ALASKA

Department of Transportation and Public Facilities

Statewide Geotechnical Services

FOUNDATION GEOLOGY REPORT

Parks Highway
Milepost 237

Riley Creek Bridge Replacement
No. 0695

June 2014

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Parks Highway MP 237
Project No. 63763

June 2014

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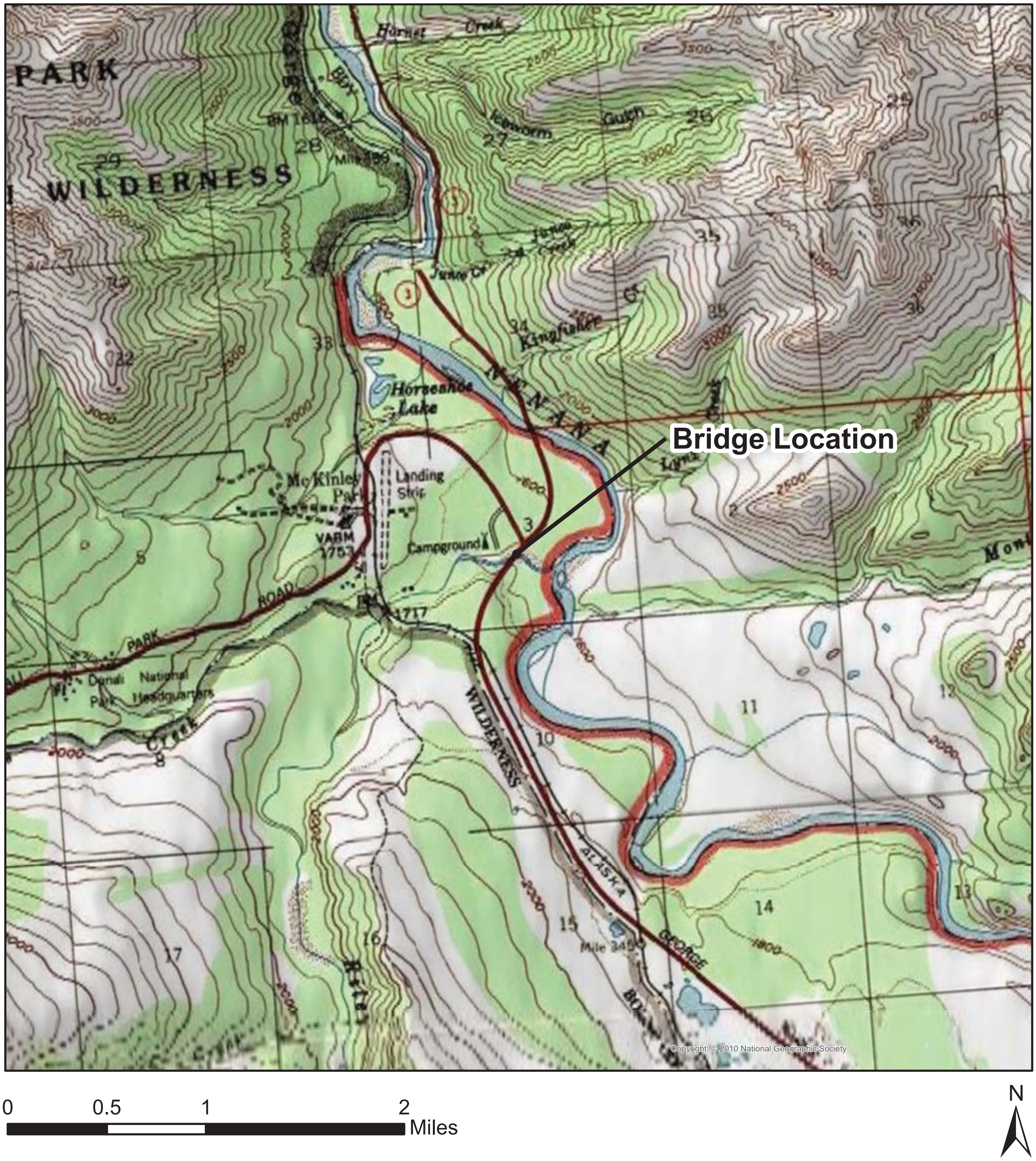
State of Alaska
Department of Transportation and Public Facilities
Statewide Design and Engineering Services
Materials Section

TABLE OF CONTENTS



State of Alaska
Department of Transportation
and Public Facilities

Figure 1: Vicinity Map
Parks Highway MP 237
Riley Creek Bridge Replacement
Project No. 63763
Bridge No. 0695

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INTRODUCTION

The Department of Transportation and Public Facilities (ADOT&PF) plans to construct a new bridge crossing Riley Creek at approximately milepost 237 on the Parks Highway. This two or three span structure will have an overall length of about 249 feet with an overall width of about 55 feet. The proposed replacement bridge centerline is offset approximately 45 feet right (NE) of the existing bridge location to accommodate the new alignment. This report represents the conditions observed during the geotechnical foundation investigation of the site.

Purpose and Scope of Work

ADOT & PF Statewide Geotechnical Services conducted this two phase geotechnical investigation utilizing DOT & PF personnel and equipment (CME 850 tracked rig) from June, 2012 to April, 2014. The initial investigation consisted of six test holes drilled to depths of up to 143 feet and five penetrometers driven to refusal. A second mobilization was conducted in April of 2014 to better characterize cohesive soils at two alternative pier locations and north abutment structure locations. The second phase consisted of advancing three test holes to acquire Shelby tube samples and collect additional standard penetration test (SPT) data. Drill sites for the second phase were selected by CH2M HILL (a project consultant) based on the proposed structure alternatives and approach embankment locations. At the time of the initial investigation a three-span structure was proposed.

The purpose of this investigation was to document subsurface geotechnical conditions and provides data to assist in the design of the proposed bridge structure foundations and associated structures. This document provides analyses and interpretation of anticipated site conditions and establishes a geotechnical baseline. This report is intended for use by the project design engineering staff, construction personnel, bidders, and contractors.

Geologic logs are presented here as preliminary in gINT graphical format. Final drafted logs are included in the project plans and specifications.

Subsequent Investigations

At the time of the initial field effort a US Park Service geologist provided ADOT with a recent LIDAR image indicating relatively recent tectonic activity along the Hines Creek Fault which intersects the project site, existing bridge, and proposed bridge location. At the behest of

ADOT&PF, two additional investigations were conducted to better delineate the fault, estimate the recurrence interval, and estimate potential deformation during future seismic events. The *Geophysical Fault Mapping* report prepared by Zonge International Inc. and Active Fault *Characteristics of the Hines Creek Fault* report prepared by University of Kentucky Department of Earth Sciences have been included as an attachment to this report.

Previous Investigations

- Alaska Department of Highways Foundation Section: Foundation Report – Riley Creek Bridge, August 1966

  Test hole logs from this investigation are included in Appendix D.

- ADOT Materials Section: Foundation Report - Repair of Riley Creek Bridge Pier 3, June 1986

  The test hole log from this investigation is included in Appendix D.

- ADOT Northern Region Geotechnical Report: Parks Hwy MP 237 Riley Creek Bridge Replacement, February 2014

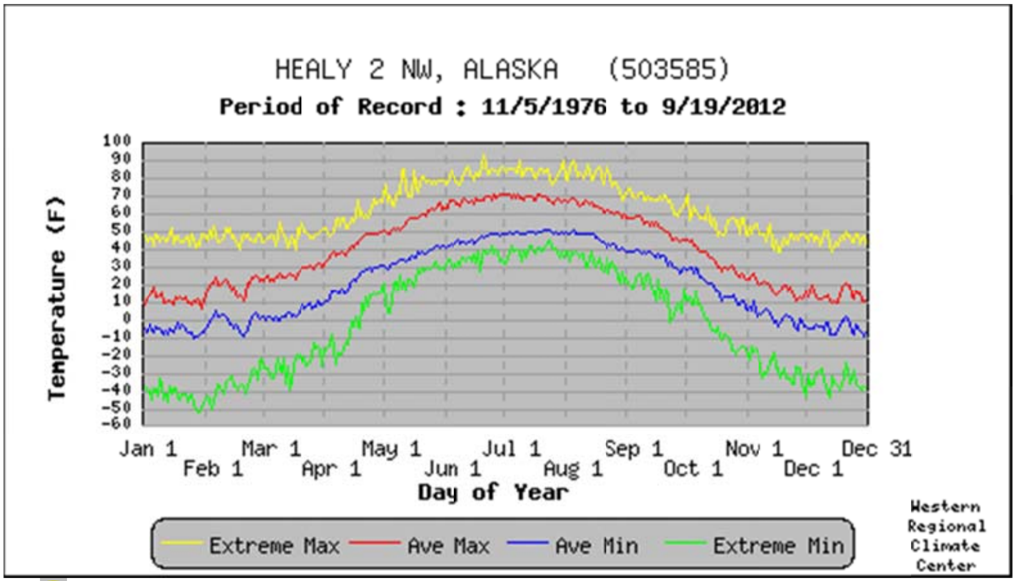
  This centerline investigation report is available by request.

REGIONAL SETTING

Location & Climate

Riley Creek, a tributary of the Nenana River, is located at approximately mile 237 of the Parks Highway, immediately south of Denali Park Road. Riley Creek lies roughly 12 miles south of Healy in the Nenana River valley at approximately 63.7275 N latitude, 148.8885 W longitude.

The project lies within the continental climatic zone of Alaska, characterized by relatively wide variations in seasonal temperatures and low precipitation and humidity. January temperatures average -22 to -2 °F, but temperatures below -50 °F have been recorded. July temperatures range from 50 to 72 °F. Average annual precipitation is approximately 11.3 inches. The following figure provided by the Western Region Climate Center shows daily temperature averages and extremes for the most recent period of record in Healy, Alaska.



● Extreme Max.is the maximum of all daily maximum temperatures recorded for the day of the year.

●- Ave. Max. is the average of all daily maximum temperatures recorded for the day of the year.

●- Ave. Min. is the average of all daily minimum temperatures recorded for the day of the year.

●- Extreme Min. is the minimum of all daily minimum temperatures recorded for the day of the year.

Figure 2

Topography, Drainage, & Vegetation

The project site lies in the Western Alaska Range foothills, a relatively broad and forested alluvial terrace which abruptly ends at the confluence of Riley Creek and the Nenana River approximately 600 feet to the east. The Riley Creek floodplain is roughly 200 feet wide and is littered with boulders, cobbles, and woody debris. The local topographic high is a glacial terrace rising roughly 300 feet in elevation immediately west to southwest of the project site.

The upper terraces are typically thickly covered by black spruce, birch, and alder while the stream banks of Riley Creek are generally populated by alder willows, shrubs, and grasses.

Geology

The stratigraphy and upper terrace development in the lower Nenana River Valley were formed by rapidly changing erosional and deposition environments during the Healy Ice Advance. The most recent major advance in this area was the Riley Creek event which consisted of up to four separate advances occurring between 25,000 and 9,500 YBP (Ten Brink & Waythomas). The ice limit during the peak Riley event is located in the vicinity of the project site. Immediately north of the project, a rapidly formed glacial lake (Lake Moody) about 9 miles long and 1/3 mile wide extended up the Nenana River gorge from Riley Creek from about 12,000 to 15,000 YBP.

The result of this dramatic and relatively rapid land form development is the highly variable stratigraphy we see in the general vicinity of this project.

The tectonically active Denali Fault lies approximately 19 miles south of the project site. The Denali Fault (right lateral strike-slip) is the fastest moving and most active fault in interior Alaska, slipping at a rate of 1/4” to 1/3” per year. A magnitude 7.9 earthquake ruptured the fault in November of 2002, representing interior Alaska’s largest recorded event. This seismic event involved a complex series of sub-events summarized in the figure below.

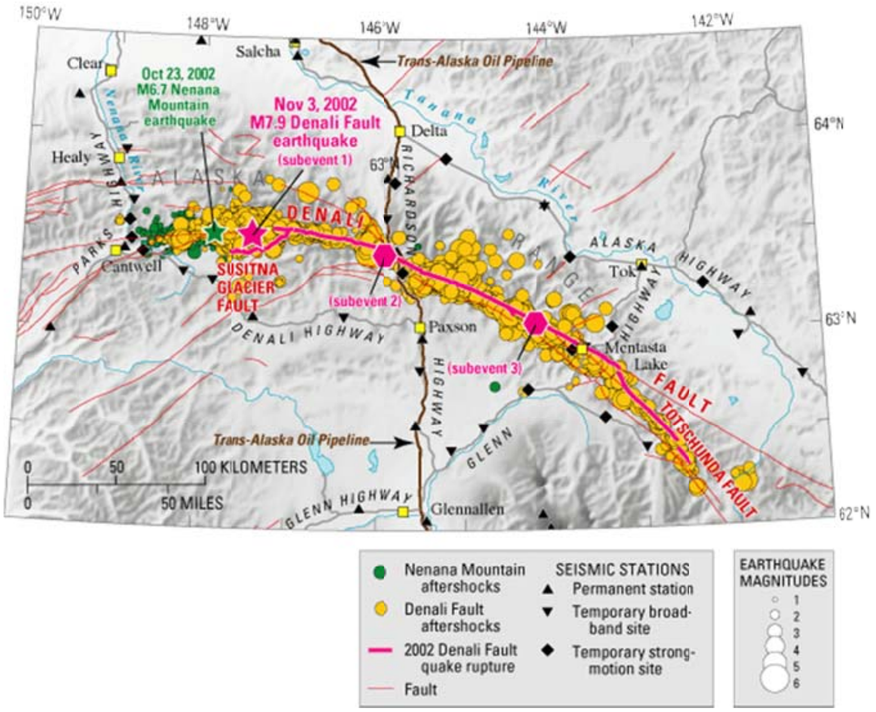


Figure 3: Denali Fault Earthquakes (Source - USGS)

METHODS AND PROCEDURES

Drilling Machinery and Tooling

- The Statewide Materials Section in Anchorage provided a track mounted CME 850 rotary drill for both phases of the drilling program.

- Test holes during the first phase were advanced using driven NW (3” nominal I.D.) casing, driven to sampling depth and cleaned out with a tri-cone bit and water circulation. Water and cuttings return are circulated through a settling tub, using no drilling fluid additives.

- During the second phase of the investigation 6.25” auger was used to accommodate a Pitcher tube assembly. A Pitcher tube assembly was utilized to improve the quality and recovery of relatively undisturbed samples.

- Open hole techniques were sometimes employed where firm soils allow the test hole to remain open without the need to install casing. Open hole drilling can be advantageous in material which refuses casing advance but can be readily penetrated by a tri-cone bit.

Penetration Tests

- Penetrometer Test soundings - 2.5-inch diameter, flush coupled, closed-end steel rod driven with a 340 pound CME automatic hammer. Blow counts are recorded for each 12-inch interval. The test terminates when 1000 blows or more are required to advance 12 inches.

- Standard Penetration Tests (SPT) - 1.4-inch I.D. x 2.0-inch O.D. standard split tube sampler, driven with a 140-pound CME automatic hammer with a 30-inch free-fall drop (ASTM D-1586).

  SPT measurements are recorded as hammer blows required to advance the sampler each 6-inches of penetration. N-values are the sum of the second and third 6-inch intervals. They are reported as counted, uncorrected for depth or hammer efficiency.

- Non-Standard Split Barrel Sampling - At samples depths where coarse gravels and/or very dense conditions were anticipated a 2.5” O.D. sampler driven by a 340 lb hammer was utilized to obtain adequate sample recovery. Hammer blows were recorded for each 6 inches of penetration.

Recovered Samples

- Material samples were collected using a standard (SPT) split tube sampler or non-standard split spoon sampler. Samples collected were packaged in double, polyethylene ZipLok® bags for transportation to the ADOT & PF Central Region Materials Lab in Anchorage.

- Recovered undisturbed samples (Shelby Tubes) were sealed in paraffin wax, capped at both ends and transported in an upright orientation to prevent degradation of the samples. Samples were maintained in an unfrozen (in-situ) state throughout transport.

- The driven casing and tri-cone method employed during this investigation introduces water which results in some collected samples not being suitable for reliable moisture analyses, particularly non-cohesive, granular samples.

- Loose or unbound in-situ material at sample depth may be mobilized by ground water and/or drilling disturbance to wash up into the pipe ("heave"), making testing unreliable. The height of rods above the casing collar ("stickup") is monitored as the sampler is placed at the bottom of the hole, to assure a clean hole or detect a heaving condition. If such a condition was observed, it has been included in the attached test hole logs.

Laboratory Testing

- Selected soil samples were submitted to the Central Region Materials Laboratory for testing. Test results are shown in the Preconstruction Sample Summary sheets (Appendix C). Field and laboratory testing procedures followed the appropriate ADOT&PF Geotechnical Procedures Manual, AASHTO or ASTM procedures.

- Undisturbed in-situ samples collected during the second phase of the investigation were transported to the University of Alaska Fairbanks (UAF) by ADOT personnel. The results of the testing program developed by CH2M HILL engineers and the Department of Civil and Environmental Engineering staff at UAF have been included as an attachment to this report.

Other In-Situ Measurements

- A one-inch I.D. PVC pipe was installed in two boreholes prior to backfilling for future thermistor readings if necessary. Thermistor tube joints are cemented and end-capped to seal against ground water.

- Elevations and locations were established using measuring tape, surveyed topographic data, and a recreational grade Garmin GPS unit.

GEOTECHNICAL CONDITIONS

Site Geology

Soils and Bedrock

Tectonic deformation and significant displacement combined with a complex erosional and depositional history have resulted in highly variable soil profile across the project site. This lack of continuity in sub-surface profile is most evident when comparing profiles across the fault zone which runs oblique to the bridge alignment and intersects the proposed north abutment (see Figure 4).

Subsurface soils observed beneath the Riley Creek floodplain are predominantly cohesive (CL, CL-ML, ML) containing variable amounts of sand and some gravel lenses. The clays and silts are capped by alluvial deposits up to 6.5 feet thick consisting of coarse, silty granular material with cobbles and boulders. Cohesive soils at the south abutment are overlain by up to 31 feet of coarse granular material containing cobbles and boulders. It should be noted that historical test holes advanced along the existing bridge alignment (project left) indicate a substantially different soil profile than those observed during this investigation, particularly ahead station from the north bank of Riley Creek. Beneath the embankment fill at the proposed north abutment the cohesive and fine granular soils observed were in excess of 100 feet deep near the right project margin at test hole TH12-11. By contrast, test hole TH12-12 along centerline indicated predominantly granular material (see below). Bedrock was not encountered during this investigation.

Hines Creek Fault

Disparate sub-surface conditions observed in closely spaced test holes advanced through the proposed north abutment provide corroborating evidence that the Hines Creek Fault passes through the proposed bridge alignment (Figure 4). The reverse fault dips 84-87 degrees to the northwest and has recently been identified as active. This fault has been characterized by pure dip/slip displacement and does not exhibit any measureable lateral component. Based on this investigation and historical boring logs, the fault obliquely intersects the proposed bridge alignment between TH12-11 and TH12-12 extending to the west beneath the existing pier 2. For further information on the characteristics of the Hines Creek fault, refer to the attached reports.

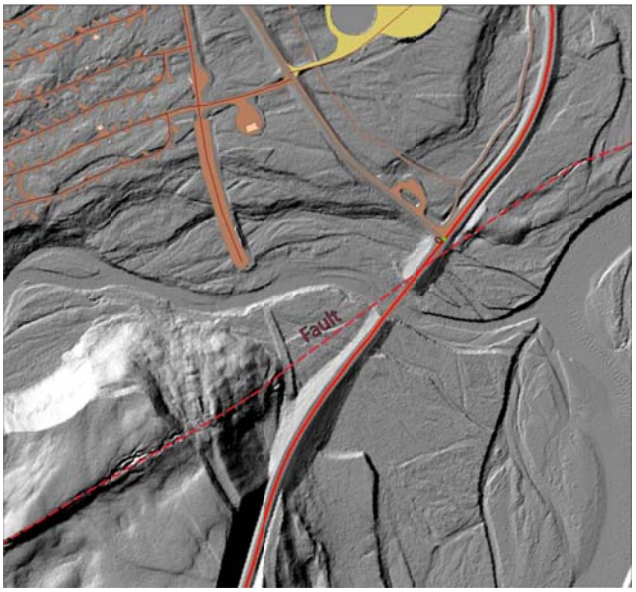


Figure 4 (fault location approximate)

Permafrost

No evidence of ice or frozen soil was observed during this investigation. Thermistor readings collected in TH12-09 one week after drilling did not indicate sub-freezing temperatures to a depth of 60 feet below ground surface. It should be noted, however, that historical logs (Appendix D) indicate the presence of "frozen silt with ice" at the existing south abutment and discontinuous permafrost may be present at this site.

South Approach

Cobbles and boulders should be expected in the upper 30 feet of gravels at this location though they were not observed during drilling (see Abutment 1 below). A layer of gravel containing cobbles and boulders was encountered from 65-73 feet below ground surface (bgs) which damaged our drill casing. The casing continued to deteriorate, preventing advancement of the test hole beyond 90 feet bgs. A penetrometer was driven from this depth to verify hard bottom below the cohesive soils. Penetrometer refusal was met at 103 feet bgs.

Generalized Subsurface Profile (TH12-01)

Description	USCS	Depth BGS	N-Value	P-200	Moisture
Gravel with Silt & Sand	GW-GM	0-27'	Non-standard spoon	10%	--
Inter-bedded Silts, Sands, & Clays	CL, CL-ML, ML, SM	27-65'	31-34	21-95%	20.6-22.9%
Gravel with Silt, Sand, Cobbles, & Boulders	GP-GM	65-73'	Non-standard spoon	8%	--
Silty Sand	SM	73-80'	Invalid (heave)	13%	18.7%
Silty Clay	CL-ML	80-90.1'	N/A	--	27.7%

South Abutment

P12-02 Location

The presence of coarse sands and gravels containing cobbles and boulders in the upper 31 feet of test hole TH12-01 prevented the collection of valid SPT data and drilling proved very difficult. A dense gravel layer was encountered at 64 feet bgs, beneath 33 feet of cohesive and fine granular soils which damaged the casing shoe to the degree that we could not continue beyond 68 feet of depth. Penetrometer P12-02 met refusal at 60 feet bgs.

Generalized Subsurface Profile (TH12-03)

Description	USCS	Depth BGS	N-Value	P-200	Moisture
Silty Sand with Gravel, Cobbles, & Boulders	SM	0.5-9’	Non-standard sampler	15%	--
Silty Gravel with Sand, Cobbles, & Boulders	GM	9-31’	Non-standard sampler	17%	--
Interbedded Silts, Sands, & Clays	CL, CL-ML, ML, SM, SP-SM	31-64’	31	21-93%	18.9-24%
Gravel	GP	64-68’	--	--	--

Pier 1 (2-Span Alternative)

The proposed pier 1 location in the center of the creek channel and near the south bank of the creek was inaccessible, therefor; drilling for this structure was not performed.

Center Pier (2-Span Alternative)

TH12-06 Site

Soils just ahead station from the proposed center pier are primarily stiff to hard cohesive soils overlain by 5 to 7.5 feet of course alluvial material. Penetrometer P12-07 met refusal at 72 feet bgs.

Generalized Subsurface Profile (TH12-06 & TH14-01)

Description	USCS	Depth BGS	N-Value	P-200	Moisture
Gravel with Sand, Cobbles & Boulders, Sand with Gravel, Silty Gravel	GP, GM, SP	0-7.5’	--	--	--
Inter-bedded Silts, Sands, & Clays	CL, CL-ML, ML, SM	7.5-125.5’	14-47	74-99%	20.6-32.7%
Silty Sand with Gravel	SM	125.5-130’	50	28%	--
Gravel with Cobbles & Boulders	GP	130-136’	--	--	--
Silt with Sand	ML	136-143’ (BOH)	31	82%	17.2%

Pier 3 (3-Span Alternative)

P12-08 Site

Soils at this site are primarily stiff to very stiff cohesive soils overlain by 5 to 6.5 coarse alluvial material containing organics. Note that the soils observed during this investigation portrays a significantly different soil profile than is indicated by historical data collected at the existing pier location (see Appendix D). These test holes are located within the fault zone and soil conditions may vary significantly over short horizontal distances. Penetrometer P12-08 met refusal at 78 feet bgs.

Generalized Subsurface Profile (TH12-09 & TH14-02)

Description	USCS	Depth BGS	N-Value	P-200	Moisture
Silty Gravel with Sand	GM	0-6.5’	--	--	--
Interbedded Silts & Clays	CL, CL-ML, ML	6.5-130’ (BOH)	9-45	52-100%	22.1-29.1%

North Abutment

TH12-11 Site

The Hines Creek Fault intersects this proposed abutment structure. This is evident when comparing test hole TH12-11 with test hole TH12-12 (50 feet ahead station) and historical borings 3 and 9 beneath the existing north abutment (Appendix D). Very fine grained and cohesive soils extending to 103 feet bgs (bottom of test hole) were observed beneath the embankment material at TH12-11. In contrast, historical borings advanced beneath the existing abutment indicate coarse granular material beneath approximately 21 feet of clayey silt. The refusal depths of the two penetrometers advanced adjacent to TH12-11 may indicate that conditions at these locations correspond with soil profiles seen in TH12-12 and the historical borings 3 and 9. Penetrometer P12-10 and P12-13 met refusal at 45 and 53 feet, respectively, which roughly corresponds with denser, granular soils observed in test holes on the north side of the fault (project left).

Generalized Subsurface Profile (TH12-11 & TH14-03)

Description	**USCS**	**Depth BGS**	**N-Value**	**P-200**	**Moisture**
Gravel with Silt, Sand, Cobbles & Boulders	GP-GM	0-12’	Refusal	--	--
Interbedded Silts, Clays, & Sands	CL, CL-ML, ML, SC	12-103’ (BOH)	11-32	22-98%	11.2-26.6%

North Approach

With the exception of a three foot layer of silty clay beneath the embankment material, soils at this location are primarily granular. This test hole is located within the fault zone and soil conditions may vary significantly over short horizontal distances. Cobbles and boulders may be present throughout the soil column.

Generalized Subsurface Profile (TH12-12)

Description	USCS	Depth BGS	N-Value	P-200	Moisture
Gravel with Silt, Sand, Cobbles & Boulders	GP-GM	0-17’	Non-Standard Sampler	7%	--
Silty Clay	CL-ML	17-20’	Non-Standard Sampler	--	19.1%
Silty Sand	SM	20-35’	21-22	--	--
Gravel with Silt & Sand	GP-GM	35-42’	Non Standard Sampler	9%	7.1%
Silty Sand with Gravel, Cobbles & Boulders	SM	42-59’	Non Standard Sampler	15-16%	--
Gravel with Silt & Sand	GP-GM	59-67.8’ (BOH)	Non Standard Sampler	--	--

SELECTED REFERENCES

Alaska Department of Transportation and Public Facilities; *Alaska Geotechnical Procedures Manual*, Oct 2007.

Alaska Earthquake Information Center (AEIC), (web site: www.aeic.alaska.edu), Geophysical Institute, University of Alaska Fairbanks.

Bemis, S.P & Federschmidt, S., *Parks Highway MP 237 Riley Creek Bridge Replacement: Investigation Targetting the Active Fault Characteristics of the Hines Creek Fault*, Department of Earth Sciences, University of Kentucky, May 2013.

NOAA National Weather Service, Alaska - Pacific River Forecast Center, web site: http://aprfc.arh.noaa.gov/.

Ritter, D.F., *"Complex River Terrace Development in the Nenana Valley Near Healy, Alaska"*, Geological Society of American Bulletin, Volume 93 No. 4, April 1982.

U.S. Geological Survey, National Seismic Earthquake Hazards program, Interactive Deaggregations, 1996. Web site http://eqint.cr.usgs.gov/deaggint/1996/index.php.

U.S. Geological Survey, *The Geology of North America Volume G-1: The Geology of Alaska*, 1994.

Wahrhaftig, C., *"Quaternary Geology of the Nenana River Valley and Adjacent Parts of the Alaska Range"*, Geological Survey Professional Paper No. 293, 1958.

Wahrhaftig, C. & Black, R., *"Engineering Geology Along Part of the Alaska Railroad"*, Geological Survey Professional Paper No. 293, 1958.

Western Region Climate Center, Reno, NV 89512-1095, website: http://www.wrcc.dri.edu

Zonge International, Inc., *"Geophysical Fault Mapping – Riley Creek Bridge Replacement Project – Parks Highway MP 237, Denali, Alaska"*, February, 2013.

ASTM References

D1586 - Test Method for Penetration Test and Split-Barrel Sampling of Soils

D1587 – Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2487 - Practice for Classification of Soils for Engineering Purposes

D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

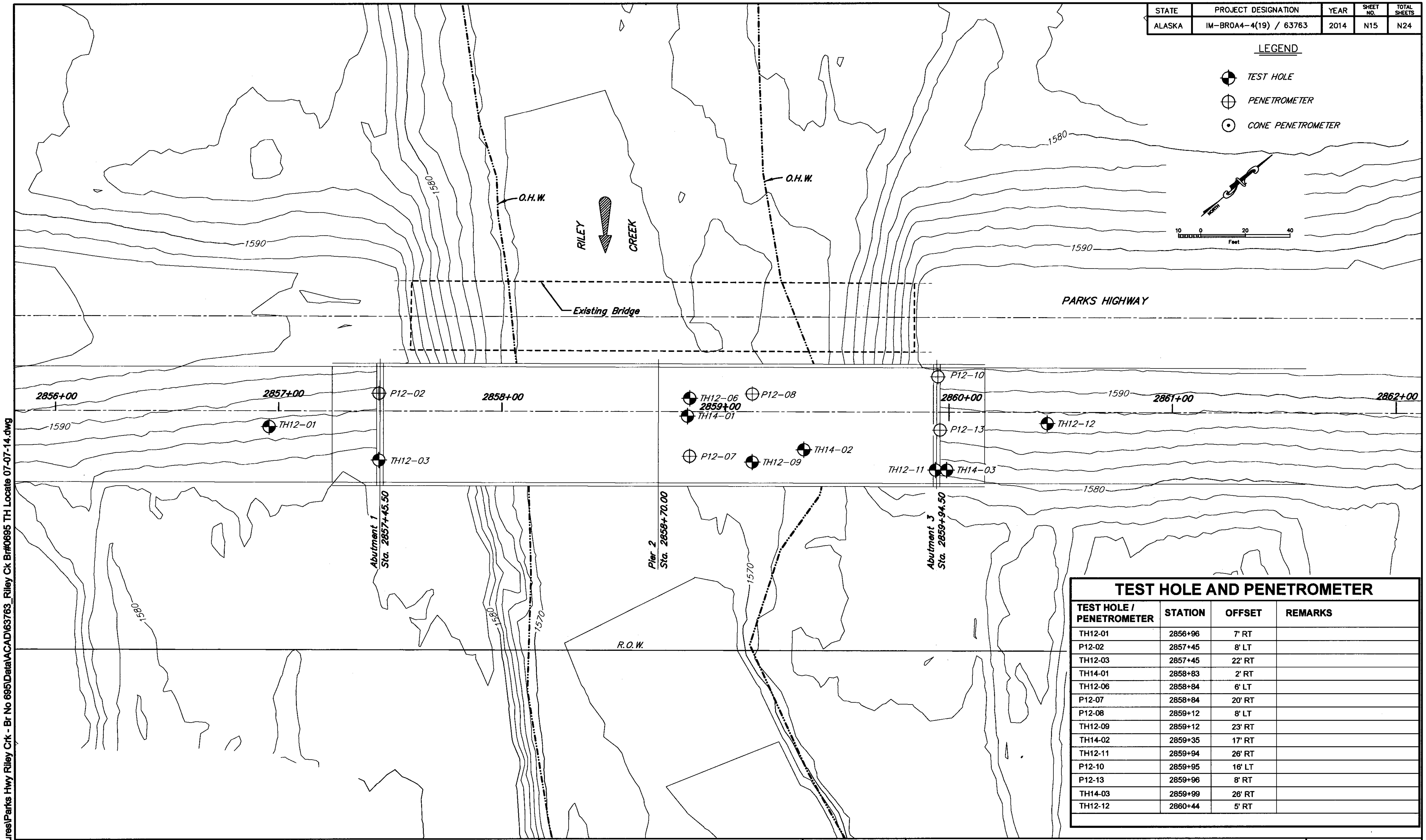
D-3550 – Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D3740 - Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	IM-BR0A4-4(19) / 63763	2014	N15	N24

LEGEND

- ● TEST HOLE
- ⊕ PENETROMETER
- ⊙ CONE PENETROMETER



TEST HOLE AND PENETROMETER

TEST HOLE / PENETROMETER	STATION	OFFSET	REMARKS
TH12-01	2856+96	7' RT	
P12-02	2857+45	8' LT	
TH12-03	2857+45	22' RT	
TH14-01	2858+83	2' RT	
TH12-06	2858+84	6' LT	
P12-07	2858+84	20' RT	
P12-08	2859+12	8' LT	
TH12-09	2859+12	23' RT	
TH14-02	2859+35	17' RT	
TH12-11	2859+94	26' RT	
P12-10	2859+95	16' LT	
P12-13	2859+96	8' RT	
TH14-03	2859+99	26' RT	
TH12-12	2860+44	5' RT	

N:\Northern\Structures\Parks Hwy Riley Crk - Br No 695\Data\ACAD\63763_Riley Ck Br#0695 TH Locate 07-07-14.dwg

DESIGNED BY:	D.Hemstreet	CHECKED:	Engineer
DRAWN BY:	D.R.Dodge	CHECKED:	Engineer
QUANTITIES BY:	Engineer	CHECKED:	Engineer

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND PUBLIC FACILITIES
STATEWIDE MATERIALS

RILEY CREEK BRIDGE

PARKS HIGHWAY

TEST HOLE & PENETROMETER LOCATION

BRIDGE NO. 0695
DWG. NO. 15

APPENDIX A

EXPLANATIONS AND TERMINOLOGY

Laboratory Classification

of Soils for Engineering Purposes
Unified Soil Classification System
ASTM D2487

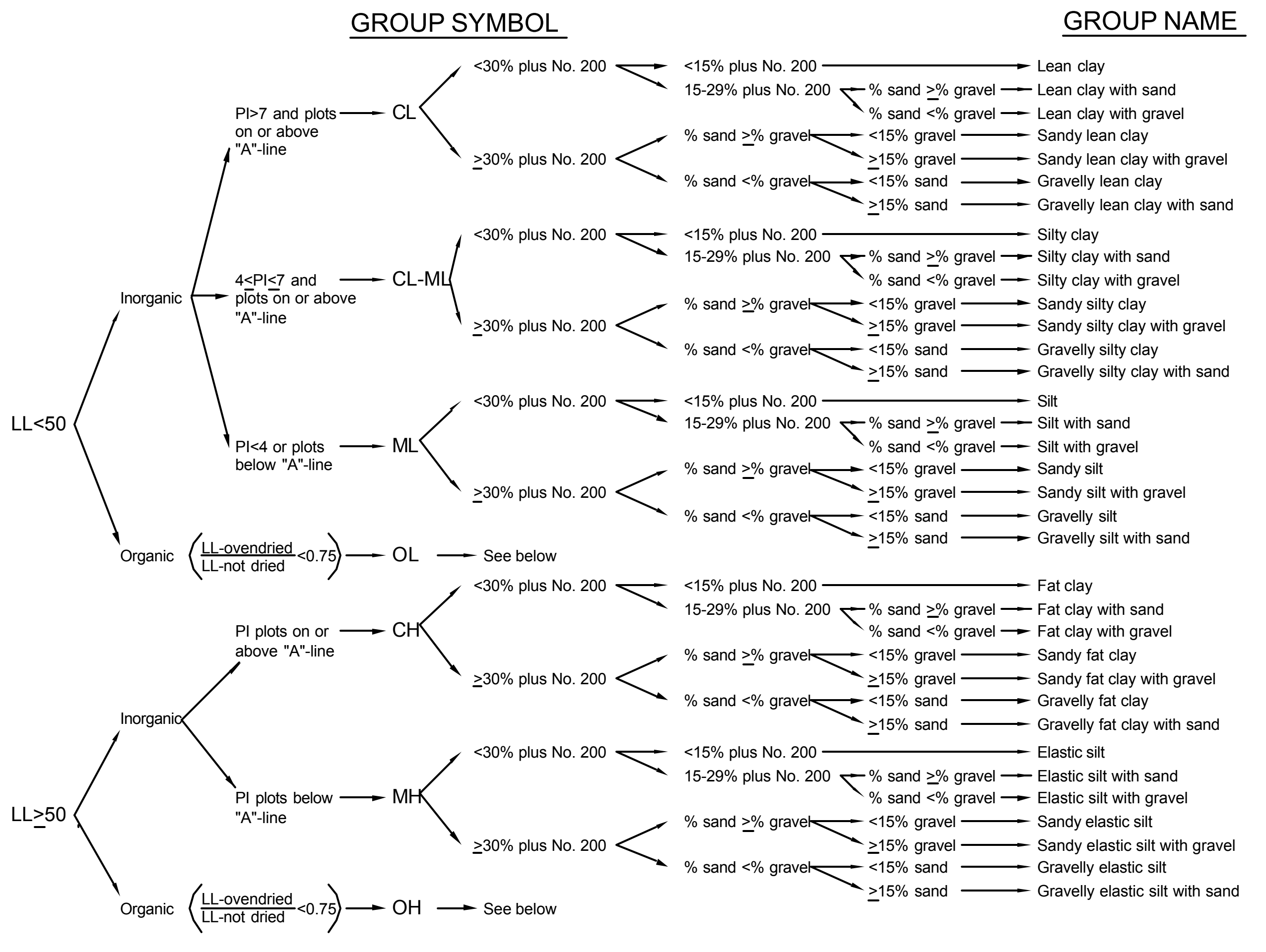


Figure 1: Flow Chart for Classifying Fine-Grained Soil (50% or More Passes No. 200 Sieve)

Coefficient of Uniformity , Cu
the ratio D60/D10, where D60 and D10 are the particle diameters corresponding to 60 and 10 % finer on the cumulative particle-size distribution curve respectively.

Coefficient of Curvature, Cc
the ratio (D30)*(D30)/(D10)*(D60) where D60 and D10 are the particle diameters corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve respectively.

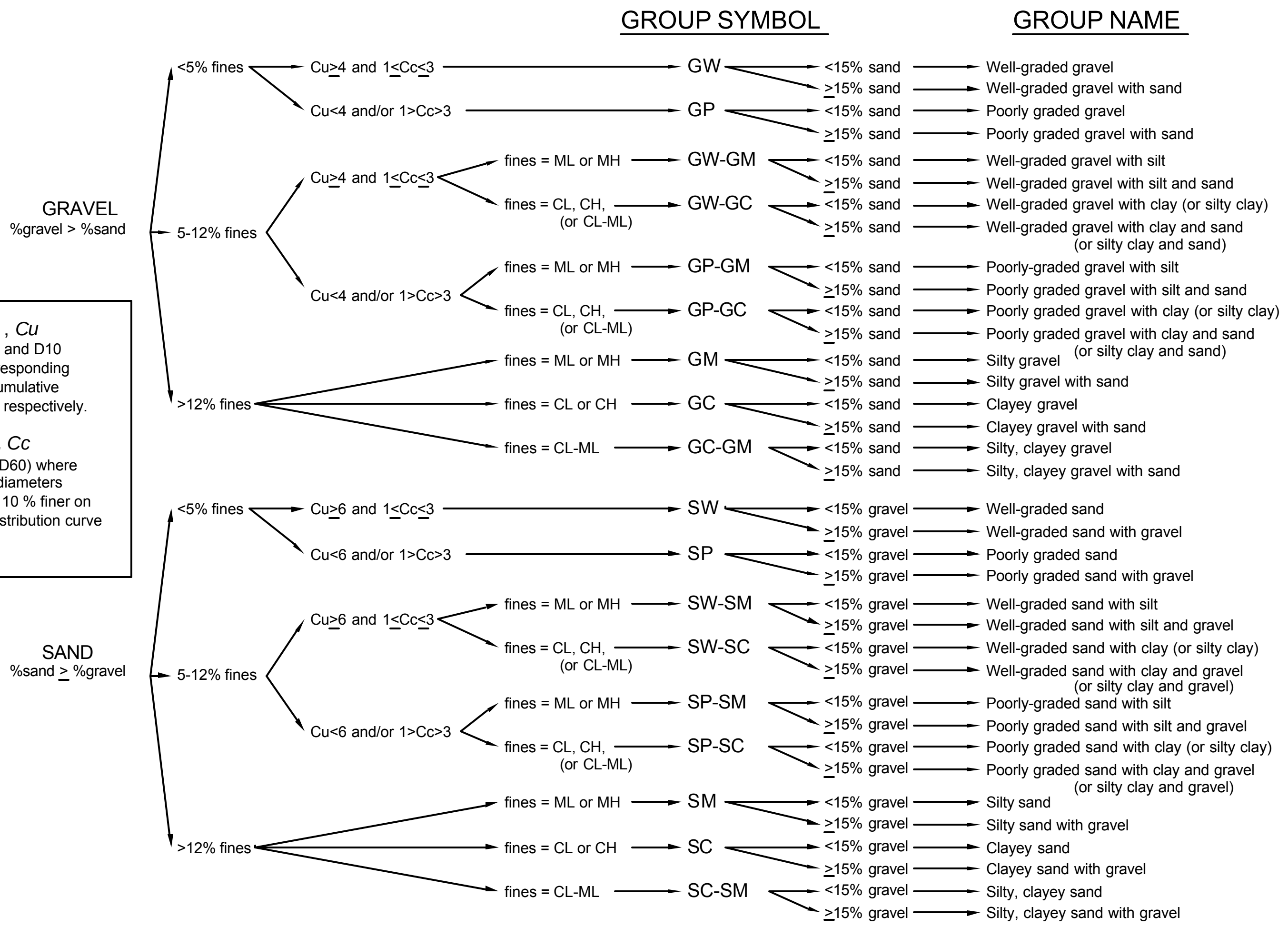
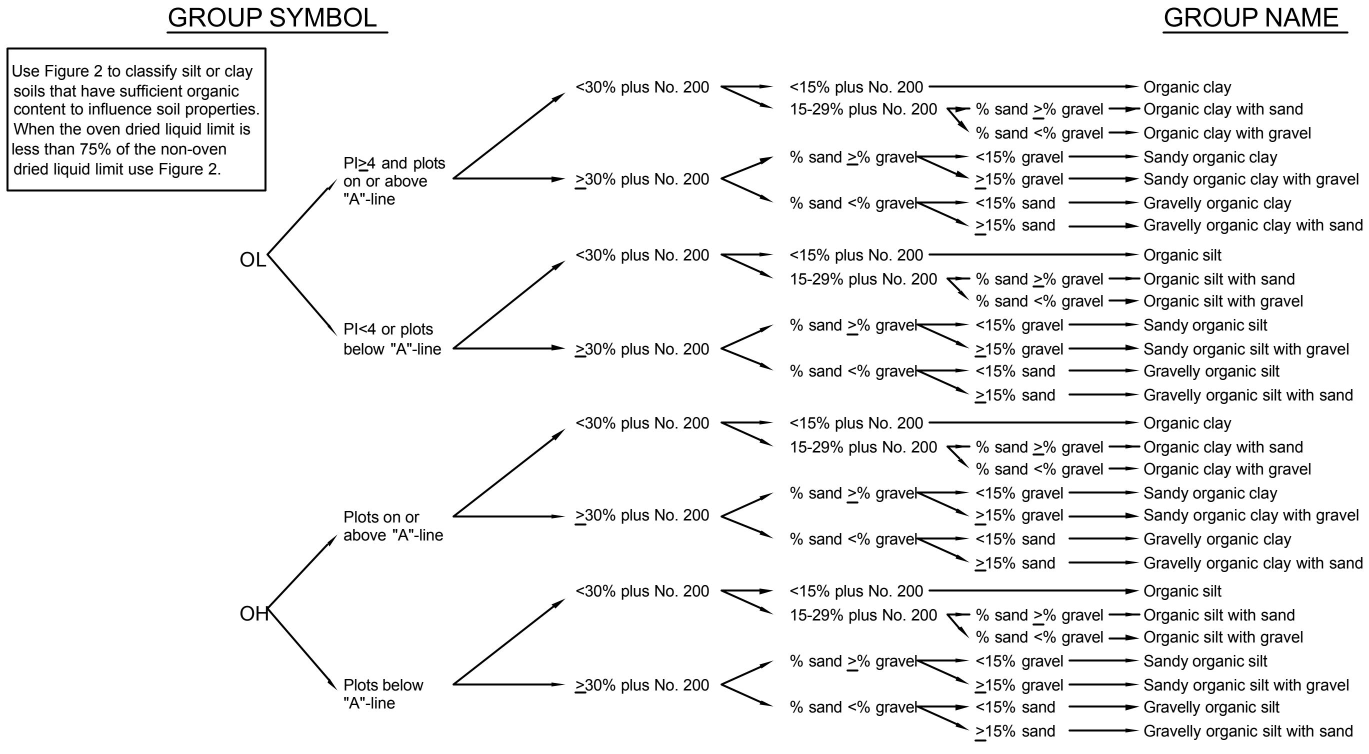


Figure 3: Flow Chart for Classifying Coarse-Grained Soil (More Than 50% Retained on No. 200 Sieve)



Use Figure 2 to classify silt or clay soils that have sufficient organic content to influence soil properties. When the oven dried liquid limit is less than 75% of the non-oven dried liquid limit use Figure 2.

Figure 2: Flow Chart for Classifying Organic Fine-Grained Soil (50% or More Passes No. 200 Sieve)

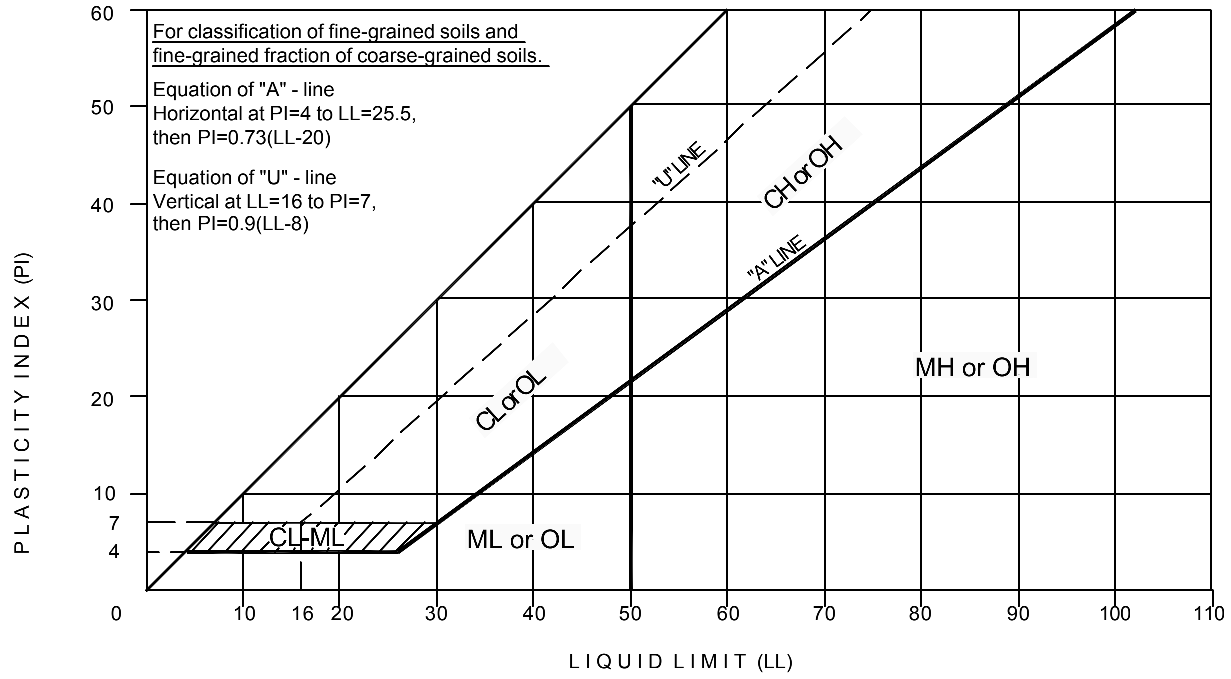
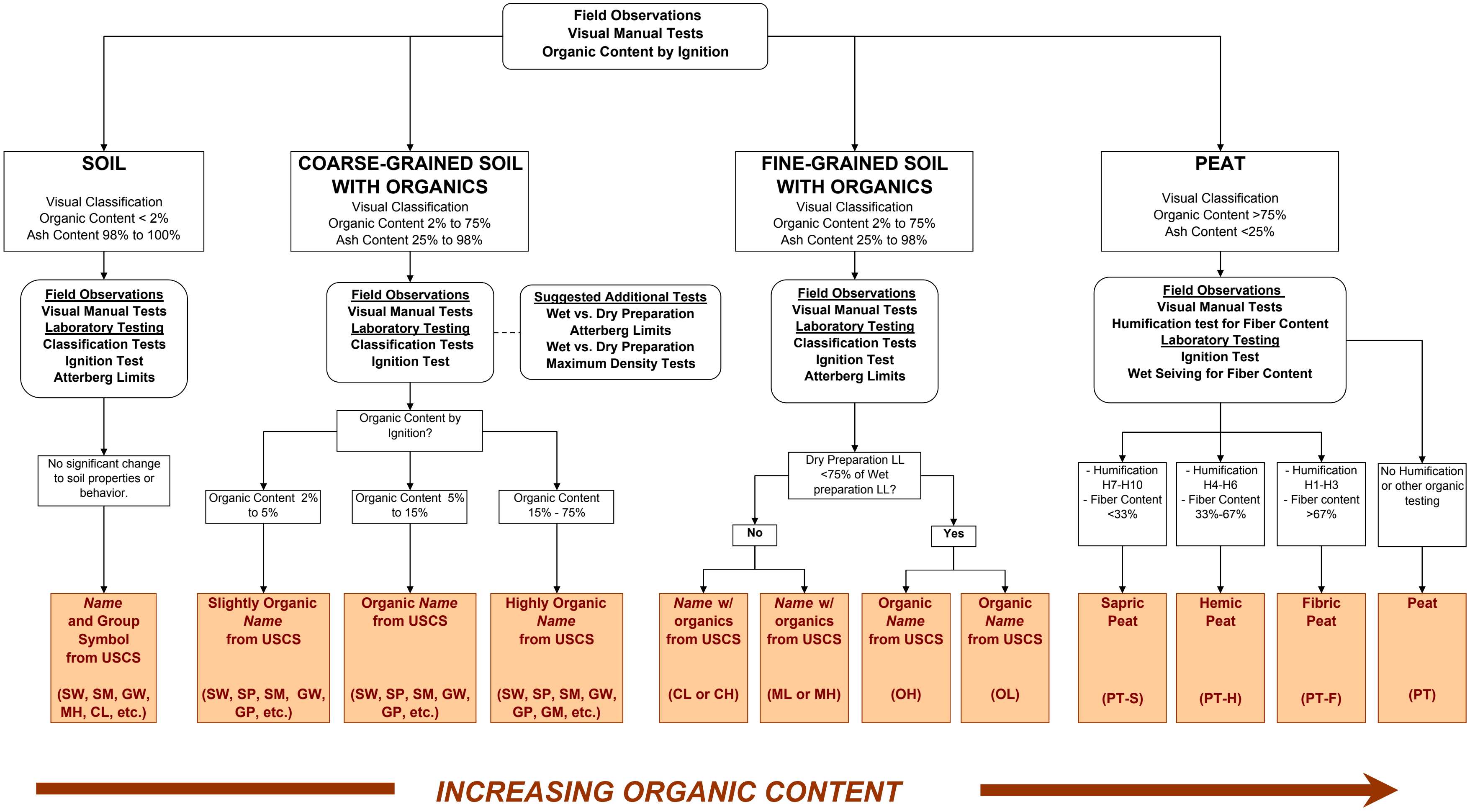


Figure 4: Plasticity Chart

H:\GEOLOGY StwMat\USCS CHART\ASTM D2487-D2488 Chart.dwg 26 APRIL 2005 ASP

Peat and Organic Soil Classification System



Field Observations
Visual Manual Tests
Organic Content by Ignition

SOIL
Visual Classification
Organic Content < 2%
Ash Content 98% to 100%

Field Observations
Visual Manual Tests
Laboratory Testing
Classification Tests
Ignition Test
Atterberg Limits

No significant change to soil properties or behavior.

***Name* and Group Symbol from USCS**
(SW, SM, GW, MH, CL, etc.)

COARSE-GRAINED SOIL WITH ORGANICS
Visual Classification
Organic Content 2% to 75%
Ash Content 25% to 98%

Field Observations
Visual Manual Tests
Laboratory Testing
Classification Tests
Ignition Test

Suggested Additional Tests
Wet vs. Dry Preparation
Atterberg Limits
Wet vs. Dry Preparation
Maximum Density Tests

Organic Content by Ignition?

Organic Content 2% to 5%

Slightly Organic *Name* from USCS
(SW, SP, SM, GW, GP, etc.)

Organic Content 5% to 15%

Organic *Name* from USCS
(SW, SP, SM, GW, GP, etc.)

Organic Content 15% - 75%

Highly Organic *Name* from USCS
(SW, SP, SM, GW, GP, GM, etc.)

FINE-GRAINED SOIL WITH ORGANICS
Visual Classification
Organic Content 2% to 75%
Ash Content 25% to 98%

Field Observations
Visual Manual Tests
Laboratory Testing
Classification Tests
Ignition Test
Atterberg Limits

Dry Preparation LL <75% of Wet preparation LL?

No

***Name* w/ organics from USCS**
(CL or CH)

***Name* w/ organics from USCS**
(ML or MH)

Yes

Organic *Name* from USCS
(OH)

Organic *Name* from USCS
(OL)

PEAT
Visual Classification
Organic Content >75%
Ash Content <25%

Field Observations
Visual Manual Tests
Humification test for Fiber Content
Laboratory Testing
Ignition Test
Wet Seiving for Fiber Content

- Humification H7-H10
- Fiber Content <33%

Sapric Peat
(PT-S)

- Humification H4-H6
- Fiber Content 33%-67%

Hemic Peat
(PT-H)

- Humification H1-H3
- Fiber content >67%

Fibric Peat
(PT-F)

No Humification or other organic testing

Peat
(PT)

INCREASING ORGANIC CONTENT

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Geology Section

LOG OF TEST HOLE

HOLE # LEGEND

PROJECT NUMBER :
PROJECT : *TEST HOLE EXPLANATION 2009*

Station / Location: *(Station, Lat./Long.)*
Offset: *Offset Location if applicable*
Elevation: *Elevation*

Equipment Type:
Hole Type:
Field Crew: *Driller, Helper*

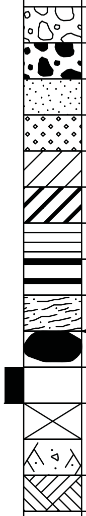
Total Depth: *19.0 ft*
Date: *3/12/2009 -*
Geologist:

Ground Water Data

Depth in (ft.)	15.8	
Time	10:00	
Date	3/12/09	
Symbol	▼	

Weather: This section is for weather notes

Depth (Feet) | Sample Data: Drill Method, Blow Count, N Value, Number, Recovery, Sample Type, Sample | USCS Classification | Frozen Zone | Soil Graphic | SUBSURFACE MATERIAL



USCS	SUBSURFACE MATERIAL	
	SOIL GRAPHIC AND SOIL TYPE EXPLANATION All graphics are generic representations of soil type and do not match soils as seen in-situ.	0.0 0.5
GP	**GRAVEL** (GP)	1.0
GW	**GRAVEL** (GW)	1.5
SP	**SAND** (SP)	2.0
SW	**SAND** (SW)	2.5
ML	**SILT** (ML)	3.0
MH	**SILT** (MH)	3.5
CL	**CLAY** (CL)	4.0
CH	**CLAY** (CH)	4.5
PT	**ORGANICS OR PEAT** (PT)	5.0
	Cobbles or Boulder Location with approximate strata contact	5.5
	ICE or Frozen Soil Interval	6.0
	TRANSITIONAL SOIL CHANGE	6.5
	WEATHERED BEDROCK (Strength Grade, Weathering Grade)	7.0
	BEDROCK (Strength Grade, Weathering Grade)	7.5

SAMPLE DATA EXPLANATION

(09-3533) = Sample Number

Blow Count	N Value	Sample Type	
1	5	SPT	Standard Penetration Test Split Spoon Sample 1.4" ID x 2" OD with 140 lb. Hammer
2		SS	Split Spoon Sample 2.0" ID x 2.5" OD with 340 lb. Hammer
3		MC	Split Spoon Sample 2.5" ID x 3" OD with 340 lb. Hammer
4		GRAB	Grab Sample
		AUGER	Auger Cuttings Grab Sample
		EB	Excavator Bucket Grab Sample
		CORE	Rock Core
		ST	Shelby Tube thin wall 3" OD
		MS	Modified Shelby Tube (size)
		NR	No Recovery
		SNT	Sample Not Tested or Retained
		FLD WT	Field Weighted Sample
		UNDIST	Undisturbed Sample
		VANE	Vane Shear Test: Vane Diameter =X", Vane Height = X", Vane Shear Undisturbed Torque=X ft.-lbs., Vane Shear Remolded Torque=X ft.-lbs.

9.5

SPT = BLOWCOUNT / ft. (TOTAL BLOWS FOR SECOND & THIRD 6" INCREMENT) WITH STANDARD PENETRATION TEST SAMPLER w/ 1.4" ID, 2" OD USING A CME AUTOHAMMER WITH 140 lb. HAMMER AND A 30" FREEFALL LATEST EDITION AASHTO T 206 (ASTM D1586).

SS = BLOW COUNT w/ 2" ID, 2.5" OD SAMPLER DRIVEN BY A 340 lb. CME AUTOHAMMER w/ A 30" FREEFALL.

MC = BLOW COUNT w/ 2.5" ID, 3" OD SAMPLER DRIVEN BY A 340 lb. CME AUTOHAMMER WITH A 30" FREEFALL

AN ASTERISK IN THE N-VALUE COLUMN INDICATES SAMPLER REFUSAL. REFUSAL DEFINED AS 50 OR MORE BLOWS PER 6" INCREMENT, 100 TOTAL BLOWS, OR NO MOVEMENT OBSERVED WITH 10 SUCCESSIVE BLOWS.

AN "X" IN THE N-VALUE COLUMN INDICATES NO VALID SPT.

15.5

▼ Observed Groundwater

16.0

SAMPLE TEST RESULTS EXPLANATION

Boulders = > 12"	Plasticity Index (PI) = % or Nonplastic (NP)
Cobbles = 3" to 12"	Liquid Limit (LL) = % or No Value (NV)
Gravel = #4 to 3"	Degradation = Dimensionless Number
Sand = #200 to #4	LA Abrasion = % Loss
Silt/Clay (P200) = <#200	Sodium Sulfate (Cse or Fine) = % Loss
Clay = <0.0075 Size	Max. Dry Density = Pounds Per Cubic Foot
Natural Moisture Content = %	Optimum Moisture = %
Organic Content = %	

19.0

BOH
19

Notes:
This section is for drilling notes and additional equipment descriptions

Depth (Feet): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

☐ CME Auto Hammer ☐ Cathead Rope Method

APPENDIX B

TEST HOLE AND PENETROMETER LOGS

LOG OF TEST HOLE

HOLE # TH12-01

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2856+96*
Offset: *7' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *90.1 feet*
Date: *6/24/2012 - 6/25/2012*
Geologist: *B. Benko & S. Evans*

Weather: Partly cloudy

Ground Water Data		
Depth in (ft.)	12.86	
Time		
Date	6/24/12	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	N-Value
3–5	SS	NS	9 11 6 9	
8–10	SS	FS-71	6 10 13 14	
13	SS	NS	37	
18	SS	NS	18 31	
23–25	SS	FS-72	40 33 26	
28–30	SS	FS-73	8 6 5 5	
33–35	SPT	FS-74	15 18 16 16	34

SUBSURFACE MATERIAL

Depth	USCS Classification	Subsurface Material
0.0	OL	**ORGANIC SILT** (OL)
0.5	GW-GM	**GRAVEL with Silt and Sand** (GW-GM)
4		NS 340 lb hammer
9		FS-71 340 lb hammer, p200=10%, Sa=36%, Gr=54%
13		NS 340 lb hammer, 3 inch advance with 37 blows
18		NS 340 lb hammer, 1 inch advance with 31 blows
23		FS-72 340 lb hammer
27.0	ML	**SILT** (ML)
28.0	SM	**SILTY SAND** (SM) FS-73 p200=26%, Sa=74%, Gr=0%, Moisture=21.5%, PI=NP, LL=NV
29.0	CL	**CLAY** (CL) Dark gray, homogeneous
32.0	SM	**SILTY SAND** (SM) Interbedded Silt and Sand
34		FS-74 p200=33%, Sa=67%, Gr=0%

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH12-01

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2856+96*
Offset: *7' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *90.1 feet*
Date: *6/24/2012 - 6/25/2012*
Geologist: *B. Benko & S. Evans*

Weather: Partly cloudy

Ground Water Data		
Depth in (ft.)	12.86	
Time		
Date	6/24/12	
Symbol	▼	

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value
38–40	SPT	FS-75	9 14 16 14	☒	■	30
43–45	SPT	FS-76	11 19 18 26	☒	■	
48–50	SPT	FS-77	6 12 20 20	☒	■	32
58–60	SPT	FS-78	8 11 20 27	☒	■	31
65–67	SS	FS-79	65 37 35 15	⧗	■	

Depth (Feet)	USCS Classification	SUBSURFACE MATERIAL	
35		**SILTY SAND** (SM) Interbedded Silt and Sand (cont.) FS-75 p200=21%, Sa=79%, Gr=0%, Moisture=20.6%	
41.0	ML	**SANDY SILT** (ML) Gray, wet, sand occurs as layers and ribbons FS-76 p200=65%, Sa=35%, Gr=0%, Moisture=22.6%, PI=NP, LL=NV	41.0
44.5	SP-SM	**SAND with Silt** (SP-SM) Moist	44.5
47.0	ML	**SILT with Sand** (ML) Gray, wet	47.0
47.8	SM	**SILTY SAND** (SM) Gray, wet FS-77 p200=46%, Sa=54%, Gr=0%, Moisture=22.5%	47.8
52.5	CL-ML	**SILTY CLAY** (CL-ML) Gray, moist, trace sand as thin layers FS-78 p200=95%, Sa=5%, Gr=0%, Moisture=22.9%, PI=4, LL=24	52.5
60.0	SM	**SILTY SAND** (SM) Gray, wet	60.0
65.0	GP-GM	**GRAVEL with Silt, Sand, Cobbles, & Boulders** (GP-GM) Gray FS-79 340 lb hammer, destroyed sampler shoe, p200=8%, Sa=41%, Gr=51%	65.0
70			

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-01

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2856+96*
Offset: *7' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

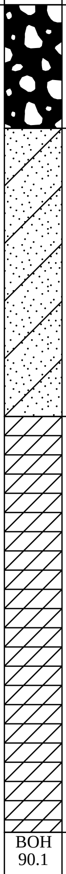
Total Depth: *90.1 feet*
Date: *6/24/2012 - 6/25/2012*
Geologist: *B. Benko & S. Evans*

Ground Water Data

Depth in (ft.)	12.86	
Time		
Date	6/24/12	
Symbol	▼	

Weather: Partly cloudy

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone
76–78	SPT	FS-80		☒	■		SM	
90	GRAB	FS-81			■		CL-ML	



SUBSURFACE MATERIAL

70 **GRAVEL with Silt, Sand, Cobbles, & Boulders** (GP-GM) Gray FS-79 340 lb hammer, destroyed sampler shoe, p200=8%, Sa=41%, Gr=51% (cont.)

73.0 **SILTY SAND** (SM)

FS-80 Sampler advanced through disturbed material to verify composition, heaving sands, p200=13%, Sa=83%, Gr=4%, Moisture=18.7%

80.0 **SILTY CLAY** (CL-ML)

FS-81 Sample collected from tri-cone, Moisture=27.7%, PI=15, LL=34

90.1

BOH
90.1

Notes:
Cobbles and boulder present on surface. Pulled out of hole when casing was compromised and continued advancing a penetrometer (open hole) at 90 feet to estimate hard bottom.

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Foundation Geology

PENETROMETER LOG

HOLE # TH12-01

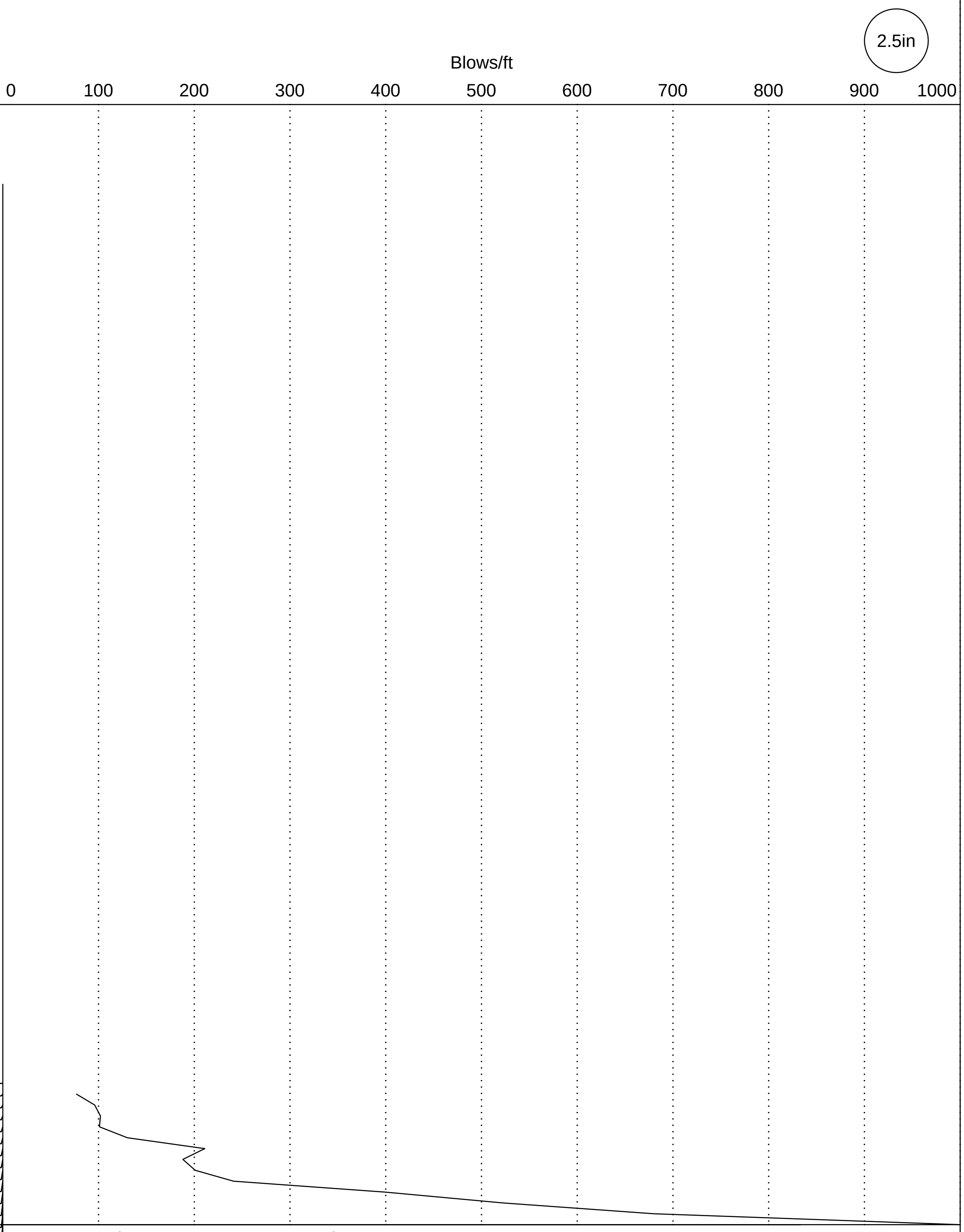
PROJECT NUMBER *63763*
PROJECT: *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2856+96*
Offset: *7' Rt*
Elevation: *1588.0 feet*

Equipment Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *103.0 feet*
Date: *6/24/2012 - 6/25/2012*
Geologist: *B. Benko & S. Evans*

Weather: Partly cloudy



Elevation	Depth	Blow Count
1588	0	
1587	1	
1586	2	
1585	3	
1584	4	
1583	5	
1582	6	
1581	7	
1580	8	
1579	9	
1578	10	
1577	11	
1576	12	
1575	13	
1574	14	
1573	15	
1572	16	
1571	17	
1570	18	
1569	19	
1568	20	
1567	21	
1566	22	
1565	23	
1564	24	
1563	25	
1562	26	
1561	27	
1560	28	
1559	29	
1558	30	
1557	31	
1556	32	
1555	33	
1554	34	
1553	35	
1552	36	
1551	37	
1550	38	
1549	39	
1548	40	
1547	41	
1546	42	
1545	43	
1544	44	
1543	45	
1542	46	
1541	47	
1540	48	
1539	49	
1538	50	
1537	51	
1536	52	
1535	53	
1534	54	
1533	55	
1532	56	
1531	57	
1530	58	
1529	59	
1528	60	
1527	61	
1526	62	
1525	63	
1524	64	
1523	65	
1522	66	
1521	67	
1520	68	
1519	69	
1518	70	
1517	71	
1516	72	
1515	73	
1514	74	
1513	75	
1512	76	
1511	77	
1510	78	
1509	79	
1508	80	
1507	81	
1506	82	
1505	83	
1504	84	
1503	85	
1502	86	
1501	87	
1500	88	
1499	89	
1498	90	
1497	91	77
1496	92	96
1495	93	102
1494	94	101
1493	95	130
1492	96	211
1491	97	188
1490	98	201
1489	99	241
1488	100	399
1487	101	523
1486	102	680
1485	103	1000

Bottom of Penetrometer Test at: 103 feet
Notes: Cobbles and boulder present on surface

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH12-03

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2857+45*
Offset: *22' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *68.0 feet*
Date: *6/21/2012 - 6/23/2012*
Geologist: *S. Evans & B. Benko*

Ground Water Data

Depth in (ft.)	23	
Time		
Date	6/21/12	
Symbol	▼	

Weather: Mostly sunny

Trees and shrubs

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification
0 – 0.5					OL
0.5 – 9.0					SM
3 – 5	SS	FS-62	17 9 15 13		SM
8 – 9	SS	FS-63	32 50		SM
9.0 – 31.0					GM
13	SS		32 25		GM
23 – 24.5	SS	FS-64	2 16 42		GM
28 – 29.5	SS	FS-65	12 43 49		GM
31.0 – 32.0					ML
32.0 –					SM
33 – 35	SS	FS-66	15 13 11 11		SM

SUBSURFACE MATERIAL

0.0 – 0.5: **ORGANIC SILT** (OL) Contains roots

0.5 – 9.0: **SILTY SAND with Gravel, Cobbles, & Boulders** (SM)

FS-62 340 lb Hammer

FS-62&63 Combined, p200=15%, Sa=47%, Gr=38%

FS-63 340 lb Hammer, destroyed sampler shoe

9.0 – 31.0: **SILTY GRAVEL with Sand, Cobbles, & Boulders** (GM)

340 lb Hammer; No advance with 25 blows, recovered primarily freshly broken gravel

▼ 23 (ground water)

FS-64 340 lb Hammer

FS-64&65 Combined, p200=17%, Sa=33%, Gr=50%

FS-65 340 lb Hammer

31.0 – 32.0: **SILT** (ML)

32.0: **SILTY SAND** (SM) Gray

FS-66 340 lb Hammer, p200=21%, Sa=79%, Gr=0%, Moisture=18.9%

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-03

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2857+45*
Offset: *22' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *68.0 feet*
Date: *6/21/2012 - 6/23/2012*
Geologist: *S. Evans & B. Benko*

Ground Water Data

Depth in (ft.)	23	
Time		
Date	6/21/12	
Symbol	▼	

Weather: Mostly sunny

Trees and shrubs

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification	SUBSURFACE MATERIAL	
35						**SILTY SAND** (SM) Gray (cont.)	37.0
37					CL-ML	**SILTY CLAY** (CL-ML)	38.5
38	SPT	FS-67	10 14 16 14		SM	**SILTY SAND** (SM) FS-67, p200=24%, Sa=76%, Gr=0%, Moisture=19.3%, PI=NP, LL=NV	42.0
42	SPT	FS-68	20 12 19 23	31	CL-ML	**SILTY CLAY** (CL-ML) FS-68 p200=92%, Sa=8%, Gr=0%, Moisture=23.9%, PI=6, LL=24	48.0
48	SPT	FS-69	10 13 18 11		SM	**SILTY SAND/SANDY SILT** (SM) Interbedded Silt and Sand FS-69 Moisture=21.1%, PI=NP, LL=NV	49.0
49					ML	**SILT** (ML)	55.0
55					CL	**CLAY** (CL) FS-70 p200=93%, Sa=7%, Gr=0%, Moisture=22.3%, PI=12, LL=30	58.5
58	SPT	FS-70	10 24 29 25		SP-SM	**SAND with Silt** (SP-SM) Fine to medium sand	64.0
64					GP	**GRAVEL** (GP)	68.0
68						BOH 68	

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH12-06

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+84*
Offset: *6' Lt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *143.0 feet*
Date: *6/10/2012 - 6/12/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	0.5	
Time		
Date	6/10/12	
Symbol	▼	

Weather: Cloudy

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification	SUBSURFACE MATERIAL	
0 ▼					GM	Thin vegetative mat	0.0
						SILTY GRAVEL with Sand, Cobbles, & Boulders (GM)	0.2
5					CL	**CLAY** (CL) Gray, moist to wet, trace sand and gravel	5.0
8–10	SPT	FS-1	6 5 5 6	10		FS-1 Moisture=21.9%	
13–15	SPT	FS-2	2 3 3 4	6		FS-2 Moisture=32.7%	
15						FS-2&3 Combined, p200=99%, Sa=1%, Gr=0%, PI=22, LL=45	
18–20	SPT	FS-3	1 3 5 5	8		FS-3 Moisture=29.9%	
23–25	SPT	FS-4	3 4 6 7	10		FS-4 Moisture=25.8%	
27					ML	**SILT with Sand** (ML) Gray, wet, very fine to fine sand present as layers	27.0
28–30	SPT	FS-5	10 11 12 9	23		FS-5 Moisture=22.2%	
30						FS-5&6 Combined, p200=76%, Sa=24%, Gr=0%, PI=NP, LL=NV	
33–35	SPT	FS-6	9 8 13 16	21		FS-6 Moisture=25.3%	

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-06

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER : 63763
PROJECT : Parks Highway MP 237.5 - Riley Creek Bridge (#695)

Station / Location: *2858+84*
Offset: *6' Lt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *143.0 feet*
Date: *6/10/2012 - 6/12/2012*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	0.5	
Time		
Date	6/10/12	
Symbol	▼	

Weather: Cloudy

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	N-Value
38–40	SPT	FS-7	6 9 12 13	21
43–45	SPT	FS-8	10 12 10 13	
48–50	SPT	FS-9	11 10 12 15	22
58–60	SPT	FS-10	16 18 21 15	39
68–70	SPT	FS-11	3 6 8 9	14

SUBSURFACE MATERIAL

Depth (Feet)	USCS Classification	Subsurface Material
35		**SILT with Sand** (ML) Gray, wet, very fine to fine sand present as layers (cont.)
36.5	CL-ML	**CLAYEY SILT with Sand** (CL-ML) Gray, wet, interbedded Clayey Silt and silty sand FS-7 Moisture=25.4%, PI=3, LL=25
41.5	SM	**SILTY SAND** (SM) Gray, wet FS-8 Moisture=24.1%
44.0	CL-ML	**SILTY CLAY** (CL-ML) Gray, moist to wet, trace sand as thin layers
47.0	ML	**SILT with Sand** (ML) Gray, wet FS-9 p200=74%, Sa=26%, Gr=0%, Moisture=21.9% FS-10 p200=85%, Sa=15%, Gr=0%, Moisture=20.6%, PI=NP, LL=NV
64.0	CL	**CLAY** (CL) Gray, moist to wet FS-11 p200=98%, Sa=2%, Gr=0%, Moisture=22.3%, PI=11, LL=30

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH12-06

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+84*
Offset: *6' Lt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *143.0 feet*
Date: *6/10/2012 - 6/12/2012*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	0.5	
Time		
Date	6/10/12	
Symbol	▼	

Weather: Cloudy

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
70									▤	**CLAY** (CL) Gray, moist to wet (cont.)	
78–80	SPT	FS-12	7 9 13 15	☒	■	22			▤	FS-12 Moisture=23.4%	
80									▤	Trace fine sand	80.0
84							ML		▨	**SILT with Sand** (ML) Gray, moist to wet, silt (possibly clay) present as layers up to 2 inches thick	84.0
88–90	SPT	FS-13	6 9 10 13	☒	■	19			▨	FS-13 p200=75%, Sa=25%, Gr=0%, Moisture=23.5%	
95							CL-ML		▨	**SILTY CLAY** (CL-ML) Gray, moist, sand present as thin lenses	95.0
98–100	SPT	FS-14	6 9 16 20	☒	■	25			▨	FS-14 Moisture=29%	
100									▨	FS-14&15, p200=96%, Sa=4%, Gr=0%, PI=4, LL=24	
105											

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-06

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+84*
Offset: *6' Lt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *143.0 feet*
Date: *6/10/2012 - 6/12/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	0.5	
Time		
Date	6/10/12	
Symbol	▼	

Weather: Cloudy

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL
105										**SILTY CLAY** (CL-ML) Gray, moist, sand present as thin lenses (cont.)
108–110	SPT	FS-15	7 15 27 40	☒	■	42				FS-15 Moisture=24.2%
118–120	SPT	FS-16	12 23 24 27	☒	■	47				FS-16 Moisture=22.3%, PI=3, LL=21
125.5							SM			**SILTY SAND with Gravel**(SM) Gray, wet
128–130	SPT	FS-17	15 27 23 33	☒	■	50				FS-17 p200=28%, Sa=52%, Gr=20%
130.0							GP			**GRAVEL with Cobbles & Boulders**(GP) Very slow casing advance following pre-drilling
136.0							ML			**SILT with Sand** (ML) Gray, moist, very fine to fine sand
138–140	SPT	FS-18	15 13 18 23	☒	■	31				FS-18 p200=82%, Sa=18%, Gr=0%, Moisture=17.2%

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-06

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+84*
Offset: *6' Lt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *143.0 feet*
Date: *6/10/2012 - 6/12/2012*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	0.5	
Time		
Date	6/10/12	
Symbol	▼	

Weather: Cloudy

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL
140								▨	**SILT with Sand** (ML) Gray, moist, very fine to fine sand (cont.)
141								▨	
142								▨	
143								BOH 143	143.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-09

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+12*
Offset: *23' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *130.0 feet*
Date: *6/14/2012 - 6/15/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	0.5	
Time		
Date	6/14/12	
Symbol	▼	

Weather: Sunny

Sparse shrubs (flood plain)

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value
8–10	SPT	FS-19	10 4 6 6	☒	■	10
12.5–14.5	SPT	NR	7 5 6 8	☒		11
18–20	SPT	FS-20	3 5 6 8	☒	■	11
23–25	SPT	FS-21	5 6 6 10	☒	■	12
28–30	SPT	FS-22	3 5 7 10	☒	■	12
33–35	SPT	FS-23	5 8 10 10	☒	■	18

SUBSURFACE MATERIAL

Depth (Feet)	USCS Classification	Subsurface Material
0.0		Thin vegetative mat
0.2	GM	**SILTY GRAVEL with Sand**(GM) Contains organics, strong organic odor, cobbles present to 4 feet bgs
5.0	ML	**SILT** (ML) Gray, wet, trace very fine sand FS-19 p200=92%, Sa=8%, Gr=0%, Moisture=23.5%
15.0	CL	**CLAY** (CL) Gray, moist to wet FS-20 p200=100%, Sa=0%, Gr=0%, Moisture=27.4%, PI=11, LL=31
22.0	CL-ML	**SILTY CLAY**(CL-ML) Gray, moist to wet, trace very fine to fine sand occurring as thin layers and ribbons FS-21 Moisture=24.7% FS-22 Moisture=24.9% FS-22&23 Combined, p200=99%, Sa=1%, Gr=0%, PI=7, LL=27 FS-23 Moisture=25%

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-09

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+12*
Offset: *23' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *130.0 feet*
Date: *6/14/2012 - 6/15/2012*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	0.5	
Time		
Date	6/14/12	
Symbol	▼	

Weather: Sunny

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification	Frozen Zone	SUBSURFACE MATERIAL
35							**SILTY CLAY** (CL-ML) Gray, moist to wet, trace very fine to fine sand occurring as thin layers and ribbons (cont.)
38	SPT	FS-24	3 6 11 12	17			FS-24 Moisture=23.4%
43	SPT	FS-25	5 7 12 12	19			
48.0	SPT	FS-26	4 5 8 10	13	CL		**CLAY** (CL) Gray, moist, trace very fine sand FS-26 Moisture=29.1%, PI=14, LL=33
55.0					ML		**SILT** (ML) Gray, wet, contains very fine to fine sand
58	SPT	FS-27	5 8 9 9	17			FS-27&28 Combined, p200=91%, Sa=9%, Gr=0%
68	SPT	FS-28	6 8 11 14	19			FS-28 Moisture=20.8%

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-09

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+12*
Offset: *23' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *130.0 feet*
Date: *6/14/2012 - 6/15/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	0.5	
Time		
Date	6/14/12	
Symbol	▼	

Weather: Sunny

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL
70									▨	**SILT** (ML) Gray, wet, contains very fine to fine sand (cont.)
71							CL		▤	71.0 **CLAY** (CL) Gray, wet, trace sand occurring as thin layers
78–80	SPT	FS-29	5 8 10 13	☒	■	18			▤	FS-29 p200=96%, Sa=4%, Gr=0%, Moisture=26%, PI=8, LL=28
88–90	SPT	FS-30	8 13 13 17	☒	■	26			▤	FS-30 Moisture=22.2%
94							CL-ML		▨	94.0 **SILTY CLAY** (CL-ML)
98–100	SPT	FS-31	9 10 14 13	☒	■	24			▨	FS-31 Moisture=22.1% FS-31&32 Combined, p200=92%, Sa=8%, Gr=0%, PI=6, LL=26
105										

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH12-09

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+12*
Offset: *23' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *130.0 feet*
Date: *6/14/2012 - 6/15/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	0.5	
Time		
Date	6/14/12	
Symbol	▼	

Weather: Sunny

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
105										**SILTY CLAY** (CL-ML) (cont.)	
106											
107											
108										FS-32 Moisture=25.7%	
109	SPT	FS-32	8 9 15 25	☒	■	24					
110											
111											
112											
113											
114											
115							ML			**SANDY SILT** (ML) Very fine to medium sand	115.0
116											
117											
118										FS-33 p200=52%, Sa=48%, Gr=0%	
119	SPT	FS-33	3 8 13 22	☒	■	21					
120											
121											
122											
123											
124											
125							CL-ML			**SILTY CLAY** (CL-ML) Contains sandy layers	125.0
126											
127											
128										FS-34 p200=94%, Sa=6%, Gr=0%, Moisture=24.4%, PI=7, LL=26	
129	SPT	FS-34	12 19 26 30	☒	■	45					
130									BOH 130	Notes: Cobbles and boulder present on surface	130.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH12-11

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+94*
Offset: *26' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *103.0 feet*
Date: *6/16/2012 - 6/17/2012*
Geologist: *S. Evans*

Weather: Cloudy to raining

Sparse shrubs and trees

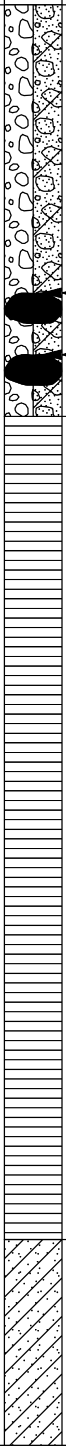
Ground Water Data

Depth in (ft.)	10	
Time		
Date	6/16/12	
Symbol	▼	

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification
0							GP-GM
8	MC		63				
10							CL
13	SPT	FS-36	11 7 9 12			16	
18	SPT	NS	2 6 6 6			12	
20	ST	NR					
22	SPT	FS-37	5 5 6 9			11	
27	SPT	FS-38	3 5 7 10			12	
30							ML
32	SPT	FS-39	14 13 10 9			23	

Soil Graphic



SUBSURFACE MATERIAL

0.0 **GRAVEL with Silt, Sand, Cobbles, & Boulders** (GP-GM) FILL, brown, estimated 10-15% oversize

7.0 Cobble

8.5 340 lb hammer
Boulder

10.0 **CLAY** (CL) Gray, wet

FS-36 Moisture=21.6%

FS-36&37 Combined, p200=98%, Sa=2%, Gr=0%, PI=11, LL=31

NS Disturbed sample, not retained

NR Shelby: No recovery

FS-37 Moisture=26.2%

24.0 Trace sand as very thin layers and ribbons

FS-38 Moisture=24.3%

30.0 **SILT with Sand** (ML) Gray, wet, fine sand, homogeneous

FS-39&40 Combined, p200=86%, Sa=14%, Gr=0%

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-11

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+94*
Offset: *26' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *103.0 feet*
Date: *6/16/2012 - 6/17/2012*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	10	
Time		
Date	6/16/12	
Symbol	▼	

Weather: Cloudy to raining

Sparse shrubs and trees

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	SUBSURFACE MATERIAL
35									**SILT with Sand** (ML) Gray, wet, fine sand, homogeneous (cont.)
37-39	SPT	FS-40	10 11 9 6	☒	■	20			
42-44	SPT	FS-41	14 13 19 17	☒	■	32			
44									FS-41&42 Combined, p200=74%, Sa=26%, Gr=0%
47-49	SPT	FS-42	7 9 14 13	☒	■	23			
50							CL-ML		50.0 **SILTY CLAY** (CL-ML) Contains thin layers of silty sand
52									FS-43 p200=88%, Sa=12%, Gr=0%, Moisture=23.9%, PI=4, LL=22
52-54	SPT	FS-43	6 8 9 11	☒	■	17			
60							CL		60.0 **CLAY** (CL) Gray, moist to wet, trace sand as very thin layers and ribbons
62									FS-44 Moisture=26.6%
62-64	SPT	FS-44	5 8 10 11	☒	■	18			
64									FS-44&45 Combined, p200=92%, Sa=8%, Gr=0%, PI=9, LL=29
70									

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-11

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :63763
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+94*
Offset: *26' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *103.0 feet*
Date: *6/16/2012 - 6/17/2012*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	10	
Time		
Date	6/16/12	
Symbol	▼	

Weather: Cloudy to raining

Sparse shrubs and trees

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification
72–74	SPT	FS-45	5 8 9 13	17	
79					ML
82–84	SPT	FS-46	10 13 18 23	31	
87–89	SPT	FS-47	8 11 14 16	25	
95.5					SC
97–99	SS	FS-49	4 9 7 14		
98					CL-ML

SUBSURFACE MATERIAL

CLAY (CL) Gray, moist to wet, trace sand as very thin layers and ribbons (cont.)

FS-45 Moisture=24.2%

79.0

SILT with Sand (ML) Gray, wet, very fine to fine sand

FS-46 p200=82%, Sa=18%, Gr=0%

95.5

CLAYEY SAND with Gravel (SC) Gray, wet

FS-49 340 lb hammer, p200=22%, Sa=47%, Gr=31%, Moisture=11.2%, PI=17, LL=22

98.0

CLAYEY SILT (CL-ML) Gray, moist, tight

103.0

BOH
103

Notes:
Cobbles and boulder present on surface, high percentage of oversized material (estimated 10-15%) present in constructed embankment.

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-12

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2860+44*
Offset: *5' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *67.8 feet*
Date: *6/19/2012 - 6/20/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	15	
Time		
Date	6/19/12	
Symbol	▼	

Weather: Sunny

Sparse shrubs

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification	SUBSURFACE MATERIAL	
0					GP-GM	**GRAVEL with Silt, Sand, Cobbles, & Boulders**(GP-GM) FILL, brown	0.0
4–5	MC	NS	5 19 14 3			NS 340 lb hammer	
8–10	SS	FS-50	4 8 11 11			FS-50 340 lb hammer FS-50&51 Combined, p200=7%, Sa=39%, Gr=54%	
12–14	SS	FS-51	15 11 23 10			FS-51 340 lb hammer	
15 ▼							
17–19	SS	FS-52	11 7 5 6		CL-ML	**SILTY CLAY** (CL-ML) Gray, wet FS-52 340 lb hammer, Moisture=19.1%, PI=5, LL=23	17.0
20					SM	**SILTY SAND with Gravel**(SM) Gray, wet	20.0
22–24	SPT	FS-53 & 54	10 9 9 10				
23					SM	**SILTY SAND** (SM) Gray, wet	23.0
27–29	SPT	FS-55	11 9 12 11	21			
32–34	SPT	FS-56	11 11 11 11	22			

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH12-12

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2860+44*
Offset: *5' Rt*

Equipment_Type: *CME 850*
Drilling Method: *Casing Size NW*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *67.8 feet*
Date: *6/19/2012 - 6/20/2012*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	15	
Time		
Date	6/19/12	
Symbol	▼	

Weather: Sunny

Sparse shrubs

Depth (Feet)	Sample Type	Number	Blow Count	N-Value
37–39	SS	FS-57	18 12 13 40	
42–44	SS	FS-58	16 14 13 13	
47–48	SS	FS-59	35 50	
57–58.5	SS	FS-60	34 39 53	
67–67.5	SS	FS-61	70	

Depth (Feet)	USCS Classification	SUBSURFACE MATERIAL
35.0	GP-GM	**GRAVEL with Silt and Sand**(GP-GM) Dark gray to greenish gray gravel in silty sand matrix, high gravel concentration FS-57 340 lb hammer, p200=9%, Sa=28%, Gr=63%, Moisture=7.1%, PI=3, LL=17
42.0	SM	**SILTY SAND with Gravel, Cobbles, & Boulders**(SM) Primarily angular grains FS-58 340 lb hammer FS-58&59 Combined, p200=16%, Sa=55%, Gr=29% FS-59 340 lb hammer FS-60 340 lb hammer, p200=15%, Sa=57%, Gr=28%
59.0	GP-GM	**GRAVEL with Silt and Sand**(GP-GM) FS-61 340 lb hammer
67.8		BOH 67.8

Notes:
Cobbles and boulder present on surface

☒ CME Auto Hammer ☐ Cathead Rope Method ☐ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH14-01

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+83*
Offset: *2' Rt*

Equipment_Type: *CME 850*
Drilling Method: *6.25" ID Auger*
Field Crew: *R. Wagster & J. Young*

Total Depth: *39.8 feet*
Date: *4/24/2014 - 4/24/2014*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	0	
Time		
Date		
Symbol	▼	

Weather: Sunny

Sparse shrubs along river bank (flood plain)

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	N-Value
7 - 10	SHELBY			
12 - 14.8	SHELBY	FS-91		
15 - 16.5	SPT	NS	1 2 3	
17 - 19.8	SHELBY	FS-92		
20 - 21.5	SPT	NS	4 5 12	17
22 - 24.8	SHELBY	FS-93		
24.8 - 26.3	SPT	NS	5 12 10	22
27 - 29.8	SHELBY	FS-94		
30 - 31.5	SPT	NS	5 8 10	18
32 - 34.5	SHELBY	FS-95		
34.5 -			4	

SUBSURFACE MATERIAL

USCS Classification	Subsurface Material	Depth
GP	**GRAVEL with Sand, Cobbles, and Boulders** (GP)	0.0
	Boulder	1.0 2.0
SP	**SAND with Gravel** (SP) Sand and Gravel recovered	5.0
ML	**SILT** (ML)	7.5
SP	**SAND** (SP)	8.0
CL-ML	**SILTY CLAY** (CL-ML) FS-91 See Riley Creek In-Situ Sample Test Report for lab results	10.0
	Tore Vane: 0.2 Tons/ft²	13.5
CL	**CLAY with Gravel** (CL)	15.0
CL	**CLAY** (CL) FS-92 See Riley Creek In-Situ Sample Test Report for lab results	16.0
	Tore Vane: 0.2 Tons/ft²	19.0
	FS-93 See Riley Creek In-Situ Sample Test Report for lab results	
CL	**CLAY with Sand** (CL) FS-94 See Riley Creek In-Situ Sample Test Report for lab results	27.0
	Tore Vane: 0.5 Tons/ft²	29.0
CL-ML	**SILTY CLAY** (CL-ML) FS-95 Sample not tested	32.0
	Tore Vane: 0.35 Tons/ft²	34.0

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH14-01

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+83*
Offset: *2' Rt*

Equipment_Type: *CME 850*
Drilling Method: *6.25" ID Auger*
Field Crew: *R. Wagster & J. Young*

Total Depth: *39.8 feet*
Date: *4/24/2014 - 4/24/2014*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	0	
Time		
Date		
Symbol	▼	

Weather: Sunny

Sparse shrubs along river bank (flood plain)

Depth (Feet)	Sample Data						USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
	Sample Type	Number	Blow Count	Sample	Recovery	N-Value					
35	SPT	NS	7 11	☒	■	18			▨	**SILTY CLAY** (CL-ML) FS-95 Sample not tested (cont.)	
36									▨		
37					■				▨	FS-96 See Riley Creek In-Situ Sample Test Report for lab results	
38	SHELBY	FS-96			■				▨		
39					■				▨	Tore Vane: 0.25 Tons/ft²	39.0
									BOH 39.8		39.8

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH14-02

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+35*
Offset: *17' Rt*

Equipment_Type: *CME 850*
Drilling Method: *6.25" ID Auger*
Field Crew: *R. Wagster & J. Young*

Total Depth: *39.2 feet*
Date: *4/23/2014 - 4/23/2014*
Geologist: *S. Evans*

Ground Water Data		
Depth in (ft.)	1	
Time		
Date		
Symbol	▼	

Weather: Sunny

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
0										Gravel with cobbles	0.0
1	▼										
6.5							ML			**SILT** (ML) Contains trace sand	6.5
10							CL			**CLAY** (CL) CLAY to Silty CLAY with some sand and gravel present FS-86 See Riley Creek In-Situ Sample Test Report for lab results	10.0
11	SHELBY	FS-86			■						
12										Tore Vane: 0.45 Tons/ft²	12.0
13	SPT	NS	2 3 6	☒	■	9					
15										Damaged Sample Tube	
16	SHELBY										
21	SHELBY	FS-87			■						
23	SPT	NS	15 19 16	☒		35				NS Trace Recovery	
25										FS-88 Damaged Sample Tube	
26	SHELBY	FS-88			■						
28	SPT	NS	7 8 10	☒	■	18					
29										Sand and Gravel lens	29.0
30							CL-ML			**SILTY CLAY** (CL-ML) FS-89 Damaged Sample Tube, disturbed sample	30.0
31	SHELBY	FS-89			■					Tore Vane: 0.3 Tons/ft²	31.0
33	SPT	NS	8 13 11	☒	■	24					
35											

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

LOG OF TEST HOLE

HOLE # TH14-02

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

PROJECT NUMBER :*63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+35*
Offset: *17' Rt*

Equipment_Type: *CME 850*
Drilling Method: *6.25" ID Auger*
Field Crew: *R. Wagster & J. Young*

Total Depth: *39.2 feet*
Date: *4/23/2014 - 4/23/2014*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	1	
Time		
Date		
Symbol	▼	

Weather: Sunny

Sparse shrubs (flood plain)

Depth (Feet)	Sample Type	Number	Blow Count	Sample	Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL	
35					■				▨	**SILTY CLAY** (CL-ML) FS-89 Damaged Sample Tube, disturbed sample (cont.) FS-90 Sample not tested	
36	SHELBY	FS-90			■				▨	Tore Vane: Exceeds device limit	36.5
37									▨		
38	SPT	NS	6 6 8	☒	■	14			▨		
39									▨		39.2
									BOH 39.2	Notes: Cobbles and boulder present on surface	

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH14-03

PROJECT NUMBER : 63763
PROJECT : Parks Highway MP 237.5 - Riley Creek Bridge (#695)

Station / Location: 2859+99
Offset: 26' Rt

Equipment_Type: CME 850
Drilling Method: 6.25" ID Auger
Field Crew: R. Wagster & J. Young

Total Depth: 33.8 feet
Date: 4/22/2014 - 4/22/2014
Geologist: S. Evans

Ground Water Data

Depth in (ft.)	15	
Time		
Date		
Symbol	▼	

Weather: Sunny

Sample Data

Depth (Feet)	Sample Type	Number	Blow Count	N-Value	USCS Classification
12					CL
15–17	SHELBY	FS-82			
18–19.5	SPT	NS	4 6 6	12	
20–22	SHELBY	FS-83			
22.5–24	SPT	NS	3 8 10	18	
25–27	SHELBY	FS-84			
27					ML
27.5–29	SPT	NS	8 12 11	23	
30–32	SHELBY	FS-85			
32.5–33.75	SPT	NS	6 9 12	21	

SUBSURFACE MATERIAL

0.0 Sandy GRAVEL with cobbles and boulders

12.0 **CLAY** (CL) Clay

FS-82 See Riley Creek In-Situ Sample Test Report for lab results

17.0 Tore Vane: 0.3 Tons/ft²

FS-83 See Riley Creek In-Situ Sample Test Report for lab results

FS-84 See Riley Creek In-Situ Sample Test Report for lab results

27.0 **SILT with Sand** (ML)

27.1 Tore Vane: 0.3 Tons/ft²

FS-85 Sample not tested

33.8 BOH 33.75

Notes:
Cobbles and boulder present on surface, high percentage of oversized material (estimated

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

STATE OF ALASKA DOT&PF
Statewide Materials
Geology Section

LOG OF TEST HOLE

HOLE # TH14-03

PROJECT NUMBER : *63763*
PROJECT : *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+99*
Offset: *26' Rt*

Equipment_Type: *CME 850*
Drilling Method: *6.25" ID Auger*
Field Crew: *R. Wagster & J. Young*

Total Depth: *33.8 feet*
Date: *4/22/2014 - 4/22/2014*
Geologist: *S. Evans*

Ground Water Data

Depth in (ft.)	15	
Time		
Date		
Symbol	▼	

Weather: Sunny

Depth (Feet)	Sample Data: Sample Type	Number	Blow Count	Sample Recovery	N-Value	USCS Classification	Frozen Zone	Soil Graphic	SUBSURFACE MATERIAL
									10-15%) present in constructed embankment.

☒ CME Auto Hammer ☐ Cathead Rope Method ☒ 140 lb. hammer with 30 in. drop ☐ 340 lb. hammer with 30 in. drop

PENETROMETER LOG

HOLE # P12-02

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Foundation Geology

PROJECT NUMBER *63763*
***PROJECT**: Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2857+45*
Offset: *8' Lt*
Elevation: *1590.0 feet*

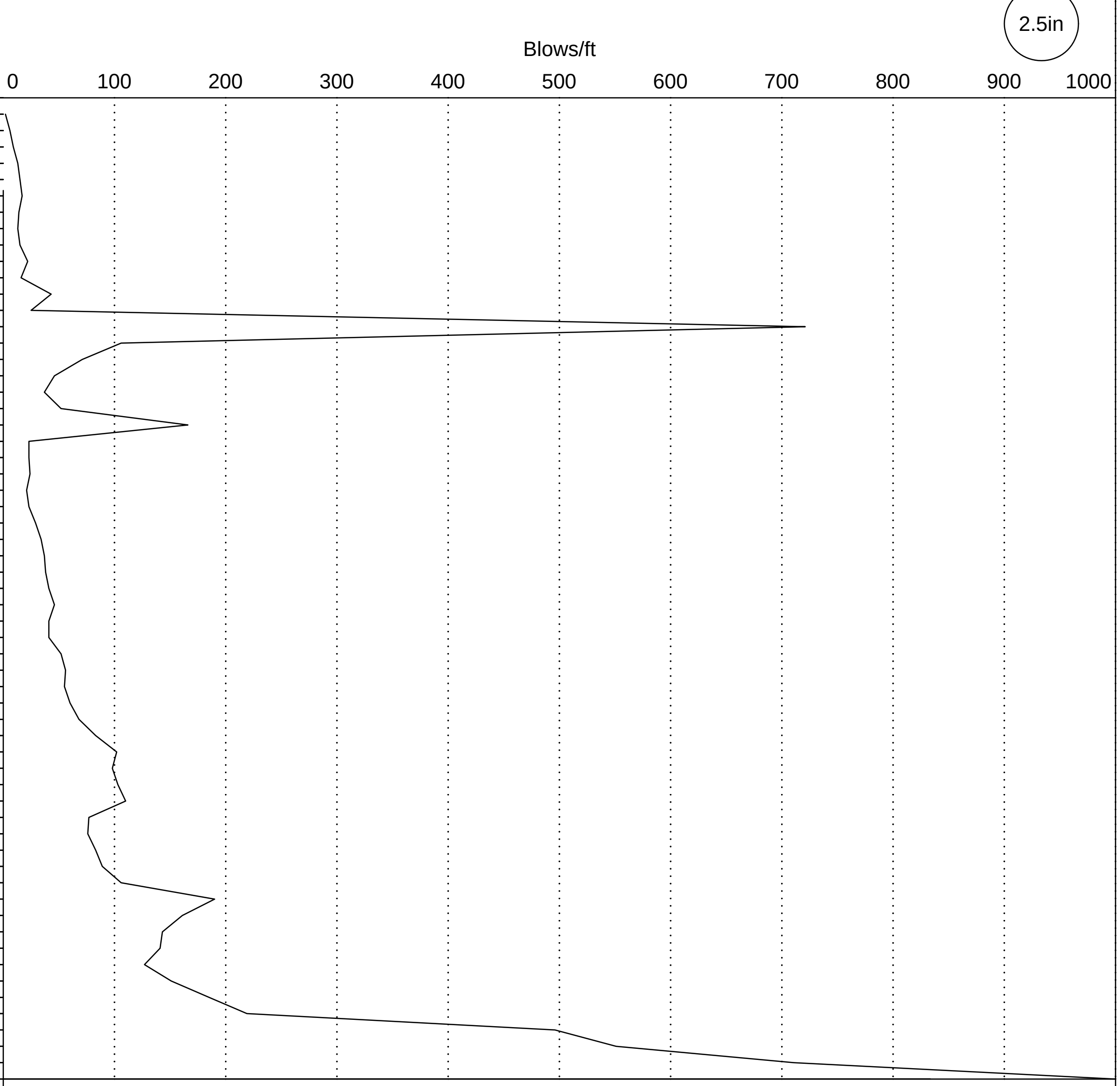
Equipment Type: *Penetrometer*
Drilling Method: *2.5" Closed Penetrometer*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *60.0 feet*
Date: *6/21/2012 - 6/21/2012*
Geologist: *S. Evans*

Weather: Mostly sunny

Sparse shrubs (embankment)

Elevation	Depth	Blow Count
1590	0	2
1589	1	6
1588	2	9
1587	3	13
1586	4	15
1585	5	17
1584	6	14
1583	7	13
1582	8	15
1581	9	22
1580	10	16
1579	11	43
1578	12	25
1577	13	721
1576	14	106
1575	15	71
1574	16	46
1573	17	37
1572	18	52
1571	19	166
1570	20	23
1569	21	23
1568	22	24
1567	23	21
1566	24	23
1565	25	29
1564	26	34
1563	27	37
1562	28	38
1561	29	41
1560	30	46
1559	31	41
1558	32	41
1557	33	52
1556	34	56
1555	35	55
1554	36	60
1553	37	68
1552	38	83
1551	39	102
1550	40	98
1549	41	103
1548	42	110
1547	43	77
1546	44	76
1545	45	83
1544	46	89
1543	47	106
1542	48	190
1541	49	161
1540	50	143
1539	51	141
1538	52	127
1537	53	151
1536	54	185
1535	55	219
1534	56	496
1533	57	551
1532	58	711
1531	59	1000
1530	60	



Bottom of Penetrometer Test at: 60 feet
Notes:

D USCS PEN LOG BRIDGE 695 RILEY CREEK.GPJ 2006DATATEMPLATE.GDT 6/23/14

PENETROMETER LOG

HOLE # P12-07

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Foundation Geology

PROJECT NUMBER *63763*
***PROJECT**: Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2858+84*
Offset: *20' Rt*
Elevation: *1570.0 feet*

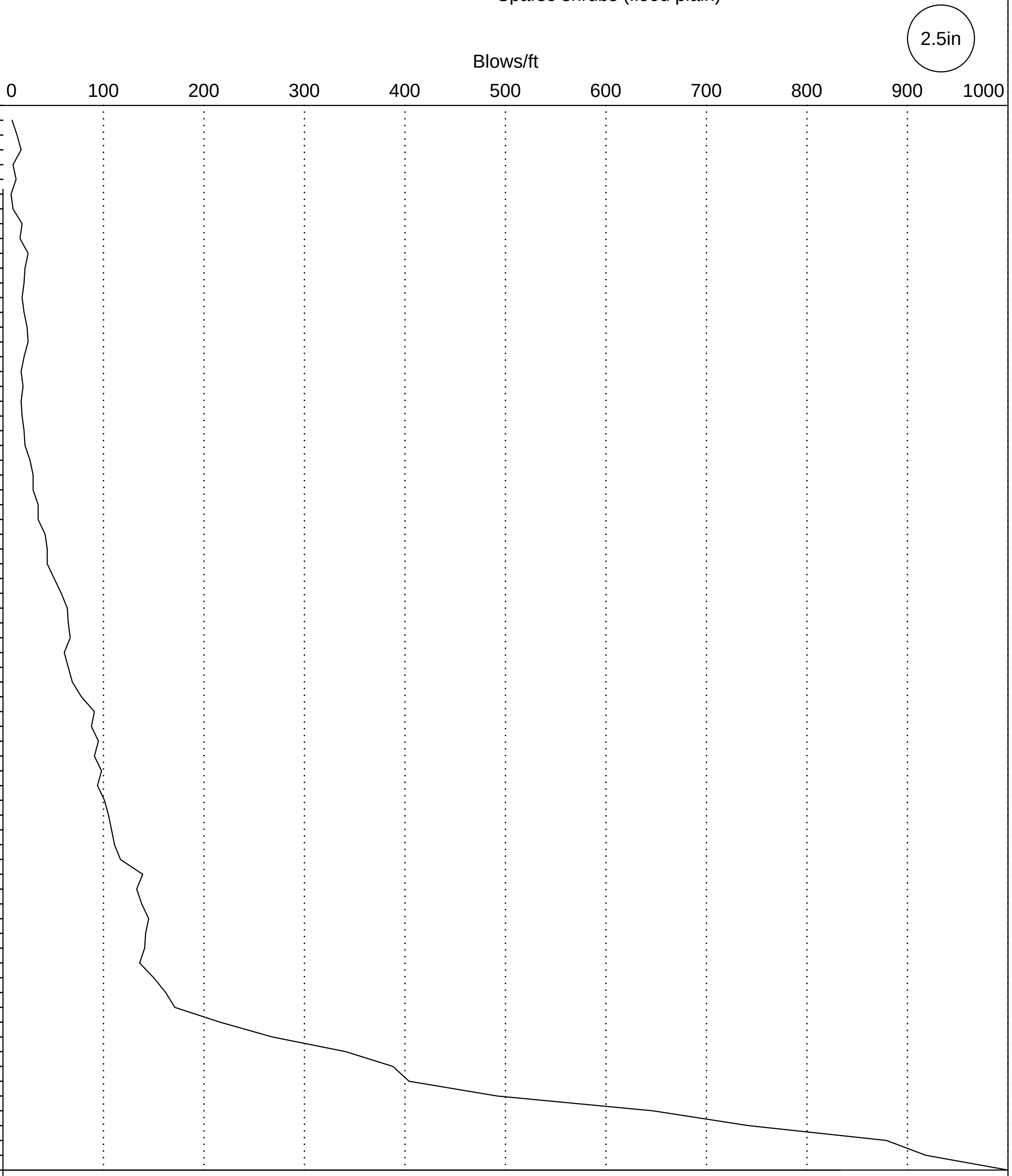
Equipment Type: *CME 850*
Drilling Method: *2.5" Closed Penetrometer*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *72.0 feet*
Date: *6/13/2012 - 6/13/2012*
Geologist: *S. Evans*

Weather: Partly cloudy

Sparse shrubs (flood plain)

Elevation	Depth	Blow Count
1570	0	9
1569	1	14
1568	2	18
1567	3	10
1566	4	13
1565	5	8
1564	6	10
1563	7	19
1562	8	17
1561	9	25
1560	10	22
1559	11	21
1558	12	19
1557	13	21
1556	14	24
1555	15	25
1554	16	21
1553	17	18
1552	18	20
1551	19	18
1550	20	19
1549	21	21
1548	22	22
1547	23	27
1546	24	30
1545	25	30
1544	26	35
1543	27	35
1542	28	42
1541	29	44
1540	30	44
1539	31	51
1538	32	58
1537	33	64
1536	34	65
1535	35	67
1534	36	61
1533	37	65
1532	38	69
1531	39	78
1530	40	91
1529	41	88
1528	42	95
1527	43	91
1526	44	98
1525	45	94
1524	46	101
1523	47	105
1522	48	108
1521	49	111
1520	50	117
1519	51	139
1518	52	133
1517	53	138
1516	54	145
1515	55	142
1514	56	141
1513	57	136
1512	58	150
1511	59	162
1510	60	171
1509	61	216
1508	62	268
1507	63	341
1506	64	388
1505	65	404
1504	66	492
1503	67	647
1502	68	742
1501	69	879
1500	70	918
1499	71	1000
1498	72	



Bottom of Penetrometer Test at: 72 feet
Notes: Cobbles present on surface. 2000 psi pull back (casing jack and rig)

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Foundation Geology

PENETROMETER LOG

HOLE # P12-08

PROJECT NUMBER *63763*
PROJECT: *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+12*
Offset: *8' Lt*
Elevation: *1572.0 feet*

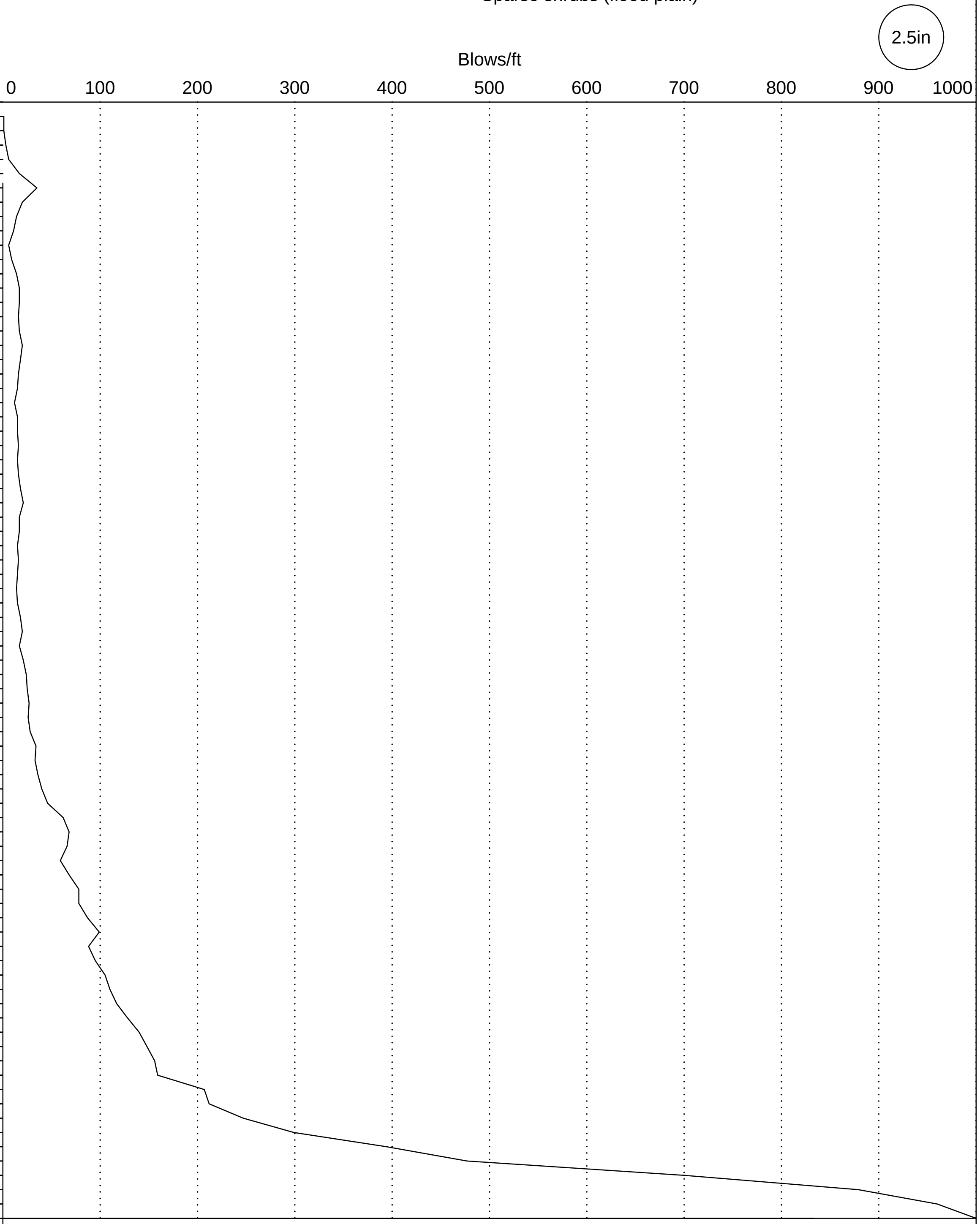
Equipment Type: *CME 850*
Drilling Method: *2.5" Closed Penetrometer*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *78.0 feet*
Date: *6/9/2012 - 6/9/2012*
Geologist: *S. Evans*

Weather: Cloudy

Sparse shrubs (flood plain)

Elevation	Depth	Blow Count
1572	0	1
1571	1	1
1570	2	3
1569	3	6
1568	4	17
1567	5	35
1566	6	20
1565	7	14
1564	8	11
1563	9	6
1562	10	9
1561	11	14
1560	12	17
1559	13	17
1558	14	16
1557	15	17
1556	16	20
1555	17	18
1554	18	16
1553	19	15
1552	20	12
1551	21	15
1550	22	15
1549	23	16
1548	24	15
1547	25	16
1546	26	18
1545	27	21
1544	28	17
1543	29	17
1542	30	15
1541	31	16
1540	32	15
1539	33	14
1538	34	15
1537	35	18
1536	36	20
1535	37	17
1534	38	21
1533	39	24
1532	40	25
1531	41	27
1530	42	26
1529	43	28
1528	44	34
1527	45	33
1526	46	36
1525	47	40
1524	48	46
1523	49	62
1522	50	68
1521	51	66
1520	52	59
1519	53	68
1518	54	78
1517	55	78
1516	56	87
1515	57	99
1514	58	88
1513	59	95
1512	60	105
1511	61	110
1510	62	117
1509	63	128
1508	64	140
1507	65	148
1506	66	156
1505	67	159
1504	68	207
1503	69	212
1502	70	247
1501	71	299
1500	72	394
1499	73	477
1498	74	700
1497	75	879
1496	76	960
1495	77	1000
1494	78	



Bottom of Penetrometer Test at: 78 feet
Notes: Cobbles and boulder present on surface. 2000 psi pull back (casing jack and rig)

PENETROMETER LOG

HOLE # P12-10

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Foundation Geology

PROJECT NUMBER *63763*
***PROJECT**: Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+95*
Offset: *16' Lt*
Elevation: *1591.0 feet*

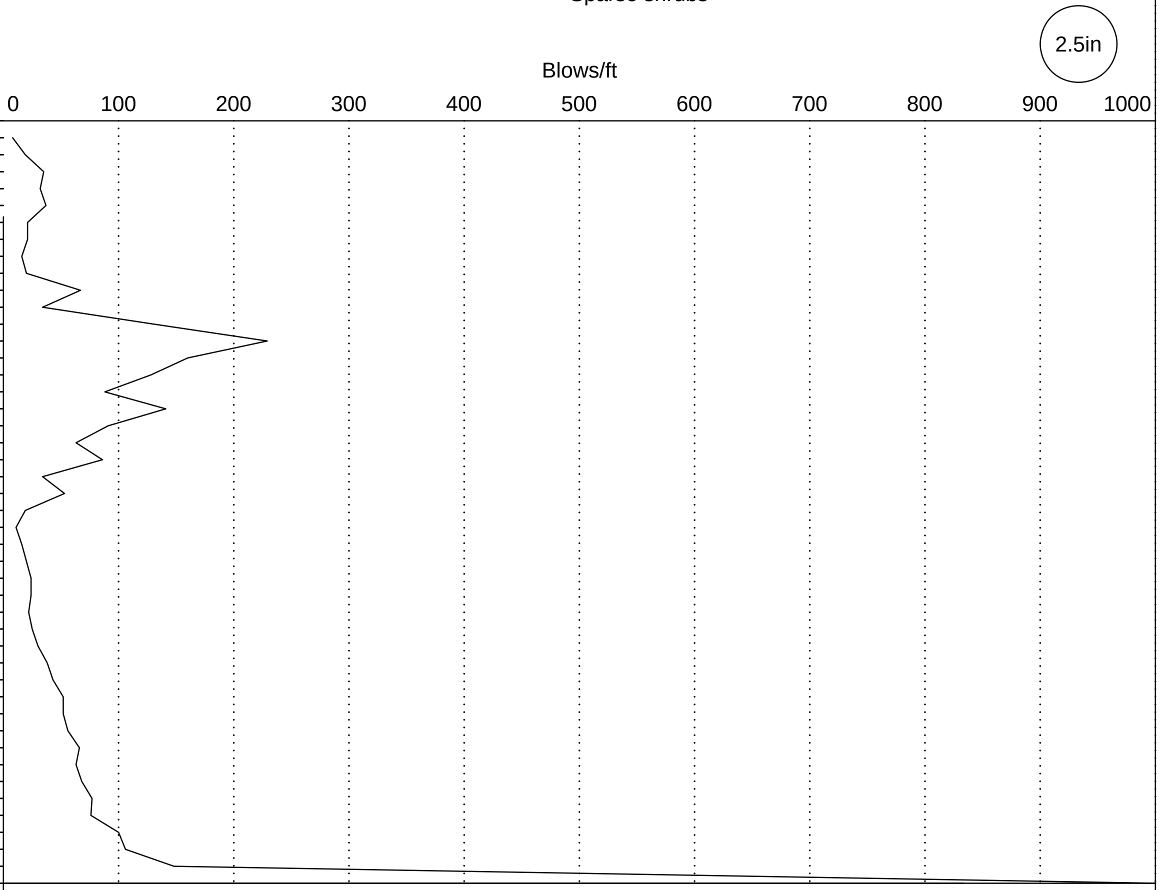
Equipment Type: *CME 850*
Drilling Method: *2.5" Closed Penetrometer*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *45.0 feet*
Date: *6/18/2012 - 6/18/2012*
Geologist: *S. Evans*

Weather: Mostly sunny

Sparse shrubs

Elevation	Depth	Blow Count
1591	0	8
1590	1	19
1589	2	35
1588	3	32
1587	4	37
1586	5	21
1585	6	21
1584	7	16
1583	8	20
1582	9	67
1581	10	34
1580	11	131
1579	12	229
1578	13	160
1577	14	128
1576	15	88
1575	16	141
1574	17	91
1573	18	63
1572	19	86
1571	20	34
1570	21	53
1569	22	19
1568	23	11
1567	24	16
1566	25	20
1565	26	24
1564	27	24
1563	28	22
1562	29	25
1561	30	30
1560	31	38
1559	32	43
1558	33	52
1557	34	52
1556	35	56
1555	36	66
1554	37	63
1553	38	68
1552	39	77
1551	40	76
1550	41	100
1549	42	106
1548	43	148
1547	44	1000
1546	45	



Bottom of Penetrometer Test at: 45 feet
Notes: Cobbles and boulder present on surface. 1600 psi pull back (casing jack)

PENETROMETER LOG

HOLE # P12-13

STATE OF ALASKA DOT&PF
Statewide Geotechnical Services
Foundation Geology

PROJECT NUMBER *63763*
PROJECT: *Parks Highway MP 237.5 - Riley Creek Bridge (#695)*

Station / Location: *2859+96*
Offset: *8' Rt*
Elevation: *1587.0 feet*

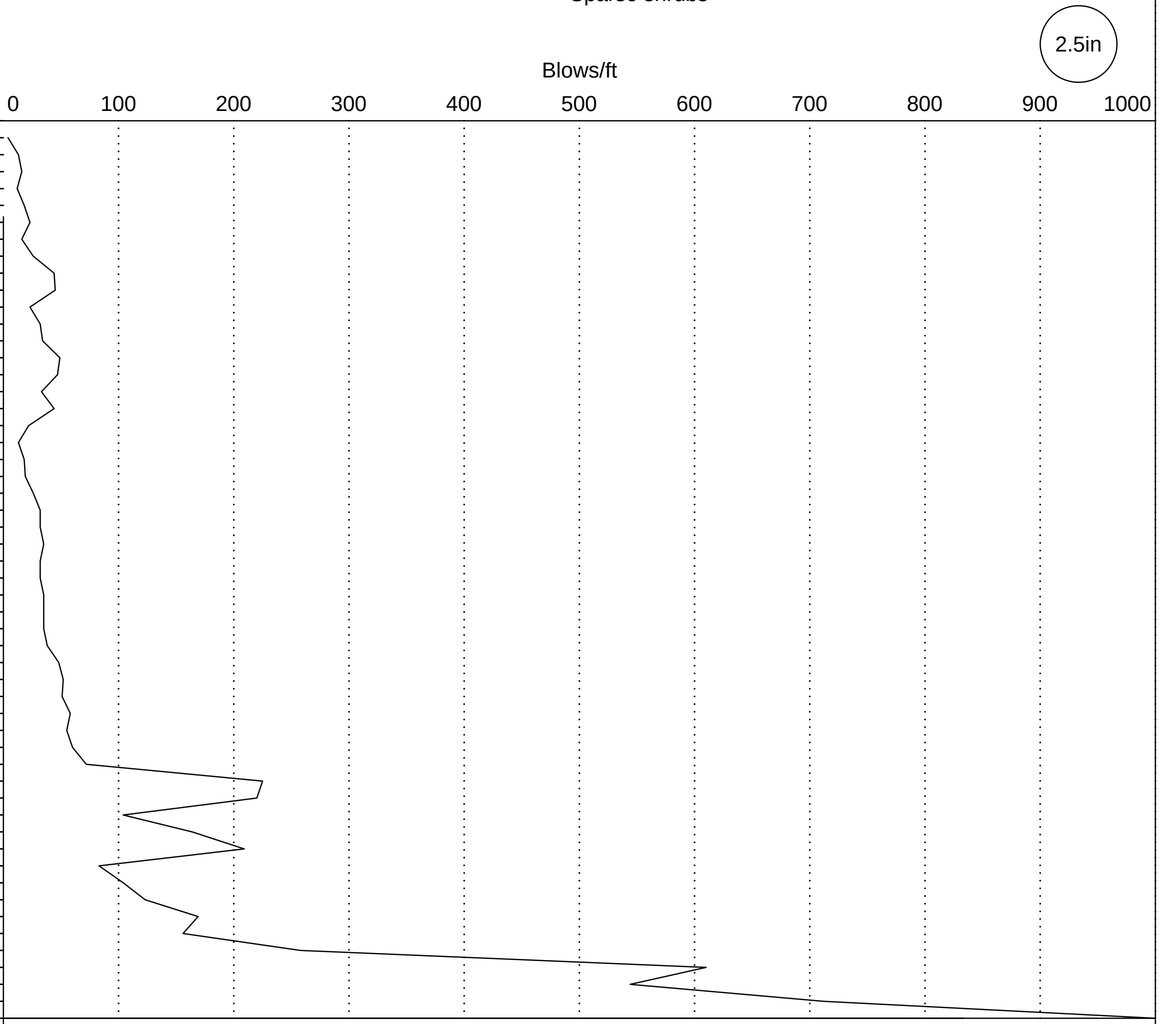
Equipment Type: *CME 850*
Drilling Method: *2.5" Closed Penetrometer*
Field Crew: *R. Wagster & B. Platt*

Total Depth: *53.0 feet*
Date: *6/18/2012 - 6/18/2012*
Geologist: *S. Evans*

Weather: Mostly sunny

Sparse shrubs

Elevation	Depth	Blow Count
1587	0	4
1586	1	13
1585	2	16
1584	3	12
1583	4	18
1582	5	23
1581	6	16
1580	7	26
1579	8	44
1578	9	45
1577	10	23
1576	11	32
1575	12	34
1574	13	49
1573	14	47
1572	15	33
1571	16	44
1570	17	22
1569	18	13
1568	19	18
1567	20	19
1566	21	26
1565	22	32
1564	23	32
1563	24	35
1562	25	32
1561	26	32
1560	27	35
1559	28	35
1558	29	35
1557	30	38
1556	31	48
1555	32	52
1554	33	51
1553	34	58
1552	35	55
1551	36	60
1550	37	72
1549	38	225
1548	39	220
1547	40	104
1546	41	164
1545	42	209
1544	43	83
1543	44	104
1542	45	123
1541	46	169
1540	47	156
1539	48	258
1538	49	610
1537	50	544
1536	51	712
1535	52	1000
1534	53	



Bottom of Penetrometer Test at: 53 feet
Notes: Cobbles and boulder present on surface. 1900 psi pull back (casing jack)

APPENDIX C

PRECONSTRUCTION SAMPLE SUMMARY FORMS

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		8.0-9.5'	28.25-29.0'	33.0-34.5'	38.5-38.75'	43.0-44.5'	48-50'
Test Site ID		TH12-01	TH12-01	TH12-01	TH12-01	TH12-01	TH12-01
Field No.		FS-71	FS-73	FS-74	FS-75	FS-76	FS-77
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/24/2012	6/24/2012	6/24/2012	6/24/2012	6/25/2012	6/25/2012
Lab No.		2012A-1828	2012A-1829	2012A-1830	2012A-1831	2012A-1832	2012A-1833
Percent Passing Sieve Size	3"						
	2"						
	1"	70					
	3/4"	67					
	1/2"	58					
	3/8"	55					100
	#4	46	100				100
	#10	37	100	100	100	100	100
	#40	22	95	97	89	99	90
	#80						
	#200	10	26.2	33.3	20.6	65.1	45.7
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	A-2-4(0) /	/	/	A-4(0) /	/
Unified Class			SM			ML	
USCSD Class			Silty sand			Sandy silt	
Atterburg LL/PL/PI		/ /	NV / NV / NP	/ /	/ /	NV / NV / NP	/ /
Sample Prep			Dry			Dry	
Nat Moist / Organic		/	21.5 /	/	20.6 /	22.6 /	22.5 /
% Grvl / Snd / Fines		54 / 36 / 10	0 / 74 / 26	0 / 67 / 33	0 / 79 / 21	0 / 35 / 65	0 / 54 / 46
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		58-60'	65-67'	76-78'	90.0-90.25'	3.0-8.5'	23-29'
Test Site ID		TH12-01	TH12-01	TH12-01	TH12-01	TH12-03	TH12-03
Field No.		FS-78	FS-79	FS-80	FS-81	FS-62, 63	FS-64, 65
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/25/2012	6/25/2012	6/25/2012	6/25/2012	6/21/2012	6/21/2012
Lab No.		2012A-1834	2012A-1835	2012A-1836	2012A-1837	2012A-1821	2012A-1822
Percent Passing Sieve Size	3"						
	2"						
	1"		82	100		98	87
	3/4"		76	98		86	76
	1/2"		69	97		78	66
	3/8"		62	96		73	61
	#4		49	96		62	50
	#10	100	37	95		47	40
	#40	100	23	72		29	28
	#80						
	#200	94.6	8.4	13.4		15.3	16.8
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		A-4(2) /	/	/	/	/	/
Unified Class		CL-ML					
USCSD Class		Silty clay					
Atterburg LL/PL/PI		24 / 20 / 4	/ /	/ /	34 / 19 / 15	/ /	/ /
Sample Prep		Dry			Dry		
Nat Moist / Organic		22.9 /	/	18.7 /	27.7 /	/	/
% Grvl / Snd / Fines		0 / 5 / 95	51 / 41 / 8	4 / 83 / 13	/ /	38 / 47 / 15	50 / 33 / 17
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		33-35'	38.5-39.5'	42-44'	48.0-49.5'	58.0-58.5'	8.0-9.25'
Test Site ID		TH12-03	TH12-03	TH12-03	TH12-03	TH12-03	TH12-06
Field No.		FS-66	FS-67	FS-68	FS-69	FS-70	FS-1
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/22/2012	6/22/2012	6/22/2012	6/22/2012	6/22/2012	6/10/2012
Lab No.		2012A-1823	2012A-1824	2012A-1825	2012A-1826	2012A-1827	2012A-1762
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4					100	
	#10	100	100	100		100	
	#40	94	89	100		98	
	#80						
	#200	21.1	24.2	91.5		93	
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	A-2-4(0) /	A-4(4) /	/	A-6(10) /	/
Unified Class			SM	CL-ML		CL	
USCSD Class			Silty sand	Silty clay		Lean clay	
Atterburg LL/PL/PI		/ /	NV / NV / NP	24 / 18 / 6	NV / NV / NP	30 / 18 / 12	/ /
Sample Prep			Dry	Dry	Dry	Dry	
Nat Moist / Organic		18.9 /	19.3 /	23.9 /	21.1 /	22.3 /	21.9 /
% Grvl / Snd / Fines		0 / 79 / 21	0 / 76 / 24	0 / 8 / 92	/ /	0 / 7 / 93	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		13.0-14.5'	18-20'	13-20'	23-25'	28-30'	33-35'
Test Site ID		TH12-06	TH12-06	TH12-06	TH12-06	TH12-06	TH12-06
Field No.		FS-2	FS-3	FS-2, 3	FS-4	FS-5	FS-6
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/10/2012	6/10/2012	6/10/2012	6/10/2012	6/10/2012	6/10/2012
Lab No.		2012A-1763	2012A-1764	2012A-1765	2012A-1766	2012A-1767	2012A-1768
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4						
	#10						
	#40			100			
	#80						
	#200			98.5			
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	/	A-7-6(24) /	/	/	/
Unified Class				CL			
USCSD Class				Lean clay			
Atterburg LL/PL/PI		/ /	/ /	45 / 23 / 22	/ /	/ /	/ /
Sample Prep				Dry			
Nat Moist / Organic		32.7 /	29.9 /	/	25.8 /	22.2 /	25.3 /
% Grvl / Snd / Fines		/ /	/ /	0 / 1 / 99	/ /	/ /	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		28-35'	38-40'	43-45'	48.0-49.5'	58-60'	68-70'
Test Site ID		TH12-06	TH12-06	TH12-06	TH12-06	TH12-06	TH12-06
Field No.		FS-5, 6	FS-7	FS-8	FS-9	FS-10	FS-11
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/10/2012	6/10/2012	6/10/2012	6/10/2012	6/10/2012	6/10/2012
Lab No.		2012A-1769	2012A-1770	2012A-1771	2012A-1772	2012A-1773	2012A-1774
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"					100	
	#4					100	
	#10				100	99	100
	#40	100			100	99	100
	#80						
	#200	75.7			74.2	84.6	97.9
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		A-4(0) /	/	/	/	A-4(0) /	A-6(10) /
Unified Class		ML				ML	CL
USCSD Class		Silt with sand				Silt with sand	Lean clay
Atterburg LL/PL/PI		NV / NV / NP	25 / 22 / 3	/ /	/ /	NV / NV / NP	30 / 19 / 11
Sample Prep		Dry	Dry			Dry	Dry
Nat Moist / Organic		/	25.4 /	24.1 /	21.6 /	20.6 /	22.3 /
% Grvl / Snd / Fines		0 / 24 / 76	/ /	/ /	0 / 26 / 74	0 / 15 / 85	0 / 2 / 98
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		78-80'	88-90'	98-100'	108-110'	98-110'	118-120'
Test Site ID		TH12-06	TH12-06	TH12-06	TH12-06	TH12-06	TH12-06
Field No.		FS-12	FS-13	FS-14	FS-15	FS-14, 15	FS-16
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/11/2012	6/11/2012	6/11/2012	6/11/2012	6/11/2012	6/11/2012
Lab No.		2012A-1775	2012A-1776	2012A-1777	2012A-1778	2012A-1779	2012A-1780
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4						
	#10		100			100	
	#40		100			100	
	#80						
	#200		75			96.4	
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	/	/	/	A-4(2) /	/
Unified Class						CL-ML	
USCSD Class						Silty clay	
Atterburg LL/PL/PI		/ /	/ /	/ /	/ /	24 / 20 / 4	21 / 18 / 3
Sample Prep						Dry	Dry
Nat Moist / Organic		23.4 /	23.5 /	29 /	24.2 /	/	22.3 /
% Grvl / Snd / Fines		/ /	0 / 25 / 75	/ /	/ /	0 / 4 / 96	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		128-130'	138-140'	8.0-8.5'	18-20'	23-25'	28-30'
Test Site ID		TH12-06	TH12-06	TH12-09	TH12-09	TH12-09	TH12-09
Field No.		FS-17	FS-18	FS-19	FS-20	FS-21	FS-22
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/12/2012	6/12/2012	6/14/2012	6/14/2012	6/14/2012	6/14/2012
Lab No.		2012A-1781	2012A-1782	2012A-1783	2012A-1784	2012A-1785	2012A-1786
Percent Passing Sieve Size	3"						
	2"						
	1"	94					
	3/4"	89					
	1/2"	87					
	3/8"	85		100			
	#4	80		100			
	#10	73	100	99			
	#40	46	100	99	100		
	#80						
	#200	27.6	82.4	91.6	99.6		
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	/	/	A-6(11) /	/	/
Unified Class					CL		
USCSD Class					Lean clay		
Atterburg LL/PL/PI		/ /	/ /	/ /	31 / 20 / 11	/ /	/ /
Sample Prep					Dry		
Nat Moist / Organic		/	17.2 /	23.5 /	27.4 /	24.7 /	24.9 /
% Grvl / Snd / Fines		20 / 52 / 28	0 / 18 / 82	0 / 8 / 92	0 / 0 / 100	/ /	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		33-35'	28-35'	38-40'	43-45'	48-50'	58-60'
Test Site ID		TH12-09	TH12-09	TH12-09	TH12-09	TH12-09	TH12-09
Field No.		FS-23	FS-22 23	FS-24	FS-25	FS-26	FS-27
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/15/2012	6/15/2012	6/15/2012	6/15/2012	6/15/2012	6/15/2012
Lab No.		2012A-1787	2012A-1788	2012A-1789	2012A-1790	2012A-1791	2012A-1792
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4						
	#10						
	#40		100				
	#80						
	#200		98.7				
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	A-4(6) /	/	/	/	/
Unified Class			CL-ML				
USCSD Class			Silty clay				
Atterburg LL/PL/PI		/ /	27 / 20 / 7	/ /	/ /	33 / 19 / 14	/ /
Sample Prep			Dry			Dry	
Nat Moist / Organic		25 /	/	23.4 /	69.4 /	29.1 /	62.5 /
% Grvl / Snd / Fines		/ /	0 / 1 / 99	/ /	/ /	/ /	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		68-70'	58-70'	78-80'	88-90'	98-100'	108-110'
Test Site ID		TH12-09	TH12-09	TH12-09	TH12-09	TH12-09	TH12-09
Field No.		FS-28	FS-27, 28	FS-29	FS-30	FS-31	FS-32
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/15/2012	6/15/2012	6/15/2012	6/15/2012	6/15/2012	6/15/2012
Lab No.		2012A-1793	2012A-1794	2012A-1795	2012A-1796	2012A-1797	2012A-1798
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4						
	#10		100	100			
	#40		100	100			
	#80						
	#200		90.8	96.1			
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	/	A-4(7) /	/	/	/
Unified Class				CL			
USCSD Class				Lean clay			
Atterburg LL/PL/PI		/ /	/ /	28 / 20 / 8	/ /	/ /	/ /
Sample Prep				Dry			
Nat Moist / Organic		20.8 /	/	26 /	22.2 /	22.1 /	25.7 /
% Grvl / Snd / Fines		/ /	0 / 9 / 91	0 / 4 / 96	/ /	/ /	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		98-110'	118-120'	128-130'	18-20'	22.0-24.25'	13-14'
Test Site ID		TH12-09	TH12-09	TH12-09	TH12-09B	TH12-09B	TH12-11
Field No.		FS-31, 32	FS-33	FS-34	ST-1	ST-2	FS-36
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/15/2012	6/15/2012	6/15/2012	6/15/2012	6/15/2012	6/16/2012
Lab No.		2012A-1799	2012A-1800	2012A-1801	2012A-1802	2012A-1803	2012A-1804
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4		100		100		
	#10	100	100	100	100	100	
	#40	100	98	99	96	100	
	#80						
	#200	91.9	52.4	94.4	72.9	93.8	
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		A-4(4) /	/	A-4(5) /	A-6(7) /	A-4(2) /	/
Unified Class		CL-ML		CL-ML	CL	CL-ML	
USCSD Class		Silty clay		Silty clay	Lean clay with sand	Silty clay	
Atterburg LL/PL/PI		26 / 20 / 6	/ /	26 / 19 / 7	30 / 18 / 12	22 / 18 / 4	/ /
Sample Prep		Dry		Dry	Dry	Dry	
Nat Moist / Organic		/	/	24.4 /	19.7 /	23.7 /	21.6 /
% Grvl / Snd / Fines		0 / 8 / 92	0 / 48 / 52	0 / 6 / 94	0 / 27 / 73	0 / 6 / 94	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		22.0-23.5'	13.0-23.5'	27.0-28.5'	32-39'	42-49'	52-54'
Test Site ID		TH12-11	TH12-11	TH12-11	TH12-11	TH12-11	TH12-11
Field No.		FS-37	FS-36, 37	FS-38	FS-39, 40	FS-41, 42	FS-43
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/16/2012	6/16/2012	6/16/2012	6/16/2012	6/16/2012	6/16/2012
Lab No.		2012A-1805	2012A-1806	2012A-1807	2012A-1808	2012A-1809	2012A-1810
Percent Passing Sieve Size	3"						
	2"						
	1"						
	3/4"						
	1/2"						
	3/8"						
	#4		100				
	#10		100		100	100	100
	#40		100		100	100	100
	#80						
	#200		98.4		86.4	74.4	87.9
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	A-6(11) /	/	/	/	A-4(1) /
Unified Class			CL				CL-ML
USCSD Class			Lean clay				Silty clay
Atterburg LL/PL/PI		/ /	31 / 20 / 11	/ /	/ /	/ /	22 / 18 / 4
Sample Prep			Dry				Dry
Nat Moist / Organic		26.2 /	/	24.3 /	/	/	23.9 /
% Grvl / Snd / Fines		/ /	0 / 2 / 98	/ /	0 / 14 / 86	0 / 26 / 74	0 / 12 / 88
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		62-64'	72-74'	62-74'	82.0-88.5'	97-98'	8.0-12.5'
Test Site ID		TH12-11	TH12-11	TH12-11	TH12-11	TH12-11	TH12-12
Field No.		FS-44	FS-45	FS-44, 45	FS-46, 48	FS-49	FS-50, 51
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans	S. Evans	S. Evans
Date Sampled		6/16/2012	6/16/2012	6/16/2012	6/17/2012	6/17/2012	6/19/2012
Lab No.		2012A-1811	2012A-1812	2012A-1813	2012A-1814	2012A-1815	2012A-1816
Percent Passing Sieve Size	3"						
	2"						100
	1"					96	77
	3/4"					94	71
	1/2"					87	63
	3/8"					83	58
	#4					69	46
	#10			100	100	44	33
	#40			100	100	29	15
	#80						
	#200			91.6	81.9	21.7	7.1
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	/	A-4(7) /	/	A-2-6(0) /	/
Unified Class				CL		SC	
USCSD Class				Lean clay		Clayey sand with gravel	
Atterburg LL/PL/PI		/ /	/ /	29 / 20 / 9	/ /	29 / 17 / 12	/ /
Sample Prep				Dry		Dry	
Nat Moist / Organic		26.6 /	24.2 /	/	/	11.2 /	/
% Grvl / Snd / Fines		/ /	/ /	0 / 8 / 92	0 / 18 / 82	31 / 47 / 22	54 / 39 / 7
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

Gradation tests based on minus 3" material.

PRECONSTRUCTION SAMPLE SUMMARY

Project No. 63763 Project Name Parks MP 237.5 Riley Cr. Bridge Replacement

Station							
Offset (feet)							
Depth (feet)		17.0-17.25'	32-34'	42-48'	57.0-58.5'		
Test Site ID		TH12-12	TH12-12	TH12-12	TH12-12		
Field No.		FS-52	FS-57	FS-58, 59	FS-60		
Submitted By		S. Evans	S. Evans	S. Evans	S. Evans		
Date Sampled		6/19/2012	6/20/2012	6/20/2012	6/20/2012		
Lab No.		2012A-1817	2012A-1818	2012A-1819	2012A-1820		
Percent Passing Sieve Size	3"						
	2"		100				
	1"		67	96	100		
	3/4"		58	92	97		
	1/2"		51	87	90		
	3/8"		46	83	85		
	#4		37	71	72		
	#10		27	57	60		
	#40		16	30	38		
	#80						
	#200		8.6	15.9	14.9		
	.02mm						
	.002mm						
FSV Class							
AASHTO / DOTTSD		/	A-1-a(0) /	/	/	/	/
Unified Class			GP-GM				
USCSD Class			Poorly graded gravel with silt and sand				
Atterburg LL/PL/PI		23 / 18 / 5	17 / 14 / 3	/ /	/ /	/ /	/ /
Sample Prep		Dry	Dry				
Nat Moist / Organic		19.1 /	7.1 /	/	/	/	/
% Grvl / Snd / Fines		/ /	63 / 28 / 9	29 / 55 / 16	28 / 57 / 15	/ /	/ /
Opt Mois/Max Dry Den		/	/	/	/	/	/
SpG Bulk Coarse/Fine		/	/	/	/	/	/
SpG SSD Coarse/Fine		/	/	/	/	/	/
SpG App Coarse/Fine		/	/	/	/	/	/
Absorption Coarse/Fine		/	/	/	/	/	/
Degradation Value							
LA / LA Low / Nordic		/ /	/ /	/ /	/ /	/ /	/ /
Sulfate Soundness C/F		/	/	/	/	/	/
Comment:							

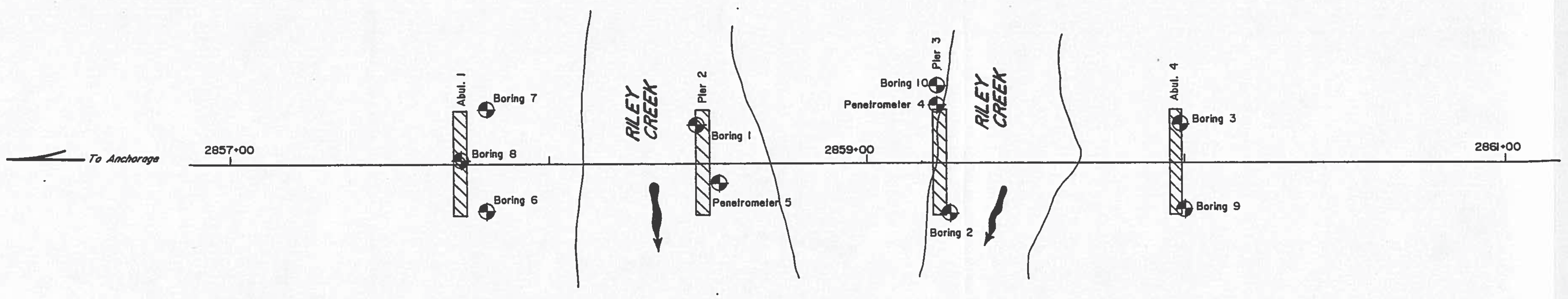
Gradation tests based on minus 3" material.

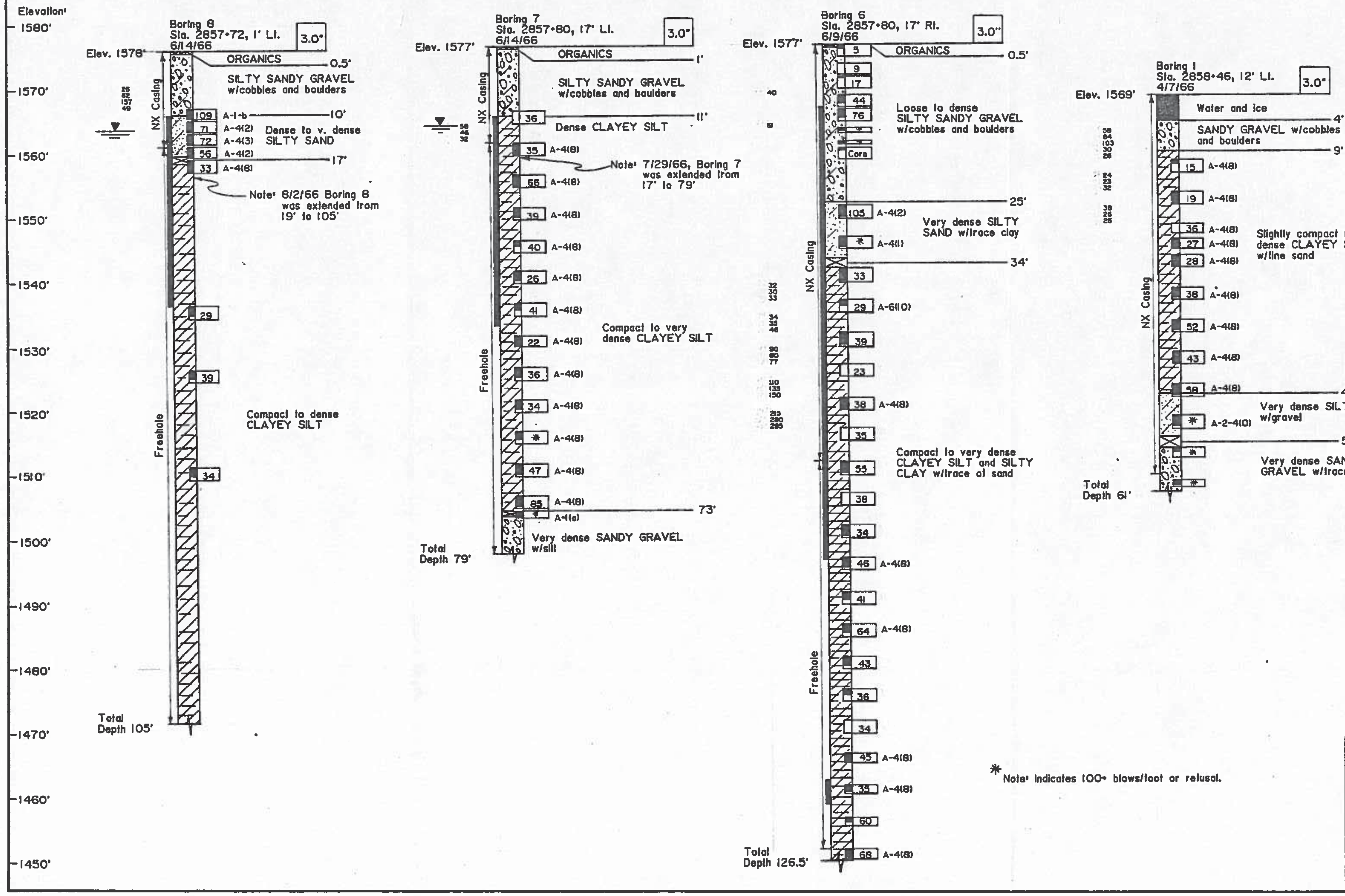
APPENDIX D

HISTORICAL TEST HOLE LOGS

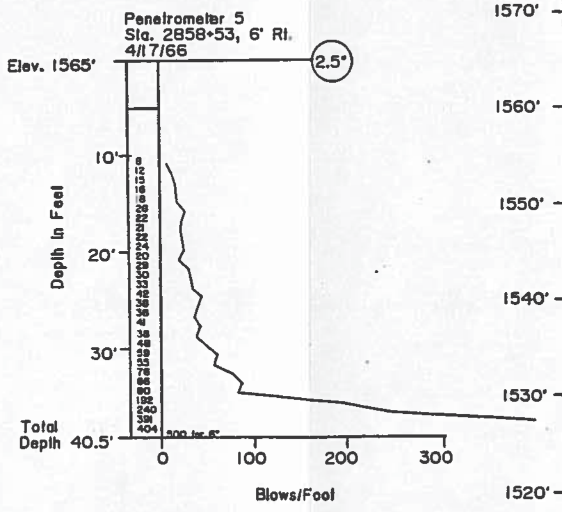
NORTHERN TRADING ASSOC. 130-3 5-71 45799+

STATE	PROJECT DESIGNATION	YEAR
ALASKA	BR-0A4-4(3)	1986





* Note: indicates 100+ blows/foot or refusal.



BASIC MATERIALS SYMBOLS

- ▤ Organic
- ▤ Cobbles; Boulders
- ▤ Gravel
- ▨ Sand

Note: Significant soil mixtures are shown by combining soil symbols

TYPICAL TEST HOLE SYMBOLS

Plan View

- ⊕ Location of any hole

Section View

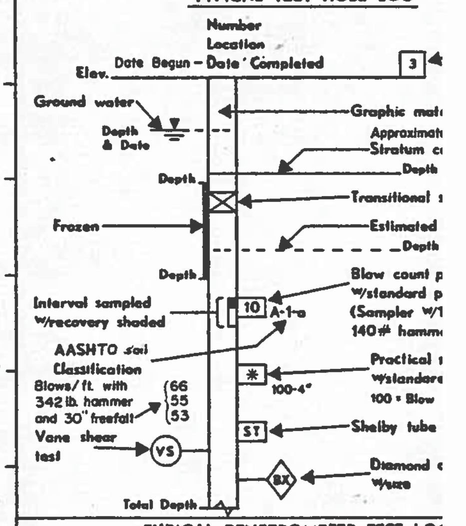
- ☐ Rotary
- ☐ Auger
- ◇ Diamond Core
- ○ Penetrometer

RELATIVE DENSI
CONSISTENCY CLASS

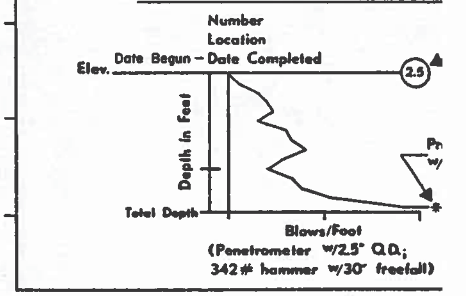
Based on Standard Penet

GRANULAR		
Blows/ft	Rel. Density	Blows
0 - 5	Very Loose	
6 - 10	Loose	2 -
11 - 20	Firm	5 -
21 - 35	Compact	9 -
36 - 50	Dense	16 -
51 - 70	Very Dense	31 -
71+	V. Very Dense	61

TYPICAL TEST HOLE LOG



TYPICAL PENETROMETER TEST LOG



LOG OF TEST HOLE

RILEY CREEK BRID

NO. 1349-E

SOIL GRAIN SIZE DEFINITIONS

Boulder (rounded)_____________>10" Diameter
Cobbie (rounded)______________3" Diameter - 10" Diameter
Broken rock (angular)__________>3" Diameter
Gravel (rounded); Stone (angular)___#10 Sieve - 3" Diameter
Sand________________________#200 Sieve - #10
Silt/clay_____________________<#200 Sieve

Note: Soil classifications are visual only unless AASHTO soil class is shown on the log.

State of Alaska
DEPARTMENT OF TRANSPORTATION & PUBLIC
Juneau, Alaska

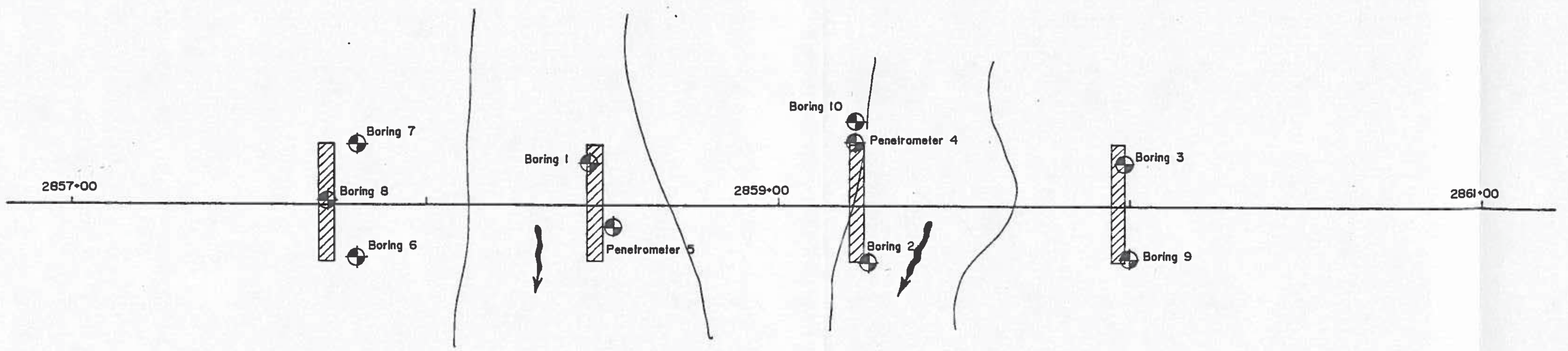
Date July, 1986
Approved ____________

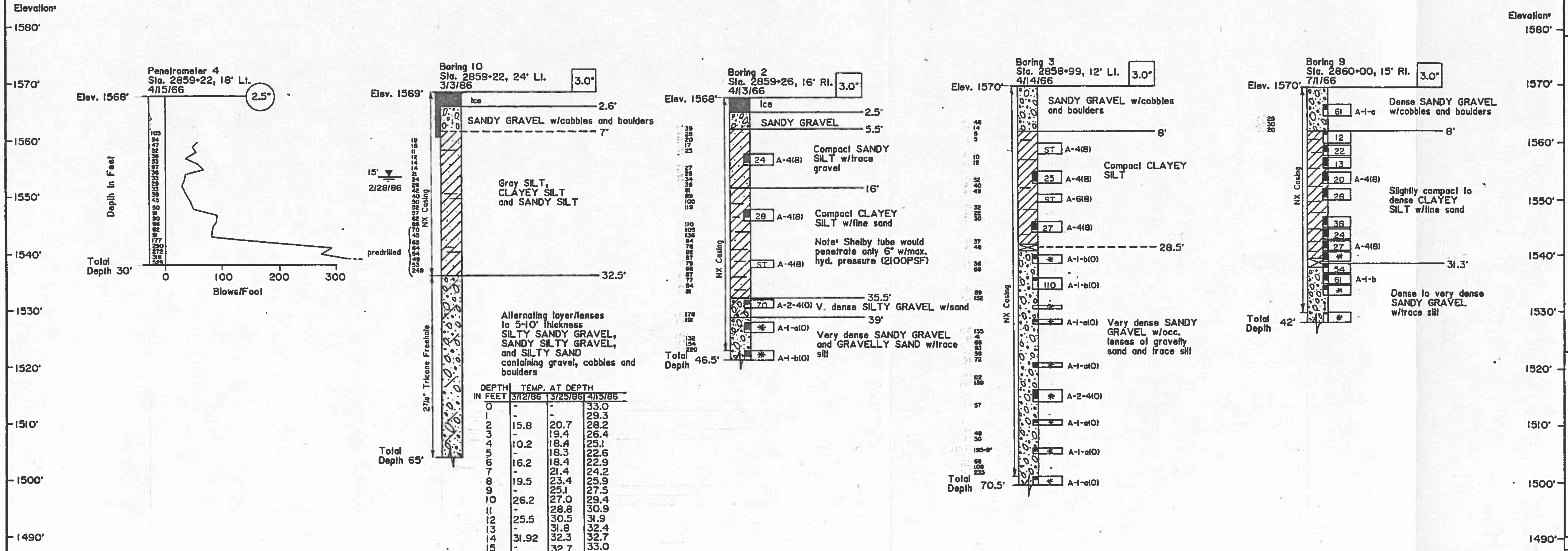
BRIDGE
DWNG.

Designed By________ Date________
Checked By________ Date________
Drawn By________ Date________
Checked By________ Date________
Traced By________ Date________

NORTHERN TRADING ASSOC.

STATE	PROJECT DESIGNATION	YEAR
ALASKA	BR-0A4-4(3)	1986





DEPTH IN FEET	TEMP. AT DEPTH 3/12/86	3/25/86	4/15/86
0	-	-	33.0
1	-	-	29.3
2	15.8	20.7	28.2
3	-	19.4	26.4
4	10.2	18.4	25.1
5	-	18.3	22.6
6	16.2	18.4	22.9
7	-	21.4	24.2
8	19.5	23.4	25.9
9	-	25.1	27.5
10	26.2	27.0	29.4
11	-	28.8	30.9
12	25.5	30.5	31.9
13	-	31.8	32.4
14	31.92	32.3	32.7
15	-	32.7	33.0
16	33.2	33.0	33.2
18	33.7	33.5	33.6
20	34.03	33.9	33.9
22	34.3	34.2	34.2
24	34.43	34.4	34.4
26	34.6	34.5	34.6
28	34.7	34.7	34.7
30	34.78	34.8	34.8
32	34.83	34.8	34.8
34	34.85	34.85	34.9
36	34.87	34.9	34.9
38	34.9	34.9	34.9
40	34.92	34.9	34.95
41	-	-	34.97
42	34.93	34.95	
43	-	34.95	
43.5	34.94		

BASIC MATERIALS SYMBOLS

- ≈ Organic
- Cobbles; Boulders
- Gravel
- Sand

Note: Significant soil mixtures are shown by combining soil symbols

TYPICAL TEST HOLE SYMBOLS

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- ⊕ Location of any hole

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- ☐ Rotary
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Based on Standard Penetr

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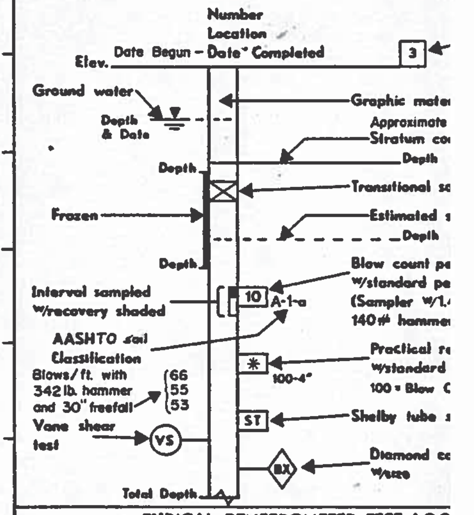
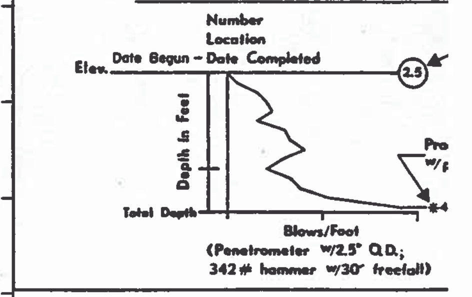
6 - 10	Loose	2 -
11 - 20	Firm	5 -
21 - 35	Compact	9 - 1
36 - 50	Dense	16 - 3
51 - 70	Very Dense	31 - 6
71+	V. Very Dense	61+

TYPICAL TEST HOLE LOG



TYPICAL PENETROMETER TEST LOG



NO. 1349-E

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Sand________________________#200 Sieve - #10
Silt/clay_____________________<#200 Sieve
Note: Soil classifications are visual only unless AASHTO soil class is shown on the log.

LOG OF TEST HOLE

RILEY CREEK BRIDG

State of Alaska
DEPARTMENT OF TRANSPORTATION & PUBLIC
Juneau, Alaska

Date July, 1986
Approved
BRIDGE
DWNG.

Designed By_______ Date_______
Checked By_______ Date_______
Drawn By_______ Date_______
Checked By_______ Date_______
Traced By_______ Date_______

ATTACHMENTS

Geophysical Fault Mapping

Riley Creek Bridge Replacement Project

Parks Highway MP 237

Denali, Alaska

SUBCONTRACT NO. 025-3-1-012
AKSAS Project No. 63763

Prepared For

Northern Region
Alaska Department of Transportation
and Public Facilities
2301 Peger Road, Fairbanks, AK 99709-5399

Prepared By:

Zonge International, Inc.
8366 SW Nimbus Avenue
Beaverton, Oregon 97008

Zonge Project # 12180

February 2013

Geophysical Fault Mapping

Riley Creek Bridge Replacement Project

Parks Highway MP 237

Denali, Alaska

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

Geophysical Fault Mapping

Riley Creek Bridge Replacement Project

Parks Highway MP 237

Denali, Alaska

EXECUTIVE SUMMARY

Zonge International, Inc. (Zonge) conducted a seismic reflection survey in support of the Riley Creek Bridge Replacement project. The site is at Mile Post 237 of the George Parks Highway. The Park Road Fault has recently been mapped from LIDAR data as passing through the proposed bridge site. Figure 2 shows the seismic line locations, the mapped fault location, the Parks Highway, and the Denali Park Road

Figure 3 shows the interpreted seismic sections. The interpretation shown was guided by the mapped fault position and published information about the fault. This data and interpretation are consistent with, and reinforces, the published data. Other more complex interpretations are also consistent with the data but cannot be unambiguously resolved.

1 INTRODUCTION

Zonge International, Inc. (Zonge) presents this report for Geophysical Fault Mapping near the Riley Creek Bridge, George Parks Highway MP 237 (Figure 1). Zonge acquired seismic reflection data on four lines (Figure 2) which cross the mapped trace of the Park Road Fault. This work was conducted under agreement 025-1-015 with the Northern Region, Alaska Department of Transportation and Public Facilities, in support of their project number 63763 for the Riley Creek Bridge Replacement.

Interpreted seismic sections are shown in Figure 3. Alternate interpretations for lines SL1, SL2, and SL4 are included as Figure 4 and fault traces shown on the site map, Figure 5. Appendix A contains selected site photographs. Appendix B is a list of geophone station coordinates. Appendix C is a technical note on the seismic reflection technique.

2 BACKGROUND

The Park Road Fault has been mapped by others as near-coincident with the existing Riley Creek Bridge alignment (Bemis et al., 2012). That mapping was based on LIDAR data (Hubbard et al, 2011) and ground mapping. Our attached Figure 2a shows the LIDAR image and the fault trace as mapped, taken from the Koehler et al., 2012. The fault is mapped as a high-angle thrust fault, with the upthrown thrust block coming from the north. Bemis has subsequently trenched the fault near our proposed seismic lines SL1 and SL3 (Figure 2; personal communications, Bemis). The fault scarps on lines SL3 and SL4 would suggest up to 15 feet of Holocene vertical displacement.

While drilling for the replacement bridge in June 2012, the Alaska Department of Transportation & Public Facilities (DOT) encountered disturbed zones and widely differing conditions in closely spaced boreholes. Borings extended up to 140 feet in alluvial sediments.

The site lies on thick Quaternary alluvial sediments of the Nenana River and Riley Creek. On the north side of the fault Wilson et al. (1998) have mapped bedrock as a Paleozoic or Pre-Cambrian pelitic and quartzose schist. To the south of the fault they have mapped sedimentary and volcanic units of the Late Cretaceous Cantwell Formation.

This report presents the results of a seismic reflection program which Zonge undertook to further characterize the Park Road Fault. Shallow seismic reflection has been used successfully by Zonge and others to map faults and geologic structure, including the Seattle Fault (Liberty & Pratt, 2008) and other faults in Alaska and the continental US.

3 GEOPHYSICAL INVESTIGATION

Seismic reflection provides a two-dimensional cross-section showing depositional horizons within the shallow geologic section. Faults appear as discontinuities or offsets through those horizons.

3.1 Seismic Data Acquisition

Zonge collected seismic reflection data along four lines shown on Figure 2. Those lines vary in length from 710 feet to 1,190 feet, with their lengths constrained by the Parks Highway, Riley Creek, and the Nenana River.

Field work was conducted from October 18 to October 22, 2012. Zonge employed a four person crew: one senior geophysicist, two staff geophysicists, and a geophysical technician. Weather for the first two days was in the mid 20’s °F with occasional light snow. For the final three days it turned crisp and clear with 4” to 6” of snow on the ground; temperatures were -5°F in the mornings, warming to +20°F during the day.

Data were collected with a Geometrics Geode seismic system using 96 to 120 channels (geophones). Geophone (station) spacing was 10 feet. A shot interval of 10 feet was used throughout the survey, shooting midway between geophones. The seismic source was 30-pound slide hammer. At each shot point, 5 separate records of one hammer blow each were obtained. Those 5 records were selectively stacked during processing to improve the signal to noise ratio.

Line SL1 followed the clearing for an 8 inch HDPE sewer outfall pipe alignment, providing easy access. The thin or absent organic mat enabled good coupling with the mineral soil. The pipeline was on the opposite side of the clearing, 15-20 feet from the seismic line, at a depth of 5 to 15 feet.

Line SL2 runs under the existing highway bridge. Some river noise from the fast flowing water in Riley Creek degraded the data to some degree, particularly where the line was closest to the river, under the bridge. Data were acquired on a Sunday, timing shots (hammer blows) to occur between crossing truck traffic.

Line SL3 is on a terrace ¼ mile southwest of the Riley Creek Bridge and 200-250 feet higher in elevation. On Line SL3 there were some data quality issues due to the thick organic mat (which attenuates the seismic signal both from the source and then returning to the geophones) and the seismic noise generated by the wind blowing the spruce trees.

Line SL4 is a short (710 feet) line northeast of the bridge and between SL1 and SL2. Its length is limited by the Parks Highway on the north and the river on the south. Line SL4 was shot on a relatively calm day, with little wind noise, and ground coupling was good with thin organic soils, hence it produced the clearest image of all the lines.

3.2 Denali Park Permit Requirements

Beyond the 300 foot wide Parks Highway right-of-way, all the seismic lines were inside the boundary of Denali National Park and Preserve. Work was carried out under Research Permit number 940.

The research permit prohibited any clearing or brushing of the seismic lines. It also required that if the organic mat ground cover was disturbed (i.e. holes for the geophones or hammer) that the vegetation be returned to its former state. While working within the NPS permit restrictions, we were able to deploy the 120 channel seismic system with little or no impact on the vegetation, leaving minimal evidence of our geophysical operations. However, the permit requirements did limit the energy source options available to us, and hence resulted in some degradation of the data.

3.3 Location Control

Position and elevation information was acquired by surveyors from Design Alaska, Inc. of Fairbanks, Alaska, following the completion of the seismic data acquisition. Zonge placed stakes at selected geophone locations and slope breaks, at an interval not more than 100 feet. Those locations were surveyed using RTK GPS equipment. Geophone and shot point locations were interpolated from those positions.

The *Exploration Plan* shown in Figure 2 uses Alaska State Plane, Zone 4, coordinates, North American Datum of 1983 (NAD83), with units of US Survey feet. State Plane coordinates, UTM coordinates, and Alaska DOT Project coordinates for each line are listed in Appendix B. DOT project coordinates differ from Alaska State Plane by less than two feet over the geophysical project area.

3.4 Data Processing

Data were processed using a processing flow typical for high resolution 2D data. Processing was performed by Excel Geophysical Services of Denver, Colorado. The basics of seismic processing are discussed in Appendix C or Yilmaz, 2001.

Field records were acquired in SEG-2 format with a 0.5-second record lengths, 0.5-millisecond sample rate, and no recording field filters (other than standard antialiasing filters). The shot records were converted to 2D binned common-depth-point stacks (CDP) in processing. Refraction statics were tested, but were not utilized in the final processing as they did not enhance data quality. The final seismic processing datum is 1800 feet above sea level.

The data processing sequences for this survey are listed below:

1. Reformat Field Data
2. Trace & Record Edit
3. Geometry Definition & Application
4. **Spectral Analysis & Filter Analysis to determine frequency range
5. **Green Mountain Refraction Program (tested, not used)
6. Picking of First Breaks & Refraction Solution
7. Gain Recovery & Spherical Divergence Correction
8. Deconvolution / Surface Consistent Spiking

9 **Spectral Whitening (tested, not used)

10. Long Gate Trace Balance
11. Elevation Statics Calculations (Datum: 1800 ft. / Vr: 6000 ft./sec.)
12. Statics to Floating Datum
13. Whole Line Velocity Analysis
14. Brute Stacks: Datum Statics vs. Refraction Statics
15. Surface Consistent Residual Autostatics
16. Interactive Velocity Analysis
18. Normal Moveout
19. Statics to Flat Datum
20. **First Break Mute Analysis

21. First Break Mute Application
22. CDP Stack
23. **Filter Testing on Unfiltered Final Stack
24. Bandpass Filter / 30-40-120-135 Hz. 0.000 sec. to 1.000 sec.
26. Random Noise Attenuation
27. Long Gate Trace Balance
28. Kirchhoff Migration (40%, 60%, 80% of Stacking Velocities)
29. Output SEG-Y Stacks for Interpretation

Note: ** Indicates that processing tests were made to determine appropriate processing parameters at steps 4, 9, 20 and 23.

Since the objective of this survey was primarily for structural information, the full one half (1/2) second of the recorded data was processed.

Figures 6 and 7 show the uninterpreted final stacked and migrated time sections that were used for the interpretation. The time section is shown in color scale displays, where a peak is black and a trough is red. It is assumed that the data are normal polarity for which a peak would indicate an increase in velocity. These color displays were used for the interpretation.

3.5 Data Interpretation

Zonge was assisted in the interpretation process by Summit Geosciences, LLC, of Denver, Colorado. Processed seismic lines were loaded into an IHS - Kingdom seismic interpretation workstation. Geological and shallow borehole information, including the previously mapped fault position at the surface, was used to aid with the interpretation.

Two seismic reflection events (or horizons) and a single fault were interpreted on the four project lines. The position and attitude (or dip) of the fault was identified by offsets in seismic reflectors on the vertical seismic sections.

4 RESULTS & INTERPRETATION

The four interpreted seismic sections are presented in Figure 3. These are presented as time sections, with the vertical axis as two-way travel time. They have not been converted to depth sections as we do not have any reliable velocity information (borehole or ground truth depth information) for the conversion. For the shallow alluvial section an approximate velocity of 6000 ft/sec is probably appropriate, as discussed below. Hence, a two-way travel time of 0.100 seconds corresponds approximately to a depth of 300 feet.

Profiles in Figure 3 show the interpreted horizons and fault on the 2D seismic time sections. The interpreted near-base of alluvium horizon (orange) is evidenced by a very strong trough that lies below a relatively reflection-less interval. This is a relatively strong and consistent seismic event that can be picked on each line and is thought to be near the unconsolidated sediment – rock interface. The relatively reflection-less interval above the horizon is typical of unconsolidated young fluvial sediments. Below the alluvium-bedrock interface, a weak discontinuous bedrock seismic horizon was mapped (blue) to aid with fault interpretation. The bedrock horizon may not be exactly the same geologic surface from line to line, but can be used to help with fault attitude determination. Interpretation of the fault dip on Lines SL1, SL2 and SL4 is shown on Figure 3. Line SL3 also shows the general location of the fault and we have indicated a tentative position of the fault, although the data are of lower quality. The fault is interpreted as a high-angle reverse fault that dips to the northwest. The detailed interpretations of each line are described in the following sections.

Additional faulting can be interpreted on the seismic sections, but cannot be unambiguously resolved. Some possible additional fault traces are shown in Figure 4. Locations of these possible fault traces are shown on Figure 5 over the LIDAR image. Resolution of these features does not warrant any correlation between lines and are not discussed in detail.

As mentioned previously, the conversion from seismic two-way travel time to depth requires additional information about subsurface velocities. The most reliable velocity data are from direct velocity measurements (such as sonic logs, velocity surveys, vertical seismic profiles, etc.) made in boreholes that penetrate into the objective geological section. As none of this type of data is available, a direct conversion is not possible for this project. However, we can use seismic stacking velocities (see Appendix C) to very roughly estimate depths. The stacking velocities used for processing were 5,000 to 6,000 feet per second (ft/sec).

Seismic data have been shifted to a datum of 1,800 feet above mean sea level (MSL). Hence, the zero two-way travel-time of the processed seismic sections (Figures 3 through 6) corresponds to an elevation of 1,800 feet MSL. This datum shift was performed using a velocity of 6,000 ft/sec.

The approximate elevation scale shown in Figures 3 and 4 assumes a velocity of 6,000 ft/sec. This is probably a good estimate for the alluvial section (± 20%) but is too slow for the bedrock section, resulting in overestimation of depths below the base of alluvium.

4.1 Line SL1

On SL1 (Figure 3) the position of the shallow orange horizon is evident on the NW side of the fault. An integrated interpretation of the orange and blue horizons indicates that the NW side of the fault is upthrown and that the fault shows an apparent dip of 84 degrees to the NW, which would be a high-angle reverse fault. This dip and displacement (vertical separation) is more pronounced on lines SL2 and SL4, where the alluvial fill above the bedrock surface is clearer. The downthrown area to the SE of the fault shows some internal reflections, suggesting that area has either no river down-cutting/erosion, or the stream deposits are layered.

4.2 Line SL2

On SL2 the position of the shallow orange event is very clear on the NW side of the fault. A section of alluvial fill above that event is well imaged. The interpretation of the orange and blue events shows that the NW side of the fault is upthrown and that the high-angle reverse fault shows an apparent dip of 87 degree to the NW. The downthrown area to the SE of the fault is relatively featureless, supporting an interpretation of river down-cutting/erosion and alluvial fill on that side of the fault.

4.3 Line SL3

As previously discussed, the processed seismic image for SL3 is very noisy due to local conditions at the time of data acquisition. Nonetheless, general characteristics can be identified across the section which supports the position and general high-angle reverse-fault nature of the fault seen on other lines. The orange event was identified at the top of the higher energy, semi-coherent data observed across the section. The orange event is vertically offset near the mapped surface position of the fault. The dip of the fault cannot be determined on this line due to poor quality data, but the offset is consistent with the other lines in this survey.

4.4 Line SL4

SL4 clearly shows the top of bedrock (orange event) across the entire section, the position of the fault, and the apparent 88 degrees north dip of the fault. The position of the fault is well defined within the bedrock by the coherent seismic horizon to the north of the fault. The relatively reflection-less interval above the orange horizon suggests a thicker deposition of fluvial sediments above the bedrock.

4.5 Conclusions

The 2D seismic reflection survey performed at the Riley Creek Bridge project site produced variable quality seismic data. Three of the lines (SL1, SL2, & SL4) produced seismic images that allowed mapping the position and dip of the Park Road Fault. This interpretation is consistent with the surface position of the fault mapped previously by others. The fourth line (SL3) was very noisy, but the rough position of the fault could be inferred as well as the relative vertical displacement of the bedrock/alluvium interface. One horizon, the base of alluvial fill (stream deposits), appears as a strong seismic trough on these lines. This surface was interpreted across each seismic section. The interpretation indicates that the northwest side of the fault is upthrown with better seismic imaging on that upthrown side. This may be due to chaotic unconsolidated sediment deposition on the downthrown side. The interpretation shows that the Park Road Fault is a northwest steeply dipping (84 to 87 degree) reverse fault.

Data quality and imaging of the subsurface and Park Road Fault would have been better with a stronger source such as shotgun or other impulsive source. However, permit conditions would not allow more than the slide hammer that was used on the project.

5 CLOSURE

Zonge International, Inc. has performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of the study described within.

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Zonge Project: 12180

ZONGE PROJECT #: 12180 FILE: Riley Creek Location.dwg DATE: OCTOBER 2012 REVISION: A-29-NOV-12

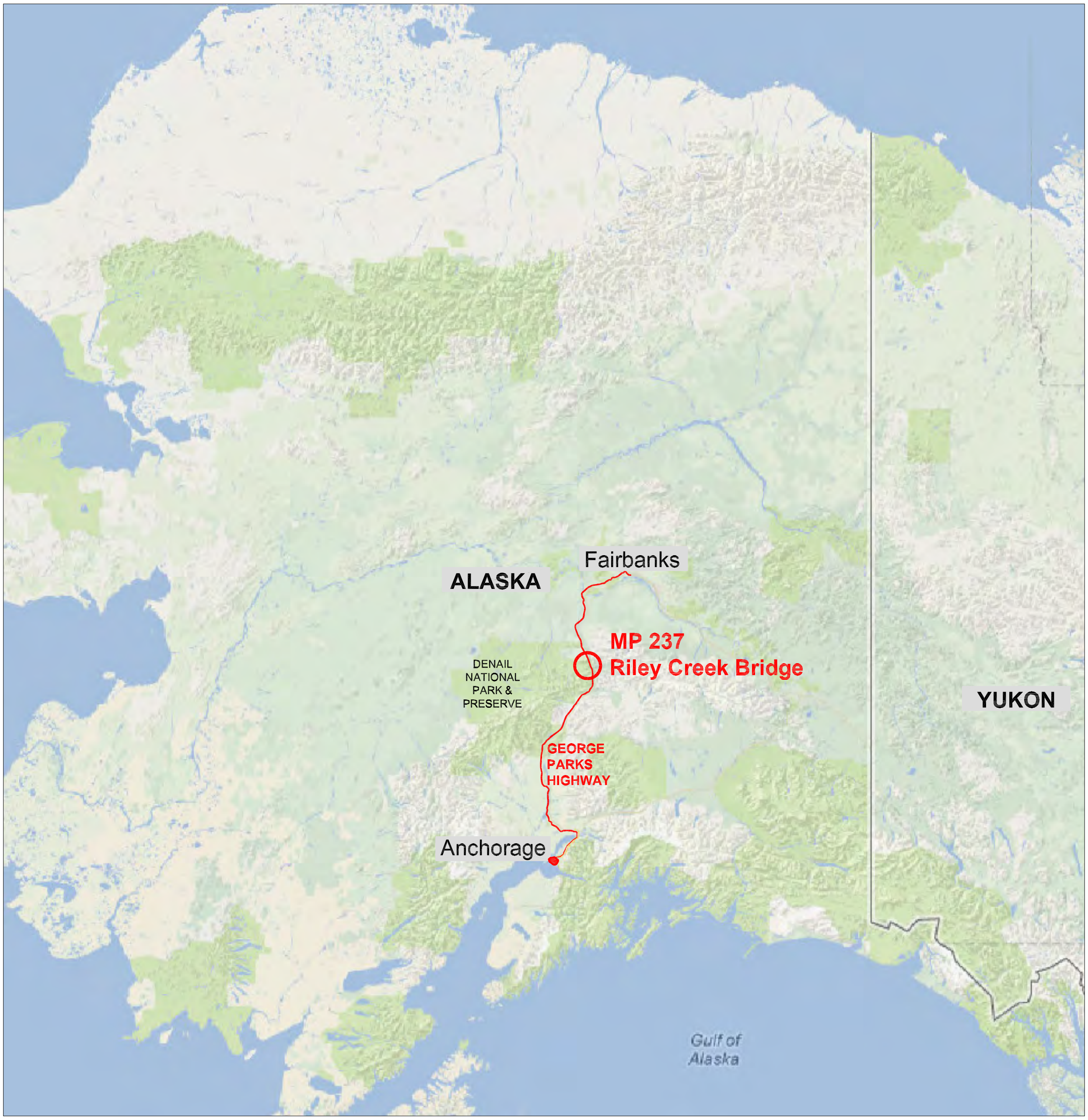


FIGURE 1

Prepared by:
ZONGE INTERNATIONAL, Inc.
Portland, Oregon

Prepared for:
ALASKA DEPARTMENT OF TRANSPORTATION and PUBLIC FACILITIES
Northern REgion, Fairbanks, Alaska

Under Agreement # 025-3-1-012; Project # 63763

PROJECT LOCATION MAP

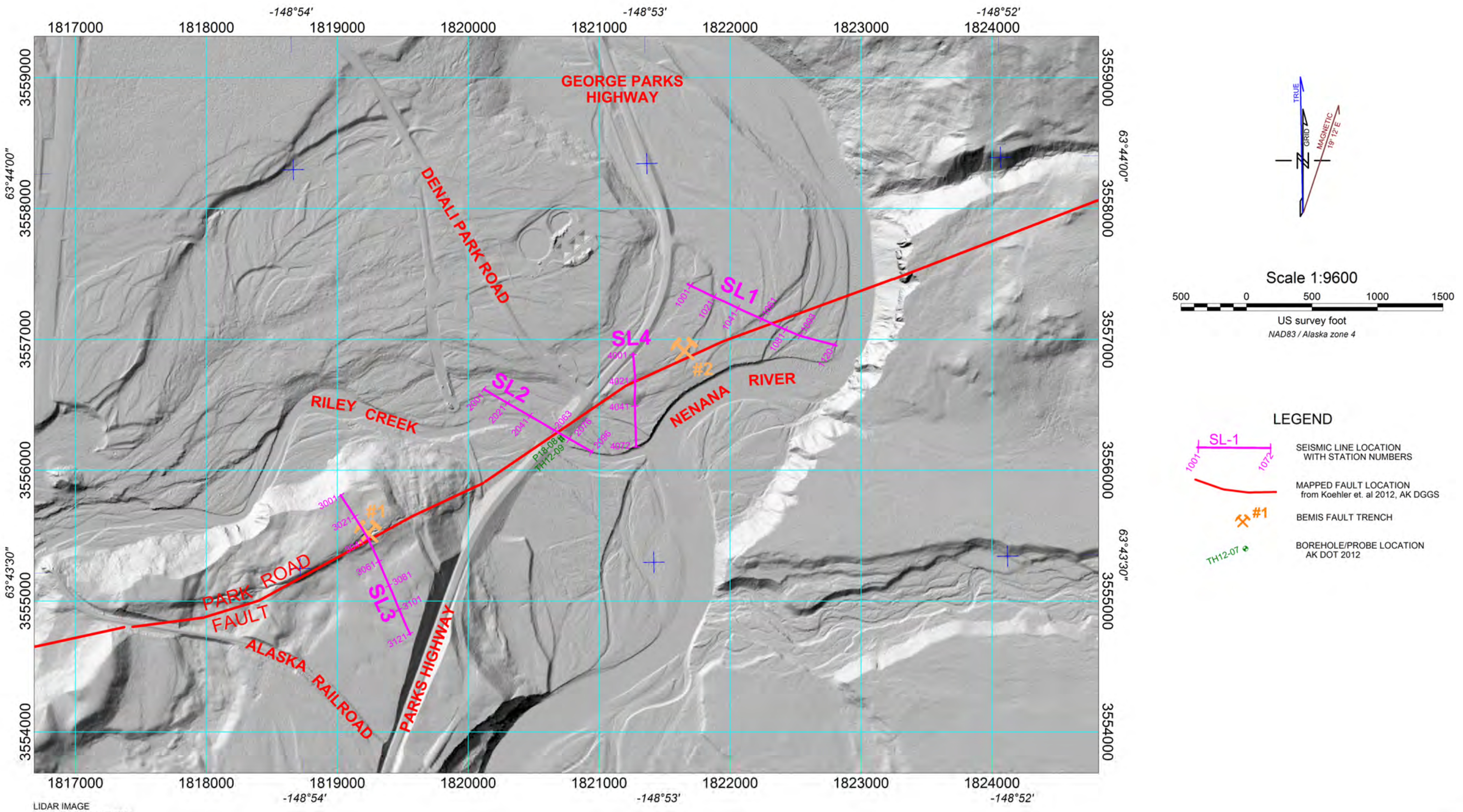
Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

REVISION: D-30-NOV-12

DATE: OCTOBER 2012

FILE: DETAIL6a_AKSP4.map

ZONGE PROJECT 12080



LIDAR IMAGE
from Hubbard et.al 2011
AK DGGS

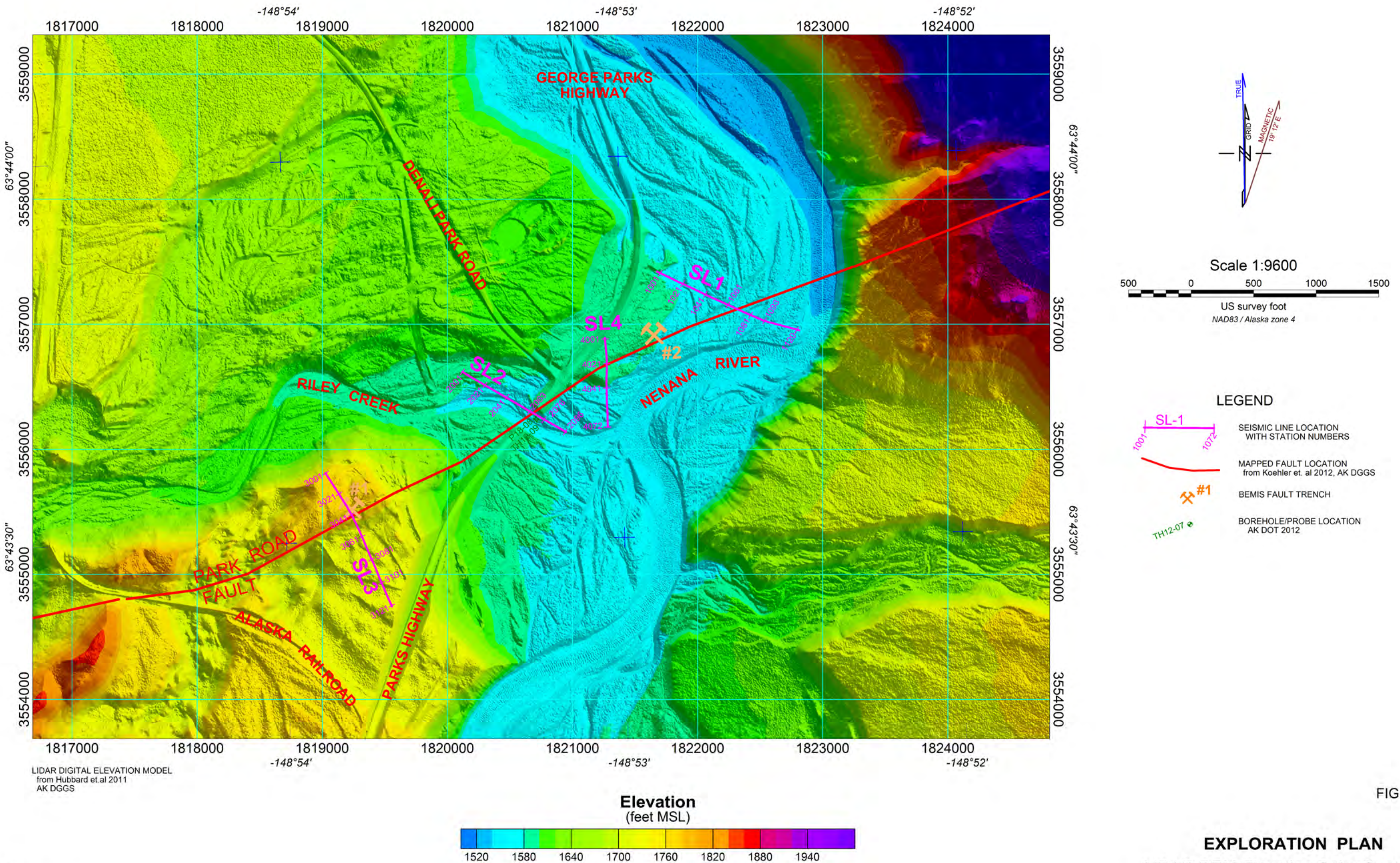
FIGURE 2A

EXPLORATION PLAN

LIDAR Hill Shade Image

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

Prepared by:
ZONGE INTERNATIONAL, Inc.
Portland, Oregon
Prepared for:
ALASKA DEPARTMENT OF TRANSPORTATION and PUBLIC FACILTIES
Northern Region, Fairbanks, Alaska
Under Agreement # 025-3-1-012; Project # 63763



LIDAR DIGITAL ELEVATION MODEL
from Hubbard et.al 2011
AK DGGS

FIGURE 2B

Prepared by:
ZONGE INTERNATIONAL, Inc.
Portland, Oregon
Prepared for:
ALASKA DEPARTMENT OF TRANSPORTATION and PUBLIC FACILTIES
Northern Region, Fairbanks, Alaska
Under Agreement # 025-3-1-012; Project # 63763

EXPLORATION PLAN

LIDAR DEM Elevation Color Contours

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

REVISION: D-30-NOV-12

DATE: OCTOBER 2012

FILE: DETAIL6c_AKSP4.map

ZONGE PROJECT 12080

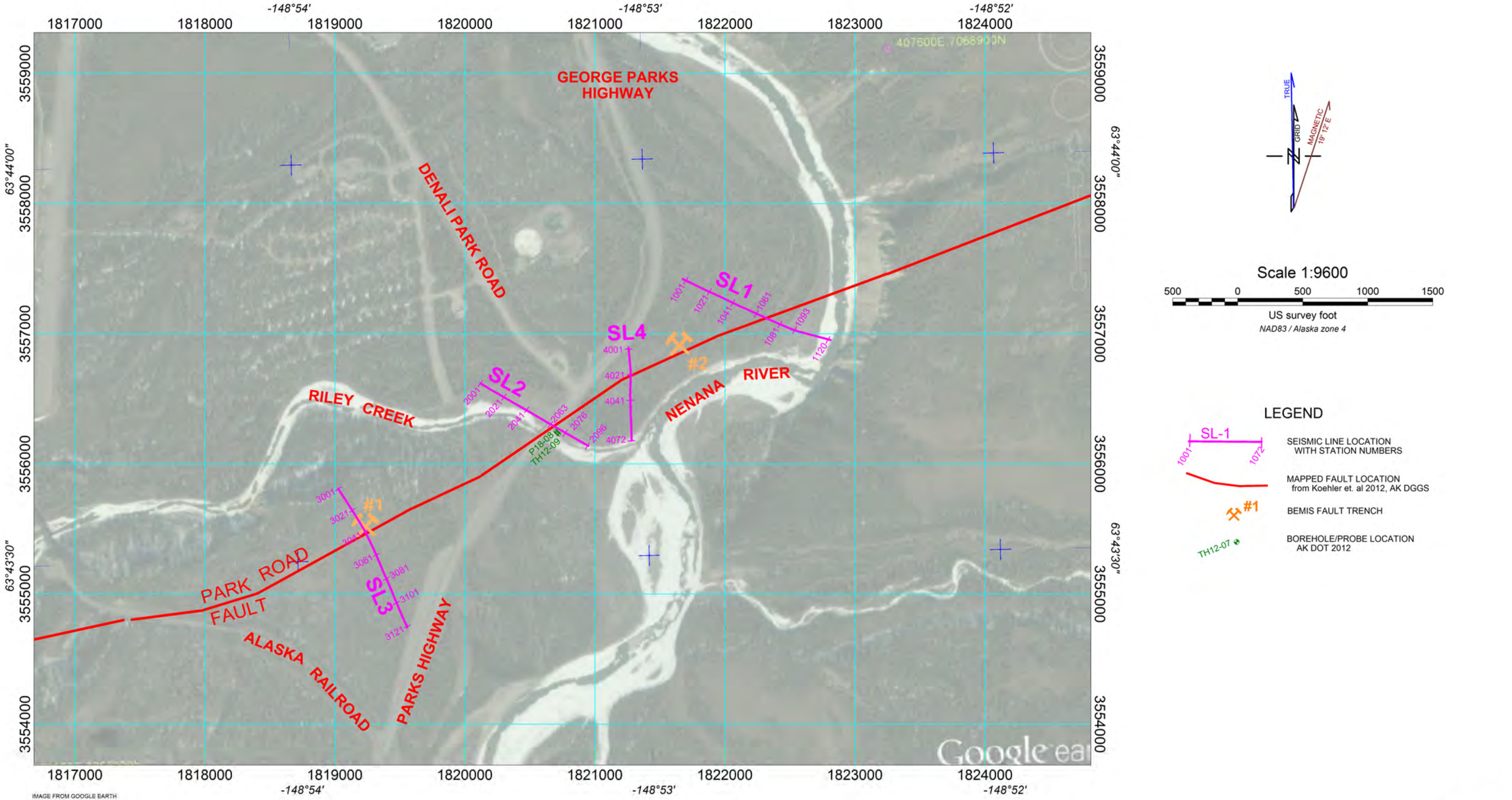


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FIGURE 2C

EXPLORATION PLAN

Satellite Photo Image

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

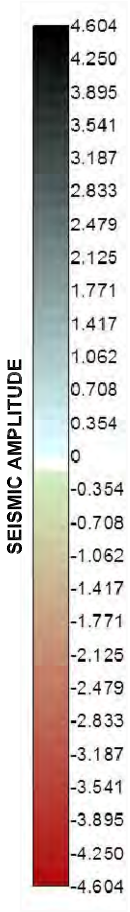
Prepared by:
ZONGE INTERNATIONAL, Inc.
Portland, Oregon
Prepared for:
ALASKA DEPARTMENT OF TRANSPORTATION and PUBLIC FACILTIES
Northern Region, Fairbanks, Alaska
Under Agreement # 025-3-1-012; Project # 63763

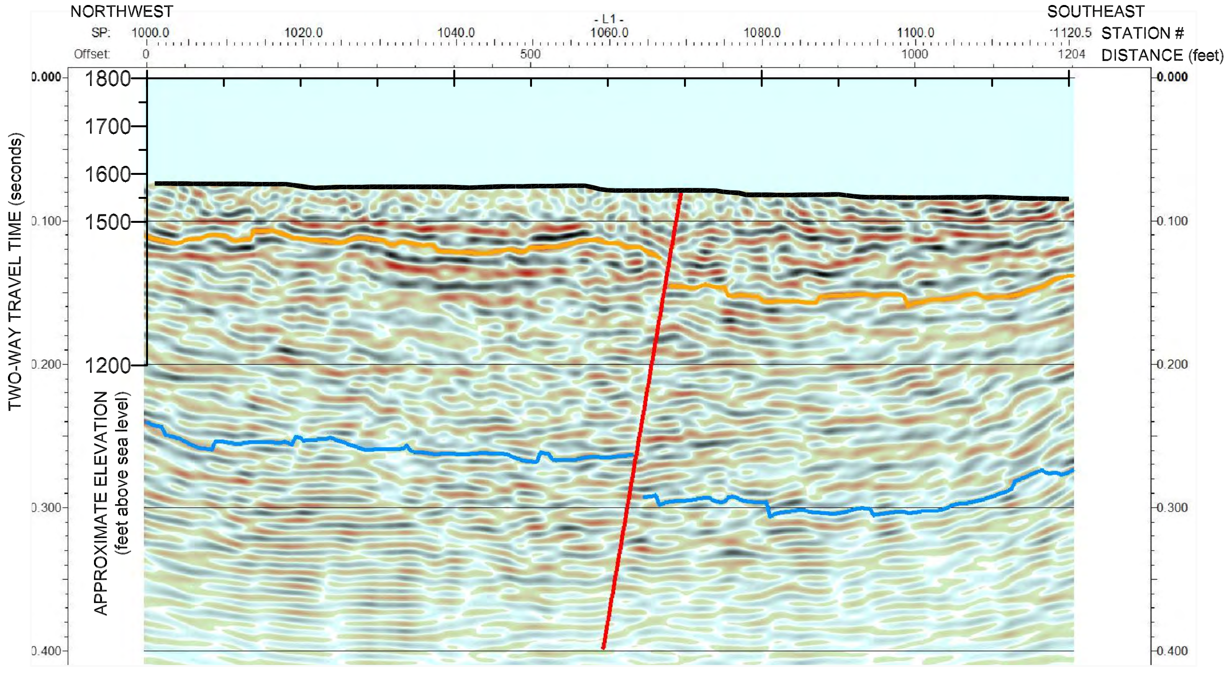
REVISION: A-25-NOV-12

DATE: October 2012

FILE: PROFILES_BL(INTERP).dwg

ZONGE PROJECT #: 12180





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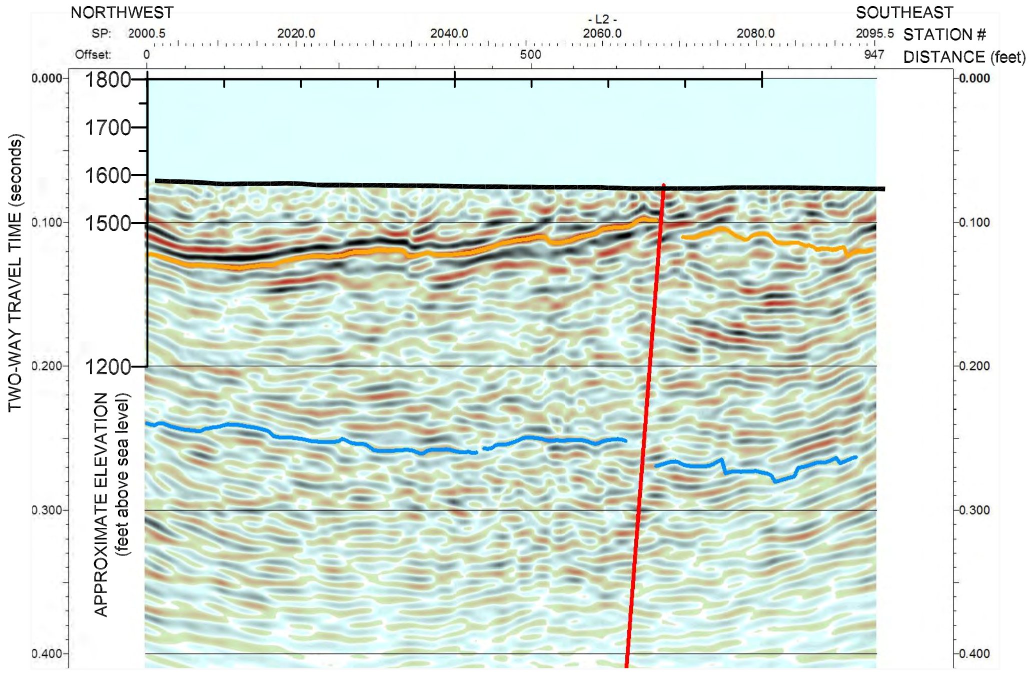

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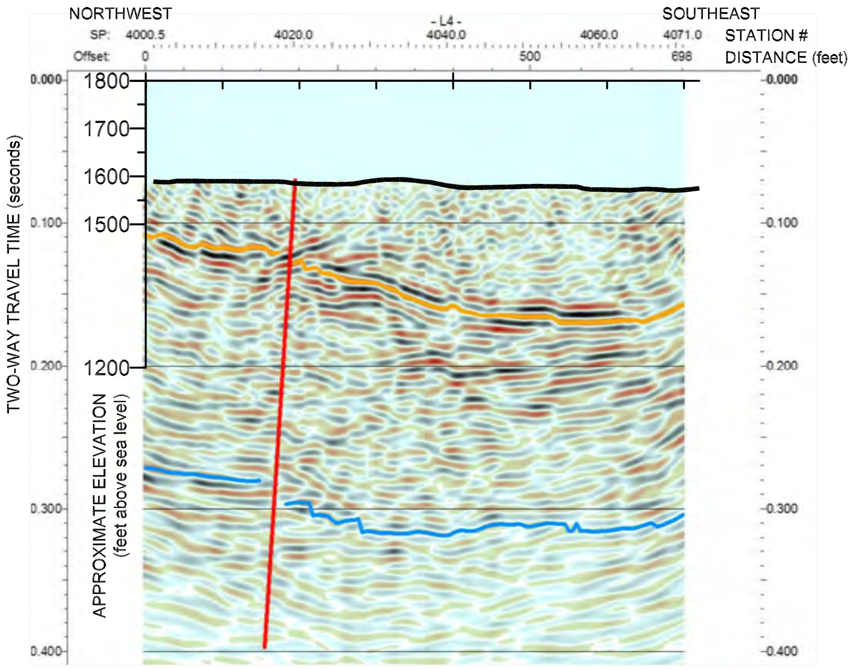

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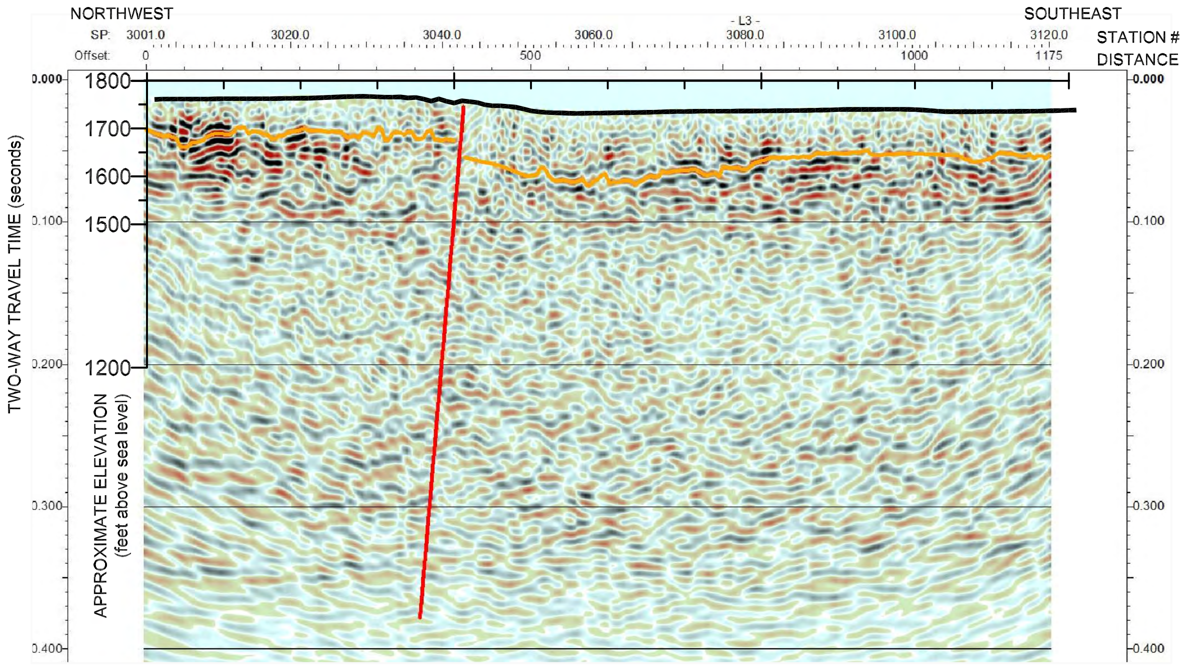

LINE SL3: INTERPRETED SEISMIC SECTION

FIGURE 3

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INTERPRETED SEISMIC SECTIONS

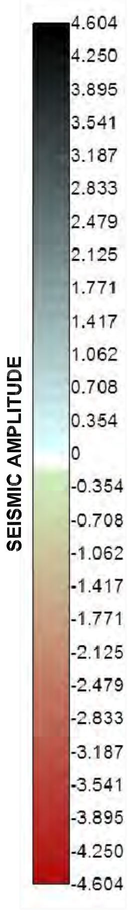
Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

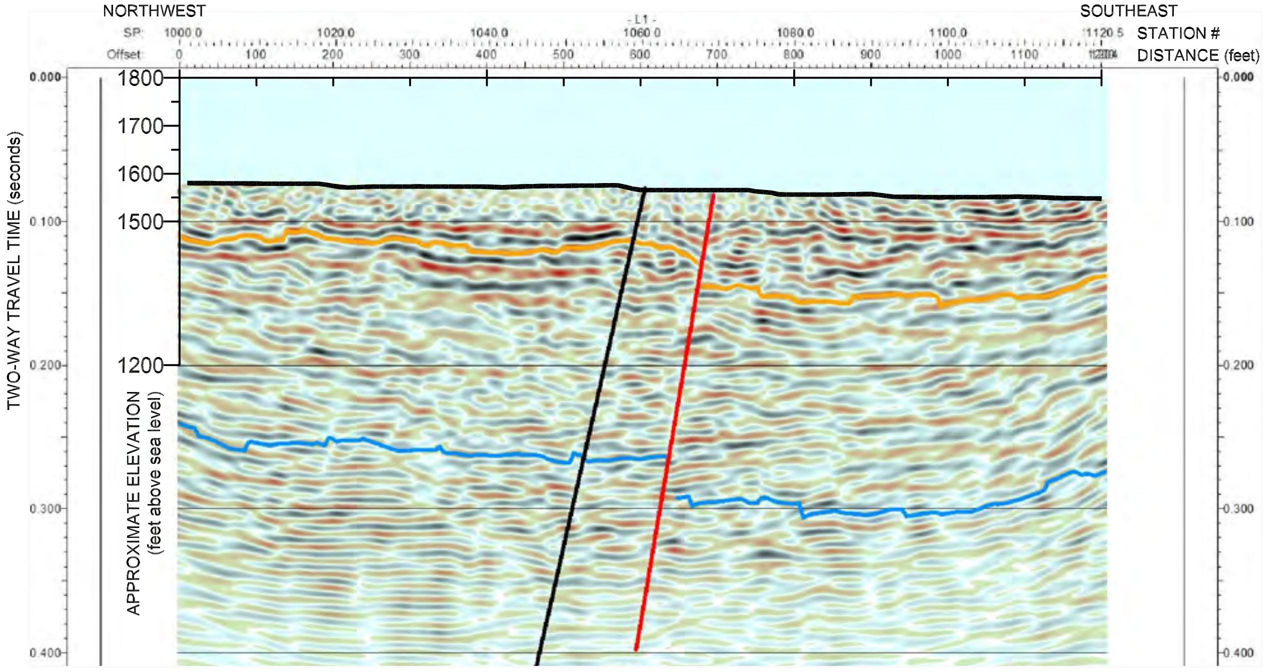
ZONGE PROJECT #: 12180

FILE: PROFILES_BL(ALTERNATE).dwg

DATE: October 2012

REVISION: A-25-NOV-12





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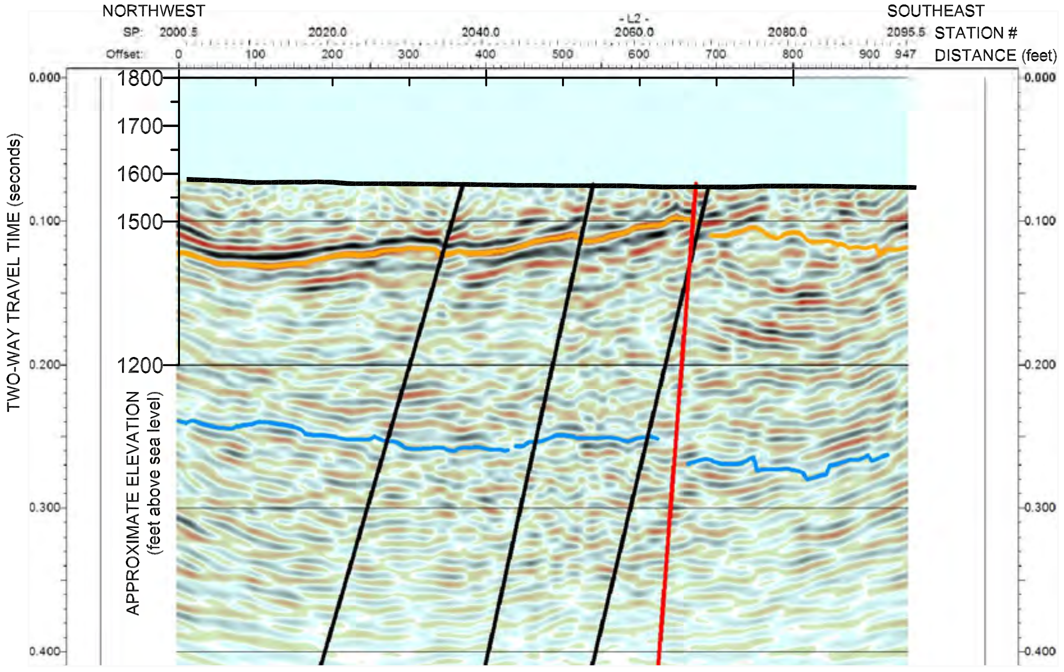

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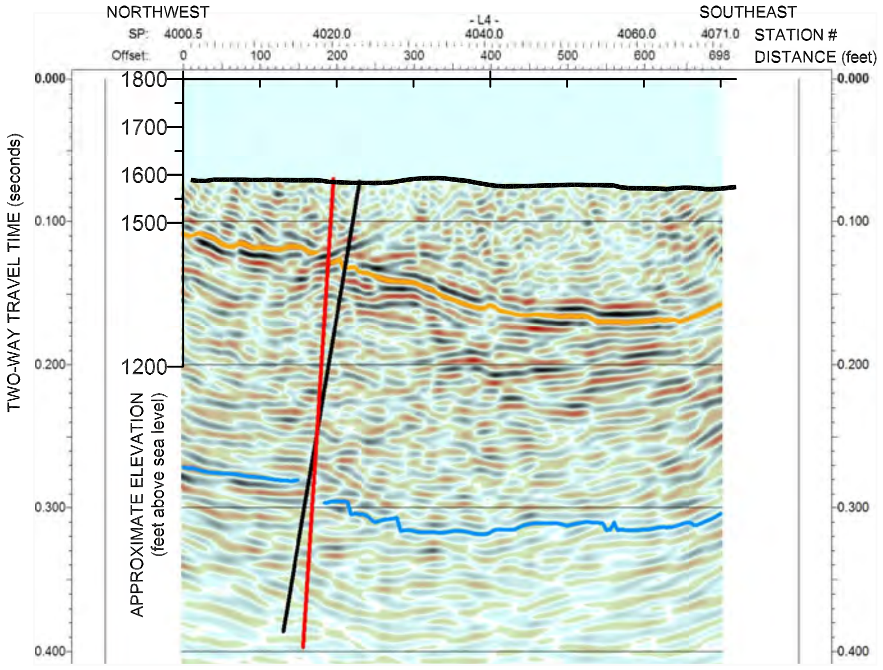

LINE SL4: ALTERNATE INTERPRETATION

FIGURE 4

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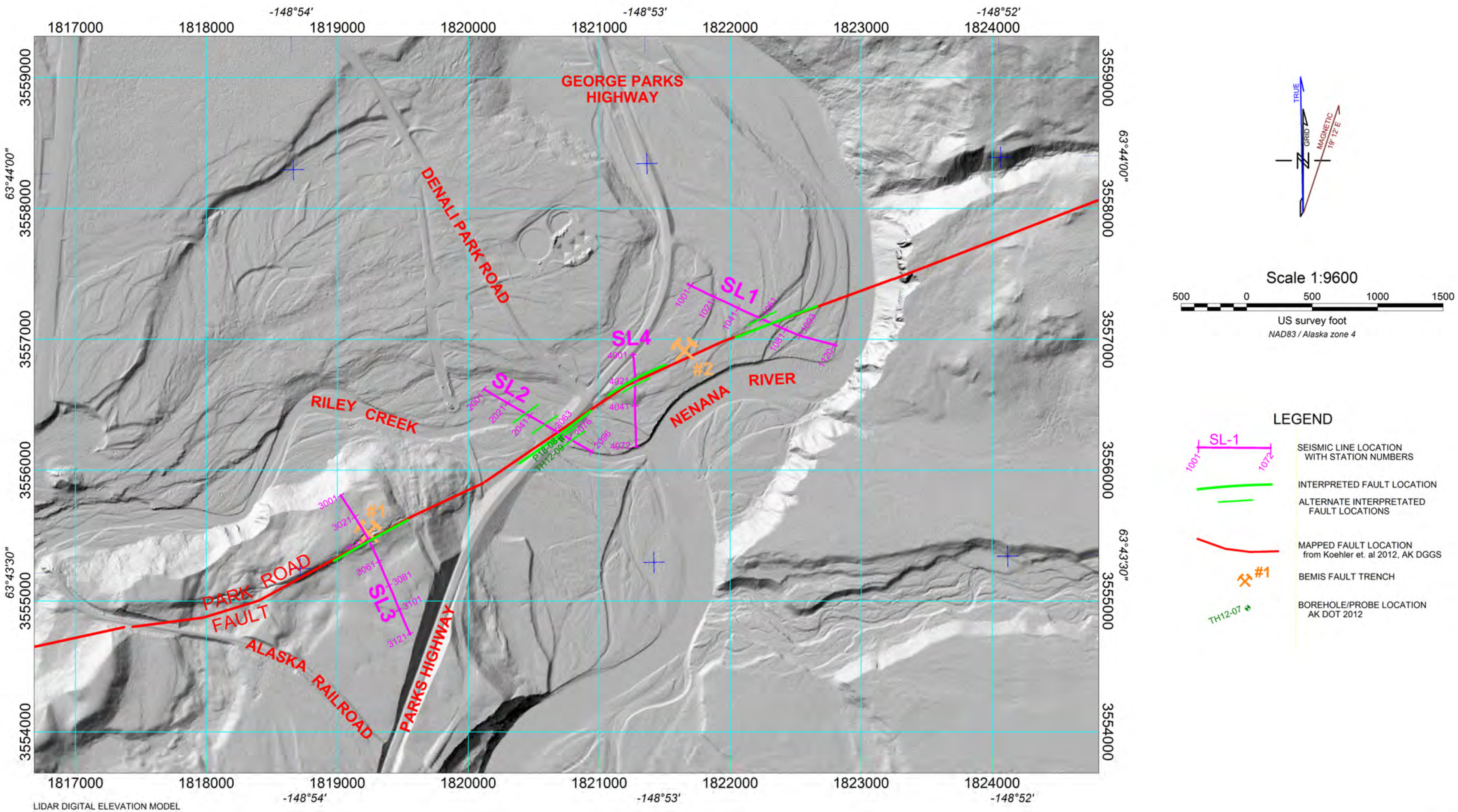
ALTERNATE INTERPRETATIONS

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

REVISION: E-19-FEB-13
DATE: OCTOBER 2012
FILE: DETAIL6alt_AKSP4.map
ZONGE PROJECT 12180



LIDAR DIGITAL ELEVATION MODEL
from Hubbard et.al 2011
AK DGGS

FIGURE 5

EXPLORATION PLAN
WITH ALTERNATE INTERPRETION

LIDAR Hill Shade Image

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

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Portland, Oregon
Prepared for:
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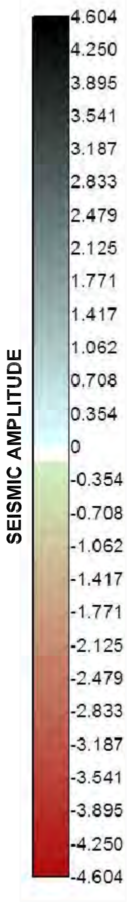
Northern Region, Fairbanks, Alaska
Under Agreement # 025-3-1-012; Project # 63763

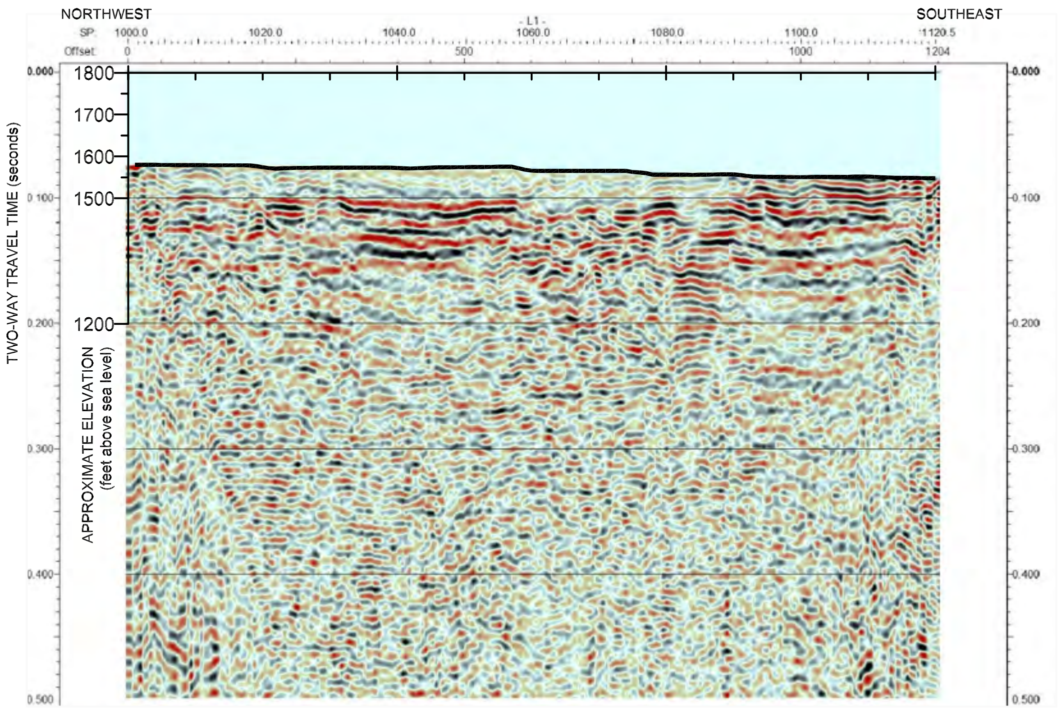
ZONGE PROJECT #: 12180

FILE: PROFILES_BL(SL1&2).dwg

DATE: October 2012

REVISION: B-19-FEB-13





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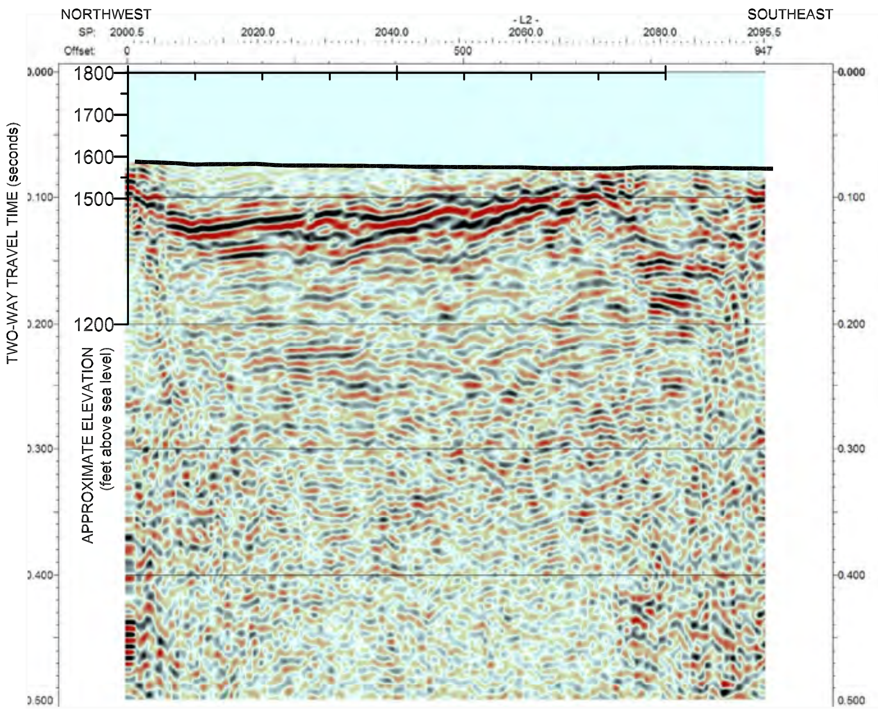

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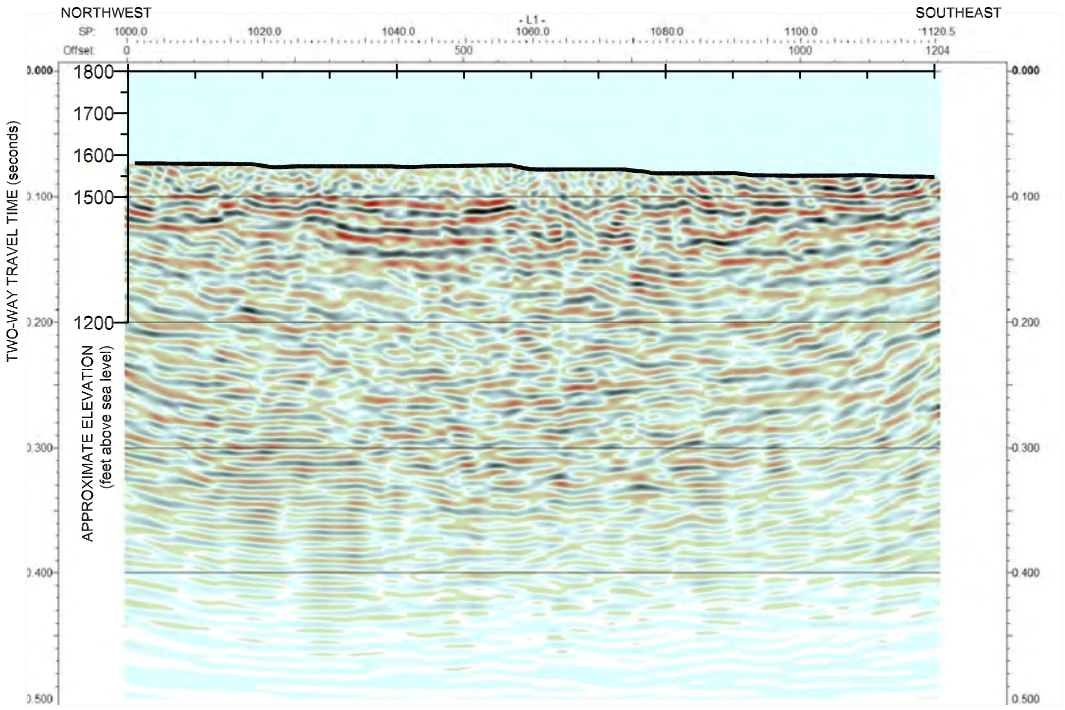

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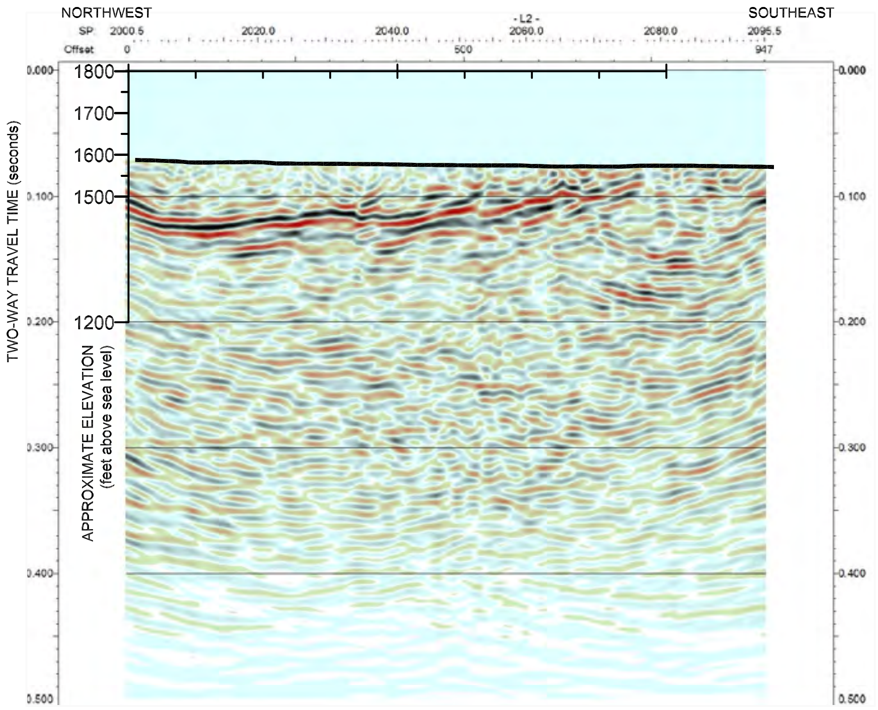

LINE SL2: MIGRATED SECTION

FIGURE 6

PROCESSED SEISMIC SECTIONS
SL1 and SL2

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

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Northern Region, Fairbanks, Alaska

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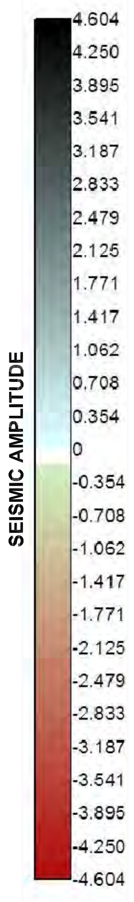
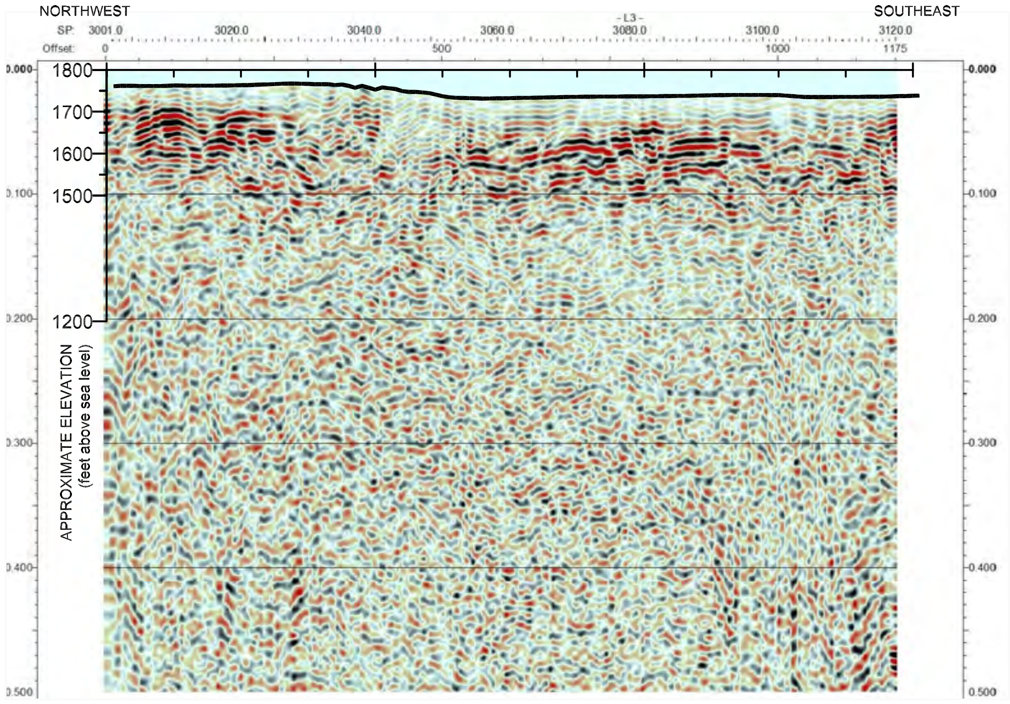
ZONGE PROJECT #: 12180

FILE: PROFILES_BL(SL3$4).dwg

DATE: October 2012

REVISION: B-19-FEB-13





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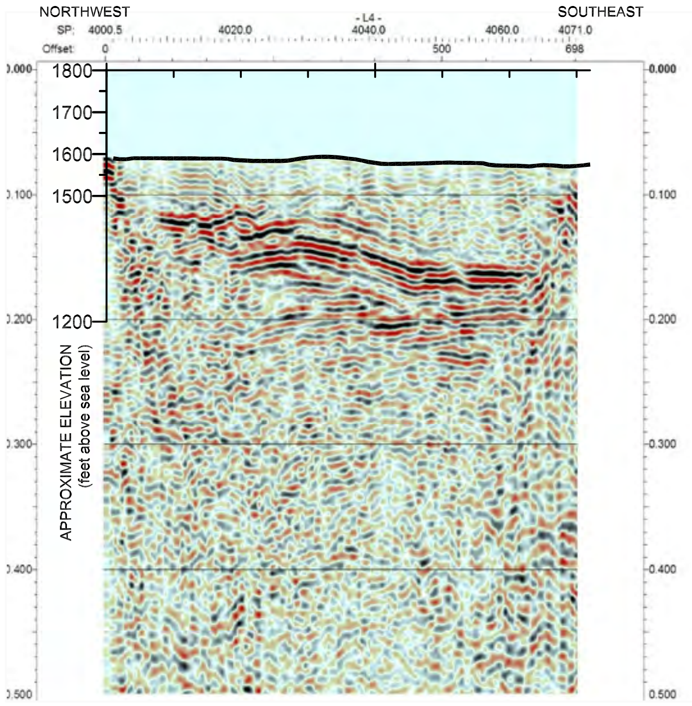

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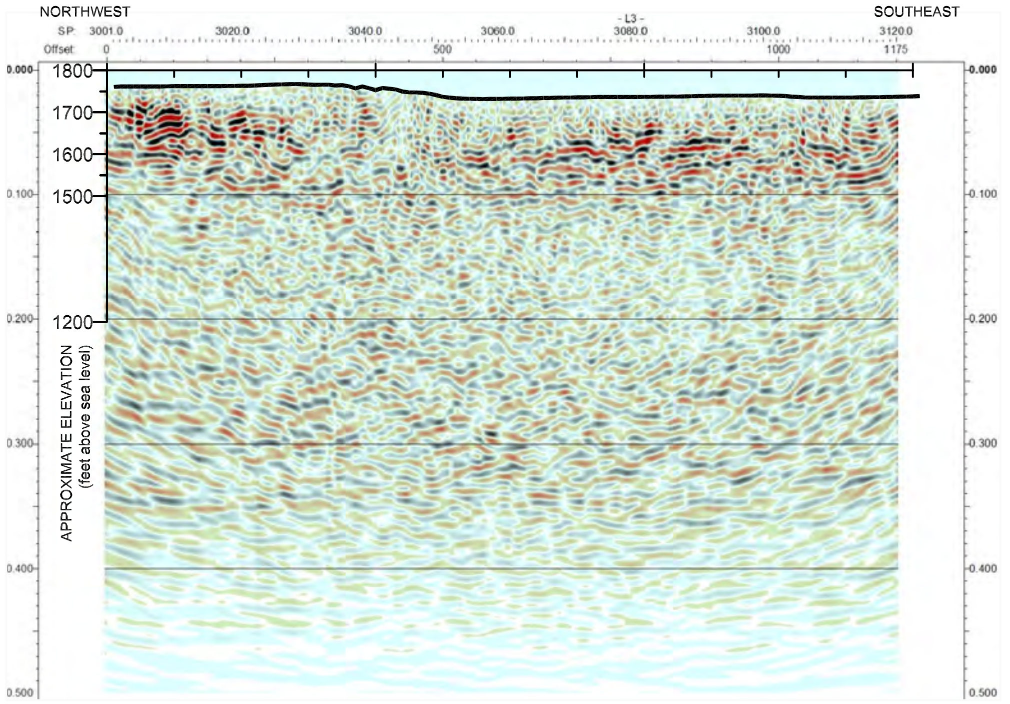

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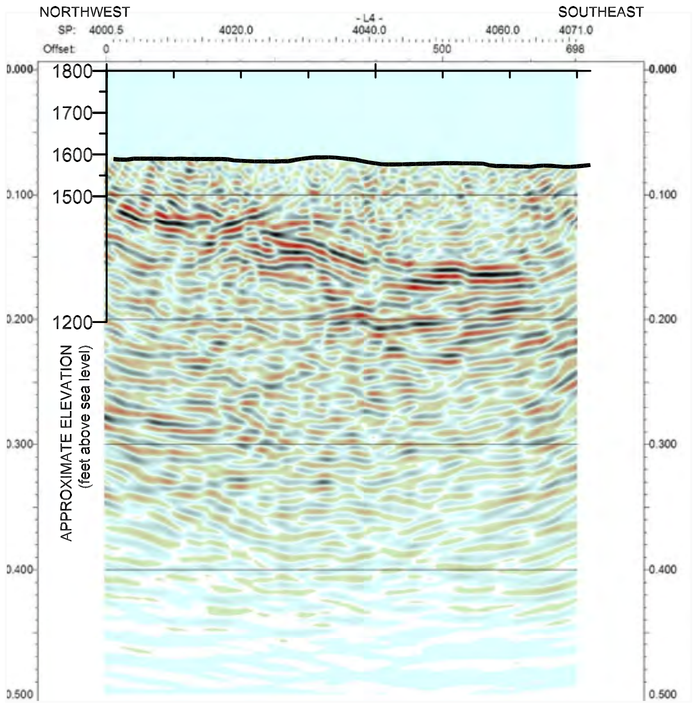

LINE SL4: MIGRATED SECTION

FIGURE 7

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Northern Region, Fairbanks, Alaska

Under Agreement # 025-3-1-012; Project # 63763

PROCESSED SEISMIC SECTIONS
SL3 and SL4

Geophysical Fault Mapping
Riley Creek Bridge Replacement Project
Parks Highway MP 237
Denali, Alaska

PARKS HIGHWAY MP 237 RILEY CREEK BRIDGE REPLACEMENT: INVESTIGATION TARGETING THE ACTIVE FAULT CHARACTERISTICS OF THE HINES CREEK FAULT

FINAL REPORT

Prepared for:
The State of Alaska Department of Transportation and Public Facilities

By
Dr. Sean P Bemis
and
Sara Federschmidt

Dept. of Earth & Environmental Sciences
University of Kentucky
Lexington, KY

May 2013

PARKS HIGHWAY MP 237 RILEY CREEK BRIDGE REPLACEMENT: INVESTIGATION TARGETING THE ACTIVE FAULT CHARACTERISTICS OF THE HINES CREEK FAULT

Table of Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

Dr. Sean Bemis and graduate student Sara Federschmidt, both of the University of Kentucky's Department of Earth & Environmental Sciences, conducted a geologic investigation into the prehistoric fault activity and characteristics of the Hines Creek fault in support of the Riley Creek Bridge Replacement project. The Hines Creek fault has only recently been recognized as a tectonically-active fault in this location, and trends roughly east-west, passing directly underneath the present Riley Creek bridge. This report provides an introduction to the historical discrepancies of how the Hines Creek fault has been interpreted and mapped by previous researchers (Figures 1 and 2), but highlights the fact that in the context of seismic hazards, the fault is clearly active and thus the nomenclature is somewhat irrelevant.

We introduce our studies by describing the general first-order observations that show the Hines Creek fault is tectonically active, and the basic geomorphic/neotectonic concepts and principles we apply in our active faulting assessment. The Hines Creek fault is a near-vertical reverse fault, with a north-side-up relative displacement and no evidence for lateral displacement across the fault. Our paleoearthquake data is primarily derived from a single trench, and suggests a cluster of earthquakes between ~500-1200 AD. These earthquakes, on average, produced surface displacements of less than 0.5 m. The long-term slip rate, derived from the cumulative offset of a late Pleistocene glacial outwash terrace, is ~0.6 mm/yr. Supplementing the report text is two appendices. Appendix A is simply a single table of raw and calibrated radiocarbon data with supplemental contextual information. Appendix B contains photomosaics and interpretive trench logs from each of the paleoseismic trenches, along with tables summarizing lithostratigraphic unit descriptions and the interpreted sequence of deformational events.

General Project Summary

Unpublished reconnaissance investigations by project PI Sean Bemis and Gary Carver (Carver Geologic, Inc.) along the Nenana River corridor in 2008 identified the surface trace of an active fault a short distance south of the Denali National Park & Preserve entrance. The release of airborne LiDAR (Light Distance and Ranging) data by the Alaska Division of Geological and Geophysical Surveys in 2011 provided an excellent view of the topographic scarp along this fault, illustrating both the evidence of recent fault activity and clearly defining the trace of the fault across the Parks Highway. Recognizing the regional geological significance of documenting this previously unknown Holocene and late Pleistocene fault activity, project PI Sean Bemis and graduate student Sara Federschmidt (University of Kentucky) initiated local surficial geologic mapping and began the application process for a Denali National Park & Preserve research permit to conduct paleoseismic trenching investigations on this fault during the summer of 2012. This research permit allowed us to hand-excavate a limited number of trenches across the topographic scarp formed during prehistoric earthquakes on the Hines Creek fault on either side of Riley Creek and the Parks Highway. We excavated a total of four trenches, two trenches at two different sites, and documented the stratigraphy and deformation exposed in the walls of these trenches.

The purpose of this study is to utilize the geomorphic and stratigraphic record of recent fault activity on the Hines Creek fault to provide information regarding the active faulting characteristics for use by the Alaska Department of Transportation and Public Facilities in their development of the new Parks Highway bridge across Riley Creek. The current bridge spans the Hines Creek fault in addition to Riley Creek, and therefore establishing a basic understanding of the timing of past earthquakes, the long-term slip rate, possible magnitude of surface displacement during earthquakes, width of the deformed zone, and potential for interseismic deformation will inform the engineering parameters of the replacement bridge.

Introduction

The Hines Creek fault at the Nenana River

The Hines Creek fault is a major crustal fault that lies within the Alaska Range, forming a broad, north-convex arc north of the Denali fault. This fault forms a major geologic boundary between the Yukon-Tanana Composite terrace to the north and younger late Paleozoic and Mesozoic rocks to the south. It is traditionally interpreted as a former trace of the central section of the Denali fault (e.g., Grantz, 1966) with significant right lateral displacement occurring during the late Mesozoic until ~95 Ma (Wahrhaftig et al., 1975). A pluton emplaced across the Hines Creek fault at ~95 Ma precludes significant additional right-lateral displacement, but several studies document evidence for Cenozoic dip-slip displacement along different sections of this fault (Ridgway et al., 2002; Nokleberg and Bundtzen, 2009; Wahrhaftig et al., 1975). The cumulative slip across the Hines Creek fault is unknown, but the lack of correlative geologic features across the fault suggests that this slip is significant.

The published geologic mapping of the Hines Creek fault in the vicinity of the Nenana River presents a complicated range of interpretations for the trace of the fault. As the most recent published geologic map of this region, the 1:250,000 Healy quadrangle geologic map (Csejtey et al., 1992) includes the previously mapped fault traces and introduces a new interpretation of the trace of the Hines Creek fault (Figure 1). Previous geologic maps by Wahrhaftig (1958) and Sherwood and Craddock (1979) depict similar traces for the Hines Creek fault to the west of the Nenana River, but these fault traces diverge significantly to the east (Figure 2). Both Wahrhaftig (1958) and Sherwood and Craddock (1979) map the Hines Creek fault as offsetting the late Cretaceous to Paleogene Cantwell Formation, but only Wahrhaftig (1958) clearly indicates that this fault is visible within late Quaternary deposits (Figure 2).

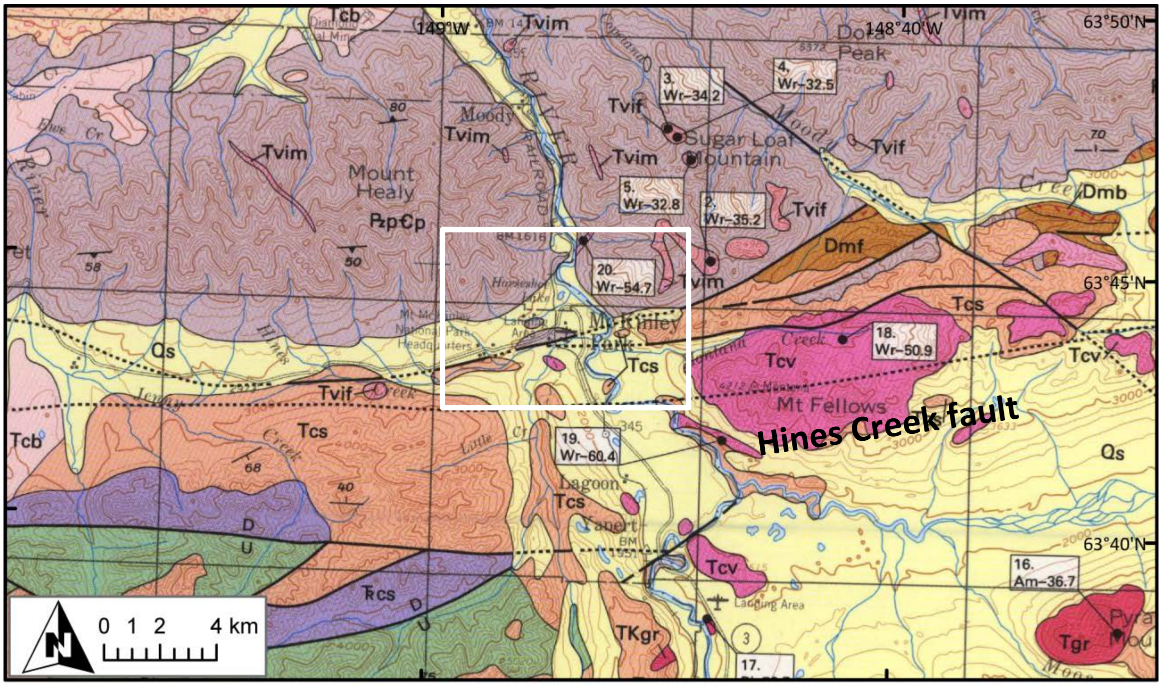

Figure 1. Geologic map of the Hines Creek fault/Riley Creek area excerpted from Csejtey et al. (1992). The white box illustrates the map areas of Figure 2. Note that this map depicts the Hines Creek fault as concealed across the entire region and as a separate fault from those identified as the Hines Creek fault by previous studies.

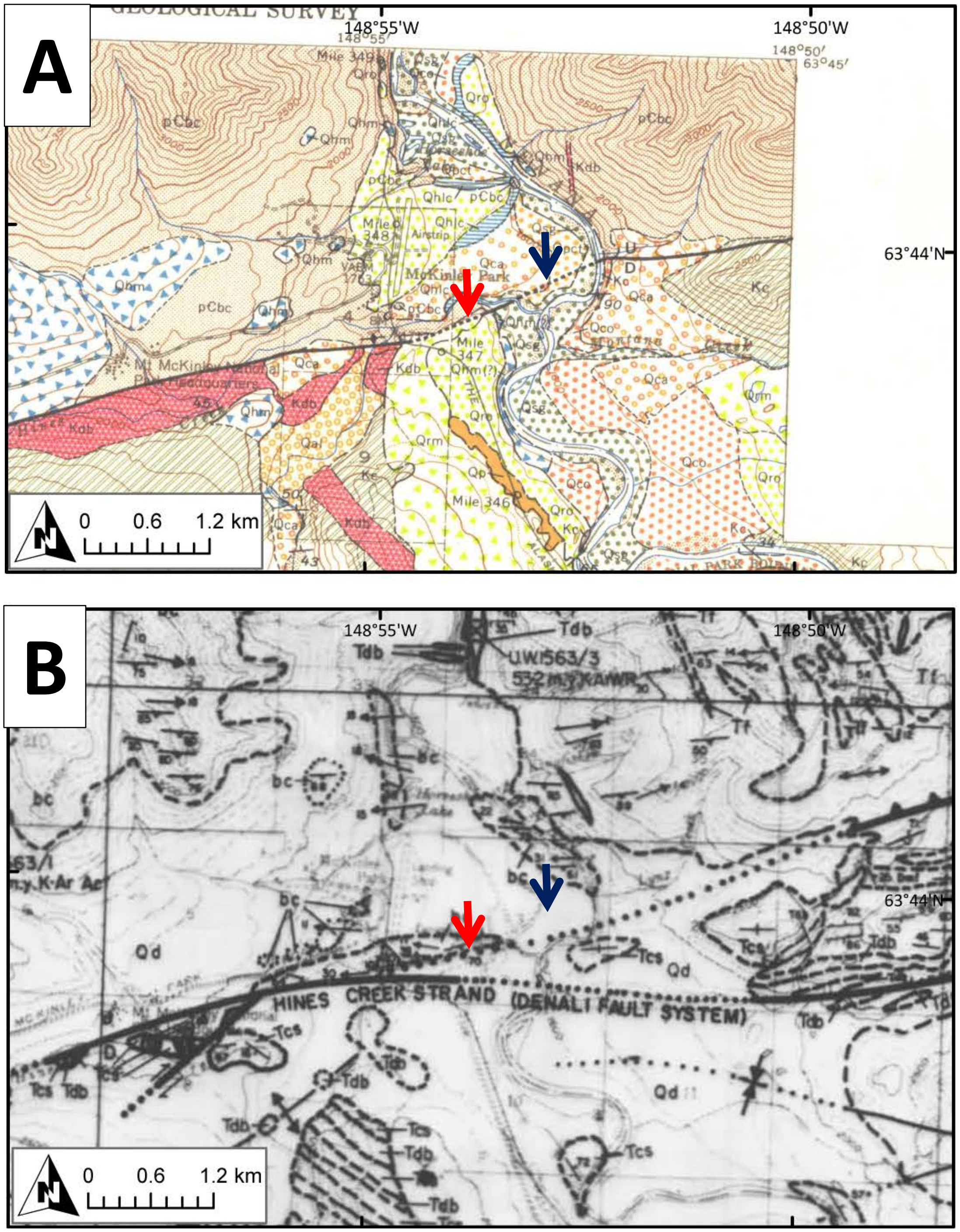

Figure 2. Excerpts of geologic maps from A) Wahrhaftig (1958) and B) Sherwood and Craddock (1979). The white box on Figure 1 illustrates the location of these two maps where the Hines Creek fault crosses the Nenana River. The solitary fault on (A) is the Hines Creek fault, and is depicted as locally offsetting late Quaternary geologic units as well as juxtaposing Cretaceous against Precambrian metamorphic rocks. The Hines Creek "Strand" shown on (B) follows an identical trace to the west, but to the east they connect the Hines Creek fault to a different fault with a more southerly trace. The blue and red arrows denote Sites A and B from this study, respectively.

The inferred logic for Csejtey et al. (1992) mapping an entirely new, concealed, trace for the Hines Creek fault through the map area would appear to be an interpretation that the ~95 Ma pluton precludes any post-95 Ma activity on this fault, and thus must be concealed by any younger geologic deposits (Figure 1). An additional interpretation not presented in Figures 1 and 2 is presented by Bemis and Wallace (2007) and Bemis et al. (2012) as the interpretation of the Park Road fault. This fault was mapped based upon intermittent fault scarps observed in the field and the previously mapped Cenozoic fault traces from Wahrhaftig (1958) and Sherwood and Craddock (1979) and was interpreted to have accommodated the late Cenozoic uplift of the east-west trending ridge of metamorphic rocks immediately north of the Hines Creek fault (e.g., Figure 1). It has become apparent through the studies contributing to this report that the Park Road fault may be essentially synonymous with the tectonically active portions of the Hines Creek fault in this portion of the Alaska Range.

Regardless of the specific fault nomenclature, we have documented clear topographic evidence of an active fault along the full trace of the Hines Creek fault as mapped by Wahrhaftig (1958). The subsequent reinterpretation of the Hines Creek fault by Sherwood and Craddock (1979) may be appropriate for the older history of the Hines Creek fault, but our preferred interpretation of the Hines Creek fault in terms of Cenozoic activity is the mapped trace of Wahrhaftig (1958).

Active fault characterization studies of the Hines Creek fault at the Nenana River

Reconnaissance fieldwork by Bemis and Gary Carver (Carver Geologic, Inc.) during 2008 and airborne LiDAR topographic data revealed a fault scarp west of the Nenana River that cuts through late Pleistocene and Holocene fluvial terraces. The initial assessment based upon our field and LiDAR reconnaissance studies established the following observations regarding the activity and faulting style of the Hines Creek fault:

1. The linear trace of the fault scarp across geomorphic surfaces of different elevations indicates that it has a near-vertical dip.
2. The scarp is increasingly taller on older geomorphic surfaces and has down-to-the-south relative displacement.
3. It also projects eastward across the Nenana River into an exposed fault zone that was first mapped by Wahrhaftig (1958).
4. Coseismic fissures are visible on the crest of the scarp west of the Parks Highway and south of Riley Creek. These fissures exhibit no evidence of lateral shear and appear to represent extension across the crest of the scarp.
5. The scarps are up to ~10 m tall and thus indicate that the fault in question has experienced several ruptures across a narrow fault zone.
6. The surficial organic mat that covers the coseismic features has been completely regrown and mature aspen and spruce trees can be found within the fissures, which suggest that this fault has not experienced a major surface rupture for at least 200 years.

With these reconnaissance observations establishing the basic parameters regarding active faulting style and geometry, we undertook a fieldwork plan specifically targeted at extracting a record of prehistoric earthquakes for this section of the Hines Creek fault. We selected two easily accessible sites along this fault for our paleoseismic investigations, Site A on the lowest faulted terrace (north of Riley Creek and east of the Parks Highway) and Site B on the highest faulted surface (south of Riley Creek and west of the Parks Highway) (Figures 2 and 3).

Overview of our Assessment of Active Faulting Parameters

Slip Rate

The slip rate for a fault represents the long term average of displacement per unit time across the fault. For seismogenic faults, the actual discrete relative displacement across the fault occurs coseismically – during an earthquake. Therefore, this slip rate should ideally be averaged over numerous seismic cycles in order to reduce the influence of the time since an earthquake on the resulting slip rate. The ability to average across multiple seismic cycles is easily accomplished by recognizing older landforms that have experienced displacement during numerous earthquakes on the fault of interest.

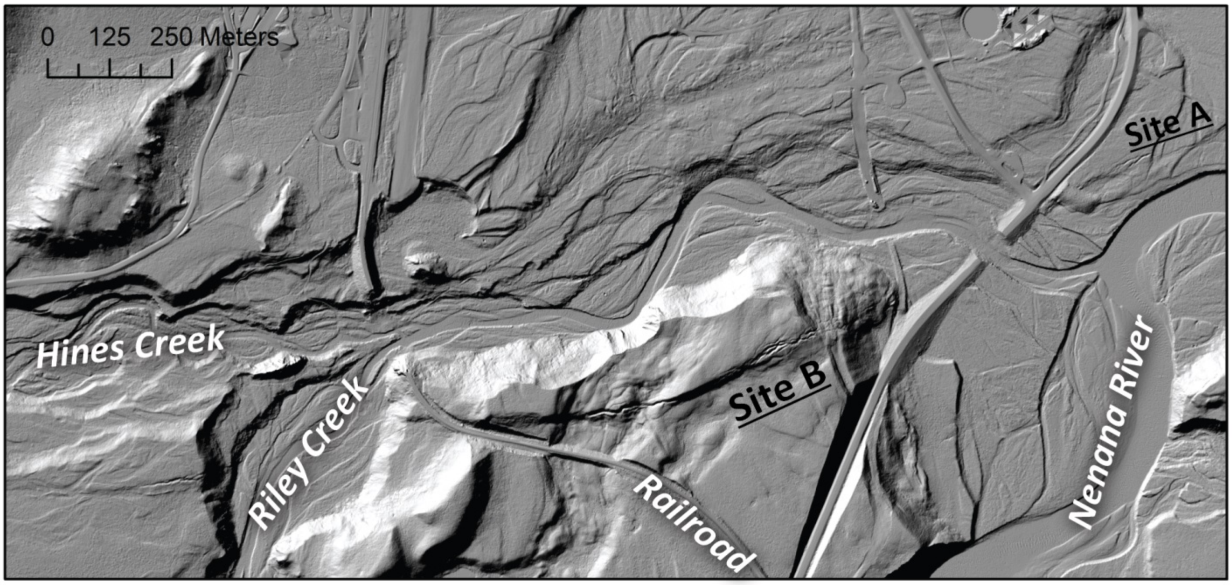

Figure 3. Shaded-relief LiDAR-derived topography of the Hines Creek fault near the Nenana River. Site A and B are the locations of our focused paleoseismic studies.

Fluvial terraces are geomorphic surfaces that form as a result of vertical stream incision forcing the abandonment of the stream's floodplain. Because a floodplain exists parallel to the stream gradient, fluvial terraces have a well-constrained original geometry, and thus these surfaces are ideal markers for measuring the cumulative displacement across a fault since the time of surface abandonment. For the Hines Creek fault near the Nenana River, we worked on two distinct fluvial terraces that are both offset by the fault, and for which we have at least basic age control. These two surfaces represent the oldest and youngest landforms in the study area that are deformed by a well-preserved fault scarp (Figure 3). Several terraces exist at intermediate elevations, but only their relative ages are known.

Constraints on Paleoearthquake History

The extraction of earthquake timing and magnitude from recent, but prehistoric, geologic archives fundamentally relies upon the preservation of the ground disturbance (often the "surface rupture") that results from a prehistoric earthquake. Paleoearthquake timing is derived by identifying limiting ages of earthquake deformation – essentially recognizing the youngest feature deformed by the earthquake, and the oldest feature not deformed by the earthquake. Paleoearthquake magnitude is broadly related to the amount of offset that occurs during an earthquake, but is complicated by the fact that, for example, a 1 meter displacement could be the maximum displacement for that earthquake, or could be the "tail" end of a much larger earthquake rupture.

Our investigations into the paleoearthquake history of the Hines Creek fault near Riley Creek focused on two sites – herein referred to as Site A and Site B (Table 1; Figures 2 and 3). Site A occupies a low fluvial terrace that appears to have been abandoned sometime after ~500 AD (~1500 years ago) based upon the oldest radiocarbon sample collected from within the fluvial deposits (Appendix A - Table A1). At this site we excavated a trench across a topographic fissure (Figure 4) to target the sediment that would be trapped and deformed within the fissure and recording the most recent record of paleoearthquakes. Site B occupies the highest terrace surface in the study area and targets two of the most distinct fissures preserved on the crest of the fault scarp. Similar to Site A, this site was selected due to the interpretation that these fissures would preferentially trap fine-grained sediment and provide a high-resolution record of older paleoearthquakes.

Table 1. Basic information on the paleoseismic trenches documented in this study.

Trench Name	Coordinates*	Fault Type	Length/Width (m)	Depth Range (m)	Paleoseismic Results
Hines Creek Fault, Site A, T2	407,078 E, 7,068,226 N	Reverse, near vertical dip	4.3/1	1-1.75	2 complex deformation zones, 2 shear zones, secondary extensional faults, 1 event well constrained, 2 events partially constrained, several fault offsets
Hines Creek Fault, Site B, T3	406,323 E, 7,067,831 N	Reverse, near vertical dip	4.5/0.9	1-1.25	1 fault offset, 1 event partially constrained
Hines Creek Fault, Site B, T4	406,326 E, 7,067,843 N	Reverse, near vertical dip	4/1	0.75-1.5	1 fault offset
***UTM zone 6, WGS 1984**					

The general character of the earthquake-related stratigraphy and deformation exposed in our trenches at both Site A and B consists primarily of packages of relatively fine-grained deposits bounded by diffuse shear zones. Therefore, the primary fault evidence is derived from alternating poorly sorted reworked terrace gravel with fine grained deposits - where the reworked terrace gravel represents raveling and mass wasting that occurs immediately after an earthquake, and the fine grained deposits represent low-energy, interseismic deposition within the confined fissures. Except for a single north-dipping thrust fault trace in the north end of T2 at Site A (Appendix B - Figure B2 and B4), the near-surface expression of this faulting consists of secondary deformation above the primary fault displacement in the shallow subsurface. It appears that this discrete displacement at depth manifests as distributed deformation in the unconsolidated materials at the surface and fissures are zones of focused extension within the distributed deformation across the crest of the fault scarp. Therefore, most of the deformation exposed in our trenches is essentially the manifestation of gravitational collapse of unconsolidated deposits within the extension across the fault scarp.

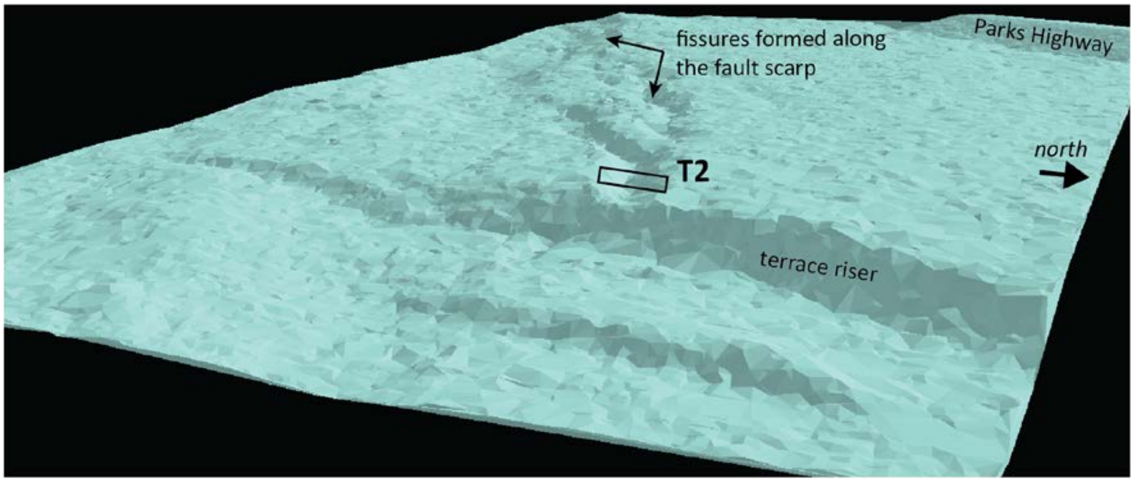

Figure 4. Oblique, southwest-looking view along the Hines Creek fault and paleoseismic Site A. The location of trench 2 is illustrated by the black rectangle, at a site chosen because the deformation of the scarp surface appears to be concentrated along a single fissure. Photomosaics and interpreted trench logs are presented in Appendix B. Base data is a full resolution shaded-relief of a TIN surface constructed from the ground-classified LiDAR point cloud.

Project Deliverables

(1) Predicted fault recurrence interval

A quantitative evaluation of an earthquake recurrence interval for an active fault requires both the knowledge of the timing for multiple paleoearthquake events on the fault of interest and a statistical model for the earthquake recurrence behavior. Traditional conceptual earthquake recurrence models, such as the characteristic earthquake model (Schwartz and Coppersmith, 1984), are based upon elastic rebound theory (Reid, 1911) and predict essentially regular intervals between similarly sized earthquakes on a particular section of a fault. However, recent theoretical and geologic studies raise questions about the validity of these simple models (e.g., Goldfinger et al., 2013; Kagan et al., 2012; Weldon et al., 2004).

The constraints from our paleoseismic investigations on earthquake timing recognizes a potential cluster of earthquakes occurring between ~500 and 1200 AD, with no obvious evidence for surface rupturing earthquakes since that time. Temporal clustering suggests it is inappropriate to assign a recurrence interval for our current state of understanding of earthquake occurrence on this fault. However, if we assume the long-term slip rate (described in #3 below) remains constant at ~0.6 mm/yr, then we can use the slip rate derived from a tentative 1-2 m vertical offset of the ~1500 year-old fluvial terrace across Site A of 0.7-1.3 mm/yr to infer that the cluster of earthquakes released a significant amount of strain on this fault, and that at least 500 years would need to pass before the next earthquake for the strain release (slip) rate recorded by this lower terrace to match the long-term slip rate recorded by the upper terrace at Site B.

(2) Predicted fault magnitude potential

The nature of the secondary deformation that characterizes the coseismic surface rupture along the Hines Creek fault makes direct measurement of displacement during individual earthquakes very difficult. However, recognizing the occurrence of possibly 5 earthquakes that contributed to the 1-2 m cumulative offset of the lower terrace surface at Site A, we can infer that individual earthquakes that have occurred on this section of the fault produce vertical offsets on average less than ~0.5 m.

(3) Predicted rate of movement during life span of bridge

The preserved surface expression of the earthquake ruptures and stratigraphic relationships exposed in our cross-fault trenches suggests that the relative displacement across the Hines Creek fault within the study area occurs episodically during earthquakes. Therefore, the displacement rate across this fault will be 0 mm/yr during the interseismic period (the time between major fault ruptures). In terms of the life span of the bridge, the cumulative near-field displacement across the fault will be 0 mm unless there happens to be an earthquake during that time.

The long-term rate of movement across the Hines Creek fault in the study area is determined from the cumulative offset of the latest Pleistocene outwash surface (Figures 5 and 6) across the fault. This long-term slip rate averages the near-instantaneous relative motion during earthquakes with the long interseismic periods and serves as a proxy for the far-field tectonic loading rate for this fault. We did not determine any new age constraints for this surface, but based upon the close proximity to glacial moraine deposits associated with the Riley Creek glacial advance (Marine Isotope Stage 2), we can establish reasonable limits on the surface age. Surface exposure ages of the next younger glacial advance along the Nenana River valley indicate that the absolute minimum age for this surface is ~16 ka (Dortch et al., 2010), whereas the maximum age is provided by the correlation with the initiation of the global cooling trend. However, we suggest that the global maximum ice volume at ~20-22 ka is a more likely maximum age, because this upper terrace surface represents a proximal outwash surface that formed as the glaciers began to retreat from their maximum extent. With a cumulative offset of this terrace surface across the Hines Creek fault of ~12 m (Figure 5), the late Quaternary slip rate for this fault is ~0.6 mm/yr.

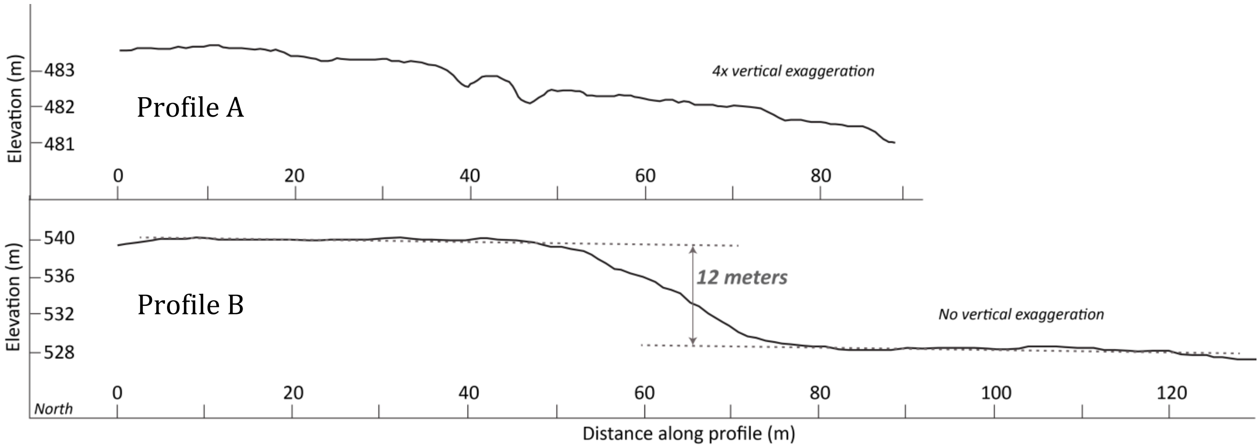

Figure 5. Topographic profiles across the Hines Creek fault scarp. Profile A, from the lower terrace east of the Parks Highway (Figure 7), crosses a potentially complex surface that may have experienced some deposition and erosion during the formation of the fault scarp, and thus direct measurement of vertical offset is uncertain. Profile B, from the high terrace west of the Parks Highway (Figure 7), has a clear 12 m offset of the terrace surface, and the parallel surface on either side supports our interpretation that surface offset during earthquakes is concentrated across the narrow fault scarp zone.

(4) Physical fault characteristics

The active trace of the Hines Creek fault, as defined in this report, is a near-vertical dip-slip fault. The verticality of the fault in the near surface is demonstrated geomorphically by the linear trace that the fault scarp maps out across topography (Figure 6) and by the Zonge International, Inc. Geophysical Report. A particular advantage of the geophysical interpretations of the fault plane at depth is that it allows the resolution that the fault has a slight dip to the north. Therefore, with the north side of the fault moving up relative to the south, and the fault hanging-wall on the north side, this is a reverse fault. The occurrence of numerous geomorphic piercing points on the oldest offset surface that show no systematic or measureable lateral displacement (Figure 7) demonstrates that the fault is characterized by pure dip-slip displacement since at least the late Pleistocene.

Coseismic deformation associated with the Hines Creek fault appears to be confined to a narrow zone along the fault scarp through this study area (Figure 7). Across the upper terrace surface, the deformation associated with the fault scarp ranges from a width of 25 to 75 m. This fault-related deformation is confined to a narrow zone of 10 to 25 m along the fault scarp on the lower terrace surface

(5) Additional site-specific seismic behavior

Not applicable.

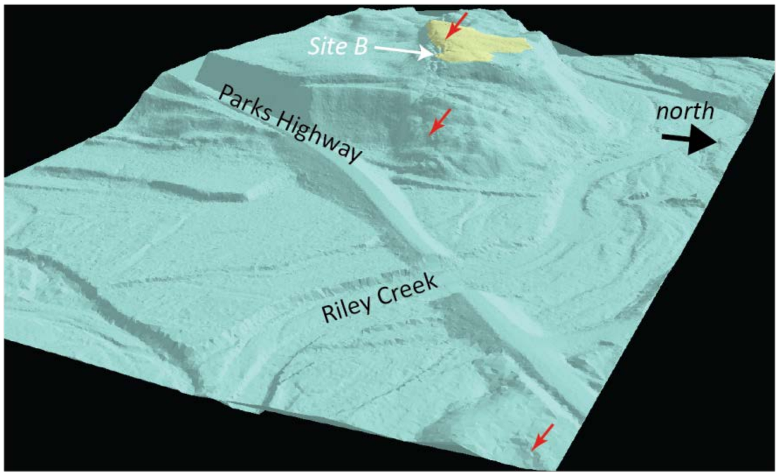

Figure 6. Oblique view to the southwest along the Hines Creek fault scarp. Red arrows highlight the fault trace and illustrate the linear trace of the fault across significant topographic relief, providing evidence for a near-vertical fault dip.

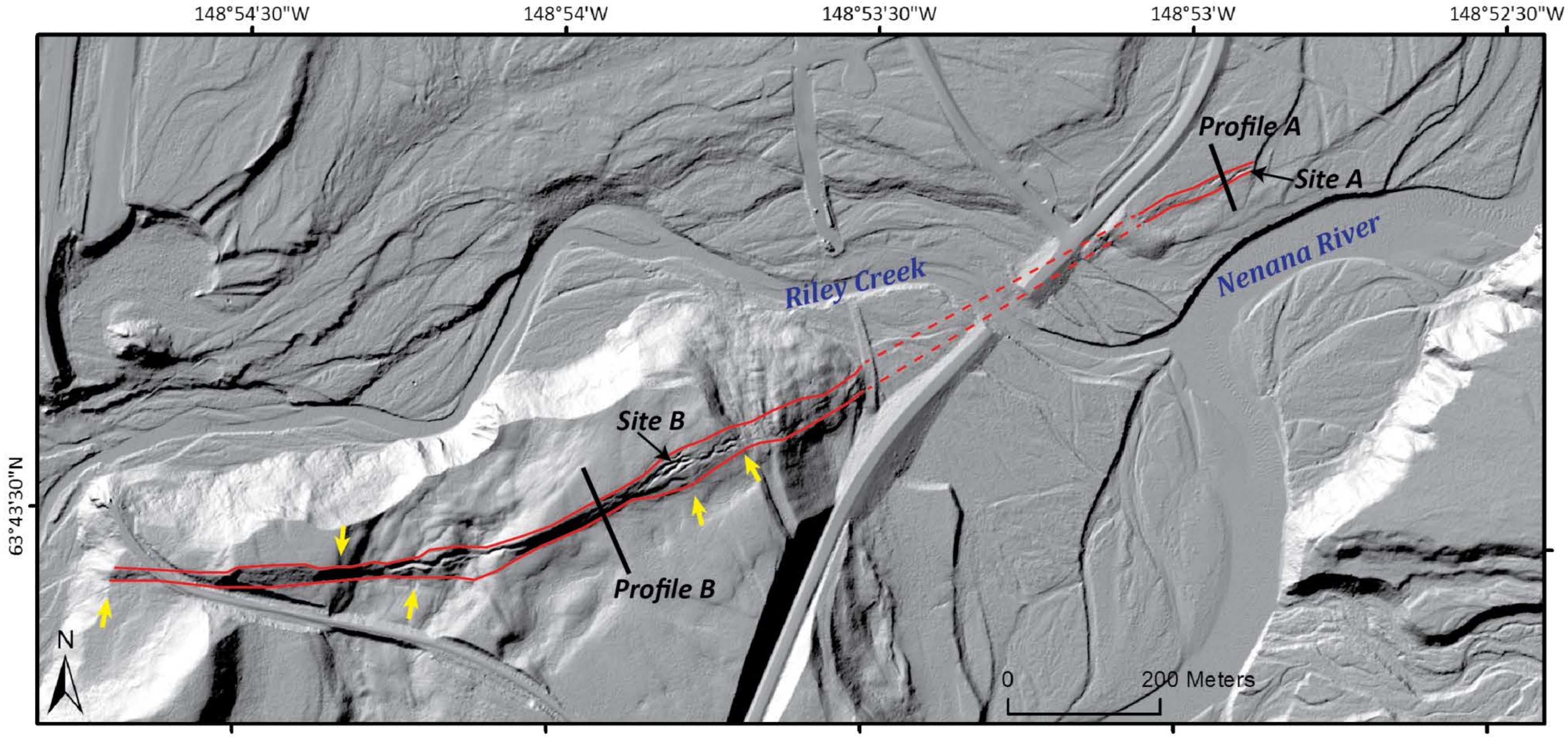

Figure 7. High-resolution shaded-relief topography of the Hines Creek fault scarp across the upper terrace surface west of the Parks Highway and low terraces to the east. Yellow arrows highlight some of the linear geomorphic features that project across the fault scarp without displaying lateral offset, demonstrating this fault is purely dip-slip since the late Pleistocene. The solid red lines depict the width of the primary deformed zone along the fault scarp- essentially where discrete offset is concentrated during earthquakes. Topographic profiles in Figure 5 are shown as Profile A and B, with nearby paleoseismic sites A and B shown for reference.

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Appendix A: Radiocarbon Data

Table A1. Results of radiocarbon analyses

Lab Name	^{14}C Age (BP)	Calibrated age interval (cal BP)	Calibrated age interval (cal AD)	Sample Material	Sampled Unit	Relevance
T2-1	1173±26	1175-998	776-952	Charcoal	OS2	
T2-2	1110±30	1071-937	880-1014	Charcoal	OS2	
T2-3	1250±30	1274-1081	676-870	Charcoal	OS2	
T2-4	1005±27	968-800	982-1150	Charcoal	OS2	
T2-5	817±28	779-684	1171-1267	Charcoal	A1	
T2-6	1285±28	1285-1175	666-776	Wood	SCZ2	Min age of event 2, max age of event 3
T2-7	1360±28	1333-1188	617-763	Wood	A4	
T2-8	1603±25	1541-1414	410-537	Charcoal	NCZ2	Max age of event 1
T2-10	921±23	919-783	1031-1168	Charcoal	OS2	
T2-12	1475±27	1404-1309	547-641	Wood	SCZ1	Max age of event 2
T2-13	1228±24	1258-1070	692-880	Wood	OS2	
T3-1	1136±31	1169-965	782-986	Charcoal	Ba1	Possible max age of event 5/most recent event
T3-2	835±26	789-690	1161-1260	Wood	Ba1	
T3-3	1208±25	1234-1060	716-890	Wood	Ba1	Possible max age of event 5/most recent event
T4-1	902±23	910-741	1040-1210	Charcoal	Bb1	
T4-2	2188±24	2310-2127	-359- -176	Charcoal	Bb4	

Basic sample cleaning and separation was conducted by Sara Federschmidt at the University of Kentucky, with sample chemical pretreatment and AMS measurements performed by DirectAMS. Oxcal 4.1 was used to calibrate radiocarbon ages. Calibrated ages denoted as cal BP (calibrated years before 1950) and cal AD (calendar years).

Appendix B: Paleoseismic Trench Logs and Interpretations

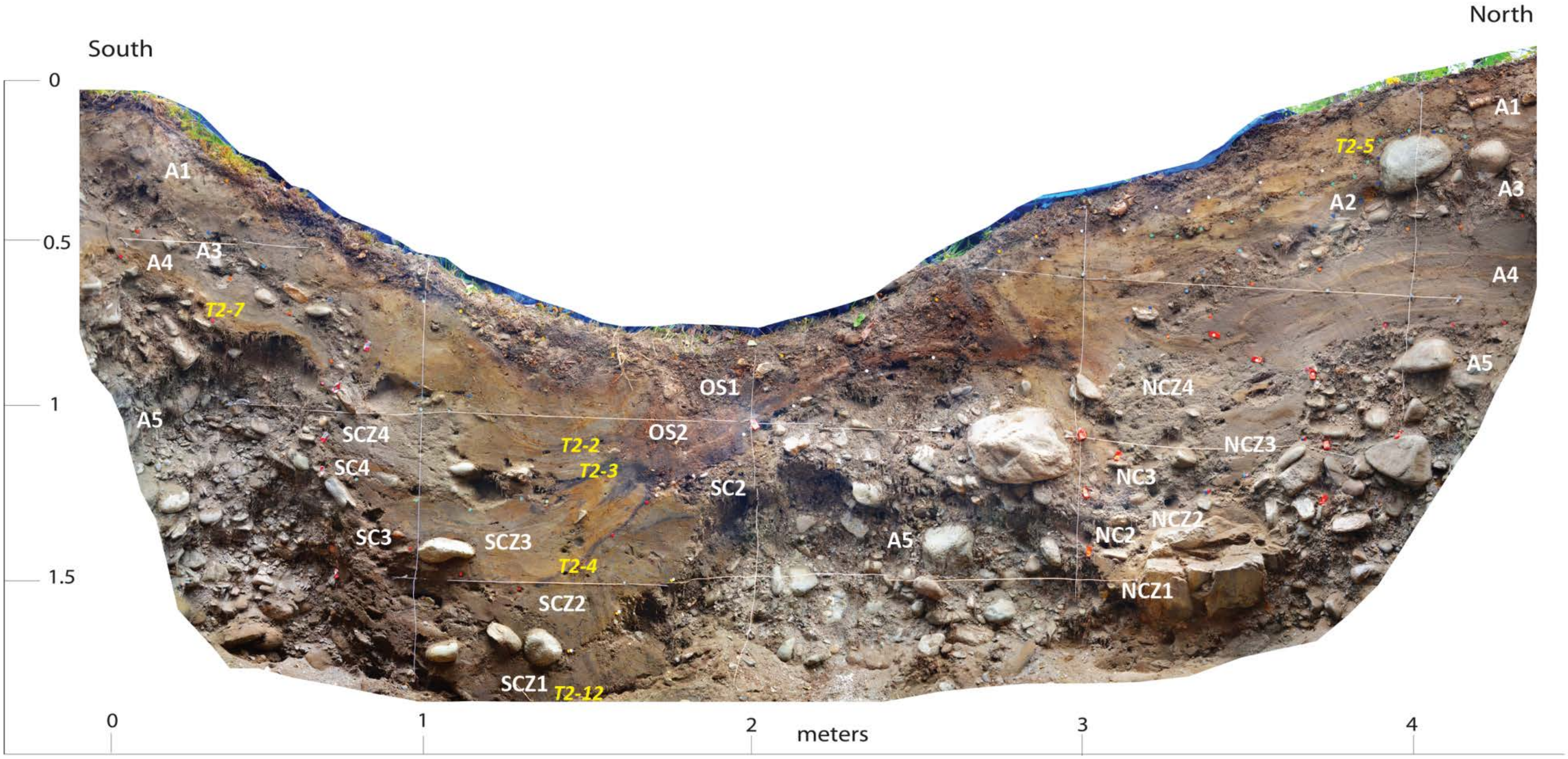

Figure B1. Photomosaic of the east wall of trench 2 (Site A) across the Hines Creek fault, reversed to imitate the same orientation of the west wall (Figures B3 and B4). White labels define lithostratigraphic units (unit descriptions in Table B1) and yellow labels identify locations of dated radiocarbon samples (age data in Table A1).

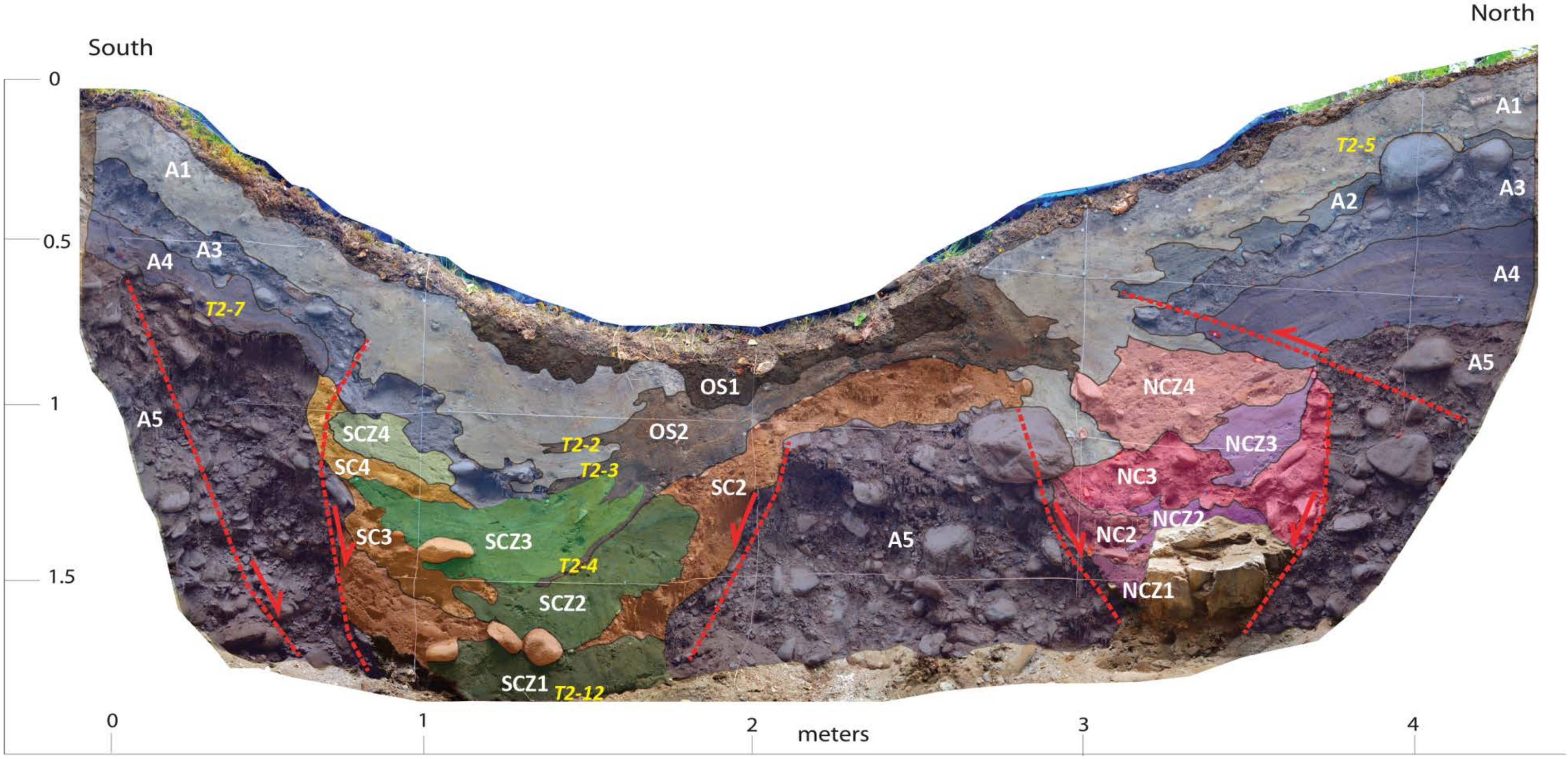

Figure B2. Photomosaic and trench log of the east wall of trench 2 (Site A) across the Hines Creek fault, reversed to imitate the same orientation of the west wall (Figures B3 and B4). Transparent overlay illustrates the interpretation of geologic units and deformation preserved within the trench stratigraphy. All labels in the same position at Figure B1. Red lines indicate locations of faults and shear zones, and arrows depict relative displacement. Much of the discrete displacement in the stratigraphy appears to have occurred as distributed zones of sheared and rotated gravel.

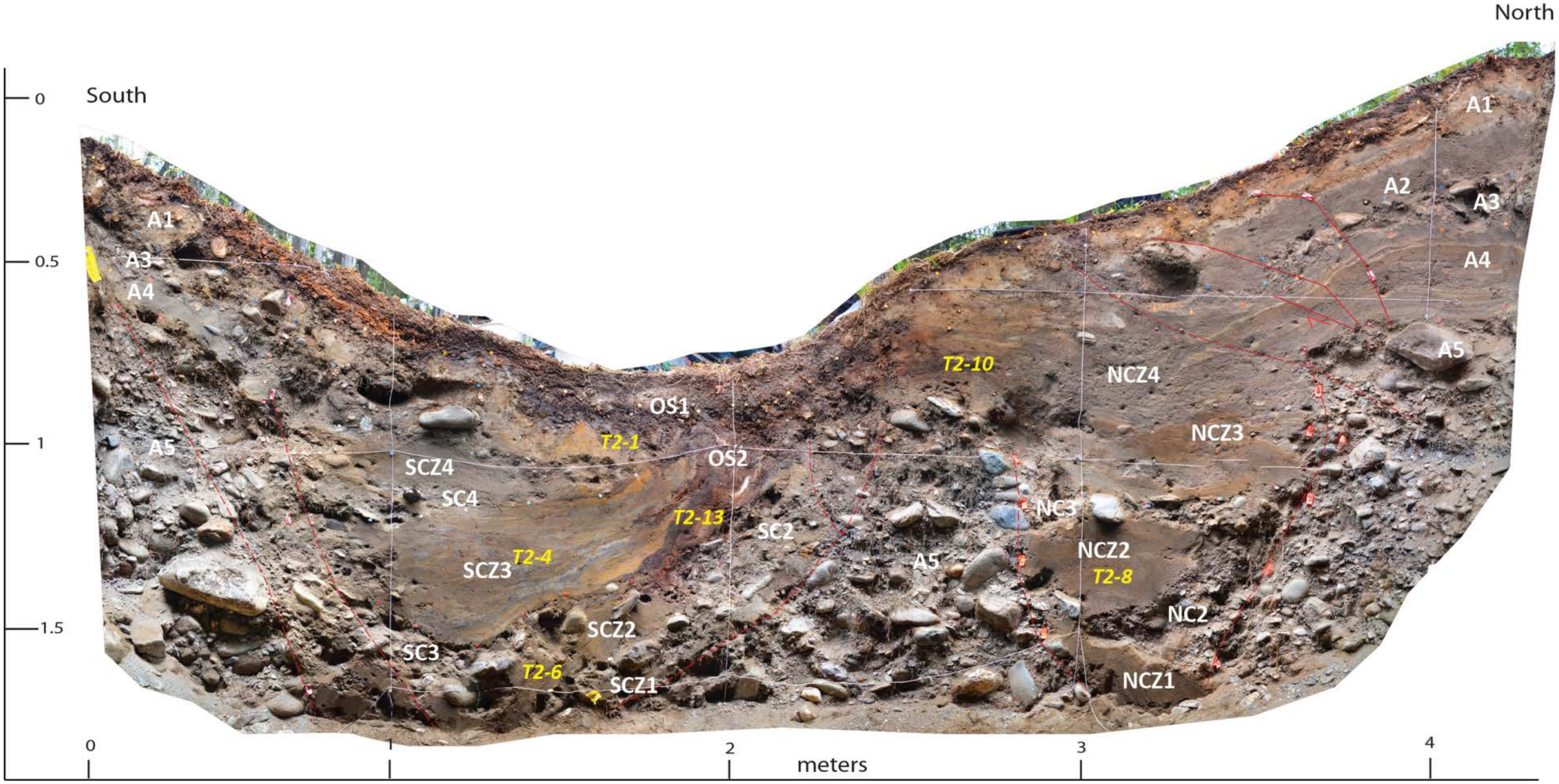

Figure B3. Photomosaic of the west wall of trench 2 (Site A) across the Hines Creek fault. White labels define lithostratigraphic units (unit descriptions in Table B1) and yellow labels identify locations of dated radiocarbon samples (age data in Table A1).

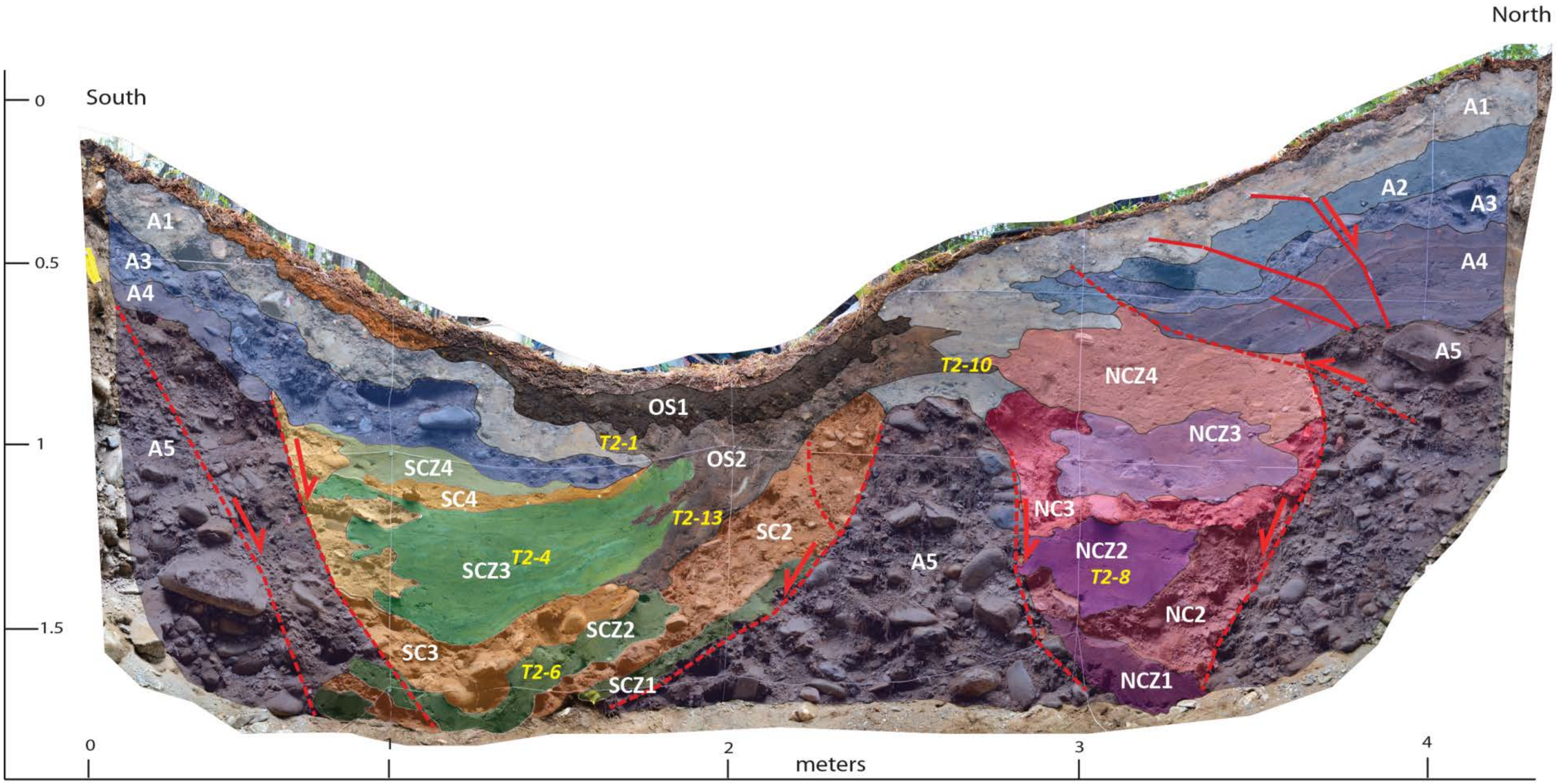

Figure B4. Photomosaic and trench log of the west wall of trench 2 (Site A) across the Hines Creek fault. Transparent overlay illustrates the interpretation of geologic units and deformation preserved within the trench stratigraphy. All labels in the same position at Figure B3. Red lines indicate locations of faults and shear zones, and arrows depict relative displacement. Much of the discrete displacement in the stratigraphy appears to have occurred as distributed zones of sheared and rotated gravel.

Table B1. Unit Descriptions from Site A, Trench 2.

*Unit Label	Descriptive Name	Dominant Grain Size	Matrix/Clast Supported	Comments	Event Relevance	Unit Age (cal BP)
A1	Sandy silt	Silt	n/a	Fine grained sand and silt layers with small pebbly lens	n/d	~700
A2	Fluvial sands	Coarse sand	n/a	Well sorted, only seen on north side	n/d	Between 700 - 1250
A3	Fluvial sands and cobbles	Coarse sand	Matrix	Fine to coarse sand, cobbles up to 8 inches	n/d	Between 700 - 1250
A4	Bedded fluvial silts and sands	Fine sand	n/a	Interbedded silts and sands, drastically thicker on the north, organics run through silt layers	n/d	~1250
A5	Terrace gravels	Cobbles	Clast	Clear contact with above silts and sand, broken by two rupture areas	n/d	>1500
OS1	Organic-rich silt	Silt	n/a	Roots present, dark grey/black organics	n/d	< 700
OS2	Organic-rich silt	Silt	n/a	Brown to grey organics, charcoal present, strands break off into ruptured areas, white silt pockets (volcanic ash?)	n/d	700 - 1200
NCZ1	Coarse sand	Coarse sand	n/a	Noticeably more worked over than above collapse zones, scattered pebbles	n/d	
NCZ2	Pebbly sand	Fine sand	n/a	Fine sand with packets of coarse sands and scattered pebbles	Max age for event 1	~1500
NCZ3	Silty sand	Fine sand	n/a	Silty sand with packets of well-sorted silt, some cobbles	n/d	
NCZ4	Pebbly sand with silt pockets	Coarse sand	n/a	Mixed sands, silt packets up to 15cm, scattered cobbles, contact with A1 difficult to distinguish	n/d	
NC2	Sandy gravels	Cobbles	Clast	Increasingly sandy towards the bottom, mostly large pebbles, some cobbles	n/d	
NC3	Pebbly sand	Coarse sand	n/a	Mixed sands and gravels, less terrace gravel than older colluvial wedge (NC2)	n/d	
SCZ1	Coarse sand	Coarse sand	n/a	Predominantly sands, scattered pebbles	Max age for event 2	~1350
SCZ2	Pebbly sand	Coarse sand	n/a	Mixed sand with minor organic stringers, sands are slightly darker in color than sands in younger collapse packages	Min age for event 2, max age for event 3	~1200
SCZ3	Massive silty sand	Fine sand	n/a	Bedding still noticeable, grey silt contains small pieces of charcoal	n/d	
SCZ4	Silty sand	Fine sand	n/a	Light grey sand and silt, very small amount of silt well mixed with the sand	n/d	
SC2	Sandy gravels	Coarse sand	Matrix	Predominantly coarse sand with small cobbles found throughout, shear zone present at top of layer	n/d	
SC3	Sand with cobbles	Fine sand	Matrix	Massive cobbles supported by matrix of fine sands, some organic-rich silt present	n/d	
SC4	Pebbly sand	Coarse sand	n/a	Mixed sands with packets of coarse sands	n/d	

Note: n/a= not applicable, n/d= no data

***CZ in the unit name designates a unit that has been defined as a collapse zone, C in the unit name designates a unit that has been defined as a colluvial wedge**

Figure B5. Photomosaic of the west wall of trench 3 (Site B) across a portion of the Hines Creek fault scarp. White labels define lithostratigraphic units (unit descriptions in Table B1) and yellow labels identify locations of dated radiocarbon samples (age data in Table A1). The significantly lower proportion of fine-grained deposits in this trench relative to trench 2 provides fewer stratigraphic markers for use in the interpretation of the structure and deformation.

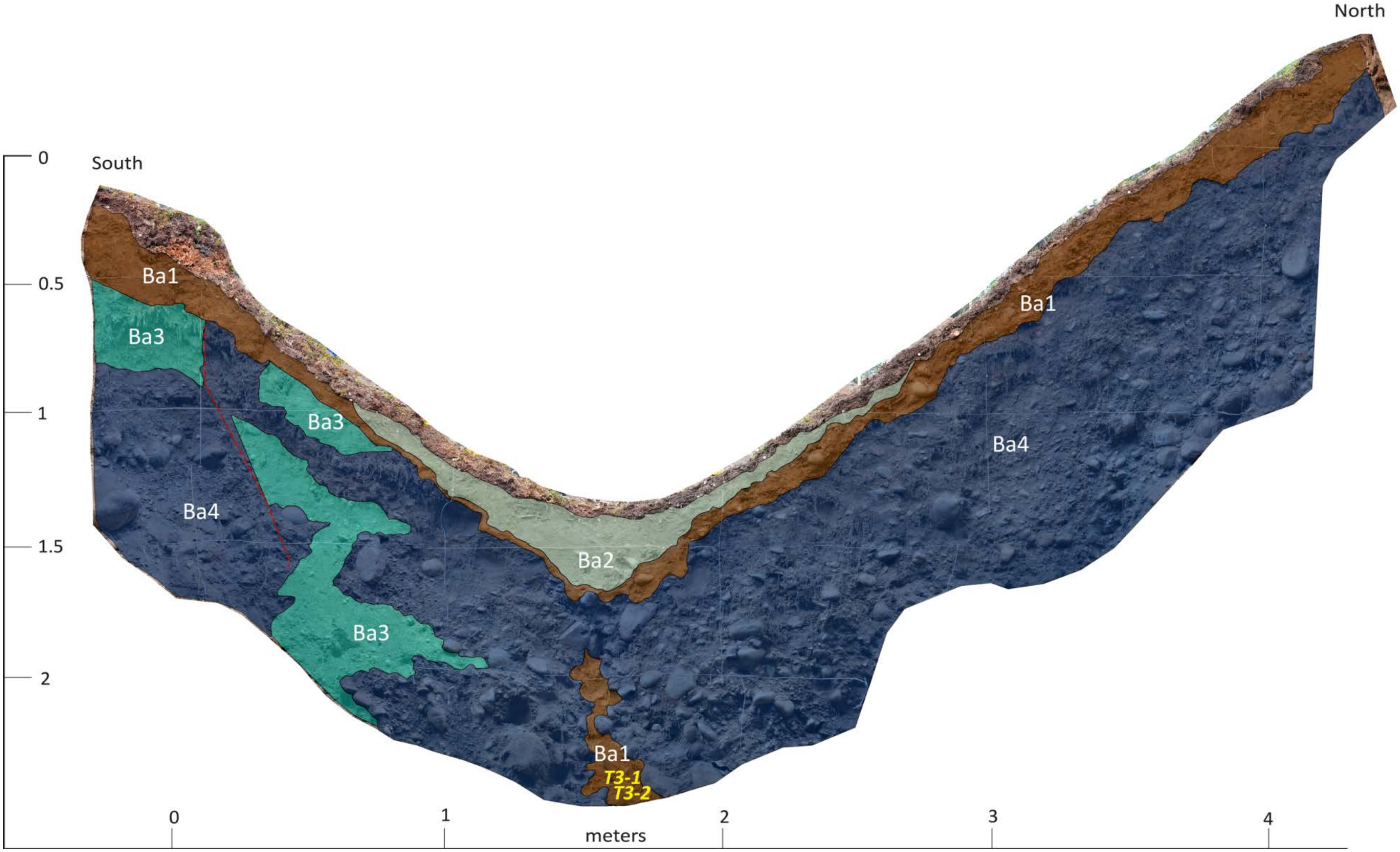

Figure B6. Photomosaic and trench log of the west wall of trench 3 (Site B) across a portion of the Hines Creek fault scarp. White labels and transparent polygons define lithostratigraphic units (unit descriptions in Table B1) and yellow labels identify locations of dated radiocarbon samples (age data in Table A1). Red lines indicate locations of faults and shear zones, and arrows depict relative displacement. The significantly lower proportion of fine-grained deposits in this trench relative to trench 2 provides fewer stratigraphic markers for use in the interpretation of the structure and deformation.

Table B2. Unit Descriptions from Site B, Trench 3

Unit Label	Descriptive Name	Dominant Grain Size	Matrix/Clast Supported	Comments	Event Relevance	Unit Age
Ba1	Recent loess	Silt	n/a	Deformed into vertical strip in center of trench, organic strand through middle of vertical silt	Possible max age of event 5/most recent event	~1100
Ba2	Fluvial sand	Very coarse sand	n/a	Predominantly coarse sands, silt strips cut through on west side, scattered cobbles	n/d	
Ba3	Fluvial sand	Very coarse sand	n/a	Very coarse, loose sand, scattered pebbles, deformed	n/d	
Ba4	Terrace gravel	Gravel	matrix	Poorly sorted coarse sands, gravels, and cobbles	n/d	
Note: n/a= not applicable, n/d= no data						

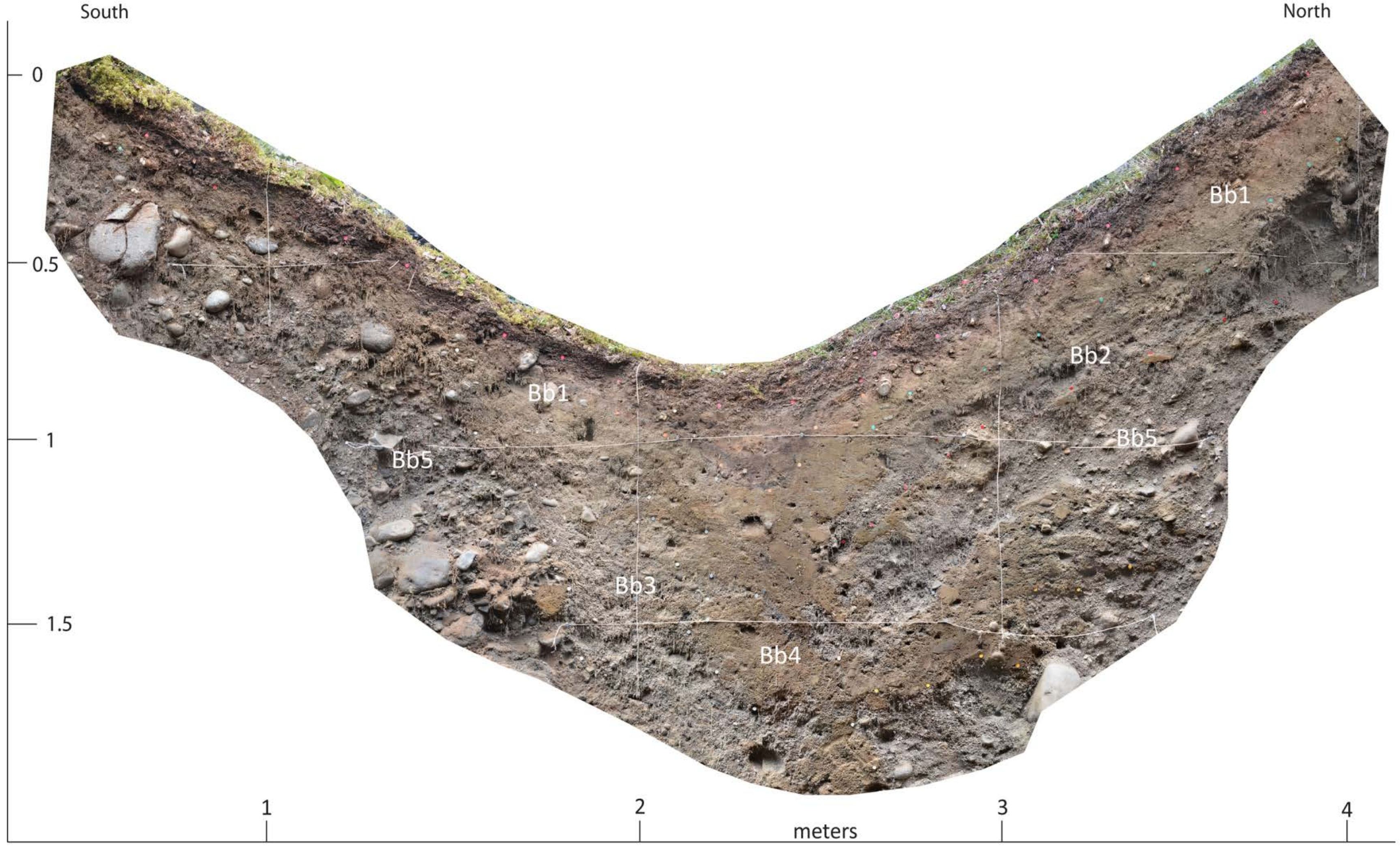

Figure B7. Photomosaic of the west wall of trench 3 (Site B) across a portion of the Hines Creek fault scarp. White labels define lithostratigraphic units (unit descriptions in Table B1). The significantly lower proportion of fine-grained deposits in this trench relative to trench 2 provides fewer stratigraphic markers for use in the interpretation of the structure and deformation.

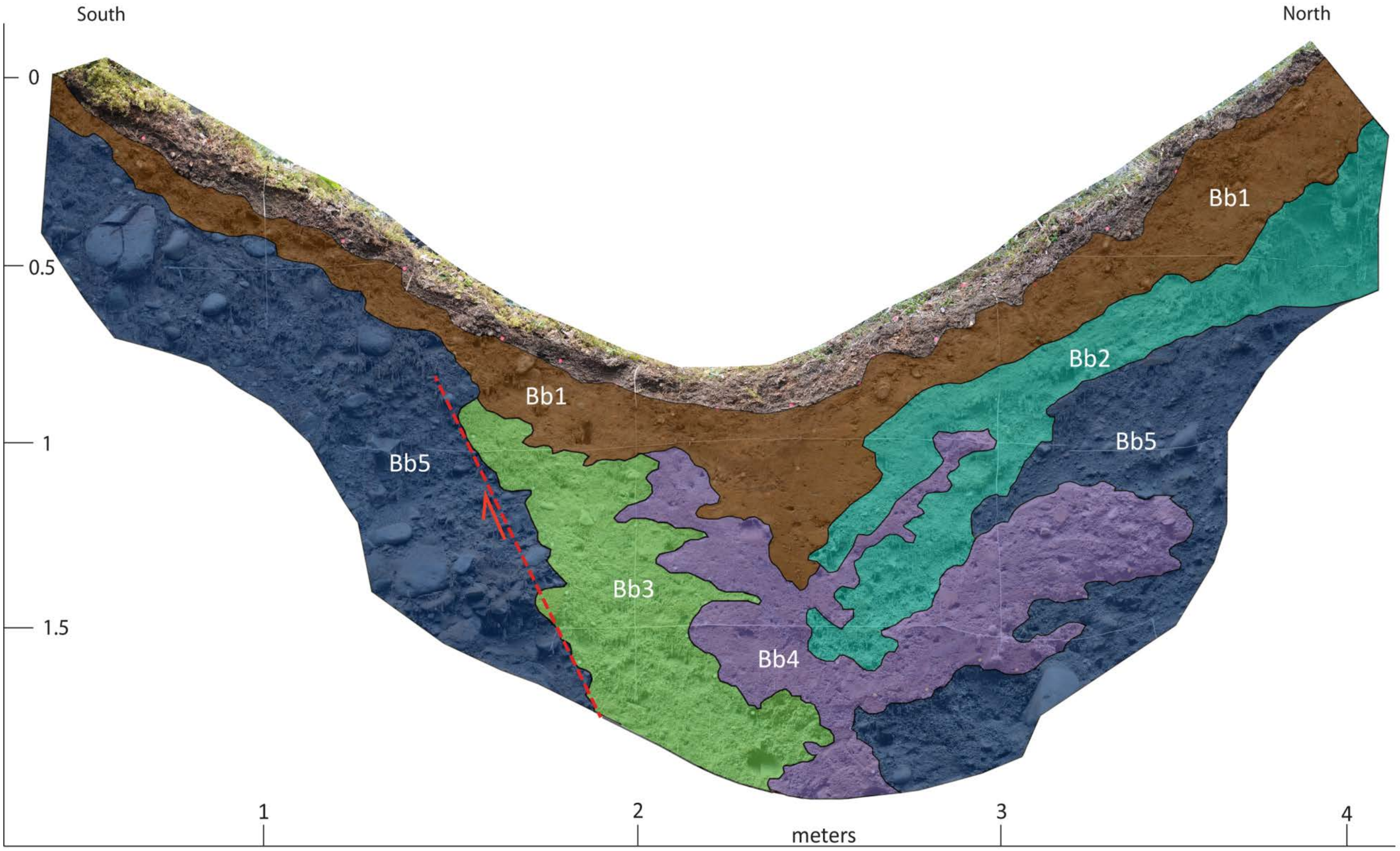

Figure B8. Photomosaic and trench log of the west wall of trench 4 (Site B) across a portion of the Hines Creek fault scarp. White labels and transparent polygons define lithostratigraphic units (unit descriptions in Table B1). Red lines indicate locations of faults and shear zones, and arrows depict relative displacement. The significantly lower proportion of fine-grained deposits in this trench relative to trench 2 provides fewer stratigraphic markers for use in the interpretation of the structure and deformation.

Table B3. Unit Descriptions from Site B, Trench 4.

Unit Label	Descriptive Name	Dominant Grain Size	Matrix/Clast Supported	Comments	Event Relevance	Unit Age
Bb1	Recent loess	Silt	n/a	Thicker on the north, some charcoal present, scattered small cobbles, light grey to light brown	Possible max age of event 5/most recent event	~1100
Bb2	Fluvial sand	Very coarse sand	n/a	Predominantly coarse sands scattered cobbles, contact with Bb4 difficult to distinguish	n/d	
Bb3	Colluvial sands	Very coarse sand	n/a	Very coarse, loose sand, scattered pebbles	n/d	
Bb4	Pebbly sand	Fine sand	n/a	Reworked fine and coarse sands, small cobbles throughout	n/d	
Bb5	Terrace gravel	Gravel	matrix	Poorly sorted coarse sands, gravels, and cobbles	n/d	
Note: n/a= not applicable, n/d= no data						

Table B4. Constraints on the Sequence of Deformational Events

Event #	Constraining Units	Min Age (cal AD)	Max Age (cal AD)	Comments
1	NCZ2 (max)	Event 2	410-537	Difficult to constrain, no datable material in next younger or older collapse zone, possibility of at least one older event
2	SCZ2 (min), SCZ1 (max)	666-776	547-641	Well constrained with dated material and colluvial wedge/collapse zone pairs
3	SCZ2 (max)	n/d	666-776	Possibility of OS2 providing a minimum age, maximum age well constrained
4	SCZ4 (min), SCZ3 (max)	n/d	n/d	Constrained by distinct colluvial wedge and collapse zone pairs, distinct pairs suggest separate events, possibility of north and south collapse zones being correlated, suggesting both rupture zones were active during the same event
5	A1 (min), OS2 (max)	1171-1267 (?)	1031-1168	Max age constrained by the youngest age for OS2. This material is also clearly involved in the deformation. Minimum age is inferred from the Age of unit A1. This constraint is uncertain due to several small displacements terminating upwards into A1, thus we cannot directly relate the min age to indisputably undeformed A1.
Note: n/d= no data				

RILEY CREEK IN-SITU SAMPLE TEST REPORT

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ABSTRACT

AKDOT&PF is planning to replace the existing Riley Creek Bridge with a new bridge. Site investigation indicates that there is a clay layer which is roughly 10 to 30 feet below the abutment 3 of existing Riley Creek Bridge. Previous geologic history would suggest that the clay layer should be moderately to highly overconsolidated. However, available laboratory test results do not corroborate this interpretation. Research is needed to further understand the stress-strain behavior of the clay soils. This lab test program determines the mechanical and physical properties of the soil specimens obtained from the Riley Creek Bridge project site.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX

CHAPTER 1 INTRODUCTION

1.1 Introduction

AKDOT&PF is planning to replace the existing Riley Creek Bridge with a new bridge. Site investigation indicates that there is a clay layer which is roughly 10 to 30 feet below the abutment 3 of existing Riley Creek Bridge. Previous geologic history would suggest that the clay layer should be moderately to highly overconsolidated. However, available laboratory test results do not corroborate this interpretation. Research is needed to further understand the stress-strain behavior of the clay soils.

CHAPTER 2 TEST PROGRAM

2.1 Test Program Introduction

The objective of the lab test program is to determine the mechanical and physical properties of the targeted soil specimens. The classification tests include specific gravity test (9 samples), moisture content test (9 samples), unit weight test (9 samples), Atterberg limits test (9samples) and hydrometer test (9 samples). After that, one dimensional consolidation test (6 samples) is performed to determine the OCR (Over Consolidation Ratio). Then, isotropically consolidated undrained (ICU) test (3 samples) is conducted based on the preconsolidation stress obtained from the consolidation test. Finally, unconsolidated undrained (UU Test) test (3 samples) is completed to verify the test results from ICU test.

2.2 Soil Sample Demolding

Two methods were used to extract the in-situ soil sample. The first method was to use the cutting disc to disintegrate the sample into small sections (7-8 inches) as shown in Figure 2.1. Then the sample was extracted by a hydraulic extruder. However, some disturbance on sample surface was observed after extraction as shown in Figure 2.1. To minimize the disturbance during cutting and extraction, as shown in Figure 2.2, hydraulic extruder in Shannon & Wilson Inc. was utilized to extract the soil samples. As shown in Figure 2.2, no obvious disturbance on sample surface was observed after extraction.

Figure 2.1 Soil Sample Extraction with Cutting Disc

Figure 2.2 Soil Sample Extraction with Hydraulic Extruder

Table 2.1 presents the in-situ identification numbers for all tubes and their extraction methods.

Table 2.1 Summarized In-situ Samples and Extraction Methods

Test Hole	Tube ID	Depth (ft)	Extraction Method
TH14-01	FS-91	12-13.5	Cutting Disc
TH14-01	FS-92	17-19.5	Cutting Disc
TH14-01	FS-93	22-24	Cutting Disc

TH14-01	FS-94	27-29.2	Cutting Disc
TH14-01	FS-95	32-34.5	Cutting Disc
TH14-01	FS-96	37-39.5	Cutting Disc
TH14-02	FS-86	10-12	Cutting Disc
TH14-02	FS-87	20-21.2	Cutting Disc
TH14-02	FS-88	25-25.75	Hydraulic Extruder
TH14-02	FS-89	30-31.5	Hydraulic Extruder
TH14-02	FS-90	35-36.5	Hydraulic Extruder
TH14-03	FS-82	15-17	Hydraulic Extruder
TH14-03	FS-83	20-22	Hydraulic Extruder
TH14-03	FS-84	25-27	Hydraulic Extruder
TH14-03	FS-85	30-32.5	Hydraulic Extruder

After extraction, some fundamental tests were performed first to determine soil water content, unit weight, Atterberg limits, specific gravity, and gradation curve. Before testing, soil sample was oven-dried to a constant mass. Then, soil passed a No.40 sieve, as shown in Figure 2.3, before being used for testing. A rubber hammer was used to powdering soil clods.

Figure 2.3 Soil sieving

2.3 Atterberg Limits

Water content was first determined based on ASTM D 4643-00 (Determination of Water Content of Soil by the Microwave Oven Heating), as shown in Figure 1.4. The sample was first divided into 9 pieces and the middle piece was used to determine the water content. Then, Atterberg limits were determined according to ASTM D 4318-00 (Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils) as shown in Figure 2.5 for liquid limit and Figure 2.6 for plastic limit, respectively. Calibrate the liquid limit device before performing the test, the height of the drop of the cup was adjusted so that the cup was raised to a height of 10 mm. Then, several trials with different water content were conducted to adjust the samples water content until the constancy required about 25 to 35 blows of the liquid limit device to close the groove. A minimum of 3 trials were conducted and based on the regression analysis of the water content of each trial, the liquid limit of the soil sample is the water content corresponding to 25 blow counts.

Then select about 20 g of soil sample to determine the plastic limit. Mix the sample with water until a consistency at which it can be rolled without sticking to the hands. Roll the mass between the palm and the ground-glass plate with just sufficient pressure to roll the mass in to a thread of uniform diameter throughout its length. The thread shall be further deformed on each stroke so that its diameter reaches 3.2 mm (0.125 in), taking no more than 2 min. finally, measure the water content of the soil sample.

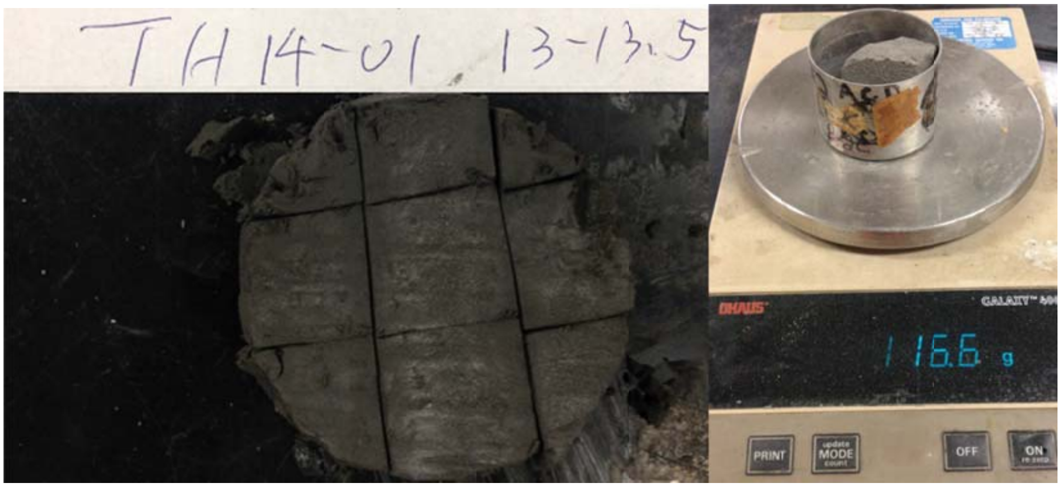


Figure 2.4 Water Content

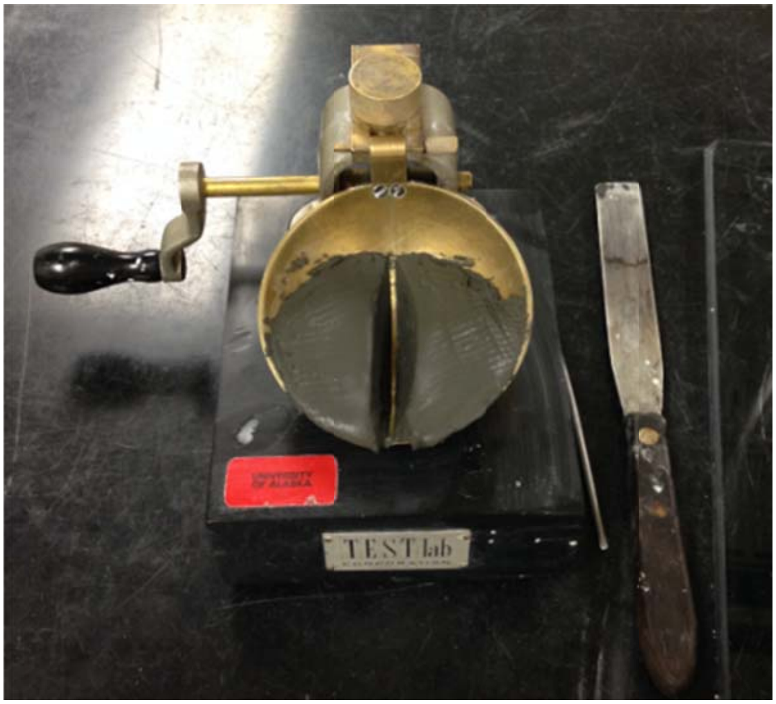


Figure 2.5 Liquid Limit

Figure 2.6 Plastic Limit

2.4 Gradation Curves

Since all the soil samples have passed No. 40 sieve, only hydrometer tests were conducted to determine the gradation curves for the soil samples from different tubes, as shown in Figure 2.7, according to ASTM D422-63 (Standard Test Method for Particle-Size Analysis of Soils).

First, the hydrometer reading correction was conducted. Prepare 1000 ml of liquid composed of distilled water and dispersing agent (sodium hexametaphosphate, 40 g/L) in the same proportion as will prevail in the sedimentation test. When the temperature of the liquid became constant, insert the hydrometer and record the reading. Since hydrometer 151H was used, the composite correction is the difference between this reading and one.

Second, measure 50 g of tested sample and place it in the 250 ml beaker with 125 ml of sodium hexametaphosphate solution. Stir the soil slurry until thoroughly wetted and at least 16 hours were allowed for it to soak.

After dispersion, transfer the soil slurry to the glass sedimentation cylinder and add distilled water until total volume was 1000 ml. Use the palm of the hand over the open end of the cylinder upside down for a period of 1 min to complete the agitation of the slurry. At the end of 1 min set the cylinder in a convenient located and take the hydrometer readings at the following intervals of time: 2, 5, 15, 30, 60, 250, 1440 min.

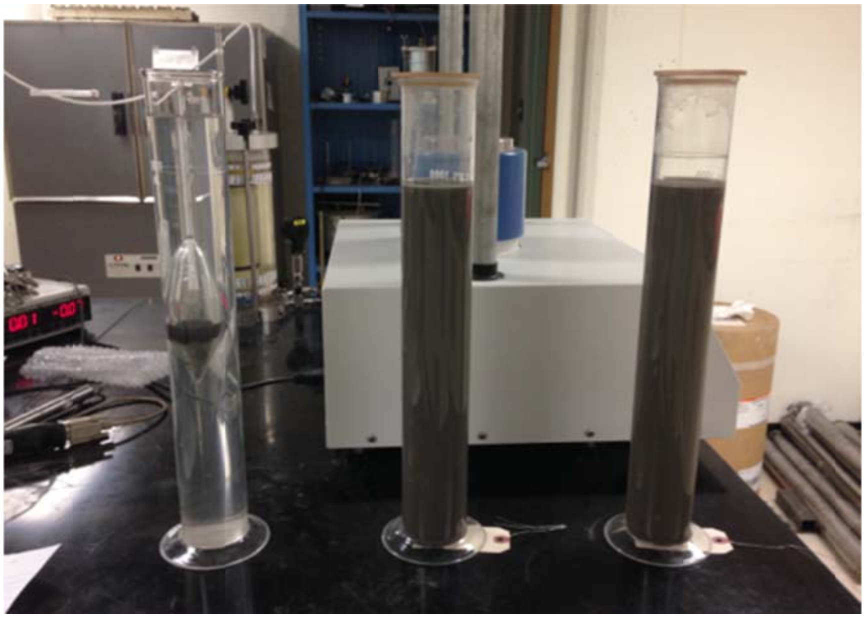


Figure 2.7 Hydrometer Tests

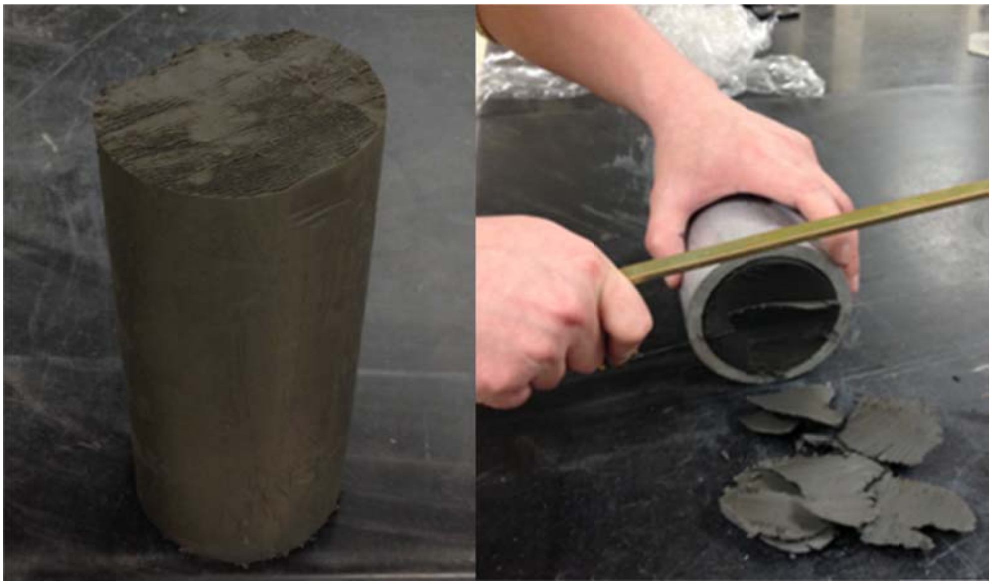
2.5 Specific Gravity

Soil specific gravity of the in-situ soil sample was determined according to ASTM D 854-00 (Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer) as shown in Figure 2.8. Before conducting the test, the pycnometer was calibrated. Then determine the mass of the pycnometer, verify that the mass of pycnometer is within 0.06 g of the average calibrated mass. Measure 50 g soil sample and add water until the water level is between 1/3 and 1/2 of the depth of the main body of the pycnometer. And add water to the pycnometer to the 500 ml mark then measure the mass of the water and pycnometer. Measure 50 g of the oven dried soil sample and add distilled water. Agitate the water until slurry is formed. Rinse any soil adhering to the pycnometer into the slurry. After that, deair the water with a vacuum and the pycnometer was continually agitated under vacuum for at least 2 hours. Continually agitated means the soil solid will remain in suspension and the slurry is in constant motion. The vacuum must remain relative constant and be sufficient to cause bubbling at the beginning of the deairing process. Finally, fill the pycnometer with deaired water to the 500 ml mark. Measure and record the mass of the pycnometer, soil and water to the nearest 0.01 g using the same balance used for pycnometer calibration. Measure and record the temperature of the soil slurry to the nearest 0.1ºC.

Figure 2.8 Specific Gravity

2.6 Unconsolidated Undrained Triaxial Test

The unconsolidated undrained triaxial test was performed according to ASTM D2166 (Standard Test Method for Unconfined Compressive Strength of Cohesive Soil). To perform the unconsolidated undrained triaxial test, in-situ soil sample as shown in Figure 2.9a was cut into 142 mm in height and 71 mm in diameter cylinder using a wire saw as shown in Figure 2.9b. The mass of the wet sample was determined right after the sampling to accurately determine its water content before testing.



(a) Sample after extraction (b) Sampling

Figure 2.9 Sampling for Unconsolidated Undrained Test

Then, the sample was mounted into the triaxial cell as shown in Figure 2.10. The triaxial cell was filled up with water. Then, de-aired water was utilized to saturate he soil sample through back pressure with help of the triaxial test control panel. In this test, a back pressure of 500 kPa was applied to saturate the sample with a net confining pressure of 35 kPa (i.e., water pressure in the triaxial cell was 535 kPa).

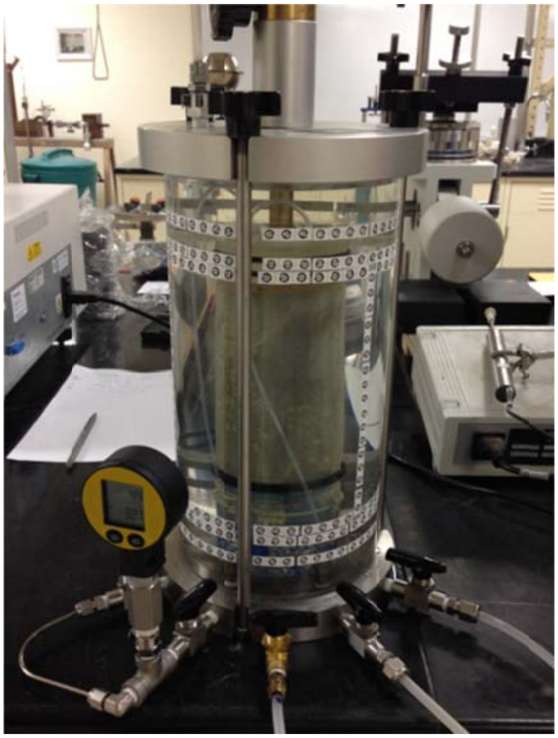


Figure 2.10 Testing Sample Saturation

After saturation, which could be checked by B-value (B>0.95 indicated saturation), the saturated soil sample was sheared with a loading rate of 1 mm/min as shown in Figure 2.11. During this process, the pore water pressure inside the soil sample was recorded by the pressure meter as shown in Figure 2.11. Also, the applied axial load was recorded to determine soil strength properties. Shearing was stopped when reached the 15% axial strain.

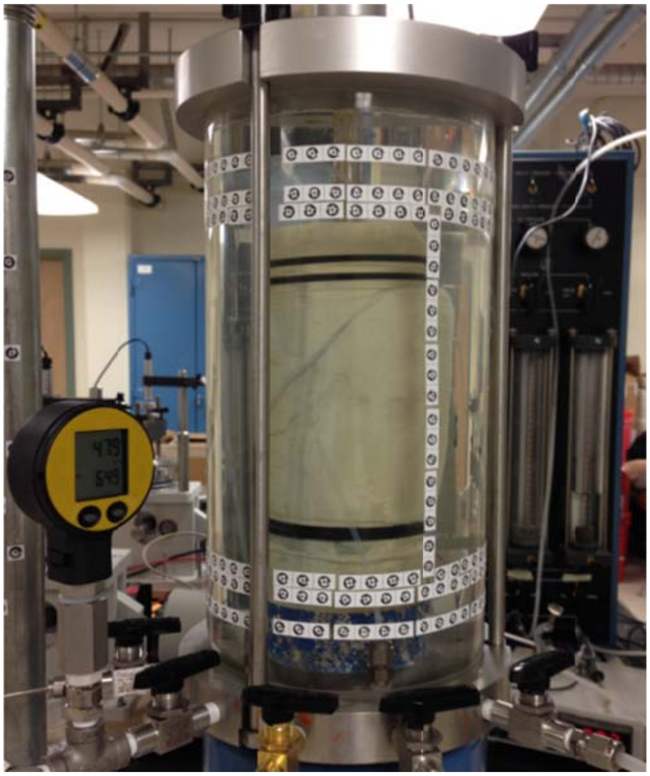


Figure 2.11 Unconsolidated Undrained Test

After shearing, triaxial cell was disassembled and soil sample was extracted for water content determination. In order to prevent water absorption, the disassembling process was performed under undrained condition. Figure 2.12 shows pictures of three soil samples after oven-dried. After oven drying, data analysis was performed to determine the corresponding shear strength of the tested soil sample. Also, comparisons were made on soil water content, void ratio, and unit weight variations before and after the unconsolidated undrained triaxial test.

Figure 2.12 Samples after Unconsolidated Undrained Test

2.7 One-Dimensional Consolidation Test

The consolidation test was performed according to ASTM D2435 (Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading). In the test, a soil specimen was restrained laterally and loaded axially with total stress increments. Each stress increment was maintained until excess pore water pressures were essentially dissipated. Pore water pressure was assumed to be dissipated based on interpretation of the time deformation under constant total stress. Measurements were made of change in the specimen height and these data were used to determine the relationship between the effective axial stress and void ratio. When time deformation readings were taken throughout an increment, the rate of consolidation is evaluated with the coefficient of consolidation.

The diameter and height of the specimen ring were 2.5 in (63.5 mm) and 1.0 in (25.4 mm), as shown in Figure 2.13(a). First, determine the mass of the ring and trim the specimen and insert it into the consolidation ring. The specimen must fit tightly in the ring without any perimeter gaps. Then determine the mass of the specimen ring and wet soil sample. Assemble the ring with specimen, porous disk, filter screens in the consolidometer as shown in Figure 2.13(b). Add water into the consolidometer to keep the soil sample saturated. Then put the consolidometer on the lab bench and insert the load holding screw into the block at the channel end from the bottom so that the ball end of the screw will make contact with the bottom of the lever arm when changing to the next higher load. Attach the weight hanger with the ratio position (10:1). Attach the LVDT (with an accuracy of 0.0003 in or 0.01 mm) to the dial indicator support rod to the right of the base. Then screw the counter weight threaded rod into the rear of the lever arm about 1 in and tighten the jam nut. Figure 2.13(c) shows the final setup of the testing system.

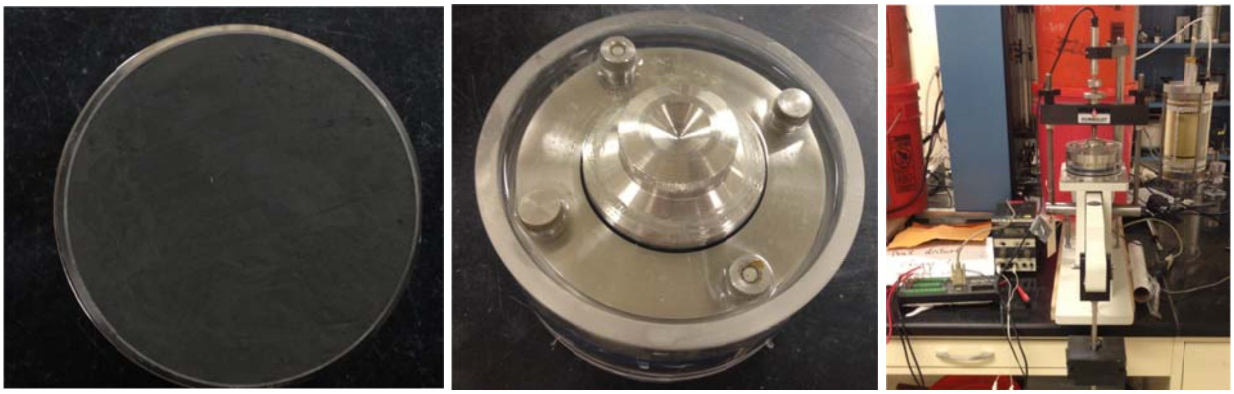

(a) (b) (c)

Figure 2.13 Specimen Ring and Consolidometer for Consolidation Test

The specimen is to be subjected to load increments of constant total axial stress. The standard loading schedule shall consist of a load increment ratio (LIR) of one which is obtained by approximately doubling the total axial stress on the soil. According to the testing plan, the maximum pressure for the soil sample is 500 psi. The loading schedule for each test sample is shown in Table 2.2. Each load increment duration shall be approximately 24 h. record the axial deformation at time intervals of approximately 0.1, 0.25, 0.5, 1, 2, 4, 8, 15, and 30 min, and 1, 2, 4, 8 and 24 h.

Table 2.2 Loading Schedule for Consolidation Test

Test Hole	TH14-03		TH14-03		TH14-03	
Identification	FS-82		FS-83		FS-83	
Depth (ft)	16		21		22	
Day	Stress(psi)	Stress (KPa)	Stress(psi)	Stress (KPa)	Stress(psi)	Stress (KPa)
1	2	12	4	31	4	31
2	4	25	9	62	9	62
3	7	50	18	124	18	124
4	15	100	36	248	36	248
5	29	200	72	495	72	496
6	15	100	36	248	36	248
7	7	50	18	124	18	124
8	15	100	36	248	36	248
9	29	200	72	495	72	496
10	58	400	144	990	144	990
11	116	800	287	1980	287	1980
12	232	1600	508	3500	508	3500
13	508	3500				

2.8 Isotropically Consolidated Undrained Triaxial Test

The isotropically consolidated undrained triaxial tests were performed according to ASTM D4767 (Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils). A total number of five isotropically consolidated undrained triaxial tests for samples from three tubes (FS-82, FS-83, and FS-84) were performed to evaluate the saturated soil behavior under undrained condition. The test setup for the isotropically consolidated undrained triaxial test is consistent with the unconsolidated undrained triaxial test. However, after saturation, the test specimen suffered an isotropically consolidation process. In this test, for samples from different tubes, the applied consolidation stress is the corresponding preconsolidation stress obtained from the one-dimensional consolidation test. Two more isotropically consolidated undrained triaxial tests were performed on samples from tube FS-83 to evaluate saturated soil behavior under different confining pressure levels. After consolidation, specimens were sheared to 15% axial strain under undrained condition. During this process, pore water pressure change in the specimen was recorded by a pressure meter. Specimens from different tubes before and after the triaxial tests are shown in Figure 2.14 and 2.15, respectively.

After oven drying, data analysis was performed to determine the corresponding strength properties. Also, comparisons were made on soil water content, void ratio, and unit weight variations before and after the unconsolidated undrained triaxial test.

For the specimen from tube FS-84 as shown in Figure 2.14, water was observed at the surface of the specimen. Specimen became very weak due to liquefaction during handling process. So, it's required to pay attention on this silt layer, which has great potential to liquefy under vibration, during foundation design.

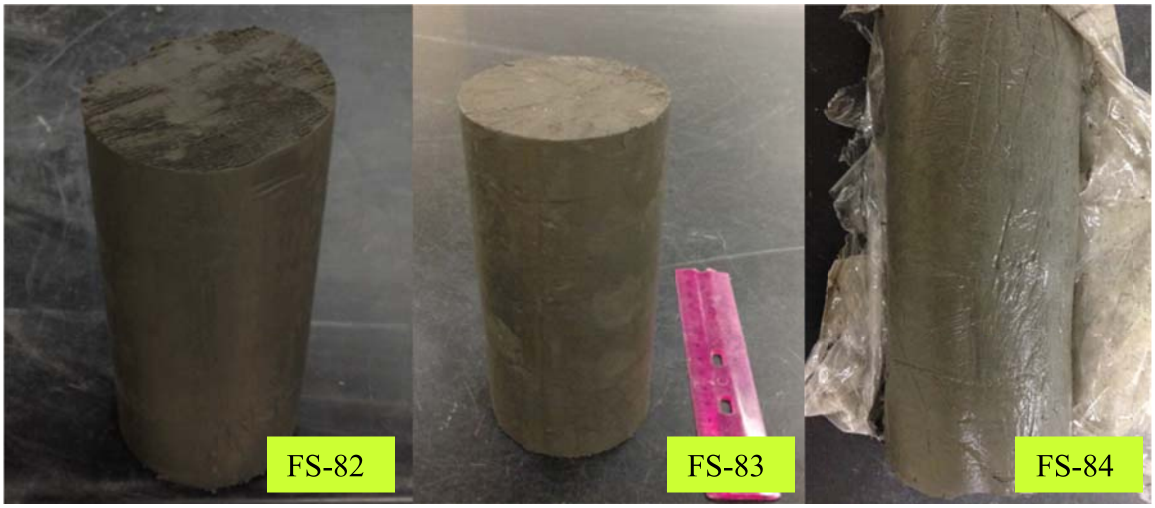


Figure 2.14 Soil Samples before Isotropically Consolidated Undrained Test

Figure 2.15 Samples after Isotropically Consolidated Undrained Test

CHAPTER 3 TEST RESULTS

3.1 Atterberg Limits and Specific Gravity

Atterberg limits and specific gravity tests were performed on in-situ samples from different tubes. Test results are summarized in Table 3.1.

Table 3.1 Summarized Atterberg limits and Specific Gravity Results

Test Hole	Tube ID	Depth (ft)	W_c (%)	Unit Weight (pcf)	PL	LL	PI	USCS Classification	G_s
TH14-02	FS-86	12	22.2	125.85	21.7	33.4	11.7	CL	2.730
TH14-01	FS-91	13	20.7		16.4	20.5	4.1	CL-ML	2.776
TH14-01	FS-92	19.5	26.7	125.85	20.2	29.8	9.6	CL	2.715
TH14-01	FS-93	24	19.6	125.85	19.6	30.7	11.1	CL	2.807
TH14-01	FS-94	29	23.7	126.48	17.6	28.2	10.4	CL	2.760
TH14-01	FS-96	39	22.7		19.4	23.4	4.0	CL-ML	2.745
TH14-03	FS-82	17	25.7	129.95	17.9	26.9	9.0	CL	2.776
TH14-03	FS-83	20-22	26.1	124.43	19.8	31.2	11.4	CL	2.76
TH14-03	FS-84	25-27	20.7	133.42	21.4	20.2	1.2	ML	2.72

3.2 Gradation Curves

In-situ sample gradation curves were determined by Hydrometer tests. Test results are summarized in Table 3.2. Gradation curves are presented in Appendix A.

Table 3.2 Summarized Hydrometer Test Results

TH14-01-13'		TH14-01-19.5'		TH14-01-29'		TH14-01-39'	
Percent	Size (in)	Percent	Size (in)	Percent	Size (in)	Percent	Size (in)
100.00	0.016535	100.00	0.016535	100.00	0.016535	100.00	0.016535
71.91	0.001116	88.65	0.001106	84.67	0.001046	92.81	0.001055
59.40	0.000743	74.40	0.000742	75.26	0.000693	89.66	0.000679
45.33	0.000453	58.57	0.000455	62.72	0.000421	81.80	0.000406
35.95	0.000331	50.66	0.000331	54.25	0.000308	73.93	0.000296
29.70	0.000239	39.58	0.000243	47.04	0.000224	66.07	0.000216
23.45	0.000120	26.91	0.000124	31.99	0.000115	50.34	0.000112
14.07	0.000051	20.58	0.000052	20.38	0.000050	36.18	0.000049
0.00	0.000000	0.00	0.000000	0.00	0.000000	0.00	0.000000

TH14-01-24'		TH14-02-12'		TH14-03-21`		TH14-03-16`	
Percent	Size (in)	Percent	Size (in)	Percent	Size (in)	Percent	Size (in)
100.00	0.016535	100.00	0.016535	100.00	0.016535	100.00	0.016535
92.51	0.001002	92.51	0.001002	90.95	0.004587	87.07	0.004588
87.81	0.000650	87.81	0.000650	84.68	0.001061	66.49	0.001061
75.26	0.000400	78.40	0.000400	76.84	0.000698	56.99	0.000698
65.86	0.000295	72.13	0.000295	65.86	0.000422	39.58	0.000422
56.76	0.000216	63.97	0.000216	58.02	0.000307	33.24	0.000307
43.28	0.000111	47.04	0.000111	48.61	0.000225	26.91	0.000225
31.36	0.000048	32.93	0.000048	36.07	0.000115	15.83	0.000115
0.00	0.000004	0.00	0.000004	20.39	0.000050	3.17	0.000050

TH14-03-27'	
Percent Passing	Size (in)
100.00	0.016535
66.49	0.001061
56.99	0.000698
39.58	0.000422
33.24	0.000307
26.91	0.000225
15.83	0.000116
3.17	0.000051
0.00	0.000004

3.3 Unconsolidated Undrained Strength

Unconsolidated undrained triaxial test were performed on in-situ samples at TH14-01-29’, TH14-01-24’, and TH14-02-12’. Test results are summarized in Table 3.3. As shown in Table 3.2, it could be found that the shear strength of sample TH14-01-29’ is approximately two times of the shear strengths of samples TH14-01-24’ and TH14-02-12’. There are two possible reasons for phenomenon. Firstly, the sample is in layers as clearly shown in Figure 2.12 for sample TH14-02-12’. However, sample TH14-01-29’ was quite uniform as shown in Figure 2.12. Secondly, the samples used for unconsolidated undrained triaxial tests were extracted using cutting disc and extruder which could bring disturbances to the in-situ samples. Based upon three unconsolidated undrained triaxial tests, three Mohr-Column circles were obtained as presented in Figure 3.1. Stress-strain, pore water pressure, and net confining pressure variation curves for three unconsolidated undrained triaxial tests are presented in Appendix B.

Table 3.3 Specimen Information before and after the Unconsolidated Triaxial Test

Sample ID	Unit weight (pcf)		Void ratio		Water content		Shear Strength (psi)
	Before	After	Before	After	Before	After	
TH14-01-29'	2.026	2.02	0.699	0.704	24.6%	25.5%	10.73
TH14-01-24'	2.016	1.99	0.773	0.792	27.3%	28.2%	4.87
TH14-02-12'	2.016	1.97	0.722	0.758	27.1%	27.8%	5.74

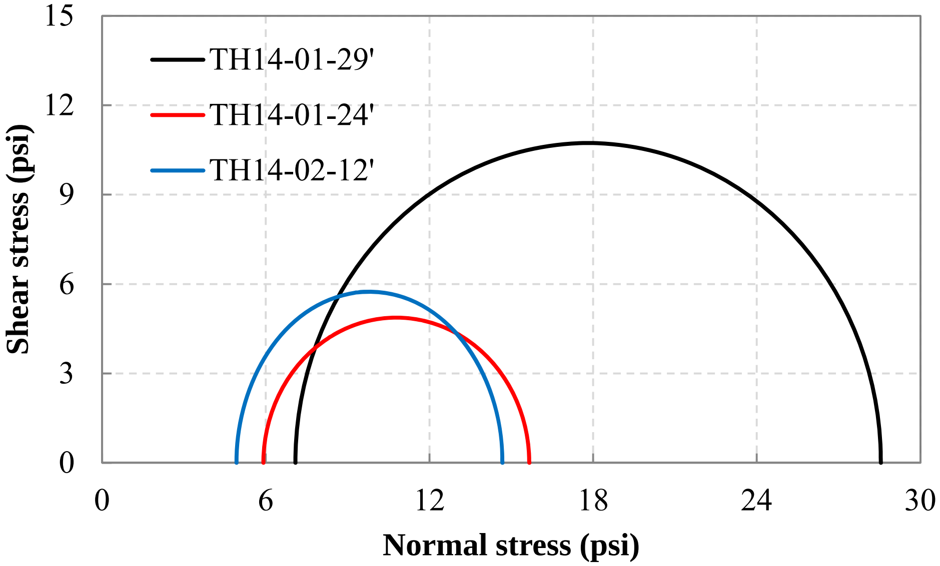


Figure 3.1 Three Unconsolidated Undrained Test Results

3.4 One-dimensional Consolidation Test

Table 3.4 Consolidation TH14-03 FS-83 at 22 ft

Day	Load		Stress		e	C_v		σ_c`
	(kg)	(lb)	(kPa)	(psi)		(cm^2/sec)	(in^2/sec)	(psi)
1	1	2	31	4	0.714591	0.010	0.001612	50
2	2	4	62	9	0.7003	0.008	0.001268	
3	4	9	124	18	0.686485	0.011	0.001719	
4	8	18	248	36	0.672262	0.015	0.002318	
5	16	35	495	72	0.649056	0.016	0.002423	
6	8	18	248	36	0.649532	0.018	0.002857	
7	4	9	124	18	0.654772	0.115	0.01789	
8	8	18	248	36	0.653139	0.066	0.01024	
9	16	36	495	72	0.647355	0.046	0.007115	
10	32	72	991	144	0.607271	0.020	0.003085	
11	64	144	1982	288	0.576103	0.020	0.003117	
12	113	250	3500	508	0.554326	0.013	0.001945	

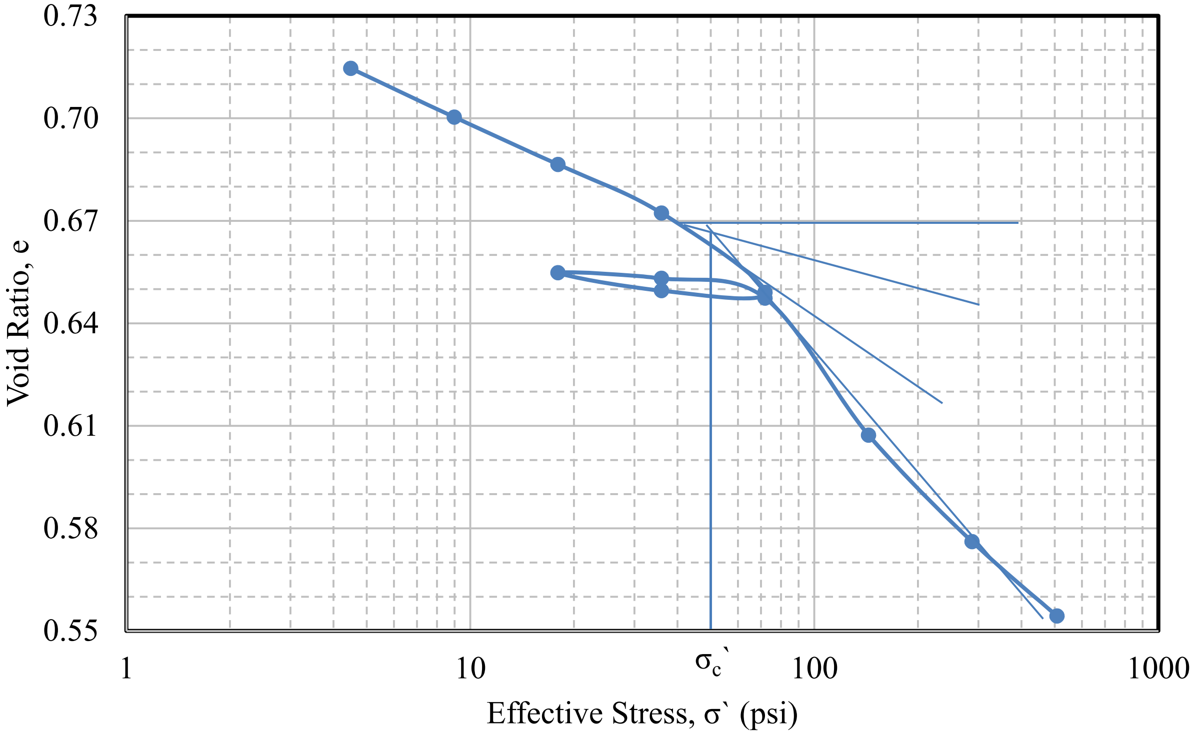


Figure 3.2 Void Ratio vs. Effective Stress (TH14-03 FS-83 at 22 ft)

Table 3.5 Consolidation TH14 - 03 FS – 83 at 21 ft

Day	Stress		e	C_v		σ_c`
	(kPa)	(psi)		(cm^2/sec)	(in^2/sec)	(psi)
1	31	4	0.724125248	0.021	0.00321	70
2	62	9	0.711706949	0.020	0.00315	
3	124	18	0.698707076	0.031	0.00473	
4	248	36	0.683791432	0.026	0.00398	
5	495	72	0.665044247	0.025	0.00382	
6	248	36	0.666275814	0.041	0.00633	
7	124	18	0.66914947	0.056	0.00863	
8	248	36	0.668321583	0.051	0.00788	
9	495	72	0.664578988	0.030	0.00467	
10	991	144	0.623807282	0.105	0.01627	
11	1982	288	0.588180788	0.022	0.00347	
12	3499	508	0.560340534	0.003	0.00041	

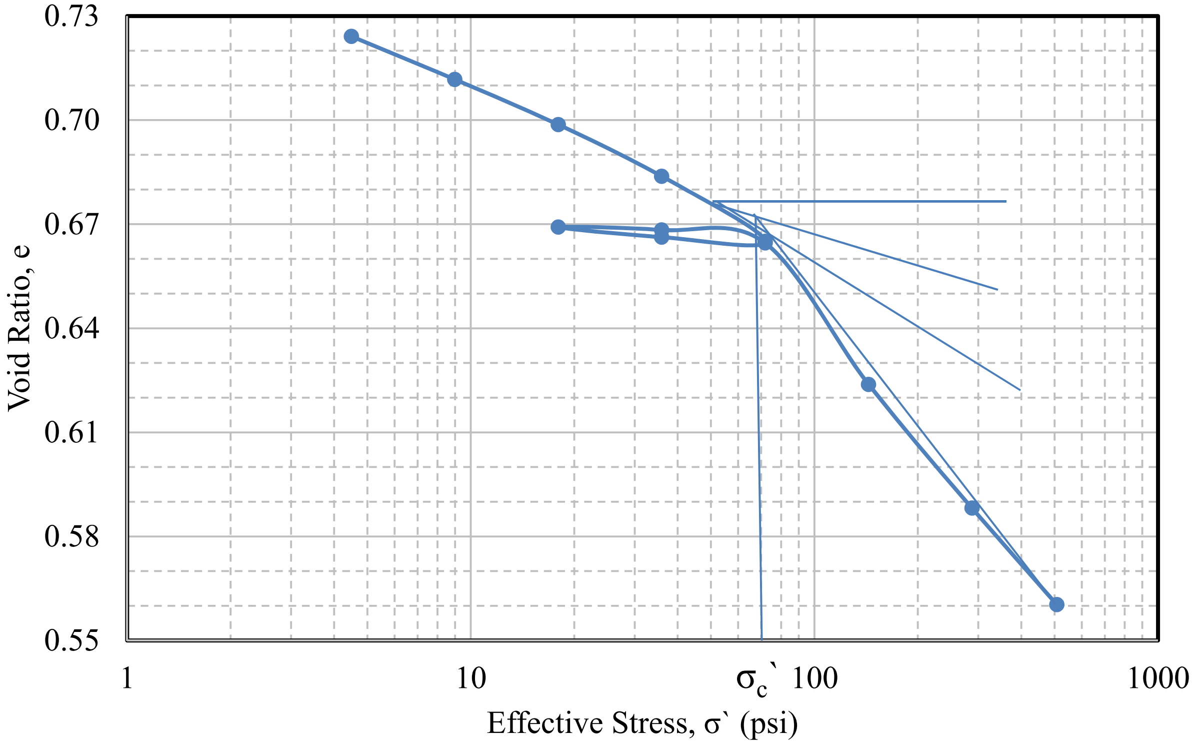


Figure 3.3 Void Ratio vs. Effective Stress (TH14-03 FS-83 at 21 ft)

Table 3.6 Consolidation TH14-03 FS-82 at 16 ft

Day	Stress		e	C_v		σ_c`
	(kPa)	(psi)		(cm^2/sec)	(in^2/sec)	(psi)
1	12	2	0.6764	0.015	0.00234	90
2	25	4	0.6697	0.036	0.00560	
3	50	7	0.6634	0.032	0.00492	
4	100	15	0.6556	0.041	0.00628	
5	200	29	0.6477	0.033	0.00511	
6	100	15	0.6486	0.014	0.00218	
7	50	7	0.6503	0.016	0.00255	
8	100	15	0.6502	0.002	0.00024	
9	200	29	0.6489	0.001	0.00014	
10	400	58	0.6382	0.064	0.00994	
11	800	116	0.6222	0.060	0.00925	
12	1600	232	0.5882	0.047	0.00725	
13	3500	508	0.5458	0.0578	0.00896	

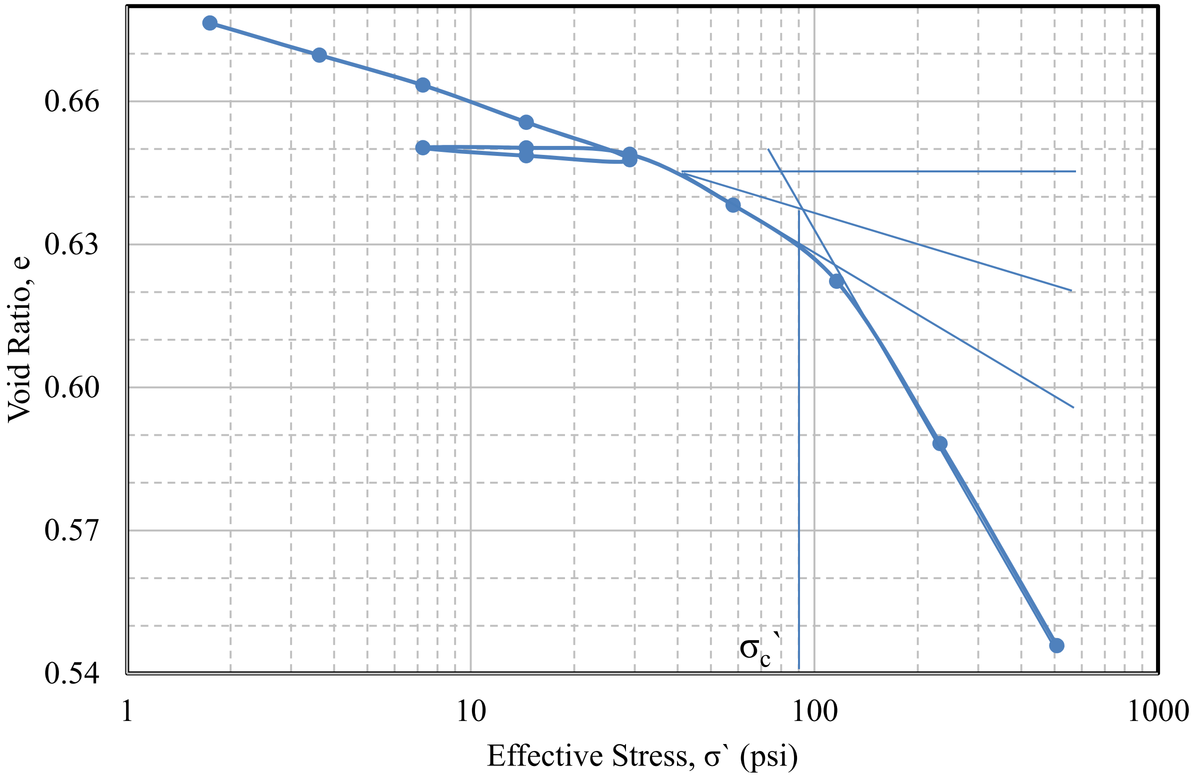


Figure 3.4 Void Ratio vs. Effective Stress (TH14-03 FS-82 at 16 ft)

3.5 Isotropically Consolidated Undrained Test Results

Isotropically consolidated undrained triaxial test were performed on in-situ samples at TH14-03-17', TH14-03-22', TH14-03-21', TH14-03-20', and TH14-03-27'. Samples TH14-03-22', TH14-03-21', and TH14-03-20' are from the same tube FS-83. Triaxial test results for five isotropically consolidated undrained triaxial tests are presented in Appendix C. Based upon three isotropically consolidated undrained triaxial tests results of samples from tube FS-83 (three samples from the same tube are assumed to be identical to each other with the same soil properties), three Mohr-Column circles were obtained as presented in Figure 2.5. Then, the corresponding cohesion (1.1 psi) and internal friction angle (29.2^o) of the soil from tube FS-83 are determined as shown in Figure 2.5 using a least square method. Since the properties of sample TH14-03-17' (FS-82) are very close to those of soil from tube FS-83 as shown in Table 2.1, the obtained Mohr-Column circle for sample TH14-03-17' is also plotted as shown in Figure 2.6. It's noted that the failure envelope (the straight line in Figure 2.6) is tangential to the obtained Mohr-Column circle which verified that the obtained cohesion and internal friction angle for the tested soil are accurate and can be utilized to predict soil shear strength under different stress conditions. However, as shown in Table 2.1, the soil from tube TH14-03-27' (FS-84) is classified as low plasticity silt (ML) which is different from the soil in tube FS-83 (classified as CL). Thus, the Mohr-Column circle for specimen TH14-03-27' is not plotted in Figure 2.6.

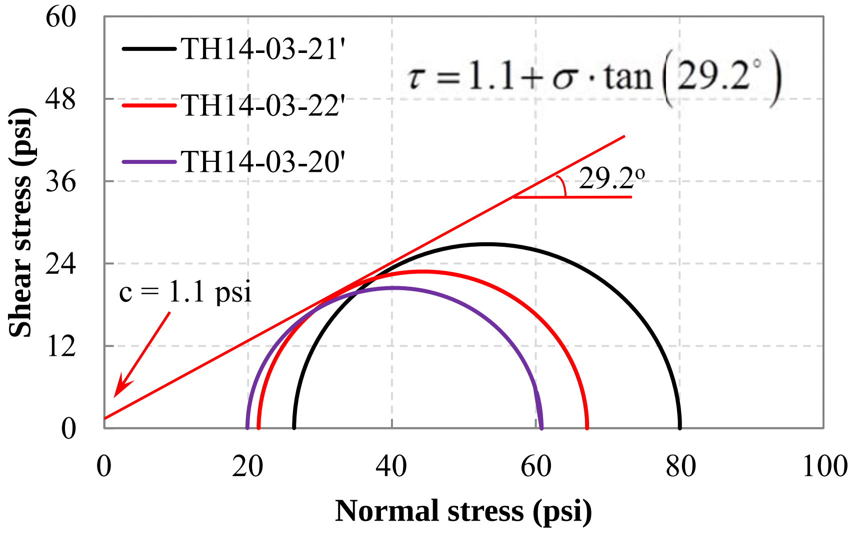


Figure 3.5 Triaxial Test Results for 3 Samples from Tube FS-83 at different Depths

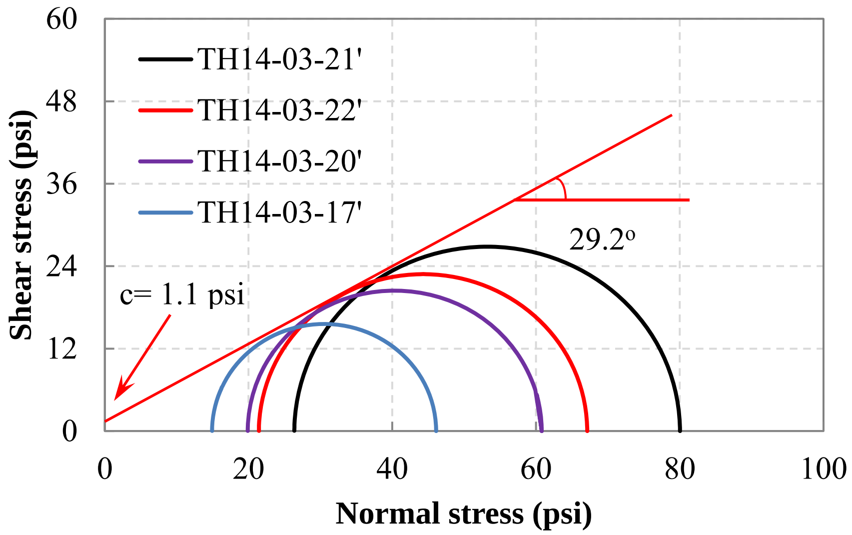


Figure 3.6 Triaxial Test Results for 4 Samples from Tube FS-82 and FS-83

Table 3.7 Specimen Information before and after the Consolidated Triaxial Test

Sample ID	Consolidation stress (psi)	Unit weight (pcf)		Void ratio		Water content	
		Before	After	Before	After	Before	After
FS-82 at 17'	6.4	129.98	129.98	0.668	0.668	25.7%	25.7%
FS-83 at 20'	30.7	135.34	143.44	0.612	0.521	26.7%	23.3%
FS-83 at 21'	20.3	132.53	133.19	0.625	0.617	25.0%	24.7%
FS-83 at 22'	10.2	133.03	132.79	0.604	0.607	23.8%	23.9%
FS-84 at 27'	13.1	134.1	139.05	0.571	0.515	22.2%	21.0%

REFERENCE

ASTM (2007) Designation: ASTM D 4643: “Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating,” Annual Book of ASTM Standards.

ASTM (2007) Designation: ASTM D 4318: “Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils,” Annual Book of ASTM Standards.

ASTM (2007) Designation: ASTM D 422: “Standard Test Method for Particle-Size Analysis of Soils,” Annual Book of ASTM Standards.

ASTM (2007) Designation: ASTM D 854: “Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer,” Annual Book of ASTM Standards.

ASTM (2007) Designation: ASTM D 2166: “Standard Test Method for Unconfined Compressive Strength of Cohesive Soil,” Annual Book of ASTM Standards.

ASTM (2007) Designation: ASTM D 2435: “Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading,” Annual Book of ASTM Standards.

ASTM (2007) Designation: ASTM D 2435: “Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils,” Annual Book of ASTM Standards.

APPENDIX

Appendix A Gradation Curves

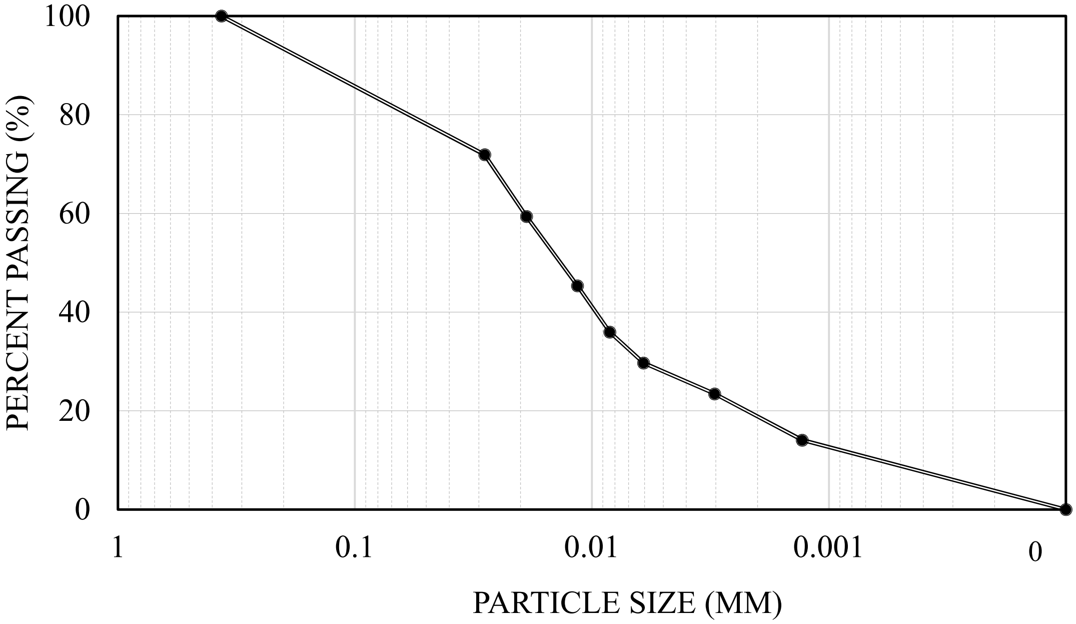


Figure A.1 Gradation Curve (TH14-01 FS-91 at 13 ft)

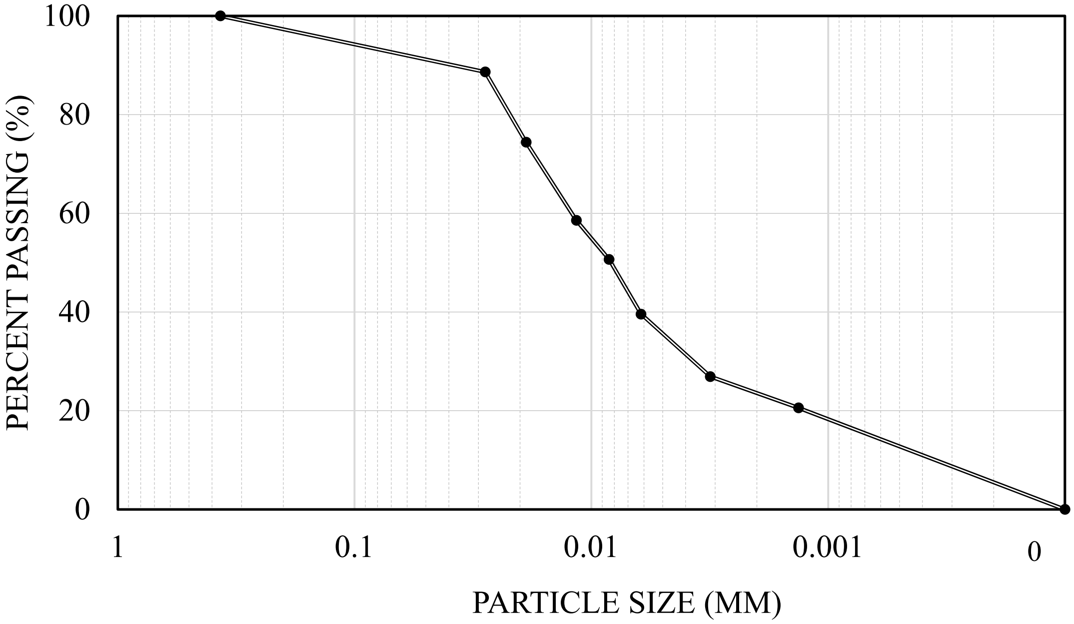


Figure A.2 Gradation Curve (TH14-01 FS-92 at 19.5 ft)

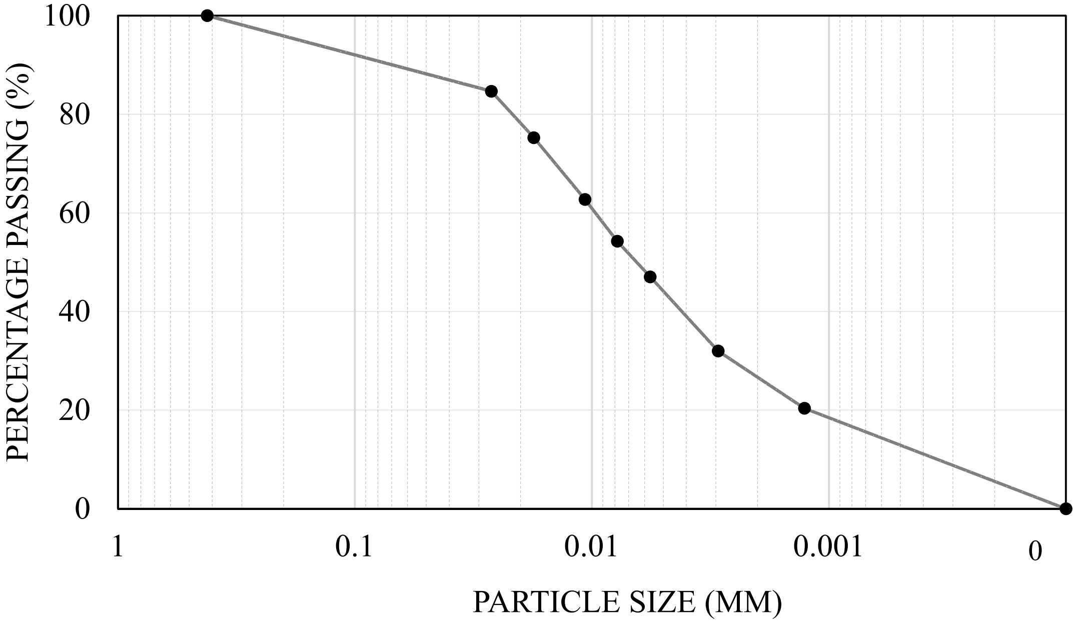


Figure A.3 Gradation Curve (TH14-01 FS-94 at 28 ft)

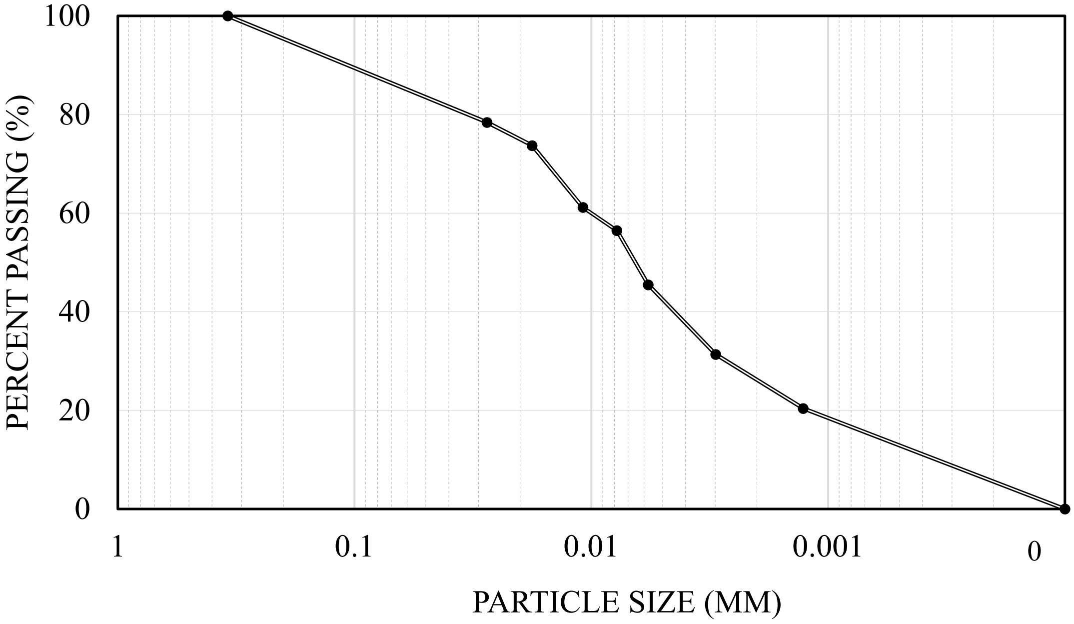


Figure A.4 Gradation Curve (TH14-01 FS-94 at 29 ft)

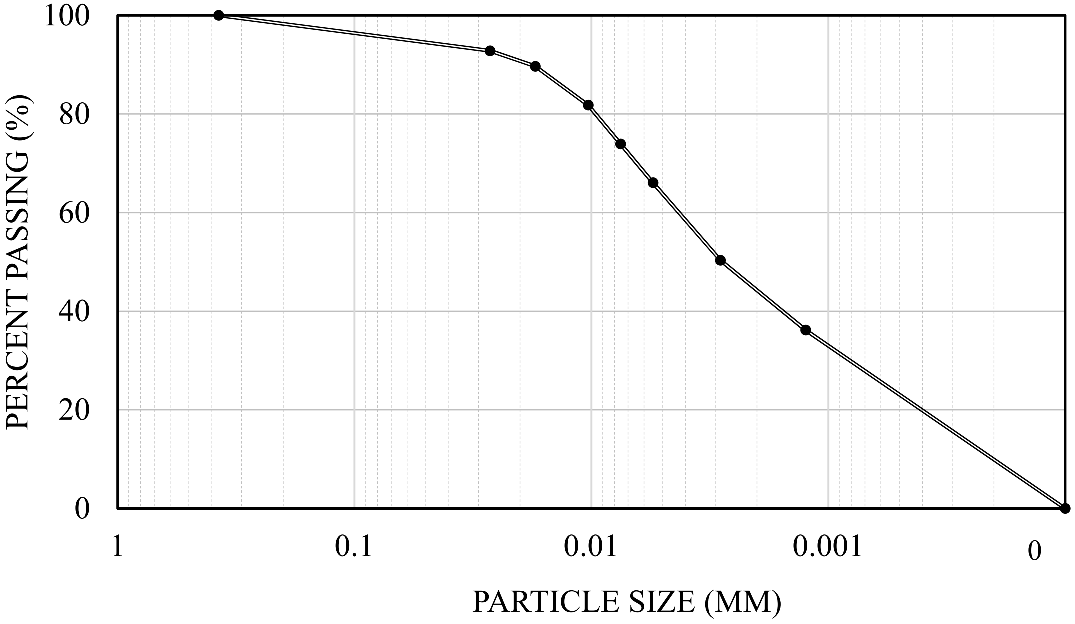


Figure A.5 Gradation Curve (TH14-01 FS-96 at 39 ft)

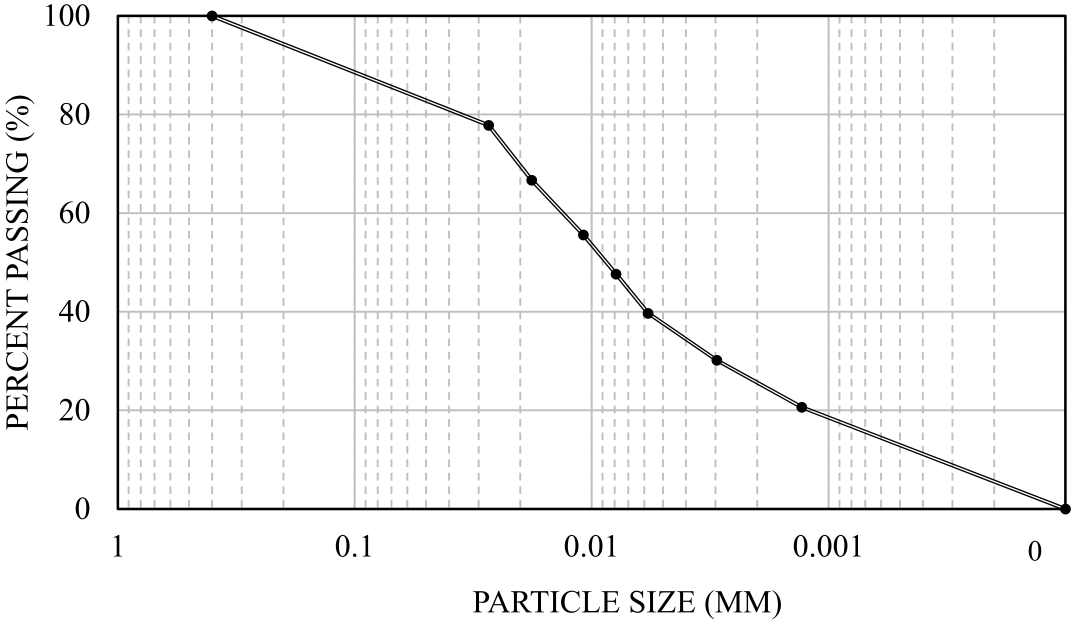


Figure A.6 Gradation Curve (TH14-03 FS-82 at 16 ft)

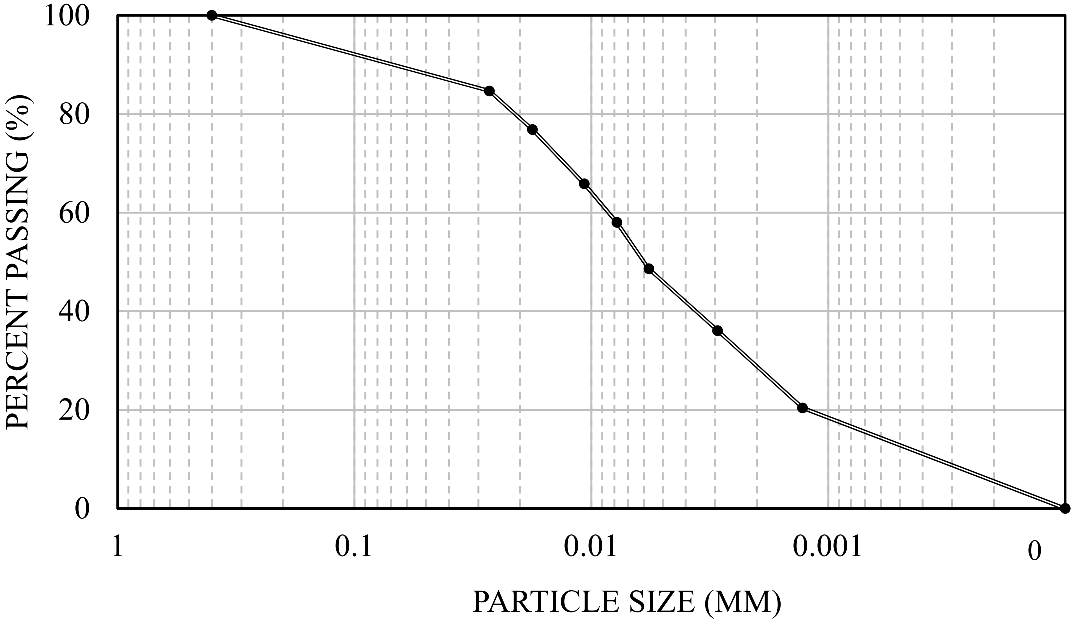


Figure A.7 Gradation Curve (TH14-03 FS-83 at 21 ft)

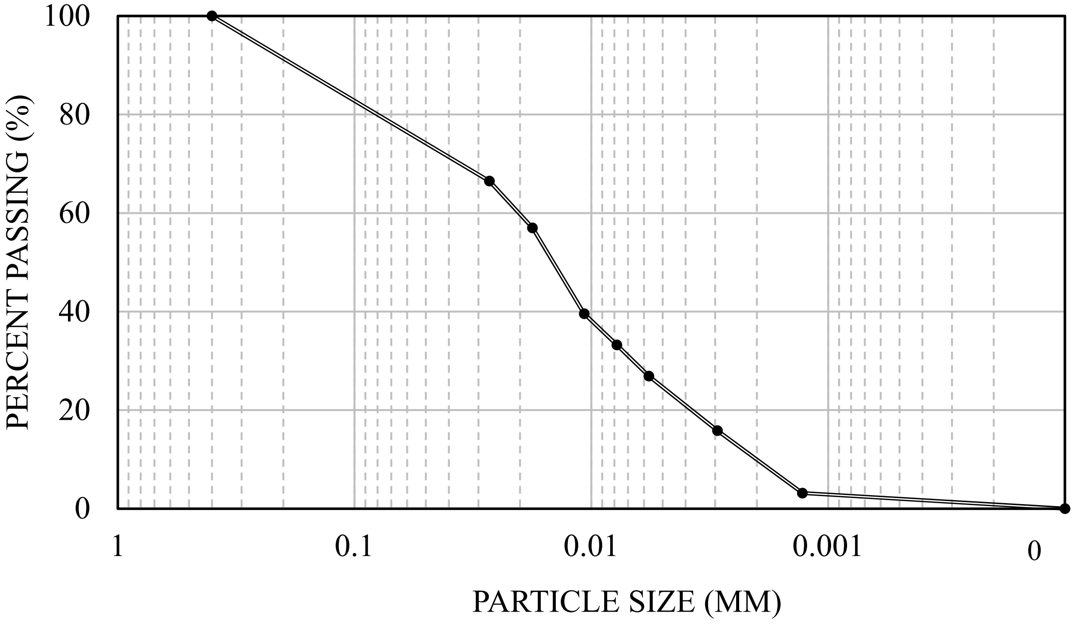


Figure A.8 Gradation Curve (TH14-03 FS-84 at 26 ft)

Appendix B Unconsolidated Undrained Test Results

Table B.1 Soil Sample TH14-01, FS-94 at 29 ft

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0.000	0.0	67.7	66.4	1.3	0.0	0.000	0.000
0.012	9.0	67.7	67.0	0.7	1.4	0.002	-0.001
0.024	13.5	67.7	67.0	0.7	2.2	0.004	-0.002
0.035	18.0	67.7	67.0	0.7	2.9	0.006	-0.003
0.047	20.2	67.7	67.0	0.7	3.2	0.008	-0.004
0.059	22.5	67.7	66.8	0.9	3.6	0.010	-0.005
0.071	27.0	67.7	66.7	1.0	4.3	0.013	-0.006
0.083	29.2	67.7	66.4	1.3	4.6	0.015	-0.007
0.094	33.7	67.7	66.3	1.4	5.3	0.017	-0.008
0.106	38.2	67.7	66.3	1.4	6.0	0.019	-0.009
0.118	42.7	67.7	66.1	1.6	6.7	0.021	-0.010
0.130	47.2	67.7	66.1	1.6	7.4	0.023	-0.012
0.142	51.7	67.7	66.0	1.7	8.1	0.025	-0.013
0.154	56.2	67.7	65.8	1.9	8.8	0.027	-0.014
0.165	60.7	67.7	65.7	2.0	9.4	0.029	-0.015
0.177	62.9	67.7	65.5	2.2	9.8	0.031	-0.016
0.189	67.4	67.7	65.5	2.2	10.5	0.033	-0.017
0.201	74.2	67.7	65.4	2.3	11.5	0.036	-0.018
0.213	80.9	67.7	65.1	2.6	12.5	0.038	-0.019
0.224	85.4	67.7	64.8	2.9	13.2	0.040	-0.020
0.236	89.9	67.7	64.7	3.0	13.8	0.042	-0.021
0.252	96.7	67.7	64.4	3.3	14.8	0.045	-0.022
0.268	103.4	67.7	64.1	3.6	15.8	0.047	-0.024
0.283	110.2	67.7	63.8	3.9	16.8	0.050	-0.025
0.299	116.9	67.7	63.4	4.3	17.8	0.053	-0.027
0.315	121.4	67.7	63.1	4.6	18.4	0.056	-0.028
0.331	128.1	67.7	62.6	5.1	19.3	0.059	-0.029
0.346	132.6	67.7	62.1	5.6	20.0	0.061	-0.031
0.362	134.9	67.7	61.5	6.2	20.2	0.064	-0.032
0.378	139.4	67.7	61.0	6.7	20.9	0.067	-0.033
0.394	143.9	67.7	60.6	7.1	21.5	0.070	-0.035
0.413	146.1	67.7	60.0	7.7	21.7	0.073	-0.037
0.433	148.4	67.7	59.6	8.1	22.0	0.077	-0.038
0.453	150.6	67.7	59.3	8.4	22.2	0.080	-0.040
0.472	150.6	67.7	59.0	8.7	22.1	0.084	-0.042
0.492	152.9	67.7	58.6	9.1	22.4	0.087	-0.044
0.512	152.9	67.7	58.4	9.3	22.3	0.091	-0.045

0.531	152.9	67.7	58.3	9.4	22.2	0.094	-0.047
0.551	155.1	67.7	58.1	9.6	22.4	0.098	-0.049
0.571	159.6	67.7	57.6	10.1	23.0	0.101	-0.051
0.591	159.6	67.7	57.3	10.4	22.9	0.105	-0.052
0.610	161.9	67.7	57.3	10.4	23.2	0.108	-0.054
0.630	161.9	67.7	57.0	10.7	23.1	0.112	-0.056
0.650	164.1	67.7	56.8	10.9	23.3	0.115	-0.058
0.669	166.4	67.7	56.7	11.0	23.5	0.119	-0.059
0.689	168.6	67.7	56.4	11.3	23.7	0.122	-0.061
0.709	168.6	67.7	56.1	11.6	23.6	0.126	-0.063
0.728	170.9	67.7	56.0	11.7	23.9	0.129	-0.065
0.748	173.1	67.7	55.8	11.9	24.1	0.133	-0.066
0.768	182.1	67.7	55.8	11.9	25.2	0.136	-0.068
0.787	186.6	67.7	55.5	12.2	25.8	0.140	-0.070
0.807	186.6	67.7	55.2	12.5	25.6	0.143	-0.071
0.827	177.6	67.7	55.1	12.6	24.3	0.146	-0.073
0.846	182.1	67.7	55.0	12.7	24.8	0.150	-0.075
0.866	184.3	67.7	54.8	12.9	25.0	0.153	-0.077

Where,
p_c = cell pressure,
p_w = pore water pressure,
p_{net} = net confining pressure (σ_3), and
σ_d = deviatoric stress ($\sigma_1 - \sigma_3$).

Table B.2 Soil Sample TH14-01, FS-93 at 24`

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0.000	0.0	81.8	78.0	3.740	0.0	0.000	0.000
0.012	11.2	81.8	79.0	2.725	1.9	0.002	-0.001
0.024	13.5	81.8	79.3	2.435	2.2	0.004	-0.002
0.035	15.7	81.8	79.5	2.290	2.6	0.006	-0.003
0.047	18.0	81.8	79.6	2.145	2.9	0.008	-0.004
0.059	20.2	81.8	79.6	2.145	3.3	0.010	-0.005
0.071	20.2	81.8	79.6	2.145	3.3	0.013	-0.006
0.083	20.2	81.8	79.6	2.145	3.3	0.015	-0.007
0.094	22.5	81.8	79.6	2.145	3.7	0.017	-0.008
0.106	24.7	81.8	79.6	2.145	4.0	0.019	-0.009
0.118	24.7	81.8	79.8	2.000	4.0	0.021	-0.010
0.130	27.0	81.8	79.8	2.000	4.4	0.023	-0.012
0.142	27.0	81.8	79.8	2.000	4.3	0.025	-0.013
0.154	27.0	81.8	79.8	2.000	4.3	0.027	-0.014
0.165	29.2	81.8	79.8	2.000	4.7	0.029	-0.015
0.177	29.2	81.8	79.8	2.000	4.7	0.031	-0.016
0.189	31.5	81.8	79.8	2.000	5.0	0.034	-0.017
0.201	31.5	81.8	79.6	2.145	5.0	0.036	-0.018
0.213	31.5	81.8	79.6	2.145	5.0	0.038	-0.019
0.224	31.5	81.8	79.6	2.145	5.0	0.040	-0.020
0.236	33.7	81.8	79.6	2.145	5.3	0.042	-0.021
0.252	33.7	81.8	79.6	2.145	5.3	0.045	-0.022
0.268	33.7	81.8	79.5	2.290	5.3	0.047	-0.024
0.283	36.0	81.8	79.5	2.290	5.6	0.050	-0.025
0.299	36.0	81.8	79.5	2.290	5.6	0.053	-0.027
0.315	36.0	81.8	79.5	2.290	5.6	0.056	-0.028
0.331	36.0	81.8	79.3	2.435	5.6	0.059	-0.029
0.346	38.2	81.8	79.3	2.435	5.9	0.061	-0.031
0.362	40.5	81.8	79.3	2.435	6.3	0.064	-0.032
0.378	40.5	81.8	79.3	2.435	6.2	0.067	-0.034
0.394	40.5	81.8	79.3	2.435	6.2	0.070	-0.035
0.413	42.7	81.8	79.2	2.580	6.5	0.073	-0.037
0.433	42.7	81.8	79.2	2.580	6.5	0.077	-0.038
0.453	42.7	81.8	78.9	2.870	6.5	0.080	-0.040
0.472	42.7	81.8	78.9	2.870	6.5	0.084	-0.042
0.492	45.0	81.8	78.7	3.015	6.8	0.087	-0.044
0.512	45.0	81.8	78.7	3.015	6.8	0.091	-0.045
0.531	47.2	81.8	78.6	3.160	7.1	0.094	-0.047
0.551	49.5	81.8	78.6	3.160	7.4	0.098	-0.049

0.571	49.5	81.8	78.4	3.305	7.3	0.101	-0.051
0.591	51.7	81.8	78.4	3.305	7.7	0.105	-0.052
0.610	51.7	81.8	78.3	3.450	7.6	0.108	-0.054
0.630	54.0	81.8	78.2	3.595	7.9	0.112	-0.056
0.650	54.0	81.8	78.0	3.740	7.9	0.115	-0.058
0.669	54.0	81.8	77.9	3.885	7.9	0.119	-0.059
0.689	56.2	81.8	77.7	4.030	8.2	0.122	-0.061
0.709	56.2	81.8	77.6	4.175	8.1	0.126	-0.063
0.728	60.7	81.8	77.4	4.320	8.7	0.129	-0.065
0.748	62.9	81.8	77.3	4.465	9.0	0.133	-0.066
0.768	62.9	81.8	77.1	4.610	9.0	0.136	-0.068
0.787	65.2	81.8	76.9	4.900	9.3	0.140	-0.070
0.807	65.2	81.8	76.6	5.190	9.2	0.143	-0.072
0.827	67.4	81.8	76.1	5.625	9.5	0.147	-0.073
0.846	67.4	81.8	76.0	5.770	9.5	0.150	-0.075
0.866	69.7	81.8	75.8	5.915	9.7	0.154	-0.077

Table B.3 Soil sample: TH14-02, FS-86 at 12`

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0.000	0.0	71.5	69.7	1.7	0.0	0.000	0.000
0.012	13.5	71.5	70.8	0.7	2.2	0.002	-0.001
0.024	20.2	71.5	70.9	0.6	3.3	0.004	-0.002
0.035	22.5	71.5	70.9	0.6	3.6	0.006	-0.003
0.047	27.0	71.5	70.9	0.6	4.3	0.009	-0.004
0.059	29.2	71.5	70.9	0.6	4.7	0.011	-0.005
0.071	31.5	71.5	70.9	0.6	5.0	0.013	-0.006
0.083	33.7	71.5	70.9	0.6	5.4	0.015	-0.008
0.094	38.2	71.5	70.9	0.6	6.1	0.017	-0.009
0.106	40.5	71.5	70.9	0.6	6.4	0.019	-0.010
0.118	40.5	71.5	70.9	0.6	6.4	0.022	-0.011
0.130	42.7	71.5	70.9	0.6	6.7	0.024	-0.012
0.142	45.0	71.5	70.9	0.6	7.1	0.026	-0.013
0.154	47.2	71.5	70.9	0.6	7.4	0.028	-0.014
0.165	49.5	71.5	70.9	0.6	7.8	0.030	-0.015
0.177	49.5	71.5	70.9	0.6	7.7	0.032	-0.016
0.189	51.7	71.5	71.1	0.4	8.1	0.035	-0.017
0.201	54.0	71.5	71.1	0.4	8.4	0.037	-0.018
0.213	54.0	71.5	71.1	0.4	8.4	0.039	-0.019
0.224	56.2	71.5	70.9	0.6	8.7	0.041	-0.021
0.236	58.5	71.5	70.8	0.7	9.0	0.043	-0.022
0.252	60.7	71.5	70.9	0.6	9.4	0.046	-0.023
0.268	60.7	71.5	70.8	0.7	9.3	0.049	-0.025
0.283	62.9	71.5	70.8	0.7	9.7	0.052	-0.026
0.299	65.2	71.5	70.8	0.7	10.0	0.055	-0.027
0.315	65.2	71.5	70.6	0.9	9.9	0.058	-0.029
0.331	67.4	71.5	70.6	0.9	10.3	0.061	-0.030
0.346	69.7	71.5	70.5	1.0	10.6	0.064	-0.032
0.362	69.7	71.5	70.5	1.0	10.5	0.066	-0.033
0.378	69.7	71.5	70.3	1.2	10.5	0.069	-0.035
0.394	71.9	71.5	70.3	1.2	10.8	0.072	-0.036
0.413	71.9	71.5	70.2	1.3	10.8	0.076	-0.038
0.433	74.2	71.5	70.0	1.5	11.1	0.079	-0.040
0.453	76.4	71.5	69.9	1.6	11.3	0.083	-0.042
0.472	76.4	71.5	69.7	1.7	11.3	0.087	-0.043
0.492	76.4	71.5	69.6	1.9	11.3	0.090	-0.045
0.512	76.4	71.5	69.5	2.0	11.2	0.094	-0.047
0.531	76.4	71.5	69.3	2.2	11.2	0.097	-0.049
0.551	76.4	71.5	69.2	2.3	11.1	0.101	-0.051

0.571	76.4	71.5	69.0	2.5	11.1	0.105	-0.052
0.591	76.4	71.5	68.9	2.6	11.0	0.108	-0.054
0.610	78.7	71.5	68.6	2.9	11.3	0.112	-0.056
0.630	78.7	71.5	68.4	3.0	11.3	0.115	-0.058
0.650	78.7	71.5	68.3	3.2	11.2	0.119	-0.060
0.669	80.9	71.5	68.3	3.2	11.5	0.123	-0.061
0.689	80.9	71.5	68.4	3.0	11.4	0.126	-0.063
0.709	78.7	71.5	68.6	2.9	11.1	0.130	-0.065
0.728	78.7	71.5	68.6	2.9	11.0	0.134	-0.067
0.748	78.7	71.5	68.9	2.6	11.0	0.137	-0.069
0.768	78.7	71.5	68.9	2.6	10.9	0.141	-0.070
0.787	78.7	71.5	68.9	2.6	10.9	0.144	-0.072
0.807	78.7	71.5	69.0	2.5	10.8	0.148	-0.074
0.827	78.7	71.5	69.2	2.3	10.8	0.152	-0.076
0.846	80.9	71.5	69.0	2.5	11.1	0.155	-0.078
0.866	80.9	71.5	69.0	2.5	11.0	0.159	-0.079

Appendix C Isotropically Consolidated Undrained Triaxial Test Results

Table C.1 Soil sample: TH14-03, FS-82 at 17`

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0	0	65.0	58.6	6.4	0	0	0
0.012	31.5	65.0	58.9	6.1	5.1	0.002	-0.001
0.024	45.0	65.0	59.9	5.1	7.3	0.004	-0.002
0.035	51.7	65.0	60.0	4.9	8.4	0.006	-0.003
0.047	56.2	65.0	60.2	4.8	9.1	0.008	-0.004
0.059	60.7	65.0	60.2	4.8	9.8	0.011	-0.005
0.071	65.2	65.0	60.2	4.8	10.5	0.013	-0.006
0.083	71.9	65.0	60.2	4.8	11.5	0.015	-0.007
0.094	76.4	65.0	60.0	4.9	12.2	0.017	-0.008
0.106	80.9	65.0	59.9	5.1	12.9	0.019	-0.010
0.118	85.4	65.0	59.9	5.1	13.6	0.021	-0.011
0.130	89.9	65.0	59.7	5.2	14.3	0.023	-0.012
0.142	96.7	65.0	59.5	5.5	15.3	0.025	-0.013
0.154	103.4	65.0	59.3	5.7	16.4	0.028	-0.014
0.165	107.9	65.0	59.0	5.9	17.1	0.030	-0.015
0.177	114.7	65.0	58.7	6.2	18.1	0.032	-0.016
0.189	119.1	65.0	58.6	6.4	18.8	0.034	-0.017
0.201	125.9	65.0	58.3	6.7	19.8	0.036	-0.018
0.213	130.4	65.0	58.1	6.8	20.4	0.038	-0.019
0.224	134.9	65.0	57.7	7.3	21.1	0.040	-0.020
0.236	139.4	65.0	57.6	7.4	21.7	0.042	-0.021
0.256	143.9	65.0	57.4	7.5	22.4	0.046	-0.023
0.276	148.4	65.0	56.8	8.1	23.0	0.049	-0.025
0.295	152.9	65.0	56.6	8.4	23.6	0.053	-0.027
0.315	159.6	65.0	56.1	8.8	24.5	0.057	-0.028
0.335	164.1	65.0	55.7	9.3	25.1	0.060	-0.030
0.354	170.9	65.0	55.2	9.7	26.1	0.064	-0.032
0.374	175.4	65.0	54.8	10.2	26.6	0.067	-0.034
0.394	179.8	65.0	54.2	10.7	27.2	0.071	-0.035
0.413	186.6	65.0	53.9	11.0	28.1	0.074	-0.037
0.433	191.1	65.0	53.4	11.6	28.7	0.078	-0.039
0.453	193.3	65.0	52.9	12.0	28.9	0.081	-0.041
0.472	195.6	65.0	52.6	12.3	29.2	0.085	-0.042
0.492	197.8	65.0	52.3	12.6	29.4	0.088	-0.044
0.512	200.1	65.0	52.1	12.9	29.6	0.092	-0.046
0.531	204.6	65.0	51.6	13.3	30.1	0.095	-0.048
0.551	206.8	65.0	51.3	13.6	30.4	0.099	-0.049

0.571	209.1	65.0	51.0	13.9	30.6	0.102	-0.051
0.591	211.3	65.0	50.8	14.2	30.8	0.106	-0.053
0.610	213.6	65.0	50.5	14.5	31.0	0.110	-0.055
0.630	213.6	65.0	50.2	14.8	30.9	0.113	-0.057
0.650	215.8	65.0	50.0	14.9	31.1	0.117	-0.058
0.669	215.8	65.0	49.7	15.2	30.9	0.120	-0.060
0.689	215.8	65.0	49.6	15.4	30.8	0.124	-0.062
0.709	218.1	65.0	49.4	15.5	31.0	0.127	-0.064
0.728	218.1	65.0	49.4	15.5	30.9	0.131	-0.065
0.748	220.3	65.0	49.3	15.7	31.1	0.134	-0.067
0.768	222.6	65.0	49.2	15.8	31.3	0.138	-0.069
0.787	224.8	65.0	49.0	16.0	31.4	0.141	-0.071
0.807	224.8	65.0	48.9	16.1	31.3	0.145	-0.072
0.827	224.8	65.0	48.7	16.2	31.2	0.148	-0.074
0.846	224.8	65.0	48.6	16.4	31.1	0.152	-0.076
0.866	224.8	65.0	48.4	16.5	30.9	0.155	-0.078

Table C.2 Soil sample: TH14-03, FS-84 at 27`

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0	0	77.4	64.4	13.1	0	0	0
0.020	56.2	77.4	69.5	8.0	9.1	0.003	-0.002
0.039	74.2	77.4	70.5	7.0	12.0	0.007	-0.003
0.059	89.9	77.4	70.6	6.8	14.5	0.010	-0.005
0.079	107.9	77.4	70.3	7.1	17.3	0.014	-0.007
0.098	128.1	77.4	69.7	7.7	20.5	0.017	-0.009
0.118	152.9	77.4	68.9	8.6	24.4	0.021	-0.010
0.138	179.8	77.4	67.9	9.6	28.6	0.024	-0.012
0.157	209.1	77.4	66.6	10.9	33.1	0.028	-0.014
0.177	245.0	77.4	65.1	12.3	38.7	0.031	-0.016
0.197	281.0	77.4	63.7	13.8	44.2	0.035	-0.017
0.217	314.7	77.4	62.2	15.2	49.3	0.038	-0.019
0.236	353.0	77.4	60.8	16.7	55.1	0.042	-0.021
0.256	395.7	77.4	59.0	18.4	61.5	0.045	-0.023
0.276	442.9	77.4	57.1	20.3	68.6	0.049	-0.024
0.295	494.6	77.4	55.1	22.3	76.3	0.052	-0.026
0.315	546.3	77.4	52.9	24.5	84.0	0.056	-0.028
0.335	598.0	77.4	50.6	26.8	91.6	0.059	-0.030
0.354	654.2	77.4	48.1	29.3	99.9	0.063	-0.031
0.374	712.6	77.4	45.7	31.8	108.4	0.066	-0.033
0.394	762.1	77.4	43.5	33.9	115.5	0.070	-0.035
0.413	818.3	77.4	41.0	36.4	123.5	0.073	-0.037
0.433	874.5	77.4	38.4	39.0	131.5	0.077	-0.038
0.453	928.5	77.4	36.3	41.2	139.1	0.080	-0.040
0.472	982.4	77.4	33.9	43.5	146.6	0.084	-0.042
0.492	1038.6	77.4	31.6	45.8	154.4	0.087	-0.044
0.512	1090.3	77.4	29.1	48.3	161.5	0.091	-0.045
0.531	1144.3	77.4	26.5	50.9	168.8	0.094	-0.047
0.551	1200.5	77.4	23.9	53.5	176.4	0.098	-0.049
0.571	1267.9	77.4	21.9	55.5	185.6	0.101	-0.051
0.591	1299.4	77.4	19.6	57.9	189.5	0.105	-0.052
0.610	1335.4	77.4	17.5	59.9	194.0	0.108	-0.054
0.630	1366.8	77.4	15.7	61.8	197.8	0.112	-0.056
0.650	1396.1	77.4	14.1	63.4	201.2	0.115	-0.058
0.669	1425.3	77.4	12.6	64.8	204.6	0.119	-0.059
0.689	1447.8	77.4	11.2	66.3	207.0	0.122	-0.061
0.709	1454.5	77.4	9.7	67.7	207.1	0.126	-0.063
0.728	1411.8	77.4	9.0	68.4	200.2	0.129	-0.065
0.748	1423.0	77.4	8.8	68.6	201.0	0.133	-0.066

0.768	1423.0	77.4	8.7	68.7	200.2	0.136	-0.068
0.787	1425.3	77.4	8.4	69.0	199.7	0.140	-0.070
0.807	1434.3	77.4	8.3	69.2	200.2	0.143	-0.072
0.827	1441.0	77.4	8.0	69.5	200.3	0.147	-0.073
0.846	1450.0	77.4	7.8	69.6	200.7	0.150	-0.075
0.866	1459.0	77.4	9.1	68.3	201.1	0.154	-0.077

Table C.3 Soil sample: TH14-03, FS-83 at 22'

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0.000	0.0	59.9	49.7	10.2	0.0	0.000	0.000
0.012	33.7	59.9	51.2	8.7	5.5	0.002	-0.001
0.024	45.0	59.9	52.3	7.5	7.3	0.004	-0.002
0.035	54.0	59.9	53.1	6.8	8.7	0.006	-0.003
0.047	60.7	59.9	53.7	6.2	9.8	0.008	-0.004
0.059	69.7	59.9	54.2	5.7	11.2	0.010	-0.005
0.071	76.4	59.9	54.8	5.1	12.3	0.012	-0.006
0.083	83.2	59.9	54.2	5.7	13.4	0.014	-0.007
0.094	89.9	59.9	53.8	6.1	14.4	0.016	-0.008
0.106	94.4	59.9	53.9	5.9	15.1	0.018	-0.009
0.118	101.2	59.9	54.1	5.8	16.1	0.021	-0.010
0.130	107.9	59.9	53.5	6.4	17.2	0.023	-0.011
0.142	116.9	59.9	53.1	6.8	18.6	0.025	-0.012
0.154	125.9	59.9	52.9	7.0	20.0	0.027	-0.013
0.165	134.9	59.9	52.6	7.3	21.3	0.029	-0.014
0.177	141.6	59.9	52.5	7.4	22.4	0.031	-0.015
0.189	150.6	59.9	52.1	7.8	23.7	0.033	-0.016
0.201	157.4	59.9	51.5	8.4	24.7	0.035	-0.017
0.213	164.1	59.9	51.2	8.7	25.8	0.037	-0.018
0.224	168.6	59.9	50.9	9.0	26.4	0.039	-0.019
0.236	175.4	59.9	50.9	9.0	27.4	0.041	-0.021
0.256	188.8	59.9	50.2	9.7	29.4	0.044	-0.022
0.276	193.3	59.9	49.4	10.4	30.0	0.048	-0.024
0.295	200.1	59.9	48.9	11.0	30.9	0.051	-0.026
0.315	211.3	59.9	48.1	11.7	32.6	0.055	-0.027
0.335	218.1	59.9	47.6	12.3	33.5	0.058	-0.029
0.354	229.3	59.9	47.0	12.9	35.1	0.062	-0.031
0.374	236.0	59.9	46.4	13.5	36.0	0.065	-0.032
0.394	245.0	59.9	45.8	14.1	37.2	0.068	-0.034
0.413	249.5	59.9	45.4	14.5	37.7	0.072	-0.036
0.433	254.0	59.9	44.8	15.1	38.3	0.075	-0.038
0.453	260.8	59.9	44.2	15.7	39.2	0.079	-0.039
0.472	263.0	59.9	43.8	16.1	39.3	0.082	-0.041
0.492	267.5	59.9	43.4	16.5	39.9	0.085	-0.043
0.512	272.0	59.9	43.1	16.8	40.4	0.089	-0.044
0.531	281.0	59.9	42.6	17.3	41.6	0.092	-0.046
0.551	285.5	59.9	41.9	18.0	42.1	0.096	-0.048
0.571	292.3	59.9	41.3	18.6	42.9	0.099	-0.050
0.591	294.5	59.9	41.0	18.9	43.1	0.103	-0.051

0.610	296.7	59.9	40.7	19.1	43.2	0.106	-0.053
0.630	299.0	59.9	40.2	19.7	43.4	0.109	-0.055
0.650	303.5	59.9	39.9	20.0	43.9	0.113	-0.056
0.669	305.7	59.9	39.7	20.2	44.0	0.116	-0.058
0.689	310.2	59.9	39.6	20.3	44.5	0.120	-0.060
0.709	317.0	59.9	39.3	20.6	45.3	0.123	-0.062
0.728	319.2	59.9	38.9	21.0	45.4	0.127	-0.063
0.748	321.5	59.9	38.6	21.3	45.6	0.130	-0.065
0.768	323.7	59.9	38.4	21.5	45.7	0.133	-0.067
0.787	323.7	59.9	38.3	21.6	45.5	0.137	-0.068
0.807	323.7	59.9	38.1	21.8	45.4	0.140	-0.070
0.827	326.0	59.9	38.0	21.9	45.5	0.144	-0.072
0.846	326.0	59.9	37.8	22.0	45.3	0.147	-0.074
0.866	326.0	59.9	37.7	22.2	45.1	0.150	-0.075

Table C.4 Soil sample: TH14-03, FS-83 at 21'

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0.000	0.0	70.0	49.7	20.3	0.0	0.000	0.000
0.020	76.4	70.0	56.0	14.1	12.4	0.003	-0.002
0.039	101.2	70.0	57.7	12.3	16.4	0.007	-0.003
0.059	125.9	70.0	58.3	11.7	20.3	0.010	-0.005
0.079	143.9	70.0	58.4	11.6	23.1	0.014	-0.007
0.098	161.9	70.0	58.4	11.6	25.9	0.017	-0.009
0.118	175.4	70.0	58.0	12.0	28.0	0.021	-0.010
0.138	188.8	70.0	57.7	12.3	30.0	0.024	-0.012
0.157	200.1	70.0	57.3	12.8	31.7	0.028	-0.014
0.177	213.6	70.0	56.7	13.3	33.7	0.031	-0.016
0.197	227.1	70.0	56.0	14.1	35.7	0.035	-0.017
0.217	240.5	70.0	55.2	14.8	37.7	0.038	-0.019
0.236	249.5	70.0	54.7	15.4	39.0	0.042	-0.021
0.256	260.8	70.0	54.4	15.7	40.6	0.045	-0.023
0.276	269.8	70.0	53.5	16.5	41.8	0.049	-0.024
0.295	278.8	70.0	52.9	17.1	43.1	0.052	-0.026
0.315	283.3	70.0	52.3	17.7	43.6	0.056	-0.028
0.335	290.0	70.0	51.9	18.1	44.5	0.059	-0.030
0.354	296.7	70.0	51.3	18.7	45.3	0.063	-0.031
0.374	303.5	70.0	50.8	19.3	46.2	0.066	-0.033
0.394	310.2	70.0	50.0	20.0	47.0	0.070	-0.035
0.413	319.2	70.0	49.4	20.6	48.2	0.073	-0.037
0.433	323.7	70.0	49.0	21.0	48.7	0.077	-0.038
0.453	326.0	70.0	48.6	21.5	48.9	0.080	-0.040
0.472	330.5	70.0	48.3	21.8	49.3	0.084	-0.042
0.492	332.7	70.0	48.0	22.0	49.5	0.087	-0.044
0.512	337.2	70.0	47.6	22.5	50.0	0.091	-0.045
0.531	339.5	70.0	47.3	22.8	50.1	0.094	-0.047
0.551	344.0	70.0	47.0	23.1	50.6	0.098	-0.049
0.571	346.2	70.0	46.7	23.3	50.7	0.101	-0.051
0.591	350.7	70.0	46.3	23.8	51.2	0.105	-0.052
0.610	355.2	70.0	46.1	23.9	51.6	0.108	-0.054
0.630	357.4	70.0	45.8	24.2	51.8	0.111	-0.056
0.650	359.7	70.0	45.7	24.4	51.9	0.115	-0.057
0.669	361.9	70.0	45.5	24.5	52.0	0.118	-0.059
0.689	364.2	70.0	45.2	24.8	52.1	0.122	-0.061
0.709	366.4	70.0	44.8	25.2	52.2	0.125	-0.063
0.728	368.7	70.0	44.5	25.5	52.3	0.129	-0.064
0.748	370.9	70.0	44.4	25.7	52.4	0.132	-0.066

0.768	373.2	70.0	44.4	25.7	52.5	0.136	-0.068
0.787	377.7	70.0	44.2	25.8	53.0	0.139	-0.070
0.807	379.9	70.0	44.1	26.0	53.1	0.143	-0.071
0.827	382.2	70.0	43.9	26.1	53.2	0.146	-0.073
0.846	384.4	70.0	43.8	26.2	53.3	0.150	-0.075
0.866	386.7	70.0	43.6	26.4	53.3	0.153	-0.077

Table C.5 Soil sample: TH14-03, FS-83 at 20’

Displacement (inch)	Load (lb)	p_c (psi)	p_w (psi)	p_{net} (psi)	σ_d (psi)	ε_a	ε_r
0.000	0.0	81.2	50.5	30.7	0.0	0.000	0.000
0.020	83.2	81.2	58.4	22.8	14.3	0.004	-0.002
0.039	103.4	81.2	61.8	19.4	17.7	0.007	-0.004
0.059	112.4	81.2	63.4	17.8	19.2	0.011	-0.006
0.079	121.4	81.2	64.4	16.8	20.6	0.015	-0.007
0.098	132.6	81.2	65.4	15.8	22.5	0.019	-0.009
0.118	139.4	81.2	66.0	15.2	23.5	0.022	-0.011
0.138	148.4	81.2	66.1	15.1	24.9	0.026	-0.013
0.157	157.4	81.2	66.4	14.8	26.3	0.030	-0.015
0.177	166.4	81.2	66.3	14.9	27.7	0.033	-0.017
0.197	173.1	81.2	66.1	15.1	28.8	0.037	-0.019
0.217	182.1	81.2	66.1	15.1	30.1	0.041	-0.020
0.236	186.6	81.2	66.0	15.2	30.8	0.044	-0.022
0.256	193.3	81.2	65.8	15.4	31.8	0.048	-0.024
0.276	197.8	81.2	65.7	15.5	32.4	0.052	-0.026
0.295	204.6	81.2	65.5	15.7	33.3	0.056	-0.028
0.315	211.3	81.2	65.3	16.0	34.3	0.059	-0.030
0.335	215.8	81.2	65.0	16.2	34.9	0.063	-0.031
0.354	220.3	81.2	64.7	16.5	35.5	0.067	-0.033
0.374	224.8	81.2	64.2	17.0	36.1	0.070	-0.035
0.394	231.6	81.2	63.9	17.3	37.0	0.074	-0.037
0.413	233.8	81.2	63.8	17.4	37.2	0.078	-0.039
0.433	238.3	81.2	63.4	17.8	37.8	0.081	-0.041
0.453	240.5	81.2	63.2	18.0	38.0	0.085	-0.043
0.472	242.8	81.2	63.1	18.1	38.2	0.089	-0.044
0.492	247.3	81.2	62.9	18.3	38.7	0.093	-0.046
0.512	247.3	81.2	62.8	18.4	38.6	0.096	-0.048
0.531	251.8	81.2	62.5	18.7	39.1	0.100	-0.050
0.551	256.3	81.2	62.2	19.0	39.6	0.104	-0.052
0.571	256.3	81.2	61.9	19.3	39.5	0.107	-0.054
0.591	260.8	81.2	61.9	19.3	40.0	0.111	-0.056
0.610	265.3	81.2	61.9	19.3	40.5	0.115	-0.057
0.630	265.3	81.2	61.5	19.7	40.3	0.119	-0.059
0.650	269.8	81.2	61.3	19.9	40.9	0.122	-0.061
0.669	269.8	81.2	61.3	19.9	40.7	0.126	-0.063
0.689	269.8	81.2	61.3	19.9	40.5	0.130	-0.065
0.709	272.0	81.2	61.0	20.2	40.7	0.133	-0.067
0.728	272.0	81.2	61.0	20.2	40.5	0.137	-0.069
0.748	272.0	81.2	61.0	20.2	40.3	0.141	-0.070

0.768	274.3	81.2	60.9	20.3	40.5	0.144	-0.072
0.787	274.3	81.2	60.9	20.3	40.3	0.148	-0.074
0.807	274.3	81.2	60.9	20.3	40.1	0.152	-0.076
0.827	276.5	81.2	60.8	20.4	40.3	0.156	-0.078
0.846	276.5	81.2	60.8	20.4	40.1	0.159	-0.080
0.866	276.5	81.2	60.8	20.4	39.9	0.163	-0.081