MEMORANDUM

DEPARTMENT OF TRANSPORTATION
Region 3

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DeBeque Canyon Bridge
Plan of Action
Structure G-04-BA

Date: September 28, 2009
To: File
From: Stuart Gardner – Region 3 Hydraulics Engineer
Subject: Scour Critical Plan of Action

The purpose of this memorandum is to present the Plan of Action (POA) for the Scour Critical Bridge on I-70 near DeBeque, Structure Number G-04-BA, Milepost 58.055. This memo serves as an Executive Summary. Detailed reports are attached.

Structure G-04-BA was identified as Scour Critical due to the meandering of the Colorado River upstream of the structure, which produced a severe angle of attack on the bridge piers, which resulted in scouring of the riverbed to a depth below the pier pile caps. The scour depth below the pile caps produced an unsupported pile length which is believed to be unstable and may buckle.

Ayres Associates was retained to study the stream reach and produce a report with mitigation alternatives. This study was completed in December 2008. Region 3 Hydraulics prepared an Executive Summary of the report, and held a meeting in January 2009. The purpose of that meeting was to select a countermeasure and proceed with plans for a bid package to repair the bridge. The selected alternative was to construct new piers for the bridge, with the removal of Pier Two below the new pier element, and to stabilize the Right Bank of the river upstream of the bridge. The plans and specifications have been subsequently prepared, bids were opened September 3, 2009, GA Western is the apparent low bidder. Construction is expected to begin October 2009.

Attachments:

Scour Countermeasures Options Memorandum dated December 19, 2008
Ayres Associates Scour Countermeasure Investigation dated December 2008
Highway Construction Bid Plans dated July 28, 2009

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DeBeque Canyon Bridge
Scour Countermeasures Study

Date: December 19, 2008
To: Craig Snyder, PE – Resident Engineer
From: Stuart Gardner, PE – Region 3 Hydraulics Engineer
Subject: Scour Countermeasures Options

The purpose of this memorandum is to present findings and options for scour countermeasures for the I-70 bridge near DeBeque, Structure Number G-04-BA, Milepost 58.055. This memo serves as an Executive Summary, and is written with the assumption that the reader is familiar with the project and the bridge's scour critical history.

The objective of this project is to construct a scour countermeasure that will make the bridge scour-proof to at least a 500-year runoff event. To that end, CDOT retained Ayres Associates to produce a Scour Countermeasure Investigation report to study the bridge and its environs, and present countermeasure alternatives and recommendations. Ayres Associates was selected to prepare this report because they have extensive experience and are recognized nationally for their expertise with Bridge Scour, Scour Countermeasures, and River Geomorphology. The results of that report and CDOT's internal discussions are summarized in this memo.

Pier Two of the bridge has been observed to scour to depths well into the pile foundation, leaving the piles vulnerable to buckling which would result in a catastrophic bridge collapse. The primary way to prevent pile buckling is to stabilize the foundation. To that end, a pier retrofit has been proposed and a sketch design created by CDOT Staff Bridge as seen in Figure One. It is recommended that all three piers be retrofitted.

The two options considered for the retrofit are to: 1) Leave the remainder of the existing pier below the 12' diaphragm (shown in Fig. 1) or 2) Remove the existing pier below the diaphragm.

If the existing pier is not removed below the retrofit, the overall resulting pier geometry will be considerably larger than the current pier. This will present a larger obstruction to the river's flow, and will result in a larger scour hole around the pier. The scour hole has been documented to reach nearly to the extents of the Abutment One riprap protection, which jeopardizes the safety of Abutment One. It is important to note that the scour hole measurement was performed post-runoff event, which means that the scour hole that occurred during the peak of the runoff event was most likely larger than what was measured, which means the scour hazard to Abutment One is likely higher than what has been documented. Therefore, leaving the existing pier below the diaphragm without additional countermeasures is not acceptable. The recommended additional countermeasures are to properly design and install pier scour armoring at Pier Two, and channel realignment with a Longitudinal Dike constructed parallel to the bridge piers, in line with Abutment One, and extending 500 to 600 feet upstream of the bridge. In order for this countermeasure to be effective, much of the cobble bank along the left side of the river will need to be removed, some of which would need to be beyond the existing CDOT Right of Way. See Figure Two. This work will bring the channel into alignment with the bridge piers and minimize the scour hole at the piers.

If the existing pier is removed below the proposed diaphragm, it will open up a large flow area between the proposed columns. Scour will still occur at the pier, but it will be reduced enough to minimize the threat to Abutment One. However, work upstream of the bridge will still be required. The recommended countermeasure is a series of Bendway Weirs along the right bank of the stream channel with additional armoring in between. The weirs will serve to hold the bank in its current alignment, encourage deposition between the weirs, and encourage the channel to move to the left which will improve the hydraulics at the bridge. No work on the left bank is recommended. See Figure Three.

These alternatives and others will be discussed in greater detail during the January 13, 2009 Design Decision Meeting.

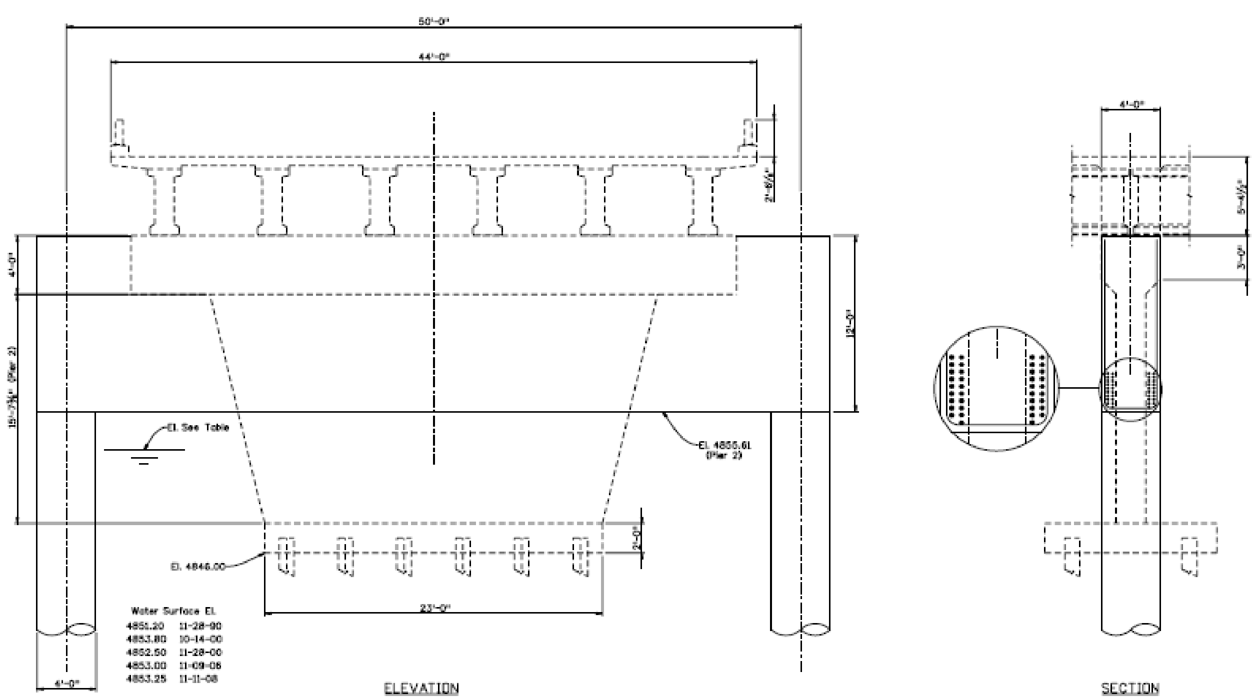

Figure One – Pier Details

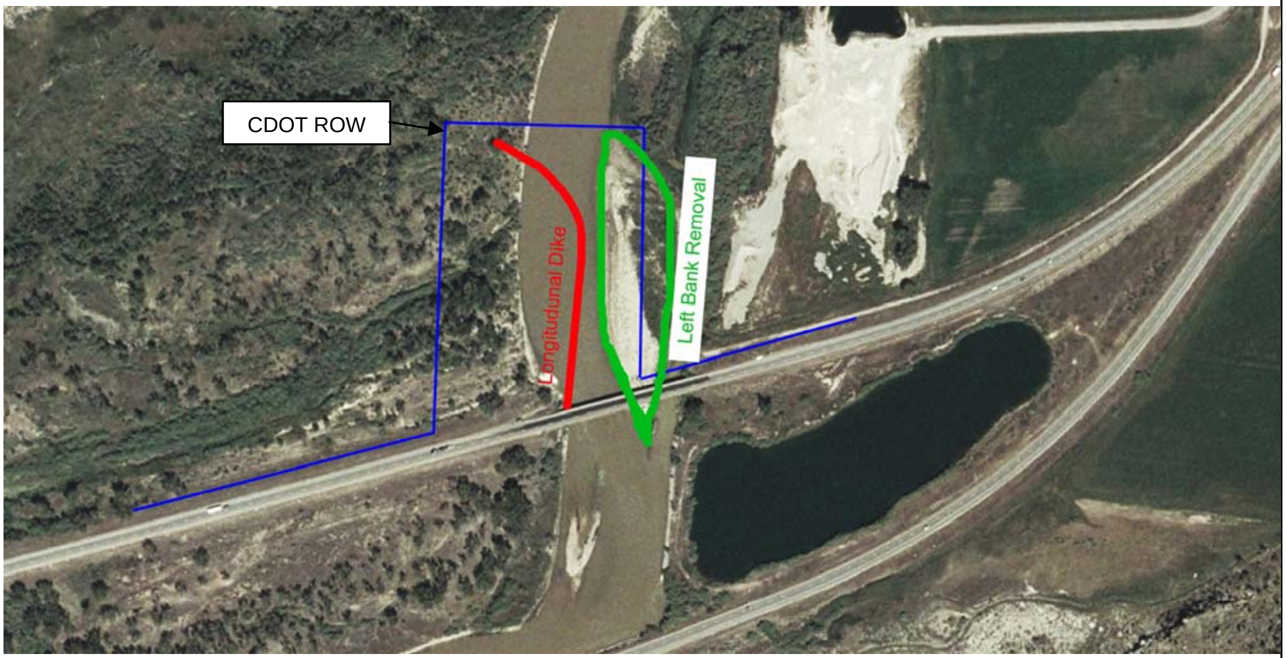

Figure Two – Longitudinal Dike

Figure Three – Bendway Weirs

I-70 Westbound Bridge over the Colorado River in DeBeque Canyon

SCOUR COUNTERMEASURE INVESTIGATION

Prepared for

Colorado Department of Transportation
Region 3

AYRES ASSOCIATES

I-70 Westbound Bridge over the Colorado River in DeBeque Canyon

SCOUR COUNTERMEASURE INVESTIGATION

Prepared for

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Ayres Project No. 32-1347.00
CDOT-I70.DOC

December 2008

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1. INTRODUCTION

1.1 Site Description

Bridge G-04-BA is located approximately four miles downstream of DeBeque, Colorado near milepost 58 along westbound Interstate 70 (I-70). The Colorado River in the vicinity of DeBeque Canyon is an actively migrating channel over a gravel to coarse cobble bed material with sandy gravel banks. **Figure 1.1** presents the project location.

Figure 1.1. Westbound I-70 over the Colorado River site location (Google Earth Pro 2008).

Bridge G-04-BA was constructed in 1981, is approximately 420 ft long, and consists of 4 spans with riprapped, spill-through abutments and concrete solid-wall piers supported by pile foundations. Bridge G-04-BA over the Colorado River is located just upstream of the apex of a sharp bend in the channel that turns to the right (southwest). The Colorado River in the vicinity of Bridge G-04-BA is generally a single-thread meandering channel with active point and island bars and a coarse cobble bed. Historically, the channel meandered and changed location throughout a larger alluvial floodplain as evidenced by meander scars and abandoned oxbow lakes on the adjacent floodplain. Just downstream of Bridge G-04-BA the river is laterally confined within DeBeque Canyon by exposed bedrock.

Within the last 30 years an island has formed upstream of Pier 4 that has become vegetated with willow and other shrub species causing local split flow patterns during lower flows. Overbank regions consist of a small to moderate sized floodplain with low-lying vegetation and brush interspersed with pockets of mature trees. At the bridge the right bank is 3 to 5 ft high and relatively unvegetated. The left bank at the bridge is 6 to 8 ft high and moderately vegetated with willow, tamarisk, and other shrub species. The river is bounded by a high relief valley and sparsely vegetated hill slopes to the north and south. USGS gaging site 09095500 is located 4.5 miles downstream of the bridge and provides real-time discharge information.

Large quarried riprap was mounded at Pier 2 in 2003 and Pier 3 in 2008 in an urgent attempt to protect the bridge foundations from observed scour at the noses of both piers. Migration of the right riverbank has resulted in a severe angle of attack at Pier 2 and a moderate to considerable angle of attack at Pier 3. Riprap has been placed upstream of Abutment 1 (right) to prevent flanking by local flow patterns and continued channel meandering, however it is in relatively poor condition and has been partially undermined by an eddy formation immediately upstream.

In addition to scour and channel stability considerations, other concerns at Bridge G-04-BA are as follows,

- Habitat – this section of the Colorado River is protected habitat for four endangered fish species. These four fish are the Colorado pike minnow, razorback sucker, bonytail and humpback chub

- Environmental – Just upstream of the bridge, at about the 2-year event a portion of the flow spills over the right channel bank upstream of the bridge and follows the road embankment, rejoining the main channel about a mile downstream. The split flow channel is a natural part of the Colorado River in this section allowing for the formation of wetland areas used by various wildlife.

2. HYDRAULIC MODELING

A hydraulic analysis was conducted using the U.S. Army Corps of Engineers HEC-RAS v.4.0 computer software (USACE 2008). The analysis was conducted for current conditions and realigned-channel conditions. Each condition was modeled for the 2-, 100-, and 500-year recurrence interval events, as provided by CDOT personnel. The incipient right-bank overtopping event for the split flow path was also evaluated and determined to occur between the 2- and 3-year events.

2.1 Model Development

Geometric data used in the analysis were derived from publicly available Digital Elevation Model (DEM) of the area, floodplain workmaps created by USACE in 1982, and the bridge design plans. The vertical and horizontal datum of the model are the North American Vertical Datum of 1988 (NAVD) and Universal Transverse Mercator North American Datum (UTM NAD) 1983 Zone 12, respectively. The HEC-RAS model extends about 2000 feet upstream and 2300 feet downstream of the bridge. The model includes thirteen cross sections and a lateral weir upstream of the bridge along the right bank to account for flow leaving the main channel and traveling along the split flow path. A schematic of the HEC-RAS model and cross section locations is shown in **Figure 2.1**, below.

The bridge structure was modeled using the HEC-RAS bridge routines. In the current conditions model, Piers 2, 3, and 4 were skewed 60-, 40- and 20-degrees respectively, based on complex local flow patterns and severe angle of attack observed during the field reconnaissance. In the re-aligned conditions model Piers 2, 3, and 4 were skewed 15-degrees, assuming the channel resumes the historic location corresponding to when the bridge was constructed.

Manning's n values of 0.030 for the main channel and 0.08 to 0.10 for the overbanks were determined based upon field observations in conjunction with standard references (Chow 1959, Barnes 1967). Flow contraction and expansion into and out of the bridge were accounted for using the HEC-RAS ineffective flow option and increased contraction and expansion coefficients. The downstream starting water-surface elevation was estimated using normal depth with the energy slope set equal 0.0025 ft/ft.

Discharge values were set based upon a Flood Frequency Analysis (FFA), as performed by CDOT personnel, of annual peak flows at USGS gage 09095500 on the Colorado River near Cameo, CO. Results for the FFA are shown below in **Table 2.1**.

Hydraulic modeling indicated that incipient split flow on the right bank begins at approximately 13,700 cfs. This was determined by adjusting the discharge rate in the model until the hydraulic grade line elevation along the lateral weir was approximately equal to the minimum weir crest elevation. In the 100-year event, approximately 26,450 cfs continues in the main channel and 16,000 cfs is diverted along the split flow channel, see **Figure 2.2**. Profiles, cross section plots, and summary printout tables from HEC-RAS are included in Appendix A.

Figure 2.1. HEC-RAS model cross sections for I-70 over the Colorado River.

Table 2.1. FFA Analysis of Annual Peak Flows at USGS Gage 09095500.		
Exceedance (%)	Recurrence Interval (yrs)	Flow (cfs)
0.2	500	50200
0.5	200	45900
1	100	42500
2	50.0	39000
5	20.0	34000
10	10.0	25500
20	5.00	18200
50	2.00	12500
90	1.11	10100
95	1.05	8320
99	1.01	5650

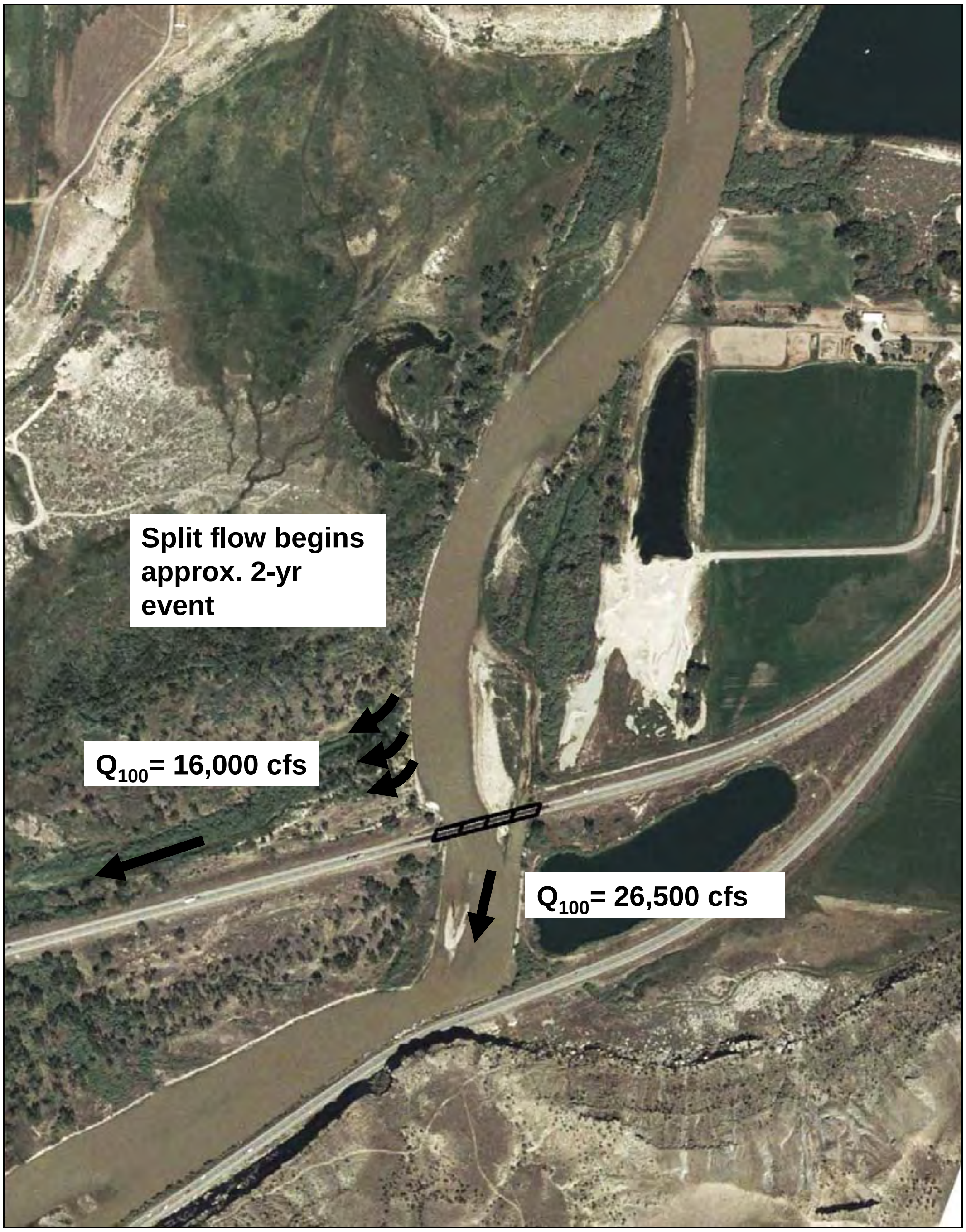


Figure 2.2. In the 100-year event 26,450 cfs flows in the main channel and 16,000 cfs is diverted along the split flow channel.

2.2 Summary of Model Results

Summaries of the hydraulic properties for the current conditions and re-aligned conditions at the contracted and approach sections for incipient split flow, 100- and 500-year events are shown in **Tables 2.2 and 2.3**, respectively.

Table 2.2. Hydraulic Properties for Current Conditions.			
	Incipient split flow Q_{sf}=13,700 cfs	100-Year Q_{100}=42,500 cfs	500-Year Q_{500}=50,200 cfs
Contracted (bridge) Section RS 2380 BRU			
Discharge (cfs)	13,675	26,450	29,000
Flow Area (ft^2)	1,900	3,070	3,260
Average Velocity (ft/s)	7.2	8.6	8.9
Hydraulic (average) Depth (ft)	6.0	9.2	9.7
Top width (ft)	318	334	337
Froude Number (channel)	0.50	0.52	0.53
Approach Section RS 4553			
Discharge (cfs)	13,675	42,500	50,200
Flow Area (ft^2)	3,715	7,550	8,235
Average Velocity (ft/s)	3.7	5.6	6.1
Hydraulic (average) Depth (ft)	3.5	6.1	6.7
Top width (ft)	1075	1230	1230
Froude Number (channel)	0.40	0.56	0.60

Table 2.3. Hydraulic Properties for Re-Aligned Conditions.		
	100-Year Q_{100}=42,500 cfs	500-Year Q_{500}=50,200 cfs
Contracted (bridge) Section RS 2380 BRU		
Discharge (cfs)	27,240	29,960
Flow Area (ft^2)	3,280	3,485
Average Velocity (ft/s)	8.3	8.6
Hydraulic (average) Depth (ft)	9.5	10.0
Top width (ft)	345	347
Froude Number (channel)	0.49	0.50
Approach Section RS 4553		
Discharge (cfs)	42,500	50,200
Flow Area (ft^2)	9,280	10,560
Average Velocity (ft/s)	4.6	4.8
Hydraulic (average) Depth (ft)	6.7	7.6
Top width (ft)	1,395	1,395
Froude Number (channel)	0.43	0.44

3. SCOUR ANALYSIS

A quantitative evaluation of the scour potential was performed following procedures outlined in FHWA HEC-18, Fourth Edition (Richardson and Davis 2001). Scour components considered in the calculations included contraction and pier scour. Abutment scour was not quantified but was evaluated qualitatively. Calculations were carried out for the 100-, 500-year, and incipient split flow discharge. Calculations were also carried out based upon current (severe angle of attack) and future (adjusted angle of attack) conditions.

According to the HEC-18 critical velocity equation the approach section channel bed is immobile for the 100-year and incipient split-flow discharge, indicating clearwater contraction scour conditions for those events. The HEC-18 critical velocity equation predicts a live-bed or mobile bed condition during the 500-year event. Assumptions in the HEC-18 critical velocity equation are not consistent with the very coarse nature of the channel bed. Therefore, a separate incipient motion analysis was carried out to evaluate whether the channel bed is mobile, indicating whether live-bed or clear-water scour conditions govern.

Incipient motion analysis was carried out by evaluating the effective shear stress on the channel bed in relation to the amount of shear stress that is required to move the sediment sizes that are present. The shear stress required for bed mobilization was estimated using the Shields (1936) relation, given by:

$$\tau_c = \Phi(\gamma_s - \gamma)D_{50}$$

where τ_c is the critical shear stress for particle motion, Φ is the dimensionless critical shear stress (often referred to as the Shields parameter), γ_s is the unit weight of sediment (~165 lb/ft^3), γ is the unit weight of water (62.4 lb/ft^3) and D_{50} is the median particle size of the bed material. The Shields parameter was set equal to 0.03, which corresponds to incipient motion in gravel and cobble bed streams (see for example, Parker et al. 1982, Andrews 1984).

In performing the incipient motion analysis, the bed shear stress due to grain resistance (τ') is used rather than the total shear stress, because it is a better descriptor of the near-bed hydraulic conditions that are responsible for sediment movement. The grain shear stress is computed from the following relation:

$$\tau' = \gamma YS'$$

where Y is the total hydraulic depth and S' is the portion of the energy slope associated with grain roughness (Einstein 1950). The value of S' is computed by solving the semilogarithmic velocity profile equation:

$$\frac{V}{u_*'} = 5.75 \log\left(\frac{12.2Y}{k_s}\right)$$

where V is the mean velocity, k_s is the characteristic grain roughness of the bed, and u_*' is the shear velocity due to grain resistance given by:

$$u_*' = \sqrt{gYS'}$$

The characteristic roughness height of the bed (k_s) was assumed to be 3.5 D_{84} (Hey 1979).

The forgoing analysis indicates that the channel bed upstream and through the bridge opening would be immobile during the incipient split flow discharge, indicating clearwater contraction scour conditions and mobile during the 100- and 500-year discharge, indicating live-bed contraction scour conditions. Using the HEC-18 live-bed and clearwater contraction scour equations the computed contraction scour depth was negative for all cases analyzed. This indicates that the contracted section has already achieved any expected contraction scour and therefore any further scour due to flow contraction is not likely.

Pier scour calculations were carried out using the CSU Equation as presented in HEC-18, see Appendix B. The K_4 factor used to account for bed armoring was not used. Pier scour calculations were carried out using the local pier calculation procedure (Richardson and Davis 2001). A skew angle for Piers 2, 3, and 4 of 60-, 40-, and 20-degrees, respectively, was applied in the current conditions analysis. A skew angle of 15-degrees was applied to Piers 2, 3, and 4 in the realigned conditions analysis. Debris blockage and the obstructive width of existing boulder riprap at Piers 2 and 3 was not explicitly accounted for in the pier scour calculations.

A summary of the results of the scour calculations for Pier 2 is presented in **Table 3.1**. Computed total scour depths are great enough to destabilize the pile foundations of all piers and scenarios analyzed. Review of Table 3.1 indicates realigning the channel and reducing current skew angle does provide some benefit by reducing local pier scour. However, the realigned conditions total scour is still likely to destabilize the pile foundations requiring pier scour countermeasures to be implemented in addition to any river training countermeasures considered to realign the channel to its historic (pre-1980) location.

Table 3.1. Summary of Scour Calculations for Pier 2.

	Current Conditions			Realigned Conditions	
Flow Event	ISF*	100-Year	500-Year	100-Year	500-Year
Long-term Degradation (ft)	0.0	0.0	0.0	0.0	0.0
Contraction Scour (ft)	0.0	0.0	0.0	0.0	0.0
Local (Pier) Scour (ft)	23.2	26.6	27.1	14.6	15.0
Total Scour (ft)	23.2	26.6	27.1	14.6	15.0
Initial Ground Elevation** (ft)	4850.8	4850.8	4850.8	4850.8	4850.8
Scour Elevation** (ft)	4827.6	4824.2	4824.2	4836.2	4835.9
Pile Tip Elevation*** (ft)	4821.7	4821.7	4821.7	4821.7	4821.7
Pile Length (ft)	27.7	27.7	27.7	27.7	27.7
Post Scour Pile Embedment (ft)	5.9	2.5	2.0	14.5	14.2

*Incipient Split Flow (ISF)
** Elevations reference NAVD88–ft
*** Pile tip elevation taken from bridge design plans

3.1 Channel Stability Assessment

A qualitative lateral channel stability assessment was performed for the study reach. Aerial photographs from 1957, 1972, 1980, 1988, and 2005, obtained from CDOT personnel, were georectified and overlaid to determine approximately how much the channel and banks have changed location within the given time frame. Results from this analysis are shown in **Figures 3.1 and 3.2** and included in Appendix C.

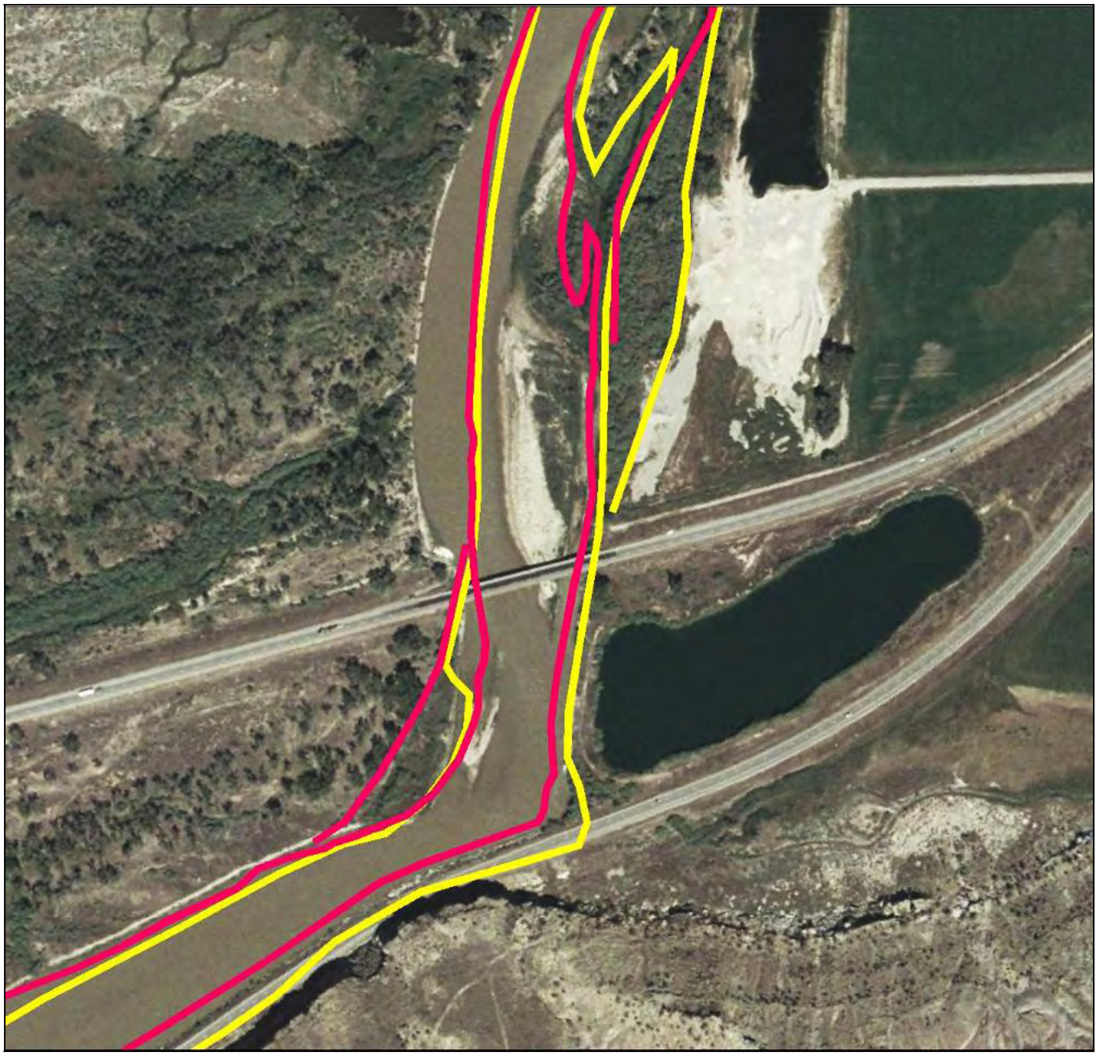


Figure 3.1. Colorado River historical banklines near DeBeque, CO.
(Yellow - 1955, Red - 1980, Aerial image 2005)

Review of Figures 3.1 and 3.2 indicates the river channel was relatively stable prior to 1980. After 1980 the right bank upstream of the bridge migrated to the west and an island formed extending from upstream to downstream of the bridge. Given the relatively high frequency of the incipient split flow event and angle of attack issues on Piers 2 and 3, continued channel migration and possible channel avulsion is a serious concern for Bridge G-04-BA. Colonization of the channel island upstream of the bridge by willows and other shrub species will tend to facilitate/encourage the right bank to migrate further to the west. Review of past aerial photos and observations during the field reconnaissance provide no basis to expect the channel migration will slow or stop in the future. In fact, as the channel continues to migrate westward the rate of migration is likely to increase as the radius of curvature of the right bank decreases and the angle of attack at the bridge worsens.

3.2 Scour Vulnerability Assessment

Quantitative scour calculations indicated that pile foundations of the piers would likely become unstable during all events and scenarios analyzed, indicating a scour-critical situation. Results from the current and realigned-channel conditions indicate that even if the angle of attack issue is addressed at Piers 2 and 3, pier scour countermeasures will likely be required to protect the pile foundations from scour. Existing boulder riprap placed at Piers 2 and 3 should be removed due to mounding at the piers and the absence of filtering between the riprap and bed material and adequately designed pier scour countermeasures installed. The riprap currently mounded at the piers has the potential to be reused in a different location/application within the project reach to address lateral instability issues.

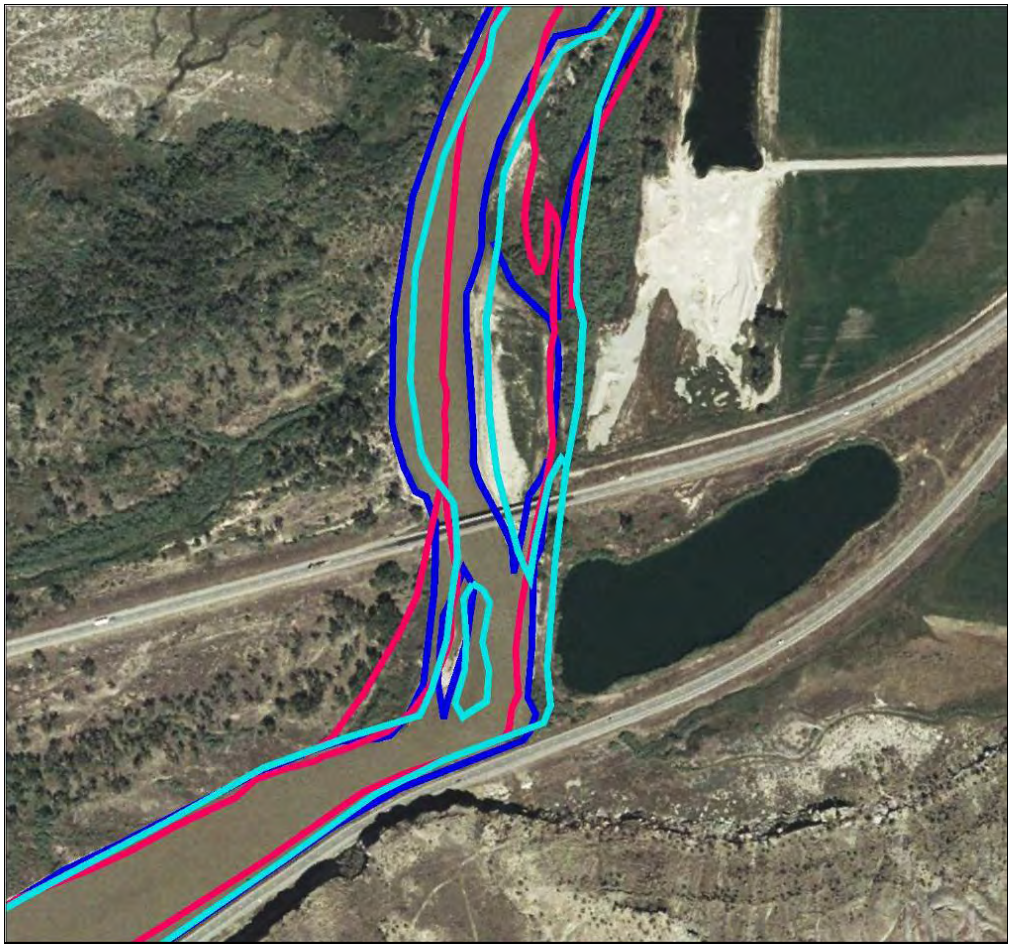


Figure 3.2. Colorado River historical banklines near DeBeque, CO.
(Red - 1980, Cyan - 1998, Blue - 2005, Aerial image 2005)

Channel training structures should be considered to address the potential for continued right bank migration and possible channel avulsion into the split flow path in the right overbank upstream of the bridge. Due to the relatively high frequency of the incipient split-flow event and the amount of water conveyed in the split flow path during larger events, the potential for channel avulsion and bypass of Bridge G-04-BA is a significant concern that should be addressed.

4. SCOUR MITIGATION ALTERNATIVES

Scour mitigation alternatives were determined using the Countermeasure Matrix presented by Lagasse et al. (2008 draft, see Appendix D), modified to accommodate project specifics. Functional applications examined included local scour at piers and lateral stream instability. Results of this analysis can be seen in **Figure 4.1.** Countermeasure alternatives for the abutments were not examined in this study because field examinations indicated the riprap was in good condition.

STREAM INSTABILITY AND BRIDGE SCOUR COUNTERMEASURES MATRIX
I-70 over the Colorado River Debeque Canyon

Countermeasure Group	FUNCTIONAL APPLICATIONS			
	Local Scour		Lateral Stream Instability	Contraction Scour Floodplain and Channel
	Abutments	Piers		
GROUP 1. HYDRAULIC COUNTERMEASURES				
GROUP 1.A. RIVER TRAINING STRUCTURES				
TRANSVERSE STRUCTURES				
Impermeable spurs (jetties, groins, wing dams)			◗	N/A
Bendway weirs/Stream barbs	◗	◗	◗	N/A
LONGITUDINAL STRUCTURES				
Longitudinal dikes (crib/rock toe/embankments)	◗	◗	●	N/A
AREAL STRUCTURES/TREATMENTS				
Channelization	◗	◗	●	N/A
GROUP 1.B. ARMORING COUNTERMEASURES				
REVETMENTS AND BED ARMOR				
Flexible/articulating				
Riprap	●	●	●	N/A
Articulated blocks (interlocking and/or cable tied)		●	●	N/A
Partially grouted riprap		●	●	N/A
Concrete armor units (Toskanes, tetrapods, etc.)		◗	●	N/A
Grout filled bags/sand cement bags		◗	◗	N/A
Sheet pile/cofferdam		◗		N/A
GROUP 2. STRUCTURAL COUNTERMEASURES				
FOUNDATION STRENGTHENING				
Lower foundation		●		N/A
PIER GEOMETRY MODIFICATION				
Pier shape modifications		●		N/A
GROUP 3. BIOTECHNICAL COUNTERMEASURES				
Vegetated riprap			●	N/A
GROUP 4. MONITORING				
FIXED INSTRUMENTATION				
Sonar scour monitor	◗	●	◗	N/A
Magnetic sliding collar	●	●	◗	N/A
Float out device	●	●	●	N/A
Sounding rods	◗	●	◗	N/A
PORTABLE INSTRUMENTATION				
Physical probes	●	●	●	N/A
Sonar probes	●	●	●	N/A
VISUAL MONITORING				
Periodic Inspection	●	●	●	N/A
Flood watch	●	●	●	N/A

● well suited for this site
◗ possible application

Figure 4.1. Countermeasure selection matrix.

4.1 Local Pier Scour Mitigation

Riprap was placed as an emergency pier scour mitigation measure at Pier 2 in 2003 and at Pier 3 in 2008. The riprap was mounded around the pier to an approximate height of 6-8 feet above the level of the streambed. Success rates are low when riprap is installed using this method and replacement with a properly designed and installed pier scour countermeasure is strongly recommended.

Two basic methods may be used at this site to prevent damage from local scour at piers. The first measure is to prevent erosive vortices from forming or to reduce their strength and intensity. The second method is to provide protection at or below the streambed to inhibit the development of a scour hole.

Reducing the strength and intensity of erosive forces at the pier may be accomplished with abatement of lateral channel migration and realignment of the channel with the piers. Recommended methods of channel realignment are covered later in this report.

4.1.1 Pier Geometry Modification

In general, piers should be aligned with the main channel design flow direction and skew angles greater than 5 degrees should be avoided. However, at this site flow direction has and is likely to continue to change with time and stage. Piers oriented with flow direction at one point in time have skewed with flow direction to almost 60 degrees currently at Pier 2. A single cylindrical pier or a row of 2 or 3 cylindrical columns with clear space at least 5 times the column diameter would produce a lesser depth of local scour in addition to eliminating future concern regarding flow direction. In this active migrating stream channel pier replacement in conjunction with lateral stream migration abatement may be the ideal solution.

4.1.2 Foundation Strengthening

Foundation strengthening includes additions to the original structure, which will reinforce and/or extend the foundations of the bridge. These countermeasures are designed to prevent failure when the channel bed is lowered to an expected scour elevation, or to restore structural integrity after scour has occurred.

Piles (sheet, H beams or concrete) have been successfully used as a retrofit measure to lower the effective foundation elevation of structures where footings or pile caps have been exposed by scour. Typically, the piling is placed around the pile footings and anchored to the pile cap or seal to retain or restore the bearing capacity of the foundation. Though this is an option at the I-70 Bridge it is not recommended because the increased mass of the retrofit pile will produce a greater depth of scour.

A retrofit option that should be considered at this site is replacement of the existing piers through extension of the foundation depth by installation of drilled caissons, transfer of load to the caissons, and removal of the existing pier walls and pile caps. For this option to provide the desired benefits the existing pier structure must be removed. This solution would provide added foundation strength as well as mitigate pier geometry and angle of attack concerns.

4.1.3 Riprap

Riprap is commonly used to inhibit local scour at piers at existing bridges. At the I-70 Bridge riprap was placed as an emergency scour mitigation measure at Pier 2 in 2003 and at Pier 3 in 2008. The riprap was mounded around the pier to an approximate height of 6-8 feet above the streambed. Mounding riprap around a pier is not acceptable for design in most cases because it obstructs flow, captures debris, and increases scour at the periphery of the installation. Additionally, the mounded riprap was placed without a filter. A filter is highly recommended under riprap placed at bridge piers. Backwater from the mounded riprap may even be contributing to the bulging of the right bank. Though replacement of the existing riprap is recommended, it may be possible to salvage it for use in a lateral migration mitigation method.

Properly constructed riprap can provide long-term protection if it is inspected and maintained on a periodic basis as well as after high flow events. When properly designed and used for erosion protection, riprap has an advantage over rigid structures because it is flexible when under attack by river currents, it can remain functional even if some individual stones are lost, and it can be repaired relatively easily.

Riprap should be placed in a pre-excavated hole around the pier so that the top of the riprap layer is level with the ambient channel bed elevation (**Figure 4.2)**. Placing the top of the riprap flush with the bed is ideal for inspection purposes, and does not create any added obstruction to the flow. Using the HEC-23 methods, median riprap stone size, d_{50}, was calculated to be 1.5 ft for a realigned flow direction, see Appendix E. The riprap layer should have a minimum thickness of 3 times the d_{50} size of the rock. If the decision is made not to correct the flow alignment through the bridge, the required riprap stone size and layer thickness will be greater.

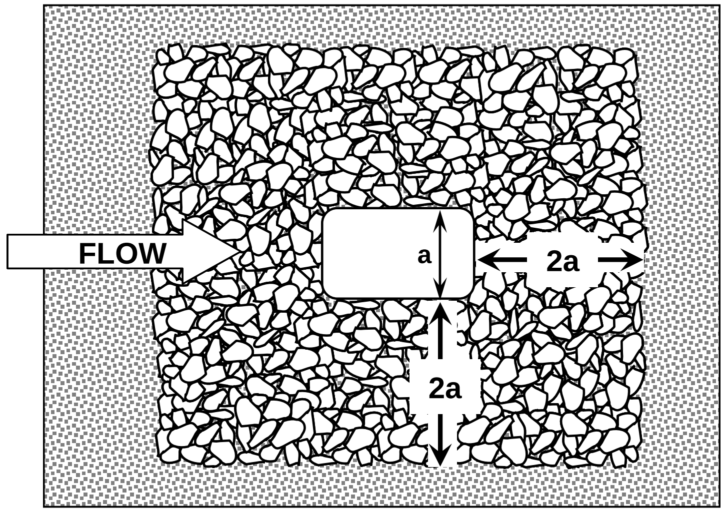
The importance of the filter component of any riprap installation should not be under-estimated and is typically recommended at bridge piers. There are two kinds of filters used in conjunction with riprap; granular filters and geotextile filters. Some situations call for a composite filter consisting of both a granular layer and a geotextile. The specific characteristics of the base soil determine the need for, and design considerations of the filter layer. Further information regarding the composition of the channel bed material is required for filter selection.

Sand-filled geotextile containers (geobags) would be a convenient option for placement at the I-70 Bridge. Geobags can be placed in flowing water and used to partially fill the already existing scour hole when the emergency placed riprap is removed.

For more information on riprap as a pier scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition) Design Guideline 8 and NCHRP Report 593.

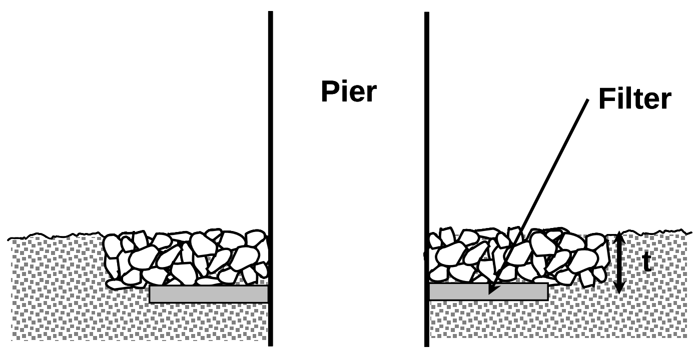
4.1.4 Articulating Concrete Blocks

Articulating concrete block systems (ACBs) provide a flexible alternative to riprap and rigid revetments. These systems consist of preformed units that either interlock, are held together by cables, or both to form a continuous blanket or block matrix. Manufacturers of ACBs have a responsibility to test their products and to develop design parameters based on the results from these tests. Since ACBs vary in shape, size, and performance from one system to the next, each system will have unique design parameters. Hydraulic design for ACBs is based on hydraulic stability performance data for a particular block system.



Pier width = "a" (normal to flow)

Riprap placement = 2(a) from pier (all around)



Minimum riprap thickness t = $3d_{50}$, depth of contraction scour, or depth of bedform trough, whichever is greatest

Filter placement = 4/3(a) from pier (all around)

Figure 4.2. Riprap layout diagram for pier scour protection. Note that dimensions increase for skewed flow conditions.

Where only local scour is present, the ACB system may be placed horizontally such that the top of the blocks are flush with the bed elevation, with turndowns provided at the system periphery. **Figure 4.3** shows a layout for ACBs installed around a pier with a turndown incorporated to account for other types of scour. In the case of the I-70 wall piers where the axis of the structure is skewed to the flow direction, the lateral extent of the protection would need to be increased in proportion to the additional scour potential caused by the skew.

NCHRP Report 593 provides a method for estimating the increase extent of the armor layer for a given skew.

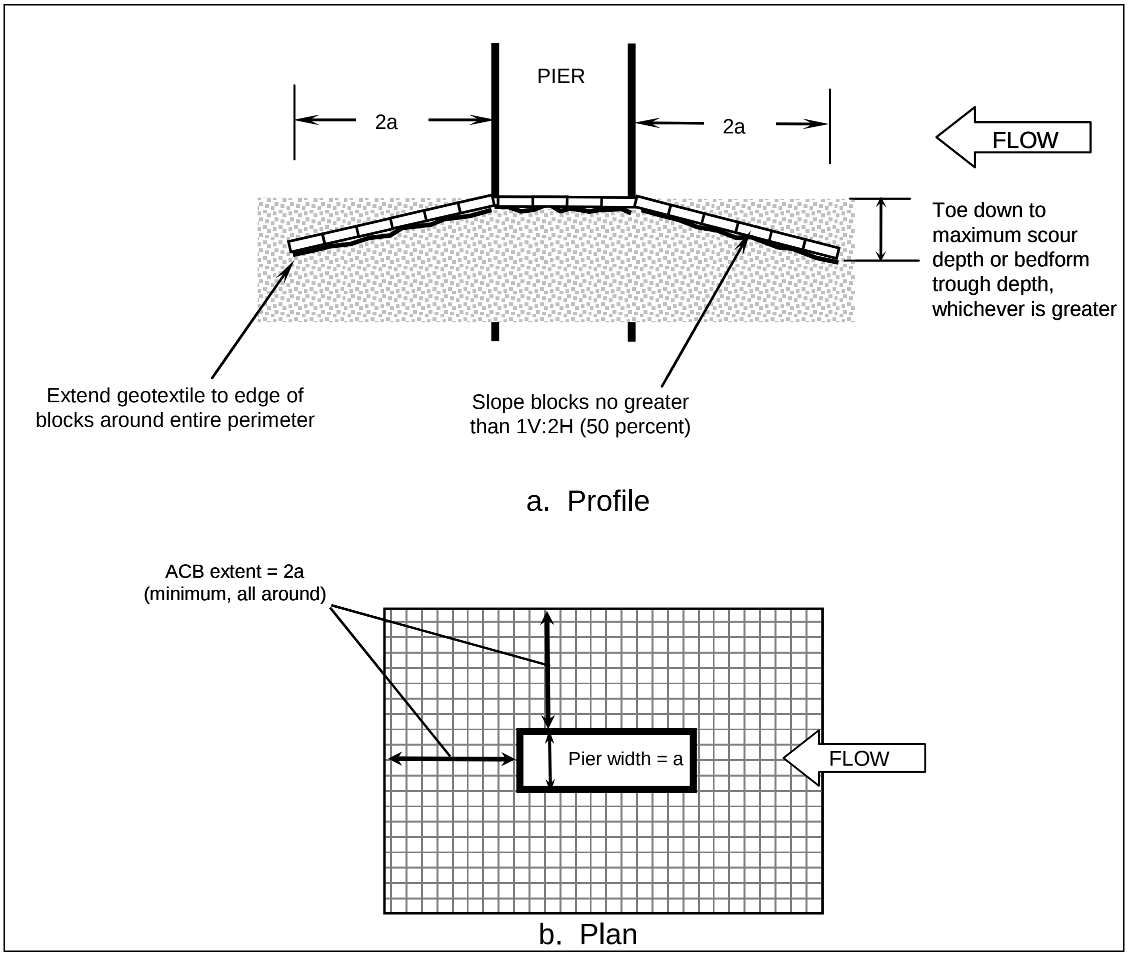


Figure 4.3. ACB layout diagram for pier scour countermeasures.

The importance of the filter component of any ACB installation should not be underestimated and is recommended at bridge piers. Sand-filled geotextile containers (geobags) would be the most practical choice for filter placement if ACBs are installed at the I-70 Bridge. Placed on top of the cobble bed material, geobags could create the smooth installation surface necessary to meet block tolerance requirements. Geobags can be placed in flowing water and used to partially fill the already existing scour hole when the emergency placed riprap is removed. The specific characteristics of the base soil determine the need for, and design considerations of the filter layer. Further information regarding the composition of the channel bed material is required for geotextile filter selection.

For more information on ACBs as a pier scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition) Design Guideline 4.

4.1.5 Partially Grouted Riprap

Partially grouted riprap, when properly designed and used for erosion protection, has an advantage over rigid structures because it is flexible when under attack by river currents, it can remain functional even if some individual stones may be lost, and it can be repaired relatively easily. Properly constructed, partially grouted riprap can provide long-term protection if it is inspected and maintained on a periodic basis as well as after high flow events. Partially grouted riprap may be used for bank protection as well as a scour countermeasure at piers and abutments.

Partially grouted riprap consists of specifically sized rocks that are placed and grouted together, with the grout filling only 1/3 to 1/2 of the total void space (**Figure 4.4)**. In contrast to fully grouted riprap, partial grouting increases the overall stability of the riprap installation unit without sacrificing flexibility or permeability. The voids of the riprap matrix are partially filled with a Portland cement based grout by hose or tremie, or by automated mechanical means. Hydraulic stability of the armor is increased significantly over that of loose riprap by virtue of the much larger mass and high degree of interlocking of the "conglomerate" particles created by the grouting process. The intent of partial grouting is to "glue" stones together to create a conglomerate of particles. Each conglomerate is therefore significantly greater than the d_{50} stone size, and typically is larger than the d_{100} size of the individual stones in the riprap matrix.

Permeability of the completed installation is maintained because less than 50% of the void space is filled with grout. Flexibility of the installation occurs because the matrix will fracture into the conglomerate-sized pieces under hydraulic loading and/or differential settlement. The surface of each conglomerate particle is highly rough and irregular, and so maintains excellent interlocking between particles after fracturing occurs.

Figure 4.4. Close-up view of partially grouted riprap.

In general, the layout dimensions for partially grouted riprap follow those for loose riprap in applications involving bank protection and for armoring bridge abutments. At bridge piers, however, the recommended guidance for partially grouted riprap provides for a reduced lateral extent compared to loose riprap. The optimum performance of partially grouted riprap as a pier scour countermeasure is obtained when the armor is extended a distance of at least 1.5 times the pier width in all directions around the pier. In contrast, with loose (ungrouted) riprap, where the recommended extent is 2.0 times the pier width. As with all pier scour countermeasure recommendations for the I-70 Bridge where the axis of the structure is skewed to the flow direction, the lateral extent of the protection would need to be increased in proportion to the additional scour potential caused by the skew.

A filter layer is typically required for partially grouted riprap at bridge piers. The filter should not be extended fully beneath the armor; instead, it should be terminated 2/3 of the distance from the pier to the edge of the armor layer. As with ungrouted riprap, geobags would be a convenient option for placement at the I-70 Bridge (**Figure 4.5**). Geobags can be placed in flowing water and used to partially fill the already existing scour hole when the existing riprap is removed.

A concern with using partially grouted riprap at the piers is the requirement that grout must be placed in flow velocities less than 4 ft/s or in the dry. This may require a cofferdam or flow diversion.

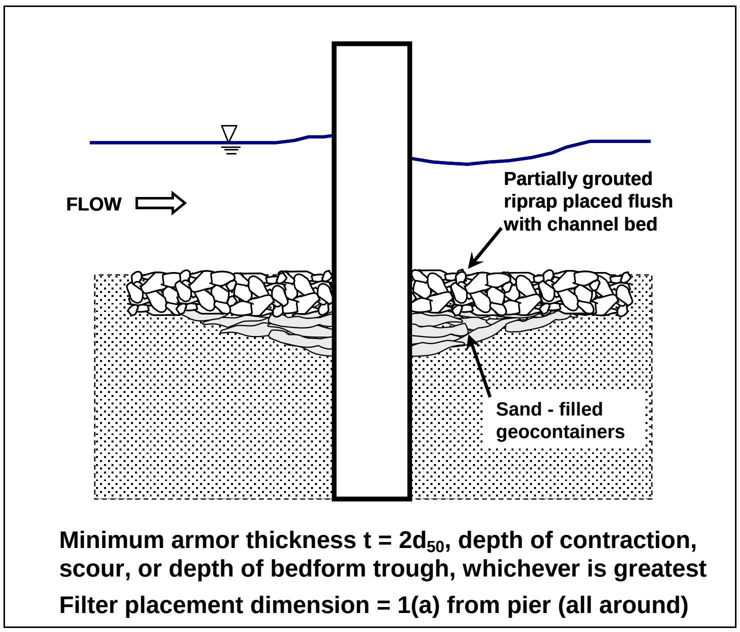


Figure 4.5. Schematic diagram showing sand-filled geotextile container filter beneath partially grouted riprap.

For more information on partially grouted riprap as a pier scour countermeasure see NCHRP Report 593.

4.1.6 Pier Scour Monitoring

Monitoring or closing a bridge during high flows and inspection after the high flows may be an effective countermeasure to reduce the risk from scour. However, monitoring of the bridge during high flow may not reveal that it is about to collapse from scour. It also may not be practical to close the I-70 Bridge during high flow because of traffic volume, poor alternate routes the need for emergency vehicles to use the bridge, etc. A countermeasure installed to reduce the risk from scour along with monitoring during and inspection after high flows could provide for the safety of the public without closing the bridge, but monitoring alone is not a reasonable option for this bridge.

4.2 Lateral Stability Scour Mitigation Options

The classes of countermeasures identified for bank stabilization and bend control are bank revetments, spurs, bendway weirs, and longitudinal dikes. Channel relocation could be an added component of any the listed countermeasures for added effectiveness.

River training structures are those that modify the flow by altering the hydraulics to mitigate the undesirable flow along the right bank. River training structures can be constructed of various material types and are not distinguished by their construction material, but rather, by their orientation to flow. Transverse training structures are countermeasures that project in the flow field at an angle or perpendicular to the direction of flow. Transverse training structures considered for application at this site include impermeable spurs and bendway weirs. Longitudinal river training structures are countermeasures that are oriented parallel to the flow field or along a bankline. The only longitudinal training structure considered for application at this site was a longitudinal dike.

Armoring the channel bank places a physical boundary between the stream and the bank. Armoring may consist of rock riprap, articulating concrete blocks, concrete armor units such as Ajax™, or other immobile objects. The revetment may cover the entire bank or only a portion.

The following sections offer a description of the various river training and armoring countermeasures considered at the I-70 Bridge over the Colorado River. Advantages and disadvantages of each are discussed at the end of each countermeasure description to assist in the decision making process.

4.2.1 Impermeable Spurs

A spur can be a pervious or impervious structure projecting from the streambank into the channel. Spurs are used to deflect flowing water away from, or to reduce flow velocities in critical zones near the streambank, to prevent erosion of the bank, and to establish a more desirable channel alignment or width. The main function of spurs is to reduce flow velocities near the bank, which in turn, encourages sediment deposition due to reduced velocities. Increased protection of banks can be achieved over time, as more sediment is deposited behind the spurs. Because of this, spurs may protect a streambank more effectively and at less cost than revetments. Furthermore, by moving the location of any scour away from the bank, partial failure of the spur can often be repaired before damage is done to structures along and across the stream. **Figure 4.6** presents an example of a spur field design. **Figure 4.7** is a photograph of a spur field on the lower Mississippi River. A primary function of an impermeable spur is to rebuild the bank, but because the availability of suspended sediment is unknown during both normal flow and high flows, it is unclear whether rebuilding would occur. However, impermeable spurs would relieve erosion stress on the outside of the bend regardless of available suspended sediment. Further information regarding the composition of the channel bed and bank material is required to determine if sufficient suspended sediment is available in the stream to fill in between the spurs.

The crest of impermeable spurs should slope downward away from the bank line because it is difficult to construct and maintain a level spur of rock. Use of a sloping crest will avoid the possibility of overtopping at a low point in the spur profile, which could cause damage by particle erosion or damage to the streambank. **Figure 4.8** shows a close up of a typical round-nosed impermeable spur installation.

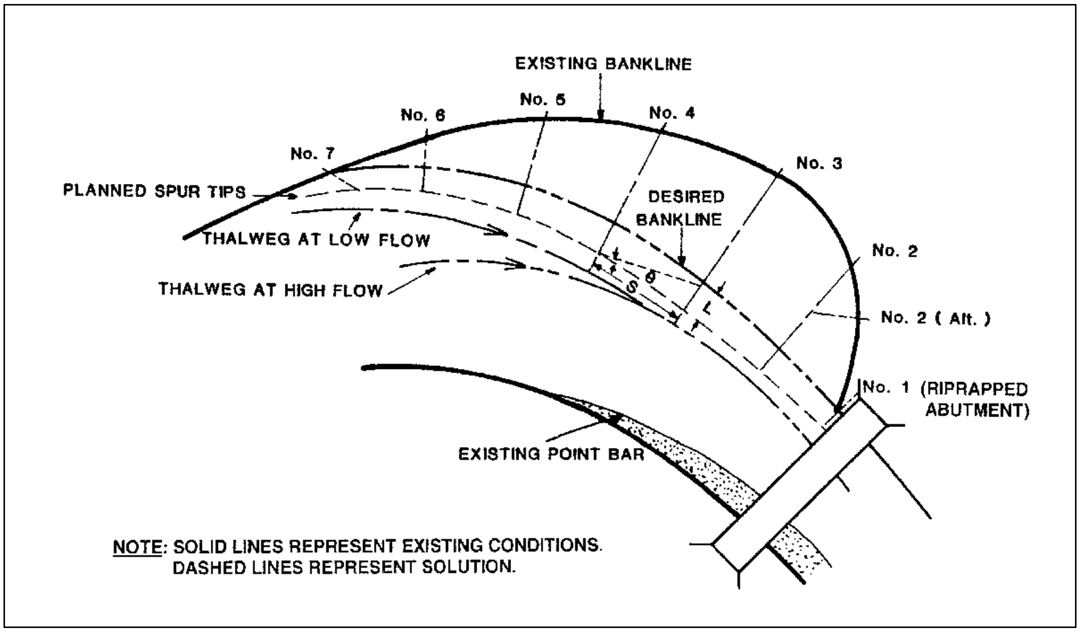


Figure 4.6. Example of a spur design.

Figure 4.7. Embankment spurs in the lower Mississippi River near Lake Providence, Mississippi (photo obtained form Google Pro 2008).

Figure 4.8. Close-up photograph of a spur in the vicinity of Richardson Highway, Delta River, Alaska.

Impermeable spurs are generally designed not to exceed the bank height because erosion at the end of the spur in the overbank area could increase the probability of outflanking at high stream stages. Where stream stages are greater than or equal to the bank height, impermeable spurs should be equal to the bank height. At the site under consideration, bank overtopping occurs at about the 2-year event and a significant portion of the overtopping flow is directed into the split flow channel and away from the bridge cross section, installation of a spur field would not be expected to disrupt the split flow. Though a spur design at the site in question could be made with some confidence, further investigation using 2D modeling of flow through the specified bend with and without spurs is recommended to investigate the impact of these structures on the fluvial process.

Advantages of Impermeable Spurs

- Spurs may more effectively protect banks from erosion than revetment.
- Spurs may protect the stream bank at less cost than riprap revetment.

Disadvantages of Impermeable Spurs

- Further information regarding the composition of the channel bed and bank material is recommended.
- Spurs may project a long distance into the current channel.
- Further investigation using 2D modeling of flow through the specified bend with and without spurs is recommended

For more information on impermeable spurs as a scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition) Design Guideline 2.

4.2.2 Bendway Weirs

Bendway weirs are low elevation stone sills used to improve lateral stream stability and flow alignment problems at river bends and highway crossings.

Bendway weirs are similar in appearance to stone spurs, but have significant functional differences. Spurs are typically visible above the flow line and are designed so that either flow is diverted around the structure, or flow along the bank line is reduced as it passes over the structure. Bendway weirs are normally not visible, especially at stages above low water, and are intended to redirect flow by utilizing weir hydraulics over the structure. Flow passing over the bendway weir is redirected perpendicular to the axis of the weir and is directed back towards the channel centerline, see **Figure 4.9**. Similar to stone spurs, bendway weirs reduce near bank velocities, reduce the concentration of currents on the outer bank, and can produce a better alignment of flow through the bend and downstream crossing. **Figure 4.10** presents a sketch of how bendway weirs may look from plan view at the site.

The bendway weir height should be between 30 to 50% of the depth at the mean annual high water level, see **Figure 4.11**. The height of the structure should also be below the normal or seasonal mean water level and should be equal to or above the mean low water level. The weir must be of adequate height to intercept a large enough percentage of the flow to produce the desired results.

The typical and standard application of bendway weirs is to address ongoing migration of a channel bank at the outside of a bend. The channel migration process is usually driven primarily by frequent in-channel flows (e.g. up to the 1.5-year to 2-year event). The effectiveness of bendway weirs in this role has been well established.

If the bendway weirs applied to the I-70 Bridge project would have the additional goal of creating a favorable attack angle for flows through the bridge under high flow conditions, such as the 100-year and 500-year events, two-dimensional modeling would be necessary to examine the weir's effectiveness toward that goal. The additional modeling is necessary because of the split flow conditions and because of the deep submergence of the weirs. It is highly unlikely, however, that the bendway weirs would be successful in this function. The, bendway weirs would need to extend a long distance into the channel to achieve the desired alignment. This distance may exceed normal practice for bendway weir design.

Advantages of Bendway Weirs:

- Flow can be redirected towards a predictable area away from the bank
- Work well with other bank protection methods
- Beneficial for aquatic habitat
- Weirs can be retrofitted after project completion to improve effectiveness
- May be less costly than continuous protection

Figure 4.9. Bendway weirs would reduce near bank velocities, in order to produce a better alignment of flow through the bend and downstream crossing.

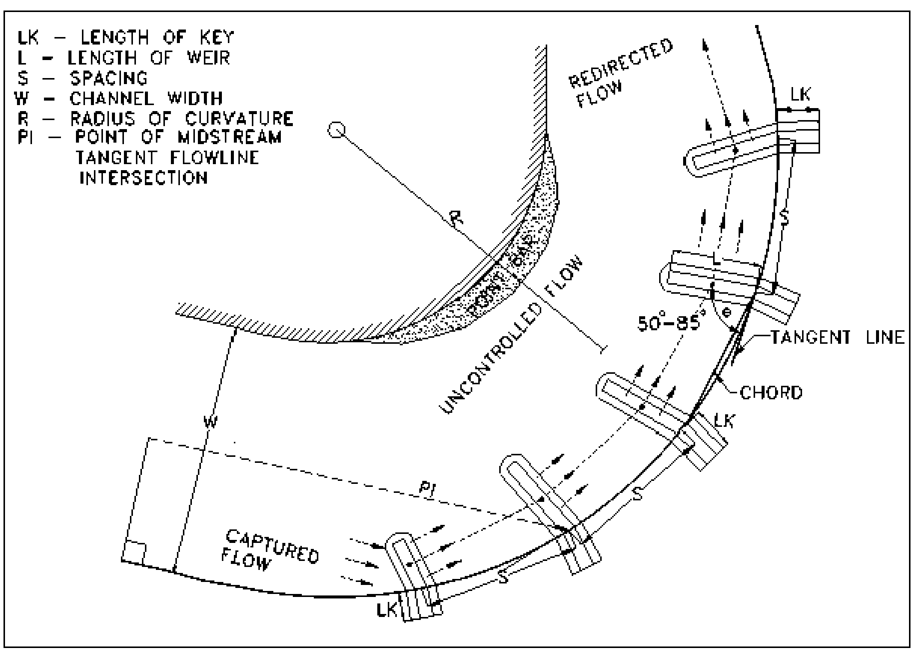


Figure 4.10. Bendway weir typical plan view.

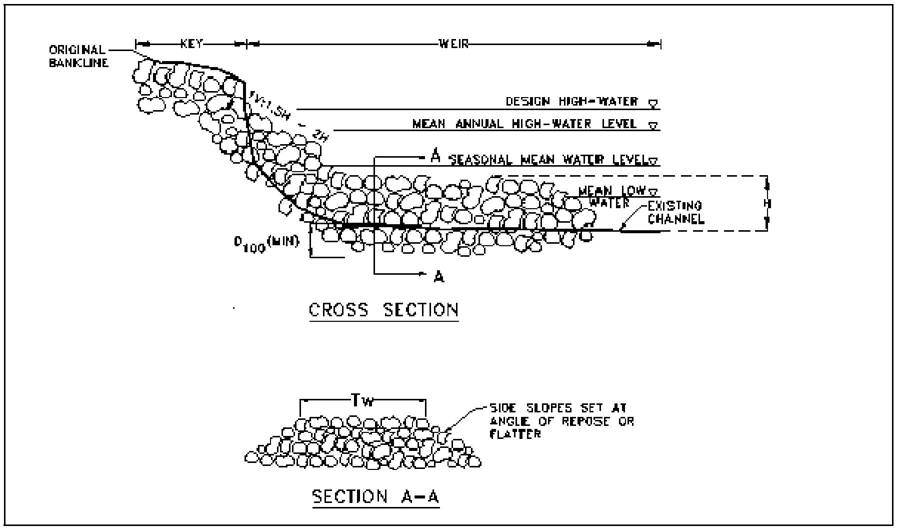


Figure 4.11. Bendway weir typical cross section.

Disadvantages of Bendway Weirs:

- Data is limited as to the effect of cross currents such as those that would spill over the right bank into the split flow channel at the project site. The decision process would require further investigation, perhaps by 2D modeling, of the complex hydraulics created by the split flow path.
- Bendway weirs would need to extend a long distance into the current channel to achieve the desired alignment. This distance may exceed normal design practice.
- Further investigation by 2D modeling required.
- In most weir keys the stone on the banks connecting the weir to the keyed back section protrudes from the surrounding banks. Scour around keys protruding from the bank could cause turbulence in the boundary flow near the bank, which could result in some bank scalloping between weirs. This concern increases in importance as cross flow into the overbank increases.

For more information on bendway weirs as a scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition) Design Guideline 1.

4.2.3 Longitudinal Dikes

Longitudinal dikes are essentially impermeable linear structures constructed parallel with the streambank or along the desired flow path. They protect the streambank in a bend by moving the current away from the bank. See **Figure 4.12** for an example application of a longitudinal dike by the U.S. Army Corps of Engineers on the Upper Mississippi River. In Figure 4.12 the flow direction is from lower left to upper right. Longitudinal dikes may be classified as earth or rock embankment dikes, crib dikes, or rock toe-dikes.

Figure 4.12. Longitudinal dike and chevron structures used as river training structures by the U.S. Army Corps of Engineers on the Upper Mississippi (photo obtained from Google Pro 2008) 38˚53'23.77 N, 90˚34.36" W.

Since secondary currents transport sediment supplied, in large part, from outer bank erosion toward the inner bank of a bend, hardening of the outer bank by longitudinal bank protection structures may cause the channel cross section to narrow and deepen by preventing the recruitment of eroded outer bank sediments. Height of the proposed dike would be equal to the bank height. It is highly recommended that any longitudinal dike structure be accompanied by removal of a portion of the left bank to a location about equivalent to the 1980 bankline in order to maintain conveyance. Fill from channelization efforts could be used to rebuild the right bank. **Figure 4.13** presents a schematic of how a longitudinal dike may look from plan view at the site. The region highlighted in yellow on the left bank represents the area of channelization and the area highlighted in blue represents the area to be filled using material removed from the left bank. The black arrow in Figure 4.13 represents the approximate flow path after longitudinal dike construction.

Advantages of a Longitudinal Dike:

- Effectively move current away from migrating right bank
- May be able to reuse some of existing riprap
- Uses less material than revetment riprap, spurs or bendway weirs.

Disadvantages of a Longitudinal Dike:

- Can be difficult and expensive to make changes once installed
- Channelization of left bank highly recommended

- If not installed in conjunction with channelization efforts on left bank, flooding may be increased until the current sand bar is washed out.

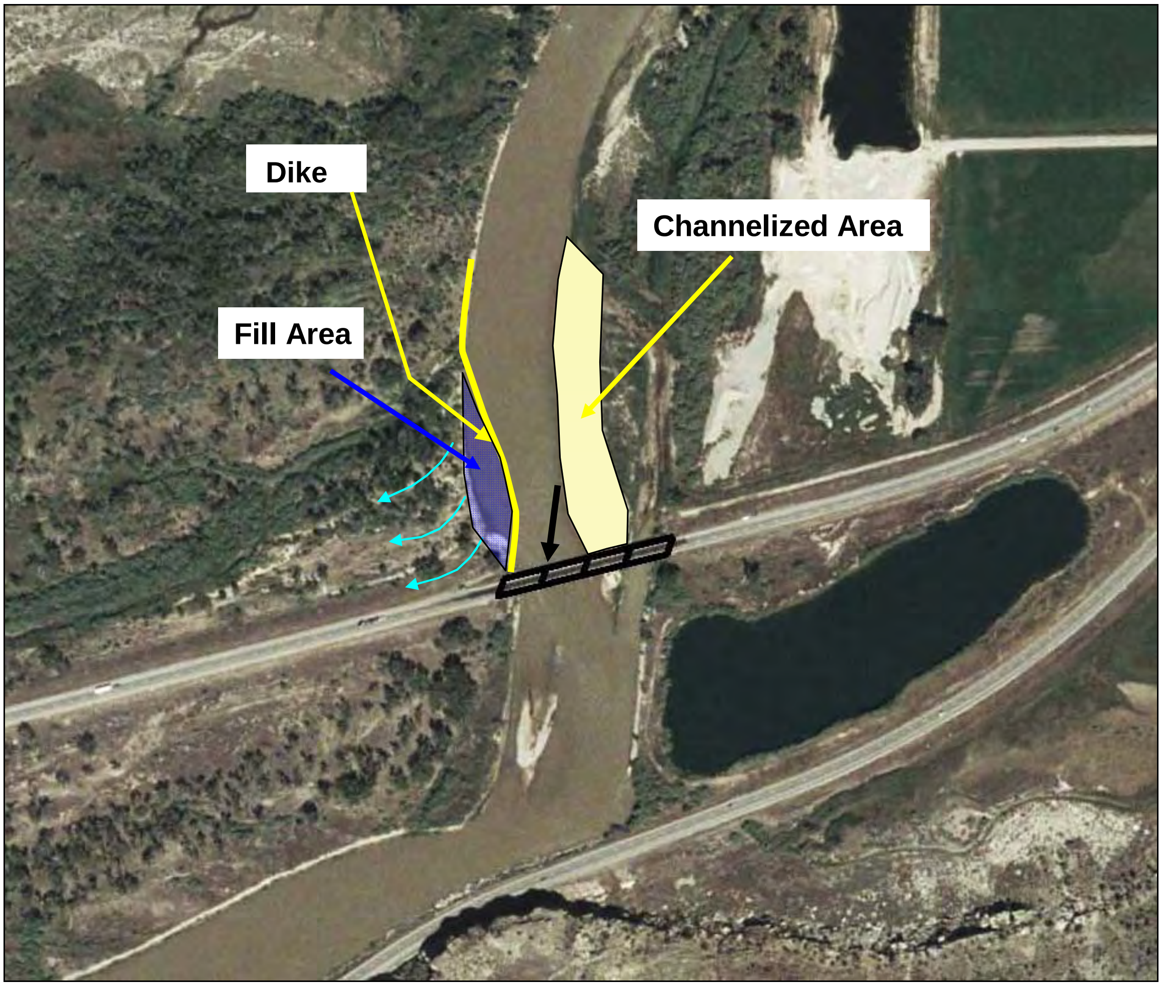


Figure 4.13. A longitudinal dike would prevent further movement of the channel towards the right bank.

4.2.4 Channelization

At this site, channelization would involve reshaping and relocating the left bank in the vicinity of the historic 1980 bankline location. Channelization of the left bank may be necessary if river realignment or training mitigation measures are implemented on the right bank. The intent of channelization at this site would be to regain conveyance that would otherwise be lost due to the construction of river training structures on the right bank. Channelization efforts should be considered in conjunction with in-channel training structures such as a longitudinal dike, bendway weirs, or spurs.

The probability of local bank erosion at some point along the area of channelization is likely and revegetation efforts should be considered. The importance of vegetation, both in appearance and in erosion control, may justify a serious and possibly sustained effort to establish new growth as soon as possible on regraded banks.

4.2.5 Riprap Bank Revetment

Rock riprap is the most widely used revetment in the United States. Its effectiveness has been well established where it is of adequate size, of suitable size gradation, and properly installed. Riprap revetment along the bankline could provide protection against further migration while allowing for distortion and articulation of the revetment. Rock riprap would be placed along the existing bankline with a filter and keyed in to the bank with the lower toe extending into the streambed, see **Figure 4.14** for a sketch of how a riprap bankline would appear in plan view at the site. Using the NCHRP Report 568 method, the required revetment riprap d_{50} is 1.5 feet, see Appendix E.

Figure 4.14. Riprap would be placed along the existing bankline with a filter and keyed in to the bank.

Riprap revetment should be toed down below the toe of the bank slope to a depth at least as great as the depth of anticipated long-term bed degradation plus toe scour, **Figure 4.15** presents a schematic diagram that summarizes these recommendations.

Advantages of Riprap Revetment:

- Ease of installation
- Can be vegetated
- Reliable design parameters

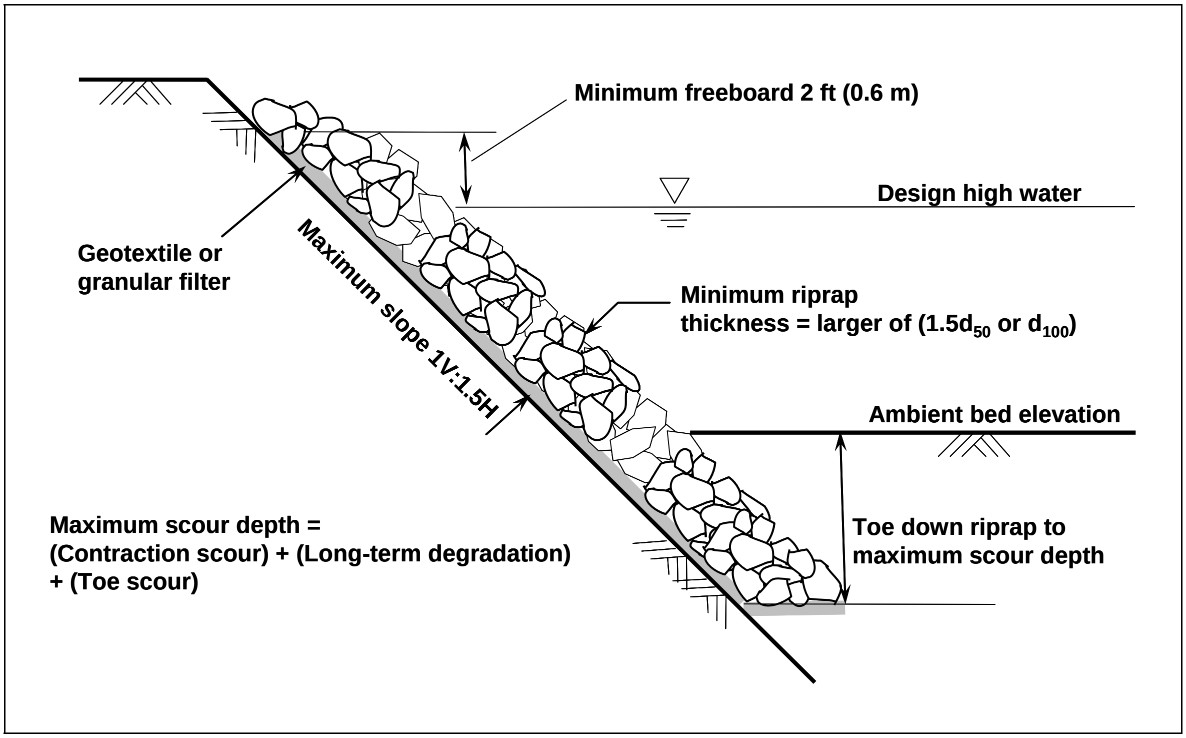


Figure 4.15. Riprap revetment with buried toe.

Disadvantages of Riprap Revetment:

- Stream alignment with piers not addressed

For more information on riprap revetment as a scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition) Design Guideline 12.

Vegetated Riprap. Streambank protection designs that consist of riprap or other inert structures alone may be unacceptable for lack of environmental and aesthetic benefits. Combining vegetation with riprap should be considered at this site with the intention of protecting against bank erosion while providing environmental and aesthetic benefits. See **Figure 16** for an application of vegetated riprap as stream bank protection.

Correctly designed and installed, vegetated riprap offers an opportunity for the designer to attain the immediate and long-term protection afforded by riprap with the habitat benefits inherent with the establishment of a healthy riparian buffer. The riprap will resist the hydraulic forces, while roots and branches increase geotechnical stability, prevent soil loss (or piping) from behind the structures, and increase pullout resistance.

Above ground components of the plants create habitat for both aquatic and terrestrial wildlife, provide shade (reducing thermal pollution), and improve aesthetic and recreational opportunities. The roots, stems, and shoots will help anchor the rocks and resist 'plucking' and gouging by ice and debris.

Figure 4.16. Vegetated riprap protecting a bank on the Chippewa River in Madison, WI.

Vegetated riprap can be a useful and cost-effective tool in controlling bank erosion or providing bank stability at highway bridges, while increasing the aesthetics and habitat diversity of the site. Vegetated riprap needs to be applied in a prudent manner, in conjunction with channel planform and bed stability-analysis, and rigorous engineering design. A design will need to account for a multitude of factors associated with the geotechnical characteristics of this site, the local and watershed geomorphology, local soils, plant biology, hydrology, and site hydraulics. Finally, a program for monitoring and maintenance must be included in the project and strictly adhered to. This is essential to the success and effectiveness of any vegetated riprap installation.

4.2.6 Articulated Blocks

For over three decades, ACB systems have been used for streambank revetment or full channel armoring where the mat is placed across the entire channel cross section. For this reason, guidelines for these applications are well established (Harris County Flood Control District 2001). ACBs stabilize the channel but have open areas that quickly vegetate, forming a more naturalistic feel in addition to providing more agreeable habitat for the local wildlife. See **Figure 4.17** for an example of ACBs used to stabilize the channel bottom and banks of Sims Bayou in Houston, Texas. The ACBs in Figure 4.17 have been fully vegetated.

At this site, it is recommended that a drainage layer be used in conjunction with an ACB system. A drainage layer lies between the blocks and the geotextile and/or granular filter. This layer allows "free" flow of water beneath the block system while still holding the filter material to the subsoil surface under the force of the block weight. This free flow of water can relieve sub-block pressure and has appeared to significantly increase the hydraulic stability of ACB systems based on full-scale performance testing conducted since the mid 1990s.

Figure 4.17. ACBs were used to stabilize the channel bottom and banks in Sims Bayou, Houston, Texas.

The revetment armor should be continuous for a distance that extends both upstream and downstream of the region that experiences hydraulic forces severe enough to cause dislodging and/or transport of bed or bank material. The minimum distances recommended are an upstream distance of one channel width beyond the bend and a downstream distance extending to the bridge embankment.

The vertical extent of the revetment should provide freeboard above the design water surface. The revetment system should extend below the bed far enough so that the revetment is not undermined from toe scour. Recommended revetment termination at the top and toe of the bank slope are provided in **Figure 4.18**.

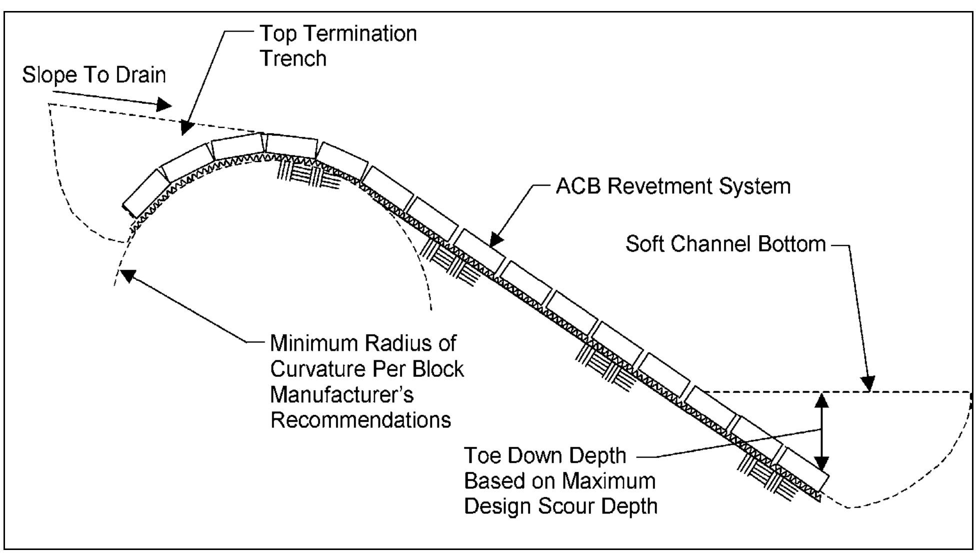


Figure 4.18. Recommended layout detail for bank revetment at the I-70 Bridge site.

Advantages of ACBs:

- Can be used to hold existing bankline in place
- Can be vegetated
- Reliable design parameters

Disadvantages of ACBs:

- Stream alignment with piers not addressed
- Requires more rigorous control during construction than riprap revetment in order to meet placement tolerances

For more information on ACBs as a scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition) Design Guideline 4.

4.2.7 Partially Grouted Riprap

In contrast to fully grouted riprap, partial grouting increases the overall stability of the riprap installation unit without sacrificing flexibility or permeability. It also allows for the use of smaller rock compared to standard riprap, resulting in decreased layer thickness.

The holes in the grout allow for drainage of pore water so a filter is required. The grout forms conglomerates of riprap so the stability against particle erosion is greatly improved and a smaller thickness of stone can be used. Although not as flexible as riprap, partially grouted riprap will conform somewhat to bank settlement and toe exposure.

An important consideration for partially grouted riprap is that construction methods must be closely monitored to ensure that the appropriate voids and surface openings are provided. **Figure 4.19** shows an installation of partially grouted riprap on a streambank in Germany. The equipment requirements, placement techniques, and construction QA/QC requirements for partially grouted riprap are straightforward for working in the dry; however, placement underwater requires construction equipment and placement technologies that are much more sophisticated.

Partially grouted riprap can be vegetated similar to loose riprap, see previous section on vegetation riprap for more information.

Advantages of Partially Grouted Riprap:

- Ease of installation
- Can be vegetated
- Reliable design parameters

Disadvantages of Partially Grouted Riprap:

- Stream alignment with piers not addressed
- Dewatering required for installation in the dry
- For installation in flowing water, Sicotan^{TM} additive is required as well as velocities less than 4 ft/s

Figure 4.19. Installation of partially grouted riprap.

For more information on partially grouted riprap as a scour countermeasure see NCHRP Report 593.

4.2.8 Concrete Armor Units

Concrete armor units, also known as artificial riprap, consist of individual pre-cast concrete units with complex shapes that are placed individually or in interconnected groups. These units were originally developed for shore protection to resist wave action during extreme storms. All are designed to give a maximum amount of interlocking using a minimum amount of material. These devices are used where natural riprap is unavailable or is more costly to obtain than fabrication of the artificial riprap units.

The primary advantage of armor units is that they usually have greater stability compared to riprap particles of equivalent weight. This is due to the interlocking characteristics of their complex shapes. The increased stability allows their placement on steeper slopes or the use of lighter weight units for equivalent flow conditions as compared to riprap. This may be significant if site-specific hydraulic properties require a stone size that is inappropriate for the design bank height.

Advantages of Armor Units:

- Armor units usually have greater stability compared to riprap particles of equivalent weight
- Can be vegetated
- Reliable design parameters

Disadvantage of Armor Units:

- Some units may not be appropriate for use in cobble bed stream

4.3 Monitoring

Monitoring as a countermeasure involves three basic categories: visual, portable instruments and fixed instruments. Implementation of a monitoring countermeasure is relative to the timeframe developed for installation of physical countermeasures. It is strongly recommended that a monitoring protocol be implemented prior to the 2009 runoff season.

The monitoring program should obviously verify the continued safe condition of the bridge and its capacity to carry traffic. The monitoring protocol should also monitor the existing riprap at the piers and the right (west) abutment. It should verify that the riprap is remaining intact, that it is not settling, and that stones are not being moved away from the protected element by the flow during the spring runoff period and other high flow periods. The ongoing migration of the right stream bank should also be monitored and corrective action taken if a critical situation develops. Monitoring at intervals should be adequate for typical spring runoff conditions that are below bank-full stage and remaining relatively steady with time. Continuous monitoring is needed, however, for out-of-bank flooding, especially when the discharge is increasing with time.

If construction of physical countermeasures will be delayed past the next runoff season, fixed sonar is recommended. Float-out devices located under the temporary riprap should be considered if the countermeasure installation timeframe is prolonged. For more information on monitoring as a scour countermeasure see Hydraulic Engineering Circular No. 23 (HEC-23 Second Edition).

4.4 Other Considerations

4.4.1 ACB Grade Control at Split-Flow Location

Stabilizing the split flow path at the right bank of the main channel is highly recommended to prevent channel avulsion. Grade control could be established using articulating concrete blocks (ACBs) to stabilize the existing riverbank that forms the existing crest of the split flow path. **Figure 4.20** shows where the ACB grade control structure would be located on the right bank. **Figure 4.21** presents a schematic diagram of the ACB grade control structure in longitudinal section. Open-cell blocks are designed to be vegetated with native grasses that will enhance stability and habitat. Blocks should be selected for hydraulic stability based on HEC-23 methodology.

4.4.2 Embankment Spurs

Embankment spurs, similar in composition to those proposed for lateral channel migration, could be installed along the split flow channel next to the road embankment to ensure scour does not threaten the road. Design of this option would require further investigation of the topographic and hydraulic characteristics of the split flow channel. **Figure 4.22** presents a sketch of how embankment spurs may look like from plan view at the site.

Figure 4.20. A low channel would direct flow into the split-flow channel without threatening main channel stability.

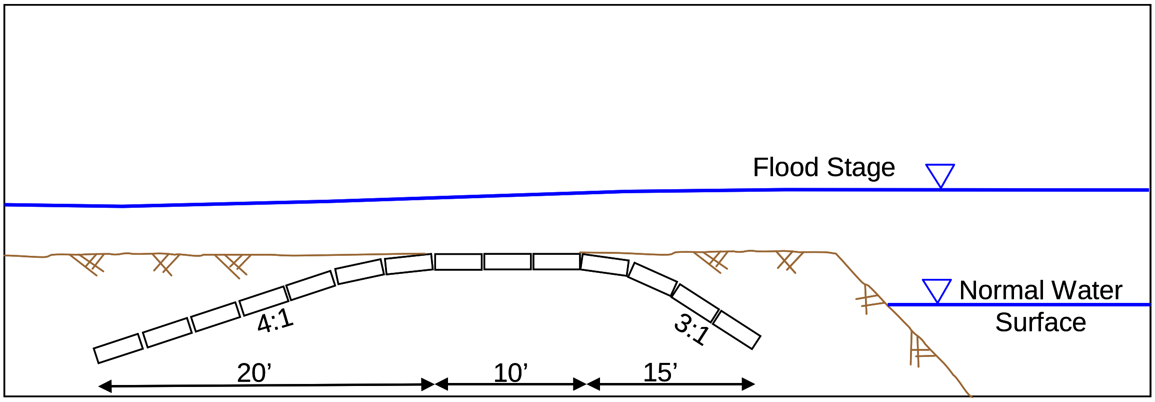


Figure 4.21. Recommended layout detail for ACB bank armor, cross section A-A' from Figure 4.20 above.

Figure 4.22. Embankment spurs could be installed to prevent scour along the road due to flow in the split flow channel.

5. CONCLUSION

5.1 Protecting Against Pier Scour Failure

Bridge G-04-BA has been shown to be vulnerable to scour and channel migration through field observations, a quantitative scour analyses, and a qualitative lateral stability analysis. Scour analysis of the current and realigned-channel conditions indicate that even if the angle of attack issue is addressed through channel realignment, pier scour countermeasures will be required to protect the pile foundations from scour. The existing boulder riprap mounded at Piers 2 and 3 should be removed and adequately designed pier scour countermeasures installed.

Pier scour countermeasures may be avoided by extending the foundation depth through installation of drilled caissons and removal of the existing piers. This solution would provide added foundation strength as well as mitigate the pier geometry and angle of attack concerns.

5.2 Mitigating Stream Migration Problems

Whether pier scour countermeasures are installed or pier geometry and foundation strengthening is employed using caissons or drilled shafts, bank stabilization and installation on the right bank of a grade control structure for the split flows is recommended. The right bank could be stabilized through river training techniques or a number of armoring methods such as riprap revetment, articulating concrete blocks, partially grouted riprap or concrete armor units.

If the pier geometry and foundations are not modified using caissons or drilled shafts, it will be more important to correct the flow alignment through the bridge through installation of river training structures such as a longitudinal dike, bendway weirs, or spurs is recommended. River training structures would move flow in the main channel away from the existing right bank. Channelization of the left bank may be necessary if river realignment or training mitigation measures are implemented on the right bank. The intent of channelization at this site would be to regain conveyance that would otherwise be lost due to the construction of river training structures on the right bank. The most effective method of realigning the flow through the bridge would be a longitudinal dike completed in conjunction with channelization of the left bank.

Further hydraulic analysis utilizing field survey and two-dimensional modeling techniques is recommended for river training techniques except the longitudinal dike, due to complex local flow patterns associated with the bank-overtopping split flow event.

6. REFERENCES

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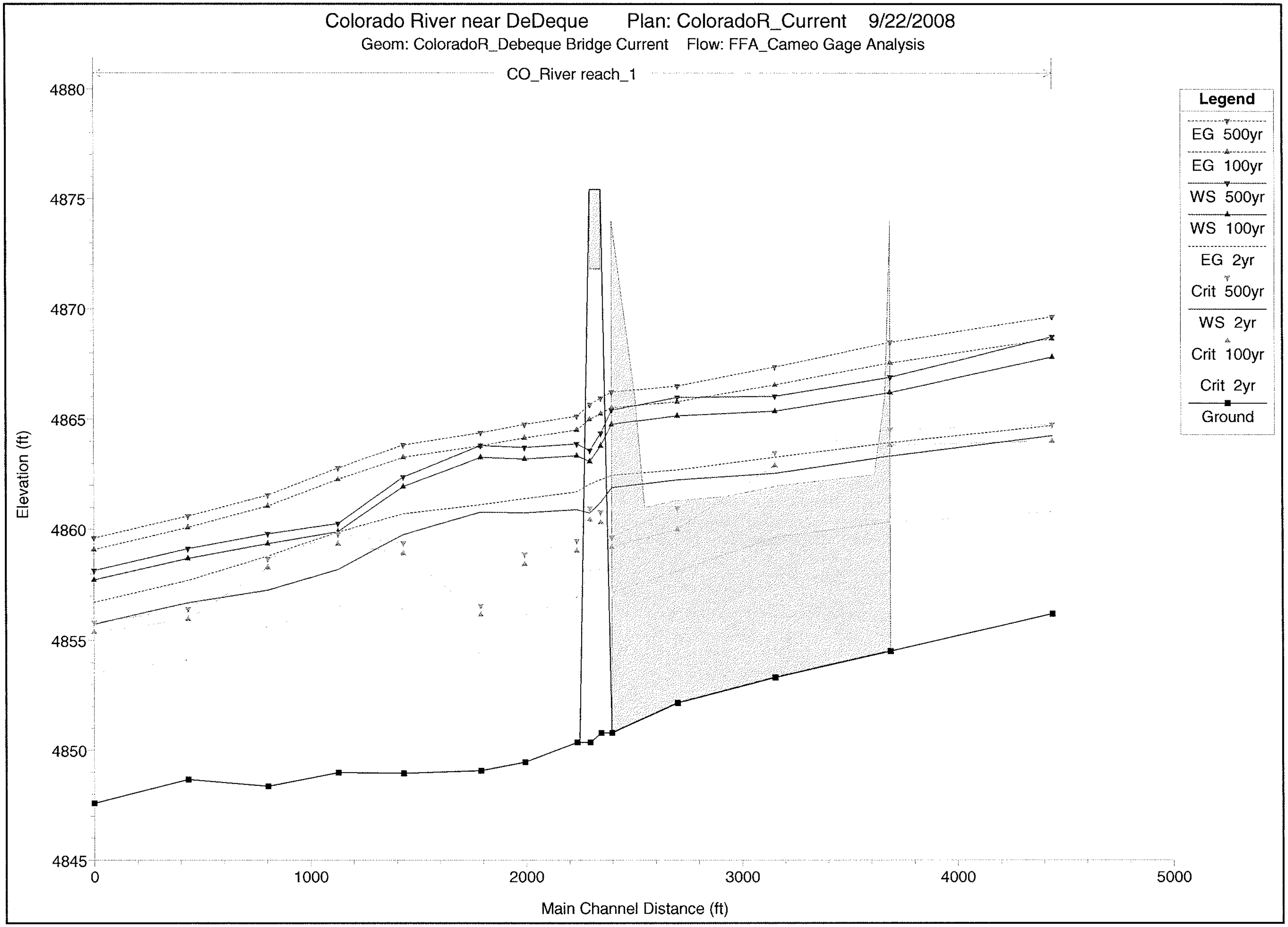
APPENDIX A
Riverine Hydraulic Model



Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
CO_River reach_1
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
Crit 500yr
WS 2yr
Crit 100yr
Crit 2yr
Ground
Elevation (ft)
4880
4875
4870
4865
4860
4855
4850
4845
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

HEC-RAS Plan: Current River: CO_River Reach: reach_1 Profile: 2yr

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)	
reach_1	4553.805	2yr	18200.00	4856.21	4864.28	4860.81	4864.74	0.000917	5.71	4723.39	1085.96	0.37
reach_1	3802.484	2yr	18200.00	4854.52	4863.35	4860.34	4863.96	0.001118	6.86	4704.69	1227.54	0.42
reach_1	3600		Lat Struct									
reach_1	3267.803	2yr	17696.68	4853.33	4862.57	4859.64	4863.29	0.001285	7.35	4102.94	1211.09	0.45
reach_1	2815.442	2yr	16973.44	4852.17	4862.26	4858.12	4862.73	0.000737	5.71	4201.05	1141.20	0.34
reach_1	2510.449	2yr	16619.16	4850.79	4861.90	4857.16	4862.47	0.000777	6.17	3191.25	1012.13	0.35
reach_1	2380		Bridge									
reach_1	2349.427	2yr	16619.16	4850.35	4860.90	4856.95	4861.71	0.001138	7.30	2582.03	517.20	0.42
reach_1	2108.129	2yr	16619.16	4849.46	4860.75	4856.16	4861.39	0.000826	6.72	3250.27	761.93	0.37
reach_1	1903.796	2yr	16619.16	4849.07	4860.79	4854.39	4861.13	0.000395	4.77	4062.90	715.73	0.26
reach_1	1545.269	2yr	16619.16	4848.95	4859.77	4856.42	4860.71	0.001398	8.05	2710.65	627.74	0.47
reach_1	1242.784	2yr	16619.16	4848.99	4858.20	4856.55	4859.88	0.003167	10.48	1812.28	507.96	0.68
reach_1	917.653	2yr	16619.16	4848.37	4857.27	4855.62	4858.79	0.003200	9.96	1938.90	782.71	0.68
reach_1	548.136	2yr	16619.16	4848.68	4856.70	4854.13	4857.71	0.002036	8.05	2065.08	326.91	0.54
reach_1	113.319	2yr	16619.16	4847.60	4855.73	4853.53	4856.73	0.002501	8.03	2070.48	354.20	0.59

HEC-RAS Plan: Current River: CO_River Reach: reach_1 Profile: 100yr

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)	
reach_1	4553.805	100yr	42500.00	4856.21	4867.84	4864.05	4868.67	0.001088	8.07	9292.87	1395.23	0.43
reach_1	3802.484	100yr	42500.00	4854.52	4866.22	4863.85	4867.57	0.001849	10.72	7545.34	1227.54	0.56
reach_1	3600		Lat Struct									
reach_1	3267.803	100yr	36045.94	4853.33	4865.38	4862.93	4866.57	0.001602	9.94	6806.94	1211.09	0.52
reach_1	2815.442	100yr	29337.89	4852.17	4865.16	4859.99	4865.80	0.000734	6.90	6612.67	1141.20	0.36
reach_1	2510.449	100yr	26450.31	4850.79	4864.77	4859.20	4865.53	0.000759	7.27	4562.59	1012.13	0.36
reach_1	2380		Bridge									
reach_1	2349.427	100yr	26450.31	4850.35	4863.37	4859.04	4864.52	0.001222	8.86	3664.57	556.91	0.46
reach_1	2108.129	100yr	26450.31	4849.46	4863.21	4858.45	4864.16	0.000951	8.32	4322.82	844.52	0.41
reach_1	1903.796	100yr	26450.31	4849.07	4863.29	4856.17	4863.81	0.000473	6.00	5323.87	748.86	0.29
reach_1	1545.269	100yr	26450.31	4848.95	4861.95	4858.93	4863.29	0.001571	9.84	3770.74	644.02	0.52
reach_1	1242.784	100yr	26450.31	4848.99	4859.89	4859.35	4862.29	0.003597	12.84	2875.53	664.28	0.75
reach_1	917.653	100yr	26450.31	4848.37	4859.36	4858.28	4861.07	0.002741	11.04	3604.84	811.53	0.65
reach_1	548.136	100yr	26450.31	4848.68	4858.69	4855.97	4860.10	0.002092	9.67	3396.57	868.58	0.57
reach_1	113.319	100yr	26450.31	4847.60	4857.72	4855.38	4859.09	0.002501	9.38	2836.34	416.84	0.61

HEC-RAS Plan: Current River: CO_River Reach: reach_1 Profile: 500yr

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)	
reach_1	4553.805	500yr	50200.00	4856.21	4868.75	4864.78	4869.67	0.001104	8.57	10563.43	1395.23	0.44
reach_1	3802.484	500yr	50200.00	4854.52	4866.91	4864.56	4868.50	0.002033	11.70	8235.66	1227.54	0.60
reach_1	3600		Lat Struct									
reach_1	3267.803	500yr	41722.44	4853.33	4866.05	4863.50	4867.38	0.001697	10.63	7446.57	1211.09	0.54
reach_1	2815.442	500yr	32974.98	4852.17	4865.99	4860.97	4866.52	0.000611	6.59	9063.50	1141.20	0.33
reach_1	2510.449	500yr	29003.86	4850.79	4865.41	4859.65	4866.23	0.000760	7.53	4870.32	1012.13	0.37
reach_1	2380		Bridge									
reach_1	2349.427	500yr	29003.86	4850.35	4863.90	4859.49	4865.15	0.001250	9.24	3903.55	564.15	0.47
reach_1	2108.129	500yr	29003.86	4849.46	4863.73	4858.88	4864.77	0.000987	8.71	4552.21	846.17	0.42
reach_1	1903.796	500yr	29003.86	4849.07	4863.82	4856.55	4864.40	0.000494	6.29	5594.99	755.98	0.30
reach_1	1545.269	500yr	29003.86	4848.95	4862.39	4859.38	4863.85	0.001633	10.29	3989.34	647.27	0.53
reach_1	1242.784	500yr	29003.86	4848.99	4860.26	4859.80	4862.81	0.003678	13.33	3122.01	667.61	0.77
reach_1	917.653	500yr	29003.86	4848.37	4859.80	4858.67	4861.56	0.002692	11.30	3964.79	813.96	0.65
reach_1	548.136	500yr	29003.86	4848.68	4859.13	4856.41	4860.60	0.002081	9.96	3780.99	873.18	0.58
reach_1	113.319	500yr	29003.86	4847.60	4858.14	4855.80	4859.61	0.002501	9.73	3013.64	431.54	0.61

HEC-RAS Plan: Current River: CO_River Reach: reach_1 Profile: 2yr

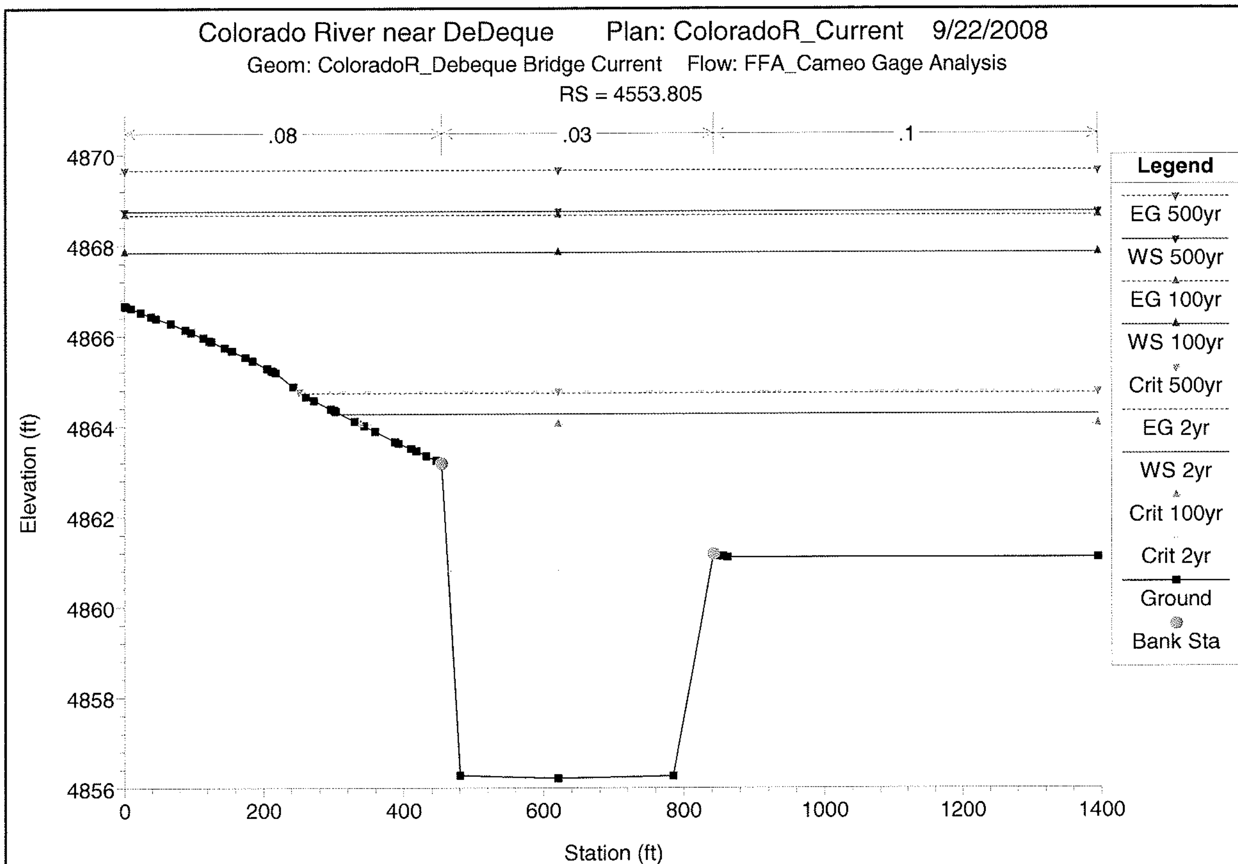
Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
reach_1	4553.805	2yr	4864.74	4864.28	0.46	0.76	0.02	30.83	16466.85	1702.32	1085.96
reach_1	3802.484	2yr	4863.96	4863.35	0.61	0.64	0.03	1213.00	15149.18	1837.82	1227.54
reach_1	3600		Lat Struct								
reach_1	3267.803	2yr	4863.29	4862.57	0.72	0.44	0.13	1473.05	15230.38	993.25	1211.09
reach_1	2815.442	2yr	4862.73	4862.26	0.47	0.23	0.03	837.13	15586.12	550.19	1141.20
reach_1	2510.449	2yr	4862.47	4861.90	0.57	0.06	0.14	499.73	16014.50	104.93	1012.13
reach_1	2380		Bridge								
reach_1	2349.427	2yr	4861.71	4860.90	0.81	0.23	0.08	299.09	16263.40	56.68	517.20
reach_1	2108.129	2yr	4861.39	4860.75	0.64	0.11	0.15	835.29	15146.84	637.03	761.93
reach_1	1903.796	2yr	4861.13	4860.79	0.34	0.24	0.18	103.83	15982.98	532.35	715.73
reach_1	1545.269	2yr	4860.71	4859.77	0.94	0.61	0.22	36.85	15489.81	1092.51	627.74
reach_1	1242.784	2yr	4859.88	4858.20	1.68	1.03	0.05	93.43	16375.33	150.40	507.96
reach_1	917.653	2yr	4858.79	4857.27	1.52	0.93	0.15	13.57	16415.47	190.13	782.71
reach_1	548.136	2yr	4857.71	4856.70	1.01	0.98	0.00	0.27	16618.89		326.91
reach_1	113.319	2yr	4856.73	4855.73	1.00				16619.16		354.20

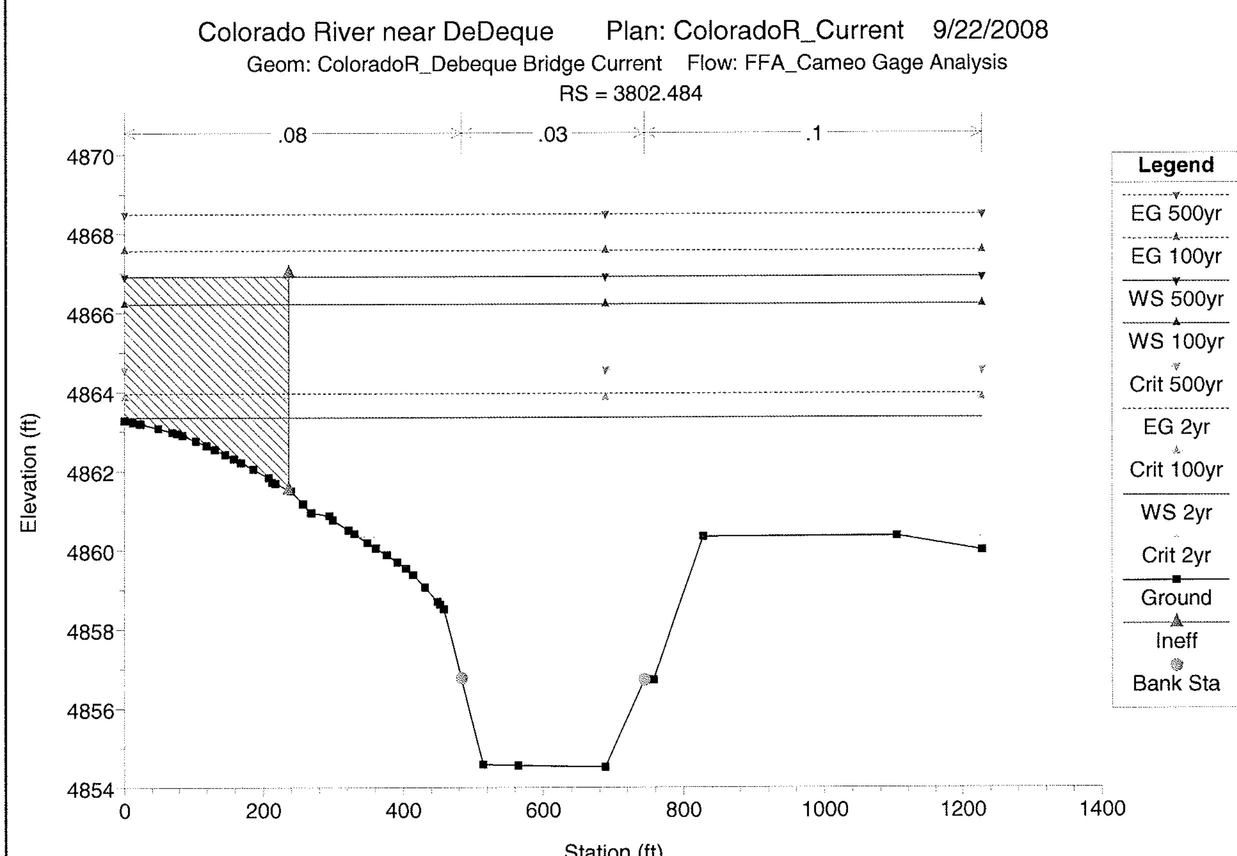
HEC-RAS Plan: Current River: CO_River Reach: reach_1 Profile: 100yr

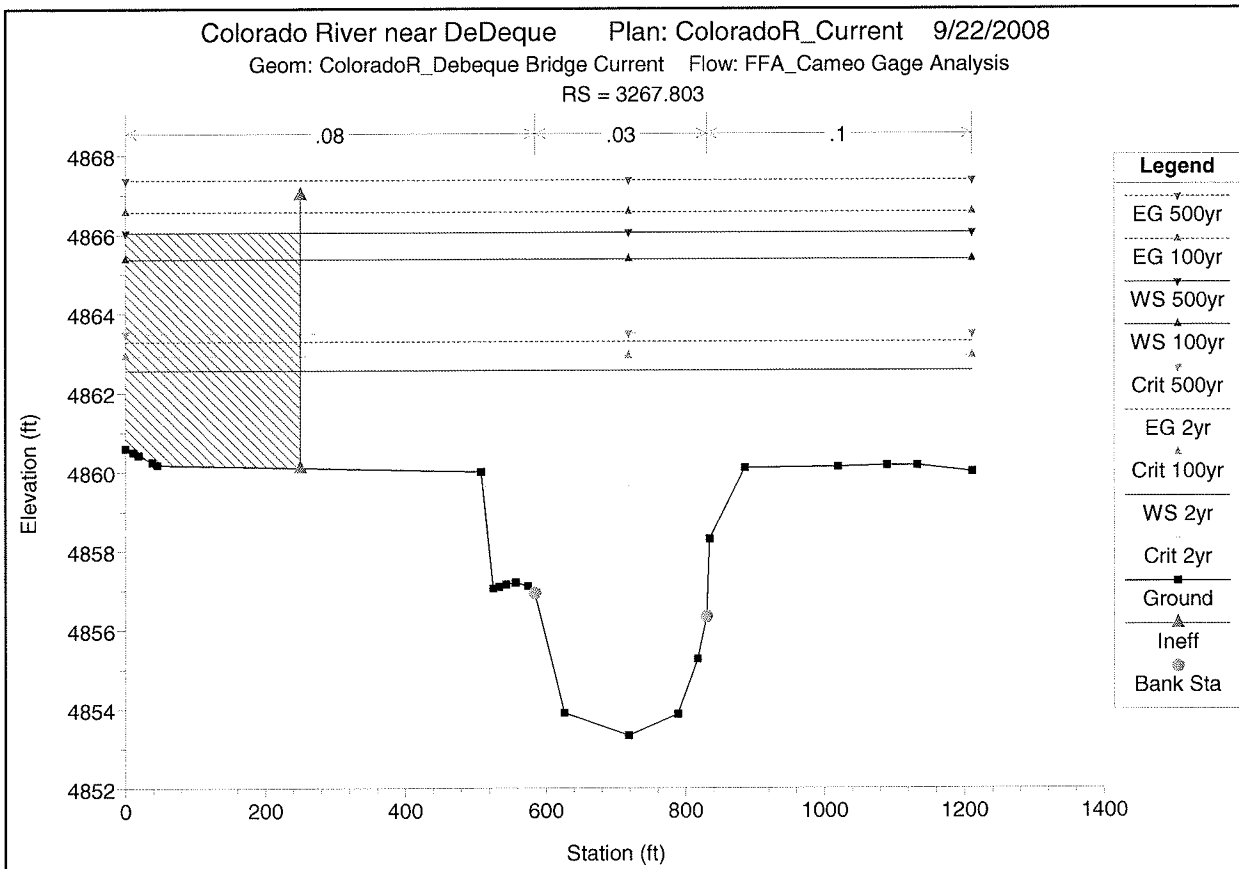
Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
reach_1	4553.805	100yr	4868.67	4867.84	0.83	1.05	0.05	1593.84	34436.66	6469.50	1395.23
reach_1	3802.484	100yr	4867.57	4866.22	1.36	0.92	0.08	4264.75	31717.96	6517.29	1227.54
reach_1	3600		Lat Struct								
reach_1	3267.803	100yr	4866.57	4865.38	1.19	0.49	0.28	4815.60	27488.41	3741.93	1211.09
reach_1	2815.442	100yr	4865.80	4865.16	0.64	0.23	0.04	2209.52	25045.83	2082.54	1141.20
reach_1	2510.449	100yr	4865.53	4864.77	0.77	0.06	0.21	1481.05	24598.10	371.16	1012.13
reach_1	2380		Bridge								
reach_1	2349.427	100yr	4864.52	4863.37	1.16	0.26	0.10	983.20	25064.91	402.19	556.91
reach_1	2108.129	100yr	4864.16	4863.21	0.95	0.13	0.21	1741.66	23225.60	1483.05	844.52
reach_1	1903.796	100yr	4863.81	4863.29	0.53	0.28	0.24	327.50	24823.59	1299.22	748.86
reach_1	1545.269	100yr	4863.29	4861.95	1.34	0.69	0.32	152.24	23453.48	2844.60	644.02
reach_1	1242.784	100yr	4862.29	4859.89	2.39	1.01	0.20	373.07	24696.11	1381.13	664.28
reach_1	917.653	100yr	4861.07	4859.36	1.71	0.88	0.09	239.84	23816.02	2394.45	811.53
reach_1	548.136	100yr	4860.10	4858.69	1.41	0.99	0.01	122.76	25699.71	627.84	868.58
reach_1	113.319	100yr	4859.09	4857.72	1.37			0.77	26441.88	7.66	416.84

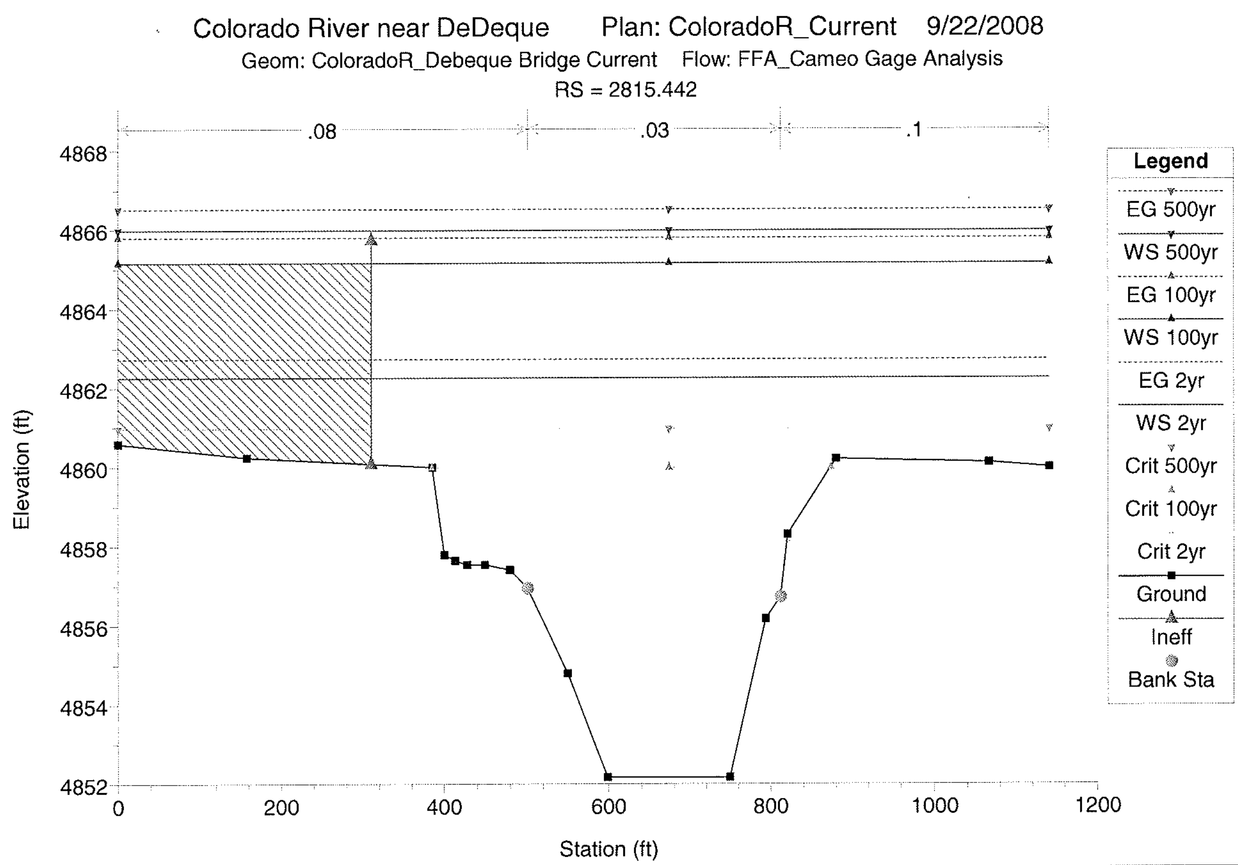
HEC-RAS Plan: Current River: CO_River Reach: reach_1 Profile: 500yr

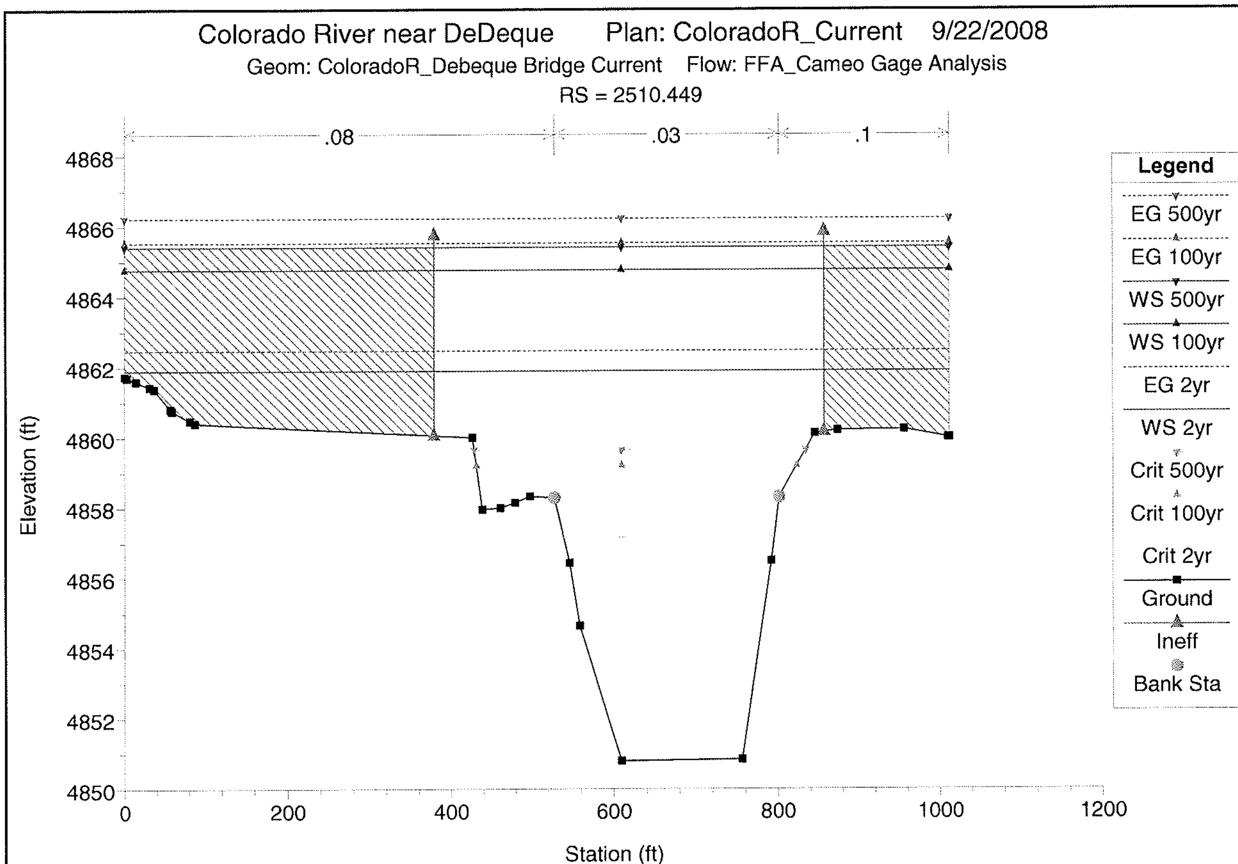
Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
reach_1	4553.805	500yr	4869.67	4868.75	0.91	1.10	0.07	2545.15	39612.76	8042.09	1395.23
reach_1	3802.484	500yr	4868.50	4866.91	1.59	0.99	0.13	5321.88	36740.91	8137.21	1227.54
reach_1	3600		Lat Struct								
reach_1	3267.803	500yr	4867.38	4866.05	1.33	0.46	0.40	5918.78	31137.55	4666.11	1211.09
reach_1	2815.442	500yr	4866.52	4865.99	0.53	0.20	0.09	4958.70	25598.41	2417.86	1141.20
reach_1	2510.449	500yr	4866.23	4865.41	0.82	0.06	0.22	1759.33	26795.85	448.68	1012.13
reach_1	2380		Bridge								
reach_1	2349.427	500yr	4865.15	4863.90	1.25	0.27	0.11	1183.61	27308.79	511.46	564.15
reach_1	2108.129	500yr	4864.77	4863.73	1.04	0.14	0.23	1986.48	25301.59	1715.79	846.17
reach_1	1903.796	500yr	4864.40	4863.82	0.58	0.29	0.26	392.71	27097.66	1513.48	755.98
reach_1	1545.269	500yr	4863.85	4862.39	1.46	0.71	0.33	190.33	25492.84	3320.69	647.27
reach_1	1242.784	500yr	4862.81	4860.26	2.54	1.01	0.24	457.94	26698.07	1847.84	667.61
reach_1	917.653	500yr	4861.56	4859.80	1.76	0.87	0.08	324.65	25605.71	3073.50	813.96
reach_1	548.136	500yr	4860.60	4859.13	1.48	0.99	0.00	173.09	27794.48	1036.28	873.18
reach_1	113.319	500yr	4859.61	4858.14	1.47			1.95	28982.52	19.39	431.54


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 4553.805
.08
.03
.1
Elevation (ft)
Station (ft)
Legend
EG 500yr
WS 500yr
EG 100yr
WS 100yr
Crit 500yr
EG 2yr
WS 2yr
Crit 100yr
Crit 2yr
Ground
Bank Sta

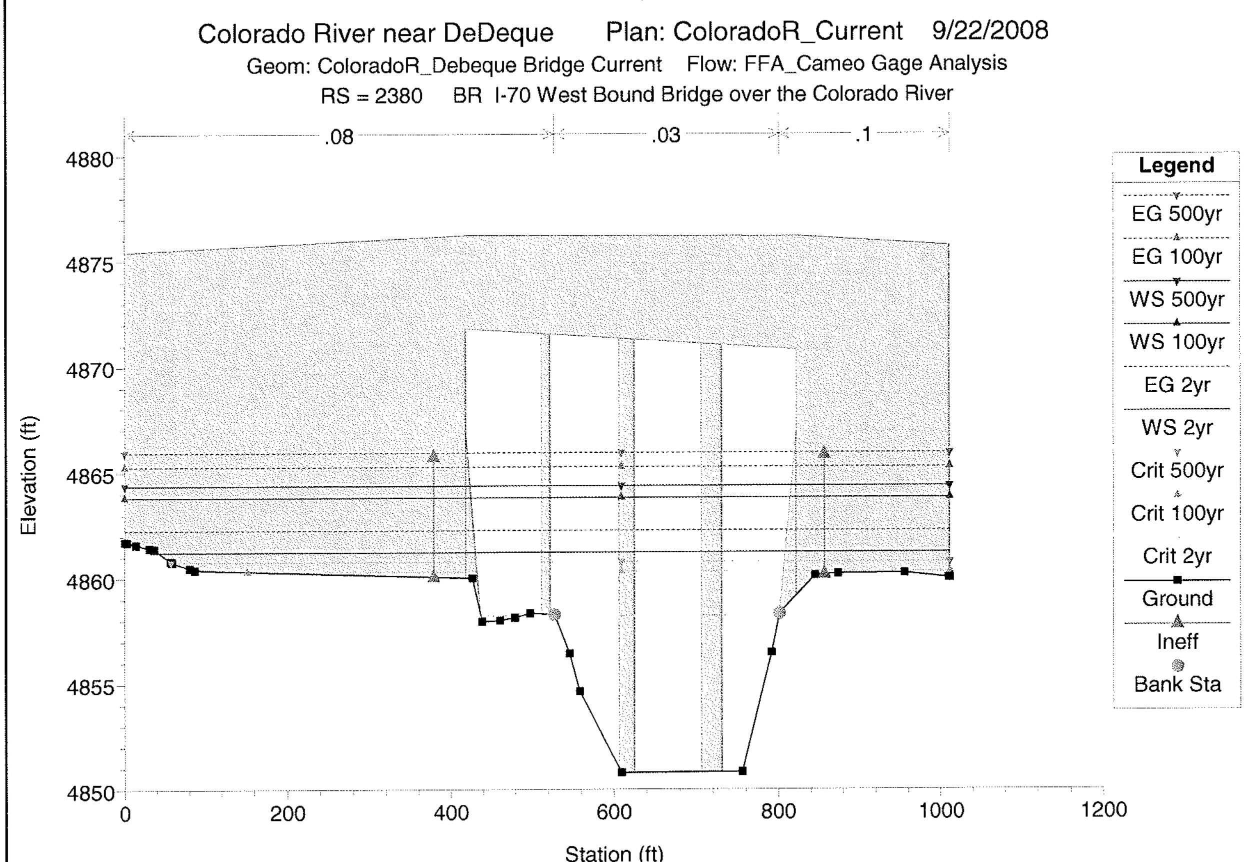

Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 3802.484
.08
.03
.1
Elevation (ft)
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
Crit 500yr
EG 2yr
Crit 100yr
WS 2yr
Crit 2yr
Ground
Ineff
Bank Sta


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 3267.803
.08
.03
.1
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
Crit 500yr
EG 2yr
Crit 100yr
WS 2yr
Crit 2yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
4852
4854
4856
4858
4860
4862
4864
4866
4868
0
200
400
600
800
1000
1200
1400

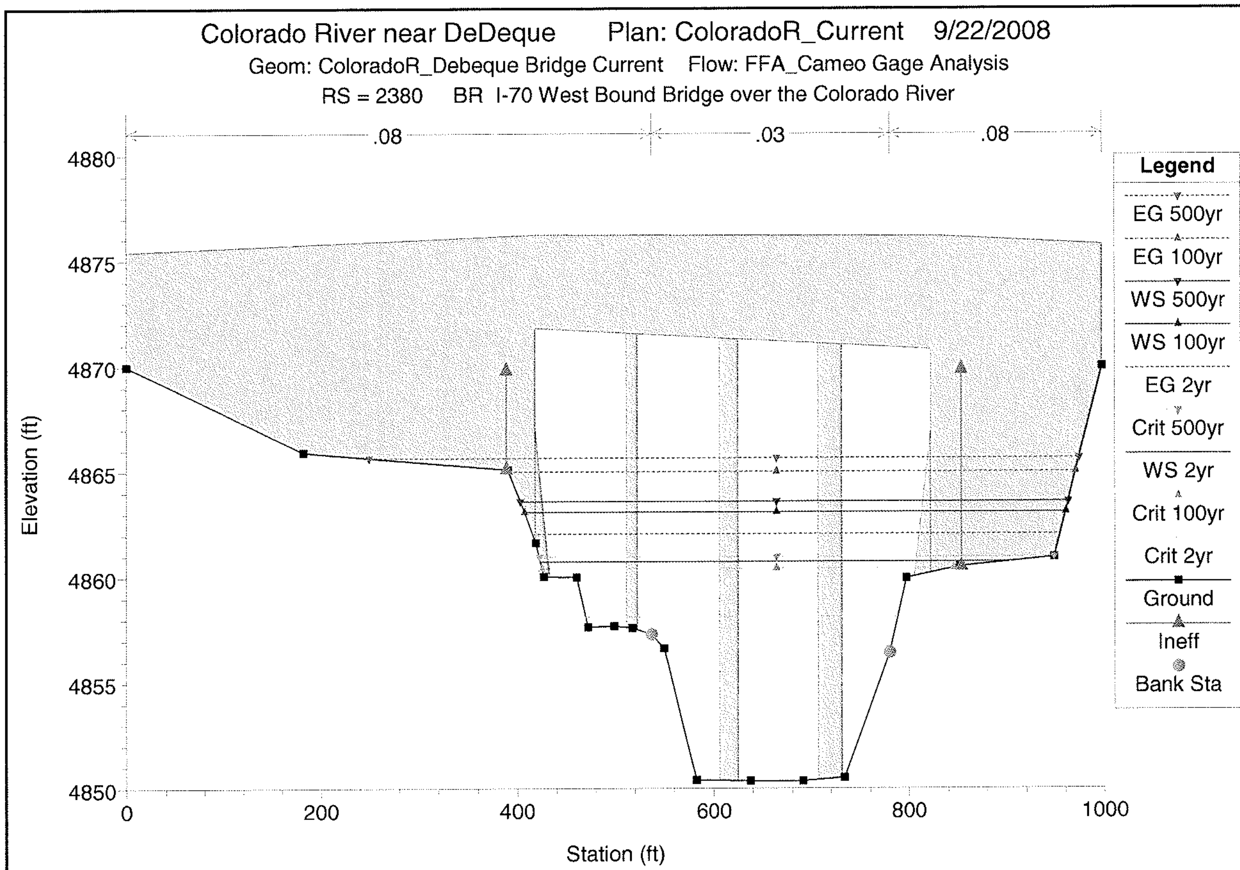

Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 2815.442
.08
.03
.1
Legend
EG 500yr
WS 500yr
EG 100yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
4852
4854
4856
4858
4860
4862
4864
4866
4868
0
200
400
600
800
1000
1200

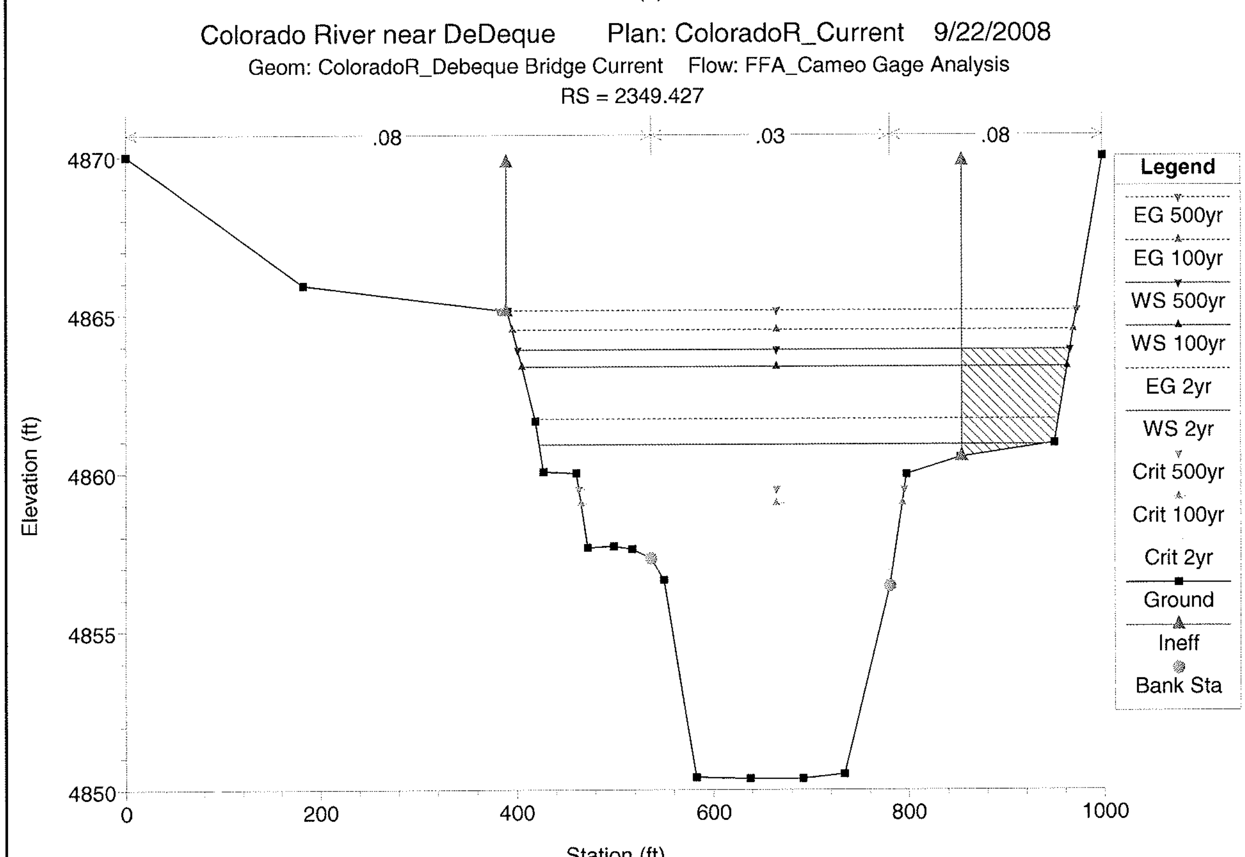


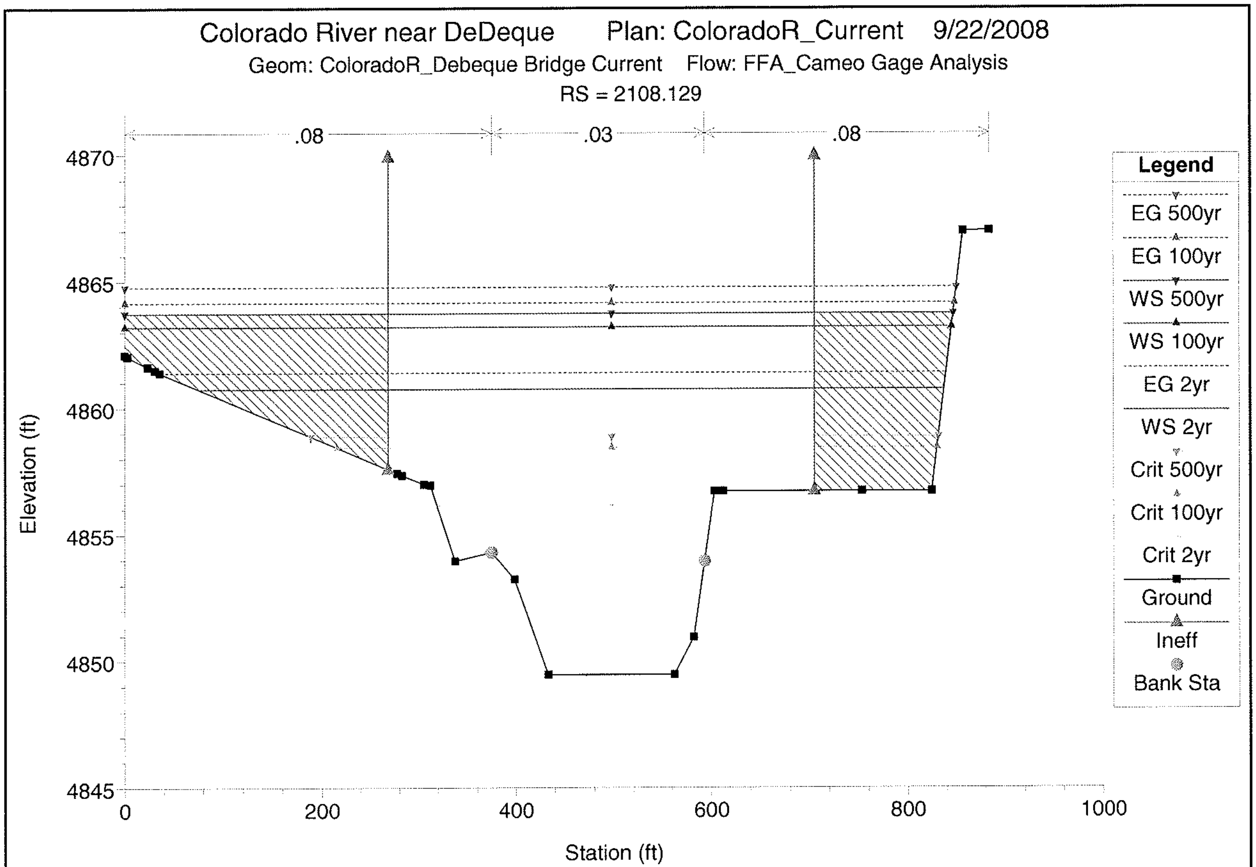
Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 2510.449
.08
.03
.1
Elevation (ft)
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta



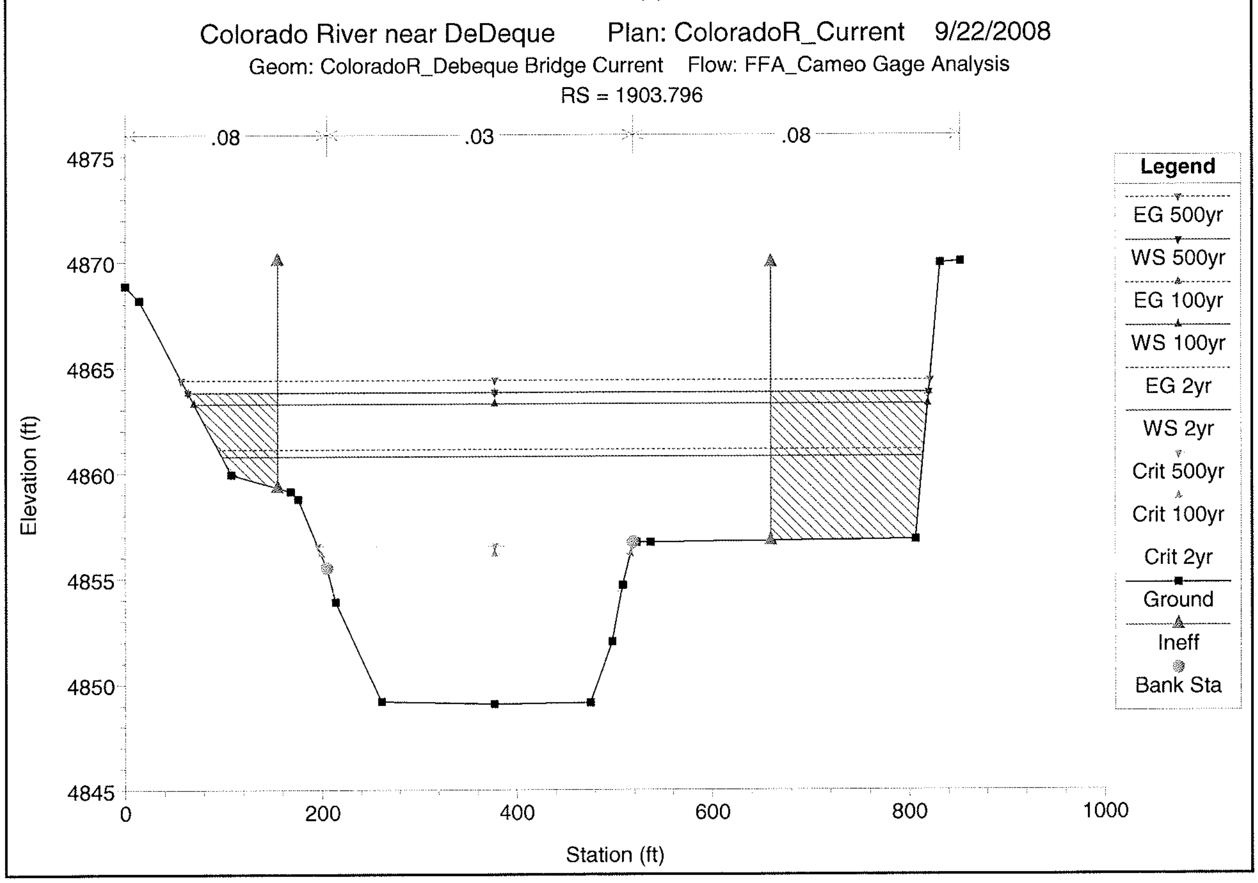
Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 2380 BR I-70 West Bound Bridge over the Colorado River
.08
.03
.1
Elevation (ft)
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 2380 BR I-70 West Bound Bridge over the Colorado River
.08
.03
.08
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
Crit 500yr
WS 2yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta
Elevation (ft)
4880
4875
4870
4865
4860
4855
4850
0
200
400
600
800
1000
Station (ft)

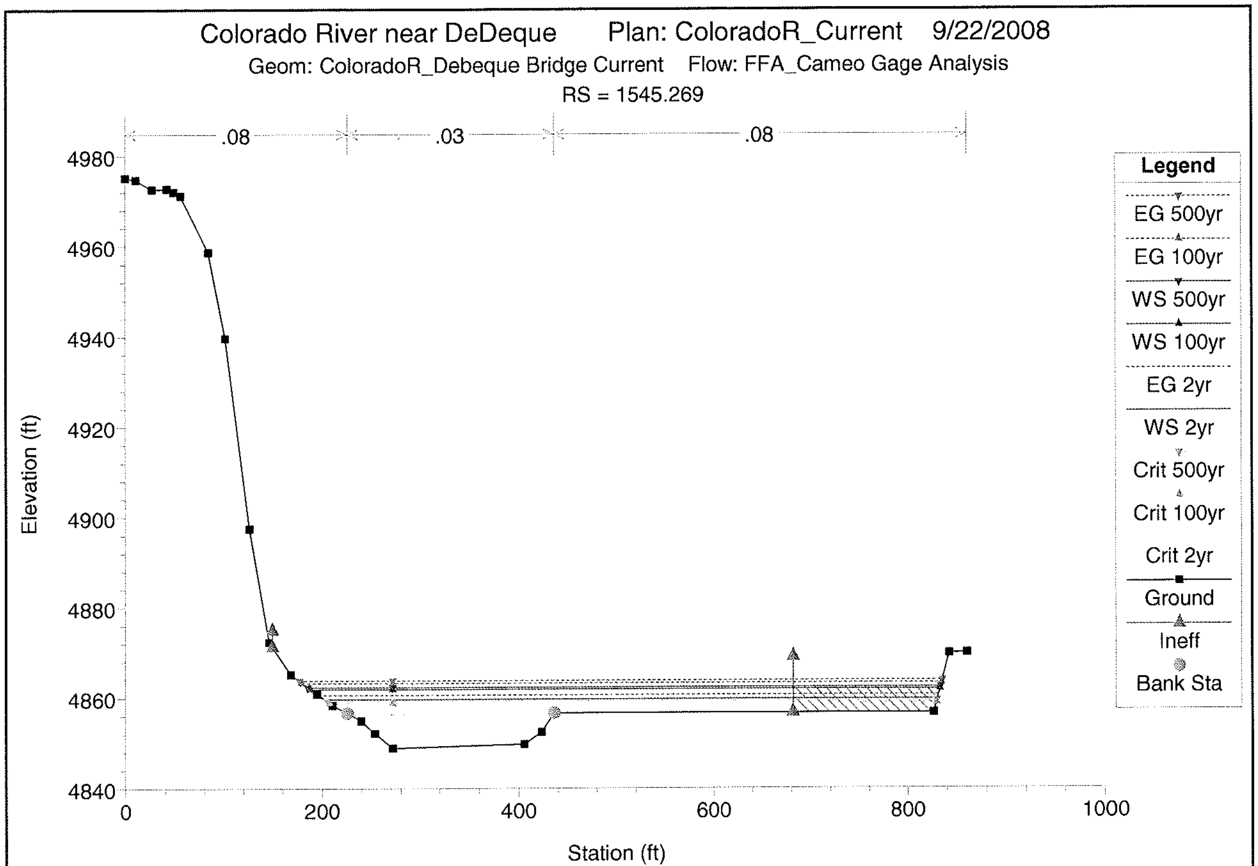

Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 2349.427
.08
.03
.08
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta
Elevation (ft)
4870
4865
4860
4855
4850
0
200
400
600
800
1000
Station (ft)

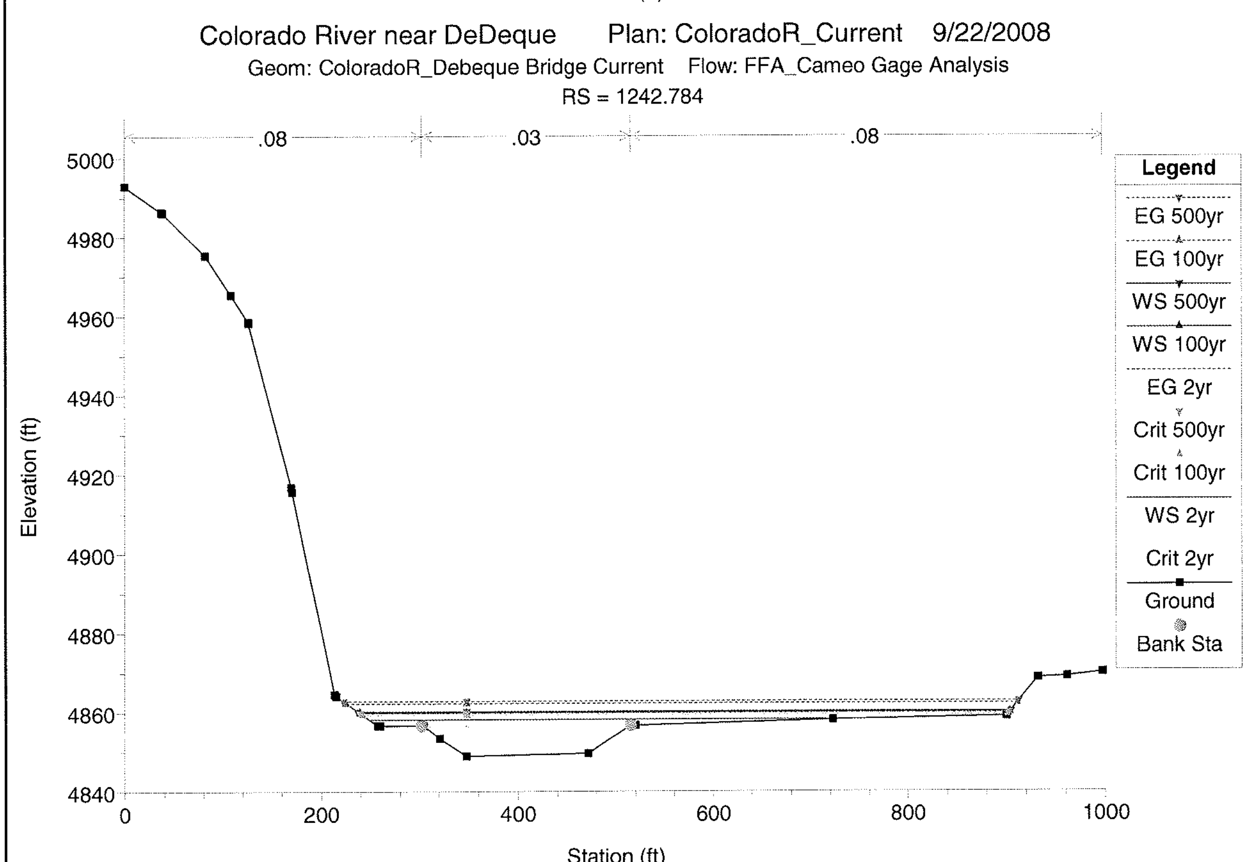


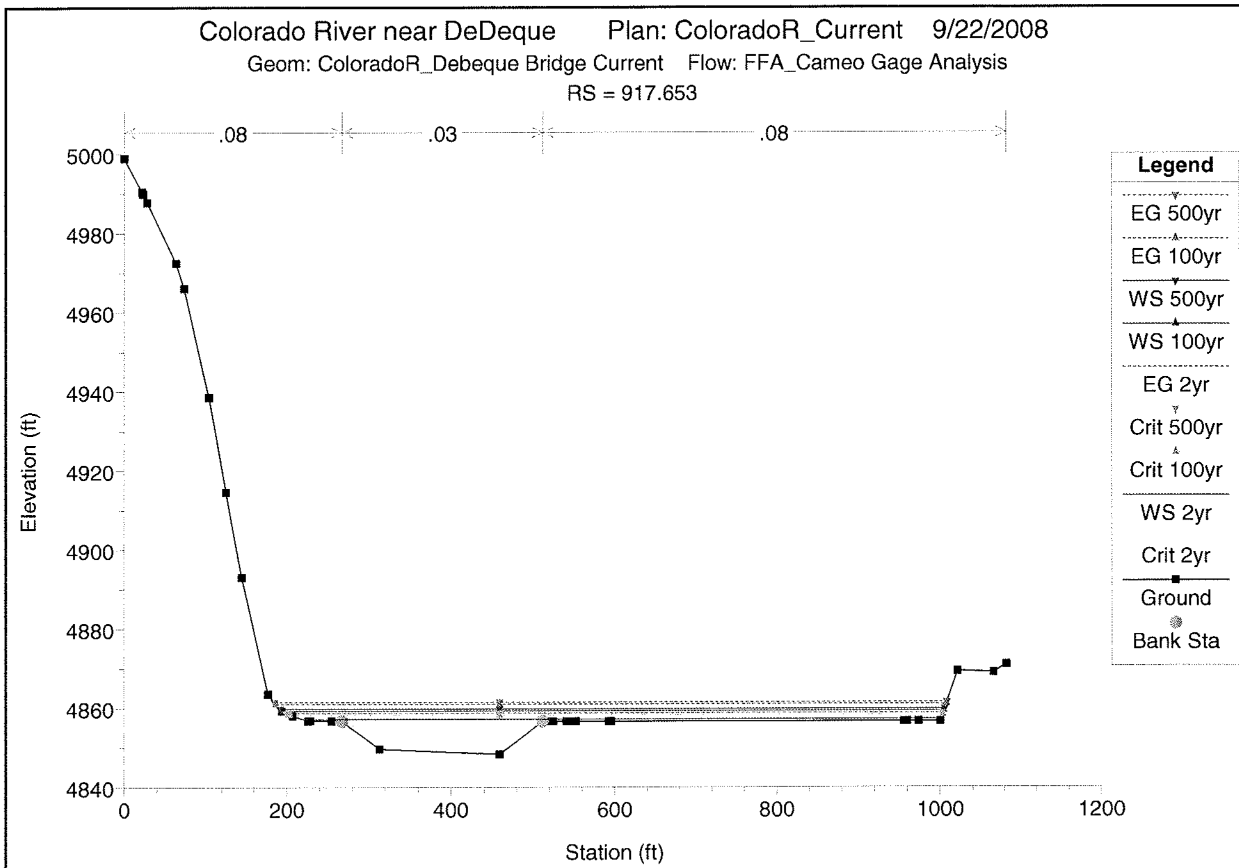
Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 2108.129
.08
.03
.08
Elevation (ft)
4870
4865
4860
4855
4850
4845
0
200
400
600
800
1000
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta

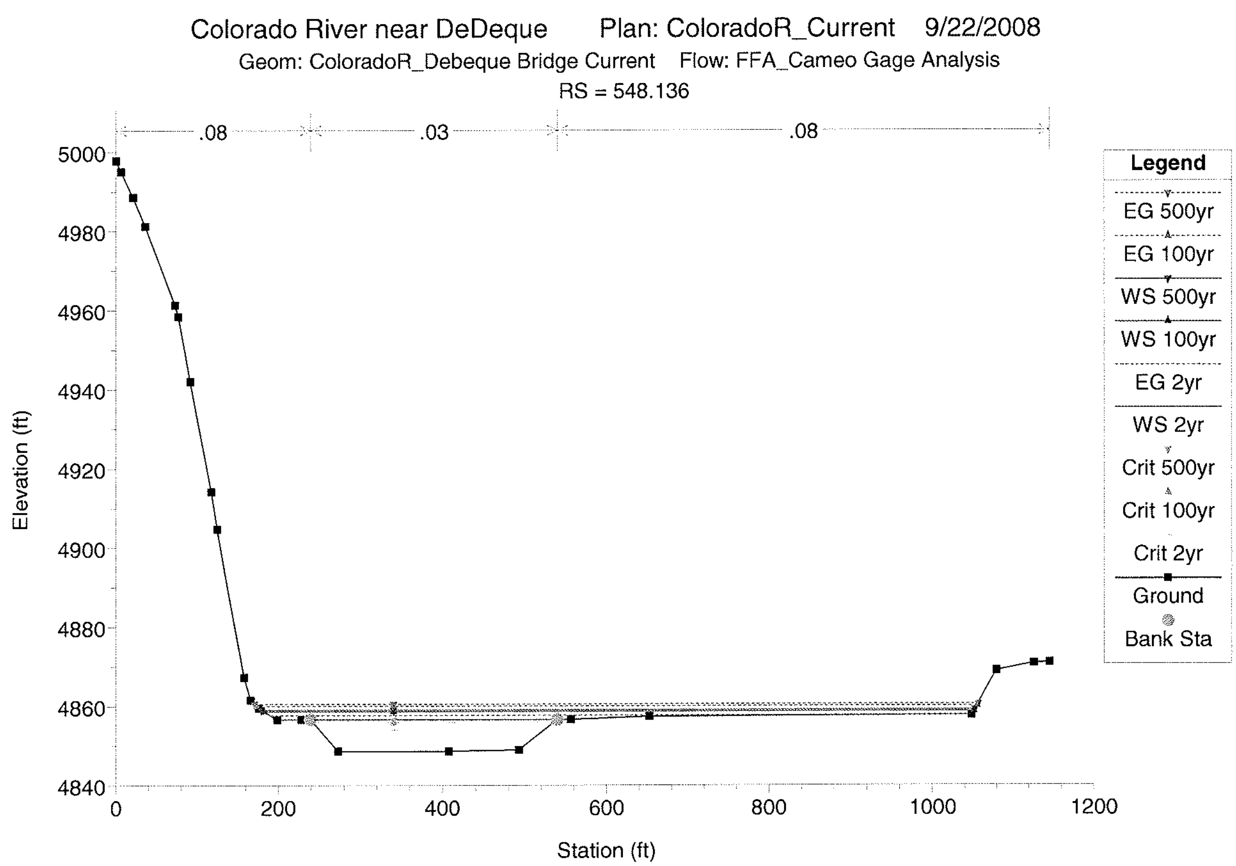


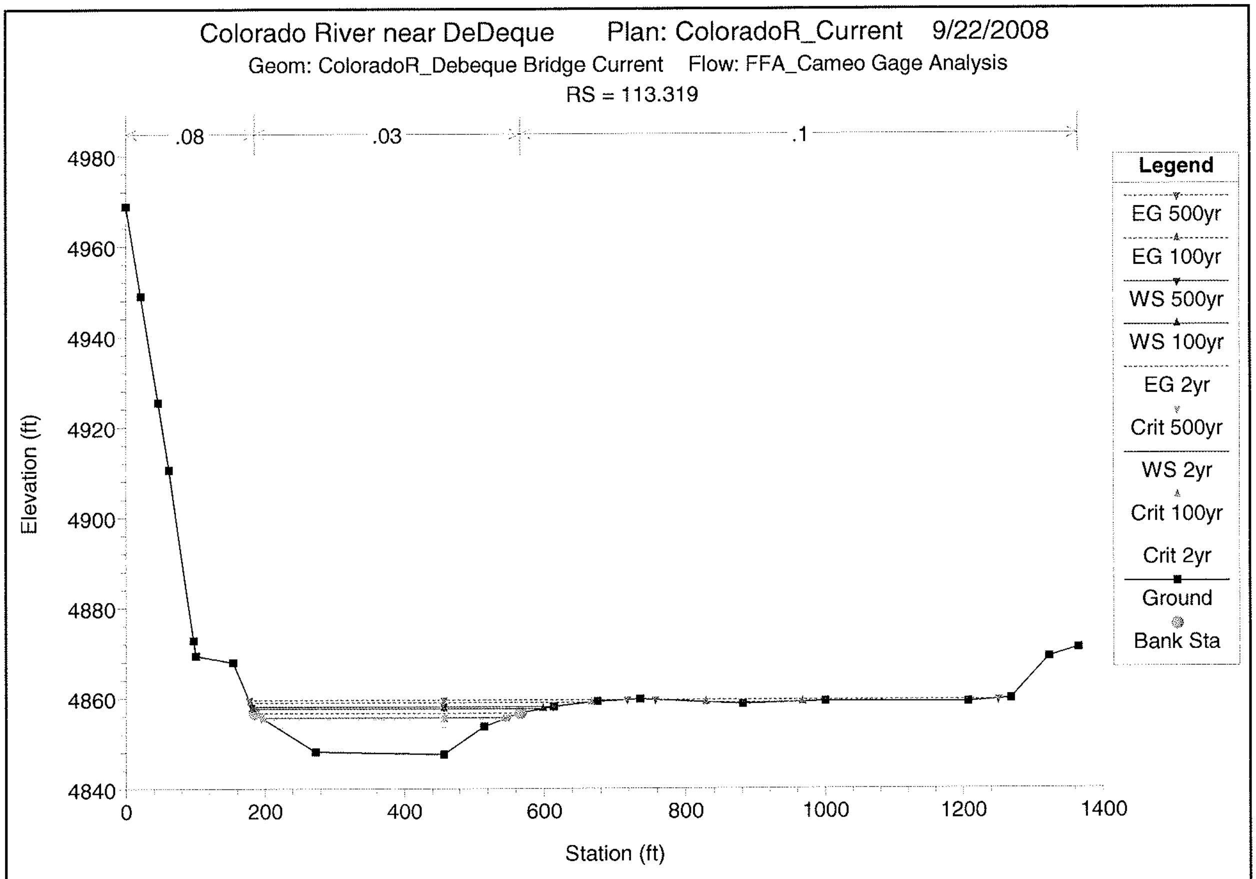
Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 1903.796
.08
.03
.08
Elevation (ft)
4875
4870
4865
4860
4855
4850
4845
0
200
400
600
800
1000
Station (ft)
Legend
EG 500yr
WS 500yr
EG 100yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 1545.269
.08
.03
.08
Elevation (ft)
4980
4960
4940
4920
4900
4880
4860
4840
0
200
400
600
800
1000
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Ineff
Bank Sta


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 1242.784
.08
.03
.08
Elevation (ft)
5000
4980
4960
4940
4920
4900
4880
4860
4840
0
200
400
600
800
1000
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
Crit 500yr
Crit 100yr
WS 2yr
Crit 2yr
Ground
Bank Sta


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 917.653
.08
.03
.08
Elevation (ft)
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
Crit 500yr
Crit 100yr
WS 2yr
Crit 2yr
Ground
Bank Sta


Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 548.136
.08
.03
.08
Elevation (ft)
Station (ft)
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
WS 2yr
Crit 500yr
Crit 100yr
Crit 2yr
Ground
Bank Sta



Colorado River near DeDeque Plan: ColoradoR_Current 9/22/2008
Geom: ColoradoR_Debeque Bridge Current Flow: FFA_Cameo Gage Analysis
RS = 113.319
.08
.03
.1
Legend
EG 500yr
EG 100yr
WS 500yr
WS 100yr
EG 2yr
Crit 500yr
WS 2yr
Crit 100yr
Crit 2yr
Ground
Bank Sta
Elevation (ft)
4980
4960
4940
4920
4900
4880
4860
4840
0
200
400
600
800
1000
1200
1400
Station (ft)

APPENDIX B
Scour Calculations

**INCIPIENT OVERTOPPING FLOOD EVENT SCOUR SUMMARY
FOR I-70 WB BRIDGE OVER
THE CURRENT COLORADO RIVER
DEBEQUE, COLORADO**

October 2008

Pier	Groundline Elevation (ft)	Initial Embedded Pile Length (ft)	Long-term Degradation (ft)	Contraction Scour (ft)	Local Scour (ft)	Total Scour (ft)	Scour Elevation (ft)	Remaining Embedded Pile Length (ft)
4	4854.5	19.2	0.0	0.0	11.1	11.1	4843.4	13.2
3	4850.8	19.8	0.0	0.0	19.8	19.8	4831.0	1.4
2	4850.8	27.7	0.0	0.0	23.2	23.2	4827.6	5.9

NOTES:
This table presents potential scour depths for the associated hydraulic event. If a soil horizon exists beneath the bridge which is resistant to scour, the predicted scour depths could be reduced to reflect the competence of the material. This reduction would require examination and approval by a qualified geotechnical engineer with knowledge of the properties of the material.

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

COARSE BED SCOUR MODE COMPUTATION
FOR I-70 WB BRIDGE OVER
THE CURRENT COLORADO RIVER
DEBEQUE, COLORADO

October 2008

The scour mode is determined using the following equations (after Julien, 1998):

$$S_f' = \left[\frac{1}{gy}\right]\left\{\frac{V_{ch}}{\left[6.25+5.75Log_{10}\left(\frac{y}{3.5D_{84}}\right)\right]}\right\}^2, S_f' \le S_f;$$

$$\tau' = \gamma y S_f';$$

$$\tau_c = \Phi\gamma(G-1)D_{50};$$

INCIPIENT OVERTOPPING DISCHARGE

MAIN CHANNEL SCOUR MODE

APPROACH SECTION MAIN CHANNEL DISCHARGE (cfs), Q_1	=	11,996
APPROACH SECTION MAIN CHANNEL AREA (ft^2), A_1	=	1,946
APPROACH SECTION MAIN CHANNEL WIDTH (ft), W_1	=	262
APPROACH SECTION ENERGY SLOPE, S_f (ft/ft)	=	1.067E-03
APPROACH SECTION CHANNEL VELOCITY, V_{ch} (fps)	=	6.16
APPROACH SECTION AVERAGE CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	7.44
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.315
D_{84}, ft	=	0.420
Specific Weight of water, γ (lb/ft^3)	=	62.4
Specific Gravity, G	=	2.65
Gravitational Acceleration Constant, (ft/sq. sec), g	=	32.2
Critical Shields Parameter (Unitless), Φ	=	0.03
Calculated Grain Effective Shear Stress (lb/ft^2), Sf'c	=	1.495E-03
Effective Grain Shear Stress (lb/ft^2), Sf'	=	1.067E-03
Grain Shear Stress τ', (lb/ft^2)	=	0.495
Critical Shear Stress, τ_c (lb/ft^2)	=	0.973
Dimensionless Shear Stress, τ'/τ_c	=	0.509
MAIN CHANNEL SCOUR MODE	=	**CLEAR WATER**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS
FOR I-70 WB BRIDGE OVER
THE CURRENT COLORADO RIVER
DEBEQUE, COLORADO

October 2008

The following computations are made using the HEC-18 equation for Clear Water Contraction Scour:

Scour Depth, $Y_s = Y_2 - Y_1$

where:

$$Y_2 = (+Q^2/(Ku*(1.25*D_{50})^{(2/3)}*W^2))^{(3/7)}$$

INCIPIENT OVERTOPPING FLOOD DISCHARGE
Main Channel

DISCHARGE IN CONTRACTED SECTION (cfs), Q	=	13,450
WIDTH OF CONTRACTED SECTION (ft), W	=	230.2
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.315000
Ku, CLEAR WATER CONTRACTION SCOUR COEFFICIENT	=	130
COMPUTED DEPTH OF CONTRACTED SECTION (ft), Y_2	=	5.29
AVERAGE FLOOD PLAIN DEPTH (ft), Y_1	=	7.48
DEPTH OF CONTRACTION SCOUR (ft), Y_s	**=**	**-2.2**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

INCIPIENT OVERTOPPING FLOOD DISCHARGE
LOCAL PIER SCOUR COMPUTATIONS
FOR I-70 WB BRIDGE OVER
THE CURRENT COLORADO RIVER
DEBEQUE, COLORADO

October 2008

PILE BENT SCOUR ANALYSIS

Reference for methodology: HEC-18 4th Edition Chapter 6

Bent Number	**Pier 4**	**Pier 3**	**Pier 2**
V_1: VELOCITY (fps)	4.27	6.29	6.27
Y_1: DEPTH (ft)	5.66	10.02	9.99
ATTACK ANGLE, Degrees	20	40	60
INDIVIDUAL PIER WIDTH (ft)	2.00	2.00	2.00
a: PILE WIDTH (ft)	2.00	2.00	2.00
L: PILE LENGTH (ft)	27.50	27.50	27.50
PIER SHAPE	S	S	S
K_1: SHAPE COEFFICIENT	1.00	1.00	1.00
K_2: ANGLE COEFFICIENT	2.86	4.01	4.72
K_3: BED COND. COEFFICIENT	1.10	1.10	1.10
K_4: ARMORING COEFFICIENT	1.00	1.00	1.00
g: gravitational constant (ft/sec^2)	32.20	32.20	32.20
FROUDE NUMBER, Fr	0.32	0.35	0.35
COMPUTED LOCAL SCOUR DEPTH (ft), Y_{scomp}	**11.05**	**19.76**	**23.22**
MINIMUM SCOUR DEPTH (ft), Y_{smin}	N/A	N/A	N/A
MAXIMUM SCOUR DEPTH (ft), $Y_{smax}=2.4aK_1(K_2)^{1.538}$	24.21	40.70	52.28
TOTAL SCOUR DEPTH (ft), Y_s	**11.1**	**19.8**	**23.2**

Calc. By:	RLE	Date:	10/14/08
Check By:	JHH	Date:	11/1/2008

Hydraulic Data for I-70 WB Over the Colorado River

Incipient Overtopping Flood Data

Y_o =	7.48	ft.	Y_o =	#DIV/0!	ft.
Q_1 =	11,996	cfs	Q_1 =	0	cfs
Channel Q_2 =	13,450	cfs	Channel Q_2 =	0	cfs
A_1 =	1,946.4	$ft.^2$	A_1 =	0.0	$ft.^2$
A_2 =	1,723.2	$ft.^2$	A_2 =	0.0	$ft.^2$
W_1 =	261.7	ft.	W_1 =	0.0	ft.
Channel W_2 =	230.2	ft.	Channel W_2 =	0.0	ft.
V_m =	6.16	ft/s	V_m =	#DIV/0!	ft/s
D_{50} =	0.315	ft.	D_{50} =	0.315	ft.
Energy Slope =	1.07E-03	ft.	Energy Slope =	0.00E+00	ft.
Gravity Acceleration =	32.2	ft/s^2	Gravity Acceleration =	32.2	ft/s^2
Fall Vel., ω =	3.80	ft/s	Fall Vel., ω =	3.80	ft/s

BY: Leif Embertson
DATE: 8/1/2008

Hydraulic Data from HEC-RAS (I70 R3 NECRAS.prj)

OT hydraulics for contraction scour calculations

Contracted Section

Plan: Current OT CO River reach 1 RS: 2330 BR U Profile: OT						
E.G. Elev (ft)	4861.15	Element	Left OB	Channel	Right OB	
Vel Head (ft)	0.93	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4860.22	Reach Len. (ft)	50.00	50.00	50.00	
Crit W.S. (ft)	4857.44	Flow Area (sq ft)	169.41	1723.16	3.44	
E.G. Slope (ft/ft)	0.002084	Area (sq ft)	169.41	1723.16	3.44	1896.01
Q Total (cfs)	13675	Flow (cfs)	223.42	13449.61	1.97	
Top Width (ft)	317.86	Top Width (ft)	83.52	230.23	4.11	
Vel Total (ft/s)	7.21	Avg. Vel. (ft/s)	1.32	7.81	0.57	3.23
Max Chl Dpth (ft)	9.42	Hydr. Depth (ft)	2.03	7.48	0.84	
Conv. Total (cfs)	299579.1	Conv. (cfs)	4894.4	294641.6	43.1	
Length Wtd. (ft)	50	Wetted Per. (ft)	87.84	268.65	4.44	
Min Ch El (ft)	4850.8	Shear (lb/sq ft)	0.25	0.83	0.1	
Alpha	1.15	Stream Power (lb/ft s)	0.33	6.51	0.06	
Frctn Loss (ft)	0.11	Cum Volume (acre-ft)	6.19	100.89	13.65	
C & E Loss (ft)	0.06	Cum SA (acres)	3.32	13.79	6.07	
		Froude	0.16	0.50	0.11	

Approach Section

Plan: Current OT CO River reach 1 RS: 3302.484 Profile: OT						
E.G. Elev (ft)	4862.87	Element	Left OB	Channel	Right OB	
Vel Head (ft)	0.52	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4862.35	Reach Len. (ft)	498.44	534.68	540.31	
Crit W.S. (ft)	4859.36	Flow Area (sq ft)	607.42	1946.36	1160.47	3714.25
E.G. Slope (ft/ft)	0.001067	Area (sq ft)	641.32	1946.36	1160.47	
Q Total (cfs)	13675	Flow (cfs)	671.5	11996.14	1007.36	
Top Width (ft)	1074.23	Top Width (ft)	329.72	261.69	482.82	358.08
Vel Total (ft/s)	3.68	Avg. Vel. (ft/s)	1.11	6.16	0.87	
Max Chl Dpth (ft)	7.83	Hydr. Depth (ft)	2.46	7.44	2.4	
Conv. Total (cfs)	418607.7	Conv. (cfs)	20555.4	367215.9	30836.4	
Length Wtd. (ft)	533.08	Wetted Per. (ft)	246.99	261.81	485.27	
Min Ch El (ft)	4854.52	Shear (lb/sq ft)	0.16	0.5	0.16	
Alpha	2.47	Stream Power (lb/ft s)	0.18	3.05	0.14	
Frctn Loss (ft)	0.64	Cum Volume (acre-ft)	29.2	164.5	32.3	
C & E Loss (ft)	0.05	Cum SA (acres)	17.53	22.14	17.47	
		Froude	0.12	0.40	0.10	

100-year hydraulics for local scour calculations

[illegible]

	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	
1	LOB	0	94.71	0	10.2	38.5	0	0.27	0	
2	LOB	94.71	189.42	0	46.15	94.71	0	0.49	0	
3	LOB	189.42	284.13	0	56.72	94.71	0	0.6	0	
4	LOB	284.13	378.85	0	67.31	94.71	0	0.71	0	
5	LOB	378.85	527.28	249.39	297.08	148.6	1.82	2	0.84	
6	Chan	527.28	535.11	63.59	23.01	7.87	0.47	2.94	2.76	
7	Chan	535.11	542.95	94.52	29.19	7.87	0.69	3.73	3.24	
8	Chan	542.95	550.78	133.09	35.88	7.9	0.97	4.58	3.71	
9	Chan	550.78	558.62	189.11	44.33	7.91	1.38	5.66	4.27	<- Pier 4
10	Chan	558.62	566.45	238.63	50.83	7.86	1.75	6.49	4.69	
11	Chan	566.45	574.29	276.17	55.49	7.86	2.02	7.08	4.98	
12	Chan	574.29	582.12	315.87	60.15	7.86	2.31	7.68	5.25	
13	Chan	582.12	589.96	357.66	64.8	7.86	2.62	8.27	5.52	
14	Chan	589.96	597.79	401.51	69.46	7.86	2.94	8.86	5.78	
15	Chan	597.79	605.63	447.36	74.11	7.86	3.27	9.46	6.04	
16	Chan	605.63	613.46	488.66	78.1	7.85	3.57	9.97	6.26	
17	Chan	613.46	621.3	494.15	78.58	7.84	3.61	10.03	6.29	
18	Chan	621.30	629.13	493.93	78.56	7.84	3.61	10.03	6.29	
19	Chan	629.13	636.97	493.71	78.54	7.84	3.61	10.02	6.29	<- Pier 3
20	Chan	636.97	644.8	493.49	78.52	7.84	3.61	10.02	6.28	
21	Chan	644.8	652.64	493.27	78.5	7.84	3.61	10.02	6.28	
22	Chan	652.64	660.47	493.05	78.48	7.84	3.61	10.02	6.28	
23	Chan	660.47	668.31	492.83	78.46	7.84	3.6	10.01	6.28	
24	Chan	668.31	676.14	492.63	78.44	7.84	3.6	10.01	6.28	
25	Chan	676.14	683.98	492.41	78.42	7.84	3.6	10.01	6.28	
26	Chan	683.98	691.81	492.19	78.4	7.84	3.6	10.01	6.28	
27	Chan	691.81	699.65	491.97	78.37	7.84	3.6	10	6.28	
28	Chan	699.65	707.48	491.75	78.35	7.84	3.6	10	6.28	
29	Chan	707.48	715.32	491.53	78.33	7.84	3.59	10	6.27	
30	Chan	715.32	723.15	491.31	78.31	7.84	3.59	9.99	6.27	
31	Chan	723.15	730.99	491.11	78.29	7.84	3.59	9.99	6.27	
32	Chan	730.99	738.82	490.89	78.27	7.84	3.59	9.99	6.27	
33	Chan	738.82	746.66	490.67	78.25	7.84	3.59	9.99	6.27	<- Pier 2
34	Chan	746.66	754.49	490.45	78.23	7.84	3.59	9.98	6.27	
35	Chan	754.49	762.33	457.32	75.3	7.91	3.34	9.61	6.07	
36	Chan	762.33	770.16	364.69	65.81	7.93	2.67	8.4	5.54	
37	Chan	770.16	778	279.24	56.07	7.93	2.04	7.16	4.98	
38	Chan	778	785.83	203.18	46.33	7.93	1.49	5.91	4.39	
39	Chan	785.83	793.67	136.7	36.55	7.94	1	4.66	3.74	
40	Chan	793.67	801.51	75.03	25.54	7.97	0.55	3.26	2.94	
41	ROB	801.51	856.65	41.95	78.42	55.18	0.31	1.42	0.53	
42	ROB	856.65	895.52	0	24.5	38.87	0	0.63	0	
43	ROB	895.52	934.39	0	23.6	38.87	0	0.61	0	
44	ROB	934.39	973.26	0	23.76	38.87	0	0.61	0	
45	ROB	973.26	1012.13	0	29.06	39.69	0	0.75	0	

100-YEAR FLOOD EVENT SCOUR SUMMARY
FOR I-70 WB BRIDGE OVER
THE COLORADO RIVER
DEBEQUE, COLORADO

October 2008

Pier	Groundline Elevation (ft)	Initial Embedded Pile Length (ft)	Long-term Degradation (ft)	Contraction Scour (ft)	Local Scour (ft)	Total Scour (ft)	Scour Elevation (ft)	Remaining Embedded Pile Length (ft)
4	4854.5	19.2	0.0	0.0	13.7	13.7	4840.8	10.6
3	4850.8	19.8	0.0	0.0	22.6	22.6	4828.2	-1.4
2	4850.8	27.7	0.0	0.0	26.6	26.6	4824.2	2.5

500-YEAR FLOOD EVENT SCOUR SUMMARY
FOR I-70 WB BRIDGE OVER
THE COLORADO RIVER
DEBEQUE, COLORADO

October 2008

Pier	Groundline Elevation (ft)	Initial Embedded Pile Length (ft)	Long-term Degradation (ft)	Contraction Scour (ft)	Local Scour (ft)	Total Scour (ft)	Scour Elevation (ft)	Remaining Embedded Pile Length (ft)
4	4854.5	19.2	0.0	0.0	14.1	14.1	4840.4	10.2
3	4850.8	19.8	0.0	0.0	23.1	23.1	4827.7	-1.9
2	4850.8	27.7	0.0	0.0	27.1	27.1	4823.7	2.0

NOTES:
This table presents potential scour depths for the associated hydraulic event. If a soil horizon exists beneath the bridge which is resistant to scour, the predicted scour depths could be reduced to reflect the competence of the material. This reduction would require examination and approval by a qualified geotechnical engineer with knowledge of the properties of the material.

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

COARSE BED SCOUR MODE COMPUTATION
FOR I-70 WB BRIDGE OVER
THE COLORADO RIVER
DEBEQUE, COLORADO

October 2008

The scour mode is determined using the following equations (after Julien, 1998):

$$S_f' = \left[\frac{1}{gy}\right]\left\{\frac{V_{ch}}{\left[6.25+5.75Log_{10}\left(\frac{y}{3.5D_{84}}\right)\right]}\right\}^2, S_f' \le S_f;$$

$$\tau' = \gamma y S_f';$$

$$\tau_c = \Phi\gamma(G-1)D_{50};$$

100-YEAR DISCHARGE
MAIN CHANNEL SCOUR MODE

APPROACH SECTION MAIN CHANNEL DISCHARGE (cfs), Q_1	=	31,718
APPROACH SECTION MAIN CHANNEL AREA (ft^2), A_1	=	2,958
APPROACH SECTION MAIN CHANNEL WIDTH (ft), W_1	=	262
APPROACH SECTION ENERGY SLOPE, S_f (ft/ft)	=	1.849E-03
APPROACH SECTION CHANNEL VELOCITY, V_{ch} (fps)	=	10.72
APPROACH SECTION AVERAGE CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	11.30
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.315
D_{84}, ft	=	0.420
Specific Weight of water, γ (lb/ft^3)	=	62.4
Specific Gravity, G	=	2.65
Gravitational Acceleration Constant, (ft/sq. sec), g	=	32.2
Critical Shields Parameter (Unitless), Φ	=	0.03
Calculated Grain Effective Shear Stress (lb/ft^2), Sf'c	=	2.456E-03
Effective Grain Shear Stress (lb/ft^2), Sf'	=	1.849E-03
Grain Shear Stress τ', (lb/ft^2)	=	1.304
Critical Shear Stress, τ_c (lb/ft^2)	=	0.973
Dimensionless Shear Stress, τ'/τ_c	=	1.340
MAIN CHANNEL SCOUR MODE	=	**LIVE BED**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

COARSE BED SCOUR MODE COMPUTATION
FOR I-70 WB BRIDGE OVER
THE COLORADO RIVER
DEBEQUE, COLORADO

October 2008

The scour mode is determined using the following equations (after Julien, 1998):

$$S_f^{'} = \left[\frac{1}{gy}\right]\left\{\frac{V_{ch}}{\left[6.25+5.75Log_{10}\left(\frac{y}{3.5D_{84}}\right)\right]}\right\}^2, S_f^{'} \le S_f;$$

$$\tau^{'} = \gamma y S_f^{'};$$

$$\tau_c = \Phi\gamma(G-1)D_{50};$$

500-YEAR DISCHARGE
MAIN CHANNEL SCOUR MODE

APPROACH SECTION MAIN CHANNEL DISCHARGE (cfs), Q_1	=	36,741
APPROACH SECTION MAIN CHANNEL AREA (ft^2), A_1	=	3,140
APPROACH SECTION MAIN CHANNEL WIDTH (ft), W_1	=	262
APPROACH SECTION ENERGY SLOPE, S_f (ft/ft)	=	2.033E-03
APPROACH SECTION CHANNEL VELOCITY, V_{ch} (fps)	=	11.70
APPROACH SECTION AVERAGE CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	12.00
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.315
D_{84}, ft	=	0.4
Specific Weight of water, γ (lb/ft^3)	=	62.4
Specific Gravity, G	=	2.7
Gravitational Acceleration Constant, (ft/sq. sec), g	=	32.2
Critical Shields Parameter (Unitless), Φ	=	0.03
Calculated Grain Effective Shear Stress (lb/ft^2), Sf'c	=	2.683E-03
Effective Grain Shear Stress (lb/ft^2), Sf'	=	2.033E-03
Grain Shear Stress τ', (lb/ft^2)	=	1.522
Critical Shear Stress, τ_c (lb/ft^2)	=	0.973
Dimensionless Shear Stress, τ'/τ_c	=	1.564
MAIN CHANNEL SCOUR MODE	=	**LIVE BED**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

100-YEAR FLOOD EVENT
LOCAL PIER SCOUR COMPUTATIONS
FOR I-70 WB BRIDGE OVER
THE COLORADO RIVER
DEBEQUE, COLORADO

October 2008

PILE BENT SCOUR ANALYSIS

Reference for methodology: HEC-18 4th Edition Chapter 6

Bent Number	**Pier 4**	**Pier 3**	**Pier 2**
V_1: VELOCITY (fps)	6.01	7.76	7.75
Y_1: DEPTH (ft)	9.60	13.97	13.95
ATTACK ANGLE, Degrees	20	40	60
INDIVIDUAL PIER WIDTH (ft)	2.00	2.00	2.00
a: PILE WIDTH (ft)	2.00	2.00	2.00
L: PILE LENGTH (ft)	27.50	27.50	27.50
PIER SHAPE	S	S	S
K_1: SHAPE COEFFICIENT	1.00	1.00	1.00
K_2: ANGLE COEFFICIENT	2.86	4.01	4.72
K_3: BED COND. COEFFICIENT	1.10	1.10	1.10
K_4: ARMORING COEFFICIENT	1.00	1.00	1.00
g: gravitational constant (ft/sec^2)	32.20	32.20	32.20
FROUDE NUMBER, Fr	0.34	0.37	0.37
COMPUTED LOCAL SCOUR DEPTH (ft), Y_{scomp}	**13.75**	**22.62**	**26.60**
MINIMUM SCOUR DEPTH (ft), Y_{smin}	N/A	N/A	N/A
MAXIMUM SCOUR DEPTH (ft), $Y_{smax}=2.4aK_1(K_2)^{1.538}$	24.21	40.70	52.28
TOTAL SCOUR DEPTH (ft), Y_s	**13.7**	**22.6**	**26.6**

Calc. By:	RLE	Date:	10/14/08
Check By:	JHH	Date:	11/1/2008

500-YEAR FLOOD EVENT
LOCAL PIER SCOUR COMPUTATIONS
FOR I-70 WB BRIDGE OVER
THE COLORADO RIVER
DEBEQUE, COLORADO

October 2008

PILE BENT SCOUR ANALYSIS

Reference for methodology: HEC-18 4th Edition Chapter 6

Bent Number	**Pier 4**	**Pier 3**	**Pier 2**
V_1: VELOCITY (fps)	6.29	8.02	8.01
Y_1: DEPTH (ft)	10.25	14.61	14.59
ATTACK ANGLE, Degrees	20	40	60
INDIVIDUAL PIER WIDTH (ft)	2.00	2.00	2.00
a: PILE WIDTH (ft)	2.00	2.00	2.00
L: PILE LENGTH (ft)	27.50	27.50	27.50
PIER SHAPE	S	S	S
K_1: SHAPE COEFFICIENT	1.00	1.00	1.00
K_2: ANGLE COEFFICIENT	2.86	4.01	4.72
K_3: BED COND. COEFFICIENT	1.10	1.10	1.10
K_4: ARMORING COEFFICIENT	1.00	1.00	1.00
g: gravitational constant (ft/sec^2)	32.20	32.20	32.20
FROUDE NUMBER, Fr	0.35	0.37	0.37
COMPUTED LOCAL SCOUR DEPTH (ft), Y_{scomp}	**14.14**	**23.09**	**27.15**
MINIMUM SCOUR DEPTH (ft), Y_{smin}	N/A	N/A	N/A
MAXIMUM SCOUR DEPTH (ft), $Y_{smax}=2.4aK_1(K_2)^{1.538}$	24.21	40.70	52.28
TOTAL SCOUR DEPTH (ft), Y_s	**14.1**	**23.1**	**27.1**

Calc. By:	RLE	Date:	10/14/08
Check By:	JHH	Date:	11/1/2008

Hydraulic Data for I-70 WB Over the Colorado River

100-year Flood Data				500-year Flood Data			
Y_o	=	11.08	ft.	Y_o	=	11.64	ft.
Q_1	=	31,718	cfs	Q_1	=	36,741	cfs
Channel Q_2	=	25,235	cfs	Channel Q_2	=	27,563	cfs
A_1	=	2,957.6	$ft.^2$	A_1	=	3,139.8	$ft.^2$
A_2	=	2,550.5	$ft.^2$	A_2	=	2,680.5	$ft.^2$
W_1	=	261.7	ft.	W_1	=	261.7	ft.
Channel W_2	=	230.2	ft.	Channel W_2	=	230.2	ft.
V_m	=	10.72	ft/s	V_m	=	11.70	ft/s
D_{50}	=	0.315	ft.	D_{50}	=	0.315	ft.
Energy Slope	=	1.85E-03	ft.	Energy Slope	=	2.03E-03	ft.
Gravity Acceleration	=	32.2	ft/s^2	Gravity Acceleration	=	32.2	ft/s^2
Fall Vel., ω	=	3.80	ft/s	Fall Vel., ω	=	3.80	ft/s

BY: Leif Embertson
DATE: 10/14/2008

Hydraulic Data from HEC-RAS (I70 R3 NECRAS.prj)

100-year hydraulics for contraction scour calculations

Contracted Section

Plan: Current CO River Reach 1 RS: 2360 BR U Profile: 100yr						
E.G. Elev (ft)	4865.27	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.45	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4863.81	Reach Len. (ft)	50.00	50.00	50.00	
Crit W.S. (ft)	4860.32	Flow Area (sq ft)	482.8	2550.54	34.12	
E.G. Slope (ft/ft)	0.002128	Area (sq ft)	482.8	2550.54	34.12	3067.46
Q Total (cfs)	26450.31	Flow (cfs)	1172.61	25235.32	42.38	
Top Width (ft)	334.08	Top Width (ft)	90.89	230.23	12.96	
Vel Total (ft/s)	8.62	Avg. Vel. (ft/s)	2.43	9.89	1.24	4.52
Max Chl Dpth (ft)	13.02	Hydr. Depth (ft)	5.31	11.08	2.63	
Conv. Total (cfs)	573415.9	Conv. (cfs)	25421	547076.1	918.8	
Length Wtd. (ft)	50	Wetted Per. (ft)	103.23	283.02	13.99	
Min Ch El (ft)	4850.8	Shear (lb/sq ft)	0.62	1.2	0.32	
Alpha	1.26	Stream Power (lb/ft s)	1.51	11.84	0.4	
Frctn Loss (ft)	0.12	Cum Volume (acre-ft)	23.31	142.86	53.24	
C & E Loss (ft)	0.14	Cum SA (acres)	6.3	14.14	17.22	
		Froude	0.19	0.52	0.13	

Approach Section

Plan: Current CO River Reach 1 RS: [illegible] Profile: 100yr						
E.G. Elev (ft)	4867.57	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.36	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4866.22	Reach Len. (ft)	498.44	534.68	540.31	
Crit W.S. (ft)	4863.85	Flow Area (sq ft)	1561.54	2957.59	3026.21	7545.34
E.G. Slope (ft/ft)	0.001849	Area (sq ft)	2424.66	2957.59	3026.21	
Q Total (cfs)	42500	Flow (cfs)	4264.75	31717.96	6517.29	
Top Width (ft)	1227.54	Top Width (ft)	483.03	261.69	482.82	409.18
Vel Total (ft/s)	5.63	Avg. Vel. (ft/s)	2.73	10.72	2.15	
Max Chl Dpth (ft)	11.69	Hydr. Depth (ft)	6.32	11.3	6.27	
Conv. Total (cfs)	988246.8	Conv. (cfs)	99167.5	737533.4	151545.8	
Length Wtd. (ft)	531.23	Wetted Per. (ft)	246.99	261.81	489.13	
Min Ch El (ft)	4854.52	Shear (lb/sq ft)	0.73	1.3	0.71	
Alpha	2.75	Stream Power (lb/ft s)	1.99	13.99	1.54	
Frctn Loss (ft)	0.92	Cum Volume (acre-ft)	105.53	239.15	116.42	
C & E Loss (ft)	0.08	Cum SA (acres)	21.6	22.48	28.62	
		Froude	0.19	0.56	0.15	

100-year hydraulics for local scour calculations

Plan: Current CO River Reach 1 RS: 2.10449 Profile: 100yr										
	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	
1	LOB	0	94.71	0	351.64	97.76	0	3.71	0	
2	LOB	94.71	189.42	0	419.77	94.71	0	4.43	0	
3	LOB	189.42	284.13	0	430.34	94.71	0	4.54	0	
4	LOB	284.13	378.85	0	440.93	94.71	0	4.66	0	
5	LOB	378.85	527.28	1481.05	882.61	148.6	5.6	5.95	1.68	
6	Chan	527.28	535.11	260.08	53.92	7.87	0.98	6.88	4.82	
7	Chan	535.11	542.95	311.62	60.1	7.87	1.18	7.67	5.19	
8	Chan	542.95	550.78	370.86	66.79	7.9	1.4	8.52	5.55	
9	Chan	550.78	558.62	451.83	75.24	7.91	1.71	9.6	6.01	<- Pier 4
10	Chan	558.62	566.45	521.08	81.74	7.86	1.97	10.43	6.37	
11	Chan	566.45	574.29	571.5	86.4	7.86	2.16	11.03	6.61	
12	Chan	574.29	582.12	623.75	91.05	7.86	2.36	11.62	6.85	
13	Chan	582.12	589.96	677.8	95.71	7.86	2.56	12.22	7.08	
14	Chan	589.96	597.79	733.65	100.37	7.86	2.77	12.81	7.31	
15	Chan	597.79	605.63	791.23	105.02	7.86	2.99	13.4	7.53	
16	Chan	605.63	613.46	842.77	109.01	7.85	3.19	13.91	7.73	
17	Chan	613.46	621.3	849.76	109.49	7.84	3.21	13.97	7.76	
18	Chan	621.30	629.13	849.49	109.47	7.84	3.21	13.97	7.76	
19	Chan	629.13	636.97	849.21	109.45	7.84	3.21	13.97	7.76	<- Pier 3
20	Chan	636.97	644.8	848.95	109.43	7.84	3.21	13.97	7.76	
21	Chan	644.8	652.64	848.67	109.41	7.84	3.21	13.96	7.76	
22	Chan	652.64	660.47	848.41	109.39	7.84	3.21	13.96	7.76	
23	Chan	660.47	668.31	848.13	109.36	7.84	3.21	13.96	7.76	
24	Chan	668.31	676.14	847.89	109.35	7.84	3.21	13.96	7.75	
25	Chan	676.14	683.98	847.61	109.32	7.84	3.2	13.95	7.75	
26	Chan	683.98	691.81	847.34	109.3	7.84	3.2	13.95	7.75	
27	Chan	691.81	699.65	847.06	109.28	7.84	3.2	13.95	7.75	<- Pier 2
28	Chan	699.65	707.48	846.8	109.26	7.84	3.2	13.95	7.75	
29	Chan	707.48	715.32	846.52	109.24	7.84	3.2	13.94	7.75	
30	Chan	715.32	723.15	846.25	109.22	7.84	3.2	13.94	7.75	
31	Chan	723.15	730.99	846	109.2	7.84	3.2	13.94	7.75	
32	Chan	730.99	738.82	845.74	109.18	7.84	3.2	13.93	7.75	
33	Chan	738.82	746.66	845.46	109.16	7.84	3.2	13.93	7.75	
34	Chan	746.66	754.49	845.19	109.14	7.84	3.2	13.93	7.74	
35	Chan	754.49	762.33	802.61	106.21	7.91	3.03	13.56	7.56	
36	Chan	762.33	770.16	685.41	96.72	7.93	2.59	12.34	7.09	
37	Chan	770.16	778	574.27	86.98	7.93	2.17	11.1	6.6	
38	Chan	778	785.83	471.15	77.24	7.93	1.78	9.86	6.1	
39	Chan	785.83	793.67	375.62	67.45	7.94	1.42	8.61	5.57	
40	Chan	793.67	801.51	278.41	56.45	7.97	1.05	7.2	4.93	
41	ROB	801.51	856.65	371.16	295.94	55.18	1.4	5.37	1.25	
42	ROB	856.65	895.52	0	177.84	38.87	0	4.58	0	
43	ROB	895.52	934.39	0	176.94	38.87	0	4.55	0	
44	ROB	934.39	973.26	0	177.1	38.87	0	4.56	0	

500-year hydraulics for contraction scour calculations

Contracted Section

Plan: Current CO River Reach 1 RS: 2350 BR D Profile: 500yr						
E.G. Elev (ft)	4865.94	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.57	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4864.38	Reach Len. (ft)	50.00	50.00	50.00	
Crit W.S. (ft)	4860.79	Flow Area (sq ft)	534.43	2680.50	41.83	
E.G. Slope (ft/ft)	0.002174	Area (sq ft)	534.43	2680.50	41.83	3256.76
Q Total (cfs)	29003.86	Flow (cfs)	1384.71	27562.94	56.20	
Top Width (ft)	336.63	Top Width (ft)	92.05	230.23	14.35	
Vel Total (ft/s)	8.91	Avg. Vel. (ft/s)	2.59	10.28	1.34	4.74
Max Chl Dpth (ft)	13.58	Hydr. Depth (ft)	5.81	11.64	2.91	
Conv. Total (cfs)	622083	Conv. (cfs)	29699.7	591177.9	1205.5	
Length Wtd. (ft)	50	Wetted Per. (ft)	105.65	285.28	15.49	
Min Ch El (ft)	4850.8	Shear (lb/sq ft)	0.69	1.28	0.37	
Alpha	1.27	Stream Power (lb/ft s)	1.78	13.11	0.49	
Frctn Loss (ft)	0.13	Cum Volume (acre-ft)	26.48	149.34	60.95	
C & E Loss (ft)	0.15	Cum SA (acres)	6.46	14.14	17.34	
		Froude	0.19	0.53	0.14	

Approach Section

Plan: Current CO River Reach 1 RS: 3802.484 Profile: 500yr						
E.G. Elev (ft)	4868.5	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.59	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4866.91	Reach Len. (ft)	498.44	534.68	540.31	
Crit W.S. (ft)	4864.56	Flow Area (sq ft)	1733.46	3139.81	3362.39	8235.66
E.G. Slope (ft/ft)	0.002033	Area (sq ft)	2760.99	3139.81	3362.39	
Q Total (cfs)	50200	Flow (cfs)	5321.88	36740.91	8137.21	
Top Width (ft)	1227.54	Top Width (ft)	483.03	261.69	482.82	409.18
Vel Total (ft/s)	6.1	Avg. Vel. (ft/s)	3.07	11.7	2.42	
Max Chl Dpth (ft)	12.39	Hydr. Depth (ft)	7.02	12	6.96	
Conv. Total (cfs)	1113292	Conv. (cfs)	118024.2	814808.3	180460	
Length Wtd. (ft)	531.03	Wetted Per. (ft)	246.99	261.81	489.83	
Min Ch El (ft)	4854.52	Shear (lb/sq ft)	0.89	1.52	0.87	
Alpha	2.75	Stream Power (lb/ft s)	2.74	17.81	2.11	
Frctn Loss (ft)	0.99	Cum Volume (acre-ft)	119.58	251.63	132.27	
C & E Loss (ft)	0.13	Cum SA (acres)	21.76	22.48	28.74	
		Froude	0.20	0.60	0.16	

500-year hydraulics for local scour calculations

Plan: Current CO River Reach 1 RS: 2610.349 Profile: 500yr										
	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	
1	LOB	0	94.71	0	412.64	98.41	0	4.36	0	
2	LOB	94.71	189.42	0	480.77	94.71	0	5.08	0	
3	LOB	189.42	284.13	0	491.34	94.71	0	5.19	0	
4	LOB	284.13	378.85	0	501.93	94.71	0	5.3	0	
5	LOB	378.85	527.28	1759.33	978.2	148.6	6.07	6.59	1.8	
6	Chan	527.28	535.11	302.71	58.96	7.87	1.04	7.53	5.13	
7	Chan	535.11	542.95	357.39	65.14	7.87	1.23	8.31	5.49	
8	Chan	542.95	550.78	419.84	71.84	7.9	1.45	9.17	5.84	
9	Chan	550.78	558.62	504.8	80.28	7.91	1.74	10.25	6.29	<- Pier 4
10	Chan	558.62	566.45	577.33	86.79	7.86	1.99	11.08	6.65	
11	Chan	566.45	574.29	629.89	91.44	7.86	2.17	11.67	6.89	
12	Chan	574.29	582.12	684.25	96.1	7.86	2.36	12.27	7.12	
13	Chan	582.12	589.96	740.38	100.76	7.86	2.55	12.86	7.35	
14	Chan	589.96	597.79	798.28	105.41	7.86	2.75	13.45	7.57	
15	Chan	597.79	605.63	857.9	110.07	7.86	2.96	14.05	7.79	
16	Chan	605.63	613.46	911.23	114.05	7.85	3.14	14.56	7.99	
17	Chan	613.46	621.3	918.48	114.54	7.84	3.17	14.62	8.02	
18	Chan	621.30	629.13	918.21	114.52	7.84	3.17	14.62	8.02	
19	Chan	629.13	636.97	917.92	114.49	7.84	3.16	14.61	8.02	<- Pier 3
20	Chan	636.97	644.8	917.65	114.47	7.84	3.16	14.61	8.02	
21	Chan	644.8	652.64	917.36	114.45	7.84	3.16	14.61	8.02	
22	Chan	652.64	660.47	917.08	114.43	7.84	3.16	14.6	8.01	
23	Chan	660.47	668.31	916.79	114.41	7.84	3.16	14.6	8.01	
24	Chan	668.31	676.14	916.55	114.39	7.84	3.16	14.6	8.01	
25	Chan	676.14	683.98	916.26	114.37	7.84	3.16	14.6	8.01	
26	Chan	683.98	691.81	915.98	114.35	7.84	3.16	14.59	8.01	
27	Chan	691.81	699.65	915.7	114.33	7.84	3.16	14.59	8.01	<- Pier 2
28	Chan	699.65	707.48	915.42	114.31	7.84	3.16	14.59	8.01	
29	Chan	707.48	715.32	915.13	114.29	7.84	3.16	14.59	8.01	
30	Chan	715.32	723.15	914.86	114.27	7.84	3.15	14.58	8.01	
31	Chan	723.15	730.99	914.6	114.25	7.84	3.15	14.58	8.01	
32	Chan	730.99	738.82	914.33	114.23	7.84	3.15	14.58	8	
33	Chan	738.82	746.66	914.04	114.2	7.84	3.15	14.58	8	
34	Chan	746.66	754.49	913.76	114.18	7.84	3.15	14.57	8	
35	Chan	754.49	762.33	869.49	111.26	7.91	3	14.2	7.82	
36	Chan	762.33	770.16	748.03	101.77	7.93	2.58	12.99	7.35	
37	Chan	770.16	778	632.55	92.03	7.93	2.18	11.75	6.87	
38	Chan	778	785.83	524.96	82.29	7.93	1.81	10.5	6.38	
39	Chan	785.83	793.67	424.74	72.5	7.94	1.46	9.25	5.86	
40	Chan	793.67	801.51	321.97	61.49	7.97	1.11	7.85	5.24	
41	ROB	801.51	856.65	448.68	331.45	55.18	1.55	6.01	1.35	
42	ROB	856.65	895.52	0	202.87	38.87	0	5.22	0	
43	ROB	895.52	934.39	0	201.97	38.87	0	5.2	0	
44	ROB	934.39	973.26	0	202.13	38.87	0	5.2	0	

100-YEAR FLOOD EVENT SCOUR SUMMARY
FOR I-70 WB BRIDGE OVER
THE RE-ALIGNED COLORADO RIVER
DEBEQUE, COLORADO

October 2008

Pier	Groundline Elevation (ft)	Initial Embedded Pile Length (ft)	Long-term Degradation (ft)	Contraction Scour (ft)	Local Scour (ft)	Total Scour (ft)	Scour Elevation (ft)	Remaining Embedded Pile Length (ft)
4	4850.8	19.2	0.0	-1.4	12.4	11.0	4839.8	9.6
3	4850.8	19.8	0.0	-1.4	14.6	13.2	4837.6	8.0
2	4850.8	27.7	0.0	-1.4	14.6	13.2	4837.6	15.9

500-YEAR FLOOD EVENT SCOUR SUMMARY
FOR I-70 WB BRIDGE OVER
THE RE-ALIGNED COLORADO RIVER
DEBEQUE, COLORADO

October 2008

Pier	Groundline Elevation (ft)	Initial Embedded Pile Length (ft)	Long-term Degradation (ft)	Contraction Scour (ft)	Local Scour (ft)	Total Scour (ft)	Scour Elevation (ft)	Remaining Embedded Pile Length (ft)
4	4850.8	19.2	0.0	0.0	12.8	12.8	4838.0	7.8
3	4850.8	19.8	0.0	0.0	15.0	15.0	4835.8	6.2
2	4850.8	27.7	0.0	0.0	15.0	15.0	4835.8	14.1

NOTES:
This table presents potential scour depths for the associated hydraulic event. If a soil horizon exists beneath the bridge which is resistant to scour, the predicted scour depths could be reduced to reflect the competence of the material. This reduction would require examination and approval by a qualified geotechnical engineer with knowledge of the properties of the material.

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

COARSE BED SCOUR MODE COMPUTATION
FOR I-70 WB BRIDGE OVER
THE RE-ALIGNED COLORADO RIVER
DEBEQUE, COLORADO

October 2008

The scour mode is determined using the following equations (after Julien, 1998):

$$S_f' = \left[\frac{1}{gy}\right]\left\{\frac{V_{ch}}{\left[6.25+5.75Log_{10}\left(\frac{y}{3.5D_{84}}\right)\right]}\right\}^2, S_f' \le S_f;$$

$$\tau' = \gamma y S_f';$$

$$\tau_c = \Phi\gamma(G-1)D_{50};$$

100-YEAR DISCHARGE
MAIN CHANNEL SCOUR MODE

APPROACH SECTION MAIN CHANNEL DISCHARGE (cfs), Q_1	=	31,733
APPROACH SECTION MAIN CHANNEL AREA (ft^2), A_1	=	2,954
APPROACH SECTION MAIN CHANNEL WIDTH (ft), W_1	=	262
APPROACH SECTION ENERGY SLOPE, S_f (ft/ft)	=	1.860E-03
APPROACH SECTION CHANNEL VELOCITY, V_{ch} (fps)	=	10.74
APPROACH SECTION AVERAGE CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	11.29
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.315
D_{84}, ft	=	0.420
Specific Weight of water, γ (lb/ft^3)	=	62.4
Specific Gravity, G	=	2.65
Gravitational Acceleration Constant, (ft/sq. sec), g	=	32.2
Critical Shields Parameter (Unitless), Φ	=	0.03
Calculated Grain Effective Shear Stress (lb/ft^2), Sf'c	=	2.470E-03
Effective Grain Shear Stress (lb/ft^2), Sf'	=	1.860E-03
Grain Shear Stress τ', (lb/ft^2)	=	1.310
Critical Shear Stress, τ_c (lb/ft^2)	=	0.973
Dimensionless Shear Stress, τ'/τ_c	=	1.346
MAIN CHANNEL SCOUR MODE	=	**LIVE BED**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

COARSE BED SCOUR MODE COMPUTATION
FOR I-70 WB BRIDGE OVER
THE RE-ALIGNED COLORADO RIVER
DEBEQUE, COLORADO

October 2008

The scour mode is determined using the following equations (after Julien, 1998):

$$S_f' = \left[\frac{1}{gy}\right]\left\{\frac{V_{ch}}{\left[6.25+5.75Log_{10}\left(\frac{y}{3.5D_{84}}\right)\right]}\right\}^2, S_f' \le S_f;$$

$$\tau' = \gamma y S_f';$$

$$\tau_c = \Phi\gamma(G-1)D_{50};$$

500-YEAR DISCHARGE

MAIN CHANNEL SCOUR MODE

APPROACH SECTION MAIN CHANNEL DISCHARGE (cfs), Q_1	=	36,744
APPROACH SECTION MAIN CHANNEL AREA (ft^2), A_1	=	3,139
APPROACH SECTION MAIN CHANNEL WIDTH (ft), W_1	=	262
APPROACH SECTION ENERGY SLOPE, S_f (ft/ft)	=	2.036E-03
APPROACH SECTION CHANNEL VELOCITY, V_{ch} (fps)	=	11.71
APPROACH SECTION AVERAGE CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	11.99
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.315
D_{84}, ft	=	0.4
Specific Weight of water, γ (lb/ft^3)	=	62.4
Specific Gravity, G	=	2.7
Gravitational Acceleration Constant, (ft/sq. sec), g	=	32.2
Critical Shields Parameter (Unitless), Φ	=	0.03
Calculated Grain Effective Shear Stress (lb/ft^2), Sf'c	=	2.686E-03
Effective Grain Shear Stress (lb/ft^2), Sf'	=	2.036E-03
Grain Shear Stress τ', (lb/ft^2)	=	1.524
Critical Shear Stress, τ_c (lb/ft^2)	=	0.973
Dimensionless Shear Stress, τ'/τ_c	=	1.566
MAIN CHANNEL SCOUR MODE	=	**LIVE BED**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

LIVE-BED CONTRACTION SCOUR COMPUTATIONS FOR I-70 WB BRIDGE OVER THE RE-ALIGNED COLORADO RIVER DEBEQUE, COLORADO

October 2008

The following computations are made using the HEC-18 equation for Live Bed Contraction Scour:

$Y_s = Y_2 - Y_0$

$Y_2 = ((Q_2/Q_1)^{6/7}((W_1/W_2)^{K1}))*Y_1$

100-YEAR FLOOD DISCHARGE
Main Channel
LIVE-BED CONTRACTION SCOUR COMPUTATIONS

ENERGY SLOPE	=	1.86E-03
ω FALL VELOCITY (fps)	=	3.80
AVERAGE UPSTREAM CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	11.29
g GRAVITATIONAL ACCELERATION (ft/sqsec)	=	32.20
V- SHEAR VELOCITY IN UPSTREAM SECTION (fps)	=	0.82
V^*/ω	=	0.22
k_1 HEC-18	=	0.59
DISCHARGE IN UPSTREAM CHANNEL (cfs), Q_1	=	31,733
DISCHARGE IN CONTRACTED SECTION (cfs), Q_2	=	26,112
WIDTH OF UPSTREAM CHANNEL SECTION (ft), W_1	=	261.7
WIDTH OF MAIN CHANNEL CONTRACTED SECTION (ft), W_2	=	243.7
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.32
COMPUTED WATER DEPTH OF CONTRACTED SECTION (ft), Y_2	=	9.96
AVERAGE WATER DEPTH AT BRIDGE(ft), Y_0	=	11.37
AVERAGE SCOUR DEPTH AT CONTRACTED SECTION, Y_S	=	**-1.4**

500-YEAR FLOOD DISCHARGE
Main Channel
LIVE-BED CONTRACTION SCOUR COMPUTATIONS

ENERGY SLOPE	=	2.04E-03
ω FALL VELOCITY (fps)	=	3.80
AVERAGE UPSTREAM CHANNEL DEPTH (ft), $Y_1 = A_1/W_1$	=	11.99
g GRAVITATIONAL ACCELERATION (ft/sqsec)	=	32.20
V- SHEAR VELOCITY IN UPSTREAM SECTION (fps)	=	0.89
V^*/ω	=	0.23
k_1 HEC-18	=	0.59
DISCHARGE IN UPSTREAM CHANNEL (cfs), Q_1	=	36,744
DISCHARGE IN CONTRACTED SECTION (cfs), Q_2	=	28,614
WIDTH OF UPSTREAM CHANNEL SECTION (ft), W_1	=	261.7
WIDTH OF MAIN CHANNEL CONTRACTED SECTION (ft), W_2	=	243.7
MEDIAN GRAIN SIZE (ft), D_{50}	=	0.32
COMPUTED WATER DEPTH OF CONTRACTED SECTION (ft), Y_2	=	10.10
AVERAGE WATER DEPTH AT BRIDGE(ft), Y_0	=	11.95
AVERAGE SCOUR DEPTH AT CONTRACTED SECTION, Y_S	=	**-1.9**

Calc. By:	RLE	Date:	10/14/2008
Check By:	JHH	Date:	11/1/2008

100-YEAR FLOOD EVENT
LOCAL PIER SCOUR COMPUTATIONS
FOR I-70 WB BRIDGE OVER
THE RE-ALIGNED COLORADO RIVER
DEBEQUE, COLORADO

October 2008

PILE BENT SCOUR ANALYSIS

Reference for methodology: HEC-18 4th Edition Chapter 6

Bent Number	**Pier 4**	**Pier 3**	**Pier 2**
V_1: VELOCITY (fps)	6.62	8.61	8.60
Y_1: DEPTH (ft)	9.31	13.68	13.66
ATTACK ANGLE, Degrees	15	15	15
INDIVIDUAL PIER WIDTH (ft)	2.00	2.00	2.00
a: PILE WIDTH (ft)	2.00	2.00	2.00
L: PILE LENGTH (ft)	27.50	27.50	27.50
PIER SHAPE	S	S	S
K_1: SHAPE COEFFICIENT	1.00	1.00	1.00
K_2: ANGLE COEFFICIENT	2.49	2.49	2.49
K_3: BED COND. COEFFICIENT	1.10	1.10	1.10
K_4: ARMORING COEFFICIENT	1.00	1.00	1.00
g: gravitational constant (ft/sec^2)	32.20	32.20	32.20
FROUDE NUMBER, Fr	0.38	0.41	0.41
COMPUTED LOCAL SCOUR DEPTH (ft), Y_{scomp}	**12.42**	**14.64**	**14.63**
MINIMUM SCOUR DEPTH (ft), Y_{smin}	N/A	N/A	N/A
MAXIMUM SCOUR DEPTH (ft), $Y_{smax}=2.4aK_1(K_2)^{1.538}$	19.54	19.54	19.54
TOTAL SCOUR DEPTH (ft), Y_s	**12.4**	**14.6**	**14.6**

Calc. By:	RLE	Date:	10/14/08
Check By:	JHH	Date:	11/1/2008

500-YEAR FLOOD EVENT
LOCAL PIER SCOUR COMPUTATIONS
FOR I-70 WB BRIDGE OVER
THE RE-ALIGNED COLORADO RIVER
DEBEQUE, COLORADO

October 2008

PILE BENT SCOUR ANALYSIS

Reference for methodology: HEC-18 4th Edition Chapter 6

Bent Number	**Pier 4**	**Pier 3**	**Pier 2**
V_1: VELOCITY (fps)	6.95	8.92	8.91
Y_1: DEPTH (ft)	9.95	14.32	14.30
ATTACK ANGLE, Degrees	15	15	15
INDIVIDUAL PIER WIDTH (ft)	2.00	2.00	2.00
a: PILE WIDTH (ft)	2.00	2.00	2.00
L: PILE LENGTH (ft)	27.50	27.50	27.50
PIER SHAPE	S	S	S
K_1: SHAPE COEFFICIENT	1.00	1.00	1.00
K_2: ANGLE COEFFICIENT	2.49	2.49	2.49
K_3: BED COND. COEFFICIENT	1.10	1.10	1.10
K_4: ARMORING COEFFICIENT	1.00	1.00	1.00
g: gravitational constant (ft/sec^2)	32.20	32.20	32.20
FROUDE NUMBER, Fr	0.39	0.42	0.42
COMPUTED LOCAL SCOUR DEPTH (ft), Y_{scomp}	**12.79**	**14.96**	**14.95**
MINIMUM SCOUR DEPTH (ft), Y_{smin}	N/A	N/A	N/A
MAXIMUM SCOUR DEPTH (ft), $Y_{smax}=2.4aK_1(K_2)^{1.538}$	19.54	19.54	19.54
TOTAL SCOUR DEPTH (ft), Y_s	**12.8**	**15.0**	**15.0**

Calc. By:	RLE	Date:	10/14/08
Check By:	JHH	Date:	11/1/2008

Hydraulic Data for I-70 WB Over the Colorado River

100-year Flood Data				500-year Flood Data			
Y_o	=	11.37	ft.	Y_o	=	11.95	ft.
Q_1	=	34,444	cfs	Q_1	=	39,614	cfs
Channel Q_2	=	26,112	cfs	Channel Q_2	=	28,614	cfs
A_1	=	4,265.8	$ft.^2$	A_1	=	4,621.0	$ft.^2$
A_2	=	2,770.5	$ft.^2$	A_2	=	2,911.8	$ft.^2$
W_1	=	387.8	ft.	W_1	=	387.8	ft.
Channel W_2	=	243.7	ft.	Channel W_2	=	243.7	ft.
V_m	=	8.07	ft/s	V_m	=	8.57	ft/s
D_{50}	=	0.315	ft.	D_{50}	=	0.315	ft.
Energy Slope	=	1.09E-03	ft.	Energy Slope	=	1.11E-03	ft.
Gravity Acceleration	=	32.2	ft/s^2	Gravity Acceleration	=	32.2	ft/s^2
Fall Vel., ω	=	3.80	ft/s	Fall Vel., ω	=	3.80	ft/s

BY: Leif Embertson
DATE: 8/1/2008

Hydraulic Data from HEC-RAS (I70 R3 NECRAS.prj)

100-year hydraulics for contraction scour calculations

Contracted Section

Plan: Realigned CO_River reach_1 RS: 2380 BR U Profile: 100yr						
E.G. Elev (ft)	4865.24	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.33	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4863.92	Reach Len. (ft)	50.00	50.00	50.00	
Crit W.S. (ft)	4860.01	Flow Area (sq ft)	479.78	2770.47	33.87	
E.G. Slope (ft/ft)	0.001846	Area (sq ft)	479.78	2770.47	33.87	3284.12
Q Total (cfs)	27243.99	Flow (cfs)	1092.96	26111.51	39.51	
Top Width (ft)	345	Top Width (ft)	88.72	243.67	12.61	
Vel Total (ft/s)	8.3	Avg. Vel. (ft/s)	2.28	9.42	1.17	4.29
Max Chl Dpth (ft)	13.13	Hydr. Depth (ft)	5.41	11.37	2.69	
Conv. Total (cfs)	634177.8	Conv. (cfs)	25441.7	607816.4	919.8	
Length Wtd. (ft)	50	Wetted Per. (ft)	101.35	297.19	13.71	
Min Ch El (ft)	4850.79	Shear (lb/sq ft)	0.55	1.07	0.28	
Alpha	1.24	Stream Power (lb/ft s)	1.24	10.12	0.33	
Frctn Loss (ft)	0.1	Cum Volume (acre-ft)	24.15	144.82	55.57	
C & E Loss (ft)	0.09	Cum SA (acres)	6.32	14.12	17.23	
		Froude	0.17	0.49	0.13	

Approach Section

Plan: Realigned CO_River reach_1 RS: 3802.484 Profile: 100yr						
E.G. Elev (ft)	4867.56	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.36	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4866.2	Reach Len. (ft)	498.44	534.68	540.31	
Crit W.S. (ft)	4863.78	Flow Area (sq ft)	1557.69	2953.51	3018.66	
E.G. Slope (ft/ft)	0.00186	Area (sq ft)	2417.11	2953.51	3018.66	8389.28
Q Total (cfs)	42500	Flow (cfs)	4258.98	31732.65	6508.37	
Top Width (ft)	1227.54	Top Width (ft)	483.03	261.69	482.82	
Vel Total (ft/s)	5.64	Avg. Vel. (ft/s)	2.73	10.74	2.16	5.21
Max Chl Dpth (ft)	11.68	Hydr. Depth (ft)	6.31	11.29	6.25	
Conv. Total (cfs)	985514.2	Conv. (cfs)	98759.5	735834.8	150919.8	
Length Wtd. (ft)	531.23	Wetted Per. (ft)	246.99	261.81	489.11	
Min Ch El (ft)	4854.52	Shear (lb/sq ft)	0.73	1.31	0.72	
Alpha	2.75	Stream Power (lb/ft s)	2	14.07	1.54	
Frctn Loss (ft)	0.93	Cum Volume (acre-ft)	104.82	239.96	117.82	
C & E Loss (ft)	0.07	Cum SA (acres)	21.53	22.43	28.59	
		Froude	0.19	0.56	0.15	

100-year hydraulics for local scour calculations

Plan: Realigned CO_River reach_1 RS: 2510.449 Profile: 100yr										
	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	
1	LOB	0	90.37	0	309.36	93.13	0	3.42	0	
2	LOB	90.37	180.75	0	374.38	90.37	0	4.14	0	
3	LOB	180.75	271.12	0	384.46	90.37	0	4.25	0	
4	LOB	271.12	361.49	0	394.56	90.37	0	4.37	0	
5	LOB	361.49	503.12	1465.15	801.17	141.81	5.38	5.66	1.83	
6	Chan	503.12	510.6	259.94	49.28	7.52	0.95	6.59	5.27	
7	Chan	510.60	518.07	313.81	55.18	7.52	1.15	7.38	5.69	
8	Chan	518.07	525.55	375.83	61.57	7.54	1.38	8.24	6.1	
9	Chan	525.55	533.03	460.87	69.63	7.55	1.69	9.31	6.62	**<- Pier 4**
10	Chan	533.03	540.5	533.92	75.83	7.5	1.96	10.14	7.04	
11	Chan	540.50	547.98	587.1	80.28	7.5	2.15	10.74	7.31	
12	Chan	547.98	555.45	642.24	84.72	7.5	2.36	11.33	7.58	
13	Chan	555.45	562.93	699.34	89.16	7.5	2.57	11.93	7.84	
14	Chan	562.93	570.41	758.38	93.6	7.5	2.78	12.52	8.1	
15	Chan	570.41	577.88	819.31	98.05	7.5	3.01	13.11	8.36	
16	Chan	577.88	585.36	873.94	101.85	7.49	3.21	13.62	8.58	
17	Chan	585.36	592.84	881.41	102.31	7.48	3.24	13.68	8.62	
18	Chan	592.84	600.31	881.11	102.29	7.48	3.23	13.68	8.61	
19	Chan	600.31	607.79	880.83	102.27	7.48	3.23	13.68	8.61	**<- Pier 3**
20	Chan	607.79	615.26	880.54	102.25	7.48	3.23	13.68	8.61	
21	Chan	615.26	622.74	880.26	102.23	7.48	3.23	13.67	8.61	
22	Chan	622.74	630.22	879.96	102.21	7.48	3.23	13.67	8.61	
23	Chan	630.22	637.69	879.68	102.19	7.48	3.23	13.67	8.61	
24	Chan	637.69	645.17	879.42	102.17	7.48	3.23	13.67	8.61	
25	Chan	645.17	652.64	879.12	102.15	7.48	3.23	13.66	8.61	
26	Chan	652.64	660.12	878.84	102.13	7.48	3.23	13.66	8.6	
27	Chan	660.12	667.6	878.55	102.11	7.48	3.22	13.66	8.6	**<- Pier 2**
28	Chan	667.6	675.07	878.27	102.09	7.48	3.22	13.66	8.6	
29	Chan	675.07	682.55	877.98	102.07	7.48	3.22	13.65	8.6	
30	Chan	682.55	690.03	877.68	102.05	7.48	3.22	13.65	8.6	
31	Chan	690.03	697.5	877.43	102.03	7.48	3.22	13.65	8.6	
32	Chan	697.5	704.98	877.13	102.01	7.48	3.22	13.65	8.6	
33	Chan	704.98	712.45	876.85	101.99	7.48	3.22	13.64	8.6	
34	Chan	712.45	719.93	876.56	101.97	7.48	3.22	13.64	8.6	
35	Chan	719.93	727.41	831.08	99.18	7.56	3.05	13.27	8.38	
36	Chan	727.41	734.88	707.05	90.13	7.58	2.6	12.06	7.85	
37	Chan	734.88	742.36	589.75	80.83	7.58	2.16	10.81	7.3	
38	Chan	742.36	749.83	481.13	71.54	7.58	1.77	9.57	6.73	
39	Chan	749.83	757.31	380.75	62.2	7.59	1.4	8.32	6.12	
40	Chan	757.31	764.79	278.96	51.69	7.62	1.02	6.91	5.4	
41	ROB	764.79	817.4	363.81	267.15	52.65	1.34	5.08	1.36	
42	ROB	817.4	854.49	0	158.95	37.09	0	4.29	0	
43	ROB	854.49	891.58	0	158.09	37.09	0	4.26	0	
44	ROB	891.58	928.67	0	158.25	37.09	0	4.27	0	
45	ROB	928.67	965.76	0	163.3	41.57	0	4.4	0	

500-year hydraulics for contraction scour calculations

Contracted Section

Plan: Realigned CO_River reach_1 RS: 2380 BR U Profile: 500yr						
E.G. Elev (ft)	4865.93	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.44	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4864.5	Reach Len. (ft)	50.00	50.00	50.00	
Crit W.S. (ft)	4860.48	Flow Area (sq ft)	531.57	2911.81	41.58	
E.G. Slope (ft/ft)	0.001897	Area (sq ft)	531.57	2911.81	41.58	3484.96
Q Total (cfs)	29962.66	Flow (cfs)	1295.97	28614.03	52.67	
Top Width (ft)	347.49	Top Width (ft)	89.85	243.67	13.98	
Vel Total (ft/s)	8.6	Avg. Vel. (ft/s)	2.44	9.83	1.27	4.51
Max Chl Dpth (ft)	13.71	Hydr. Depth (ft)	5.92	11.95	2.98	
Conv. Total (cfs)	687922.3	Conv. (cfs)	29754.5	656958.6	1209.2	
Length Wtd. (ft)	50	Wetted Per. (ft)	103.78	299.51	15.19	
Min Ch El (ft)	4850.79	Shear (lb/sq ft)	0.61	1.15	0.32	
Alpha	1.25	Stream Power (lb/ft s)	1.48	11.31	0.41	
Frctn Loss (ft)	0.11	Cum Volume (acre-ft)	27.47	151.63	63.7	
C & E Loss (ft)	0.1	Cum SA (acres)	6.49	14.12	17.37	
		Froude	0.18	0.50	0.13	

Approach Section

Plan: Realigned CO_River reach_1 RS: 3802.484 Profile: 500yr						
E.G. Elev (ft)	4868.5	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.59	Wt. n-Val.	0.080	0.030	0.100	
W.S. Elev (ft)	4866.91	Reach Len. (ft)	498.44	534.68	540.31	
Crit W.S. (ft)	4864.56	Flow Area (sq ft)	1732.62	3138.91	3360.74	
E.G. Slope (ft/ft)	0.002036	Area (sq ft)	2759.34	3138.91	3360.74	9258.99
Q Total (cfs)	50200	Flow (cfs)	5320.58	36744.24	8135.19	
Top Width (ft)	1227.54	Top Width (ft)	483.03	261.69	482.82	
Vel Total (ft/s)	6.1	Avg. Vel. (ft/s)	3.07	11.71	2.42	5.73
Max Chl Dpth (ft)	12.39	Hydr. Depth (ft)	7.02	11.99	6.96	
Conv. Total (cfs)	1112663	Conv. (cfs)	117928.4	814421.4	180313.2	
Length Wtd. (ft)	531.04	Wetted Per. (ft)	246.99	261.81	489.82	
Min Ch El (ft)	4854.52	Shear (lb/sq ft)	0.89	1.52	0.87	
Alpha	2.75	Stream Power (lb/ft s)	2.74	17.84	2.11	
Frctn Loss (ft)	1.01	Cum Volume (acre-ft)	119.19	252.86	134.24	
C & E Loss (ft)	0.11	Cum SA (acres)	21.69	22.43	28.73	
		Froude	0.20	0.60	0.16	

500-year hydraulics for local scour calculations

Plan: Realigned CO River reach 1 RS: 2510.449 Profile: 500yr										
	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	
1	LOB	0	90.37	0	367.17	93.77	0	4.06	0	
2	LOB	90.37	180.75	0	432.18	90.37	0	4.78	0	
3	LOB	180.75	271.12	0	442.26	90.37	0	4.89	0	
4	LOB	271.12	361.49	0	452.37	90.37	0	5.01	0	
5	LOB	361.49	503.12	1755.35	891.76	141.81	5.86	6.3	1.97	
6	Chan	503.12	510.6	304.59	54.07	7.52	1.02	7.23	5.63	
7	Chan	510.60	518.07	361.94	59.96	7.52	1.21	8.02	6.04	
8	Chan	518.07	525.55	427.52	66.35	7.54	1.43	8.87	6.44	
9	Chan	525.55	533.03	516.98	74.41	7.55	1.73	9.95	6.95	<- Pier 4
10	Chan	533.03	540.5	593.69	80.61	7.5	1.98	10.78	7.36	
11	Chan	540.50	547.98	649.24	85.06	7.5	2.17	11.38	7.63	
12	Chan	547.98	555.45	706.74	89.5	7.5	2.36	11.97	7.9	
13	Chan	555.45	562.93	766.16	93.94	7.5	2.56	12.57	8.16	
14	Chan	562.93	570.41	827.5	98.39	7.5	2.76	13.16	8.41	
15	Chan	570.41	577.88	890.71	102.83	7.5	2.97	13.75	8.66	
16	Chan	577.88	585.36	947.35	106.63	7.49	3.16	14.26	8.88	
17	Chan	585.36	592.84	955.12	107.09	7.48	3.19	14.32	8.92	
18	Chan	592.84	600.31	954.81	107.07	7.48	3.19	14.32	8.92	
19	Chan	600.31	607.79	954.52	107.05	7.48	3.19	14.32	8.92	<- Pier 3
20	Chan	607.79	615.26	954.21	107.03	7.48	3.18	14.32	8.92	
21	Chan	615.26	622.74	953.92	107.01	7.48	3.18	14.31	8.91	
22	Chan	622.74	630.22	953.62	106.99	7.48	3.18	14.31	8.91	
23	Chan	630.22	637.69	953.33	106.97	7.48	3.18	14.31	8.91	
24	Chan	637.69	645.17	953.06	106.95	7.48	3.18	14.31	8.91	
25	Chan	645.17	652.64	952.75	106.93	7.48	3.18	14.3	8.91	
26	Chan	652.64	660.12	952.46	106.91	7.48	3.18	14.3	8.91	
27	Chan	660.12	667.6	952.15	106.89	7.48	3.18	14.3	8.91	<- Pier 2
28	Chan	667.6	675.07	951.86	106.87	7.48	3.18	14.3	8.91	
29	Chan	675.07	682.55	951.57	106.85	7.48	3.18	14.29	8.91	
30	Chan	682.55	690.03	951.26	106.83	7.48	3.17	14.29	8.9	
31	Chan	690.03	697.5	951	106.82	7.48	3.17	14.29	8.9	
32	Chan	697.5	704.98	950.69	106.79	7.48	3.17	14.28	8.9	
33	Chan	704.98	712.45	950.4	106.77	7.48	3.17	14.28	8.9	
34	Chan	712.45	719.93	950.1	106.75	7.48	3.17	14.28	8.9	
35	Chan	719.93	727.41	902.69	103.96	7.56	3.01	13.91	8.68	
36	Chan	727.41	734.88	773.91	94.91	7.58	2.58	12.69	8.15	
37	Chan	734.88	742.36	651.76	85.61	7.58	2.18	11.45	7.61	
38	Chan	742.36	749.83	538.16	76.32	7.58	1.8	10.21	7.05	
39	Chan	749.83	757.31	432.58	66.98	7.59	1.44	8.96	6.46	
40	Chan	757.31	764.79	324.63	56.48	7.62	1.08	7.55	5.75	
41	ROB	764.79	817.4	444.32	300.8	52.65	1.48	5.72	1.48	
42	ROB	817.4	854.49	0	182.68	37.09	0	4.93	0	
43	ROB	854.49	891.58	0	181.82	37.09	0	4.9	0	
44	ROB	891.58	928.67	0	181.97	37.09	0	4.91	0	
45	ROB	928.67	965.76	0	187.03	42.21	0	5.04	0	

APPENDIX C
Channel Stability Assessment

LEGEND

BANKLINE 1998

BANKLINE 1980

2007 AERIAL IMAGERY
1998 & 1980 BANKLINES
BASED ON GEO-RECITFIED
AERIAL IMAGES.

N

0 100 200 300
SCALE IN FEET

AYRES ASSOCIATES
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HISTORICAL BANKLINE EXHIBIT

I-70 WB BRIDGE OVER COLORADO RIVER

Revisions	Date

Filename:

Project Mgr. RLE
Designed By: RLE
Drawn By: DAS
Approved By: ----
Date: 08/01/2008

PROJECT NO. 32-1347.00
DRAWING NO. 1
SHEET 1 OF 1

APPENDIX D
HEC-23 Countermeasure Matrix

Table 2.1 STREAM INSTABILITY AND BRIDGE SCOUR COUNTERMEASURES MATRIX

Countermeasure Group	Countermeasure Characteristics																
	FUNCTIONAL APPLICATIONS						SUITABLE RIVER ENVIRONMENT								MAINTENANCE	INSTALLATION EXPERIENCE BY STATE	DESIGN GUIDELINE REFERENCE*
	Local Scour		Contraction Scour	Stream Instability		Overtopping Flow	River Type	Stream Size	Bend Radius	Velocity	Bed Material	Ice/Debris Load	Bank Slope	Floodplain	Estimated Allocation of Resources		
	Abutments	Piers[4]	Floodplain and Channel	Vertical	Lateral	Approach Embankments	B = braided M = meandering S = straight	W = wide M = moderate S = small	L = long M = moderate S = short	F = fast M = moderate S = slow	C = coarse bed S = sand bed F = fine bed	H = high M = moderate L = low	V = very steep S = steep M = mild	W = wide M = moderate N = narrow/none	H = high M = moderate L = low		
GROUP 1. HYDRAULIC COUNTERMEASURES																	
GROUP 1.A. RIVER TRAINING STRUCTURES																	
TRANSVERSE STRUCTURES																	
Impermeable spurs (jetties, groins, wing dams)	◗	◗	○	○	●	○	B, M	W, M	L, M	✓	✓	✓	✓	✓	M - L	Widely Used	DG 2
Permeable spurs (fences, netting)	◗	◗	○	○	●	○	B, M	W, M	L, M	M, S	S, F	L	✓	✓	H - M	Widely Used	DG 2
Transverse dikes	○	○	○	○	●	○	B, M	W, M	✓	✓	✓	✓	✓	✓	M - L	NE	
Bendway weirs/Stream barbs[1]	◗	◗	○	○	●	○	M	✓	M, S	✓	✓	✓	✓	✓	L	CO, ID, IL, MO, MT, OR, WA	DG 1
Hardpoints	○	○	○	○	●	○	✓	✓	✓	✓	✓	✓	✓	✓	L	CA, ND, NE, SD	CH 8
Drop structures (check dams, grade control)	◗	◗	◗	●	○	○	✓	✓	✓	✓	✓	✓	✓	✓	M	Widely Used	DG 3
Embankment Spurs	◗	○	◗	○	○	○	✓	✓	✓	✓	✓	✓	✓	W	L	AK, OK	
LONGITUDINAL STRUCTURES																	
Longitudinal dikes (crib/rock toe/embankments)	◗	○	○	○	●	◗	✓	✓	L, M	✓	✓	M, L	✓	✓	M - L	AK, AZ, CA, OK, OR, MS	CH 8
Retards	◗	○	○	○	●	○	✓	✓	L, M	✓	S, F	L	✓	✓	H - M	Widely Used	CH 8
Bulkheads	●	○	○	○	●	○	✓	✓	✓	✓	✓	✓	V, S	✓	M	Widely Used	CH 8
Guide banks	●	◗	◗	○	◗	◗	✓	W, M	✓	✓	✓	✓	✓	W, M	M - L	Widely Used	DG 15
AREAL STRUCTURES/TREATMENTS																	
Jacks/tetrahedron jetty fields	○	○	○	○	●	○	B, M	W, M	L	M, S	S, F	M, L	✓	W, M	M	Widely Used	CH 8
Vanes	○	◗	○	○	●	○	B, M	W, M	L, M	M, S	S, F	L	✓	✓	H - M	IA	
Channelization	◗	◗	○	○	●	○	B, M	✓	✓	✓	✓	✓	✓	✓	M	MS, MO, MT, TX	CH 8
Flow relief (overflow, relief bridge)	◗	◗	●	○	○	●	✓	✓	✓	✓	✓	✓	✓	W	M	Widely Used	
Sediment detention basin	○	○	○	●	○	○	✓	✓	✓	✓	C, S	✓	✓	✓	H - M	Widely Used	
GROUP 1.B. ARMORING COUNTERMEASURES																	
REVETMENTS AND BED ARMOR																	
Rigid																	
Soil cement	●	●	◗	◗	●	●	✓	✓	✓	✓	S, F	✓	✓	✓	L	AZ, CO, NM	DG 7
Roller compacted concrete	●	◗	●	●	●	●	✓	✓	✓	✓	S, F	✓	✓	✓	L	Widely Used	
Concrete pavement	◗	○	●	◗	●	◗	✓	✓	✓	✓	✓	✓	S, M	✓	M	Widely Used	
Rigid grout filled mattress/concrete fabric mat	◗	○	◗	◗	●	◗	✓	✓	✓	✓	✓	✓	S, M	✓	M	GA, MA, MD, ME, SD, WA	
Fully grouted riprap	○	○	○	○	◗	○	✓	✓	✓	✓	✓	✓	S, M	✓	M	AZ, CA, CT, ME, MI, TN	CH 5
Flexible/articulating																	
Riprap	●	●	◗	◗	●	◗	✓	✓	✓	✓	✓	✓	S, M	✓	M	Widely Used	DG 4
Self launching riprap (windrow)	○	○	○	○	◗	○	✓	✓	✓	✓	C,S	✓	V, S	✓	H - M	GA, CA, IL, PA	DG 4
Riprap fill-trench	◗	○	○	○	●	○	✓	✓	✓	✓	✓	✓	✓	✓	M	Widely Used	DG 4
Gabions/gabion mattress[2]	●	●	◗	◗	●	◗	✓	✓	✓	✓	S, F	M, L	✓	✓	M	Widely Used	DG 11
Wire enclosed riprap mattress (rail bank/sausage)	●	○	○	○	●	○	✓	✓	✓	M, S	S, F	M, L	S, M	✓	M	AZ, CO, NM	DG 6
Articulated blocks (interlocking and/or cable tied)	●	●	●	◗	●	●	✓	✓	✓	✓	✓	✓	S, M	✓	M - L	Widely Used	DG 9
Concrete/grout mattress (fabric-formed)	●	◗	●	◗	●	◗	✓	✓	✓	M, S	✓	✓	S, M	✓	M - L	OR, CA, IA, IL, AZ	DG 10
Partially grouted riprap	●	●	◗	◗	●	○	✓	✓	✓	✓	✓	✓	S, M	✓	L	European practice	DG 12
LOCAL SCOUR ARMORING																	
Riprap (fill/apron)	●	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	S, M	✓	H - M	Widely Used	DG 8, DG 14
Fully grouted riprap	◗	○	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	S, M	✓	H - M	Widely Used	CH 5
Concrete armor units (Toskanes, tetrapods, etc.)[3]	◗	◗	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	M	✓	M - L	AZ, PA, NY, VA	CH 5
Grout filled bags/sand cement bags	●	◗	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	M, L	M	✓	H - M	Widely Used	DG 13
Gabions/gabion mattress[2]	●	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	S, F	M, L	S, M	✓	M	FL, WA, TN, OR	DG 11
Articulated blocks (interlocking and/or cable tied)	●	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	S, M	✓	M - L	Widely Used	DG 9
Sheet pile/cofferdam	◗	◗	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	M - L	CA, CT, FL, NH, WA	
Partially grouted riprap	●	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	S, M	✓	L	European practice	DG 12

● well suited/primary use
◗ possible application/secondary use
○ unsuitable/rarely used
N/A not applicable

✓ suitable for the full range of the characteristic

DG# HEC-23 Design Guideline
CH# HEC-23 Chapter

Table 2.1 STREAM INSTABILITY AND BRIDGE SCOUR COUNTERMEASURES MATRIX (continued).

Countermeasure Group	Countermeasure Characteristics																
	FUNCTIONAL APPLICATIONS						SUITABLE RIVER ENVIRONMENT								MAINTENANCE	INSTALLATION EXPERIENCE BY STATE	DESIGN GUIDELINE REFERENCE*
	Local Scour		Contraction Scour	Stream Instability		Overtopping Flow	River Type	Stream Size	Bend Radius	Velocity	Bed Material[5]	Ice/Debris Load	Bank Slope	Floodplain	Estimated Allocation of Resources		
	Abutments	Piers[4]	Floodplain and Channel	Vertical	Lateral	Approach Embankments	B = braided M = meandering S = straight	W = wide M = moderate S = small	L = long M = moderate S = short	F = fast M = moderate S = slow	C = coarse bed S = sand bed F = fine bed	H = high M = moderate L = low	V = very steep S = steep M = mild	W = wide M = moderate N = narrow/none	H = high M = moderate L = low		
GROUP 2. STRUCTURAL COUNTERMEASURES																	
FOUNDATION STRENGTHENING																	
Crutch bents/Underpinning	○	●	●	●	◗	N/A	✓	✓	✓	✓	✓	✓	✓	✓	L	FL, NC, OR, TX	
Cross bracing	○	●	●	●	○	N/A	✓	✓	✓	✓	✓	✓	✓	✓	L	NC, FL, LA	
Continuous spans	○	●	●	●	○	N/A	✓	✓	✓	✓	✓	✓	✓	✓	L	NC	
Pumped concrete/grout under footing	●	●	◗	◗	◗	N/A	✓	✓	✓	✓	✓	✓	✓	✓	M	Widely Used	DG 13
Lower foundation	●	●	●	●	●	N/A	✓	✓	✓	✓	✓	✓	✓	✓	L	CA, OR, TX	
PIER GEOMETRY MODIFICATION																	
Extended footings	N/A	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	L	Widely Used	
Pier shape modifications	N/A	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	M	FL	
Debris deflectors	N/A	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	H - M	CA, FL, NM, OR	
Sacrificial piles/dolphins	N/A	●	N/A	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓	✓	H - M		
GROUP 3. BIOTECHNICAL COUNTERMEASURES[5]																	
Vegetated geosynthetic products	○	○	○	○	●	◗	M, S	M, S	✓	M, S	✓	M, L	M, S	✓	H - M	Widely Used	CH 6
Fascines/woody mats	○	○	○	○	●	○	✓	M, S	✓	M, S	✓	L	M, S	✓	H - M	Widely Used	CH 6
Vegetated riprap	○	○	○	○	●	◗	✓	✓	✓	✓	✓	✓	M, S	✓	M - L	Widely Used	CH 6
Root wads	○	○	○	○	●	○	✓	M, S	✓	M, S	✓	L	M	✓	H - M	Widely Used	CH 6
Live staking	○	○	○	○	●	○	✓	M, S	✓	M, S	✓	M, L	M, S	✓	H - M	Widely Used	CH 6
GROUP 4. MONITORING																	
FIXED INSTRUMENTATION																	
Sonar scour monitor	◗	●	●	●	◗	○	✓	✓	✓	✓	✓	L	✓	✓	M	CO, FL, IN, NY, VA, TX	CH 9
Magnetic sliding collar	●	●	●	●	◗	○	✓	✓	✓	✓	S, F	✓	✓	✓	M	Widely Used	CH 9
Float out device	●	●	●	●	●	●	✓	✓	✓	✓	S, F	✓	✓	✓	L	AZ, CA, NV	CH 9
Sounding rods	◗	●	●	●	◗	○	✓	✓	✓	M, S	C	M, L	✓	✓	H	AR, IA, NY	CH 9
PORTABLE INSTRUMENTATION																	
Physical probes	●	●	●	●	●	○	✓	✓	✓	M, S	✓	M, L	✓	✓	L	Widely Used	CH 9
Sonar probes	●	●	●	●	●	○	✓	✓	✓	M, S	✓	L	✓	✓	L	Widely Used	CH 9
VISUAL MONITORING																	
Periodic Inspection	●	●	●	●	●	●	✓	✓	✓	✓	✓	M, L	✓	✓	H	Widely Used	CH 2
Flood watch	●	●	●	●	●	●	✓	✓	✓	✓	✓	M, L	✓	✓	H	Widely Used	CH 2

● well suited/primary use
◗ possible application/secondary use
○ unsuitable/rarely used
N/A not applicable

✓ suitable for the full range of the characteristic

DG# HEC-23 Design Guideline
CH# HEC-23 Chapter

NOTES:

1. There is limited but successful field experience using bendway weirs/stream barbs as stream instability countermeasures.

2. Performance of welded vs. twisted wire, and PVC coated vs. uncoated wire gabions is not distinguished in the matrix.

3. There is limited but successful field experience using concrete armor units for scour protection at bridge piers.

4. Piers at new bridges cannot rely on countermeasures to reduce the design depths of foundation elements (Federal guidance).

5. Biotechnical countermeasures are only intended for stream banks, not stream beds. This matrix assumes that any biotechnical treatments are fully grown, with well-established root systems. The toe of <u>any</u> streambank treatment should be reinforced with rock riprap or other armor material, as discussed in Chapter 6 of this document.

6. See Chapter 3 for discussion of selection criteria for countermeasures.

7. See Chapter 6 for discussion of biotechnical engineering countermeasures.

8. See Chapter 8 for discussion of other countermeasures and case histories of performance.

APPENDIX E
Sizing Computations

RIPRAP SIZING COMPUTATIONS
FOR PIER ARMORING AT COLORADO RIVER
I-70 Debeque Canyon Bridge G-04-BA
Mesa County, Colorado
PIER 2, realigned
October 2008
HEC-23 METHOD

The following computations are made using HEC-23 equation 8.1:

$$D_{50} = \frac{0.692\ (V_{des})^2}{(S_s - 1)\ 2g} \qquad V_{des} = K_1 K_2 V_{avg}$$

HEC-23 Pier Riprap Sizing Computations

Storm Event		**100-Year**
VELOCITY (fps), V_{avg}	=	8.60
PIER SHAPE (unitless), Rectangular = R, Circular = C	=	R
PIER SHAPE FACTOR (no units), K_1	=	1.70
PIER LOCATION FACTOR (unitless), K_2	=	1.00
SPECIFIC GRAVITY OF RIPRAP (no units), S_s	=	2.65
MEDIAN RIPRAP STONE SIZE (D_{50}), ft	**=**	**1.39**

1. The minimum rock riprap thickness should be the **larger of the diameter of D_{100}, 3 times D50, depth of contraction scour, or depth of bedform trough**. Riprap thickness should not be less than 12 in for practical placement.

2. The rock riprap thickness should be **increased by 50 percent** when it is placed under water to provide for the uncertainties associated with this type of placement.

3. An **increase in riprap thickness of 6 to 12 in**, accompanied by an appropriate increase in stone sizes, should be provided where riprap revetment will be subject to attack by floating debris or ice, or by waves from boat wakes, wind, or bedforms.

4. The rock riprap gradation and the potential need for underlying filter material must be considered.

5. If flow distribution is calculated and depth-averaged velocity is utilized, then K_2 should be specified as 1.0. Otherwise, K_2 ranges from 0.9 for piers near the bank in a straight reach to 1.7 for piers located in the main current of flow around a sh

Calc. By:	LGG	Date:	10/17/2008
Check By:	RLE	Date:	11/4/2008

RIPRAP SIZING COMPUTATIONS
FOR REVETMENT ARMORING AT THE COLORADO RIVER
I-70 Debeque Canyon Bridge G-04-BA
Mesa County, Colorado

November 2008
NCHRP 568 METHOD

The following computations are made using NCHRP 568 equations C2.1and C2.2:

$$d_{30} = y(S_f C_S C_V C_T)\left[\frac{(V_{des})}{\sqrt{K_1(S_g - 1)gy}}\right]^{2.5}$$

$$d_{50} = 1.2 d_{30}$$

$$K_1 = \sqrt{1 - \left(\frac{(\sin\theta - 14°)}{\sin(32°)}\right)^{1.6}}$$

NCHRP Revetment Riprap Sizing Computations

Storm Event		**100-Year**
Riprap Specific Gravity, Sg		2.65
Channel Average Velocity (fps), V_{avg}	=	10.07
Flow Depth Above Particle (ft), y	=	12.00
Safety Factor (>1), S_f	=	1.10
Rock Shape (A = Angular R = Rounded)		A
Stability Coefficient (no units), C_s		0.300
Channel Position of Riprap:		
On Straight Channel = S, Downstream of Concrete Channel = D		
At end of Dike = K, Outside of Bend = B		B
If Outside of Bend		
Centerline Radius Of Curvature, R_c		1,600
Width of Water Surface at Upsteam end of Bend, W		230
Velocity Distribution Coefficient (no units)		1.11
Natural Channel = N Trapezoidal Channel = T		N
Characteristic Velocity for Design, V_{des}		13.11
Bank Angle Degrees, Ø		22.00
Side Slope Correction Factor, K_1		0.94
COMPUTED RIPRAP STONE SIZE (D_{30}), ft	=	0.93
COMPUTED RIPRAP STONE SIZE (D_{50}), ft	=	1.11
USE RIPRAP STONE SIZE (D_{50}), ft	**=**	**1.50**

1. The flow depth used in equation C.21 is defined as the local flow depth above the particle. The flow depth at the toe of the slope can be used or the average channel depth. The smaller value produces a slightly larger computed d_{30} size since riprapsi

2. The blanket thickness coefficient (C_T) is 1.0 for standard riprap applications where the thickness is equal to $1.5d_{50}$ or d_{100}, whichever is greater. Because only limited data are available for selecting lower values of C_T when greater thicknesses of ri

3. The standard safety factor is 1.1. Greater values should be considered where there is significant potential for large debris, freeze-thaw that would significantly decrease the particle size, or large uncertainty in the design variables, especially velo

4.Limitations to equation C2.1 is that the longitudinal slope of the channwl should be less than 2%. For steeper channels the riprap sizing approach should be considered and the results compared with equation C2.1.

5. A standard size gradation class can be selected once a design size has been established, if design criteria and ecanomic consideration permit. Using standard sizes the appropriate gradation can be achieved by selectimg the next larger size class, there

Calc. By:	LGG	Date:	11/4/2008
Check By:	RLE	Date:	11/4/2008

Oversight / NHS	
FHWA OVERSIGHT?	■ NO □ YES
NATIONAL HIGHWAY SYSTEM?	□ NO ■ YES

DEPARTMENT OF TRANSPORTATION
STATE OF COLORADO

Related Projects:
P. E. UNDER PROJECT:
Project Number BR 0701-192
Project Code: 16689

R.O.W. Projects:
R.O.W. Project Description
N/A

HIGHWAY CONSTRUCTION BID PLANS OF PROPOSED
FEDERAL AID PROJECT NO. BR 0701-192
INTERSTATE HIGHWAY 70
MESA COUNTY
CONSTRUCTION PROJECT CODE NO. 16689
I-70 COLORADO RIVER BRIDGE-DEBEQUE

TABULATION OF LENGTH & DESIGN DATA

STATION	FEET	MILES
BEGIN PROJECT BR 0701-192 M.P. 57.56		
	2,640.00	0.50
COLORADO RIVER BRIDGE STRUCTURE G-04-BA BEGIN STRUCTURE M.P. 58.06		
	417.00	0.08
COLORADO RIVER BRIDGE STRUCTURE G-04-BA END STRUCTURE M.P. 58.14		
	5,280.00	1.00
END PROJECT BR 0701-192 M.P. 59.14		
ROADWAY (NET LENGTH)	7,920.00	1.5
MAJOR STRUCTURE	417.00	0.08
PROJECT GROSS LENGTH	8,337.00	1.58

DESCRIPTION OF PROJECT

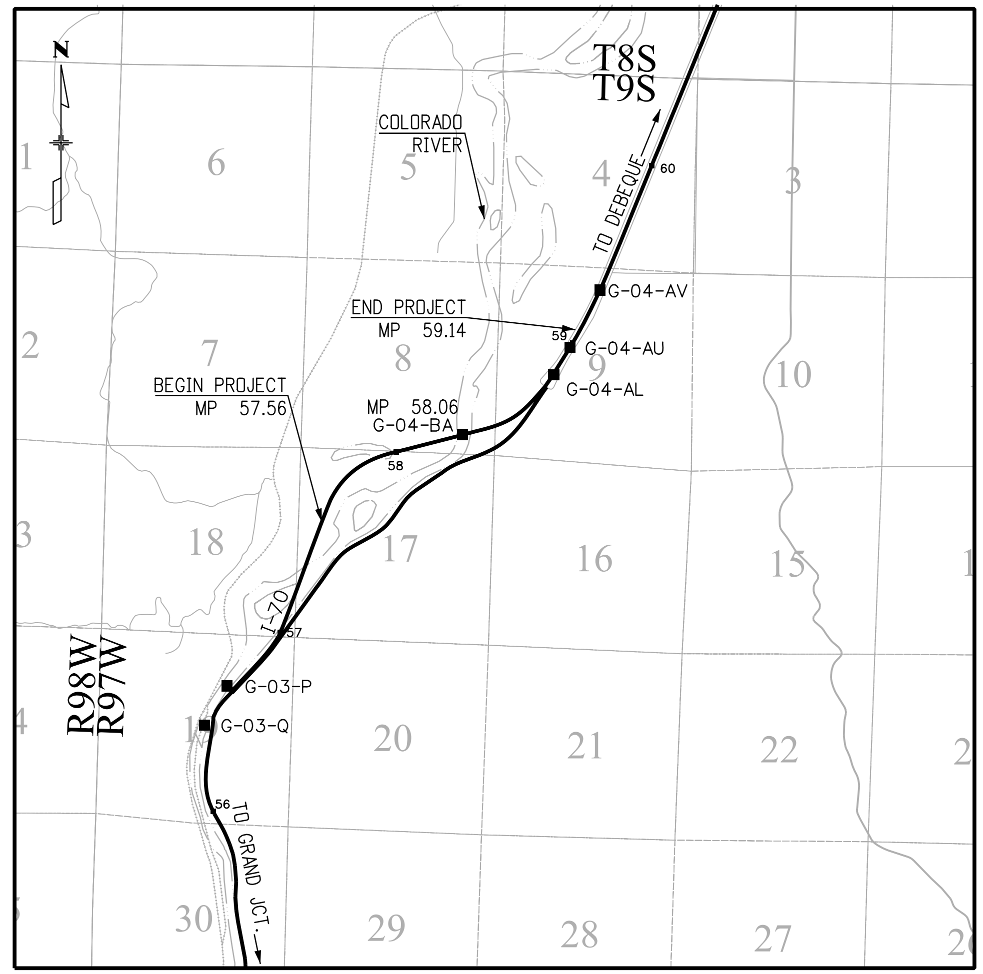
THIS PROJECT IS LOCATED ON WESTBOUND INTERSTATE 70, WEST OF DEBEQUE, AT M.P. 58.06. THE WORK IS TO TAKE PLACE ON THE COLORADO RIVER BRIDGE STRUCTURE G-04-BA.

THE PROJECT WILL INSTALL NEW PIER COLUMNS AND PIER CAPS AT PIERS 2, 3, AND 4. EXISTING PIER 2 STEM WALL AND PILES WILL BE REMOVED AND THE BRIDGE DECK WILL BE RESURFACED. WORK ON THE PIERS WILL TAKE PLACE INSIDE OF COFFER DAMS. WORK WILL BE COMPLETED IN THREE PHASES AS FOLLOWS:

PHASE 1: PLACE RIPRAP ALONG WEST BANK, CONSTRUCT NEW PIER 2, REMOVE EXISTING PIER 2.

PHASE 2: CONSTRUCT TEMPORARY ACCESS ROAD TO PIERS 3 AND 4, CONSTRUCT NEW COLUMNS AND CAPS AT PIER 3 AND PIER 4.

PHASE 3: BRIDGE DECK RESURFACING, SEEDING AND PLANTING.



PROJECT LOCATION MAP

0 Miles 0.5 Miles 1.0 Miles 2.0 Miles

INDEX OF SHEETS

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Region 3 CLS

As Constructed
No Revisions:
Revised:
Void:

Contract Information
Contractor:
Resident Engineer:
Project Engineer:
PROJECT STARTED: / / ACCEPTED: / /
Comments:

Project No./Code
BR 0701-192
16689
Sheet Number 1

PLAN NUMBER		NEW OR REVISED	M STANDARD TITLE	PAGE NUMBER
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□	M-203-2	□	DITCH TYPES	5
□	M-203-11	□	SUPERELEVATION CROWNED AND DIVIDED HIGHWAYS (3 SHEETS)	6–8
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□	M-208-1	■	TEMPORARY EROSION CONTROL (7 SHEETS) (REVISED ON JULY 09, 2009)	~~15–21~~
□	M-210-1	□	MAILBOX SUPPORTS (2 SHEETS)	22–23
■	M-214-1	□	PLANTING DETAILS	24
□	M-412-1	□	CONCRETE PAVEMENT JOINTS (5 SHEETS) (REVISED ON JULY 09, 2009)	~~25–29~~
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PLAN NUMBER		NEW OR REVISED	S STANDARD TITLE	PAGE NUMBER
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□	S-614-6	□	CONCRETE FOOTINGS AND SIGN ISLANDS FOR CLASS III SIGNS (2 SHEETS)	145–146
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□	S-614-11	□	MILEPOST SIGN DETAIL FOR HIGH SNOW AREAS (NEW, JUNE 22, 2009)	
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□	S-614-14	□	FLASHING BEACON AND SIGN INSTALLATIONS (3 SHEETS)	154–156
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■	S-630-2	□	BARRICADES, DRUMS, CONCRETE BARRIERS (TEMP) AND VERTICAL PANELS	203
□	S-630-3	□	FLASHING BEACON (PORTABLE) DETAILS	204

THE STANDARD PLAN SHEETS INDICATED HEREON BY A MARKED BOX ARE TO BE USED TO CONSTRUCT THIS PROJECT.

ALL OF THE M&S STANDARD PLANS, AS SUPPLEMENTED AND REVISED, APPLY TO THIS PROJECT WHEN USED BY DESIGNATED PAY ITEM OR SUBSIDIARY ITEM.

COLORADO
DEPARTMENT OF TRANSPORTATION

STANDARD PLANS LIST
M&S STANDARDS
July 04, 2006
Revised on July 09, 2009

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Project Development Branch DD/LTA

STANDARDS PLANS LIST

Issued By: Project Development Branch July 04, 2006

BR 0701-192

16689

GENERAL NOTES

For preliminary plan quantities of paving materials, the following rate of application was used:

Hot Mix Asphalt (GR SX)(100)(PG 76-28) @ 110 LBS/SQ. YD./IN.

The cost of Asphalt Cement will be included in the cost of the HMA.

Water shall be used as a dust palliative where required. Locations shall be as directed by the Engineer. This shall not be paid for separately but shall be included in the cost of the work.

The Contractor shall not park any vehicles or equipment in, or disturb any areas not approved by the Engineer.

Excavation required for compaction of bases of cuts and fills will be considered as subsidiary to that operation and will not be paid for separately.

Existing wire fence removal and reinstallation shall be done by CDOT Maintenance forces. The Contractor shall coordinate this work with the Project Engineer and CDOT Maintenance.

The Contractor shall be required to log Type, Size, Color and Location of existing lane markings for duplication prior to paving operations. All lane markings shall be laid out by the Contractor on the new surface for final striping. This work will not be measured and paid for separately but will be included in the cost of pavement marking.

Final striping will begin at a point that matches the adjacent striping location and spacing.

It is estimated that4 Gallons of Epoxy Pavement Marking will be required on this project (2 gallons of yellow, 2 gallons of white).

It is estimated that 50 SF of Preformed Plastic Pavement Marking (Type I)(Inlaid) will be required on this project.

It is estimated that 110 days of Traffic Control Management will be required on this project.

It is estimated that 45 days of Traffic Control Inspection will be required on this project.

It is estimated that 500 hours of Flagging will be required on this project.

It is estimated that 2 Sanitary Facilities will be required on this project.

It is estimated that 200 CY of Unclassified Excavation (Complete In Place)(Special) will be required on this project.

It is estimated that 1 lump sum or clearing and grubbing will be required on this project.

No Right-Of-Way acquisition will be needed for this project. All work will be completed entirely within the existing CDOT Right-Of-Way.

All surveying necessary to complete the project will be paid for using the Construction Surveying lump sum pay item.

The Contractor shall protect all existing survey monumentation from damage during construction operations. Any monuments disturbed by the Contractor shall be reset at the Contractor's expense.

When a lane closure is necessary on westbound I-70 there shall only be one lane of traffic closed at any time, with the exception of complete closure of westbound I-70 during the transfer of loading to the new pier 2.

The coffer dam lump sum pay item shall include, but is not limited to, the installation and removal of all (anticipating two) coffer dams, any dewatering or pumping operations, safety requirements, imported base material for a work surface, permit compliance, and any other items necessary to complete the work. The temporary access road installation and removal shall also be included in the coffer dam pay item.

To comply with environmental restrictions the project shall be completed in the following sequence of phasing:
Phase 1: Grading and installation of riprap along the west bank and all work on pier 2.
Phase 2: All work associated with pier 3 and pier 4.
Phase 3: Bridge deck resurfacing, seeding and planting.

All material and items used within the work zone inside of the coffer dam shall be completely removed prior to the removal of the coffer dam.

It is estimated that 40 LF of 48 Inch Culvert Pipe will be required on this project. The cost of the 48 Inch Culvert Pipe in Phase 2 shall include the installation and removal of the 48 Inch Culvert Pipe and any structure excavation and backfill. The 48 Inch Culvert Pipe shall become the property of the Contractor.

Any dewatering permit(s) required are the responsibility of the Contractor and shall not be paid for separately.

A safety plan prepared by the Contractor shall cover all work including, but not limited to, installing the coffer dams, removing the coffer dams, and any work done inside of the coffer dams.

The Field Office Class 2 and Field Laboratory Class 2 shall be provided with a high speed internet connection compatible with the CDOT internet system. This will be considered subsidiary to the pay items for Field Office and Field Laboratory, and will be paid for by the Contractor.

The concrete washout structure located at the Field Laboratory will be included in the cost of the Field Laboratory.

It shall be the Contractor's responsibility to review available geotechnical information at no additional cost to the project.

All waste material generated within the project limits shall be removed from the site and disposed of properly at no additional cost to the project.

The Limits of Disturbed Area, as shown on the plans, shall be delineated at the project site using orange construction fencing and shall be paid for as 607-11525 Fence (Plastic) LF. The construction fence shall be installed at the start of the project and remain in place until the project is completed, at which time it shall be removed by the Contractor at no additional cost to the project. It is estimated that 1,900 LF of Fence (Plastic) will be required on this project.

All staging areas, stockpiles and equipment shall be kept outside of wetland areas as noted on the plans, and shall be located at least 50 feet from any live watercourse. Prior to construction all wetland areas shall be protected in accordance with the Stormwater Management Plans. Any incidental fills, litter or debris shall promptly be removed from wetland areas at the contractors expense.

All fills, geotextile fabric and straw associated with the temporary access to the river and site is covered under a section 404 Permit of the Clean Water Act. Upon demolition of the temporary access the area shall be returned to its original grade and restored.

It is in violation of the Migratory Bird Treaty Act (MBTA) to impact active nests of ground dwelling birds or birds on or under existing structures at any time between April 1st and August 31st, and measures should be taken to deter nest building before or after these dates. This includes nests in nearby trees and shrubs. Any costs associated with surveying for nests prior to clearing and grubbing, and/or nest removals shall not be paid for separately, but shall be included in the work. Approved measures to prevent nesting include mowing, installing exclusionary netting and otherwise physical removal of nests by hand. If any trees or shrubs are to be removed between April 1st and August 31st, a survey must be completed. If an active nest is found, no work may be done within 50' of the nest until the nest becomes inactive. For further information, contact Gary Spinuzzi at 970-683-6254.

The project is in close proximity to prime raptor habitat that includes an active bald eagle nest site. The line on the project plans delineating CDOT ROW, or the A-Line, shall not be crossed at any time by workers or equipment. As a precaution, CDOT shall monitor the activity of the eagles and nest throughout the duration of the project. For further information, contact Paula Durkin at 970-683-6255.

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Region 3 CLS

As Constructed
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Designer: MHM
Detailer: MHM
Structure Numbers: G-04-BA
Sheet Subset: Gen. Notes
Subset Sheets: 1 of 2

Project No./Code
BR 0701-192
16689
Sheet Number 3

GENERAL NOTES

Unless specifically providing an obstruction to construction equipment every effort to preserve native trees (for example cottonwoods) shall be made. All trees not specifically designated and approved for removal shall be protected from construction equipment by installing temporary fencing around the perimeter of each tree or cluster of trees, and shall be identified during the Environmental Pre-Construction Meeting. All protective fencing shall be adequately maintained and provide a functional barrier during construction. Vegetation and tree removals shall be included in the lump sum pay item clearing and grubbing.

All native shrubs in temporarily impacted areas within the the boundary of the Limits of Disturbed Area shall be trimmed to within 2 inches of the ground. Non-native species, including Tamarisk and Russian Olive shall be removed and disposed of. Temporary access through wetland areas shall be protected with geotextile fabric (erosion control)(Class 1). Above the fabric, place a 12 - 24 inch layer of loose straw and a minimum of 2 feet of soil.

After construction activities are complete, soil, straw and geotextile shall be carefully removed. The final lift shall be removed using a toothless backhoe. Straw and geotextile shall become the property of the contractor and shall be removed from the site. Excess fill shall not be wasted in adjacent wetlands or floodplain areas. All work to protect temporarily impacted areas including removal of straw, soil, and geotextile shall be included in the price of the work. Pruning shall be included in the price of clearing and grubbing.

The Contractor shall limit construction activities to those areas within the limits of disturbance as shown on the plans. Any disturbance beyond these limits shall be restored to original condition by the contractor at the contractor's expense. Staging, stockpiles, materials storage, and parking areas shall be limited to the areas shown for the east access and west access and shall not be allowed within 50 feet of wetlands or the river. The Contractor shall otherwise be required to make arrangements offsite.

Installation and of temporary coffer dams (for example, interlocking sheet pile) shall be constructed with clean materials to protect water quality and shall be designed to withstand scouring or undermining by rapidly flowing water. The coffer dams shall be constructed so as to minimize disruption of existing flow conditions.

Utilities shown on the plan sheets are plotted from the best available information. The Contractor's attention is directed to paragraph 105.10 of the Standard Specifications concerning utilities.

811

FOR BURIED UTILITY INFORMATION
THREE (3) BUSINESS DAYS
BEFORE YOU DIG
CALL 811
(or 1-800-922-1987)
UTILITY NOTIFICATION
CENTER OF COLORADO (UNCC)
www.uncc.org

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Print Date: 7/30/2009
File Name: 16689DES_GenlNote##.dgn
Horiz. Scale: N/A Vert. Scale: N/A
Unit Information: GJ DESIGN Unit Leader: JEB

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
606 South 9th Street
Grand Junction, CO 81501
Phone: 970-683-6351 FAX: 970-683-6369
Region 3 CLS

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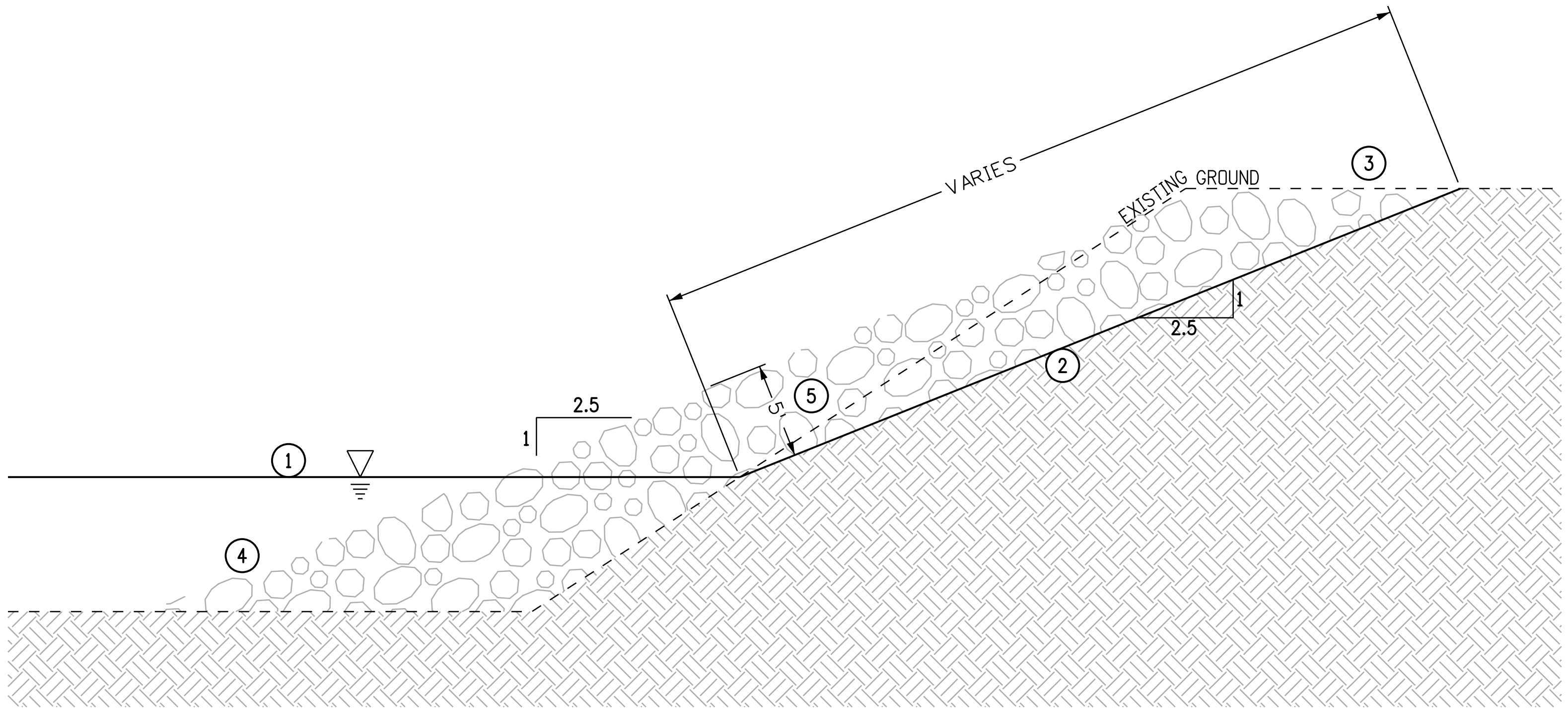
No Revisions:
Revised:
Void:

GENERAL NOTES
Designer: MHM
Detailer: MHM
Sheet Subset: Gen. Notes
Structure Numbers: G-04-BA
Subset Sheets: 2 of 2

Project No./Code
BR 0701-192
16689
Sheet Number 4



1. WATER SURFACE DURING CONSTRUCTION.
2. GRADE THE EXISTING BANK TO A 2.5H :1V SLOPE STARTING AT THE WATER SURFACE. EXCAVATED MATERIAL WILL BECOME THE PROPERTY OF THE CONTRACTOR AND MAY BE USED FOR OTHER ASPECTS OF THE CONSTRUCTION. EXCAVATED MATERIAL SHALL BE REMOVED FROM THE CONSTRUCTION SITE PRIOR TO PROJECT ACCEPTANCE.
3. RIPRAP SHALL NOT BE PLACED ABOVE THE NATURAL TOP OF EXISTING BANK ELEVATION.
4. RIPRAP SHALL BE PLACED BELOW THE WATER SURFACE AS DIRECTED BY THE ENGINEER TO PROVIDE SUITABLE SUPPORT FOR THE RIPRAP PLACED ABOVE THE WATER SURFACE.
5. RIPRAP SHALL BE PLACED IN A 5' LAYER NORMAL TO THE SLOPE. THE GRADATION SHALL BE AS FOLLOWS:

PAY ITEM	STONE SIZE d50[1] (INCHES)	% OF MATERIAL SMALLER THAN TYPICAL STONE[2]	TYPICAL STONE DIMENSIONS[3] (INCHES)	TYPICAL STONE WEIGHT[4] (POUNDS)
RIPRAP (SPECIAL)	30	100	48	5200
		50-70	36	2200
		35-50	30	1280
		2-10	12	85

1 d50 = NOMINAL STONE SIZE
2 BASED ON TYPICAL ROCK MASS
3 EQUIVALENT SPHERICAL DIAMETER
4 BASED ON A SPECIFIC GRAVITY = 2.5

SUMMARY OF QUANTITIES

ITEM NUMBER	DESCRIPTION	UNIT	TOTAL
506-00013	RIPRAP (SPECIAL)	TON	4,500

Know what's below. Call before you dig.

Print Date: 7/29/2009	
File Name: 16689DES_Riprap_Detail.dgn	
Horiz. Scale: 1:10	Vert. Scale: N/A
Unit Information: GJ DESIGN	Unit Leader: JEB

Sheet Revisions

Date:	Comments	Init.

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Void:

RIPRAP CROSS-SECTION DETAIL

Designer:	SG	Structure Numbers	G-04-BA
Detailer:	MHM		
Sheet Subset:		Subset Sheets:	

Project No./Code
BR 0701-192
16689
Sheet Number 5

INDEX			CONTRACT ITEM NO.	CONTRACT ITEM	UNIT	ROADWAY										STRUCTURES								PROJECT TOTALS	
BOOK	PAGE	SHEET				PLAN	AS CONST.									PLAN	AS CONST.							PLAN	AS CONST.
			201-00000	Clearing and Grubbing	L S	1																		1	
			202-00240	Removal of Asphalt Mat (Planing)	SY	530										1,878								2,408	
			202-00495	Removal of Portions of Present Structure	L S											1								1	
			202-00500	Removal of Portions of Present Structure	EACH											3								3	
			202-05150	Sandblasting	SF											2,454								2,454	
			203-00012	Unclassified Excavation (Complete In Place) (Special)	CY	200																		200	
			203-01500	Blading	HOUR	40																		40	
			206-01500	Cofferdam	L S	1																		1	
			208-00002	Erosion Log (12 Inch)	LF	500																		500	
			208-00045	Concrete Washout Structure	EACH	2																		2	
			208-00070	Stabilized Construction Entrance	EACH	2																		2	
			208-00206	Erosion Control Supervisor	DAY	100																		100	
			211-00100	Drilling Hole	LF											768								768	
			212-00006	Seeding (Native)	ACRE	1																		1	
			212-00022	Seeding (Riparian)	ACRE	0.45																		0.45	
			212-00032	Soil Conditioning	ACRE	1.45																		1.45	
			213-00002	Mulching (Weed Free Hay)	ACRE	1.45																		1.45	
			213-00061	Mulch Tackifier	LB	290																		290	
			214-00350	Deciduous Shrub (5 Gallon Container)	EACH	35																		35	
			403-34871	Hot Mix Asphalt (Grading SX) (100) (PG 76-28)	TON	60																		60	
			503-00060	Drilled Caisson (60 Inch)	LF											333								333	
			506-00013	Riprap (Special)	TON	4,500																		4,500	
			518-03000	Sawing and Sealing Bridge Joint	LF											168								168	
			519-03000	Thin Bonded Epoxy Overlay	SY											1,878								1,878	
			601-03040	Concrete Class D (Bridge)	CY											288								288	
			602-00020	Reinforcing Steel (Epoxy Coated)	LB											92,130								92,130	
			607-11525	Fence (Plastic)	LF	1,900																		1,900	
			617-00048	48 Inch Culvert Pipe	LF	40																		40	
			620-00002	Field Office (Class 2)	EACH	1																		1	
			620-00012	Field Laboratory (Class 2)	EACH	1																		1	
			620-00020	Sanitary Facility	EACH	2																		2	
			625-00000	Construction Surveying	L S	1																		1	

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Print Date: 7/21/2009
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Unit Information: GJ DESIGN Unit Leader Initials JEB

Sheet Revisions

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SUMMARY OF APPROXIMATE QUANTITIES

Designer: MHM
Detailer: CSM
Sheet Subset: SAQ
Structure Numbers
Subset Sheets: 1 OF 2

Project No./Code
BR 0701-192
16689
Sheet Number 6

INDEX			CONTRACT ITEM NO.	CONTRACT ITEM	UNIT	ROADWAY		STRUCTURES		PROJECT TOTALS	
BOOK	PAGE	SHEET				PLAN	AS CONST.	PLAN	AS CONST.	PLAN	AS CONST.
			626-00000	Mobilization	L S	1				1	
			627-00005	Epoxy Pavement Marking	GAL	4				4	
			627-01010	Preformed Plastic Pavement Marking (Type I)(Inlaid)	SF	50				50	
			630-00000	Flagging	HOUR	500				500	
			630-00007	Traffic Control Inspection	DAY	45				45	
			630-00012	Traffic Control Management	DAY	110				110	
			630-80336	Barricade (Type 3 M-B) (Temporary)	EACH	3				3	
			630-80341	Construction Traffic Sign (Panel Size A)	EACH	16				16	
			630-80342	Construction Traffic Sign (Panel Size B)	EACH	23				23	
			630-80343	Construction Traffic Sign (Panel Size C)	EACH	12				12	
			630-80358	Advance Warning Flashing or Sequencing Arrow Panel (C Type)	EACH	2				2	
			630-80359	Portable Message Sign Panel	DAY	155				155	
			630-80360	Drum Channelizing Device	EACH	20				20	
			630-80363	Drum Channelizing Device (With Light) (Flashing)	EACH	10				10	
			630-80390	Channelizing Device (Special)	EACH	60				60	
			630-85040	Impact Attenuator (Truck Mounted Attenuator) (Temporary)	EACH	1				1	
				FORCE ACCOUNT ==========							
			700-70010	F/A Minor Contract Revisions	F A	1				1	
			700-70011	F/A Partnering	F A	1				1	
			700-70016	F/A Fuel Cost Adjustment	F A	1				1	
			700-70021	F/A On-The-Job Trainee	HOUR	640				640	
			700-70022	F/A OJT Colorado Training Program	F A	1				1	
			700-70028	F/A ESB Program	F A	1				1	

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Unit Information: GJ DESIGN Unit Leader Initials JEB

Sheet Revisions		
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SUMMARY OF APPROXIMATE QUANTITIES

Designer: MHM
Detailer: CSM
Sheet Subset: SAQ
Structure Numbers
Subset Sheets: 2 OF 2

Project No./Code
BR 0701-192
16689
Sheet Number 7

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Unit Information: GJ DESIGN Unit Leader: JEB

Sheet Revisions		
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PLAN VIEW
OVERALL PROJECT SITE

Designer: MHM
Detailer: MHM
Sheet Subset:
Structure Numbers G-04-BA
Subset Sheets:

Project No./Code
BR 0701-192
16689
Sheet Number 8

LEGEND

RIGHT-OF-WAY

LIMITS OF DISTURBED AREA

WORK AREA INSIDE OF COFFER DAM

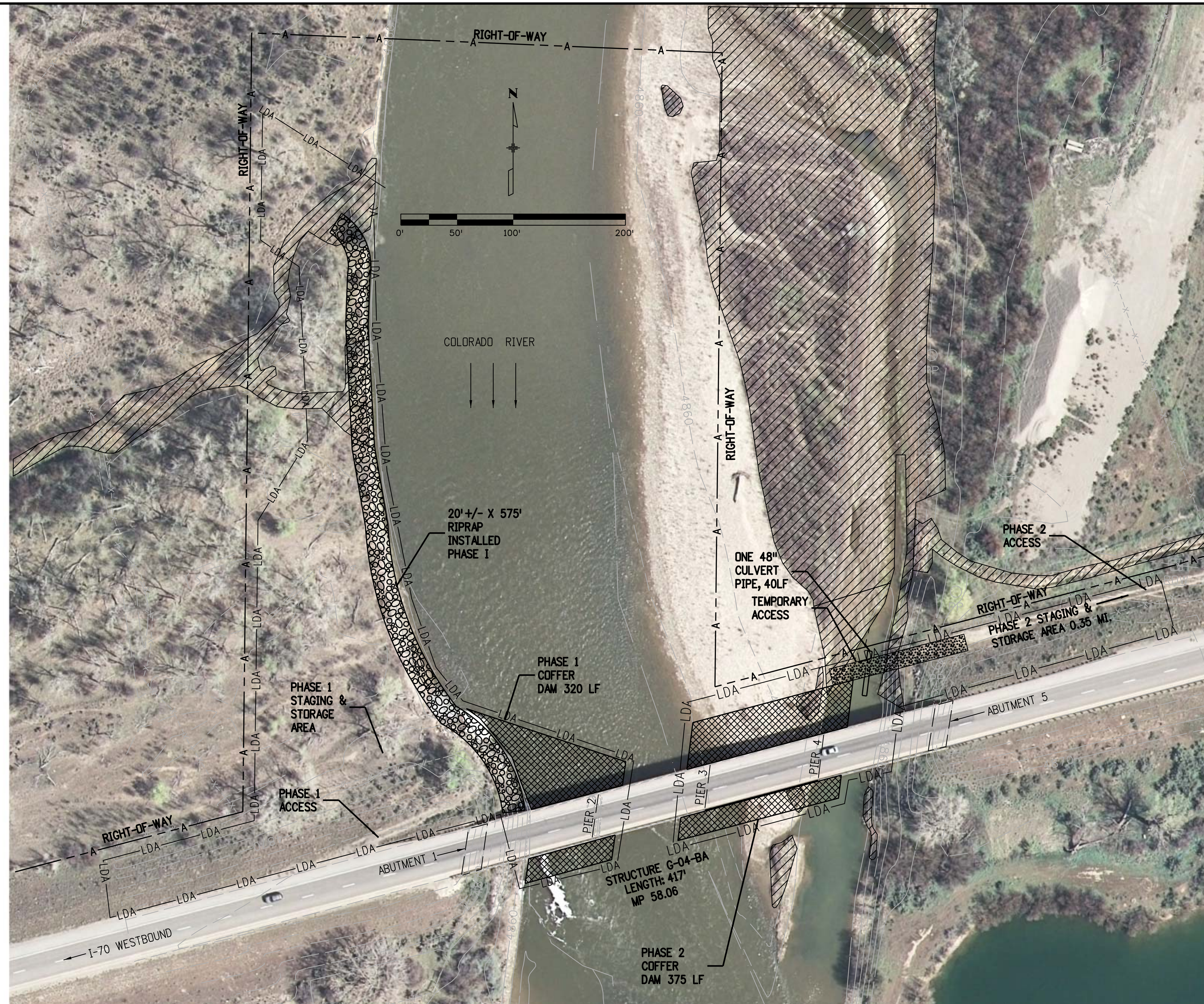
WETLANDS

TEMPORARY ACCESS ROAD

RIPRAP SPECIAL

NOTES:

1. TIE NEW RIPRAP INTO EXISTING RIPRAP ARMOR AT ABUTMENT 1.
2. 20' MIN. CLEAR WORK AREA AROUND EACH PIER INSIDE OF THE COFFER DAMS.
3. CONSTRUCTION FENCE SHALL BE INSTALLED AROUND THE PERIMETER OF THE LIMITS OF DISTURBED AREA EXCEPT WHERE THE COFFER DAM IS USED AS THE DISTURBED AREA BOUNDARY.
4. WORK IN PHASE 1, OTHER THAN REMOVAL OF PORTIONS OF PRESENT STRUCTURE (LS), SHALL BE COMPLETED FIRST, PRIOR TO BEGINNING ANY WORK ON THE COFFER DAM IN PHASE 2 OF THE PROJECT.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING COFFER DAM PLANS THAT HAVE BEEN STAMPED BY A COLORADO REGISTERED PROFESSIONAL ENGINEER.
6. COFFER DAMS SHALL BE INSTALLED, MAINTAINED, AND REMOVED IN ACCORDANCE WITH THE APPROVED PLANS.
7. THE CONTRACTOR SHALL PREPARE AND SUBMIT TO THE PROJECT ENGINEER A SITE SPECIFIC SAFETY PLAN FOR ALL WORK ON, AND WITHIN, THE COFFER DAMS PRIOR TO BEGINNING CONSTRUCTION.
8. NO CONSTRUCTION EQUIPMENT OR MATERIAL SHALL BE LEFT INSIDE OF THE COFFER DAM WHEN THERE IS NO WORK IN PROGRESS.
9. ONCE THE NEW PIER 2 COLUMNS AND CAP ARE IN PLACE AND HAVE ACHIEVED THE SPECIFIED DESIGN STRENGTH THE EXISTING PIER 2 STEM WALL, PILES, AND PILE CAP SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR AS DETAILED IN THE PLANS.
10. ALL MATERIAL PLACED IN THE RIVER CHANNEL, EXCEPT THE UNCLASSIFIED EXCAVATION (CIP)(SPECIAL), SHALL BE REMOVED TO ACHIEVE THE ORIGINAL RIVER BOTTOM PROFILE.



811 Know what's below. Call before you dig.

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Print Date: 7/29/2009
File Name: 16689DES_Plan01.dgn
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Unit Information: GJ DESIGN Unit Leader: JEB

Sheet Revisions		
Date:	Comments	Init.

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WORK AREA PLAN VIEW

Designer: MHM
Detailer: MHM
Sheet Subset:
Structure Numbers G-04-BA
Subset Sheets:

Project No./Code
BR 0701-192
16689
Sheet Number 9

N

0' 50' 100' 200'

LIMITS OF DISTURBED AREA ——LDA——LDA——

NOTES:

1. CONSTRUCTION FENCE SHALL BE INSTALLED AROUND THE PERIMETER OF THE LIMITS OF DISTURBED AREA (PHASE 2 STAGING AREA) EXCEPT FOR THE SMALL FRONTAGE ROAD WHICH LEADS TO THE PROJECT.

2. NO DIRECT ACCESS TO OR FROM I-70 TO THE PROJECT AREAS EAST OF THE COLORADO RIVER ARE ALLOWED.

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Print Date: 7/27/2009		
File Name: 16689DES_Plan01_Enviro_Limits_East.dgn		
Horiz. Scale: 1:100	Vert. Scale: N/A	
Unit Information: GJ DESIGN	Unit Leader: JEB	

Sheet Revisions		
Date:	Comments	Init.

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Region 3 CLS

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EAST ACCESS
STAGING & STORAGE AREA

Designer:	MHM	Structure Numbers	G-04-BA
Detailer:	MHM		
Sheet Subset:		Subset Sheets:	

Project No./Code
BR 0701-192
16689
Sheet Number 10

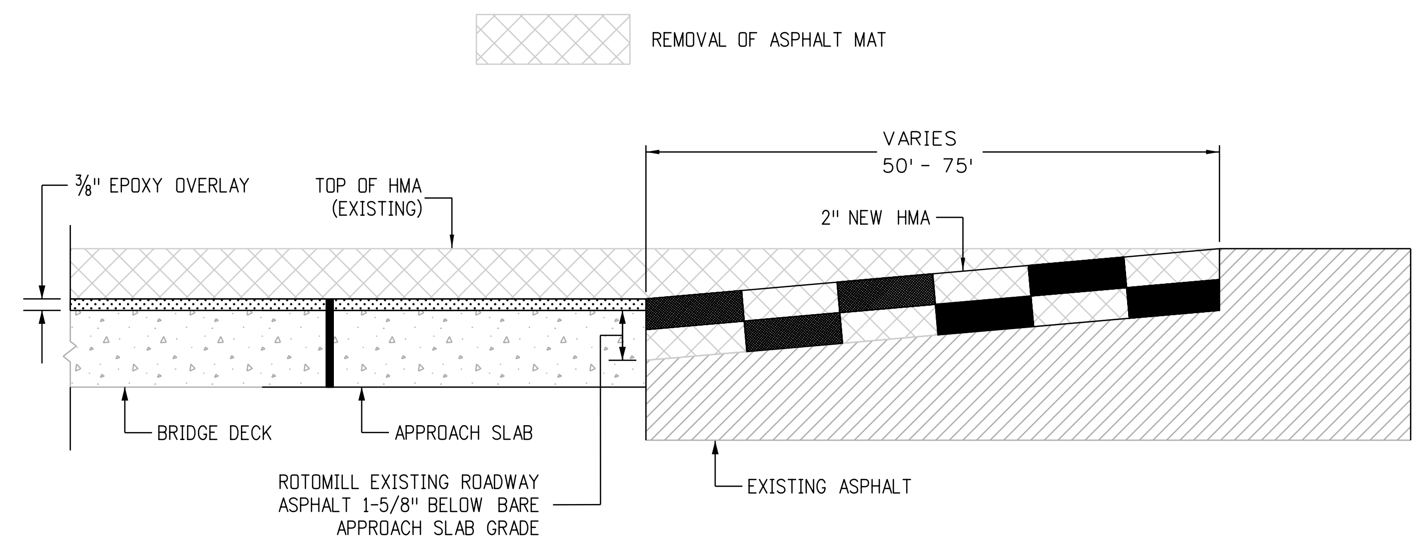
TABULATION OF BRIDGE TRANSITION RESURFACING

STRUCTURE	REMOVAL OF ASPHALT MAT (PLANING)		HOT MIX ASPHALT (GRADING SX)(100) (PG 76-28) 2 INCH DEPTH	
	SY		TON	
		As Built		As Built
G-04-BA (Westbound I-70)	530		60	
PROJECT TOTAL	530		60	

NOTES:

1. FOR BRIDGE DECK AND APPROACH SLAB QUANTITIES SEE BRIDGE PLAN SHEET "GENERAL INFORMATION SUMMARY OF QUANTITIES."
2. TAPER REMOVAL OF ASPHALT MAT AT BOTH APPROACHES TO THE BRIDGE AS SHOWN TO CREATE A 2" DEEP BUTT JOINT.
3. CONTRACTOR SHALL AVOID DAMAGE TO THE BRIDGE DECK ON STRUCTURE G-04-BA DURING PLANING OPERATIONS. DAMAGE TO THE DECK SHALL BE REPAIRED BY THE CONTRACTOR AT NO ADDITIONAL COST TO THE PROJECT.
4. MILLINGS SHALL BE REMOVED AND STOCKPILED AT THE CDOT MAINTENANCE YARD NEAR DEBEQUE AT NO ADDITIONAL COST TO THE PROJECT.

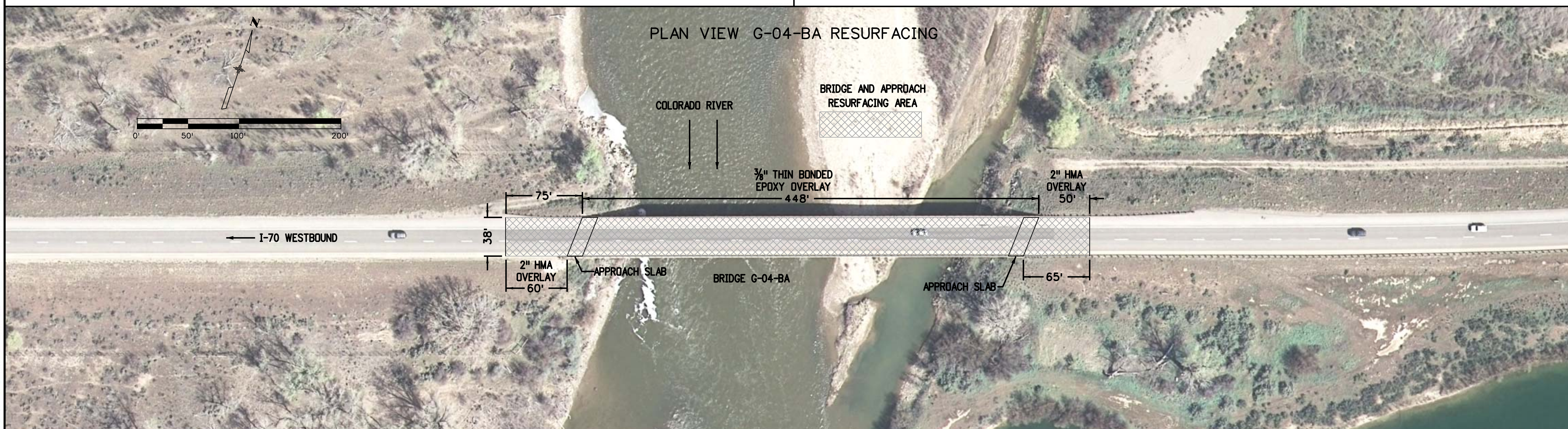
MILLING AND OVERLAY DETAIL



NOTES:

1. **DRAWING IS NOT TO SCALE.**
2. **DETAIL APPLIES TO BOTH THE EAST AND WEST APPROACHES TO THE BRIDGE.**

PLAN VIEW G-04-BA RESURFACING



Print Date: 7/29/2009		Sheet Revisions	
File Name: 16689DES_TabBridgeResurface.dgn		Date:	Comments	Init.
Horiz. Scale: 1:100	Vert. Scale: N/A		
Unit Information: GJ DESIGN	Unit Leader:JEB		

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Region 3 CLS

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TABULATION OF BRIDGE TRANSITION RESURFACING & PLAN VIEW

Designer:	MHM	Structure Numbers	G-04-BA
Detailer:	MHM		
Sheet Subset:		Subset Sheets:	

Project No./Code	
BR 0701-192	
16689	
Sheet Number	11

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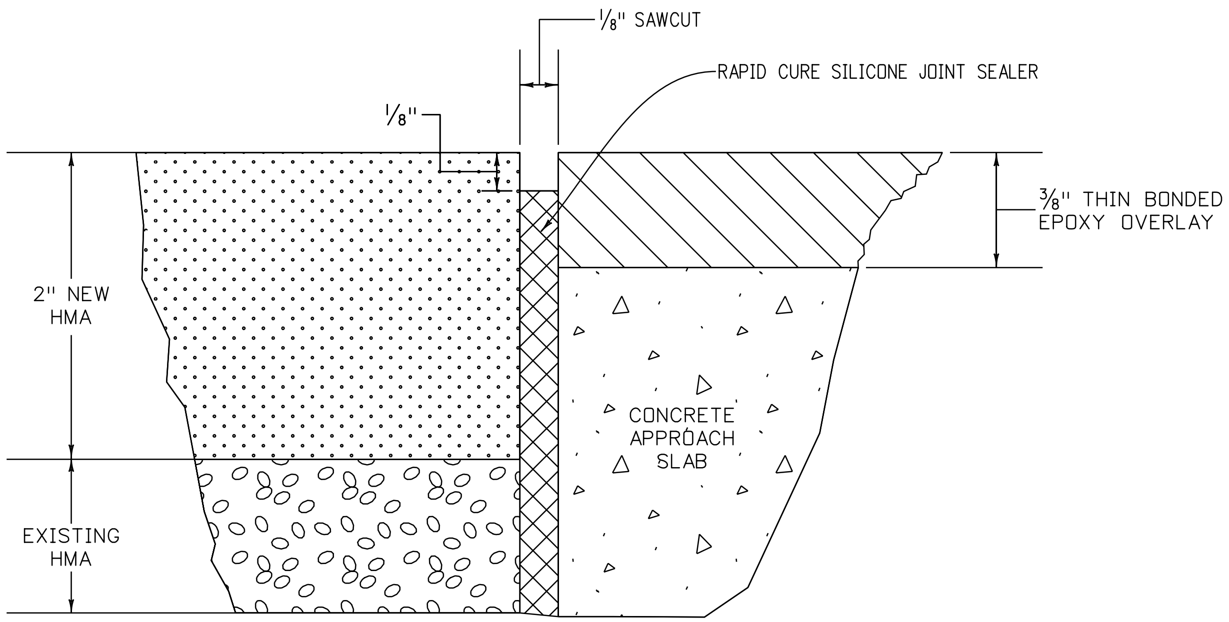


SAWCUT DETAIL

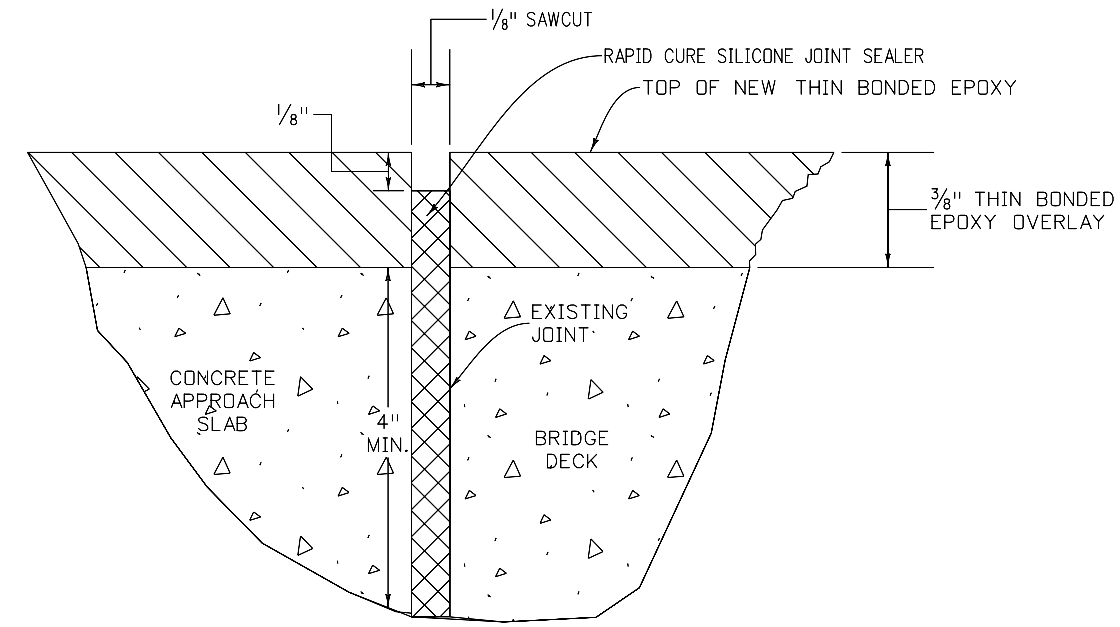
NOT TO SCALE

NOTES:

SAWCUT SHALL BE ALIGNED DIRECTLY ABOVE EXISTING JOINT.

SAWCUT SHALL PENETRATE THE FULL DEPTH OF ASPHALT.

THE COST OF THE ABOVE SHALL BE INCLUDED IN THE COST OF 518 ITEM SAWING AND SEALING BRIDGE JOINT.



SAWCUT DETAIL

NOT TO SCALE

NOTES:

SAWCUT SHALL BE ALIGNED DIRECTLY ABOVE EXISTING JOINT.

SAWCUT SHALL PENETRATE THE FULL DEPTH OF THIN BONDED EPOXY OVERLAY PLUS 4 INCHES.

THE COST OF THE ABOVE SHALL BE INCLUDED IN THE COST OF 518 ITEM SAWING AND SEALING BRIDGE JOINT.

Print Date: 7/30/2009	Sheet Revisions	Colorado Department of Transportation	As Constructed	Project No./Code
File Name: 16689_sawcut joint-detail.dgn	Date: / Comments / Init.	606 South 9th Street	No Revisions:	BR 0701-192
Horiz. Scale: N/A — Vert. Scale: N/A		Grand Junction, CO 81501	Revised:	16689
Unit Information: GJ DESIGN — Unit Leader: JEB		Phone: 970-683-6351 FAX: 970-683-6369	Void:	Sheet Number 12
		Region 3 — CLS		

JOINT DETAILS			
Designer:	A. HARAJLI	Structure Numbers	G-04-BA
Detailer:	A. HARAJLI		
Sheet Subset:	BRIDGE	Subset Sheets:	01 of 01

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GENERAL NOTES

Grade 60 reinforcing steel is required.

All reinforcing steel shall be epoxy coated unless otherwise noted.

Ⓝ denotes non coated reinforcing steel.

The following table gives the minimum lap splice length for epoxy coated reinforcing bars placed in accordance with Subsection 602.06. These splice lengths shall be increased by 25% for bars spaced at less than 6" on center.

Bar Size	#4	#5	#6	#7	#8	#9	#10	#11
Splice length for Class D concrete	1'-3"	1'-7"	2'-5"	2'-10"	3'-8"	4'-8"	5'-11"	7'-3"

When the Contractor elects to substitute epoxy coated reinforcement for black reinforcing bars, the minimum lap splice shall be as described above.

The following table gives the minimum lap splice length for black reinforcing bars placed in accordance with Subsection 602.06. These splice lengths shall be increased by 25% for bars spaced at less than 6" on center.

Bar Size	#4	#5	#6	#7	#8	#9	#10	#11
Splice length for Class D concrete	1'-1"	1'-4"	1'-7"	1'-11"	2'-6"	3'-1"	3'-11"	4'-10"

The above splice lengths shall be increased by 20 percent for 3 bar bundles and 33 percent for 4 bar bundles.

The above splice lengths may be reduced by 20% when 3" of clear cover exists and bar spacing is 6" or greater on center.

The Contractor shall be responsible for the stability of the structure during construction.

Stations, elevations, and dimensions contained in these plans are calculated from the "As Constructed Plans". These stations, elevations, and dimensions may be adjusted to meet the existing structure. The Contractor shall verify all dependent dimensions in the field before ordering or fabricating any material.

SUMMARY OF QUANTITIES

ITEM NO.	DESCRIPTION	UNIT	SUPER-STRUCTURE	PIER 2	PIER 3	PIER 4	TOTAL
202	REMOVAL OF ASPHALT MAT (PLANING)	SY	1878	0	0	0	1878
202	REMOVAL OF PORTIONS OF PRESENT STRUCTURE	LS		1	0	0	1
* 202	REMOVAL OF PORTIONS OF PRESENT STRUCTURE	EACH		1	1	1	3
202	SANDBLASTING	SQFT		818	818	818	2454
211	DRILLING HOLE	LF		256	256	256	768
503	DRILLED CAISSON (60 INCH)	LF		115	108	110	333
518	SAWING AND SEALING BRIDGE JOINT	LF	168	0	0	0	168
519	THIN BONDED EPOXY OVERLAY	SQYD	1,878	0	0	0	1,878
601	CONCRETE (CLASS D) (BRIDGE)	CUYD		96.0	96.0	96.0	288.0
602	REINFORCING STEEL (EPOXY COATED)	LB		30,710	30,710	30,710	92,130

* For the removal of portions of Armor plates.

INDEX OF DRAWINGS

DESIGN DATA

AASHTO, Fourth Edition LRFD with current interims

Design Method: Load and Resistance Factor Design

Live Load: HL-93 (design truck or tandem, and design lane load)
Dead Load: Assumes 36 lbs. per sq. ft. for bridge deck overlay
Widening Load: Includes a 12'-0" future widening Dead & Live Load.

Reinforced Concrete:

Class D Concrete: f'c = 4,500 psi
Reinforcing Steel: fy = 60,000 psi

Caisson Concrete:

Class BZ Concrete: f'c = 4,000 psi
Reinforcing Steel: fy = 60,000 psi

XX
BXX
Section or Detail Identification
Cross Reference Drawing Number
(if blank or dash, reference is to same sheet)

BRIDGE DESCRIPTION

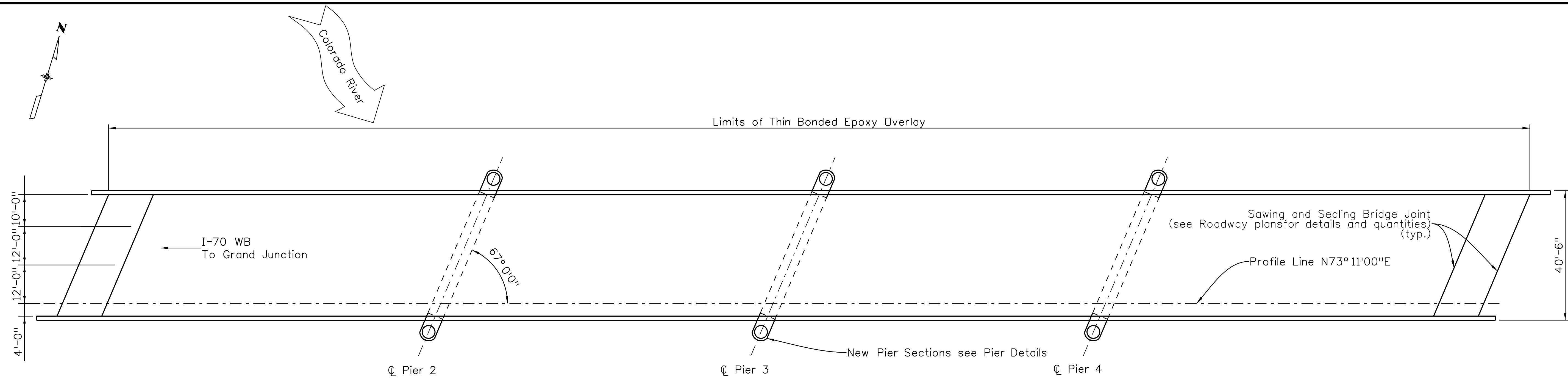
Pier repairs for an existing 4-span continuous concrete prestressed girder bridge over the Colorado River.

Deck width is 38'-0" curb to curb, skew is 67°.

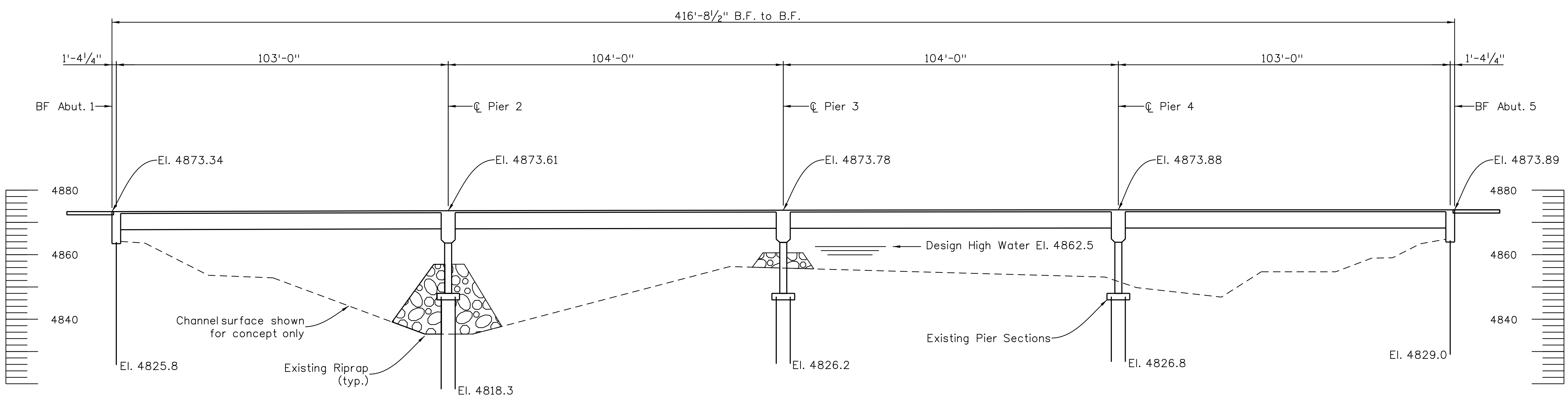
The work consists of :
Modifying existing pier caps and drilling new caissons outside of the limits of the bridge deck to mitigate scour damage.

Removal of a portion of existing pier 2 wall, footing and piling.

Replacing asphalt and membrane with Thin Bonded Epoxy Overlay.



PLAN



SECTION

(Taken at Profile Line)

Print Date: 7/27/2009		
File Name: G-04-BA(ALL models) (combined-working).dgn		
Horiz. Scale: 1:1	Vert. Scale: As Noted	R-X
Unit Information	Unit Leader Initials	

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
4201 East Arkansas Avenue
Room 107
Denver, CO 80222
Phone: 303-757-9193 FAX: 303-757-9197
Staff Bridge Branch BMF

As Constructed
No Revisions:
Revised:
Void:

GENERAL LAYOUT

Designer:	A. Harajli	Structure Numbers	G-04-BA
Detailer:	C. Jackson		
Sheet Subset:	BRIDGE	Subset Sheets:	B2 of 7

Project No./Code
BR0701-192
16689
Sheet Number 14

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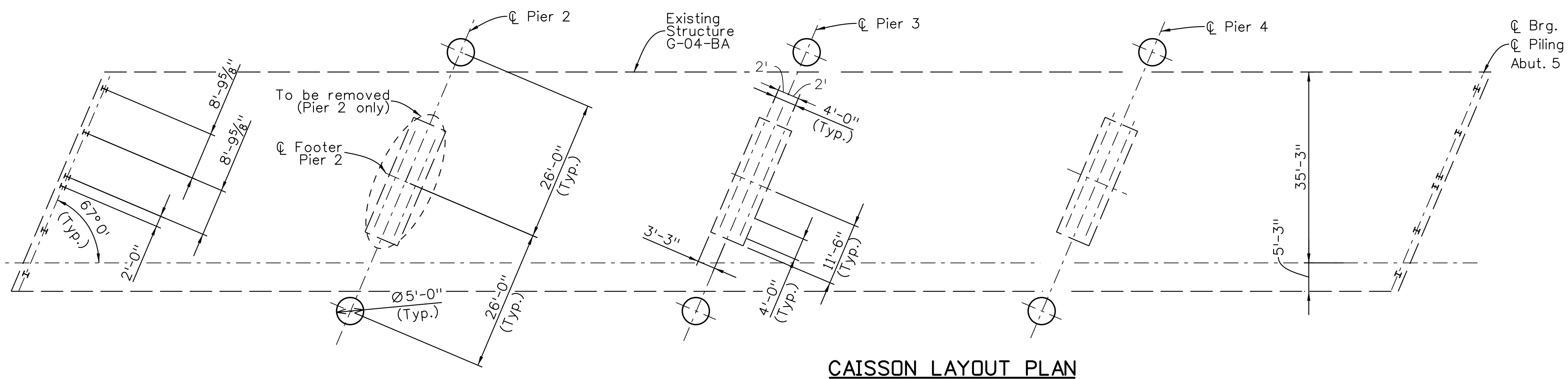
Revision Dates					(Preliminary Stage Only)		
3/99	4/99	11/99	5/00	4/02	6/04	2/06	3/07

	Design		Detail		Quantities	
	INITIAL	DATE	INITIAL	DATE	INITIAL	DATE
Designed By / Detailed By / Quantities By	AAH	05/09	CJ	05/09	C J	06/09
Checked By	C J	06/09	BF	05/09	H K	06/09



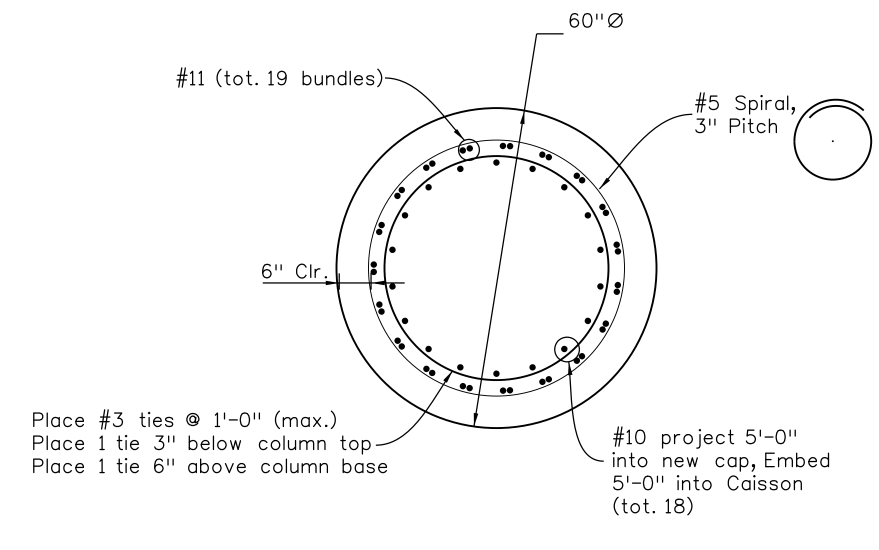
CAISSON LAYOUT PLAN

Not to scale

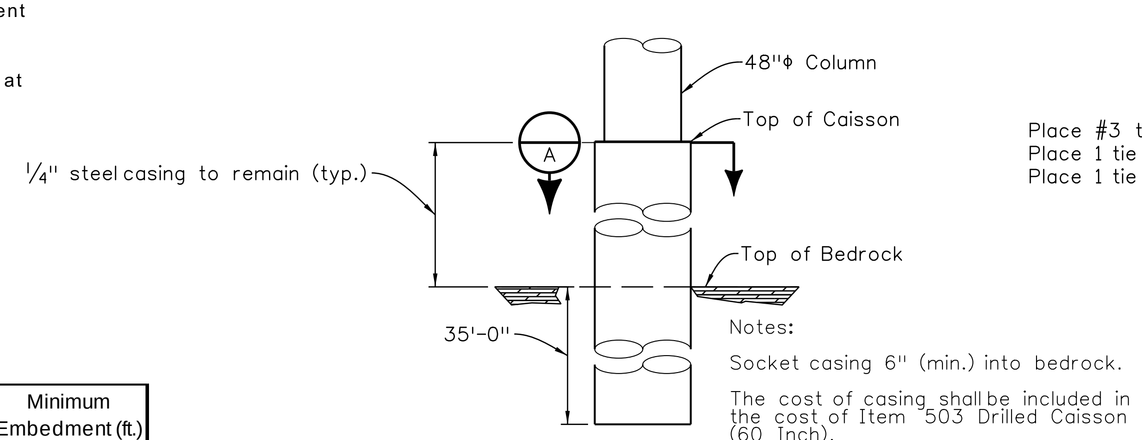
NOTES:

1. Caisson capacities are based upon a performance factor of 0.5 and a load factor of approximately 1.5.

2. Competent bedrock elevations were estimated in accordance with generally accepted geotechnical engineering practice. The elevation at which competent bedrock exists may not become evident until caissons are drilled. On-site observation of the drilling and bearing strata by a representative of the CDOT geotechnical branch will be provided to determine the exact elevation at which the competent bedrock exists.



SECTION-A



DRILLED CAISSON ELEVATION

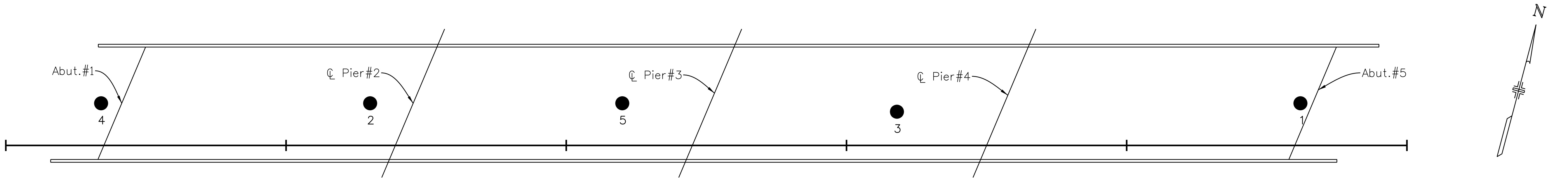
Reinforcing not shown for clarity

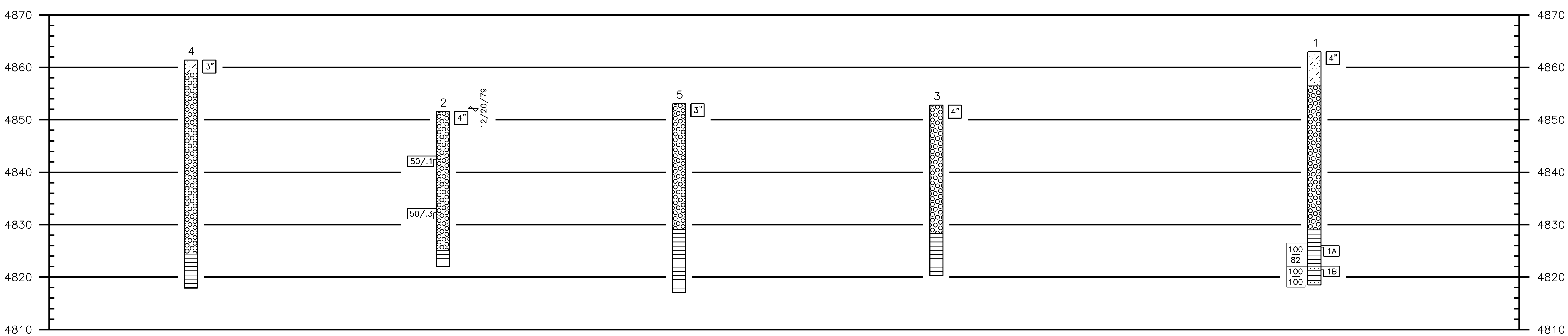
Pier Location	Factored Load (kips)	Allowable Load (kips)	Estimated Tip Elevation	Caisson Size (in.)	Estimated Bedrock Elevation	Minimum Embedment (ft.)
2	2,370	1,550	4,790	60	4,825	35
3	2,370	1,550	4,794	60	4,829	35
4	2,370	1,550	4,793	60	4,828	35

Print Date: 7/27/2009	Sheet Revisions	Colorado Department of Transportation	As Constructed	CAISSON LAYOUT
Drawing File Name: G-04-BA(ALL models) (combined-working).dgn	Date: / Comments / Init.	4201 East Arkansas Avenue, Room 107, Denver, CO 80222	No Revisions:	Project No./Code: BR 0701-192
Horiz. Scale: NTS / Vert. Scale: NTS		Phone: 303-757-9193 FAX: 303-757-9197	Revised:	Designer: A. Harajli / Structure Numbers: G-04-BA / 16689
Unit 230 / Unit Leader BMF		Staff Bridge Branch BMF	Void:	Detailer: T. Edwards
				Sheet Subset: Bridge / Subset Sheets: B03 of 7 / Sheet Number 15

Design	INITIAL	DATE	Detail	INITIAL	DATE	Quantities	INITIAL	DATE
Designed By	AAH	05/09	Detailed By	TDE	05/09	Quantities By	C J	06/09
Checked By	C J	06/09	Checked By	AAH	05/09	Checked By	H K	06/09

Revision Dates (Preliminary Stage Only): 3/99, 4/99, 11/99, 5/00, 4/02, 6/04, 2/06, 3/07





This geology sheet is a reproduction of the geology sheet produced for the original bridge foundation investigation memo dated March 4, 1980.

The boring logs of the above test holes and geotechnical report are on file in the Geotechnical Program Office, Staff Materials and Geotechnical Branch, (303)398-6601

SUMMARY OF TEST RESULTS

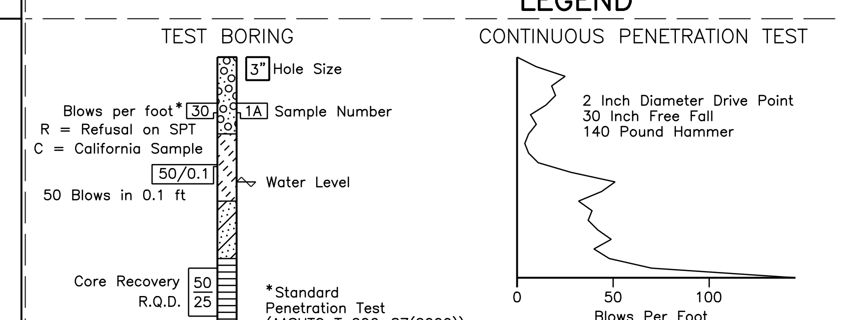
Sample Number	Depth (feet)	Classification: Corps of Engrs. or Visual	Classification: USCS	Classification: AASHTO	Grading Analysis (AASHTO) Percent: Gravel	Coarse Sand	Fine Sand	Silt and Clay	Atterberg Limits: L.L. L_W	P.L. P_W	P.I. I_W	Water Content W %	Wet Unit Weight P.C.F.	Unconfined Strength Q_u T.S.F.
1A	37.0–37.3	Shale											145.8	796.6
1B	40.9–41.6	Sandstone											144.2	469.2

TYPE OF MATERIAL

- Silty Sand
- Sandy Gravel with Cobbles and Boulders
- Shale
- Sandstone

Note: Boulders may be encountered at any depth

LEGEND



- Location of Test Boring
- Location of Continuous Penetration Test
- 3 Inch Wireline Boring
- Rotary Boring
- Auger Boring

Revision Dates (Preliminary Stage Only)		
Quantities	Initial	Date
Quantities By	C J	06/09
Checked By	H K	06/09
Detail	Initial	Date
Detailed By	TDE	05/09
Checked By	AAH	05/09
Design	Initial	Date
Designed By	AAH	05/09
Checked By	C J	06/09

Print Date: 7/28/2009
Drawing File Name: G-04-BA(ALL models) (combined-working).dgn
Horiz. Scale: 1:1 Vert. Scale: As Noted
Staff Geotechnical Program HCL

R-X

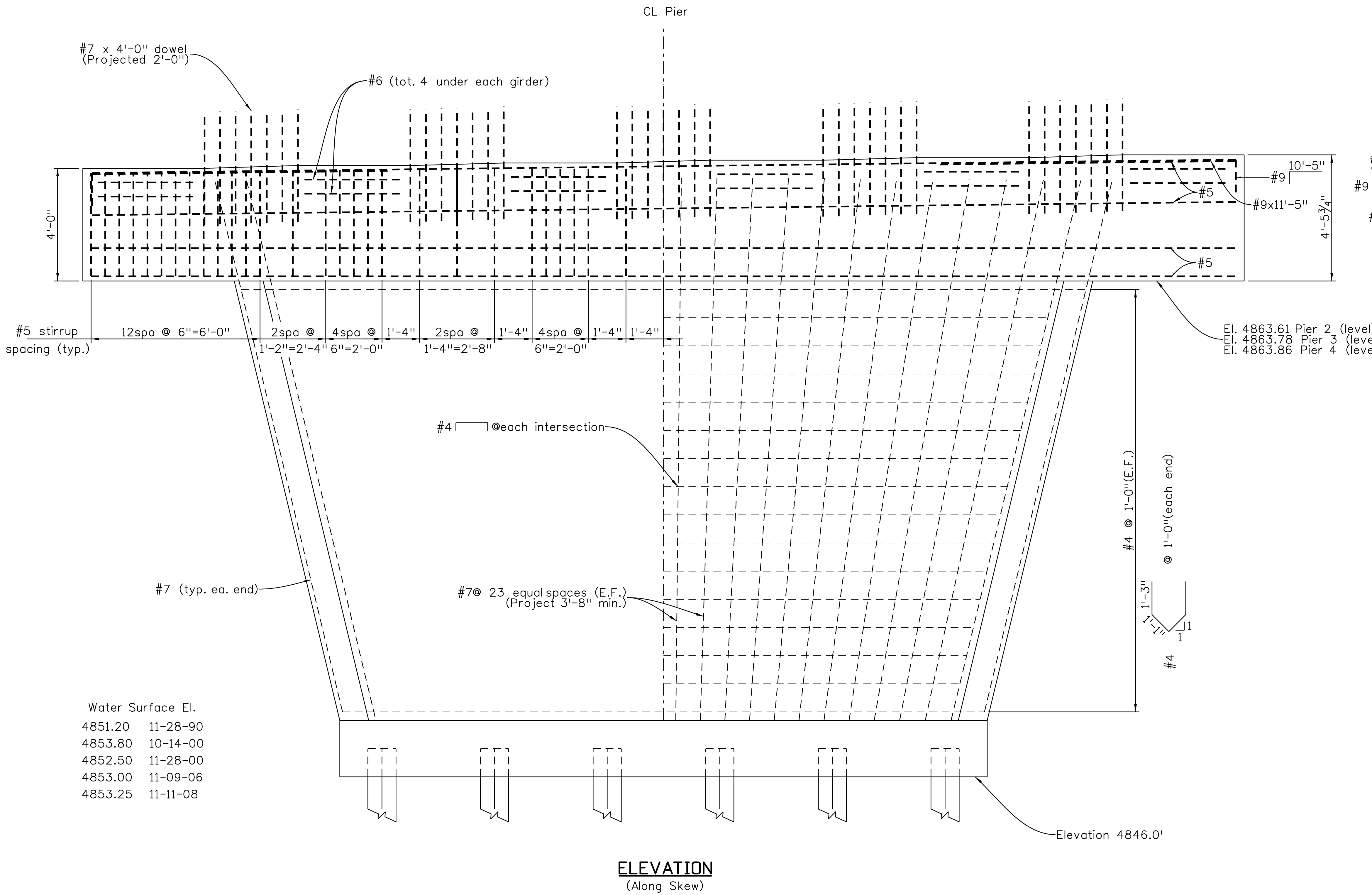
Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
DOT — DEPARTMENT OF TRANSPORTATION
4670 Holly Street, Unit A
Denver, CO 80216
Phone: 303-398-6601 FAX: 303-398-6504
Staff Geotechnical Program BMF

As Constructed
No Revisions:
Revised:
Void:

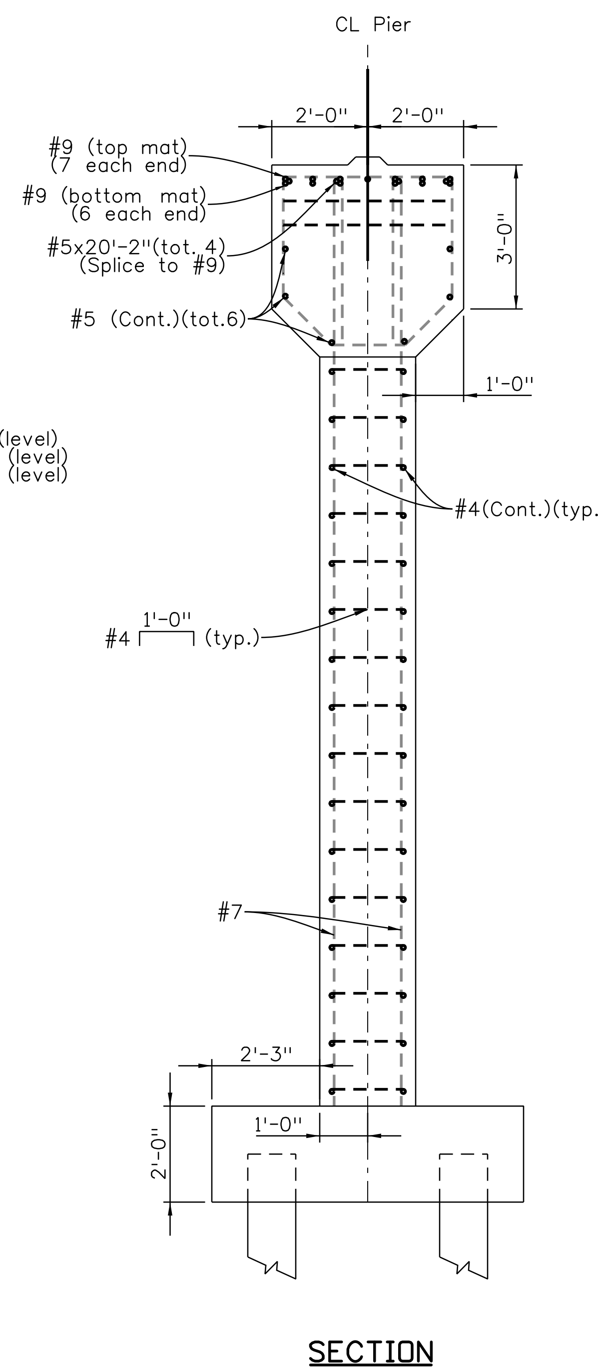
ENGINEERING GEOLOGY
Designer: L. Bong
Detailer: T. McNulty
Sheet Subset: Geology
Structure Numbers: G-04-BA
Subset Sheets: B04 of 7

Project No./Code
BR 0701-192
16689
Sheet Number 16



Water Surface El.

4851.20	11-28-90
4853.80	10-14-00
4852.50	11-28-00
4853.00	11-09-06
4853.25	11-11-08



Note:
For clarity, pile cap reinforcing not shown

Print Date: 7/27/2009	
File Name: G-04-BA(ALL models) (combined-working).dgn	
Horiz. Scale: 1:1	Vert. Scale: As Noted
Unit Information	Unit Leader Initials

Sheet Revisions

Date:	Comments	Init.
R-X		

Colorado Department of Transportation
4201 East Arkansas Avenue
Room 107
Denver, CO 80222
Phone: 303-757-9193 FAX: 303-757-9197
Staff Bridge Branch BMF

As Constructed

No Revisions:

Revised:

Void:

PIER DETAILS (EXISTING)

Designer:	A. Harajli	Structure Numbers	G-04-BA
Detailer:	C. Jackson		
Sheet Subset:	BRIDGE	Subset Sheets:	B5 of 7

Project No./Code
BR0701-192
16689
Sheet Number 17

Design	INITIAL	DATE
Designed By	AAH	05/09
Checked By	C J	06/09

Detail	INITIAL	DATE
Detailed By	TOE	05/09
Checked By	AAH	05/09

Quantities	INITIAL	DATE
Quantities By	C J	06/09
Checked By	H K	06/09

Revision Dates (Preliminary Stage Only)

3/99	4/99	11/99	5/00	4/02	6/04	2/06	3/07

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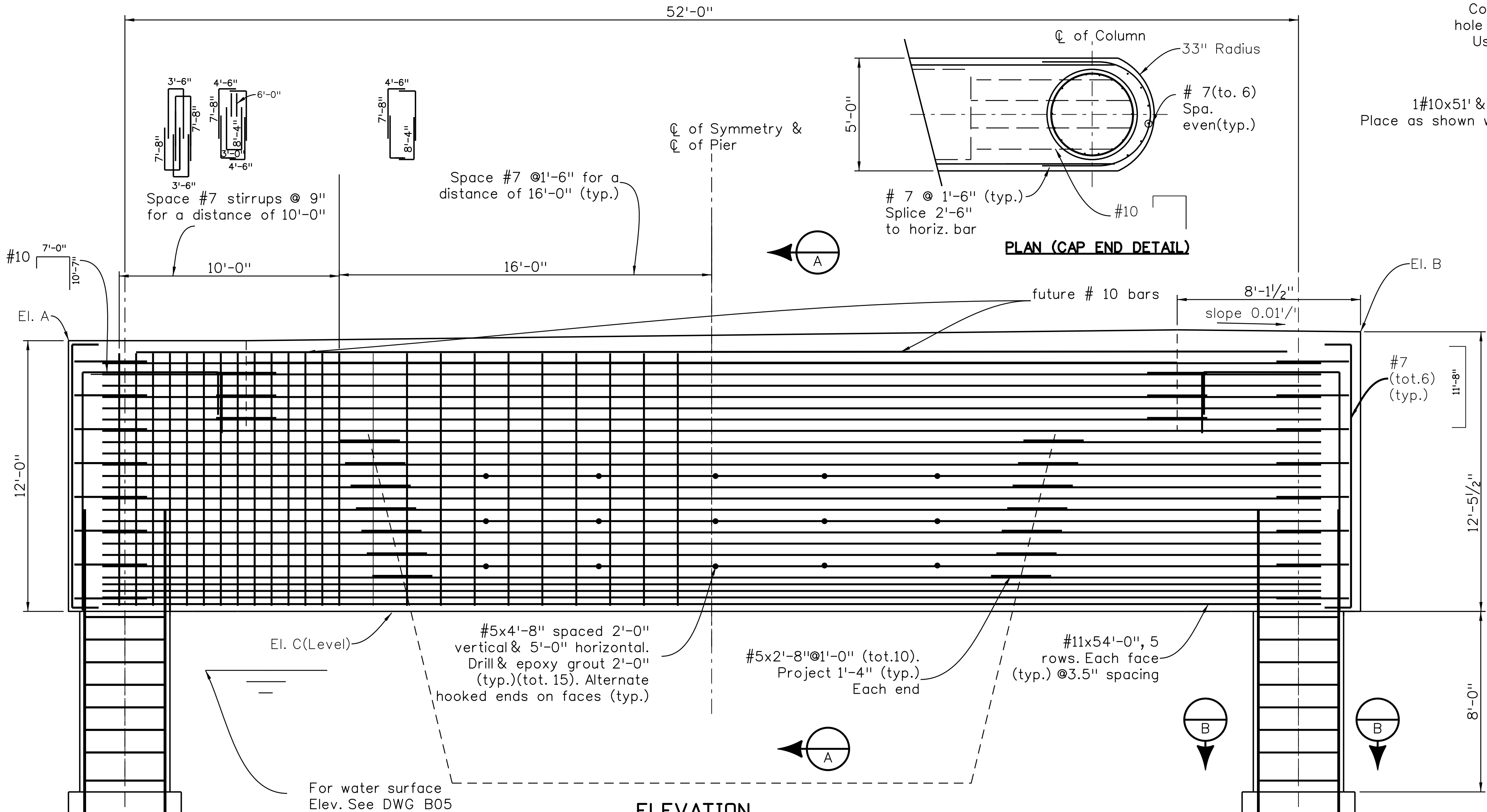

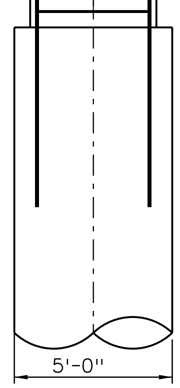

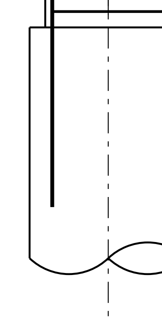

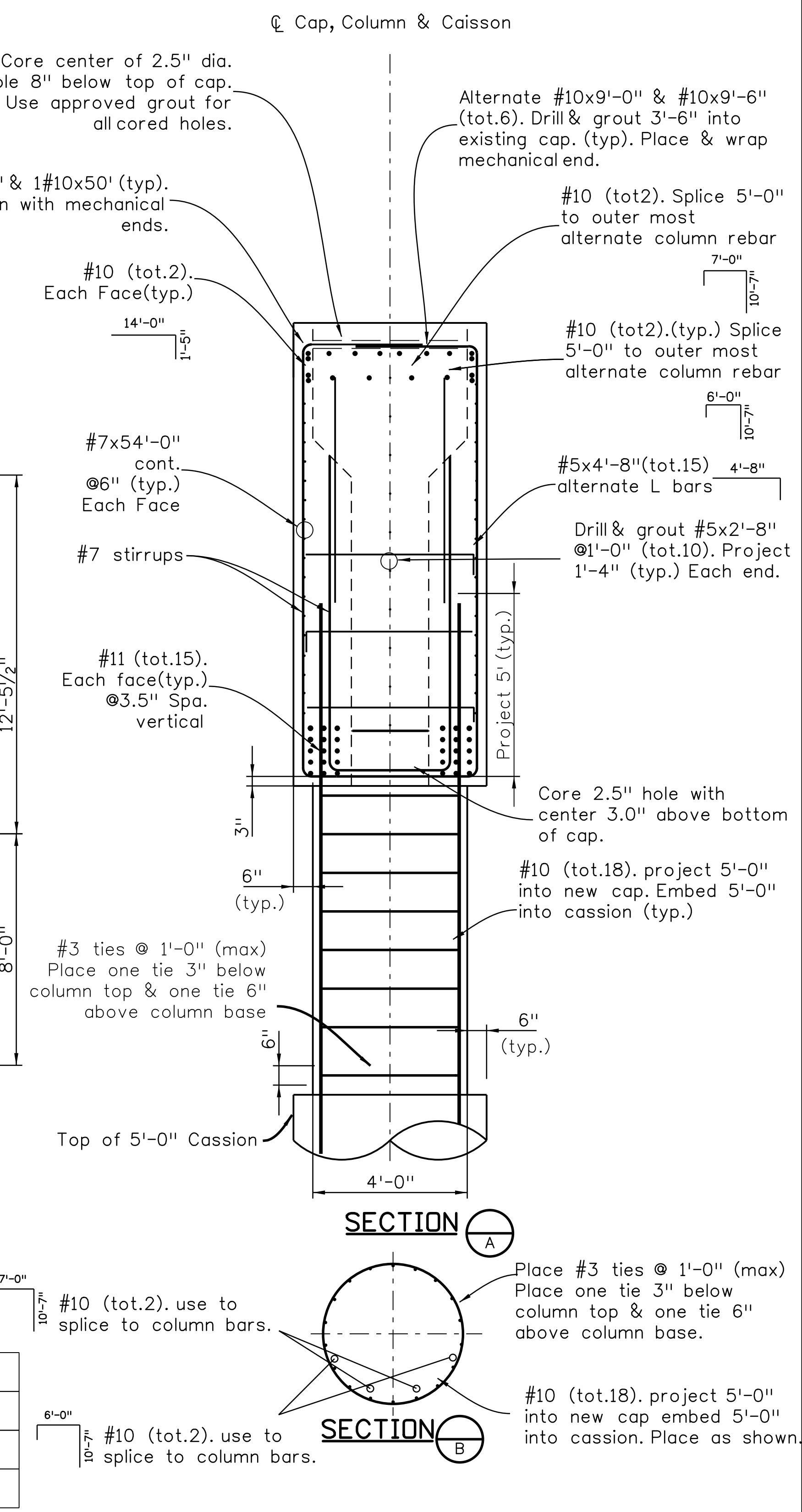

Note:

- The contractor shall use CDOT approved epoxies or non-shrink grouts for any drilled or cored holes.
- Contractor shall avoid drilling through existing rebar when possible. Any damaged rebar shall be repaired at the contractor's expense. New rebar can be moved slightly to facilitate drilling new holes.
- All drilled & epoxied holes shall be 1/8" larger in diameter than diameter of the bar. This work will be paid under Item 211 Drilling Hole.
- Roughen all surfaces in contact with newly placed concrete to an amplitude of 1/4". New concrete shall be placed on a dry existing surface. Do not wet existing concrete surfaces before placing new concrete.
- Remove portions of existing armor plate on the upstream side of all pier walls to facilitate hole drilling (typ.).
- After Pier#2 new cap has attained 28 day strength, saw cut existing concrete pier wall and remove portion of remaining existing wall, footing and piling. Piling shall be removed down to the elevation of natural stream bottom or the existing scourelevation whichever is lower or as directed by the engineer. All cut existing rebar shall be burned 1/2" below concrete surface. Fill holes with a CDOT approved epoxy.

Pier	El. A	El. B	El. C
2	67.498	68.121	55.498
3	67.668	68.301	55.668
4	67.748	68.391	55.748

Revision Dates (Preliminary Stage Only)							
3/99	4/99	11/99	5/00	4/02	6/04	2/06	3/07

	Design INITIAL	DATE		Detail INITIAL	DATE		Quantities INITIAL	DATE
Designed By	AAH	05/09	Detailed By	TOE	05/09	Quantities By	C J	06/09
Checked By	C J	06/09	Checked By	AAH	05/09	Checked By	H K	06/09

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Print Date: 7/28/2009
File Name: G-04-BA(ALL models) (combined-working).dgn
Horiz. Scale: 1:1.01271 Vert. Scale: As Noted
Unit Information Unit Leader Initials

R-X

Sheet Revisions		
Date:	Comments	Init.

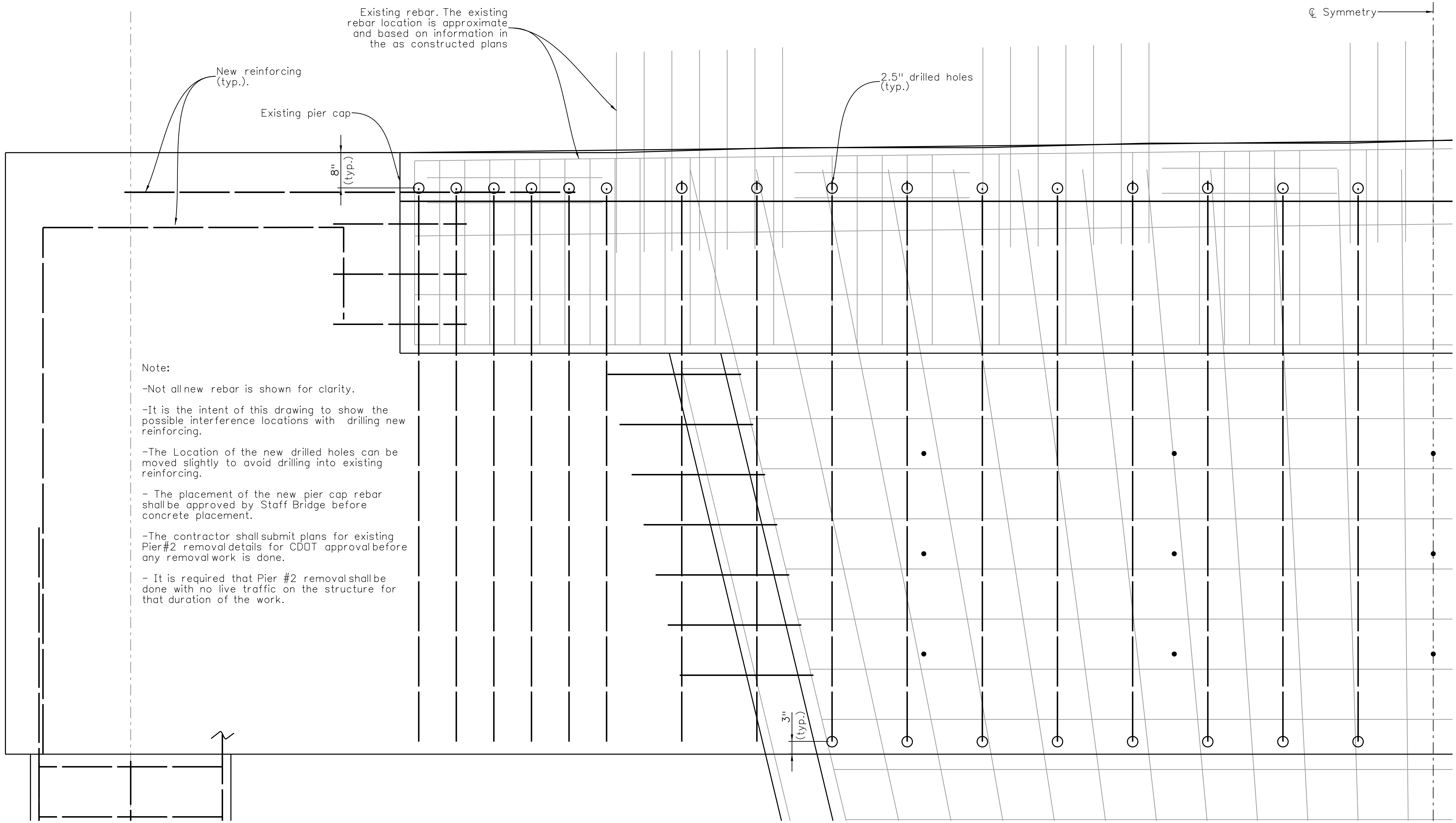
Colorado Department of Transportation
4201 East Arkansas Avenue
Room 107
Denver, CO 80222
Phone: 303-757-9193 FAX: 303-757-9197
Staff Bridge Branch BMF

As Constructed
No Revisions:
Revised:
Void:

PIER DETAILS (NEW)

Designer: A. Harajli
Detailer: H. Kayhan
Sheet Subset: BRIDGE
Structure Numbers: G-04-BA
Subset Sheets: B6 of 7

Project No./Code
BR0701-192
16689
Sheet Number 18



Note:

-Not all new rebar is shown for clarity.

-It is the intent of this drawing to show the possible interference locations with drilling new reinforcing.

-The Location of the new drilled holes can be moved slightly to avoid drilling into existing reinforcing.

- The placement of the new pier cap rebar shall be approved by Staff Bridge before concrete placement.

-The contractor shall submit plans for existing Pier#2 removal details for CDOT approval before any removal work is done.

- It is required that Pier #2 removal shall be done with no live traffic on the structure for that duration of the work.

ELEVATION (EXISTING & NEW)

Revision Dates					(Preliminary Stage Only)		
3/99	4/99	11/99	5/00	4/02	6/04	2/06	3/07

Design	INITIAL	DATE	Detail	INITIAL	DATE	Quantities	INITIAL	DATE
Designed By	AAH	05/09	Detailed By	TOE	05/09	Quantities By	C J	06/09
Checked By	C J	06/09	Checked By	AAH	05/09	Checked By	H K	06/09

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Print Date: 7/28/2009
File Name: G-04-BA(ALL models) (combined-working).dgn
Horiz. Scale: 1:1.01271 Vert. Scale: As Noted
Unit Information Unit Leader Initials

R-X

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
4201 East Arkansas Avenue
Room 107
Denver, CO 80222
Phone: 303-757-9193 FAX: 303-757-9197
Staff Bridge Branch BMF

As Constructed
No Revisions:
Revised:
Void:

PIER DETAILS
(EXISTING AND NEW)

Designer:	A. Harajli	Structure Numbers	G-04-BA
Detailer:	A. Harajli		
Sheet Subset:	BRIDGE	Subset Sheets:	B7 of 7

Project No./Code
BR0701-192
16689
Sheet Number 19

Colorado Department of Transportation
222 South 6th Street
Room 317
Grand Junction, CO 81501
Phone: 970-683-6234 FAX: 970-683-6249
Region 3 LED

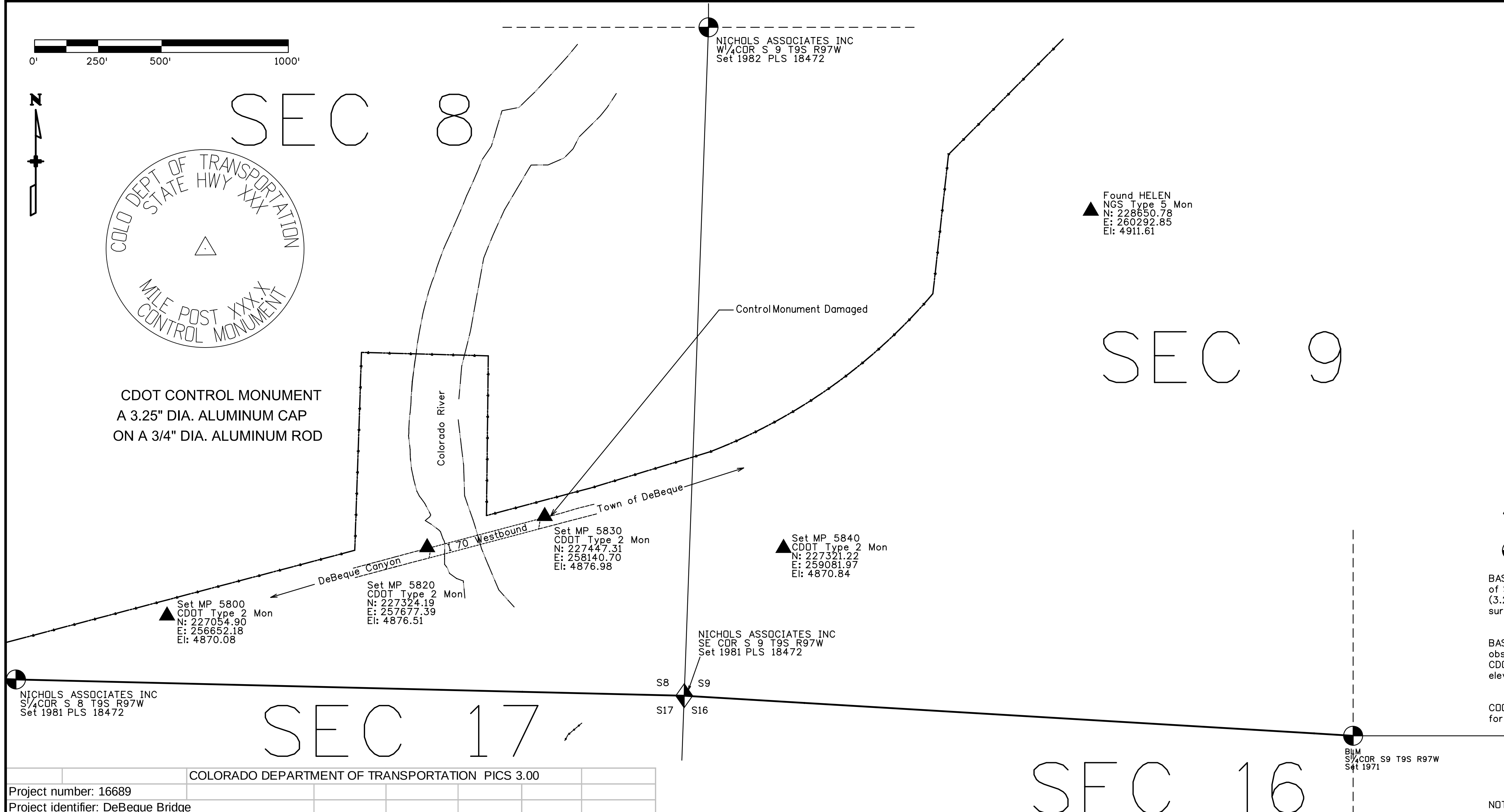
Sheet Revisions		
Date	Description	Initials

Interstate 70 Westbound MP 57.56 to 59.14
Located in
Section 8, TOWNSHIP 9 SOUTH, RANGE 97 WEST
6th PRINCIPLE MERIDIAN
MESA COUNTY, COLORADO

Project Control Diagram
Title Sheet

Project Number: BR 0701-192
Project Location: I-70 Westbound Entering DeBeque Canyon
Project Location: South of DeBeque, Mesa County Colorado

Project Code:	Last Mod. Date	Subset Sheets	Sheet No.	Total No. of Sheets
16689	07-30-2009		20	1



Construction Surveying and Monumentation Requirements

1. This Project Control Diagram represents the horizontal and vertical control for the project established by the Division. It is possible that some of the survey control monuments listed have been disturbed or obliterated. It is the Contractor's responsibility to verify the existence and stability of the control monuments before submitting a bid price.

2. All Type 1 and Type 2 monuments shall be set flush with the ground. Witness posts shall be installed 1 foot from and facing all Type 1 and Type 2 monuments, or as directed by the Project Engineer.

3. Installation of Type 3 and Type 3-A monuments shall be completed in the same day that installation is commenced. Under no circumstances shall holes in the roadway be left open overnight.

4. When installing Type 3-A monuments, the aluminum monument box shall be positively secured in the roadway surface. The monument box shall be caulked with asphalt caulking between the monument box and the edges of the roadway surface to provide a positive moisture barrier around the monument box.

5. Control survey procedures, statistical analysis, and accuracy obtained for horizontal and vertical control shall be documented in the field book.

6. Legible copies of the field books shall be submitted to the Project Engineer for review on a monthly basis.

7. It is ultimately the prime Contractors responsibility to insure that these requirements, as well as any contained in the CDOT specifications, project special provisions, and CDOT Survey Manual are fulfilled under this contract.

8. The minimum staking intervals for each item are described on the plans or in the CDOT Survey Manual. If the contractor wishes to reduce the minimum intervals, a Contract Modification Order must be negotiated and the cost of the item reduced accordingly.

9. Whenever the contract includes the setting of CDOT Type 2 monuments, a Project Control Diagram, signed and sealed by the P.L.S. in responsible charge, shall be submitted to the Project Engineer.

Section Corner

Quarter Corner

BASIS OF BEARINGS: Bearings in the calculations of coordinates are based on a grid bearing of S42°19'31"W from the NGS HARN Point Helen (3.25" Brass NGS Cap) to CDOT MP5840 (3.25" CDOT Control Point Aluminum Cap) as obtained from a Global Positioning System (GPS) survey based on the Colorado High Accuracy Reference Network (CHARN).

BASIS OF ELEVATIONS: An elevation of 4870.837 feet for MP 5840 was obtained by GPS observation and being on the North American Vertical Datum of 1988(NAVD 88). It is a CDOT Type 5 Monument that was set on DeBeque Bridge. The other control point elevations were derived by differential leveling from MP 5840.

COORDINATE DATUM: Coordinates on this project are for the exclusive use of the CDOT for the construction of this project and are considered Project Coordinates only.

CP - Control Point Monuments set by CDOT. They were CDOT type 2 monuments, a 3-1/4" dia. aluminum control monument cap (as shown) on a 3' X¾" dia. finned aluminum security rod on a 3' X¾" dia. smooth aluminum rod.

NOTE: This control survey is for the use of the CDOT personnel. The survey is not a complete Boundary Survey. Title Policy, Title Commitment, and Title Research were not part of this control survey, therefore, easements, rights of way, property boundaries, and restriction, as described in the instruments of record, were not included in this control survey.

NOTE: According to Colorado law you must commence any legal action based upon any defect in this survey within three years after you first discover such defect. In no event may any action based upon any defect in this survey be commenced more than ten years from the date of the statement shown.

NOTE: No guarantee as to the accuracy of the information contained on the attached drawing is either stated or implied unless this copy bears an original signature of the professional land surveyor hereon named.

SURVEYOR STATEMENT (PROJECT CONTROL DIAGRAM)

I, Leslie E. Doehling, a professional land surveyor licensed in the State of Colorado, do hereby state to the Colorado Department of Transportation this Project Control Diagram was prepared and the field survey it represents was performed under my responsible charge and, based upon my knowledge, information and belief is in accordance with applicable standards of practice defined by Colorado Department of Transportation publications. This statement is not a guaranty or warranty, either expressed or implied.

Leslie E. Doehling PLS No. 31551 — *Date*

	COLORADO DEPARTMENT OF TRANSPORTATION PICS 3.00						
Project number: 16689							
Project identifier: DeBeque Bridge							
Route I70, from MP 57.56 to MP 59.14							
Project Latitude	39.165596		Scale Factor		0.999941		
Project Longitude	108.140555		Combined Factor		0.999708		
Project Elevation	1486.5060m		Northing Reduction		400000		
Zone	Colorado Central		Easting Reduction		600000		
Units are METERS.							
To get from Modified to State Plane: add Reduction amount then Multiply by the Combined Factor							
Geodetic State Plane Coordinates							
GPS file C:\Trimble Geomatics Office\Projects\12-2-02-2nd\Export\12-2-02-3rd.gps							
Pnt#	Latitude	Longitude	SP Northing	SP Easting	Elip Elev	Grnd Elev	Description
MCCARY	39ø 22' 27.10216" N	108ø 09' 44.37283" W	479210.120	685038.750	1561.000	1577.262	MCCARY
HELEN	39ø 17' 08.48947" N	108ø 13' 38.65738" W	469555.594	679138.832	1480.620	1497.061	HELEN
5840	39ø 16' 54.99827" N	108ø 13' 53.53869" W	469150.463	678769.864	1468.187	1484.634	5840
5830	39ø 16' 55.96387" N	108ø 14' 05.54932" W	469188.885	678483.048	1470.058	1486.506	5830
5820	39ø 16' 54.60999" N	108ø 14' 11.39024" W	469151.368	678341.873	1469.911	1486.364	5820
5800	39ø 16' 51.64498" N	108ø 14' 24.31615" W	469069.313	678029.477	1467.951	1484.403	5800
LARRY	39ø 11' 53.77180" N	108ø 16' 00.62436" W	459957.997	675442.701	1466.180	1482.623	LARRY

Modified Project Coordinates (FEET)						Modified Project Coordinates (METERS)					
Point Name	Northing	Easting	Elevation	Mon Type		Pnt#	Northing	Easting	Elevation	Mon Type	
5800	227054.90	256652.18	4870.08	CDOT TYPE II Monument		5800	69206.47	78227.74	1484.40	CDOT TYPE II Monument	
5820	227324.19	257677.39	4876.51	CDOT TYPE II Monument		5820	69288.55	78540.23	1486.36	CDOT TYPE II Monument	
5830	227447.31	258140.70	4876.98	CDOT TYPE II Monument		5830	69326.08	78681.44	1486.51	CDOT TYPE II Monument	GPS Base Point
5840	227321.22	259081.97	4870.84	CDOT TYPE II Monument		5840	69287.65	78968.34	1484.63	CDOT TYPE II Monument	
HELEN	228650.78	260292.85	4911.61	NGS TYPE 5 Monument		HELEN	69692.90	79337.42	1497.06	NGS TYPE 5 Monument	

TO ESTABLISH GEOMETRIC CONTROL FOR THE CONSTRUCTION OF THIS PROJECT, THE DEPARTMENT HAS PROVIDED THE FOLLOWING INFORMATION:

	Format*
[x] Horizontal Control	Plan Sheets
[x] Vertical Control	Plan Sheets
[ ] Roadway Alignment	Plan Sheets
[ ] Original Terrain Data	Plan Sheets
[ ] Other:	

* Specify the information format, ie., plan sheet, computer disk, computer printout, or other.
The information marked is either contained on the plans or is available from the Engineer.

TYPE OF PROJECT

- [ ] Landscaping
- [ ] Signalization
- [ ] Safety Improvement
- [ ] Asphalt Overlay
- [ ] Concrete Overlay
- [ ] Minor Widening
- [ ] Major Reconstruction
- [ ] New Roadway Construction
- [ ] Bridge Replacement
- [ ] Bridge Widening
- [ ] New Bridge
- [x] Other: BRIDGE REPAIR

SURVEY WORK TO BE PERFORMED BY OTHERS: ____________

WORK PERFORMED BY THE CONTRACTOR'S SURVEYOR UNDER ITEM 625:

- ___ [ ] Establish and Maintain Project Centerline or Engineer Approved Offset Line(s)
- ___ [ ] Verification and Maintenance of Horizontal and Vertical Control
- ___ [ ] Verify or Determine existing grades and alignments
- ___ [ ] Verify or Determine existing topography
- ___ [ ] Clearing and Grubbing Limits
- ___ [ ] Removal Limits
- ___ [ ] Reset Items
- ___ [ ] Excavation and Embankment
  - ___ [ ] Excavation
    - ___ [ ] Unclassified
    - ___ [ ] Stripping
    - ___ [ ] Muck
    - ___ [ ] Rock
    - ___ [ ] Borrow
    - ___ [x] Other: EXISTING WEST BANK ELEVATION PRIOR TO RIPRAP INSTALLATION.
  - ___ [ ] Embankment
  - ___ [ ] Site Grading
  - ___ [ ] Erosion Control
  - ___ [x] Other: RIPRAP (SPECIAL)
  - ___ [ ] As Staked Earthwork Quantities (See General Notes)

		SLOPE STAKING (Y/N)	GRID (Y/N)	GRADE STAKES	SPECIAL INTERVAL
Excavation	Unclassified	-	-	-	-
Excavation	Stripping	-	-	-	-
Excavation	Muck	-	-	-	-
Excavation	Rock	-	-	-	-
Excavation	Borrow	-	-	-	-
Excavation	Other	-	-	-	-
Embankment	Embankment	-	-	-	-
Embankment	Site Grading	-	-	-	-
Embankment	Erosion Control	-	-	-	-
Embankment	Other	-	-	-	50'

- ___ [ ] Landscaping
  - ___ [ ] Top Soil
  - ___ [ ] Seeding
  - ___ [ ] Mulching
  - ___ [ ] Planting
  - ___ [ ] Herbicide: ________
  - ___ [ ] Other: ________
- ___ [ ] Erosion Control
  - ___ [ ] Seeding (Temp)
  - ___ [ ] Silt Fences
  - ___ [ ] Straw Bales
  - ___ [ ] Temporary Berm
  - ___ [ ] Riprap (Temp)
  - ___ [ ] Other (Temp Diversion, Temp Slope Drain, Brush Barrier, Check Dam, Other): ________
- ___ [x] Riprap (Perm)
- ___ [ ] Slope and Ditch Paving
- ___ [ ] Delineators
  - ___ [ ] Temporary
  - ___ [ ] Permanent

- ___ [ ] Roadway Bases
  - ___ [ ] Untreated Subgrade
  - ___ [ ] Treated Subgrade
  - ___ [ ] Aggregate Base Course
  - ___ [ ] Reconditioning
  - ___ [ ] PMBB - Plant Mix Bituminous Base
  - ___ [ ] Other: ________
- ___ [ ] Pavements
  - ___ [ ] HBP - Hot Bituminous Pavement
  - ___ [ ] Concrete
  - ___ [ ] Overlay
  - ___ [ ] Heating & Scarifying Treatment
  - ___ [ ] Prime Coat, Tack Coat & Rejuvenating Agent
  - ___ [ ] Seal Coat or Chip Seal
  - ___ [ ] Other: ________

		GRID (Y/N)	SPECIAL INTERVAL	SPECIAL OFFSET
Roadway Bases	Untreated Subgrade	-	-	-
Roadway Bases	Treated Subgrade	-	-	-
Roadway Bases	Aggregate Base Course	-	-	-
Roadway Bases	Reconditioning	-	-	-
Roadway Bases	PMBB	-	-	-
Roadway Bases	Other	-	-	-
Pavements	HBP	-	-	-
Pavements	Concrete	-	-	-
Pavements	Overlay	-	-	-
Pavements	Heating & Scarifying Treatment	-	-	-
Pavements	Prime Coat, Tack Coat & Rejuvenating Agent	-	-	-
Pavements	Seal Coat or Chip Seal	-	-	-
Pavements	Other	-	-	-

	Tangent Interval	Curve Interval	Special Offset
Curb & Gutter	-	-	-

- ___ [ ] Roadway Elements
  - ___ [ ] Curb and Gutter
  - ___ [ ] Drop inlets - alignment and grades
  - ___ [ ] Retaining Walls
  - ___ [ ] Guard Rail
  - ___ [ ] Sidewalk
  - ___ [ ] Other: ________
- ___ [ ] Minor Structures
  - ___ [ ] Structure Excavation limits
  - ___ [ ] Culverts
  - ___ [ ] Culverts w/ Headwalls and Wingwalls
  - ___ [ ] Concrete Box Culverts w/ Headwalls and Wingwalls
  - ___ [ ] Pipes
    - ___ [ ] Sanitary Sewer
    - ___ [ ] Storm Sewer
    - ___ [ ] Water
    - ___ [ ] Irrigation
    - ___ [ ] Miscellaneous
  - ___ [ ] Manholes
  - ___ [ ] Inlets
  - ___ [ ] Other: ________
- ___ [x] Major Structures - Overhead Signs, Concrete Box Culverts, Bridges - and all other structures assigned a structure number
  - ___ [ ] Structure Excavation limits
  - ___ [ ] Concrete Box Culverts w/ Headwalls and Wingwalls
  - ___ [ ] Piling locations and cut off elevations
  - ___ [x] Caisson locations and elevations
  - ___ [ ] Footing locations, alignment, and elevations
  - ___ [ ] Abutment/Pier locations, alignment, and elevations
  - ___ [ ] Wingwall skew angles/offsets
  - ___ [ ] Structural concrete form locations
  - ___ [ ] Substructure As-constructed survey (Required by Subsection 601 .12 for Bridges and S-614-50 for Overhead signs)
  - ___ [ ] Bridge expansion joint(s) alignment and grade (longitudinal and transverse)
  - ___ [ ] Deck grades at Girder 10th or "n" th point locations and elevations
  - ___ [ ] Slope and Ditch Paving
  - ___ [x] Other: Center line of structure G-04-BA before and after pier work and prior to milling of bridge deck and approaches. Top of pier caps on structure G-04-BA before and after construction
- ___ [x] Fencing
  - ___ [x] Temporary
  - ___ [ ] Permanent
  - ___ [ ] Sound Barriers
  - ___ [ ] Other: ________
- ___ [ ] Lighting and Traffic Control Devices (Perm)
  - ___ [ ] Signal pole locations and elevations
  - ___ [ ] Light pole locations and elevations
  - ___ [ ] Signs
  - ___ [ ] Field verify sign post locations, elevations, and lengths before fabrication.
  - ___ [ ] Other: ________
- ___ [ ] Pavement Marking
  - ___ [ ] Striping (Temp)
  - ___ [ ] Striping (Perm)
  - ___ [ ] Symbols
  - ___ [ ] Other: ________

- ___ [ ] Temporary Lighting and Construction Traffic Control Devices
  - ___ [ ] Signal pole locations and elevations (Temp)
  - ___ [ ] Light pole locations and elevations (Temp)
  - ___ [ ] Signs (Temp)
  - ___ [ ] Other: ________
- ___ [ ] Easement (Temp)(Staking)(P.L.S. Only)
- ___ [x] Right of Way (Temp) (Staking)(P.L.S. Only)

WORK PERFORMED BY THE CONTRACTOR'S SURVEYOR UNDER ITEM 629:

- ___ [ ] Monumentation
  - ___ [ ] Control
  - ___ [ ] Right of Way
  - ___ [ ] Land corners, Aliquot corners
  - ___ [ ] Easement (Perm)
  - ___ [ ] Reference the specified existing monuments: ** ________
  - ___ [ ] Relocate the specified existing monuments: ** ________
  - ___ [ ] Locate monuments. It is estimated_____hours are required. Includes Land

** A Tabulation of Survey Monuments may be provided on the plans.
Note: All 629 items shall include adequate research, calculations, and evaluations of evidence for all monuments to be set.

GENERAL NOTES:

Unless indicated otherwise on this Survey Tabulation Sheet, all survey work and staking intervals shall be done in accordance with the latest edition of the entire CDOT Survey Manual.
Adequate information for establishing lines, grades, and locations for all work items have been specified on the plans. Any additional information required to stake the item or element shall be generated by the Contractor's surveyor.

The Contractor's surveyor shall provide an estimate of the man-hours necessary to complete the work items indicated on this sheet. A copy of this sheet, with the estimated man-hours written on the blank line to the left of the specified items, shall be submitted with the Survey Schedule to the Engineer 3 days prior to Presurvey Conference - Construction Survey.

Stakes and Monuments which are damaged or destroyed by the progress of construction shall be replaced by the Contractor at no additional cost to the Department.

For this project, The Contractor shall submit existing and As-Built cross sections, and a certified letter confirming earthwork quantities, to the Engineer each month prior to the Estimate cut-off date.
The Surveyors shall survey this project in 25 foot segments, and the Contractor shall submit requests for payment of Earthwork quantities to the nearest completed survey segment.

Prior to beginning work on any subsequent operation, such as placing base course or paving, the Contractor shall certify in writing to the Engineer that the final grade is within specified tolerance.

The Contractor's surveyor shall perform all field surveying and calculations necessary to tie plan grades into field grades.

The Contractor shall coordinate construction staking on the project with any utility work.

Fieldbooks shall contain daily records of points set and or measurements observed. The information recorded shall contain: date, crew members' names, point no., description, staking information, and sketches. If the survey information is collected electronically, information recorded shall be provided to the Project Engineer in a hard copy format that is intuitive, clear and related to the supplemental information recorded in the field books. All linear surveys, such as slope stakes and blue tops, shall have the station and offset information related to the measured information. Non-linear surveys such as structures staking shall have sketches relating electronic information, such as point numbers, to the sketch.

The Contractor's surveyor shall submit the following fieldbooks to the Engineer:

- [ ] Horizontal Control (Primary & Secondary)
- [ ] Vertical Control (i.e. Benchmarks)
- [ ] Property Pin Ties
- [ ] Horizontal Alignment
- [ ] Grading
- [ ] Slope Staking
- [ ] Minor Structures
- [x] Major Structures
- [ ] One fieldbook for each work category shown on this sheet
- [ ] Other Fieldbook(s): ________

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Horiz. Scale: N/A	Vert. Scale: N/A		
Unit Information: GJ DESIGN	Unit Leader: JEB		

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
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Region 3 CLS

As Constructed	SURVEY TABULATION SHEET			Project No./Code
No Revisions:				BR 0701-192
Revised:	Designer:	Structure Numbers	G-04-BA	16689
Void:	Detailer: MHM			
	Sheet Subset:	Subset Sheets:		Sheet Number 21

1. Site Description

Additional information for permitted projects. For information only to fulfill the CDPS-SCP (Colorado Discharge Permit - Stormwater Construction Permit)

A. Project Site Description: This project is located on westbound Interstate 70, west of DeBeque at M.P. 58.06. The work is to take place on Colorado River Bridge Structure G-04-BA. Riprap will be placed north of the bridge along the west bank of the river to prevent further erosion of the bank. Some grading will be required for the installation of riprap and for the construction of a temporary access road to piers 3 and 4. The project will install new pier columns and pier caps at piers 2, 3, and 4. Six 60" caissons will be drilled in the river bed for the new piers. The existing pier 2 stem wall, piles, and pile cap will be removed. Work on the piers will take place inside of coffer dams. No utilities will be affected. The deck of the bridge will be milled then covered with thin coat epoxy. Once construction is completed the disturbed areas will be seeded with a mix specified in the plans.

B. Proposed Sequencing For Major Activities: The project is scheduled to take place in three phases. Phase 1 is to begin in early October, 2009, followed immediately by Phase 2 which is to be completed by February 26, 2010. Phase 3 work requires a temperature of at least 60°F and will therefore take place in the Spring of 2010. Phase 1 work will include the installation of the riprap along the west bank and all work associated with pier 2. Phase 2 work will cover all work for pier 3 and pier 4. Phase 3 work will be the bridge deck resurfacing with thin bond epoxy, final project clean up, planting and seeding.

C. Acres Of Disturbance:

Total area of construction site: 4.21 Acres
Total area of disturbance: 3.78 Acres
Acreage of native seeding: 1.0 Acres
Acreage of riparian seeding: 0.45 Acres

D. Existing Soil Data: Cobble and river Alluvium. Moderately erosive.

E. Existing Vegetation, Including Percent Cover: Existing vegetation is riparian woodland and scrub; also semi-arid sagebrush rangeland.
Date of survey: June 17, 2009. Transect 1, East access: 48% vegetative cover; Transect 2, West access: 28% vegetative cover. The location of each transect is documented in the project's Stormwater Management Notebook. Prior to construction the ECS shall provide photo documentation of the pre-construction vegetative cover (excluding noxious weeds) at each footmark at approximately 90° to the surface.

F. Potential Pollutants Sources: See First Construction Activities under Potential Pollutant Sources. The Erosion Control Supervisor shall prepare a list of all potential pollutants and their locations in accordance with subsection 107.25.

G. Receiving Water:
1. Outfall locations: No outfalls.
2. Names of receiving water(s) on site and the ultimate receiving water: Colorado River. All work is in the Colorado River floodplain.
3. Distance ultimate receiving water is from project: Project takes place in the ultimate receiving water, the Colorado River.
4. Does the receiving water have an approved TMDL: No.

H. Allowable Non-Stormwater Discharges: None.
1. Groundwater and stormwater dewatering: Discharge to the ground of water from construction dewatering activities may be authorized provided that:
   a. The source is groundwater and/or groundwater combined with stormwater that does not contain pollutants.
   b. The source and BMPs are identified in the SWMP.
   c. Discharges do not leave the site as surface runoff or to surface waters.
2. If discharges do not meet the above criteria a separate permit from the Colorado Department of Public Health and Environment will be required. Contaminated groundwater requiring coverage under a separate permit may include groundwater contaminated with pollutants from a landfill, mining activities, industrial pollutant plumes, underground storage tank, etc.

I. Environmental Impacts:
1. Wetland Impacts: Yes
2. Stream Impacts: Yes
3. Threatened and Endangered Species: No, the project will not occur during spawning of known threatened and endangered fish species.

2. Site Map Components

Pre-construction
A. Construction Site Boundaries See plan sheets “Work Area Plan View” and “East Access Staging & Storage Area”.
B. All Areas Of Ground Surface Disturbance See plan sheets “Work Area Plan View” and “East Access Staging & Storage Area”.
C. Areas Of Cut And Fill N/A
D. Location Of All Structural BMPs Identified In The SWMP See plan sheet “SWMP Site Map East.”
E. Location Of Non-Structural BMPs As Applicable In The SWMP See plan sheet “SWMP Site Map West.”
F. Springs, Stream, Wetlands And Other Surface Water See plan sheet “SWMP Site Map West.”
G. Protection Of Trees, Shrubs, Cultural Resources And Mature Vegetation See plan sheet “SWMP Site Map West.”

3. SWMP Administrator For Design: Mike Morgan

4. Stormwater Management Controls First Construction Activities

The Contractor Shall Perform The Following:
A. Designate A SWMP Administrator/Erosion Control Supervisor (To be filled out at time of construction; designate the individual(s) responsible for implementing, maintaining and revising SWMP, including the title and contact information. The activities and responsibilities of the administrator shall address all aspects of the project's SWMP.)
B. Potential Pollutant Sources
Evaluate, identify and describe all potential sources of pollutants at the site in accordance with subsection 107.25 and place in the SWMP notebook. All BMPs related to potential pollutants shall be shown on the SWMP site map by the contractor's ECS.

C. Best Management Practices (BMPs) For Stormwater Pollution Prevention
Phased BMP Implementation

During design: Fields are marked when used in the SWMP. During construction: the ECS shall update the checked boxes to match site conditions. Clearly describe the relationship between the phases of construction and the implementation of BMP controls. Add a narrative to the table or to the site map describing why the BMPs are being used in specific locations

Structural BMP practices for erosion and sediment control; practices may include, but are not limited to:

BMP	Type Of Control	BMP as Designed	In use on site	First Construction Activities	During Construction	Interim/Final Stabilization
Erosion Logs	sediment	X		X	X	
Concrete Washouts	construction	X			X	
Stabilized Construction Entrance	construction	X		X	X	
Temporary Stream Crossing	erosion	X		X	X	

EROSION LOGS
Erosion logs are used to capture and filter sediment laden run-off from disturbed areas during construction.

CONCRETE WASHOUTS
Concrete washouts are used to capture all water used to clean concrete chutes and pumps.

STABILIZED CONSTRUCTION ENTRANCE
Stabilized construction entrances are used to prevent the equipment from tracking soil out of the construction area.

TEMPORARY STREAM CROSSING
A temporary stream crossing is used to prevent unnecessary disturbance of the stream bottom and to reduce the amount of sediment transferred to the stream channel.

NON-STRUCTURAL BMP practices for erosion and sediment control; practices may include, but are not limited to:

BMP	Type Of Control	BMP As Designed	In Use On Site	First Construction Activities	During Construction	Interim/Final Stabilization
Seeding Permanent	Erosion	X				X
Mulch/Mulch Tackifier	Erosion	X				X
Vegetative Buffer Strips	Erosion	X		X	X	X
Protection Of Trees	Erosion	X		X	X	

PERMANENT SEEDING
Permanent Seeding is used as final stabilization to control runoff and erosion on disturbed areas. Drill seeding shall occur on slopes flatter than 2:1 and shall occur on the contour of the slope. Completed areas (any portion of a slope that is at final grade) shall be seeded within 48 hours during seeding seasons. Seeded areas shall be inspected frequently for areas of failure. Slopes that are too steep for drill seeding shall have seed broadcast at double the rate and raked into the surface, see interim and final seeding. Seeding in ditch lines shall follow the contour, drill rows running down a ditch line shall not be allowed.

During the seeding season, top of slopes adjacent to paving operations shall be seeded, per Section 9 of the SWMP template. When the Engineer approves, the top portion of the slope (approx. 15') can remain unseeded until paving operations occur. Once paving operations are completed in an area, shouldering shall occur immediately. Seeding per Section 9 of the SWMP shall then take place within 48 hours. Slopes that had been previously seeded and were disturbed by paving/shouldering operations shall be reseeded at no additional cost to the project.

MULCH AND MULCH TACKIFIER
Mulch and mulch tackifier shall be in accordance with subsection 213.03 (a). Crimping in ditch lines shall follow the contour, crimp rows running down a ditch line shall not be allowed.

VEGETATIVE BUFFER STRIPS
Existing vegetation shall be used as a BMP on the project. Existing vegetation aids with erosion and sediment control, and protects water quality. Areas of preserved vegetation shall be marked on the site map; preserved vegetation are those areas outside of disturbance (shoulder operation limit) line to the right of way fence. The amount of sediment reaching buffer strips shall be kept to a minimum by placing temporary and permanent erosion control features on disturbed slopes. If sediment does enter buffer strips and covers existing vegetation it shall be cleaned/re-seeded as directed. Sediment in vegetative ditches shall be avoided to prevent sediment laden water from exiting the project site. All vegetative ditch outfalls (from CDOT right of way) shall be protected with erosion logs as shown in the plans or as directed.

PROTECTION OF MATURE TREES
Fence (plastic) shall be placed adjacent to the wetlands; erosion logs shall be placed between the plastic fence and disturbance area. Logs shall be placed to direct flows away from or filter water running into wetlands from disturbance areas. A combination of silt fence or erosion logs and fence (plastic) shall be used in areas indicated in the plans to protect mature trees.

- Erosion control devices are used to limit the amount of erosion on site.
- Sediment control devices are designed to capture sediment on the project site.
- Construction control are BMPs related to construction access and staging.
- BMP locations are indicated on the site map.
- BMP installation details and general narratives are in the SWMP notebook.

D. Offsite Drainage (Run On Water)
   1. Describe and record BMPs on the SWMP site map that have been implemented to address run-on water in accordance with subsection 208.03.

E. Stabilized Construction Entrance/Vehicle Tracking Control
   1. BMPs shall be implemented in accordance with subsection 208.04.

F. Perimeter Control
   1. Perimeter control shall be established as the first item on the SWMP to prevent the potential for pollutants leaving the construction site boundaries, entering the stormwater drainage system, or discharging to state waters.
   2. Perimeter control may consist of vegetation buffers, berms, silt fence, erosion logs, existing landforms, or other BMPs as approved.
   3. Perimeter control shall be in accordance with subsection 208.04.

5. During Construction

Responsibilities of the SWMP administrator/erosion control supervisor during construction.

The SWMP should be considered a "living document" that is continuously reviewed and modified. During construction, the following items shall be added, updated, or amended as needed by the SWMP Administrator/Erosion Control Supervisor (ECS) in accordance with section 208.

A. Materials Handling And Spill Prevention
B. Stockpile Management
C. Grading And Slope Stabilization
D. Surface Roughening
E. Vehicle Tracking
F. Temporary Stabilization
G. Concrete Washout: Concrete washout water or waste from field laboratories and paving equipment shall be contained in accordance with subsection 208.05.
H. Saw Cutting
I. New Inlet/Culvert Protection
J. Street Cleaning

6. Inspections

A. Inspections shall be in accordance with subsection 208.03 (c).

7. BMP Maintenance

A. Maintenance shall be in accordance with subsection 208.04 (e).

8. Record Keeping

A. Records shall be in accordance with subsection 208.03 (c).

9. Interim And Final Stabilization

A. Seeding Plan

Soil preparation, soil conditioning or topsoil, seeding (native) (1.0 acre), seeding (riparian) (0.45 acres), mulching (weed free), and mulch tackifier will be required for an estimated 1.45 acres of disturbed area within the right-of-way limits which are not surfaced. The following types and rates shall be used:

Seeding (Native) mix:

COMMON NAME	SCIENTIFIC NAME	RATE LBS PLS/AC
'Vaughn' Sideoats grama	Bouteloua curtipendula	5
'San Luis' Slender wheatgrass	Elymus trachycaulus ssp. trachycaulus	6
'Lodorm' Green needlegrass	Nasella viridula	5
'Arriba' Western wheatgrass	Pascopyrum smithii	8
'Salado' Alkali sacaton	Sporobolus airoides	2
'VNS' Sand dropseed	Sporobolus cryptandrus	1
Total		27

Seeding (Riparian) mix:

COMMON NAME	SCIENTIFIC NAME	RATE LBS PLS/AC	COWARDIN WETLAND CLASSIFICATION (R8)
'NEZPAR' INDIAN RICEGRASS	ACHNATHERUM HYMENOIDES	6	UPL
'EGAN' AMERICAN SLOUGHGRASS	BECKMANNIA SYZIGACHNE	3	OBL
'ARRIBA' WESTERN WHEATGRASS	PASCOPYRUM SMITHII	8	FACU
'SALADO' ALKALI SACATON	SPOROBOLUS AIROIDES	2	FAC
'VNS' SAND DROPSEED	SPOROBOLUS CRYPTANDRUS	1	FACU
TOTAL		20	

B. Seeding Application: Drill seed 0.25 inch to 0.5 inch into the soil. In small areas not accessible to a drill, hand broadcast at double the rate and rake 0.25 inch to 0.5 inch into soil.

C. Mulching Application: Apply 1 ½ tons of certified weed free hay per acre mechanically crimped into the soil in combination with an organic mulch tackifier.

D. Special Requirements: Due to high failure rates, hydromulching and/or hydroseeding will not be allowed.

E. Soil Conditioning And Fertilizer Requirements:
1. Fertilizer will not be required on the project.
2. Soil conditioner or an approved organic amendment consistent with 90% fungal biomass (mycelium) and 10% potassium-magnesia with a grade of 6-1-3 or approved equal shall be applied to all seeded areas at 3 cy/1,000 sf or 1,000 lbs/acre.

F. Blanket Application: On slopes and ditches requiring a blanket, the blanket shall be placed in lieu of mulch and mulch tackifier. See SWMP for blanket locations.

G. Reseeding Operations/Corrective Stabilization

Prior To Final Acceptance.
1. Seeded areas shall be reviewed during the 14 day inspections by the Erosion Control Supervisor for bare soils caused by surface or wind erosion. Bare areas caused by surface or gully erosion, blown away mulch, etc. shall be regraded, seeded, mulched and have mulch tackifier (or blanket) applied as necessary.
2. Areas where seed has not germinated after one season shall be evaluated by the Engineer, ECS, or Region Water Pollution Control Manager. Areas that have not germinated shall have seed, mulch and mulch tackifier (or blanket) applied. Work shall be paid for by the appropriate bid item.
3. The Contractor shall maintain seeding/mulch/tackifier, mow to control weeds or apply herbicide to control weeds in the seeded areas until final acceptance.

10. Prior To Final Acceptance

A. Final acceptance shall be in accordance with subsection 208.061.

11. Tabulation Of Stormwater Quantities

Pay Item	Description	Unit	Quantity Plan	Quantity As-built
203	Blading	Hour	40	
208	Erosion Log (12 Inch)	Lf	500	
208	Concrete Washout Structure	Each	2	
208	Stabilized Construction Entrance	Each	2	
208	Erosion Control Supervisor	Day	100	
212	Seeding (Native)	Acre	1.0	
212	Seeding (Riparian)	Acre	0.45	
212	Soil Conditioning	Acre	1.45	
213	Mulching (Weed Free Hay)	Acre	1.45	
213	Mulch Tackifier	Lb	290	
214	Deciduous Shrub (5 Gallon Container)	Each	35	

1. BMP maintenance shall be paid for as: Included in the cost of the work.
2. It is estimated that 2 concrete washout structures will be required on the project.
3. It is estimated that 2 stabilized construction entrances will be required as directed to minimize vehicle tracking. Locate BMP on the SWMP map.
4. Maintenance of seeded areas shall be included in the cost of 212 Seeding (native) and 212 Seeding (Riparian).
5. Blading will be accomplished by a motor grader in the 130 to 140 flywheel horsepower range.

LEGEND

- RIGHT-OF-WAY — A —
- LIMITS OF DISTURBED AREA — LDA — LDA
- WORK AREA INSIDE OF COFFER DAM
- WETLANDS
- TEMPORARY ACCESS ROAD
- RIPRAP SPECIAL
- 10' VEGETATIVE BUFFER
- STABILIZED CONSTRUCTION ENTRANCE
- OVERLAND FLOW

NOTES:

1. DURING CONSTRUCTION, CONSTRUCTION FENCE SHALL BE INSTALLED AROUND THE PERIMETER OF THE LIMITS OF DISTURBED AREA EXCEPT WHERE THE COFFER DAM IS USED AS THE DISTURBED AREA BOUNDARY.
2. NO CONSTRUCTION EQUIPMENT OR MATERIAL SHALL BE LEFT INSIDE OF THE COFFER DAM WHEN THERE IS NO WORK IN PROGRESS.
3. ALL DEBRIS SHALL BE REMOVED FROM THE WORK AREA INSIDE THE COFFER DAM PRIOR TO THE REMOVAL OF THE COFFER DAM.
4. THE PURPOSE OF THE STABILIZED CONSTRUCTION ENTRANCES IS TO CLEAR SEDIMENT OFF OF VEHICLES AS THEY LEAVE THE SITE.
5. THE PURPOSE OF THE VEGETATIVE BUFFER IS TO PROVIDE AN AREA FOR SEDIMENT TO SETTLE OUT.

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Print Date: 7/29/2009			
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Horiz. Scale: 1:100	Vert. Scale: N/A		
Unit Information: GJ DESIGN	Unit Leader: JEB		

Sheet Revisions		
Date:	Comments	Init.

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Region 3 CLS

As Constructed
No Revisions:
Revised:
Void:

SWMP SITE MAP WEST

Designer: MHM	Structure Numbers	G-04-BA	
Detailer: MHM			
Sheet Subset:	Subset Sheets:	1 of 2	

Project No./Code
BR 0701-192
16689
Sheet Number 25

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Print Date: 7/27/2009	
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Sheet Revisions

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CLS

As Constructed
No Revisions:
Revised:
Void:

SWMP SITE MAP EAST

Designer:	MHM	Structure Numbers	G-04-BA
Detailer:	MHM		
Sheet Subset:		Subset Sheets:	2 of 2

Project No./Code
BR 0701-192
16689
Sheet Number 26

LANDSCAPE TABULATION - RIPARIAN VEGETATIVE BUFFER

ITEM DESCRIPTION	SYMBOL	COMMON NAME	SCIENTIFIC NAME	UNIT	QUANTITY
DECIDUOUS SHRUB (5 GAL.)		GOLDEN CURRANT (GC)	RIBES AUREUM	EA	20
DECIDUOUS SHRUB (5 GAL.)		SKUNKBUSH SUMAC (SS)	RHUS TRILOBATA	EA	5
DECIDUOUS SHRUB (5 GAL.)		WOOD'S ROSE (WR)	ROSA WOODSII	EA	10
TOTAL					35

SEEDING (RIPARIAN)[1]

COMMON NAME	SCIENTIFIC NAME	RATE LBS PLS/AC	COWARDIN WETLAND CLASSIFICATION (R8)
"NEZPAR" INDIAN RICEGRASS	ACHNATHERUM HYMENOIDES	6	UPL
"EGAN" AMERICAN SLOUGHGRASS	BECKMANNIA SYZIGACHNE	3	OBL
"ARRIBA" WESTERN WHEATGRASS	PASCOPYRUM SMITHII	8	FACU
"SALADO" ALKALI SACATON	SPOROBOLUS AIROIDES	2	FAC
"VNS" SAND DROPSEED	SPOROBOLUS CRYPTANDRUS	1	FACU
TOTAL		20	

1. SEED AND MULCH AS PER THE SWMP, OR HAND BROADCAST AT DOUBLE THE RATE SHOWN.

RIPARIAN AREA MITIGATION PLAN WEST ACCESS

THE PURPOSE OF THIS PLAN IS TO RESTORE RIPARIAN WILDLIFE HABITAT DISTURBED BY CONSTRUCTION ACTIVITIES. ALL OF THE 0.07 ACRES OF DIRECT WETLAND IMPACTS WILL OTHERWISE BE MITIGATED AT AN AREA WETLAND MITIGATION BANK (SPRINGWATER RANCH WETLAND BANK) AS AUTHORIZED UNDER THE PROJECT'S 404 PERMIT.

MITIGATION SHALL CONSIST OF NATIVE RIPARIAN SEED AND RIPARIAN SHRUB PLANTINGS TO OCCUR WITHIN DISTURBED AREAS OF THE LDA. FINAL PLANTING LOCATIONS SHALL BE SET BACK FROM THE RIVER'S EDGE AT LOCATIONS APPROVED BY THE R3 WETLANDS BIOLOGIST OR THE PROJECT ENGINEER.

ONCE THE BRIDGE PIERS ARE CONSTRUCTED AND RIPRAP IS SET AND ACCESS TO THE WEST BANK OF THE RIVER IS NO LONGER REQUIRED, THE CONTRACTOR SHALL RESTORE THE AREA TO ITS ORIGINAL LINE AND GRADE. THIS WILL REQUIRE THE CAREFUL REMOVAL OF ALL TEMPORARY FILLS, INCLUDING STRAW AND GEOTEXTILE FABRIC TO ENSURE THAT NO FILL ENTERS THE ACTIVE FLOW OF THE RIVER. THE AREA SHALL THEN BE RAKED, PLANTED AND SEEDED.

PLANTINGS SHALL CONSIST OF 5-GALLON CONTAINERS OF NATIVE SHRUBS AVAILABLE FROM LOCAL NURSERY STOCK. DEPENDING ON AVAILABILITY, DESIRED SPECIES INCLUDE GOLDEN CURRANT, SKUNKBUSH SUMAC, AND WOOD'S ROSE. SHRUBS SHALL BE PLACED AT APPROXIMATELY 3 FT. CENTERS IN GROUPINGS.

SHRUBS SHALL BE PLANTED AS DIRECTED BY THE M-214-1 SHRUB PLANTING DETAIL STANDARD. SOIL CONDITIONER SHALL BE USED IN THE PLANTING PITS PER STANDARD SPECIFICATION 214. WOOD CHIP MULCH SHALL BE PLACED AROUND THE PLANTING PITS TO A DEPTH OF 6 INCHES. SOIL CONDITIONER AND MULCH SHALL BE INCLUDED IN THE COST OF THE WORK.

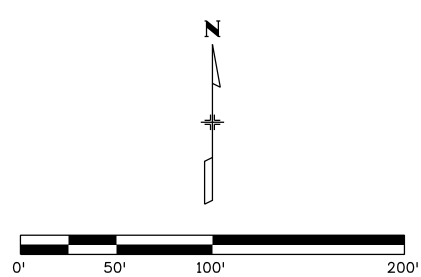
LEGEND

LIMITS OF DISTURBED AREA — LDA —

RIPARIAN SEEDING

COFFER DAMS

RIPRAP (SPECIAL)



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Sheet Revisions

Date:	Comments	Init.

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As Constructed
No Revisions:
Revised:
Void:

RIPARIAN AREA MITIGATION PLAN WEST ACCESS

Designer: PD	Structure Numbers	G-04-BA	
Detailer: MHM			
Sheet Subset:	Subset Sheets:		

Project No./Code
BR 0701-192
16689
Sheet Number 27

SCHEDULE OF CONSTRUCTION TRAFFIC CONTROL DEVICES

SIGNS					
SIGN CODE	LEGEND	DIMENSION	PANEL SIZE		
			A	B	C
			EA	EA	EA
48W20-1	ROAD/WORK/1 MILE	48x48		2	
48R52-6a	BEGIN/FINES/DOUBLE/IN WORK/ZONE	48x60			2
48R2-1(60)	SPEED/LIMIT/60	48x60			2
48G20-5	WORK ZONE	48x12	4		
48W20-5	RIGHT LANE/CLOSED/1/2 MILE	48x48		2	
48R2-1(45)	SPEED/LIMIT/45	48x60			2
48W4-2R	RIGHT LANE ENDS (SYMBOL)	48x48		2	
48R52-6b	END/FINES/DOUBLE/IN WORK/ZONE	48x48		2	
48R4-2	PASS/WITH/CARE	48x60			2
48G20-10	XYZ/CONSTRUCTION/THANKS YOU/555-555-5555	48x48		2	
48R2-1	SPEED/LIMIT/65	48x60			2
48W21-5	SHOULDER/WORK	48x48		1	
48W21-5ar	RIGHT/SHOULDER/CLOSED	48x48		1	
30W16-2a	1500 FT	30x12	1		
48W5-1	ROAD/NARROWS	48x48		2	
48R4-1	DO/NOT/PASS	48x60			2
30W8-1	BUMP	30x30	4		
48W20-52	GROOVED/PAVEMENT/AHEAD	48x48		2	
48W20-5	LEFT LANE/CLOSED/1/2 MILE	48x48		2	
48W4-24	LEFT LANE ENDS (SYMBOL)	48x48		2	
30R3-7b	ALL/TRAFFIC/MUST/EXIT	30x36	1		
48R11-2	ROAD/CLOSED	48x30		3	
48M4-10	DETOUR (RIGHT ARROW)	48x18	3		
48M4-10	DETOUR (LEFT ARROW)	48x18	3		
TOTALS			16	23	12

TABULATION OF TRAFFIC ENGINEERING ITEMS

ITEM NUMBER	ITEM DESCRIPTION	UNIT	PROJECT TOTALS
630-80336	BARRICADE (TYPE 3 M-B) (TEMPORARY)	EACH	3
630-80358	ADVANCE WARNING FLASING OR SEQUENCING ARROW PANEL (C TYPE)	EACH	2
630-80359	PORTABLE MESSAGE SIGN PANEL	DAY	155
630-80360	DRUM CHANNELIZING DEVICE	EACH	20
630-80363	DRUM CHANNELIZING DEVICE (WITH LIGHT)(FLASHING)	EACH	10
630-80390	CHANNELIZING DEVICE (SPECIAL)	EACH	60
630-85040	IMPACT ATTENUATOR (TRUCK MOUNTED ATTENUATOR)(TEMPORARY)	EACH	1