

GEOTECHNICAL DATA REPORT NORTH 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:

Kentucky Transportation Cabinet

Geotechnical Branch 1236 Wilkinson Boulevard Frankfort, Kentucky



422 Codell Drive Lexington, Kentucky 40509

September 8, 2011



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Kentucky Transportation Cabinet Geotechnical Branch 1236 Wilkinson Boulevard Frankfort, Kentucky 40601

Attention: Mr. Daryl Greer, P.E.

Subject: Geotechnical Data Report Louisville Tunnel Project North Bound Section Jefferson County, Kentucky Project No. 1831-10-5629

Dear Mr. Greer:

S&ME, Inc. is pleased to submit the following *Geotechnical Data Report* conducted along the proposed alignment of Louisville Tunnel in Jefferson County, Kentucky. The following report presents the data generated from our horizontal directional core drilling and laboratory testing. Should you have any questions regarding this report, or if we can be of any further assistance, please contact us at your convenience.

Respectfully Submitted,

S&ME, Inc.

Nathan J. Peterson, P.G. Ku Geotechnical Professional

William A. Leake, P.E., P.L.S. Project Manager

Attachments: Geotechnical Data Report

Craig Lee, P.E Senior Geotechnical Engineer

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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 begins 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 advance horizontal directional core borings through the crown of each tunnel and in the pillar section between the tunnel openings and perform laboratory testing on the recovered rock core to assess the engineering properties of the rock. 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. Figures, boring logs, laboratory test results and packer test data are attached in the Appendices. Our scope of work included the following:

- Drilling a total of 1,900 feet along the North 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.
- Hydraulic Conductivity (Packer) of the borehole
- 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; probably at least 95 percent is shale. The shale is dolomitic and weathers with angular fracture or crude fissility, eventually producing a 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. In addition, the Shale will undergo a change in it physical properties over time after exposure to the elements.

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.

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 (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 North 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 333 feet, which is the distance to the tunnel face, to the termination of the boring at 1,900 feet.

The slake durability samples were selected from the Waldron Shale. These samples were collected approximately every 30 feet along the boring starting at the contact of the Waldron Shale to the termination of the boring (1220 feet to 1900 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 pH, saturation and void ratio, and sulfur testing were also selected from the Waldron Shale. 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 North Bound section of the tunnel alignment were explored with a single horizontal directional core boring. The coordinates for the North Bound Boring alignment were provided by Parsons and used by S&ME in our boring plan. The North Bound Boring was advanced using HQ size core tools to a distance of 163 feet. The HQ tools cut a 2.5 inch diameter core and a 3.7 inch diameter boring. From a distance of 163 feet NQ size and AQ size 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 3 inch diameter boring and a 1 inch diameter core.

Continuous core samples were collected along the North 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 North 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 NORTH BOUND SECTION TO TUNNEL FACE

The North Bound Boring was located within an abandoned exit ramp from Highway 841. From the hole collar to the face of the tunnel is a distance of 333 feet. In this 333 foot interval the boring encountered gray, slightly weathered, hard, crystalline limestone (Louisville Limestone). The recovered core was logged, photographed, and boxed; however, laboratory testing was not performed on the core from this portion of the alignment as it was not within the tunnel.

4.3 LOUISVILLE LIMESTONE

The tunnel face of the North Bound section is located at a distance of 333 feet and an elevation of 541.6 feet along the alignment. From the collar to a distance of 1,220 feet the boring advanced through Louisville Limestone consisting 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 Splitting Tensile Stress, Diametrial and Axial Point Load, and Unconfined Compression. The results of these laboratory tests can be found in Appendix B.

4.4 WALDRON SHALE

The North Bound tunnel alignment encountered the Waldron Shale formation at a distance of 1,220 feet to 1,420 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 1,420 feet to 1,530 feet the Waldron Shale transitions from moderately hard to soft, moderately to severely fractured with the fractures occurring near horizontal to the core. The shale contains calcite and occasional thin white calcite veins which can be observed in the recovered core. The Rock Quality Designation (RQD) values ranged from 0 to 70

percent. The low RQD values reflect the fractures that were occurring horizontal to the rock core. The shale recovered was platy and occasionally friable along these fractures.

The Waldron Shale becomes slightly fractured to sound at a distance of 1,530 feet to 1,780 feet. The shale varies from moderately hard to soft within this section; however the rock was recovered in solid 10 foot long core sections for this distance along the alignment.

The Waldron Shale becomes soft, friable, severely fractured with thin clay seams at the fractures at a distance of 1,780 feet to 1,862 feet. The fractures occurred at very low angles to near horizontal and the shale along the fractures is very soft. The aperture of the fractures observed in the core was typically one to two millimeters with no indication of movement along the observed fractures. The RQD values along this section ranged from 0 to 70 percent with an average RQD of 50 percent.

The North Bound Boring was terminated at a distance of 1,900 feet within the Waldron Shale. The loss of hole integrity in the fractured and broken zone beginning at 1,530 feet created conditions that put the Devico tool at high risk of getting stuck in the borehole and blocking the borehole. After discussions with Parsons, the team elected to advance the boring from 1,530 feet without steering until the boring intersected the tunnel excavation limits. At that point, the boring was terminated.

Samples were collected for laboratory analysis within the Waldron Shale formation and were tested for Splitting Tensile Stress, Diametrial 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 Pillar 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. The fractures and bedding features encountered in these formations were transporting water from the nearby Pillar Boring, which was being drilled simultaneously, to the North Bound Boring. The Pillar

Boring was located to the west and at a higher elevation to the North Bound Boring. Water gain of approximately 5 to 10 percent was observed during drilling. At the termination of the Pillar Boring the water gain in the North Bound Boring was lost. Complete water return within the North Bound Boring was lost at approximately 1,220 feet at the contact between the Louisville Limestone and the Waldron Shale.

5.0 PACKER TESTING

Hydraulic conductivity testing (also known as permeability or "packer" testing) was conducted in the North 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.

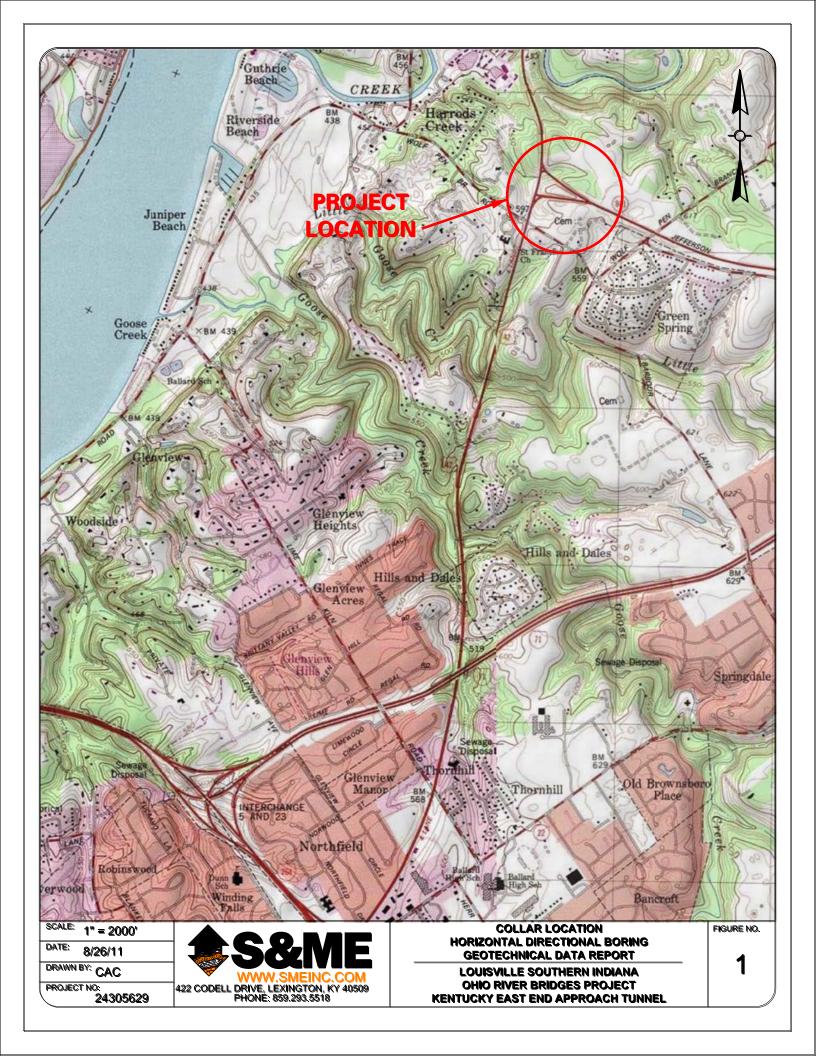
The permeability test results were reported as Lugeon values. The Lugeon unit is commonly used in grouting practice for measuring the permeability and the grout take potential of bedrock. Reporting the permeability test results using this method allows for the evaluation of the permeability characteristics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

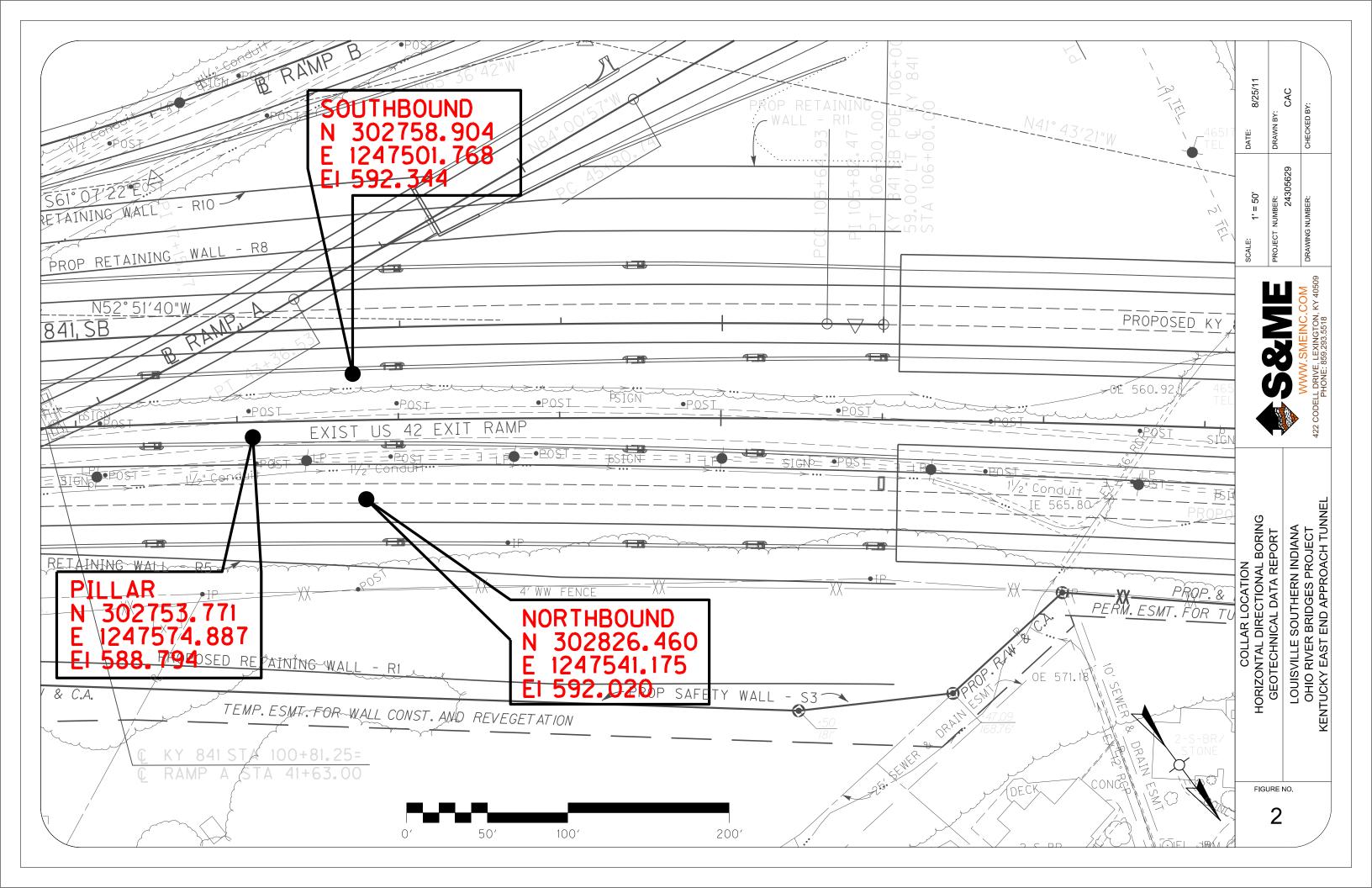
 $L_u = ((Water take, in gallons \div 7.48 gal/ft^3) \times (142 \div gauge pressure in psi))$ divided by (Stage length in feet x test time in minutes x 0.0107620)

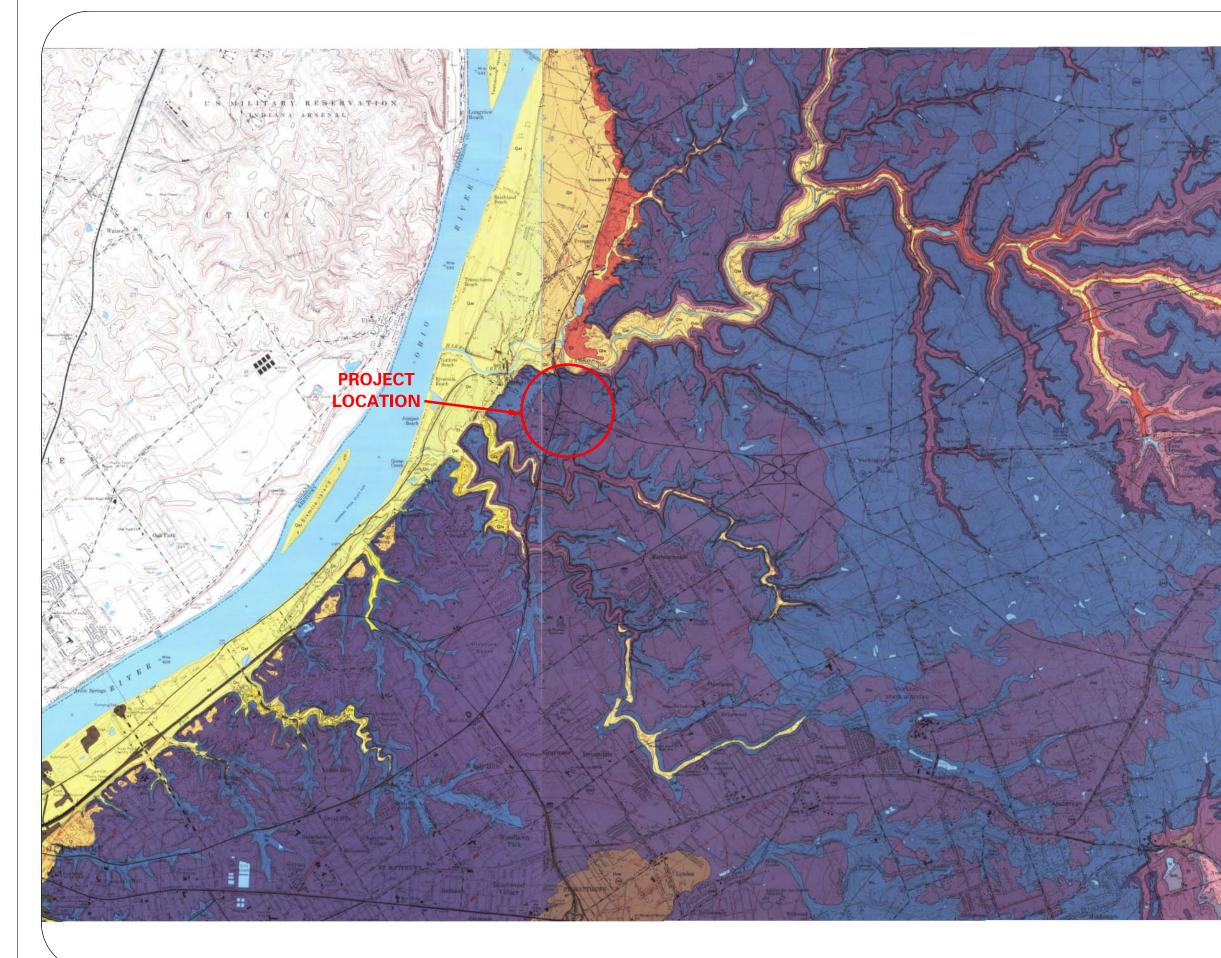
The packer system used in the North Bound Boring was provided by Tam International. A packer system consisting of two inflatable packers 2 foot in length and 2 inches in diameter were set 22 feet apart. Solid steel centralizers were placed above each packer to protect them during the placement and retrieval from the boring. Between the packers one inch diameter steel pipes were connected. The central section of the steel pipe contained off set holes to allow the water to fill up 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 allowed the selected pressure levels to be set and held at each test interval.

The tests were conducted at three pressure intervals with a low pressure of 30 psi and a high pressure of 90 psi. 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/WTExpBody.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. 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).









APPENDIX A

BORING LOGS

ROCK CORE PHOTOGRAPHS

		DN: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILLIN DRILL R	IG: I	_M90							NOF EAS	TIN	G:12	475	41.1	8		20.07	_			L	DATUM:
	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	-	(ft/min)	% RETURN		FR-F CL-C SH-S VN-\	CLEA CHEA /EIN ECO	TURE VAGE R VERY	F J F S	-FAUL -JOIN -POLI -SLIC R.Q. %	T ISHE KEN D.	D	SM R- ST D PL CT.	I-SM ROUG	DOTH GH PPED VAR DISC	UE-UNEVEN W-WAVY C-CURVED	BC- MB- B-B	BRO MEC EDD HYE	ing		POINT LOAD INDEX (psi)	(cod)
4	DRI		Ś			EP BE	FLUSH		COR 88		CORI 888		8 8 9		۲ <u>۲</u> ۳			AXIS 66 66	TYPE AND SURFACE DESCRIPTION	╞			100 200 200		<u> </u>
0 -	1102/22/6	GROUND SURFACE 0.0 ft to 3.8 ft (Run No. 1) LIMESTONE - Light gray; very slight weathering; sound; crystalline; fossiliferous; pressure solution features throughout; close to moderately close joint spacing with joint at 3.0 feet.		591.4	1														J, R						-
5	HQ Core	3.8 ft to 8.9 ft (Run No. 2) LIMESTONE - Same as previous run. All breaks mechanical.		3.8 590.6	2																			 	-
0	5/23/2011	8.9 ft to 13.9 ft (Run No. 3) LIMESTONE - Same as previous run; Joints at 11.8 and 12.2 feet.		589.8	3			590											J, R J, R						_
5	.,	13.9 ft to 19.0 ft (Run No. 4) LIMESTONE - Same as previous run; Joint at 17.2 feet.		13.9	4														J, R						
D	HQ Core	19.0 ft to 24.0 ft (Run No. 5) LIMESTONE - Same as previous run; Joints at 20.0', 21.2' (with iron staining approximately 1 inch on either side of joint), 23.7' (with iron staining approximately 2 inches on either side of joint).			5														J, R J, R, FE J, R, FE						
5		24.0 ft to 29.0 ft (Run No. 6) LIMESTONE - Gray; very slight weathering; hard; slightly fractured with fracture at 28.4' to 28.6'; crystalline; with pressure solution features throughout; wide joint spacing; fossiliferous.		24.0	6																				-
0		29.0 ft to 34.0 ft (Run No. 7) LIMESTONE - Same as previous run; fractures at 30.2' to 30.8', 31.9' to 32.1', 32.3' to 32.5', 32.9' to 33.1', 33.6' to 33.9'. Fractures occur at approximately 60 degrees.		29.0	7														Azimuth: 306.07 Inclination: -9.36					 	-
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-		29.0 ft to 34.0 ft (Run No. 7) LIMESTONE - Same as previous run; fractures at 30.2' to 30.8', 31.9' to 32.1', 32.3' to 32.5', 32.9' to 33.1', 33.6' to 33.9'. Fractures occur at approximately 60 degrees.																										-
- 35 - -		34.0 ft to 39.0 ft (Run No. 8) LIMESTONE - Same as previous run. Joint at 34.7'; Fractures at 36.7' to 36.9', 38.3' to 38.4'.			8															J, R								
- 40 - -		34.0 ft to 44.0 ft (Run No. 9) LIMESTONE - Same as previous run; Joint at 40.0'.		<u>585.7</u> 39.0	9			585												J, R								-
-				584.9				565																				
- 45 - -	HQ Core	44.0 ft to 49.0 ft (Run No. 10) LIMESTONE - Same as previous run.		584.1	10																							-
- 50 - -		49.0 ft to 54.0 ft (Run No. 11) LIMESTONE - Light gray; very slight weathering out to 53.4' the limestone becomes iron stained, friable, solution weathering (water loss at 53.4 feet). Limestone is crystalline, hard, with stylolitic features throughout.			11																							-
- 55 - -		54.0 ft to 59.0 ft (Run No. 12) LIMESTONE - Light gray; very slight weathering; slightly fractured with fractures at 56.4' to 57.2', 58.1' to 58.3' (weathered and friable), both fractures contain iron staining. Limestone is hard, crystalline; with pressure solution features; fossiliferous; with calcite crystals.			12																							-
- 60 -		59.0 ft to 64.0 ft (Run No. 13) LIMESTONE - Same as previous run; fractures at 60.1' to 60.5' and 61.0' to 61.3', both fractures contain iron staining.		59.0																Azimuth: 305.02 Inclination: -9.97								-
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-				581.6	13														T						
- 65 - -		64.0 ft to 69.0 ft (Run No. 14) LIMESTONE - Same as previous run; fracture at 65.1' to 65.4'; Joint at 66.6'.		64.0 580.8	14													J, R							
- 70 - -	5/24/2011	69.0 ft to 74.0 ft (Run No. 15) LIMESTONE - Same as previous run; fractured rock from 71.2' to 73.0' with friable rock at fractures and iron staining.		580.0	15		_ 580																		-
- 75 - -		74.0 ft to 79.0 ft (Run No. 16) LIMESTONE - Gray; very slight weathering; slightly fractured with fractures at 75.9' to 76.2' and 77.0' to 77.2'. Both fractures are iron stained and friable. Rock is hard, crystalline, with pressure solution features.		74.0	16		_ 380																		-
- 80 - -		79.0 ft to 84.0 ft (Run No. 17) LIMESTONE - Same as previous run; Significant weathering and solutional features at 82.8' with clay to the end of the run.		79.0																					
- 85 - -		B4.0 ft to 89.0 ft (Run No. 18) LIMESTONE - Same as previous run; severly weathered feature continues from 82.8' to 84.5', iron stained, friable, pitted rock. From 84.5' to the end of the run limestone is gray; moderately fractured at 10 degrees with black oxide staining at fractures and abundant fossils. Limestone is crystalline, hard, with pressure solution features.			18																				
- 90 - -		89.0 ft to 93.2 ft (Run No. 19) LIMESTONE - Gray; slightly weathered; hard; crystalline; fossiliferous; slightly fractured with fractures at 90.0' to 90.3', 90.9' to 91.1', 92.0' to 92.8'; pressure solution features throughout.		89.0 576.9	19													Azimuth: 304.58							
-				93.2	20													Inclination: -10.29							-
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		NCE SCALE DRILLING CONTRAC		:Boart Lo	ongy	ear													<u> </u>			<u> </u>			LOGGED: NJP CHECKED:

		DN: Louisville, Kentucky		DRILLIN DRILL R			5/22/2	011					IORT ASTI										I	DATUM:
PRC	JEC	T NUMBER: 1831-10-5629		drill r Drillin			D: HQ	/NQ/	AQ									AZIMUTH: N 3	06°E	E				
L	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (ft/min) COLOR	% RETURN	ELEVATION	FR-FI CL-CI SH-SI VN-VI	LEAV	AGE	J-J P-I S-0	AULT OINT POLISH BLICKE R.Q.D.	HED	F	R-RO ST-S ⁻ PL-PL		UE-UNEVEN ED W-WAVY	MB- B-B	-MEC BEDD	ing	COR REAK		
	DRILLI		SYM	(ft)	Œ	PENET			TOTA CORE	%	SOLIE CORE	D %	% %	PE	NDEX ERFT ₽₽€8	r co	REAXI			k,	cm/s	IVIIN ec	583 583	<u> </u>
	_	CONTINUED FROM PREVIOUS PAGE																	\bot					
95		93.2 ft to 98.2 ft (Run No. 20) LIMESTONE - Same as previous run; fractures at 94.1' to 94.3', 95.1' to 95.4', 96.4' to 96.7'.		576.0	20																			
00		98.2 ft to 103.4 ft (Run No. 21) LIMESTONE - Same as previous run; fracture at 100.5' to 100.7'.		98.2 575.2	21																			
05		103.4 ft to 108.6 ft (Run No. 22) LIMESTONE - Same as previous run; all breaks mechanical.		103.4	22		5	75																
10	HQ Core	108.6 ft to 113.6 ft (Run No. 23) LIMESTONE - Gray; slightly weathered; hard; moderately fractured with fractures occuring at 110.3' to 111.9'; rock is severly weathered, friable, and iron stained along fracture. Limestone is hard; crystalline; fossiliferous; with pressure solution features throughout.		108.6	23																			_
15		113.6 ft to 118.8 ft (Run No. 24) LIMESTONE - Gray; slightly weathered; hard; crystalline; slightly fractured with fractures at 113.6' to 114.0', 117.1' to 117.4', 118.2' to 118.4'; fractures contain fossils and calcite crystals; pressure solution features throughout.		113.6	24																			
20		118.8 ft to 123.9 ft (Run No. 25) LIMESTONE - Same as previous run; all breaks mechanical.		118.8	25																			
25		123.9 ft to 129.0 ft (Run No. 26) LIMESTONE - Same as previous run; all breaks mechanical.		571.9 123.9	26													Azimuth: 304.64 Inclination: -10.81						
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PRC	JEC	ON: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILLIN	<u>م</u> م	TE												Boring							
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ω _⊢	RECORD		C LOG	ELEV.	40.	PENETRATION RATE (ft/min) COLOR		CL SH	-FRAG	AVAG AR			INT DLISH		F	-ROL	EPPE	UE-UNEVEN D W-WAVY		MEC	H. BF	REAK			L
DISTANCE SCALE FEET	DRILLING R	DESCRIPTION	SYMBOLIC LOG	DISTANCE (ft)	RUN No.	ETRATIC (ft/mir	ELEVATION		-VEIN RECO	OVEF	RY		.ICKE .Q.D. %	FR IN	ACT. DEX		DI	SCONTINUITY DATA	С	HYE	DRAL	ILIC IVITY			
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		123.9 ft to 129.0 ft (Run No. 26) LIMESTONE - Same as previous run;			00																				
		all breaks mechanical.			26																				
			Ħ	571.0 129.0			-			⋕															-
130																									
		129.0 ft to 134.0 ft (Run No. 27) LIMESTONE - Same as previous run;																							
		LIMESTONE - Same as previous run; all breaks mechanical.			27																				
			Ħ	570.2 134.0			-	\mathbb{H}		╟		+		$\left \right $											
- 135							570	Ш																	
		134.0 ft to 139.2 ft (Run No. 28)																							
		LIMESTONE - Same as previous run; all breaks mechanical.			28																				
				569.4 139.2			_					+		$\left \right \right $											
140																									
	Core	ງ 139.2 ft to 144.2 ft (Run No. 29)																							_
	P				29																				
				568.6 144.2			-	$\left \right $		╟		╫		$\left \right \right $											
- 145																									
		144.2 ft to 149.2 ft (Run No. 30) LIMESTONE - Light gray; very slight weathering; hard; crystalline; with			30																				
		pressure solution features; all breaks mechanical.			00																				_
				567.8 149.2			-	H		╟	$\left \right $	+	$\left \right $	$\left \right $											
- 150														$\left \right \right $											
		149.2 ft to 154.2 ft (Run No. 31) LIMESTONE - Same as previous run;			31																				
		all breaks mechanical.												$\left \right \right $											
				500.0				Щ		\parallel						\parallel									_
- 155		154.2 ft to 159.2 ft (Run No. 32)		566.9 154.2			1	Ħ		Ħ		\ddagger		1											
100		LIMESTONE - Same as previous run; all breaks mechanical.			32									$\left \right \right $				Azimuth: 304.39							
		Note: Terminate HQ core at 159.2 feet and begin NQ core to open boring for directional barrel.												$\left \right \right $				Inclination: -11.11							
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		ICE SCALE DRILLING CONTRA 0 4 feet DRILLER:D. Sammo		:Boart Lo	ongye	ear			Ŵ	F	NG	NEFE			GRIT										LOGGED: NJP CHECKED:

PRO	JEC	T: Jefferson County, Louisville Tunn	OF	rd o	F	DR	LLH	0	LE			Ν	lor	th	E	80	u	nd	Boring							S	SHEET 6 OF 61
		DN: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	G: L	_M90			h			I	NOR EAS ⁻ NCLI	TING	G:12	47	541.	.18	AZIMUTH: N	206	₀⊏					C	DATUM:
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FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	μ.	[%] EVAT	s v	TOTAL	IEAR IN COVE		P- S-	JOINT POLIS SLICH R.Q.E %	SHEI KENS		S D P CT. EX	T-ST		ED W-WAVY R C-CURVED	в. —	BED HY	CH. E DING /DRA /DRA			DIAMETRAL	POINT LOAD INDEX (psi)	
	DRI		Ś			PENET	2		CORE 9		3 8 4 3 0 4		8 8 9	_ I	<u>ہ د</u>			8 8 8 8 8 8		-		10%		79 Å			
5/95/9011	HQ Core	CONTINUED FROM PREVIOUS PAGE			32							╫															
160	NQ Core	159.2 ft to 163.6 ft (Run No. 33) LIMESTONE - Same as previous run; all breaks mechanical. Note: Terminate NQ core at 163.6 feet and begin AQ directional core.			33																						-
165		163.6 ft to 172.6 ft (Run No. 34) LIMESTONE - Light gray; very slight weathering; slightly fractured with severly weathered solutional feature at 167.8' to 173.8' and fractured with iron staining; wide joint spacing; crystalline; fossiliferous; with pressure solution features throughout.		163.6	34		565																				
175	AQ Core				35																						-
180				<u>562.3</u> 182.6				-																			
185		182.6 ft 192.6 ft (Run No. 36) LIMESTONE - Same as previous run; all breaks mechanical.			36														Azimuth: 304.39 Inclination: -11.11								-
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		CE SCALE DRILLING CONTRAC 4 feet DRILLER:D. Sammo		:Boart Lo	ongye	ear		1			S					BIT					1	1	1	1		<u> </u>	LOGGED: NJP CHECKED:

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DISTANCE SCALE FEET	חמובנוועם מבטטמט	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH	EVA7	CL-C SH-S VN-V F TOT COR	FRAC CLEA SHEA VEIN RECC TAL RECC		έ	J-J(P-P S-S F	OLIS	HED ENS	IDED FRAC INDE PER F	R-F ST PL T. X	-STE -PLA DIP CORE	EPPE ANAR	UE-UNEVEN ED W-WAVY C-CURVED SCONTINUITY DATA	ME B-E	B-ME BEDI HY CON	YDRA NDUC	чк Сту	DIAMETRAL POINT LOAD	INDEX (psi)	
190		CONTINUED FROM PREVIOUS PAGE 182.6 ft 192.6 ft (Run No. 36) LIMESTONE - Same as previous run; all breaks mechanical.		560.7	36																					
200		192.6 ft to 202.6 ft (Run No. 37) LIMESTONE - Same as previous run; Joint at 193.1'; fracture at 193.7' to 193.9'; joint at 199.8'; fracture at 200.6' to 201.2'; joint at 201.4' and 202.0'.		192.6	37		560												J, R J, R J, R J, R							
205	AQ Core	202.6 ft to 212.6 ft (Run No. 38) LIMESTONE - Light gray; slightly weathered; sound; crystalline; with pressure solution features throughout; all breaks mechanical.			38																					
215		212.6 ft to 222.6 ft (Run No. 39) LIMESTONE - Same as previous run; all breaks mechanical.		212.6	39														Azimuth: 304.39 Inclination: -11.11							
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DISTA 1 inch		E SCALE DRILLING CONTRAC 4 feet DRILLER:D. Sammo		:Boart Lo	ongye	ear		ł	ø	E	NGI	NEE	RING		TEGF	ITY										LOGGED: NJP CHECKED:

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			N: Louisville, Kentucky		DRILL R	IG:	LM90	5/22/2011): HQ/NQ		ç			I	EAS	STIN	ING IG:1 ATIC	247	54	1.18	3	AZIMUTH: N 30	06°	E					D	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) F11ISH COLOR	EVAT	CI SI VI	R-FRA L-CLE H-SHE N-VEI REC TOTAL ORE %	AVA AR N OVE	GE	J- P· S·		NT LISHE CKEN I.D.	FR/ INE PEI	F	R-RC ST-S PL-P		H PEC AR DIS	UE-UNEVEN	MB B-B	HY CON	DING	N CC BRE à AULIO CTIVI /sec	AK C TY	DIAMETRAL	POINT LOAD INDEX (psi)	
		1	CONTINUED FROM PREVIOUS PAGE						Ţ	Щ	Ţ	Ţ	П	Ţ			Ţ		Ţ			Ţ							
-			212.6 ft to 222.6 ft (Run No. 39) LIMESTONE - Same as previous run; all breaks mechanical.			39																_							
- 225 - 225 - 230 -			222.6 ft to 232.6 ft (Run No. 40) LIMESTONE - Same as previous; all breaks mechanical.		554.0	40		555																					
- 235 - - - - 240 -		AQ Core	232.6 ft to 242.6 ft (Run No. 41) LIMESTONE - Same as previous run; all breaks mechanical.			41																-							
- 245 - 250 - 250 - 1 ir		-	242.7 ft to 252.8 ft (Run No. 42) LIMESTONE - Same as previous run; all breaks mechanical.			42															Azimuth: 308.50 Inclination: -9.38								
			CONTINUED NEXT PAGE																										
DIS			E SCALE DRILLING CONTRA 4 feet DRILLER:D. Sammo		l:Boart Lo	ongy	ear									NTE													Logged: NJP Checked:

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	CE SCALE	g record	DESCRIPTION	DOLIC LOG		N No.	ATION RATE /min) COLOR	% RETURN VATION	C S	L-CL H-SH N-VE	EAV IEAR	AGE	J F S	-JOIN P-POL	IT ISHE	SIDE	R S D P	-ROL T-ST	JGH EPPE ANAF	UE-UNEVEN ED W-WAVY R C-CURVED	MB B-E	B-ME BEDI	CH. E DING	BREA	к	AETRAL IT LOAD	EX (psi)	
280 22.8 10 202 7 (fan No. 43) Mit Broke mechanical 43 550 44 280 22.8 10 202 7 (fan No. 43) Mit Broke mechanical 550 44 280 257.7 to 27.28 f (fan No. 44) Mit Broke mechanical 550 44 280 257.7 to 27.28 f (fan No. 44) Mit Broke mechanical 550 44 280 257.7 to 27.28 f (fan No. 44) Mit Broke mechanical 550 44 280 257.7 to 27.28 f (fan No. 44) Mit Broke mechanical 44 280 27.8 to 27.0 f (fan No. 44) Mit Broke mechanical 44 280 37.7 to 27.28 f (fan No. 44) Mit Broke mechanical 44 280 27.8 to 27.0 f (fan No. 44) Mit Broke mechanical 44 280 37.7 to 27.28 f (fan No. 44) Mit Broke mechanical 44 44 44 44		DRILLIN		SYMB		ВL	PENETR (f		C	OTAL ORE 9	%	SOLI	ID 1%	%	,	PEF	RFT		P w.r.t. RE AXI			k	k, cm/	sec		POIN		
25 4 4 4 4 5 5 7 1 5 6			CONTINUED FROM PREVIOUS PAGE		-	40															\downarrow							
282.7 ft to 272.8 ft (Run No. 44) LMESTORE: Upht gaz, wey slight solution features throughout. 272 272 272 272 272 44 44 44 44 44 44 44 44 44 4			LIMESTONE - Same as previous run;		252.8			550												Azimuth: 308.50 Inclination: -9.38								
275 272.8 ft to 282.9 ft (Run No. 45) LIMESTONE - Same as previous run; joints at 273.0', 273.2', 273.7', 273.9', 274.1', 274.3', 279.3', 282.1'. 45		AQ Core	LIMESTONE - Light gray; very slight weathering; sound to slightly fractured with fracture at 270.2' to 270.8'; close joint spacing with joints at 271.0' to 272.8'; crystalline; hard; with pressure		262.7	44														J, R								
546.0			LIMESTONE - Same as previous run; joints at 273.0', 273.2', 273.7', 273.9',		272.8													\square		J, R J, R J, R J, R J, R J, R J, R J, R								
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PR	OJE	CT: Jefferson County, Louisville Tunr	OF	RD O	F	DRI	LLHO	DL	E:			No	rt	h I	Bc	u	nc	Boring					s	HEET 10 OF 61
		ON: Louisville, Kentucky CT NUMBER: 1831-10-5629		drillin Drill R Drillin	IG: I	_M90	22/2011	/AQ				EA	STI	HING NG:1 ATIC	247	541	.18	AZIMUTH: N 3	06°	E			D	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL-0 SH-3 VN-1 F TOT COF	CLEA SHEA VEIN RECC	SC SC	E Y	- R.(NT LISH	NSIDI FR IN PE	F	ROI T-ST L-PL		UE-UNEVEN PED W-WAVY R C-CURVED DISCONTINUITY DATA L L L L L L L L L L L L L	MB B-B	-MEC BEDD HYE CONE	CH. BI		POINT LOAD INDEX (psi)	
	_	CONTINUED FROM PREVIOUS PAGE						Ш								Ţ		J, R						
- 285 - - - - 290 -		282.9 ft to 292.9 ft (Run No. 46) LIMESTONE - Same as previous run; Joints at 283.5', 283.9', 284.1'; fracture at 284.6' to 284.8'; Joints at 285.0' to 286.9' (approximately 3 inches apart); fracture at 290.5' to 290.9'.		544.4	46		545											J.R J.R J.R J.R J.R J.R J.R J.R J.R J.R						
- 295 - 295 - 300 	AO Core	292.9 ft to 302.9 ft (Run No. 47) LIMESTONE - Same as previous run; fracture at 297.4' to 297.6' and 299.8' to 307.3'; occasional fossils.		292.9	47																			
- 305 		302.9 ft to 312.9 ft (Run No. 48) LIMESTONE - Light gray; very slight weathering; sound; hard; crystalline; with occasional fossils; pressure solution features throughout. 312.9 ft to 322.9 ft (Run No. 49) LIMESTONE - Same as previous run; slightly fractured with fractures at 319.1' to 319.3' and 320.1' to 320.3'.		302.9	48													Azimuth: 310.47 Inclination: -6.98						
		CONTINUED NEXT PAGE																						
DIS 1 in		CE SCALE DRILLING CONTRAC o 4 feet DRILLER:D. Sammo		:Boart Lo	ongye	əar				E	SNGIN	\sim	Z		GRIT									LOGGED: NJP CHECKED:

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DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) F111SH COLOR	EVA1	FR-FF CL-CL SH-SH VN-VE RE TOTAL CORE		AGE	- R.(NT LISHI	ED NSIDED FRAC INDE PER	R-F ST-) PL-) T. ST. FT		H PEE IAR DIS	UE-UNEVEN	MB-N B-BE	HECH DDI HYD OND k, c	H. BF NG RAU UCTI	1	POINT LOAD INDEX (psi)	
- 315 ·		CONTINUED FROM PREVIOUS PAGE 312.9 ft to 322.9 ft (Run No. 49) LIMESTONE - Same as previous run; slightly fractured with fractures at 319.1'																					
- 320		to 319.3' and 320.1' to 320.3'.		539.5	49		540						-										
- 325	AQ Core	322.9 ft to 332.9 ft (Run No. 50) LIMESTONE - Same as previous run; fracture at 325.6' to 326.1'. Note: North Bound Tunnel Face at 332.9 feet.			50																		
- 335		332.9 ft to 342.9 ft (Run No. 51) LIMESTONE - Same as previous run; sound; all breaks mechanical.		332.9	51																		2927
- 340 -				536.3 342.9			_																
- 345		342.9 ft 352.9 ft (Run No. 52) LIMESTONE - Same as previous run; all breaks mechanical.			52												Azimuth: 310.41 Inclination: -5.34						
		CE SCALE DRILLING CONTRA 0.4 feet DRILLER:D. Sammo		l R:Boart Lo	ongye	ear	<u> </u>			\sim	\sim						1	<u> </u>					Logged: NJP Checked:

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DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>		CL-C SH-S VN-V	CLEA SHEA VEIN RECO	TURE VAGE R VERY SOI COR	/ LID E %	F-FAUL J-JOINT P-POLI S-SLICI R.Q.I %	r SHEI KENS D.		R-F ST PL T. X	-STEI -PLAI	PPED NAR DIS	UE-UNEVEN D W-WAVY C-CURVED CONTINUITY DATA	мв- в-ві	HYE HYE K,	H. BR		POINT LOAD INDEX (psi)	
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- 350		342.9 ft 352.9 ft (Run No. 52) LIMESTONE - Same as previous run; all breaks mechanical.			52		535																	
- 355		352.9 ft to 362.2 ft (Run No. 53) LIMESTONE - Light gray; slight weathering; sound; hard; crystalline; fossiliferous; pressure solution features throughout.		352.9	53																			
- 365		362.2 ft to 371.6 ft (Run No. 54) LIMESTONE - Same as previous run; all breaks mechanical.			54		_																	
- 375		371.6 ft to 381.6 ft (Run No. 55) LIMESTONE - Same as previous run; all breaks mechanical.		531.6	55													Azimuth: 309.10 Inclination: -3.64						
		CONTINUED NEXT PAGE																						
		ICE SCALE DRILLING CONTRAC o 4 feet DRILLER:D. Sammo		R:Boart Lo	ongye	ar				EN					RITY	l I								LOGGED: NJP CHECKED:

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PRC	NEC	CT NUMBER: 1831-10-5629					D: HQ/NC					INCI	_IN/	ATIC	N:	-9.3	6°	AZIMUTH:								
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) COLOR	EVAT	CI SI VI	'OTAL ORE %	AGE ERY SOLI	J P S D	R.Q %	IT ISHI CKEI	FR/ INE PEI	F S D P ACT. DEX R FT	-ROL T-ST L-PL DI	D P w.r.t RE AX	UE-UNEVEN ED W-WAVY R C-CURVED ISCONTINUITY DATA	ACE	AB-MI B-BEC H CO	ECH. DDING IYDR/ NDUG k, cm	AULIC CTIVI /sec	κ ; ty	DIAMETRAL POINT LOAD	INDEX (psi)	
		CONTINUED FROM PREVIOUS PAGE				- 1	<u> </u>	8	848		50 10	8.9	<u>8</u>	10 10	15		888	2	-	10	<u><u></u></u>	200	78		Т	
380		371.6 ft to 381.6 ft (Run No. 55) LIMESTONE - Same as previous run; all breaks mechanical.		530.0	55		530																			
385		381.6 ft to 390.1 ft (Run No. 56) LIMESTONE - Same as previous run; all breaks mechanical.		528.6	56																					
390	AQ Core	390.1 ft to 400.2 ft (Run No. 57) LIMESTONE - Same as previous run; weathered seam at 396.6' to 397.0 (soft with clay).		390.1	57																				•	8927
405		400.2 ft to 407.6 ft (Run No. 58) LIMESTONE - Light gray; very slight weathering; sound; hard; fine grained with pressure solution features.		400.2	58																					
		407.6 ft to 412.6 ft (Run No. 59) LIMESTONE - Same as previous run; all breaks mechanical.		525.7 407.6	59													Azimuth: 309.10 Inclination: -3.64								
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		CE SCALE DRILLING CONTRAG 4 feet DRILLER:D. Sammo		Boart Lo	ongye	ar				ENC	GINE			NTE	GRIT											LOGGED: NJP CHECKED:

PR	ΟJE	CT: Jefferson County, Louisville Tunr	COF	RD O	F	DRI	LLH	OL	E	:		N	or	th	B	οι	JN	d	Boring							SI	IEET 14 OF 61
		ON: Louisville, Kentucky		DRILLIN DRILL R			/22/2011						ORT AST													D	ATUM:
		CT NUMBER: 1831-10-5629		DRILLIN	g me		: HQ/NG			OTU	25								AZIMUTH: N 3				100	DE			
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	FENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	EVAT	CL SH VN	-FRA -CLE -SHE -VEII REC 0TAL 0RE % 8 8 8		θE	J-J(P-P S-S	AULT OLIS CLICK	HED ENSI		R-R ST- PL- T. T.	OUG	PPE NAR DIS w.r.t.	UE-UNEVEN	MB B-E	B-MEC BEDD HYI CONI	DING	ULIC	к ; тү	DIAMETRAL	POINT LOAD INDEX (psi)	
	_	CONTINUED FROM PREVIOUS PAGE						8	940	8	840	5 B	849	2 5	Ţ	Ň		3.6		+	Ţ		4 ú i	ž			
410		407.6 ft to 412.6 ft (Run No. 59) LIMESTONE - Same as previous run; all breaks mechanical.		524.9	59		525																				
415 420		412.6 ft to 422.6 ft (Run No. 60) LIMESTONE - Same as previous run; crystalline; all breaks mechanical.		412.6 523.3	60		_																				
425 430	AD Con	422.6 ft to 432.6 ft (Run No. 61) LIMESTONE - Same as previous run; all breaks mechanical.		422.6	61																						
435 440		432.6 ft to 442.6 ft (Run No. 62) LIMESTONE - Light gray; slightly weathered; slightly fractured; hard; crystalline; close joint spacing with joint at 436.0' (rough, iron stained); all other breaks mechanical.		521.7 432.6	62														Azimuth: 307.45 Inclination: -1.85	-							
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		ICE SCALE DRILLING CONTRA o 4 feet DRILLER:D. Samm		:Boart Lo	ongye	ear				E		NEE	RING			ITY											LOGGED: NJP CHECKED:

PR	JJE	CT: Jefferson County, Louisville Tunne ECCORD OF DRILLHOLE: North Bound Boring SHEET 15 10N: Louisville, Kentucky DRILLING DATE: 5/22/2011 NORTHING:302826.46 DATUM: 10N: Louisville, Kentucky DRILL RIG: LM90 EASTING:1247541.18 DATUM: 10N: LING METHOD: HQ/NQ/AQ INCLINATION: -9.36° AZIMUTH: N 306°E				SHEET 15 OF	61																					
					DRILL R	IG: I	LM90						E٨	AST	NG:	124	754	1.18	3		16 ⁰⊏						DATUM:	
						-				FRA	сти	RE			IA H			SMOC					KEN	COR	E			
FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) =LUSH <u>COLOR</u>	EVA	SH- VN-	CLE/ SHE/ VEIN RECO	AR I OVE	RY	S-S	JLISI			ST-9 PL-F		PED AR DISC		B-BE		RAU		Y	DIAMETRAL POINT LOAD	INDEX (psi)	
	DRILL			SYN	(11)		PENET FLUSH	ш	CO	TAL RE%		SOLID ORE %		% 898	PE	ER F ₽₽8	Гс			TYPE AND SURFACE DESCRIPTION		k, (cm/se	ec 000	- I		-	
			CONTINUED FROM PREVIOUS PAGE							П	Ĩ				Ĩ													
				臣		62																						
					520.0 442.6			520																				
15		₽ LI	2.6 ft to 452.6 ft (Run No. 63) MESTONE - Same as previous run; breaks mechanical.			63																						
			te: Terminate AQ directional core at 2.6 feet and begin standard NQ core.																								4	
60	6/1/2011				518.4																							
;5			2.6 ft to 458.6 ft (Run No. 64)		452.6																						7028	
		we	WESTONE - Gray; very slight athering; sound; hard; crystalline; with <i>l</i> olitic features throughout.		517.4	64																						
50					458.6																							
65		LI	8.6 ft to 468.6 ft (Run No. 65) MESTONE - Same as previous run; breaks mechanical.			65																						
					515.8 468.6																							
70		LI	8.6 ft to 478.6 ft (Run No. 66) MESTONE - Same as previous run; breaks mechanical.			66														Azimuth: 308.58 Inclination: -0.36								
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		TION: Louisville, Kentucky ECT NUMBER: 1831-10-5629		DRILL R	IG: L	_M90	5/22/2011 9: HQ/NG					E	IOR AST	ΓINC	G:12	475	41.	18	AZIMUTH: N 3	D6 °	Ē					D	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) F111SH COLOR		CL- SH- VN- TO CO	FRAC CLEA SHEA VEIN RECO TAL RE %		θE	J-J P-F S-S	FAUL OINT POLIS SLICK R.Q.E %	SHED		R- ST D PL CT. EX FT	ROU -STE -PLA DIP COR	EPPE ANAF	UE-UNEVEN ED W-WAVY C-CURVED ISCONTINUITY DATA	MB B-E	B-MEO BEDE HY CON	DING	ULIC	λK ; TY	DIAMETRAL POINT LOAD	INDEX (psi)	
		CONTINUED FROM PREVIOUS PAGE						Ĩ	Ţ	Ĩ				Ï													
- - 475 - -		468.6 ft to 478.6 ft (Run No. 66) LIMESTONE - Same as previous run; all breaks mechanical.		514.2	66		515																				
- 480 - 485 		478.6 ft to 488.6 ft (Run No. 67) LIMESTONE - Same as previous run; all breaks mechanical.			67																						
- 490 495 		2 488.6 ft to 498.6 ft (Run No. 68) LIMESTONE - Same as previous run; all breaks mechanical.			68																						
- 500 		498.6 ft to 508.6 ft (Run No. 69) LIMESTONE - Same as previous run; all breaks mechanical.		498.6	69														Azimuth: 308.62 Inclination: -0.29								
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		NCE SCALE DRILLING CONTRA to 4 feet DRILLER:D. Samme		Boart Lo	ongye	ear				E	NG	NEE	RINO			RITY											LOGGED: NJP CHECKED:

PRO	ΟJE	CT: Jefferson County, Louisville Tunn	COF	RD O	F	DRII	LH	OL	E			ſ	10	rtł	۱E	30	ur	٦d	Boring							Sł	HEET 17 OF 61
		ON: Louisville, Kentucky		DRILLING			22/2011						NOI EAS													D	ATUM:
PRO	JEC	CT NUMBER: 1831-10-5629		DRILLIN			HQ/NC						INC	_IN/		N: -	9.36	6°	AZIMUTH: N 3								
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH % RETURN	ELEVATION	CL S⊢ VN CC	-FR/ -CLE -SHE -SHE REC OTAL DRE %		AGE ERY SOLI	E E E N	-FAU I-JOIN P-POL S-SLIC R.C	IT ISHE CKEN	FRA IND PEF	R- S ⁻ D PL CT. EX	-ROU T-STI L-PL/ DIP COR	EPPE ANAF DI ? w.r.t. E AXI	UE-UNEVEN ED W-WAVY R C-CURVED ISCONTINUITY DATA		BEDE HY CON	CH. I DING DRA DRA	N CO BREA	ικ ; rγ	DIAMETRAL POINT LOAD	INDEX (psi)	
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505		498.6 ft to 508.6 ft (Run No. 69) LIMESTONE - Same as previous run; all breaks mechanical.		509.3	69		510																				
· 510		508.6 ft to 518.6 ft (Run No. 70) LIMESTONE - Gray; very slight weathering; sound; crystalline; hard; occasional fossils; occasional oolitic matrix; all breaks mechanical.		508.6	70															-							8294
520	NO Core	518.6 ft to 528.6 ft (Run No. 71) LIMESTONE - Same as previous run; all breaks mechanical.		506.0 528.6	71																						
530		528.6 ft to 538.6 ft (Run No. 72) LIMESTONE - Same as previous run; all breaks mechanical.		528.6	72		505												Azimuth: 307.93 Inclination: -0.28	+							
		CONTINUED NEXT PAGE															$\ $										
		CE SCALE DRILLING CONTRA 9.4 feet DRILLER:D. Samme		Boart Lo	ongye	ear						GIN			NTEG	BRIT											LOGGED: NJP CHECKED:

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			J: Louisville, Kentucky		DRILLIN DRILL R DRILLIN	IG: L	.M90			Q			E	ASTI	HING NG:1 IATIC	247	541.	18	AZIMUTH: N 3	306°	Æ				DA	ΓUM:
FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	<u> </u>	PENETRATION RATE (ft/min) COLOR	% RETURN		FR-FF CL-CL SH-SF VN-VE RE TOTA CORE		AGE ERY SOLID CORE S	F-F. J-J(P-P S-S	AULT DINT DLISH LICKE	IED INSID FR IN PE	S ED P ACT. DEX R FT	M-SM -ROU T-STE L-PLA	OOTH GH EPPEE NAR DIS W.r.t. E AXIS	I FL-FLEXURED UE-UNEVEN	BC MB B-E	C-BRC BEDD HY CON	DING DRA DUC , cm/s	ULIC TIVITY		POINT LOAD INDEX (psi)	
┥			CONTINUED FROM PREVIOUS PAGE							8 8 4	5 50	8 8 9	8 5	2 4 6	22	115	08	396		1	10	<u></u>	402			
			528.6 ft to 538.6 ft (Run No. 72) LIMESTONE - Same as previous run; all breaks mechanical.			72																				
40	6/2/2011	NQ Core	538.6 ft to 548.6 ft (Run No. 73) LIMESTONE - Gray; very slight weathering; sound; crystalline; hard; with dark gray, thin shale partings along healed fractures at 539.0' to 544.8'. From 544.8' to 548.6' limestone is hard; sound; crystalline; all breaks mechanical.			73			-																	
550		NQ Core	548.6 ft to 558.6 ft (Run No. 74) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; with white calcite veins and pressure solution features throughout.		548.6	74			-																	
60			558.6 ft to 568.6 ft (Run No. 75) LIMESTONE - Same as previous run; all breaks mechanical.		558.6	75		50											Azimuth: 307.93 Inclination: -0.28						25	343
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PR	OJE	CT NUMBER: 1831-10-5629		drill r Drillin			D: HQ/N	Q/AC	Q					ig:12 Atioi				AZIMUTH: N 3	06°E	Ξ					
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) COLOR		CI SH VI	R-FRA CLE SHE SHE N-VEIN REC	AVAG AR N OVEF	θE	R.C	NT LISHI CKEI Q.D.	ED ISIDE FRA IND	R- ST D PL	ROUG	PPEI NAR DIS	UE-UNEVEN D W-WAVY	MB- B-B		H. BF	CORE REAK LIC IVITY		PUINI LUAD INDEX (psi)	
DIST	DRIL		SYI	(-4		PENET		C	S 4 S	CC	0011D DRE %		20 %	PER ₀₽	FT	CORE	E AXIS	TYPE AND SURFACE DESCRIPTION		¢، و و	cm/se			-	
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-		558.6 ft to 568.6 ft (Run No. 75) LIMESTONE - Same as previous run; all breaks mechanical.		499.5	75																				
- 570 		568.6 ft to 578.6 ft (Run No. 76) LIMESTONE - Same as previous run; all breaks mechanical.			76																				
- 580 		578.6 ft to 588.6 ft (Run No. 77) LIMESTONE - Same as previous run; all breaks mechanical.			77																				
- 590 		588.6 ft to 598.6 ft (Run No. 78) LIMESTONE - Same as previous run; all breaks mechanical; thin shale partings at healed fractures. Note: Terminate NQ core at 598.6 feet and begin directional AQ core.			78		495											Azimuth: 308.68 Inclination: -0.34							
		CONTINUED NEXT PAGE																							
		ICE SCALE DRILLING CONTRA o 4 feet DRILLER:D. Samme		:Boart Lo	ongye	ear				E	S	EERI	Z NG I		RIT										LOGGED: NJP CHECKED:

		TION: Louisville, Kentucky ECT NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	IG: I	_M90)		E	ORT ASTI	ING	:124	1754	41.1	8	AZIMUTH: N 30	Jea	Ē				[DATUM:
FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG		-	PENETRATION RATE (ft/min) =LUSH <u>COLOR</u>		FF CL SH VN	R-FR/ CLE 1-SHE 1-VEI	GE	F-F J-J(P-P S-S	AULT DINT OLISH LICKE	HED		SM R-F ST PL-	-SMC ROUG -STEI)oth Gh Ppei Nar	FL-FLEXURED	BC- MB- B-B	-BRO I-MEO BEDD	DKEI CH. E DING DRA DUC	BRE/	AK	POINT LOAD	(rod) yang
	DRILLI		SYM	(ft)	ш	PENET FLUSH	Ē	CC	OTAL DRE %	SOLID ORE 9 8 9 1	6	898 898	P	NDE: PERF , ₽ ₽	-Τ I			TYPE AND SURFACE DESCRIPTION		k	000 , cm/ 2	sec			÷
600	6/2/2011	CONTINUED FROM PREVIOUS PAGE		\$ 98.6																					
05		598.6 ft to 607.6 ft (Run No. 79) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; with white calcite veins and pressure solution features throughout.			79																				
510				<u>493.2</u> 607.6															+						_
515		607.6 ft to 617.6 (Run No. 80) LIMESTONE - Same as previous run; all breaks mechanical.			80														 						-
520				<u>491.6</u> 617.6																					8053
325	6/3/2011	617.6 ft to 627.6 ft (Run No. 81) LIMESTONE - Same as previous run; all breaks mechanical.			81		490																		
;30 -				627.6	82													Azimuth: 309.00 Inclination: -1.6							
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FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	(ft/mir	FLUSH <u>CULUR</u>	ELEVATION	CL-C SH-S VN-V	ECOV AL	AGE	J-J P-F S-S	AULT DINT OLISH LICKE 3.Q.D. %	FF IN PE	:	R-ROU ST-ST PL-PL	EPPE ANAR	UE-UNEVEN D W-WAVY C-CURVED SCONTINUITY DATA	MB B-E	BEDD BEDD HYI CONI	DRAL DUCT cm/s	JLIC FIVITY		POINT LOAD INDEX (psi)	
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635	6/3/2011	 LIMESTO weatheri white ca features 635.9' al Note: Te 	to 637.6 ft (Run No. 82) ONE - Gray; very slight ng; sound; hard; crystalline; with Icite veins and pressure solution throughout; fracture at 635.6' to ong thin shale parting. rminate AQ directional core at et and begin NQ core.			82			-																	
	<u>ه</u>	LIMEST	to 643.6 ft (Run No. 83) ONE - Same as previous run; is mechanical.			83			-																	
650		all break	to 653.6 ft (Run No. 84) ONE - Same as previous run; s mechanical.			84			-																	
655		LIMEST weather	to 663.6 ft (Run No. 85) ONE - Gray; very slight ng; sound; hard; crystalline; all nechanical.		<u>485.7</u> 653.6	85			485 -										Azimuth: 308.42 Inclination: -2.53							
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E_ROCK GLO NEW.GPJ GLDR_LDN	8/18/11	
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		ION: Louisville, Kentucky CT NUMBER: 1831-10-5629		drillin Drill R Drillin	IG:	LM90			Q				EA	STI	HING NG:1 ATIC	24	754	1.18	3	AZIMUTH: N 30)6°£	Ξ					C	DATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	₽₽	FLUSH % RETURN ELEVATION		R-FF CL-CL SH-SH /N-VE RE TOTAL CORE	EAV IEAR IN COV	AGE	/ LID E %	S-SL	INT DLISH	NSID FR IN PE		R-RO ST-S PL-F		H PPEI AR DIS	UE-UNEVEN		MEC EDD HYI CONE	DRAI DRAI DUC		AK C TY	DIAMETRAL	POINT LOAD INDEX (psi)	
-		CONTINUED FROM PREVIOUS PAGE 653.6 ft to 663.6 ft (Run No. 85) LIMESTONE - Gray; very slight			85																							
- 665 - 665 - 670 		663.6 ft to 673.6 ft (Run No. 86) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; all breaks mechanical.		482.5	86																							
- 675 	NO O	673.6 ft to 683.6 ft (Run No. 87) LIMESTONE - Same as previous run; all breaks mechanical.		490.0	87			_																				20262
- 685 - - - 690 -		683.6 ft to 693.6 ft (Run No. 88) LIMESTONE - Same as previous run; all breaks mechanical.		683.6	88		480) –												Azimuth: 308.42 Inclination: -2.53								
-		CONTINUED NEXT PAGE																										
		ICE SCALE DRILLING CONTRA o 4 feet DRILLER:D. Sammo		::Boart Lo	ongy	ear					EN		EER			GR		_	_		_	_	_	_		_	_	LOGGED: NJP CHECKED:

PR	OJE	CT: Jefferson County, Louisville Tunr	CO	RD O	F	DRII	LHO	OL	.E		Ν	10	rt	h	B	οι	ın	d	Boring						:	SHEET 23 OF 61
		ION: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	IG: I	_M90						EA	STI	HINC NG:' ATIC	124	754	1.1	8	AZIMUTH: N 30		o r -				I	DATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG			PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	FF CL SH VN	R-FRA -CLE I-SHE I-VEI REC DTAL DRE %	AGE	F J F S	-FAU -JOII P-POI S-SLI R.C	JLT NT LISH CKE Q.D. %	ED NSID FF IN PE		SM- R-R ST-{ PL-f	SMC OUG STEF	OTH H PPED VAR DIS AXIS	I FL-FLEXURED UE-UNEVEN	BC ME B-f	BED BED HN CON	CH. DINC	BRE G AUL CTIV			INDEX (ps)
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- 695 - - - 700 -	6/4/201	693.6 ft to 703.6 ft (Run No. 89) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; all breaks mechanical.			89																					
- 705 - 710 		703.6 ft to 713.6 ft (Run No. 90) LIMESTONE - Same as previous run; Joint at 707.0'			90														J, R							
- 715 - 715 - 720 - 720 - 720 - 720 - 720 - 720 - 715		703.6 ft to 723.6 ft (Run No. 91) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; occasional pressure solution features.		474.0	91		475												Azimuth: 308.42 Inclination: -2.53							
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DIS 1 ir		ICE SCALE DRILLING CONTRA o 4 feet DRILLER:D. Sammo		:Boart Lo	ongy	ear							_													LOGGED: NJP CHECKED:

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No.	FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	DISTANCE	RUN No.	RATIC (ft/mir	%	ELEVATION	CL- SH- VN-	CLEA SHEA VEIN RECO	AVAG AR J DVEF	RY SOLID DRE %	J-JC P-P S-SI	DINT DLISH LICKE .Q.D. %	FI FI II PI	F S DED F RACT. NDEX ER FT	R-ROI	UGH EPPE ANAF DI P w.r.t. RE AXI	UE-UNEVEN ED W-WAVY C-CURVED ISCONTINUITY DATA	MB B-E	BEDE BEDE HY CON	DING		κ ; ty	DIAMETRAL POINT LOAD	INDEX (psi)	
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728 1 728.6 728.6 728.6 1 728.6 1			723.6 ft to 733.6 ft (Run No. 92) LIMESTONE - Same as previous run; all breaks mechanical.			92																						
Image: state Image: state<	740	_	733.6 ft to 743.6 ft (Run No. 93) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; occasional pressure solution features; all breaks mechanical. Note: Terminate NQ core and begin AQ		471.1	93																						4399
CONTINUED NEXT PAGE	750	AQ	I IMESTONE - Samo as provious rup:			94			470																			
	755	AQ Core	Joint at 761.7'.		752.6	95														Azimuth: 308.07 Inclination: -2.59								
DISTANCE SCALE DRILLING CONTRACTOR:Boart Longyear LOGGED: NJP			UUNTINUED NEXT PAGE																									

LOC	ATIC	T: Jefferson County, Louisville Tunr BEC DN: Louisville, Kentucky T NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	g da Ig: l	ATE: 5/ _M90	22/2011			-		N E	ORT AST	HING NG:1 NATIC	3:30 247	282 754 ⁻	6.46 1.18	A Boring	306°	۴					DATI	ET 25 OF 61 JM:
FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL SH VN	-FRA -CLE I-SHE I-VEII REC DTAL DRE %		GE	J-J(P-P S-S F	AULT DINT OLISI LICKI 8.Q.D. %	FR FR IN PE	:	R-RC ST-S PL-P		UE-UNEVEN W-WAVY R C-CURVED DISCONTINUITY DATA L IS TYPE AND SURFAC DESCRIPTION	MB B-E	CONE k,	DRA DUC		K TY	DIAMETRAL POINT LOAD	INDEX (psi)	
		CONTINUED FROM PREVIOUS PAGE	1,1					Π		Π	\square	Π	\prod			П						П		\square		
760		752.6 ft to 762.6 ft (Run No. 95) LIMESTONE - Same as previous run; Joint at 761.7'.			95													J, R								
765	AQ Core	762.6 ft to 772.6 ft (Run No. 96) LIMESTONE - Light gray; very slight weathering; crystalline; hard; slightly fractured with fractures occuring along dark gray, moderately hard, thin shale partings. The shale partings occur at healed fractures.		762.6	96																					
775		772.6 ft to 781.9 ft (Run No. 97) LIMESTONE - Gray; moderately weathered; moderately hard; moderately to severly fractured; fractures contain gray clay; fractures occur along thin, dark gray, moderately hard, shale partings.		464.9	97		465																			
-		781.9 ft to 792.0 ft (Run No. 98) LIMESTONE - Gray; very slight weathering; hard; crystalline; sound.			98													Azimuth: 309.74 Inclination: -2.7								
		CONTINUED NEXT PAGE																								

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PR	JJE	ECT: Jefferson County, Louisville Tunr	:01	RD C)F I	DRI	LLH	J L	E:		I	No	rtł	۱E	30	ur	۱d	Boring							s	HEET 26 OF 61
		TION: Louisville, Kentucky ECT NUMBER: 1831-10-5629		DRILL R	IG: L	V90	5/22/2011 : HQ/NQ	/AQ				EAS	STIN	ing: G:12 Tioi	2475	541.	18	AZIMUTH: N 30)6 °	Æ					D	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	(ft/min) (ft/min) FLUSH <u>COLOR</u>		CL-C SH-S VN-V			/ _ID E %	F-FAU J-JOIN P-POL S-SLIC R.C %	IT ISHE CKEN		R S D PI CT. EX FT	ROU I-STE -PLA DIP COR	EPPE ANAR	UE-UNEVEN ED W-WAVY C-CURVED ISCONTINUITY DATA	мв в-в		CH. I DING	AULIO AULIO CTIVI	AK C ITY	DIAMETRAL	POINT LOAD INDEX (psi)	
	_	CONTINUED FROM PREVIOUS PAGE																	ļ					\square		
- - - 790 -		781.9 ft to 792.0 ft (Run No. 98) LIMESTONE - Gray; very slight weathering; hard; crystalline; sound.			98																					
-				792.0]																			
- - 795 - -		792.0 ft to 802.0 ft (Run No. 99) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; with dark gray, moderately hard, shale partings at healed fractures.			99																					
- 800 - -		0 0 0		461.6 802.0			_																			2451
- 805 - 805 - 810 -	6/6/2011	802.0 ft to 812.0 ft (Run No. 100) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; with dark gray, moderately hard; shale partings at healed fractures; all breaks mechanical.		460.0	100		460																			22451
 - - 815 - -		812.0 ft to 822.0 ft (Run No. 101) UMESTONE - Same as previous run; all breaks mechanical.		812.0	101													Azimuth: 311.1 Inclination: -3.2								
.			Ë		$\left \right $	_		$\left \right \right $		\parallel		$\left \right \right $	\parallel	\parallel	\parallel				+	+	+	+		\parallel	\parallel	
		CONTINUED NEXT PAGE																	T							
		NCE SCALE DRILLING CONTRAC to 4 feet DRILLER:D. Sammo		R:Boart Lo	ongye	ar			1	EN	GIN	EERII			RIT											LOGGED: NJP CHECKED:

PR	OJE	CT	: Jefferson County, Louisville Tunn	COF	RD O	F	DRI	LLH	OL	E			No	ort	h	Bo	bu	n	3 E	Boring					ę	SHEET 27 OF 61
			V: Louisville, Kentucky		DRILLIN DRILL R			/22/2011								G:30 1247									[DATUM:
PR		CI	NUMBER: 1831-10-5629	-	DRILLIN	g Me		: HQ/NC							IATI	ON:				AZIMUTH: N 30						
DISTANCE SCALE FEET	DRILLING RECORD)))	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>		CL- SH VN	-FRA(-CLE/ -SHE/ -VEIN REC()TAL RE %	AVAG	RE RY SOLID DRE %	S-SI	int DLISH ICKE .Q.D. %	FI FI II P	I		UGH TEPF _ANA		FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED DNTINUITY DATA TYPE AND SURFACE DESCRIPTION	MB-I B-BI	HEC EDD HYE CONE	DRAL DUCT			3
			CONTINUED FROM PREVIOUS PAGE						8.6	48	8.0	2 4 6 0		3 4 %	1 0	1	10	8.9	6			2	2 2	7.01		
- 820			812.0 ft to 822.0 ft (Run No. 101) LIMESTONE - Same as previous run; all breaks mechanical.		458.3	101																				
- 825 - 825 830 			822.0 ft to 832.0 ft (Run No. 102) LIMESTONE - Same as previous run; Joint at 827.7'.		822.0 456.7	102														J, R						-
- 835 - 840		AQ Core	832.0 ft to 842.0 ft (Run No. 103) LIMESTONE - Gray; very slight weathering; hard; crystalline; with dark gray, moderately hard, shale partings at healed fractures.; Joint at 840.4', 840.6', 840.8'.		832.0 455.1	103														-1-1 1912 1912						-
- 845			842.0 ft to 852.0 ft (Run No. 104) LIMESTONE - Same as previous run; all breaks mechanical.		433.1 842.0	104		455												Azimuth: 311.27 Inclination: -3.1						-
- 850		_							$\parallel \mid$	\parallel			\parallel		\parallel		\parallel	\parallel			╀					<u> </u>
			CONTINUED NEXT PAGE																		\bot					
			E SCALE DRILLING CONTRA feet DRILLER:D. Sammo		:Boart Lo	ongye	ear				E	S	NEEF	ING		EGRI										LOGGED: NJP CHECKED:

	ст	N: Louisville, Kentucky NUMBER: 1831-10-5629 DESCRIPTION		DRILLIN DRILL R DRILLIN	IG: L	.M90	22/2011 HQ/NQ						ORTH STI											DA	TUM:
FEET DRILLING RECORD							HQ/NQ								1241	341									
		DESCRIPTION	OG									IN	CLIN	ATIC				AZIMUTH: N	306°	Æ					
			SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) -LUSH <u>COLOR</u>	ELEVATION	CL SH VN	-FRA -CLE -SHE -SHE -VEIN REC	AVAC AR J OVEF	GE	S-SI	INT ILISH	NSID FR	F	R-ROL ST-ST PL-PL	EPPE ANAR	UE-UNEVEN D W-WAVY C-CURVED SCONTINUITY DATA	MB B-E	BEDD HYE CONE	H. BF	LIC		INDEX (psi)	
6/7/2011 AQ Core			ŵ			FLUSH			0RE %		0 RE %		3 4 8		2 2 2 3			DESCRIPTION	-		260°		<u> </u>		
6/7/2011 AQ Cor	e	CONTINUED FROM PREVIOUS PAGE 842.0 ft to 852.0 ft (Run No. 104)						╢		╢	$\left \right $	╂		╢		╢	$\left \right \right $		+	+	$\left \right $	_	$\left \right $		
<u>ہ</u>	AC CO	LIMESTONE - Same as previous run; all breaks mechanical.		450.5	104																				
55 00 00 00	Core	852.0 ft to 861.0 ft (Run No.105) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; with pressure solution features throughout; occasional white calcite veins.		452.0	105																				
59 6/7/2011		861.0 ft to 869.0 ft (Run No. 106) LIMESTONE - Same as previous run; all breaks mechanical. Note: Terminate NQ core and begin AQ directional core at 869.0 feet.			106																			*	2408
20 6(8/2011 A.O. Core A.O. Core	AQ Core	869.0 ft to 878.0 ft (Run No. 107) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline; with pressure solution features throughout; occasional white calcite veins.		449.2	107		450																		
AQ Core	AU Core	878.0 ft to 888.0 ft (Run No. 108) LIMESTONE - Same as previous run; all breaks mechanical.		878.0	108													Azimuth: 311.68 Inclination: -3.2							
		CONTINUED NEXT PAGE																							

		N: Louisville, Kentucky T NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	IG: L	_M90	1		AQ				EAS	STIN	G:12	475		18	AZIMUTH: N 30)6°E	:				C	
	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	TIC (ft/mir	FLUSH <u>COLOR</u>	ELEVATION	CL-C SH-S VN-V	ECO AL E %	/AGE R	F F S C LID E %	-FAU -JOIN -POL -SLIC R.Q. %	IT ISHE KEN .D.	D SIDEL FRAG INDE PER	R- ST) PL CT. EX FT	DIP CORI	IGH EPPE ANAF DI	UE-UNEVEN ED W-WAVY C-CURVED ISCONTINUITY DATA	MB-N B-BE		H. BF NG RAU UCT cm/se		DIAMETRAL	POINT LOAD INDEX (psi)	(
t		CONTINUED FROM PREVIOUS PAGE									Ĩ	4.0		4.0						Ē	Ī				Ш	
5		878.0 ft to 888.0 ft (Run No. 108) LIMESTONE - Same as previous run; all breaks mechanical.			108																					_
10		888.0 ft to 898.0 ft (Run No. 109)																	Calcite vug							
5	Core	LIMESTONE - Gray; very slight weathering; slightly fractured; close joint spacing with joints at 892.6', 893.1', 894.7', 894.8', 894.9', 895.0', 895.1', 895.4'; occasional pressure solution features and white calcite veins; hard; crystalline.			109														J, R J, R J, R J, R J, R J, R J, R J, R							
0	AQ	898.0 ft to 908.0 ft (Run No. 110) LIMESTONE - Gray; very slight weathering; sound; moderately close joint spacing with joint at 899.0'; hard; crystalline; with pressure solution features.		898.0	110			445																		
5																										
0		908.0 ft to 918.0 ft (Run No. 111) LIMESTONE - Same as previous run; with wide joint spacing and calcite crystals.			111														Azimuth: 312.45 Inclination: -3.3							-
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			N: Louisville, Kentucky NUMBER: 1831-10-5629		DRILL R	IG: L	_M90	5/22/2011 : HQ/NG						EA	STIN	IING IG:1 ATIC	247	754 ⁻	1.18	3	AZIMUTH: N 30	06°	E				[DA	ΓUM:
DISTANCE SCALE FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)		PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	% HEIUHN EVATION	FR CL SH VN	-FRA -CLE -SHE -VEII REC DTAL RE %		GE RY SOLI	ID 1%	F-FAU J-JOI P-PO S-SLI R.(JLT NT LISHI CKEI Q.D. %	ED NSIDE FR. INI PEI	ED ACT DEX R F1	SM-S R-RC ST-S PL-P		DTH PEC AR DIS	FL-FLEXURED	BC MB B-B	-BRO BEDI BEDI HY CON	DING	AULIO AULIO CTIVI	C ITY	POINT LOAD	INUEA (psi)	
_			CONTINUED FROM PREVIOUS PAGE				- <u>-</u>		80	348	3 8	88	20	8 9	20 40	122	12 8		, <u>8</u> 8 	6	DESCRIPTION	╈	10.6	10.5	202	190			
915			908.0 ft to 918.0 ft (Run No. 111) LIMESTONE - Same as previous run; with wide joint spacing and calcite crystals.			111																						9	538
920	6/9/2011	AQ Core	918.0 ft to 928.0 ft (Run No. 112) LIMESTONE - Same as previous run; all breaks mechanical.		918.0	112																							
930		AQ Core	928.0 ft to 938.0 ft (Run No. 113) LIMESTONE - Gray; very slight weathering; hard; sound; crystalline with calcite crystals; all breaks mechanical.		439.5	113		440														-							
940 945 -			938.0 ft to 948.0 ft (Run No. 114) LIMESTONE - Same as previous run; trace fossils; all breaks mechanical.			114															Azimuth: 313.8 Inclination: -1.7								
			CONTINUED NEXT PAGE																			\bot							
DIST 1 inc			E SCALE DRILLING CONTRAC feet DRILLER:D. Sammo		:Boart Lo	ongye	ear						GIN	EER	Z NG I	NTE	GRI												LOGGED: NJP CHECKED:

		N: Louisville, Kentucky																Boring							
PRO				DRILLIN DRILL RI			/22/2011							ING: IG:12											DATUM:
	JEC	FNUMBER: 1831-10-5629		DRILLIN			: HQ/NC)/AQ										AZIMUTH: N 3	06°	Ē					
FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENEIRAIION RAIE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL-I SH-I VN-I	CLEA SHEA VEIN		έE		NT LISHE CKEN	D ISIDE	R S D Pl	ROU I-STE	NAR	UE-UNEVEN D W-WAVY	MB- B-B	B-MEC)H. B ING			POINT LOAD	LX (psi)
	BILLIN		SYMB	(ft)	B	FLUSH	ELE	TO COF	TAL RE %	SC CO	olid Dre %	·	2.D. %	IND PEF	DEX R FT		w.r.t. E AXIS	TYPE AND SURFACE DESCRIPTION		k,	cm/s		- I	POI	
45 -		CONTINUED FROM PREVIOUS PAGE				- ш		89	9 8	89	9 4 8	88	20	102	20	08	600		+	<u><u></u></u>	<u>;</u>	500 500 780		Π	
ŧ		938.0 ft to 948.0 ft (Run No. 114) LIMESTONE - Same as previous run; trace fossils; all breaks mechanical.			114														_						
50	AQ Core	948.0 ft to 958.0 ft (Run No. 115) LIMESTONE - Same as previous run; with dark gray pressure solution features.		436.2	115																				
60 6/10/2011		958.0 ft to 968.0 ft (Run No. 116) LIMESTONE - Same as previous run; all breaks mechanical.			116		435																		
70	AQ Core	968.0 ft to 978.0 ft (Run No. 117) LIMESTONE - Same as previous run. Note: Core came out of inner barrel in boring when retrieving. Attempted to recover core, but rock was pulverized during attempt.		<u>434.6</u> 968.0	117													Azimuth: 313.8 Inclination: -1.7							9 ⁹¹⁶¹
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PR	OJE	ECT: Jefferson County, Lo		OF	RD O	FI	DRI	LLHO	SL	E:		Ν	or	th	Bo	ou	nc	Boring						SI	HEET 32 OF 61
		FION: Louisville, Kentucky			DRILLIN DRILL RI			/22/2011					IORT											D	ATUM:
PR	OJE	ECT NUMBER: 1831-10-56	529					: HQ/NQ				11			ON:	-9.3	36°	AZIMUTH: N	306°	۰E					
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIF	PTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	FLUSH <u>COLOR</u>	L ≥	CL-C SH-S VN-V	ECOV	AGE	J P-I S-I	FAULT POLIS SLICK			R-RO ST-S' PL-PI		UE-UNEVEN ED W-WAVY R C-CURVED ISCONTINUITY DATA	ME B-f	BEDD HYE CONE	CH. BF	LIC		POINT LOAD INDEX (psi)	
ā	Ц	CONTINUED FROM		0)			2		883		884		8848	2 5	5 th 5		888		+	10.6	8 6	500 790	+	П	
		CONTINUED FROM	PREVIOUS PAGE		433.0	117																			
- 980 - 985		978.0 ft to 988.0 ft (Ru LIMESTONE - Gray; w weathering; slightly fra spacing with joints at 1 978.9°, 979.2°; hard; ci pressure solution featu	ery slight actured; close joint 978.2', 978.4', ystalline; with		978.0	118												J. R J. R J. R J. R							
- 990 - 995	6/11/2011	978.0 ft to 998.0 ft (Ru LIMESTONE - Same a all breaks mechanical Note: Terminate AQ d 998.0 feet and begin N	as previous run;		988.0	119		430																	
- 1000		998.0 ft to 1009.0 ft (R UMESTONE - Same a fracture at 1000.7', 10 1004.5'.	is previous run; 01.3', 1002.0',		429.7 998.0	120												Azimuth: 313.97 Inclination: -0.28							
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			DRILLING CONTRAC DRILLER:D. Sammo		:Boart Lo	ongye	ar								EGRI										LOGGED: NJP CHECKED:

PR	OJEC	T: Jefferson County, Louisville Tunr	OF	RD C)F	DF	RIL	LHC	C	E	:		N	lo	rtł	n E	Зо	ou	n	d	Boring							S	HEET 33 OF 61
		N: Louisville, Kentucky		DRILLIN DRILL R				2/2011								ING G:1												D	DATUM:
PR		T NUMBER: 1831-10-5629	1	DRILLIN	IG M			HQ/NQ/			OT	0.5				TIO					AZIMUTH: N 30								
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	RATIC (ft/mir	FLUSH <u>COLOH</u> RETURN	ELEVATION	CL- SH- VN- TO CO	-CLE -SHE -VEII		GE.	J- P- S-		IT ISHE CKEN	FR/ INE PEF	F	R-RC		H PED AR DISC r.t. XIS	UE-UNEVEN	мв- в-в	MEC EDD HYI CONE	DRA DUC cm/s	ULIC	AK C TY	DIAMETRAL	POINT LOAD INDEX (psi)	
_	_	CONTINUED FROM PREVIOUS PAGE											Ĩ	Ĩ						Ĩ									
- 1010 -				1009.0	120																								
- - 1015 - -		1009.0 ft to 1021.0 ft (Run No. 121) LIMESTONE - Same as previous run; all breaks mechanical.			121																								
- 1020 - -				426.0 1021.0																									
- - 1025 -	NQ Core	1021.0 ft to 1031.0 ft (Run No. 122) LIMESTONE - Gray; very slight weathering; moderately hard; fine grained.			122			425																					-
- - 1030				424.3																									-
-				1031.0																									
- - 1035 - -		1031.0 ft to 1041.0 ft (Run No. 123) LIMESTONE - Light gray with dark gray, thin shale partings; very slight weathering; moderately hard; sound; fine grained.			123																Azimuth: 313.86 Inclination: 0.25								-
							+		╞┼┤		╫	╫	╢	⋕	\parallel			╂	╫			╞	+		\vdash	╞╡	╞	╞	
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		E SCALE DRILLING CONTRAC 4 feet DRILLER:D. Sammo		:Boart Lo	ongy	ear						ENG	_	~															LOGGED: NJP CHECKED:

PRC	ЛЕ	ECT: Jefferson County, Louisville Tunn	COF	rd o	F	DRI	LLHO	C	E:		ľ	10	rtł	ו B	So	ur	۱d	Boring						S	SHEET 34 OF 61
		TION: Louisville, Kentucky ECT NUMBER: 1831-10-5629		DRILLIN DRILL RI	IG: L	M90						EAS	STIN	ING:: G:12	475	41.	18							0	DATUM:
			1	DRILLIN	<u> </u>					TURE		INC		TION			3° ЮОТІ	AZIMUTH: N 3			KEN	CORI	F 1		1
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	Г Ш	CL-0 SH-3 VN-1 F	CLEA SHEA VEIN RECO		E J F Y NLID RE %	I-JOIN P-POL S-SLIC R.C	IT ISHE CKEN	FRAG INDE PER	R- ST D PL CT. EX FT	-STE -PLA DIP CORE	GH EPPE ANAR DIS w.r.t. E AXIS	UE-UNEVEN D W-WAVY C-CURVED SCONTINUITY DATA	MB- B-B	HYC	DRAL DRAL DUCT				
		CONTINUED FROM PREVIOUS PAGE				- ш		8.9	20	80	20	80	20	<u>, e</u> ;	20	<u> </u>	386		+	9 9	2 ¥	36.55		Π	
1040				422.7	123																				
1045	6/12/2011	2 1041.0 ft to 1051.0 ft (Run No. 124) LIMESTONE - Same as previous run; all breaks mechanical.			124																				
1055		1051.0 ft to 1061.0 ft (Run No. 125) LIMESTONE - Same as previous run; fracture at 1052.0' to 1059.0' with clay.			125		420																		
1060		1061.0 ft to 1071.0 ft (Run No. 126) LIMESTONE - Light gray; very slight			126		-																		-
1070		weathering; moderately hard; sound; fine grained; all breaks mechanical.			120													Azimuth: 313.86 Inclination: 0.25							-
		CONTINUED NEXT PAGE							ļ																
		NCE SCALE DRILLING CONTRA to 4 feet DRILLER:D. Samm		:Boart Lo	ongye	ar		ł		EN				NTEG	RITY										LOGGED: NJP CHECKED:

PR	OJEC	T: Jefferson County, Louisville Tunr	OF	rd C)F	DR	LLH	OL	E			N	loi	rth	ו E	Зо	u	nc	b	Boring							Sł	HEET 35 OF 61
		N: Louisville, Kentucky T NUMBER: 1831-10-5629		DRILL R	IG:	LM90	5/22/2011): HQ/NC		Q			I	NOF EAS NCL	TIN	G:1	247	541	.18		AZIMUTH: N 30	06°₽	E					D	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FI LISH COLOR	EVA]	CL SH VN	R-FRA CLE SHE VEI REC OTAL OTAL ORE %	AVA AR N OVE	GE	J- P- S-	FAUI JOIN POLI SLIC R.Q. %	IT ISHE KEN	FR/ INE PEF	R S ED P	I-RO		H PED AR DISC	UE-UNEVEN	MB-I	-MEC EDD HYI CON	DRAI		K TY	DIAMETRAL	INDEX (psi)	
_		CONTINUED FROM PREVIOUS PAGE	<u> </u>	1071.0					Ĩ			Ĭ	Ĩ		Ĩ		Ĭ	Ĩ	Ť		Ţ			Ш				
- - - - - - - - - - - -		1071.0 ft to 1081.0 ft (Run No. 127) LIMESTONE - Same as previous run; all breaks mechanical.			127																							
- - - - - - - - - - - - - - - - - -	NQ Core	1081.0 ft to 1091.0 ft (Run No. 128) LIMESTONE - Gray; very slight weathering; moderately hard; sound; fine grained.					415																					9322
- - - 1095 -		1091.0 ft to 1101.0 ft (Run No. 129) LIMESTONE - Same as previous run; all breaks mechanical.		<u>414.6</u> 1091.0																								
- - 1100 -		1101.0 ft to 1111.0 ft (Run No. 130) LIMESTONE - Same as previous run; all breaks mechanical. CONTINUED NEXT PAGE		<u>413.0</u> 1101.0	130		-													Azimuth: 314.32 Inclination: 0.04								-
		OOM HINDED INEX I FAGE								Ш											\bot							
		2E SCALE DRILLING CONTRAC 4 feet DRILLER:D. Sammo		:Boart Lo	ongy	ear					ENG		ERIN															LOGGED: NJP CHECKED:

LOC	атю	CT: Jefferson County, Louisville Tunr BEC CN: Louisville, Kentucky CT NUMBER: 1831-10-5629		RD O DRILLING DRILL RI	G DA	ATE: 5			-E	:		N	OR ⁻	THI	NG:3	3028	326	.46	Boring								HEET 36 OF 61 ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)		(ft/min) <u>COLOR</u>	% HEIUHN EVATION	FF CL SH VN	R-FRA CLE H-SHE H-VEII REC	AVA AR N OVE	GE RY SOLID	F-F J-J(P-P S-S	AUL" DINT	T SHED KENS	FRAC	SM R-I ST) PL CT.	A-SM ROU -STE -PLA	IOOTH GH EPPE ANAR	UE-UNEVEN D W-WAVY C-CURVED SCONTINUITY DATA	BC MB B-E	-BRC I-MEC BEDD HYI CONI	CH. B DING	ULIC	кI	DIAMETRAL POINT LOAD	INDEX (psi)	
DIS	DRIL		sγ			PENET FLUSH		CC	0RE %	C	ORE 9	6	84	- I	PER ₀₽¥			E AXIS	TYPE AND SURFACE DESCRIPTION					- I		_	
· 1105		CONTINUED FROM PREVIOUS PAGE 1101.0 ft to 1111.0 ft (Run No. 130) LIMESTONE - Same as previous run; all breaks mechanical.			130																						
- 1110 - 1115				<u>411.3</u> 1111.0			_																				
· 1120	NQ Core	1111.0 ft to 1121.0 ft (Run No. 131) LIMESTONE - Same as previous run; all breaks mechanical.		409.7	131		410																				
· 1125		1121.0 ft to 1131.0 ft (Run No. 132) LIMESTONE - Gray; very slight weathering; moderately hard; wide joint spacing with joint at 1129.9'; fine		1121.0	132																						
· 1130		grained;		<u>408.1</u> 1131.0			_												J, R								
		1131.0 ft to 1141.0 ft (Run No. 133) LIMESTONE - Same as previous run; all breaks mechanical.			133														Azimuth: 314.77 Inclination: 0.02								
		CONTINUED NEXT PAGE							<u> </u>																		
		CE SCALE DRILLING CONTRA 4 feet DRILLER:D. Sammo		:Boart Lo	ongye	ear					S	INEE				RITY											LOGGED: NJP CHECKED:

PR	OJE	ECT	: Jefferson County, Louisville Tunr	OF	rd o	F	DRII	LLHO	C	E	•		ľ	10	rt	h	В	0	ur	۱d	Boring							s	HEET 37 OF 61
			N: Louisville, Kentucky NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	IG: I	LM90		/AG	2				EA	STI	HIN(NG: ATI(124	175	41. [.]	18	AZIMUTH: N 3	06'	°E					D	ATUM:
DISTANCE SCALE FEET	DRILING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL S⊢ VN CC	-FRA -CLE I-SHE I-VEI REC DTAL DRE %		AGE	J F S ID	R.C	NT LISH	FF IN PE	DED RAC NDE ER F	R-F ST PL T. X	ROU -STE -PLA DIP CORE	EPPE NAR	UE-UNEVEN ED W-WAVY C-CURVED SCONTINUITY DATA	ME B-I		YDR NDU k, cn	I. BF IG RAU JCTI n/se	< Y	DIAMETRAL	POINT LUAD INDEX (psi)	
			CONTINUED FROM PREVIOUS PAGE																			1							
- 1135 - - - - 1140			1131.0 ft to 1141.0 ft (Run No. 133) LIMESTONE - Same as previous run; all breaks mechanical.		406.5	133																							
		NQ Core			1141.0																	+							
- 1145 - 1150	6/13/2011		1141.0 ft to 1151.0 ft (Run No. 134) LIMESTONE - Gray; very slight weathering; moderately hard to hard; sound; crystalline; with pressure solution features throughout; occasional white calcite veins.		404.8	134		405														_							24908
- 1155			1151.0 ft to 1161.0 ft (Run No. 135) LIMESTONE - Same as previous run;		1151.0	135																							
- 1160		NQ Core	all breaks mechanical.																										
- - 1165			1161.0 ft to 1171.0 ft (Run No. 136) LIMESTONE - Gray; very slight weathering; moderately hard to hard; sound; crystalline; with pressure solution features throughout; occasional white calcite veins; all breaks mechanical.		1161.0	136															Azimuth: 314.77 Inclination: 0.02	+							
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			E SCALE DRILLING CONTRAC I feet DRILLER:D. Sammo		:Boart Lo	ongy	ear						GINE					ITY											LOGGED: NJP CHECKED:

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		ON: Louisville, Kentucky		DRILLIN DRILL R			/22/2011						IOR												DATUM:
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UISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FI LISH COLOR		CL SH VN	-FRA -CLE -SHE -VEII REC DTAL RE %	AVA AR N OVE	IGE ERY SOLID	J-\ P- S-	FAUL IOINT POLI SLICI R.Q.I	r SHE KEN D.	FRA IND PEF	R S D PI CT. EX	-ROL T-ST L-PL DI	D P w.r.t RE AX	UE-UNEVEN ED W-WAVY R C-CURVED DISCONTINUITY DATA	B-ME BEDI HY CON	CH. E DING DRA DUC	ULIC	Y		INUEX (psi)
-		CONTINUED FROM PREVIOUS PAGE						8,	348		6 6	50 50	000	50	1	15	0	8 8 8	5	P	2 :	72.5		Π	
1170		1161.0 ft to 1171.0 ft (Run No. 136) LIMESTONE - Gray; very slight weathering; moderately hard to hard; sound; crystalline; with pressure solution features throughout; occasional white calcite veins; all breaks mechanical.			136																				
1175	Core	1171.0 ft to 1181.0 ft (Run No. 137) LIMESTONE - Same as previous run; fracture at 1173.4'.		200.0	137		400																		
185		1181.0 ft to 1191.0 ft (Run No. 138) LIMESTONE - Same as previous run; fracture at 1182.0' along stylolitic feature; fracture at 1187.2'.			138																				
195		1191.0 ft to 1201.0 ft (Run No. 139) LIMESTONE - Gray green; very slight weathering; sound; hard; crystalline; with pressure solution features throughout.		1	139														Azimuth: 314.77 Inclination: -0.10						
		CONTINUED NEXT PAGE															\square								
		CE SCALE DRILLING CONTRA 9 4 feet DRILLER:D. Samme		:Boart Lo	ongye	ear					ENG		RIN	G IN		GRIT									LOGGED: NJP CHECKED:

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	-		DRILLING DRILL RI			/22/2011					NOF EAS												[DATUM:
IECI	NUMBER: 1831-10-5629		DRILLING			: HQ/NC					INCI		TIO				AZIMUTH: N 3					- 1		
DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	(ft/mir	[®] EVA1	CL- SH- VN- TO COI	CLEA SHEA VEIN RECC		/ LID E %	J-JOIN P-POL S-SLIC R.Q	T ISHE KEN	FRA IND PER	R- ST D PL CT. EX FT	PLA	GH PPEI NAR DIS w.r.t.	UE-UNEVEN D W-WAVY C-CURVED	MB-I B-BE	HYC	H. BI	REAK		POINT LOAD INDEX (nsi)	(rdf) veren
_	CONTINUED FROM PREVIOUS PAGE						8,9	4 2	89	4 20	8.9	50	202		0 M				2,		36			
NQ Core	1191.0 ft to 1201.0 ft (Run No. 139) LIMESTONE - Gray green; very slight weathering; sound; hard; crystalline; with pressure solution features throughout.		396.7	139																				_
NQ Core	1201.0 ft to 1211.0 ft (Run No. 140) LIMESTONE - Same as previous run; all breaks mechanical. Note: Terminate NQ core at 1211.0 feet and begin AQ directional core.		1201.0	140																				2 1884
AQ Core	1211.0 ft to 1219.0 ft (Run No. 141) LIMESTONE - Light gray; very slight weathering; sound; hard; crystalline. Note: Breaks in core caused by directional core barrel.		393.8	141		395																		
AQ Core	1219.0 ft to 1229.0 ft (Run No. 142) SHALE - Gray; very slight weathering; sound; hard; calcareous with calcite crystals; pyritic; trace fossils. Note: Waldron Shale encountered at 1220.0 feet.		1219.0	142													Azimuth: 314.84 Inclination: -0.14							
	CONTINUED NEXT PAGE															\prod		Τ		Π		\prod		
	AQ Core NQ Core NQ Core NQ	CONTINUED FROM PREVIOUS PAGE Image: Colspan="2">1191.0 ft to 1201.0 ft (Run No. 139) LIMESTONE - Gray green; very slight weathering; sound; hard; crystalline; with pressure solution features throughout. Image: Colspan="2">1201.0 ft to 1211.0 ft (Run No. 140) LIMESTONE - Same as previous run; all breaks mechanical. Note: Terminate NQ core at 1211.0 feet and begin AQ directional core. Image: Colspan="2">1211.0 ft to 1219.0 ft (Run No. 140) LIMESTONE - Light gray; very slight weathering; sound; hard; crystalline. Note: Breaks in core caused by directional core barrel. Image: Colspan="2">1219.0 ft to 1229.0 ft (Run No. 141) LIMESTONE - Light gray; very slight weathering; sound; hard; crystalline. Note: Breaks in core caused by directional core barrel. Image: Colspan="2">1219.0 ft to 1229.0 ft (Run No. 142) SHALE - Gray; very slight weathering; sound; hard; crystalline. Note: Waldron Shale encountered at 1220.0 feet.	• CONTINUED FROM PREVIOUS PAGE ••• CONTINUED FROM PREVIOUS PAGE ••• CONTINUED Comparison of the total state of total				CONTINUED FROM PREVIOUS PAGE Information of the 1201.0 ft (Run No. 139) LIMESTONE - Gray green; very slight weathering; sound; hard; crystalline; with pressure solution features throughout. 139 1201.0 ft to 1211.0 ft (Run No. 140) LIMESTONE - Same as previous run; all breaks mechanical. 140 Note: Terminate NQ core at 1211.0 feet and begin AQ directional core. 140 1211.0 ft to 1219.0 ft (Run No. 140) LIMESTONE - Same as previous run; all breaks mechanical. 140 1211.0 ft to 1219.0 ft (Run No. 141) LIMESTONE - Light gray, very slight weathering; sound; hard; crystalline. 141 1211.0 ft to 1219.0 ft (Run No. 141) directional core barrel. 141 1211.0 ft to 1219.0 ft (Run No. 141) directional core barrel. 141 1211.0 ft to 1219.0 ft (Run No. 141) directional core barrel. 141 1211.0 ft to 1219.0 ft (Run No. 142) SystALE - Gray, very slight weathering; sound; hard; calcareous with calcite crystals; pyritic; trace fossils. Note: Waldron Shale encountered at 1220.0 feet. 142	BOOD DESCRIPTION OT OP OP OP OP OP OP OP OP OP OP OP OP OP	BOOD TOTAL DESCRIPTION OP OP OP OP OP OP OP OP OP OP OP OP OP O	Boot DESCRIPTION O DESCRIPTION DESCRIPTI	Boold of the second s	Book DESCRIPTION O Description O Description O Description O Description O Description O Description Descripion <thdescription< th=""> <thdescr< td=""><td>Base of the second se</td><td>000000000000000000000000000000000000</td><td>Book Book <th< td=""><td>Bit Description Bit Descri</td><td>000000000000000000000000000000000000</td><td>Open control Open contro Open control Open control<!--</td--><td>Open Processor Open Pr</td><td>Bit Discrete Discre Discrete <thdiscrete< th=""></thdiscrete<></td><td>000000000000000000000000000000000000</td><td>000 000 000 000 000 000 000 000 000 00</td><td>Notice Notice Notice<</td><td>Status Status Status<</td></td></th<></td></thdescr<></thdescription<>	Base of the second se	000000000000000000000000000000000000	Book Book <th< td=""><td>Bit Description Bit Descri</td><td>000000000000000000000000000000000000</td><td>Open control Open contro Open control Open control<!--</td--><td>Open Processor Open Pr</td><td>Bit Discrete Discre Discrete <thdiscrete< th=""></thdiscrete<></td><td>000000000000000000000000000000000000</td><td>000 000 000 000 000 000 000 000 000 00</td><td>Notice Notice Notice<</td><td>Status Status Status<</td></td></th<>	Bit Description Bit Descri	000000000000000000000000000000000000	Open control Open contro Open control Open control </td <td>Open Processor Open Pr</td> <td>Bit Discrete Discre Discrete <thdiscrete< th=""></thdiscrete<></td> <td>000000000000000000000000000000000000</td> <td>000 000 000 000 000 000 000 000 000 00</td> <td>Notice Notice Notice<</td> <td>Status Status Status<</td>	Open Processor Open Pr	Bit Discrete Discre Discrete <thdiscrete< th=""></thdiscrete<>	000000000000000000000000000000000000	000 000 000 000 000 000 000 000 000 00	Notice Notice<	Status Status<

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PF		T NUMBER: 1831-10-5629		DRILLIN		ETHC	DD: H	HQ/NQ/					IN	CLIN		ION:	: -9	.36	0	AZIMUTH: N 3							
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	RATIC (ft/mir	FLUSH <u>COLOR</u>	ELEVATION	CL- SH- VN-	CLEA SHEA VEIN RECC	I DVER	ε	S-SL		F		R-R ST- PL-	IOUC STE	PPEI NAR DIS	UE-UNEVEN D W-WAVY C-CURVED SCONTINUITY DATA	мв- в-в	-MEC EDD HYI	CH. B				INDEX (psi)
ä	DR		0			R	E			98		348	88	868	<u>م</u> 1	<u>55</u>		<u> </u>		DESCRIPTION		10.6	10°	790 2000		П	
-		CONTINUED FROM PREVIOUS PAGE		392.1 1229.0	142		╡								╢	╈						+	$\left \right $		+		
- 1230 - -		1000 0 6 4 - 1000 0 6 (E.e. N 140)		1229.0																							
- - 1235 -		1229.0 ft to 1239.0 ft (Run No. 143) SHALE - Gray; very slight weathering; sound; hard; calcareous; with calcite vugs; pyritic.			143																						
-				<u>390.5</u> 1239.0																							
- 1240 - -								390																			-
- - 1245 - -	AQ Core	1239.0 ft to 1249.0 ft (Run No. 144) SHALE - Light gray; very slight weathering; sound; hard; calcareous; trace fossils. From 1245.7' shale is dark gray; fine grained; sound; hard; pyritic.			144																						
- - 1250 - -		1249.0 ft to 1259.0 ft (Run No. 145) SHALE - Light gray to dark gray; very slight weathering; sound; hard; fine		<u>388.9</u> 1249.0																							
1255 - - -	6/21/2011	grained; calcareous; trace fossils; occasional calcite vugs.		<u>387.3</u> 1259.0																Azimuth: 314.11 Inclination: -0.55							
- 1260			<u></u>		146		+		$\left \right \right $	\parallel			\parallel		\parallel	\parallel	\parallel	\parallel	\parallel		_	-			+	\parallel	
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DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u> FLUSH <u>RETURN</u>	ELEVATION	CL S⊢ VN	-FRA -CLE I-SHE I-VEII REC DTAL DRE %	AVA AR N OVE	AGE	J- P S	FAU JOIN POL SLIC R.Q	IT ISHE CKEN	FR/ INE PEI	F	R-RC ST-S PL-P		H PED AR DISC	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED CONTINUITY DATA TYPE AND SURFACE DESCRIPTION	MB- B-B		DING	AK C TY	DIAMETRAL	POINT LOAD INDEX (psi)	
- 1260		CONTINUED FROM PREVIOUS PAGE																			Ŧ						
- - - 1265 - -		1259.0 ft to 1269.0 ft (Run No. 146) SHALE - Light gray; very slight weathering; slightly fractured with fractures at 1265.0' and 1267.0' occuring along thin calcite veins; hard; fine grained; calcareous; occasional calcite vugs.		385.6	146																+						-
- 1270 - - - - 1275 - -	AQ Core	1269.0 ft to 1279.0 ft (Run No. 147) SHALE - Light to dark gray; very slight weathering; sound; hard; fine grained; pyritic; trace fossils.		1269.0	147		385																				22972
- 1280		1279.0 ft to 1289.0 ft (Run No. 148) SHALE - Same as previous run; all breaks mechanical.		382.4	148																						
- 1290					149															Azimuth: 311.43 Inclination: -1.87	 						
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		CE SCALE DRILLING CONTRA 4 feet DRILLER:D. Samme		:Boart Lo	ongye	ear						_	_		NTE												LOGGED: NJP CHECKED:

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			N: Louisville, Kentucky		DRILLIN DRILL R	IG: I	_M90						EA	STI	HIN(NG:	124	754	41.1	18								D)ATUM:
				1	DRILLIN	i 1		HQ/NQ/		FRAC	TUR	F	INC F-FA		IATI				ооті	AZIMUTH: N		S°E BC-BR	SOKE	NC	ORE	_		T
FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL-I SH-I VN-I	CLEA SHEA VEIN RECC		E	J-JO P-PC S-SL R.	INT DLISH	FI FI I PI		R-F ST- PL- T. K		gh Ppe Nar	UE-UNEVEN ED W-WAVY C-CURVED SCONTINUITY DATA	N E CE	AB-ME B-BED H	YDR NDU k, crr	BRE G	C ITY	1	POINT LOAD INDEX (psi)	
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			1289.0 ft to 1299.0 ft (Run No. 149) SHALE - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous. Note: Terminate AQ directional core at 1299.0 feet and begin NQ core.																									
295		AQ Core	1289.0 ft to 1299.0 ft (Run No. 149) SHALE - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous. Note: Terminate AQ directional core at 1299.0 feet and begin NQ core.		380.8	149																						-
3300			1299.0 ft to 1307.0 ft (Run No. 150) SHALE - Dark gray; very slight weathering; sound; moderately hard; fine grained with thin crystalline lenses; calcareous.		379.5	150		380																				
					1307.0																							
310		NQ Core	1307.0 ft to 1317.0 ft (Run No. 151) SHALE - Gray; very slight weathering; sound; fine grained with thin crystalline lenses; moderately hard; calcareous.			151																						
320		-	1317.0 ft to 1327.0 ft (Run No. 152) SHALE - Same as previous run; all breaks mechanical.		377.8 1317.0	152																						
																				Azimuth: 311.77 Inclination: -2.29								-
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DISTANCE SCALE FEET	CORD			DRILLIN			: HQ/NC)/AQ				EA	STIN	IG:12 ATIO	2475	541.1	8	AZIMUTH: N 3	06°	E			0,	
	DRILLING RE	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	FENE INATION MALE (ft/min) FLUSH <u>COLOR</u>	Г _Ш	CL- SH VN TC CO	CLE/ SHE/		έE	R.C	NT LISHI <u>CKEI</u> Q.D. %	FRA IND PEF	R- ST D PL CT.	PLA	PPE NAR DIS	UE-UNEVEN D W-WAVY	MB B-B	HYE	DRAU DUCT		POINT LOAD INDEX (psi)	
	_	CONTINUED FROM PREVIOUS PAGE						89	48	80	14 2	8.9	4 %	- <u></u> 22	120	0 Ŭ	990			<u> </u>) 	3.22		
1325		1317.0 ft to 1327.0 ft (Run No. 152) SHALE - Same as previous run; all breaks mechanical.		376.2	152																			
1330		1327.0 ft to 1337.0 ft (Run No. 153) SHALE - Gray; very slight weathering; sound; fine grained with thin crystalline lenses; moderately hard; calcareous.		1327.0	153		075																	226
1335				374.6 1337.0			375																	
1340	NQ Core																							
· 1345		1337.0 ft to 1347.0 ft (Run No. 154) SHALE - Same as previous run; all breaks mechanical.		372.9	154																			
1350		1347.0 ft to 1357.0 ft (Run No. 155) SHALE - Same as previous run; all breaks mechanical.		1347.0	155													Azimuth: 311.77 Inclination: -2.29						
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FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>		() () ()	CL-CL SH-SH /N-VE	ECOV	/AGE ? /ERY SOI			NT LISH	NSID FF IN PE	:	R-RC ST-S PL-P	DUGH STEP PLAN	PED AR DISC	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED CONTINUITY DATA TYPE AND SURFACE DESCRIPTION	ME B-I	BEDE HY CON	DING		Y	DIAME LHAL POINT LOAD INDEX (psi)	(red) ve e :
			CONTINUED FROM PREVIOUS PAGE						6	0.004	F RI	8.9	4 2	8.6	4 2	2	228			56			-		7.076			
1355			1347.0 ft to 1357.0 ft (Run No. 155) SHALE - Same as previous run; all breaks mechanical.		371.3	155																						
1360	6/23/2011	NQ Core	1357.0 ft to 1367.0 ft (Run No. 156) SHALE - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous.		369.7 1367.0	156		370																				
1370		NQ Core	1367.0 ft to 1377.0 ft (Run No. 157) SHALE - Same as previous run; all breaks mechanical.		368.1	157																						
380			1377.0 ft to 1387.0 ft (Run No. 158) SHALE - Same as previous run; all breaks mechanical.		1377.0	158															Azimuth: 311.92 Inclination: -2.14							
1385																												
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			E SCALE DRILLING CONTRAC I feet DRILLER:D. Sammo		:Boart Lo	ongye	ear					FN		EER			GRI											LOGGED: NJP CHECKED:

LO	CAT	CT: Jefferson County, Louisville Tunn REC ION: Louisville, Kentucky CT NUMBER: 1831-10-5629		RD C DRILLIN DRILL R DRILLIN	G D/	ATE: 5/ LM90	22/2011			:		N E	ORT AST	THIN TNG	B(1G:30 :124 10N:)282 754	26.4	-6 3	AZIMUTH: N 30	6℃	E						HEET 45 OF 61 DATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL S⊦ VN	R-FRA CLE SHE VEI REC OTAL OTAL ORE %	EAVA EAR N COVE	AGE	J-J(P-P S-S	AULT DINT OLIS LICK R.Q.D %	HED ENSI		R-R ST- PL-F		H PED AR DIS .r.t. AXIS	UE-UNEVEN		HYE HYE K,	H. B	JLIC TIVIT Sec	к ; тү	DIAMETRAL	POINT LOAD INDEX (psi)	
-		CONTINUED FROM PREVIOUS PAGE			158			H					\prod				\square								H		
- - - - - - - - - - - - - - - - - - -		1387.0 ft to 1397.0 ft (Run No. 159) SHALE - Same as previous run; all breaks mechanical.		364.8	159		365																				7008
- - 1400 - - - - 1405 -		1397.0 ft to 1407.0 ft (Run No. 160) SHALE - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous.		363.2	160																						-
- 1410 - 1410 - 1415 - 1415 - DIS 1 iri		1407.0 ft to 1417.0 ft (Fun No. 161) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained; with dark gray, soft, thin shale partings; calcareous; occasional pyrite.		361.6 1417.0	161														Azimuth: 311.92 Inclination: -2.14								
		CONTINUED NEXT PAGE																									<u> </u>
DIS 1 ir		NCE SCALE DRILLING CONTRAC o 4 feet DRILLER:D. Sammo		8:Boart Lo	ongy	ear					\sim	INEE	\sim	_													LOGGED: NJP CHECKED:

		T: Jefferson County, Louisville Tunr REC DN: Louisville, Kentucky		RD C					LE					h l				Boring								HEET 46 OF 61 ATUM:
		T NUMBER: 1831-10-5629		DRILL R	IG: L	.M90			Q			EA	STI	NG:1	247	541	.18	AZIMUTH: N 3	06°E	E					5	
FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FI LISH <u>COLOR</u>	EVA1		R-FR CL-CLE SH-SH (N-VEI REC TOTAL CORE ?		GE	S-SL R.	INT DLISH	FR IN PE	:	R-ROU ST-ST PL-PL	EPPE ANAF	UE-UNEVEN ED W-WAVY C-CURVED ISCONTINUITY DATA	мв- в-в		DRAL DRAL DUCT		K Y	DIAMETRAL POINT LOAD	INDEX (psi)	
╈	_	CONTINUED FROM PREVIOUS PAGE											9410									(1) (F				
420	ov 24/ 2011 NQ Core	1417.0 ft to 1427.0 ft (Run No. 162) SHALE - Gray; very slight weathering; moderately fractured with fracture occuring horizontally for length of run. Clay present along fracture; Shale is moderately hard to soft; platy; fine grained.		359.9	162		360																			
130		1427.0 ft to 1437.0 ft (Run No. 163) SHALE - Gray; very slight weathering; slightly fractured with fractures occuring horizontally; clay at fractures (1429.0' to 1430.0' and 1430.7' to 1432.1'); moderately hard to soft at fractures; fine grained.		358.3	163																					
140	NQ Core	 1437.0 ft to 1447.0 ft (Run No. 164) SHALE - Gray; very slight weathering; moderately fractured with fractures at 1437.2 to 1438.3', 1444.1' to 1445.1', and 1445.0' to 1447.0' with gray, soft clay at fractures. Fractures occur horizonally. Shale is moderately hard; fine grained. Note: Approximately 40 percent water loss at 1440.0 feet. 1447.0 ft to 1457.0 ft (Run No. 165) SHALE - Same as previous run; fractured at 1447.0' to 1450.0'. 		1437.0	164													Azimuth: 312.07 Inclination: -1.9								
Г		CONTINUED NEXT PAGE						Г		ΙT	11	IT	ΙT	IT	ΙT	IT	IT				1		T	Π	١T	

	IECT NUMBER: 1831-10-5629	DRILI DRILI	l Ric	G: LN	190	22/2011 HQ/NQ	/AQ			NOF EAS INCI	STIN	IG:12	2475	541. ⁻	18	AZIMUTH: N 3	306°	Ē				DATUM:
DRILLING RECORD	DESCRIPTION	SVWBOLIC LOG DISTA (ft)	:V. INCE	RUN No. PENETRATION RATE	(ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL- SH VN TC CO	FRAC CLEA SHEA VEIN RECC TAL RE %	E . F Y	F-FAU I-JOIN P-POL B-SLIC R.Q %	IT ISHE KEN .D.	FRA IND PEF	R- ST D PL CT.	ROU I-STE PLA DIP CORE	PPE NAR	UE-UNEVEN D W-WAVY	MB B-E	B-MEC BEDD HYE CONE k,	DRAL DUCT cm/s	IVITY	METRAL NT LOAD	INDEX (psi)
	CONTINUED FROM PREVIOUS PAGE						Щ		Ţ		Ì		Ţ	Щ	Ţ		1		Ц			
450	1447.0 ft to 1457.0 ft (Run No. 165) SHALE - Same as previous run; fractured at 1447.0' to 1450.0'.	35		165																		266
460 465 Q	1457.0 ft to 1467.0 ft (Run No. 166) SHALE - Same as previous run; fractures at 1457.0' to 1458.0' and 1460.4' to 1463.5'. Fractures occur horizonally.		57.0	166		355																
170	1467.0 ft to 1477.0 ft (Run No. 167) SHALE - Gray; very slight weathering; moderately fractured with fractures occuring horizontally; moderately hard; fine grained; pyritic. 1477.0 ft to 1485.5 ft (Run No. 168) SHALE - Gray; slightly weathered; moderately to severly fractured with fractures occuring horizonally for length		1 51.8 77.0	167												Azimuth: 312.18						
480	of run; occasional clay at fractures; moderately hard; fine grained; pyritic.															Inclination: -1.33						
	CONTINUED NEAT FAGE									Ш	Ш		E	Ш -								

PR	JJE	CT: Jefferson County, Lo		ORD	OF	DR	LLH	OLE		Nort	h B	loi	un	d	Boring				SI	HEET 48 OF 61
		ION: Louisville, Kentucky				DATE: 4	5/22/2011			NORTI EASTI									D	ATUM:
PR	ΣJE	CT NUMBER: 1831-10-562	29): HQ/NQ			INCLIN					AZIMUTH: N 30	6°E				
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIP	ΓΙΟΝ	DISTAN (ft)		PENETRATION RATE (ft/min) COLOR	EVA1	CL-CLE SH-SH VN-VE		%	FRAG INDE PER	R-F ST D PL CT. EX FT	PLAN	AR VAR DISC	UE-UNEVEN		CH. B DING /DRAI	REAK	POINT LOAD INDEX (psi)	
	_	CONTINUED FROM P						© © 4 (0 0 0 4	0 0 0 4 0	1.1.5	- 21		96		Ī		404		
1485		1477.0 ft to 1485.5 ft (F SHALE - Gray; slightly moderately to severly fi fractures occuring hori: of run; occasional clay moderately hard; fine g	un No. 168)		168	В														
1490	6/25/2011	1485.5 ft to 1492.5 ft (F SHALE - Same as prev	un No. 169)		169	9	350													
1495		1492.5 ft to 1502.0 ft (F SHALE - Same as prev moderately hard to soft horizontally for length o	un No. 170)		17(D	_													
1505		5 1502.0 ft to 1512.0 ft (F SHALE - Dark gray; sli severly fractured; soft; clay at fractures; shale 1509.5' to 1512.0'.	un No. 171) htty weathered; is sound from		17 [,]	1									Azimuth: 312.18 Inclination: -1.33					1079
		CONTINUED N	EXT PAGE																	
			RILLING CONTRACT RILLER:D. Sammons		Long	year			ENG		INTEG	RITY								LOGGED: NJP CHECKED:

LO	CATIO	CT: Jefferson County, Louisville Tunn REC ON: Louisville, Kentucky CT NUMBER: 1831-10-5629		RD O DRILLIN DRILL R DRILLIN	g da Ig: L	.TE: 5/2 .M90	22/2011			:		NC EA	ORTH STIN	h E IING: IG:12	302 2475	826 541.	6.46 18	AZIMUTH: N 3	06 º	E						HEET 49 OF 61 ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL- SH VN TC CO	-FRAG -CLE# -SHE/ -VEIN RECO TAL RE%		GE	S-SL	INT DLISHI	FRA IND PEF	R- S ⁻ D PL CT. EX	-ROL T-STI L-PL/ DIF COF	EPPE ANAR	UE-UNEVEN ED W-WAVY C-CURVED SCONTINUITY DATA	MB B-B	-BRC -MEC BEDD HYI CONI	DRAU DRAU DUCT	JLIC TIVIT Sec	ικ ; rγ	DIAMETRAL	PUINI LUAU INDEX (psi)	
-		CONTINUED FROM PREVIOUS PAGE	 	1512.0					4 0		<u>4</u>		4 0	0+						Ī		* 0. *	-		Π	
- - 1515 - - - - 1520 -		1512.0 ft to 1522.0 ft (Run No. 172) SHALE - Dark gray; slightly weathered; severly fractured; soft and can be broken by hand; fine grained; with clay at fractures.		344 5	172		345																			
- - 1525 - - - - 1530 -	NO Corre	1522.0 ft to 1532.0 ft (Run No. 173) SHALE - Gray; very slight weathering; slightly fractured; moderately hard; fine grained; pyritic.			173																					
- 1535 - 1535 	6/26/2011 ND Core	y sound; moderately hard; fine grained; pyritic; all breaks mechanical.			174													Azimuth: 311.81 Inclination: -0.88								
		CONTINUED NEXT PAGE																								
DIS 1 ir		CE SCALE DRILLING CONTRAC		:Boart Lo	ongye	ar			V	E		\sim		NTEG												LOGGED: NJP CHECKED:

PROJECT NU LEEL COURD	Louisville, Kentucky UMBER: 1831-10-5629 DESCRIPTION	 	DRILLING DRILL RI DRILLING	ig: l g me	.M90 ETHOD			2			EA	STIN	IING: IG:12									[DATUM:
DRILLING RECORD				<u> </u>		: HQ/NC)/AQ	2								10							
	DESCRIPTION	IC LOG							OTUE				ATIO				AZIMUTH: N 30			2000	- 1		
		SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	[®] EVA1	CL S⊢ VN	I-FRA -CLE I-SHE I-VEIN REC DTAL DRE % 8 9 8		θE	S-SL	NT LISHI	FRA IND PEF	R S D PI	-ROU T-STE L-PLA DIP CORE		UE-UNEVEN D W-WAVY	HECH DDIN HYDF ONDU k, ci	H. BR NG				
1545	- CONTINUED FROM PREVIOUS PAGE																			01			
15 SH SO	542.0 ft to 1552.0 ft (Run No. 175) HALE - Gray; very slight weathering; und; moderately hard; fine grained; rritic; all breaks mechanical.		339.6	175		340																	
S⊦	552.0 ft to 1562.0 ft (Run No. 176) HALE - Same as previous run; all eaks mechanical.		338.0	176																			
S⊦	562.0 ft to 1572.0 ft (Run No. 177) HALE - Same as previous run; all eaks mechanical.		1562.0 336.4 1572.0	177		-							-										
SH SO	572.0 ft to 1582.0 ft (Run No. 178) HALE - Gray; very slight weathering; pund; fine grained; moderately hard; rritic.			178													Azimuth: 311.81 Inclination: -0.88						\$725
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PR	JJE	СТ	: Jefferson County, Louisville Tunr	COI	RD C	F	DRI	LLHO	C	E:			Nc	ort	h I	Bo	οu	In	d	Boring							S	SHEET 51 OF 61
			N: Louisville, Kentucky NUMBER: 1831-10-5629		DRILLIN DRILL R			/22/2011							HING NG:1												۵	DATUM:
			NUMBER. 1031-10-3029	-	DRILLIN							-			ATIC					AZIMUTH: N 3					205	_		1
UISTANCE SCALE FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL-I SH-I VN-I F TO	CLEA SHEA VEIN RECC TAL 82 %	VER SC CO	E Y DLID RE %		INT DLISH ICKE Q.D. %	NSID FR IN PE	ED IACT IDEX IR F	R-R(ST-S PL-F	DIP w	iH PPE JAR DIS Art. AXIS	UE-UNEVEN ED W-WAVY C-CURVED SCONTINUITY DATA	MB B-E		DING	BRE/	AK C ITY		POINT LOAD INDEX (psi)	2
		╈	CONTINUED FROM PREVIOUS PAGE				<u> </u>		88	20	80	948	88	29 60	۰ <u>۵</u>	2 12 1		8	88		╈	10-6	6	2.2	10	\mathbf{H}	Π	
1575			1572.0 ft to 1582.0 ft (Run No. 178) SHALE - Gray; very slight weathering; sound; fine grained; moderately hard; pyritic.			178		335																				
		ore			<u>334.7</u> 1582.0																							
1585	6/27/2011		1582.0 ft to 1592.0 ft (Run No. 179) SHALE - Same as previous run; all breaks mechanical.			179																						
	6/2																											-
595			1592.0 ft to 1602.0 ft (Run No. 180) SHALE - Same as previous run; all breaks mechanical.			180																						
600		NU Core			331.5			_																				
605			1602.0 ft to 1612.0 ft (Run No. 181) SHALE - Gray; very slight weathering; sound; fine grained; moderately hard; pyritic; all breaks mechanical.			181														Azimum: 311.97 Inclination: -0.80								-
		╉	CONTINUED NEXT PAGE	<u> </u>					$\left \right \right $	+	\mathbb{H}	+	+	+	╢	\parallel	\mathbb{H}	\parallel	\parallel		+	+	+	+	+	╟	+	

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LO	CAT	TION	: Jefferson County, Louisville Tunn REC N: Louisville, Kentucky NUMBER: 1831-10-5629		RD C DRILLIN DRILL R DRILLIN	g d <i>i</i> Ig: I	ATE: 5/ _M90	22/2011		E:			NOR EAS	TH TIN	В NG:3 G:124 ЛЮN	028 1754	26.4 41.1	46 8	Boring	6℃	E				HEET 52 OF 61 ATUM:
DISTANCE SCALE FEET	DBILLING BECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CL-C SH-S VN-V	ELEAN HEAN ECO	VAGE R VERY SOL COR	F F S C LID E %	-FAUL -JOIN P-POLI S-SLICI R.Q.I %	T SHE KEN D.	D SIDED FRAC INDE PER F	R-F ST- PL- T. X		AH PPEI VAR DIS V.r.t. AXIS	UE-UNEVEN	MB-N B-BE	HECI DDI HYD OND k, c	H. BF NG RAU UCTI		POINT LOAD INDEX (psi)	
			CONTINUED FROM PREVIOUS PAGE							4 01		4 0	0.04	. 0				9.6		Ľ	Π	- 04	42		
- 1610			1602.0 ft to 1612.0 ft (Run No. 181) SHALE - Gray; very slight weathering; sound; fine grained; moderately hard; pyritic; all breaks mechanical.		329.8	181		330																	
- 1615 1620	6/28/2011	NQ Core	1612.0 ft to 1622.0 ft (Run No. 182) SHALE - Same as previous run; all breaks mechanical.		1612.0	182																			
- 1625 - 1630		NQ Core	1622.0 ft to 1632.0 ft (Run No. 183) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained; pyritic.		326.6	183																			499
- 1635			1632.0 ft to 1642.0 ft (Run No. 184) SHALE - Same as previous run; all breaks mechanical.		1632.0	184													Azimuth: 312.34 Inclination: -0.72						
			CONTINUED NEXT PAGE	1																					<u> </u>
			E SCALE DRILLING CONTRAC feet DRILLER:D. Sammo		:Boart Lo	ongy	ear			1	<u> </u>		\sim		ITEGF										LOGGED: NJP CHECKED:

PR	OJE	ЕСТ	: Jefferson County, Louisville Tunn	CO	RD C)F	DR	ILLH	10	LE			Ν	or	th	В	0	ur	nd	Boring							s	HEET 53 OF 61
			N: Louisville, Kentucky NUMBER: 1831-10-5629		DRILLIN DRILL R DRILLIN	IG:	LM90			Q			E	NOR EAS ⁻ NCLI	TING	à:12	475	41.1	8	AZIMUTH: N 3	06°	E					D	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) COLOR	ELEVATION	() () ()	FR-FR CL-CL SH-SH /N-VE RE TOTAL CORE 9	EAVA IEAR IN COVE	GE	J- P- S-	FAUL JOINT POLIS SLICH R.Q.I %	SHED KENS		R- ST) PL CT. EX FT	DIP CORE	GH PPE NAR DIS	UE-UNEVEN D W-WAVY C-CURVED SCONTINUITY DATA	MB- B-B	-BRC -MEC BEDE HY CON k,	DRAI DRAI DUC	ULIC TIVI sec	ак ; тү	DIAMETRAL	POINT LOAD INDEX (psi)	
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- 1640 -			1632.0 ft to 1642.0 ft (Run No. 184) SHALE - Same as previous run; all breaks mechanical.		325.0	184		325																				_
- - 1645 - -		NQ Core	1642.0 ft to 1650.0 ft (Run No. 185) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained; pyritic; all breaks mechanical.		1642.0	185																						
- 1650 - - - - - 1655 - -	6/29/2011		1650.0 ft to 1660.0 ft (Run No. 186) SHALE - Same as previous run; all breaks mechanical.			186																						
- 1660 - - - - - 1665 - -		NQ Core	1660.0 ft to 1670.0 ft (Run No. 187) SHALE - Same as previous run; all breaks mechanical.		322.0	187														Azimuth: 312.02 Inclination: -0.83	+							
		+	CONTINUED NEXT PAGE		1	╞		-	+	+	$\left \right $	+	+	$\left \right \right $	+	$\ $	+	+	+		+	+				\parallel	\parallel	
			E SCALE DRILLING CONTRA		I R:Boart Lo	ongy	ear											_ 		1								Logged: NJP Checked:

PR	OJE	CT: Jefferson County, Louisville Tunr	CO	rd C	F	DRI	ILLH	0	LE			N	ort	h E	Во	ur	nd	Boring					SI	HEET 54 OF 61
		ON: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILLIN DRILL R			5/22/201	1					ORTH ASTIN										D	ATUM:
				DRILLIN	G MI					OTU				ATIC				AZIMUTH: N 3				- 1		
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (ft/min) LUSH <u>COLOR</u>	ELEVATION	c s	R-FRA L-CLE H-SHE N-VEII	AVA EAR N	GE	J-JO P-P	AULT DINT DLISH LICKE	NSIDE	F S ED P	M-SM -ROU T-STE L-PLA	IGH EPPE ANAR	UE-UNEVEN D W-WAVY C-CURVED	MB-N B-BB	MECH	H. BRI NG		POINT LOAD INDEX (psi)	
DISTAN	DRILLIN		SYMBO	DISTANCE (ft)	RU	PENETR/ (ft FLUSH	ELEV	C	REC	, c	SOLID ORE %		.Q.D. % ©⊋≅	PE	ACT. DEX R FT		W.r.t. E AXIS				m/se	DIAN		
		CONTINUED FROM PREVIOUS PAGE		320.4	187	_															_			
- 1670 - - - - 1675 - - -		1670.0 ft to 1680.0 ft (Run No. 188) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained; all breaks mechanical.		1670.0	188		320																	
- 1680 - - - - 1685 - - - - - -	ND Pere	1680.0 ft to 1690.0 ft (Run No. 189) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained; all breaks mechanical.		318.8 1680.0	189																			0330
- 1695 		1690.0 ft to 1702.0 ft (Run No. 190) SHALE - Same as previous run; all breaks mechanical.		1690.0	190													Azimuth: 312.02 Inclination: -0.83						
		CONTINUED NEXT PAGE																						
		CE SCALE DRILLING CONTRA 0 4 feet DRILLER:D. Sammo		:Boart Lo	ongye	ear						· · ·			GRIT					<u> </u>		 		LOGGED: NJP CHECKED:

PROJECT: Jefferson County, Louisville Tunr RECORD OF DRILLHOLE: North Bound Boring SHEET 55 OF 61														HEET 55 OF 61														
		ION: Louisville, Kentucky CT NUMBER: 1831-10-5629		drillin Drill r Drillin	IG: I	LM90			2				EAS	STIN	HING NG:1 ATIC	1247 DN:	754 -9.	1.18 36°	8 ,	AZIMUTH: N 30	06ª	Æ					C	ATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FLUSH <u>COLOR</u>	ELEVATION	CI SI VI	R-FRJ L-CLE H-SHI N-VEI REC OTAL ORE 9		AGE	J F S ID E %	-FAL -JOII -POI -POI -SLII R.C %	NT LISH CKEI Q.D. 6	NSID FF IN PE		R-RO ST-S PL-F	DUG STEF PLAN	DIS	UE-UNEVEN	MB B-B		CH. E DING	BRE ULIO	AK C ITY	1	POINT LOAD INDEX (psi)	
	Ē	CONTINUED FROM PREVIOUS PAGE						\prod									\square				Ŧ							
	6/30/201	1702.0 ft to 1712.0 ft (Run No. 191) SHALE - Same as previous run; all breaks mechanical.		<u>315.2</u> 1702.0	190		315								-													
- - - - - - - - - - - - - 1720 -		eg StALE - Gray; very slight weathering; sound to slightly fractured with clay seam at 1713.6 to 1714.8'; moderately hard; fine grained.			192																							
- - - - - - - - - - - - - - - - - - -		1722.0 ft to 1732.0 ft (Run No. 193) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained.		312.0 1722.0 310.3 1732.0	193															Azimuth: 312.15 Inclination: -0.84								
		CONTINUED NEXT PAGE		1/32.0	194			\parallel	+	╟	$\ $		+	+	\parallel		+				+	+	+	+		\parallel	+	
		NCE SCALE DRILLING CONTRA to 4 feet DRILLER:D. Samme		:Boart Lo	ongy	ear	I																			<u>ı </u>		Logged: NJP Checked:

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		ON: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILL R	IG: LI	/ 90	5/22/2011 9: HQ/NQ	/AQ				E	ASTI	NG:	G:30 124 ON:	754	1.18	В	AZIMUTH: N 30)6°€	E				DA	TUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	(ft/min) FLUSH <u>COLOR</u>		FR-F CL-C SH-S VN-V R TOT. CORE	CLEA SHEA /EIN ECO	VAG R VER	Έ	J-JC P-P(S-SI	OLISH	FI FI II PI			DUG STEP PLAN	H PPED IAR DIS Ur.t. AXIS	UE-UNEVEN	MB-I B-BE	-MEC EDD HYE CONE	DRAI	к 'Y	DIAMETRAL POINT LOAD	INDEX (psi)	
		CONTINUED FROM PREVIOUS PAGE						Ш				Ţ								Ţ					Π	
- - 1735 - - - - 1740 -		1732.0 ft to 1742.0 ft (Run No. 194) SHALE - Same as previous run; all breaks mechanical.		308.7	194		310																			
- - - 1745 - - - - - - - - - - -	NO Core	1742.0 ft to 1752.0 ft (Run No. 195) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained.		1742.0	195		-																			
		1752.0 ft to 1762.0 ft (Run No. 196) SHALE - Same as previous run; all breaks mechanical.		305.5	196		_												Azimuth: 312.15 Inclination: -0.84							
	1	CONTINUED NEXT PAGE										\parallel		\parallel	\parallel					T		T	1	\parallel	\parallel	
DIS		CE SCALE DRILLING CONTRA 0 4 feet DRILLER:D. Sammo		:Boart Lo	ongyea	ar				E	NGI	\sim	RING		EGRI								 			LOGGED: NJP CHECKED:

PR	PROJECT: Jefferson County, Louisville Tunt RECORD OF DRILLHOLE: North Bound Boring SHEET 57 OF 61																								
LOCATION: Louisville, Kentucky DRILLING DATE: 5/22/2011 NORTHING:302826.46 DATUM: DRILL RIG: LM90 EASTING:1247541.18														ATUM:											
PR	OJE	CT NUMBER: 1831-10-5629					: HQ/NC	Q/AQ				INC						AZIMUTH: N 3	306 °	E					
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG (1) ALA (1) ALA (1) ALA (1) ALA BELURA FLUSH (1) ALA (1) ALA (CL-I SH-I VN-I	FRACTURE CLEAVAGE SHEAR VEIN RECOVERY TAL SOLID E % CORE %		 	F-FAULT J-JOINT P-POLISHED S-SLICKENSIE R.Q.D. B R.Q.D. FF IN PE			R-F D ST SIDED PL FRACT.			UE-UNEVEN D W-WAVY C-CURVED CONTINUITY DATA					ETRAL LOAD ((psi)		
ā	Ц		0,			8 5		89	9 8	88		89	² 6	2 Q	20		888	DESCRIPTION		10.6	36.0	790 790	+	Т	
- 1765 - - - - 1770		CONTINUED FROM PREVIOUS PAGE 1762.0 ft to 1772.0 ft (Run No. 197) SHALE - Same as previous run; all breaks mechanical. Note: No water return at start of drilling on 7/1/2011. Water return was at approximately 45 to 50 percent on previous day.			197		305																		
-	7/1/2011							\square															Π		-
- - - - - - - - - - - - - - - -	12	1772.0 ft to 1782.0 ft (Run No. 198) SHALE - Gray; very slight weathering; slightly fractured with fractures at 1772.2'; 1773.4'; 1775.1', and 1778.2' all containing gray clay. Fractures are horizontal to core but do not penetrate completly through core. Shale is sound from 1778.2' to end of run; moderately hard; fine grained.		303.8 1772.0 302.2 1782.0	198																				
- - 1785 - - - - 1790 -		1782.0 ft to 1792.0 ft (Run No. 199) SHALE - Gray; very slight weathering; moderately hard; fine grained; sound from 1782.0 ft to 1789.0 ft then is moderately fractured from 1789.0 ft to 1792.0 ft with fractures occuring horizontally with clay.		<u>300.6</u> 1792.0	199		_																		
- - 1795		1792.0 ft to 1800.0 ft (Run No. 200) SHALE - Gray; slightly weathered; moderately hard to soft; severly fractured with clay at fractures; fine grained.			200													Azimuth: 312.04 Inclination: -1.1							-
												Ш			<u> </u>										I
		NCE SCALE DRILLING CONTRA to 4 feet DRILLER:D. Samme		:Boart Lo	ongy	ear		F	ø	EN	S				RIT										LOGGED: NJP CHECKED:

SME_ROCK GLO NEW GPJ GLDR_LDN GDT 8/18/11 DATA INPUT:

		: Jefferson County, Louisville Tunn erEC J: Louisville, Kentucky		RD C					LE	:	Nort NORT					Boring							HEET 58 OF 61 ATUM:
		NUMBER: 1831-10-5629		DRILL R	IG: I	LM90			~		EASTI	NG:12	2475	541.	18							D	ATOM.
-				DRILLIN T	-					CTURE	INCLIN F-FAULT				3° 00⊺⊦	AZIMUTH: N 3			(EN)	CORE	-		
FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FI LISH COLOR		s v	H-SHE N-VEI		J-JOINT P-POLISH S-SLICKE R.Q.D. %		ST D PL	PLA		C-CURVED SCONTINUITY DATA TYPE AND SURFACE	B-BE	HYDI OND k, c	NG RAU UCTI cm/se	VITY c	DIAMETRAL	POINT LOAD INDEX (psi)	
╉	ä	CONTINUED FROM PREVIOUS PAGE			┝	<u>م</u>		8	848	8848	8848	9 ⁰ 2	15	- 8	88	DESCRIPTION	90		860 860	200 200	+	Π	
300		1792.0 ft to 1800.0 ft (Run No. 200) SHALE - Gray; slightly weathered; moderately hard to soft; severly fractured with clay at fractures; fine grained.		299.3	200																		
.05		1800.0 ft to 1812.0 ft (Run No. 201) SHALE - Same as previous run; severly fractured for length of run.		1800.0	201																		424
15	NQ Core						_																
20		1812.0 ft to 1822.0 ft (Run No. 202) SHALE - Gray; very slight weathering; moderately to severly fractured with fractures occuring horizontally; fine grained; moderately hard; platy.		295.7	202																		
125		1822.0 ft to 1832.0 ft (Run No. 203) SHALE - Gray; very slight weathering; fine grained; sound from 1822.0' to 1835.6' then is moderately fractured with fractures occuring horizontally to core, some clay along fractures. Shale is moderately hard with soft areas at fractures.		1822.0	203		295	, _								Azimuth: 311.75 Inclination: -1.59							
F	-	CONTINUED NEXT PAGE	1	1					\parallel			111	$^{++}$		+		\uparrow	H		+	†	$^{++}$	

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PRC	JE	CT: Jefferson County, Louisville Tunr	O	rd C)F	DR	LLF	10	LE		No	rth	۱B	o	un	d	Boring							SHEET 59 OF 61
		ON: Louisville, Kentucky		DRILLIN DRILL R			5/22/201	1					ING:3 G:12											DATUM:
PRC		CT NUMBER: 1831-10-5629		DRILLIN		THOE	_										AZIMUTH: N 3							_
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min) FI I ISH COLOR		C S V	CL-CLE SH-SHI (N-VEI	θE	F-FAU J-JOIN P-POL S-SLIC R.C %	T ISHE KEN .D.		R-F ST D PL	ROUC	NAR DIS	UE-UNEVEN W-WAVY C-CURVED CONTINUITY DATA	MB B-E	HMEC BEDD HYI CONI	CH. B DING	ULIC	кΙ	DIAMETRAL POINT LOAD	INDEX (psi)
<u>5</u>	DR	CONTINUED FROM PREVIOUS PAGE	0						384	8 4 8	8.8	50	5 2 2		<u> </u>		DESCRIPTION	+	10-6	10	200	2	Π	
1830	//2/2011 MO Core	1822.0 ft to 1832.0 ft (Run No. 203) SHALE - Gray; very slight weathering; fine grained; sound from 1822.0' to		294.1	203																			
1835		1832.0 ft to 1842.0 ft (Run No. 204) SHALE - Gray; very slight weathering; sound from 1832.0' to 1835.7' then is moderately fractured with fractures occuring horizontal to core; some clay at fractures; fine grained; moderately hard.		292.4	204																			
1845	NO Core	1842.0 ft to 1852.0 ft (Run No. 205) SHALE - Gray; very slight weathering; sound at 1842.0' to 1842.8' and 1843.6' to 1851.0', all other core is moderately fractured with fractures occuring horizontal to core; moderately hard throughout; fine grained.		1842.0	205																			
1855		1852.0 ft to 1862.0 ft (Run No. 206) SHALE - Gray; very slight weathering; slightly fractured at 1852.0' to 1855.3' then is sound to 1862.0'. Fine grained; moderately hard.		290.8 1852.0	206		290										Azimuth: 311.75 Inclination: -1.59							
		CONTINUED NEXT PAGE	1																					

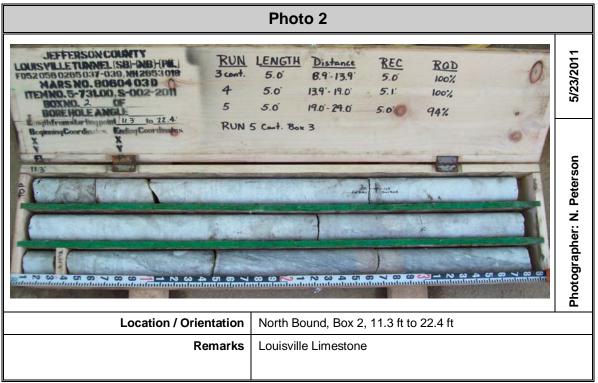
LOC	АТЮ	CT: Jefferson County, Louisville Tunn REC DN: Louisville, Kentucky CT NUMBER: 1831-10-5629		DRILLIN DRILL R	g da Ig: L	ATE: _M90	5/22/	2011		E:		I	NO EAS	rth Stin	ING:: G:12	3028 475	326. 41.1	.46 18	Boring							SHEET 60 OF 61 DATUM:
DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG		i		NE		FR-I CL-0 SH-3 VN-1	FRAC CLEA SHEA VEIN	VAGE .R	E .	F-FAL J-JOII P-POI	ILT NT LISHE	SIDE	SM R-I ST D PL	1-SMC ROUC	ooth Gh Eppei Nar	UE-UNEVEN D W-WAVY C-CURVED	BC ME B-E	-BRC 3-MEC 3EDD	CH. B DING	REAK			
DISTAN	DRILLING		SYMBO	DISTANCE (ft)	RU	PENETRA	FLUSH	ELEV	TOT COP	4 0 4 0 7	SO COF	LID	R.C 9 86	6	FRA INDI PER	FT		w.r.t.	SCONTINUITY DATA		k,	, cm/s				
ŀ		CONTINUED FROM PREVIOUS PAGE			$\left \cdot \right $	+	+			H		+		+	++		+	╢		+	+	+	$\left \right $	+	\square	
- - 1860 -		1852.0 ft to 1862.0 ft (Run No. 206) SHALE - Gray; very slight weathering; slightly fractured at 1852.0' to 1855.3' then is sound to 1862.0'. Fine grained; moderately hard.		<u>289.2</u> 1862.0	206		_																			
- - - - - - - - - - - - - - -		1862.0 ft to 1872.0 ft (Run No. 207) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained.		287.6	207																					4 ⁹¹¹
- - - 1875 - - - - - - - - 1880 -	NQ Core	1872.0 ft to 1882.0 ft (Run No. 208) SHALE - Gray; very slight weathering; slightly fractured at 1872.6' to 1874.0' and becomes sound to 1882.0'; moderately hard; fine grained.		285.9	208																					
- - - 1885 - - -		1882.0 ft to 1892.0 ft (Run No. 209) SHALE - Same as previous run; all breaks mechanical.		1882.0	209			285											Azimuth: 311.75 Inclination: -1.59							
- 1890		CONTINUED NEXT PAGE			$\left \right $		+		\mathbb{H}	+	\mathbb{H}	+	\parallel	+	+		+	+		+	-	-	\mathbb{H}	+		
		CE SCALE DRILLING CONTRA 4 feet DRILLER:D. Samme		:Boart Lo	ongye	ear										RITY										LOGGED: NJP CHECKED:

		ECT: Jefferson County, Louisville Tunr RE							C	E	:				h E				Boring							HEET 61 OF 61 ATUM:
		ECT NUMBER: 1831-10-5629		DRILL R DRILLIN	IG: I	LM90)		/AQ				EA	STI	NG:12	2475	541.	18	AZIMUTH: N	306	°E				_	
PIO ANUCE SUALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	₽¥	FLUSH <u>COLOR</u>	ELEVATION	CL-I SH-I VN-I F TO	CLE SHE VEIN REC TAL RE %		NE NOLID DRE %	- R.(NT LISH I <u>CKE</u> Q.D. %	FRA INC PEF	R S D PI ACT. DEX R FT	-ROU T-STE L-PLA DIP CORE	NAR DIS w.r.t. E AXIS	UE-UNEVEN D W-WAVY	ME B-I	B-ME(BEDE HY CON	DING DRAU DUCT			POINT LOAD INDEX (psi)	
1890		CONTINUED FROM PREVIOUS PAGE				-	ш.		88	9 6	80	2 4 0	8 9	9 8	- ²	20	08	600		╉	10	10	190			
	7/3/2011	8 SHALE - Same as previous run; all breaks mechanical.		284.3	209																					
895		8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9		283.0	210														Asimula 211 75							
900		Terminate North Bound Boring at 1900.0 Feet.)	1900.0															Azimuth: 311.75 Inclination: -1.59							
905																										
910																										
115																										
915 920 DIS 1 in																										
DIS		NCE SCALE DRILLING CONTR to 4 feet DRILLER:D. Samr		l R:Boart Lo	ongy	ear	[S	8						1					1		LOGGED: NJP CHECKED:

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 1 of 66



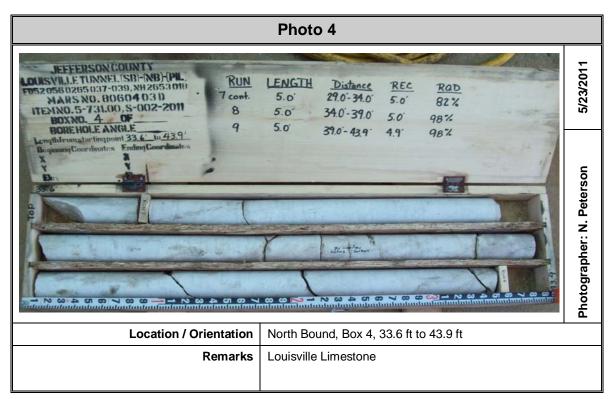




Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 2 of 66



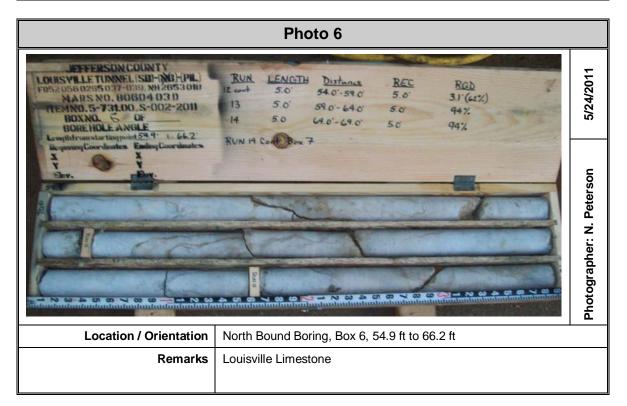
Photo 3 JEFFERSON COUNTY LOUISVILLE TUNNEL (SB)-IN)-[PIL) F052 056 0265 037-039, NH 2053 018 MARS NO. 80604 03 0 ITEMNO.5-731.00, S-002 2011 BOXNO. 3 05 BOREHOLE ANGLE 5/23/2011 RUN LENGTH Distance REC ROD 5 cont. 5.0 19.0-24.0 5.0 94% 6 5.0 24.0-29.0 5.0 96% 7 5.0 29.0 - 34.0 5.0 startingpo Ending Coo 82% 33.6-RUN 7 cont. Borg nates Photographer: N. Peterson North Bound, Box 3, 22.4 ft to 33.6 ft Location / Orientation Remarks Louisville Limestone



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 3 of 66

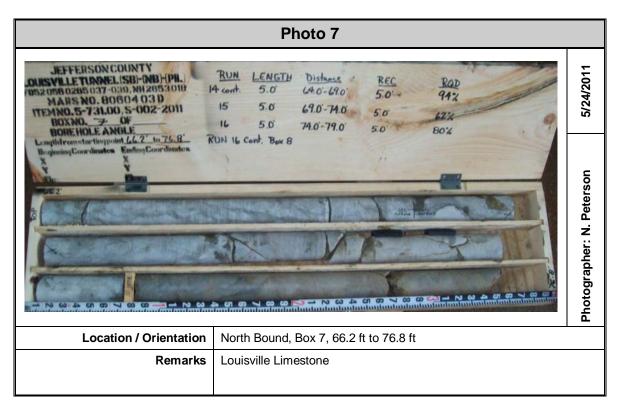


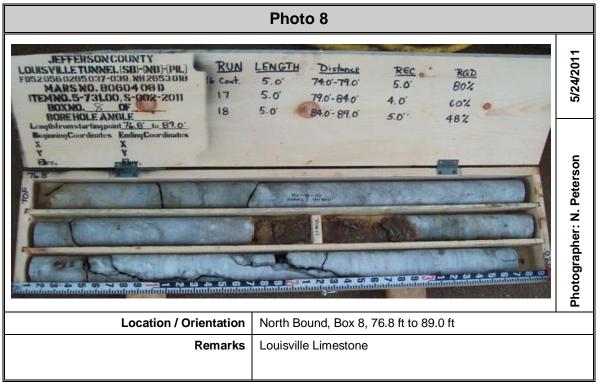
Photo 5 AFFERSON COUNTY MILLETUNNEL SBI-MBHPIL S6 0205 037-159, M265300 ARS NO. 80604 03 D 5/23/2011 RUN LENGTH REC ROD 10 5.0 50 97% 002-2011 11 731.00,5 5.0 49.0-54.0 4.9: 78% 5.0 12 54.0- 59.0' 5.0' 62% to 54.9' RUN 12 Con Box 6 Photographer: N. Peterson - N W A CT 00 Location / Orientation North Bound, Box 5, 43.9 ft to 54.9 ft Remarks Louisville Limestone



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 4 of 66







Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 5 of 66



	Photo 9
FUIS2 056 0265 037-039, NH 2653 018 19 MARS NO. 80604 03 D 10 ITEMNO. 5-731.00, S-002-2011 20 BOXNO. 9 DF HOME HOLE ANGLE 21 Longithfrom starting point B9.0' to 94.0' Beginning Courdinates RUN 21 Co. X X Home Hole Angle 20	.0' 982'-1034' 5.2' 100%
Location / Orientation	North Bound, Box 9, 89.0 ft to 94.0 ft
Remarks	Louisville Limestone

	Photo 10	
JEFFERSON COUNTY LOUIS VILLE TUNNEL (SD)-(MB)-(PIL) FD 2 056 0265 037-039, NH 2653018 MARS NO. 00604 03 D ITEM NO. 5-73100, S-002-2011 BOXEN IO. 0F BONEHOLE ANGLE	RUN LENGTH Distance REC Rap 21 cont. 5.0' 98.7-103.4' 5.2' 100% 22 5.0' 103.4'-108.6' 5.2' 100% 23 5.0' 108.6'-113.6' 4.3' 50%	5/24/2011
Ever Here Parks and the point of the second	RUN 23 Cont. Box 11	N. Peterson
	4 5 6 V 8 5 0 - N 8 4 5 8 V 8 5 0 - N 6 4 5 8 V 8 5 0 - N 8 5 5 0 - N 8 5 5 0 - N 8 5 5 0 - N 8 5 5 0 - N 8 5 0 - N	Photographer: N. Peterson
Location / Orientation	North Bound, Box 10, 94.0 ft to 110.9 ft	
Remarks	Louisville Limestone	

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 6 of 66



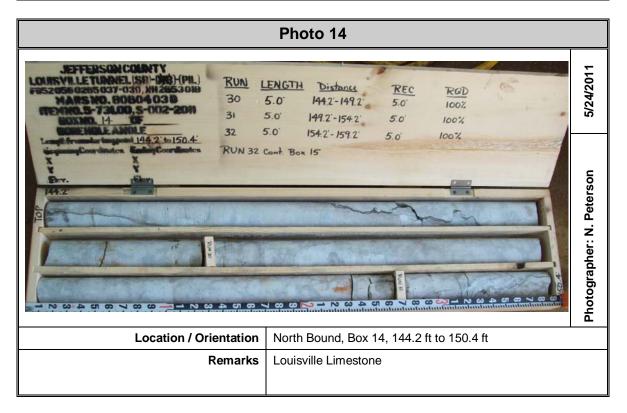
	Photo 11
JEFFERSONCOUNTY LOUIS VILLE TUNNEL (SB)-IN BHPIL P052 056 0265 037-039, ML2653018 MARS NO. 800604 030 TEMINO. 5-731.00, S-002-2011 BOXMO. 40 GF BOXED AND A GF BOXED AND A COMMISSION BOXING. 40 GF BOXED AND A COMMISSION BOXED AND A COMMISSION AND A COMMISSION BOXED AND A COMMISSION BOXED AND A COMMISSION AND A COMMISSION BOXED AND A COMMISSION AND A COMMISSION BOXED AND A COMMISSION AND A COMMISSION AND A COMMISSION BOXED AND A COMMISSION AND A C	RUN LENGTH Distance REC ROD 24 5.0' 108.0-113.6' 4.3' 50% 25 5.0' 113.6'-118.8' 5.2' 80% 25 5.0' 118.8'-123.9' 5.1' 106% RUN 25 Comt. Box 12 50 % 108.0'-10.0' 100.0' 100.0'
Location / Orientation	North Bound, Box 11, 110.9 ft to 122.6 ft
Remarks	Louisville Limestone

	Photo 12
MARS NO. 80604 030 ITEMNO. 5-731.00, S-002-2011 BOXNO. 12 OF BORE HOLE ANGLE Length from starting point (122.6-to. 133.5) Reginning Courdinates Ending Coordinates X X V Elev.	RUN LENGTH Distance REC Distance Distance <thdistance< th=""> <thdistance< th=""> <thdistanc< th=""></thdistanc<></thdistance<></thdistance<>
Location / Orientation	North Bound, Box 12, 122.6 ft to 133.5 ft
Remarks	Louisville Limestone

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 7 of 66

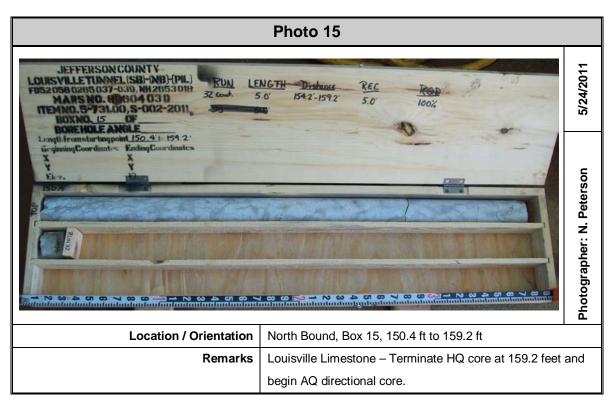


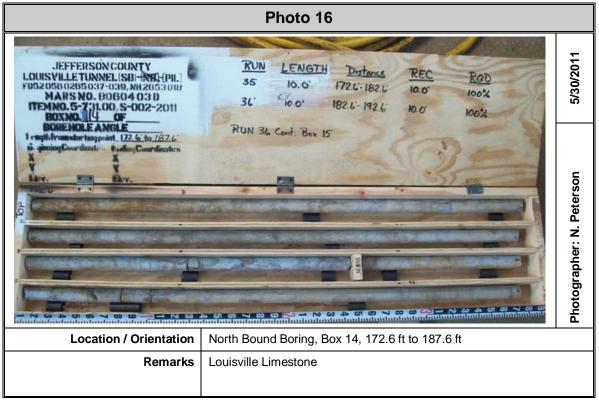
	Photo 13	
JEFFERSON COUNTY, LOUIS VILLE TURNIEL (SB)-MB)-MA PD52 056 0265 037-039, MH2053019 MARS NO. B06044 039 ITEMNO.5-731.00, S-002-2019 BORHOLE ANGLE Company Coordinates Ending Coordinates X X X X X X X X X X X X X X X X X X X	RUN LENCTH Distance REC Rad 271 cent. 5.0' 129.0'-134.0' 5.0' 1002 28 5.0' 134.0'-139.2' 5.2' 1002 29 5.0' 139.2'-144.2 5.0' 1002	Photographer: N. Peterson 5/24/2011
Location / Orientation	North Bound, Box 13, 133.5 ft to 144.2 ft	<u>a</u>
Remarks	Louisville Limestone	



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 8 of 66

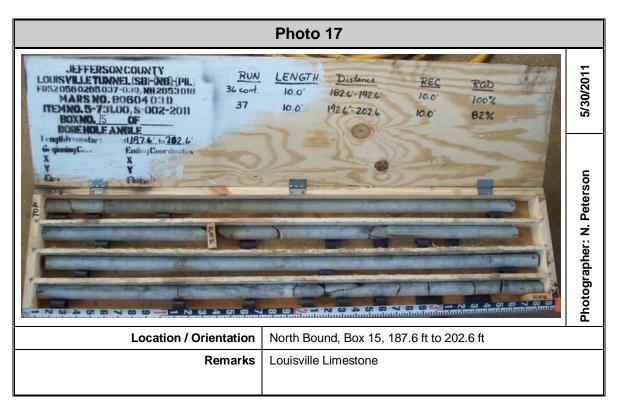






Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 9 of 66

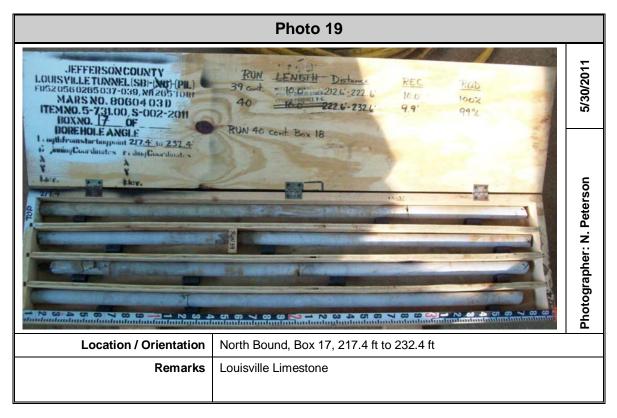


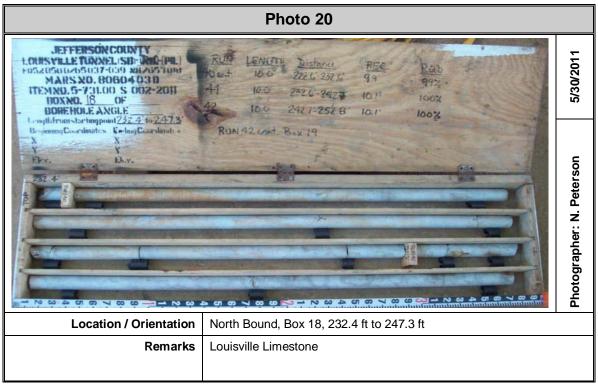




Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 10 of 66



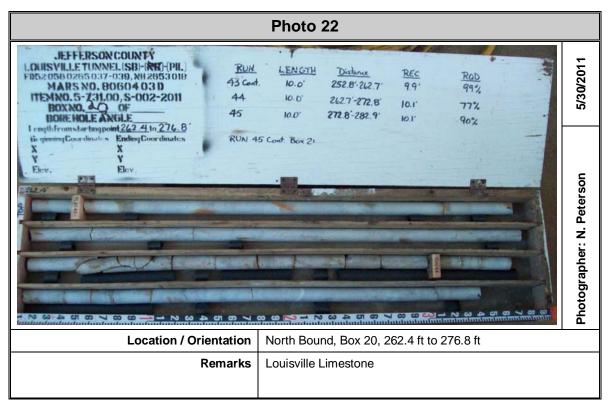




Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 11 of 66



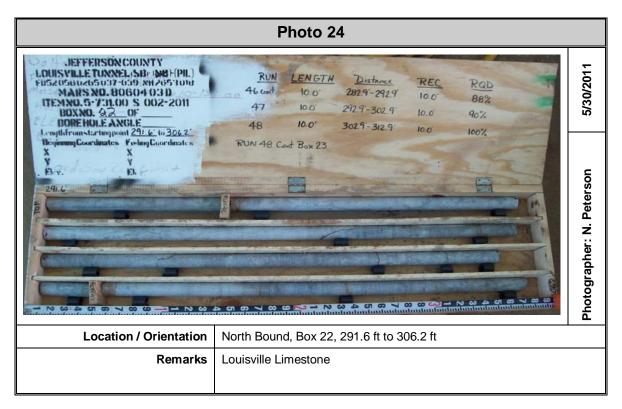
	Photo 21	
JEFFERSON COUNTY LOUIS VILLE TUNNEL ISB (PIL) F0520560205037-039 MH2653098 MARS NO. 80604 03 D ITEMNO. 5-731.00 S 002-2011 BOXNO. 19 0F BOREHOLE ANGLE	RUN LENGTH Distance Rec Rot 42 cart 10.0' 242.7-252.8' 10.1' 10072 43 10.0' 252.8'-262.7' 99 992	5/30/2011
Longthfrom starting point 247.3' to 262.4' Regimming Coordinates Ending Coordinates x Y Elev. Elev. 247.3' C C C C C C C C C C C C C C C C C C C	RUN 43 cont Box 20	Photographer: N. Peterson
Location / Orientation	North Bound, Box 19, 247.3 ft to 262.4 ft	
Remarks	Louisville Limestone	



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 12 of 66



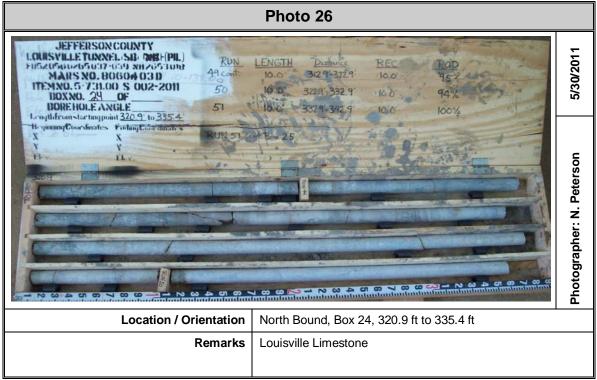
Photo 23 JEFFERSON COUNTY MARS NO. 80604 030 MARS NO. 8005 002-2011 BOXNO. 80 OF 5/30/2011 RUN LENGTH Distance REC 45 cont. 10.0 272 8-282 9 Rab 10.1 90% 46 10.0 282 9:292.9 BOREHOLE ANGLE 10.0 88% rom-tartingpoint 276.8 to 291.6 RUN 16 Cont. Bax 22 a dinatos Ending Coordinates El.x. Photographer: N. Peterson North Bound, Box 21, 276.8 ft to 291.6 ft Location / Orientation Remarks Louisville Limestone



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 13 of 66







Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 14 of 66



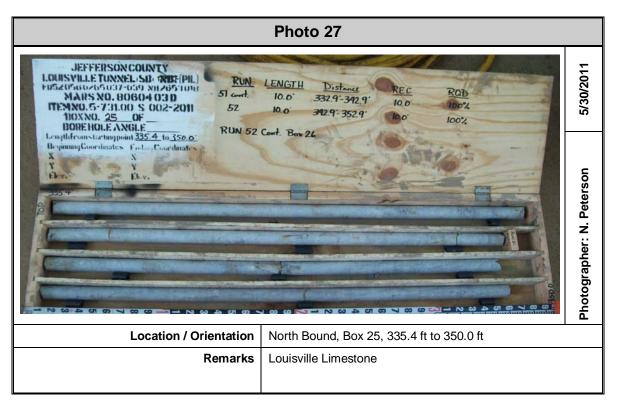


	Photo 28
FD5207000205037-039_XH2653008 52 Code MARS NO. 80604 030 53 ITEMN0.5-731.00 S 002-2011 53 BOXNO. 26_0F 54 BOREHOLE ANGLE 54 Longthframstartingpoint 350.0 to 364.9 71 Int 54 code	LENGTH Distance REC ROD 10.0' 342.9'-352.9' 10.0' 100% 10.0' 352.9'-362.2' 9.3' 93% 9.4' 362.2'-371.6' 9.4' 100%
RegimmgCoordinates FielungCoordinates	tographer: N. Peterson
Location / Orientation	North Bound, Box 26, 350.0 ft to 364.9 ft
Remarks	Louisville Limestone

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 15 of 66



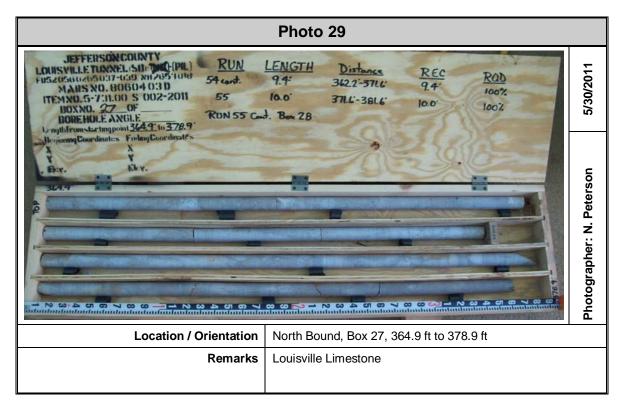
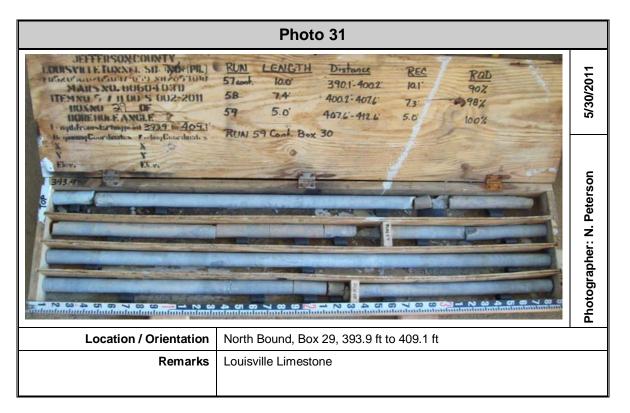


	Photo 30
and the second state of th	LENGTH Distance <u>REC</u> <u>ROD</u> 10.0' 371.6'-381.6' 10.0' 100% REZ 85 381.6'-390.1' 8.5' 100% 9.8' 390.1'-399.9' 9.8' 90% ant. Box 29
HjourngCoordmates + rolongCoordmates X X X Y Y Fb.v. Eb.v.	Photographer: N. Peterson
Location / Orientation	North Bound, Box 28, 378.4 ft to 393.9 ft
Remarks	Louisville Limestone

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 16 of 66







Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 17 of 66



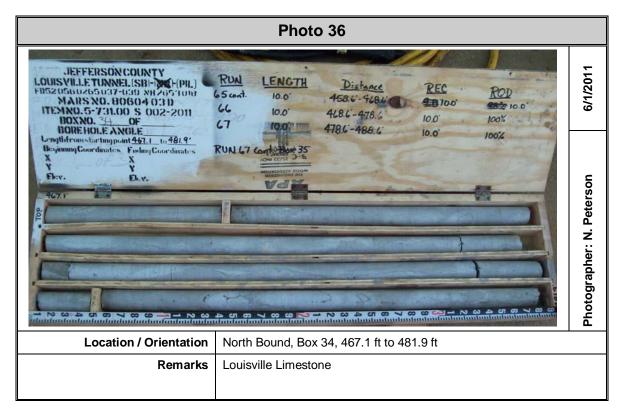




Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 18 of 66



	Photo 35	
JEFFERSON COUNTY LOUISVILLE TUNNEL (SBI-DALE(PIL) FD52 050 0265 037-039 NH 2653009 MARS NO. 80604 03 D ITEMNO. 5-731.00 S 002-2011 BOREHOLE ANGLE Langhitromstartingpoint 452.4: 10 ALCL1	RUN LENGTH Distance REC RQD 64 6.0' 452.6'-458.6' 6.0' 100% 65 10.0' 458.6'-468.6' 10.0' 100% RUN L5 cort. Box 34	11/2/1/0
BeginningGoordinates X X Y Elev 452.C		reterson
		rnotographer: N.
Location / Orientation	North Bound, Box 33, 452.6 ft to 467.1 ft	
Remarks	Louisville Limestone – Terminate AQ directional core at 452.6 feet and begin NQ core.	



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 19 of 66



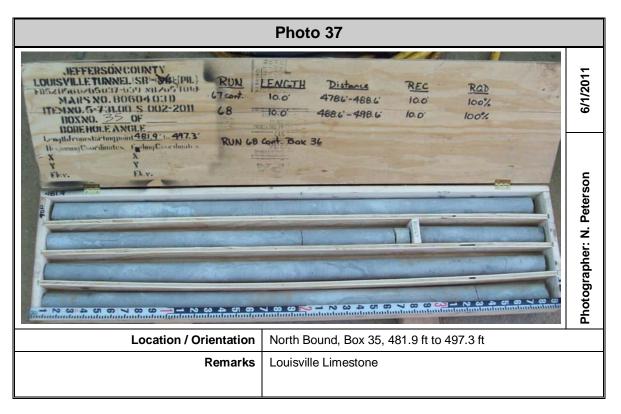


Photo 38			
PD52050024050037-039 M1205 (101) C8 conf. MARS NO. B0604 030 69 10 ITEMNU.5-7/31.00 S 002-2011 69 10 B0XNO. 36 0F 70 10 B0XEHOLE ANGLE 70 10 brownstartungpoint 497.3: to 512.1' BON 70 corr X X Y Y Exc. Exc.	Buddher: N. Peterson 5.912 P. 20 P.		
Location / Orientation	North Bound, Box 36, 497.3 ft to 512.1 ft		
Remarks	Louisville Limestone		

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 20 of 66

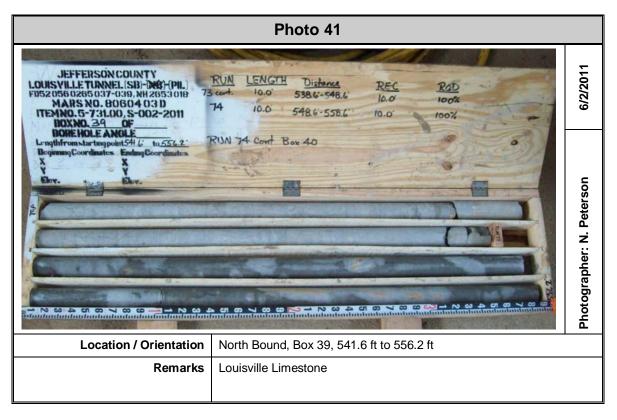


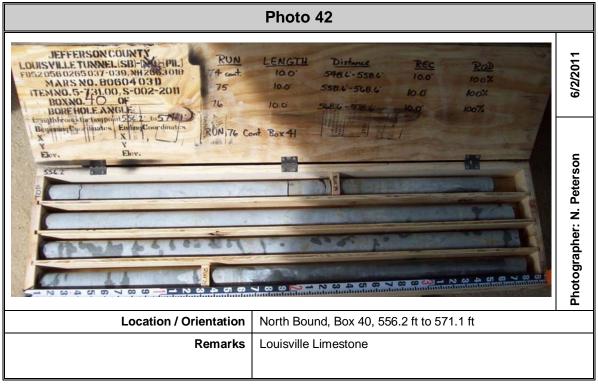
Photo 39 JEFFERSON COUNTY LOUIS VILLE TUNNEL (SBI-MG) F(PIL) FD52 050 02050 037-030 NH 2053 009 MARS NO. 80604 03 D ITEMNQ.5-731.00 S 002-2011 DOXNO. 37 OF DORE HOLE ANGLE Lengtheromstartungpoint 512.11 to 527.21 HegimmgCoordinates Fielding Coordinates X X 5/31/2011 RUN LENGTH Distance REC ROD 70 cont. 10.0 508.4-518.4 10.0 100% 71 10.0 518.6-528.6 10.0 100% RUN 71 cont. Box 38 E.k.v Photographer: N. Peterson North Bound, Box 37, 512.1 ft to 527.2 ft Location / Orientation Remarks Louisville Limestone



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 21 of 66

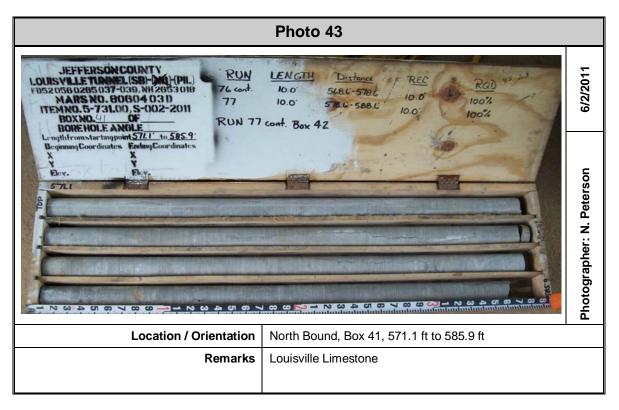






Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 22 of 66





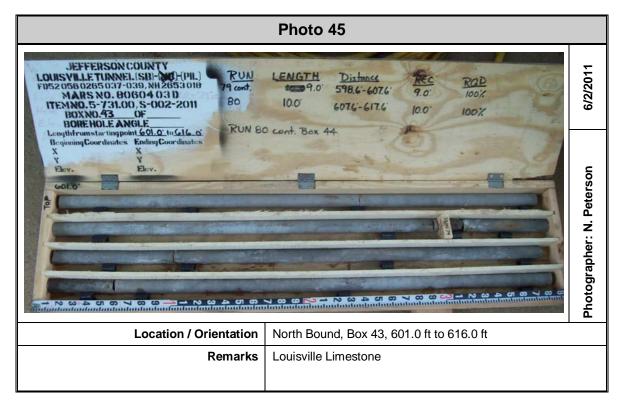


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Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629



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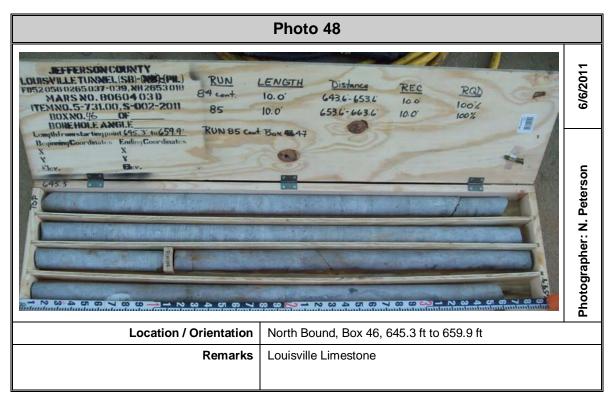




Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 24 of 66



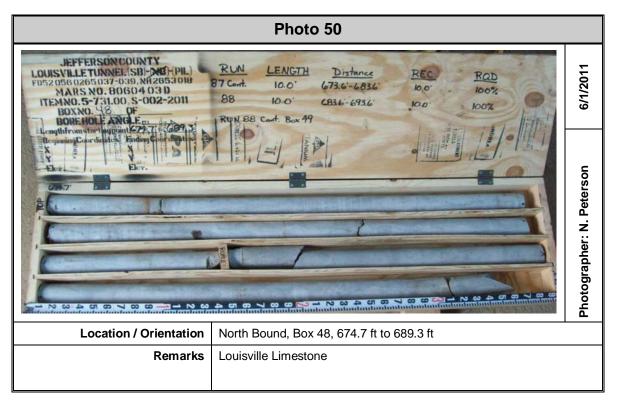
Photo 47 JEFFERSON COUNTY LOUISVILLE TUNNEL (SBI-DAD) (PL) FD52 056 0265 037-039, NH 2653 018 MARS NO. 80604 03 D ITEMNO.5-731.00, S-002-2011 BOXNO.45 OF BOREHOLE ANGLE Lengthfromstartingpoint 631.0° to 645.3° Boginning Coordinates Ending Coordinates 6/6/2011 RUN LENGTH Distance REC RaD B2 cont. 10.0 627.6-637.6 10.0 98% F6.0 637.6-643.6 83 6.0' 100% 6436-6536 84 10.0 10.0 100% RUN 84 cont. Box 46 Photographer: N. Peterson Location / Orientation North Bound, Box 45, 631.0 ft to 645.3 ft Louisville Limestone - Terminate AQ directional core at Remarks 637.6 feet and begin NQ core.



Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 25 of 66



Photo 49 JEFFERSON COUNTY LOUISVILLE TUNNEL (SBI-NO)-[PIL, FD520560265037-039, NI 2053018 MARS NO, 80604 03D ITEMNO, 5-731.00, S-002-2011 BOXNO, 7 OF 87 RUN LENGTH Distance 6/1/2011 REC RAD 10.0' 653.6-663.6 10.0 100% 10.0 6631-6736 10.0 00% 10.0 673.6-683.6 10.0 100% BOREHOLE ANGLE 16999 to 674.7 RUN 87 Cont. Box 48 EndingCoordi De Photographer: N. Peterson -Location / Orientation North Bound, Box 47, 659.9 ft to 674.7 ft Remarks Louisville Limestone



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Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 26 of 66



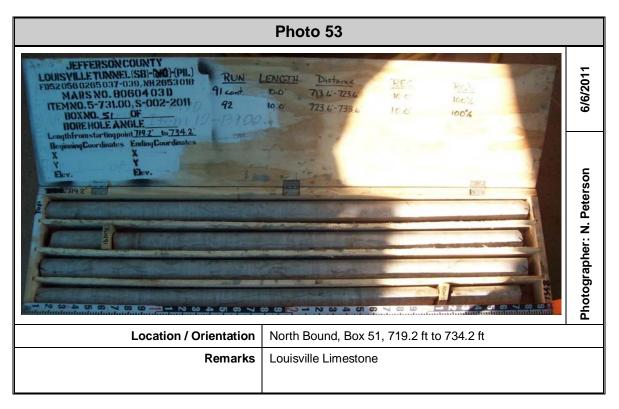
Photo 51		
JEFFERSONCOUNTY LOUISVILLE TUNNEL. ISBE-DAU (PIL) PD520560265037-039, NH2653018 MARS NO. 806004 0310 ITEMNO. 5-7/31.00, S-002-2011 BONEHOLE ANGLE BONEHOLE ANGLE Longithfromstartiagoon/BRST to 704.5 Bone Elev.	tographer: N. Peterson	
Location / Orientation	North Bound, Box 49, 689.3 ft to 704.5 ft	
Remarks	Louisville Limestone	

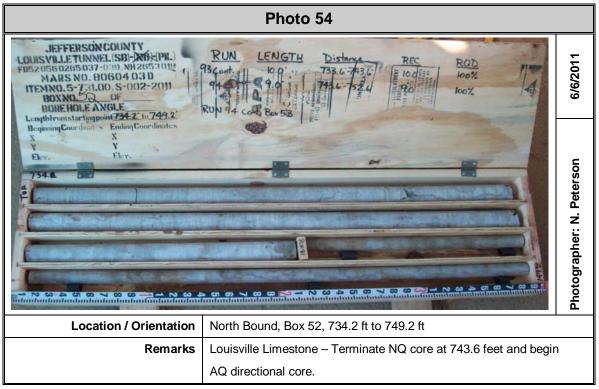
Photo 52		
MARS NO. 80604 03 D ITEMNO. 5-731.00, S-002-2011 BOXNO. 50 05	RUN LENGTH Distance REC Rad 90 cont. 10.0' 703.6'-713.6' 10.0' 487. 2 91 10.0' 713.6'-725.6' 10.0' 100% 2 2 RUN 91 Cont. Bax 51 3 <	6/6/2011
Ecv. Ecv.		Photographer: N. Peterson
Location / Orientation	North Bound, Box 50, 704.5 ft to 719.2 ft	
Remarks	Louisville Limestone	

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



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Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 28 of 66



Photo 55 JEFFERSON COUNTY LOUIS VILLE TUNNEL (SBI-INE)-[PR.] F052 056 0265 037-039, NH2653019 MARS NO. 80604 03D ITEMNO. 5-731.00, S-002-2011 B0XNO. 53 OF RUN LENGTH 6/2/2011 94 Latter Distance REC Rad 19:0 743 6-7526 9.0 95 100% 10.0 0. 752 6-762.6 100 98% 96 BOREHOLE ANGLE 10.0 9.8 762.6- 772.6 78% 1749.2 to 764.0 LongthFromstartingpo BeginningCoordinates RUN 96 Cant. Box 54 EndingCoordinates FI Eley. Photographer: N. Peterson 4 01 00 Nº 60 North Bound, Box 53, 749.2 ft to 764.0 ft Location / Orientation Remarks Louisville Limestone



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Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 29 of 66





Photo 58				
JEFFERSON COUNTY LOUISVILLE TUNNEL (SB)-TMC-[PIL] FD520560265037-039, M42653019 MARS NO. B0604 03D MEMNO. 5-731.00, S-002-2011 FDM NO. 56 3 DF BUMPAD E ANRI-E BUMPAD E ANRI-E	RUN LENGTH Distance 99 Cont. 10.0' 792.0'-802.0' 100 100', B02.0'-812.0' RUN 100 Cont. B02.57 15 110, 5	P(0) P(0)		
Elev. Elev.	None of the second seco	Peterson		
		Photographer: N. Peterson		
Location / Orientation	North Bound, Box 56, 793.1 ft to			
Remarks	Louisville Limestone			

Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 30 of 66







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



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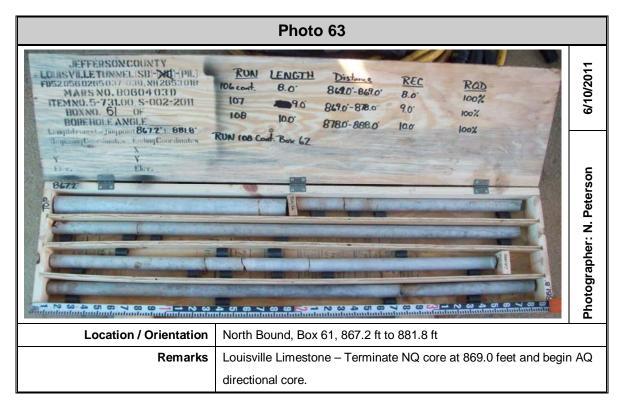


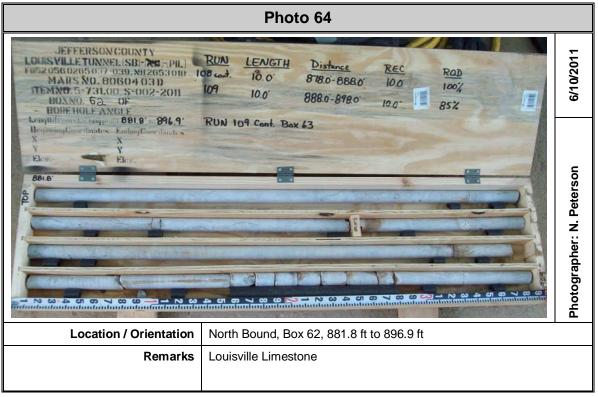


Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629



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Louisville Tunnel Project Louisville, Jefferson County, Kentucky Project # 1831-10-5629 Sheet 33 of 66



Photo 65 JEFFERSON COUNTY JEFFERSON COUNTY LOUISVILLE TUNNEL (SBI-200)-(PII.) 0520560265037-030, NH 265300 MARS NO. 80604 030 ITEMNO. 5-731.00, S-002-2011 BOXNO. 63_0F_____ BOREHOLE ANGLE Leophfromstarting out 866.71690.8 RUN 6/10/2011 LENGTH Distance REC ROD 104 cont. 10.0 888.0-898.0 10.0 85% 110 10.0 898.0-908.0 10.0 100% 111 10.0 908.0-918.0 10.0 100% Ending Coordinates RUN III Cont. Box 64 Peterson Photographer: N. 840010 Location / Orientation North Bound, Box 63, 896.9 ft to 911.8 ft Remarks Louisville Limestone



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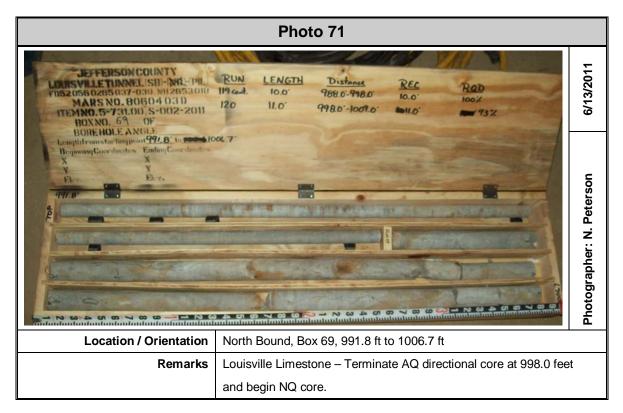


Photo 69 EFFERSON COUNTY OUT ALLE TUNNEL (SB)=200-(PIL) D52 056 0285 037-039, NH265 3018 MARS NO. 80604 03 D ITEMNO. 5-73100, S-002-2011 POXNO. 5-73100, S-002-2011 BORE HOLE ANGLE BORE HOLE ANGLE 9708 6/13/2011 RUN LOU LENGTH Distance REC 115 cont. Rab 948.0-958.0 10.0 10.0 100% 116 10.0 958.0-968.0 10.0 100% 117 100 ... 968.0-978.0 athfromstartingpoint 956.7 to 971.8 44 44% RUN IT Cont. Box 68 Elex Peterson Photographer: N. Location / Orientation North Bound Boring, Box 67, 956.7 ft to 971.8 ft Remarks Louisville Limestone





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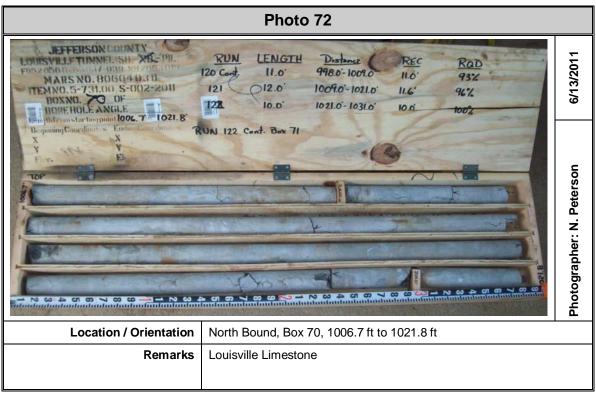




Photo 73 JEFFERSON COUNTY LOUIS Y LLETUNNEL ISB- MC PIL. F0520580265037-039.NII 2653019 MARS NO. 80604 030 122 cont. 6/13/2011 RUN LENGTH Distance REC ROD 10.0 1021.0-1031.0 10.0' 100% BOXNO, 71 OF BOREHOLE ANGLE 123 10.0 1031.0-1041.0 10.0' 100% RUN 123 Cont. Box 72 anstartingpoint 1021.B' to 1036.9 Coordinate Ending Coordinat Peterson Photographer: N. Location / Orientation North Bound, Box 71, 1021.8 ft to 1036.9 ft Remarks Louisville Limestone

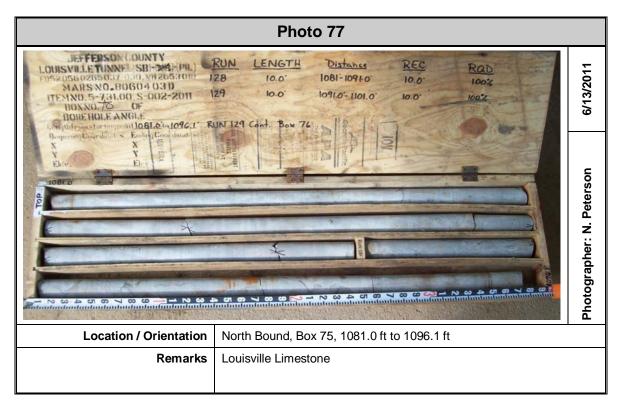


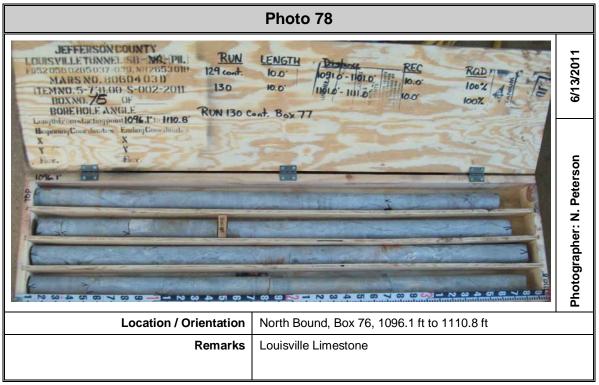


Photo 75		
RUN LENGTH Distance REC Rad Rad 125 cent. 10.0' 10510'-1061.0' 10.0' 1007. 1007. 1007. 126 10.0' 1061.0'-1071.0' 10.0' 1007. 1007. 1007. RUN 126 cent. Bax 74 10.0' 1007. 1007. 1007. 1007.		
Photographer: N. Peterson		
North Bound, Box 73, 1051.4 ft to 1066.3 ft		





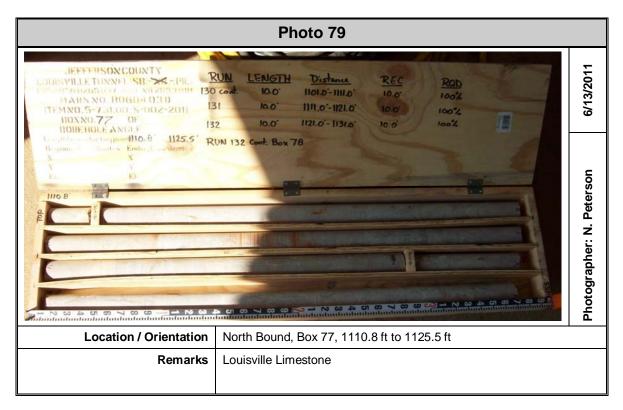




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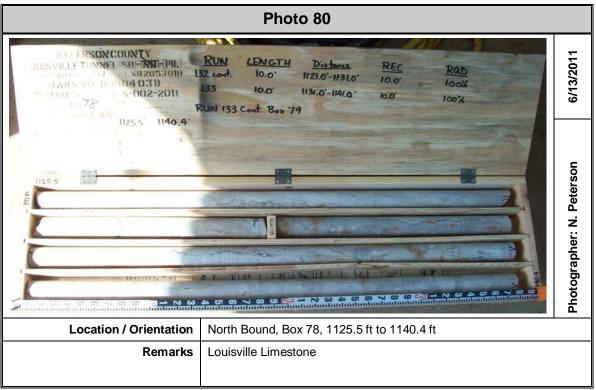
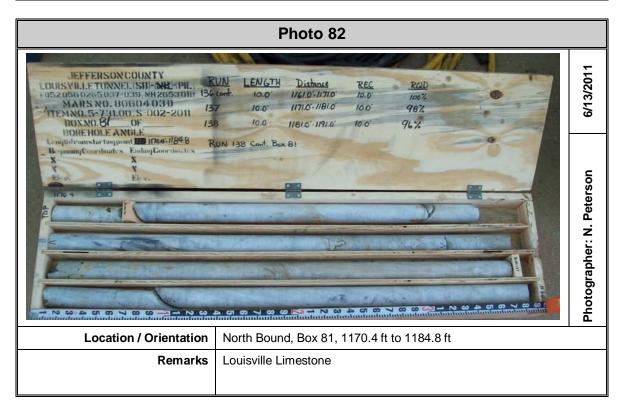




Photo 81 6/13/2011 JEFFERSONCOUNTY LOUISVILLE TUNNEL (SB)-INKI-PIL RUN F0520560265037-039.NH 2653018 135 cont. LENGTH Distance REC RaD 1151.0'-1161.0' 10.0' 10.0 MARS NO. 80604 03 D 100% HARS NO. 00004050 HEMD.5-73L00, S-002-2011 BOREHOLE ANGLE Longthfromstartingpoint HS5.3' 0. [[70:4] Beginning Courdinates Ending Courdinates 136 10.0 1161.0-1171.0 10.0 100% RUN 136 Cont. Box BI Photographer: N. Peterson Elev Elev. . 1155.3 Location / Orientation North Bound, Box 80, 1155.3 ft to 1170.4 ft Remarks Louisville Limestone



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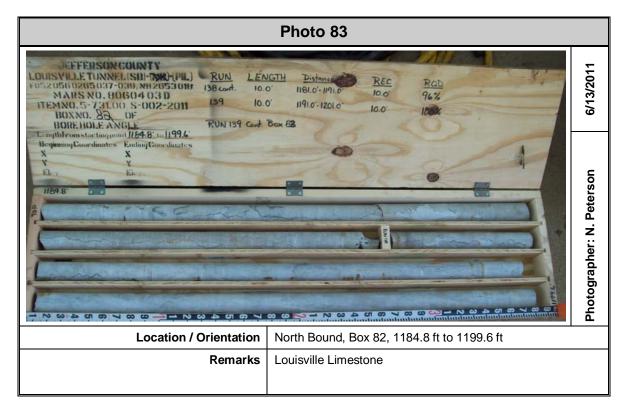
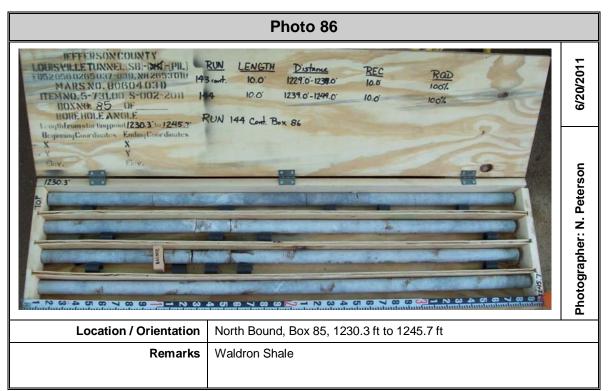


Photo 84		
F0520500265037-039, M(2653018 29 cod. MARS NO. 80604 030 ITEMNO. 5-731.00, S-002-2011 40 1	ENGTH Distance REC ROD 10.0' 1191.0'-1201.0' 10.0 100% 0.0' 1201.0'-1211.0' 10.0' 100% 3.0' 1211.0'-1214.0' B.0' 100% 100%	6/20/2011
		Photographer: N. Peterson
		Phot
Location / Orientation	North Bound Boring, Box 83, 1199.6 ft to 1214.8 ft	
Remarks	Louisville Limestone – Terminate NQ core at 1211.0 feet	
	and begin AQ directional core.	

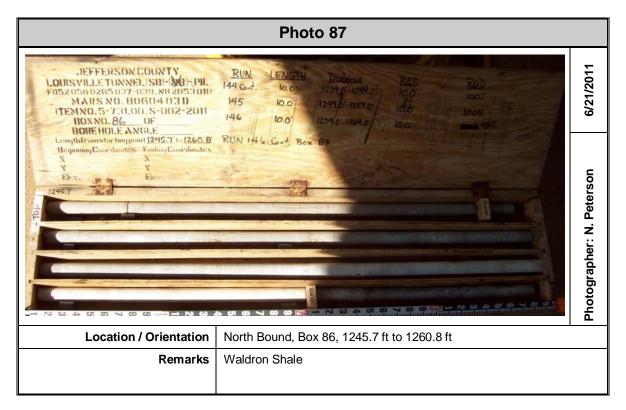


Photo 85 JEFFERSON COUNTY LOUISVILLE TUNNEL (SB)-CHE-(PIL) KUN FDS2 056 0265 037-039, NH 2653018 141 cont. LENGTH Distance 6/20/2011 REC RAD CONSVILLE TONNEL (SBI-)XB-, PHL PD520560285037-039, NH2053011 MARS NO. 8060040310 ITEMN0.5-V31.00.S-002-2011 BOXNO.84_0F_____ BOREHOLE ANGLE 1211.0'-1219.0' 8.0' 8.0 100% 142 10.0 1219.0-1229.0 10.0 100% 10.0 143 1229.0-1239.0 10.0 100% LongthFromstartingpoint/2/4, 8' to/230.3' BeginningCoordinates EndingCoordinates RUN 143 Cont. Box 85 X Flow Peterson 214 2 Photographer: N. Location / Orientation North Bound, Box 84, 1214.8 ft to 1230.3 ft Remarks Louisville Limestone to a distance of 1220.0 feet. Waldron Shale begins at 1220.0 feet.





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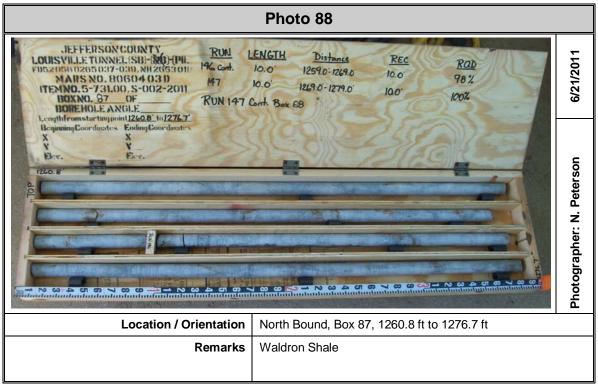
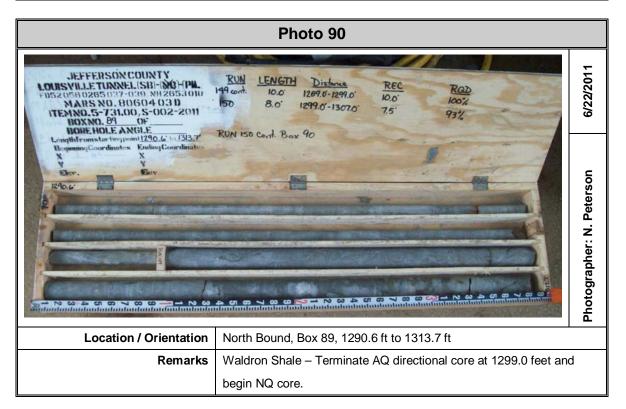


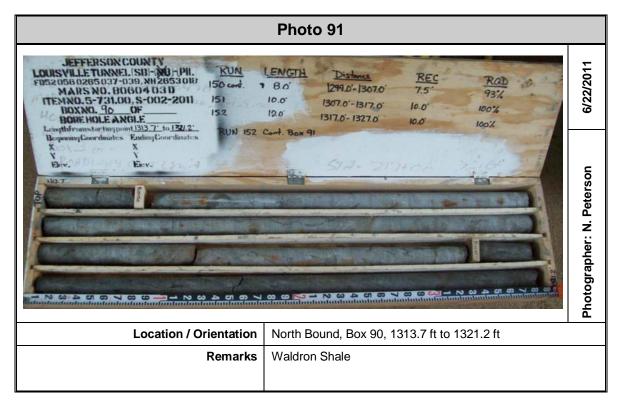


Photo 89 JEFFERSON COUNTY, LOUISVILLE TUNNEL (SB)-(NB)-(PIL) F0520560265037-039, NI 2653000 147 cord. MARS NO. 80604 03 D 6/21/2011 LENGTH Distance REC RAD 10.0' 1269.0-1279.0 10.0' 100% 148 1279.0 - 1289.0 ITEMNO.5-731.00 S-002-2011 10.0 KO' BOREHOLE ANGLE 100% 149 10.0 1259.0- 1299.0' 10.0' 100% Coordinates En Lan Coordinates RUN 149 Cent. Box 89 Coordinates Coordinates 5 Peterson Elev Photographer: N. D D 4 W M -₩ 4 0 0 × 0 × North Bound, Box 88, 1276.7 ft to 1290.6 ft Location / Orientation Remarks Waldron Shale





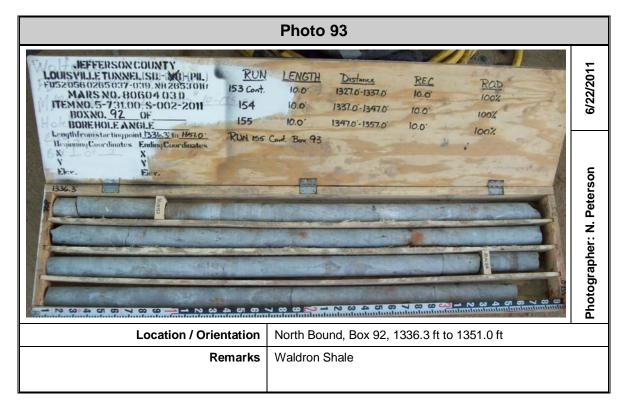
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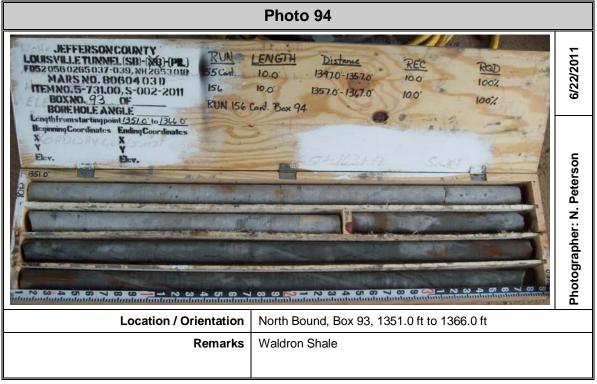
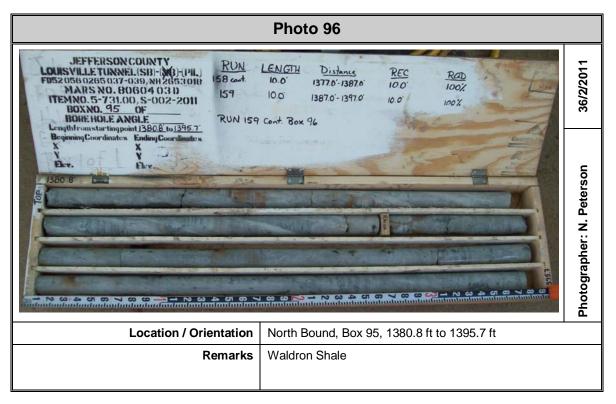




Photo 95 LEFFERSON COUNTY LOUIS VILLE TUNNEL (SBI-1300 HPL) FD52 006 0265 037-039, NH 2653 018 MARS NO. 80604 03 D TEMMO. 5-731.00, S-002-2011 BOXNO. 94 OF_____ BOINE HOLE ANGLE_____ BOINE HOLE ANGLE_____ 6/23/2011 RUN LENGTH Distance REC. ROD 156 cont. 10.0' 1357.0- 1367.0 10.0 100% 157 10.0' 1367.0-1377.0 10.0 100% 1377.0 -1387.0 158 10.0' 10.0 100% athfromstartingpoint/3660 to/380.8 RUN 158 Cont. Box 95 jimingCoordinates EndingCoordinates Dev Elev Peterson DEC Photographer: N. 60 Location / Orientation North Bound, Box 94, 1366.0 ft to 1380.8 ft Remarks Waldron Shale





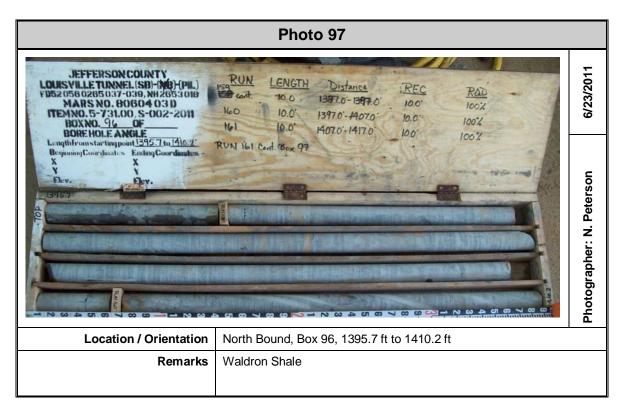


Photo 98				
JEFFERSON COUNTY LOUISVILLE TUNNEL (SB)-(NG)-(PIL) FD52 056 0265 037-039, NH 2653 018 MARS NO. 80604 03 D ITEMNO. 5-731.00, S-002-2011 BOXNO. 97 OF BURE HOLE ANGLE Lengthfromstartingpoint (HD.2' to (H25.1')	RUN LENGTH Distance REC ROD 161 cont. 10.0' 1407.0'.1417.0' 10.0' 100' 162 100' 1417.0'-1427.0' 10.0' 0% RUN 162 Cont. 80x97 10.0' 0%	6/23/2011		
Beginning Coordinates Ending Coordinates		Photographer: N. Peterson		
Location / Orientation	North Bound, Box 97, 1410.2 ft to 1425.1 ft			
Remarks	Waldron Shale			



Photo 99			
F0520560265037-039, NH 2653018 162 cont MARS NO. 80604 03 0 ITEM NO. 5-731.00, S-002-2011 163	ENGTIH Distance REC RaD 100' 1417.0'.427.0' 100' 0% 100' 4270'-4370' 10.0' 78% 10.0' 1437.0-1447.0' 10.0' 78% 10.0' 56%		
	Photographer: N. Peterson		
Location / Orientation	North Bound Boring, Box 98, 1425.1 ft to 1438.5 ft		
Remarks	Waldron Shale		

Photo 100			
JEFFERSON COUNTY LOUIS VILLE TUNNEL (SB)-(NG) (PH,) F0520560265037-039, MH 2635009 MARS NO. 80604 030 TEXNO. 99 - 0F BORE HOLE ANGLE MORE HOLE ANGLE HORE HOLE ANGLE Levy Coordinates / Ending Coordinates X X X Elev H39.5	RUN LENGTH Distance REC ROD FROD RUN 100 56% 76%		
Location / Orientation	North Bound, Box 99, 1438.5 ft to 1452.7 ft		
Remarks	Waldron Shale		



Photo 101 JEFFERSON COUNTY LOUISVILLE TUNNEL ISBI-MEF[PII. F9520560265037-039, NH 2653018 MARS NO. 80604 0310 ITEMNO. 5-731.00, S-002-2011 BOXNO. 100 OF BOREHOLE ANGLE 6/27/2011 RUN LENGTH Distance REC Rab 165 cont. 10.0 1447.0-1457.0 10.0 76% 166 10.0 1457.0-1467.0 . 10.0 54% thfromstartingpoint/452.7' to 1467.0' miningCourdinates EndingCoordinates Elev. Elev. Peterson -1000 Photographer: N. 5 5 North Bound, Box 100, 1452.7 ft to 1467.0 ft Location / Orientation Waldron Shale Remarks

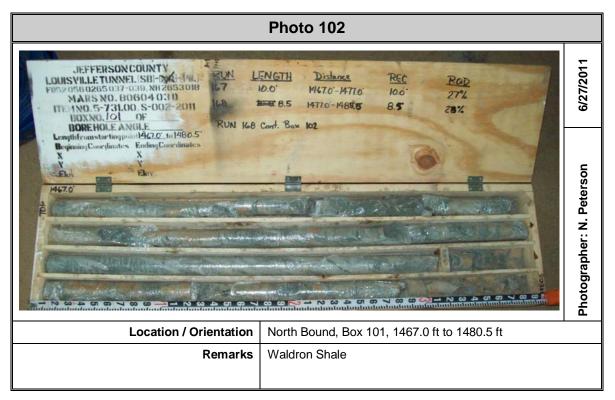
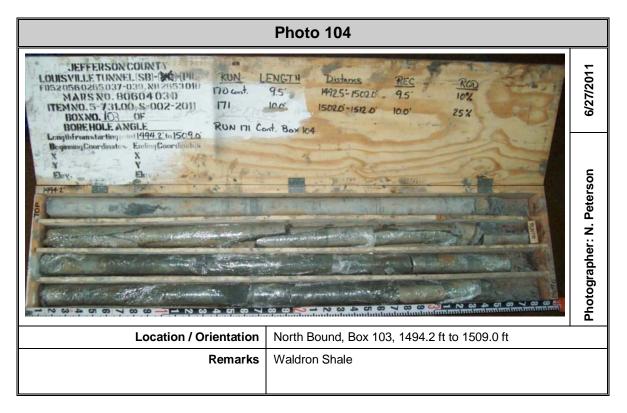


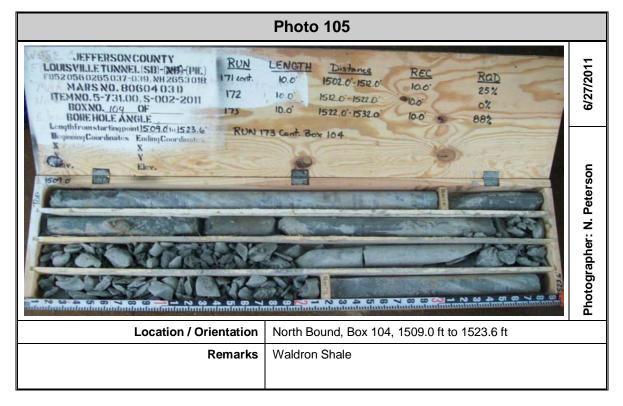


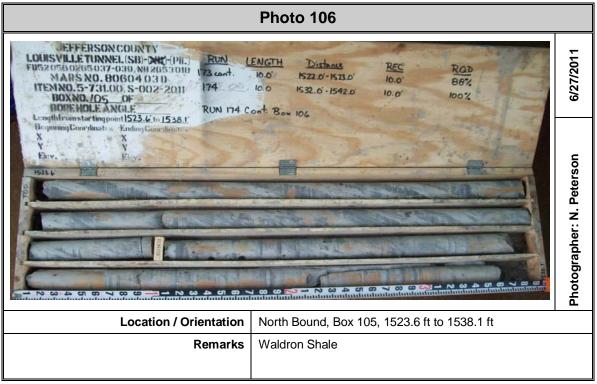
Photo 103		
FD520560265037-039, NH2653018 L4 MAPS NO, 806040310 ITEMN0.5-731.00, S-002-2011 BOXNO, [02, 0F BOREHOLE ANGLE	RUN LENGTH Distance REC ROD ROD 8 cont. 1000'8.5' 1477.0'-1485.5' 8.5' 2.0'(25%) 100'120'8' 100'120'8'8' 100'120'8'8'8'8'8'8'8'8'8'8'8'8'8'8'8'8'8'8'8	
Beginning Coordinates X Y Fhrv. Else 1980 5	Photographer: N. Peterson	
Location / Orientation	North Bound, Box 102, 1480.5 ft to 1494.2 ft	
Remarks	Waldron Shale	



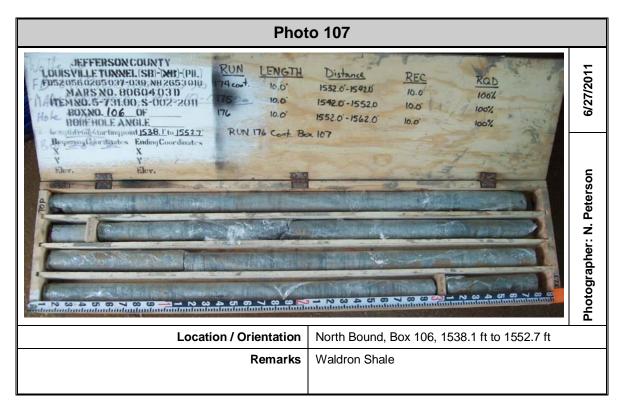


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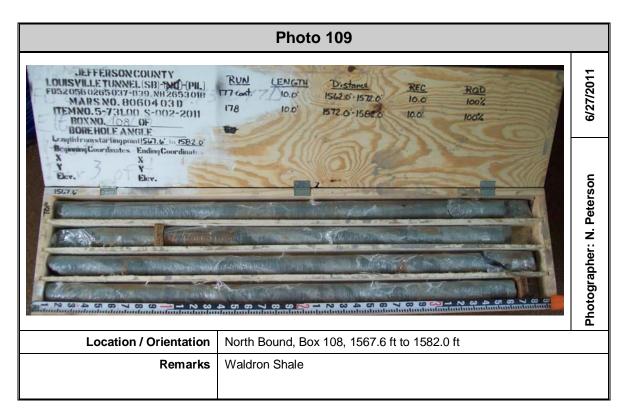


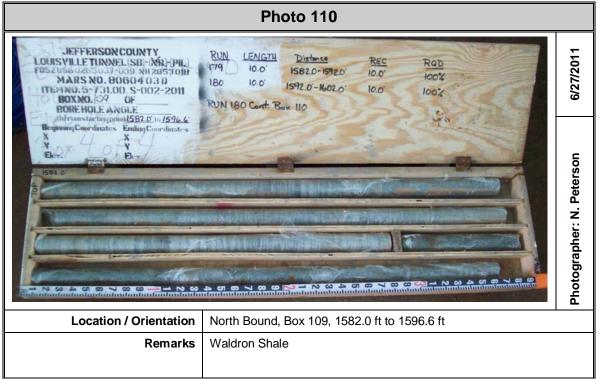






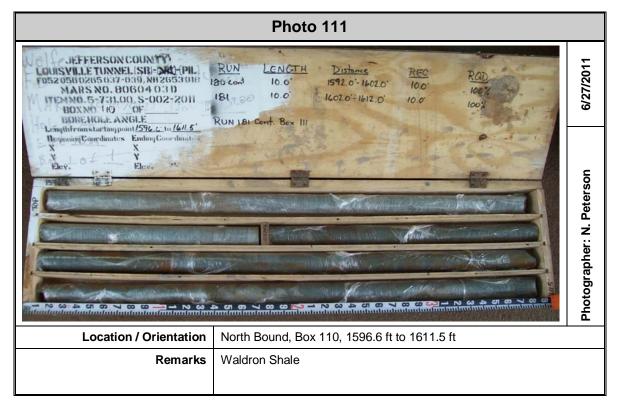


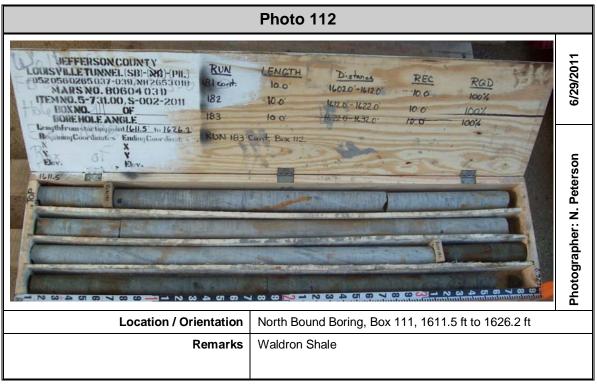






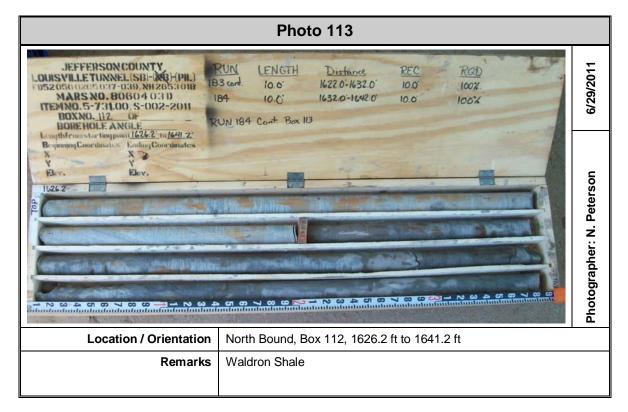
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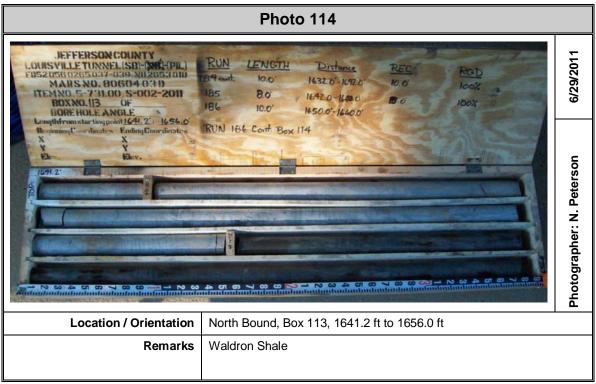
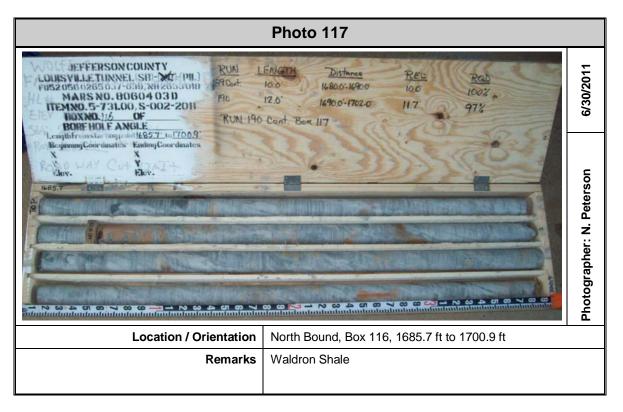


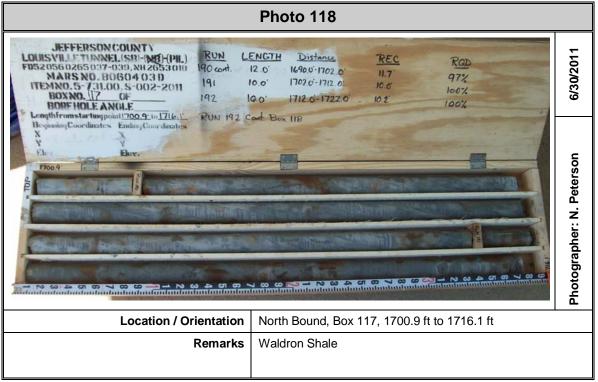


Photo 115 JEFFERSONCOUNTY RUN LENGTH 6/29/2011 Distance REC RAD 6 cont. 10.0 1650.0-1660.0 100 100% 187 10.0 1660.0-1670.0 10.0 100% 188 10.0 1670.0-1680.0 10.0 100% engthfromstartingp leginningCoordinate Ending Coordinates RUN 188 Cont. Box 115 12. Elev Peterson 0 0 Photographer: N. 9-N8400 V8 North Bound, Box 114, 1656.0 ft to 1670.9 ft Location / Orientation Remarks Waldron Shale

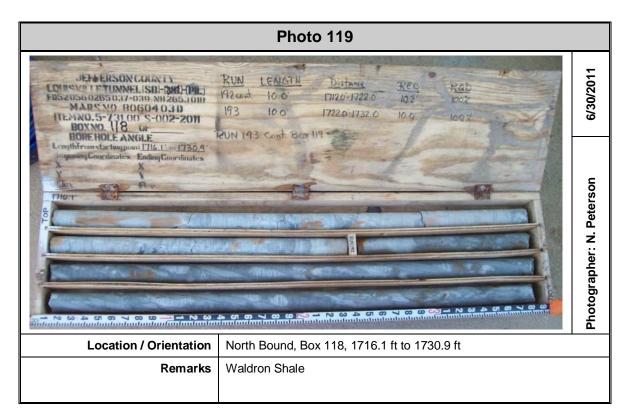






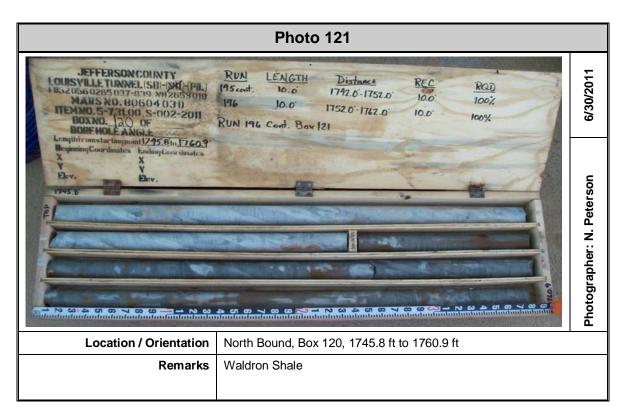


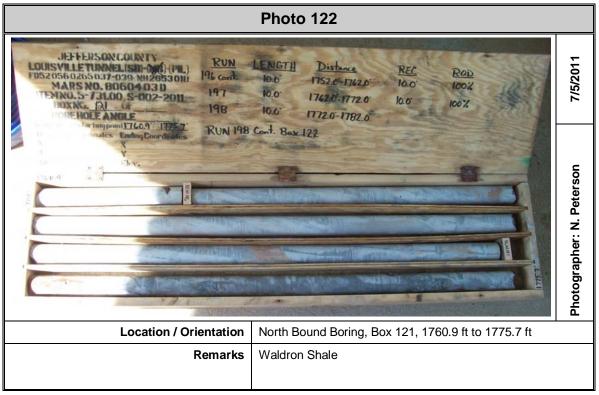














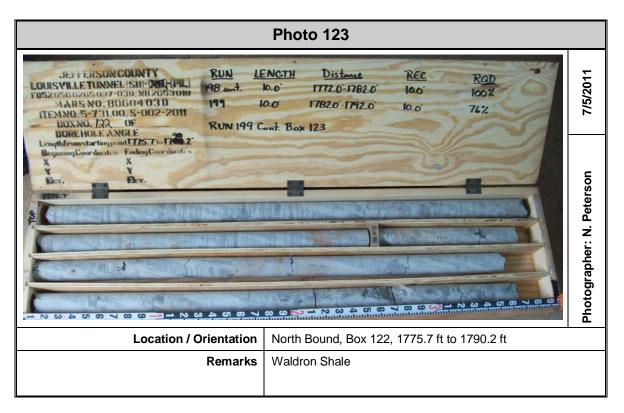
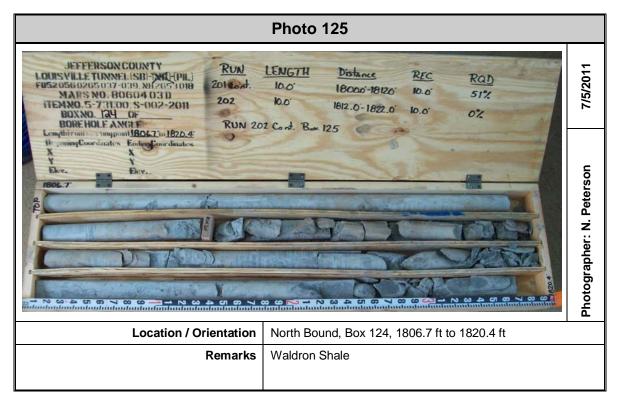


Photo 124			
MARS NO. 80604 030	RUN LENGTH Distance REC ROD 10.0 8.0 1782.0 10.0 74% 200 8.0 1792.0 10.0 74% 201 10.0 1800.0 63% 0% RUN 201 Cont. Bax 124 10.0 51% 0%		
Location / Orientation	North Bound, Box 123, 1790.2 ft to 1806.7 ft		
Remarks	Waldron Shale		



Sheet 63 of 66



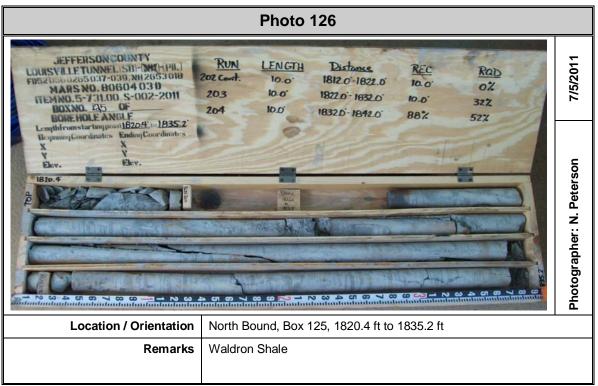
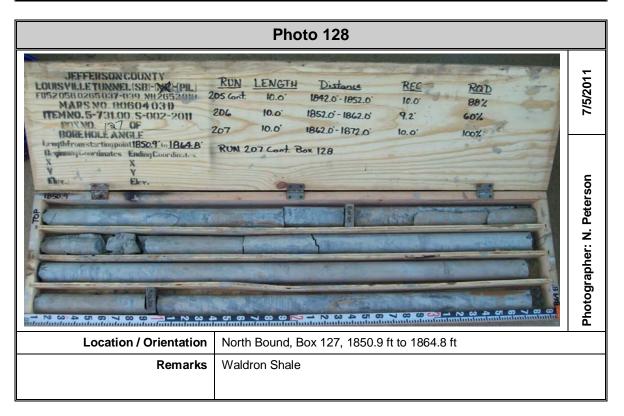


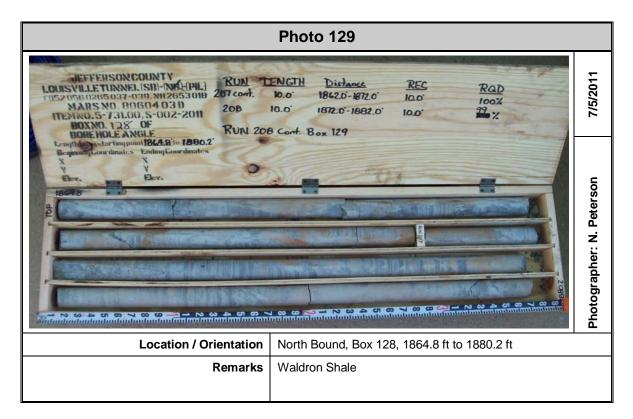


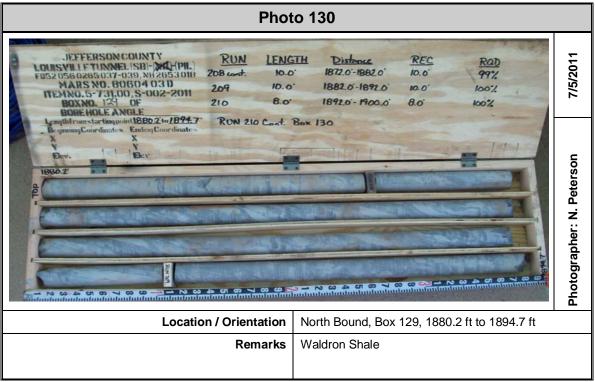
Photo 127 JEFFERSONCOUNTY RUN LENGTH JEFFERSON COUNTY LOUIS VILLE TURNEL (SB)-[SHJ-PIL) F052 056 0265 037-039, NH 2653 019 MARS NO. 80604 03 D TEMNO.5-731.00, S-002-200 BOND (JAC OF BONE HOLE ANGLE Lengthfrom startingpoint (B35.2, to (B50.9) Bonte for the Starting for the formation Bonte for the Starting for the formation Distance REC ROD 7/5/2011 204 cont. 10.0 18320-18420 2882 52% 205 10.0 1842.0-1852.0 10.0 88% RUN 205 Cont. Box 127 Peterson 1835.2 Photographer: N. ~ 80 North Bound, Box 126, 1835.2 ft to 1850.9 ft Location / Orientation Remarks Waldron Shale



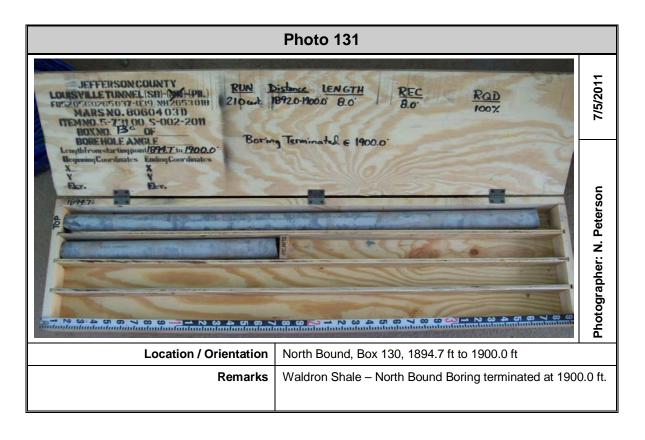


Sheet 65 of 66





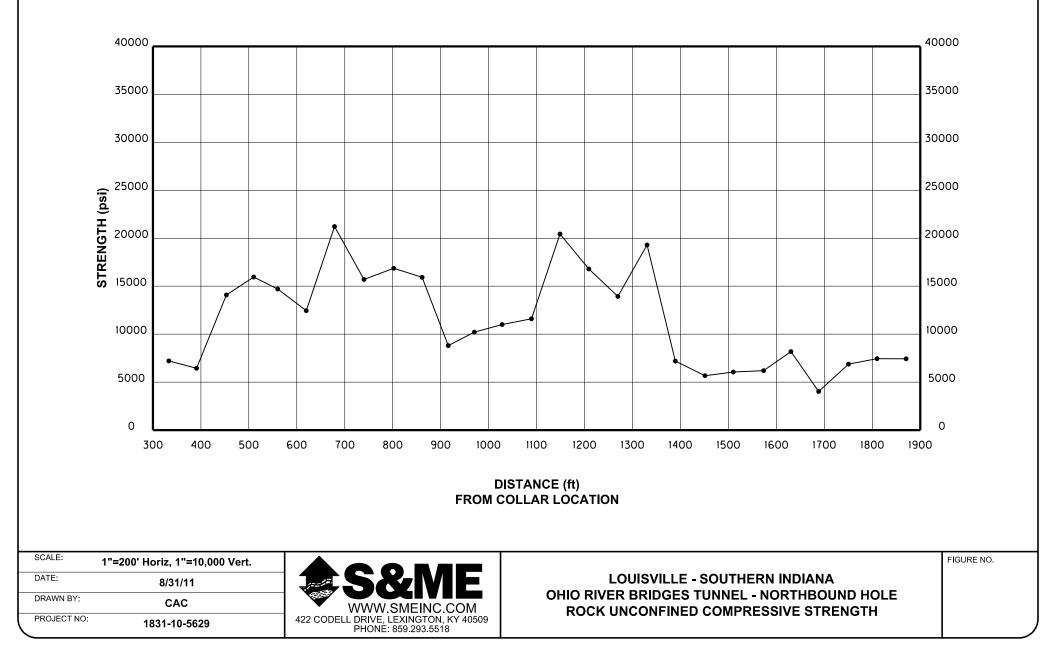


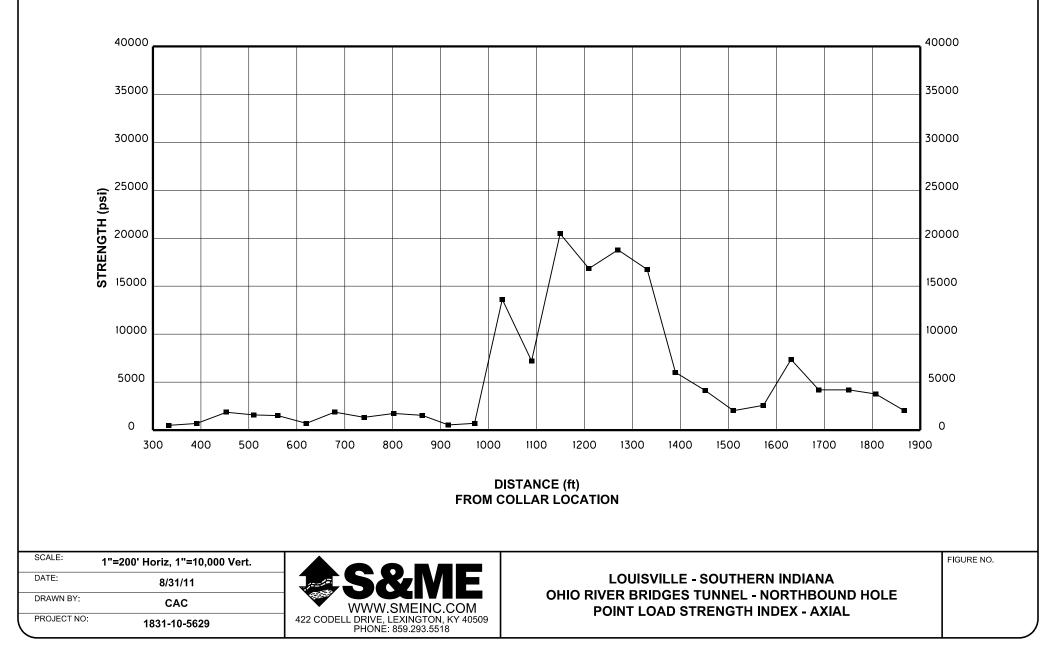


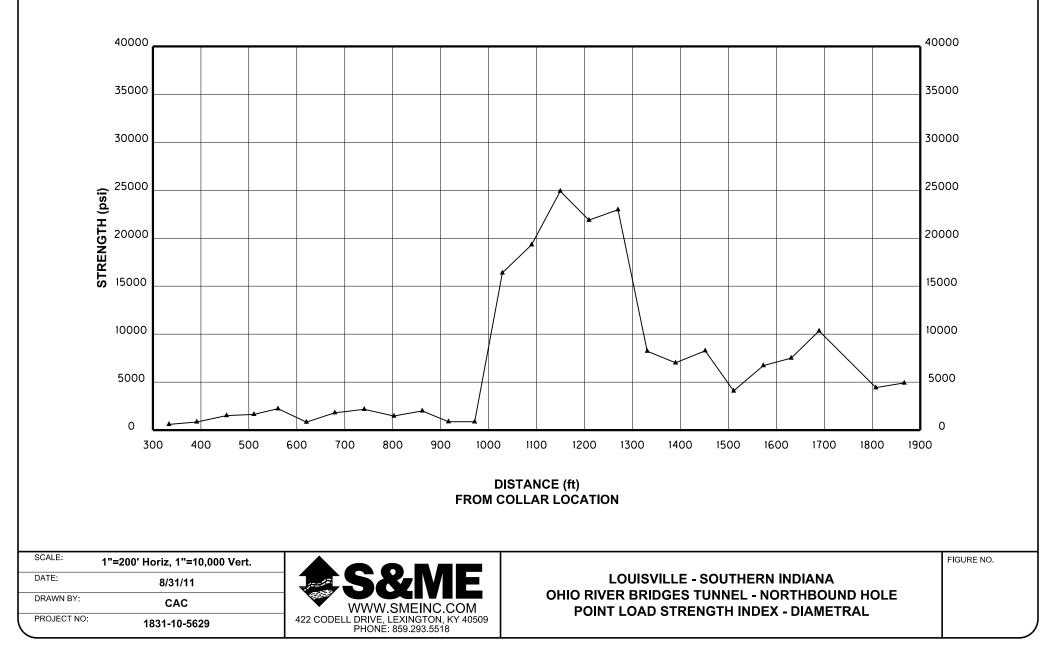
APPENDIX B

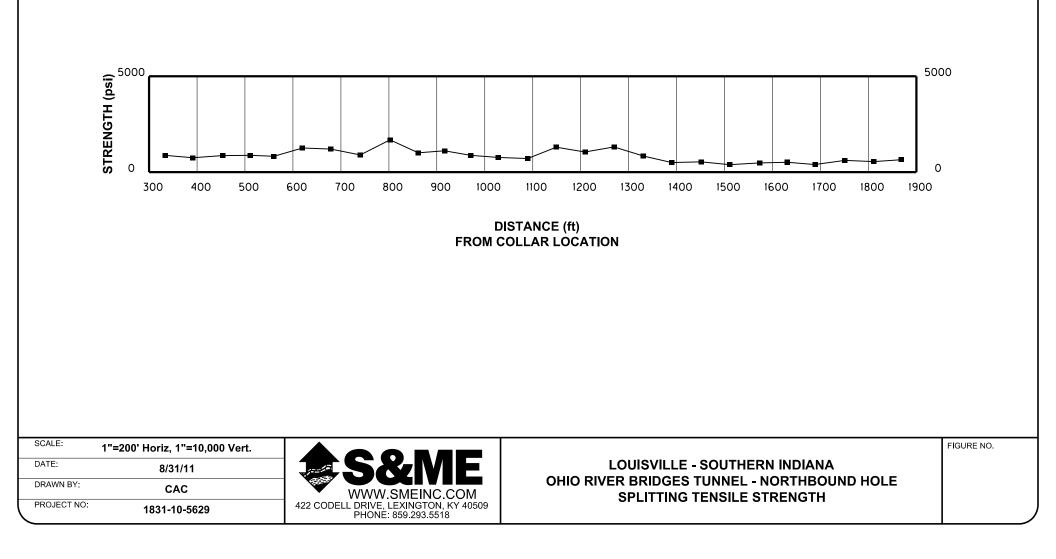
GRAPH "Unconfined Compression versus Distance" Graph "Point Load Index - Diametral versus Distance" Graph "Point Load Index - Axial versus Distance" Graph "Splitting Tensile Strength versus Distance" Graph "Splitting Tensile Strength versus Distance" TABULATION OF ROCK CORE SAMPLE LOCATIONS LABORATORY TEST REPORTS

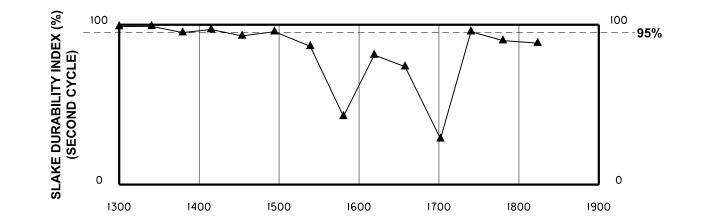
SAMPLE COLLECTION LOCATIONS











DISTANCE (ft) FROM COLLAR LOCATION

> KYTC GEOTECHNICAL MANUAL DURABLE SHALE ≥ 95 NONDURABLE SHALE ≤ 95



SUMMARY OF LABORATORY DATA

					Unconfined (Compression			strength Inde		Splitting Ten	sile Strength	Slake Durability
					Distance	Strength	Distance A	Strength A	Distance D	Strength D	Distance	Strength	Slake Durability Index
Sample	Distance	Northing	Easting	Elevation	(ft)	(psi)	(ft)	(psi)	(ft)	(psi)	(ft)	(psi)	(Second Cycle)
1	332.9-335.3	303021.76	1247276.48	541.59	333.1	7,207	333.3	493	333.4	593	333.2	1,759	
2	390.9-393.1	303056.63	1247230.61	535.19	391.0	6,438	391.3	687	391.4	847	391.2	1,505	
3	452.9-455.7	303094.88	1247181.97	531.36	453.1	14,085	453.4	1,859	453.6	1,511	453.3	1,732	
4	510.0-511.6	303130.15	1247137.20	527.97	510.2	15,952	510.5	1,584	510.7	1,636	510.4	1,753	
5	560.0-562.0		1247098.29	525.57	560.2	14,695	560.5	1,508	560.7	2,228	560.4	1,658	
6	619.0-622.6	303199.13	1247052.94	523.75	619.7	12,446	620.0	702	620.1	833	619.9	2,516	
7	678.5-680.8	303237.52	1247007.50	522.45	678.7	21,215	679.0	1,865	679.2	1,807	678.9	2,406	
8	740.0-741.6	303277.20	1246960.53	521.11	740.2	15,702	740.5	1,326	740.7	2,167	740.4	1,801	
9	802.0-804.2	303317.38	1246913.33	519.73	802.1	16,876	802.4	1,726	802.5	1,465	802.3	3,373	
10	861.0-862.5	303356.35	1246869.06	518.30	861.2	15,926	861.5	1,540	861.7	1,996	861.4	2,019	
11	915.8-918.0	303392.56	1246827.95	516.97	915.9	8,810	916.2	531	916.3	873	916.1	2,229	
12	970.3-971.8	303428.57	1246787.06	515.65	970.4	10,207	970.7	706	970.8	867	970.6	1,753	
13	1028.0-1029.4	303466.70	1246743.77	514.25	1028.2	11,000	1028.5	13,632	1028.7	16,391	1028.4	1,532	
14	1089.0-1090.0	303507.84	1246698.77	512.68	1089.2	11,599	1089.5	7,208	1089.7	19,322	1089.4	1,431	
15	1148.5-1150.0		1246655.09	511.12	1148.7	20,445	1149.0	20,473	1149.2	24,908	1148.9	2,611	
16	1208.5-1210.5		1246611.05	509.55	1208.7	16,800	1209.0	16,838	1209.2	21,884	1208.9	2,101	
17	1269.2-1270.8		1246566.49	507.96	1269.3	13,942	1269.6	18,787	1269.7	22,972	1269.5	2,635	
18	1300.0-1301.6	303651.17	1246544.02	507.19									99.1%
19	1330.0-1332.0	303671.83	1246522.27	506.47	1330.2	19,298	1330.5	16,739	1330.7	8,226	1330.4	1,693	
20	1340.5-1342.0	303679.06	1246514.66	506.21									98.8%
			1246486.47	505.28									94.3%
	1389.0-1390.5			505.04	1389.2	7,193	1389.5	6,019	1389.7	7,008	1389.4	1,005	
23	1415.0-1416.9	303754.45	1246435.30	503.58									92.3%
	1450.7-1452.6		1246434.79	503.56	1450.9	5,673	1451.2	4,140	1451.4	8,266	1451.1	1,075	
25	1453.7-1454.8	303757.00	1246432.62	503.49									91.5%
	1494.2-1495.7	303784.88	1246403.26	502.51									85.6%
	1510.0-1511.5	303795.76	1246391.81	502.13	1510.2	6,056	1510.5	2,023	1510.7	4,079	1510.4	788	
	1539.0-1540.5		1246370.88	501.43									91.1%
			1246347.34	500.64	1573.3	6,197	1573.0	2,581	1572.8	6,725	1573.1	962	
30	1580.5-1582.0	303844.90	1246341.29	500.43									95.8%
	1619.0-1621.0		1246313.89	499.51									97.3%
	1630.0-1631.5		1246306.07	499.24	1630.2	8,178	1630.5	7,360	1630.7	7,499	1630.4	1,035	
	1657.6-1659.0		1246286.43	498.58									96.2%
	1688.0-1689.5		1246264.79	497.84	1688.2	4,022	1688.5	4,186	1688.9	10,330	1688.4	805	
	1702.0-1703.5		1246254.83	497.51									91.5%
	1740.0-1741.5		1246227.79	496.59									94.0%
	1750.0-1752.0		1246220.68	496.35	1750.3	6,881	1750.6	4,198			1750.5	1,232	
	1753.2-1754.6		1246218.40	496.27									
	1780.0-1781.5		1246199.38	495.65									96.5%
	1807.1-1807.0			495.13			1807.2	3,761	1807.4	4,424			
	1809.2-1810.3				1809.9	7,442							
	1810.4-1811.3			495.08							1811.3	1,099	
	1823.5-1824.6			494.88									94.2%
	1859.5-1861.0			494.32									93.5%
	1865.8-1866.8			494.22			1866.7	2,023	1866.5	4,911			
	1867.1-1868.5			494.20							1868.1	1,306	
47	1870.0-1871.3	304049.58	1246136.67	494.16	1870.5	7,432							

Form No: D5731-1 Revision No. 0

Revision No. 0 Revision Date: 4/26/2011

Point Load Strength Index of Rock

ASTM D5731, ISRM Point Load Test

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 3777 Sample Date: 6/3/2011

> 1831-10-5629 Louisville Tunnel

> > Project Name:

Project #:

 Report Date:
 6/23/2011

 Test Date(s):
 6/22/2011

			Failure	Type	8	1	9	5	0	1	3	10	6	2, 3	3	1	
			land.		_	_								_	-		
			Stress	(isd)	493	593	687	847	1859	1511	1584	1636	1508	2228	702	833	
		_			24.5	30.5	24.0	30.0	37.0	45.5	35.5	46.0	38.0	45.5	24.0	30.5	
I				ח (שש) ח	25.0	31.0	24.5	31.0	38.0	47.0	36.5	47.0	39.0	47.0	25.0	31.5	
			W (Diam)	(Axial)	1.24	N/A	1.24	N/A	1.86	N/A	1.86	N/A	1.86	N/A	1.24	N/A	
		Specimen Check (Axial 0.3W <d<w), (diametral="" (l="">0.5D)</d<w),>	L (0.5 Length)	(Diametral)	N/A	0.94	N/A	0.95	N/A	1.40	N/A	1.40	N/A	1.40	N/A	0.94	
•), (Dian	in)	Avg	1.01	1.87	0.97	1.89	1.51	2.79	1.45	2.81	1.56	2.81	0.99	1.87	
		W>Q>1	ecimen (e S	1.02	1.87	0.98	1.90	1.50	2.80	1.46	2.81	1.55	2.79	0.99	1.88	
		al 0.3W	Length of Specimen (in)	~1	1.01	1.87	0.97	1.90	1.50	2.79	1.46	2.81	1.56	2.81	66.0	1.87	
		cck (Axi	Leng	-	1.01	1.87	0.97	1.88	1.52	2.78	1.44	2.80	1.56	2.82	66.0	1.86	
		nen Cho	(in)	Avg	1.24	1.24	1.24	1.23	1.86	1.86	1.86	1.86	1.86	1.86	1.24	1.24	
		Specin	Diameter of Specimen (in)	3	1.24	1.24	1.23	1.24	1.86	1.86	1.86	1.86	1.86	1.86	1.24	1.24	
			eter of S _l	0	1.24	1.24	1.24	1.23	1.86	1.86	1.86	1.86	1.86	1.86	1.24	1.24	
			Diamo	-	1.24	1.24	1.24	1.23	1.86	1.86	1.86	1.86	1.86	1.86	1.24	1.24	
			Folliation /	Joint Dip	W	W	MP	MP	MP	MP	M	M	W	W	M	M	
			Aniso.	Load	N/A												
			Test	Type	A	Ω	A	Ω	A	D	A	D	A	۵	A	D	
			Moisture	Condition	As-Received												
			Rock	Type	Limestone												
			Distance	(¥)	333.3	333.4	391.3	391.4	453.4	453.6	510.5	510.7	560.5	560.7	620.0	620.1	
	ess:			poing in	NB-1 Run 51 Box 24	NB-1 Run 51 Box 24	NB-2 Run 57 Box 28	NB-2 Run 57 Box 28	NB-3 Run 64 Box 33	NB-3 Run 64 Box 33	NB-4 Run 70 Box 36	NB-4 Run 70 Box 36	NB-5 Run 75 Box 40	NB-5 Run 75 Box 40	NB-6 Run 81 Box 44	NB-6 Run 81 Box 44	
Client Name:	Client Address:		Lab	A	C11-128	C11-128	C11-129	C11-129	C11-130	C11-130	C11-131	C11-131	C11-132	C11-132	C11-133 N	C11-133 N	

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

Anisotropic Load: 🗕 = Load applied perpendicular to anisotropic planes 🛛 🛛 = Load applied parallel to anisotropic planes.

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of I, and De

Notes / Deviations / References: ASTM D5731

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Quality Assurance

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Form No: D5731-1 Revision No. 0

Revision Date: 4/26/2011

Point Load Strength Index of Rock

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777 ASTM D5731, ISRM Point Load Test

6/10/2011 Sample Date:

> Louisville Tunnel 1831-10-5629

> > Project Name:

Project #:

Client Name:

6/27/2011 Report Date: Test Date(s):

Client Address:	idress:				2																
										Specir	nen Che	ck (Axi	al 0.3W	<pre>(M>d></pre>	, (Diam	Specimen Check (Axial 0.3W <d<w), (diametral="" (l="">0.5D)</d<w),>			_		
Lab	Boring ID	Distance	Rock	Moisture	Test	Aniso.	Folliation /	Dian	Diameter of Specimen (in)	pecimen	(in)	Leng	Length of Specimen (in)	cimen (ii		L (0.5 Length)	W (Diam)	() (1	11,14	Stress	Failure
Ð		(Ų)	Type	Condition	Type	Load	Joint Dip	1	5	3	Avg	1	5	3	Avg	(Diametral)	(Axial)			(isd)	Type
C11-162	NB-7 Run 87 Box 48	679.0	Limestone	As-Received	×	N/A	M	1.87	1.87	1.87	1.87	1.50	1.50	1.50	1.50	N/A	1.87	38.0	37.0	1865	e
C11-162	NB-7 Run 87 Box 48	679.2	Limestone	As-Received	D	≟ PSF	MP	1.87	1.87	1.87	1.87	2.91	2.91	2.89	2.90	1.45	N/A	47.0	46.0	1807	61
C11-163	NB-8 Run 93 Box 52	740.5	Limestone	As-Received	¥	N/A	MP	1.86	1.86	1.86	1.86	1.52	1.50	1.53	1.52	N/A	1.86	38.5	37.5	1326	ŝ
C11-163	NB-8 Run 93 Box 52	740.7	Limestone	As-Received	D	N/A	MP	1.86	1.86	1.86	1.86	2.92	2.92	2.93	2.92	1.46	N/A	47.0	46.0	2167	2, 3
C11-164	NB-9 Run 100 Box 56	802.4	Limestone	As-Received	A	N/A	M	1.24	1.24	1.24	1.24	1.05	1.06	1.06	1.06	N/A	1.24	27.0	26.0	1726	'n
C11-164	NB-9 Run 100 Box 56	802.5	Limestone	As-Received	۵	N/A	M	1.24	1.24	1.24	1.24	1.92	1.92	1.92	1.92	0.96	N/A	31.0	30.5	1465	2, 3
C11-165	NB-10 Run 106 Box 60	861.5	Limestone	As-Received	A	N/A	MP	1.86	1.86	1.86	1.86	1.52	1.51	1.51	1.51	N/A	1.86	38.0	37.0	1540	ŝ
C11-165	NB-10 Run 106 Box 60	861.7	Limestone	As-Received	D	± PSF	MP	1.86	1.86	1.86	1.86	2.90	2.90	2.90	2.90	1.45	N/A	47.0	46.0	1996	61
C11-166	NB-11 Run 111 Box 64	916.2	Limestone	As-Received	A	N/A	MP	1.24	1.24	1.24	1.24	1.05	1.05	1.06	1.05	N/A	1.24	26.5	26.0	531	Ś
C11-166	NB-11 Run 111 Box 64	916.3	Limestone	As-Received	D	± PSF	MP	1.24	1.24	1.24	1.24	1.88	1.87	1.89	1.88	0.94	N/A	31.0	30.0	873	6
C11-167	C11-167 NB-12 Run 117 Box 67	970.7	Limestone	As-Received	A	N/A	AM	1.24	1.24	1.24	1.24	1.00	0.99	0.98	66.0	N/A	1.24	25.0	24.0	706	e
C11-167	NB-12 Run 117 Box 67	970.8	Limestone	As-Received	D	± PSF	MP	1.24	1.24	1.24	1.24	1.87	1.85	1.87	1.86	0.93	N/A	31.0	30.5	867	сі
														-	-						
																			1		

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

= Load applied parallel to anisotropic planes. ± = Load applied perpendicular to anisotropic planes Anisotropic Load:

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of L, and De.

ASTM D5731 Notes / Deviations / References:

Reviewed By:

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Date:



Quality Assurance

6/28/2011

Form No: D5731-1	Revision No. 0

Revision Date: 4/26/2011

Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test



Quality Assurance

Report Date: 7/1/2011

 Project #:
 1831-10-5629

 Project Name:
 Louisville Tunnel Project

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777 Sample Date: 6/17/2011

3011 Date: // 1/20

Sc	(isd)	13,632	16,391	7,208	19,322	20,473	24,908				Γ	
Failure	Type	с	5	1,3	7	m	2					
I _{S(50)}	(psi)	596	717	315	845	894	1090					
μ	4	0.975	0.968	0.972	0.965	0.977	0.968					
ĥ	(isi)	611	741	324	876	915	1126					
Load	(Ibs)	2115	2482	1105	2901	3202	3772					
D°	(in)	1.86	1.83	1.85	1.82	1.87	1.83					
D°5	(in)	3.46	3.35	3.41	3.31	3.50	3.35					
D,	(in)	1.46	1.81	1.44	1.79	1.48	1.81					
D	(in)	1.50	1.85	1.48	1.85	1.52	1.85					
M	(in)	1.86	N/A	1.86	N/A	1.86	N/A					
Folliation /	Joint Dip	MP	MP	MP	MP	M	M					
Aniso.	Load	PSF	± PSF	PSF	± PSF	N/A	N/A					
Test	Type	A	D	A	D	A	D					
Moisture	Condition	As-Received	Limestone As-Received	As-Received	As-Received	As-Received	As-Received					
Rock	Type	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone As-Received					
Distance	(ft)	1028.5	1028.7	1089.5	1089.7	1149.0	1149.2					
Boring ID	an Simoa	NB-13 Run 122 Box 71	C11-168 NB-13 Run 122 Box 71	C11-169 NB-14 Run 128 Box 75	NB-14 Run 128 Box 75	NB-15 Run 134 Box 79	C11-170 NB-15 Run 134 Box 79					
Lab	A	C11-168	C11-168	C11-169	C11-169	C11-170	C11-170					

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

 Load applied parallel to anisotropic planes. = Load applied perpendicular to anisotropic planes Anisotropic Load:

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of I, and De-

Notes / Deviations / References: ASTM D5731

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S&ME, Inc. - Corporate

3201 Spring Forest Road Raleigh, NC.. 27616

Form No: D5731-1 Revision No. 0

Revision No. 0 Revision Date: 4/26/2011

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

6/24/2011

Sample Date:

1831-10-5629 Louisville Tunnel Project

Project Name:

Project #:

Report Date: 7/29/2011

S&ME

Quality Assurance

Sc	(isd)	16,838	21,884	18,787	22,972	16,739	8.226	6,019	7,008	4,140	8,266		
Failure	Type	с	2	ю	2	3	7	3	4	'n	5		
I _{S(50)}	(isd)	736	958	793	963	731	360	263	306	181	362		
μ	4	0.970	0.963	0.812	0.800	0.98	0.963	0.987	0.972	0.982	0.958		
ŗ	(isd)	759	995	976	1204	746	374	266	315	184	378		
Load	(lbs)	2565	3254	1513	1734	2647	1222	965	1076	661	1211		
صٌ	(in)	1.84	1.81	1.24	1.20	1.88	1.81	1.91	1.85	1.89	1.79		
D [~]	(in)	3.38	3.27	1.55	1.44	3.55	3.27	3.63	3.42	3.59	3.20		
D'	(in)	1.42	1.77	86.0	1.18	1.50	1.77	1.54	1.85	1.54	1.77		
D	(in)	1.46	1.85	1.00	1.22	1.54	1.85	1.57	1.85	1.57	1.81		
M	(in)	1.87	N/A	1.24	N/A	1.86	N/A	1.85	N/A	1.83	N/A		
Folliation /	Joint Dip	M	M	M	M	M	W	M	W	M	W		
Aniso.	Load	N/A	N/A	PSF	PSF	N/A	N/A	N/A	N/A	N/A	N/A		
Test	Type	A	D	A	D	A	D	A	D	A	D		
Moisture	Condition	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received		
Rock	Type	L'ville Limestone	L'ville Limestone As-Received	Waldron Shale As-Received	Waldron Shale	Waldron Shale	Waldron Shale	Waldron Shale As-Received	Waldron Shale	Waldron Shale	Waldron Shale		
Distance	(ţJ)	1209.0	1209.2	1269.6	1269.7	1330.5	1330.7	1389.5	1389.7	1451.2	1451.4		
Boring ID	an gilling	NB-16 Run 140 Box 83	NB-16 Run 140 Box 83	C11-193 NB-17 Run 147 Box 87	C11-193 NB-17 Run 147 Box 87	NB-19 Run 153 Box 91	NB-19 Run 153 Box 91	C11-198 NB-22 Run 159 Box 95	C11-198 NB-22 Run 159 Box 95	C11-200 NB-24 Run 165 Box 99	NB-24 Run 165 Box 99		
Lab	D	C11-192	C11-192	C11-193	C11-193	C11-195	C11-195	C11-198	C11-198	C11-200	C11-200		

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

 Load applied parallel to anisotropic planes. = Load applied perpendicular to anisotropic planes Anisotropic Load:

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of I, and De.

Notes / Deviations / References: ASTM D5731



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

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

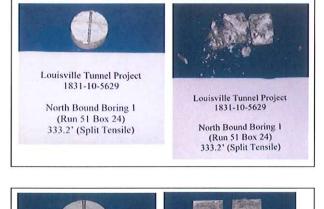
Sample Date: 6/3/2011

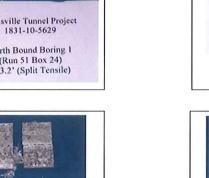
Report Date: 6/23/2011

Distance **Specimen Dimension** Bulk Moisture Maximum Load Strength Hole ID (Sample #) (ft) Diameter Thickness t/D Density Content Load Rate (lb/ft^3) (in) (in) Ratio (%) (lbs) (psi/min) (psi) NB-1 Run 51 Box 24 333.2 1.24 0.82 0.66 166.6 0.1 2,810 918 1,759 NB-2 Run 57 Box 28 391.2 1.24 0.87 0.70 160.0 2,550 759 1,505 0.8 NB-3 Run 64 Box 33 453.3 1.86 167.6 0.2 1,732 1.14 0.61 5,770 962 NB-4 Run 70 Box 36 510.4 1.86 1.16 0.62 165.0 0.4 5,940 751 1,753 1.09 NB-5 Run 75 Box 40 560.4 1.86 0.59 164.6 0.4 896 1,658 5,280 NB-6 Run 81 Box 44 619.9 1.24 0.81 0.65 166.3 0.4 3,970 1,227 2,516

NOTE:

Bulk Density includes any moisture that is within the specimen.





Louisville Tunnel Project 1831-10-5629

North Bound Boring 3 (Run 64 Box 33) 453.3' (Split Tensile)

Louisville Tunnel Project

1831-10-5629

North Bound Boring 5

(Run 75 Box 40)

560.4' (Split Tensile)

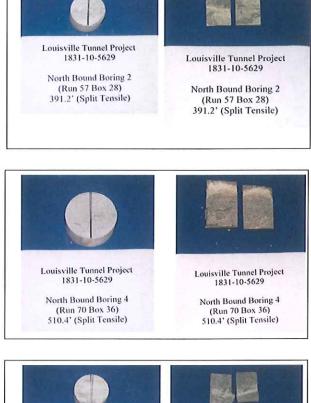


Louisville Tunnel Project 1831-10-5629

North Bound Boring 3

(Run 64 Box 33)

453.3' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 6 (Run 81 Box 44) 619.9' (Split Tensile) Louisville Tunnel Project 1831-10-5629

North Bound Boring 6 (Run 81 Box 44) 619.9' (Split Tensile)



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

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

Sample Date: 6/10/2011

Report Date: 6/28/2011

	Distance	Speci	men Dimensi	on	Bulk	Moisture	Maximum	Load	Strength
Hole ID (Sample #)	(ft)	Diameter (in)	Thickness (in)	t/D Ratio	Density (lb/ft ³)	Content (%)	Load (lbs)	Rate (psi/min)	(psi)
NB-7 Run 87 Box 48	678.9	1.87	1.18	0.63	164.3	0.2	8,340	1,094	2,406
NB-8 Run 93 Box 52	740.4	1.86	1.18	0.63	168.3	0.2	6,210	688	1,801
NB-9 Run 100 Box 56	802.3	1.24	0.79	0.64	169.0	0.1	5,190	1,163	3,373
NB-10 Run 106 Box 60	861.4	1.86	1.20	0.65	168.9	0.1	7,080	1,072	2,019
NB-11 Run 111 Box 64	916.1	1.24	0.85	0.69	166.2	0.1	3,690	1,262	2,229
NB-12 Run 117 Box 67	970.6	1.24	0.82	0.66	169.5	0.3	2,800	1,267	1,753

NOTE:

Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project 1831-10-5629

North Bound Boring 7 (Run 87 Box 48) 678.9' (Split Tensile)

Louisville Tunnel Project

1831-10-5629

North Bound Boring 9

(Run 100 Box 56)

802.3' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 7 (Run 87 Box 48) 678.9' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 9 (Run 100 Box 56) 802.3' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 8 (Run 93 Box 52) 740.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 8 (Run 93 Box 52) 740.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 10 (Run 106 Box 60) 861.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 10 (Run 106 Box 60) 861.4' (Split Tensile)





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

Project #: **Project Name:** 1831-10-5629

Sample Date: 6/17/2011 Report Date: 7/1/2011

Louisville Tunnel Project

	Distance	Speci	men Dimensi	on	Bulk	Moisture	Maximum	Load	Strength
Hole ID (Sample #)	(ft)	Diameter	Thickness	t/D	Density	Content	Load	Rate	
		(in)	(in)	Ratio	(lb/ft ³)	(%)	(lbs)	(psi/min)	(psi)
NB-13 Run 122 Box 71	1,028.4	1.87	1.20	0.64	166.9	0.4	5,400	766	1,532
NB-14 Run 128 Box 75	1,089.4	1.86	1.27	0.68	168.5	0.4	5,310	641	1,431
NB-15 Run 134 Box 79	1,148.9	1.86	1.21	0.65	171.3	0.2	9,230	699	2,611

NOTE:

Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project 1831-10-5629

North Bound Boring 13 (Run 122 Box 71) 1028.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 13 (Run 122 Box 71) 1028.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 14 (Run 128 Box 75) 1089.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 14 (Run 128 Box 75) 1089.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 15 (Run 134 Box 79) 1148.9' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 15 (Run 134 Box 79) 1148.9' (Split Tensile)



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

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

Sample Date: 6/24/2011

Report Date: 7/29/2011

	Distance	Speci	men Dimensi	on	Bulk	Moisture	Maximum	Load	Strength
Hole ID (Sample #)	(ft)	Diameter (in)	Thickness (in)	t/D Ratio	Density (lb/ft ³)	Content (%)	Load (lbs)	Rate (psi/min)	(psi)
NB-16 Run 140 Box 83	1,208.9	1.87	1.16	0.62	170.8	0.1	7,160	1,341	2,101
NB-17 Run 147 Box 87	1,269.5	1.24	0.83	0.67	169.5	0.2	4,260	2,592	2,635
NB-19 Run 153 Box 91	1,330.4	1.86	1.14	0.61	167.5	0.1	5,640	1,168	1,693
NB-22 Run 159 Box 95	1,389.4	1.85	1.14	0.62	161.0	1.3	3,330	773	1,005
NB-24 Run 165 Box 99	1,451.1	1.83	1.12	0.61	164.4	1.5	3,460	921	1,075

NOTE:

Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project 1831-10-5629

North Bound Boring 16 (Run 140 Box 83) 1208.9' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 16 (Run 140 Box 83) 1208.9' (Split Tensile)



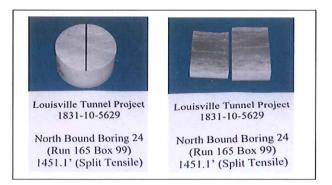
Louisville Tunnel Project 1831-10-5629

North Bound Boring 19 (Run 153 Box 91) 1330.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 19 (Run 153 Box 91) 1330.4' (Split Tensile)





Louisville Tunnel Project 1831-10-5629

North Bound Boring 17 (Run 147 Box 87) 1269.5' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 17 (Run 147 Box 87) 1269.5' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 22 (Run 159 Box 95) 1389.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 22 (Run 159 Box 95) 1389.4' (Split Tensile)

"OMPRESSION	Method C)
JNCONFINEL	(ASTM D;



6/3/2011 Sample Date:

6/23/2011

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

Report Date:

Sample	Boring	Distance	Specimen Dimen	Dimension, in.	Area	Bulk Density	Loading Rate	Max. Load	Strength	Moisture
No.	Location	(ft)	Length	Diameter	(in^2)	(lb/ft ³)	(psi/sec)	(II)	(psi)	(%)
NB-1	Run 51 Box 24	333.1	2.70	1.24	1.21	169.1	88	8,720	7,207	0.1
NB-2	Run 57 Box 28	391.0	2.65	1.24	1.21	162.2	92	7,790	6,438	0.7
NB-3	Run 64 Box 33	453.1	4.05	1.86	2.72	167.0	85	38,310	14,085	0.3
NB-4	Run 70 Box 36	510.2	4.10	1.86	2.72	165.4	06	43,390	15,952	0.4
NB-5	Run 75 Box 40	560.2	4.09	1.86	2.72	167.5	96	39,970	14,695	0.3
NB-6	Run 81 Box 44	619.7	2.65	1.24	1.21	168.1	86	15,060	12,446	0.3
NOTES:	Bulk Density includes any moisture that is within the specimen	sture that is within the	specimen.							



Unconfined Compression Cores received 6-03-11 North Bound.xls Page 1 of 1

3201 Spring Forest Road

Raleigh, NC 27616

S&ME, Inc. - Corporate

"OMPRESSION	Method C)
UNCONFINEL	(ASTM D7



6/10/2011 Sample Date:

6/28/2011 Report Date:

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

Sample	Boring	Distance	Specimen Di	dimension, in.	Area	Bulk Density	Loading Rate	Max. Load	Strength	Moisture
No.	Location	(ft)	Length	Diameter	(in^2)	(lb/ft ³)	(psi/sec)	(Ib)	(psi)	(%)
NB-7	Run 87 Box 48	678.7	4.07	1.87	2.75	164.2	66	58,340	21,215	0.2
NB-8	Run 93 Box 52	740.2	4.03	1.86	2.72	169.0	108	42,710	15,702	0.2
NB-9	Run 100 Box 56	802.1	2.72	1.24	1.21	169.7	109	20,420	16,876	0.1
NB-10	Run 106 Box 60	861.2	4.03	1.86	2.72	170.0	94	43,320	15,926	0.1
NB-11	Run 111 Box 64	915.9	2.63	1.24	1.21	170.6	94	10,660	8,810	0.1
NB-12	Run 117 Box 67	970.4	2.65	1.24	1.21	169.0	113	12,350	10,207	0.3
NOTES:	Bulk Density includes any moisture that is within the specimen	ture that is within the	specimen.							



North Bound Boring 7 (Run 87 Box 48) 678.7' (Unconfined)







-bad

Louisville Tunnel Project 1831-10-5629 North Bound Boring 8 (Run 93 Box 52) 740.2' (Unconfined)





North Bound Boring 8 (Run 93 Box 52) 740.2" (Unconfined)







Louisville Tunnel Project 1831-10-5629

Louisville Tunnel Project 1831-10-5629

North Bound Boring 10 (Run 106 Box 60) 861.2" (Unconfined)

North Bound Boring 9 (Run 100 Box 56) 802.1° (Unconfined)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 9 (Run 100 Box 56) 802.1' (Unconfined)

North Bound Boring 10 (Run 106 Box 60) 861.2' (Unconfined) Louisville Tunnel Project 1831-10-5629

.85%-

North Bound Boring 11 (Run 111 Box 64) 915.9' (Unconfined) Louisville Tunnel Project 1831-10-5629













Louisville Tunnel Project 1831-10-5629

North Bound Boring 12 (Run 117 Box 67) 970.4' (Unconfined)

North Bound Boring 11 (Run 111 Box 64) 915.9° (Unconfined)

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3201 Spring Forest Road Raleigh, NC 27616

~ OMPRESSION	Method C)
UNCONFINEL	(ASTM D;



6/17/2011 Sample Date:

7/1/2011

Project Name: Louisville Tunnel Project

Project #: 1831-10-5629

Report Date:

Sample	Boring	Distance	Specimen D	Dimension, in.	Area	Bulk Density	Loading Rate	Max. Load	Strength	Moisture
No.	Location	(ft)	Length	Diameter	(in^2)	(lb/ft ³)	(psi/sec)	(Ib)	(psi)	(%)
NB-13	Run 122 Box 71	1028.2	4.07	1.86	2.72	168.2	66	29,920	11,000	0.4
NB-14	Run 128 Box 75	1089.2	4.03	1.86	2.72	168.3	85	31,550	11.599	0.4
NB-15	Run 134 Box 79	1148.7	4.10	1.86	2.72	171.8	104	55,610	20,445	0.2

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



Louisville Tunnel Project 1831-10-5629

North Bound Boring 13 (Run 122 Box 71) 1028.2* (Unconfined)



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Louisville Tunnel Project 1831-10-5629

North Bound Boring 14 (Run 128 Box 75) 1089.2* (Unconfined)

North Bound Boring 15 (Run 134 Box 79) 1148.7* (Unconfined)

Louisville Tunnel Project 1831-10-5629



North Bound Boring 14 (Run 128 Box 75) 1089.2' (Unconfined)

Unconfined Compresion Cores received 6-17-11 North Bound.xls

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North Bound Boring 15 (Run 134 Box 79) 1148.7' (Unconfined)

Louisville Tunnel Project 1831-10-5629

Page 1 of 1

DESSION	d C)
NCONFINED COM	(ASTM D7012 M



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

6/24/2011 Sample Date:

7/29/2011 Report Date:

Sample	Boring	Distance	Specimen L	Specimen Dimension, in.	Area	Bulk Density	Loading Rate	Max. Load	Strength	Moisture
No.	Location	(ft)	Length	Diameter	(in ²)	(Ib/ft ³)	(psi/sec)	(Ib)	(psi)	(%)
NB-16	Run 140 Box 83	1208.7	4.07	1.87	2.75	171.2	87	46,200	16,800	0.1
NB-17	Run 147 Box 87	1269.3	2.64	1.24	1.21	172.2	95	16,870	13,942	0.1
NB-19	Run 153 Box 91	1330.2	4.06	1.86	2.72	167.8	87	52,490	19,298	0.3
NB-22	Run 159 Box 95	1389.2	4.00	1.85	2.69	160.5	86	19.350	7,193	1.1
NB-24	Run 165 Box 99	1450.9	3.91	1.83	2.63	165.1	85	14,920	5.673	0.9
NOTES:	Bulk Density includes any moisture that is within the specimen.	ture that is within the	specimen.							



North Bound Boring 16 (Run 140 Box 83) 1208.7' (Unconfined) Louisville Tunnel Project 1831-10-5629

Louisville Tunnel Project 1831-10-5629

North Bound Boring 17 (Run 147 Box 87) 1269.3' (Unconfined)



North Bound Boring 17 (Run 147 Box 87) 1269.3* (Unconfined)

Louisville Tunnel Project 1831-10-5629

North Bound Boring 16 (Run 140 Box 83) 1208.7* (Unconfined)

Louisville Tunnel Project 1831-10-5629





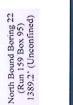
North Bound Boring 19 (Run 153 Box 91) 1330.2* (Unconfined)

Louisville Tunnel Project 1831-10-5629

North Bound Boring 24 (Run 165 Box 99) 1450.9* (Unconfined)

Louisville Tunnel Project 1831-10-5629

Louisville Tunnel Project 1831-10-5629







North Bound Boring 24 (Run 165 Box 99) 1450.9' (Unconfined)

Louisville Tunnel Project 1831-10-5629

Unconfined Compression Cores received 6-24-11 North Bound xls

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S&ME, Inc. - Corporate

Page 1 of 1

			Moisture	1.8	1.3	1.1	1.3	1	Real Protocol Protoco
S&ME		8/9/2011	Strength (nsi)	6.056	6,197	8,178	4,022	1000	American from the former of th
		Report Date:	Max. Load	16,110	16,670	22,000	10,820	2	
	37777		Loading Rate	81	79	80	53	a	Louisville Tunnel Project 1831-10-5629 Nerth Ikanid Ikoring 34 (Kuri 189 Ikov 110) 1688.2 (Uncertified) 1688.2 (Uncertified) 1688.2 (Uncertified) 1688.2 (Uncertified) 1688.2 (Uncertified)
SSION C)	d, Louisville, TN		Bulk Density	162.8	163.1	162.9	164.9	1.101	
UNCONFI, الم COMPRESSION (ASTM D7012 Method C)	S&ME, Inc Knoxville 1413 Topside Road, Louisville, TN 37777	7/1/2011	Area (in ²)	2.66	2.69	2.69	2.69	201	Louisette Taned Project 1.011-010-5629 1630.2 (Unconfined) 1630.2 (Unconfined) 1630.2 (Unconfined) 1630.2 (Unconfined)
UNCONFI (ASTM	- Knoxville 1-	Sample Date:	Specimen Dimension, in. I anoth Diamater	1.84	1.85	1.85	1.85	00.1	
	S&ME, Inc.		Specimen I	3.91	3.94	4.05	3.97	te specimen.	Minel Project 0-5629 d Baring 29 Baring 29 Baring 29 Rennig 29 Baring 29 antined)
		ct	Distance	1510.2	1573.3	1630.2	1688.2	sture that is within th	Louisville Tunnel Project 1831-10-5629 North Bound Boring 29 (Run 178 Boxn 108) 1573.37 (Unconfined) 1573.37 (Unconfined) Lausville Tunnel Project 1831-10-5629 (Run 178 Box 108) 1573.37 (Unconfined)
		Project #: 1831-10-5629 Project Name: Louisville Tunnel Project	Boring	Run 172 Box 104	Run 178 Box 108	Run 183 Box 112	Run 189 Box 116	Bulk Density includes any moisture that is within the specimen.	Physics 1 Physics 1 Physics 1 Physics 2 Physics 2 Physics 2 Physics 1 Physics 1
		Project Mame:	Sample	NB-27	NB-29	NB-32	NB-34	NOTES:	Lausselle Tunnel Project 1831-10-5629 North Bound Boring 27 (Bun 172 Box 104) 1510-2 (Unconfined) 1531-10-5629 North Bound Boring 27 (Bun 172 Box 104) 1510-2 (Unconfined)

S&ME, Inc. - Corporate

3201 Spring Forest Road Rateigh, NC 27616

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Unconfined Compression Cores received 7-01-11 North Bound Page 1 of 1

COMPRESSION (ASTM D7012 Method C) UNCONFIL



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

Sample Date:

8/12/2011

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

7/8/2011

Report Date:

Sample	Boring	Distance	Specimen D	Dimension, in.	Area	Bulk Density	Loading Rate	Max. Load	Strength	Moisture
No.	Location	(ft)	Length	Diameter	(in^2)	(lb/ft ³)	(psi/sec)	(1b)	(psi)	(%)
NB-41	Run 201 Box 124	1809.9	4.06	1.85	2.69	164.5	16	20,020	7,442	1.1
NB-47	Run 207 Box 128	1870.5	3.97	1.84	2.66	165.1	92	19,770	7,432	1.5

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



Louisville Tunnel Project 1831-10-5629

North Bound Boring 41 (Run 201 Box 124) 1809.9* (Unconfined)



North Bound Boring 41 (Run 201 Box 124) 1809.9° (Unconfined)



Louisville Tunnel Project 1831-10-5629 North Bound Boring 47 (Run 207 Box 128) 1870.5' (Unconfined)



North Bound Boring 47 (Run 207 Box 128) 1870.5' (Unconfined)

Unconfined Compression Cores received 7-08-11 North Bound Page 1 of 1

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S&ME, Inc. - Corporate

Form No: D5731-1	Revision No. 0	ision Date: 4/26/2011
Form N	Revisio	Revision

Point Load Strength Index of Rock (for Horizontal Borings)

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

Sample Date:

1831-10-5629 Louisville Tunnel Project

Project Name:

Project #:

6/24/2011

ASTM D5731, ISRM Point Load Test



Kumar

Report Date: 7/29/2011

Sc	(isd)	16,838	21,884	18,787	22,972	16,739	8,226	6,019	7,008	4,140	8,266		
Failure	Type	e	2	ŝ	6	ŝ	7	'n	4	m	6		
I _{S(50)}	(isd)	736	958	793	963	731	360	263	306	181	362		
μ	4	0.970	0.963	0.812	0.800	0.98	0.963	0.987	0.972	0.982	0.958		
цř	(isi)	759	566	976	1204	746	374	266	315	184	378		
Load	(lbs)	2565	3254	1513	1734	2647	1222	965	1076	661	1211		
പ്	(in)	1.84	1.81	1.24	1.20	1.88	1.81	1.91	1.85	1.89	1.79		
D°,	(in)	3.38	3.27	1.55	1.44	3.55	3.27	3.63	3.42	3.59	3.20		
D,	(in)	1.42	1.77	86.0	1.18	1.50	1.77	1.54	1.85	1.54	1.77		
D	(in)	1.46	1.85	1.00	1.22	1.54	1.85	1.57	1.85	1.57	1.81		
M	(in)	1.87	N/A	1.24	N/A	1.86	N/A	1.85	N/A	1.83	N/A		
Folliation /	Joint Dip	M	M	W	W	M	W	W	W	W	W		
Aniso.	Load	N/A	N/A	PSF	PSF	N/A	N/A	N/A	N/A	N/A	N/A		
Test	Type	A	D	A	D	A	D	A	D	A	D		
Moisture	Condition	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received	As-Received		
Rock	Type	L'ville Limestone	L'ville Limestone As-Received	Waldron Shale	Waldron Shale As-Received	Waldron Shale As-Received	Waldron Shale	Waldron Shale	Waldron Shale	Waldron Shale	Waldron Shale As-Received		
Distance	(Ĥ)	1209.0	1209.2	1269.6	1269.7	1330.5	1330.7	1389.5	1389.7	1451.2	1451.4		
Roring ID	an Simina	C11-192 NB-16 Run 140 Box 83	C11-192 NB-16 Run 140 Box 83	NB-17 Run 147 Box 87	C11-193 NB-17 Run 147 Box 87	C11-195 NB-19 Run 153 Box 91	C11-195 NB-19 Run 153 Box 91	C11-198 NB-22 Run 159 Box 95	C11-198 NB-22 Run 159 Box 95	C11-200 NB-24 Run 165 Box 99	C11-200 NB-24 Run 165 Box 99		
Lab	Ð	C11-192	C11-192	C11-193	C11-193	CI1-195	CI1-195	CI1-198	C11-198	C11-200	C11-200		

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

= Load applied parallel to anisotropic planes. = Load applied perpendicular to anisotropic planes Anisotropic Load:

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of I, and De-

Notes / Deviations / References: ASTM D5731

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D5731-I	Vo. 0
Form No:	Revision 1

revision No. y Revision Date: 4/26/2011

Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 3777 Sample Date: 7/1/2011

Report Date: 8/9/2011

Quality Assurance

S&ME

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

Sc	(isd)	2,023	4,079	2,581	6,725	7,360	7,499	4,186	10,330	4,198		
Failure	Type	ŝ	4	e	e	ŝ	5	3	5	3		
I _{S(50)}	(isd)	89	6/1	113	294	321	328	183	452	183		
μ	4	0.963	0.961	0.972	0.968	0.98	0.968	0.987	0.968	0.989		
ľ	(isd)	92	186	116	304	328	339	185	467	185		
Load	(lbs)	302	603	398	1020	1166	1137	671	1564	686		
Ď	(in)	1.81	1.80	1.85	1.83	1.88	1.83	16.1	1.83	1.92		
D°,	(in)	3.29	3.24	3.44	3.35	3.55	3.35	3.63	3.35	3.70		
'n	(in)	1.42	1.77	1.46	1.81	1.50	1.81	1.54	1.81	1.57		
D	(in)	1.46	1.83	1.50	1.85	1.54	1.85	1.57	1.85	1.59		
M	(in)	1.82	N/A	1.85	N/A	1.86	N/A	1.85	N/A	1.85		
Folliation /	Joint Dip	M	M	M	M	M	M	M	M	M		
Aniso.	Load	N/A	bed	N/A	bed	N/A	N/A	N/A	± bed	N/A		
Test	Type	A	D	¥	D	A	D	A	۵	A		
Moisture	Condition	As-Received										
Rock	Type	Waldron Shale	Waldron Shale	Waldron Shale	Waldron Shale As-Received	Waldron Shale	Waldron Shale	Waldron Shale	Waldron Shale As-Received	Waldron Shale As-Received		
Distance	(ft)	1510.5	1510.7	1573.0	1572.8	1630.5	1630.7	1688.5	1688.9	1750.6		
Boring ID		C11-225 NB-27 Run 172 Box 104	C11-225 NB-27 Run 172 Box 104	C11-227 NB-29 Run 178 Box 108	C11-227 NB-29 Run 178 Box 108	C11-230 NB-32 Run 183 Box 112	C11-230 NB-32 Run 183 Box 112	C11-234 NB-34 Run 189 Box 116	C11-234 NB-34 Run 189 Box 116	C11-235 NB-37 Run 195 Box 120		
Lab	Ð	C11-225	C11-225	C11-227	C11-227	C11-230	C11-230	C11-234	C11-234	C11-235		

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

= Load applied parallel to anisotropic planes. = Load applied perpendicular to anisotropic planes Anisotropic Load:

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of Is and De.

Notes / Deviations / References: ASTM D5731

A diametral test for NB-37 Run 195 Box 120 could not be obtained due to cracking within the reaminder of the core.

5731-1	0.0
No: D	ion N
Form	Revis

Revision Date: 4/26/2011

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: 7/8/2011

Quality Assurance Report Date: 8/12/2011

S&ME

 Project #:
 1831-10-5629

 Project Name:
 Louisville Tunnel Project

Sc	(isd)	3,761	4,424	2,023	4,911					
Failure	Type	3 NOTE	3 NOTE	ŝ	3 NOTE					
I _{S(50)}	(isd)	165	194	89	215					
۵ ۵	4	0.953	0.968	0.963	0.968					
L,	(isd)	173	200	92	222					
Load	(lbs)	542	671	302	743					
Ď	(in)	1.77	1.83	1.81	1.83					
D°7	(in)	3.14	3.35	3.28	3.35					
'n	(in)	1.34	1.81	1.40	1.81					
D	(in)	1.36	1.85	1.42	1.85					
M	(in)	1.84	N/A	1.84	N/A					
Folliation /	Joint Dip	M	M	M	M					
Aniso.	Load	N/A	bed	N/A	N/A					
Test	Type	A	D	A	D					
Moisture	Condition	As-Received	As-Received	As-Received	As-Received					
Rock	Type	Waldron Shale As-Received	Waldron Shale As-Received	Waldron Shale As-Received	Waldron Shale As-Received					
Distance	(ŧ)	1807.2	1807.4	1866.7	1866.5					
CI estero	Boring ID	C11-243 NB-40 Run 201 Box 124	C11-243 NB-40 Run 201 Box 124	C11-248 NB-45 Run 207 Box 128	C11-248 NB-45 Run 207 Box 128					
Lab	Ð	C11-243	C11-243	C11-248	C11-248					

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

= Load applied parallel to anisotropic planes. = Load applied perpendicular to anisotropic planes Anisotropic Load:

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

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

Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of 1, and De.

Notes / Deviations / References: ASTM D5731

NOTE: The failure was along the core axis but did not go through both contact points.

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3201 Spring Forest Road Raleigh, NC., 27616



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

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

Sample Date: 6/24/2011

Report Date: 7/29/2011

Distance **Specimen Dimension** Bulk Moisture Maximum Strength Load Hole ID (Sample #) Diameter Thickness (ft) t/D Density Content Load Rate (lb/ft^3) (in) (in) Ratio (%) (lbs) (psi/min) (psi) NB-16 Run 140 Box 83 1,208.9 1.87 1.16 0.62 170.8 0.1 7,160 1,341 2,101 NB-17 Run 147 Box 87 1,269.5 1.24 0.83 0.67 169.5 0.2 4,260 2,592 2,635 NB-19 Run 153 Box 91 1,330.4 1.86 1.14 0.61 167.5 0.1 5,640 1,693 1,168 NB-22 Run 159 Box 95 1,389.4 1.85 1.14 0.62 161.0 1.3 3,330 773 1,005 NB-24 Run 165 Box 99 1,451.1 1.83 0.61 1.5 921 1,075 1.12 164.4 3,460

NOTE:

Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project 1831-10-5629

North Bound Boring 16 (Run 140 Box 83) 1208.9' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 16 (Run 140 Box 83) 1208.9' (Split Tensile)



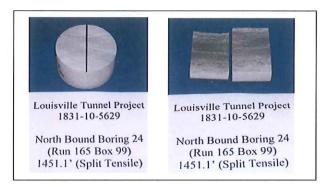
Louisville Tunnel Project 1831-10-5629

North Bound Boring 19 (Run 153 Box 91) 1330.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 19 (Run 153 Box 91) 1330.4' (Split Tensile)





Louisville Tunnel Project 1831-10-5629

North Bound Boring 17 (Run 147 Box 87) 1269.5' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 17 (Run 147 Box 87) 1269.5' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 22 (Run 159 Box 95) 1389.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 22 (Run 159 Box 95) 1389.4' (Split Tensile)



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

Project #:1831-10-5629Sample Date:7/1/2011Report Date:8/9/2011Project Name:Louisville Tunnel ProjectSample Date:7/1/2011Report Date:8/9/2011

	Distance	Specimen Dimension			Bulk	Moisture	Maximum	Load	Strength
Hole ID (Sample #)	(ft)	Diameter (in)	Thickness (in)	t/D Ratio	Density (lb/ft ³)	Content (%)	Load (lbs)	Rate (psi/min)	(psi)
NB-27 Run 172 Box 104	1,510.4	1.82	1.23	0.68	165.8	1.7	2,770	598	788
NB-29 Run 178 Box 108	1,573.1	1.85	1.08	0.58	161.4	1.3	3,020	1,069	962
NB-32 Run 183 Box 112	1,630.4	1.85	1.10	0.59	163.1	1.0	3,310	1,150	1,035
NB-34 Run 189 Box 116	1,688.4	1.85	1.12	0.61	163.4	1.2	2,620	1,342	805
NB-37 Run 195 Box 120	1,750.5	1.85	1.12	0.61	163.1	1.1	4,010	1,027	1,232

NOTE:

Bulk Density includes any moisture that is within the specimen.



Louisville Tunnel Project 1831-10-5629

North Bound Boring 27 (Run 172 Box 104) 1510.4* (Split Tensile)



Louisville Tunnel Project 1831-10-5629 North Bound Boring 27 (Run 172 Box 104) 1510.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 32 (Run 183 Box 112) 1630.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 32 (Run 183 Box 112) 1630.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 29 (Run 178 Box 108) 1573.1' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 29 (Run 178 Box 108) 1573.1' (Split Tensile)



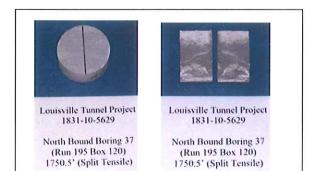
Louisville Tunnel Project 1831-10-5629

North Bound Boring 34 (Run 189 Box 116) 1688.4' (Split Tensile)



Louisville Tunnel Project 1831-10-5629

North Bound Boring 34 (Run 189 Box 116) 1688.4' (Split Tensile)



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 3201 Spring Forest Road
 Split Tensile Comparison

Raleigh, NC 27616

Split Tensile Cores received 7-01-11 (North Bound) Page 1 of 1



Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-18 Run 150 Box 89 (1300.0' - 1301.7')
Date Tested:	7/27/2011 to 7/28/2011

Sample Date:	6/24/2011		
Report Date:	7/29/2011		

Slake Durability Index (Second Cycle) 99.1 % 0.5 °F Range of water temperature (Cycle 1) Average water temperature (Cycle 1) 75.8 °F Range of water temperature (Cycle 2) 0.0 °F 75.5 °F Average water temperature (Cycle 2) Natural Moisture Content % 0.24

Sample Description (Check which applies)

Туре	Description	
Ι	Retained specimen remain virtually unchanged	\checkmark
II	Retained specimen consists of large and small fragments	
III	Retained specimen is exclusively small fragments	



Before Test



Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-20 Run 154 Box 92 (1340.5' - 1342.0')
Date Tested:	7/27/2011 to 7/28/2011

Sample Date:	6/24/2011		
Report Date:	7/29/2011		

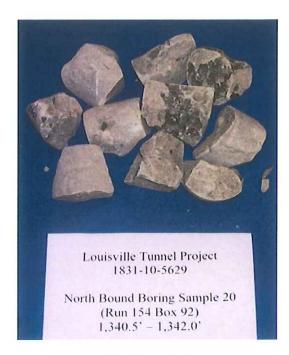
Slake Durability Index (Second Cycle)	98.8	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	75.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	75.3	°F
Natural Moisture Content	0.37	%

Sample Description (Check which applies)

Туре	Description			
Ι	Retained specimen remain virtually unchanged	\checkmark		
II	Retained specimen consists of large and small fragments			
III	Retained specimen is exclusively small fragments			









Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-21 Run 158 Box 94 (1379.4' - 1380.8')
Date Tested:	7/27/2011 to 7/28/2011

Sample Date:	6/24/2011		
Report Date:	7/29/2011		

Slake Durability Index (Second Cycle)	94.3	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	75.5	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	75.5	°F
Natural Moisture Content	1.07	%

Sample Description (Check which applies)

Туре	e Description	
I	Retained specimen remain virtually unchanged	\checkmark
II	Retained specimen consists of large and small fragments	
III	Retained specimen is exclusively small fragments	









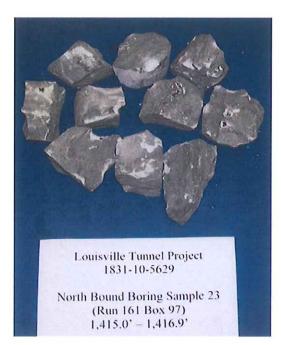
Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-23 Run 161 Box 97 (1415.0' - 1416.9')
Date Tested:	7/27/2011 to 7/28/2011

Sample Date:	6/24/2011
Report Date:	7/29/2011

Slake Durability Index (Second Cycle)	92.3	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	75.8	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	74.8	°F
Natural Moisture Content	1.29	%

Sample Description (Check which applies)

Туре	Description	
I	Retained specimen remain virtually unchanged	
Π	Retained specimen consists of large and small fragments	\checkmark
III	Retained specimen is exclusively small fragments	





Louisville Tunnel Project 1831-10-5629 North Bound Boring Sample 23 (Run 161 Box 97) 1,415.0° – 1,416.9°



Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-25 Run 165 Box 100 (1453.7' - 1454.8')
Date Tested:	8/01/2011 to 8/02/2011

Sample Date:	7/1/2011
Report Date:	8/9/2011

Slake Durability Index (Second Cycle)	91.5	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	77.3	°F
Range of water temperature (Cycle 2)	1.5	°F
Average water temperature (Cycle 2)	77.8	°F
Natural Moisture Content	1.89	%

Sample Description (Check which applies)

Туре	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	\checkmark
III	Retained specimen is exclusively small fragments	



Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 25 (Run 165 Box 100) 1,453.7' – 1,454.8'

Before Test



Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 25 (Run 165 Box 100) 1,453.7' – 1,454.8'



Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-26 Run 170 Box 103 (1494.2' - 1495.7')
Date Tested:	8/01/2011 to 8/02/2011

Sample Date:	7/1/2011
Report Date:	8/9/2011

Slake Durability Index (Second Cycle)	85.6	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	77.8	°F
Range of water temperature (Cycle 2)	2.0	°F
Average water temperature (Cycle 2)	77.5	°F
Natural Moisture Content	1.78	%

Sample Description (Check which applies)

Туре	Description	
I	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	\checkmark
III	Retained specimen is exclusively small fragments	







Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 26 (Run 170 Box 103) 1,494.2' – 1,495.7'



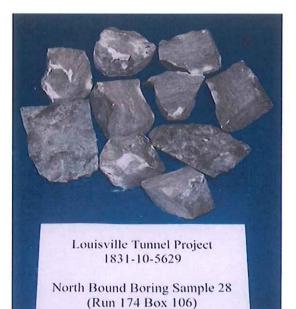
Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-28 Run 174 Box 106 (1539.0' - 1540.5')
Date Tested:	8/01/2011 to 8/02/2011

Sample Date:	7/1/2011	
Report Date:	8/9/2011	

Slake Durability Index (Second Cycle)	91.1	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	78.3	°F
Range of water temperature (Cycle 2)	1.5	°F
Average water temperature (Cycle 2)	77.8	°F
Natural Moisture Content	1.75	%

Sample Description (Check which applies)

Туре	Description	
Ι	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	\checkmark
III	Retained specimen is exclusively small fragments	



Before Test

1,539.0' - 1,540.5'



Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 28 (Run 174 Box 106) 1,539.0' – 1,540.5'



7/1/2011

8/9/2011

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

Sample Date:

Report Date:

Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-30 Run 178 Box 108 (1580.5' - 1582.0')
Date Tested:	8/01/2011 to 8/02/2011

Slake Durability Index (Second Cycle)	95.8	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	77.8	°F
Range of water temperature (Cycle 2)	2.0	°F
Average water temperature (Cycle 2)	78.0	°F
Natural Moisture Content	1.68	%

Sample Description (Check which applies)

Туре	Description	
I	Retained specimen remain virtually unchanged	\checkmark
II	Retained specimen consists of large and small fragments	
III	Retained specimen is exclusively small fragments	



Before Test



Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 30 (Run 178 Box 108) 1,580.5' - 1,582.0'



7/1/2011

8/9/2011

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

Sample Date:

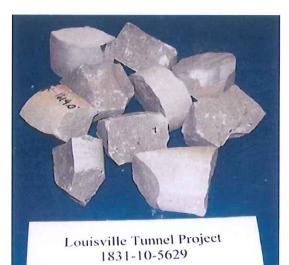
Report Date:

Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-31 Run 182 Box 111 (1619.0' - 1621.0')
Date Tested:	8/02/2011 to 8/03/2011

Slake Durability Index (Second Cycle)	97.3	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	78.5	°F
Range of water temperature (Cycle 2)	1.0	°F
Average water temperature (Cycle 2)	76.0	°F
Natural Moisture Content	1.22	%

Sample Description (Check which applies)

Туре	Description	
I	Retained specimen remain virtually unchanged	\checkmark
II	Retained specimen consists of large and small fragments	
III	Retained specimen is exclusively small fragments	



North Bound Boring Sample 31 (Run 182 Box 111) 1,619.0' – 1,621.0'

Before Test



Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 31 (Run 182 Box 111) 1,619.0' – 1,621.0'



Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-33 Run 186 Box 114 (1657.6' - 1659.0')
Date Tested:	8/02/2011 to 8/03/2011

Sample Date:	7/1/2011
Report Date:	8/9/2011

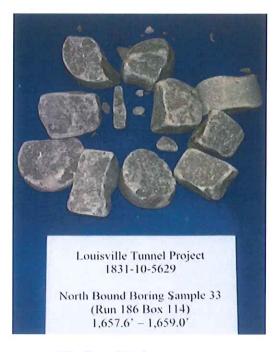
Slake Durability Index (Second Cycle)	96.2	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	78.5	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	75.5	°F
Natural Moisture Content	1.41	%

Sample Description (Check which applies)

Туре	Description	
Ι	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	\checkmark
III	Retained specimen is exclusively small fragments	



North Bound Boring Sample 33 (Run 186 Box 114) 1,657.6' – 1,659.0'



Before Test



7/1/2011

8/9/2011

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

Sample Date:

Report Date:

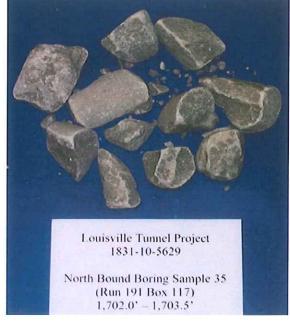
Project:	Louisville Tunnel	
S&ME Project No.	1831-10-5629	
Material:	Waldron Shale	
Sample ID:	NB-35 Run 191 Box 117 (1702.0' - 1703.5')	
Date Tested:	8/02/2011 to 8/03/2011	

Slake Durability Index (Second Cycle)	91.5	%
Range of water temperature (Cycle 1)	0.0	٥F
Average water temperature (Cycle 1)	78.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	76.3	°F
Natural Moisture Content	1.67	%

Sample Description (Check which applies)

Туре	Description	
Ι	Retained specimen remain virtually unchanged	
II	Retained specimen consists of large and small fragments	\checkmark
III	Retained specimen is exclusively small fragments	





Before Test



7/1/2011

8/9/2011

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

Sample Date:

Report Date:

Project:	Louisville Tunnel	
S&ME Project No.	1831-10-5629	
Material:	Waldron Shale	
Sample ID:	NB-36 Run 194 Box 119 (1740.0' - 1741.5')	
Date Tested:	8/02/2011 to 8/03/2011	

NB-36 Run 194 Box 119 (1740.0' - 1741.5')
8/02/2011 to 8/03/2011

Slake Durability Index (Second Cycle)	94.0	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	78.3	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	75.8	°F
Natural Moisture Content	1.51	%

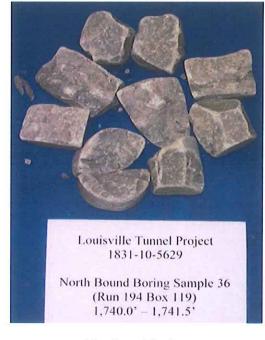
Sample Description (Check which applies)

Туре	Description	
Ι	Retained specimen remain virtually unchanged	
П	Retained specimen consists of large and small fragments	V
Ш	Retained specimen is exclusively small fragments	



Louisville Tunnel Project 1831-10-5629

North Bound Boring Sample 36 (Run 194 Box 119) 1,740.0' – 1,741.5'



After Second Cycle

Before Test



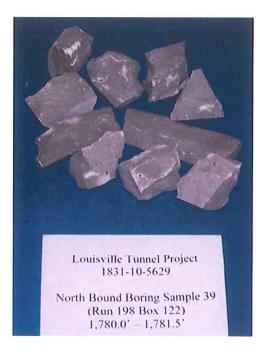
Project:	Louisville Tunnel	
S&ME Project No.	1831-10-5629	
Material:	Waldron Shale	
Sample ID:	NB-39 Run 198 Box 122 (1780.0' - 1781.5')	
Date Tested:	7/29/2011 to 8/01/2011	

Sample Date:	7/8/2011
Report Date:	8/12/2011

Slake Durability Index (Second Cycle)	96.5	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	76.3	°F
Range of water temperature (Cycle 2)	1.0	°F
Average water temperature (Cycle 2)	76.5	°F
Natural Moisture Content	1.98	%

Sample Description (Check which applies)

Туре	Description	
Ι	Retained specimen remain virtually unchanged	\checkmark
II	Retained specimen consists of large and small fragments	
111	Retained specimen is exclusively small fragments	









7/8/2011

8/12/2011

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

Sample Date:

Report Date:

Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-43 Run 203 Box 125 (1823.5' - 1824.6')
Date Tested:	7/29/2011 to 8/01/2011

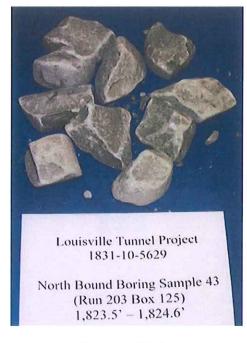
Slake Durability Index (Second Cycle)	94.2	%
Range of water temperature (Cycle 1)	0.0	°F
Average water temperature (Cycle 1)	76.5	°F
Range of water temperature (Cycle 2)	0.5	°F
Average water temperature (Cycle 2)	76.3	°F
Natural Moisture Content	1.78	%

Sample Description (Check which applies)

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



Before Test



After Second Cycle



7/8/2011

8/12/2011

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

Sample Date:

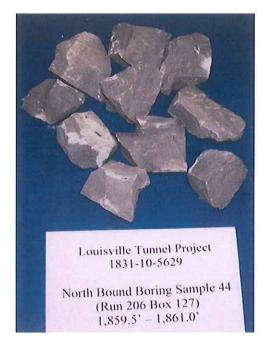
Report Date:

Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Waldron Shale
Sample ID:	NB-44 Run 206 Box 127 (1859.5' - 1861.0')
Date Tested:	7/29/2011 to 8/01/2011

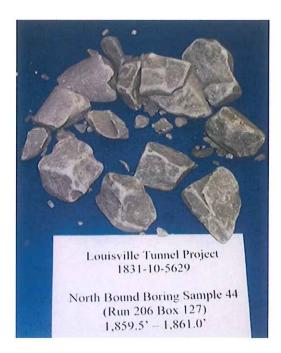
Slake Durability Index (Second Cycle)	93.5	%
Range of water temperature (Cycle 1)	0.5	°F
Average water temperature (Cycle 1)	76.3	°F
Range of water temperature (Cycle 2)	0.0	°F
Average water temperature (Cycle 2)	76.5	°F
Natural Moisture Content	2.11	%

Sample Description (Check which applies)

Туре	Description	Description	
I	Retained specimen remain virtually unchanged		
II	Retained specimen consists of large and small fragments	\checkmark	
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: 5/20/2011

Operator: MDK Checked By: NRR

Specimen ID:	PIL 17	PIL 18	PIL 20	PIL 22
Depth (ft):	1193.7-1196.5	1249.0-1251.8	1314.1-1315.9	1373.8-1375.8
Specimen Mass (g):	447.1	461.2	148.8	427.3
Specimen Volume:				
Avgerage Dia. (mm)	47.29	47.30	31.50	47.00
Average Length (mm)	96.42	98.17	74.28	95.77
Area (cm²)	17.56	17.57	7.79	17.35
Volume (cm ³), V	169.36	172.53	57.87	166.18
Water Content (ratio)	0.0020	0.0020	0.001	0.006
Crushed Minus No. 4 Mass				
Mass of Solids (g)	443.50	459.40	147.12	424.88
Effective Unit Weight (g/cm ³)	2.64	2.67	2.57	2.57
Dry Unit Weight (g/cm³)	2.62	2.66	2.54	2.56
Dry Unit Weight (lb/ft ³)	163.5	166.2	158.7	159.6
Specific Gravity of Solids from RTH 108	2.85	2.85	2.86	2.84
Grain Unit Weight (lb/ft ³)	177.7	177.7	178.2	177.0
Total Porosity (%), n=V _v /V	7.99	6.47	10.93	9.82
Volume of Solids (cm ³), V _s	155.82	161.35	51.55	149.86
Volume of Voids (cm ³), V _v	13.54	11.17	6.33	16.32
Volume of Water (cm ³), V _w	0.89	0.92	0.15	2.55
¹ Void Ratio, e=V _v /V _s	0.0869	0.0692	0.1227	0.1089
¹ Degree of Saturation (%), S=V _w /V _v	7%	8%	2%	16%

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

Sample Date: 7/1/2011

Operator: MDK Checked By: NRR

Specimen ID:	NB 31	NB 38	
Depth (ft):	1619.0-1621.0	1753.2-1754.6	
Specimen Mass (g):	402.7	459.2	
Specimen Volume:			
Average Dia. (mm)	47.21	47.37	
Average Length (mm)	88.25	99.32	
Area (cm²)	17.50	17.62	
Volume (cm³), V	154.47	175.04	
Water Content (ratio)	0.0150	0.0140	
Crushed Minus No. 4 Mass			
Mass of Solids (g)	393.01	445.78	
Effective Unit Weight (g/cm ³)	2.61	2.62	
Dry Unit Weight (g/cm ³)	2.54	2.55	
Dry Unit Weight (lb/ft ³)	158.8	159.0	
Specific Gravity of Solids from RTH 108	2.83	2.83	
Grain Unit Weight (lb/ft³)	176.2	176.6	
Total Porosity (%), n=V _v /V	9.85	9.95	
Volume of Solids (cm ³), V_s	139.26	157.62	
Volume of Voids (cm ³), V _v	15.22	17.42	
Volume of Water (cm ³), V _w	5.91	6.25	
¹ Void Ratio, e=V _v /V _s	0.1093	0.1105	
¹ Degree of Saturation (%), S=V _w /V _v	39%	36%	

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.



Moisture Content of Intact Rock Core

S&ME Project Name: S&ME Project Number: Test Procedure:	e: lber:	Louisville Tunnel Project 1831-10-5629 ASTM D 2216	lel Project					
		Tare	Tare	Moisture Specimen including tare	n including tare	Percent	Tockool	
Location	Distance (ft)	D Cl	Weight (g)	Wet Weight (g)	Oven Dry Weight (g)	Moisture (%)	By	Date
NB-16 Run 140 Box 83	1208.7	305	8.38	364.10	363.77	0.1	TJW	7/29/2011
NB-17 Run 147 Box 87	1269.3	112	8.20	150.84	150.71	0.1	TJW	7/29/2011
NB-19 Run 153 Box 91	1330.2	1	8.19	398.31	397.13	0.3	TJW	7/29/2011
NB-22 Run 159 Box 95		314	8.43	442.31	437.68	1.1	TJW	7/29/2011
NB-24 Run 165 Box 99	1450.9	2	8.19	453.39	449.32	0.9	TJW	7/29/2011
NB-16 Run 140 Box 83	1208.9	12	8.14	150.51	150.37	0.1	TJW	7/29/2011
NB-17 Run 147 Box 87	1269.5	203	8.24	52.66	52.58	0.2	TJW	7/29/2011
NB-19 Run 153 Box 91	1330.4	22	8.23	143.84	143.33	0.4	TJW	7/29/2011
NB-22 Run 159 Box 95		З	8.20	135.07	133.47	1.3	TJW	7/29/2011
NB-24 Run 165 Box 99	1451.1	25	8.21	135.26	133.41	1.5	TJW	7/29/2011
	•							
		27						

Reviewed By:

Date:

CERCHAR Abrasiveness test

Test procedure: ASTM D7625



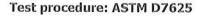
The University of Texas at Austin

Geotechnical Engineering Center Department of Civil, Architectural and Environmental Engineering

Cerchar

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CERCHAR Abrasiveness test





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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	7/11/11	
Test Performer	Moo Yeon Kim	
Checked by	Mahdi Heidari	
Location	Louisville, Kentucky	
Boring and sample	NB, 2	
Specimen depth	1822.0-1823.5 ft	
Rock Type .	Shale	
Formation	Waldron Shale	
Pin Rockwell Hardness	55/56	

Surface condition	Cut by slab saw		
Direction of scratch	Perpendicular to o	core axis	
Pin Wear	Max width (mm)	Min width (mm)	
	0.04	0.036	
	0.036	0.027	
	0.067	0.054	
	0.058	0.027	
	0.036	0.022	
Average (mm)	0.040		
CAI	0.40		
Equipment	Ergo Tech CERCHAR Test A		
	No.1	00225	

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.

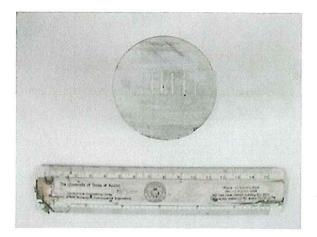


Photo after test

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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 mudstone/shale
GEC reference		Rock name	Dolomitized mudstone/shale
Drill hole and depth	NB2 1822.0-1823.5	Studied by	K. Surpless
Specimen number	1822.0-1823.5	Date Studied	August 25, 2011
Formation	Waldron Shale Formation	Reviewed by	Tonon, Fulvio
Rock Type	Shale/mudstone		

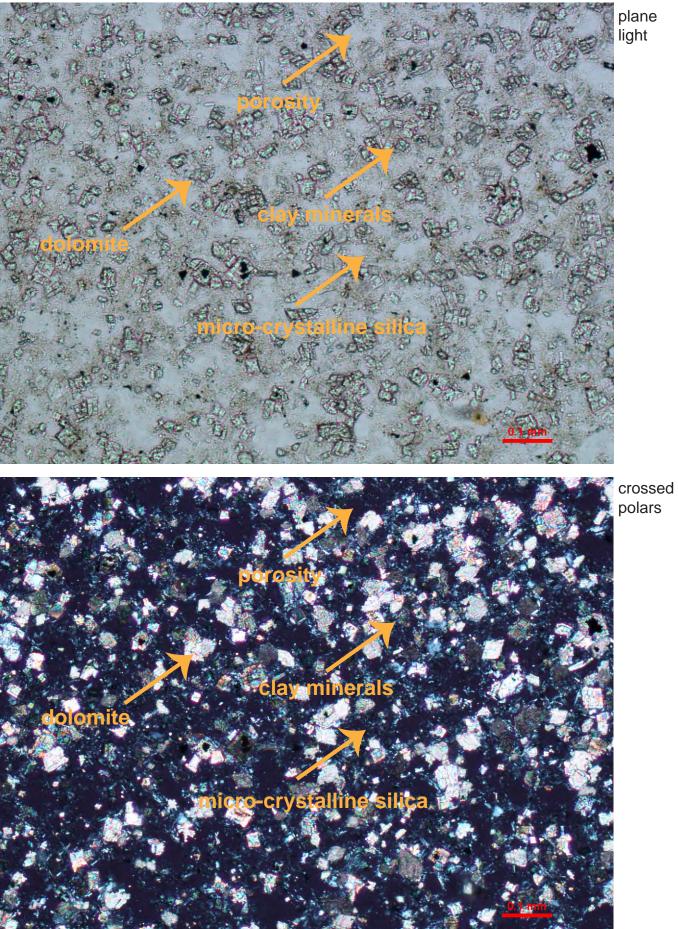
Description of Individual Minerals:

Description						
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments		
Microcrystalline silica	10%	7	<0.01	Low relief, clear in plane light, irregular extinction, possibly chalcedony		
Dolomite	40%	3.5-4	0.02-0.09; ave 0.05	Evenly distributed throughout the slide; dolomite in well- formed, distinctive rhombs		
Opaque minerals	3%	4.5-5	variable	Probably iron oxide minerals; irregular shape, formed through diagenesis		
porosity	22%	NA	variable	Throughout slide		
Clay minerals	25%	1-3	<0.01	Throughout slide; potassium-rich clay picks up yellow stain on stained half of slide		
Weighted A	verage:	3.6		Excludes porosity		

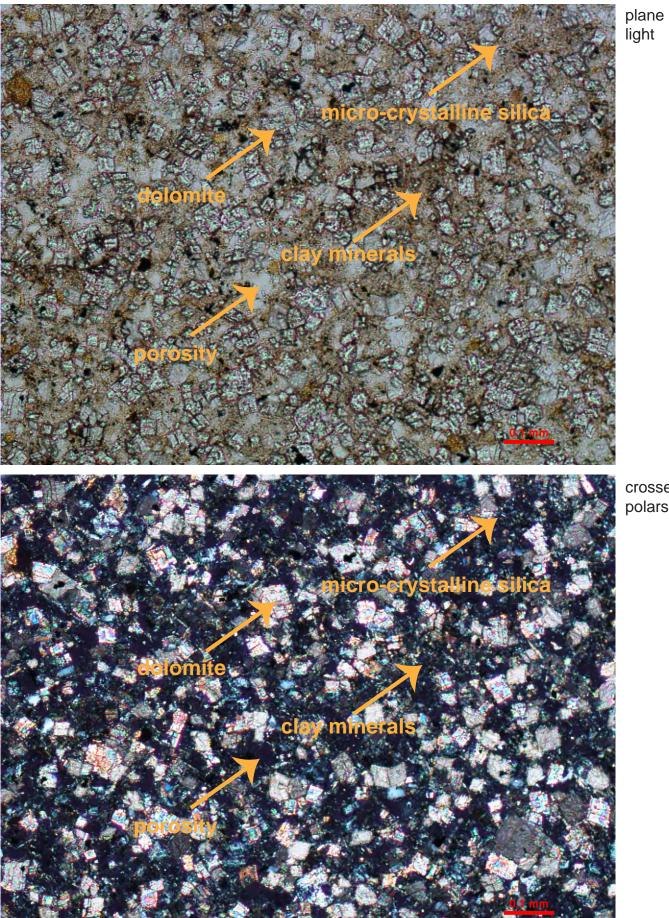
Remarks: partial dolomitization of clay-rich, silicic matrix in porous shale or mudstone; no preferred orientation visible in slide; no variability in the intensity of dolomitization

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NB2 1822.0-1823.5 ft, unstained slide



NB2 1822.0-1823.5 ft, stained slide (for K)



crossed polars

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



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Geotechnical Engineering Department of Civil, Architectural and Environmental Engineering

Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	6/29/2011
Start Test Date	7/10/11
Test Performer / Checker	Mahdi Heidari/Moo Y. Kim
Boring no.	NB 1
Depth	1401.3-1402.8
Rock Type	Shale

Orientation of specimen axis	Orthogonal to bedding		
Method of sampling	Core boring		
Method of specimen preparation	Cut by slab saw		
Max. axial strain	0.50 %		
Original height of specimen	19.03 mm 0.75 i		
Maximum pressure requested	4644 kPa 9700 p		
Diameter of specimen	47.19 mm 1.86		
Test temperature	20.0 °C 68.0		

Testing set-up



Testing set-up



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



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Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
7/10/11	11	225	10.16	0.4	0.05
7/10/11	22	450	25.4	1	0.13
7/10/11	22	450	38.1	1.5	0.20
7/10/11	65	1350	68.58	2.7	0.36
7/11/11	129	2700	111.76	4.4	0.59
7/12/11	215	4500	175.26	6.9	0.92
7/16/11	0	0	152.4	6	0.80
7/19/11	-215	-4500	111.76	4.4	0.59
7/22/11	-129	-2700	66.04	2.6	0.35
7/25/11	-65	-1350	38.1	1.5	0.20
7/28/11	-22	-450	25.4	1	0.13
8/2/11	-22	-450	5.08	0.2	0.03

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

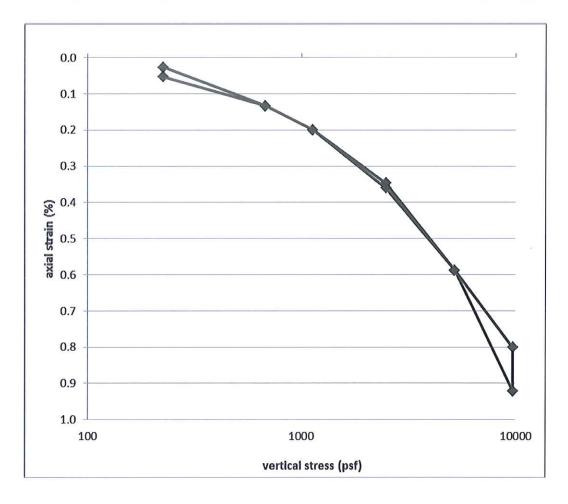
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(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)



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Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	7/7/2011
Start Test Date	7/8/11
Test Performer / Checker	Mahdi Heidari/Moo Y. Kim
Boring no.	NB 2
Depth	1822.0-1823.5
Rock Type	Shale

Orientation of specimen axis	Orthogonal to bedding		
Method of sampling	Core boring		
Method of specimen preparation	Cut by slab saw		
Max. axial strain	0.50 %		
Original height of specimen	18.38 mm 0.72 i		
Maximum pressure requested	4644 kPa 9700		
Diameter of specimen	46.75 mm 1.84		
Test temperature	20.0 °C 68		

Testing set-up 1



Testing set-up 2



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Date Axial load increment		crement	Axial displacement		Axial strain (%)
	kPa	Psf	mm (x 1,000)	in (x 1,000)	
7/8/11	11	225	7.62	0.3	0.04
7/9/11	22	450	15.24	0.6	0.08
7/10/11	22	450	25.4	1	0.14
7/14/11	65	1350	43.18	1.7	0.23
7/17/11	129	2700	73.66	2.9	0.40
7/20/11	215	4500	104.14	4.1	0.57
7/23/11	0	0	81.28	3.2	0.44
7/26/11	-215	-4500	53.34	2.1	0.29
7/30/11	-129	-2700	35.56	1.4	0.19
7/31/11	-65	-1350	20.32	0.8	0.11
8/1/11	-22	-450	12.7	0.5	0.07
8/2/11	-22	-450	0	0	0.00

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

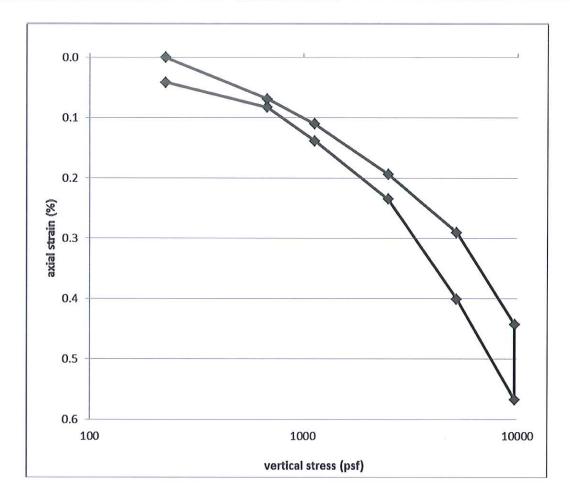
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(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)



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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 mudstone/shale
GEC reference		Rock name	Dolomitized mudstone/shale
Drill hole and depth	NB2 1822.0-1823.5	Studied by	K. Surpless
Specimen number	1822.0-1823.5	Date Studied	August 25, 2011
Formation	Waldron Shale Formation	Reviewed by	Tonon, Fulvio
Rock Type	Shale/mudstone		

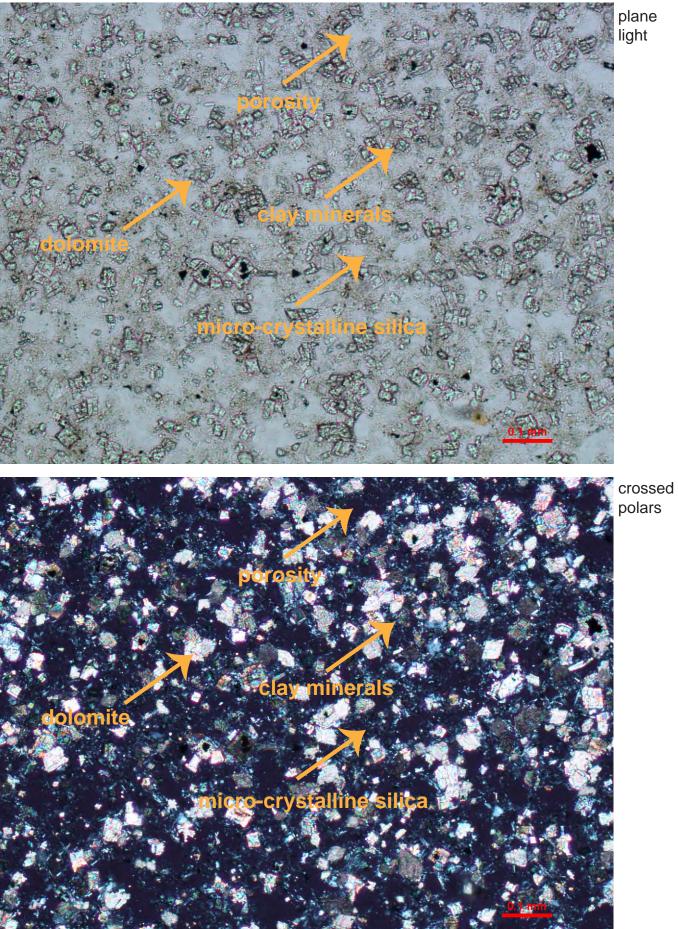
Description of Individual Minerals:

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments				
Microcrystalline silica	10%	7	<0.01	Low relief, clear in plane light, irregular extinction, possibly chalcedony				
Dolomite	40%	3.5-4	0.02-0.09; ave 0.05	Evenly distributed throughout the slide; dolomite in well- formed, distinctive rhombs				
Opaque minerals	3%	4.5-5	variable	Probably iron oxide minerals; irregular shape, formed through diagenesis				
porosity	22%	NA	variable	Throughout slide				
Clay minerals	25%	1-3	<0.01	Throughout slide; potassium-rich clay picks up yellow stain on stained half of slide				
Weighted Average: 3.6			Excludes porosity					

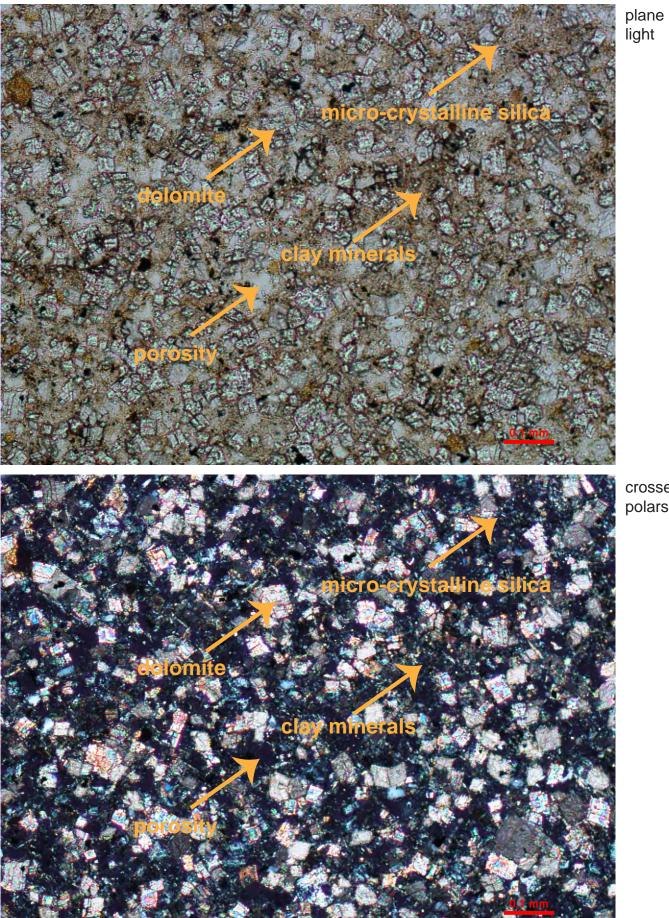
Remarks: partial dolomitization of clay-rich, silicic matrix in porous shale or mudstone; no preferred orientation visible in slide; no variability in the intensity of dolomitization

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NB2 1822.0-1823.5 ft, unstained slide



NB2 1822.0-1823.5 ft, stained slide (for K)



crossed polars

APPENDIX C

PACKER TEST RESULTS

LEGEND TO LUGEON VALUES

Louisville Tunnel Project Louisville, KY 1831-10-5629

Field Test Data



Tested By: <u>N. Peterson</u>

.

Ground Surface Elev. _____.

Boring No. North Bound

Date	Stage	Time (Reqd = 10 min.)			Guage Pressure		Flow Meter Start	Flow Meter Stop	Water Take (gallons)
7/7/2011		From	То	Actual	Reqd	Actual	(gallons)	(gallons)	,
Packer Pressures	from	1613	1623	10	30	37.08	274.19	278.04	3.85
Тор	<u>1371.0 ft</u>	1627	1637	10	60	61.01	278.04	280.01	1.97
200	<u>1400.0 ft</u>	1638	1648	10	90	91	280.01	280.03	0.02
Bottom	Midpt. ELEV	1649	1659	10	60	61	280.03	280.04	0.01
200	<u>ft.</u>	1700	1710	10	30	37	280.04	280.04	0
Packer Pressures	from	1750	1800	10	30	30.65	302.33	309.98	7.65
Тор	<u>1350.0 ft</u>	1805	1815	10	60	60.3	321.26	321.44	0.18
200	<u>to 1321.0 ft.</u>	1818	1828	10	90	90.3	323.86	324.27	0.41
Bottom	Midpt. ELEV	1830	1840	10	60	59.8	324.88	324.94	0.06
200	<u>ft.</u>	1841	1851	10	30	37.5	325.3	326.64	1.34
Packer Pressures	from	745	755	10	30	29.1	341.94	342.05	0.11
Тор	1300.0 ft.	757	807	10	60	60.3	355.45	355.9	0.45
200	<u>to 1271.0 ft.</u>	810	820	10	90	89.1	359.44	359.8	0.36
Bottom	Midpt. ELEV	823	833	10	60	58.4	363.4	363.94	0.54
200	ft.	835	845	10	30	34.4	364.32	365.3	0.98
Packer Pressures	from	1115	1125	10	30	31	410.64	410.64	0
Тор	1250.0 ft	1127	1137	10	60	58.9	419.04	419.04	0
200	to 1221.0 ft.	1139	1149	10	90	91	424.09	424.09	0
Bottom	Midpt. ELEV	1150	1200	10	60	61.1	424.3	424.3	0
200	<u>ft.</u>	1201	1211	10	30	34.9	424.44	424.44	0

Louisville Tunnel Project Louisville, KY 1831-10-5629

Field Test Data

Boring No. North Bound Boring



Tested By: David Durman

Ground Surface Elev.

Date	Stage	Time (Reqd = 10 min.)			Gauge Pressure		Flow Meter Start	Flow Meter Stop	Water Take (gallons)
7/8/11		From	То	Actual	Reqd	Actual	(gallons)	(gallons)	
Packer Pressures	from	12:39	12:49	10	30	32.0	438.72	438.72	0.00
Тор	1150.0 ft.	12:50	13:00	10	60	58.7	450.07	450.07	0.00
200	to 1121.0 ft.	13:00	13:10	10	90	92.1	450.99	450.99	0.00
Bottom	Midpt. ELEV	13:10	13:20	10	60	59.9	451.12	451.12	0.00
200	510.73	13:20	13:30	10	30	35.9	451.24	451.24	0.00
Packer Pressures	from	13:54	14:04	10	30	30.0	465.95	466.00	0.05
Тор	1100.0 ft.	14:10	14:20	10	60	58.9	475.77	475.77	0.00
200	to 1071.0 ft.	14:23	14:33	10	90	90.4	478.66	478.71	0.05
Bottom	Midpt. ELEV	14:35	14:45	10	60	59.2	479.25	479.25	0.00
200	510.68	14:45	14:55	10	30	36.1	479.44	479.46	0.02
Packer Pressures	from	15:42	15:52	10	30	31.2	559.76	590.15	30.39
Тор	1050.0 ft.	15:56	16:06	10	60	63.8	613.84	672.14	58.30
200	to 1021.0 ft.	16:07	16:17	10	90	91.0	695.12	789.90	94.78
Bottom	Midpt. ELEV	16:18	16:28	10	60	58.2	802.52	863.34	60.82
200	510.59	16:30	16:40	10	30	35.3	870.95	886.46	15.51
Packer Pressures	from	17:06	17:16	10	30	29.8	896.92	898.80	1.88
Тор	1000.0 ft.	17:21	17:31	10	60	57.8	915.02	933.00	17.98
200	to 971.0 ft.	17:38	17:48	10	90	93.3	971.58	996.06	24.48
Bottom	Midpt. ELEV	17:49	17:59	10	60	61.5	1000.34	1023.62	23.28
200	510.78	18:00	18:10	10	30	34.7	1024.44	1024.44	0.00

Louisville Tunnel Project Louisville, KY 1831-10-5629

Field Test Data

Boring No. North Bound Boring



Tested By: David Durman

Ground Surface Elev.

Date	Stage	Time (Reqd = 10 min.)			Gauge Pressure		Flow Meter Start	Flow Meter Stop	Water Take (gallons)
7/9/11		From	То	Actual	Reqd	Actual	(gallons)	(gallons)	
Packer Pressures	from	7:47	7:57	10	30	30.5	1051.51	1054.27	2.76
Тор	950.0 ft.	8:02	8:12	10	60	61.1	1063.34	1069.37	6.03
200	to 921.0 ft.	8:19	8:29	10	90	91.2	1082.22	1094.63	12.41
Bottom	Midpt. ELEV	8:31	8:41	10	60	59.0	1098.00	1106.00	8.00
200	512.45	8:43	8:53	10	30	28.9	1106.50	1107.10	0.60
Packer Pressures	from	9:20	9:30	10	30	29.3	1128.26	1128.26	0.00
Тор	900.0 ft.	9:32	9:42	10	60	60.8	1135.16	1135.16	0.00
200	to 871.0 ft.	9:48	9:58	10	90	88.4	1138.94	1138.94	0.00
Bottom	Midpt. ELEV	10:00	10:10	10	60	59.6	1144.50	1144.50	0.00
200	512.25	10:12	10:22	10	30	33.4	1144.90	1144.90	0.00
Packer Pressures	from	10:45	10:55	10	30	29.3	1163.68	1163.68	0.00
Тор	850.0 ft.	10:57	11:07	10	60	61.5	1172.50	1172.50	0.00
200	to 821.0 ft.	11:10	11:20	10	90	89.2	1175.96	1175.96	0.00
Bottom	Midpt. ELEV	11:20	11:30	10	60	62.1	1176.71	1176.71	0.00
200	518.01	11:30	11:40	10	30	30.7	1177.16	1177.16	0.00
Packer Pressures	from	12:12	12:22	10	30	28.4	1196.69	1196.69	0.00
Тор	750.0 ft.	12:23	12:33	10	60	58.2	1208.07	1208.07	0.00
200	to 721.0 ft.	12:36	12:46	10	90	88.1	1213.80	1213.80	0.00
Bottom	Midpt. ELEV	12:47	12:57	10	60	60.2	1214.54	1214.54	0.00
200	522.96	12:58	13:08	10	30	29.7	1215.07	1215.07	0.00
Packer Pressures	from	13:37	13:47	10	30	29.0	1232.04	1232.04	0.00
Тор	650.0 ft.	13:51	14:01	10	60	60.8	1241.09	1241.09	0.00
200	to 621.0 ft.	14:05	14:15	10	90	89.6	1244.96	1244.96	0.00
Bottom	Midpt. ELEV	14:16	14:26	10	60	60.9	1245.42	1245.42	0.00
200	526.93	14:25	14:35	10	30	30.1	1245.72	1245.72	0.00

LOUSIVILLE TUNNEL PROJECT GEOTECHNICAL INVESTIGATION WATER PRESSURE TESTING

Field Test Data

Boring : <i>North Bound</i>	Test by:	<u>N. Peterson</u>
Elevation:	Date:	

Formula for Lugeon (Lu) calculation:

(water take in gallons \div 7.48 gal/ft³) x (142 psi \div 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)		
1371.0	1371.0	1	29.0	10	30.0	3.9	1			
1400.0	1400.0	2	29.0	10	60.0	2.0	0			
		3	29.0	10	90.0	0.0	0	1		
		4	29.0	10	30.0	0.0	0			
		5	29.0	10	60.0	0.0	0			
1321.0	1321.0	1	29.0	10	30.0	7.7	2			
1350.0	1350.0	2	29.0	10	60.0	0.2	0			
		3	29.0	10	90.0	0.4	0	2		
		4	29.0	10	60.0	0.1	0			
		5	29.0	10	30.0	1.3	0			
1271.0	1271.0	1	29.0	10	30.0	0.1	0			
1300.0	1300.0	2	29.0	10	60.0	0.5	0			
		3	29.0	10	90.0	0.4	0			
		4	29.0	10	60.0	0.5	0			
		5	29.0	10	30.0	1.0	0			

LOUISVILLE TUNNEL PROJECT GEOTECHNICAL INVESTIGATION WATER PRESSURE TESTING

Field Test Data

Boring : N	lorth Bound	Test by:	N. Peterson
Elevation:	510.7	Date:	

Formula for Lugeon (Lu) calculation:

(water take in gallons \div 7.48 gal/ft³) x (142 psi \div 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)		
1121.0	1121.0	1	29.0	10	30.0	0.0	0			
1150.0	1150.0	2	29.0	10	60.0	0.0	0			
		3	29.0	10	90.0	0.0	0			
		4	29.0	10	60.0	0.0	0			
		5	29.0	10	30.0	0.0	0			
1071.0	1071.0	1	29.0	10	30.0	0.0	0			
1100.0	1100.0	2	29.0	10	60.0	0.1	0			
		3	29.0	10	90.0	0.0	0			
		4	29.0	10	60.0	0.0	0			
		5	29.0	10	30.0	0.0	0			
1021.0	1021.0	1	29.0	10	30.0	30.4	6			
1050.0	1050.0	2	29.0	10	60.0	58.3	6			
		3	29.0	10	90.0	94.8	6	6		
		4	29.0	10	60.0	60.8	6			
		5	29.0	10	30.0	15.5	3			

LOUSIVILLE TUNNEL PROJECT GEOTECHNICAL INVESTIGATION WATER PRESSURE TESTING

Field Test Data

Boring : A	lorth Bound	Test by:	<u>N. Peterson</u>
Elevation:	512.5	Date:	

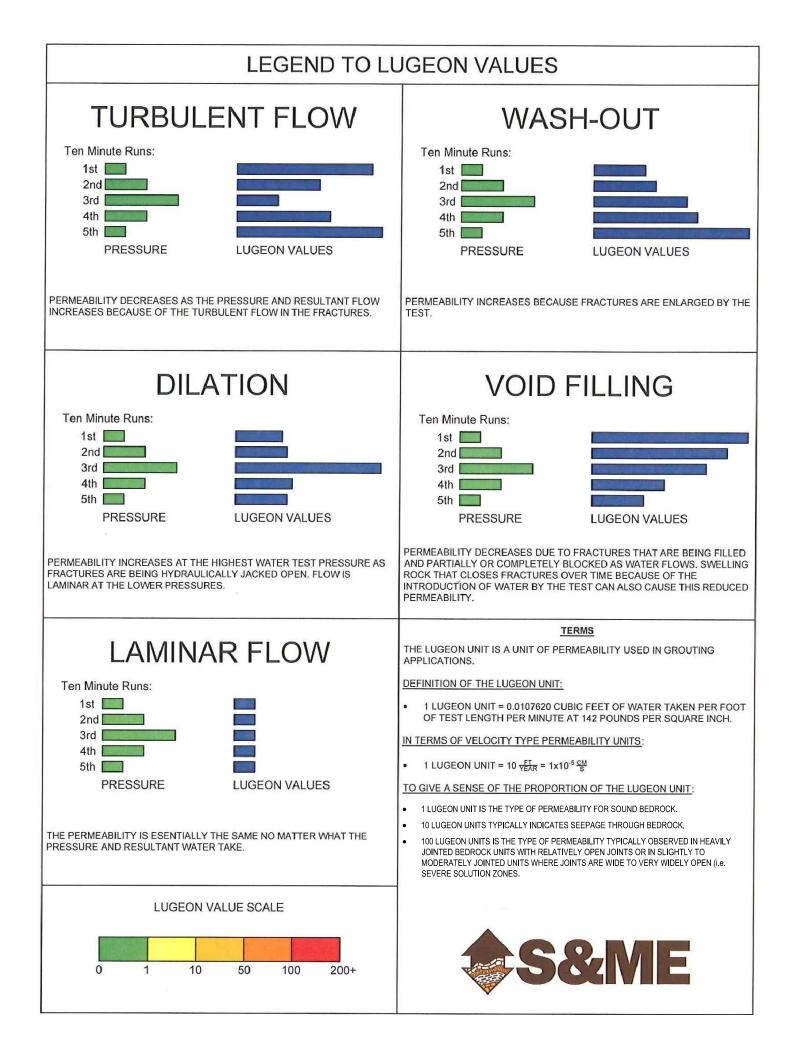
Formula for Lugeon (Lu) calculation:

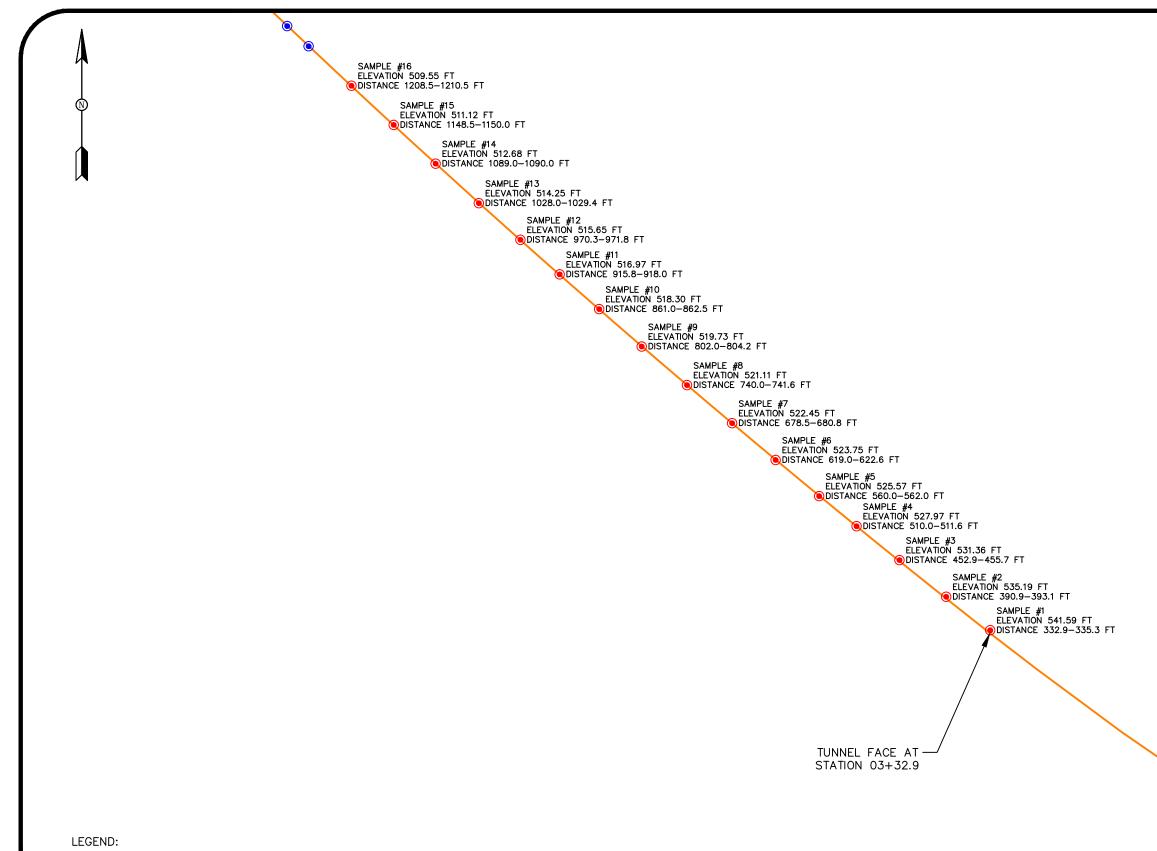
(water take in gallons \div 7.48 gal/ft³) x (142 psi \div gauge pressure in psi) divided by (stage length in feet x test time in minutes x 0.0107620)

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)		
921.0	921.0	1	29.0	10	30.0	2.8	1			
950.0	950.0	2	29.0	10	60.0	6.0	1			
		3	29.0	10	90.0	12.4	1			
		4	29.0	10	30.0	8.0	0			
		5	29.0	10	60.0	0.6	0			
871.0	871.0	1	29.0	10	30.0	0.0	0			
900.0	900.0	2	29.0	10	60.0	0.0	0			
		3	29.0	10	90.0	0.0	0			
		4	29.0	10	60.0	0.0	0			
		5	29.0	10	30.0	0.0	0			
821.0	821.0	1	29.0	10	30.0	0.0	0			
850.0	850.0	2	29.0	10	60.0	0.0	0			
		3	29.0	10	90.0	0.0	0			
		4	29.0	10	60.0	0.0	0			
		5	29.0	10	30.0	0.0	0			





LIMESTONE SAMPLE LOCATION

• SHALE SAMPLE LOCATION

