TYPE STUDY

Structure Carrying US 6 over the South Platte River

Replacement of Bridge Structures F-16-EF & F-16-EE
at M.P. 284.345
Denver County, Colorado

Project Number: FBR 06A-050
Sub Account Number: 18192

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Prepared for
Colorado Department of Transportation
Staff Bridge Design Region 6

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Colorado Department of Transportation

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1. PROJECT DESCRIPTION

Many of the bridges in the Denver metro are currently rated as structurally deficient or functionally obsolete. It is imperative that the replacement of these bridges are identified and prioritized. Among the replacement candidates are structure numbers F-16-EF and F-16-EE, which carry eastbound and westbound US 6 over the South Platte River in CDOT Region 6.

This project involves the replacement of the US 6 Bridge over the South Platte River as part of the larger project of improvements to US 6 from approximately Federal Blvd to the BNSF bridge on the east side of I-25 in the City and County of Denver. The project includes adjustments to the existing US 6 roadway elevation and improvements to the hydraulic opening of the structure. The complete project generally includes replacements of the following structures: US 6 over the South Platte River, US 6 over Bryant Street, US 6 over Interstate 25, US 6 over the BNSF Railroad and Federal Boulevard Bridge over US 6. The project will also include improvements to the US 6 – Federal Boulevard interchange by providing a diamond type interchange at US 6 and Federal Boulevard while adding slip ramps to Bryant Street and a braided ramp from Federal Boulevard to eastbound US 6. Additional project improvements include upgrading Federal Boulevard between 5th and 7th Avenues, converting 5th Avenue east of Federal Boulevard into two-way traffic, revising portions of the South Platte River Trail to current standards, reconstructing US 6 from Federal Boulevard to the BNSF Railroad Bridge with collector-distributor roads or auxiliary lanes, in-kind replacements to impacted facilities at Barnum East Park, adding a bicycle/pedestrian bridge connecting North and South Barnum Park, and paving all structures between the north and south project limits of Interstate 25 and the east and west project limits of US 6.

2. PROJECT GOALS AND OBJECTIVES

The purpose of this project is to replace the existing US 6 bridge over the South Platte River. The new bridge must be cost effective and improve both vertical clearance and hydraulic capacity while minimizing impacts on the South Platte River and surrounding traffic on US6.

The proposed replacement bridge has a total out–to-out width of 176 feet - 1 inch. Three 12-foot wide eastbound travel lanes with 12-foot shoulders on both sides will be accommodated by a width of 62 feet – 6 inches. A width of 113 feet – 7 inches will support westbound traffic including two 12-foot travel lanes with two 12-foot shoulders, plus four 12-foot lanes from northbound and southbound I-25 on-ramps with an inside shoulder width of 4 feet and an outside shoulder width of 8 feet. A 2-foot wide barrier will be placed between the eastbound and westbound lanes and between the westbound mainline and the merging on-ramps. Each exterior edge of the bridge will carry a CDOT Bridge Rail Type 7.

The current 100-year flood event water level is 5207.05 upstream of the bridge. The South Platte River will overtop the existing roadway and existing bridge during a 100-

year event. The superstructure soffit of the proposed bridge has an elevation of approximately 5220.00, or about 13 feet above the 100-year flood level. The proposed roadway profile is set at approximately 15 feet higher than the existing US 6 roadway.

The existing bike trail on the east bank of the South Platte is currently shown at its existing location with a vertical clearance of 19 feet – 11 inches. Embankments will be sloped at 2:1 on both sides of the river, which will widen the existing hydraulic opening and offer more room for recreational use.

3. PROJECT SITE

The bridge containing structures F-16-EF and F-16-EE is located in the City of Denver on U.S. Route 6, milepost 284.345, about one-tenth of a mile west of Interstate 25. Within Denver city limits, US 6 is an east – west freeway is also known as 6th Avenue that connects Denver to Golden. The replacement structure will be located within the existing CDOT right-of-way (ROW) in the location where the original 1956 structure was constructed.

The bridge crosses the South Platte River and a bike trail that is located on the east bank of the South Platte. The path runs below the east end of the existing bridge directly adjacent to the east abutment. While the river level varies throughout the year, it tends to flow from bank to bank most of the year and inundates the bike trail during periods of high flows.

4. EXISTING STRUCTURE

The original structures F-16-EF and F-16-EE were constructed in 1956, and in 1967 both underwent widening reconstruction to incorporate additional width and laneage. Currently north of the bridge centerline, westbound traffic is carried by structure F-16-EE and south of the bridge centerline, eastbound traffic is carried by structure F-16-EF. Alignment of the bridge substructure is perpendicular to the South Platte River, while the US 6 roadway is on a 5 degree skew to the substructure.

The existing structure is a three span continous bridge that consists of rolled steel I-beams and a cast-in-place (CIP) concrete deck. A span configuration of 48 feet – 59 feet – 48 feet for a total bridge length of approximately 155'. The out-to-out width of the existing bridge is 172 feet – 7 inches, and is currently striped with four westbound traffic lanes and four eastbound traffic lanes. Reinforced concrete piers and abutments are currently supported on shallow spread footings.

December 28, 2009 dates the most recent structure inspection. The existing bridges, F-16-EE and F-16-EF, are currently categorized as Structurally Deficient (SD) and have a Sufficiency Rating of 42.8 and both on the Colorado Bridge Enterprise list for replacement.

The "Structure Inspection and Inventory Report" (Appendix B) states that the girders suffer from heavy flaking rust and corrosion. Concrete piers and abutments are described to have numerous cracks, efflorescence and spalling. Additionally, both pier caps exhibit excessive spalling with exposed and corroded reinforcing steel. Pier 3 was observed to have to moderate stream abrasion. Photographs of the structural damage described above can be seen in Appendix C.

Furthermore, the structure has an insufficient freeboard, which in the event of an 100-year flood would allow the South Platte River to overtop the existing US 6 roadway and bridge.

5. UTILITIES

The existing utilities at the bridge location include a storm sewer crossing under each abutment, and a 44-inch brick sewer located behind the existing west abutment and in front of the proposed west abutment. The existing brick sewer will be replaced under this project contract.

6. HYDRAULICS

The following hydraulic information references the *Preliminary Bridge Hydraulics Report* prepared by Olsson Associates, and is provided in Appendix D

6.1 Previous Studies

Urban Drainage and Flood Control District (UDFCD) and City and County of Denver (CCD) have constructed the Zuni and Sun Valley Reach Channel Improvements project. This project included improvements along the South Platte River from approximately 100 feet upstream of Spear Boulevard to about 360 feet downstream of 3rd Avenue. As a result, the 100-base flood elevations (BFEs) and flood plain extents on the South Platte River have been reduced at the proposed project site.

6.2 Hydraulic Analysis and Recommended Design

The freeboard requirement was obtained from Chapter 8 of the *Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual*, which states that the distance between the design flow water surface and the bottom of the bridge deck should be a minimum of three feet for the 100-year flood on larger streams or rivers where large floating debris is likely.

The computer model from the Zuni to Sun Valley Reach Channel Improvements project was used for the preliminary hydraulic analysis for the new US 6 Bridge over the South Platte River. From the analysis, it was determined that the 100-year discharge at the existing bridge site is 16,500 cubic feet per second (cfs), and the

average velocity through the existing bridge opening is 9 feet per second (fps). The lowest low chord elevation occurs on the downstream side of the existing bridge is 5204.73. The 100-year water surface elevation upstream of the bridge is 5207.42, 2.69 feet higher than the low chord.

The following define the overall length of the bridge opening in the analysis model. The new bridge opening is desired to be at least as wide as the floodway downstream of the bridge, which is approximately 156 feet. To achieve 2 horizontal feet to 1 vertical foot (2:1) embankment slopes, the lower portion of the South Platte River channel is left intact in the model cross sections. Above the lower flow portion of the channel, the 2:1 slopes continue to the potential locations of the abutments. The abutments in the model are set so that some vertical distance is available between the low chord and the bank. Two 4-foot diameter piers are set about 67 feet apart to configure a 3-span bridge. The resulting overall minimum opening is 202.9 feet.

Analysis results show an average velocity through the bridge opening is 7.2 fps, which is less than for existing conditions. The indicated water surface elevation at cross section 11204 is 5206.69. The resulting required bridge low chord is 5209.69. For this level of analysis, the low chord was set at 5210.0.

If necessary, adjustments can be made to the analysis. The bridge opening can be reduced if warranted by additional input on the bridge design parameters. If the minimum vertical distance must be greater, the abutments can be moved in, reducing the bridge opening. If the bridge opening decreases, the low chord elevation of the bridge may need to increase. Also, for one- or two-span bridge configurations, the low chord could potentially be lowered.

6.3 Scour Analysis

For a 3-span bridge configuration with two piers, the piers are assumed to have rounded noses. During the 100-year flood event, the left abutment scour depth is predicted to be 12.8 feet, and the channel/pier scour depth is predicted to be 10.9 feet at the right bank. For a single span bridge, the maximum scour depth is predicted to be 8.3 feet at the left abutment during the 100-year event.

Foundations used in the bridge design should be constructed below the anticipated scour depth. Riprap protection should be used at the abutments and piers and will be provided.

6.4 Future Design Considerations

The hydraulic analysis in this report is based on the existing channel bottom elevation. However, the 1985 Major Drainageway Planning (MDP) shows the South Platte River channel bottom being lowered by approximately 4 feet in the area of the bridge. The bridge design must take into account the future lowering of the South Platte River channel.

7. ENVIRONMENTAL

Potential environmental impacts identified as of July, 2012 for the South Platte River Bridge include Air Quality, Noise, Construction Noise, Historic Resources, Parks and Recreation, Vegetation, Visual, Wildlife and Hazmat. The required mitigation commitments and permits required for the project can be found in *Book 2- Technical Requirements, Section 5- Environmental Requirements*.

8. GEOTECHNICAL

The following preliminary geotechnical foundation discussion is based on the *Geotechnical Memorandum* prepared by RockSol Consulting Group, Inc. and is provided in Appendix E.

Geotechnical information reviewed primarily consisted of engineering geology sheets and borehole logs, from which the depth to bedrock was interpreted based on material descriptions. In addition, the bearing capacity of the bedrock was evaluated, based on available blow count data obtained during drilling and sampling from the previous explorations.

8.1 Site Geology

Based on the borehole logs, overburden soils consist of fill materials associated with development of the project area, especially roadway construction for US 6 and I-25, and native soils consisting of clay, sands, and gravel. The native sands are generally characterized as medium dense and the clays generally characterized as medium stiff to stiff. Some boreholes encountered material identified as “trash”. Sedimentary bedrock was encountered in most boreholes and primarily consisted of claystone with sandstone also encountered in several borings. Groundwater was encountered within the native soils at elevations around 5,190 feet in the vicinity of the South Platte River Bridge.

Boreholes indicate an approximate bedrock elevation of 5,179 feet at the east side of the South Platte River Bridge and an approximate bedrock elevation of 5,173 feet to 5,176 feet at the west side of the bridge.

8.2 Foundation Design Parameters

<u>Drilled Shafts</u>
Drilled shafts will provide axial support by embedment into sedimentary bedrock. Based on their evaluation, RockSol suggests a nominal base resistance of 135 kips per square foot (ksf) and a nominal side resistance of 13.5 ksf for use with Load and Resistance Factor Design (LRFD) methods.

Due to the anticipated depth to bedrock at the proposed bridge locations, the side resistance is applicable to the entire portion of the shaft embedded in competent bedrock. Side resistance in the soil zone above competent bedrock should be neglected. For LRFD strength limit state evaluation, a resistance factor of 0.55 is recommended for base/ tip resistance and a resistance factor of 0.60 is recommended for side resistance evaluation for redundant single shafts. Per *AASHTO LRFD Section 10.5.5.2.4*, the resistance factors for base/tip and side resistance should be reduced by 20 percent for non-redundant single shafts.

A minimum shaft penetration into competent bedrock of 10 feet is suggested for drilled shafts less than 5 feet in diameter. For drilled shafts 5 feet and greater in diameter, a minimum penetration of 15 feet is recommended. A minimum shaft diameter of 36 inches is suggested for axial load resistance for piers.

Driven Piles

Alternatively, driven piles (Grade 50 steel H-pile is assumed) may be considered for the proposed bridges, including the abutments. Evaluation of the effect of pile driving on existing foundations should be considered. RockSol recommends the piles be driven to refusal in the bedrock. Based on anticipated subsurface conditions, practical refusal is estimated to occur within approximately 5 feet of penetration into competent bedrock. Pile driving shall be monitored per CDOT requirements. Monitoring shall be conducted using a Pile Driving Analyzer (PDA) to determine the condition of the pile, the efficiency of the hammer and the static bearing capacity of the pile, and to establish the pile driving criteria.

For the LRFD method, a nominal (ultimate) capacity of 37.5 kips per square inch (ksi), based on the cross section area of the pile, can be used for Grade 50 steel. A resistance factor of 0.65 is recommended for LRFD strength limit state design for axial compression.

9. ARCHITECTURAL REQUIREMENTS

There are no architectural requirements dictated for this bridge although all formed concrete surfaces will have a Class 1 finish (Ordinary Surface Finish) and/or all exposed concrete surfaces will be coated per Standard Specification 509, color to be determined. See project Technical Requirements for additional information.

10. BRIDGE DESIGN CRITERIA

10.1 Design Specifications

The following design criteria were used to evaluate the structure alternatives:

American Association of State Highway and Transportation Officials (AASHTO), *AASHTO LRFD Bridge Design Specifications*, 6th Edition, 2012.

Colorado Department of Transportation (CDOT), *Bridge Design Manual* and "Technical Memorandums", 2009 Revision.

CDOT, *Bridge Detail Manual*, 2012 Revision.

CDOT, *CADD Manual*, 2011 Edition.

CDOT, *Bridge Rating Manual*, 1995 Edition.

CDOT, *Standard Specifications for Road and Bridge Construction*, 2011 Edition.

10.2 Design Method

This project shall be designed for applicable strength, service, and extreme event limit states as defined by the load groups in the AASHTO Load and Resistance Design (LRFD) Specifications.

10.3 Design Loads

10.3.1 Permanent Loads (DC, DW)

Unit Weight Reinforced Concrete	150 pcf
Unit Weight Prestressed Concrete	155 pcf
HBP	36 psf
Utilities (future and existing)	100 lb/lf
Hot Mix Asphalt	140 pcf

10.3.2 Live Loads Roadway Bridge

HL-93 (Design Truck or Tandem with Design Lane Load)
Colorado Permit Vehicle (Strength II)

10.3.3 Bridge Rail

Bridge Rail Type 7	486 lb/lf

10.3.4 Wind Loads

AASHTO LRFD Bridge Design Specification

10.3.5 Thermal Forces (TU)

Thermal Coefficient	0.000006 / ^{o}F
Body Temperature Range	0° F to 80°F (Temperature rise and Design Parameters of 45° F; Temperature drop of 60° F)

10.3.6 Creep and Shrinkage (CR, SH)

In accordance with AASHTO LRFD Bridge Design Specifications
Long Term Camber in accordance with ACI-318 (92)

10.3.7 Extreme Event (EQ)

Earthquake effects in accordance with AASHTO LRFD Bridge Design Specifications, Seismic Performance Zone 1

10.4 Materials

Precast Prestressed Concrete	f'_c = 7500 psi (max)
	f'_{ci} = 6500 psi (max)
Reinforced Concrete	Class D, f'_c = 4500 psi
	Class B, f'_c = 3000 psi
Drilled Caissons	Class BZ, f'_c = 4000 psi
Reinforcing Steel	ASTM A-615, Grade 60
Prestressing Steel	ASTM A-416 Grade 270, Low Relaxation

10.5 Deck Protection

Three inches Hot Bituminous Pavement (H.B.P.) over waterproofing membrane on bridge deck and approach slabs

11. DISCUSSION OF ALTERNATIVE

The superstructure alternative considered in this report has a three span arrangement with an approximate span configuration of 82 feet - 103 feet - 82 feet. The total determined structure length is 274 feet – 6 inches. A proposed center span of 103 feet is about 44 feet longer than the current center span of 59 foot long. New pier locations increase the channel's accessibility for recreational activities. Additionally, the new center span length will accommodate the necessary clear distance from existing piers for the construction of the proposed piers 2 and 3.

Vertical clearance distances for both the hydraulics and the existing bike path have increased to 19 feet - 11 inches. This minimum vertical clearance allows for a 2:1 slope on both east and west embankments of the river.

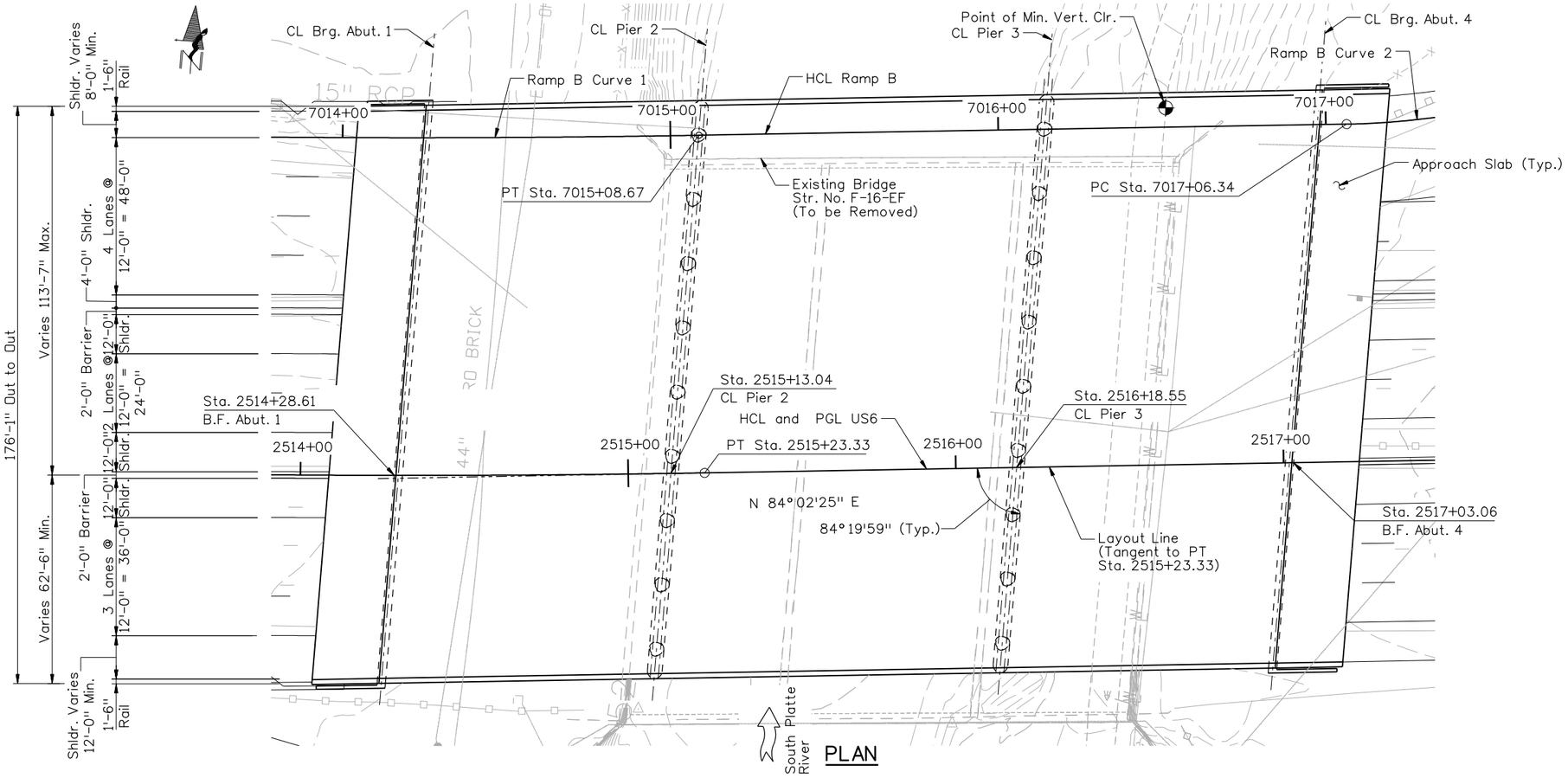
The investigated superstructure alternative is comprised of 63 inch Colorado prestressed concrete bulb-T (BT63) girders with a 9 inch cast in place concrete deck and CDOT Bridge Rail Type 7 along each side of the bridge deck. Preliminary analysis indicates that 14 girder lines spaced at 12 feet -11 inches would meet the design requirements. The superstructure depth for the bulb-t alternative is 6 feet - 4 inches.

12. COST ANALYSIS SUMMARY

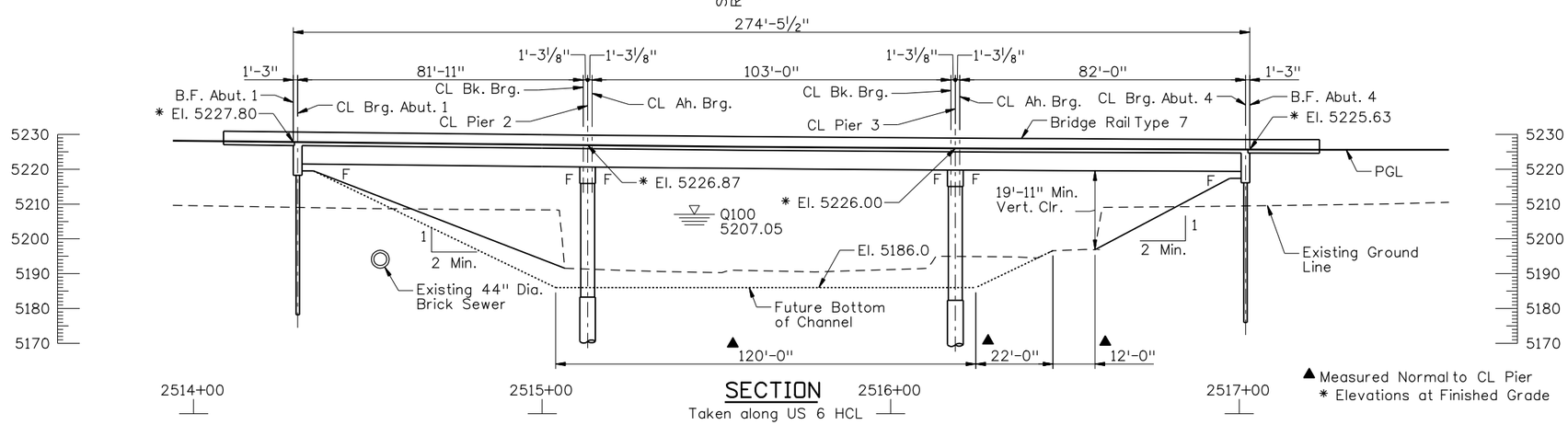
The total estimated cost for construction of the South Platte River replacement bridge is $4,007,802, or $83.00 per square foot. Note that expenses for riprap and structure excavation for riprap are not included in this estimate. Costs associated with the predrilling of piles, which may be required, are also excluded. Details of these projected construction costs are itemized and provided in Appendix F.

APPENDIX A

General Bridge Layout and Typical Section



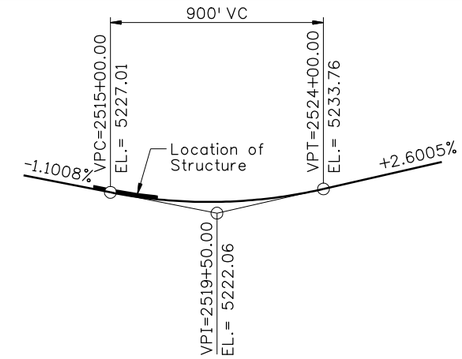
PLAN



SECTION

Taken along US 6 HCL

▲ Measured Normal to CL Pier
* Elevations at Finished Grade



US 6 PROFILE GRADE

RAMP B CURVE 1 DATA

P.I. Sta. = 7012+10.70
Δ = 6° 42'31" (LT)
D = 1° 07'28"
L = 596.62'
T = 298.65'
R = 5095.61'
P.C. Sta. = 7009+12.05
P.T. Sta. = 7015+08.67

RAMP B CURVE 2 DATA

P.I. Sta. = 7018+73.61
Δ = 71° 49'07" (LT)
D = 24° 48'12"
L = 289.55'
T = 167.27'
R = 231.00'
P.C. Sta. = 7017+06.34
P.R.C. Sta. = 7019+95.89

US 6 CURVE DATA

P.I. Sta. = 2510+73.04
Δ = 9° 57'03" (LT)
D = 1° 06'08"
L = 902.86'
T = 452.57'
R = 5198.61'
P.C. Sta. = 2506+20.47
P.T. Sta. = 2515+23.33

Print Date: 7/30/2012	Sheet Revisions			Colorado Department of Transportation	As Constructed
File Name: 18192_PlatteGlt01.dgn	Date:	Comments	Init.	8833 South Wadsworth Court Littleton, CO 80128 Phone: 303-972-9112 FAX: 303-972-9114	No Revisions:
Horiz. Scale: 1:40 Vert. Scale: As Noted	R-X			Region 6 HC	Revised:
Unit Information Unit Leader Initials					Void:

US 6 OVER SOUTH PLATTE RIVER
GENERAL LAYOUT

Designer:	Structure Numbers	F-16-YZ
Detailer:		
Sheet Subset:	Subset Sheets:	of

Project No./Code
US 6 BRIDGES
DESIGN BUILD PROJECT
18838
Sheet Number

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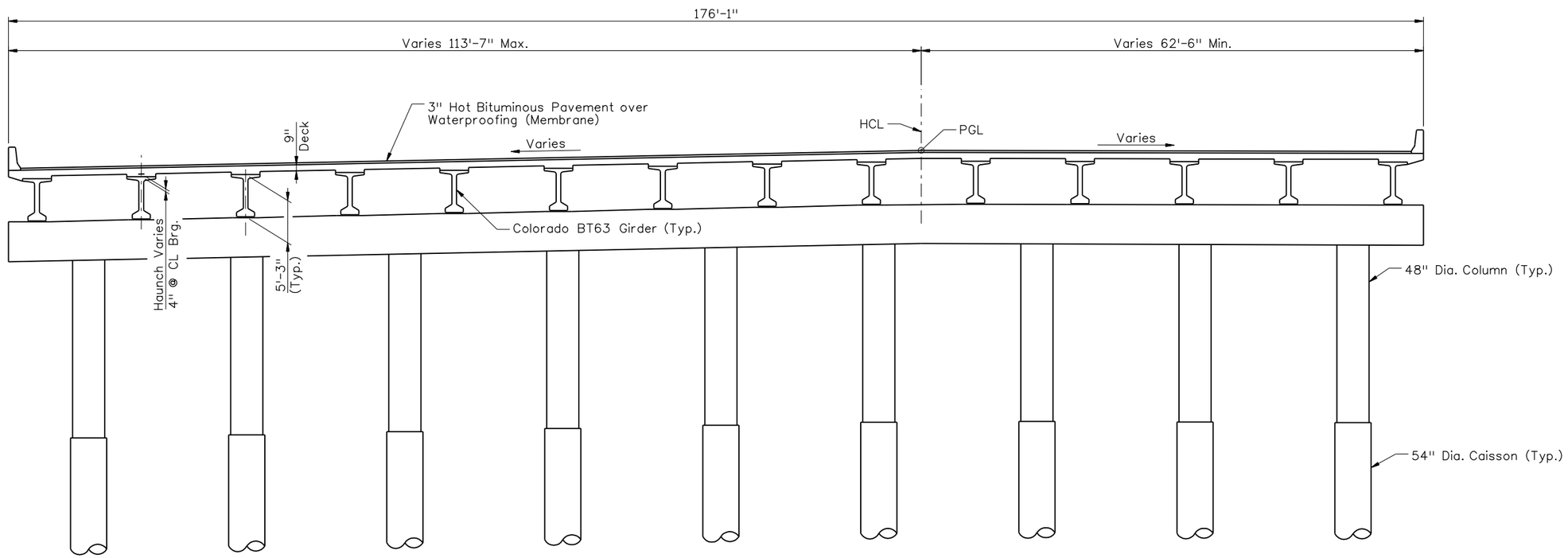
7/30/2012



TYPICAL SECTION

Print Date: 7/30/2012		Sheet Revisions			Colorado Department of Transportation	As Constructed	US 6 OVER SOUTH PLATTE RIVER TYPICAL SECTION	Project No./Code
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Horiz. Scale: 1:15 Vert. Scale: As Noted	R-X				Region 6 HC	Revised:	Designer: / Structure Numbers F-16-YZ	18838
Unit Information Unit Leader Initials						Void:	Detailer: / Sheet Subset: / Subset Sheets: of	Sheet Number

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7/30/2012

APPENDIX B

Structure Inspection Report

Highway Number (ON) 5D: 0006G 1

Mile Post (ON)11: 284.345 mi

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Bridge Key: F-16-EF | Inspection Date: 12/28/2009 | Sufficiency Rating: 42.8 SD

Rgn/Sectn 2E/2M:	68	Hist Signif 37:	5	UW Inspection Date 93B	
Trans Region 2T	02	Posting status 41:	A	SI Date 93C:	
County Code 3:	031	Service on/un 42A/B:	1 5	Bridge Cost 94:	$ 5,605,600
DENVER		Main Mat/Desgn 43A/B:	4 2	Roadway Cost 95:	$ 560,560
Place Code 4:	20000	Appr Mat/Desgn 44A/B:	0 0	Total Cost 96:	$ 8,408,400
DENVER		Main Spans Unit 45:	3	Year of Cost Estimate 97:	2007
Rte.(On/Under)5A:	1	Approach Spans 46:	0	Brdr Brdg Code/% 98A/B:	
Signing Prefix 5B:	2	Horiz Clr 47:	81.0 ft	Border Bridge Number 99:	
Level of Service 5C:	1	Max Span 48:	59.1 ft	Defense Highway 100:	0
Directional Suffix 5E:	0	Str Length 49:	159.0 ft	Parallel Structure 101:	N
Feature Intersected 6:		Curb Wdth L/R 50A/B:	3.0 ft 0.0 ft	Direction of Traffic 102:	2
SOUTH PLATTE RIVER		Width Curb to Curb 51	162.0 ft	Temporary Structure 103	_
Facility Carried 7:		Width Out to Out 52:	172.5 ft	Highway System 104:	1
US 6 ML		Deck Area:	27,430. sq. ft	Fed Lands Hiway 105:	0
Alias Str No.8A:		Min Clr Ovr Brdg 53:	99.99	Year Reconstructed 106	1967
#F-16-EE		Min Undrclr Ref 54A:	N	Deck Type 107:	1
Prll Str No. 8P		Min Undrclr 54B:	0.0 ft	Wearing Surface 108A	6
F-16-EE		Min Lat Clrnce Ref R 55A:	N	Membrane 108B:	2
Location 9:		Min Lat Undrclr R 55B:	0.0 ft	Deck Protection 108C:	0
W SIDE OF I-25 INT. DENVR		Min Lat Undrclr L 56:	0	Truck ADT 109:	2 %
Max Clr 10:	99.99	Deck 58:	5	Trk Net 110:	1
BaseHiway Net12:	1	Super 59:	5	Pier Protection 111:	#
IrsinvRout 13A	000000006G	Sub 60:	4	NBIS Length 112:	Y
IrssubRout No13B:	00	Channel/Protection 61:	7	Scour Critical 113:	8
Latitude 16:	39d 43' 31"	Culvert 62:	N	Scour Watch 113M:	_
Longitude 17:	105d 00' 58"	Oprtng Rtg Method 63:	1 LF Load Facto	Future ADT 114:	167,671
Range18A:	68 W	Operating Rating 64:	37.0	Year of Future ADT 115	2025
Township18B:	68	Inv Rtng Method 65:	1	CDOT Str Type 120A:	CIC
Section18C:	5	Inventory Rating 66:	22.0	CDOT Constr Type 120B	0.
Detour Length 19:	2.0 mi	Asph/Fill Thick 66T:	002 "in"	Inspection Indic 122A:	
Toll Facility 20:	3	Str. Evaluation 67:	4	Inspection Trip 122AA	
Custodian 21:	1	Deck Geometry 68:	9	Scheduling Status 122B	
Owner 22:	1	Undrclr Vert/Hor 69:	N	Maintenance Patrol 123:	7
Functional Class 26:	12	Posting 70:	5	Expansion Dev/Type124	B
Year Built 27:	1956	Waterway Adequacy 7	8	Brdg Rail Type/Mod 125A/B	Y 4
Lanes on 28A:	9	Approach Alignment 72:	8	Posting Trucks 129A/B/C	0 0 0
Lanes Under 28B:	0	Type of Work 75A:	31	Str Rating Date 130:	5/1/1996
ADT 29:	140,900	Work Done By 75B:		Special Equip 133:	-1
Year of ADT 30:	2005	Length of Improvment 76:	157.5 ft	Vert Clr N/E 134A/B/C:	X 99.99 0.00
Design Load 31:	6	Insp Team Indicator 90B	GREEN TEAM (	Vert Clr S/W 135A/B/C	X 99.99 0.00
Apr Rdwy Width 32:	162.0 ft	Inspector Name 90C:	MOSST	Vertical Clr Date:	1/1/1901
Median 33:	2	Frequency 91:	24 months	Weight Limit Color: 139	0
Skew 34:	5.00 °	FC Frequency 92A:	-1	Str Billing Type:	U
Structure Flared 35:	0	UW Frequency 92B:	-1	Userkey 1 - System:	ONSYS
Sfty Rail 36a/b/c/d:	1 1 1 1	SI Frequency 92C:	-1	Userkey 7-Update Indic	
Rail ht36h:	51 "in"	FC Inspection Date 93A:			

Inspector Name: MOSST

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Element Inspection Report

Elm/Env	Description	Units	Total Qty	% in 1	CS 1	% in 2	CS 2	% in 3	CS 3	% in 4	CS 4	% in 5	CS 5
14/4	P Conc Deck/AC Ovly	(SF)	27,430	100 %	27,430	0 %	0	0 %	0	0 %	0	0 %	0
107/4	Paint Stl Opn Girder	(LF)	3,611	90 %	3,244	5 %	167	5 %	171	1 %	25	0 %	4
205/4	R/Conc Column	(EA)	22	91 %	20	9 %	2	0 %	0	0 %	0	0 %	0
215/4	R/Conc Abutment	(LF)	348	70 %	242	20 %	70	10 %	36	0 %	0	0 %	0
234/4	R/Conc Cap	(LF)	304	29 %	89	12 %	35	43 %	130	16 %	50	0 %	0
302/4	Compressn Joint Seal	(LF)	173	0 %	0	42 %	73	58 %	100	0 %	0	0 %	0
308/4	Constr Non Exp Jt	(LF)	346	88 %	306	12 %	40	0 %	0	0 %	0	0 %	0
311/4	Moveable Bearing	(EA)	69	0 %	0	94 %	65	6 %	4	0 %	0	0 %	0
313/4	Fixed Bearing	(EA)	23	100 %	23	0 %	0	0 %	0	0 %	0	0 %	0
321/4	R/Conc Approach Slab	(EA)	2	100 %	2	0 %	0	0 %	0	0 %	0	0 %	0
326/4	Bridge Wingwalls	(EA)	4	100 %	4	0 %	0	0 %	0	0 %	0	0 %	0
331/4	Conc Bridge Railing	(LF)	318	100 %	318	0 %	0	0 %	0	0 %	0	0 %	0
334/4	Metal Rail Coated	(LF)	318	47 %	149	50 %	159	3 %	10	0 %	0	0 %	0
338/4	Conc Curbs/SW	(LF)	477	58 %	277	10 %	50	31 %	150	0 %	0	0 %	0
359/4	Soffit Smart Flag	(EA)	1	0 %	0	100 %	0	0 %	1	0 %	0	0 %	0
501/4	Channel Cond	(EA)	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0
502/4	ChannProtMatCond	(EA)	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0
504/4	BankCond	(EA)	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0
505/4	Debris Smart Flag	(EA)	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0

Elem/Env	Description	Element Notes
14/4	P Conc Deck/AC Ovly	2 inches of asphalt - Light raveling in wheel lines & along seams. Starting to rut in wheel lines.

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Elem/Env	Description	Element Notes
107/4	Paint Stl Opn Girder	Exterior web of girder 1W, and bottom flange have R2 to R3 corrosion especially at deck drain. Heavy flaking rust, R2 corrosion at 2B, 2F, 2K, and 2L. R2 to R3 corr. at base of webs on girders B, C, D, L, and V at P2. R3 corr. at girders K and L at P2 and L at P3. R3 corrosion at base of web and top flange of girder A, I, L, T, U, V, and W at P2 and R3 top flange of girder W at P2. R4 on ends at abutment 3 of girders 3T, 3U, 3V, & 3W at Abutment 4. Heavy corrosion (R3), on diaphragm at bays K & L at both piers. See 2008 photos. See Notes & Sketch for info on 1977 FIRE & replacement of Girders. There are short, less than 2 ft. long, cover plates welded on bottom of Girders 1T through 1W, 2009 PHOTO, at midspan.
205/4	R/Conc Column	Columns look good for most part. Some have vertical and random cracks. Debris walls between columns, have minor stream abrasion. P3 under girders 3F and 3G has moderate stream abrasion. P3 nose, and 3C delamination. P2 column 2A & 2C have delam.
215/4	R/Conc Abutment	Retaining wall abutments - Horizontal delamination cracks along seats. Vertical cracks at construction joints with seepage. Vertical cracks in backwalls with efflor. and rust stains. Moderate random 1/2 inch cracks with spalls delamination, and efflor. in bay 1S, trans. and shrinkage cracks between bays M-S at A-1. Horizontal crack (1/8 inch wide) 4-5 ft. below the seat of A-1 between bays D & J. It was patched but ineffective. Abutment 4 spall at bay A; active leakage 2008 insp., See 2008 photo. Both badly stained from leaking deck joints.

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Elem/Env	Description	Element Notes
234/4	R/Conc Cap	Original (1956) portions of piers (Below the riveted girders are generally worst) PIER 2 - Horiz. delam. cracking below edge of seat, (some spalled with rebar exposed) at girders 1A to 1B, 1D, 1G, 1H, 1I, 1M, 1N, 1Q , 1R, & 1S; then forward face at 2A to 2D, 2E, 2F, 2J (10 s.f face spalling with exposed rebar), 2K to 2M o 2O, 2Q - (forward face completely spalled bays 2Q to 2S, full height of most stirrups with R2 & R3 corrosion, & Top & Bottom main reinf. seen corroding too 12-2009 PHOTO) Bad rust stains (badly infiltrated) left end of Pier 2, 2009 PHOTO. Bottom of Pier 2 cap has delam. cracks with rust stains, pulled some off / spalled 2 inches deep to the main reinf. below Bay F, 2009 PHOTOs. PIER 3 - Horiz. delam. cracking below edge of seat (or spalled) at girders 2R to 2S; forward face - 3K to 3M, (spalling), 3N, 3O, 3R to 3W. Rt. end & Bay V badly spalled, both faces - stirrups exposed with R3 & R4 Corrosion. The TOP of Cap also spalled, more main reinf. over column exposed & losing section, R3 corr. bay V.
302/4	Compressn Joint Seal	Compression seal below the asphalt cover along Abut. 4. Asphalt cracked and breaking up all along joint and creating medium size potholes, (a couple of s.f. x few inches deep); see 2008 PHOTOS.
308/4	Constr Non Exp Jt	Along Abut. 1 & Piers - Asphalt cover - there is a light crack along Abut. 1. Signs of leakage below, worst at bays K & L at both piers. See 2008 PHOTO.
311/4	Moveable Bearing	Rockers At both Piers & A-4 - Heavy Rust and R2 corrosion on rockers and plates at P-3 & A-4. R2 corrosion at 2F, 3L and 3W. R3 corr. with section loss at brgs A, K, L and W at P2.
313/4	Fixed Bearing	At A-1 - R1corrosion on plates.
321/4	R/Conc Approach Slab	Overlaid - Longit. cracks along with raveling & rutting wheel lines. Smooth transitions though, no settling.
326/4	Bridge Wingwalls	Flared; Map cracks; Efflorescence at cold joints; Small chip #1 right.
331/4	Conc Bridge Railing	Portable Jersey barrier, type R, along median and on top of right curb (in front of old type U steel rail left in place), 2009 PHOTOs. Corner broken off 2nd barrier. Some scuff marks along them.

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Elem/Env	Description	Element Notes
334/4	Metal Rail Coated	Galvanized square tube rails, Type Y rail, on left side, new in 2001; still good cond. The right side has Concrete Jersey barriers in front of the original Valley Highway rail, old style with multiple pipe posts, Type U. This old-style rail painted but there is some R3 corrosion at base of pipe posts, 2009 PHOTOs. This rail was left in-place rather than removed when the approved barrier placed in front of it - old rail is not being effective, OK.
338/4	Conc Curbs/SW	Includes exterior curbs & WBL lane divider. Right side with jersey barrier on top now, has horizontal cracks,rust stains, and delamination on gutter face, exposed rebar @ P-2, 2009 PHOTO. Right backside also has longit cracks. Left curb has longit. cracks, with light scale on backside in span 1.
359/4	Soffit Smart Flag	Random cracks throughout. Many trans cracks with efflorescence all spans. Some areas of map cracking & scale with efflor., bays 1A, 1B (12-2009 PHOTO including longit. cracking), 1C, K & L the worse and with rust stains and active leaking. Deterioration, spalling & seepage, around old deck drains, 12-2009 PHOTOs, in bays, both sides of Gir. D & F, right side of gir. L . Spall in bay 2F. Spalls with exposed rebar in bays 1E, 1H and at A1 left edge.
501/4	Channel Cond	South Platte River - Reservoir about 15 miles upstream. Year-round flow; good alignment. Sand and silt bed. Gentle, low flow thru this section at this time.
502/4	ChannProtMatCond	Bike path along Abut. 4. Shallow sheet piling in front of retaining wall Abut. 1 up to about waterline. Some loosely scattered riprap on banks in spots.
504/4	BankCond	Steep. Built up. Rock and dirt/ grass/ bushes. Span 3 has pipe outlet causing erosion trough to Pier 3.
505/4	Debris Smart Flag	A little drift wood and trash in channel.

Maintenance Activity Summary

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
356.02	Curb & Rl	1/3/2002	-1	2011	5000

Consider repairing the right curb, where it has cracked, delaminated & spalling exposing rebar. However, it is under the temporary Jersey barrier in front of the old 'valley highway' steel rail.

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Maintenance Activity Summary

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
**358.05	Substr	1/3/2002	-1	2011	30000

Pier 3 right end may need additional support - some corroded stirrups have broken.

REHABILITATE the delaminated and spalled concrete from pier caps to retain the remaining integrity.

Properly preparing the surface via saw-cutting (to eliminate feathered edges) then adequately chipping & cleaning concrete and steel then applying an approved grout per manufactures'

355.02	Cln & Pnt	1/3/2002	-1	2011	5000

Clean and spot paint the ends of the steel girders, at the supports, and their bearings.

*353.08	Br Dk Rpr	1/3/2002	-1	2010	20000

Abut. 4 should have a real expansion joint installed to protect the bearings and abutment as well as have a smooth surface.

Seal asphalt cracks above the Piers, the piers are spalling.

*354.02	Suprstr	2/4/2008	-1	2011	1000

Repair Girder ends at Abutment 4. Girders T, U, V, and W have R4 corrosion holes.

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Bridge Notes

Utilities - 2.5 inch diameter metal conduit attached to face of Abut. 4 full width.
Platte River Bike path along Abut. 4.

Tanker Fire on bridge in 1977 - Replaced 11 lines (A through K) Girders from Abut 4 to 1st splice plate in Span 2 & deck above these girders & rehabbed left 1/2 of Pier 3.

EB & WB Bridges were widened & combined at median in 1967, 4 girders on both sides & 3 along median, Widening girders are welded but originals were riveted.

Inspection Notes

Time:) 10:00 Temp.:) 25-30 deg. F. Weather:) Clear Team Leader:) TAM

Scope:

☑ **NBI:** ☑ **Element:** ☐ **Underwater:** ☐ **Fracture Critical:** ☐ **Other:** **Type:** Regular NBI

Inspector: MOSST **Inspection Team:**

Inspection Date: 12/28/2009

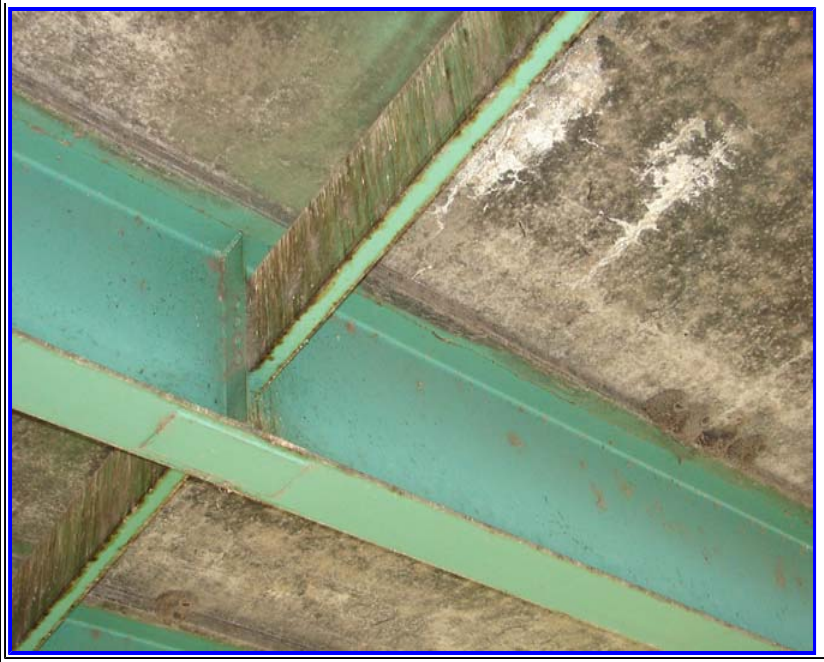
Inspector

Inspector

APPENDIX C

Existing Bridge Photos

			file_size	
	F16EF Spalling on rt end of P3 cap exposed loose heavily corroded stirrups.JPG taken: 2009/12/28 2:45	posted: 2010/05/03	685719	\\public\
	F16EF Spalling on Pier 2 cap face Bays 2Q to 2S.JPG taken: 2009/12/28 2:45	posted: 2010/05/03	731018	\\public\

	F16EF Short cover plate welded to bottom flange of girder 1V, typ of 1T to 1W.JPG taken: 2009/12/28 1:12	posted: 2010/05/03	586121	\\public\
	F16EF Right curb has horiz delam cracking below edge & starting to spall, this is at P2.JPG taken: 2009/12/28 1:28	posted: 2010/05/03	618885	\\public\

	F16EF Old painted steel rail has portable jersey barrier placed in front of it.JPG taken: 2009/12/28 1:22	posted: 2010/05/03	629099	\\public\
	F16EF Moisture & significant rust stains & delam cracks on left end of Pier 2 cap.JPG taken: 2009/12/289 12:	posted: 2010/05/03	587114	\\public\

	F16EF Longit crack & map cracking wiht efflor & rust stains in bay 1B, similar in 1A.JPG taken: 2009/12/289 12:	posted: 2010/05/03	561716	\\public\
	F16EF Drains on both sides of Gir 1D.JPG taken: 2009/12/289 12:	posted: 2010/05/03	590137	\\public\

	F16EF Delam cracking & spall on bottom of Pier 2 cap below bay F.JPG taken: 2009/12/28 2:55	posted: 2010/05/03	787191	\\public\
	F16EF delam cracking & rust stains on bottom of Pier 2 cap.JPG taken: 2009/12/28 1:53	posted: 2010/05/03	627704	\\public\

			file_size	
	F16EF Closeup of spall with exposed corroding rebar on bottom of Pier 2 cap below bay F.JPG taken: 2009/12/28 2:55	posted: 2010/05/03	902914	\\public\
	F16EF Badly spalled top of pier 3 cap.JPG taken: 2009/12/28 2:39	posted: 2010/05/03	880107	\\public\

	F16EF Badly spalled right end of Pier 3.JPG taken: 2009/12/28 2:41	posted: 2010/05/03	853658	\\public\
	F16EF Badly spalled right end & forward face of Pier 3 cap.JPG taken: 2009/12/28 2:41	posted: 2010/05/03	825221	\\public\

	F16EF Pier Cap 3 right end, and under 3W with spalling with exposed rebar. Bay 3V and column with spalling exposed rebar and d taken: 2008/02/05 3:31	posted: 2008/02/06	1377714
	F16EF A4 Breast wall and Abutment seat with vertical, diagonal, and horizontal cracks. Efflorescence, Rust stains, and active m taken: 2008/02/05 3:14	posted: 2008/02/06	1622355

	F16EF A4 Close up of potholes forming at the joint.JPG taken: 2008/02/04 8:35	posted: 2008/02/06	1005016
	F16EF A4 Close up of abutment seat with exposed rebar at the horizontal crack, just up from metal conduit.JPG taken: 2008/02/04 8:48	posted: 2008/02/06	1324588

	F16EF-c_12_.JPG taken: 2008/02/04 8:42	posted: 2009/01/09	1586542	e:\web\f
	F16EF-b_11_.JPG taken: 2008/02/04 9:11	posted: 2009/01/09	1233018	e:\web\f

			file_size	
	F16EF-a_13_.JPG taken: 2008/02/04 8:34	posted: 2009/01/09	1258736	e:\web\f
	F16EF A4 Breast wall with Metal conduit electrical that has R4 corrosion.JPG taken: 2008/02/04 8:42	posted: 2008/02/06	1461759	

	F16EF Girders K,L,& M have heavy R2 corrosion on the bottom flange.JPG taken: 2008/02/0410:08	posted: 2008/02/06	1611354
	F16EF This is Girder 3W with R4 corrosion holes about 4 inches long.JPG taken: 2008/02/04 8:54	posted: 2008/02/06	1168247

	F16EF Span 1 concrete jersey barrier has deep diagonal crack at the joint.JPG taken: 2008/02/0410:35	posted: 2008/02/06	1201028
	F16EF Right side of girder 1W has heavy R2 corrosion as the Drain pipe needs to be extended. Span 1.JPG taken: 2008/02/0410:33	posted: 2008/02/06	1407053

	F16EF This is Girder 3U with R4 corrosion. Hole is about 6 inches long.JPG taken: 2008/02/04 8:54	posted: 2008/02/06	1405228
	F16EF Pier Cap has spalled with exposed rebar under girder 3S to the sole plate, and bay 3R.JPG taken: 2008/02/04 9:33	posted: 2008/02/06	1392295

	F16EF Pier Cap 2 at Girder 2M. Spall is to the Edge of the Sole Plate at both sides .JPG taken: 2008/02/0410:20	posted: 2008/02/06	1666147
	F16EF Pier 3W with spalling and exposed rebar. There is no bearing loss at this time. Spall goes to the sole plate.JPG taken: 2008/02/04 9:40	posted: 2008/02/06	1185868

			file_size
	F16EF Pier 3 Girders 3M and 3N with diaphragms have R3 corrosion.JPG taken: 2008/02/04 9:19	posted: 2008/02/06	1512714
	F16EF Pier 2 Cap with spalling exposed rebar, rust stains under girders 2B, 2C, 2D, and 2E.JPG taken: 2008/02/04 9:47	posted: 2008/02/06	1655217

	F16EF Pier 2 Cap 1K-1M with large horizontal crack and Delam.JPG taken: 2008/02/0410:08	posted: 2008/02/06	1549305
	F16EF Girders 3V and 3W with R4 corrosion holes.JPG taken: 2008/02/04 9:03	posted: 2008/02/06	1637916

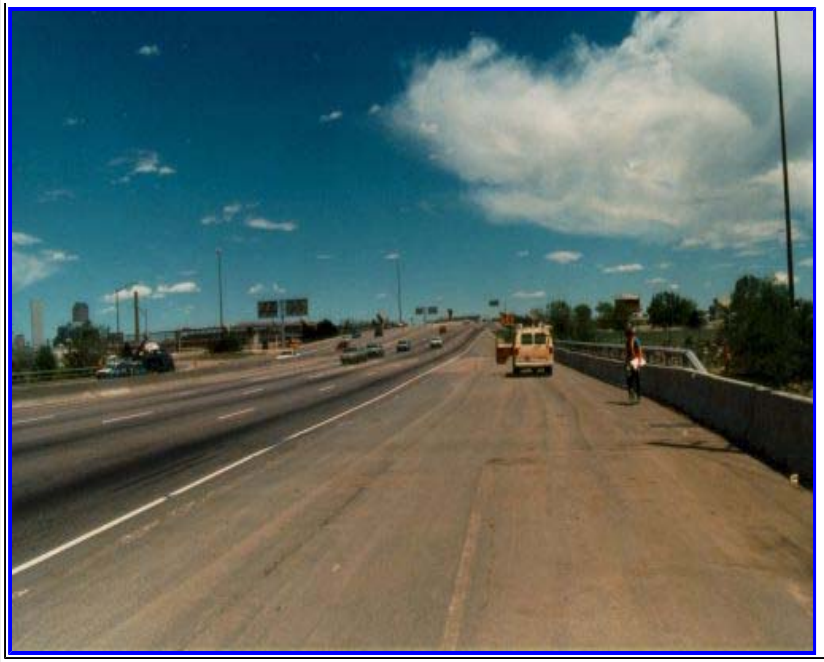
	F16EF Concrete Jersey Barrier in theMedian has small spalls near the base and vertical cracks.JPG taken: 2008/02/04 8:36	posted: 2008/02/06	834642
	F16EF Abutment 1 medium vertical cracks with efflorescence. This is Bay 1D.jpg taken: 2008/02/04 3:45	posted: 2008/02/06	2052590

	F16EF A4 Joint potholing in both directions.JPG taken: 2008/02/04 8:35	posted: 2008/02/06	1078852
	F16EF Pier3 Cap with Spalling with exposed rebar, Delam, and rust stains under girders 3M, 3N, and 3O just to the sole plate b taken: 2008/02/04 9:30	posted: 2008/02/06	1340134

	F16EF A4 Joint is cracked and starting to pothole.JPG taken: 2008/02/04 8:35	posted: 2008/02/06	1403548
	F16EF PIER 2 Cap Below Girders 2S and 2R - Spalled with exposed rebar.JPG taken: 2006/01/25 1:05	posted: 2006/03/09	726784

			file_size
	F16EF PIER 2 CAP BELOW GIR 2J - Spalled with exposed rebar.JPG taken: 2006/01/2512:45	posted: 2006/03/09	644028
	F16EF Right end PIER 3 CAP spalling and broken strap rebar..JPG taken: 2006/01/25 1:38	posted: 2006/03/09	570952

	Inspector photos_4_.JPG taken: 2004/11/24 1:17	posted: 2009/01/09	81844	e:\web\f
	Inspector photos.JPG taken: 2004/11/24 1:17	posted: 2009/01/09	94642	e:\web\f

	DTD archives_2_.JPG taken: 2004/11/23 7:32	posted: 2009/01/09	23911	e:\web\f
	DTD archives.JPG taken: 2004/11/23 7:32	posted: 2009/01/09	27295	e:\web\f

APPENDIX D

Hydraulics Report

Preliminary Bridge Hydraulics Report

US6 Bridges Design Build Project
BR 0061-083
Sub Account Number 18838 (CN)

Denver, Colorado

Prepared for
Colorado Department of Transportation

Prepared by
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July 6, 2012

Olsson Associates Project No. 011-2359

OLSSON ASSOCIATES

Preliminary Bridge Hydraulics Report
US6 Bridges Design Build Project
BR 0061-083
Sub Account Number 18838 (CN)

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Appendix

Bridge Upstream and Downstream Cross Sections

100-year Scour Calculations – 3-span Bridge

100-year Scour Calculations – Single Span Bridge

FIRM Panel

CLOMR Model HEC-RAS Output

3-span Bridge Model HEC-RAS Output

Figure 1 – 100-Year Floodplains

Preliminary Bridge Hydraulics Report
US6 Bridges Design Build Project
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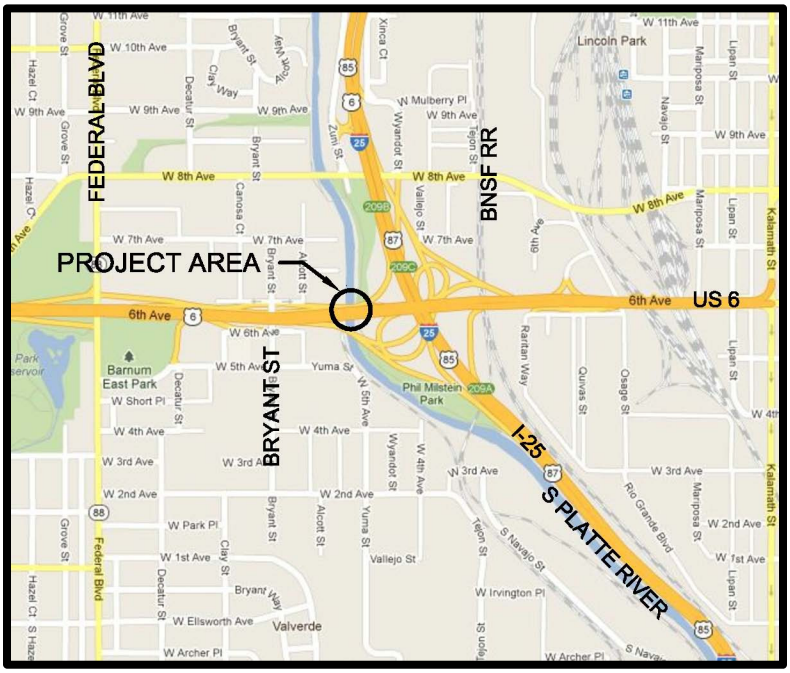
1.0 Introduction

The purpose of this report is to identify the minimum requirements for a new bridge on US6 over the South Platte River and to evaluate the resulting floodplain impacts. The bridge is located in Section 8 Township 4 South Range 68 West in the City and County of Denver, Colorado. The project location is shown in the Vicinity Map.



Vicinity Map

2.0 Hydrology

2.1 Previous Studies

A Flood Hazard Area Delineation (FHAD) was prepared for the South Platter River from Sand Creek to Oxford by Wright Water Engineers in September 1985. A Major Drainageway Plan (MDP) was prepared for the river from Chatfield Dam to Baseline Road by Wright Water Engineers in November 1985.

Urban Drainage and Flood Control District (UDFCD) and City and County of Denver (CCD) have constructed the Zuni and Sun Valley Reach Channel Improvements project, from approximately 100 feet upstream of Spear Boulevard to approximately 360 feet downstream of 3rd Avenue. A conditional Letter of Map Revision (CLOMR) was completed by Matrix Design Group in April 2009 and approved for this work. The CLOMR was assigned Case No. 09-08-0632R. A Letter of Map Revision (LOMR) has been submitted for review. These improvements reduce the 100-base flood elevations (BFEs) and flood plain extents on the South Platte River

through the subject project area. The HEC-RAS model from the approved CLOMR was used for the preliminary hydraulic analysis of the new US6 bridge.

2.2 Peak Discharges

Peak discharges at the US6 bridge were obtained from the approved CLOMR model and are presented in Table 1.

Table 1 – Peak Discharge at US6 Bridge (cfs)

River Station	10-Year	50-Year	100-Year	500-year
11014 (Downstream of US6)	7,550	15,000	19,200	31,500
11204 (Upstream of US6)	6,400	12,700	16,500	31,500

3.0 Existing Structure

The original existing structures appear to have been constructed around 1955, based on as-built plans. The structure ID Numbers are F-16-EE and F-16-EF for the north and south structures, respectively. The structures appear to have been widened about 1967.

Photo 1 – Existing US6 bridges over the South Platte River

4.0 Design Discussion

4.1 Freeboard Criteria

The freeboard requirement was obtained from Chapter 8 of the Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual. The City and County of Denver's Storm Drainage Design and Technical Criteria Manual refers to the UDFCD manual for bridge criteria. The manual states that the distance between the design flow water surface

and the bottom of the bridge deck should be a minimum of three feet for the 100-year flood on larger streams or rivers where large floating debris is likely.

4.2 Hydraulic Analysis and Recommended Design

The HEC-RAS model from the Zuni to Sun Valley Reach Channel Improvements CLOMR submittal was used for analysis. HEC-RAS model version 3.1.3 was used for both the CLOMR analysis and the bridge analysis for this study.

The 100-year discharge at the location of the bridge is 16,500 cfs. The average velocity through the existing bridge was 9.0 fps. The lowest low chord elevation on the existing bridge was 5204.73, which occurred on the downstream side. The 100-year water surface elevation upstream of the bridge, at cross section 11204 in the HEC-RAS model, was 5207.42, 2.69 feet higher than the low chord.

It was desired that the new bridge opening length should be at least as wide as the floodway downstream of the bridge, which is approximately 156 feet. To achieve 2 horizontal to 1 vertical side slopes (2:1) to the bridge abutments, the lower portion of the South Platte River channel was left intact in the model cross sections. Above the lower flow portion of the channel bottom, the 2:1 slope started and continued to the locations where the abutments might intersect the slopes. The abutments were set so that some vertical distance was available between the low chord and the bank. The vertical distances were 1.5 feet and 2.8 feet. These locations defined the overall length of the bridge opening. If the minimum vertical distance must be greater, the abutments can be moved in, reducing the bridge opening length. Two piers of 4-foot diameter were set to indicate a 3-span bridge. The piers are 67-68 feet apart.

The resulting overall opening was 202.9 feet long. The average velocity through the bridge was 7.2 fps, less than for existing conditions. The water surface elevation at cross section 11204 was 5206.69. The resulting required bridge low chord would be 5209.69. For this level of analysis, the low chord was set at 5210.0. The bridge opening can be reduced if warranted by additional input on the bridge design parameters. If it does decrease, the low chord elevation of the bridge might need to increase. If a 1- or 2-span bridge were used, the low chord could potentially be slightly lowered. Upstream and downstream cross sections of the bridge opening are included in the Appendix.

An existing 44-inch diameter brick sanitary line is located west of the bridge. The center line of the sanitary line is approximately 31.7 feet away from the proposed west bridge abutment.

4.3 Design Considerations for Potential Future Projects

The 1985 MDP shows the South Platte River channel bottom being lowered by approximately 4 feet in the area of the bridge. The bridge design must take into account the future lowering of the South Platte River. The hydraulic analysis in this report is based on the existing channel bottom elevation.

5.0 Scour Analysis

A preliminary analysis was prepared to evaluate the scour potential at the US6 bridge opening needed to convey the 100-year South Platte River flow and meet freeboard requirements.

Soil boring information near the bridge was provided by RockSol Consulting Group, Inc. The borings indicated the soils are generally sand over sandstone bedrock. Soil boring 10 was located south of the existing bridge in the South Platte River channel. Sandstone bedrock was encountered at a depth of 14 feet. Soil boring 11 was located in the channel north of the bridge. Sandstone bedrock was encountered at a depth of 8 feet.

The HEC-RAS model from the approved CLOMR for the South Platte River Zuni to Sun Valley reach was used as the basis of the bridge analysis. A 3-span bridge and a single-span bridge were evaluated.

Input parameters of d_{50} = 1.0 mm and d_{95} = 2.0 mm were used in the analyses. For the 3-span bridge with two piers, the piers were assumed to have rounded noses. For the 3-span bridge, the left abutment scour depth was predicted to be 12.8 feet, and the channel/pier scour depth was predicted to be 10.9 feet at the right bank during the 100-year event. For the single span bridge, the maximum scour depth was predicted to be 8.3 feet at the left abutment during the 100-year event. Scour calculations are included in the appendix.

Foundations used in the bridge design should be constructed below the anticipated scour depth. Riprap protection should be used at the abutments and piers. Riprap size and dimensions of protection should be determined as the design progresses.

6.0 Floodplain Analysis

The South Platte River in the project area is channelized. The existing US6 bridge low chord is below the 100-year water surface elevation. Although the bridge is not overtopped, it causes a rise in the 100-year water surface elevation upstream of US6. Upstream of US6, the west bank is not adequate to contain the 100-year discharges. As a result, extensive flooding occurs on the low-lying west side of the South Platte River from Vallejo Street to 6th Avenue, affecting many warehouses, retail stores, and small fabricating shops. In places, the floodplain in this area is more than 1,500 feet wide. The effective Flood Insurance Rate Map (FIRM) is included in the Appendix.

The South Platte River Zuni to Sun Valley reach CLOMR was prepared for improvements along the river downstream of 8th Avenue. Those improvements reduce the 100-year floodplain in the vicinity of this project.

In the proposed preliminary alternative, the South Platte River bridge low chord will be a minimum of 3 feet above the 100-year water surface elevation to meet UDFCD and CCD freeboard requirements, allowing the 100-year flood to pass underneath. Without the obstruction of the bridge, the upstream water surface elevation will be lowered by 0.5 foot to 0.7 foot and the floodplain will be reduced. However, shallow flooding will still exist on the west side of the river, due to the low bank elevations upstream of US6. HEC-RAS output for the original CLOMR model and the 3-span bridge are included in the appendix. The floodplain map showing the effective FEMA floodplain, CLOMR floodplain and US6 bridge replacement floodplain is shown in Figure 1.

7.0 Agency Coordination

Approvals from UDFCD, CCD, Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers will be needed for the US6 bridge construction over the South Platte River.

8.0 References

Urban Drainage and Flood Control District. April 2008. *Urban Storm Drainage Criteria Manual Vol. 2, Chapter 8: Hydraulic Structures*.

U.S. Army Corps of Engineers Hydrologic Engineering Center. May 2005. Hydrologic Engineering Center River Analysis System (HEC-RAS) Version 3.1.3.

Wright Water Engineers, Inc. November 1985. *Major Drainageway Plan: South Platte River Chatfield Dam to Baseline Road, Phase B – Volume 1: Preliminary Engineering Design*.

Wright Water Engineers, Inc. September 1985. *Flood Hazard Area Delineation: South Platte River Denver Metropolitan Area Sand Creek to Oxford Avenue*.

Appendix

Bridge Upstream and Downstream Cross Sections

100-year Scour Calculations – 3-span Bridge

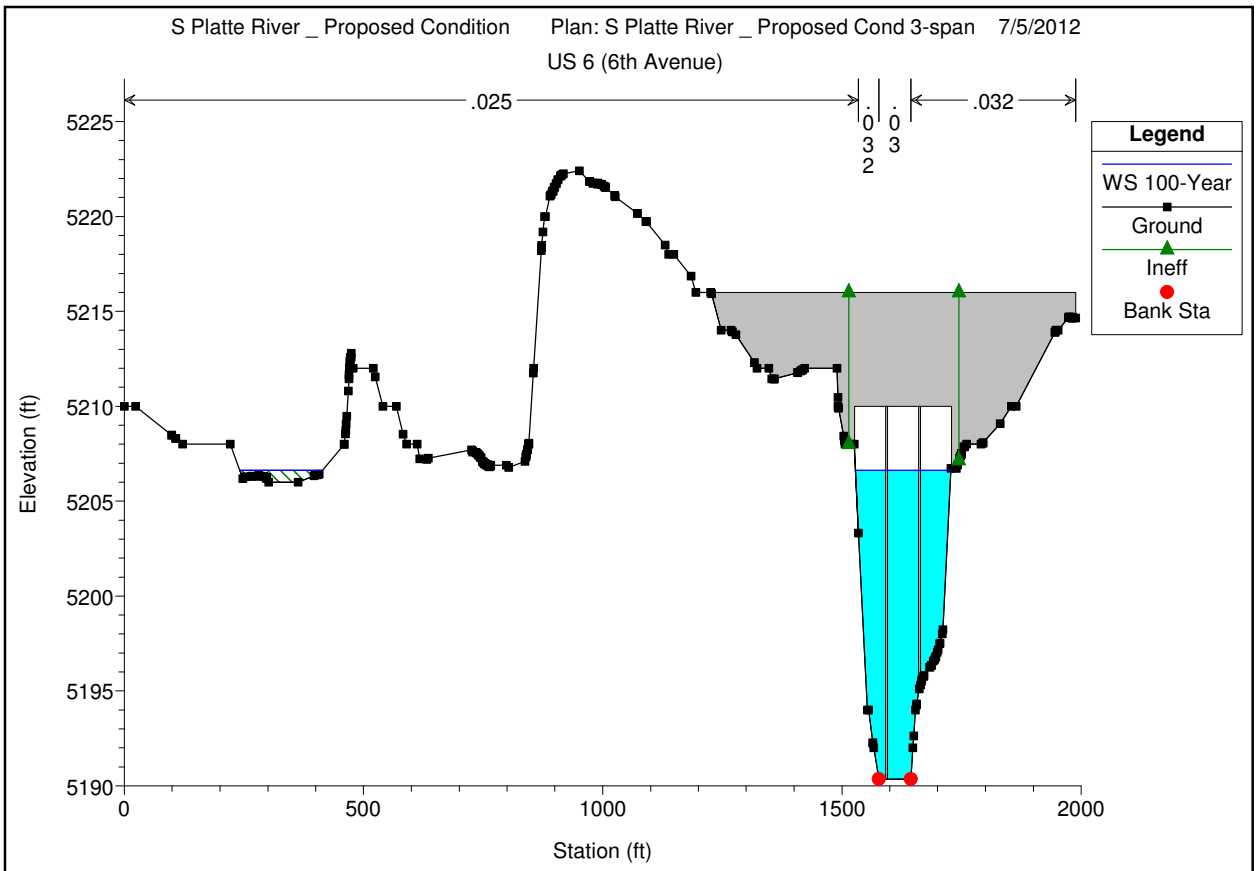
100-year Scour Calculations – Single Span Bridge

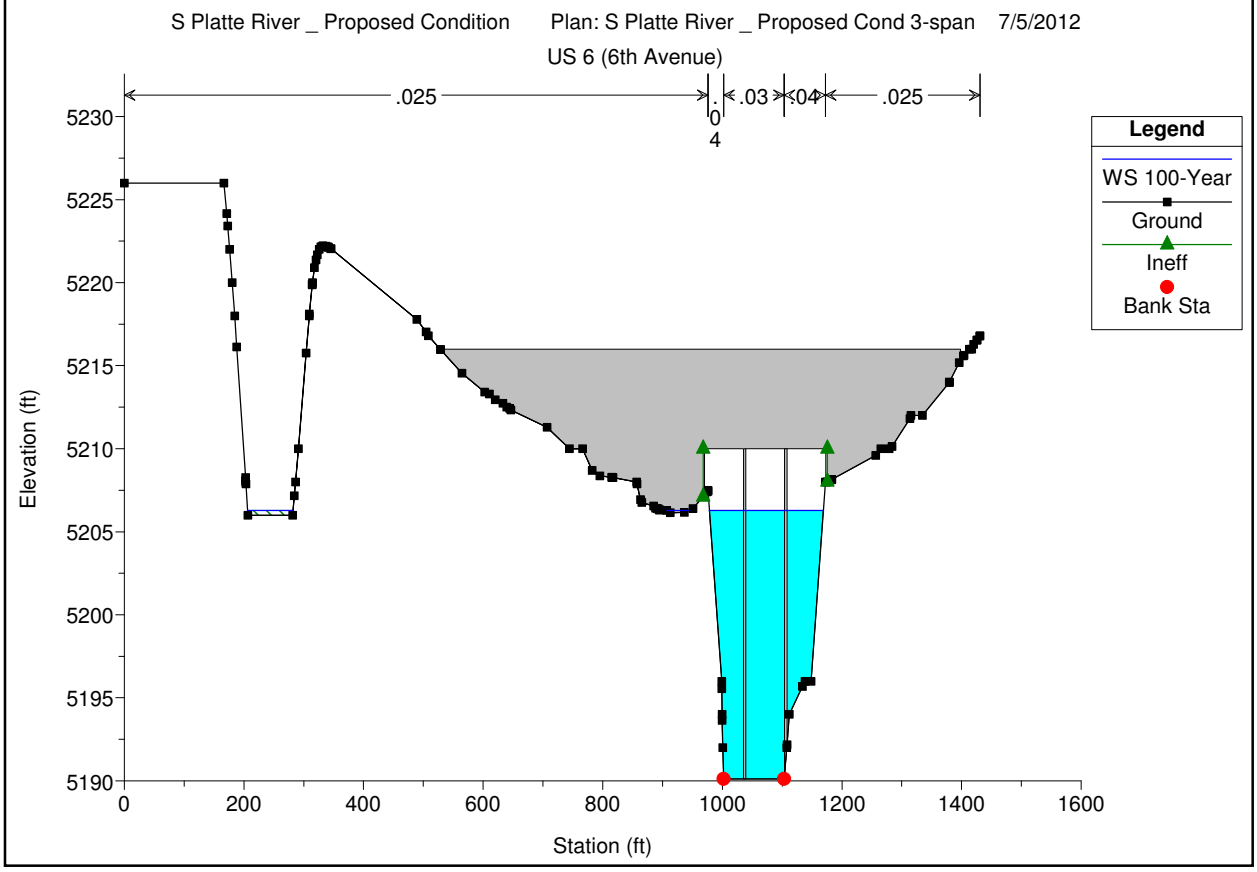
FIRM Panel

CLOMR Model HEC-RAS Output

3-span Bridge Model HEC-RAS Output

Figure 1 – 100-Year Floodplains


S Platte River _ Proposed Condition
Plan: S Platte River _ Proposed Cond 3-span
7/5/2012
US 6 (6th Avenue)
.025
.032
Legend
WS 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


S Platte River _ Proposed Condition
Plan: S Platte River _ Proposed Cond 3-span
7/5/2012
US 6 (6th Avenue)
.025
.03
.04
.025
Legend
WS 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

3-span bridge 100-year scour

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	4.98	16.66	8.09
	Approach Velocity (ft/s):	2.54	7.00	3.81
	Br Average Depth (ft):	10.24	16.28	9.55
	BR Opening Flow (cfs):	3777.04	8302.19	4420.77
	BR Top WD (ft):	48.92	63.07	79.55
	Grain Size D50 (mm):	1	1	1
	Approach Flow (cfs):	671.54	9916.52	5911.94
	Approach Top WD (ft):	53.05	85.03	191.94
	K1 Coefficient:	0.640	0.640	0.640
Results				
	Scour Depth Ys (ft):	12.80	1.04	1.53
	Critical Velocity (ft/s):	2.17	2.66	2.36
	Equation:	Live	Live	Live

Pier Scour

All piers have the same scour depth

Input Data		
	Pier Shape:	Round nose
	Pier Width (ft):	4.00
	Grain Size D50 (mm):	1.00000
	Depth Upstream (ft):	16.34
	Velocity Upstream (ft/s):	8.35
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (ft):	172.58
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	2.00000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	9.32
	Froude #:	0.36
	Equation:	CSU equation

Combined Scour Depths

Pier Scour + Contraction Scour (ft):

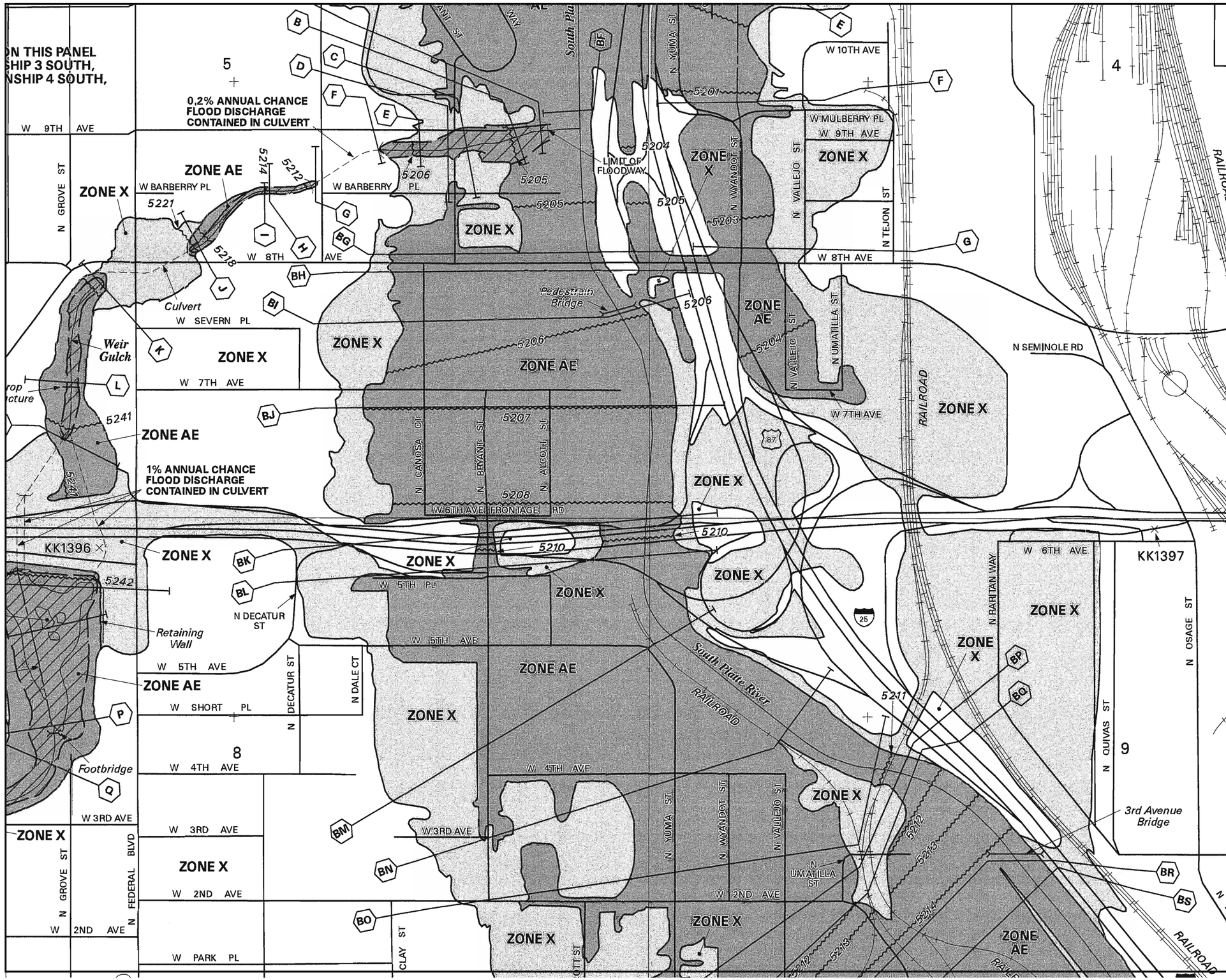
Channel:	10.37
Right Bank:	10.86

Single-span bridge 100-year scour

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	4.82	16.50	7.93
	Approach Velocity (ft/s):	2.57	7.12	3.85
	Br Average Depth (ft):	10.16	16.15	9.55
	BR Opening Flow (cfs):	2960.16	9185.78	4354.06
	BR Top WD (ft):	48.68	67.07	83.30
	Grain Size D50 (mm):	1.00	1.00	1.00
	Approach Flow (cfs):	657.30	9989.59	5853.11
	Approach Top WD (ft):	53.05	85.03	191.94
	K1 Coefficient:	0.640	0.640	0.640
Results				
	Scour Depth Ys (ft):	8.33	1.72	0.95
	Critical Velocity (ft/s):	2.16	2.66	2.35
	Equation:	Live	Live	Live

Combined Scour Depths



MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0182G

FIRM

FLOOD INSURANCE RATE MAP

CITY AND COUNTY OF DENVER, COLORADO

PANEL 182 OF 300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
DENVER, CITY AND COUNTY OF	080046	0182	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 0800460182G

MAP REVISED: NOVEMBER 17, 2005

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

HEC-RAS Plan: S Platte Riv River: S_Platte_Prp Reach: 01 Profile: 100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	13420	100-Year	16500.00	5201.34	5212.04	5208.92	5213.86	0.002326	10.87	1553.75	1116.50	0.59
01	13196	100-Year	16500.00	5201.14	5210.32	5209.38	5213.01	0.005283	13.29	1278.60	626.62	0.81
01	13064	100-Year	16500.00	5194.50	5210.83	5204.12	5211.94	0.001117	9.13	2243.73	1110.61	0.40
01	12997		Bridge									
01	12930	100-Year	16500.00	5193.22	5208.65	5204.44	5210.31	0.002101	11.64	1927.69	236.91	0.53
01	12427	100-Year	16500.00	5192.20	5208.15	5202.23	5209.43	0.000980	9.83	2088.34	531.27	0.43
01	11658	100-Year	16500.00	5190.90	5207.87	5199.78	5208.70	0.000612	8.09	2561.74	374.57	0.35
01	11372	100-Year	16500.00	5190.55	5207.90	5200.78	5208.36	0.000386	6.52	3460.77	800.99	0.28
01	11288		Bridge									
01	11204	100-Year	16500.00	5190.35	5207.42	5200.38	5208.15	0.000576	7.88	2505.87	584.05	0.34
01	11110		Bridge									
01	11014	100-Year	19200.00	5190.12	5206.15	5200.01	5207.52	0.001005	9.98	2218.22	238.76	0.44
01	10431	100-Year	19200.00	5189.41	5204.82	5200.15	5206.67	0.001482	12.65	1995.24	860.08	0.57
01	9926	100-Year	19200.00	5188.81	5203.49		5205.78	0.001963	12.67	1693.75	157.76	0.60
01	9898	100-Year	19200.00	5188.77	5203.51	5199.21	5205.65	0.001743	12.43	1825.28	162.63	0.57
01	9893		Bridge									
01	9887	100-Year	19200.00	5188.74	5203.30		5205.54	0.001854	12.71	1786.49	163.48	0.59
01	9849	100-Year	19200.00	5188.67	5202.98		5205.38	0.005542	13.04	1587.69	141.33	0.61
01	9749	100-Year	19200.00	5188.48	5202.42		5204.83	0.005517	12.78	1553.87	160.66	0.60
01	9713	100-Year	19200.00	5188.41	5202.28		5204.64	0.003672	13.00	1606.96	159.01	0.61
01	9687	100-Year	19200.00	5188.24	5202.29		5204.49	0.001908	12.60	1708.10	157.51	0.59
01	9637	100-Year	19200.00	5187.53	5202.40	5197.26	5204.03	0.000904	10.81	2064.60	165.59	0.49
01	9611		Bridge									
01	9584	100-Year	19200.00	5187.19	5201.73	5196.76	5203.29	0.000881	10.51	2052.91	162.50	0.49
01	9517	100-Year	19200.00	5186.76	5201.71		5203.20	0.000834	10.42	2131.42	182.25	0.47
01	9377	100-Year	19200.00	5186.58	5201.02		5203.01	0.001152	11.96	1884.83	174.41	0.55
01	9100	100-Year	19200.00	5186.22	5200.02		5202.50	0.002549	13.49	1591.10	165.77	0.64
01	9000	100-Year	19200.00	5186.09	5200.00	5196.14	5202.09	0.001252	12.17	1857.90	820.85	0.57
01	8910	100-Year	19200.00	5185.97	5199.86	5196.00	5201.97	0.001268	12.23	1861.56	228.35	0.58
01	8852	100-Year	19200.00	5185.90	5199.79	5195.90	5201.90	0.001261	12.20	1874.27	201.45	0.58
01	8599	100-Year	19200.00	5185.57	5199.61		5201.54	0.001145	11.71	1964.20	204.65	0.55
01	8199	100-Year	19200.00	5185.05	5199.23		5201.07	0.001090	11.49	2010.13	240.51	0.54
01	7951	100-Year	19200.00	5184.73	5198.92		5200.79	0.001101	11.56	1975.74	200.02	0.54
01	7649	100-Year	19200.00	5184.34	5197.86		5200.34	0.001563	13.33	1723.47	161.30	0.64
01	7611	100-Year	19200.00	5184.28	5197.79		5200.28	0.001565	13.34	1721.15	161.18	0.64
01	7551	100-Year	19200.00	5184.21	5197.71		5200.18	0.001555	13.29	1726.72	161.70	0.64
01	7344	100-Year	19200.00	5183.94	5197.74		5199.76	0.001229	11.99	1897.15	179.02	0.57
01	7184	100-Year	19200.00	5183.73	5198.18		5199.37	0.000656	9.03	2367.83	208.18	0.42

HEC-RAS Plan: S Platte Riv River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	7129	100-Year	19200.00	5182.24	5198.27		5199.29	0.000496	8.42	2600.23	207.36	0.37
01	7049	100-Year	19200.00	5182.13	5198.15	5190.91	5199.24	0.000525	8.66	2450.92	202.89	0.38
01	6956	100-Year	19200.00	5181.98	5198.00	5191.02	5199.18	0.000567	8.99	2344.94	181.84	0.40
01	6899	100-Year	19200.00	5181.89	5198.03		5199.06	0.000477	8.29	2409.42	158.13	0.36
01	6876	100-Year	19200.00	5181.85	5198.02	5190.45	5199.05	0.000466	8.20	2377.86	153.83	0.36
01	6851		Bridge									
01	6817	100-Year	19200.00	5181.77	5197.83	5190.53	5198.90	0.000493	8.40	2325.71	169.65	0.37
01	6764	100-Year	19200.00	5181.67	5197.48		5198.79	0.000620	9.32	2108.02	142.05	0.41
01	6646	100-Year	19200.00	5181.49	5195.94		5198.56	0.001370	13.05	1497.92	129.71	0.60
01	6545	100-Year	19200.00	5181.33	5196.00	5191.63	5198.09	0.001123	11.94	1748.21	148.00	0.55
01	6381	100-Year	19200.00	5181.07	5196.05		5197.46	0.000755	9.92	2181.56	185.87	0.45
01	6341	100-Year	19200.00	5181.02	5196.04	5190.85	5197.41	0.000746	9.88	2213.19	193.85	0.45
01	6321		Bridge									
01	6302	100-Year	19200.00	5180.96	5195.97	5191.15	5197.37	0.000787	10.14	2233.59	293.24	0.46
01	6270	100-Year	19200.00	5177.56	5196.14	5187.84	5197.16	0.000429	8.64	2689.00	551.16	0.35
01	6169	100-Year	19200.00	5177.26	5195.75	5189.42	5197.08	0.000654	9.93	2392.68	273.26	0.43
01	5999	100-Year	19200.00	5176.97	5195.54	5189.57	5196.95	0.000701	10.34	2256.62	287.97	0.44
01	5849	100-Year	19300.00	5176.72	5194.01		5196.68	0.001422	14.08	1687.02	165.00	0.62
01	5799	100-Year	19300.00	5176.63	5193.91	5190.38	5196.60	0.001398	13.93	1643.58	135.96	0.62
01	5734		Bridge									
01	5709	100-Year	19300.00	5176.16	5193.50		5196.13	0.001354	13.73	1665.69	141.91	0.61
01	5649	100-Year	19300.00	5175.96	5193.45		5196.02	0.001291	13.47	1727.18	146.44	0.59
01	5559	100-Year	19300.00	5175.86	5193.34	5190.07	5195.87	0.001697	13.87	1696.54	148.80	0.61
01	5509		Bridge									
01	5401	100-Year	19300.00	5175.69	5193.13		5195.28	0.001099	12.37	1873.55	172.06	0.55
01	5310	100-Year	19300.00	5175.59	5192.87		5195.14	0.001172	12.70	1799.27	155.49	0.56
01	4655	100-Year	19300.00	5174.87	5191.13	5187.93	5194.16	0.001653	14.43	1589.39	163.48	0.66
01	4573	100-Year	19300.00	5174.78	5190.89	5187.95	5194.00	0.001727	14.66	1486.88	127.58	0.68
01	4554		Bridge									
01	4523	100-Year	19300.00	5174.73	5189.87		5193.69	0.002965	16.47	1319.63	123.96	0.78
01	4430	100-Year	19300.00	5174.62	5189.75	5187.92	5193.29	0.002757	15.81	1474.97	152.30	0.75
01	4327		Bridge									
01	4226	100-Year	19300.00	5174.40	5189.25		5192.58	0.003135	15.53	1425.19	153.48	0.75
01	4135	100-Year	19300.00	5173.86	5189.14		5192.07	0.003608	14.59	1491.54	173.80	0.69
01	3985	100-Year	19300.00	5173.76	5189.15		5191.00	0.000948	11.28	2123.33	215.39	0.54
01	3213	100-Year	19400.00	5173.22	5188.44		5190.22	0.001016	11.64	2291.26	259.33	0.53
01	2200	100-Year	19400.00	5172.51	5187.92		5189.07	0.000888	10.97	2653.95	299.95	0.49
01	1650	100-Year	19400.00	5172.12	5187.50		5188.60	0.000807	10.44	2742.56	313.29	0.47

HEC-RAS Plan: S Platte Riv River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	863	100-Year	19400.00	5171.57	5186.94		5188.00	0.000699	9.71	2846.69	335.49	0.44
01	164	100-Year	19400.00	5171.08	5186.74	5180.27	5187.53	0.000451	7.90	3190.13	1459.79	0.35
01	45	100-Year	19400.00	5171.00	5185.95	5180.58	5187.40	0.000822	10.34	2335.09	1262.71	0.47

3-span bridge HEC-RAS output

HEC-RAS Plan: 3-span River: S_Platte_Prp Reach: 01 Profile: 100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	13420	100-Year	16500.00	5201.34	5212.99	5208.92	5213.54	0.000856	6.98	3576.55	1297.01	0.36
01	13196	100-Year	16500.00	5201.14	5209.65	5209.38	5212.86	0.007010	14.48	1166.70	164.47	0.92
01	13064	100-Year	16500.00	5194.50	5210.33	5204.12	5211.53	0.001257	9.49	2154.68	1039.89	0.42
01	12997		Bridge									
01	12930	100-Year	16500.00	5193.22	5208.14	5204.44	5209.95	0.002399	12.15	1838.03	234.52	0.57
01	12427	100-Year	16500.00	5192.20	5207.54	5202.23	5208.96	0.001137	10.31	1972.80	388.22	0.46
01	11658	100-Year	16500.00	5190.90	5207.20	5199.78	5208.12	0.000714	8.50	2423.97	361.72	0.37
01	11372	100-Year	16500.00	5190.55	5207.21	5200.78	5207.75	0.000469	7.00	3234.04	782.37	0.30
01	11288		Bridge									
01	11204	100-Year	16500.00	5190.35	5206.69	5200.32	5207.51	0.000685	8.35	2410.21	375.46	0.36
01	11110		Bridge									
01	11014	100-Year	19200.00	5190.12	5206.32		5207.53	0.000903	9.53	2419.50	318.11	0.42
01	10431	100-Year	19200.00	5189.41	5204.82	5200.15	5206.67	0.001482	12.65	1995.24	860.08	0.57
01	9926	100-Year	19200.00	5188.81	5203.49		5205.78	0.001963	12.67	1693.75	157.76	0.60
01	9898	100-Year	19200.00	5188.77	5203.51	5199.21	5205.65	0.001743	12.43	1825.28	162.63	0.57
01	9893		Bridge									
01	9887	100-Year	19200.00	5188.74	5203.30		5205.54	0.001854	12.71	1786.49	163.48	0.59
01	9849	100-Year	19200.00	5188.67	5202.98		5205.38	0.005542	13.04	1587.69	141.33	0.61
01	9749	100-Year	19200.00	5188.48	5202.42		5204.83	0.005517	12.78	1553.87	160.66	0.60
01	9713	100-Year	19200.00	5188.41	5202.28		5204.64	0.003672	13.00	1606.96	159.01	0.61
01	9687	100-Year	19200.00	5188.24	5202.29		5204.49	0.001908	12.60	1708.10	157.51	0.59
01	9637	100-Year	19200.00	5187.53	5202.40	5197.26	5204.03	0.000904	10.81	2064.60	165.59	0.49
01	9611		Bridge									
01	9584	100-Year	19200.00	5187.19	5201.73	5196.76	5203.29	0.000881	10.51	2052.91	162.50	0.49
01	9517	100-Year	19200.00	5186.76	5201.71		5203.20	0.000834	10.42	2131.42	182.25	0.47
01	9377	100-Year	19200.00	5186.58	5201.02		5203.01	0.001152	11.96	1884.83	174.41	0.55
01	9100	100-Year	19200.00	5186.22	5200.02		5202.50	0.002549	13.49	1591.10	165.77	0.64
01	9000	100-Year	19200.00	5186.09	5200.00	5196.14	5202.09	0.001252	12.17	1857.90	820.85	0.57
01	8910	100-Year	19200.00	5185.97	5199.86	5196.00	5201.97	0.001268	12.23	1861.56	228.35	0.58
01	8852	100-Year	19200.00	5185.90	5199.79	5195.90	5201.90	0.001261	12.20	1874.27	201.45	0.58
01	8599	100-Year	19200.00	5185.57	5199.61		5201.54	0.001145	11.71	1964.20	204.65	0.55
01	8199	100-Year	19200.00	5185.05	5199.23		5201.07	0.001090	11.49	2010.13	240.51	0.54
01	7951	100-Year	19200.00	5184.73	5198.92		5200.79	0.001101	11.56	1975.74	200.02	0.54
01	7649	100-Year	19200.00	5184.34	5197.86		5200.34	0.001563	13.33	1723.47	161.30	0.64
01	7611	100-Year	19200.00	5184.28	5197.79		5200.28	0.001565	13.34	1721.15	161.18	0.64
01	7551	100-Year	19200.00	5184.21	5197.71		5200.18	0.001555	13.29	1726.72	161.70	0.64
01	7344	100-Year	19200.00	5183.94	5197.74		5199.76	0.001229	11.99	1897.15	179.02	0.57
01	7184	100-Year	19200.00	5183.73	5198.18		5199.37	0.000656	9.03	2367.83	208.18	0.42

HEC-RAS Plan: 3-span River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	7129	100-Year	19200.00	5182.24	5198.27		5199.29	0.000496	8.42	2600.23	207.36	0.37
01	7049	100-Year	19200.00	5182.13	5198.15	5190.91	5199.24	0.000525	8.66	2450.92	202.89	0.38
01	6956	100-Year	19200.00	5181.98	5198.00	5191.02	5199.18	0.000567	8.99	2344.94	181.84	0.40
01	6899	100-Year	19200.00	5181.89	5198.03		5199.06	0.000477	8.29	2409.42	158.13	0.36
01	6876	100-Year	19200.00	5181.85	5198.02	5190.45	5199.05	0.000466	8.20	2377.86	153.83	0.36
01	6851		Bridge									
01	6817	100-Year	19200.00	5181.77	5197.83	5190.53	5198.90	0.000493	8.40	2325.71	169.65	0.37
01	6764	100-Year	19200.00	5181.67	5197.48		5198.79	0.000620	9.32	2108.02	142.05	0.41
01	6646	100-Year	19200.00	5181.49	5195.94		5198.56	0.001370	13.05	1497.92	129.71	0.60
01	6545	100-Year	19200.00	5181.33	5196.00	5191.63	5198.09	0.001123	11.94	1748.21	148.00	0.55
01	6381	100-Year	19200.00	5181.07	5196.05		5197.46	0.000755	9.92	2181.56	185.87	0.45
01	6341	100-Year	19200.00	5181.02	5196.04	5190.85	5197.41	0.000746	9.88	2213.19	193.85	0.45
01	6321		Bridge									
01	6302	100-Year	19200.00	5180.96	5195.97	5191.15	5197.37	0.000787	10.14	2233.59	293.24	0.46
01	6270	100-Year	19200.00	5177.56	5196.14	5187.84	5197.16	0.000429	8.64	2689.00	551.16	0.35
01	6169	100-Year	19200.00	5177.26	5195.75	5189.42	5197.08	0.000654	9.93	2392.68	273.26	0.43
01	5999	100-Year	19200.00	5176.97	5195.54	5189.57	5196.95	0.000701	10.34	2256.62	287.97	0.44
01	5849	100-Year	19300.00	5176.72	5194.01		5196.68	0.001422	14.08	1687.02	165.00	0.62
01	5799	100-Year	19300.00	5176.63	5193.91	5190.38	5196.60	0.001398	13.93	1643.58	135.96	0.62
01	5734		Bridge									
01	5709	100-Year	19300.00	5176.16	5193.50		5196.13	0.001354	13.73	1665.69	141.91	0.61
01	5649	100-Year	19300.00	5175.96	5193.45		5196.02	0.001291	13.47	1727.18	146.44	0.59
01	5559	100-Year	19300.00	5175.86	5193.34	5190.07	5195.87	0.001697	13.87	1696.54	148.80	0.61
01	5509		Bridge									
01	5401	100-Year	19300.00	5175.69	5193.13		5195.28	0.001099	12.37	1873.55	172.06	0.55
01	5310	100-Year	19300.00	5175.59	5192.87		5195.14	0.001172	12.70	1799.27	155.49	0.56
01	4655	100-Year	19300.00	5174.87	5191.13	5187.93	5194.16	0.001653	14.43	1589.39	163.48	0.66
01	4573	100-Year	19300.00	5174.78	5190.89	5187.95	5194.00	0.001727	14.66	1486.88	127.58	0.68
01	4554		Bridge									
01	4523	100-Year	19300.00	5174.73	5189.87		5193.69	0.002965	16.47	1319.63	123.96	0.78
01	4430	100-Year	19300.00	5174.62	5189.75	5187.92	5193.29	0.002757	15.81	1474.97	152.30	0.75
01	4327		Bridge									
01	4226	100-Year	19300.00	5174.40	5189.25		5192.58	0.003135	15.53	1425.19	153.48	0.75
01	4135	100-Year	19300.00	5173.86	5189.14		5192.07	0.003608	14.59	1491.54	173.80	0.69
01	3985	100-Year	19300.00	5173.76	5189.15		5191.00	0.000948	11.28	2123.33	215.39	0.54
01	3213	100-Year	19400.00	5173.22	5188.44		5190.22	0.001016	11.64	2291.26	259.33	0.53
01	2200	100-Year	19400.00	5172.51	5187.92		5189.07	0.000888	10.97	2653.95	299.95	0.49
01	1650	100-Year	19400.00	5172.12	5187.50		5188.60	0.000807	10.44	2742.56	313.29	0.47

HEC-RAS Plan: 3-span River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	863	100-Year	19400.00	5171.57	5186.94		5188.00	0.000699	9.71	2846.69	335.49	0.44
01	164	100-Year	19400.00	5171.08	5186.74	5180.27	5187.53	0.000451	7.90	3190.13	1459.79	0.35
01	45	100-Year	19400.00	5171.00	5185.95	5180.58	5187.40	0.000822	10.34	2335.09	1262.71	0.47

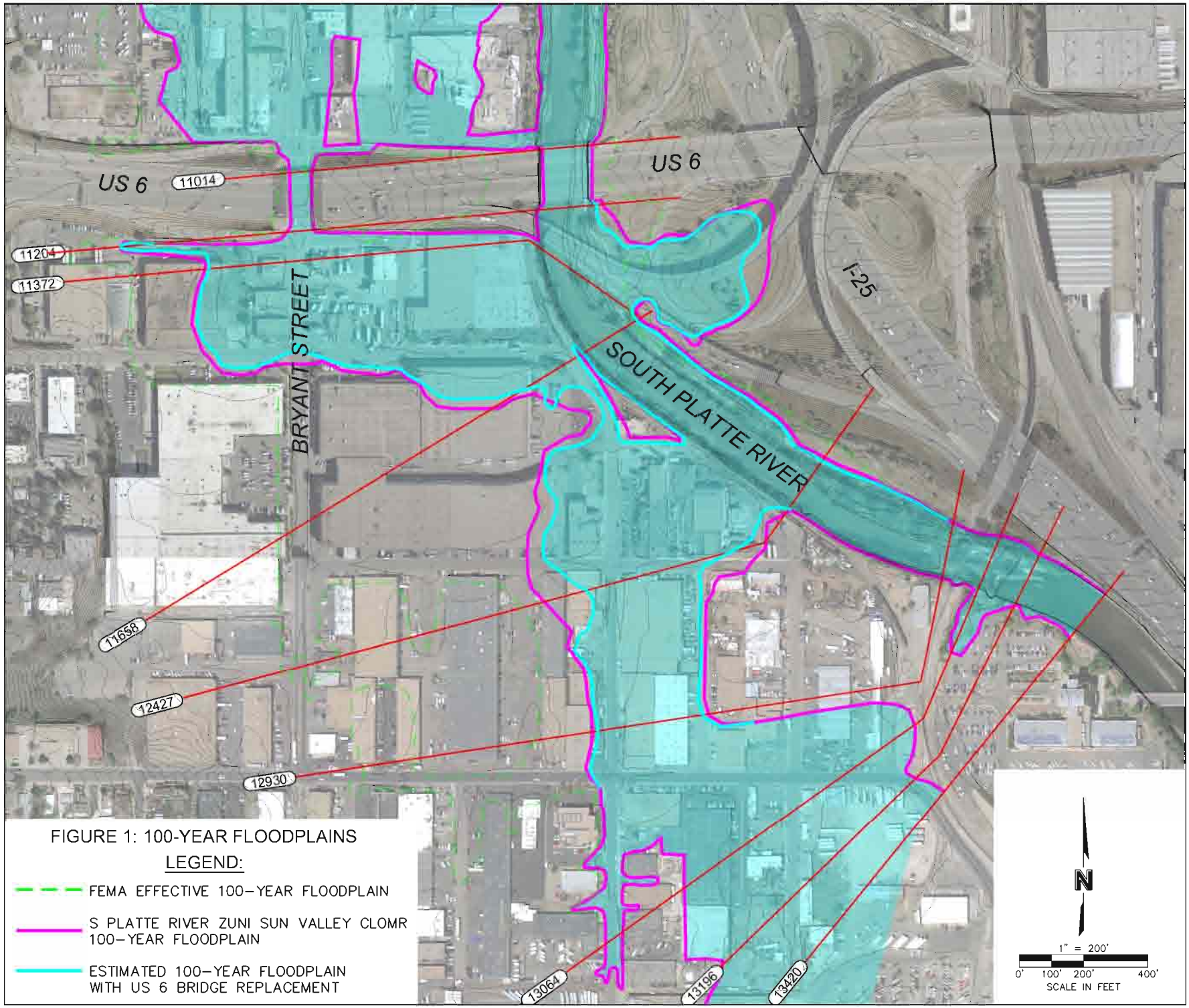


FIGURE 1: 100-YEAR FLOODPLAINS

APPENDIX E

Geotechnical Report

GEOTECHNICAL MEMORANDUM
US 6 BRIDGES, KNOX COURT TO BNSF - FBR 06A-050 (18192)

Preliminary Geotechnical Deep Foundation Design Parameters for US 6 Bridges at I-25, South Platte River and Bryant Street

Prepared For: Hartwig and Associates and Parsons Brinckerhoff
Prepared by: Donald Hunt, RockSol Consulting Group, Inc.
Date: November 16, 2011
RS Project Number: 280.01

The purpose of this memo is to provide preliminary geotechnical foundation design parameters for deep foundations for proposed US 6 bridges at I-25, the South Platte River and Bryant Street. The preliminary foundation design parameters are based on RockSol's review and interpretation of geotechnical information documented on project plans for the existing bridges at I-25, the South Platte River and Bryant Street. In addition, RockSol was provided a copy of a geotechnical report that was prepared by the Colorado Department of Transportation (CDOT) for the replacement of the Colorado Highway 88 (Federal Boulevard) bridge structure (Structure F-16-EK) over US 6. Geotechnical information reviewed primarily consisted of engineering geology sheets and borehole logs, from which the depth to bedrock was interpreted based on material descriptions. In addition, the bearing capacity of the bedrock was evaluated, based on available blow count data obtained during drilling and sampling from the previous explorations. Environmental conditions have not been evaluated by RockSol for this memorandum. Plan sheets and reports reviewed included:

- CDOT Geotechnical Report, *Geotechnical Recommendations for Replacement of Structure F-16-EK*, Project IM 088A-024, SA 16228, dated December 3, 2009
- Bryant Street Bridge, *General Layout, Summary of Quantities and Notes*, Sheet No. 43, Project No. U012-2(3)
- South Platte River Bridge, *General Layout, Summary of Quantities, General Notes, Sheet No. 4,* Project U1002-2(30)
- US 6 Bridge Over I-25, *General Plan and Elevation*, Sheet No. 36, Project No. U012-2(13)
- *Ramp G Engineering Geology*, Sheet No. 85, Project IR 25-2(208)
- *Ramp H Engineering Geology,* Sheet No. 131, Project IR 25-2(191)
- *Ramp F Engineering Geology*, Sheet No. 97, Project IR 25-2(187)

General Site Geology Discussion

Based on the borehole logs presented in the documents reviewed, overburden soils consist of fill materials associated with development of the project area, especially roadway construction for US 6 and I-25, and native soils consisting of clay, sands, and gravel. The native sands are generally characterized as medium dense and the clays generally characterized as medium stiff to stiff. Some boreholes encountered material identified as "trash". Sedimentary bedrock was encountered in most boreholes and primarily consisted of claystone with sandstone also encountered in several borings. Groundwater was encountered within the native soils at elevations ranging from about 5,190 feet in the vicinity of the Bryant Street and South Platte

River Bridges; 5,194 feet to 5,224 feet in the vicinity of the Federal Boulevard Bridge; and about 5,195 feet in the vicinity of the US 6 Bridge over I-25.

Boreholes which encountered bedrock have been plotted on the attached Figure No.1. Included with each borehole location is the approximate elevation that bedrock was encountered. Approximate bedrock elevation contours have been added for preliminary design purposes to illustrate the general trend in the bedrock elevation along US 6 in the vicinity of the project limits. Based on the available bedrock elevations it appears that the highest bedrock elevations occur in the vicinity of the US 6 Bridge over I-25 with elevations in the range of 5,180 feet to 5,187 feet. A gradual drop in bedrock elevation is observed along US 6, west of I-25. At the South Platte River Bridge an approximate bedrock elevation of 5,179 is noted at the east side of the bridge and an approximate bedrock elevation of 5,173 feet to 5,176 feet is noted at the west side of the bridge. The lowest bedrock elevation is noted in the vicinity of the Bryant Street Bridge at approximately 5,170 feet. Bedrock elevations noted at the Federal Boulevard Bridge range from 5,171 feet to 5,173 feet.

Preliminary Foundation Design Parameters

Drilled Shafts

Drilled shafts will provide axial support by embedment into sedimentary bedrock. RockSol evaluated blow count data from boreholes drilled for the Federal Boulevard Bridge, Ramp F, Ramp H, and Ramp G. Blow count data was not provided on the engineering geology sheets for the Bryant Street, South Platte River, and I-25 bridges.

Based on our evaluation, suggested nominal (unfactored) base resistance and nominal (unfactored) side resistance values for the bedrock material are presented in Table 1.1 for use with Load and Resistance Factor Design (LRFD) methods and allowable bearing and side resistance capacities using Allowable Strength Design (ASD) methods.

Table 1.1 - Base and Side Resistance Values for Drilled Shafts

Bearing Material	Nominal Values (LRFD)		Allowable Capacity (ASD)	
	Base Resistance (ksf)	Side Resistance (ksf)	Bearing Resistance (ksf)	Side Resistance (ksf)
Bedrock	135	13.5	45	4.5

Due to the anticipated depth to bedrock at the proposed bridge locations, the side resistance is applicable to the entire portion of the shaft embedded in competent bedrock. Side resistance in the soil zone above competent bedrock should be neglected. For LRFD strength limit state evaluation, a resistance factor of 0.55 is recommended for base/ tip resistance and a resistance factor of 0.60 is recommended for side resistance evaluation for redundant single shafts. Per AASHTO LRFD (Section 10.5.5.2.4), the resistance factors for base/tip and side resistance should be reduced by 20 percent for non-redundant single shafts.

A minimum shaft penetration into competent bedrock of 10 feet is suggested for drilled shafts less than 5 feet in diameter. For drilled shafts 5 feet and greater in diameter, a minimum penetration into competent bedrock of 15 feet is recommended. If needed, the embedment

length may be increased to provide additional resistance to lateral loads and to provide additional axial capacity.

Shaft diameters should be appropriate to resistance structure loads. A minimum shaft diameter of 36 inches is suggested for axial load resistance for structure piers. Smaller diameter shafts may be considered at the abutments. Lateral load resistance requirements may result in larger shaft diameters.

Groundwater will be encountered during construction of drilled shafts embedded into bedrock.

Additional design and construction considerations are listed below.

(a) The construction of drilled shafts should follow the guidelines specified in the "CDOT Standard Specifications for Road and Bridge Construction (SSRBC), Section 503, 2011" and "Drilled Shafts: Construction Procedures and LRFD Design Methods, FHWA-NHI-10-016, May 2010".

(b) During construction of drilled shafts, casing or slurry will be required to support the excavation where groundwater exists and or where holes are unstable due to soil conditions.

(c) Prior to the placement of the concrete, the drilled shaft excavation, including the bottom should be cleaned of all loose material. Due to the presence of water, dewatering of the excavation may be required. For wet conditions (more than two inches of water), concrete placement by "tremie" methods should be used.

(d) Special provisions should be specified for drilling operations and equipment where hard bedrock and or difficult subsurface conditions exist.

(e) Lateral load capacity of the drilled shafts should also be evaluated. As preliminary design efforts progress, RockSol will provide soil parameters appropriate for the conditions encountered in boreholes drilled for this project.

(f) All piers should be reinforced full depth for the applied axial, lateral and uplift stresses imposed. The amount of reinforcing steel for extension should be determined by the tensile force created by the uplift force on each pier, with allowance for dead load.

(g) Drilled shafts should be constructed at least three shaft diameters center to center. For closely spaced drilled shafts, the axial and lateral capacities should be appropriately reduced. Group action of drilled shafts should be analyzed on an individual basis to assess the appropriate reduction.

<u>Driven Piles</u>

Alternatively, driven piles (Grade 50 steel H-pile is assumed) may be considered for the proposed bridges, including the abutments. Evaluation of the effect of pile driving on existing foundations should be considered. RockSol recommends the piles be driven to refusal in the bedrock. Based on anticipated subsurface conditions, practical refusal is estimated to occur within approximately 5 feet of penetration into competent bedrock. Pile driving shall be monitored per CDOT requirements. Monitoring shall be conducted using a Pile Driving Analyzer (PDA) to determine the condition of the pile, the efficiency of the hammer and the static bearing capacity of the pile, and to establish the pile driving criteria. For the LRFD method, a nominal (ultimate) capacity of 37.5 ksi, based on the cross section area of the pile, can be used for Grade 50 steel. A resistance factor of 0.65 is recommended for LRFD strength limit state design for axial compression. Additional design and construction details of the driven piles are presented below:

(a) Steel piling, pile driving equipment, and installation of the driven steel H-piles should follow the guidelines specified in "CDOT Standard Specifications for Road and Bridge Construction (SSRBC), Section 502, 2011 Edition.

(b) Lateral load capacity of the driven piles should also be evaluated. As preliminary design efforts progress, RockSol will provide soil parameters appropriate for the conditions encountered in boreholes drilled for this project. Battered piles may be used to resist the lateral loads. The battered piles inclination should be within one (1) horizontal to four (4) vertical.

(c) RockSol anticipates that approximately 5 feet of pile penetration into bedrock will be required to achieve capacity. The actual length of the piles should be determined during installation.

(d) Center to center pile spacing should not be less than 30 inches or 2.5 pile diameters. For evaluation of horizontal pile foundation movement, the effects of group interaction shall be evaluated in accordance with AASHTO LRFD Bridge Design Specifications, Section 10.7.2.4.

(e) Predrilling may be required for difficult subsurface conditions. Pile tips should be protected against damage using driving shoes for hard sedimentary bedrock.

(f) Potential damage to the property or adjacent structures during pile installation due to noise and vibrations should be evaluated.

RockSol Consulting Group, Inc.

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Phone: 303.962.9300

Bedrock elevation contours are approximate and presented for preliminary design purposes only. The contours are subject to revision as additional subsurface information is obtained.

-------- 5170' Indicates approximate bedrock elevation contour

Indicates approximate borehole location

BR-5171.5' Indicates Bedrock encountered at approximate depth of 5171.5'

Print Date: $DATE$			
File Name: $FILES$			
Horiz. Scale: $SCALESHORT$	Vert. Scale: As Noted		
Unit Information	Unit Leader Initials		

R-X

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation

DOT DEPARTMENT OF TRANSPORTATION

8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114

Region 6 HC

No Revisions:

Revised:

Void:

Approximate Bedrock Elevations Based on Existing Information

Designer:

Detailer:

Sheet Subset:

Structure Numbers

Subset Sheets: of

Project No./Code

Project Number

FBR 06A-050 (18192)

Figure 1

APPENDIX F

Preliminary Cost Estimate

PARSONS BRINCKERHOFF

Sheet
Job No.

Project:	US 6 Bridges	**Client:**	CDOT		
Subject:	Quantity Estimate	**Made By:**	BZP	**Date:**	02/23/12
Item:	**Platte River Bridge**	**Checked By:**	CJS	**Revised:**	07/25/12

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST
202-00400	REMOVAL OF BRIDGE	EACH	1	$266,135.00	$266,135.00
206-00000	STRUCTURE EXCAVATION	CY	1358	$8.00	$10,867.20
206-00100	STRUCTURE BACKFILL (CLASS 1)	CY	2029	$20.00	$40,582.43
206-00200	STRUCTURE BACKFILL (CLASS 2)	CY	1324	$18.00	$23,825.99
206-00360	MECHANICAL REINFORCEMENT OF SOIL	CY	1794	$18.00	$32,295.19
206-01781	SHORING (AREA 1)	LS	1	$30,000.00	$30,000.00
206-01782	SHORING (AREA 2)	LS	1	$30,000.00	$30,000.00
403-09221	STONE MATRIX ASPHALT (FIBERS) (ASPHALT)	TON	964	$95.00	$91,574.37
502-00460	PILE TIP	EACH	40	$140.00	$5,600.00
502-02000	DYNAMIC LOAD TESTING	LS	1	$10,000.00	$10,000.00
502-11274	STEEL PILING (HP 12X74)	LF	1840	$70.00	$128,800.00
503-00054	DRILLED CAISSON (54 INCH)	LF	468	$500.00	$234,000.00
513-00600	BRIDGE DRAIN	EACH	4	$3,500.00	$14,000.00
515-00120	WATERPROOFING (MEMBRANE)	SY	5909	$14.00	$82,729.01
518-01004	BRIDGE EXPANSION DEVICE (0-4 INCH)	LF	354	$200.00	$70,779.27
601-03040	CONCRETE CLASS D (BRIDGE)	CY	3082.7	$400.00	$1,233,071.38
601-40300	STRUCTURAL CONCRETE COATING	SY	4361	$10.00	$43,610.00
602-00020	REINFORCING STEEL (EPOXY COATED)	LB	726978	$1.15	$836,024.73
606-10700	BRIDGE RAIL TYPE 7	LF	679	$100.00	$67,907.37
618-00163	PRESTRESSED CONCRETE I (BT63)	LF	3780	$200.00	$756,000.00

TOTAL =	**$4,007,802**
DECK AREA (ft^2) =	48341
COST PER SQUARE FT. =	**$83**

Note: - Quantities do not include Riprap or Structure Excavation for Riprap.
Note: - Quantities assume two (2) shoring areas for construction phasing.
Note: - Predrilling of piles may be required, but are not included in the estimate.