

August 26, 2020



Missouri Department of Transportation  
1711 S Highway 61  
Hannibal, Missouri 63401

Attn: Mr. Jeff Gander, P.E.  
(660) 651 0057  
jeffery.gander@modot.mo.gov

Re: Geotechnical Data Report  
Bridge T0103 – Route 46 over Little Tarkio Creek  
Atchison County, Missouri  
MoDOT Project Number: J1S0596  
Terracon Project Number: 0220P078

Dear Mr. Gander:

Terracon Consultants, Inc. (Terracon) has completed the subsurface exploration for the referenced bridge. This report presents the findings of the subsurface exploration.

## PROJECT INFORMATION

This geotechnical data report presents the results of our subsurface exploration and laboratory testing program for the Route 46 Bridge (T0103) over Little Tarkio Creek in Atchison County, Missouri. The subsurface exploration included the advancement of two (2) test borings to depths of approximately 100 feet below the existing ground surface. The purpose of the exploration was to obtain subsurface information for use in the preliminary design of a future bridge replacement.

Maps showing the site location and boring locations are shown in the **Site Location Plan** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and test data sheets in the **Exploration Results** section of this report. The **General Comments** section provides an understanding of the report limitations.

## Exploration Procedures

The exploration was performed with an ATV-mounted Central Mine Equipment Company (CME) drill rig. The boreholes were advanced using solid-stem augers and mud rotary drilling procedures. Upon completion, the borings were backfilled with bentonite chips and auger cuttings and the asphalt was surface patched with cold asphalt patch compound.

Terracon Consultants, Inc. 15620 W 113<sup>th</sup> Street Lenexa, Kansas 66219  
P [913] 492 7777 F [913] 492 7443 [terracon.com](http://terracon.com)

Environmental



Facilities



Geotechnical



Materials

## Geotechnical Data Report

T0103 – Route 46 over Little Tarkio Creek ■ Atchison County, Missouri

August 26, 2020 ■ Project No. 0220P078



The northing/easting and ground surface elevations at the boring locations were provided by Crawford, Murphy & Tilly, Inc.

## Laboratory Testing

Classification of the soil samples was performed in accordance with the Unified Soil Classification System (USCS) based on the material's texture and plasticity. The following tests were performed on selected portions of the recovered soil and rock samples:

- Moisture Content
- Atterberg limits (Liquid Limit, Plastic Limit, and Plasticity Index)
- Particle-Size Analysis

## SUBSURFACE CONDITIONS

Approximately 6 inches of asphalt was encountered at the ground surface at the boring locations. The asphalt was underlain by existing fill materials composed of lean clay that extended to depths ranging from approximately 8½ feet to 15 feet. The existing fill materials were underlain by native clay and sand that extended to the boring termination depths of 100 feet. The boring location information and subsurface conditions are summarized in the following table:

Boring	Location	Total Depth (feet)	Top of Rock Elevation (feet)	Overburden Depth (feet)
B-101 (West)	2554727.49 E 1519322.63 N	100	N/A	100+
B-102 (East)	2554896.89 E 1519320.11 N			

## Groundwater Conditions

The borings were observed during auger drilling for the presence and level of water. Groundwater was not observed while auger drilling. The borings were advanced below depths of approximately 5 feet using mud rotary drilling procedures. Introduction of water during the mud rotary drilling procedure masks indications of naturally occurring groundwater. Due to the low permeability of some of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Long-term observations in piezometers or observation wells, sealed from the influence of surface water, are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, the water level in Little Tarkio Creek, and other factors not evident at the time the borings were

## Geotechnical Data Report

T0103 – Route 46 over Little Tarkio Creek ■ Atchison County, Missouri

August 26, 2020 ■ Project No. 0220P078



performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be different than the levels indicated on the boring logs.

## GENERAL COMMENTS

The data presented in this letter and attachments were obtained from borings performed at the indicated locations. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction.

This letter has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical exploration practices. No warranties, either express or implied, are intended or made.

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions or if we can be of further assistance.

Sincerely,

**Terracon Consultants, Inc.**

Daniel A. Barnett, P.G.  
Project Geologist  
Missouri: 2007035892

Mohammad T. Ibrawish, P.E.  
Geotechnical Department Manager  
Missouri: 2013000582

A handwritten signature in blue ink that reads "K. C. Berg".

Kole C. Berg, P.E.  
Senior Engineer  
Missouri: 2002016417

### Attachments

- n Site Location Plan
- n Exploration Plan
- n Exploration Results
- n Supporting Information

## **SITE LOCATION PLAN**



## SITE LOCATION

Bridge T0103 – Route 46 over Little Tarkio Creek ■ Atchison County, Missouri  
August 26, 2020 ■ Terracon Project No. 0220P078

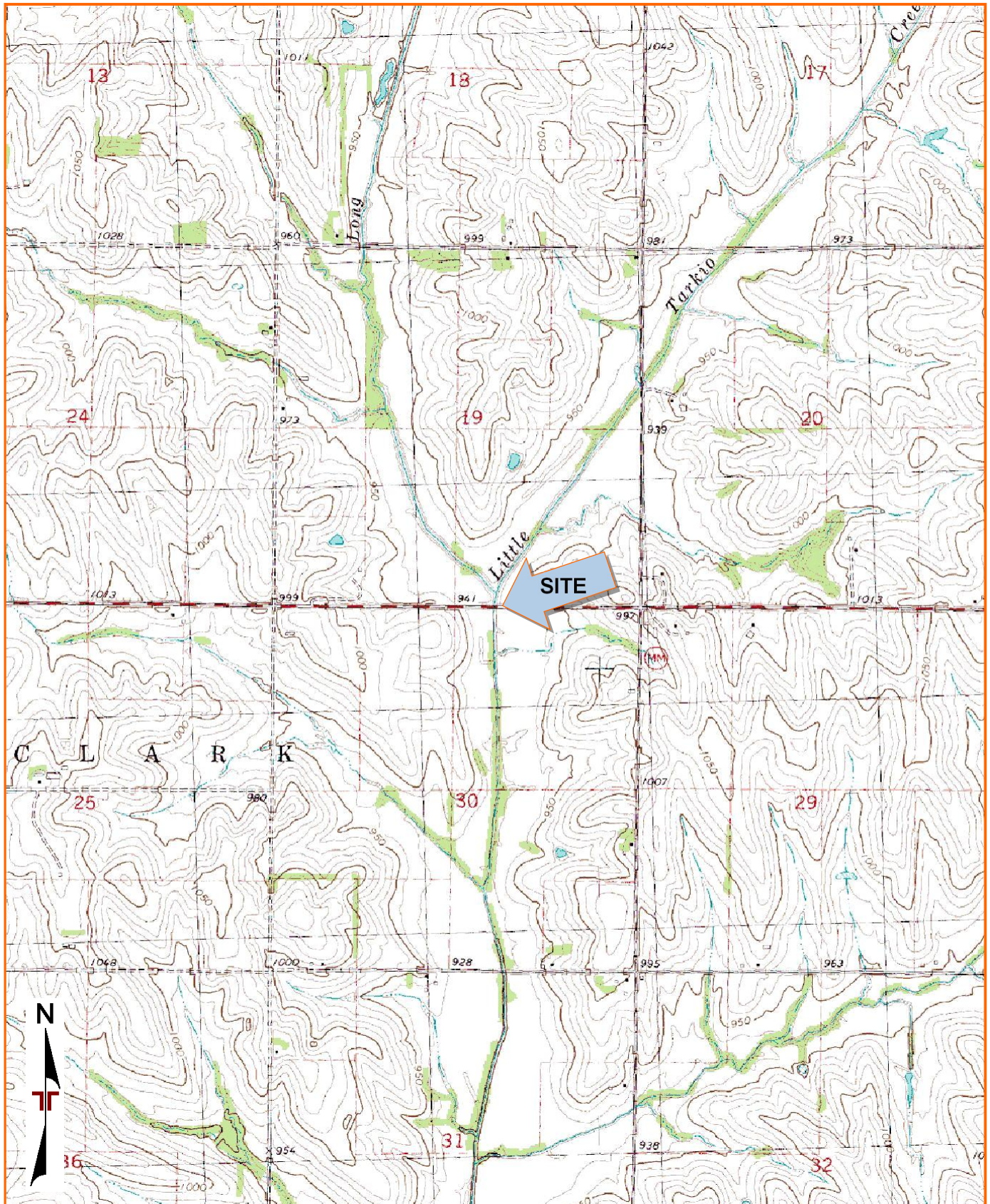


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS  
NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY  
QUADRANGLES INCLUDE: TARKIO SE, MO (1/1/1981).

## EXPLORATION PLAN



## EXPLORATION PLAN

Bridge T0103 – Route 46 over Little Tarkio Creek ■ Atchison County, Missouri  
August 26, 2020 ■ Terracon Project No. 0220P078



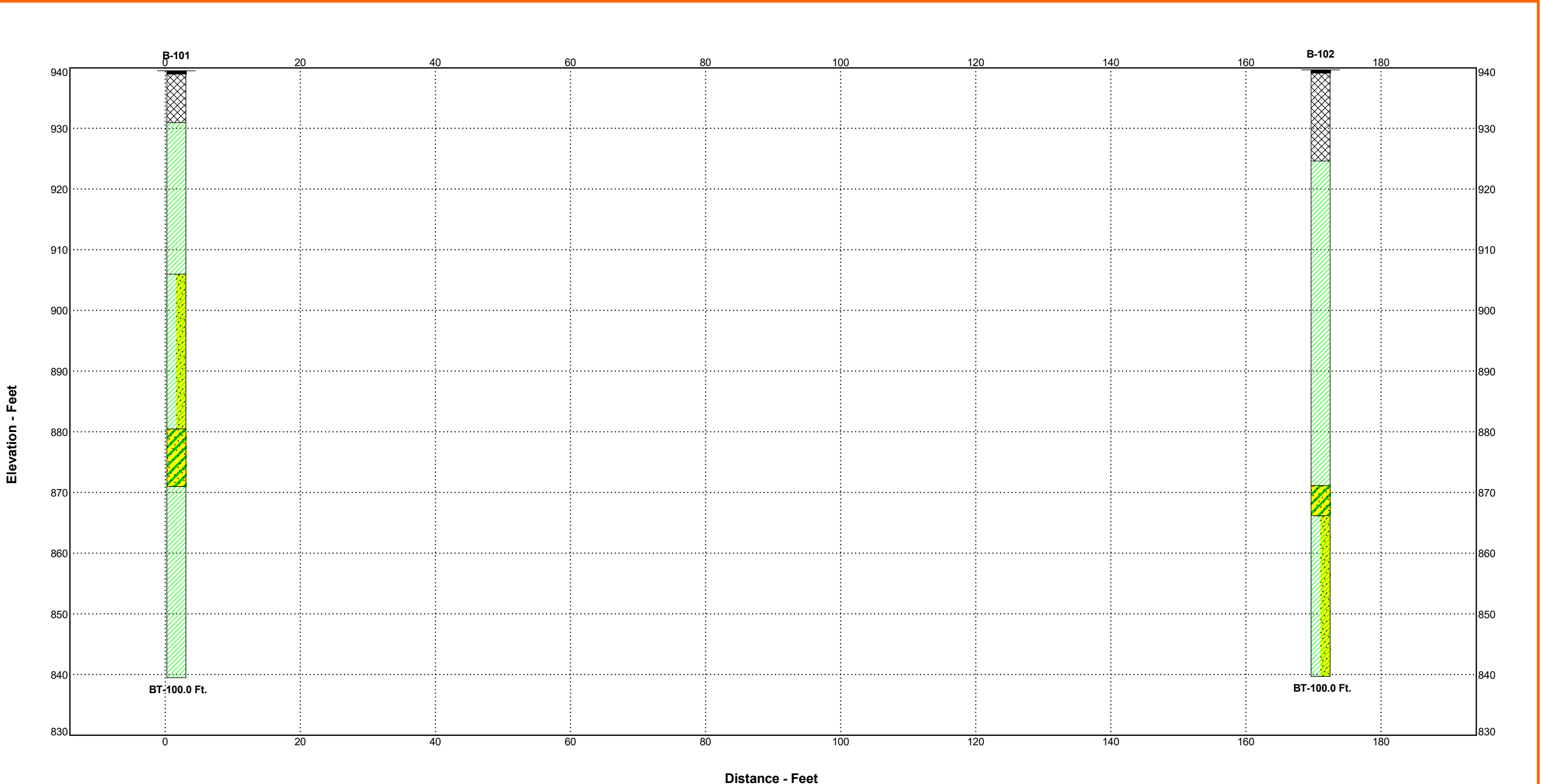
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS  
NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED  
BY MICROSOFT BING MAPS

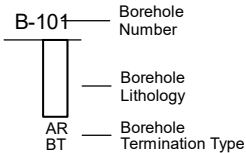
## EXPLORATION RESULTS



THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT: SMART FENCE 0220P078 MODOT FARM BRIDGE.GPJ TERRACON\_DATATEMPLATE.GDT 8/20/20



Explanation



- Asphalt
- Fill
- Lean Clay
- Lean Clay with Sand
- Clayey Sand

NOTES:  
See General Notes in [Supporting Information](#) for symbols and soil classifications.  
Soils profile provided for illustration purposes only.  
Soils between borings may differ  
AR - Auger Refusal  
BT - Boring Termination

Project No.: 0220P078	<div>Terracon</div> <div>15620 W 113th St Lenexa, KS</div>	SUBSURFACE PROFILE
Date: 8/20/2020		BRIDGE T0103 - ROUTE 46 OVER LITTLE TARIKO CREEK ATCHISON COUNTY, MISSOURI
Scale: As shown		

# BORING LOG NO. B-101

Page 1 of 2

**PROJECT:** MoDOT FARM Bridges Project

**CLIENT:** Missouri Department of Transportation  
Hannibal, Missouri

**SITE:** Project J1S0596 - Bridge T0103  
Atchison County, Missouri

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 0220P078 MODOT FARM BRIDGE GPJ TERRACON\_DATATEMPLATE.GDT 8/26/20

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a>	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	BLOW COUNTS (N <sub>60</sub> )	COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	Northing: 1519322.63    Easting: 2554727.49  Surface Elev.: 939.5 (Ft.) DEPTH ELEVATION (Ft.)										
	0.5' <b>6" ASPHALT</b>	939			17		3-3-3 (9)		22.8		
	<b>FILL - LEAN CLAY WITH SAND (CL)</b> , dark gray, soft to medium stiff				6		1-2-1 (5)		23.5		
	8.5'	931			18		0-1-1 (3)		29.8		
	<b>LEAN CLAY (CL)</b> , with silt, dark gray, stiff				18		5-5-4 (14)		24.5		
	soft to medium stiff below 13.5 feet				12		1-1-2 (5)		34.3	49-24-25	
					18		0-0-1 (2)		44.3		
					18		1-2-3 (8)		40.0		
					18		1-1-2 (5)		36.6		
	33.5'	906			18		2-2-2 (6)		32.6		
	<b>LEAN CLAY WITH SAND (CL)</b> , dark gray and gray, medium stiff to stiff				18		1-2-1 (5)		26.3		
					18		1-2-2 (6)		45.9		
					18		1-2-1 (5)		31.6		
					18		4-3-5 (12)		28.5		
	59.0'	880.5			12		3-4-5 (14)		16.9		47
	<b>SANDY LEAN CLAY (CL)</b> , gray, stiff to hard										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:  
0'-5': solid-stem flight augers  
below 5' : mud rotary

Abandonment Method:  
Boring backfilled with Auger Cuttings and/or Bentonite  
Surface Capped with Asphalt

Elevations were provided by others.

Notes:

1) SPT hammer energy transfer ratio (ETR): 90%

## WATER LEVEL OBSERVATIONS

Not encountered prior to initiating mud rotary advancement method

**Terracon**  
15620 W 113th St  
Lenexa, KS

Boring Started: 08-11-2020

Drill Rig: 726

Project No.: 0220P078

Boring Completed: 08-11-2020

Driller: SF

# BORING LOG NO. B-101

Page 2 of 2

**PROJECT:** MoDOT FARM Bridges Project

**CLIENT:** Missouri Department of Transportation  
Hannibal, Missouri

**SITE:** Project J1S0596 - Bridge T0103  
Atchison County, Missouri

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a>	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	BLOW COUNTS (N <sub>60</sub> )	COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	ATTERBERG LIMITS	PERCENT FINES
										LL-PL-PI	
	Northing: 1519322.63    Easting: 2554727.49  Surface Elev.: 939.5 (Ft.) DEPTH _____ ELEVATION (Ft.) _____										
	<b>SANDY LEAN CLAY (CL)</b> , gray, stiff to hard (continued)			X	12		11-15-10 (38)		11.9		
	68.5 _____ 871			X	18		4-7-8 (23)		21.5		
	<b>LEAN CLAY (CL)</b> , trace gravel, dark gray, stiff to very stiff	70		X	18		4-5-6 (17)		21.2		
				X	18		3-5-6 (17)		21.0		
		80		X	1		3-6-7 (20)		26.8		
				X	8		4-5-6 (17)		22.1	40-15-25	
		90		X	18		4-6-8 (21)		21.2		
	100.0 _____ 839.5	100		X	12		3-6-9 (23)		14.6		
	<b>Boring Terminated at 100 Feet</b>										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:  
0'-5': solid-stem flight augers  
below 5' : mud rotary

Abandonment Method:  
Boring backfilled with Auger Cuttings and/or Bentonite  
Surface Capped with Asphalt

Elevations were provided by others.

Notes:

1) SPT hammer energy transfer ratio (ETR): 90%

## WATER LEVEL OBSERVATIONS

Not encountered prior to initiating mud rotary advancement method

**Terracon**  
15620 W 113th St  
Lenexa, KS

Boring Started: 08-11-2020

Drill Rig: 726

Project No.: 0220P078

Boring Completed: 08-11-2020

Driller: SF

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 0220P078 MODOT FARM BRIDGE GPJ TERRACON\_DATATEMPLATE.GDT 8/26/20



# BORING LOG NO. B-102

Page 1 of 2

**PROJECT:** MoDOT FARM Bridges Project

**CLIENT:** Missouri Department of Transportation  
Hannibal, Missouri

**SITE:** Project J1S0596 - Bridge T0103  
Atchison County, Missouri

GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a>  Northing: 1519320.11 Easting: 2554896.89  Surface Elev.: 939.7 (Ft.) DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	BLOW COUNTS (N <sub>60</sub> )	COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	ATTERBERG LIMITS	PERCENT FINES
										LL-PL-PI	
	0.5' <b>6" ASPHALT</b>	939			12		4-4-4 (12)		21.1		
	<b>FILL - LEAN CLAY WITH SAND (CL)</b> , trace silt, dark gray, stiff soft to medium stiff below 3.5 feet				6		2-2-2 (6)		20.9		
		10			12		0-1-1 (3)		26.6		
					12		1-2-1 (5)		27.9	46-21-25	
					12		1-1-1 (3)		36.9		
	<b>LEAN CLAY (CL)</b> , dark gray, soft to medium stiff	15.0 924.5			18		2-3-2 (8)		32.1		
					18		1-2-1 (5)		41.1		
	stiff at 28.5 feet	30			18		2-3-3 (9)		37.4		
					18		0-2-2 (6)		28.4		
	with sand below 39.5 feet	40			18		0-0-2 (3)		30.3	42-25-17	
					18		1-1-1 (3)		27.2		
		50			18		0-1-1 (3)		29.5		
					18		0-0-1 (2)		29.8		
		60			18		0-1-2 (5)		31.3		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:  
0'-5': solid-stem flight augers  
below 5' : mud rotary

Abandonment Method:  
Boring backfilled with Auger Cuttings and/or Bentonite  
Surface capped with concrete

Elevations were provided by others.

Notes:

1) SPT hammer energy transfer ratio (ETR): 90%

## WATER LEVEL OBSERVATIONS

Not encountered prior to initiating mud rotary advancement method

**Terracon**  
15620 W 113th St  
Lenexa, KS

Boring Started: 08-12-2020

Drill Rig: 726

Project No.: 0220P078

Boring Completed: 08-12-2020

Driller: SF

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 0220P078 MODOT FARM BRIDGE GPJ TERRACON\_DATATEMPLATE.GDT 8/26/20



# BORING LOG NO. B-102

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**PROJECT:** MoDOT FARM Bridges Project

**CLIENT:** Missouri Department of Transportation  
Hannibal, Missouri

**SITE:** Project J1S0596 - Bridge T0103  
Atchison County, Missouri

GRAPHIC LOG	LOCATION    See <a href="#">Exploration Plan</a>  Northing: 1519320.11    Easting: 2554896.89  Surface Elev.: 939.7 (Ft.)  DEPTH
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Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:  
0'-5': solid-stem flight augers  
below 5': mud rotary

Abandonment Method:  
Boring backfilled with Auger Cuttings and/or Bentonite  
Surface capped with concrete

Elevations were provided by others.

Notes:

1) SPT hammer energy transfer ratio (ETR): 90%

## WATER LEVEL OBSERVATIONS

Not encountered prior to initiating mud rotary advancement method

**Terracon**  
15620 W 113th St  
Lenexa, KS

Boring Started: 08-12-2020

Drill Rig: 726

Project No.: 0220P078

Boring Completed: 08-12-2020

Driller: SF

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 0220P078 MODOT FARM BRIDGE GPJ TERRACON DATATEMPLATE GDT 8/26/20

## ASTM D4318

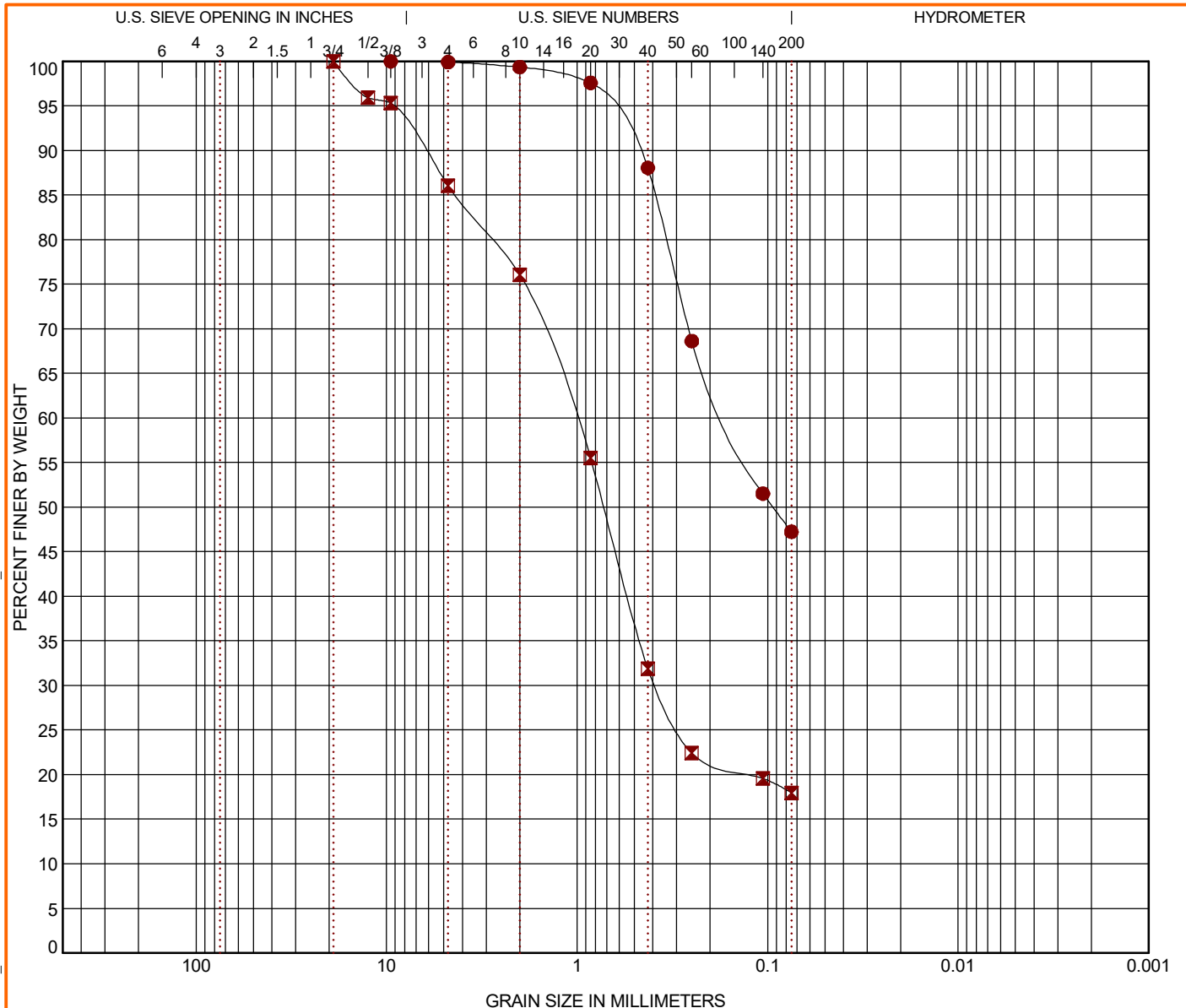


CLIENT: Missouri Department of Transportation  
Hannibal, Missouri

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE USCS-2\_SOUR 0220P078 MODOT FARM BRIDGE.GPJ TERRACON\_DATATEMPLATE.GDT 8/21/20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification				WC (%)	LL	PL	PI	Cc	Cu
● B-101	58.5 - 60					16.9					
■ B-102	68.5 - 70					14.1					
Boring ID	Depth	D <sub>90</sub>	D <sub>50</sub>	D <sub>30</sub>	D <sub>10</sub>	%Gravel	%Sand	%Silt	%Fines	%Clay	
● B-101	58.5 - 60	0.489	0.094			0.1	52.7		47.2		
■ B-102	68.5 - 70	6.378	0.723	0.382		13.9	68.1		18.0		

PROJECT: MoDOT FARM Bridges Project

SITE: Project J1S0596 - Bridge T0103  
Atchison County, Missouri

**Terracon**  
15620 W 113th St  
Lenexa, KS






PROJECT NUMBER: 0220P078

CLIENT: Missouri Department of Transportation  
Hannibal, Missouri

## **SUPPORTING INFORMATION**



## GENERAL NOTES

SAMPLING	WATER LEVEL	FIELD TESTS
 Rock Core  Split Spoon	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	(N) Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer (UC) Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

### DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

### LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

### STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength $q_u$ , (psf)	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12
GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	Particle Size	Term	Plasticity Index
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm)	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

# UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests <sup>A</sup>					Soil Classification	
					Group Symbol	Group Name <sup>B</sup>
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels:	Cu <sup>3</sup> 4 and 1 ≤ Cc ≤ 3 <sup>E</sup>		GW	Well-graded gravel <sup>F</sup>
		Less than 5% fines <sup>C</sup>	Cu < 4 and/or 1 > Cc > 3 <sup>E</sup>		GP	Poorly graded gravel <sup>F</sup>
		Gravels with Fines:	Fines classify as ML or MH		GM	Silty gravel <sup>F, G, H</sup>
		More than 12% fines <sup>C</sup>	Fines classify as CL or CH		GC	Clayey gravel <sup>F, G, H</sup>
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands:	Cu <sup>3</sup> 6 and 1 ≤ Cc ≤ 3 <sup>E</sup>		SW	Well-graded sand <sup>I</sup>
		Less than 5% fines <sup>D</sup>	Cu < 6 and/or 1 > Cc > 3 <sup>E</sup>		SP	Poorly graded sand <sup>I</sup>
		Sands with Fines:	Fines classify as ML or MH		SM	Silty sand <sup>G, H, I</sup>
		More than 12% fines <sup>D</sup>	Fines classify as CL or CH		SC	Clayey sand <sup>G, H, I</sup>
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	PI > 7 and plots on or above “A”		CL	Lean clay <sup>K, L, M</sup>
			PI < 4 or plots below “A” line <sup>J</sup>		ML	Silt <sup>K, L, M</sup>
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay <sup>K, L, M, N</sup>
			Liquid limit - not dried			Organic silt <sup>K, L, M, O</sup>
	Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots on or above “A” line		CH	Fat clay <sup>K, L, M</sup>
			PI plots below “A” line		MH	Elastic Silt <sup>K, L, M</sup>
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay <sup>K, L, M, P</sup>
			Liquid limit - not dried			Organic silt <sup>K, L, M, Q</sup>
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup> Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

<sup>D</sup> Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

$$^E \text{ Cu} = D_{60}/D_{10} \quad \text{Cc} = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

<sup>F</sup> If soil contains <sup>3</sup> 15% sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains <sup>3</sup> 15% gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains <sup>3</sup> 30% plus No. 200 predominantly sand, add "sandy" to group name.

<sup>M</sup> If soil contains <sup>3</sup> 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>N</sup> PI <sup>3</sup> 4 and plots on or above "A" line.

<sup>O</sup> PI < 4 or plots below "A" line.

<sup>P</sup> PI plots on or above "A" line.

<sup>Q</sup> PI plots below "A" line.

