

CENTRAL FEDERAL LANDS HIGHWAY DIVISION HIGHWAY DESIGN STANDARDS

Project Number and Name: CO PRA BICA 123(1) 3R Example Road

Location: Eleven miles east of Cortez, CO. South of main entrance station.

Type of Project: New Construction Reconstruction RRR Other (describe)

Description of Work: This project will provide resurfacing, restoration, and rehabilitation to the 10.5 miles of the main entrance road from the Park Entrance to Park Point. Pulverizing and a 3.0" surfacing will be used to improve the surface and ride of the existing roadway.

System:

<input checked="" type="checkbox"/> National Park Service <input type="checkbox"/> Forest Service <input type="checkbox"/> Bureau of Land Management <input type="checkbox"/> Bureau of Indian Affairs	<input type="checkbox"/> National Highway System (NHS) <input checked="" type="checkbox"/> Non NHS <input type="checkbox"/> Off system (county road) <input type="checkbox"/> Other (describe)
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Functional Classification: NPS Class 1: Principal Park Road/Rural Parkway

Owner Agency: National Park Service

Terrain: Mountainous **Design Vehicle:** SU

		ADT – 1+00 to 556+22			PERCENT TRUCKS	D
TRAFFIC	YEAR	AVERAGE	SEASONAL	DHV		
Current	2008	1600		20	1	50
Design	2028	1953				

Crash Data Summary: The NPS provided crash data for the route; there are no documented safety issues related to any engineering features of the roadway. NPS maintenance and park ranger staff also stated that there were very few known accidents within the limits of the project. There is no evidence of unreported crashes (e.g. no areas with skid marks or scarred trees).

Design Standards: AASHTO 2004 NPS State Other (describe)

GEOMETRIC AND BRIDGE CRITERIA – 1+00 to 216+54 and 335+75 to 556+22			
GEOMETRIC AND BRIDGE CRITERIA	STANDARD	AS DESIGNED	EXCEPTION
1. Design Speed	Minimum = 20 MPH Design Speed should equal or exceed Posted or Regulatory Speed of completed facility	35 MPH Posted or Regulatory = 35 MPH	No
2. Traveled Way Width	11 ft	11 ft	No
3. Shoulder Width	3 ft	1 ft	Yes - See (1) below
4. Crown	1% -3%	~2%	No

5. Horizontal Curvature	340 ft	180 ft	Yes - See (2) below
6. Superelevation	e(max) = 6% $\Delta = 0.62\%$	e(max) = ~6% $\Delta = *$	See (3) below
7. Grades	13%	<13%	No
8. Vertical Curvature	K (crest) = 40 K (sag) = 50	K (crest) = * K (sag) = *	See (4) below
9. Stopping Sight Distance	225 ft	>225 ft	No
10. Horizontal Clearance to Structure (not clear zone)	N/A	N/A	N/A
11. Vertical Clearance to Structure	N/A	N/A	N/A
12. Bridge Width	28 ft	32 ft	No
13. Bridge Loading	HL 93	HL 93	No

* Match existing

GEOMETRIC AND BRIDGE CRITERIA – 216+54 to 335+75			
GEOMETRIC AND BRIDGE CRITERIA	STANDARD	AS DESIGNED	EXCEPTION
1. Design Speed	Minimum = 20 MPH Posted or Regulatory = 45 MPH	45 MPH	No
2. Traveled Way Width	11 ft	11 ft	No
3. Shoulder Width	3 ft	1 ft	Yes - See (1) below
4. Crown	1% -3%	~2%	No
5. Horizontal Curvature	643 ft	200 ft	Yes - See (2) below
6. Superelevation	e(max) = 6% $\Delta = 0.62\%$	e(max) = ~6% $\Delta = *$	See (3) below
7. Grades	13%	<13%	No
8. Vertical Curvature	K (crest) = 80 K (sag) = 70	K (crest) = * K (sag) = *	See (4) below
9. Stopping Sight Distance	325 ft	>325 ft	No
10. Horizontal Clearance to Structure (not clear zone)	N/A	N/A	N/A
11. Vertical Clearance to Structure	N/A	N/A	N/A
12. Bridge Width	N/A	N/A	N/A

13. Bridge Loading	N/A	N/A	N/A
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* Match existing

(1) Shoulder

Description: The NPS standards recommend 3-foot wide paved shoulders. The proposed project will have 1-foot wide paved shoulders.

Reasons for exceptions to standards: To minimize impacts to Park resources, many of which are buried artifacts near the edge of the existing roadway, the proposed project maintains the existing shoulder width. Due to unacceptable environmental impacts, shoulder widening was not included in this project.

Analysis of risks: The project is consistent with adjacent roadway segments, maintaining consistency in shoulder width along the route. Risk associated with this design exception is determined to be low considering the lack of site-specific safety issues, low vehicle speeds, and consistency of the existing roadway corridor.

Design features proposed to mitigate exception: The new pavement will have the safety edge treatment. New regulatory and warning signs will be installed on the project including speed limit, advanced curve, and grade warning signs. Pavement markings will be improved.

(2) Horizontal curves

Description: There are 46 existing curves that have a centerline radius below the required 340 feet for a 35 mph design speed and 2 existing curves below the required 643 feet for a 45 mph design speed.

The 35 mph design exception curves are located approximately at stations: 62+50, 78+40, 82+60, 88+20, 92+90, 100+85, 107+13, 120+25, 122+20, 128+95, 131+60, 135+15, 136+55, 158+35, 162+35, 178+53, 192+73, 337+22, 356+95, 363+75, 366+85, 374+98, 380+60, 384+30, 388+50, 393+96, 403+71, 420+50, 430+38, 433+73, 439+15, 453+02, 453+40, 456+41, 4559+76, 466+13, 483+53, 495+20, 502+48, 505+76, 510+96, 518+99, 527+03, 532+26, 545+13, 549+28.

The 45 mph design exception curves are located approximately at stations: 217+62, 222+30.

Reasons for exceptions to standards: The proposed horizontal alignment matches existing due to environmental constraints, steep terrain with limited roadway bench width at horizontal curve locations, and excessive construction cost to meet standards.

Analysis of risks: Risk associated with this design exception is determined to be low considering the lack of site-specific safety issues, low vehicle speeds, low volume of truck traffic, and consistency of the existing roadway corridor.

Design features proposed to mitigate exception: New curve warning and advisory speed signs will be installed on the project. Pavement markings will be improved.

(3) Superelevation

Description: The proposed values for superelevation and relative gradient of the horizontal curves match existing. NPS maintenance staff indicated that some of the superelevation has been reduced over the years during the numerous patching and overlay projects. Specific values for existing superelevation and relative gradient are unknown, but field observations indicated that there are only minor variations from the standard criteria.

Reasons for exceptions to standards: Improving the existing superelevation to meet current standards would require placing embankment material outside the existing roadway bench, resulting in unacceptable environmental and cost impacts. Including superelevation adjustments in the project scope would not provide any cost-effective safety or operational improvements.

Analysis of risks: Risk associated with this design exception is determined to be low considering the lack of site-specific safety issues, low vehicle speeds, low volume of truck traffic, and consistency of the existing roadway corridor. No new substandard superelevation areas will be created, or existing ones made worse.

Design features proposed to mitigate exception: New curve warning and advisory speed signs will be installed on the project. Pavement markings will be improved. Selected trees on the outside of curves will be removed to improve roadside safety.

(4) Vertical Curves

Vertical curves have been evaluated using the as-built drawings and visidata (video of the roadway). In addition, the vertical curves have been evaluated in the field. Based on available information, it has been determined that vertical curvature and stopping sight distance is adequate.

FLH SUPPLEMENTAL STANDARDS – 1+00 to 556+22			
DESIGN CRITERIA	STANDARD	AS DESIGNED	EXCEPTION
1. Clear Zone	See (1) below	6-10 ft	Yes - See (1) below
2. Barrier Crashworthiness	NCHRP 350 TL-3	NCHRP 350 TL-3	No
3. Design Flood	FLH <i>Project Development and Design Manual</i> Exhibit 7.1-A		* - See (2) below
4. Pavement Design Service Life	20-year	20-year	No

* Match existing

(1) Clear Zone

Description: According to the 2006 AASHTO *Roadside Design Guide* the recommended clear zone distances are as follows (for roadways with ADT between 1500 and 6000):

Design Speed	1:4 Foreslope	1:3 Backslope
35 MPH	14 ft	12 ft
45 MPH	20 ft	12 ft

The as-designed clear zone is typically 10 ft wide. However, the clear zone width for some of the sections with paved ditches is less than 10 ft.

Reasons for exceptions to FLH standards: Achieving the minimum clear zone distance of 12 ft -20 ft would require extensive reconstruction of existing cut slopes. Due to funding and environmental constraints, cut slope reconstruction is not part of the scope of this project.

Analysis of risks: Adjacent sections of roadway have a similar cross section and there is no significant run-off-the-road crash history on the roadway. Since there are very few known accidents along this project route and no evidence of unreported crashes (e.g. no areas with skid marks or scarred trees), the safety performance indicates that the existing roadway is considered substantively safe. No new substandard features will be created, or existing ones made worse. Risk associated with this design exception is determined to be low.

Design features proposed to mitigate exceptions: Roadway delineation is improved by installing new edge lines and posting warning signs.

(2) Design Flood

Description: No hydraulic improvements are included in the scope of the project. Existing drainage patterns, including culverts, will be maintained.

Reasons for exceptions to FLH standards: CFLHD assessed the condition and performance of the existing culverts according to the *Culvert Assessment and Decision-Making Procedures Manual for Federal Lands Highway* in June 2011. Based on the results of the culvert assessment, no culverts were recommended for repair, replace, or maintenance actions. In addition, NPS maintenance staff are unaware of any hydraulic issues.

Analysis of risks: Risk is considered minimal since no documentable site-specific hydraulic issues exist for Main Entrance Road.

Design features proposed to mitigate exceptions: Based on the results of the culvert assessment, no hydraulic repairs are currently needed.

APPROVAL:

- There are no exceptions to applicable standards.
- The exceptions to the design standards as noted and their related risks have been reviewed with the appropriate agencies and parties and are considered acceptable for this project.

PREPARED BY:

Lead Designer Signature
Lead Designer

April 27, 2011
Date

APPROVAL IS RECOMMENDED:

Highway Design Manager Signature
Highway Design Manager

April 27, 2011
Date

Project Manager Signature
Project Manager

April 27, 2011
Date

Project Management Engineer Signature
Project Management Engineer

April 27, 2011
Date

PM Engineer Comments: Discussed design exceptions at Management Board (MB) meeting on March 12, 2011. MB recommends approval.

I CONCUR WITH THE ABOVE RECOMMENDATIONS:

NPS Signature
Big Canyon National Park, NPS

April 30, 2011
Date

Maintaining Agency, if different from above (i.e. County)

Date
Date

THE ABOVE RECOMMENDATIONS ARE APPROVED:

Project Delivery Director Signature
Director, Project Delivery

September 18, 2011
Date

After all signatures have been obtained:

cc: Ed Hammontree, Project Management Engineer
Bryant Gonsalves, Project Development Engineer
Gary Strike, Acting Technical Services Engineer
Bryant Gonsalves, Senior Highway Designer
Ed Demming, Safety Engineer
 , Project Manager
 , Highway Design Manager
 , Lead Designer

Name, Partner Agency

Name, Partner Agency

3R EXAMPLE

CENTRAL FEDERAL LANDS HIGHWAY DIVISION HIGHWAY DESIGN STANDARDS

Project Number and Name: CA PFH 123-1(1) 4R Example Road

Location: North Fork Blue River Road MP 3.6 to 13.6. Located east of Dakota, CA between Van Gordon and Alameda off of State Route 199

Type of Project: New Construction Reconstruction RRR Other (describe)

Description of Work: Spot improvements: Grading, drainage, aggregate base, asphalt pavement, MSE walls, soil nail walls, and bridge construction

System:

<input type="checkbox"/> National Park Service <input checked="" type="checkbox"/> Forest Service <input type="checkbox"/> Bureau of Land Management <input type="checkbox"/> Bureau of Indian Affairs	<input type="checkbox"/> National Highway System (NHS) <input type="checkbox"/> Non NHS <input checked="" type="checkbox"/> Off system (county road) <input type="checkbox"/> Other (describe)
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Functional Classification: Rural collector

Owner Agency: Jefferson County

Terrain: Mountainous

Design Vehicle: MH

		ADT – MP 3.6 to 13.6			PERCENT TRUCKS	D
TRAFFIC	YEAR	AVERAGE	SEASONAL	DHV		
Current	2008	211		21	1	50
Design	2028	314				

Crash Data Summary: No crash data was available; neither Jefferson County nor the California State Patrol had any documented crash history along the route. No evidence of undocumented crashes (e.g. skid marks or broken vehicle mirrors) was noted in the field.

Design Standards: AASHTO 2004 NPS State Other (describe)

GEOMETRIC AND BRIDGE CRITERIA – MP 3.6 to 13.6 (Spot Improvements)			
GEOMETRIC AND BRIDGE CRITERIA	STANDARD	AS DESIGNED	EXCEPTION
1. Design Speed	Minimum = 20 MPH Design Speed should equal or exceed Posted or Regulatory Speed of completed facility	35 MPH Posted or Regulatory = 35 MPH	No
2. Traveled Way Width	10 ft	11 ft	No
3. Shoulder Width	2 ft	1 ft	Yes - see (1) below
4. Crown	2%	2%	No
5. Horizontal Curvature	340 ft	110 ft	Yes - see (2) below

6. Superelevation	e(max) = 6% $\Delta = 0.62\%$	e(max) = 6% $\Delta = 0.98\%$	Yes - see (3) below
7. Grades	14%	8.2%	No
8. Vertical Curvature	K (crest) = 29 K (sag) = 49	K (crest) = 46 K (sag) = 31	K (crest) - No K (sag) - Yes - see (4) below
9. Stopping Sight Distance	250 ft	257 ft	No
10. Horizontal Clearance to Structure (not clear zone)	N/A	N/A	N/A
11. Vertical Clearance to Structure	N/A	N/A	N/A
12. Bridge Width	28 ft	32 ft	No
13. Bridge Loading	HL 93	HL 93	No

Descriptions of and reasons for exceptions to standards:

(1) Shoulder

Description: The AASHTO *Green Book* recommends 2-foot wide paved shoulders. The proposed project will have 1-foot wide paved shoulders.

Reasons for exceptions to standards: The shoulder width was selected to match the existing shoulder width of the adjacent segments of the roadway (MP 0.0 to MP 3.6 and MP 13.6 to MP 20.4).

Analysis of risks: The project is consistent with adjacent roadway segments, maintaining consistency in shoulder width along the route. Risk associated with this design exception is determined to be low considering the lack of site-specific safety issues, low vehicle speeds, and consistency of the existing roadway corridor.

Design features proposed to mitigate exception: The new pavement will have the safety edge treatment. Delineation is improved with new pavement markings.

(2) Horizontal curves

Description: The AASHTO *Green Book* recommends a minimum horizontal curve radius (R) of 340 ft. Below are the minimum curve radii for this project:

- Site C, Station 504+75 to 506+50, R=110 ft.
- Site C, 518+32 to 519+50, R = 205 ft.
- Rock Creek Bridge: 211+96 to 213+40, R=250 ft.

Reasons for exceptions to standards:

- Site C, Station 504+75 to 506+50, R=110 ft. The design speed of a 110 ft radius curve is 20 MPH, so there is a 15 MPH reduction in speed on this curve (35 MPH project design speed - 20 MPH design speed for this curve). This is undesired, but necessary on this project due to environmental and cost constraints. To correct this curve, a retaining wall would have to be constructed exceeding 50 feet in height. The 110 ft radius curve matches existing and is necessary to tie into the existing roadway.
- Site C, 518+32 to 519+50, R = 205 ft. The design speed of a 205 ft radius curve is 25 MPH, so there is a 10 MPH reduction in speed on this curve (35 MPH project design speed - 25 MPH design speed for this curve). This is undesired, but

necessary on this project due to environmental and cost constraints. Steep terrain limits the amount of centerline shift. The 205 ft radius matches the existing alignment.

- Rock Creek Bridge: 211+96 to 213+40, R=250 ft. The 250 ft radius curve matches existing and is necessary to tie into the existing roadway. A larger radius curve would extend the length of the project and increase embankment and excavation limits. The 250 ft radius curve is used to limit project length and keep environmental impacts to a minimum.

Analysis of risks: Risk associated with this design exception is determined to be low considering the lack of site-specific safety issues, low vehicle speeds, and consistency of the proposed horizontal curve radii with the existing roadway corridor.

Design features proposed to mitigate exception

- Site C, 504+75 to 506+50, R=110 ft.
An advance curve warning with speed advisory sign will be added.
- Site C, 518+32 to 519+50, R = 205 ft.
An advance curve warning with speed advisory sign will be added. Sight distance will be improved around both the inside and outside of this curve.
- Rock Creek Bridge: 211+96 to 213+40, R=250 ft.
Curve widening will be applied to the inside of the curve at the bridge. An advance curve warning with speed advisory sign will be added.

(3) Superelevation (Maximum relative gradient)

Description: There is insufficient superelevation runoff on Site A at Station 111+05.70 and Site C at Station 518+20.

Reasons for exceptions to standards: Curve radii as large as possible were used to minimize short tangents and to match the reversing horizontal curves in the existing alignment. This keeps the roadway close to the existing alignment and minimizes impacts outside of the existing roadway bench. Improving the maximum relative gradient to meet current standards would not provide any cost-effective safety improvements.

Analysis of risks: Risk associated with this design exception is determined to be low considering the low vehicle speeds, low volume of truck traffic, and consistency of the existing roadway corridor.

Design features proposed to mitigate exception: New curve warning and advisory speed signs will be installed on the project. Pavement markings will be improved.

(4) Sag Vertical Curves

Description: The AASHTO *Green Book* recommends a minimum k(sag) of 49. Below are the minimum k(sag) for this project:

- Rock Creek Bridge: 210+30 to 211+95, symmetrical vertical curve, L=165 ft, k(sag)=31
- Boulder Creek Bridge: 409+27 to 411+67, asymmetrical vertical curve, L1=115 ft, k(sag) =40; L2=125 ft, k(sag)=47

Reasons for exceptions to standards:

- Rock Creek Bridge: The lower K value of the sag vertical curve is necessary to match the bridge grade with the driveways accessing private property. The bridge grade was set based on keeping the bottom edge of the girders above the

water surface elevation for Q50. The lower k value provides stopping sight distance on the bridge to meet an inferred design speed of 25 MPH.

- Boulder Creek Bridge: The bridge grade was set based on keeping the bottom edge of the girders above the water surface elevation for Q100. The lower k value is necessary to keep vertical curves off the bridge and to maintain access to driveways.

Analysis of risks: Risk associated with this design exception is determined to be low considering that very little traffic travels on the roadway at night.

Design features proposed to mitigate exception: Curve widening will be added to both bridges, allowing vehicles more room to maneuver and improving sight distance.

FLH SUPPLEMENTAL STANDARDS – MP 3.6 to 13.6			
DESIGN CRITERIA	STANDARD	AS DESIGNED	EXCEPTION
1. Clear Zone	7-10 ft	4-10 ft	Yes - see (1) below
2. Barrier Crashworthiness	NCHRP 350 TL-2	NCHRP 350 TL-2 and TL-3	No
3. Design Flood	FLH <i>Project Development and Design Manual</i> Exhibit 7.1-A		Yes - see (2) below
4. Pavement Design Service Life	25-year	25-year	No

Descriptions of and reasons for exceptions to FLH standards:

(1) Clear Zone

Description: The AASHTO *Roadside Design Guide* recommends a clear zone width of 7-10 ft. Clear zone widths on this project are limited to the edge of subgrade (typically 4 ft) and to bottom of ditch (typically 10 ft). Additional clear zone widths are obtained when available.

Reasons for exceptions to FLH standards: Achieving the minimum clear zone distance of 7 - 10 feet would require extensive reconstruction of existing cut slopes. Due to project constraints, including steep terrain, limited right of way, and sensitive environment, cut slope reconstruction is not part of the scope of this project.

Analysis of risks: The as-designed clear zone width of 4-10 ft is as wide as practical, considering the steep mountainous terrain, limited right of way, and sensitive riparian area along the route. These clear zone widths are consistent along the entire roadway corridor. Since documentable site-specific safety problems do not exist, it is unlikely that any roadside improvement would provide substantial safety benefits.

Design features proposed to mitigate exceptions: Roadway delineation is improved by installing new edge lines and posting warning signs. The new pavement edge will have the safety edge treatment.

(2) Design Flood

Description: The FLH Standard Practice for hydraulic design of bridges is to use a 50-year design flood for capacity design and a 100-year design flood for stability design.

The low chord elevation of the proposed bridge design is more than 3 ft below the 50-yr water surface elevation of 403.8 ft.

Reasons for exceptions to FLH standards: For this bridge the 50-year design flood for the North Fork of the Blue River was used in the design instead of the design floods for Rock Creek. The 50-yr event in the North Fork of the Blue River controls the water surface elevation at the bridge, regardless of the flow in Rock Creek. When water surface elevations are controlled by high tailwater in the Blue River, the velocities through the bridge during high flows are relatively low (5-6 ft/s). Since there are several private driveways and sensitive wetlands adjacent to the bridge, the elevation of Rock Creek Bridge is constrained by right of way, cost, and environmental impacts. The proposed bridge is 4 ft higher than existing.

Analysis of risks: The durability, operational, and maintenance risks are considered to be minimal. Capacity and stability risks are considered to be low: during high flows debris may temporarily get caught by the bridge, but should pass once the flows recede. There is minimal risk for property loss and hazard to life during the service life of the bridge.

Design features proposed to mitigate exceptions: Berms are included to help protect the private driveways near the bridge.

APPROVAL:

- There are no exceptions to applicable standards.
- The exceptions to the design standards as noted and their related risks have been reviewed with the appropriate agencies and parties and are considered acceptable for this project.

PREPARED BY:

Lead Designer Signature
Lead Designer

April 27, 2011
Date

APPROVAL IS RECOMMENDED:

Highway Design Manager Signature
Highway Design Manager

April 27, 2011
Date

Project Manager Signature
Project Manager

April 27, 2011
Date

Project Management Engineer Signature
Project Management Engineer

April 27, 2011
Date

PM Engineer Comments: Discussed design exceptions at Management Board (MB) meeting on March 12, 2011. MB recommendations have been incorporated into HDS form.

I CONCUR WITH THE ABOVE RECOMMENDATIONS:

USFS Signature
Four Rivers National Forest, USFS

April 30, 2011
Date

County Signature
Jefferson County

April 30, 2011
Date

THE ABOVE RECOMMENDATIONS ARE APPROVED:

Project Delivery Director Signature
Director, Project Delivery

September 18, 2011
Date

After all signatures have been obtained:

cc: Ed Hammontree, Project Management Engineer
Gary Strike, Project Development Engineer
Bob Welch, Technical Services Engineer
Christine Black, Senior Highway Designer
Ed Demming, Safety Engineer
 , Project Manager
 , Highway Design Manager
 , Lead Designer

Name, Four Rivers National Forest, USFS

Name, Jefferson County

4R EXAMPLE