD PRA BADL 10(7) DILLON PASS

Bore No.	Mile Post	Lane	Offset from CL	Log	Notes
C #1	23.0	Right	5'	0 - 3" HACP 3" - 7.5" Base	3" old pavement, broken apart.
C #2	23.2	Left	4'	0 - 6" HACP 6" - 10" Base 10" - 52" Subgrade	
C #3	23.57	Right		0 - 6.5" HACP 6.5" - 11.5" Base	Surfacing has 4" overlay
C #4	24.00	Left	5'	0 - 6.5" HACP 6.5" - 10.5" Base	Surfacing has 3" overlay
C #5	24.37	Right	5'	0 - 6.5" HACP 6.5" - 11" Base	Surfacing has 3" overlay
C #6	24.60	Left	5'	0 - 6.5" HACP 6.5" - 11" Base 11" - 60" Subgrade	5" of dark, oiled gravelly sand Subgrade is gray, fat clay
C #7	25.00	Right	5'	0 - 7" HACP 7" - 12" Base	Surfacing has 4" overlay, older core portion fell apart.
C #8	25.20	Left	5'	0 - 7" HACP 7" - 12" Base	Surfacing has 3.5" overlay
C #9	25.40	Right	5'	0 - 7" HACP 7" - 12" Base	Surfacing has 3" overlay, broken apart.
C #10	25.80	Left	5'	0 - 6" HACP 6" - 11" Base 11" - 60" Subgrade	Subgrade is brpwn sandy clay

C #11	26.05	Right	5'	0 - 6" HACP 6" - 11" Base	
C #12	26.13	Left	5'	0 - 6.5" HACP 6.5" - 11" Base	Surfacing has 4.5" overlay
C #13	26.40	Right	5'	0 - 7" HACP 7" - 12" Base	

CONATA ROAD

Bore No.	Mile Post	Lane	Offset from CL	Log	Notes
CC #1	0.13	Left	5' Rt of CL	0 - 2" HACP (patch) 2" - 5" Base 5" - 11" Subgrade	2" of HACP - core on patch 3" of sandy gravel, brown 6" of gravelly clay, brown
CC #2	0.25	Right	4' Rt of CL	0 < 1" Chip Seal 1" - 3" Base 3" - 57"	<1" of chip seal material for surfacing 2" brown sandy gravel 4.75 ft heavy gray clay material
CC #3	0.37	Left	4'	0 < 1" Chip Seal 1" - 8" Base 8" - 12" Subgrade	<1" of chip seal material for surfacing 7" of gravelly sandy, light brown 4" of gravelly clay

APPENDIX C

LABORATORY TEST RESULTS

SD PRA BADL 10(7)

Badlands Loop Road

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

Report of Soil or Aggregate Tests

AASHTO R18 ISO/IEC 17025

Project: South Dakota PRA BADL 10(7) Dillon Pass – Badlands Loop Road
Submitted By: Beau Williams
Date Reported: 4/20/2011

Sample Number	Lab Number		11-213-RV	11-215-RV	11-217-RV		
	Mile Post		23.20	24.60	25.80		
	Hole Number		C#2	C#6	C#10		
	Field Number		Subgrade	Subgrade	Subgrade		
Sample Location	Location		Route 10				
	Offset		Left Lane	Left Lane	Left Lane		
	Depth	Feet	1-5	1-5	1-5		
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	1 1/2"	37.5 mm					
	1"	25.0 mm					
	3/4"	19.0 mm					
	1/2"	12.5 mm	100				
	3/8"	9.5 mm	99	100	100		
	#4	4.75 mm	96	99	98		
	#8	2.36 mm					
	#10	2.00 mm	91	96	94		
	#16	1.18 mm	89	95	92		
	#30	600 µm					
	#40	425 µm	89	90	86		
	#50	300 µm					
	#100	150 µm	77	86	82		
	#200	75 µm	74	85	79		
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		101	142	72		
	Plasticity Index		78	119	50		
Soil Classification	AASHTO M 145		A-7-6 (70)	A-7-6 (112)	A-7-6 (41)		
	ASTM D 2487		CH	CH	CH		
AASHTO T 190	R – Value		< 5	< 5	< 5		
AASHTO T 288	Min. Resistivity, ohm x cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Beau Williams
Materials	Mike Peabody

Remarks:

Reported By:

Darrell Harding
Laboratory Manager

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

AASHTO R18 ISO/IEC 17025

Report of Soil or Aggregate Tests

Project: South Dakota PRA BADL 10(7) Dillon Pass – Badlands Loop Road

Submitted By: Beau Williams

Date Reported: 4/20/2011

Sample Number	Lab Number		11-212-AGG	11-214-AGG	11-216-AGG		Combined
	Mile Post		23.20	24.60	25.80		
	Hole Number		C#2	C#6	C#10		
	Field Number		Base	Base	Base		Base
Sample Location	Location		Route 10				
	Offset		Left Lane	Left Lane	Left Lane		
	Depth	Inches	6-10	7-12	6-11		
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	1 1/2"	37.5 mm					
	1"	25.0 mm					
	3/4"	19.0 mm			100		
	1/2"	12.5 mm	100	100	99		100
	3/8"	9.5 mm	98	97	96		97
	#4	4.75 mm	88	84	83		85
	#8	2.36 mm	71	66	66		68
	#10	2.00 mm	68	62	63		64
	#16	1.18 mm					
	#30	600 µm	45	37	38		40
	#40	425 µm	38	30	31		33
	#50	300 µm	33	24	27		28
	#100	150 µm					
	#200	75 µm	23	16	16		18
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		29	24	21		24
	Plasticity Index		17	6	5		9
Soil Classification	AASHTO M 145		A-2-6 (1)	A-1-b (0)	A-1-b (0)		A-2-4 (0)
	ASTM D 2487		SC	SC-SM	SC-SM		SC
AASHTO T 190	R – Value						
AASHTO T 288	Min. Resistivity, ohm x cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Beau Williams
Materials	Mike Peabody

Remarks: The combined base course gradation is a mathematical blend of the three base samples.
The liquid limit and plasticity index are from testing the actual blend.

Reported By:

Darrell Harding
Laboratory Manager

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

Report of Soil or Aggregate Tests

AASHTO R18 ISO/IEC 17025

Project: South Dakota PRA BADL 10(7) Dillon Pass – Badlands Loop Road
Submitted By: Beau Williams
Date Reported: 4/20/2011

Sample Number	Lab Number		11-218-C	11-(212,214 & 216)-C		Combined HACP/Base 75 / 25	
	Hole Number		*	C #2, 4 & 10			
	Field Number			Base			
Sample Location	Station or Location		Route 10				
	Offset						
	Depth						
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	1 1/2"	37.5 mm					
	1"	25.0 mm	100			100	
	3/4"	19.0 mm	93			95	
	1/2"	12.5 mm	63	100		72	
	3/8"	9.5 mm	47	97		60	
	#4	4.75 mm	24	85		39	
	#8	2.36 mm	14	68		28	
	#10	2.00 mm	13	64		26	
	#16	1.18 mm					
	#30	600 µm	5	40		14	
	#40	425 µm	3	33		11	
	#50	300 µm	2	28		9	
	#100	150 µm					
	#200	75 µm	0.6	18		5.0	
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit			24			
	Plasticity Index			9			
Soil Classification	AASHTO M 145			A-2-4 (0)			
	ASTM D 2487			SC			
AASHTO T 190	R – Value		80			79	
AASHTO T 288	Min. Resistivity, ohm x cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Beau Williams
Materials	Mike Peabody

Remarks:
* C-1, 3, 4, 5, 7, 8, 9, 11, 12 & 13

The HACP gradation is the result of laboratory crushing 10 HACP cores and performing a dry sieve analysis.

Reported By:

Darrell Harding
Laboratory Manager

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

AASHTO R18 ISO/IEC 17025

Report of Soil or Aggregate Tests

Project: South Dakota PRA BADL 10(7) Dillon Pass – Badlands Loop Road
Submitted By: Beau Williams
Date Reported: 4/20/2011

Sample Number	Lab Number		11-210-AGG	11-211-S			
	Hole Number		CC#2	CC#2			
	Field Number		Base	Subgrade			
Sample Location	Station or Location		Conata Road – MP 0.25				
	Offset		Right Lane	Right Lane			
	Depth		1"-2"	6"-5'			
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm					
	1"	25.0 mm					
	3/4"	19.0 mm	100				
	1/2"	12.5 mm	96				
	3/8"	9.5 mm	88	100			
	#4	4.75 mm	69	98			
	#8	2.36 mm	55				
	#10	2.00 mm	53	93			
	#16	1.18 mm		91			
	#30	600 μm	41				
	#40	425 μm	38	86			
	#50	300 μm	34				
	#100	150 μm		80			
	#200	75 μm	26	70			
		20 μm					
		2 μm					
		1 μm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		27	36			
	Plasticity Index		13	22			
Soil Classification	AASHTO M 145		A-2-6 (0)	A-6 (13)			
	ASTM D 2487		SC	CL			
AASHTO T 190	R – Value						
AASHTO T 288	Min. Resistivity, ohm x cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:	Num. / Project File
Laboratory	Darrell Harding
Pavements	Beau Williams
Materials	Mike Peabody

Remarks:

Reported By:

Darrell Harding
Laboratory Manager

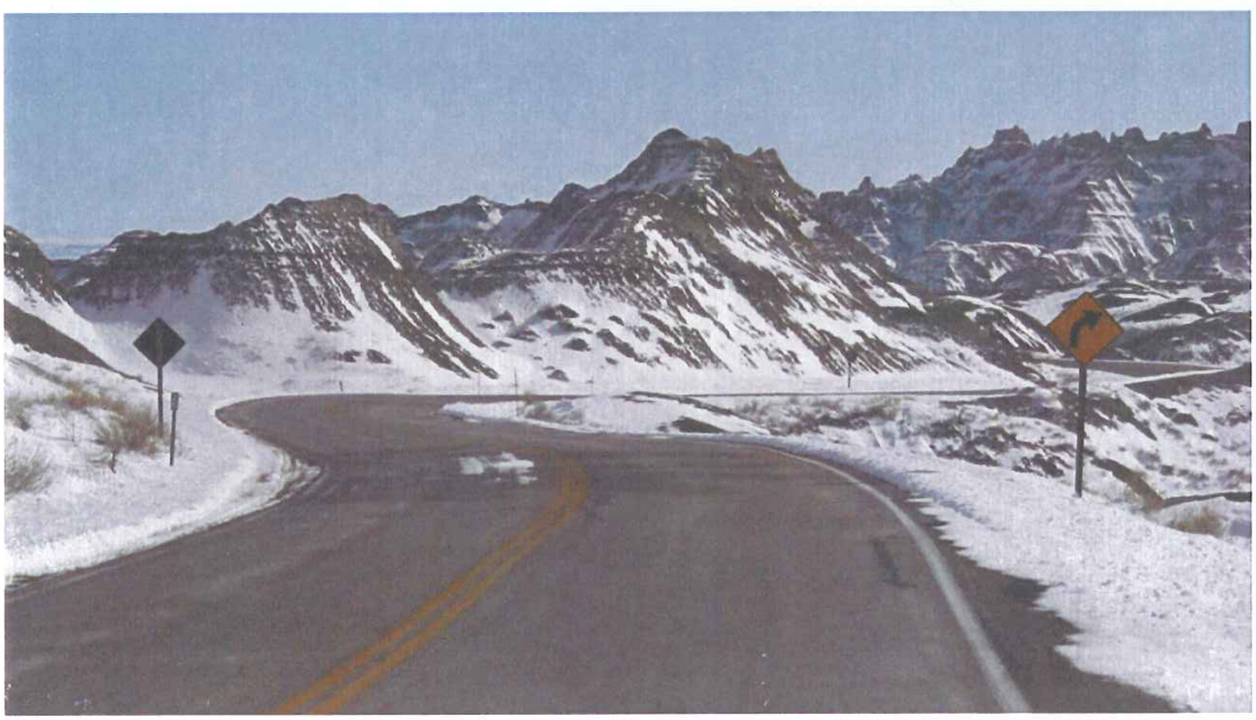
APPENDIX D

PHOTOGRAPHS
SD PRA BADL 10(7)
BADLANDS LOOP ROAD

Frost heave area on Badlands Loop Road.

Undulations affecting the ride on Badlands Loop Road.

Area of subsidence in the northbound lane near Ancient Hunters Pullout.



Frost heave area on Badlands Loop Road.

Pavement crack accepting roadway moisture.

Typical cracking of pavement on Badlands Loop Road.

APPENDIX E

PHOTOGRAPHS
SD PRA BADL 10(7)
CONATA ROAD

SD PRA BADL 10(7) CONATA ROAD

Cold mix pavement on Conata Road.

Cattleguard at south end of Conata Road.

APPENDIX F

PAVEMENT THICKNESS CHARTS

SD PRA BADL 10(7)

Badlands Loop Road

SD PRA BADL 10(7) DILLON PASS

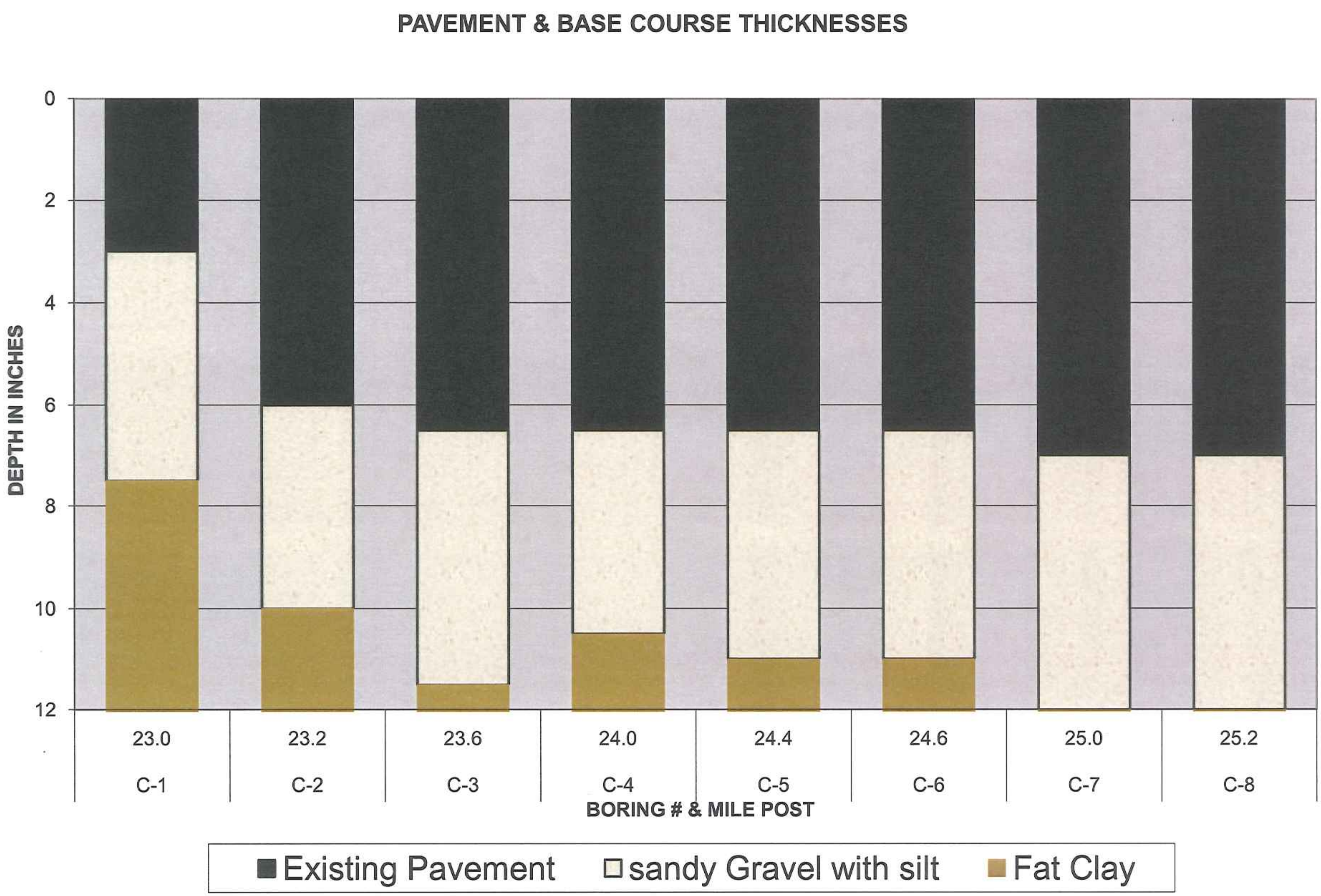


Chart 1

SD PRA BADL 10(7) DILLON PASS

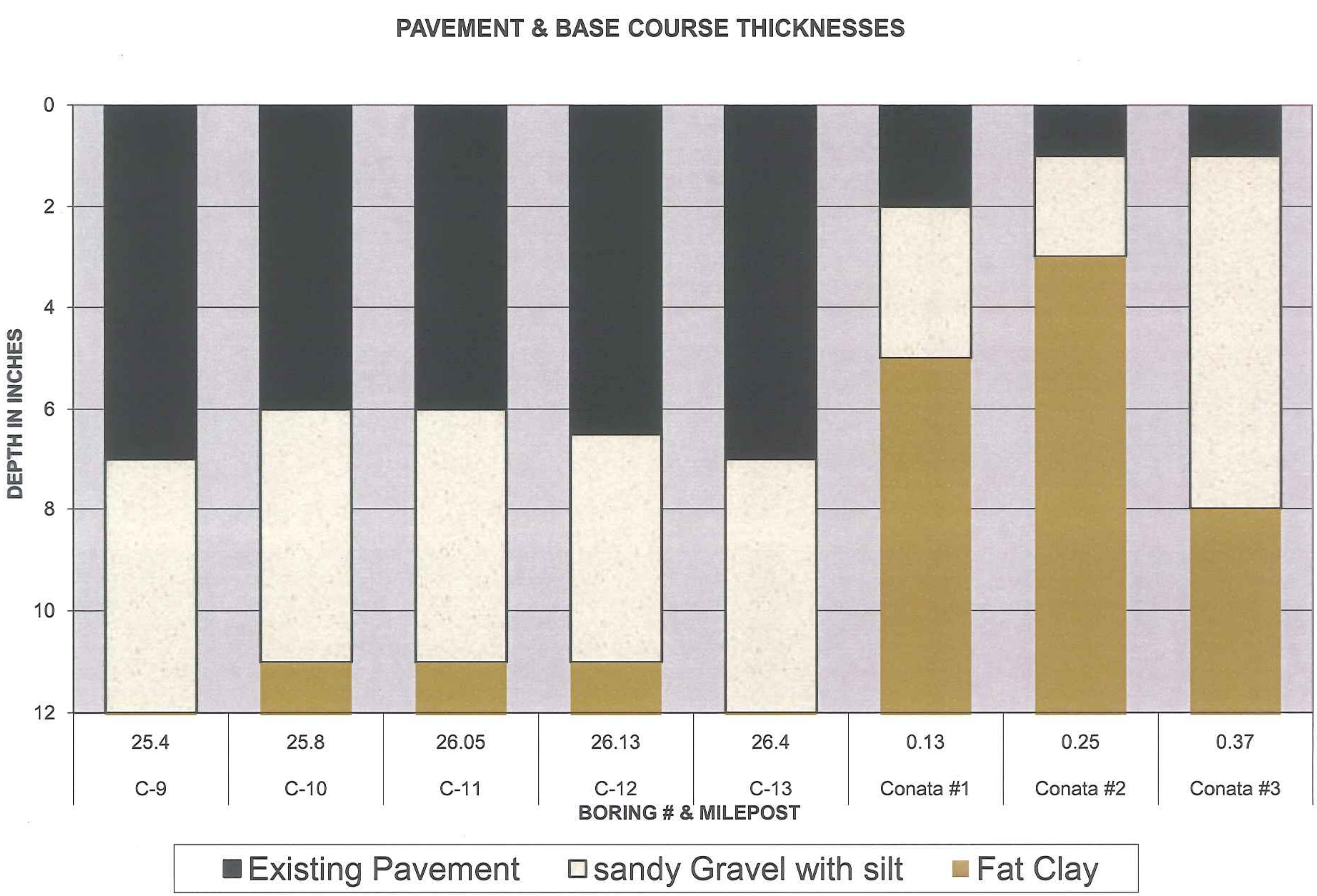


Chart 2

APPENDIX G

PAVEMENT DESIGN CALCULATIONS

SD PRA BADL 10(7)

Badlands Loop Road

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

Badlands - Dillon Pass portion of Badlands Loop Road

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.23 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	255
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	93	0	0.0004	0	416
3	0.5	0	0.88	0	4,918
5	4.5	0	0.2	0	10,059
6	2	0	1	0	22,353
Total	100	-	-	-	37,746

Growth	Simple
Total Calculated Cumulative ESALs	37,746

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	FDR	0.12	1	8	12	0.96
2	HACP	0.44	1	3	12	1.32
Total	-	-	-	11.00	-	2.28

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

Badlands - Dillon Pass (Mill and Fill)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.23 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	255
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	93	0	0.0004	0	416
3	0.5	0	0.88	0	4,918
5	4.5	0	0.2	0	10,059
6	2	0	1	0	22,353
Total	100	-	-	-	37,746

Growth	Simple
Total Calculated Cumulative ESALs	37,746

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Existing Base	0.08	1	5	12	0.40
2	Original Aspahlt Pavement	0.3	1	4	12	1.20
3	Recent Asphalt Overlay	0.4	1	2	12	0.80
4	Aspahlt Overlay	0.44	1	2	12	0.88
Total	-	-	-	13.00	-	3.28

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.23 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	255
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	93	0	0.0004	0	416
3	0.5	0	0.88	0	4,918
5	4.5	0	0.2	0	10,059
6	2	0	1	0	22,353
Total	100	-	-	-	37,746

Growth	Simple
Total Calculated Cumulative ESALs	37,746

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Existing Base	0.08	1	5	12	0.40
2	Original Asphalt	0.3	1	4	12	1.20
3	HACP - Asphalt Overlay	0.44	1	2	12	0.88
Total	-	-	-	11.00	-	2.48

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

Conata - Road (FDR Option)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	21,994
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	1.95 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	50
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	90	0	0.0004	0	79
6	10	0	1	0	21,915
Total	100	-	-	-	21,994

Growth	Simple
Total Calculated Cumulative ESALs	21,994

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	FDR	0.12	1	6	12	0.72
2	HACP - New	0.44	1	3	12	1.32
Total	-	-	-	9.00	-	2.04

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

Conata Road - Overlay Option

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	21,994
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	1.95 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	50
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	90	0	0.0004	0	79
6	10	0	1	0	21,915
Total	100	-	-	-	21,994

Growth	Simple
Total Calculated Cumulative ESALs	21,994

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Aggregate Base - Existing	0.1	1	3	12	0.30
2	Asphalt Pavement - Existing	0.4	1	2	12	0.80
3	HACP - New	0.44	1	2	12	0.88
Total	-	-	-	7.00	-	1.98

APPENDIX H

PRICE ESTIMATIONS AND ASSUMPTIONS

SD PRA BADL 10(7)

Badlands Loop Road

SD PRA 10(7) DILLON PASS
5/10/2011

		24' paved width			
MP	23.0	to	26.4		

Option Items	**inches convert to feet**				**feet in mile**		**width**		**unit weight**		**lbs to tons**		**tons**		**$ / ton**			
2" HACP	2	x	0.1667	x	5280	x	24	x	145.2	/	2000	=	1533	x $	120	= $	183,960	
Lime	1%												16	x $	200	= $	3,200	
															SUBTOTAL =		**187,160**	(10
4" HACP	4	x	0.3333	x	5280	x	24	x	145.2	/	2000	=	3067	x $	120	= $	368,040	
Lime	1%												31	x $	200	= $	6200	
															SUBTOTAL =		**374,240**	(14
7" FDR -Pulverize or pave removal	6		5280	x	24			=	14,080					x $	3.00	= $	**42,240**	(16
Minor Crushed Aggregate	6	x	0.5000	x	5280	x	24	x	139.0	/	2000	=	4405	x $	45	= $	**198,225**	(19
															$ / sq yd			
Prime	5280	x	24	x	0.1111	=	14,080	x	0.33 gal x 1 ton / 253 gal			=	19	x $	1200	= $	22,800	
Chip Seal 1st lift	5280	x	24	x	0.1111	=	14,080							x $	1	= $	14,080	
Chip Seal 2nd lift	5280	x	24	x	0.1111	=	14,080							x $	1	= $	14,080	
CRS-2P 1st lift	5280	x	24	x	0.1111	=	14,080	x	0.59 gal x 1 ton / 253 gal			=	33	x $	1000	= $	33,000	
CRS-2P 2nd lift	5280	x	24	x	0.1111	=	14,080	x	0.29 gal x 1 ton / 253 gal			=	17	x $	1000	= $	17,000	
															SUBTOTAL =		**100,960**	(28
					sq ft to sq yds													
Tack	5280	x	24	x	0.1111	=	14,080	x	0.1 gal x 1 ton / 241 gal			=	6	x $	850	= $	5100	
Fog	5280	x	24	x	0.1111	=	14,080	x	0.1 gal x 1 ton / 241 gal			=	6	x $	850	= $	5100	
															SUBTOTAL =		**10,200**	(33
Prime	5280	x	24	x	0.1111	=	14,080	x	0.33 gal x 1 ton / 253 gal			=	19	x $	1200	= $	22,800	
Blotter	5280	x	24	x	0.1111	=	14,080	x	14.75 lb x 1 ton / 2000 lb			=	104	x $	60	= $	6240	
															SUBTOTAL =		**29,040**	(37
Mill 3/4 inches							14,080								1.50		21,120	
Mill 1 inches							3520								2.00		7,040	
Crack Sealing															3000		3,000	
Patching Type 1													150		150		22,500	
Patching Type 2													450		125		56,250	
Wedge & Level	1	x	0.0833	x	1320	x	24	x	145.2	/	2000	=	200	x $	200	= $	40,000	
															SUBTOTAL =		**149,910**	(45

Rte 10 Typical 20-Year Design	4" hacp + 7" fdr - pulverize (14 + (16 + (33 + (37 374,240 + 42,240 + 10,200 + 29,040 =	**$**	**455,720**	per mile
Rte 10 Mill & Fill	2" hacp + milling + wedge & level + double chip (10 + (28 + (33 + (45 187,160 + 100,960 + 10,200 + 149,910 =	**$**	**448,230**	per mile
Rte 204 Typical 20-Year Design	4" hacp + 6" Minor Crushed Aggregate (14 + (16 + (19 + (33 + (37 = 374,240 + 42,240 + 198,225 + 10,200 + 29,040 =	**$**	**653,945**	per mile
Rte 204 8 to 12 Year Design	double chip + 6" minor crushed aggregate (16 + (19 + (28 + (33 + (37 = 42,240 + 198,225 + 100,960 + 10,200 + 29,040 =	**$**	**380,665**	per mile
Rte 204 Gravel Road 5-Year Design	6" minor crushed aggregate + pavement removal (16 + (19 + (37 = 42,240 + 198,225 + 29,040 =	**$**	**269,505**	per mile

SD PRA 10(7) DILLON PASS
5/10/2011

	24' paved width		
Dillon Pass MP	23.0	to	26.4
Conata Rd MP	0.0	to	0.6

Rte 10	4" hacp + 7" fdr - pulverize			
Typical	(14 + (16 + (33 + (37			
20-Year Design	374,240 + 42,240 + 10,200 + 29,040 =	**$**	**455,720**	per mile
Rte 10	2" hacp + milling + wedge & level + double chip			
Mill & Fill	(10 + (28 + (33 + (45			
	187,160 + 100,960 + 10,200 + 149,910 =	**$**	**448,230**	per mile
Rte 204	4" hacp + 6" Minor Crushed Aggregate			
Typical	(14 + (16 + (19 + (33 + (37 =			
20-Year Design	374,240 + 42,240 + 198,225 + 10,200 + 29,040 =	**$**	**653,945**	per mile
Rte 204	double chip + 6" minor crushed aggregate			
8 to 12 Year	(16 + (19 + (28 + (33 + (37 =			
Design	42,240 + 198,225 + 100,960 + 10,200 + 29,040 =	**$**	**380,665**	per mile
Rte 204	6" minor crushed aggregate + pavement removal			
Gravel Road	(16 + (19 + (37 =			
5-Year Design	42,240 + 198,225 + 29,040 =	**$**	**269,505**	per mile

APPENDIX I

PRELIMINARY PAVEMENTS MEMORANDUM

SD PRA BADL 10(7)

Badlands Loop Road

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **SD PRA BADL 10(7) DILLON PASS PAVEMENT RECOMMENDATION**

Date: July 7, 2011

From: Steve Deppmeier, Pavements Engineer

To: Mike Will, PM
Dave Balding, COE
Jill Mathewson, Designer

A pavement investigation for the above referenced project from project limits of MP 23 to 26.4 of Badlands Loop Road and MP 0.0 to 0.6 of Conata Road occurred on March 30, 2011 with Beau Williams logging the borings and collecting the samples.

Route 10, Badlands Loop Road MP 23.0 to MP 26.4, Dillon Pass Area

For the portion of Route 10 within the project limits, the average pavement thickness was 6.25 inches, with 3 inches of original pavement and 3.5 inches of overlay. The base course averaged 5 inches and consisted of material with a soil classification of A-2-4. The subgrade soil classification was A-7-6 with R-Values <5 and some of the highest plasticity indexes the Central Lab has seen.

The traffic inputs from SD PRA BADL 10(5) Badlands Loop Road were used. These inputs include 2% growth factor, ADT of 316 for 2012, and assumed the following factors:

	ADT	ESAL Factor
Passenger vehicles	93%	0.0004
Bus	1%	0.88
Recreational vehicle	4%	0.2
Single Unit Truck	2%	1.5

If updated traffic information becomes available, the Pavement Section should be contacted to review the new data.

From the above information the following is the **recommended pavement structural section**:

Route 10 MP 23 to 26.4
Crack Seal
Double Chip Seal Designation 2C (first layer Grading C followed by D)
2 inches HACP placed in one lift
Pavement Roughness 402.16(e) Straightedge Measurement

The double chip seal will aid in retarding reflective cracking, but it will not eliminate reflective cracking indefinitely.

A typical 3R rehabilitation method of 4 inches HACP on 7 inches of FDR – Pulverization was evaluated and not recommended due to the watering & compaction effort needed for 7 inches of depth. The subgrade is extremely poor and by opening up the roadway surfacing, we risk encountering subexcavation that will continue to grow.

Include quantities for Type 1 pavement patching, which is 12 inches deep removal, placement of a geogrid, 6 inches of aggregate base followed by 6 inches of HACP. A separation fabric Type IV-F should be included with the geogrid as subsidiary to the pavement patching item.

Route 204 Conata Road

Conata Road, Route 204, consists mainly of blade laid pavement over aggregate base. The aggregate base course averaged 3 inches in depth and the soil classification was A-2-6. Subgrade soil classification was A-6.

From the 70% field review, the CFT agreed to the following:

Route 204 Conata Road MP 0.0 to 1.6:
Crack Seal
Double Chip Seal Designation 2C (first layer Grading C followed by D)
2 inches HACP placed in one lift
Pavement Roughness 402.16(e) Straightedge Measurement

Pavement Materials for both Routes

- **40201-2300** Hot Asphalt Concrete Pavement, Marshall Test, Class B, Grading C or E. The unit weight for can be estimated at 145.0 lb/ft^3. The asphalt cement should be a PG 64-28. Estimate at 6% by weight of mix.
- **40205-3000** Antistrip Additive, Type 3 (Hydrated Lime). Estimate at 1% by weight of mix.
- **40910-0800** Surface Treatment, Designation 2C but include in the SCR to replace Aggregate Gradation B with C. Estimate Aggregate Gradation C at 35 lb/yd^2 and Grading D at 22 lb/yd^2.
- **40940-1300** Emulsified Asphalt, Grade CRS-2P. Estimate the first application of emulsified asphalt at 0.44 gal/yd^2 and the second application at 0.52 gal/yd^2.
- **40920-1000** Fog Seal, Emulsified Asphalt Grade CSS-1, CSS-1h, SS-1, SS-1h. Estimated at 0.10 gal/yd^2.
- **41201-1000** Tack Coat Grade CSS-1, CSS-1h, SS-1, SS-1h is required between the chip seal and HACP. Estimated at 0.10 gal/yd^2.
- **41411-1000** Crack, Cleaning and Sealing.

- **42801-0100** Flexible Pavement, Full Depth Patch, Type 1. A separation fabric Type IV-F should be included with the geogrid as subsidiary to the pavement patching item.

CC: Chuck Luedders, Pavements Division Engineer
Ron Andresen, Staff Materials Engineer
Joe Wilson, Associate Materials Engineer
Project Files

APPENDIX J

ROUTE INVENTORY PROGRAM SCOPING REPORT

SD PRA BADL 10(7)

Badlands Loop Road

Supplemental Pavement Condition Data and Analysis for Scoping of

Project PRA-BADL 10(7)

National Park Service
Badlands National Park
Pennington County, Tennessee

Federal Lands Highway
March, 2011

Badlands National Park

BADL 10(1), 204(1), 208(1), 920(1), & 921(1)

Pavement Information for Project Scoping and
Reconnaissance Needs

General Project Information

Project Length: Route 10 – MP 22.98 – 26.42, Average Roadway Width 27.3 feet
Route 204 – MP 0.0 – 1.0, Average Roadway Width 24.5 feet
Route 208 – MP 0.0 – 0.21, Average Roadway Width 21.7 feet
Route 920 – 11592 ft^2 Parking Area
Route 921 – 8843 ft^2 Parking Area
Route Numbers and Milepost/Area based on RIP Cycle 4 Report

Programmed Funding: $5M

Traffic: Route 10 Loop Road
Service to approximately 1.3 million visitors/year
Seasonal Services is approximately 8000 visitors/day

Year Programmed: 2012

Pavement Costs (based on HPMA data): $2,063,165

Reconnaissance Needs

1. Evaluate performance of previous rehabilitation projects. Determine if pavement treatment will provide necessary restoration for Preventive Maintenance and Light 3R treatments.

2. Determine if expected life-cycles of previous projects are being met, or if alternative methods may be more cost effective.

3. Determine significance of drainage issues of the roadway. Has the pavement experienced ponding of water? Does the pavement and shoulders show signs of moisture related distress?

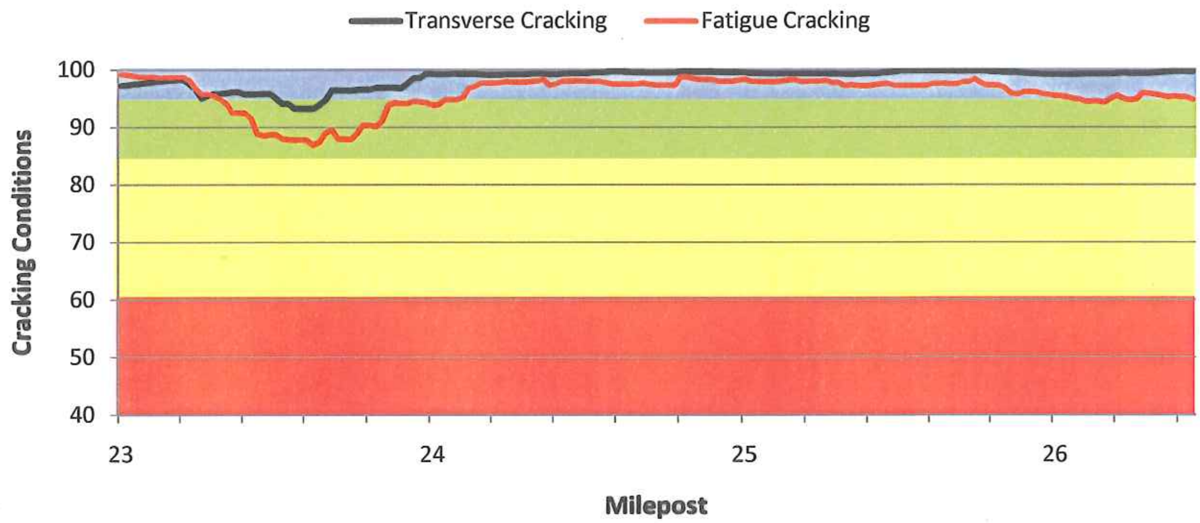
4. Determine amount, if any, of side slope failure and if any wash out related accidents have been reported.

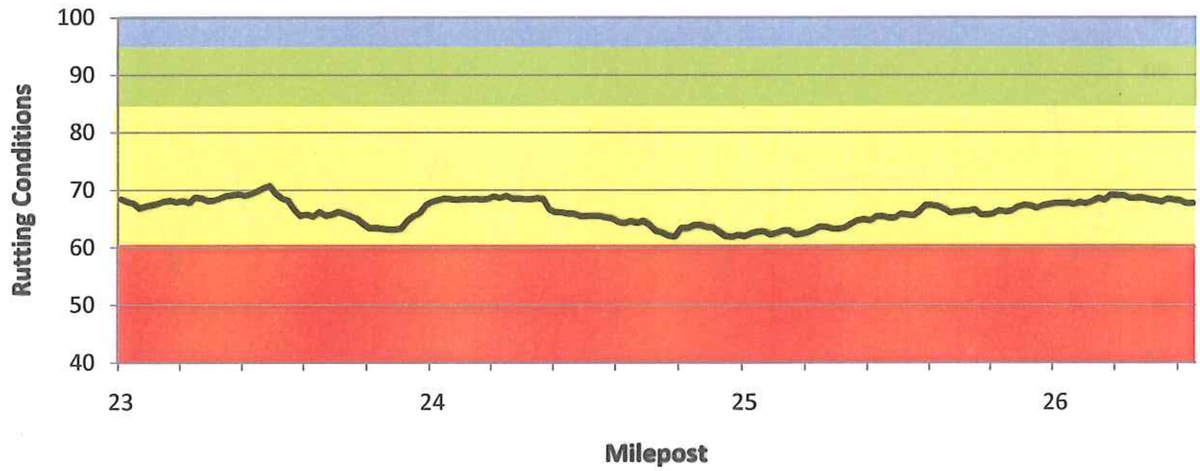
5. Determine if recommended fix for corrective road roughness or ride quality is a feasible and economic alternative for the age of the pavement.

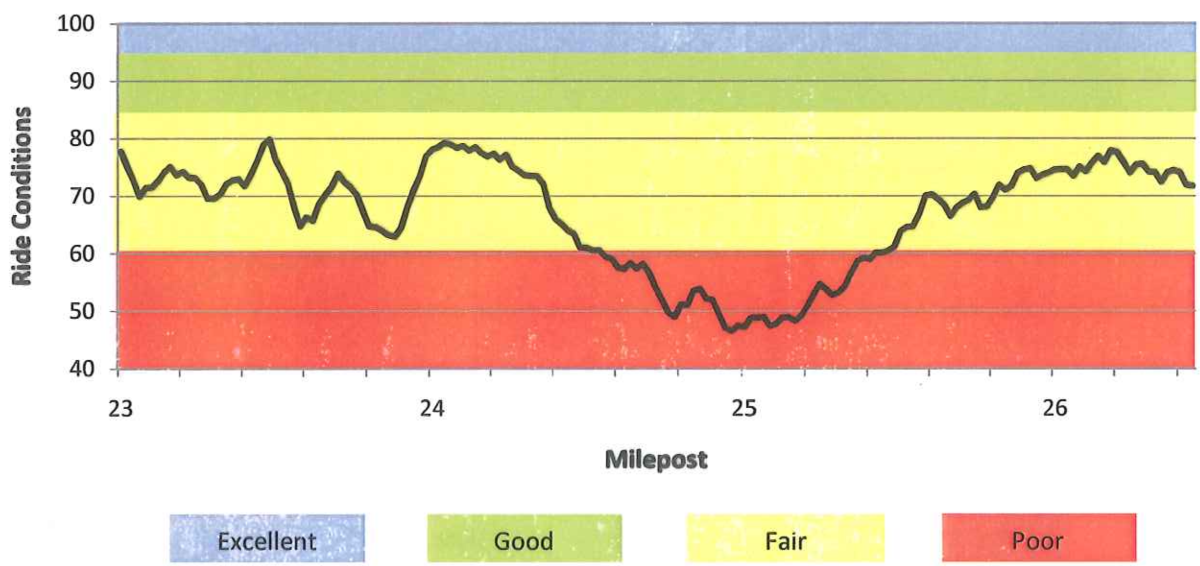
Project Summary / Description

The project will consist of rehabilitating approximately 3.4 miles of the Badlands Loop Road at Dillon Pass in Badlands National Park. The rehabilitation will include full depth reclamation or pulverizing of the existing 3.4 miles of asphalt roadway including roadside pullouts and parking areas, resurfacing with a new asphalt concrete pavement, potentially improving two parking areas with new curbing and sidewalk, replacing or cleaning culverts and drop inlets where deficiencies exist, replacing or adding culvert rundowns to reduce roadside erosion, and rehabilitating roadside ditches as necessary. Additionally, Conata Road, beginning at its intersection with the Badlands Loop Road and extending approximately 1.0 mile to the South, including parking areas, will be designed for rehabilitation to the 30% level of development as a part of the Badlands Loop Road – Dillon Pass project.

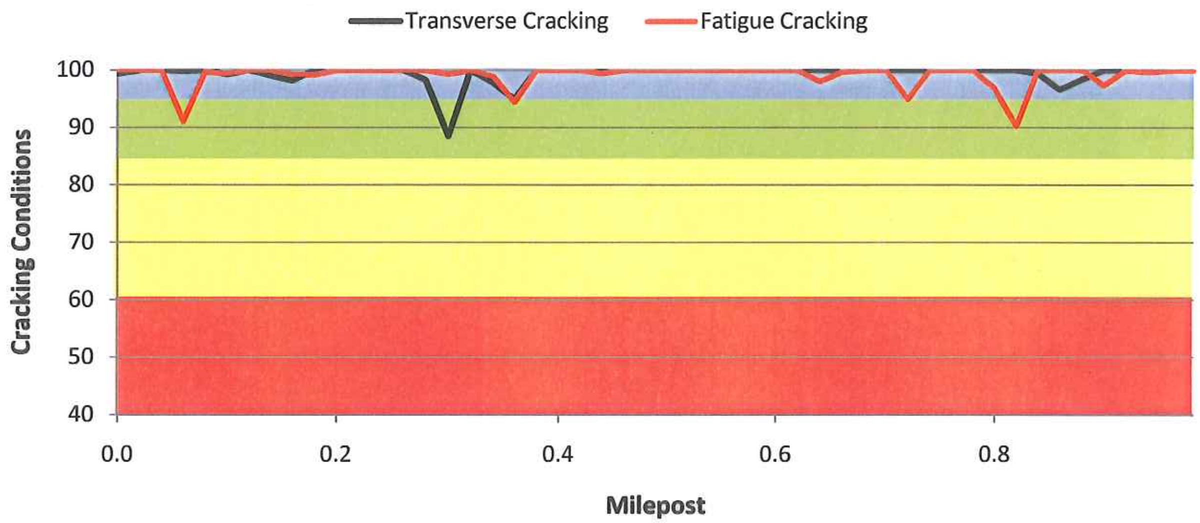
BADL-0010 Pavement Conditions from 2008 Cycle 4 RIP Survey
Badlands Loop Road MP 22.98 to 26.42

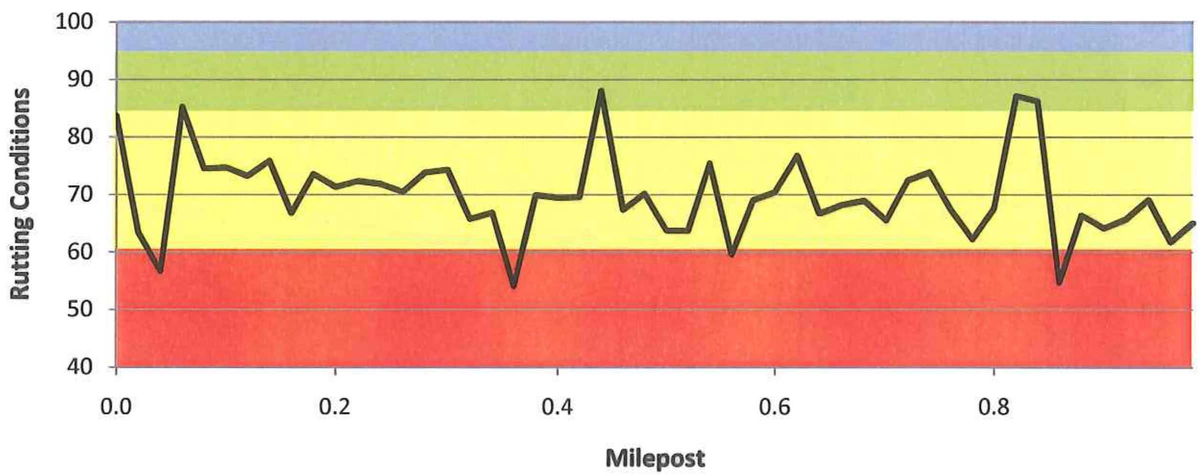


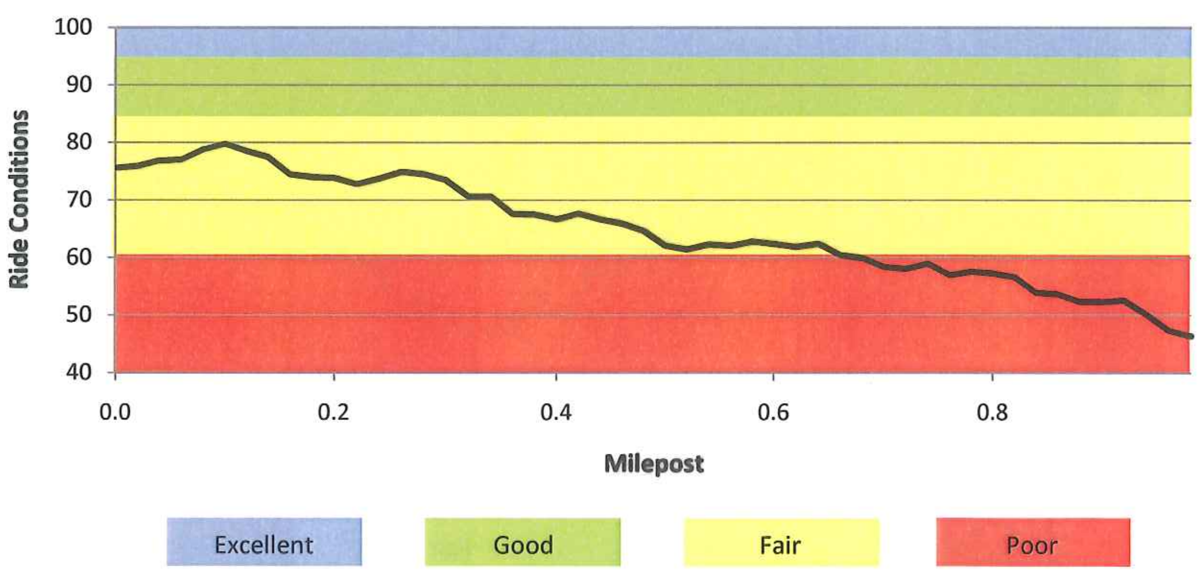




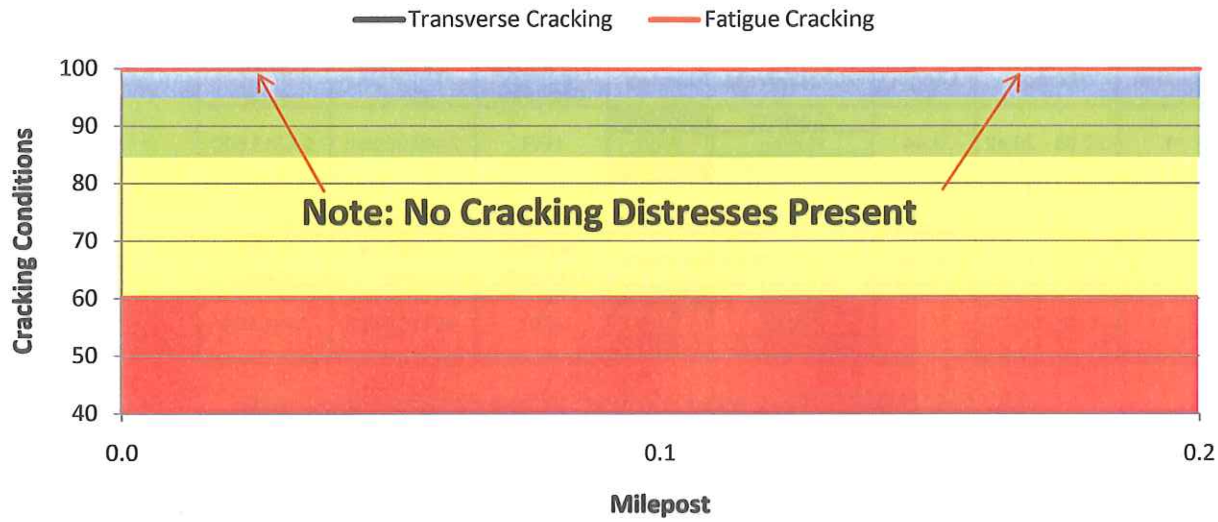
BADL-0204 Pavement Conditions from 2008 Cycle 4 RIP Survey
Conata Road

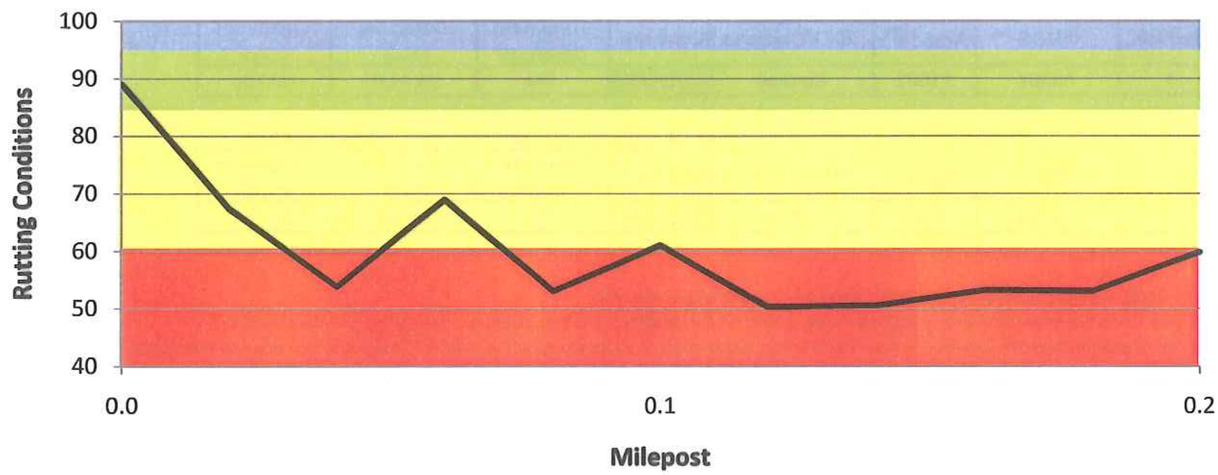


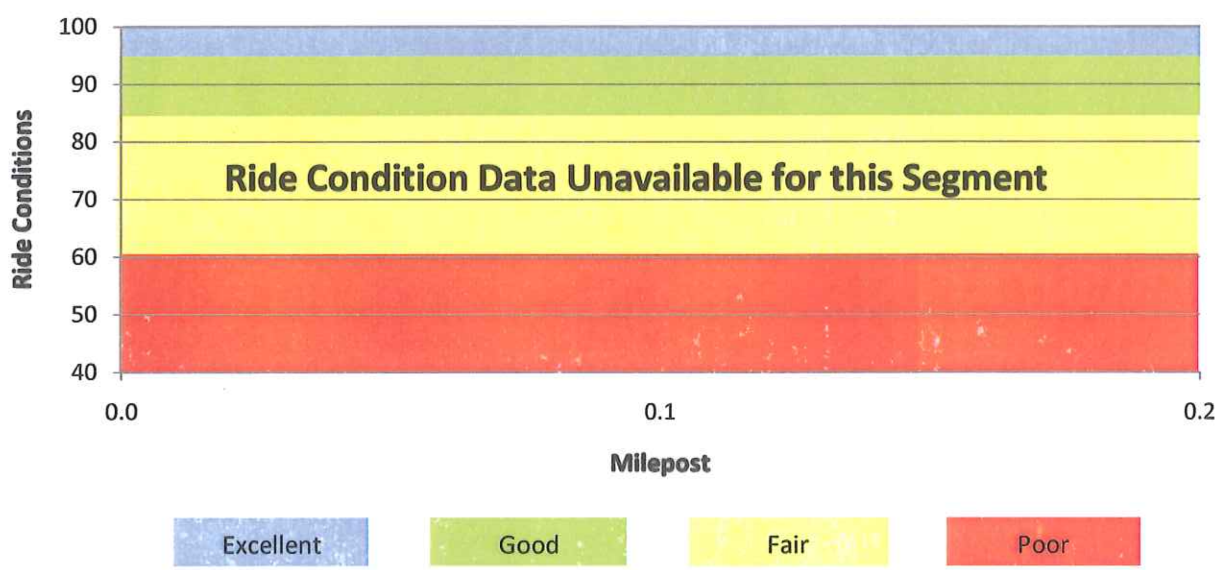




BADL-0208 Pavement Conditions from 2008 Cycle 4 RIP Survey
Conata Picnic Road







Badlands National Park - PMIS 86786

ROUTE 10 FMSS# 43372 - Badlands Loop Road - Sections and Rehabilitation Strategy

Section	Milepost	Length	2012 Distress Summary		Treatment Category	Category Cost*	Treatment Cost*
1	22.98 - 26.42	3.44	Cracking	GOOD	H3R	$440,000/mi	$1,513,600
			Rutting	FAIR			
			Ride Quality	POOR			

ROUTE 204 FMSS# 43352 - Conata Road - Sections and Rehabilitation Strategy

Section	Milepost	Length	2012 Distress Summary		Treatment Category	Category Cost*	Treatment Cost*
1	0 - 1.0	1	Cracking	GOOD	H3R	$440,000/mi	$440,000
			Rutting	FAIR			
			Ride Quality	POOR			

ROUTE 208 FMSS# 61759 - Conata Picnic Road - Sections and Rehabilitation Strategy

Section	Milepost	Length	2012 Distress Summary		Treatment Category	Category Cost*	Treatment Cost*
1	0 - 0.21	0.21	Cracking	GOOD	H3R	$440,000/mi	$92,400
			Rutting	FAIR			
			Ride Quality	NO DATA			

ROUTE 920 - Yellow Mounds Overlook Parking - Sections and Rehabilitation Strategy

Section	FMSS	Area (ft^2)	2012 Distress Summary		Treatment Category	Category Cost*	Treatment Cost*
1	53304	11592	Surface	GOOD	PM	$0.84/ft^2$	$9,737

ROUTE 921 - Ancient Hunters Overlook Parking - Sections and Rehabilitation Strategy

Section	FMSS	Area (ft^2)	2012 Distress Summary		Treatment Category	Category Cost*	Treatment Cost*
1	53305	8843	Surface	GOOD	PM	$0.84/ft^2$	$7,428

*2010 Costs. Does not include non-pavement items such as drainage, signs, etc.

Category Costs are national network average per mile, based on the identified treatment category. Cost variations due to location and size of project should be expected. These costs are for comparison only and should not be used for programming or engineer's estimate. Treatments are subject to change following detailed pavement investigation and analysis.

Explanation of Distress Ratings

Ride Quality- Ride quality is based on Roughness, the deviation of a surface from a true planar surface, and is determined using the International Roughness Index (IRI) and measured in inches/mile. This is the primary characteristic dimension that affects vehicle dynamics and ride quality.

Ride Quality:	Good	Section average of measured IRI < 170 in/mi.
	Fair	Section average of measured IRI are between 170 and 240 in/mi.
	Poor	Section average of measured IRI > 240 in/mi.

Cracking- Cracking is based on the extent and severity of transverse, longitudinal and fatigue (alligator) cracking. An index is calculated based on the area of pavement affected by cracking and a severity factor. Severity levels are split into low, moderate, and high. For transverse and longitudinal cracking, severity levels are based on crack widths. For alligator cracking, severity is based on interconnectedness of the crack pattern and spalling.

Cracking:	Good	Occasional or no incidence of low severity cracking.
	Fair	Widespread low severity cracking or occasional moderate severity cracking.
	Poor	Widespread low to moderate severity cracking or occasional high severity cracking.

Rutting- Rutting is based on the average of measured rut depths along a section. A rutting index is calculated based on the frequency of measured rut depths meeting a depth criterion. Like cracking, rutting contains levels of severity (low, moderate and high) based on increasing rut depth.

Rutting:	Good	Section average of measured rut depths < 0.25".
	Fair	Section average of measured rut depths are between 0.25" and 0.50".
	Poor	Section average of measured rut depths > 0.50".

Explanation of Treatment Categories

***PM** – Preventive Maintenance*; Includes non-structural surface treatments

ACP Examples: Crack Sealing, Fog Seal, Chip Seal, Slurry Seal, Micro surfacing, Ultra-thin Bonded Wearing Course, Cape Seal, or Thin AC Overlay less than 1.5" in total thickness

***L3R** – Light Rehabilitation*; Includes pavement rehabilitation without grade improvement

ACP Examples: Single-Lift AC Overlay less than or equal to 2.5" in total thickness, Mill and AC Overlay, Wedge & Level and Overlay

PCC Examples: Joint and Crack Repair

***H3R** – Heavy Rehabilitation*; Includes pavement rehabilitation with grade improvement

ACP Examples: Multiple Lift AC Overlay greater than 2.5" in total thickness, Mill and Multiple-Lift AC Overlay, Cold-In-Place Recycling, Full Depth Reclamation, Reconstruction

PCC Examples: Individual slab replacement or Reconstruction

APPENDIX K

TRAFFIC DATA

SD PRA BADL 10(7)

Badlands Loop Road

Badlands NP

TRAFFIC COUNT AT INTERIOR ENTRANCE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC			
2011	2,348	2,373	4,423												
2010	2,568	2,365	1,700	4,834	9,111	16,307	20,471	22,296	12,130	5,830	3,466	2,721	103,799	/365 =	284
2009	2,332	2,275	2,780	6,814	9,893	17,970	22,944	20,118	12,657	4,928	3,666	2,499	108,876	/365 =	298
2008	2,569	2,344	2,967	2,216	8,226	14,792	20,326	19,564	12,555	5,209	2,534	2,291	95,593	/366 =	261
2007	2,804	2,402	3,474	4,862	9,214	16,159	18,144	18,564	10,246	5,679	3,217	2,497	97,262	/365 =	266
2006	930	2,419	2,887	4,100	8,177	14,062	16,885	18,147	10,030	5,685	5,703	2,866	91,891	/365 =	252
2005	2,780	2,784	2,595	4,494	8,182	15,007	18,726	20,535	10,732	5,233	3,064	2,556	96,688	/365 =	265
2004	2,741	1,587	3,597	5,197	8,565	15,365	18,265	22,137	11,103	5,974	3,525	3,155	101,211	/366 =	277
2003	440	411	555	642	3,562	10,029	17,701	14,147	12,093	6,650	3,532	3,176	72,938	/365 =	200
2002	1,514	1,367	1,278	1,327	2,940	18,932	16,128	14,962	9,986	2,125	867	710	72,136	/365 =	198
2001	1,347	1,237	1,175	1,766	7,302	17,807	16,898	23,132	9,780	4,428	1,578	1,055	87,505	/365 =	240
2000	1,360	893	1,425	2,065	7,265	21,741	16,770	24,980	8,950	4,871	1,538	1,050	92,908	/366 =	254
1999	1,835	1,970	1,233	1,453	6,879	17,248	14,605	21,806	9,470	3,990	1,393	919	82,801	/365 =	227
1998	844	850	867	1,781	7,762	14,433	19,321	22,612	10,919	4,425	1,804	1,197	86,815	/365 =	238
1997	1,984	937	1,730	2,594	6,180	12,737	16,167	18,304	7,751	3,383	1,417	1,034	74,218	/365 =	203
1996	1,543	2,647	1,780	1,435	6,668	10,206	16,987	13,129	8,803	5,729	958	525	70,410	/366 =	192
1995	2,487	2,707	2,723	3,720	6,729	9,563	16,463	12,456	10,388	4,164	3,038	2,033	76,471	/365 =	210
1994	2,341	2,240	3,497	3,703	8,235	10,068	16,600	16,453	12,345	3,015	3,623	2,531	84,651	/365 =	232
1993	2,427	2,324	3,355	4,323	7,873	13,572	20,695	19,621	13,279	3,922	3,136	2,806	97,333	/365 =	267
1992	1,600	1,480	3,971	2,993	8,712	16,037	17,766	19,454	9,699	5,086	2,915	2,378	92,091	/366 =	252
1991	1,612	1,716	2,700	6,500	7,260	12,030	19,091	17,264	9,398	3,775	1,111	1,250	83,707	/365 =	229
														average =	242

TRAFFIC COUNT AT NORTHEAST ENTRANCE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC			
2011	1,244	1,509	2,534												
2010	1,049	1,206	2,523	3,862	12,356	30,717	38,719	30,192	18,087	9,729	2,207	1,409	152,056	/365 =	417
2009	1,422	1,432	2,090	3,202	12,224	27,471	36,050	29,260	17,390	5,340	2,056	1,175	139,112	/365 =	381
2008	1,319	1,405	2,420	3,066	11,054	25,307	30,618	25,802	14,264	5,840	1,902	1,373	124,370	/366 =	340
2007	1,444	1,361	2,429	3,715	12,399	27,194	33,136	25,953	16,155	6,743	2,165	1,521	134,215	/365 =	368
2006	1,477	1,410	2,298	3,685	11,620	25,480	31,826	25,509	15,634	6,159	2,307	1,428	128,833	/365 =	353
2005	2,623	2,452	3,493	4,945	12,562	27,280	35,818	29,088	15,346	7,297	2,135	1,393	144,432	/365 =	396
2004	1,930	1,831	3,556	5,297	13,165	27,285	36,003	31,185	17,999	8,317	3,717	2,953	153,238	/366 =	419
2003	1,755	1,745	2,731	3,967	10,141	30,125	36,627	35,209	20,934	3,566	2,719	1,460	150,979	/365 =	414
2002	1,338	2,620	2,527	5,732	16,242	29,627	34,352	34,073	18,111	8,043	2,942	2,328	157,935	/365 =	433
2001	1,477	1,571	2,619	4,638	13,049	36,977	40,066	41,308	23,009	8,519	3,136	1,912	178,281	/365 =	488
2000	1,807	2,142	3,269	4,112	12,343	41,909	53,634	56,178	26,444	8,820	3,130	1,847	215,635	/366 =	589
1999	730	1,199	2,878	5,370	13,192	37,038	34,171	34,507	17,502	7,634	3,609	2,376	160,206	/365 =	439
1998	1,893	1,373	1,710	4,431	13,611	31,984	32,394	33,240	25,082	9,103	2,668	1,512	159,001	/365 =	436
1997	2,101	1,693	2,036	4,637	14,829	32,239	43,750	36,889	24,167	9,723	3,114	1,651	176,829	/365 =	484
1996	1,606	1,861	2,367	4,422	11,136	31,149	42,826	49,442	27,572	11,648	3,098	1,093	188,220	/366 =	514

1995	2,110	2,405	3,514	4,640	13,481	32,982	47,980	45,161	25,507	8,654	3,708	1,792	191,934	/365 =	526
1994	1,988	1,905	3,489	3,807	14,987	31,984	47,924	66,704	19,564	7,719	3,352	2,607	206,030	/365 =	564
1993	2,133	1,980	3,038	4,804	14,131	32,425	49,025	68,667	20,920	8,219	2,979	2,502	210,823	/365 =	578
1992	2,051	2,161	3,297	6,223	15,765	34,536	43,645	67,988	35,070	15,627	2,783	2,309	231,455	/366 =	632
1991	1,804	1,824	2,992	10,200	13,029	33,104	43,534	37,377	20,578	14,321	2,291	2,158	183,212	/365 =	502
														average =	464

TRAFFIC COUNT AT PINNACLES ENTRANCE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC			
2011	557	339	1,246												
2010	553	610	387	2,383	8,949	17,212	19,933	24,428	13,526	4,701	1,277	646	94605	/365 =	259
2009	681	856	1,458	2,138	7,729	17,609	24,264	22,485	13,041	4,112	1,027	267	95667	/365 =	262
2008	757	694	1,800	4,213	7,152	16,032	20,837	21,361	11,428	4,786	831	636	90527	/366 =	247
2007	3,307	708	1,842	2,811	7,284	16,209	20,973	22,393	12,265	5,758	1,894	744	96188	/365 =	264
2006	2,875	938	1,275	2,435	6,463	15,277	18,585	22,113	11,297	4,961	1,843	915	88977	/365 =	244
2005	846	793	2,637	2,386	6,200	16,127	21,872	24,751	10,378	4,836	1,671	817	93314	/365 =	256
2004	889	968	1,719	3,076	4,620	12,627	21,537	27,240	12,182	4,934	1,887	1,131	92810	/366 =	254
2003	1,273	755	1,469	2,282	7,741	11,408	21,994	29,584	12,645	5,803	1,720	1,258	97932	/365 =	268
2002	2,433	1,201	991	3,624	5,164	16,882	23,986	24,345	13,883	7,115	5,538	906	106068	/365 =	291
2001	2,309	662	1,268	2,784	5,873	9,590	22,027	20,499	11,219	5,494	2,628	1,001	85354	/365 =	234
2000	1,413	1,352	1,844	3,310	4,888	16,726	17,305	25,392	11,332	5,639	1,682	1,212	92095	/366 =	252
1999	1,069	1,370	1,543	2,845	7,535	13,528	25,252	28,445	13,618	7,035	2,302	1,091	105633	/365 =	289
1998	1,347	1,394	1,565	3,103	9,656	25,306	29,059	28,445	15,868	11,501	1,604	1,032	129880	/365 =	356
1997	1,127	1,000	1,344	3,060	7,269	17,507	24,805	27,396	13,898	5,777	1,513	730	105426	/365 =	289
1996	846	611	1,137	1,656	5,661	14,077	29,129	36,007	15,077	5,832	1,945	1,577	113555	/366 =	310
1995	820	1,004	2,491	2,982	7,085	19,032	29,074	38,263	14,789	6,121	1,692	791	124144	/365 =	340
1994	799	844	2,483	2,894	9,063	19,412	30,770	30,795	14,485	5,437	2,340	1,121	120443	/365 =	330
1993	939	1,043	2,063	3,306	8,460	17,784	32,988	28,366	15,958	5,938	1,803	942	119590	/365 =	328
1992	1,276	1,134	2,233	3,482	9,132	19,902	27,608	28,086	14,376	5,975	1,571	968	115743	/366 =	316
1991	761	835	1,333	7,335	8,527	19,199	26,776	27,874	14,498	5,736	2,333	1,667	116874	/365 =	320
														average =	285