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-GU
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-GU (I25 over Ilex St.)**

Per your request, we have conducted a subsurface exploration for the above-referenced structure K-18-GU. The existing bridge structure K-18-CK (I25 NB over Ilex St., and UPRR) will be replaced by two proposed bridges: K-18-GU and K-18-GV (I25 over UPRR). The location of the structures is at approximately MP 97.89. This report presents foundation recommendations for proposed structure K-18-GU, Structure K-18-GV will be addressed in another report. The proposed bridge K-18-GV is a two span bridge. A new embankment approch 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, 2012 near the proposed abutments and pier locations. Four borings (B01, B02, B03, and B04) were drilled using a CME 550 drill rig and hollow-stem augers. B04 was redrilled the week of Oct 30, 2012 using CME 75 hollow stem augers and wireline coring. B01 and B02, B02 and B03, and B03 and B04 were used to provide foundation recommedations for Abutment 1, Pier 2, and Abutment 3 respectively.

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 30 to 31 feet of medium dense to very dense gravelly sand to sand with some cobble materials underlain by very hard shale bedrock. The bedrock was encountered at depths of 31 to 32 feet below the existing ground surface, corresponding to approximate elevations of 4615.3 feet to 4616.7 feet above mean sea level (amsl). Groundwater was encountered in all drilled borings. It was measured at approximate elevations of 4638.3 feet to 4639.2 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 a 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 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 pier. 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 obatin 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 caissson 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 4615	50	4	150	12
Pier 2	Below 4615	50	4	150	12
Abutment 3	Below 4615	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. Adiitionally, 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 recommed that when ordering pile an estimated penetration of 10 feet into bedrock be used. Predrilling 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.

Structure Locations	Estimated Tip Elevation (ft)
Abutment 1	4612
Pier 2	4612
Abutment 3	4612

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 (Vs) 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.

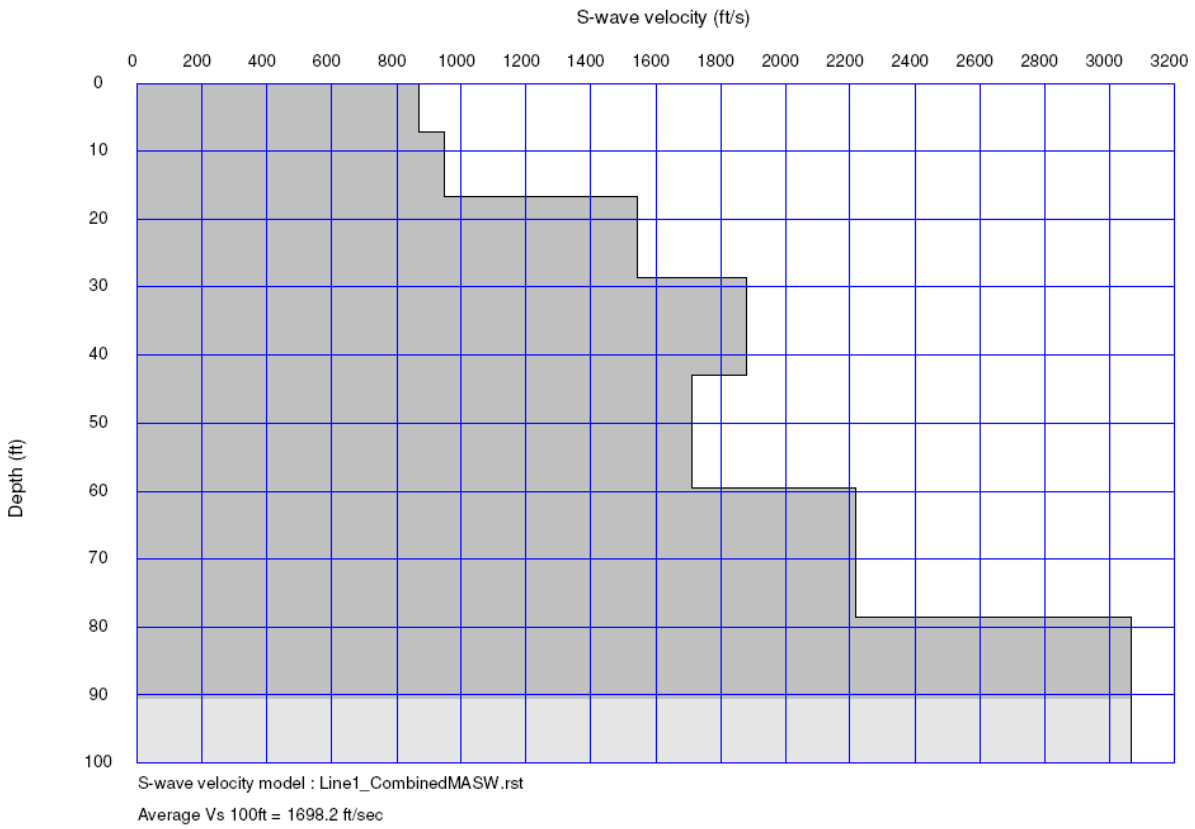


Figure 1. Shear Wave Velocity Model

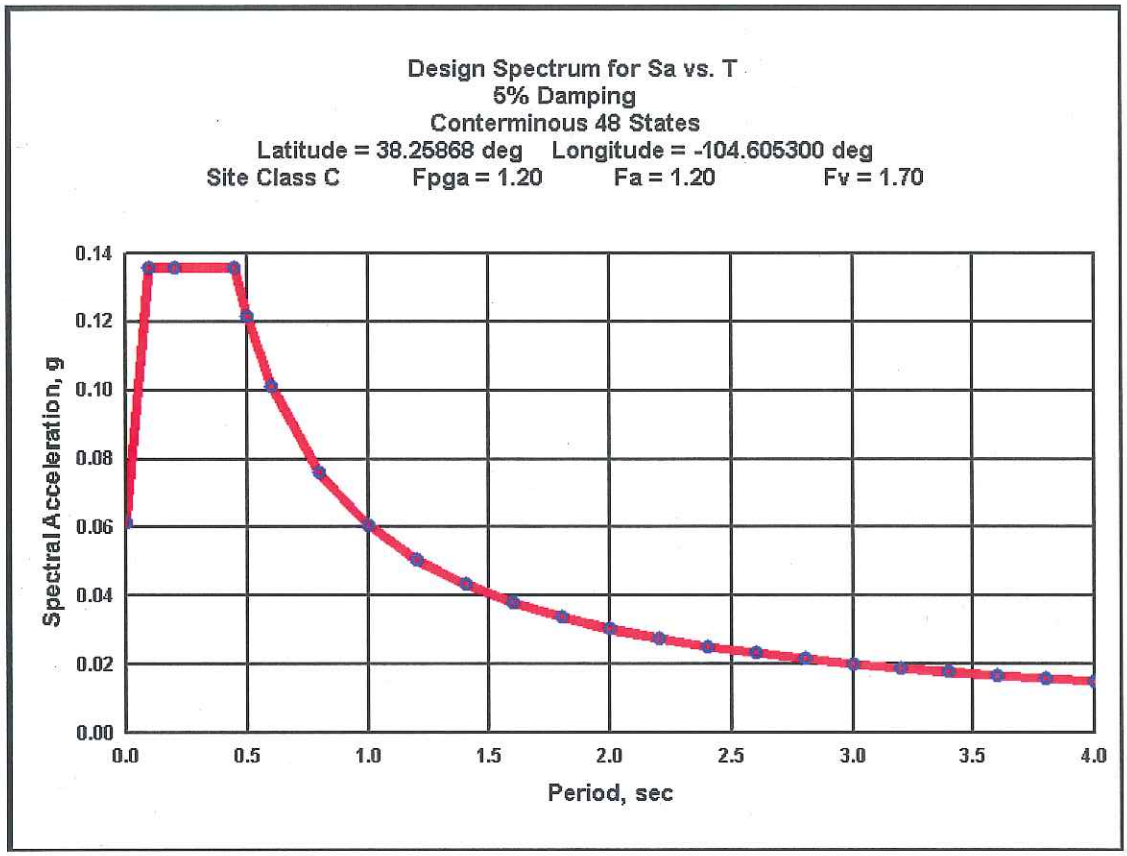


Figure 2. Design Spectrum

REVIEW: Thomas

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

COLORADO LICENSED
DAVID B. THOMAS
46594
3/16/13
PROFESSIONAL ENGINEER

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # **B01**

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
IM 0251-334	17666	I25 Ilex Bridge	7/11/12

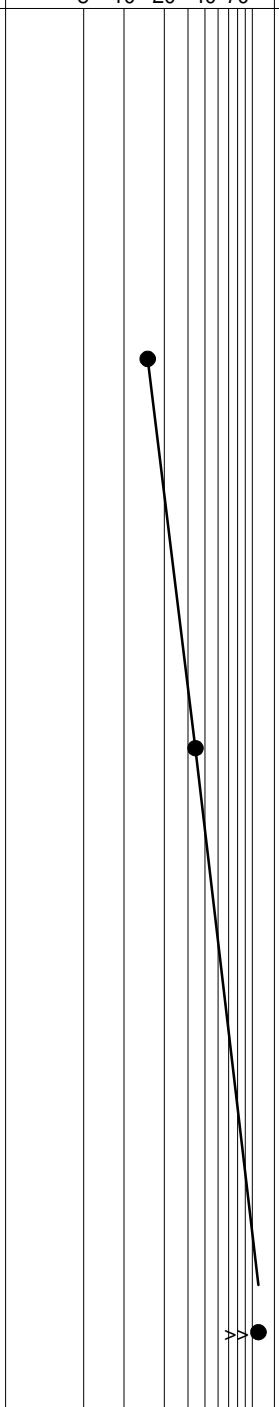
ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
I25	Pueblo	K-18-GU/Abut 1	Pueblo South

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
4,647.3ft	34.5ft	N:1581341.94, E:3257801.66	I. Ksouri/H. Blailes

ELEV (ft)	DEPTH (ft)	DESCRIPTION
		Asphalt pavement.
	1.0	Gravelly sand, some cobbles, medium dense to dense, moist to wet, brown. No visible petroleum contamination or odor.
4645		
4640		
4635		
4630		
4625		
4620		
4615	32.0	Shale bedrock, very hard, dark gray.
	34.5	Total Boring Depth 34.5ft

SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%
SPT	9.0	A 5-7-8	15
SPT	19.0	B 12-17-17	34
SPT	34.0	C 50/1"	50/1"

SPT DATA



WELL DIAGRAM

SPT | CON'T | GRAB | SHELBY | CORE

H_2O DEPTH	∇ 9.0				
DATE	7/11/12				
TIME	9:30 AM				

NOTES: CME 550, Hollow Stem Auger

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

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # **B02**

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
IM 0251-334	17666	I25 Ilex Bridge	7/9/12

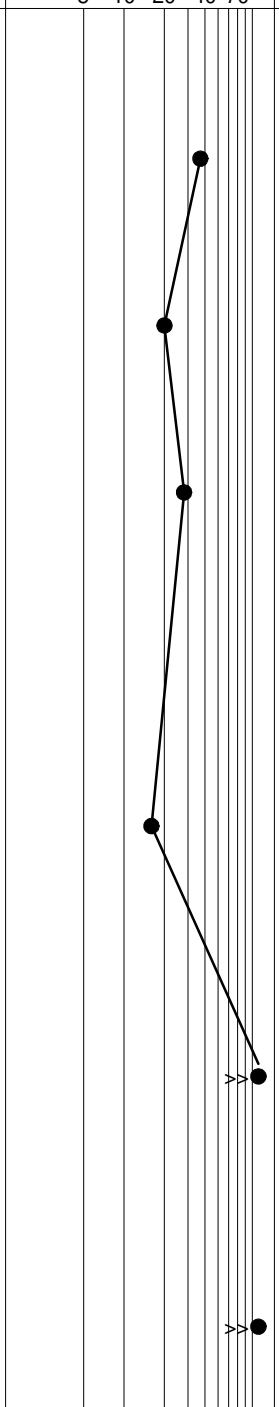
ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
I25	Pueblo	K-18-GU/Abut 1 & Pier 2	Pueblo South

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
4,648.2ft	40.0ft	N:1581482.04, E:3257668.82	I. Ksouri/H. Blailes

ELEV (ft)	DEPTH (ft)	DESCRIPTION
	0.0	Topsoil, moist, brown.
	1.0	Gravelly sand, some cobbles, medium dense to dense, moist to wet, brown. Traces of petroleum contamination (dark gray color and a strong petroleum odor).
4645		
4640		
4635		
4630		
4625		
4620		
4615	32.0	Shale bedrock, very hard, slightly moist, dark gray.
4610		
	40.0	Total Boring Depth 40.0ft

SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%
SPT	4.5	A 9-17-20	37
SPT	9.5	B 5-8-12	20
SPT	14.5	C 5-14-14	28
SPT	24.5	D 5-4-12	16
SPT	32.0	E 50/2"	50/2"
SPT	39.5	F 50/2"	50/2"

SPT DATA



WELL DIAGRAM

SPT | CON'T | GRAB | SHELBY | CORE

H_2O DEPTH	∇ 9.0
DATE	7/9/12
TIME	12:30 PM

NOTES: CME 550, Hollow Stem Auger

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

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # **B03**

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
IM 0251-334	17666	I25 Ilex Bridge	7/10/12

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
I25	Pueblo	K-18-GU/Pier 2 & Abut 3	Pueblo South

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
4,647.7ft	33.5ft	N:1581507.86, E:3257809.53	I. Ksouri/A. Moreno

ELEV (ft)	DEPTH (ft)	DESCRIPTION
		Asphalt pavement.
	1.0	Gravelly sand, some cobbles, medium dense to very dense, moist to wet, brown. Traces of petroleum contamination (dark gray color and strong petroleum odor).
4645		
4640		
4635		
4630		
4625		
4620		
	31.0	Shale bedrock, very hard, slightly moist, dark gray.
4615		
	33.5	Total Boring Depth 33.5ft

SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%
	9.0	A 8-22-11	33
	19.0	B 9-16-43	59
	33.0	C 50/2"	50/2"

SPT DATA: 5 10 20 40 70

WELL DIAGRAM

SPT | CON'T | GRAB | SHELBY | CORE

H_2O DEPTH	∇ 9.0				
DATE	7/10/12				
TIME	9:30 AM				

NOTES: CME 550, Hollow Stem Auger

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

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # **B04**

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
IM 0251-334	17666	I25 Ilex Bridge	7/10/12

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
I25	Pueblo	K-18-GU/Abut 3	Pueblo South

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
4,647.5ft	45.5ft	N:1581639.14, E:3257662.95	I. Ksouri/A. Moreno

ELEV (ft)	DEPTH (ft)	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID	N-VALUE REC%/RQD%
	1.0	Asphalt pavement.				
4645		Gravelly sand, some cobbles, medium dense, very moist to wet, brown. Traces of petroleum contamination (dark gray color and strong petroleum odor).				
4640						
				9.5	A 7-8-13	21
4635						
4630						
				19.5	B 5-7-12	19
4625						
4620						
4615	32.0	Shale bedrock, very hard, slightly moist, dark gray.		32.0	C 50/1"	50/1"
				33.0		100% / 75%
				35.0		100% / 98%
4610						
				40.0		100% / 97%
4605						
	45.5	Total Boring Depth 45.5ft		45.0	D 50/1"	50/1"

SPT DATA (N-VALUE): 5, 10, 20, 40, 70

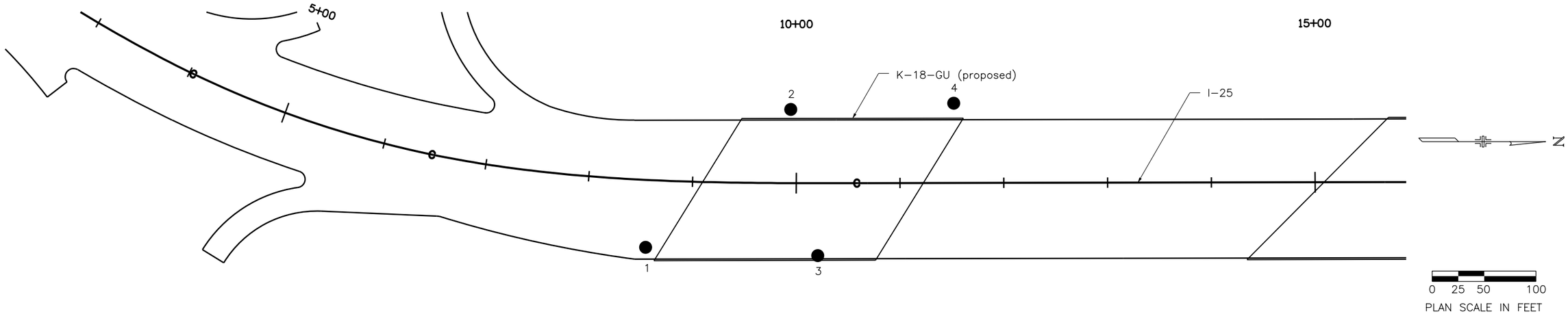
WELL DIAGRAM

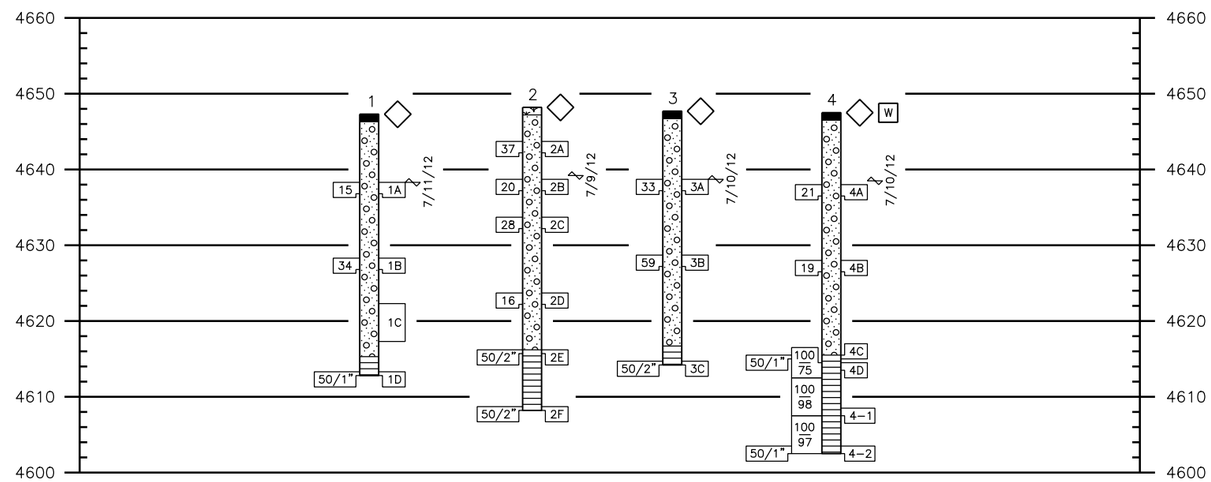
SPT | CON'T | GRAB | SHELBY | CORE

H_2O DEPTH	▽ 9.0				
DATE	7/10/12				
TIME	2:00 PM				

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

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





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 %	Dry Density (lb/ft³)	Uniaxial Compressive Strength/Strain (psf/%)	Chlorides (% mass)	Water Soluble Sulfates (% mass)	Soil pH ($H_2O/CaCl_2$)	Resistivity ohm-cm Saturated
1A	9.0–10.5	Gravelly Sand	SP	A-1-b(0)	41.8	35.9	20.5	1.8	NV	NP	NP	8.9	–	–	–	–	–	–
1C	25–30	Gravelly Sand	–	–	–	–	–	–	–	–	–	–	–	–	0.008	0.019	8.75	5350
2D	24.5–26.0	Gravelly Sand	SP	A-1-b(0)	22.2	56.6	20.3	0.9	NV	NP	NP	15.9	–	–	–	–	–	–
3B	19.0–20.0	Sand	SP	A-3(0)	1.6	40.4	54.0	4.1	NV	NP	NP	19.9	–	–	–	–	–	–
4D	33–34	Shale	SM	A-2-4(0)	4.4	24.2	46.9	24.4	NL	NP	NP	–	–	–	–	0.360	7.930	1300
4-1	39–40	Shale	–	A-2-4(0)	–	–	–	–	–	–	–	4.2	148	1,230,673/1.7	–	–	–	–
4-2	44–45	Shale	–	A-2-4(0)	–	–	–	–	–	–	–	3.7	147.7	1,264,501/2.1	–	–	–	–

TYPE OF MATERIAL

- Asphalt Pavement
- Topsoil
- Gravelly Sand, some Cobbles
- Shale Bedrock

Note: Boulders may be encountered at any depth

LEGEND

TEST BORING

Blows per foot* 30
R = Refusal on SPT
C = California Sample
50/0.1
50 Blows in 0.1 ft

3" Hole Size
1A Sample Number
Water Level

Core Recovery 50
R.Q.D. 25

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

CONTINUOUS PENETRATION TEST

2 Inch Diameter Drive Point
30 Inch Free Fall
140 Pound Hammer

0 50 100
Blows Per Foot

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

Print Date: 5/16/2013			
Drawing File Name: 17666geosheet01.dgn			
Horiz. Scale: 1:100	Vert. Scale: As Noted	R-X	
Staff Geotechnical Program	LAC		

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-GU
Detailer:	T. McNulty		
Sheet Subset:	Geology	Subset Sheets: XXX of XXX	

Project No./Code
IM 0251-334
17666
Sheet Number XXX