

Memorandum

MATERIALS AND GEOTECHNICAL BRANCH
GEOTECHNICAL PROGRAM
4670 HOLLY STREET, UNIT A. DENVER, COLORADO 80216
PHONE: 303-398-6606 FAX: 303-398-6504



IM 0251-334
I25 Ilex Bridge K-18-GV
Pueblo, CO
Subaccount # 17666

To: Dan Groeneman, Bridge Design and Management

From: Ilyess Ksouri, Materials and Geotechnical Branch

Date: May 16, 2013

Subject: Final Foundation Report, Bridge Structure K-18-GV (I25 over UPRR)

Per your request, we have conducted a subsurface exploration for the above-referenced structure K-18-GV. The existing bridge structure K-18-CK (I25 NB over Ilex St., and UPRR) will be replaced by two proposed bridges: K-18-GV and K-18-GU (I25 over Ilex St.). The location of the structures is at approximately MP 97.89. This report presents foundation recommendations for proposed structure K-18-GV, Structure K-18-GU will be addressed in another report. The proposed bridge K-18-GV is a three span bridge. A new embankment approach connecting the two proposed bridges will be constructed as part of the replacement of the existing bridge structure.

The subsurface exploration was conducted the week of July 9 and July 16, 2012 near the proposed abutments and piers locations. Four borings (B05, B06, B07, and B08) were drilled using a CME 550 drill rig and hollow-stem augers. B05 and B08 were redrilled the week of Oct 30, 2012 using CME 75 hollow stem augers and wireline coring. B05 and B06 were used to provide foundation recommendations for Abut 1 and Pier 2, and B07 and B08 were used to provide foundation recommendations for Pier 3 and Abutment 4.

Subsurface soil and bedrock samples were obtained using a standard split spoon in accordance with ASTM-D1586. Samples from the core drilling were placed in labeled core boxes. Depths at which samples were taken and standard penetration resistance N-values are shown on the attached logs of the exploratory borings and the geology sheet. Soil and chemical tests were performed on samples of representative material retrieved from the exploratory borings. Unconfined compressive strength tests were also performed on selected bedrock core samples. The soil lab results are shown on the geology sheet.

GEOLOGY

The subsurface conditions encountered generally consisted of one foot of topsoil overlying 31 to 38 feet of medium dense to dense gravelly sand to sand with some cobble materials underlain by very hard shale bedrock. The bedrock was encountered at depths of 32 to 39 feet below the existing ground surface, corresponding to approximate elevations of 4617.2 feet to 4619.5 feet above mean sea level (amsl). Groundwater was encountered in all drilled borings. It was measured at approximate elevations of 4639.4 feet to 4642.2 feet amsl immediately after drilling.

Based on the sulfate analysis results from samples retrieved near the two proposed bridges, the potential for sulfate attack on Portland cement concrete in direct contact with the ground would be classified as Class 2 exposure per Table 601-2 *CDOT Standard Specifications for Road and Bridge Construction 2011*. Based on current information regarding corrosion of steel relative to soil sulfate, chlorides, and resistivity, the soil at this site would be considered strong corrosion potential/aggressive per Table 3.9 *Geotechnical Engineering Circular No.7 Soil Nail Walls. FHWA0-IF-03-01*

FOUNDATION RECOMMENDATIONS

The proposed bridge structure can be supported by drilled caissons and/or driven steel H-piles.

Drilled Caissons:

Drilled caissons embedded into bedrock can be used to support the proposed bridge at the abutments and piers. Resistance provided by the bedrock was estimated using methods consistent with local practice. The allowable unit tip resistance q_a , and the allowable unit side resistance f_a , required for the Allowable Stress Design (ASD) method are presented in Table 1. The nominal unit tip resistance q_p , and nominal unit side resistance, q_s , required for the Load and Resistance Factor Design (LRFD) method are converted from ASD values and also presented in Table 1. Shafts should be completed into the very hard bedrock to obtain tip and side resistance. The recommended minimum bedrock penetration is 10 feet. Side resistance in the overburden soil should be ignored due to the difference in strain limits between the soil and the bedrock. Also, the top 5 feet of bedrock penetration should be ignored for side resistance due to material weathering and potential disturbance from temporary casing. The side resistance values are applicable in both vertical directions without reduction. The nominal resistances assume a weighted load factor of 1.5. We recommend a resistance factor of 0.5 for end bearing and side shear. Should a different load factor be applied for shafts, the resistance factor should be adjusted by dividing the new load factor by 3 to obtain the corresponding resistance factor. The minimum spacing requirements between caissons should be 3 caisson diameters from center to center. Caissons grouped

less than 3 caisson diameters center to center should be studied on an individual basis to evaluate the appropriate reduction in axial capacity. For lateral loading, the horizontal caisson group analysis should be performed in accordance with Section 10 of AASHTO LRFD Bridge Design Specifications. Caving soil may occur below groundwater. Slurry and/or casing may be needed to support the soil overlying the bedrock during shaft excavation. Dewatering of the drilled holes may be required prior to placement of the concrete. The potential for dewatering may increase with the amount of time the drill holes remain open. Alternatively, the concrete may be placed by tremie as described in CDOT 2011 *Standard Specifications for Roads and Bridge Construction* Section 503 – Drilled Caissons. Due to possibility of caving conditions, it is recommended that cross hole sonic logging tubes be installed in the caissons for construction quality assurance. Materials properties for lateral load analysis are presented in the following Steel H-Piles section.

Table 1. Recommended Drilled Caisson Resistance Values

Location	Estimated Unweathered Bedrock Elevation (feet)	ASD		LRFD	
		q _a (ksf)	f _a (ksf)	q _p (ksf)	q _s (ksf)
Abutment 1	Below 4617	50	4	150	12
Pier 2	Below 4617	50	4	150	12
Pier 3	Below 4618	50	4	150	12
Abutment 4	Below 4618	50	4	150	12

Steel H-Piles:

Section 6 of AASHTO LRFD specifications should be followed for the design of end bearing driven piles. Applying the structural limit state per AASHTO LRFD Table 10.5.5.2.3-1 for driven H-piles with Grade 50 steel in good driving conditions, a combined unit side and tip resistance up to 30 kips per square inch (ksi) times the cross sectional area of the pile is recommended. Additionally, pile tips are recommended because of the hard bedrock. If used, the tips should be associated Pile & Fitting Corp. (APF) HARD-BITE HP-77600 for hard rock, or equivalent. Per Section 502 Piling, of *CDOT Standard Specifications for Road and Bridge Construction, 2011*, a Pile Driving Analyzer (PDA) should be used during installation to establish pile driving criteria and verify design capacity. Geotechnical resistance factor may be 0.65 in accordance with AASHTO LRFD specifications. Estimated final pile tip elevations are shown below for Grade 50 steel. However, actual pile tip elevations will depend on PDA results. We recommend that when ordering pile an estimated penetration of 10 feet into bedrock be used. Pre-drilling might be required to reach the minimum embedment depth as specified in section 502.06 Driving Piles, *CDOT Standard Specifications for Road and Bridge Construction, 2011*.

Battered piles not exceeding 1(h):4(v) batter may be used to provide lateral resistance. Center-to center pile spacing shall not be less than the greater of 30 inches or 2.5 pile widths unless a group analysis is performed and approved by the CDOT engineer. For lateral loading, the horizontal pile group analysis should be performed in accordance with Section 10 of AASHTO LRFD Bridge Design Specifications. For steel H-piles, the minimum manufacturer's rated energy for the hammer should be as recommended in Table 502-1, *CDOT Standard Specifications for Road and Bridge Construction, 2011*.

Estimated driven H-pile tip elevations for the proposed abutments and pier are presented below.

<u>Structure Locations</u>	<u>Estimated Tip Elevation (ft)</u>
Abutment 1	4614
Pier 2	4614
Pier 3	4615
Abutment 4	4615

Lateral Capacity for Drilled Caissons and Steel H-Piles:

For the lateral load analysis of drilled caissons and driven piles using COM 624 or L-Pile computer program, the following soil parameters can be used:

Sand and Gravel Material Above Water Table

Total Unit Weight:	125 pcf
Coefficient of Horizontal Subgrade Reaction:	90 pci
Internal friction angle	34 degrees

Sand and Gravel Material Below Water Table

Total Unit Weight:	125 pcf
Coefficient of Horizontal Subgrade Reaction:	60 pci
Internal friction angle	34 degrees

Shale Bedrock

Total Unit Weight:	140 pcf
Coefficient of Horizontal Subgrade Reaction:	2000 pci
Cohesion:	8000 psf
E50:	0.004

Embankment

Total Unit Weight:	125 pcf
Coefficient of Horizontal Subgrade Reaction:	90 pci
Internal friction angle	32 degrees

Embankment:

Total settlement of the existing natural soils due to the placement of new approach embankment fills consists mainly of short-term immediate settlement. The settlement of the embankment material will be largely dependant on the quality and compaction of the material. If possible, the approach embankments should be constructed prior to final grading and roadway construction to allow for the total settlement to occur thus minimizing potential bridge approach settlement problems.

SEISMIC DESIGN CONSIDERATIONS

The CDOT Geotechnical Program conducted a surface wave survey on October 24, 2012. The average shear wave velocity (V_s) of the upper 100 feet was calculated to be 1700 feet per second as presented in Figure 1. Seismic analysis parameters were developed in accordance with AASHTO LRFD Bridge Design Specifications Section 3.10. Based on soil properties, this site is designated as Site Class C and seismic zone "1" using Tables 3.10.3.1-1 and 3.10.6-1, respectively. The design response spectra was developed using the General Procedure as provided in the computer program provided with the AASHTO specifications, and is included here as Figure 2.

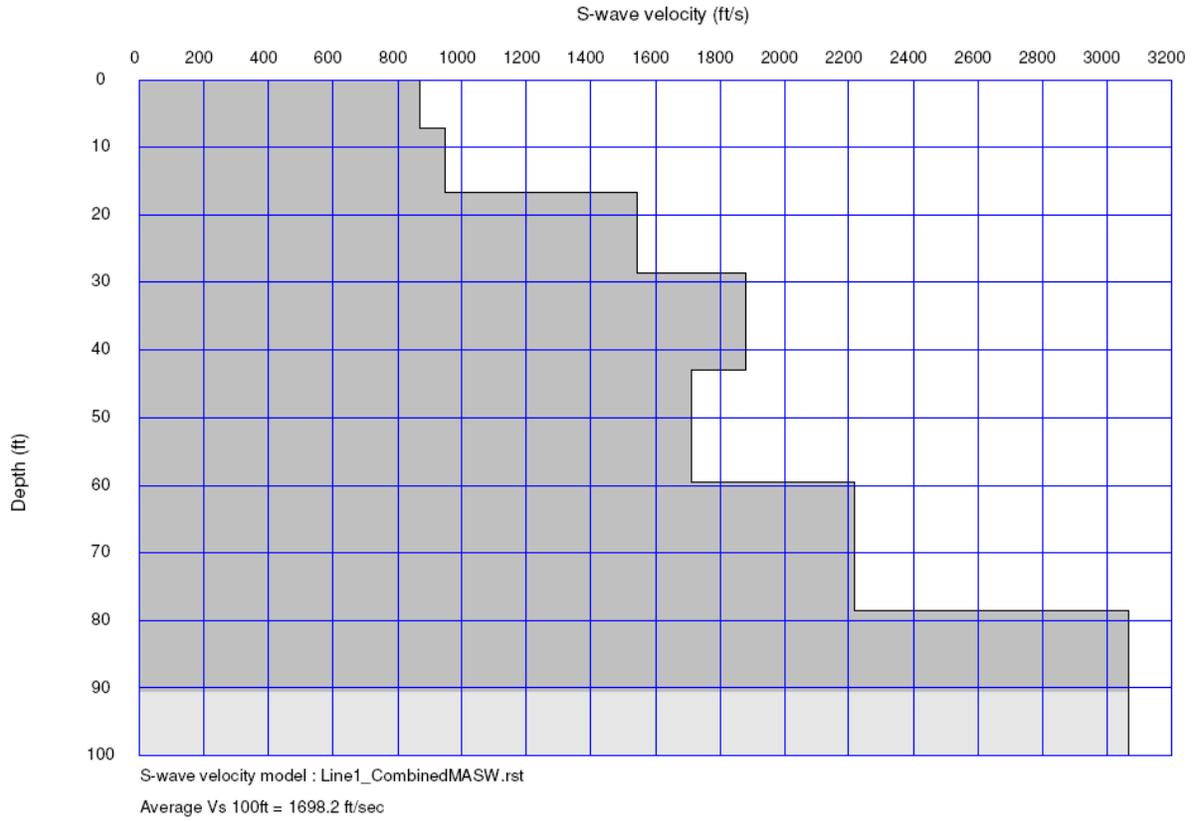


Figure 1. Shear Wave Velocity Model

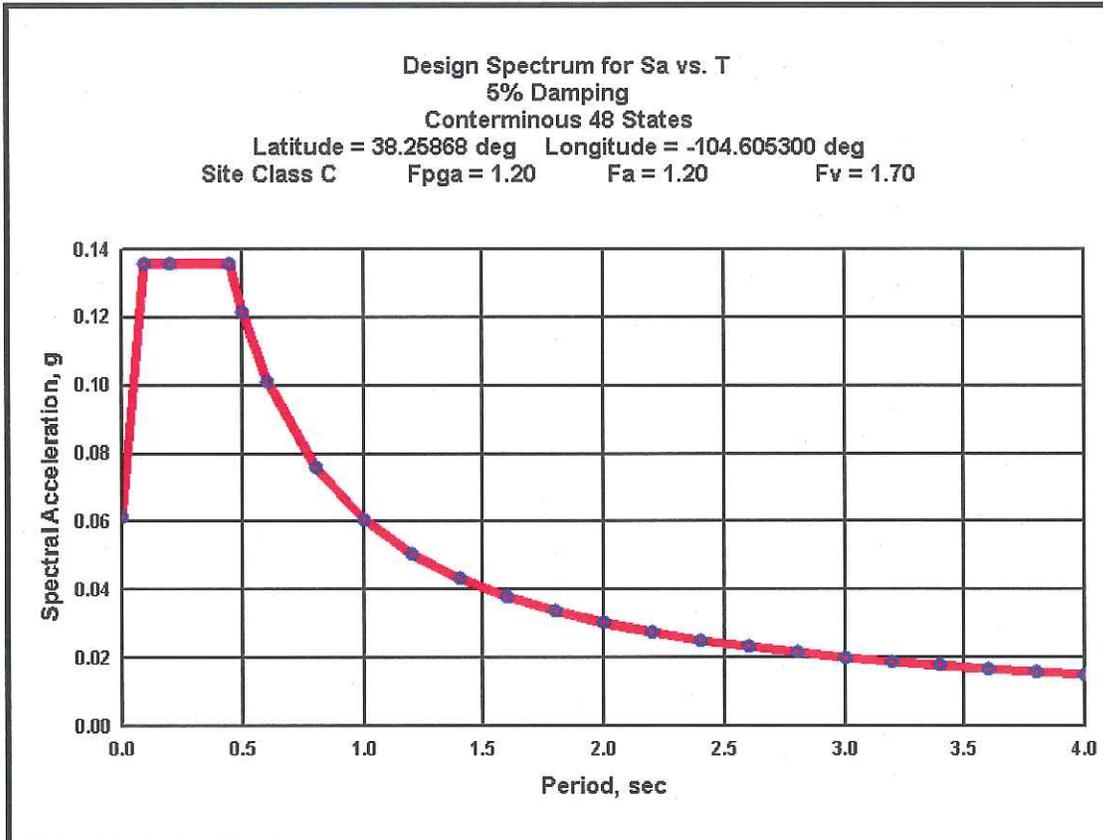


Figure 2. Design Spectrum

REVIEW: Thomas

COPY: Wrona/Wieden
Groeneman
DeHeart/Garcia
Cress
Schiebel/Hernandez/Ortiz





GEOLOGICAL BORING LOG

BORING #

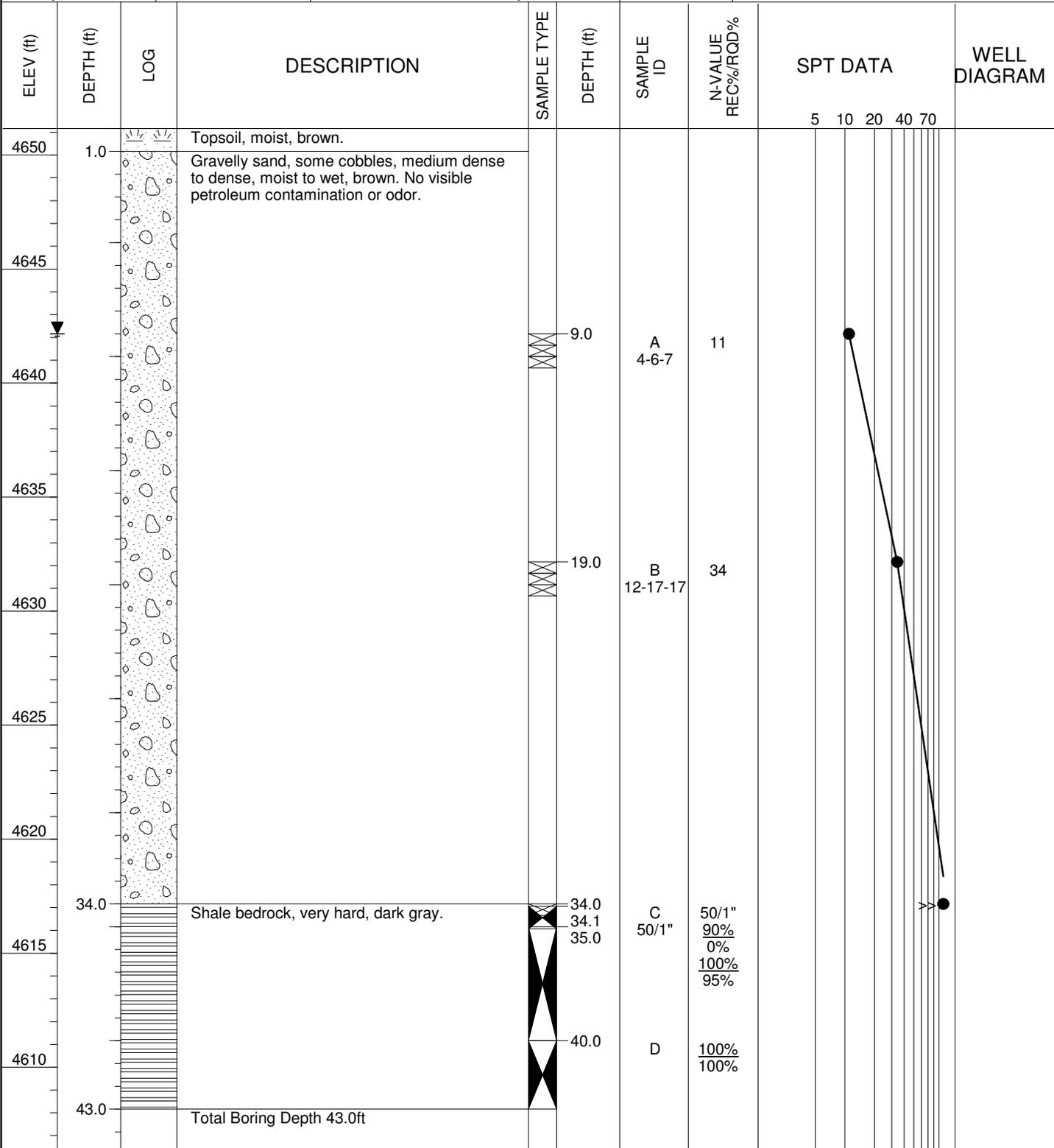
B05

PROJECT ID: IM 0251-334 SA: 17666 PROJECT NAME: I25 Ilex Bridge

DATE DRILLED: 7/18/12

ROUTE: I25 COUNTY: Pueblo STRUCTURE/BENT: K-18-GV/Abut 1 & Pier 2 LOCATION: Pueblo South

TOP HOLE ELEV: 4,651.2ft TOTAL DEPTH: 43.0ft SURVEY INFO: N:1581986.91, E:3257788.64 GEOLOGIST/FOREMAN: I. Ksouri/A. Moreno



GEOLOGIC BORING LOG I25 ILEX BRIDGES AND RETAINING WALL.GPJ CO_DOT.GDT 5/16/13

X SPT
 | CONT
 ◇ GRAB
 ■ SHELBY
 ◀▶ CORE

H ₂ O DEPTH	▽ 9.0
DATE	7/18/12
TIME	10:00 AM

NOTES: CME 550, Hollow Stem Auger and Wireline. Wireline done on 10/30/12



GEOLOGICAL BORING LOG

BORING #

B06

PROJECT ID: IM 0251-334 SA: 17666 PROJECT NAME: I25 Ilex Bridge

DATE DRILLED: 7/11/12

ROUTE: I25 COUNTY: Pueblo STRUCTURE/BENT: K-18-GV/Abut 1 & Pier 2 LOCATION: Pueblo South

TOP HOLE ELEV: 4,650.8ft TOTAL DEPTH: 34.5ft SURVEY INFO: N:1582078.4, E:3257686.62 GEOLOGIST/FOREMAN: I. Ksouri/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%	SPT DATA					WELL DIAGRAM
								5	10	20	40	70	
4650	1.0		Topsoil, moist, brown.										
4645			Gravelly sand, some cobbles, medium dense to dense, moist to wet, brown. Traces of petroleum contamination and odor.										
4640				X	9.0	A 9-7-4	11						
4630				X	19.0	B 16-14-18	34						
4620	32.0		Shale bedrock, very hard, dark gray.										
4615	34.5		Total Boring Depth 34.5ft	X	34.0	C 50/1"	50/1"						

GEOLOGIC BORING LOG I25 ILEX BRIDGES AND RETAINING WALL.GPJ CO.DOT.GDT 5/16/13

SPT	CONT	GRAB	SHELBY	CORE
H ₂ O DEPTH	▽ 9.0			
DATE	7/11/12			
TIME	1:00 PM			

NOTES: CME 550, Hollow Stem Auger



GEOLOGICAL BORING LOG

BORING #

B07

PROJECT ID
IM 0251-334

SA
17666

PROJECT NAME
I25 Ilex Bridge

DATE DRILLED
7/17/12

ROUTE
I25

COUNTY
Pueblo

STRUCTURE/BENT
K-18-GV/Pier 3 & Abut 4

LOCATION
Pueblo South

TOP HOLE ELEV
4,657.4ft

TOTAL DEPTH
40.5ft

SURVEY INFO
N:1582185.31, E:3257787.76

GEOLOGIST/FOREMAN
I. Ksouri/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%	SPT DATA					WELL DIAGRAM
								5	10	20	40	70	
4655	1.0		Topsoil, moist, brown.										
4650			Gravelly sand, some cobbles, medium dense to dense, moist to wet, brown. No visible petroleum contamination or odor.										
4645					9.0	A 2-2-8	10						
4640					19.0	B 5-15-15	30						
4635					29.0	C 12-14-14	28						
4625					39.0	D 50/1"	50/1"						
4620													
	39.0		Shale bedrock, very hard, dark gray.		39.0								
	40.5		Total Boring Depth 40.5ft										

GEOLOGIC BORING LOG I25 ILEX BRIDGES AND RETAINING WALL.GPJ CO.DOT.GDT 5/16/13

	SPT		CONT		GRAB		SHELBY		CORE
H ₂ O DEPTH	∇ 18.0					NOTES: CME 550, Hollow Stem Auger			
DATE	7/17/12								
TIME	10:00 AM								



GEOLOGICAL BORING LOG

BORING #

B08

PROJECT ID: IM 0251-334 SA: 17666 PROJECT NAME: I25 Ilex Bridge

DATE DRILLED: 7/12/12

ROUTE: I25 COUNTY: Pueblo STRUCTURE/BENT: K-18-GV/Pier 3 & Abut 4 LOCATION: Pueblo South

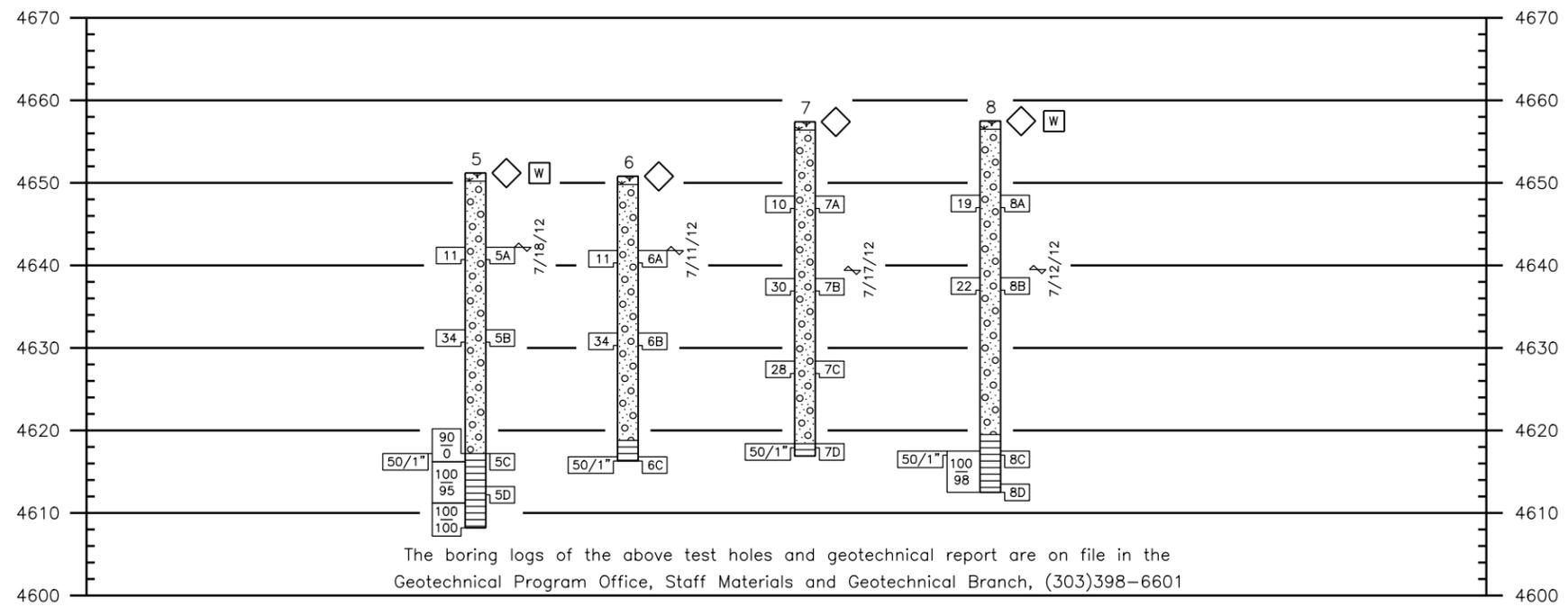
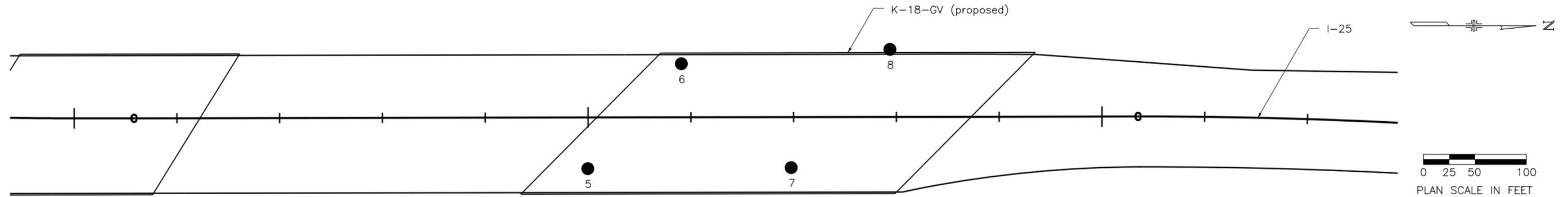
TOP HOLE ELEV: 4,657.5ft TOTAL DEPTH: 45.0ft SURVEY INFO: N:1582281.33, E:3257672.78 GEOLOGIST/FOREMAN: I. Ksouri/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%	SPT DATA					WELL DIAGRAM	
								5	10	20	40	70		
	1.0		Topsoil, moist, brown.											
4655			Gravelly sand, some cobbles, medium dense, moist to wet, brown. No visible petroleum contamination or odor.											
4650														
4645														
4640														
4635					9.0	A 4-12-7	19							
4630														
4625														
4620														
4615					19.0	B 11-10-12	22							
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3960														
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10+00

15+00

20+00



SUMMARY OF TEST RESULTS

TYPE OF MATERIAL

LEGEND

Sample Number	Depth (feet)	Classification			Grading Analysis (AASHTO)				Atterberg Limits			Water Content W %	Dry Density (lb/ft ³)	Uniaxial Compressive Strength/Strain (psf/%)	Chlorides (% mass)	Water Soluble Sulfates (% mass)	Soil pH (H ₂ O/CaCl ₂)	Resistivity ohm-cm Saturated
		Corps of Engrs. or Visual	USCS	AASHTO	Percent				L.L. LW	P.L. PW	P.I. IW							
					Gravel	Coarse Sand	Fine Sand	Silt and Clay										
5D	38-39	Shale	-	-	-	-	-	-	-	-	-	3.9	147.5	1,056,010/1.7	-	-	-	-
6B	19-20	Sand	-	-	-	-	-	-	-	-	-	-	-	0.012	0.024	8.65	7500	
8D	44-45	Shale	-	-	-	-	-	-	-	-	-	3.6	146.3	1,014,881/2.4	-	-	-	-

Topsoil
Gravelly Sand, some Cobbles
Shale Bedrock

Note: Boulders may be encountered at any depth

TEST BORING

CONTINUOUS PENETRATION TEST

Blows per foot * [30]
R = Refusal on SPT
C = California Sample

50 Blows in 0.1 ft

Core Recovery R.Q.D. 25

*Standard Penetration Test (AASHTO T 206-87(2000))

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

Print Date: 5/15/2013		Sheet Revisions Date: Comments Init.			Colorado Department of Transportation 4670 Holly Street, Unit A Denver, CO 80216 Phone: 303-398-6601 FAX: 303-398-6504 Staff Geotechnical Program LAC	As Constructed No Revisions: Revised: Void:	ENGINEERING GEOLOGY Designer: I. Ksouri Structure Numbers K-18-GV Detailer: T. McNulty Sheet Subset: Geology Subset Sheets: XXX of XXX			Project No./Code IM 0251-334 17666 Sheet Number XXX
Drawing File Name: 17666geosheet02.dgn										
Horiz. Scale: 1:100 Vert. Scale: As Noted										