US 6 over the BNSF Railway Bridge Replacement

Replacement Structure Alternative Analysis
Existing Structure F-16-EJ
New Structure F-16-YJ

Prepared for CDOT Region 6
Project Number: FBR 0062-026 (18202)
December 28, 2011

Executive Summary

Existing structure F-16-EJ carrying US 6 over the BNSF Railway is structurally deficient and will be replaced. The bridge replacement will be part of a design-build project on US 6. The existing structure fails to meet minimum vertical and horizontal clearance requirements to the railroad. In order to conform to the clearance requirements the profile grade of US 6 will have to be raised. However, changes to the profile are constrained on either side of the bridge by the existing conditions. These constraints limit the structure depth available for the replacement structure.

Two feasible superstructure types, adjacent prestressed box girder and composite steel I-girder, were developed for a two-span arrangement to replace the existing structure. Preliminary design of both structure type including construction phasing was performed to develop construction cost estimates. These designs were developed in conformance with the geometric requirements provided in the *Guidelines for Railroad Grade Separation Project.* The width of the replacement structure was determined based on the preferred alignment of the *Valley Highway Environmental Impact Statement*.

The total construction cost of the two structure types is competitive, with the concrete option costing $172 per square foot, and the steel option costing $185 per square foot. Additional constructability and phasing analysis may help to select the best option.

The replacement of structure F-16-EJ will be part of a design-build project on US 6. This report presents the results preliminary analysis conducted prior to the decision to incorporate the replacement in the design-build project. The Contractor may elect to use a different structure type, layout, or wall configuration based on the requirements of the design-build project.

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1.0 Existing Conditions

The existing structure F-16-EJ was originally constructed in 1956 as a set of twin structures carrying eastbound and westbound traffic over railroad lines. Subsequent widening, with additions to the interior and exterior of both bridges, created a single structure in 1967. The existing bridge is a two-span, W36 rolled steel girder with a non-composite concrete deck slab that is 130 feet long. The bridge currently carries four lanes of eastbound and four lanes of westbound traffic on US 6. See Appendix A for photographs of the existing bridge.

The west span of the bridge crosses two main line and two siding tracks of the BNSF Railway Company (BNSF). The west abutment is a tall, cantilever wall-type abutment on a spread footing while the east abutment is short, seat-type abutment founded on a combination of steel pipe and H-piles. The pier consists of several reinforced concrete columns founded in individual spread footings with a combination of hammerhead and continuous cap beams. Both the existing west abutment and the pier are located within the BNSF's right-of-way and fail to meet the minimum clearance requirements of the railroad. The current minimum horizontal clearance is approximately 9'-6" at both the west abutment and the pier. Additionally, with a current minimum vertical clearance of 22'-2", the existing bridge also fails to meet the minimum vertical clearance requirement for railroad grade separation facilities of 23'-4".

In 2009, the bridge received a sufficiency rating of 47.8 and was categorized as Structurally Deficient. The most recent Structural Inventory and Appraisal is provided in Appendix B. A temporary repair conducted in 2008 provided additional support at the southern column of the pier which is badly deteriorated.

2.0 Bridge Replacement Constraints

2.1 Railroad Clearance Requirements

To facilitate railroad approval on grade separation projects, it is generally desirable to provide minimum horizontal and vertical clearances given in the *Guidelines for Railroad Grade Separation Projects (Guidelines)*. The minimum required vertical clearance above the top of high rail to the low chord of the structure given in the *Guidelines* is 23'-4". The minimum required horizontal clearance measured perpendicular from the centerline of the track to piers or abutments located within the railroad's right-of-way is 25'-0". The *Guidelines* also suggests placing piers and abutments outside of the railroad's right-of-way whenever feasible.

It is noted that CDOT's requirement for vertical clearance over a railroad is 23'-0", or 4 inches less than the requirement of the *Guidelines*. The relative cost impact of the reduced minimum vertical clearance is likely small; however, not meeting the requirements detailed in the *Guidelines* increases the potential for delay in the railroad's approval. Therefore, the more restrictive vertical clearance requirement of the *Guidelines* was used in this analysis.

In addition to clearances for existing tracks, the *Guidelines* also requires consideration of future track alignments and maintenance roads. However, the BNSF currently has no planned projects for this area (see Field Diagnostic Meeting Minutes, Appendix C) and consequently this analysis was conducted with the current track alignment. The configuration given in this report will allow for one maintenance road on the west side within the railroad's right-of-way. There is currently no maintenance road under the existing structure.

2.2 Vertical Alignment and Available Structure Depth

In order to provide the required minimum vertical clearance of 23'-4" over the railroad, the profile grade of US 6 must be raised. Significant modifications to the profile are constrained to both the east and west along US 6 including the following:

- Located approximately 190 feet east of the existing east abutment, a gore for the westbound US 6 to eastbound I-25 ramp (Structure F-16-OL) restricts modification of the roadway profile.

- Approximately 450 feet west of the existing west abutment, a minimum under clearance of 16'-6" to Structure F-16-OL must be maintained.

- Any profile which provides adequate vertical clearance over the railroad and meets the existing constrained conditions to the east and west of the structure along US 6 will have design speeds reduce to approximately 45 mph.

These constrains from the existing roadway facilities combined with the minimum vertical clearance requirement at the railroad limit the available structure depth for the replacement bridge. Based on feasible roadway profile geometry, a maximum available structure envelope of 4'-2" was determined. However, this dimension does not account for the additional structure depth required to accommodate the roadway geometry including chording of the profile grade and superelevation transition (discussed in section 2.4), and deflection of the structure.

2.3 Roadway Width for Current and Future Alignment

The preferred system of the *Valley Highway Environmental Impact Statement (EIS)* was used to determine the required roadway width over the replacement structure. This ultimate configuration for US 6 provides for three through lanes of traffic in each direction with divergent ramps in both directions on the west side of the bridge. The replacement structure must be proportioned to accommodate the final roadway alignment while the current lane configuration on the bridge is maintained in the interim. These requirements result in a variable width superstructure on the west end of the bridge.

2.4 Superelevation Transition

The existing US 6 alignment east of the bridge requires a superelevation transition to occur within the limits of the replacement bridge. This superelevation transition will require an increased structure depth to account for the additional haunch required to accommodate the transition.

2.5 Maintenance of Traffic

During construction of the replacement bridge, two westbound lanes and four eastbound lanes must be maintained. The replacement bridge configuration needs to be capable of conforming to the phasing requirements.

2.6 Additional Requirements and Restrictions

There are not any special environmental or architectural requirements that need to be addressed. Additionally, there are no known utility requirements for the replacement structure. However, it is not know if there are any fiber optic lines within the BNSF right of way. Subsequent investigation regarding the existence of fiber optic lines is warranted.

3.0 Alternatives Considered

3.1 Single-Span Structure

The feasibility of a single-span structure was initially evaluated. In order to locate all substructure elements outside of the BNSF's right-of–way, a span length of 157 feet was used. Table 2.5.2.6.3-1 in the *AASHTO LRFD Bridge Design Specifications* was used to determine minimum structure depths for standard structure types constructed in Colorado. The required minimum structure depths are shown in Table 3.1. A cast-in-place structure was not evaluated because it is not feasible over the railroad.

Table 3.1—Single Span Minimum Structure Depths

Superstructure Type	Minimum Total Structure Depth
Precast Concrete I-Beams	0.045L = 7'-1"
Adjacent Concrete Box Beams	0.03L = 4'-9"
Composite Steel I-Beams	0.04L = 6'-3"

Since all of the superstructure types have a required minimum structure depth greater than the available depth of 4'-2", a single span structure is not feasible.

3.2 Two-Span Continuous Structure

Using the same overall bridge length of 157 feet for a two-span continuous structure, both abutments can be located outside the BNSF's right-of-way with a pier located to the east of the existing bridge pier with at least 25 feet of clearance to the nearest railroad track. For this arrangement, unequal spans of 109 feet and 48 feet were evaluated for the required structure depth. The required minimum structure depths for the maximum span length of 109 feet in this arrangement are given in Table 3.2.

Table 3.2—Two-Span Continuous Minimum Structure Depths

Superstructure Type	Minimum Total Structure Depth
Precast Concrete I-Beams	0.04L = 4’-4”
Adjacent Concrete Box Beams	0.025L = 2’-9”
Composite Steel I-Beams	0.032L = 3’-6”

The precast concrete I-beam (bulb tee) superstructure is not feasible because the minimum structure depth is greater than the available depth. However, both of the adjacent concrete box beam and composite steel I-beam structure types are feasible from the standpoint of minimum structure depths. A general layout for the two-span bridge arrangement is provided in Appendix D.

Preliminary designs for both the adjacent concrete box beam and composite steel I-beam structure types were completed to determine overall feasibility and cost. Both superstructure types were found to be feasible based on project constraints. Preliminary phasing for each structure type is also provided in Appendix D.

3.2.1 Adjacent Prestressed Concrete Box Girder Superstructure

An adjacent prestressed concrete box girder superstructure cross-section was developed using 25 girder lines of 34” deep by 58” wide girders with a minimum 5” cast-in-place deck slab. This superstructure has a minimum structure depth of 3’-3”. Typical sections of this superstructure type are provided on sheet B2 of the preliminary plans in Appendix D.

3.2.2 Composite Steel I Girder Superstructure

A composite steel I girder cross-section was developed consisting of 16 lines of W30x230 rolled steel girders with an 8” composite concrete deck slab. This superstructure has a minimum structure depth of 3’-8”. Typical sections of this superstructure type are provided on sheet B3 of the preliminary plans in Appendix D.

3.3 Advantages of Two-Span Structure

The two-span arrangement is advantageous because it facilitates construction, minimizes structure costs, and meets all railroad minimum clearance criteria. The location of the abutment on the east end of the structure minimizes the amount of earthwork that will be required on the existing embankment; it will also not require construction of any wall system in front of the new abutment. While a more balance span arrangement might be more efficient from a structural standpoint, any cost savings are likely to be minor and easily overcome by the additional embankment work required at the east end.

3.4 Preliminary Variable Width Analysis

The width of the replacement structure will vary on the south side in span 1 in order to accommodate the ramp from northbound I-25 to eastbound US 6. To accommodate the variable width, preliminary investigation of a cast-in-place edge beam that is integral with the deck has been conducted to determine the feasibility of construction over the railroad. In this configuration, the girders would be parallel to the bridge layout line, with the edge beam on the southwestern edge of deck in span 1. An under-hung falsework system, with beams supported under the bridge girders is feasible and could be proportioned meets the railroad's temporary minimum vertical clearance requirement of 21'-0". Another option for accommodating the variable width deck would be to flare the girders in span 1 of the replacement bridge.

3.5 Surplus Vertical Clearance

The current roadway profile provides surplus vertical clearance to the railroad. Clearances based on the Guidelines and CDOT criteria are given in Table 3.5.

Table 3.3—Preliminary Surplus Vertical Clearance

Superstructure Type	Surplus Clearance per Guidelines	Surplus Clearance per CDOT
Concrete	5"	9"
Steel	2"	6"

Additional investigation of the final roadway profile should be considered to help minimize costs and increase design speeds.

4.0 Substructure & Walls

4.1 Bridge Substructure

A letter of preliminary geotechnical recommendations was provided by Geocal, Inc. on April 1, 2011, and it is attached as Appendix E of this report. The letter recommends conventional driven steel H-pile or drilled caisson foundations. A feasible approach for the bridge substructure includes standard integral diaphragm type abutments founded on steel H-piles, with drilled caisson foundations and columns at the pier. Requirements in the *Guidelines* call for heavy construction of all substructure elements within the railroad's right-of-way. Accordingly, large columns with a minimum cross-sectional area of 30 square-feet are required at the pier.

Preliminary design of bridge foundations for both concrete and steel superstructure options were performed for cost estimating purposes.

4.2 Soil Nail Wall

Phased construction of the replacement structure will require the preservation of the existing abutment wall at the west end of the structure to retain the embankment as the new abutment is constructed behind the existing one. The final configuration of the bridge will require removal of the existing abutment wall that is located within the BNSF's right-of-way, and construction of a new wall to retain the embankment adjacent to the new abutment.

The preferred solution is to construct a soil nail wall behind the existing abutment and in front of the new abutment. The soil nail wall will be constructed after the phased construction of the replacement structure has been completed. The advantages of this type of construction include the reduced need for temporary shoring during phased construction of the replacement structure, lower overall cost, and reduced impact to rail operations since the existing adjacent Siding Track No. 1 will likely have to be taken out of service during demolition of the existing abutment. While cast-in-place retaining walls or a tall abutment are likely to be feasible, they are also likely to be significantly more expensive.

5.0 Cost and Constructability

Estimated construction costs for both feasible superstructure types are provided in Appendix F. Based on these estimates, the prestressed box girder is approximately 7% cheaper than the composite steel girder. However, it may be prudent to make the final determination of the structure type after further investigating the constructability of each with respect to the railroad's right-of-way and constraints to the project site as well as additional study of the construction phasing. The steel girder option may be easier to construct in this scenario, and possibly negate the cost advantage of the prestressed box girder calculated in the initial estimate.

Appendix A

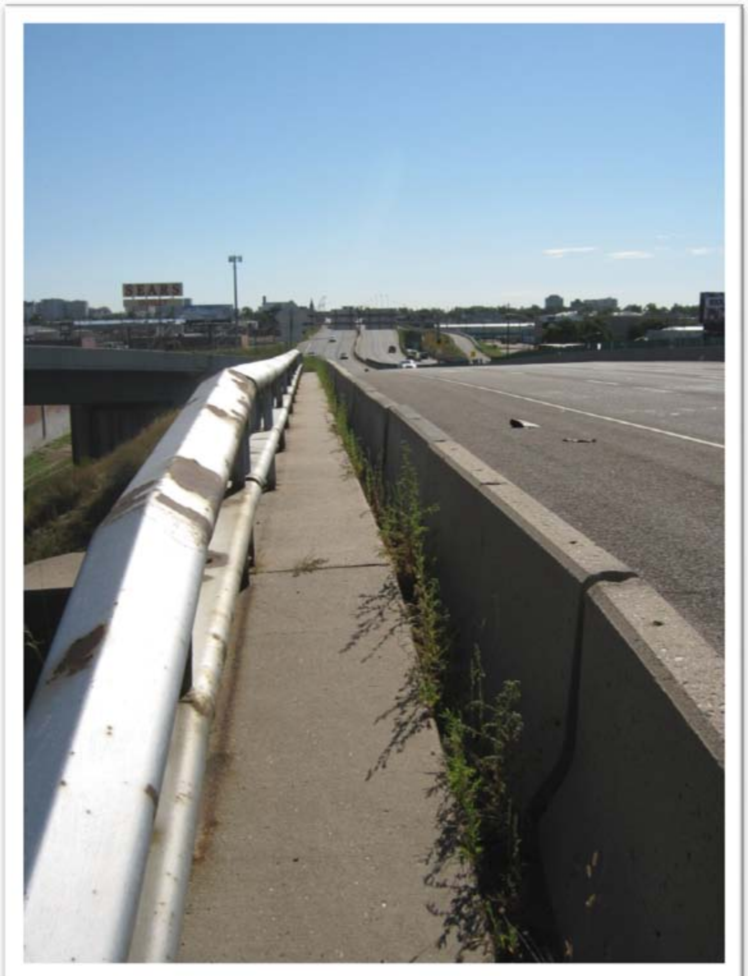
Existing Bridge Photographs

Photograph 1 – Elevation of existing bridge looking north

Photograph 2 – Elevation of existing pier looking east

Photograph 3 – Existing abutment looking west

Photograph 4 – West approach looking east



Photograph 5 – Existing bridge rail and deck looking east

Photograph 6 – Existing US-6 under Structure F-16-OL looking west

Appendix B

2009 Structure Inventory and Inspection Report

Colorado Department of Transportation

Structure Inspection and Inventory Report (English Units)

Bridge Key: F-16-EJ | Inspection Date: 12/21/2009 | Sufficiency Rating: 47.8 SD

Rgn/Sectn 2E/2M:	68
Trans Region 2T	02
County Code 3:	031
DENVER	
Place Code 4:	20000
DENVER	
Rte.(On/Under)5A:	1
Signing Prefix 5B:	2
Level of Service 5C:	1
Directional Suffix 5E:	0
Feature Intersected 6:	
BNSF RR	
Facility Carried 7:	
US 6 ML	
Alias Str No.8A:	
BRIDGE ENTERPRISE, TC1889	
Prll Str No. 8P	
F-16-EI	
Location 9:	328.05117409
EAST EDGE OF I-25 INT.	
Max Clr 10:	99.99
BaseHiway Net12:	1
IrsinvRout 13A	000000006G
IrssubRout No13B:	00
Latitude 16:	39d 43' 36"
Longitude 17:	105d 00' 46"
Range18A:	68 W
Township18B:	68
Section18C:	4
Detour Length 19:	2.0 mi
Toll Facility 20:	3
Custodian 21:	1
Owner 22:	1
Functional Class 26:	02
Year Built 27:	1956
Lanes on 28A:	8
Lanes Under 28B:	0
ADT 29:	137,000
Year of ADT 30:	2008
Design Load 31:	6
Apr Rdwy Width 32:	162.0 ft
Median 33:	2
Skew 34:	7.00 °
Structure Flared 35:	1
Sfty Rail 36a/b/c/d:	0 0 0 0
Rail ht36h:	38 "in"

Hist Signif 37:	5
Posting status 41:	A
Service on/un 42A/B:	1 2
Main Mat/Desgn 43A/B:	4 2
Appr Mat/Desgn 44A/B:	0 0
Main Spans Unit 45:	2
Approach Spans 46:	0
Horiz Clr 47:	70.0 ft
Max Span 48:	68.7 ft
Str Length 49:	130.0 ft
Curb Wdth L/R 50A/B:	0.0 ft 0.0 ft
Width Curb to Curb 51	140.0 ft
Width Out to Out 52:	148.5 ft
Deck Area:	19,310.5 sq. ft
Min Clr Ovr Brdg 53:	99.99
Min Undrclr Ref 54A:	R
Min Undrclr 54B:	22.3 ft
Min Lat Clrnce Ref R 55A	R
Min Lat Undrclr R 55B	15.5 ft
Min Lat Undrclr L 56:	0
Deck 58:	5
Super 59:	5
Sub 60:	4
Channel/Protection 61:	N
Culvert 62:	N
Oprtng Rtg Method 63:	1 LF Load Facto
Operating Rating 64:	56.0
Inv Rtng Method 65:	1
Inventory Rating 66:	33.1
Asph/Fill Thick 66T:	004 "in"
Str. Evaluation 67:	4
Deck Geometry 68:	9
Undrclr Vert/Hor 69:	6
Posting 70:	5
Waterway Adequacy 7	N
Approach Alignment 72:	8
Type of Work 75A:	31
Work Done By 75B:	1
Length of Improvment 76	129.9 ft
Insp Team Indicator 90B	GREEN TEAM (
Inspector Name 90C:	MOSST
Frequency 91:	24 months
FC Frequency 92A:	-1
UW Frequency 92B:	-1
SI Frequency 92C:	-1
FC Inspection Date 93A:	

UW Inspection Date 93B	
SI Date 93C:	
Bridge Cost 94:	$ 3,058,770
Roadway Cost 95:	$ 305,877
Total Cost 96:	$ 4,588,155
Year of Cost Estimate 97:	2006
Brdr Brdg Code/% 98A/B:	
Border Bridge Number 99	
Defense Highway 100:	0
Parallel Structure 101:	N
Direction of Traffic 102	2
Temporary Structure 103	_
Highway System 104:	1
Fed Lands Hiway 105:	0
Year Reconstructed 106	1966
Deck Type 107:	1
Wearing Surface 108A	6
Membrane 108B:	0
Deck Protection 108C:	0
Truck ADT 109:	2 %
Trk Net 110:	1
Pier Protection 111:	#
NBIS Length 112:	Y
Scour Critical 113:	N
Scour Watch 113M:	_
Future ADT 114:	154,810
Year of Future ADT 115	2028
CDOT Str Type 120A:	CIC
CDOT Constr Type 120B	0.
Inspection Indic 122A:	
Inspection Trip 122AA	
Scheduling Status 122B	
Maintenance Patrol 123	7
Expansion Dev/Type124	1
Brdg Rail Type/Mod 125A/B	U 3
Posting Trucks 129A/B/C	0 0 0
Str Rating Date 130:	7/27/1995
Special Equip 133:	-1
Vert Clr N/E 134A/B/C:	X 99.99 0.00
Vert Clr S/W 135A/B/C	X 99.99 0.00
Vertical Clr Date:	11/8/1993
Weight Limit Color: 139	0
Str Billing Type:	U
Userkey 1 - System:	ONSYS
Userkey 7-Update Indic	

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
13/4	**Unp Conc Deck/AC Ovl**	**(SF)**	19,311	0 %	0	100 %	19,311	0 %	0	0 %	0	0 %	0
107/4	**Paint Stl Opn Girder**	**(LF)**	2,540	77 %	1,953	15 %	370	7 %	181	1 %	36	0 %	0
205/4	**R/Conc Column**	**(EA)**	9	56 %	5	11 %	1	22 %	2	11 %	1	0 %	0
215/4	**R/Conc Abutment**	**(LF)**	300	42 %	125	25 %	75	33 %	100	0 %	0	0 %	0
234/4	**R/Conc Cap**	**(LF)**	135	0 %	0	37 %	50	56 %	75	7 %	10	0 %	0
304/4	**Open Expansion Joint**	**(LF)**	142	58 %	82	42 %	60	0 %	0	0 %	0	0 %	0
308/4	**Constr Non Exp Jt**	**(LF)**	300	0 %	0	100 %	300	0 %	0	0 %	0	0 %	0
311/4	**Moveable Bearing**	**(EA)**	40	28 %	11	28 %	11	45 %	18	0 %	0	0 %	0
313/4	**Fixed Bearing**	**(EA)**	20	0 %	0	0 %	0	100 %	20	0 %	0	0 %	0
321/4	**R/Conc Approach Slab**	**(EA)**	2	100 %	2	0 %	0	0 %	0	0 %	0	0 %	0
325/4	**Slope Prot/Berms**	**(EA)**	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0
326/4	**Bridge Wingwalls**	**(EA)**	4	75 %	3	25 %	1	0 %	0	0 %	0	0 %	0
331/4	**Conc Bridge Railing**	**(LF)**	260	92 %	240	8 %	20	0 %	0	0 %	0	0 %	0
334/4	**Metal Rail Coated**	**(LF)**	260	45 %	118	0 %	0	45 %	116	10 %	26	0 %	0
338/4	**Conc Curbs/SW**	**(LF)**	260	0 %	0	42 %	110	29 %	75	29 %	75	0 %	0
359/4	**Soffit Smart Flag**	**(EA)**	1	0 %	0	0 %	0	0 %	0	100 %	1	0 %	0

Elem/Env	Description	Element Notes
13/4	**Unp Conc Deck/AC Ovl**	4 inches of Asphalt - Raveling of asphalt along seams.
107/4	**Paint Stl Opn Girder**	Span 1 girders heavily blackened by train exhaust. Girders at A3; 2I to 2R have been blacken by camp Fires. R1 to R2 on top flanges where deck leaks & may be loose. Light rust/poor paint is mainly in span 1. R1 & R2 rust in span 2, mainly below joints and exterior girders and girders I & K. See tally sheet. Corners of flanges digging 1/4 inch into A-3 backwall, 2Q maybe an inch.
205/4	**R/Conc Column**	Col. 2I has right side (full heigth) spalled over 3 inches deep / behind the main vertical reinf. bars. These bars have at least 25% section loss & are bowing out (probably due to the rustpack behind them). The 12 CONSECUTIVE TIE BARS ARE ALL CORRODED THROUGH ON THIS SOUTH FACE. Banding (for attaching signs to poles) 8 bands were placed around the column to limit the bowing of the main reinf., see 2008 & 2009 PHOTOs. Column A has a 3/16 vertical crack, rust stains with delamination. Column E has vertical cracks and delamination. See 2003 & 2008 photos.

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Elem/Env	Description	Element Notes
215/4	**R/Conc Abutment**	Abut 1 is a tall retaining wall - with horizontal, vertical, & diagonal cracks, some with efflorescence and face of A1 right has delams. Series of 1/8 inch vertical cracks with efflorescence that extend from groundline to below girder C at A-1. Breastwall of A-3 cap has areas of spalled concrete with exposed corrosion in rebar, the worst is right 1/2 of A3, 2008 PHOTO. Spalling & delaminating is along moderate horizontal cracks, worst conditions is below girders D, E, F, M, N, O & P. Backwall of A-3 has light vertical, horizontal & diagonal cracks with efflorescence. Bearing seat at A-3 has areas of up to 6 inches of debris. Abut. 1 Wall is probably being pushed towards Abut 3 - A3 Rockers have rotated, girders are pushing against backwall of A3 causing minor spalling. This is not a problem yet; bridge will probably be replaced before it is very significant.
234/4	**R/Conc Cap**	Pier caps have moderate to heavy horizontal cracks with areas of shallow to deep delamination, rust stains, and many areas of efflorescence, 2009 PHOTO of typical. No apparent bearing loss, but unable to get bucket truck below, used long ladder in 2008 Inspection. Cap under girders 1A, 1B, and 1C shallow concrete spalled to rebar, no loss of bearing at this time. See 2003 & 2008 photos. Heavy spall with exposed rebar that is corroded, and moderate delam. cracks at P2 cap below girders 2R, 2S and 2T. See photos.
304/4	**Open Expansion Joint**	At A-3. Asphalt covered, reopening and potholes are forming. See 2008 photo.
308/4	**Constr Non Exp Jt**	At A-1 & P-2 Asphalt cover cracked and leaking, noted by icicles at times.
311/4	**Moveable Bearing**	Rockers at P-2 & A-3 - Rockers have R2 to R3 corrosion and heavy flaking rust. 3G, 3H, 3L to 3Q have rotated to where girders are pushing against A-3 backwall and causing some minor spalling, probably due to Abut. 1 being pushed inward.
313/4	**Fixed Bearing**	At A-1. R1 to R2 corrosion.
321/4	**R/Conc Approach Slab**	Per plans - Covered with asphalt, no problems yet but edges starting to become exposed due to settling and erosion of fill at wings.
325/4	**Slope Prot/Berms**	Dirt slope & berm at A-3; homeless persons living on top of wide dirt berm area.
326/4	**Bridge Wingwalls**	TALL Flared wings for retaining wall abut. 1. Joint open over 2 inches at the top of right rear, allowing some loss of backfill, 2009 PHOTOs. The left wing joint is open slightly. Stubs for abut. #3 cap, ok.
331/4	**Conc Bridge Railing**	Jersey barriers - In median (cast-in-place & continuous), but portable sections in front of left metal rail. Minor spalling, scale, tire marks, shrinkage, vertical cracks and delamination at base, see 2008 PHOTOs. Many vert. fiberglass glare strips on median barrier damaged, 2009 PHOTO.
334/4	**Metal Rail Coated**	Galv. Type Y at right, was new in 1998, still OK. The original Type U at left, not being used because Jersey barrier has been placed in front of it. But it has R2-R4 corrosion on left posts @ base, spots of peeling paint, with R1-R4 corrosion, on railing. See 2009 & 2003 photos.
338/4	**Conc Curbs/SW**	Many spalls along top edges some with exposed rebar. Extensive horiz. cracking along face, delamination, right side is the worst, see 2009 & 2008 PHOTOs.

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

Elem/Env	Description	Element Notes
359/4	**Soffit Smart Flag**	Areas of map cracking with moderate efflorescence and rust stains, saturation in some of these areas with stalactites and Icicles. The worst are in bays A, B, C and I. Few other trans cracks with efflor.: Span 2, 5 to 20 feet from A-3, 1/32 inch trans cracks with some differential espec bay 2Q with 1/8 inch difference, (PHOTO 11/08/93), spall in bay 2P, 5 feet from A-3, 2.5 feet x 2 feet with rebar exposed, 11/08/93 photo. Spall with exposed rebar from contamination, bay 2I, about 14 sq feet, about 15 feet from P-2, 11/08/93 & 01/07/02 photos. Right exterior bay T cracked, spalled, delamination, and rust stains whole length. Patches, 2 in bay 2H adjacent to girder I, 1 in bay 2L next to girder L. Shallow delam cracking in bay 2H, 12 feet from A-3. Delamination cracking and spalls in bay 2-O: Estimate about 25% total deck bad.

Maintenance Activity Summary

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
*398	Debri	12/18/2003	-1	2010	50000

Please corelate with other municipalities to clear the area. Remove all debris and trash from abutment 3.

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
355.02	Cln & Pnt	1/7/2002	-1	2011	5000

Clean and spot paint the steel girders and their bearings, Abut 3 ends & bearings espec.

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
*353.03	Br Dk Rpr	1/7/2002	-1	2010	75000

Shore up 40 feet of bay 2J or replace section of deck.

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
360.00	App Sl & S	12/21/2009	-1	2012	400

Place fill at both sides of rear slab, there is settlement and erosion 2-3 ft. deep between roadway and wings, 2009 PHOTO.

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	2/4/2008	-1	2011	5000

Column 2I needs rehabilitation of South face.

MMS Activity	Description	Recommended	Status	Target Year	Est Cost
357.05	Bearings	2/4/2008	-1	2011	3000

Clean and paint dirty and rusting rocker bearings at A3.

Bridge Notes

Homeless persons are living at Abutment 3 & had sleeping quarters.
There is soot from camp fires, Abut. 3 & girders;
Much of this was taken to a roll-off dumpster but soma remains; 2008 & 2009 PHOTOs.

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

Inspection Notes

Time:) 1:55 Temp.:) 55 deg. F. Weather:) Partly Cloudy Team Leader:) TAM

Scope:

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

Inspector: MOSST **Inspection Team:**

Inspection Date: 12/21/2009

____
Inspector

____
Inspector

Appendix C

Field Diagnostic Meeting Minutes

FBR 0062-026 (18202)

6th Avenue Bridge over BNSF Railroad **05/18/11**

Field Diagnostic Meeting

Action Items Summary List

- ✓ Pam Fischhaber to check at PUC for the legal description of the existing bridge
- ✓ Andy Amparan to follow up with BNSF on legal description of the existing bridge
- ✓ Andy Amparan to check when the last maintenance project occurred (to make sure survey will be adequate to determine vertical clearances for design)
- ✓ Andy Amparan to check how often the maintenance is performed on the tracks
- ✓ Gene Eliassen to confirm if BNSF wants/needs 1 or 2 maintenance roads and on which side
- ✓ Bill Snowden to research Design Build language for BNSF & UPRR

1. Introductions

See attached sign in sheet.

2. BNSF Safety Briefing

Jerad Esquibel:

- No need since we are rained out and indoors

3. Proposed Scope of Work

Scott Waterman:

- Location: on 6th Ave. approximately 700 feet east of I-25 centerline
- Structure Sufficiency < 50 so will need a bridge replacement
- Current vertical clearance is deficient so will likely need to raise vertical profile of 6th Ave.
- Valley Highway EIS will define ultimate laneage
- FIR: August 2011
- FOR: December 2011 (IF Design/Bid/Build)
- AD: July 2012 (right of way dependent) (IF Design/Bid/Build)
- Now through August will be setting the bridge footprint with BNSF (30% design)

4. Planned Projects/Improvements

Andy Amparan

- No planned projects for BNSF as of right now
- BNSF is like CDOT though, that if funding is to become available there could be

Scott Waterman:

- Have had one meeting with Denver, and they have no future projects planned for this area
- There is high potential this bridge will be added to the Bridge Enterprise US 6 Corridor Projects west of I-25

5. Easements

Scott Waterman:
- Legal description has been pulled for the flyover
- Still looking for the legal description of this existing bridge

Andy Amparan:
- BNSF Real Estate contact for Colorado has moved on
- Andy will check back with the BNSF real estate office for new contact to research

Pam Fischhaber:
- Will also check PUC records for the legal description of the existing bridge

6. Geometric Requirements for Proposed Improvements

Gene Eliassen:
- BNSF ROW is approx. 65' from the original mainline
  - Original/mainline is 2nd from the east
  - ROW most likely dimensioned from here in the legal description
- See attached ROW exhibit provided by Gene

Andy Amparan:
- PDF submittals are good for BNSF review

Scott Waterman:
- Surveyors have permit, resubmitted and waiting to get flaggers
- Need to survey from 8th Ave. to the I-25 crossing on the south
  - Need the 1000' on each side of the structure to verify there are no sags in the tracks

Andy Amparan:
- Will check when the last maintenance was performed on the tracks
- Will check to see how often maintenance is performed on the tracks

Andy Leifheit:
- Minimum 25' horizontal pier clearance without crash wall per Grade Separation Guidelines
- Absolute minimum 18' horizontal pier clearance with crash wall per Grade Separation Guidelines
- Minimum vertical clearance 23'-4" per Grade Separate Guidelines
- Looking to move pier back on the east side to get 25'
- West side depends on the ROW, but will most likely have a wall with tall abutment
  - NO MSE walls on BNSF ROW
  - NO drainage onto BNSF ROW
- 6th Ave will likely have to be raised as existing vertical clearance may be below 23'4"

Gene Eliassen:
- BNSF is supposed to have a maintenance road on both side of a triple track, but physical constraints on either side make it difficult
- Gene will check with BNSF maintenance to see how many they want/need since there isn't one there currently

Scott Leiker:

- A drainage report will be needed for the project and the report should include a specific section discussing impacts to BNSF
  - This will need to be presented to BNSF
- Historic drainage patterns must be maintained
- The drainage system should be designed for the ultimate lane configuration of 6th Ave
- Based on an ultimate design, it is assumed that to meet increased impervious area and current drainage criteria, that the outfall may need to be upsized or detention pond may be required
- There is no water quality banking policy in place, therefore we will need to treat our impacted drainage while not precluding future WQ improvements for the Valley Highway EIS
- This project will need to provide 100% Water Quality Capture Volume or 80% TSS removal for the impervious areas within the limits of disturbance
- Susie Smith should be contacted early in the design process to discuss the water quality concept
- We should anticipate future improvements to 6th Ave, both east and west of this project, and design our drainage system accordingly (let's look at the big picture)
- At or before FIR, the water quality basin map (34" x 22") with proposed BMP's should be discussed with Susie Smith or CDOT Hydraulics so that concept going forward meets requirements with CDPHE and right of way needs can be addressed

7. Utilities

Ron Dickey:

- Overhead high voltage electric
- We need to check if fiber is present along railroad
- Try not to impact these

8. Construction Time Constraints

Andy Amparan:

- No work Oct. – Dec. that will affect train operations

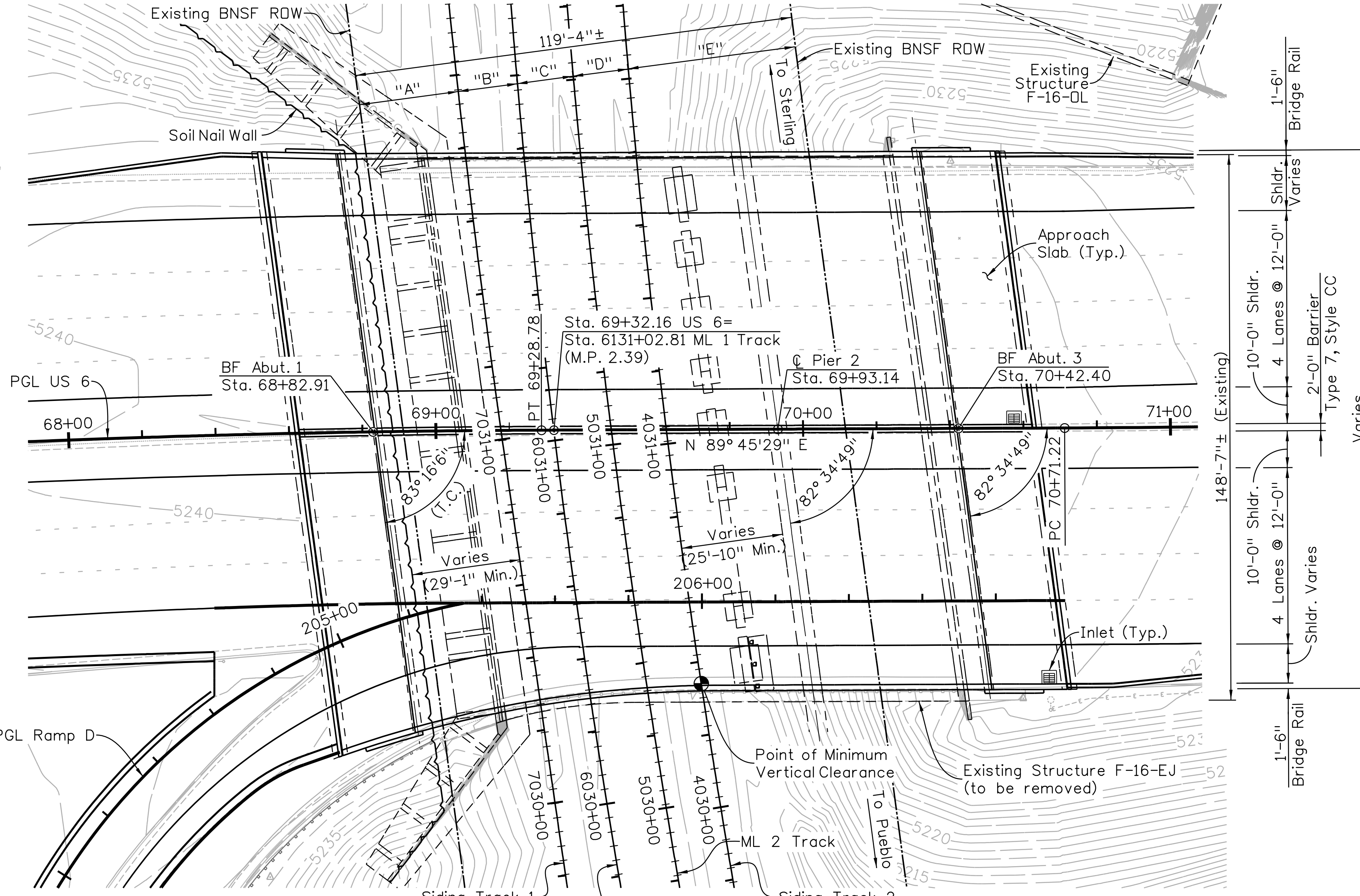
- Procurement process – need to know sooner than later – will know July 1st
- C&M agreement will be affected if this project changes from DBB to DB
- Bill Snowden to research Design Build (DB) language for BNSF and UPRR
- DBB or DB could also affect the PUC application
- Pam Fischhaber says to have PUC application in early to mid April to maintain July 2012 AD date

Appendix D

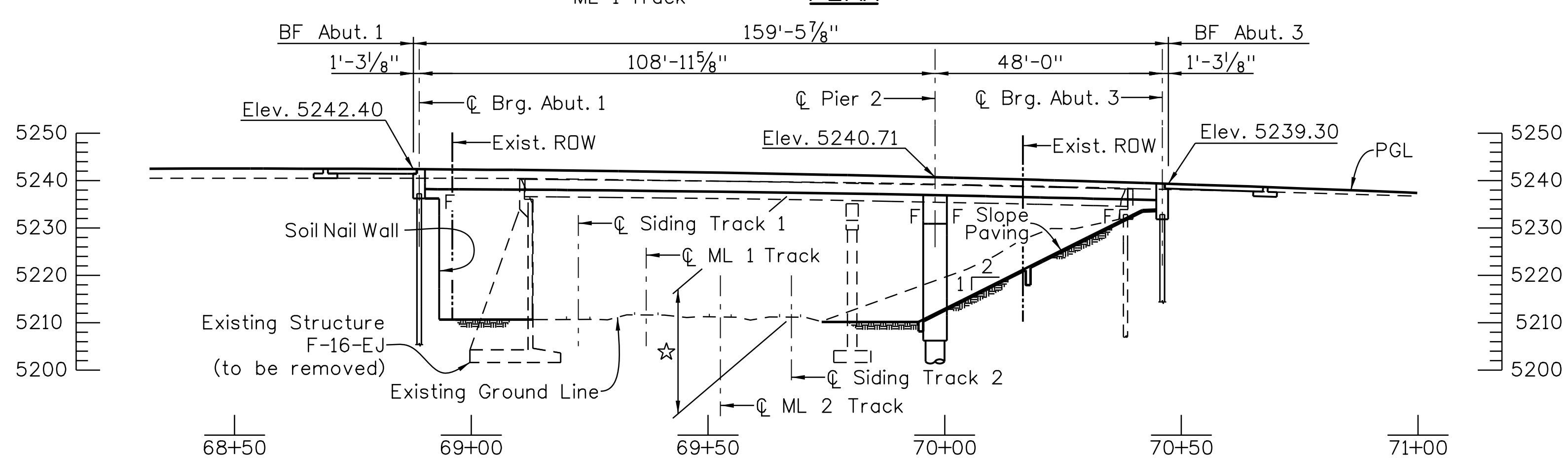
Preliminary Bridge Plans

HORIZONTAL CURVE DATA

Δc = 4° 58'26" Rt.
Tc = 165.90'
Lc = 331.60'
Rc = 3819.89'
PI = Sta. 67+63.09



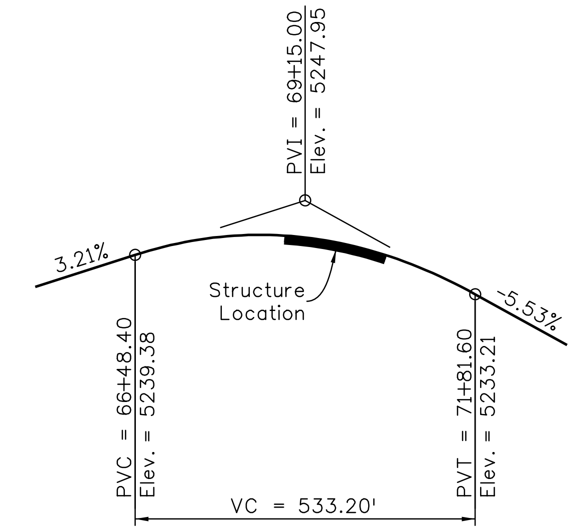
PLAN



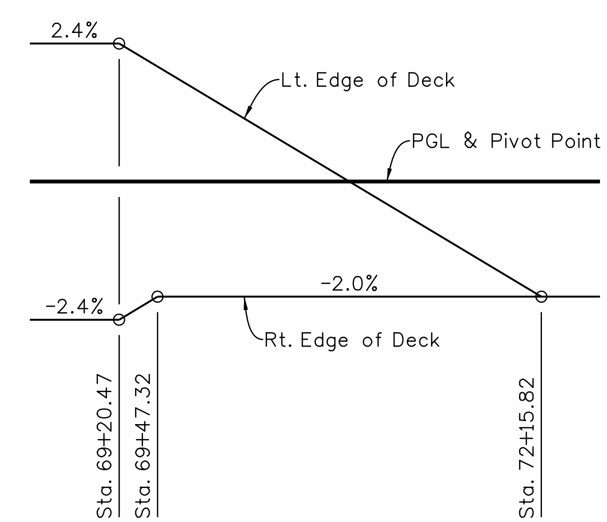
SECTION
(Taken along PGL)

TRACK CLEARANCE TABLE

"A"	"B"	"C"	"D"	"E"
Varies 26'-3" Min.	Varies 13'-7" Min.	Varies 15'-4" Min.	Varies 14'-8" Min.	Varies 46'-10" Min.



US 6 PROFILE GRADE



SUPERELEVATION DIAGRAM

☆ Minimun Vertical Clearance
23'-9" Concrete Alternate
23'-6" Steel Alternate

FIR
12/28/2011

Design			Detail			Quantities		
	INITIAL	DATE		INITIAL	DATE		INITIAL	DATE
Designed By	BJA	12/11	Detailed By	DRA	12/11	Quantities By	JAR	12/11
Checked By	JAR	12/11	Checked By	BJA	12/11	Checked By	BJA	12/11

Print Date: 12/22/2011
File Name: 18202BRDG_GeneralLayout.dgn
Horiz. Scale: 1:1 Vert. Scale: As Noted
Staff Bridge Branch - Unit 022X Unit Leader Initials
WILSON & COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 MP

As Constructed
No Revisions:
Revised:
Void:

US 6 OVER BNSF
GENERAL LAYOUT

Designer: B. Allen
Detailer: D. Anderson
Structure Numbers: F-16-YJ
Sheet Subset: BRIDGE Subset Sheets: B1 of BX

Project No./Code
FBR 0062-026
18202
Sheet Number

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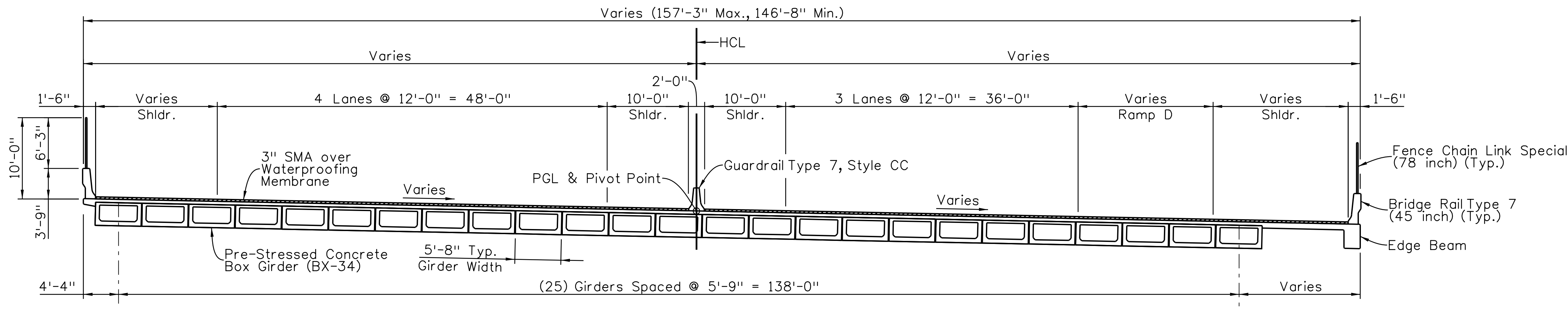

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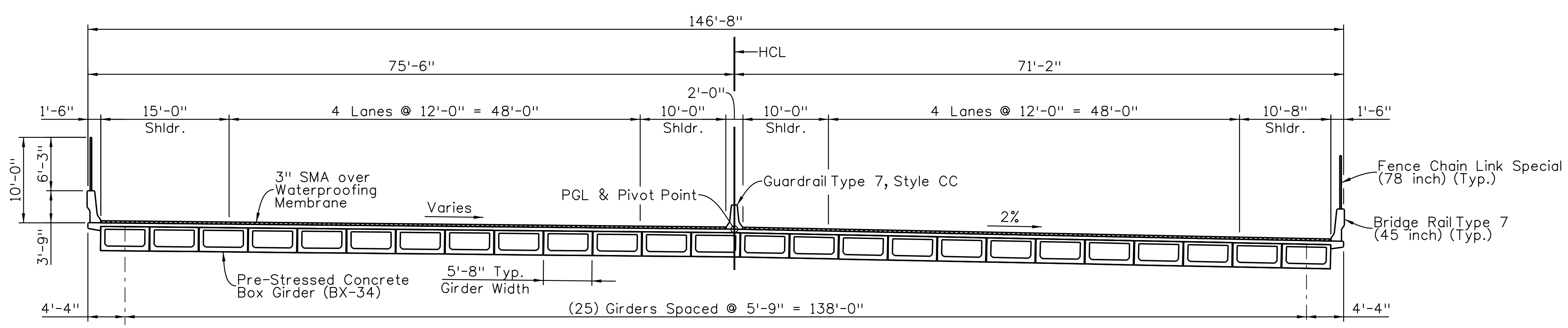

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12/28/2011

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Checked By	JAR	12/11				
Detailed By			BJA	12/11		
Checked By			JAR	12/11		
Quantities By					JAR	12/11
Checked By					BJA	12/11

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Staff Bridge Branch - Unit 022X Unit Leader Initials
WILSON & COMPANY

Sheet Revisions		
Date:	Comments	Init.

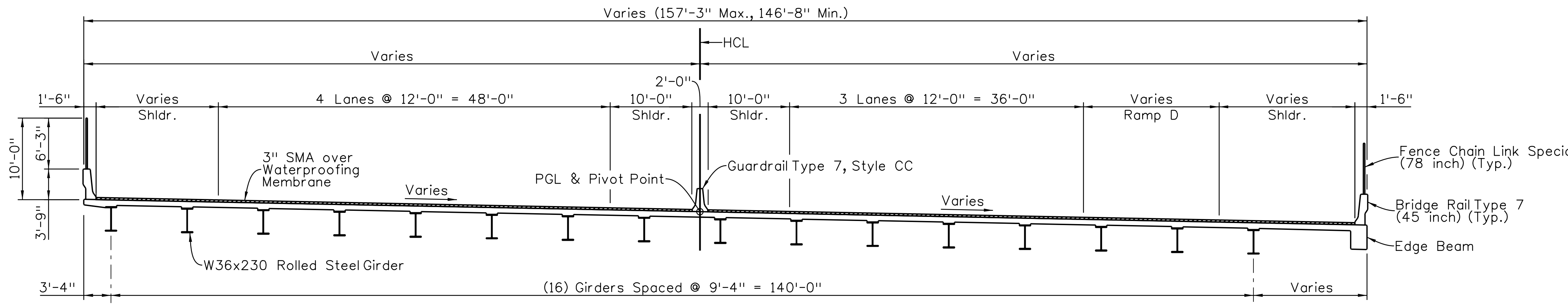
Colorado Department of Transportation
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 MP

As Constructed
No Revisions:
Revised:
Void:

US 6 OVER BNSF
TYPICAL SECTION
CONCRETE ALTERNATE

Designer:	B. Allen	Structure Numbers	F-16-YJ
Detailer:	B. Allen		
Sheet Subset:	BRIDGE	Subset Sheets:	B2 of BX

Project No./Code
FBR 0062-026
18202
Sheet Number



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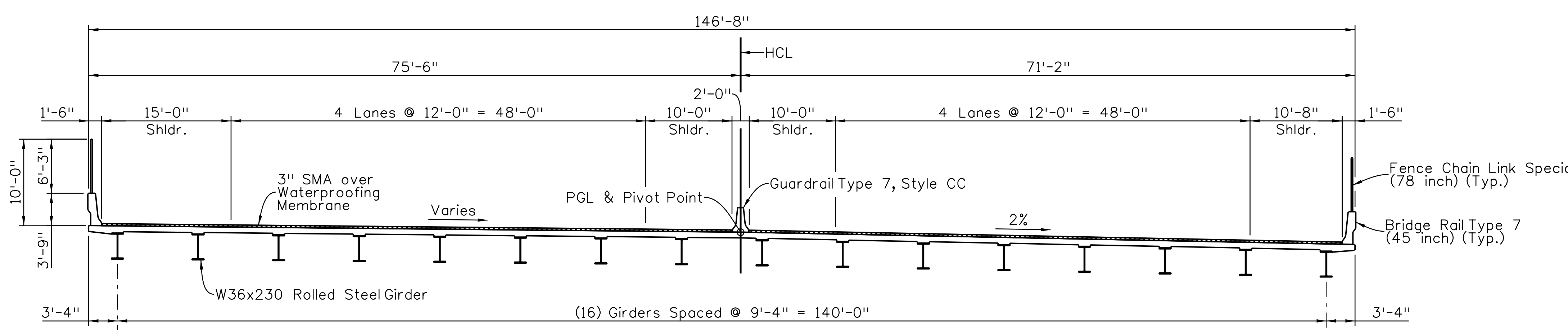

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Sta. 69+76.53 to Abut. 3

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12/28/2011

	Initial	Date
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Design – Checked By	JAR	12/11
Detail – Detailed By	BJA	12/11
Detail – Checked By	JAR	12/11
Quantities – Quantities By	JAR	12/11
Quantities – Checked By	BJA	12/11

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Staff Bridge Branch - Unit 022X Unit Leader Initials
WILSON & COMPANY

Sheet Revisions

Date:	Comments	Init.

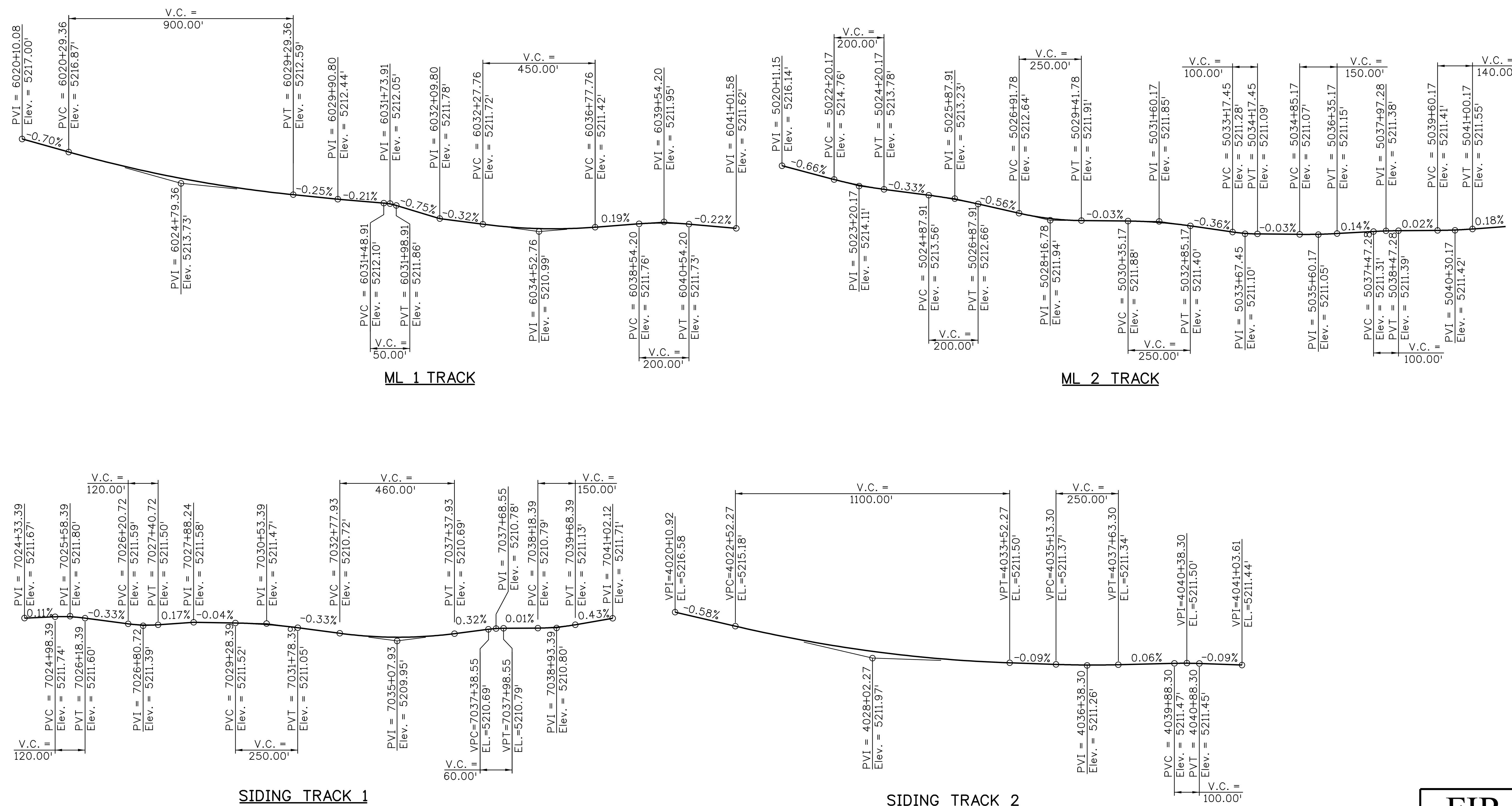
Colorado Department of Transportation
DOT
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 MP

As Constructed
No Revisions:
Revised:
Void:

US 6 OVER BNSF
TYPICAL SECTION
STEEL ALTERNATE

Designer: B. Allen
Detailer: B. Allen
Sheet Subset: BRIDGE
Structure Numbers: F-16-YJ
Subset Sheets: B3 of BX

Project No./Code
FBR 0062-026
18202
Sheet Number



FIR
12/28/2011

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Checked By		Checked By		Checked By	

Print Date: 12/27/2011	Sheet Revisions (Date: / Comments / Init.)	Colorado Department of Transportation
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Horiz. Scale: 1:1 Vert. Scale: As Noted		Phone: 303-972-9112 FAX: 303-972-9114
Staff Bridge Branch - Unit 022X Unit Leader Initials		Region 6 MP
WILSON & COMPANY		

As Constructed	US 6 OVER BNSF EXISTING TRACK PROFILES		Project No./Code
No Revisions:	Designer: B. Allen	Structure Numbers: F-16-YJ	FBR 0062-026
Revised:	Detailer: D. Anderson		18202
Void:	Sheet Subset: BRIDGE	Subset Sheets: B4 of BX	Sheet Number

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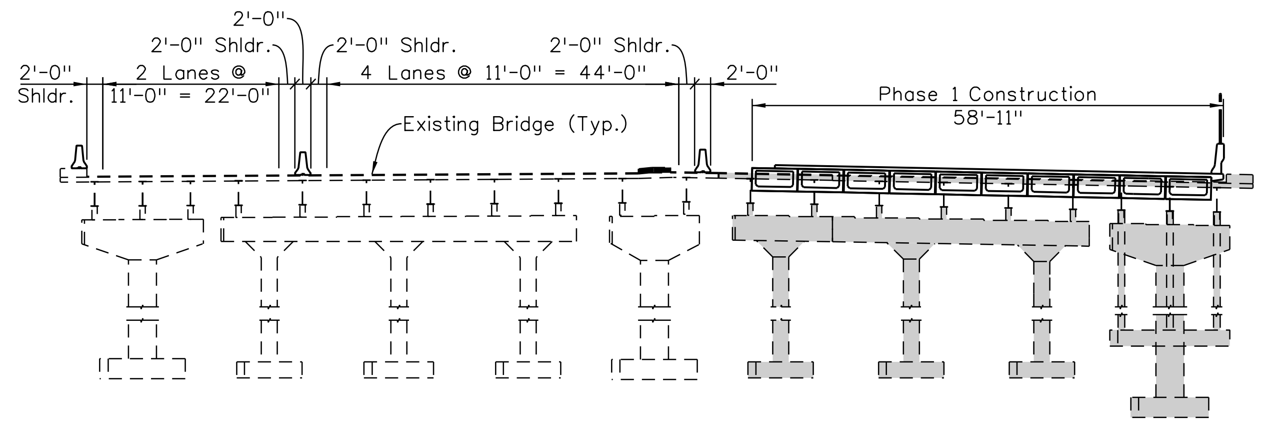

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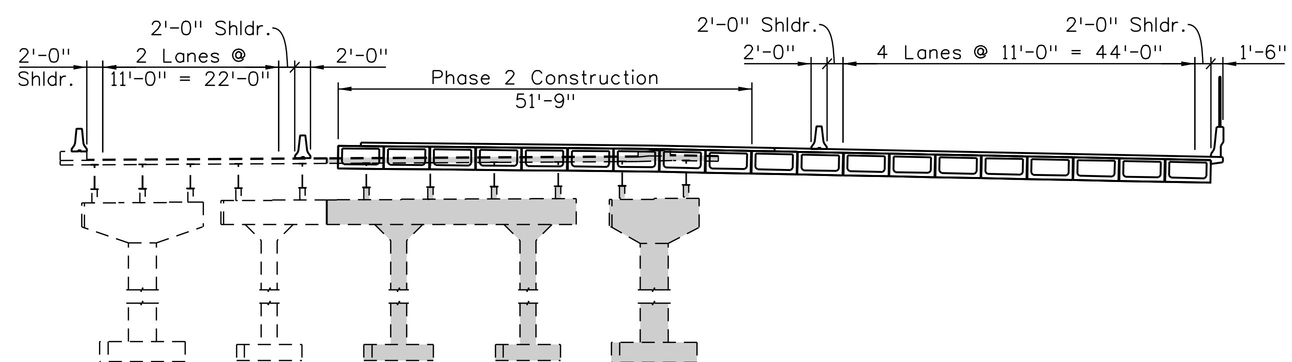

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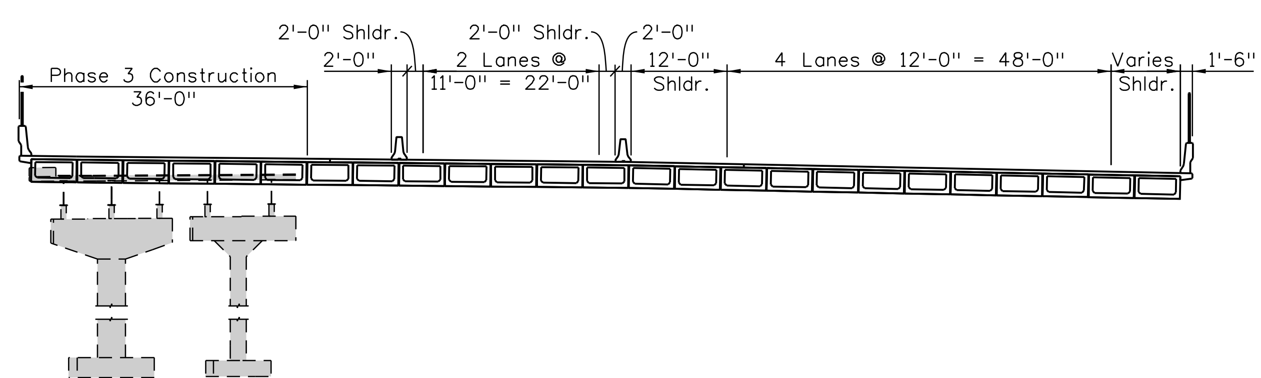

PHASE 3 CONSTRUCTION

Indicates removal during phase

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12/28/2011

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Checked By	JAR	12/11	Checked By	BJA	12/11	Checked By	BJA	12/11

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Staff Bridge Branch - Unit 022X Unit Leader Initials
WILSON & COMPANY

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 MP

As Constructed
No Revisions:
Revised:
Void:

US 6 OVER BNSF
CONSTRUCTION PHASING
CONCRETE ALTERNATE

Designer: B. Allen
Detailer: D. Anderson
Sheet Subset: BRIDGE
Structure Numbers: F-16-YJ
Subset Sheets: B5 of BX

Project No./Code
FBR 0062-026
18202
Sheet Number

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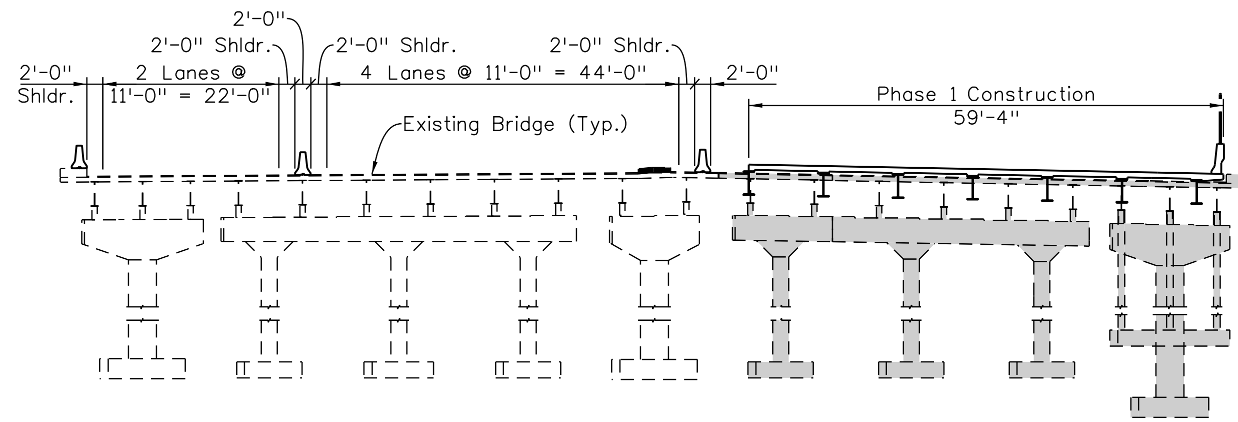

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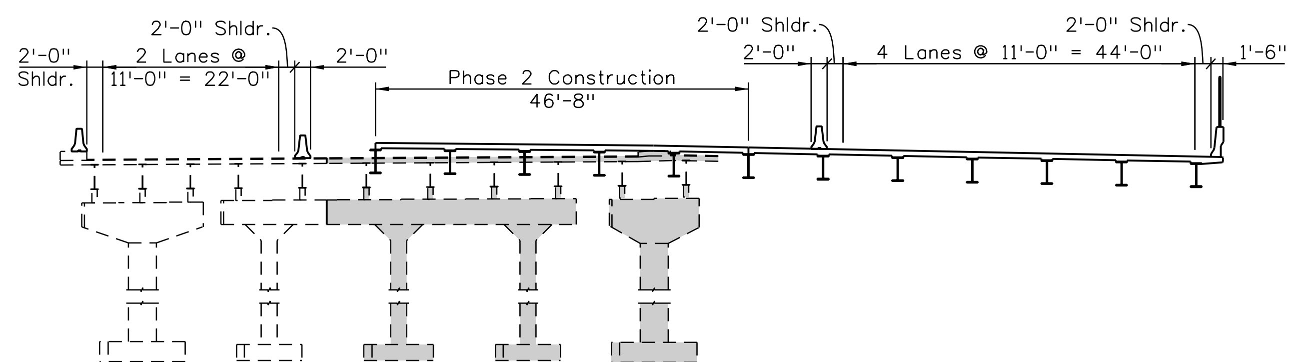

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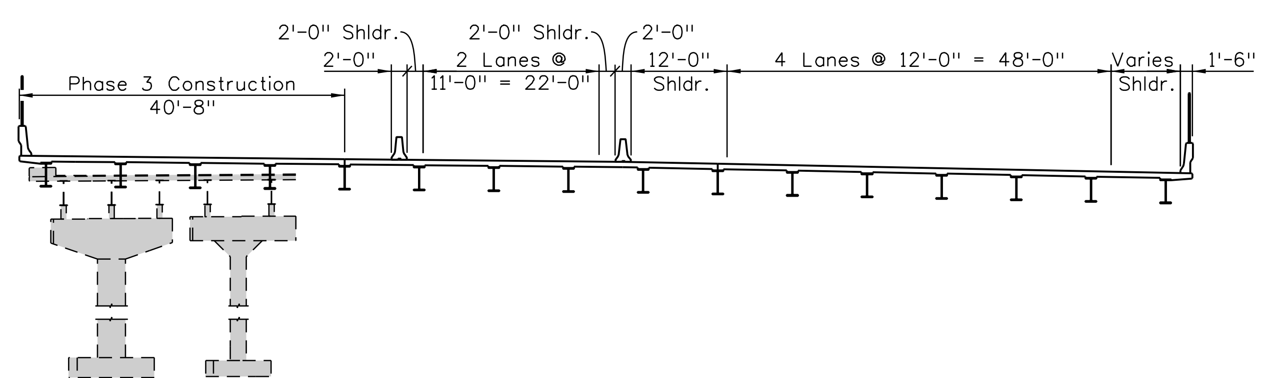

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Indicates removal during phase

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12/28/2011

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Checked By	JAR	12/11

Detail	INITIAL	DATE
Detailed By	DRA	12/11
Checked By	BJA	12/11

Quantities	INITIAL	DATE
Quantities By	JAR	12/11
Checked By	BJA	12/11

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Staff Bridge Branch - Unit 022X Unit Leader Initials
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Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
8833 South Wadsworth Court
Littleton, CO 80128
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Region 6 MP

As Constructed
No Revisions:
Revised:
Void:

US 6 OVER BNSF
CONSTRUCTION PHASING
STEEL ALTERNATE

Designer: B. Allen
Detailer: D. Anderson
Sheet Subset: BRIDGE
Structure Numbers: F-16-YJ
Subset Sheets: B6 of BX

Project No./Code
FBR 0062-026
18202
Sheet Number

Appendix E

Preliminary Geotechnical Recommendations

Geocal, Inc.

April 1, 2011

Scott Waterman, P.E.
Wilson & Company, Inc., Engineers & Architects
999 18th Street
Denver, CO 80202

RE: Preliminary Geotechnical Recommendations
Soil & Foundation Investigation
6th Avenue Bridge over BNSF, Denver, Colorado

Dear Scott:

This letter provides preliminary recommendations for the referenced 6th Avenue bridge project over the BNSF Railroad in CDOT's Region 6, Denver, Colorado. The recommendations contained are based on subsurface information detailed in drawings provided by the Division of Highways, dated February 1988 and for investigations conducted for Ramp H planned to be constructed north of this bridge project. Our recommendations are subject to change once the site specific subsurface investigation is completed.

Subsurface Conditions

The subsoils graphically shown on the drawing indicate that a layer of fill consisting of clayey sands to sandy clays was over relatively clean natural sands with trace gravel. Claystone Bedrock was encountered at about elevation 5180 feet. Ground water was encountered at about elevation 5192 feet. Ground surface was at about 5210 feet.

Preliminary Foundation Recommendations

Based on the subsurface conditions described a drilled shaft or driven pile foundation may be used for support of the structure. The following design and construction recommendations should be observed.

Drilled Shafts

1. Drilled shafts should be designed for ultimate end bearing pressure and side shear values as shown below for that portion of the shaft in competent claystone bedrock.

Ultimate End Bearing (psf)	Ultimate Side Shear (psf)
130,000	13,000

Using LRFD methodology, a resistance factor of 0.50 should be applied to end bearing, 0.55 should be applied to side shear, and 0.45 should be applied to side shear for uplift resistance. The ultimate capacity recommendations assume that a weighted load factor of 1.6 is used.

The above ultimate strength parameters are intended to correspond to the following Allowable Stress Design (ASD) capacities.

Allowable End Bearing (psf)	Allowable Side Shear (psf)	Allowable Side Shear Uplift (psf)
40,000	4,400	3,600

2. Some variation in the bedrock surface should be anticipated. Drilled shafts should penetrate at least 20 feet into claystone bedrock and have a minimum length of at least 25 feet for the upper capacities to be valid. These are geotechnical parameters, greater penetration depths may be needed based on the structural requirements.

3. The minimum spacing requirements between drilled shafts should be 3 diameters from center to center. At this spacing, no reduction in axial design parameters is required. Drilled shafts grouped less than 3 diameters center to center should be studied on an individual basis to evaluate the appropriate reduction in axial capacity.

4. Drilled shaft holes should be properly cleaned prior to placement of reinforcing steel or concrete. A maximum length to diameter ratio of 25 is recommended to facilitate cleaning and observation of the shaft hole.

5. Concrete utilized in the drilled shafts should be a fluid mix with sufficient slump so it will fill the voids between reinforcing steel and the shaft hole. Concrete with a slump in the range of 5 to 7 inches is recommended.

6. Casing and mud slurry will be required to reduce water infiltration and to help control caving. If water cannot be removed prior to placement of concrete, then concrete should be placed with an approved tremie method. The drilling contractor should be aware that water may be encountered in the bedrock as well as overburden soils. Concrete placement should occur after the hole has been well cleaned and approved. Concrete should not be placed through more than 2-inches of water.

7. A sufficient head of concrete should be maintained inside the casing during casing extraction to prevent voids being formed in the concrete upon casing removal. The concrete level should not be allowed to rise during casing removal. If it becomes apparent that voids may have formed during shaft installation, the contractor should be required to perform non-destructive tests to evaluate the continuity and integrity of the shaft. Tests may include sonic echo tests or other tests.

8. Bedrock penetration should be measured down from the bottom of the casing or top of competent bedrock, whichever is the lower elevation.

9. Care should be taken to prevent forming mushroom shapes at the top of the drilled shafts.

10. Concrete should be placed in the holes the same day they are drilled. The presence of water will most likely require concrete to be placed immediately after the shaft hole is completed. Failure to place concrete the day of drilling will result in degradation of bedrock capacity and a requirement for additional bedrock

penetration. The amount of additional bedrock penetration will be a function of how long the hole is left open and whether or not water accumulates during the inactive period. If holes are left open over night, this office should be contacted for additional bedrock penetration requirements.

11. The drilling contractor should mobilize equipment of sufficient size and operating condition to penetrate the materials and to achieve the required bedrock penetration.

12. Installation of drilled shafts should be observed by a representative of Geocal, Inc.

Driven Pile Foundation

Recommendations presented in this section are based on the "AASHTO LRFD Bridge Design Specifications" manual, the subsurface data described, our experience, and local geotechnical engineering practice. Installation of driven piles should be in accordance with Section 502 of *Standard Specifications for Road and Bridge Construction (2011)*, by the Colorado Department of Transportation.

1. Piles should consist of heavy steel H-sections driven into and supported by the underlying bedrock. A Pile Driving Analyzer (PDA) should be used to establish the pile driving refusal criteria. For preliminary design purposes, a combined side shear friction and end bearing ultimate capacity of 30,000 pounds per square inch (30 ksi) times the cross sectional area of the pile may be used for the Load and Resistance Factor Design (LRFD) method. The ultimate capacity assumes a weighted load factor of 1.6. A resistance factor of 0.45 should be applied. For the Allowable Stress Design (ASD) method, an allowable load equal to 9 ksi times the cross sectional area of the pile may be used for piles driven into the underlying bedrock. The above values are for f_y = 36 ksi steel H-piles.

2. For H-piles consisting of f_y = 50 ksi steel driven into bedrock, a combined side shear friction and end bearing ultimate capacity of 42,000 pounds per square inch (42 ksi) times the cross sectional area of the pile may be used for the Load and Resistance Factor Design (LRFD) method. The ultimate capacity assumes a weighted load factor of 1.6. A resistance factor of 0.45 should be applied. For the Allowable Stress Design (ASD) method, an allowable load equal to 12 ksi times the cross sectional area of the pile may be used.

3. Settlement of properly constructed driven piles is expected to be nominal, on the order of ½ inch or less.

4. H-piles are expected to encounter refusal within about 2 feet to 5 feet of the bedrock surface, although some variation in the bedrock surface elevation and penetration should be expected.

5. Penetration into the bedrock may vary and could be nominal. Therefore, uplift resistance should be limited to the soil-pile side shear above bedrock. Side shear capacity should be assumed zero "0" in the upper three feet to account for frost activity and surface disturbance. At three feet the side shear can be assumed to be an ultimate value of 500 psf. The ultimate value of 500 psf may be assumed constant for the remaining depth. A Resistance Factor of 0.25 should be applied. Pile and pile cap weights may be included in dead weight resistance to uplift forces.

6. Pile groups will require appropriate reductions of the axial capacities based on the effective envelope of the pile group. For axial and uplift, this reduction can be avoided by spacing the piles no closer than 3

diameters from center to center. Piles spaced closer than 3 diameters should be evaluated on an individual basis to establish the appropriate reduction in the design parameters.

7. The pile hammer should be operated at the manufacturer's recommended stroke when measuring penetration resistance. The pile capacity should be verified during construction by using a Pile Driving Analyzer (PDA). A minimum of two piles per structure should be monitored using a PDA, each at a separate foundation element (abutment or pier foundation).

8. The pile driving operation should be observed by qualified personnel on a full-time basis. Piles should be observed and checked for buckling, crimping and alignment in addition to recording penetration resistance and general pile driving operations.

Retaining Structure Earth Pressures

For this preliminary report, we have assumed that walls will be cast-in-place concrete and cantilevered. Retaining structures which are laterally supported and can be expected to undergo only a slight amount of deflection should be designed for lateral earth pressures based on the "at-rest" earth pressure condition. Cantilevered or gravity retaining structures which rotate and/or deflect sufficiently to mobilize the internal soil strength of the wall backfill may be designed for the "active" earth pressure condition. The following ultimate earth pressure coefficients are recommended for imported Class 1 material. Fine grained soils (i.e. clays and silts) produce excessive earth pressures on walls and are not recommended for use as structure backfill.

The following values assume placement and compaction in accordance with the CDOT standard specifications.

Material or location	Active (K_a)	At-Rest (K_o)	Passive (K_p)	γ_T – Unit Weight (pcf)	Friction Angle (ϕ), degrees
Imported Class 1	0.28	0.44	3.54	135	34

For granular backfill, lateral wall movements or rotation equal to 1% of the wall height is typically required to develop the full active case, whereas lateral movement equal to at least 2% of the wall height is normally required to establish full passive resistance. Suitable factors of safety should be applied to the above ultimate values to limit strain needed to reach ultimate strength, particularly in the case of passive resistance where large strains are needed to mobilize resistance. Imported material should meet CDOT Class 1 structure backfill grading requirements. Equivalent fluid unit weights may be taken as follows:

Above ground water: $\gamma_{eq} = \gamma_T \times K_{a,o,p}$

Below ground water: $\gamma_{eq} = (\gamma_T - 62.4) \times K_{a,o,p}$

where γ_T = soil total unit weight

$K_{a,o,p}$ = appropriate earth pressure coefficient

The above parameters are for a horizontal backfill and no surcharge load to the backfill. Retaining structures should be designed for appropriate surcharge pressures such as from traffic, etc. The buildup of water behind a wall or an upward sloping backfill surface will increase the lateral pressure imposed on retaining structures and should be accounted for. An under-drain should be provided to help reduce hydrostatic pressure buildup, unless the wall is designed to accommodate the additional pressure.

Limitations

This ***preliminary*** report has been prepared in accordance with generally accepted geotechnical engineering practices used in this area, and has been prepared for planning purposes. The conclusions and recommendations are based upon the data obtained from a review of previous information collected by others. The nature and extent of the variations adjacent to the borings may not become evident until our investigation is done or excavation is performed. If during construction, soil, bedrock, fill, or ground water conditions appear to be different from those described, this office should be advised so that re-evaluation of our recommendations may be made. Onsite observation of foundation bearing materials and testing of fill placement by a representative of this office is recommended.

If you have any questions, or if we can be of further service, please feel free to give me a call.

Sincerely,

GEOCAL, INC.

Ronald J. Vasquez, P.E.
Principal Engineer

RJV/G10.1354.002

Appendix F

Estimated Construction Costs

Option 1 - Prestressed Concrete Box Girder
Two Span (109'-48')

Bridge Length: 157 ft
Bridge Width: Varies ft
Bridge Deck Area: 23564 ft

CONTRACT ITEM NO.	CONTRACT ITEM	UNIT	BRIDGE TOTALS	2007 AVE UNIT COST	2008 AVE UNIT COST	2010 AVE UNIT COST	2011 AVE UNIT COST	ENGINEER'S UNIT COST	ENGINEER'S TOTAL COST
202-00400	Removal of Bridge	EACH	1	$ 104,005.30	$ 75,509.02	$ 57,452.50	$ 181,565.99	$ 250,000.00	$ 250,000
206-00000	Structure Excavation	CY	1,648	$ 17.33	$ 7.96	$ 7.79	$ 7.00	$ 7.00	$ 11,536
206-00100	Structure Backfill (Class 1)	CY	1,420	$ 35.66	$ 28.20	$ 16.68	$ 13.08	$ 15.00	$ 21,300
206-00360	Mechanical Reinforcement of Soil	CY	1,014	$ 17.58	$ 25.20	$ 17.57	$ 19.64	$ 20.00	$ 20,280
403-09210	Stone Matrix Asphalt	TON	528	$ 71.70	$ 71.32	$ 81.73	#N/A	$ 80.00	$ 42,240
502-11274	Steel Piling (HP 12x74)	LF	1,947	$ 51.99	$ 77.73	$ 48.44	#N/A	$ 65.00	$ 126,555
503-00048	Drilled Caisson (48 Inch)	LF	322	$ 492.27	$ 295.24	$ 295.27	$ 211.01	$ 215.00	$ 69,230
504-06100	Ground Nailed Wall	SF	5,750	$ 85.00	#N/A	$ 17.95	#N/A	$ 40.00	$ 230,000
513-00600	Bridge Drain	EACH	2	$ 3,714.29	$ 10,893.33	$ 3,000.00	$ 10,500.00	$ 2,500.00	$ 5,000
515-00120	Waterproofing (Membrane)	SY	3,260	$ 10.20	$ 15.41	$ 13.71	$ 12.84	$ 13.00	$ 42,380
518-01004	Bridge Expansion Device (0-4 Inch)	LF	314	$ 186.87	$ 267.88	$ 154.74	$ 210.33	$ 250.00	$ 78,500
601-03040	Concrete Class D (Bridge)	CY	1,446	$ 473.70	$ 432.91	$ 396.97	$ 366.72	$ 375.00	$ 542,250
602-00020	Reinforcing Steel (Epoxy Coated)	LB	302,550	$ 1.02	$ 0.99	$ 0.79	$ 0.75	$ 1.00	$ 302,550
606-00720	Guardrail Type 7 (Style CC)	LF	200	$ 66.00	$ 47.84	$ 32.49	#N/A	$ 70.00	$ 14,000
606-10700	Bridge Rail Type 7	LF	399	$ 83.69	$ 95.69	$ 74.52	$ 68.15	$ 70.00	$ 27,930
607-53173	Fence Chain Link (Special) (72 Inch)	LF	238	#N/A	$ 12.20	#N/A	#N/A	$ 90.00	$ 21,420
618-01994	Prestressed Concrete Box (Depth 32" Through 48")	SF	21,971	$ 49.89	$ 62.72	$ 51.29	#N/A	$ 60.00	$ 1,318,260
								Subtotal:	**$ 3,123,431**
626-00000	Mobilization (10%)	LS	1					$ 312,343	$ 312,343
								Contingency (20%)	**$ 624,686**
								Total Cost:	***$ 4,060,460***
								Cost per SF:	***$172***

Option 2 - Composite Steel W36 Girders
Two Span (109'-48')

Bridge Length: 157 ft
Bridge Width: Varies ft
Bridge Deck Area: 23564 ft

CONTRACT ITEM NO.	CONTRACT ITEM	UNIT	TOTAL	2007 AVE UNIT COST	2008 AVE UNIT COST	2010 AVE UNIT COST	2011 AVE UNIT COST	ENGINEER'S UNIT COST	ENGINEER'S TOTAL COST
202-00400	Removal of Bridge	EACH	1	$ 104,005.30	$ 75,509.02	$ 57,452.50	$ 181,565.99	$ 250,000.00	$ 250,000
206-00000	Structure Excavation	CY	1,648	$ 17.33	$ 7.96	$ 7.79	$ 7.00	$ 7.00	$ 11,536
206-00100	Structure Backfill (Class 1)	CY	1,420	$ 35.66	$ 28.20	$ 16.68	$ 13.08	$ 15.00	$ 21,300
206-00360	Mechanical Reinforcement of Soil	CY	1,014	$ 17.58	$ 25.20	$ 17.57	$ 19.64	$ 20.00	$ 20,280
403-09210	Stone Matrix Asphalt	TON	528	$ 71.70	$ 71.32	$ 81.73	#N/A	$ 80.00	$ 42,240
502-11274	Steel Piling (HP 12x74)	LF	1,593	$ 51.99	$ 77.73	$ 48.44	#N/A	$ 65.00	$ 103,545
503-00048	Drilled Caisson (48 Inch)	LF	322	$ 492.27	$ 295.24	$ 295.27	$ 211.01	$ 215.00	$ 69,230
504-06100	Ground Nailed Wall	SF	5,750	$ 85.00	#N/A	$ 17.95	#N/A	$ 40.00	$ 230,000
509-00000	Structural Steel	LB	839,296	$ 1.49	$ 1.65	$ 2.27	$ 1.55	$ 1.75	$ 1,468,768
509-90003	Paint Structural Steel	L S	1	$ 8,150.00	#N/A	$ 36,926.73	#N/A	$ 25,000.00	$ 25,000
513-00600	Bridge Drain	EACH	2	$ 3,714.29	$ 10,893.33	$ 3,000.00	$ 10,500.00	$ 2,500.00	$ 5,000
515-00120	Waterproofing (Membrane)	SY	3,260	$ 10.20	$ 15.41	$ 13.71	$ 12.84	$ 13.00	$ 42,380
518-01004	Bridge Expansion Device (0-4 Inch)	LF	314	$ 186.87	$ 267.88	$ 154.74	$ 210.33	$ 250.00	$ 78,500
601-03040	Concrete Class D (Bridge)	CY	1,591	$ 473.70	$ 432.91	$ 396.97	$ 366.72	$ 375.00	$ 596,625
602-00020	Reinforcing Steel (Epoxy Coated)	LB	328,789	$ 1.02	$ 0.99	$ 0.79	$ 0.75	$ 1.00	$ 328,789
606-00720	Guardrail Type 7 (Style CC)	LF	200	$ 66.00	$ 47.84	$ 32.49	#N/A	$ 70.00	$ 14,000
606-10700	Bridge Rail Type 7	LF	399	$ 83.69	$ 95.69	$ 74.52	$ 68.15	$ 70.00	$ 27,930
607-53173	Fence Chain Link (Special) (72 Inch)	LF	238	#N/A	$ 12.20	#N/A	#N/A	$ 90.00	$ 21,420
								Subtotal:	**$ 3,356,543**
626-00000	Mobilization (10%)	LS	1					$ 335,654	$ 335,654
								Contingency (20%)	**$ 671,309**
								Total Cost:	***$ 4,363,506***
								Cost per SF:	***$185***