



GEOTECHNICAL DATA REPORT SOUTH BOUND TUNNEL

**Louisville-Southern Indiana Ohio River Bridges Project
Section 4 – East End Approach Twin Tunnels
Jefferson County, Kentucky
Project No. 1831-10-5629**

Prepared For:

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October 7, 2011

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1. PROJECT INFORMATION

The Louisville-Southern Indiana Ohio River Bridges Project is a "priority" national transportation project which addresses long-term, cross-river transportation needs in Louisville, Kentucky and Southern Indiana. It is one of the largest transportation projects in the country and will result in safer travel, less congestion and improved access to destinations in the region. The overall project consists of six segments:

1. Kennedy Interchange
2. New Downtown Bridge
3. Downtown Indiana Approach
4. East End River Bridge
5. Kentucky East End Approach
6. Indiana East End Approach

The tunnel project is part of the Kentucky East End Approach segment. The approximate 2,000 foot twin tunnels begin about 1,000 feet east of the intersection of Highway 841 North and Route 42. The original design of the I-265 extension proposed a conventional open cut roadway through the hillside that includes the Drumanard Estate. The Drumanard Estate was recently placed in the National Registry of Historic Places and must be preserved. This forced the alignment underground into twin tunnels, a northbound and a southbound tunnel. As of this date, the tunnels have an inside finished width of approximately 60 feet with an inside finished height of approximately 41 feet.

The objectives of our subsurface exploration were to determine general subsurface conditions along the proposed alignment and provide geotechnical analysis for design and construction of the proposed tunnel.

An assessment of site environmental conditions for the presence or absence of pollutants in the soil, bedrock, surface water, or groundwater along the alignment or on adjacent properties was beyond the scope of this exploration.

The geotechnical exploration involved field exploration, laboratory testing, and an engineering analysis. The following sections of this report present discussions of the field exploration and laboratory testing programs. Following the text of this report, figures, test boring Logs, and laboratory test results are provided in the Appendices. Our scope of work included the following:

- Drilling a total of 2,287 feet along the South Bound Tunnel section of the alignment.
- Providing a brief review of our field exploration and the results of the laboratory testing conducted.
- Review of subsurface rock stratigraphy with pertinent available physical properties.
- Review of the Packer Test Data
- Providing boring logs

2. GEOLOGY

The project site lies within the Bluegrass Physiographic Province of central Kentucky, which is located near the center of the state and is bordered by the Ohio River in the north and west and a ring of hills known as the Knobs in the west, south, and east. It is a rolling plateau that becomes more rugged near the edges. The Bluegrass Region is characterized by gently rolling hills and fertile soils created by weathering of thick-bedded limestone from the Ordovician and Silurian strata along the crest of the Cincinnati Arch. The soils are fertile because the Ordovician limestones contain phosphate minerals which are natural fertilizers.

The Louisville Bridges Twin Tunnels will encounter three rock formations along the alignment. The Silurian aged Louisville Limestone is the uppermost formation at the project site and is comprised of soluble limestone. The Louisville Limestone is mostly thin-bedded gray dolomitic limestone and gray calcitic dolomite, commonly in lumpy or irregular beds. Shale, in partings and very thin beds, constitutes a few percent, and very sparse chert is present in nodules and thin layers. In the project site, the Louisville Limestone is finely crystalline calcitic dolomite; the sparse fossils are dolomitized and include crinoid columnals, brachiopods, horn corals, and colonial corals.

From an engineering perspective, the Louisville Limestone is characterized by solution enlarged joints and bedding planes. Deep weathering and sinkhole formation are common. The primary impact for conventional building and roadway construction is the presence of latent drop-outs and a highly variable top of rock profile. The residuum derived from the Louisville Limestone is predominantly fat clay with limestone slabs and can exhibit problematic shrink and swell characteristics. For the tunnel, the Louisville Limestone presents several potential problems most associated with the discontinuities such as solution enlarged joints (both horizontal and vertical), solutioning along bedding planes, voids, and sinkholes. The Louisville Limestone can also produce significant groundwater flows after rain events. Water flow is largely along open joints, fractures and bedding planes.

The Waldron Shale is immediately below the Louisville Limestone. The Waldron Shale is composed of greenish-gray shale and minor gray dolomite; with at least 95 percent being shale. The shale is dolomitic and weathers with angular fracture or crude fissility, eventually producing plastic clay. The dolomite is clayey and occurs in irregular masses, lumps, and thin discontinuous beds. Fossils, which are sparse in both the shale and the dolomite, include brachiopods, crinoid columnals, gastropods, and bryozoans. At the tunnel site, the Waldron Shale ranges in thickness from 9 to 15 feet. The basal contact with the underlying Laurel Dolomite is conformable and sharp.

The Waldron Shale breaks down when exposed to water and air. This formation is problematic in conventional earthwork construction as those unfamiliar with its properties, mistakenly place the shale as a durable shot rock fill. Over time the shale will degrade causing structurally significant settlement of buildings and roadways. The Waldron Shale presents a challenge to the construction of the tunnel as the shale is prone to delaminating and degrading during construction of the tunnel.

The Laurel Dolomite underlies the Waldron Shale. The Laurel Dolomite is composed 95 percent or more of gray dolomite with minor greenish-gray shale and sparse gray limestone. The Waldron Shale was encountered to the termination of the South Bound Boring and the Laurel Dolomite was not encountered.

3. LABORATORY GEOTECHNICAL TESTING PROGRAM

The following strength and index tests were performed on selected rock core specimens in general conformance with ASTM International Standards, Kentucky Methods Manual, or other standards where applicable. The laboratory tests were conducted in the S&ME Knoxville, Tennessee Rock Mechanics laboratory and at the Geotechnical Engineering Center at the University of Texas at Austin.

- Axial and Diametrial Point Load Test (D5731)
- Unconfined compressive strength (D7012)
- Direct Shear (D5607)
- Brazilian Stress/Splitting Tensile Strength (D3967)
- Slake Durability Index (D4644)
- Cerchar Abrasivity (D7625)
- Huder-Amberg (Axial Swelling)
- Thin Section Petrographic Analysis
- pH
- Saturation and void ratio

The samples collected for testing were selected from the proposed alignment starting at the tunnel face to the termination of the South Bound Boring. The point load, unconfined compressive strength, and Brazilian Split Tensile tests were selected approximately every 60 feet along the boring starting at a distance of 339.2 feet, which is the distance to the tunnel face, to the termination of the boring at 2,287.0 feet.

The Slake Durability Index (SDI) samples were selected from the Waldron Shale. These samples were collected approximately every 36 feet along the boring starting at the contact of the Waldron Shale (1,100.0 feet). Samples collected for the Cerchar Abrasivity, Huder-Amberg, and petrographic analysis were also selected from the Waldron Shale and then sent to the University of Texas at Austin. The saturation and void ratio testing were selected from the Waldron Shale approximately every 120 feet. The locations of these samples along the alignment were selected by the S&ME geologist in the field based on visual observations and characteristics of the shale.

4. SUBSURFACE CONDITIONS

4.1 GENERAL

Subsurface conditions along the proposed South Bound section of the tunnel alignment were explored with a single horizontal directional core boring. The coordinates for the South Bound Boring alignment were provided by Parsons Engineering, Inc. and used by S&ME in our boring plan. The South Bound Boring was advanced using HQ size core tools to a distance of 199.0 feet. The HQ tools cut a 2.5 inch diameter core and a 3.7 inch diameter boring. From a distance of 199.0 feet NQ size and AQ size directional core equipment was advanced the remainder of the boring. The NQ tools cut a 1.8 inch diameter core and a 3 inch diameter boring. The AQ core was cut during directional drilling. The directional equipment cut a three inch diameter boring and a one inch diameter core. The South Bound Boring was cased with HQ size tools to a distance of 1,480.0 feet to prevent the Waldron Shale from collapsing or swelling in on the drill string. The casing was removed at the completion of the core drilling.

The boring logs for the South Bound Boring indicate the initial boring inclination and azimuth at the boring collar on the top of each page. The inclination and azimuth at the bottom of each page indicates the inclination and azimuth over the drilled distance for that page.

Continuous core samples were collected along the South Bound Boring during both the conventional and directional phases. Our boring logs, laboratory test sheets, and core boxes reference the location of the core with respect to “distance” from the boring collar instead of depth. The report also includes a table of distance from the collar as well as project datum coordinates for each rock core sample interval. The field logging was performed by an S&ME geologist and consisted of:

- Measuring and logging the core and describing the physical appearance and lithology of the rock.
- Identifying and documenting the discontinuities, and bedding planes within the formations.
- Measuring the core recovery and Rock Quality Designation (RQD)
- Selecting specimens for laboratory testing
- Photographing the core after placing the recovered core in the labeled core boxes. The rock core photographs are included in Appendix A of this report.
- Assigning project coordinates of the selected rock core specimens

The Devico System used at the Louisville Bridges tunnel job consists of the DeviDrill, the PeeWee tool, and the DeviFlex. The DeviDrill is the steerable core barrel while both the PeeWee and DeviFlex are used to measure the physical parameters of the borehole. The principle behind the DeviDrill core barrel is a drive shaft running through a bushing, offset from the center line of the tool. Expanding pads operated by a differential pressure is keeping the DeviDrill in a fixed tool face while drilling in a curve. The inner assembly carries an inner tube collecting the core, a mule shoe system, and an instrument barrel with the survey tool

recording inclination and tool orientation. Data is stored inside the tool and downloaded wirelessly to a PDA after each run.

The PeeWee is a miniature electronic multishot based on the same technology as the DeviTool Standard. The PeeWee uses three high-accuracy magnetometers and accelerometers. It records inclination, azimuth, tool face, temperature, gravity vector, magnetic field vector, magnetic dip angle, and battery status.

DeviFlex is a non- magnetic electronic multishot for surveying inside casings and drill strings by simply using the wireline system. The DeviFlex is less prone to magnetic disturbances. The DeviFlex tool consists of two independent measuring systems. Three accelerometers and four strain gauges are used to calculate inclination and change in azimuth. In addition, the DeviFlex records and stores gravity vector, temperature, and battery capacity

Subsurface conditions encountered at the South Bound Boring location are shown on the boring log. The boring log represents our interpretation of the subsurface conditions, based on the field log and visual examination of the field samples by a geotechnical professional.

4.2 BEGINNING OF SOUTH BOUND SECTION TO TUNNEL FACE

The South Bound Boring was located within an abandoned exit ramp from Highway 841. The proposed tunnel alignment encountered gray, slightly weathered, hard, crystalline limestone of the Louisville Limestone formation out to the tunnel face which is located at a distance of 339.2 feet along the alignment. Continuous rock core was collected, logged and photographed from the boring collar to the tunnel face; however laboratory samples were not collected along this portion of the alignment as it was not within the tunnel.

4.3 LOUISVILLE LIMESTONE

The tunnel face of the South Bound section is located at a distance of 339.2 feet along the borehole alignment. From this distance to 1,099.0 feet the Louisville Limestone was encountered which consisted of gray, very slightly weathered, hard, crystalline limestone with occasional joint sets and fossils. Samples were collected along the alignment at approximately every 60 feet. The samples along this section of the alignment were tested for Brazilian Stress, Diametral and Axial Point Load, and Unconfined Compression. The results of these laboratory tests can be found in Appendix B.

4.4 WALDRON SHALE

The South Bound tunnel alignment encountered the Waldron Shale formation at a distance of 1,099.0 feet. The Waldron Shale consisted of light gray calcareous shale, very slightly weathered, hard, with calcite crystals and pyrite along the upper portion of the formation. This portion of the Waldron Shale strongly resembles limestone in appearance, but contains thin, dark gray shale partings and pyrite which are indentifying characteristics of the Waldron Shale.

At a distance of 1,318 feet to 1,400 feet the Waldron Shale transitions from moderately hard to soft, moderately to severely fractured, with fractures occurring nearly horizontal along bedding planes and containing gray soft clay. The Rock Quality Designation (RQD) values ranged from 0 to 89 percent with the majority of the values being between 30 to 50 percent. The recovered shale was platy and occasionally friable along these fractures.

The Waldron Shale becomes slightly fractured to sound at a distance of 1,400.0 feet to 1,730.0 feet. The shale is moderately hard to soft within this section; however the rock was recovered in single solid pieces.

The Waldron Shale becomes soft, friable, severely fractured with thin clay seams along fractures at a distance of 1,730 feet to 2,029 feet. The fractures occurred nearly horizontal along bedding planes and the shale along the fractures is very soft. The RQD values along this section ranged from 0 to 94 percent with the majority of the values being between 30 to 60 percent.

The Waldron Shale continues from 2,029 feet to the end of the South Bound alignment at a distance of 2,287 feet. The shale recovered over this distance was recovered in single solid pieces with the exception of the last run which was soft to moderately hard, severely fractured with fractures occurring nearly horizontal along bedding planes. The bedding planes were clay filled and friable.

Samples were collected for laboratory analysis within the Waldron Shale formation and were tested for Brazilian Stress, Diametral and Axial Point Load, Unconfined Compression, slake durability, saturation and void ratio, and pH. Additional samples were collected and sent to the University of Texas at Austin under chain of custody and were analyzed for Cerchar Abrasivity, Huder-Amber (Axial Swelling), and petrographic analysis. The results of these laboratory tests can be found in Appendix B.

4.5 DISCONTINUITIES

The Louisville Limestone can be observed at road cuts along Highway 181 and Highway 42. The Limestone is weathered to light gray with substantial fossils throughout. Solutional weathering can be observed in the exposed rock extending ten to twenty feet deep into the rock. Reddish brown clay exists within the solution channels.

The features observed within the road cut were not observed within the South Bound Boring rock core. The Louisville Limestone along the alignment was observed to be sound to slightly fractured, hard, and crystalline. No solutional weathering or features were observed within the limestone portion of the alignment.

Water circulation was lost during the drilling process through small fractures and bedding features within the Louisville Limestone and Waldron Shale. Complete water return within the South Bound Boring was lost at approximately 1,100 feet at the contact between the Louisville Limestone and the Waldron Shale.

The Louisville Limestone observed along the boring alignment was observed to be sound to slightly fractured with very wide joint spacing. Most of the recovered limestone was recovered in single solid pieces.

The fractures encountered within the Waldron Shale occurred along bedding planes at low angles to nearly horizontal. The fractures observed contained gray, soft, plastic clay. The aperture of the fractures and clay filled bedding planes was generally two millimeters or less. The weathering along the fractures was only observed within the exposed rock surface at the fracture. The weathering did not penetrate into the rock surface greater than the fracture aperture. The shale along the fractures was friable and easily broken by hand.

5.0 PACKER TESTING

Hydraulic conductivity testing (also known as permeability or “packer” testing) was conducted in the South Bound Boring upon completion of coring activities. The test intervals were selected by KYTC and S&ME based on the results of the coring activities and subsurface conditions encountered in the bedrock.

The permeability test results were reported as Lugeon values. The Lugeon unit is commonly used in grouting practice for measuring the permeability and the grout take potential of bedrock. Reporting the permeability test results using this method allows for the evaluation of the permeability characteristics for each stage tested. The equation to calculate permeability in Lugeon units is:

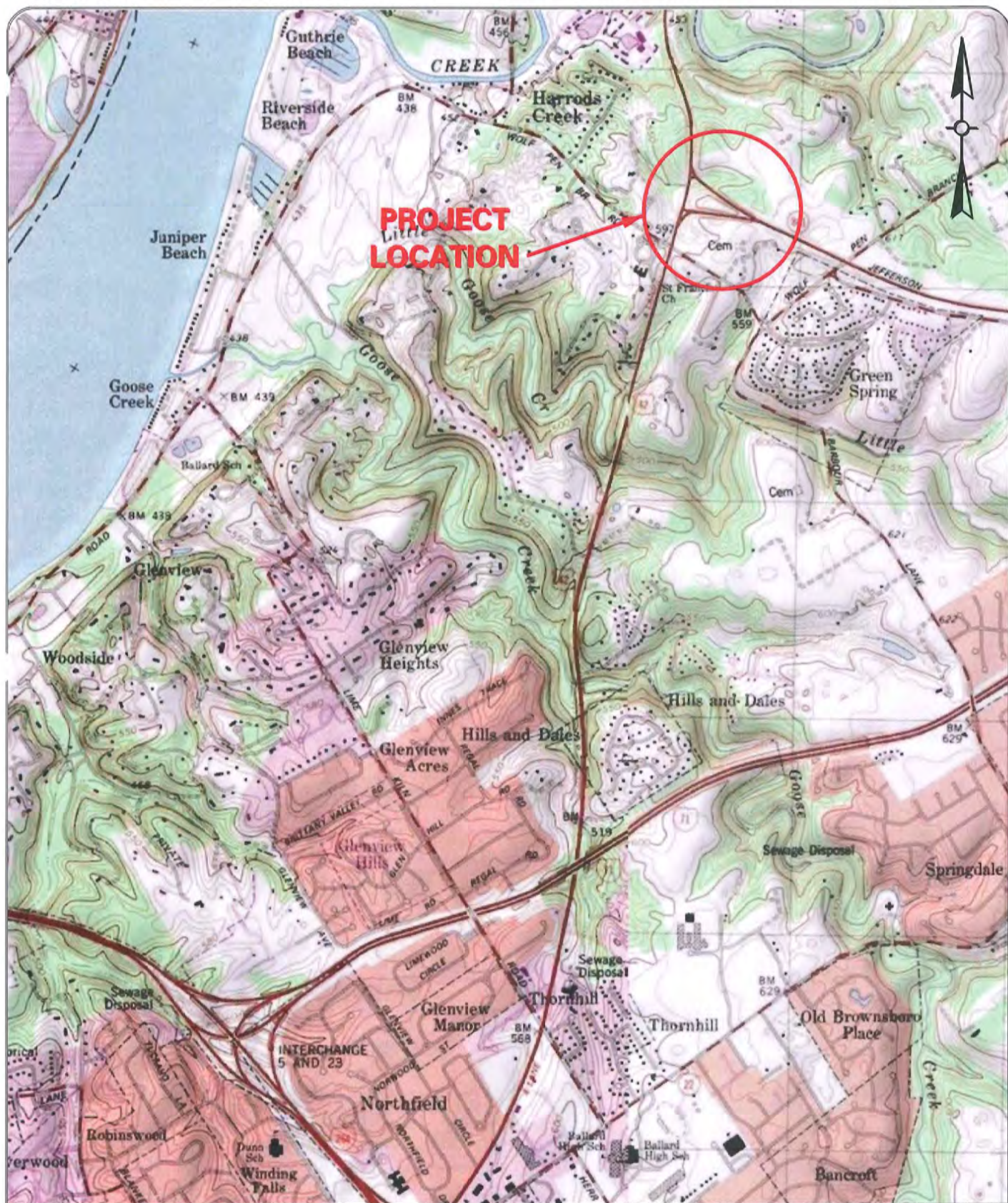
$$L_u = ((\text{Water take, in gallons} \div 7.48 \text{ gal/ft}^3) \times (142 \div \text{gauge pressure in psi})) \\ \text{divided by } (\text{Stage length in feet} \times \text{test time in minutes} \times 0.0107620)$$

The packer system used in the South Bound Boring was provided by Tam International. A packer system consisting of two inflatable packers two feet in length and two or three inches in diameter were set 22 feet apart. The two inch packers were used within the NQ size core section of the boring which was from a distance of 1,470 feet to 2,287 feet. Once the testing was completed within the NQ size core section the two inch packers were removed from the boring and the HQ casing was removed from the boring, the three inch packers were set into the boring to resume the testing back to the tunnel face. Solid steel centralizers were placed above each packer to protect them during the placement into and retrieval from the boring. One inch diameter steel pipes connected the packers with the central section of the steel pipe containing offset holes to allow water to pressurize the test section between the packers. Above the packer at the top of the boring an In-Situ Incorporated transducer was attached. The transducer provided the pressure level within the boring as the water filled the test section between the packers. The transducer assisted in keeping the pressure at each test interval near the selected pressure levels.

The tests were conducted at three pressure intervals with a low pressure of 60 psi and a high pressure of 120 psi. The test results indicated that from 457 feet to 1,287 feet along the boring alignment laminar flow was occurring. Dialation was indicated from 1,357 feet to 1,587 indicating that fractures were being hydraulically opened. At distances of 1,757 feet and

2,257 feet the test results indicated decreased permeability potentially caused by fractures being filled or partially or completely blocked as water flows. All other test intervals indicated laminar flow through the rock formations. The recorded Lugeon values and the hydraulic conductivity summary sheets are included in Appendix C. Refer to the *Legend to Lugeon Values* sheet in Appendix C for additional information describing the Lugeon unit, as well as an explanation of the various flow types that are observed during the water pressure testing.

According to A.C. Houlsby (<http://www.grouters.org/rockgrout/WTEpBody.htm#20>), 1 Lugeon unit is the type of permeability consistent with sound bedrock, 10 Lugeon units typically indicates a permeable formation in which seepage occurs, and 100 Lugeon units is the type of permeability typically observed in heavily jointed bedrock with relatively open joints, or in slightly to moderately jointed bedrock where joints are wide to very widely open (i.e., severe solution zones).



SCALE: 1" = 2000'

DATE: 8/26/11

DRAWN BY: CAC

PROJECT NO:
24305629



S&ME

WWW.SMEINC.COM

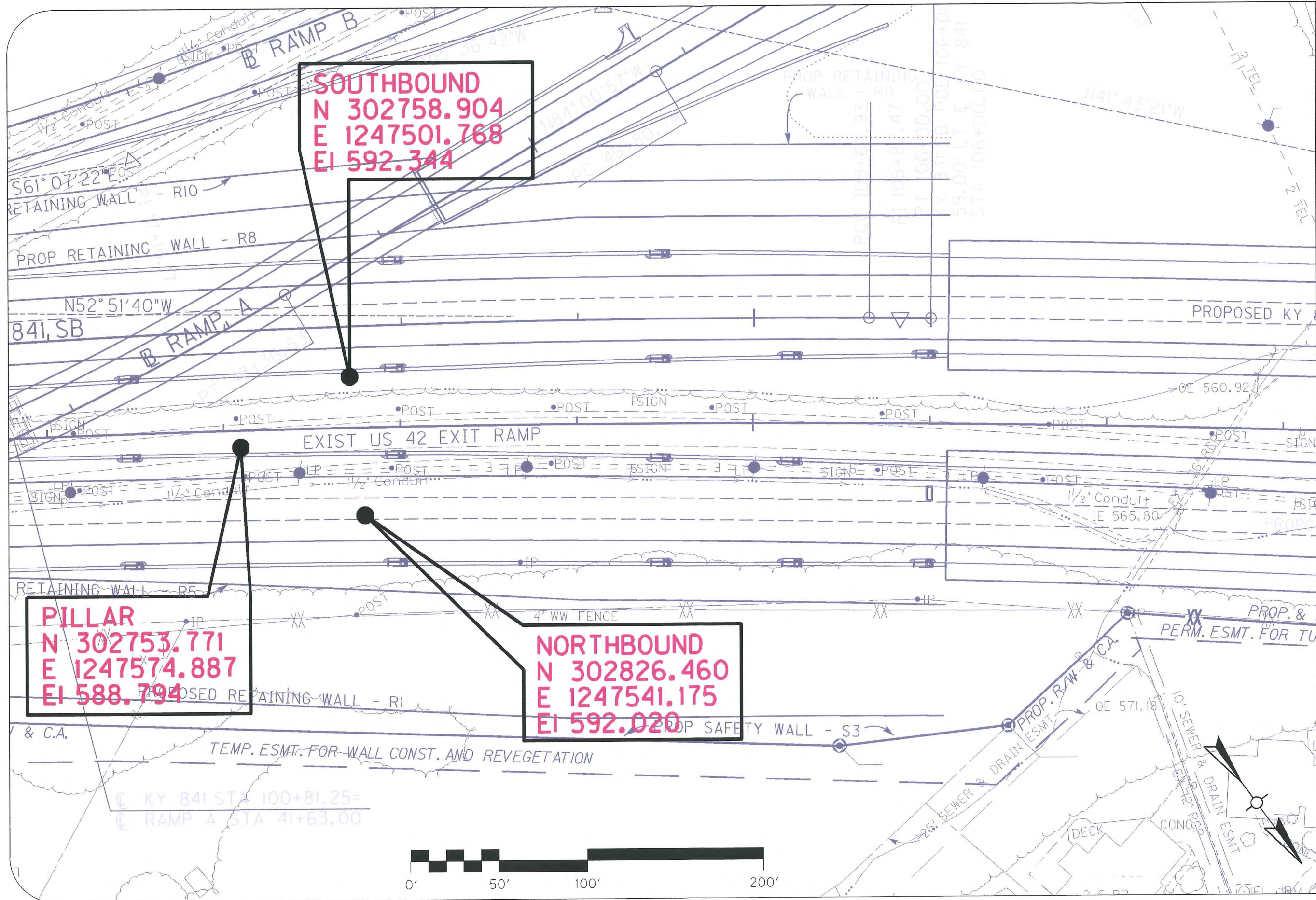
422 CODELL DRIVE, LEXINGTON, KY 40509
PHONE: 859.293.5518

**COLLAR LOCATION
HORIZONTAL DIRECTIONAL BORING
GEOTECHNICAL DATA REPORT**

**LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL**

FIGURE NO.

1



SOUTHBOUND
N 302758.904
E 1247501.768
EI 592.344

PILLAR
N 302753.771
E 1247574.887
EI 588.794

NORTHBOUND
N 302826.460
E 1247541.175
EI 592.020

 S&ME WWW.SMEINC.COM 422 CODELL DRIVE, LEXINGTON, KY 40509 PHONE: 859.293.5518	SCALE: 1" = 50'	DATE: 8/25/11
	PROJECT NUMBER: 24305629	DRAWN BY: CAC
COLLAR LOCATION HORIZONTAL DIRECTIONAL BORING GEOTECHNICAL DATA REPORT		CHECKED BY:
LOUISVILLE SOUTHERN INDIANA OHIO RIVER BRIDGES PROJECT KENTUCKY EAST END APPROACH TUNNEL		DRAWING NUMBER:
FIGURE NO.		
2		

APPENDIX A
BORING LOGS
ROCK CORE PHOTOGRAPHS

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 1 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH BREAK SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING VN-VEIN S-SUCKEN/DED PL-PLANAR C-CURVED										DIAMETRAL POINT LOAD INDEX (psi)	
									RECOVERY		R.Q.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec	TYPE AND SURFACE DESCRIPTION	10" 10" 10" 10" 10"			
									TOTAL CORE %	SOLID CORE %			DP #1/L CORE AXIS							
									0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10			0 1 2 3 4 5 6 7 8 9 10							
0	7/20/2011	GROUND SURFACE																		
5		0.0 ft to 9.0 ft (Run No. 1) LIMESTONE - shot-crete out to 0.55' then into the limestone. Light gray, medium to fine-grained, poorly-sorted, highly fossiliferous, crystalline limestone with occasional chert nodule. Several breaks associated with bedding and heavily oxidized. Two jointing series running along 30 degrees and 45 degrees off vertical. Three jointing breaks throughout run at 4.75', 5.4', and 5.7'.		591.1 9.0	1											J, R J, R J, R				
10		9.0 ft to 19.0 ft (Run No. 2) LIMESTONE - Lithology same as previous run. One joint break at 11.1'; all other breaks are mechanical.		589.6 19.0	2			590								J, R				
20		19.0 ft to 29.0 ft (Run No. 3) LIMESTONE - Lithology same as previous run. Two joint breaks at 25.3' and 25.55'; all other breaks are mechanical.		588.2 29.0	3											J, R J, R				
30		29.0 ft to 38.0 ft (Run No. 4) LIMESTONE - Lithology same as previous run. Solution feature (void) associated with bedding from 30.8' to 32.45'; all other breaks are mechanical.			4											Azimuth: 305.38 Inclination: -0.54 FR, R, Solution feature				
— CONTINUED NEXT PAGE —																				

SME ROCK GLO NEW GPJ GLDR LDN GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NO/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 2 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE ft/min	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SUCKEN/SIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH. BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																		
									RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/sec				TYPE AND SURFACE DESCRIPTION																																																																																																																																																																																																																																																																																																																																																
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SME ROCK GLO NEW.GPJ GLDR_LDNG.DOT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 3 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	ELEVATION	CORRELATION										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

SME ROCK LOG NEW.GPJ GLDR_LDNGDT_9/29/11 DATA INPUT:

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 4 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	DISCONTINUITY DATA										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24° AZIMUTH: $N 305^{\circ}E$

SHEET 5 OF 73

DATUM: NAVD 88

[illegible]

SSME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING:302758.9

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 6 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED										SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR										FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED										BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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PROJECT: Jefferson County, Louisville Tunnel
LOCATION: Louisville, Kentucky
PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9
EASTING: 1247501.77
INCLINATION: -8.24°
AZIMUTH: N 305°E

SHEET 7 OF 73
DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH COLOR % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SUCKEN/SIDED										SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR										FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED										BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 8 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (ft/min)	COLOR	% RETURN	FLUSH	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED										SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR										FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED										BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
				DISTANCE (ft)	R.Q.D. %							RECOVERY		R.Q.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Board Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 9 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH COLOR % RETURN	ELEVATION	CORRECTION										DIAMETRAL POINT LOAD INDEX (psi)		
									FR-FRACTURE		F-FAULT		R-SMOOTH		FL-FLEXURED		BC-BROKEN CORE			HYDRAULIC CONDUCTIVITY K, cm/sec	DIAMETRAL POINT LOAD INDEX (psi)
									CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK				
									SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		B-BEDDING				
									VN-VEIN		S-SUCKEN SIDED		PL-PLANAR		C-CURVED						
RECOVERY		R.O.D. %		FRACT. INDEX PER FT		DISCONTINUITY DATA															
TOTAL CORE %		SOLID CORE %		D.P.W.L. CORE AXES		TYPE AND SURFACE DESCRIPTION															
55.5		55.5		55.5		55.5		55.5		55.5		55.5									
--- CONTINUED FROM PREVIOUS PAGE ---																					
255	AQ Core	253.0 ft to 263.0 ft (Run No. 30) LIMESTONE - Lithology same as previous run. One joint break at 261.4'; all other breaks are mechanical. Note: Terminate AQ directional core at 263.0 feet and begin NQ core.	556.1 253.0	29	30	555	554.6 263.0	31	553.2 273.0	32	551.8 283.0	33	Azimuth: 305.62 Inclination: -9.20								
260																					
265	NQ Core	263.0 ft to 273.0 ft (Run No. 31) LIMESTONE - Lithology same as previous run; mechanical breaks only. Note: Terminate NQ core at 273.0 feet and begin AQ directional core.	554.6 263.0	30	31	555	553.2 273.0	32	551.8 283.0	33	Azimuth: 305.62 Inclination: -9.20										
270																					
275	AQ Core	273.0 ft to 283.0 ft (Run No. 32) LIMESTONE - Light gray, medium to fine grained, well sorted, crystalline limestone with minimal fossil content, displaying a very consistent matrix. Mechanical breaks only.	553.2 273.0	31	32	555	551.8 283.0	33	551.8 283.0	33	Azimuth: 305.62 Inclination: -9.20										
280																					
--- CONTINUED NEXT PAGE ---																					

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

EASTING:1247501.77

INCLINATION: -8.24° AZIMUTH: N 305°E

SHEET 10 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (%)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN												F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

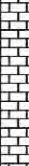
DRILLING METHOD: HQ/NQ/AQ

EASTING:1247501.77

INCLINATION: -8.24° AZIMUTH: N 305° E

SHEET 14 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (Munsell)	FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED										HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (psi)	
										RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		TYPE AND SURFACE DESCRIPTION						
										TOTAL CORE %	SOLID CORE %			D.P. #1 CORE AXES	TYPE AND SURFACE DESCRIPTION							
										50 50 50 50	50 50 50 50			50 50 50 50			50 50 50 50					
— CONTINUED FROM PREVIOUS PAGE —																						
410	AQ Core	403.0 ft to 413.0 ft (Run No. 45) LIMESTONE - The weathered phosphatic shale seam associated with bedding ends at 409.0' (397.3' to 409.0'). Below the shale seam the limestone described in previous run is encountered; all other breaks mechanical.		533.1 413.0	45																	
415																						
420		413.0 ft to 423.0 ft (Run No. 46) LIMESTONE - Light gray, medium to fine grained, moderately to well sorted, crystalline limestone with minimal fossil content, displaying a very consistent matrix. Mechanical breaks only.																				
425																						
430		423.0 ft to 433.0 ft (Run No. 47) LIMESTONE - Lithology has been slowly grading from a coarse grained, poorly sorted, with a conglomerate type fossiliferous matrix limestone from just beneath the shale seam that stopped at 409.0' into a consistent matrix of fine grained, well sorted, crystalline limestone exhibiting larger sized individual fossils; mechanical breaks only.		531.7 423.0	46																	
435																						
440		433.0 ft to 443.0 ft (Run No. 48) LIMESTONE - Lithology same as previous run; mechanical breaks only. Note: Terminate AQ directional core at 443.0 feet and begin NQ core.																				
445																						
— CONTINUED NEXT PAGE —																						

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING:302758.9

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 15 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SUCKER-SIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)
									RECOVERY		R.Q.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/sec																		
									TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION																						
									50 50																										

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boat Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

EASTING:1247501.77

INCLINATION: -8.24° AZIMUTH: N 305°E

SHEET 16 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	CORRECTIONS										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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CSME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 18 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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Azimuth: 308.40
Inclination: -2.25

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

RECORD OF DRILLHOLE: South Bound

SHEET 22 OF 73

LOCATION: Louisville, Kentucky

DRILLING DATE: 7/20/2011

NORTHING:302758.9

DATUM: NAVD 88

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247501.77

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION											DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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DISTANCE SCALE

DRILLING CONTRACTOR:Boart Longyear

1 inch to 4 feet

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

SME ROCK GLO NEW.GPJ GLDR.LDN.GDT 9/29/11 DATA INPUT:

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 33 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SUCKEN-SIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH. BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)
									RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/sec																		
									TOTAL CORE %	SOLID CORE %			DP #11 CORE AXIS	TYPE AND SURFACE DESCRIPTION			1"	1"	1"	1"															
									100	200			300	400	500	600	700	800	900	1000															
— CONTINUED FROM PREVIOUS PAGE —																																			
1010	AQ Core	1003.0 ft to 1013.0 ft (Run No. 107) LIMESTONE - Gray; very slight weathering; hard; crystalline; slightly fractured with fractures at 1009.5' to 1009.9'; joints at 1010.9' to 1012.1'; occasional calcite vugs.		447.2	107																														
		1013.0																																	
1015		1013.0 ft to 1023.0 ft (Run No. 108) LIMESTONE - Same as previous run; joints at 1015.2' and 1016.8'.			108																														
1020	AQ Core			445.7																															
		1023.0																																	
1025		1023.0 ft to 1033.0 ft (Run No. 109) LIMESTONE - Same as previous run; all breaks mechanical caused by directional tool. Note: Terminate AQ directional core at 1033.0 feet and begin NQ core.			109	445																													
1030																																			
1035	NQ Core	1033.0 ft to 1039.0 ft (Run No. 110) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline.		444.3																															
		1033.0																																	
				443.4																															
				1039.0	111																														
— CONTINUED NEXT PAGE —																																			

SME ROCK GLO NEW.GPJ GLDR_LDRNGDT 8/28/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 34 OF 73

DATUM: NAVD 88

[illegible]

1 inch to 4 feet

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 35 OF 73

DATUM: NAVD 88

[illegible]

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 36 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH % RETURN	ELEVATION	FRACTURE / FAULT / SMOOTH / FLEXURED / BROKEN CORE										DIAMETRAL POINT LOAD INDEX (psi)	
									FR-FRACTURE		F-FAULT		SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE			
									CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH BREAK	B-BEDDING	DISCONTINUITY DATA					
									SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	TYPE AND SURFACE DESCRIPTION							
									VN-VEIN	S-SUCKEN/SLIDED	PL-PLANAR	C-CURVED	HYDRAULIC CONDUCTIVITY k, cm/sec							
									RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DP #11 CORE AXIS							
									TOTAL CORE %	SOLID CORE %										
		— CONTINUED FROM PREVIOUS PAGE —																		
1105	NO Core	1099.0 ft to 1109.0 ft (Run No. 117) SHAILE - Gray; very slight weathering; sound; moderately hard; fine grained; calcareous; occasional thin calcite veins. Waldron Shale encountered at 1099.0 feet			117															
1110			433.4 1109.0																	
1115		1109.0 ft to 1119.0 ft (Run No. 118) SHAILE - Same as previous run; all breaks mechanical.			118															
1120	NO Core	1119.0 ft to 1129.0 ft (Run No. 119) SHAILE - Gray; very slight weathering; moderately hard; sound; fine grained; calcareous; with healed fractures containing dark gray, moderately hard shale.			119															
1125			430.5 1129.0																	15396
1130		1129.0 ft to 1139.0 ft (Run No. 120) SHAILE - Same as previous run; all breaks mechanical.			120			430												
		— CONTINUED NEXT PAGE —																		

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 37 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR LOG	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN												F-FAULT J-JOINT P-POLISHED S-SLICKENS/DED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH. BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)
										RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																						
										TOTAL CORE %	SOLD CORE %			DP #1 CORE AXES	TYPE AND SURFACE DESCRIPTION																							
										10"	100"			1000"	10000"		10"	100"	1000"	10000"																		
— CONTINUED FROM PREVIOUS PAGE —																																						
1135	NO Core	1129.0 ft to 1139.0 ft (Run No. 120) SHALE - Same as previous run; all breaks mechanical.		429.1	120																																	
1140		1139.0																																				
1145																																						
1150		427.7		1149.0																																		
1155		1149.0 ft to 1159.0 ft (Run No. 122) SHALE - Gray; very slight weathering; hard; sound; fine grained with thin crystalline calcareous seams; healed fractures with dark gray; moderately hard shale.			122																																	
	426.2	1159.0																																				
1160		1159.0 ft to 1169.0 ft (Run No. 123) LIMESTONE - Gray; very slight weathering; hard; sound; crystalline; with fossils.				123																																
1165																																						
— CONTINUED NEXT PAGE —																																						

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons

425



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING:302758.9

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 38 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK SH-SHEAR P-POLISHED ST-STEPPED PL-PLANAR W-WAVY B-BEDDING VN-VEIN S-SLICKENSIDED C-CURVED										DIAMETER POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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19024

Azimuth: 311.30
Inclination: -0.95

S&ME ROCK GLO NEW.GPJ GLDR, LONGOT 9/29/11, DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 39 OF 73

DATUM: NAVD 88

[illegible]

1 inch to 4 feet

DRILLER:D. Sammons



CHECKED: CSL

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 41 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	SYMBOLIC LOG	DESCRIPTION	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE										F-FAULT										SM-SMOOTH										FL-FLEXURED										BC-BROKEN CORE										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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1260	NQ Core 8/13/2011		1259.0 ft to 1269.0 ft (Run No. 133) SHALE - Dark gray; slightly weathered; moderately hard to soft along fractures; moderately fractured with fractures occurring at low angles along dark gray, soft shale; fine grained; calcareous; thinly bedded.	410.5	133																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										</

S&ME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/28/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24° AZIMUTH: $N 305^{\circ}E$

SHEET 42 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	FLUSH	ELEVATION	CORRECTION DATA										DIAMETER POINT LOAD INDEX (psi)				
										FR-FRACTURE		F-FAULT		S-SMOOTH		FL-FLEXURED		BC-BROKEN CORE						
										CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH BREAK						
										SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		B-BEDDING						
									RECOVERY		R.O.D. %		FRACT. INDEX PER FT		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec							
									TOTAL CORE %		SOLID CORE %				DP = 11 CORE AXIS		TYPE AND SURFACE DESCRIPTION		10 10 10 10 10 10 10 10 10 10					
									0.0000		0.0000		0.0000		0.0000		0.0000		0.0000					
— CONTINUED FROM PREVIOUS PAGE —																								
1295	AQ Core	1289.0 ft to 1298.0 ft (Run No. 136) SHALE - Same as previous run; all breaks mechanical.			136																			
1300																								
1305	AQ Core	1298.0 ft to 1308.0 ft (Run No. 137) SHALE - Gray; slightly weathered; slightly fractured with fractures at 1300.1', 1304.3' to 1305.6' (with clay); moderately hard with the exposed rock at fractures being soft; shale is fine grained; calcareous; thinly bedded; pyritic.			137																			
1310																								
1315	AQ Core	1308.0 ft to 1318.0 ft (Run No. 138) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; calcareous; thinly bedded; pyritic.			138																			
1320																								
	AQ Core	1318.0 ft to 1328.0 ft (Run No. 139) SHALE - Gray; very slight weathering; moderately hard; moderately fractured with low angle fractures at 1323.2' to 1328.0'. Shale is fine grained; calcareous; thinly bedded; pyritic.			139																			
— CONTINUED NEXT PAGE —																								

USME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 43 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	SYMBOLIC LOG	DESCRIPTION	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE F-FAULT J-JOINT R-ROUGH SH-SHEAR P-POLISHED S-SLICKENSIDED VN-VEIN SMSMOOTH R-ROUGH ST-STEPPED PL-PLANAR FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED BC-BROKEN CORE MB-MECH BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)
										RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec				
										TOTAL CORE %	SOLID CORE %			OP w / L CORE AVG	TYPE AND SURFACE DESCRIPTION					
										100	100			100	100		100	100		
— CONTINUED FROM PREVIOUS PAGE —																				
1325	AQ Core	8/15/2011	1318.0 ft to 1328.0 ft (Run No. 139) SHALE - Gray; very slight weathering; moderately hard; moderately fractured with low angle fractures at 1323.2' to 1328.0'. Shale is fine grained; calcareous; thinly bedded; pyritic.	1328.0	139															
1330			1328.0 ft to 1333.0 ft (Run No. 140) SHALE - Gray; very slight weathering; moderately hard; severely fractured. Note: Rock core blocked off in inner barrel.	401.3	140															
1335	AQ Core	8/15/2011	1333.0 ft to 1343.0 ft (Run No. 141) SHALE - Gray; slightly weathered; moderately hard; moderately fractured with fractures occurring at low angles at 1334.4' to 1337.7' and 1338.4' to 1339.2'. Fractures contain clay and soft shale. Shale is fine grained; thinly bedded; pyritic.	1333.0	141															
1340				399.9	141															
1345	NO Core	8/15/2011	1343.0 ft to 1349.0 ft (Run No. 142) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; calcareous; pyritic.	1343.0	142															
1350			1349.0 ft to 1359.0 ft (Run No. 143) SHALE - Gray; slightly weathered; moderately fractured with clay at fractures. Fractures occur at low angles. Fractures at 1350.0' to 1353.7', 1355.7' to 1356.1', and 1358.0'. Shale at fractures is soft and friable. Shale surrounding fractures is moderately hard; fine grained; thinly bedded; calcareous.	399.0	143															
— CONTINUED NEXT PAGE —																				

SME ROCK GLO NEW/GPJ GLDR_LON.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 44 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH BREAK SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING VN-VEIN S-SUCKEN/DED PL-PLANAR C-CURVED										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
										RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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1355	NO Core	1349.0 ft to 1359.0 ft (Run No. 143) SHALE - Gray; slightly weathered; moderately fractured with clay at fractures. Fractures occur at low angles. Fractures at 1350.0' to 1353.7', 1355.7' to 1356.1', and 1358.0'. Shale at fractures is soft and friable. Shale surrounding fractures is moderately hard; fine grained; thinly bedded; calcareous.		397.6 1359.0	143																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302759.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 45 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH COLOR % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED										SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR										FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED										BC-BROKEN CORE MB-MECH BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 46 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED BC-BROKEN CORE MB-MECH BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)	
									RECOVERY		R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	TYPE AND SURFACE DESCRIPTION				
									TOTAL CORE %	SOLID CORE %			DP #11 CORE AVG	DP #11 CORE MAX						
									FLUSH	%			FLUSH	%			FLUSH	%		FLUSH
— CONTINUED FROM PREVIOUS PAGE —																				
		1409.0 ft to 1419.0 ft (Run No. 149) SHALE - Same as previous run; all breaks mechanical.		389.0	149															
1420				1419.0																
		1419.0 ft to 1429.0 ft (Run No. 150) SHALE - Same as previous run; all breaks mechanical.			150															
1425																				
				387.5																
1430				1429.0																
		1429.0 ft to 1439.0 ft (Run No. 151) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; calcareous.			151															
1435																				
				386.1																
1440				1439.0																
		1439.0 ft to 1449.0 ft (Run No. 152) SHALE - Same as previous run; all breaks mechanical.			152															
1445																				
				384.7																
		— CONTINUED NEXT PAGE —																		

9468

385

Azimuth: 312.44
Inclination: -2.59

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

PROJECT NUMBER: 1831-10-5629

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

DATUM: NAVD 88

PSME ROCK GLO NEW.GPJ GLDR LDN.GDT 9/29/11 DATA INPUT:

1 inch to 4 feet

DRILLER:D. Sammons



CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 48 OF 73

DATUM: NAVD 88

[illegible]

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel
LOCATION: Louisville, Kentucky
PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9
EASTING: 1247501.77
INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 49 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 50 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION											DIAMETRAL POINT LOAD INDEX (psi)
									FR-FRACTURE		F-FAULT		SMSMOOTH		FL-FLEXURED		BC-BROKEN CORE		
									CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK		
									SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		B-BEDDING		
VN-VEIN		S-SLICKENSIDED		PL-PLANAR		C-CURVED													
RECOVERY		R.O.D. %		FRACT. INDEX PER FT		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec											
TOTAL CORE %	SOLID CORE %																		
99999	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999				
TYPE AND SURFACE DESCRIPTION																			

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

SME ROCK GLO NEW.GPJ GLDR.LONGDT 9/29/11 DATA INPUT:

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24° AZIMUTH: N 305° E

SHEET 51 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	SYMBOLIC LOG	DESCRIPTION	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	ELEVATION	CORRECTION										DIAMETRAL POINT LOAD INDEX (psi)		
									RECOVERY		FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec							
									TOTAL CORE %	SOLID CORE %		OP well CORE AXIS	TYPE AND SURFACE DESCRIPTION								
									FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED		SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED		BC-BROKEN CORE MB-MECH. BREAK B-BEDDING						
1575	— CONTINUED FROM PREVIOUS PAGE —																				
1580	831/2011 AQ Core		1578.0 ft to 1584.0 ft (Run No. 168) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.	366.2 1578.0	168			365													
1585	NO Core		1584.0 ft to 1594.0 ft (Run No. 169) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.	365.3 1584.0	169																
1590			1594.0 ft to 1604.0 ft (Run No. 170) SHALE - Same as previous run; all breaks mechanical.	363.9 1594.0																	
1595			1604.0 ft to 1614.0 ft (Run No. 171) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.	362.5 1604.0	171																
1600	— CONTINUED NEXT PAGE —																				

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PSME ROCK GLO NEW.GPJ GLDR LDN.GDT 9/29/11 DATA INPUT:

PROJECT: Jefferson County, Louisville Tunnel
 LOCATION: Louisville, Kentucky
 PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

SHEET 52 OF 73
 DATUM: NAVD 88

DRILLING DATE: 7/20/2011 NORTHING: 302758.9
 DRILL RIG: LM90 EASTING: 1247501.77
 DRILLING METHOD: HQ/NQ/AQ INCLINATION: -8.24° AZIMUTH: N 305°E

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH BREAK SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING VN-VEIN S-SUCKER SIDED PL-PLANAR C-CURVED										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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5574

Azimuth: 315.06
 Inclination: 0.0

SME ROCK GLO NEW.GPJ GLDR.LDNGDT 9/29/11 DATA INPUT:

DISTANCE SCALE
 1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear
 DRILLER: D. Sammons



LOGGED: NJP
 CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel
 LOCATION: Louisville, Kentucky
 PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

SHEET 54 OF 73
 DATUM: NAVD 88

DRILLING DATE: 7/20/2011 NORTHING: 302758.9
 DRILL RIG: LM90 EASTING: 1247501.77
 DRILLING METHOD: HQ/NQ/AQ INCLINATION: -8.24° AZIMUTH: N 305°E

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SUCKEN/DED	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH BREAK B-BEDDING	DIAMETRAL POINT LOAD INDEX (psi)
		--- CONTINUED FROM PREVIOUS PAGE ---												
1670	NQ Core	1664.0 ft to 1674.0 ft (Run No. 177) SHALE - Gray, moderately weathered; soft to moderately hard; severely fractured with fractures occurring throughout run. Fractures occur at low angles to 30 degrees. Fractures contain clay and soft shale along fractures. Aperture of fractures are approximately 2 mm into core. Shale is fine grained; occasionally friable; thinly bedded.			177									
				352.4 1674.0										
1675	NQ Core	1674.0 ft to 1684.0 ft (Run No. 178) SHALE - Gray; very slight weathering; slightly fractured at 1674.0' to 1676.0' with clay at fracture. The fracture is a continuation of fractures from the previous run. Shale is sound from 1676.0' to the end of the run; fine grained; thinly bedded.			178									
1680				351.0 1684.0										
1685	NQ Core	1684.0 ft to 1694.0 ft (Run No. 179) SHALE - Gray; very slight weathering; soft; sound; fine grained; thinly bedded; all breaks mechanical.			179									
1690				349.6 1694.0										
1695	NQ Core	1694.0 ft to 1704.0 ft (Run No. 180) SHALE - Gray; slightly weathered; slightly fractured with fracture at 1701.5' to 1703.0'; fracture occurs at low angle with clay; shale is moderately hard, fine grained, thinly bedded.			180									
1700														
		--- CONTINUED NEXT PAGE ---												

SME ROCK GLO NEW.GPJ GLDR_LDRING.DAT 9/29/11 DATA INPUT:

DISTANCE SCALE
 1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear
 DRILLER: D. Sammons



LOGGED: NJP
 CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel
LOCATION: Louisville, Kentucky
PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9
EASTING: 1247501.77
INCLINATION: -8.24°
AZIMUTH: N 305°E

SHEET 55 OF 73
DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH BREAK SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING VN-VEIN S-SUCKEN/DED PL-PLANAR C-CURVED												DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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SME ROCK GLO NEW.GPJ GLDR LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear
DRILLER: D. Sammons



LOGGED: NJP
CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 56 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH COLOR	% RETURN	ELEVATION	CORRECTION										DIAMETRAL POINT LOAD INDEX (psi)	
										FR-FRACTURE		F-FAULT		SM-SMOOTH		FL-FLEXURED		BG-BROKEN CORE			
										CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK			
										SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		B-BEDDING			
VN-VEIN		S-SLICKENSIDED		PL-PLANAR		C-CURVED															
RECOVERY		R.O.D. %		FRACT. INDEX PER FT		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec													
TOTAL CORE %		SOLID CORE %				D.P. w/L CORE AXIS		TYPE AND SURFACE DESCRIPTION													
— CONTINUED FROM PREVIOUS PAGE —																					
1724.0 ft to 1734.0 ft (Run No. 183) SHALE - Same as previous run; all breaks mechanical.																					
1734.0 ft to 1744.0 ft (Run No. 184) SHALE - Gray; very slight to moderately weathered; slightly fractured with fracture at 1738.0' to 1744.0'. Fracture occurs at low angle with clay; moderately hard shale throughout run; fine grained; thinly bedded.																					
1744.0 ft to 1754.0 ft (Run No. 185) SHALE - Same as previous run; fractures at 1744.0' to 1745.0' (continued from previous run) and 1749.5' to 1752.9'. Fractures occur at low angle.																					
1754.0 ft to 1764.0 ft (Run No. 186) SHALE - Gray; slight weathering with clay seam at 1757.3' to 1758.1'. Shale is moderately hard; sound; fine grained; thinly bedded.																					
— CONTINUED NEXT PAGE —																					

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel
LOCATION: Louisville, Kentucky
PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9
EASTING: 1247501.77
INCLINATION: -8.24°
AZIMUTH: N 305°E

SHEET 57 OF 73
DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SUCKEN/SLIDED										SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR										FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED										BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 58 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE										F-FAULT		SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETRAL POINT LOAD INDEX (psi)
										CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH BREAK		B-BEDDING								
										SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		C-CURVED										
										S-SUCKERSIDED		PL-PLANAR																
RECOVERY		R.O.D. %		FRACT. INDEX PER FT		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																				
TOTAL CORE %	SOLID CORE %	DP #1 CORE AXIS	TYPE AND SURFACE DESCRIPTION	k ₁	k ₂	k ₃	k ₄																					
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— CONTINUED FROM PREVIOUS PAGE —										335																1809		
1800	NQ Core 9/4/2011	1794.0 ft to 1804.0 ft (Run No. 191) SHALE - Gray; slightly weathered; moderately fractured with fractures at 1784.0' to 1784.6' (continued from previous run) and 1799.0' to 1801.0'. Fractures occur at low angle to 30 degrees and contain clay. Shale is fine grained, moderately hard, thinly bedded.			191																							
				333.8 1804.0																								
1805	NQ Core	1804.0 ft to 1814.0 ft (Run No. 192) SHALE - Gray; slightly weathered from 1804.0' to 1810.0' then is moderately weathered, moderately fractured with fractures occurring at low angles to 30 degrees to end of run. Shale is fine grained, moderately hard, thinly bedded.			192																							
				332.4 1814.0																								
1810																												
1815	NQ Core	1814.0 ft to 1824.0 ft (Run No. 193) SHALE - Gray; moderately weathered; moderately fractured at 1814.0' to 1816.2' then is sound out to 1821.3'. From 1821.3' shale is moderately fractured, slightly weathered, moderately hard, with clay at fractures and fractures occurring near horizontal to end of run.			193																							
				330.9 1824.0																								
1820		1824.0 ft to 1834.0 ft (Run No. 194) SHALE - Gray; moderately weathered; moderately fractured with fractures occurring at low angles to 30 degrees for the length of the run. Fractures contain clay and very soft shale. Surrounding shale is moderately hard, fine grained, thinly bedded.			194																							
1825																												
— CONTINUED NEXT PAGE —																												

SME ROCK GLO NEW.GPJ GLDR.LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel
LOCATION: Louisville, Kentucky
PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NO/AQ

NORTHING: 302758.9
EASTING: 1247501.77
INCLINATION: -8.24°
AZIMUTH: N 305°E

SHEET 59 OF 73
DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR OF CORE	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				BC-BROKEN CORE MB-MECH. BREAK B-BEDDING				DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear
DRILLER: D. Sammons



LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING:302758.9

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 61 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	SYMBOLIC LOG	DESCRIPTION	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	ELEVATION	FR-FRACTURE F-FAULT SMSMOOTH FL-FLEXURED BC-BROKEN CORE CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED										DIAMETER POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING METHOD: HQ/NQ/AQ

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 62 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	FLUSH	ELEVATION	CORRECTION										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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1925		1924.0 ft to 1934.0 ft (Run No. 205) SHALE - Gray; very slight weathering; slightly fractured with low angle fractures containing clay at 1927.2', 1927.8' to 1930.3'. Shale is fine grained thinly bedded.		316.6 1924.0	204				315																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

CSME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING:302758.9

EASTING:1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 63 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	CORRECTION												DIAMETER POINT LOAD INDEX (psi)																	
									FR-FRACTURE		F-FAULT		SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		MB-MECH BREAK			B-BEDDING																
									CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	W-WAVY	C-CURVED	SH-SHEAR	P-POLISHED	ST-STEPED	PL-PLANAR	VE-VEIN	SL-SUCKENED		DE-DEFORMED	PL-PLANAR															
									RECOVERY	R.O.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																								
TOTAL CORE %	SOLID CORE %	DP #1 CORE AXIS	TYPE AND SURFACE DESCRIPTION	10"	10"	200"	200"	300"	300"	400"	400"	500"	500"	600"	600"																							
— CONTINUED FROM PREVIOUS PAGE —																																						
1955	NO Core	1954.0 ft to 1964.0 ft (Run No. 208) SHALE - Gray; moderately weathered; moderately hard; severely fractured for length of run. Fracture occurs at low angle and contains clay. Fracture appature is approximately 2 to 3 millimeter. Shale is fine grained, thinly bedded.	207	312.3	208			310																														
				1954.0																																		
1965	NO Core	1964.0 ft to 1974.0 ft (Run No. 209) SHALE - Gray; moderately weathered; moderately hard; moderately fractured with fractures occurring at low angles with clay throughout. Shale is soft at fractures and fine grained, thinly bedded in surrounding shale.	209	310.9	210			310																														
				1964.0																																		
1975	NO Core	1974.0 ft to 1984.0 ft (Run No. 210) SHALE - Gray; slightly weathered; moderately hard; slightly fractured with fracture at 1975.1' to 1978.0'. Fracture occurs at low angle with clay throughout and soft shale along fracture. Shale is fine grained, thinly bedded throughout.	210	309.4	211			310																														
				1974.0																																		
1980	NO Core	1984.0 ft to 1994.0 ft (Run No. 211) SHALE - Gray; slightly weathered; moderately hard; slightly fractured with fracture at 1984.0' to 1988.0'. Fracture occurs at low angle with clay throughout and soft shale along fracture. Shale is fine grained, thinly bedded throughout.	211	308.0	212			310																														
				1984.0																																		
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SME ROCK GLO NEW.GPJ GLDR LDNG.DOT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 65 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE										DIAMETRAL POINT LOAD INDEX (psi)	
										CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH BREAK			B-BEDDING
										SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		C-CURVED			
										VN-VEIN		S-SUCKENSIDED		PL-PLANAR							
RECOVERY		R.O.D. %		FRACT. INDEX PER FT		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec		TYPE AND SURFACE DESCRIPTION											
TOTAL CORE %		SOLD CORE %				DP #1 L CORE AXIS															
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SME ROCK GLO NEW.GPJ GLDR_LON.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 67 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE	COLOR (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE	DIAMETRAL POINT LOAD INDEX (psi)															
										CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH BREAK																
										SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING																
										VN-VEIN	S-SUCKEN/SED	PL-PLANAR	C-CURVED																	
RECOVERY		R.O.D.		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																								
TOTAL CORE %	SOLID CORE %	%	FRACT. INDEX PER FT	DP #11 CORE AXIS	TYPE AND SURFACE DESCRIPTION	10'	10'	45'	50'	75'																				
88.8	88.8	88.8	0.2	0.2																										
— CONTINUED FROM PREVIOUS PAGE —																														
2080		2079.0 ft to 2089.0 ft (Run No. 221) SHALE - Same as previous run; fracture with clay at 2084.2' to 2085.9' which occurs at a low angle.		221									FR, S, with clay																	
2085																														
		2089.0 ft to 2099.0 ft (Run No. 222) SHALE - Gray; slightly weathered; moderately hard; slightly fractured at 2089.0' to 2090.0'; fine grained, thinly bedded.		222									FR, S																	
2090																														
2095	NG Core															4553														
		2099.0 ft to 2109.0 ft (Run No. 223) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.		223																										
2100																														
2105																														
		2109.0 ft to 2119.0 ft (Run No. 224) SHALE - Same as previous run; all breaks mechanical.		224					290					Azimuth: 315.16 Inclination: -1.84																
2110	NG Core																													
		— CONTINUED NEXT PAGE —																												

SME ROCK GLO NEW.GPJ GLDR_LDR.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 68 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR (ft/min) % RETURN	ELEVATION	FR-FRACTURE										F-FAULT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK		DIAMETRAL POINT LOAD INDEX (psi)
									CL-CLEAVAGE		SH-SHEAR		VN-VEIN		S-SLICKENS-DE		PL-PLANAR		C-CURVED		TYPE AND SURFACE DESCRIPTION		HYDRAULIC CONDUCTIVITY k, cm/sec				
									RECOVERY		R.O.D. %		FRACT. INDEX PER FT		D.P.#1 CORE AXES												
									TOTAL CORE %	SOLID CORE %																	
		— CONTINUED FROM PREVIOUS PAGE —																									
2115	NO Core	2109.0 ft to 2119.0 ft (Run No. 224) SHALE - Same as previous run; all breaks mechanical.			224																						
2120																											
2125		2119.0 ft to 2129.0 ft (Run No. 225) SHALE - Same as previous run; all breaks mechanical.			225																						
2130																											
2135		2129.0 ft to 2139.0 ft (Run No. 226) SHALE - Same as previous run; fractures at 2131.2' to 2131.5' and 2132.9' to 2133.2' with clay.			226																						
2140		2139.0 ft to 2149.0 ft (Run No. 227) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.			227																						
		— CONTINUED NEXT PAGE —																									

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 70 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH % RETURN	ELEVATION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN										F-FAULT J-JOINT P-POLISHED S-SUCKEN/DED										SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR										FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED										BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																							
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INDEX PER FT	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec	TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE AND SURFACE DESCRIPTION		TYPE 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SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 71 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	ELEVATION	CORRECTION												DIAMETRAL POINT LOAD INDEX (psi)								
									FR-FRACTURE				F-FAULT				SM-SMOOTH					FL-FLEXURED				BC-BROKEN CORE			
									CL-CLEAVAGE				J-JOINT				R-ROUGH					UE-UNEVEN				MB-MECH BREAK			
									SH-SHEAR				P-POLISHED				ST-STEPPED					W-WAVY				B-BEDDING			
VN-VEIN				S-SLICKENSIDED				PL-PLANAR				C-CURVED																	
RECOVERY				R.O.D.				FRACT.				DISCONTINUITY DATA				HYDRAULIC													
TOTAL CORE %				SOLID CORE %				%				INDEX PER FT				TYPE AND SURFACE DESCRIPTION				CONDUCTIVITY k, cm/sec									
50 50 50 50				50 50 50 50				50 50 50 50				50 50 50 50				50 50 50 50				50 50 50 50				50 50 50 50					
2205		— CONTINUED FROM PREVIOUS PAGE —																											
		2199.0 ft to 2209.0 ft (Run No. 233) SHALE - Gray; slightly weathered; moderately hard; slightly fractured with clay at fractures. Fractures occur at low angles at 2199.0' to 2199.5' and 2202.6' to 2205.5'.			233																								
				275.7																									
2210				2209.0																									
		2209.0 ft to 2219.0 ft (Run No. 234) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.			234			275																					
				274.3																									
2215				2219.0																									
		2219.0 ft to 2229.0 ft (Run No. 235) SHALE - Same as previous run; all breaks mechanical.			235																								
				272.9																									
2220				2229.0																									
		2229.0 ft to 2239.0 ft (Run No. 236) SHALE - Gray; very slight weathering; moderately hard; sound; fine grained; thinly bedded.			236																								
2225																													
2230																													
2235																													
		— CONTINUED NEXT PAGE —																											

4504

Azimuth: 314.66
Inclination: 0.05

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

SME ROCK GLO NEW.GPJ GLDR_LDNG.DOT 9/29/11 DATA INPUT:

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 72 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR FLUSH % RETURN	ELEVATION	FACILITY										DIAMETRAL POINT LOAD INDEX (psi)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Azimuth: 314.20
Inclination: -0.81

SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: South Bound

DRILLING DATE: 7/20/2011

DRILL RIG: LM90

DRILLING METHOD: HQ/NQ/AQ

NORTHING: 302758.9

EASTING: 1247501.77

INCLINATION: -8.24°

AZIMUTH: N 305°E

SHEET 73 OF 73

DATUM: NAVD 88

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	COLOR % RETURN	FLUSH % RETURN	ELEVATION	FR-FRACTURE										F-FAULT		SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETER POINT TO POINT INDEX (in)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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SME ROCK GLO NEW.GPJ GLDR_LDN.GDT 9/29/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR: Boart Longyear

DRILLER: D. Sammons



LOGGED: NJP

CHECKED: CSL

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
 Project # 1831-10-5629
 Sheet 1 of 79

S&ME
 422 Codell Drive
 Lexington, KY 40509

Photo 1



7/20/2011

Photographer: M. DeVoe

Location / Orientation South Bound Boring, Box 1, 0.0 ft to 19.0'

Remarks Louisville Limestone – HQ Core

Photo 2



7/20/2011

Photographer: M. DeVoe

Location / Orientation South Bound, Box 2, 9.0 ft to 29.0 ft

Remarks Louisville Limestone

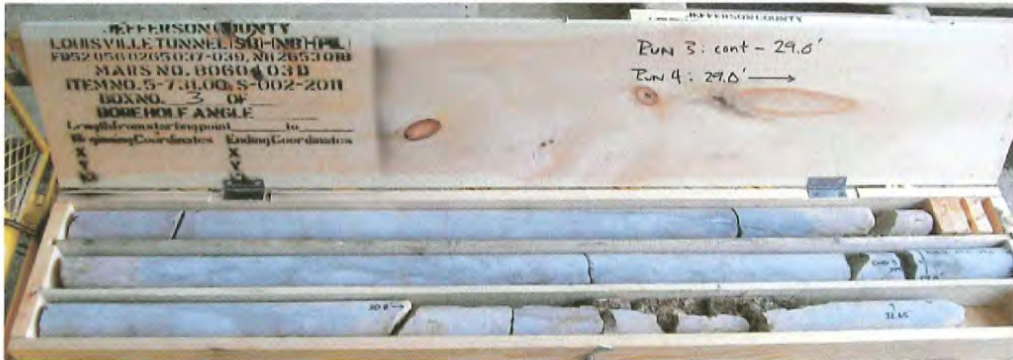
Photo 3	
	7/20/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 3, 29.0 ft to 33.0 ft
Remarks	Louisville Limestone

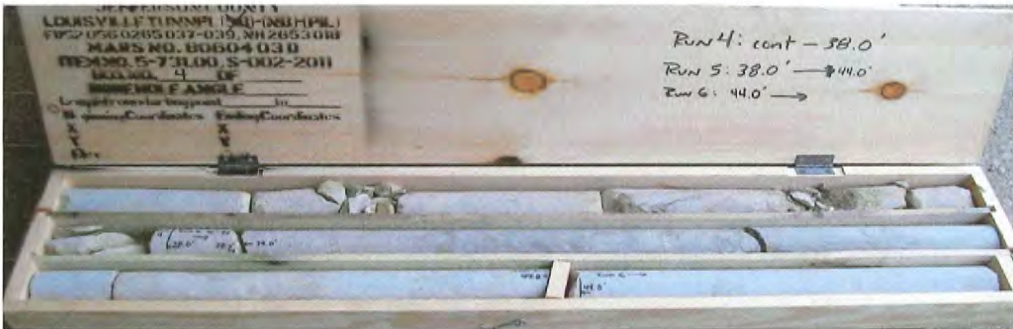
Photo 4	
	7/20/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 4, 33.0 ft to 46.0 ft
Remarks	Louisville Limestone

Photo 5	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 5, 46.0 ft to 57.0 ft
Remarks	Louisville Limestone

Photo 6	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 6, 57.0 ft to 66.0 ft
Remarks	Louisville Limestone

Photo 7	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 7, 66.0 ft to 79.0 ft
Remarks	Louisville Limestone

Photo 8	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 8, 79.0 ft to 90.6 ft
Remarks	Louisville Limestone

Photo 9	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 9, 90.6 ft to 102.0 ft
Remarks	Louisville Limestone

Photo 10	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 10, 102.0 ft to 112.0 ft
Remarks	Louisville Limestone

Photo 11	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 11, 112.0' to 123.0 ft
Remarks	Louisville Limestone

Photo 12	
	7/21/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 12, 123.0 ft to 137.0 ft
Remarks	Louisville Limestone

S&ME
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Lexington, KY 40509

		Photo 14	7/22/2011
Location / Orientation	South Bound, Box 14, 148.0 ft to 159.9 ft	Photographer: M. DeVoe	
Remarks	Louisville Limestone		

Photo 15	
	7/22/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 15, 159.9 ft to 172.0 ft
Remarks	Louisville Limestone

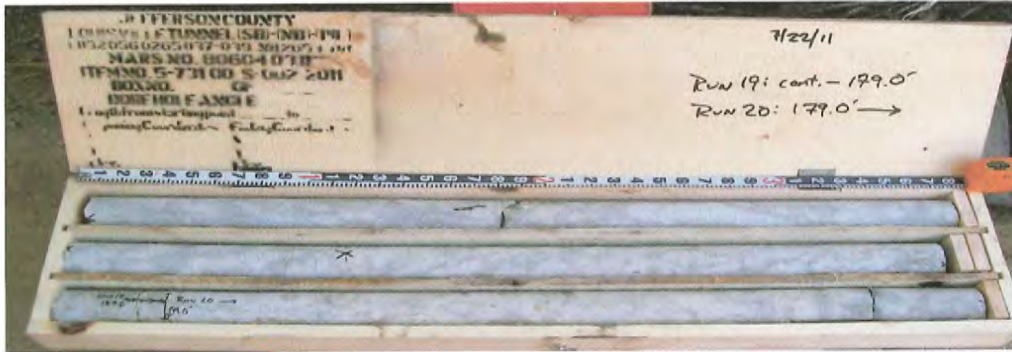
Photo 16	
	7/22/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 16, 172.0 ft to 182.0 ft
Remarks	Louisville Limestone

Photo 17



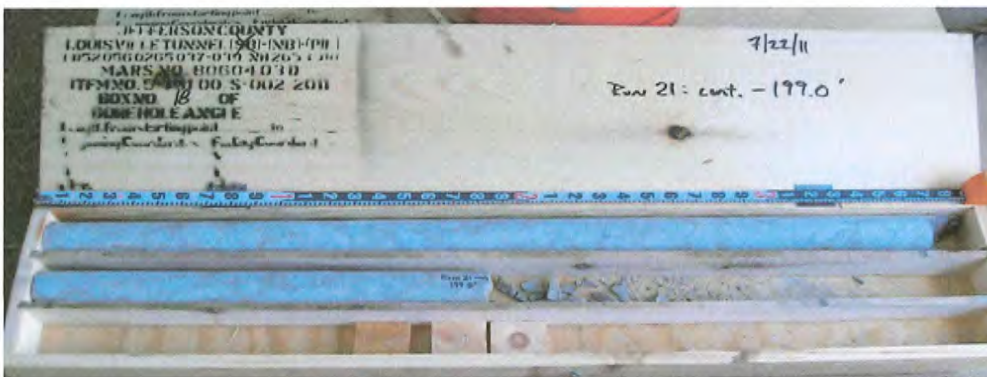
7/22/2011

Photographer: M. DeVoe

Location / Orientation South Bound, Box 17, 182.0 ft to 193.0 ft

Remarks Louisville Limestone

Photo 18



7/22/2011

Photographer: M. DeVoe

Location / Orientation South Bound, Box 18, 182.0 ft to 199.0 ft

Remarks Louisville Limestone – Terminate HQ core at 199.0 feet and begin NQ core.

Photo 19	
	7/22/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 19, 199.0 ft -214.0 ft
Remarks	Louisville Limestone – Begin NQ core at 199.0 feet and terminate at 214.0 feet. Begin AQ directional core at 214.0 ft.

Photo 20	
	7/23/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 20, 214.0 ft to 230.0 ft
Remarks	Louisville Limestone

Photo 21	
	7/23/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 21, 230.0 ft to 236.0 ft
Remarks	Louisville Limestone – Terminate AQ directional core at 237.0 ft. Begin NQ core at 229.0 ft to cut out over curve.

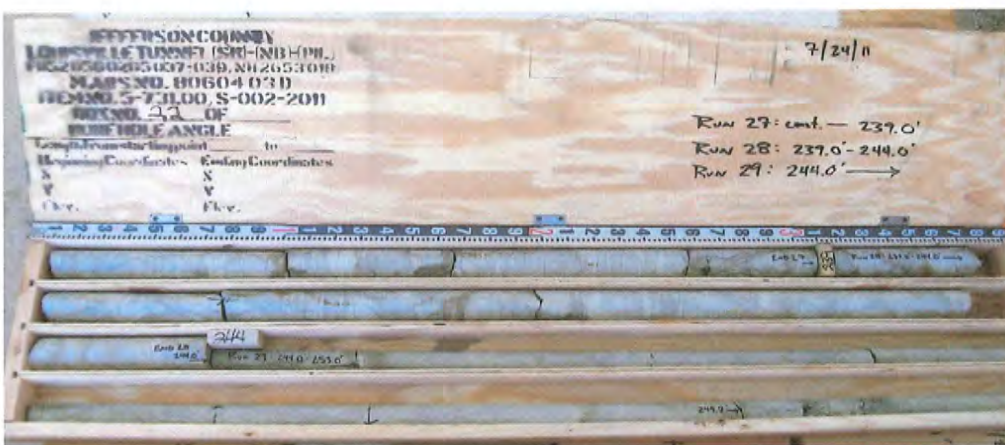
Photo 22	
	7/24/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound Boring, Box 22, 236.0 ft to 252.0 ft
Remarks	Louisville Limestone – Terminate NQ core at 244.0 ft. Begin AQ directional core at 244.0 ft.

Photo 23

		7/26/2011
		Photographer: M. DeVoe
Location / Orientation	South Bound, Box 24, 266.9 ft to 277.0 ft	
Remarks	Louisville Limestone – Terminate AQ directional core at 263.0 ft and begin NQ core to 273.0 ft.	

Photo 24

		7/26/2011
		Photographer: M. DeVoe
Location / Orientation	South Bound, Box 25, 277.0 ft to 297.2 ft	
Remarks	Louisville Limestone – AQ directional core	

Photo 25

		7/26/2011
		Photographer: M. DeVoe
Location / Orientation	South Bound, Box 26, 297.2 ft to 313.0 ft	
Remarks	Louisville Limestone	

Photo 26

		7/26/2011
		Photographer: M. DeVoe
Location / Orientation	South Bound, Box 27, 313.0 ft - 327.7 ft	
Remarks	Louisville Limestone	

Photo 27

		7/27/2011
		Photographer: M. DeVoe
Location / Orientation	South Bound, Box 28, 327.7 ft to 343.0 ft	
Remarks	Louisville Limestone – AQ core terminated at 333.0 feet and begin NQ core to 343.0 ft. Tunnel face at 337.0 feet.	

Photo 28

		7/27/2011
		Photographer: M. DeVoe
Location / Orientation	South Bound, Box 29, 343.0 ft to 360.3 ft	
Remarks	Louisville Limestone – Begin AQ directional core at 343.0 ft.	

Photo 29	
	7/27/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 30, 360.3 ft to 375.2 ft
Remarks	Louisville Limestone

Photo 30	
	7/27/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 31, 375.3 ft to 390.8 ft
Remarks	Louisville Limestone

Photo 31	
	7/28/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 32, 390.8 ft to 406.2 ft
Remarks	Louisville Limestone

Photo 32	
	7/28/2011
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 33, 406.2 ft to 423.0 ft
Remarks	Louisville Limestone

Photo 33	
	7/28/11
	Photographer: M. DeVoe
Location / Orientation	South Bound, Box 34, 423.0 ft to 438.2 ft
Remarks	Louisville Limestone

Photo 34	
	8/1/2011
	Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 35, 438.2 ft to 453.4 ft
Remarks	Louisville Limestone – Terminate AQ directional core at 443.0 ft and begin NQ core.

Photo 35



8/1/2011

Photographer: N. Peterson

Location / Orientation	South Bound Boring, Box 36, 453.4 ft to 468.1 ft
Remarks	Louisville Limestone

Photo 36



8/1/2011

Photographer: N. Peterson

Location / Orientation	South Bound Boring, Box 37, 468.1 ft to 482.8 ft
Remarks	Louisville Limestone

Photo 37

		8/1/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 38, 482.8 ft to 498.1 ft	
Remarks	Louisville Limestone	

Photo 38

		8/1/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 39, 498.1 ft to 502.8 ft	
Remarks	Louisville Limestone	

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project # 1831-10-5629
Sheet 20 of 79

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Photo 39



8/1/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 40, 502.8 ft to 527.4 ft

Remarks Louisville Limestone

Photo 40



8/1/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 41, 527.4 ft to 542.4 ft

Remarks Louisville Limestone

Photo 41



8/1/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 42, 542.4 ft to 557.4 ft

Remarks Louisville Limestone

Photo 42



8/1/2011

Photographer: N. Peterson

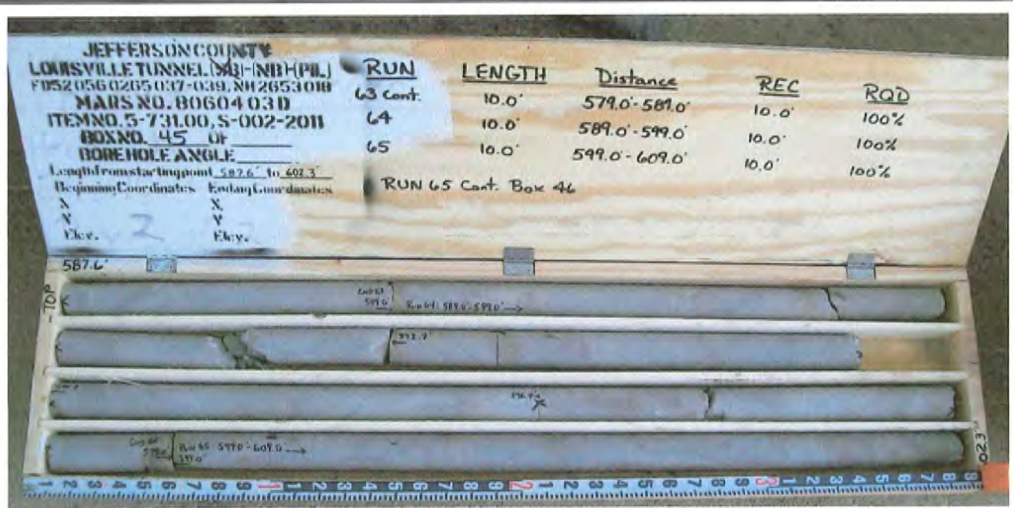
Location / Orientation South Bound Boring, Box 43, 557.4 ft to 572.5 ft

Remarks Louisville Limestone

Photo 43

		8/1/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 44, 572.5 ft to 587.6 ft	
Remarks	Louisville Limestone – South Bound Boring terminated at 1900.0 ft.	

Photo 44

		8/1/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 45, 587.6 ft to 602.3 ft	
Remarks	Louisville Limestone	

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
 Project # 1831-10-5629
 Sheet 23 of 79

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 422 Codell Drive
 Lexington, KY 40509

Photo 45

		8/3/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 46, 602.3 ft to 617.6 ft	
Remarks	Louisville Limestone	

Photo 46

		8/3/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 47, 617.6 ft to 632.6 ft	
Remarks	Louisville Limestone	

Photo 47

		8/3/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 48, 632.6 ft to 647.4 ft	
Remarks	Louisville Limestone	

Photo 48

		8/3/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 49, 647.4 ft to 661.7 ft	
Remarks	Louisville Limestone – Terminate NQ core at 649.0 ft and begin AQ directional core.	

Photo 49



8/3/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 50, 661.7 ft to 676.4 ft

Remarks Louisville Limestone

Photo 50



8/3/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 51, 676.4 ft to 691.6 ft

Remarks Louisville Limestone

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Photographer: N. Peterson

8/4/2011

Photographer: N. Peterson

Photo 53



8/4/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 54, 721.8 ft to 736.8 ft

Remarks Louisville Limestone

Photo 54



8/4/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 55, 736.8 ft to 751.3 ft

Remarks Louisville Limestone – Terminate AQ directional core at 748.0 feet and begin NQ core.

Photo 55



8/4/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 56, 751.3 ft to 766.6 ft

Remarks

Louisville Limestone

Photo 56



8/4/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 57, 766.6 ft to 781.0 ft

Remarks

Louisville Limestone

Photo 57



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 58, 781.0 ft to 795.9 ft

Remarks Louisville Limestone

Photo 58



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 59, 795.9 ft to 811.0 ft

Remarks Louisville Limestone

Photo 59



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 60, 811.0 ft to 826.0 ft

Remarks Louisville Limestone

Photo 60



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 61, 826.0 ft to 840.8 ft

Remarks Louisville Limestone

Photo 61



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 62, 840.8 ft to 855.3 ft

Remarks Louisville Limestone

Photo 62



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 63, 855.3 ft to 869.9 ft

Remarks Louisville Limestone

Photo 63



8/8/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 64, 869.9 ft to 885.0 ft

Remarks

Louisville Limestone

Photo 64



8/8/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 65, 885.0 ft to 899.0 ft

Remarks

Louisville Limestone

Photo 65



8/4/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 66, 899.0 ft to 913.9 ft

Remarks

Louisville Limestone

Photo 66



8/8/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 67, 913.9 ft to 928.4 ft

Remarks

Louisville Limestone

Photo 67



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 68, 928.4 ft to 942.7 ft

Remarks Louisville Limestone

Photo 68



8/8/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 69, 942.7 ft to 957.7 ft

Remarks Louisville Limestone – Terminate NQ core at 949.0 feet and begin AQ directional core.

Photo 69

		8/8/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 70, 957.7 ft to 972.8 ft	
Remarks	Louisville Limestone	

Photo 70

		8/8/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 71, 972.8 ft to 988.0 ft	
Remarks	Louisville Limestone	

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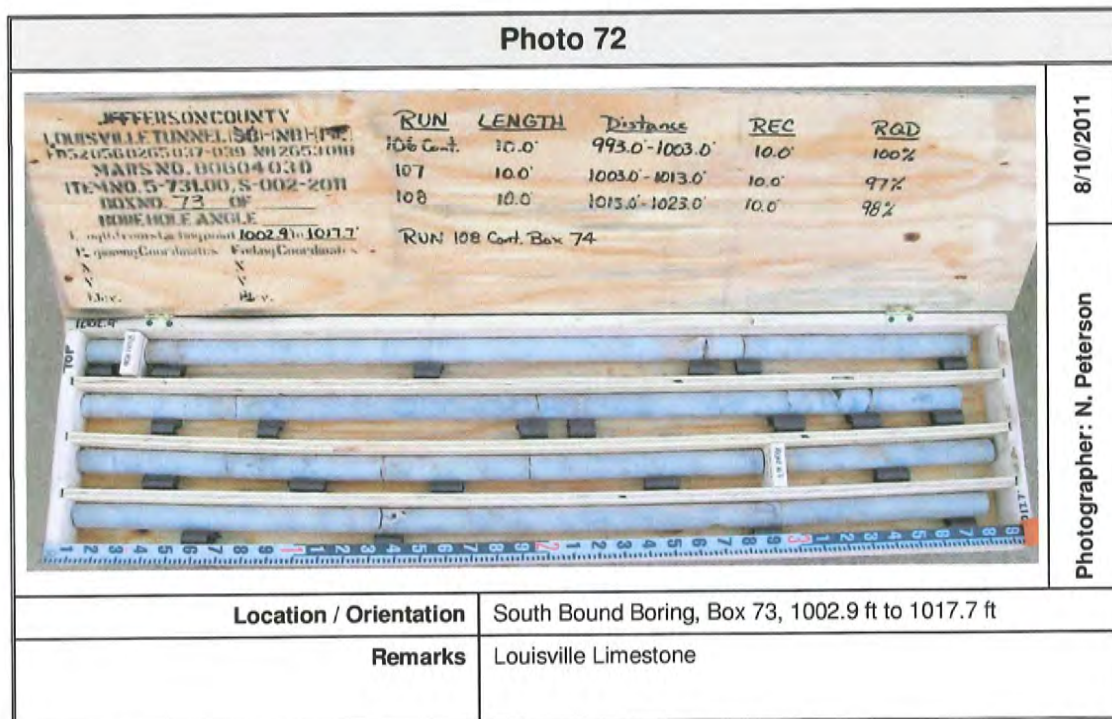


Photo 73



8/10/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 74, 1017.0 ft to 1032.8 ft

Remarks Louisville Limestone

Photo 74



8/10/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 75, 1032.8 ft to 1048.0 ft

Remarks Louisville Limestone – Terminate AQ directional core at 1033.0 feet and begin NQ core.

Photo 75



8/10/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 76, 1048.0 ft to 1062.7 ft

Remarks

Louisville Limestone

Photo 76



8/10/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 77, 1062.7 ft to 1077.6 ft

Remarks

Louisville Limestone

Photo 77



8/10/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 78, 1077.6 ft to 1092.5 ft

Remarks Louisville Limestone

Photo 78



8/10/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 79, 1092.5 ft to 1107.6 ft

Remarks Louisville Limestone out to 1099.0 feet. Waldron Shale encountered at 1099.0 feet.

Photo 79

		8/15/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 80, 1107.6 ft to 1122.4 ft	
Remarks	Louisville Limestone out to 1099.0 feet. Waldron Shale begins at 1099.0 feet.	

Photo 80

		8/15/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 81, 1122.4 ft to 1137.7 ft	
Remarks	Waldron Shale	

Photo 81

		8/15/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 82, 1137.7 ft to 1152.6 ft	
Remarks	Waldron Shale	

Photo 82

		8/15/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 83, 1152.6 ft to 1167.6 ft	
Remarks	Waldron Shale	

Photo 83



8/15/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 84, 1167.6 ft to 1182.7 ft

Remarks

Waldron Shale

Photo 84



8/15/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 85, 1182.7 ft to 1197.8 ft

Remarks

Waldron Shale

Photo 85

		8/15/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 86, 1197.8 ft to 1212.8 ft	
Remarks	Waldron Shale	

Photo 86

		8/15/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 87, 1202.8 ft to 1227.5 ft	
Remarks	Waldron Shale	

Photo 87



8/15/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 88, 1227.5 ft to 1242.6 ft

Remarks Waldron Shale

Photo 88



8/15/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 89, 1242.6 ft to 1256.5 ft

Remarks Waldron Shale

Photo 89

8/15/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 90, 1256.5 ft to 1270.2 ft

Remarks

Waldron Shale

Photo 90

8/15/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 91, 1270.2 ft to 1285.0 ft

Remarks

Waldron Shale

Photo 91

		8/15/2011
Location / Orientation South Bound Boring, Box 92, 1285.0 ft to 1299.5 ft		Photographer: N. Peterson
Remarks	Waldron Shale – Terminate NQ core at 1289.0 feet and begin AQ directional core.	

Photo 92

		8/15/2011
Location / Orientation South Bound Boring, Box 93, 1299.5 ft to 1314.5 ft		Photographer: N. Peterson
Remarks	Waldron Shale	

Photo 93

		8/15/2011
JEFFERSON COUNTY LOUISVILLE TUNNEL (SB)-(NB)-(PL) F052 056 0265 037-039, NH 2653018 MARS NO. 80604 03 D ITEM NO. 5-731.00, S-002-2011 BOX NO. 94 OF BOREHOLE ANGLE Length from starting point 1314.5 to 1334.4 Beginning Coordinates Ending Coordinates X Y Elev. X Y Elev.		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 94, 1314.5 ft to 1334.4 ft	
Remarks	Waldron Shale	

Photo 94

		8/15/2011
JEFFERSON COUNTY LOUISVILLE TUNNEL (SB)-(NB)-(PL) F052 056 0265 037-039, NH 2653018 MARS NO. 80604 03 D ITEM NO. 5-731.00, S-002-2011 BOX NO. 95 OF BOREHOLE ANGLE Length from starting point 1334.4 to 1349.0 Beginning Coordinates Ending Coordinates X Y Elev. X Y Elev.		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 95, 1334.4 ft to 1349.0 ft	
Remarks	Waldron Shale	

Photo 95



8/15/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 96, 1349.0 ft to 1363.5 ft

Remarks Waldron Shale

Photo 96



8/15/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 97, 1363.5 ft to 1378.2 ft

Remarks Waldron Shale

Photo 97

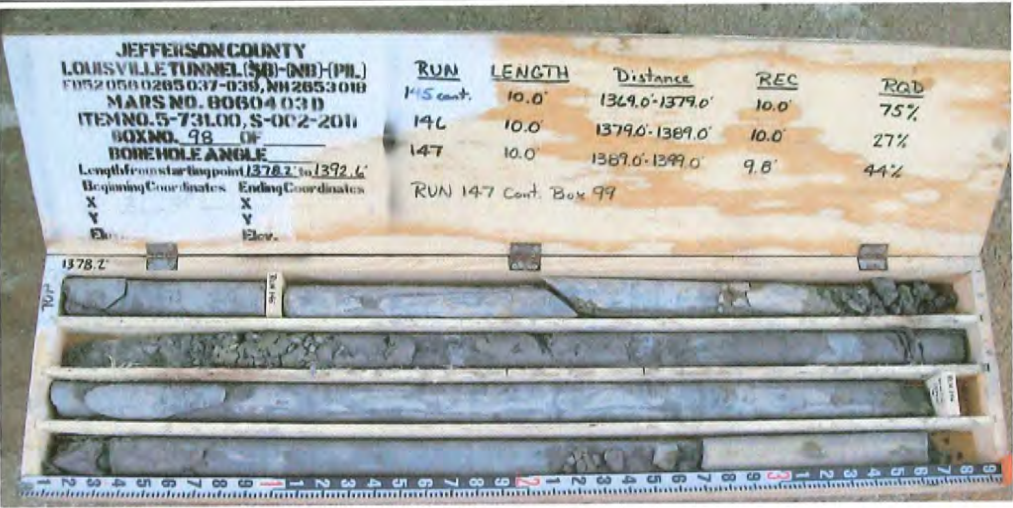
		8/18/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 98, 1378.2 ft to 1392.6 ft	
Remarks	Waldron Shale	

Photo 98

		8/18/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 99, 1392.6 ft to 1407.8 ft	
Remarks	Waldron Shale	

Photo 99



8/18/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 100, 1407.8 ft to 1422.5 ft

Remarks

Waldron Shale

Photo 100



8/18/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 101, 1422.5 ft to 1437.6 ft

Remarks

Waldron Shale

Photo 101

		8/18/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 102, 1437.6 ft to 1452.3 ft	
Remarks	Waldron Shale	

Photo 102

		8/18/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 103, 1452.3 ft to 1467.3 ft	
Remarks	Waldron Shale	

Photo 103



8/18/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 104, 1467.3 ft to 1482.2 ft

Remarks Waldron Shale

Photo 104



8/18/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 105, 1482.2 ft to 1497.0 ft

Remarks Waldron Shale

Photo 105

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 106, 1497.0 ft to 1511.8 ft	
Remarks	Waldron Shale	

Photo 106

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 107, 1511.8 ft to 1527.0 ft	
Remarks	Waldron Shale	

Photo 107



9/2/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 108, 1527.0 ft to 1541.8 ft

Remarks Waldron Shale

Photo 108



9/2/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 109, 1541.8 ft to 1556.3 ft

Remarks Waldron Shale

Photo 109

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 110, 1556.3 ft to 1571.5 ft	
Remarks	Waldron Shale	

Photo 110

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 111, 1571.5 ft to 1586.7 ft	
Remarks	Waldron Shale – Terminate AQ directional core at 1578.0 ft and begin NQ core.	

Photo 111

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 112, 1586.7 ft to 1601.5 ft	
Remarks	Waldron Shale	

Photo 112

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 113, 1601.5 ft to 1616.3 ft	
Remarks	Waldron Shale	

Photo 113

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 114, 1616.3 ft to 1631.3 ft	
Remarks	Waldron Shale	

Photo 114

		9/2/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 115, 1631.3 ft to 1646.3 ft	
Remarks	Waldron Shale	

Photo 115

JEFFERSON COUNTY
LOUISVILLE TUNNEL (SBI-NHHPIL)
FMS 20550265 037-038 NH 2053000
MARS NO. 00604030
ITEM NO 5-73100 S-002-2011
BOX NO. 116 OF
BOREHOLE ANGLE
Length from start of Borehole to 1646.3 to 1661.3
Beginning Coordinates Ending Coordinates
X Y Z X Y Z
1646.3

RUN	LENGTH	Distance	REC	ROD
175 cont.	10.0	1644.0-1654.0	10.0	100%
176	10.0	1654.0-1664.0	10.0	100%

RUN 176 Cont. Box 117

9/2/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 116, 1646.3 ft to 1661.3 ft

Remarks

Waldron Shale

Photo 116

JEFFERSON COUNTY LOUISVILLE TUNNEL (SBI-NHHPIL) FMS 05002650 17-038 NH2053000 MARS NO 00604030 ITEM NO 5-71100, S-002-2011 BOX NO 117 OF BOREHOLE ANGLE Length from start of Borehole to 1661.3 to 1675.4 Beginning Coordinates Ending Coordinates X Y Z X Y Z <table><thead><tr><th>RUN</th><th>LENGTH</th><th>Distance</th><th>REC</th><th>ROD</th></tr></thead><tbody><tr><td>176 cont.</td><td>10.0'</td><td>1654.0'-1664.0'</td><td>10.0'</td><td>100%</td></tr><tr><td>177</td><td>10.0'</td><td>1664.0'-1674.0'</td><td>9.5'</td><td>0%</td></tr><tr><td>178</td><td>10.0'</td><td>1674.0'-1684.0'</td><td>10.0'</td><td>98%</td></tr></tbody></table> RUN 178 Cont. Box 118		RUN	LENGTH	Distance	REC	ROD	176 cont.	10.0'	1654.0'-1664.0'	10.0'	100%	177	10.0'	1664.0'-1674.0'	9.5'	0%	178	10.0'	1674.0'-1684.0'	10.0'	98%	9/2/2011
RUN	LENGTH	Distance	REC	ROD																		
176 cont.	10.0'	1654.0'-1664.0'	10.0'	100%																		
177	10.0'	1664.0'-1674.0'	9.5'	0%																		
178	10.0'	1674.0'-1684.0'	10.0'	98%																		
		Photographer: N. Peterson																				
Location / Orientation	South Bound Boring, Box 117, 1661.3 ft to 1675.4 ft																					
Remarks	Waldron Shale																					

Photo 117



9/2/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 118, 1675.4 ft to 1690.4 ft

Remarks Waldron Shale

Photo 118



9/5/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 119, 1690.4 ft to 1705.1 ft

Remarks Waldron Shale

Photo 119

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 120, 1705.1 ft to 1719.5 ft	
Remarks	Waldron Shale	

Photo 120

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 121, 1719.5 ft to 1734.0 ft	
Remarks	Waldron Shale	

Photo 121

JEFFERSON COUNTY
LOUISVILLE TUNNEL (S&ME-IND-IMP)
F05205602050 17-0 10, V02051000
MARS NO. B0604030
ITEM NO. 5-731.00 S-002-2011
BOX NO. 121 OF
BORE HOLE ANGLE
1. depth of next stage at 1734.0 to 1744.1
2. by coordinates to by coordinates

RUN	LENGTH	Distance	REC	RCD
184	10.0'	1734.0-1744.0	10.0'	10%
185	10.0'	1744.0-1754.0	10.0'	63%

9/5/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 122, 1734.0 ft to 1749.1 ft

Remarks

Waldron Shale

Photo 122																	
 JEFFERSON COUNTY LOUISVILLE TUNNEL (S&ME-IND-IMP) F05205602050 17-0 10, V02051000 MARS NO. B0604030 ITEM NO. 5-731.00 S-002-2011 BOX NO. 123 OF BOREHOLE ANGLE 1. depth of next stage at 1749.1 to 1763.1 2. by coordinates to by coordinates <table><thead><tr><th>RUN</th><th>LENGTH</th><th>Distance</th><th>REC</th><th>RCD</th></tr></thead><tbody><tr><td>185 cont.</td><td>10.0'</td><td>1744.0-1754.0</td><td>10.0'</td><td>63%</td></tr><tr><td>186</td><td>10.0'</td><td>1754.0-1764.0</td><td>10.0'</td><td>99%</td></tr></tbody></table> RUN 186 Cont. Box 124		RUN	LENGTH	Distance	REC	RCD	185 cont.	10.0'	1744.0-1754.0	10.0'	63%	186	10.0'	1754.0-1764.0	10.0'	99%	9/5/2011
RUN	LENGTH	Distance	REC	RCD													
185 cont.	10.0'	1744.0-1754.0	10.0'	63%													
186	10.0'	1754.0-1764.0	10.0'	99%													
Photographer: N. Peterson																	
Location / Orientation	South Bound Boring, Box 123, 1749.1 ft to 1763.1 ft																
Remarks	Waldron Shale																

Photo 123

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 124, 1763.1 ft to 1775.7 ft	
Remarks	Waldron Shale	

Photo 124

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 125, 1775.7 ft to 1791.9 ft	
Remarks	Waldron Shale	

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project # 1831-10-5629
Sheet 63 of 79

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 125



9/5/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 126, 1791.9 ft to 1806.3 ft

Remarks Waldron Shale

Photo 126



9/5/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 127, 1806.3 ft to 1820.9 ft

Remarks Waldron Shale

Photo 127



9/5/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 128, 1820.9 ft to 1835.6 ft

Remarks Waldron Shale

Photo 128



9/5/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 129, 1835.6 ft to 1852.0 ft

Remarks Waldron Shale

Photo 129

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 130, 1852.0 ft to 1866.6 ft	
Remarks	Waldron Shale	

Photo 130

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 131, 1866.6 ft to 1881.5 ft	
Remarks	Waldron Shale	

Photo 131

		9/5/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 132, 1881.5 ft to 1896.6 ft	
Remarks	Waldron Shale	

Photo 132

		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 133, 1896.6 ft to 1911.4 ft	
Remarks	Waldron Shale	

Photo 133

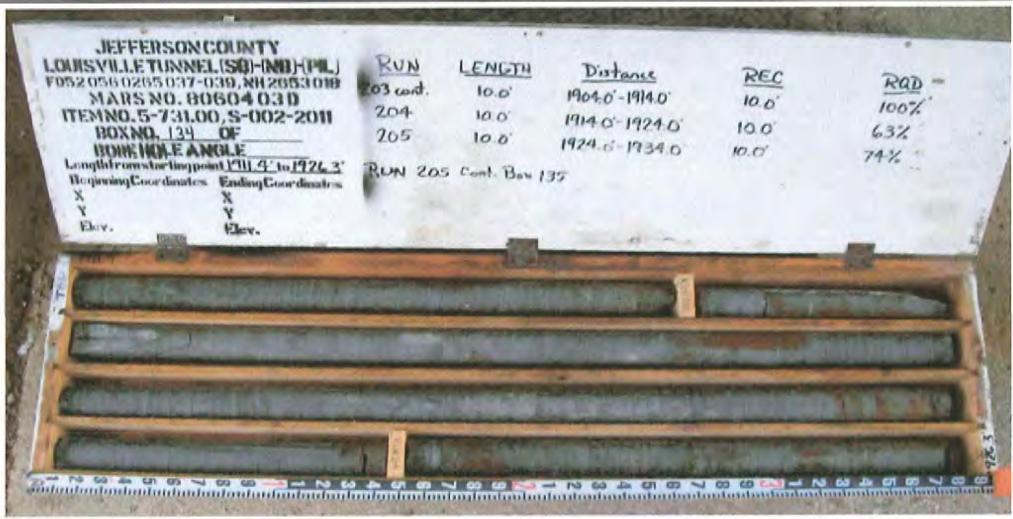
		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 134, 1911.4 ft to 1926.3 ft	
Remarks	Waldron Shale	

Photo 134

		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 135, 1926.3 ft to 1941.1 ft	
Remarks	Waldron Shale	

Photo 135



9/9/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 136, 1941.1 ft to 1956.7 ft

Remarks Waldron Shale

Photo 136



9/9/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 137, 1956.7 ft to 1971.7 ft

Remarks Waldron Shale

Photo 137



9/9/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 138, 1971.7 ft to 1986.5 ft

Remarks Waldron Shale

Photo 138



9/9/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 139, 1986.5 ft to 2001.7 ft

Remarks Waldron Shale

Photo 139

		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 140, 2001.7 ft to 2019.0 ft	
Remarks	Waldron Shale	

Photo 140

		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 141, 2019.0 ft to 2033.7 ft	
Remarks	Waldron Shale	

Photo 141

		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 142, 2033.7 ft to 2048.7 ft	
Remarks	Waldron Shale	

Photo 142

		9/9/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 143, 2048.7 ft to 2063.2 ft	
Remarks	Waldron Shale	

Photo 143



9/12/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 144, 2063.2 ft to 2078.0 ft

Remarks Waldron Shale

Photo 144



9/12/2011

Photographer: N. Peterson

Location / Orientation South Bound Boring, Box 145, 2078.0 ft to 2092.4 ft

Remarks Waldron Shale

Photo 145

		9/12/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 146, 2092.4 ft to 2107.8 ft	
Remarks	Waldron Shale	

Photo 146

		9/12/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 147, 2107.8 ft to 2122.3 ft	
Remarks	Waldron Shale	

S&ME
422 Codell Drive
Lexington, KY 40509

[illegible]

Photo 149

JEFFERSON COUNTY LOUISVILLE TUNNEL (SBI-DNB) HPL F052050 02050 17-0-09, M02653010 MARK NO. 00604030 ITEM NO. S-731.00, S-002-2011 BOX NO. 150 OF _____ BOREHOLE ANGLE _____ Length from start logs _____ 2152.7' to 2167.0' Beginning Coordinates _____ Ending Coordinates _____ X _____ Y _____ Z _____		9/12/2011 Photographer: N. Peterson
<u>RUN</u> <u>LENGTH</u> <u>Distance</u> <u>REC</u> <u>QAD</u> 228 cont. 10.0' 2149.0'-2159.0' 10.0' 100% 229 10.0' 2159.0'-2169.0' 10.0' 100% RUN 229 Cont. Box 151		

Location / Orientation	South Bound Boring, Box 150, 2152.7 ft to 2167.0 ft
Remarks	Waldron Shale

Photo 150

		9/12/2011
Location / Orientation South Bound Boring, Box 151, 2167.0 ft to 2181.6 ft		Photographer: N. Peterson
Remarks Waldron Shale		

Photo 151

JEFFERSON COUNTY
LOUISVILLE TUNNEL 1901-IND-IMP.
F052050-02050-17-030, NH 265.3000
MARS NO. 8080403D
ITEM NO. 5-73100, S-002-2011
BOX NO. 152 OF _____
DOWNSIDE ANGLE
Length from start to top of 2181.6 to 2196.6
Beginning Co. down = 4' to back of chamber
X
Y
Elev. 45.0'

RUN	LENGTH	Distance	REC	ROD
231 Cont.	10.0'	2179.0'-2189.0'	10.0'	98%
232	10.0'	2189.0'-2199.0'	10.0'	100%

RUN 232 Cont. Box 153

TOP

BOTTOM

9/12/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 152, 2181.6 ft to 2196.6 ft

Remarks

Waldron Shale

Photo 152

JEFFERSON COUNTY
LOUISVILLE TUNNEL 1901-IND-IMP.
F052050-02050-17-030, NH 265.3000
MARS NO. 8080403D
ITEM NO. 5-73100, S-002-2011
BOX NO. 153 OF _____
DOWNSIDE ANGLE
Length from start to top of 2196.6 to 2211.2
Beginning Co. down = 4' to back of chamber
X
Y
Elev. 45.0'

RUN	LENGTH	Distance	REC	ROD
232 cont.	10.0'	2189.0'-2199.0'	10.0'	100%
233	10.0'	2199.0'-2209.0'	10.0'	55%
234	10.0'	2209.0'-2219.0'	10.0'	100%

RUN 234 Cont. Box 154

9/12/2011

Photographer: N. Peterson

Location / Orientation

South Bound Boring, Box 153, 2196.6 ft to 2211.2 ft

Remarks

Waldron Shale

Photo 153

		9/12/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 154, 2211.2 ft to 2225.7 ft	
Remarks	Waldron Shale	

Photo 154

		9/14/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 155, 2225.7 ft to 2241.0 ft	
Remarks	Waldron Shale	

Photo 155

		9/14/2011
		Photographer: N. Peterson
Location / Orientation South Bound Boring, Box 156, 2241.0 ft to 2257.0 ft		
Remarks Waldron Shale		

Photo 156

		9/14/2011
		Photographer: N. Peterson
Location / Orientation South Bound Boring, Box 157, 2257.0 ft to 2272.0 ft		
Remarks Waldron Shale		

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project # 1831-10-5629
Sheet 79 of 79

 **S&ME**
422 Codell Drive
Lexington, KY 40509

Photo 157

		9/14/2011
		Photographer: N. Peterson
Location / Orientation	South Bound Boring, Box 158, 2272.0 ft to 2287.0 ft	
Remarks	Waldron Shale – South Bound Boring terminated at a distance of 2287.0 feet.	

APPENDIX B

GRAPH “Unconfined Compression versus Distance”

Graph “Point Load Index - Diametral versus Distance”

Graph “Point Load Index - Axial versus Distance”

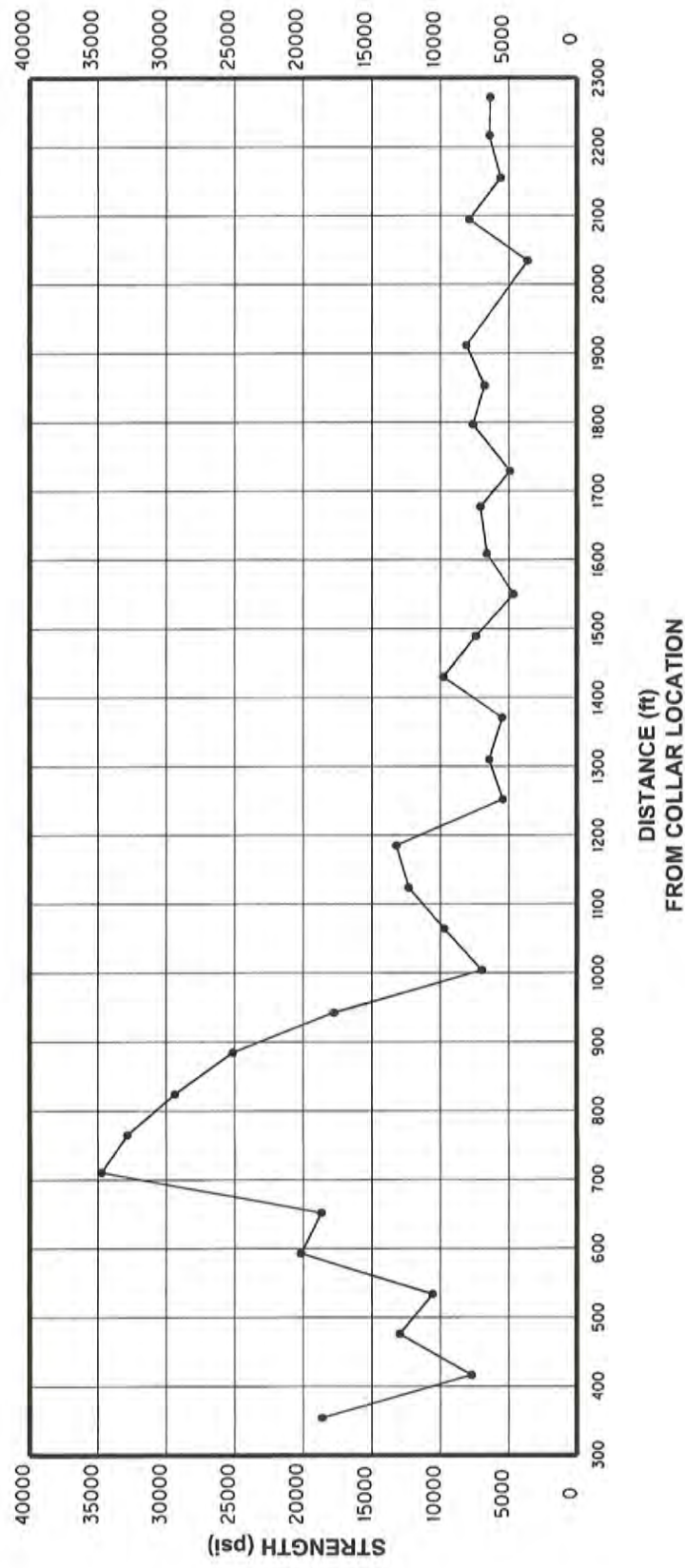
Graph “Splitting Tensile Strength versus Distance”

Graph “Splitting Tensile Strength versus Distance”

TABULATION OF ROCK CORE SAMPLE LOCATIONS

LABORATORY TEST REPORTS

SAMPLE COLLECTION LOCATIONS



SCALE: 1"=250' Horiz, 1"=10,000 Vert.

DATE: 8/31/11

DRAWN BY: CAC

PROJECT NO: 1831-10-5629

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 422 CODELL DRIVE, LEXINGTON, KY 40509
 PHONE: 859.293.5518

LOUISVILLE - SOUTHERN INDIANA
 OHIO RIVER BRIDGES TUNNEL - SOUTHBOUND HOLE
 ROCK UNCONFINED COMPRESSIVE STRENGTH

FIGURE NO.

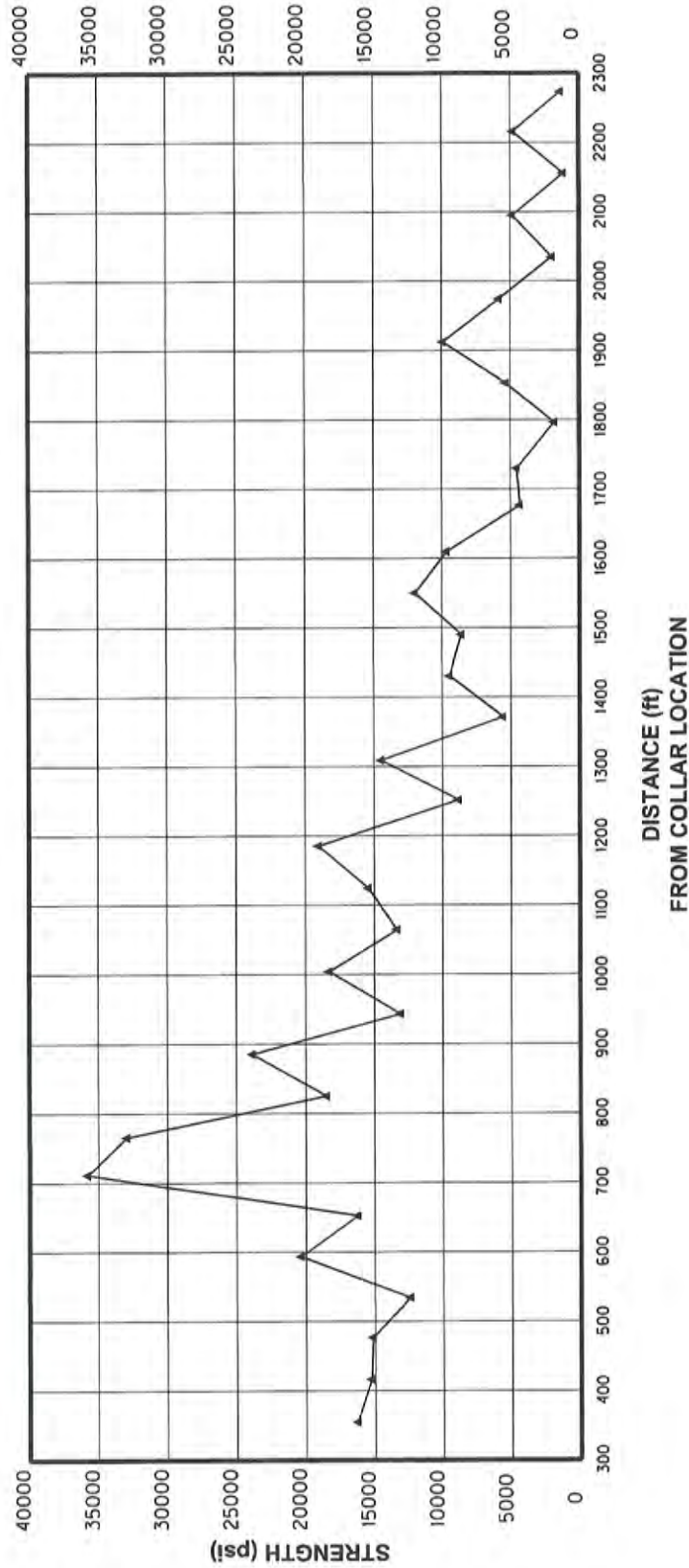


FIGURE NO.

LOUISVILLE - SOUTHERN INDIANA
OHIO RIVER BRIDGES TUNNEL - SOUTHBOUND HOLE
POINT LOAD STRENGTH INDEX - DIAMETRAL

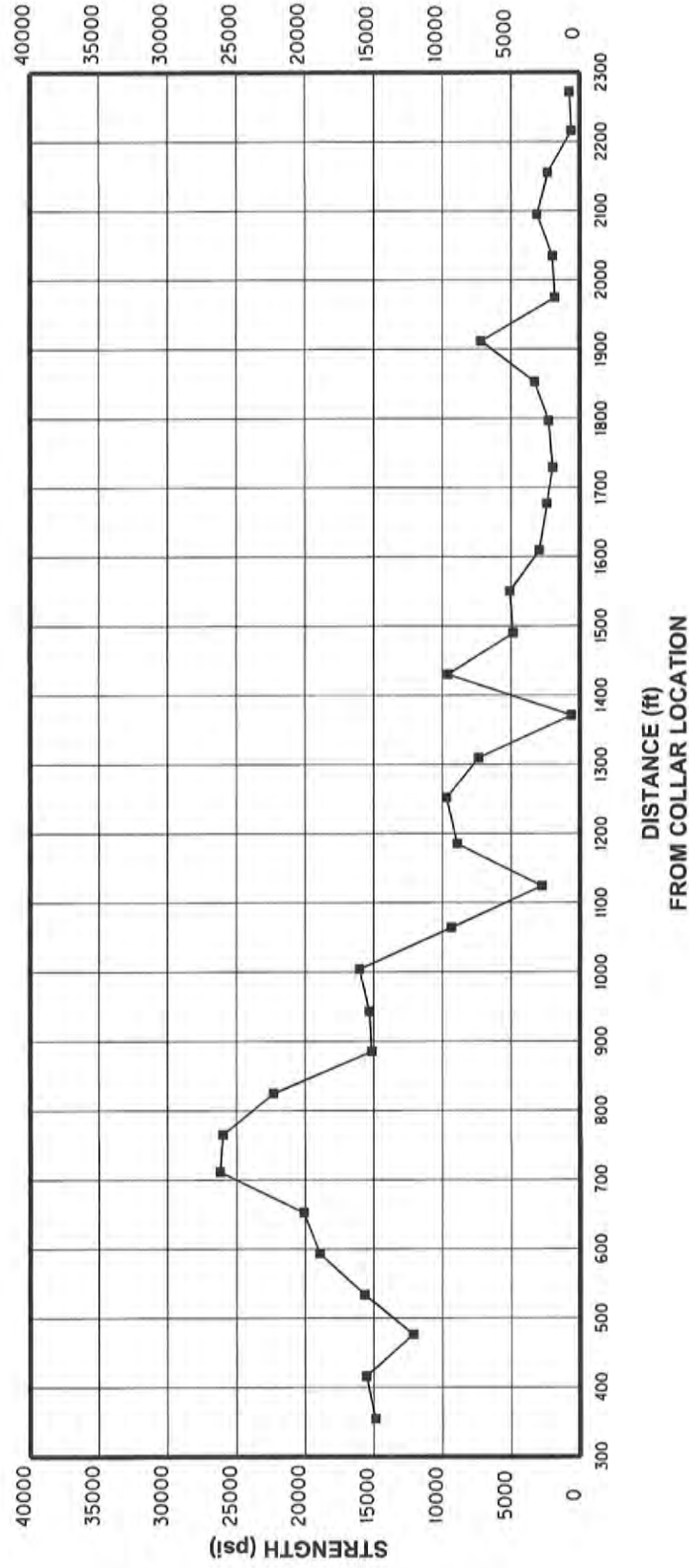


SCALE: 1"=250' Horiz, 1"=10,000 Vert.

DATE: 8/31/11

DRAWN BY: CAC

PROJECT NO: 1831-10-5629



SCALE: 1"=250' Horiz, 1"=10,000 Vert.

DATE: 8/31/11

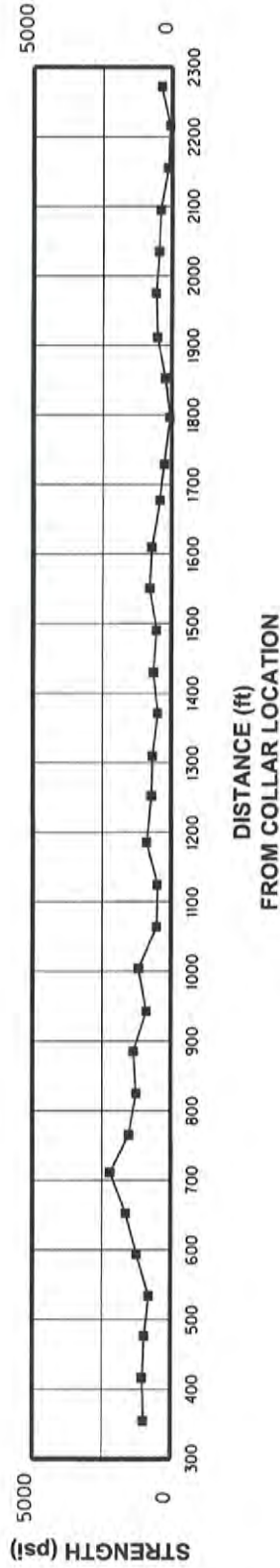
DRAWN BY: CAC

PROJECT NO: 1831-10-5629

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 PHONE: 859.293.5518

LOUISVILLE - SOUTHERN INDIANA
 OHIO RIVER BRIDGES TUNNEL - SOUTHBOUND HOLE
 POINT LOAD STRENGTH INDEX - AXIAL

FIGURE NO.



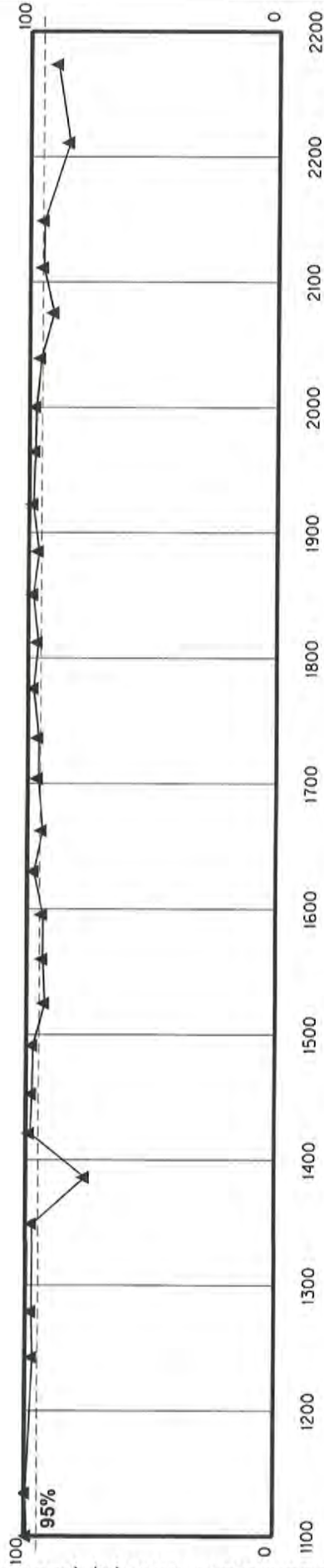
SCALE:	1"=250' Horiz, 1"=10,000 Vert.		
DATE:	8/31/11		
DRAWN BY:	CAC		
PROJECT NO:	1831-10-5629		

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FIGURE NO.

**LOUISVILLE - SOUTHERN INDIANA
 OHIO RIVER BRIDGES TUNNEL - SOUTHBOUND HOLE
 SPLITTING TENSILE STRENGTH**

SLAKE DURABILITY INDEX (%) (SECOND CYCLE)



DISTANCE (ft)
FROM COLLAR LOCATION

KYTC GEOTECHNICAL MANUAL
DURABLE SHALE ≥ 95
NONDURABLE SHALE ≤ 95

SCALE:

NONE

DATE:

8/31/11

DRAWN BY:

CAC

PROJECT NO:

1831-10-5629



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FIGURE NO.

LOUISVILLE - SOUTHERN INDIANA
OHIO RIVER BRIDGES TUNNEL - SOUTHBOUND HOLE
SLAKE DURABILITY INDEX (SECOND CYCLE)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Report Date: 8/23/2011

Sample Date: 8/5/2011

Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-1	Run 40 Box 29	354.6	2.65	1.24	1.21	168.0	89	22,530	18,620	0.3
SB-2	Run 46 Box 33	416.7	2.61	1.24	1.21	168.3	82	9,380	7,752	0.1
SB-3	Run 52 Box 37	476.5	4.01	1.86	2.72	168.6	93	35,310	12,982	0.3
SB-4	Run 58 Box 41	533.7	4.10	1.86	2.72	166.7	85	28,750	10,570	0.5
SB-5	Run 64 Box 45	593.5	4.00	1.86	2.72	166.0	88	54,820	20,154	0.3

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629
South Bound Boring 1
(Run 40 Box 29)
354.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 2
(Run 46 Box 33)
416.7' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 3
(Run 52 Box 37)
476.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 4
(Run 58 Box 41)
533.7' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 5
(Run 64 Box 45)
593.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 1
(Run 40 Box 29)
354.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 2
(Run 46 Box 33)
416.7' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 3
(Run 52 Box 37)
476.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 4
(Run 58 Box 41)
533.7' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 5
(Run 64 Box 45)
593.5' (Unconfined)

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S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Sample Date: 8/5/2011

Report Date: 8/23/2011

Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-6	Run 70 Box 49	652.4	2.69	1.24	1.21	170.1	90	22,600	18,678	0.1
SB-7	Run 76 Box 53	711.1	2.66	1.24	1.21	173.9	93	42,060	34,760	0.1
SB-8	Run 82 Box 56	765.2	4.10	1.87	2.75	172.8	91	90,370	32,862	0.0
SB-9	Run 88 Box 60	824.7	4.08	1.86	2.72	172.9	96	79,950	29,393	0.1

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629
South Bound Boring 6
(Run 70 Box 49)
652.4' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 7
(Run 76 Box 53)
711.1' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 8
(Run 82 Box 56)
765.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 9
(Run 88 Box 60)
824.7' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 6
(Run 70 Box 49)
652.4' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 7
(Run 76 Box 53)
711.1' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 8
(Run 82 Box 56)
765.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 9
(Run 88 Box 60)
824.7' (Unconfined)

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S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Sample Date: 8/12/2011

Report Date: 8/29/2011

Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-10	Run 94 Box 65	885.2	4.08	1.86	2.72	170.3	87	68,380	25,140	0.0
SB-11	Run 100 Box 69	942.9	3.99	1.86	2.72	168.7	92	48,300	17,757	0.1
SB-12	Run 107 Box 73	1004.3	2.68	1.24	1.21	167.8	65	8,450	6,983	0.1
SB-13	Run 113 Box 77	1064.2	3.92	1.86	2.72	166.0	90	26,480	9,735	0.2
SB-16	Run 119 Box 81	1124.2	3.91	1.86	2.72	166.2	95	33,500	12,316	0.3
SB-18	Run 125 Box 85	1185.2	3.90	1.86	2.72	168.5	88	35,920	13,206	0.2

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629
South Bound Boring 10
(Run 94 Box 65)
885.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 11
(Run 100 Box 69)
942.9' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 12
(Run 107 Box 73)
1,004.3' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 13
(Run 113 Box 77)
1,064.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 16
(Run 119 Box 81)
1,124.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 18
(Run 125 Box 85)
1,185.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 10
(Run 94 Box 65)
885.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 11
(Run 100 Box 69)
942.9' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 12
(Run 107 Box 73)
1,004.3' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 13
(Run 113 Box 77)
1,064.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 16
(Run 119 Box 81)
1,124.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 18
(Run 125 Box 85)
1,185.2' (Unconfined)

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3701 Spring Forest Road
Raleigh, NC 27616

S&ME, Inc. - Corporate

UNCONFINED COMPRESSION
(ASTM D7012 Method C)



S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Report Date: 9/7/2011

Sample Date: 8/19/2011

Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-22	Run 132 Box 89	1252.5	3.94	1.86	2.72	159.0	81	14,810	5,445	0.8
SB-24	Run 138 Box 93	1309.9	2.56	1.24	1.21	159.4	89	7,790	6,438	0.9
SB-27	Run 145 Box 97	1371.0	3.89	1.81	2.57	165.6	83	14,150	5,506	2.1
SB-30	Run 151 Box 101	1430.0	3.84	1.85	2.69	164.3	82	26,310	9,781	1.2
SB-33	Run 157 Box 105	1489.8	3.74	1.84	2.66	166.9	74	19,750	7,425	1.6

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629
South Bound Boring 22
(Run 132 Box 89)
1252.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 24
(Run 138 Box 93)
1309.9' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 27
(Run 145 Box 97)
1,371.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 30
(Run 151 Box 101)
1,430.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 33
(Run 157 Box 105)
1,489.8' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 22
(Run 132 Box 89)
1252.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 24
(Run 138 Box 93)
1309.9' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 27
(Run 145 Box 97)
1,371.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 30
(Run 151 Box 101)
1,430.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629
South Bound Boring 33
(Run 157 Box 105)
1,489.8' (Unconfined)

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Raleigh, NC 27616

S&ME, Inc. - Corporate

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Report Date: 9/15/2011

Project Name: Louisville Tunnel Project

Sample Date: 9/2/2011

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-36	Run 165 Box 109	1550.5	2.69	1.22	1.17	165.5	71	5,450	4,658	1.5
SB-40	Run 171 Box 113	1609.2	3.94	1.84	2.66	165.7	83	17,610	6,620	1.6
SB-44	Run 178 Box 118	1677.3	3.88	1.84	2.66	164.7	87	18,870	7,094	1.7

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629

South Bound Boring 36
(Run 165 Box 109)
1550.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 40
(Run 171 Box 113)
1609.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 44
(Run 178 Box 118)
1677.3' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 36
(Run 165 Box 109)
1550.5' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 40
(Run 171 Box 113)
1609.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 44
(Run 178 Box 118)
1677.3' (Unconfined)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 9/16/2011

Report Date: 9/28/2011

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-67	Run 222 Box 146	2094.6	3.99	1.83	2.63	165.6	89	20,840	7,924	2.3
SB-70	Run 228 Box 150	2155.0	3.91	1.83	2.63	165.8	78	14,770	5,616	2.4
SB-71	Run 234 Box 154	2216.6	4.00	1.83	2.63	165.7	85	16,920	6,433	2.3
SB-73	Run 240 Box 158	2272.2	3.97	1.83	2.63	165.5	84	16,770	6,376	2.4

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629

South Bound Boring 67
(Run 222 Box 146)
2,094.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 70
(Run 228 Box 150)
2,155.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 71
(Run 234 Box 154)
2,216.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 73
(Run 240 Box 158)
2,272.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 67
(Run 222 Box 146)
2,094.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 70
(Run 228 Box 150)
2,155.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 71
(Run 234 Box 154)
2,216.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 73
(Run 240 Box 158)
2,272.2' (Unconfined)

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Unconfined Compression Cores received 9-16-11 South Bound
Page 1 of 1

UNCONF. J COMPRESSION
(ASTM D7012 Method C)



S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Report Date: 9/27/2011

Sample Date: 9/9/2011

Project #: 1831-10-5629

Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-47	Run 183 Box 121	1729.2	3.97	1.83	2.63	165.8	79	12,930	4,916	1.9
SB-50	Run 191 Box 126	1796.9	3.96	1.84	2.66	165.1	79	20,330	7,643	1.7
SB-54	Run 197 Box 130	1853.3	3.96	1.84	2.66	165.0	77	18,060	6,789	1.8
SB-56	Run 203 Box 134	1911.6	3.92	1.85	2.69	163.9	77	21,820	8,112	1.3
SB-63	Run 216 Box 142	2034.6	3.96	1.83	2.63	164.6	71	9,560	3,635	2.0

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629

South Bound Boring 47
(Run 183 Box 121)
1,729.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 50
(Run 191 Box 126)
1,796.9' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 54
(Run 197 Box 130)
1,853.3' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 56
(Run 203 Box 134)
1,911.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 63
(Run 216 Box 142)
2,034.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 47
(Run 183 Box 121)
1,729.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 50
(Run 191 Box 126)
1,796.9' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 54
(Run 197 Box 130)
1,853.3' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 56
(Run 203 Box 134)
1,911.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 63
(Run 216 Box 142)
2,034.6' (Unconfined)

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Unconfined Compression Cores received 9-09-11 South Bound
Page 1 of 1

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Report Date: 9/28/2011

Project Name: Louisville Tunnel Project

Sample Date: 9/16/2011

Sample No.	Boring Location	Distance (ft)	Specimen Dimension, in.		Area (in ²)	Bulk Density (lb/ft ³)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
SB-67	Run 222 Box 146	2094.6	3.99	1.83	2.63	165.6	89	20,840	7,924	2.3
SB-70	Run 228 Box 150	2155.0	3.91	1.83	2.63	165.8	78	14,770	5,616	2.4
SB-71	Run 234 Box 154	2216.6	4.00	1.83	2.63	165.7	85	16,920	6,433	2.3
SB-73	Run 240 Box 158	2272.2	3.97	1.83	2.63	165.5	84	16,770	6,376	2.4

NOTES: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629

South Bound Boring 67
(Run 222 Box 146)
2,094.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 70
(Run 228 Box 150)
2,155.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 71
(Run 234 Box 154)
2,216.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 73
(Run 240 Box 158)
2,272.2' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 67
(Run 222 Box 146)
2,094.6' (Unconfined)



Louisville Tunnel Project
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South Bound Boring 70
(Run 228 Box 150)
2,155.0' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 71
(Run 234 Box 154)
2,216.6' (Unconfined)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 73
(Run 240 Box 158)
2,272.2' (Unconfined)

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S&ME, Inc. - Corporate

Unconfined Compression Cores received 9-16-11 South Bound
Page 1 of 1



Quality Assurance

Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777
Sample Date: 8/5/2011 Report Date: 8/23/2011

Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Lab ID	Boring ID	Distance (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation / Joint Dip	W (in)	D (in)	D' (in)	D ² (in)	D _e (in)	Load (lbs)	I _p (psi)	F	I _{s(50)} (psi)	Failure Type	s _e (psi)
C11-254	SB-1 Run 40 Box 29	354.8	L'ville Limestone	As-Received	A	N/A	M	1.24	1.04	1.02	1.61	1.27	1237	768	0.821	631	3	14,881
C11-254	SB-1 Run 40 Box 29	354.9	L'ville Limestone	As-Received	D	N/A	M	N/A	1.22	1.18	1.44	1.20	1227	852	0.800	682	2	16,256
C11-255	SB-2 Run 46 Box 33	416.4	L'ville Limestone	As-Received	A	N/A	M	1.24	0.98	0.94	1.48	1.22	1201	811	0.806	654	3	15,543
C11-255	SB-2 Run 46 Box 33	416.3	L'ville Limestone	As-Received	D	N/A	M	N/A	1.22	1.18	1.44	1.20	1151	799	0.800	639	2	15,245
C11-256	SB-3 Run 52 Box 37	476.8	L'ville Limestone	As-Received	A	N/A	M	1.86	1.50	1.46	3.46	1.86	1881	544	0.975	530	3	12,137
C11-256	SB-3 Run 52 Box 37	477.0	L'ville Limestone	As-Received	D	N/A	M	N/A	1.85	1.81	3.35	1.83	2292	684	0.968	662	2	15,130
C11-257	SB-4 Run 58 Box 41	534.0	L'ville Limestone	As-Received	A	N/A	M	1.86	1.46	1.42	3.36	1.83	2379	708	0.968	685	3	15,661
C11-257	SB-4 Run 58 Box 41	534.2	L'ville Limestone	As-Received	D	N/A	M	N/A	1.85	1.81	3.35	1.83	1876	560	0.968	542	2	12,387
C11-258	SB-5 Run 64 Box 45	593.8	L'ville Limestone	As-Received	A	N/A	M	1.87	1.50	1.46	3.48	1.87	2943	846	0.977	827	3	18,929
C11-258	SB-5 Run 64 Box 45	594.0	L'ville Limestone	As-Received	D	N/A	M	N/A	1.85	1.81	3.35	1.83	3083	920	0.968	891	2	20,351
C11-259	SB-6 Run 70 Box 49	652.7	L'ville Limestone	As-Received	A	N/A	M	1.24	1.04	1.02	1.61	1.27	1670	1037	0.821	851	3	20,093
C11-259	SB-6 Run 70 Box 49	652.8	L'ville Limestone	As-Received	D	N/A	M	N/A	1.22	1.18	1.44	1.20	1222	849	0.800	679	2	16,199
C11-260	SB-7 Run 76 Box 53	711.4	L'ville Limestone	As-Received	A	N/A	M	1.24	1.02	0.98	1.55	1.24	2110	1361	0.812	1105	3	26,198
C11-260	SB-7 Run 76 Box 53	711.5	L'ville Limestone	As-Received	D	N/A	M	N/A	1.22	1.18	1.44	1.20	2700	1875	0.800	1500	2, 3	35,775
C11-261	SB-8 Run 82 Box 56	765.5	L'ville Limestone	As-Received	A	N/A	M	1.87	1.50	1.46	3.48	1.87	4045	1162	0.977	1135	3	25,999
C11-261	SB-8 Run 82 Box 56	765.7	L'ville Limestone	As-Received	D	N/A	M	N/A	1.85	1.81	3.35	1.83	4988	1489	0.968	1441	2, 3	32,937
C11-262	SB-9 Run 88 Box 60	825.0	L'ville Limestone	As-Received	A	N/A	M	1.87	1.50	1.46	3.48	1.87	3470	997	0.977	974	3	22,307
C11-262	SB-9 Run 88 Box 60	825.2	L'ville Limestone	As-Received	D	N/A	M	N/A	1.85	1.81	3.35	1.83	2797	835	0.968	808	2	18,471

Nomenclature Test Type: D = Diametral, A = Axial, B = Block, and I = Irregular
 Anisotropic Load: $\perp$ = Load applied perpendicular to anisotropic planes
 Foliation / Joint Dip: Angle measured from plane perpendicular to core axis, F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints), P = Pressure Solution Feature
 Failure Type: 1 = Along joint, foliation or other feature, 2 = across core axis, 3 = along core axis, 4 = pop-out (invalid), 5 = failure prior to loading (invalid)
 Se calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of J and D_e.

Notes / Deviations / References: ASTM D5731

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Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629

Project Name: **Louisville Tunnel Project**

Sample Date: 8/19/2011

Report Date: 9/7/2011

Quality Assurance

[illegible]

Nomenclature

Test Type: D = Diametral, A = Axial, B = Block, and I = Irregular

Anisotropic Load: $\perp$ = Load applied perpendicular to anisotropic planes

Foliation / Joint Dip: Angle measured from plane perpendicular to core axis. F =

Failure Type: 1 = Along joint, foliation or other feature, 2 = across core axis, 3 =

Sc calculated using generalized strength conversion factors interpolated from Table 1.

= Load applied parallel to anisotropic planes.

Joint. B = Bedding. M = Massive (no apparent foliation of joints). P = Pressure Solution Feature

Fig. 4 = pop-out (invalid). 5 = failure prior to loading (invalid)

D5731 and values of J and D_c

Notes / Deviations / References: ASTM D5731

NOTE: Samples had thinly bedded shale seams that were opening up prior to test.

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Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test

S&ME, Inc. - Knoxville 1413 Topsis Road, Louisville, TN 37777

Report Date: 9/15/2011

1831-10-5629

Sample Date: 9/2/2011

Project #:

Project Name: Louisville Tunnel Project[illegible]

Nomenclature

Test Type: D = Diametral, A = Axial, B = Block, and I = Irregular

$\perp$ = Load applied perpendicular to anisotropic planes

Foliation / Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint. B = Bedding. M = Massive (no apparent foliation of joints), P = Pressure Solution Feature

Foundation / Joint Dip: Angle measured from plane perpendicular to core axis, 1 = rotation, 2 = swing, 3 = bedding, 4 = strike-slip, 5 = normal, 6 = thrust, 7 = contraction, 8 = extension, 9 = compressive, 10 = tension, 11 = shear, 12 = normal, 13 = thrust, 14 = contraction, 15 = extension, 16 = compressive, 17 = tension, 18 = shear, 19 = normal, 20 = thrust, 21 = contraction, 22 = extension, 23 = compressive, 24 = tension, 25 = shear, 26 = normal, 27 = thrust, 28 = contraction, 29 = extension, 30 = compressive, 31 = tension, 32 = shear, 33 = normal, 34 = thrust, 35 = contraction, 36 = extension, 37 = compressive, 38 = tension, 39 = shear, 40 = normal, 41 = thrust, 42 = contraction, 43 = extension, 44 = compressive, 45 = tension, 46 = shear, 47 = normal, 48 = thrust, 49 = contraction, 50 = extension, 51 = compressive, 52 = tension, 53 = shear, 54 = normal, 55 = thrust, 56 = contraction, 57 = extension, 58 = compressive, 59 = tension, 60 = shear, 61 = normal, 62 = thrust, 63 = contraction, 64 = extension, 65 = compressive, 66 = tension, 67 = shear, 68 = normal, 69 = thrust, 70 = contraction, 71 = extension, 72 = compressive, 73 = tension, 74 = shear, 75 = normal, 76 = thrust, 77 = contraction, 78 = extension, 79 = compressive, 80 = tension, 81 = shear, 82 = normal, 83 = thrust, 84 = contraction, 85 = extension, 86 = compressive, 87 = tension, 88 = shear, 89 = normal, 90 = thrust, 91 = contraction, 92 = extension, 93 = compressive, 94 = tension, 95 = shear, 96 = normal, 97 = thrust, 98 = contraction, 99 = extension, 100 = compressive, 101 = tension, 102 = shear, 103 = normal, 104 = thrust, 105 = contraction, 106 = extension, 107 = compressive, 108 = tension, 109 = shear, 110 = normal, 111 = thrust, 112 = contraction, 113 = extension, 114 = compressive, 115 = tension, 116 = shear, 117 = normal, 118 = thrust, 119 = contraction, 120 = extension, 121 = compressive, 122 = tension, 123 = shear, 124 = normal, 125 = thrust, 126 = contraction, 127 = extension, 128 = compressive, 129 = tension, 130 = shear, 131 = normal, 132 = thrust, 133 = contraction, 134 = extension, 135 = compressive, 136 = tension, 137 = shear, 138 = normal, 139 = thrust, 140 = contraction, 141 = extension, 142 = compressive, 143 = tension, 144 = shear, 145 = normal, 146 = thrust, 147 = contraction, 148 = extension, 149 = compressive, 150 = tension, 151 = shear, 152 = normal, 153 = thrust, 154 = contraction, 155 = extension, 156 = compressive, 157 = tension, 158 = shear, 159 = normal, 160 = thrust, 161 = contraction, 162 = extension, 163 = compressive, 164 = tension, 165 = shear, 166 = normal, 167 = thrust, 168 = contraction, 169 = extension, 170 = compressive, 171 = tension, 172 = shear, 173 = normal, 174 = thrust, 175 = contraction, 176 = extension, 177 = compressive, 178 = tension, 179 = shear, 180 = normal, 181 = thrust, 182 = contraction, 183 = extension, 184 = compressive, 185 = tension, 186 = shear, 187 = normal, 188 = thrust, 189 = contraction, 190 = extension, 191 = 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compressive, 255 = tension, 256 = shear, 257 = normal, 258 = thrust, 259 = contraction, 260 = extension, 261 = compressive, 262 = tension, 263 = shear, 264 = normal, 265 = thrust, 266 = contraction, 267 = extension, 268 = compressive, 269 = tension, 270 = shear, 271 = normal, 272 = thrust, 273 = contraction, 274 = extension, 275 = compressive, 276 = tension, 277 = shear, 278 = normal, 279 = thrust, 280 = contraction, 281 = extension, 282 = compressive, 283 = tension, 284 = shear, 285 = normal, 286 = thrust, 287 = contraction, 288 = extension, 289 = compressive, 290 = tension, 291 = shear, 292 = normal, 293 = thrust, 294 = contraction, 295 = extension, 296 = compressive, 297 = tension, 298 = shear, 299 = normal, 300 = thrust, 301 = contraction, 302 = extension, 303 = compressive, 304 = tension, 305 = shear, 306 = normal, 307 = thrust, 308 = contraction, 309 = extension, 310 = compressive, 311 = tension, 312 = shear, 313 = normal, 314 = thrust, 315 = contraction, 316 = extension, 317 = compressive, 318 = tension, 319 = shear, 320 = normal, 321 = thrust, 322 = contraction, 323 = extension, 324 = compressive, 325 = tension, 326 = shear, 327 = normal, 328 = thrust, 329 = contraction, 330 = extension, 331 = compressive, 332 = tension, 333 = shear, 334 = normal, 335 = thrust, 336 = contraction, 337 = extension, 338 = compressive, 339 = tension, 340 = shear, 341 = normal, 342 = thrust, 343 = contraction, 344 = extension, 345 = compressive, 346 = tension, 347 = shear, 348 = normal, 349 = thrust, 350 = contraction, 351 = extension, 352 = compressive, 353 = tension, 354 = shear, 355 = normal, 356 = thrust, 357 = contraction, 358 = extension, 359 = compressive, 360 = tension, 361 = shear, 362 = normal, 363 = thrust, 364 = contraction, 365 = extension, 366 = compressive, 367 = tension, 368 = shear, 369 = normal, 370 = thrust, 371 = contraction, 372 = extension, 373 = compressive, 374 = tension, 375 = shear, 376 = normal, 377 = thrust, 378 = contraction, 379 = extension, 380 = compressive, 381 = tension, 382 = shear, 383 = normal, 384 = thrust, 385 = contraction, 386 = extension, 387 = compressive, 388 = tension, 389 = shear, 390 = normal, 391 = thrust, 392 = contraction, 393 = extension, 394 = compressive, 395 = tension, 396 = shear, 397 = normal, 398 = thrust, 399 = contraction, 400 = extension, 401 = compressive, 402 = tension, 403 = shear, 404 = normal, 405 = thrust, 406 = contraction, 407 = extension, 408 = compressive, 409 = tension, 410 = shear, 411 = normal, 412 = thrust, 413 = contraction, 414 = extension, 415 = compressive, 416 = tension, 417 = shear, 418 = normal, 419 = thrust, 420 = contraction, 421 = extension, 422 = compressive, 423 = tension, 424 = shear, 425 = normal, 426 = thrust, 427 = contraction, 428 = extension, 429 = compressive, 430 = tension, 431 = shear, 432 = normal, 433 = thrust, 434 = contraction, 435 = extension, 436 = compressive, 437 = tension, 438 = shear, 439 = normal, 440 = thrust, 441 = contraction, 442 = extension, 443 = compressive, 444 = tension, 445 = shear, 446 = normal, 447 = thrust, 448 = contraction, 449 = extension, 450 = compressive, 451 = tension, 452 = shear, 453 = normal, 454 = thrust, 455 = contraction, 456 = extension, 457 = compressive, 458 = tension, 459 = shear, 460 = normal, 461 = thrust, 462 = contraction, 463 = extension, 464 = compressive, 465 = tension, 466 = shear, 467 = normal, 468 = thrust, 469 = contraction, 470 = extension, 471 = compressive, 472 = tension, 473 = shear, 474 = normal, 475 = thrust, 476 = contraction, 477 = extension, 478 = compressive, 479 = tension, 480 = shear, 481 = normal, 482 = thrust, 483 = contraction, 484 = extension, 485 = compressive, 486 = tension, 487 = shear, 488 = normal, 489 = thrust, 490 = contraction, 491 = extension, 492 = compressive, 493 = tension, 494 = shear, 495 = normal, 496 = thrust, 497 = contraction, 498 = extension, 499 = compressive, 500 = tension, 501 = shear, 502 = normal, 503 = thrust, 504 = contraction, 505 = extension, 506 = compressive, 507 = tension, 508 = shear, 509 = normal, 510 = thrust, 511 = contraction, 512 = extension, 513 = compressive, 514 = tension, 515 = shear, 516 = normal, 517 = thrust, 518 = contraction, 519 = extension, 520 = compressive, 521 = tension, 522 = shear, 523 = normal, 524 = thrust, 525 = contraction, 526 = extension, 527 = compressive, 528 = tension, 529 = shear, 530 = normal, 531 = thrust, 532 = contraction, 533 = extension, 534 = compressive, 535 = tension, 536 = shear, 537 = normal, 538 = thrust, 539 = contraction, 540 = extension, 541 = compressive, 542 = tension, 543 = shear, 544 = normal, 545 = thrust, 546 = contraction, 547 = extension, 548 = compressive, 549 = tension, 550 = shear, 551 = normal, 552 = thrust, 553 = contraction, 554 = extension, 555 = compressive, 556 = tension, 557 = shear, 558 = normal, 559 = thrust, 560 = contraction, 561 = extension, 562 = compressive, 563 = tension, 564 = shear, 565 = normal, 566 = thrust, 567 = contraction, 568 = extension, 569 = compressive, 570 = tension, 571 = shear, 572 = normal, 573 = thrust, 574 = contraction, 575 = extension, 576 = compressive, 577 = tension, 578 = shear, 579 = normal, 580 = thrust, 581 = contraction, 582 = extension, 583 = compressive, 584 = tension, 585 = shear, 586 = normal,

 σ_{sc} calculated using generalized strength conversion factors interpolated from Table I in ASTM D5731 and values of J and D_e .

Notes / Deviations / References: ASTM D5731

NOTE 1: Failure plane did not go through both points.

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Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

1831-10-5629

Project #:	1831-10-5629
Project Name:	Louisville Tunnel Project

9/9/2011

Sample Date:

Report Date: 9/27/2011

Quality Assurance

[illegible]

Nomenclature

Test Type: D = Diametral, A = Axial, B = Block, and I = Irregular

Anisotropic Load: $\perp$ = Load applied perpendicular to anisotropic planes

Foliation / Joint Dip: Angle measured from plane perpendicular to core axis, F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints), P = Pressure Solution Feature

Failure Type: 1 = Along joint, foliation or other feature. 2 = across core axis. 3 = along core axis. 4 = pop-out (invalid). 5 = failure prior to loading (invalid)

Se calculated using generalized conversion factors interpolated from Table I in ASTM D5731 and values of J and D_c .

Notes / Deviations / References:

ASTM D5731

NOTE 1: Failure plane did not go through both points.

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S&ME, Inc. - Corporate

3201 Spring Forest Road
Raleigh, NC 27616

Point Load Cores received 9-09-2011 South Bound
Page 1 of 1



SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

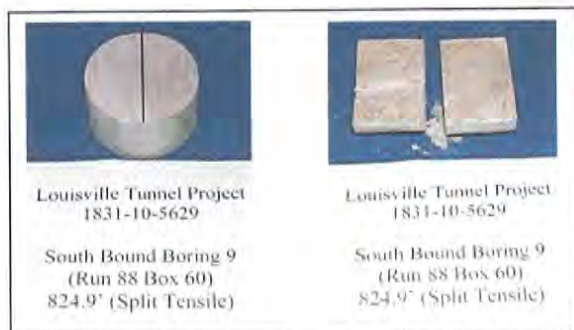
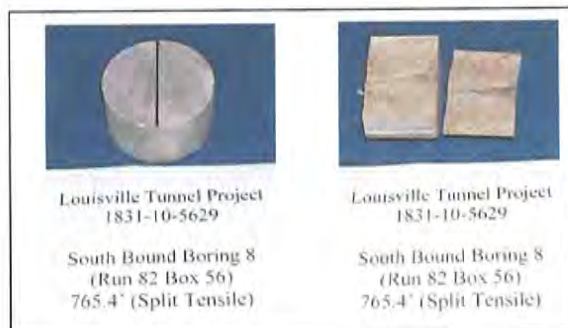
Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 8/5/2011

Report Date: 8/23/2011

Hole ID (Sample #)	Distance (ft)	Specimen Dimension			Bulk Density (lb/ft ³)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
SB-7 Run 76 Box 53	711.3	1.24	0.89	0.72	172.6	0.1	7,650	1,789	4,413
SB-8 Run 82 Box 56	765.4	1.87	1.20	0.64	171.7	0.1	10,780	1,223	3,058
SB-9 Run 88 Box 60	824.9	1.87	1.17	0.63	170.6	0.1	8,720	1,119	2,537

NOTE: Bulk Density includes any moisture that is within the specimen.



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3201 Spring Forest Road
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Split Tensile Cores received 8-5-11 (South Bound)

Page 2 of 2



SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 8/12/2011

Report Date: 8/29/2011

Hole ID (Sample #)	Distance (ft)	Specimen Dimension			Bulk Density (lb/ft ³)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
SB-10 Run 94 Box 65	885.4	1.86	1.18	0.63	170.0	0.0	9,410	915	2,729
SB-11 Run 100 Box 69	943.1	1.86	1.19	0.64	167.9	0.1	6,290	810	1,809
SB-12 Run 107 Box 73	1,004.5	1.24	0.83	0.67	166.9	0.0	3,830	1,895	2,369
SB-13 Run 113 Box 77	1,064.4	1.86	1.16	0.62	165.8	0.2	3,600	664	1,062
SB-16 Run 119 Box 81	1,124.4	1.86	1.16	0.62	164.9	0.3	3,380	843	997
SB-18 Run 125 Box 85	1,185.4	1.87	1.11	0.59	167.6	0.1	5,820	992	1,785

NOTE: Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project
1831-10-5629

South Bound Boring 10
(Run 94 Box 65)
885.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 10
(Run 94 Box 65)
885.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 11
(Run 100 Box 69)
943.1' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 11
(Run 100 Box 69)
943.1' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 12
(Run 107 Box 73)
1,004.5' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 12
(Run 107 Box 73)
1,004.5' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 13
(Run 113 Box 77)
1,064.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 13
(Run 113 Box 77)
1,064.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 16
(Run 119 Box 81)
1,124.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 16
(Run 119 Box 81)
1,124.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 18
(Run 125 Box 85)
1,185.4' (Split Tensile)



Louisville Tunnel Project
1831-10-5629

South Bound Boring 18
(Run 125 Box 85)
1,185.4' (Split Tensile)

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Split Tensile Cores received 8-12-11 (South Bound)

Page 1 of 1



SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

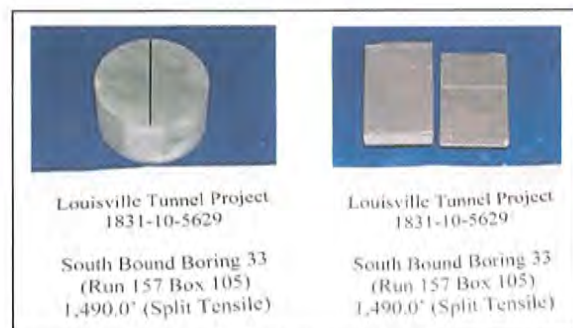
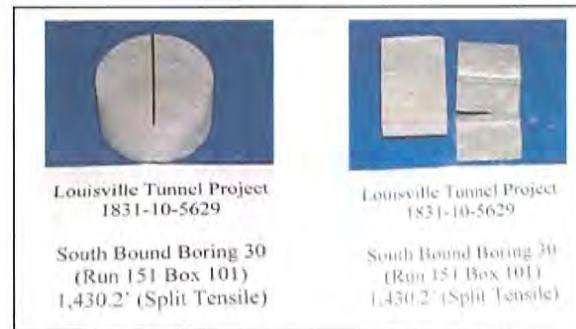
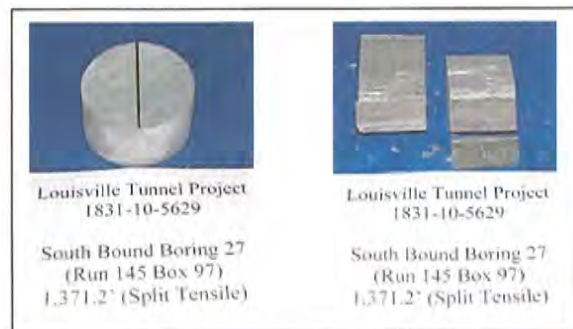
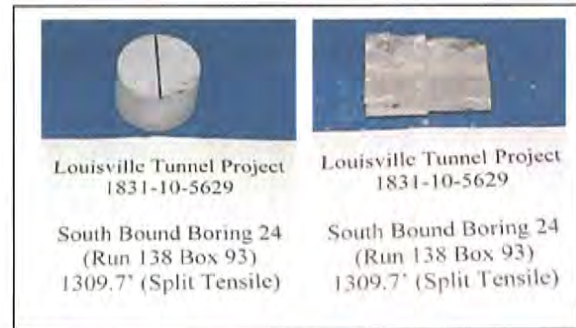
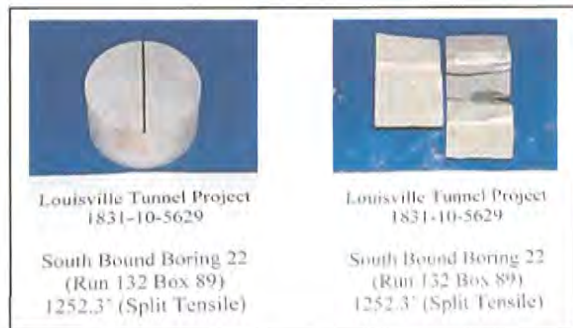
Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 8/19/2011

Report Date: 9/7/2011

Hole ID (Sample #)	Distance (ft)	Specimen Dimension			Bulk Density (lb/ft ³)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
SB-22 Run 132 Box 89	1,252.3	1.86	1.14	0.61	160.7	0.7	4,840	1,118	1,453
SB-24 Run 138 Box 93	1,309.7	1.24	0.88	0.71	159.5	0.8	2,370	1,338	1,383
SB-27 Run 145 Box 97	1,371.2	1.82	1.13	0.62	163.2	2.0	3,270	1,012	1,012
SB-30 Run 151 Box 101	1,430.2	1.85	1.12	0.61	164.4	1.2	4,310	854	1,324
SB-33 Run 157 Box 105	1,490.0	1.84	1.13	0.61	167.4	1.5	3,580	756	1,096

NOTE: Bulk Density includes any moisture that is within the specimen.



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SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

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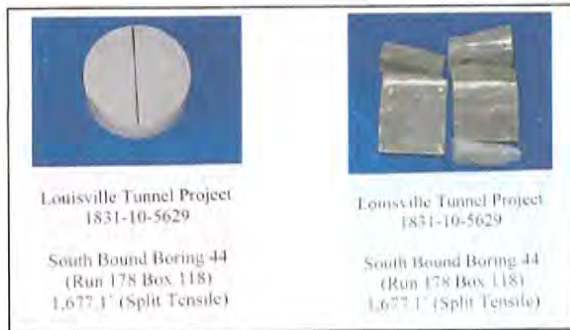
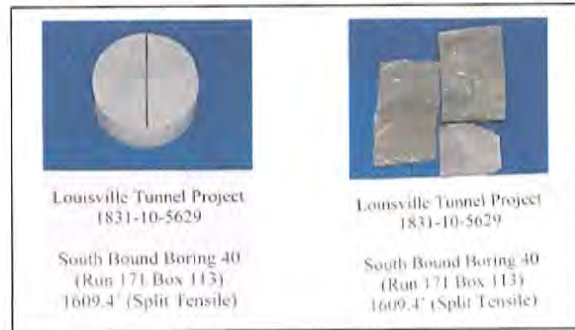
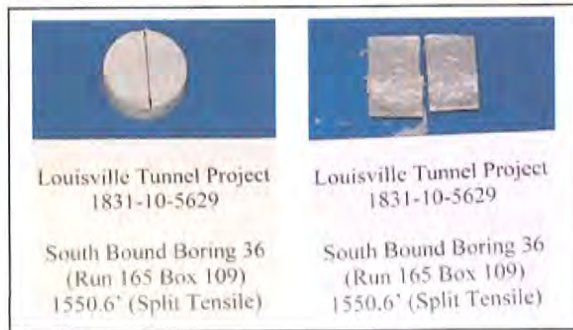
Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 9/2/2011

Report Date: 9/15/2011

Hole ID (Sample #)	Distance (ft)	Specimen Dimension			Bulk Density (lb/ft ³)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
SB-36 Run 165 Box 109	1,550.6	1.22	0.73	0.60	164.6	1.3	2,220	787	1,587
SB-40 Run 171 Box 113	1,609.4	1.84	1.15	0.63	164.2	1.4	4,830	765	1,453
SB-44 Run 178 Box 118	1,677.1	1.84	1.19	0.65	165.0	1.4	2,980	641	866

NOTE: Bulk Density includes any moisture that is within the specimen.



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SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

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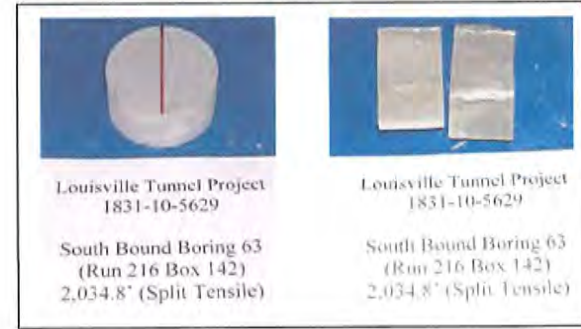
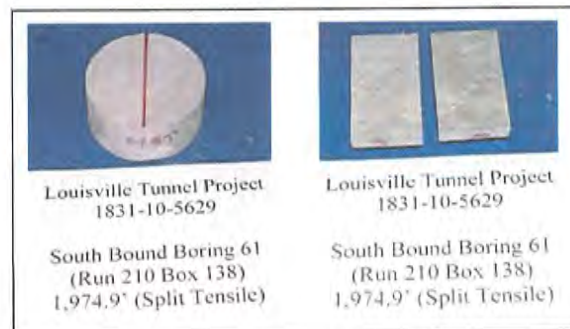
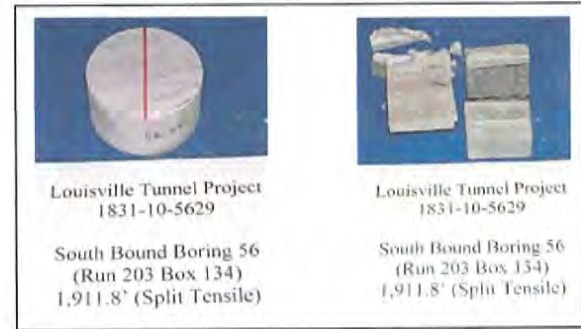
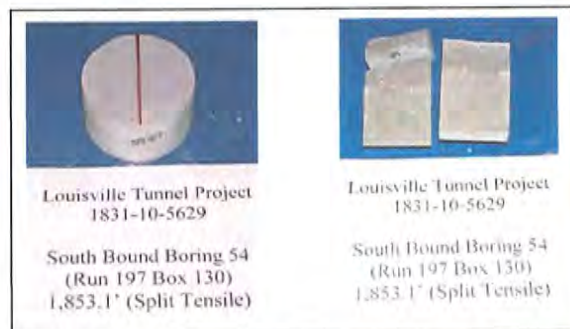
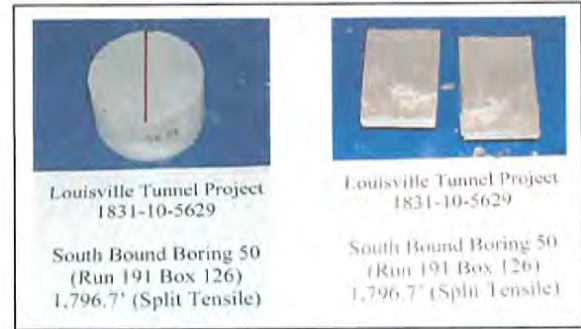
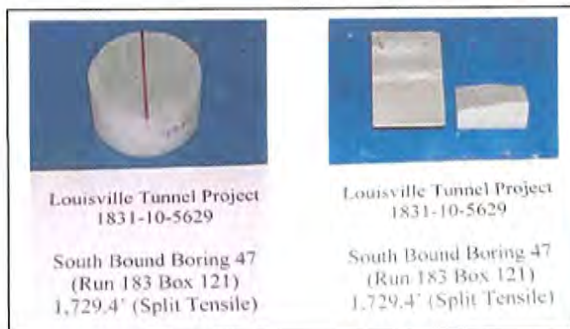
Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 9/9/2011

Report Date: 9/27/2011

Hole ID (Sample #)	Distance (ft)	Specimen Dimension			Bulk Density (lb/ft ³)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
SB-47 Run 183 Box 121	1,729.4	1.83	1.16	0.63	166.9	1.8	1,870	443	561
SB-50 Run 191 Box 126	1,796.7	1.84	1.20	0.65	162.5	1.8	520	429	150
SB-54 Run 197 Box 130	1,853.1	1.84	1.14	0.62	166.5	1.8	1,540	395	467
SB-56 Run 203 Box 134	1,911.8	1.85	1.16	0.63	164.1	1.3	3,510	578	1,041
SB-61 Run 210 Box 138	1,974.9	1.85	1.02	0.55	165.8	1.4	3,430	451	1,157
SB-63 Run 216 Box 142	2,034.8	1.82	1.06	0.58	166.7	1.9	2,840	450	937

NOTE: Bulk Density includes any moisture that is within the specimen.



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Split Tensile Cores received 9-09-11 (South Bound)



SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

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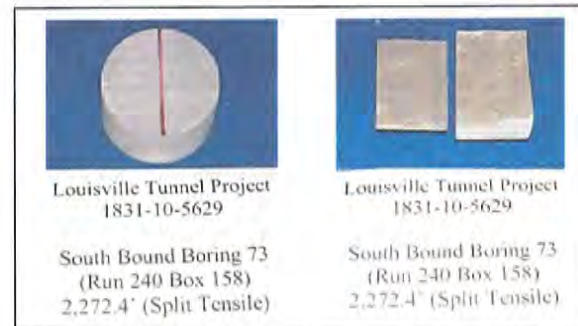
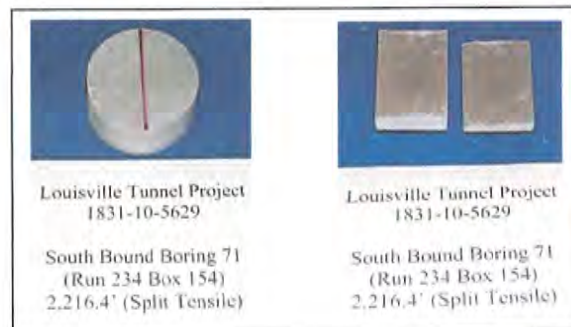
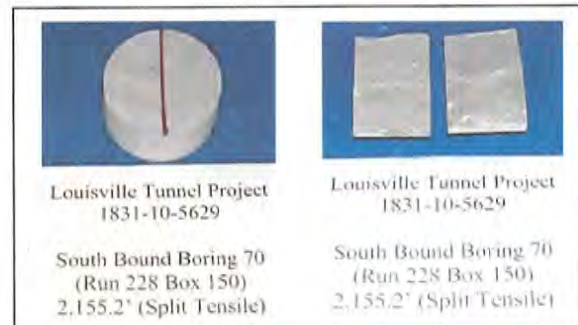
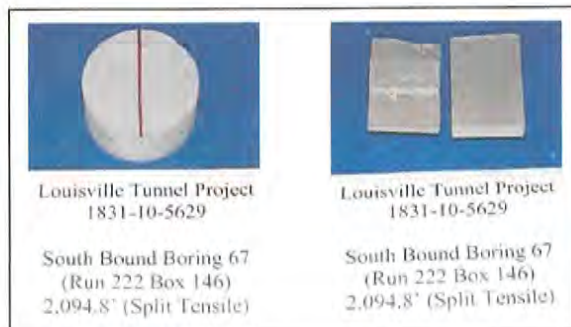
Project #: 1831-10-5629
Project Name: Louisville Tunnel Project

Sample Date: 9/16/2011

Report Date: 9/28/2011

Hole ID (Sample #)	Distance (ft)	Specimen Dimension			Bulk Density (lb/ft ³)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
SB-67 Run 222 Box 146	2,094.8	1.82	1.13	0.62	167.6	2.2	2,660	461	823
SB-70 Run 228 Box 150	2,155.2	1.83	1.15	0.63	166.6	2.2	950	278	287
SB-71 Run 234 Box 154	2,216.4	1.83	1.15	0.63	166.5	2.2	530	160	160
SB-73 Run 240 Box 158	2,272.4	1.83	1.14	0.62	164.4	2.3	2,510	354	766

NOTE: Bulk Density includes any moisture that is within the specimen.



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3201 Spring Forest Road
Raleigh, NC 27616

Split Tensile Cores received 9-16-11 (South Bound)

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-14 Run 117 Box 79 (1100.0 - 1101.5)
 Date Tested: 8/24/2011 to 8/26/2011

Sample Date: 8/12/2011
 Report Date: 8/29/2011

Slake Durability Index (Second Cycle)	98.1	%
Range of water temperature (Cycle 1)	1.0	°F
Average water temperature (Cycle 1)	76.5	°F
Range of water temperature (Cycle 2)	2.5	°F
Average water temperature (Cycle 2)	75.3	°F
Natural Moisture Content	1.29	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	☒
II	Retained specimen consists of large and small fragments	☐
III	Retained specimen is exclusively small fragments	☐



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-17 Run 120 Box 81 (1134.2 - 1135.9)
 Date Tested: 8/24/2011 to 8/26/2011

Sample Date: 8/12/2011
 Report Date: 8/29/2011

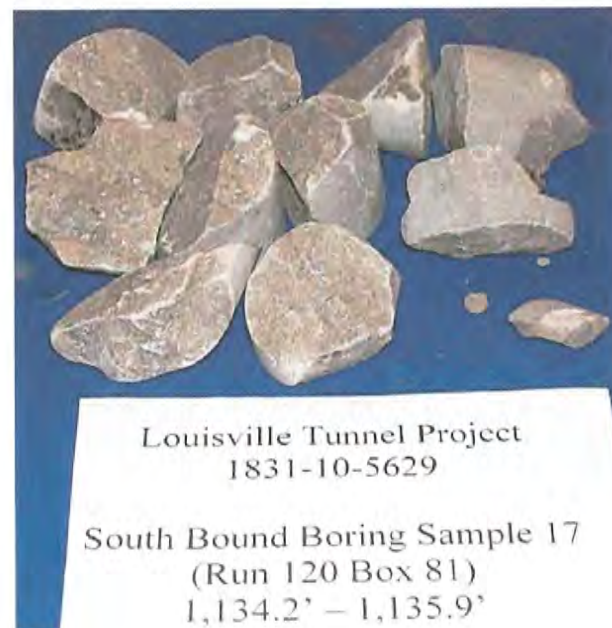
Slake Durability Index (Second Cycle)	99.3	%
Range of water temperature (Cycle 1)	1.5	°F
Average water temperature (Cycle 1)	76.3	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	74.8	°F
Natural Moisture Content	0.32	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	☒
II	Retained specimen consists of large and small fragments	☐
III	Retained specimen is exclusively small fragments	☐



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-21 Run 131 Box 89 (1246.2 - 1243.8)
 Date Tested: 8/24/2011 to 8/26/2011

Sample Date: 8/19/2011
 Report Date: 9/7/2011

Slake Durability Index (Second Cycle)	94.1	%
Range of water temperature (Cycle 1)	3.5	°F
Average water temperature (Cycle 1)	76.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	74.3	°F
Natural Moisture Content	2.73	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-23 Run 135 Box 91 (1279.0 - 1280.0)
 Date Tested: 8/24/2011 to 8/26/2011

Sample Date: 8/19/2011
 Report Date: 9/7/2011

Slake Durability Index (Second Cycle)	95.2	%
Range of water temperature (Cycle 1)	1.5	°F
Average water temperature (Cycle 1)	76.3	°F
Range of water temperature (Cycle 2)	3.0	°F
Average water temperature (Cycle 2)	75.0	°F
Natural Moisture Content	2.33	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-25 Run 143 Box 96 (1349.0 - 1350.5)
 Date Tested: 8/26/11 to 8/29/2011

Sample Date: 8/19/2011
 Report Date: 8/31/2011

Slake Durability Index (Second Cycle)	94.6	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	76.3	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	74.3	°F
Natural Moisture Content	2.64	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-28 Run 146 Box 98 (1386.0 - 1387.5)
 Date Tested: 8/26/11 to 8/29/2011

Sample Date: 8/19/2011
 Report Date: 9/7/2011

Slake Durability Index (Second Cycle)	52.7	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	76.5	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	74.0	°F
Natural Moisture Content	3.93	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	
III	Retained specimen is exclusively small fragments	☒



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

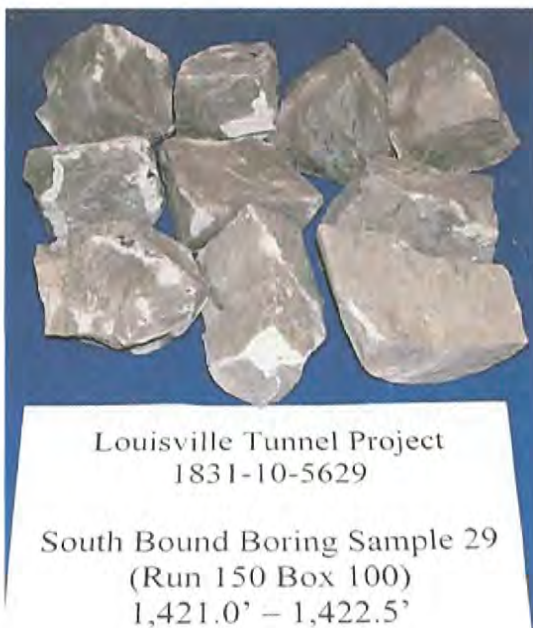
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-29 Run 150 Box 100 (1421.0 - 1422.5)
 Date Tested: 8/26/11 to 8/29/2011

Sample Date: 8/19/2011
 Report Date: 9/7/2011

Slake Durability Index (Second Cycle)	96.6	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	76.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	74.3	°F
Natural Moisture Content	2.62	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	☒
II	Retained specimen consists of large and small fragments	
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-31 Run 153 Box 103 (1452.3 - 1453.8)
 Date Tested: 8/26/11 to 8/29/2011

Sample Date: 8/19/2011
 Report Date: 9/7/2011

Slake Durability Index (Second Cycle)	95.1	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	76.3	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.8	°F
Natural Moisture Content	2.64	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

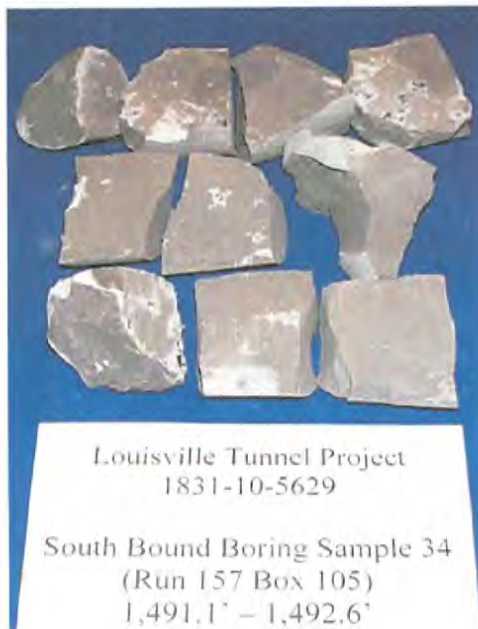
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-34 Run 157 Box 105 (1491.1 - 1492.6)
 Date Tested: 8/29/11 to 8/31/2011

Sample Date: 8/19/2011
 Report Date: 9/7/2011

Slake Durability Index (Second Cycle)	94.7	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	75.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.3	°F
Natural Moisture Content	2.16	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-35 Run 162 Box 107 (1524.8 - 1527.0)
 Date Tested: 9/09/2011 to 9/13/2011

Sample Date: 9/2/2011
 Report Date: 9/15/2011

Slake Durability Index (Second Cycle)	85.6	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	74.3	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.3	°F
Natural Moisture Content	2.25	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

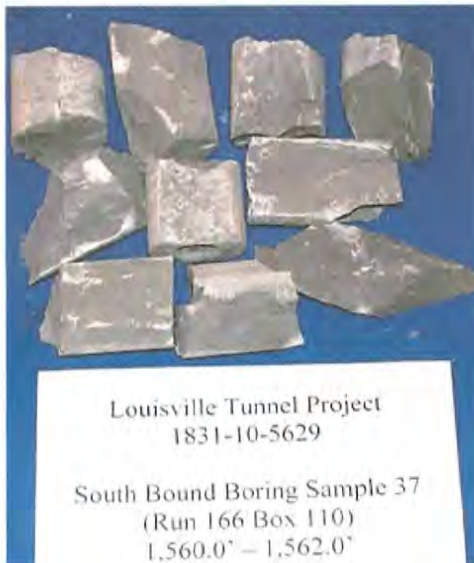
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-37 Run 166 Box 110 (1560.0 - 1562.0)
 Date Tested: 9/09/2011 to 9/13/2011

Sample Date: 9/2/2011
 Report Date: 9/15/2011

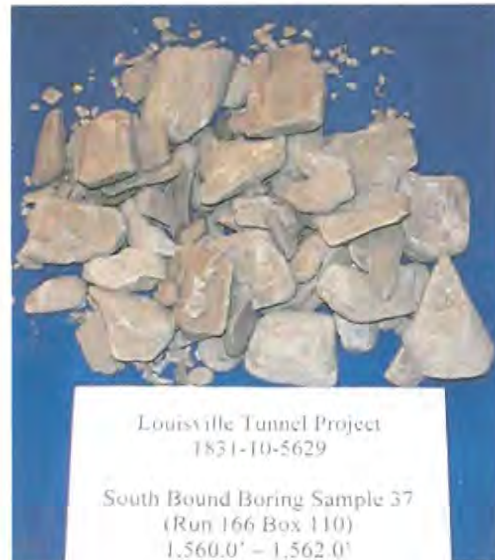
Slake Durability Index (Second Cycle)	87.2	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	74.3	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	73.5	°F
Natural Moisture Content	2.03	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-38 Run 170 Box 112 (1595.5 - 1597.0)
 Date Tested: 9/09/2011 to 9/13/2011

Sample Date: 9/2/2011
 Report Date: 9/15/2011

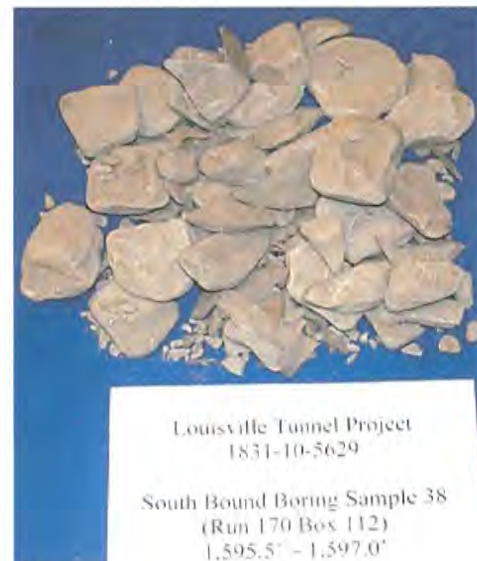
Slake Durability Index (Second Cycle)	87.5	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	74.0	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.3	°F
Natural Moisture Content	2.88	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-41 Run 173 Box 114 (1629.8 - 1631.3)
 Date Tested: 9/09/2011 to 9/13/2011

Sample Date: 9/2/2011
 Report Date: 9/15/2011

Slake Durability Index (Second Cycle)	94.5	%
Range of water temperature (Cycle 1)	1.0	°F
Average water temperature (Cycle 1)	74.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.3	°F
Natural Moisture Content	2.52	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

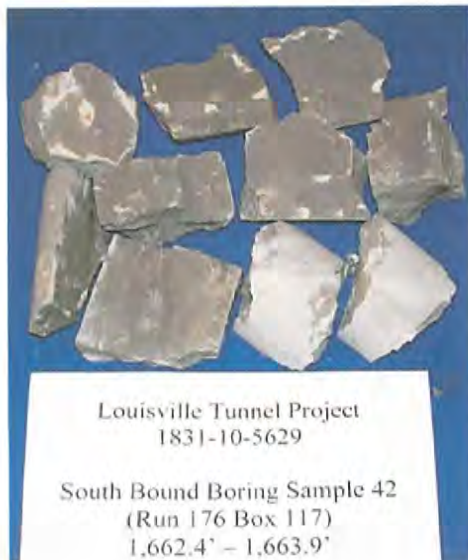
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-42 Run 176 Box 117 (1662.4 - 1663.9)
 Date Tested: 9/13/2011 to 9/15/2011

Sample Date: 9/2/2011
 Report Date: 9/15/2011

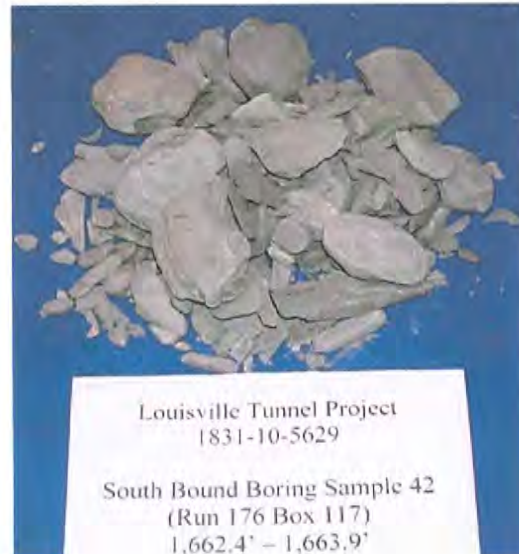
Slake Durability Index (Second Cycle)	88.1	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	75.3	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.3	°F
Natural Moisture Content	2.61	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-68 Run 224 Box 147 (2111.4 - 2113.0)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

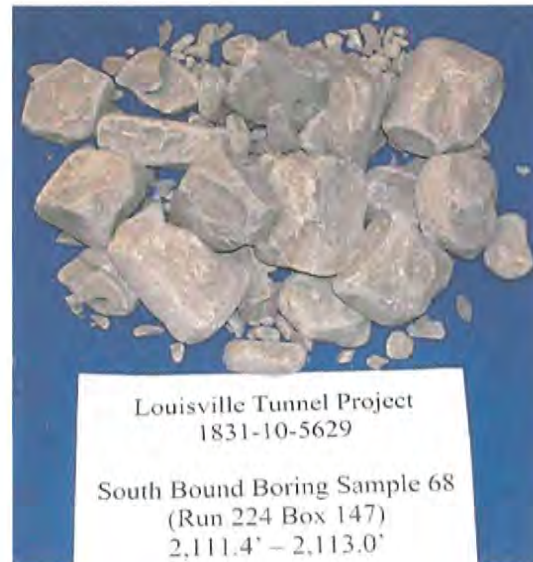
Slake Durability Index (Second Cycle)	89.4	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	73.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.3	°F
Natural Moisture Content	1.78	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

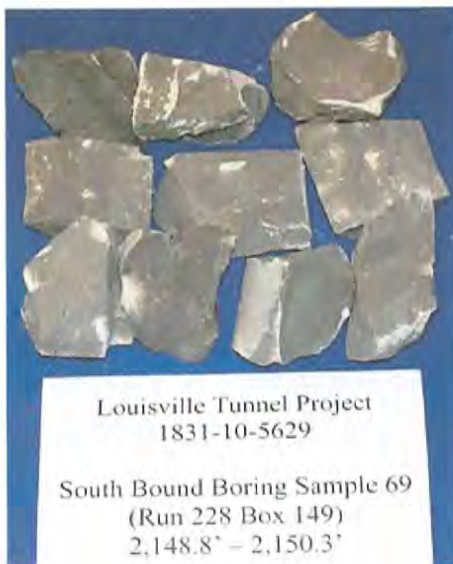
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-69 Run 228 Box 149 (2148.8 - 2150.3)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

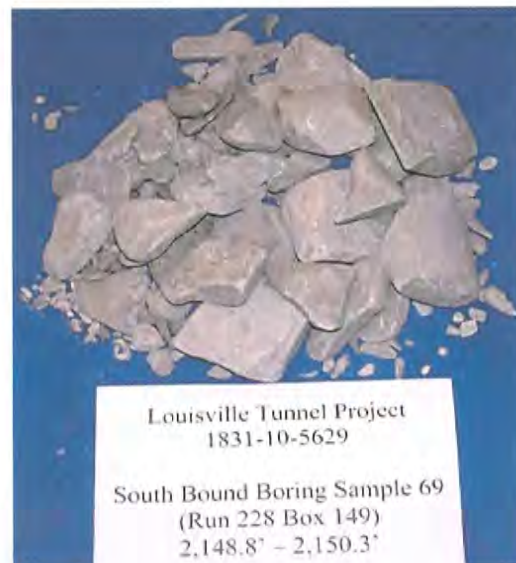
Slake Durability Index (Second Cycle)	88.9	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	73.8	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	73.0	°F
Natural Moisture Content	1.94	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

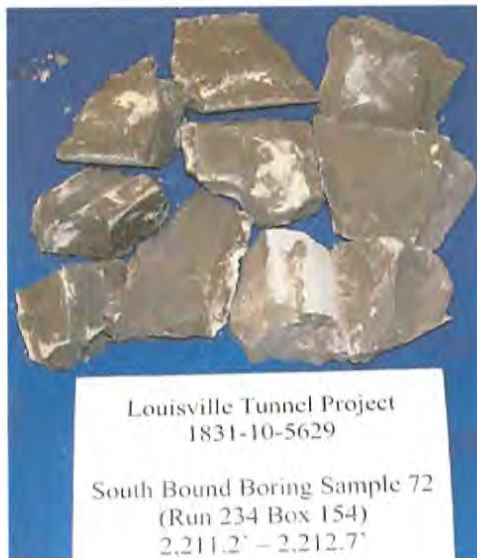
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-72 Run 234 Box 154 (2211.2 - 2212.7)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

Slake Durability Index (Second Cycle)	68.7	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	73.5	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	72.5	°F
Natural Moisture Content	2.51	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-74 Run 240 Box 158 (2273.5 - 2274.7)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

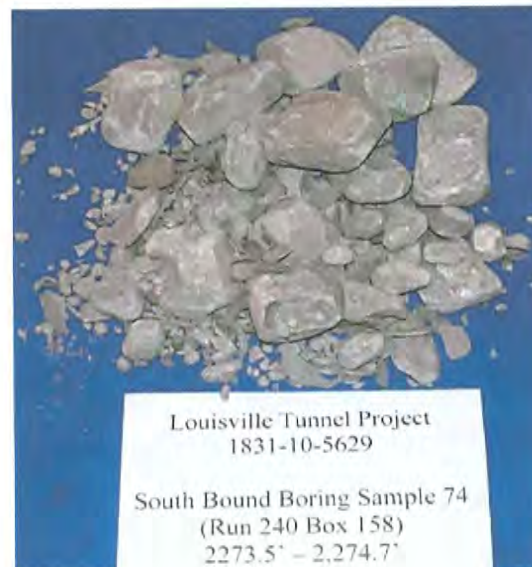
Slake Durability Index (Second Cycle)	78.4	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	73.8	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	73.0	°F
Natural Moisture Content	2.37	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-74 Run 240 Box 158 (2273.5 - 2274.7)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

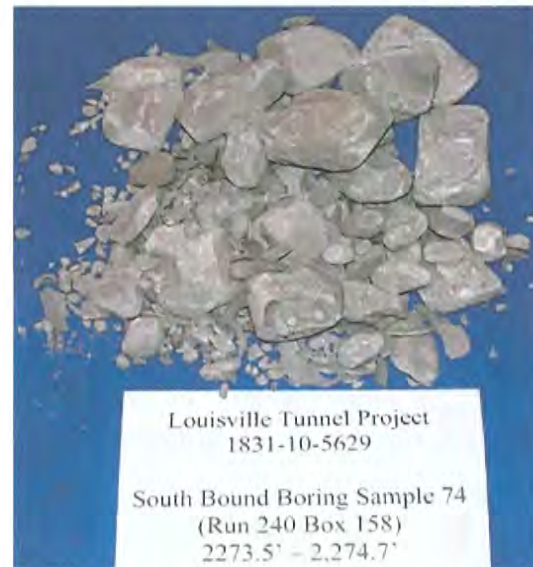
Slake Durability Index (Second Cycle)	78.4	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	73.8	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	73.0	°F
Natural Moisture Content	2.37	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-72 Run 234 Box 154 (2211.2 - 2212.7)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

Slake Durability Index (Second Cycle)	68.7	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	73.5	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	72.5	°F
Natural Moisture Content	2.51	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

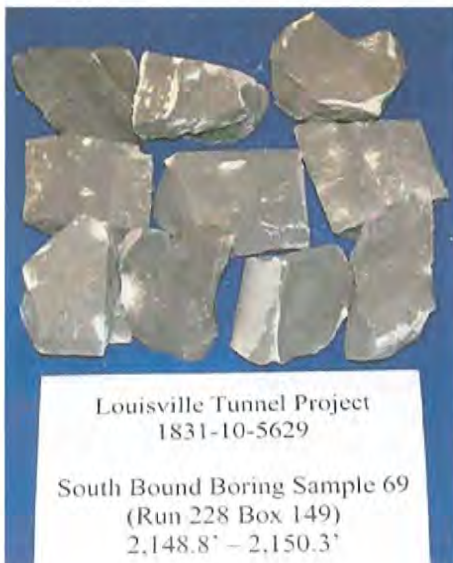
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-69 Run 228 Box 149 (2148.8 - 2150.3)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

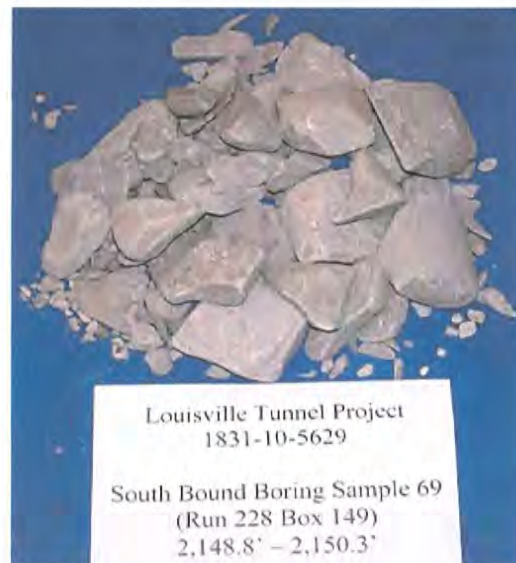
Slake Durability Index (Second Cycle)	88.9	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	73.8	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	73.0	°F
Natural Moisture Content	1.94	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-68 Run 224 Box 147 (2111.4 - 2113.0)
 Date Tested: 9/23/2011 to 9/26/2011

Sample Date: 9/16/2011
 Report Date: 9/28/2011

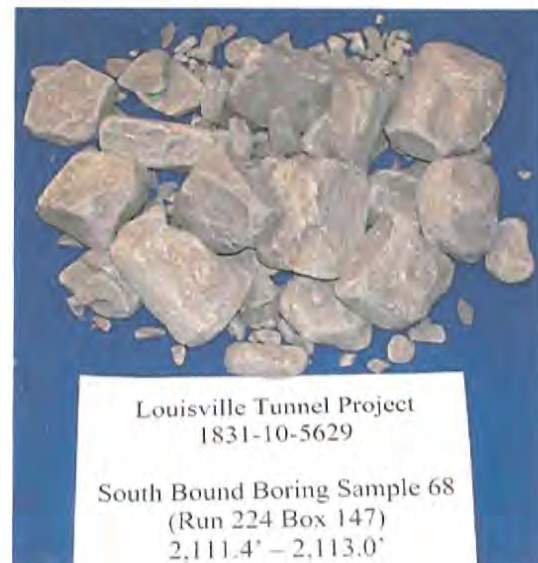
Slake Durability Index (Second Cycle)	89.4	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	73.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	73.3	°F
Natural Moisture Content	1.78	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-65 Run 220 Box 144 (2075.3 - 2077.0)
 Date Tested: 9/21/2011 to 9/23/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

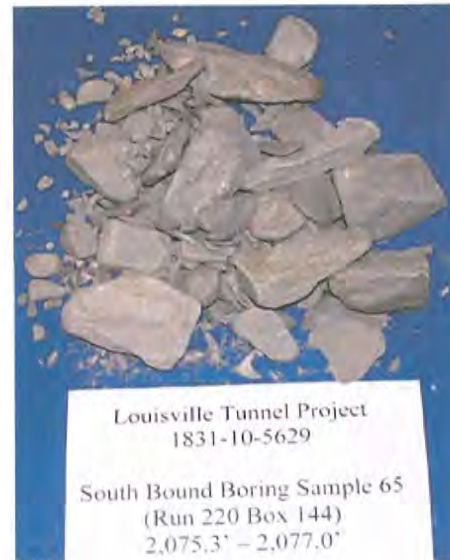
Slake Durability Index (Second Cycle)	80.9	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	74.5	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	72.5	°F
Natural Moisture Content	2.24	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

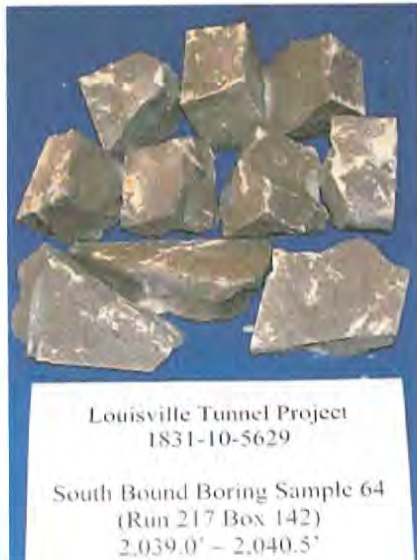
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-64 Run 217 Box 142 (2039.0 - 2040.5)
 Date Tested: 9/21/2011 to 9/23/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	91.1	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	74.0	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.8	°F
Natural Moisture Content	2.56	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

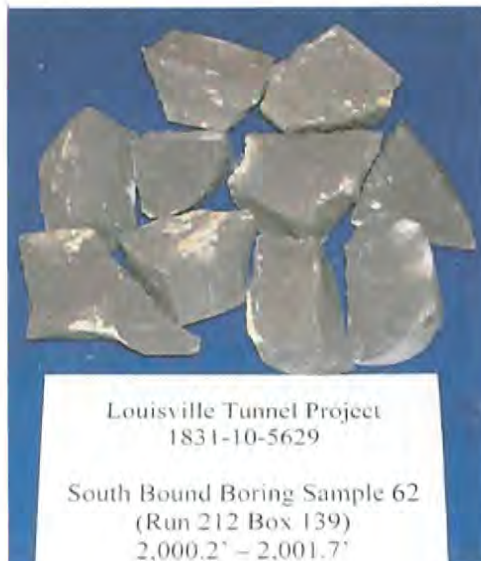
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-62 Run 212 Box 139 (2000.2 - 2001.7)
 Date Tested: 9/21/2011 to 9/23/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	94.8	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	74.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.8	°F
Natural Moisture Content	2.22	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-59 Run 209 Box 137 (1964.6 - 1966.1)
 Date Tested: 9/21/2011 to 9/23/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	95.4	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	74.0	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	72.5	°F
Natural Moisture Content	2.58	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

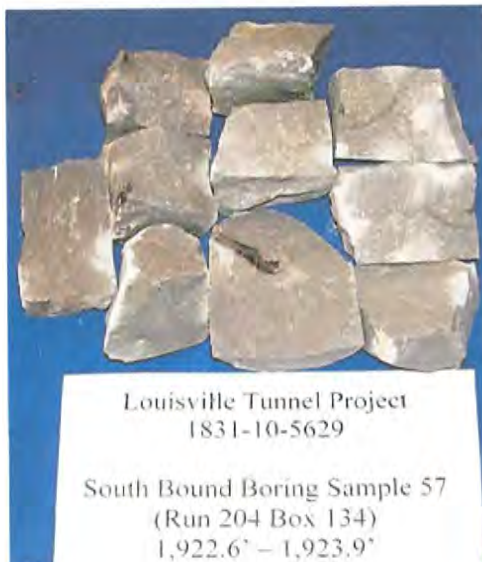
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-57 Run 204 Box 134 (1922.6 - 1923.9)
 Date Tested: 9/15/2011 to 9/20/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	96.7	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	72.5	°F
Range of water temperature (Cycle 2)	1.0	°F
Average water temperature (Cycle 2)	73.0	°F
Natural Moisture Content	2.87	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-55 Run 201 Box 132 (1885.1 - 1886.5)
 Date Tested: 9/15/2011 to 9/20/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

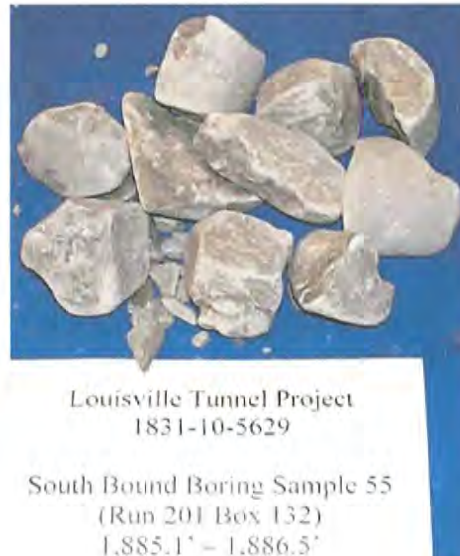
Slake Durability Index (Second Cycle)	92.0	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	72.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.8	°F
Natural Moisture Content	3.34	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

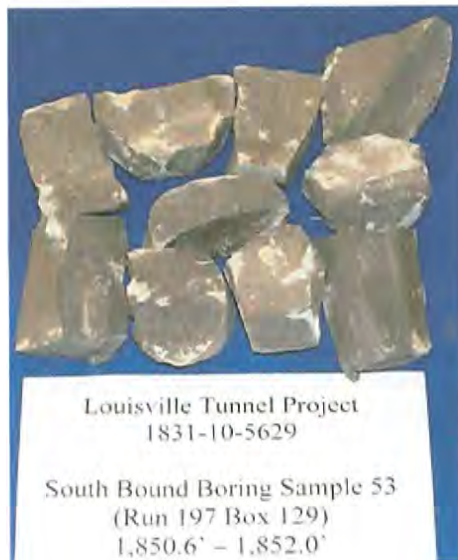
Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-53 Run 197 Box 129 (1850.6 - 1852.0)
 Date Tested: 9/15/2011 to 9/20/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	96.1	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	72.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.8	°F
Natural Moisture Content	2.68	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-51 Run 192 Box 127 (1812.5 - 1813.8)
 Date Tested: 9/15/2011 to 9/20/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	92.3	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	72.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.8	°F
Natural Moisture Content	3.02	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Louisville Tunnel Project
1831-10-5629

South Bound Boring Sample 51
(Run 192 Box 127)
1,812.5' - 1,813.8'

Before Test



Louisville Tunnel Project
1831-10-5629

South Bound Boring Sample 51
(Run 192 Box 127)
1,812.5' - 1,813.8'

After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-49 Run 188 Box 125 (1775.7 - 1777.2)
 Date Tested: 9/13/2011 to 9/15/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	95.6	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	75.0	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.3	°F
Natural Moisture Content	1.85	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-48 Run 184 Box 122 (1736.3 - 1737.6)
 Date Tested: 9/13/2011 to 9/15/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

Slake Durability Index (Second Cycle)	91.4	%
Range of water temperature (Cycle 1)	1.5	°F
Average water temperature (Cycle 1)	75.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.3	°F
Natural Moisture Content	2.25	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project: Louisville Tunnel
 S&ME Project No. 1831-10-5629
 Material: Waldron Shale
 Sample ID: SB-45 Run 181 Box 119 (1704.0 - 1705.1)
 Date Tested: 9/13/2011 to 9/15/2011

Sample Date: 9/9/2011
 Report Date: 9/27/2011

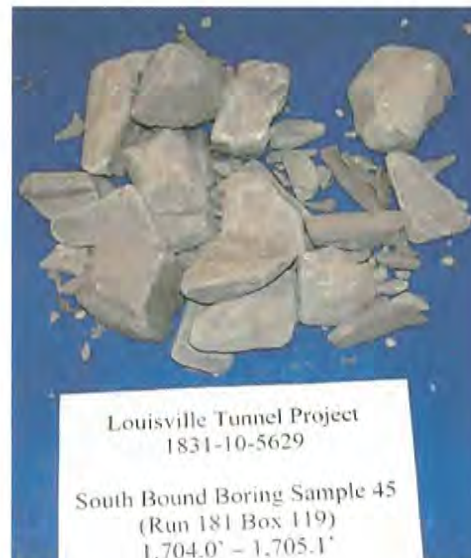
Slake Durability Index (Second Cycle)	91.5	%
Range of water temperature (Cycle 1)	1.5	°F
Average water temperature (Cycle 1)	75.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	72.3	°F
Natural Moisture Content	2.28	%

Sample Description (Check which applies)

Type	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	☒
III	Retained specimen is exclusively small fragments	



Before Test



After Second Cycle

Method of Determining Effective (As Received) and Dry Unit Weights and Total Porosity of Rock Cores
RTH 109-80



Job Name: Louisville Twin Tunnels

Job Number: 1831-10-5629

Sampl Date: 9/2/2011

Operator: MDK, DB
Checked By: NRR

Specimen ID:	SB-39				
Depth (ft):	1601.5-1603.0				
Specimen Mass (g):	400.3				
Specimen Volume:					
Average Dia. (mm)	46.83				
Average Length (mm)	87.27				
Area (cm ²)	17.23				
Volume (cm ³), V	150.33				
Water Content (ratio)	0.0220				
Crushed Minus No. 4 Mass					
Mass of Solids (g)	387.47				
Effective Unit Weight (g/cm ³)	2.66				
Dry Unit Weight (g/cm ³)	2.58				
Dry Unit Weight (lb/ft ³)	160.9				
Specific Gravity of Solids from RTH 108	2.81				
Grain Unit Weight (lb/ft ³)	175.3				
Total Porosity (%), $n=V_v/V$	8.22				
Volume of Solids (cm ³), V_s	138.0				
Volume of Voids (cm ³), V_v	12.35				
Volume of Water (cm ³), V_w	8.54				
¹ Void Ratio, $e=V_v/V_s$	0.0895				
¹ Degree of Saturation (%), $S=V_w/V_v$	69%				

Corps of Engineers Rock Testing Handbook RTH 109-80, RTH 108-89
ASTM D854, D2216

Notes: ¹These parameters are not a part of RTH 109 or RTH 108, they are included at the request of the client

The water content was determined from a separate specimen

Method of Determining Effective (As Received) and Dry Unit Weights and Total Porosity of Rock Cores RTH 109-80



Job Name: Louisville Twin Tunnels

Job Number: 1831-10-5629

Sampl Date: 8/19/2011

Operator: MDK, DB
Checked By: NRR

Specimen ID:	SB-20	SB-26	SB-32		
Depth (ft):	1239.0-1240.0	1359.7-1360.7	1479.0-1479.8		
Specimen Mass (g):	474.2	440.2	412.2		
Specimen Volume:					
Average Dia. (mm)	47.26	47.06	46.80		
Average Length (mm)	105.05	97.57	90.18		
Area (cm ²)	17.54	17.39	17.20		
Volume (cm ³), V	184.25	169.69	155.15		
Water Content (ratio)	0.0110	0.0190	0.016		
Crushed Minus No. 4 Mass					
Mass of Solids (g)	467.60	428.90	400.48		
Effective Unit Weight (g/cm ³)	2.57	2.59	2.66		
Dry Unit Weight (g/cm ³)	2.54	2.53	2.58		
Dry Unit Weight (lb/ft ³)	158.4	157.8	161.1		
Specific Gravity of Solids from RTH 108	2.86	2.84	2.84		
Grain Unit Weight (lb/ft ³)	178.1	176.6	177.1		
Total Porosity (%), $n=V_v/V$	11.02	10.66	9.02		
Volume of Solids (cm ³), V_s	163.9	151.6	141.2		
Volume of Voids (cm ³), V_v	20.31	18.09	14.00		
Volume of Water (cm ³), V_w	5.15	8.17	6.42		
¹ Void Ratio, $e=V_v/V_s$	0.1239	0.1193	0.0992		
¹ Degree of Saturation (%), $S=V_w/V_v$	25%	45%	46%		

Corps of Engineers Rock Testing Handbook RTH 109-80, RTH 108-89
ASTM D854, D2216

Notes: ¹These parameters are not a part of RTH 109 or RTH 108, they are included at the request of the client

The water content was determined from separate specimens

**Method of Determining Effective (As Received) and Dry Unit Weights and Total Porosity of Rock Cores
RTH 109-80**



Job Name: Louisville Twin Tunnels

Job Number: 1831-10-5629

Sampl Date: 8/12/2011

Operator: MDK
Checked By: NRR

Specimen ID:	SB - 15	SB-19			
Depth (ft):	1119.0-1120.5	1205.2-1206.2			
Specimen Mass (g):	514.3	489.1			
Specimen Volume:					
Average Dia. (mm)	47.45	47.36			
Average Length (mm)	107.60	101.66			
Area (cm ²)	17.68	17.61			
Volume (cm ³), V	190.28	179.07			
Water Content (ratio)	0.0030	0.0020			
Crushed Minus No. 4 Mass					
Mass of Solids (g)	509.53	482.21			
Effective Unit Weight (g/cm³)	2.70	2.73			
Dry Unit Weight (g/cm³)	2.68	2.69			
Dry Unit Weight (lb/ft³)	167.2	168.1			
Specific Gravity of Solids from RTH 108	2.81	2.82			
Grain Unit Weight (lb/ft³)	174.9	175.9			
Total Porosity (%), $n=V_v/V$	4.44	4.42			
Volume of Solids (cm ³), V_s	181.8	171.2			
Volume of Voids (cm ³), V_v	8.45	7.91			
Volume of Water (cm ³), V_w	1.53	0.97			
¹Void Ratio, $e=V_v/V_s$	0.0465	0.0462			
¹Degree of Saturation (%), $S=V_w/V_v$	18%	12%			

Corps of Engineers Rock Testing Handbook RTH 109-80, RTH 108-89
ASTM D854, D2216

Notes: ¹These parameters are not a part of RTH 109 or RTH 108, they are included at the request of the client

The water content was determined from separate specimens.

Form No: TR-D4972-1

Revision No. 0

Revision Date: 07/10/08

Sample Log No.: 8325

pH of Soil

AASHTO T 289



Quality Assurance

S&ME, Inc., 1413 Topside Road, Louisville, TN 37777

Project #:	1831-10-5629	Report Date:	9/23/11
Project Name:	Louisville Tunnel	Test Date(s):	9/12/2011
Client Name:	Kentucky Transportation Cabinet		
Client Address:	Louisville, KY		
Sample ID:	SB-39	Type: Rock Core	Sample Date: 9/2/2011
Location:	South Bound Boring		Depth: 1601.5 to 1603.0 ft

Equipment:

Balance	S&ME ID#	18435	Cal. Date:	4.11.11	Due:	4.11.12
Sieve: #10	S&ME ID#	2482	Cal. Date:	4.1.11	Due:	10.1.11
pH Meter:	S&ME ID#	16576	Cal. Date:	Per Use		

pH Meter Calibration

Buffer Solution	Results
pH buffer 4.0	4.01
pH buffer 7.0	7.00
pH buffer 10.0	10.01
Buffer Temperature °C	24.1°C

Measuring pH of Soil

Measurements	
Weight of Air Dry Soil (g)	30.0
Distilled Water (ml)	30.1
Temperature °C	24.0°C
pH Reading	8.7

Notes / Deviations / References: AASHTO T 289 Determining pH of Soil for Use in Corrosion Testing

Michael Kelso

Technician Name

9/12/2011

Date

N. Randy Rainwater

Technical Responsibility

N. Randy Rainwater

Signature

Laboratory Department Manager

Position

9/23/2011

Date

This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

Huder-Amberg Test

(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)



The University of Texas at Austin

**Geotechnical Engineering
Department of Civil, Architectural
and Environmental Engineering**

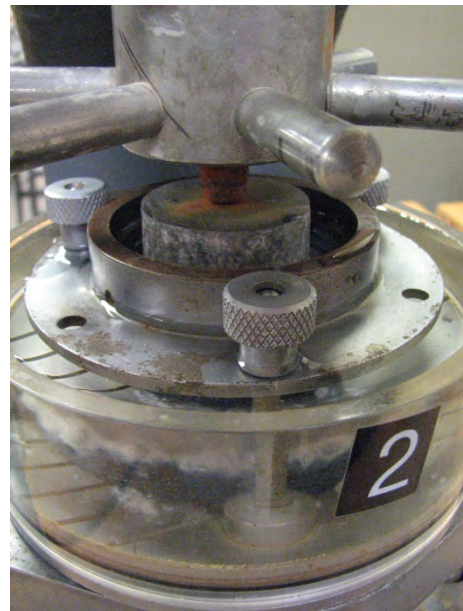
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	8/19/11
Start Test Date	8/20/11
Test Performer / Checker	Mahdi Heidari/Moo Y. Kim
Boring no.	SB-1
Depth	1343.0-1344.5
Rock Type	Shale

Orientation of specimen axis	Parallel to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	0.992 %	
Original height of specimen	19.45 mm	0.77 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	47.05 mm	1.85 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2



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Huder-Amberg Test

(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)

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 Department of Civil, Architectural
 and Environmental Engineering**

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	Psf	mm (x 1,000)	in (x 1,000)	
8/20/11	110	225	12.7	0.5	0.065
8/21/11	215	450	27.94	1.1	0.144
8/22/11	215	450	43.18	1.7	0.222
8/23/11	645	1350	76.2	3.0	0.392
8/24/11	1075	2250	116.84	4.6	0.601
8/25/11	2400	5000	193.04	7.6	0.992
8/28/11		-----	180.34	7.1	0.927
8/31/11	-2400	-5000	132.08	5.2	0.679
9/3/11	-1075	-2250	99.06	3.9	0.509
9/6/11	-645	-1350	76.2	3.0	0.392
9/9/11	-215	-450	60.96	2.4	0.313
9/12/11	-215	-450	40.64	1.6	0.209

Note: axial load, displacement and strains increments are positive if compressive, negative is tensile or extensional.

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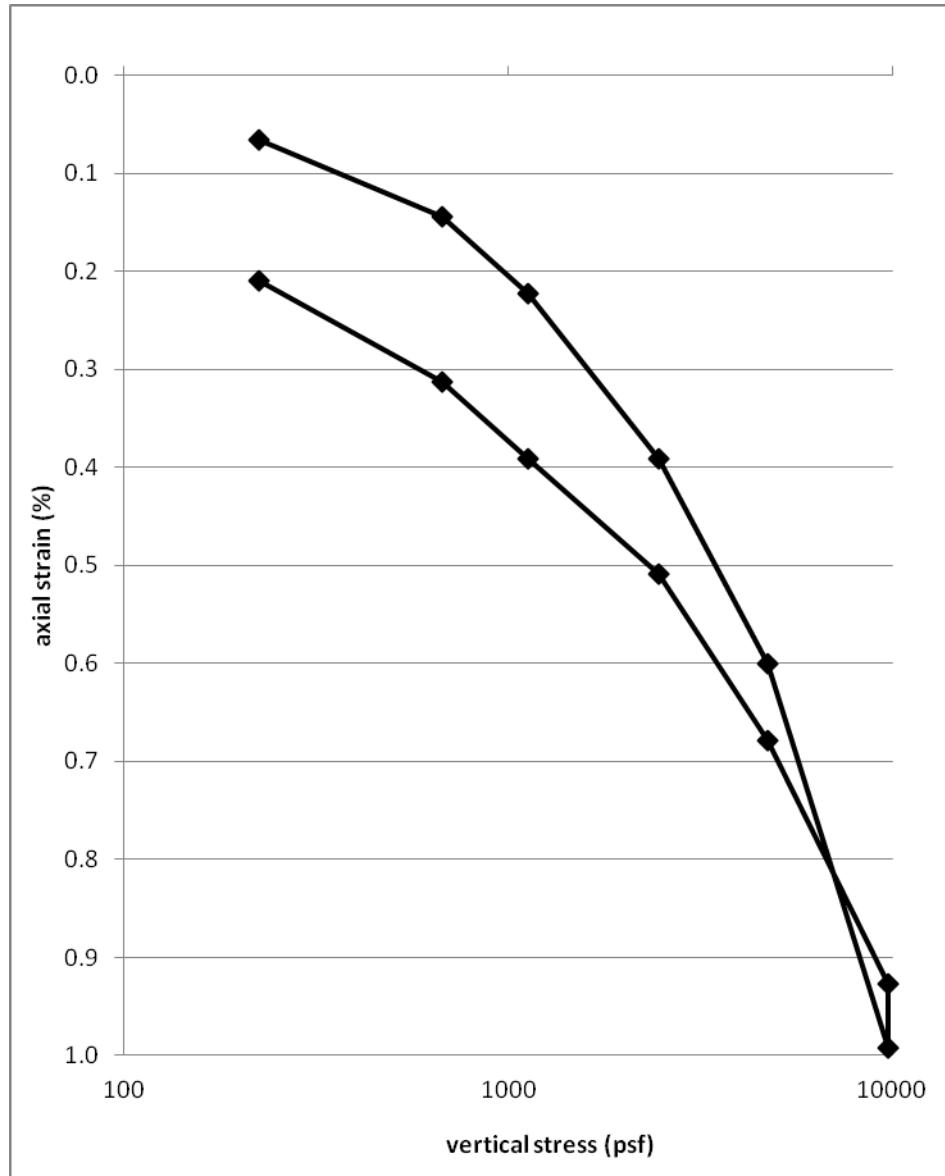
Huder-Amberg Test

(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)



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**THIN SECTION PETROGRAPHIC
ANALYSIS**


**The University of Texas at Austin
Geotechnical Engineering Center
Department of Civil, Architectural
and Environmental Engineering**

Project Name	Louisville Tunnel	Alteration	Dolomitized
Job No.	1831-10-5629	Texture	Crystalline dolomite with remnant clay minerals
GEC reference		Rock name	Dolomite
Drill hole and depth	SB 1343.0-1344.5	Studied by	K. Surpless
Specimen number	1343.0-1344.5	Date Studied	September 16, 2011
Formation	Waldron Shale Formation	Reviewed by	Tonon, Fulvio
Rock Type	Shale/mudstone		

Description of Individual Minerals:

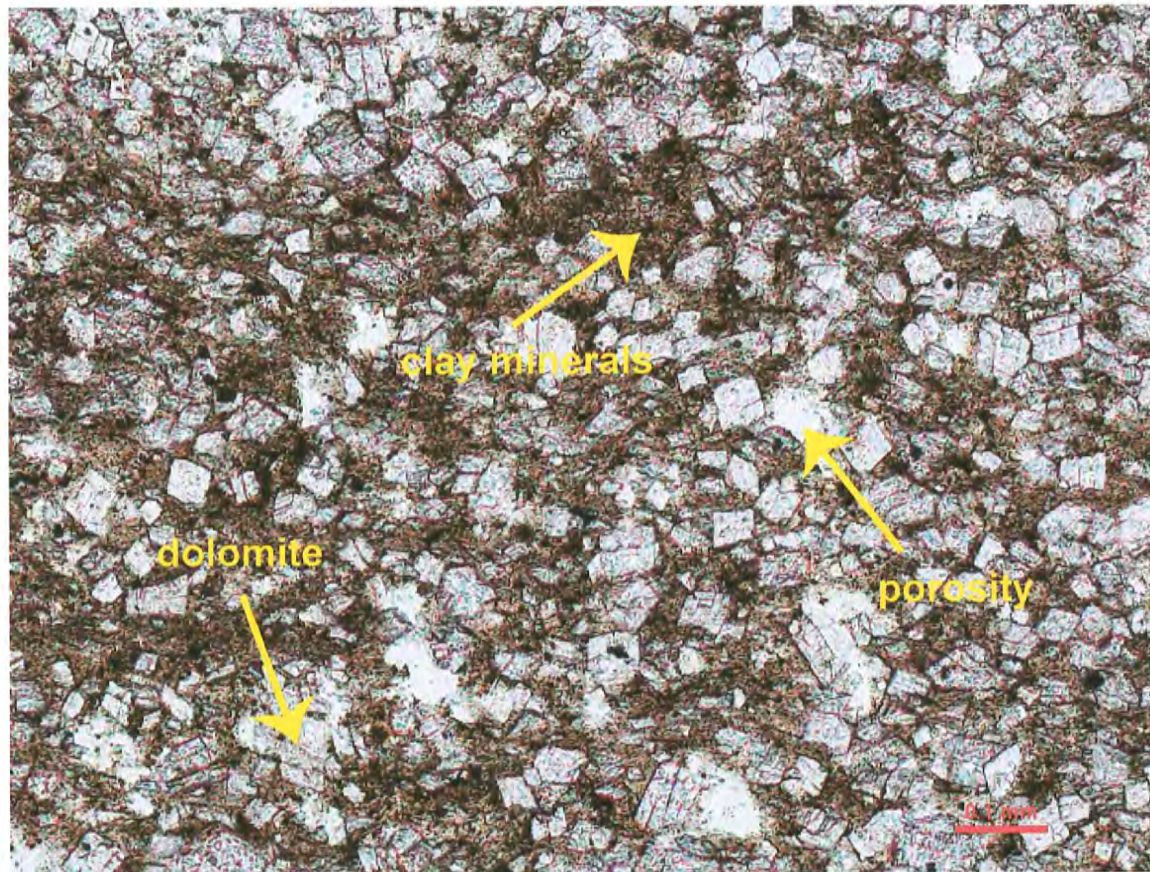
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	5%	3	Variable, <0.1	In zones that are partially dolomitized; likely related to fluid flow
Dolomite	60%	3.5-4	0.03-0.08; ave 0.05	Evenly distributed throughout the slide; dolomite in well-formed, distinctive rhombs
Opaque minerals	5%	4.5-5	Variable	Probably iron oxide minerals; irregular shape, formed through diagenesis
porosity	15%	NA	Variable, <0.1	Throughout slide
Clay minerals	15%	1-3	<0.01	Throughout slide; potassium-rich clay picks up yellow stain on stained half of slide; some zones are more dolomitized than others
Weighted Average:		3.5	Excludes porosity	

Remarks: nearly complete dolomitization of clay-rich matrix in porous shale or mudstone; some preferred orientation visible in slide; some variability in the intensity of dolomitization; evidence of fluid flow in areas with calcite and/or opaque minerals

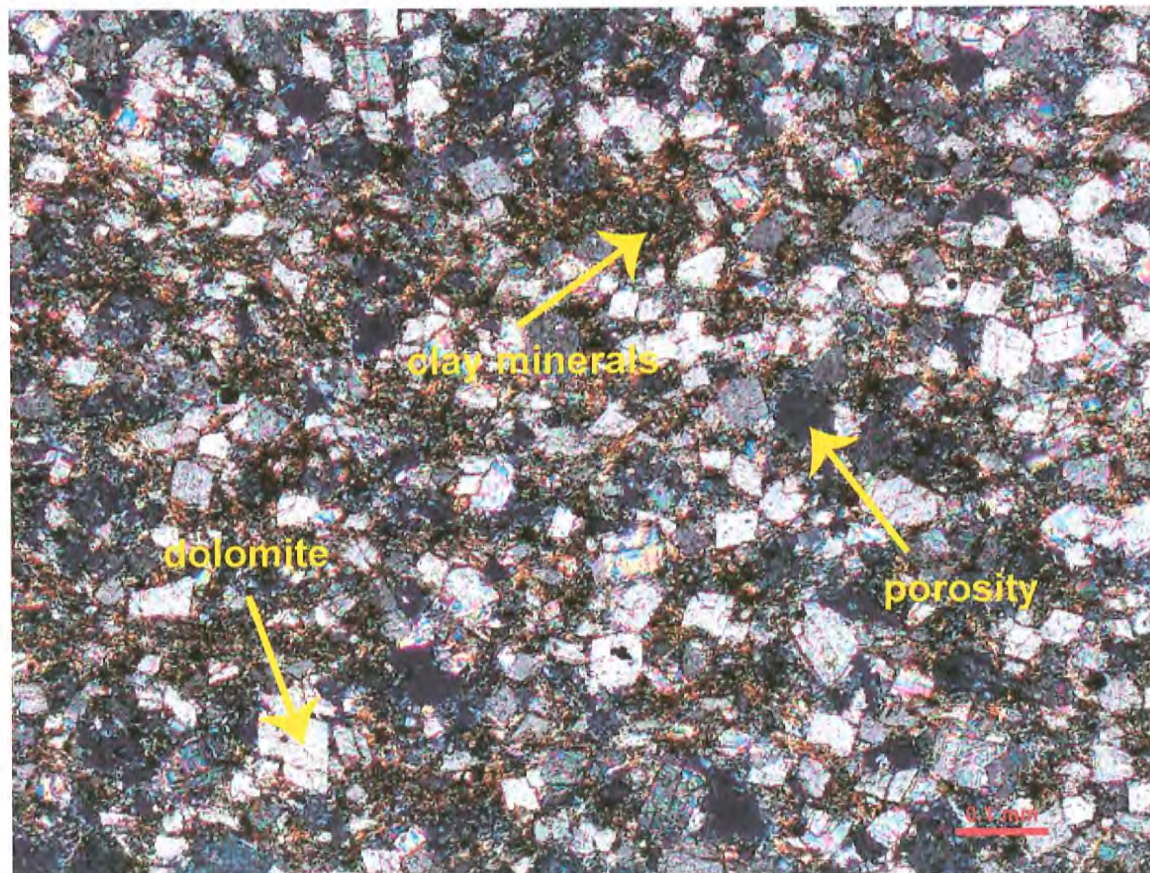
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1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon (Assistant Professor)
Phone: +1-512-471-4929
Fax: +1-512-471-6548

SB 1343.0-1344.5 ft, stained slide

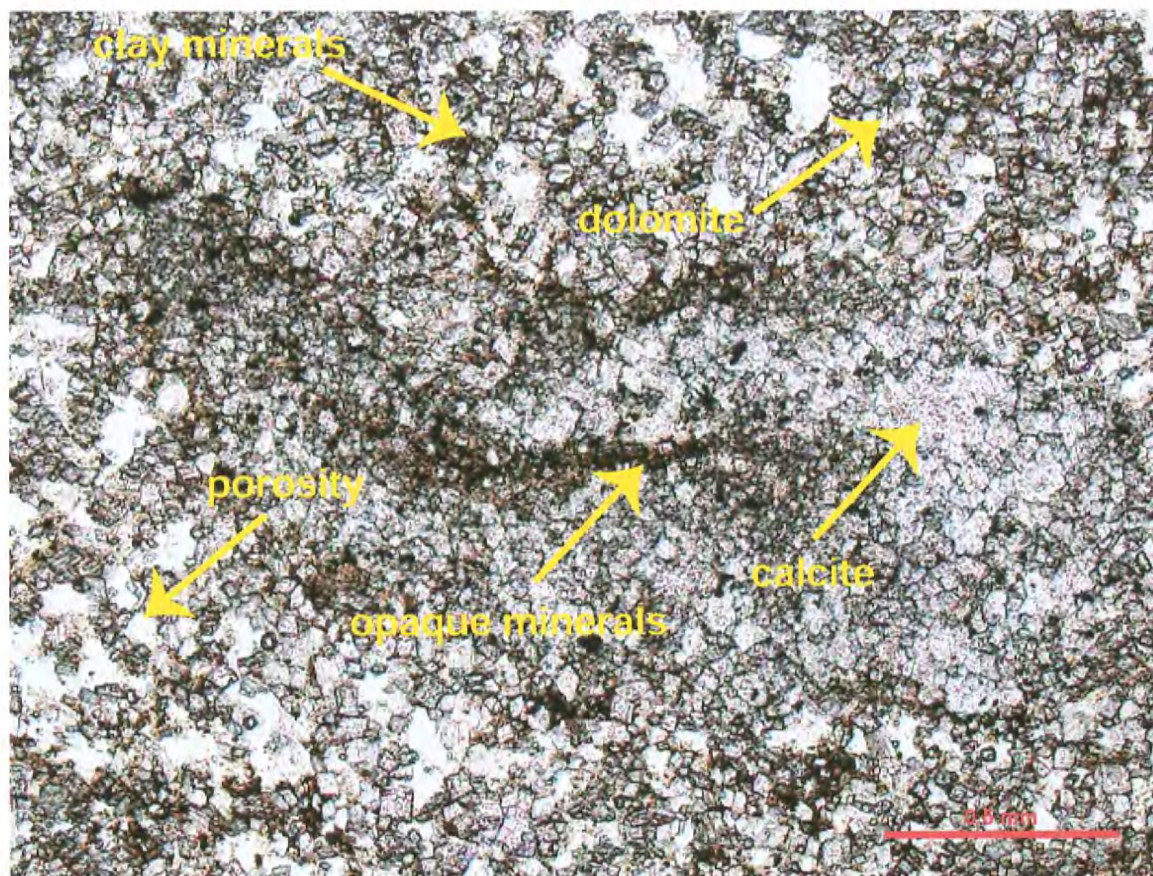


plane
light

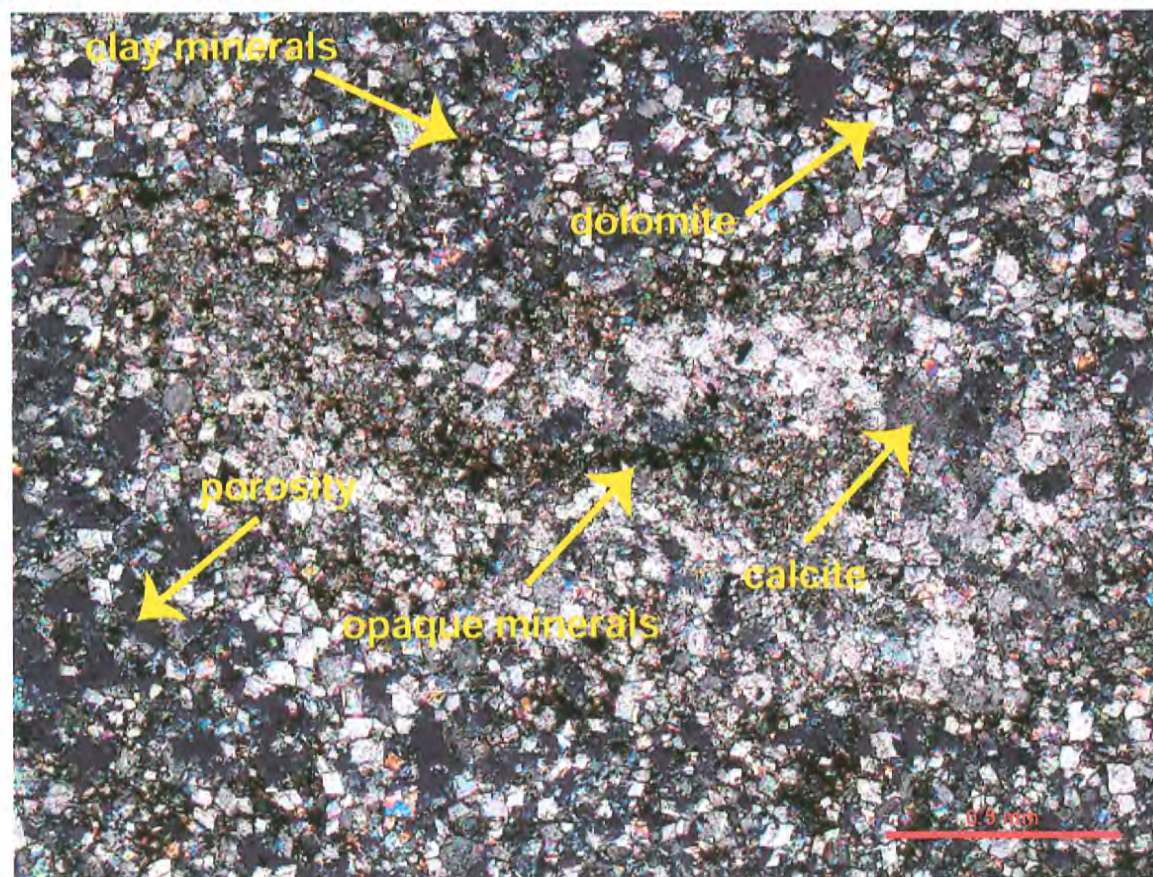


crossed
polars

SB 1343.0-1344.5 ft, stained slide



plane
light



crossed
polars

CERCHAR Abrasiveness test**Test procedure: ASTM D7625****The University of Texas at Austin****Geotechnical Engineering Center
Department of Civil, Architectural
and Environmental Engineering**

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
UT reference	2011_SME_001_01
Test Date	8/17/11
Test Performer	Moo Yeon Kim
Checked by	Mahdi Heidari
Location	Louisville, Kentucky
Boring and sample	SB, 2
Specimen depth	1343.0-1344.5 ft
Rock Type	Shale
Formation	Waldron Shale
Pin Rockwell Hardness	55/56

Surface condition	Cut by slab saw	
Direction of scratch	Perpendicular to core axis	
Pin Wear	Max width (mm)	Min width (mm)
	0.036	0.031
	0.040	0.031
	0.036	0.031
	0.040	0.031
	0.049	0.040
Average (mm)	0.037	
CAI	0.37	
Equipment	Ergo Tech CERCHAR Test Apparatus No.100225	

Note:

Reference: G.West (1989) *Rock Abrasiveness testing for tunneling* International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, Volume 26, Issue 2, March 1989, 151-160.

R.Plinninger, H.K.asling, K.Thuro, G.Spaun (2003) *Testing conditions and geomechanical properties in influencing the CERCHAR abrasiveness index (CAI) value.* Journal of Rock Mechanics and Mining Sciences, 40(2003) 159-263.



Photo after test

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Huder-Amberg Test

(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)



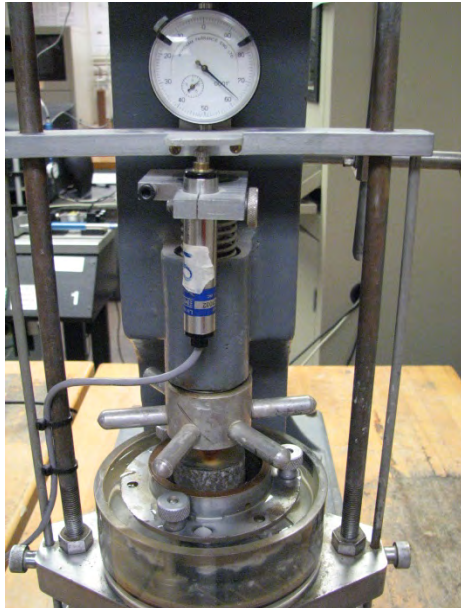
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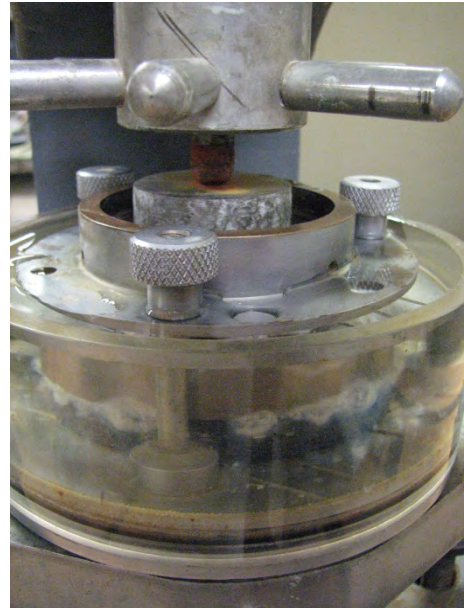
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	
Start Test Date	9/12/11
Test Performer / Checker	Mahdi Heidari/Moo Y. Kim
Boring no.	SB 3
Depth	1900.4-1901.8
Rock Type	Shale

Orientation of specimen axis	Parallel to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	0.75 %	
Original height of specimen	19.74 mm	0.78 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	47.12 mm	1.86 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2



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(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)

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 and Environmental Engineering**

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	Psf	mm (x 1,000)	in (x 1,000)	
9/12/11	110	225	7.6	0.3	0.039
9/12/11	215	450	20.3	0.8	0.103
9/12/11	215	450	30.5	1.2	0.154
9/12/11	645	1350	53.3	2.1	0.270
9/16/11	1075	2250	86.4	3.4	0.437
9/16/11	2400	5000	147.3	5.8	0.746
9/19/11	-----	-----	142.2	5.6	0.721
9/19/11	-2400	-5000	88.9	3.5	0.450
9/22/11	-1075	-2250	58.4	2.3	0.296
9/22/11	-645	-1350	38.1	1.5	0.193
9/25/11	-215	-450	25.4	1	0.129
9/25/11	-215	-450	12.7	0.5	0.064

Note: axial load, displacement and strains increments are positive if compressive, negative is tensile or extensional.

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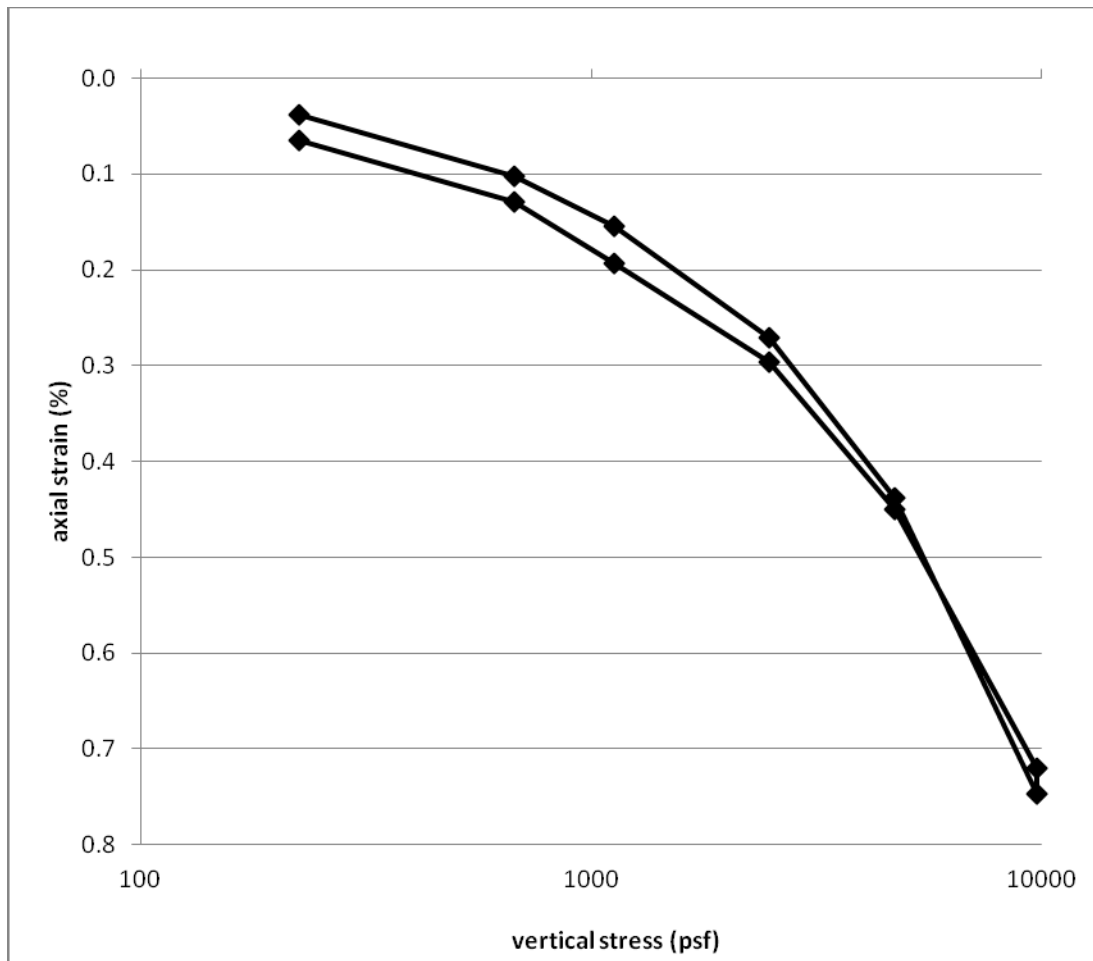
Huder-Amberg Test

(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)



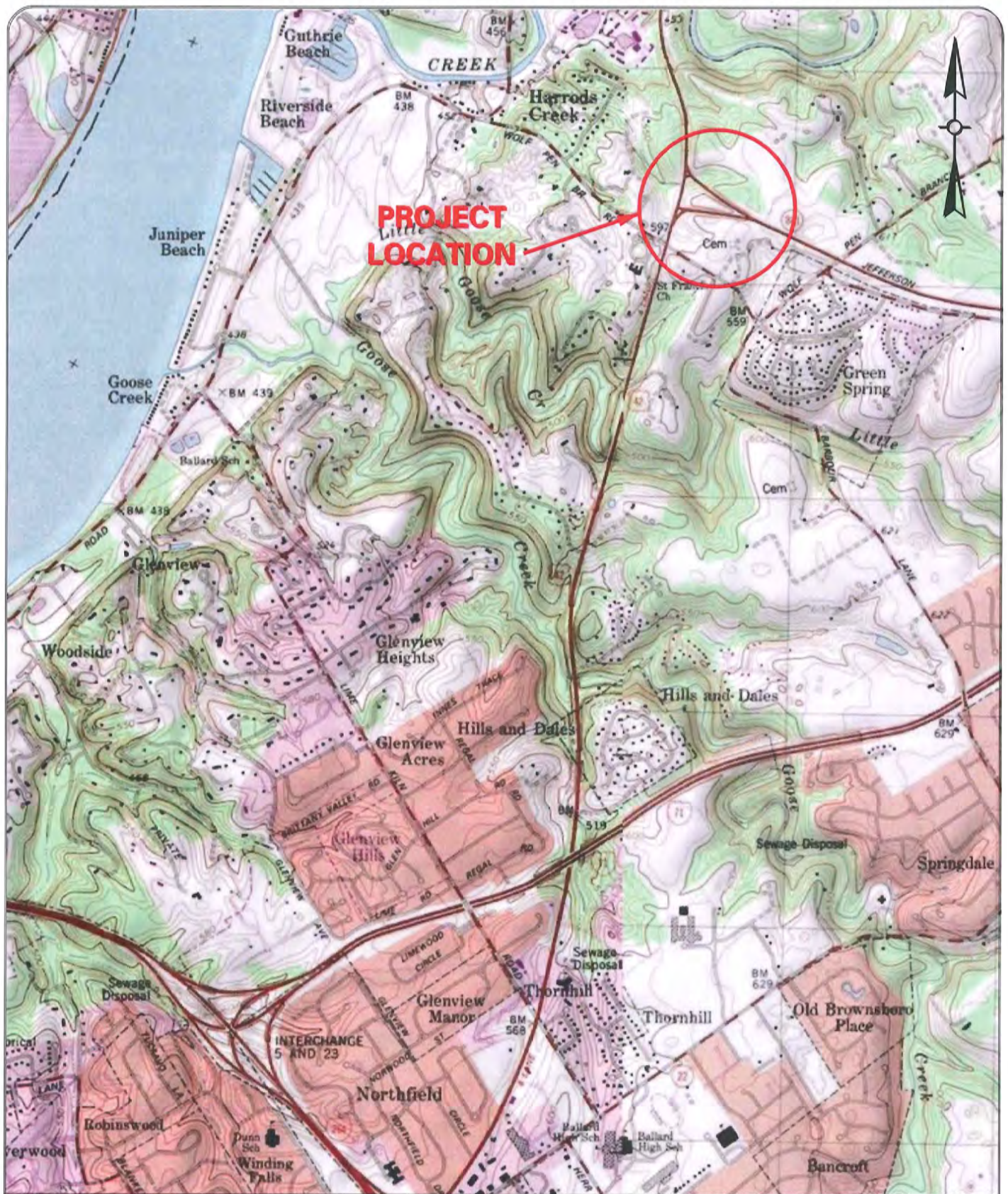
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SCALE: 1" = 2000'

DATE: 8/26/11

DRAWN BY: CAC

PROJECT NO:
24305629



S&ME

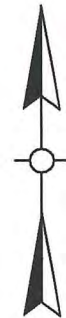
WWW.SMEINC.COM
422 CODELL DRIVE, LEXINGTON, KY 40509
PHONE: 859.293.5518

**COLLAR LOCATION
HORIZONTAL DIRECTIONAL BORING
GEOTECHNICAL DATA REPORT**

**LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL**

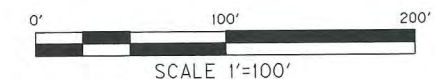
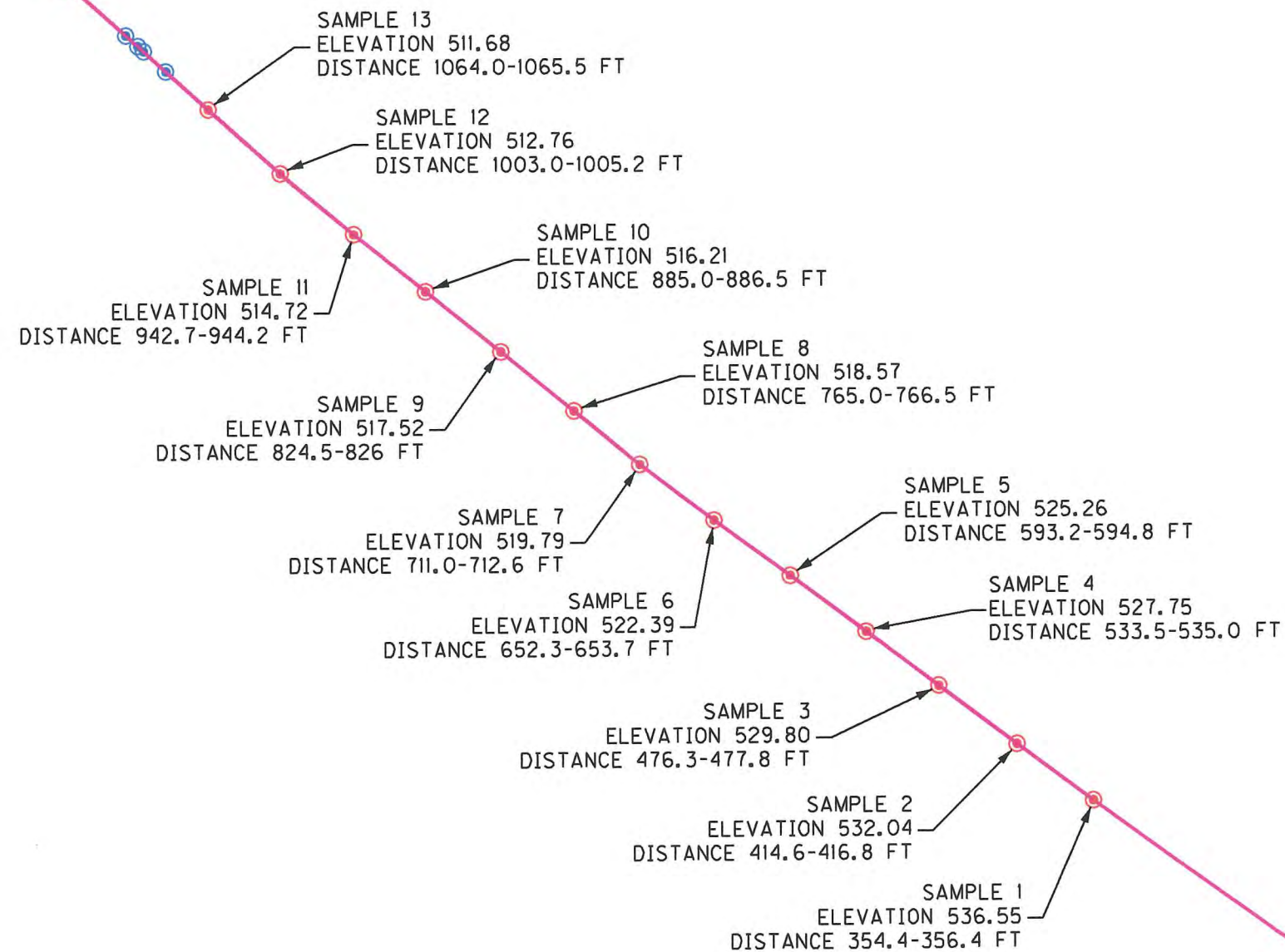
FIGURE NO.

1



LEGEND:

- LIMESTONE SAMPLE LOCATION
- SHALE SAMPLE LOCATION



SOUNDBOUND BORING
LIMESTONE SAMPLE LOCATIONS
STA 03+54 TO STA 10+65

LOUISVILLE TUNNELS
LOUISVILLE, KENTUCKY

FIGURE NO.

1



SCALE: 1"=100'
PROJECT NUMBER: 24305629
DRAWING NUMBER:

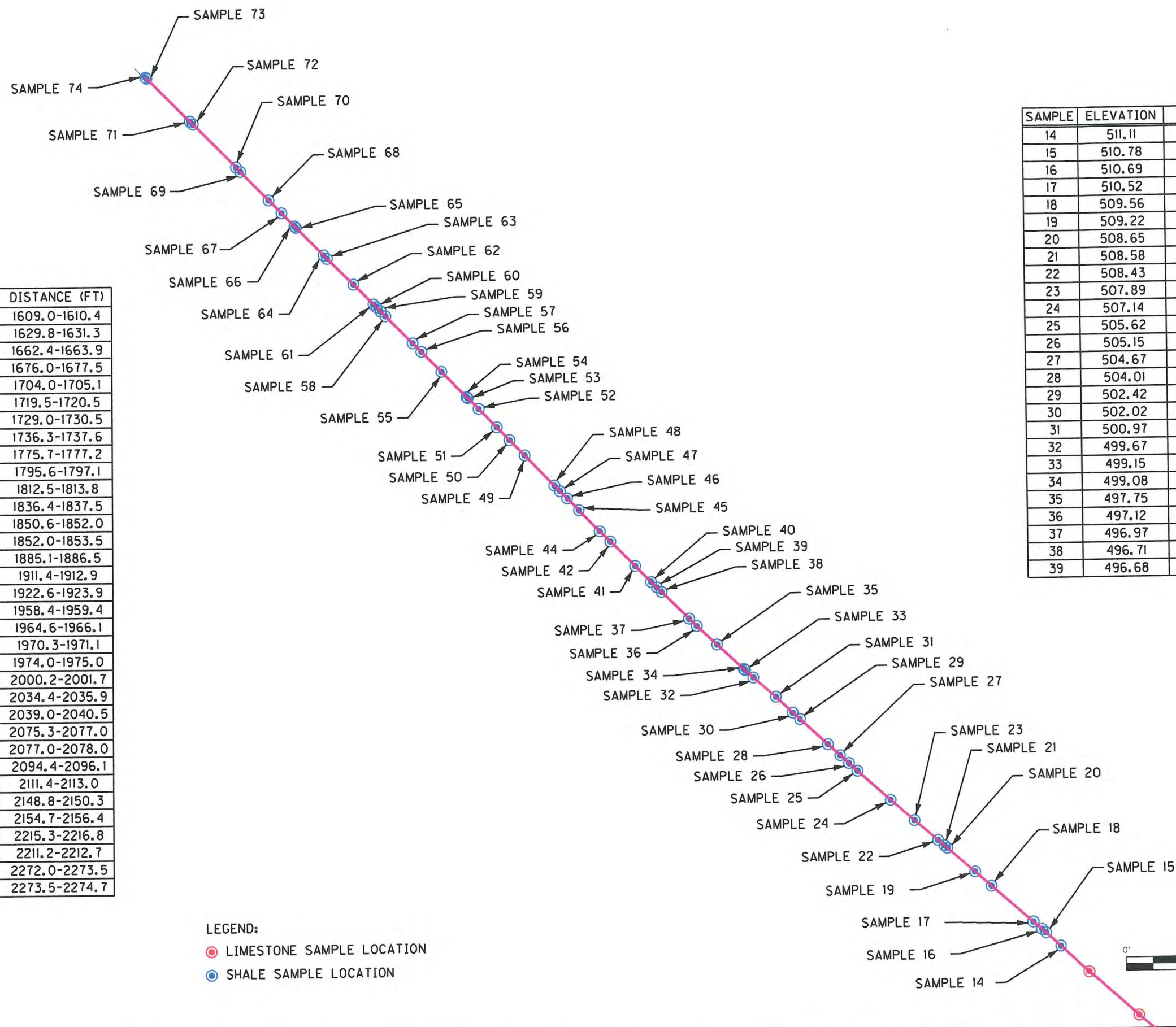
DATE: 10-10-11
DRAWN BY: CAC
CHECKED BY:



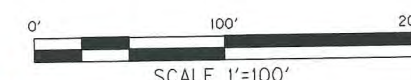
SAMPLE	ELEVATION	DISTANCE (FT)
40	496.63	1609.0-1610.4
41	496.51	1629.8-1631.3
42	496.49	1662.4-1663.9
44	496.48	1676.0-1677.5
45	496.60	1704.0-1705.1
46	496.68	1719.5-1720.5
47	496.73	1729.0-1730.5
48	496.78	1736.3-1737.6
49	497.04	1775.7-1777.2
50	497.17	1795.6-1797.1
51	497.28	1812.5-1813.8
52	497.42	1836.4-1837.5
53	497.49	1850.6-1852.0
54	497.49	1852.0-1853.5
55	497.62	1885.1-1886.5
56	497.53	1911.4-1912.9
57	497.49	1922.6-1923.9
58	497.07	1958.4-1959.4
59	496.99	1964.6-1966.1
60	496.90	1970.3-1971.1
61	496.85	1974.0-1975.0
62	496.31	2000.2-2001.7
63	495.52	2034.4-2035.9
64	495.41	2039.0-2040.5
65	494.42	2075.3-2077.0
66	494.37	2077.0-2078.0
67	493.98	2094.4-2096.1
68	493.71	2111.4-2113.0
69	493.15	2148.8-2150.3
70	493.15	2154.7-2156.4
71	493.27	2215.3-2216.8
72	493.26	2211.2-2212.7
73	493.08	2272.0-2273.5
74	493.07	2273.5-2274.7

LEGEND:

- Limestone Sample Location
- Shale Sample Location



SAMPLE	ELEVATION	DISTANCE (FT)
14	511.11	1100.0-1110.15
15	510.78	1119.0-1120.5
16	510.69	1124.0-1125.5
17	510.52	1134.2-1135.9
18	509.56	1185.0-1186.5
19	509.22	1205.2-1206.2
20	508.65	1239.0-1240.0
21	508.58	1242.6-1243.8
22	508.43	1250.5-1252.7
23	507.89	1279.0-1280.0
24	507.14	1308.0-1310.0
25	505.62	1349.0-1350.5
26	505.15	1359.7-1360.7
27	504.67	1370.8-1372.3
28	504.01	1386.0-1387.5
29	502.42	1421.0-1422.5
30	502.02	1429.8-1431.3
31	500.97	1452.3-1453.8
32	499.67	1479.0-1479.8
33	499.15	1489.6-1491.1
34	499.08	1491.1-1492.6
35	497.75	1524.8-1527.0
36	497.12	1550.2-1551.7
37	496.97	1560.0-1562.0
38	496.71	1595.5-1597.0
39	496.68	1601.5-1603.0



DATE: 10-10-11
DRAWN BY: CAC
CHECKED BY:

SCALE: 1"=100'
PROJECT NUMBER: 24305629
DRAWING NUMBER:

SOUNDBOUND BORING
SHALE SAMPLE LOCATIONS
STA 11+00 TO STA 22+81.66
LOUISVILLE TUNNELS
LOUISVILLE, KENTUCKY

FIGURE NO. 2

APPENDIX C

PACKER TEST RESULTS

LEGEND TO LUGEON VALUES

**LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING**



Field Test Data

Boring : *South Bound*
Elevation: 592.3

Test by: *N. Peterson*
Date: *9/18/2011*

Formula for Lugeon (Lu) calculation:

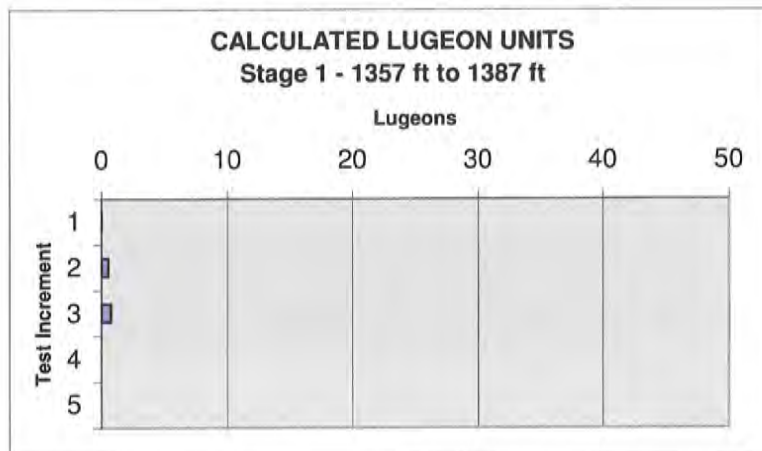
(water take in gallons ÷ 7.48 gal/ft³) × (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet × test time in minutes × 0.0107620)

Data Entry -

Enter Borehole Stage (from & to); Test Time; Gauge Pressure; and Water Take.
Spreadsheet calculates Stage Length and Lugeon Units.

Borehole Stage Interval (ft)	Vertical Stage Interval (ft)	Increment	Stage Length (ft)	Test Time (min.)	Gauge Pressure (psi)	Water Take (gallons)	Lu (incr.)	Lu (stage)
1357.0	1357.0	1	30.0	10	60.0	0.3	0	1
1387.0	1387.0	2	30.0	10	90.0	8.4	1	
		3	30.0	10	120.0	15.7	1	
		4	30.0	10	90.0	12.1	0	
		5	30.0	10	60.0	5.3	0	
1257.0	1257.0	1	30.0	10	60.0	0.2	0	2
1287.0	1287.0	2	30.0	10	90.0	8.9	1	
		3	30.0	10	120.0	20.8	1	
		4	30.0	10	90.0	13.8	1	
		5	30.0	10	60.0	10.3	1	
1157.0	1157.0	1	30.0	10	60.0	0.0	0	3
1187.0	1187.0	2	30.0	10	90.0	6.1	0	
		3	30.0	10	120.0	0.0	0	
		4	30.0	10	90.0	1.9	0	
		5	30.0	10	60.0	5.5	1	
1057.0	1057.0	1	30.0	10	60.0	2.2	0	4
1087.0	1087.0	2	30.0	10	90.0	10.8	1	
		3	30.0	10	120.0	14.4	1	
		4	30.0	10	90.0	25.6	2	
		5	30.0	10	60.0	3.4	0	
957.0	957.0	1	30.0	10	60.0	2.2	0	5
987.0	987.0	2	30.0	10	90.0	10.8	1	
		3	30.0	10	120.0	14.4	1	
		4	30.0	10	90.0	25.6	2	
		5	30.0	10	60.0	3.4	0	

Boring: South Bound

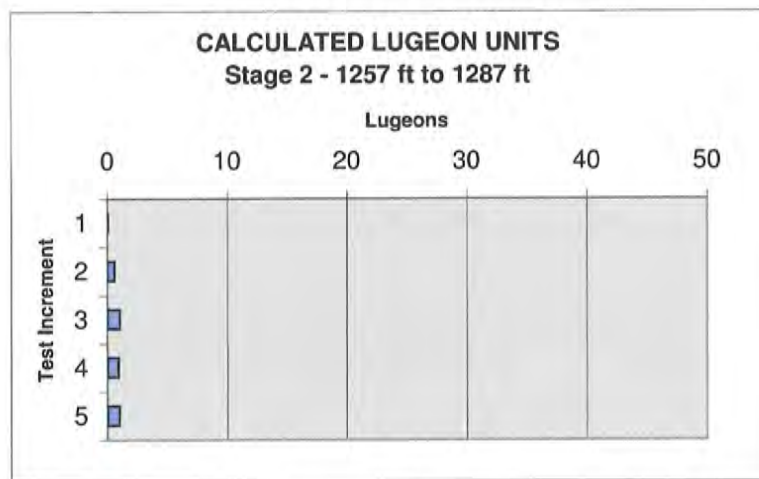


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	1
Test Increment 3	120	1
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: Dialation

Permeability increases at the highest water test pressure as fractures are being hydraulically opened. Flow is laminar at the lower pressures.

Boring: South Bound

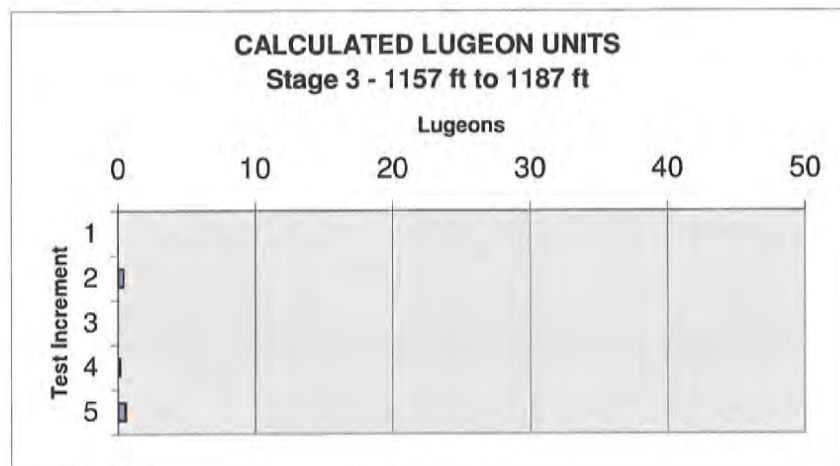


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	1
Test Increment 3	120	1
Test Increment 4	90	1
Test Increment 5	60	1

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take

Boring: South Bound

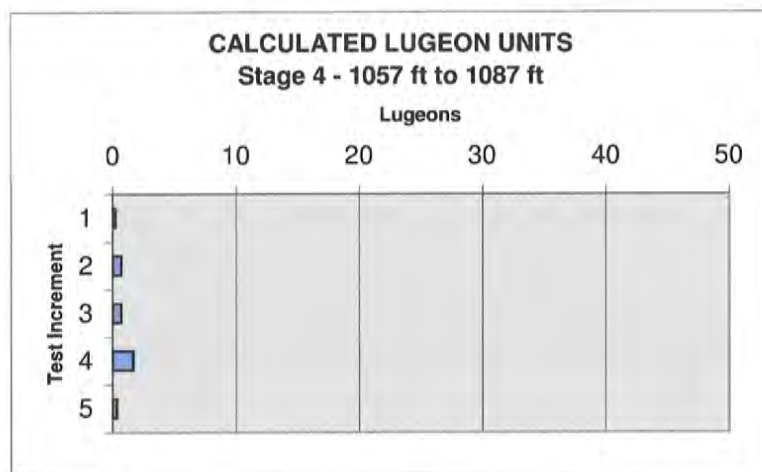


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	1

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take.

Boring: South Bound

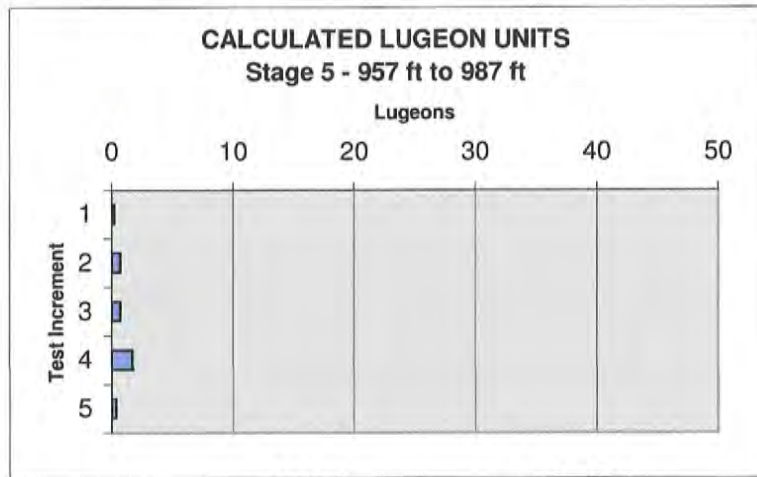


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	1
Test Increment 3	120	1
Test Increment 4	90	2
Test Increment 5	60	0

INTERPRETATION OF RESULTS: Laminar

The permeability is essentially the same no matter what the pressure and resultant water take.

Boring: South Bound



	TEST	LUGEON
Test Increment 1	60	0
Test Increment 2	90	1
Test Increment 3	120	1
Test Increment 4	90	2
Test Increment 5	60	0

INTERPRETATION OF RESULTS: Laminar

The permeability is essentially the same no matter what the pressure and resultant water take.

**LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING**



Field Test Data

Boring : *South Bound*
Elevation: 592.3

Test by: *N. Peterson*
Date: *9/19/2011*

Formula for Lugeon (Lu) calculation:

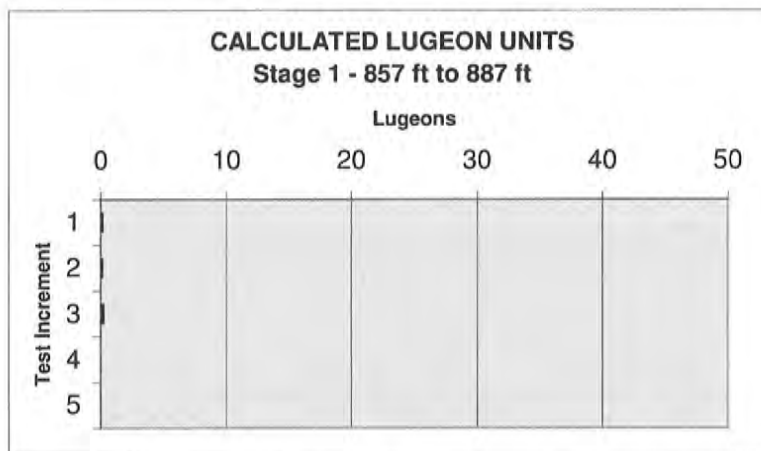
(water take in gallons ÷ 7.48 gal/ft³) × (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet × test time in minutes × 0.0107620)

Data Entry -

Enter Borehole Stage (from & to); Test Time; Gauge Pressure; and Water Take.
Spreadsheet calculates Stage Length and Lugeon Units.

Borehole Stage Interval (ft)	Vertical Stage Interval (ft)	Increment	Stage Length (ft)	Test Time (min.)	Gauge Pressure (psi)	Water Take (gallons)	Lu (incr.)	Lu (stage)
857.0	857.0	1	30.0	10	60.0	1.2	0	1
887.0	887.0	2	30.0	10	90.0	1.6	0	
		3	30.0	10	120.0	4.3	0	
		4	30.0	10	90.0	2.1	0	
		5	30.0	10	60.0	2.6	0	
757.0	757.0	1	30.0	10	60.0	0.0	0	2
787.0	787.0	2	30.0	10	90.0	0.0	0	
		3	30.0	10	120.0	0.0	0	
		4	30.0	10	90.0	0.0	0	
		5	30.0	10	60.0	0.0	0	
657.0	657.0	1	30.0	10	60.0	1.3	0	3
687.0	687.0	2	30.0	10	90.0	3.1	0	
		3	30.0	10	120.0	0.0	0	
		4	30.0	10	90.0	0.0	0	
		5	30.0	10	60.0	0.0	0	
557.0	557.0	1	30.0	10	60.0	3.8	0	4
587.0	587.0	2	30.0	10	90.0	7.2	0	
		3	30.0	10	120.0	4.7	0	
		4	30.0	10	90.0	1.0	0	
		5	30.0	10	60.0	0.8	0	
457.0	457.0	1	30.0	10	60.0	0.2	0	5
487.0	487.0	2	30.0	10	90.0	3.5	0	
		3	30.0	10	120.0	0.2	0	
		4	30.0	10	90.0	0.2	0	
		5	30.0	10	60.0	1.4	0	

Boring: South Bound

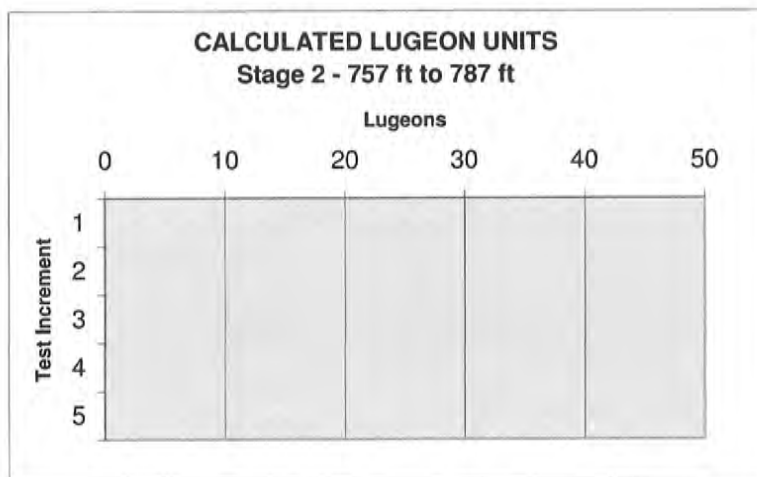


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take

Boring: South Bound

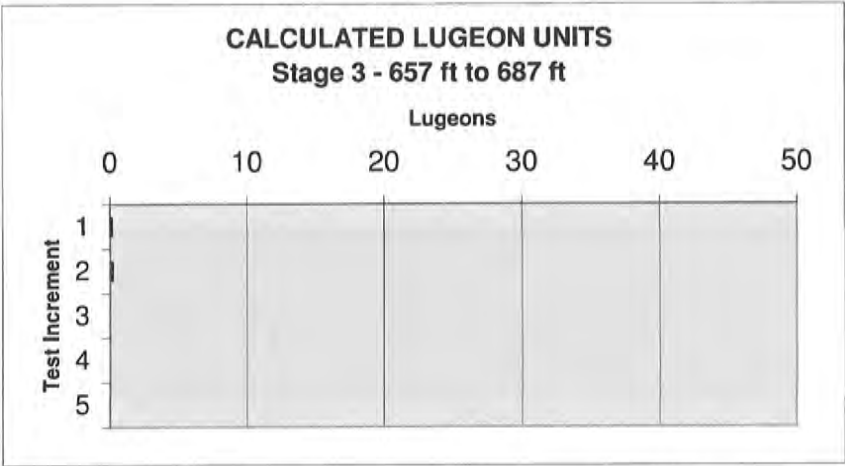


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take

Boring: South Bound

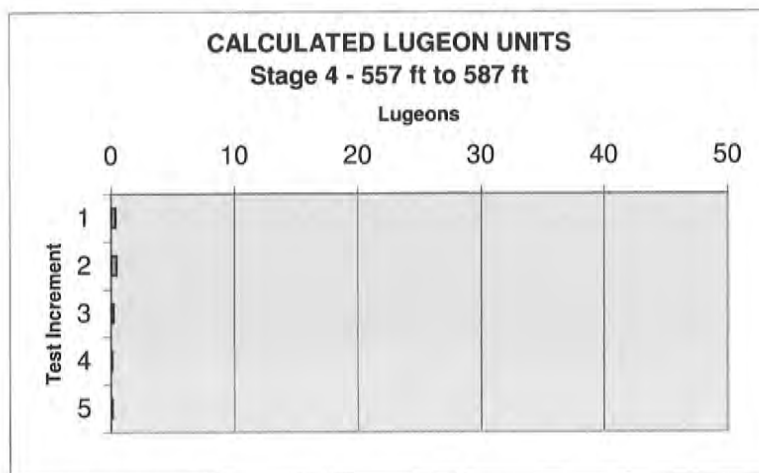


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

The permeability is esentially the same no matter what the pressure and resultant water take.

Boring: South Bound

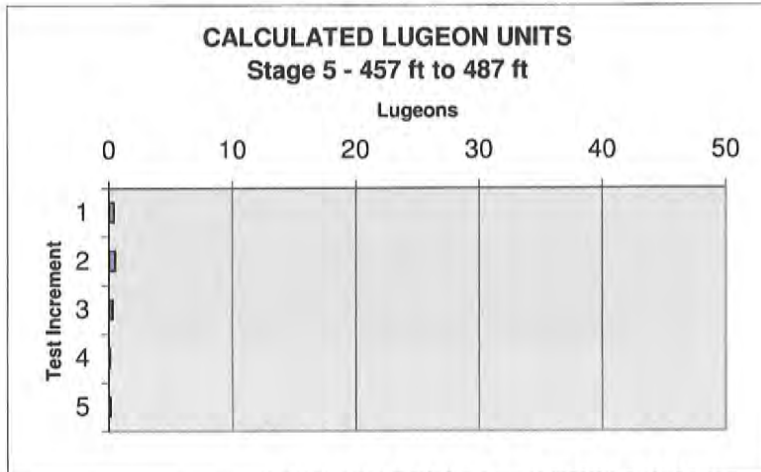


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take.

Boring: South Bound



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: Laminar

The permeability is essentially the same no matter what the pressure and resultant water take.

**LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING**



Field Test Data

Boring : *South Bound*
Elevation: **592.3**

Test by: *N. Peterson*
Date: *9/17/2011*

Formula for Lugeon (Lu) calculation:

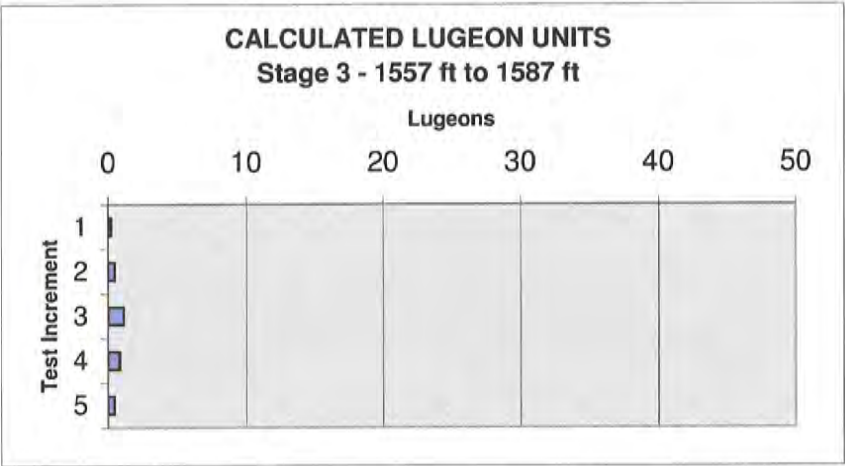
(water take in gallons ÷ 7.48 gal/ft³) x (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet x test time in minutes x 0.0107620)

Data Entry -

Enter Borehole Stage (from & to); Test Time; Gauge Pressure; and Water Take.
Spreadsheet calculates Stage Length and Lugeon Units.

Borehole Stage Interval (ft)	Vertical Stage Interval (ft)	Increment	Stage Length (ft)	Test Time (min.)	Gauge Pressure (psi)	Water Take (gallons)	Lu (incr.)	Lu (stage)
1757.0	1757.0	1	30.0	10	60.0	32.5	3	1
1787.0	1787.0	2	30.0	10	90.0	41.2	3	
		3	30.0	10	120.0	42.7	2	
		4	30.0	10	90.0	28.9	0	
		5	30.0	10	60.0	21.8	0	
1657.0	1657.0	1	30.0	10	60.0	25.8	3	2
1687.0	1687.0	2	30.0	10	90.0	38.9	3	
		3	30.0	10	120.0	43.2	2	
		4	30.0	10	90.0	35.7	2	
		5	30.0	10	60.0	25.0	2	
1557.0	1557.0	1	30.0	10	60.0	2.0	0	3
1587.0	1587.0	2	30.0	10	90.0	7.2	0	
		3	30.0	10	120.0	22.7	1	
		4	30.0	10	90.0	12.5	1	
		5	30.0	10	60.0	4.7	0	

Boring: South Bound

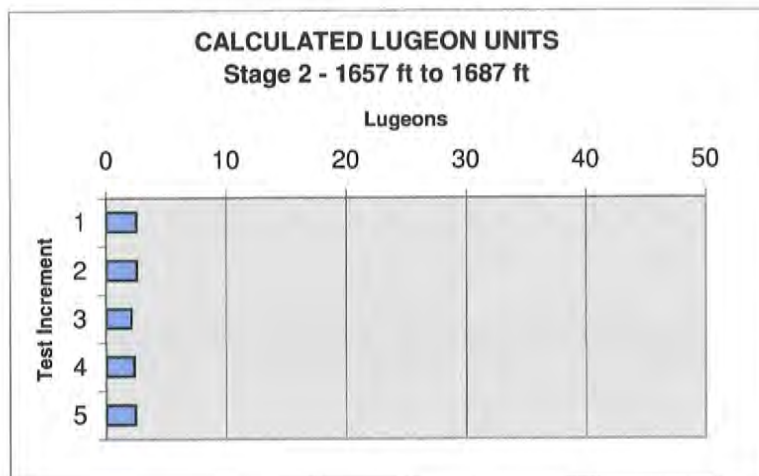


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	1
Test Increment 4	90	1
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

Permeability increases at the highest water test pressure as fractures are being hydraulically opened. Flow is laminar at the lower pressures.

Boring: South Bound

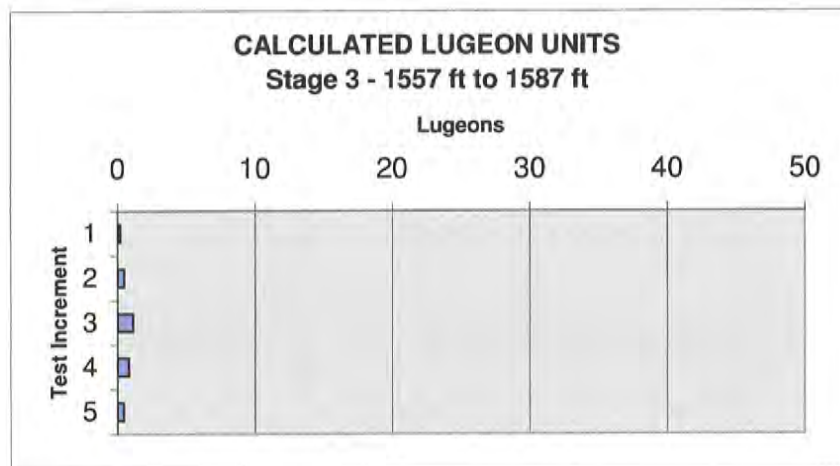


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	3
Test Increment 2	90	3
Test Increment 3	120	2
Test Increment 4	90	2
Test Increment 5	60	2

INTERPRETATION OF RESULTS: Laminar Flow

The permeability is essentially the same no matter what the pressure and resultant water take

Boring: South Bound



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	1
Test Increment 4	90	1
Test Increment 5	60	0

INTERPRETATION OF RESULTS: Dilation

Permeability increases at the highest water test pressure as fractures are being hydraulically opened. Flow is laminar at the lower pressures.

**LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING**



Field Test Data

Boring : *South Bound*
Elevation: 592.3

Test by: *N. Peterson*
Date: *9/15/2011*

Formula for Lugeon (Lu) calculation:

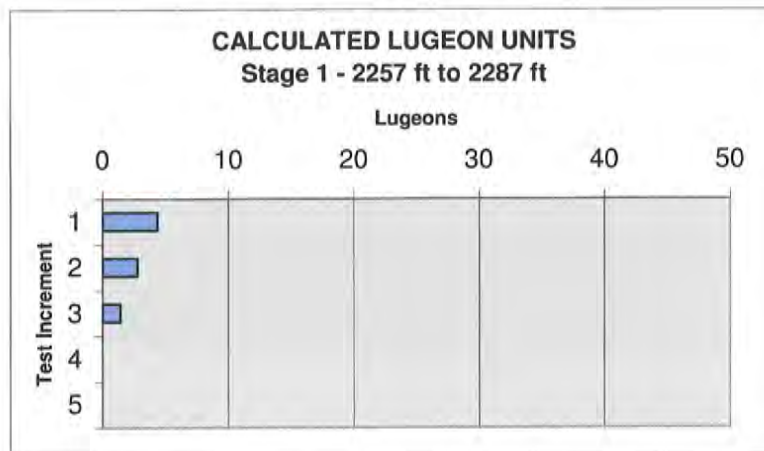
(water take in gallons ÷ 7.48 gal/ft³) × (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet × test time in minutes × 0.0107620)

Data Entry -

Enter Borehole Stage (from & to); Test Time; Gauge Pressure; and Water Take.
Spreadsheet calculates Stage Length and Lugeon Units.

Borehole Stage Interval (ft)	Vertical Stage Interval (ft)	Increment	Stage Length (ft)	Test Time (min.)	Gauge Pressure (psi)	Water Take (gallons)	Lu (incr.)	Lu (stage)
2257.0	2257.0	1	30.0	10	60.0	44.4	4	1
2287.0	2287.0	2	30.0	10	90.0	42.3	3	
		3	30.0	10	120.0	29.1	1	
		4	30.0	10	90.0	18.7	0	
		5	30.0	10	60.0	14.4	0	
2157.0	2157.0	1	30.0	10	60.0	0.1	0	2
2187.0	2187.0	2	30.0	10	90.0	0.7	0	
		3	30.0	10	120.0	0.0	0	
		4	30.0	10	90.0	0.0	0	
		5	30.0	10	60.0	0.0	0	
2057.0	2057.0	1	30.0	10	60.0	28.6	3	3
2087.0	2087.0	2	30.0	10	90.0	36.0	2	
		3	30.0	10	120.0	53.5	3	
		4	30.0	10	90.0	41.3	3	
		5	30.0	10	60.0	28.7	3	
1957.0	1957.0	1	30.0	10	60.0	19.5	2	4
1987.0	1987.0	2	30.0	10	90.0	30.2	2	
		3	30.0	10	120.0	41.5	2	
		4	30.0	10	90.0	30.3	2	
		5	30.0	10	60.0	21.7	2	
1857.0	1857.0	1	30.0	10	60.0	23.5	2	5
1887.0	1887.0	2	30.0	10	90.0	30.9	2	
		3	30.0	10	120.0	38.8	2	
		4	30.0	10	90.0	31.8	2	
		5	30.0	10	60.0	21.8	2	

Boring: South Bound

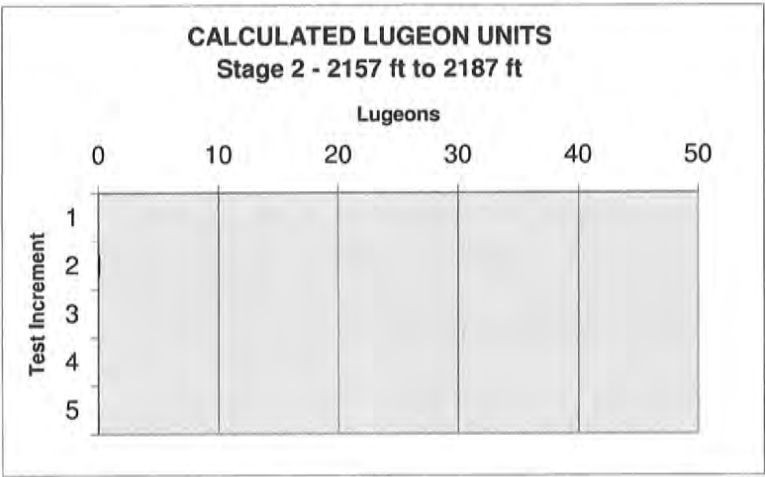


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	4
Test Increment 2	90	3
Test Increment 3	120	1
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: Void Filling

Permeability decreases due to fractures that are being filled and partially or completely blocked as water flows. Swelling rock that closes fractures over time because of the introduction of water by the test can also cause this reduced permeability.

Boring: South Bound

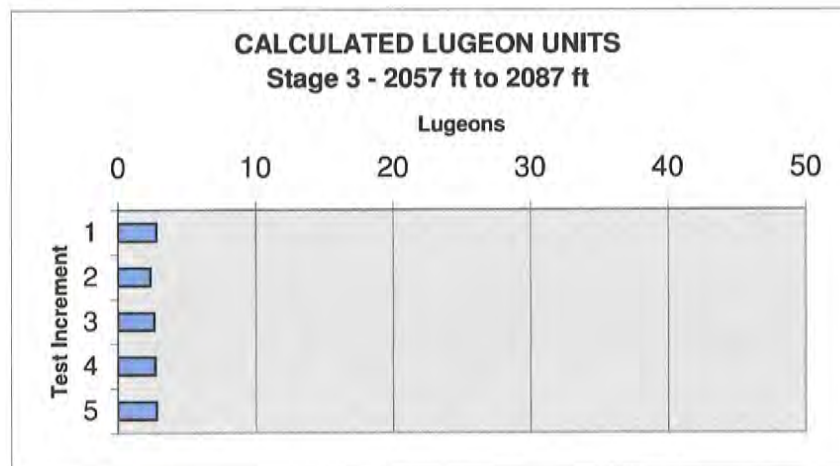


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

The permeability is esentially the same no matter what the pressure and resultant water take

Boring: South Bound

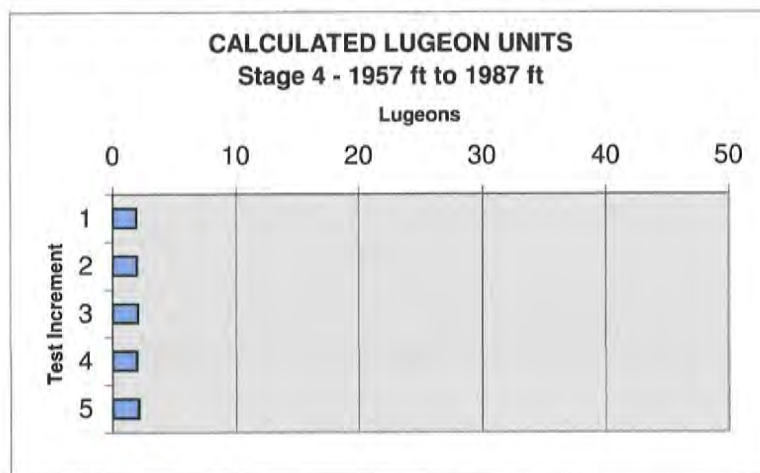


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	3
Test Increment 2	90	2
Test Increment 3	120	3
Test Increment 4	90	3
Test Increment 5	60	3

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take.

Boring: South Bound

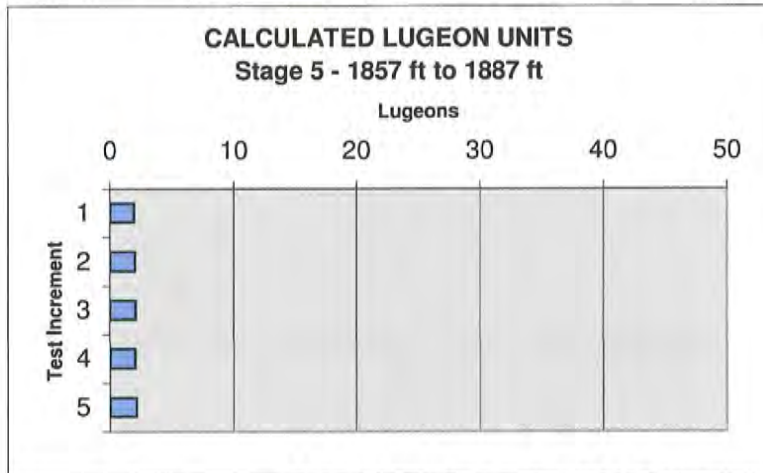


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	2
Test Increment 2	90	2
Test Increment 3	120	2
Test Increment 4	90	2
Test Increment 5	60	2

INTERPRETATION OF RESULTS: Laminar

The permeability is essentially the same no matter what the pressure and resultant water take.

Boring: South Bound



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	2
Test Increment 2	90	2
Test Increment 3	120	2
Test Increment 4	90	2
Test Increment 5	60	2

INTERPRETATION OF RESULTS: **Laminar**

The permeability is essentially the same no matter what the pressure and resultant water take.